STEP-BY-STEP OFFICES
OFFICE NBO SELECTION
FOR TERMINAL BALANCE

CONTENTS PAGE

1. GENERAL

1.01 This section provides the procedures for determining and installing the network build-out (NBO) capacitor value to be applied across the compromise network (COMP NET) in the 4-wire terminating set (4WTS) of intertoll (IT) trunks in step-by-step (SXS) offices. The procedures should be performed in the sequence shown in Table A for initial or rebalancing work.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

TABLE A

TEST SEQUENCE SUMMARY

TEST	PROCEDURE	
	PART	FIGURE
IT to TC, Machine-Switched	2B	1
TC to IT, Machine-Switched	2C	2
IT to TC via Switchboard	2D	3
TC to IT via Switchboard	2E	4

1.03 This section does not affect Equipment Test Lists.

1.04 All measurement results should be recorded and retained. Section 660-474-010 describes the forms required and the suggested method of record retention.

1.05 When initially balancing an office, a balance test (BAL TST) circuit must be provided on a local basis as described in Section 660-474-504 to perform balancing work. The test circuit should have short cable paths to and from the hybrid to permit build-out capacitance adjustment. Code 970 should be assigned to the outgoing IT appearance of the circuit. The BAL TST circuit is made to simulate the average of both incoming and outgoing IT trunk paths. The simulation is accomplished with the build-out (BO) capacitor in the 2-wire lines. ***Capacitance buildout of the BAL TST circuit 2-wire lines according to the procedures in Section 660-474-504, Part 3, is required before performing the procedures in this section to permit substitution of the BAL TST circuit for the average IT paths necessary to determine an NBO value.*** After the NBO value is determined, the BAL TST circuit BO capacitors must be changed to include the office growth factor since the factor is based on the actual NBO value. Section 660-474-504 contains (a) all the procedures for establishing the

BAL TST circuit and performing the building out and verification required, (b) the procedures for building out and verifying the code 100 and switchboard balance test terminations (SWBD BAL TST TERM), and (c) a listing of all test equipment and terminations and the techniques of their application for all the procedures of this section.

1.06 A general discussion on office balancing is contained in Section 660-474-100. Verification of the NBO capacitor selection and strapping in an office requires echo return loss (ERL) and singing point or singing return loss (SP/SRL) measurements. The methods for making these measurements are contained in Section 660-474-502.

1.07 Before procedures of this section are performed, all trunks to be tested must meet the noise limits and 1000-Hz trunk loss requirements as specified in the applicable section for trunk transmission testing.

1.08 Information concerning the operation of testboards, toll switchboards, and class 5 office test facilities used in this section to establish connections in performing procedures is contained in the section applicable to the test facility used. A necessary requirement on all connections, regardless of the method of establishing the connection, is that the trunk involved be in an off-hook signaling condition during tests.

Caution: Balance testing must be made on an out-of-service basis. The proper out-of-service procedure should be made on any working trunk prior to performing any balance tests.

2. CAPACITANCE MEASUREMENTS FOR DETERMINING NBO

A. General

2.01 The measurements of cable capacitance used to determine NBO capacitance values are made with the BAL TST circuit. The BAL TST circuit 2-wire paths are to build out to equal the average value of capacitance in the cable paths between incoming IT trunk hybrids and the IT first selector jacks and outgoing IT trunk hybrids and CAMA switch selector banks. The BAL TST circuit paths are connected to or from samples of the toll connecting (TC) trunks. The IT to TC and TC to IT connections are terminated at a point of good impedance, ie, code 100, office side of 2-dB pad, office side of impedance compensators, or 4-wire ports of hybrids. With these terminated connections established, various amounts of capacitance are then connected across the COMP NET of the 4WTS of the BAL TST circuit until the greatest return loss is measured. The amount of capacitance across the COMP NET required to balance the BAL TST 4WTS network with the connected office cable is very near the actual amount of capacitance in the connection path.

2.02 All balance measurements require that the trunk equipment in a connection be held in an off-hook signaling condition. In most cases the SIG drop jack at the toll testboard can be used to provide the signal condition.

