E6 REPEATER LINEUP
SUBSCRIBER LOOPS
LONG ROUTE DESIGN

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1. GENERAL

1.01 This section provides lineup procedures for E6 repeaters required on local loops engineered on a Long Subscriber Route Design basis. Loops designed with more than 1600 ohms of cable conductor resistance (including load coils) require the use of a repeater. The repeater will be assigned to the loop when the initial station(s) is installed. Special service lines are not a part of this practice.

1.02 The repeater will be located either at the central office (terminal arrangement) or at a remote repeater cabinet (intermediate arrangement) based on a resistance zone code. A zone code will be shown on service orders involving long loops.

1.03 Specific gain unit (831A network) gain settings should be used based on the resistance zone code assigned to the loop. The 831A network setting for each zone code along with the location where the repeater is to be applied to the loop is as follows:

RESISTANCE ZONE CODE	831A NETWORK GAIN SETTING	
	CO	REMOTE
18	4.6	
28	6.6	
36		10.6

1.04 Preliminary information for the settings on the line build-out (LBO) network(s) will be furnished by the Plant Assignment Center. The data provided will be on a Voice Repeater Index Form E-6037 and secured from information shown on the Engineering Work Order.

2. APPARATUS

2.01 The following test apparatus is required to perform the lineup and overall measurement work:

1—Line Extension Cord, ED-97023-30

1—J99254A,L1 (54A) Transmission Measuring Set (TMS) with Cords

1—J99254B (54B) Test Stand

1—J99254C (54C) Return Loss Measuring Set (RLMS) with Cords

1—KS-14418 Head Set equipped with 419A Plug

3. GAIN SETTING OF E6 REPEATER

3.01 Set the gain of the E6 repeater using the procedure as follows.

STEP	PROCEDURE
	ADJUSTMENT OF REPEATER GAIN
1	Consult the service order for the resistance zone code. Determine the setting of the 831A gain-unit network using the zone code and the gain-unit gain value specified for the zone as shown in 1.03.
2	Place the printed wiring-board side of the 831A network face up. Loosen the screws labeled A through K and 1 through 9. All adjustments on the gain network are now made by tightening some of these screws. Contact with the printed wiring-board conductors is made under the screwheads. Therefore, the screwheads should be either fully down on, or fully clear of, the printed wiring board as required.
3	Set the 54B test stand and 54A TMS near the −48 volt power distribution outlet which is provided on bays equipped with E6 repeaters.
4	Connect −48 volt power to the 54B test stand and connect the test stand to the 54A TMS as shown in Fig. 1. ***Note:*** The 54A TMS has no switch to apply power, nor is there a pilot light. No warmup period is necessary. No connection to the cable pairs is required for the gain adjustment of the 831A network.
5	Carefully insert the repeater into the 54B test stand. Lower (do not drop or force) the repeater into the stand so that the repeater terminals at the back of the repeater fit into the connector of the test stand. Rotate the head of the 54B test stand so that the 831A gain-unit side of the repeater is easily accessible.
6	All screws on the gain-unit side should have been loosened as in Step 2. Refer to the 831A network adjustment card (P-30C109) in the 54B test stand pocket, or to Table A of this section, to determine the necessary screw settings for the gain value arrived at in Step 1. ***Example:*** In the row corresponding to 6.6-dB gain, series screws A, F, and J and shunt screws 2, 3, 4, 7, and 8 are listed to be turned down. Tighten these firmly, but not excessively, and leave all other screws raised. ***Caution: Excessive tightening may strip threads.***
	Converter Unit Gains
7	On the 54B test stand, set switch S2 to a neutral position and switch S1 to the GAIN position.
8	Operate switch S2 on the 54A TMS to CAL and adjust the knurled knob CAL ADJ to give a 0-dB reading. Then set S2 to the MEAS position. The position of other keys and knobs on the 54A TMS does not affect this reading.

