COCHANNEL INTERFERENCE STUDIES
COMPUTATIONAL METHODS
MOBILE RADIO
RADIO ENGINEERING

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1. GENERAL

1.01 On September 8, 1980, Part 22 of the Federal Communications Commission (FCC) Rules and Regulations that covers "PUBLIC MOBILE RADIO SERVICES" was amended to require cochannel interference information, where applicable, with each Domestic Public Land Mobile Radio Service (DPLMRS) construction permit application for a new base station or for a major modification to an existing base station. In addition to the information previously required, such applications must now contain an interference study if cochannel facilities either exist or have been applied for within certain specified distances. These interference studies must use procedures consistent with the section of the FCC Rules on "Service area of base station" and with FCC Report No. R-6406, "Technical Factors Affecting the Assignment of Facilities in the Domestic Public Land Mobile Radio Service" by Roger B. Carey.

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

1.03 This section describes the computational method to be used when making cochannel interference studies, as outlined in FCC Report No. R-6406, for existing or proposed base stations in the DPLMRS. The method involves calculating the geographical location of a base station's protected service area boundary as defined by field intensity contours, calculating the required ratio in dB between the field intensity of the desired signal (F_d) and the field intensity of the undesired cochannel signal (F_u) at the protected service area boundary, and then determining if the required field intensity ratio between the two signals is met.

1.04 The DPLMRS encompasses both 2-way service with mobile units and 1-way signaling service to paging receivers. From the standpoint of operation in the 2-way mobile service, system parameters in both directions of transmission are equally important. However, in cochannel interference studies using FCC procedures, only the reception of the base station by the mobile unit is considered since this is the controlling direction of transmission for frequency assignment. The methods in this section should only be used to satisfy FCC requirements in preparation of cochannel interference studies. Section 940-230-100 should continue to be used for preparing coverage estimates.

2. WHEN STUDY IS REQUIRED

2.01 The section of the FCC Rules on "Technical content of applications," as amended September 8, 1980, requires submission of an interference study showing that the proposed facilities for ***2-way base stations*** will not cause harmful electrical interference to existing or proposed 2-way cochannel facilities. The cochannel stations to be considered are those which are located:

(a) At less than the minimum mileage separation distances specified for each of the three operating bands shown in Tables B, C, and D of this section for the classes of stations defined in Table A or

(b) Within 125 miles of the proposed station if the combination of effective radiated power (ERP) and antenna height in the direction of the cochannel station exceeds the ERP limit determined by applying the section of the FCC Rules on "Antenna height-power limit for base stations" (e.g., in some cases, the average of the eight cardinal radials complies with the height-power limit, but the combination of ERP and antenna height along the particular radial between the two stations exceeds the limit). Figure 1 of this section is identical to the figure shown in the FCC Rules and is included here to facilitate computation of the ERP limit.

2.02 For base stations providing 1-way signaling service, the section of the FCC Rules on "Technical content of applications" requires submission of data showing that the proposed facilities for ***1-way signaling*** service will not cause harmful electrical interference to existing or proposed cochannel facilities which are located:

(a) Within 75 miles of the proposed station or within the minimum mileage separation distances specified in Tables B, C, and D of this section for the classes of stations and antenna heights shown in Table A, ***whichever is less,*** or

(b) Within 125 miles of the proposed station if the combination of ERP and antenna height in the direction of the cochannel station exceeds the ERP limit determined by applying the section of the FCC Rules covering "Antenna height-power limit for base stations" or Fig. 1 of this section.

2.03 The interference studies must use procedures consistent with the section of the FCC Rules covering "Service area of base station" and FCC Report No. R-6406. All supporting data and calculations must be included with the results of the studies.

3. DATA REQUIRED AND SOURCE

3.01 Specific conditions requiring submission of an interference study as part of the FCC application are described in Part 2 of this section. To decide if an interference study is required and to prepare the study, first determine the geographical coordinates of, and azimuth toward, each existing or proposed base station that is operating or will operate cochannel with the proposed Bell System base station to a distance of 125 miles for both 2-way mobile service and 1-way signaling service. The mileage separation distance and azimuth between the stations can be determined through the use of the AT&T Company's AZIMU1, or equivalent, computer program by entering the coordinates of the proposed Bell System station and each cochannel station involved.

3.02 The general location of existing cochannel base stations in the DPLMRS and those for which FCC construction permit (CP) applications (FCC Form 401 or replacing form) have been accepted for filing (proposed stations) can be obtained from one or more of the following sources:

	Existing Stations	Proposed Stations
(a) "National Mobile Telephone Service - Area Listings" booklet published by AT&T Co.	X	
(b) Area frequency coordinators	X	X
(c) FCC Public Notices (published weekly)	X	X
(d) FCC Frequency Allocation Microfiche List (updated semiannually)	X	
(e) "Industrial Communications" (published weekly)	X	X
(f) Various Computerized Data Information Service Companies	X	

3.03 If the maximum ERP permitted by the section of the FCC Rules covering "Antenna height-power limit for base stations" or Fig. 1 of this section for the antenna radiation center height at the proposed Bell System station ***will not be exceeded*** toward any cochannel station involved, the minimum mileage separations between cochannel stations shown in Table B, C, or D of this section, rather than 125 miles, determine the limits for 2-way base stations that require a cochannel interference study for the FCC. For base stations providing 1-way signaling service, the controlling separation distance is the lesser of 75 miles or the distance shown on Table B, C, or D, as appropriate, for the frequency band used.

3.04 When the 125-mile rule does not apply, the following ***additional information will be necessary*** for each cochannel base station providing 2-way service within 105, 83, and 73 miles for the 35-MHz, 150-MHz, and 450-MHz bands, respectively, or for any cochannel base station providing 1-way signaling service within 75 miles in the above frequency bands:

(a) Name of licensee

(b) Site elevation above mean sea level

(c) Antenna radiation center height above mean sea level

(d) Effective radiated power in direction of proposed Bell System base station

(e) Antenna pattern

(f) Average elevation above mean sea level of intervening radial toward proposed Bell System base station between 2 and 10 miles from cochannel base station site

(g) Class of base station (A through E) in accordance with Table A of this section or with the section of the FCC Rules that defines the "Classification of base stations."

Items (a), (b), (c), and (e) can usually be obtained directly from the cochannel licensee's FCC CP application. Unless the intervening radial is one of the eight basic radials (0°, 45°, 90°, 135°, 180°, 225°, 270°, or 315°) normally required in FCC CP applications, it will be necessary to acquire topographical maps covering the cochannel user's existing or proposed base station site and the operating area up to 10 miles from the site toward the proposed Bell System base station along the intervening radial and to compute the average radial elevation in the 2- to 10-mile section.

3.05 If the existing or proposed cochannel licensee's base station antenna has or will have an omnidirectional radiation pattern, the effective radiated power will be the same in all directions and the ERP value, as shown in the FCC CP application, should be used both in the cochannel interference study calculations and to determine the class of station from Table A. If the cochannel station has other than an omnidirectional antenna radiation, the ERP toward the proposed Bell System station must be calculated using the antenna power input and the gain (or loss) of the antenna in that specific direction. An exception would be cases where the intervening radial between the cochannel station and the proposed Bell System station falls on one of the eight basic azimuths that require ERP reporting on the FCC CP application. In those cases, the ERP shown on the cochannel station's FCC CP application should be used in the interference calculations and determination of station classes. The height of the antenna radiation center above the average terrain of the intervening radial and the ERP of the cochannel station in the direction of the proposed Bell System station determine the class of station for geographical separation purposes as shown in Table A. Any station which requires a reduction of ERP below 500 watts due to excessive antenna height shall be considered a class A station.

4. DETERMINATION OF RELIABLE SERVICE AREA

4.01 The minimum signal power required at the RF input jack of a radio receiver is a function of the receiver's sensitivity, the ambient electrical noise power introduced via the antenna system, and the power level of any interfering radio signals falling within the passband of the receiver.

4.02 Most state-of-the-art radio receivers presently available have usable sensitivities well below 1 microvolt for 12-dB ratio of signal plus noise plus distortion to noise plus distortion (SINAD). Thus, the coverage areas of mobile radio systems using modern, properly working receivers are generally limited by either the electrical noise power levels present at the antenna or radio-frequency interference from outside sources.

4.03 In a properly adjusted mobile radio system, assuming an interference-free environment, the power level of the on-frequency signal necessary at the input to the receiver is a function of the ambient electrical noise level present at the same point. The controlling noise at a mobile system receiver is usually man-made and is caused by auto ignition systems, sparking motor brushes, relay contacts, etc. Experience has shown that a speech-to-noise ratio of approximately 12 dB is needed for a voice-modulated signal of commercial quality; that is, one that is perfectly readable, requires only occasional repeats, and is commonly referred to as circuit merit 3 (CM3).

4.04 The FCC has concluded (Report No. R-6406) that the median RF field strength required for commercially acceptable service for stations providing 2-way service is:

20 dB above 1 microvolt-per-meter (dBu) for 35 through 44 MHz

26 dB above 1 microvolt-per-meter (dBu) for 152 through 162 MHz

25 dB above 1 microvolt-per-meter (dBu) for 450 through 460 MHz.

Using the formula:

$$\text{Field strength (in microvolts-per-meter)} = \log^{-1}\left[\frac{\text{dBu}}{20}\right],$$

the above values equate to:

10 uv/m for the 35- through 44-MHz band

20 uv/m for the 152- through 162-MHz band

18 uv/m for the 450- through 460-MHz band.

4.05 Figures 2 and 3 are median F(50,50) propagation curves for the 35- through 162-MHz and 450- through 460-MHz bands, respectively, for various antenna heights using an effective radiated power of 1 kilowatt. The F(50,50) curves represent the field strength, in dBu (decibels referenced to 1 microvolt-per-meter), exceeded at 50 percent of the locations for at least 50 percent of the time. Since base stations authorized in the Domestic Public Land Mobile Radio Services may not normally employ effective radiated power levels in excess of 500 watts, the F(50,50) curve values, which are based on 1 kilowatt ERP, must be adjusted for the specific ERP used in each case.

4.06 In the DPLMRS, a reliability of at least 90 percent is desirable for commercial service. To achieve this grade of service, the F(50,50) curves must, therefore, be further adjusted to include a reliability factor, R(L). In the mobile radio service, messages may be received while the mobile unit is in motion. This means that the time and terrain variations, although they may be independent of each other, cannot be statistically separated. The reliability factor cannot distinguish between the time variability and the terrain variability. At the relatively short distances involved in the DPLMRS, the time variability of the desired signal is insignificant compared to the terrain variability.

4.07 Figure 4 shows reliability factors for modifying the F(50,50) median curves to provide increased reliabilities up to 99.9 percent. Figure 4 shows that in the 35- through 162-MHz band, there is a 90-percent probability that the received signal level in a given area will be greater than a value 11 dB below the average median value for the area. The average mean level is represented by a 0-dB reference on the graph. In the 450- through 460-MHz band, there is a 90-percent probability that the received signal level in a given area will be greater than a level 14 dB below the average median value for the area. Therefore the ordinate values, R(L), in dB as shown in Fig. 4 must be added to the median field strengths specified in paragraph 4.04 of this section to obtain the field intensities required for 90-percent service reliability.

Band	Median Field Strength Required	Ordinate Value R(L) for 90% Probability	Field Strength Required for 90% Reliability
35–44 MHz	+20 dBu	11 dB	+31 dBu
152–162 MHz	+26 dBu	11 dB	+37 dBu
450–460 MHz	+25 dBu	14 dB	+39 dBu

This was adopted by the FCC to determine the required field intensities of +31 dBu, +37 dBu, and +39 dBu for 90-percent service reliability for the 35- through 44-MHz, 152- through 162-MHz, and 450- through 460-MHz frequency bands, respectively. These values are specified by the FCC in the section of the Rules entitled "Service area of base station."

4.08 The FCC has specified that the field strength required for 90-percent reliability in DPLMRS base stations providing 1-way signaling service is +43 dBu in the bands from 35 through 44 MHz, 152 through 162 MHz, and 450 through 460 MHz.

4.09 Field strength contours with the value given in paragraphs 4.07 and 4.08 define base station service area limits for protection from cochannel electrical interference. Refer to the section of the FCC Rules on "Service area of base station."

5. DETERMINATION OF REQUIRED RATIO BETWEEN DESIRED AND UNDESIRED SIGNAL

5.01 When considering cochannel interference between two stations, be sure to take into account the minimum acceptance ratio between the desired and undesired signal as well as the terrain and time variations of the desired (F_d) and undesired (F_u) fields. The desired field at the edge of the coverage area is determined by methods already discussed in Part 4 of this section. For the usual coverage area, the time variation of the desired field can be neglected compared with the time variation of the undesired field and variations introduced by terrain factors. These three variables—a terrain factor for the desired field (L_d), a terrain factor for the undesired field (L_u), and a time variation of the undesired field (T_u)—can be combined and added to the acceptance ratio to determine the required ratio between the F_d (50,50) field and the F_u (50,50) field. Because these variations follow a normal distribution, they can be combined to determine the required ratio (R) as follows:

$$R = A + K \cdot \left(L_d^2 + L_u^2 + T_u^2\right)^{1/2} \quad \text{dB}$$

where R = required ratio between the intensity of the desired field (F_d) and the intensity of the undesired field (F_u) in dB.

A = acceptance ratio of the mobile receiver (assumed to be 6 dB).

L_d = R(L) = desired terrain probability factor from Fig. 4 (L = 90 percent in this case).

L_u = R(L) = interfering field terrain probability factor from Fig. 4 (L = 10 percent in this case).

T_u = time fading of the interfering signal (factors which determine the value of T_u will be discussed later).

K = 1 for 90-percent probability.

Due to the constancy of the values of L_d and L_u for 90-percent and 10-percent reliability, respectively, the above formula can be simplified by combining these factors into a new factor C.

$$C = L_d^2 + L_u^2$$

Therefore,

$$R = 6 + \left(C + T_u^2\right)^{1/2} \quad \text{dB}$$

where:

$C = (\overline{11}^2 + \overline{11}^2) = 242$ for 35- through 162-MHz band

and $C = (\overline{14}^2 + \overline{14}^2) = 392$ for 450- through 460-MHz band.

5.02 The value of T_u is equal to the difference between the F(50,10) and F(50,50) field strength curves shown in the section of the FCC Rules covering "Service area of base station." Values of T_u have been determined from these field strength curves, and smoothed curves for values of T_u for various antenna heights and distances are shown on Fig. 5 and 6. Values for 35 through 162 MHz are shown on Fig. 5 and for 450 through 460 MHz on Fig. 6.

6. PREPARATION OF COCHANNEL INTERFERENCE STUDY

6.01 First, decide if the study is required by determining the distance to all cochannel stations within 125 miles of the proposed station and referring to the requirements in Part 2 of this section.

6.02 If a study is required, use the procedure in the section of the FCC Rules on "Method of determining average terrain elevation" to determine each transmitter's antenna height above the average terrain of the radial between the two stations. Using the ERP of each base station transmitter, determine the distance from each to the edge of its own coverage area along this radial by reading the distance at which the required field is produced from the appropriate F(50,50) field strength curve.

6.03 The distance from each station to the edge of the coverage area of another station can now be found by a straightforward calculation. In each case, this is the distance from the interfering transmitter to the edge of the coverage area. By use of the appropriate field strength curve, the value of F_u (50,50) at the edge of the coverage area can be calculated for each case.

