

**TRAFFIC SERVICE POSITION SYSTEM NO. 1**  
**REMOTE TRUNKING ARRANGEMENT**  
**POSITION SUBSYSTEM 2**  
**AUTOMATIC COIN TOLL SERVICE**  
**BALANCE**  
**GENERAL INFORMATION**

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**1. GENERAL**

1.01 Transmission balancing is the combination of adjustment, measurement, and evaluation processes employed to control echo and singing at a hybrid junction needed to provide the necessary conversion between 2-wire and 4-wire facilities. This section covers the general information pertaining to these processes and their applications in Traffic Service Position System No. 1 (TSPS No. 1), both at the Base Unit and at the Remote Trunk Arrangement (RTA) installations. It should be noted that both the TSPS Base Unit switching network and the RTA concentrator are 2-wire switches.

1.02 This section is reissued to include the general balance information for the Automatic Coin

Toll Service (ACTS) feature of the TSPS No. 1. Change arrows are used to indicate additional information related to ACTS.

**1.03** The general considerations contained in this section provide a basic understanding of the purposes, requirements, apparatus, measurements, and techniques encountered in the balancing processes. Detailed information concerning specific areas within the broad scope of balancing can be found in the reference material outlined in Part 11. Additional sections which concern balancing in TSPS Base Units and/or RTAs and provide more detail are as follows.

SECTION	TITLE
660-463-010	Administration and Records
660-463-500	Base Unit Balance
660-463-502	RTA Balance
660-463-504	Balance Test Equipment and Test Circuits—Base Units and RTAs

**1.04** The information contained in this section and the sections listed above can be applied to balance work initially in a new base unit or RTA installation or on a circuit-order work basis. The structure of the information contained in these sections is in accordance with the sequence required in the performance of balance work.

**1.05** The initial performance and subsequent maintenance of balance in all TSPS base units and RTAs is important and essential to meet present-day toll transmission objectives. Balancing in a TSPS base unit or RTA is directly related to the length and type of switchboard cabling and the types of trunk circuits and other equipment and/or apparatus appearing in the 2-wire voice transmission path through a TSPS base unit or RTA concentrator. A comprehensive system of records for all balancing work is required. These records should also reflect any subsequent balance work performed as required in circuit-order work. Proper records permit periodic inspection to determine whether the uniqueness of balance conditions within a TSPS base unit or RTA concentrator has been disturbed.

## 2. SYSTEM DESCRIPTION

**2.01** A functional block diagram of the voice transmission configuration of a TSPS base unit, operator positions, and an RTA is presented in Fig. 1. Referring to Fig. 1, the Position Subsystem No. 2 (PSS No. 2), the service observing circuit, the PSS No. 1, and coin detection and announcement (CDA) circuits all have 2-wire appearances on the position link circuit of the TSPS base unit switching network. The facilities for the PSS No. 1, PSS No. 2 operator positions, the CDA circuit and the service observing circuit are 4-wire. The 2-wire to 4-wire conversion is provided by a 1P 4-wire terminating set, or equivalent.

**2.02** The following types of trunks have a 2-wire appearance on the trunk link circuit of the TSPS base unit switching network and can be connected to at least one of the four types of trunks having an appearance on the position link circuit of the TSPS base unit switching network discussed above:

- (a) Toll-connecting (TC) trunks
- (b) Inward trunks
- (c) Delayed call trunks
- (d) Base-remote (BR) trunks
- (e) Operator service trunks
- (f) Incoming centralized automatic message accounting (CAMA) transfer trunks
- (g) Service observing trunks when service observing trunk access circuit SD-1B275-01 is used.
- (h) CDA Circuits .

All BR trunks are 4-wire while operator service trunks and incoming CAMA transfer trunks may be either 2-wire or 4-wire. When 4-wire facilities are used in these types of trunks, a 900-ohm 4-wire terminating set (eg, 1M terminating set, or equivalent) is used to provide the necessary 2-wire to 4-wire conversion. Toll-connecting trunks may provide either TSPS 4-wire bridging access via a TSPS, 4-wire bridging repeater or TSPS 2-wire bridging access via a straight bridging arrangement. All inward trunks, delayed call trunks, and service

observing trunks provide TSPS 4-wire bridging access via a TSPS 4-wire bridging repeater. A 900-ohm 4-wire terminating set (4WTS) is incorporated in the 3-way, 4-wire bridging repeater to provide the necessary 2-wire to 4-wire conversion on inward trunks, delayed call trunks, service observing trunks, and TC trunks providing TSPS 4-wire bridging access.

**2.03** Referring to Fig. 1, all BR trunks and inward trunks associated with an RTA are 4-wire facilities but have 2-wire appearances on the RTA concentrator. The TC trunks also have 2-wire appearances on the RTA concentrator but may provide RTA 4-wire bridging access via TSPS 4-wire bridging repeater or RTA 2-wire bridging access via a straight bridging arrangement. As indicated earlier, a 900-ohm 4WTS is incorporated in the 3-way, 4-wire bridging repeater to provide the necessary 2-wire to 4-wire conversion. A 1P 4WTS is used to provide the necessary 2-wire to 4-wire conversion at the RTA concentrator location of the BR trunks.

**2.04** Referring to Fig. 1, the CDA type I circuit has two 4WTS. A 1P 4WTS with its 2-wire appearances on the position link and a 1M 4WTS with its 2-wire appearance on the trunk link. The CDA type II circuit shown in Fig. 1 has two 4WTS and a 3-way, 4-wire bridging repeater, a 1P and 1M 4WTS with their 2-wire appearances on the position link. The 2-wire port of the 3-way, 4-wire bridging repeater has its appearance on the trunk link.

### 3. TRANSMISSION CONSIDERATION

#### A. General

**3.01** The TSPS No. 1 Base Unit and the RTA concentrator are 2-wire switches. All position trunks and base remote trunks are on 4-wire facilities. The transmission paths of trunks terminating on the trunk link or RTA concentrator are either 2- or 4-wire. The interface between 2-wire and 4-wire circuits is a transformer-type hybrid circuit known as a 4-wire terminating set (4WTS).

**3.02** Fig. 2A demonstrates the power division that occurs when a signal is applied to any port of a balanced hybrid coil arrangement such as that used in 4WTS. The figure assumes that all impedances including the source impedance are

identical. First if  $Z_3$  is a signal source, and  $Z_4$  is an impedance equal to  $Z_3$ , the hybrid circuit will split the energy between  $Z_1$  and  $Z_2$ . The signal from  $Z_3$  is balanced out in the hybrid so that it does not appear in  $Z_4$ . Second,  $Z_2$  may represent a signal source. Energy transmitted through the hybrid divides between  $Z_3$  and  $Z_4$ . The signal is balanced out so that it does not appear in  $Z_1$ .

**3.03** Applying the parameters listed in Note 2 of Fig. 2A to impedances  $Z_1$  through  $Z_4$  of the balanced hybrid coil arrangement permits this model to be used to analyze the operation of a typical 4WTS which is shown in Fig. 2B. Here, the impedance value of the circuit connected to the balance network port ( $Z_1$ ) and the impedance value of the circuit connected to the 2-wire line port ( $Z_2$ ) are indicated to be different (impedances are not matched). In addition, the impedance value of the circuit connected to the 4-wire receive port ( $Z_3$ ), a 600-ohm signal source, and the impedance value of the circuit connected to the 4-wire transmit port ( $Z_4$ ), a 600 ohm power detector, are indicated to be the same (impedances are matched). This is the general case in most applications of a 4WTS before any impedance balancing is made between the balance network and the 2-wire circuit connected to the 2-wire line port. Transmission is from the amplifier with output impedance  $Z_3$  to the two-wire trunk with impedance  $Z_2$  and from the two-wire trunk  $Z_2$  to the amplifier with impedance  $Z_4$ . When transmitting from  $Z_2$  to  $Z_4$  half the energy is dissipated in  $Z_3$ , but the signal is not transmitted through the amplifier because of its one-way transmission characteristics. When transmitting from  $Z_3$  to  $Z_2$  half the power is lost in  $Z_1$ . The important thing, however, is that no energy reaches  $Z_4$ . If this were not so, the signal would circulate through the two sides of the four-wire trunk and the hybrid circuits at each end, being amplified by the amplifier circuits each time. This could result in circuit instability, or singing, as discussed in paragraph 3.06.

**3.04** The loss between  $Z_3$  and  $Z_4$  or between  $Z_2$  and  $Z_1$  is known as hybrid balance. In carefully controlled laboratory circuits, a balance of 50 dB is easily achievable. However, in the application described, impedance  $Z_2$  represents any of a large number of two-wire trunks which may be switched into the connection. The impedances of these trunks vary widely, and so only a compromise value may be used for  $Z_1$  to provide

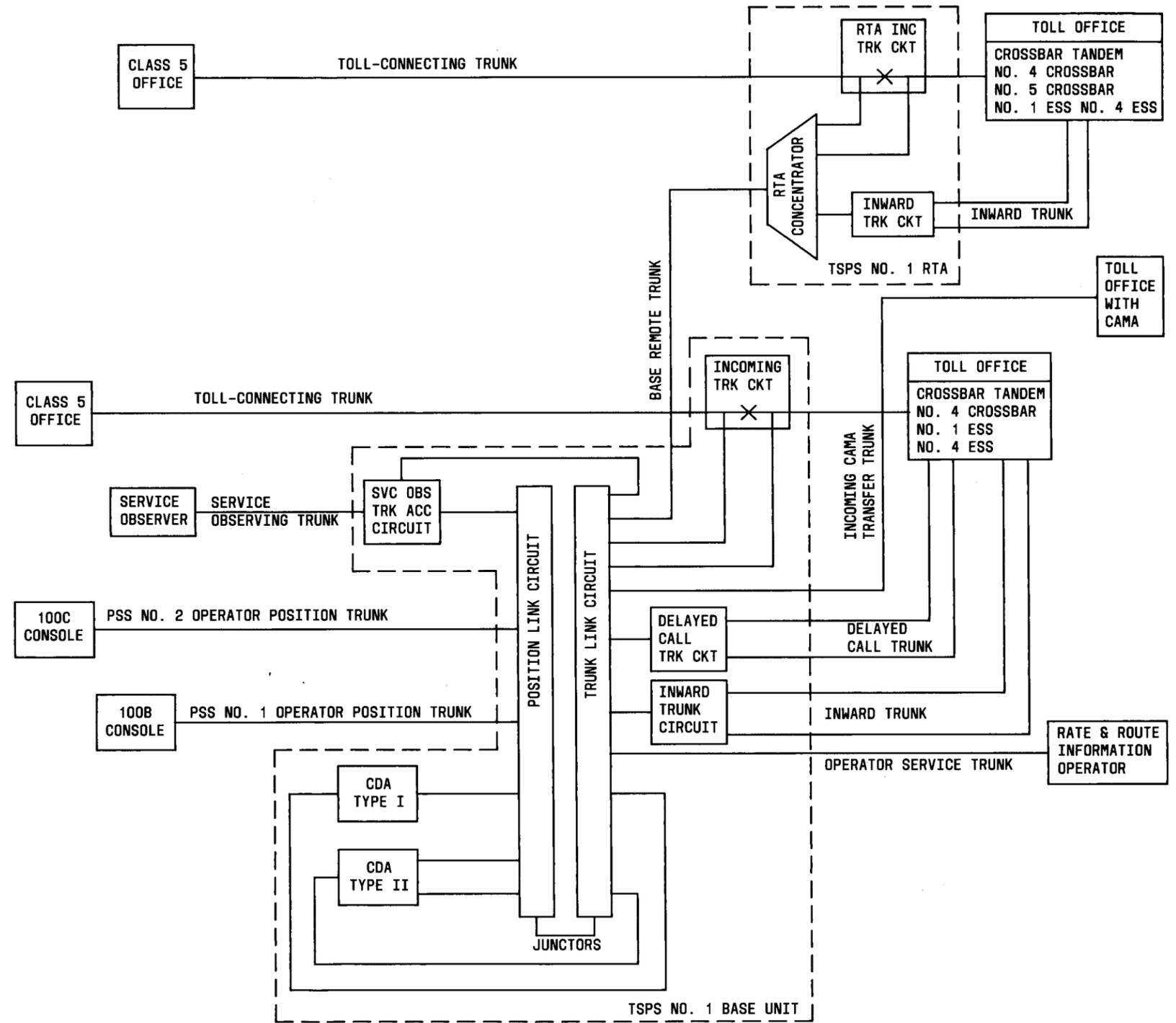
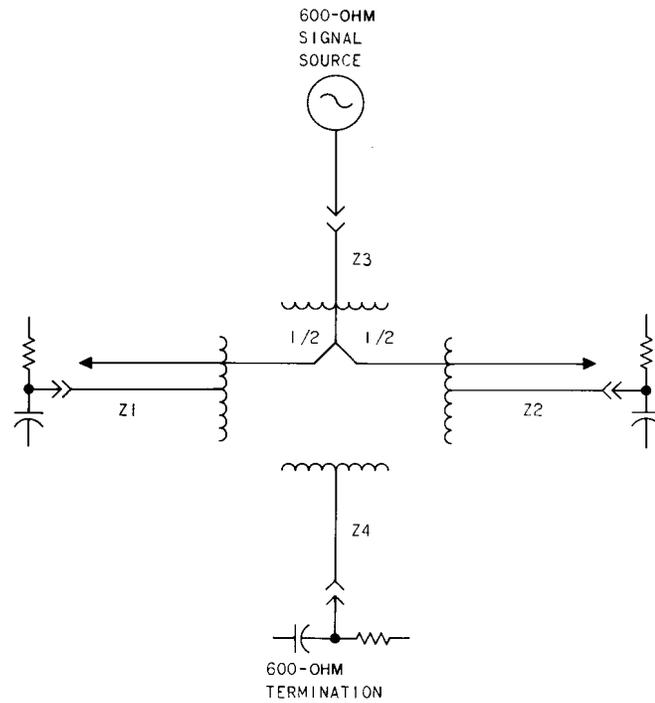
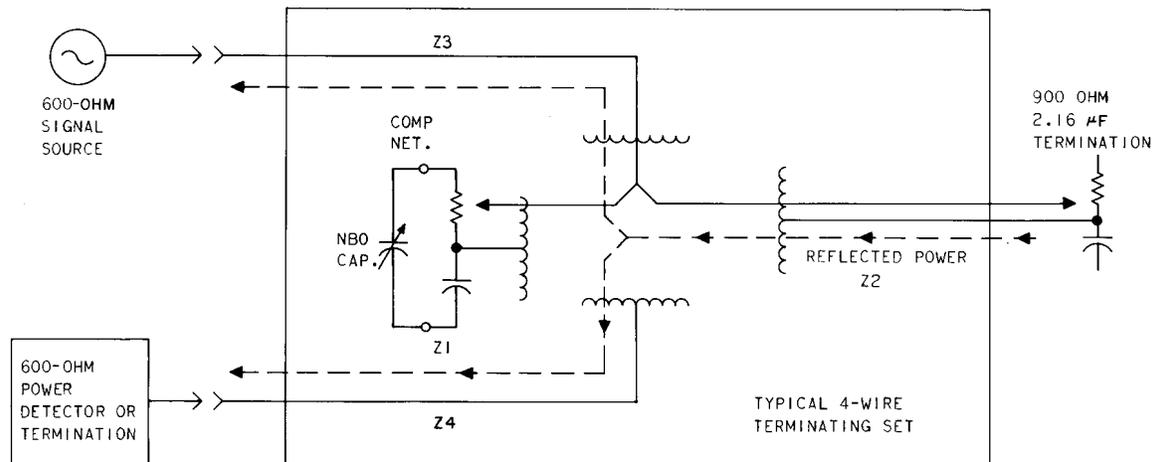


Fig. 1—Traffic Service Position No. 1—Voice Transmission Configuration



- NOTES:
1.  $Z1 = Z2, Z3 = Z4$
  2. PARAMETERS ARE COMPARED TO PARAMETERS OF FIG. 3B AS FOLLOWS:  
 $Z1$  = 2-WIRE NETWORK LINE  
 $Z2$  = 2-WIRE LINE  
 $Z3$  = 4-WIRE RECEIVE  
 $Z4$  = 4-WIRE TRANSMIT

A. POWER DIVISION IN A BALANCED HYBRID COIL ARRANGEMENT



B. INPUT AND REFLECTED POWER PATHS IN TYPICAL 4WTS

Fig. 2—Hybrid Power Division and Application

control of echoes that are returned to the speaker at four-wire terminating sets.