STEP	PROCEDURE
9	Rotate GAIN DB knob S1 to 12 dB. Make certain that screw K on the 831A network is loosened. Operate switch S3 to SERIES and rotate GAIN DB knob S1 counterclockwise until the meter reads between 0 and +1 dB. The series converter gain equals the sum of the GAIN DB knob setting plus the meter reading. Note this value.
10	Throw switch S3 from SERIES to SHUNT. Rotate knob S1 until the meter reads between 0 and +1 dB. The shunt-converter gain equals the sum of the S1 knob setting and the meter reading. Note this gain.
11	Compare the two measured gain values with the value given in Table A or on the 831A network adjustment card in the 54B test stand pocket for individual converter gains. ***Example:*** As shown in Table A, for 6.6-dB total gain, each converter should measure 3.9-dB gain. ***Requirement 1:*** Series and shunt gain measurements must fall within ±0.2 dB of the value shown on the adjustment card or in Table A in the row corresponding to the required total gain. ***Requirement 2:*** Series and shunt gain measurements must be within ±0.2 dB of each other. If these requirements are met, proceed to measure the combined gain beginning with Step 14. If not, adjust the gain of either the series or shunt converter using Steps 12 and 13.
	Series or Shunt Gain Adjustment
12	Check to see that the proper screws are turned down and that all others are clear of the printed wiring. If no error can be found and the series-converter gain measurement deviates by more than ±0.2 dB from the listed value, operate switch S3 to SERIES. Recalibrate as in Step 7 and then restore S2 to MEAS. Adjust screws A through J on the 831A network to give the tabulated gain for a single converter to within ±0.1 dB. ***Note:*** Screw A gives the finest gain change; screws B, C, etc., give larger changes in approximately 2:1 steps. Tightening a screw on the series converter lowers the gain; loosening a screw raises the gain.
13	If the shunt-converter gain measurement deviates by more than ±0.2 dB from the listed value, operate switch S3 to SHUNT and adjust the measured gain to within ±0.1 dB of the listed value, using screws 1 through 9 on the 831A network. ***Note:*** Screws 1, 2, etc., are the fine-gain adjustment. Raising a screw on this converter lowers the gain; loosening a screw raises the gain.
	Combined Gain
14	Tighten screw K on the 831A network and leave it in this position. (This screw connects series- and shunt-converter units together in the operating position.)

STEP	PROCEDURE
	Note: The gains of the individual converters must agree with each other within 0.2 dB before the combined gain can be measured.
15	Recalibrate the 54A TMS.
16	Operate switch S3 to SH & SER and measure the combined gain. This should agree with specified gain to within $\pm$0.3 dB. Record the measured gain in pencil in the rectangular recess on the front face of the repeater after the word GAIN.
17	With S3 on SH & SER, operate S2 to LOAD MEAS: the meter reading will decrease slightly. If this decrease is less than 0.4 dB, record both gain measurements on the repeater face. This data will be valuable for future maintenance checks on the repeater.
18	Repeaters which fall off in gain more than 0.4 dB between MEAS and LOAD MEAS are considered defective. Their converters should be returned to the Western Electric Company for repair.

4. SETTINGS FOR 830A NETWORK

4.01 The loop should have had a return-loss measurement performed on it to ensure that it is structurally capable of having a repeater applied to it. Details are contained in Section 330-300-520.

4.02 The low-frequency corrector (LFC), build-out capacitance (BOC), and build-out resistance (BOR) values required for each 830A network are shown on the Voice Repeater Index Form E-6037 prepared by Assignment Forces. Screw settings required to meet the indicated BOC and BOR values are shown in procedure and steps under 4.04.

4.03 When a repeater is to be used at a remote message repeater cabinet installation (Resistance Zone 36), separate LFC, BOC, and BOR values are specified for each 830A network (line A side for CO direction and line B side for customer or field direction). After screw settings have been set for the LFC, BOC, and BOR values, the assembled repeater is ready for installation in the remote message repeater cabinet. No additional adjustments in settings for the 830A networks are required upon installation of the repeater. Make a singing check on the repeater at the time of its installation. Singing is determined by monitoring across the TST2 jack on the front of the repeater with a KS-14418 headset. If singing occurs and the repeater settings are satisfactory, the facility is inadequate and should not be used. Secure another facility and refer the original facility to the appropriate Plant or Engineering organization for corrective action.

