

KIRKHOF TRANSFORMER DIVISION

FLX CORPORATION

Dietrick K. Roth

SELECTING A FIXTURE-TYPE RESISTANCE
WELDING TRANSFORMER

INTRODUCTION

The selection of transformers for resistance welding applications is frequently done by "past experience". The reason for this is the difficulty, at the design stage of a welder, of predicting and evaluating the variables of the welding circuit such as resistance, reactance, etc. Therefore, it frequently happens that changes in the welding circuit have to be made during tryout of a welder to achieve the desired welding characteristics. These changes may be as simple as varying the shunt sizes, but, in some instances, a different welding transformer must be installed, which results in costly rework.

The purpose of the material presented here is to aid in the selection of welding transformers and to point out areas which have a great influence on the performance of a welder. It is not the requirement nor the purpose of this material to predict exactly the secondary voltage necessary to drive the weld current through a given welding circuit, since most fixture-type transformers have a secondary voltage range and controls will provide additional variables such as weld time and phase shift heat control to allow for needed adjustment.

The first step in selecting a transformer is to gather all the information pertaining to the welding circuit. Therefore, data sheets have been prepared which serve as a guide in tabulating the needed information. These data sheets cover all typical items which are common to welding circuits. However, it is important that the person securing the information take notice of any unusual conditions, such as: conductors which are in close proximity (less than 2 to 3 inches spacing) to structural machine members made of ferrous material; parts to be welded which extend more than 25% of the throat depth into the loop; poor contact joints; inadequate cooling water supply; adverse environmental conditions; etc. These items should be noted under remarks and supported by sketches, if necessary. The effect which these conditions have on the welding circuit will have to be evaluated on an individual basis and should be referred to the Kirkhof office for analysis.

The calculation sheets are used to evaluate the information on the data sheets. The instruction sheets, tables, graphs, and nomograms are to be used in conjunction with the calculation sheets to aid in computing the quantitative amounts of the individual items.

The values given in the instruction sheets are drawn from various sources. A more extensive calculation could be made but the scope of this material and the unpredictability of some of the variables do not justify the effort.

For information on weld schedules, such as tip force, weld current, minimum weld spacing, etc., the A.W.S. publication, "Recommended Practices for Resistance Welding", may be used as the source. Similar information can be found in the "Resistance Welding Manual, Volume I", published by R.W.M.A.

Three sample calculations and a discussion of the results are included with this material to further support its use.

It should be emphasized that the power source for the welder has to be stiff enough to furnish the demand load without excessive voltage drop in the feeder system. If this requirement is not met, not only will the performance of the welder be seriously affected, but other undesirable conditions, such as light flicker in the power distribution system, may result. For a complete treatment of this subject refer to the "Resistance Welding Manual, Volume II, Chapter 27" or "Power Supply for Resistance Welding Machines", published by the American Institute of Electrical Engineers.

Finally, the selection of transformers should be made only by qualified personnel having a background in electrical engineering, in addition to the capability of passing judgment on sound resistance welding practices.

Grand Rapids, Michigan
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I. INSTRUCTIONS FOR DETERMINING RESISTANCE VALUES OF THE SECONDARY CIRCUIT

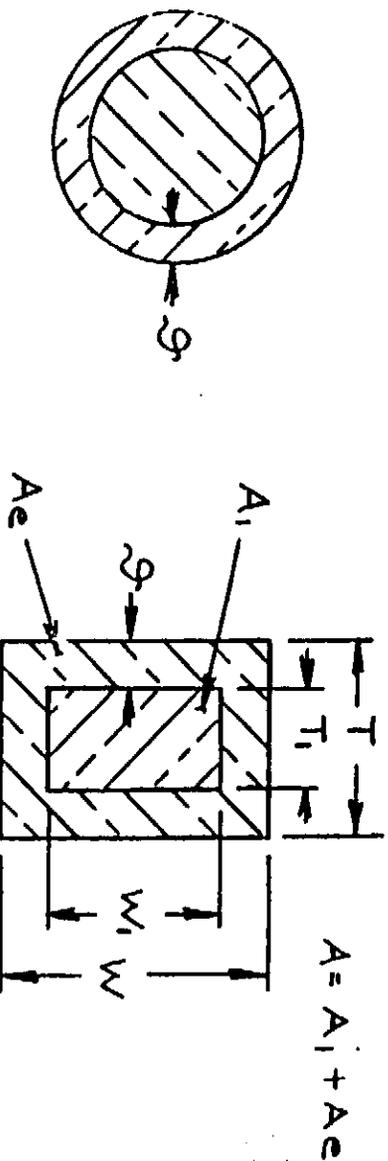
A. THE FOLLOWING TABLES AND NOMOGRAMS ARE TO BE USED

1. Transformer Resistance - Table #1.
2. Resistance of Air and Water cooled Jumpers - Table #2.
3. Copper Bus Bars - Nomogram #1.
4. Aluminum Bus Bars - Nomogram #2.
5. R.W.M.A. Copper Class #1 - Nomogram #3.
6. R.W.M.A. Copper Class #2 - Nomogram #4.
7. R.W.M.A. Copper Class #3 - Nomogram #5.

For materials other than those listed consult factory.

B. SKIN EFFECT

For conductors listed under items A3 thru A7 the effective cross-section A_e must be calculated before Nomograms #1 thru #5 can be used. This calculation is based on the assumption that the current flows at a constant density from the skin of a conductor to a line inside the conductor spaced by the depth of penetration δ from a contour of the skin. (Figure 1.)



Material	Copper 100% Cond.	Aluminum 61% Cond.	Cu. Class #1 80% Cond.	Cu. Class #2 75% Cond.	Cu. Class #3 45% Cond.
Depth of Penetration δ Inch	.35 Inch	.45 Inch	.4 Inch	.4 Inch	1.0 Inch

Figure 1

The above values for δ are based on a frequency of 60 Hz and the conductivities shown.

For round conductors the effective cross-section A_e is shown as a function of the diameter in graphs 1 and 2. Therefore, the effective cross-section can be determined from these graphs if the diameter of the conductor is known. For rectangular or square conductors the procedure as outlined under B3 below must be followed. The same procedure can be applied to other geometric shapes by using the appropriate formulas for the area of the cross-section and values for depth of penetration.

I. INSTRUCTIONS FOR DETERMINING RESISTANCE VALUES OF THE SECONDARY CIRCUIT (Cont'd.)

B. SKIN EFFECT (Cont'd.)

Refer to the following graphs and nomogram to determine the effective cross-section A_e .

1. ROUND CONDUCTORS
Copper 100% conductivity, Aluminum EC 61% conductivity - Graph #1.
2. ROUND CONDUCTORS
Copper R.W.M.A. Class 1, 2, 3 - Graph #2.
3. RECTANGULAR AND SQUARE CONDUCTORS

To obtain the effective cross-section A_e , the following steps must be taken:

- a. Find cross-section "A" of conductor based on width "W" and thickness "T". (Nomogram #6.)
- b. Find width $W_1 = W - 2\delta$ (Fig. 1)
- c. Find thickness $T_1 = T - 2\delta$ (Fig. 1)
- d. If both values W_1 and T_1 are positive, find cross-section A_1 based on width W_1 and thickness T_1 . (Nomogram #6.)
- e. The effective cross-section A_e is
 EITHER $A_e = A$ if W_1 or T_1 is negative or zero,
 OR $A_e = A_1$ if W_1 and T_1 are positive numbers.

C. PROXIMITY EFFECT

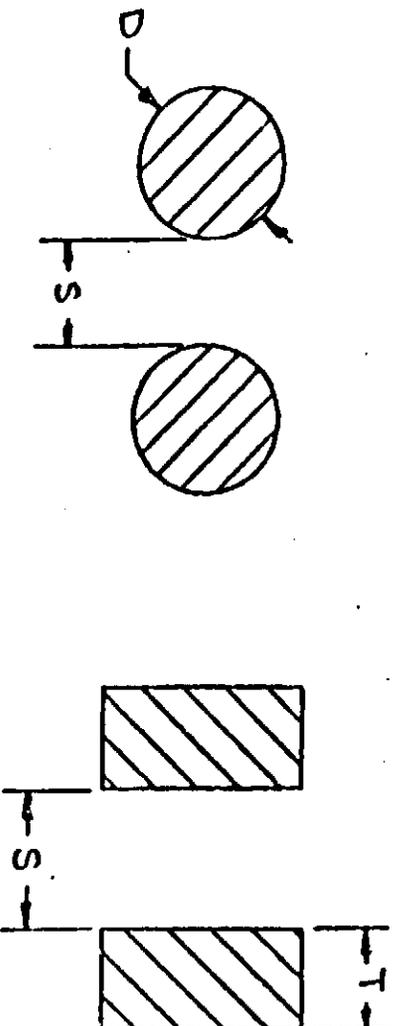
The proximity effect is the distortion of the current distribution over the conductor cross-section caused by inductive influence between two current-carrying conductors. Concentration of current exists in the parts of the conductors nearest to each other by current flow in opposite directions and vice versa by current flow in the same direction.

This results in a resistance increase which is directly proportional to the magnitude of the current and inversely proportional to the distance between conductors. No exact values can be given; however, the following approximations should be used:

Multiply conductor resistance by the factors shown in the table below. (Figure 2.)

I. INSTRUCTIONS FOR DETERMINING RESISTANCE VALUES OF THE SECONDARY CIRCUIT (Cont'd.)

C. PROXIMITY EFFECT (Cont'd.)



S	4 x D or T and over	3 x D or T	2 x D or T	1 x D or T
Factor	1.0	1.2	1.4	1.75

Figure 2

D. CONTACT RESISTANCE (BETWEEN CONDUCTORS)

The contact resistance depends on the contact area, the condition of the contact surfaces, and the force with which the contact surfaces are held together. In general, only the contact resistances given under item D1 need to be considered in the calculation. The contact resistances listed under items D2 and D3 are a part of the total resistance for electrode holders and back-ups as outlined in Section IE. Therefore, items D2 and D3 are to be used only if a detailed evaluation of electrode holder or back-up is required.

The following are experience values which apply to one (1) contact joint. It is important that these joints comply with good resistance welding practices.

1. Shunts to bus bar, transformer, or welding gun terminal - 1 to 2 Micro Ohms per joint.
2. Electrode holder to electrode - 2 to 3 Micro Ohms per joint.
3. Electrode caps and button to back-ups, etc. - 3 to 4 Micro Ohms per joint.

E. RESISTANCE OF ELECTRODE HOLDERS AND ELECTRODES FOR FIXTURE-TYPE WELDING GUNS AND BACK-UPS

The resistance of standard fixture-type electrode holders, including electrode and contact resistance between electrode and holder, can be assumed to be between 8 and 12 Micro Ohms.

I. INSTRUCTIONS FOR DETERMINING RESISTANCE VALUES OF THE SECONDARY CIRCUIT (Cont'd.)

E. RESISTANCE OF ELECTRODE HOLDERS AND ELECTRODES FOR FIXTURE-TYPE WELDING GUNS AND BACK-UPS (Cont'd.)

The resistance of welding back-ups depends largely upon the design. For normal welding applications the following values, which include the actual back-up, electrode caps, and the contact resistance between the two items, are suggested:

1. Direct welding back-up - 5 to 7 Micro Ohms.
2. Series welding back-up - 6 to 8 Micro Ohms for the first 2" spot spacing. Add 1 Micro Ohm for each additional inch of spot spacing.

In cases where long electrodes (over 2 inches long) or special electrode holders are used, it is suggested that these items be sub-divided into constant cross-sections and then evaluated individually using the information given in sections IA thru ID.

F. RESISTANCE OF THE MATERIAL TO BE WELDED

This resistance is composed of two parts. The first part is the actual material resistance, which can be defined as the resistance based on a cylinder of the same diameter as the electrode face and a length equal to the total material thickness. The second part is the contact resistance between electrode and part. This is influenced by the condition of the electrode, the welding schedules used, and the material composition itself.

The values given in the following table may be used for mild steel applications and normal weld schedules.

TOTAL WELD METAL THICKNESS	*RESISTANCE
INCH	MICRO OHMS
.080	105
.090	112
.100	120
.110	129
.120	100
.140	112
.160	120

*For series weld applications double resistance values shown. The resistance values include 40 Micro Ohms (20 per interface electrode to material) for contact resistance.

II. INSTRUCTIONS FOR DETERMINING REACTANCE VALUES OF THE SECONDARY CIRCUIT

A. THE FOLLOWING TABLE AND GRAPHS ARE TO BE USED

1. Transformer Reactance - Table #1.
2. Reactance of Loop Area - Graphs #3, #4 and #5.

B. GENERAL

The reactance is not only a function of the loop area (throat depth times throat height) but depends also on the diameter of conductors, the ratio of throat depth to throat height, and the relative size of the loop.

Graphs 3, 4 and 5 should be used for fixture-type welding circuits only. The three graphs cover short (12 inch), medium (18 inch), and long (24 inch) throat depths. The reactance per square inch of loop area has been plotted as the ordinate, the ratio of throat depth to throat height as the abscissa, and the shunt size in MCM and diameter as the parameter.

To determine the reactance per square inch, use the curve with the throat depth closest to the actual throat depth, or interpolate between the two curves associated with the actual throat depth.

The loop area is defined as the area encompassed by the perimeter of the secondary current and is expressed by the product of throat depth times throat height. The calculation is based on a rectangular-shaped perimeter where the dimensions of throat depth and throat height are taken as the distance from centerline to centerline of the two parallel conductors forming opposite sides of the rectangle. In cases where this does not apply, an equivalent rectangle must be established using mean throat height but with the same loop area and throat depth as the actual welding circuit. Secondly, the calculation assumes that the perimeter of the current is totally composed of the same cross-section as that of the shunts being used. The error introduced by this assumption may be disregarded if (as is normally the case) the part of the perimeter made up of the electrode holder, tips, and back-up represents only a small portion of the total perimeter.

Graphs 3, 4 and 5 may also be applied to conductors other than shunts. The diameter of round conductors should be used in selecting the appropriate parameter in graphs 3, 4 and 5. For conductors of other cross-sections the equivalent diameter must be calculated using the formula:

$$D = 1.128 \times \sqrt{A}$$

Where

D = Equivalent diameter in inches

A = Cross-section in square inches

II. INSTRUCTIONS FOR DETERMINING REACTANCE VALUES OF THE SECONDARY CIRCUIT (Cont'd.)

B. GENERAL (Cont'd.)

Compare the calculated diameter with the diameters of the shunt sizes given as parameters in graphs 3, 4 and 5 and use the curve closest to it. (NOTE: It should be understood that the graphs are approximations.)

The data supplied will give results sufficiently accurate for transformer selection. In cases where the welding circuit is composed of various sizes and shapes of conductors, as well as in cases where the geometric configuration cannot be related to the curves, refer the problem with complete information to the factory.

III. INSTRUCTIONS FOR SELECTION OF THE WELDING TRANSFORMER

A. SELECTION

1. APPLICATION OF GRAPHS

a. One (1) Welding Circuit per Transformer and Secondaries Connected in Parallel

Use graph 7. This arrangement should be used for external load voltages up to approximately 9.5 volts.

b. One (1) Welding Circuit per Transformer and Secondaries Connected in Series

Use graph 8. This arrangement should be used only if the required external load voltage cannot be obtained with secondaries in parallel.

c. Two (2) Separate Welding Circuits per Transformer or One (1) Welding Circuit per Secondary

Use graph 9.

2. SELECTION PROCEDURE

The following steps must be taken in selecting a transformer:

a. Select graph 7, 8 or 9 depending on the application.

b. Mark required external load voltage on the ordinate and the weld current on the abscissa. Bring these points to an intersection.

c. Select the frame size for which the intersecting point is located approximately mid-way between the Tap 1 and Tap 4 curves belonging to the same frame. In cases where the intersecting point falls closer to the Tap 4 curve, select next larger frame size.

III. INSTRUCTIONS FOR SELECTION OF THE WELDING TRANSFORMER (Cont'd.)

A. SELECTION (Cont'd.)

3. COMPILING THE TRANSFORMER DATA

- a. Obtain resistance R_{TR} and reactance X_{TR} of selected transformer from proper column of Table 1:

<u>Graph No. Used</u>	<u>Column of Table 1</u>
7	Secondaries shorted in parallel
8	Secondaries shorted in series
9	One secondary open, one secondary shorted

- b. Obtain secondary voltage range from Table 1.
 c. Obtain KVA_{50%DC} from Table 1.

B. CHECKING THE SECONDARY VOLTAGE RANGE

1. Calculate total resistance and reactance of welding circuit by adding:

$$\text{Total resistance } R = R_E + R_{TR} \text{ Micro Ohms}$$

$$\text{Total reactance } X = X_E + X_{TR} \text{ Micro Ohms}$$

2. Calculate total impedance of welding circuit:

$$\text{Total impedance } Z = \sqrt{R^2 + X^2} \quad \text{Use graph \#6.}$$

Note: Do not add impedance values of external circuit and transformer to obtain total impedance.

3. Calculate required secondary voltage:

$$V = I_{\text{Weld}} \times Z \times 10^{-3} \quad \text{Use nomogram \#7.}$$

V	Secondary voltage in volts
I _{Weld}	Welding current in kilo amps
Z	Total impedance in micro ohms

The secondary voltage obtained from the foregoing calculation should be approximately the secondary voltage of the selected transformer at the mid-point of its range or less (depending on the selection made in Section III A2c).

In installations where the power factors of external circuit and transformer differ greatly, a new transformer selection based on the calculated secondary voltage may be necessary.

