FEDERAL COMMUNICATIONS COMMISSION

STANDARDS OF GOOD ENGINEERING PRACTICE CONCERNING TELEVISION BROADCAST STATIONS

EFFECTIVE DECEMBER 19, 1945

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INTRODUCTION

There are presented herein the Commission's engineering standards relating to the allocation and operation of television broadcast stations. The Commission's Rules and Regulations contain references to these standards, which have been approved by the Commission and thus are considered as reflecting its opinion in all matters involved.

The standards set forth herein are those deemed necessary for the construction and operation of television broadcast stations to meet the requirements of technical regulations and for operation in the public interest along technical lines not otherwise enunciated. These standards are based upon the best engineering data available, including evidence at hearings, conferences with radio engineers, and data supplied by manufacturers of radio equipment and by licensees of television broadcast stations. These standards are complete in themselves and supersede previous engineering standards or policies of the Commission concerning television broadcast stations. While these standards provide for flexibility and indicate the conditions under which they are applicable, it is not expected that material deviation from the fundamental principles will be recognized unless full information is submitted as to the need and reasons therefor.

These standards will necessarily be revised from time to time as progress is made in the art. The Commission will accumulate and analyze engineering data available as to the progress of the art so that these standards may be kept current with technical developments.

NOTICE

91086-B

This form should be completed and forwarded to the Federal Communications Commission, Washington, D. C., and upon receipt of same any amendment to this Standards of Good Engineering Practice adopted since the date of this publication will be mailed.

Standards of Good Engineering (Television)

Effective date _____

Revised date _____

_____
Name

_____
Address

* * * * *

Copies of amendments to Standards of Good Engineering Practice of the Commission will be furnished so far as available.

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All new rules and amendments to the Rules and Regulations adopted by the Federal Communications Commission are also printed in the Federal Register and are available in this form for reference or use by interested parties.

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*Sections 13 to 20, inclusive, are to be supplied in a later printing.

1. DEFINITIONS

A. GENERAL

1. *Television broadcast station.*—The term "television broadcast station" means a station in the television broadcast band transmitting simultaneous visual and aural signals intended to be received by the general public.

2. *Television broadcast band.*—The term "television broadcast band" means those frequencies in the band extending from 44 to 216 megacycles which are assignable to television broadcast stations. These frequencies are 44 to 50 megacycles (channel No. 1), 54 to 72 megacycles (channels 2 through 4), 76 to 88 megacycles (channels 5 and 6) and 174 to 216 megacycles (channels 7 through 13).

3. *Television channel.*—The term "television channel" means a band of frequencies 6 megacyles wide in the television broadcast band and designated either by number or by the extreme lower and upper frequencies.

4. *Television transmission standards.*—The term "television transmission standards" means the standards which determine the characteristics of the television signal as radiated by a television broadcast station. (See section 2A.)

5. *Standard television signal.* — The term "standard television signal" means a signal which conforms with the television transmission standards.

6. *Television transmitter.*—The term "television transmitter" means the radio transmitter or transmitters for the transmission of both visual and aural signals.

7. *Antenna field gain.*—The term "antenna field gain" of a television antenna means the ratio of the effective free space field intensity produced at 1 mile in the horizontal plane expressed in millivolts per meter for 1 kilowatt antenna input power to 137.6 MV/m.

8. *Free space field intensity.*—The term "free space field intensity" means the field intensity that would exist at a point in the absence of waves reflected from the earth or other reflecting objects.

9. *Polarization.* — The term "polarization" means the direction of the electric vector as radiated from the transmitting antenna.

10. *Effective radiated power.*—The term "effective radiated power" means the product of the antenna power (transmitter output power less transmission line loss) times (1) the antenna power gain, or (2) the antenna field gain squared.

11. *Service area.*—The term "service area" as applied to television broadcasting means the service area resulting from an assigned effective radiated power and antenna height above average terrain.

12. *Antenna height above average terrain.*—The term "antenna height above average terrain" means the average of the antenna heights above the terrain from two to 10 miles from the antenna. (In general a different antenna height will be determined by each direction from the antenna. The average of these various heights is considered as the antenna height above average terrain.)

B. VISUAL TRANSMITTER

1. *Visual transmitter.*—The term "visual transmitter" means the radio equipment for the transmission of the visual signal only.

2. *Amplitude modulation.*—The term "amplitude modulation" (AM) means a system of modulation in which the envelope of the transmitted wave contains a component similar to the wave form of the signal to be transmitted.

3. *Aspect ratio.*—The term "aspect ratio" means the numerical ratio of the frame width to frame height, as transmitted.

4. *Black level.*—The term "black level" means the amplitude of the modulating signal corresponding to the scanning of a black area in the transmitted picture.

5. *Color transmission.*—The term "color transmission" means the transmission of television signals which can be reproduced with different color values.

6. *Field frequency.*—The term "field frequency" means the number of times per second the frame area is fractionally scanned in the interlaced scanning.

7. *Frame.*—The term "frame" means one complete picture.

8. *Frame frequency.*—The term "frame frequency" means the number of times per second the picture area is completely scanned.

9. *Interlaced scanning.*—The term "interlaced scanning" means a scanning process in which successively scanned lines are spaced an integral number of line widths, and in which the adjacent lines are scanned during successive cycles of the field frequency scanning.

10. *Monochrome transmission.*—The term "monochrome transmission" means the transmission of television signals which can be reproduced in gradations of a single color only.

11. *Negative transmission.*—The term "negative transmissions" means that a decrease in initial light intensity causes an increase in the transmitted power.

12. *Positive transmission.*—The term "positive transmission" means that an increase in initial light intensity causes an increase in the transmitted power.

13. *Progressive scanning.*—The term "progressive scanning" means a scanning process in which scanning lines trace one dimension substantially parallel to a side of the frame and in which successively traced lines are adjacent.

14. *Scanning.*—The terms "scanning" means the process of analyzing successively, according to a predetermined method, the light values of picture elements constituting the total picture area.

15. *Scanning line.*—The term "scanning line" means a single continuous narrow strip containing highlights, shadows, and halftones which is determined by the process of scanning.

16. *Synchronization.*—The term "synchronization" means the maintaining of one operation in step with another.

17. *Vestigial side band transmission.*—The term "vestigial side band transmission" means a system of transmission wherein one of the generated side bands is partially attenuated at the transmitter and radiated only in part. (See Appendix II.)

18. *Visual frequency.*—The term "visual frequency" means the frequency of the signal resulting from television scanning.

19. *Visual transmitter power.*—The term "visual transmitter power" means the peak power output when transmitting a standard television signal.

20. *Peak power.*—The term "peak power" means the power over a radio frequency cycle corresponding in amplitude to synchronizing peaks.

C. AURAL TRANSMITTER

1. *Aural transmitter.*—The term "aural transmitter" means the radio equipment for the transmission of the aural signal only.

2. *Center frequency.*—The term "center frequency" means:

(1) The average frequency of the emitted wave when modulated by a sinusoidal signal.

(2) The frequency of the emitted wave without modulation.

3. *Frequency modulation.*—The term "frequency modulation" means a system of modulation where the instantaneous radio frequency varies in proportion to the instantaneous *amplitude* of the modulating signal (amplitude of modulating signal to be measured after pre-emphasis, if used) and the instantaneous radio frequency is independent of the *frequency* of the modulating signal.

4. *Frequency swing.*—The term "frequency swing" means the instantaneous departure of the frequency of the emitted wave from the center frequency resulting from modulation.

5. *Percentage modulation.*—The term "percentage modulation" as applied to frequency modulation means the ratio of the actual frequency swing to the frequency swing defined as 100-percent modulation, expressed in percentage. For the aural transmitter of television broadcast stations, a frequency swing of ±25 kilocycles is defined as 100-percent modulation.

2. TRANSMISSION STANDARDS AND CHANGES OR MODIFICATIONS THEREOF

A. TRANSMISSION STANDARDS

1. The width of the television broadcast channel shall be six megacycles per second.

2. The visual carrier shall be located 4.5 megacycles lower in frequency than the aural center frequency.

3. The aural center frequency shall be located 0.25 megacycles lower than the upper frequency limit of the channel.

4. The visual transmission amplitude characteristic shall be as shown in Appendix II.

5. The number of scanning lines per frame period shall be 525, interlaced two to one.

6. The frame frequency shall be 30 per second and the field frequency shall be 60 per second.

7. The aspect ratio of the transmitted television picture shall be 4 units horizontally to 3 units vertically.

8. During active scanning intervals, the scene shall be scanned from left to right horizontally and from top to bottom vertically, at uniform velocities.

9. A carrier shall be modulated within a single television channel for both picture and synchroniz-

ing signals, the two signals comprising different modulation ranges in amplitude. (See Appendices I and II.)

10. A decrease in initial light intensity shall cause an increase in radiated power (negative transmission).

11. The black level shall be represented by a definite carrier level, independent of light and shade in the picture.

12. The pedestal level (normal black level) shall be transmitted at 75 percent (with a tolerance of plus or minus 2.5 percent) of the peak carrier amplitude.

13. The maximum white level shall be 15 percent or less of the peak carrier amplitude.

14. The signals radiated shall have horizontal polarization.

15. A radiated power of the aural transmitter not less than 50 percent or more than 150 percent of the peak radiated power of the video transmitter shall be employed.