4.04 When a repeater is to be used at the central office (Resistance Zones 18 and 28), use the following procedures and steps for settings required on the 830A LBO network. If the loop has had a return-loss measurement performed on it and it meets the requirements specified in Section 330-300-520, optimizing the return loss by adjustments of the LFC, BOC, and BOR values shown on the Voice Repeater Index Form E-6037 should not be necessary. In these instances, only Step 9, parts of Steps 10 and 11, and Steps 13 through 16 should be all that are needed. If a structural return-loss measurement has not been performed on the loop, adjustments in the preliminary LFC, BOC, and BOR values should be made, using all the steps, to secure an optimum return-loss value. Connect the 832A network to the line A side and the 830A network to the line B side of the repeater.

STEP	PROCEDURE
	830A NETWORK ADJUSTMENT
1	Patch from the TST PWR jack of the 54C RLMS to the RLMS jacks of the 54B test stand. Patch from the CONTR jack of the 54B test stand to the MEAS RL jack of the 54C RLMS, using a 3P7B cord. These connections are shown in Fig. 2.
2	Patch from the vacant position on the repeater shelf, where the E6 repeater will be installed, to the 54B test stand LINE EXT A and B jacks, using the ED-97023-30, Group 2 cord as shown in Fig. 2. Insert the plug gently in order not to damage the shelf-connector spring contacts. Rotate the head of the 54B test stand to bring the 830-type network forward for easy accessibility.
	Building-Out Capacitor (BOC) Adjustment
3	Set the switch on the 54B test stand to RL LINE B. Set switch S1 on the 54C RLMS to 2000-3000~. If the 54A TMS is also plugged into the 54B test stand, operate switch S3 on the 54A TMS to SH & SER. This is required only on early models of the 54B test stand.
4	Plug in the power cord of the 54C RLMS to a 120-volt 60-Hz outlet and turn the PWR switch on. A 10-minute warmup period is required. On the 54C RLMS, set switch S2 to SEND LEVEL CAL, switch S3 to 900Ω 2 MF, and gain knob AT1 to 0 on the RETURN-LOSS scale. Calibrate the 2000-3000~ range of the 54C RLMS to 0 dB by adjusting the SEND LEVEL ADJ knob for 2000-3000~. Operate switch S2 to MEAS.
5	Adjust gain knob AT1 on the 54C RLMS until the meter reads on scale.
6	Set the line B LBO network screws to the preliminary screw settings for those values given on the Voice Repeater Index Form E-6037 by tightening the required screws and loosening all others. Refer to Step 9 for screw settings required to provide BOC values.
7	Bring the meter on scale by rotating switch S2 on the 54C RLMS.
8	Optimize the return loss by adjusting BOC screws A through G to obtain the highest return loss. Do this by increasing the BOC in 0.004-μF steps; if this causes the return loss to rise, increase the capacitance still further until a maximum is reached. If no maximum is found by increasing the BOC, decrease the capacitance in 0.004-μF steps, continuing until a maximum return loss is obtained. Additional refinement to obtain maximum return loss can be secured by using 0.002-μF steps. ***Note 1:*** If there are two BOC settings which give the same average meter reading, choose the setting for which the meter needle wavers less. ***Note 2:*** Negative values of return loss sometimes occur. ***Note 3:*** Remove the screwdriver from screwheads when observing 54C RLMS readings.

STEP	PROCEDURE
9	The values of the BOC screws are as follows:

CAPACITANCE OF BOC SCREWS OF NETWORK ±2 PERCENT

A	0.001 μF	D	0.007 μF	F	0.025 μF
B	0.002 μF	E	0.013 μF	G	0.049 μF
C	0.004 μF				

Example: Tightening a screw adds capacitance. Thus, if screws D, E, and F are down, 0.007 μF plus 0.013 μF plus 0.025 μF, or 0.045 μF, is added. Tightening screw C would add 0.004 μF. To reduce the amount of added capacitance by 0.004 μF, screw D would be loosened and screws A and B tightened, leaving screws A, B, E, and F down.