III. INSTRUCTIONS FOR SELECTION OF THE WELDING TRANSFORMER (Cont'd.)C. CHECKING THE THERMOCAPACITY

1. Determine KVA demand (for one (1) weld circuit):

$$KVA_D = V_{\text{High Tap}} \times I_{\text{Weld}} \quad \text{Use Nomogram \#8.}$$

$$KVA_D \quad \text{KVA demand (for one (1) weld circuit)}$$

$V_{\text{High Tap}}$ Highest secondary voltage of selected transformer in volts

I_{Weld} Weld current in Kilo Amps

2. Determine KVA demand for the transformer:

$$KVA_{DTR} = KVA_D \times k$$

KVA_{DTR} KVA demand for the transformer.

KVA_D KVA demand for one (1) weld circuit.

$k = 1$ For one (1) weld circuit per transformer.

$k = 1$ For two (2) weld circuits per transformer which are not energized simultaneously.

$k = 2$ For two (2) weld circuits per transformer which are energized simultaneously.

3. Determine the duty cycle:

$$DC\% = \frac{N \times T}{3600} \times 100 \quad \text{Use Nomogram \#9.}$$

DC Duty cycle in %

N Number of transformer energizations per minute (one energization equals one weld time).

T Weld time in cycles (60 Hz)

4. KVA rating at 50% duty cycle:

$$KVA_{50\%DC} = KVA_{DTR} \times \frac{\sqrt{DC\%}}{7.07} \quad \text{Use Nomogram \#10.}$$

The value obtained for $KVA_{50\%DC}$ shall not exceed the nameplate rating of the selected transformer.

3

TABLE 1.1

KIRKHOF STACKED CORE TRANSFORMER DATA

FRAME	KVA 50% DC	SECONDARY VOLTAGE	SECONDARY SHORTED IN PARALLEL			SECONDARY SHORTED IN SERIES			ONE SECONDARY OPEN ONE SECONDARY SHORTED		
			IMPEDANCE Z_{TR}	REACTANCE X_{TR}	RESISTANCE R_{TR}	IMPEDANCE Z_{TR}	REACTANCE X_{TR}	RESISTANCE R_{TR}	IMPEDANCE Z_{TR}	REACT. X_{TR}	RESI R_{TR}
R	35	2.5 - 3.61	44	31	31	197	145	134	94	69	63
T	45	2.93 - 4.24	47	33	33	208	152	142	101	78	64
W	55	3.4 - 5.35	60	44	40	259	199	165	124	98	76
WB	65	4.4 - 6.47	64	44	47	281	200	197	137	105	89
F	80	5.0 - 7.45	57	43	37	259	198	167	121	99	70
K	100	6.5 - 9.00	61	43	43	272	203	181	135	107	82
KS	150	9.36 - 11.00	60	42	43	274	197	190	153	118	97

- NOTE: 1. All values for impedance, reactance and resistance are in micro ohms referred to the secondary of the transformer.
2. All values for impedance, reactance and resistance are average values given for the highest secondary voltage tap.
3. All values for impedance, reactance and resistance will apply to transformers having a 220, 440 or 550 volt, 60 hertz primary supply as long as these transformers have: The same frame size, the same KVA rating and the same secondary voltage range.

TABLE 1

KIRKHOF WOUND CORE TRANSFORMER DATA

FRAME	KVA 50% DC	SECONDARY VOLTAGE	SECONDARY SHORTED IN PARALLEL			SECONDARY SHORTED IN SERIES			ONE SECONDARY OPEN ONE SECONDARY SHORTED		
			IMPEDANCE Z_{TR}	REACTANCE X_{TR}	RESISTANCE R_{TR}	IMPEDANCE Z_{TR}	REACTANCE X_{TR}	RESISTANCE R_{TR}	IMPEDANCE Z_{TR}	REACT. X_{TR}	RESIS R_{TR}
60	3.2 - 5.0	50	35	36	200	140	144	104	82	64	
70	4.0 - 6.0	54	38	38	216	152	152	112	89	70	
85	5.3 - 7.1	57	39	42	228	156	168	124	96	79	
130	7.2 - 9.0	63	41	48	252	164	192	140	105	93	
130	7.2 - 9.2	60	43	42	240	172	168	126	101	77	
150	9.4 - 11.6	68	47	48	272	188	192	154	117	100	
200	12.22 - 15.17	73	52	51	304	234	195	170	134	105	

- NOTE: 1. All values for impedance, reactance and resistance are in micro ohms referred to the secondary of the transformer.
2. All values for impedance, reactance and resistance are average values given for the highest secondary voltage tap.
3. All values for impedance, reactance and resistance will apply to transformers having a 220, 440 or 550 volt, 60 hertz primary supply as long as these transformers have: The same frame size, the same KVA rating and the same secondary voltage range.

TABLE 2

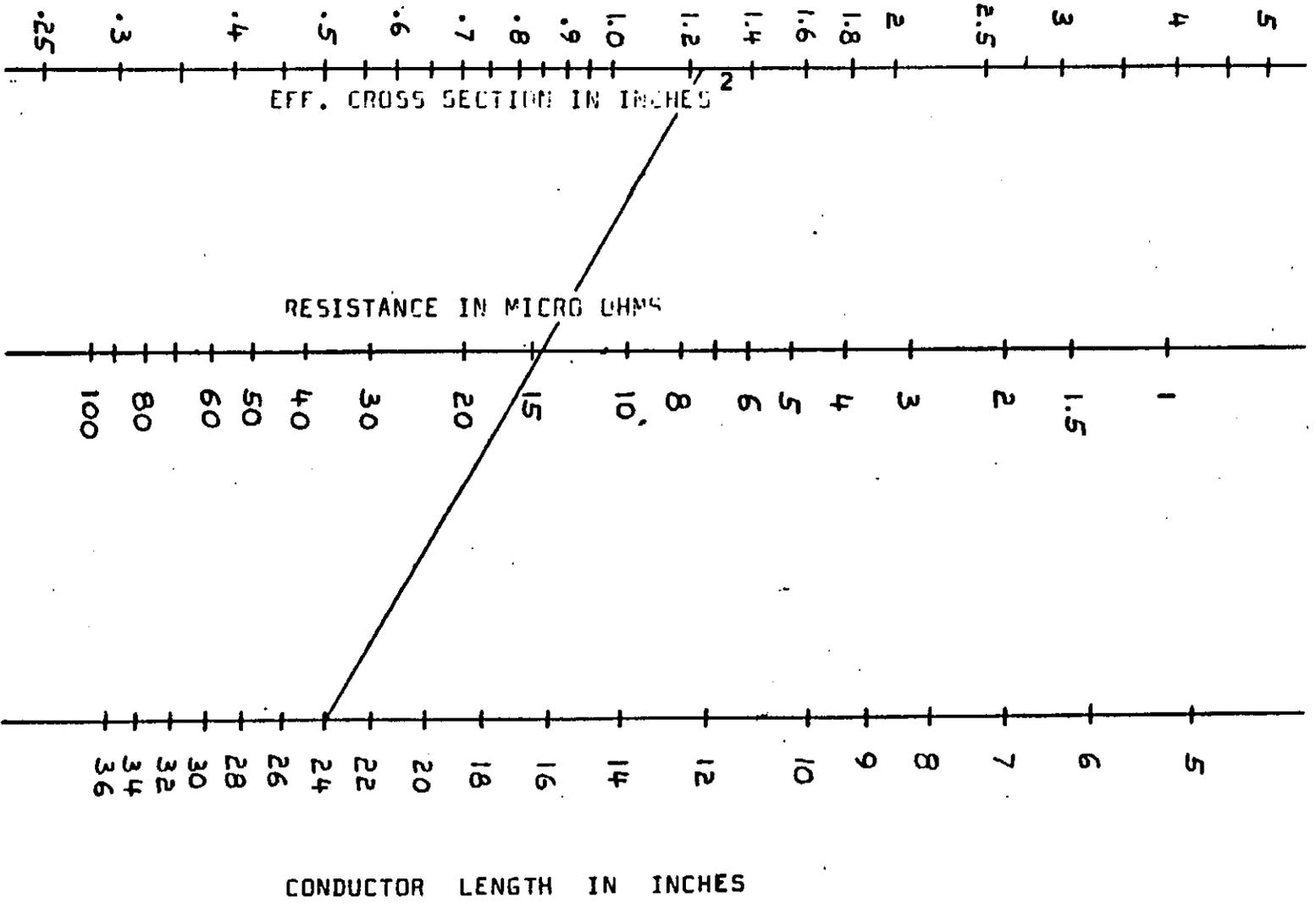
AC RESISTANCE FOR JUMPER

MCM	350	400	450	500	600	750	1000	1200	1500	2000
DIA.	.81"	.88"	.93"	.99"	1.12"	1.28"	1.42"	1.45"	1.62"	1.87"
1"	3.04	2.67	2.39	2.15	1.81	1.47	1.13	.97	.8	.65
6"	18.2	16.0	14.3	12.9	10.9	8.8	6.8	5.8	4.9	3.9
7"	21.3	18.7	16.7	15.0	12.7	10.3	7.9	6.8	5.6	4.5
3"	24.3	21.4	19.1	17.2	14.5	11.8	9.0	7.8	6.4	5.2
9"	27.4	24.0	21.5	19.3	16.3	13.2	10.2	8.7	7.2	5.8
10"	30.4	26.7	23.9	21.5	18.1	14.7	11.3	9.7	8.0	6.5
11"	33.4	29.4	26.3	23.6	19.9	16.2	12.4	10.7	8.8	7.1
12"	36.5	32.0	28.7	25.8	21.7	17.6	13.6	11.6	9.6	7.8
13"	39.5	34.7	31.1	27.9	23.5	19.1	14.7	12.6	10.4	8.4
14"	42.6	37.4	33.5	30.1	25.3	20.6	15.8	13.6	11.2	9.1
15"	45.6	40.0	35.8	32.2	27.1	22.0	16.9	14.5	12.0	9.7
16"	48.6	42.7	38.2	34.4	29.0	23.5	18.1	15.5	12.8	10.4
17"	51.7	45.4	40.6	36.5	30.8	25.0	19.2	16.5	13.6	11.0
18"	54.7	48.1	43.0	38.7	32.6	26.5	20.3	17.5	14.4	11.7
19"	57.8	50.7	45.4	40.8	34.4	27.9	21.5	18.4	15.2	12.3
20"	60.8	53.4	47.8	43.0	36.2	29.4	22.6	19.4	16.0	13.0
21"	63.8	56.1	50.2	45.1	38.0	30.9	23.7	20.4	16.8	13.6
22"	66.9	58.7	52.6	47.3	39.8	32.3	24.9	21.3	17.6	14.3
23"	69.9	61.4	55.0	49.4	41.6	33.8	26.0	22.3	18.4	14.9
24"	73.0	64.1	57.4	51.6	43.4	35.3	27.1	23.3	19.2	15.6
26"	79.0	69.4	62.1	55.9	47.0	38.2	29.4	25.2	20.3	16.5
28"	85.1	74.8	66.9	60.2	50.7	41.2	31.6	27.2	22.4	18.2
30"	91.2	80.1	71.7	64.5	54.3	44.1	33.9	29.1	24.0	19.9
32"	97.3	85.4	76.5	68.8	57.9	47.0	36.2	31.0	25.6	20.6
34"	103.4	90.8	81.3	73.1	61.5	50.0	38.4	33.0	27.2	22.1
36"	109.4	96.1	86.0	77.4	65.2	52.9	40.7	34.9	28.8	23.4

LENGTH IN INCHES

NOTES:

1. The resistance values are given in Micro Ohms and are based on a frequency of 60 Hz and a temperature of 70°C (158°F).
2. The resistance values are based on nominal MCM ratings.
3. The resistance values consider the skin effect only but not resistance increase due to proximity effect.

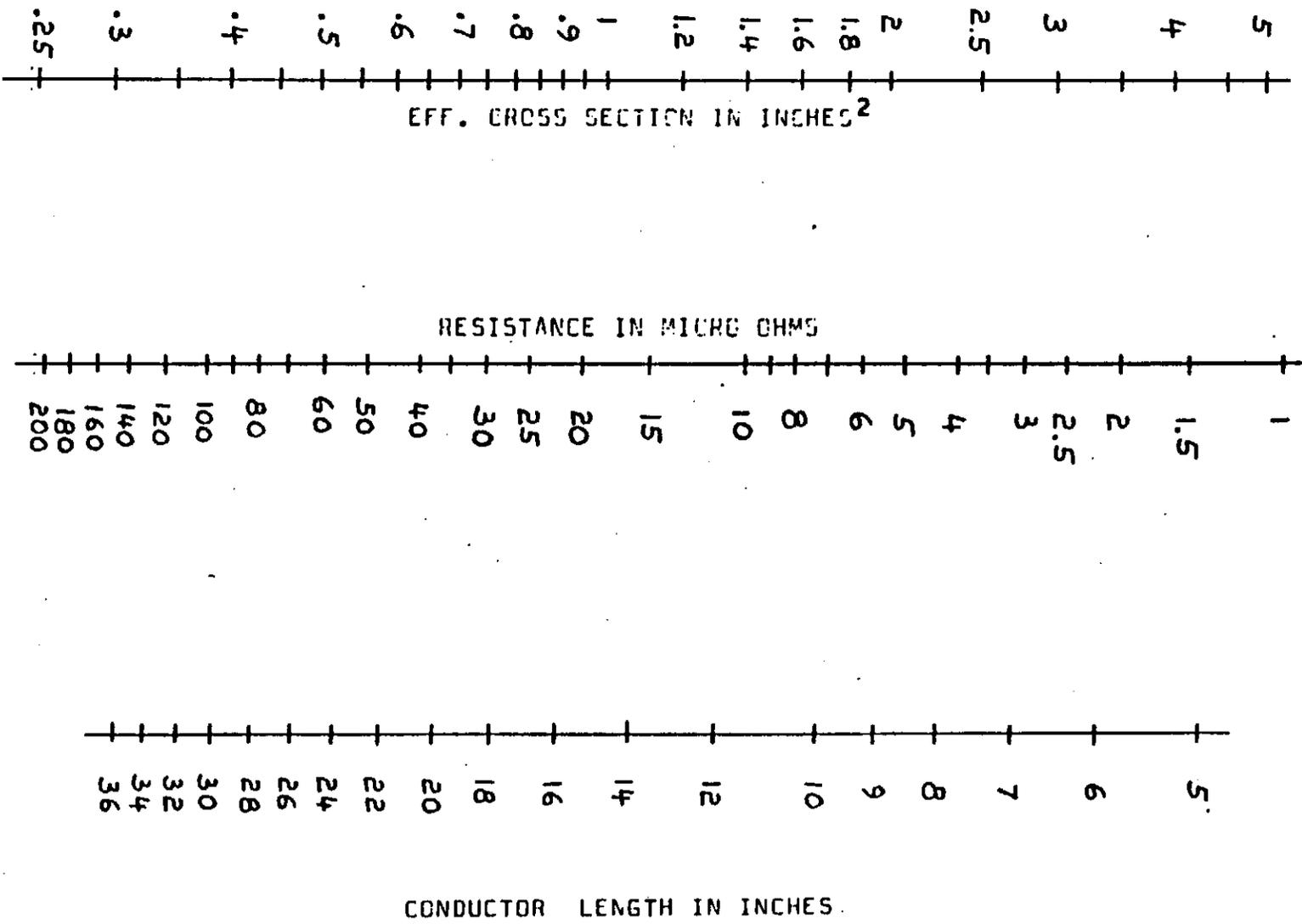


MATERIAL: COPPER 100% CONDUCT

NOTES:

1. This graph is based on 50°C Conductor Temperature
2. This graph does not include resistance increase due to skin or proximity effect. (See instructions)

NOMOGRAM #1

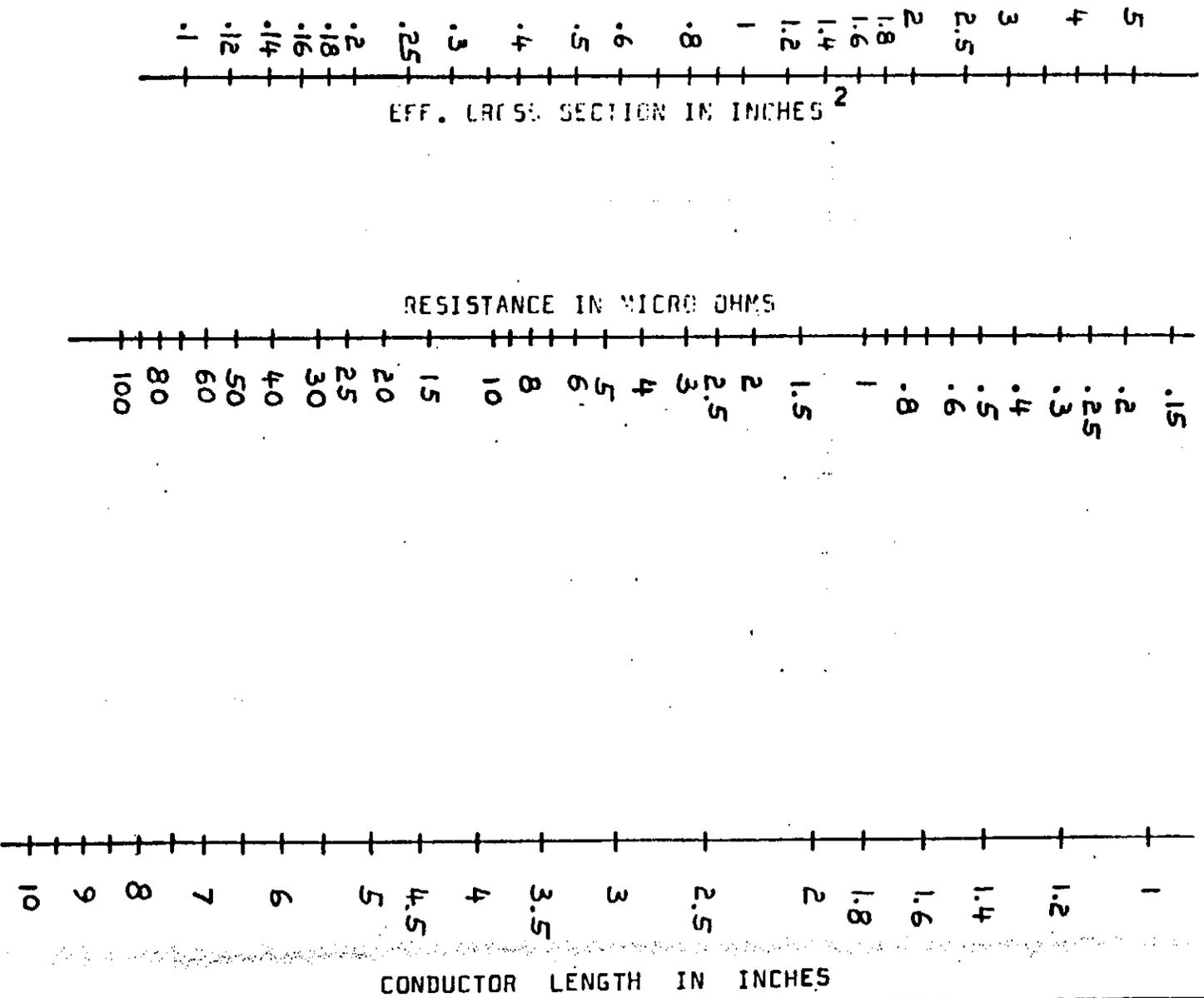


MATERIAL: ALUMINUM EC (ELECTRICAL CONDUCTOR AND BUSS BAR GRADE)
CONDUCTIVITY 61%

NOTES:

1. This graph is based on 50°C Conductor Temperature.
2. This graph does not include resistance increase due to skin or proximity effect. (See instructions)

NOMOGRAM #2

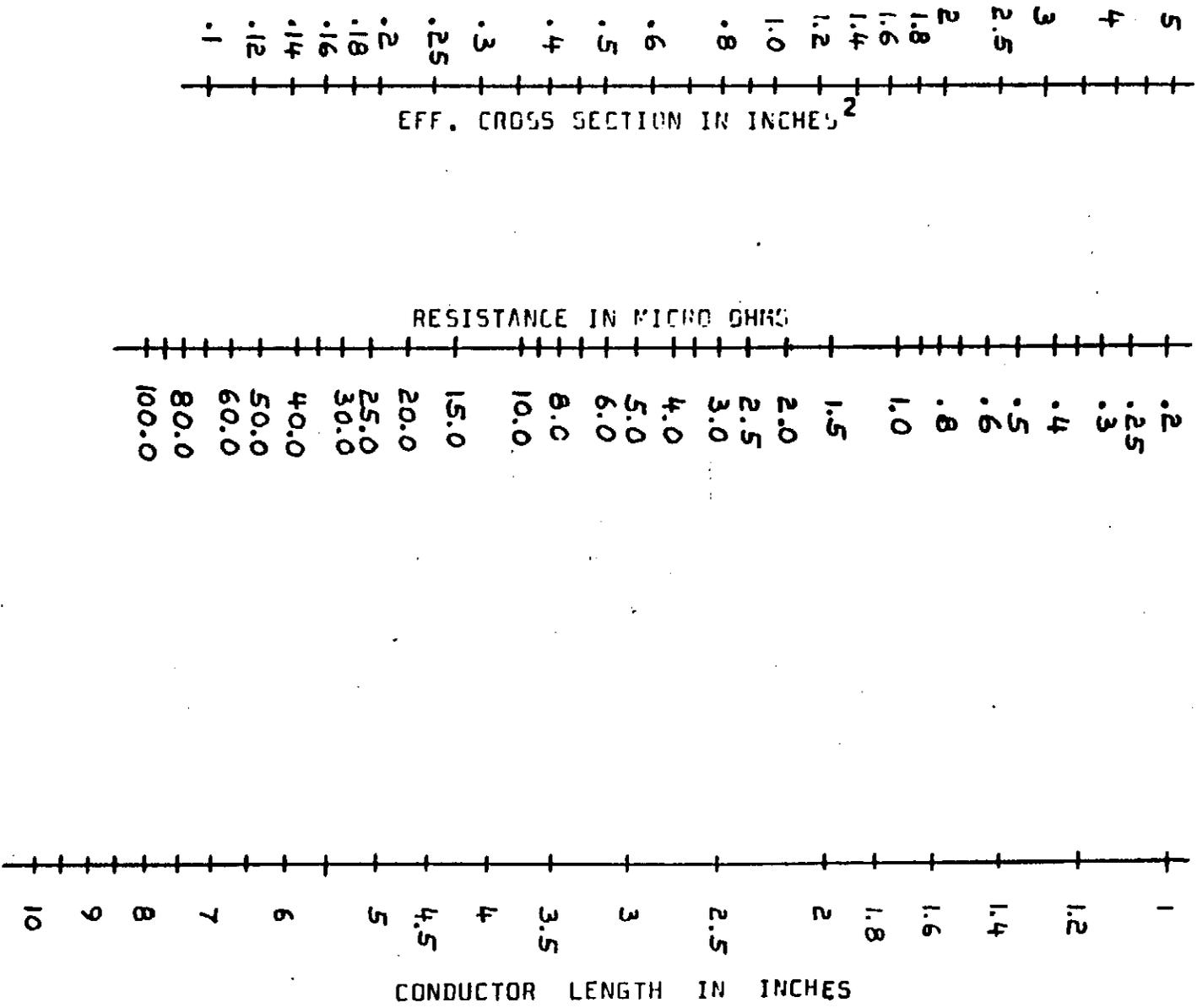


MATERIAL: RWMA COPPER CLASS #1 80% CONDUCTIVITY

NOTES:

1. This graph is based on 50°C conductor temperature.
2. This graph does not include resistance increase due to skin or proximity effect. (See instructions)

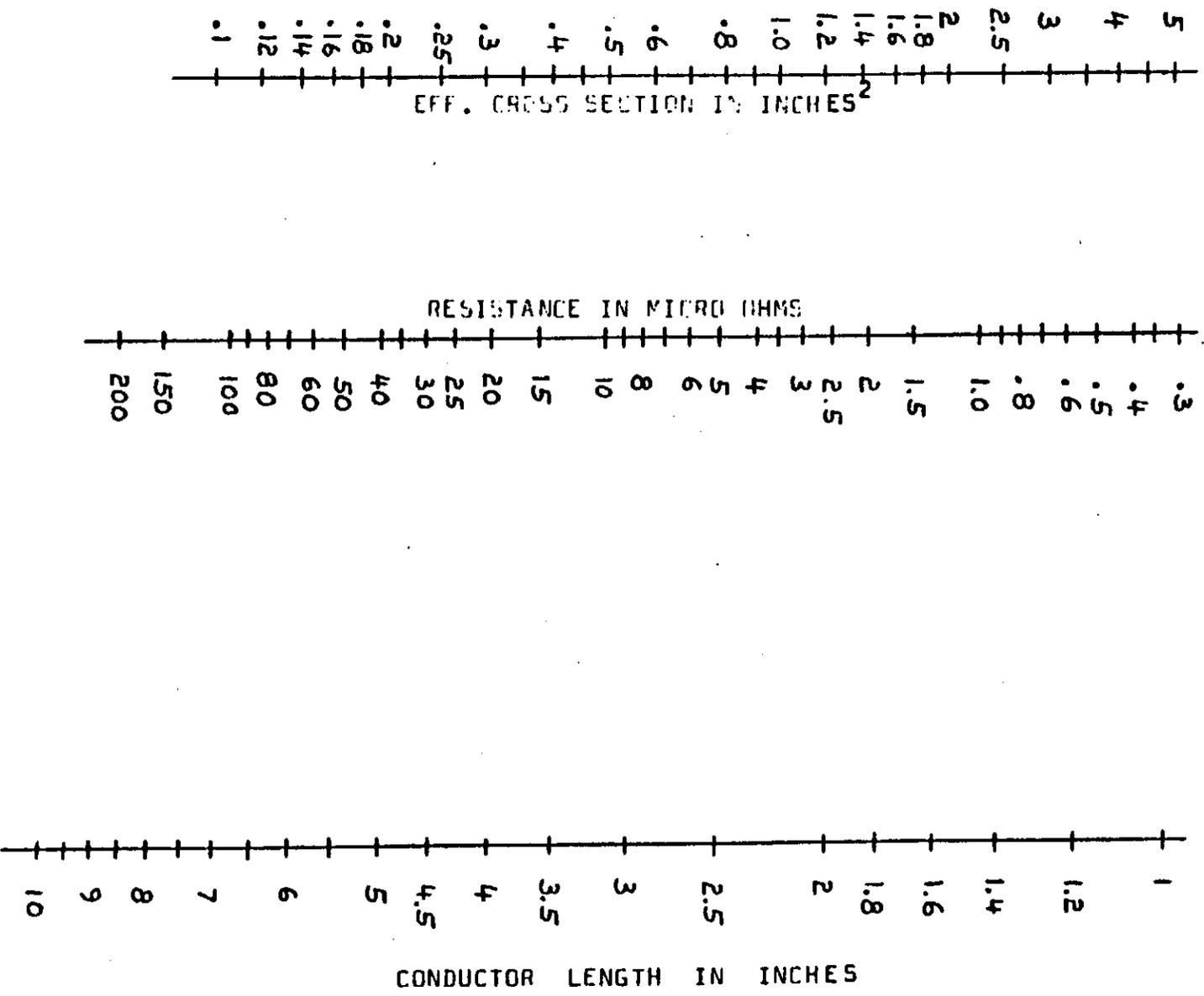
NOMOGRAM #3



MATERIAL: RWMA COPPER CLASS #2 75% CONDUCTIVITY

- NOTES:
1. This graph is based on 50°C Conductor temperature.
 2. This graph does not include resistance increase due to skin or proximity effect. (See instructions)

NOMOGRAM #4



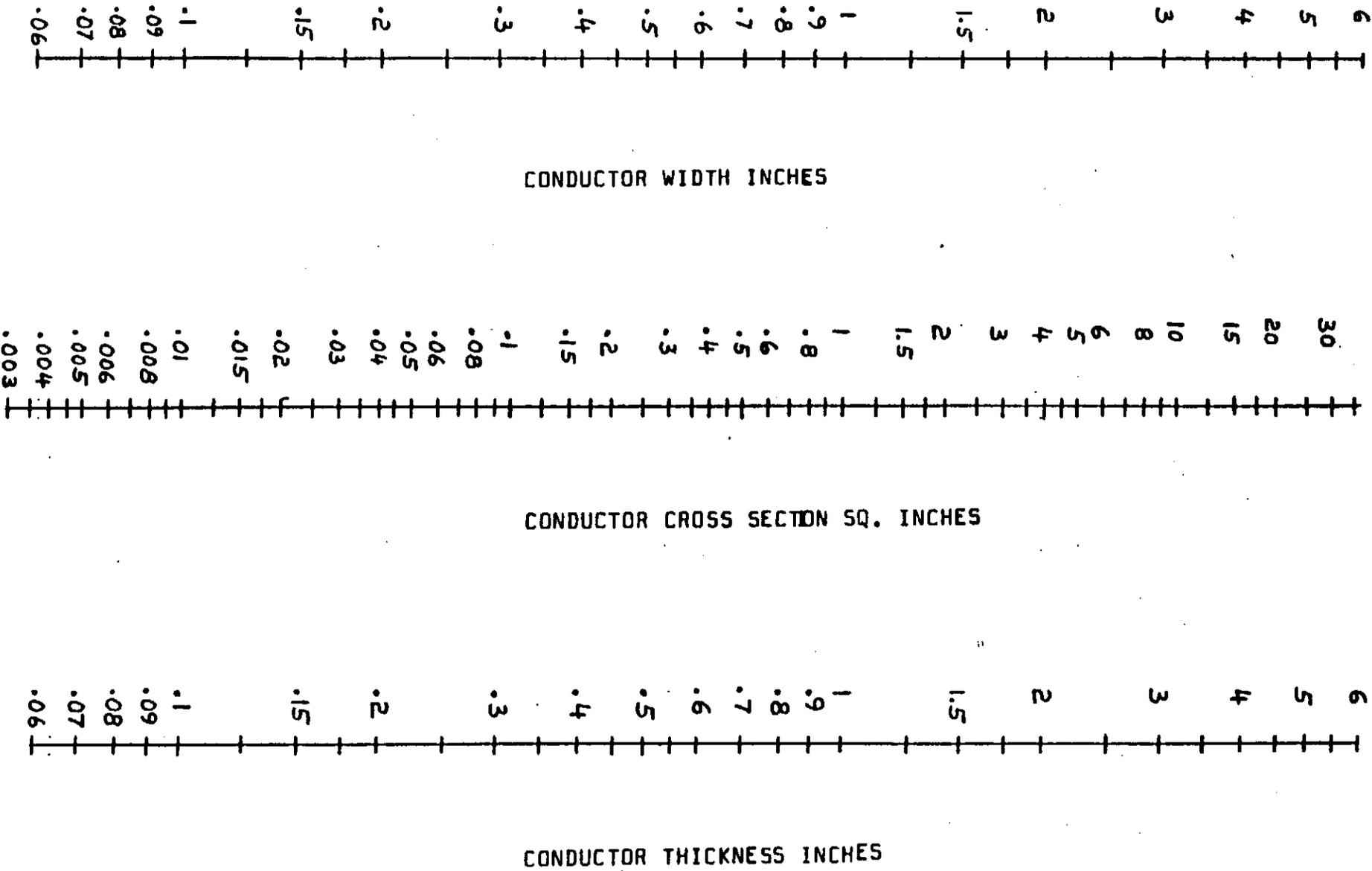
MATERIAL: RWMA COPPER CLASS #3 45% CONDUCTIVITY

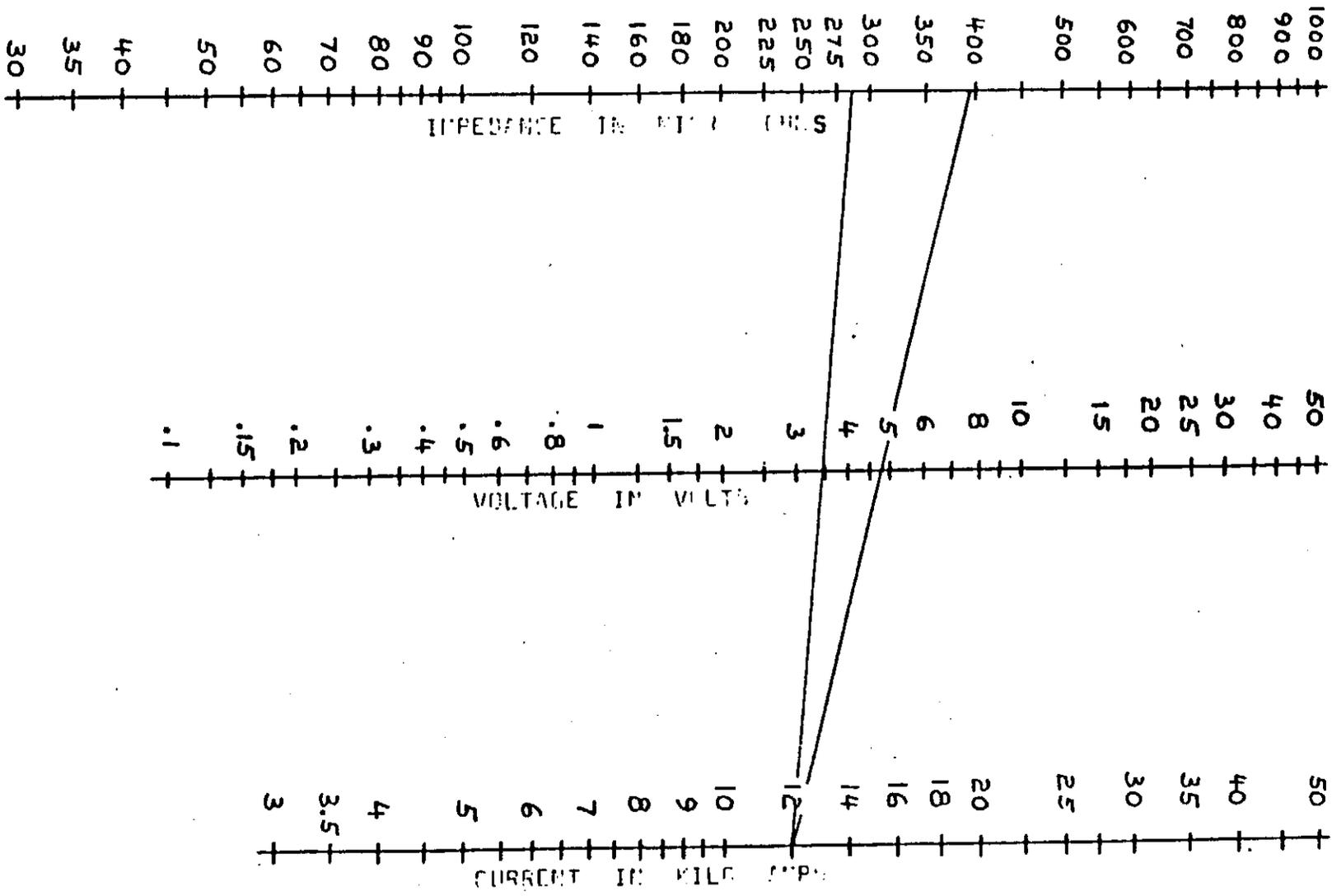
NOTES:

1. This graph is based on 50°C Conductor temperature
2. This graph does not include resistance increase due to skin or proximity effect. (See instructions)

NOMOGRAM #5

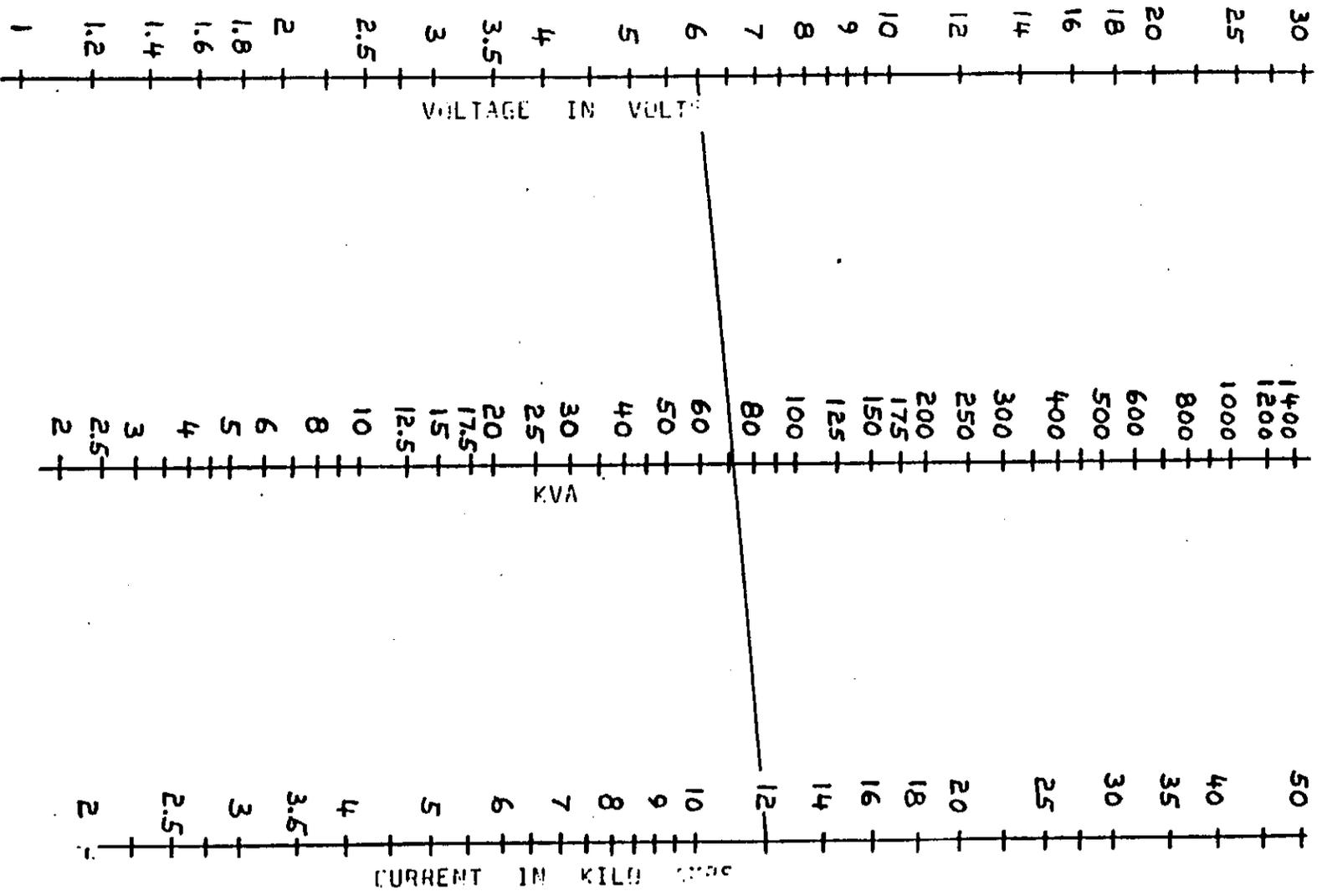
NOMOGRAM #6
CROSS SECTION OF SQUARE AND RECTANGULAR CONDUCTORS





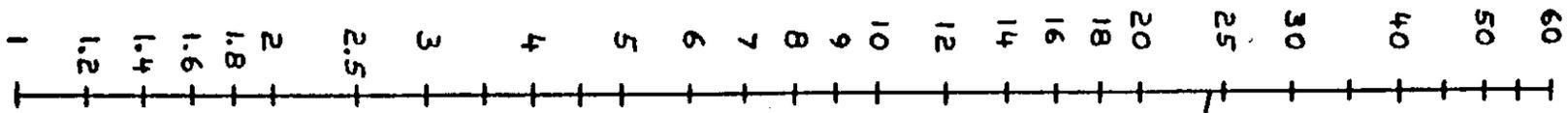
VOLTAGE = CURRENT X IMPEDANCE

NOMOGRAM #7

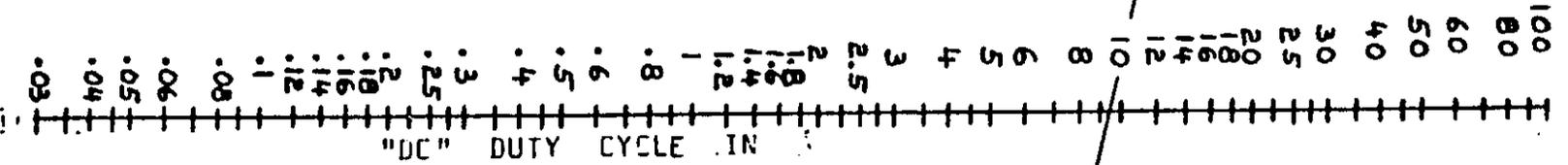


$$\text{KVA} = \frac{\text{VOLTAGE} \times \text{CURRENT}}{1000}$$

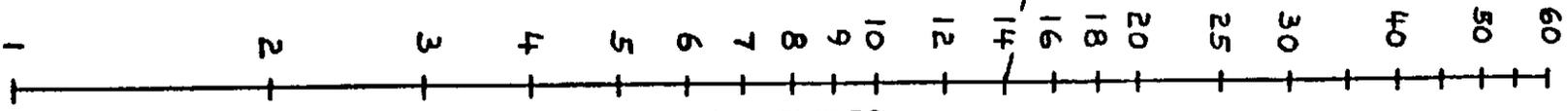
NOMOGRAM #8



"N" NUMBER OF TRANSFORMER ENERGIZATIONS PER MINUTE



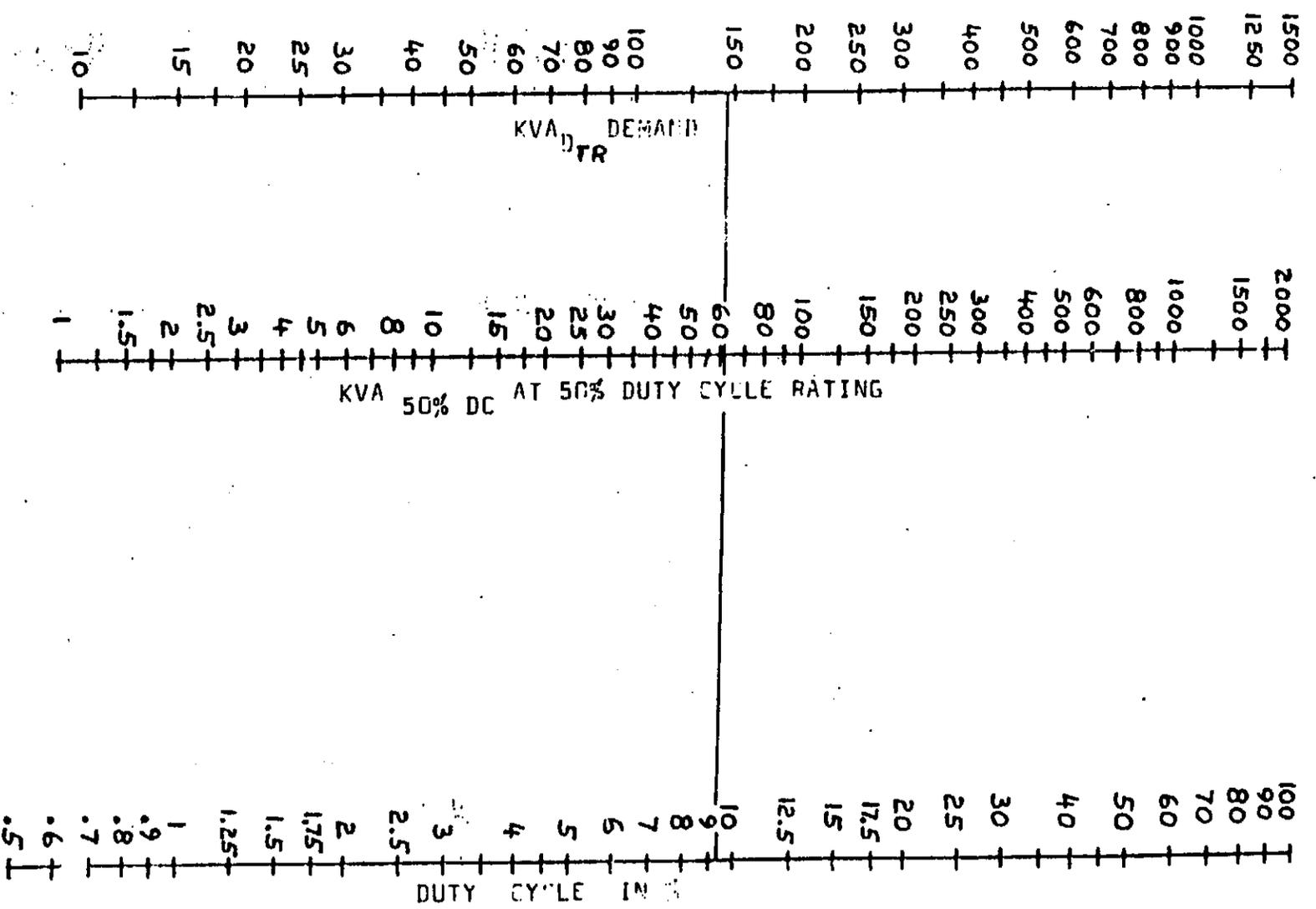
"DC" DUTY CYCLE IN



"T" WELD TIME IN CYCLES

$$DC\% = \frac{N \times T}{3600} \times 100$$

NOMOGRAM # 9



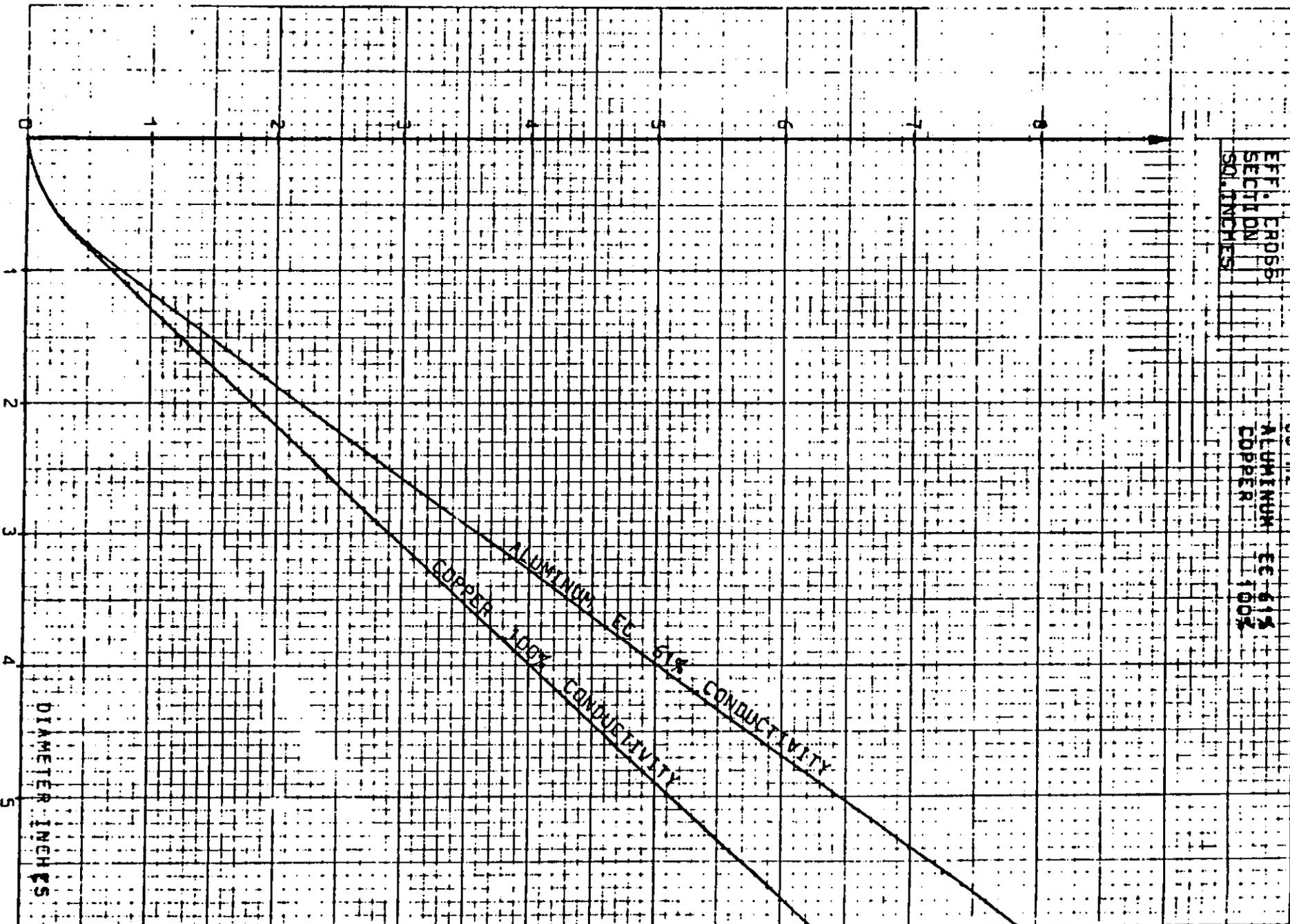
$$KVA_{50\% DC} = KVA_{DTR} \times \frac{V_{DC}}{7.07}$$