6.04 The value of R is determined by following the procedures in paragraphs 5.01 and 5.02. After the value of R has been found for each station, the unwanted field for interference-free operation from the interfering station can be calculated. If the value of F_u (50,50) is less than the value of F_d (50,50) $-$R, the system will be noise-limited. With an equal-to or larger value, the system will be interference-limited.

7. LIMITATIONS

7.01 Although the methods in this section are valid only under average terrain conditions, they do provide for the calculation of service areas and furnish information required on new CP applications or a major modification of an existing facility in the DPLMRS. The criteria defined in paragraph 6.04 should be used to determine if the new or modified facility will either cause interference to, or be caused interference from, an existing facility. In unusual terrain or topographical conditions, modified F(50,50) curves based on shadow losses introduced by such terrain or topographical factors may indicate interference-free operation. The FCC section titled "Technical content of application" provides for submission of additional interference studies using other procedures. Any pertinent data and calculations supporting the modified curves must be submitted with the study. Requirements specified in paragraph 6.04 are, however, the only ones needed to determine if the system is interference- or noise-limited. Because precise path losses cannot be calculated in the usual environment of mobile systems, sound engineering practice might suggest the use of directional antennas, reduction of power, or employment of other alternatives to provide reasonable (1 or 2 dB) interference protection at the service area boundary.

8. EXAMPLE OF A COCHANNEL INTERFERENCE STUDY

8.01 As previously noted, various data must be accumulated to complete the cochannel interference study. For simplicity of presentation, the following example assumes station KEJ901, Walton, NY, to be the only cochannel station located within 125 miles of Bell of Pennsylvania station KGA474, Wyoming, PA, to which Bell of Pennsylvania proposes to add a channel on the frequency of 152.60 MHz. In practice, however, this is seldom the case. Because of the small number of radio channels available and the proliferation of DPLMRS in certain areas, it may be necessary to consider two or more cochannel stations when filing an FCC CP application for new facilities. Figure 7 lists the necessary data which can be obtained from the FCC CP application for cochannel station KEJ901.

8.02 In this example, the information not available from the cochannel licensee's FCC CP application (Form 401) is:

(a) The azimuth and back-azimuth of the intervening radial between the two base stations

(b) The geographical separation between the two base stations

(c) The terrain profile from station KEJ901 toward the proposed Bell System base station to a distance of 10 miles along the intervening radial

(d) The class of station for KEJ901 in accordance with the section of the FCC Rules titled "Classification of base stations" or with Table A of this section toward the proposed Bell System station.

8.03 The azimuth and back-azimuth relative to true north and the distance between the two stations may be obtained from the AZIMU1 computer program of AT&T Company or equivalent as shown in Fig. 8. The azimuth from station KGA474, Wyoming, PA, toward station KEJ901, Walton, NY, is found to be 36° 40′, and the back-azimuth (from station KEJ901 toward station KGA474) is 217° 12′. The distance between the two base stations is found to be 68.3 miles.

8.04 Since the back-azimuth from station KEJ901 along the intervening radial is not one of the eight basic radials normally reported on an FCC CP, the average terrain elevation for the 217° 12′ radial would not be shown on the FCC CP application (Form 401) for station KEJ901 and must, therefore, be computed from contour data taken from topographical maps covering the area of interest. To obtain this data, the following U.S. Geological Survey 7-1/2 minute quadrangle topographical maps (or equivalent) are needed:

Walton East, NY
Corbett, NY
Readburn, NY.

Note: U. S. Army Corps of Engineers topographical maps of the area may also be used.

8.05 The site location of station KEJ901 is plotted on the Walton East, NY, 7-1/2 minute quadrangle map at coordinates 42° 07′ 40″ N. and 75° 03′ 13″ W. accurate to within 1 second of latitude and longitude. A straight line representing the 217° 12′ radial is then drawn on the topographical maps beginning at the site of station KEJ901 and extending 10 miles toward station KGA474, Wyoming, PA.

8.06 A radial elevation worksheet (Fig. 9) is used to determine the average radial elevation. Fifty tick marks are placed at 0.2-mile intervals along the 217° 12′ radial beginning at the site of station KEJ901 and extending the full 10-mile length of the radial. The elevation of the terrain at each tick mark is read from the elevation contour intervals of the topographical map and recorded on the radial elevation worksheet as shown in Fig. 10. The elevations between 2 and 10 miles are totaled to find the average radial elevation above mean sea level in the 2- to 10-mile section which in this example equates to 1883 feet AMSL.

8.07 The data obtained from the FCC CP application showed an antenna radiation center of 2630 feet above mean sea level for station KEJ901. Finding the difference between the two values yields an antenna radiation center height of 747 feet above the average elevation of the 217° 12′ radial (for the 2- to 10-mile section).

8.08 The station classifications in Table A do not cover stations with antenna radiation center heights more than 500 feet above the average elevation of the radial. In the example being discussed, the classification of station KEJ901 cannot be directly selected from Table A, and therefore, the minimum permissible mileage separation between the two cochannel stations becomes questionable. In such cases, the interference study should be included as an exhibit in the FCC CP application for additional channel facilities.

8.09 In the example, the antenna radiation center height of station KEJ901 is 247 feet above the maximum antenna height of 500 feet shown on Table A. The following procedure suggests a logical choice for assigning a class to the station. Table A shows that a base station with an antenna height of 400 feet and an ERP of 250 watts is considered a class A station. If 20 miles is taken as a convenient distance, Fig. 2 indicates that a 250-watt transmitter with a 400-foot antenna will produce an F(50,50) field of +38 dBu (44−6). Station KEJ901 with an antenna height of 747 feet and an ERP of 100 watts will produce an F(50,50) field of +39.5 dBu (49.5−10) at a distance of 20 miles (Fig. 2). Because station KEJ901 produces a field exceeding that of a class A station at a specific distance, it must be considered a class A station.

8.10 By this stage in the design of the additional channel to station KGA474, the radio system designer will have reached a tentative conclusion regarding the proposed antenna type, antenna height, and effective radiated power necessary to cover the area of interest as shown by the data in Fig. 11.

8.11 The design data of Fig. 11 shows that the proposed No. M-28358A antenna manufactured by Phelps Dodge Company produces a radiation pattern with 4.7 dB of gain (as referenced to a 1/2-wave dipole antenna) in the direction of station KEJ901 and a transmission line loss of 1.2 dB. The net antenna system gain is then calculated to be 3.5 dB [(+4.7 dB) + (−1.2 dB)] in that direction. The proposed transmitter output power is shown as 100 watts or +20 dBW (dBW = 10 log power in watts). To find the effective radiated power, use the following formula:

$$\text{ERP} = 10^{\frac{(20 + 4.7 - 1.2)}{10}} = 224 \text{ watts}$$

or

$$\text{ERP} = 10^{(2.35)} = 224 \text{ watts}$$

or

$$\text{ERP} = \log \frac{\text{-1 TX output power (dBW)} + \text{antenna gain (dB)}}{10} = 224 \text{ watts.}$$

8.12 The proposed antenna radiation center height as shown in Fig. 11 is 1544 feet above mean sea level, and the average radial elevation toward station KEJ901 (in the 2- to 10-mile section) is 1259 feet above mean sea level. The antenna radiation center height above the average elevation of the 36° 40′ radial toward station KEJ901 is 1544 feet minus 1259 feet or 285 feet. Table A shows that a station radiating 224 watts of power from an antenna 285 feet above the average terrain of the radial is classified as a B station. This is determined by using the 250-watt ERP column and the antenna height above average terrain of 200 to 300 feet.

8.13 The minimum mileage separation for various classes of stations in the 152- through 162-MHz frequency band can be determined from the table in the section of the FCC Rules on "Geographical separation of cochannel stations" or from Table C of this section. It has been concluded that station KEJ901, because of its design and operating parameters, is a class A station and that the proposed channel addition to Bell System station KGA474 will categorize that station as class B. Table C shows that the minimum mileage separation permitted between a class A and a class B station is 78 miles. In this example, the printout from the AZIMU1 computer program shows the geographical separation between the two stations to be only 68.3 miles; therefore, the section of the FCC Rules covering "Technical content of applications" requires a cochannel interference study as part of the FCC CP application for the additional channel facilities for station KGA474. The applicant for the cochannel facilities must prove that interference-free operation is possible at less than the minimum specified geographical separations.

8.14 Figure 12 shows a cochannel interference worksheet. Using the information given in Fig. 7 and 11, begin preparation of a cochannel interference diagram as shown in Fig. 13 and complete Items 1 through 7 of a cochannel interference worksheet as shown on the example in Fig. 14. The field intensity of interest defining the protected service area boundary for 2-way service in the 152- through 162-MHz band is +37 dBu.

8.15 As covered in paragraph 4.05, the F(50,50) field strength curves are based on an effective radiated power of 1 kilowatt, and the maximum permissible ERP in the DPLMRS is 500 watts. Therefore an adjustment factor, in decibels, must ***always*** be included in these calculations to compensate for the difference between the actual ERP used and the 1 kW used in preparation of the F(50,50) field strength curves. The adjustment factor, in dB, is entered as Items 8A and 8B on the cochannel interference worksheet as shown in Fig. 15 and may be computed as follows:

$$\text{Adjustment factor (dB)} = 10 \log \frac{1000}{\text{ERP used}}$$

$$\text{Adjustment factor (dB)} = 10 \log \frac{1000}{224} = 6.5 \text{ dB for Item 8A}$$

and

$$\text{Adjustment factor (dB)} = 10 \log \frac{1000}{100} = 10 \text{ dB for Item 8B.}$$

8.16 In Item 9A of the cochannel interference worksheet, enter the sum of Items 6 and 8A; in Item 9B, enter the sum of Items 6 and 8B. The sums shown on Fig. 16 represent the adjusted field intensity contour of interest which, when used with the F(50,50) curves, compensates for the difference between the actual ERP used at the particular station and the 1-kW ERP from which the curves were derived.

8.17 Enter in Item 10B the antenna radiation center height, in feet AMSL (2630 feet), of cochannel station KEJ901. Enter in Item 11B the average elevation of the 217° 12′ radial, in feet AMSL (1883 feet), as determined from the topographical maps for the 2- to 10-mile section from station KEJ901 toward proposed cochannel station KGA474.

8.18 In Item 12B, enter the antenna radiation center height (747 feet) above the average elevation of the 217° 12′ radial emanating from station KEJ901 toward Bell System station KGA474. This value is the difference between the values in Items 10B and 11B as shown in Fig. 17.

8.19 At this point in the interference study, the protected service area boundary of station KEJ901 toward Bell System station KGA474 must be determined. The protected service area boundary surrounding a base station is a specific RF field intensity contour within which at least 90-percent reliability of communications is expected toward the mobile unit or paging receiver. For 2-way mobile services in the 152- through 162-MHz band, the field intensity required for at least 90-percent reliability is +37 dBu, as covered in paragraph 4.07 of this section. For cochannel interference studies, the point at which specific field intensities will occur for a given ERP and antenna height is calculated by using the F(50,50) curves shown in Fig. 2 or 3, depending upon the frequency band used. The point at which the field intensity contour of interest falls, Item 6 of the cochannel interference worksheet, defines the protected area boundary. However, this value must ***always*** be adjusted (in dB) by the difference between the ERP at the station in a specific direction and the 1-kW ERP from which the F(50,50) curves were derived. This adjustment factor is the value shown in Items 8A and 8B of the worksheet. To find the distance to the adjusted field intensity contour of interest defining the protected service area boundary, the values shown in Items 9A and 9B of the worksheet are used with the F(50,50) curves.

8.20 The F(50,50) curves on Fig. 18 represent field intensities at various distances from the base station for antenna heights of 100, 200, 500, 1000, 2000, and 5000 feet. Antenna heights other than those shown must be found by interpolation, which is generally the case in actual practice.

8.21 To find the distance from base station KEJ901 to its own protected service area boundary along the intervening radial toward station KGA474, the antenna height from Item 12B (747 feet) and the adjusted field intensity contour of interest (+47 dBu) from Item 9B are used. Using a straightedge as a guide, find the point along the +47 dBu line of the F(50,50) curve for 35 through 162 MHz where the 747-foot antenna height curve would approximately intersect. Interpolation would show the midpoint between the 500-foot and 1000-foot curves to represent a curve for a 750-foot antenna. Due to the small scale used in the F(50,50) curves, extreme accuracy is difficult to achieve and is not justified. Once the point of intersection has been determined, read the distance, in miles, along the base of the chart. In this example, for a 747-foot antenna height, the +37 dBu field strength contour (adjusted to +47 dBu for the power difference) falls 22 miles from the base station along the intervening radial toward station KGA474. Enter 22 miles in Item 13B of the worksheet, and add this information to the cochannel interference diagram as shown in Fig. 19.

8.22 Next, determine the distance from Bell System station KGA474 to its own +37 dBu field intensity contour point which defines the station's protected service area boundary. Using the data from Fig. 11 relative to station KGA474, enter the antenna radiation center height of 1544 feet AMSL in Item 10A of the worksheet and the average radial elevation of 1259 feet AMSL in Item 11A of the worksheet. The difference between the two entries (285 feet) is the antenna radiation center height above the average elevation of the intervening 36° 40′ radial. This amount should be entered in Item 12A as shown on Fig. 20.

8.23 Now find the distance to the +37 dBu field intensity contour point of station KGA474 toward cochannel station KEJ901 along the intervening radial, which defines the protected service area boundary of Bell System station KGA474. Refer to Item 9A of the cochannel interference worksheet (Fig. 16), and note that the ***adjusted*** field intensity contour of interest is +43.5 dBu. The adjustment of 6.5 dB is the difference between the 1-kW ERP from which the F(50,50) curves were derived and the proposed 224-watt ERP for station KGA474. The 6.5-dB adjustment is ***added*** to the +37 dBu field intensity contour of interest to arrive at the adjusted value of +43.5 dBu. Refer to Fig. 21, and locate the point along the vertical scale representing +43.5 dBu. Follow the line representing this value to the point where it intersects the curve (found by interpolation) that represents an antenna height of 285 feet (Item 12A of the worksheet). Read the distance of 17.5 miles from the mileage scale along the bottom of the chart. Enter 17.5 miles in Item 13A of the worksheet, and sketch the distance to the protected service area boundary on the interference diagram as shown in Fig. 22.

8.24 After establishing the distances to the protected service area boundary for each station, find the mileage to be entered in Items 14A and 14B by subtracting the mileage shown in Items 13A and 13B from the total distance between stations (68.3 miles). Place the difference value in Item 14A or 14B, as appropriate (Fig. 23).

8.25 The value of the undesired field F_u (50,50) must now be determined for each station at the boundary of its own protected service area. The distance from KEJ901, station B, to the boundary of the protected service area for KGA474, station A, is 50.8 miles (Item 14A on worksheet). Figure 24 can be used to determine the value of F_u (50,50) at a distance of 50.8 miles for the antenna height of station

KEJ901 at an ERP of 1 kW. Locate the 50.8-mile point, and determine the F(50,50) value for an antenna height of 747 feet. Read the value of +25 dBu from the vertical scale, and enter this value in Item 15A on the worksheet (Fig. 25). This is the value for an ERP of 1 kW, and the actual value will be decreased by the difference between the ERP of the station and 1 kW. This is Item 8B on the worksheet; its value, 10 dB in this case, must be subtracted from +25 dBu, Item 15A. The result, +15 dBu, is entered under Item 16A on the worksheet and is the value of F_u (50,50) at the boundary of the protected coverage area of station KGA474.

