INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE JZ-72.6 LINE COUPLING TUNERS

TWO–FREQUENCY PHASE-TO-GROUND
LINE COUPLING TUNERS
WITH TWO–WINDING MATCHING TRANSFORMER

TYPE JZ 72.6 – STYLE 290B883A23 – WITHOUT DRAIN COIL
TYPE JZ 72.6D – STYLE 606B363A10 – WITH DRAIN COIL
TYPE JZ 72.64 – STYLE 606B363A13 – WITH 0.006 MFD. SERIES CAPACITOR

NEW INFORMATION

EFFECTIVE JANUARY 1968

SAFETY WARNING!

Protect your life while making adjustments! Before handling any part of the electrical circuits:

1. BE SURE THE GROUNDING SWITCHES IN THIS ASSEMBLY ARE IN THE "GROUNDED" OR CLOSED POSITION.
2. BE SURE THAT ALL POWER SWITCHES IN THIS ASSEMBLY ARE TURNED "OFF".

Protect the equipment against damage by not applying power until thoroughly familiar with the ADJUSTMENTS described in this book.

SAFETY FIRST!

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SUPPLEMENTARY DATA

APPLICATION

These Line Coupling Tuners are designed for phase-to-ground coupling of two carrier frequencies from separate coaxial cables through a single coupling capacitor to a power line.

DESCRIPTION

Mechanical Description

The line tuner is mounted in a cabinet suitable for outdoor installation. Knockouts are provided on each side of the cabinet for the capacitor lead-in bushing. Knockouts for 1½ inch conduit for the coaxial cables are located in the bottom of the cabinet. The outline, mounting dimensions and the location of the knockouts are shown in Fig. 3.

All electrical components are mounted on a hinged panel which can be opened for making the coaxial cable, capacitor lead-in and ground connections. The grounding switch, spark gap, tuning controls, metering jacks and all tap connections are accessible from the front of the panel.

Electrical Description

The electrical circuits are shown in Fig. 2. The circuit for each frequency employs identical components. Each coaxial cable connects through a Jack, J-1 to the primary of a matching transformer, T-1. The secondary winding of the transformer connects through a Jack, J-2, to a line tuning coil, L-1. The capacitors C-1 and C-2 which are in series between the line tuning coil and the trap circuit are short circuited except when the inductance of the trap circuit at the tuner frequency is greater than the inductance required to resonate the coupling capacitor. The shorting links can be changed to connect the capacitors in series, one capacitor alone, or both capacitors in parallel. The trap circuit consists of the tapped inductance L-2, which has an adjustable powdered-iron core, and tuning capacitors C-3 and C-4. Links on the front of the panel provide for connecting the tuning capacitors in series, one capacitor alone, or both capacitors in parallel. Both trap circuits are connected to a protector unit, which consists of an adjustable spark gap SG-1 and a knife switch S-1. The spark gap protects the equipment from excessive voltage surges. The knife switch is provided for grounding the lead-in from the coupling capacitor while adjustments are being made.

The JZ 72.64 tuner includes a 0.006-mfd. capacitor in series with the output lead to the protector unit. This allows the tuner to be used with coupling capacitors up to 0.015 mfd. When a drain coil is supplied with the tuner, it is identified as a Type JZ 72.6D tuner. If both capacitor and drain coil are included, the tuner is Type JZ 72.64D.

Typical response curves for the type JZ 72.6 tuners are plotted in Fig. 1. These curves were taken with an 1870-mmf. coupling capacitor and a 300-ohm resistive load. The two sections of the tuner were adjusted for resonance (f_r) at 30 and 37.5 kHz, 80 and 100 kHz, and 160 and 200 kHz, respectively, for the three pairs of curves.

CHARACTERISTICS

Frequency Range:	30 to 200 kHz.
Input Impedance:	50 to 70 Ohms
Output Impedance:	100 to 1000 Ohms
Power Rating:	100 Watts Carrier-Unmodulated 25 Watts Carrier-100% Modulated
Coupling Capacitor Range:	JZ 72.6 – .00075 to .004 mfd. JZ 72.64 – .00075 to .015 mfd.
Minimum Frequency Separation:	25% of the lower frequency

INSTALLATION

It is recommended that the Line Tuner be located as near to the coupling capacitor as possible. The mounting dimensions are shown in Fig. 3.

Remove the upper knockout from the side of the cabinet nearest the coupling capacitor and install the porcelain bushing for the capacitor lead-in as described in the following section.

Connections

CAUTION

Before making any connections to this equipment, turn off the power switch of the carrier transmitter and ground or open circuit the lead-in at the coupling capacitor.

The assembly of the Style 1352445 accessories for the coupling capacitor lead-in cable is shown in Fig. 10. Before permanently assembling the bushing in the cabinet wall, run the lead-in cable through the bushing and into the cabinet to determine the correct length of lead-in cable. Allow sufficient length of cable to connect to the ground-

ing switch contact stud with the panel swung open. Mark the cable at the bushing to locate its position and remove the cable and bushing from the cabinet. Place the bushing in an inverted position with the openings level. Melt the cement supplied with the accessory package and pour it into the bushing. After the cement has hardened, install the bushing in the cabinet wall.

Remove the connection of the tuning unit from the terminal stud of the jaw contact of the grounding switch. Connect the capacitor lead-in cable to this terminal stud using the cable terminal supplied with the bushing. Tighten the nut securely. Replace the connection from the tuning unit using the second nut. This will permit disconnecting the tuning unit without disturbing the coupling capacitor lead-in cable connection.

Coupling Capacitor Lead-In Cable

Since the lead-in cable between the coupling capacitor and the line tuning unit is in a high-impedance carrier-frequency circuit, care must be exercised to keep the leakage to a minimum value.

The lead-in cable should be supported with as few insulators as possible. The insulation of this lead-in cable with respect to ground must be much better than is ordinarily employed for the voltage which exists between these points, as it effectively shunts the reactive elements of the resonant circuit at carrier frequency. The impedance of this resonant circuit may be as high as five thousand ohms and leakage resulting from rain, snow, sleet, too long a lead-in cable, or too many supporting insulators will reduce the effective power output of the transmitter and the sensitivity of the receiver.

An installation which limits this leakage to a minimum will have less signal strength variation under adverse conditions, when reliable operation is of the greatest value.

The insulators used for supporting the lead-in cable should have at least a 7.5-kv rating. Care should be taken not to break the insulation of the cable when clamping it to the insulators. At least once a year the insulators should be washed to remove the accumulation of dirt.

For the lead-in, use a good quality rubber covered cable of at least 7500 volts service grade, with a conductor equivalent to No. 14 gauge or larger. This cable is usually supplied with the coupling capacitor.

Coaxial Cable

Two screws are mounted in the left wall of the cabinet for securing the coaxial cables. Connect the shield of the cable to terminals #2 and #4, and the center conductors to terminals #3 and #5. Connect a good ground to the cabinet and to terminal #1 of the terminal board. Run a copper bonding cable from the cabinet to the base of the coupling capacitor.

Follow the instructions given in Fig. 2 for the connection of the coaxial cables. Remove the shield braid so that one to two inches of the inner insulation is exposed. The outer jacket of the coaxial cable should cover the shield braid as much as possible to insulate it against the high voltage that may exist between the shield braid and the tuner cabinet during a fault. Connect the cable shields to terminals 2 and 4 as indicated in Fig. 2, but do not ground these leads to the tuner cabinet. See that the coaxial cable leads are positioned so that the exposed portion of the cable shield and its lead are spaced away from the metal cabinet proper. The coaxial cable is grounded at the carrier equipment end only. The use of two-winding transformers allows grounding of the coaxial-cable shield braid at the carrier-set end only, and this eliminates any path for the flow of 60-cycle current (during a ground fault) through the coaxial cable and transformer winding.

ADJUSTMENTS

CAUTION

When making any tap adjustments or changing any connections in this tuner, make certain that the grounding switch is closed. Do not depend on the drain coil for personal safety. Do not touch any terminal when the transmitter is on.

The first consideration in adjusting this tuner is to determine the two operating frequencies. In general, it is recommended that the higher of the two operating frequencies be at least 125 per cent of the lower frequency. This is because the losses increase as the operating frequencies approach each other. Also, for close frequency separation, the inductive reactance of the trap circuit at the tuner frequency may be much greater than the value re-

quired to resonate the coupling capacitor. This requires the insertion of capacitance in series with the tuning circuit in order for resonance to be obtained.

In addition to the operating frequencies, the capacitance of the coupling capacitor must be known in order to determine the appropriate tuning adjustments.

PRELIMINARY ADJUSTMENTS

The transformers used in this line tuner provide an impedance match for a 50 to 70 ohm coaxial cable to 100 to 1000 ohm power line. The impedance of the different taps of the transformer, T-1, are given in the following table.

Coaxial Tap	Tuner Tap	Line Impedance
2	4- 5	100
3	4- 5	139
2	6- 7	193
3	6- 7	268
2	8- 9	372
3	8- 9	517
2	10 - 11	720
3	10 - 11	1000

The average power line impedance is 400 to 600 ohms. If the impedance of the power line is known, connect the COAX and TUNER leads of the transformer to the corresponding taps. If the power line impedance is not known, connect the COAX lead to tap 3 and the TUNER leads to taps 8 and 9. Readjustment of the taps will be made as a part of the Final Adjustment.

The following procedure will determine the approximate adjustment of the line tuning coils and the trap circuits.

For these calculations:

F_1 = lower frequency in kHz.

F_2 = higher frequency in kHz.

C_0 = capacitance of coupling capacitor in MMF

For the JZ 72.64 tuner, in determining the required inductance, do not use the rated capacitance of the coupling capacitor for Cc. Because of the 0.006-mfd. capacitor (C5) in the tuner output circuit, the net capacitance must be calculated from the formula:

$$Co = \frac{(.006)\ (Cc)}{(.006 + Cc)}$$

where Cc is the rated capacitance of the coupling capacitor, and Co is the calculated value to use in the procedure described in the following paragraphs. (All values are in micro-microfarads) For example, if the coupling capacitor is 0.006 mfd., then the net value of Co is 0.003 mfd. Similarly, for a 0.005 mfd. coupling capacitor, $Co = \frac{.006 \times .005}{.011} = .0027$ mfd. (Then use 2700 mmf. in determining required inductance.)

A. Calculation of Line Tuner adjustments for the lower frequency section.

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F-2.

2. Determine the percentage that the trap frequency F_2 is above the line tuner frequency F-1 by using the following formula:

$$\frac{F2 - F_1}{F_1} \times 100 = \text{percentage}$$

Refer to Fig. 7 and determine the inductance of the trap circuit at the line tuner frequency F1 for the trap tuning capacitor and per cent separation determined above.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_1.

Calculate the value of inductance required to resonate the coupling capacitor by using the following formula:

$$\frac{\text{L-C product}}{C_O} = \text{mh for resonance at } F_1$$

If this value of inductance is greater than the inductance of the trap circuit obtained in 2 above, then the difference is the value of inductance required in the line tuning coil.

In this case, refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

4. If the inductance of the trap circuit at F_1 is greater than the value required to resonate the coupling capacitor, then series capacitance must be included in the tuning circuit in order to obtain resonance. Three values of

capacitance are available, which for these calculations will be designated as C_A, C_B, and C_C.

$C_A = C_1$ and C_2 in parallel = 2400 mmf

$C_B = C_1$ (or C_2) = 1200 mmf

$C_C = C_1$ and C_2 in series = 600 mmf

Calculate the resultant capacitance of the coupling capacitor in series with capacitors C_1 and C_2 in parallel.

$$\frac{C_O \times C_A}{C_O + C_A} = \text{capacitance in tuning circuit}$$

Divide the L-C product obtained in 3 above by this value to determine the inductance required for resonance.

5. If this value of inductance is not greater than the inductance of the trap circuit, repeat the calculation as in 4, above, with capacitance C_B (1200 mmf) and, if necessary, with C_C (600 mmf).

6. Subtract the inductance of the trap circuit from the value of inductance determined in 4 or 5, above. This is the value of inductance required in the line tuning coil.

   Refer to Fig. 5 for the tap number on the line tuning coil for this value of inductance.

NOTE

When the two frequencies are separated by more than 100 per cent, the inductance of the trap circuit at the line tuner frequency will be only a small part of the inductance required for resonance and so will cause a change of only one or two taps on the line tuning coil.

B. Calculation of Line Tuner adjustments for the higher frequency section.

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F_1.

2. Determine the percentage that the trap frequency F_1 is below the line tuner frequency F_2 by using the following formula:

$$\frac{F_2 - F_1}{F_2} \times 100 = \text{percentage}$$

   Refer to Fig. 8 and determine the capacitance of the trap circuit for the trap tuning capacitor and per cent separation determined above.

   Calculate the resultant capacitance of this value in series with the coupling capacitor, using the following formula:

$$\frac{C_O \times C_T}{C_O + C_T} = \text{capacitance in tuning circuit}$$

   This is the value of capacitance which must be resonated by the line tuning coil.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_2.

   This product divided by the capacitance value calculated in 2, above, is the value of inductance required in the line tuning coil.

4. Refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

NOTE

Since the preceding calculations cannot include the effect of stray capacitance, possible inductance of the power line, or inductance of the matching transformer, the final adjustment of the line tuning coil may vary by one or two taps.

Two sample calculations for tap setting are shown on the following pages.

SAMPLE CALCULATION #1

F_1 = 160 kHz

F_2 = 200 kHz

C_0 = 4000 mmf

A. 1. F_2 = 200 kHz trap frequency. From Fig. 6 tuning capacitor = 1100 mmf. Tap number = 80.

2. $$\frac{200 - 160}{160} \times 100 = 25\%$$

   From Fig. 7.
   For 1100 mmf capacitor and 25% separation.
   Inductance = 1.6 mh.

3. From Fig. 9.
   L-C product at 160 kHz = 980.
   $\frac{980}{4000}$ = 0.245 mh for resonance

4. 1.6 mh greater than 0.245 mh.
   With C-1 and C-2 in parallel in tuning circuit.
   2400 mmf in series with 4000 mmf is 1500 mmf.

   $\frac{980}{1500}$ = 0.653 mh for resonance

5. 1.6 mh greater than 0.653 mh.
   With C-1 in tuning circuit (C-2 shorted)
   1200 mmf in series with 4000 mmf is 924 mmf.

   $\frac{980}{924}$ = 1.06 mh for resonance

   1.6 mh greater than 1.06 mh.
   With C-1 and C-2 in series in tuning circuit.
   600 mmf in series with 4000 mmf is 522 mmf.

   $\frac{980}{522}$ = 1.88 mh for resonance at 160 kHz

6. 1.88 − 1.6 = 0.28 mh required in line tuning coil.

   Refer to Fig. 5. For 0.28 mh use tap number 67 of the line tuning coil. Short the unused taps.

B. 1. F_1 = 160 kHz trap frequency.

   From Fig. 6.

   C = 1100 mmf
   Tap = 100

2. $\frac{200 - 160}{200}$ x 100 = 20%

   From Fig. 8.
   Trap capacitance for 1100 mmf. tuning capacitor and 20% separation is 390 mmf.
   390 mmf in series with 4000 mmf is 356 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

   $\frac{630}{356}$ = 1.77 mh for resonance at 200 kHz.

4. From Fig. 5.
   For 1.77 mh, use tap number 184 of line tuning coil.
   Short the unused taps.

SAMPLE CALCULATION #2

F_1 = 30 kHz
F_2 = 200 kHz
C_0 = 850 mmf

A. 1. F_2 = 200 kHz trap frequency.

   From Fig. 6.

   Tuning Capacitor = 1100 mmf.

   Tap Number = 80.

2. $\frac{200 - 30}{30}$ x 100 = 566%

   From Fig. 7.

   For 1100 mmf capacitor and 566% separation.

   Inductance will be less than the 2.5 mh shown for 85% separation at 63 kHz.

3. From Fig. 9.

   L-C product at 30 kHz = 28000.

   $\frac{28000}{850}$ = 33 mh for resonance

   From Fig. 5.

   Tap number 780 gives the inductance range of 26 to 40 mh so the trap inductance can be compensated for without changing taps.

B. 1. F_1 = 30 kHz trap frequency

   From Fig. 6.
   Tuning Capacitor = 4400 mmf.
   Tap Number = 300.

2. $\frac{200 - 30}{200}$ x 100 = 85%

   From Fig. 8.

   Trap capacitance for 4400 mmf and 85% separation is 4270 mmf.

   4270 mmf in series with 850 mmf is 710 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

   $\frac{630}{710}$ = 0.89 mh for resonance

4. From Fig. 5.

   For 0.89 mh use tap number 125 of line tuning coil.

   Short the unused taps.

NOTE

The instructions in Fig. 5 state that the unused taps are to be shorted when a tap lower than 100 is used and also when the frequency is above 150 kHz.

This procedure will leave a gap in the inductance range between tap 100 with the unused turns not shorted and tap 88 with the unused turns shorted. Continuous inductance adjustment can be obtained by using tap 113 with unused turns shorted as the next lower inductance tap below tap 100 with the unused turns not shorted.

Final Adjustments

After making the connections of trap capacitors, trap coil taps, and line tuning coil taps as determined under Preliminary Adjustments, the circuits must be adjusted to meet the requirements of the particular installation.

The trap circuits should be tuned to resonance before the line tuning coils are adjusted. For tuning with a local transmitter connected to cabinet terminal number 3, connect a thermocouple-type milliammeter to Jack J-1 on the right side of the panel or connect a vacuum-tube voltmeter from Jack J-2 on the right to ground. Turn on the local transmitter and adjust the core of the trap coil L-2 on the right for minimum current in Jack J-1 or minimum voltage from Jack J-2 to ground. Lock core in this position.

If the other channel also has a local transmitter, adjust the trap coil L-2 on the left for minimum current in Jack J-1 on the left or minimum voltage from Jack J-2 on the left to ground.

To adjust the trap circuit with a signal from a remote transmitter, measure the signal voltage from Jack J-2 to ground. Have the transmitter turned on and off several times to be certain that the desired signal is the one which is being received. Adjust the core of the trap coil for minimum voltage and lock the shaft.

After both trap circuits have been adjusted, tune the line tuning coils for resonance. Turn on the local transmitter and adjust the core of the line tuning coil, L-1, for maximum current in Jack J-1. If the current is increasing with the core all the way in or all the way out, change the tap connection to the next higher or lower tap, respectively.

To tune the line tuning coil with a signal from a remote transmitter, adjust the coil for maximum voltage from Jack J-2 to ground.

A line coupling tuner which is used to bypass a circuit breaker should be adjusted with the circuit breaker open. However, since this may be very difficult to arrange, an alternate method is to disconnect the coupling capacitor from the line and connect its high potential side to ground through a resistor. If the impedance of the line with the circuit breaker open is known, use a resistor of this value. If the line impedance is not known, use a 500-ohm resistor. Adjust the trap coils and line tuning coils in accordance with the previous instructions.

The matching transformer taps should then be adjusted by the following procedure:

Open the coaxial-cable circuit by disconnecting the COAX link from the transformer tap (2 or 3). Connect a non-inductive resistor of approximately 60 ohms between the COAX terminals (cabinet terminals 2-3 or 4-5). The wattage rating of the resistor must be sufficient to dissipate the output of the transmitter. Connect a thermocouple-type milliammeter in series with the 60-ohm resistor. Turn on the local transmitter and record the current through the resistor. Then turn off the transmitter.

Disconnect the resistor and reconnect the COAX link to the transformer tap. Turn on the transmitter and compare the current reading in Jack J-1 with the value obtained with the resistor. If the current values are different, change the transformer tap connections to the taps which give a current in Jack J-1 nearest the current measured through the resistor. After each change of transformer taps, readjust the core of the line tuning coil for maximum current.

Tuning Adjustment with Dummy Load Resistors

An adjustment procedure for obtaining a more exact impedance match is shown in Fig. 4, Line Coupling Tuner Adjustment. The dummy load resistors must be of sufficient wattage rating to dissipate the transmitter output.

Adjustment of Spark Gap

Adjust the spark gap SG-1 to 0.015 inch spacing. Observe the gap while the local transmitter is trans-

mitting full power. If the gap arcs over, increase the spacing until the arcing stops. The minimum spacing for the gap depends upon the carrier power, the power line impedance, and the capacitance of the coupling capacitor.

MAINTENANCE

Routine Checks and Records

This Tuning Unit requires very little maintenance. It should be inspected occasionally to see if there has been excessive burning of the spark gap.

If the spark gap shown signs of burning, rotate the discs to a new position and readjust the gap. Usually a semi-annual or yearly inspection is sufficient.

A permanent record should be kept of tap settings and the position of the coil-tuning cores so that they can be restored to the correct positions in case of unauthorized changes.

Ordering Replacement Parts

Replacement parts for this Tuning Unit may be ordered through the nearest Westinghouse District Office. When ordering, include:

1. The following data from the nameplate of the Line Tuner:

   (a) The type number; (b) the style number.

2. The (a) Electrical Parts List symbol; (b) the function; (c) the description; (d) the designation.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	FUNCTION	DESCRIPTION	STYLE NUMBER
SUB-ASSEMBLIES			
L-1	Line Tuning Coil	Line Tuning Coil Assembly	1474218
T-1	Transformer	Transformer Assembly	407C741G02
—	Trap	Trap Unit Assembly	1474013
—	Protector Unit	Protector Unit Assembly	1474014
COMPONENT PARTS			
C-1	Capacitor-Series	Mica- 1200 mmf. ± 5%, 5000V	290B762H01
C-2	Capacitor-Series	Same as C-1	
C-3	Capacitor-Trap Tuning	Mica- 2200 mmf. ± 5%, 5000V	290B762H02
C-4	Capacitor-Trap Tuning	Same as C-3	
J-1	Jack-Coax Metering	Binding Post Type 2 Binding Posts 1 Shorting Link	 185A431H01 1474455
J-2	Jack-Line Metering	Same as J-1	
SG-1	Spark Gap	Disc Type	2 of 183A358H20 (discs only)
OPTIONAL			
L-3	Drain Coil (When Used)	20,000 ohms minimum impedance over 30 - 200 kHz.	670B069G02
C-5	Series Capacitor (When Used)	Mica, 0.006 mfd., ± 5% 3000V, PACW.	584C256H03

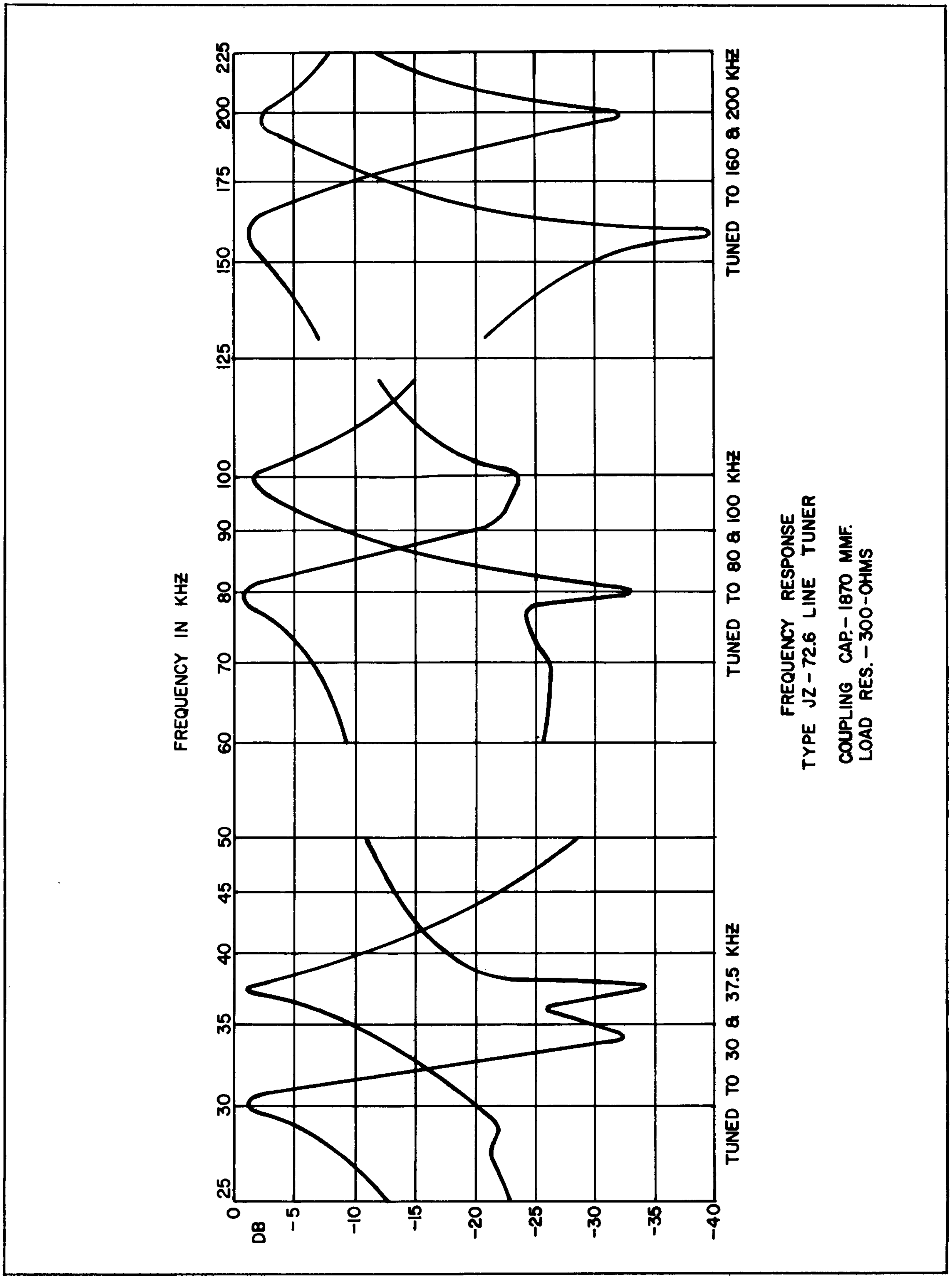

Fig. 1. Response Curves of JZ 72.6 Tuner. (Dwg. 862A348)

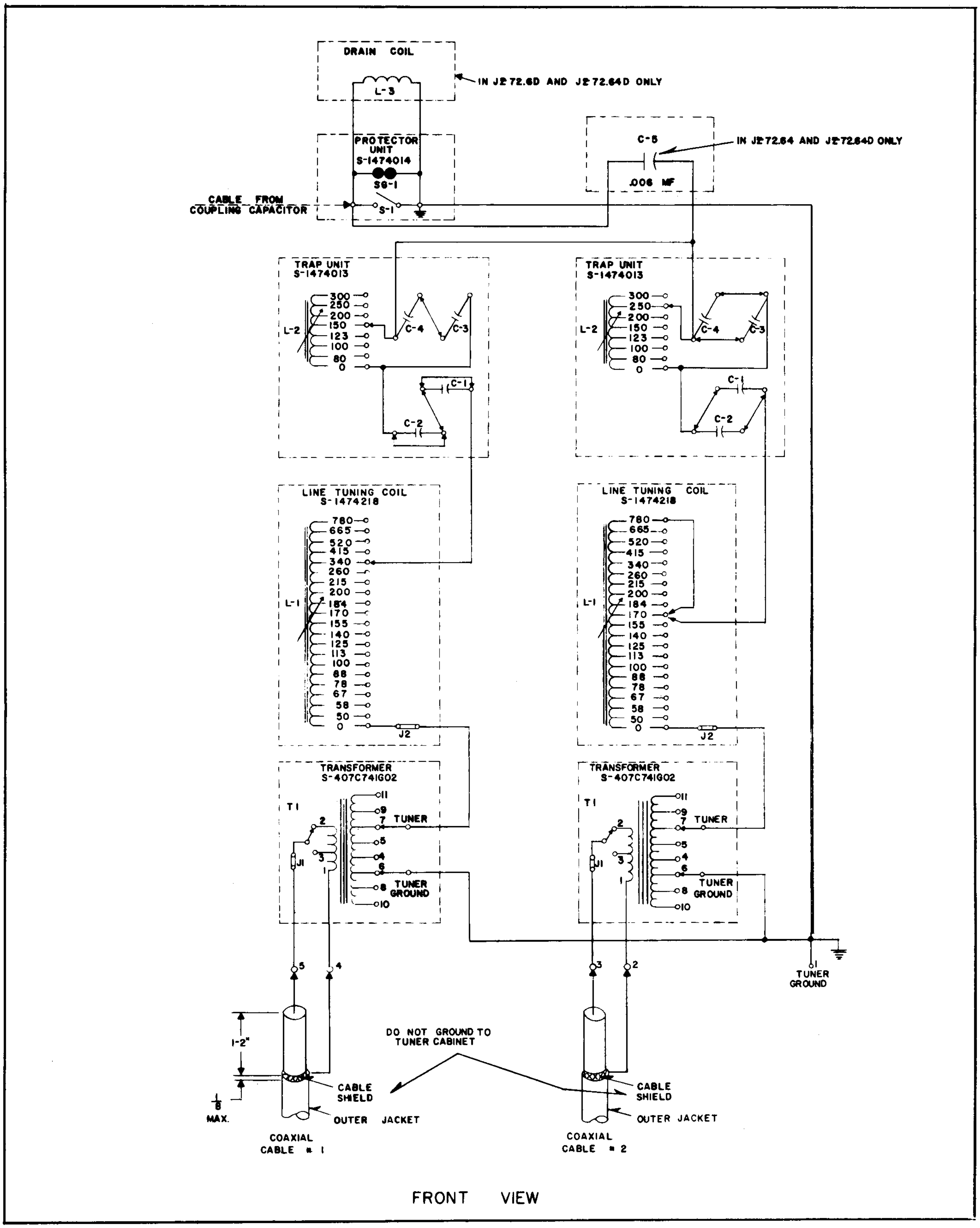

Fig. 2. Internal Schematic (Dwg. 410C054)