Low-Frequency Corrector (LFC) Network Adjustment

10 Set switch S1 on the 54C RLMS to 500-2500~. Set switch S2 to SEND LEVEL CAL. Calibrate the 500-2500~ range of the 54C RLMS to 0 dB by adjusting the SEND LEVEL ADJ knob for 500-2500~. Operate S2 to MEAS. Bring the reading of the meter on scale by rotating gain knob AT1. Turn out the LFC screw for the cable gauge originally selected from the Voice Repeater Index Form E-6037. Turn the LFC screw in for one of the other gauges.

Note 1: The screw setting which gives the greater return-loss value is the best setting, but the screw for one gauge only shall be left down.

Note 2: If the setting for two different gauges gives the same results, use the one for coarser wire, i.e., set for 19 gauge when the same results within 0.5 dB are obtained on 19 and 22 gauges.

Building-Out Resistor (BOR) Adjustment

11 Set switch S1 on the 54C RLMS to 500-2500~sweep. Reduce the initial BOR value on the LBO to the next lower value to check if return loss is increased. If not, increase the BOR value.

Note 1: The condition which gives the greater return-loss value is the best setting. If the same results are obtained for two different values of BOR, set for the lower value of resistance. Be sure that the same value of resistance is used in the tip and ring side of line, i.e., both No. 1 screws must be in the same position, as must both No. 2 screws and both No. 3 screws. When different values are used, the circuit becomes unbalanced and is susceptible to noise.

STEP	PROCEDURE

Note 2: The resistance values which can be obtained are as follows:

SCREWS DOWN		VALUE (OHMS)
TIP SIDE	RING SIDE	
All	All	0
1,2	1,2	28
1,3	1,3	56
1	1	84
2,3	2,3	112
2	2	140
3	3	168
None	None	196

Stability Test (Singing Check)

12 Set switch S1 on the 54B test stand to NORM.

13 Plug the KS-14418 headset into the TST 2 jack at the front of the repeater to check for a singing condition on an open-ended loop at the field location.

14 If the repeater does not sing, remove all test connections and place it in the shelf for service.

15 If the repeater sings, check the test setup and the equipment. If defective units are found, replace them and return to Step 1.

16 If the test setup and equipment are satisfactory and the singing condition still exists, secure a new facility assignment and return to Step 1. Refer the original facility to the appropriate Plant or Engineering organization for corrective action.

Note: Do not lower the gain setting of the repeater to correct the singing condition.

5. DISABLING LEAD CONNECTION

5.01 All E6 repeaters used on loops in Resistance Zone 28 should have remote disabling leads G and G1 terminated on connecting blocks at the CDF or MDF.

5.02 All 96-volt dial long line units will have a G1 lead terminated on connecting blocks at the CDF or MDF which can be used to disable the E6 repeater during the idle condition.

5.03 After the E6 repeater has been readied for service on loops in Resistance Zone 28, break the connection between leads G and G1 on the appropriate repeater and provide a cross-connection between the G1 lead of the repeater and the appropriate 96-volt dial long line circuit.

6. REFERENCES

6.01 The following references provide additional information:

SECTION	TITLE
103-106-110	J99254C (54C) Return Loss Measuring Set
103-107-111	J99254A (54A) Transmission Measuring Set
103-107-112	J99254B (54B) Test Stand
330-300-520	Return Loss Measurement—Local Exchange Cables, Long Route Design
332-206-100	E-Type Repeaters, E6 Repeater
332-206-120	Subscriber Loop Remote Message Repeater—General Description
332-206-520	Subscriber Loop Remote Message Repeater—Tests and Adjustments
680-800-010	Resistance Zoning of Exchange Services, Including Long Subscriber Route Design