NOMOGRAM #110

EFFECTIVE CROSS SECTION
FOR ROUND CONDUCTORS AT

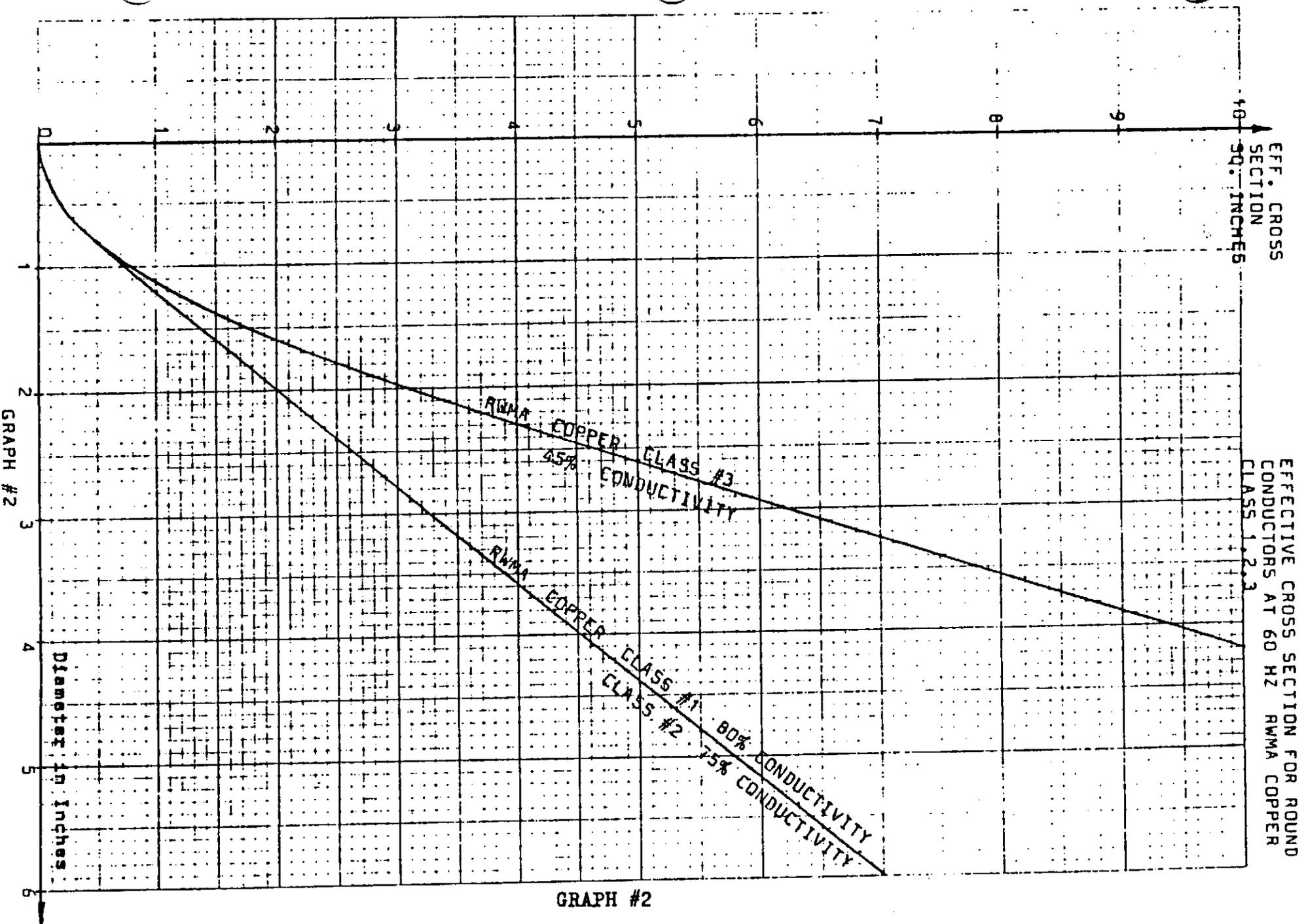
EFF. CROSS
SECTION
SQ. INCHES

60 M²
ALUMINUM EC 61%
COPPER EC 100%

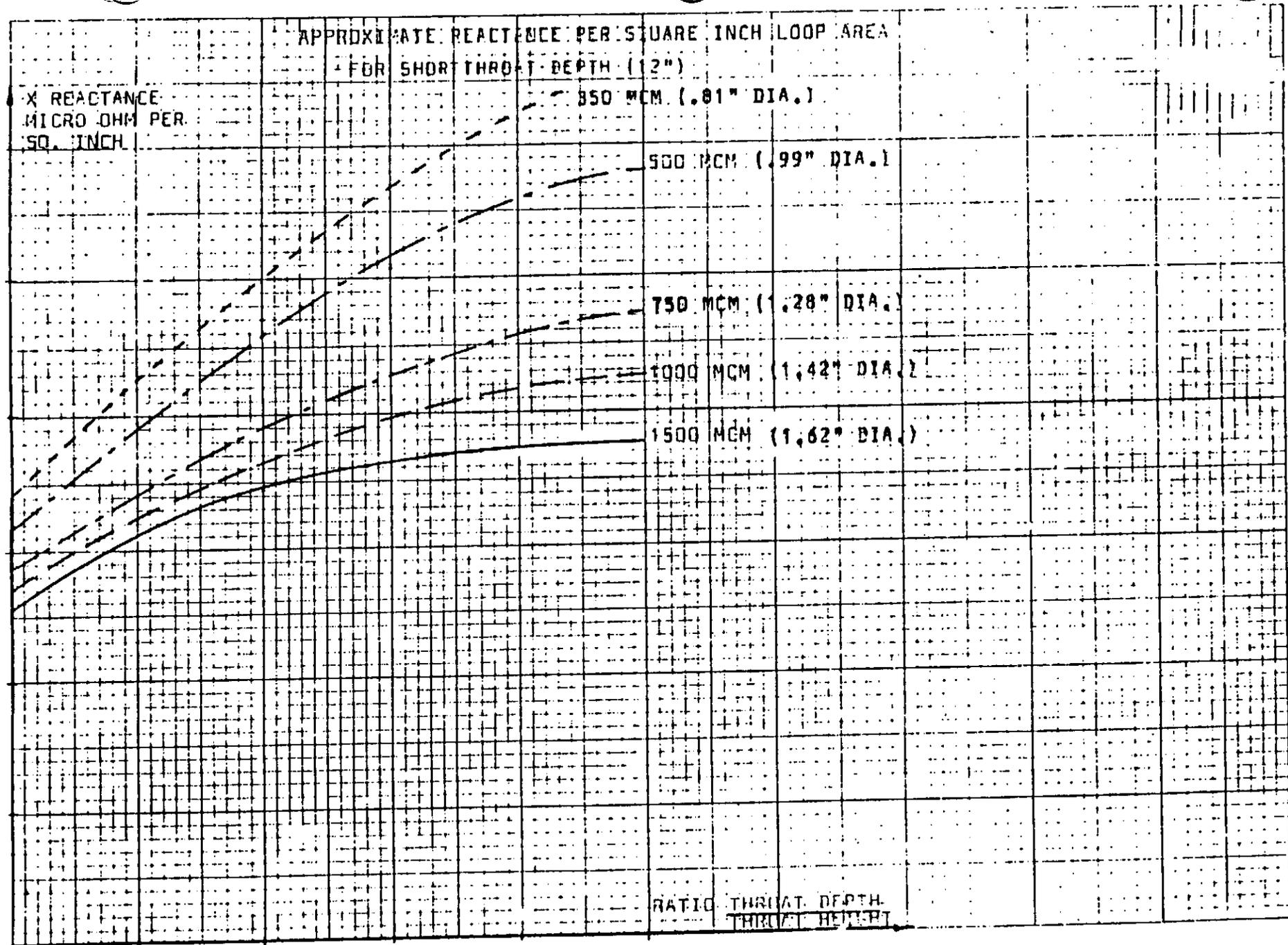


GRAPH #1

GRAPH #1



GRAPH #2



GRAPH #3

APPROXIMATE REACTANCE PER SQUARE INCH
LOOP AREA FOR MEDIUM THROAT DEPTH (10")

K REACTANCE
MICRO OHM PER
SQ. INCH

350 MCM (.81" DIA.)

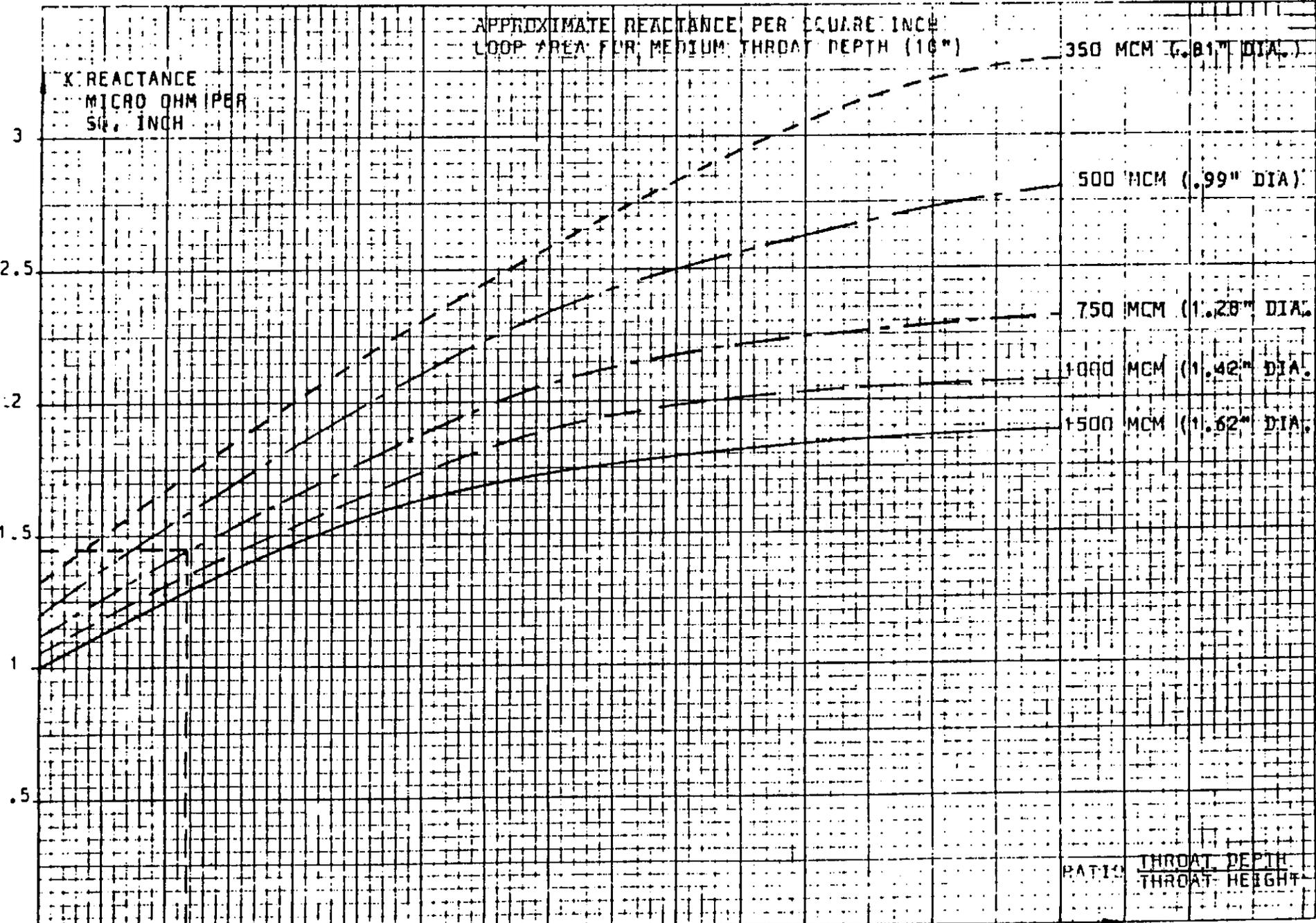
500 MCM (.99" DIA.)

750 MCM (1.28" DIA.)

1000 MCM (1.42" DIA.)

1500 MCM (1.62" DIA.)

RATIO THROAT DEPTH
THROAT HEIGHT



GRAPH #4

APPROXIMATE REACTANCE PER SQUARE INCH
LOOP AREA FOR LONG THROAT; DEPTH (24")

X REACTANCE
MICRO OHM PER
SQ. INCH

350 MCM

(.81" DIA.)

500 MCM

(.99" DIA.)

750 MCM

(1.28" DIA.)

1000 MCM

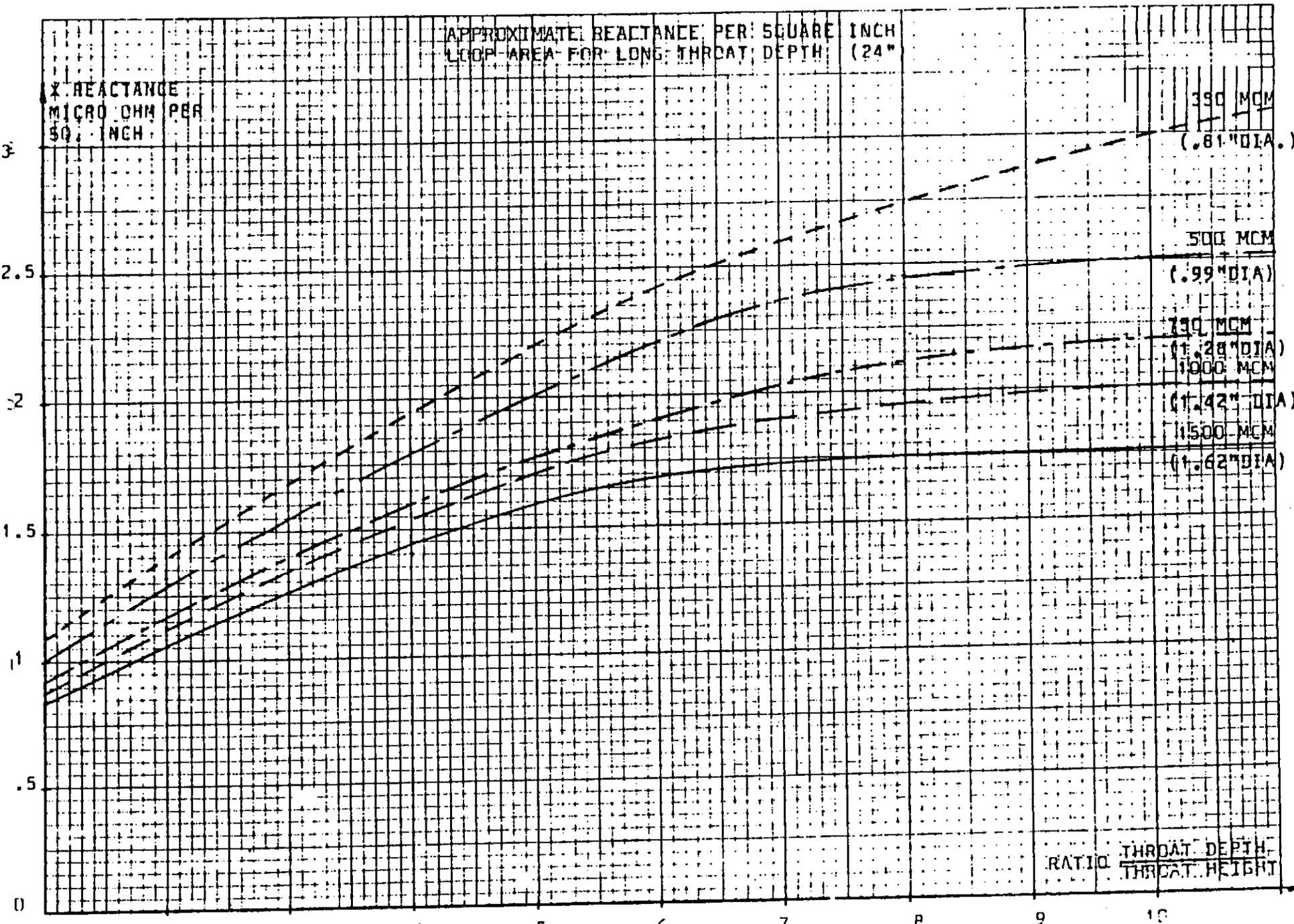
(1.42" DIA.)

