STANDARDS OF GOOD ENGINEERING PRACTICE CONCERNING STANDARD BROADCAST STATIONS

(535-1605 kc)

INTRODUCTION

There are presented herein the Standards of Good Engineering Practice giving interpretations and further considerations concerning the Rules and Regulations of the Communications Commission governing standard broadcast stations. While the Rules and Regulations form the basis of good engineering practice, these Standards may go beyond the Rules and Regulations and set up engineering principles for consideration of various allocation problems. These Standards have been approved by the Commission and thus are considered as reflecting the opinion of the Commission in all matters involved.

The Rules and Regulations contain references to these Standards; however, as further Standards may be issued after the Rules and Regulations are published, the absence of such references does not relieve the responsibility of meeting the requirements specified herein. The Standards of Good Engineering Practice are collected in this publication for the convenience of all considering broadcast station operation and problems.

The Standards of Good Engineering Practice set forth herein are those deemed necessary for the construction and operation of standard broadcast stations to meet the requirements of technical regulations and for operation in public interest along technical lines not specifically enunciated in the regulations. These Standards are based on the best engineering data available from evidence supplied in formal and informal hearings and extensive surveys conducted in the field by the Commission's personnel. Numerous informal conferences have been held with radio engineers, manufacturers of radio equipment and others for the guidance of the Commission in the formulation of these Standards.

These Standards are complete in themselves and supersede any previous announcements or policies which may have been enunciated by the Commission on engineering matters concerning standard broadcast stations.

While these Standards provide for flexibility and set forth the conditions under which they are applicable, it is not expected that material deviation therefrom as to fundamental principles will be recognized unless full information is submitted as to the reasonableness of such departure and the need therefor.

These Standards of Good Engineering Practice will necessarily change as progress is made in the art, and accordingly it will be necessary to make revisions from time to time. The Commission will accumulate and analyze engineering data available as to the progress of the art so that its Standards may be kept current with the developments.

Effective August 1, 1939
(Revised to July 10, 1955)

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STANDARDS OF GOOD ENGINEERING PRACTICE CONCERNING STANDARD BROADCAST STATIONS

(535-1605 kc.)

1. ENGINEERING STANDARDS OF ALLOCATION

Sec. 3.28 requires that individual broadcast station assignments shall be made in accordance with the standards of good engineering practice prescribed and published from time to time by the Commission. These standards for each class of station are set out below.

Sec. 3.21 to 3.34, inclusive, govern the allocation of facilities in the standard broadcast band of 535 to 1605 kc, inclusive. Sec. 3.21 establishes three classes of channels in this band, namely, clear channels for the use of high-powered stations, regional channels for the use of medium-powered stations, and local channels for the use of low-powered stations. The classes and power of standard broadcast stations which will be assigned to the various channels are set forth in Sec. 3.22. The classifications of the standard broadcast stations are as follows:

Class I stations are dominant stations operating on clear channels as follows:

(1) Class I stations operate with powers of not less than 10 or more than 50 kw. These stations are designed to render primary and secondary service over an extended area and at relatively long distances, hence have their primary service areas 1/ free from objectionable interference from other stations on the same and adjacent channels and secondary service areas free from objectionable interference from stations on the same channels. 2/ 3/

(2) From an engineering point of view, Class I stations may be divided into two groups:

(a) The Class I stations in Group 1 are those assigned to the channels allocated by Sec. 3.25, paragraph (a), on which duplicate nighttime operation is not permitted, that is, no other station is permitted to operate on a channel with a Class I station of this group within the limits of the United States (the Class II stations assigned the channels operate limited time or daytime only), and during daytime the Class I station is protected to the 100 uv/m groundwave contour. Protection is given this class of station to the 500 uv/m groundwave contour from adjacent channel stations for both day and nighttime operations. 2/ The power of each such Class I station shall not be less than 50 kw.

(b) The Class I stations in Group 2 are those assigned to the channels allocated by Sec. 3.25, paragraph (b), on which duplicate operation is permitted, that is, other Class I or Class II stations operating unlimited time may be assigned to such channels. During nighttime hours of operation a Class I station of this group is protected to the 500 uv/m 50 percent skywave contour and during daytime hours of operation to the 100 uv/m groundwave contour from stations on the same channel.

1/ See Sec. 3.11 for the definitions of primary and secondary service areas.

2/ See Tables IV and V.

3/ The secondary service area of a Class I station is not protected from adjacent channel interference. However, if it is desired to make a determination of the area in which adjacent channel groundwave interference (10 kc. removed) to skywave service exists, it may be considered as the area where the ratio of the desired 50 percent skywave of the Class I station to the undesired groundwave of a station 10 kc. removed is 1 to 4.

Protection is given to the 500 uv/m groundwave contour from stations on adjacent channels for both day and nighttime operation. 2/ The operating powers of Class I stations on these frequencies shall be not less than 10 kw nor more than 50 kw.

Hereafter, for the purpose of convenience, the two groups of Class I stations will be termed Class Ia or Ib in accordance with the assignment to channels allocated by Sec. 3.25 (a) or 3.25 (b).

Class II stations are secondary stations which operate on clear channels with powers not less than 0.25 kw or more than 50 kw. These stations are required to use a directional antenna or other means to avoid causing interference within the normally protected service areas of Class I stations or other Class II stations. These stations normally render primary service only, the area of which depends on the geographical location, power, and frequency. This may be relatively large but is limited by and subject to such interference as may be received from Class I stations. However, it is recommended that Class II stations be so located that the interference received from Class I stations will not limit the service area to greater than the 2500 uv/m groundwave contour, which is the value for the mutual protection of this class of station with other stations of the same class. 2/

Class III stations operate on regional channels and normally render primary service to the metropolitan district and the rural area contained therein and contiguous thereto, and are subdivided into two classes:

(a) Class III-A stations which operate with powers not less than 1 kw or more than 5 kw are normally protected to the 2500 uv/m groundwave contour nighttime and the 500 uv/m groundwave contour daytime. 2/

(b) Class III-B stations which operate with powers not less than 0.5 kw or more than 1 kw nighttime and 5 kw daytime are normally protected to the 4000 uv/m groundwave contour nighttime and 500 uv/m groundwave contour daytime. 2/

Class IV stations operate on local channels normally rendering primary service only to a city or town and the suburban and rural areas contiguous thereto with powers not less than 0.1 kw or more than 0.25 kw. These stations are normally protected to 500 uv/m groundwave contour daytime. On local channels the separation required for the daytime protection shall also determine the nighttime separation. The actual nighttime limitation will be calculated. 3a/

The class of any station is determined by the channel assignment, the power and the field intensity contour to which it renders service free of interference from other stations as determined by these standards. No station will be permitted to change to a class normally protected to a contour of less intensity than the contour to which the station actually renders interference-free service. Any station of a class normally protected to a contour of less intensity than that to which the station actually renders interference-free service, will be automatically reclassified according to the class normally protected, the minimum consistent with its power and channel assignment. Likewise, any station to which the interference is reduced so that service is rendered to a contour normally protected for a higher class will be automatically changed to that class if consistent with its power and channel assignment.

2/ See Tables IV and V.

3a/ The following approximate method may be used. It is based on the assumption of 0.25 wavelength antenna height and 88 mv/m at 1 mile effective field for 250 watts power, using the 10 percent skywave field intensity curve of Figure

When it is shown that primary service is rendered by any of the above classes of stations, beyond the normally protected contour, and when primary service to approximately 90 percent of the population (population served with adequate signal) of the area between the normally protected contour and the contour to which such station actually serves, is not supplied by any other station or stations carrying the same general program service, the contour to which protection may be afforded in such cases will be determined from the individual merits of the case under consideration.

When a station is already limited by interference from other stations to a contour of higher value than that normally protected for its class, this contour shall be the established standard for such station with respect to interference from all other stations.

Tables IV and V give a complete summary of the protected service contours and permissible interference signals for broadcast stations on the same and adjacent channels, respectively.

The several classes of broadcast stations have in general three service areas;4a/ namely, primary, secondary, and intermittent service areas. Class I stations render service to all three service areas. Class II stations render service to a primary area but the secondary and intermittent service areas may be materially limited or destroyed due to interference from other stations depending on the station assignments involved. Class III and IV stations usually have only primary service areas as interference from other stations generally prevents any secondary service and may limit the intermittent service area. However, complete intermittent service may be obtained in many cases depending on the station assignments involved.

1-A. Zones defined by circles of various radii specified below are drawn about the desired station and the interfering 10 percent skywave signal from each station in a given zone is considered to be the value tabluated below. The effective interfering 10 percent skywave signal is taken to be the RSS value of all signals originating within these zones. (Stations beyond 500 miles are not considered.)

Zone	Inner radius	Outer radius	10 percent skywave signal
			mv/m
A	--	60	0.10
B	60	80	.12
C	80	100	.14
D	100	250	.16
E	250	350	.14
F	350	450	.12
G	450	500	.10

Where the power of the interfering station is not 250 watts, the 10 percent skywave signal should be adjusted by the square root of the ratio of the power to 250 watts.

4a/ See Sec. 3.11 for the definitions of primary, secondary, and intermittent service areas.

The signals necessary to render the different types of service are listed below.

Table I. - Primary Service

Area:	Field intensity groundwave 1/
City business or factory areas	10 to 50 mv/m
City residential areas	2 to 10 mv/m
Rural - all areas during winter or northern areas during summer	0.1 to 0.5 mv/m
Rural - southern areas during summer	0.25 to 1.0 mv/m

1/ See Appendix I for curves showing distance to various groundwave field intensity contours for different frequency and ground conductivities and annex I.

All these values are based on an absence of objectionable fading, either in changing intensity or selective fading, the usual noise level in the areas 5/ and an absence of limiting interference from other broadcast stations. The values apply both day and night but generally fading or interference from other stations limits the primary service at night in all rural areas to higher values of field intensity than the values given.

In determining the population of the primary service area, it may be considered that the following signals are satisfactory to overcome man-made noise in towns of the population given.

Table II

Population:	Field intensity groundwave
Up to 2,500	0.5 mv/m
2,500 to 10,000	2.0 mv/m
10,000 and up	Values given in Table I.

These values are subject to wide variations in individual areas and especial attention must be given to interference from other stations. The values are not considered satisfactory in any case for service to the city in which the main studio of the station is located. The values in Table I shall apply except as individual consideration may determine.

All classes of broadcast stations have primary service areas subject to limitation by fading and noise, and interference from other stations to the contours set out for each class of station.

Secondary Service

Secondary service is delivered in the areas where the skywave for 50 percent or

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5/ Standards have not been established for interference from atmospherics or man-made electric noise as no uniform method of measuring noise or static has been established. In any individual case objectionable interference from any source, except other broadcast signals, may be determined by comparing the actual noise interference reproduced during reception of a desired broadcast signal to the degree of interference that would be caused by another broadcast signal within 20 cycles of the desired signal and having a carrier ratio of 20 to 1 with both signals modulated 100 percent on peaks of usual programs. Standards of noise measurements and interference ratio for noise are now being studied.

more of the time has a field intensity of 500 uv/m or greater. 6/ It is not considered that satisfactory secondary service can be rendered to cities unless the skywave approaches in value the groundwave required for primary service. The secondary service is necessarily subject to some interference and extensive fading whereas the primary service area of a station is subject to no objectionable interference or fading. 7/ Class I stations only are assigned on the basis of rendering secondary service.

Intermittent Service

The intermittent service is rendered by the groundwave and begins at the outer boundary of the primary service area and extends to the value of signal where it may be considered as having no further service value. This may be down to only a few microvolts in certain areas and up to several millivolts in other areas of high noise level, interference from other stations, or objectionable fading at night. The intermittent service may vary widely from day to night and generally varies from time to time as the name implies. Only Class I stations are assigned for protection from interference from other stations into the intermittent service area.

