RADIO ENGINEERING
MICROWAVE RADIO
C/I OBJECTIVES
11-GHZ SYSTEMS

CONTENTS PAGE

1. GENERAL 1
2. 11-GHZ RADIO SYSTEMS 1
3. BASEBAND INTERFERENCE SPECTRA . . 2
4. C/I OBJECTIVES 3

1. GENERAL

1.01 This section contains the carrier-to-interference (C/I) objectives for 11-GHz Microwave Radio Systems. Also included are the baseband interference spectra from which the C/I objectives are derived.

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

1.03 The C/I objectives are calculated for the TL-2 and TN-1 systems; however, the objectives can be used for other radio systems which have characteristics similar to those specified in this section.

1.04 Refer to Section 940-330-104 for instructions regarding the interpretation of the data contained in this section and for the relationship between the baseband interference spectra and the tabulated C/I objectives.

2. 11-GHZ RADIO SYSTEMS

2.01 The characteristics of the TL-2 and the TN-1 radio systems were used in the calculation of the 11-GHz C/I objectives. These characteristics are shown in Table A. All of the parameters are used to calculate the baseband interference spectrum of both received signals. It can be assumed that systems which have characteristics similar to those given in Table A will have similar spectral densities, with the resulting C/I objectives and interference spectra similar to those shown in this section.

2.02 The TL-2 and TN-1 systems considered here are identified by their circuit loadings; for example, TN-1(1200) designates a TN-1 system with 1200-circuit loading, and TN-1 (TV) designates a TN-1 system carrying a television video signal, with or without diplexed audio. Additionally, the 600-channel loadings are differentiated according to the two types of multiplex in common use; thus, TL-2(U600) and TL-2(L600) designate, respectively, a TL-2 system carrying U600 multiplex and one carrying L600 multiplex. All other voice-circuit loadings are assumed to be U600 derived circuits. Finally, TN-1(1800*) designates an 1800-circuit TN-1 system having reduced deviation.

2.03 All calculations were performed assuming CCIR pre-emphasis. Although the calculations are relatively insensitive to the type of pre-emphasis used, this assumption does facilitate coordination with other carriers and allows a more universal approach to verification outside the Bell System.

2.04 The characteristics of a system carrying TV is omitted from Table A because the spectrum of a TV signal does not lend itself to calculation, and the parameters used to describe message service are not suitable for describing TV signals. Consequently, the measured spectrum of an FM signal modulated by the "Girl in Straw Hat" color picture is used. The low-index FM signal uses 226L pre-emphasis and contains a simulated diplexed-audio signal at 6.2 MHz adjusted to −12 dB relative to the 0-dBV TLP.

TABLE A

11-GHz RADIO SYSTEM CHARACTERISTICS

RADIO SYSTEM TYPE	CHANNEL CAPACITY (CKTS)	TOP BASEBAND FREQUENCY (MHz)	BOTTOM BASEBAND FREQUENCY (MHz)	TOTAL RMS FREQUENCY DEVIATION (kHz)	PER CKT (0 dBm0) DEVIATION (kHz)	FREQUENCY STABILITY (%)	PRE-EMPHASIS TYPE
TL-2(U600)	600	3.084	0.564	1124	289	0.050	CCIR
TL-2(L600)	600	2.788	0.060	893	230	0.050	CCIR
TL-2(1200)	1200	5.772	0.564	894	163	0.050	CCIR
TN-1(1200)	1200	5.772	0.564	894	163	0.002	CCIR
TN-1(1800)	1800	8.524	0.564	1120	167	0.002	CCIR
TN-1(1800*)	1800	8.524	0.564	793	118	0.002	CCIR
TN-1(2400)	2400	11.404	0.564	1193	154	0.002	CCIR

Note: TN-1(1800*) has reduced deviation for interconnecting TN-1 and TH-3.

2.05 The "Girl in Straw Hat" color picture was chosen as an average, rather than a worst-case, signal on the basis of spectrum shape and peak deviation. The use of a different TV signal would produce a different power density spectrum and, consequently, different C/I objectives.

3. BASEBAND INTERFERENCE SPECTRA

3.01 Baseband interference spectra from all combinations of 11-GHz systems are presented in Fig. 1 through 28. The odd-numbered figures present the interference spectra from the collective TL-2 systems into individual TL-2 and TN-1 systems, and the even-numbered figures present the interference spectra from the collective TN-1 systems into individual TL-2 and TN-1 systems. Further, Fig. 1 through 14 are for cochannel interference, and Fig. 15 through 28 are for interference from an adjacent (20-MHz away) channel. Baseband spectra for interference into TV are not given because only single video channels are involved, and the interference at a particular frequency in a video channel is of little significance. For convenience, the interference spectra are calculated for normalized interference signals (the interfering signal is assumed equal in strength to the desired signal). This is equivalent to having zero RF suppression (C/I=0) and provides a useful starting point for C/I objective calculations.

3.02 Each interference spectrum curve was calculated for the worst-case frequency separation allowed by the frequency stability of both carriers. For cochannel message service, worst-case frequency separation occurs when the frequency difference is equal to the top baseband frequency of the desired signal; for other frequency differences, the interference decreases. If the maximum frequency separation is less than the top baseband frequency, as is the case with systems having more stable carriers and greater message capacities, the curves reflect the interference at maximum allowable separation. Maximum frequency separation is determined from the frequency tolerance values in Table A. Thus, for a TL-2/TN-1 combination, the maximum frequency separation is 5.72 MHz (11 GHz × 0.05% + 11 GHz × 0.002%). For such a combination and with the desired system being TN-1(1800), the worst-case sideband interference occurs at 5.72 MHz, which is within the 8.524-MHz top baseband frequency. Maximum frequency separation for a TL-2/TL-2 combination is 11 MHz and 0.44 MHz for a TN-1/TN-1 combination. For the TL-2/TL-2 combination, the maximum top baseband frequency with 1200-channel loading is 5.772 MHz. Hence, the calculations are performed at that separation. For interference from a system carrying TV service, maximum interference occurs at a frequency separation that is less than the top baseband frequency and is dependent on the power distribution of the interfering TV signal at a specific instant. (See 2.05.)

3.03 In the cochannel baseband interference spectra, the continuous, or sideband, interference is the result of the interaction of the desired carrier and the interfering sidebands and the interaction of the desired sidebands and the interfering carrier. When the total instability of the two systems makes possible a frequency difference in the two carriers that exceeds the bottom baseband frequency of the desired system, a carrier beat may occur in that baseband. This does not mean that carrier beats are not possible with more stable systems and/or higher bottom baseband frequencies. However, the assumption is made that the probability of inband beats on such routes is negligibly small, and thus the carrier beat is not used as a basis for coordination.

3.04 On the baseband interference spectra plots, carrier beats are graphically represented by a vertical "spike." The spikes are placed at the highest baseband frequency allowed by the nominal frequency instabilities of the two systems, or at the top baseband frequency if the total instability is greater than the top baseband frequency. (The maximum interference increases with frequency separation up to a separation equal to the top baseband frequency; however, the maximum interference does not necessarily fall at the top baseband frequency. In practice, the carrier beat for most systems will not be a pure tone but will contain some jitter. For this reason, the interference level of the spike includes a 10-dB "burble factor" reduction. For systems that can not inherently justify this reduction, it is assumed that an intentional burble has been introduced through the use of a carrier spreading circuit. See Section 940-330-104 for the application of this factor.

3.05 In the adjacent-channel (20-MHz spacing) interference spectra, the interference is due almost entirely to sideband overlap. And since the overlap occurs from the higher-order sidebands where the power levels are lower, the interference is lower; this is reflected in the baseband interference spectra. Like the cochannel interference, the adjacent-channel interference is determined for worst-case frequency separation using the frequency tolerance values from Table A. Unlike the cochannel cases, worst-case adjacent channel separation is the minimum frequency separation. Thus, worst-case separation for adjacent channel operation of a TN-1/TL-2 combination is 14.28 MHz (20-5.72). Similarly, for TN-1/TN-1 and TL-2/TL-2 combinations, the worst-case separations are, respectively, 19.56 MHz and 9.0 MHz.

3.06 In the cochannel spectra for interference from a system carrying TV service, carrier beats are not present because the TV-FM spectrum does not contain a carrier. The interference is caused by interaction between the TV sidebands and the carrier and sidebands of the desired system; except for systems with L600 multiplex, the interference from a TV service system is greater than that from a message-service system because TV-FM sideband energy is greater near the carrier frequency.

4. C/I OBJECTIVES

4.01 Tables B and C contain the minimum C/I objectives necessary to meet the baseband noise objectives. For a "high noise, low stability" system (formerly termed short haul) such as TL-2, the noise objective is 14 dBrnc0 per exposure in a 4-kHz channel for both carrier beat and continuous interference. For a "low noise, high stability" system such as TN-1, the carrier beat objective is 17 dBrnc0 per exposure for carrier beat and 4 dBrnc0 per exposure for continuous interference. Note that because TN-1 has the noise performance per hop and high stability common to systems in the long haul network and may be used in the long haul network, the system requires the same protection from interference as does a long haul radio system. The entries in Tables B and C express in dB the total isolation (the ratio of the desired signal to the interfering signal at the input of the desired receiver) necessary to achieve the noise objective. Section 940-330-104 describes more fully the use of these objective tables as well as adjustments which can be made for specific situations.

4.02 Table B contains the objectives for cochannel operation. When carrier beats are possible, the table matrix element contains three entries. The top and middle enteries are, respectively, the required isolation (1) when both carriers are unmodulated and (2) when both are modulated; the bottom entry is the required isolation when no carrier beat is present and is based on continuous

TABLE B

INTERFERENCE OBJECTIVES (C/I) IN 11-GHz BAND COCHANNEL ANALOG SYSTEMS

DESIRED CARRIER	INTERFERING CARRIER: TL-2 (U600)	TL-2 (L600)	TL-2 (1200)	TN-1 (1200)	TN-1 (1800)	TN-1 (1800*)	TN-1 (2400)	TL-2 (TV)	TN-1 (TV)
TL-2 (U600)	78 73 58	78 67 63	78 75 58	78 75 58	78 75 58	78 75 57	78 75 57	61	61
TL-2 (L600)	79 68 65	79 62 64	79 69 66	79 69 66	79 70 66	79 71 66	79 71 65	62	62
TL-2 (1200)	88 85 68	88 79 75	88 87 66	88 87 66	88 87 66	88 87 65	88 87 65	73	73
TN-1 (1200)	85 82 78	85 76 84	85 84 76	70	70	69	69	81	75
TN-1 (1800)	88 85 81	88 80 88	88 87 79	70	70	69	69	86	74
TN-1 (1800*)	91 89 84	91 83 91	91 90 81	72	72	70	71	89	78
TN-1 (2400)	91 88 84	91 83 89	91 90 81	70	70	69	70	88	75
TL-2 (TV)	52	53	59	59	60	62	61	62	62
TN-1 (TV)	62	62	62	62	62	62	62	62	62

Note: C/I values for interference into TL-2 systems based on 14 dBrnc0 per exposure noise contribution.
C/I values for interference into TN-1 systems based on 4 dBrnc0 per exposure for carrier-sideband and 17 dBrnc0 for carrier-beat.

TL-2	Transmitter Type
(U600)	Voice Circuit Loading or TV Signal
78	C/I with both carriers unmodulated (dB)
73	C/I with both carriers modulated (dB)
58	C/I with carrier-sideband interference (dB)

interference only. Both carrier beat entries assume sufficient carrier jitter to allow the use of the burble factor mentioned in 3.04. Therefore, if both carriers are inherently very pure and if neither are modulated by carrier spreading circuits, both carrier-beat objectives must be increased by 10 dB.

4.03 The differences beween the unmodulated and the modulated carrier-beat interference for the various interfering/desired-carrier combinations range from as little as 1 dB to as much as 17 dB, as is indicated by the corresponding C/I entries in Table B. When the difference is insignificant (2 dB or less), it is practical to use the unmodulated C/I objective. However, when the difference is greater, an objective half-way between the two entries is recommended. This is because the unmodulated-carrier objective is more stringent than is usually necessary, and the use of the modulated-carrier objective requires full modulation on the interfering carrier.

4.04 An exception to the "half-way" recommendation is an interference situation in which L600 multiplex is used. Where the desired system uses L600 multiplex, the middle entry (modulated carrier beat) should be increased by 2.0 dB and used as the carrier-beat objective. When the interfering system uses L600 multiplex, the top entry (unmodulated carrier beat) should be decreased by 2.0 dB. When both systems use L600 multiplex, the middle entry plus 2.0 dB should be used. (L600 is the desired system.)

4.05 Table C contains the objectives for adjacent-channel operation (20-MHz separation). Since carrier beats are not predicted by the characteristics of the systems considered here, Table C does not contain any such objectives. Also, since the basic calculations used to derive these objectives yield unrealistically low values for some adjacent-channel cases, Table C includes additional values which have been adjusted for equipment considerations such as AGC capture or threshold degradation. The C/I value of 40 dB is necessary to prevent AGC capture of an interfering signal by a TL-2 system in a deep fade. The C/I objective of 56 dB is used to prevent the phenomenon of threshold degradation on a TN-1 system in a deep fade. An interfering system 20 MHz away from a TN-1 channel requires the threshold degradation objective to be the fade margin (assumed to be 50 dB) plus 6 dB. If a lower or higher fade margin is expected on a particular hop of TN-1, this number may be adjusted. If the fade margin were 45 dB, the C/I value would be 45 + 6 = 51 dB. The number may be adjusted downward to the calculated C/I value (bottom figure in Table C) if the fade margin is sufficiently low. This threshold degradation number may be further reduced by 10 dB if a 20-MHz filter (1042A) is used on the desired TN-1 channel. The filter sufficiently attenuates FM analog message or TV interference 20 MHz away. The 10-dB reduction may not be used if the interfering signal uses digital modulation. The 20-MHz calculated C/I values (rather than the threshold degradation values) may be used to evaluate interference between TN-1 channels on the same hop.