16.[1] *Variation of output.*—The peak-to-peak variation of transmitter output within one frame of video signal due to all causes, including hum, noise, and low-frequency response, measured at both synchronizing peak and pedestal level, shall not exceed 5 percent of the average synchronizing peak signal amplitude.

17.[1] *Black level.*—The black level should be made as nearly equal to the pedestal level as the state of the art will permit. If they are made essentially equal, satisfactory operation will result and improved techniques will later lead to the establishment of the tolerance if necessary.

18.[1] *Brightness characteristics.*—The transmitter output shall vary in substantially inverse logarithmic relation to the brightness of the subject. No tolerances are set at this time.

B. CHANGE OR MODIFICATION OF TRANSMISSION STANDARDS

The Commission will consider the question whether a proposed change or modification of transmission standards adopted for television would be in the public interest, convenience and necessity, upon petition being filed by the person proposing such change, or modification, setting forth the following:

(1) The exact character of the change or modification proposed;

(2) The effect of the proposed change or modification upon all other transmission standards that have been adopted by the Commission for television broadcast stations;

(3) The experimentation and field tests that have been made to show that the proposed change or modification accomplishes an improvement and is technically feasible;

(4) The effect of the proposed change or modification in the adopted standards upon operation and obsolescence of receivers;

(5) The change in equipment required in existing television broadcast stations for incorporating the proposed change or modification in the adopted standards, and

(6) The facts and reasons upon which the petitioner bases his conclusion that the proposed change or modification would be in the public interest, convenience, and necessity.

Should a change or modification in the transmission standards be adopted by the Commission, the effective date thereof will be determined in the light of the considerations mentioned in subparagraph (4) above.

3. ENGINEERING STANDARDS OF ALLOCATION

A. Sections 3.603 through 3.606 of the Commission's Rules prescribes the basis of assignment of television broadcast facilities. Section 3.601 indicates the groups of channels that are available for assignment to television broadcast stations. As indicated by these rules, the number of channels are limited and therefore have been allocated in advance to specific areas. This listing has been carefully planned with a view to providing the greatest service to a maximum number of people, and in general no departure from this plan will be made. However, where it can be shown that the public interest will be benefited by an alteration or rearrangement in this listing, the Commission will consider such adjustments as are necessary.

B. The extent of service is determined by the point at which the ground wave is no longer of sufficient intensity to provide satisfactory broadcast service. The field intensity considered necessary for service is as follows:

[1] These items are subject to change but are considered the best practice under the present state of the art. They will not be enforced pending a further determination thereof.

TABLE I

Area:	*Median field intensity*
City, business, or factor areas	5,000 μv/m
Residential and rural areas	500 μv/m

These figures are based upon the usual noise levels encountered in the two areas and upon the absence of interference from other television broadcast stations. The Commission will require that the transmitting antenna be so located as to provide a coverage area which is contiguous with the population density of the cities or metropolitan area with which the station is associated.

The field intensity indicated above for computing coverage is the visual transmitter operating peak power.

C. THE SERVICE AREA IS PREDICTED AS FOLLOWS:

Profile graphs must be drawn for at least eight radials from the proposed antenna site. These profiles should be prepared for each radial beginning at the antenna site and extending to 10 miles therefrom. Normally the radials are drawn for each 45° of azimuth; however, where feasible the radials should be drawn for angles along which roads tend to follow. (The latter method may be helpful in obtaining topographical data where otherwise unavailable, and is particularly useful in connection with mobile field intensity measurements of the station and the correlation of such measurements with predicated field intensities.) In each case one or more radials must include the principal city or cities to be served, particularly in cases of rugged terrain, even though the city may be more than 10 miles from the antenna site. The profile graph for each radial should be plotted by contour intervals of from 40 to 100 feet and, where the data permits, at least 50 points of elevation (generally uniformly spaced) should be used for each radial. In instances of very rugged terrain where the use of contour intervals of 100 feet would result in several points in a short distance, 200- or 400-feet contour intervals may be used for such distances. On the other hand, where the terrain is uniform or gently sloping the smallest contour interval indicated on the topographic map (see below) should be used, although only a relatively few points may be available. The profile graph should accurately indicate the topography for each radial, and the graphs should be plotted with the distance in miles as the abscissa and the elevation in feet above mean sea level as the ordinate. The profile graphs should indicate the source of the topographical data employed. The graph should also show the elevation of the center of the radiating system. The graph may be plotted either on rectangular coordinate paper or on special paper which shows the curvature of the earth. It is not necessary to take the curvature of the earth into consideration in this procedure, as this factor is taken care of in the charts showing signal intensities (Appendix IV).

The average elevation of the 8-mile distance between 2 and 10 miles from the antenna site should then be determined from the profile graph for each radial. This may be obtained by averaging a large number of equally spaced points, by using a planimeter, or by obtaining the median elevation (that exceeded for 50 percent of the distance) in sectors and averaging those values. To determine the distance to a particular contour concerning the range of television broadcast stations, Appendix IV should be used. These charts have been prepared for frequencies in the center of the various portions of the television band and are to be used as follows: Figure 1 for channel 1; Figure 2 for channels 2 through 4; Figure 3 for channels 5 and 6; and Figure 4 for channels 7 through 13. The distance to a contour is determined by the effective radiated power and the antenna height. The height of the antenna used in connection with Appendix IV should be the height of the center of the proposed antenna radiator above the average elevation obtained by the preceding method. The distances shown by Appendix IV are based upon an effective radiated power of one kilowatt; to use the charts for other powers the sliding scale associated with the charts should be trimmed and used as the ordinate scale. This sliding scale is placed on the charts with the appropriate gradation for power in line with the lower line of the top edge of the charts. The right edge of the scale is placed in line with the appropriate antenna height graduations and the charts then become direct reading for this power and antenna height. Where the antenna height is not one of those for which a scale is provided, the signal strength or distance is determined by interpolation between the curves connecting the equidistant points.

The foregoing process of determining the extent of the required contours shall be followed in determining the boundary of the proposed service area. The areas within the 5,000 μv/m and 500 μv/m contours must be determined and submitted with each application for television broadcast stations. Each application shall include a map showing these contours, and for this purpose Sectional Aeronautical Charts or other maps having a convenient scale may be used. The map shall show the radials along which the profile charts and expected field strength have been determined. The area within each contour should then be measured (by planimeter or other approximate means) to determine the number of square miles therein. In computing the area within the contours, exclude (1) areas beyond the borders of the United States, and (2) large bodies of water, such as ocean areas, gulfs, sounds, bays, large lakes, etc., but not rivers. Where interference is involved such areas shall be determined as indicated by section V.

In cases where the terrain in one or more directions from the antenna site departs widely from the average elevation of the 2 to 10 miles sector, the application of this prediction method may indicate contour distances that are different from those which may be expected in practice. In such cases the prediction method should be followed, but a showing may be made if desired concerning the distance to the contour as determined by other means. Such showing should include data concerning the procedure employed and sample calculations. For example, a mountain ridge may indicate the practical limit of service although the prediction method may indicate the contour elsewhere. In cases of such limitation, the map of predicted coverage should show both the regular predicted area and the area as limited or extended by terrain. Both areas should be measured, as previously described; the area obtained by the regular prediction method should be given in the application form, with a supplementary note giving the limited or extended area. In special cases the Commission may require additional information as to the terrain in the proposed service area.

In determining the population served by television broadcast stations, it is considered that the built-up city areas and business districts in cities having over 10,000 population and located beyond the 5,000 μv/m contour do not receive adequate service. Minor Civil Division maps (1940 census) should be used in making population counts, excluding cities not receiving adequate service. Where a contour divides a minor division, uniform distribution of population within the division should be assumed in order to determine the population included within the contour, unless a more accurate count is available.

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4. TOPOGRAPHICAL DATA

In the preparation of the profile graphs previously described, the elevations or contour intervals shall be taken from the United States Geological Topographical Quadrangle Sheets for all areas for which such maps are available. If such maps are not published for the area in question, the next best topographic information should be used. Topographic data may sometimes be obtained from State and municipal agencies. The data from the sectional aeronautical charts (including bench marks), or railroad depot elevations and highway elevations from road maps, may be used where no better information is available. In cases where limited topographic data can be obtained, use may be made of an altimeter in a car driven along roads extending generally radially from the transmitter site.

The Commission will not ordinarily require the submission of topographical maps for areas beyond 15 miles from the antenna site, but the maps must include the principal city or cities to be served. If it appears necessary, additional data may be requested.

The United States Geological Survey Topography Quadrangle sheets may be obtained from the United States Geological Survey, Department of the Interior, Washington, D. C., for 10 cents each. The Sectional Aeronautical Charts are available from the United States Coast and Geodetic Survey, Department of Commerce, Washington, D. C., for 25 cents each. Other sources of topographic maps or data will be furnished at a later date.

5. INTERFERENCE STANDARDS

Field intensity measurements are preferable in predicting interference between television broadcast stations and should be used, when available, in determining the extent of interference. (For

methods and procedure, see sec. 6.) In lieu of measurements, the interference should be predicted in accordance with the method described herein.

Objectionable visual interference is considered to exist when the interfering signal exceeds that given by the ratios of table II. In table II the desired signal is median field and the undesired signal is the tropospheric signal intensity exceeded for 10 percent of the time.