2.03 The switching paths and trunk circuits described in the tests and figures should be considered as typical rather than all inclusive. Although specific installations may differ in some respects, the principles and methods of balance testing as given are similar.

TABLE B

TRUNK GROUP SAMPLE SIZES

TOTAL NUMBER OF TRUNKS	NUMBER IN SAMPLE
5 or less	All trunks
6 to 10	5
11 to 15	6
16 to 25	7
26 to 50	8
Over 50	Approximately 18 percent of total

B. Paths From IT to TC, Machine-Switched—TS, IT OG Dial, Comb IT and TT Selectors

2.04 The measurements in this procedure are made on representative samples of the TC trunk groups. To be representative, the sample should contain the longest and shortest trunks in the trunk group plus a certain number of trunks as determined from Table B. In selecting trunks for sampling, consideration should be given to in-bay location, the switch multiplying (bridged capacitance), adjacent equipment areas within trunk groups, and portions of trunk groups remotely located from other trunks in the same group.

2.05 This procedure should be performed with the BAL TST circuit properly built out. The procedure for building out is in Section 660-474-504.

STEP	PROCEDURE
1	Using the testboard appearance of the BAL TST circuit, seize the trunk and dial ABC-XXXX code for the balance test termination in the class 5 office. ***Note:*** When required, precede the ABC-XXXX code with the digits necessary to direct the connection to the proper class 5 office.
2	Block operated the B relay in the IT Dialing Auxiliary trunk circuit (SD-64469-01) or the relay that is operated from battery simplex in TS trunks if the BAL TST circuit is a one-way trunk.
3	Open the transmission path of the trunk and place 900-ohm plus 2.16 μf or 600-ohm test termination(s) on the office side as shown in Fig. 1. ***Note:*** The connection may release at the class 5 office. Two-way trunks must be made busy at the class 5 office to prevent customer seizures.
4	Verify that no straps are connected on the BO capacitors in the trunk being tested.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET in the BAL TST circuit 4WTS.
6	Set up test equipment to perform capacitance measurements as described in Section 660-474-504 and connect test equipment to the transmit and receive ports of the BAL TST circuit 4WTS.
7	Adjust the capacitor box to a value giving the greatest return loss.
8	Record the value of capacitance and other information required to complete an entry on Form E-6002.
9	Release connection, remove the termination(s) placed in Step 3, and restore the transmission path of the trunk. Remove make-busy plug at the class 5 office if trunk tested is a 2-way trunk.
10	Repeat Steps 2 through 9 on all TC trunks in each sample.
11	When measurements for all trunks in each sample have been made and recorded, release the BAL TST circuit and disconnect the test equipment.