Sec. 3.23 provides that the several classes of broadcast stations may be licensed to operate unlimited time, limited time, daytime, sharing time, and specified hours, with full explanation given in the section.

Sec. 3.24 sets out the general requirements for obtaining an increase in facilities of a licensed station and for a new station. Sec. 3.24 (b) concerns the matter of interference that may be caused by a new assignment or increase in facilities of an existing assignment.

(In a Proposed Report and Order and Notice of Further Rule Making, Docket No. 8333, FCC proposes to delete the preceding two paragraphs and substitute engineering standards concerning daytime skywave propagation.)

Objectionable interference from another broadcast station 8/ is the degree of interference produced when, at a specified field intensity contour with respect to the desired station, the field intensity of an undesired station (or the root-sum-square value of field intensities of two or more stations on the same frequency) exceeds for ten (10) percent or more of the time the values set forth in these standards.

With respect to the root-sum-square values of interfering field intensities referred to herein, except in the case of Class IV stations on local channels, calculation is accomplished by considering the signals in order of decreasing magnitude, adding the squares of the values and extracting the square root of the sum, excluding those signals which are less than 50 percent of the RSS value of the higher signals already included.

The RSS value will not be considered to be increased when a new interfering signal is added which is less than 50 percent of the RSS value of the interference

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6/ The secondary service area of a Class Ia station should be considered as having this limit only for determination of service in comparison with other stations.

7/ Standards have not been established for objectionable fading as such standards would necessarily depend on the receiver characteristics which have been changed considerably in this regard during the last several years. Selective fading causing audio distortion and the signal fading below the noise level are the objectionable characteristics of fading on modern design receivers. The AVC circuits in the better designed modern receivers in general maintain the audio output sufficiently constant to be satisfactory during most fading.

8/ See Footnote 6.

from existing stations, and which at the same time is not greater than the smallest signal included in the RSS value of interference from existing stations.

It is recognized that application of the above "50 percent exclusion" method of calculating the RSS interference may result in some cases in anomalies wherein the addition of a new interfering signal or the increase in value of an existing interfering signal will cause the exclusion of a previously included signal and may cause a decrease in the calculated RSS value of interference. In order to provide the Commission with more realistic information regarding gains and losses in service (as a basis for determination of the relative merits of a proposed operation) the following alternate method for calculating the proposed RSS values of interference will be employed wherever applicable.

In the cases where it is proposed to add a new interfering signal which is not less than 50 percent of the RSS value of interference from existing stations or which is greater than the smallest signal already included to obtain this RSS value, the RSS limitation after addition of the new signal shall be calculated without excluding any signal previously included. Similarly, in cases where it is proposed to increase the value of one of the existing interfering signals which has been included in the RSS value, the RSS limitation after the increase shall be calculated without excluding the interference from any source previously included.

If the new or increased signal proposed in such cases is ultimately authorized, the RSS values of interference to other stations affected will thereafter be calculated by the "50 percent exclusion" method without regard to this alternate method of calculation.

Example of RSS interference calculations:

1. Existing interferences:

Station No. 1	1.0 mv/m
Station No. 2	0.60 mv/m
Station No. 3	0.59 mv/m
Station No. 4	0.58 mv/m

The RSS value from Nos. 1, 2, and 3 is 1.31 mv/m; therefore interference from No. 4 is excluded for it is less than 50 percent of 1.31 mv/m

2. Station A receives interference from:

Station No. 1	1.0 mv/m
Station No. 2	0.60 mv/m
Station No. 3	0.59 mv/m

It is proposed to add a new limitation=0.68 mv/m. This is more than 50 percent of 1.31 mv/m, the RSS value of Nos. 1, 2, and 3. The RSS value of Station No. 1 and of the proposed station would be 1.21 mv/m which is more than twice as large as the limitation from Station No. 2 or No. 3. However, under the above provision the new signal and the three existing interferences are nevertheless calculated for purposes of comparative studies, resulting in an RSS value of 1.47 mv/m. However, if the proposed station is ultimately authorized, only No. 1 and the new signal are included in all subsequent calculations for the reason that Nos. 2 and 3 are less than 50 percent of 1.21 mv/m the RSS value of the new signal and No. 1.

3. Station A receives interference from:

Station No. 1	1.0 mv/m
Station No. 2	0.60 mv/m
Station No. 3	0.59 mv/m

No. 1 proposes to increase the limitation it imposes on Station A to 1.21 mv/m. Although the limitations from Stations Nos. 2 and 3 are less than 50 percent of the 1.21 mv/m limitation under the above provision, they are nevertheless included for comparative studies, and the RSS limitation is calculated to be 1.47 mv/m. However, if the increase proposed by Station No. 1 is authorized, the RSS value then calculated is 1.21 mv/m because Stations Nos. 2 and 3 are excluded in view of the fact that the limitations they impose are less than 50 percent of 1.21 mv/m.

Objectionable interference from a station on the same channel shall be considered to exist to a station when, at the field intensity contour specified in Table IV with respect to the class to which the station belongs, the field intensity of an interfering station (or the root-sum-square value of the field intensities of two or more interfering stations) operating on the same channel, exceeds for ten (10) percent or more of the time the value of the permissible interfering signal set forth opposite such class in Table IV.

Objectional interference from a station on an adjacent channel shall be considered to exist to a station when, at the normally protected contour of a desired station, the field intensity of the groundwave of an undesired station operating on an adjacent channel (or the root-sum-square value of the field intensities of two or more such undesired stations operating on the same adjacent channel) exceeds a value specified in Table V.

For the purpose of estimating the coverage and the interfering effects of stations in the absence of field intensity measurements, use shall be made of Figure 8 which describes the estimated effective field for one kilowatt power input of simple vertical omnidirectional antennas of various heights with ground systems of at least 120 one quarter wavelength radials. Certain approximations, based on the curve or other appropriate theory, may be made when other than such antennas and ground systems are employed, but in any event the effective field to be employed shall not be less than given in the following:

Table III

Class of Station:	Effective Field
I	225 mv/m
II and III	175 mv/m
IV	150 mv/m

In case a directional antenna is employed, the interfering signal of a broadcasting station will vary in different directions, being greater than the above values in certain directions and less in others, depending upon the design and adjustment of the directional antenna system. To determine the interference in any direction, the measured or calculated radiated field (unabsorbed field intensity at 1 mile from the array) must be used in conjunction with the appropriate propagation curves. 9/

The existence or absence of objectionable groundwave interference from stations on the same or adjacent channels shall be determined by actual measurements made according to the method hereinafter described, or, in the absence of such measurements, by reference to the propagation curves of Appendix I. The existence or absence of objectionable interference due to skywave propagation shall be determined by reference to the appropriate propagation curves in Figure 1 or Figure 1-A.

In computing the fifty (50) percent skywave field intensity values and the ten (10) percent skywave field intensity values of a station on a clear channel, use shall be made of the appropriate graph set forth in Figure 1 entitled "Average Skywave Field Intensity" (corresponding to the second hour after sunset at the recording station).

9/ See Annex II for further discussion and solution of a typical directional antenna case.

These graphs are drawn for a radiated field of 100 mv/m at 1 mile in the horizontal plane from a 0.311 wavelength antenna. In computing the ten (10) percent skywave field intensity of a regional channel station, use shall be made of the appropriate curve in Figure 1-A entitled "10 percent Skywave Signal Range". This graph is drawn for a radiated field of 100 mv/m at 1 mile at the vertical angle pertinent to transmission by one reflection. This curve supersedes the ten (10) percent skywave curve of Figure 1, only for regional and local channels at the present time. 10/ Adoption of revised skywave curves for use on clear channels will await the outcome of the Clear Channel Hearing (Docket No. 6741).

The distance to any specified groundwave field intensity contour for any frequency may be determined from the appropriate curves in Appendix I entitled "Ground Wave Field Intensity vs. Distance".

10/ The Commission will not authorize a directive antenna for a Class IV station assigned to a local channel.

Table IV. - Protected service contours and permissible interference signals for broadcast stations

Class of station	Class of channel used	Permissible power	Signal intensity contour of area protected from objectionable interference 1/ Day 3/	Night	Permissible interfering signal on same channel 2/ Day 3/	Night 4/
Ia	Clear	50 kw	*SC 100 uv/m *AC 500 uv/m	Not duplicated	5 uv/m	Not duplicated
Ib	do	10 kw to 50 kw	SC 100 uv/m AC 500 uv/m	500 uv/m (50 percent skywave)	5 uv/m	25 uv/m
II	do	0.25 kw to 50 kw	500 uv/m	2500 uv/m 5/ (groundwave)	25 uv/m	125 uv/m5/
III-A	Regional	1 kw to 5 kw	500 uv/m	2500 uv/m (groundwave)	25 uv/m	125 uv/m
III-B	do	0.5 to 1 kw night and 5 kw day	500 uv/m	4000 uv/m (groundwave)	25 uv/m	200 uv/m
IV	Local	0.1 kw to 0.25 kw	500 uv/m	Not prescribed 6/	25 uv/m	Not prescribed 6/

1/ When it is shown that primary service is rendered by any of the above classes of stations, beyond the normally protected contour, and when primary service to approximately 90 percent of the population (population served with adequate signal) of the area between the normally protected contour and the contour to which such station actually serves, is not supplied by any other station or stations, the contour to which protection may be afforded in such cases will be determined from the individual merits of the case under consideration. When a station is already limited by interference from other stations to a contour of higher value than that normally protected for its class, this contour shall be the established standard for such station with respect to interference from all other stations.

The following table is to be used for determining the minimum ratio of the field intensity of a desired to an undesired signal for interference free service. In the case of a desired groundwave signal interfered with by two or more skywave signals on the same frequency, the RSS value of the latter is used.

Table V. - Interference Ratios

Frequency separation of desired to undesired signals	Desired groundwave to - Undesired groundwave	Desired groundwave to - Undesired 10 percent skywave	Desired 50 percent skywave to undesired 10 percent skywave
0 kc	20:1	20:1	20:1
10 kc	1:1	1:5	1/
20 kc	1:30	—	—

1/ See Footnote 3, page 1.

From the above, it is apparent that in many cases stations operating on channels 10 and 20 kc apart may be operated with antenna systems side by side or otherwise in proximity without any indications of interference if the interference is defined only in terms of permissible ratios hereinbefore listed in Table V headed "Interference Ratios". As a practical matter, serious interference problems may arise when two or more stations with the same general service area are operated on channels 10, 20,and 30 kc apart.

(Requirements for minimum separation of stations now appears in Section 3.37 of the FCC Rules.)

Two stations, one with a frequency twice that of the other, should not be assigned in the same groundwave service area unless special precautions are taken to avoid interference from the second harmonic of the lower frequency. In selecting a frequency, consideration should be given to the fact that occasionally the frequency assignment of two stations in the same area may bear such a relation to the intermediate frequency of some broadcast receivers as to cause so-called "image" interference. However, since this can usually be rectified by readjustment of the intermediate

2/ For adjacent channels see Table V.

3/ Groundwave

4/ Skywave field intensity for 10 percent or more of the time.

5/ These values are with respect to interference from all stations except Class Ib, which stations may cause interference to a field intensity contour of higher value. However, it is recommended that Class II stations be so located that the interference received from Class Ib stations will not exceed these values. If the Class II stations are limited by Class Ib stations to higher values, then such values shall be the established standard with respect to protection from all other stations.

6/ See Class IV station operation, page 2 of this section.

* SC Same Channel. AC Adjacent channel.

frequency of such receivers, the Commission in general will not take this kind of interference into consideration in allocation problems.