4.06 For 40-MHz separation, the C/I objective is 20 dB for any interfering system into any desired system except TV. An interfering system into TV at 40-MHz separation requires a C/I objective of 35 dB. These are also equipment (not directly calculated interference) related numbers.

> ***Note:*** For most recent changes to C/I values consult Long Lines Headquarters—Frequency Coordination Group.

TABLE C

INTERFERENCE OBJECTIVES (C/I) IN 11-GHz BAND 20-MHz SEPARATION ANALOG SYSTEMS

		INTERFERING CARRIER								
		TL-2 (U600)	TL-2 (L600)	TL-2 (1200)	TN-1 (1200)	TN-1 (1800)	TN-1 (1800*)	TN-1 (2400)	TL-2 (TV)	TN-1 (TV)
DESIRED CARRIER	TL-2 (U600)	40/37	40/35	40/36	40/16	40/14	40/21	40/33	40/37	40/11
	TL-2 (L600)	40/34	40/30	40/36	40/14	40/23	40/19	40/35	40/37	40/9
	TL-2 (1200)	55	55	54	40/35	47	44	44	54	40/30
	TN-1 (1200)	56/47	56/44	56/45	56/23	56/37	56/32	56/39	56/41	56/20
	TN-1 (1800)	62	61	65	56/45	56/46	56/42	57	64	56/40
	TN-1 (1800*)	64	62	68	56/45	56/47	56/43	60	66	56/40
	TN-1 (2400)	77	75	70	61	65	64	64	69	61
	TL-2 (TV)	40/23	40/22	40/36	40/20	40/21	40/20	40/33	40/35	40/35
	TN-1 (TV)	56/20	56/20	56/20	56/20	56/20	56/20	56/20	56/35	56/20

Note: C/I values for interference into TL-2 systems based on 14 dBrnc0 per exposure noise contribution.
C/I values for interference into TN-1 systems based on 4 dBrnc0 per exposure noise contribution.

TN-1 (1200)	←Transmitter Type ←Voice Circuit Loading or TV Signal
40/16	←C/I for 20-MHz separation

1. Top Figure — Adjusted for equipment limitation (dB):
   AGC capture for interference into TL-2
   Threshold degradation for interference into TN-1
2. Bottom Figure — Computed C/I number (dB)
3. Single Figure — Computed C/I number (dB)

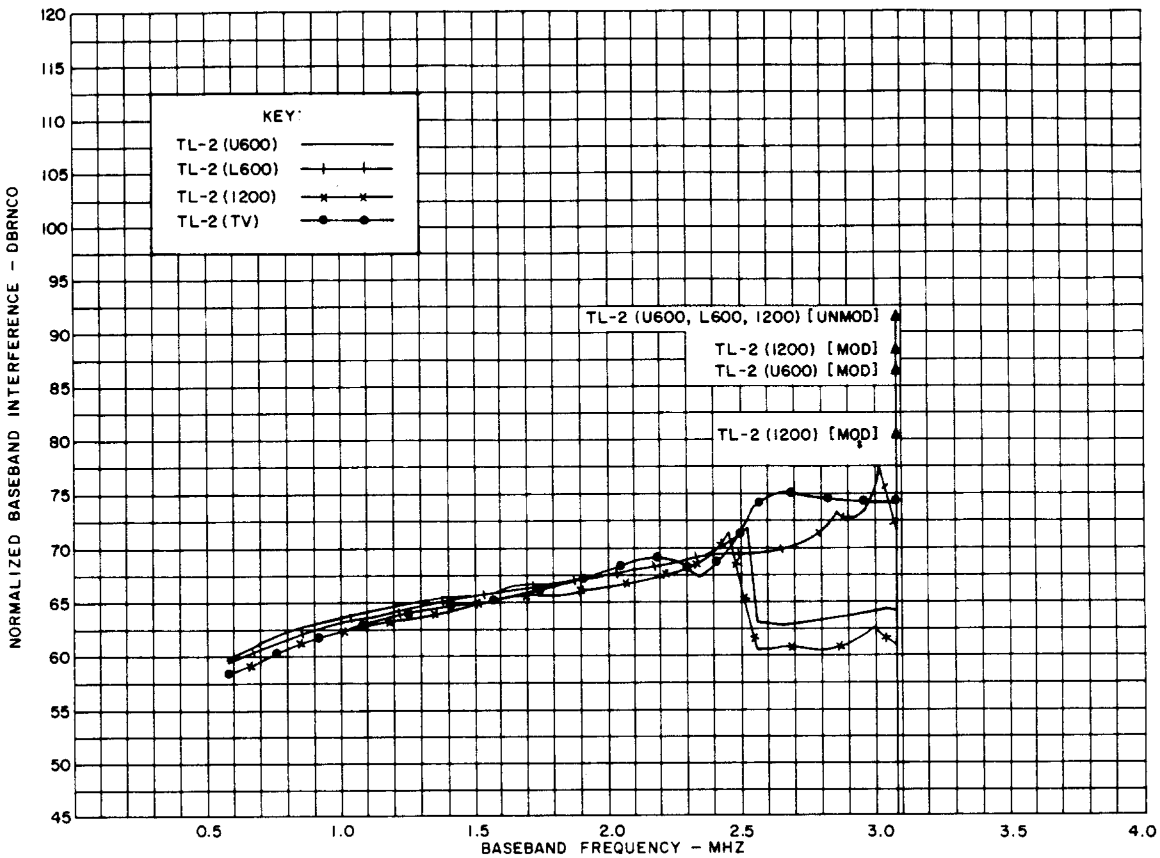

Fig. 1—Baseband Spectra—Cochannel Interference From TL-2 Into TL-2(U600)

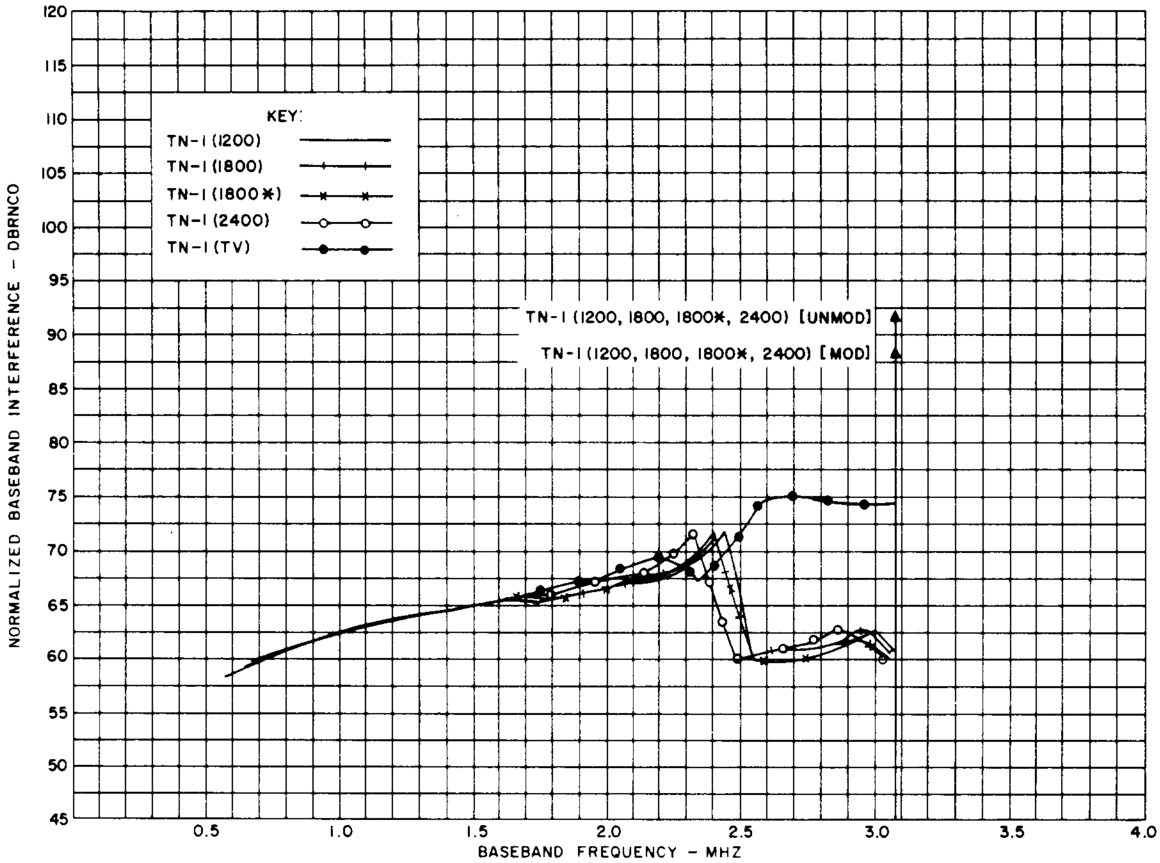

Fig. 2—Baseband Spectra—Cochannel Interference From TN-1 Into TL-2(U600)

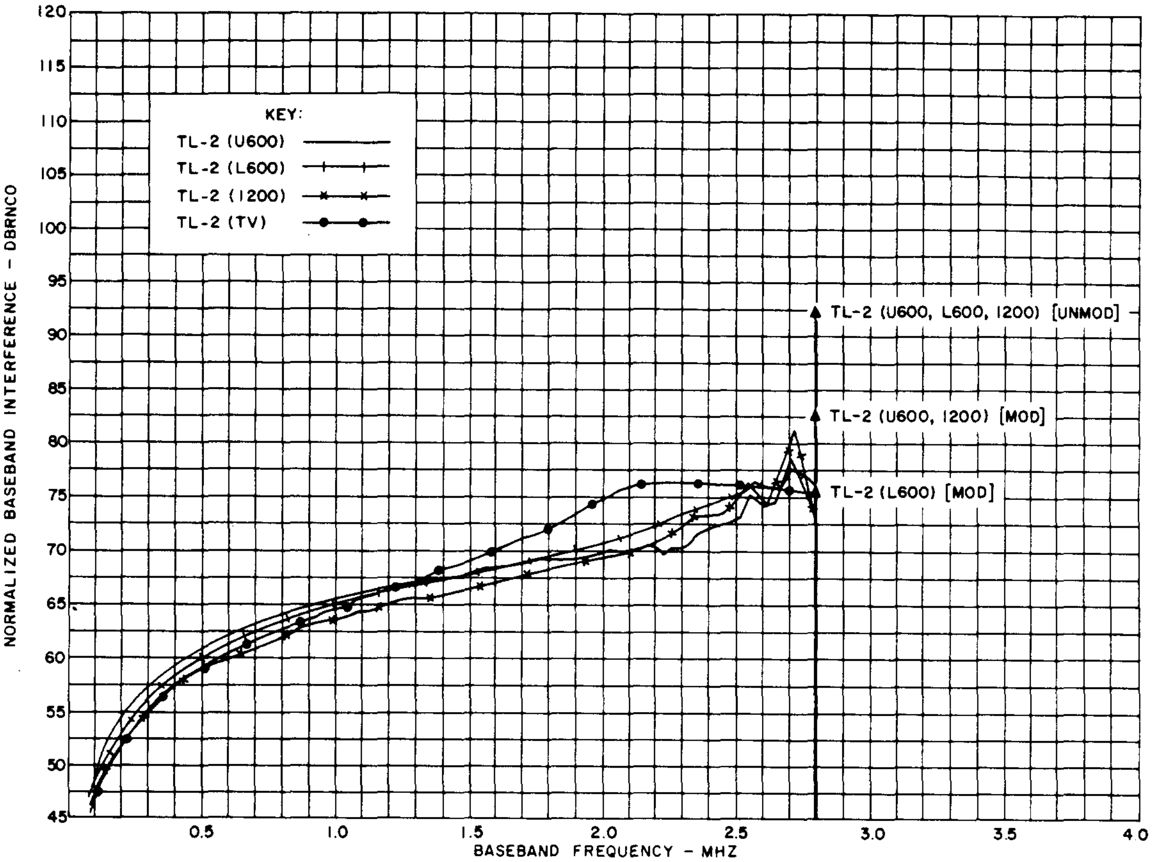

Fig. 3—Baseband Spectra—Cochannel Interference From TL-2 Into TL-2(L600)

