LOCATION OF IRREGULARITIES ON LOADED CABLE PAIRS THROUGH ANALYSIS OF IMPEDANCE AND IMPEDANCE UNBALANCE CURVES

CONTENTS PAGE

1. GENERAL

1.01 This section gives a step-by-step procedure to be followed in the interpretation of impedance and impedance unbalance curves for determining accurately the position of:

(1) Toll cable faults that cause low return losses (or singing points) such as deficient or excessive loading section capacitance or inductance.

(2) Toll cable faults that cause high crosstalk or noise such as resistance unbalances.

1.02 This issue has been given a Standard rating and replaces Issue 1, Provisional Standard. The following new information is given in this issue.

(1) Data which permits the location of impedance unbalance and impedance irregularities on H-88-50 and B-88-50 facilities and also the location of impedance irregularities on B-22 facilities.

(2) Data covering the use of K factor in impedance unbalance locations.

(3) Information describing the use of valley frequencies as well as peak frequencies for impedance unbalance locations.

(4) Revised Form E-1294 which makes it more usable in impedance unbalance locations.

1.03 The term impedance irregularity designates the type of fault that causes low return losses or low singing point, and the series of measurements made to locate the fault is termed an impedance run or impedance-frequency run. These measurements plotted in curve form are called an impedance curve.

1.04 The term impedance unbalance designates the type of fault that causes crosstalk or noise. The series of measurements made to locate this type of fault is termed an impedance unbalance run, and when plotted in curve form for convenience of interpretation is called an impedance unbalance curve.

1.05 Impedance and impedance unbalance measurements are usually made in terms of resistance and reactance components and these components are plotted separately on the curve sheet. Only the resistance curves will be used in the procedure of this section.

1.06 This section assumes that the fault to be investigated has been revealed by such means as routine tests, circuit order tests, cable completion tests, or trouble developing under the operating condition of the circuit; and that an impedance or impedance unbalance run has been made on the circuit and the measurements plotted on standard curve sheet form.

2. ANALYSIS OF IMPEDANCE CURVES

2.01 The step-by-step procedure to follow will in itself explain the majority of the details of the analysis form E-1294, a copy of which is attached as page 101. Those details not so covered will be taken up under Part 4, Analysis Form. For convenience the form is divided by heavy boundary lines into blocks, which as far as practicable are numbered consecutively in the order they are used. In the procedure to follow references will be given by block numbers and by space designations in a block.

Step-by-Step Analysis Procedure

2.02 Computation of Apparent Location of Irregularity

(1) From the resistance curve determine the frequencies at which all well defined peaks occur. Record these frequencies consecutively in Block 2 under the column headed "Freq. at Res. Peaks or Valleys," with the lowest frequency in the top space.

(2) From the attached phase shift charts for irregularities (Drawings 616-281, 282, 283, 284, 290, 316, 317, 318, 319 and 320 on pages 103-112), select the one corresponding to the type of circuit under investigation, and from this determine the values of "B" corresponding to the frequencies of item (1). Record these in Block 2 under the column "B," opposite the corresponding frequencies.

Note: In case a phase shift chart is not available for the type of circuit involved, Drawing 616-280, page 102, may be used. In this drawing values of B are plotted against f/f_c, where f is the peak frequency and f_c the cutoff frequency of the type of circuit under test. If this procedure is followed the ratios f/f_c must first be computed for each value of f recorded in item (1), and entered in Block 2 under the column headed "f/f_c." Values of B are then determined from Drawing 601-280 and entered as instructed in item (2)

(3) In Block 3 in spaces designated B_N and B_1 record the B values for the highest and lowest peak frequencies (B_1 refers to lowest frequency, in top space, that is, the one opposite "1" of the "N" column; B_N is for the highest frequency, that is, the last entry in the "B" column). Subtract B_1 from B_N and record result in space "$B_N - B_1$." Divide $B_N - B_1$ into N - 1, where N is the total number of peak frequencies recorded. Record the result in space $\frac{N-1}{B_N - B_1}$. This result as indicated on the form is called "d," which is the apparent distance in loading sections to the irregularity.

2.03 Correction of Apparent Location for B-T Curve Slope

(1) Multiply the value of d found in item (3) of paragraph 2.02, by each of the B values of Block 2, column "B." Record these products in Block 2, column "d x B," opposite corresponding B values.

(2) In Block 2, column "T," opposite corresponding d x B values, record the smallest values that added to or subtracted from the d x B values will give numbers ending in .50.

Note: If the "d x B" values were 1.25, 2.25, 3.25, etc., the "T" values would be +.25, +.25, +.25, etc. If the "d x B" values were 1.75, 2.75, 3.75, etc., the "T" values would be -.25, -.25, -.25, etc. The "d x B" values will "try to be" numbers ending in .50 and each value will be about 1.0 larger than the preceding one. In unusual cases it may be that "T" in one instance will not actually be the smallest value in accordance with the above. For example, a few of the consecutive "d x B" values from an actual analysis were 5.85, 6.95, 8.09, and 8.90. These values are evidently "trying to be" 5.5, 6.5, 7.5, and 8.5 so that "T" values are -.35, -.45, -.59, and -.40. The value 8.09 is actually nearer to 8.5 than to 7.5, but since there should be a difference of one between values, the trend indicates that it must be 7.5, otherwise, there would be two 7.5's. The T value is therefore -.59, rather than +.41 as it might at first appear to be. The lowest "d x B" value will be close enough to .50, 1.50, or possibly 2.50 to indicate definitely the consecutive numbers ending in .50 that the "d x B" values are "trying to be."

(3) On the small graph paper section in Block 6, plot the "T" values against the corresponding "B" values of Block 2, and draw a curve through the points so plotted. (This curve will be referred to as the "B-T" curve.)

(4) Determine, as follows, T_0, which is the number the various T values of Block 2 are "trying to be" and record the value in Block 7, space "T_0."

T_0 in most cases will be equal to, or very close to, +.25, -.25, +.50, -.50, or 0, the value depending on the type of irregularity. If the B-T curve were a straight horizontal line it would be separated from the 0-axis of the graph section at a distance equal to T_0. If at an angle to the 0-axis a straight-line B-T curve if extended would start from the left edge of the graph (where B = 0) at a T value equal or very close to T_0. If the B-T curve contained peaks and valleys as it may when more irregularities than one are present, the axis of the curve, that is, a straight line so drawn as to bisect the curve, would appear to "point at" the T_0 value on the left edge of the graph. The T_0 value can in one of these ways be determined closely enough. Figs. 1 and 2 illustrate this procedure. Fig. 1 is for an almost straight-line B-T curve for a case of $T_0 = 0$. Fig. 2 is a case of pronounced peaks and valleys in the B-T curve, where $T_0 = -.25$.

(5) Determine as follows the slope of the B-T curve and record both size and sign of slope in Block 3, in the space designated "Slope Correction P = ".

Beginning at the left edge of the graph from a point on the vertical scale that equals T_0, draw a straight line all the way across the graph in such manner as to follow the general trend of the B-T curve or so as to bisect this curve, that is, to appear as the axis of the curve. Call the value of T where this bisecting line intersects the right edge of the graph (where B = 1.0) T_1. Subtract T_0 algebraically from T_1. The result $(T_1 - T_0)$, gives both the sign and the magnitude of the slope. It will be noted that if the bisecting line slopes upwards from left to right the sign of the slope is positive (+). If the bisecting line slopes downwards from left to right, the sign is negative (-).

In Fig. 1 the dashed line is the bisecting line. It begins from the left at $T_0 = 0$ and ends at the right at $T_1 = +.25$. The slope is

$$T_1 - T_0 = +.25 - 0 = +.25$$

(The dashed line slopes upwards, also indicating positive (+) slope.)

In Fig. 2 the bisecting line begins at $T_0 = -.25$, and ends at $T_1 = -.75$. The slope is

$$T_1 - T_0 = -.75 - (-.25) = -.50.$$

(The line slopes downwards, indicating negative (-) slope.)

(6) Add the slope correction determined in (5) algebraically to d and record the result in Block 3 after the designation "(d + slope) P = ".

Note: "d" is always positive (+), so if the slope is positive (+), then (d + slope) will be larger than d by the magnitude or size of slope. If the slope is negative (d + slope) will be less than d by the magnitude of slope.

2.04 Correction of Apparent Location for Deviations in Cable Constants

(1) In Block 4, space "K = ," record from the office records the K factor applicable to the type of circuit

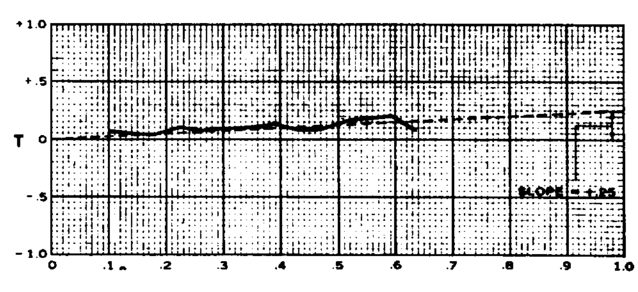


Fig. 1.

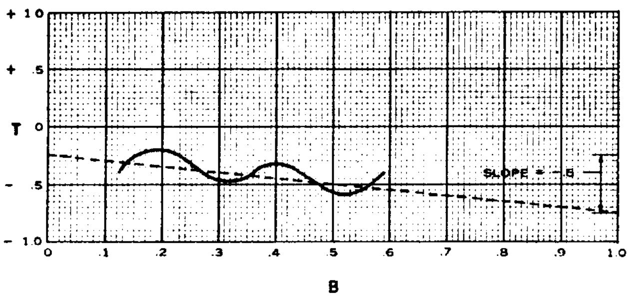


Fig. 2.

under test and to the particular cable repeater section under test.

Note: The phase shift charts already used are based on certain nominal electrical characteristics for the circuit types concerned. In actual practice certain deviations from these nominal characteristics exist, and the K factor is a multiplier to correct for such error in location as is caused by the deviations. The K factors will be very nearly equal to 1.0. The method of determining K factors is given in Paragraph 2.15 and an actual determination is given in Illustrative Example 1 of Part 5.

(2) Multiply the (d + slope) value of Block 3 by the K factor and record the product in Block 4, space

"(d + slope) x K."

Interpretation of Nature and Exact Location of Irregularity

2.05 The value of (d + slope) x K arrived at by the foregoing step-by-step procedure is the final location of the irregularity and practically completes the mathematical steps. The remaining steps are largely an interpretation of the data already found for determining more exactly the position of the irregularity and also the nature of the irregularity.

2.06 Theoretically, small capacitance irregularities locate at the middle of loading sections, and small inductance irregularities locate at the middle of loading coils. Large irregularities cause the location (d + slope) x K to vary from the true location, by an amount depending on the size of the irregularity; and in a direction, that is, further out from or nearer to the sending end, which depends on the type of irregularity.

2.07 Considering first the "theoretical" locations, that is, locations of small irregularities, the distance to a capacitance irregularity is the number of loading sections from the testing or sending end to the middle of the loading section involved. The distance to a small inductance irregularity is the number of loading sections to the middle of the loading coil involved. In computing this distance the sending end section including any office cable, wiring, and trunks between the toll cable and the measuring set is equated to a fraction of a section. Thus, a 3000-foot sending end section of an H-spaced circuit (coils every 6000 feet) is .50 section, and a 1200-foot section is 1200/6000 or .20 section. A small capacitance irregularity in the fifth full loading section would thus locate 5.0 sections away if the sending end section were .5 section; and an inductance irregularity in the fifth coil out would locate 4.5 sections away. (d + slope) x K would come out very nearly equal to these values. Fig. 3 illustrates theoretical locations of capacitance and inductance irregularities on H-spaced circuits (loading coils every 6000 feet) for three different sending end section lengths. The locations shown are for convenience, those in the first several loading sections.

2.08 Each type of irregularity produces a characteristic T_0, and in case of inductance and capacitance irregularities, which are of primary interest, tends to make the computed location (d + slope) x K in error in a definite direction and magnitude from the true location. A summary of these effects is given in Table 1 and for convenience of reference is reproduced in large part on the analysis form.

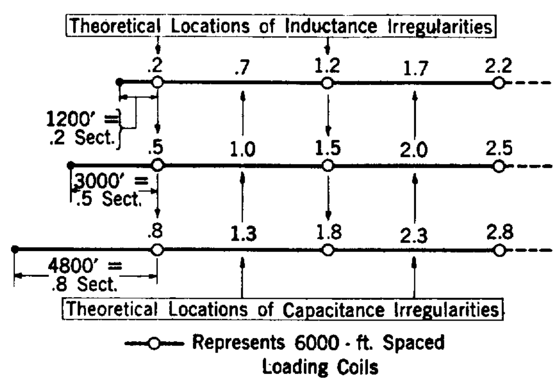


Fig. 3.

TABLE 1

Nature of Irregularity	T_o	Makes Computed Location	Approximate Maximum Error in Loading Sections
Excess Inductance (+L)	+.25	Long	.25
Deficient Capacitance (-C)	+.25	Short	.25
Deficient Inductance (-L)	-.25	Short	.25
Excess Capacitance (+C)	-.25	Long	.25
Excess Resistance (+R)	$\pm$.50	(No effect)	0
Deficient Resistance (-R)	0	(No effect)	0

Under the heading "Makes Computed Location," the notation "long" indicates that the computed location (d + slope) x K for a large irregularity is more distant than the theoretical location. "Short" means (d + slope) x K would be less distant than the theoretical location.

2.09 For illustration, suppose that on an H-loaded circuit having a .5 sending end section, an analysis showed (d + slope) x K to be 8.9 loading sections, and T_o to be +.25. The theoretical location of an inductance irregularity in the ninth coil would be 8.5 sections; the theoretical location of a capacitance irregularity in the ninth full loading section would be 9.0 sections. Since 8.9 is nearer to 9.0 than to 8.5, a capacitance irregularity is indicated. That the capacitance irregularity **is caused by deficient rather than excessive capacitance is indicated in two ways;** (a) T_o is +.25 which is the value for deficient capacitance; (b) the computed location is "short," that is 8.9 is less than 9.0 the theoretical location, which is as it should be for deficient capacitance (see Table 1).

2.10 Final Analysis

The foregoing may be put in step-by-step form approximately as follows:

(1) In Block 7 in space following "Sending End Section Length =," record the sending end section length expressed in fraction of a loading section.

(2) Compute the "theoretical" location of inductance and capacitance irregularities that falls nearest to the computed location (d + slope) x K.

(3) If the computed location is nearer to the theoretical location of the inductance irregularity, enter in Block 7 the suspected trouble as an inductance irregularity; record a capacitance irregularity if the location is nearer to the theoretical location of a capacitance irregularity.

Note: Resistance irregularities will seldom be encountered and when existing they usually will be revealed and located by direct current tests.

(4) If the suspected trouble is a capacitance irregularity:

(a) Record as deficient capacitance if T_o = +.25, and the computed location is "short."

(b) Record as excessive capacitance if T_o = -.25, and the computed location is "long."

(5) If item (3) indicates inductance irregularity:

(a) Record as deficient inductance, if T_o = -.25 and computed location is "short."

(b) Record as excessive inductance, if T_o = +.25 and computed location is "long."

2.11 One special case of a misleading "T_o" factor has been observed which might well be kept in mind. This was for a circuit containing excess capacitance in one loading section and deficient capacitance in the adjacent loading section. Such a condition would occur if the middle coil of three successive loading coils were located appreciably off the center of the cable length, making one section longer than the average and the other correspondingly shorter than the average. "T_o" came out to be very nearly zero indicating deficient resistance, but such an irregularity would scarcely be expected and if existing would more than likely be revealed by direct current tests. A short circuit would be one example of deficient resistance. Consequently, if such a condition is noted and direct current tests show no trouble, deficient and excess capacitance in the two loading sections adjacent to the apparent location should be suspected.

Value of Cable History

2.12 Familiarity with the history of a repeater section such as of the maintenance work done in the section in the past, recent loading of complements and the like will often be quite helpful in interpreting results and tying down more definitely the probable trouble and its location. For example if an analysis of an irregularity locating in a particular section indicates deficient capacitance, the trouble would pretty surely be due to defective building-out if it were known that a building-out stub cable had recently been installed in that section or that maintenance work had recently been done on a building-out stub at that point. Again, if a trouble indicated excess inductance in a section where a new complement had just been loaded, a wrong type loading coil might be suspected. If the complement involved both H-44-25 and H-172-63 loading an H-172 coil connected into an H-44 circuit would insert (172-44) or 128 excess milhenries or 128/44 x 100 = 290 per cent. excess inductance.

2.13 Loading coils are the most prevalent source of trouble and in general should first fall under suspicion. Troubles such as opens, shorts, and leakages are both detected and located by direct current methods and will seldom be involved in the analysis procedure discussed in this section. The principal exception will be in the initial determination of the correction factor K as discussed in paragraph 2.15, where a run is made on a good circuit terminated in a short circuit (deficient resistance or -R) at the adjacent office.

Procedure for Circuits Containing Two Irregularities

2.14 In most cases only a single large irregularity will exist. A second irregularity as previously mentioned will reveal itself by humps in the B-T curve but usually will not prevent an accurate location of the larger irregularity. One important exception was mentioned in paragraph 2.11. The nature of the B-T curve tells something about the second irregularity and will often enable both the position and nature of this irregularity to be determined. Exception to this, however, and the relatively infrequent occurrence of the two-irregularity condition suggest at present that the larger irregularity be located and cleared before an attempt is made to study the smaller irregularity. With the larger one removed, a second impedance run should be made and the procedure of this section repeated for locating the second irregularity.

Determination of Correction Factor (K)

2.15 To determine K for a given type of circuit in a particular repeater section:

(1) Make an impedance run on a good circuit of the type involved, with the circuit terminated at the adjacent repeater station in a short circuit.

(2) Analyze the impedance run in accordance with the steps of paragraphs 2.02 and 2.03, thus determining (d + slope).

(3) Divide (d + slope) into the "actual distance" in loading sections from the testing end to the short circuit. The result is the K value.

Note: In determining the "actual distance" to the short-circuit count the terminating end section a half section, but the sending end section actually what it is. Suppose a repeater section contained 24 full 6000-foot loading sections, a sending end section of 2300 feet (.38 of a section), and a terminating end section of 1975 feet. The actual length would be 24 + .38 + .50 = 24.88 sections. (Note that the 1975-foot section was assumed to be .50 section.) If (d + slope) determined by steps (1) and (2) were 24.05, the correction would be: K = 24.88/24.05 = 1.035. The illustrative examples under Part 5 will include a determination of a "K" factor.

3. ANALYSIS OF IMPEDANCE UNBALANCE CURVES

Step-by-Step Analysis Procedure

3.01 Computation of Apparent Location of Unbalance

(1) From the resistance curve determine the peak frequencies and record them as outlined in Step (1) paragraph 2.02. Only use peaks within the following frequency range for the various types of facilities.

Facility	Lower Frequency	Upper Frequency
H-44-25	800	4500
H-174-63	400	2250
H-174-106	400	2250
B-88-50	800	4500
H-88-50	550	3200

(2) Determine the values of B from one of the attached phase shift charts applicable (Drawings 611-162, 163, 165, 228 and 229, pages 113-117) and record them as outlined in Step (2), paragraph 2.02.

Note: In case a phase-shift chart is not available for the type of circuit involved, Drawing 616-280, Page 102, may be employed as follows in order to obtain B for each peak frequency.

Let f = any peak frequency

f_{cs} = the nominal cut-off frequency of the side circuit.

f_{cp} = the nominal cut-off frequency of the phantom circuit.

B_s = the round-trip phase-shift per loading section on side circuit.

B_p = round-trip phase-shift per loading section on phantom circuit.

B = phase-shift out on phantom and back on side $= \frac{1}{2}(B_s + B_p)$.

A. Compute $\frac{f}{f_{cs}}$ and $\frac{f}{f_{cp}}$.

B. Using values obtained in Step A, read B_s and B_p from the curve of Drawing 616-280.

C. Compute B from the relation

$$B = \frac{1}{2} (B_s + B_p).$$

(3) Determine "d" the apparent distance in loading sections to the fault as outlined in Step (3) paragraph 2.02.

3.02 Correction of Apparent Location for B-T Curve Slope

(1) Determine and record "d x B" as outlined in Step (1) paragraph 2.03.

(2) Determine and record "T" as outlined in Step (2) paragraph 2.03.

(3) Plot the "B-T" curve as outlined in Step (3) paragraph 2.03.

(4) Determine and record T_0 as outlined in Step (4) paragraph 2.03.

(5) Determine and record the slope of the B-T curve as outlined in Step (5) paragraph 2.03.

(6) Determine and record "(d + slope)" as outlined in Step (6) paragraph 2.03.

3.03 Following the methods given in paragraphs 3.01 and 3.02 make a computation of the apparent location of the unbalance and determine the correction of the apparent location for the B-T curve slope using the "Valley" frequencies of the resistance curve. In recording the data there will usually be sufficient space in Block 2 under the data recorded for the peak frequencies. If not the valley data can be recorded on a separate form. In Block 3 the valley data would be recorded under "Valley" or opposite "V."

3.04 Average the (d + slope) P value and the (d + slope) V value and record the result in Block 3 opposite (d + slope) Ave.

3.05 Correction of Apparent Location for Deviations in Cable Constants

(1) In Block 4, space "K=," record the K factor applicable to the particular circuit under test.

Note: The phase shift charts already used are based on certain nominal electrical characteristics for the circuit types concerned. In actual practice certain deviations from these nominal characteristics exist, and the K factor is a multiplier to correct for such error in location as is caused by the deviations. The K factors will be very nearly equal to 1.0. The method of determining K is given in paragraph 3.16 and an actual determination is given in Illustrative Example 4 of Part 5.

(2) Multiply the (d + slope) Ave. value of Block 3 by the K factor and record the product in Block 4, space "(d + slope) x K."

3.06 In some cases particularly in cases involving small faults distant from the testing point it may be necessary to use a 44-A-1 repeater in connection with the impedance unbalance run. Although the introduction of the repeater gives peaks and valleys of larger magnitude it results in an error in the location and a correction must be applied to take account of this. This correction in terms of loading sections is .25 for H-172-63 or H-174-63 facilities, .25 for H-174-106 facilities, .55 for H-44-25 facilities, .35 for H-88-50 facilities and .55 for B-88-50 facilities.

3.07 Repeater Correction (to be made only in case a 44-A-1 repeater is used in making the unbalance run).

(1) Knowing the type of facility under test record the repeater correction in Block 5 after the designation "Repeater Correction (R.C.)." Subtract the repeater correction from "(d + slope) Ave." obtained as outlined in Step (2) paragraph 3.05. Record the result in Block 5 after the designation "K (d + slope) - R.C."

Interpretation of Nature and Exact Location of Resistance Unbalance

3.08 The location just determined should give the correct location with a maximum error of about .2 of a loading section. Certain features of unbalances and more precise location methods as applied to resistance unbalances are discussed below.

3.09 Each type of unbalance produces a characteristic T_0. These are indicated in Table 2 below.

TABLE 2

Nature of Unbalance	T_0
Resistance Unbalance (R)	0 or $\pm$ .5
Inductance Unbalance (L)	$\pm$ .25
Capacitance Unbalance (C)	$\pm$ .25
Leakage Unbalance (G)	0 or $\pm$ .5

It will be noted that a particular value of T_0 may indicate either one of two types of unbalance. In this connection the ordinary direct current measurements will indicate whether a resistance or leakage unbalance is present.

3.10 If the analysis indicates the presence of an inductance unbalance and since it will usually be large it can be more accurately located by an impedance measurement and it is suggested that it be located by this means. For this reason no further discussion is given here.

3.11 Leakage unbalances are generally located by means of the ordinary direct current tests and it is assumed that if such are present they will be located in this manner.

3.12 All capacitance unbalances will locate at approximately the midpoint of the loading section. It is not necessary to know the exact location of such troubles since they may be corrected at any point within the loading section. Single capacitance unbalances large enough to cause noise or crosstalk trouble rarely occur.