TABLE A

831A NETWORK ADJUSTMENTS FOR 900-OHM IMAGE IMPEDANCE

TOTAL GAIN (dB)	SERIES OR SHUNT CONVERTER GAIN (dB)	SERIES SCREWS DOWN	SHUNT SCREWS DOWN	TOTAL GAIN (dB)	SERIES OR SHUNT CONVERTER GAIN (dB)	SERIES SCREWS DOWN	SHUNT SCREWS DOWN
1.0	0.5	ADEFHJ	36	7.9	4.8	CDEFGH	25678
1.1	0.6	CEFHJ	146	8.0	4.9	ADEFGH	135678
1.3	0.7	ABCDFHJ	12346	8.1	5.0	ACEFGH	145678
1.5	0.8	BDFHJ	356	8.2	5.1	AEFGH	1345678
1.7	0.9	ACFHJ	1456	8.4	5.2	ACDFGH	9
1.9	1.0	FHJ	123456	8.6	5.3	ADFGH	129
2.1	1.1	ABDEHJ	137	8.7	5.4	BCFGH	1239
2.2	1.2	BCEHJ	1247	8.8	5.5	BFGH	249
2.4	1.3	BEHJ	157	9.0	5.6	ABCDEGH	2349
2.6	1.4	ACDHJ	2357	9.1	5.7	ABDEGH	159
2.8	1.5	DHJ	12457	9.2	5.8	ABCEGH	1359
3.0	1.6	CHJ	167	9.4	5.9	CEGH	1459
3.1	1.7	ABCDEFGJ	2367	9.5	6.0	AEGH	3459
3.3	1.8	ABDEFGJ	12467	9.6	6.1	ACDGH	69
3.4	1.9	ABCEFGJ	567	9.8	6.2	BDGH	369
3.6	2.0	BEFGJ	13567	9.9	6.3	BCGH	12369
3.8	2.1	ACDFGJ	124567	10.0	6.4	ABGH	12469
4.0	2.2	ADFGJ	8	10.2	6.5	ABCDEFH	23469
4.1	2.3	ACFGJ	138	10.3	6.6	CDEFH	1569
4.3	2.4	FGJ	148	10.4	6.7	ADEFH	13569
4.4	2.5	CDEGJ	2348	10.6	6.8	BCEFH	4569
4.6	2.6	DEGJ	1258	10.7	6.9	BEFH	124569
4.8	2.7	ABEGJ	12358	10.8	7.0	ABCDFH	1234569
4.9	2.8	ABCDGJ	3458	11.0	7.1	CDFH	279
5.1	2.9	BDGJ	168	11.1	7.2	ADFH	1379
5.3	3.0	BCGJ	2368	11.2	7.3	BCFH	479
5.4	3.1	BGJ	2468	11.3	7.4	ABFH	12479
5.6	3.2	BCDEFJ	123468	11.5	7.5	FH	123479
5.7	3.3	BDEFJ	12568	11.6	7.6	ACDEH	2579
5.8	3.4	ACEFJ	4568	11.7	7.7	BDEH	13579
6.0	3.5	AEFJ	34568	11.8	7.8	ABCEH	4579
6.1	3.6	ACDFJ	178	12.0	7.9	ABEH	124579
6.3	3.7	ADFJ	1378	12.1	8.0	AEH	234579
6.5	3.8	ACFJ	1478	12.2	8.1	BCDH	1679
6.6	3.9	AFJ	23478	12.3	8.2	ABDH	3679
6.7	4.0	CDEJ	2578	12.5	8.3	DH	123679
6.9	4.1	DEJ	23578	12.6	8.4	ACH	24679
7.0	4.2	CEJ	24578	12.7	8.5	BH	234679
7.2	4.3	EJ	234578	12.8	8.6	H	15679
7.3	4.4	CDJ	12678	13.0	8.7	ACDEFG	35679
7.5	4.5	DJ	23678	13.1	8.8	BDEFG	1235679
7.6	4.6	CJ	24678	13.2	8.9	ABCEFG	245679
7.7	4.7	J	234678	13.3	9.0	CEFG	1345679