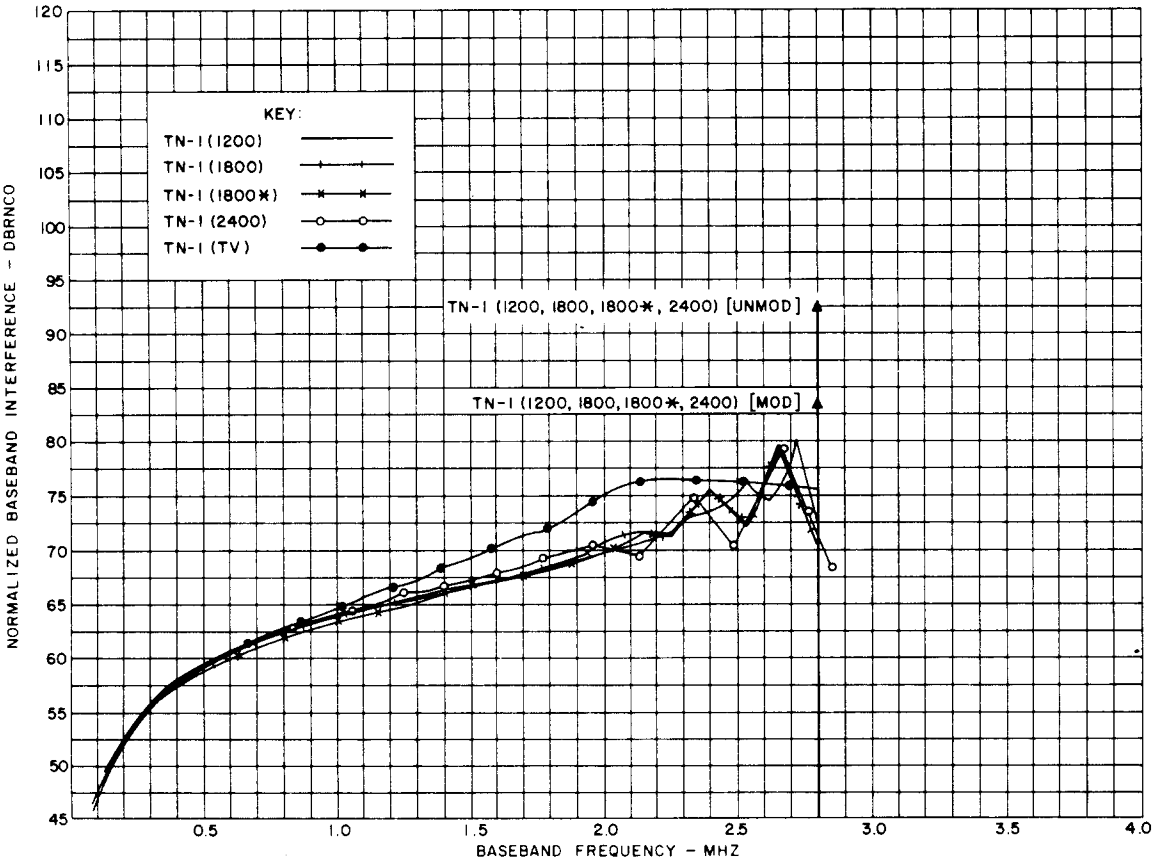

Fig. 4—Baseband Spectra—Cochannel Interference From TN-1 Into TL-2(L600)

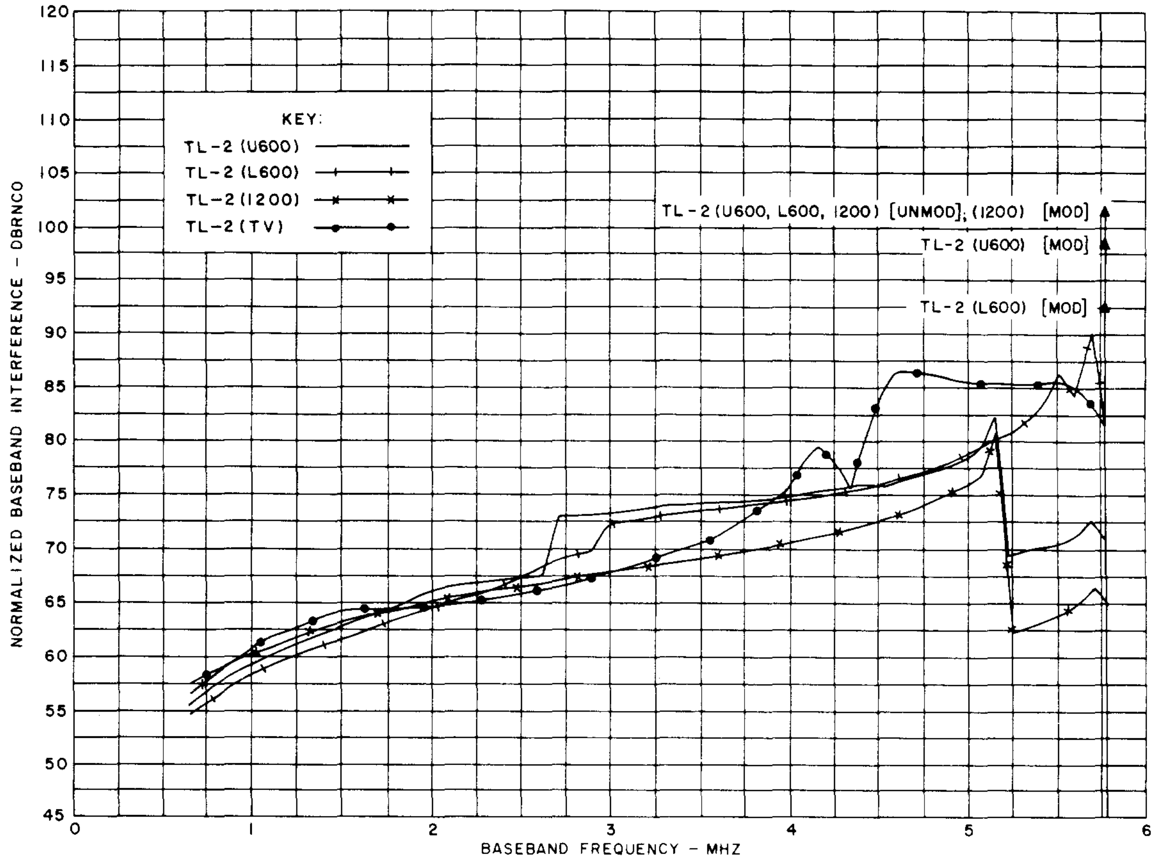

Fig. 5—Baseband Spectra—Cochannel Interference From TL-2 Into TL-2(1200)

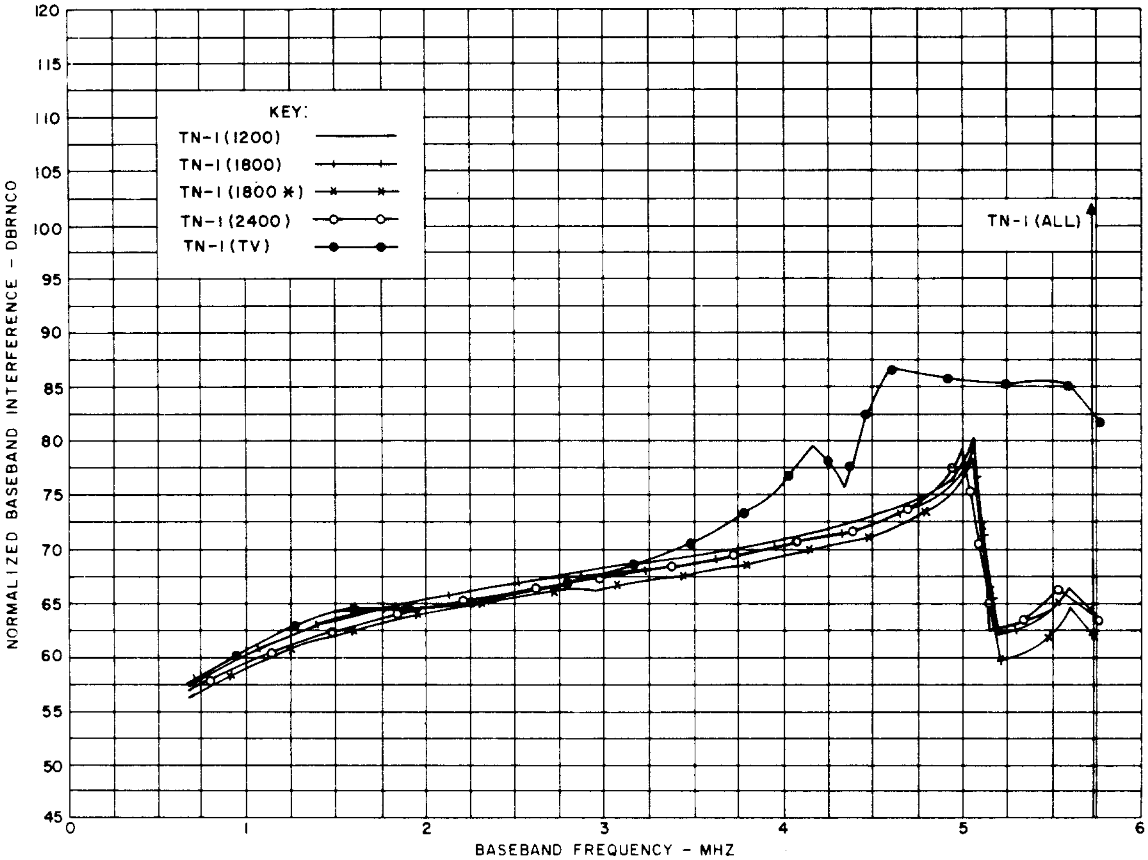

Fig. 6—Baseband Spectra—Cochannel Interference From TN-1 Into TL-2(1200)

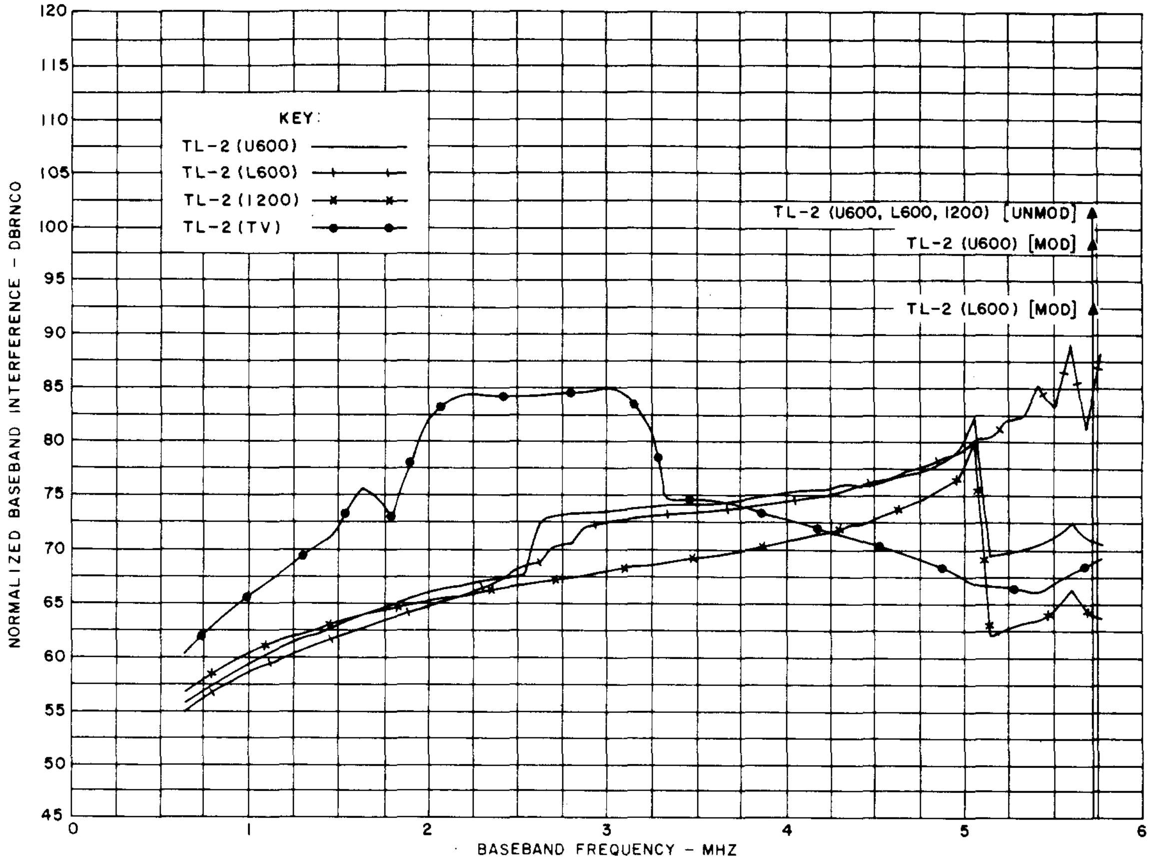

Fig. 7—Baseband Spectra—Cochannel Interference From TL-2 Into TN-1(1200)

