NO. 5 CROSSBAR OFFICES
NETWORK BUILD-OUT SELECTION
FOR THROUGH AND/OR TERMINAL BALANCE

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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 sets (4WTSs) of intertoll (IT) trunks in No. 5 crossbar offices. The procedures should be performed in the sequence shown in Table A for initial or rebalancing work.

1.02 This section is reissued to include information on the Balance Test 3 circuit and to change testing procedures when making cabling capacitance measurements. Due to the extensive revision, arrows normally used to indicate changes have been omitted.

1.03 All measurement results should be recorded and retained. Section 660-472-010 describes the forms required and the suggested method of record retention.

TABLE A

TEST SEQUENCE SUMMARY

TEST	PROCEDURE	
	PART	FIGURE
All Offices		
Operator Assistance Trunks (121, WH, TX, etc)	2B	1
Operator Junctor Trunks	2B	2
Class 3 and Higher Ranking Offices		
IT to IT, Machine-Switched	2C	3
IT to IT via Toll Switchboard	2C	4
Class 4 Offices Only		
IT to TC, Machine-Switched	2D	5
TC to IT, Machine-Switched	2D	6
IT to TC via Toll Switchboard	2D	7
TC to IT via Toll Switchboard	2D	8

1.04 When initially balancing an office, balance test (BAL TST) circuits must be provided on a local basis, as described in Section 660-472-504. The test circuits should have short cable paths [relative to the length of working IT and toll-connecting (TC) trunks] to the line link and trunk link frames (LLF and TLF), to allow adjustment of build-out capacitance. Code 970 should be assigned to the TLF appearance of the BAL TST 1 circuit. The BAL TST 2 and BAL TST 3 circuits should be jack-terminated at the toll testboard. In class 3 and higher ranking offices, the BAL TST circuits are made to simulate the longest incoming and outgoing IT trunks; and in an office with machine protection trunks, they are made to simulate the longest direct paths in the office between the switchboard and IT trunks. In class 4 offices, the BAL TST 1 circuit is made to simulate the average IT trunk path and the BAL TST 3 circuit is made to simulate the average TC trunk path. The simulations are accomplished with build-out capacitance in the BAL TST circuit 2-wire lines. ***Capacitance buildout of the BAL TST circuit 2-wire lines, according to procedures in Section 660-472-504, is required before performing the procedures in this section. This is to permit substitution of the BAL TST circuits for the longest (class 3 and higher) IT paths or the average (class 4) IT or TC paths necessary for determining an NBO capacitance value.*** When the procedures of this section have been completed and the NBO capacitance value for an office is known, the BAL TST circuit BO capacitor strapping must be changed to include the office growth factor (when required), since the factor is based on the actual office NBO capacitance value. In addition to procedures for establishing and building out the BAL TST circuits, Section 660-472-504 contains the build-out procedures for the code 100 and the switchboard balance test terminations (SWBD BAL TST TERMs). Section 660-472-504 also includes a listing of all test equipment, test terminations, and the techniques of their application for all procedures in this section.

1.05 A general discussion on office balancing is contained in Section 660-472-100. Verification of the NBO capacitor selection and strapping is made using echo return loss (ERL) and singing point or singing return loss (SP/SRL) measurements. The procedures for making these measurements are described in Sections 660-472-501 and -502.

1.06 Before procedures of this section are performed, the trunk being tested must meet the noise limits and 1000-Hz trunk loss requirements as specified in the applicable sections on trunk transmission testing.

1.07 The operation of testboards, toll switchboards, class 5 office test facilities, and portions of the master test frame (MTF) used in this section

to establish connections in performing these procedures is contained in the sections applicable to the test facility used. A necessary requirement on all connections, regardless of the method of establishing the connection, is that the trunk being tested 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 working trunks prior to performing any balance work.

2. CAPACITANCE MEASUREMENTS FOR DETERMINING NBO VALUE

A. General

2.01 The measurements of cable capacitance used to determine NBO capacitance values in class 3 and higher ranking offices are made with the BAL TST 2 circuit, which is built out to equal the incoming IT trunk having the greatest capacitance in the cable path to the LLF and which is connected through the office to the outgoing IT trunk with the longest path from the TLF. In class 4 offices, the measurements used are made with the BAL TST 1 and BAL TST 3 circuits. The BAL TST 1 is the average value of capacitance in the cable paths between incoming IT trunks and the LLF and TLF appearances connected, respectively, to outgoing TC trunks. The BAL TST 3 circuit is built out to equal the average value of capacitance in the cable paths between outgoing IT trunks and the LLF and TLF appearances connected, respectively, to incoming TC trunks. Average values of cable capacitance are determined by averaging capacitance values of representative samples of trunks. (To determine the correct number of trunks to be sampled, refer to Table B.) In selecting trunks for sampling, consideration should be given to in-bay location, the switching and switchboard multiples, service observing bridges, adjacent equipment areas within trunk groups, and portions of trunk groups remotely located from other trunks in the same group. The last appearance in the switchboard multiple should be used so as to include all resistance present in the trunk paths. The trunks (IT or TC) in a connection are always terminated to include all office cable in the 2-wire paths of the connected trunk circuits. When a connection is established, various amounts of capacitance are then connected across the COMP NET of the 4WTS of a 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 line with the connected office cable is very near the actual amount of capacitance in the connection path.

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

2.02 When adjusting BO capacitors or making office cabling capacitance measurements, two types of test equipment are suggested: the General Purpose Portable Test Equipment [eg, 54C Return-Loss Measuring Set (RLMS)] and the KS-20501 RLMS (see Section 660-472-100). (For test equipment setup, refer to the Applications Chart, Test 1 in Section 660-472-504.) When making greatest return-loss measurements using the General Purpose Portable Test Equipment, the output frequency of the measuring set should be set, at or within, a range that includes 2000 Hz. Adjust the 7A capacitor box (or strap the BO capacitor if capacitor box is not used) for maximum meter deflection. When making greatest return-loss measurements using the KS-20501 RLMS, the TEST TYPE switch should be set to ERL (frequency band between 560 Hz and 1965 Hz). Adjust the 7A capacitor box (or strap the BO capacitor if capacitor box is not used) for maximum meter deflection. By using these methods, optimum capacitance measurements can be made.

Note: When using the KS-20501 RLMS, after selecting the highest capacitance value that appears to optimize ERL (maximum meter deflection), set the TEST TYPE switch to

SRL HI to insure that the values here are at least equal to the ERL values. If the SRL HI values are not at least equal to or greater than the ERL values, investigate for trouble.

2.03 When initially balancing an office, the procedures of Part 2B in this section must be completed before measurements can be made on connections involving the toll switchboard.

2.04 All balance measurements require that the trunk equipment in a connection be held in an off-hook signaling condition during the measurement.

B. Class 3 and Higher Ranking or Class 4 Offices

Selection of Capacitor Value for 121 Operator Assistance Trunks

2.05 Compensated operator assistance (OA) trunks are equipped with lightweight loading coils that inductively compensate for the wiring capacitance in the transmission path from the machine to the switchboard. In general, the inductance more than offsets the capacitance of the office cable. This procedure adds additional build-out capacitance. In those cases where the office cable capacitance is greater than can be compensated for by the available inductance, assistance of the transmission engineer is required. The compensation will usually reduce the size of the NBO capacitor value requirement for an office, since the effects of the adjustment tend to make the trunk transparent from an impedance viewpoint.