8.26 Using the same procedure, determine the value of F_u (50,50) from station KGA474 at the boundary of the protected coverage area of station KEJ901. While the details are not shown, the values obtained are entered on the worksheet as Items 15B and 16B as shown in Fig. 26.

8.27 The next step is to determine the required ratio, R, between the value of F_d (50,50) and the value of F_u (50,50) at the boundary of the protected service area for the station in question. To find the value of R, the value of T_u must be determined. The value of T_u is equal to the difference in dB between the F(50,10) and F(50,50) curves at any given point along the transmission path. These curves form a part of the section of the FCC Rules on "Service area of base station." As indicated in paragraph 5.02 of this section, the difference between these curves has been taken on a point-by-point basis. Smoothed curves of the values obtained have been plotted as a function of distance and antenna height. Values for 35 through 162 MHz and 450 through 460 MHz are shown on Fig. 5 and 6 of this section, respectively. The distance used to determine the value of T_u is the distance from the interfering station to the protected service area boundary of the station for which the value of R is being calculated.

8.28 To find the value of R at the service boundary of station A (KGA474), the value of T_u associated with station B (KEJ901) must be determined using the distance from station B to the service boundary and the antenna radiation center height of station B above the average radial elevation. The distance is Item 14A, 50.8 miles, and the antenna height is Item 12B, 747 feet. From Fig. 27, the value of T_u for this distance and antenna height is about 4.0 dB. Enter this value under Item 17A on the worksheet (Fig. 29). Refer to paragraph 5.01 of this section to determine the value of R at the service area boundary of station A. The value of R can be computed by use of the formula:

$$R(dB) = 6 + \left[C + T_u^2\right]^{1/2}$$

For 35 through 162 MHz, C = 242.

It follows that for the case being considered,

$$R(dB) = 6 + \left[242 + (4.0)^2\right]^{1/2}$$

$$R = 22.1 \text{ dB}.$$

Enter this value under Item 18A of the worksheet (Fig. 29).

8.29 Follow the same procedure to determine the value of R at the boundary of the protected service area of station B, KEJ901. In this case, T_u is determined by reading its value from Fig. 28. The distance used, 46.3 miles, is that from station A to the coverage boundary of station B; the antenna height, 285 feet, is the radiation center height of the antenna for station A above the average elevation of the radial. The value of T_u is equal to 5.1 dB and is entered on the worksheet under Item 17B. The corresponding calculated value for R is 22.4 dB; this value is entered as Item 18B on the worksheet. These steps are shown on Fig. 29.

8.30 The desired field at the boundary of the protected service area is F_d (50,50) = +37 dBu. The value of R at each boundary has already been computed in paragraphs 8.28 and 8.29 of this section. By subtracting the associated value of R from +37 dB, the limiting field strength of the unwanted signal can be determined at each service boundary. The value of the field of the unwanted signal F_u (50,50) was determined for each base station in paragraphs 8.25 and 8.26. If the field strength of the interfering signal is equal to or greater than the limiting value, the system will be interference-limited; if less, the system will be noise-limited.

8.31 The remaining steps to complete the calculations for the example will now be made and the worksheet completed as shown on Fig. 30. The maximum permitted field intensity at the service boundary of station A from station B is equal to 37 minus the value of R computed as Item 18A. The value computed is 22.1, and this subtracted from +37 dBu equals 14.9 dBu. Any value equal to, or greater than, this means that the system performance will be limited by interference from station B. Previous calculations indicate that station B will produce an unwanted field of +15 dBu (Item 16A), so the noise and interference limits are about the same and system A will be interference-limited by the signal from system B. The worksheet entries are shown on Fig. 30. Follow the same procedure to determine whether the system served by station B is noise- and/or interference-limited. The worksheet entries for station B are also shown on Fig. 30. For this station, the value of R was calculated to be 22.4 dB which means that the unwanted field should not exceed 14.6 dBu (Item 19B on the worksheet). Previous calculations indicated a value of +14 dBu for Item 16B. This is less than the permitted maximum field strength, so the system will be noise-limited. The margin is so small that for both cases, it is within the error allowance of the calculation. A summary of the cochannel interference evaluation procedures is shown in Fig. 31.

8.32 In this example, system A is just interference-limited by the signal from system B because at the service boundary of A the value of the field strength of the undesired signal (from B) subtracted from the desired signal (from A) is equal to the required value of R (the protection ratio) within only 0.1 dB. System B is noise-limited because at its protected service boundary, the value of the field strength of the undesired signal (from A) subtracted from the field strength of the desired signal is greater than the required value of R by 0.6 dB. This information is sufficient to fulfill FCC requirements for an interference study.

(a) Though not a requirement of the FCC interference study, it may be of interest to determine the distance between the service area boundary of a noise-limited system and the interference boundary of another system or, conversely, the overlap distance in the case of an interference-limited system. In either case, the distance can be determined by use of the F(50,50) curves (Fig. 2 or 3, depending on the frequency band).

(b) After determining the amount (dB) by which the ratio of the desired to interfering signal exceeds the required ratio at the service area boundary, the slope of the curves can be used to determine the distance separating the service area boundary of one station from the interference contour of another station. Conversely, if the ratio of the desired signal to the interfering signal is less than the required ratio, the slope of the curves can be used to determine the overlap distance. At distances of 40 to 60 miles from a base station transmitter (a commonly encountered range of distance from an interfering transmitter to the service area boundary of another system), the slope of the curves changes very little as a function of either distance or antenna height. A fixed slope can be used for a given frequency band; e.g., about 0.6 dB per mile for 150 MHz.

(c) In the example, the level of the interfering signal from station A is about 0.6 dB below the maximum allowed at the service area boundary of system B. The slope of the field strength curve (0.6 dB per mile at about 50 miles) indicates a separation of about a mile between the service area boundary of system B and the interference contour of station A. For system A, the interfering signal from station B is just about equal to the maximum value allowed at the service area boundary of system A. In this case, the service area of system A abuts the interference contour of station B.

9. SPECIAL CASES INVOLVING STATIONS WITH HIGHLY DIRECTIONAL ANTENNA SYSTEMS

9.01 In some instances, a base station in the DPLMRS may be using an antenna system which produces a highly directional radiation pattern to cover a specific area of interest. This is particularly true in DPLMRS Systems where the base station is on or near the seashore with the antenna oriented for maximum radiation inland. In such situations, the shortest distance between the new applicant's proposed base station site and the protected service area boundary of the existing cochannel station may not lie on the direct radial between the two base stations. Under these circumstances, an interference study should also be completed to ensure that the new applicant's proposed operation will not overlap and cause electrical interference within the existing station's protected service area (Fig. 32).

10. USEFUL FORMULAS

10.01 The following formulas may be useful to the mobile radio system designer when preparing cochannel interference studies:

(a) To find the power level, P, in dBW, at the receiver RF input jack when the voltage across the input, e, in microvolts and the receiver input impedance, Z, in ohms, are known:

$$P = \left[10 \log \left(\frac{e^2}{Z}\right)\right] - 120 \quad \text{dBW.}$$

(b) To find the voltage, e, in microvolts, at a receiver RF input jack when the power level, in dBW, and the receiver input impedance, Z, in ohms, are known:

$$e = \left(Z \cdot \log^{-1}\left(\frac{\text{dBW} + 120}{10}\right)\right)^{1/2} \quad \text{uv.}$$

(c) To find the field strength, FS, in dBu (dB from 1 microvolt-per-meter), when the field strength, E, in microvolts-per-meter, is known:

$$FS = 20 \log E \quad \text{dBu.}$$

(d) To find the field strength, E, in microvolts-per-meter, when the power level, in dBW, from a λ/2 matched dipole, is known:

$$E = \frac{\text{MHz} \cdot \log^{-1}\left(\frac{\text{dBW} + 120}{20}\right)}{5.58} \quad \text{uv/m.}$$

(e) To find the field strength, E, in microvolts-per-meter, when the field strength, FS, in dBu, is known:

$$E = \log^{-1}\left(\frac{FS}{20}\right) \quad \text{uv/m.}$$

(f) To find the received signal power, Rsp, in dBW, across a 50-ohm receiver input jack when the wavelength, λ, in meters, and the field strength, E, in microvolts-per-meter, are known, assuming a receiving antenna with the same effective area as a λ/2 dipole:

$$Rsp = \left(20 \cdot \log\left(\frac{E \cdot \lambda}{53.8}\right)\right) - 120 \quad \text{dBW}$$

where λ equals the wavelength, in meters or $\frac{300}{f\ (\text{MHz})}$.

(g) To find the received signal power, in dBW, across a 50-ohm receiver input jack when the frequency, in MHz, and the field strength, E, in microvolts-per-meter, are known, assuming a receiving antenna with the same effective area as a λ/2 dipole:

$$Rsp = \left(20 \cdot \log\left(\frac{5.58 \cdot E}{\text{MHz}}\right)\right) - 120 \quad \text{dBW.}$$

11. REFERENCES

11.01 The following reference material was used in the preparation of this section:

(a) Federal Communications Commission Report No. R-6406, "Technical Factors Affecting the Assignment of Facilities in the Domestic Public Land Mobile Radio Service," by Roger B. Carey, June 24, 1964

(b) FCC Rules and Regulations, Volume VII, Part 22

(c) FCC Memorandum Opinion and Order, "Amendment of FCC Rules, Section 22.15(b), Technical Content of Applications," released July 30, 1980 (FCC 80-450, #27848)

(d) Bell System Practices, Section 940-230-100, Issue 1, July 1963.

TABLE A

ANTENNA HEIGHT ABOVE AVERAGE TERRAIN (FEET)	CLASS OF STATION				
400 to 500	C	B	B	A	A
300 to 400	C	C	B	B	A
200 to 300	D	C	C	B	B
100 to 200	D	D	C	C	B
0 to 100	E	D	D	C	C
	30	60	120	250	500
	Effective Radiated Power (Watts)				

TABLE B

CLASS OF STATION IN THE 35- TO 44-MHZ BAND	MINIMUM MILEAGE SEPARATION BETWEEN COCHANNEL STATIONS				
A	105				
B	99	92			
C	93	87	76		
D	88	81	70	58	
E	82	75	65	52	40
	A	B	C	D	E
	Class of Station				

TABLE C

CLASS OF STATION IN THE 152- TO 162-MHZ BAND	MINIMUM MILEAGE SEPARATION BETWEEN COCHANNEL STATIONS				
A	83				
B	78	72			
C	73	67	58		
D	69	62	54	43	
E	65	59	50	39	29
	A	B	C	D	E
	Class of Station				

TABLE D

CLASS OF STATION IN THE 450- TO 460-MHZ BAND	MINIMUM MILEAGE SEPARATION BETWEEN COCHANNEL STATIONS				
A	73				
B	69	59			
C	66	56	43		
D	63	53	41	38	
E	60	51	38	35	27
	A	B	C	D	E
	Class of Station				

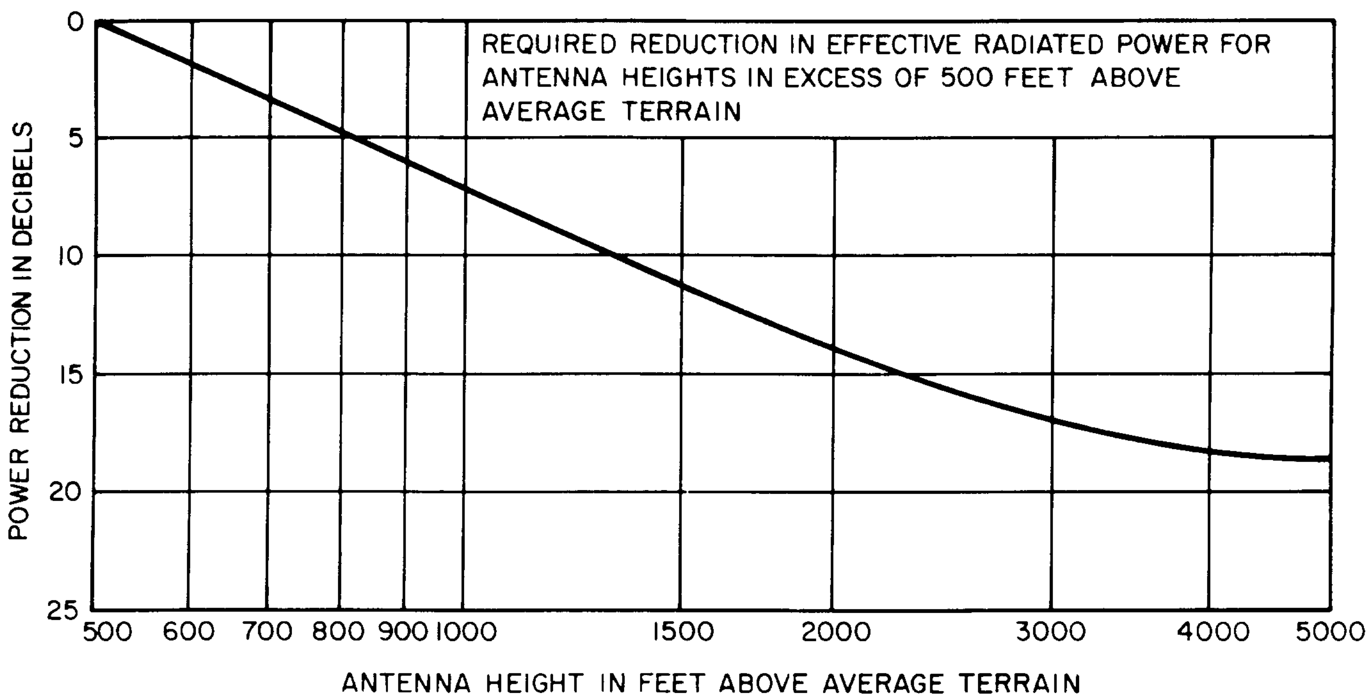

Fig. 1—Required Reduction in ERP for Antenna Heights in Excess of 500 Feet Above Average Terrain

