

NOTES ON
 DESIGN OF TOLL CONNECTING AND TANDEM TRUNKS
 WHEN
 INTERTOLL OR INTERTANDEM TRUNKS ARE TERMINATED
 ON 2-WIRE SWITCHES AT VNL

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- (2) Addition of 2 db fixed pad in connecting trunks with losses less than 2 db;
- (3) Improving impedance of loaded connecting trunks to provide better balance against compromise networks.

2. S-PAD FUNCTIONS

- 2.01 Since the S Pad is provided for terminating connections only, it is obvious that without any change whatsoever in the transmission layout, and with some economies in the general case, fixed pads of value "S" could be introduced in all connecting trunks adjacent to the switches, and the S Pad with its switching relay omitted from the intertoll trunks.
- 2.02 The transmission functions provided by the S Pad are:
 - (a) Prevent overloading due to talker on very short loops.
 - (b) Provide a measure for controlling the crosstalk from talkers on short loops.
 - (c) Provide echo return loss benefit equal to twice the value of the pad.

1. GENERAL

1.01 There has been considerable discussion over the past year of a new technique for terminating intertoll or intertandem trunks at their via net losses (VNL) on the 2-wire switches at tandem outlets or at toll dispersal offices at which through intertoll switching is contemplated. These notes provide a brief review of the current status of this plan and its transmission requirements and reactions.

1.02 The plan provides for:

- (1) Omission of switching pads in intertoll trunks at 2-wire offices and their termination at via net loss as for intermediate links;

- 2.03 From the standpoints of (a) and (b) above, the same benefit will be obtained from a fixed pad equal to the value of S in all connecting trunks of less than 2 db. Where the toll connecting trunks have a facility loss in excess of 2 db, Items (a) and (b) are not controlling and only Item (c) is of importance if the pad is omitted. If the return loss of such a trunk facility can be improved by the amount of the benefit obtained from the switching pad then the first 2 db of the connecting trunk can be assumed to care for the level and crosstalk requirements and will correspond to the functions of the fixed 2 db pad put in the shorter trunks.
- 2.04 The loading layout technique over the years has been based on half section termination at the toll or switching center. This

has produced adequate results for the types of design and operation in effect, which included the benefit of an S Pad in the intertoll circuit whether switchable or whether built into the facility loss of the end link. However, the omission of the S Pad would degrade return losses against the local trunks by a value of 2S. If the return loss of a loaded trunk against a compromise net can be increased by 2S then the pad can be omitted without sacrificing echo return loss performance and will result in an S db improvement for all calls routed via that trunk group.

3. IMPEDANCE COMPENSATOR

3.01 The low return loss range of loaded trunks vs. a compromise network is at the higher frequencies, since the impedance of the compromise net is substantially the same at all frequencies whereas that of the half section of loaded cable rises with frequency. Compensated loading is an artifice to control the impedance of the loaded cable to make it have a substantially uniform impedance, resistive at the higher frequencies. The equipment to accomplish this has been coded as an Impedance Compensator, and will consist of a multi-unit capacitor, such as the 187B and a 44 mh coil. The capacitor will be used to build out the cable end section to approximately .8 section at which the resistance component of the impedance is substantially the same at all frequencies but the reactance component increases negatively with frequency. The addition of the 44 mh coil provides a positive reactance varying with frequency which substantially compensates, that is offsets, the negative component of the cable and results in substantially uniform impedances with small angles over the frequency range from 1000 cycles up to about .8 cutoff.

3.02 The following table will illustrate the advantages of this type of treatment. The constants for 22H88 are used in this example.

Freq.	Half Section Termination		.8 Section with 44 mh Coil	
	Impedance	Return Loss vs. 900 ohms + 2 mf	Impedance	Return Loss vs. 900 ohms + 2 mf
300	1230 $\sqrt{25}$	16	1212 $\sqrt{24}$	17
500	1090 $\sqrt{18}$	19	1072 $\sqrt{15}$	21
1000	1050 $\sqrt{10}$	21	1004 $\sqrt{4}$	25
2000	1196 $\sqrt{5}$	17	1005 $\sqrt{3}$	23
3000	1877 $\sqrt{6}$	9	902 $\sqrt{8}$	25

3.03 It should not be inferred that use of the impedance compensator will correct poor structural return losses of a trunk. The above figures are for theoretical lines and the correction is obtained only for the sending end impedance mismatch, which is there even though the trunk were structurally perfect.

4. APPLICATION

(A) H88 Loading

4.01 As stated above the impedance compensator is effective only at the frequencies between about 1000 cycles and .8 cutoff. With 19 and 22-gauge D and H88, the return losses at the lower frequencies (300-500 cycles) are sufficiently good so that no special low-frequency correction measures are justified. With 24-gauge H88 the low-frequency return loss is as low as 12 db at 300 cycles which does not appear to provide much echo return loss margin considering omission of the 4 db benefit from the "S" Pad. Consequently consideration is being given to augmenting the impedance compensation with a low-frequency corrector for use on 24 gauge. The low-frequency corrector would consist of a resistor, inductor and capacitor in series tuned at about 250 cycles. With this arrangement the 300-cycle return loss would be increased from around 12 to 30 db.