3.13 In case a resistance unbalance is indicated, as outlined in paragraph 3.08, a more accurate location can be obtained by studying the envelope of the impedance unbalance curve. The dotted lines of Fig. 4 show the general shape of a typical envelope. It will be noted that this envelope has been obtained by connecting each of the "peaks" together and also connecting the "valleys" of the curves.

3.14 Determination of Location of Unbalance Within Loading Section

(1) Draw the envelope of the resistance curve on the standard curve form.

(2) Measure the height of the envelope at 1000 cycles, (F_L). Next measure the height of the envelope at some higher frequency (F_H) see Fig. 4. Record this higher frequency in cycles opposite H in Block 5. Divide (F_H) by (F_L) and record in Block 5 in space "F_H/F_L." The quantity thus obtained is a current ratio.

Note: The higher frequency referred to above should be chosen from the upper frequency range of the resistance curve at a point where the curve is fairly well defined. A frequency near 2000 cycles for H-172-63, H-174-63 or H-174-106 facilities, near 3500 cycles for H-44-25 or B-88-50 facilities or near 2500 cycles for H-88-50 facilities is satisfactory.

(3) From Table 3 page 100 determine the db corresponding to the current ratio F_H/F_L. Record this in Block 5 after the designation "Equivalent to."

(4) Drawing 611-164 page 118 shows the deviation in loss per loading section from the 1000-cycle value for the frequency range above 1000 cycles for the various types of cable facilities. Select the particular curve applicable for the type of circuit under test and determine the deviation from the 1000-cycle loss for the higher frequency used in (2) above. Multiply this deviation by K (d + slope) - R.C. and record the operation and result respectively in Block 5 after the designation "[K (d + slope) - R.C.] x Deviation." The result obtained is in db. Add this result in db to that obtained as outlined in (3) above and record in Block 5 after the designation "Total db." This "Total db" represents the deviation at the unbalance of the higher frequency over the 1000-cycle value.

(5) The attached charts (Drawings 611-160, 161, 167, 230, 232, 168, 169, 170, 231 and 233), pages 119-128, show the deviation in db from the 1000-cycle value at the unbalance. It will be noted that where a 44-A-1 repeater is used in connection with the bridge, a different chart is used than where a run is made without using a repeater. The charts for the condition where the 44-A-1 repeater is used assume the repeater to be placed in the trouble pair, as shown in Section 103-102-500.

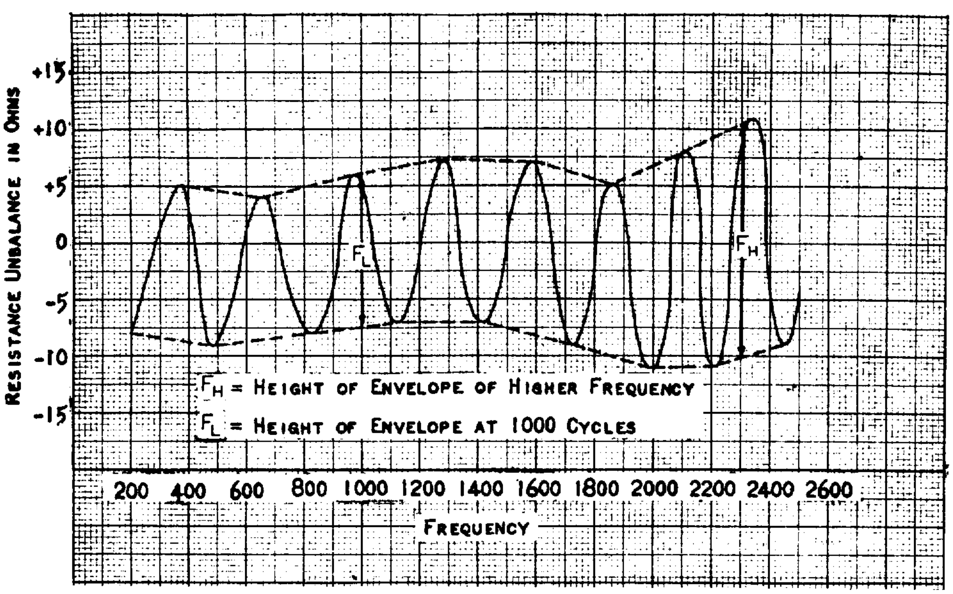


Fig. 4.

select the chart corresponding to the type of circuit under investigation, making sure to use a curve for a repeater if one were used in making the run, and determine the location within the loading section. Record this location in feet from the loading point in Block 5 after the designation "Distance from Load Point to Fault."

Note: As an illustration to show how Drawings 611-160, 161, 167, 230, 232, 168, 169, 170, 231 and 233 are to be interpreted, suppose the "total db" at 2300 cycles is 4.5 db for an H-174-63 facility where no repeater is used in making the run and it is desired to know the location within the loading section. Referring to Drawing 611-160, page 119, the location is 600 feet from a loading point. Intermediate values between the series of curves on the drawings may be estimated to the nearest curve. As an illustration of this latter point, suppose the "Total db" discussed above were 2.8 db instead of 4.5 db. The location would be then at a point approximately 1200 feet from the loading point.

3.15 Determination of Final Location of Unbalance

(1) Knowing the particular loading section in which the unbalance is located (see Step 6, paragraph 3.02 or Step 1, paragraph 3.07) and also its location within the loading section (see Step 5, paragraph 3.14), determine the final location of the fault in loading sections from the testing end. Record this value in Block 5 after the designation "Final Location of Fault."

Note: As discussed in paragraph 3.08 the location recorded in Block 5 after the designation "K (d + slope) - R.C." or "K (d + slope)" where no repeater is used should fix the location of the fault with a maximum error of about .2 of a loading section. In case Step (5) of paragraph 3.14 indicates the fault to be at a loading point, the particular loading point will be known by the value of "K (d + slope) - R.C." or "K (d + slope)."

Determination of Correction Factor (K)

3.16 To determine K for a given circuit:

(1) Introduce a resistance unbalance at a known location (usually the distant repeater office) in the good pair of the quad, the other pair of which is in trouble. Make an impedance unbalance run on this good pair in the normal manner using the defective pair as the other side of the phantom sending circuit.

Note: If a repeater is used in making the unbalance run on the defective pair, it should also be used in making the K run. The value of the resistance should be in the order of 500 ohms if no repeater is used in making the run and about 100 ohms if a repeater is used. It is very important that a K run be made in connection with each trouble location immediately following the run made on the defective pair.

(2) Analyze the unbalance run (both peaks and valleys) in accordance with the steps of paragraphs 3.01, 3.02, 3.03 and 3.04 thus determining (d + slope) Ave.

(3) Divide (d + slope) Ave. into the actual distance in loading sections from the unbalance bridge to the resistance unbalance introduced. The result is the K value.

Note: The actual distance from the unbalance bridge to the resistance unbalance should include all office cabling and trunks as well as the length (in load sections) of the main cable as shown by the Testboard Cable Record. This applies to the office cabling and trunks at the terminating as well as the sending end if the resistance unbalance is introduced adjacent to the terminating network. The equivalent length of office cable and trunks may be determined by measuring their side circuit capacitances and multiplying the reading in mf. by 14.2 to obtain the equivalent length in load sections. It will usually be found desirable to establish a value for the office cabling in a particular toll cable entering an office by making measurements on a representative number of pairs between the MDF and the testboard.

Value of Cable History

3.17 Familiarity with the history of a repeater section such as with the maintenance work done in the section in the past will often be quite helpful in interpreting results and fixing more definitely the probable location of the trouble.

Procedure for Circuits Containing Two Unbalances

3.18 In most cases only a single unbalance will exist. A second unbalance as previously mentioned will be revealed by the humps in the B-T curve. The nature of the B-T curve tells something about the second fault and will often enable both the position and nature of **this trouble** to be determined. For the present in view of the relatively infrequent occurrence of the two-unbalance condition and other factors, the larger unbalance should be cleared before an attempt is made to study the smaller unbalance. With the larger one removed a second impedance unbalance run should be made and the procedure of this section repeated for locating the second unbalance.

4. ANALYSIS FORM

4.01 Most of the details of the analysis form have already been covered. At the heading of the form is a space for entering the serial number of the analysis sheet. This number may be the same as the serial number of the associated impedance or impedance unbalance curve as listed in Block 1, or some other number depending on local practice.

4.02 In Block 1 "Reason for Test" is to indicate what led to the necessity for the impedance or impedance unbalance run and analysis such as trouble detected during routine tests, circuit order tests, cable completion tests, or during the normal operation of a circuit. The space "f_c" is for recording the nominal cutoff frequency of the circuit under test, in those cases where values of B are determined in terms of f/f_c. The other items are self-explanatory.

4.03 Block 8 provides space for recording the trouble found and error of location, following the actual determination or removal of the trouble. Under "Remarks" of this block may be entered any pertinent data not provided for by the form.

4.04 The "Special Block" is for an analysis of the B-T curve to locate a second irregularity. This Block is not used under the procedure of this Section.

5. ILLUSTRATIVE EXAMPLES

Impedance Irregularities

5.01 Three examples of the procedure for locating impedance irregularities are attached. Each example sheet contains at the top the resistance component of the impedance curve; and at the bottom the accompanying analysis form.

5.02 Example 1 is of an impedance run made to a short circuit for determining K for an H-172-63 side circuit. This example is given first since the value of K must be known for use with Examples 2 and 3. The steps taken in recording the peak frequencies, and in deriving values of B, d x B, and T need no explanation. The slope of the B-T curve is +.5, which added to d(= 23.55) gives 24.05 as the value of (d + slope). The actual distance is a 2300-foot sending end section (.38), plus 24 full loading sections, plus .5 terminating end section (actually 1975 feet or .33 section) or .38 + 24 + .5 = 24.88 sections. K is the actual distance divided by (d + slope), or 24.88/24.05 = 1.035. The B-T curve, it will be noted, points to 0 on the T scale, indicating deficient resistance.

5.03 Example 2 is of a single irregularity in an H-172-63 19-gauge side circuit. As the slope of the bisecting line of the B-T curve in this case is zero, the only correction necessary is for K, giving a location 14.95 sections away. The B-T curve suggests a T_0 value of -.25, indicating either deficient inductance or excess capacitance. The circuit begins in a .38 sending-end section so that an inductance deviation in the 16th coil would locate 15.38 sections away, and a capacitance deviation in the 15th full loading section (between 15th and 16th coils) would locate 14.88 sections away. The computed location 14.95 is nearer to 14.88 than to 15.38, indicating a capacitance deviation. The location is "long" and the T_0 value equals -.25, both indicating excessive capacitance. The natural conclusion is therefore that the irregularity is due to excess capacitance in the 15th full loading section. The trouble actually was .035 excess mf. in the 15th section.

5.04 Example 3 is for the same circuit condition as for Example 2, but with a second irregularity inserted at another point. This second irregularity distorts the resistance component curve of the impedance run, causes humps to appear in the B-T curve, but as noted from the analysis, does not prevent determining either the location or the nature of the larger irregularity.

Impedance Unbalances

5.05 Example 4 shows an impedance unbalance run made on an H-172-63 facility with a resistance unbalance introduced at a known location, the run being made for determining K. The value of K obtained in the analysis is used in Example 5. It will be noted that an analysis is made of both the peak and valley frequencies. In view of the large number of peaks and valleys it was necessary to employ two forms for analyzing the data. The average of the (d + slope) peak value and the (d + slope) valley value is 33.09. The actual distance is a .33 sending end section plus 33 full loading sections plus a .39 terminating end section or .33 + 33 + .39 = 33.72. Then

$$K = \frac{33.72}{33.09} = 1.019.$$

5.06 The attached illustration, Example 5, shows in detail the application of the method of accurately locating resistance unbalances. It will be noted that the value of K obtained in Example 4 has been used in this example.

ATTACHMENTS

TABLE 3

Relation between Current Ratio and DB

Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	∞	-40.00	-33.98	-30.46	-27.96	-26.02	-24.44	-23.10	-21.94	-20.92
.1	-20.00	-19.17	-18.42	-17.72	-17.08	-16.48	-15.92	-15.39	-14.89	-14.43
.2	-13.98	-13.56	-13.15	-12.77	-12.40	-12.04	-11.70	-11.37	-11.06	-10.75
.3	-10.46	-10.17	- 9.90	- 9.63	- 9.37	- 9.12	- 8.87	- 8.64	- 8.40	- 8.18
.4	- 7.96	- 7.74	- 7.54	- 7.33	- 7.13	- 6.94	- 6.74	- 6.56	- 6.38	- 6.20
.5	- 6.02	- 5.85	- 5.68	- 5.51	- 5.35	- 5.19	- 5.04	- 4.88	- 4.73	- 4.58
.6	- 4.44	- 4.29	- 4.15	- 4.01	- 3.88	- 3.74	- 3.61	- 3.48	- 3.35	- 3.22
.7	- 3.10	- 2.97	- 2.85	- 2.73	- 2.62	- 2.50	- 2.38	- 2.27	- 2.16	- 2.05
.8	- 1.94	- 1.83	- 1.72	- 1.62	- 1.51	- 1.41	- 1.31	- 1.21	- 1.11	- 1.01
.9	- .92	- .82	- .72	- .63	- .54	- .45	- .35	- .26	- .18	- .09
1.0	0.00	.09	.17	.26	.34	.42	.51	.59	.67	.75
1.1	.83	.91	.98	1.06	1.14	1.21	1.29	1.36	1.44	1.51
1.2	1.58	1.66	1.73	1.80	1.87	1.94	2.01	2.08	2.14	2.21
1.3	2.28	2.35	2.41	2.48	2.54	2.61	2.67	2.73	2.80	2.86
1.4	2.92	2.98	3.05	3.11	3.17	3.23	3.29	3.35	3.41	3.46
1.5	3.52	3.58	3.64	3.69	3.75	3.81	3.86	3.92	3.97	4.03
1.6	4.08	4.14	4.19	4.24	4.30	4.35	4.40	4.45	4.51	4.56
1.7	4.61	4.66	4.71	4.76	4.81	4.86	4.91	4.96	5.01	5.06
1.8	5.11	5.15	5.20	5.25	5.30	5.34	5.39	5.44	5.48	5.53
1.9	5.58	5.62	5.67	5.71	5.76	5.80	5.85	5.89	5.93	5.98
2.0	6.02	6.06	6.11	6.15	6.19	6.24	6.28	6.32	6.36	6.40
2.1	6.44	6.49	6.53	6.57	6.61	6.65	6.69	6.73	6.77	6.81
2.2	6.85	6.89	6.93	6.97	7.01	7.04	7.08	7.12	7.16	7.20
2.3	7.23	7.27	7.31	7.35	7.38	7.42	7.46	7.50	7.53	7.57
2.4	7.60	7.64	7.68	7.71	7.75	7.78	7.82	7.85	7.89	7.92
2.5	7.96	7.99	8.03	8.06	8.10	8.13	8.16	8.20	8.23	8.27
2.6	8.30	8.33	8.37	8.40	8.43	8.47	8.50	8.53	8.56	8.60
2.7	8.63	8.66	8.69	8.72	8.76	8.79	8.82	8.85	8.88	8.91
2.8	8.94	8.97	9.01	9.04	9.07	9.10	9.13	9.16	9.19	9.22
2.9	9.25	9.28	9.31	9.34	9.37	9.40	9.43	9.46	9.48	9.51

Ratio	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3	9.54	9.83	10.10	10.37	10.63	10.88	11.13	11.36	11.60	11.82
4	12.04	12.26	12.47	12.67	12.87	13.06	13.26	13.44	13.62	13.80
5	13.98	14.15	14.32	14.49	14.65	14.81	14.96	15.12	15.27	15.42
6	15.56	15.71	15.85	15.99	16.12	16.26	16.39	16.52	16.65	16.78
7	16.90	17.03	17.15	17.27	17.38	17.50	17.62	17.73	17.84	17.95
8	18.06	18.17	18.28	18.38	18.49	18.59	18.69	18.79	18.89	18.99
9	19.08	19.18	19.28	19.37	19.46	19.55	19.65	19.74	19.32	19.91
10	20.00	20.09	20.17	20.26	20.34	20.42	20.51	20.59	20.67	20.75
11	20.83	20.91	20.98	21.06	21.14	21.21	21.29	21.36	21.44	21.51
12	21.58	21.66	21.73	21.80	21.87	21.94	22.01	22.08	22.14	22.21
13	22.28	22.35	22.41	22.48	22.54	22.61	22.67	22.73	22.80	22.86
14	22.92	22.98	23.05	23.11	23.17	23.23	23.29	23.35	23.41	23.46
15	23.52	23.58	23.64	23.69	23.75	23.81	23.86	23.92	23.97	24.03

NOTE: To extend Table multiply ratio by 10 and add 20 to corresponding DB value, or divide ratio by 10 and subtract 20.

FORM E-128.
(11-30)

ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

ANALYSIS SERIAL NO.

BLOCK 1

CABLE ____________ PAIR ______

CIRCUIT TYPE ____________ f_c ______

TESTED FROM ____________ TO ______

DATE ______ REASON FOR TEST ______

CURVE SHEET SERIAL NO. ______

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_c}$	B	d × B	T
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
B_N (FOR LAST PEAK OR VALLEY)=		
B_1 (FOR FIRST PEAK OR VALLEY)=		
$B_N - B_1$ =		
d (LOAD SECTIONS)= $\frac{N-1}{B_N - B_1}$ =		

SLOPE CORRECTION P= V=

(d+SLOPE) P= V= AVE.=

BLOCK 4

K= (d+SLOPE)×K=

BLOCK 5— IMPEDANCE UNBALANCE ONLY

REPTR. CORRECTION (R.C.)= K(d+SLOPE) —R.C.=

$\frac{F_H}{F_L}$ = ______ = EQUIVALENT TO db

[K(d+SLOPE) —R.C.] x DEVIATION = x = ______ db

H= TOTAL db = db

DISTANCE FROM LOAD POINT TO FAULT = FT.

FINAL LOCATION OF FAULT = LOAD SECT.

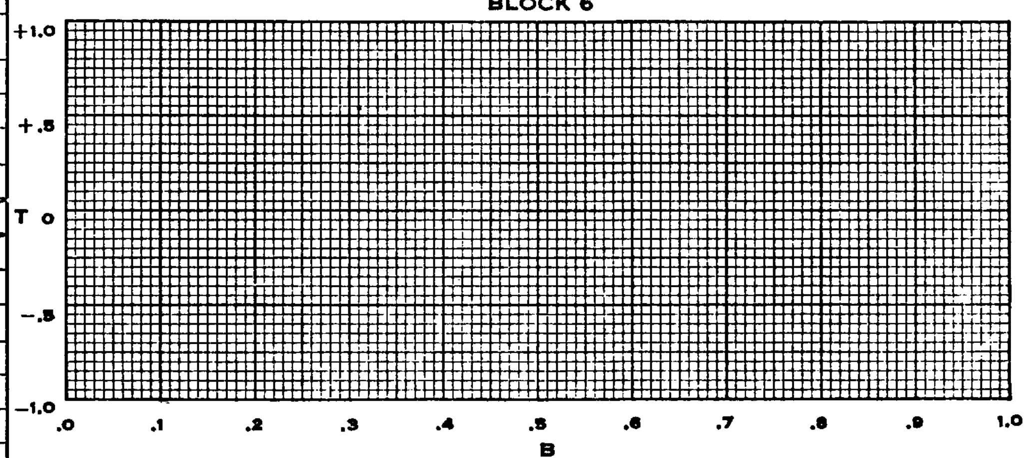
IMPEDANCE IRREGULARITIES

T_o	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	—C	SHORT
—.25	—L	SHORT
—.25	+C	LONG
±.50	+R	
0	—R	

IMPEDANCE UNBALANCES

T_o	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

VALUES OF B AT WHICH CORRESPONDING VALUES OF T OCCUR	1	2	3	4

AVERAGE VALUE OF B BETWEEN CORRESPONDING VALUES OF T =

APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{\quad}{\text{AVE. B}}$ =

BLOCK 7 - DIAGNOSIS

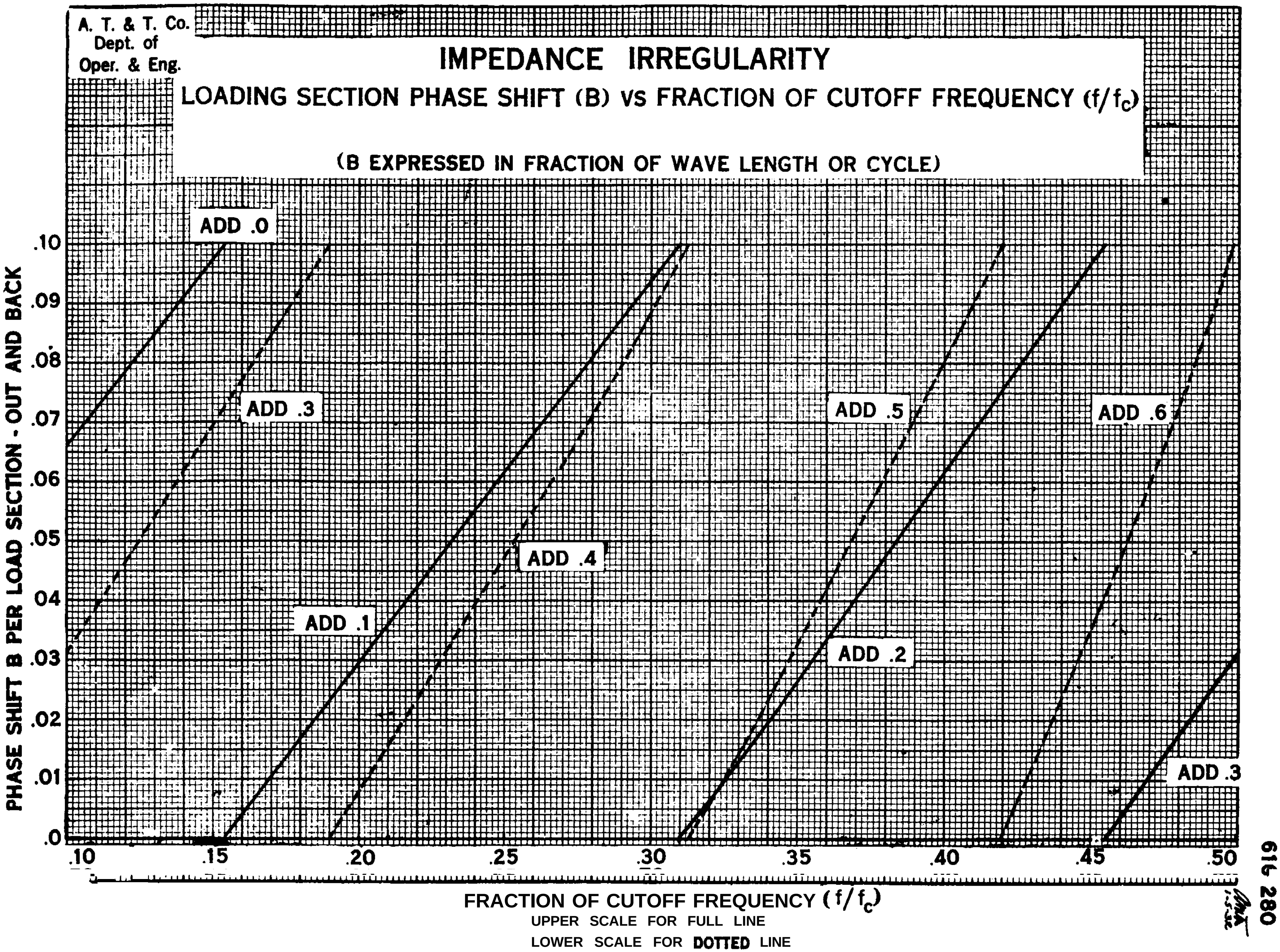
T_o = SENDING END SECTION LENGTH =

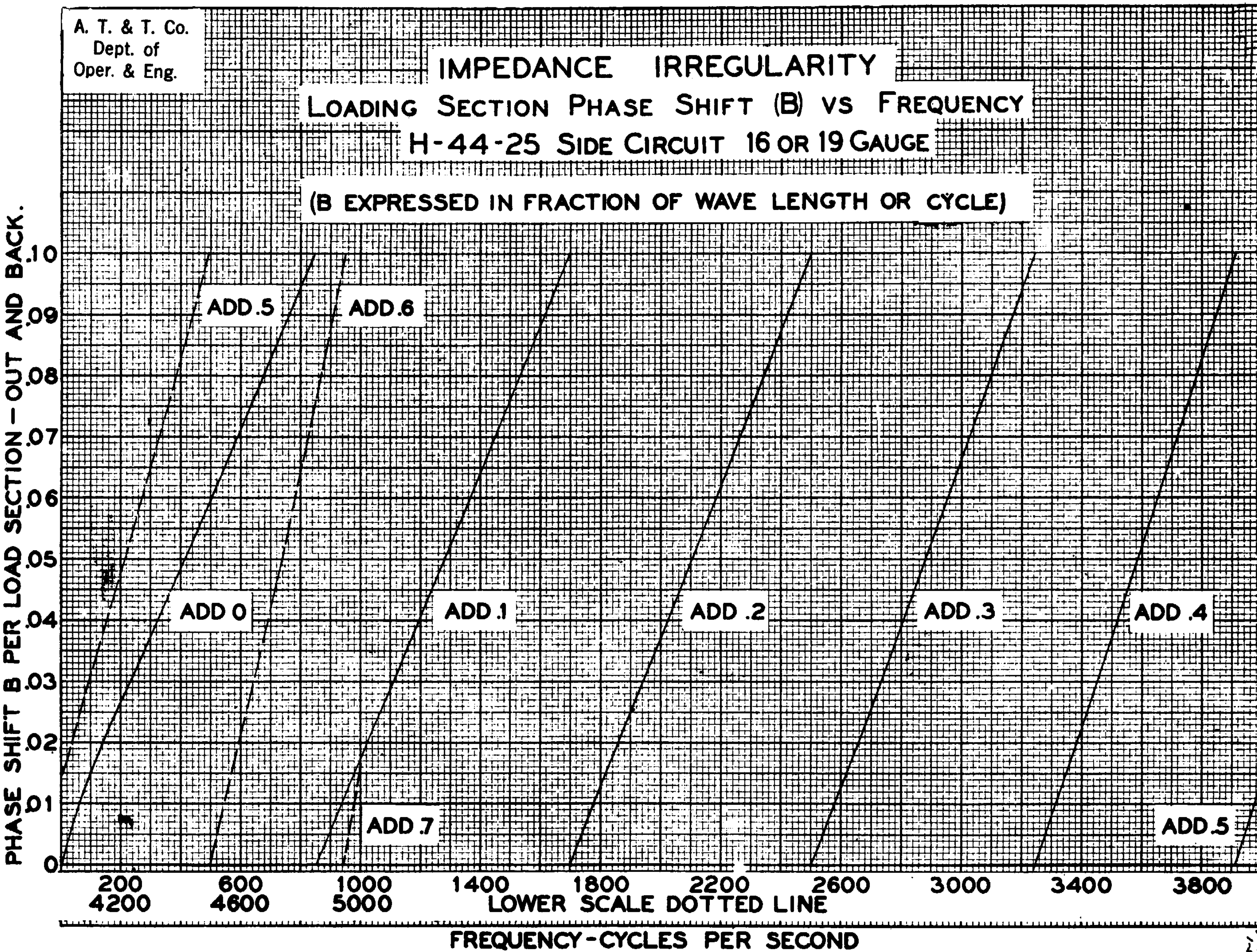
BLOCK 8

TROUBLE FOUND ____________ ERROR IN LOCATION ______

REMARKS:

ANALYZED BY:


A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FRACTION OF CUTOFF FREQUENCY (f/f_c)
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
ADD .0
ADD .3
ADD .5
ADD .6
ADD .4
ADD .1
ADD .2
ADD .3
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
.0
PHASE SHIFT B PER LOAD SECTION - OUT AND BACK
.10
.15
.20
.25
.30
.35
.40
.45
.50
FRACTION OF CUTOFF FREQUENCY (f/f_c)
UPPER SCALE FOR FULL LINE
LOWER SCALE FOR DOTTED LINE
616 280



A. T. & T. Co.
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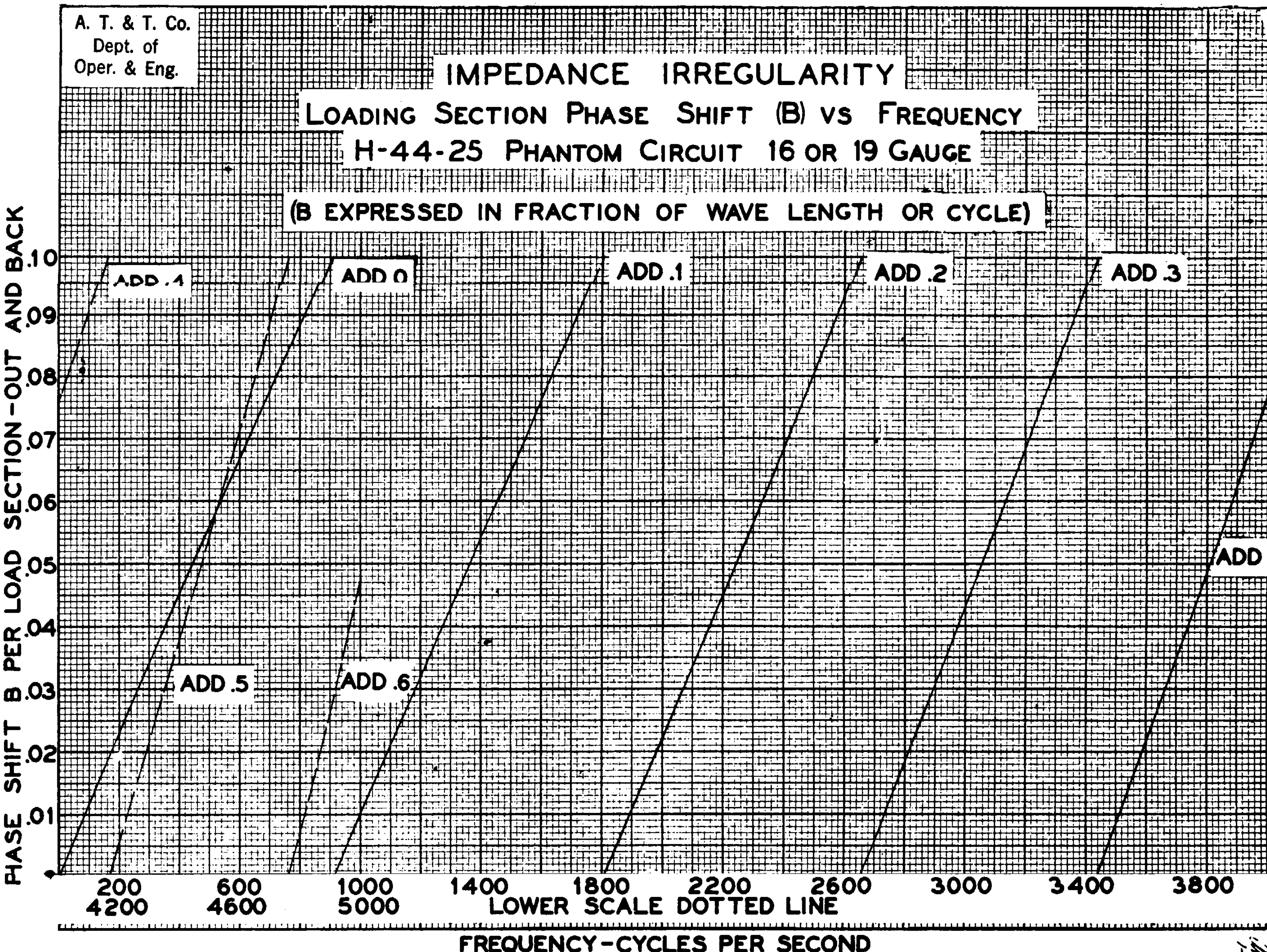
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-44-25 SIDE CIRCUIT 16 OR 19 GAUGE
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
PHASE SHIFT B PER LOAD SECTION - OUT AND BACK.
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
ADD .5
ADD .6
ADD 0
ADD .1
ADD .2
ADD .3
ADD .4
ADD .7
ADD .5
200
600
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
LOWER SCALE DOTTED LINE
FREQUENCY - CYCLES PER SECOND

616 - 281



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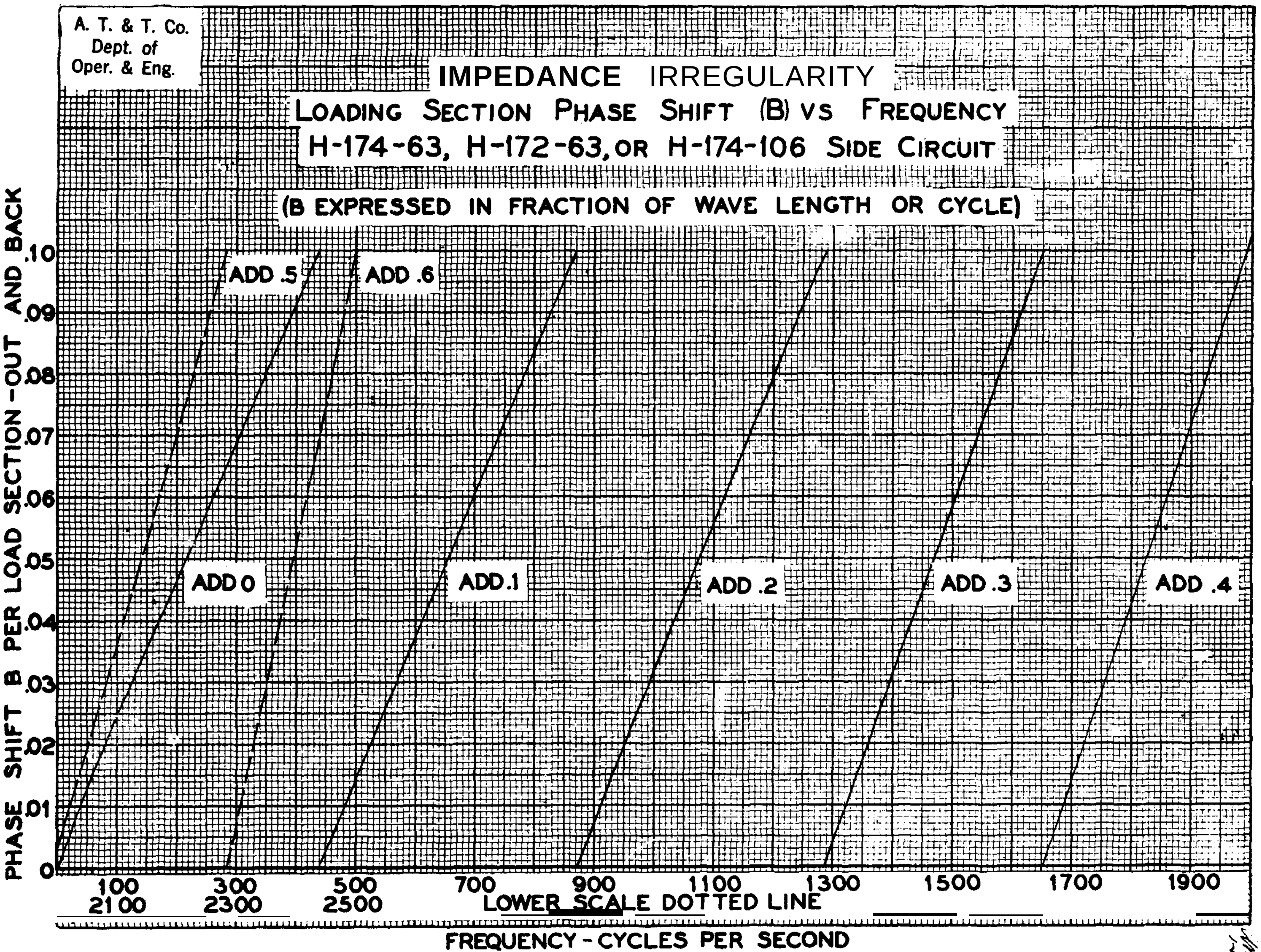
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-44-25 PHANTOM CIRCUIT 16 OR 19 GAUGE
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
PHASE SHIFT B PER LOAD SECTION-OUT AND BACK
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
ADD .4
ADD 0
ADD .1
ADD .2
ADD .3
ADD .4
ADD .5
ADD .6
200
600
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
LOWER SCALE DOTTED LINE
FREQUENCY-CYCLES PER SECOND

104

616 - 282



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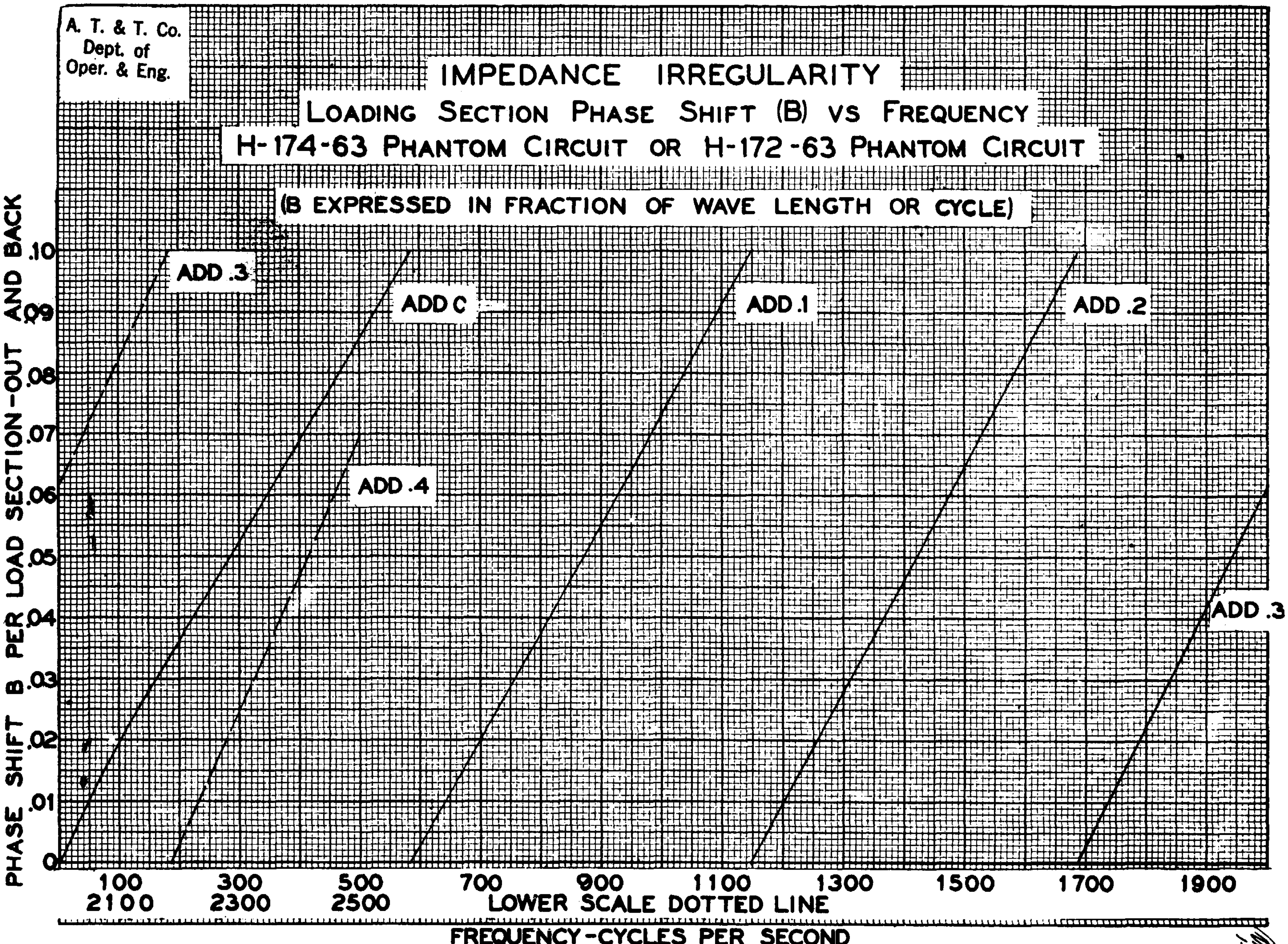
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-174-63, H-172-63, OR H-174-106 SIDE CIRCUIT
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
PHASE SHIFT B PER LOAD SECTION - OUT AND BACK
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
ADD .5
ADD .6
ADD 0
ADD .1
ADD .2
ADD .3
ADD .4
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
LOWER SCALE DOTTED LINE
FREQUENCY - CYCLES PER SECOND

105

616 - 283



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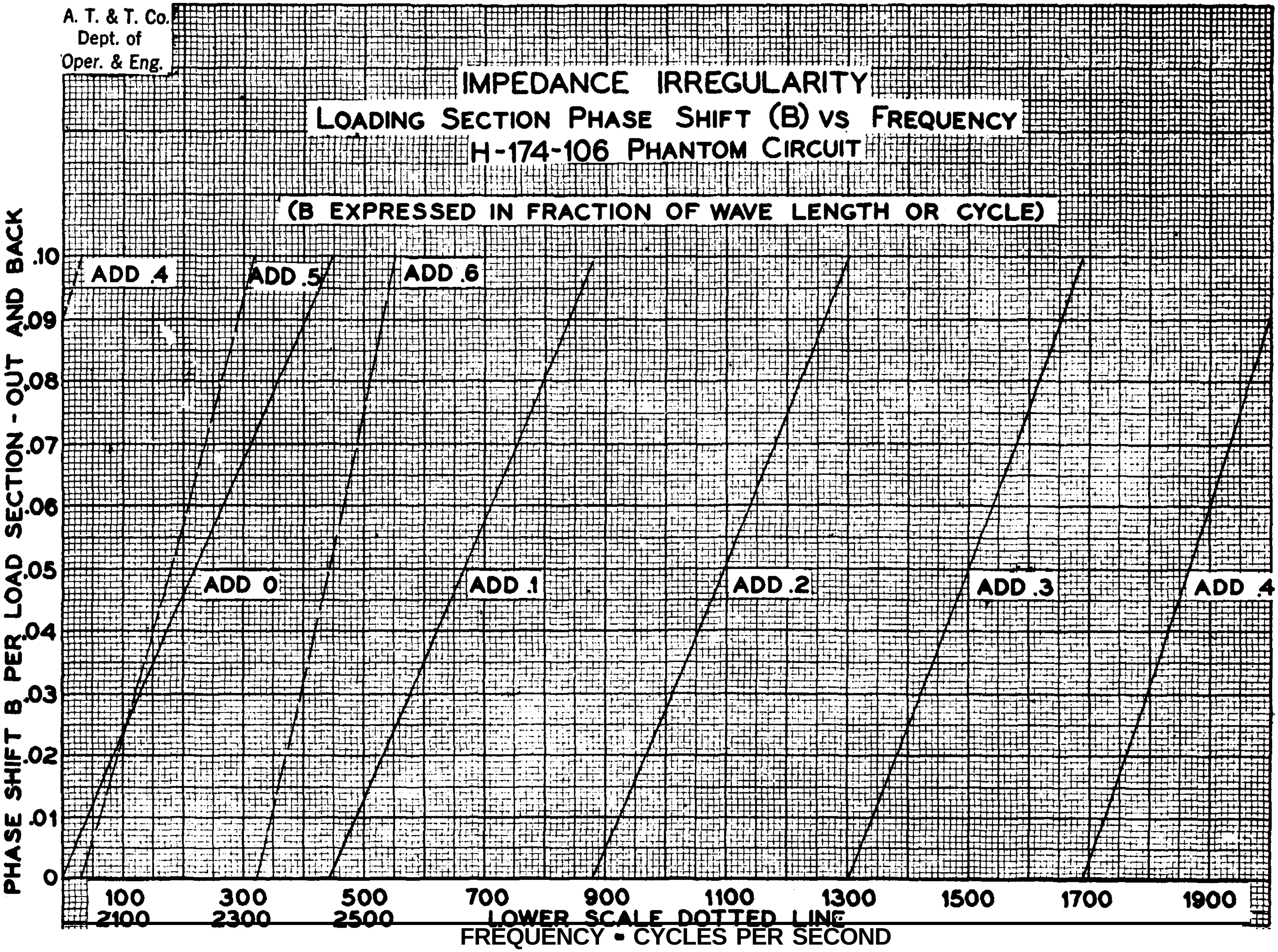
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-174-63 PHANTOM CIRCUIT OR H-172-63 PHANTOM CIRCUIT
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
ADD .3
ADD C
ADD .1
ADD .2
ADD .4
ADD .3
PHASE SHIFT B PER LOAD SECTION-OUT AND BACK
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
LOWER SCALE DOTTED LINE
FREQUENCY-CYCLES PER SECOND

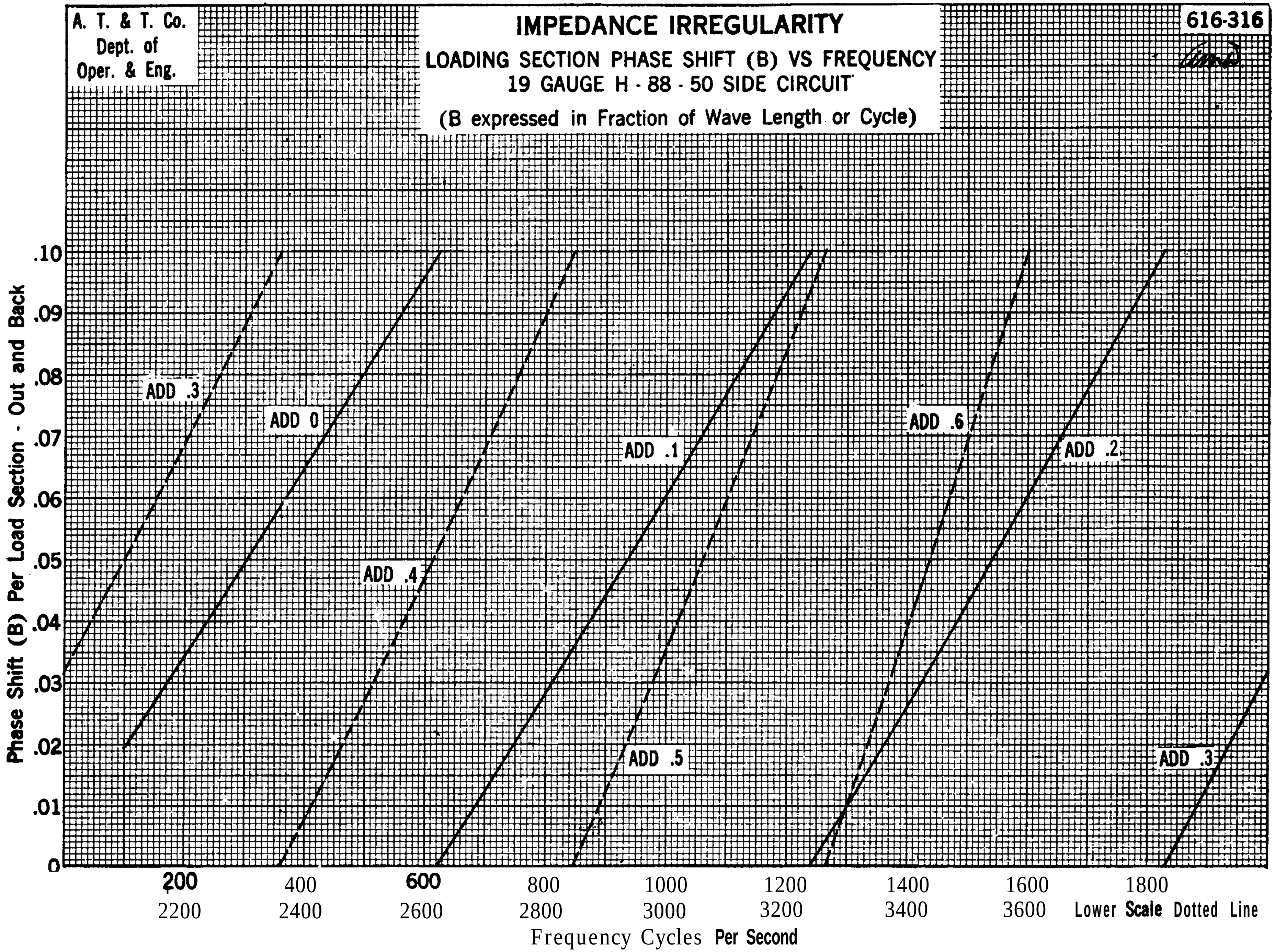
106

616 - 284


A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-174-106 PHANTOM CIRCUIT
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
PHASE SHIFT B PER LOAD SECTION - OUT AND BACK
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
ADD .4
ADD .5
ADD .6
ADD 0
ADD .1
ADD .2
ADD .3
ADD .4
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
LOWER SCALE DOTTED LINE
FREQUENCY - CYCLES PER SECOND