Two stations operating with synchronized carriers 12/ and carrying the identical program will have their groundwave service subject to some distortion in areas where the signals from the two stations are of comparable intensity. For the purpose of estimating coverage of such stations, areas in which the signal ratio is between 1 to 2 and 2 to 1 will not be considered as having satisfactory service.

12/ NOTE - Two stations are consideredto be operated synchronously when the carriers are maintained within one-fifth of a cycle per second of each other and they transmit identical programs.

ANNEX I

Groundwave Signals

A. Interference that may be caused by a proposed assignment or an existing assignment during day time should be determined, when possible, by measurements on the frequency involved or on another frequency over the same terrain and by means of the curves in Appendix I entitled "Ground Wave Field Intensity vs. Distance".

B. In determining interference based upon field intensity measurements, it is necessary to do the following:

First, establish the outer boundary of the protected service area of the desired station in the direction of the station that may cause interference to it. Second, at this boundary, measure the interfering signal from the undesired station. The ratio of the desired to the undesired signal given in Table V should be applied to the measured signals and if the required ratio is observed, no objectionable interference is foreseen. When measurements of both the desired and undesired stations are made in one area to determine the point where objectionable interference from groundwave signals occur or to establish other pertinent contours, several measurements of each station shall be made within a few miles of this point or contour. The effective field of the antennas in the pertinent directions of the stations must be established and all measurements must be made in accordance with Section 2 (Field Intensity Measurements in Allocation).

C. In all cases where measurements taken in accordance with the requirements are not available, the groundwave intensity must be determined by means of the pertinent map of ground conductivity and the groundwave curves of field intensity versus distance. The conductivity of a given terrain may be determined by measurements of any broadcast signal traversing the terrain involved. Figures M3 13/ and R3 show the conductivity throughout the United States by general areas of reasonably uniform conductivity. When it is clear that only one conductivity value is involved, Figure R3, which is a replica of Figure M3 and contained in these Standards, may be used; in all other situations Figure M3 must be employed. It is recognized that in areas of limited size or over a particular path, the conductivity may vary widely from the values

13/ Figure M3 which is incorporated in these Standards by reference, was derived by indicating ground conductivity values in the United States on the United States Albers equal area projection map (based on standard parallels 29 1/2° and 45 1/2°; North American datum; scale 1/2,500,000). Figure M3, consisting of two sections, an eastern and a western half, may be obtained from the Superintendent of Documents, Washington, D. C.

given; therefore, these maps are to be used only when accurate and acceptable measurements have not been made. Figure 4 is a map of ground conductivity in Canada prepared by the Canadian Department of Transport. It is to be noted that at some locations there are differences in conductivity on either side of the border, which cannot be explained by geophysical cleavages. Pending adjustment of the maps for such inconsistencies, all variations at the border will be treated as real.

D. An example of determining interference by the curves in Appendix I follows:

It is desired to find whether objectionable interference exists between a 5kw Class III station on 990 kc and a 1 kw Class III station on 1000 kc, the stations being separated by 130 miles; both stations use non-directional antennas 14/ having such height as to produce an effective field for 1 kw or 175 mv/m. The conductivity at each station and of the intervening terrain is determined at 6 mmhos/m. The protection to Class III stations during daytime is to the 500 uv/m contour. The distance to the 500 uv/m groundwave contour of the 1 kw station is determined by the use of the appropriate curve in Appendix I - Graph 12. Since the curve is plotted for 100 mv/m at a mile, to find the distance to the 500 uv/m contour of the 1 kw station, it is necessary to determine the distance to the 285 uv/m contour $\left(\frac{100 \times 500}{175} = 285\right)$. From the appropriate curve, the estimated radius of the service area for the desired station is found to be 39.5 miles. Subtracting this distance from the distance between the two stations leaves 90.5 miles for the interfering signal to travel. From the above curve it is found that the signal from the 5 kw station at this distance would be 158 uv/m. Since a one to one ratio applies for stations separated by 10 kc, the undesired signal at that point can have a value up to 500 uv/m without objectionable interference. If the undesired signal had been found to be greater than 500 uv/m, then objectionable interference would exist. For other channel separations, the appropriate ratio of desired to undesired signal should be used.

E. Where a signal traverses a path over which different conductivities exist, the distance to a particular groundwave field intensity contour shall be determined by the use of the equivalent distance method. Reasonably accurate results may be expected in determining field intensities at a distance from the antenna by application of the equivalent distance method when the unattenuated field of the antenna, the various ground conductivities and the location of discontinuities are known. This method considers a wave to be propagated across a given conductivity according to the curve for a homogeneous earth of that conductivity. When the wave crosses from a region of one conductivity into a region of a second conductivity, the equivalent distance of the receiving point from the transmitter changes abruptly but the field intensity does not. From a point just inside the second region the transmitter appears to be at that distance where, in the curve for a homogeneous earth of the second conductivity, the field intensity equals the value that occurred just across the boundary in the first region. Thus the equivalent distance from the receiving point to the transmitter may be either greater or less than the actual distance. An imaginary transmitter is considered to exist at that equivalent distance. This technique is not intended to be used as a means of evaluating unattenuated field or ground conductivity by the analysis of measured data. The method to be employed for such determinations is set out in Section 2 of these Standards.

14/ See Annex II in case of use of directional antennas.

F. An example of the use of the equivalent distance method follows:

It is desired to determine the distance to the 0.5 mv/m and 0.025 mv/m contours of a station on a frequency of 1000 kc with an inverse distance field of 100 mv/m at one mile being radiated over a path having a conductivity of 10 mmhos/m for a distance of 15 miles, 5 mmhos/m for the next 20 miles and 15 mmhos/m thereafter. By the use of the appropriate curves in Appendix I - Graph 12, it is seen that at a distance of 15 miles on the curve for 10 mmhos/m the field is 3.45 mv/m. The equivalent distance to this field intensity for a conductivity of 5 mmhos/m is 11 miles. Continuing on the propagation curve for the second conductivity, the 0.5 mv/m contour is encountered at a distance of 27.9 miles from the imaginary transmitter. Since the imaginary transmitter was 4 miles nearer (15-11 miles) to the 0.5 mv/m contour, the distance from the contour to the actual transmitter is 31.9 miles (27.9+ 4 miles). The distance to the 0.025 mv/m contour is determined by continuing on the propagation curve for the second conductivity to a distance of 31 miles (11 + 20 miles), at which point the field is read to be 0.39 mv/m. At this point the conductivity changes to 15 mmhos/m and from the curve relating to that conductivity, the equivalent distance is determined to be 58 miles - 27 miles more distant than would obtain had a conductivity of 5 mmhos/m prevailed. Using the curve representing the conductivity of 15 mmhos/m the 0.025 mv/m contour is determined to be at an equivalent distance of 172 miles. Since the imaginary transmitter was considered to be 4 miles closer at the first boundary and 27 miles farther at the second boundary, the net effect is to consider the imaginary transmitter 23 miles (27-4 miles) more distant than the actual transmitter; thus the actual distance to the 0.025 mv/m contour is determined to be 149 miles (172-23 miles).

ANNEX II

Computation on Interfering Signal from a Directional Antenna

In case of an antenna directional in the horizontal plane, the groundwave interference can be readily computed from the calculated horizontal pattern by determining the vectors toward the service area of the station to be protected and apply these values to the groundwave curves set out in Annex I.

For signals from stations operating on clear channels, in case of determining skywave interference from an antenna with a vertical pattern different from that on which Figure 1 is predicated, it is necessary to compare the appropriate vectors in the vertical plane.

The skywave curves entitled "Average Skywave Field Intensity" (corresponding to the second hour after sunset at the recording station) as shown in Figure 1 are based on antenna systems having height of 0.311 wavelength (112°) and producing a vertical pattern as shown in Figure 5. A nondirectional antenna system, as well as a directional antenna system having vertical patterns other than essentially the same as shown, must be converted to the pattern of a 0.311 wavelength antenna having the same field intensity at the critical angle as does the pattern of the antenna involved. Example:

Figure 6 is a graph entitled "Variation with Distance of Two Important Parameters in the Theory of Skywave Propagation". The curve for θ showing the angle above the horizon at which radiation occurs plotted against distance, must be used for this purpose. For instance, assuming the station with which interference may be expected is located at a distance of 450 miles from a proposed station, the critical angle of radiation as determined from this curve is approximately 15°. Therefore, if the vertical pattern of the proposed station in the direction of the other station is such that at 15° above the horizon the radiation is 1.3 times that from an antenna having a vertical pattern as shown in Figure 5 and producing the same field intensity at

1 mile in the horizontal plane, the interfering signal would be 1.3 times that determined from Figure 1 for an antenna having the same field intensity in the horizontal plane. That is, if the field intensity in the horizontal plane of the proposed station is 124 mv/m the interfering field intensity exceeded 10 percent of the time at the other station would be $140 \times 1.30 \times \frac{124}{100}$ or 225 uv/m and would cause interference to the 4.5 mv/m groundwave contour of the existing station.

For signals from stations on regional and local channels, in computing the ten (10) percent skywave (interference) field intensity values of Class III and Class IV stations, 17/ Figure 1-A is to be used in place of Figure 1. Since Figure 1-A is predicated upon a radiated field of 100 mv/m at 1 mile in the pertinent direction, no comparison with the vertical pattern of a 0.311 wavelength antenna is to be made. Instead the appropriate radiated field in the vertical plane corresponding to the distance to the receiving station, divided by 100, is multiplied into the value of ten (10) percent skywave field intensity determined from Figure 1-A. There are two new factors to be considered, however, namely the variation of received field with latitude of the path and the variaton of pertinent vertical angle due to variations of ionosphere height and ionosphere scattering.

Figure 1-A, "10 percent Skywave Signal Range Chart", shows the ten (10) percent skywave signal as a function of the latitude of the transmission path and the distance from a transmitting antenna with a radiated field of 100 mv/m at the pertinent angle for the distance. The latitude of the transmission path is defined as the geographic latitude of the midpoint between the transmitter and the receiver. Latitude 35° should be used in case the midpoint of the path lies below 35°N. and latitude 50° should be used in case the midpoint of the path lies above 50°N.

Figure 6-A, entitled "Angles of Departure vs. Transmission Range", is to be used in determining the angles in the vertical pattern of the antenna of an interfering station to be considered as pertinent to transmission by one reflection. Corresponding to any given distance, the curves 4 and 5 indicate the upper and lower angles within which the radiated field is to be considered. The maximum value of field intensity occurring between these angles will be used to determine the multiplying factor for the ten (10) percent skywave field intensity determined from Figure 1-A. (Curves 2 and 3 are considered to represent the variation due to the variation of the effective height of the E-layer while curves 4 and 5 extend the range of pertinent angles to include a factor which allows for scattering. The dotted lines are included for imformation only.)

In the case of nondirectional vertical antennas, the vertical distribution of relative fields for several heights, assuming sinusoidal distribution of current along the antenna, is shown in Figure 5. In the case of directional antennas the vertical pattern in the great circle direction toward the point of reception in question must first be calculated. Then for the distance to the points, the upper and lower pertinent angles are determined from Figure 6-A. The ratio of the largest value of radiated field occurring between these angles, to 100 mv/m (for which Figure 1-A is drawn) is then used as the multiplying factor for the value of the field read from the curves of Figure 1-A. Note that while the accuracy of the curves is not as well established by measurements for distances less than 250 miles as for distances in excess of 250 miles, the curves represent the most accurate data available today. Pending accumulation of additional data to establish firm standards for skywave calculations in this range, the curves may be used. In cases where the radiation in the vertical plane, in the pertinent azimuth, contains a large lobe at a higher angle than the pertinent angle for one reflection, the method of calculating interference will not be restricted to that described above, but each such case will be considered on the basis of

17/ Certain simplifying assumptions may be made in the case of Class IV stations on local channels: See footnote 3a.

the best knowledge available.