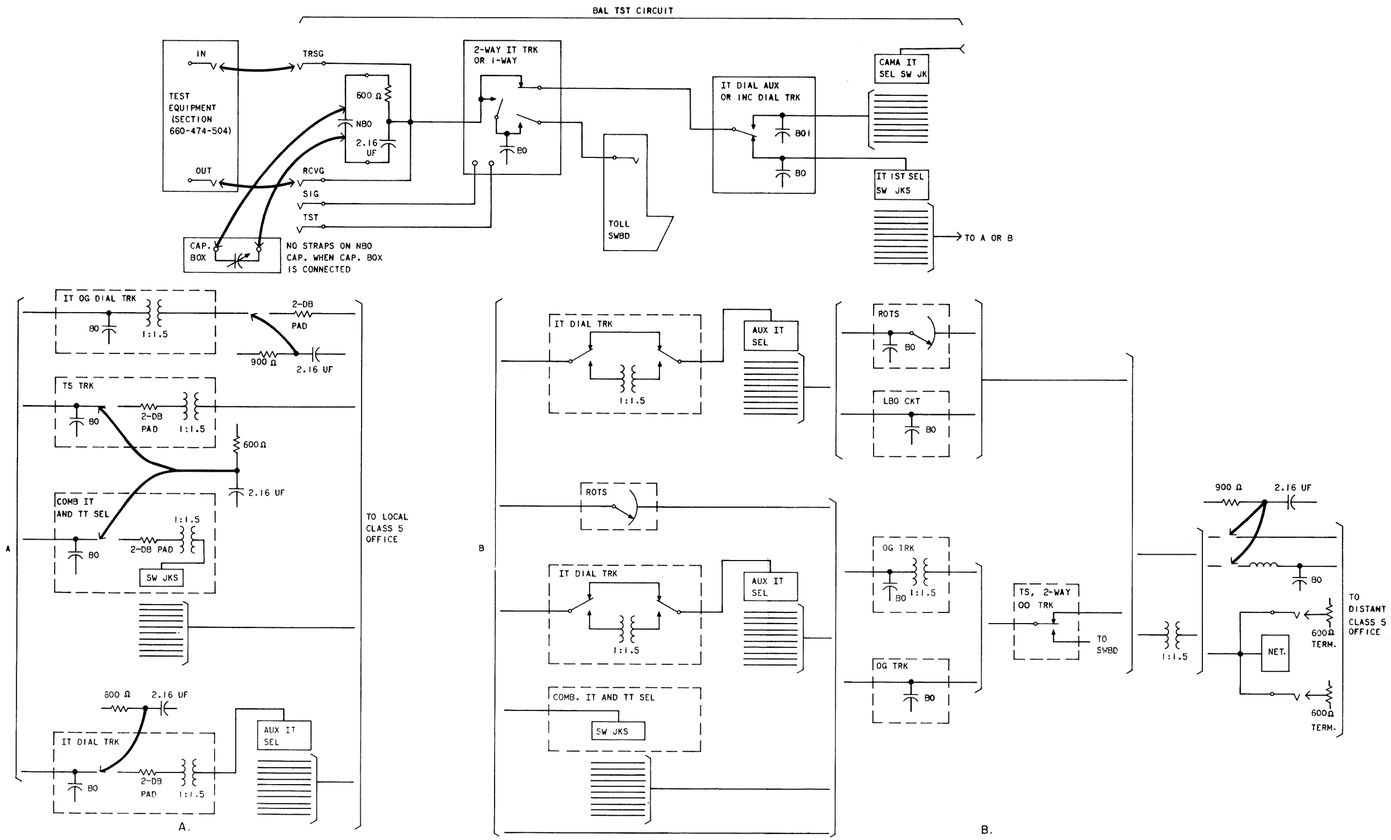

Fig. 1—Paths From IT to TC, Machine-Switched—Machine TS, SWBD TS, 2-Way OO Trunks

C. Paths From TC to IT, Machine-Switched—ANI, CAMA, AMA Trunks

2.06 The measurements in this procedure are made on representative samples of the TC trunk groups. To be representative, the sample should contain the longest and shortest trunks in the trunk group plus a certain number of trunks as determined from Table B. In selecting trunks for sampling, consideration should be given to in-bay location, the switch multiplying (bridged capacitance), adjacent equipment areas within trunk groups, and portions of trunk groups located remotely from other trunks in the same group.

2.07 This procedure should be performed with the BAL TST circuit properly built out. The procedure for building out is in Section 660-474-504. Code 970 must be assigned to the outgoing appearance of the BAL TST circuit.

STEP	PROCEDURE
1	In the class 5 office, use the proper method described in Section 660-576-500 to originate and terminate a test call to 970-1111 to establish a connection to the BAL TST circuit. ***Note 1:*** In a class 5 office in the same building, the connection may be originated from the selectors or the Outgoing Test Frame. ***Note 2:*** A test telephone number should be available to satisfy CAMA operator requirements.
2	In the toll office, perform (a) or (b): (a) On loop signaling type trunks, block the line relay operated in the trunk under test. (b) On E&M signaling type trunks, ground the E lead of the trunk under test.
3	Open the transmission path of the trunk and place a 900-ohm plus 2.16 μF, 600-ohm plus 2.16 μF, or 600-ohm termination(s) as shown in Fig. 2. ***Note:*** Two-way trunks must be made busy at the toll office to prevent customer seizures.
4	Verify that no straps are connected to the BO capacitors in the trunk under test.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET of the BAL TST circuit.
6	Set up test equipment to perform capacitance measurements as described in Section 660-474-504 and connect test equipment to the transmit and receive ports of the BAL TST circuit.
7	Adjust the capacitor box to a value giving the greatest return loss.
8	Record the capacitance value and other information required to complete an entry on Form E-6002.
9	Remove the termination(s) placed in Step 3 and remove the blocking tool in the line relay or the ground on the E lead placed in Step 2. Release the connection at the class 5 office. Remove the trunk make-busy plug at the class 4 office if the trunk tested is a 2-way trunk.
10	Repeat Steps 1 through 9 on all TC trunks in each sample.
11	When measurements for all TC trunks in each sample have been completed and recorded, disconnect the test equipment from the BAL TST circuit.