2.06 The BAL TST 2 circuit for class 3 and higher ranking offices only or the BAL TST 3 circuit for class 4 offices only must be properly built out (see Section 660-472-504) before this procedure is performed.

STEP	PROCEDURE
1	At the MTF, connect the toll-originating test line to the toll switchboard by dialing 121 on the OA trunk to be tested. Transfer the connection to the TRK TST jack appearance by operating the MTF TTBD key and then the RL key.
2	Patch the TRK TST jack to the 2-wire line jack appearance of the 4WTS assigned to the BAL TST 2 or BAL TST 3 circuit depending on which class of office is being used (see Fig. 1).
3	Verify that no screw settings or straps are present on the BAL TST 2 or BAL TST 3 NBO capacitor.
4	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the 4WTS transmit and receive ports of the BAL TST 2 or BAL TST 3 circuit.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET in the 4WTS of the BAL TST 2 or BAL TST 3 circuit.
6	On the line link vertical assigned to the MTF toll-originating test line, place a 351E plug to bridge the connection and hold supervision. Manually release the vertical hold magnet on the TLF appearance of the OA trunk under test. (Magnet may be allowed to reoperate if no other select magnet is operated.)
7	At the LLF, connect a portable 600Ω + 2.16 μF test termination across the tip and ring punchings of the 351E plug.

STEP	PROCEDURE
8	Adjust the capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
9	Remove the 351E plug and the test termination.
10	At the MTF, remove the patch to prevent test equipment interference, release the test line, and reestablish a connection to the ***same*** OA trunk.
11	Use a cord circuit to connect the portable test termination to the SWBD jack appearance of the OA trunk under test. The TALK-MON key must be closed during the measurement.
12	Permanently strap the BO capacitor in the OA trunk to a value giving the greatest return loss (see 2.02). ***Note:*** The return loss will not increase with added capacitance when the path capacitance is greater than can be compensated for by the load coil inductance (see 2.05).
13	Record the build-out capacitance value strapped and other information required to complete Form E-6002.
14	At the MTF, release the connection and establish a connection to the TOLL SWBD on the next OA trunk to be tested (Steps 1 and 2).
15	Perform Steps 6 through 14 on each remaining trunk.
16	When all OA trunks have been adjusted, remove the capacitor box from the BAL TST circuit and the patch cord from the MTF TRK TST jack.

Selection of Capacitor Value for Operator Junctor Trunks

2.07 Compensated operator junctors (OJ) are equipped with lightweight loading coils that inductively compensate for wiring capacitance in the transmission path from the switchboard to the machine. In general, the inductance more than offsets the capacitance of the office cable. This procedure adds additional build-out capacitance. In those cases where the office cable capacitance is greater than can be compensated for by the available inductance, the assistance of the transmission engineer is required. The compensation adjustment will usually reduce the amount of the NBO capacitance required for an office, since the effects of the adjustment tend to make the trunk transparent from an impedance viewpoint.

2.08 The BAL TST 1 circuit must be properly built out as described in Section 660-472-504 before this procedure is performed.

STEP	PROCEDURE
1	At the toll switchboard, seize the selected OJ trunk with a cord circuit and key pulse (dial) 970 to connect to the TLF appearance of the BAL TST 1 circuit.

STEP	PROCEDURE
2	Verify that no screw settings or straps are present on the NBO of the BAL TST 1 4WTS.
3	Connect a 7A capacitor box (or equivalent) across the COMP NET of the BAL TST 1 circuit 4WTS (see Fig. 2).
4	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the transmit and receive ports of the BAL TST 1 circuit.
5	Place ground on the sleeve at the TLF appearance of the BAL TST 1 circuit to provide off-hook supervision. Manually release the vertical hold magnet. (The magnet may be allowed to reoperate if no other select magnet is operated on the switch.)
6	At the TLF, connect a portable 600Ω + 2.16 μF test termination across the tip and ring of the FA or FB terminal punchings.
7	Adjust the capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
8	At the TLF, remove the portable test termination and the off-hook ground placed in Step 5.
9	At the TOLL SWBD, release and reestablish the connection to 970 (BAL TST 1) on the same OJ trunk.
10	Using the cord circuit at the SWBD, connect the portable test termination to the jack appearance of the OJ trunk. (The TALK-MON key must be closed for transmission testing.)
11	Permanently strap the BO capacitor in the OJ trunk to the value giving the greatest return loss (see 2.02). ***Note:*** The return loss will not increase with added capacitance when the path capacitance is greater than can be compensated for by the load coil inductance (see 2.07).
12	Record the trunk build-out capacitance value strapped and other information required to complete Form E-6002.
13	At the TOLL SWBD, release the connection and establish a connection to 970 (BAL TST 1) on the next OJ trunk to be tested.
14	Perform Steps 5 through 13 on each remaining trunk.

C. Class 3 and Higher Ranking Offices

Paths From IT to IT, Machine-Switched

2.09 The BAL TST 2 circuit, properly built out as described in Section 660-472-504 as the longest incoming IT trunk in the office, must be used to perform this procedure. This procedure should be performed on the outgoing IT trunk having the greatest amount of cable capacitance as determined from visual inspection, records, and bridge-type capacitance measurements. This path may include an auxiliary trunk for subscriber access.

STEP	PROCEDURE
1	At the MTF, connect the toll-originating test line to the outgoing IT trunk with the longest path. Transfer the connection to the TRK TST jack appearance.
2	Patch the TRK TST jack to the 2-wire line jack appearance of the 4WTS assigned to the BAL TST 2 circuit.
3	Place 600-ohm terminations in the transmit and receive ports of the 4WTS associated with the IT trunk under test (see Fig. 3).
4	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the 4WTS transmit and receive ports of the BAL TST 2 circuit.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET of the 4WTS in the BAL TST 2 circuit.
6	Verify that no straps are connected on the NBO capacitor in the 4WTS of the BAL TST 2 circuit or the BO3 capacitor in the IT trunk circuit.
7	Adjust the capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
8	Record the value obtained and other information required to complete Form E-6002.
9	Remove 600-ohm terminations and release the connection.

Paths From IT to IT via Toll Switchboard

2.10 The BAL TST 1 and BAL TST 2 circuits, properly built out as described in Section 660-472-504 as the longest incoming and outgoing IT trunks, must be used to perform this procedure. The 121 trunk and operator junctor trunk build-out adjustments as described in Part 2B of this section must also be completed. The longest direct access path to an IT trunk (required when operator completes IT connections in this manner) is determined from visual inspection, records, and bridge-type capacitance measurements.

STEP	PROCEDURE
1	At the MTF, connect the toll-originating test line to the TOLL SWBD on any 121 OA trunk and transfer the connection to the TRK TST jack.
2	Patch the TRK TST jack to the jack appearance of the BAL TST 2 circuit (see Fig. 4).
3	At the switchboard, use a cord circuit to seize and key pulse (dial) 970 (BAL TST 1) into any OJ trunk. (The cord circuit TALK-MON key must be closed for the transmission testing.)