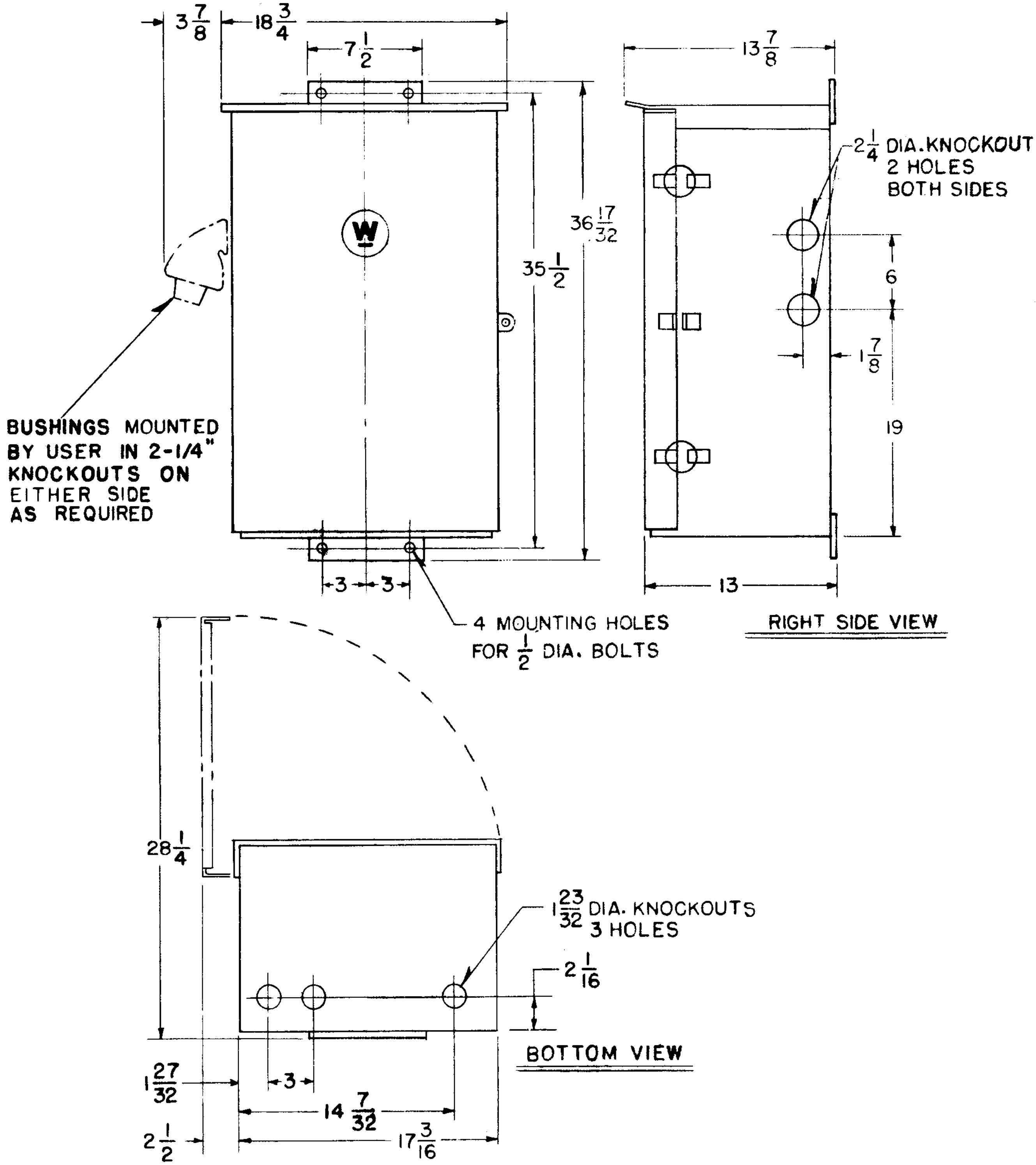

Fig. 3. Tuner Cabinet – Outline (Dwg. 50-B-7683)

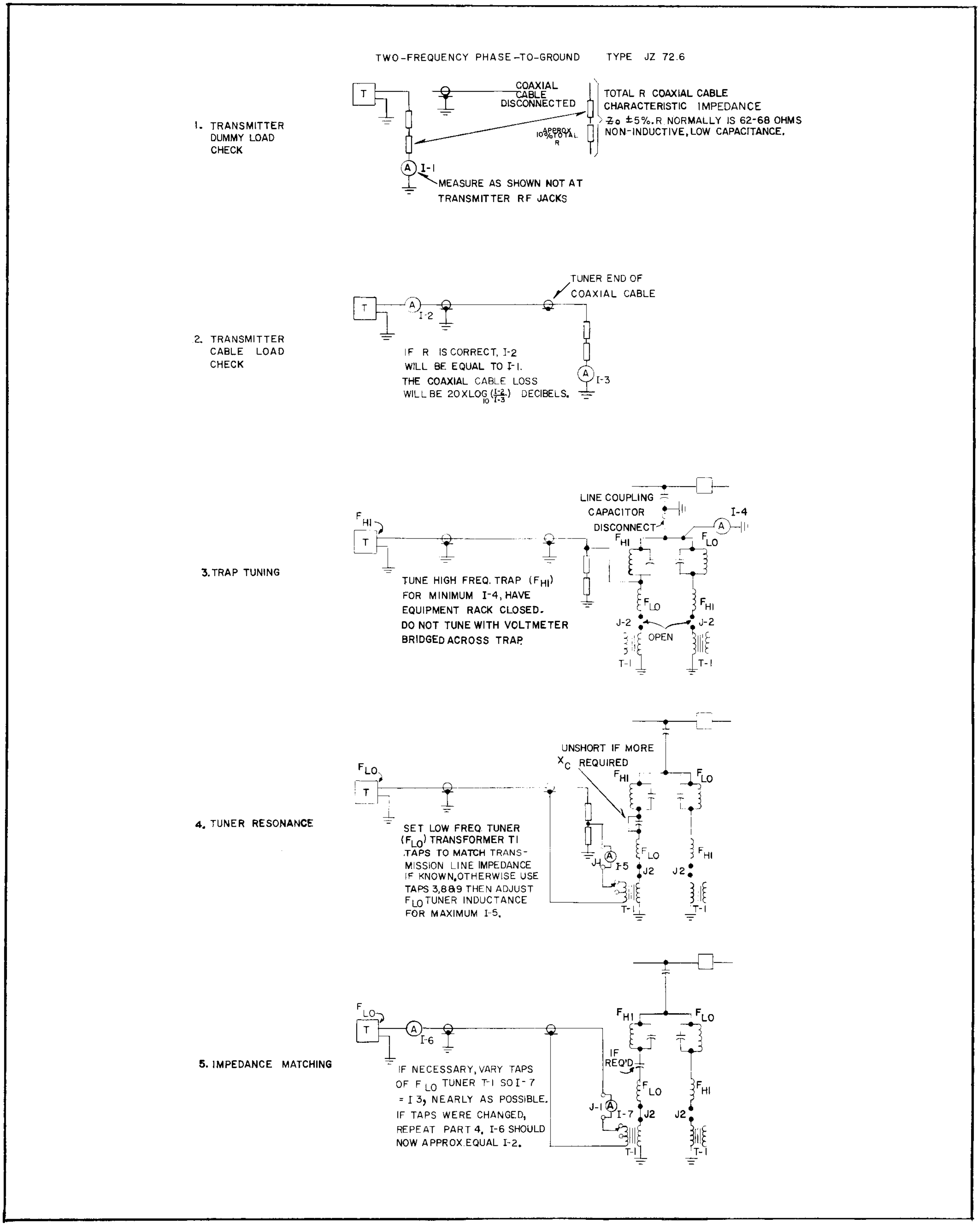

Fig. 4. Line Coupling Tuner Adjustment (Dwg. 585C117)

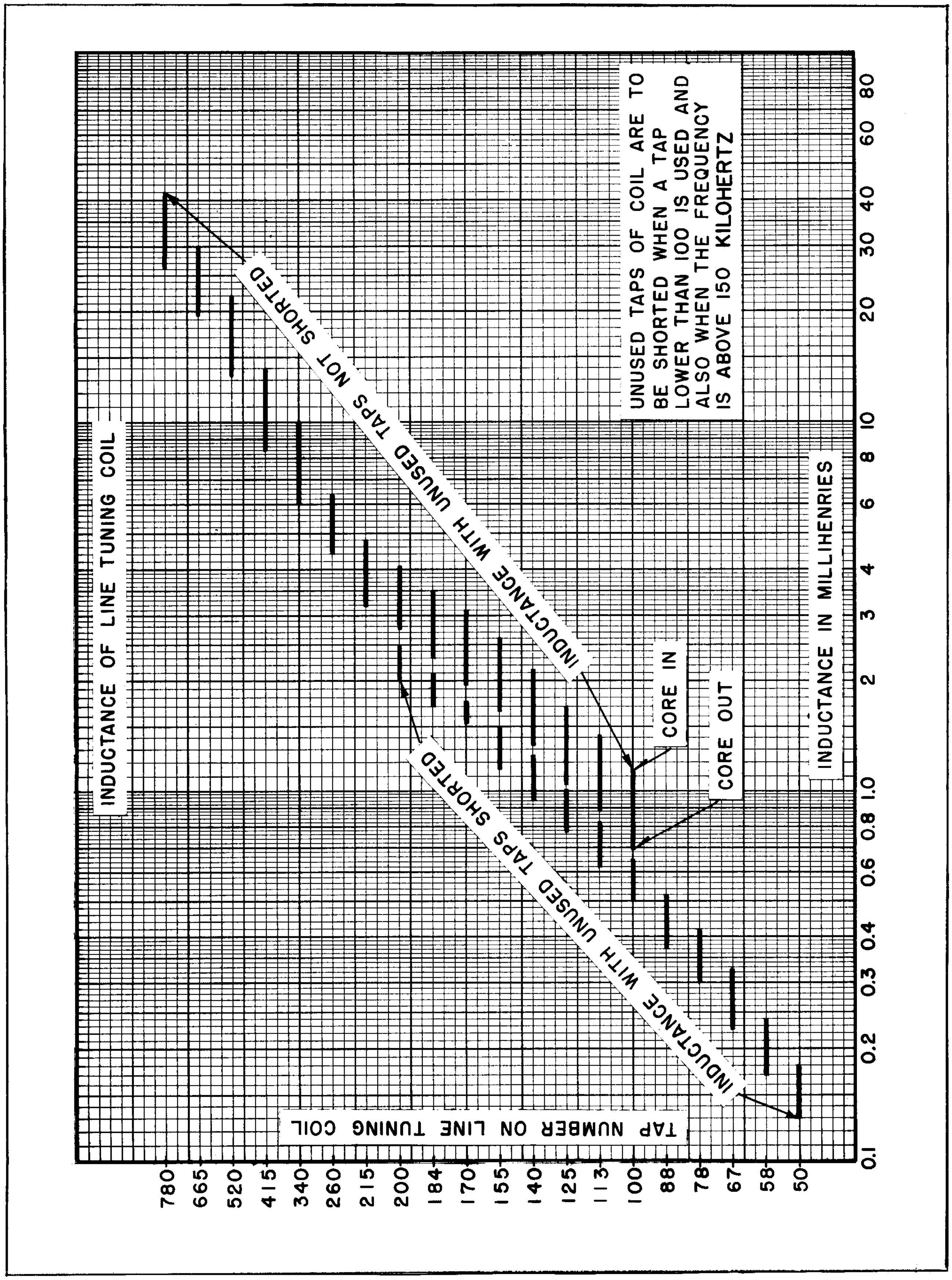

Fig. 5. Inductance of Line Tuning Coil (Curve 358433)

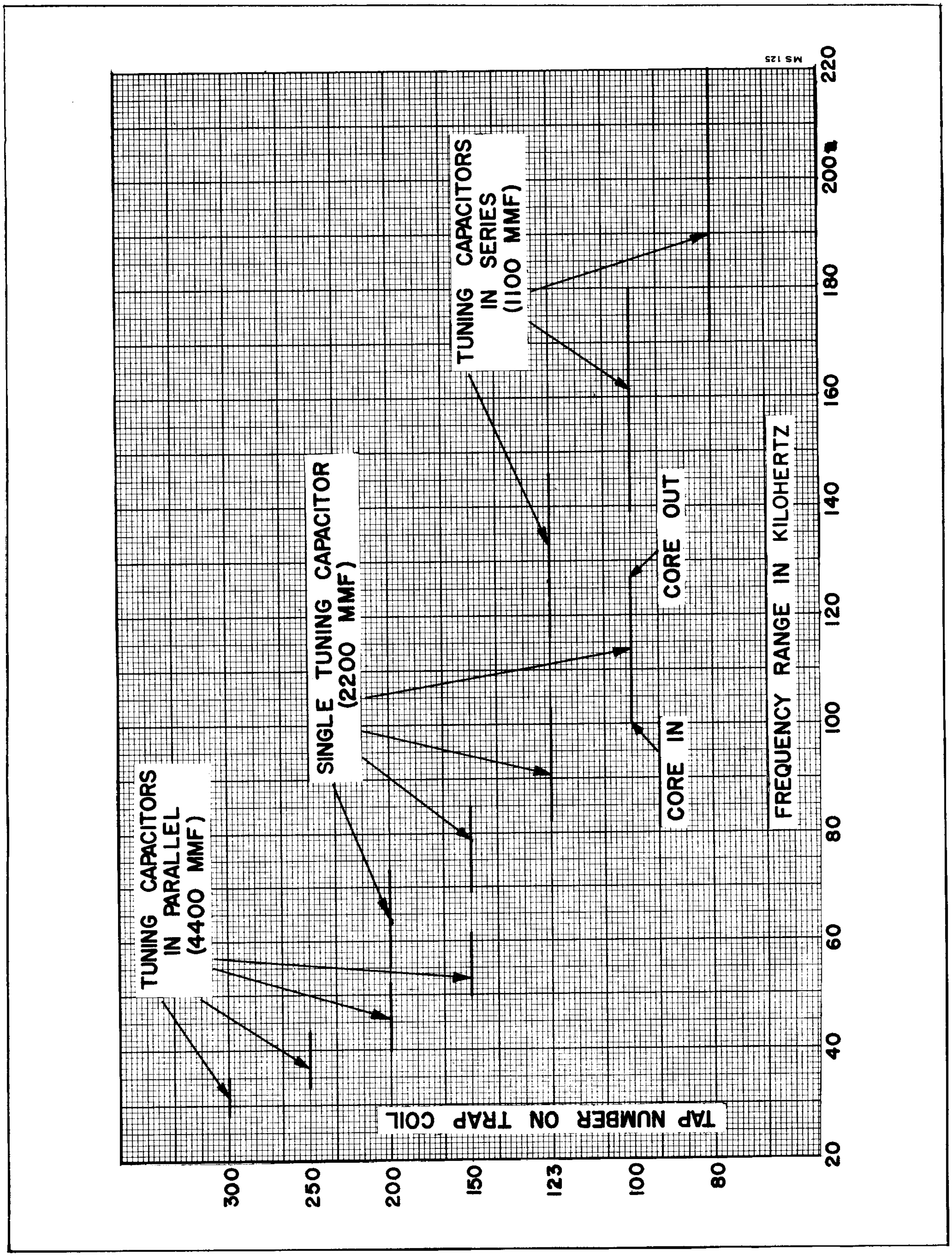

Fig. 6. Frequency Calibration of Trap Circuit (Curve 358434)

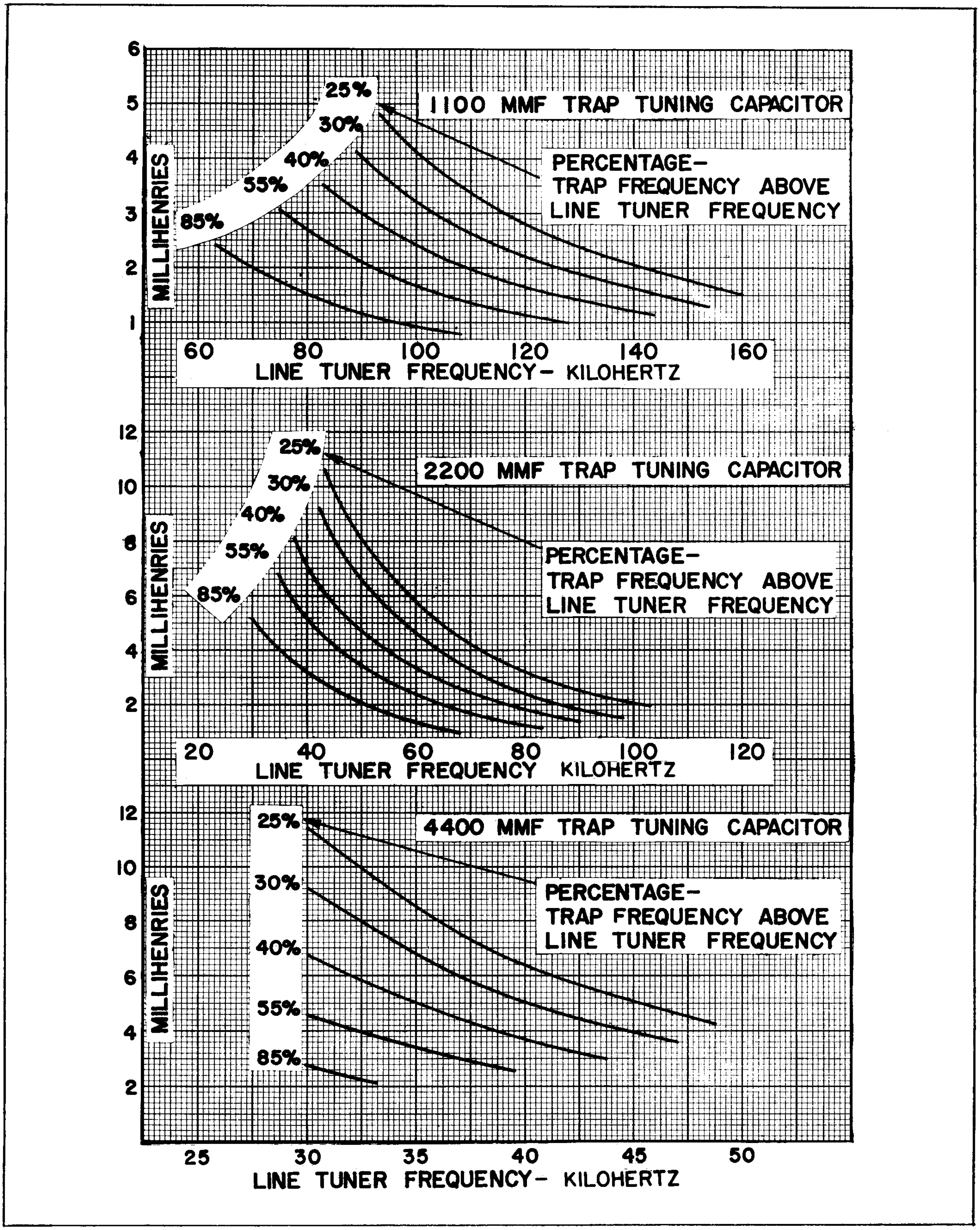

Fig. 7. Inductance of Trap Circuit at Line Tuner Frequency (Curve 358435)

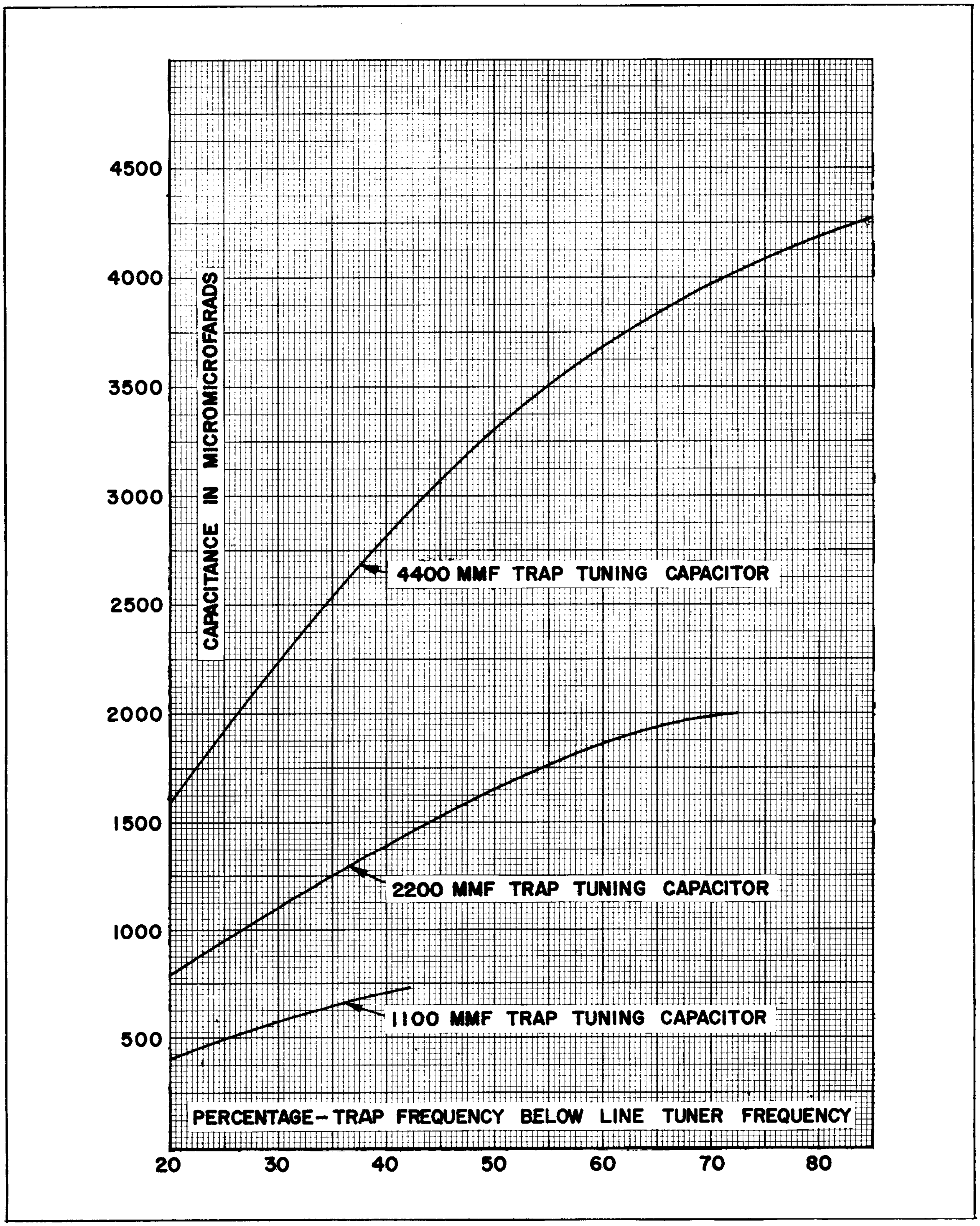

Fig. 8. Capacitance of Trap Circuit at Line Tuner Frequency (Curve 358436)

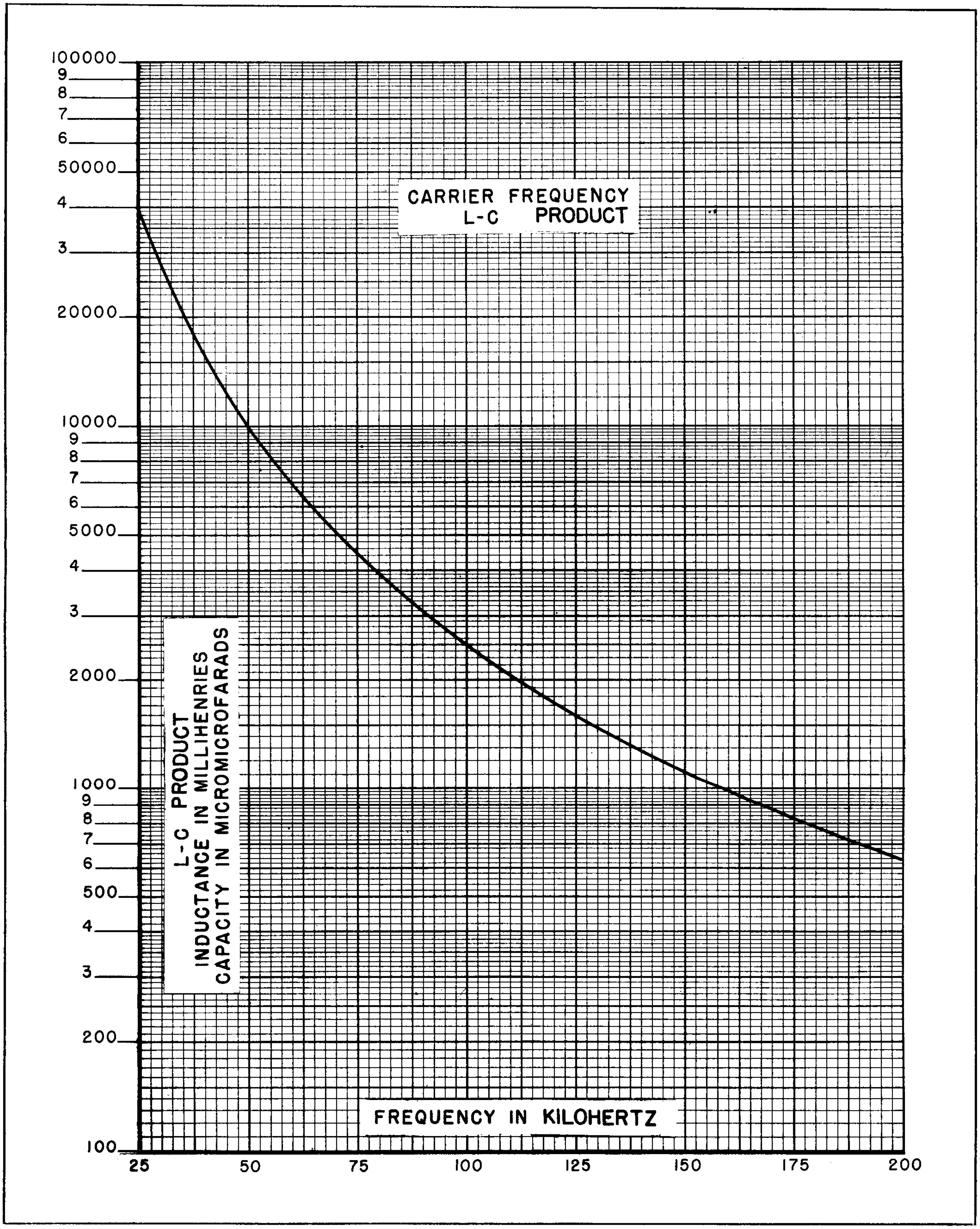

Fig. 9. Carrier Frequency L-C Product (Curve 358437)

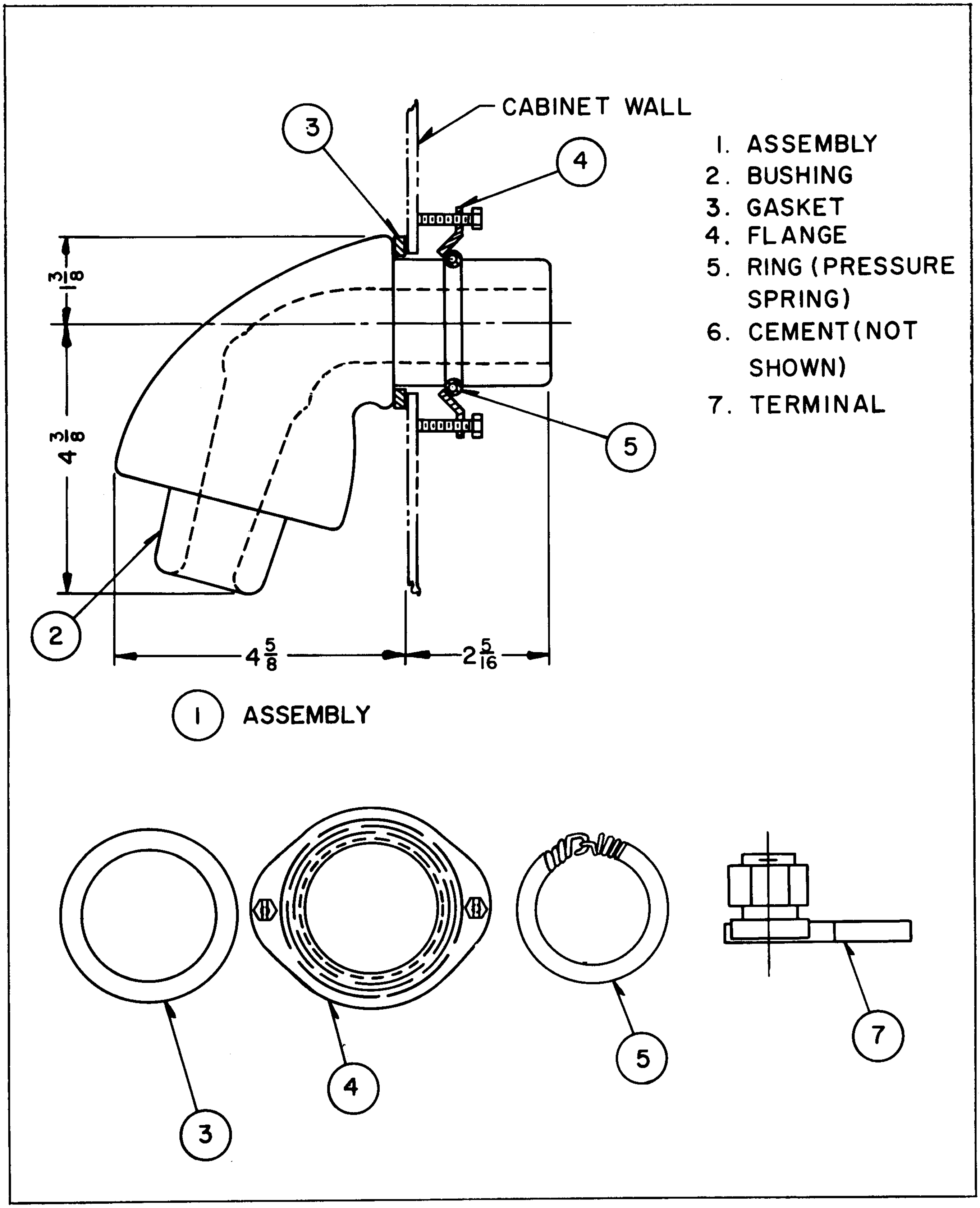

Fig. 10. Lead-In Bushing Assembly (862A186)

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
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TYPE JZ 72.64 – STYLE 606B363A13 – WITH 0.006 MFD. SERIES CAPACITOR

*** TYPE JZ 72.64D – STYLE 290B883A25 – WITH .006 MFD. SERIES CAPACITOR AND DRAIN COIL**

Supersedes I.L. 41-947.3
*Denotes change from superseded issue.