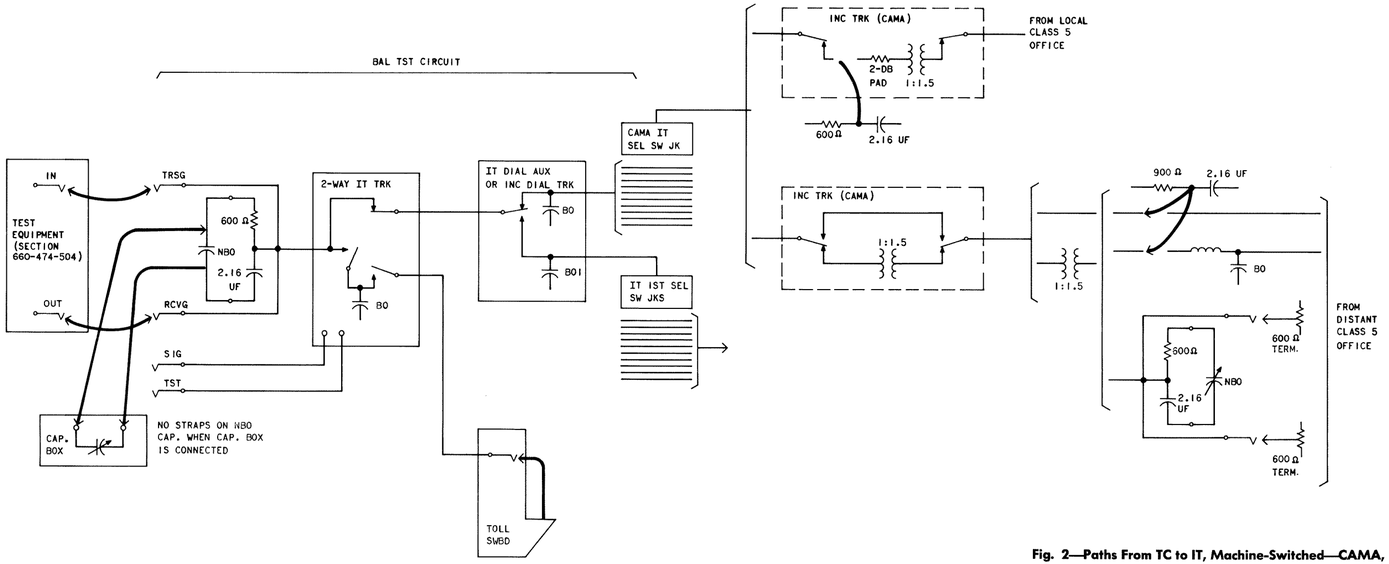

Fig. 2—Paths From TC to IT, Machine-Switched—CAMA, AMA Trunks

D. Paths From IT to TC via Switchboard—SWBD TS, 2-Way OO (Outgoing), Miscellaneous Trunks (TOLL SUB, EMG TRF, Mobile Radio, etc)

2.08 The measurements in this procedure are made on representative samples of the TC trunk groups. To be representative, the sample should contain the longest and shortest trunks in the trunk group plus a certain number of trunks as determined from Table B. In selecting trunks for sampling, consideration should be given to in-bay location, the switch multiplying (bridged capacitance), adjacent equipment areas within trunk groups, and portions of trunk groups located remotely from other trunks in the same group. The last appearance in switchboard multiple should be used so as to include all resistance in measurements.

2.09 This procedure should be performed with the BAL TST circuit properly built out. The building out procedure is in Section 660-474-504.