STEP	PROCEDURE
4	Terminate the transmit and receive ports of the 4WTS of the BAL TST 1 circuit with 600 ohms.
5	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the transmit and receive ports of the BAL TST 2 4WTS.
6	Connect a 7A capacitor box (or equivalent) across the COMP NET in the 4WTS of the BAL TST 2 circuit.
7	Verify that no straps are connected on the NBO capacitor of the 4WTS in the BAL TST 1 circuit.
8	Adjust the capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
9	Record the value obtained in Step 8 and other information required to complete Form E-6002.
10	***In those offices where direct access to IT trunks appears in the switchboard multiple,*** it is necessary to perform the following steps: (a) At the switchboard, change the calling cord connection from the OJ jack appearance to the jack appearance for direct access to the IT trunk determined to have the longest cable path. (The cord circuit TALK-MON key must be closed for transmission testing.) (b) Terminate the transmit and receive ports of the 4WTS associated with the direct-accessed trunk under test and verify that no strapping is present on the NBO capacitor. (c) Perform Steps 5 through 9.

D. Class 4 Offices

Paths From IT to TC, Machine-Switched—TC, 2-Way OO, SWBD TS

2.11 This procedure should be performed on a sample of trunks from each trunk group. The selected sample should include the paths with the least and the greatest cable capacitance and a sufficient number of trunks randomly selected (see 2.01). The total number in the sample size is determined by the number of trunks in the trunk group (see Table B). The procedures are performed with the BAL TST 1 circuit properly built out as described in Section 660-472-504. The trunk groups to be tested are as follows:

(a) Intermarker group trunks (TRK to SUB)

(b) Toll-switching (TS) trunks (SWBD)

(c) 2-way operator office (OO) trunks

(d) Toll-completing (TC) trunk.

STEP	PROCEDURE
1	Perform (a) or (b): (a) At the testboard, seize the BAL TST 1 circuit and key pulse (dial) the office code and directory number assigned to the distant class 5 office BAL TST line and termination circuit. Identify the TC trunk selected by the machine at the test jack and lamp panel. (b) At the testboard, seize the BAL TST 1 circuit and key pulse (dial) the directory number assigned to the BAL TST line and termination circuit for the class 5 office served by the same machine. Identify the TC trunk selected by the machine at the test jack and lamp panel.
2	Verify that no screw settings or straps are present on the BO capacitor of the trunk under test.
3	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the transmit and receive ports of the 4WTS associated with the BAL TST 1 circuit.
4	Connect a 7A capacitor box (or equivalent) across the COMP NET of the 4WTS assigned to the BAL TST 1 circuit (see Fig. 5).
5	When testing TC trunks to distant offices, place a 900Ω + 2.16 μF termination at the interface of office cable and outside cable plant or at the office side of impedance compensators, or place 600-ohm terminations in the transmit and receive ports of the 4WTS in a 4-wire interoffice facility. On trunks served by the same machine, place the 600Ω + 2.16 μF test termination on the IT trunk side of the 2-dB pad.
6	Adjust the 7A capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
7	Record the capacitance value and other information required to complete Form E-6002.
8	Remove the termination and release the connection.

Paths From TC to IT, Machine-Switched—AMA, CAMA, LAMA, TSPS

2.12 This procedure should be performed on a sample of trunks from each trunk group. The selected sample should include the paths with the least and greatest cable capacitances and a sufficient number of trunks randomly selected (see 2.01). The total number of trunks in the sample size is determined by the number of trunks in the trunk group (see Table B). The procedures are performed with the BAL TST 1 circuit properly built out as described in Section 660-472-504. The trunk groups to be tested are as follows:

(a) Auxiliary junctor circuits and outgoing interoffice trunks—LAMA

(b) Junctor trunks—CAMA

(c) Intermarker group trunks—LAMA or CAMA

(d) Incoming trunks—LAMA, CAMA, or TSPS

(e) Auxiliary trunk circuits for subscriber access—LAMA.

STEP	PROCEDURE
1	Perform (a), (b), and (c): (a) ***Class 5 office served by same machine:*** At the MTF, connect the toll-originating test line to the trunk selected for test and key pulse (dial) 970-1111. (b) ***Distant class 5 office:*** Using equipment in that office, seize and key pulse (dial) 970-1111 into the trunk selected for test. (c) ***At the MTF,*** set up an outgoing class call in the subscriber access mode and key pulse (dial) 970-1111.
2	Depending on the type of signaling used in the trunk being tested, either block the line relay operated (loop signaling types) or ground the E lead (E&M signaling types).
3	Place appropriate test terminations (600Ω or 900Ω + 2.16 μF) in the transmission path of the selected trunk (Note 2, Fig. 6).
4	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the transmit and receive ports of the BAL TST 1 circuit.
5	Connect a 7A capacitor box (or equivalent) across the COMP NET of the 4WTS in the BAL TST 1 circuit.
6	Verify that no strapping is connected on NBO or BO capacitors in the connection. (This does not apply to the BO3 capacitor adjusted in Section 660-472-504 to build out the BAL TST 1 circuit.)
7	Adjust the 7A capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
8	Record this value and other information required to complete Form E-6002.
9	Remove the line relay block or E lead ground of Step 2 and release the connection.
10	Repeat Steps 1 through 9 on all remaining TC trunks selected for testing.

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

2.13 This procedure should be performed on a sample of trunks from each trunk group. The selected sample should include the paths with the least and greatest cable capacitance and a sufficient number of trunks randomly selected (see 2.01). The total number of trunks in the sample size is determined by the number of trunks in the trunk group (see Table B). The procedures are

performed with the BAL TST 1 circuit properly built out as described in Section 660-472-504. The trunk groups to be tested are:

(a) SWBD TS trunks

(b) 2-way OO trunks

(c) Miscellaneous lines and trunks (such as manual or toll subscriber lines, emergency transfer trunks, mobile radio service trunks, etc). Both working and spare equipment should be considered and circuit turndown procedures followed when testing these trunks.

STEP	PROCEDURE
1	At the toll testboard, seize the BAL TST 1 circuit and key pulse (dial) 121 to signal the toll switchboard.
2	At the TOLL SWBD, use a cord circuit to answer the incoming signal.
3	At the switchboard, use the calling cord of the cord circuit to seize and signal on the trunk selected for test. (The TALK-MON key must be closed for transmission testing.) ***Note:*** Emergency transfer, manual toll subscriber lines, and other miscellaneous trunks require no dialing but must be answered at the far end to provide off-hook condition for test purposes. In the case of mobile radio, a spare line number should be dialed.
4	Depending on the type of signaling used in the trunk being tested, either block the line relay operated (loop signaling) or ground the E lead (E&M signaling).
5	Place appropriate test terminations (600Ω or 900Ω + 2.16 μF) in the transmission path of the selected trunk (Note 2, Fig. 7).
6	Verify that no screw settings or straps are connected on the BO capacitor in the TC trunk under test.
7	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 660-472-504 and connect to the transmit and receive ports of the 4WTS in the BAL TST 1 circuit.
8	Connect a 7A capacitor box (or equivalent) across the COMP NET in the 4WTS of the BAL TST 1 circuit.
9	Adjust the 7A capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
10	Record the value and other information required to complete Form E-6002.
11	Repeat Steps 3 through 10 on each trunk selected for testing.