**3.05** When supposedly matched impedances are in reality unequal in either their resistive or reactive components, or both, the hybrid balance deteriorates so that the achievable balance may be much less than 50 dB. When this occurs, echo is produced in the transmission circuit. The echo may be evaluated in terms of the return loss at the hybrid junction, which may be measured as described later in this Section.

## **B. Echo and Singing**

**3.06** Whenever the impedance of the 2-wire circuit connected to the 2-wire line port of a 4WTS differs from the impedance of the balancing network of this 4WTS, some of the incident signal power is reflected. That portion of the reflected signal power reaching the 4-wire transmit port of the 4WTS is returned to the distant end. If this portion of the reflected signal power is received at the distant end with sufficient magnitude, significant impairments to transmission can occur.

**3.07** Subjective testing has shown that a talker, hearing his own words returned with sufficient volume and sufficient delay, will experience disturbance of his thought process and interference with his ease of conversation. This type of transmission impairment is called talker echo. The effect of operator talker echo on a given call will most likely be to increase the TSPS operator work time on that call. Another type of transmission impairment caused by the return of reflected signal power occurs when the power of the returned signal is sufficiently large at one or more frequencies to start self-sustained oscillations. This type of transmission impairment is called singing (ie, circuit instability) or near singing (ie, circuit oscillation will eventually damp out). Singing will always exist in a 4-wire circuit with 4WTSs at both ends of the circuit where the transmission gains in the circuit exceed the transmission losses in the circuit including the transhybrid loss (THL) of both 4WTSs. Singing will most likely make the connection unusable and could result in an acoustic disturbance problem for the TSPS operator. The energy paths for both types of transmission impairment are shown in Fig. 3.

**3.08** In the various possible connections involving TSPS operators, the voiceband frequencies

are normally limited to the 200-Hz to 3200-Hz frequency range. When transmission in any connection is impaired by echo, the frequencies which most talkers will notice as objectionable are in the 500-Hz to 2500-Hz frequency range. At these frequencies, the talker will normally complain of echo somewhat before the circuit will start to sing. Therefore, the balancing objectives for control of the return loss in this frequency range are more stringent than would otherwise be necessary to prevent circuit singing in this frequency range.

**3.09** Circuit singing will generally occur in the frequency ranges from 200 Hz to 500 Hz and from 2500 Hz to 3200 Hz. Singing or near singing in these frequency ranges will be noticed by a talker before he will complain of any echo impairment. Near singing is sometimes referred to as being a hollow sound, like speaking into an empty barrel. Near singing will occur somewhat before actual singing starts. Fig. 4 indicates the echo and singing frequency ranges within the voice-frequency (VF) band.

**3.10** Referring to the energy paths illustrated in Fig. 3, it should be noted that the talker echo path is dependent upon the balance conditions at only one end of a 4-wire facility. Another type of echo impairment is possible which manifests itself as a second signal received by the listener but delayed in time and changed in amplitude. This type of transmission impairment is called listener echo. Listener echo is dependent upon poor balance of the 4WTSs at both ends of a 4-wire circuit or facility. Since controlling the talker echo energy paths in both directions of transmission will also result in control of the listener echo energy path, the listener echo paths are not specifically considered in balancing procedures.

**3.11** Singing and near singing transmission impairments are also dependent upon poor balance conditions at the 4WTS at each end of a 4-wire circuit or facility. Unlike the listener echo transmission impairment which is influenced by propagation delay, singing and near singing transmission impairments are influenced by frequency, phase relationships, transmission gains and losses, and power addition.

**3.12** As discussed above, talker echo impairment and singing and near singing impairments are different, although occurring as a consequence of the same mechanisms, eg, the imperfect balancing

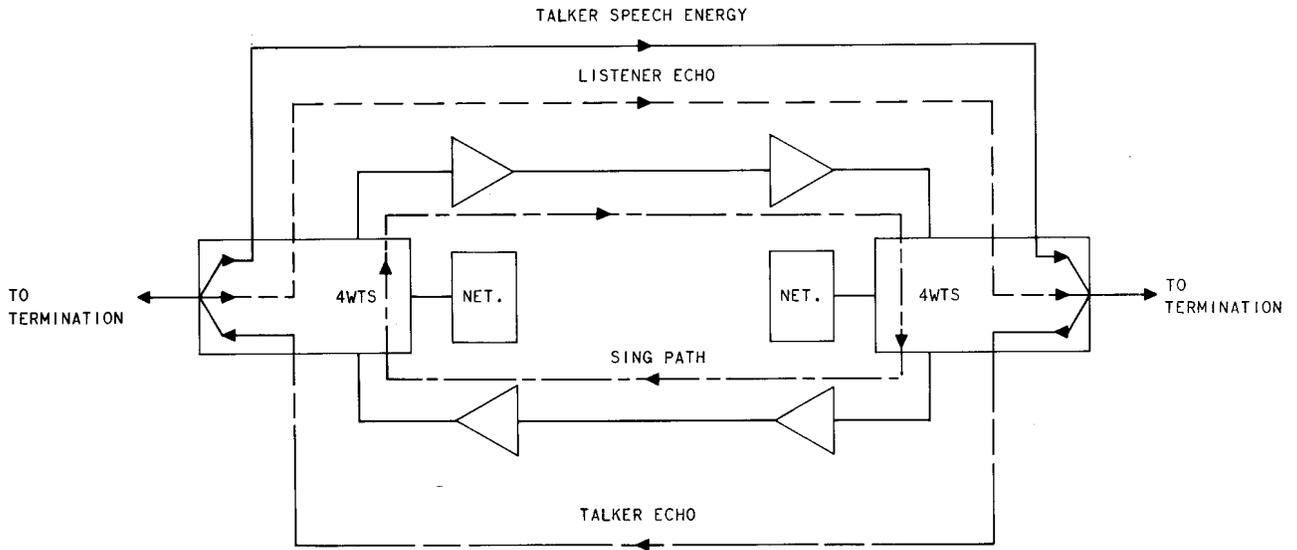


Fig. 3—One-Way Energy Paths in 4-Wire Terminated Circuits Terminating in 2-Wire Circuits

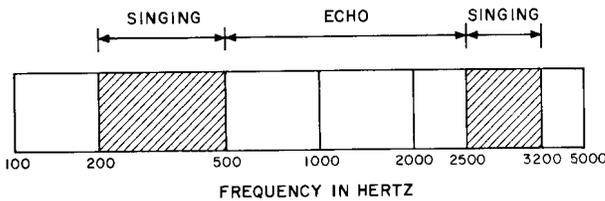


Fig. 4—Echo and Singing Ranges in a Typical Voiceband Frequency Spectrum

of a 4WTS. Consequently, balancing of a 4WTS includes separate test methods for each of these two types of transmission impairment. Echo return loss (ERL) measurements of the balance of a 4WTS determine the echo conditions. The singing point, or equivalently the singing return loss (SRL), measurements of the balance of a 4WTS determine the singing and near singing conditions. The results of both measurements are necessary to obtain integrity in the evaluations of balance in a given circuit.

**C. Definitions**

**Return Loss**

3.13 Return loss (RL) is the measure of an impedance match between circuits at the point of their interconnection. It can be expressed for any frequency as:

$$RL \text{ (in dB)} = 20 \log_{10} \left| \frac{Z_1 + Z_2}{Z_1 - Z_2} \right|$$

Where  $Z_1$  and  $Z_2$  are the impedances of the interconnecting circuits. Considering this equation, it can be seen that at a given frequency the RL is infinite at the interconnection point when the impedances are equal (balanced), since,  $20 \log$  of infinity is defined to be infinity and 2 divided by zero is defined to be infinity. Conversely, a complete mismatch will occur when either, but not both,  $Z_1$  or  $Z_2$  is zero. The RL at that frequency then becomes zero since  $20 \log$  of one is zero.

**Echo Return Loss**

3.14 An echo return loss (ERL) measurement is a weighted average measurement of the RLs for all of the frequencies in the echo frequency range. The signal source used for this ERL measurement includes all frequencies in the echo band and is weighted to approximate a human male voice. The power level of each frequency in the echo band is then added on a power summation basis, and a composite ERL is presented by the detector. This measurement does not necessarily indicate the RL at an individual frequency.

**3.15** The KS-20501 return loss measuring set (RLMS), or equivalent, is used in the balance test procedures for TSPS base units and RTAs. This test set uses a noise generator capable of a frequency output from dc to 200 kHz. The desired noise band and weighting for a given test is obtained by use of bandpass filters in the transmit section of the RLMS. The detector section of the KS-20501 RLMS is not weighted for frequencies up to 15 kHz and measures the power of all frequencies in this band on an as-received basis. For this reason, it is necessary that the circuit under test meet noise requirements before RL measurements are made. It should be noted that circuits which have 60-Hz noise can meet C-message weighted noise requirements and still affect the RL reading. More information on the KS-20501 RLMS may be found in Section 103-106-115.

#### Singing Point/Singing Return Loss

**3.16** The singing point is a measure of the RL for a single frequency in the VF band (200 Hz to 3200 Hz). This single frequency is usually but not always the frequency having the poorest return loss at the hybrid interconnection and is the critical frequency in the VF band at which transmission gain and phase relationship would most likely cause a singing condition. When singing conditions exist in a circuit and the degree of balance is conducive to singing, it may occur at any frequency within the VF band. However, as a consequence of the impedance characteristics in 2-wire line apparatus and equipment, the upper and lower ends of the VF band will generally contain the critical frequency as previously discussed in paragraph 3.06.

**3.17** The singing return loss (SRL) may be determined using the KS-20501 RLMS. The SRL at the hybrid interconnection is the lesser of two SRL measurements made using the KS-20501 RLMS; namely (a) SRL at the low end of the VF band (TEST TYPE switch of the KS-20501 RLMS set to SRL) and (b) SRL at the upper end of the VF band (TEST TYPE switch of the KS-20501 RLMS set to SRL HI). The KS-20501 RLMS functions in the same manner during these SRL measurements as described in paragraph 3.12 during ERL measurements.

**3.18** It has been demonstrated that the SRL readings obtained using a KS-20501 RLMS for a given circuit correspond closely with SP measurements on the same circuit. Thus, the SP and SRL may be considered as equivalent, the difference being in the manner in which they are obtained. Consequently, singing point measurements will not be required on circuits associated with TSPS Base Units or RTAs, and SRL measurements using the KS-20501 RLMS will suffice in all instances.

#### Point of Good Impedance

**3.19** The term "point of good impedance of a trunk," as used in balancing procedures, is defined as a point of an essentially fixed 2-wire impedance, usually either a nominal  $600\Omega + 2.16 \mu\text{F}$  or  $900\Omega + 2.16 \mu\text{F}$ . This is where balancing terminations should be applied or where balance measurements should be made in the test procedures used to enable the necessary adjustments to be made to balance a given 2-wire switch. For example, the point of good impedance of a trunk using 4-wire facilities is usually provided at a 4WTS while that of a trunk using all 2-wire facilities is usually provided at an impedance compensator. Impedance matching to obtain a point of good impedance is a prerequisite to good balance of any 2-wire switch in order to remove any impedance irregularities that may exist between the facilities and the nominal impedance of the switch.

**3.20** The appearance of all trunks on the trunk link circuit of the TSPS base unit switching network has a nominal impedance of  $450\Omega + 4.32 \mu\text{F}$ . This value was chosen because it is the nominal impedance seen by a bridge on a properly terminated 2-wire 900-ohm trunk which corresponds to the actual case of TSPS 2-wire access to a TC trunk. This nominal impedance is achieved for all other types of trunks having an appearance on the trunk link circuit through use of an impedance matching network associated with the TSPS 4-wire bridging repeater or associated with the trunk circuits in BR trunks, operator service trunks, incoming CAMA transfer trunks, CDA circuits, and service observing circuits. In order for the impedance matching network associated with any of these trunks to produce the desired results, the point of good impedance of the associated trunk facilities for each of these types of trunks should be nominally

900 $\Omega$  + 2.16  $\mu$ F with one exception. The incoming CAMA transfer circuit SD-1B016-01 includes an impedance matching transformer (ie, 120T repeating coil) with the appropriate wiring options to permit the point of good impedance of the incoming CAMA transfer trunk facilities to be either 600 $\Omega$  + 2.16  $\mu$ F or 900 $\Omega$  + 2.16  $\mu$ F.

**3.21** The point of good impedance of all operator positions trunks of both PSS No. 2 and retrofitted PSS No. 1, CDA circuits, and all service observing trunks having an appearance on the position link circuit of the TSPS Base Unit switching network is provided by the 1P 4WTS. The nominal input impedance of the 1P 4WTS is 11,550 ohms. Since there is no impedance matching network associated with the operator cut-through circuit SD-1B020-01, the position link appearance of these types of trunks has a nominal impedance of 11,550 ohms. The impedance matching network associated with the TSPS 4-wire bridging repeater or with the various TSPS Base Unit circuits provides the total required impedance matching interface between the 1P 4WTS and the 900 $\Omega$  + 2.16  $\mu$ F point of good impedance of the trunk facilities associated with the trunks having a trunk link circuit appearance.

**3.22** The above discussion on the TSPS base unit switching network also applies to the RTA concentrator. In this case, the 1P 4WTS provides the point of good impedance at the RTA end of a BR trunk and the 900-ohm 4WTS associated with the TSPS 4-wire bridging repeater provides the point of good impedance of the 4-wire TCTs and inward trunks served by the RTA. The required impedance matching network is provided with the TSPS 4-wire bridging repeater.

#### **4. APPARATUS CONSIDERATIONS**

##### **A. General**

**4.01** Typical trunking and switching arrangements in a TSPS No. 1 base unit which has both the PSS No. 2 and the RTA features are illustrated in Fig. 5. Fig. 6 illustrates the typical trunking and switching arrangements in an RTA. The apparatus and equipment shown in these figures are representative of that found in TSPS Base Unit and RTA installations.

**4.02** A compromise network (COMP NET) which is part of the balancing network of a 4WTS plays an important part in the balancing process

and is the impedance to which all 2-wire connections to the 2-wire line port of the 4WTS are balanced. A COMP NET is designed to provide impedances over the VF band (200 Hz to 3200 Hz) that will match the nominal impedance of the 2-wire circuits which may be connected to the 2-wire line port of that 4WTS. For example, a PSS No. 2 operator position trunk of a TSPS base unit can be connected through the TSPS base unit switching network to many different types of trunks and to many different trunks within each trunk type category. Although all of these connecting trunks have a nominal impedance of 450 $\Omega$  + 4.32  $\mu$ F, the actual impedance of each of these trunks will vary. This variation is due to different lengths of office cabling, the normal variation among different equipment in the same types of trunks, different equipment arrangements for each type of trunk, and/or different types of cable pairs.

**4.03** The network connected to the balancing network port of 1P 4WTS of the PSS No. 2 must adequately balance the impedance of any particular one of the many possible 2-wire circuits which may be connected to the 2-wire line port of the 1P 4WTS. To achieve this, a COMP NET consisting of a 450-ohm resistor in series with a 4.32  $\mu$ F capacitor is used in the balancing network of the 1P 4WTS with provisions for adding an adjustable network build-out capacitor (NBOC) in parallel with the COMP NET. A new bridging D1C channel unit containing the equivalent of a 1P 4WTS is used to replace the existing bridging D1C channel unit of the PSS No. 1 operator position trunk during retrofit.