EFFECTIVE JANUARY 1969

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All electrical components are mounted on a hinged panel which can be opened for making the coaxial cable, capacitor lead-in and ground connections. The grounding switch, spark gap, tuning controls, metering jacks and all tap connections are accessible from the front of the panel.

Electrical Description

The electrical circuits are shown in Fig. 2. The circuit for each frequency employs identical components. Each coaxial cable connects through a Jack, J-1 to the primary of a matching transformer, T-1. The secondary winding of the transformer connects through a Jack, J-2, to a line tuning coil, L-1. The capacitors C-1 and C-2 which are in series between the line tuning coil and the trap circuit are short circuited except when the inductance of the trap circuit at the tuner frequency is greater than the inductance required to resonate the coupling capacitor. The shorting links can be changed to connect the capacitors in series, one capacitor alone, or both capacitors in parallel. The trap circuit consists of the tapped inductance L-2, which has an adjustable powdered-iron core, and tuning capacitors C-3 and C-4. Links on the front of the panel provide for connecting the tuning capacitors in series, one capacitor alone, or both capacitors in parallel. Both trap circuits are connected to a protector unit, which consists of an adjustable spark gap SG-1 and a knife switch S-1. The spark gap protects the equipment from excessive voltage surges. The knife switch is provided for grounding the lead-in from the coupling capacitor while adjustments are being made.

The JZ 72.64 tuner includes a 0.006-mfd. capacitor in series with the output lead to the protector unit. This allows the tuner to be used with coupling capacitors up to 0.015 mfd. When a drain coil is supplied with the tuner, it is identified as a Type JZ 72.6D tuner. If both capacitor and drain coil are included, the tuner is Type JZ 72.64D.

Typical response curves for the type JZ 72.6 tuners are plotted in Fig. 1. These curves were taken with an 1870-mmf. coupling capacitor and a 300-ohm resistive load. The two sections of the tuner were adjusted for resonance (f_r) at 30 and 37.5 kHz, 80 and 100 kHz, and 160 and 200 kHz, respectively, for the three pairs of curves.

CHARACTERISTICS

Frequency Range:	30 to 200 kHz.
Input Impedance:	50 to 70 Ohms
Output Impedance:	100 to 1000 Ohms
Power Rating:	100 Watts Carrier-Unmodulated 25 Watts Carrier-100% Modulated
Coupling Capacitor Range:	JZ 72.6 – .00075 to .004 mfd. JZ 72.64 – .00075 to .015 mfd.
Minimum Frequency Separation:	25% of the lower frequency

INSTALLATION

It is recommended that the Line Tuner be located as near to the coupling capacitor as possible. The mounting dimensions are shown in Fig. 3.

Remove the upper knockout from the side of the cabinet nearest the coupling capacitor and install the porcelain bushing for the capacitor lead-in as described in the following section.

Connections

CAUTION

Before making any connections to this equipment, turn off the power switch of the carrier transmitter and ground or open circuit the lead-in at the coupling capacitor.

The assembly of the Style 1352445 accessories for the coupling capacitor lead-in cable is shown in Fig. 10. Before permanently assembling the bushing in the cabinet wall, run the lead-in cable through the bushing and into the cabinet to determine the correct length of lead-in cable. Allow sufficient length of cable to connect to the ground-

ing switch contact stud with the panel swung open. Mark the cable at the bushing to locate its position and remove the cable and bushing from the cabinet. Place the bushing in an inverted position with the openings level. Melt the cement supplied with the accessory package and pour it into the bushing. After the cement has hardened, install the bushing in the cabinet wall.

Remove the connection of the tuning unit from the terminal stud of the jaw contact of the grounding switch. Connect the capacitor lead-in cable to this terminal stud using the cable terminal supplied with the bushing. Tighten the nut securely. Replace the connection from the tuning unit using the second nut. This will permit disconnecting the tuning unit without disturbing the coupling capacitor lead-in cable connection.

Coupling Capacitor Lead-In Cable

Since the lead-in cable between the coupling capacitor and the line tuning unit is in a high-impedance carrier-frequency circuit, care must be exercised to keep the leakage to a minimum value.

The lead-in cable should be supported with as few insulators as possible. The insulation of this lead-in cable with respect to ground must be much better than is ordinarily employed for the voltage which exists between these points, as it effectively shunts the reactive elements of the resonant circuit at carrier frequency. The impedance of this resonant circuit may be as high as five thousand ohms and leakage resulting from rain, snow, sleet, too long a lead-in cable, or too many supporting insulators will reduce the effective power output of the transmitter and the sensitivity of the receiver.

An installation which limits this leakage to a minimum will have less signal strength variation under adverse conditions, when reliable operation is of the greatest value.

The insulators used for supporting the lead-in cable should have at least a 7.5-kv rating. Care should be taken not to break the insulation of the cable when clamping it to the insulators. At least once a year the insulators should be washed to remove the accumulation of dirt.

For the lead-in, use a good quality rubber covered cable of at least 7500 volts service grade, with a conductor equivalent to No. 14 gauge or larger. This cable is usually supplied with the coupling capacitor.

Coaxial Cable

Two screws are mounted in the left wall of the cabinet for securing the coaxial cables. Connect the shield of the cable to terminals #2 and #4, and the center conductors to terminals #3 and #5. Connect a good ground to the cabinet and to terminal #1 of the terminal board. Run a copper bonding cable from the cabinet to the base of the coupling capacitor.

Follow the instructions given in Fig. 2 for the connection of the coaxial cables. Remove the shield braid so that one to two inches of the inner insulation is exposed. The outer jacket of the coaxial cable should cover the shield braid as much as possible to insulate it against the high voltage that may exist between the shield braid and the tuner cabinet during a fault. Connect the cable shields to terminals 2 and 4 as indicated in Fig. 2, but do not ground these leads to the tuner cabinet. See that the coaxial cable leads are positioned so that the exposed portion of the cable shield and its lead are spaced away from the metal cabinet proper. The coaxial cable is grounded at the carrier equipment end only. The use of two-winding transformers allows grounding of the coaxial-cable shield braid at the carrier-set end only, and this eliminates any path for the flow of 60-cycle current (during a ground fault) through the coaxial cable and transformer winding.

ADJUSTMENTS

CAUTION

When making any tap adjustments or changing any connections in this tuner, make certain that the grounding switch is closed. Do not depend on the drain coil for personal safety. Do not touch any terminal when the transmitter is on.

The first consideration in adjusting this tuner is to determine the two operating frequencies. In general, it is recommended that the higher of the two operating frequencies be at least 125 per cent of the lower frequency. This is because the losses increase as the operating frequencies approach each other. Also, for close frequency separation, the inductive reactance of the trap circuit at the tuner frequency may be much greater than the value re-

quired to resonate the coupling capacitor. This requires the insertion of capacitance in series with the tuning circuit in order for resonance to be obtained.

In addition to the operating frequencies, the capacitance of the coupling capacitor must be known in order to determine the appropriate tuning adjustments.

PRELIMINARY ADJUSTMENTS

The transformers used in this line tuner provide an impedance match for a 50 to 70 ohm coaxial cable to 100 to 1000 ohm power line. The impedance of the different taps of the transformer, T-1, are given in the following table.

Coaxial Tap	Tuner Tap	Line Impedance
2	4- 5	100
3	4- 5	139
2	6- 7	193
3	6- 7	268
2	8- 9	372
3	8- 9	517
2	10- 11	720
3	10- 11	1000

The average power line impedance is 400 to 600 ohms. If the impedance of the power line is known, connect the COAX and TUNER leads of the transformer to the corresponding taps. If the power line impedance is not known, connect the COAX lead to tap 3 and the TUNER leads to taps 8 and 9. Readjustment of the taps will be made as a part of the Final Adjustment.

The following procedure will determine the approximate adjustment of the line tuning coils and the trap circuits.

For these calculations:

F_1 = lower frequency in kHz.

F_2 = higher frequency in kHz.

C_0 = capacitance of coupling capacitor in MMF

For the JZ 72.64 tuner, in determining the required inductance, do not use the rated capacitance of the coupling capacitor for Cc. Because of the 0.006-mfd. capacitor (C5) in the tuner output circuit, the net capacitance must be calculated from the formula:

$$Co = \frac{(.006)\ (Cc)}{(.006 + Cc)}$$

where Cc is the rated capacitance of the coupling capacitor, and Co is the calculated value to use in the procedure described in the following paragraphs. (All values are in micro-microfarads) For example, if the coupling capacitor is 0.006 mfd., then the net value of Co is 0.003 mfd. Similarly, for a 0.005 mfd. coupling capacitor, $Co = \frac{.006 \times .005}{.011} = .0027$ mfd. (Then use 2700 mmf. in determining required inductance.)

A. Calculation of Line Tuner adjustments for the lower frequency section.

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F-2.

2. Determine the percentage that the trap frequency F_2 is above the line tuner frequency F-1 by using the following formula:

$$\frac{F2 - F_1}{F_1} \times 100 = \text{percentage}$$

   Refer to Fig. 7 and determine the inductance of the trap circuit at the line tuner frequency F1 for the trap tuning capacitor and per cent separation determined above.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_1.

   Calculate the value of inductance required to resonate the coupling capacitor by using the following formula:

$$\frac{\text{L-C product}}{C_O} = \text{mh for resonance at } F_1$$

   If this value of inductance is greater than the inductance of the trap circuit obtained in 2 above, then the difference is the value of inductance required in the line tuning coil.

   In this case, refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

4. If the inductance of the trap circuit at F_1 is greater than the value required to resonate the coupling capacitor, then series capacitance must be included in the tuning circuit in order to obtain resonance. Three values of

capacitance are available, which for these calculations will be designated as C_A, C_B, and C_C.

$C_A = C_1$ and C_2 in parallel = 2400 mmf

$C_B = C_1$ (or C_2) = 1200 mmf

$C_C = C_1$ and C_2 in series = 600 mmf

Calculate the resultant capacitance of the coupling capacitor in series with capacitors C_1 and C_2 in parallel.

$$\frac{C_O \times C_A}{C_O + C_A} = \text{capacitance in tuning circuit}$$

Divide the L-C product obtained in 3 above by this value to determine the inductance required for resonance.

5. If this value of inductance is not greater than the inductance of the trap circuit, repeat the calculation as in 4, above, with capacitance C_B (1200 mmf) and, if necessary, with C_C (600 mmf).

6. Subtract the inductance of the trap circuit from the value of inductance determined in 4 or 5, above. This is the value of inductance required in the line tuning coil.

   Refer to Fig. 5 for the tap number on the line tuning coil for this value of inductance.

NOTE

When the two frequencies are separated by more than 100 per cent, the inductance of the trap circuit at the line tuner frequency will be only a small part of the inductance required for resonance and so will cause a change of only one or two taps on the line tuning coil.

B. Calculation of Line Tuner adjustments for the higher frequency section.

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F_1.

2. Determine the percentage that the trap frequency F_1 is below the line tuner frequency F_2 by using the following formula:

$$\frac{F_2 - F_1}{F_2} \times 100 = \text{percentage}$$

   Refer to Fig. 8 and determine the capacitance of the trap circuit for the trap tuning capacitor and per cent separation determined above.

   Calculate the resultant capacitance of this value in series with the coupling capacitor, using the following formula:

$$\frac{C_O \times C_T}{C_O + C_T} = \text{capacitance in tuning circuit}$$

   This is the value of capacitance which must be resonated by the line tuning coil.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_2.

   This product divided by the capacitance value calculated in 2, above, is the value of inductance required in the line tuning coil.

4. Refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

NOTE

Since the preceding calculations cannot include the effect of stray capacitance, possible inductance of the power line, or inductance of the matching transformer, the final adjustment of the line tuning coil may vary by one or two taps.

Two sample calculations for tap setting are shown on the following pages.

SAMPLE CALCULATION #1

F_1 = 160 kHz

F_2 = 200 kHz

C_0 = 4000 mmf

A. 1. F_2 = 200 kHz trap frequency. From Fig. 6 tuning capacitor = 1100 mmf. Tap number = 80.

2. $\frac{200 - 160}{160} \times 100 = 25\%$

   From Fig. 7.
   For 1100 mmf capacitor and 25% separation.
   Inductance = 1.6 mh.

3. From Fig. 9.
L-C product at 160 kHz = 980.
$\frac{980}{4000}$ = 0.245 mh for resonance

4. 1.6 mh greater than 0.245 mh.
With C-1 and C-2 in parallel in tuning circuit.
2400 mmf in series with 4000 mmf is 1500 mmf.

$\frac{980}{1500}$ = 0.653 mh for resonance

5. 1.6 mh greater than 0.653 mh.
With C-1 in tuning circuit (C-2 shorted)
1200 mmf in series with 4000 mmf is 924 mmf.

$\frac{980}{924}$ = 1.06 mh for resonance

1.6 mh greater than 1.06 mh.
With C-1 and C-2 in series in tuning circuit.
600 mmf in series with 4000 mmf is 522 mmf.

$\frac{980}{522}$ = 1.88 mh for resonance at 160 kHz

6. 1.88 − 1.6 = 0.28 mh required in line tuning coil.

Refer to Fig. 5. For 0.28 mh use tap number 67 of the line tuning coil. Short the unused taps.

B. 1. F_1 = 160 kHz trap frequency.

From Fig. 6.

C = 1100 mmf
Tap = 100

2. $\frac{200 - 160}{200}$ x 100 = 20%

From Fig. 8.
Trap capacitance for 1100 mmf. tuning capacitor and 20% separation is 390 mmf.
390 mmf in series with 4000 mmf is 356 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

$\frac{630}{356}$ = 1.77 mh for resonance at 200 kHz.

4. From Fig. 5.
For 1.77 mh, use tap number 184 of line tuning coil.
Short the unused taps.

SAMPLE CALCULATION #2

F_1 = 30 kHz
F_2 = 200 kHz
C_0 = 850 mmf

A. 1. F_2 = 200 kHz trap frequency.

From Fig. 6.

Tuning Capacitor = 1100 mmf.

Tap Number = 80.

2. $\frac{200 - 30}{30}$ x 100 = 566%

From Fig. 7.

For 1100 mmf capacitor and 566% separation.
Inductance will be less than the 2.5 mh shown for 85% separation at 63 kHz.

3. From Fig. 9.
L-C product at 30 kHz = 28000.
$\frac{28000}{850}$ = 33 mh for resonance

From Fig. 5.
Tap number 780 gives the inductance range of 26 to 40 mh so the trap inductance can be compensated for without changing taps.

B. 1. F_1 = 30 kHz trap frequency

From Fig. 6.
Tuning Capacitor = 4400 mmf.
Tap Number = 300.

2. $\frac{200 - 30}{200}$ x 100 = 85%

From Fig. 8.
Trap capacitance for 4400 mmf and 85% separation is 4270 mmf.
4270 mmf in series with 850 mmf is 710 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

$\frac{630}{710}$ = 0.89 mh for resonance

4. From Fig. 5.
For 0.89 mh use tap number 125 of line tuning coil.
Short the unused taps.

NOTE

The instructions in Fig. 5 state that the unused taps are to be shorted when a tap lower than 100 is used and also when the frequency is above 150 kHz.

This procedure will leave a gap in the inductance range between tap 100 with the unused turns not shorted and tap 88 with the unused turns shorted. Continuous inductance adjustment can be obtained by using tap 113 with unused turns shorted as the next lower inductance tap below tap 100 with the unused turns not shorted.

Final Adjustments

After making the connections of trap capacitors, trap coil taps, and line tuning coil taps as determined under Preliminary Adjustments, the circuits must be adjusted to meet the requirements of the particular installation.

The trap circuits should be tuned to resonance before the line tuning coils are adjusted. For tuning with a local transmitter connected to cabinet terminal number 3, connect a thermocouple-type milliammeter to Jack J-1 on the right side of the panel or connect a vacuum-tube voltmeter from Jack J-2 on the right to ground. Turn on the local transmitter and adjust the core of the trap coil L-2 on the right for minimum current in Jack J-1 or minimum voltage from Jack J-2 to ground. Lock core in this position.

If the other channel also has a local transmitter, adjust the trap coil L-2 on the left for minimum current in Jack J-1 on the left or minimum voltage from Jack J-2 on the left to ground.

To adjust the trap circuit with a signal from a remote transmitter, measure the signal voltage from Jack J-2 to ground. Have the transmitter turned on and off several times to be certain that the desired signal is the one which is being received. Adjust the core of the trap coil for minimum voltage and lock the shaft.

After both trap circuits have been adjusted, tune the line tuning coils for resonance. Turn on the local transmitter and adjust the core of the line tuning coil, L-1, for maximum current in Jack J-1. If the current is increasing with the core all the way in or all the way out, change the tap connection to the next higher or lower tap, respectively.

To tune the line tuning coil with a signal from a remote transmitter, adjust the coil for maximum voltage from Jack J-2 to ground.

A line coupling tuner which is used to bypass a circuit breaker should be adjusted with the circuit breaker open. However, since this may be very difficult to arrange, an alternate method is to disconnect the coupling capacitor from the line and connect its high potential side to ground through a resistor. If the impedance of the line with the circuit breaker open is known, use a resistor of this value. If the line impedance is not known, use a 500-ohm resistor. Adjust the trap coils and line tuning coils in accordance with the previous instructions.

The matching transformer taps should then be adjusted by the following procedure:

Open the coaxial-cable circuit by disconnecting the COAX link from the transformer tap (2 or 3). Connect a non-inductive resistor of approximately 60 ohms between the COAX terminals (cabinet terminals 2-3 or 4-5). The wattage rating of the resistor must be sufficient to dissipate the output of the transmitter. Connect a thermocouple-type milliammeter in series with the 60-ohm resistor. Turn on the local transmitter and record the current through the resistor. Then turn off the transmitter.

Disconnect the resistor and reconnect the COAX link to the transformer tap. Turn on the transmitter and compare the current reading in Jack J-1 with the value obtained with the resistor. If the current values are different, change the transformer tap connections to the taps which give a current in Jack J-1 nearest the current measured through the resistor. After each change of transformer taps, readjust the core of the line tuning coil for maximum current.

Tuning Adjustment with Dummy Load Resistors

An adjustment procedure for obtaining a more exact impedance match is shown in Fig. 4, Line Coupling Tuner Adjustment. The dummy load resistors must be of sufficient wattage rating to dissipate the transmitter output.

Adjustment of Spark Gap

Adjust the spark gap SG-1 to 0.015 inch spacing. Observe the gap while the local transmitter is trans-

mitting full power. If the gap arcs over, increase the spacing until the arcing stops. The minimum spacing for the gap depends upon the carrier power, the power line impedance, and the capacitance of the coupling capacitor.

MAINTENANCE

Routine Checks and Records

This Tuning Unit requires very little maintenance. It should be inspected occasionally to see if there has been excessive burning of the spark gap.

If the spark gap shown signs of burning, rotate the discs to a new position and readjust the gap. Usually a semi-annual or yearly inspection is sufficient.

A permanent record should be kept of tap settings and the position of the coil-tuning cores so that they can be restored to the correct positions in case of unauthorized changes.

Ordering Replacement Parts

Replacement parts for this Tuning Unit may be ordered through the nearest Westinghouse District Office. When ordering, include:

1. The following data from the nameplate of the Line Tuner:

   (a) The type number; (b) the style number.

2. The (a) Electrical Parts List symbol; (b) the function; (c) the description; (d) the designation.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	FUNCTION	DESCRIPTION	STYLE NUMBER
		SUB-ASSEMBLIES	
L-1	Line Tuning Coil	Line Tuning Coil Assembly	1474218
T-1	Transformer	Transformer Assembly	407C741G02
—	Trap	Trap Unit Assembly	1474013
—	Protector Unit	Protector Unit Assembly	1474014
		COMPONENT PARTS	
C-1	Capacitor-Series	Mica- 1200 mmf. ±5%, 5000V	290B762H01
C-2	Capacitor-Series	Same as C-1	
C-3	Capacitor-Trap Tuning	Mica- 2200 mmf. ±5%, 5000V	290B762H02
C-4	Capacitor-Trap Tuning	Same as C-3	
J-1	Jack-Coax Metering	Binding Post Type 2 Binding Posts 1 Shorting Link	 185A431H01 1474455
J-2	Jack-Line Metering	Same as J-1	
SG-1	Spark Gap	Disc Type	2 of 183A358H20 (discs only)
		OPTIONAL	
L-3	Drain Coil (When Used)	20,000 ohms minimum impedance over 30 - 200 kHz.	670B069G02
C-5	Series Capacitor (When Used)	Mica, 0.006 mfd., ±5% 3000V, PACW.	584C256H03

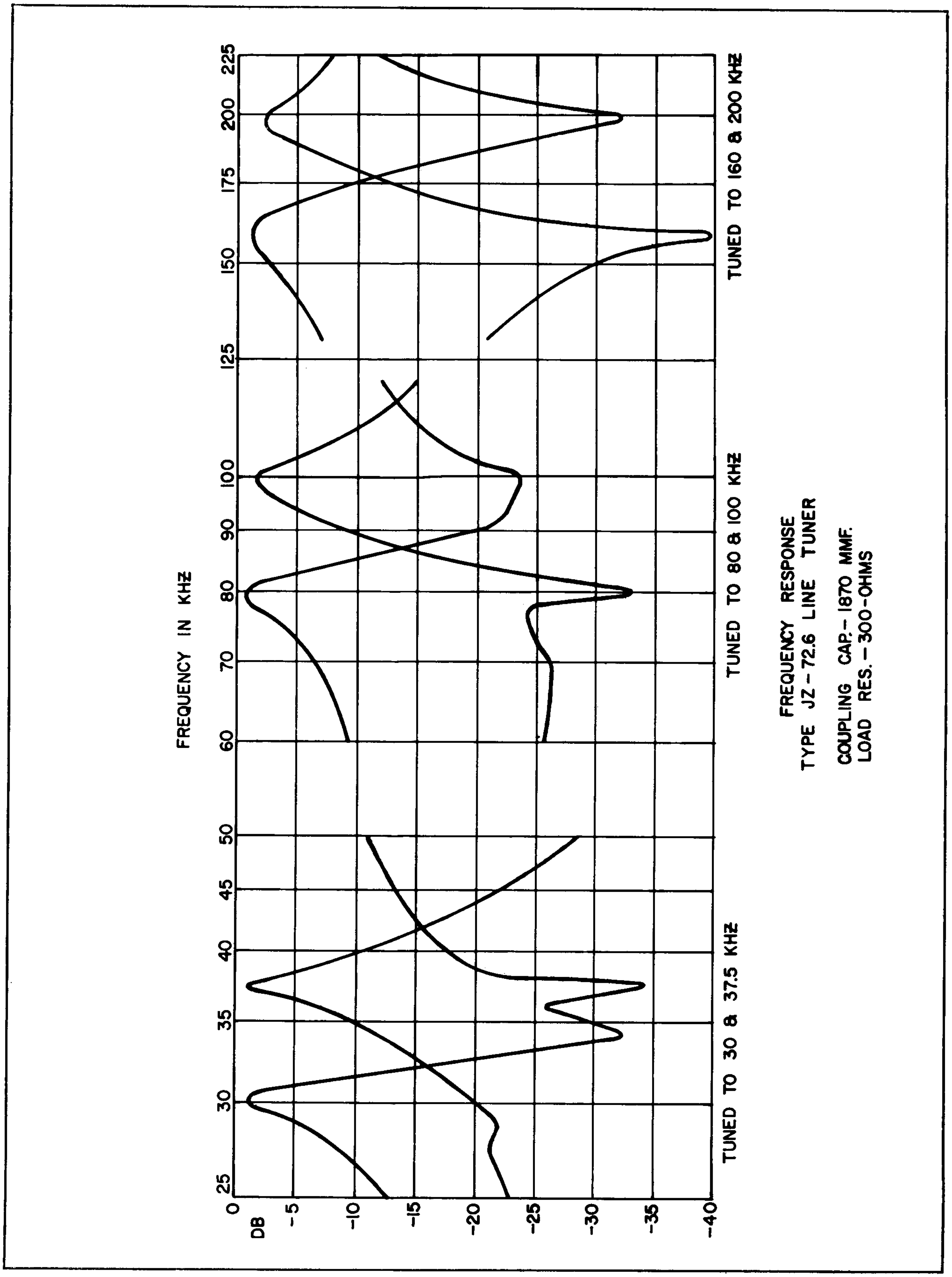


Fig. 1. Response Curves of JZ 72.6 Tuner. (Dwg. 862A348)

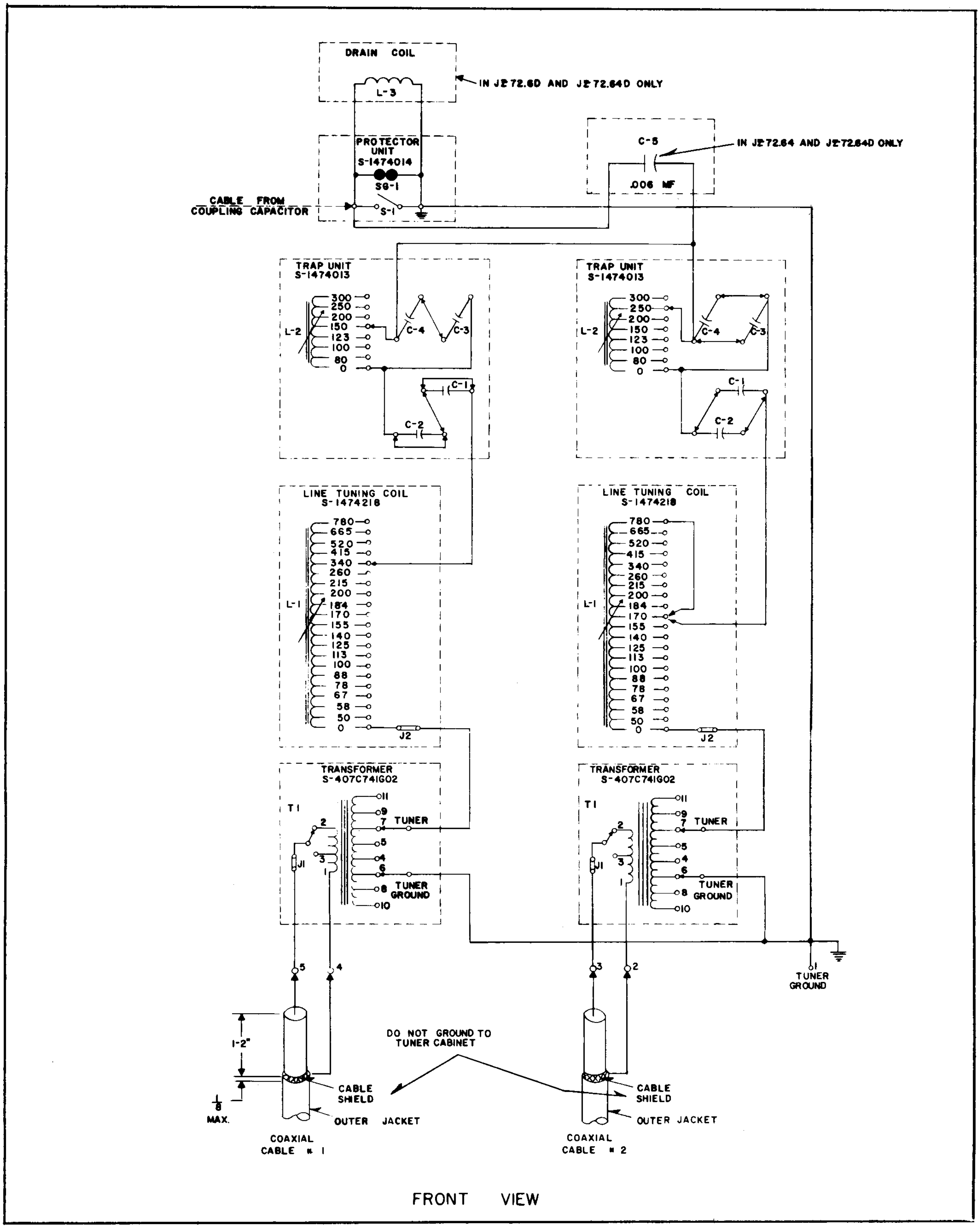


Fig. 2. Internal Schematic (Dwg. 410C091)