Paths From TC to IT via Toll Switchboard—RC, 2-Way OO, Miscellaneous (TOLL SUB, EMG TRF, Mobile Radio, etc)

2.14 This procedure should be performed on a sample of trunks from each trunk group. The selected sample should include the paths with the least and greatest cable capacitances and a sufficient number of trunks randomly selected. The total number of trunks in the sample size is determined by the number of trunks in the trunk group (see Table B). The procedures are performed

with the BAL TST 1 circuit properly built out as described in Section 660-472-504. The trunk groups to be tested are as follows:

(a) Recording completing (RC) trunks

(b) 2-way OO trunks

(c) Miscellaneous lines and trunks (such as manual or toll subscriber lines, emergency transfer trunks, mobile radio service trunks, etc). Both working and spare equipment should be considered and circuit turn-down procedures followed when testing these trunks.

STEP	PROCEDURE
1	Perform (a), (b), or (c): (a) ***At the class 5 office,*** seize the trunk selected for test and key pulse (dial) zero to signal the TOLL SWBD. (b) ***At the MTF,*** connect the toll-originating test line to the trunk selected for test. (c) ***At the subscriber location,*** signal the TOLL SWBD and leave the station off-hook.
2	At the TOLL SWBD, answer the incoming signal using a cord circuit and perform (a) or (b): (a) Using the calling cord of the cord circuit, seize any OJ trunk and key pulse (dial) 970 (BAL TST 1 circuit). (The TALK-MON key of the cord circuit must be closed during the transmission testing.) (b) In an office with jack appearances in the switchboard multiple for direct access to IT trunks, connect the calling cord to the direct-accessed path of the BAL TST 1 circuit. ***Note:*** When both (a) and (b) apply in an office, alternate the method of IT trunk completion from the switchboard by successive TC trunks so as to include both IT paths in the sampling measurements.
3	Depending on the type of signaling used in the trunk under test, block the line relay operated (loop signaling type) or ground the E lead (E&M signaling type).
4	Place appropriate test terminations (600Ω or 900Ω + 2.16 μF) in the transmission path of the trunk under test (see Fig. 8).
5	Verify that no screw settings or straps are connected on the BO capacitor in the TC trunk under test.
6	Set up the test equipment to perform capacitance measurements as described in the Applications Chart, Test 1 in Section 600-472-504 and connect to the transmit and receive ports of the 4WTS in the BAL TST 1 circuit.
7	Connect a 7A capacitor box (or equivalent) across the COMP NET of the 4WTS in the BAL TST 1 circuit.

STEP	PROCEDURE
8	Adjust the 7A capacitor box (or equivalent) to a value giving the greatest return loss (see 2.02).
9	Record the value obtained and other information required to complete Form E-6002.
10	Repeat Steps 1 through 9 on all remaining trunks selected for testing.

3. NBO CAPACITANCE VALUE DETERMINATION AND APPLICATION

A. Class 3 and Higher Ranking Offices

3.01 In general, the greatest capacitance value measured in one of the procedures in Part 2C will be used in determining the NBO value for class 3 and higher ranking offices. One of these measurements should be the longest IT-to-IT connection through the office, or very nearly so, considering that the bridge capacitance of the switch frames and that of the switchboard multiple is similar in each trunk group. The NBO value should be equal to the measured value of the longest IT-to-IT paths through the office plus 10-percent additional capacitance for growth. This NBO value must not exceed a total value of 0.080 μF. If it is greater than 0.080 μF, steps must be taken to reduce the NBO value. In some class 3 offices where the greater part of the TC trunks (class 4 switched) is exceptionally long and the largest value plus 10 percent is small, it may be necessary to consider increasing the NBO value and adding build-out capacitance to the shorter IT trunks to obtain better balance on the IT-to-TC paths. In addition, for offices where the network-to-line impedance ratio of the 4WTS in some of the 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 in IT and TC trunking.

3.02 When NBO reduction or increase is necessary, the condition should be referred to the transmission engineer for engineering assistance. In all cases it is recommended that the transmission engineer approve the final selection of the office NBO value.

3.03 In general, the final selection and installation of the NBO value for class 3 and higher ranking offices is completed as follows.

(a) Increase, by 10 percent, the value of each measurement recorded in the procedures in Part 2C.

(b) Select the largest value (not exceeding 0.080 μF) as the NBO value for the office.

Note: When the exact value required is not compatible with the values of capacitance that can be obtained with straps or screw settings on the NBO capacitors, it is necessary to round off to the nearest 0.001 μF.

(c) Strap or screw down the NBO capacitor adjustments to obtain the capacitance value selected in (b) above, in the 4WTSs of all incoming and outgoing IT trunks, in the 4WTSs of all TC trunks having a 600-ohm 2-wire line impedance, and in the 4WTSs of the balance test circuits.

(d) Use Table C to determine a correction factor. Multiply the office NBO value by the factor and, to obtain the resultant value, strap or screw down the NBO capacitor value on the 4WTSs of all TC trunks having 2-wire line impedances other than 600 ohms.

B. Class 4 Offices

3.04 In class 4 offices, a compromise value must be determined for the NBO value since paths vary more on terminal connections than on through connections. To evaluate the compromise value, the greatest and least capacitance of all measurements made in the procedures in Part 2D are used. The ***average*** of the greatest measurement and the least measurement plus the growth factors obtained

on the samples will, in general, be the NBO value unless the difference between the values is greater than 0.025 μF. The NBO value in this case is determined by calculation to be 0.0125 μF less than the greatest measurement plus the 10-percent growth factor. Some buildout in part of the TC trunks is always required in this case. The required build-out capacitance is added in the procedures of Section 660-472-502 to all TC trunks with less capacitance than the calculated NBO value minus 0.0125 μF.

3.05 In offices where the network-to-line impedance ratio of the 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.

3.06 It is recommended that the transmission engineer approve the final selection of the NBO value for an office.

3.07 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 the procedures of Part 2D. Identify the paths having the least capacitance (shortest) and the path with the greatest capacitance (longest).

(b) Calculate 10 percent of each path measurement and add the value to the path measurement itself (adjustment for growth).

(c) Determine the difference between the longest path plus 10 percent and the shortest path plus 10 percent.

(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 plus the growth factor: ie, NBO = (Longest path + Shortest path) ÷ 2 × 1.1. 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 10 percent: ie, NBO = (1.1 × Longest path) - 0.0125 μF.

Note: The switch paths with less capacitance than the longest path plus 10 percent minus 0.025 μF will require drop buildout in the procedures of Section 660-472-502.

(e) To obtain the capacitance value selected in (d) above, strap or screw down the NBO capacitor value on the 4WTSs of all incoming and outgoing IT and TC trunks having a 600-ohm 2-wire line impedance.

(f) Multiply the capacitance value selected in (d) above by the factor 0.67. Strap or screw down this value on the NBO capacitor adjustments in the 4WTSs of all TC trunks having a 900-ohm 2-wire line impedance.

4. OFFICE GROWTH FACTOR

4.01 The growth factor, as determined in Part 3A or 3B, must be divided between the incoming and outgoing trunks. This should be done either by apportioning the factor relative to the known capacitance of the paths or by equally dividing the factor between the incoming and outgoing portion of the path. Once the office growth factor is known, completion of the preliminary buildout of the BAL TST 2 circuit before determining the office NBO value (Section 660-472-504) can be accomplished.