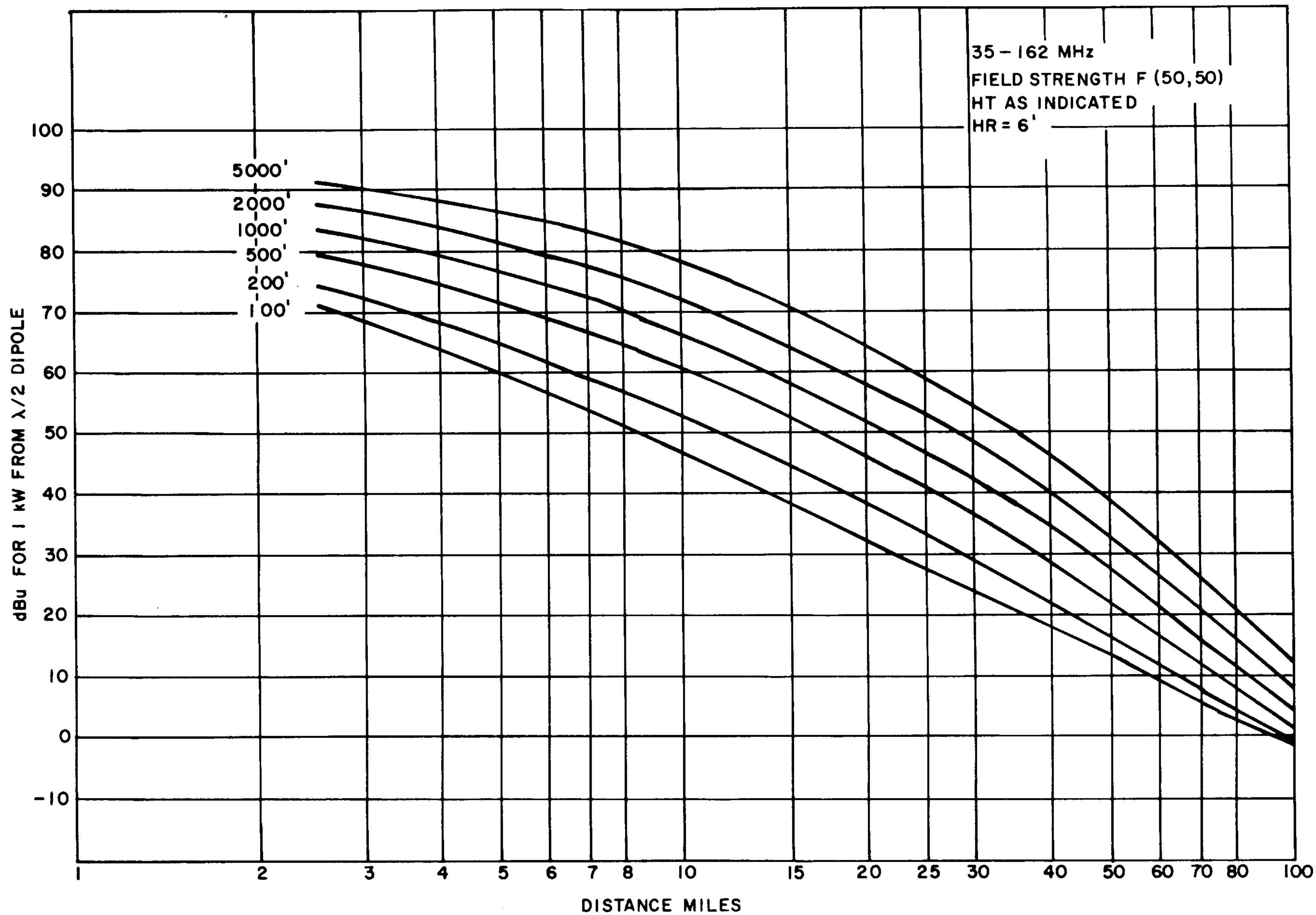

Fig. 2—Field Strength F(50,50) for 35 through 162 MHz

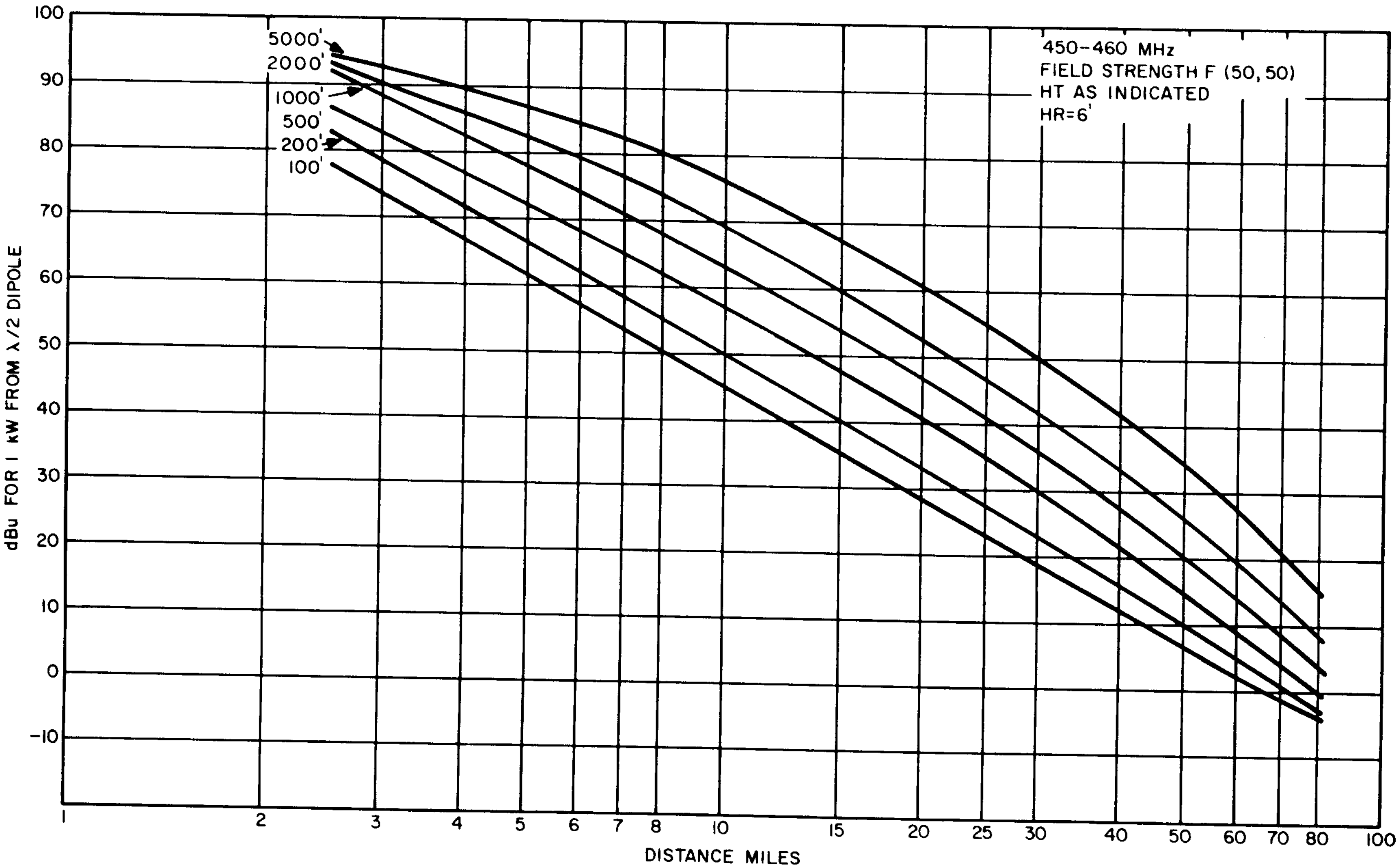

Fig. 3—Field Strength F(50,50) for 450 through 460 MHz

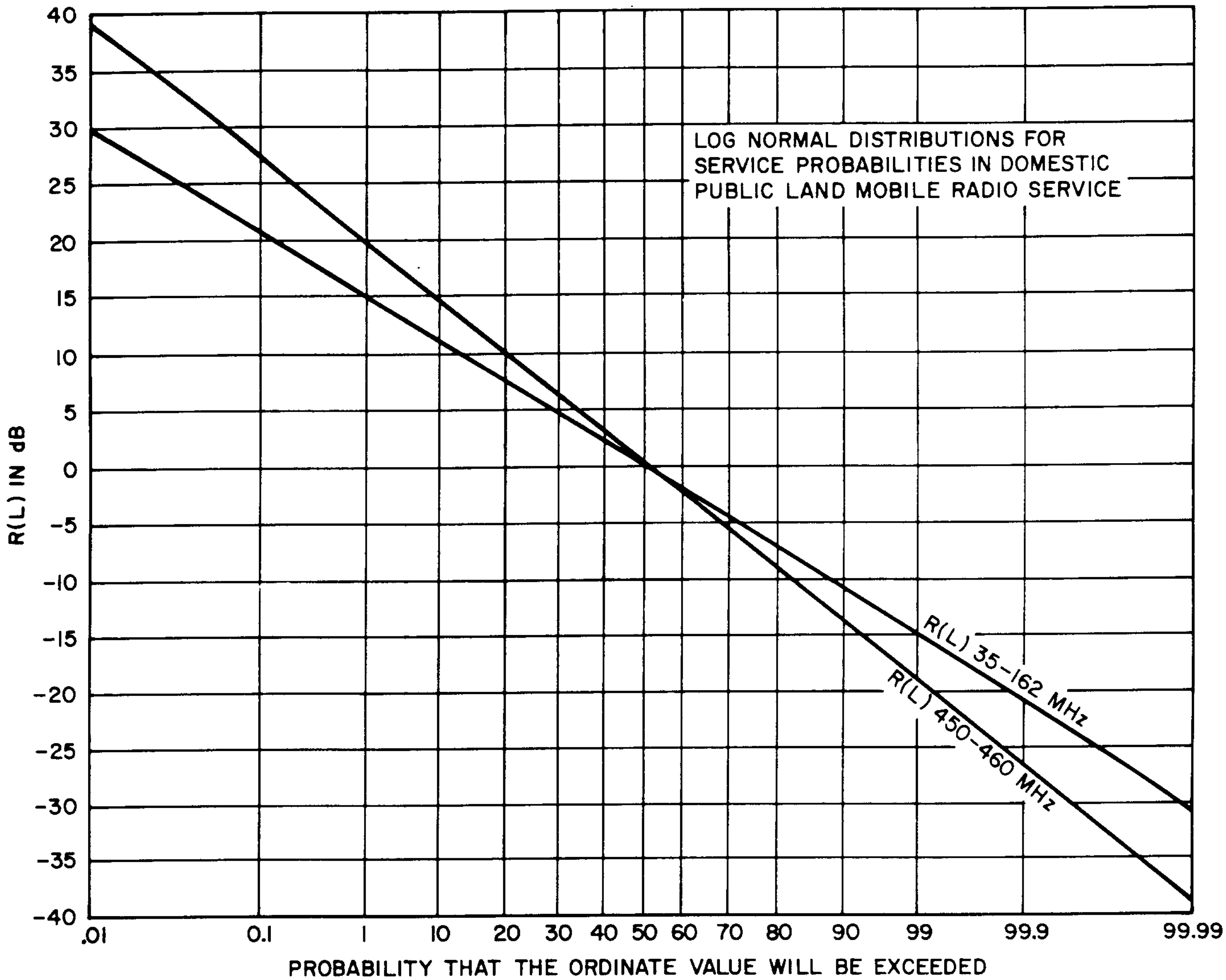

Fig. 4—Log Normal Distributions for Service Probabilities

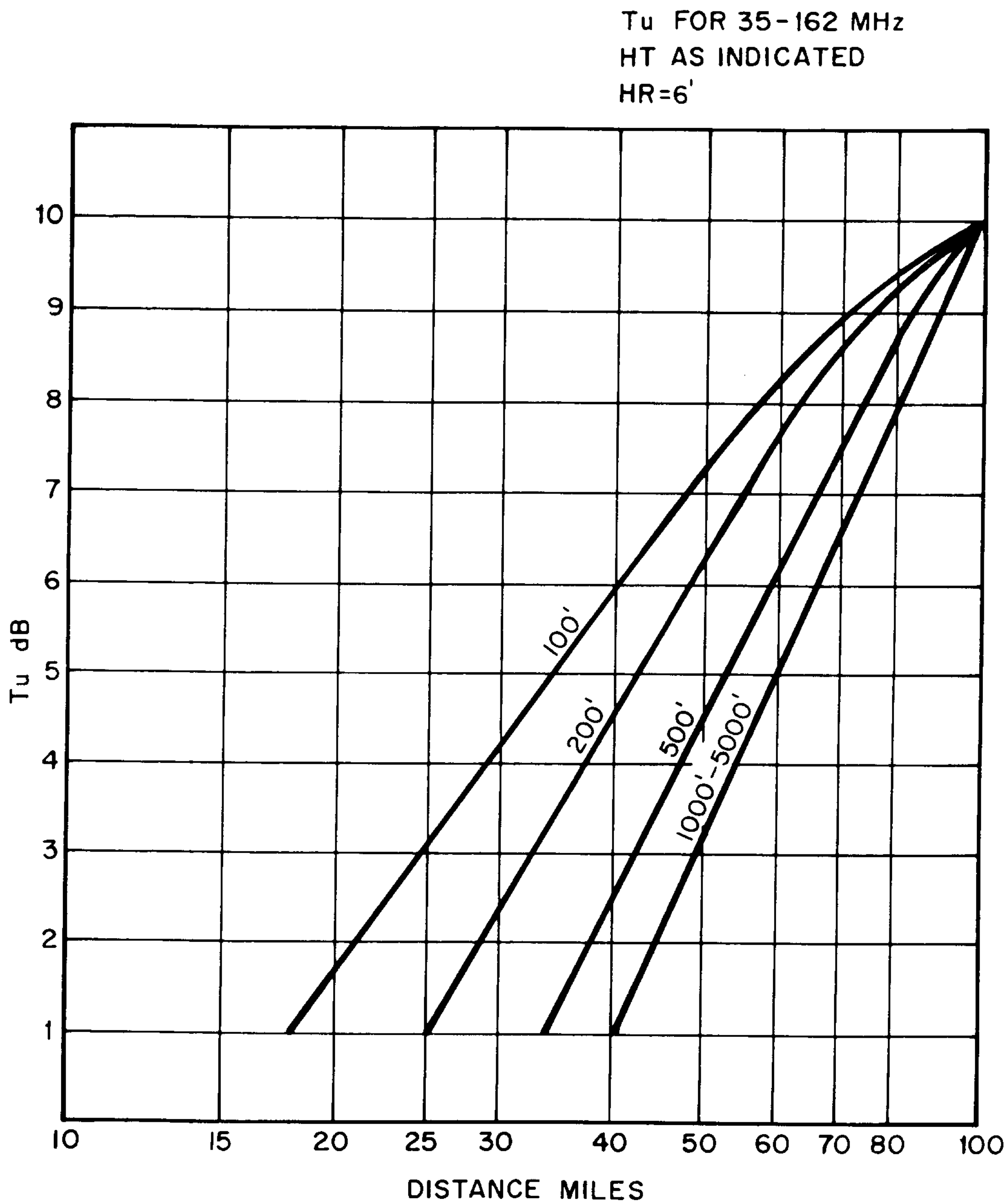

Fig. 5—Values of T_u for 35 through 162 MHz

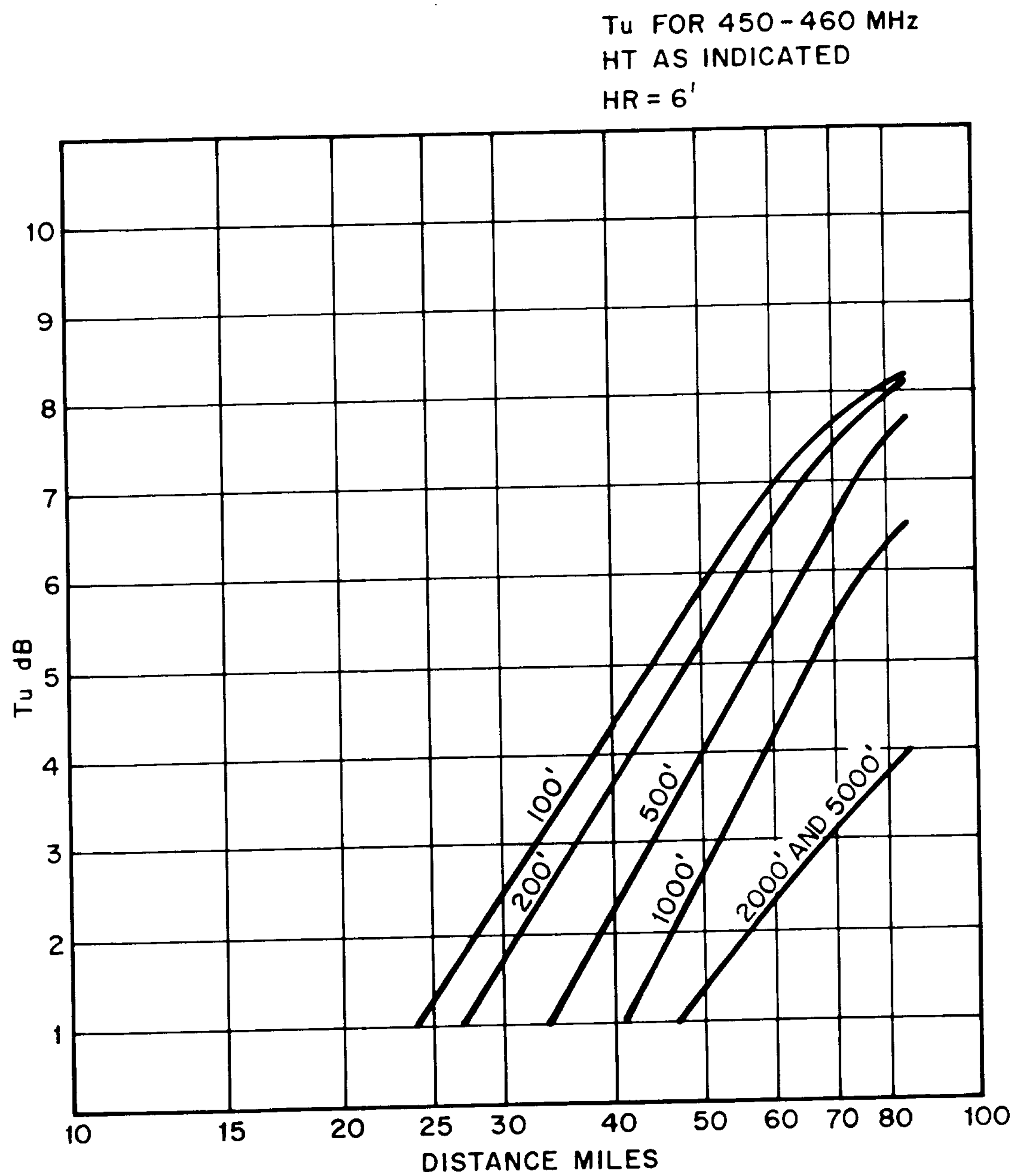

Fig. 6—Values of T_u for 450 through 460 MHz

```
EXISTING COCHANNEL STATION CALL SIGN: KEJ901
LOCATION: WALTON, NEW YORK
LICENSEE: DELAWARE TELEPHONE COMPANY
OPERATING FREQUENCY: 152.60 MHz
COORDINATES: 42° 07' 40" N. & 75° 03' 13" W.
SITE ELEVATION: 2465 FEET AMSL
TRANSMITTER OUTPUT POWER: 39 WATTS (+15.9 dBW)
TRANSMISSION LINE LOSS: 1.9 dB
EFFECTIVE RADIATED POWER: 100.2 WATTS
ANTENNA TYPE: PHELPS DODGE CO. TYPE PD340 (OMNIDIRECTIONAL)
ANTENNA GAIN: 6 dB (OMNIDIRECTIONAL)
ANTENNA RADIATION CENTER HEIGHT: 2630 FEET AMSL
```

Fig. 7—Example of Information Obtained From a CP Application

```
         DATE OF RUN 10/13/80
ENTER NAME OF STATION A
>WYOMING
ENTER NAME OF STATION B
>WALTON
ENTER LATITUDE(D,M,S) AND LONGITUDE(D,M,S) OF WYOMING
>41 20 11  75 50 52
ENTER LATITUDE(D,M,S) AND LONGITUDE(D,M,S) OF WALTON
>42 07 40  75 03 13


WYOMING      41-20-11    75-50-52   WALTON        42- 7-40    75- 3-13
AZIMUTH  36-40- 5    B.AZIMUTH 217-11-48       PATH       MILES  63.33
 (DEG.)   36.67          (DEG.) 217.20       DISTANCE      KM   109.96
P.LOSS - 2GHZ 139.90 4GHZ 145.20 6GHZ 149.08 11GHZ 154.25 18GHZ 158.45

ENTER A (1) TO ENTER UNFORMATED DATA OR
        (2) TO ENTER FORMATED DATA (100 COLUMN M682)  OR
        (0) TO STOP

>0

*END OF JOB
R; T=0.05/0.16 13:04:25
```

Fig. 8—Example of AZIMU1 Printout

RADIAL ELEVATION WORKSHEET

SITE LOCATION ______________________ RADIAL ________ TRUE NORTH

MILES—ELEVATION		MILES—ELEVATION	MILES—ELEVATION
0 ______	Not Used In Average Radial Elevation Computation	3.4 ______	6.8 ______
.2 ______		3.6 ______	7.0 ______
.4 ______		3.8 ______	7.2 ______
.6 ______		4.0 ______	7.4 ______
.8 ______		4.2 ______	7.6 ______
1.0 ______		4.4 ______	7.8 ______
1.2 ______		4.6 ______	8.0 ______
1.4 ______		4.8 ______	8.2 ______
1.6 ______		5.0 ______	8.4 ______
1.8 ______		5.2 ______	8.6 ______
2.0 ______		5.4 ______	8.8 ______
2.2 ______		5.6 ______	9.0 ______
2.4 ______		5.8 ______	9.2 ______
2.6 ______		6.0 ______	9.4 ______
2.8 ______		6.2 ______	9.6 ______
3.0 ______		6.4 ______	9.8 ______
3.2 ______		6.6 ______	10.0 ______

Total ______
2–10 MILES

AVERAGE RADIAL ELEVATION = $\frac{\text{ELEVATION TOTAL (2-10 miles)}}{\text{NUMBER OF DIVISIONS (2-10 miles)}}$ = ______ 41

AVERAGE RADIAL ELEVATION (2 to 10 MILES) ______________ FT.

Fig. 9—Example of Radial Elevation Worksheet

RADIAL ELEVATION WORKSHEET

SITE LOCATION KEJ901, WALTON, N.Y. RADIAL 217° 12' TRUE NORTH

MILES	ELEVATION	MILES	ELEVATION	MILES	ELEVATION
0	2465	3.4	2205	6.8	2050
.2	2250	3.6	2205	7.0	2060
.4	2000	3.8	2130	7.2	1820
.6	2080	4.0	2110	7.4	1660
.8	2180	4.2	2060	7.6	1630
1.0	1940	4.4	1735	7.8	1580
1.2	1805	4.6	1510	8.0	1880
1.4	2000	4.8	1340	8.2	2100
1.6	2200	5.0	1680	8.4	2065
1.8	2445	5.2	1950	8.6	2100
2.0	2305	5.4	1670	8.8	2220
2.2	1960	5.6	1380	9.0	2185
2.4	1760	5.8	1580	9.2	2120
2.6	1865	6.0	1970	9.4	2000
2.8	2060	6.2	2020	9.6	1660
3.0	2220	6.4	1700	9.8	1340
3.2	2400	6.6	1640	10.0	1280

(Miles 0 to 1.8: Not Used In Average Radial Elevation Computation)

Total 2–10 MILES 77205

AVERAGE RADIAL ELEVATION = ELEVATION TOTAL (2–10 miles) / NUMBER OF DIVISIONS (2–10 miles) = 77205 / 41

AVERAGE RADIAL ELEVATION (2 to 10 MILES) 1883 FT.

Fig. 10—Example of Completed Radial Elevation Worksheet for Station KEJ901

STATION CALL SIGN: KGA474
LOCATION: WYOMING, PENNSYLVANIA
LICENSEE: THE BELL TELEPHONE CO. OF PENNA.
PROPOSED OPERATING FREQUENCY: 152.60 MHz
COORDINATES: 41° 20' 11" N. & 75° 50' 52" W.
SITE ELEVATION: 1480 FEET AMSL
TRANSMITTER OUTPUT POWER: 100 WATTS (+20 dBW)
TRANSMISSION LINE LOSS: 1.2 dB
EFFECTIVE RADIATED POWER TOWARD KEJ901: 224 WATTS