107

616 - 290



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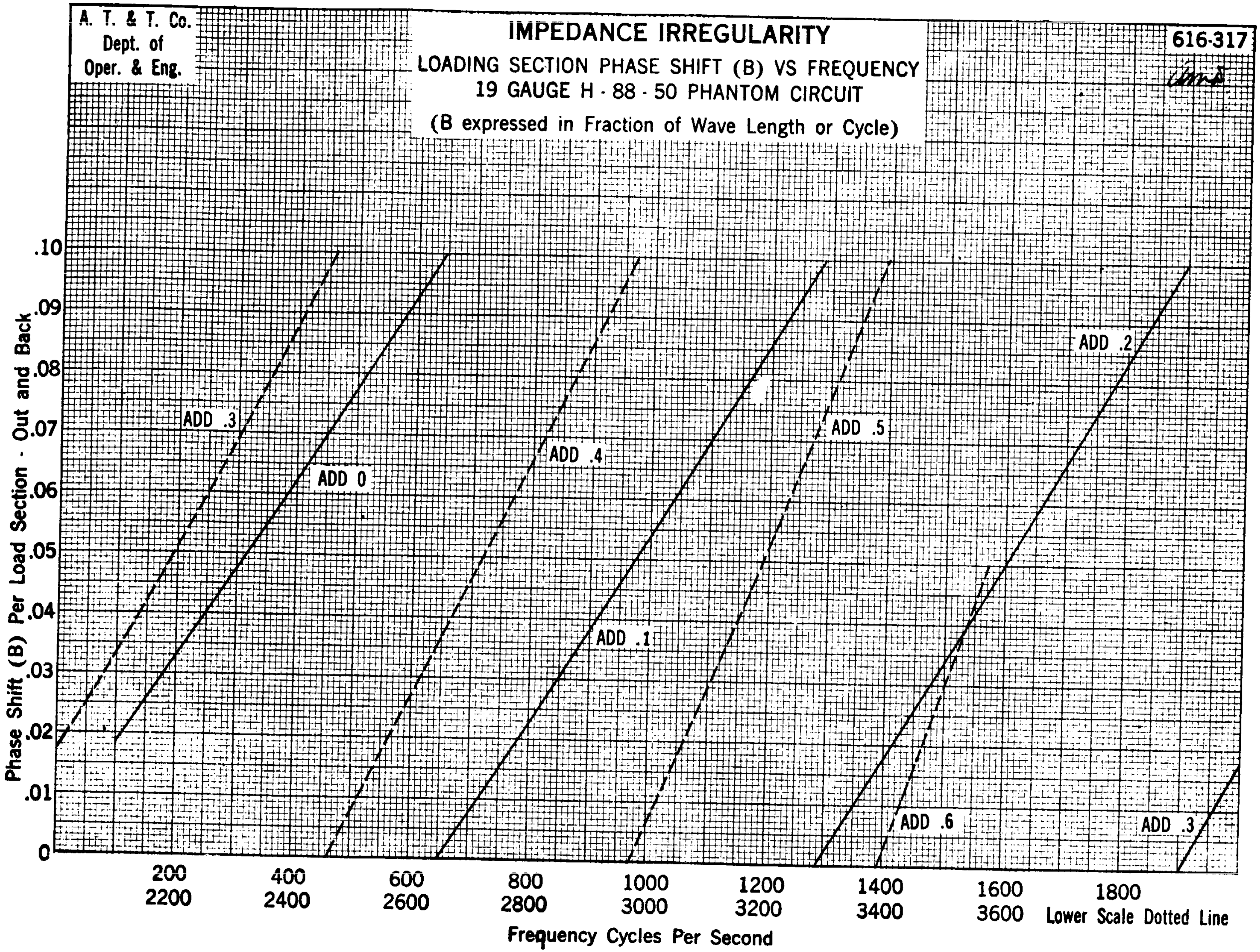
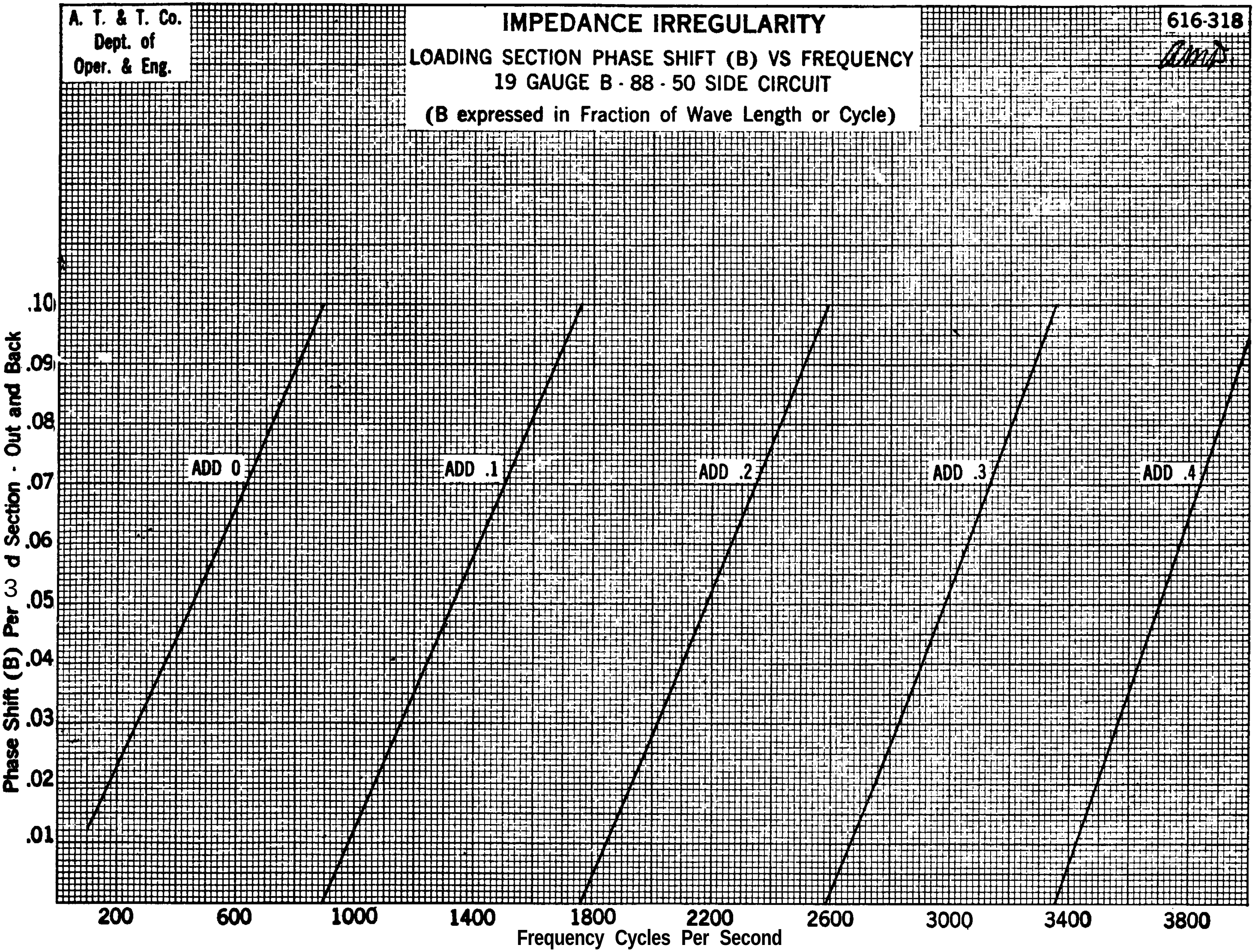
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
19 GAUGE H - 88 - 50 SIDE CIRCUIT
(B expressed in Fraction of Wave Length or Cycle)
616-316
Phase Shift (B) Per Load Section - Out and Back
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
ADD .3
ADD 0
ADD .1
ADD .6
ADD .2
ADD .4
ADD .5
ADD .3
200
400
600
800
1000
1200
1400
1600
1800
2200
2400
2600
2800
3000
3200
3400
3600
Lower Scale Dotted Line
Frequency Cycles Per Second


A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
19 GAUGE H - 88 - 50 PHANTOM CIRCUIT
(B expressed in Fraction of Wave Length or Cycle)
616-317
Phase Shift (B) Per Load Section - Out and Back
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
ADD .3
ADD 0
ADD .4
ADD .1
ADD .5
ADD .2
ADD .6
ADD .3
200
2200
400
2400
600
2600
800
2800
1000
3000
1200
3200
1400
3400
1600
3600
1800
Lower Scale Dotted Line
Frequency Cycles Per Second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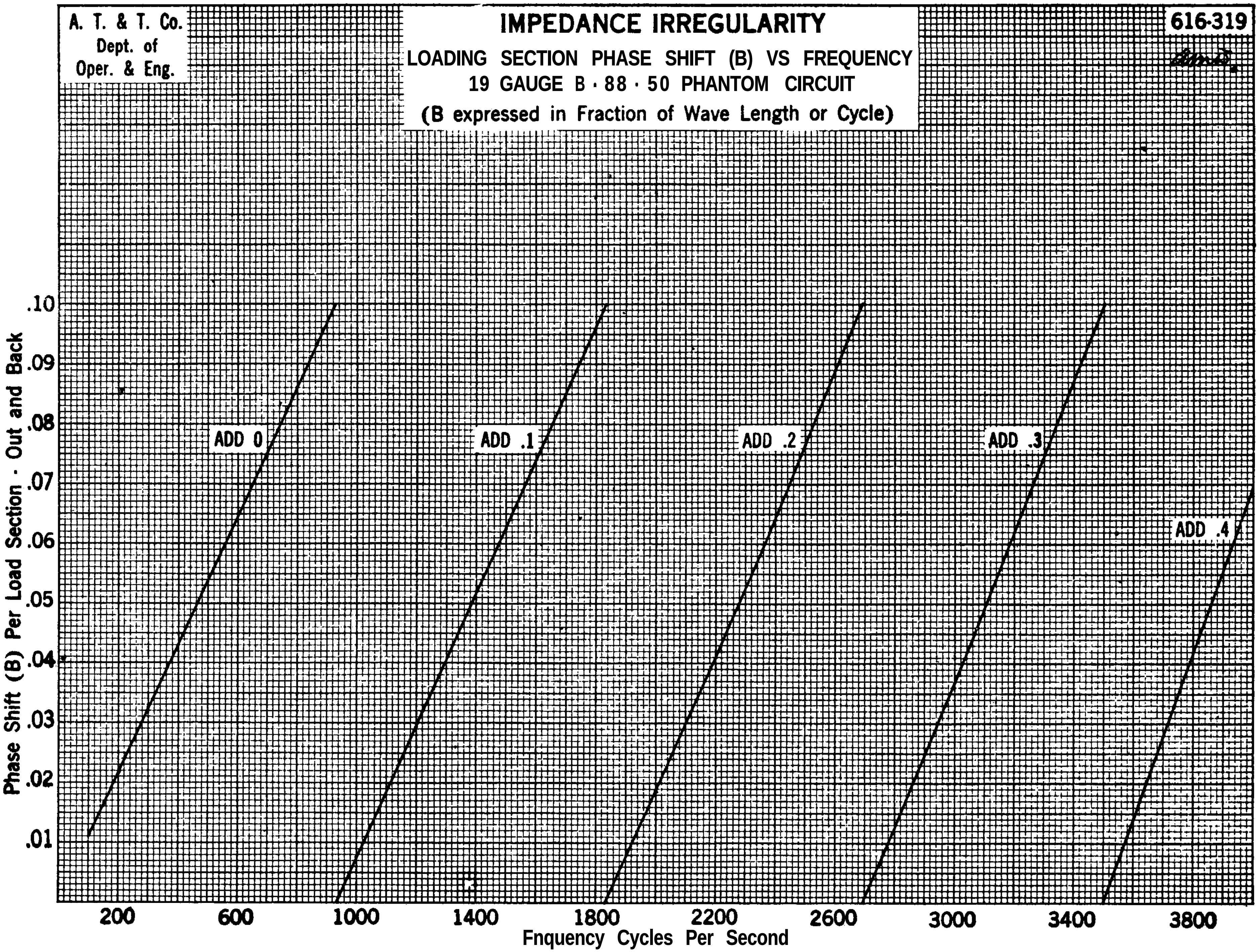
Dept. of
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
19 GAUGE B - 88 - 50 SIDE CIRCUIT
(B expressed in Fraction of Wave Length or Cycle)
616-318
ADD 0
ADD .1
ADD .2
ADD .3
ADD .4
Phase Shift (B) Per 3 d Section - Out and Back
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
200
600
1000
1400
1800
2200
2600
3000
3400
3800
Frequency Cycles Per Second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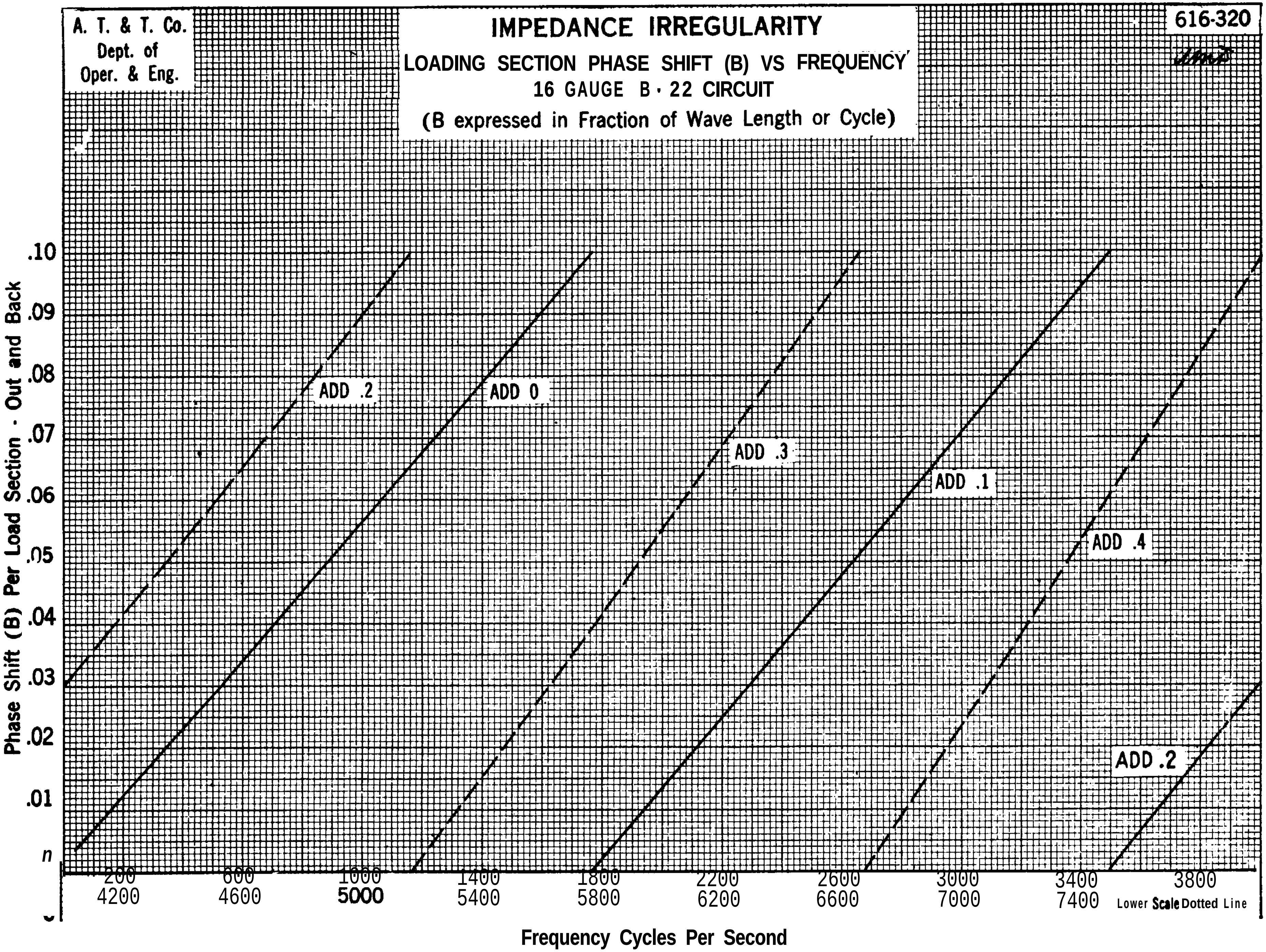
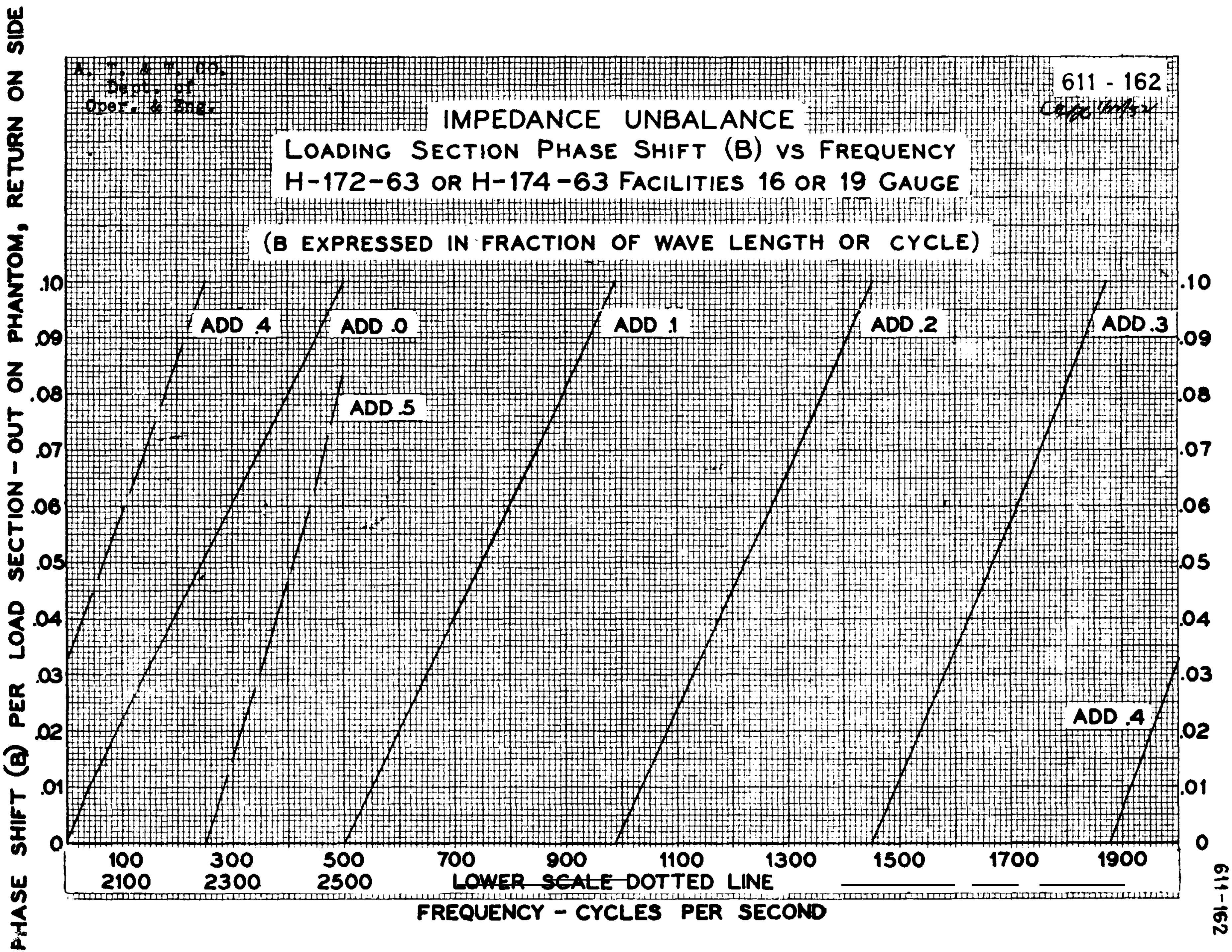
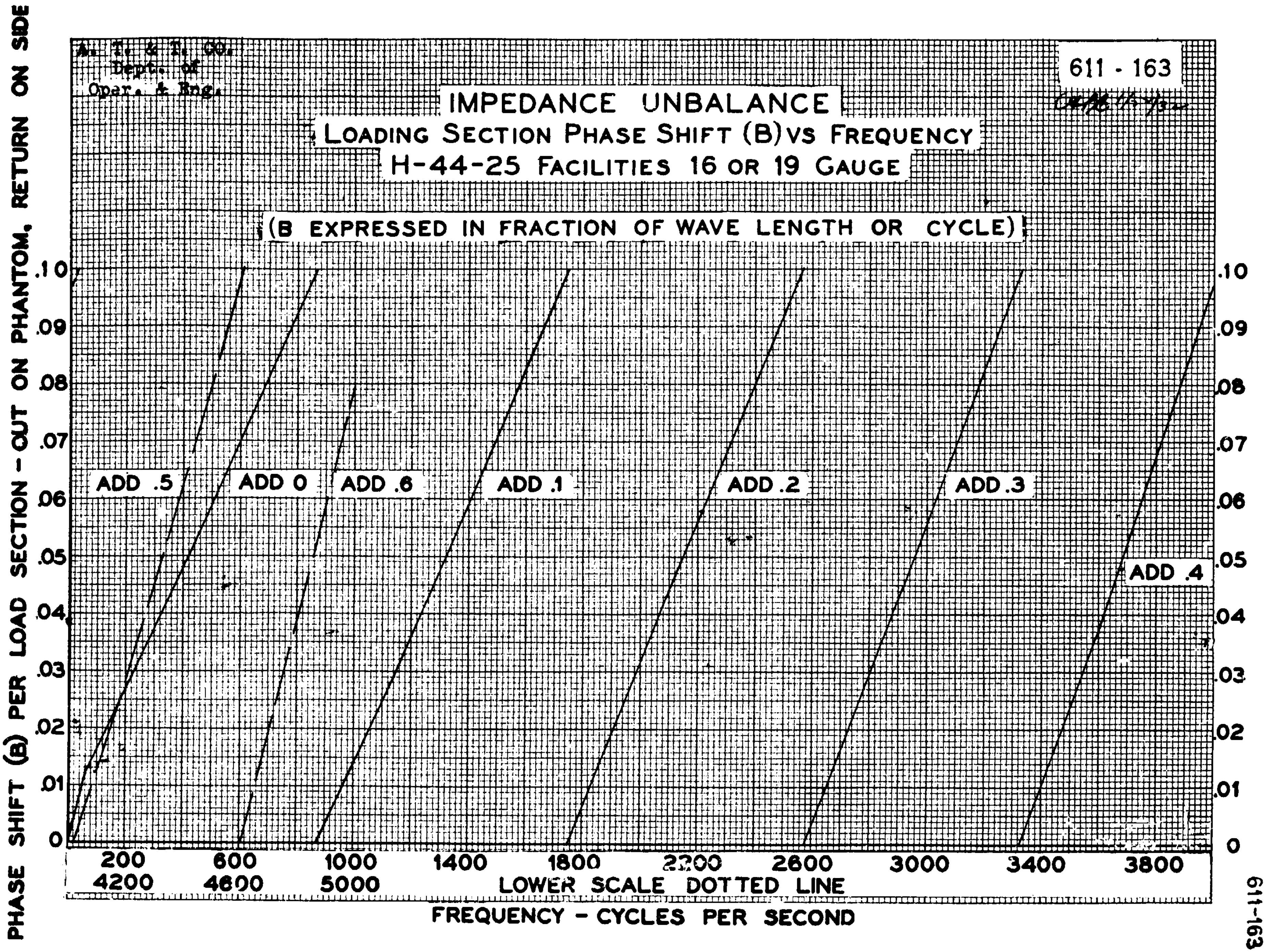
Dept. of
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
19 GAUGE B · 88 · 50 PHANTOM CIRCUIT
(B expressed in Fraction of Wave Length or Cycle)
616-319
ADD 0
ADD .1
ADD .2
ADD .3
ADD .4
Phase Shift (B) Per Load Section · Out and Back
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
200
600
1000
1400
1800
2200
2600
3000
3400
3800
Fnquency Cycles Per Second