**4.04** In a similar manner, the balancing network of the 900-ohm 4WTS associated with the 4-wire trunk which terminates on the trunk link circuit of the TSPS switching unit was chosen to consist of a COMP NET of a 898-ohm resistor in series with a 2.15  $\mu$ F capacitor plus an adjustable NBOC. The same balancing network will also be used in the 900-ohm 4WTSs used in the 24V4 repeaters associated with the TSPS base unit end of BR trunks, operator service trunks, and incoming CAMA transfer trunks.

**4.05** In any given TSPS base unit or RTA, the various trunks will have different impedances at any frequency from trunk to trunk because of the different amounts of resistance and reactance introduced by office wiring, circuits, and apparatus located between the point of good impedance of

the various trunks and their appearance on the switching network. Return loss, and consequently the degree of balance, depends upon both of these components of impedance. Resistance mismatch is controlled by limiting the maximum length of office wiring (26-gauge switchboard cable) in the 2-wire paths in the TSPS base units and RTAs. The NBOC parallel to the COMP NET in the balancing networks of both 1P 4WTSs and 900-ohm 4WTSs is used to control reactance mismatch.

**4.06** The ideal 2-wire line extending from the point of good impedance of a trunk through the switch to a 4WTS would have office cable and apparatus causing little or no modification in the value of the point of good impedance of the trunk. As a consequence, the impedance presented to a 4WTS by any trunk connected through the switch would be quite similar to the impedance of the COMP NET of the balancing network of the 4WTS. However, long cable lengths, toll office switchbank multiples, and toll office testboard multiples are associated with some types of trunks but not with other types of trunks. This results in significant variations in cabling capacity between different trunks which may be connected to the same 4WTS and could make it impossible to meet balance requirements with a single value for the NBOC of the balancing network. Consequently, drop build-out capacitors (DBOCs) are provided in the 2-wire lines from the point of good impedance of some trunks to the Base Unit or RTA switch to permit narrowing the range of cable capacitance presented to a given 4WTS when connected to a number of different trunks.

**Cabling Length Restrictions**

**4.07** No resistance build-out capability is currently provided in the balancing networks of the 1P 4WTS and the 900-ohm 4WTS used in TSPS base unit and RTA applications. Therefore, it is necessary to limit the value of the cabling resistance of the 2-wire path between the point of good impedance of each type of trunk through the TSPS base unit switching network or the RTA concentrator to a 4WTS. In TSPS base units and RTAs, 26-gauge switchboard (26SB) cabling is used exclusively so that reasonable control of the series resistance factor of the 2-wire impedance of a trunk can only be accomplished by a TSPS base unit and RTA layout which limits the length of SB cabling in the 2-wire paths in the various allowable connections. Therefore, when equipment rearrangements,

additions, deletions, and modifications are made which change the amount of 26SB cabling in these 2-wire paths, the impedances will change and the effect on the balance in the TSPS Base Unit or RTA should be investigated.

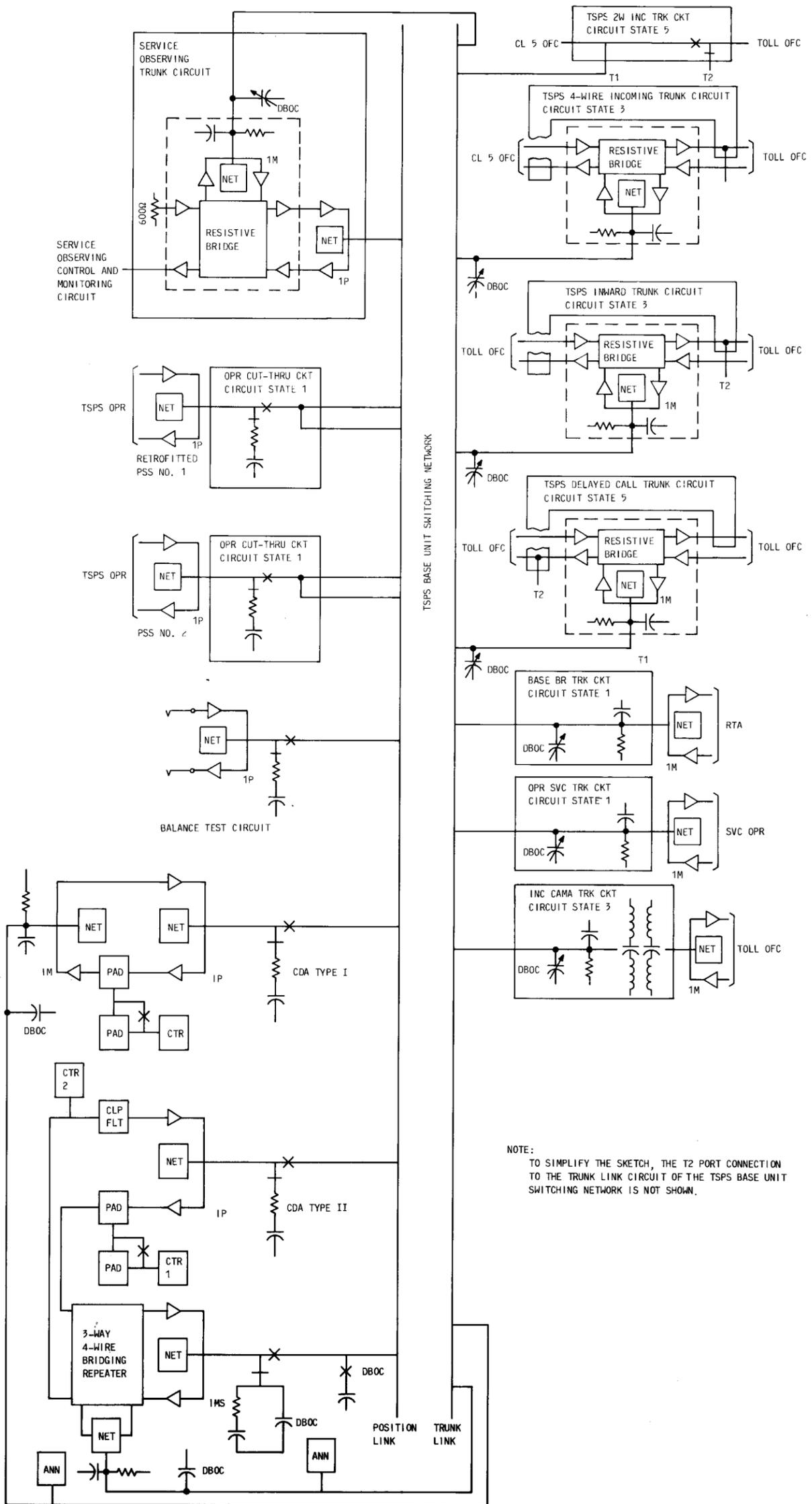
**4.08** The restrictions on the length of 26SB cable permitted in the various possible voice transmission connections through the TSPS base unit and RTA are summarized in Tables A and B, respectively. These restrictions apply only if DBOCs are provided in the 2-wire path where indicated (see Fig. 5 and 6). These restrictions are rather sensitive to the value of the resistance portion of the impedance matching network associated with the TSPS, 4-wire bridging repeater. The value of the resistance portion of the impedance matching network of the 3-way, 4-wire bridging repeater is 942 ohms. The value of the resistance portion of the impedance matching network of the base trunk BR trunk circuit (SD-1B135-01), and the incoming CAMA transfer trunk circuit (SD-1B016-01) is 942 ohms. The resistance portion of the impedance matching network of the operator service trunk is 1020 ohms.

**4.09** The maximum cable length restriction requirements summarized in Tables A and B do not include requirements on the maximum length and the gauge of office wiring to interconnect on a 2-wire basis the TSPS 2-wire incoming trunk circuit (located at either the Base Unit or the RTA), the toll office, and the point of good impedance of the TC trunk facilities. However, studies have shown that if terminal balance can be achieved in the toll office on connections involving such a TC trunk, then balance requirements can be met at the 1P 4WTS. Reliable toll office terminal balance NBOC values and balance records are essential prior to balancing a TSPS or RTA.

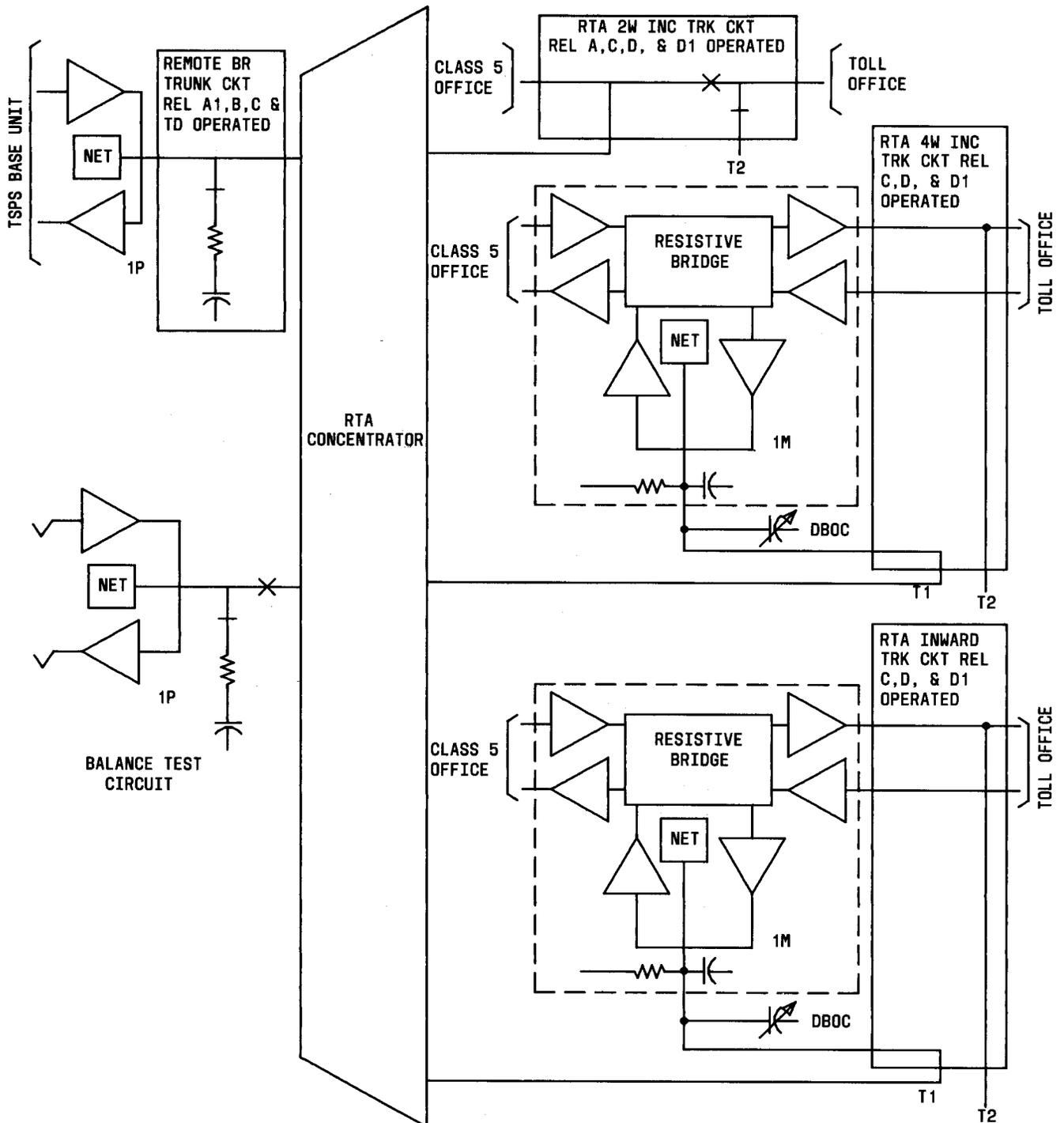
**Cabling Capacitance Restrictions**

**4.10** There is no specific maximum permissible value for the capacitance in the SB cabling for any 2-wire connection through either the TSPS Base Unit switching network or the RTA concentrator. The maximum adjustment available for the NBOC of the balancing network of the 1P 4WTS is 0.063  $\mu$ F. It should be noted that there is already a maximum value of capacitance in office cabling specified for any 2-wire connection to a 4WTS in the toll office to which these TCTs providing TSPS 2-wire access terminate. This maximum permissible

Fig. 5—TSPS Base Unit Trunks and Switching Arrangements



NOTE: TO SIMPLIFY THE SKETCH, THE T2 PORT CONNECTION TO THE TRUNK LINK CIRCUIT OF THE TSPS BASE UNIT SWITCHING NETWORK IS NOT SHOWN.



NOTE:  
 TO SIMPLIFY THE SKETCH, THE T2 PORT CONNECTION  
 TO THE RTA CONCENTRATOR IS NOT SHOWN.

Fig. 6—RTA Trunks and Switching Arrangements

TABLE A

**RESTRICTION ON MAXIMUM LENGTH OF 26-GAUGE SWITCHBOARD CABLE INCLUDED  
IN VARIOUS VOICE CONNECTIONS THROUGH A TSPS BASE UNIT**

CIRCUIT	CONNECTIONS AND CONNECTING CIRCUIT	MAXIMUM LENGTH (FEET)
Operator Position Trunk 1P 4WTS	PLN	100
2-Wire TC Trunk	TLN	150
3-Way, 4-Wire Bridging Repeater associated with 4-Wire TC Trunk	TLN	250
3-Way, 4-Wire Bridging Repeater associated with inward and delayed call trunk	TLN	250
Base-Remote Trunk	TLN	150
	24V4 Repeater	300
Operator Service Trunk	TLN	150
	24V4 Repeater	150
	NIC	150
Incoming CAMA Transfer Trunk	TLN	150
	24V4 Repeater	300
3-Way, 4-Wire Bridging Repeater associated with service observing trunk	TLN	250
	PLN	100
CDA Type I & II	TLN	250
	PLN	100

TABLE B

**RESTRICTION ON MAXIMUM LENGTH OF 26-GAUGE SWITCHBOARD CABLE INCLUDED  
IN VARIOUS VOICE CONNECTIONS THROUGH A TSPS RTA CONCENTRATOR**

CIRCUIT	CONNECTIONS AND CONNECTING CIRCUIT	MAXIMUM LENGTH (FEET)
2-Wire TC Trunk	RTA Concentrator	150
IP 4WTS	RTA Concentrator via BR Trunk	100
3-Way, 4-Wire Bridging Repeater associated with 4-Wire TC Trunk	RTA Concentrator	450
3-Way, 4-Wire Bridging Repeater associated with Inward Trunk	RTA Concentrator	450

value is limited by attenuation distortion characteristics such that the NBOC of the balancing networks of 4WTS in the toll office should not exceed 0.080  $\mu$ F. Large values of capacitance introduce increased attenuation distortion at the upper portion of the VF band (2000 Hz to 3200 Hz).

**4.11** Once the value of the NBOC of the balancing networks associated with all of the 1P 4WTSs in a given RTA or in a given TSPS base unit has been selected to meet balance requirements on connections to TC trunks providing TSPS 2-wire access, this effectively specifies the maximum permissible value for the capacitance in the switchboard cabling for any other connection in that RTA or that TSPS base unit involving a 1P 4WTS. It should be remembered that the capacitance of the SB cabling in the 4-wire paths between 4-wire transmit or receive ports of a 4WTS and the points of good impedance of the associated 4-wire trunk facilities also contribute to the total capacitance of a connection to a 1P 4WTS in an RTA or a TSPS base unit. A point of good impedance of the 4-wire trunk facilities is provided by a 227-type amplifier or equivalent. The effect of the SB cabling between the 4-wire transmit and receive ports of the 4WTS and the points of good impedance of the 4-wire facilities may be sufficiently masked by introducing 600-ohm pads between the 4-wire transmit and receive ports on this SB cabling.