TABLE II

Channel separation:	*Ratio of desired to undesired signals*
Same channel	100:1
Adjacent channel	2:1

It is considered that stations on alternate channels or on channels separated by 4 Mc can be operated in the same city or area without objectionable interference (i. e., on this basis channels 1 and 2 or 4 and 5 could be used in the same city or area).

As an example of the application of the data contained in table II, objectionable interference from a co-channel station is considered to exist at the 500 μv/m contour of a station if a tropospheric signal from the co-channel station equals or exceeds 5 μv/m for at least ten percent of the time. The ten percent values for 1 kilowatt of power and various antenna heights are given in Appendix V,[2] and values for other powers may be obtained by using the sliding scale as for Appendix IV. The values indicated by Appendix V are based upon available data, and are subject to change as additional information concerning tropospheric wave propagation is obtained.

At the present time it is considered sufficient to consider only the ground wave field intensities in determining the extent of adjacent channel interference.

In determining the points at which the interference ratio is equal to the values shown in table II, the field intensities for the two interfering signals under consideration should be computed for a considerable number of points along the line between the two stations. Using this data, field intensity versus distance curves should be plotted (e. g., cross-curves on graph paper) in order to determine the points on this path where the interference ratios exist. The points established by this method, together with the points along the contour where the same ratios are determined, are considered to be generally sufficient to predict the area of interference. Additional points may be required in case of irregular terrain or directional antenna systems.

The area of interference, if any, shall be shown in connection with the map of predicted coverage required by the application form, together with the basic data employed in computing such interference. The map shall show the interference within the 500 μv/m contour.

6. FIELD INTENSITY MEASUREMENTS IN ALLOCATION

When field intensity measurements are required by the Commission's rules or when employed in determining the extent of service or interference of existing stations, such measurements should be made in accordance with the procedure outlined herein.

Measurements made to determine the service and interference areas of television broadcast stations should be made with mobile equipment along roads which are as close and similar as possible to the radials showing topography which were submitted with the application for construction permit. Suitable measuring equipment and a continuous recording device must be employed, the chart of which is either directly driven from the speedometer of the automobile in which the equipment is mounted or so arranged that distances and identifying landmarks may be readily noted. The measuring equipment must be calibrated against recognized standards of field intensity and so constructed that it will maintain an acceptable accuracy of measurement while in motion or when stationary. The equipment should be so operated that the recorder chart can be calibrated directly in field intensity in order to facilitate analysis of the chart. The receiving antenna must be nondirectional and horizontally polarized.

Mobile measurements should be made with a minimum chart speed of 3 inches per mile and preferably 5 or 6 inches per mile. Locations shall be noted on the recorder chart as frequently as necessary to definitely fix the relation between the measured field intensity and the location. The

[2] Charts for Appendix V will be available at some future date when sufficient measurements of tropospheric signals are available. Until such time as these charts are available, interference should be predicted on the basis of ground wave charts (Appendix IV).

time constant of the equipment should be such as to permit adequate analysis of the charts, and the time constant employed shall be shown. Measurements should be made to a point on each radial well beyond the particular contour under investigation.

While making field intensity measurements the visual transmitter shall be used. It is recommended that a black picture be transmitted or that the transmitted be operated at black level without synchronization peaks. Operation at a power somewhat less than black level is permissible but too great a reduction in power is not recommended due to the difficulty of recording weak signals. In any event, an appropriate factor shall be used to convert the readings obtained to the field strength that would exist on synchronization peaks while operating at the authorized power. If other means of measurements are to be used a request should be made to the Commission stating the reasons therfor and the means to be used.

After the measurements are completed, the recorder chart shall be divided into not less than 15 sections on each equivalent radial from the station. The field intensity in each section of the chart shall be analyzed to determine the field intensity received 50 percent of the distance (medium field) throughout the section, and this median field intensity associated with the corresponding sector of the radial. The field intensity figures must be corrected for a receiving antenna elevation of 30 feet and for any directional effects of the automobile not otherwise compensated. This data should be plotted for each radial, using log-log coordinate paper with distance as the abscissa and field intensity as the ordinate. A smooth curve should be drawn through these points (of median fields for all sectors) and this curve used to determine the distance to the desired contour. The distances obtained for each radial may then be plotted on the map of predicted coverage or on polar coordinate paper (excluding water areas, etc.) to determine the service and interference areas of a station.

In making measurements to establish the field intensity contours of a station mobile recordings should be made along each of the radials drawn in section 3C above. Measurements should extend from the vicinity of the station out to the 500 μv/m measured contour and somewhat beyond. These measurements would be made for the purpose of determining the variation of the measured contours from those predicted. Adjustment of power or antenna may be required to fit the actual contours to that predicted.

In predicting tropospheric interference on the basis of the above measurements, such measurements shall be carried out in the manner indicated above to determine the 500 μv/m contour. Using the appropriate figure in Appendix IV for the channel involved and the sliding scale, the equivalent radiated power shall be determined by placing the sliding scale on the chart (using the appropriate antenna height) and moving the scale until the distance to the 500 μv/m contour (as determined above), and the 500 μv/m mark are opposite. The equivalent radiated power is then read from the sliding scale where it crosses the lower line of the top edge of the chart. Changing to the corresponding figure in Appendix V and using the equivalent radiated power just determined, the distance to the interfering contour under investigation is read in the usual manner.

In certain cases the Commission may desire more information or recordings and in these instances special instructions will be issued. This may include fixed location measurements to determine tropospheric propagation and finding ratios.

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

A. Map or maps showing the roads or points where measurements were made, the service and/or interference areas determined by the prediction method and by the measurements, and any unusual terrain characteristics existing in these areas. (This map may preferably be of a type showing topography in the area.) The 5,000 and 500 μv/m contours shall be shown.

B. If a directional transmitting antenna is employed, a diagram on polar coordinate paper showing the predicted free space field intensity in millivolts per meter at one mile in all directions. (See sec. 8.)

C. A full description of the procedures and methods employed including the type of equipment, the method of installation and operation, and calibration procedures.

D. Complete data obtained during the survey, including calibration.

E. Antenna system and power employed during the survey.

F. Name, address, and qualifications of the engineer or engineers making the measurements.

All data shall be submitted to the Commission in triplicate, except that only the original or one photostatic copy need be submitted of the actual recording tapes.

7. TRANSMITTER LOCATION

A. The transmitter location should be as near the center of the proposed service area as possible consistent with the applicant's ability to find a site with sufficient elevation to provide service throughout the area. Location of the antenna at a point of high elevation is necessary to reduce to a minimum the shadow effect on propagation due to hills and buildings which may reduce materially the intensity of the station's signals in a particular direction. The transmitting site should be selected consistent with the purpose of the station, i. e., whether it is intended to serve a small city, a metropolitan area or a large area. Inasmuch as service may be provided by signals of 5,000 μv/m or greater field intensities in metropolitan areas, and inasmuch as signals below 500 μv/m may provide service in rural areas, considerable latitude in the geographical location of the transmitter is permitted; however, the necessity for a high elevation for the antenna may render this problem difficult. In general, the transmitting antenna of a station should be located at the most central point at the highest elevation available. In providing the best degree of service to an area, it is usually preferable to use a high antenna rather than a lower antenna with increased transmitter power. The location should be so chosen that line-of-sight can be obtained from the antenna over the principal city or cities to be served; in no event should there be a major obstruction in this path.

B. The transmitting location should be selected so that the 5,000 μv/m contour encompasses the urban population within the area to be served and the 500 μv/m or the interference free from contour coincides generally with the limits of the area to be served. It is recognized that topography, shape of the desired service area, and population distribution may make the choice of a transmitter location difficult. In such cases consideration may be given to the use of a directional antenna system, although it is generally preferable to choose a site where a nondirectional antenna may be employed.

C. In cases of questionable antenna locations it is desirable to conduct propagation tests to indicate the field intensity expected in the principal city or cities to be served and in other areas, particularly where severe shadow problems may be expected. In considering applications proposing the use of such locations, the Commission may require site tests to be made. Such tests should be made in accordance with the measurement procedure previously described, and full data thereon must be supplied to the Commission. Test transmitters should employ an antenna having a height as close as possible to the proposed antenna height, using a balloon or other support if necessary and feasible. Information concerning the authorization of site tests may be obtained from the Commission upon request.

D. Present information is not sufficiently complete to establish "blanket areas" of television broadcast stations. A "blanket area" is that area adjacent to a transmitter in which the reception of other stations is subject to interference due to the strong signal from this station. Where it is found necessary to locate the transmitter in a residential area where blanketing problems may appear to be excessive, the application must include a showing concerning the availability of other sites. The authorization of station construction in areas where blanketing problems appear to be excessive will be on the basis that the applicant will assume full responsibility for the adjustment of reasonable complaints arising from excessively strong signals of the applicant's station.

Cognizance must of course be taken regarding the possible hazard of the proposed antenna structure to aviation and the proximity of the proposed site to airports and airways. In passing on proposed construction, the Commission refers each case to the Civil Aeronautics Administration for its recommendations. Antenna painting and/or lighting may be required at the time of construction or at a later date.

8. ANTENNA SYSTEMS

A. An antenna which is high in respect to the average level of the territory it serves is desirable in order to reduce the effect of shadows. The antenna must be constructed so that it is as clear as possible of surrounding buildings or objects that would cause shadow problems.

B. Applications proposing the use of directional antenna systems must be accompanied by the following:

(1) Complete description of the proposed antenna system.