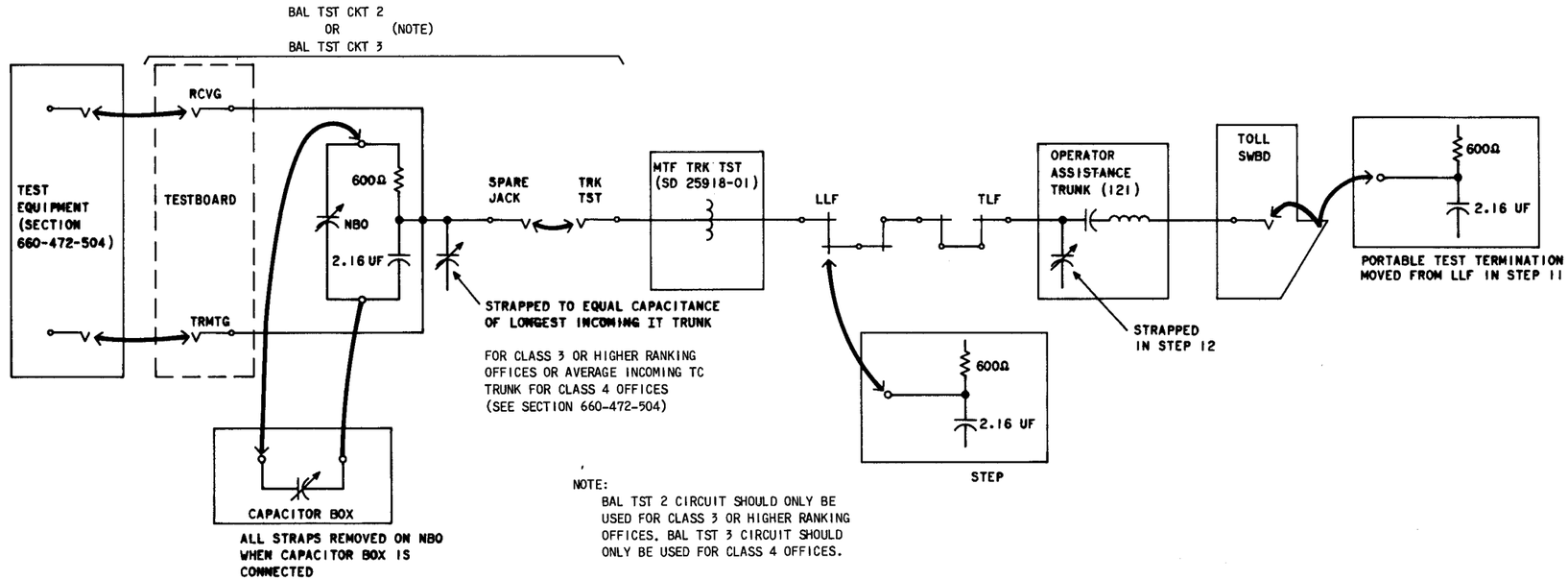


Fig. 1—Class 3 and Higher Ranking or Class 4 Offices: Selection of Capacitor Value for Operator Assistance Trunks

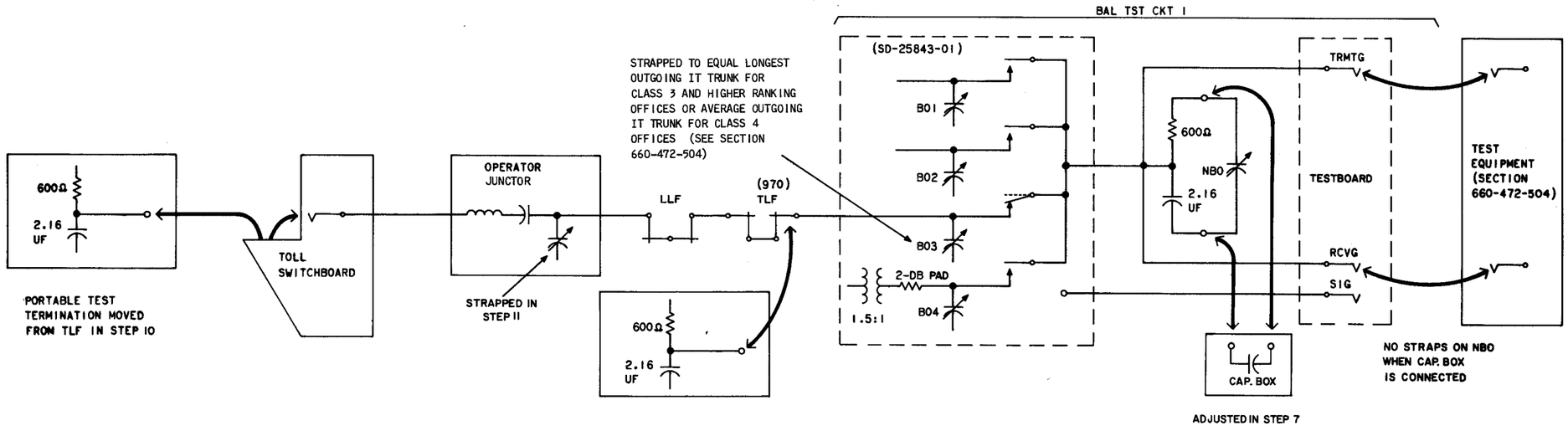


Fig. 2—Class 3 and Higher Ranking or Class 4 Offices: Selection of Capacitor Value for Operator Junctor Trunks