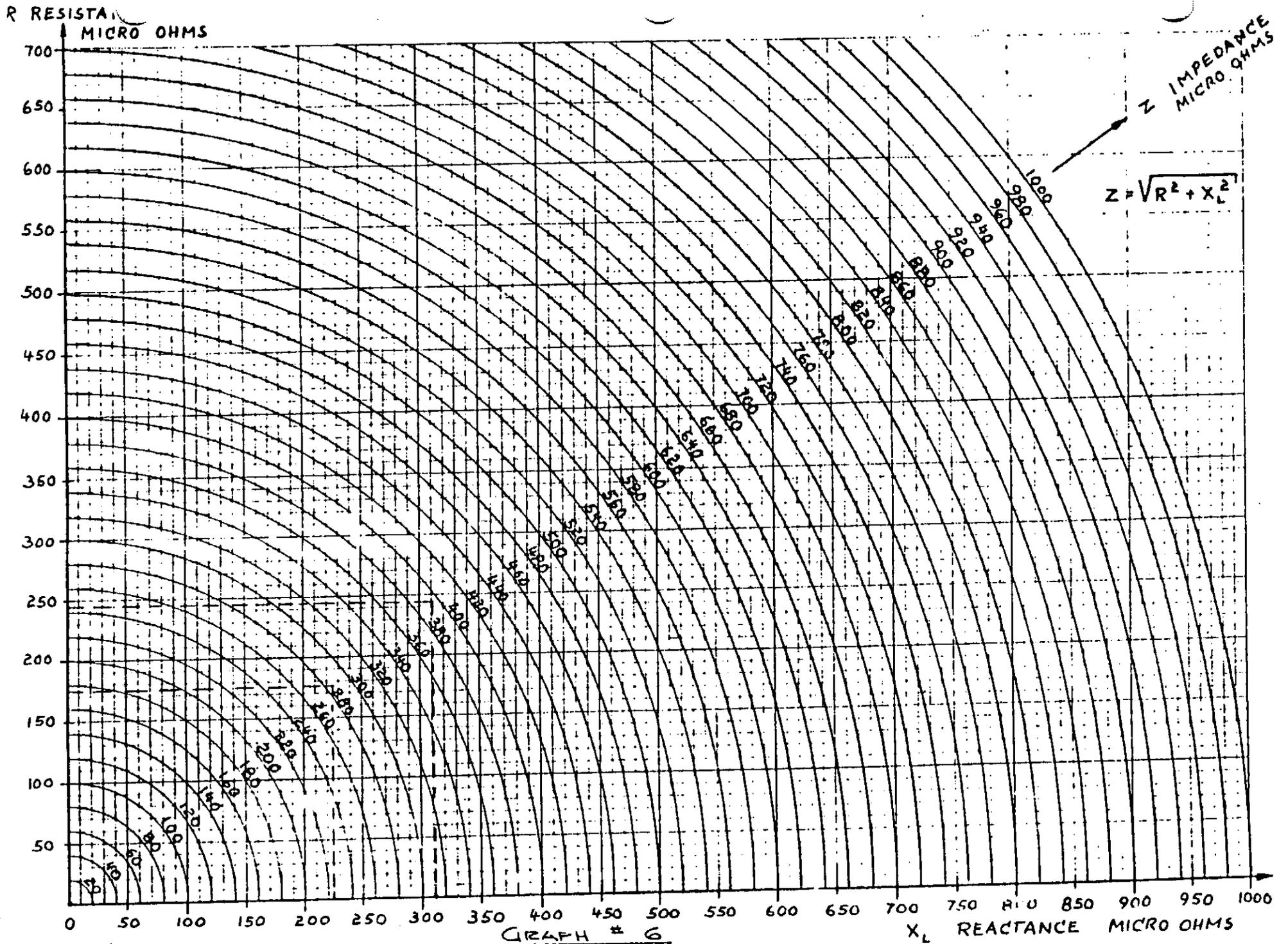
1500 MCM

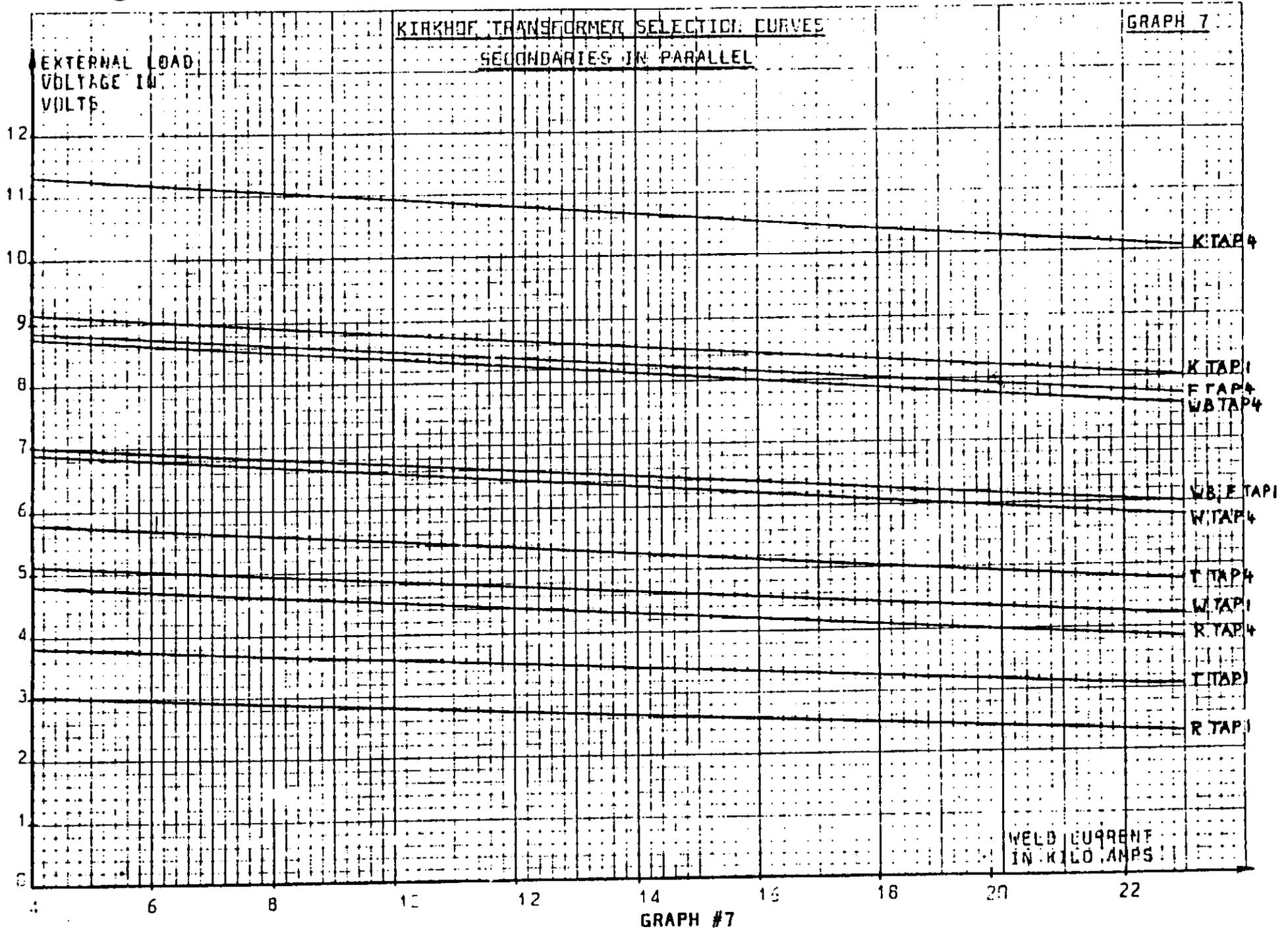
(1.62" DIA.)

RATIO THROAT DEPTH
THROAT HEIGHT

GRAPH #5





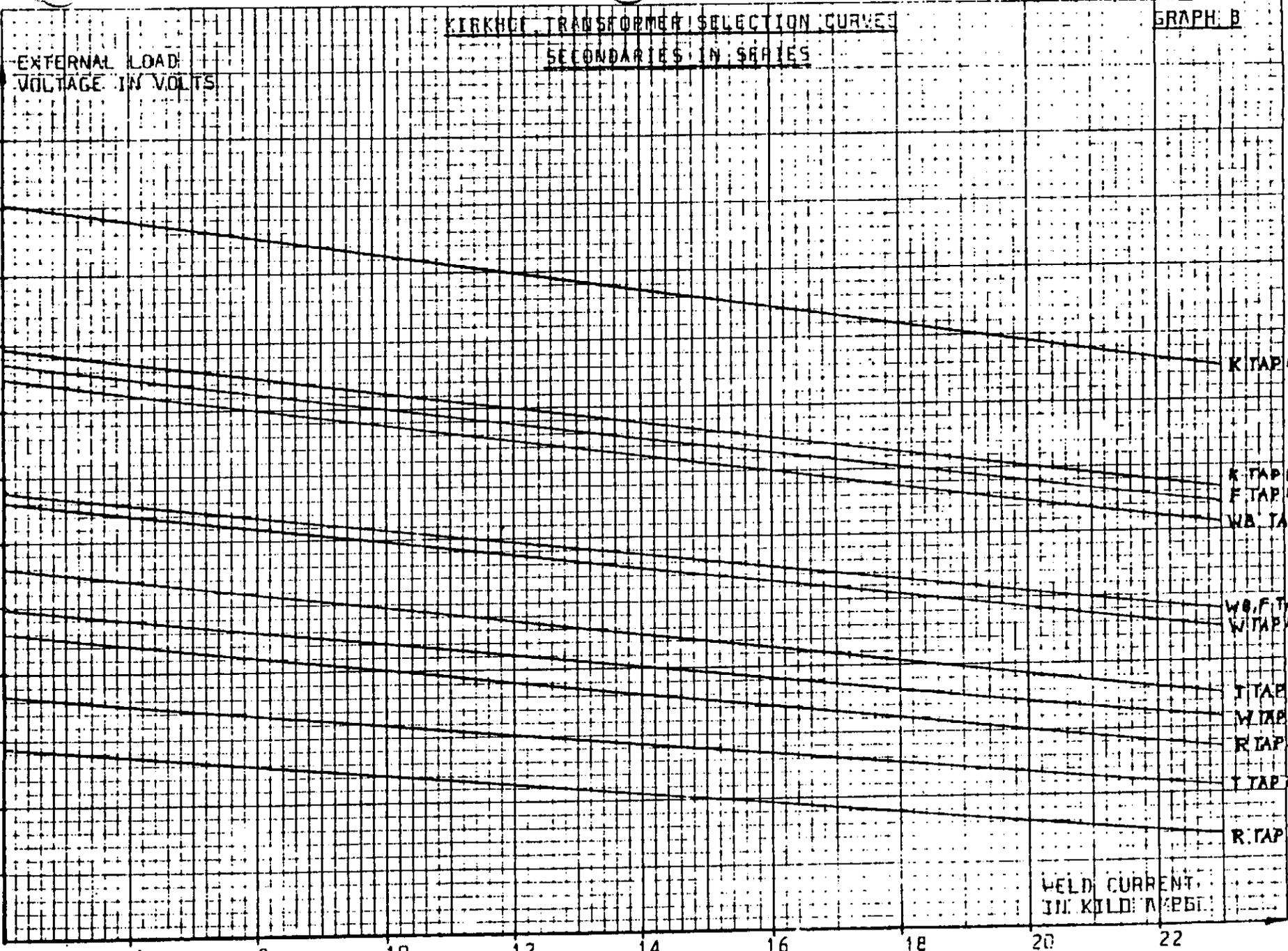


KIRKHOFF TRANSFORMER SELECTION CURVES SECONDARIES IN SERIES

GRAPH B

EXTERNAL LOAD
VOLTAGE IN VOLTS

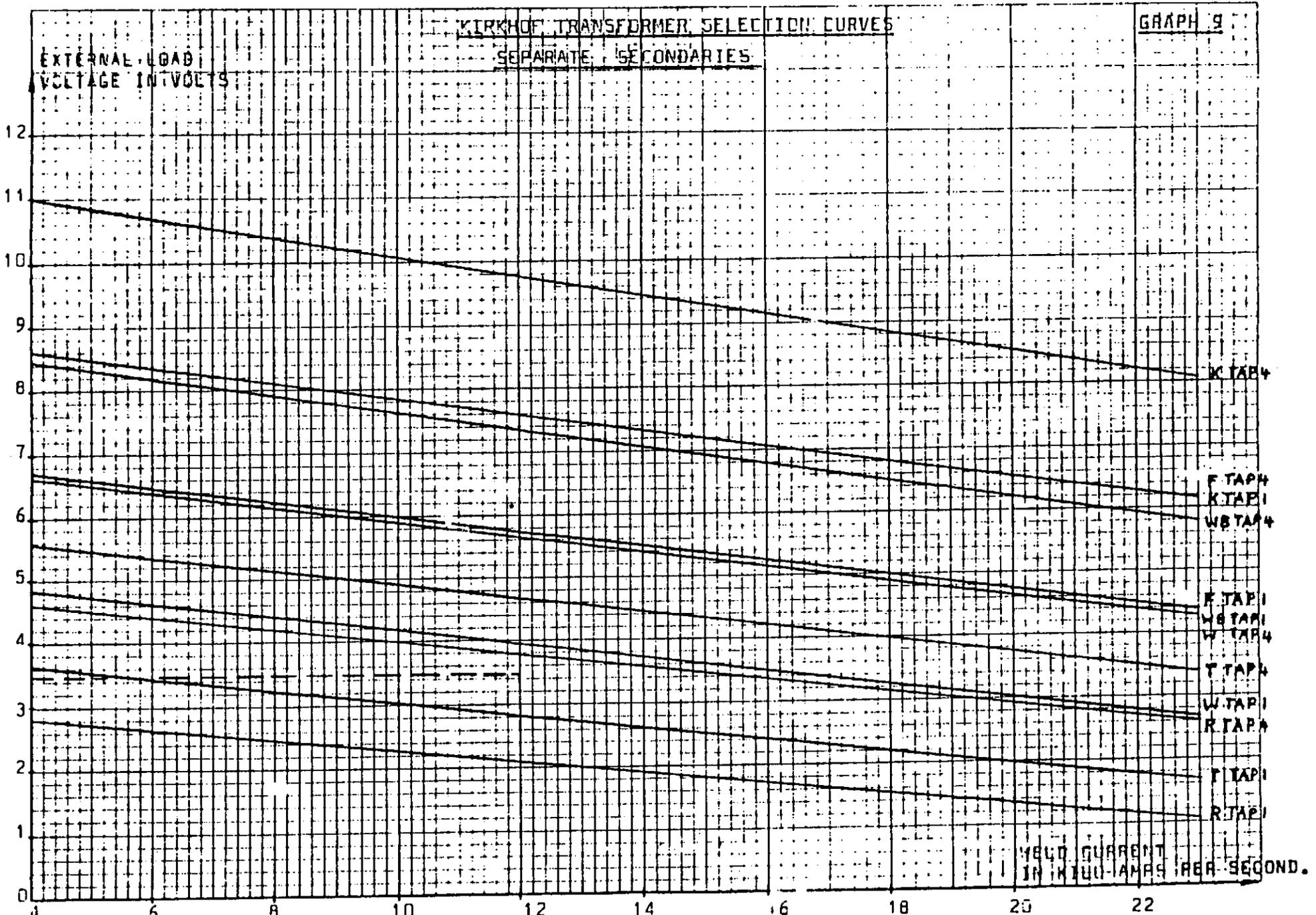
24
22
20
18
16
14
12
10
8
6
4
2
0



WELD CURRENT
IN KILO AMPS

K TAP 4
K TAP 1
F TAP 4
W B TAP 4
W B F TAP 1
W TAP 4
T TAP 4
W TAP 1
R TAP 4
T TAP 1
R TAP 1

GRAPH #8



GRAPH #9

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

CUSTOMER: _____

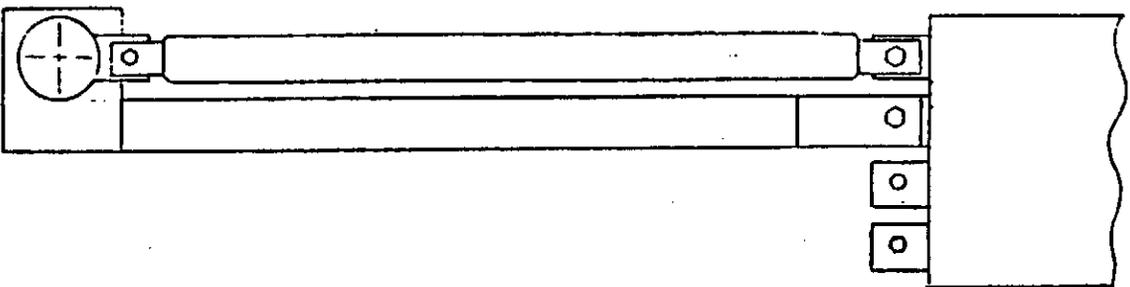
NAME OR NO: SAMPLE #1 DIRECT WELDING CIRCUIT

PROCESSED BY: _____

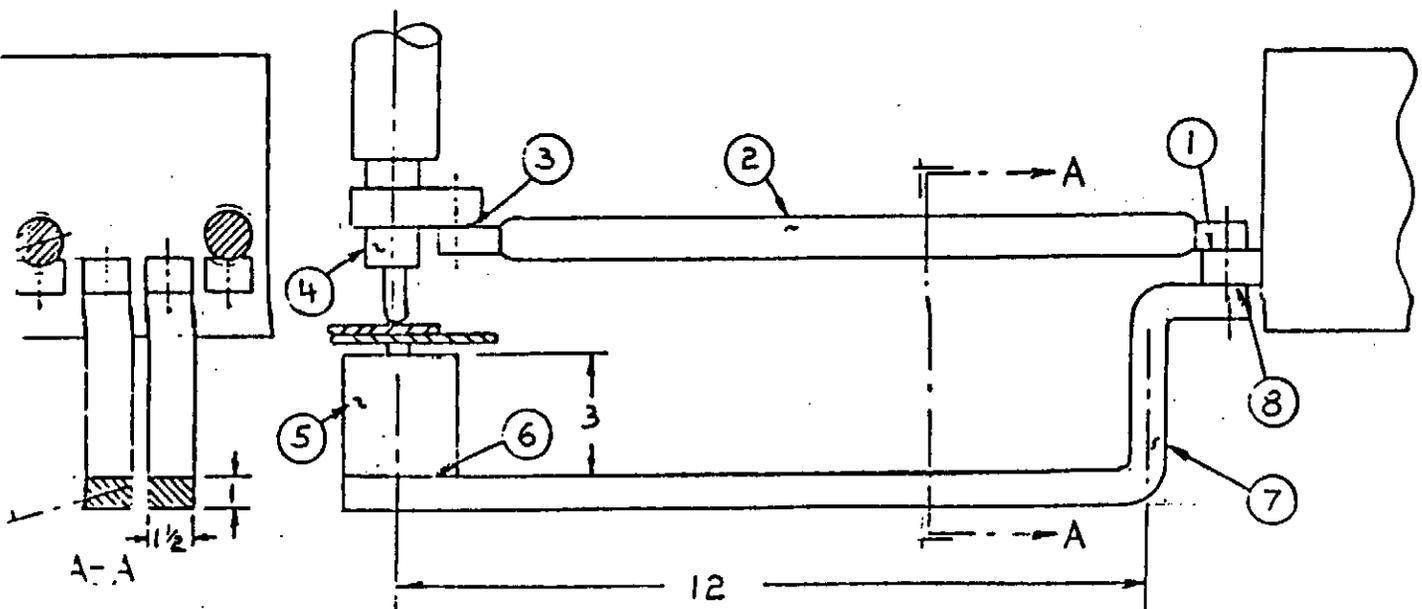
DATE: _____

SECTION OF EXTERNAL WELDING CIRCUIT

(Prepare sketch giving all important dimensions etc. Balloon all items for cross-reference on the following data sheets. Substitute or support with drawings, if available.)



TRANSFORMER SUPPLIES TWO (2) WELDING CIRCUITS AS SHOWN



FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS2. DESCRIPTION OF WELDING CIRCUITa. WELDING CIRCUIT CONDUCTORS
(Shunts, Jumpers, Bus Bars, etc.)

List size, length, and material of each conductor used and cross-reference to sketch on sheet 1.

② H₂O COOLED JUMPER 750 MCM 11" LONG

⑦ COPPER BAR 100% COND 1" x 1 1/2" x 16' LONG

EFF. AREA = $1 \times 1 \frac{1}{2} - .3 \times .8 = 1.5 - .24 = 1.26 \text{ IN}^2$

EQUIVALENT DIA. = 1.128 x $\sqrt{1 \times 1.5} = 1.38 \text{ INCI APPROX. 750 MCM}$

b. ELECTRODE HOLDER AND ELECTRODES

Furnish sketch or description.

⑪ STANDARD 1 1/2" LONG TIP

c. BACK UP

Furnish sketch or description and cross-reference to sketch on sheet 1.

⑤ 3" x 3" x 3" R.W.M.A. GLASS 1

d. CONTACT JOINTS

Give number of contact joints and cross-reference to sketch on sheet 1.

① ③ ⑥ ⑧

Total No. of Contact Joints: 4

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

1. WELDING CIRCUIT (Cont'd.)

B. REACTANCE

(NOTE: Enter all values in Micro Ohms. See section II of instructions.)

Throat Depth 12 Inch
Throat Height 5.5 Inch

Ratio $\frac{\text{Throat Depth}}{\text{Throat Height}} = \frac{12}{5.5} = \underline{2.18}$

Loop Area = Throat Depth x Throat Height
Loop Area = 12 x 5.5 = 66 Sq. Inch.

Reactance per Sq. Inch 1.85

Graph Used: 3 4 5 (Mark one)

Reactance of External Circuit X_E

X_E = Reactance per Sq. Inch x Loop Area

$X_E = \underline{1.85} \times \underline{66} = \underline{122}$ Micro Ohms

C. IMPEDANCE

$Z_E = \sqrt{R_E^2 + X_E^2}$ Use Graph #6. (For R_E see IA of calculation sheet)

$Z_E = \sqrt{\underline{156}^2 + \underline{122}^2} = \underline{195}$ Micro Ohms

D. EXTERNAL LOAD VOLTAGE

$V_E = I_{\text{Weld}} \times Z_E \times 10^{-3}$ Use Nomogram #7.