The minimum value for these pads depends upon the length and gauge of the SB cabling to be masked. For example, a 600-ohm pad introducing a transmission loss of at least 4 dB is required to adequately mask the effect on balance of 1000 feet of 24 gauge SB cable.

**B. 4-Wire Terminating Sets**

**4.12** As indicated in Part 2, 900-ohm 4WTSs associated with TSPS 4-wire bridging repeaters, 24V4-type repeaters, or metallic facility terminals (MFTs) are used, as appropriate, to terminate and to convert to 2-wire facilities (for subsequent 2-wire switching by the TSPS Base Unit switching network or by the RTA concentrator) the 4-wire facilities associated with:

- (a) TSPS base unit or RTA 4-wire bridging access to 4-wire TC trunks and inward trunks
- (b) TSPS base unit 4-wire bridging access to delayed call trunks
- (c) Trunk link appearance on the TSPS base unit switching network of the service observing trunks

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(d) TSPS base unit end of BR trunks, operator service trunks, and incoming CAMA transfer trunks, and

(e) CDA type I and II circuits.◀

**4.13** A 1P 4WTS is used to terminate and to convert to 2-wire facilities (for subsequent 2-wire switching by the TSPS base unit switching network or by the RTA concentrator) the 4-wire facilities associated with:

(a) The RTA end of BR circuits

(b) The TSPS base unit end of PSS No. 2 and retrofitted PSS No. 1 operator position trunks

(c) The position link appearance on the TSPS base unit switching network of the service observing trunks, and

(d) CDA type I and II circuits.◀

**4.14** The 900-ohm 4WTS is designed for terminal applications where the input impedance of the 2-wire port of the 4WTS whose 4-wire transmit and receive ports are properly terminated is nominally 875 ohms. In contrast, the 1P 4WTS is designed for bridging applications where the input impedance of the 2-wire port of the 1P 4WTS whose 4-wire transmit and receive ports are properly terminated is nominally 11,550 ohms. The design differences between these two types of 4WTSs and their operation are briefly discussed below.

### 900-Ohm 4-Wire Terminating Set

**4.15** A typical 900-ohm 4WTS, such as the 1M terminating set, includes a 2-transformer balanced hybrid, a series blocking capacitor in both the 2-wire line port and in the balance network port, and a balancing network, as shown schematically in Fig. 7. The balanced hybrid coil arrangement has been designed to accommodate a nominal 900-ohm impedance on both the 2-wire line and balancing network ports and a nominal 600-ohm impedance on both the 4-wire transmit and receive ports. The 900-ohm 4WTS provides means for connecting 2-wire 900-ohm circuits to 4-wire 600-ohm VF circuits. The COMP NET is composed of an 898-ohm resistor in series with a 2.15  $\mu\text{F}$  capacitor. The NBOC is arranged in parallel with the COMP NET and is adjusted to the value prescribed that will provide adequate balance in the specific application

of each 900-ohm 4WTS in the RTA or TSPS base unit. The 900-ohm 4WTS has a nominal 2-wire line port input impedance of  $875\Omega + 2.16 \mu\text{F}$ .

**4.16** Access is provided via the A and B leads to the hybrid coil windings of these 900-ohm 4WTSs to permit external equipment to develop dc signaling on the 2-wire circuit connected to the 2-wire line port of these 4WTSs. When this is done, the 1- $\mu\text{F}$  capacitor bridged across the A and B leads of the 900-ohm 4WTS is utilized to provide ac continuity for the voice path and dc isolation for the signaling path. When the 900-ohm 4WTS is used to provide signaling access, this 1- $\mu\text{F}$  capacitor may be located in either the 4WTS or in the associated trunk circuit. This 1- $\mu\text{F}$  capacitor is also required when the 900-ohm 4WTS is not used to provide dc signaling access and, in this case, will be provided in the 4WTS.

### 1P 4-Wire Terminating Set

**4.17** The 1P 4WTS was designed to be bridged across a 2-wire 900-ohm trunk, or other circuits of similar impedance (ie, nominally  $450\Omega + 4.32 \mu\text{F}$ ), with negligible effect on the circuit being bridged. The 1P 4WTS, shown schematically in Fig. 8, consists of a 2-transformer hybrid arrangement, a blocking capacitor in both the 2-wire line and balancing network ports, a build-out resistor in both the 2-wire line and balancing network ports, and a balancing network which is comprised of a compromise network ( $450\Omega + 4.32 \mu\text{F}$ ) shunted by an adjustable NBOC. In order to ensure that the 1P 4WTS has negligible effect on the bridged circuit, the associated 2-transformer hybrid arrangement has been designed to accommodate a nominal 6000-ohm impedance on both the 2-wire line and balancing network ports and a nominal 600-ohm impedance on both the 4-wire transmit and receive ports. Therefore, since the impedance of the compromise network and the nominal impedance of the circuits connected to the 2-wire port of the 1P 4WTS are both  $450\Omega + 4.32 \mu\text{F}$ , a 5550-ohm build-out resistor is required in both the 2-wire line port and the balance network port of the 2-transformer hybrid.

**4.18** Two-wire transducer loss measurements on the 1P 4WTS are made with 900-ohm test equipment bridged with a 900-ohm resistor terminating the 2-wire line port (resulting in an effective impedance of 450 ohms) and 600-ohm test equipment or 600-ohm termination, as appropriate, terminating

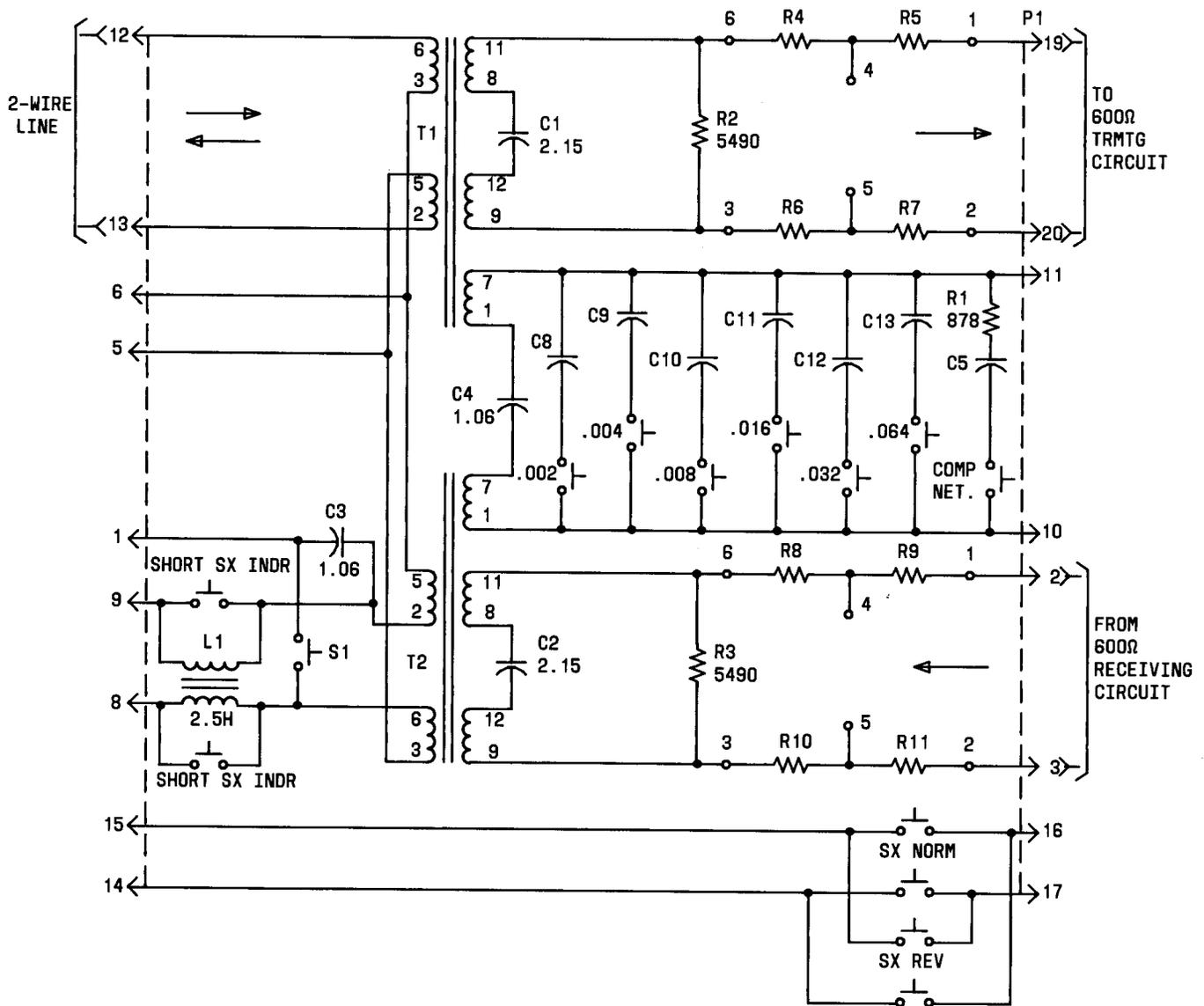


Fig. 7—900-Ohm 4-Wire Terminating SSet

the 4-wire transmit and receive ports of the 1P 4WTS. This test configuration simulates the configuration of the 1P 4WTS encountered in actual applications when the 1P 4WTS is bridged across a 900-ohm 2-wire line. As a consequence of the addition of the 5550-ohm build-out resistor in the 2-wire line port, the transducer loss from the bridged line to the 4-wire transmit port of the 1P 4WTS and from the 4-wire receive port of the 1P 4WTS to the bridged line is very high, approximately 18 dB. For the range of impedances for the 2-wire connecting circuit expected in TSPS applications,

a good estimate of the THL of the 1P 4WTS in a given connection may be obtained by adding 30 dB to the return loss of the impedance of the 2-wire connecting circuit versus the impedance of the balancing network.

### C. Trunk Circuits for TSPS Base Unit and RTA

**4.19** All TSPS Base Unit and RTA 4-wire incoming trunk circuits and inward trunk circuits and TSPS base unit delayed call trunk circuits, BR trunk circuits, operator service trunk circuits,

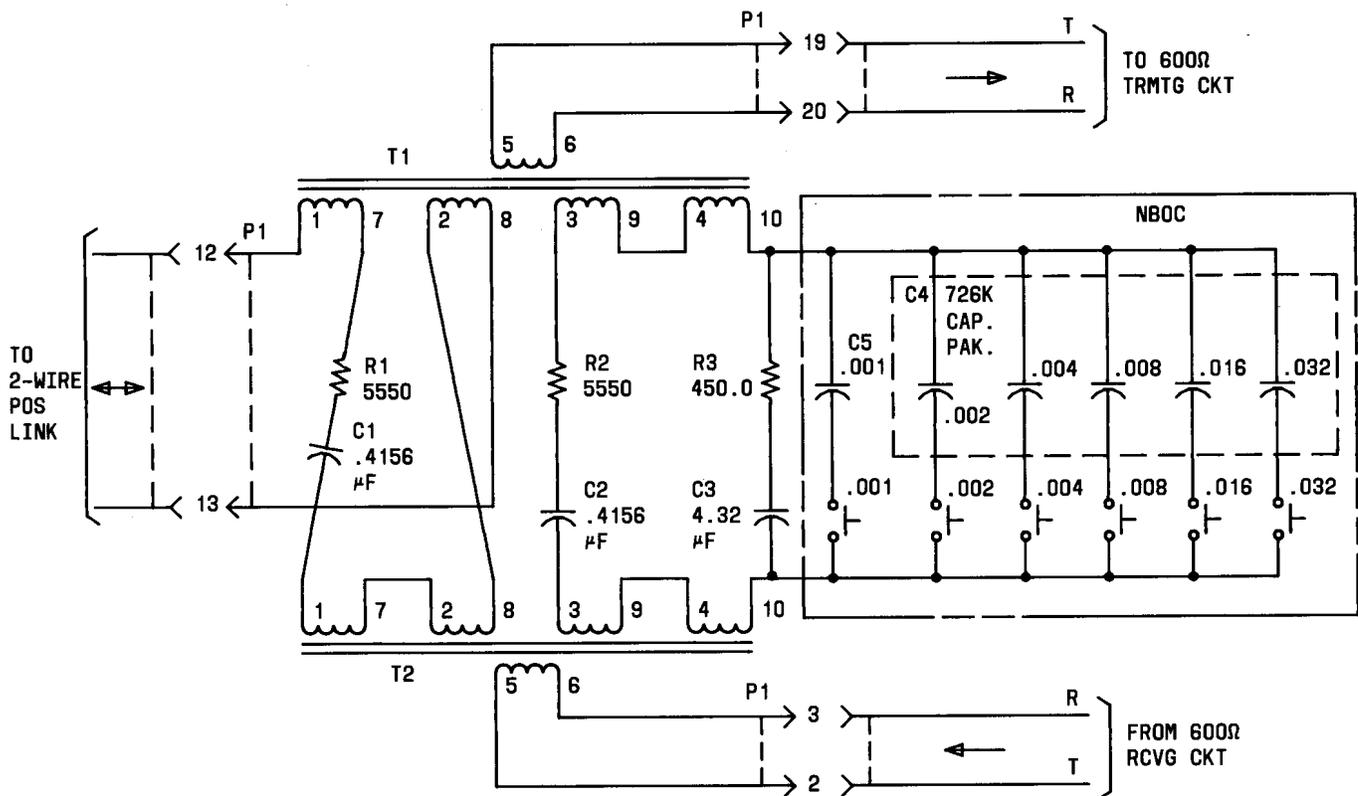


Fig. 8—1P 4-Wire Terminating Set

incoming CAMA transfer trunk circuits, CDA circuits, and service observing trunk circuits should be provided with an adjustable drop build-out capacitor (DBOC) bridged across the 2-wire transmission path having an appearance on the RTA concentrator or a trunk link circuit appearance on the TSPS Base Unit switching network.

**4.20** An idle circuit termination of  $450\Omega + 4.32\ \mu\text{F}$  must be connected to the 2-wire line port of the 1P 4WTS, when these trunks are not connected through the RTA concentrator or the TSPS Base Unit switching network. This is necessary to prevent singing due to the hybrid unbalance that occurs without a termination and the high gains of the 227-type amplifiers associated with the 4-wire transmit and receive ports of the 1P 4WTSs. This necessary idle circuit termination is provided by the remote trunk BR trunk circuit (SD-1B120-01) in the RTA for BR trunks, by the operator cut-through circuit (SD-1B020-01) in the TPSP base unit for operator position trunks, and by the service observing trunk access circuit

SD-1B275-01 in the TSPS base unit for service observing trunks. The idle circuit termination is also provided in the CDA circuits.

**4.21** An idle circuit termination, or equivalent, must be connected to the 2-wire line port of the 900-ohm 4WTS associated with the TSPS 4-wire bridging repeater in both RTAs and TSPS base units. The termination  $942\Omega\ 2.16\ \mu\text{F}$  supplied as part of the 3-way, 4-wire bridging repeater and used in these RTA and TSPS base unit applications as the impedance matching network also serves as the required idle circuit termination for the 900-ohm 4WTS associated with the TSPS 4-wire bridging repeater.