For example, suppose it is desired to determine the amount of interference to a Class III station at Portland, Oregon, caused by another Class III station at Los Angeles, Calif., which is radiating a signal of 560 mv/m unattenuated at 1 mile in the great circle direction of Portland, using a 0.5 wavelength antenna. The distance is 825 miles. From Figure 6-A the upper and lower pertinent angles are 7^{o} and 3.5^{o} and, from Figure 5 the maximum radiation within these angles is 99 percent of the horizontal radiation or 554 mv/m at 1 mile. The latitude of the path is 39.8^{o}N. and from Figure 1-A, the 10 percent skywave field at 825 miles is 0.050 mv/m for 100 mv/m radiated. Multiplying by 554/100 to adjust the value to the actual radiation gives 0.277 mv/m. At 20 to 1 ratio the limitation to the Portland station is to the 5.5 mv/m contour.

When the distance is large, more than one reflection may be involved and due consideration must be given each appropriate vector in the vertical pattern, as well as the constants of the earth where reflection takes place between the transmitting station and the service area to which interference may be caused.

2. FIELD INTENSITY MEASUREMENTS IN ALLOCATION

A. Field Intensity Measurements to Establish Effective Field Intensity at 1 Mile

Sec. 3.45 provides that certain minimum field intensities are acceptable in lieu of the required minimum physical vertical heights of the antennas proper. Also in other allocation problems, it is necessary to determine the effective field at 1 mile. The following requirements shall govern the taking and submission of data on the field intensity produced:

Beginning as near to the antenna as possible without including the induction field and to provide for the fact that a broadcast antenna not being a point source of radiation (not less than one wave length or 5 times the vertical height in the case of a single element, i.e., non-directional antenna or 10 times the spacing between the elements of a directional antenna), measurements shall be made on eight or more radials, at intervals of approximately one-tenth mile up to 2 miles from the antenna, at intervals of approximately one-half mile from 2 miles to 6 miles from the antenna, at intervals of approximately 2 miles from 6 miles to 15 or 20 miles from the antenna, and a few additional measurements if needed at greater distances from the antenna. Where the antenna is rurally located and unobstructed measurements can be made, there shall be as many as 18 or 20 measurements on each radial. However, where the antenna is located in a city where unobstructed measurements are difficult to make, measurements shall be made on each radial at as many unobstructed locations as possible, even though the intervals are considerably less than stated above, particularly within 2 miles of the antenna. In cases where it is not possible to obtain accurate measurements at the closer distances (even out to 5 or 6 miles due to the character of the intervening terrain), the measurements at greater distances should be made at closer intervals. 18/

These data should be plotted for each radial in accordance with either of the two methods set forth below:

18/ It is suggested that "wave tilt" measurements may be made to determine and compare locations for taking field intensity measurements, particularly to determine that there are no abrupt changes in ground conductivity or that reflected waves are not causing abnormal intensities.

(1) Using log-log coordinate paper, plot field intensities as ordinate and distance as abscissa.

(2) Using semi-log coordinate paper, plot field intensity times distance as ordinate on the log scale and distance as abscissa on the linear scale.

However, regardless of which of these methods is employed, the proper curve to be drawn through the points plotted shall be determined by comparison with the curves in Appendix I as follows: Place the sheet on which the actual points have been plotted over the appropriate Graph in Appendix I, hold to the light if necessary and adjust until the curve most closely matching the points is found. This curve should then be drawn on the sheet on which the points were plotted, together with the inverse distance curve corresponding to that curve. The field at 1 mile for the radial concerned shall be the ordinate on the inverse distance curve at 1 mile.

When all radials have been analyzed in this manner, a curve shall be plotted on polar coordinate paper from the fields obtained, which gives the inverse distance field pattern at 1 mile. The radius of a circle, the area of which is equal to the area bounded by this pattern, is the effective field. (See Sec. 3.14.)

While making the field intensity survey, the output power of the station shall be maintained at the licensed power as determined by the direct method. To do this it is necessary to determine accurately the total antenna resistance (the resistance variation method, the substitution method or bridge method is acceptable) and to measure the antenna current by means of an ammeter of acceptable accuracy. 19/

Complete data taken in conjunction with the field intensity measurements shall be submitted to the Commission in affidavit form including the following:

(1) Tabulation by number of each point of measurement to agree with the map required in (2) below and the field intensity meter reading, the attenuation constant, the field intensity (E), the distance from the antenna (D) and the product of the field intensity and distance (ED) (if data for each radial are plotted on semi-logarithmic paper, see above) for each point of measurement.

(2) Map showing each point of measurement numbered to agree with tabulation required above.

(3) Description of method used to take field intensity measurements.

(4) The family of theoretical curves used in determining the curve for each radial properly identified by conductivity and dielectric constants.

(5) The curves drawn for each radial and the field intensity pattern.

(6) Antenna resistance measurement:
- a. Antenna resistance at operating frequency.
- b. Description of method employed.
- c. Tabulation of complete data.
- d. Curve showing antenna resistance versus frequency.

(7) Antenna current or currents maintained during field intensity measurements.

(8) Description, accuracy, date, and by whom each instrument was last calibrated.

19/ See Sec. 3.54 and "Indicating Instruments Pursuant to Section 3.58".

(9) Name, address, and qualifications of the engineer making the measurements.

(10) Any other pertinent information.

(Section 2B of the Standards dealt with Field Intensity Measurements to Establish Performance of Directional Antennas. This has now been shifted to Section 3.151 of the FCC Rules. In addition to the former requirements, it is now necessary to submit photographs of the monitoring points and a rough sketch or map showing the most accessible approaches. The photographs may be ordinary snapshots, so long as they are clear and sharp, taken with the field intensity meter in its measuring position and with the camera so located that its field of view takes in as many pertinent landmarks as possible.)

(Section 2C of the Standards dealt with Field Intensity Measurements of Broadcast Stations for Presentation in Hearings before the Commission. It has now been shifted to Section 3.152 of the FCC Rules. Since the submission of data on the measurements of antenna resistance has been found burdensome and unnecessary, this requirement has now been deleted.)

3. DATA REQUIRED WITH APPLICATIONS INVOLVING DIRECTIONAL ANTENNA SYSTEMS (DELETED)

(Section 3 of the Standards is now contained in Section 3.150 of the FCC Rules. Graphs must now be submitted indicating the calculated field intensity vs azimuth patterns for every five degrees of elevation through 60 degrees instead of the vertical patterns formerly required.)

4. LOCATIONS OF TRANSMITTERS OF STANDARD BROADCAST STATIONS

A. The four primary objectives to be obtained in the selection of a site for a transmitter of a broadcast station are as follows:

(1) To serve adequately the center of population in which the studio is located and to give maximum coverage to adjacent areas.

(2) To cause and experience minimum interference to and from other stations.

(3) To present a minimum hazard to air navigation consistent with objectives 1 and 2.

(4) To fulfill certain other requirements given below.

B. The site selected should meet the following conditions:

(1) A minimum field intensity of 25 to 50 mv/m will be obtained over the business or factory areas of the city.

(2) A minimum field intensity of 5 to 10 mv/m will be obtained over the most distant residential section.

(3) The absorption of the signal is the minimum for any obtainable sites in the area. As a guide in this respect the absorption of the signals from other stations in the area should be followed, as well as the results of tests on other sites.

(4) The population within the blanket contour does not exceed that specified by Sec. 3.24 (g).

C. In selecting a site in the center of a city it is usually necessary to place the radiating system on the top of a building. This building should be large enough to permit the installation of a satisfactory ground and/or counterpoise system. Great care must be taken to avoid selecting a building surrounded by taller buildings or where any nearby building higher than the antenna is located in the direction which it is desired to serve. Such a building will tend to cast "radio shadows" which may materially reduce the coverage of the station in that direction. Irrespective of the height of surrounding buildings, the building on which the antenna is located should not have height of approximately one-quarter wavelength. A study of antenna systems located on buildings tends to indicate that where the building is approximately a quarter wavelength in height, the efficiency of radiation may be materially reduced.

D. Particular attention must be given to avoiding cross-modulation. In this connection, attention is invited to the fact that it has been found very unsatisfactory to locate broadcast stations so that high signal intensities occur in areas with overhead electric power or telephone distribution systems and sections where the wiring and plumbing are old or improperly installed. These areas are usually found in the older or poorer sections of a city. These conditions give rise to cross-modulation interference due to the nonlinear conductivity characteristics of contacts between wiring, plumbing, or other conductors. This type of interference is independent of the selectivity characteristics of the receiver and normally can be eliminated only by correction of the condition causing the interference. Cross-modulation tends to increase with frequency and in some areas it has been found impossible to eliminate all sources of cross-modulation, resulting in an unsatisfactory condition for both licensee and listeners. The Commission will not authorize, (1) new stations, (2) increased facilities to existing stations, or (3) auxiliary transmitters, for use with other than the authorized antenna system of the main transmitter, located in such areas or utilizing roof-top antennas, when the operating power would be in excess of 500 watts.

E. If it is determined that a site should be selected removed from the city, there are several general conditions to be followed in determining the exact site. Three maps should be given consideration if available:

(1) Map of the density of population and number of people by sections in the area. 22a/

(2) Geographical contour map with contour intervals of 20 to 50 feet.

(3) Map showing the type, nature and depth of the soil in the area with special reference to the condition of the moisture throughout the year.

From these maps a site should be selected with a minimum number of intervening hills between it and the center of the city. In general, because of ground conditions, it is better to select a site in a low area rather than on top of a hill, and the only condition under which a site on top of a hill should be selected is that it is only possible by this means to avoid a substantial number of hills, between the site and the center of a city with the resulting radio shadows. If a site is to be selected to serve a city which is on a general sloping area, it is generally better to select a site below the city than above the city.

22a/ See Bureau of Census series P-D and H-E available from Superintendent of Documents, Washington 25, D. C.

F. If a compromise must be made between probable radio shadows from intervening hills and locating the transmitter on top of a hill, it is generally better to compromise in favor of the low area, where an efficient radiating system may be installed which will more than compensate for losses due to shadows being caused by the hills, if not too numerous or too high. Several transmitters have been located on top of hills, but so far as data has been supplied not a single installation has given superior efficiency of propagation and coverage.

G. The ideal location of a broadcast transmitter is in a low area of marshy or "crawfishy" soil or area which is damp the maximum percentage of time and from which a clear view over the entire center of population may be had and the tall buildings in the business section of the city would cast a shadow across the minimum residential area.

H. The type and condition of the soil or earth immediately around a site is very important. Important, to an equal extent, is the soil or earth between the site and the principal area to be served. Sandy soil is considered the worst type, with glacial deposits and mineral-ore areas next. Alluvial, marshy areas and salt-water bogs have been found to have the least absorption of the signal. One is fortunate to have available such an area and, if not available, the next best condition must be selected.

I. Figures M3 and R3 indicate effective conductivity values in the United States and are to be used for determining the extent of broadcast station coverage when adequate field intensity measurements over the path in question are not available. Since the values specified are only for general areas and since conductivity values over particular paths may vary widely from those shown, caution must be exercised in using the maps for selection of a satisfactory transmitter site. Where the submission of field intensity measurements is deemed necessary or advisable, the Commission, in its discretion, may require an applicant for new or changed broadcast facilities to submit such data in support of its application.

J. In general, broadcast transmitters operating with approximately the same power can be grouped in the same approximate area and thereby reduce the interference between them. If the city is of irregular shape, it is often possible to take advantage of this in selecting a suitable location that will give a maximum coverage. The maps giving the density of population will be a key to this. The map giving the elevation by contours will be a key to the obstructing hills between the site and city. The map of the soil conditions will assist in determining the efficiency of the radiating system that may be erected and the absorption of the signal encountered in the surrounding area.