A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE IRREGULARITY
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
16 GAUGE B·22 CIRCUIT
(B expressed in Fraction of Wave Length or Cycle)
616-320
Phase Shift (B) Per Load Section - Out and Back
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
ADD .2
ADD 0
ADD .3
ADD .1
ADD .4
ADD .2
200 600 1000 1400 1800 2200 2600 3000 3400 3800
4200 4600 5000 5400 5800 6200 6600 7000 7400
Lower Scale Dotted Line
Frequency Cycles Per Second


A. T. & T. CO.
Dept. of
Oper. & Eng.
611 - 162
IMPEDANCE UNBALANCE
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-172-63 OR H-174-63 FACILITIES 16 OR 19 GAUGE
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
ADD .4
ADD .0
ADD .5
ADD .1
ADD .2
ADD .3
ADD .4
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
100 300 500 700 900 1100 1300 1500 1700 1900
2100 2300 2500
~~LOWER SCALE~~ DOTTED LINE
FREQUENCY - CYCLES PER SECOND
PHASE SHIFT (B) PER LOAD SECTION - OUT ON PHANTOM, RETURN ON SIDE
611-162



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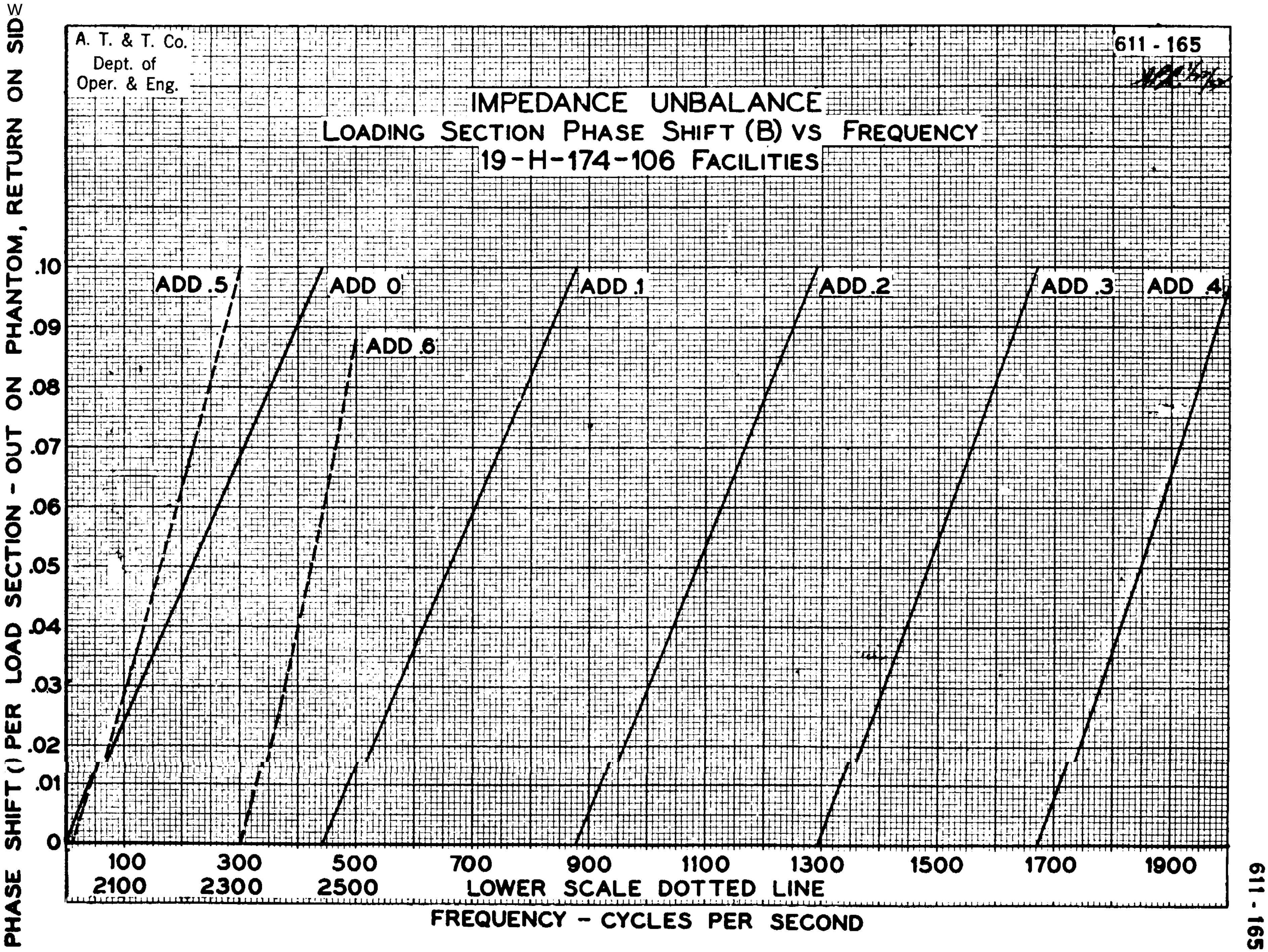
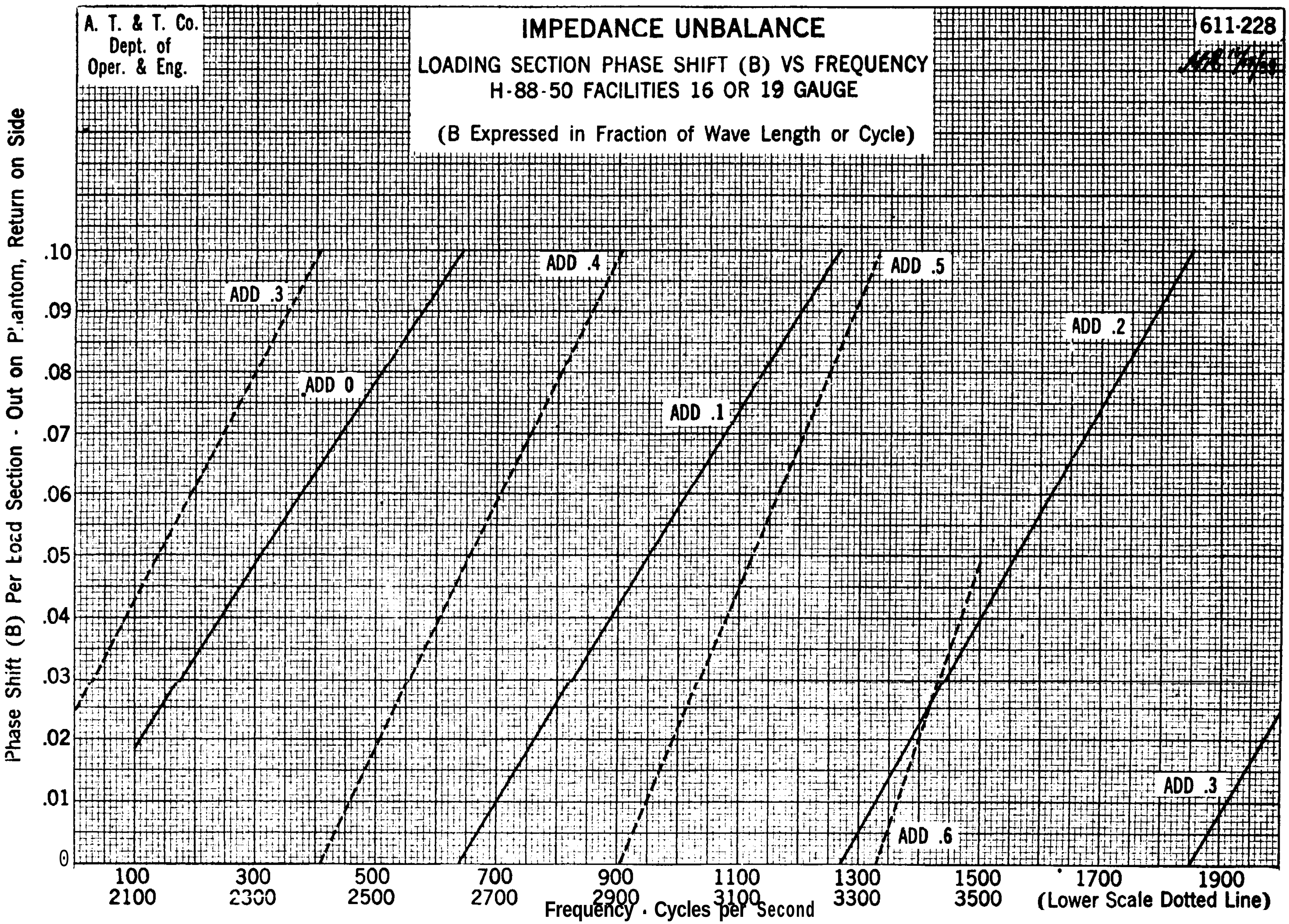
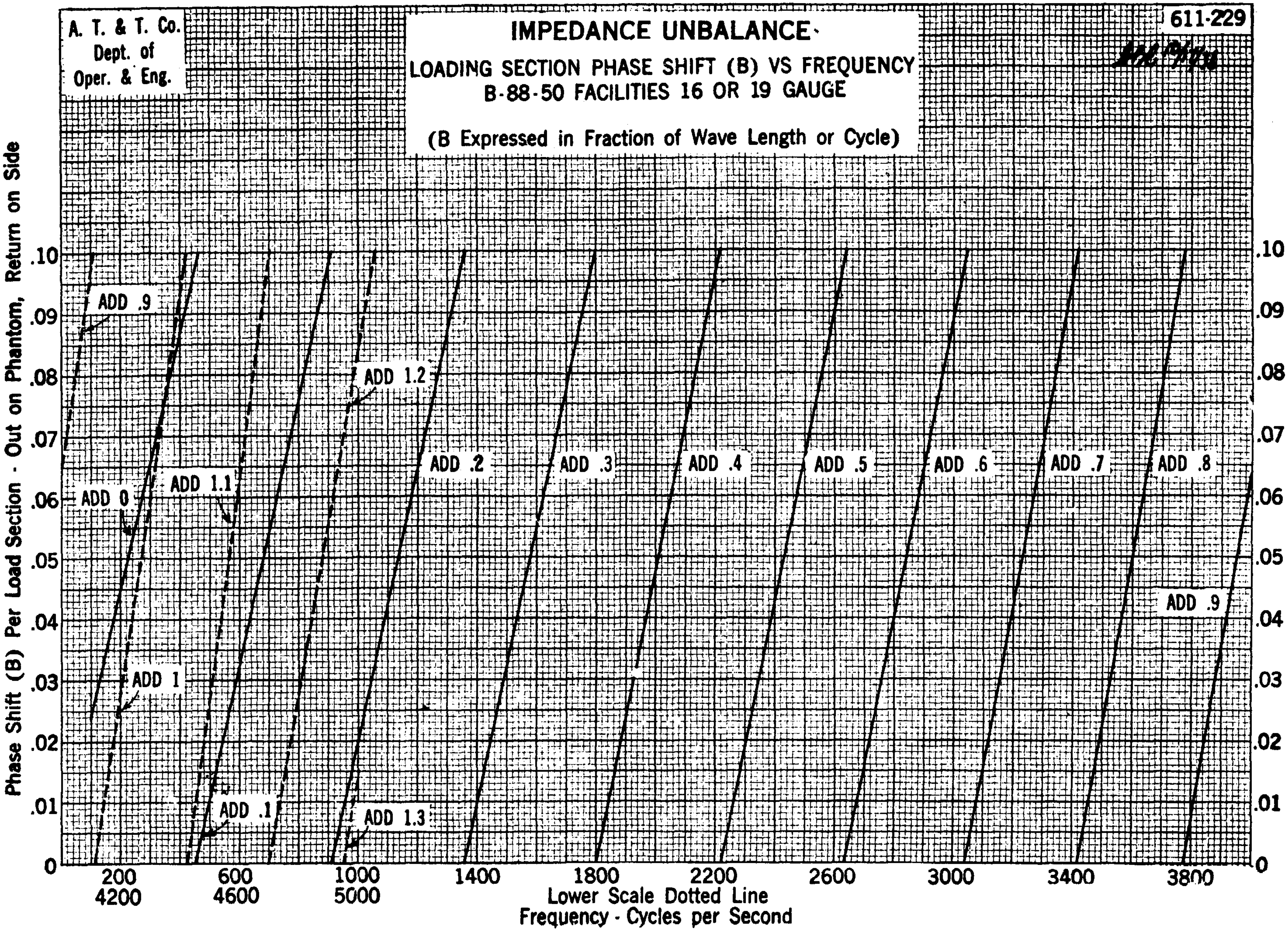
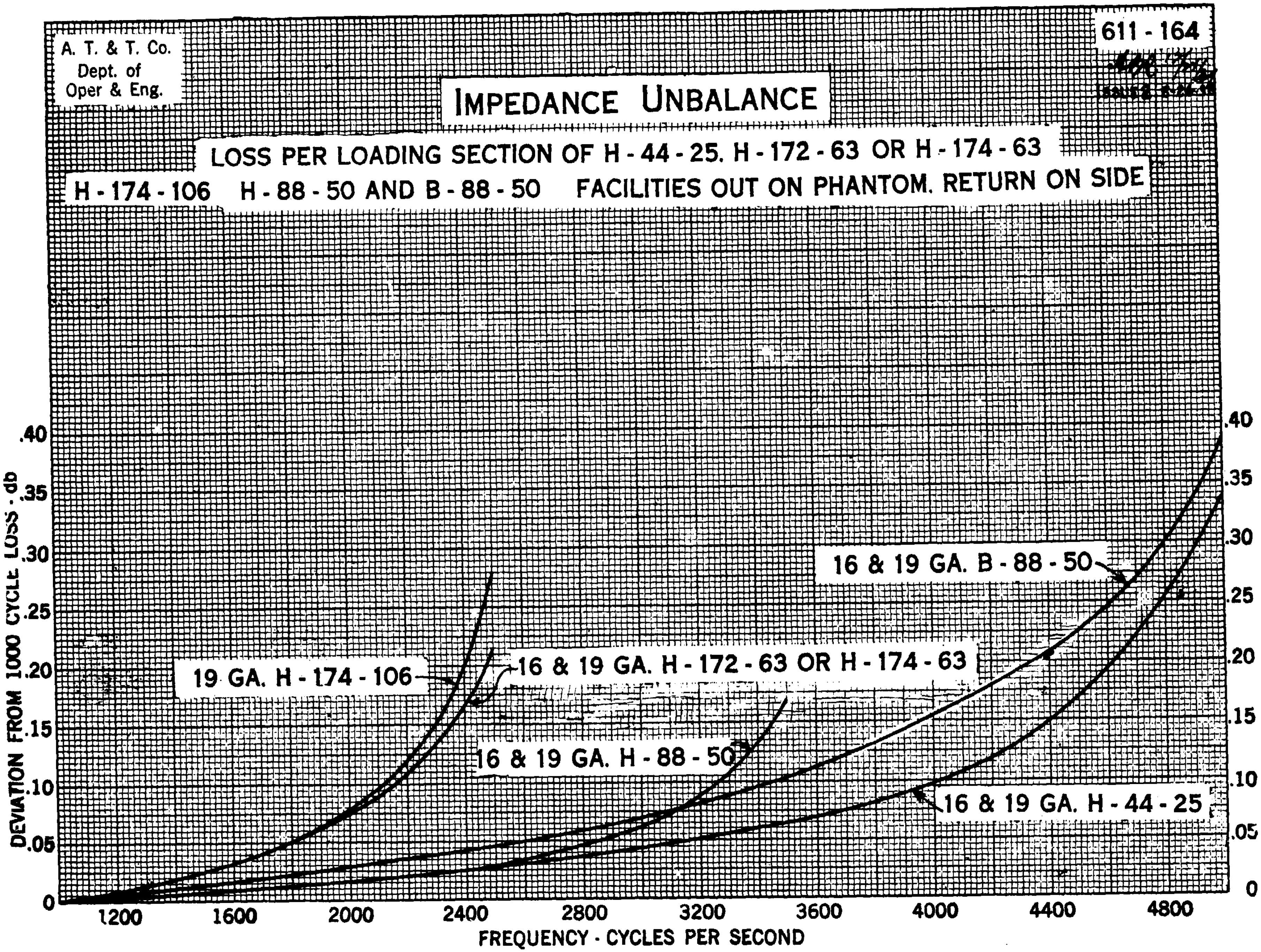
611 - 163
IMPEDANCE UNBALANCE
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-44-25 FACILITIES 16 OR 19 GAUGE
(B EXPRESSED IN FRACTION OF WAVE LENGTH OR CYCLE)
ADD .5
ADD 0
ADD .6
ADD .1
ADD .2
ADD .3
ADD .4
PHASE SHIFT (B) PER LOAD SECTION - OUT ON PHANTOM, RETURN ON SIDE
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
200
600
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
LOWER SCALE DOTTED LINE
FREQUENCY - CYCLES PER SECOND
611-163


A. T. & T. Co.
Dept. of
Oper. & Eng.
611 - 165
IMPEDANCE UNBALANCE
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
19-H-174-106 FACILITIES
ADD .5
ADD 0
ADD .6
ADD .1
ADD .2
ADD .3
ADD .4
PHASE SHIFT (ꞵ) PER LOAD SECTION - OUT ON PHANTOM, RETURN ON SIDE
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
LOWER SCALE DOTTED LINE
FREQUENCY - CYCLES PER SECOND
611 - 165

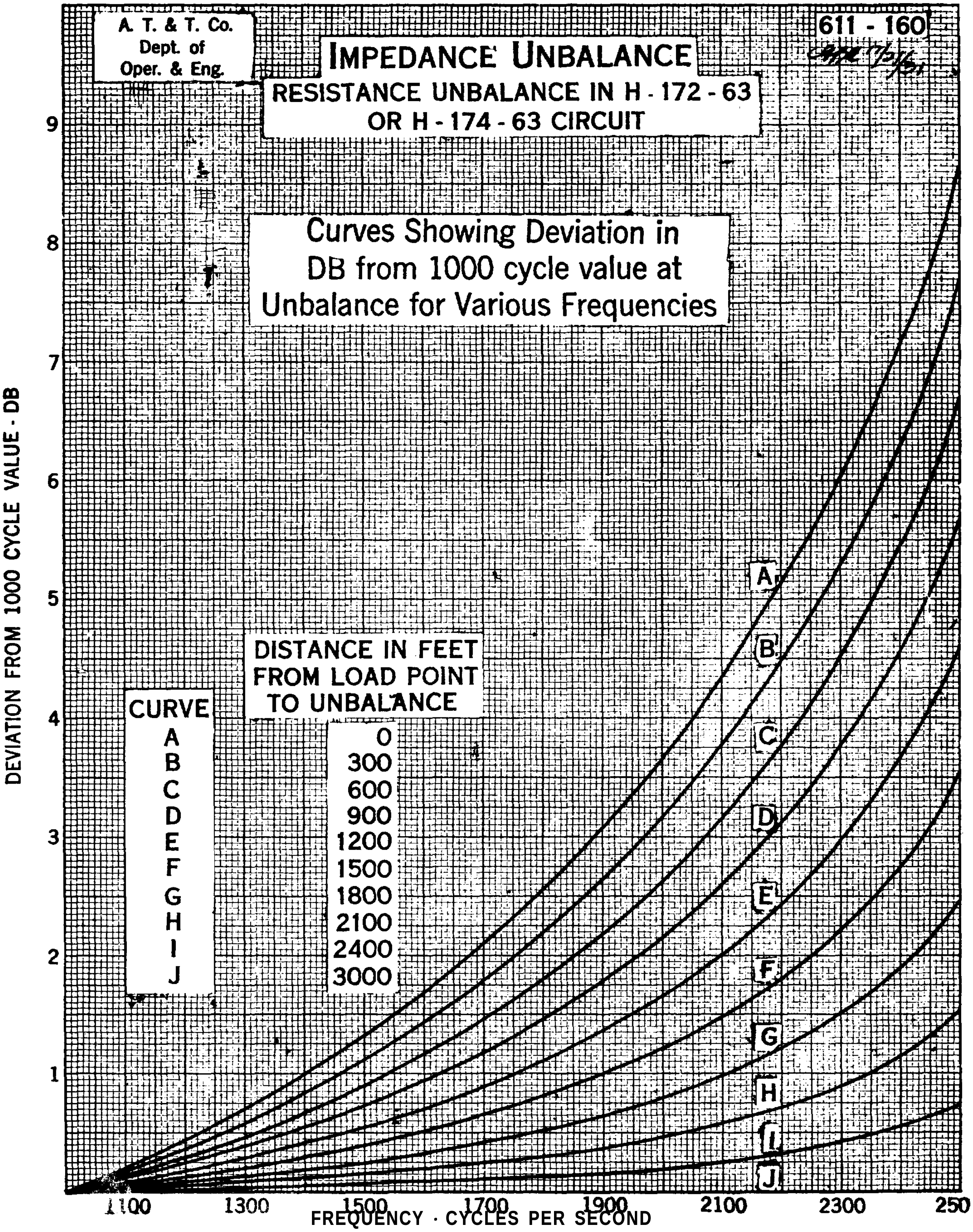


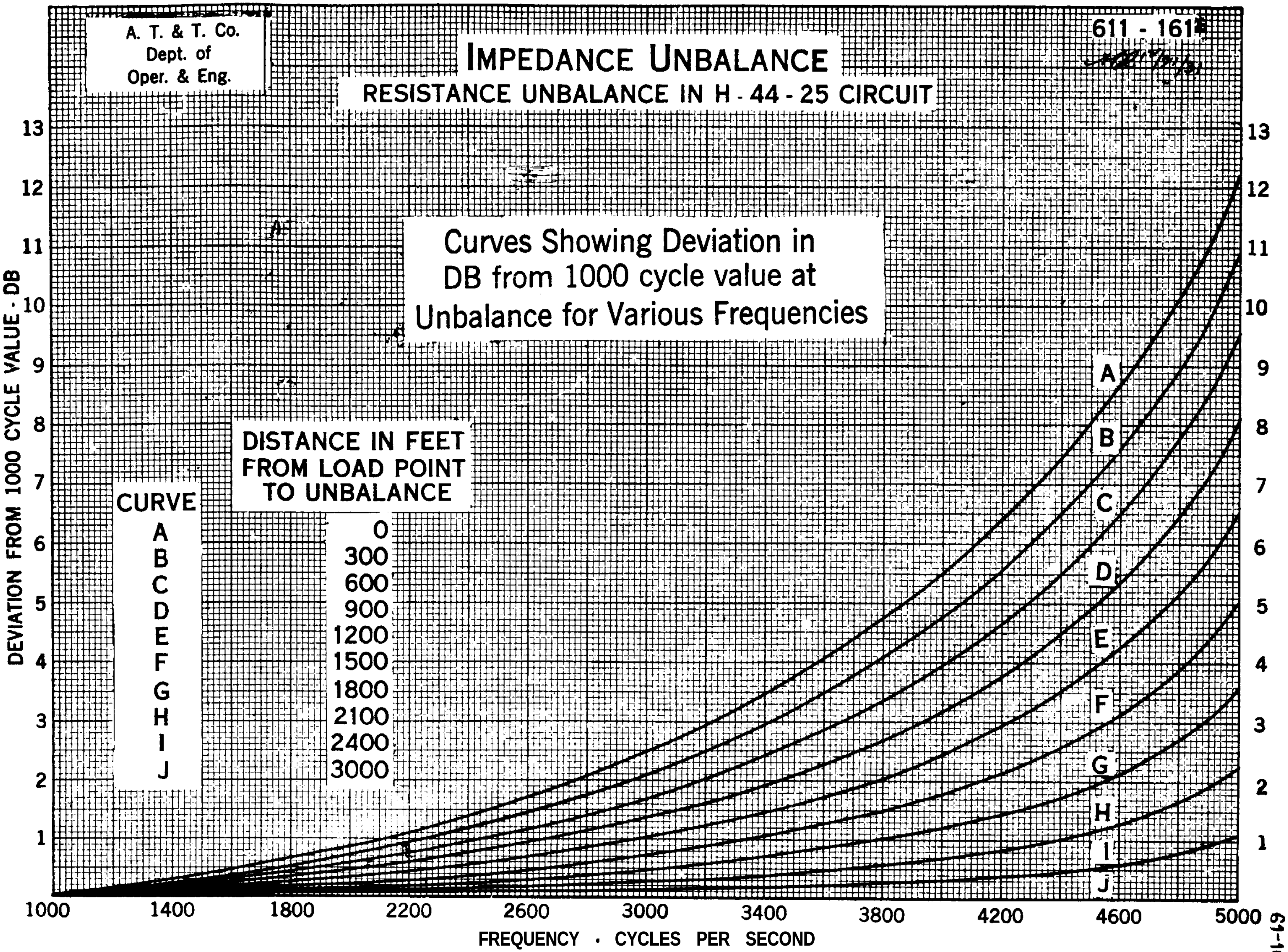
A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE UNBALANCE
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
H-88-50 FACILITIES 16 OR 19 GAUGE
(B Expressed in Fraction of Wave Length or Cycle)
611-228
Phase Shift (B) Per Load Section - Out on Phantom, Return on Side
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
ADD .3
ADD 0
ADD .4
ADD .1
ADD .5
ADD .2
ADD .6
ADD .3
100 300 500 700 900 1100 1300 1500 1700 1900
2100 2300 2500 2700 2900 3100 3300 3500
(Lower Scale Dotted Line)
Frequency - Cycles per Second


