SINGING POINT TESTS FOR VOICE FREQUENCY TRUNKS

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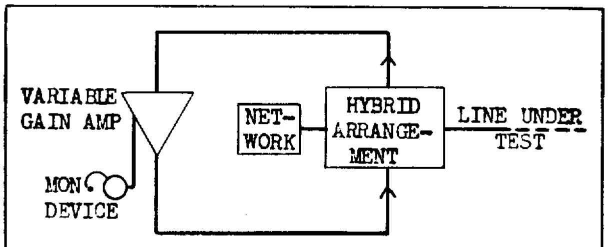
1. GENERAL

1.01 This section describes methods for making singing point tests with telephone repeaters and other apparatus employing hybrid transformers. Information on locating trouble is also included to assist in correcting low singing points (unbalances). The simplified theory of singing point tests is covered in Section 332-015-100.

1.02 This section is reissued to incorporate information previously covered in the addendum. The changes are indicated by marginal arrows.

1.03 Singing point tests have been known by various names in the past. In order to clarify the situation, the following names have been selected as being more descriptive, and a brief explanation is given for each.

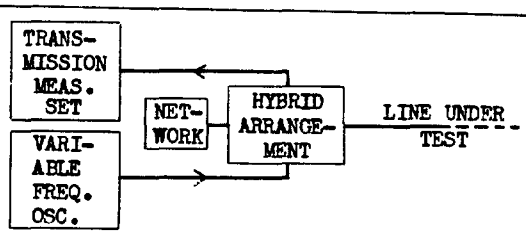
(1) Singing Point: A singing point is an expression of the degree of balance existing between a line and its balancing network. The higher this singing point is maintained, the higher the repeater gain can be operated and the lower the over-all net loss of the trunk can be adjusted. A singing point is in effect a measure of the loss across a hybrid transformer (minus the actual transmission loss) due to the difference in impedance at various frequencies presented by the line and balancing circuits connected to this hybrid transformer. A singing point is established by increasing the gain of an amplifier, connected from the hybrid transformer output to input, until the circuit just starts a sustained sing. The measured singing point is the 1000-cycle gain necessary to cause singing minus the transmission loss of the hybrid transformer (the 1000-cycle gain of 22-type repeaters includes the hybrid losses). Fig. 1A shows the basic singing point testing method.



BASIC SINGING POINT TESTING METHOD
FIG. 1A

(2) Return Loss: Return loss is also an expression of the degree of balance existing between a line and its balancing network. It differs from a singing point by the method of making the tests. The

results obtained may differ by a small amount. A return loss is the actual measured loss at various frequencies through a hybrid arrangement to which the line and its balancing network are connected. Fig. 1B shows the basic return loss testing method.



BASIC RETURN LOSS TESTING METHOD
FIG. 1B

(3) Section Singing Point Tests were formerly called "21 circuit balance tests" or "passive singing point tests." These are singing point tests made on one section of a trunk to a termination at the next repeater office or to the next office which has a hybrid arrangement on the trunk, such as a carrier terminal. If there is no intermediate hybrid arrangement the termination should be placed on the trunk at the distant terminal. These tests are made to detect equipment or structural irregularities.

(4) Over-all Active Singing Point Tests were formerly called "active balance tests" or "active singing point tests." They are singing point tests made on an over-all trunk (including dial type trunks) from a switching point to a termination at the other terminal. These tests are made with an additional repeater or measuring device at the testing end with all the regular repeaters in a normal operating condition and a termination secured at the switchboard, secondary toll testboard, or through the switches at the distant terminal. These tests are made to detect low section singing points.

(5) Office Cabling Balance Tests or office drop balance tests are described and the methods of making these tests are covered in other sections of the practices.

Note: The term "hybrid transformer" as used in this section applies to any hybrid arrangement (e.g., hybrid transformers in 22-type repeaters, V-type line units, 4-wire terminating sets, and resistor hybrids used with V-type repeaters, etc.).

1.04 The line and network to be tested are connected, respectively, to the line and network terminals of a hybrid transformer. In the case of the 22-type repeater, this hybrid transformer together with the other elements of the repeater (amplifiers, filters, and the "other" hybrid transformer) are connected in a closed path which will sing when the necessary conditions are present. (See Chart 3A.) In the case of V-type repeaters and 4-wire terminating sets on 2-wire extensions an attenuator replaces the "other" hybrid transformer, completing the closed path which will sing when the necessary conditions are present. (See Charts 3B, 3C, and 3D.)

1.05 Singing is detected by listening with a telephone receiver connected to the monitoring circuit of the repeater or amplifiers or bridged on the singing path in such a way that singing will not be influenced. (See Charts 3A, 3B, 3C, and 3D.)

1.06 Singing is established by increasing amplifier gains, by decreasing the loss through the "other" hybrid transformer in the case of the 22-type repeater, or by decreasing the loss through the attenuator in the case of V-type repeaters. To determine the singing points, the losses should always be decreased (or gain increased) gradually until sustained singing is just obtained. In no case is the singing point to be determined by starting with a singing condition and increasing the losses (or lowering the gain) until singing ceases. Accordingly, to make a second determination of a singing point when singing is once established, losses shall be increased beyond the point necessary to stop singing and then shall be decreased gradually until sustained singing is just obtained. The tester should be on guard to observe for an intermittent or interrupted sing if an echo suppressor or a single frequency signal filter is in the singing path.

1.07 The measured singing point may be determined from the amplifier gains and equipment losses in the singing path as covered in the charts. The singing point is influenced by the frequency characteristics of the measuring equipment but for convenience the gains or losses are measured at 1000 cycles without regard to the fact that singing may occur at any frequency in the range of the measuring circuit. The gains and losses at the singing frequency may be different from those measured at 1000 cycles. The results of the singing point tests are expressed in decibels (db). High numerical values in db indicate good singing points and conversely, low numerical values indicate poor singing points.

1.08 Singing is greatly affected by the phase relation of the reflected or return current. The reflected current may have any phase relation for any type of facility. In measuring a singing point by any of the methods described in this section, two different phasing arrangements are established in the testing circuit to determine the worst singing condition, which for convenience are termed the "positive poling" and "negative poling" tests. The singing point determined by one poling test may differ either in magnitude or singing frequency or in both from that determined by the other poling test.

1.09 The change in "poling" (equivalent to a phase shift of 180 degrees) in the singing circuit is obtained in one of three ways.

(1) By the interchanging of the line and network circuits at one hybrid transformer, but not at both. (See Chart 3A.)

(2) By a change from a short circuit to an open circuit condition on the line side of one hybrid transformer. (See Chart 3A.)

(3) By a turnover of the two conductors somewhere in the singing circuit. (See Chart 3A.)

The choice of which poling is "positive" and which is "negative" is purely arbitrary.

1.10 <u>All singing point tests should be made with both polings but only the results of the test with the poling which gives the smaller numerical value should be reported as the singing point.</u>

1.11 When making singing point tests by any of the methods described in this section, the trunk should not be allowed to sing any longer than necessary since a singing condition may induce a disturbance into other trunks or circuits. The singing should be stopped by decreasing the gain of the repeater used for the test or by increasing the attenuator loss.

1.12 The singing path should include at least one low pass filter which limits the frequency of singing to the frequency band normally transmitted by the trunk being tested. In the case of cable trunks, the filters (or the filter having the lower cutoff if they are not alike) should correspond to the filter codes listed in the following table:

Toll Cable Facility	Facility Nominal Cutoff Frequency	Circuit Layout Code	13-type Filter	128-type Filter	Critical Singing Frequency
16 or 19 ga. H-172-S	2800	B	B	B	2000
16 or 19 ga. H-174-S	2800	B	B	B	2000
16 or 19 ga. H-106-P	2900	B	B	B	2000
16 or 19 ga. H-63-P	3700	C	C	C	2200
16 or 19 ga. H-88-S	4000	D	D Spec.	A	2900
16 or 19 ga. B-88-S	5600	D	D "	A	2900
16 or 19 ga. H-50-P	4200	D	D "	A	2900
16 or 19 ga. B-50-P	5900	D	D "	A	2900
16 or 19 ga. H-44-S	5600	D	D "	A	2900
16 or 19 ga. H-25-P	5900	D	D "	A	2900
Open Wire 3 kc carrier filter		C	C	C)	See Note
" " 5 kc or no carr. filter		D	D Spec.	A)	

Note: The critical frequency on open wire may be low, intermediate or high.

The usual practice is to assign "C" filters for open wire trunks with 3 kc carrier line filters, and "D" filters where the open wire trunks employ 5 kc or no carrier line filters and where there are no large intermediate irregularities. The critical singing frequencies listed are the approximate frequencies at which singing is likely to occur on a normal trunk, during singing point tests, for the different facilities and filters.

1.13 In general, for 22-type repeaters, section singing point tests should be made with the repeater regularly assigned to the trunk, where it is convenient to do so. In case it is desirable to use a "test" repeater, it should have the same type of filters and equalization as the repeater assigned to the trunk. With V-type repeaters the tests should include the line equipment associated with the facility but not necessarily the regularly assigned repeater.

1.14 Telephone set panels should be disconnected from all intermediate and terminal repeaters except the test repeater while either section or over-all active singing point tests are being made. Any monitoring at other than the test point may cause erroneous results.

1.15 When a singing point test is to be made involving a working trunk, the control office should be notified to remove it from service in the proper manner unless the test itself, such as an over-all active singing point test, requires a connection over the trunk. This is particularly important on dial type trunks (not only those equipped with single frequency signaling).

1.16 Where single frequency signaling is employed over ringdown trunks, the tone is absent in both the idle and busy conditions, so the trunk may be interrupted without affecting the signaling circuit.

1.17 Where single frequency signaling is employed for dial or multi-frequency key pulsing trunks, the tone is present on the trunk in the idle condition and any interruption of this tone will cause a seizure of the switching equipment.

1.18 For making section singing point tests on intertoll trunks employing single frequency signaling, it seems preferable not to disable the signaling equipment, provided care is taken to terminate the various parts of the trunk under test so that singing will not occur in the parts not being tested. Any singing might cause interference to other trunks and possibly cause a disconnect signal. It is suggested that the trunk be made busy by dialing the termination reached by code 100 or by calling the distant testboard (code 101) or operator to have the trunk connected to a holding circuit. This procedure could be followed for over-all active singing point tests but the danger of causing a disconnect by a sing near the signaling frequency, especially at 2600 cycles, makes it preferable to disable the signaling equipment.