K. Another factor to be considered is the relation of the site to airports and airways. Procedures and standards with respect to the Commission's consideration of proposed antenna structures which will serve as a guide to persons intending to apply for radio station licenses are contained in Part 17 of the Commission rules (Rules Concerning the Construction, Marking and Lighting of Antenna Structures).

L. In finally selecting the site, consideration must be given to the required space for erecting an efficient radiating system, including the ground or counterpoise. It is the general practice to use direct grounds consisting of a radial buried wire system. If the area is such that it is not possible to get such ground system in soil that remains moist throughout the year, it probably will be found better to erect a counterpoise. (Such a site should be selected only as a last resort.) It, like the antenna itself, must of course be designed properly for the operating frequency and other local conditions.

M. While an experienced engineer can sometimes select a satisfactory site for a 100 watt station by inspection, it is necessary for a higher power station to make a field intensity survey to determine that the site selected will be entirely satisfactory. There are several facts that cannot be determined by inspection that make a survey very desirable for all locations removed from the city. Often two or more sites may be selected that appear to be of equal promise. It is only by means of field intensity surveys taken with a transmitter at the different sites or from measurements on the signal of nearby stations traversing the terrain involved that the most desirable site can be determined. There are many factors regarding site efficiency that cannot be determined by any other method. When making the final selection of a site, the need for a field intensity survey to establish the exact conditions cannot be stressed too strongly. The selection of a proper site for a broadcast station is an important engineering problem and can only be done properly by experienced radio engineers.

5. MINIMUM ANTENNA HEIGHTS OR FIELD INTENSITY REQUIREMENTS

Sec. 3.45 requires that all applicants for new, additional, or different broadcast facilities and all licensees requesting authority to move the transmitter of an existing station, shall specify a radiating system, the efficiency of which complies with the requirements of good engineering practice for the class and power of the station.

The specifications deemed necessary to meet the requirements of good engineering practice at the present state of the art are set out in detail below.

The licensee of a standard broadcast station requesting a change in power, time of operation, frequency, or transmitter location must also request authority to install a new antenna system or to make changes in the existing antenna system which will meet the minimum height requirements, or submit evidence 23/ that the present antenna system meets the minimum requirements with respect to field intensity, before favorable consideration will be given thereto. In the event it is proposed to make substantial changes in an existing antenna system, the changes shall be such as to meet the minimum height requirements or will be permitted subject to the submission of field intensity measurements showing that it meets the minimum requirements with respect to effective field intensity.

These minimum actual physical vertical heights of antennas permitted to be installed are shown by curves A, B, and C of Figure 7 as follows:

A. Class IV stations, 150 feet 24/ or a minimum effective field intensity of 150 mv/m for 1 kw (100 watts, 47.5 mv/m and 250 watts, 75 mv/m).

B. Class II and III stations, or a minimum effective field intensity of 175 mv/m for 1 kw.

C. Class I stations, or a minimum effective field intensity of 225 mv/m for 1 kw.

The heights given on the graph for the antenna apply regardless of whether the antenna is located on the ground or on a building. Except for the reduction of shadows locating the antenna on a building does not necessarily increase the efficiency and where the height of the building is in the order of a quarter wave the efficiency may be materially reduced.

23/ See Field Intensity Measurements in Broadcast Allocation, section A.
24/ This height applies to a Class IV station on a local channel only. In case a Class IV station is assigned a regional channel Curve A shall apply.

To obtain the maximum efficiency of which any antenna is capable a good ground system must be employed (a counterpoise may be substituted under certain conditions).

At the present development of the art, it is considered that where a vertical radiator is employed with its base on the ground, the ground system should consist of buried radial wires at least one-fourth wavelength long. There should be as many of these radials evenly spaced as practicable and in no event less than 90. (120 radials of 0.35 to 0.4 of a wavelength in length and spaced 3° is considered an excellent ground system and in case of high base current, a base screen of suitable dimensions should be employed.)

It should be borne in mind that the above specifications are the minimum and where possible better antenna and ground systems should be installed.

In case it is contended that the required antenna efficiency can be obtained with an antenna height or ground system less than the minimum specified, a complete field intensity survey 25/ must be supplied to the Commission showing that the field intensity at a mile without absorption fulfills the minimum requirements. This field survey must be made by a qualified engineer using equipment of acceptable accuracy.

The main element or elements of a directional antenna system shall meet the above minimum requirements with respect to height or effective field intensity. No directional antenna system will be approved which is so designed that the effective field of the array is less than the minimum prescribed for the class of station concerned, or in case of a Class I station less than 90 percent of the groundwave field which would be obtained from a perfect antenna of the height specified by Figure 7 for operation on frequencies below 1000 kc., and in the case of a Class II or III station less than 90 percent of the groundwave field which would be obtained from a perfect antenna of the height specified by Figure 7 for operation on frequencies below 750 kc.

Before any changes are made in the antenna system, it is necessary to submit full details to the Commission for approval. These data may be submitted by letter.

6. STANDARD LAMPS AND PAINTS (DELETED)

7. FURTHER REQUIREMENTS FOR DIRECT MEASUREMENT OF POWER (DELETED)

(For compactness, this has been incorporated in Section 3.54 of the FCC Rules.)

8. POWER RATING OF VACUUM TUBES (DELETED)

(Section 8 has been deleted because vacuum tube ratings are now established by the manufacturers and transmitters, including the associated vacuum tubes, are type accepted by the Commission.)

9. REQUIREMENTS FOR APPROVAL OF POWER RATING OF VACUUM TUBES (DELETED)

(See Section 8 above.)

10. PLATE EFFICIENCY OF LAST RADIO STAGE (DELETED)

(Since stations now determine power by the direct method, except in case of emergency, this section has been deleted.)

25/ See Field Intensity Measurements in Broadcast Allocation, section A.

11. OPERATING POWER TOLERANCE (DELETED)

12. OPERATION AND SAFETY OF LIFE REQUIREMENTS

The specifications deemed necessary to meet the requirements of Sec. 3.46 with respect to design and construction are set forth below.

A. Design - The general design of standard broadcast transmitting equipment (main studio microphone (including telephone lines, if used, as to performance only 30/) to antenna output) shall be in accordance with the following specifications. For the points not specifically covered below, the principles set out shall be followed:

The equipment shall be so designed that:

(1) The maximum rated carrier power (determined by Sec. 3.42) is in accordance with the requirements of Sec. 3.41.

(2) The equipment is capable of satisfactory operation at the authorized operating power or the proposed operating power with modulation of at least 85 to 95 percent with no more distortion than given in (3) below.

(3) The total audio frequency distortion from microphone terminals, including microphone amplifier, to antenna output does not exceed 5 percent harmonics (voltage measurements of arithmetical sum or RSS) when modulated from 0 to 84 percent, and not over 7.5 percent harmonics (voltage measurements of arithmetical sum or RSS) when modulating 85 percent to 95 percent (distortion shall be measured with modulating frequencies of 50, 100, 400, 1000, 5000 and 7500 cyles up to tenth harmonic or 16,000 cycles, or any intermediate frequency that readings on these frequencies indicate is desirable).

(4) The audio frequency transmitting characteristics of the equipment from the microphone terminals (including microphone amplifier unless microphone frequency correction is included in which event proper allowance shall be made accordingly) to the antenna output does not depart more than 2 decibels from that at 1000 cycles between 100 and 5000 cycles.

(5) The carrier shift (current) at any percentage of modulation does not exceed 5 percent.

(6) The carrier hum and extraneous noise (exclusive of microphone and studio noises) level (unweighted RSS) is at least 50 decibels below 100 percent modulation for the frequency band of 150 to 5000 cycles and at least 40 decibels down outside this range.

(7) The transmitter shall be equipped with suitable indicating instruments in accordance with the requirements of Sec. 3.58 and any other instruments necessary for the proper adjustment and operation of the equipment.

(8) Adequate provision is made for varying the transmitter power output between sufficient limits to compensate for excessive variations in line voltage, or other factors which may affect the power output.

30/ In cases where telephone lines are not available to give the performance as required in these specifications a relay transmitter may be authorized to supersede the lines.

(9) The transmitter is equipped with automatic frequency control equipment capable of maintaining the operating frequency within the limit specified by Sec.3.59.

a. The maximum temperature variation 31/ at the crystal from the normal operating temperature shall not be greater than:

1. Plus or minus 0.1°C. when an X or Y cut crystal is employed, or
2. Plus or minus 1.0°C. when low temperature coefficient crystal is employed.

b. Unless otherwise authorized, a thermometer shall be installed in such manner that the temperature at the crystal can be accurately measured within 0.05°C. for X or Y cut crystal or 0.5° for low temperature coefficient crystal.

c. It is prefereable that the tank circuit of the oscillator tube be installed in the temperature controlled chamber.

(10) Means are provided for connection and continuous operation of approved modulation monitor and approved frequency monitor.

a. The radio frequency energy for operation of the approved frequency monitor shall be obtained from a radio frequency stage prior to the modulated stage unless the monitor is of such design as to permit satisfactory operation when otherwise connected and the monitor circuits shall be such that the carrier is not heterodyned thereby.

(11) Adequate margin is provided in all component parts to avoid overheating at the maximum rated power output.

B. Construction - In general, the transmitter shall be constructed either on racks and panels or in totally enclosed frames 33/ protected as required by article 810 of the National Electrical Code 34/ and as set forth below:

(1) Means shall be provided for making all tuning adjustments, requiring voltages in excess of 350 volts to be applied to the circuit, from the front of the panels with all access doors closed.

31/ Explanations of excessive frequency deviations will not be accepted when temperature variations are in excess of the values specified below.

33/ The final stages of high power transmitters may be assembled in open frames provided the equipment is enclosed by a protective fence.

34/ The pertinent sections of article 810 of the National Electrical Code read as follows:
"8191. General - Transmitters shall comply with the following:
"a. Enclosing - The transmitter shall be enclosed in a metal frame or grille, or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.
"b. Grounding of controls - All external metallic handles and controls accessible to the operating personnel shall be effectually grounded. No circuit in excess of 150 volts shall have any parts exposed to direct contact. A complete dead-front type of switchboard is preferred.
"c. Interlocks on doors - All access doors shall be provided with interlocks which will disconnect all voltages in excess of 350 volts when any access door is opened."

(2) Proper bleeder resistors or other automatic means shall be installed across all the condenser banks to remove any charge which may remain after the high voltage circuit is opened (in certain instances the plate circuit of the tubes may provide such protection; however, individual approval of such shall be obtained by the manufacturer in case of standard equipment, and the licensee in case of composite equipment).

(3) All plate supply and other high voltage equipment, including transformers, filters, rectifiers and motor generators, shall be protected so as to prevent injury to operating personnel.

a. Commutator guards shall be provided on all high voltage rotating machinery (coupling guards on motor generators, although desirable, are not required).

b. Power equipment and control panels of the transmitter shall meet the above requirements (exposed 220 volt AC switching equipment on the front of the power control panels is not recommended; however, is not prohibited).

c. Power equipment located at a broadcast station but not directly associated with the transmitter (not purchased as part of same), such as power distribution panels, control equipment on indoor or outdoor stations and the substations associated therewith, are not under the jurisdiction of the Commission; therefore, Sec. 3.46 does not apply.

d. It is not necessary to protect the equipment in the antenna tuning house and the base of the antenna with screens and interlocks, provided the doors to the tuning house and antenna base are fenced and locked at all times, with the keys in the possession of the operator on duty at the transmitter. Ungrounded fencing or wires should be effectively grounded, either directly or through proper static leaks. Lightning protection for the antenna system is not specifically required but should be installed.

e. The antenna, antenna lead-in, counterpoise (if used), etc., shall be installed so as not to present a hazard. The antenna may be located close by or at a distance from the transmitter building. A properly designed and terminated transmission line should be used between the transmitter and the antenna when located at a distance.