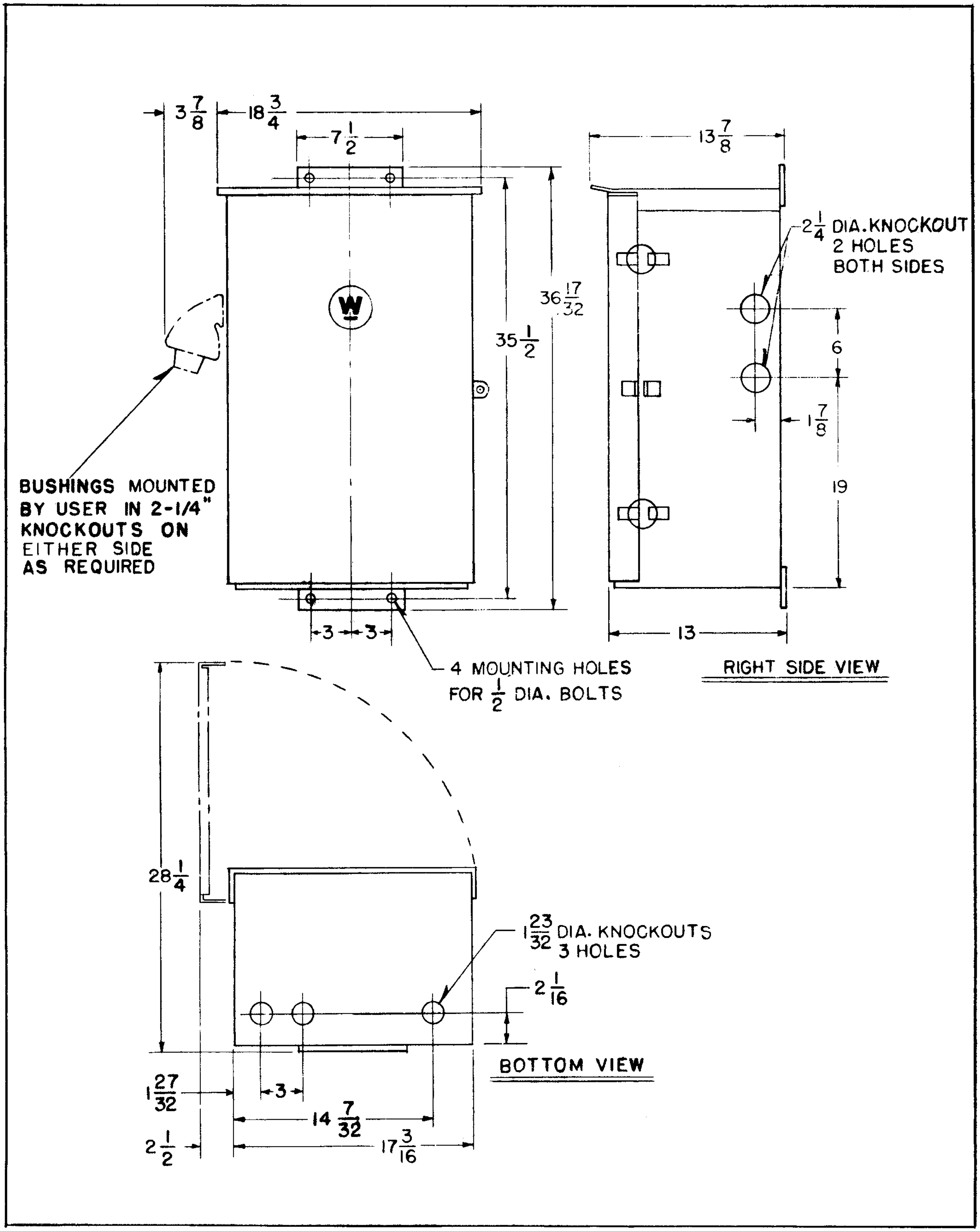


Fig. 3. Tuner Cabinet – Outline (Dwg. 50-B-7683)

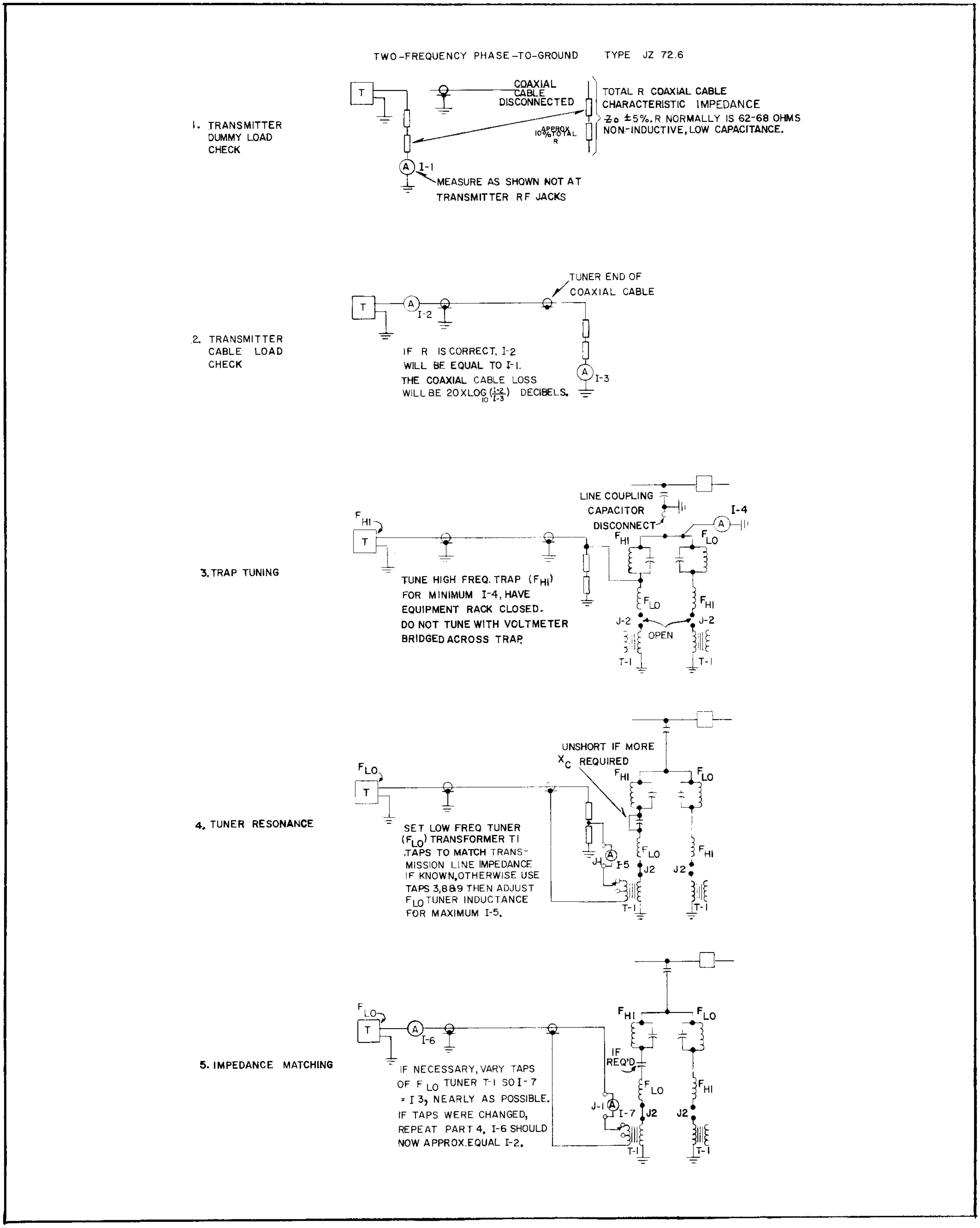


Fig. 4. Line Coupling Tuner Adjustment (Dwg. 585C117)

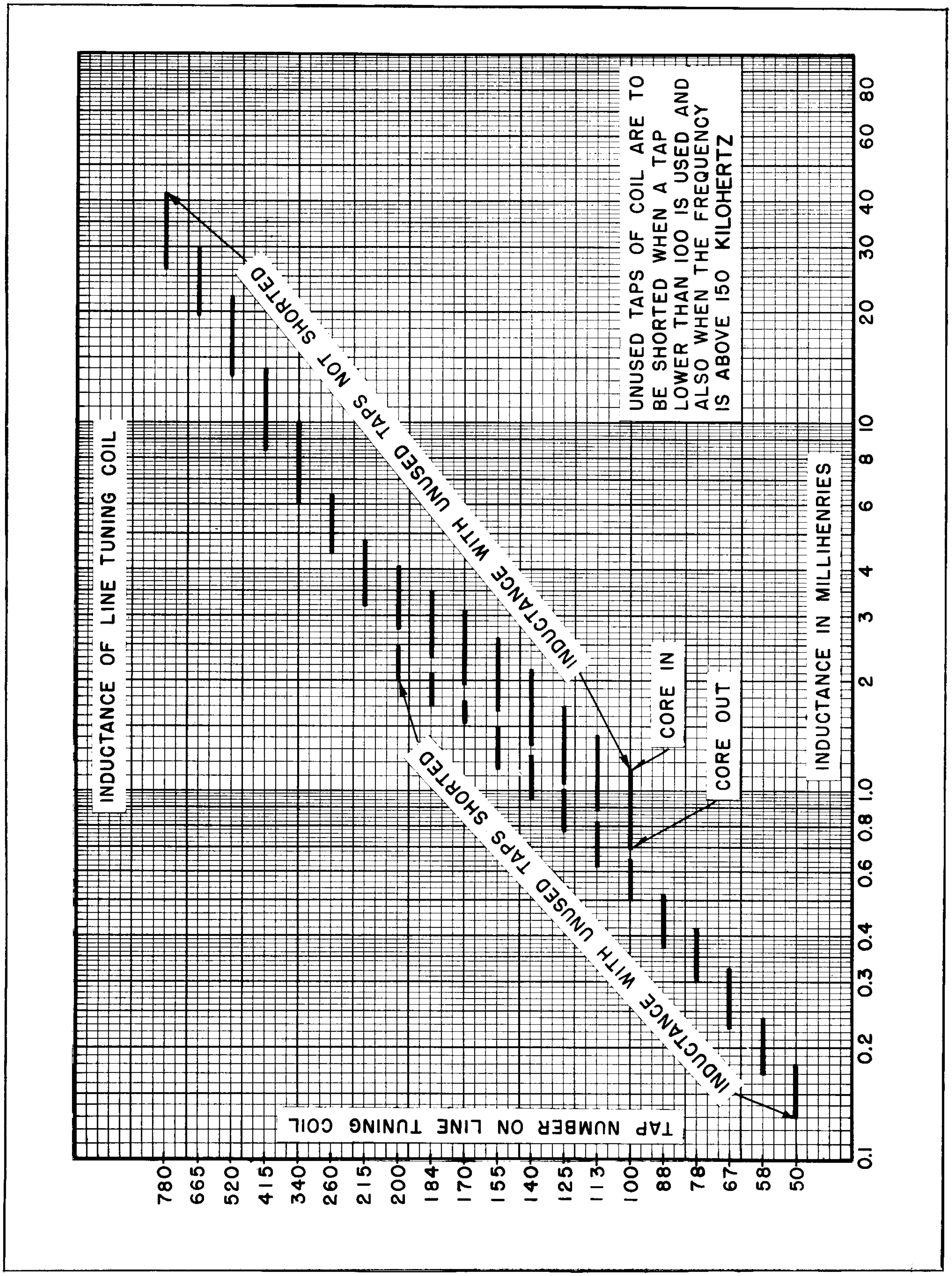


Fig. 5. Inductance of Line Tuning Coil (Curve 358433)

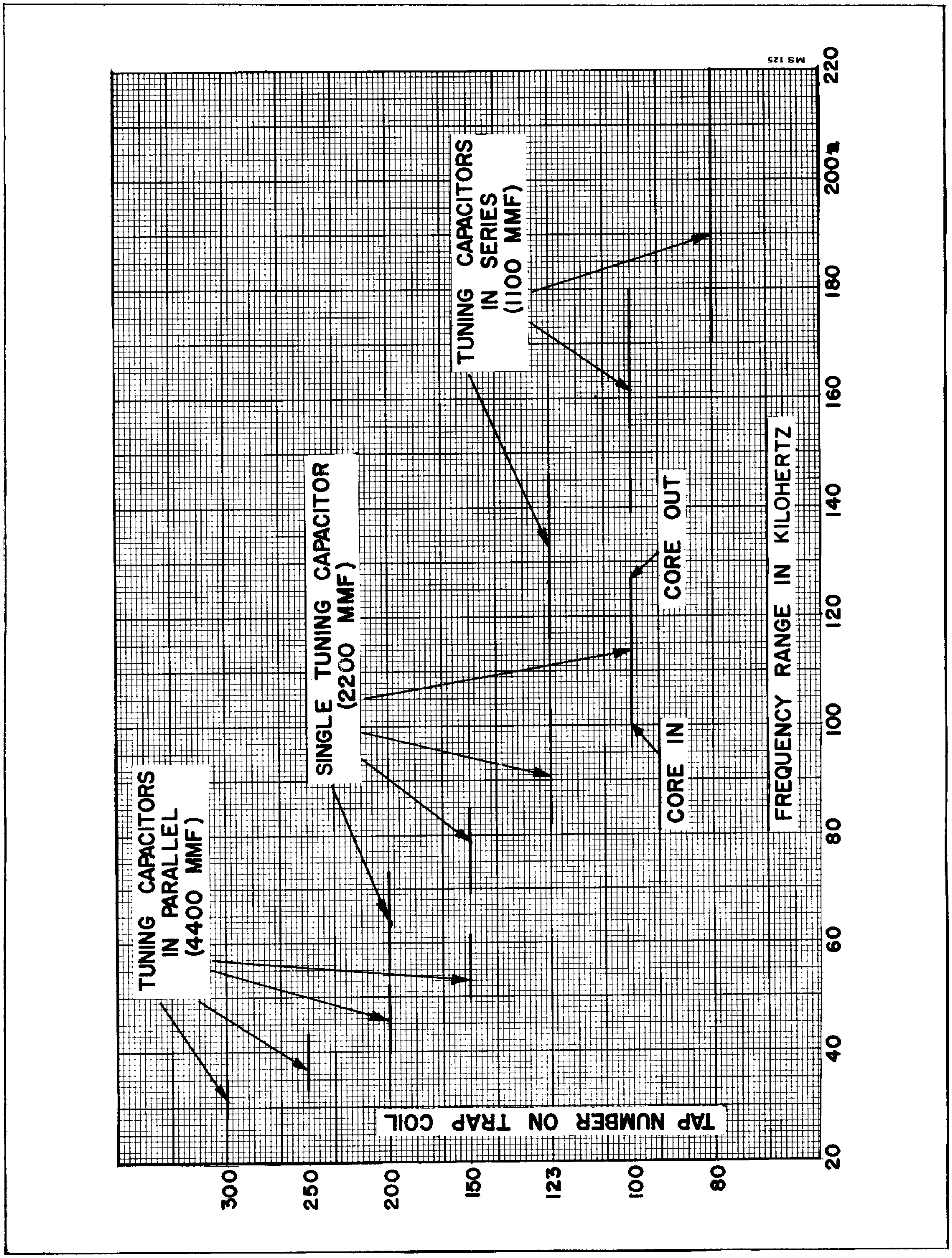


Fig. 6. Frequency Calibration of Trap Circuit (Curve 358434)

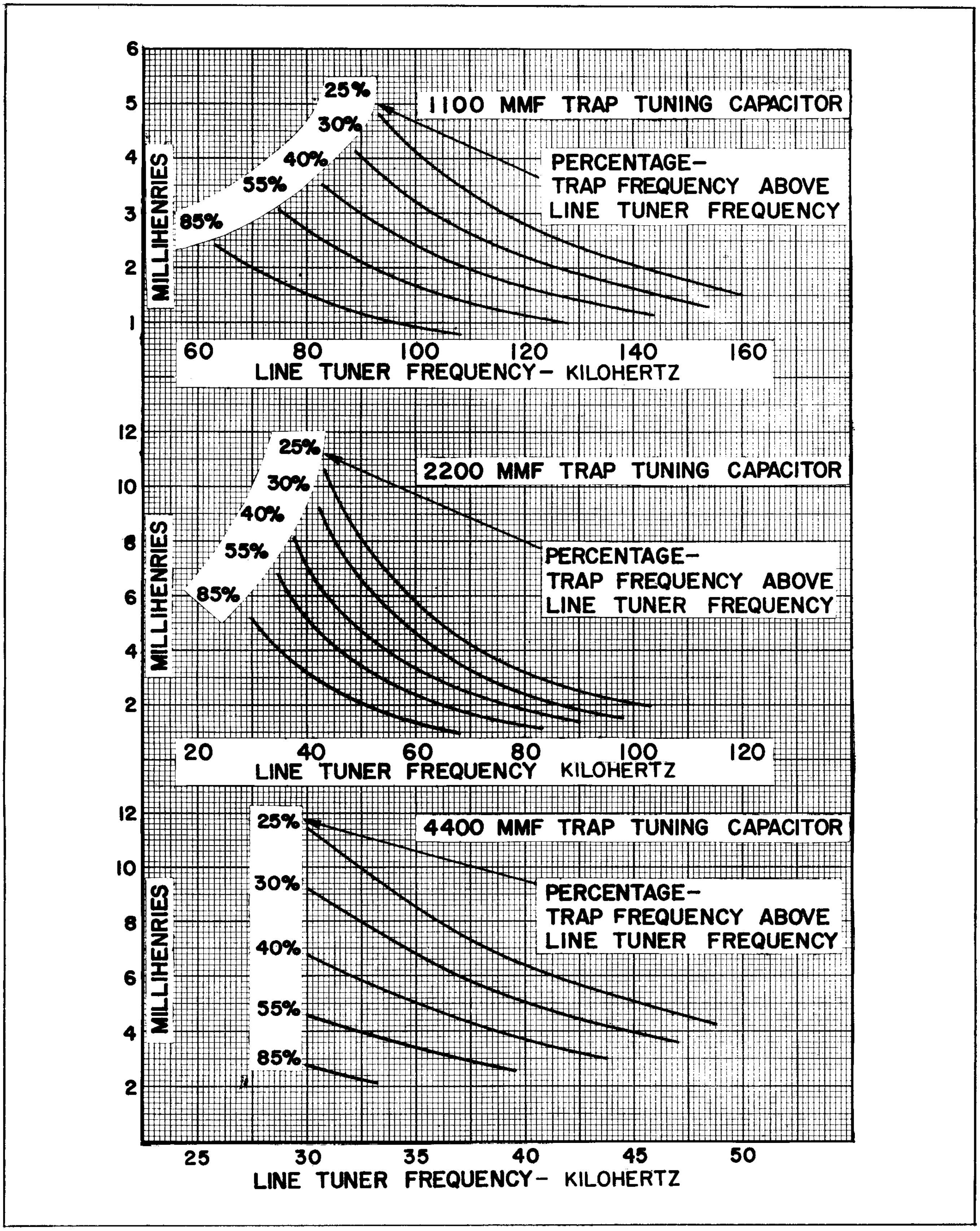


Fig. 7. Inductance of Trap Circuit at Line Tuner Frequency (Curve 358435)

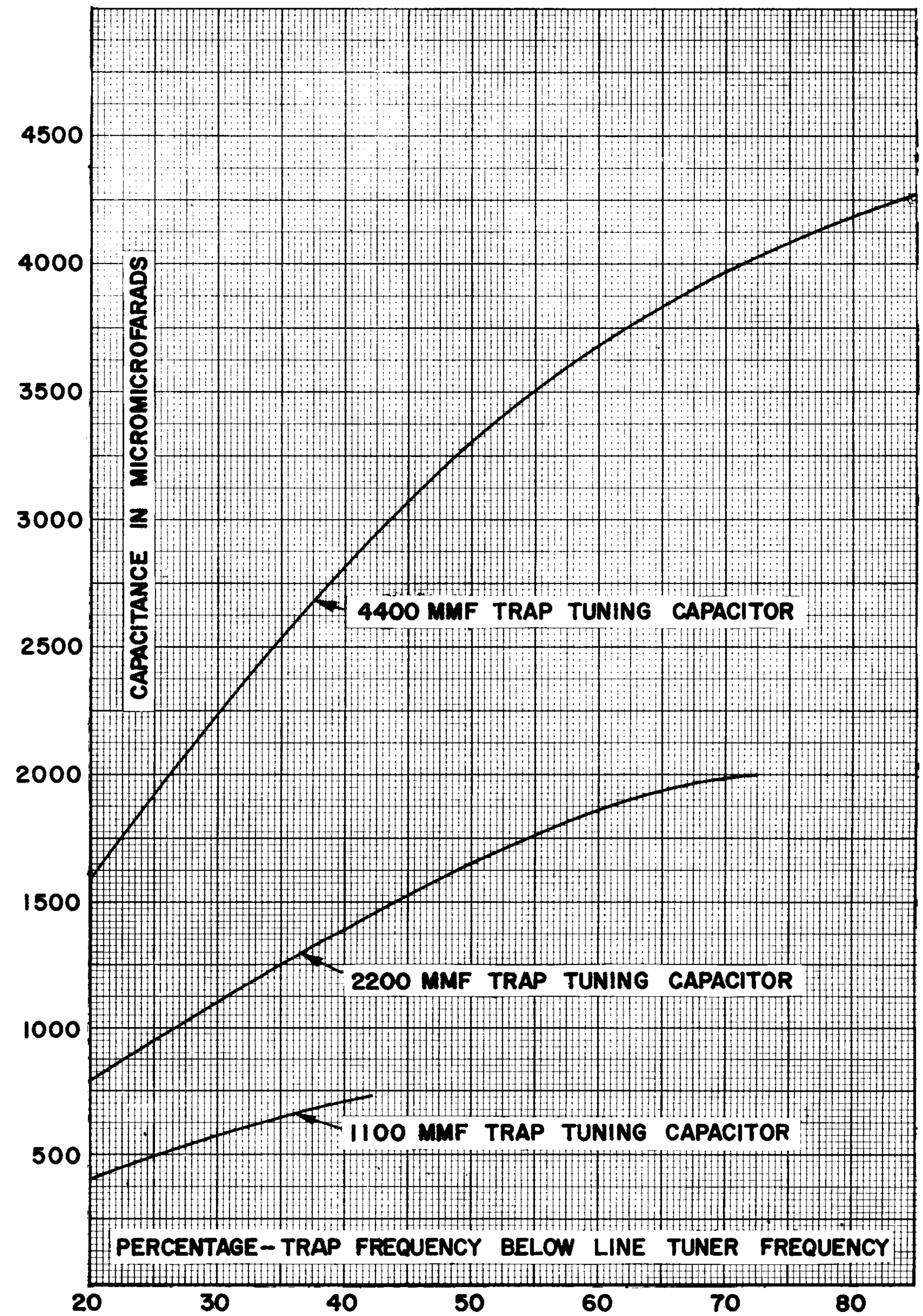


Fig. 8. Capacitance of Trap Circuit at Line Tuner Frequency (Curve 358436)

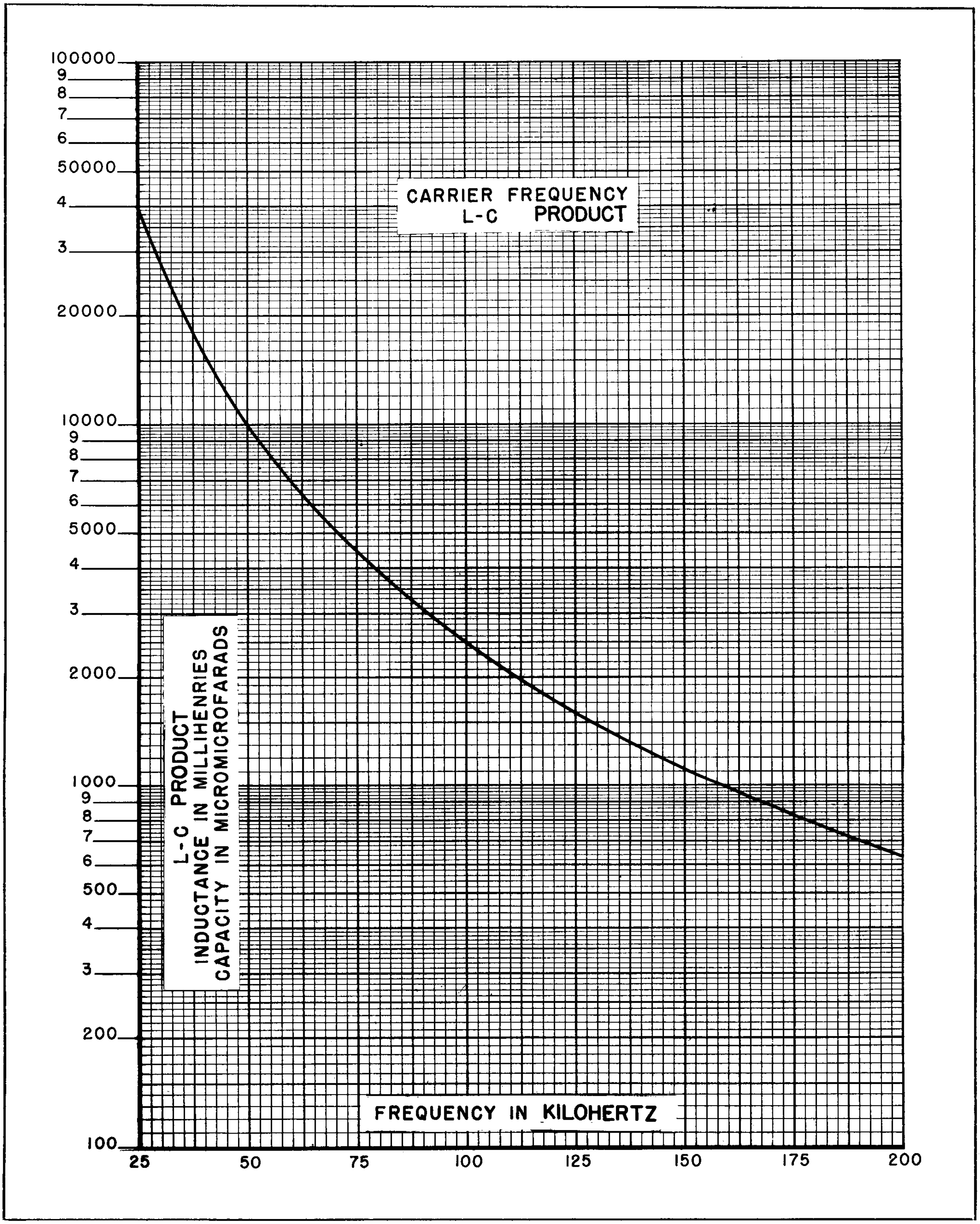


Fig. 9. Carrier Frequency L-C Product (Curve 358437)

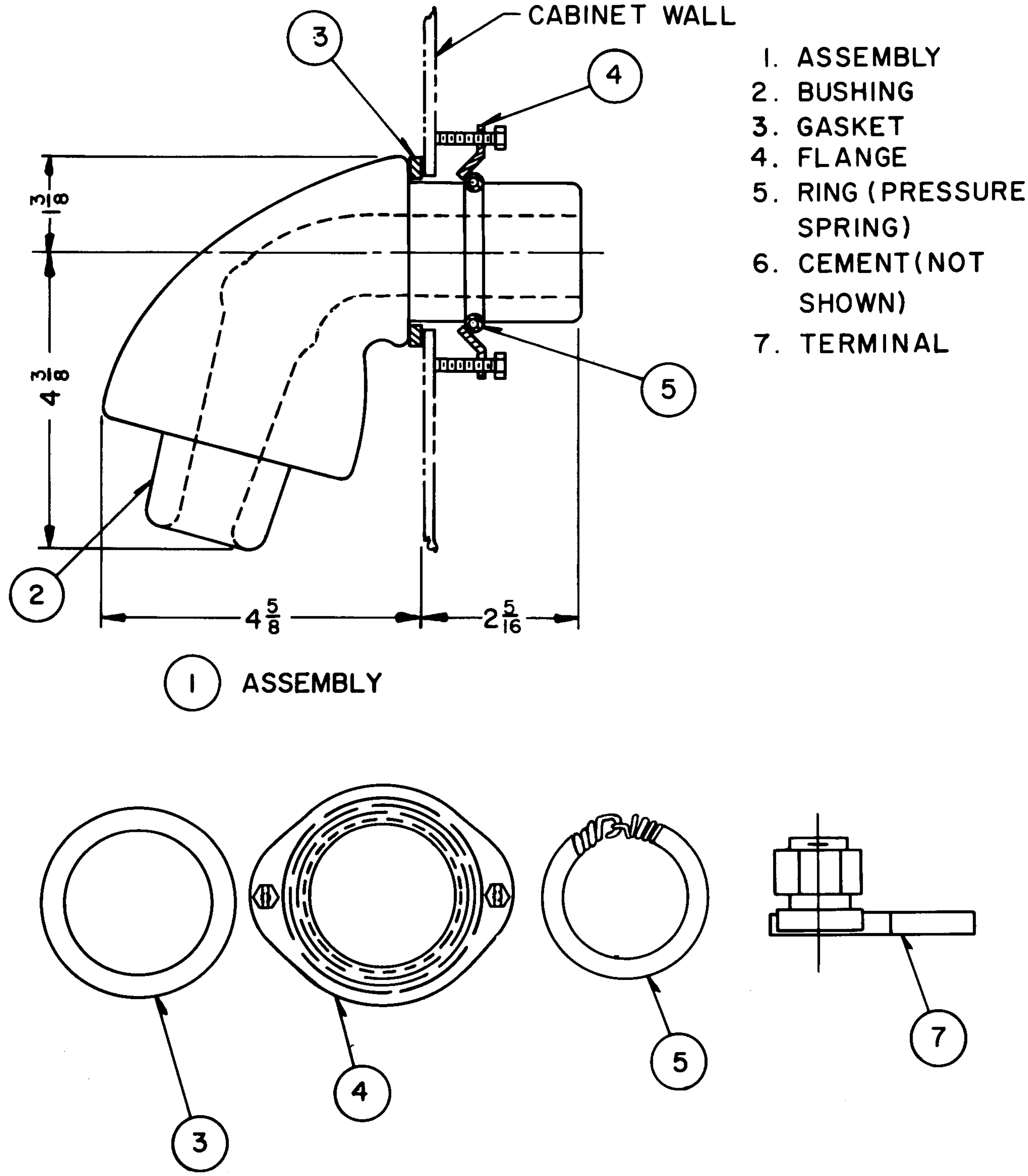


Fig. 10. Lead-In Bushing Assembly (862A186)

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE JZ-72.6 LINE COUPLING TUNERS

TWO-FREQUENCY PHASE-TO-GROUND
LINE COUPLING TUNERS
WITH TWO-WINDING MATCHING TRANSFORMER

TYPE JZ 72.6	– STYLE 290B883A23	– WITHOUT DRAIN COIL
TYPE JZ 72.6D	– STYLE 606B363A10	– WITH DRAIN COIL
TYPE JZ 72.64	– STYLE 606B363A13	– WITH 0.006 MFD. SERIES CAPACITOR
TYPE JZ 72.64D	– STYLE 290B883A25	– WITH .006 MFD. SERIES CAPACITOR AND DRAIN COIL

SUPERSEDES I.L. 41-947.3A
*Denotes change from superseded issue.

EFFECTIVE SEPTEMBER 1971

SAFETY WARNING!