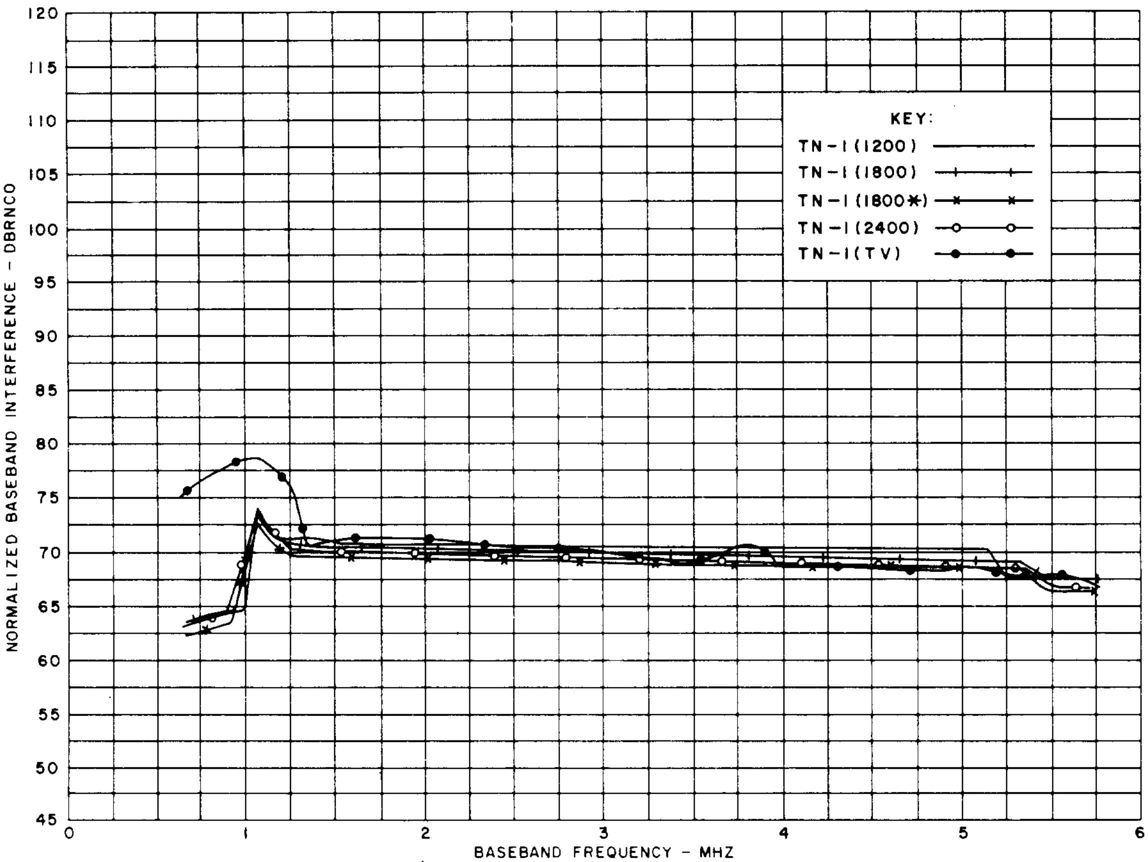

Fig. 8—Baseband Spectra—Cochannel Interference From TN-1 Into TN-1(1200)

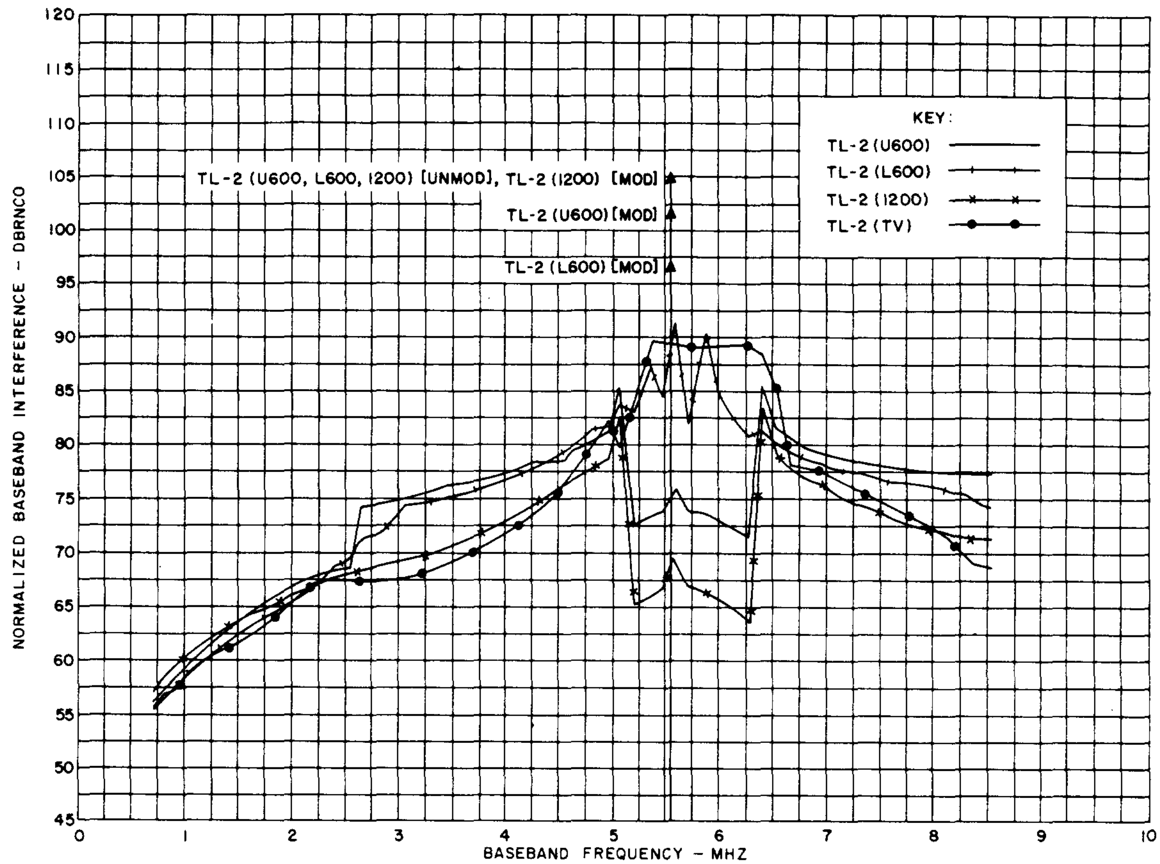

Fig. 9—Baseband Spectra—Cochannel Interference From TL-2 Into TN-1(1800)

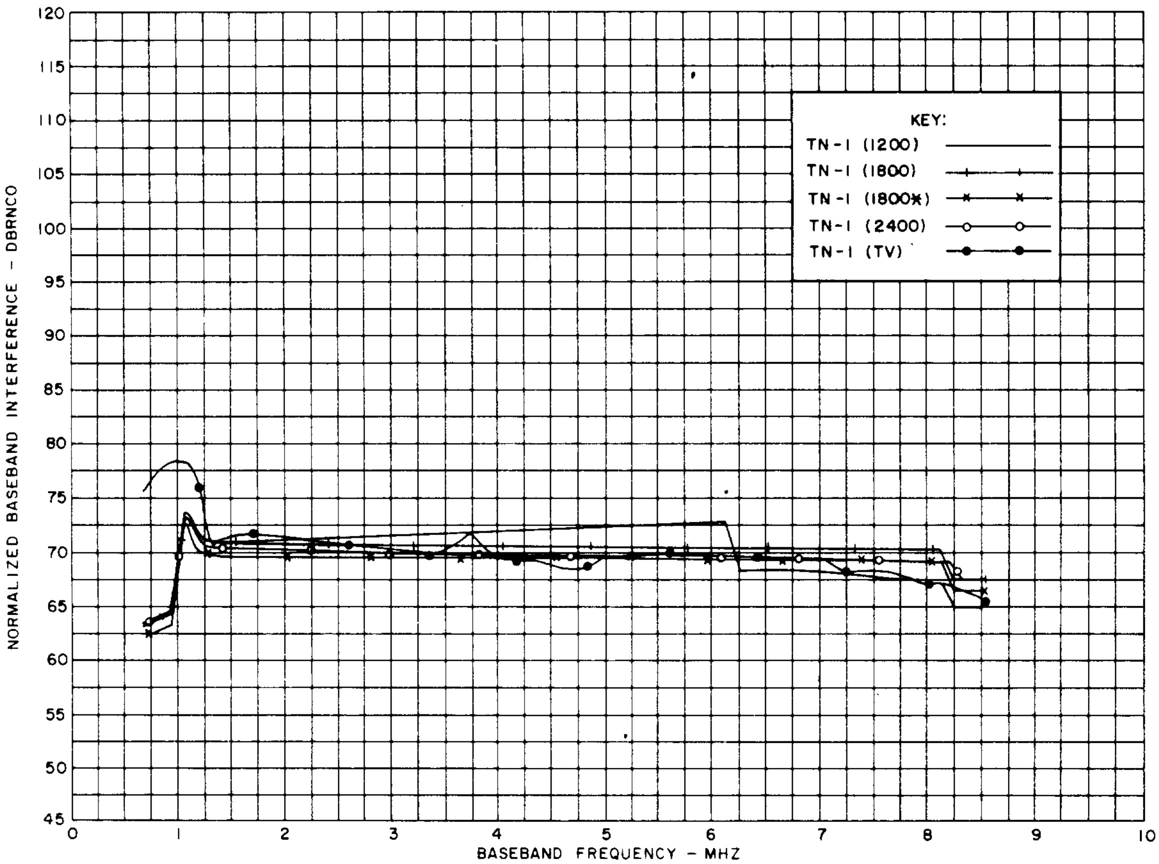

Fig. 10—Baseband Spectra—Cochannel Interference From TN-1 Into TN-1(1800)

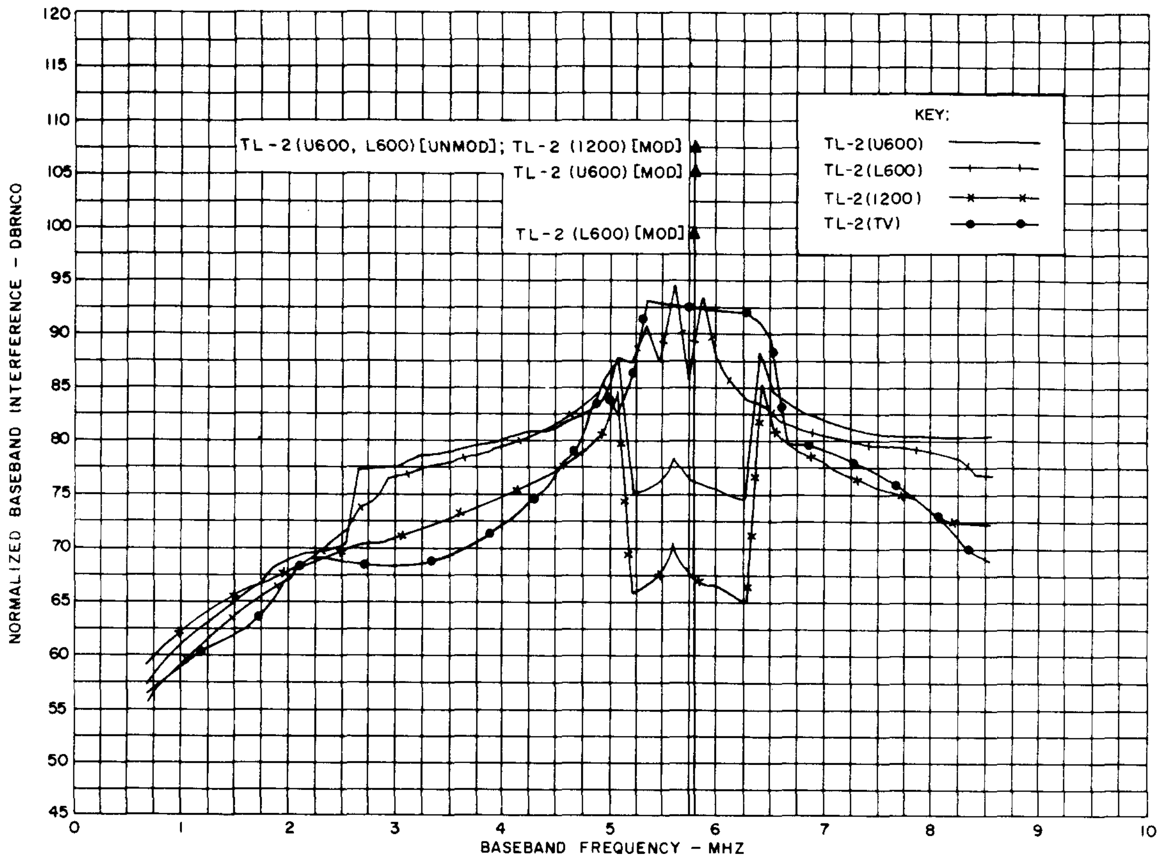

Fig. 11—Baseband Spectra—Cochannel Interference From TL-2 Into TN-1(1800*)