(4) Metering equipment. 36/

a. All instruments having more than 1,000 volts potential to ground on the movement shall be protected by a cage or cover in addition to the regular case. (Some instruments are designed by the manufacturer to operate safely with voltages in excess of 1,000 volts on the movement. If it can be shown by the manufacturer's rating that the instrument will operate safely at the applied potential, additional protection is not necessary.)

b. In case the plate voltmeter is located on the low potential side of the multiplier resistor with one terminal of the instrument at or less than 1000 volts above ground, no protective case is required. However, it is good practice to protect voltmeters subject to more than 5000 volts with suitable over-voltage protective devices across the instrument terminals in case the winding opens.

c. The antenna ammeters (both regular and remote and any other radio frequency instrument which it is necessary for the operator to read) shall be so installed as to be easily and accurately read without the operator having to risk contact with circuits carrying high potential radio frequency energy.

36/ In addition to the following requirements, instruments shall meet the requirements of Sec. 3.58 and "Indicating Instruments Pursuant to Section 3.58".

C. Wiring and shielding - (1) The transmitter panels or units shall be wired in accordance with standard switchboard practice, either with insulated leads properly cabled and supported or with rigid bus bar properly insulated and protected.

(2) Wiring between units of the transmitter, with the exception of circuits carrying radio frequency energy, shall be installed on conduits or approved fiber or metal raceways to protect it from mechanical injury.

(3) Circuits carrying low level radio frequency energy between units shall be either concentric tube, two wire balanced lines, or properly shielded to prevent the pickup of modulated radio frequency energy from the output circuits.

(4) Each stage (including the oscillator) preceding the modulated stage shall be properly shielded and filtered to prevent unintentional feedback from any circuit following the modulated stage (an exception to this requirement may be made in the case of high level modulated transmitters of approved manufacture which have been properly engineered to prevent reaction).

(5) The crystal chamber, together with the conductor or conductors to the oscillator circuit shall be totally shielded.

(6) The monitors and the radio frequency lines to the transmitter shall be thoroughly shielded.

D. Installation - (1) The installation shall be made in suitable quarters.

(2) Since an operator must be on duty at the transmitter control point during operation, suitable facilities for his welfare and comfort shall be provided at the control point.

E. Spare tubes - A spare tube of every type employed in the transmitter and frequency and modulation monitors shall be kept on hand. When more than one tube of any type are employed, the following table determines the number of spares of that type required:

Number of each type employed:	Spares required
1 or 2	1
3 to 5	2
6 to 8	3
9 or more	4

F. Studio equipment - The studio equipment shall be subject to all the above requirements where applicable except as follows:

(1) If it is properly covered by an underwriter's certificate, it will be considered as satisfying the safety requirements.

(2) Section 8191 of article 810 of the National Electrical Code shall apply for voltages only when in excess of 500 volts.

No specific requirements are made relative to the design and acoustical treatment. However, the studios and particularly the main studio should be in accordance with the standard practice for the class of station concerned, keeping the noise level as low as reasonably possible.

13. INDICATING INSTRUMENTS PURSUANT TO SECTION 3.58

The following requirements and specifications shall apply to indicating instruments used by standard broadcast stations:

A. Instruments indicating the plate current or plate voltage of the last radio stage (linear scale instruments), shall meet the following specifications:

(1) Length of scale shall be not less than 2.3 inches.

(2) Accuracy shall be at least 2 percent of the full scale reading.

(3) The maximum rating of the meter shall be such that it does not read off scale during modulation.

(4) Scale shall have at least 40 divisions.

(5) Full scale reading shall not be greater than five times the minimum normal indication.

B. Instruments indicating the antenna current shall meet the following specifications:

(1) Instruments having logarithmic or square law scales.
  a. Shall meet same requirements as 1, 2, and 3 above for linear scale instruments.
  b. Full scale reading shall not be greater than three times the minimum normal indication.
  c. No scale division above one-third full scale reading (in amperes) shall be greater than one-thirtieth of the full scale reading. (Example: An ammeter meeting requirement (a) above having full scale reading of 6 amperes is acceptable for reading currents from 2 to 6 amperes, provided no scale division between 2 and 6 amperes is greater than one-thirtieth of 6 amperes, 0.2 ampere.)

(2) Radio frequency instruments having expanded scales.
  a. Shall meet same requirements as 1, 2, and 3 for linear scale instruments.
  b. Full scale reading shall not be greater than five times the minimum normal indication.
  c. No scale division above one-fifth full scale reading (in amperes) shall be greater than one-fiftieth of the full scale reading. (Example: An ammeter meeting the requirement (a) above is acceptable for indicating currents from 1 to 5 amperes, provided no division between 1 and 5 amperes, is greater than one-fiftieth of 5 amperes, 0.1 ampere.)
  d. Manufacturers of instruments of the expanded scale type must submit data to the Commission showing that these instruments have acceptable expanded scales, and the type number of these instruments must include suitable designation.

(3) Remote reading antenna ammeters may be employed and the indications logged as the antenna current in accordance with the following:
  a. Remote reading antenna ammeters may be provided by:
    1. Inserting second thermocouple directly in the antenna circuit with remote leads to the indicating instrument.
    2. Inductive coupling to thermocouple or other device for providing direct current to indicating instrument.

3. Capacity coupling to thermocouple or other device for providing direct current to indicating instrument.
4. Current transformer connected to second thermocouple or other device for providing direct current to indicating instrument.
5. Using transmission line current meter at transmitter as remote reading ammeter. See paragraph (h) below.
6. Using indications of phase monitor for determining the ratio of antenna currents in the case of directional antennas, provided the indicating instruments in the unit are connected directly in the current sampling circuits with no other shunt circuits of any nature.

b. A thermocouple type ammeter meeting the above requirements shall be permanently installed in the antenna circuit. (This thermocouple ammeter may be so connected that it is short circuited or open circuited when not actually being read. If open circuited, a make-before-break switch must be employed.)

c. The remote ammeter shall be connected at the same point in the antenna circuit as the thermocouple ammeter and shall be so connected and calibrated as to read in amperes within 2 percent of this meter over the entire range above one-third or one-fifth full scale. See sections B 1 (c) and B 2 (c) above respectively.

d. The regular antenna ammeter shall be above the coupling to the remote meter in the antenna circuit so it does not read the current to ground through the remote meter.

e. All remote meters shall meet the same requirements as the regular antenna ammeter with respect to scale accuracy, etc.

f. Calibration shall be checked against the regular meter at least once a week.

g. All remote meters shall be provided with shielding or filters as necessary to prevent any feed-back from the antenna to the transmitter.

h. In the case of shunt excited antennas, the transmission line current meter at the transmitter may be considered as the remote antenna ammeter provided the transmission line is terminated directly into the excitation circuit feed line, which shall employ series tuning only (no shunt circuits of any type shall be employed), and insofar as practicable, the type and scale of the transmission line meter should be the same as those of the excitation circuit feed line meter (meter in slant wire feed line or equivalent).

i. Remote reading antenna ammeters employing vacuum tube rectifiers are acceptable provided:
   1. The indicating instruments shall meet all the above requirements for linear scale instruments.
   2. Data are submitted under oath showing the unit has an over-all accuracy of at least 2 percent of the full scale reading.
   3. The installation, calibration, and checking are in accordance with the above requirements.

j. In the event there is any question as to the method of providing or the accuracy of the remote meter, the burden of proof of satisfactory performance shall be upon the licensee and the manufacturer of the equipment.

C. Stations determining power by the indirect method may log the transmission line current in lieu of the antenna current provided the instrument meets the above requirements for antenna ammeters, and further provided that the ratio between the transmission line current and the antenna current is entered each time in the log. In case the station is authorized for the same operating power for both day and nighttime operation, this ratio shall be checked at least once daily. Stations which are authorized to operate with nighttime power different from the daytime power shall check the ratio for each power at least once daily.

D. No instrument, the seal of which has been broken, or the accuracy of which is questionable, shall be employed. Any instrument which was not originally sealed by the manufacturer that has been opened shall not be used until it has been recalibrated and sealed in accordance with the following: Repairs and recalibration of instruments shall be made by the manufacturer, by an authorized instrument repair service of the manufacturer or by some other properly qualified and equipped instrument repair service. In either case the instrument must be resealed with the symbol or trade mark of the repair service and a certificate of calibration supplied therewith.

E. Since it is usually impractical to measure the actual antenna current of a shunt excited antenna system, the current measured at the input of the excitation circuit feed line is accepted as the antenna current.

F. Recording instruments may be employed in addition to the indicating instruments to record the antenna current and the direct plate current and direct plate voltage of the last radio stage provided that they do not affect the operation of the circuits or accuracy of the indicating instruments. If the records are to be used in any proceedings before the Commission as representation of operation with respect to plate or antenna current and plate voltage only, the accuracy must be the equivalent of the indicating instruments and the calibration shall be checked at such intervals as to insure the retention of the accuracy.

G. The function of each instrument shall be clearly and permanently shown on the instrument itself or on the panel immediately adjacent thereto.

14. REQUIREMENTS FOR TYPE APPROVAL OF BROADCAST TRANSMITTERS AND AUTOMATIC FREQUENCY CONTROL EQUIPMENTS (DELETED)

(Type approval is no longer required, instead transmitters (including TV transmitters) will be accepted for licensing by the Commission. See Subpart F of Part 2 and Section 3.48 of the FCC Rules.)

15. REQUIREMENTS FOR APPROVAL OF FREQUENCY MONITORS

A. General Requirements and Approval

There are several ways or means by which it can be determined whether the frequency of the emitted carrier wave is within the required limits of the assigned frequency. However, one of the commonest ways is by means of a local piezo oscillator of known frequency producing a beat with the emitted wave used in conjunction with an instrument to indicate the resultant beat frequency. The visual indicator 37/ is the only method now in common use by which it is considered that the frequency of the beat may be determined with the required degree of accuracy. Approval of a frequency monitor will be given based upon data taken by the Laboratory Division of the FCC.

37/ In addition to the visual indicator, the range of which is necessarily limited in order to obtain the required accuracy, an aural indicator should also be employed to indicate frequency deviations beyond the range of the visual indicator, particularly where the visual indicator is so designed that the indication becomes zero when the deviations become considerably greater than the range of the instrument. When it is desired to make any change, either mechanical or electrical, the details shall be submitted to the Commission for its consideration.

Any manufacturer desiring to submit a monitor for approval shall supply the Commission with full details. If the specifications appear to meet the requirements, the Commission will authorize the Laboratory Division to issue shipping instructions. The shipping charges to and from the Laboratory at Laurel, Md., shall be paid by the manufacturer.

In approving a frequency monitor, based upon the tests by the Laboratory, the Commission merely recognizes that the type of monitor has the inherent capability of functioning in compliance with Sec. 3.60, if properly constructed, maintained, and operated. The Commission accepts no responsibility beyond this and further realizes that these monitors may have a limited range over which the visual indicator will determine deviations. Accordingly, it is necessary that adjunct equipment be used to determine major deviations. 37/

No change whatsoever will be permitted in the monitors sold under approval number issued by the Commission except when the licensee or the manufacturer is specifically authorized to make such changes.

When it is desired to make any change, either mechanical or electrical, the details shall be submitted to the Commission for its consideration.

Approval is given subject to withdrawal if the unit proves defective in service and cannot be relied upon under usual conditions of maintenance and operation encountered in the average standard broadcast station. Withdrawal of approval means that no further units may be installed by standard broadcast stations for the purpose of complying with Sec. 3.60, but will not affect units already sold, unless it is found that there has been an unauthorized change in design or construction, or the material or workmanship is defective.