(2) Orientation of array with respect to true north; time phasing of fields from elements (degrees leading or lagging); space phasing of elements (in feet and degrees); and ratio of fields from elements.

(3) Calculated field intensity pattern (on letter-size polar coordinate paper) giving the free space field intensity in millivolts per meter at one mile in the horizontal plane, together with the formula used, constants employed, sample calculations, and tabulations of calculation data.

(4) Name, address, and qualifications of the engineer making the calculations.

C. Applications proposing (1) the use of television broadcast antennas in the immediate vicinity (i. e., 200 feet or less) of television broadcast antennas operating on a channel within 20 percent in frequency of the proposed channel, or (2) the use of television antennas on channels 5 or 6 in the immediate vicinity of FM broadcast antennas, must include a showing as to the expected effect, if any, of such proximate operation.

D. In cases where it is proposed to use a tower of a standard broadcast station as a supporting structure for a television broadcast antenna, an application for construction permit (or modification of construction permit) for such station must be filed for consideration with the television application. An application may be required for other classes of stations when the tower is to be used in connection with a television station.

When a television antenna is mounted on a non-directional standard broadcast antenna, new resistance measurements must be made of the standard broadcast antenna after installation and testing of the television antenna. During the installation and until the new resistance determination is approved, the standard broadcast station licensee should apply for authority (informal application) to operate by the indirect method of power determination. The television license application will not be considered until the application form concerning resistance measurements is filed for the standard broadcast station.

When a television antenna is mounted on an element of a standard broadcast directional antenna, a full engineering study concerning the effect of the television antenna on the directional pattern must be filed with the application concerning the standard broadcast station. Depending upon the individual case, the Commission may require readjustment and certain field intensity measurements of the standard broadcast station following the completion of the television antenna system.

When the proposed television antenna is to be mounted on a tower in the vicinity of a standard broadcast directional array and it appears that the operation of the directional antenna system may be affected, an engineering study must be filed with the television application concerning the effect of the television antenna on the directional pattern. Readjustment and field intensity measurements of the standard broadcast station may be required following construction of the television antenna.

Information regarding data required in connection with standard broadcast directional antenna systems may be found in the Standards of Good Engineering Practice Concerning Standard Broadcast Stations.

E. In the event a common tower is used by two or more licensees for antenna and/or antenna supporting purposes, the licensee who is owner of the tower shall assume full responsibility for the installation and maintenance of any painting and/or lighting requirements,

In the event of shared ownership, one license shall assume such responsibility and advise the Commission accordingly.

F. STANDARD LAMPS AND PAINTS

When necessary for the protection of air navigation, the antenna and supporting structure shall be painted and illuminated in accordance with the specifications supplied by the Commission pursuant to Section 303 (q) of the Communications Act of 1934, as amended.

These individual specifications are issued for and attached to each authorization for an installa-

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tion. The details of the specifications depend on the degree of hazard presented by the particular installation. The tower paint shall be kept in good condition and repainted as often as necessary to maintain this condition.

General information regarding painting and lighting requirements is contained in the Obstruction Marking Manual available from the Civil Aeronautics Administration, Washington 25, D. C.

9. TRANSMITTERS AND ASSOCIATED EQUIPMENT

A. VISUAL TRANSMITTER DESIGN

The general design of television broadcast visual transmitting equipment shall be in accordance with the following principles and specifications:

(1) The over-all attenuation characteristics of the transmitter measured in the antenna transmission line after the vestigial side band filters shall not be greater than—

2 db at 0.5 Mc
2 db at 1.25 Mc
3 db at 2.0 Mc
6 db at 3.0 Mc
12 db at 3.5 Mc

below the ideal demodulated curve. (See Appendix III.) The curve shall be substantially smooth between these specified points exclusive of the region from 0.75 Mc to 1.25 Mc.[3]

(2) The field strength or voltage of the lower side band as radiated or dissipated and measured as described in (3) below shall not be greater than −20 db for a modulating frequency of 1.25 Mc or greater.[3]

(3) The attenuation characteristics of a visual transmitter shall be measured by application of a modulating signal to the transmitter input terminals in place of the normal composite television video signal. The signal applied shall be a composite signal composed of a synchronizing signal to establish peak output voltage plus a variable frequency sine wave voltage occupying the interval between synchronizing pulses. The axis of the sine wave in the composite signal observed in the output monitor shall be maintained at an amplitude 0.5 of the voltage at synchronizing peaks. The amplitude of the sine wave input shall be held at a constant value. This constant value should be such that at no modulating frequency does the maximum excursion of the sine wave, observed in the composite output signal monitor, exceed the value 0.75 of peak output voltage. The amplitude of the 100-kilocycle sideband shall be measured and designated zero db as a basis for comparison. The modulation signal frequency shall then be varied over the desired range and the field strength or signal voltage of the corresponding sidebands measured.

As an alternate method of measuring, in those cases in which the automatic d-c insertion can be replaced by manual control, the above characteristic may be taken by the use of a video sweep generator and without the use of pedestal synchronizing pulses. The d-c level shall be set for midcharacteristic operation.[3]

(4) The radio frequency signal, as radiated, shall have an envelope as would be produced by a modulating signal in conformity with Appendix I, as modified by vestigial operation specified by Appendix II.

(5) The time interval between the leading edges of successive horizontal pulses shall vary less than one half of one percent of the average interval.

(6) The rate of change of the frequency of recurrence of the leading edges of the horizontal synchronizing signals shall be not greater than 0.15 percent per second, the frequency to be determined by an averaging process carried out over a period of not less than 20, nor more than 100 lines, such lines not to include any portion of the vertical blanking signal.

B. AURAL TRANSMITTER DESIGN

The general design of the aural transmitting equipment associated with a television station shall be in accordance with the following principles and specifications:

(1) The transmitter shall operate satisfactorily with a frequency swing of ±25 kilocycles, which is considered 100 percent modulation. It is rec-

[3] In the case of (1) above, output measurement shall be made with the transmitter operating into a dummy load of pure resistance and the demodulated voltage measured across this load. The ideal demodulated curve is that shown in Appendix III.

In the case of (2) above, field strength measurements are desired. It is anticipated that these may not yield data which are consistent enough to prove compliance with the attenuation standards prescribed above. In that case, measurements with a dummy load of pure resistance together with data on the antenna characteristics shall be taken in place of over-all field measurements. The "synchronizing signal" referred to in these paragraphs means either a standard synchronizing wave form or any pulse that will properly set the peak.

ommended, however, that the transmitter be designed to operate satisfactorily with a frequency swing of at least ±40 kilocycles.

(2) The transmitting system (from input terminals of microphone pre-amplifier, through audio facilities at the studio, through telephone lines or other circuits between studio and transmitter, through audio facilities at the transmitter, and through the transmitter, but excluding equalizers for the correction of deficiencies in microphone response) shall be capable of transmitting a band of frequencies from 50 to 5,000 cycles. Pre-emphasis shall be employed in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 75 microseconds. (See Appendix VI.) The deviation of the system response from the standard pre-emphasis curve shall lie between two limits as shown by Appendix VI. The upper of these limits shall be uniform (no deviation) from 50 to 15,000 cycles. The lower limit shall be uniform from 100 to 7,500 cycles, and three db below the upper limit; from 100 to 50 cycles the lower limit shall fall from three db limit at a uniform rate of one db per octave (4 db at 50 cycles); from 7,500 to 15,000 cycles the lower limit shall fall from three db limit at a uniform rate of two db per octave (5 db at 15,000 cycles).

(3) At any modulating frequency between 50 and 15,000 cycles and at modulation percentage of 25 percent, 50 percent and 100 percent, the combined audio frequency harmonics measured in the output of the system shall not exceed the root-mean-square values given in the following table:

Modulation frequency:	*Distortion (Percent)*
50 to 100 cycles	3.5
100 to 7,500 cycles	2.5
7,500 to 15,000 cycles	3.0

Measurement shall be made employing 75 microsecond de-emphasis in the measuring equipment and 75 microsecond pre-emphasis in the transmitting equipment, and without compression if a compression amplifier is employed. Harmonics shall be included to 30 kc.[4]

[4] Measurements of distortion using de-emphasis in the measuring equipment are not practical at the present time for the range 7,500 to 15,000 cycles for 25 and 50 percent modulation. Therefore, measurements should be made at 100 percent modulation and on at least the following modulating frequencies: 50, 100, 400, 1,000, 5,000, 10,000, and 15,000 cycles. At 25 and 50 percent modulation measurements should be made on at least the following modulating frequencies: 50, 100, 400, 1,000 and 5,000 cycles.

It is recommended that none of the three main divisions of the system (transmitter, studio to transmitter circuit, and audio facilities) contribute over one-half of these percentages, since at some frequencies the total distortion may become the arithmetic sum of the distortions of the divisions.

(4) The transmitting system output noise level (frequency modulation) in the band of 50 to 15,000 cycles shall be at least 55 db below the audio frequency level representing a frequency swing of ±25 kc.[5]

(5) The transmitting system output noise level (amplitude modulation) in the band of 50 to 15,000 cycles shall be at least 50 db below the level representing 100 percent amplitude modulation.[5]

(6) If a limiting or compression amplifier is employed, precaution should be maintained in its connection in the circuit due to the use of pre-emphasis in the transmitting system.