**4.22** An idle circuit termination, or equivalent, must also be connected to the 2-wire line port of the 4WTSs associated with 4-wire operator service trunks and incoming CAMA transfer trunks in TSPS Base Units. Because of the low-loss design of these types of trunks, the idle circuit termination is necessary to prevent possible singing in the idle

condition. A  $1020\Omega + 2.15 \mu\text{F}$  impedance matching network is included as part of the operator service trunk circuit SD-1B278-01. The incoming CAMA transfer trunk circuit SD-1B016-01 has an impedance matching network of  $942\Omega + 2.15 \mu\text{F}$ . This impedance matching network is required to permit interconnection of the 2-wire port of a 900-ohm 4WTS and the 2-wire port of a 1P 4WTS through the appropriate trunk circuits and the TSPS base unit switching network. As was the case for the TSPS 4-wire bridging repeater discussed above, this impedance matching network will also serve as the required idle circuit termination for the 900-ohm 4WTS associated with the 24V4-type repeater, or equivalent, used in the 4-wire facilities for 4-wire operator service trunks and 4-wire incoming CAMA transfer trunks.

**4.23** It should be noted that an idle circuit termination should not be provided for the 900-ohm 4WTS in the 24V4A repeater, or equivalent, associated with the TSPS base unit end of the BR trunk facilities because a completely unbalanced 4WTS (ie, 2-wire line port open circuited) is required to permit continuous transmission integrity check testing on all idle BR trunks. Although an impedance matching network of  $942\Omega + 2.16 \mu\text{F}$  is included as part of the base trunk BR trunk circuit SD-1B135-01, it will never be connected across the 2-wire line port of the 900-ohm 4WTS when the BR trunk is idle.

**4.24** TSPS base unit 2-wire incoming trunk circuits (SD-1B002-01, SD-1B003-01, SD-1B004-01, and SD-1B005-01) and RTA 2-wire incoming trunk circuits (SD-1B115-01 and SD-1B116-01) may be configured for a 3-way connection among the calling and the called parties and the TSPS operator or may be configured for a 2-way connection between the calling party and the TSPS operator. When these 2-wire incoming trunk circuits are configured for a 2-wire connection between the calling party and the TSPS operator, a termination must be included in the 2-way, 2-wire connection to simulate the nominal impedance of the connection to the called party. This termination should be approximately equal to  $900\Omega + 2.16 \mu\text{F}$  shunted by a fixed build-out capacitor of about  $0.040 \mu\text{F}$ . This termination will be included as part of the appropriate TSPS base unit or RTA 2-wire incoming trunk circuit.

**4.25** Any signaling relays or inductors bridged across the 2-wire transmission path of TSPS

base unit and RTA 2-wire incoming trunk circuits or TSPS base unit incoming CAMA transfer trunk circuits must have a high enough inductance (with their normal operating dc currents) to have negligible effect on the 2-wire path impedance in the 200-Hz to 3200-Hz frequency band.

#### D. Repeating Coils

**4.26** The 120T repeating coil appearing in the 2-wire transmission path through the TSPS base unit incoming CAMA transfer circuit SD-1B016-01 must be equipped with properly valued midcoil capacitors to obtain the optimum impedance transformation characteristics. The 120T repeating coil can optionally provide a 1:1 impedance transformation ratio for use when the impedance of the incoming CAMA transfer trunk facilities is nominally 900 ohms or 1:1.5 impedance transformation ratio for use when the impedance of the incoming CAMA transfer trunk facilities is nominally 600 ohms. The values for the capacitors located at the midpoint of the two sides of the 120T repeating coil have been selected to obtain the best compromise in impedance transformation looking toward the incoming CAMA transfer trunk facilities and toward the impedance matching network of the incoming CAMA transfer trunk circuit SD-1B016-01 terminated in a 1P 4WTS. The value of both midcoil capacitors should be  $3.24 \mu\text{F}$  when the impedance transformation ratio is 1:1 and  $4.32 \mu\text{F}$  when the impedance transformation ratio is 1:1.5.

**4.27** When a repeating coil is present in a 2-wire circuit connected to the 2-wire line port of a 4WTS in order to derive signaling access or to transform impedances for matching purposes, the degree of balance that can be obtained is limited in a 4WTS whose balancing network consists of a COMP NET plus a shunt NBOC. For example, a repeating coil providing a 1:1 impedance transformation ratio has some leakage reactance and a finite valued mutual inductance. The repeating coil will also add to the series resistance of the 2-wire circuit. These effects will modify the impedance of the 2-wire circuit connected to the 2-wire line port of the 4WTS by different amounts over the VF band and, in general, lower the average degree of balance obtainable against the balancing network of the 4WTS. If the repeating coil has a 1:1.5 impedance transformation ratio and is used to interconnect a  $900\Omega + 2.16 \mu\text{F}$  circuit and a  $600\Omega + 2.16 \mu\text{F}$  circuit, the capacitance parts of the impedances will not be in the proper ratio. That

is, the  $600\Omega + 2.16 \mu\text{F}$  impedance transformed through an ideal 1.5:1 ratio repeating coil will be equivalent to a  $900\Omega + 1.44 \mu\text{F}$  impedance. This capacitance unbalance will be in addition to the unbalance caused by leakage reactance, series resistance, and self-inductance effects in the repeating coil itself. Since the unbalance caused by the repeating coil itself will appear greater in 600-ohm 2-wire circuits than in 900-ohm 2-wire circuits, the nominal impedance of the incoming CAMA transfer trunk facilities should be  $900\Omega + 2.16 \mu\text{F}$  whenever possible.

**4.28** In 2-wire TC trunks, any repeating coils appearing in a 2-wire path between the point of good impedance of the TC trunk and the connection in a toll office to an intertoll trunk must also be equipped with properly valued midcoil capacitors to obtain optimum impedance transformation characteristics. If a repeating coil is included in this part of a TC trunk it is usually part of the toll office incoming trunk circuit. The values for the midcoil capacitors provided with the repeating coils in this application have been designed to obtain the best compromise in impedance transformation between the intertoll trunk and the TC trunk facilities for impedance matching and/or to derive dc signaling leads. In this case, the compromise is to obtain the best impedance presentation in the intertoll trunk direction. This results in a poorer impedance presentation in the TC trunk direction and, consequently, in the direction of the TSPS base unit or RTA. Therefore, the maximum balance achievable at the 1P 4WTS on connections through the RTA concentrator or through the TSPS Base Unit switching network to TC trunks providing TSPS 2-wire access will, in general, be less when the toll office incoming trunk circuits contain repeating coils than when they do not. This is most evident at the lower frequencies (200 Hz to 1000 Hz) in the VF band.

#### **E. Build-Out Capacitors**

##### **Network Build-Out Capacitor**

**4.29** As indicated in 4.13, the COMP NET provided in the balancing network of the 900-ohm 4WTS and the COMP NET provided in the balancing network of the 1P 4WTS have been chosen to provide satisfactory balance against the nominal impedance of the 2-wire circuits expected to be connected to the 2-wire line ports of these 4WTSs in TSPS base unit and RTA applications. Switchboard

cabling used in TSPS base units and RTAs to establish the 2-wire voice transmission paths which interconnect 4WTS, trunk circuits and the TSPS base unit switching network or the RTA concentrator has distributed capacitance throughout its length. This distributed capacitance modifies the nominal impedance of the 2-wire circuits to be connected to the 2-wire line port of these 4WTSs at the upper frequencies in the VF band. This effect can be approximately balanced in the balancing network by bridging an equal amount of capacitance across the COMP NET. The adjustable NBOC is added across the COMP NET in the balancing network of the 900-ohm 4WTSs and 1P 4WTSs used in TSPS base unit and RTA application to compensate for the capacitance of switchboard cabling. Since the optimum value for the NBOC of a given 4WTS will vary depending on its specific application, the NBOC of the 900-ohm 4WTSs and 1P 4WTSs used in TSPS base unit and RTA applications are adjustable to provide the necessary flexibility.

##### **Drop Build-Out Capacitor**

**4.30** To obtain balance across 4WTS hybrids when the value of the NBOC of the balancing network is fixed, the variance in the value of the SB cabling capacitance of the various 2-wire switching paths through the TSPS base unit or RTA between a given 4WTS and the point of good impedance of the various trunks to which it may be connected must be considered. If this capacitance variation is sufficiently large, balance requirements on the connection of all possible 2-wire circuits to the 2-wire line port of a given 4WTS cannot be met if the value for the NBOC is to be single-valued. In order to reduce this capacitance variation, bridged capacitance can be added to the shorter 2-wire SB cabling paths to increase the value of their shunt capacitance to that of the longer 2-wire SB cabling paths. This is accomplished by adding DBOCs in the shorter 2-wire SB cabling paths.

**4.31** A DBOC capability associated with the 2-wire appearance on the TSPS base unit switching network or the RTA concentrator will be required for 4-wire TC trunks and inward trunks in both the TSPS base unit and the RTA; and for delayed call trunks, BR trunks, operator service trunks, incoming CAMA transfer trunks, and service observing trunks in the TSPS base unit. In some cases, the DBOC will be supplied as part of the trunk circuit while in other cases it will be supplied as part of another circuit associated with a given trunk. In

other cases, a separate DBOC must be supplied and wired on a bridged basis to the tip and ring conductors of the 2-wire path between the point of good impedance of that trunk and the TSPS base unit switching network or the RTA concentrator. ♦DBOCs are also associated with the CDA type I and II circuits.♦

## 5. BALANCING CONSIDERATIONS

### A. General

**5.01** The use of successive step techniques with intermediate evaluations is recommended when balancing the TSPS base unit switching network or the RTA concentrator using the test equipment and techniques prescribed in Sections 660-463-500, 660-463-502, and 660-463-504. The successive step methods simplify the balancing process, and specify that intermediate ERL and SRL evaluations be made in relation to the requirements to substantiate completed steps and verify portions of balance work before the total dynamic structure of switch balancing can become distorted by improper analysis or adjustments. When performing balance work, any trunks not meeting ERL and/or SRL requirements as specified in Section 660-463-301 should be reported to the transmission engineer. The transmission engineer will determine if an investigation is required and corrective action taken. Trouble should also be suspected if poorer test results are obtained on some trunks which are similar in design to other trunks which have good test results.

**5.02** Before starting the balancing tests and adjustments, a certain amount of preliminary work is usually required. This includes verifying that:

- (a) Outside plant cable acceptance testing is complete
- (b) Impedance compensators are provided where required and are properly adjusted
- (c) 2 dB pads are present where required in 2-wire intrabuilding TC trunks
- (d) DBOCs are provided where required
- (e) Impedance matching is provided where required, and

- (f) The associated toll office is certified as being balanced.

The preliminary work also includes checking for proper impedance matching ratio and proper midcoil capacitance for the 120T repeating coil of the TSPS base unit incoming CAMA transfer trunk circuit. Record preparation, bay locating, and other test planning should also be made part of the preliminary work. In addition, 1000-Hz loss measurements and noise measurements are required on all trunks having an appearance on the TSPS base unit switching network or RTA concentrator, before the ERL and SRL tests and adjustments are made, to ensure that the trunks meet the transmission requirements for the particular type of trunk being tested. Where the trunks employ carrier or 4-wire metallic facilities, the 1000-Hz loss in both directions of transmission must be measured. Balance measurements are of little value if the trunks do not meet their 1000-Hz loss requirements or their noise requirements. Standard methods of measuring 1000-Hz trunk losses and noise are given in other sections as indicated in Section 660-450-301.

**5.03** Figures 9, 10, and 11 illustrate the three general categories of connections that must meet balance requirements into which all of the voice transmission connections can be put that occur at either a TSPS base unit or an RTA. ♦Figures 12, 13, 14, and 15 illustrate the connections of the CDA type I and II that must meet balance requirements.♦

**5.04** Figure 9 shows a connection between a balance test circuit and a TC trunk providing TSPS 2-wire access which has been properly terminated in both the class 5 and toll offices. The balance test hybrid of the Control, Display, and Test (CDT) frame in the TSPS base unit is used to simulate the TSPS base unit end of an operator position trunk or the position link circuit appearance of a service observing trunk on the TSPS base unit switching network. The balance test hybrid of the Test and Display Circuit (TDC) in the RTA is used to simulate the RTA end of a BR trunk.

**5.05** Figure 10 shows a connection between a balance test circuit and a TSPS 4-wire bridging repeater. The TSPS 4-wire bridging repeater is used to provide TSPS bridging access to 4-wire TC trunks and inward trunks in both the TSPS base unit and the RTA and also to delayed call trunks and the trunk link circuit

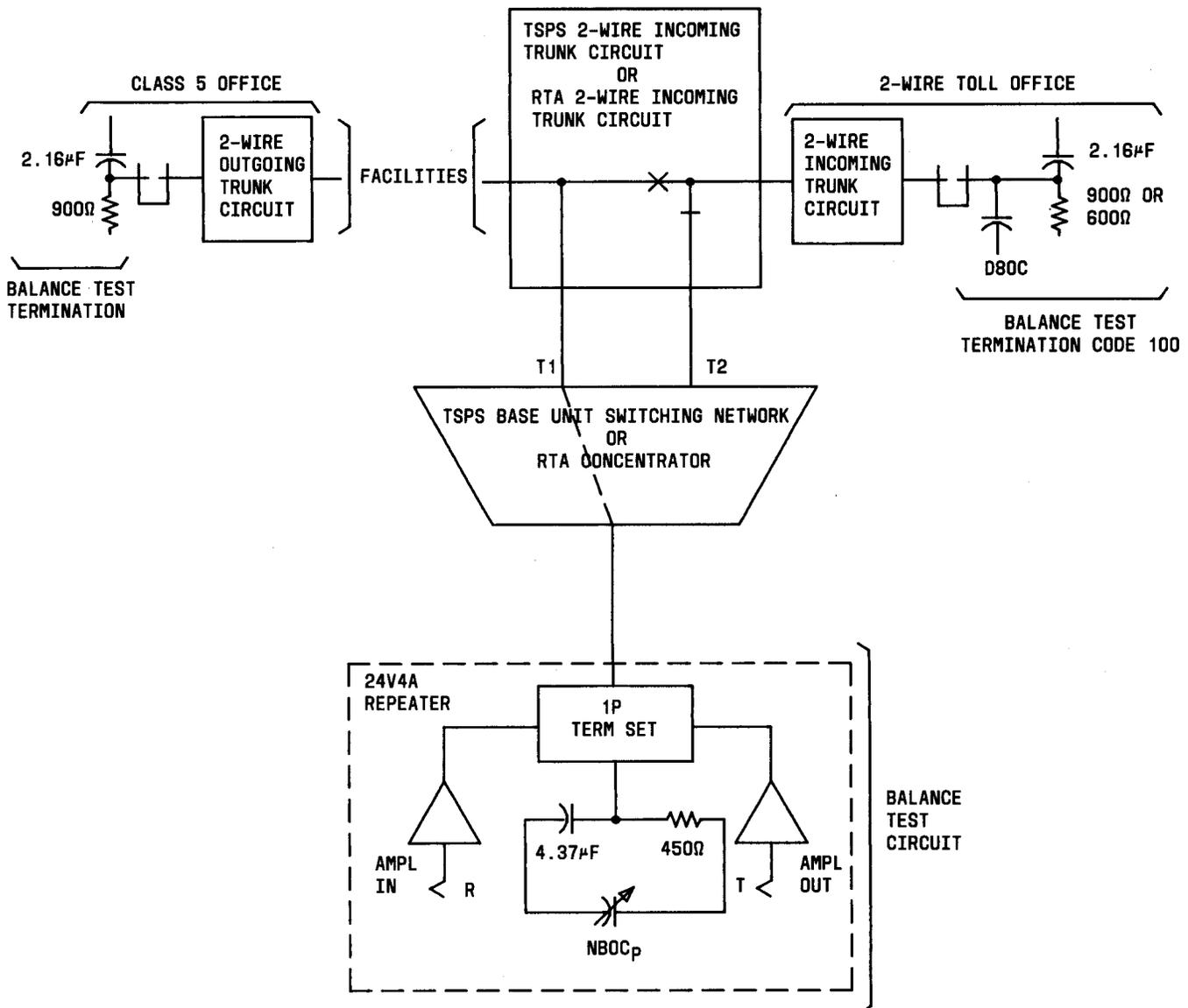


Fig. 9—Balance Test Circuit Connection to a TC Trunk Providing 2-Wire TSPS Bridging Access

appearance of service observing trunks on the switching network in the TSPS base unit. The impedance matching termination  $942\Omega + 2.16 \mu\text{F}$ ) shown is part of the TSPS 4-wire bridging repeater. The DBOC shown will be supplied as part of the TSPS 4-wire bridging repeater if SD-7C022-01 is used or must be supplied separately if the 3-way, 4-wire bridging repeater is supplied separately. The TSPS base unit or RTA trunk circuits associated with these types of trunks do not insert any components into the portion of the voice transmission path of interest in this type of connection.