Protect your life while making adjustments! Before handling any part of the electrical circuits:

1. BE SURE THE GROUNDING SWITCHES IN THIS ASSEMBLY ARE IN THE "GROUNDED" OR CLOSED POSITION.

2. BE SURE THAT ALL POWER SWITCHES IN THIS ASSEMBLY ARE TURNED "OFF".

Protect the equipment against damage by not applying power until thoroughly familiar with the ADJUSTMENTS described in this book.

SAFETY FIRST!

TABLE OF CONTENTS

SUPPLEMENTARY DATA

APPLICATION

These Line Coupling Tuners are designed for phase-to-ground coupling of two carrier frequencies from separate coaxial cables through a single coupling capacitor to a power line.

DESCRIPTION

Mechanical Description

The line tuner is mounted in a cabinet suitable for outdoor installation. Knockouts are provided on each side of the cabinet for the capacitor lead-in bushing. Knockouts for 1½ inch conduit for the coaxial cables are located in the bottom of the cabinet. The outline, mounting dimensions and the location of the knockouts are shown in Fig. 3.

All electrical components are mounted on a hinged panel which can be opened for making the coaxial cable, capacitor lead-in and ground connections. The grounding switch, spark gap, tuning controls, metering jacks and all tap connections are accessible from the front of the panel.

Electrical Description

* The electrical circuits are shown in Fig. 2. The high frequency tuner components are mounted on the left hand side of the panel and the low frequency components are on the right. Each coaxial cable connects through a jack J1 to the primary of a matching transformer T1. The secondary winding of T1 connects, through a jack J2 to to the line tuning coil L1. The line tuning coils are connected to the trap units. Both trap units consist of tapped inductance L2, which has an adjustable powdered-iron core, and tuning capacitors C-3 and C-4. Links on the front of the panel provide for connecting the tuning capacitors in series, parallel or one capacitor alone. The High Frequency Trap, mounted on the right hand side of the panel contains two additional capacitors C-1 and C-2 which may be required for proper tuner adjustment. Links are provided on the front panel to permit series, parallel or single capacitor connections.

* Both trap circuits are connected to a protector unit, which consists of an adjustable spark gap SG-1 and a knife switch S-1. The spark gap protects the equipment from excessive voltage surges. The knife switch is provided for grounding the lead-in from the coupling capacitor while adjustments are being made.

* The JZ72.64 tuner includes a .006 mfd. capacitor in series with the output lead to the protector unit. This allows the tuner to be used with coupling capacitors up to 0.015 mfd. When a drain coil is supplied with the tuner, it is identified as a Type JZ 72.6D tuner. If both capacitor and drain coil are included, the tuner is Type JZ 72.64D.

Typical response curves for the type JZ 72.6 tuners are plotted in Fig. 1. These curves were taken with an 1870-mmf. coupling capacitor and a 300-ohm resistive load. The two sections of the tuner were adjusted for resonance (f_r) at 30 and 37.5 kHz, 80 and 100 kHz, and 160 and 200 kHz, respectively, for the three pairs of curves.

CHARACTERISTICS

Frequency Range:	30 to 200 kHz.
Input Impedance:	50 to 70 Ohms
Output Impedance:	100 to 1000 Ohms
Power Rating:	100 Watts Carrier-Unmodulated 25 Watts Carrier-100% Modulated
Coupling Capacitor Range:	JZ 72.6 – .00075 to .004 mfd. JZ 72.64 – .00075 to .015 mfd.
Minimum Frequency Separation:	25% of the lower frequency

INSTALLATION

It is recommended that the Line Tuner be located as near to the coupling capacitor as possible. The mounting dimensions are shown in Fig. 3.

Remove the upper knockout from the side of the cabinet nearest the coupling capacitor and install the porcelain bushing for the capacitor lead-in as described in the following section.

Connections

CAUTION

Before making any connections to this equipment, turn off the power switch of the carrier transmitter and ground or open circuit the lead-in at the coupling capacitor.

The assembly of the Style 1352445 accessories for the coupling capacitor lead-in cable is shown in Fig. 10. Before permanently assembling the bushing in the cabinet wall, run the lead-in cable through the bushing and into the cabinet to determine the correct length of lead-in cable. Allow sufficient length of cable to connect to the ground-

ing switch contact stud with the panel swung open. Mark the cable at the bushing to locate its position and remove the cable and bushing from the cabinet. Place the bushing in an inverted position with the openings level. Melt the cement supplied with the accessory package and pour it into the bushing. After the cement has hardened, install the bushing in the cabinet wall.

Remove the connection of the tuning unit from the terminal stud of the jaw contact of the grounding switch. Connect the capacitor lead-in cable to this terminal stud using the cable terminal supplied with the bushing. Tighten the nut securely. Replace the connection from the tuning unit using the second nut. This will permit disconnecting the tuning unit without disturbing the coupling capacitor lead-in cable connection.

Coupling Capacitor Lead-In Cable

Since the lead-in cable between the coupling capacitor and the line tuning unit is in a high-impedance carrier-frequency circuit, care must be exercised to keep the leakage to a minimum value.

The lead-in cable should be supported with as few insulators as possible. The insulation of this lead-in cable with respect to ground must be much better than is ordinarily employed for the voltage which exists between these points, as it effectively shunts the reactive elements of the resonant circuit at carrier frequency. The impedance of this resonant circuit may be as high as five thousand ohms and leakage resulting from rain, snow, sleet, too long a lead-in cable, or too many supporting insulators will reduce the effective power output of the transmitter and the sensitivity of the receiver.

An installation which limits this leakage to a minimum will have less signal strength variation under adverse conditions, when reliable operation is of the greatest value.

The insulators used for supporting the lead-in cable should have at least a 7.5-kv rating. Care should be taken not to break the insulation of the cable when clamping it to the insulators. At least once a year the insulators should be washed to remove the accumulation of dirt.

For the lead-in, use a good quality rubber covered cable of at least 7500 volts service grade, with a conductor equivalent to No. 14 gauge or larger. This cable is usually supplied with the coupling capacitor.

Coaxial Cable

Two screws are mounted in the left wall of the cabinet for securing the coaxial cables. Connect the shield of the cable to terminals #2 and #4, and the center conductors to terminals #3 and #5. Connect a good ground to the cabinet and to terminal #1 of the terminal board. Run a copper bonding cable from the cabinet to the base of the coupling capacitor.

Follow the instructions given in Fig. 2 for the connection of the coaxial cables. Remove the shield braid so that one to two inches of the inner insulation is exposed. The outer jacket of the coaxial cable should cover the shield braid as much as possible to insulate it against the high voltage that may exist between the shield braid and the tuner cabinet during a fault. Connect the cable shields to terminals 2 and 4 as indicated in Fig. 2, but do not ground these leads to the tuner cabinet. See that the coaxial cable leads are positioned so that the exposed portion of the cable shield and its lead are spaced away from the metal cabinet proper. The coaxial cable is grounded at the carrier equipment end only. The use of two-winding transformers allows grounding of the coaxial-cable shield braid at the carrier-set end only, and this eliminates any path for the flow of 60-cycle current (during a ground fault) through the coaxial cable and transformer winding.

ADJUSTMENTS

CAUTION

When making any tap adjustments or changing any connections in this tuner, make certain that the grounding switch is closed. Do not depend on the drain coil for personal safety. Do not touch any terminal when the transmitter is on.

The first consideration in adjusting this tuner is to determine the two operating frequencies. In general, it is recommended that the higher of the two operating frequencies be at least 125 per cent of the lower frequency. This is because the losses increase as the operating frequencies approach each other. Also, for close frequency separation, the inductive reactance of the trap circuit at the tuner frequency may be much greater than the value re-

quired to resonate the coupling capacitor. This requires the insertion of capacitance in series with the tuning circuit in order for resonance to be obtained.

In addition to the operating frequencies, the capacitance of the coupling capacitor must be known in order to determine the appropriate tuning adjustments.

PRELIMINARY ADJUSTMENTS

The transformers used in this line tuner provide an impedance match for a 50 to 70 ohm coaxial cable to 100 to 1000 ohm power line. The impedance of the different taps of the transformer, T-1, are given in the following table.

Coaxial Tap	Tuner Tap	Line Impedance
2	4- 5	100
3	4- 5	139
2	6- 7	193
3	6- 7	268
2	8- 9	372
3	8- 9	517
2	10- 11	720
3	10- 11	1000

The average power line impedance is 400 to 600 ohms. If the impedance of the power line is known, connect the COAX and TUNER leads of the transformer to the corresponding taps. If the power line impedance is not known, connect the COAX lead to tap 3 and the TUNER leads to taps 8 and 9. Readjustment of the taps will be made as a part of the Final Adjustment.

The following procedure will determine the approximate adjustment of the line tuning coils and the trap circuits.

For these calculations:

F_1 = lower frequency in kHz.

F_2 = higher frequency in kHz.

C_0 = capacitance of coupling capacitor in MMF

For the JZ 72.64 tuner, in determining the required inductance, do not use the rated capacitance of the coupling capacitor for Cc. Because of the 0.006-mfd. capacitor (C5) in the tuner output circuit, the net capacitance must be calculated from the formula:

$$Co = \frac{(.006)\ (Cc)}{(.006 + Cc)}$$

where Cc is the rated capacitance of the coupling capacitor, and Co is the calculated value to use in the procedure described in the following paragraphs. (All values are in micro-microfarads) For example, if the coupling capacitor is 0.006 mfd., then the net value of Co is 0.003 mfd. Similarly, for a 0.005 mfd. coupling capacitor, $Co = \frac{.006 \times .005}{.011} = .0027$ mfd. (Then use 2700 mmf. in determining required inductance.)

*A. Calculation of Line Tuner adjustments for the lower frequency section. (Right side of panel.)

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F-2.

2. Determine the percentage that the trap frequency F_2 is above the line tuner frequency F-1 by using the following formula:

$$\frac{F2 - F_1}{F_1} \times 100 = \text{percentage}$$

   Refer to Fig. 7 and determine the inductance of the trap circuit at the line tuner frequency F1 for the trap tuning capacitor and per cent separation determined above.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_1.

   Calculate the value of inductance required to resonate the coupling capacitor by using the following formula:

$$\frac{\text{L-C product}}{C_O} = \text{mh for resonance at } F_1$$

   If this value of inductance is greater than the inductance of the trap circuit obtained in 2 above, then the difference is the value of inductance required in the line tuning coil.

   In this case, refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

4. If the inductance of the trap circuit at F_1 is greater than the value required to resonate the coupling capacitor, then series capacitance must be included in the tuning circuit in order to obtain resonance. Three values of

capacitance are available, which for these calculations will be designated as C_A, C_B, and C_C.

$C_A = C_1$ and C_2 in parallel = 2400 mmf

$C_B = C_1$ (or C_2) = 1200 mmf

$C_C = C_1$ and C_2 in series = 600 mmf

Calculate the resultant capacitance of the coupling capacitor in series with capacitors C_1 and C_2 in parallel.

$$\frac{C_O \times C_A}{C_O + C_A} = \text{capacitance in tuning circuit}$$

Divide the L-C product obtained in 3 above by this value to determine the inductance required for resonance.

5. If this value of inductance is not greater than the inductance of the trap circuit, repeat the calculation as in 4, above, with capacitance C_B (1200 mmf) and, if necessary, with C_C (600 mmf).

6. Subtract the inductance of the trap circuit from the value of inductance determined in 4 or 5, above. This is the value of inductance required in the line tuning coil.

   Refer to Fig. 5 for the tap number on the line tuning coil for this value of inductance.

   NOTE

   When the two frequencies are separated by more than 100 per cent, the inductance of the trap circuit at the line tuner frequency will be only a small part of the inductance required for resonance and so will cause a change of only one or two taps on the line tuning coil.

* B. Calculation of Line Tuner adjustments for the higher frequency section. (Left side of panel.)

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F_1.

2. Determine the percentage that the trap frequency F_1 is below the line tuner frequency F_2 by using the following formula:

$$\frac{F_2 - F_1}{F_2} \times 100 = \text{percentage}$$

   Refer to Fig. 8 and determine the capacitance of the trap circuit for the trap tuning capacitor and per cent separation determined above.

   Calculate the resultant capacitance of this value in series with the coupling capacitor, using the following formula:

$$\frac{C_O \times C_T}{C_O + C_T} = \text{capacitance in tuning circuit}$$

   This is the value of capacitance which must be resonated by the line tuning coil.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_2.

   This product divided by the capacitance value calculated in 2, above, is the value of inductance required in the line tuning coil.

4. Refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

   NOTE

   Since the preceding calculations cannot include the effect of stray capacitance, possible inductance of the power line, or inductance of the matching transformer, the final adjustment of the line tuning coil may vary by one or two taps.

Two sample calculations for tap setting are shown on the following pages.

SAMPLE CALCULATION #1

F_1 = 160 kHz

F_2 = 200 kHz

C_0 = 4000 mmf

A. 1. F_2 = 200 kHz trap frequency. From Fig. 6 tuning capacitor = 1100 mmf. Tap number = 80.

2. $\frac{200 - 160}{160} \times 100 = 25\%$

   From Fig. 7.
   For 1100 mmf capacitor and 25% separation.
   Inductance = 1.6 mh.

3. From Fig. 9.
   L-C product at 160 kHz = 980.
   $\frac{980}{4000} = 0.245$ mh for resonance

4. 1.6 mh greater than 0.245 mh.
   With C-1 and C-2 in parallel in tuning circuit.
   2400 mmf in series with 4000 mmf is 1500 mmf.

   $\frac{980}{1500} = 0.653$ mh for resonance

5. 1.6 mh greater than 0.653 mh.
   With C-1 in tuning circuit (C-2 shorted)
   1200 mmf in series with 4000 mmf is 924 mmf.

   $\frac{980}{924} = 1.06$ mh for resonance

   1.6 mh greater than 1.06 mh.
   With C-1 and C-2 in series in tuning circuit.
   600 mmf in series with 4000 mmf is 522 mmf.

   $\frac{980}{522} = 1.88$ mh for resonance at 160 kHz

6. 1.88 − 1.6 = 0.28 mh required in line tuning coil.

   Refer to Fig. 5. For 0.28 mh use tap number 67 of the line tuning coil. Short the unused taps.

B. 1. F_1 = 160 kHz trap frequency.

   From Fig. 6.

   C = 1100 mmf
   Tap = 100

2. $\frac{200 - 160}{200} \times 100 = 20\%$

   From Fig. 8.
   Trap capacitance for 1100 mmf. tuning capacitor and 20% separation is 390 mmf.
   390 mmf in series with 4000 mmf is 356 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

   $\frac{630}{356} = 1.77$ mh for resonance at 200 kHz.

4. From Fig. 5.
   For 1.77 mh, use tap number 184 of line tuning coil.
   Short the unused taps.

SAMPLE CALCULATION #2

F_1 = 30 kHz
F_2 = 200 kHz
C_0 = 850 mmf

A. 1. F_2 = 200 kHz trap frequency.

   From Fig. 6.
   Tuning Capacitor = 1100 mmf.
   Tap Number = 80.

2. $\frac{200 - 30}{30} \times 100 = 566\%$

   From Fig. 7.

   For 1100 mmf capacitor and 566% separation.
   Inductance will be less than the 2.5 mh shown for 85% separation at 63 kHz.

3. From Fig. 9.
   L-C product at 30 kHz = 28000.
   $\frac{28000}{850} = 33$ mh for resonance

   From Fig. 5.
   Tap number 780 gives the inductance range of 26 to 40 mh so the trap inductance can be compensated for without changing taps.

B. 1. F_1 = 30 kHz trap frequency

   From Fig. 6.
   Tuning Capacitor = 4400 mmf.
   Tap Number = 300.

2. $\frac{200 - 30}{200} \times 100 = 85\%$

   From Fig. 8.
   Trap capacitance for 4400 mmf and 85% separation is 4270 mmf.
   4270 mmf in series with 850 mmf is 710 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

   $\frac{630}{710} = 0.89$ mh for resonance

4. From Fig. 5.
   For 0.89 mh use tap number 125 of line tuning coil.
   Short the unused taps.

NOTE

The instructions in Fig. 5 state that the unused taps are to be shorted when a tap lower than 100 is used and also when the frequency is above 150 kHz.

This procedure will leave a gap in the inductance range between tap 100 with the unused turns not shorted and tap 88 with the unused turns shorted. Continuous inductance adjustment can be obtained by using tap 113 with unused turns shorted as the next lower inductance tap below tap 100 with the unused turns not shorted.

Final Adjustments

After making the connections of trap capacitors, trap coil taps, and line tuning coil taps as determined under Preliminary Adjustments, the circuits must be adjusted to meet the requirements of the particular installation.

The trap circuits should be tuned to resonance before the line tuning coils are adjusted. For tuning with a local transmitter connected to cabinet terminal number 3, connect a thermocouple-type milliammeter to Jack J-1 on the right side of the panel or connect a vacuum-tube voltmeter from Jack J-2 on the right to ground. Turn on the local transmitter and adjust the core of the trap coil L-2 on the right for minimum current in Jack J-1 or minimum voltage from Jack J-2 to ground. Lock core in this position.

If the other channel also has a local transmitter, adjust the trap coil L-2 on the left for minimum current in Jack J-1 on the left or minimum voltage from Jack J-2 on the left to ground.

To adjust the trap circuit with a signal from a remote transmitter, measure the signal voltage from Jack J-2 to ground. Have the transmitter turned on and off several times to be certain that the desired signal is the one which is being received. Adjust the core of the trap coil for minimum voltage and lock the shaft.

After both trap circuits have been adjusted, tune the line tuning coils for resonance. Turn on the local transmitter and adjust the core of the line tuning coil, L-1, for maximum current in Jack J-1. If the current is increasing with the core all the way in or all the way out, change the tap connection to the next higher or lower tap, respectively.

To tune the line tuning coil with a signal from a remote transmitter, adjust the coil for maximum voltage from Jack J-2 to ground.

A line coupling tuner which is used to bypass a circuit breaker should be adjusted with the circuit breaker open. However, since this may be very difficult to arrange, an alternate method is to disconnect the coupling capacitor from the line and connect its high potential side to ground through a resistor. If the impedance of the line with the circuit breaker open is known, use a resistor of this value. If the line impedance is not known, use a 500-ohm resistor. Adjust the trap coils and line tuning coils in accordance with the previous instructions.

The matching transformer taps should then be adjusted by the following procedure:

Open the coaxial-cable circuit by disconnecting the COAX link from the transformer tap (2 or 3). Connect a non-inductive resistor of approximately 60 ohms between the COAX terminals (cabinet terminals 2-3 or 4-5). The wattage rating of the resistor must be sufficient to dissipate the output of the transmitter. Connect a thermocouple-type milliammeter in series with the 60-ohm resistor. Turn on the local transmitter and record the current through the resistor. Then turn off the transmitter.

Disconnect the resistor and reconnect the COAX link to the transformer tap. Turn on the transmitter and compare the current reading in Jack J-1 with the value obtained with the resistor. If the current values are different, change the transformer tap connections to the taps which give a current in Jack J-1 nearest the current measured through the resistor. After each change of transformer taps, readjust the core of the line tuning coil for maximum current.

Tuning Adjustment with Dummy Load Resistors

An adjustment procedure for obtaining a more exact impedance match is shown in Fig. 4, Line Coupling Tuner Adjustment. The dummy load resistors must be of sufficient wattage rating to dissipate the transmitter output.

Adjustment of Spark Gap

Adjust the spark gap SG-1 to 0.015 inch spacing. Observe the gap while the local transmitter is trans-

mitting full power. If the gap arcs over, increase the spacing until the arcing stops. The minimum spacing for the gap depends upon the carrier power, the power line impedance, and the capacitance of the coupling capacitor.

MAINTENANCE

Routine Checks and Records

This Tuning Unit requires very little maintenance. It should be inspected occasionally to see if there has been excessive burning of the spark gap.

If the spark gap shown signs of burning, rotate the discs to a new position and readjust the gap. Usually a semi-annual or yearly inspection is sufficient.

A permanent record should be kept of tap settings and the position of the coil-tuning cores so that they can be restored to the correct positions in case of unauthorized changes.

Ordering Replacement Parts

Replacement parts for this Tuning Unit may be ordered through the nearest Westinghouse District Office. When ordering, include:

1. The following data from the nameplate of the Line Tuner:

   (a) The type number; (b) the style number.

2. The (a) Electrical Parts List symbol; (b) the function; (c) the description; (d) the designation.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	FUNCTION	DESCRIPTION	STYLE NUMBER
		* **SUB-ASSEMBLIES**	
L-1	Line Tuning Coil	Line Tuning Coil Assembly	1474218
T-1	Transformer	Transformer Assembly	407C741G02
	High Frequency Trap	Trap Unit Assembly	540D760G01
—	Low Frequency Trap	Trap Unit Assembly	6294D16G01
—	Protector Unit	Protector Unit Assembly	1474014
		COMPONENT PARTS	
C-1	Capacitor-Series	Mica- 1200 mmf. ± 5%, 5000V	290B762H01
C-2	Capacitor-Series	Same as C-1	
C-3	Capacitor-Trap Tuning	Mica- 2200 mmf. ± 5%, 5000V	290B762H02
C-4	Capacitor-Trap Tuning	Same as C-3	
J-1	Jack-Coax Metering	Binding Post Type 2 Binding Posts 1 Shorting Link	 185A431H01 1474455
J-2	Jack-Line Metering	Same as J-1	
SG-1	Spark Gap	Disc Type	2 of 183A358H20 (discs only)
		OPTIONAL	
L-3	Drain Coil (When Used)	20,000 ohms minimum impedance over 30 - 200 kHz.	* 718B988H01
C-5	Series Capacitor (When Used)	Mica, 0.006 mfd., ± 5% 3000V, PACW.	584C256H03

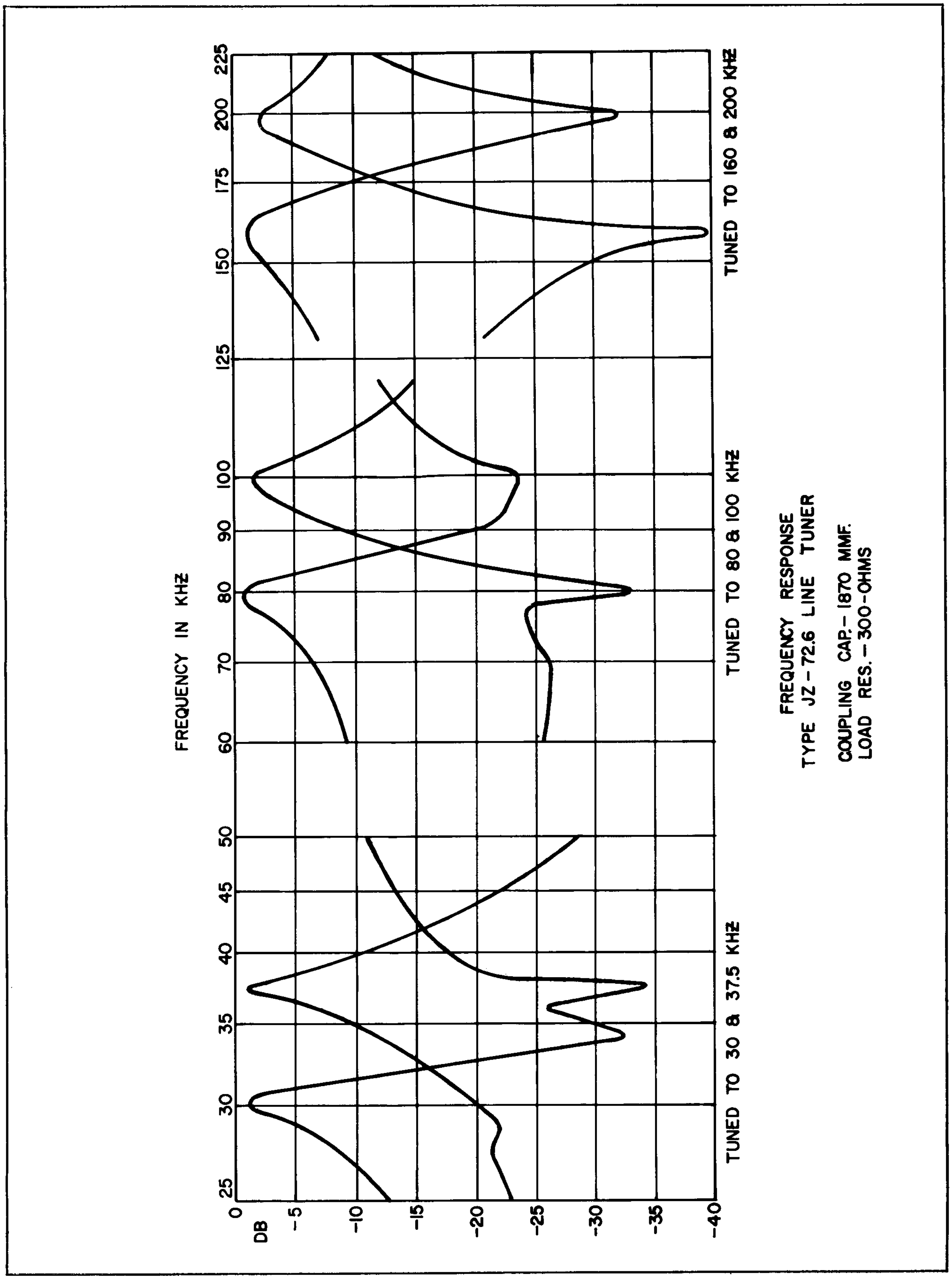
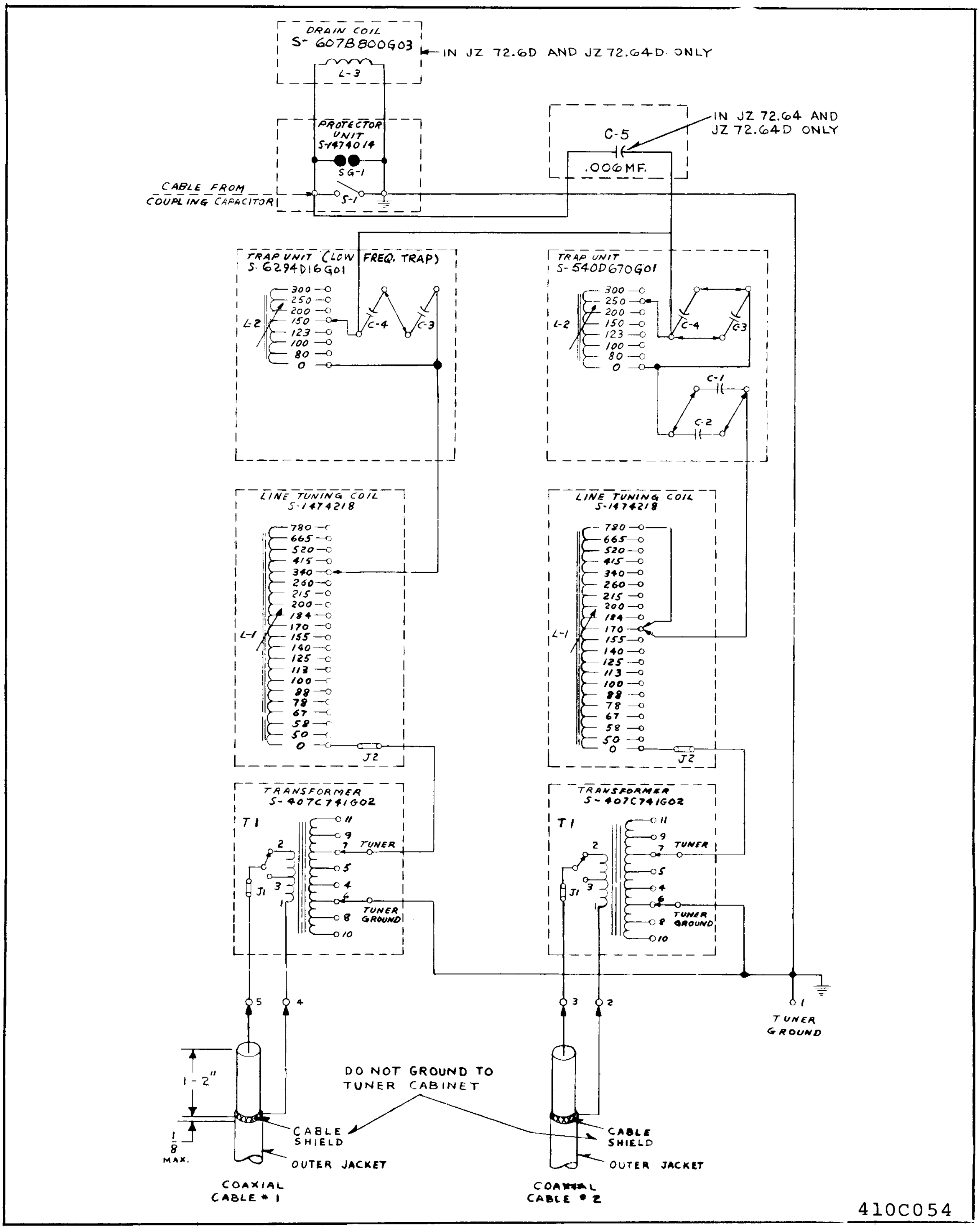


Fig. 1. Response Curves of JZ 72.6 Tuner. (Dwg. 862A348)