PROPOSED ANTENNA: PHELPS DODGE CO. TYPE M-28358A (SPECIAL)
ANTENNA GAIN TOWARD KEJ901: +4.7 dB
ANTENNA RADIATION CENTER HEIGHT: 1544 FEET AMSL
AVERAGE RADIAL ELEVATION TOWARD KEJ901: 1259 FEET AMSL
AZIMUTH TOWARD KEJ901: 36° 40' T.N.
DISTANCE BETWEEN STATIONS: 68.3 MILES

Fig. 11—Example of Information for a Proposed Cochannel Station

COCHANNEL INTERFERENCE WORKSHEET (SHEET 1 OF 2)

1. GEOGRAPHICAL COORDINATES OF STATION A = ____________ N. AND ____________ W.
2. GEOGRAPHICAL COORDINATES OF STATION B = ____________ N. AND ____________ W.
3. AZIMUTHS: STATION A TO B = __________ T.N. AND STATION B TO A = __________ T.N.
4. DISTANCE BETWEEN STATIONS A AND B = _________ MILES.
5. FREQUENCY OF PROPOSED COCHANNEL OPERATION = ____________ MHz.
6. FIELD INTENSITY CONTOUR OF INTEREST (FD) = + _______ dBu (PROTECTED SERVICE AREA BOUNDARY).

"A" STATION DATA (EXISTING OR PROPOSED BELL STATION)	"B" STATION DATA (EXISTING OR PROPOSED COCHANNEL STATION)
7A. ERP TOWARD STATION B = _________ WATTS	7B. ERP TOWARD STATION A = _________ WATTS
8A. DIFFERENCE BETWEEN ERP AND 1 kW = _______ dB (10 LOG $\frac{1000}{ERP}$)	8B. DIFFERENCE BETWEEN ERP AND 1 kW = _______ dB (10 LOG $\frac{1000}{ERP}$)
9A. ADJUSTED FIELD INTENSITY CONTOUR OF INTEREST = + _______ dBu (ITEM 8A PLUS ITEM 6) TO BE USED WITH F(50, 50) CURVES	9B. ADJUSTED FIELD INTENSITY CONTOUR OF INTEREST = + _______ dBu (ITEM 8B PLUS ITEM 6) TO BE USED WITH F(50, 50) CURVES
10A. ANTENNA RADIATION CENTER HEIGHT = _______ FT AMSL	10B. ANTENNA RADIATION CENTER HEIGHT = _______ FT AMSL
11A. AVERAGE RADIAL ELEVATION (2–10 MI) = _______ FT AMSL	11B. AVERAGE RADIAL ELEVATION (2–10 MI) = _______ FT AMSL
12A. ANTENNA RADIATION CENTER HEIGHT ABOVE AVERAGE RADIAL ELEVATION = _______ FT (ITEM 10A MINUS ITEM 11A)	12B. ANTENNA RADIATION CENTER HEIGHT ABOVE AVERAGE RADIAL ELEVATION = _______ FT (ITEM 10B MINUS ITEM 11B)
13A. DISTANCE TO OWN PROTECTED SERVICE AREA BOUNDARY FROM F(50,50) CURVES = _______ MILES	13B. DISTANCE TO OWN PROTECTED SERVICE AREA BOUNDARY FROM F(50,50) CURVES = _______ MILES
14A. DISTANCE FROM STATION B TO OWN PROTECTED SERVICE AREA BOUNDARY = _______ MILES (ITEM 4 MINUS 13A)	14B. DISTANCE FROM STATION A TO OWN PROTECTED SERVICE AREA BOUNDARY = _______ MILES (ITEM 4 MINUS 13B)

Fig. 12—Example of Cochannel Interference Worksheet (1 through 14B) (Sheet 1 of 2)

COCHANNEL INTERFERENCE WORKSHEET (SHEET 2 OF 2)

15A. FIELD, F(50,50), FOR ANTENNA HEIGHT OF STATION B (FROM ITEM 12B) AT DISTANCE IN ITEM 14A. 1 kW ERP
_______ dBu

16A. ADJUST ITEM 15A FOR ERP OF STATION B (ITEM 15A MINUS ITEM 8B = _______ dBu). THIS IS F(50,50) FROM STATION B AT SERVICE BOUNDARY OF STATION A

17A. DETERMINE T_u FOR ANTENNA HEIGHT OF STATION B AT DISTANCE IN ITEM 14A USING T_u CURVES. T_u = _________ dB

18A. CALCULATE VALUE OF R. R = _________ dB

19A. MAXIMUM PERMITTED FIELD INTENSITY FROM STATION B AT SERVICE BOUNDARY OF STATION A. 37 − R = _________ dBu

20A. IF ITEM 16A EXCEEDS ITEM 19A, SYSTEM IS INTERFERENCE-LIMITED; IF LESS, IT IS AMBIENT NOISE LIMITED

15B. FIELD, F(50,50), FOR ANTENNA HEIGHT OF STATION A (FROM ITEM 12A) AT DISTANCE IN ITEM 14B. 1 kW ERP
_______ dBu

16B. ADJUST ITEM 15B FOR ERP OF STATION A (ITEM 15B MINUS ITEM 8A = _______ dBu). THIS IS F(50,50) FROM STATION A AT SERVICE BOUNDARY OF STATION B

17B. DETERMINE T_u FOR ANTENNA HEIGHT OF STATION A AT DISTANCE IN ITEM 14B USING T_u CURVES. T_u = _________ dB

18B. CALCULATE VALUE OF R. R = _________ dB

19B. MAXIMUM PERMITTED FIELD INTENSITY FROM STATION A AT SERVICE BOUNDARY OF STATION B. 37 − R = _________ dBu

20B. IF ITEM 16B EXCEEDS ITEM 19B, SYSTEM IS INTERFERENCE-LIMITED; IF LESS, IT IS AMBIENT NOISE LIMITED

$$R(dB) = A + K\left[L_d^2 + L_u^2 + T_u^2\right]^{\frac{1}{2}}$$

A = 6 dB

L_d AND L_u = 11 FOR 35 THROUGH 162 MHz

L_d AND L_u = 14 FOR 450 THROUGH 460 MHz

T_u FROM PROPER CURVE

R = RATIO IN dB BETWEEN $F_d(50,50)$ AND $F_u(50,50)$ AT PROTECTED SERVICE AREA BOUNDARY

Fig. 12—Example of Cochannel Interference Worksheet (15A through 20B) (Sheet 2 of 2)