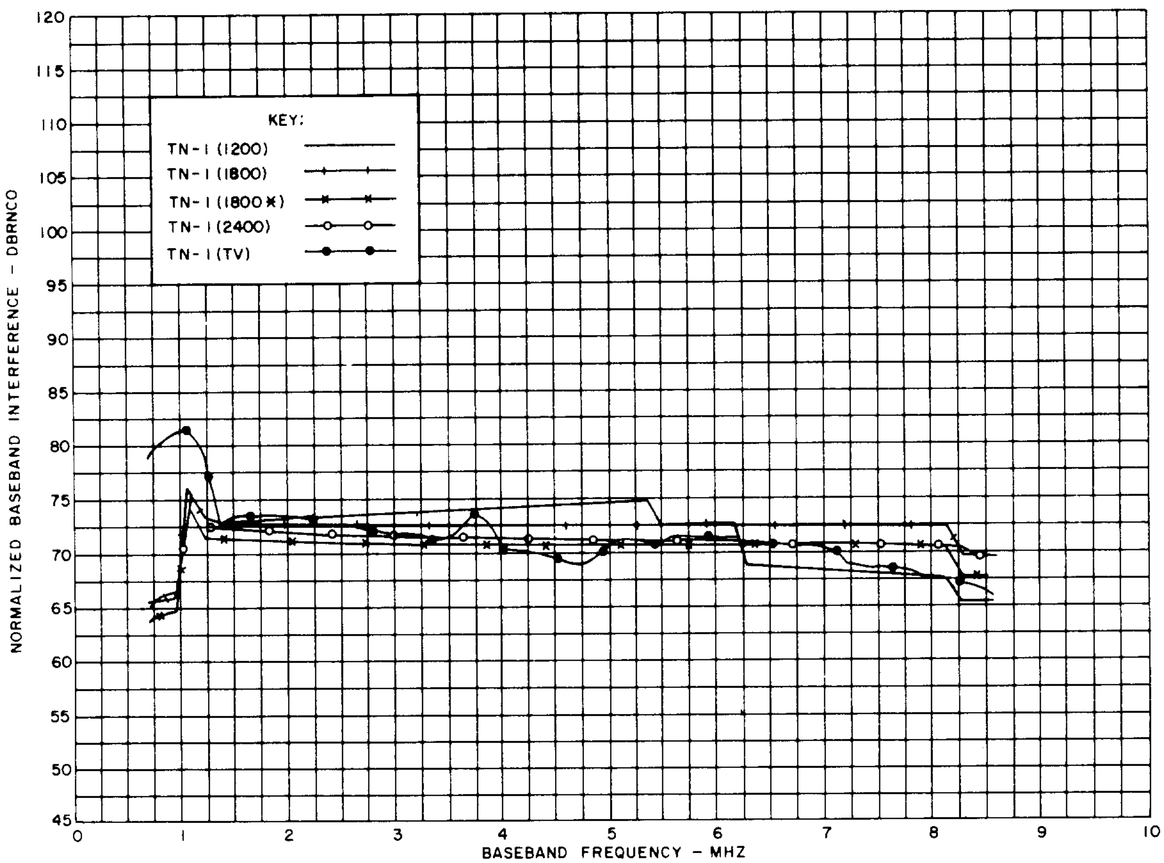

Fig. 12—Baseband Spectra—Cochannel Interference From TN-1 Into TN-1(1800*)

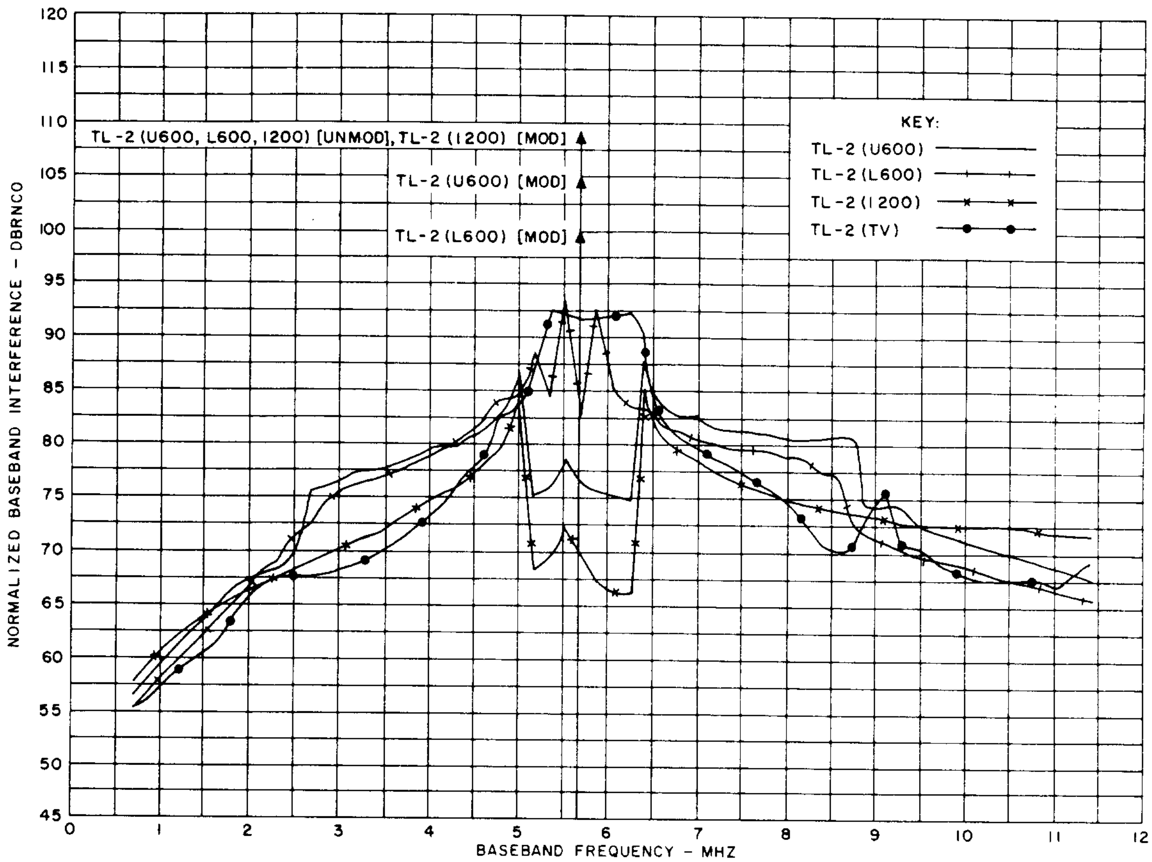

Fig. 13—Baseband Spectra—Cochannel Interference From TL-2 Into TN-1(2400)

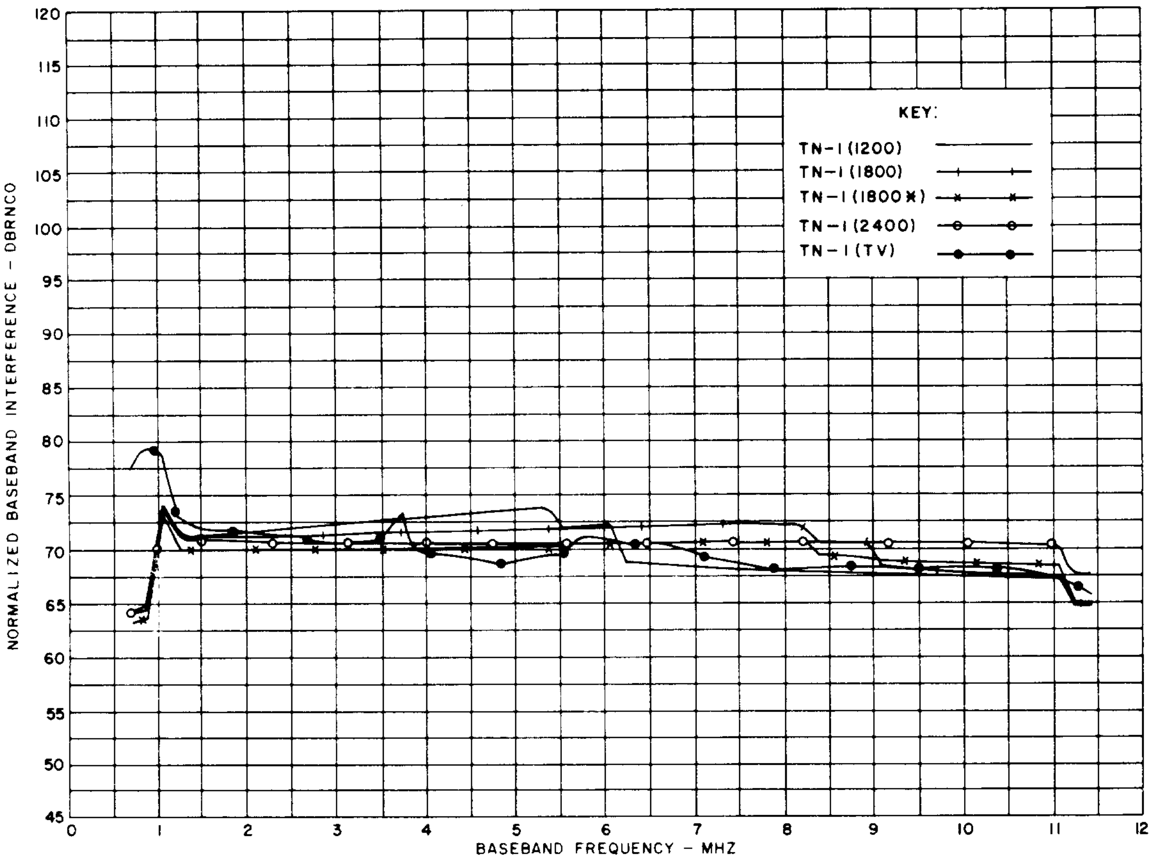

Fig. 14—Baseband Spectra—Cochannel Interference From TN-1 Into TN-1(2400)

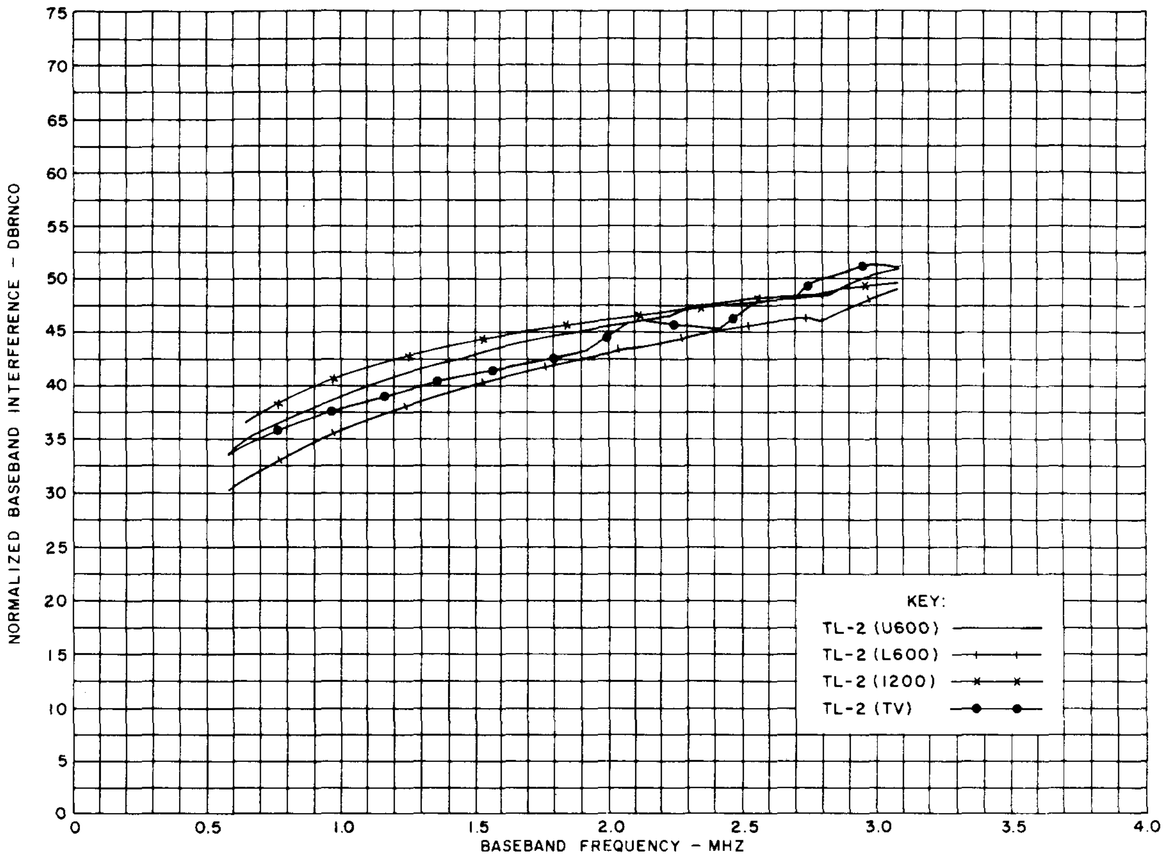

Fig. 15—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TL-2(U600)

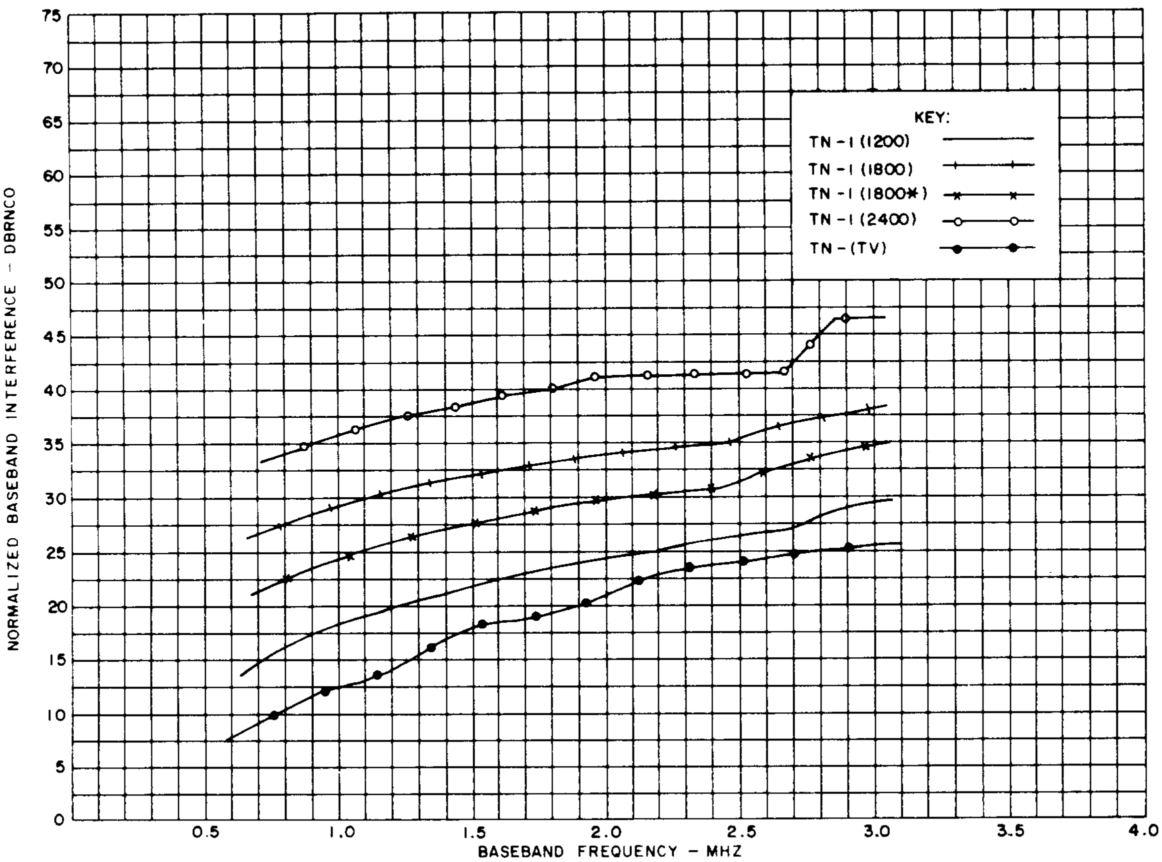

Fig. 16—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TL-2(U600)