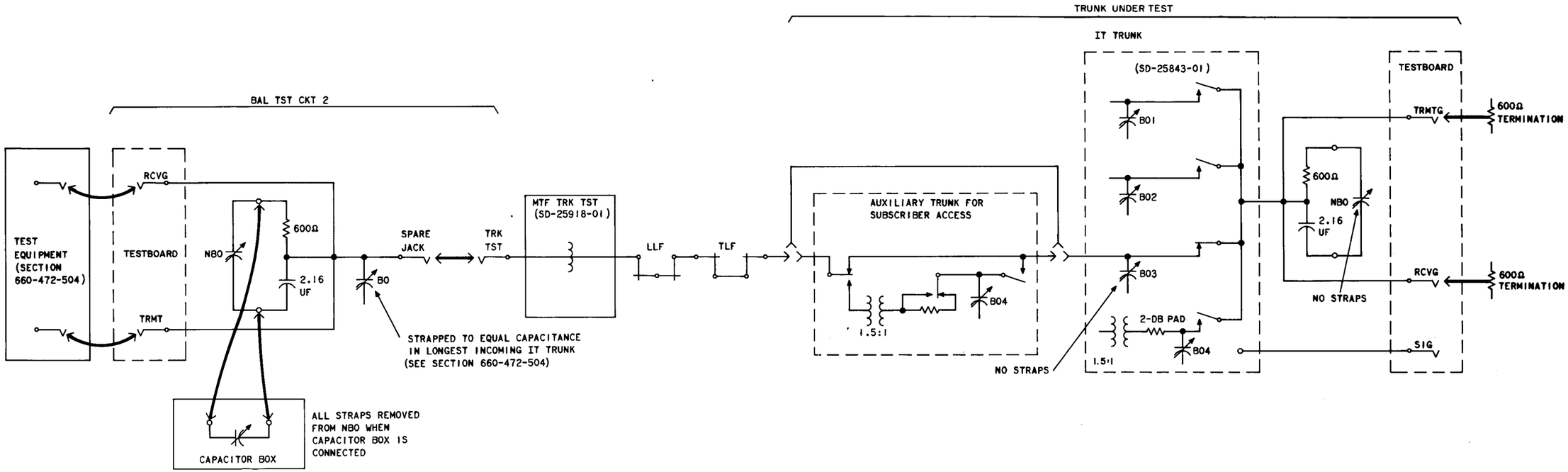


Fig. 3—Class 3 and Higher Ranking Offices: Paths From IT to IT, Machine-Switched

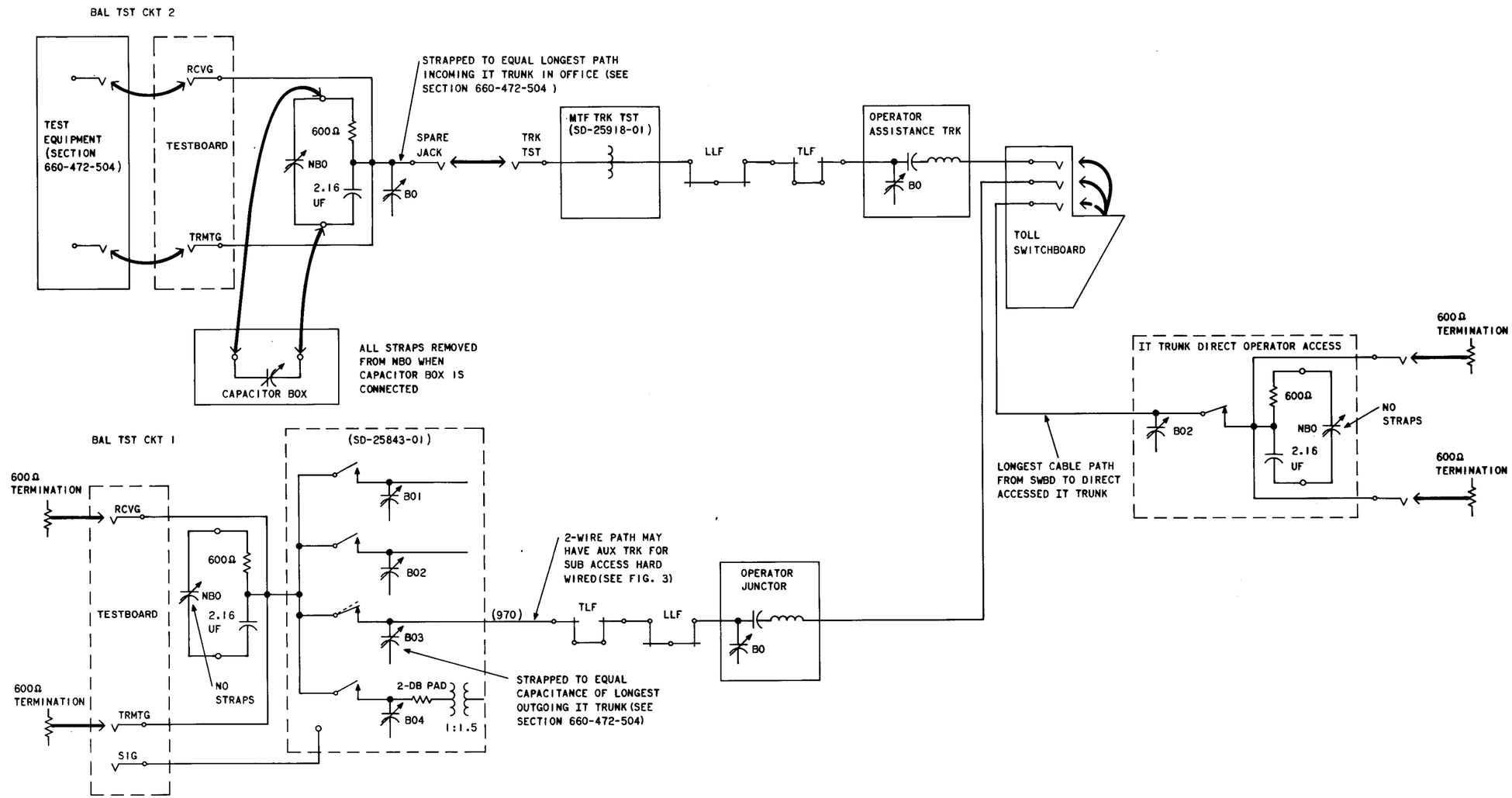


Fig. 4—Class 3 and Higher Ranking Offices: Paths From IT to IT via Toll Switchboard