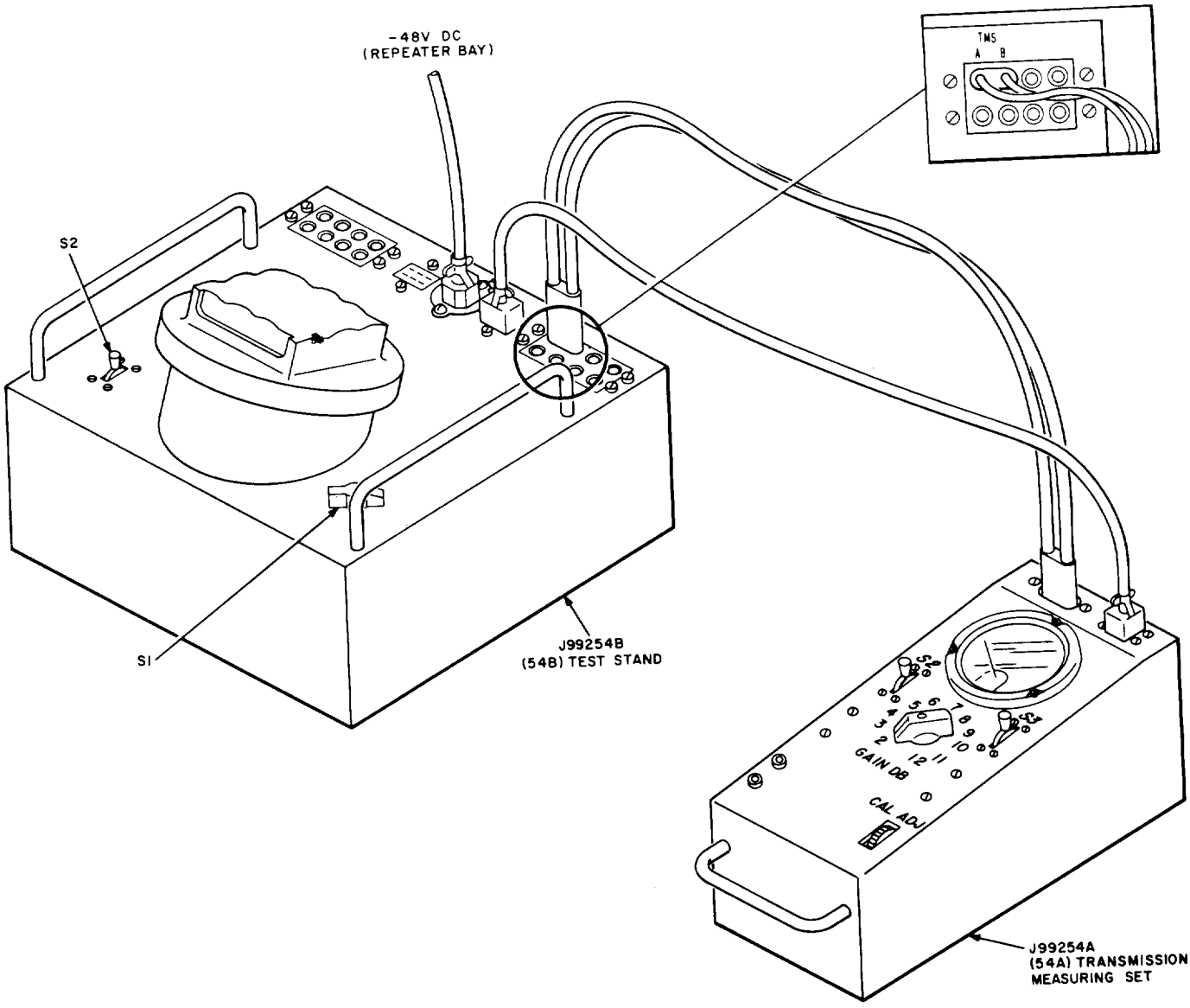

Fig. 1—Converter Gain—Test Equipment Connections