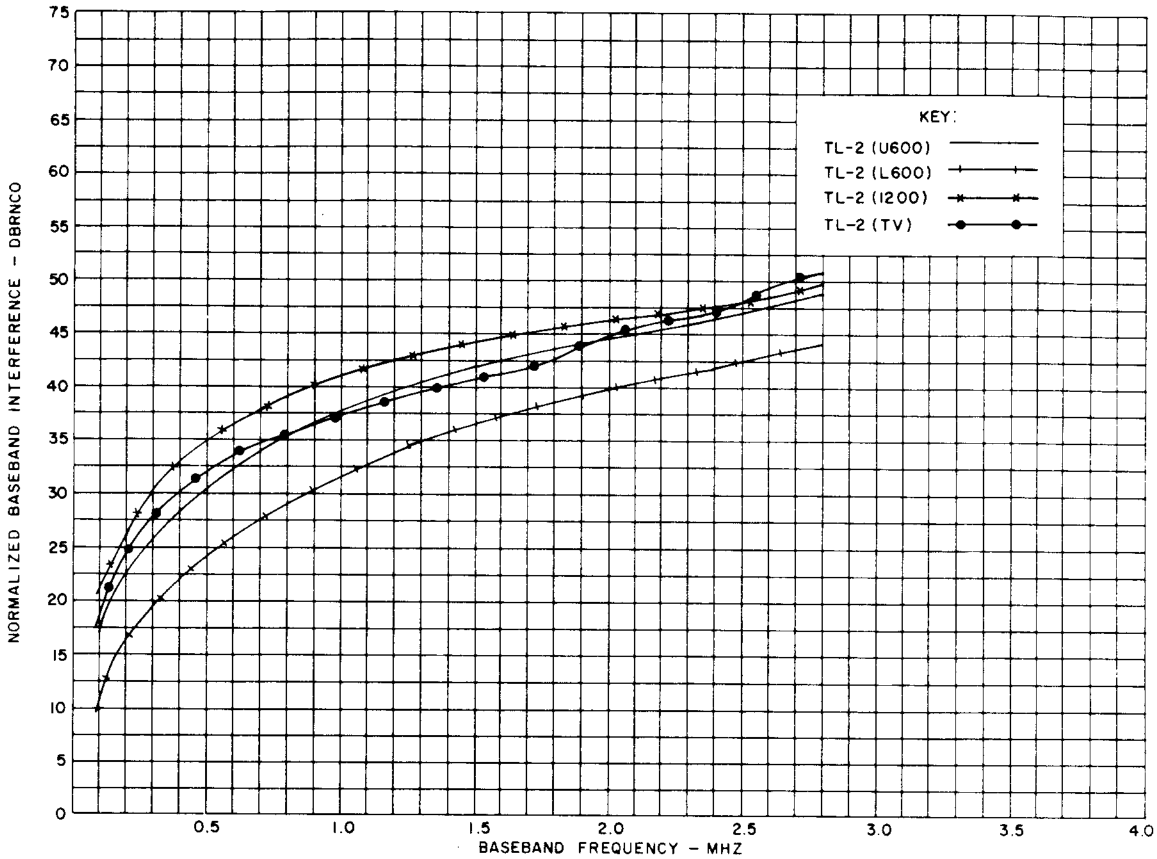

Fig. 17—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TL-2(L600)

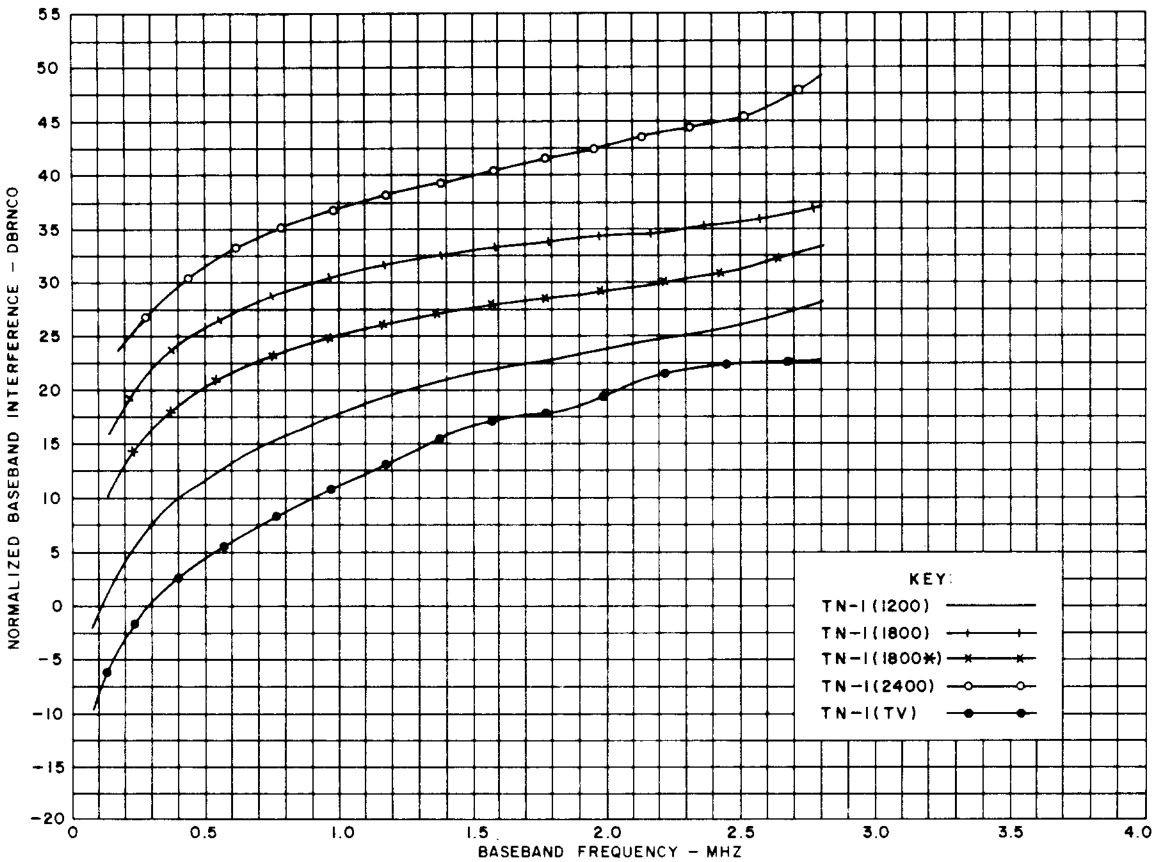

Fig. 18—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TL-2(L600)

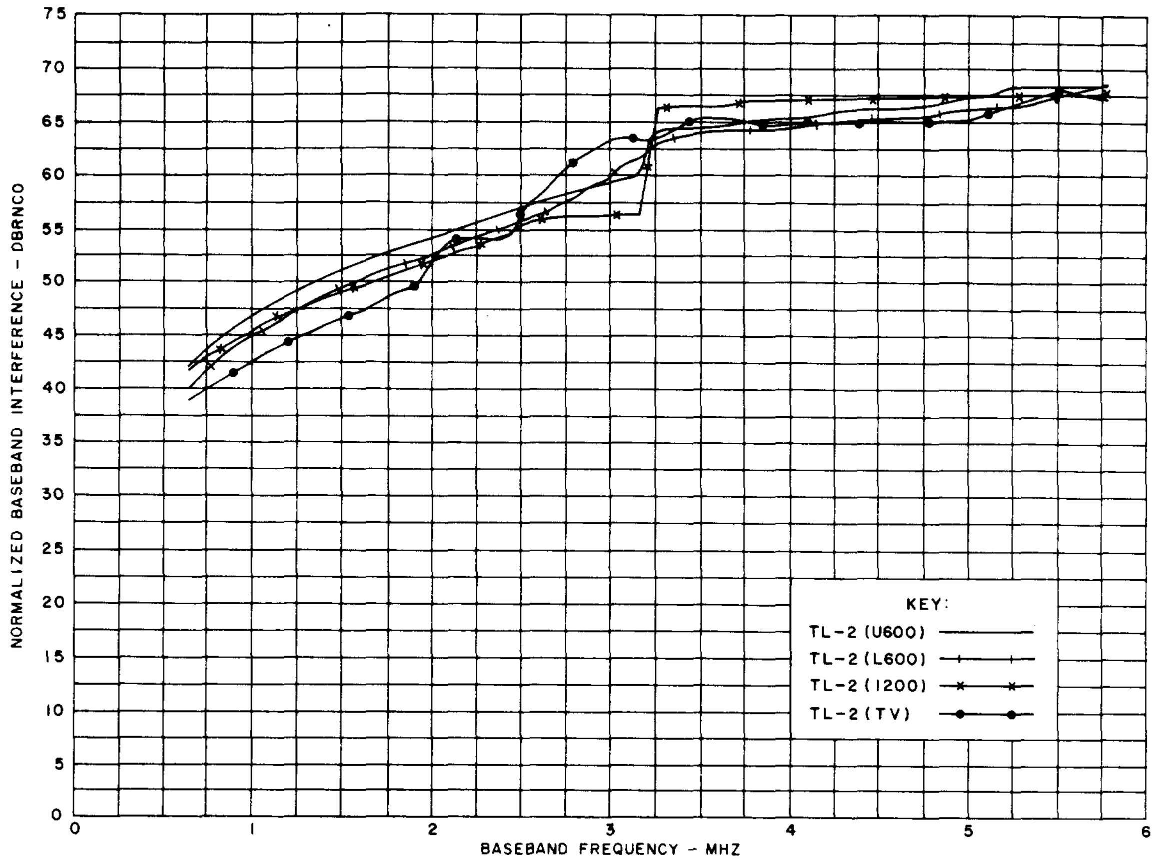

Fig. 19—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TL-2(1200)

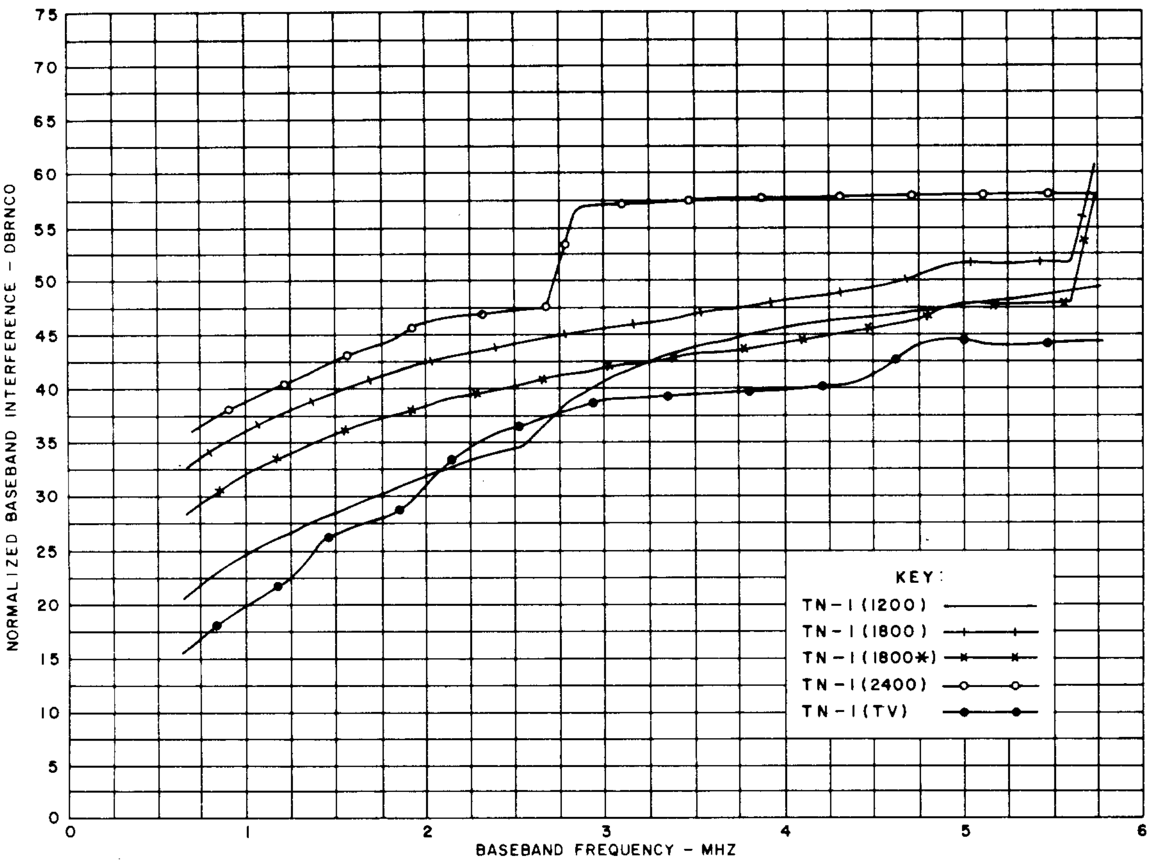

Fig. 20—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TL-2(1200)