EVALUATION OF COCHANNEL INTERFERENCE

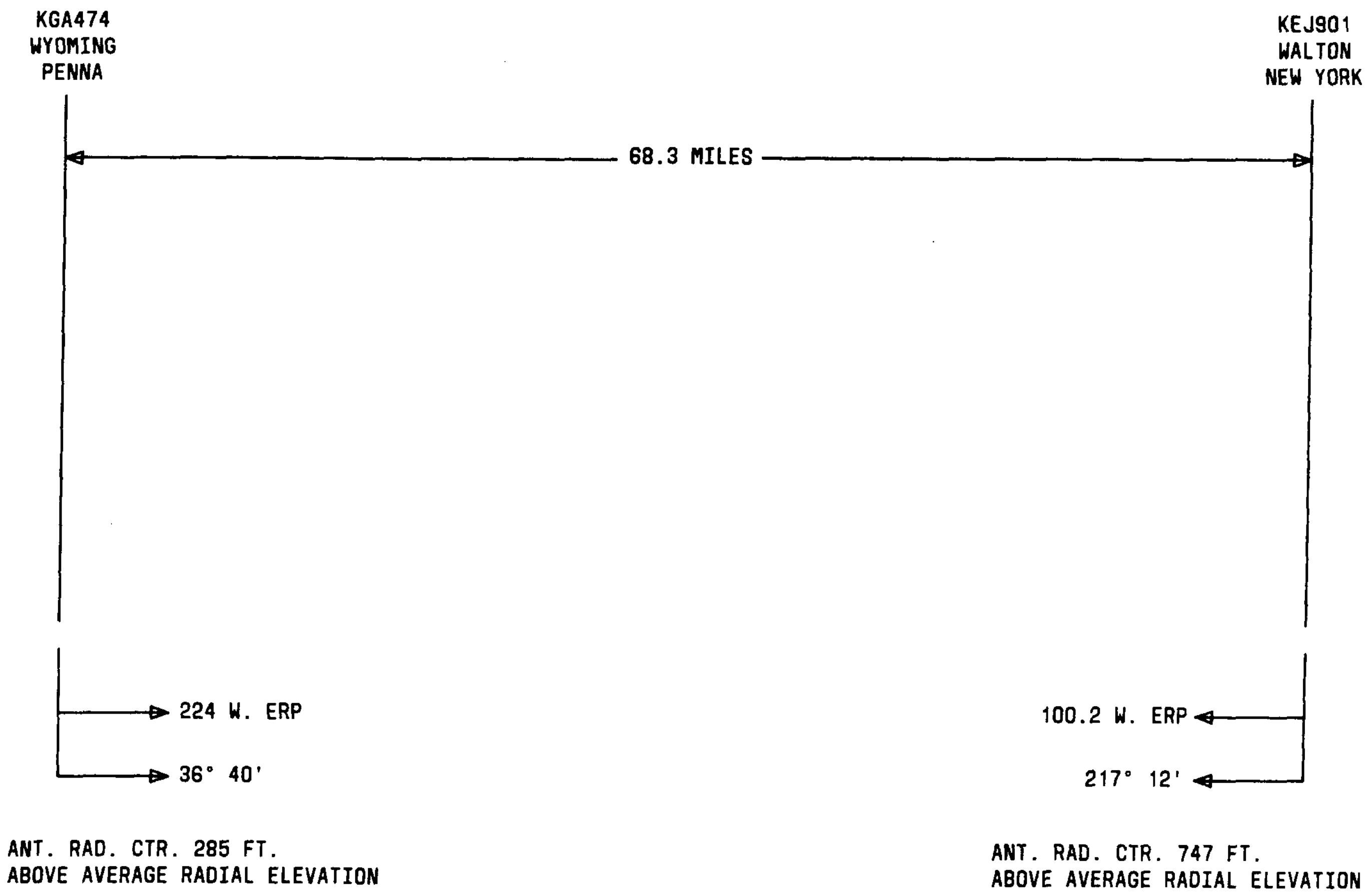

Fig. 13—Cochannel Interference Diagram

COCHANNEL INTERFERENCE WORKSHEET (SHEET 1 OF 2)

1. GEOGRAPHICAL COORDINATES OF STATION A = 41°20'11" N. AND 75°50'52" W.
2. GEOGRAPHICAL COORDINATES OF STATION B = 42°07'40" N. AND 75°03'13" W.
3. AZIMUTHS: STATION A TO B = 36°40' T.N. AND STATION B TO A = 217°12' T.N.
4. DISTANCE BETWEEN STATIONS A AND B = 68.3 MILES.
5. FREQUENCY OF PROPOSED COCHANNEL OPERATION = 152.60 MHz.
6. FIELD INTENSITY CONTOUR OF INTEREST (FD) = + 37 dBu (PROTECTED SERVICE AREA BOUNDARY).

"A" STATION DATA (EXISTING OR PROPOSED BELL STATION)

7A. ERP TOWARD STATION B = 224 WATTS

"B" STATION DATA (EXISTING OR PROPOSED COCHANNEL STATION)

7B. ERP TOWARD STATION A = 100.2 WATTS

Fig. 14—Example of Cochannel Interference Worksheet (1 through 7B)

"A" STATION DATA (EXISTING OR PROPOSED BELL STATION)

7A. ERP TOWARD STATION B = 224 WATTS

8A. DIFFERENCE BETWEEN ERP AND 1 kW = (6.5) dB (10 LOG $\frac{1000}{ERP}$)

"B" STATION DATA (EXISTING OR PROPOSED COCHANNEL STATION)

7B. ERP TOWARD STATION A = 100.2 WATTS

8B. DIFFERENCE BETWEEN ERP AND 1 kW = (10) dB (10 LOG $\frac{1000}{ERP}$)

Fig. 15—Example of Cochannel Interference Worksheet (7A through 8B)

COCHANNEL INTERFERENCE WORKSHEET (SHEET 1 OF 2)

1. GEOGRAPHICAL COORDINATES OF STATION A = 41°20'11" N. AND 75°50'52" W.
2. GEOGRAPHICAL COORDINATES OF STATION B = 42°07'40" N. AND 75°03'13" W.
3. AZIMUTHS: STATION A TO B = 36°40' T.N. AND STATION B TO A = 217°12' T.N.
4. DISTANCE BETWEEN STATIONS A AND B = 68.3 MILES.
5. FREQUENCY OF PROPOSED COCHANNEL OPERATION = 152.60 MHz.
6. FIELD INTENSITY CONTOUR OF INTEREST (FD) = + (37) dBu (PROTECTED SERVICE AREA BOUNDARY).

"A" STATION DATA (EXISTING OR PROPOSED BELL STATION)

7A. ERP TOWARD STATION B = 224 WATTS

8A. DIFFERENCE BETWEEN ERP AND 1 kW = (6.5) dB ($10 \text{ LOG } \frac{1000}{\text{ERP}}$)

9A. ADJUSTED FIELD INTENSITY CONTOUR OF INTEREST = + (43.5) dBu (ITEM 8A PLUS ITEM 6) TO BE USED WITH F(50, 50) CURVES

"B" STATION DATA (EXISTING OR PROPOSED COCHANNEL STATION)

7B. ERP TOWARD STATION A = 100.2 WATTS

8B. DIFFERENCE BETWEEN ERP AND 1 kW = (10) dB ($10 \text{ LOG } \frac{1000}{\text{ERP}}$)

9B. ADJUSTED FIELD INTENSITY CONTOUR OF INTEREST = + (47) dBu (ITEM 8B PLUS ITEM 6) TO BE USED WITH F(50, 50) CURVES

Fig. 16—Example of Cochannel Interference Worksheet (1 through 9B)

10B. ANTENNA RADIATION CENTER HEIGHT = 2630 FT AMSL

11B. AVERAGE RADIAL ELEVATION (2–10 MI) = 1883 FT AMSL

12B. ANTENNA RADIATION CENTER HEIGHT ABOVE AVERAGE RADIAL ELEVATION = (747) FT (ITEM 10B MINUS ITEM 11B)

Fig. 17—Example of Cochannel Interference Worksheet (10B, 11B, and 12B)

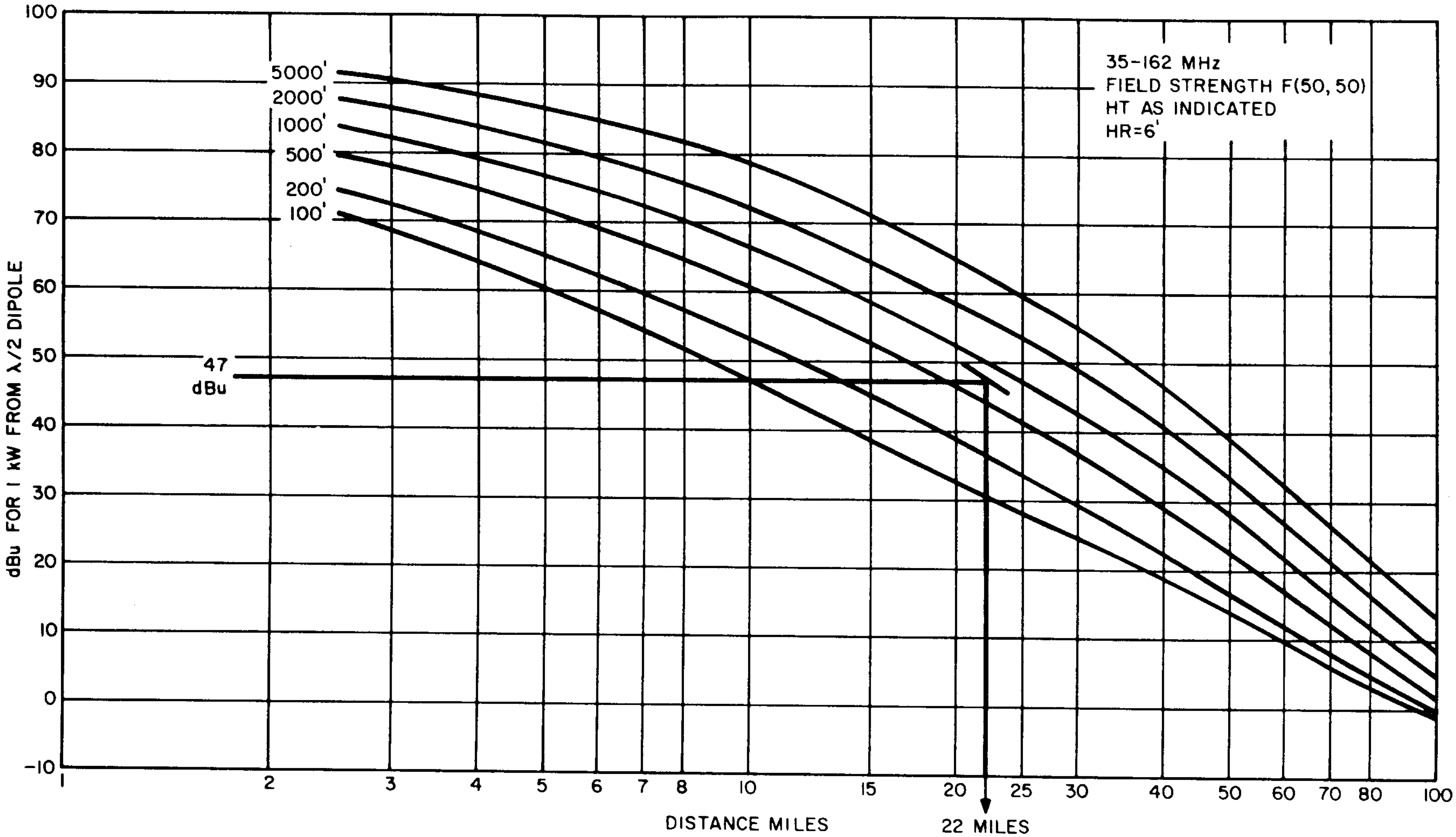

Fig. 18—Distance to Protected Service Area Boundary (47 dBu — 22 miles)

EVALUATION OF COCHANNEL INTERFERENCE

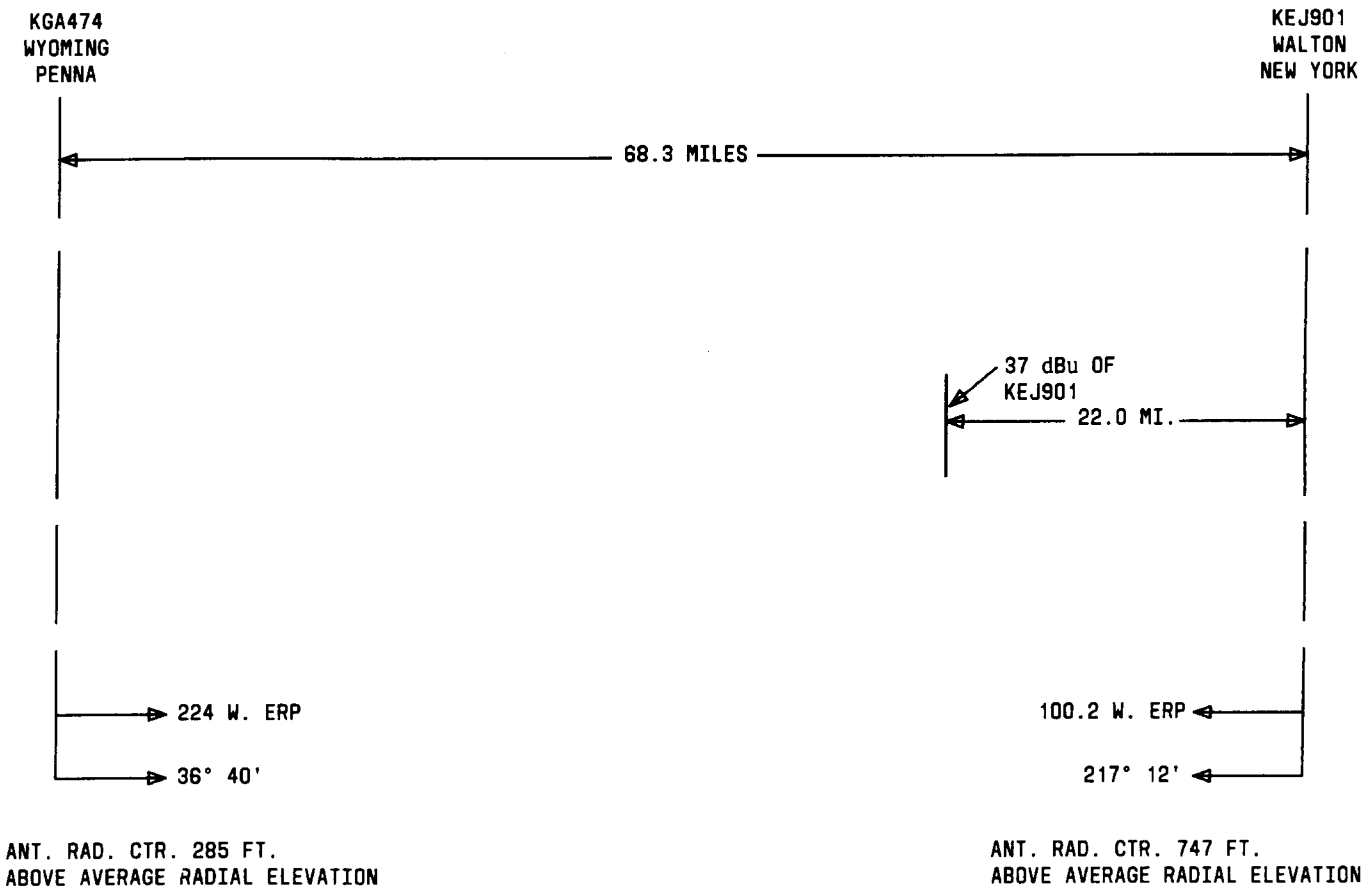

Fig. 19—Partially Completed Cochannel Interference Diagram — One End

10A. ANTENNA RADIATION CENTER HEIGHT = 1544 FT AMSL

11A. AVERAGE RADIAL ELEVATION (2–10 MI) = 1259 FT AMSL

12A. ANTENNA RADIATION CENTER HEIGHT ABOVE AVERAGE RADIAL ELEVATION = 285 FT (ITEM 10A MINUS ITEM 11A)