C. DESIGN APPLICABLE TO BOTH VISUAL AND AURAL TRANSMITTERS

In addition to design features applicable to the individual transmitters, the general design of television broadcast (visual and aural) transmitting equipment shall be in accordance with the following principles and specifications:

(1) Automatic means shall be provided in the transmitters to maintain the authorized carrier frequencies within the allowable tolerance (±0.002 percent).

(2) The transmitters shall be equipped with suitable indicating instruments for the determination of operating power and with other instruments as are necessary for proper adjustment, operation, and maintenance of the equipment.

(3) Adequate provision shall be made for varying the output power of the transmitters to compensate for excessive variations in line voltage or for other factors affecting the output powers.

(4) Adequate provisions shall be provided in all component parts to avoid overheating at the rated maximum output powers.

(5) Means should be provided for connection and continuous operation of approved frequency and modulation monitors.

[5] For the purpose of these measurements the visual transmitter should be inoperative since the exact amount of noise permissible from that source is not known at this time.

D. CONSTRUCTION

In general, the transmitters shall be constructed either on racks and panels or in totally enclosed frames protected as required by article 810 of the National Electrical Code,[6] 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.

(2) Proper bleeder resistors or other automatic means shall be installed across all the capacitor banks to lower any voltage which may remain accessible with access door open to less than 350 volts within two seconds after the access door is opened.

(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 should be provided on motor generators.

(*b*) Power equipment and control panels of the transmitters shall meet the above requirements (exposed 220-volt A. C. switching equipment on the front of the power control panels is not recommended but is not prohibited).

(*c*) Power equipment located at a television broadcast station not directly associated with the transmitters (not purchased as part of same), such as power distribution panels, are not under the jurisdiction of the Commission; therefore section 3.654 does not apply.

(4) *Metering equipment.*—(*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 manufacturers 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 voltmeters are located on the low potential side of the multiplier resistors with the potential of the high potential terminal of the instruments at or less than 1,000 volts above ground, no protective case is required. However, it is good practice to protect voltmeters subject to more than 5,000 volts with suitable over-voltage protective devices across the instrument terminals in case the winding opens.

(*c*) Transmission line meters and any other radio frequency instrument which may be 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.

(*d*) It is recommended that component parts comply as much as possible with the component specifications designated by the Army-Navy Electronics Standards Agency.

E. WIRING AND SHIELDING

(1) The transmitter panels or units shall be wired in accordance with standard practice, such as insulated leads properly cabled and supported, concentric lines or rigid bus bar properly insulated and protected.

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

(3) Circuits carrying radio frequency or video energy between units shall be either coaxial, two wire balance lines, or properly shielded.

(4) All stages or units shall be adequately shielded and filtered to prevent interaction and radiation.

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

F. INSTALLATION

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

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

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[6] The pertinent sections of article 810 of the National Electrical Code reads 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."

G. SPARE TUBES

A spare tube of every type employed in the transmitters and frequency modulation monitors shall be kept on hand at the equipment location. When more than one tube of any type are employed, the following table determines the numbers of spare 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

An accurate circuit diagram and list of required spare tubes, as furnished by the manufacturer of the equipment, shall be supplied and retained at the transmitter location.

H. OPERATION

In addition to specified requirements of the rules governing television broadcast stations, the following operating requirements are specified:

(1) Spurious emissions, including radio frequency harmonics, shall be maintained at as low a level as the state of the art permits.

(2) If a limiting or compression amplifier is used in conjunction with the aural transmitter, due operating precautions should be maintained in its use due to pre-emphasis in the transmitting system.

I. STUDIO EQUIPMENT

Studio equipment shall be subject to all the above requirements where applicable except as follows:

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

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

No specific requirements are made relative to the design and acoustical treatment of studios. However, the design of studios, particularly the main studio, shall be compatible with the required performance characteristics of television broadcast stations.

10. INDICATING INSTRUMENTS

A. A television broadcast station shall be equipped with suitable indicating instruments of accepted accuracy to measure the direct plate voltage and current of the last radio stage of the visual and aural transmitters and an instrument for reading the transmission line of both transmitters.

The following requirements and specifications shall apply to indicating instruments used by television broadcast stations in compliance with this rule:

(1) Length of scale shall be not less than $2\frac{3}{10}$ inches.

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

(3) Scale shall have at least 40 divisions.

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

No specifications are prescribed at this time regarding the peak indicating device required by section 11B (1) of these standards.

B. No instruments indicating the plate current or plate voltage of the last radio stage shall be changed or replaced without written authority of the Commission, except by instruments of the same maximum scale readings and accuracy. Requests for authority to use an instrument of different maximum scale reading and/or accuracy shall be made by letter or telegram giving the manufacturer's name, type number, and full scale reading of the proposed instrument and the values of current or voltage the instrument will be employed to indicate. Requests for temporary authority to operate without an instrument or with a substitute instrument may be made by letter or telegram stating the necessity therefor and the period involved.

C. No required instrument the accuracy of which is questionable shall be employed. Repairs and calibration of instruments shall be made by the manufacturer, or by an authorized instrument repair service of the manufacturer, or by some other properly qualified or equipped instrument repair service. In any case, the repaired instrument must be supplied with a certificate of calibration.

D. Recording instruments may be employed in addition to the indicating instruments to record the direct plate current and/or voltage to the last radio stage provided that they do not affect the operation of the circuits or accuracy of the indicat-

ing instruments. If the records are to be used in any proceeding before the Commission, as representative of operation, 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 such accuracy.

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

11. OPERATING POWER—DETERMINATION AND MAINTENANCE

A. DETERMINATION

(1) *Visual transmitter.*—The average power shall be measured while operating into a dummy load of substantially zero reactance and a resistance equal to the transmission line surge impedance, while transmitting a standard black television picture. The peak power shall be the power obtained by this method, multiplied by the factor 1.68. During this measurement the direct plate voltage and current of the last radio stage and the peak output voltage or current shall be read for use below.

(2) *Aural transmitter.*—The operating power of the aural transmitter shall be determined by the indirect method. This is the product of the plate voltage (Ep) and the plate current (Ip) of the last radio stage, and an efficiency factor, F; that is.

$$\text{Operating power} = Ep \times Ip \times F$$

The efficiency factor, F, shall be established by the transmitter manufacturer for each type of transmitter for which he requests FCC approval, and shall be shown in the instruction books supplied to the customer with each transmitter. In the case of composite equipment the factor F shall be furnished to the Commission by the applicant along with a statement of the basis used in determining such factor.

B. MAINTENANCE

(1) *Visual transmitter.*—The peak power shall be monitored by a peak reading device which reads proportionally to other voltage or current on the transmission line operating into the antenna, the meter to be calibrated during the measurement described in A (1) above. The operating power as so monitored shall be maintained as near as practicable to the authorized operating power and shall not exceed the limits of 10 percent above and 20 percent below the authorized power except in emergencies.

As a further check both plate voltage and plate current of the output stage shall be measured with a standard black television picture with the transmitter operating into the antenna. These values must agree substantially with corresponding readings taken under A (1) above.

(2) *Aural Transmitter.*—The operating power of aural transmitters shall be maintained as near as practicable to the authorized operating power, and shall not exceed the limits of 10 percent above and 20 percent below the authorized power except in emergencies.

(3) In the event it becomes impossible to operate with the authorized power, the station may be operated with reduced power for a period of 10 days or less provided the Commission and the Engineer in Charge of the district in which the station is located shall be notified in writing immediately thereafter and also upon the resumption of the normal operating power.[7]

12. AUXILIARY TRANSMITTERS

Auxiliary transmitters may not exceed the power rating of the main transmitters. As a general guide specifications for auxiliary transmitters should conform as much as possible to those of the main transmitters. No requirements are set forth at this time.

13 to 20, inclusive: These section to be supplied.