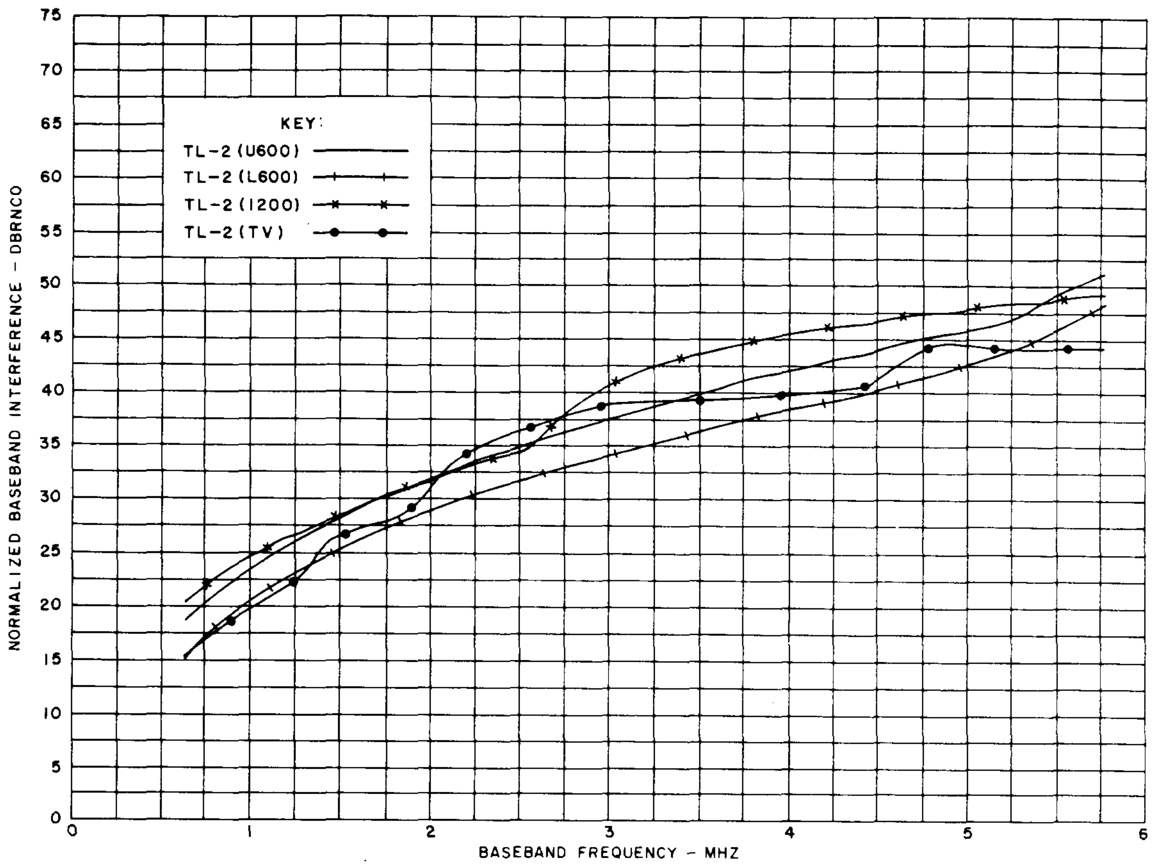

Fig. 21—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TN-1(1200)

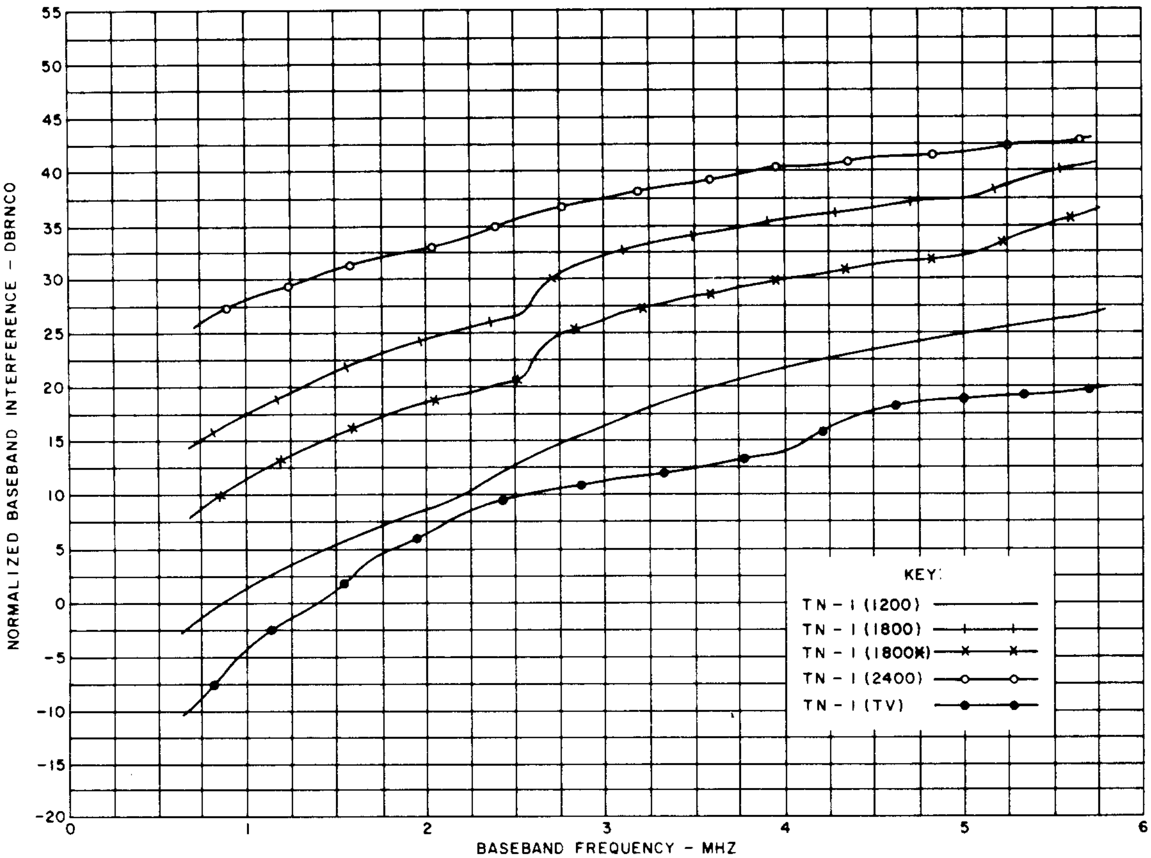

Fig. 22—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TN-1(1200)

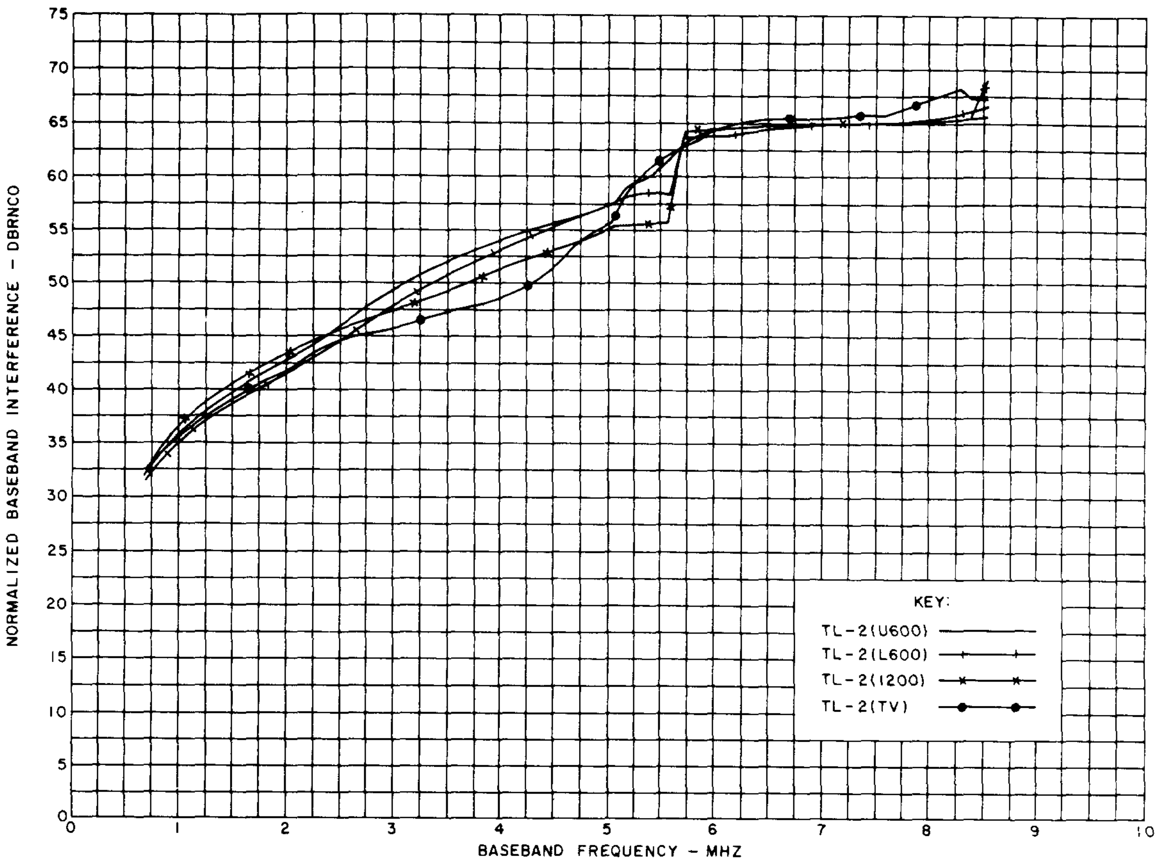

Fig. 23—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TN-1(1800)

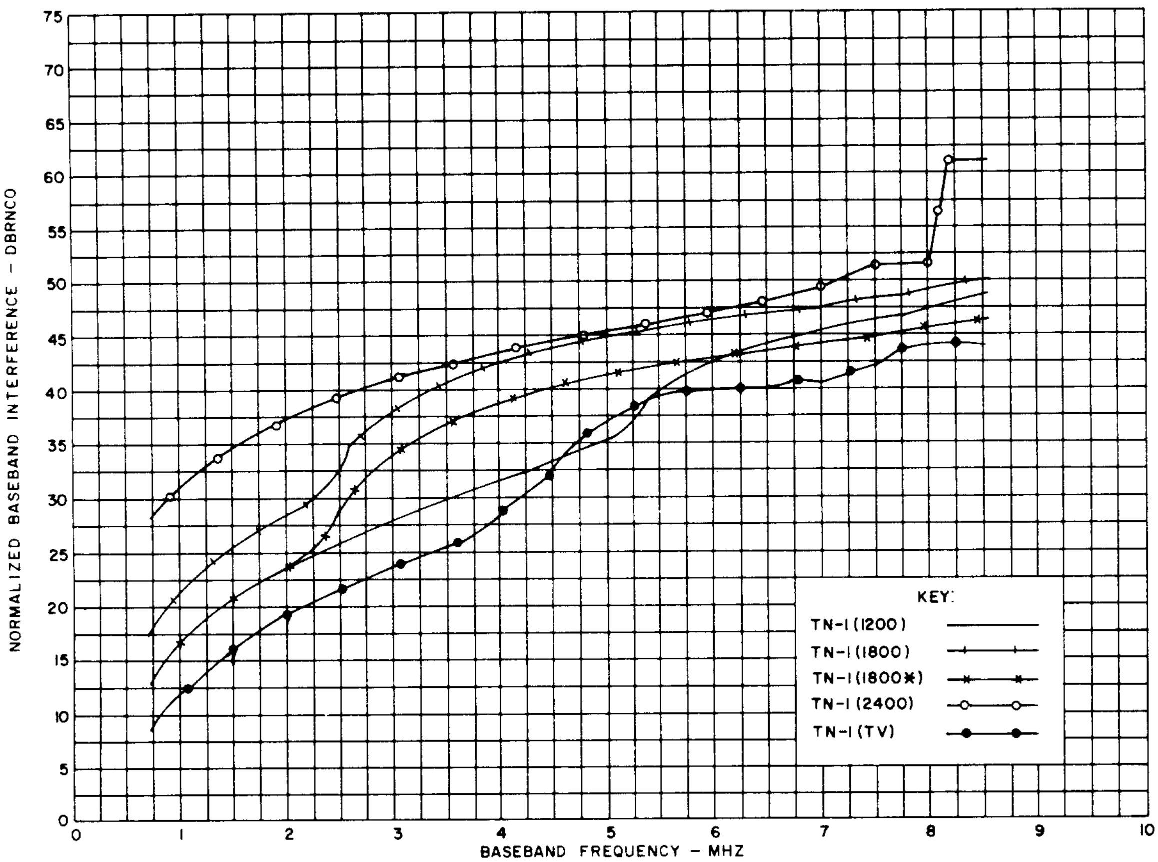

Fig. 24—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TN-1(1800)