* *Fig. 2. Internal Schematic (Dwg. 410C091)*

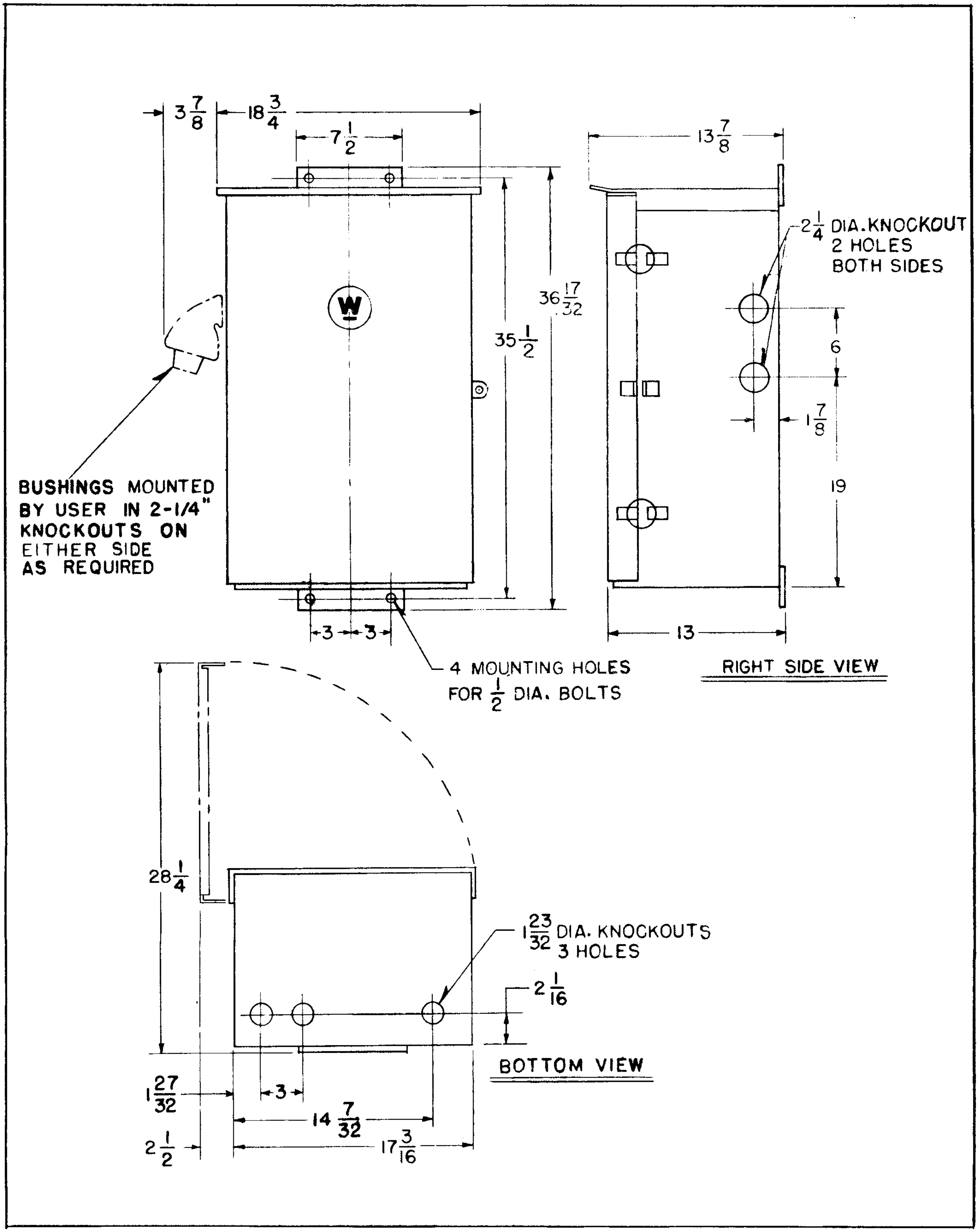
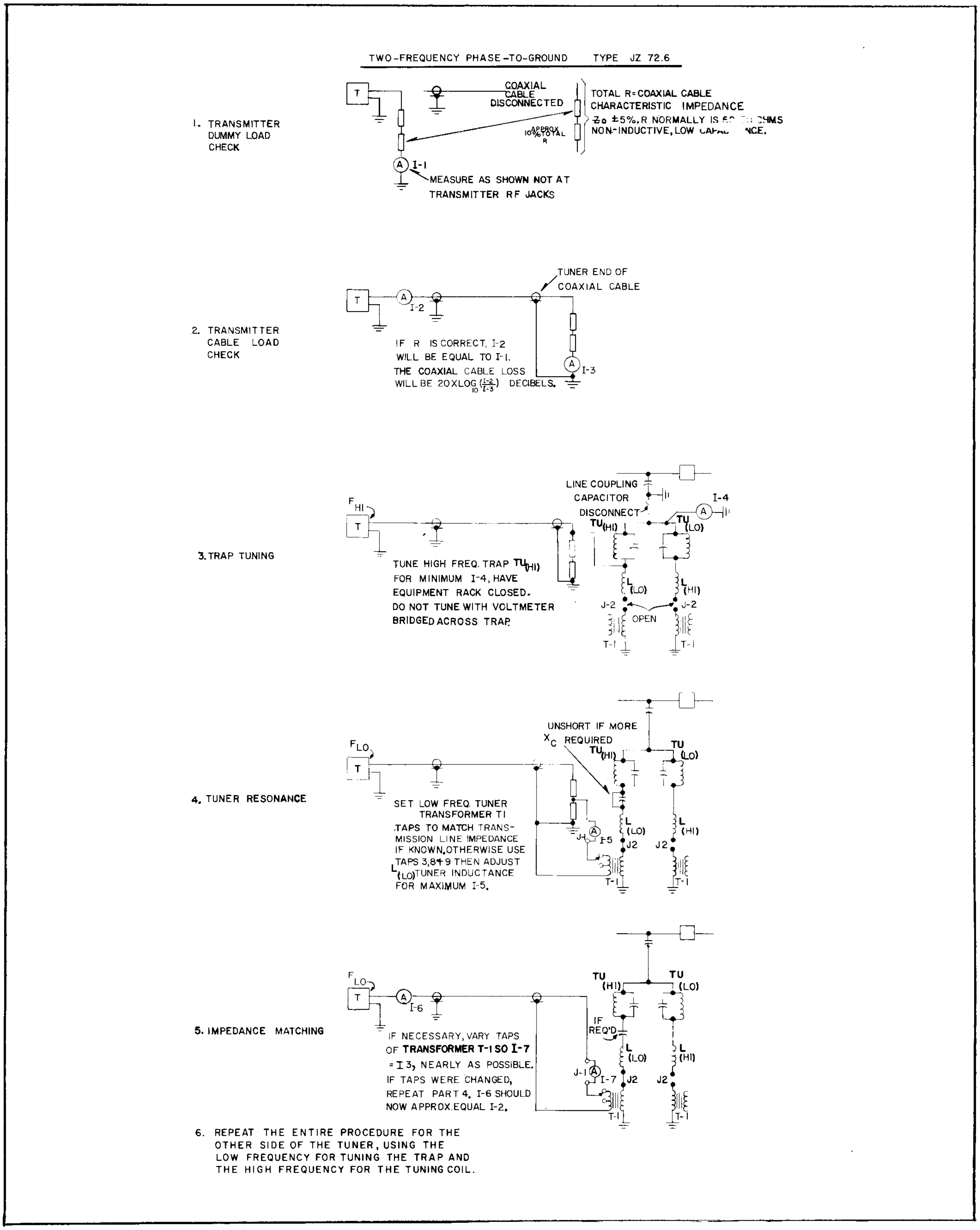


Fig. 3. Tuner Cabinet – Outline (Dwg. 50-B-7683)



**** Fig. 4. Line Coupling Tuner Adjustment (Component Location as Viewed from Rear of Panel) (Dwg. 585C117)***

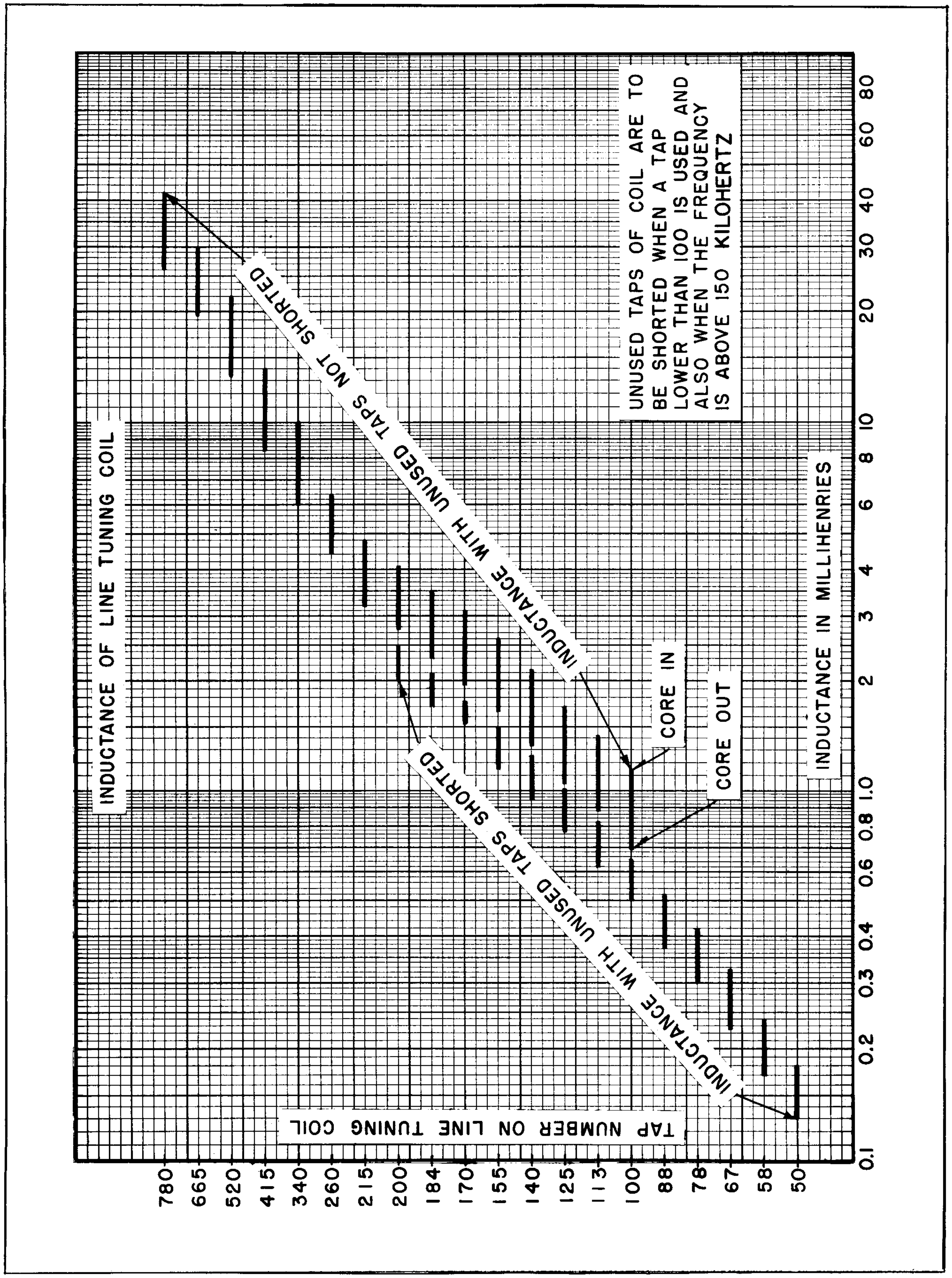


Fig. 5. Inductance of Line Tuning Coil (Curve 358433)

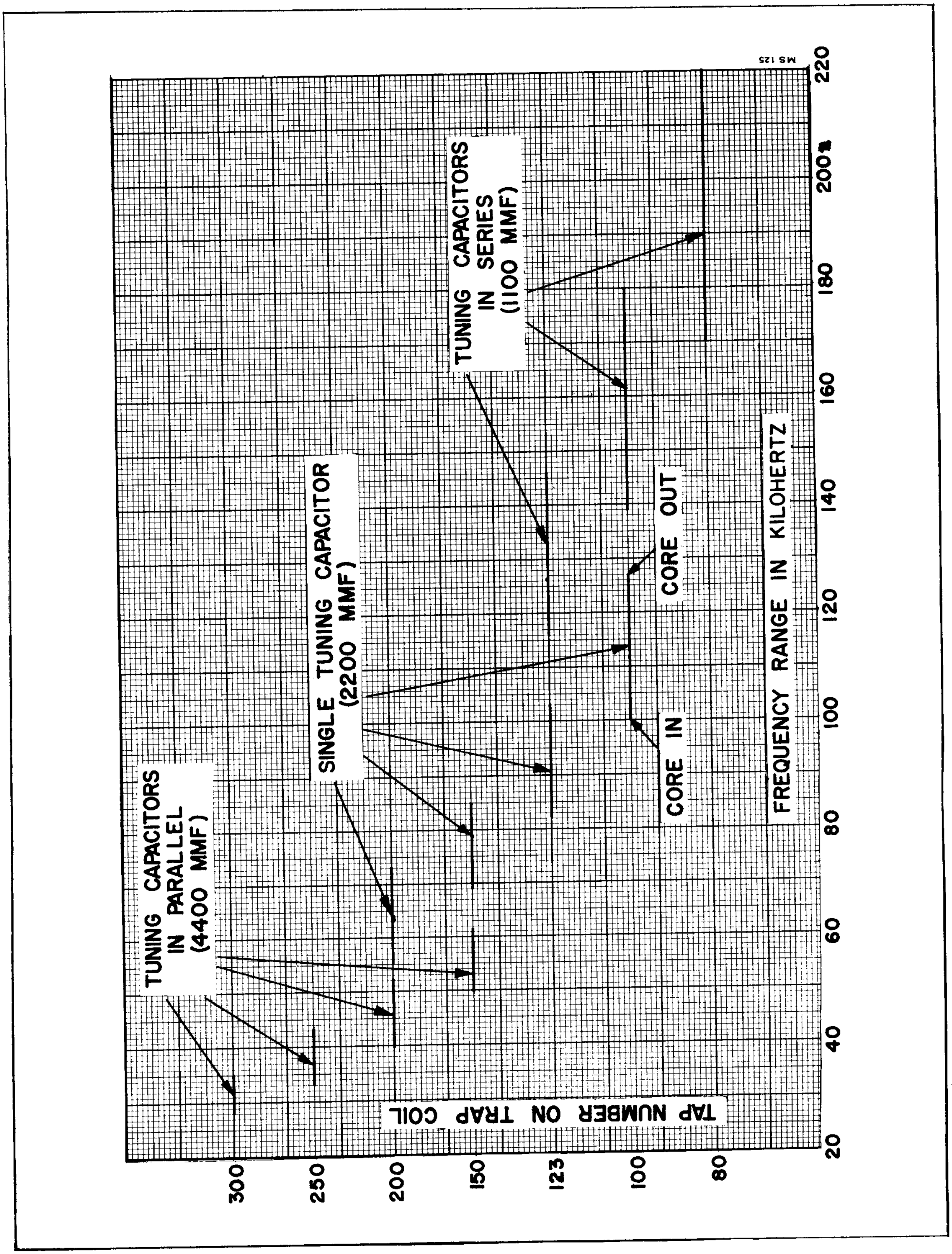


Fig. 6. Frequency Calibration of Trap Circuit (Curve 358434)

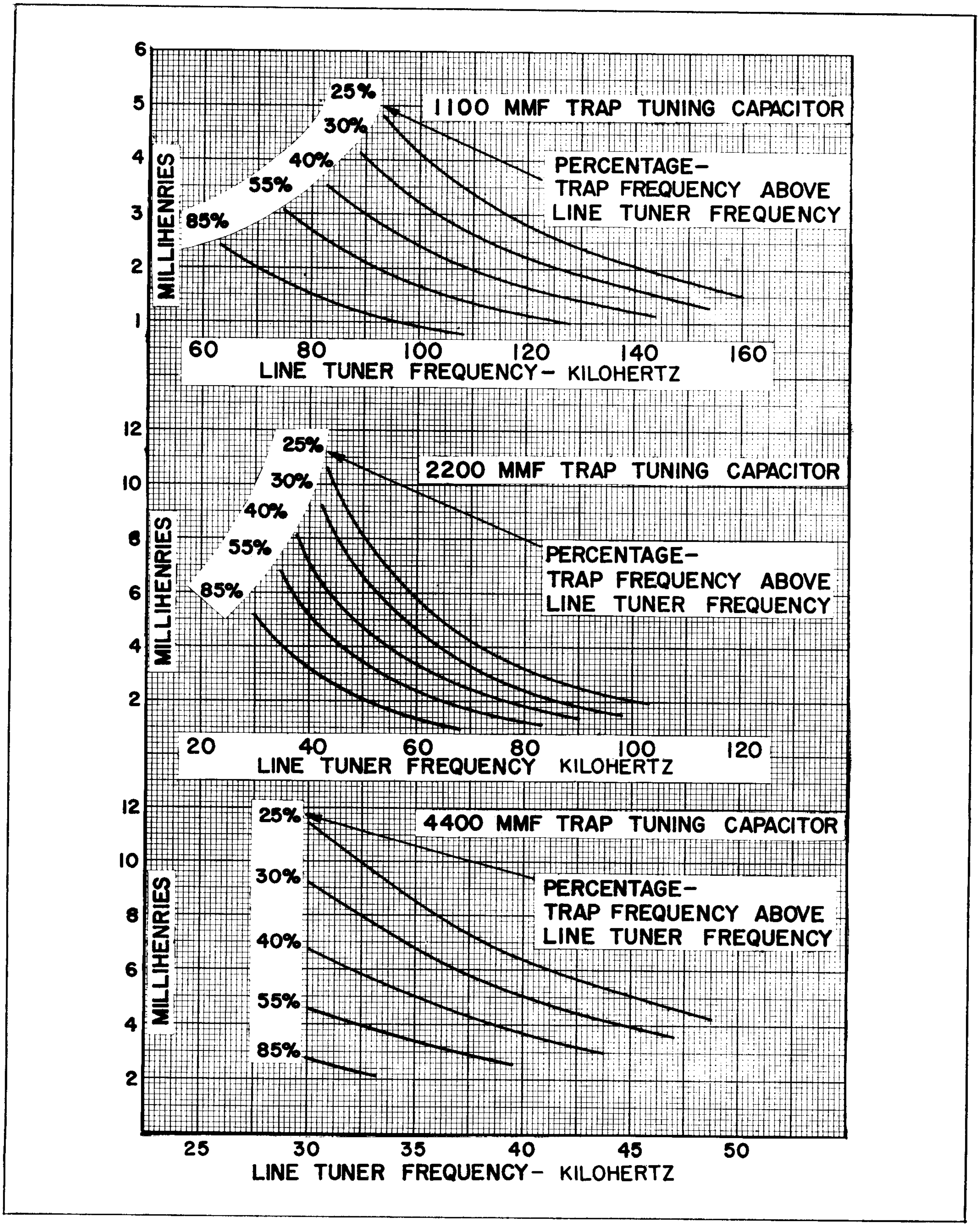


Fig. 7. Inductance of Trap Circuit at Line Tuner Frequency (Curve 358435)

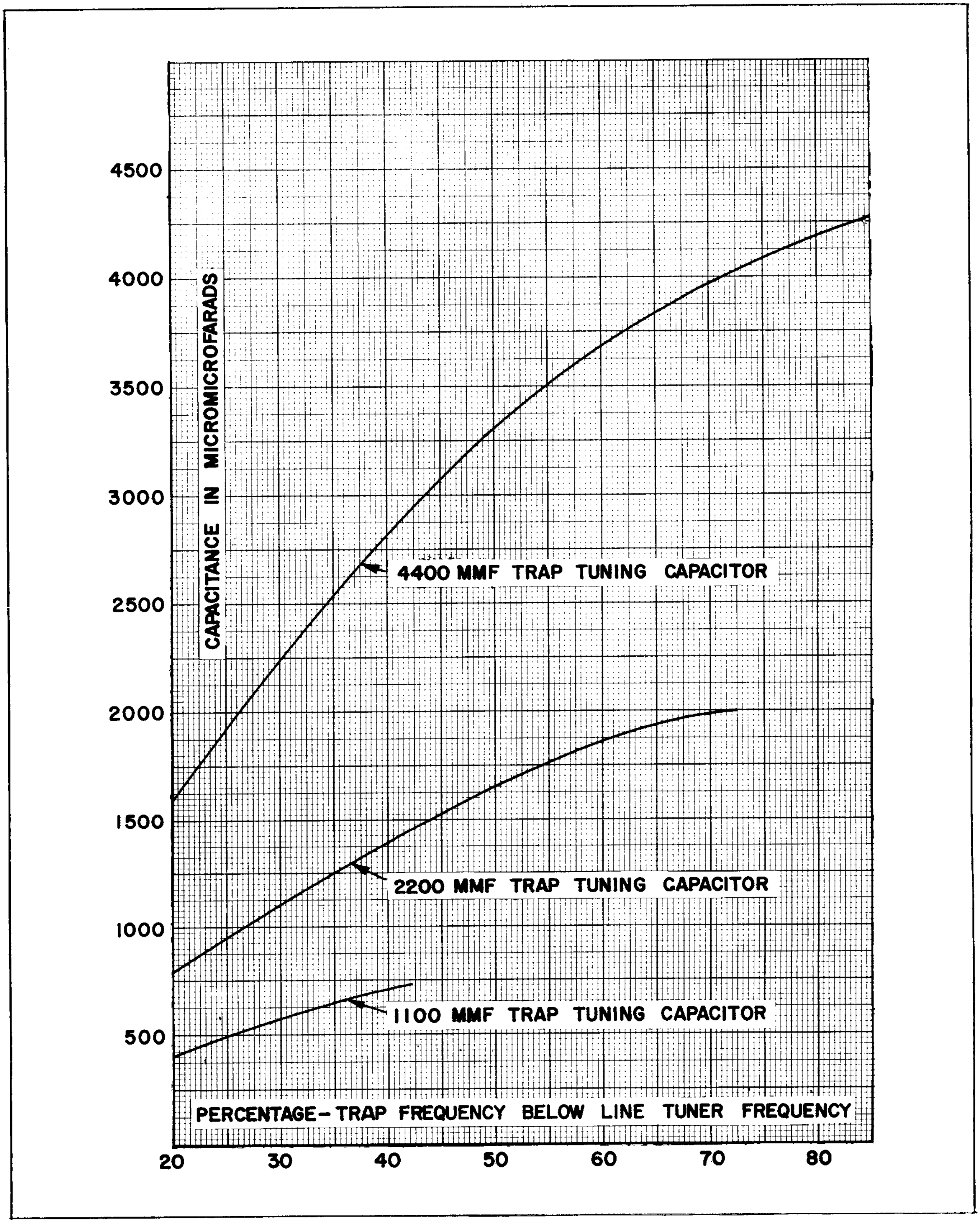


Fig. 8. Capacitance of Trap Circuit at Line Tuner Frequency (Curve 358436)

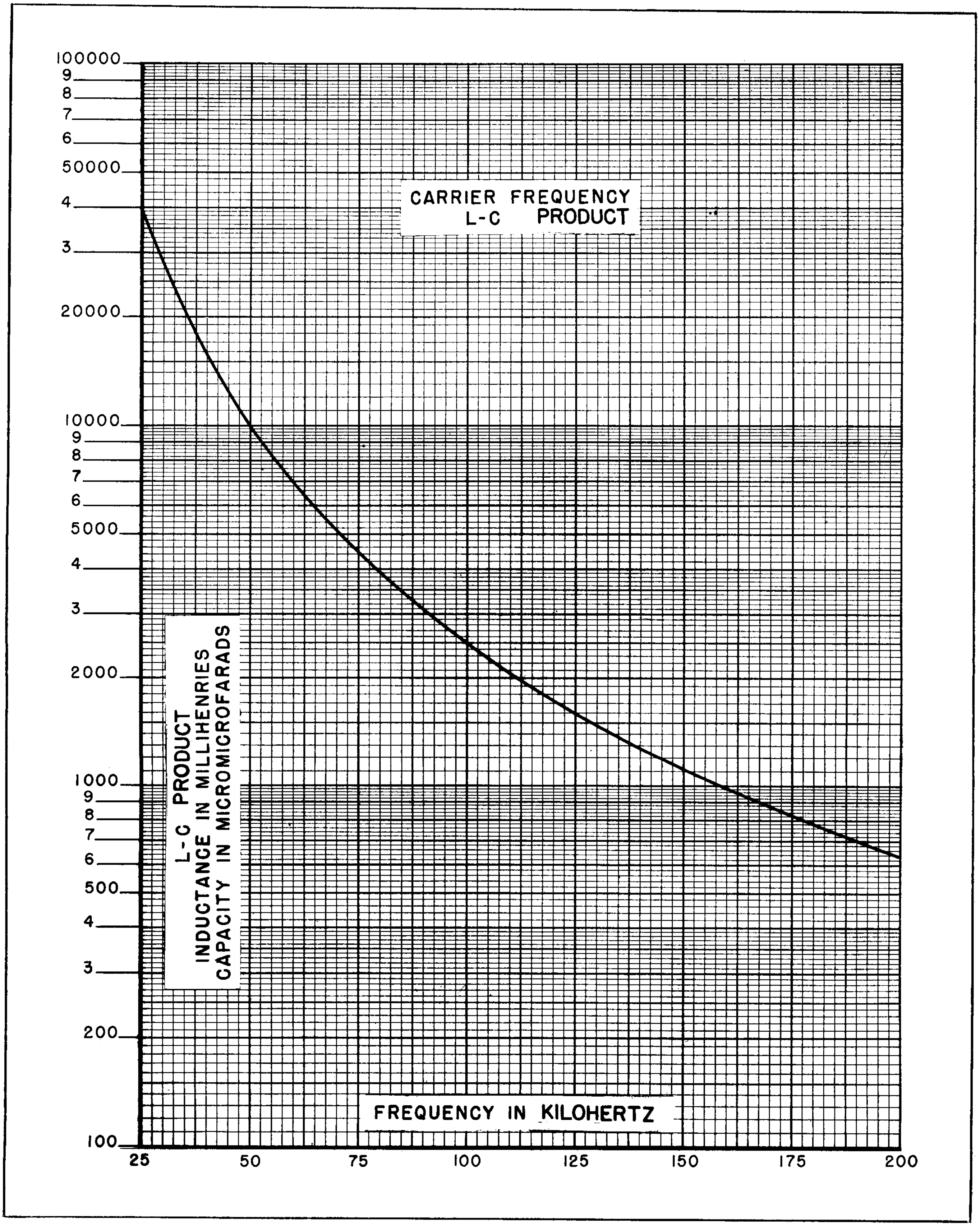


Fig. 9. Carrier Frequency L-C Product (Curve 358437)

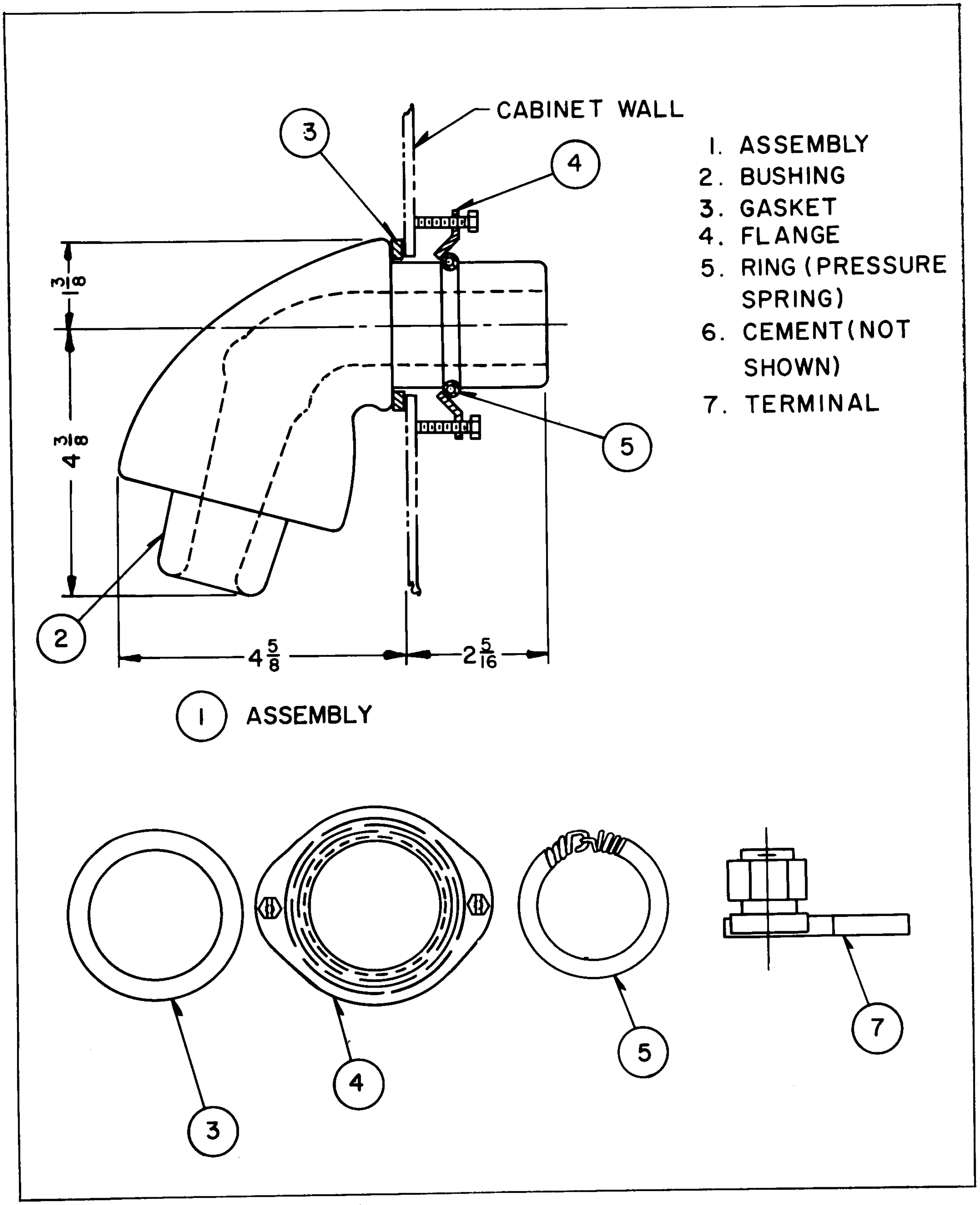


Fig. 10. Lead-In Bushing Assembly (862A186)

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE JZ-72.6 LINE COUPLING TUNERS

**TWO–FREQUENCY PHASE-TO-GROUND
LINE COUPLING TUNERS
WITH TWO–WINDING MATCHING TRANSFORMER**

TYPE JZ 72.6	– STYLE 290B883A23	– WITHOUT DRAIN COIL
TYPE JZ 72.6D	– STYLE 606B363A10	– WITH DRAIN COIL
TYPE JZ 72.64	– STYLE 606B363A13	– WITH 0.006 MFD. SERIES CAPACITOR
* TYPE JZ 72.64D	– STYLE 290B883A25	– WITH .006 MFD. SERIES CAPACITOR AND DRAIN COIL

SUPERSEDES I.L. 41-947.3B
*Denotes change from superseded issue.

EFFECTIVE APRIL 1974

SAFETY WARNING!

Protect your life while making adjustments! Before handling any part of the electrical circuits:

1. BE SURE THE GROUNDING SWITCHES IN THIS ASSEMBLY ARE IN THE "GROUNDED" OR CLOSED POSITION.
2. BE SURE THAT ALL POWER SWITCHES IN THIS ASSEMBLY ARE TURNED "OFF".

Protect the equipment against damage by not applying power until thoroughly familiar with the ADJUSTMENTS described in this book.

SAFETY FIRST!

TABLE OF CONTENTS

SUPPLEMENTARY DATA

APPLICATION

These Line Coupling Tuners are designed for phase-to-ground coupling of two carrier frequencies from separate coaxial cables through a single coupling capacitor to a power line.

DESCRIPTION

Mechanical Description

The line tuner is mounted in a cabinet suitable for outdoor installation. Knockouts are provided on each side of the cabinet for the capacitor lead-in bushing. Knockouts for 1½ inch conduit for the coaxial cables are located in the bottom of the cabinet. The outline, mounting dimensions and the location of the knockouts are shown in Fig. 3.

All electrical components are mounted on a hinged panel which can be opened for making the coaxial cable, capacitor lead-in and ground connections. The grounding switch, spark gap, tuning controls, metering jacks and all tap connections are accessible from the front of the panel.

Electrical Description

The electrical circuits are shown in Fig. 2. The high frequency tuner components are mounted on the left hand side of the panel and the low frequency components are on the right. Each coaxial cable connects through a jack J1 to the primary of a matching transformer T1. The secondary winding of T1 connects, through a jack J2 to to the line tuning coil L1. The line tuning coils are connected to the trap units. Both trap units consist of tapped inductance L2, which has an adjustable powdered-iron core, and tuning capacitors C-3 and C-4. Links on the front of the panel provide for connecting the tuning capacitors in series, parallel or one capacitor alone. The High Frequency Trap, mounted on the right hand side of the panel contains two additional capacitors C-1 and C-2 which may be required for proper tuner adjustment. Links are provided on the front panel to permit series, parallel or single capacitor connections.

Both trap circuits are connected to a protector unit, which consists of an adjustable spark gap SG-1 and a knife switch S-1. The spark gap protects the equipment from excessive voltage surges. The knife switch is provided for grounding the lead-in from the coupling capacitor while adjustments are being made.

The JZ72.64 tuner includes a .006 mfd. capacitor in series with the output lead to the protector unit. This allows the tuner to be used with coupling capacitors up to 0.015 mfd. When a drain coil is supplied with the tuner, it is identified as a Type JZ 72.6D tuner. If both capacitor and drain coil are included, the tuner is Type JZ 72.64D.

Typical response curves for the type JZ 72.6 tuners are plotted in Fig. 1. These curves were taken with an 1870-mmf. coupling capacitor and a 300-ohm resistive load. The two sections of the tuner were adjusted for resonance (f_r) at 30 and 37.5 kHz, 80 and 100 kHz, and 160 and 200 kHz, respectively, for the three pairs of curves.

CHARACTERISTICS

Frequency Range:	30 to 200 kHz.
Input Impedance:	50 to 70 Ohms
Output Impedance:	100 to 1000 Ohms
Power Rating:	100 Watts Carrier-Unmodulated 25 Watts Carrier-100% Modulated
Coupling Capacitor Range:	JZ 72.6 – .00075 to .004 mfd. JZ 72.64 – .00075 to .015 mfd.
Minimum Frequency Separation:	25% of the lower frequency

INSTALLATION

It is recommended that the Line Tuner be located as near to the coupling capacitor as possible. The mounting dimensions are shown in Fig. 3.

Remove the upper knockout from the side of the cabinet nearest the coupling capacitor and install the porcelain bushing for the capacitor lead-in as described in the following section.

Connections

CAUTION

Before making any connections to this equipment, turn off the power switch of the carrier transmitter and ground or open circuit the lead-in at the coupling capacitor.

* The assembly of the Style 719B629G01 accessories for the coupling capacitor lead-in cable is shown in Fig. 10. Allow sufficient length of cable to connect to the grounding switch contact stud with the panel swung open.

Remove the connection of the tuning unit from the terminal stud of the jaw contact of the grounding switch. Connect the capacitor lead-in cable to this terminal stud using the cable terminal supplied with the bushing. Tighten the nut securely. Replace the connection from the tuning unit using the second nut. This will permit disconnecting the tuning unit without disturbing the coupling capacitor lead-in cable connection.

Coupling Capacitor Lead-In Cable

Since the lead-in cable between the coupling capacitor and the line tuning unit is in a high-impedance carrier-frequency circuit, care must be exercised to keep the leakage to a minimum value.

The lead-in cable should be supported with as few insulators as possible. The insulation of this lead-in cable with respect to ground must be much better than is ordinarily employed for the voltage which exists between these points, as it effectively shunts the reactive elements of the resonant circuit at carrier frequency. The impedance of this resonant circuit may be as high as five thousand ohms and leakage resulting from rain, snow, sleet, too long a lead-in cable, or too many supporting insulators will reduce the effective power output of the transmitter and the sensitivity of the receiver.

An installation which limits this leakage to a minimum will have less signal strength variation under adverse conditions, when reliable operation is of the greatest value.

The insulators used for supporting the lead-in cable should have at least a 7.5-kv rating. Care should be taken not to break the insulation of the cable when clamping it to the insulators. At least once a year the insulators should be washed to remove the accumulation of dirt.

* For the lead-in, use a good quality rubber covered cable with a conductor equivalent to No. 14 gauge or larger. This cable is usually supplied with the coupling capacitor.

Coaxial Cable

Two screws are mounted in the left wall of the cabinet for securing the coaxial cables. Connect the shield of the cable to terminals #2 and #4, and the center conductors to terminals #3 and #5. Connect a good ground to the cabinet and to terminal #1 of the terminal board. Run a copper bonding cable from the cabinet to the base of the coupling capacitor.

Follow the instructions given in Fig. 2 for the connection of the coaxial cables. Remove the shield braid so that one to two inches of the inner insulation is exposed. The outer jacket of the coaxial cable should cover the shield braid as much as possible to insulate it against the high voltage that may exist between the shield braid and the tuner cabinet during a fault. Connect the cable shields to terminals 2 and 4 as indicated in Fig. 2, but do not ground these leads to the tuner cabinet. See that the coaxial cable leads are positioned so that the exposed portion of the cable shield and its lead are spaced away from the metal cabinet proper. The coaxial cable is grounded at the carrier equipment end only. The use of two-winding transformers allows grounding of the coaxial-cable shield braid at the carrier-set end only, and this eliminates any path for the flow of 60-cycle current (during a ground fault) through the coaxial cable and transformer winding.

ADJUSTMENTS

CAUTION

When making any tap adjustments or changing any connections in this tuner, make certain that the grounding switch is closed. Do not depend on the drain coil for personal safety. Do not touch any terminal when the transmitter is on.

The first consideration in adjusting this tuner is to determine the two operating frequencies. In general, it is recommended that the higher of the two operating frequencies be at least 125 per cent of the lower frequency. This is because the losses increase as the operating frequencies approach each other. Also, for close frequency separation, the inductive reactance of the trap circuit at the tuner frequency may be much greater than the value required to resonate the coupling capacitor. This requires the insertion of capacitance in series with the tuning circuit in order for resonance to be obtained.

In addition to the operating frequencies, the capacitance of the coupling capacitor must be known in order to determine the appropriate tuning adjustments.

PRELIMINARY ADJUSTMENTS

The transformers used in this line tuner provide an impedance match for a 50 to 70 ohm coaxial cable to 100 to 1000 ohm power line. The impedance of the different taps of the transformer, T-1, are given in the following table.

Coaxial Tap	Tuner Tap	Line Impedance
2	4- 5	100
3	4- 5	139
2	6- 7	193
3	6- 7	268
2	8- 9	372
3	8- 9	517
2	10- 11	720
3	10- 11	1000

The average power line impedance is 400 to 600 ohms. If the impedance of the power line is known, connect the COAX and TUNER leads of the transformer to the corresponding taps. If the power line impedance is not known, connect the COAX lead to tap 3 and the TUNER leads to taps 8 and 9. Readjustment of the taps will be made as a part of the Final Adjustment.

The following procedure will determine the approximate adjustment of the line tuning coils and the trap circuits.

For these calculations:

F_1 = lower frequency in kHz.

F_2 = higher frequency in kHz.

C_0 = capacitance of coupling capacitor in MMF

For the JZ 72.64 tuner, in determining the required inductance, do not use the rated capacitance of the coupling capacitor for Cc. Because of the 0.006-mfd. capacitor (C5) in the tuner output circuit, the net capacitance must be calculated from the formula:

$$Co = \frac{(.006)\ (Cc)}{(.006 + Cc)}$$

where Cc is the rated capacitance of the coupling capacitor, and Co is the calculated value to use in the procedure described in the following paragraphs. (All values are in micro-microfarads) For example, if the coupling capacitor is 0.006 mfd., then the net value of Co is 0.003 mfd. Similarly, for a 0.005 mfd. coupling capacitor, $Co = \frac{.006 \times .005}{.011} = .0027$ mfd. (Then use 2700 mmf. in determining required inductance.)

A. Calculation of Line Tuner adjustments for the lower frequency section. (Right side of panel.)

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F-2.

2. Determine the percentage that the trap frequency F_2 is above the line tuner frequency F-1 by using the following formula:

$$\frac{F2 - F_1}{F_1} \times 100 = \text{percentage}$$

   Refer to Fig. 7 and determine the inductance of the trap circuit at the line tuner frequency F1 for the trap tuning capacitor and per cent separation determined above.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_1.

   Calculate the value of inductance required to resonate the coupling capacitor by using the following formula:

$$\frac{\text{L-C product}}{C_O} = \text{mh for resonance at } F_1$$

   If this value of inductance is greater than the inductance of the trap circuit obtained in 2 above, then the difference is the value of inductance required in the line tuning coil.

   In this case, refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

4. If the inductance of the trap circuit at F_1 is greater than the value required to resonate the coupling capacitor, then series capacitance must be included in the tuning circuit in order to obtain resonance. Three values of

capacitance are available, which for these calculations will be designated as C_A, C_B, and C_C.

$C_A = C_1$ and C_2 in parallel = 2400 mmf

$C_B = C_1$ (or C_2) = 1200 mmf

$C_C = C_1$ and C_2 in series = 600 mmf

Calculate the resultant capacitance of the coupling capacitor in series with capacitors C_1 and C_2 in parallel.

$$\frac{C_O \times C_A}{C_O + C_A} = \text{capacitance in tuning circuit}$$

Divide the L-C product obtained in 3 above by this value to determine the inductance required for resonance.

5. If this value of inductance is not greater than the inductance of the trap circuit, repeat the calculation as in 4, above, with capacitance C_B (1200 mmf) and, if necessary, with C_C (600 mmf).

6. Subtract the inductance of the trap circuit from the value of inductance determined in 4 or 5, above. This is the value of inductance required in the line tuning coil.

   Refer to Fig. 5 for the tap number on the line tuning coil for this value of inductance.

   NOTE

   When the two frequencies are separated by more than 100 per cent, the inductance of the trap circuit at the line tuner frequency will be only a small part of the inductance required for resonance and so will cause a change of only one or two taps on the line tuning coil.

B. Calculation of Line Tuner adjustments for the higher frequency section. (Left side of panel.)

1. Refer to Fig. 6 for the capacitor combination and the trap coil tap number required to tune the trap circuit to frequency F_1.

2. Determine the percentage that the trap frequency F_1 is below the line tuner frequency F_2 by using the following formula:

$$\frac{F_2 - F_1}{F_2} \times 100 = \text{percentage}$$

   Refer to Fig. 8 and determine the capacitance of the trap circuit for the trap tuning capacitor and per cent separation determined above.

   Calculate the resultant capacitance of this value in series with the coupling capacitor, using the following formula:

$$\frac{C_O \times C_T}{C_O + C_T} = \text{capacitance in tuning circuit}$$

   This is the value of capacitance which must be resonated by the line tuning coil.

3. Refer to Fig. 9 and determine the L-C product for the line tuner frequency F_2.

   This product divided by the capacitance value calculated in 2, above, is the value of inductance required in the line tuning coil.

4. Refer to Fig. 5 for the tap number on the tuning coil for the value of inductance determined above.

   NOTE

   Since the preceding calculations cannot include the effect of stray capacitance, possible inductance of the power line, or inductance of the matching transformer, the final adjustment of the line tuning coil may vary by one or two taps.

Two sample calculations for tap setting are shown on the following pages.

SAMPLE CALCULATION #1

F_1 = 160 kHz

F_2 = 200 kHz

C_0 = 4000 mmf

A. 1. F_2 = 200 kHz trap frequency. From Fig. 6 tuning capacitor = 1100 mmf. Tap number = 80.

2. $\frac{200 - 160}{160} \times 100 = 25\%$

   From Fig. 7.
   For 1100 mmf capacitor and 25% separation.
   Inductance = 1.6 mh.

3. From Fig. 9.
L-C product at 160 kHz = 980.
$\frac{980}{4000}$ = 0.245 mh for resonance

4. 1.6 mh greater than 0.245 mh.
With C-1 and C-2 in parallel in tuning circuit.
2400 mmf in series with 4000 mmf is 1500 mmf.

$\frac{980}{1500}$ = 0.653 mh for resonance

5. 1.6 mh greater than 0.653 mh.
With C-1 in tuning circuit (C-2 shorted)
1200 mmf in series with 4000 mmf is 924 mmf.

$\frac{980}{924}$ = 1.06 mh for resonance

1.6 mh greater than 1.06 mh.
With C-1 and C-2 in series in tuning circuit.
600 mmf in series with 4000 mmf is 522 mmf.

$\frac{980}{522}$ = 1.88 mh for resonance at 160 kHz

6. 1.88 − 1.6 = 0.28 mh required in line tuning coil.

Refer to Fig. 5. For 0.28 mh use tap number 67 of the line tuning coil. Short the unused taps.

B. 1. F_1 = 160 kHz trap frequency.

From Fig. 6.

C = 1100 mmf
Tap = 100

2. $\frac{200-160}{200}$ x 100 = 20%

From Fig. 8.
Trap capacitance for 1100 mmf. tuning capacitor and 20% separation is 390 mmf.
390 mmf in series with 4000 mmf is 356 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

$\frac{630}{356}$ = 1.77 mh for resonance at 200 kHz.

4. From Fig. 5.
For 1.77 mh, use tap number 184 of line tuning coil.
Short the unused taps.

SAMPLE CALCULATION #2

F_1 = 30 kHz
F_2 = 200 kHz
C_0 = 850 mmf

A. 1. F_2 = 200 kHz trap frequency.

From Fig. 6.
Tuning Capacitor = 1100 mmf.
Tap Number = 80.

2. $\frac{200-30}{30}$ x 100 = 566%

From Fig. 7.

For 1100 mmf capacitor and 566% separation. Inductance will be less than the 2.5 mh shown for 85% separation at 63 kHz.

3. From Fig. 9.
L-C product at 30 kHz = 28000.
$\frac{28000}{850}$ = 33 mh for resonance

From Fig. 5.
Tap number 780 gives the inductance range of 26 to 40 mh so the trap inductance can be compensated for without changing taps.

B. 1. F_1 = 30 kHz trap frequency

From Fig. 6.
Tuning Capacitor = 4400 mmf.
Tap Number = 300.

2. $\frac{200-30}{200}$ x 100 = 85%

From Fig. 8.
Trap capacitance for 4400 mmf and 85% separation is 4270 mmf.
4270 mmf in series with 850 mmf is 710 mmf.

3. From Fig. 9 the L-C product at 200 kHz is 630.

$\frac{630}{710}$ = 0.89 mh for resonance

4. From Fig. 5.
For 0.89 mh use tap number 125 of line tuning coil.
Short the unused taps.

NOTE

The instructions in Fig. 5 state that the unused taps are to be shorted when a tap lower than 100 is used and also when the frequency is above 150 kHz.

This procedure will leave a gap in the inductance range between tap 100 with the unused turns not shorted and tap 88 with the unused turns shorted. Continuous inductance adjustment can be obtained by using tap 113 with unused turns shorted as the next lower inductance tap below tap 100 with the unused turns not shorted.

Final Adjustments

After making the connections of trap capacitors, trap coil taps, and line tuning coil taps as determined under Preliminary Adjustments, the circuits must be adjusted to meet the requirements of the particular installation.

The trap circuits should be tuned to resonance before the line tuning coils are adjusted. For tuning with a local transmitter connected to cabinet terminal number 3, connect a thermocouple-type milliammeter to Jack J-1 on the right side of the panel or connect a vacuum-tube voltmeter from Jack J-2 on the right to ground. Turn on the local transmitter and adjust the core of the trap coil L-2 on the right for minimum current in Jack J-1 or minimum voltage from Jack J-2 to ground. Lock core in this position.

If the other channel also has a local transmitter, adjust the trap coil L-2 on the left for minimum current in Jack J-1 on the left or minimum voltage from Jack J-2 on the left to ground.

To adjust the trap circuit with a signal from a remote transmitter, measure the signal voltage from Jack J-2 to ground. Have the transmitter turned on and off several times to be certain that the desired signal is the one which is being received. Adjust the core of the trap coil for minimum voltage and lock the shaft.

After both trap circuits have been adjusted, tune the line tuning coils for resonance. Turn on the local transmitter and adjust the core of the line tuning coil, L-1, for maximum current in Jack J-1. If the current is increasing with the core all the way in or all the way out, change the tap connection to the next higher or lower tap, respectively.

To tune the line tuning coil with a signal from a remote transmitter, adjust the coil for maximum voltage from Jack J-2 to ground.

A line coupling tuner which is used to bypass a circuit breaker should be adjusted with the circuit breaker open. However, since this may be very difficult to arrange, an alternate method is to disconnect the coupling capacitor from the line and connect its high potential side to ground through a resistor. If the impedance of the line with the circuit breaker open is known, use a resistor of this value. If the line impedance is not known, use a 500-ohm resistor. Adjust the trap coils and line tuning coils in accordance with the previous instructions.

The matching transformer taps should then be adjusted by the following procedure:

Open the coaxial-cable circuit by disconnecting the COAX link from the transformer tap (2 or 3). Connect a non-inductive resistor of approximately 60 ohms between the COAX terminals (cabinet terminals 2-3 or 4-5). The wattage rating of the resistor must be sufficient to dissipate the output of the transmitter. Connect a thermocouple-type milliammeter in series with the 60-ohm resistor. Turn on the local transmitter and record the current through the resistor. Then turn off the transmitter.

Disconnect the resistor and reconnect the COAX link to the transformer tap. Turn on the transmitter and compare the current reading in Jack J-1 with the value obtained with the resistor. If the current values are different, change the transformer tap connections to the taps which give a current in Jack J-1 nearest the current measured through the resistor. After each change of transformer taps, readjust the core of the line tuning coil for maximum current.

Tuning Adjustment with Dummy Load Resistors

An adjustment procedure for obtaining a more exact impedance match is shown in Fig. 4, Line Coupling Tuner Adjustment. The dummy load resistors must be of sufficient wattage rating to dissipate the transmitter output.

Adjustment of Spark Gap

Adjust the spark gap SG-1 to 0.015 inch spacing. Observe the gap while the local transmitter is trans-

mitting full power. If the gap arcs over, increase the spacing until the arcing stops. The minimum spacing for the gap depends upon the carrier power, the power line impedance, and the capacitance of the coupling capacitor.

MAINTENANCE

Routine Checks and Records

This Tuning Unit requires very little maintenance. It should be inspected occasionally to see if there has been excessive burning of the spark gap.

If the spark gap shown signs of burning, rotate the discs to a new position and readjust the gap. Usually a semi-annual or yearly inspection is sufficient.

A permanent record should be kept of tap settings and the position of the coil-tuning cores so that they can be restored to the correct positions in case of unauthorized changes.

Ordering Replacement Parts

Replacement parts for this Tuning Unit may be ordered through the nearest Westinghouse District Office. When ordering, include:

1. The following data from the nameplate of the Line Tuner:

   (a) The type number; (b) the style number.

2. The (a) Electrical Parts List symbol; (b) the function; (c) the description; (d) the designation.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	FUNCTION	DESCRIPTION	STYLE NUMBER
SUB-ASSEMBLIES			
L-1	Line Tuning Coil	Line Tuning Coil Assembly	1474218
T-1	Transformer	Transformer Assembly	407C741G02
	High Frequency Trap	Trap Unit Assembly	540D760G01
—	Low Frequency Trap	Trap Unit Assembly	6294D16G01
—	Protector Unit	Protector Unit Assembly	1474014
COMPONENT PARTS			
C-1	Capacitor-Series	Mica- 1200 mmf. ± 5%, 5000V	290B762H01
C-2	Capacitor-Series	Same as C-1	
C-3	Capacitor-Trap Tuning	Mica- 2200 mmf. ± 5%, 5000V	290B762H02
C-4	Capacitor-Trap Tuning	Same as C-3	
J-1	Jack-Coax Metering	Binding Post Type 2 Binding Posts 1 Shorting Link	 185A431H01 1474455
J-2	Jack-Line Metering	Same as J-1	
SG-1	Spark Gap	Disc Type	2 of 183A358H20 (discs only)
OPTIONAL			
L-3	Drain Coil (When Used)	20,000 ohms minimum impedance over 30 - 200 kHz.	* 607B800G03
C-5	Series Capacitor (When Used)	Mica, 0.006 mfd., ± 5% 3000V, PACW.	584C256H03

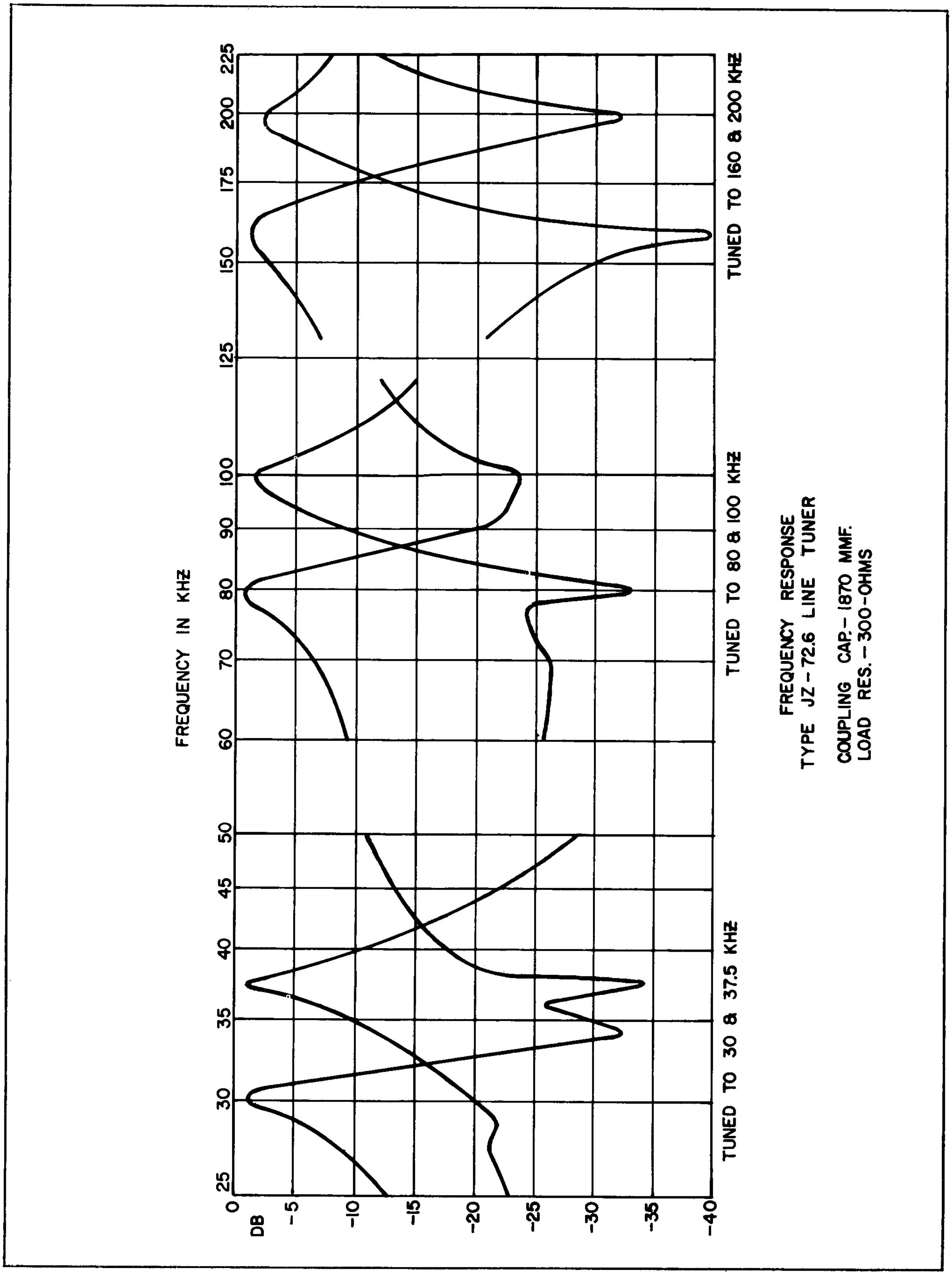


Fig. 1. Response Curves of JZ 72.6 Tuner. (Dwg. 862A348)

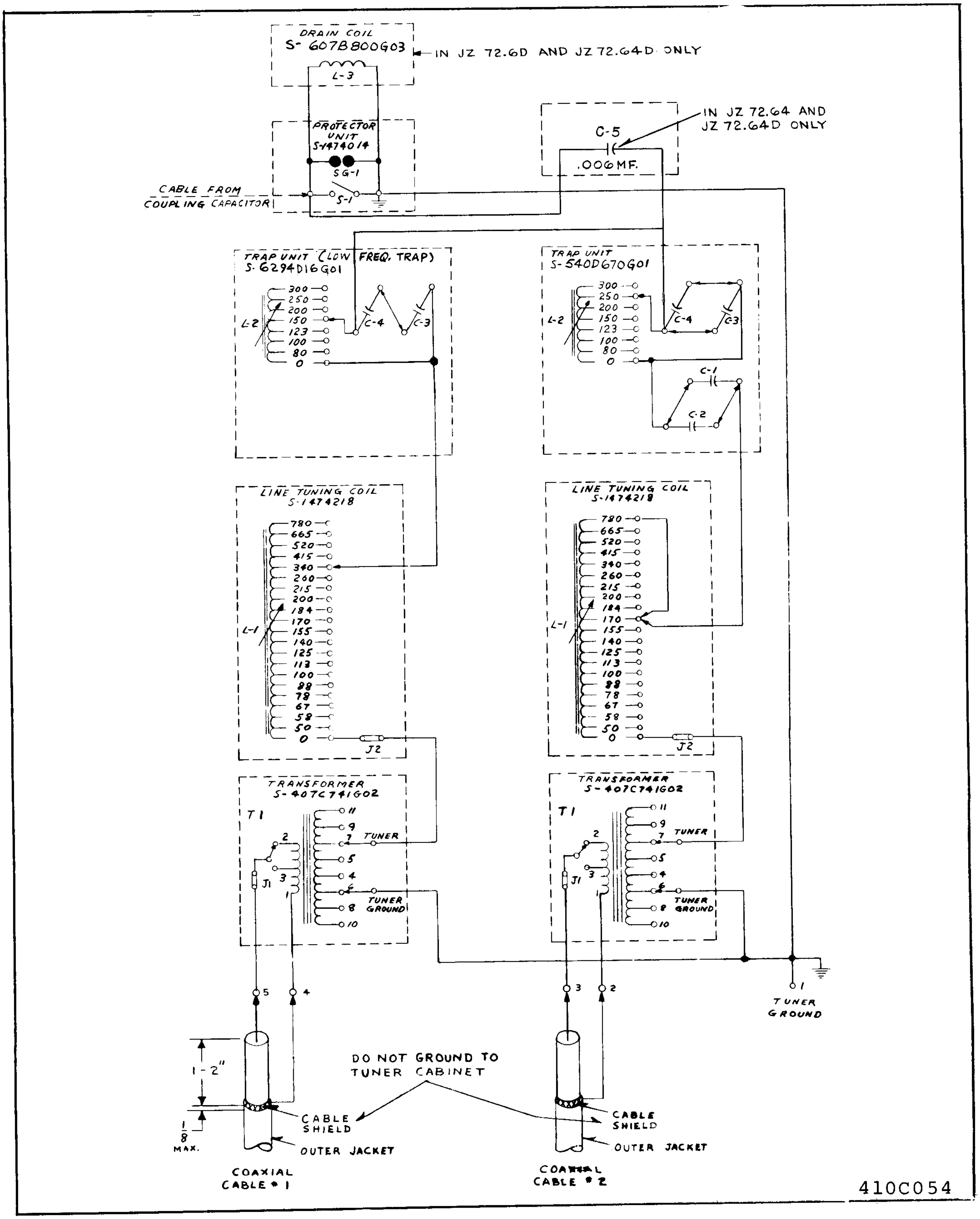
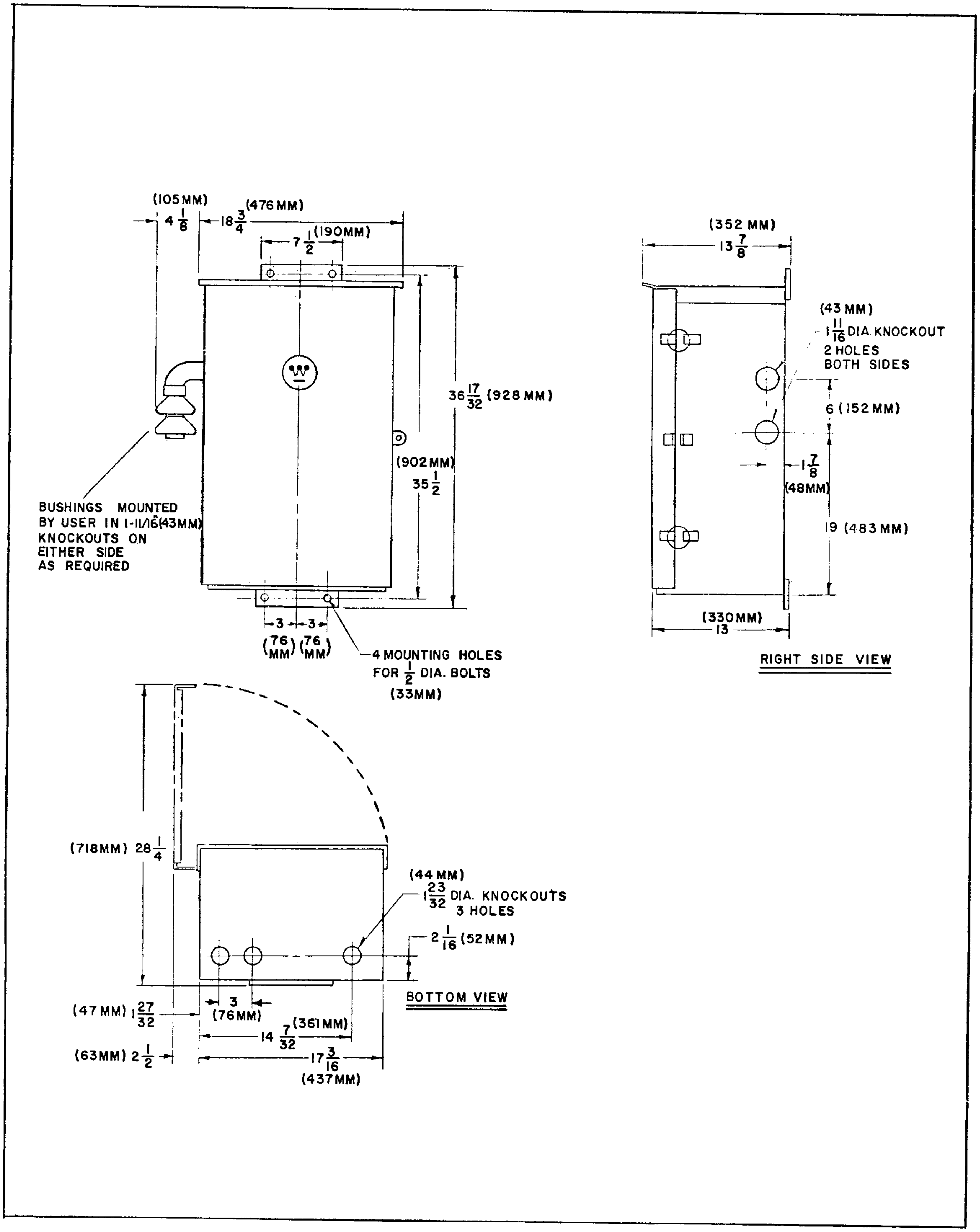