Fig. 20—Example of Cochannel Interference Worksheet (10A, 11A, and 12A)

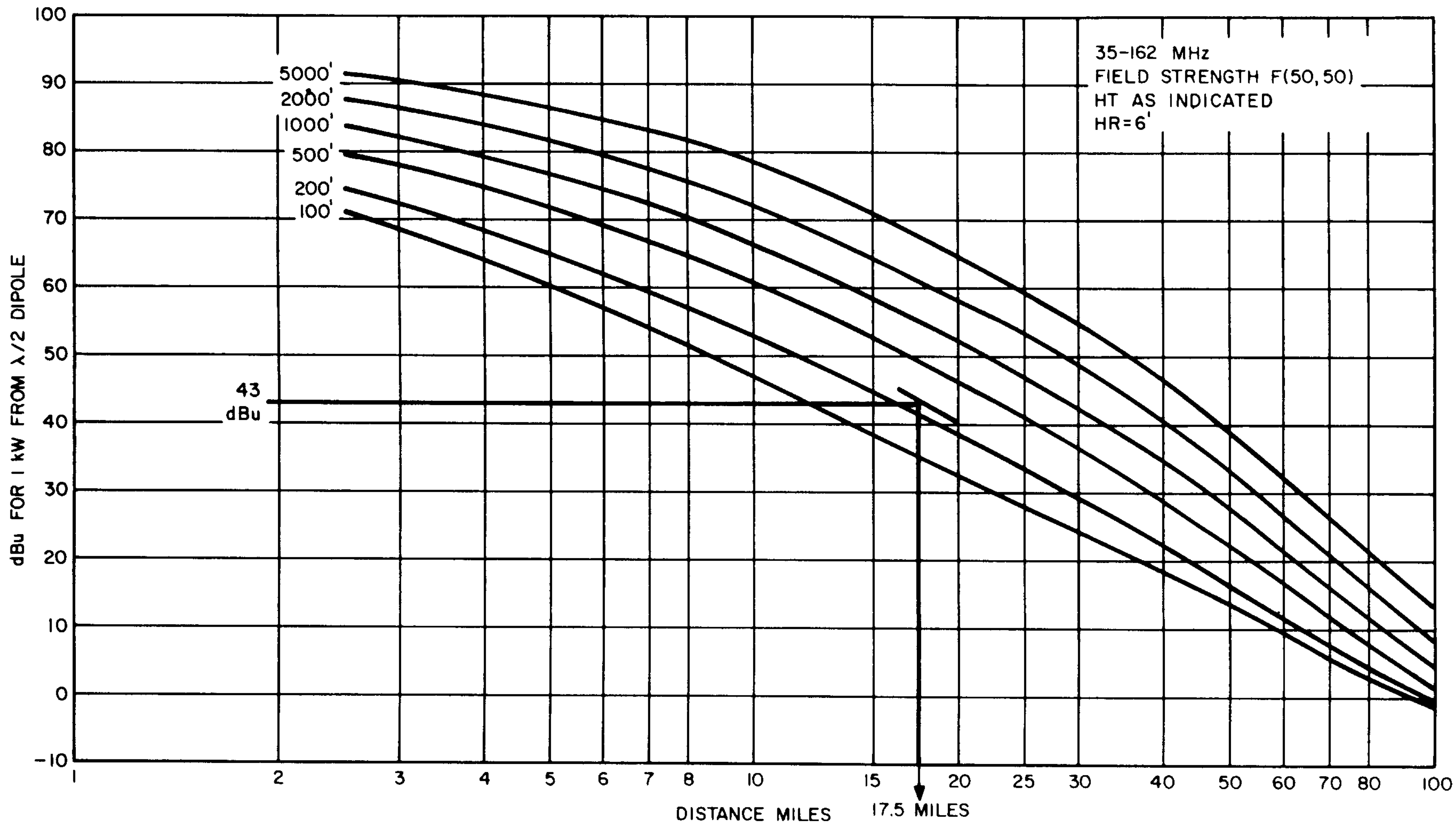

Fig. 21—Distance to Protected Service Area Boundary (43 dBu — 17.5 miles)

EVALUATION OF COCHANNEL INTERFERENCE

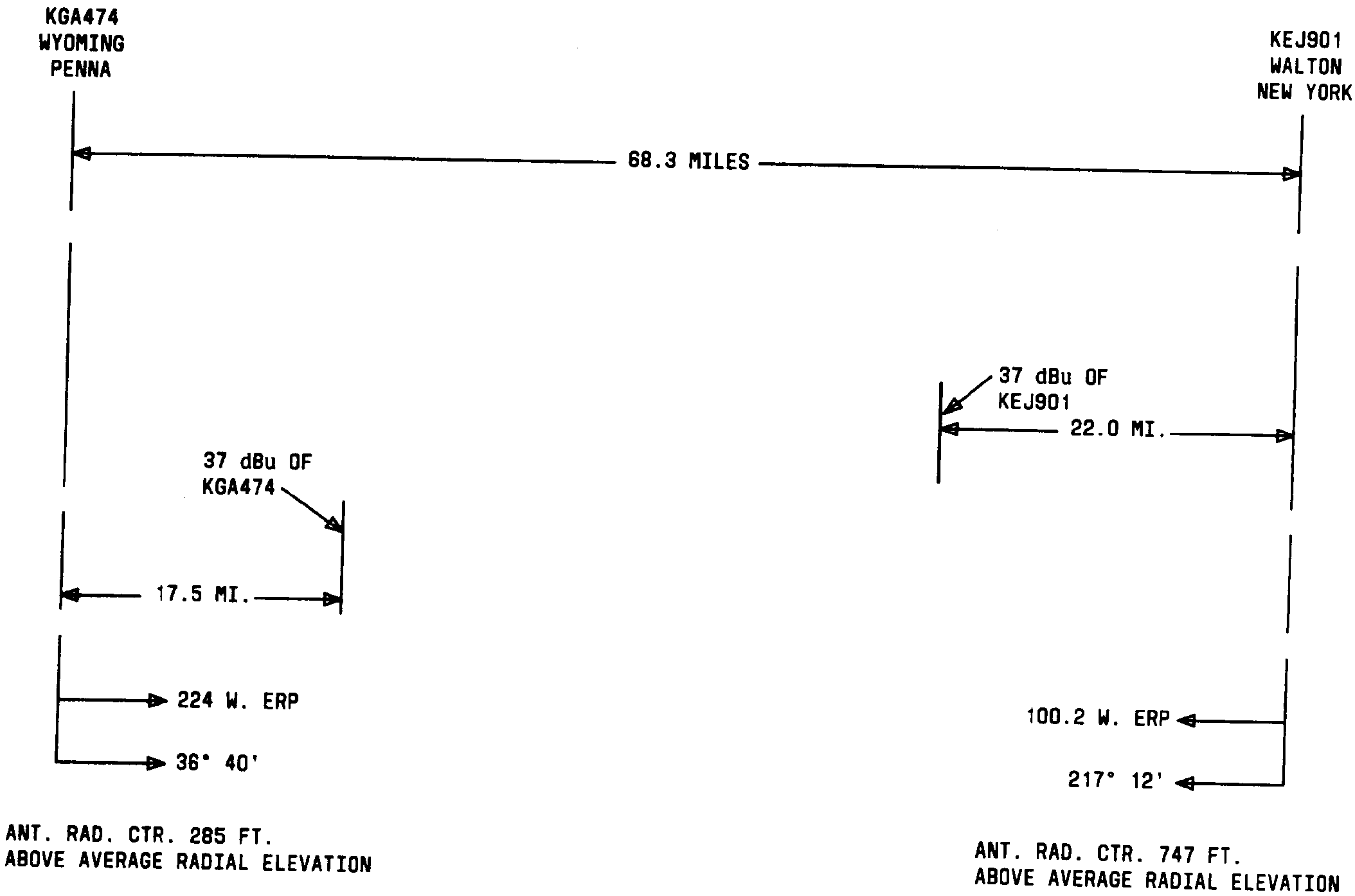

Fig. 22—Partially Completed Cochannel Interference Diagram — Both Ends

COCHANNEL INTERFERENCE WORKSHEET (SHEET 1 OF 2)

1. GEOGRAPHICAL COORDINATES OF STATION A = 41°20'11" N. AND 75°50'52" W.
2. GEOGRAPHICAL COORDINATES OF STATION B = 42°07'40" N. AND 75°03'13" W.
3. AZIMUTHS: STATION A TO B = 36°40' T.N. AND STATION B TO A = 217°12' T.N.
4. DISTANCE BETWEEN STATIONS A AND B = 68.3 MILES.
5. FREQUENCY OF PROPOSED COCHANNEL OPERATION = 152.60 MHz.
6. FIELD INTENSITY CONTOUR OF INTEREST (FD) = + 37 dBu (PROTECTED SERVICE AREA BOUNDARY).

13A. DISTANCE TO OWN PROTECTED SERVICE AREA BOUNDARY FROM F(50,50) CURVES = 17.5 MILES

14A. DISTANCE FROM STATION B TO OWN PROTECTED SERVICE AREA BOUNDARY = 50.8 MILES (ITEM 4 MINUS 13A)

13B. DISTANCE TO OWN PROTECTED SERVICE AREA BOUNDARY FROM F(50,50) CURVES = 22 MILES

14B. DISTANCE FROM STATION A TO OWN PROTECTED SERVICE AREA BOUNDARY = 46.3 MILES (ITEM 4 MINUS 13B)

Fig. 23—Example of Cochannel Interference Worksheet (1 through 6 and 13A through 14B)

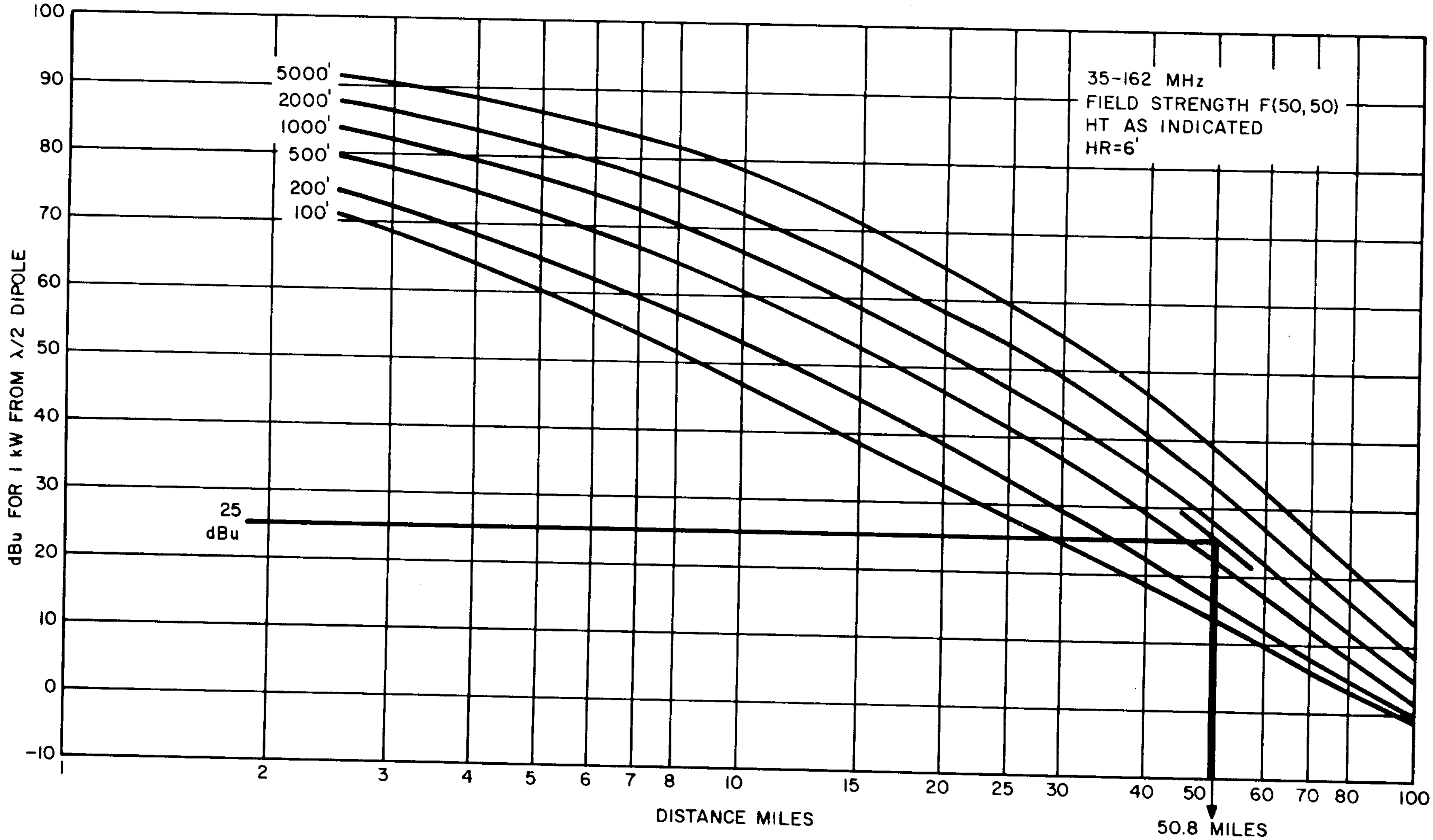

Fig. 24—Value of F_u (50,50) for Interfering Station

15A. FIELD, F(50,50), FOR ANTENNA HEIGHT OF STATION B (FROM ITEM 12B) AT DISTANCE IN ITEM 14A. 1 kW ERP
__25__ dBu

16A. ADJUST ITEM 15A FOR ERP OF STATION B (ITEM 15A MINUS ITEM 8B = __15__ dBu). THIS IS F(50,50) FROM STATION B AT SERVICE BOUNDARY OF STATION A

Fig. 25—Example of Cochannel Interference Worksheet (15A and 16A)

15B. FIELD, F(50,50), FOR ANTENNA HEIGHT OF STATION A (FROM ITEM 12A) AT DISTANCE IN ITEM 14B. 1 kW ERP
__20.5__ dBu

16B. ADJUST ITEM 15B FOR ERP OF STATION A (ITEM 15B MINUS ITEM 8A = __14__ dBu). THIS IS F(50,50) FROM STATION A AT SERVICE BOUNDARY OF STATION B

Fig. 26—Example of Cochannel Interference Worksheet (15B and 16B)