5.06 Figure 11 shows a connection between a balance test circuit through a 2-wire TSPS trunk circuit to a 24V4A repeater. The 2-wire TSPS trunk circuit may be either the base trunk BR trunk circuit SD-1B135-01, the operator service trunk circuit SD-1B278-01, or the incoming CAMA transfer trunk circuit SD-1B016-01. An impedance matching network is supplied by each of these trunk circuits. The indicated DBOC will eventually be supplied within the trunk circuits; however, early installations may have to supply a DBOC separately. The incoming CAMA transfer trunk

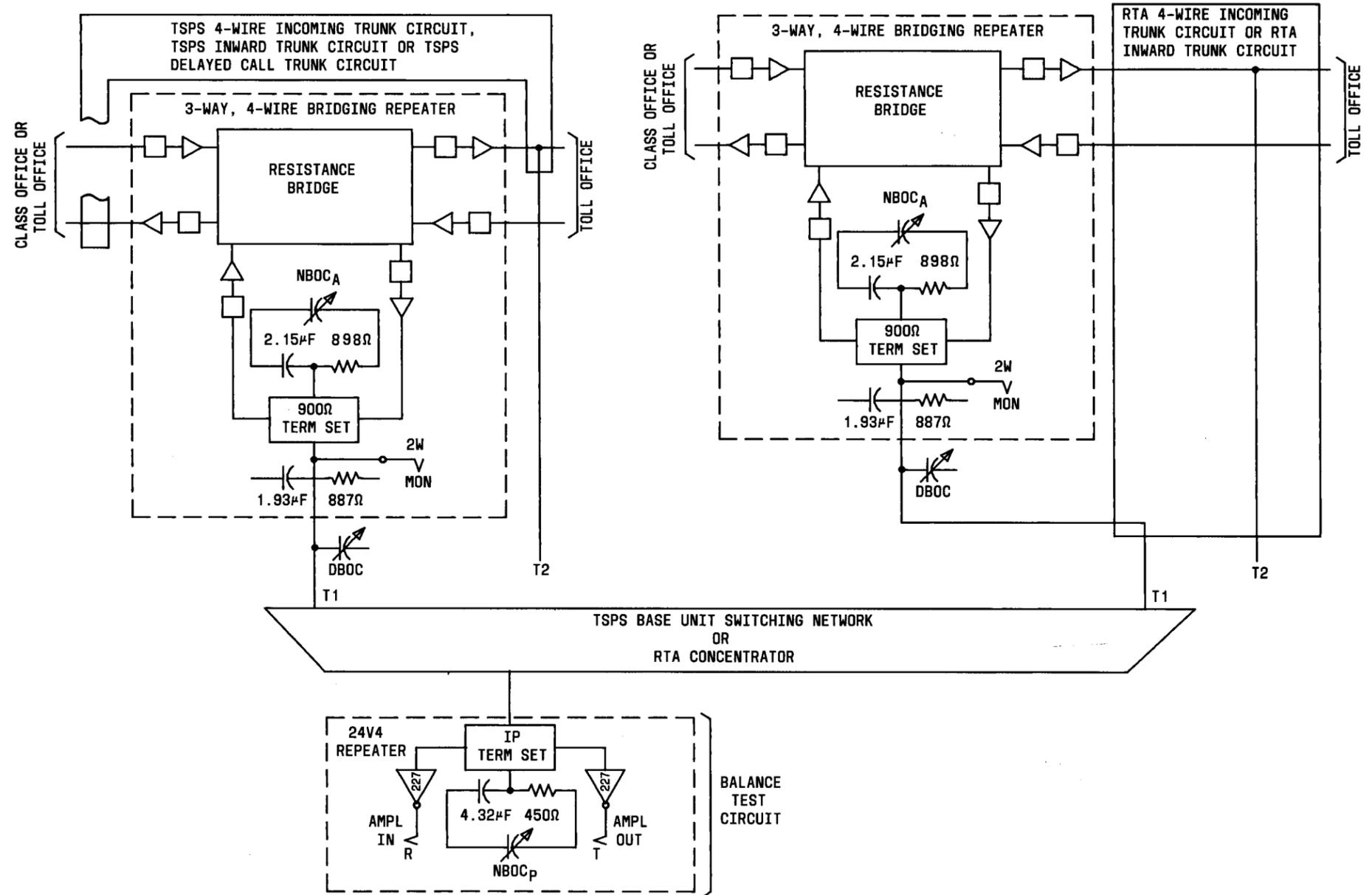


Fig. 10—Balance Test Circuit Connection to Trunks With Bridging Access Provided by a TSPS Bridging Repeater

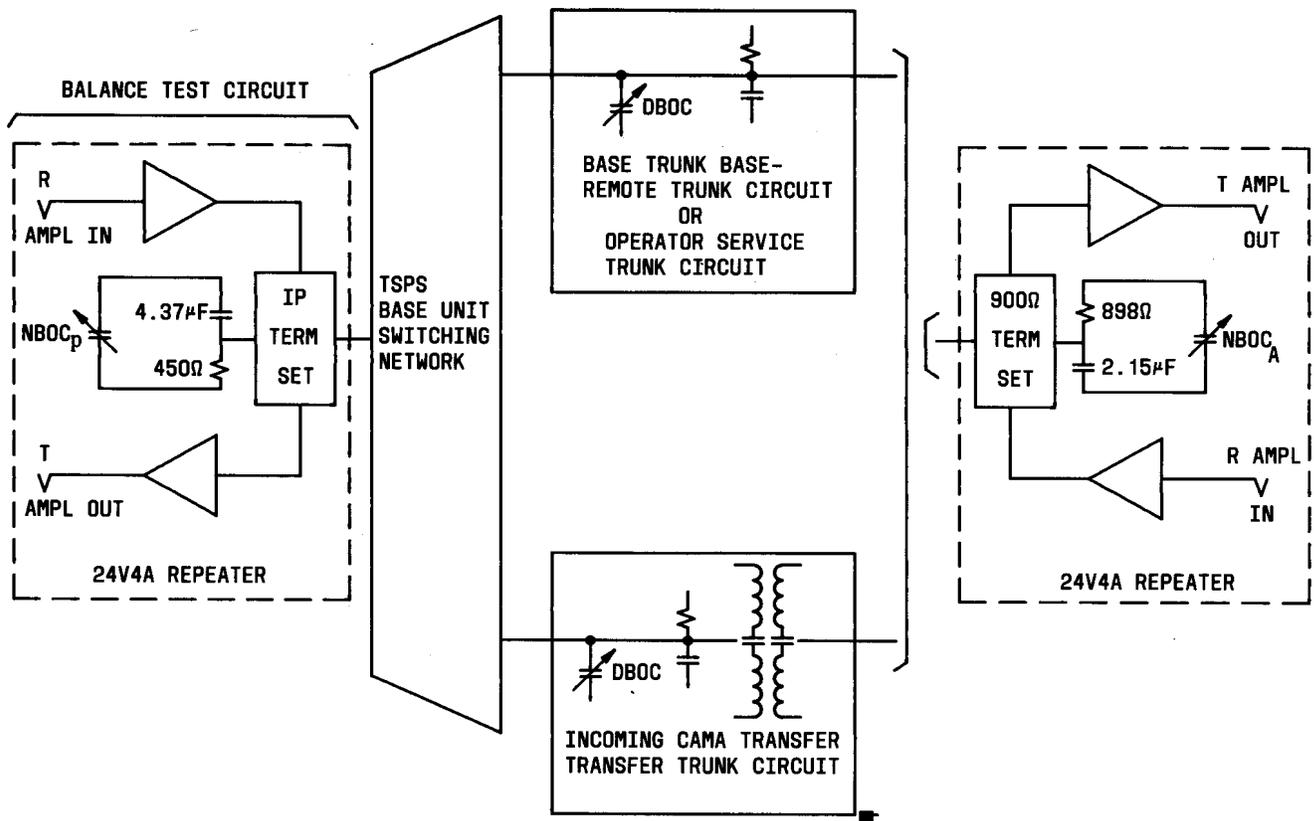


Fig. 11—Balance Test Circuit Connection to Trunks Using a 24V4 Repeater

circuit SD-1B016-01 also includes a repeating coil in the voice transmission path.

**5.07** Balancing the TSPS base unit or the RTA concentrator requires the use of successive step techniques and intermediate evaluations. The successive step methods simplify the balancing process and specify that intermediate echo return loss (ERL) and singing return loss (SRL) evaluations be made in relation to the requirements, to substantiate completed steps and verify portions of balance work before the total dynamic structure of switch balancing can become distorted by improper analyses or adjustments.

**5.08** Before the balancing steps can be started at the TSPS base unit or RTA concentrator, **the toll office associated with the TSPS base unit or RTA must be balanced and certified as being balanced.** The TSPS base unit or RTA **cannot** be successfully balanced if the associated toll office is not properly balanced.

Also, before balance work can begin, all trunks must meet loss and noise requirements.

**5.09** The following are the steps in balancing a TSPS base unit or RTA. Detail procedures are available in Sections 660-463-500 and 660-463-502.

- (a) Determine the network build-out capacitor (NBOC) value for the 1P 4WTS from a selection of 2-wire TC trunks from each 2-wire group. (If the TSPS base unit or RTA has only 4-wire groups, then make a selection from each 4-wire group.)
- (b) Strap the NBOC value into the 1P 4WTS of the CDT position link network (PLN) port of the TSPS base unit or the BAL TST circuit of the TDC on the RTA.
- (c) Verify that the 1P 4WTS NBOC value is correct by testing from the CDT's PLN port or the RTA's BAL TST circuit into two trunks of each 2-wire TC trunk group. If this test

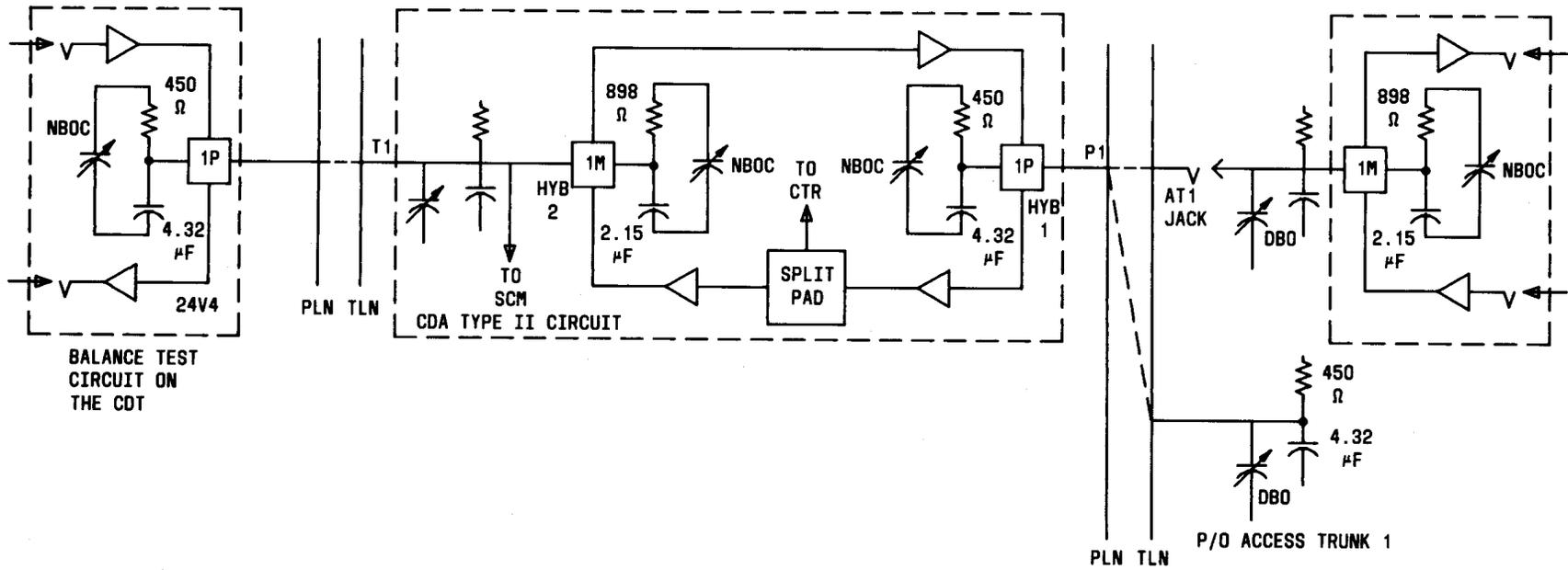


Fig. 12—Balance Test Circuit Connection to CDA Type 1 Circuit

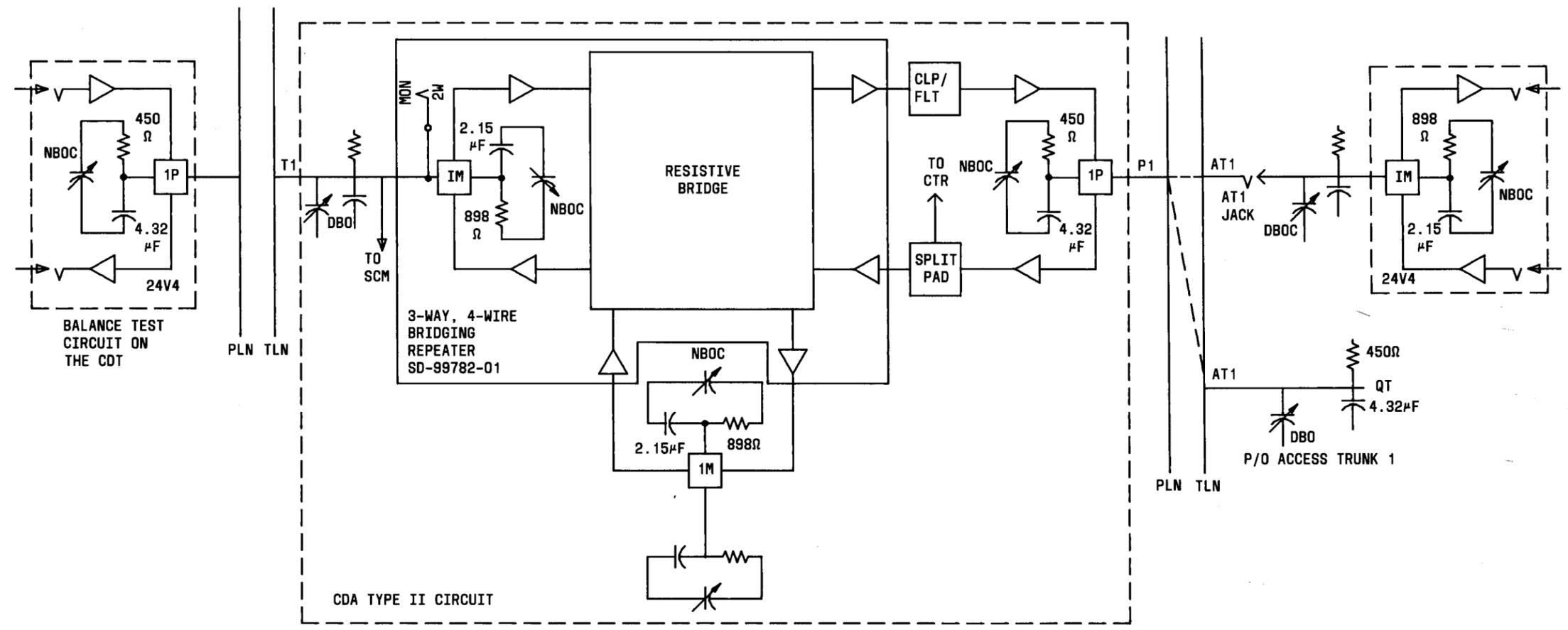


Fig. 13—Balance Test Circuit Connection to CDA Type 2 Circuit (T1-P1)

does not meet balance requirements, the NBOC selection process may need to be repeated.