(B) Systems with Cutoff Higher than H88

4.02 With loading systems having cutoffs in the order of 4500 cycles or higher, such as H44 or B88, the sending end impedance at half section does not change radically between 1000 and 3000 cycles, so that an impedance compensator would provide small improvement and can not be justified when only the echo range of 500-2500 cycles is of main consideration.

(C) Systems with Cutoff Lower than H88

4.03 With loading systems having cutoffs less than 3000 cycles, such as H135 and H175, the impedance compensator is effective up to a point approaching the cutoff frequency. However, since this is below 3000 cycles, it would be necessary to augment the compensator with a high-frequency corrector, which would hold the impedance of the circuit down to a reasonable value through the cutoff range. At the moment, complete data are not available on the transmission reactions.

5. TYPES OF OFFICES

5.01 As of now it appears that the design impedance classification for 2-W offices used to mechanically switch intertoll

and toll completing connections will be as follows:

Crossbar Tandem - 900 ohms
No. 5 Crossbar and Step-by-Step - 600 ohms

(A) Crossbar Tandem

5.02 Crossbar tandem does not provide a repeating coil in outgoing trunk circuits (completing trunks) and since in metropolitan areas the bulk of these trunks is expected to be of H88 type, this impedance is the one commonly appearing at the switches. If the intertoll trunks are arranged to terminate at 900 ohms and are provided with 900 or 1000-ohm compromise networks a highly effective terminal arrangement is realized. Ordinarily trunks of other impedances would be arranged to conform to this common switching impedance by use of proper ratio repeating coils. Since coils can not be used in this case the impedance change may be accomplished when necessary by use of the E1 or E2 repeater if a step-down is required and only nominal gain (1 or 2 db) is acceptable, or by use of an E2 and E3 repeater in an L arrangement where an important gain is required with an impedance transformation.

5.03 Where gain is required on an H88 trunk, the E-type repeaters generally should have the T arrangement, and should be located between the cable and the impedance compensator, and for best results the cable termination should approximate half section.

5.04 Connecting trunks incoming to crossbar tandem are generally equipped with repeating coils, and necessary impedance transformations should be accomplished by selection of proper ratio coils. Where E-type repeaters are required, any impedance transformation required should be done by the repeating coil, and the repeaters given a T arrangement.

(B) No. 5 Crossbar and Step-by-Step

5.05 Since repeating coils are required in all connecting trunk circuits, both incoming and outgoing, at both No. 5 crossbar and step-by-step offices, no direct advantage would accrue by a departure from the traditional 600-ohm switching impedance. It is proposed to continue this impedance at these offices thereby minimizing the amount of intertoll equipment changes required particularly at the large number of step-by-step offices that will be continued in service and adapted as tandem outlets or otherwise used as intermediate switching points.

5.06 All connecting, including tributary, trunks should be designed to the same principles as indicated above for incoming trunks to crossbar tandem with the exception that the switching impedance will be 600 instead of 900 ohms, and a different range of coil ratios will be required.

6. REPEATING COILS

6.01 The 120 series of repeating coils in the trunk circuits commonly used in connecting trunks provide return losses below 15 db at 500 cycles and as low as 7 db at 300 cycles. These values are inadequate for operation with pad omission. Extensive study has been given to this condition over the past year, including many different approaches. As a result it appears that the most practical method of raising these values is by the use of a 1 mf capacitor instead of the conventional 4 mf on the office side of the repeating coil, with an indicated improvement of about 6 db at 300 cycles. The 4 mf on the trunk side will remain unchanged.

7. ASSOCIATED INTERTOLL SWITCHING FEATURES

7.01 In addition to the material presented above, there are also some new features required in connection with the intertoll side of the house. One of these, of primary importance, is the improvement of operator's set impedance to permit stability of the facilities during the operating interval. The others are mainly associated with operator access or assistance trunks which may become links in a through connection between a ringdown and a dial intertoll trunk, where the drop balance would otherwise suffer.

7.02 An additional word might profitably be added with respect to operator set impedance. Even today, with pads in the intertoll circuit the low-frequency return loss is marginal on built-up connections as will be appreciated by those having had recent operating experience. The improvement from the proposed modification is expected to be about 6 db, which will compensate for the pad omission and provide another 2 db to bolster the existing marginal condition. The improvement appears to be obtainable by the simple expedient of adding a capacitor in series with the operator's receiver, of a value resonant with the receiver inductance around 250 cycles.

7.03 Omission of the switching pads on the intertoll trunks does not change the requirements for a high degree of office balance on through toll connections.