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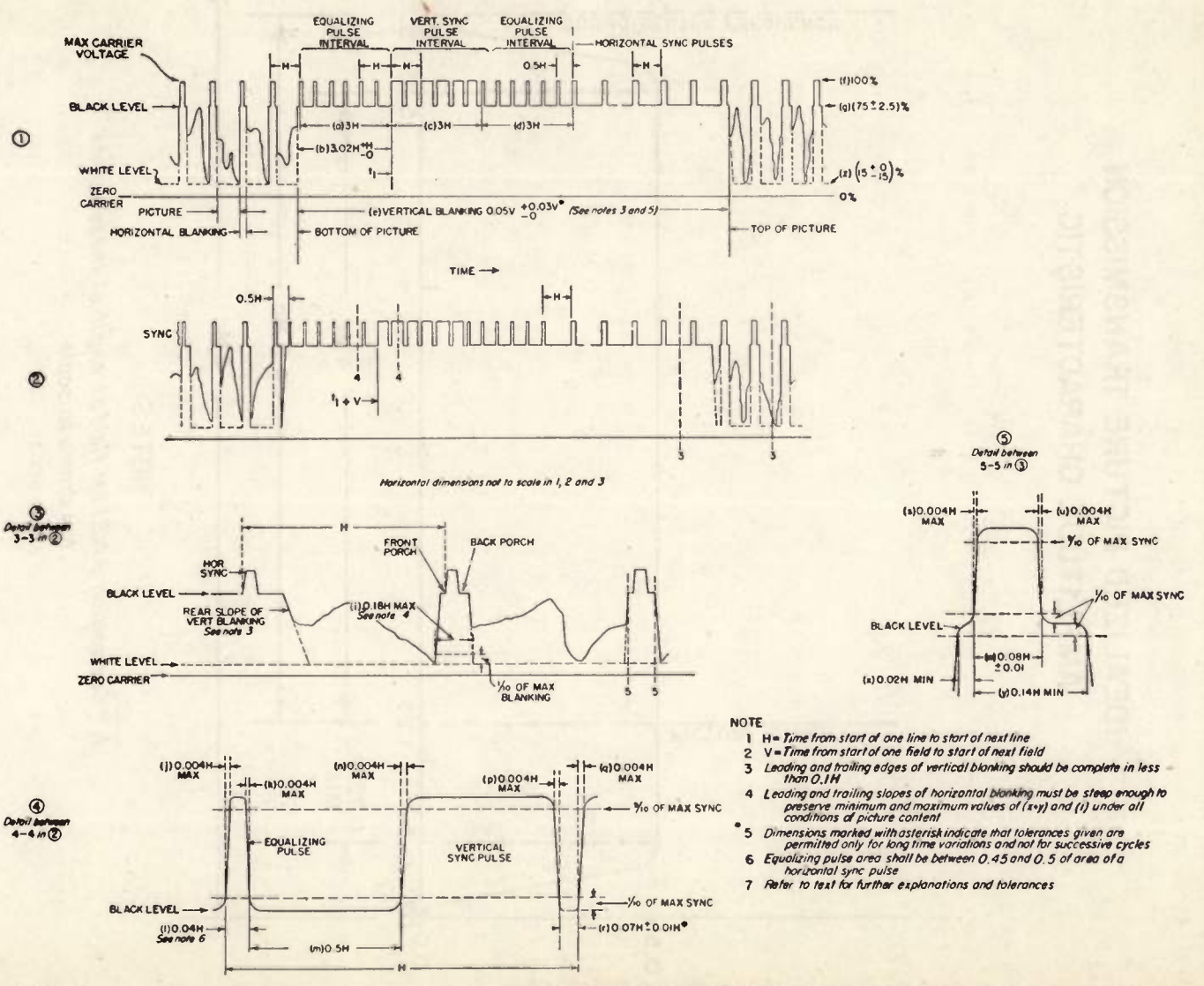
[7] See Appendix 3 of Part I of the Rules and Regulations for addresses of Field Offices.

TELEVISION SYNCHRONIZING WAVEFORM

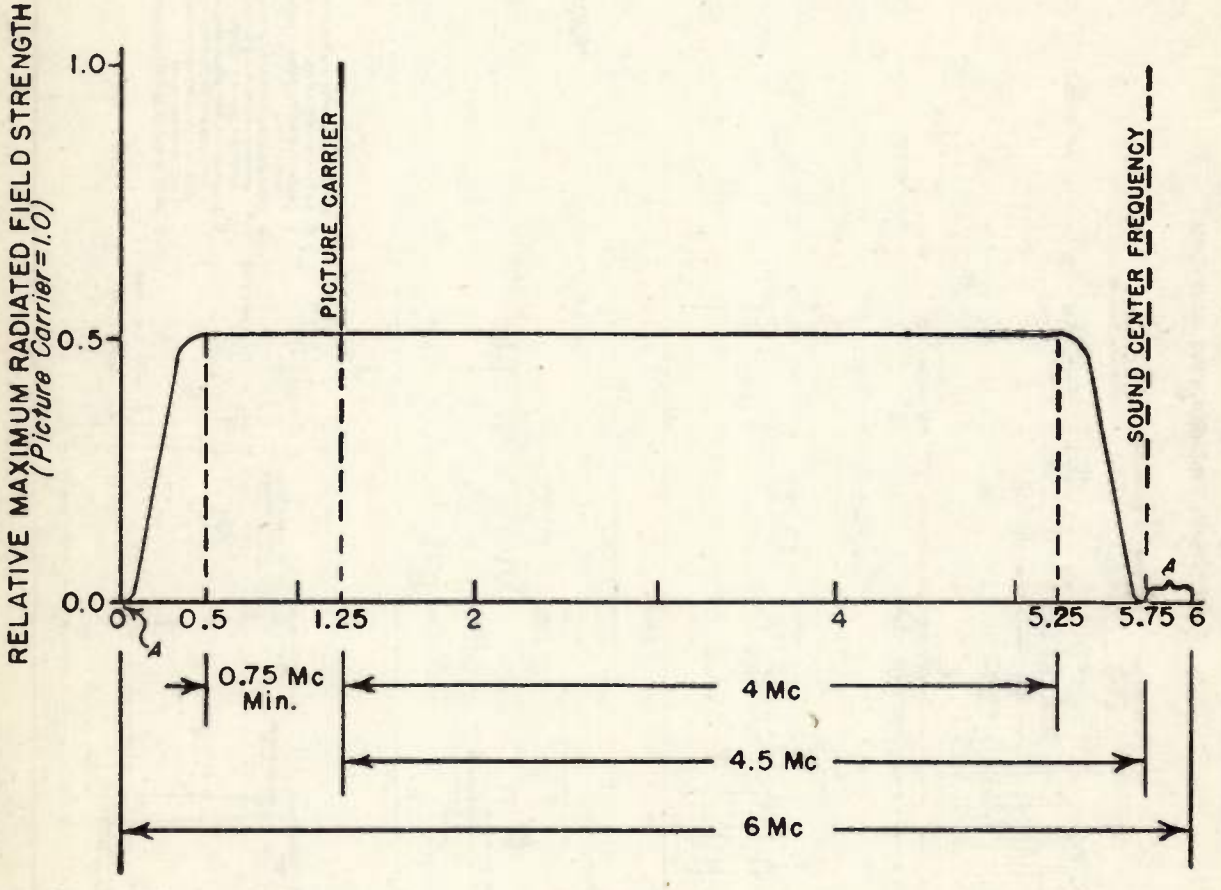


NOTE

1. H = Time from start of one line to start of next line
2. V = Time from start of one field to start of next field
3. Leading and trailing edges of vertical blanking should be complete in less than 0.1H
4. Leading and trailing slopes of horizontal blanking must be steep enough to preserve minimum and maximum values of (z+y) and (i) under all conditions of picture content
5. * Dimensions marked with asterisk indicate that tolerances given are permitted only for long time variations and not for successive cycles
6. Equalizing pulse area shall be between 0.45 and 0.5 of area of a horizontal sync pulse
7. Refer to text for further explanations and tolerances