(d) If step 3 meets requirements, proceed to test each 2-wire TC trunk and record results.

(e) Strap the NBOC value into all 1P 4WTS associated with position circuits, BR trunks, and service observing circuit. Also strap the NBOC value in the equivalent 1P 4WTS in the DIC channel unit associated with PSS No. 1 position circuit retrofitted with the 4251 network. Strap the NBOC value into all 1P 4WTS associated with the CDA type I and II trunks. Strap the NBOC value into the 1M 4WTS (HYB2) of all the CDA type II trunks.

(f) Verify that NBOCs in the 1P 4WTS have been properly strapped by testing from each 1P 4WTS to a termination provided by the CDT trunk link network (TLN) port or the TDC trunk stage access port.

(g) Determine the drop build-out capacitor (DBOC) value for each type of 4-wire trunk and TPSP 4-wire bridging repeater on the TLN side of the base unit switching network or trunk stage of the RTA concentrator. Trunks with 424V4 repeaters cannot be balanced.

(h) Strap the DBOC values in each of the 4-wire trunks and TSPS 4-wire bridging repeaters.

(i) Verify the DBOC value by testing from the CDT PLN port to each TSPS 4-wire bridging repeater on the TLN or from TDC BAL TST circuit to each TSPS 4-wire bridging repeater on the trunk stage repeater of the RTA concentrator. Record the results.

(j) Determine the NBOC values in each of the 1M 4WTS for each trunk and the 900-ohm 4WTSs in the 3-way, 4-wire bridging repeater on the TN or trunk stage of the RTA concentrator.

(k) Strap the NBOC value in each 1M 4WTS and in each TSPS 4-wire bridging repeater.

(l) Verify the DBOC and NBOC values by testing each 4WTS and each TSPS 4-wire bridging repeater into the CDT PLN port or TDC BAL TST circuits and record the results.

(m) Test each 4-wire TC trunk from the TSPS 4-wire bridging repeater towards the hybrid in the associated 2-wire toll office and record the results.

#### **B. Determination of Value for NBOC of 1P 4-Wire Terminating Set**

**5.10** If a given TSPS base unit or a given RTA serves TC trunks providing 2-wire bridging access, a compromise value is used for the NBOC in the balancing network of all 1P 4WTSs in that TSPS base unit or that RTA. This compromise value is determined from capacitance measurements made for connections of a balance test circuit to the various TC trunks providing TSPS 2-wire bridging access which have been properly terminated in both the class 5 and toll offices as shown in Fig. 9. Once determined for a given TSPS base unit or a given RTA, this compromise value for the NBOC is set into the balancing networks of the 1P 4WTSs associated with the balance test circuit, the operator position trunks (PSS No. 2 and PSS No. 1 retrofitted with the Unified Telephone Circuit), CDA circuits, and the service observing trunks in that TSPS base unit or set into the balancing networks of the 1P 4WTSs associated with the balance test circuits and BR trunks in that RTA.

**5.11** If a given TSPS Base Unit or a given RTA serves TCTs that provide only TSPS 4-wire bridging access, it is suggested that the value of this NBOC be set as small as possible consistent with maximizing the balance obtained on all possible connections. This will minimize the attenuation-distortion introduced by the 2-wire switching path through the TSPS base unit or the RTA and may eliminate the necessity and the accompanying cost of adding separate DBOCs across the 2-wire switching path which are not otherwise provided as part of the appropriate TSPS base unit or RTA trunk circuits or bridging repeaters.

**5.12** When making capacitance measurements to select a value for the NBOC of a 4WTS, more accurate determinations of the SB cabling capacitance in the 2-wire path are obtained when a 2-kHz signal or the SRL HI output of the KS-20501 RLMS is used during measurement of the THL of the 1P 4WTS. It is not necessary to actually measure the capacitance of the connection to all TC trunks providing TSPS access in a given TSPS base unit or RTA. Measurements made on a sampling basis are adequate, providing the samples

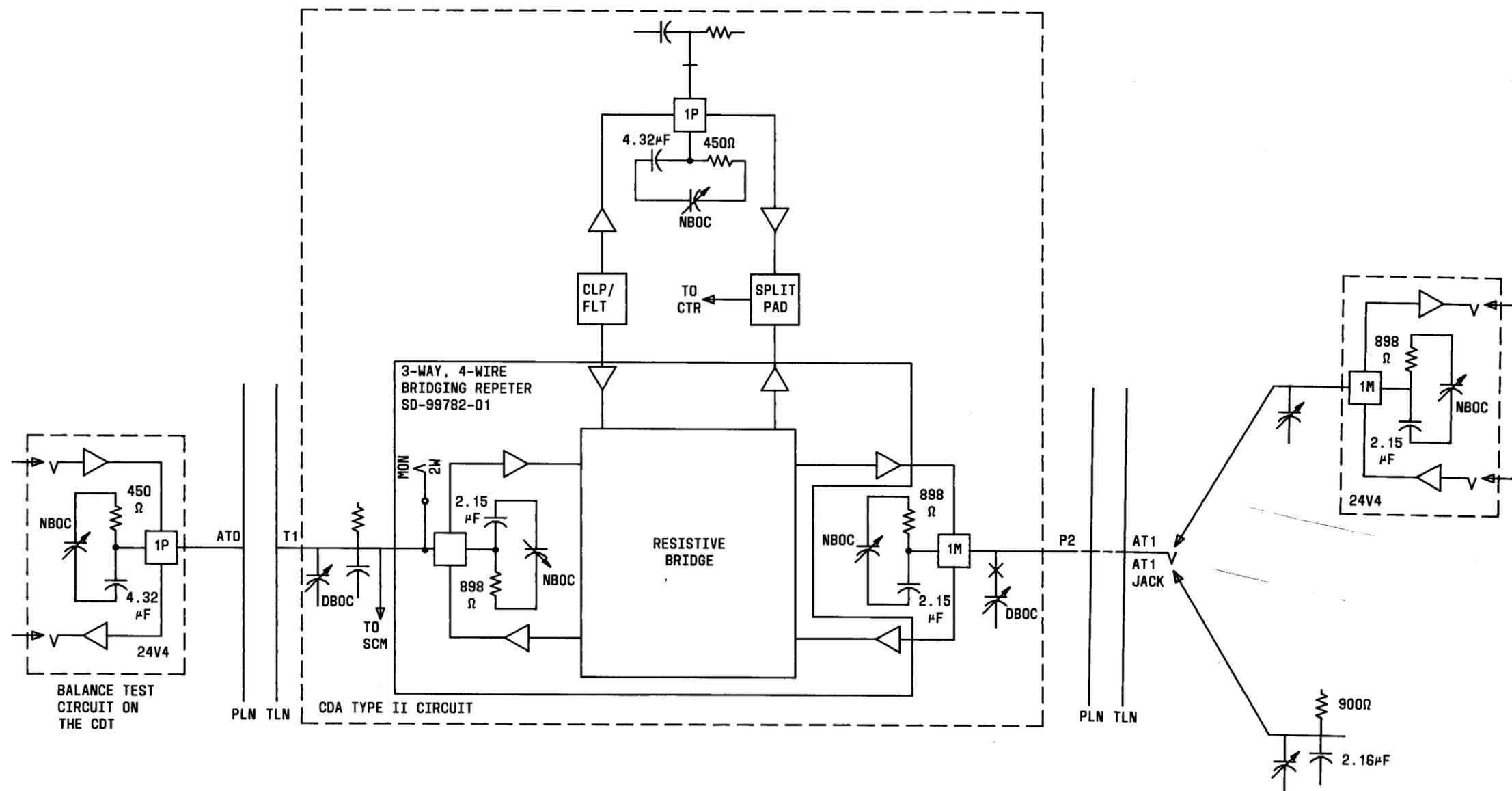


Fig. 14—Balance Test Circuit Connection to CDA Type 2 Circuit (T1-P2)

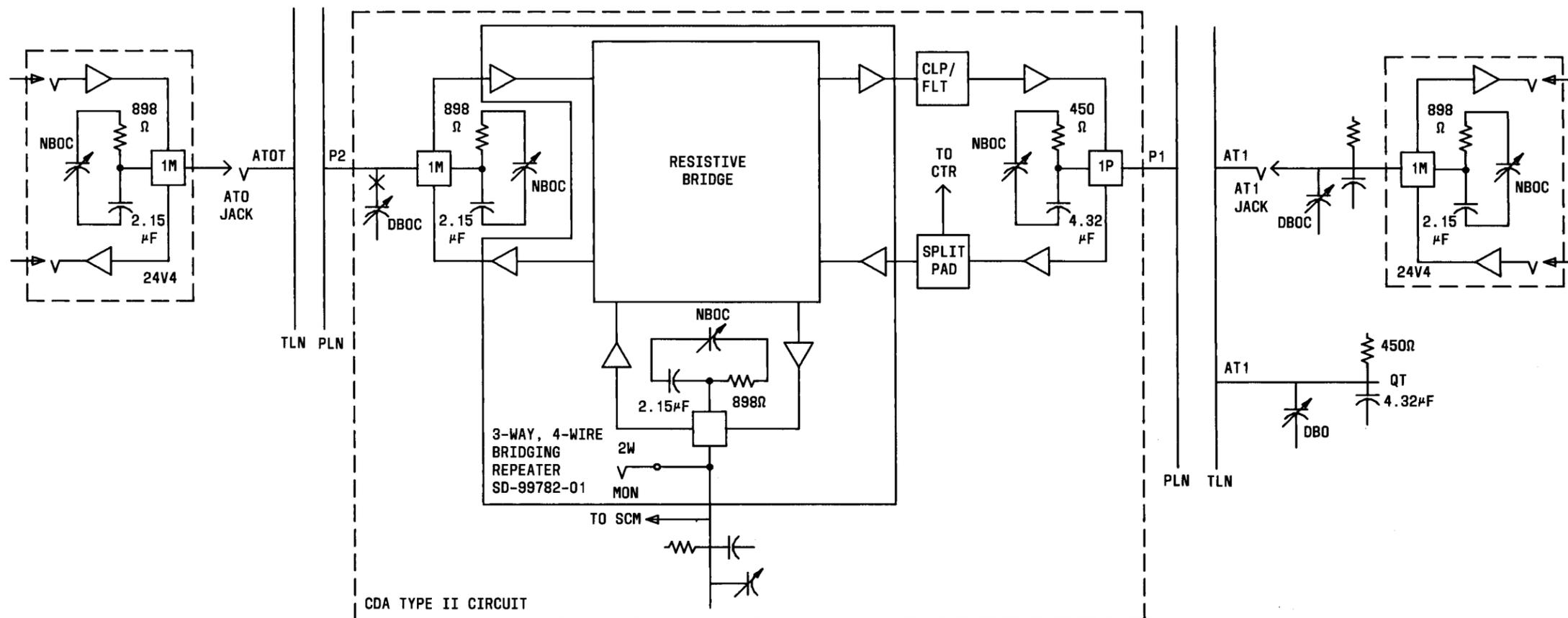


Fig. 15—Balance Test Circuit Connection to CDA Type 2 Circuit (P1-P2)

are chosen with care. Each selected sample, one for the TC trunks from each class 5 office, should include the TC trunk expected to have the greatest cable capacitance and the TC trunk expected to have the least cable capacitance plus a sufficient number of TC trunks randomly selected from the total group of TC trunks from that class 5 office. The size of each sample should be determined by the total number of TC trunks providing TSPS access from each respective class 5 office according to Table C. Furthermore, the group of TC trunks from each class 5 office should be subdivided according to the type of equipment and facilities used on these TC trunks if there are differences, and at least one sample from each subdivision should be included in the sample to be tested. Inspection of the physical locations of trunk circuits, impedance compensators, etc, will enable prediction of which TC trunk in a given subdivision will have the largest capacitance and which will have the smallest.

TABLE C

TRUNK SAMPLE SIZES

TOTAL NUMBER OF TRUNKS	NUMBER OF TRUNKS IN SAMPLE
5 or less	all
6-10	5
11-15	6
16-25	7
26-50	8
50 or greater	Approximately 18 percent of total

5.13 The procedures for determining the compromise value for the NBOC of all of the 1P 4WTSs in a given TSPS base unit or in a given RTA are presented in Sections 660-463-500 and 660-463-502.

C. Adjustment of DBOCs

5.14 As indicated in Section 660-463-301, there are no balance measurement requirements

on the 1P terminating set, or equivalent, associated with the PSS No. 2 or the retrofitted PSS No. 1 on connections involving any of the following types of trunks:

- (a) 4-wire TC trunks when bridging access is provided via either the 424V4A or the 424V4B repeater
- (b) 2-wire operator service trunks or 4-wire operator service trunks using TSPS operator service trunk circuit SD-1B010-01
- (c) 2-wire incoming CAMA transfer trunks
- (d) Service observing trunks when service observing monitoring circuit SD-3B002-01 is used alone (option Z).

However, these trunks will be *included* in the total number of trunks requiring balance and counted as not meeting minimum balance requirements.

Therefore, addition of a DBOC to the 2-wire transmission path through the TSPS Base Unit on each of the trunks listed above is not required. In the event that a DBOC has been provided on any of these types of trunks (eg, as part of the incoming CAMA transfer trunk circuit SD-1B016-01), it should be set to 0.000  $\mu$ F.

5.15 After the compromise NBOC for the 1P 4WTSs in a given TSPS base unit or a given RTA has been determined and installed in all 1P 4WTSs, the DBOCs provided in the 2-wire paths in the TSPS base unit or RTA associated with the following types of trunks must be adjusted:

- (a) In the TSPS base unit, TC trunks providing TSPS 4-wire bridging access via the TSPS 4-wire bridging repeater, inward trunks, delayed call trunks, BR trunks, operator service trunks, incoming CAMA transfer trunks, and service observing trunks, and CDA Type I and II trunks,
- (b) In the RTA, TC trunks providing TSPS 4-wire bridging access and inward trunks.

The ultimate aim is to make the 2-wire paths associated with all of the trunks listed above in the TSPS base unit or RTA have the same capacitance whose value maximizes the balance provided at the 1P 4WTS of the balance test circuit.

**D. Adjustment of NBOCs Associated With 900-Ohm 4-Wire Terminating Sets**

**5.16** A 900-ohm 4WTS is associated with the TSPS 4-wire bridging repeater. A 900-ohm 4WTS (eg, 1M terminating set) is used in the 24V4 repeater, or equivalent, associated with the 4-wire facilities of the BR trunks, operator service trunks, incoming CAMA transfer trunks and, CDA type I and II trunks in the TSPS base unit. After the DBOC associated with each trunk of the types mentioned above has been set to its optimum value of capacitance as discussed in 5.13, the NBOC in the balancing network of the 900-ohm 4WTS associated with that trunk must be adjusted so that balance requirements on this 900-ohm 4WTS presented in Section 660-463-301 for the TSPS base unit and the RTA, respectively, can be met. Adjustment of the NBOC in the balancing network of all 900-ohm 4WTSs used for these applications in the TSPS base unit or in the RTA must be made regardless of whether or not DBOC is associated with the 2-wire path.