STEP	PROCEDURE
1	At the testboard appearance of the BAL TST circuit, seize the trunk and dial 121 to establish a connection to the toll switchboard.
2	At the switchboard, use the answering cord of a cord circuit to pick up the incoming signal. Use the calling cord of the same cord circuit to seize the outgoing TC trunk circuit to be tested and key pulse (dial) the number assigned to the termination for balance testing in the class 5 office. ***Note:*** When testing mobile radio trunks, use a spare service line number. When testing other miscellaneous type trunks, the signaling may be automatic or manual and not require number dialing.
3	Open the transmission path and place a 900-ohm plus 2.16 μF, 600-ohm plus 2.16 μF, or 600-ohm test termination(s) as shown in Fig. 3. ***Note:*** The connection may release at the class 5 office. Two-way trunks must be made busy at the class 5 office to prevent customer seizures.
4	Verify that no straps are connected on the BO capacitors in the TC trunk under test.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET of the BAL TST circuit.
6	Set up test equipment to perform capacitance measurements as described in Section 660-474-504 and connect test equipment to the transmit and receive ports of the BAL TST circuit.
7	Adjust the capacitor box to a value giving the greatest return loss.
8	Record the capacitance value and other information required to complete an entry on Form E-6002.
9	Remove the termination(s) placed in Step 3 and disconnect the cord circuit at the switchboard. Remove the trunk make-busy plug at the class 5 office if the TC trunk tested is a 2-way trunk.
10	Repeat Steps 1 through 9 on each TC trunk in each trunk group sample.
11	When measurements for all trunks in each sample have been completed and recorded, disconnect the test equipment from the BAL TST circuit.