APPENDIX I

IDEALIZED PICTURE TRANSMISSION AMPLITUDE CHARACTERISTIC



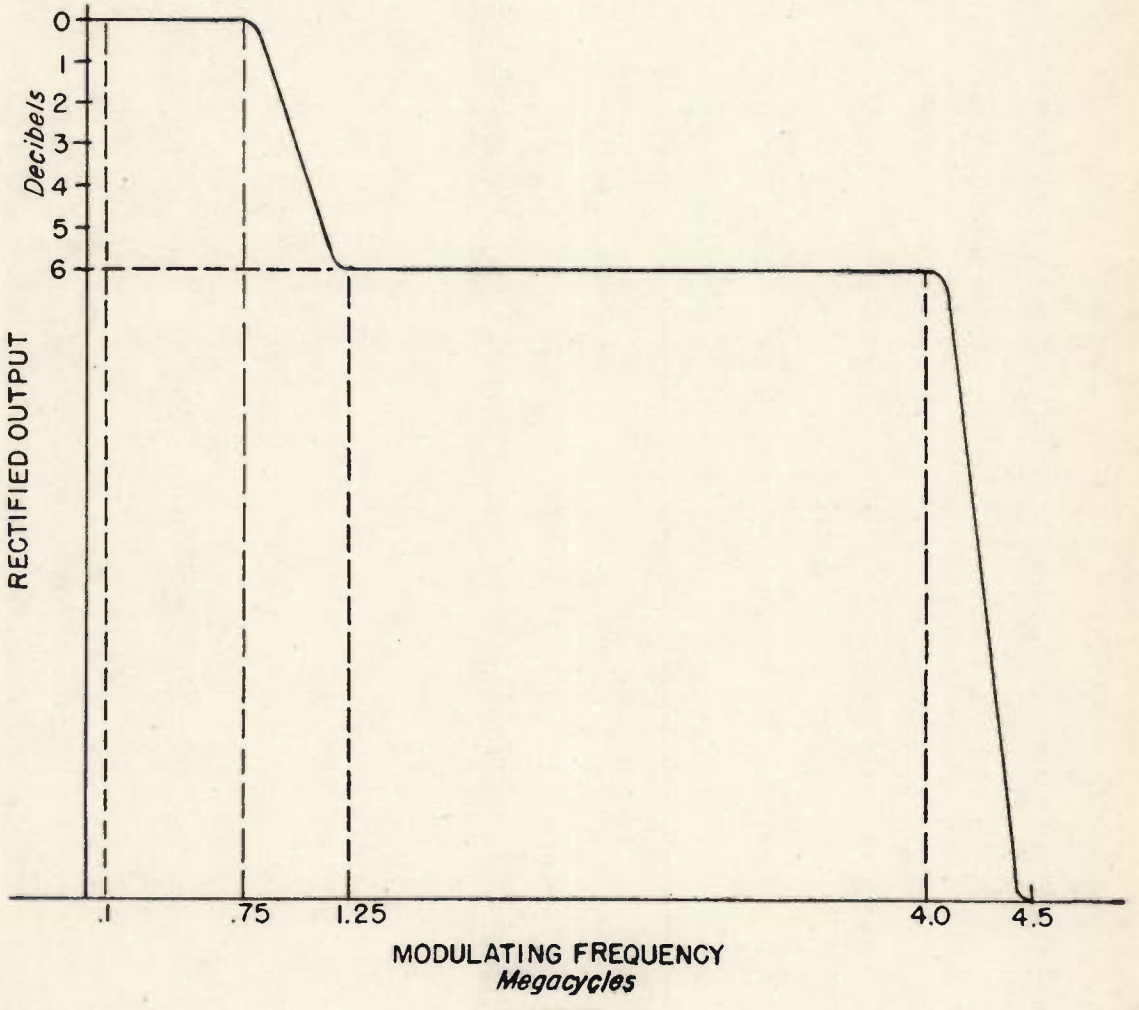
NOTES

A – *See section 9A(2) for field strength at these points*

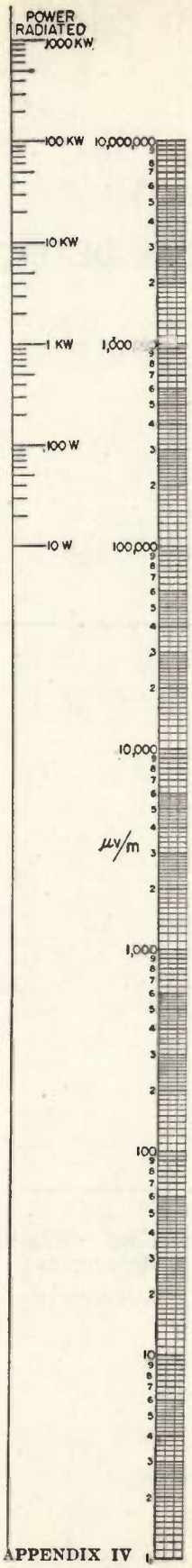
Not drawn to scale

APPENDIX II

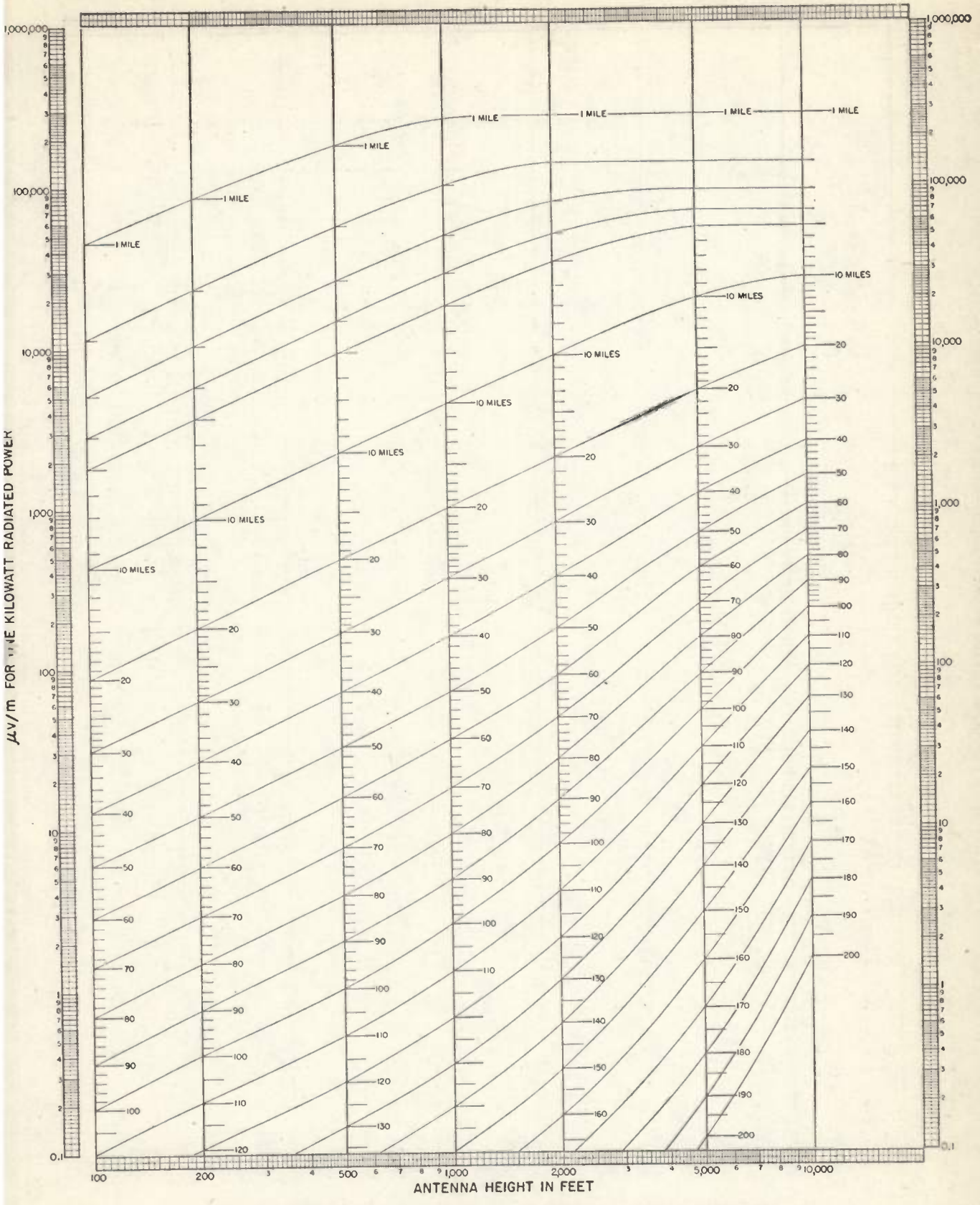
ASSUMED IDEAL DETECTOR OUTPUT



APPENDIX III


POWER RADIATED
1000 KW
100 KW
10 KW
1 KW
100 W
10 W
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
μv/m

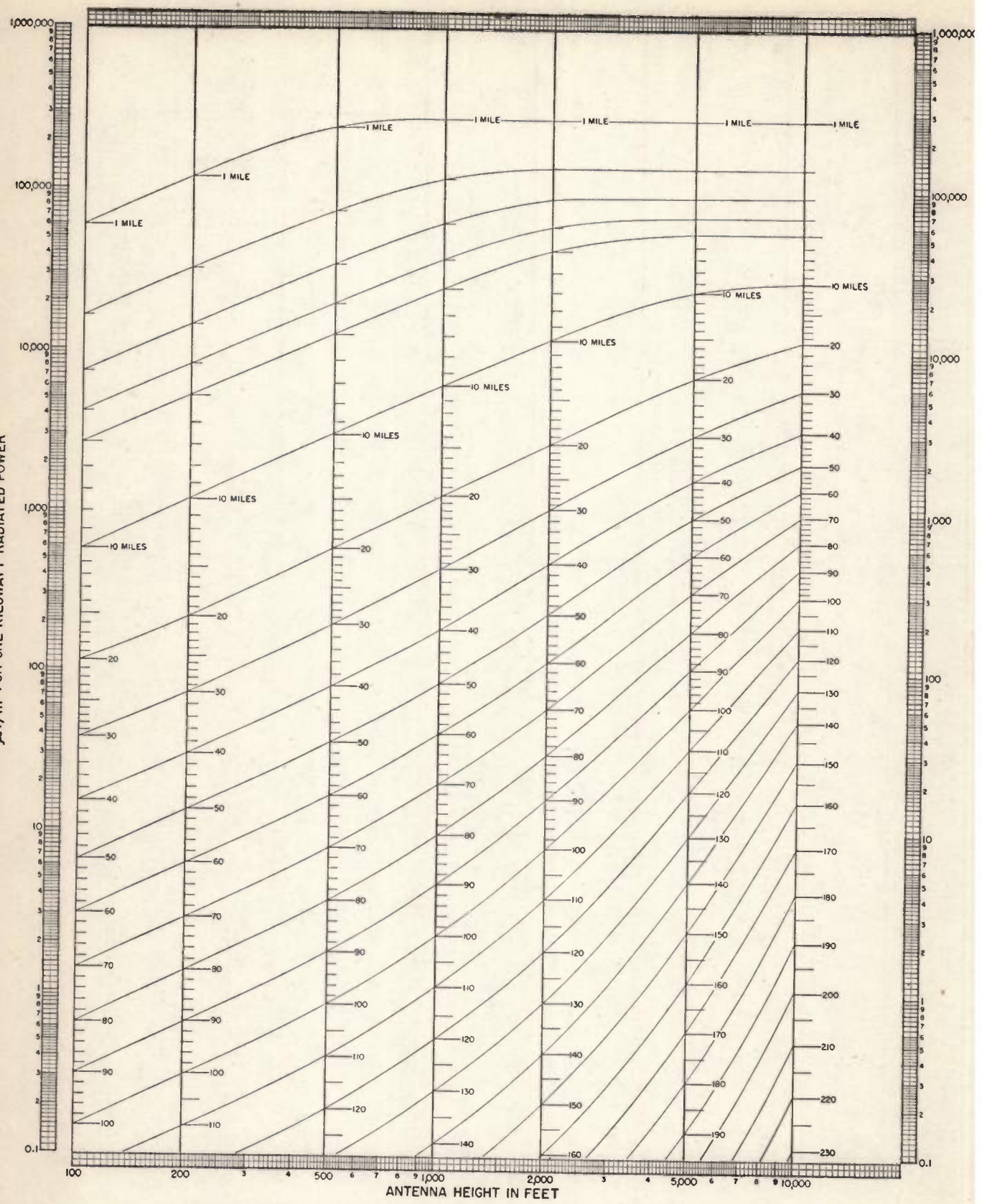
APPENDIX IV



GROUND WAVE SIGNAL RANGE FOR TELEVISION

46 mc, $\sigma = 5 \times 10^{-14}$ e.m.u., $\epsilon = 15$, RECEIVING ANTENNA HEIGHT 30 FEET
FOR HORIZONTAL (AND APPROX. FOR VERTICAL) POLARIZATION

