E7 REPEATER LINE-UP

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1. GENERAL

1.01 This section covers the installation of the E7 repeater and the measurements to be made on the bare loop prior to installation of the repeater. The bare-loop measurements furnish the data that permit the one-man adjustment of the E7 from the central office.

1.02 Two line-up procedures are described. The first and simpler requires only a return-loss adjustment at 2600 cps. This procedure will equalize most loops encountered in service. The second procedure requires the adjustment of both insertion loss and return loss. This procedure is recommended for longer loops with bridged taps.

2. APPARATUS, RECORDS AND FORMS

2.01 Table I lists apparatus, records and the form needed at the points shown and for the tests indicated.

TABLE I

APPARATUS	C.O. END	STATION END	TYPE OF TEST: RETURN LOSS	TYPE OF TEST: TRANS-MISSION	TYPE OF POWER NEEDED
Jack box ED-97101-30 Gr. 1 and 2	1			X	
Line extension cord ED-97023-30	1		X	X	
54C Return loss Set. (Note 1)	1		X	X	110-120 volts, 60 cps; −48V dc and ground supplied from 54B TS
54B Test stand	1		X	X	−48 V dc and ground fused for 1-1/3 amp.
3 power cords with P5F Jones connectors (Note 2)	3		X	X	
2AB Aux. Test Set	1		X	X	
21A TMS or suitable 600-ohm oscillator (Note 5)	1		X	X	110-120 volts, 60 cps
Portable station test set, Northeast Electronics Corp. TTS-28		1		X	Battery operated
Capacitance Decade Box (Note 3,4)	1		X	X	
Resistance Decade Box (Note 3,4)	1		X	X	
Resistor 1600 ohms ± 5% — Note 3,4	1		X		
General Radio Type 274 MB — Insulated Double Plug	1		X		
Termination of 900 ohms ± 5% in series with 2 uf ± 20%, 500 WVDC	1	1	X	X	
Patch cords 3P7B 3 ft. long	4		X	X	

TABLE I (Cont'd)

APPARATUS	C.O. END	STATION END	TYPE OF TEST: RETURN LOSS	TYPE OF TEST: TRANS-MISSION	TYPE OF POWER NEEDED
2W42A Cord	1		X		
Data form — TWX and WADS circuit layout record card, with loop information	1		X	X	
Lamp to illuminate test gear	1		X	X	110-120 volts
Table type Wagon	1		X	X	
Head phones KS-14418 with 419A plug	1		X	X	
Test resistor 600 ohms ± 5% mounted in double banana plug (Note 6)	1		X	X	

Notes:

1. The 54C Return Loss Measuring Set (J99254C — List 1) modified to provide a high-impedance detector input. New 54C sets to be used for lining up E7 repeatered loops should include J99254C — List 4. Existing J99254C List 1 sets that are to be modified must be returned to the Western Electric Company local distributing house for the addition of List 4.

2. Two of these cords are supplied with the 54B test stand. A third cord may be connected in tandem with one of the others when extra length is needed.

3. Suitable boxes for this use are listed in Appendix III.

4. Part of reference network required in Part 4.0.

5. Specifications for oscillator are in Appendix I. A 2AB AUX TTS is required with 600-ohm oscillators to step up impedance to 900 ohms.

6. Needed only when oscillator output impedance is 600 ohms, and output is adjusted with a high-impedance detector.

(A) Reference Network

2.02 An adjustable network is used to simulate the input impedance of the loop terminated in 900 ohms in series with 2 uf. When adjusted for a particular loop, it is known as the reference network. The reference network will determine the initial settings in the E7 repeater network and establish a standard against which the loop can be compared in the future, if trouble develops.

2.03 The adjustable network consists of the following items connected as shown in Fig. 1:

1 — Capacitance decade box of at least 2 decades, 0 to 0.1 uf and 0 to 1.0 uf ±3% at any step.

1 — Resistance decade box with 3 decades as follows; 0 - 10 ohms; 0 - 100 ohms; 0 - 1000 ohms; all ±3% of setting.

1 — 1600-ohm resistor ±5%.

Apparatus suitable for this application is listed in Appendix III.

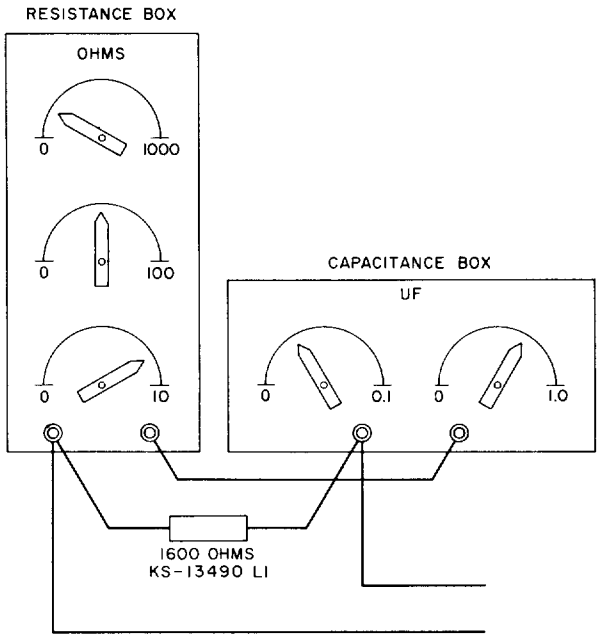

Fig. 1 – Reference Network

(B) Oscillator

2.04 The oscillator must be capable of covering a minimum frequency spectrum of 500-3500 cps with an output adjustable up to +10 dbm into 900 ohms. The output impedance should be 900 ohms ±3% and balanced to ground. Many oscillators are unbalanced to ground with a 600-ohm output impedance. If the output impedance is 600 ohms, then it will be necessary to have a 2AB (J94002AB) Auxiliary Transmission Test Set to step up the impedance to 900 ohms. Oscillators suitable for this application are given in Appendix I.

(C) Detector

2.05 A high-impedance balanced-to-ground detector having an input impedance of at least 20,000 ohms is required. A 54C set modified in accordance with J97254C — List 4 can be used. This modification makes the high-impedance detector available at a jack. When picked up at this jack, the detector is automatically disconnected from the return-loss circuit.

2.06 In addition to 60-cycle power, the 54C set requires a connection to −48 volt CO battery and ground usually via the 54B test stand. The −48 volt supply, fused at 1-1/3 amperes, is available at the test set power panel of the E6 repeater bay. If the 54C set is powered from an E23 power panel, the rheostat on the panel must be set to zero resistance. Apparatus suitable for this application is listed in Appendix II.

(D) Test Stand

2.07 The E7 repeater is designed to plug into the 54B test stand. This permits easy access to both sides of the repeater during adjustment. The 54B test stand is shown in Fig. 2 and Fig. 3.

(E) Termination

2.08 The TWX loop termination at the station end consists of a 900-ohm resistor in series with a 2.0-uf capacitor. The loop will be terminated during the E7 line-up. The termination must be removed when the data set is connected.

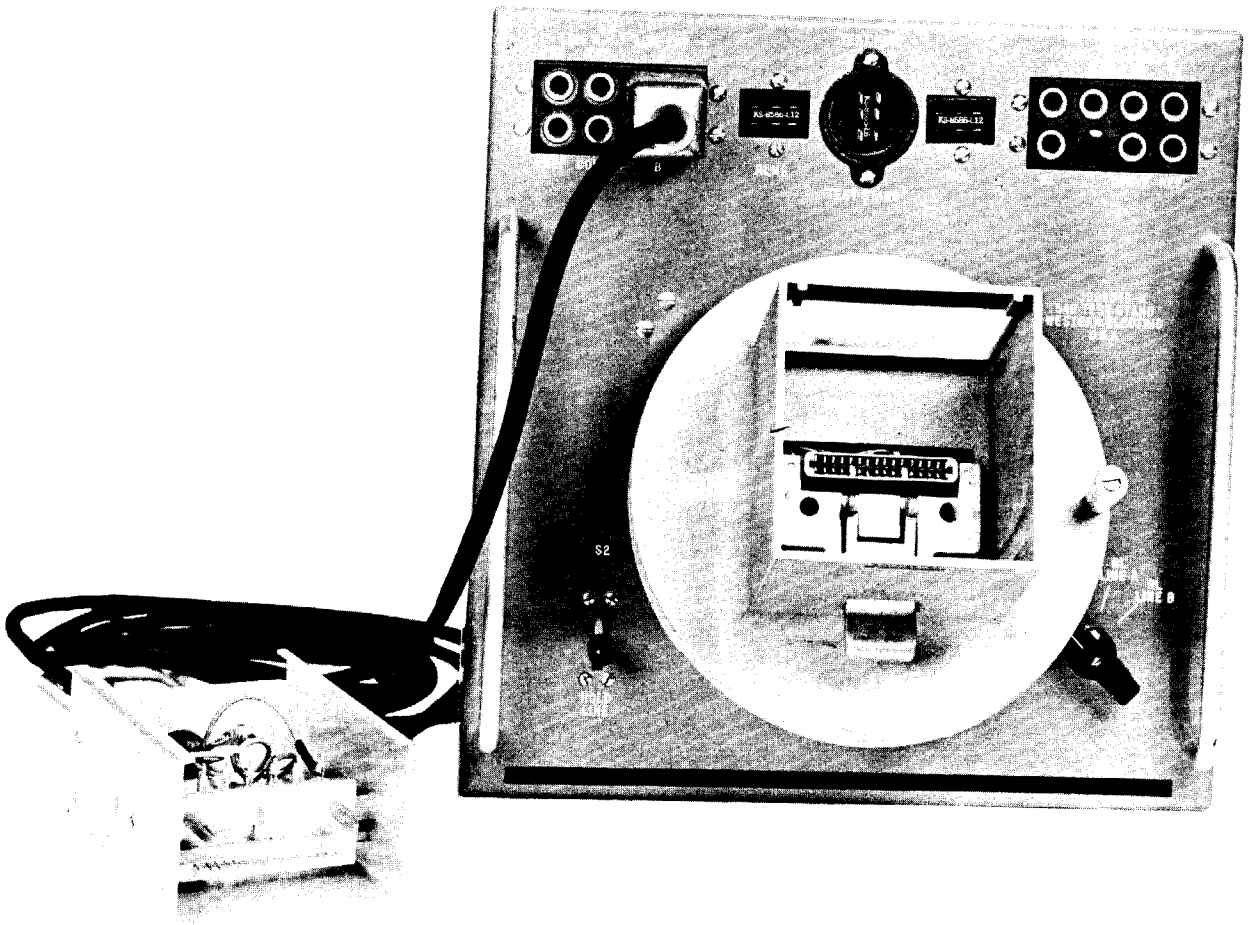

Fig. 2 – 54B Test Stand With ED-97023-30 Line Extension Cord

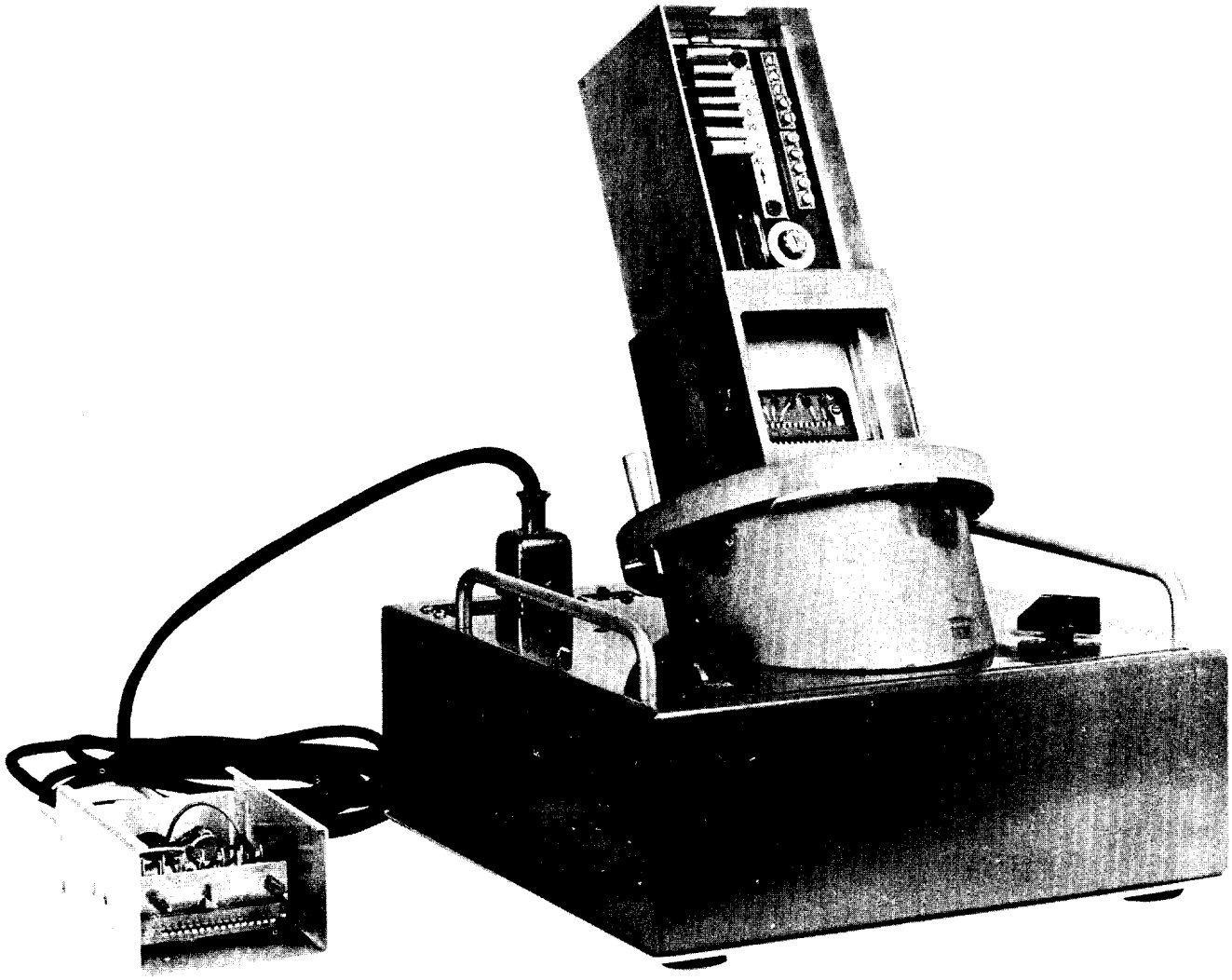

Fig. 3 – 54B Test Stand With E7 Repeater in Place

(F) Data Forms

2.09 Form E-4921 ML is a double-sided form for recording data on TWX and WADS circuits. The completed forms are to be kept on file. Information pertinent to the repeater line-up is also recorded in the space provided on the front cap of the E7 repeater.

3. PREPARATIONS

3.01 Take the test equipment to the points of use. Connect all necessary power sources to test sets and turn them on.

3.02 Check the calibration of the 54C set as follows: Connect the oscillator output to the 2AB AUX TRANS TEST SET and set oscillator frequency to 2300 cps. Connect a transmission measuring set to the TMS jack. Connect the 54C H IMP jack to 2AB MEAS jack bridged with a 900-ohm resistor. This test arrangement is shown in Fig. 4. First, set TEST switch to CAL OSC and, with the aid of the transmission measuring set, set the oscillator level to +0.5 db above 0 dbm. Now set TEST switch to SEND 900 and read the meter on the 54C set. This should read 0 dbm ±0.25 db. A slight readjustment of the METER CAL shaft beneath the protective cap is permissible to get this result.

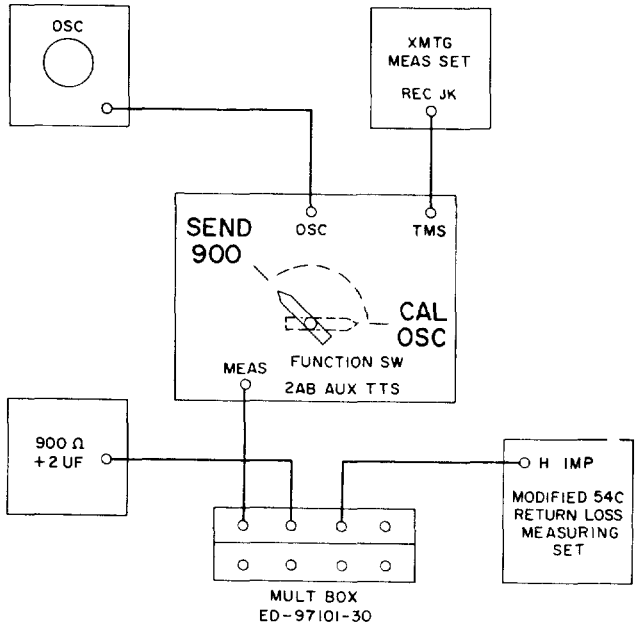

Fig. 4 – Calibration of 54C Return Loss Measuring Set

3.03 The following information is required before the E7 repeater can be lined up.

1. AML (actual meas. loss) of loop at 1000 and 2300 cps.

2. For those loops that fall outside the limits of Par. 4.15, an additional measurement will be required. This is the reference level which appears on the circuit layout card as V_o. The reference level (V_o) is measured in db at the input of the loop as shown in Fig. 5. With this information the loss of the repeatered loop can be checked from the central office on a one-man basis as explained in Par. 4.27. It is expected that relatively few loops will need to be adjusted by this process. If possible the bare-loop measurements should be made before the installation of the E7 repeater.

3.04 Make sure that the loop is connected to the T_1 and R_1 (B) terminals of the repeater and the office to the T and R (A) terminals. The E7 repeater will not do its job if connected backwards.

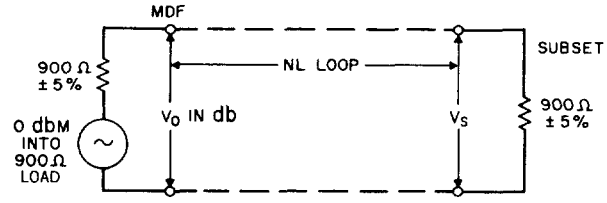

Fig. 5 – Measurement of V_o at Input of Loop

4. REPEATER LINE-UP

(A) Bare-Loop Measurement at E7 Shelf

4.01 The bare-loop measurements may be made at any time prior to the installation of the E7 repeater. The measurements have a two-fold purpose. They will check whether the loop meets the transmission requirements for TWX service and they will make possible a one-man lineup of the E7 repeater from the central office. The bare-loop measurements will require two men; one at the central office, and one at the subscriber's premises. It will be necessary to have a talking circuit between the two locations. These measurements determine the insertion loss of the loop between 900-ohm terminations and also the input level to the line, V_o in db, as shown schematically in Fig. 5.

Caution: Do not touch the TTS 28 while reading the meter, as this may result in an incorrect indication.

For calibration at 0 dbm the TTS 28 includes only an internal adjustment. The bulletin entitled "Operating Instructions, Model TTS 28 Portable Station Test Set," published by the manufacturer, tells how to adjust the mechanical meter zero and how to check and, if necessary, correct the calibration. The insertion-loss measurement is made at two frequencies, 1000 and 2300 cps. When the oscillator level is set at a reference value of 0 dbm into 900 ohms, V_s (db) is the insertion loss (AML) of the loop.* A measurement of V_o (db) is required only on loops where the line-up procedure requires a transmission-loss measurement of the repeatered loop. The loops requiring the measurement of V_o are those where:

(a) The total length of bridged tap is 0-3000 ft. and the ACT. LOOP LOSS W/o REPT is over 5 db at 1000 cps.

(b) The total length of bridged tap is 3000-6000 ft. and the ACT. LOOP LOSS W/o REPT is over 7 db at 1000 cps.

Once the insertion loss and V_0 (db) are known, and the loop is terminated in 900 ohms and 2 uf at the station, all the measurements required for line-up can be made from the central office.

* ***Note:*** Throughout this section the dial switch of the measuring set should always be set so that V_s is indicated between zero and 10 db to the left of the zero on the meter scale. Indications to the left denote losses and are to be considered positive, rather than negative, regardless of the signs or colors on the scale. In the measurements of V_0, readings of the 54C set in the black range of the meter with the AT1 switch on a white figure are considered positive; readings in the red range of meter and switch are considered negative.

4.02 The apparatus required for these tests is listed in Table II.

4.03 Assemble the apparatus at the location where the measurements are to be made. Connect apparatus as shown in Fig. 6, but connect 2AB MEAS to MULT B rather than MULT A of the jack box.

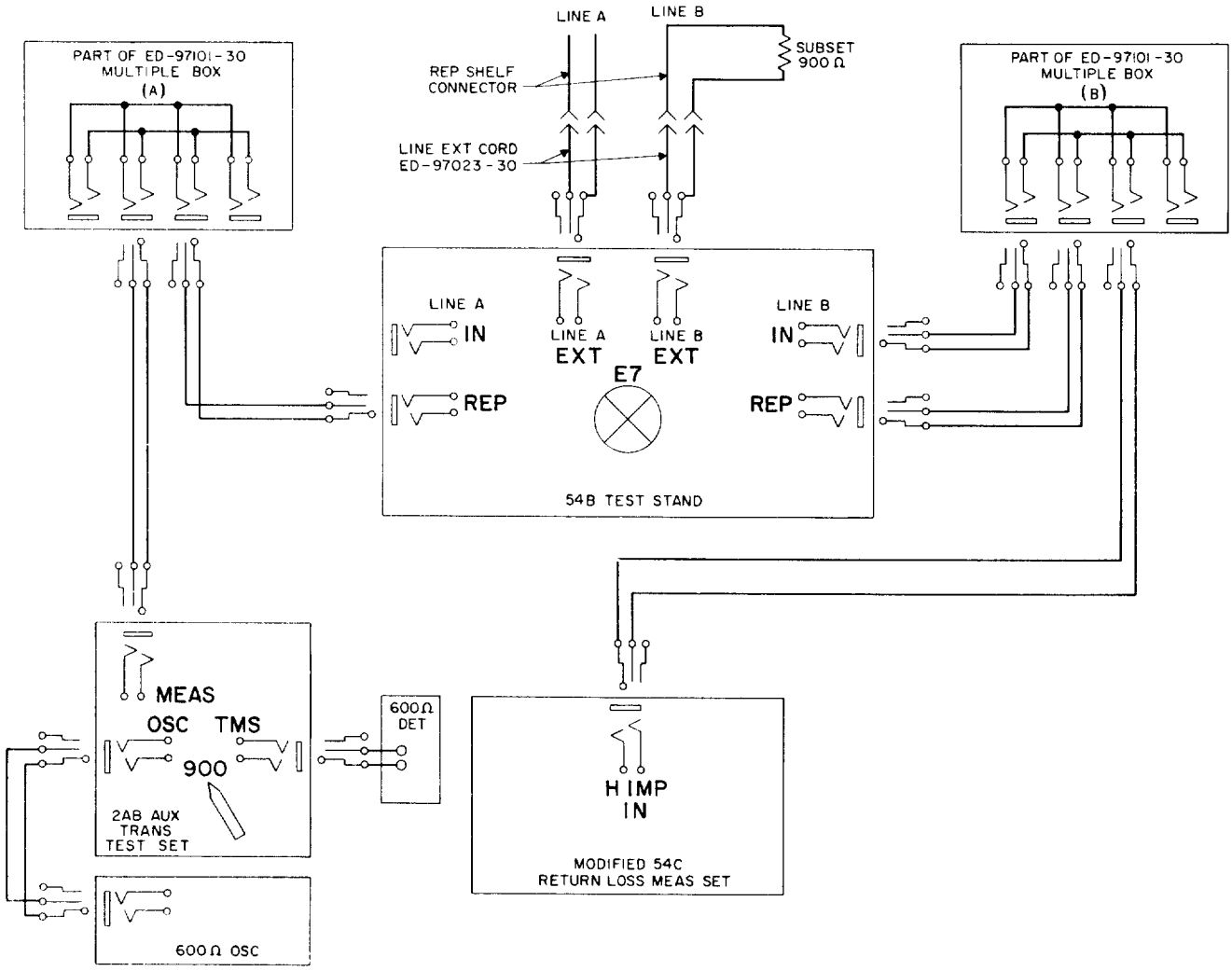

Fig. 6 – Transmission Measurement

4.04 Plug the line extension cord (ED-97023-30) into the shelf position to be checked. Be sure that there is no repeater in the test stand. Check to see that loop comes down to the T_1 and R_1 side of the 54B test stand indicated in Fig. 6.

(B) Oscillator Output Calibration

4.05 Turn the 2AB set TEST FUNCTION SWITCH to position CAL OSC. Connect a 600-ohm transmission measuring set to the 2AB set jack labeled TMS. Set the oscillator frequency at 1000 cps. Adjust the oscillator output to obtain +0.5 db above 0 dbm. The 0.5 db higher level is to compensate for 2AB set transformer loss.

(C) Loop Measurement

4.06 Turn the 2AB set TEST FUNCTION SWITCH to SEND 900 ohms. Measure V_s in db at the far end of the loop and V_o when required.* Both measurements should be recorded on the circuit layout card. Note that for this measurement the oscillator connection shown in Fig. 6 should be to the "B" side of the jack box. Repeat this procedure at 2300 cps and record V_s and V_o on the circuit layout card.

* ***Caution: Do not touch the TTS 28 while reading the meter, as this may result in an incorrect indication.***

For calibration at 0 dbm the TTS 28 includes only an internal adjustment. The bulletin entitled "Operating Instructions, Model TTS 28 Portable Station Test Set," published by the manufacturer, tells how to adjust the mechanical meter zero and how to check and, if necessary, correct the calibration.

4.07 In some cases, the bare-loop measurements may be made at the MDF, in which case assemble apparatus required from Table II. Connect apparatus as shown in Fig. 7.

Caution: Do not touch the TTS 28 while reading the meter, as this may result in an incorrect indication.

For calibration at 0 dbm the TTS 28 includes only an internal adjustment. The bulletin entitled "Operating Instructions, Model TTS 28 Portable Station Test Set," published by the manufacturer, tells how to adjust the mechanical meter zero and how to check and, if necessary, correct the calibration. The ED-97101 jack box will permit easy access to the line for making bridged voltage measurements across the line. It is assumed that a talking circuit for communication with the man at the subscriber's premises is available. The measurements made at the MDF are the same as those made at the E7 shelf position. The 54B test stand is not used at the MDF.

4.08 Before the man leaves the subscriber's premises, he should terminate the loop in 900 ohms +2 uf since subsequent steps at the central office require a terminated line. The termination is removed when the data set is connected to the line.

(D) Reference Network

4.09 The purpose of this adjustment is to determine the resistance and capacitance constants of a reference network whose impedance is equal to the input impedance of the terminated loop. From the information obtained, the initial resistance and capacitance settings for the E7 can be determined. The reference network will also be used later for routine checking of the repeater performance.

4.10 The apparatus required for determining the reference network is listed in Table I under the return-loss measurements. The 54B test stand is used as a convenient way of getting at the line terminals; no repeater is required for these measurements. Note that the reference network is adjusted at 2600 cps. This gives the best performance for both transmission and return loss.

4.11 Assemble the apparatus at the location where the measurements are to be made. Connect the apparatus for this test as shown in Fig. 8. The reference network should terminate in a General Radio Type 274 MB double banana plug for this test. Connect the reference network to the 54C set EXT. NET jack. Turn switch S3 of the 54C set to the EXT. NET position.

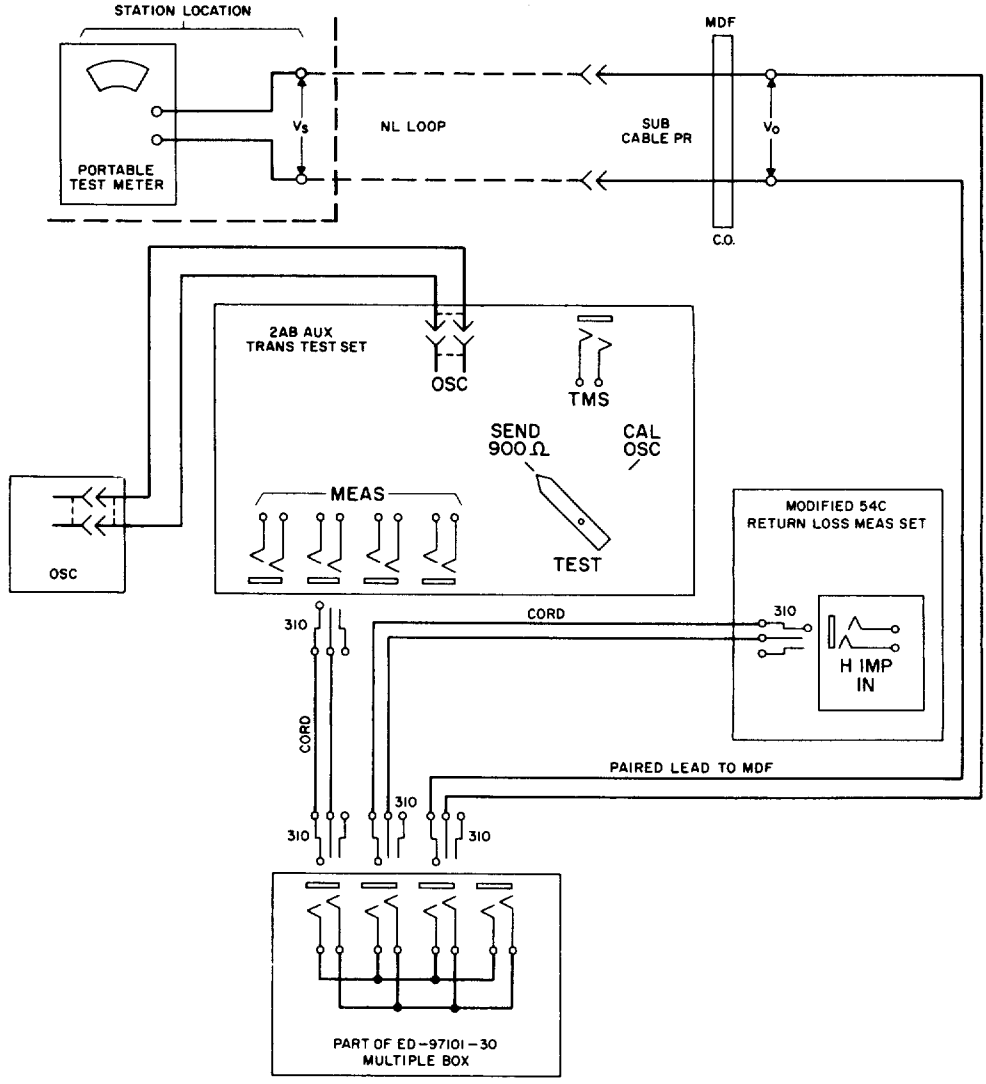

Fig. 7 – Loop Measurements at MDF

TABLE II

APPARATUS	C.O. END	SUBSET END	TYPE OF TEST V_o	TYPE OF TEST V_s	POWER REQUIRED AND COMMENTS
Oscillator 21A TMS Hewlett-Packard No. 200CD or equivalent	1		X	X	110-120 volts 60~ Note 1
Portable Station Test Set, Northeast TTS-28		1		X	Battery Operated
Termination 900 ohms ±5% +2 uf ±20%	1	1		X	Note 2
Line Extension Cord ED-97023-30	1		X		Note 3
54B Test Stand Plus Power Cords	1				Note 3
54C Return Loss Set (P5F Power Cord) Modified per ED-97254C, List 4	1		X		110-120 volts 60~; −48V dc and ground 1-1/3 amps. Supplied through 54B stand. Note 4
Data Forms	1		X	X	For Recording Data
Patch Cords 3P7B, 3 feet long	4				
Multiple Jack Box ED-97101-30, Gr. 1 and 2	1		X		Note 3

Notes:

1. A 2AB TS will transform the oscillator impedance to 900 ohms conveniently, otherwise oscillator impedance must be 900 ohms ±5% and balanced to ground.
2. Resistor — Allen Bradley and KS-134903-1 Capacitor or equivalent.
3. Equipment required when measurements are to be made at the E7 shelf position.
4. Will be used as a high-impedance voltmeter.

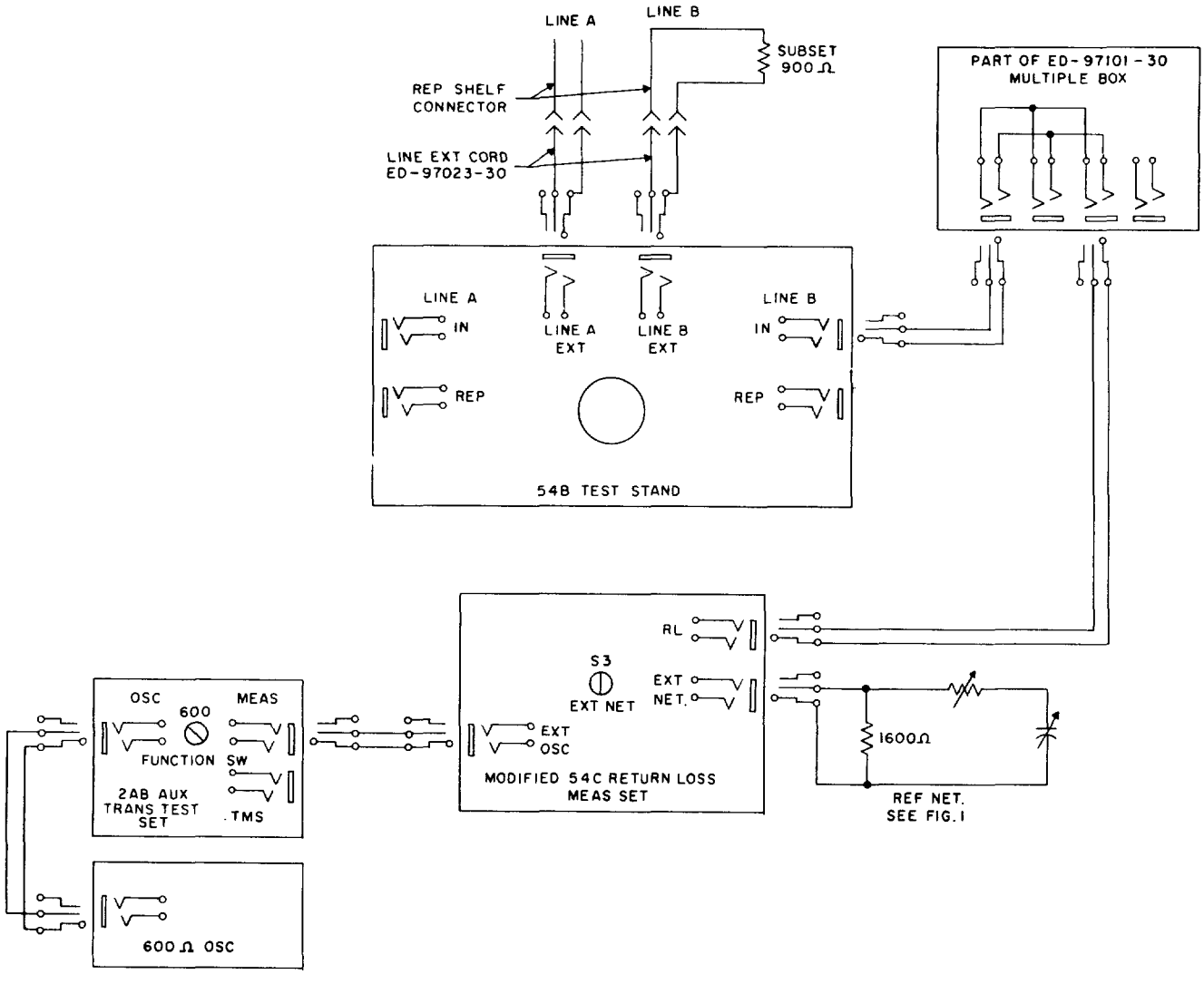

Fig. 8 – Determination of Reference Network

4.12 Set the oscillator frequency to 2600 cps ±100 cps. Operate the (S2) key to SEND LEVEL CAL on the 54C set and adjust the oscillator output level control to obtain 0 db on the black scale of the 54C set meter. Set R at 250 ohms and C at 0.15 uf. Release the S2 key and adjust for a maximum return-loss reading by alternately adjusting the resistance and capacitance decade boxes. This adjustment should continue until a maximum return loss is obtained. The maximum should be greater than 30 db.

4.13 Read the resistance and capacitance settings on the dials of the reference network. These readings should be recorded on the circuit layout card under E7 repeater data in the spaces for R and C of REF. NET.

4.14 Record the maximum 2600-cps return loss (Meter reading plus dial reading) in the space opposite 2600 RL on the circuit layout card. This completes the reference-network specification.

(E) Repeater Line-Up #1

4.15 The procedure described as Repeater Line-up #1 is used to line up the E7 with all loops that fall within the two groups listed

below, divided according to the length of bridged tap (BT).

TOTAL LENGTH OF BRIDGED TAP	1000-CPS AML
0 - 3000 ft.	Less than 5 db
3000 - 6000 ft.	Less than 7 db

Loops that do not fit into the above groups are lined up in accordance with the procedure described as Repeater Line-up #2 outlined in Par. 4.27.

4.16 The apparatus required for the repeater line-up is listed in Table I. Connect the apparatus as in Fig. 9 for making return-loss measurements.

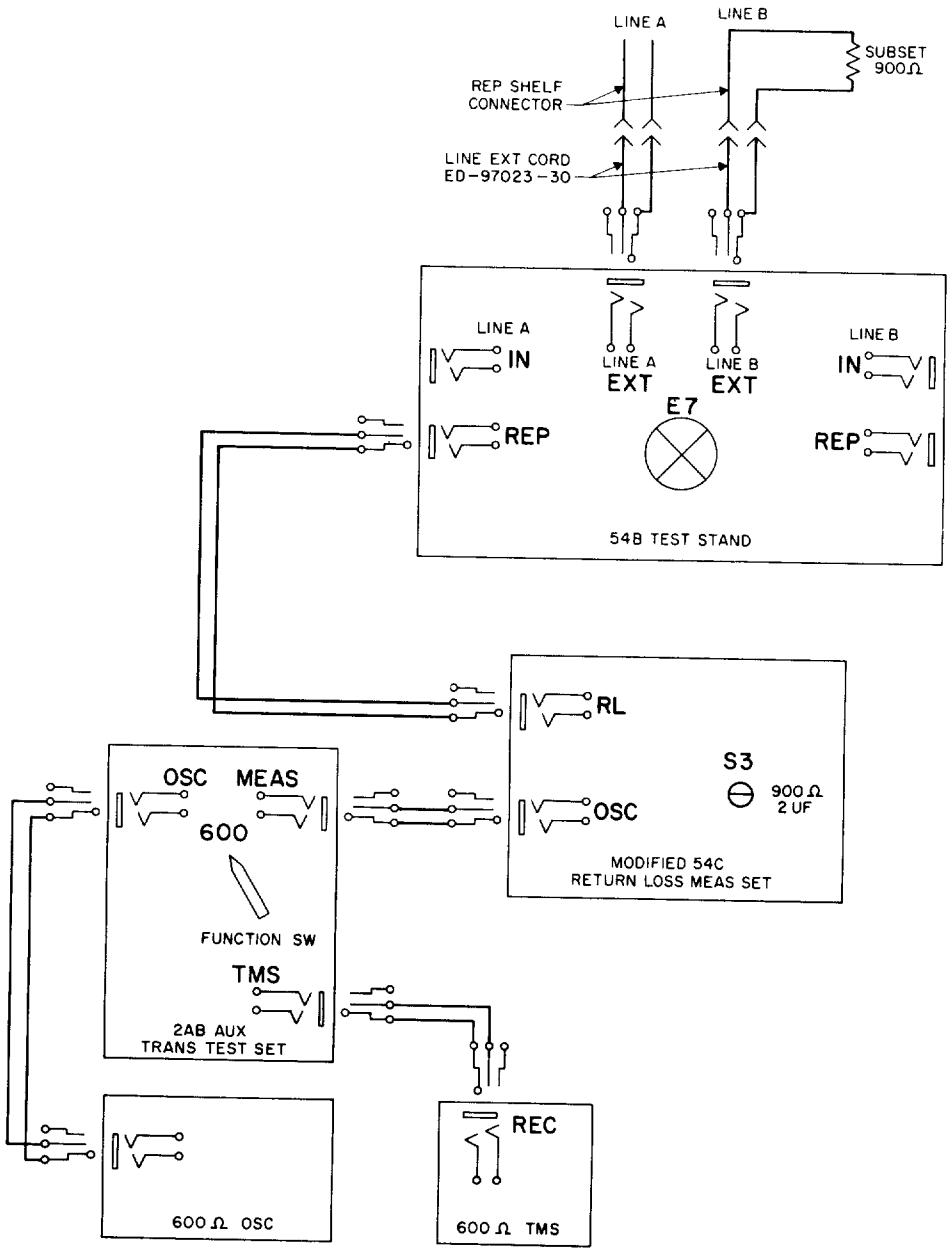

Fig. 9 – Return-Loss Measurement

4.17 Obtain the circuit layout card for the loop. (See Par. 4.06.)

4.18 From Table III select the transformer tap according to the 2300-cps loop insertion loss. The tap is set by tightening down two screws on terminal blocks on the transformer side of the repeater. Make sure all the other screws on this terminal block are turned up and are not making contact.

TABLE III

TRANSFORMER TAP SETTING				
INSERTION LOSS OF LOOP AT 2300 cps	DC RESISTANCE OF LOOP	TRANSFORMER TAP NO.	TERMINAL SCREW NO.	
			TB1	TB2
12-16 db	over 1100	4	4	4
12-16	under 1100	3	3	3
7.5-11.9		3	3	3
3.0-7.4		2	2	2
Less than 3.0		1	1	1

Note: Terminal screw #5 is not connected to transformer.

4.19 Next, find the approximate or table values of the resistance and capacitance settings by taking the RC equivalent loop RES. SET. and CAP STRAP readings given on the circuit layout card and referring to Table IV (a) and (b). In the vertical column under the proper tap ratio, Table IV (b) find the entry opposite the value given for RES. SET. taken from the card. This number is the scale setting of the adjustable resistance, (R-10) to be found on the network side of the repeater. Similarly, find the capacitance setting by referring to Table IV (a). In the vertical column of the proper tap find the required capacitance opposite the value given for CAP STRAP on the card. The capacitance required is selected by tightening down the required number of screws opposite the capacitors A, B, C, D, E, F, and G, so that the sum (in uf) of all capacitors in the circuit is equal to the table value. The locations of capacitance setting screws and the adjustable resistance (R-10) are shown on Fig. 10. Table V will be an aid in making this setting. An example of this process follows:

TWX loop No. 50

Tap No. 3 (corresponding to 10-db insertion loss (AML) at 2300 cps)

REF. NET. EQUIV. (Obtain from circuit layout card)

RES. SET.	350 ohms
CAP STRAP	0.14 uf

From Table IV

(a) Opposite 0.14 uf in column under Tap 3 find ***0.56 uf.***

(b) Opposite 350 ohms under Tap 3 find scale reading of (5).

These values are approximate settings for the E7 network. They are the starting points for the final adjustment. Table V is a short-cut to capacitor settings. Tables VI to XI give typical E7 repeater settings, return-loss and insertion-loss measurements on loops made up of 22, 24 and 26 gauge cable pairs with varying lengths of bridged tap. This information may be used as a guide for the initial repeater settings and for the transmission results that might be expected on similar loops. Information on the longer loops is given for both the No. 1 and No. 2 line-up procedures.

4.20 After the repeater has been set from the table values, plug it into the 54B stand (connected per Fig. 9 and Par. 4.16). Note again that adjustment of the capacitance and resistance in the repeater is made at 2600 cps to get the best performance for transmission and return loss.

4.21 Turn switch S3 of the 54C set to position 900 +2 uf. Switch the 2AB set to SEND 600 ohms. Set the oscillator frequency at 2600 cps. ± 100. Operate the S2 key of the 54C set to CAL position and while holding it down adjust the oscillator output control to obtain a meter reading of 10 db on the black scale. With the oscillator set at this level it will be necessary to ***subtract 10 db*** from all return-loss readings.

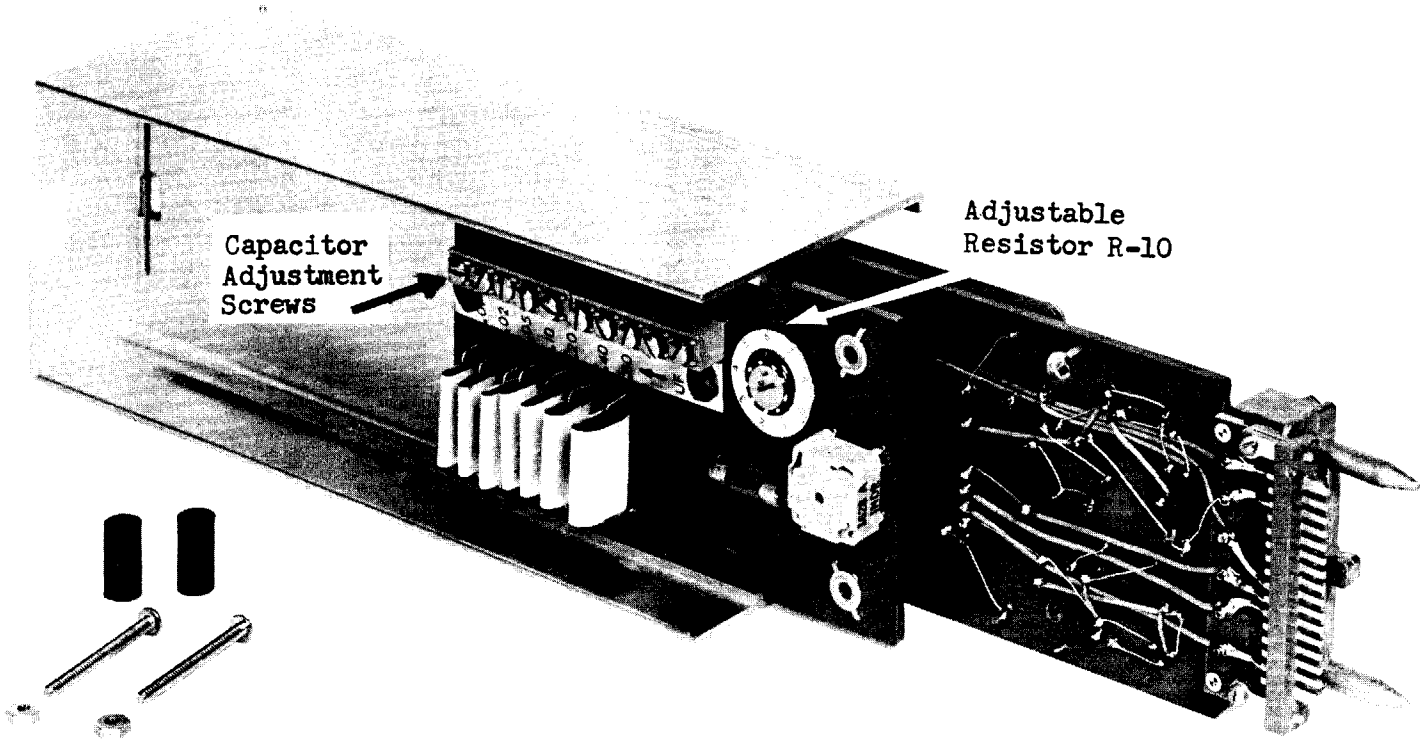

Fig. 10 – Partially Dismantled E7 Repeater Showing the Location of Capacitor Adjusting Screws

4.22 Now vary the capacitance and the resistance in the E7 repeater with the object of obtaining a maximum return loss. Vary the capacitance in small steps by screw selection of the capacitors A, B, C etc, starting with either C or D to determine the direction of adjustment. Adjust the resistance by a screwdriver adjustment of the variable resistor. Alternately adjust resistance and capacitance until a maximum return loss is obtained at 2600 cps. This should be greater than 20 db. After the maximum is found, turn the variable resistor clockwise until the return loss is 20 db. (AT1 set at 30 db and meter at 0.)

4.23 A convenient and rapid way of making the capacitance adjustment is by using an external adjustable capacitance box. For example, the decade capacitance box used in the reference network can be used as follows. Connect the capacitance box with a pair of clip leads across one of the fixed capacitors in the E7 network. The "D" capacitor is convenient, so clip across this capacitor. Now tighten (close) the screw opposite "D" and raise (open) all others. Adjust the decade box to obtain the maximum return loss at 2600 cps. The sum of the dial settings plus 0.1 uf is then the E7 capacitance setting. Remove the box and set this capacitance value into the repeater by screw selection of capacitors with aid of Table V. If the total capacitance required for maximum return loss happens to be less than 0.1 uf, then the "A" capacitor should be chosen as the clip-on point. In this case, .01 uf is the correct value to add to the dial reading. After the capacitor screws have been properly set, finish the line-up by turning the variable resistor clockwise until the desired 20-db return loss is obtained.

4.24 Measure the return loss of the repeatered loops at 1000, 2300 and 3500 cps. The following return-loss requirements should be met:

FREQ.	RL
1000 cps	14 db minimum
2300 cps	10 db minimum
3500 cps	2 db minimum

(F) Singing Test

4.25 Remove any office termination, including the oscillator. If the repeater is properly adjusted, it should not sing under these conditions. To check for singing, set the AT1 of the 54C set to 30 db and connect the H IMP jack of the 54C set to the "A" side of the jack box as shown in Fig. 11. If the pointer of the meter moves toward the right as the 54C set is connected, the repeater is singing. This is an indication of improper adjustment. An audible sing can be detected with the KS-14418 headphones.

Caution: Do not use any other type of headset for monitoring.

4.26 When the above return-loss requirements are met, the repeater is in adjustment. Do not remove the repeater from the test stand until the maintenance information described in Part 5 has been obtained.

(G) Repeater Line-up #2

4.27 This procedure is used for lining up the repeater for those loops that fall outside the limits specified in Par. 4.15. Since the initial line-up of the repeater will remain the same, the steps given in Par. 4.20-4.22 should be followed. The same apparatus used in Par. 4.16, connected per Fig. 9, is required.

4.28 Using the procedure given in Par. 4.20-4.22, adjust the repeater to obtain the maximum return loss at 2600 cps. If the maximum return loss is ***greater*** than 20 db, then with a screw-driver turn the variable resistor ***CLOCKWISE*** until the return loss is reduced to 20 db. If the maximum return loss is ***less*** than 20 db, do not readjust the resistor after the maximum is reached.

4.29 Now measure the return loss against 900 ohms +2 uf at 1000, 2300 and 3500 cps. Set the oscillator output at −10 db as in Par. 4.21. The return loss (meter reading plus dial reading minus 10 db) should meet the requirements of Par. 4.24. If necessary, trim the resistance and capacitance setting to meet these requirements.

4.30 When a satisfactory return-loss adjustment has been achieved, connect the apparatus for transmission measurement as shown in Fig. 6. Set the oscillator frequency at 2300 cps. Switch the 2AB set to SEND 900 ohms. Consult the circuit layout card and note the V_o (db) reading at 2300 cps. Now adjust the oscillator output control to get the same V_o reading on the meter of the 54C set. Connect a 600-ohm detector

TABLE IV

a					b				
REFERENCE NETWORK CAP. MF	E7 CAPACITOR SETTING				REF. NET. RESISTANCE	E7 POTENTIOMETER DIAL SETTING			
	TRANSF. TAP 1	TRANSF. TAP 2	TRANSF. TAP 3	TRANSF. TAP 4		TRANSF. TAP 1	TRANSF. TAP 2	TRANSF. TAP 3	TRANSF. TAP 4
.01	.0121	.02	.04	.063	100	1	2	—	—
.02	.024	.04	.08	.125	150	5	3	3	2
.03	.036	.06	.12	.188	200	7	4	3	2
.04	.048	.08	.16	.25	250		5	4	3
.05	.061	.10	.20	.313	300		7	4	3
.06	.073	.12	.24	.375	350		8	5	3
.07	.085	.14	.28	.445	400			6	4
.08	.097	.16	.32	.500	450			6	4
.09	.108	.18	.36	.563	500			7	5
.10	.121	.20	.40	.625	550			7	5
.11	.133	.22	.44	.688	600			7	6
.12	.145	.24	.48	.750	650			7	6
.13	.157	.26	.52	.822	700			8	7
.14	.170	.28	.56	.875	750			8	7
.15	.181	.30	.60	.938	800				7
.16	.193	.32	.64	1.00	850				8
.17	.206	.34	.68	1.06	900				8
.18	.218	.36	.72	1.12	950				8
.19	.20	.38	.76	1.19	1000				8
.20	.242	.40	.80	1.25					
.21	.254	.42	.84	1.31					
.22	.266	.44	.88	1.36					
.23	.278	.46	.92	1.44					
.24	.290	.48	.96	1.50					
.25	.303	.50	1.0	1.56					
.26	.315	.52	1.04	1.60					
.27	.327	.54	1.08						
.28	.336	.56	1.12						
.29	.35	.58	1.16						
.30	.363	.60							

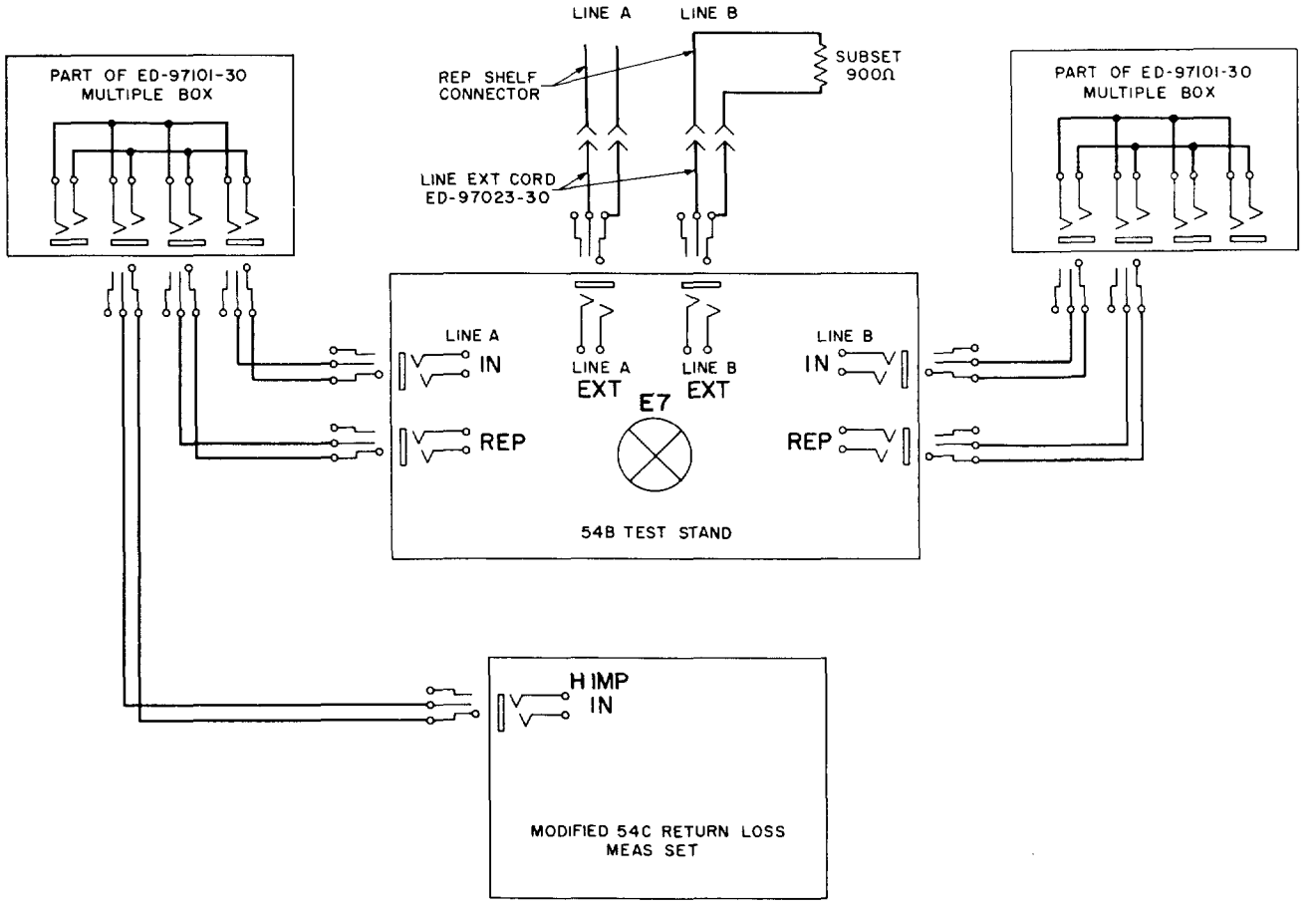

Fig. 11 – Check for Singing Repeater

or transmission measuring set to the TMS terminals of the 2AB set and operate the TEST switch to CAL OSC. Measure the oscillator output and call it DET. RDG. The net loss (db) of the repeatered loop is the difference in db between the output of the oscillator (DET RDG) and the actual measured loss without the repeater (V_s) corrected by 0.5 db for the loss in the 2AB set. V_s is obtained from the ACT LOOP LOSS W/o REPT entry on the circuit layout card. The 0.5 db loss for the 2AB set is subtracted from the difference between V_s and DET RDG.

For example:

At 2300 cps

V_s		14.7 db
DET RDG	=	6.6 db
Difference	=	8.1 db
Correction for 2AB Set	=	0.5 db
Net Loss of Repeatered Loop	=	7.6 db

Now make a similar measurement at 1000 cps. At this frequency it is quite possible that the oscillator output will give a DET RDG that indirectly indicates a slight loss through the repeater. In this case the DET RDG is considered a negative number and is combined algebraically with V_s and corrected for the 2AB set loss to obtain the net loss of the repeatered loop.

For example:

At 1000 cps

V_s	=	5.0 db
DET RDG	=	−0.8 db
Algebraic Difference	=	5.8 db
Correction for 2AB Set	=	0.5 db
Net Loss of Repeatered Loop	=	5.3 db

It is apparent for this setting of the repeater that a 0.3 db loss has been inserted at 1000 cps. This is not unusual for repeater settings that provide only a few db gain at 2300 cps. When

the repeater is adjusted to give higher gains at 2300 cps, some gain is apparent at 1000 cps.

For example:

At 1000 cps

V_s	=	8.4 db
DET RDG	=	0.3 db
Difference	=	8.1 db
Correction for 2AB Set	=	0.5 db
Net Loss of Repeatered Loop	=	7.6 db

The difference between V_s and the net loss of the repeatered loop in this case is 0.8 db and is the 1000 cps gain of the repeater. If these measurements were made by a two-man team as shown on Fig. 5, it would be important to avoid overloading the repeater. A sending level of −10 dbm is suggested.

4.31 If the net loss at 2300 cps meets the requirements of Table XII, the line-up is complete. In this case, proceed to Part 5. If the net loss at 2300 cps does not meet the requirements, a readjustment of the repeater is necessary. Connect the apparatus as shown in Fig. 6. Set the oscillator frequency to 2300 cps, turn the 2AB TEST FUNCTION switch to SEND 900 OHMS. With the 54C H IMP detector, read V_o (db) at the input to the loop at MULT "B". Adjust the oscillator level to obtain the same V_o as that recorded on the circuit layout card. Now adjust the repeater as follows to decrease or increase the 2300-cps loss, as necessary:

(1) If the net loss is too great, try to reduce it so that it is not just on the edge of the required range, but 0.1 or 0.2 db within the range. For example, if the net loss is 0.7 db outside the upper limit, try to reduce it by 0.8 or 0.9 db. To ***reduce*** the net loss, ***add*** capacitance in the repeater network in small steps until the ***decrease*** in V_o (black scale) equals the reduction needed. In the example above, this would be 0.8 or 0.9 db.

(2) If the net loss is too small, try to increase it so that it is 0.1 or 0.2 db within the required range. For example, if the net loss is 0.5 db under the lower limit, increase it by 0.6 or 0.7 db. To ***increase*** the net loss, ***reduce*** the capacitance of the repeater network in small steps until the change in V_o (black scale) equals the increase needed. In the example above, this would be 0.6 or 0.7 db.

(3) After the repeater network has been adjusted as in Step 1 or 2 above, check the net loss by repeating Par. 4.30, for 2300 cps only. The 1000-cps loss need not be measured.

The adjustments in net loss affect the return loss of the loop, and must not be carried to the point where the return loss fails to meet requirements. While making adjustments, remember the approximate rule that 0.1 db reduction in net loss causes about 0.4 db reduction in return loss.

4.32 The above adjustments will bring the net loss of the repeatered loop within requirements. Any changes made in the C settings of the repeater, however, will change the return loss measured in Par. 4.29.

4.33 Recheck the return loss of the repeater. To do this, connect the apparatus per Fig. 9 and repeat the measurements of Par. 4.29. For most lines this will usually end the adjustment process. An occasional line may be found that will require more than one round of trading between return loss and transmission before a satisfactory adjustment is obtained.

4.34 Make a singing-margin test using the method given in Par. 4.25. Check for audible singing by monitoring with the KS-14418 headphones. If the circuit is stable (not singing), record the settings in pencil on front cap of the repeater and proceed with Part 5. If the circuit is unstable (singing), increase the resistance of R-10 slightly to the point where singing stops, and then continue 0.2 division beyond this point (clockwise) for margin. After any change is made in the R setting recheck net loss and return loss to determine that requirements are met. Tables VII, IX and XI, give typical settings of E7 repeater with line-up procedure No. 2. Table XII summarizes the return loss and net loss requirements.

5. INFORMATION FOR FUTURE MAINTENANCE TESTS

5.01 The 900-ohm termination at the subscriber's end of the loop is removed when the subset is installed, so that a terminated loop is no longer available for future maintenance checks. It is necessary therefore, to find a substitute for the line. The reference network found in Par. 4.09-4.13 will serve for this purpose, as

it was adjusted to simulate the input impedance of the terminated loop.

5.02 Assemble the components for the reference network as listed in Table IV of this section and connect per Fig. 1. For this test, the reference network should terminate in a 2W42A cord. The apparatus setup is similar to that used for the line-up except that the line must be removed.

5.03 Remove the Line Extension Cord (ED-97023-30) from the shelf and disconnect it also from the 54B set. Connect the apparatus as shown in Fig. 12 for return-loss measurement.

5.04 Set the R decade box and C decade box to the values determined for the line under test as outlined in Par. 4.09 and recorded on the circuit layout card.

5.05 Set the oscillator frequency at 2600 ± 100 cps and adjust the level as indicated below.

5.06 Turn 2AB set test function switch to SEND 900 OHMS. Hold switch S2 of the 54C set in the SEND LEVEL CAL position, and adjust the output level of the oscillator to obtain a reading of 10 db on the black scale. Remember to subtract 10 db from all return-loss readings.

5.07 Release the SEND LEVEL KEY of the 54C set and measure the return loss at the input of the E7 now terminated with the reference network.

5.08 Record this reading on the cover of the E7 repeater where space is provided.

5.09 Remove the repeater from the test stand and plug into the shelf.

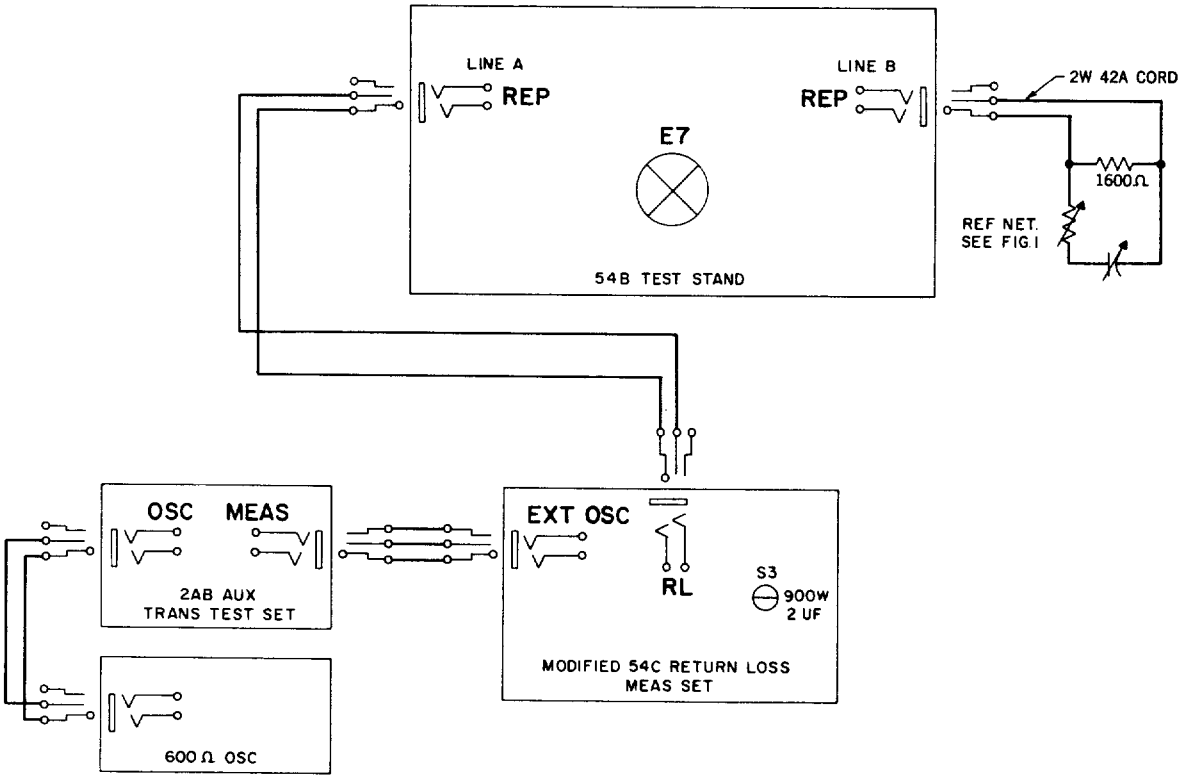

Fig. 12 – Return-Loss Measurement on Reference Network

6. SUMMARY OF LINE AND REPEATER MEASUREMENTS

(A) Line Loss Measurements

STEP	PROCEDURE
1	If measurements are at E7 shelf connect apparatus per Fig. 6.
2	If the measurements are to be made at the MDF, connect the apparatus per Fig. 7 and follow Steps 3 to 9.
3	Set the oscillator at 1000 cps.
4	Switch the 2AB set to CAL OSC.
5	Set oscillator level to +0.5 dbm.
6	Switch 2AB set to SEND 900 ohms.
7	Measure received signal (V_s) with TTS #28. This will be the insertion loss (AML) of loop at 1000 cps. — record this reading on the circuit layout card.
8	Repeat at 2300 cps. — record.
9	For lines that require Repeater Line-up #2 (Par. 4.15) measure V_o with the 54C set and record.

(B) Finding The Reference Network

STEP	PROCEDURE
1	Connect the apparatus for this measurement per Fig. 8.
2	Connect reference network components as shown in Fig. 1 and plug into EXT NET jack of 54C set.
3	Set oscillator at 2600 cps.
4	Operate SEND LEVEL CAL key S2 on the 54C set and adjust the oscillator for 0 db reading on the meter scale.
5	Adjust the R and C of the reference network for a maximum return loss.
6	Record R (ohms) and C (uf) settings of reference network.
7	Record the maximum return loss.

(C) Repeater Line-up #1

STEP	PROCEDURE
1	Connect the apparatus per Fig. 9 for return-loss measurements.
2	Refer to the circuit layout card for the loop make-up and set the transformer tap per Table III.

STEP	PROCEDURE
3	From the R and C values of the reference network find the approximate capacitance setting for the repeater per Table IV (a), and the dial setting of variable resistor per Table IV (b).
4	Plug repeater into the 54B test stand.
5	Set oscillator frequency at 2600 cps.
6	Operate switch S3 of the 54C set to 900 ohms +2 uf.
7	Operate the SEND LEVEL CAL key of the 54C set and adjust oscillator level to read −10 db on the meter scale.
8	Adjust repeater R and C in turn to obtain the maximum return loss at 2600 cps. After the maximum is found turn the variable resistor clockwise, until the return loss is 20 db. Note that with the oscillator level set at −10 db the return loss as read on the 54C set meter should be 10 db greater that is, 30 db. For those lines whose return loss is less than 20 db at maximum, this step is omitted.
9	Now check the return loss at 1000, 2300 and 3500 cps. with oscillator level at −10 db. The following requirements should be met: FREQ. — METER READING — ACTUAL RETURN LOSS 1000 — 24 db — 14 db min. 2300 — 20 db — 10 db min. 3500 — 12 db — 2 db min.
10	Step 9 completes the repeater alignment when the line falls into one of the two groups divided according to length of BT. (a) Total Length of BT is between 0 and 3000 feet and the ACT. LOOP LOSS W/O REPT. is ***less than*** 5 db. (b) Total length of BT is between 3000 and 6000 feet and the ACT. LOOP LOSS W/O REPT. is ***less than*** 7 db.

(D) Repeater Line-up #2

STEP	PROCEDURE
1	On lines where the ACT. LOOP LOSS W/O REPT. is more than that given in Step 10 (a) and (b) will require a repeatered loop gain measurement at 1000 and 2300 cps. in addition to the return-loss measurements.
2	For these measurements connect apparatus as shown in Fig. 6.
3	Set the oscillator at 2300 cps.
4	Switch the 2AB set to send 900 ohms. Consult the circuit layout card and note V_o (db) reading at 2300 cps. Now adjust the oscillator level to obtain the exact V_o reading noted on the card.

STEP	PROCEDURE
5	Switch the 2AB set to CAL. OSC. and measure the oscillator level across the TMS terminals with a 600-ohm transmission measuring set, such as the 21A TMS. This level will be called OSC level (db).
6	The net loss of the repeatered loop is computed as outlined in Par. 4.30.
7	Now repeat the measurement at 1000 cps.
8	The net loss should meet the requirements of Table XII. If these requirements are met, then the repeater is in adjustment to proceed to Part 5. If the requirements are not met, proceed as follows:
9	Switch the 2AB set to SEND 900 ohms. Set oscillator at 2300 cps. Connect the 54C set H IMP jack to MULT B to read V_o (db). To bring the 2300-cps. loss to the required value, readjust the repeater network so that V_o (db) is changed by the amount required.
10	Readjust the oscillator level to bring the V_o (db) reading back to the original value given on the circuit layout card and compute the net loss as discussed in Step 6. It will be necessary to recheck the return loss after this adjustment.
11	Reconnect the apparatus for a return-loss measurement as shown in Fig. 9. Check the loss at 1000, 2300, and 3500 cps. The requirements of Par. 4.24 should be met.

(E) Information for Future Maintenance Tests

STEP	PROCEDURE
1	Disconnect the line extension cord from the 54B set and from the shelf.
2	Connect apparatus as shown in Fig. 12.
3	Set R and C of the reference network to the values recorded on the circuit layout card.
4	Operate the SEND LEVEL key S2 on the 54C set and adjust the oscillator level for 10 db on the black scale.
5	Measure the return loss and record it on the cover of the E7 repeater.

TABLE V

TIGHTEN SCREWS OPPOSITE LETTER							
CAP. uf	.80 .806	.40 .407	.20 .203	.10 .100	.05 .0487	.02 .025	.01 .013
.01							A
.025						B	
.038						B	A
.049					C		
.062					C		A
.074					C	B	
.087					C	B	A
.100				D			
.11				D			A
.13				D		B	
.14				D		B	A
.15				D	C		
.16				D	C		A
.17				D	C	B	
.19				D	C	B	A
.20			E				
.22			E				A
.23			E			B	
.24			E			B	A
.25			E		C		
.26			E		C		A
.28			E		C	B	
.29			E	•	C	B	A
.30			E	D			
.32			E	D			A
.33			E	D		B	
.34			E	D		B	A
.35			E	D	C		
.36			E	D	C		A
.38			E	D	C	B	
.39			E	D	C	B	A
.41		F					
.42		F					A
.43		F				B	
.45		F				B	A
.46		F			C		
.47		F			C		A
.48		F			C	B	
.49		F			C	B	A
.51		F		D			
.52		F		D			A
.53		F		D		B	
.54		F		D		B	A
.56		F		D	C		
.57		F		D	C		A
.58		F		D	C	B	

— Marking
— Nom. Value

TABLE V (Cont'd)

TIGHTEN SCREWS OPPOSITE LETTER								
CAP. uf	.80 .806	.40 .407	.20 .203	.10 .100	.05 .0487	.02 .025	.01 .013	— Marking — Nom. Value
.59		F		D	C	B	A	
.61		F	E					
.62		F	E				A	
.64		F	E			B		
.65		F	E			B	A	
.66		F	E		C			
.67		F	E		C		A	
.68		F	E		C	B		
.70		F	E		C	B	A	
.71		F	E	D				
.72		F	E	D			A	
.74		F	E	D		B		
.75		F	E	D		B	A	
.76		F	E	D	C			
.77		F	E	D	C		A	
.78		F	E	D	C	B		
.80		F	E	D	C	B	A	
.81	G							
.82	G						A	
.83	G					B		
.84	G					B	A	
.85	G				C			
.87	G				C		A	
.88	G				C	B		
.89	G				C	B	A	
.91	G			D				
.92	G			D			A	
.93	G			D		B		
.94	G			D		B	A	
.95	G			D	C			
.97	G			D	C		A	
.98	G			D	C	B		
.99	G			D	C	B	A	
1.00	G		E					
1.02	G		E				A	
1.03	G		E			B		
1.05	G		E			B	A	
1.06	G		E		C			
1.07	G		E		C		A	
1.08	G		E		C	B		
1.10	G		E		C	B	A	
1.11	G		E	D				
1.12	G		E	D			A	
1.13	G		E	D		B		
1.15	G		E	D		B	A	
1.16	G		E	D	C			
1.17	G		E	D	C		A	

TABLE V (Cont'd)

TIGHTEN SCREWS OPPOSITE LETTER							
CAP. uf	.80 .806	.40 .407	.20 .203	.10 .100	.05 .0487	.02 .025	.01 .013
1.18	G		E	D	C	B	
1.20	G		E	D	C	B	A
1.21	G	F					
1.23	G	F					A
1.24	G	F				B	
1.25	G	F				B	A
1.26	G	F			C		
1.28	G	F			C		A
1.29	G	F			C	B	
1.30	G	F			C	B	A
1.31	G	F		D			
1.33	G	F		D			A
1.34	G	F		D		B	
1.35	G	F		D		B	A
1.36	G	F		D	C		
1.38	G	F		D	C		A
1.39	G	F		D	C	B	
1.40	G	F		D	C	B	A
1.42	G	F	E				
1.43	G	F	E				A
1.44	G	F	E			B	
1.45	G	F	E			B	A
1.47	G	F	E		C		
1.48	G	F	E		C		A
1.49	G	F	E		C	B	
1.50	G	F	E		C	B	A
1.52	G	F	E	D			
1.53	G	F	E	D			A
1.54	G	F	E	D		B	
1.55	G	F	E	D		B	A
1.57	G	F	E	D	C		
1.58	G	F	E	D	C		A
1.59	G	F	E	D	C	B	
1.60	G	F	E	D	C	B	A

— Marking
— Nom. Value

TABLE VI

LOOPS MADE UP OF ALL 22-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 1

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
7.5	0	0	1.5	3.3	2	3.7	.172	30.0	23.0	18.0	14.0	2.2	1.5	0.7
7.5	3	0.6	1.9	4.7	2	1.9	.323	26.0	22.0	18.0	16.0	2.4	2.2	1.6
9	3	0.6	2.6	5.7	2	2.0	.243	24.9	21.3	15.5	15.2	2.8	2.7	2.2
9	3	3	2.6	5.7	2	3.0	.240	25.5	21.2	17.5	15.5	2.8	2.8	2.4
9	3	9	2.6	5.7	2	4.0	.221	27.0	21.3	17.5	14.1	2.8	2.8	2.7
9	6	0.6	3.2	7.1	2	1.8	.298	21.7	20.7	18.2	16.5	3.1	3.4	3.2
9	6	3	3.2	7.2	2	3.0	.287	22.8	20.9	18.1	16.5	3.2	3.6	3.6
9	6	9	3.1	7.0	2	5.0	.249	24.2	21.1	17.8	15.1	3.1	3.8	4.0
12	0	0	3.0	6.0	2	4.0	.220	23.3	18.8	16.0	14.0	3.2	3.3	3.2
12	3	0.6	3.6	7.4	2	2.4	.260	20.3	18.0	17.0	15.8	3.5	4.2	4.2
12	3	3	3.6	7.5	2	3.1	.269	21.0	20.6	18.8	17.0	3.4	3.9	4.0
12	3	9	3.7	7.6	3	2.2	.553	16.8	25.0	13.5	7.8	3.5	2.4	1.0
12	6	0.6	4.3	8.8	3	0.8	.670	17.9	23.0	12.2	12.9	4.0	3.1	0.4
12	6	3	4.4	9.0	3	1.5	.760	18.2	22.8	14.0	7.2	4.3	4.0	2.2
12	6	9	4.2	8.7	3	2.5	.604	16.9	22.6	13.3	7.0	4.1	3.8	2.2
15	0	0	4.0	7.9	3	2.2	.535	17.2	24.3	13.5	7.5	3.8	3.0	1.4
15	3	0.6	4.6	9.2	3	1.2	.614	18.0	23.4	12.9	4.5	4.4	3.9	0.5
15	3	3	4.6	9.2	3	1.8	.625	18.2	23.5	13.8	7.1	4.3	3.8	2.0
15	3	9	4.6	9.2	3	2.3	.602	18.0	23.5	14.2	7.8	4.2	3.9	2.5
15	3	15	4.5	9.0	3	2.4	.577	17.5	23.0	13.5	7.0	4.2	3.8	2.5
15	6	0.6	5.3	10.3	3	0.8	.710	18.0	22.1	12.3	3.2	4.7	4.4	1.0
15	6	3	5.4	10.4	3	1.6	.716	19.0	22.0	14.0	7.2	4.6	4.5	2.8
15	6	9	5.4	10.4	3	2.5	.660	17.8	22.0	14.0	7.8	4.9	5.1	4.0
15	6	15	5.2	10.2	3	2.8	.603	16.5	22.0	13.0	6.5	4.8	5.0	3.9
18	0	0	5.0	9.6	3	2.2	.576	18.2	23.4	13.7	7.5	4.1	4.5	3.0
18	3	0.6	5.6	10.6	3	1.5	.644	18.0	21.9	12.4	3.5	5.2	5.4	2.1
18	3	3	5.8	10.7	3	2.0	.660	18.5	22.0	13.5	6.5	5.0	5.2	3.4
18	3	9	5.7	10.6	3	2.5	.637	18.0	22.1	14.3	7.2	5.2	5.6	4.4
18	3	15	5.7	10.6	3	2.5	.606	17.5	22.2	13.5	6.8	5.0	5.6	4.3
18	6	0.6	6.1	11.9	3	1.0	.773	17.0	21.0	12.7	4.0	5.6	5.9	2.8
18	6	3	6.5	12.1	3	1.6	.767	17.0	21.0	14.0	6.0	5.8	6.3	4.1
18	6	9	6.6	12.2	3	2.6	.703	16.0	21.0	13.5	6.5	6.0	6.7	5.3
18	6	15	6.6	12.2	3	2.8	.636	15.0	21.0	12.0	5.0	6.2	7.1	5.7

TABLE VII

LOOPS MADE UP OF ALL 22-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 2

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
18	6	3	6.5	12.1	3	1.6	.786	18.1	23.0	11.3	4.2	5.7	5.8	3.3
18	6	9	6.6	12.2	3	2.6	.751	18.5	23.0	9.0	3.0	5.7	5.7	3.8
18	6	15	6.6	12.2	3	2.8	.670	16.5	24.0	8.0	2.6	5.9	6.1	4.5

TABLE VIII

LOOPS MADE UP OF ALL 24-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 1

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
6	0	0	1.7	3.0	2	5.0	.139	34.0	23.0	18.0	14.0	2.2	1.7	0.9
6	1.8	0.6	2.0	3.9	2	2.8	.178	29.0	22.0	18.0	15.0	2.4	2.0	1.4
6	3	0.6	2.4	4.7	2	2.5	.202	27.8	21.6	17.2	14.8	2.7	2.4	1.8
6	3	3	2.3	4.7	2	4	.19	19.2	21.8	17.2	14.5	2.6	2.6	2.1
6	6	3.0	3.0	6.3	2	2.2	.258	23.8	22.2	19.2	17.5	3.1	3.4	3.1
6	6	3	3.0	6.5	2	4.5	.234	25.0	21.3	17.2	14.7	3.0	3.5	3.4
9	0	0	3.0	5.4	2	4.2	.172	24.2	21.0	18.0	16.0	3.2	3.4	3.4
9	3	0.6	4.2	8.4	3	1.2	.598	18.0	24.2	13.0	5.8	4.1	3.2	0.2
9	3	3	3.5	6.9	2	3.8	.22	21.8	20.5	18.0	16.2	3.5	4.2	4.3
9	3	9	3.4	6.7	2	5.1	.194	23.3	21.2	17.8	15.2	3.6	4.4	4.6
9	6	0.6	4.2	8.4	3	1.0	.598	18.1	24.2	13.0	5.2	4.1	3.2	0.2
9	6	3	4.3	8.6	3	2.2	.57	17.5	23.0	13.7	7.8	4.1	3.6	2.1
9	6	9	4.1	8.4	3	3.5	.474	16.0	23.5	13.0	6.9	4.1	4.0	2.9
12	0	0	4.1	7.6	3	3.2	.43	18.0	25.0	13.5	8.0	4.2	3.4	2.1
12	3	0.6	4.7	9.0	3	1.7	.53	18.8	24.5	13.5	5.7	4.6	4.2	1.6
12	3	3	4.8	9.1	3	2.3	.522	18.6	24.0	14.2	7.5	4.6	4.4	2.9
12	3	9	4.8	9.2	3	3.2	.476	17.8	23.3	13.5	7.2	4.7	4.7	3.6
12	6	0.6	5.5	10.3	3	1.1	.634	19.0	22.5	13.3	5.1	5.0	5.0	2.4
12	6	3	5.6	10.5	3	2.2	.61	18.8	22.4	14.0	7.5	5.1	5.3	4.0
12	6	9	5.6	10.4	3	3.5	.51	16.8	22.5	13.0	6.8	5.4	6.1	5.3
15	0	0	5.4	9.8	3	3.2	.46	19.0	23.3	13.8	7.2	5.2	5.4	4.2
15	3	0.6	6.0	10.9	3	1.7	.567	18.0	22.2	13.0	5.5	5.6	6.0	3.8
15	3	3	6.1	10.9	3	2.5	.563	18.2	22.5	14.5	8.0	5.7	6.3	5.2
15	3	9	6.1	11.0	3	3.4	.511	17.0	22.0	14.2	7.2	5.8	6.7	5.9
15	3	15	6	10.7	3	3.4	.484	17.0	22.0	13.0	7.0	5.7	6.5	5.8
15	6	0.6	6.7	12.3	3	1.2	.675	18.0	21.0	13.0	5.5	6.0	6.7	4.7
15	6	3	6.3	12.4	3	2.3	.653	18.0	21.0	14.5	8.0	6.3	7.2	6.3
15	6	15	6.5	12.3	3	3.6	.483	15.2	22.0	12.5	5.8	6.5	8.0	7.5

TABLE IX

LOOPS MADE UP OF ALL 24-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 2

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
15	3	9	6.1	11.0	3	3.4	.541	18.5	26.0	10.4	4.5	5.7	5.9	4.7
15	3	15	6.0	10.7	3	3.4	.506	18.0	25.0	10.5	4.5	5.6	6.0	4.9
15	6	0.6	6.7	12.3	3	1.2	.700	19.5	24.0	9.0	2.0	5.8	6.0	3.2
15	6	3	6.3	12.4	3	2.3	.693	20.5	21.0	9.0	3.5	5.9	6.0	4.8
15	6	15	6.5	12.3	3	3.6	.524	17.0	25.0	8.0	2.6	5.9	6.6	5.8

TABLE X

LOOPS MADE UP OF ALL 26-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 1

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
3	4.5	0.6	1.9	3.8	2	4.3	.176	30.0	23.0	17.8	14.5	2.2	1.7	1.0
3	6	0.6	2.2	4.7	2	4.5	.202	32.0	22.0	17.4	14.5	2.5	2.3	1.7
3	6	3	2.1	4.6	2	6.9	.162	36.0	38.0	34.0	24.7	2.6	3.1	3.1
6	3	0.6	3.0	5.2	2	2.8	.175	22.5	20.9	19.0	17.2	3.4	3.6	3.6
6	3	3	3.1	5.5	2	5.8	.160	23.6	21.2	18.5	16.5	3.3	3.6	3.7
6	3	6	3.0	5.2	2	7.1	.140	24.7	21.3	18.0	15.8	3.2	3.6	3.8
6	6	0.6	3.7	7.1	2	3.1	.230	20.3	20.3	19.0	17.2	3.8	4.3	4.4
6	6	3	3.7	7.2	2	7.3	.190	22.0	20.9	18.8	16.2	3.8	4.8	5.2
6	6	6	3.7	7.0	3	5.7	.380	16.0	24.7	14.0	8.5	3.7	3.1	2.9
9	0	0	4.0	6.4	2	5.2	.137	19.2	20.0	19.8	19.0	4.2	5.0	5.5
9	3	0.6	4.5	7.9	2	3.1	.195	17.8	18.2	18.0	16.7	4.6	5.6	6.0
9	3	3	4.6	8.0	3	3.4	.410	19.0	25.2	14.0	9.2	4.5	3.9	3.2
9	3	6	4.6	8.0	3	4.5	.376	18.2	24.7	14.0	9.0	4.6	4.2	3.8
9	3	9	4.5	7.7	3	5.0	.351	18.0	26.0	14.5	9.0	4.4	4.0	3.7
9	6	0.6	5.3	9.5	3	1.8	.533	20.8	23.5	14.0	7.3	5.0	4.7	2.9
9	6	3	5.5	9.9	3	5.0	.495	21.7	12.5	8.0	6.2	4.7	4.9	6.8
9	6	6	5.4	9.8	3	5.1	.417	17.8	23.2	14.1	8.2	5.3	5.8	5.6
9	6	9	5.2	9.0	3	5.4	.365	17.0	24.2	13.6	1.8	5.2	5.7	5.6
12	0	0	5.4	8.8	3	4.2	.349	21.0	23.8	14.3	9.1	5.1	5.1	4.6
12	3	0.6	5.9	10.0	3	2.2	.449	21.8	23.5	13.6	6.8	5.7	6.0	4.3
12	3	3	6.1	10.3	3	3.6	.440	22.0	23.4	14.5	9.2	5.6	6.1	5.8
12	3	6	6.1	10.4	3	4.8	.412	19.8	22.5	14.6	9.5	5.8	6.5	6.4
12	3	9	6.1	10.4	3	5.1	.382	19.0	23.0	14.4	9.0	5.9	6.7	6.5
12	6	0.6	6.8	11.8	3	1.8	.572	20.5	22.5	15.0	8.2	6.2	6.8	5.6
12	6	3	7.0	12.1	3	3.8	.523	19.0	22.0	15.5	9.2	6.4	7.4	7.3

TABLE X (Cont'd)

LOOPS MADE UP OF ALL 26-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 1

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
12	6	6	7.1	12.2	3	5.2	.440	17.0	22.0	14.5	9.0	6.8	8.2	8.0
12	6	9	7.0	12.0	3	5.4	.385	16.2	22.5	14.4	8.0	6.9	8.4	8.3
13.2	3	0.6	6.5	11.1	3	2.4	.463	20.5	22.5	13.7	7.3	6.2	6.9	5.5
13.2	3	4.2	6.7	11.4	3	4.4	.437	20.2	22.0	15.5	9.5	6.3	7.3	7.2
13.2	4.5	0.6	7.0	12.0	3	2.2	.520	20.5	22.0	13.6	7.0	6.5	7.3	6.1
13.2	4.5	0.6	7.0	12.0	4	1.1	.878	13.6	22.2	11.0	3.0	6.6	6.1	3.8
13.2	4.2	4.2	7.1	12.0	3	4.5	.466	20.0	22.0	15.0	9.5	6.6	7.9	8.0
13.2	4.2	4.2	7.1	12.0	4	2.4	.820	13.8	22.0	12.0	6.5	6.6	6.5	6.3
14.4	0	0	6.7	10.8	3	4.8	.368	21.0	23.2	14.3	9.0	6.3	7.2	6.9
14.4	0	0	6.7	10.8	4	2.8	.644	13.5	23.0	12.0	6.0	6.4	6.0	5.2
14.4	2.4	9	7.1	12.1	4	2.8	.685	12.9	21.1	11.2	4.7	6.9	7.1	6.5
14.4	3	0.6	7.2	12.2	4	1.4	.793	13.6	22.0	10.0	2.5	7.0	6.8	4.5
14.4	3	4.2	7.4	12.4	4	2.5	.779	14.0	22.0	13.0	6.2	7.0	7.0	6.7
14.4	3	9	7.4	12.4	4	2.9	.693	13.0	21.7	11.0	4.8	7.2	7.5	7.1
14.4	3	12	7.3	12.4	4	2.9	.661	12.7	21.5	10.8	4.6	7.2	7.5	7.3
14.4	6	0.6	7.9	13.7	4	0.8	.985	14.2	21.4	10.4	3.5	7.3	7.5	5.5
14.4	6	3	8.1	13.7	4	2.0	.940	14.0	21.2	12.5	5.8	7.4	7.9	7.6

TABLE XI

LOOPS MADE UP OF ALL 26-ga
REPEATER SETTINGS AND TRANSMISSION RESULTS
USING LINE-UP PROCEDURE NO. 2

LOOP IN KF			COL. 1 BARE LOOP I.L. AT FREQ		COL. 2 REP SETTINGS			COL. 3 RETURN LOSS WITH REP AT FREQ				COL. 4 INS. LOSS (AML) WITH REP AT FREQ		
LENGTH	BR. TAP	B.T. FROM OFF.	1K	2.3K	TAP	R	C	1K	2.3K	3K	3.5K	1K	2.3K	3.5K
12	3	6	6.1	10.4	3	4.8	.439	22.0	22.5	11.4	6.5	5.6	5.7	5.4
12	3	9	6.1	10.4	3	5.1	.413	21.3	21.5	10.4	5.5	5.7	5.8	5.3
12	6	0.6	6.8	11.8	3	1.8	.602	24.0	21.5	10.0	4.0	6.0	6.0	3.9
12	6	3	7.0	12.1	3	3.8	.578	25.0	18.0	8.5	4.0	6.0	6.0	5.5
12	6	6	7.1	12.2	3	5.2	.502	22.0	18.5	8.0	3.7	6.3	6.6	6.4
12	6	9	7.0	12.0	3	5.4	.430	19.0	22.0	8.0	3.5	6.6	7.2	6.8
13.2	3	0.6	6.5	11.1	3	2.4	.496	24.2	20.5	8.5	2.2	6.1	6.0	3.3
13.2	3	4.2	6.7	11.4	3	4.4	.486	25.8	18.0	8.8	4.5	6.0	6.0	5.3
13.2	4.5	0.6	7.0	12.0	3	2.2	.560	25.5	19.0	8.0	1.5	6.3	6.2	3.5
13.2	4.2	4.2	7.1	12.0	3	4.5	.530	27.5	15.8	7.5	3.5	6.2	6.2	5.8
13.2	4.2	4.2	7.1	12.0	4	2.4	.850	14.2	26.2	10.0	5.0	6.4	5.9	5.8
14.4	0	0	6.7	10.8	3	4.8	.408	25.5	18.8	8.5	4.0	6.1	6.1	4.9
14.4	2.4	9	7.1	12.1	4	2.8	.715	13.5	29.5	8.5	3.0	6.8	6.5	6.0
14.4	3	0.6	7.2	12.2	4	1.4	.811	14.0	29.0	7.2	1.2	6.9	6.4	3.7
14.4	3	9	7.4	12.4	4	2.9	.733	13.7	35.0	7.8	2.8	7.0	6.6	6.2
14.4	3	12	7.3	12.4	4	2.9	.701	13.5	31.0	7.2	2.7	7.0	6.6	6.4
14.4	6	0.6	7.9	13.7	4	2.8	1.010	14.9	28.8	7.8	1.6	7.1	6.9	4.6
14.4	6	3	8.1	13.7	4	2.0	1.000	15.0	25.2	7.8	3.2	7.0	6.8	6.7

TABLE XII

TOTAL LENGTH OF BRIDGED TAPS	AML AT 1000 CPS W/O REPT.	ALIGN-MENT PROCEDURE	REQUIREMENTS FOR RETURN LOSS WITH REPEATER			V_o (DB) MEAS. REQUIRED	REQUIREMENT FOR NET LOSS WITH REPEATER 2300 CPS
			1000 CPS	2300 CPS	3500 CPS		
0-3000	less than 5 db	#1	min 14 db	min 10 db	min 2 db	no	not measured
0-3000	over 5 db but less than 7 db	#2	min 14 db	min 10 db	min 2 db	yes	6 db ± 1
3001-6000	less than 7 db	#1	min 14 db	min 10 db	min 2 db	no	not measured
3001-6000	over 7 db but less than 8 db	#2	min 14 db	min 10 db	min 2 db	yes	7 db ± 1

APPENDIX I

Oscillator

Minimum frequency range: 500 to 3500 cps

Output: adjustable up to +10 dbm into 900 ohms

Output impedance: 900 ohms ± 3%, balanced to ground
or 600 ohms ± 3%, balanced to ground
or 600 ohms isolated from ground

If the oscillator output impedance is 600 ohms, then it will be necessary to use the J-94002AB AUX TRANS. TEST SET (2AB set) and to adjust the oscillator levels accordingly. Oscillators suitable for this application are:

1. Oscillator section of 21A Transmission Measuring Set with 2AB set.
2. Hewlett-Packard — No. 200CD with 2AB set or equivalent.

APPENDIX II

Detector

Minimum frequency range: 500 to 3500 cps.

Dbm scales (900 ohm basis) reading at least −25 dbm to +4 dbm.

Bridging impedance: 20,000 ohms minimum, balanced-to-ground input.

Terminating impedance: 900 ohms ± 3%, balanced to ground or isolated from ground.

Working accuracy: ± 0.25 db

Suitable detectors are:

1. Portable station test set TTS 28, manufactured by Northeast Electronics Co. (This test set is used at the subscriber's premises).
2. 54C Return-Loss Measuring Set (J99254C — List 1) — modified in accordance with List 4. (For use in central office).
3. 21A Transmission Measuring Set.
4. Hewlett-Packard 400L or equivalent.

APPENDIX III

Reference Network Components

Capacitance decade box

Capacitance range:	at least 2 decades .0 to .1 uf and .0 to 1 uf

Apparatus suitable for this application:

Cornell-Dubilier	Type CDB-3 Capacitance Box
General Radio	Type 1419-A Decade Capacitor

Resistance decade box

Resistance range:	3 decades 0-10 ohms 0-100 ohms ± 3% at any step 0-1000 ohms

Apparatus suitable for this use:

General Radio	Type 1432-K Decade Resistor
Electro-Measurements, Inc.	Dekabox — Type 2B-265
Daven Co.	Type 75-DE Decade Resistance Box

1600 ohm ± 5% Resistor	Allen Bradley or KS-13490L1 Resistor, 1600 ohms