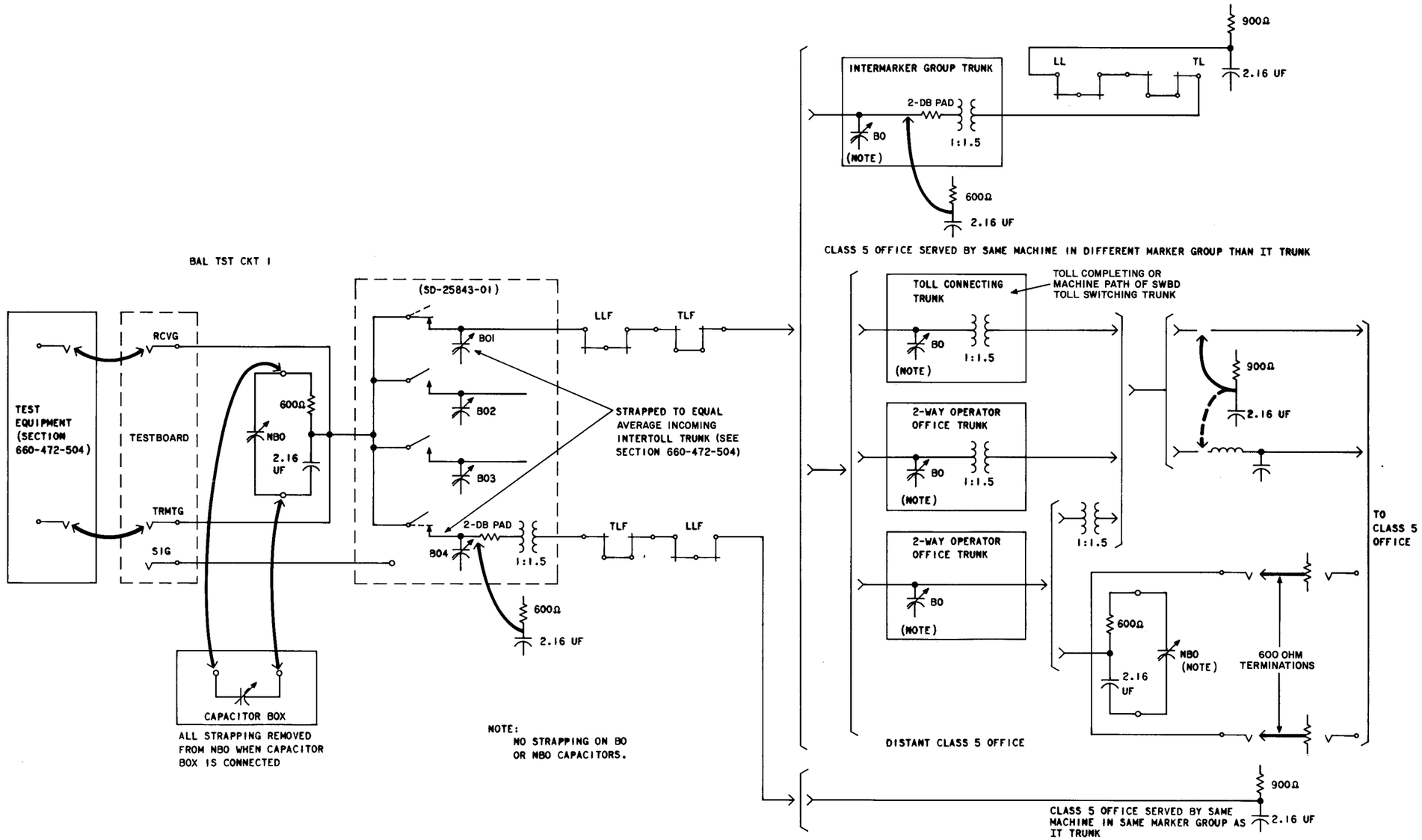
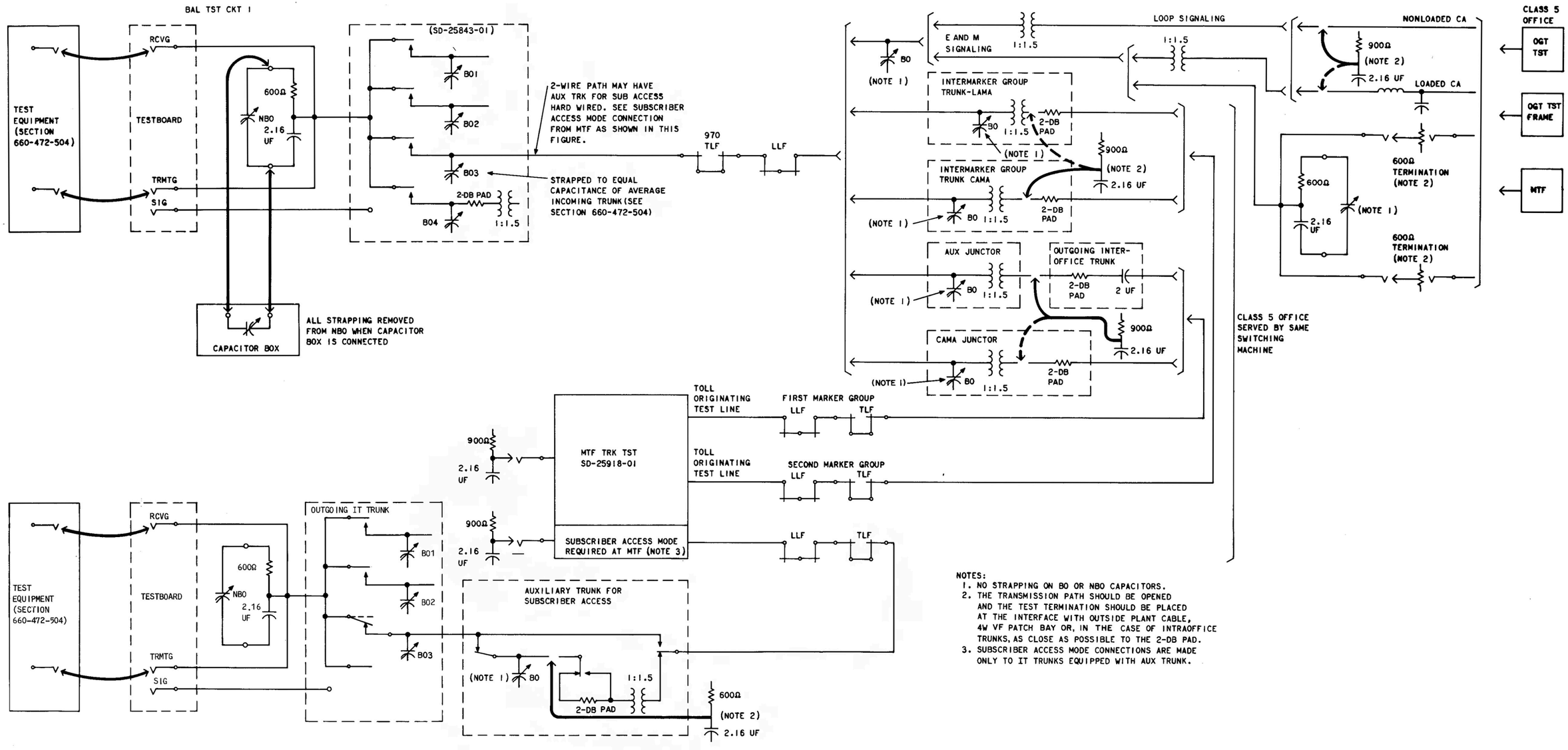
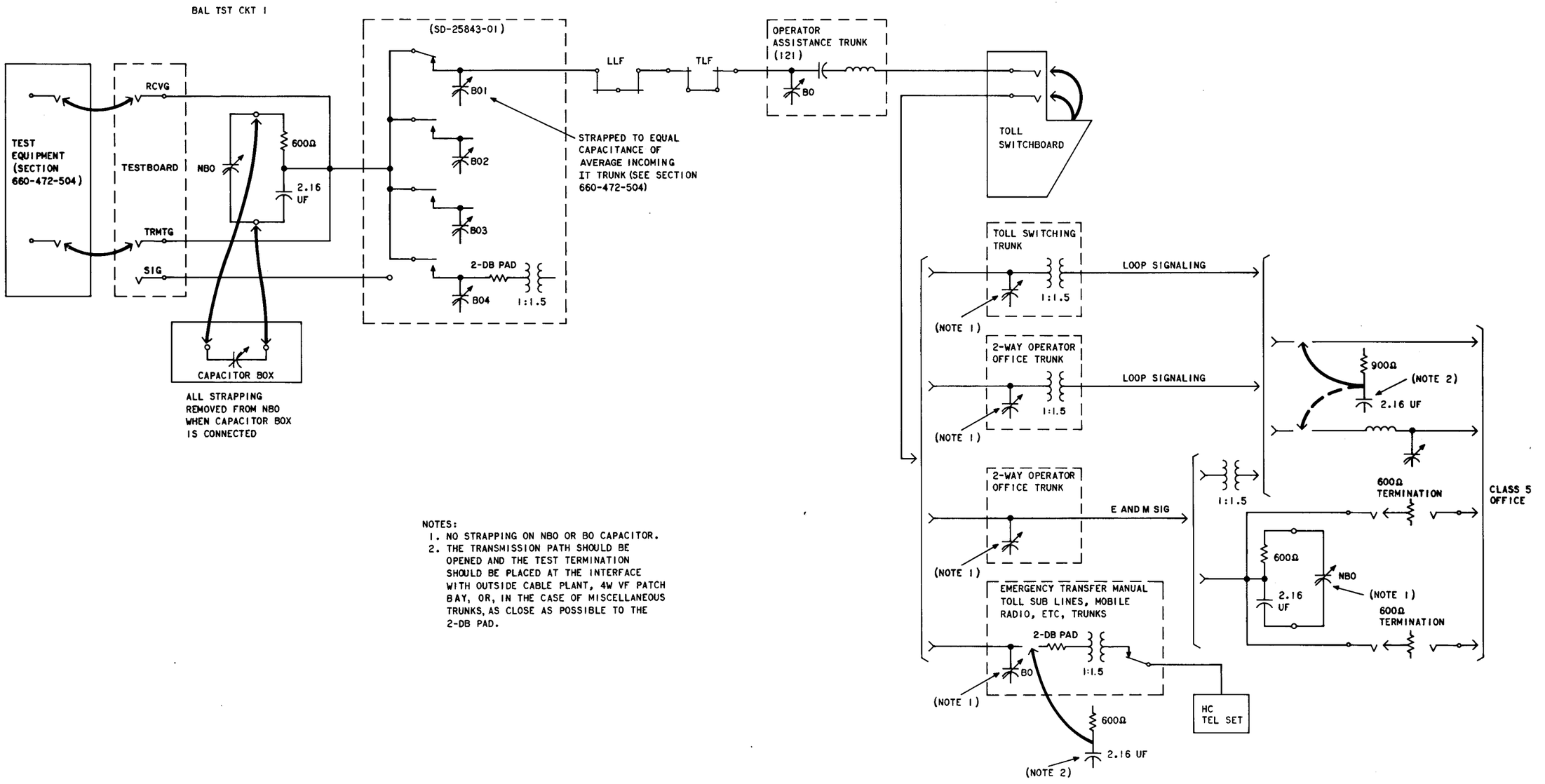