**6. MEASUREMENT CONSIDERATIONS**

**A. General**

**6.01** The ERL and SRL requirements for balancing in TSPS Base Units and RTAs presented in Section 660-463-301 are specified to provide the calling and/or called customer, the TSPS operator, and the service operator with an acceptable echo grade-of-service. The method of expressing the requirements requires that the measured values be analyzed. Trunks not meeting the requirements should be investigated for the source of poor balance. Also, any trunk having an ERL or SRL decidedly poorer than one with similar equipment should be investigated. In a TSPS base unit (or RTA) certified for balance, any trunk added by circuit-order work which does not meet requirements should be noted, and the condition should be referred to the responsible transmission engineer.

**6.02** The ERL and SRL balance requirements presented in Section 660-463-301 are reference values and are expressed in dB and are stated in a manner that assumes a measurement procedure. This measurement procedure is outlined in Section 660-463-504. The 4-wire transmit and receive ports and the 2-wire line port of the 900-ohm 4WTS and 1P 4WTS used in TSPS Base Unit and RTA applications are made accessible at a test jack field

or can be made accessible by using a test extender for convenient connection points for the transmission-type testing equipment required in making balance measurements.

**6.03** The reference THL of a 900-ohm 4WTS used in TSPS base unit and RTA applications is a measure of (a) the normal THL caused by the ideal power division in the hybrid and the inherent transmission loss of the coils comprising the hybrid and (b) the transmission losses or gains of the wiring and circuitry (eg, pads, amplifiers, etc) connected between the appropriate test access jacks and the 4-wire transmit and receive ports of the hybrid in the 900-ohm 4WTS. It is conveniently measured by a technique involving the measurement of THL with the 2-wire port short-circuited. The difference between the reference THL and another THL measurement on this 900-ohm 4WTS will indicate the return loss between the impedance of the balancing network of the 4WTS and the impedance of the 2-wire circuit connected to the 2-wire line port of the 4WTS.

**6.04** The reference THL of the 1P 4WTS is measured by the same technique as in 6.03. It is a measure of (a) the normal THL caused by ideal power division in the hybrid and the inherent transmission loss of the coils comprising the hybrid, (b) the transmission loss introduced by the build-out resistors added to the 2-wire line and balancing network ports of the hybrid, and (c) the transmission losses or gains of the circuitry connected between the appropriate test access jacks and the 4-wire transmit and receive ports of hybrid. In this case, however, the difference between the reference THL and another THL measurement on a 1P 4WTS does *not* indicate the return loss between the impedance of the balancing network and the impedance of the 2-wire circuit connected to the 2-wire line port. Instead, this measurement is a true measure of the return energy due to misbalancing of this 1P 4WTS, which is not related to the variation of the return loss between the impedance of the balancing network and the impedance of the 2-wire circuit. Approximately 6 dB more return energy will be experienced in a 1P 4WTS when comparison is made to that which would be experienced in a standard 4WTS designed for connection to a 450-ohm 2-wire circuit. This difference is fundamentally due to the use of the 1P 4WTS as a high-impedance source to drive two 2-wire 900-ohm loads connected to its 2-wire line port rather than as a 450-ohm source to drive a

single 450-ohm load connected to its 2-wire line port. To obtain the same measure of return energy in the 1P 4WTS as in a standard 450-ohm 4WTS under comparable conditions, the balancing network of the 1P 4WTS must be adjusted to more nearly equal the impedance of the 2-wire circuit connected to its 2-wire line port. Therefore, more care will be needed in adjusting the balancing network of the 1P 4WTS.

**6.05** The transmission loss introduced by the 1P 4WTS is large because of the use of a large build-out resistor. To compensate for this loss, transmission gain will be introduced by the 4-wire circuit connected to the 4-wire transmit and receive ports of the 1P 4WTS. In order to avoid large energy returns on the 4-wire circuit which would occur if the 2-wire line port of the 1P 4WTS were ever open-circuited, the 2-wire line port of the 1P 4WTS must always have a suitable termination. The TSPS trunk circuit and software design prevents open-circuiting the 2-wire line port of the 1P 4WTS in normal operation. However, care should be taken in the line-up and balancing procedures to insure that the 2-wire line port of any 1P 4WTS is never open-circuited.

#### **B. Determination of 2-Wire Path Cabling Capacitance**

**6.06** Determination of the SB cabling capacitance in a number of 2-wire circuits that may be connected to the 2-wire line port of a given 4WTS is required in order to select an optimum value for the NBOC of the balancing network of that 4WTS. The measurements for determining office cable capacitance are made with a test equipment setup using a 2000-Hz test tone or the KS-20501 RLMS with its TEST TYPE switch set to SRL HI. The 2000-Hz test tone or the SRL HI setting on the KS-20501 RLMS will give a more accurate indication than a lower frequency because of the various series capacitors and bridged inductors (such as repeating coils, relays, and battery-feed inductors) that may be present in trunk circuits appearing in overall 2-wire circuit under consideration. The impedance effects of these components are negligible at the higher frequencies in the VF band, whereas they may control measurements at the lower frequencies in the VF band. In addition, the SB cabling capacitance is a shunt capacitance whose effects are more easily measured at the higher frequencies of the VF band.

**6.07** The shunt capacitance of 2-wire circuits can be measured in the following manner. The 2-wire circuit to be measured is connected to the 2-wire line port of an appropriate balance test hybrid or any other 4WTS which has a COMP NET whose impedance is equal to the nominal impedance of the 2-wire circuit to be measured. A 2000-Hz test tone or the signal generated by the KS-20501 RLMS whose TEST TYPE switch is set to SRL HI is applied to the 4-wire receive port of the test hybrid and a power detector or receiver of the KS-20501 RLMS is connected to the 4-wire transmit port of that test hybrid. The detector value is used to indicate relative THL values for the test tone used as the capacitance value for the NBOC of the balancing network of the test hybrid is varied. When the impedance of the balancing network of the test hybrid is nearest to the impedance of the 2-wire circuit connected to the 2-wire line port of the test hybrid, the detector will indicate a maximum THL (ie, minimum power detector reading). The value of the NBOC in the balancing network of the test hybrid when the THL measurement is maximized is approximately equal to the SB cable capacitance associated with the 2-wire circuit being measured.

**6.08** The techniques of measuring are dependent on the types of test equipment used. Descriptions of the test equipment required and detailed explanations for the techniques are given in Section 660-463-504.

#### **C. ERL Determinations**

**6.09** The ERL measurement is determined indirectly as the difference between two THL measurements using the KS-20501 RLMS with TEST TYPE switch set to ERL that are taken between the 4-wire receive and transmit ports of the 4WTS being tested. One measurement must be made with the 2-wire line port of the 4WTS under test terminated in a short circuit. The other is made with the short circuit removed from the 2-wire line port of the 4WTS and an appropriate 2-wire circuit connected to this port. Once the reference ERL THL has been determined (ie, 2-wire line port of the 4WTS terminated in a short circuit) for a particular 4WTS, it need not be measured again for that 4WTS since it will remain constant. However, this reference ERL THL may be different for other 4WTSs since it is unique to the particular 4WTS tested. When the KS-20501 RLMS is used to make these THL measurements, calculations may

not be necessary to determine the value for the ERL in dB provided that the THL adjustment calibration procedure outlined in Section 660-463-504 is followed.

**D. SRL Determinations**

**6.10** The value for SRL provided at a given 4WTS whose 2-wire line port is terminated in the appropriate 2-wire circuit can be determined using the KS-20501 RLMS in a manner analogous to that used to determine the value for the ERL described in paragraph 6.09. The value for SRL is the smaller of the two values obtained, one with the TEST TYPE switch of the KS-20501 RLMS set for SRL and the second with the TEST TYPE switch of the KS-20501 RLMS set for SRL HI. Each of these two values is determined by the difference between two THL measurements made using a KS-20501 RLMS with its TEST TYPE switch set at either SRL or SRL HI: one with the 2-wire line port of the 4WTS under test terminated in a short circuit and the other with this port terminated in the appropriate 2-wire circuit.

**7. BALANCE VERIFICATION TEST CONSIDERATIONS**

**7.01** To complete balancing work on a TSPS Base Unit or in an RTA after the impedance compensators, the NBOCs of all 1P 4WTSs and all 900-ohm 4WTSs, and all DBOCs have been adjusted, the following tests should be made on the 1P 4WTS, or equivalent, of all operator position trunks on selected connections and on the 900-ohm 4WTS of all trunks of each type on selected connections:

- (a) 1000-Hz transmission loss test in both directions of transmission
- (b) Noise test
- (c) ERL test
- (d) SRL test.

Although not technically a balance objective, a transmission loss measurement and a noise measurement should be made on the trunk connection under test before the ERL and SRL tests are made. The measured loss should be within required limits of the expected measured loss (EML). The measured noise should meet requirements for that trunk. The purpose of the transmission loss test is to ensure that the test connection has been correctly

made and that the losses are within reasonable limits. The purpose of the noise measurement is to ensure that noise on the trunk will not affect the ERL and SRL measurements and that the noise is within reasonable limits. The ERL and SRL tests measure the ERL and SRL balance provided at a 4WTS on connections to properly terminated trunks and/or circuits after all necessary balancing adjustments have been completed.

**7.02** The verification test results of balancing of the TSPS base unit switching network or of the RTA concentrator should be recorded for each connection tested in the various types of different connection categories. The ERL and SRL results on all connections tested in a given connection category (eg, PSS No. 2 operator position trunk connected to a BR trunk) should follow a normal distribution and meet the appropriate balance requirements in Section 660-463-301 for TSPS base units and RTAs.

**7.03** Balance verification measurements should be made on the following connections in the direction indicated:

- (a) From the 4-wire facilities of operator position trunks in TSPS base units to TC trunks providing TSPS 2-wire access properly terminated in both the class 5 and toll offices
- (b) In both directions between the 4-wire facilities of operator position trunks in TSPS Base units and the 4-wire facilities of TC trunks providing TSPS 4-wire bridging access via a TSPS 4-wire bridging repeater, inward trunks, delayed call trunks, BR trunks, operator service trunks, incoming CAMA transfer trunks, and service observing trunks
- (c) From the 4-wire facilities of BR trunks in RTAs to TC trunks providing TSPS 2-wire access properly terminated in both the class 5 and toll offices
- (d) In both directions between the 4-wire facilities of BR trunks in RTAs and the 4-wire facilities of TC trunks providing RTA 4-wire bridging access and of inward trunks
- (e) From the 4-wire facilities of TC trunks providing TSPS or RTA 4-wire bridging access to an outgoing intertoll trunk in a 2-wire toll office.

## **8. BALANCE TESTING ARRANGEMENTS AND TERMINATIONS**

### **A. General**

**8.01** Test equipment, balance test circuits, and testing arrangements used in the TSPS Base unit and in the RTA are covered in detail in Section 660-463-504. The KS-20501 RLMS, described in Section 103-106-115, is specifically designed for making balancing measurements. The KS-20501 RLMS integrates all of the transmission test equipment and techniques for obtaining balance measurements into a single, simplified operation with a single test set. It is recommended that the KS-20501 RLMS, or equivalent, be used in both TSPS base units and RTAs to perform the required balance tests and adjustments.

**8.02** Local talking circuits between testing locations (ie, TSPS base unit, RTA, class 5 office, and toll office) should be established as required to coordinate the setup of the proper test arrangements to permit the conduct of the required balance tests and adjustments in a TSPS base unit or in an RTA.

**8.03** All test sets used in balancing a TSPS Base unit or an RTA must be calibrated in accordance with standard instructions before they are used. The calibration should be rechecked during the testing period. Ample warmup time should be allowed for all test sets to ensure that they have stabilized before they are used.

### **B. Balance Test Circuits in TSPS Base Units and RTAs**

**8.04** A balance test circuit is included as part of the CDT frame in the TSPS base unit and as part of the TDC in the RTA. These are described in Section 660-463-504. These balance test circuits are used during the tests required to determine the compromise value for the NBOC of the balancing network of all 1P 4WTSs in a given TSPS base unit or in a given RTA associated with the BR trunks. These balance test circuits are also used during DBOC adjustments in both the TSPS base unit and the RTA during adjustment of the NBOCs for all 900-ohm 4WTSs in both the TSPS base unit and the RTA.

### **C. Class 5 Office Balance Test Termination**

**8.05** To permit more practical methods of testing the ERL and SP/SRL balance on TSPS base unit operator position trunk connections or RTA BR trunk connections to TCTs providing 2-wire bridging access, a compromise termination has been selected for use at the class 5 office. This termination is used to represent subscriber loops terminated in an off-hook telephone set. This termination consists of a 900-ohm resistor in series with a 2.16- $\mu$ F capacitor and is considered to be representative of an average subscriber loop. Balance test requirements on the 1P 4WTS associated with operator position trunks in the TSPS base unit or with BR trunks in the RTA are based on the use of this termination.

### **D. Two-Wire Toll Office Balance Test Hybrid Termination**

**8.06** In order to make accurate balance measurements and to make balance measurements practical on TSPS Base Unit operator position trunks or RTA BR trunk connections to TCTs providing 2-wire bridging access, it is necessary that a proper build-out balance test termination be provided at the toll office. This termination is required to balance the toll office properly, and therefore should be available.

## **9. BALANCE TEST RESULTS ANALYSIS AND TROUBLESHOOTING**

**9.01** The method of stating balance requirements for TSPS base units and RTAs in Section 660-463-301 requires that the results of the balance measurements be analyzed. If the distribution of the measurement results is reasonably normal and the requirements are met, the overall balance objectives will be met. If the balance measurement results on any of the trunks fall below the stated minimum requirements, these trunks should be investigated for the cause of poor balance. Similarly, any trunk having significantly poorer ERL and/or SP/SRL balance test results than another trunk with similar equipment and layout should be investigated for the source of poor balance. A careful check may show that the balance can easily be improved. If balance requirements are not met and the causes of the poor balance results cannot be determined, the problem should be referred through proper channels for further investigation.

**SECTION 660-463-100**

**10. CERTIFICATION OF OFFICE BALANCE**

330-300-500

Completion Test of Exchange Area Cables—Introduction

**10.01** The basic requirement for initial certification of a No. 1 TSPS and RTA, as well as for the maintenance of that certification, is given in Section 852-400-010. The actual certification of a balanced system is the responsibility of the transmission engineer.

332-121-100

3-Way, 4-Wire Bridging Repeater—Description

332-121-101

3-Way, 4-Wire Bridging Repeater Test Extender—Description

**10.02** Any changes, such as circuit order, and traffic load balancing rearrangements or modifications, which may affect balance make it necessary for new balance measurements to be made and posted. Some of these changes are:

332-121-500

3-Way, 4-Wire Bridging Repeater—Tests and Adjustments

332-205-100

Impedance Compensators—Description and General Information

(a) Any wiring changes between the 1P 4WTS and position link

660-471-504

Crossbar Tandem Offices—Test Equipment, Test Circuits, and Terminations Used in Through and Terminal Balance Testing

(b) Any facility changes on 2-wire TC trunk

(c) Any wiring changes between the 900-ohm 4WTS and the trunk link

660-472-504

No. 5 Crossbar Offices—Test Equipment, Test Circuits, and Terminations Used in Through and Terminal Balance Testing

(d) A change in the NBOC value.

**10.03** If measurement results meet or exceed the requirements for a given test connection presented in Section 660-463-301 for a base unit or RTA, the entity will generally be certified if other requirements in Section 852-400-010 are met.

660-473-504

No. 4 Crossbar Offices—Test Equipment, Test Circuits, and Terminations Used in Through and Terminal Balance Testing

**11. REFERENCES**

**11.01** The following references are given to provide additional detailed information for use in TSPS Base Unit and RTA balancing procedures.

660-476-504

No. 1 ESS Office Test Routines, Test Circuits, Test Terminations, and Test Equipment Applications for Through and Terminal Balance

103-106-115      KS-20501 Return Loss Measuring Set—Description and Operation

731-030-100

Notes on Direct Distance Dialing