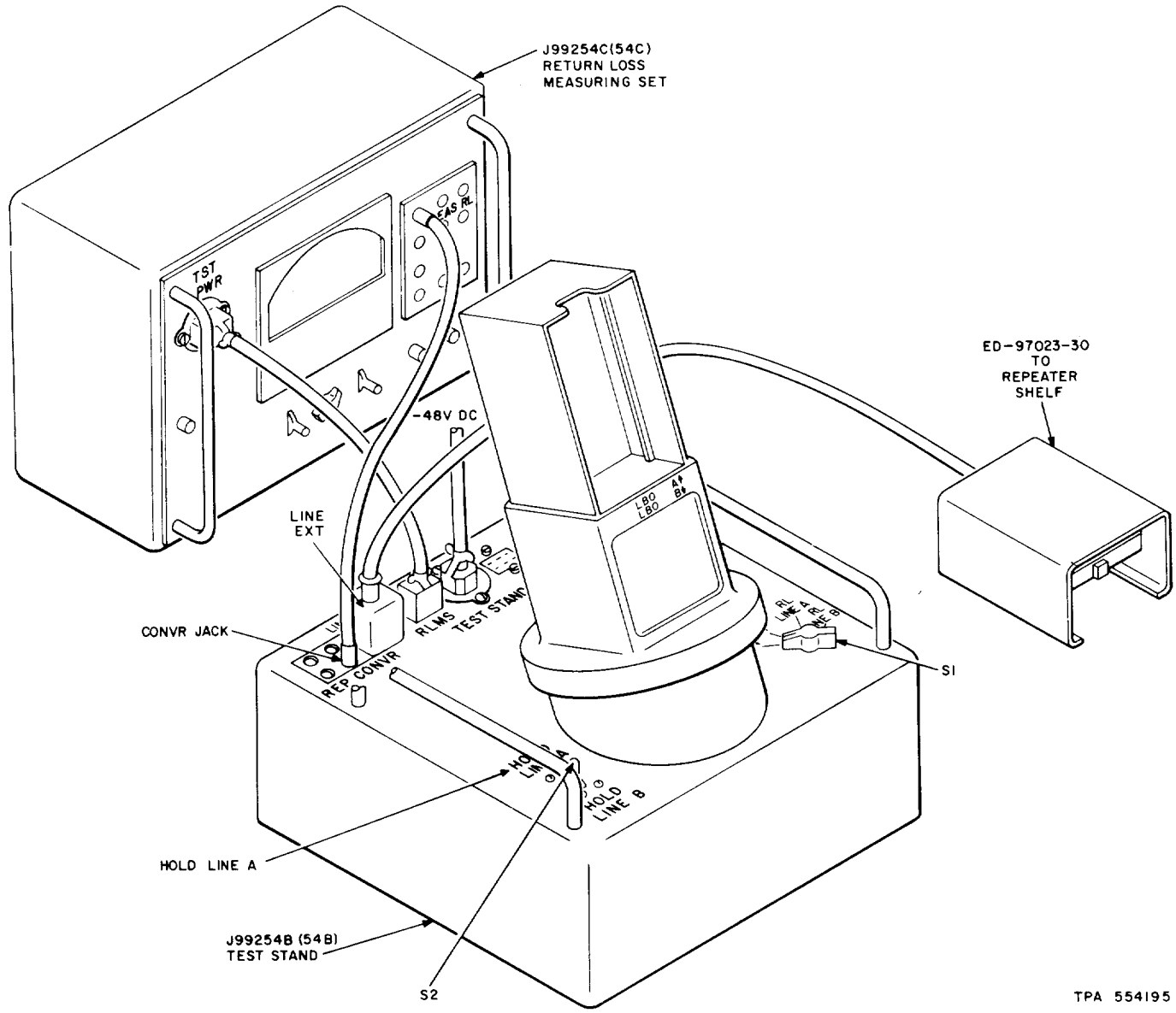

Fig. 2—Return-Loss Adjustment of E6 Repeater—Test Equipment