B. General Specifications

The general specifications that frequency monitors shall meet before they will be approved by the Commission are as follows:

(1) The unit shall have an accuracy of at least five parts per million under ordinary conditions (temperature, humidity, power supply, and other conditions which may affect its accuracy) encountered in standard broadcast stations throughout the United States.

(2) The range of the indicating device shall be at least from 20 cycles below to 20 cycles above the assigned frequency.

(3) The scale of the indicating device shall be so calibrated as to be read accurately within at least 1 cycle.

(4) The unit shall be equipped with an automatic temperature control chamber (preferably enclosing the tank circuits of the oscillator) such that the maximum temperature variation at the crystal from the normal operating temperature shall not be greater than,

(a) Plus or minus 0.05°C. when X or Y cut crystal is employed, or
(b) Plus or minus 0.5°C. when low temperature coefficient crystal is employed.

(5) Unless otherwise specifically authorized, the instrument shall be equipped with a thermometer such that the temperature can be accurately measured within 0.025°C. for X or Y cut crystal or 0.25°C. for low temperature coefficient crystal.

(6) The monitor circuit shall be such that it may be continuously operated and the emitted carrier of the station is not heterodyned thereby.

(7) Means shall be provided for adjustment of the temperature or other means for correction of the indications of the monitor to agree with the external standard.

C. Tests to be Made by the Laboratory Division of the FCC

The tests to be made by the Laboratory will include the determination of the following:

(1) Accuracy - (a) Oscillator frequency, as received.
(b) Constancy of oscillator frequency, as measured several times in 1 month.
(c) Accuracy of readings of frequency-difference instrument.
(d) Functioning of frequency adjustment device.
(e) Effects on frequency of changing tubes and of voltage variations.

(2) Temperature control stability - (a) Effect on frequency of variation of room temperature through a range not to exceed 10° to 35°C.

(3) Sensitivity - (a) Response of indicating instrument to small changes of frequency.

(4) General construction - (a) Inspection to determine ability to stand shipment and service.
(b) Special tests to determine quality of construction, such as effect of tilting or tipping on frequency.

(5) Miscellaneous performance - (a) Various, depending on character of apparatus (e.g., changes after stopping and starting, effect of varying coupling with transmitter, etc.).

The equipment will be operated in a test in the same way and the same conditions under which it will be used in service as specified by the manufacturer. The manufacturer shall supply to the Laboratory Division all instructions or services which will be supplied to the purchaser of the equipment. The equipment, as submitted, shall be adjusted for operation in connection with broadcast stations operating on 1600 kc.

16. REQUIREMENTS FOR APPROVAL OF MODULATION MONITORS

Approval will be given based on the test data taken by the Laboratory Division of the FCC. Any manufacturer desiring to submit a monitor for approval shall supply the Commission with full details and if the specifications appear to meet the requirements, the Commission will authorize the Laboratory Division to issue shipping instructions. The shipping charges to and from the Laboratory at Laurel, Md., shall be paid by the manufacturer.

The specifications that the modulation monitor shall meet before it will be approved by the Commission are as follows:

(1) A DC meter for setting the average rectified carrier at a specific value and to indicate changes in carrier intensity during modulation.

(2) A peak indicating light or similar device that can be set at any predetermined value from 50 to 120 percent modulation to indicate on positive peaks, and/or from 50 to 100 percent negative modulation.

(3) A semi-peak indicator with a meter having the characteristics given below shall be used with a circuit such that peaks of modulation of duration between 40 and 90 milliseconds are indicated to 90 percent of full value and the discharge rate adjusted so that the pointer returns from full reading to 10 percent of zero within 500 to 800 milliseconds. A switch shall be provided so that this meter will read either positive or negative modulation and, if desired, in the center position it may read both in a full-wave circuit.

The characteristics of the indicating meter are as follows:

Speed - The time for one complete oscillation of the pointer shall be 290 to 350 milliseconds. The damping factor shall be between 16 and 200. The useful scale length shall be at least 2.3 inches. The meter shall be calibrated for modulation from 0 to 110 percent and in decibels below 100 percent with 100 percent being 0 db.

The accuracy of the reading on percentage of modulation shall be ± 2 percent for 100 percent modulation, and ±4 percent of full scale reading at any other percentage of modulation.

(4) The frequency characteristics curve shall not depart from a straight line more than ± 1/2 db from 30 to 10,000 cycles. The amplitude distortion or generation of audio harmonics shall be kept to a minimum.

(5) The modulation meter shall be equipped with appropriate terminals so that an external peak counter can be readily connected.

(6) Modulation will be tested at 115 volts ± 5 percent and 60 cycles, and the above accuracies shall be applicable under these conditions.

(7) All specifications not already covered above, and the general design, construction, and operation of these units must be in accordance with good engineering practice.

17. USE OF LOW TEMPERATURE COEFFICIENT CRYSTALS BY BROADCAST STATIONS (DELETED)

18. MONEY REQUIRED TO CONSTRUCT AND COMPLETE ELECTRICAL TESTS OF STATIONS OF DIFFERENT CLASSES AND POWERS (DELETED)

19. USE OF COMMON ANTENNA BY STANDARD BROADCAST STATIONS OR ANOTHER RADIO STATION (DELETED)

20. USE OF FREQUENCY AND MODULATION MONITORS AT AUXILIARY BROADCAST TRANSMITTERS (DELETED)

(This Section has now become Section 3.153 of the FCC Rules.)

21. APPROVED FREQUENCY MONITORS (DELETED)

22. APPROVED MODULATION MONITORS (DELETED)

23. APPROVED EQUIPMENT (DELETED)

(Lists formerly contained in Sections 21, 22 and 23 of the Standards are now out of date. Lists of type accepted and type approved equipment are available for inspection at the Commission's Office in Washington and at each of its field offices.)

24. STANDARD BROADCAST APPLICATION FORMS (DELETED)

25. FIELD OFFICES OF THE COMMISSION

Sec. 3.57 and other rules of the Commission require that in certain instances, the inspector in charge of the district in which the station is located be advised of the conditions existing at the station. A list of the radio districts, giving the address of each field office of the Commission and the territory embraced in each district, may be found in Part 0 of the rules.

26. AVERAGE SUNRISE AND SUNSET TIMES (DELETED)

APPENDIX I - Groundwave Field Intensity Charts

Note: There has been no change in this Appendix since the NAB (NARTB) Engineering Handbook was published, therefore, we have ommitted duplicating it at this time.

To complete this set of "Standards of Good Engineering Practice Concerning Standard Broadcast Stations":

1. Add the following from the copy of the Standards found in the 1949 NAB (NARTB) Engineering Handbook:

   Appendix I - Groundwave Field Intensity Charts
   Graphs 1 through 20
   Figure 1 - Average Skywave Field Intensity
   Figure 1-A - 10% Skywave Signal Range (540 Kc to 1600 Kc)
   Figure 5 - Vertical Radiation Patterns for Different Heights of Vertical Wire Antennas
   Figure 6 - Variation with Distance of Two Important Parameters in the Theory of Skywave Propagation
   Figure 6-A - Angles of Departure vs Transmission Range
   Figure 7 - Antennas for Standard Broadcast Stations

2. Delete:

   Figure 2 - Groundwave Field Intensity vs Distance (1000 Kc)
   Figure 3 - Ground Conductivity in the United States and Canada
   Figure 4 - Groundwave Field Intensity vs Distance (970-1030 Kc)

3. Add the following three figures:

   Figure 4 - Ground Conductivity in Canada
   Figure R3 - Estimated Effective Ground Conductivity in the United States
   Figure 8 - Effective Field at One Mile for One Kilowatt

FCC PUBLIC NOTICE
#17174
March 24, 1955

GREATER ACCURACY TO BE REQUIRED
IN THE LOCATION AND HEIGHT
OF CERTAIN NEW ANTENNA STRUCTURES

The Commission has been advised by the Airspace Subcommittee of the Air Coordinating Committee that certain proposed antenna structures which were given aeronautical approval by the Subcommittee are, nevertheless, considered "critical obstructions" since their height closely approaches the maximum height above mean sea level recommended by the Subcommittee for a particular location. A necessary premise for the approval of such structures by the Subcommittee is substantial accuracy by the applicant in his determination of the exact location and height of such structures. The Commission has found that the degree of accuracy of such determinations heretofore secured in antenna proposals is, in general, insufficient for the construction of such "critical obstructions."

Broadcast construction permits issued by the Commission contain the geographical coordinates of the site and the height in feet above ground of the proposed antenna structure. These data are secured from the application form filed by the applicant. The height of the antenna may or may not be set forth in the construction permit for services other than broadcast. Applicants, in preparing their applications for filing, are not in a position to determine with certainty the antenna obstruction lighting which may be required by the Commission. The Commission is cognizant of this and provides in its application form for broadcast services that the height of any obstruction lighting is not to be included in computing the total height above ground and height above mean sea level of the proposed antenna structure. In services other than broadcast, the application form requests the height of the uppermost point of the antenna. In practically all instances, therefore, a slight increase in height results from the installation of a beacon or other lighting fixture, required by the terms of the construction permit.

While such slight deviations may appear insignificant in most instances, the Commission is advised by the Airspace Subcommittee that in those cases where the antenna structure is a "critical obstruction", an increase in height of even one foot above the maximum authorized may necessitate raising the minimum flight altitudes in the area or otherwise modifying aviation procedures.

In view of the above, the Commission, in the future, will include in construction permits which authorize antennas considered "critical obstructions" the following provisions:

1. The height of the uppermost point of the antenna structure, including the required obstruction lighting and any other attachments, shall not exceed - X - feet above mean sea level.

2a. A bench mark shall be established on the tower base. The elevation above mean sea level of the bench mark shall be determined within one foot from a line of spirit levels from a Municipal, State, or Federal bench mark that is a part of the national level net.

b. The horizontal position of the tower site shall be determined within 1/2 second of latitude and longitude by a ground survey tied to a Municipal, State, or Federal control point that has previously been connected to the national geodetic network.

c. An affidavit signed by a registered or qualified engineer or surveyor shall be submitted with the license application setting forth the geographic coordinates of the structure and the over-all height (which shall include the obstruction marking) above sea level of the completed structure, and describing the survey and the reference points upon which it is based, together with a plat of the antenna site and vertical plan sketch of the antenna structure portraying pertinent details.

The provisions set out above to be included in future authorizations will be employed only in those instances where it has been determined that the antenna in question would constitute a "critical obstruction."