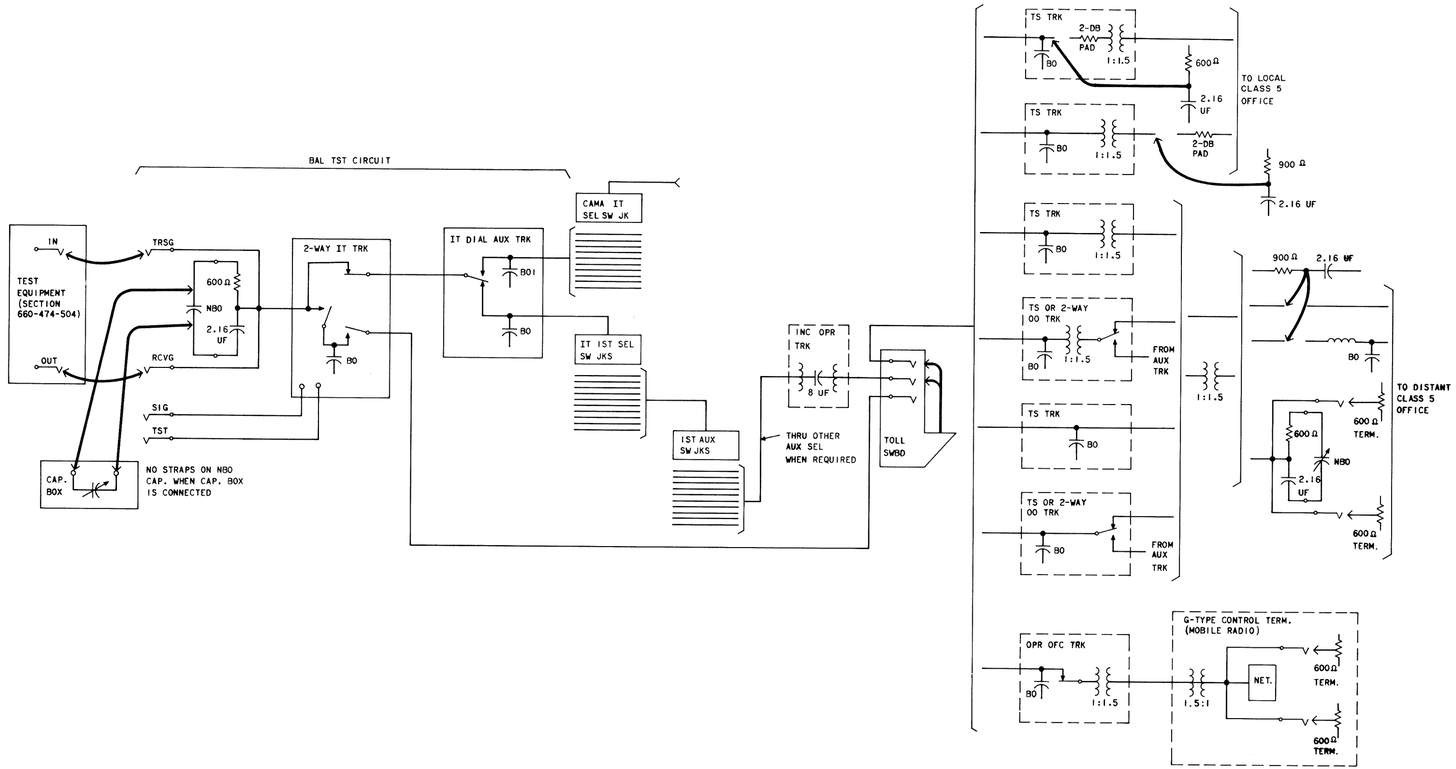

Fig. 3—Paths From IT to TC via Switchboard—SWBD TS, 2-Way OO (Outgoing), Miscellaneous (TOLL SUB, EMG TRF, Mobile Radio, etc) Trunks

E. Paths From TC to IT via Switchboard—RC (FR and Coin), 2-Way OO, Miscellaneous Trunks (TOLL SUB, EMG TRF, Mobile Radio, etc)

2.10 The measurements in this procedure are made on representative samples of the TC trunk groups. To be representative, the sample should contain the longest and shortest trunks in the trunk group plus a certain number of trunks as determined from Table B. In selecting trunks for sampling, consideration should be given to in-bay location, the switch multiplying (bridged capacitance), adjacent equipment areas within trunk groups, and portions of trunk groups located remotely from other trunks in the same group. The last appearance in switchboard multiple should be used so as to include all resistance in measurements.

2.11 This procedure should be performed with the BAL TST circuit properly built out. The procedure for building out is in Section 660-474-504.

STEP	PROCEDURE
1	Perform (a) or (b): (a) When the trunk is from the class 5 office, use the proper method to seize, originate, terminate, and hold the connection to the switchboard associated with the toll office as described in Section 660-576-500. (b) When the trunk is a miscellaneous type, establish a connection to the switchboard associated with the toll office using the subscriber equipment or a 2AB auxiliary transmission test set. ***Note:*** EMG TRF circuits require that the TR relay be blocked to establish a connection to the switchboard.
2	At the switchboard, use the answering cord of a cord circuit to pick up the incoming signal and with the calling cord of the cord circuit perform (a) or (b): (a) Select and seize an operator tandem trunk and key pulse (dial) 970 to establish a connection to the BAL TST circuit. (b) Seize the BAL TST circuit direct from the switchboard jack appearance.
3	Open the transmission path of the TC trunk and place 900-ohm plus 2.16 μF, 600-ohm plus 2.16 μF, or 600-ohm test termination(s) as shown in Fig. 4. ***Note:*** Two-way trunks must be made busy at the class 4 office to prevent operator seizure.
4	Verify that no straps are connected to the BO capacitors in the TC trunk.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET of the BAL TST circuit 4WTS.
6	Set up test equipment to perform capacitance measurements as described in Section 660-474-504 and connect test equipment to the transmit and receive ports of the BAL TST circuit 4WTS.
7	Adjust the capacitor box to a value giving the greatest return loss.
8	Record the capacitance value and other information required to complete an entry on Form E-6002.
9	Disconnect the cord circuit and release the TC trunk at the originating end.
10	Repeat Steps 1 through 9 on all trunks in each sample.
11	When measurements for all trunks in each sample have been completed and recorded, disconnect the test equipment from the BAL TST circuit.