V_E External load voltage or minimum secondary terminal voltage of transformer under load in volts.

I_{Weld} Weld current in Kilo Amps. (See item 3 of data sheet.)

Z_E Impedance in Micro Ohms. (See item C of calculation sheet.)

$V_E = \underline{12} \times \underline{195} \times 10^{-3} = \underline{2.35}$ Volts

II. TRANSFORMER

A. SELECTION (See section IIIA of instructions.)

Secondaries in Parallel Use graph #7.
Secondaries in Series Use graph #8.
Separate Secondaries Use graph #9.

Frame size selected

R

R_{TR} 64 Micro Ohms

X_{TR} 82 Micro Ohms

Secondary voltage range: From 3.0 to 5.0 Volts

KVA 50%DC 60 KVA

From Table 1

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

II. TRANSFORMER (Cont'd.)

B. CHECKING THE SECONDARY VOLTAGE RANGE OF THE SELECTED TRANSFORMER (See section III of instructions.)

Total Resistance: $R = R_E + R_{TR}$ (R_E see IA of calculation sheet.)

$R = 156 + 64 = 220$ Micro Ohms

Total Reactance: $X = X_E + X_{TR}$ (X_E see IB of calculation sheet.)

$X = 122 + 82 = 204$ Micro Ohms

Total Impedance: $Z = \sqrt{R^2 + X^2}$ Use Graph #6.

$Z = \sqrt{220^2 + 204^2} = 300$ Micro Ohms

Secondary voltage required:

$V = I_{Weld} \times Z \times 10^{-3}$ Use Nomogram #7.

$V = 12 \times 300 \times 10^{-3} = 3.6$ Volts

Secondary voltage range of selected transformer acceptable:

Yes No

C. CHECKING THE THERMOCAPACITY OF THE SELECTED TRANSFORMER (See section III of instructions.)

$KVA_D = V_{High Tap} \times I_{Weld}$ Use Nomogram #8.

$KVA_D = 5 \times 12 = 60$ KVA for one (1) weld circuit.

$KVA_{DTR} = KVA_{DJ} \times k$ (see IIIIC2 of instructions)

$KVA_{DTR} = 60 \times 2 = 120$ KVA for the transformer.

DC = $\frac{I \times T}{3600} \times 100$ Use Nomogram #9.

DC = $\frac{24 \times 14}{3600} \times 100 = 9.3$ %

$KVA_{50\%DC} = KVA_{DTR} \times \frac{\sqrt{DC\%}}{7.07}$ Use Nomogram #10.

$KVA_{50\%DC} = 120 \times \frac{\sqrt{9.3}}{7.07} = 51$ KVA

Thermocapacity of selected transformer: acceptable:

Yes No

D. SUGGESTED MODEL NUMBER OF KIRKHOFF TRANSFORMER (See catalog.)

F4460R623X

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

CUSTOMER: _____

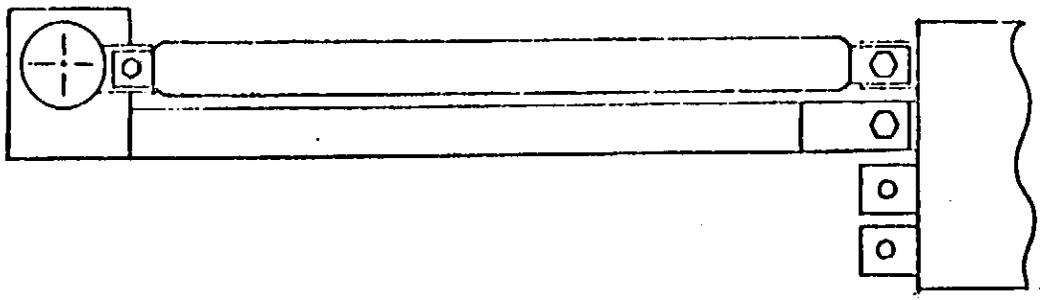
NAME OR NO: SAMPLE #2 'DIRECT WELDING CIRCUIT'

DESIGNED BY: _____

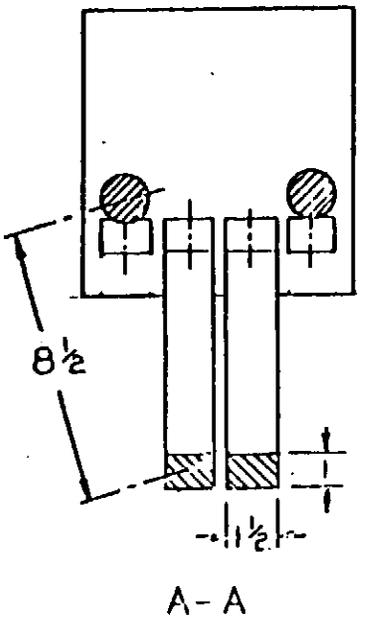
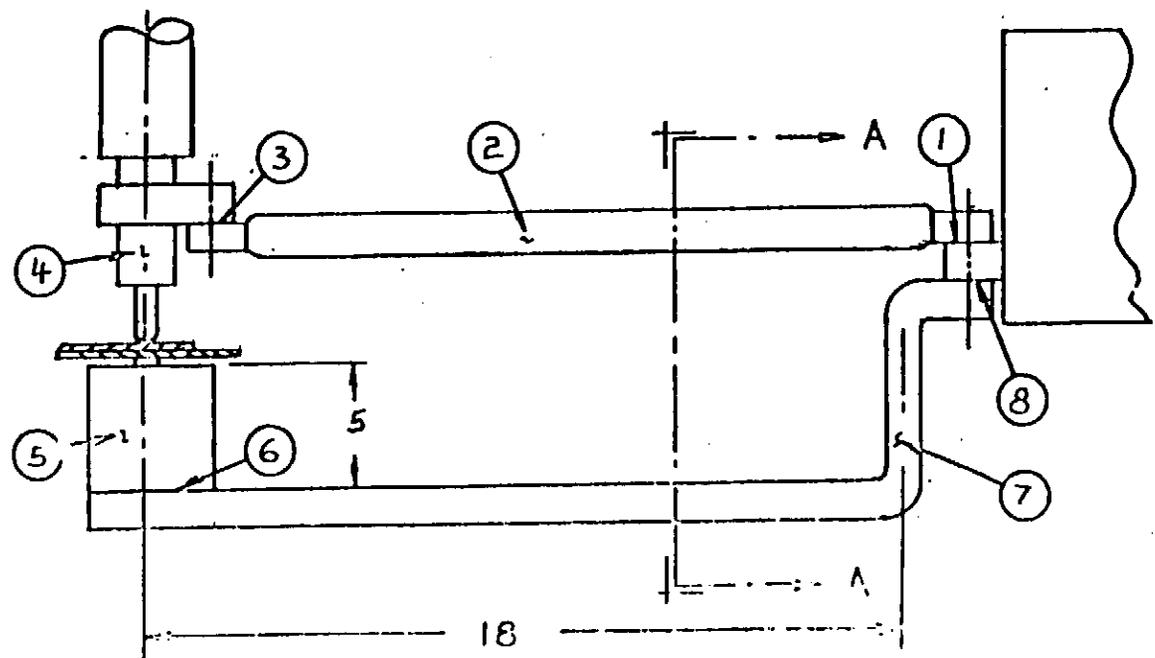
DATE: _____

1. SKETCH OF EXTERNAL WELDING CIRCUIT

(Prepare sketch giving all important dimensions etc. Balloon all items for cross-reference on the following data sheets. Substitute or support with drawings, if available.)



TRANSFORMER SUPPLIES TWO (2) WELDING CIRCUITS AS SHOWN



DESCRIPTION OF WELDING CIRCUITc. WELDING CIRCUIT CONDUCTORS
(Shunts, Jumpers, Bus Bars, etc.)

List size, length, and material of each conductor used and cross-reference to sketch on sheet 1.

② H₂O COOLED JUMPER 750 MCM 17" LONG
 ⑦ COPPER BAR 100% COND. 1' x 1 1/2" x 24' LONG
 EFF. AREA 1 x 1.5 = .3 x .8 = 1.5 - .24 = 1.26 IN²
 EQUIVALENT DIA. = 1.128 x $\sqrt{1 \times 1.5}$ = 1.38 INCH. APPROX. 750 MCM.

b. ELECTRODE HOLDER AND ELECTRODES

Furnish sketch or description.

④ STANDARD 1 1/2" LONG TIP

c. BACK UP

Furnish sketch or description and cross-reference to sketch on sheet 1.

⑤ 3" x 3" x 3" R.W.M.A. CLASS 1

a. CONTACT JOINTS

Give number of contact joints and cross-reference to sketch on sheet 1.

① ③ ⑥ ⑧

Total No. of Contact Joints: 4

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

2. WELD REQUIREMENTS

Type of Weld: Spot X Projection Direct X Indirect Service
 Material: 16 GA. TO 16 GA. LOW CARBON STEEL
 Weld Current: 12 Kilo Amps. Weld Time: 14 Cycles

4. PRODUCTION REQUIREMENTS

Number of welds per gun per minute: 24
 Number of welds per transformer per minute: 48
 Number of transformer energizations per minute: 24
 (One energization equals one weld time.)

5. WELDING CONTROL

- a. IGNITRON CONTACTOR: Yes X No
 Tube Size: A (B) C D E (Circle one)
 Make: MELTRONIC Type: NEH
 Delayed Firing: Yes X No Heat Control: Yes X No
 Does weld schedule require pulsation weld? Yes No X
- b. MAGNETIC CONTACTOR: Yes No X
 NEMA Size: 0W 1W 2W 3W 4W 5W (Circle one)
- c. OTHER (Specify)

6. POWER SUPPLY

Supply voltage: 440 Volts Frequency: 60 Hz

7. REMARKS

List and describe all items which could affect the selection of the welding transformer; i.e., large amount of steel in the loop, conductors are in close proximity to structural machine components, limitations in physical size of transformer, environmental conditions, etc. (Attach additional sheets if necessary.)

COOLING WATER AND HYDRAULIC OIL LEAKAGE
POSSIBLE. USE POTTED TRANSFORMER

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

CUSTOMER: _____

JOB NAME OR NO.: SAMPLE # 2 DIRECT WELDING CIRCUIT

PROCESSED BY: _____ DATE: _____

I. WELDING CIRCUIT

A. RESISTANCE

(NOTE: Enter all values in Micro Ohms).

1. CONDUCTORS: (Item 2a on data sheet)
See sections IA, IB, IC of instructions.

REF. NO.	RESISTANCE	x	PROXIM. FACT.	=	RESISTANCE
<u>②</u>	<u>.25</u>	x	<u>1</u>	=	<u>.25</u>
<u>⑦</u>	<u>14.5</u>	x	<u>1.75 (EST.)</u>	=	<u>25.4</u>
_____	_____	x	_____	=	_____
_____	_____	x	_____	=	_____
_____	_____	x	_____	=	_____
TOTAL ITEM 1					<u>50.4</u>

2. ELECTRODE HOLDER AND ELECTRODES (Item 2b on data sheet)
See section IE of instructions.

REF. NO.	RESISTANCE
<u>④</u>	<u>STANDARD 1 1/2" LONG TIP 10</u>
TOTAL ITEM 2 <u>10.0</u>	

3. BACK UP (Item 2c on data sheet)
See section IE of instructions.

REF. NO.	RESISTANCE
<u>⑤</u>	<u>3x3x5 INCHES R.W.M.A 1 6 (EST.)</u>
TOTAL ITEM 3 <u>6.0</u>	

4. CONTACT JOINTS (Item 2d on data sheet)
See section ID of instructions.

NUMBER OF JOINTS	x	MICRO OHMS PER JOINT	=	
<u>4</u>	x	<u>2</u>	=	<u>8.0</u>

5. MATERIAL (Item 3 on data sheet)
See section IF of instructions.

100.0

RESISTANCE OF EXTERNAL CIRCUIT
TOTAL ITEMS 1 thru 5 Re 174.4 Micro Ohms

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

I. WELDING CIRCUIT (Cont'd.)

B. REACTANCE

(NOTE: Enter all values in Micro Ohms. See section II of instructions.)

Throat Depth 18 Inch
Throat Height 8 1/2 Inch

Ratio $\frac{\text{Throat Depth}}{\text{Throat Height}} = \frac{18}{8.5} = 2.12$

Loop Area = Throat Depth x Throat Height
Loop Area = 18 x 8.5 = 153 Sq. Inch.

Reactance per Sq. Inch 1.45

Graph Used: 3 4 5 (Mark one)

Reactance of External Circuit X_E

X_E = Reactance per Sq. Inch x Loop Area

$X_E = 1.45 \times 153 = 222$ Micro Ohms

C. IMPEDANCE

$Z_E = \sqrt{R_E^2 + X_E^2}$ Use Graph #6. (For R_E see IA of calculation sheet)

$Z_E = \sqrt{174^2 + 222^2} = 285$ Micro Ohms.

D. EXTERNAL LOAD VOLTAGE

$V_E = I_{\text{Weld}} \times Z_E \times 10^{-3}$ Use Nomogram #7.

V_E External load voltage or minimum secondary terminal voltage of transformer under load in volts.

I_{Weld} Weld current in Kilo Amps. (See item 3 of data sheet.)

Z_E Impedance in Micro Ohms. (See item C of calculation sheet.)

$V_E = 12 \times 285 \times 10^{-3} = 3.45$ Volts

II. TRANSFORMER

A. SELECTION (See section IIIA of instructions.)

Secondaries in Parallel
Secondaries in Series
Separate Secondaries

Use graph #7.
Use graph #8.
Use graph #9.

Frame size selected

T

R_{TR} 70 Micro Ohms
 X_{TR} 89 Micro Ohms

Secondary voltage range: From 4 to 6 Volts

KVA 50%DC 70 KVA

} From Table 1

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

TRANSFORMER (Cont'd.)

B. CHECKING THE SECONDARY VOLTAGE RANGE OF THE SELECTED TRANSFORMER
(See section III of instructions.)

Total Resistance: $R = R_E + R_{TR}$ (R_E see IA of calculation sheet.)

$R = 174 + 70 = 244$ Micro Ohms

Total Reactance: $X = X_E + X_{TR}$ (X_E see IB of calculation sheet.)

$X = 222 + 89 = 311$ Micro Ohms

Total Impedance: $Z = \sqrt{R^2 + X^2}$ Use Graph #6.

$Z = \sqrt{244^2 + 311^2} = 395$ Micro Ohms

Secondary voltage required:

$V = I_{Weld} \times Z \times 10^{-3}$ Use Nomogram #7.

$V = 12 \times 395 \times 10^{-3} = 4.75$ Volts

Secondary voltage range of selected transformer acceptable:

Yes No

C. CHECKING THE THERMOCAPACITY OF THE SELECTED TRANSFORMER
(See section III of instructions.)

$KVA_D = V_{High\ Tap} \times I_{Weld}$ Use Nomogram #8.

$KVA_D = 6 \times 12 = 72$ KVA for one (1) weld circuit.

$KVA_{DTR} = KVA_D \times k$ (see IIIC2 of instructions)

$KVA_{DTR} = 72 \times 2 = 144$ KVA for the transformer.

$DC = \frac{N \times T}{3600} \times 100$ Use Nomogram #9.

$DC = \frac{24}{3600} \times 14 \times 100 = 9.3$ %

$KVA_{50\%DC} = KVA_{DTR} \times \frac{\sqrt{DC\%}}{7.07}$ Use Nomogram #10.