A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE UNBALANCE
LOADING SECTION PHASE SHIFT (B) VS FREQUENCY
B-88-50 FACILITIES 16 OR 19 GAUGE
(B Expressed in Fraction of Wave Length or Cycle)
611-229
ADD .9
ADD 1.2
ADD 0
ADD 1.1
ADD .2
ADD .3
ADD .4
ADD .5
ADD .6
ADD .7
ADD .8
ADD .9
ADD 1
ADD .1
ADD 1.3
Phase Shift (B) Per Load Section - Out on Phantom, Return on Side
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.10
200
4200
600
4600
1000
5000
1400
1800
2200
2600
3000
3400
3800
Lower Scale Dotted Line
Frequency - Cycles per Second


A. T. & T. Co.
Dept. of
Oper & Eng.
611 - 164
IMPEDANCE UNBALANCE
LOSS PER LOADING SECTION OF H - 44 - 25. H - 172 - 63 OR H - 174 - 63
H - 174 - 106 H - 88 - 50 AND B - 88 - 50 FACILITIES OUT ON PHANTOM. RETURN ON SIDE
16 & 19 GA. B - 88 - 50
19 GA. H - 174 - 106
16 & 19 GA. H - 172 - 63 OR H - 174 - 63
16 & 19 GA. H - 88 - 50
16 & 19 GA. H - 44 - 25
DEVIATION FROM 1000 CYCLE LOSS - db
0
.05
.10
.15
.20
.25
.30
.35
.40
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
FREQUENCY - CYCLES PER SECOND

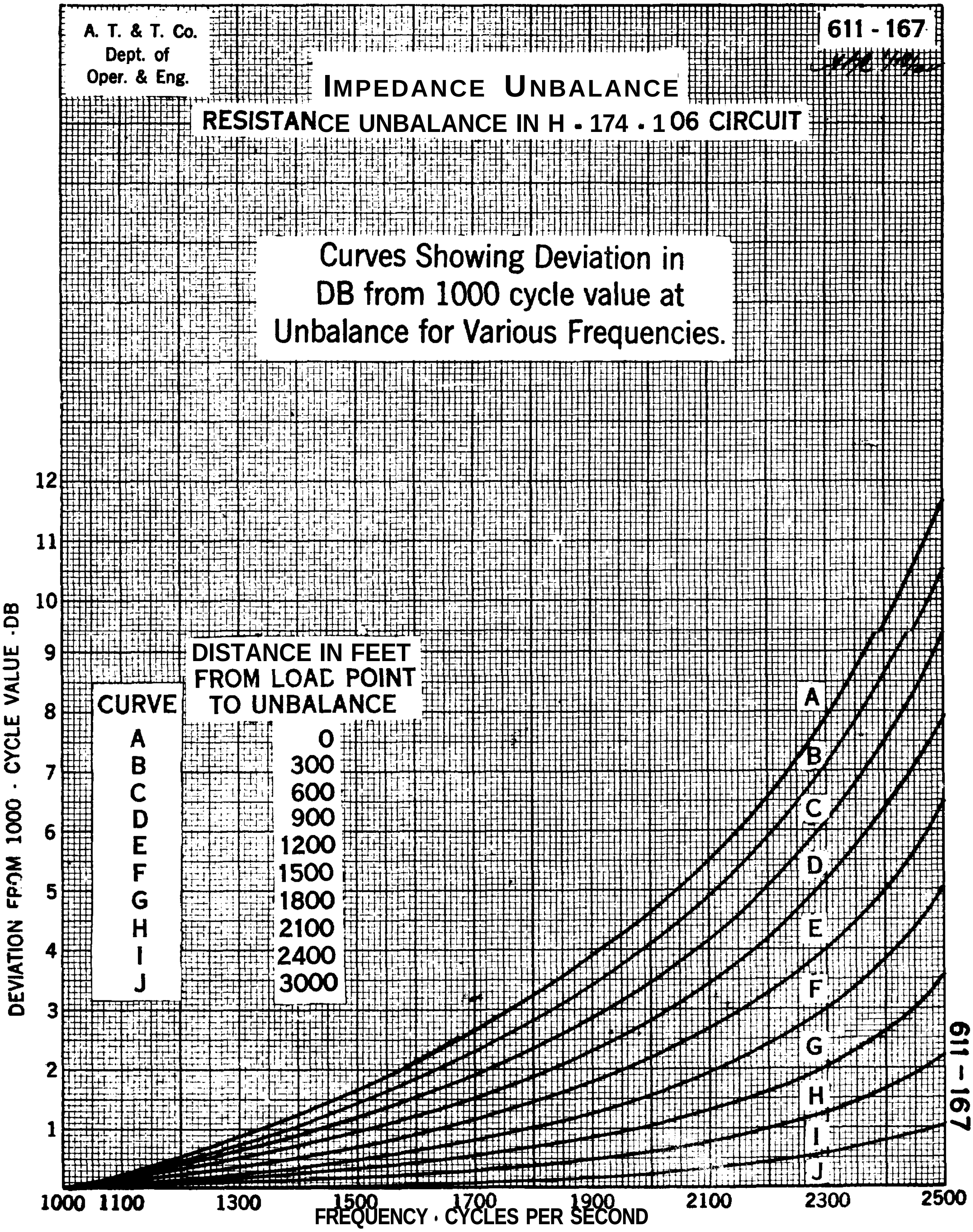
611-164

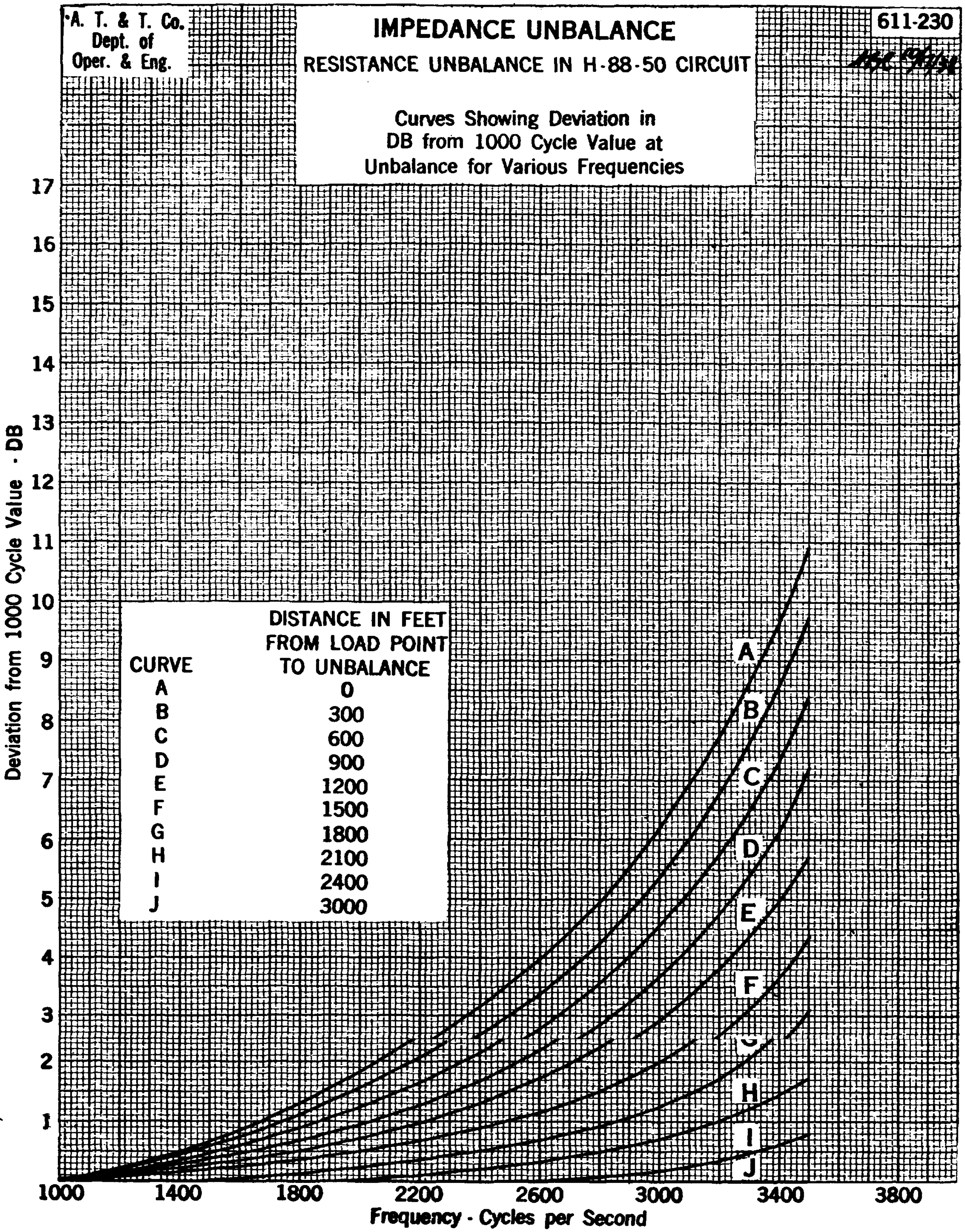

A. T. & T. Co.
Dept. of
Oper. & Eng.
611 - 160
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H - 172 - 63
OR H - 174 - 63 CIRCUIT
Curves Showing Deviation in
DB from 1000 cycle value at
Unbalance for Various Frequencies
DISTANCE IN FEET
FROM LOAD POINT
TO UNBALANCE
CURVE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
DEVIATION FROM 1000 CYCLE VALUE - DB
1
2
3
4
5
6
7
8
9
1100
1300
1500
1700
1900
2100
2300
2500
FREQUENCY · CYCLES PER SECOND
A
B
C
D
E
F
G
H
I
J

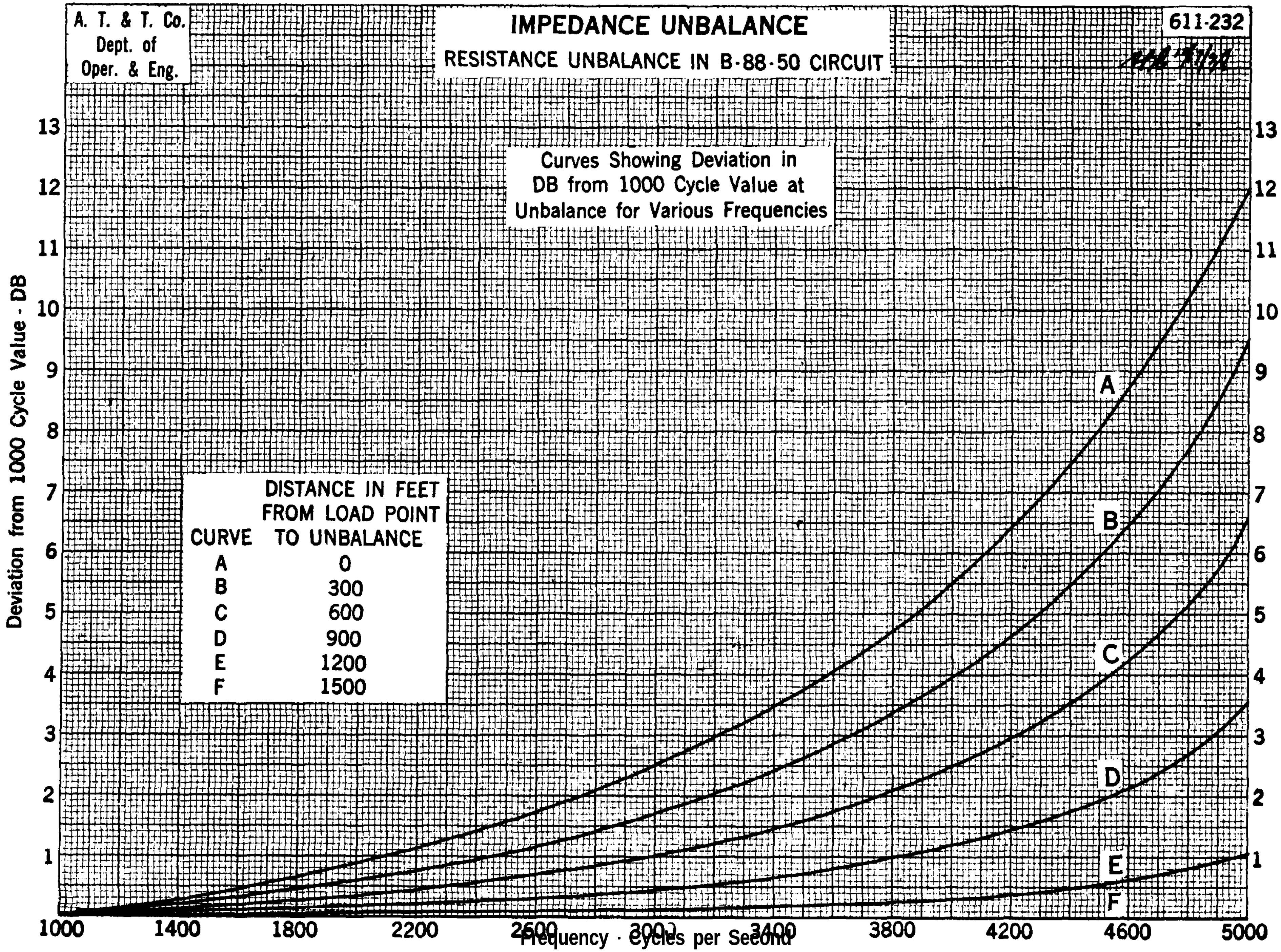


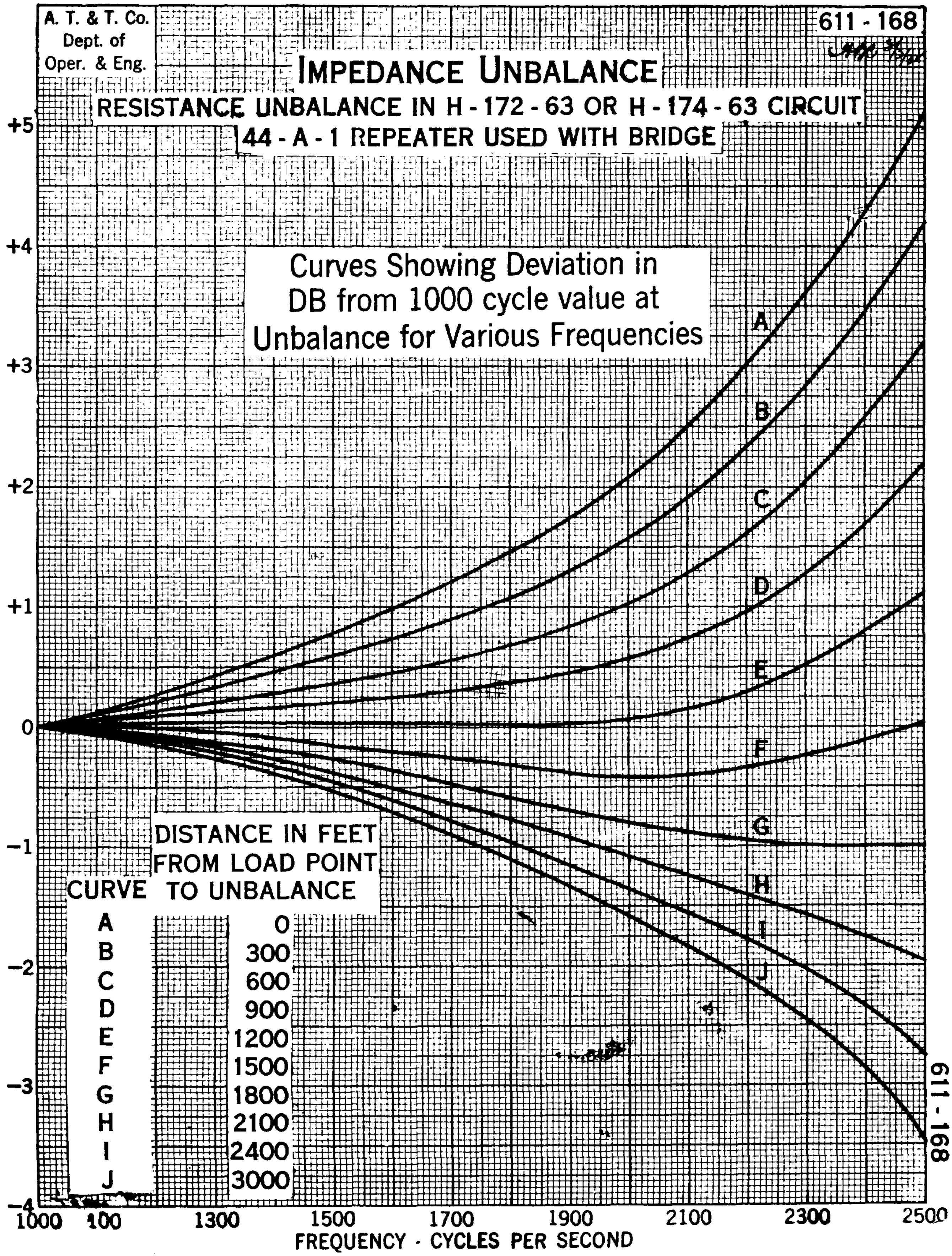
A. T. & T. Co.
Dept. of
Oper. & Eng.
611 - 161
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H - 44 - 25 CIRCUIT
Curves Showing Deviation in
DB from 1000 cycle value at
Unbalance for Various Frequencies
CURVE
A
B
C
D
E
F
G
H
I
J
DISTANCE IN FEET
FROM LOAD POINT
TO UNBALANCE
0
300
600
900
1200
1500
1800
2100
2400
3000
DEVIATION FROM 1000 CYCLE VALUE - DB
1
2
3
4
5
6
7
8
9
10
11
12
13
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
FREQUENCY - CYCLES PER SECOND

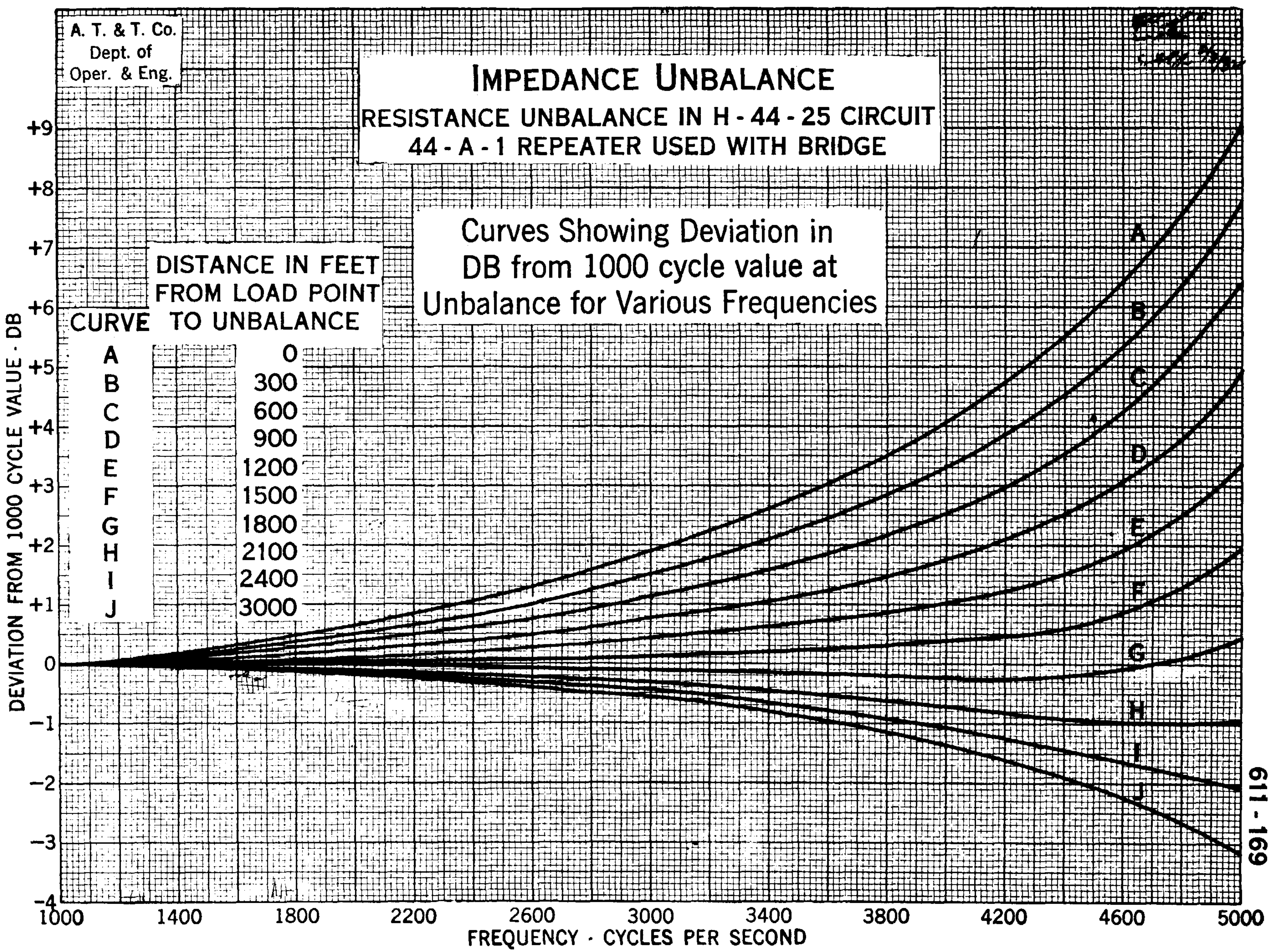
61-161


A. T. & T. Co.
Dept. of
Oper. & Eng.
611 - 167
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H - 174 - 106 CIRCUIT
Curves Showing Deviation in
DB from 1000 cycle value at
Unbalance for Various Frequencies.
DISTANCE IN FEET
FROM LOAD POINT
TO UNBALANCE
CURVE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
DEVIATION FROM 1000 - CYCLE VALUE - DB
12
11
10
9
8
7
6
5
4
3
2
1
1000
1100
1300
1500
1700
1900
2100
2300
2500
FREQUENCY - CYCLES PER SECOND
A
B
C
D
E
F
G
H
I
J
611 - 167