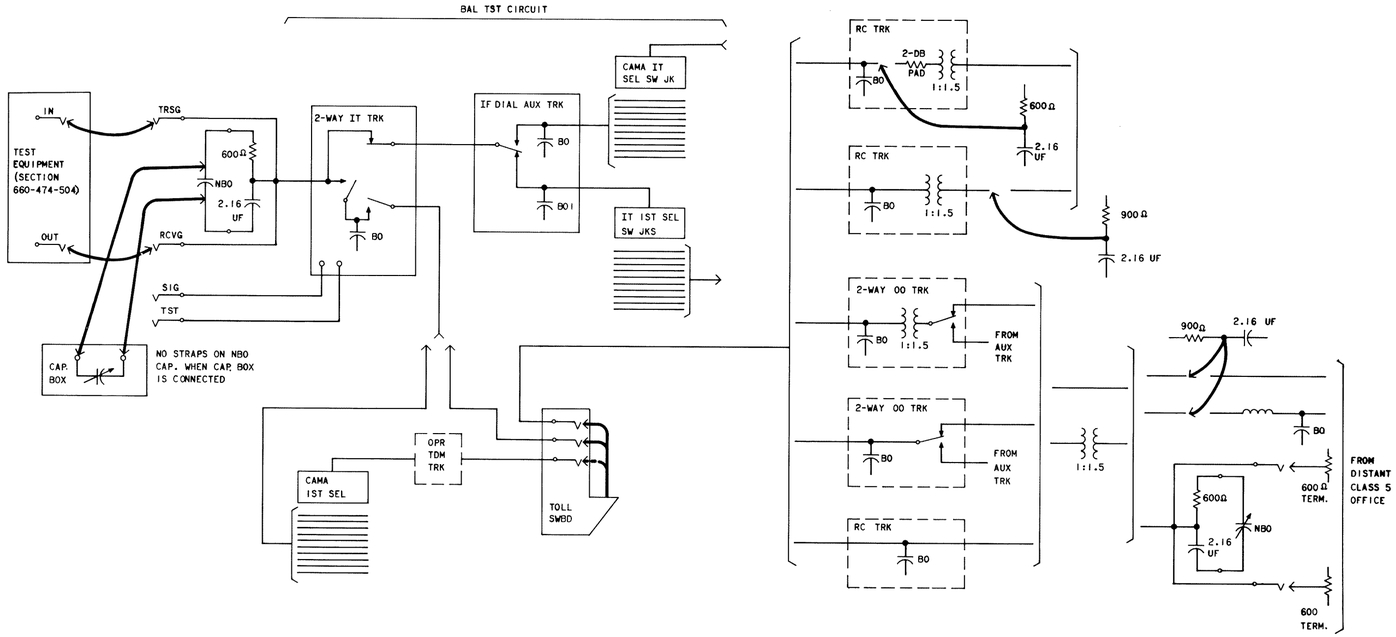

Fig. 4—Paths From TC to IT via Switchboard—RC (FR and Coin), 2-Way OO, Miscellaneous (TOLL SUB, EMG TRF, Mobile Radio, etc) Trunks

3. NBO CAPACITOR VALUE DETERMINATION AND APPLICATION

3.01 Considering that the bridge capacitance of switch frame and switchboard multiple are similar in each trunk group, a compromise value can be used for the NBO. To evaluate the compromise value, the average of the greatest measurement plus ten percent for growth and the least measurement are calculated. The result will, in general, be the NBO value unless the difference between the values is greater than 0.025 μF. If the difference is greater than 0.025 μF, the NBO value is determined by calculation to be 0.0125 μF less than the greatest measurement plus the ten percent growth factor and some buildout in part of the TC trunks is always required. The required build-out capacitance is added in the procedures of Section 660-474-502 to all TC trunks with less capacitance than the calculated NBO minus 0.025 μF.

3.02 In offices where the network-to-line impedance ratio of 4WTSs in some of the TC trunks is not 1:1, a modifying factor must be used. Table C lists the ratios and necessary modifying factors for the types of 4WTSs normally used.

3.03 The final selection of the NBO value for an office should be approved by the responsible transmission engineer.

3.04 In general, the final selection and installation of the NBO value for class 4 offices is completed as follows:

(a) Compare the capacitance values recorded on Form E-6002 in Step 8 of all procedures in Part 2. Identify the path having the least capacitance (shortest) and the path with the greatest capacitance (longest).