$KVA_{50\%DC} = 144 \times \frac{\sqrt{9.3}}{7.07} = 62$ KVA

Thermocapacity of selected transformer acceptable:

Yes No

D. SUGGESTED MODEL NUMBER OF KIRKHOFF TRANSFORMER (See catalog.)

F4470T624X

CUSTOMER: _____

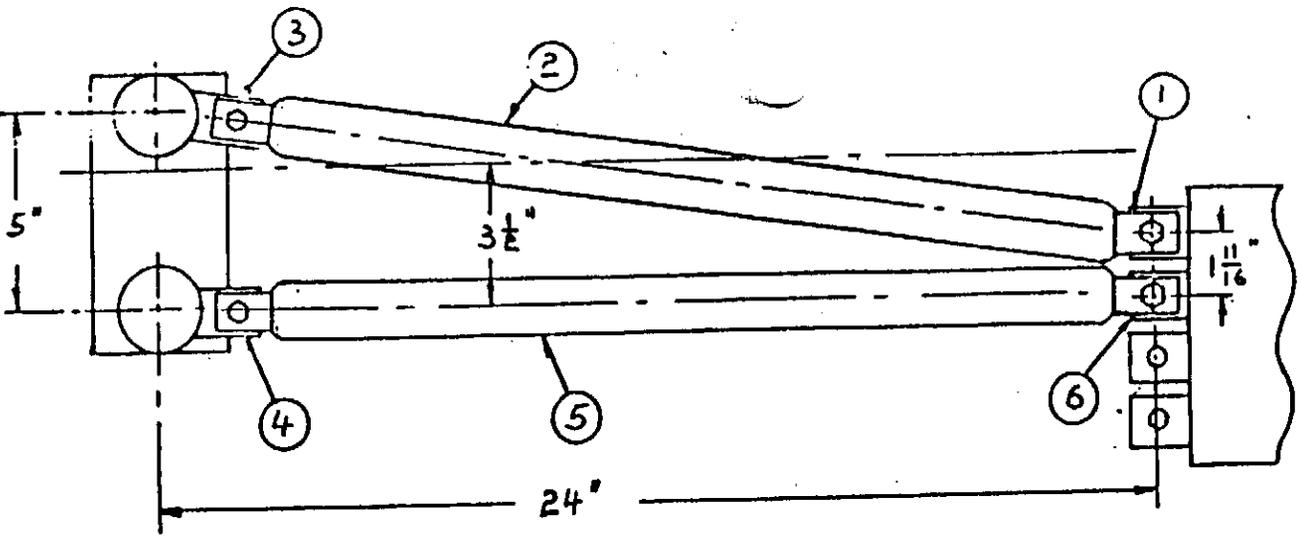
NAME OR NO: SAMPLE # 3 SERIES WELDING CIRCUIT

PREPARED BY: _____

DATE: _____

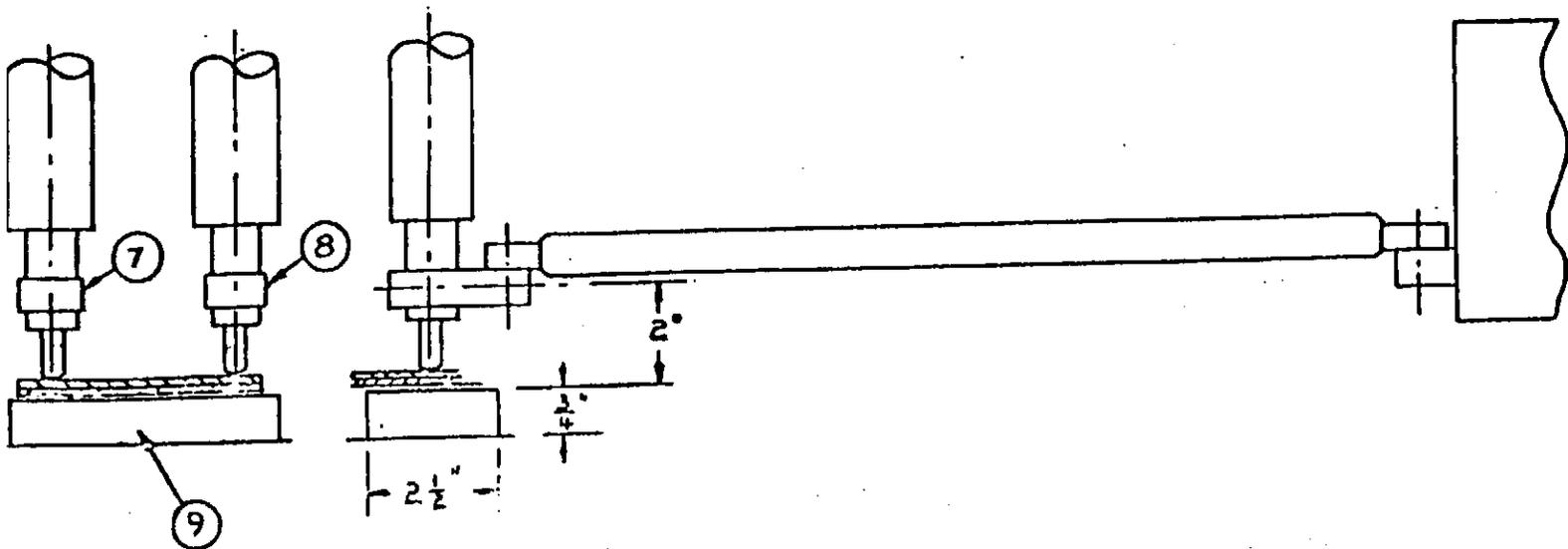
1. SKETCH OF EXTERNAL WELDING CIRCUIT

(Prepare sketch giving all important dimensions etc. Balloon all items for cross-reference on the following data sheets. Substitute or support with drawings, if available.)



TRANSFORMER SUPPLIES TWO (2) WELDING CIRCUITS AS SHOWN

$$\text{MEAN THROAT HEIGHT} = \frac{2 \times 5 + \frac{1.68 + 5}{2} \times 24}{2 + 24} = 3.47 \sim 3 \frac{1}{2}$$



FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

WELDING CIRCUIT (cont'd)

REACTANCE

NOTE: Enter all values in Micro Ohms
See section II of instructions.

Throat Depth 26 Inch
Throat Height 3 1/2 Inch

Ratio $\frac{\text{Throat Depth}}{\text{Throat Height}} = \frac{26}{3.5} = 7.43$

Loop Area = Throat Depth x Throat Height = 91 Sq. Inch
Loop Area = 26 x 3.5

Reactance per Sq. Inch 1.85
Graph Used: 3, 4, or 5 (Mark one)

Reactance of External Circuit X_E

X_E = Reactance P. Sq. Inch x Loop area

$X_E = 1.85 \times 91 = 168$ Micro Ohms

C. IMPEDANCE

$Z_E = \sqrt{R_E^2 + X_E^2}$ Use graph #6

$Z_E = \sqrt{330^2 + 168^2} = 370$ Micro Ohms

D. EXTERNAL LOAD VOLTAGE

$V_E = I_{\text{weld}} \times Z_E \times 10^{-3}$ Use Nomogram #7

V_E External load voltage or minimum secondary terminal voltage of Transformer under load in volts.

I_{weld} Weld current in Kilo Amps

Z_E Impedance in Micro Ohms

$V_E = 14 \times 370 \times 10^{-3} = 5.2$ Volts

II TRANSFORMER

A. SELECTION (See section III A1 of instructions)

Secondaries in Parallel Use graph #7
Secondaries in Series Use graph #8
Separate Secondaries X Use graph #9

Frame size selected WB

3. CHECKING THE SECONDARY VOLTAGE RANGE OF THE SELECTED TRANSFORMER
(See section III B1 thru III B4 of instructions)

R_{TR} 93 Micro Ohms X_{TR} 105 Micro Ohms } From Table 1
Secondary voltage range: From 7.2 Volts To 9.0 Volts

FOR CALCULATION OF KIRKHOFF WELDING TRANSFORMERS

CHECKING THE SECONDARY VOLTAGE RANGE OF THE SELECTED TRANSFORMER (cont'd)

(See section III B1 thru III B4 of instructions)

Total Resistance $R = R_E + R_{TR}$

$$R = \frac{330}{\quad} + \frac{93}{\quad} = \frac{423}{\quad} \quad \text{Micro Ohms}$$

(R_E see IA calculation sheet)

Total Reactance $X = X_E + X_{TR}$

$$X = \frac{168}{\quad} + \frac{105}{\quad} = \frac{273}{\quad} \quad \text{Micro Ohms}$$

(X_E see IB of calculation sheet)

Total Impedance $Z = \sqrt{R^2 + X^2}$ Use Graph #6

$$Z = \sqrt{\frac{423}{\quad}^2 + \frac{273}{\quad}^2} = \frac{505}{\quad} \quad \text{Micro Ohms}$$

Secondary voltage required

$$V = I_{\text{Weld}} \times Z \times 10^{-3} \quad \text{Use Nomogram \#7}$$

$$V = \frac{14}{\quad} \times \frac{505 \times 10^{-3}}{\quad} = \frac{7.1}{\quad} \quad \text{Volts}$$

Secondary Voltage Range of selected Transformer acceptable: Yes No

C. CHECKING THE THERMOCAPACITY OF THE SELECTED TRANSFORMER

(See section III C1 thru III C3 of instructions)

$KVA_D = V_{\text{High Tap}} \times I_{\text{Weld}}$ Use Nomogram #8

$$KVA_D = \frac{9}{\quad} \times \frac{14}{\quad} = \frac{126}{\quad} \quad \text{KVA for (1) one weld circuit.}$$

Multiply KVA_D by 2 if two separate weld circuits are used: 252 KVA

$$DC = \frac{N \times T}{3600} \times 100 \quad \text{Use Nomogram \#9}$$

$$DC = \frac{20 \times 17}{3600} \times 100 = \frac{9.2}{\quad} \%$$

$$KVA_{50\% DC} = KVA_D \times \frac{\sqrt{DC\%}}{7.07} \quad \text{Use Nomogram \#10}$$

$$KVA_{50\% DC} = \frac{252}{\quad} \times \frac{\sqrt{9.2}}{7.07} = \frac{110}{\quad} \quad \text{KVA}$$

Thermocapacity of selected Transformer acceptable Yes No

SUGGESTED MODEL NUMBER OF KIRKHOFF TRANSFORMER (See catalog)

F 44120 WB 65

FOR SELECTION OF KIRKHOF WELDING TRANSFORMERS

CUSTOMER: _____

JOB NAME OR NO.: _____

PROCESSED BY: _____ DATE: _____

1. SKETCH OF EXTERNAL WELDING CIRCUIT

(Prepare sketch giving all important dimensions, etc. Balloon all items for cross-reference on the following data sheets. Substitute or support with drawings, if available.)

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS2. DESCRIPTION OF WELDING CIRCUITa. WELDING CIRCUIT CONDUCTORS

(Shunts, Jumpers, Bus Bars etc.)

List size, length, and material of each conductor used and cross-reference to sketch on sheet 1.

② AIR COOLED JUMPER 1200 MCM 23" LONG

⑤ AIR COOLED JUMPER 1200 MCM 22" LONG

b. ELECTRODE HOLDER AND ELECTRODES

Furnish sketch or description.

⑦ STANDARD 1 3/4" LONG ELECTRODE

⑧ STANDARD 1 3/4" LONG ELECTRODE

c. BACK UP

Furnish sketch or description and cross-reference to sketch on sheet 1.

⑨ DIMENSIONS SEE SKETCH, RWMA CLASS 1 CUd. CONTACT JOINTS

Give number of contact joints and cross-reference to sketch on sheet 1.

① ③ ④ ⑥

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS3. WELD REQUIREMENTS

Type of weld: Spot _____ Projection _____ Direct
 Indirect Series _____
Material: 14 GA. TO 14 GA. MILD STEEL
Weld Current: 14 _____ Kilo Amps, Weld Time 17 _____ Cycles

4. PRODUCTION REQUIREMENTS

Number of welds per gun and part: 1 _____
Number of parts per minute: 20 _____
Number of welds per gun per minute: 20 _____

5. WELDING CONTROL

Model and make ROBOTRON NEN WITH DELAYED
FIRING OF FIRST HALFCYCLE

6. POWER SUPPLY

Supply voltage: 440 _____ Volts
Frequency: 60 _____ Hz

7. REMARKS:

List and describe all items which could affect the selection of the Welding Transformer: i.e., large amount of steel in the loop, Conductors are in close proximity to structural machine components, limitations in physical size of Transformer, environmental conditions, etc.

CUSTOMER WOULD LIKE 7 1/4 x 9 1/4 FRAME SIZE

5-WAY MOUNT TAP SWITCH

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

WELDING CIRCUIT (Cont'd.)

B. REACTANCE

(NOTE: Enter all values in Micro Ohms. See section II of instructions.)

Throat Depth _____ Inch
 Throat Height _____ Inch

Ratio $\frac{\text{Throat Depth}}{\text{Throat Height}} = \frac{\quad}{\quad} = \frac{\quad}{\quad}$

Loop Area = Throat Depth x Throat Height = _____ Sq. Inch.

Reactance per Sq. Inch _____

Graph Used: 3 4 5 (Mark one)

Reactance of External Circuit X_E

X_E = Reactance per Sq. Inch x Loop Area

$X_E = \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$ Micro Ohms

C. IMPEDANCE

$Z_E = \sqrt{R_E^2 + X_E^2}$ Use Graph #6. (For R_E see IA of calculation sheet
 $Z_E = \sqrt{\frac{\quad}{2} + \frac{\quad}{2}} = \underline{\hspace{2cm}}$ Micro Ohms

D. EXTERNAL LOAD VOLTAGE

$V_E = I_{\text{Weld}} \times Z_E \times 10^{-3}$ Use Nomogram #7.

V_E External load voltage or minimum secondary terminal voltage of transformer under load in volts.

I_{Weld} Weld current in Kilo Amps. (See item 3 of data sheet.)

Z_E Impedance in Micro Ohms. (See item C of calculation sheet.)

$V_E = \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times 10^{-3} = \underline{\hspace{2cm}}$ Volts

II. TRANSFORMER

A. SELECTION (See section IIIA of instructions.)

Secondaries in Parallel	_____	Use graph #7.
Secondaries in Series	_____	Use graph #8.
Separate Secondaries	_____	Use graph #9.
Frame size selected	=====	

R_{TR} _____ Micro Ohms X_{TR} _____ Micro Ohms

Secondary voltage range: From _____ to _____ Volts

KVA $50\%DC$ _____ KVA

} From Table 1

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

2. DESCRIPTION OF WELDING CIRCUIT

a. WELDING CIRCUIT CONDUCTORS
(Shunts, Jumpers, Bus Bars, etc.)

List size, length, and material of each conductor used and cross-reference to sketch on sheet 1.

b. ELECTRODE HOLDER AND ELECTRODES

Furnish sketch or description.

c. BACK UP

Furnish sketch or description and cross-reference to sketch on sheet 1.

d. CONTACT JOINTS

Give number of contact joints and cross-reference to sketch on sheet 1.

Total No. of Contact Joints: _____

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

I. TRANSFORMER (Cont'd.)

B. CHECKING THE SECONDARY VOLTAGE RANGE OF THE SELECTED TRANSFORMER
(See section III of instructions.)

Total Resistance: $R = R_E + R_{TR}$ (R_E see IA of calculation sheet.)

$R =$ _____ + _____ = _____ Micro Ohms

Total Reactance: $X = X_E + X_{TR}$ (X_E see IB of calculation sheet.)

$X =$ _____ + _____ = _____ Micro Ohms

Total Impedance: $Z = \sqrt{R^2 + X^2}$ Use Graph #6.

$Z = \sqrt{\frac{\quad}{2} + \frac{\quad}{2}} =$ _____ Micro Ohms

Secondary voltage required:

$V = I_{Weld} \times Z \times 10^{-3}$ Use Nomogram #7.

$V =$ _____ \times _____ $\times 10^{-3} =$ _____ Volts

Secondary voltage range of selected transformer acceptable:

Yes No

C. CHECKING THE THERMOCAPACITY OF THE SELECTED TRANSFORMER
(See section III of instructions.)

$KVA_D = V_{High Tap} \times I_{Weld}$ Use Nomogram #8.

$KVA_D =$ _____ \times _____ = _____ KVA for one (1) weld circu

$KVA_{DTR} = KVA_D \times k$ (see IIIC2 of instructions)

$KVA_{DTR} =$ _____ \times _____ = _____ KVA for the transformer.

DC = $\frac{N \times I}{3600} \times 100$ Use Nomogram #9.

DC = _____ \times _____ $\times 100 =$ _____ %

$KVA_{50\%DC} = KVA_{DTR} \times \frac{\sqrt{DC\%}}{7.07}$ Use Nomogram #10.

$KVA_{50\%DC} =$ _____ $\times \frac{\sqrt{\quad}}{7.07} =$ _____ KVA

Thermocapacity of selected transformer acceptable:

Yes No

D. SUGGESTED MODEL NUMBER OF KIRKHOFF TRANSFORMER (See catalog.)

CALCULATION SHEET

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

CUSTOMER: _____

JOB NAME OR NO.: _____

PROCESSED BY: _____ DATE: _____

I. WELDING CIRCUIT

A. RESISTANCE

(NOTE: Enter all values in Micro Ohms).

1. CONDUCTORS: (Item 2a on data sheet)
See sections IA, IB, IC of instructions.

REF. NO.	RESISTANCE	x	PROXIM. FACT.	=	RESISTANCE
_____	_____	x	_____	=	_____
_____	_____	x	_____	=	_____
_____	_____	x	_____	=	_____
_____	_____	x	_____	=	_____
_____	_____	x	_____	=	_____
					TOTAL ITEM 1 _____

2. ELECTRODE HOLDER AND ELECTRODES (Item 2b on data sheet).
See section IE of instructions.

REF. NO.	RESISTANCE
_____	_____
_____	_____
TOTAL ITEM 2 _____	

3. BACK UP (Item 2c on data sheet)
See section IF of instructions.

REF. NO.	RESISTANCE
_____	_____
_____	_____
TOTAL ITEM 3 _____	

4. CONTACT JOINTS (Item 2d on data sheet)
See section ID of instructions.

NUMBER OF JOINTS	x	MICRO OHMS PER JOINT	=	_____
_____	x	_____	=	_____

5. MATERIAL (Item 3 on data sheet)
See section IF of instructions.

RESISTANCE OF EXTERNAL CIRCUIT	_____
TOTAL ITEMS 1 thru 5	RE _____
	Micrs _____

FOR SELECTION OF KIRKHOFF WELDING TRANSFORMERS

WELD REQUIREMENTS

Type of Weld: Spot Projection Direct Indirect Series

Material: _____

Weld Current: _____ Kilo Amps. Weld Time: _____ Cycles

4. PRODUCTION REQUIREMENTS

Number of welds per gun per minute: _____

Number of welds per transformer per minute: _____

Number of transformer energizations per minute: _____
 (One energization equals one weld time.)

5. WELDING CONTROL

a. IGNITRON CONTACTOR: Yes No

Tube Size: A B C D E (Circle one)

Make: _____ Type: _____

Delayed Firing: Yes No Heat Control: Yes No

Does weld schedule require pulsation weld? Yes No

b. MAGNETIC CONTACTOR: Yes No

NEMA Size: 0W 1W 2W 3W 4W 5W (Circle one)

c. OTHER (Specify)

6. POWER SUPPLY

Supply voltage: _____ Volts Frequency: _____ Hz

7. REMARKS

List and describe all items which could affect the selection of the welding transformer; i.e., large amount of steel in the loop, conductors are in close proximity to structural machine components, limitations in physical size of transformer, environmental conditions, etc. (Attach additional sheets if necessary.)