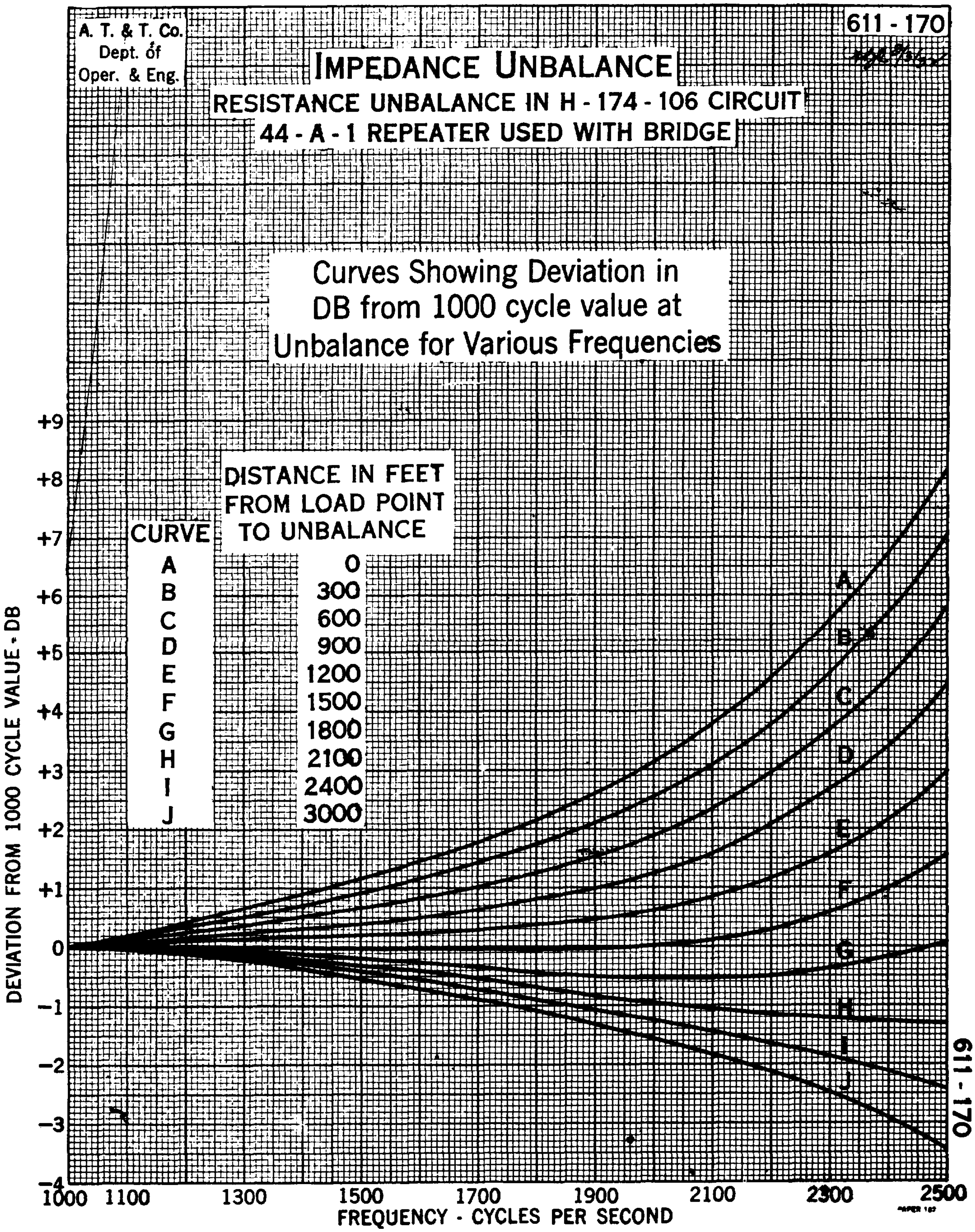

A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H-88-50 CIRCUIT
611-230
Curves Showing Deviation in
DB from 1000 Cycle Value at
Unbalance for Various Frequencies
DISTANCE IN FEET FROM LOAD POINT TO UNBALANCE
CURVE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
A
B
C
D
E
F
H
I
J
Deviation from 1000 Cycle Value - DB
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
1000
1400
1800
2200
2600
3000
3400
3800
Frequency - Cycles per Second

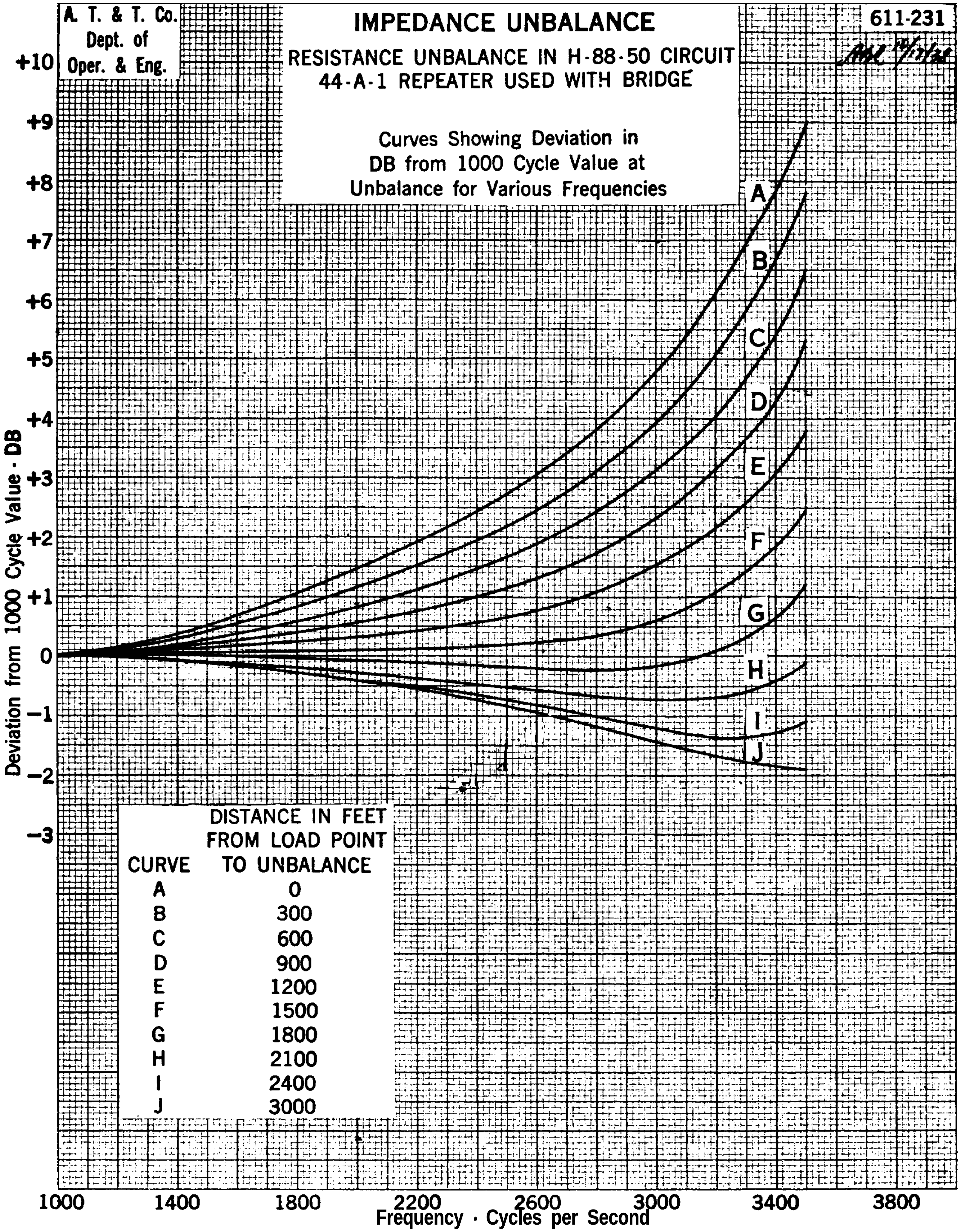

A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN B-88-50 CIRCUIT
611-232
Curves Showing Deviation in
DB from 1000 Cycle Value at
Unbalance for Various Frequencies
DISTANCE IN FEET FROM LOAD POINT TO UNBALANCE
CURVE
A 0
B 300
C 600
D 900
E 1200
F 1500
A
B
C
D
E
F
Deviation from 1000 Cycle Value - DB
Frequency - Cycles per Second
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
1
2
3
4
5
6
7
8
9
10
11
12
13

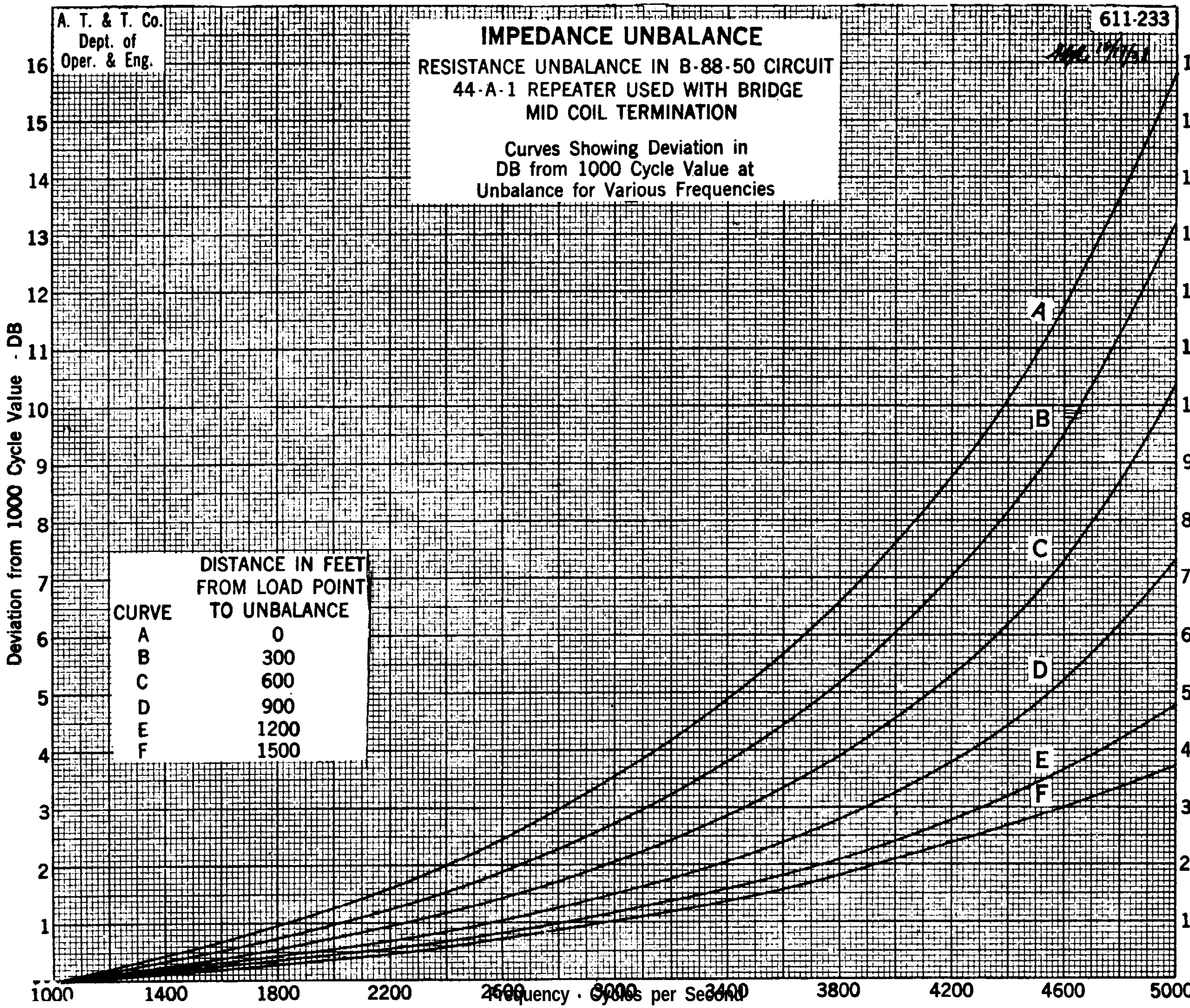

A. T. & T. Co.
Dept. of
Oper. & Eng.
611 - 168
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H - 172 - 63 OR H - 174 - 63 CIRCUIT
44 - A - 1 REPEATER USED WITH BRIDGE
Curves Showing Deviation in DB from 1000 cycle value at Unbalance for Various Frequencies
A
B
C
D
E
F
G
H
I
J
DISTANCE IN FEET FROM LOAD POINT
CURVE TO UNBALANCE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
DEVIATION FROM 1000 CYCLE VALUE - DB
+5
+4
+3
+2
+1
0
−1
−2
−3
−4
1000
1100
1300
1500
1700
1900
2100
2300
2500
FREQUENCY - CYCLES PER SECOND
611 - 168



A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H - 44 - 25 CIRCUIT
44 - A - 1 REPEATER USED WITH BRIDGE
Curves Showing Deviation in
DB from 1000 cycle value at
Unbalance for Various Frequencies
CURVE
DISTANCE IN FEET FROM LOAD POINT TO UNBALANCE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
DEVIATION FROM 1000 CYCLE VALUE - DB
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
−1
−2
−3
−4
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
FREQUENCY - CYCLES PER SECOND
A
B
C
D
E
F
G
H
I
J
611 - 169


A. T. & T. Co.
Dept. of
Oper. & Eng.
611 - 170
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H - 174 - 106 CIRCUIT
44 - A - 1 REPEATER USED WITH BRIDGE
Curves Showing Deviation in DB from 1000 cycle value at Unbalance for Various Frequencies
CURVE
DISTANCE IN FEET FROM LOAD POINT TO UNBALANCE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
DEVIATION FROM 1000 CYCLE VALUE - DB
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
−1
−2
−3
−4
1000
1100
1300
1500
1700
1900
2100
2300
2500
FREQUENCY - CYCLES PER SECOND
A
B
C
D
E
F
G
H
I
J
611 - 170

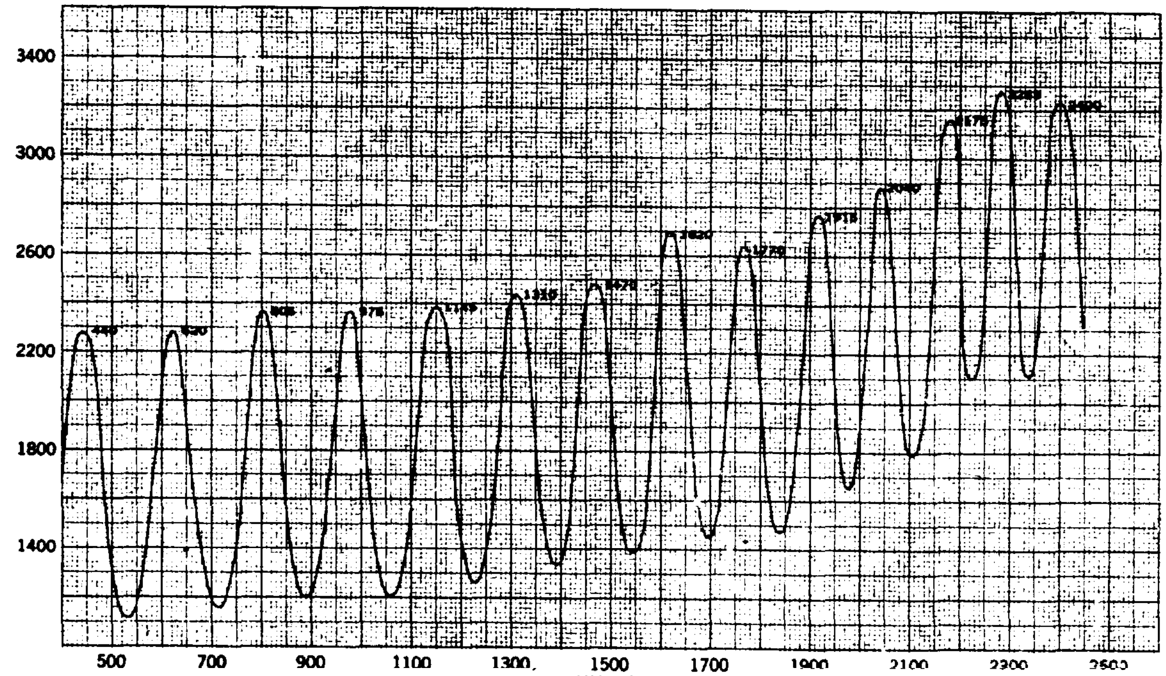

A. T. & T. Co.
Dept. of
Oper. & Eng.
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN H-88-50 CIRCUIT
44-A-1 REPEATER USED WITH BRIDGE
Curves Showing Deviation in
DB from 1000 Cycle Value at
Unbalance for Various Frequencies
611-231
A
B
C
D
E
F
G
H
I
J
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
−1
−2
−3
Deviation from 1000 Cycle Value - DB
DISTANCE IN FEET
FROM LOAD POINT
CURVE TO UNBALANCE
A 0
B 300
C 600
D 900
E 1200
F 1500
G 1800
H 2100
I 2400
J 3000
1000
1400
1800
2200
2600
3000
3400
3800
Frequency - Cycles per Second



A. T. & T. Co.
Dept. of
Oper. & Eng.
611-233
IMPEDANCE UNBALANCE
RESISTANCE UNBALANCE IN B-88-50 CIRCUIT
44-A-1 REPEATER USED WITH BRIDGE
MID COIL TERMINATION
Curves Showing Deviation in
DB from 1000 Cycle Value at
Unbalance for Various Frequencies
CURVE
DISTANCE IN FEET FROM LOAD POINT TO UNBALANCE
A 0
B 300
C 600
D 900
E 1200
F 1500
Deviation from 1000 Cycle Value - DB
Frequency - Cycles per Second
1000
1400
1800
2200
2600
3000
3400
3800
4200
4600
5000
A
B
C
D
E
F

IMPEDANCE IRREGULARITY LOCATION

ILLUSTRATIVE EXAMPLE NO. 1



FREQUENCY - CYCLES PER SECOND

ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

FORM E-1204 (11-30)

ANALYSIS SERIAL NO. *101*

BLOCK 1

CABLE *NY-Reading "D" East* PAIR *152x*

CIRCUIT TYPE *H-172-63 Mys.* —

TESTED FROM *Morristown* TO *New York*

DATE *Nov. 9, 1931* REASON FOR TEST *To find "K"*

CURVE SHEET SERIAL NO. *101*

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_c}$	B	d × B	T
1	440		.100	2.35	+.15
2	620		.1918	3.23	+.17
3	806		.185	4.35	+.15
4	975		.226	5.32	+.18
5	1145		.2665	6.27	+.23
6	1310		.3065	7.20	+.30
7	1470		.350	8.25	+.25
8	1620		.3915	9.22	+.28
9	1770		.436	10.23	+.27
10	1915		.4765	11.21	+.29
11	2040		.516	12.14	+.32
12	2175		.5615	13.21	+.29
13	2285		.600	14.12	+.38
14	2400		.652	15.35	+.15
15					
16					
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
B_N (FOR LAST PEAK OR VALLEY) =	.652	
B_1 (FOR FIRST PEAK OR VALLEY) =	.100	
$B_N - B_1$ =	.552	

d (LOAD SECTIONS) = $\frac{N-1}{B_N - B_1}$ = 13/.552 = 23.55

SLOPE CORRECTION P = +.5 V = (d + SLOPE) { P = V = AVE. = *24.05*

BLOCK 4

K = (d + SLOPE) × K =

BLOCK 5 — IMPEDANCE UNBALANCE ONLY

REFTR. CORRECTION (R.C.) = K(d + SLOPE) − R.C. =

$\frac{P_N}{P_L}$ = ______ = EQUIVALENT TO db

[K(d + SLOPE) − R.C.] × DEVIATION = × = db

H = TOTAL db = db

DISTANCE FROM LOAD POINT TO FAULT = FT.

FINAL LOCATION OF FAULT = LOAD SECT.

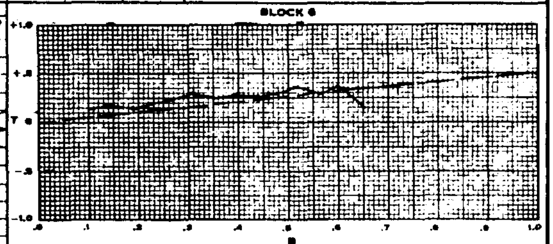
IMPEDANCE IRREGULARITIES

To	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	−C	SHORT
−.25	−L	SHORT
−.25	+C	LONG
±.50	+R	
0	−R	

IMPEDANCE UNBALANCES

To	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

VALUES OF B AT WHICH CORRESPONDING VALUES OF T OCCUR	1	2	3	4

AVERAGE VALUE OF B BETWEEN CORRESPONDING VALUES OF T =

APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{1}{\text{AVE. B}}$ =

BLOCK 7 - DIAGNOSIS

T_0 = *0* SENDING END SECTION LENGTH = *2300' = .383 Load Sect.*

M — *.383 Ld. Sect.* — X — *24 Ld. Sect.* — X — *.5* — NY

Actual Distance = .383 + 24 + .5 = 24.883 Ld. Sect.