1.19 In order to disable the signaling equipment when the trunk is turned down to traffic without holding the switches on the drop side of the signaling unit, an LOS jack may be provided at the circuit patching bay or equivalent. First one end of a 3P7-type patch cord is plugged into this jack and then the other end is plugged into the SIG LINE (or DSL) jack associated with the trunk to be disabled. Since disabling the equipment at one end only will send a seizure signal to the other end, both ends of the trunk should be disabled simultaneously if practicable. This connects battery to the M lead toward the line, removing signaling tone, and opens the E lead toward the drop to prevent seizure of the switching equipment by line signals. It is especially important, where the cord is used, to make certain that it is removed at the end of the tests. Otherwise, the trunk cannot be used to establish connections in either direction. Where this jack is not provided local means of disabling the signaling equipment should be used at both ends of the trunk.

1.20 Under some conditions, where singing point tests are made on line facilities through the single frequency signaling equipment, a sharply critical singing frequency may fall at or near the signaling frequency. As the gain in the singing point test circuit is increased, a point will be reached where sufficient feed-back energy builds up in the circuit to establish a singing condition. As soon as the energy level in the circuit has built up sufficiently, the band filter in the signaling circuit will be automatically switched into the trunk and stop the singing abruptly. There now being insufficient energy in the circuit to hold the filter in, it drops out again. The cycle then is repeated. The disabling of the single frequency signaling system does not prevent the band filter from coming into the trunk when a frequency at or near the signaling frequency is present in the trunk.

1.21 As the gain is increased continuously beyond that point which produces this filter "in and out" condition, a point finally will be reached where the unbalance is critical enough outside the range of the band filter to permit a sustained singing condition to be established. Obviously, this is not the desired singing point, and the tester should be forewarned to recognize this fact. Especially in the case of 2-wire trunks employing the lower cutoff facilities, such as H-172, the effect of the filter at 2000 cycles and frequencies near this will be of material significance as 2000 cycles is one of the signaling frequencies. Where possible the singing point testing arrangement should exclude the single frequency unit from the singing path under test. Where the tests include signaling equipment in the singing path such as over-all active singing point tests it will be necessary to disable or remove this filter from the trunk. The procedure given in the following paragraph should be followed.

1.22 The disabling of the band filter requires the cooperation of a central office man. After the signaling system has been disabled in the usual manner at the circuit patching bay or testboard, the central office attendant should be requested to disable the filter for the period of the tests by placing a dummy plug in the DC jack on the panel of the signaling unit receiving the signaling frequency from the line. This DC jack is installed on 1600/2000-cycle equipment only; the relays must, therefore, be blocked on 2400/2600-cycle equipment. It is especially important that the central office attendant be notified as soon as the tests are completed, so that the dummy plug will be removed from the DC jack or the relay blocks removed and normal operation of the band filter will be restored.

1.23 At regulating repeater offices, in order to avoid having the value of the regulating network change during the progress of a test where line equipment is involved, it will be necessary to note the step on which the regulator is operating. Then set the manual control dial at this value and transfer the operation of the regulating network circuit to the manual control dial for the duration of the test by operating the TRANSFER key. At the conclusion of the test, the working step of the regulator should again be noted and if this is more than one-half step different from its initial value, the manual control dial should be slowly brought to the step of the working regulator. Then the TRANSFER key should be restored. On V-type equipment it is suggested that the manual control dial be set on +10 to save the need for subtracting any loss for the regulating network.

1.24 With the advent of nationwide toll dialing, all section singing points on every trunk should be adjusted to the highest practicable value rather than just to meet the singing point specified on the circuit layout record card. This will result in the best over-all active singing points which are practicable and provide margins which are needed under the nationwide toll dialing plan. This plan increases to eight or more the number of intertoll trunks that may be connected together in tandem.

1.25 Over-all active singing point tests should be made on all intertoll trunks at 2-wire switching points. Any tests not meeting the specified values will indicate one or more low section balances. Part 5 gives some suggestions for locating troubles causing low section balances.

1.26 In some cases E-type repeaters may be used on toll connecting trunks or tributary trunks. The assignment of gain adjustments and methods of tests are covered in other practices.

1.27 V2 repeaters are provided in a very few offices. The functions and jack arrangement of the V1 and V2 repeaters are similar. Methods for testing V2 repeaters will be the same as for the V1.

1.28 The corrected over-all active singing point should not be less than the over-all active singing point specified on the circuit layout record card. (See Par. 4.04.)

1.29 After tests are completed the transmission and signaling paths should be checked before returning the trunk to service. A test to code 102 or to the distant testboard would be adequate.

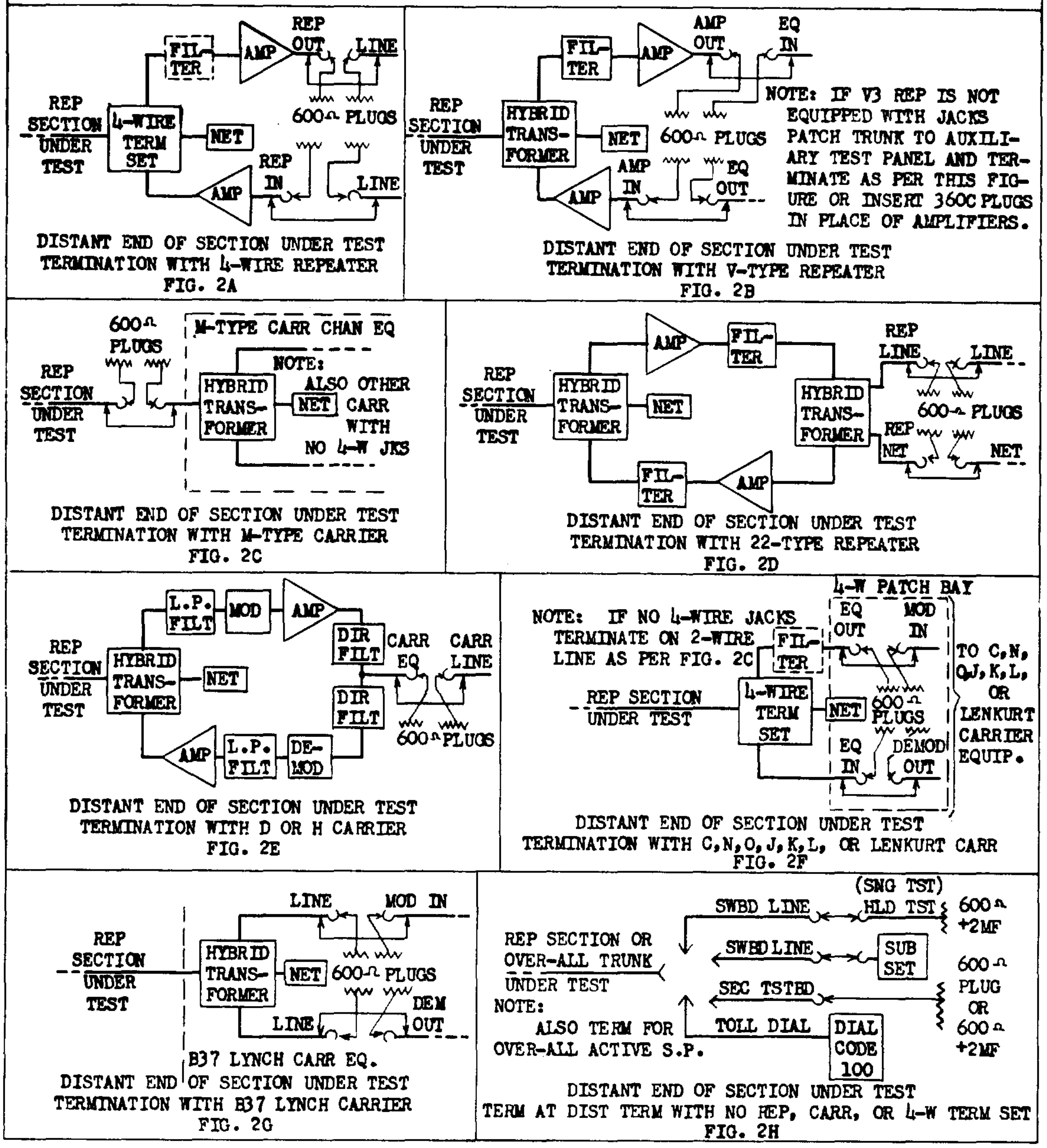
2. TERMINATIONS FOR SINGING POINT TESTS

(A) Section Singing Point Tests

2.01 The distant end of the section under test should be terminated by one of the methods shown in Chart 2 depending on the type of equipment on the trunk at that office.

2.02 When the distant end of the section under test is the terminal of the trunk and is located in an exchange type office such as a CDO and is not equipped with a repeater, carrier system, or a 4-wire terminating set, a 900-ohm resistor in series with a 1 mf capacitor should be connected to the trunk at any convenient point on the drop side of the line transformer.

CHART 2 TERMINATIONS FOR SINGING POINT TESTS



DISTANT END OF SECTION UNDER TEST TERMINATION WITH 4-WIRE REPEATER
FIG. 2A

DISTANT END OF SECTION UNDER TEST TERMINATION WITH V-TYPE REPEATER
FIG. 2B

DISTANT END OF SECTION UNDER TEST TERMINATION WITH M-TYPE CARRIER
FIG. 2C

DISTANT END OF SECTION UNDER TEST TERMINATION WITH 22-TYPE REPEATER
FIG. 2D

DISTANT END OF SECTION UNDER TEST TERMINATION WITH D OR H CARRIER
FIG. 2E

DISTANT END OF SECTION UNDER TEST TERMINATION WITH C,N,O,J,K,L, OR LENKURT CARR
FIG. 2F

DISTANT END OF SECTION UNDER TEST TERMINATION WITH B37 LYNCH CARRIER
FIG. 2G

DISTANT END OF SECTION UNDER TEST TERM AT DIST TERM WITH NO REP, CARR, OR 4-W TERM SET
FIG. 2H

2.03 Where the resistor termination is not practicable, as in some Connecting Company offices, use may be made of a standard subscriber's telephone station as a termination. The operator should connect the trunk under test to the telephone and have the receiver removed from the switchhook.

2.04 If it becomes necessary to terminate the section under test at some point other than those specified above or in Chart 2, such as at a primary board, a resistor termination should be used which corresponds as closely as practicable to the nominal impedance of the trunk at that point.

2.05 In making these singing point tests care should be taken to avoid a singing condition on the trunk beyond the termination. This condition can usually be avoided by placing a proper termination on the trunk beyond the singing point test termination.

2.06 The following methods may be used to secure a proper termination when the repeater section terminates in a switching system: For incoming and 2-way trunks the tester should request the terminal office back of him to dial the proper code (100 in most cases) to connect the singing test termination through the switches; if the trunk is outgoing from the switches the termination should be applied at the 17C testboard or at the repeater bays.

(B) Over-all Active Singing Point Tests

2.07 The termination at the distant terminal of a trunk for an over-all active singing point test, should be placed as shown in Fig. 2H on Chart 2.

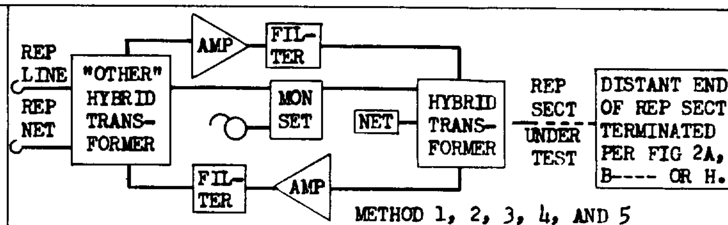
3. TESTING METHODS FOR SECTION SINGING POINT TESTS

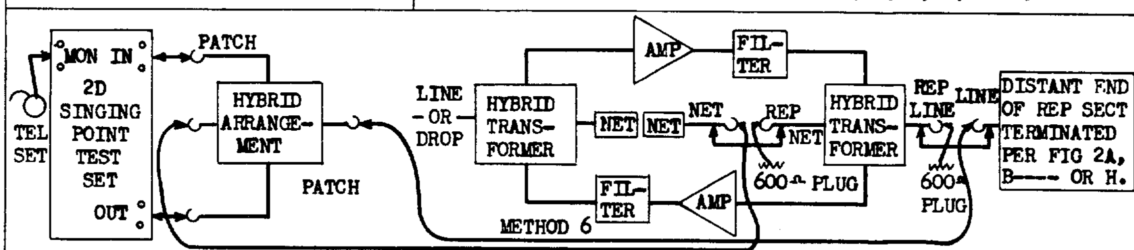
(A) Testing Methods for 22-type Repeaters

3.01 Chart 3A outlines the five different methods which may be used for making section singing point tests with 22-type repeaters. The use of these methods may be governed to a certain degree by the availability of test equipment such as a reflection attenuator and decade resistor box. Methods 1, 2, and 3 are similar and the choice between them depends on the value of the singing point to be measured. With given values of 36-type pads, Method No. 1 has a range 6 db higher than Method No. 2 and Method No. 3 has a range 10 db lower than Method No. 2. Method No. 1 is slightly more accurate than Methods 2 and 3. Methods 4 and 5 are similar and have the advantage that no

CHART 3A — TESTING METHODS FOR SECTION SINGING POINT TESTS - 22-TYPE REPEATERS

GENERAL:
Remove trunk from service. Terminate the distant end of the repeater section to be tested by one of the methods outlined in Part 2. The choice is dependent on the type of equipment on the trunk of the distant end of the section.





METHOD NO	"OTHER" HYB TST CONDITION: REP JACKS	POLING POS.	POLING NEG.	METHOD OF ESTABLISHING SINGING CONDITION	SINGING POINT COMPUTATION: GAIN MEASUREMENTS (A)	TRUE SINGING POINT
1	REP LINE REP NET	SHORT OPEN	OPEN SHORT	Monitor on the repeater and increase the amplifier gains until sustained singing just begins.	Measure the 1000-cycle gain in each direction for the poling which produced the lower ringing point.	Sum of gain meas. (A) plus 6 db.
2	REP LINE REP NET	SHORT 600	OPEN 600			Sum of gain meas. (A).
3	REP LINE REP NET	600 1130	1130 600			Sum of gain meas. (A) minus 10 db.
4	REP LINE REP NET Note: The decade resistance should be variable at least from 0 to 600 ohms in steps not larger than one ohm.	600 DECADE	DECADE 600	Monitor on the repeater and decrease the decade resistance starting at 600 ohms until sustained singing just begins. If singing does not start it will be necessary to increase the gain.	Measure the 1000-cycle repeater gain in each direction.	Sum of gain meas. (A) minus the S.P. in db determined from Fig. 3A for the higher res. value of the two polings.
5	REP LINE REP NET Note: The reflection attenuator is described in Section 103-106-100.	L REFL N REFL	OPERATE POL KEY	Monitor on the repeater and adjust the refl. atten. dial and keys until sustained singing just begins. If singing does not start increase the gain of the rep.	Measure the 1000-cycle repeater gain in each direction.	Sum of gain meas. (A) minus the higher loss in db for the two polings read on the reflection atten.
6	Make 4 patches shown in sketch. Use the method and computations given for Method 1 on Chart 3C when using locally assembled test hybrid and 2D singing point test set.					

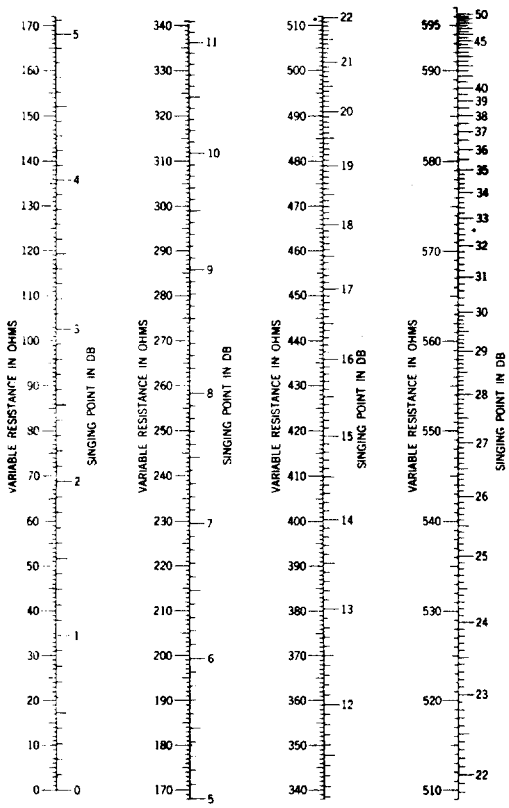


Fig. 3A - Singing Point of a Variable Resistance Versus 600 Ohms

changes in the amplifier potentiometer settings are normally required. Method No. 5 is preferable to the other methods when a reflection attenuator is available; the procedure is simplified as db values are read directly from the dial and may be subtracted directly from the gains of the test repeater.

3.02 In all cases, the line and network circuits to be tested are connected to one hybrid transformer of a repeater. The various methods differ from each other in the connections which are made to the "other" hybrid transformer. In Chart 3A the term "other" hybrid transformer will be used to designate the hybrid transformer of the test repeater to which the line and network being tested are <u>not</u> connected. Gains are increased by turning the 23A potentiometers in a clockwise direction. It is not necessary to advance the two potentiometers of a repeater by equal amounts although it is considered good practice not to allow the difference to become too great. However, it may be necessary to remove one or both 36-type pads to secure sufficient gain for the singing condition. If the test repeater is a • regulated repeater, see Paragraph 1.23.

(B) Testing Methods for V1 Repeaters

3.03 Chart 3B outlines the two methods for making section singing point tests on V1 repeaters when a 2D singing point test set is not available. If this test set is available, use the method outlined as Method No. 1 in Chart 3C. The first method in Chart 3B makes use of the repeater switching panel with the associated attenuators and spare pair of amplifiers which should be set for 30 db gain each. The second method is applicable only where the attenuator jack arrangement has been provided; in this case it will be necessary to make use of either a pair of spare or working amplifiers. The only requirement for the amplifiers is that the sum of their gains be about 8 db higher than the singing point to be measured. If the tests are made at a regulating repeater point see Paragraph 1.23.

(C) Testing Methods for V3 Repeaters

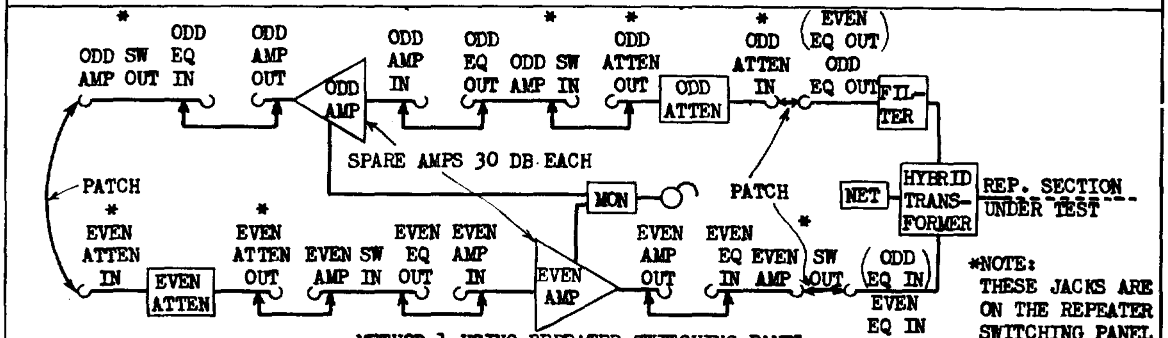
3.04 Chart 3C outlines the two methods for making section singing point tests on V3 repeaters. The first and preferable method makes use of the 2D singing point test set. The second method uses the 5A attenuator, or an equivalent 600-ohm attenuator, and is used when the 2D test set is not available. Both of these methods are also applicable to V1 repeaters. Reference is made in Paragraph 3.06 to a method of testing which can be used when the V3 repeaters are adjacent to a repeater switching panel.

3.05 If the V3 repeater is provided without jacks the amplifiers should be transferred and the trunk patched to the auxiliary test panel. Then the testing can proceed from the auxiliary test panel using the methods outlined in Chart 3C.

3.06 If the V3 repeaters are adjacent to a repeater switching panel which is normally provided with V1 repeaters, the method applicable to V1 repeaters may be used with the V3 repeaters. If the V3 repeater is provided without a complete jack field, the amplifiers should be transferred and the trunk patched to the auxiliary test panel as covered in Section 332-103-500. Then the testing can proceed from the auxiliary test panel as in Chart 3B. If the V3 repeater is provided with jacks, patch from the V3 jack field to the repeater switching panel and proceed as in Chart 3B.

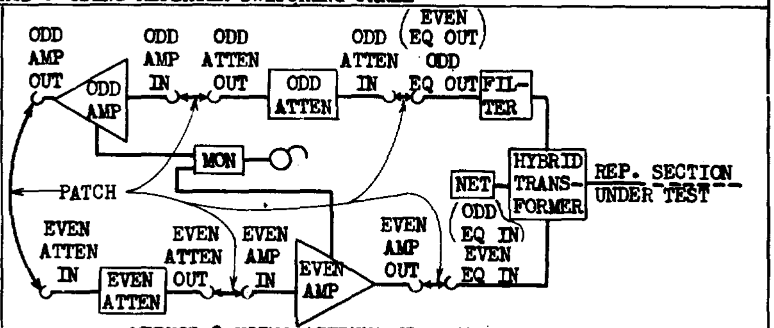
3.07 If the tests are made at a regulating repeater point see Paragraph 1.23.

CHART 3B TESTING METHODS FOR SECTION SINGING POINT TESTS – V1 REPEATERS



METHOD 1 USING REPEATER SWITCHING PANEL

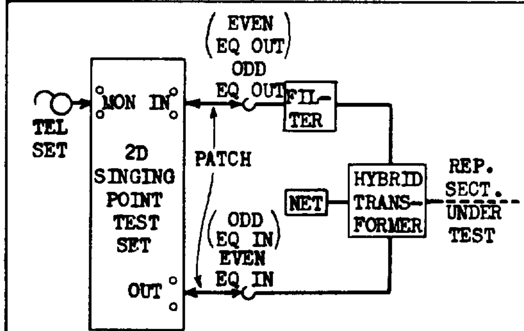
GENERAL:
Remove trunk from service. Terminate the distant end of the repeater section to be tested by one of the methods outlined in Part 2. The choice is dependent on the type of equipment on the trunk at the distant end of the section



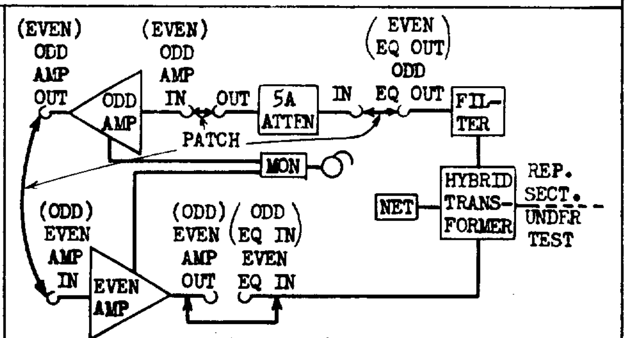
METHOD 2 USING ATTENUATOR JACK ARRANGEMENT

METH-OD NO	POLING PATCHES POS.	POLING PATCHES NEG.	METHOD OF ESTABLISHING SINGING CONDITION	SINGING POINT COMPUTATION: GAIN MEASUREMENT (A)	SINGING POINT COMPUTATION: TRUE SINGING POINT
1	Place 3 cds shown in sketch	Turn over 1 plug only on 1 cord	Monitor on amplifiers and reduce the loss in the attenuators until the reduction of a single db will just cause sustained singing to begin.	Measure 1000-cycle gain of both amplifiers. If these amplifiers are maintained at 30 db gain use this value.	Sum of gain measurements(A) minus the following 3 items: (1) The higher atten losses of the two polings. (2) The 1000-cycle insertion loss of input and output equipment at the testing point from Table I or ckt. layout card. (3) Loss of regulating network pad if used, obtained from Table II or III.
2	Place 5 cds shown in sketch	Same as Method 1	Same as Method 1	Same as Method 1	Same as Method 1

CHART 3C — TESTING METHODS FOR SECTION SINGING POINT TESTS - V3 REPEATERS



METHOD 1 USING 2D TEST SET



METHOD 2 USING 5A ATTENUATOR

GENERAL:
Remove trunk from service. Terminate the distant end of the repeater section to be tested by one of the methods outlined in Part 2. The choice is dependent on the type of equipment on the trunk at the distant end of the section.

METH-OD NO	POLING PATCHES POS.	POLING PATCHES NEG.	METHOD OF ESTABLISHING SINGING CONDITION	SINGING POINT COMPUTATION: GAIN MEASUREMENT (A)	SINGING POINT COMPUTATION: TRUE SINGING POINT
1	Place 2 cds shown above key NORMAL	key REVERSE	If filter is in trunk operate FILTER OUT key. Monitor and increase gain dials on test set until by increasing a single db, sustained singing just begins.	None other than preliminary calibration of the test set.	Sum of the two gain dials for the poling giving the lower singing point minus Items (2) and (3) in Chart 3B.
2	Place 3 cds shown in sketch	Turn over 1 plug only on 1 cord	Same as Method 1 on Chart 3B	Measure 1000-cycle gain of both amplifiers.	Same as Method 1 on Chart 3B

(D) Testing Methods for 4-Wire Terminating Sets

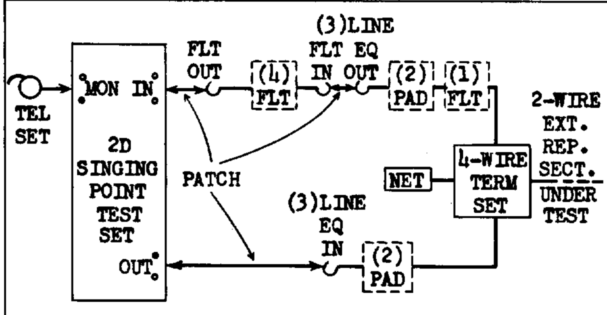
3.08 Chart 3D outlines the methods for making section singing point tests with 4-wire terminating sets. The 4-wire terminating sets involved in section singing point tests are those from which 2-wire extensions to repeater sections are obtained.

3.09 Two methods of making these section singing point tests are included. The first and preferable method uses a 2D singing point test set when this set is available. The second method makes use of an amplifier and an attenuator.

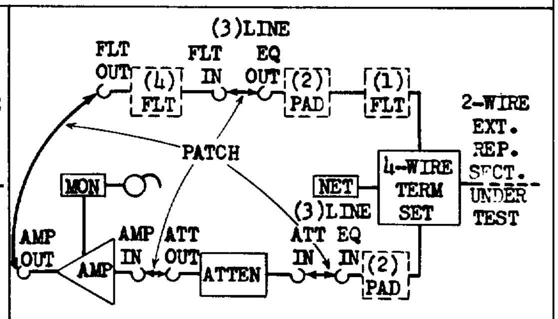
4. TESTING METHODS FOR OVER-ALL ACTIVE SINGING POINT TESTS

4.01 The secondary testboard is the most desirable location to make over-all active singing point tests. The tests can be made more rapidly and without the assistance of any other testman in the testing office. Tests at the secondary testboard will require the use of a 2D singing point test set, 2E singing point test panel, 5A attenuator, or a reflection attenuator. If one of these test sets is not available it will be necessary to make the tests at the repeater bay.

CHART 3D TESTING METHODS FOR SECTION SINGING POINT TESTS - 4-WIRE TERMINATING SETS



METHOD 1 USING 2D SINGING POINT TEST SET



METHOD 2 USING 5A ATTENUATOR AND SPARE AMP

NOTES: (1) FLT WHICH MAY BE IN 4-W TERM SET
(2) PADS WHICH MAY BE IN 4-W TERM SET
(3) JACKS IF 4-W TERM SET IS CONNECTED TO 4-W REP.
(4) FLT SAME AS REQUIRED FOR 2-W EXTENSION.

GENERAL:
Remove trunk from service. Terminate the distant end of the repeater section to be tested by one of the methods outlined in Part 2. The choice is dependent on the type of equipment on the trunk at the distant end of the section.

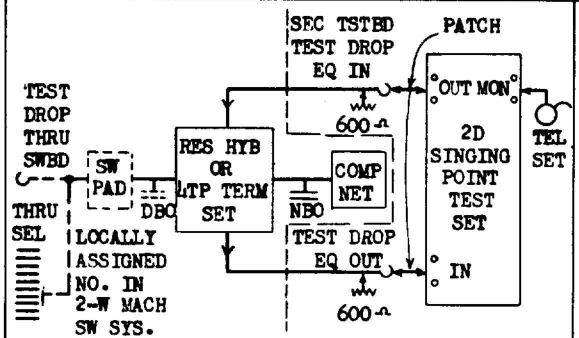
METH-OD NO	POLING PATCHES		METHOD OF ESTABLISHING SINGING CONDITION	SINGING POINT COMPUTATION	
	POS.	NEG.		GAIN MEASUREMENT (A)	TRUE SINGING POINT
1	Place 3 cds shown above key NORMAL	key REVERSE	Use only one filter of type req'd for 2-W ext. If (1) or (4) is used operate FILTER OUT key. Monitor and increase gain dials on test set until by increasing a single db, sustained singing just begins.	None other than preliminary calibration of the test set.	Sum of gain dials for poling giving lower singing point minus 1000-cycle loss (measured or from CLO card) between 2-W ext and EQ OUT or FLT OUT jacks and EQ IN jacks and 2-W ext.
2	Place 4 cds shown in sketch	Turn over 1 plug only on 1 cord	Same as Method 1 on Chart 3B. If singing does not start it will be necessary to increase the gain by patching in an additional amplifier.	Measure 1000-cycle gain of amplifier or amplifiers.	Total gain (A) minus the higher atten loss for the two polings and the 1000-cycle loss of equip. as for Method 1 above.

4.02 A test drop set up for office cabling balance tests and using a hybrid arrangement with the 4-wire connections terminating in the secondary testboard, may be used for over-all active singing point tests. If a test drop has been set up which does not include a hybrid arrangement, it may be modified to agree with one of the test drops outline in Chart 4A. The type of test drop to be used will depend on the testing equipment available in the office. Any modification of an existing test drop will necessitate the readjustment of the building-out capacitors in accordance with the procedures for office cabling balance tests. If a test drop is not available one should be set up and adjusted as outlined in Chart 4A. This is an interim arrangement and used as a temporary measure until office cabling balance tests have been made and a standard test drop set up.

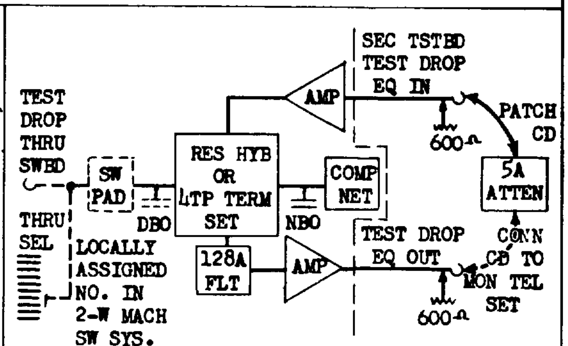
(A) Connecting and Adjusting Test Drop

4.03 Chart 4A shows the method of connecting and adjusting a test drop. Figs. 4A1, 4A2, and 4A3 show test drop arrangements for making over-all active singing point tests at the secondary testboard. Figs. 4A4 and 4A5 show test drop arrangements for making the tests from repeater bays where test equipment is not available for testing at the secondary testboard.

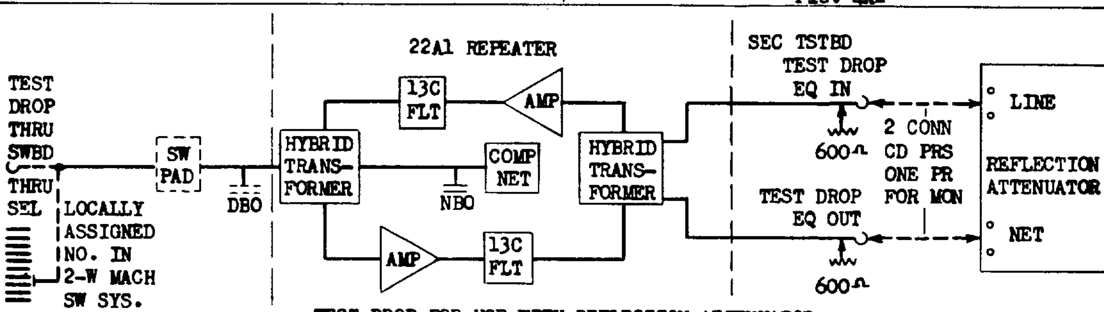
CHART 4A — CONNECTING AND ADJUSTING TEST DROP



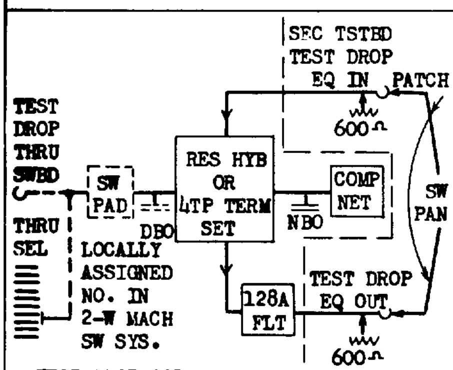
TEST DROP FOR USE WITH 2D SINGING POINT TEST SET
FIG. 4A1



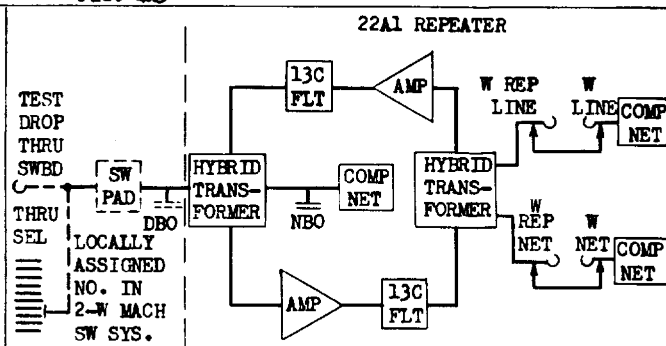
TEST DROP FOR USE WITH 5A ATTENUATOR
FIG. 4A2



TEST DROP FOR USE WITH REFLECTION ATTENUATOR
FIG. 4A3



TEST DROP FOR USE WITH REP SW PANEL
FIG. 4A4



TEST DROP FOR USE WITH 22A1 REP METHODS 1, 2, 3, AND 4
FIG. 4A5

PROCEDURE

1. Select drop of average cable length to toll switchboard and switching equipment if installed.
2. Connect switching pad if office is gain office (switching pad office).
3. If the office cabling is balanced the DBO (drop building out) capacitors may be connected.
4. Turn down an idle trunk having a term rep or carr term in office and an average length drop.
5. Have operator at through switchboard connect this trunk to TEST DROP.
6. Place terminations on terminal rep or 4-wire VF bay appearance of trunk as indicated by one of the methods given in Part 2.
7. Make singing point test on test drop by one of the methods given in Part 3 depending on the type of testing equipment available.
8. Adjust NBO (net building out) capacitor on compromise net in test drop to obtain highest practicable singing point. Requirement - Singing point measured should not be less than 20 db.
9. Restore trunk to service. Test drop may now be used for over-all active singing point tests.

(B) Testing Methods for Trunks Using 2-Wire Switching

4.04 Over-all active singing point tests on trunks which are 2-wire to the switchboard or switching equipment at 2-wire switching offices.

(1) Measure the 1000-cycle transmission in both directions on the trunk to be tested. Compute the average of these two measured net losses.

(2) Have the trunk terminated at the distant terminal by the most convenient method shown in Fig. 2H.

(3) The connection between the intertoll trunk and the TEST DROP should be established at the through switchboard as for a normal through toll connection. This connection switches out the switching pads in the trunk and test drop and operates the multiple cutoff relays to lift off certain lines of switchboards in offices where these features are provided.

(4) Connect the test equipment to the test drop as provided in Chart 4A and proceed with the singing point test in accordance with the procedure given in Part 3 for the particular testing equipment being used. When using the 2D test set operate FILT IN key.

(5) The corrected over-all active singing point is the true singing point as determined in Part 3 corrected for the average measured net loss computed in Item (1) of this paragraph. The method of correcting the over-all singing point is illustrated in Fig. 4B.

Note: The real correction may be anywhere between no correction and twice the amount of the computed correction. As it is not practicable to determine just when this should be, an average value has been chosen for the computed correction as a compromise.

Requirement: The corrected over-all active singing point should not be less than the specified value on the circuit layout record card.

5. TESTS FOR LOCATING TROUBLE

(A) Section Singing Point Tests

5.01 A procedure for locating trouble is covered by the flow diagram, Chart 5A. The diagram is only a general outline and any step may be expanded to meet particular situations.

Physical Troubles

5.02 Measurements should be made to determine that the line facilities are clear of troubles such as shorts, grounds, and crosses before proceeding with the investigation of low singing points.

Visual Inspection of Central Office Equipment

5.03 A check should be made to determine that the filters, networks, and equalizer connections agree with the toll circuit layout card. Also determine that they are of the type normally associated with the outside plant facility involved. A check should be made for possible loose connections or broken wires.

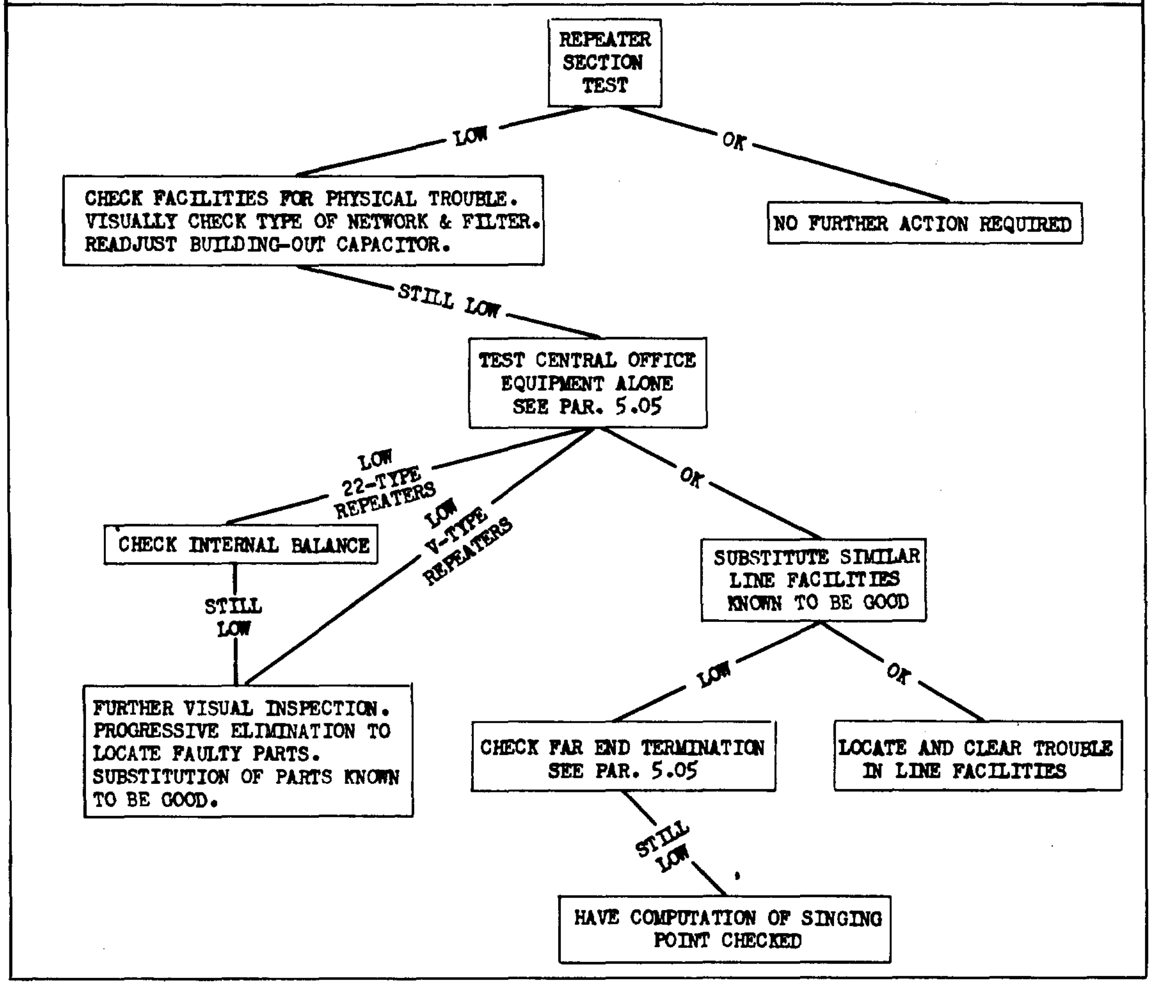
Network Building-out Section Adjustment

5.04 A check should be made to determine if the singing point can be increased by readjusting the building-out capacitors and resistors associated with the line balancing network. The method of adjusting building-out capacitors and resistors is covered in Part 6 of the section. The building-out capacitor of a network should not be used to compensate for

Illustrative Example Number		1	2	3	4
Specified Net Loss in db	= A	9.0	6.4	0	-1.0
Average Measured Net Loss in db	= B	10.3	5.7	-1.0	0.6
Active S.P. Correction in db	= A-B	-1.3	0.7	1.0	-1.6
True S.P. in db determined in Part 3	= C	6.0	5.0	3.0	4.0
Corrected Over-all Active S.P. in db	= A-B+C	4.7	5.7	4.0	2.4

Fig. 4B - Method of Correcting Over-all Active Singing Point Tests

CHART 5A FLOW CHART FOR FINDING CAUSE OF LOW SINGING POINT



large line irregularities. If the building-out capacitor which gives the highest singing point departs radically from the building-out capacitor determined by computation in Paragraph 6.07 it is an indication of a line irregularity and warrants further investigation. When building-out capacitors are correctly adjusted, the measured singing points as determined by "positive" and "negative" polings usually do not differ more than 2 db. While this is not a maintenance requirement, a large difference between "positive" and "negative" polings often is an indication of incorrect building-out capacitor adjustment.

Tests to Detect Irregularities in Central Office Equipment

5.05 The following steps may be followed to detect irregularities:

(1) Before plugging into primary testboard jacks these jacks should be cleared of all working circuits including the phantom, telegraph and carrier.

(2) Terminate the EQ jacks at the primary testboard in a spare line balancing network of the same type as the one used on the trunk under test and adjust the building-out capacitor and resistor (if provided) to the same values as the corresponding components of the trunk network.

If the trunk under test is a phantom, short the tip and ring of each associated side circuit after removing these trunks from service and connect the network between the two shorts at the EQ jacks.

Note: Where open wire carrier filters are involved, the network should be placed at the LCX jacks or at jacks on the line side of the filters instead of the EQ jacks.

(3) Make a singing point test by one of the methods covered in Part 3 of this section. At the primary board, make any minor readjustments of the building-out capacitor associated with the test terminating network which will improve the singing point.

Requirements: The singing point should be 35 db or higher with the following exceptions:

(a) The singing point should be 30 db or higher when CX signaling by-pass equipment is involved.

(b) The singing point should be 30 db or higher when open wire carrier filters are involved.

Internal Balance of the Repeater (Applicable to 22-type Repeaters Only)

5.06 The internal balance test determines whether there is any serious unbalance within the repeater itself. Place 600-ohm plugs (217D) in the REP LINE and REP NET jacks on one side of the repeater. Make a singing point test with the necessary connections on the other side of the repeater, in accordance with Part 3 of this section. Repeat the test with the 600-ohm plugs in the REP LINE and REP NET jacks on the other side of the repeater. The singing point should be 40 db or higher on both tests. If lower check termination plugs and jack contacts.

5.07 In locating trouble in central office equipment the source of unbalance first should be localized to a particular equipment and its balancing unit. This may be accomplished by a system of progressive elimination. Disconnect the outside plant facilities and the associated balancing network and substitute a 600-ohm resistor (or 217D plug) for each. Make a singing point test. If the cause of the low singing point has not been eliminated, patch out or disconnect the equipment nearest the line (such as a composite set) and its balancing unit and terminate the remaining line and balancing equipment with 600-ohm resistors. Make another singing point test to ascertain whether the cause of the low singing point has been eliminated. Proceed in this manner until the removal of one of the line equipments and its balancing unit removes the cause of the low singing point. When the equipment causing the low singing point has been located determine whether the line equipment or the balancing equipment is defective by substituting parts known to be good, or by other tests. One of the more common causes of trouble, where the measured singing point is just slightly below the required, is an incorrect or omitted resistor at the midpoint of the balancing transformer in a phantom trunk.

5.08 Procedure when the central office equipment tests do not indicate trouble.

(1) If possible, substitute similar outside plant facilities known to be good. If this eliminates the cause of the low balance the regular outside plant facilities should be investigated. When loaded cable pairs are involved, a check of the recent work in the cable may disclose the possibility of the omission, irregular spacing, or change in type of one or more loading coils due either to trouble or authorized construction activities that are partially or incorrectly completed. Entrance cables may be a similar source of trouble in open wire trunks. If the above tests and checks indicate that the trouble is in the outside plant facilities but specific corrective action cannot readily be determined or is in doubt, impedance runs may be made to definitely locate the irregularity.

(2) If substitution of similar outside plant facilities known to be good does not correct the trouble, or if such a substitution can not be made, a check should be made for errors in the far-end termination. If trouble from an incorrect far-end termination is suspected, it will be of value to terminate the trunk at the far-end primary board, preferably with a network properly built out to be used as a termination. If a network is not available, a resistor corresponding as closely as practicable to the nominal line impedance of the trunk may be used. The network termination at the distant primary board may result in a slight improvement in the singing point, without indicating trouble at the far end. The amount of the improvement will depend on the loss of the repeater section. However, a large

improvement in the singing point with the trunk terminated at the far-end primary board indicates an error in the normal termination or an irregularity in the equipment at the far end.

(3) If none of the above suggested procedures produces an explanation for the low singing point, the singing point computations should be checked or referred via lines of organization for recomputation. It is possible that an incorrectly computed singing point is higher than that which is physically possible to achieve on the trunk under test. It is also possible that the assumed component irregularities are adding more pessimistically than anticipated in the theoretical computations.

(B) Over-all Active Singing Point Tests

5.09 If the over-all active singing point test is not as high as that specified on the circuit layout record card, active singing point tests should be made on the trunk with terminations placed at the repeater located one repeater section from the testing end. Successive tests made to terminations moved one repeater section at a time toward the distant terminal should give an indication of the repeater section having a low section singing point. The active singing point normally will gradually decrease as sections are added. If there is a decidedly larger decrease of the active singing point when one section is added (by moving the termination to the next repeater toward the distant office) it is an indication that the section singing point of the section added is lower than it should be. Section singing point tests should be made on that section, making the test toward the distant end.

5.10 A simple method of computing the active singing points to terminations at different repeaters on the trunk is outlined in Chart 5B. These active singing points may be computed if desired to indicate just how much decrease can be expected when successive sections are added. This method is not entirely accurate and may not necessarily agree with the computed values specified on the circuit layout record card. It will, however, be sufficiently close to indicate the section having a low singing point.

5.11 If all section singing point tests and the test drop meet the requirements and the over-all active singing point is lower than specified, the computations may be checked or referred via lines of organization for recomputation.

6. ADJUSTMENT OF BUILDING-OUT RESISTORS AND CAPACITORS FOR SECTION S.P. TESTS

6.01 The only adjustment possible on the older types of networks, including those for open wire, are the building-out capacitors. Some of the newer types, among which are the 113P, 113R, 115P, 115R, 115AF, and 115AG, are equipped with terminals for strapping, by means of which the resistance of the network may be adjusted. This strapping should be carried out before the building-out capacitor is adjusted. With no straps on these terminals the network is in the condition intended to balance cables of the lowest capacitance per section. It is recommended that resistor strapping should be determined by one of the following methods:

(1) Capacitance data for the first few loading sections.

(2) Return loss measurements at 500 cycles or lower.

(3) In accordance with Table IV.

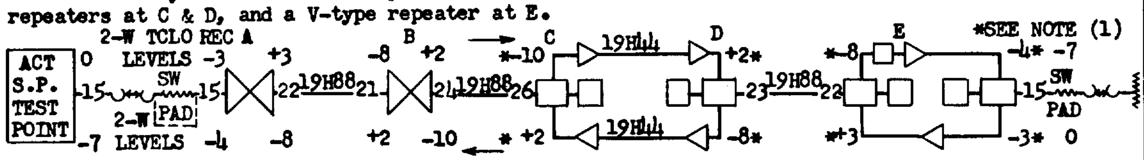
6.02 It is only practicable to obtain capacitance data from measurements made during initial splicing operations or by a check of the factory test records. However, such data are seldom available, and usually resistor adjustment based on the method indicated in Item (1) can not be used. Reference may be made to the settings used in connection with cable completion tests. Considerable difficulty may also be experienced in making resistor adjustments based on return loss measurements at 500 cycles or lower. It often happens that return loss readings on a particular pair will vary widely with frequency and comparably low values may be found at two or more frequencies. The changes in network resistor strapping may often increase the return loss at one minimum point and decrease it at another and, at the same time, may shift the frequency points at which the minimums occur. Thus, the method in Item (2) may be impractical in determining resistor strapping.

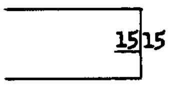
6.03 If capacitance data are not available, and the return loss method is not being used, it will be necessary to assume that the capacitance of the cable is "nominal." The resistor may then be strapped in accordance with Table IV.

6.04 The building-out capacitor associated with the balancing network should be set to a value which will give the highest singing point. Either a 7A condenser box or a W12A cord will facilitate making this adjustment.

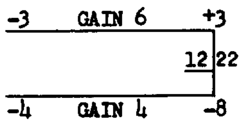
CHART 5B METHOD OF COMBINING SECTION SINGING POINTS TO OBTAIN ACTIVE SINGING POINTS TO TERMINATIONS AT DIFFERENT REPEATERS ON A TRUNK USING TERMINAL REPEATERS

The switching pad at the testing end should be out of the trunk and the switching pad at terminated end should be in trunk. The normal levels and section singing points are shown at 2-wire side of each hybrid and terminal point. The sketch shows a 22-type repeater at A & B, 4-wire repeaters at C & D, and a V-type repeater at E.

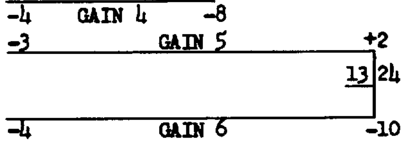




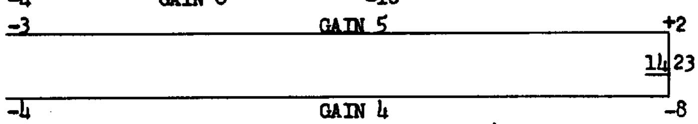
Section singing point from TEST POINT to termination at A is the same as the test drop singing point which is considered to be 15 db where there is a terminal repeater in the testing office.



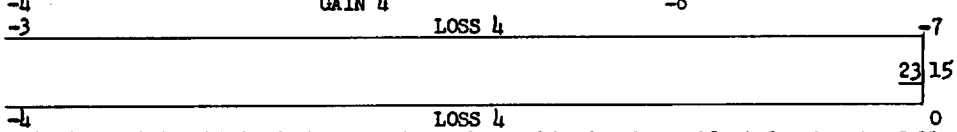
Section singing point to termination at B referred to the TEST POINT is equal to the sect. S.P. at A twd B minus the gain or plus the loss in both directions of transmission. This equals 22-6-4=12 db.



Section terminated at C referred to the TEST POINT is equal to 24-5-6=13 db. See note (2).



Termination at E repeater referred to the TEST POINT is equal to 23-5-4=14 db.



Term at E terminal 15+4+4=23 db.

These singing points obtained above must now be combined using Table below by the foll. method:
Starting at the testing end combining S.P. to A & B: 15 & 12 Diff. = 3 from Table 12-1.8=10.2 db.
Combining S.P. to A, B & C: 10.2 & 13 Diff.=2.8 from Table 10.2-1.8=8.4 db.
Combining S.P. to A, B, C & E: 8.4 & 14 Diff.=5.6 from Table 8.4-1.1=7.3 db. See note (2).
Combining S.P. to A, B, C, E & E terminal: 7.3 & 23 Diff.=15.7 from Table 7.3-0.1=7.2 db.

The active singing points to terminations at different points computed above are as follows:
From A terminal to a termination at B repeater 10.2 db.
From A terminal to a termination at C or D rep. 8.4 db. See note (2).
From A terminal to a termination at E repeater 7.3 db.
From A terminal to a termination at E terminal 7.2 db. This is the computed over-all act S.P.

Notes: (1) Two-wire levels only. TCLO record levels must be corrected to 2-W side of hybrid.
(2) No test is made to D as there is no return path in 4-w sect. Result would be same as C.

Computations may be made in the other direction by making the E terminal the ACT. S.P. TEST POINT and terminating the trunk at the A terminal computing from E to A using the above method.

TABLE OF COMBINATIONS OF TWO QUANTITIES IN DECIBELS ON POWER RATIO BASIS

When combining gains, add the combining term to the larger; when combining losses, subtract the combining term from the smaller.

DIFF OF 2 QUANTITIES	COMB TERM	DIFF OF 2 QUANTITIES	COMB TERM	DIFF OF 2 QUANTITIES	COMB TERM	DIFF OF 2 QUANTITIES	COMB TERM
0-0.1	3.0	1.7-1.9	2.2	4.1-4.3	1.4	8.0- 8.6	0.6
0.2-0.3	2.9	2.0-2.1	2.1	4.4-4.7	1.3	8.7- 9.6	0.5
0.4-0.5	2.8	2.2-2.4	2.0	4.8-5.1	1.2	9.7-10.7	0.4
0.6-0.7	2.7	2.5-2.7	1.9	5.2-5.6	1.1	10.8-12.2	0.3
0.8-0.9	2.6	2.8-3.0	1.8	5.7-6.1	1.0	12.3-14.5	0.2
1.0-1.2	2.5	3.1-3.3	1.7	6.2-6.6	0.9	14.6-19.3	0.1
1.3-1.4	2.4	3.4-3.6	1.6	6.7-7.2	0.8	19.4 & OVER	0
1.5-1.6	2.3	3.7-4.0	1.5	7.3-7.9	0.7		

It is important that the filter used in the **testing** arrangement be of the same type as **the** filter assigned to the trunk when in **service.**

6.05 The following procedure should be used when a 7A condenser box is available:

(1) Connect the 7A condenser box to the terminals "A" and "C" of the building-out capacitor with no strapping connected to terminal "A." The 7A condenser box then replaces the building-out capacitor.

(2) Adjust the 7A condenser box for the highest singing point.

(3) Remove the condenser box and strap the building-out capacitor to correspond to the values in the 7A condenser box which gave the highest singing point in Item (2). This gives a nominal setting and should not be used without a further check as given in Item (4).

(4) Check the singing point after the building-out capacitor has been strapped. It should be within 1 db of the singing point obtained in Item (2). If it is lower, the building-out capacitor should be changed to a slightly higher or slightly lower value to obtain the highest practicable singing point.

6.06 The following procedure should be used when a W12A cord is employed. (See Fig. 6.)

(1) Remove all straps from the building-out capacitor.

(2) Connect the lead with the black 360B tool to terminal "A" of the building-out capacitor.

(3) Connect the leads with red 360A tools to the other capacitor terminals with capacitance designations as required to obtain the highest singing point. It will often be found convenient to start with a value of capacitance used in similar networks associated with trunks in the same cable, and then increase or decrease the total connected capacitor in small steps until the highest singing point is obtained. When the desired combination is found the numbered terminals to which the leads have been connected should be noted.

(4) Remove the W12A cord and **strap terminal** "A" of the building-out capacitor to the terminals which were connected to red 360A tools in Item (3) when the highest singing point was obtained.

(5) Check the singing point after the strapping is completed. It should agree with the value obtained in Item (3).

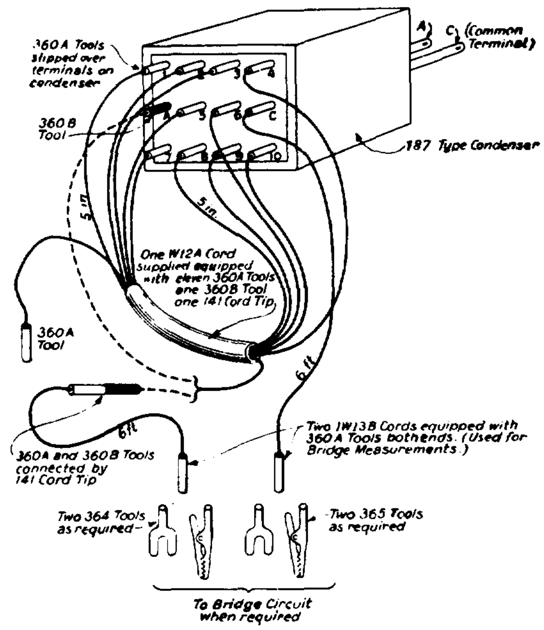


Fig. 6 - W12A Cord Used to Build Out Capacitors

6.07 If singing occurs at a low frequency, the building-out capacitor sometimes may be varied over a wide range without affecting the singing point, making it impractical and undesirable to determine the setting of the building-out capacitor by this method. In this case, the strapping of the building-out capacitor should be determined by computation as follows:

(1) Determine the effective cable length from the last load coil to the repeater (to the nearest 50 ft.) obtained from the testboard cable records. The effective cable length includes the actual length plus the equivalent length of **any** building-out cable. Convert this distance to a decimal part of a load section.

(2) Deduct the "basic end section" of the appropriate network used as given in Table IV.

(3) Convert the remainder found in Item (2) to microfarads using the "nominal" capacitance per load section. Nominal capacitance per load section:

Side	0.07 mf
Phantom	0.116 mf

(4) Strap the building-out capacitor to obtain the value of capacitance determined in Item (3). The BO capacitors should be measured as the capacitance of the units may vary appreciably from their nominal values.

(5) Check the singing point again after the building-out capacitor has been strapped.

6.08 **An example of** the computation outlined in Paragraph 6.07 is given below:

Assume the facility is an H-88 cable pair using a 115P network	
Distance from last load coil to MDF	= 2525 ft.
Load spacing	= 6000 ft.
Total distance in load sections	= 0.42 sec.
Basic end section of 115P network	= 0.18 sec.
Difference	= 0.24 sec.
Nominal capacitance per load section	= 0.07 mf
Difference converted to capacity	= 0.07 x 0.24
(Value of B.O. capacitor)	= 0.017 mf

TABLE I

1000-cycle Equipment Insertion Losses for Use in Determining Singing Points
V-type Repeater Arrangements (includes hybrid transformers)

2-wire Trunks

Cable Trunks without CX or with Type E CX Sets

Facility	Signaling & Telegraph	Insertion Loss - db Input Equipment	Insertion Loss - db Output Equipment
16 or 19 H-172-S	All	4.7	3.6
16 or 19 H-63-P	All	4.7	4.0
19 H-106-P	All	4.4	4.0
16 or 19 H-88-S	All	4.4	3.6
16 or 19 H-50-P	All	4.6	4.0
19 B-88-S	All	4.5	3.6
19 B-50-P	All	4.7	4.0
16 H-44-S	20 or CX Sig.; 135 or 1000 with Teleg.	5.5	3.8
16 H-44-S	135 or 1000 or S.F. Sig.	6.8	3.8
16 H-25-P	20 on S&P	6.8	4.0
16 H-25-P	20 P; 135 or 1000 or S.F. Sig. on S	5.6	4.0
16 H-25-P	135 or 1000 with Teleg. or 20 on S, 135 or 1000 or S.F. Sig. on P; CX on S&P	5.6	3.9
16 H-25-P	135 or 1000 or S.F. Sig. on S&P	6.9	3.8
Resistor Hybrid	All	10.7	10.7

Cable Trunks with Type C CX Sets

Facility	Signaling & Telegraph	Input Equipment	Output Equipment
16 or 19 H-172-S	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.8	3.6
16 or 19 H-63-P	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.8	4.0
19 H-106-P	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.5	4.0
16 or 19 H-88-S	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.5	3.6
16 or 19 H-50-P	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.7	4.0
19 B-88-S	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.6	3.6
19 B-50-P	CX; S.F. Sig.; 135 or 1000 with Telegraph	4.8	4.0
16 H-44-S	CX; S.F. Sig.; 135 or 1000 with Telegraph	6.8	3.8
16 H-25-P	CX on S&P; 135 or 1000 on S&P - Teleg. on S	5.6	4.0
16 H-25-P	135 or 1000 on S&P - Teleg. on P	6.8	4.0

Open Wire Trunks - All Gauges and Spacings

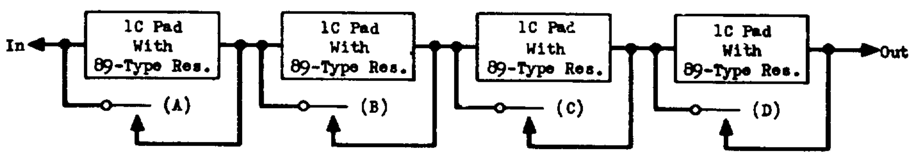
Facility	Cx and Carrier	Signaling & Telegraph	Input Equipment	Output Equipment
S	None	20	5.5	3.6
S	None	135 or 1000 or S.F. Sig.	6.5	3.6
P	None	20 or S&P	4.0	3.9
P	None	20 P; 135 or 1000 or S.F. Sig. S	6.8	3.9
P	None	135 or 1000 or S.F. Sig. P; 20S	5.5	3.9
P	None	135 or 1000 or S.F. Sig. S&P	6.8	3.9
S	Carrier	20	5.8	3.9
S	Carrier	135 or 1000 or S.F. Sig.	6.8	3.9
P	Carrier	20 S&P	4.2	4.1
P	Carrier	20 P; 135 or 1000 or S.F. Sig. S	7.0	4.1
P	Carrier	135 or 1000 or S.F. Sig. P; 20S	5.8	4.1
P	Carrier	135 or 1000 or S.F. Sig. S&P	7.0	4.1
S	Cx	Cx; 135 or 1000 with Teleg.	6.5	3.8
P	Cx on S	Cx on S&P; 135 or 1000 S&P with Teleg. on S	6.8	4.0
P	Cx on P	1000 S&P with Teleg. on P	4.1	4.0
P	Cx on P	135 S&P with Teleg. on P	6.8	4.0
S	Cx & Carrier	Cx; 135 or 1000 with Teleg.	6.8	4.1
P	Cx & Carrier on S	Cx on S&P; 135 or 1000 S&P with Teleg. on S	7.0	4.2
Resistor Hybrid		All	10.7	10.7

Note: These values include the losses of all equipment indicated, such as ringers, composite sets and carrier filters.

TABLE II

Regulating Network for Long Regulator Sections V-type Repeater Arrangements

Single Line Schematic



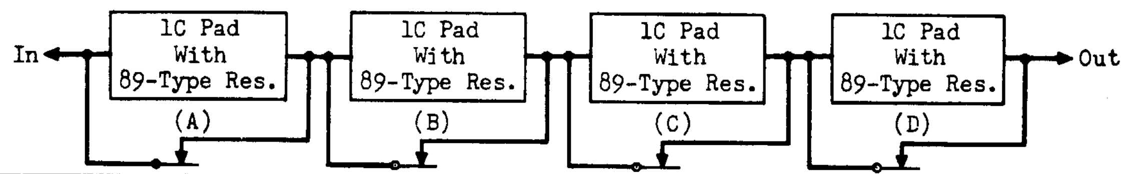
Pilot Wire Regulator Step	Regulating Network Step	Relays Operated	Pads In	Loss in DB													
				19 Ga. H88S	19 Ga. H50P	19 Ga. B88S	19 Ga. B50P	16 Ga. H44S	16 Ga. H25P	19 Ga. H172S	19 Ga. H63P	19 Ga. H44S	19 Ga. H25P	See Note			
+10 +9.5	+5	A,B,C,D	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+9 +8.5 +8 +7.5	+4	B,C,D	A	1.5	1.25	1.0	.75	1.0	.75	1.0	1.0	2.0	1.5	1.25	1.5	1.75	1.75
+7 +6.5 +6 +5.5	+3	A,C,D	B	2.75	2.5	2.25	1.5	2.0	1.5	2.25	2.25	3.75	3.25	2.5	3.0	3.5	3.5
+5 +4.5 +4 +3.5	+2	C,D	A,B	4.25	3.75	3.25	2.25	3.0	2.25	3.25	3.25	5.75	4.75	3.75	4.5	5.25	5.25
+3 +2.5 +2 +1.5	+1	B,D	A,C	5.75	4.75	4.25	3.25	4.0	3.25	4.25	4.25	7.75	6.25	5.25	6.0	6.75	7.25
+1 +0.5 0 -0.5	0	A,D	B,C	7.0	6.0	5.5	4.0	5.0	4.0	5.5	5.5	9.5	8.0	6.5	7.5	8.5	9.0
-1 -1.5 -2 -2.5	-1	D	A,B,C	8.5	7.25	6.5	4.75	6.0	4.75	6.5	6.5	11.5	9.5	7.75	9.0	10.25	10.75
-3 -3.5 -4 -4.5	-2	A,B	C,D	9.75	8.25	7.75	5.75	7.0	5.75	7.75	7.75	13.25	11.25	9.25	10.5	11.75	12.75
-5 -5.5 -6 -6.5	-3	B	A,C,D	11.25	9.5	8.75	6.5	8.0	6.5	8.75	8.75	15.25	12.75	10.5	12.0	13.5	14.5
-7 -7.5 -8 -8.5	-4	A	B,C,D	12.50	10.75	10.0	7.25	9.0	7.25	10.0	10.0	17.0	14.5	11.75	13.5	15.25	16.25
-9 -9.5 -10	-5	None	A,B,C,D	14.0	12.0	11.0	8.0	10.0	8.0	11.0	11.0	19.0	16.0	13.0	15.0	17.0	18.0
		Resistance Designation		Resistance Code													
		A B C D		89G 89M 89U 89AC	89F 89L 89R 89Y	89E 89K 89P 89W	89D 89G 89L 89F	89E 89J 89N 89T	89D 89G 89L 89P	89E 89K 89P 89W	89E 89K 89P 89W	89J 89S 89AD 89AL	89G 89P 89Y 89AG	89F 89L 89T 89AB	89G 89N 89W 89AE	89H 89R 89AA 89AH	89H 89R 89AC 89AK

Note: These columns cover loss ranges not required for standard facilities. They may be used for special cases, when suitable.

TABLE III

Regulating Network for Average Regulator Sections
V-type Repeater Arrangements

Single Line Schematic



Pilot Wire Regulator Step	Regulating Network Step	Relays Operated	Pads In	Loss in DB												
				19 Ga. H88S	19 Ga. H50P	19 Ga. B88S	19 Ga. B50P	16 Ga. H44S	16 Ga. H25P	19 Ga. H172S	19 Ga. H63P	19 Ga. H44S	19 Ga. H25P	See Note		
+10 to +6	+6	None	None	0	0	0	0	0	0	0	0	0	0	0	0	0
+5.5, +4.5	+5	A	A	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.75	0.25	0.25	0.75
+4, +3.5	+4	B	B	1.5	1.25	1.0	0.75	1.0	0.75	1.0	1.0	2.0	1.5	0.5	0.75	1.75
+3, +2.5	+3	A,B	A,B	2.25	1.75	1.5	1.25	1.5	1.25	1.5	1.5	3.0	2.25	0.75	1.0	2.5
+2, +1.5	+2	C	C	2.75	2.5	2.25	1.75	2.0	1.75	2.25	2.25	3.75	3.25	1.0	1.25	3.5
+1, +0.5	+1	A,C	A,C	3.5	3.0	2.75	2.25	2.5	2.25	2.75	2.75	4.75	4.0	1.25	1.5	4.25
0, -0.5	0	B,C	B,C	4.25	3.75	3.25	2.5	3.0	2.5	3.25	3.25	5.75	4.75	1.5	2.0	5.25
-1, -1.5	-1	A,B,C	A,B,C	5.0	4.25	3.75	3.0	3.5	3.0	3.75	3.75	6.75	5.5	1.75	2.25	6.0
-2, -2.5	-2	C,D	C,D	5.5	4.75	4.5	3.25	4.0	3.25	4.5	4.5	7.5	6.5	2.0	2.5	7.0
-3, -3.5	-3	A,C,D	A,C,D	6.25	5.25	5.0	3.75	4.5	3.75	5.0	5.0	8.5	7.25	2.25	2.75	7.75
-4, -4.5	-4	B,C,D	B,C,D	7.0	6.0	5.5	4.0	5.0	4.0	5.5	5.5	9.5	8.0	2.5	3.25	8.75
-5 to -10	-5	A,B,C,D	A,B,C,D	7.75	6.5	6.0	4.5	5.5	4.5	6.0	6.0	10.5	8.75	2.75	3.5	9.5

Resistance Designation	Resistance Code												
A	89D	89C	89C	89C	89C	89C	89C	89C	89E	89D	89CH	89CH	89D
B	89G	89F	89E	89D	89E	89D	89E	89E	89J	89G	89C	89D	89H
C	89M	89L	89K	89H	89J	89H	89K	89K	89S	89P	89E	89F	89R
D	89M	89K	89K	89G	89J	89G	89K	89K	89S	89P	89E	89F	89R

Note: These columns cover loss ranges not required for standard facilities. They may be used for special cases, when suitable.

TABLE IV

CABLE NETWORKS WITH RESISTANCE ADJUSTMENT FOR VARIATIONS IN CABLE CAPACITANCE PER SECTION				
TYPE OF NETWORK	BASIC END SECTION	GAUGE AND LOADING	CABLE CAPACITANCE PER SECTION - MF	STRAP TERMINALS
115P or 113P	.18	19 ga. H-88 Side	Below .0676 .0676 to .0694 .0694 to .0708 Above .0708	None 2-4 3-4 2-3-4
115R or 113R	.18	19 ga. H-50 Phan.	Below .109 .109 to .112 .112 to .114 Above .114	None 2-4 3-4 2-3
115AF	Mid Coil (1st coil is half coil)	19 ga. B-88 Side	Below .0336 .0336 to .0345 .0345 to .0355 Above .0355	None 3-5 5-6 3-6
115AG	Mid Coil (1st coil is half coil)	19 ga. B-50 Phan.	Below .0543 .0543 to .0560 .0560 to .0571 Above .0571	None 3-5 5-6 3-6
115AH	.168	19 ga. H-44 Side	Below .069 .069 to .0715 .0715 to .0745 Above .0745	None 2-3 3-4 2-4
115AJ	.166	19 ga. H-25 Phan.	Below .107 .107 to .112 .112 to .116 Above .116	None 2-3 3-4 2-4
115AM	.183	19 ga. H-172 Side	Below .0672 .0672 to .0694 .0694 to .0716 Above .0716	None 3-5 5-6 3-6
115AM	.183	16 ga. H-172 Side	Strap 3-4 & 6-7 in addition to 19 ga. straps	
115AN	.176	19 ga. H-63 Phan.	Below .1071 .1071 to .1115 .1115 to .1159 Above .1159	None 3-5 5-6 3-6
115AN	.176	16 ga. H-63 Phan.	Strap 3-4 & 6-7 in addition to 19 ga. straps	
115AP	.2055	19 ga. H-106 Phan.	Below .1071 .1071 to .1115 .1115 to .1159 Above .1159	None 3-5 5-6 3-6
115AP	.2055	16 ga. H-106 Phan.	Below .1071 .1071 to .1115 .1115 to .1159 Above .1159	3-4 3-4-5 3-4 & 5-6 3-4-6

OPEN WIRE NETWORKS WITH RESISTANCE ADJUSTMENT FOR VARIOUS PIN SPACINGS			
TYPE OF NETWORK	GAUGE AND USE	LINE CONSTRUCTION	STRAP TERMINALS
115T	104 Side & Phys.	12" N. P. Pr	3-5
		8" N. P. Pr	5-6
		6" N. P. Pr	3-6
		12" Pole Pr	None
		12" 1/2 Pole Pr	None
115U	128 Side & Phys.	12" N. P. Pr	3-5
		8" N. P. Pr	5-6
		6" N. P. Pr	3-6
		12" Pole Pr	None
		12" 1/2 Pole Pr	None
115W	165 Side & Phys.	12" N. P. Pr	3-5
		8" N. P. Pr	5-6
		6" N. P. Pr	3-6
		12" Pole Pr	None
		12" 1/2 Pole Pr	None
115Y	104 Phan.	12" N. P. Pr	None
115AA	128 Phan.	12" N. P. Pr	None
115AA	165 Phan.	12" N. P. Pr	5-6

OTHER NETWORKS BASIC END SECTIONS		
TYPE OF NETWORK	FACILITY	END SEC
115AB	19 H-31 S	.164
115AD	19 H-18 P	.166
115AC	16 H-31 S	.158
115AE	16 H-18 P	.166
104A	16 H-174 S	.18
104C	16 H-63 P	.16
104E	16 H-44 S	.16
104F	16 H-25 P	.17
107B	16 H-31 S	.16
107E	16 H-18 P	.17
104B	19 H-174 S	.18
104D	19 H-63 P	.16
107C	19 H-31 S	.16
107F	19 H-18 P	.17
107B	16 H-31 S	.16
107E	16 H-18 P	.17
107A	13 H-31 S	.16
107D	13 H-18 P	.17