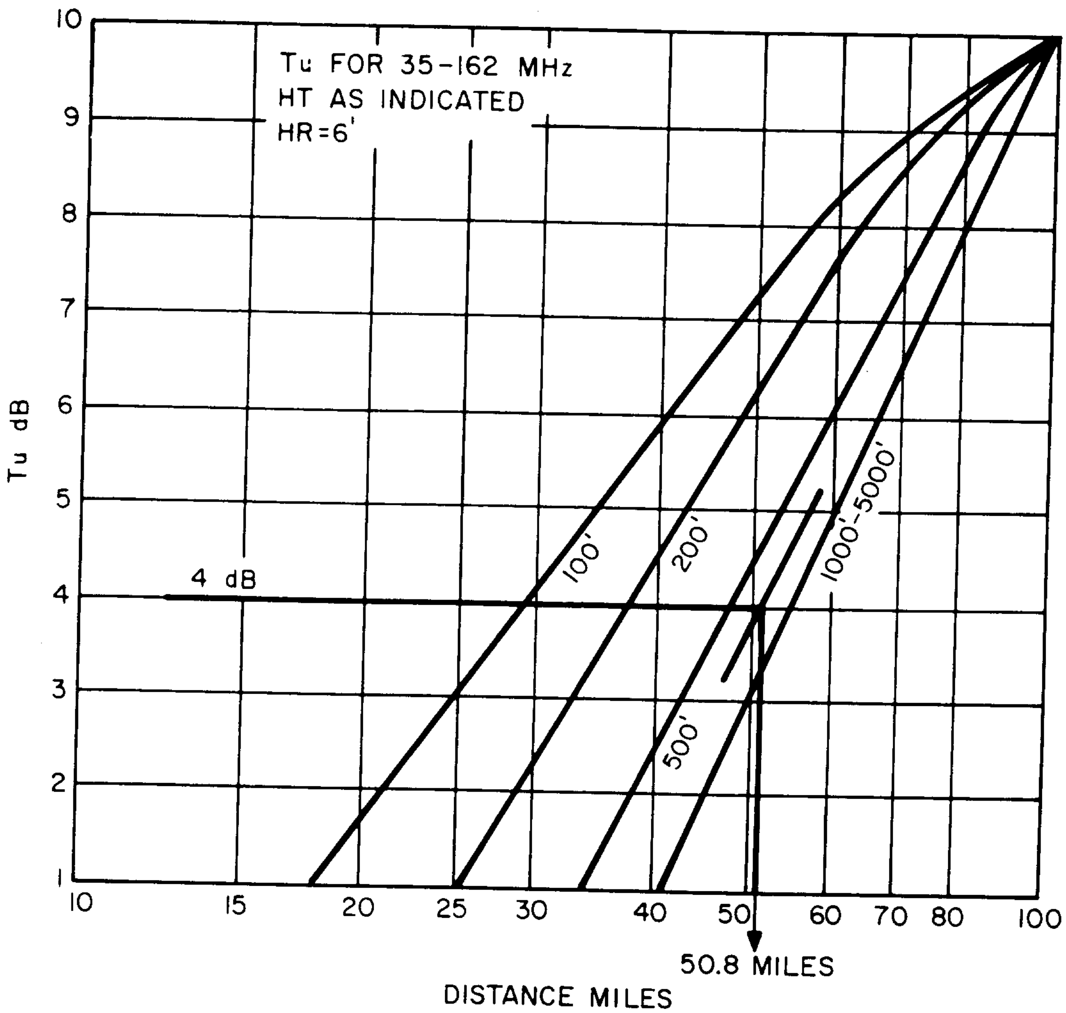

Fig. 27—Value of T_u (Example 1)

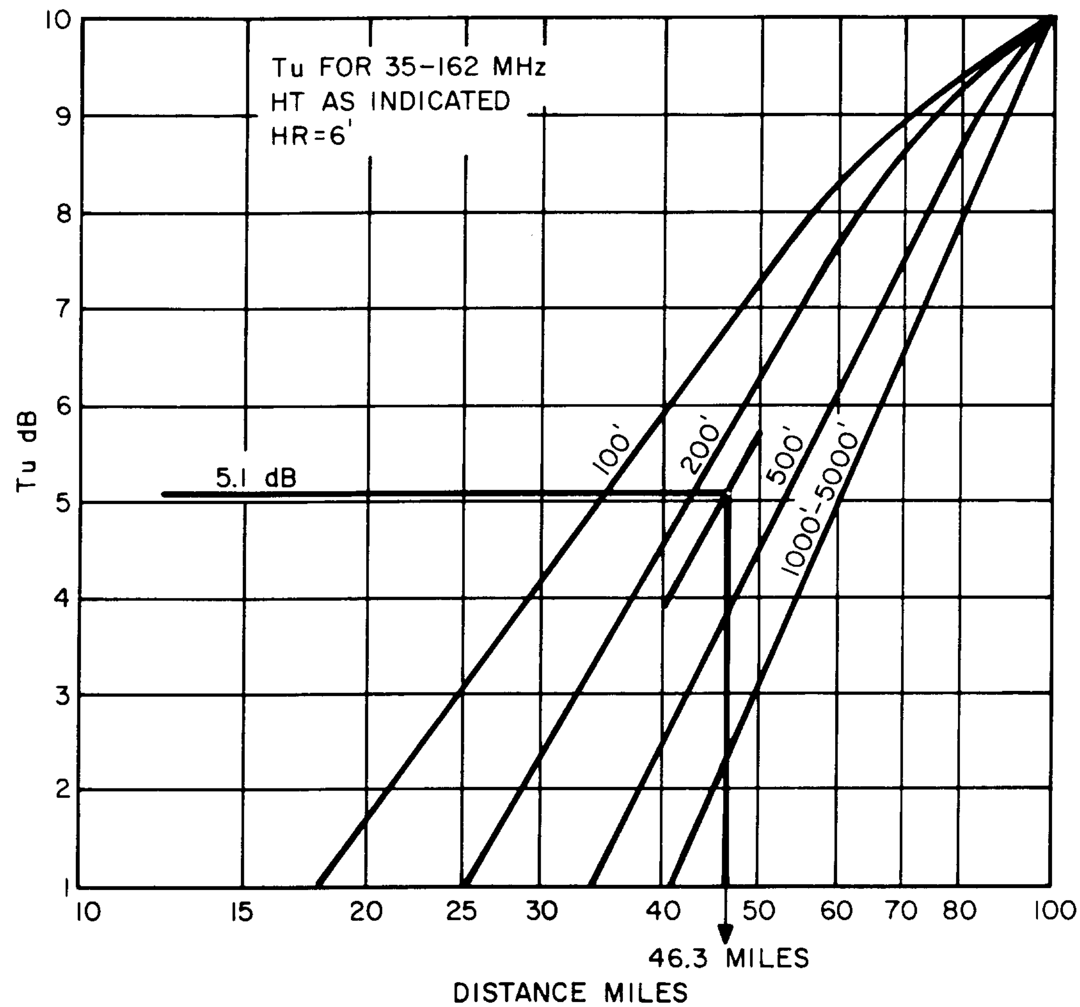

Fig. 28—Value of T_u (Example 2)

17A. DETERMINE T_u FOR ANTENNA HEIGHT OF STATION B AT DISTANCE IN ITEM 14A USING T_u CURVES. T_u = 4.0 dB

18A. CALCULATE VALUE OF R. R = 22.1 dB

17B. DETERMINE T_u FOR ANTENNA HEIGHT OF STATION A AT DISTANCE IN ITEM 14B USING T_u CURVES. T_u = 5.1 dB

18B. CALCULATE VALUE OF R. R = 22.4 dB

Fig. 29—Example of Cochannel Interference Worksheet (17A through 18B)

19A. MAXIMUM PERMITTED FIELD INTENSITY FROM STATION B AT SERVICE BOUNDARY OF STATION A. 37 − R = 14.9 dBu

19B. MAXIMUM PERMITTED FIELD INTENSITY FROM STATION A AT SERVICE BOUNDARY OF STATION B. 37 − R = 14.6 dBu

20A. IF ITEM 16A EXCEEDS ITEM 19A, SYSTEM IS (INTERFERENCE-LIMITED;) IF LESS, IT IS AMBIENT NOISE LIMITED

20B. IF ITEM 16B EXCEEDS ITEM 19B, SYSTEM IS INTERFERENCE-LIMITED; IF LESS, IT IS AMBIENT (NOISE LIMITED)

Fig. 30—Example of Cochannel Interference Worksheet (19A through 20B)

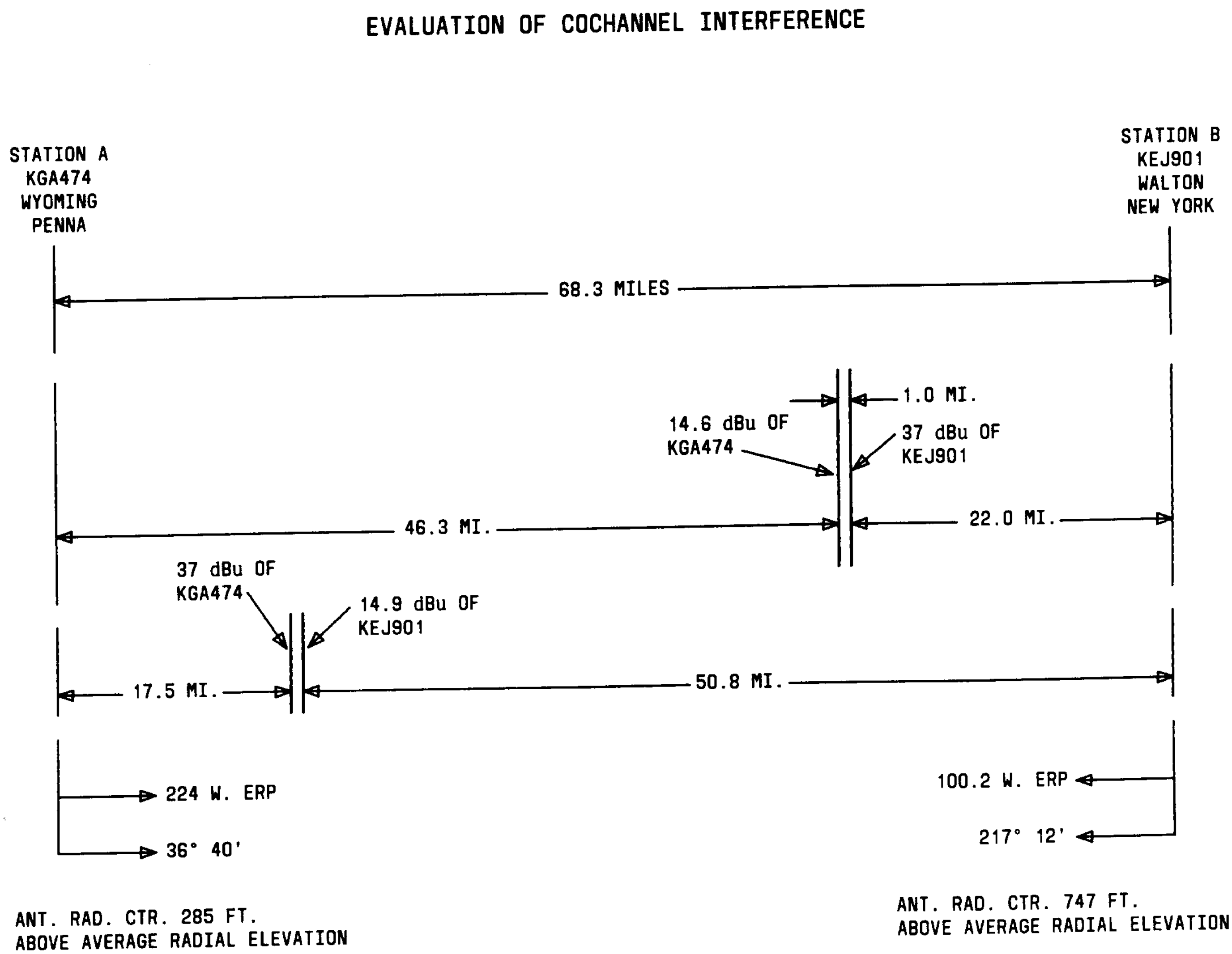

Fig. 31—Cochannel Interference Diagram—Summary

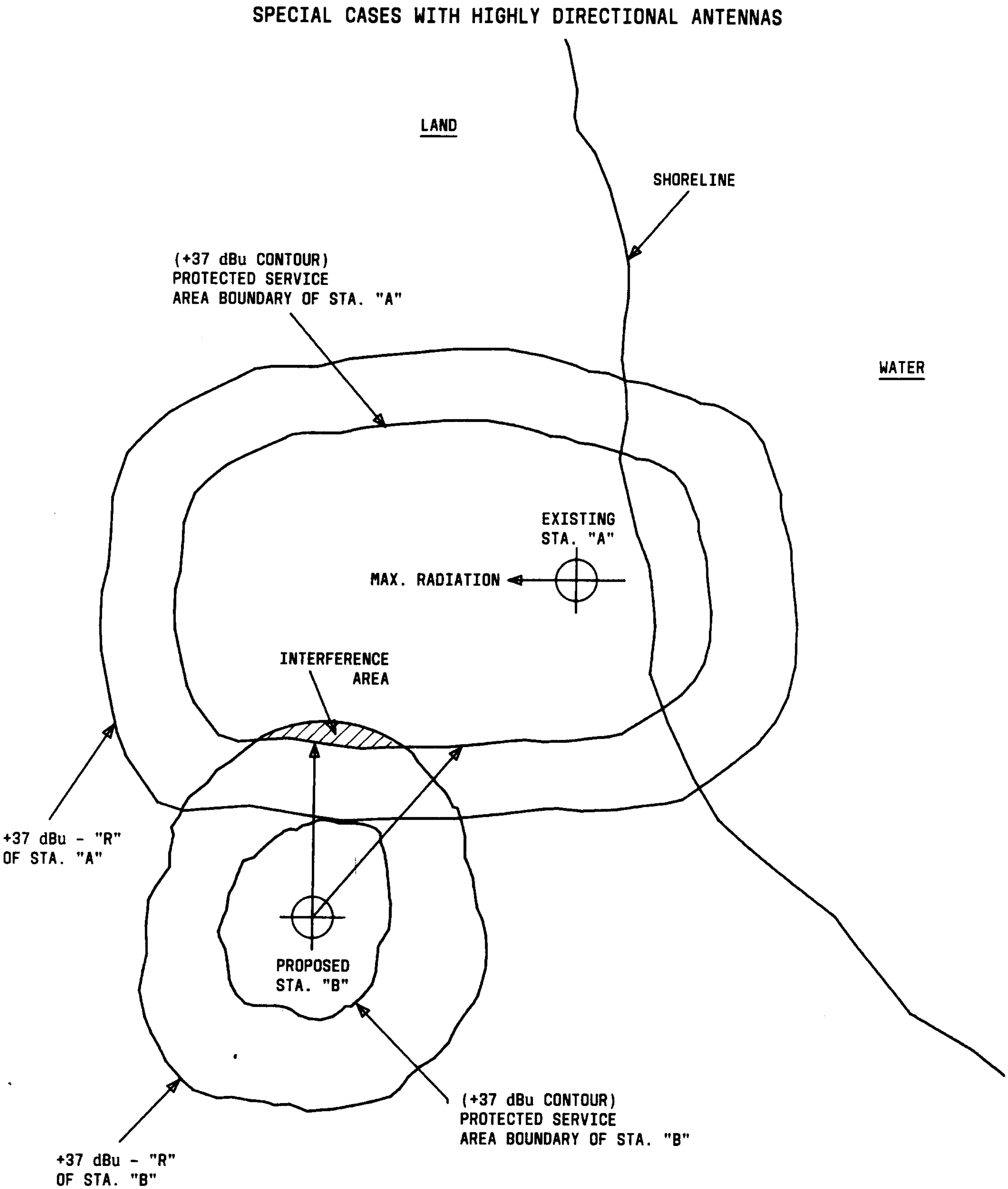

Fig. 32—Coverage Area of Stations With Highly Directional Antenna Systems