BLOCK 8

TROUBLE FOUND ______ ERROR IN LOCATION ______

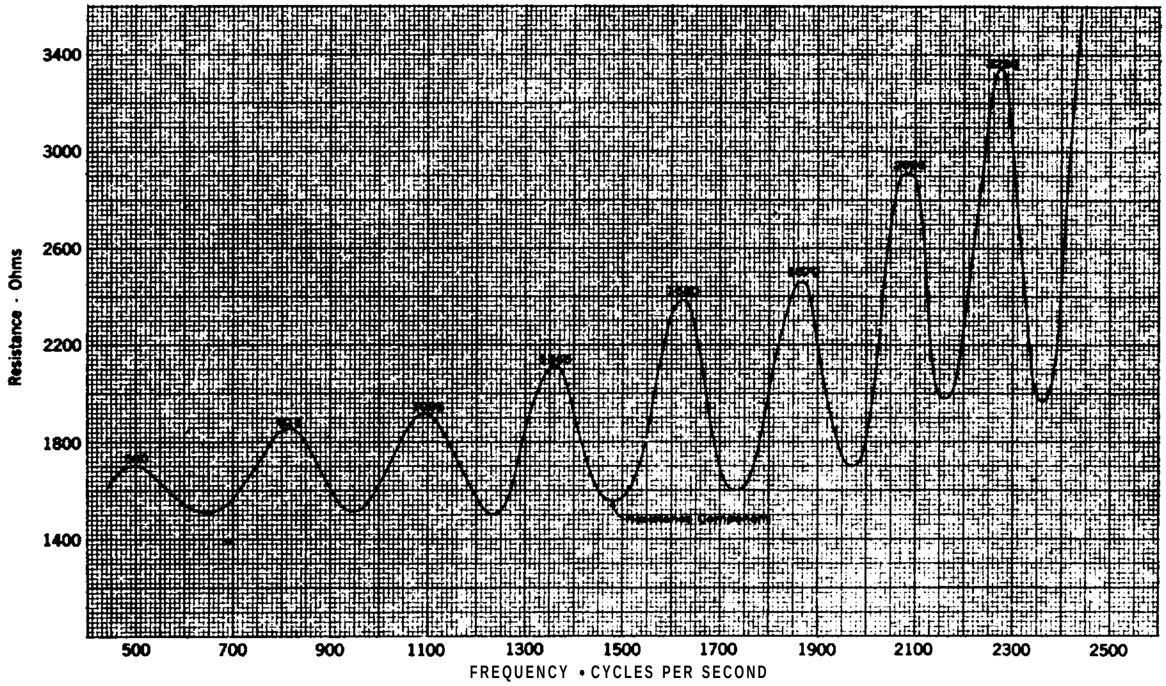
REMARKS:

$K = \frac{\text{Actual Distance to Short}}{\text{Computed Distance to Short}} = \frac{24.88}{24.05} = 1.035$

ANALYZED BY: *RCD*

IMPEDANCE IRREGULARITY LOCATION

ILLUSTRATIVE EXAMPLE NO. 2



ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

FORM E-1204 (11-30)

ANALYSIS SERIAL NO. *102*

BLOCK 1

CABLE *N.Y. - Reading "B" East* PAIR *63*

CIRCUIT TYPE *19 ga. H-172-63.5* f_c *—*

TESTED FROM *Harristown* TO *New York*

DATE *Nov. 9, 1931* REASON FOR TEST *To locate irregularity (Special Investigation)*

CURVE SHEET SERIAL NO. *102*

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_c}$	S	d × S	T
1	*500*		*.1143*	*1.65*	*-.15*
2	*815*		*.187*	*2.70*	*-.20*
3	*1095*		*.2545*	*3.68*	*-.18*
4	*1365*		*.3215*	*4.64*	*-.14*
5	*1620*		*.3915*	*5.65*	*-.15*
6	*1470*		*.4625*	*6.68*	*-.18*
7	*2045*		*.5345*	*7.72*	*-.22*
8	*2280*		*.599*	*8.65*	*-.15*
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
S_N (FOR LAST PEAK OR VALLEY) =	*.599*	
S_1 (FOR FIRST PEAK OR VALLEY) =	*.1143*	
$S_N - S_1$ =	*.485*	

d (LOAD SECTIONS) = $\frac{N-1}{S_N - S_1}$ = *7/.485 = 14.43*

SLOPE CORRECTION P = *0* V =

(d + SLOPE) P = V = AVE. = *14.43*

BLOCK 4

K = *1.035* (d + SLOPE) × K = *14.43 × 1.035 = 14.95*

BLOCK 5 — IMPEDANCE UNBALANCE ONLY

REPTR. CORRECTION (R.C.) = K(d + SLOPE) − R.C. =

$\frac{F_H}{F_L}$ = ______ = EQUIVALENT TO db

[K(d + SLOPE) − R.C.] × DEVIATION = × = db

N = TOTAL db = db

DISTANCE FROM LOAD POINT TO FAULT = FT.

FINAL LOCATION OF FAULT = LOAD SECT.

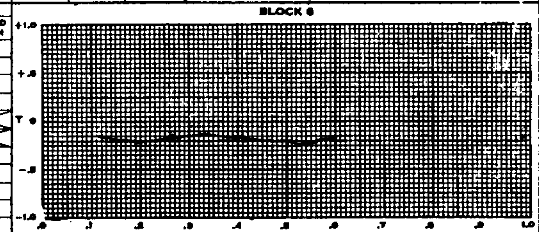
IMPEDANCE IRREGULARITIES

T_0	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	−C	SHORT
−.25	−L	SHORT
−.25	+C	LONG
±.50	+R	
0	−R	

IMPEDANCE UNBALANCES

T_0	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

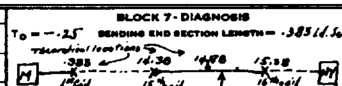
VALUES OF S AT WHICH CORRESPONDING VALUES OF T OCCUR	1	2	3	4

AVERAGE VALUE OF S BETWEEN CORRESPONDING VALUES OF T =

APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{1}{\text{AVE. S}}$ =

BLOCK 7 - DIAGNOSIS

T_0 = *−.25* SENDING END SECTION LENGTH = *.385 ld. Sect.*



Probable trouble: Excess cap. in 15th full ld. Sect.

BLOCK 8

TROUBLE FOUND *50% Excess cap. 15th ld. Section* ERROR IN LOCATION *14.95 - 14.88 = .07 ld. Sect.*

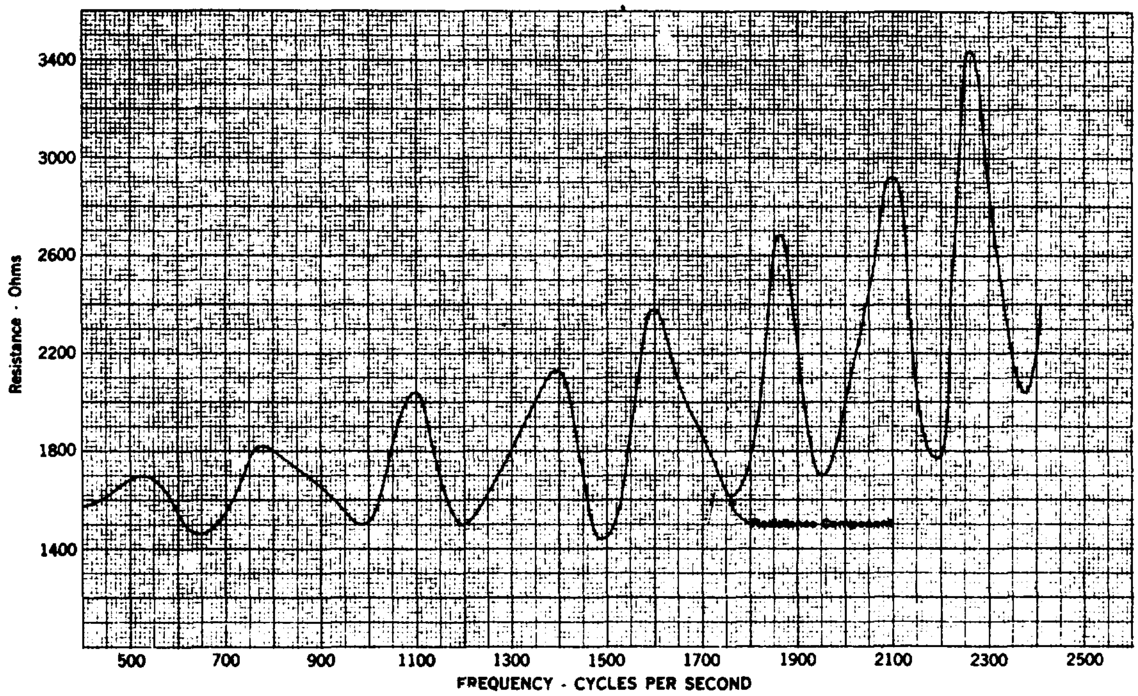
REMARKS:

Trouble due to bridging condenser at intermediate office in 15th Section.

ANALYZED BY: *DMD*

IMPEDANCE IRREGULARITY LOCATION

ILLUSTRATIVE EXAMPLE NO. 3



ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

FORM E-1266 (11-30)

ANALYSIS SERIAL NO. 103

BLOCK 1

CABLE N.Y.-Reading "B" Cut PAIR 63

CIRCUIT TYPE 19ga. H-172-63S f_c — 1

TESTED FROM Morristown TO New York

DATE Nov. 9, 1931 REASON FOR TEST To locate irregularity special investigation

CURVE SHEET SERIAL NO. 103

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_c}$	B	d × B	T
1	540		.1235	1.85	−.35
2	780		.179	2.68	−.18
3	1090		.2535	3.79	−.29
4	1390		.3285	4.91	−.41
5	1600		.386	5.78	−.28
6	1860		.460	6.89	−.39
7	2100		.536	8.02	−.52
8	2260		.5915	8.86	−.36
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
B_N (FOR LAST PEAK OR VALLEY) =	.5915	
B_1 (FOR FIRST PEAK OR VALLEY) =	.1235	
$B_N - B_1$ =	.468	

d (LOAD SECTIONS) = $\frac{N-1}{B_N - B_1}$ = 7/.468 = 14.95

SLOPE CORRECTION P = −.42 V =

(d + SLOPE) P = V = AVE. = 14.53

BLOCK 4

K = 1.035 (d + SLOPE) × K = 14.53 × 1.035 = 15.10

BLOCK 5—IMPEDANCE UNBALANCE ONLY

REPTN. CORRECTION (R.C.) = K(d + SLOPE) − R.C. =

$\frac{P_H}{P_L}$ = ——— = EQUIVALENT TO db

[K(d + SLOPE) − R.C.] × DEVIATION = × = db

N = TOTAL db = db

DISTANCE FROM LOAD POINT TO FAULT = FT.

FINAL LOCATION OF FAULT = LOAD SECT.

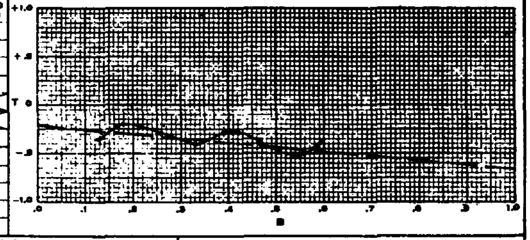
IMPEDANCE IRREGULARITIES

T_o	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	−C	SHORT
−.25	−L	SHORT
−.25	+C	LONG
±.50	+R	
0	−R	

IMPEDANCE UNBALANCES

T_o	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

	1	2	3	4
VALUES OF B AT WHICH CORRESPONDING VALUES OF T OCCUR				

AVERAGE VALUE OF B BETWEEN CORRESPONDING VALUES OF T =

APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{1}{\text{AVE. B}}$ =

BLOCK 7 - DIAGNOSIS

T_o = −.25 SENDING END SECTION LENGTH = .383 ld. sect.

(See sketch on Illustrative Example No. 2)

Probable trouble: Excess cap. 15th full ld. sect.

BLOCK 8

TROUBLE FOUND 50% excess cap. 15th ld. sect. ERROR IN LOCATION 15.10 − 14.88 = .22 ld. sect.

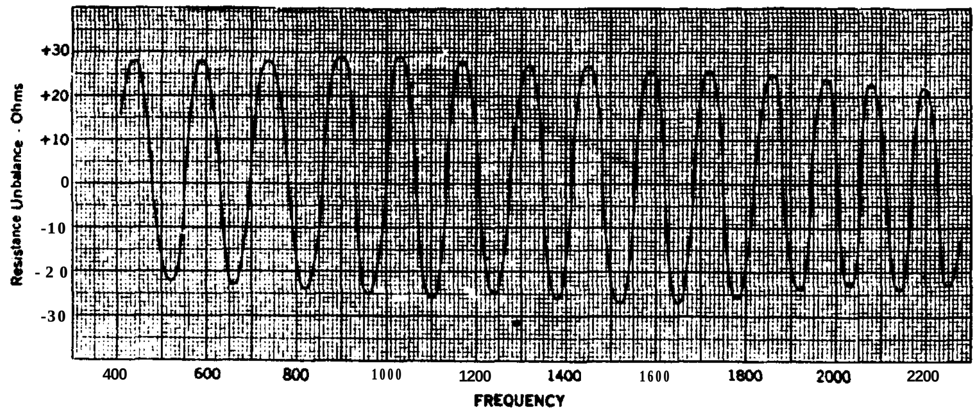
REMARKS:

Same trouble as in Illustrative Example No. 2 but with a second irregularity inserted at New York

ANALYZED BY: H.C.S.

RESISTANCE UNBALANCE LOCATION

ILLUSTRATIVE EXAMPLE NO. 4



ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

FORM E-1394 (11-38)

ANALYSIS SERIAL NO

BLOCK 1

CABLE *ALPHA-BETA "B"* PAIR *211*

CIRCUIT TYPE *19-H-174-63* f_c

TESTED FROM *ALPHA* TO *BETA*

DATE *7/9/37* REASON FOR TEST *Blenmuar K*

CURVE SHEET SERIAL NO.

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_c}$	B	d x B	T
1	520		.1040	3.41	+.02
2	660		.132	4.33	+.
3	820		.164	5.38	+.6
4	960		.1935	6.35	+.15
5	1100		.2240	7.35	+.15
6	1240		.2535	8.32	+.18
7	1380		.2840	9.32	+.18
8	1520		.3160	10.37	+.13
9	1650		.3460	11.36	+.14
10	1780		.3765	12.36	+.14
11	1920		.4110	13.49	+.01
12	2030		.4400	14.45	+.05
13	2140		.4695	15.41	+.09
14	2250		.5000	16.41	+.09
15					
16					
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
B_N (FOR LAST PEAK OR VALLEY) =		.5000
B_1 (FOR FIRST PEAK OR VALLEY) =		.1040
$B_N - B_1$ =		.3960
d (LOAD SECTIONS) = $\frac{N-1}{B_N - B_1}$ =		32.83

SLOPE CORRECTION P = V = *+.29* (d + SLOPE) P = V = *33.12* AVE. =

BLOCK 4

K = (d + SLOPE) x K =

BLOCK 5 – IMPEDANCE UNBALANCE ONLY

REPTR. CORRECTION (R.C.) = K(d + SLOPE) – R.C. =

$\frac{F_R}{F_L}$ = = EQUIVALENT TO db

[K(d + SLOPE) – R.C.] x DEVIATION = x = db

N = TOTAL db = db

DISTANCE FROM LOAD POINT TO FAULT = FT.

FINAL LOCATION OF FAULT LOAD SECT.

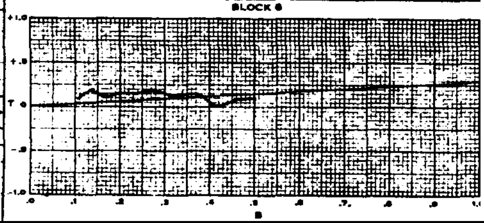
IMPEDANCE IRREGULARITIES

T_0	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	–C	SHORT
–.25	–L	SHORT
–.25	+C	LONG
±.50	+R	
0	–R	

IMPEDANCE UNBALANCES

T_0	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

VALUES OF B AT WHICH CORRESPONDING VALUES OF T OCCUR | 1 | 2 | 3 | 4

AVERAGE VALUE OF B BETWEEN CORRESPONDING VALUES OF T =

APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{1}{AVE. B}$ =

BLOCK 7 - DIAGNOSIS

T_0 = *0* SENDING END SECTION LENGTH =

BLOCK 8

TROUBLE FOUND ERROR IN LOCATION

REMARKS:

ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

FORM E-1394 (11-38)

ANALYSIS SERIAL NO

BLOCK 1

CABLE *ALPHA-BETA "B"* PAIR *211*

CIRCUIT TYPE *19-H-172-63* f_c

TESTED FROM *ALPHA* TO *Beta*

DATE *7/9/37* REASON FOR TEST *Blenmuar K*

CURVE SHEET SERIAL NO.

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_c}$	B	d x B	T
1	440		.0880	2.87	–.87
2	590		.1180	3.85	–.35
3	740		.1480	4.83	–.35
4	900		.1810	5.91	–.41
5	1030		.2070	6.83	–.33
6	1170		.2390	7.81	–.31
7	1320		.2705	8.83	–.33
8	1450		.3000	9.80	–.30
9	1590		.3320	10.84	–.34
10	1740		.3620	11.82	–.32
11	1860		.3970	12.97	–.47
12	1980		.4270	13.95	–.46
13	2080		.4535	14.81	–.81
14	2200		.4860	15.87	–.37
15					
16					
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
B_N (FOR LAST PEAK OR VALLEY) =	.4860	
B_1 (FOR FIRST PEAK OR VALLEY) =	.0880	
$B_N - B_1$ =	.3980	
d (LOAD SECTIONS) = $\frac{N-1}{B_N - B_1}$ =	32.66	

SLOPE CORRECTION P = *+.40* V = (d + SLOPE) P = *33.06* V = AVE. =

BLOCK 4

K = (d + SLOPE) x K =

BLOCK 5 – IMPEDANCE UNBALANCE ONLY

REPTR. CORRECTION (R.C.) = K(d + SLOPE) – R.C. =

$\frac{F_R}{F_L}$ = = EQUIVALENT TO db

[K(d + SLOPE) – R.C.] x DEVIATION = x = db

N = TOTAL db = db

DISTANCE FROM LOAD POINT TO FAULT = FT.

FINAL LOCATION OF FAULT LOAD SECT.

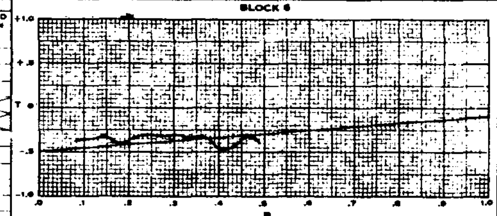
IMPEDANCE IRREGULARITIES

T_0	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	–C	SHORT
–.25	–L	SHORT
–.25	+C	LONG
±.50	+R	
0	–R	

IMPEDANCE UNBALANCES

T_0	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

VALUES OF B AT WHICH CORRESPONDING VALUES OF T OCCUR | 1 | 2 | 3 | 4

AVERAGE VALUE OF B BETWEEN CORRESPONDING VALUES OF T =

APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{1}{AVE. B}$ =

BLOCK 7 - DIAGNOSIS

T_0 = *–.5* SENDING END SECTION LENGTH =

BLOCK 8

TROUBLE FOUND ERROR IN LOCATION

REMARKS:

Ave (d+slope) from peaks and valleys = 33.09

K = $\frac{\text{Actual d}}{\text{Computed d}} = \frac{33.72}{33.09} = 1.019$

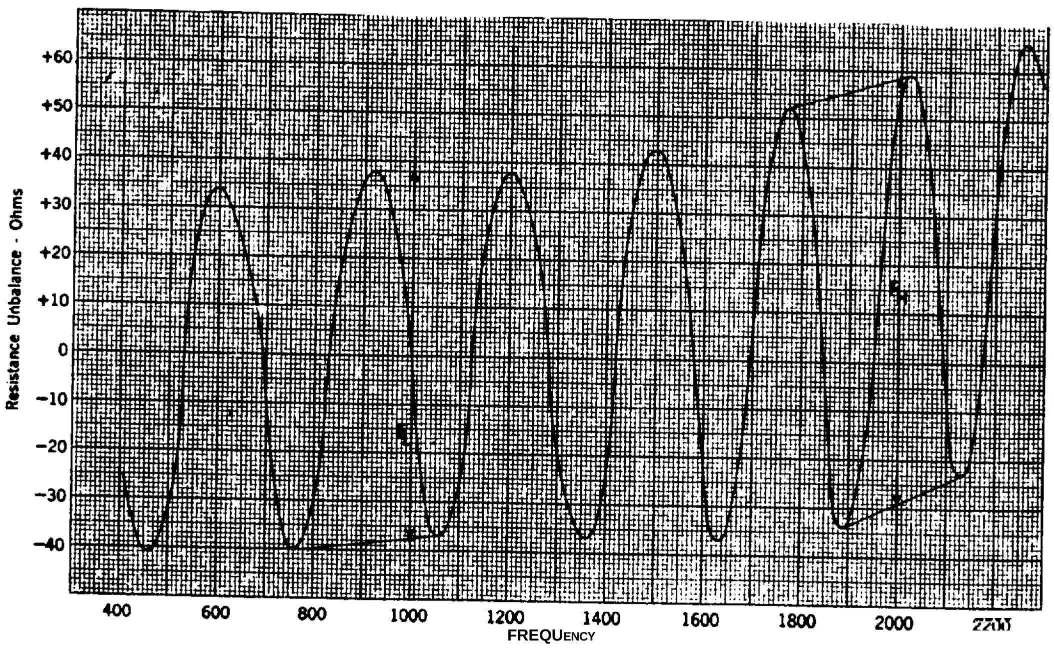
End Section ALPHA = .33

" " Beta = .39

Total Load Section = 33

RESISTANCE UNBALANCE LOCATION

ILLUSTRATIVE EXAMPLE NO. 5



ANALYSIS OF IMPEDANCE OR IMPEDANCE UNBALANCE CURVES

FORM E-1324 (11-30)

ANALYSIS SERIAL NO.

BLOCK 1

CABLE *ALPHA - BETA "B"* PAIR *212*

CIRCUIT TYPE *19-H-172-63* t_0

TESTED FROM *ALPHA* TO *BETA*

DATE *7/9/37* REASON FOR TEST *R unbalance*

CURVE SHEET SERIAL NO.

BLOCK 2

N	FREQ. AT RES. PEAKS OR VALLEYS	$\frac{f}{f_r}$	B	d × B	T
1	600		.1200	1.88	−.38
2	920		.1850	2.90	−.44
3	1200		.2450	3.84	−.34
4	1500		.3115	4.88	−.38
5	1770		.3740	5.86	−.36
6	2020		.4375	6.86	−.36
7	2260		.5030	7.88	−.38
8					
9	Valleys				
10	460		.0920	1.47	+.03
11	760		.1520	2.44	+.06
12	1060		.2155	3.45	+.05
13	1360		.2795	4.48	+.02
14	1630		.3415	5.47	+.03
15	1890		.4035	6.46	+.04
16	2130		.4665	7.47	+.03
17					
18					
19					
20					
21					
22					

BLOCK 3

	PEAK	VALLEY
B_N (FOR LAST PEAK OR VALLEY) =	.5030	.4666
B_1 (FOR FIRST PEAK OR VALLEY) =	.1200	.0920
$B_N - B_1$ =	.3830	.3745
d (LOAD SECTIONS) = $\frac{N-1}{B_N - B_1}$ =	15.67	16.02

SLOPE CORRECTION P = +.39, V = +.15

(d + SLOPE) P = 16.06, V = 16.17, AVE. = 16.12

BLOCK 4

K = 1.019 (d + SLOPE) × K = 16.43

BLOCK 5 – IMPEDANCE UNBALANCE ONLY

REPTR. CORRECTION (R.C.) = 0 K(d + SLOPE) − R.C. = 16.43

$\frac{F_H}{F_L}$ = $\frac{88}{76}$ = 1.16 EQUIVALENT TO 1.29 db

\|K(d + SLOPE) − R.C.\| × DEVIATION = 16.[illegible] × .075 = 1.2[illegible] db

N = 2000 TOTAL db = 2.[illegible] db

DISTANCE FROM LOAD POINT TO FAULT = 600 FT.

FINAL LOCATION OF FAULT = LOAD SECT.

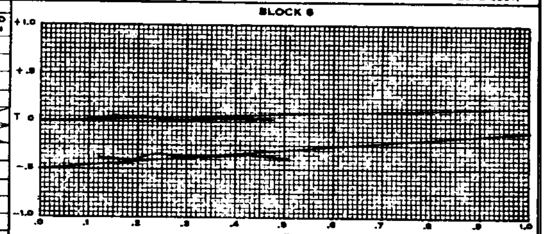
IMPEDANCE IRREGULARITIES

T_0	NATURE OF IRREG.	COMPUTED LOCATION
+.25	+L	LONG
+.25	−C	SHORT
−.25	−L	SHORT
−.25	+C	LONG
±.50	+R	
0	−R	

IMPEDANCE UNBALANCES

T_0	NATURE OF UNBALANCE
0 OR ±.50	R
0 OR ±.50	G
±.25	C
±.25	L

BLOCK 6



SPECIAL BLOCK

	1	2	3	4
VALUES OF B AT WHICH CORRESPONDING VALUES OF T OCCUR				
AVERAGE VALUE OF B BETWEEN CORRESPONDING VALUES OF T =				
APPARENT DISTANCE BETWEEN LARGER AND SMALLER TROUBLE = $\frac{1}{\text{AVE. B}}$ =				

BLOCK 7 - DIAGNOSIS

T_0 = P = −.5, V = 0 SENDING END SECTION LENGTH = .33

LP#1 LP#17 LP#18

ALPHA 600' To BETA

BLOCK 8

TROUBLE FOUND ERROR IN LOCATION

REMARKS: