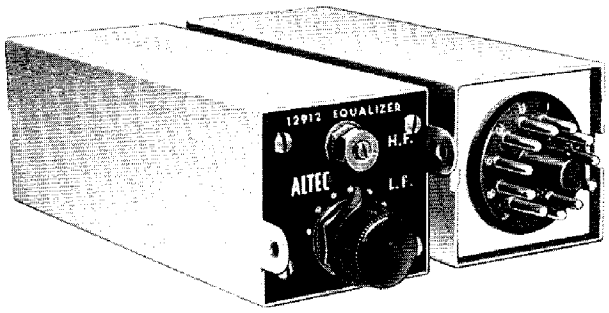
SECTION II

EQUALIZERS

12912 EQUALIZER



GENERAL

The 12912 Equalizer is used in conjunction with any one of the following Altec Transistor Amplifiers, 447, 449, 450, 453, 454, 455 or 457, to compensate for line losses over the speech frequency band on certain classifications of cable or open-wire facilities. It may be used on lines between radio transmitting and radio receiving stations and the associated radio terminal office; it may be used also on any one-way circuit, e.g. commercial speech, data transmission, facsimile transmission, etc. The combination of amplifier and equalizer enables one to equalize facilities as indicated below:

DESCRIPTION

The networks within the 12912 Equalizers are designed to effect equalization at an impedance of 600 ohms, irrespective of the facility, where characteristic impedance may be at 600 ohms open wire or H44 facility, higher at 1200 ohms (H88 facility) or lower at 150 ohms (non-loaded cable facilities). Consequently, a line transformer is included having a tapped primary which may be switched to present an impedance to line compatible with the facility. The switch is titled, "Facility" and has four (4) positions marked H88, H44, NON-LOADED and OPEN-WIRE respectively.

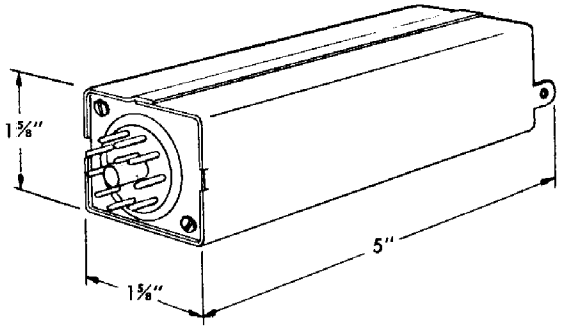
Both high frequency and low frequency correction circuits are incorporated within the equalizer.

High frequency correction is effected by means of a bridging circuit which comprises a parallel combination of inductance and capacity connected in series with an adjustable resistor. The anti-resonant frequency required in this circuit is determined by the facility characteristics. Consequently, the Facility switch, in addition to connecting the incoming line to the appropriate taps on the primary of the transformer, selects a capacity to resonate a fixed toroid inductor at the frequency desired. For loaded cable facilities this frequency is set at 3600 cps for H88 circuits, at 6100 cps for H44 circuits and at 7500 cps for non-loaded cable and open-wire lines.

Low frequency correction is effected by means of a parallel combination of capacity and resistance connected at the center of, and in series with, the secondary winding of the line transformer. There are six (6) combinations of capacity and resistance and these give progressive losses to the lower frequencies as the rotary-type L.F. switch is moved from position #1 to position #6.

A center tap is provided on the primary winding of the transformer to enable a DC control path to be operated over the facility.

The 12912 Equalizer is a plug-in type of unit. The front panel comprises a black insulated board on which are mounted the HF and LF controls; the metal framework and cover have a dichromate dip finish. The dimensions of the unit are 1 5/8" x 1 5/8" x 5 3/16" including knob less plug and it can be mounted in an Altec; 12910, 13227, 7300A/7303A, and 14115A Mounting Panel.



		MAX. LENGTH	FREQUENCY
16G	Non-loaded cable	20 miles	150 - 6000 cps.
19G	Non-loaded cable	15 miles	150 - 6000 cps.
H88	Loaded cable	60 miles	150 - 3500 cps.
H44	Loaded cable	50 miles	150 - 5000 cps.
80 mil 100% Copper	Open Wire	125 miles	150 - 6000 cps.
104 mil 40% Copper	Open Wire	75 miles	150 - 6000 cps.

The lengths obtainable with small gauge conductors are proportionally shorter.

TECHNICAL DESCRIPTION

All the cable and line facilities for which this equalizer is designed present a frequency loss characteristic similar to that indicated in Figure #1, in which attenuation is low at low frequencies and increases at the higher frequencies. The 12912 Equalizer contains networks which may be adjusted so that its attenuation-frequency characteristic is complementary to the line characteristic that produces the distortion. The net result will be a total loss characteristic which is substantially the same for all frequencies in the transmitted band. This total loss is compensated for by an amplifier which has a flat amplitude-frequency response over a wide range of frequencies. The line characteristic shown in Figure #1 is representative of a fifty (50) mile H44 loaded cable facility.

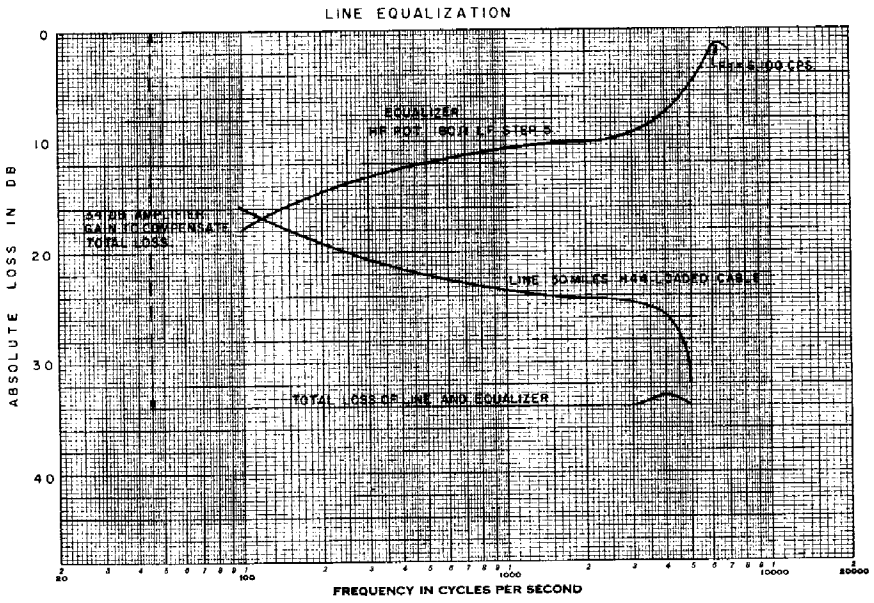


Figure 1

In general, all line facilities can be classified as either loaded or non-loaded. With loaded lines, the spacing between the loading coils and the value of their inductance determine the characteristic impedance, attenuation and the cut-off frequency of the line. The upper frequency which can be transmitted is somewhat lower than the cut-off frequency. The accompanying table shows the parameters of cable and other facilities which may be aligned with the equipment described.

Facility Cables	Impedance	Attenuation per Mile at 1000 cps		Cut-off Frequency
		16 ga.	19 ga.	
16 or 19 H88	1160	.19	.35	4000 cps
16 or 19 H44	800	.25	.49	5600
16 Non-loaded	330	.69		
19 Non-loaded	468		1.06	
Open Wire—100% Copper —80 mils dia.	766	.104		
40% Copper —104 mils dia.	800	.152		

Non-loaded cable and open-wire circuits are essentialy wide band with the effective cut-off frequency high. Loaded cable lines require more low and high frequency equalization than do 100% copper open-wire lines. At frequencies approaching the cut-off frequency of the line considerable equalization is needed. Non-loaded cables require the greatest amount of low and high frequency equalization. In the 12912 Equalizer the Facility switch matches the transformer to the line impedance and sets the resonant point of the HF network. The series resistance in the HF network determines the amount of mid-frequency loss, e.g., 1,000 cps relative to the resonant frequency loss; this is indicated in Figure #2 which is the H44 condition with the resonance at 6,100 cps. The approximate values of resistance required for different facility lengths are indicated. The low frequency equalizing networks are designed to furnish six (6) steps of increasing loss to offset the decreased transmission at the lower frequencies. Figure 3 indicates the absolute loss introduced by the transformer and L.F. correction networks. Actually, the 12912 Equalizer is marked in steps from 1 to 7. Position #1 is a condition of no capacity or resistance correction and represents the low frequency loss characteristic of the transformer.

HF NETWORK H44 CONDITION. LOSS-RESISTANCE CHARACTERISTICS.

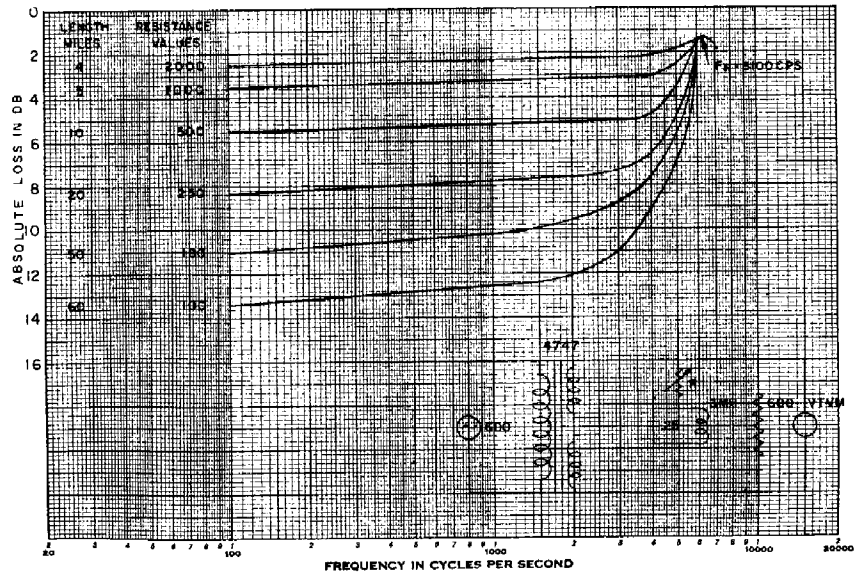


Figure 2

So far the performance of the HF and LF correction networks has been dealt with individually, the reason being that it is possible to separate the two (2) sections at the mounting socket.

However, in the general case, where the operation of the two (2) sections is combined, there is a cumulative effect presented when high degrees of low frequency and high frequency equalization are applied. From Figure #2 it can be seen that the characteristic changes only slightly between 1000 cps and 100 cps up to cable lengths of 20 miles but at 50 miles the differential amounts to about 1 db. With non-loaded cables, this feature is more pronounced and with 19 gauge cable at 15 miles it amount to about 3 db. From Figure #3 it can be seen that step #7 presents an increased loss of about 0.5 db at 1000 cps above the loss at step #1.

Figure #4 shows a family of curves which may be obtained with the 12912 Equalizer set for H44 cable correction. The resistance value indicated, namely 180 ohms, is the approximate value that would be used on a 50 mile facility. The effect of the LF switch operation is also shown.

In general, an H88 type of facility requires slightly lower values of series resistance than those employed for H44 corrections assuming equal lengths of cable. A non-loaded facility requires appreciably lower values in order to present an increased differential in the resonance curve to cope with the cable characteristic. In the latter case, assuming a 15 mile length of 19 gauge non-loaded cable, a resistance value of the order of 30 ohms would be required. This low value gives loss in the 100 to 1000 cps spectrum and, consequently, the amount of LF correction required by the LF network is reduced. Actually, the effect of the HF network on the 200 to 1000 cps region amounts to some 4 db level differential and approximately 5 db more of LF correction is needed to compensate the facility.

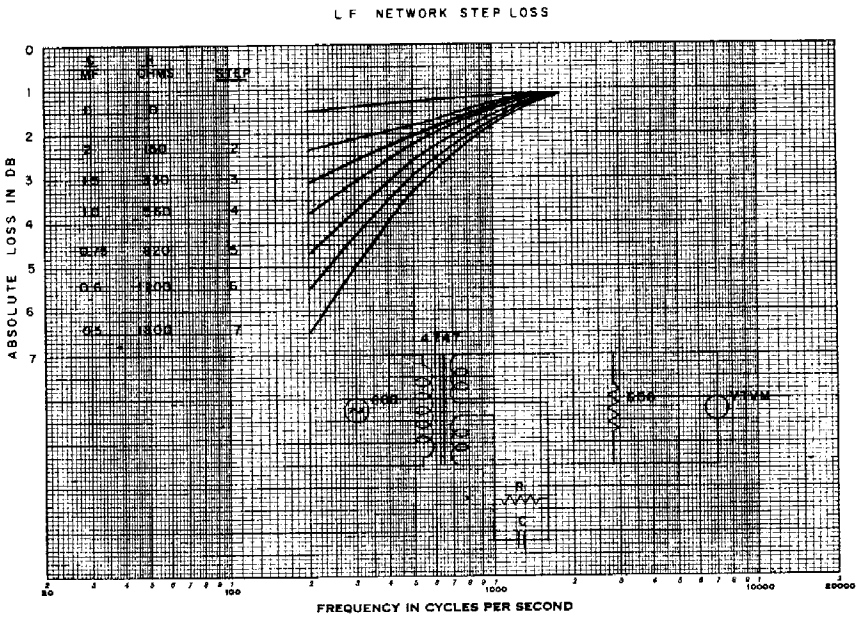


Figure 3

INSTALLATION

The 12912 Equalizer may be installed (a) in rows of ten (10) in the Altec 12910 Mounting Panel, or (b) singly in a 13227 Bracket. The 12910 Panel is suitable for mounting on a 19" relay rack and the 13227 Bracket is designed for mounting within a W.E. 105B Apparatus Box. At a central office installation, rows of equalizers would mount on a rack adjacent to rows of amplifiers.

The Apparatus Box would normally be used at a telephone customers premises and has a capacity for two amplifiers, each mounted in 13227 Brackets. Additional mounting information may be found in section on "Mounting". It has been mentioned earlier that the HF networks and the LF networks are brought out to separate pins on the 11-pin plug connector. For combined operation, as would normally be required, it is necessary to make wire strap connections at the 11-pin socket, pin 3 connects to pin 5 and pin 4 connects to pin 6. The incoming line pair is terminated at pins 1 and 2 and the outgoing pair to the amplifier is connected to pins 3 and 4. If shielded cables are used, the shields should be connected to pin 11. In some installations the center tap connection to the transformer may be used for a DC simplex circuit and the external simplex connection would be made to pin #9.

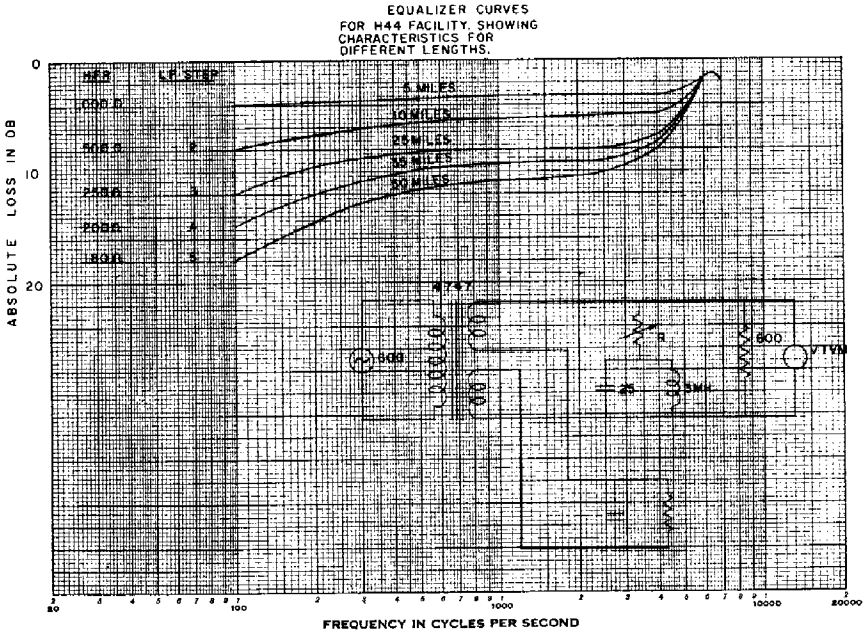


Figure 4

LINE-UP PROCEDURE

The length of circuit that can be equalized is determined by the accuracy of the equalization desired and the length and gauges of the circuits. Usually a through circuit of a specific facility and length will be required to be equalized but frequently a line loop composed of dissimilar sections may be encountered.

The following equipment is needed at the sending end of a circuit:

1. Oscillator — 19C, 21A, TMS or equivalent.
2. Repeating Coil — Altec 15036, Western Electric 111C, 119C or 119E.
3. Coordinating telephone set and order wire circuit.

The following equipment is needed at the receiving end of the circuit:

1. Measuring equipment — a TMS or VTVM.
2. 12912 Equalizer and its associated amplifier.
3. Coordinating telephone set and order wire circuit.

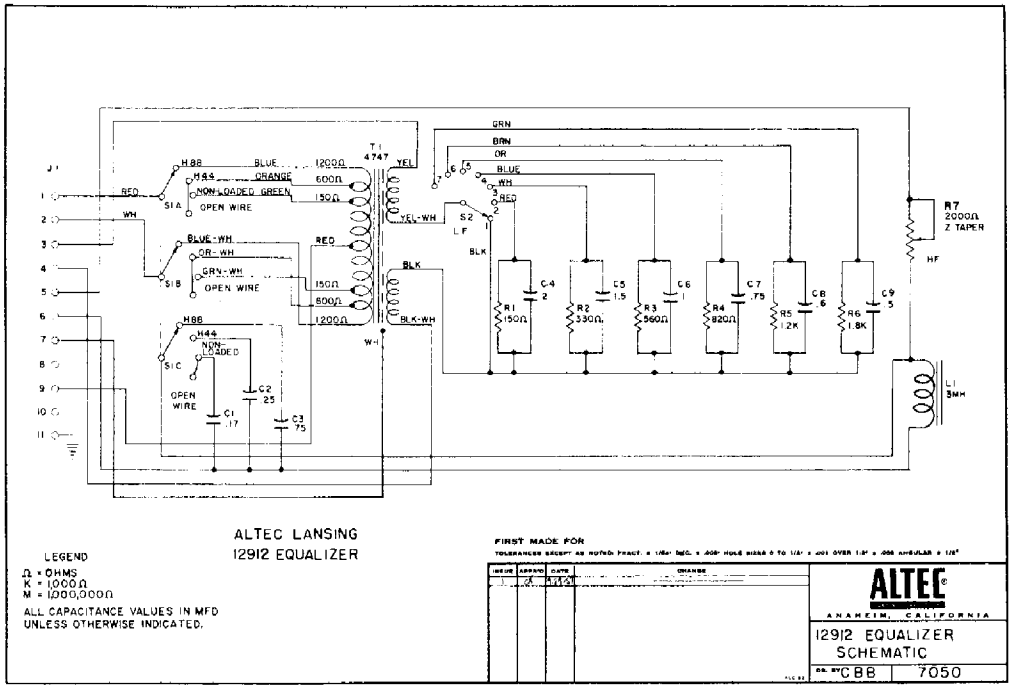
Connect the sending end transformer (with drop side 600 ohms and line side to suit the facility impedance, i.e., 150 ohms for non-loaded cables; 600 ohms for H44 loaded cables and open-wire facilities; 1200

ohms for H88 loaded cables) and apply 0 dbm at the drop side. Do not further readjust the level control when adjustment frequencies are requested by the receiving end.

Connect the equalizer and amplifier to the receive line and set the equalizer to suit the line facility. Terminate the output of the amplifier with 600 ohms and connect a TMS or VTVM across it.

The alignment of each type of facility follows a standard practice in which the HF correction is applied first and the LF correction is applied later. During HF adjustments the LF switch should be set at the #1 position. The line-up procedure is listed below:

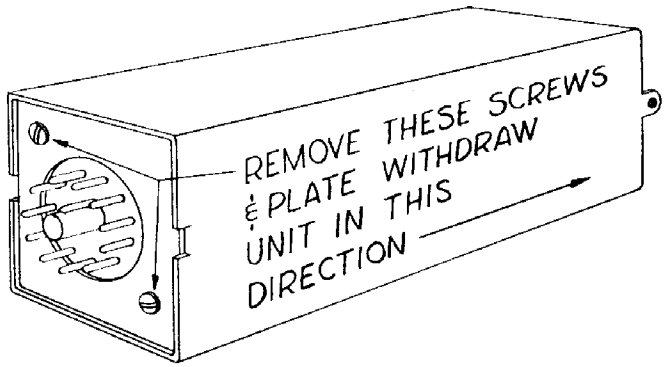
1. Set the amplifier gain at minimum.
2. Send one milliwatt at 6000 cps for non-loaded cables or open-wire lines, at 5000 cps for H44 loaded cable, at 3500 cps for H88 loaded cables.
3. Note the measured loss.
4. Send 1000 cps and adjust the HF control on the 12912 Equalizer until the loss is approximately the same as the HF loss.
5. Repeat the procedure making adjustments at the HF control until the 1000 cps and the HF loss measurements are the same.
6. Send 1000 cps and note the measured loss.
7. Send 150 cps and adjust the LF switch until the measured loss is approximately the same at the 1000 cps loss.
8. Check the measured loss across the band of frequencies from 150 cps to the HF and make slight adjustments at either the HF or the LF control until the optimum response is obtained.
9. Adjust the gain of the amplifier until the over-all transmission equivalent is at unity, i.e., the output level from the amplifier is 0 dbm.



PARTS LIST

C1	0.17 mfd 200v Hopkins P172D with Mylar Sleeve
C2	0.25 mfd 200v Hopkins P252D with Mylar Sleeve
C3, 7	0.75 mfd 200v Hopkins P752D with Mylar Sleeve
C4	2.0 mfd 200 v Hopkins 2P2D with Mylar Sleeve
C5	1.5 mfd 200v Hopkins 1P52D with Mylar Sleeve
C6	1.0 mfd 200v Hopkins 1P2D with Mylar Sleeve
C8	0.6 mfd 200v Hopkins P62D with Mylar Sleeve
C9	0.5 mfd 200v Hopkins P52D with Mylar Sleeve
J1	Plug Amphenol 86 CP 11
L1	3mh Choke, Toroid type, Freed Type T1-16 F2051
R7	2000 ohm Potentiometer. Z tape Clerostat 48M-9-2000.
R1	Resistor 150 ohms ½w 10%
R2	Resistor 330 ohms ½w 10%
R3	Resistor 560 ohms ½w 10%
R4	Resistor 820 ohms ½w 10%
R5	Resistor 1200 ohms ½w 10%
R6	Resistor 1800 ohms ½w 10%
S1	Altec 13234
S2	Altec 13235
T1	Altec 4747

DISASSEMBLY INSTRUCTIONS



17224 TELEPHONE CABLE EQUALIZER

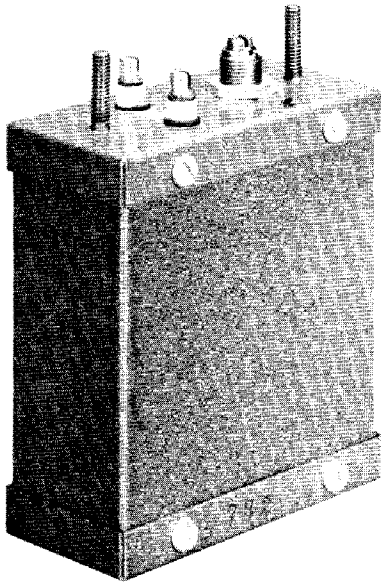
DESCRIPTION

The 17224 Equalizer consists of a continuously adjustable resistance in series with a parallel combination of fixed inductance and fixed capacitance. The equalizer is designed primarily to be used with the S-17 Program Amplifier System, connected as a shunt between the non-loaded cable circuit to be equalized and a terminating impedance which is practically constant at the frequencies for which equalization is desired.

A tapered 325 ohm continuously variable rheostat is provided for the resistive element. The taper is shown in Figure 5.

The action of the equalizer is making the transmission loss of the combination of equalizer and non-loaded cable circuit constant over the range of frequencies in question is as follows: At low frequencies, the inductive reactance is low so that the equalizer acts substantially as a resistance shunted across the circuit and the equalizer introduces relatively large loss of these frequencies, the amount of loss being controlled by the value of resistance used in the equalizer. At higher frequencies, the reactance of the inductance becomes greater so that the loss introduced by the equalizer is decreased. At still higher frequencies, the coil and condenser approach resonance in which case their parallel impedance is high and the equalizer introduces very little loss in the through circuit. Above this resonant frequency, the loss caused by the equalizer increases as the reactance of the capacitance element becomes less. For equalization covering the range to 8000 cps, the equalizer is so designed that the resonant frequency is approximately 9400 cps.

The circuit of the 17224 Equalizer is shown schematically in figure 6. Terminals 1 and 2 of the equalizer are for connection to the circuit to be equalized. The tuner circuit consists of a retardation coil, having approximately 2.5 millihenries inductance and a condenser with a capacitance of about .115 microfarad.



INSTALLATION

The elements of the equalizer are potted in a rectangular sheet metal case approximately 1¾ by 3¼ inches by 3½ inches deep. The case is arranged for single side mounting, the studs being 2¼ inches apart. A terminal plate mounting 2 terminals and the variable resistor is located between the studs. When uprights spaced for 19 inch mounting plates are employed the equalizers can be mounted horizontally on a 600 BW mounting plate, five to a row, or can be mounted within the S-17 Program Amplifier Systems.

APPLICATIONS

The lengths of circuits which can be taken care of by the equalizers are limited depending on the accuracy of the equalization desired and on the makeup of the circuits under consideration. The approximate losses for these limiting lengths of circuit when equalized are given below:

	Max. Dev. 1 db		Max. Dev. 2 db	
Gauge	Limiting Length — Miles	Equalized Loss — db	Limiting Length — Miles	Equalized Loss db
16	21.5	30.5	25.0	34.0
19	10.0	29.0	11.5	32.0
22	6.5	30.0	7.0	32.0
24	5.0	29.0	5.5	32.0
26	4.2	29.0	4.8	32.0

In the above table, maximum deviation means the maximum difference between the losses at any two frequencies within the band from 35 to 8000 cps.

LINE-UP PROCEDURE

The following equipment is needed at the sending end of the circuit:

1. Oscillator: 19C, 21A, TMS, or equivalent.
2. Repeating coil: Altec 15036, Western Electric 111C, 119C, or 119E.
3. Coordinating telephone set.

The following equipment is needed at the receiving end of the circuit:

1. Measuring equipment: a TMS or VTVM.
2. Repeating coil: Altec 15036 or equivalent.
3. 17224 Equalizer and its associated amplifier.

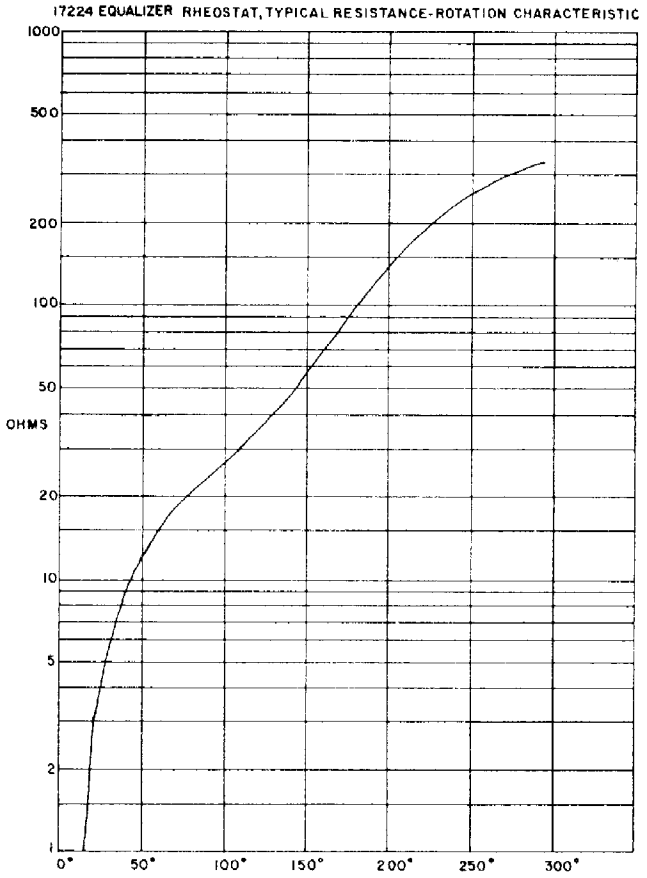


Figure 5

Connect the sending-end transformer: (with drop side 600 ohms and line side 150 ohms) and apply 0 dbm at the drop side. Do not further readjust the level control when adjustment frequencies of 1000 cps and 8000 cps are requested from the receiving end.

Connect the receiving-end transformer drop side 600 ohms and line side 150 ohms. Connect the equalizer with a 600-ohm resistor and a transmission measuring set or VTVM across the drop side of the transformer. Alternatively, the transformer and resistor may be omitted and the line coupled directly into a terminating amplifier such as the 437B (5-17 System) with level measurements made at its output.

Send 8000 cps and note measured loss. Send 1 kc and adjust the potentiometer on the equalizer until the loss is approximately the same as the 8000 cps loss. Repeat the procedure making potentiometer, inductance, and capacitance adjustments until 1-kc and 8000 cps losses are the same. (See Figure 7.)

The use of the 17224 Equalizer in a non-loaded cable circuit is shown in Figure 8. Each end of the cable circuits shown terminated in a repeating coil, such as the 15036 or equivalent, with the line windings connected in parallel for the 150-ohm condition.

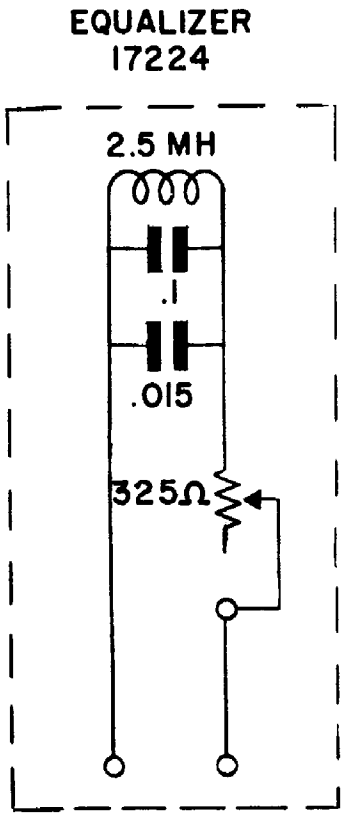


Figure 6

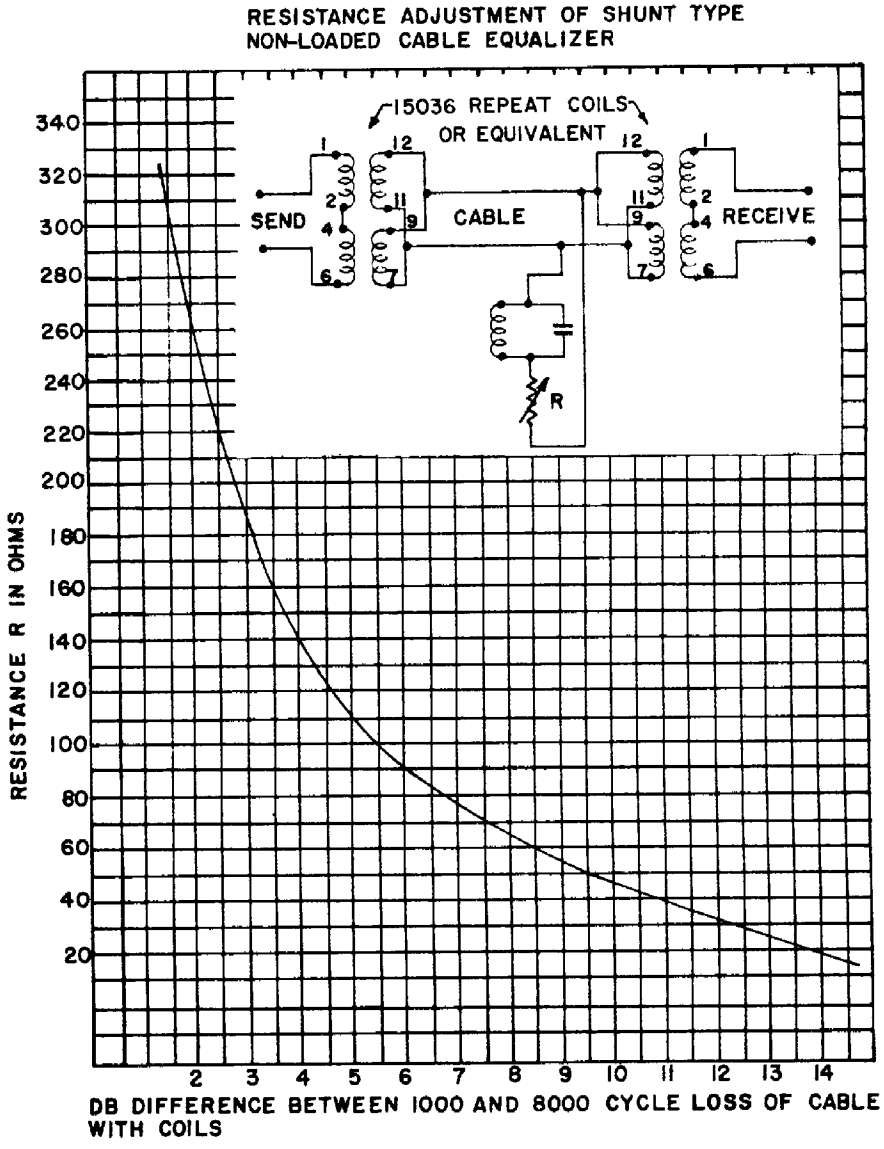


Figure 7

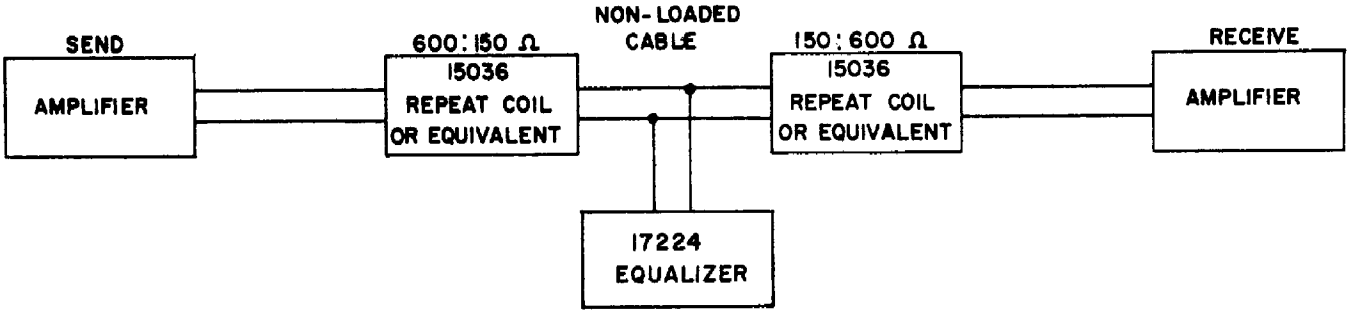


Figure 8

17249 TELEPHONE CABLE EQUALIZER

DESCRIPTION

The 17249 Equalizer consists of a continuously adjustable resistance connected in series with a parallel combination of fixed inductance and fixed capacitance. It can be used with the S-17 Program Amplifier System to equalize non-loaded cable circuits up to 15,000 cps. The equalizer is connected in shunt across the cable circuit. It is presumed that the latter is terminated by an impedance which is practically constant over the frequency range for which equalization is desired.

For 15,000 cps equalization, a resonant frequency of 18,000 cps is used. A wide range of both inductance and capacitance is available in the equalizer, whereby the L/C ratio at resonance may be selected to suit the reqiurements of a particular line facility.

A tapered 325-ohm continuously-variable rheostat is provided for the resistive element. The taper, shown in figure 9, facilitates adjustment when resistive values required for equalization are below 25 ohms.

The action of the equalizer is making the transmission loss of the combination of equalizer and non-loaded cable constant over the range frequencies in question is as follows: At low frequencies, the inductive reactance is low so that the equalizer acts substantially as a resistance shunted across the circuit and introduces relatively large loss at these frequencies, the amount of loss being controlled by the value of resistance used in the equalizer. At higher frequencies, the reactance of the inductance becomes greater so that the loss introduced by the equalizer is decreased. At still higher frequencies, the coil and condenser approach anti-resonance, in which case their parallel impedance is high and the equalizer introduces very little loss in the circuit. Above this resonant frequency, the loss caused by the equalizer increases as the reactance of the capacitive element becomes less.

Figure 10 is a schematic diagram of the 17249 Equalizer. Terminals 4 and 18 are for connection to the circuit to be equalized. As shipped, 4 is strapped to 14 and 7 to 17, this arrangement providing an inductance value of 4 mh, a capacity of 0.02 μf, and a resonant frequency of 18,00 cps. The rheostat P1 is variable from 0 to 33 ohms and thence to an open circuit condition, enabling the equalizer to be readily disconnected from the transmission path.

The elements of the equalizer are housed in a rectangular sheet metal case approximately 1¾ inches by 3¾ inches by 3½ inches deep. The case is arranged for single side mounting, the studs being 2¼ inches apart. A terminal plate (18 terminals) and the variable resistor are located between the studs.

APPLICATIONS

The length of circuit that can be equalized is determined by the accuracy of the equalization desired and the lengths and gauges of the circuits. Approximately 16 miles of 16-gauge, and ten miles of 19-gauge non-loaded cable can be equalized to 15,000 cps by the 17249 Equalizer used with an amplifier having the gain and frequency response of the Altec S-17 Amplifier System.

INSTALLATION

Two 17249 Equalizers may be mounted within the S-17 Amplifier System. Access for adjustment may be obtained by removing the amplifier cover plate adjacent to the test jacks.

Individual units can be mounted on a 600 BW type plate, the latter having a capacity for five equalizers.

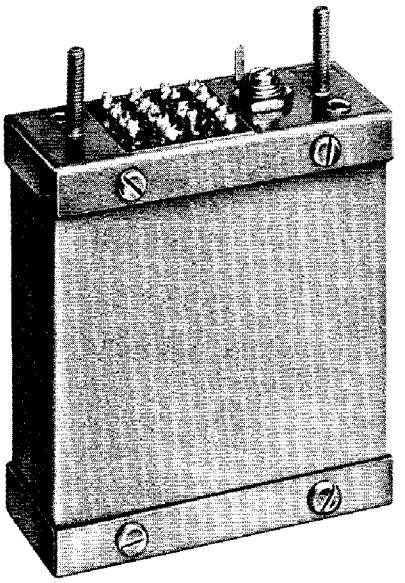
LINE-UP PROCEDURE

The following equipment is needed at the sending end of the circuit:

1. Oscillator: 19C, 21A, TMS, or equivalent.
2. Repeating coil: Altec 15036, Western Electric 111C, 119C, or 119E.
3. Coordinating telephone set.

The following equipment is needed at the receiving end of the circuit:

1. Measuring equipment: a TMS or VTVM.
2. Repeating coil: Altec 15036 or equivalent.
3. 17249 Equalizer and its associated amplifier.



17249 EQUALIZER RHEOSTAT, TYPICAL RESISTANCE-ROTATION CHARACTERISTIC

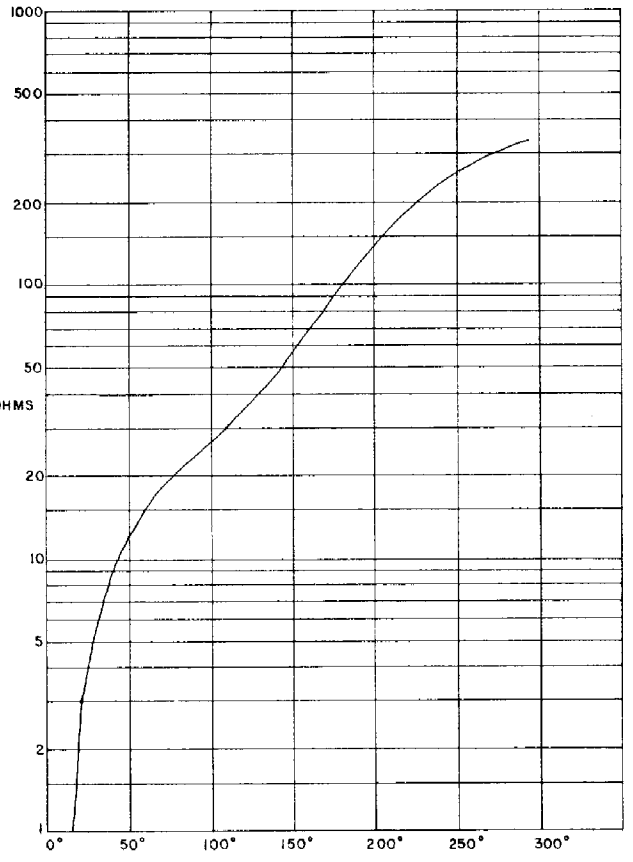


Figure 9

Connect the sending-end transformer (with drop side 600 ohms and line side 150 ohms) and apply 0 dbm at the drop side. Do not further readjust the level control when adjustment frequencies of 1000 cps and 15,000 cps are requested from the receiving end.

Connect the receiving-end transformer drop side 600 ohms and line side 150-ohms. Connect the equalizer with a 600-ohm resistor and a transmission measuring set or VTVM across the drop side of the transformer. Alternatively, the transformer and resistor may be omitted and the line coupled directly into a terminating amplifier such as the 437B (S-17 System) with level measurements made at its output.

Send 15,000 cps and note measured loss. Send 1,000 cps and adjust the potentiometer on the equalizer until the loss is approximately the same as the 15,000 cps loss. Repeat the procedure making potentiometer, inductance, and capacitance adjustments until 1,000 cps and 15,000 cps losses are the same.

Table 1 shows the capacitance values required to resonate with various inductance values at approximately 17,000 cps to 19,000 cps.

The equalizer is designed primarily for an impedance of 600 ohms. It does, however, function satisfactorily at 150 ohms. At this impedance, it will be necessary to use the lower values of the L/C ratio with inductance values from .004 henry to .001 henry.

The gain of the amplifier is adjusted to offset the cable and equalizer losses to provide the net transmission desired.

In general, the lower the L/C ratio the steeper the resonance curve, the greater the loss at 1 kc relative to the loss at 15 kc, and the higher the absolute insertion loss at 15 kc as illustrated in Table II.

TABLE I

Combinations Resonant at 17 to 19 kc

INDUCTANCE Henries	Strap Terminals	Microfarads	CAPACITANCE Strap Terminals*
.018	1 — 8	.004	11
.012	1 — 6	.007	12
.010	2 — 8	.008	9 — 10 — 11
.009	1 — 5	.009	10 — 12
.008	2 — 7	.010	9 — 10 — 12
.006	1 — 4	.013	10 — 11 — 12
.004	4 — 7	.020	14
.003	1 — 3	.026	10 — 11 — 14
.0025	4 — 6	.031	11 — 12 — 14
.002	1 — 2	.039	11 — 15
.0014	2 — 4	.056	9 — 14 — 15
.001	4 — 5	.079	14 — 16

*The common terminal is #17.

TABLE II

Bridging Loss with Potentiometer at 50 Ohms

FREQUENCY	L= .008 h. C= .01 μf.	L= .004 h. C= .02 μf.	L= .002 h. C= .039 μf.
15 kc	0.6 db	0.8 db	1.3 db
10 kc	1.6 db	3.2 db	6.8 db
6 kc	3.8 db	7.5 db	12.6 db
3 kc	8.0 db	12.2 db	15.5 db
1 kc	12.5 db	15.8 db	16.7 db
500 cps	15.7 db	16.5 db	16.8 db
100 cps	16.5 db	16.8 db	16.8 db
50 cps	16.5 db	16.8 db	16.9 db

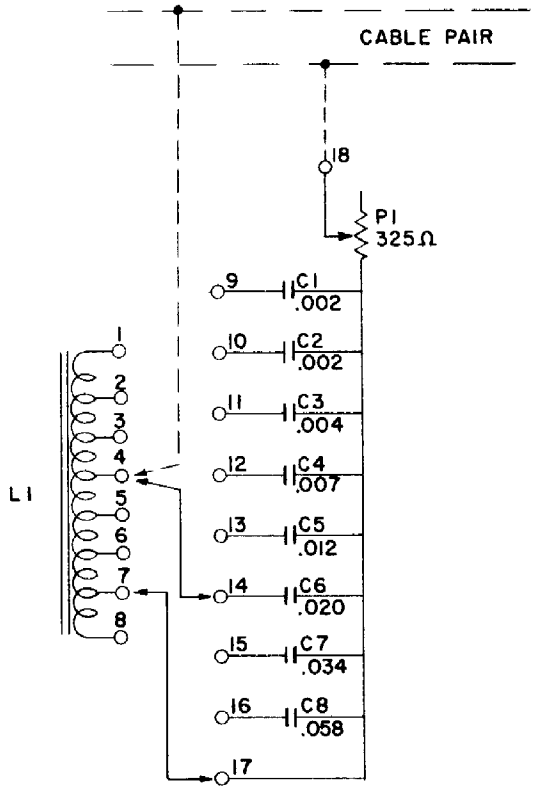


Figure 10

NOTE:

For 15 kc equalization, the resonant frequency should be 17-19 kc.

Interconnections between L & C are typical settings for commencement of equalization.

L1 VALUES

Terminals	Hy
1 - 8	.018
1 - 7	.015
1 - 6	.012
2 - 8	.010
1 - 5	.009
2- 7 or 3 - 8	.008
1 -4, or 2 - 6, 3 - 7 or 4 - 8	.006
3 - 6 or 4 - 7	.004
1 - 3 or 2 - 5	.003
4 - 6 or 5 - 8	.0025
1 - 2 or 3 - 5	.002
2 - 4 or 5 - 7	.0014
4 - 5 or 6 - 8	.001