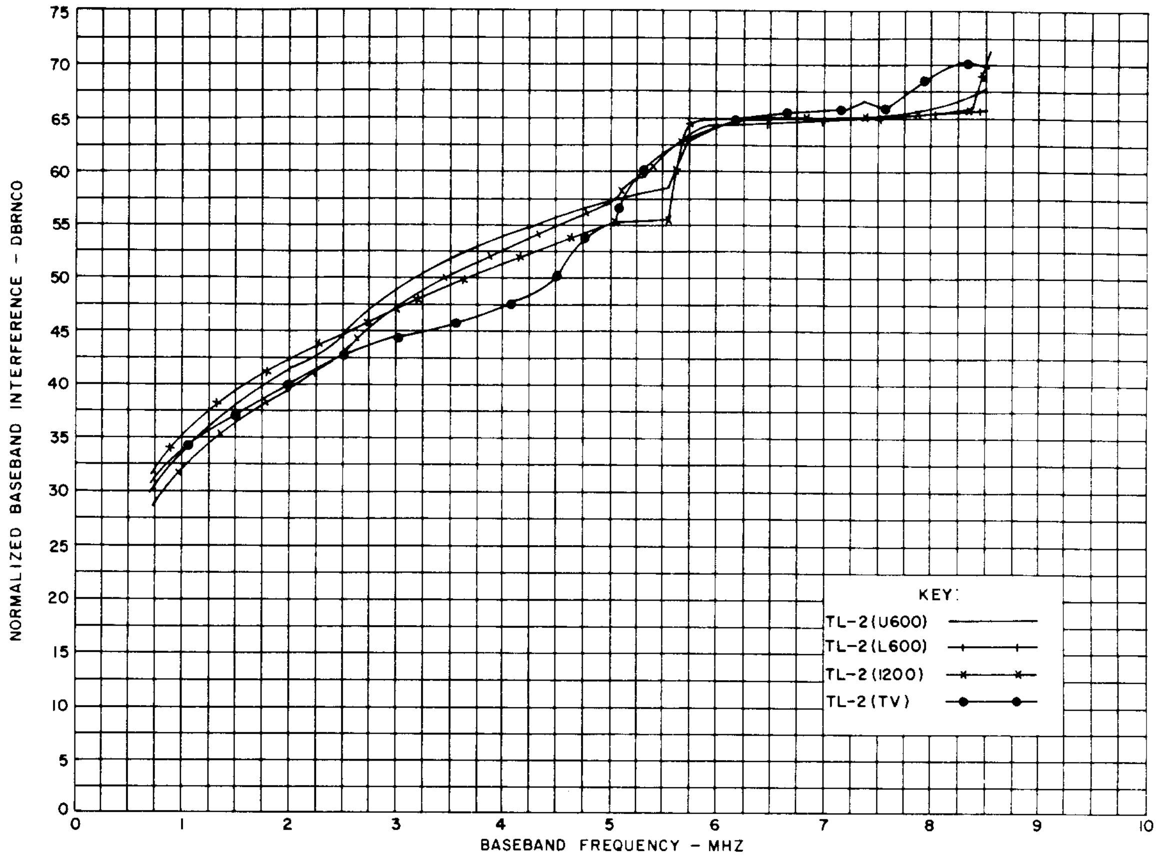

Fig. 25—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TN-1(1800*)

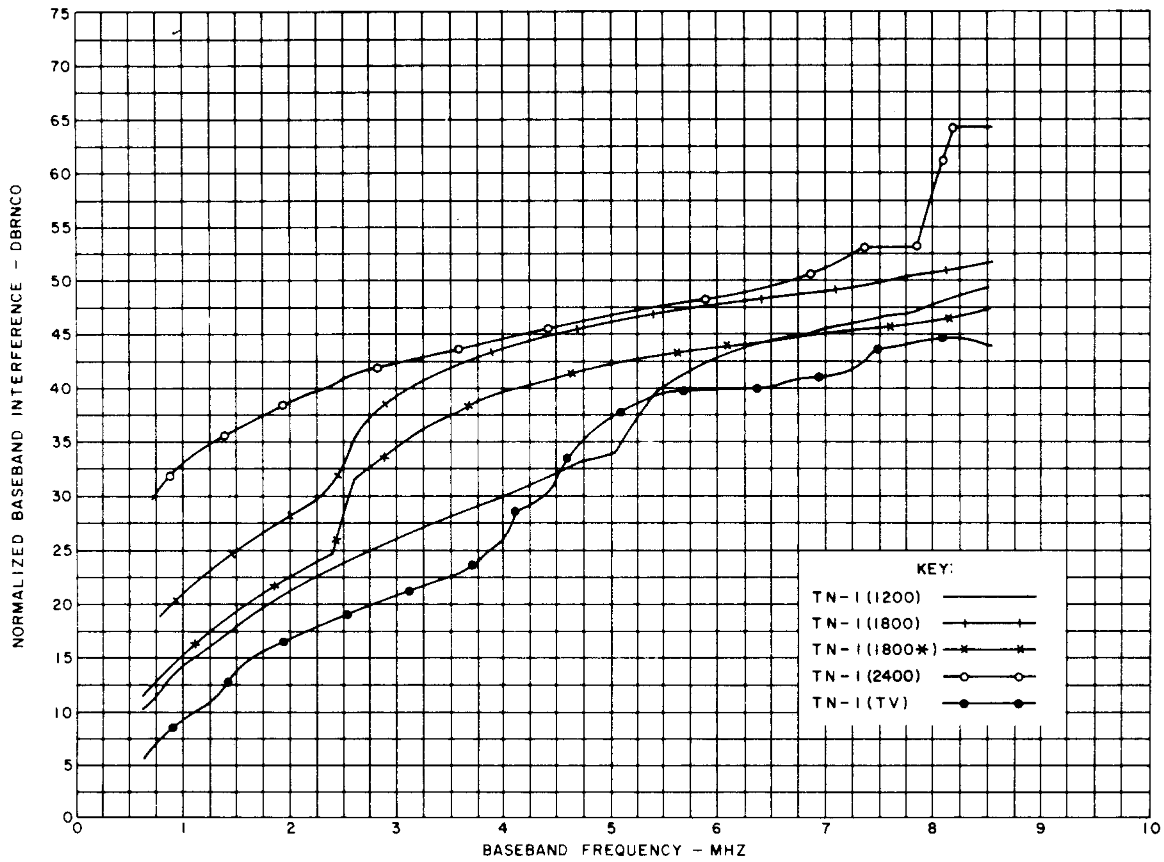

Fig. 26—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TN-1(1800*)

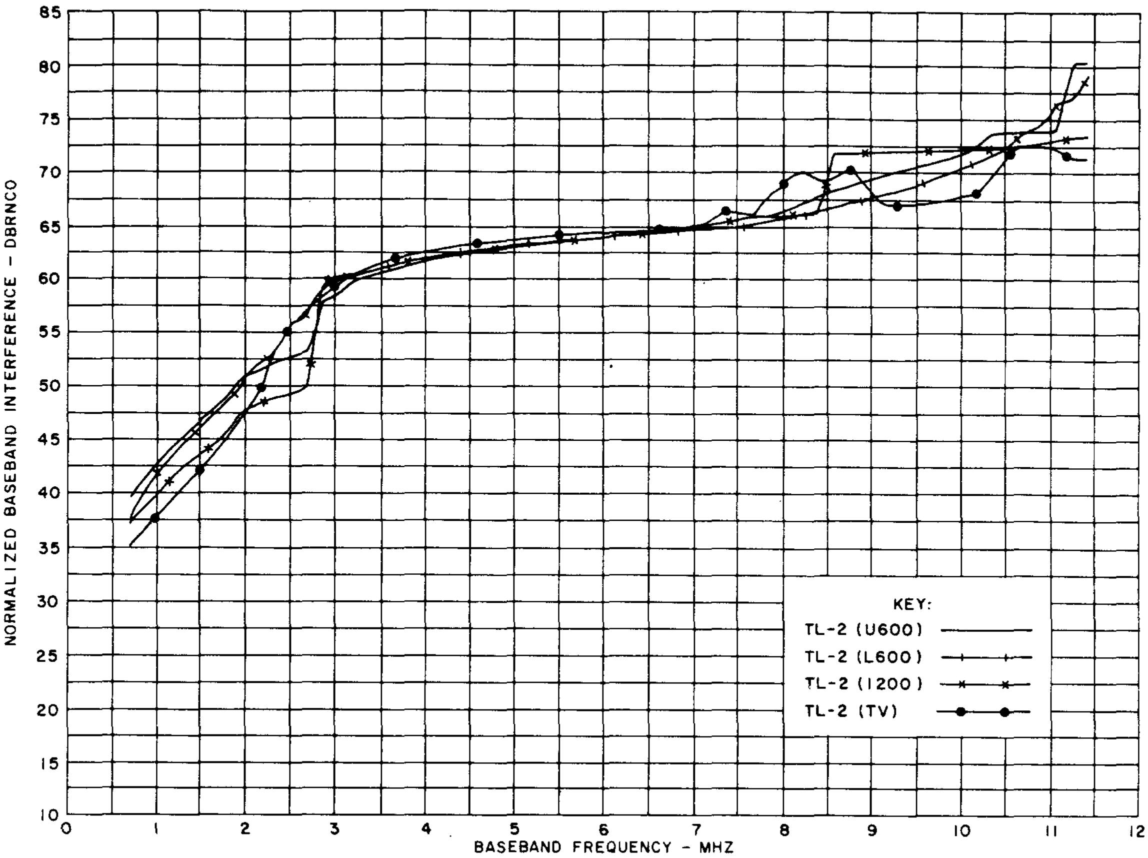

Fig. 27—Baseband Spectra—Adjacent Channel Interference From TL-2 Into TN-1(2400)

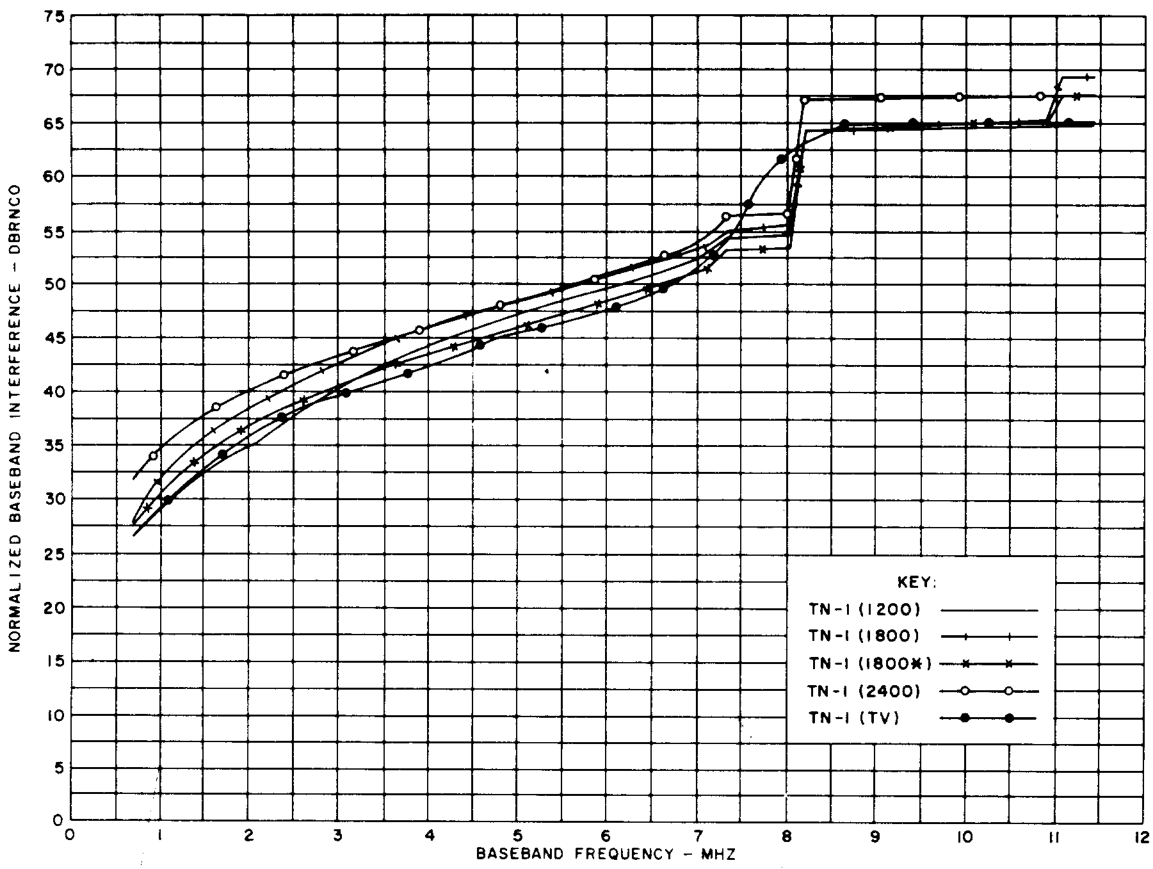

Fig. 28—Baseband Spectra—Adjacent Channel Interference From TN-1 Into TN-1(2400)