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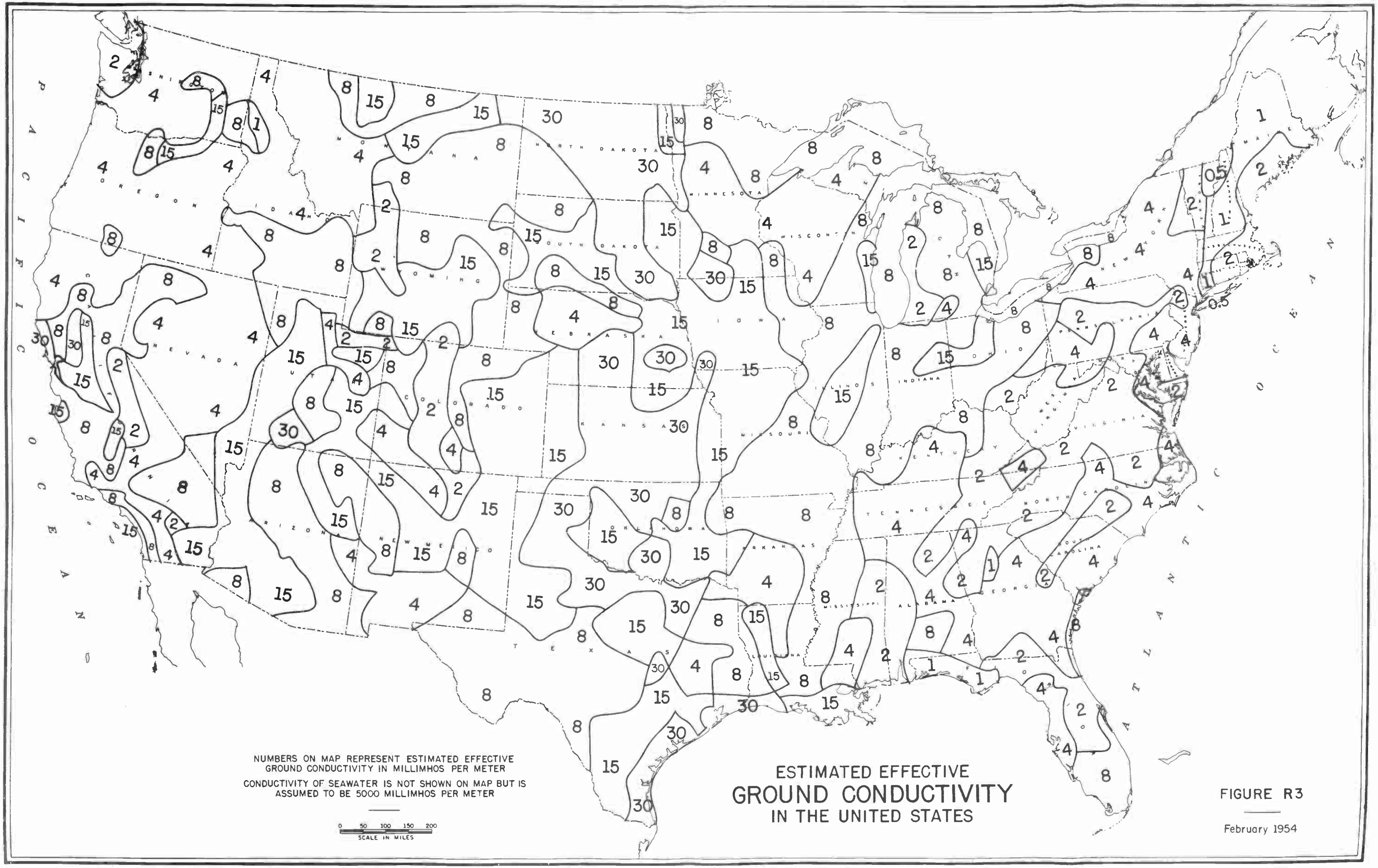
FCC PUBLIC NOTICE
#90401
May 20, 1953

USE OF AM TOWERS TO SUPPORT TV ANTENNA

An increasing number of television applications being filed with the Commission propose to use an AM station tower as support for the TV antenna. In cases where an increase in height of the AM station antenna would result in increased radiation, to a degree where interference becomes a problem, proposals have been made to sectionalize the tower as a method for preventing the additional section of the tower from radiating energy on the AM broadcast frequency. This procedure is both difficult and costly.

In many instances, particularly where nondirectional operation is involved, it is possible to completely eliminate interference problems created by the increased antenna efficiency by dissipating enough of the power supplied to the antenna in a series resistor so as to reduce the unattenuated field to its previous value.

Section 3.45(c) of the Commission Rules Governing Standard Broadcast Stations requires that an application be submitted and approved by the Commission before any change is made in the physical height of an AM station antenna. A formal application, on Form 301, is required where the proposed change is more than 20 feet. The application should specify the approximate resistance necessary to dissipate the increment of energy which is expected from the proposed higher tower. In event the application is granted, the subsequent license application must be accompanied by sufficient field intensity measurements to show that the effective field has not been increased or the pattern altered, together with the exact value of the resistance added. The license issued by the Commission will include the value of this resistor.



ESTIMATED EFFECTIVE
GROUND CONDUCTIVITY
IN THE UNITED STATES

FIGURE R3

February 1954

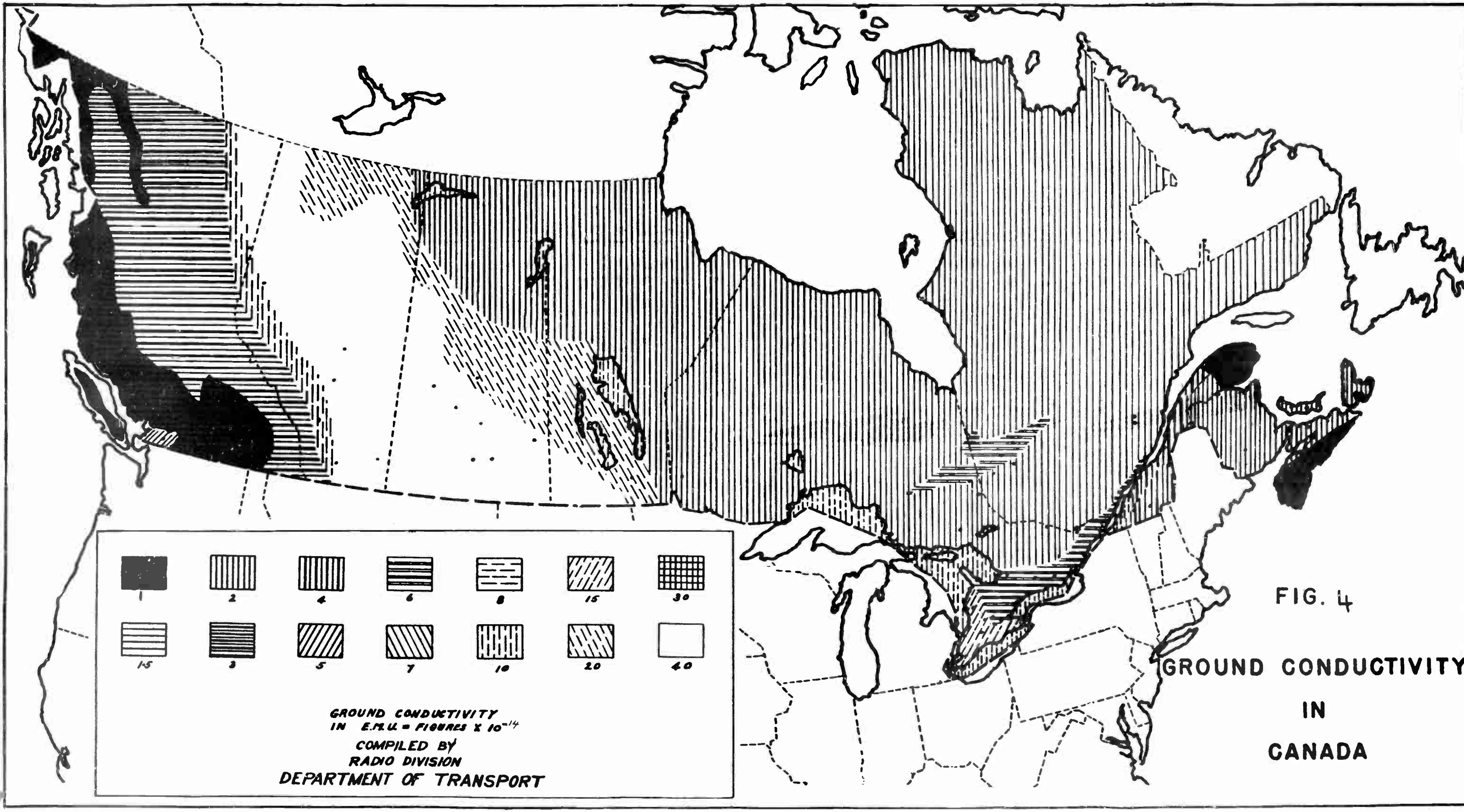


FIG. 4

GROUND CONDUCTIVITY IN CANADA

51518

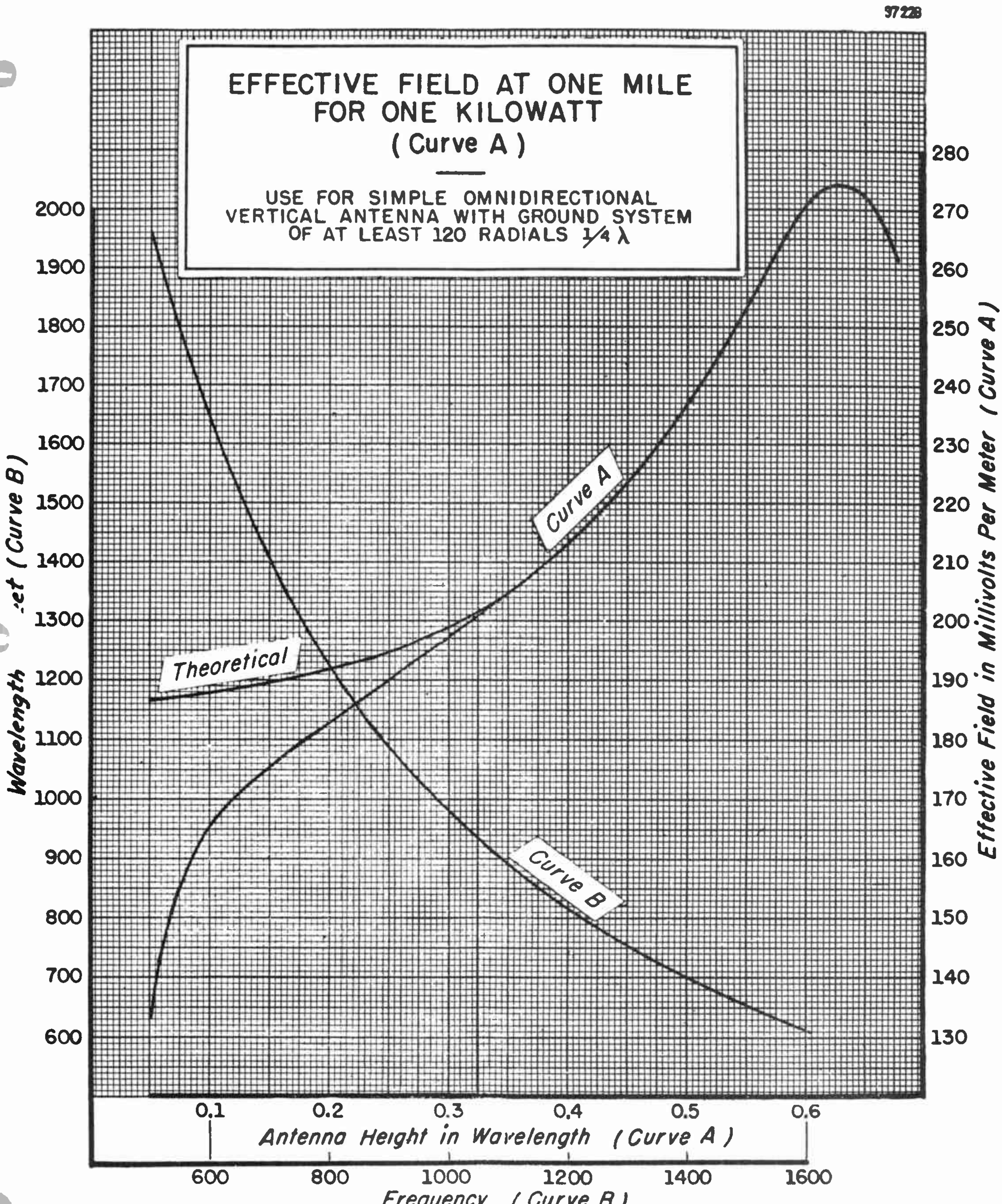


FIGURE 8

F.C.C. - Washington, D. C.