Fig. 2. Internal Schematic (Dwg. 410C091)



* *Fig. 3. Tuner Cabinet – Outline (Dwg. 50-B-7683)*

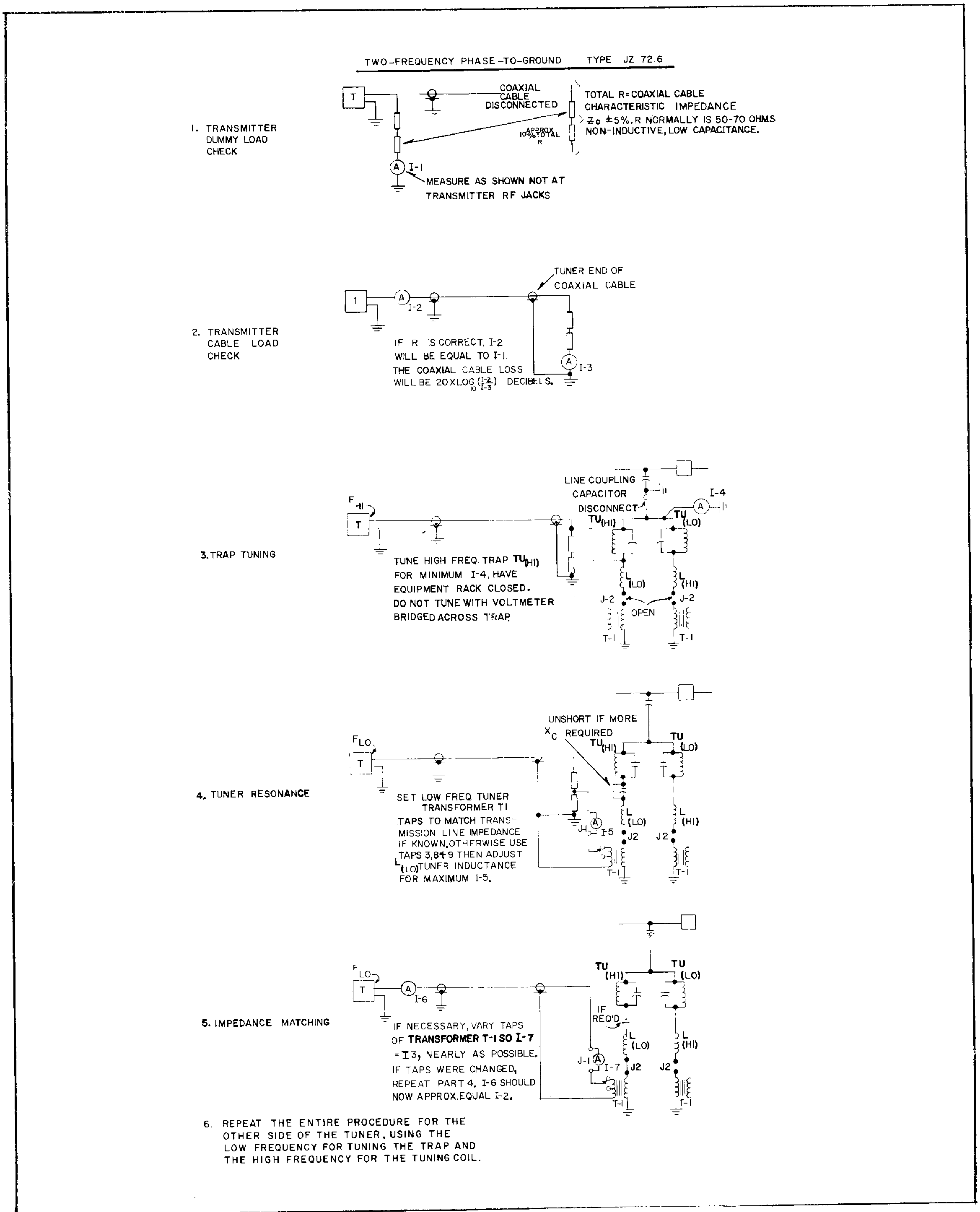


Fig. 4. Line Coupling Tuner Adjustment (Component Location as Viewed from Rear of Panel) (Dwg. 585C117)

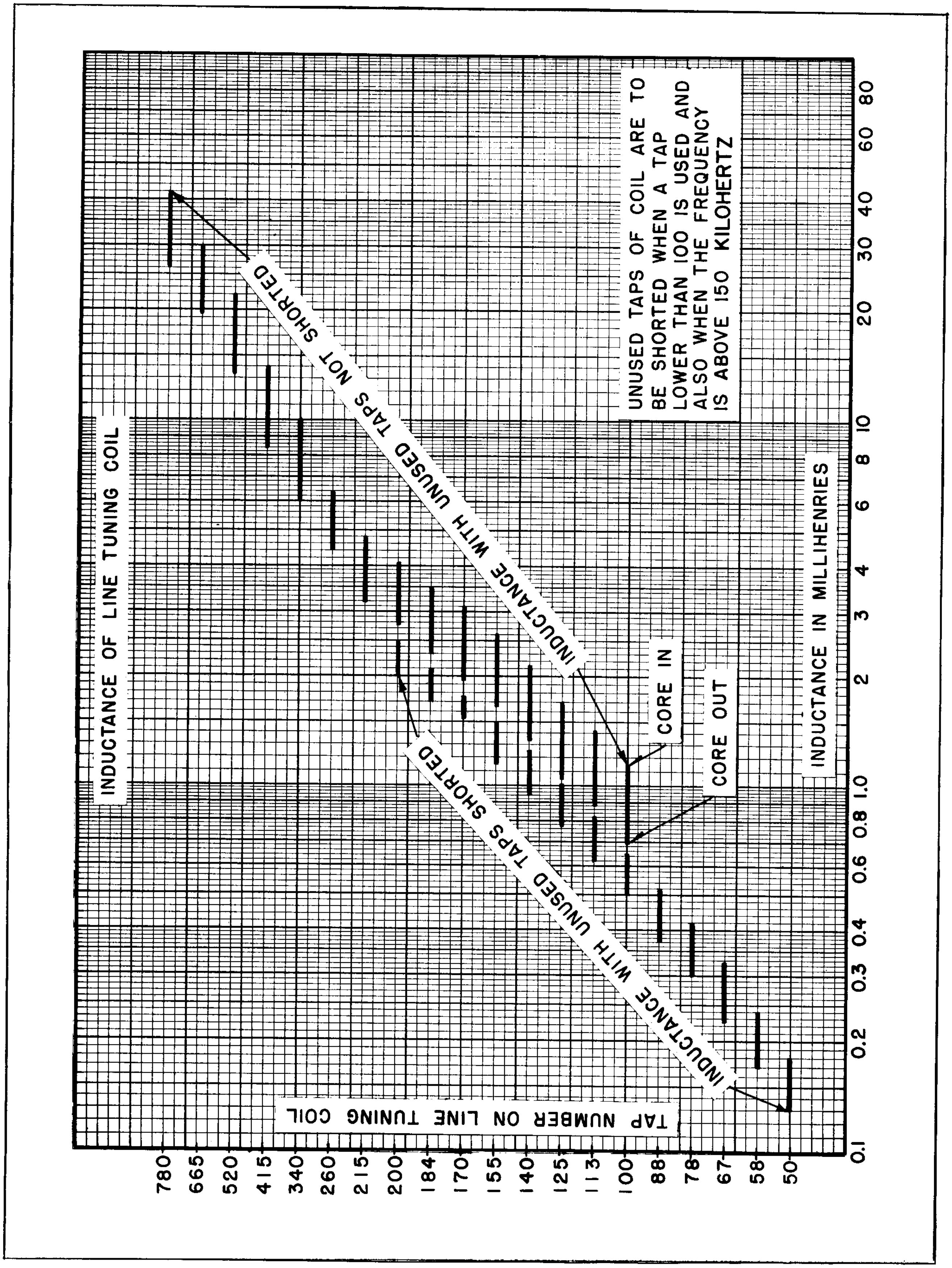


Fig. 5. Inductance of Line Tuning Coil (Curve 358433)

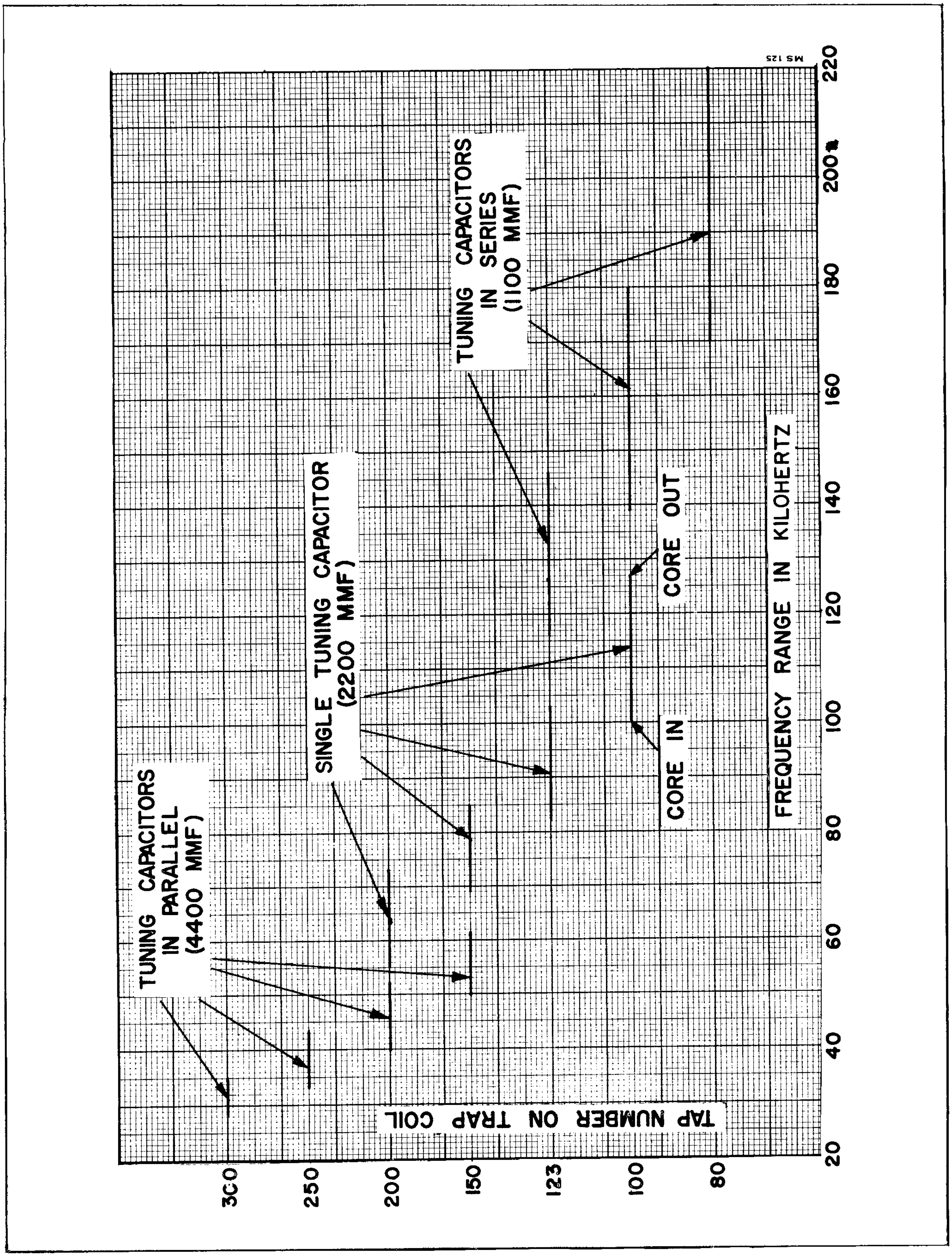


Fig. 6. Frequency Calibration of Trap Circuit (Curve 358434)

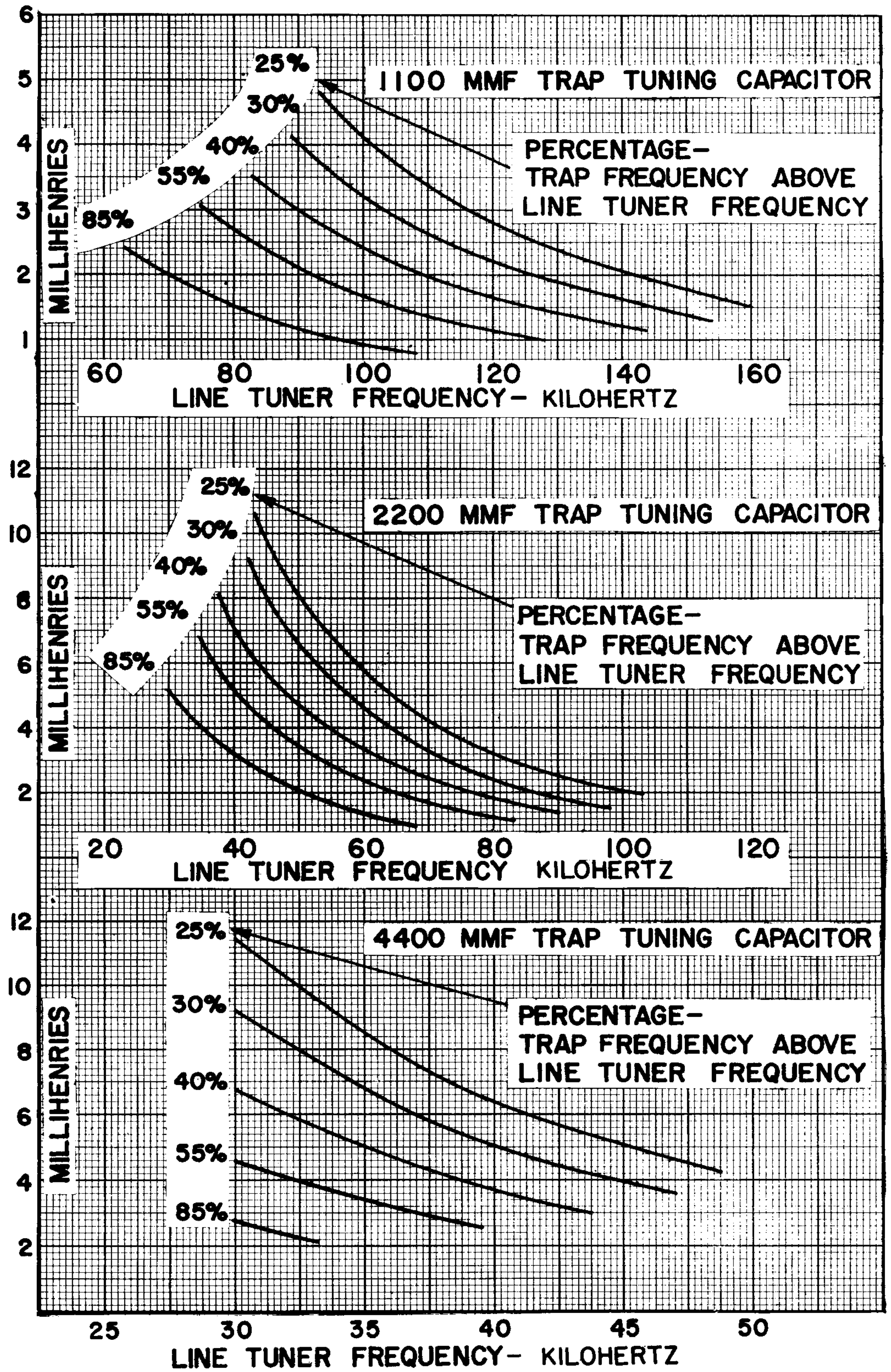


Fig. 7. Inductance of Trap Circuit at Line Tuner Frequency (Curve 358435)

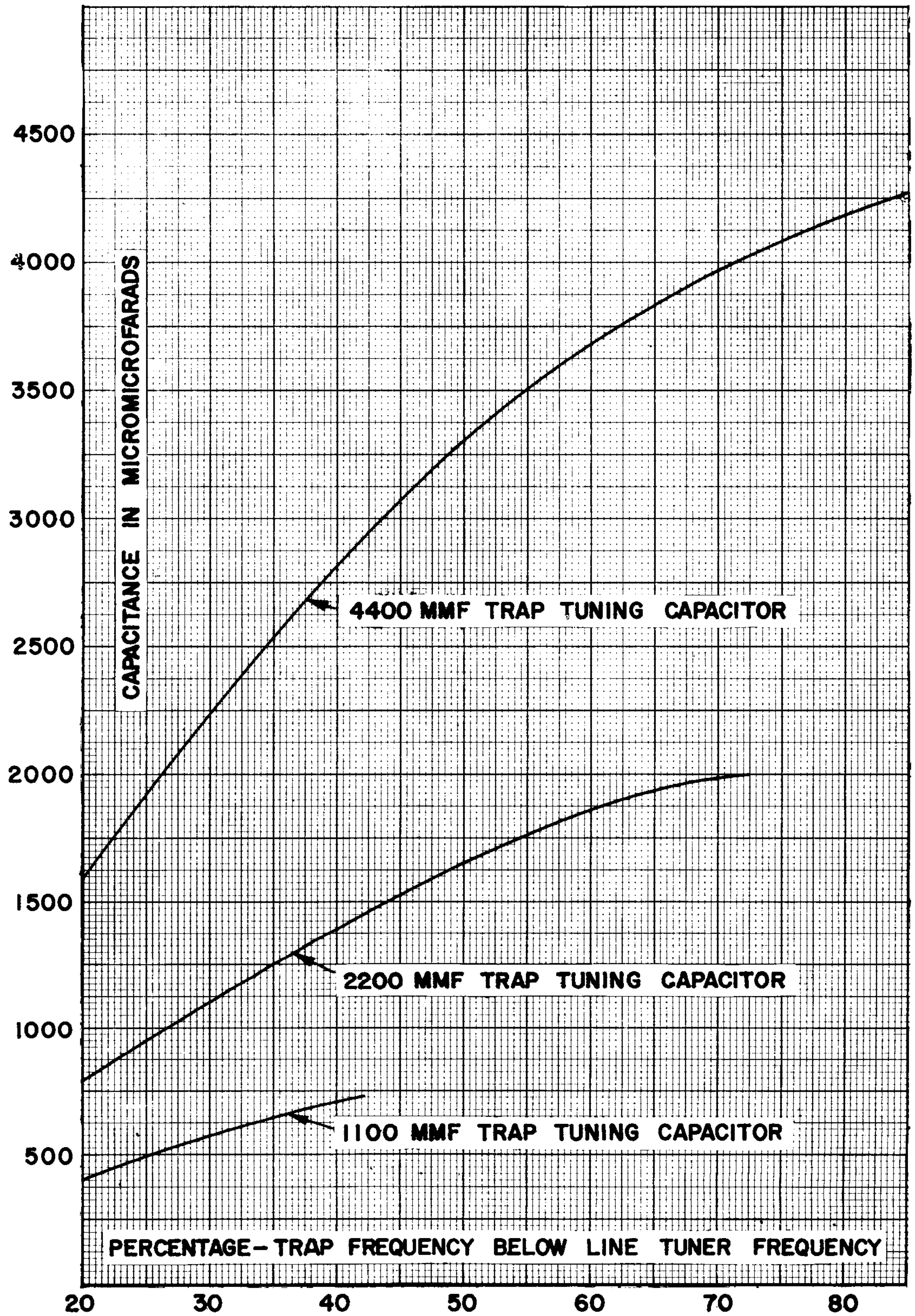


Fig. 8. Capacitance of Trap Circuit at Line Tuner Frequency (Curve 358436)

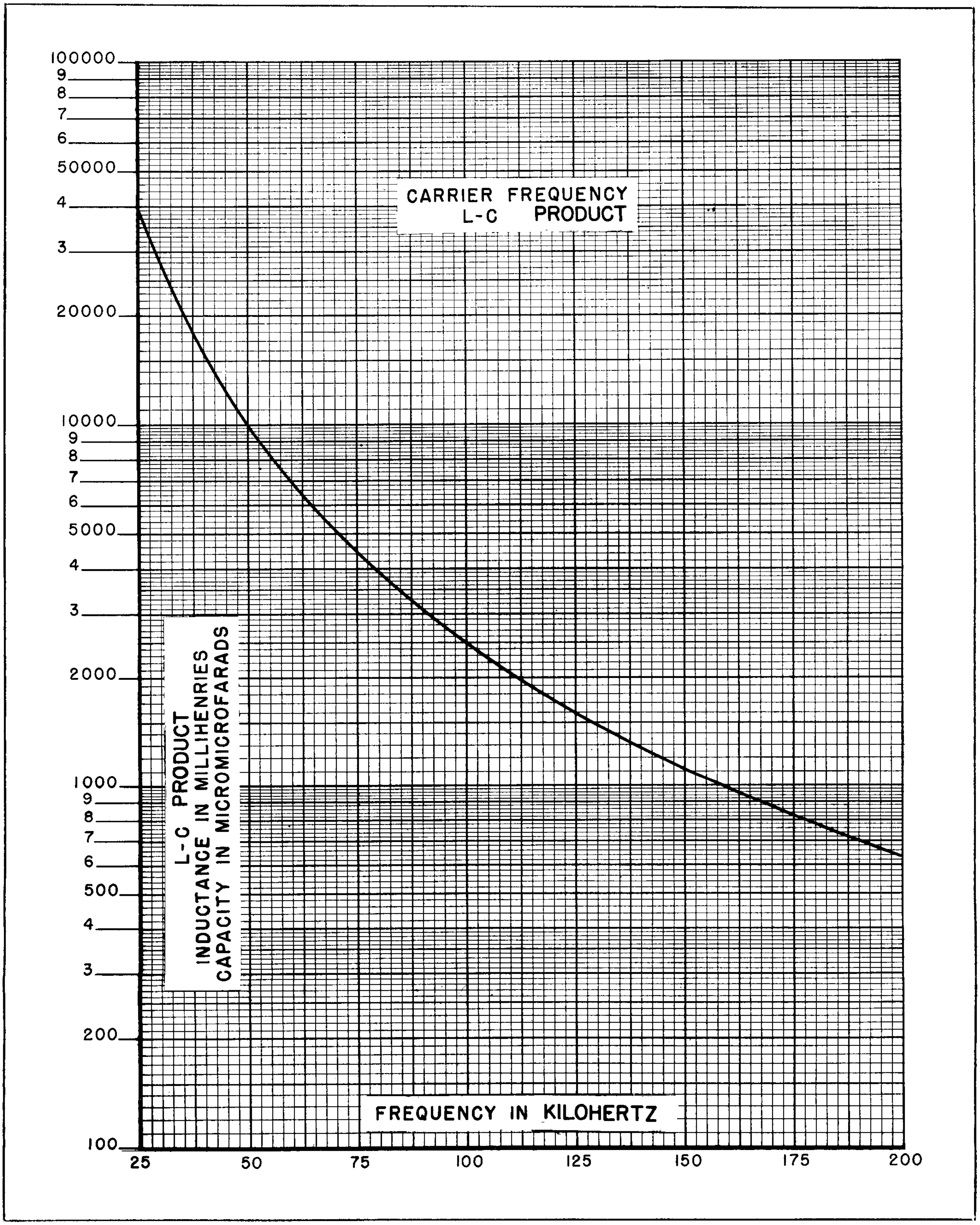
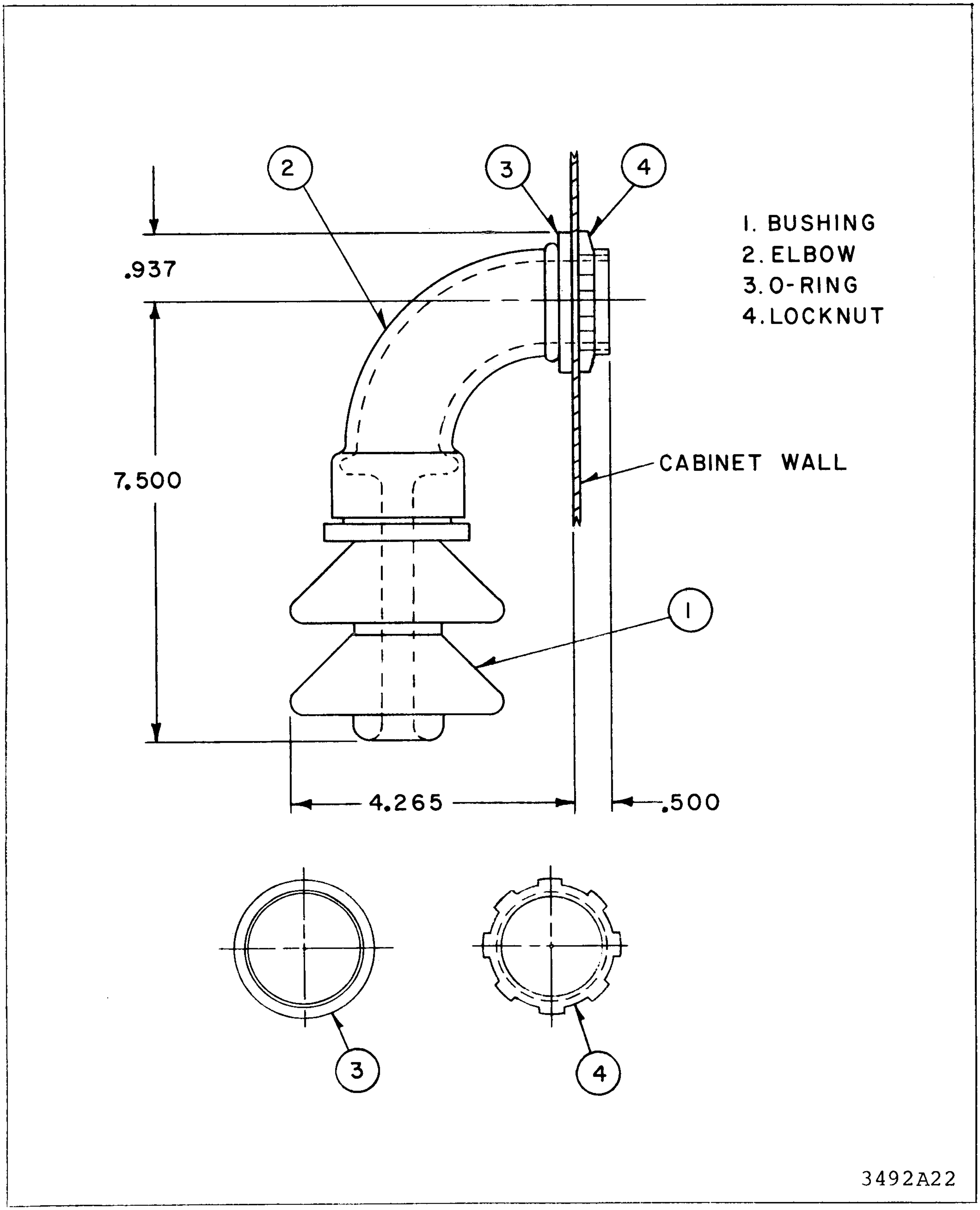


Fig. 9. Carrier Frequency L-C Product (Curve 358437)



* *Fig. 10. Lead-In Bushing Assembly*

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