(b) Calculate ten percent of the longest path measurement and add the value to the path measurement itself (adjustment for growth).

Note: A growth factor should be included in the office NBO value. The factor should not exceed ten percent of the average path and may be less in some offices.

(c) Determine the difference between the longest path plus ten percent and the shortest path.

(d) If the difference determined in (c) is less than or equal to 0.025 μF, the NBO value is the average of the two values: ie, NBO = [(1.1 × longest path) + shortest path] ÷ 2. If the difference determined in (c) is greater than 0.025 μF, the NBO value is 0.0125 μF less than the longest path plus ten percent: ie, NBO = 1.1 × longest path − 0.0125 μF.

TABLE C

4-WIRE TERMINATING SETS MODIFYING FACTORS

4-WIRE TERMINATING SETS		NBO MODIFYING FACTORS			
TYPE	IMPEDANCE OF 2-WIRE LINE SIDE	IMPEDANCE RATIO (NETWORK-TO-LINE)	DUE TO IMPEDANCE OF 2-WIRE LINE SIDE	DUE TO NETWORK-TO-LINE IMPEDANCE RATIO	FINAL* (MULTIPLY OFFICE NBO CAPACITANCE BY FIGURE SHOWN)
1D 120NH 4TP	600Ω	1:1	1.0	1.0	1.0
4TT	600Ω	2:1	1.0	0.5	0.5
(Built-in 4-Wire Term. Sets, E-Type Signaling Units	900Ω	10:1	0.67	0.1	.07

* The figures shown are nominal. In some cases it may be necessary to make actual measurements to find the best factor.

Note: The paths with less capacitance than the longest path plus the growth factor minus 0.025 μF will require DBO in the procedures of Section 660-474-502 (see Fig. 5).

(e) Strap or screw down the NBO capacitor adjustments to obtain the capacitance value selected in (d) above on the 4WTSs of all incoming and outgoing IT trunks and TC trunks.

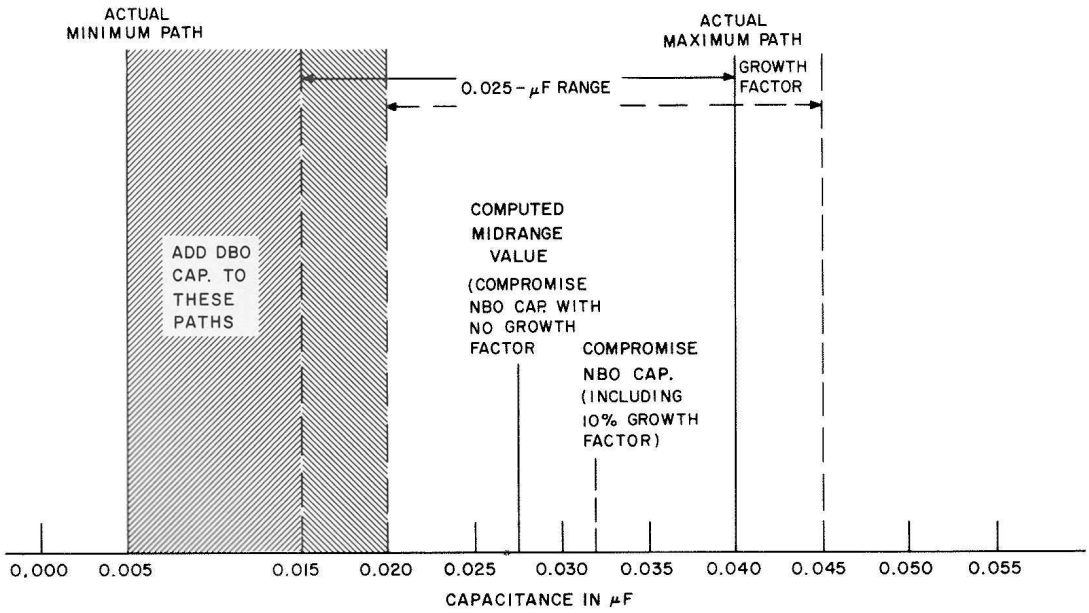

Fig. 5—Example of Determination NBO Capacitance in a Class 4 Office