Fig. 5—Class 4 Offices: Paths From IT to TC, Machine-Switched—TC, 2-Way OO, SWBD TS



NOTES:
1. NO STRAPPING ON BO OR NBO CAPACITORS.
2. THE TRANSMISSION PATH SHOULD BE OPENED AND THE TEST TERMINATION SHOULD BE PLACED AT THE INTERFACE WITH OUTSIDE PLANT CABLE, 4W VF PATCH BAY OR, IN THE CASE OF INTRAOFFICE TRUNKS, AS CLOSE AS POSSIBLE TO THE 2-DB PAD.
3. SUBSCRIBER ACCESS MODE CONNECTIONS ARE MADE ONLY TO IT TRUNKS EQUIPPED WITH AUX TRUNK.

Fig. 6—Class 4 Offices: Paths From TC to IT Machine-Switched—AMA, CAMA, LAMA, TSPS



NOTES:
1. NO STRAPPING ON NBO OR BO CAPACITOR.
2. THE TRANSMISSION PATH SHOULD BE OPENED AND THE TEST TERMINATION SHOULD BE PLACED AT THE INTERFACE WITH OUTSIDE CABLE PLANT, 4W VF PATCH BAY, OR, IN THE CASE OF MISCELLANEOUS TRUNKS, AS CLOSE AS POSSIBLE TO THE 2-DB PAD.

Fig. 7—Class 4 Offices: Paths From IT to TC via Toll Switchboard—SWBD TS, 2-Way OO (Outgoing), Miscellaneous (TOLL SUB, EMG TRF, Mobile Radio, etc)

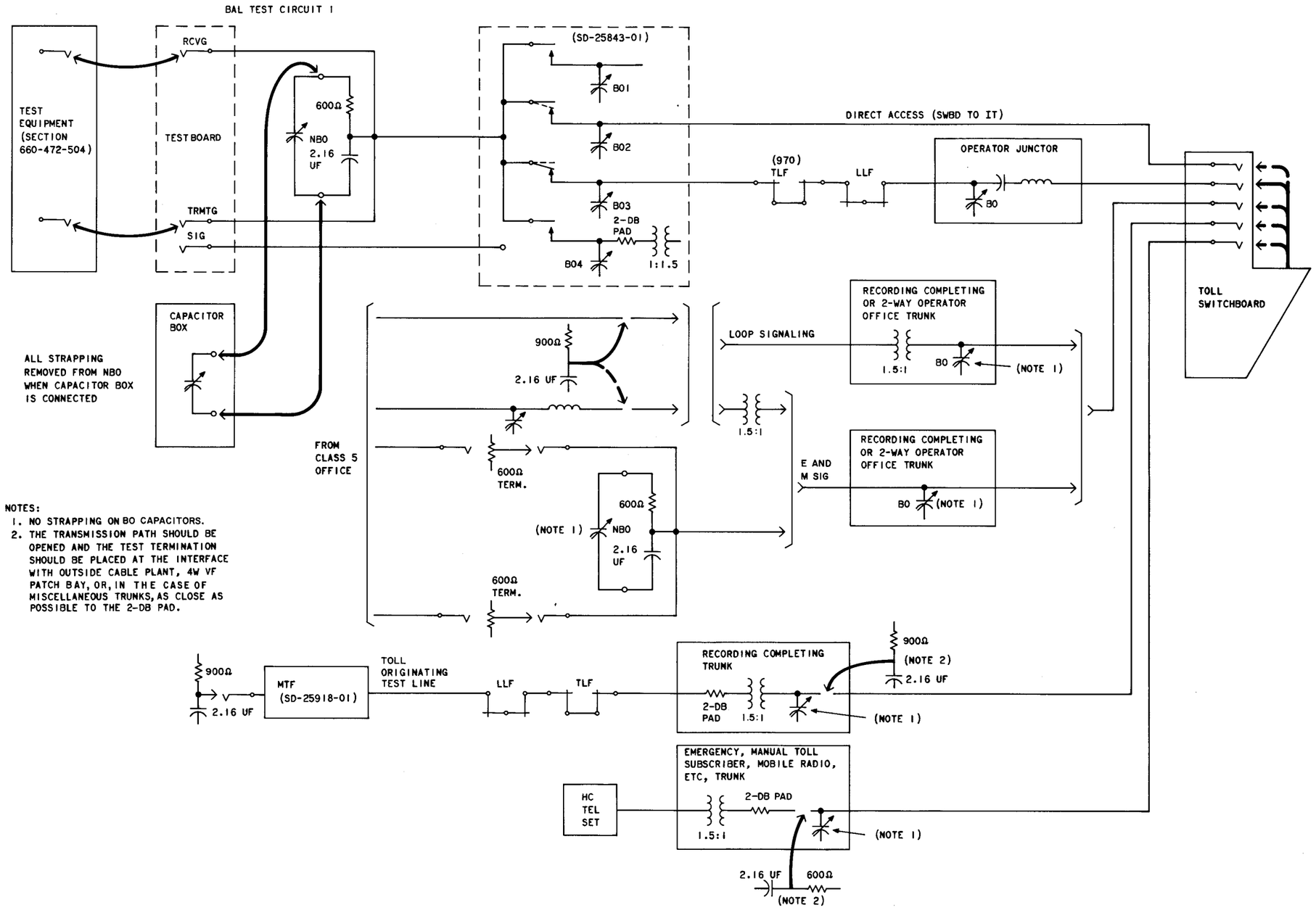


Fig. 8—Class 4 Offices: Paths From TC to IT via Toll Switchboard—RC, 2-Way OO, Miscellaneous (TOLL SUB, EMG TRF, Mobile Radio, etc)

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)
1C 120PH 1G	900Ω	1:1	0.67	1.0	0.67
1D 120NH	600Ω	1:1	1.0	1.0	1.0
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	0.07

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