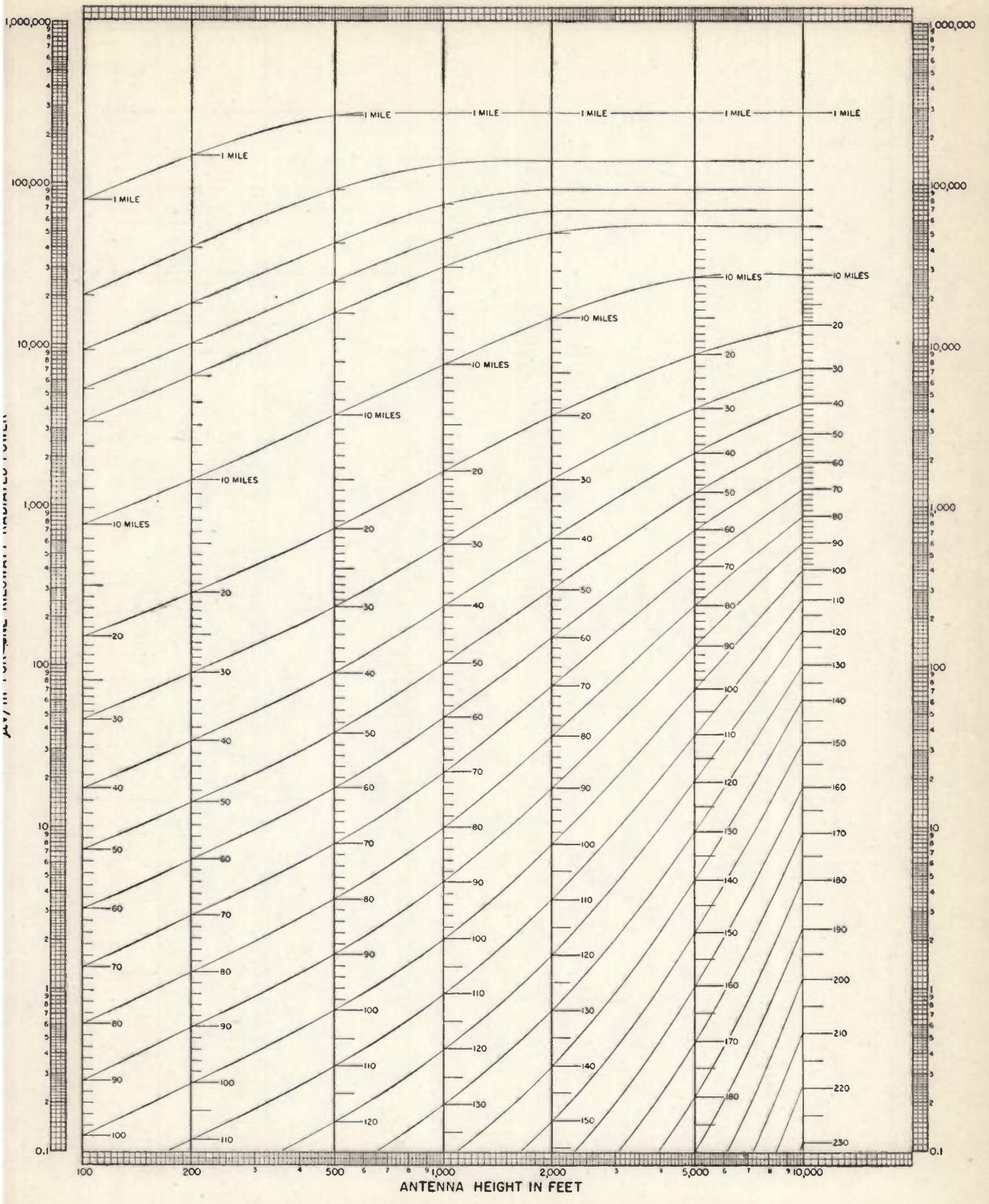
APPENDIX IV
FIGURE 1



GROUND WAVE SIGNAL RANGE FOR TELEVISION

63 mc, $\sigma = 5 \times 10^{-14}$ e.m.u, $\epsilon = 15$, RECEIVING ANTENNA HEIGHT 30 FEET
FOR HORIZONTAL (AND APPROX. FOR VERTICAL) POLARIZATION

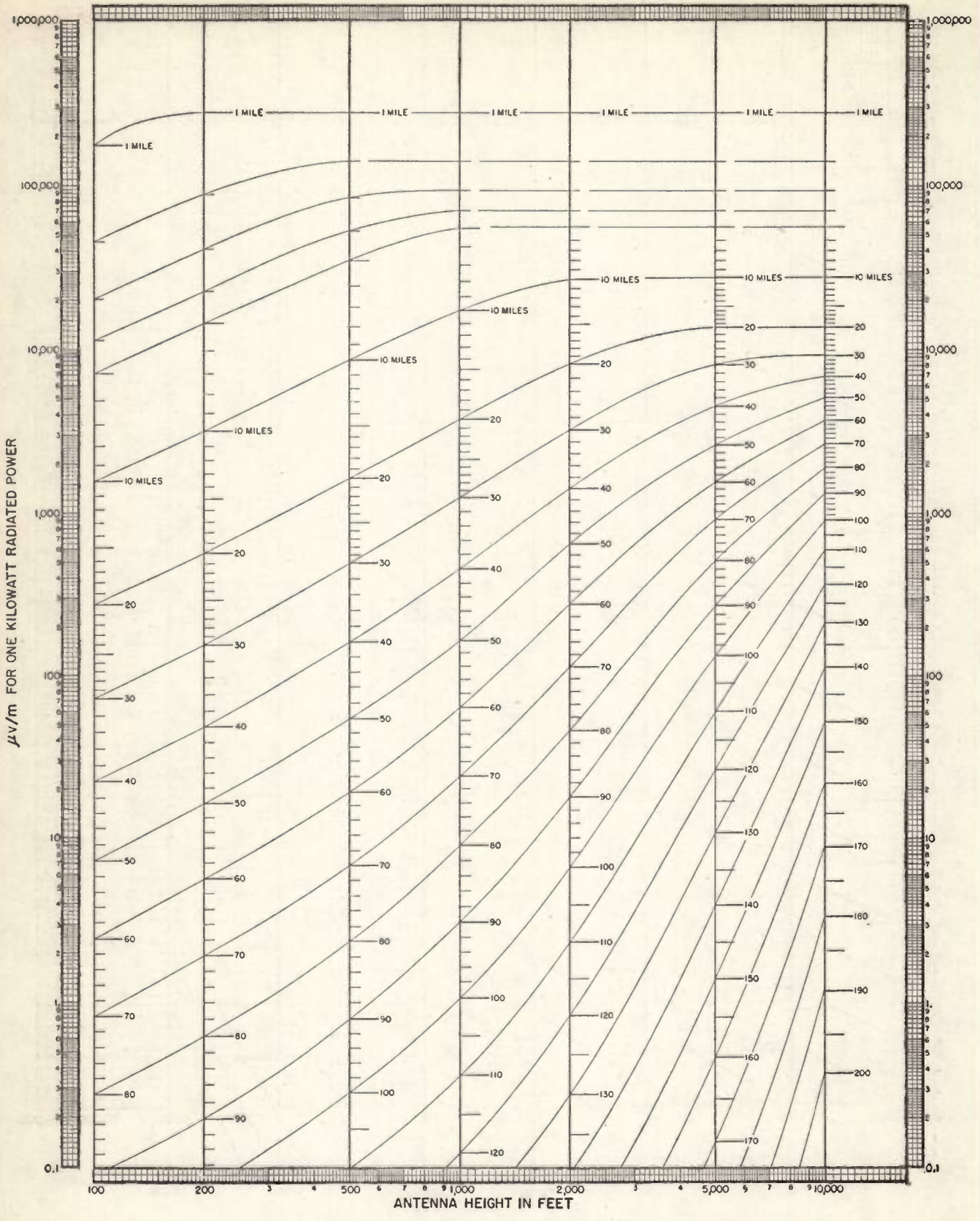
APPENDIX IV
FIGURE 2



GROUND WAVE SIGNAL RANGE FOR TELEVISION

82 mc, $\sigma = 5 \times 10^{-14}$ e.m.u, $\epsilon = 15$, RECEIVING ANTENNA HEIGHT 30 FEET
FOR HORIZONTAL (AND APPROX. FOR VERTICAL) POLARIZATION

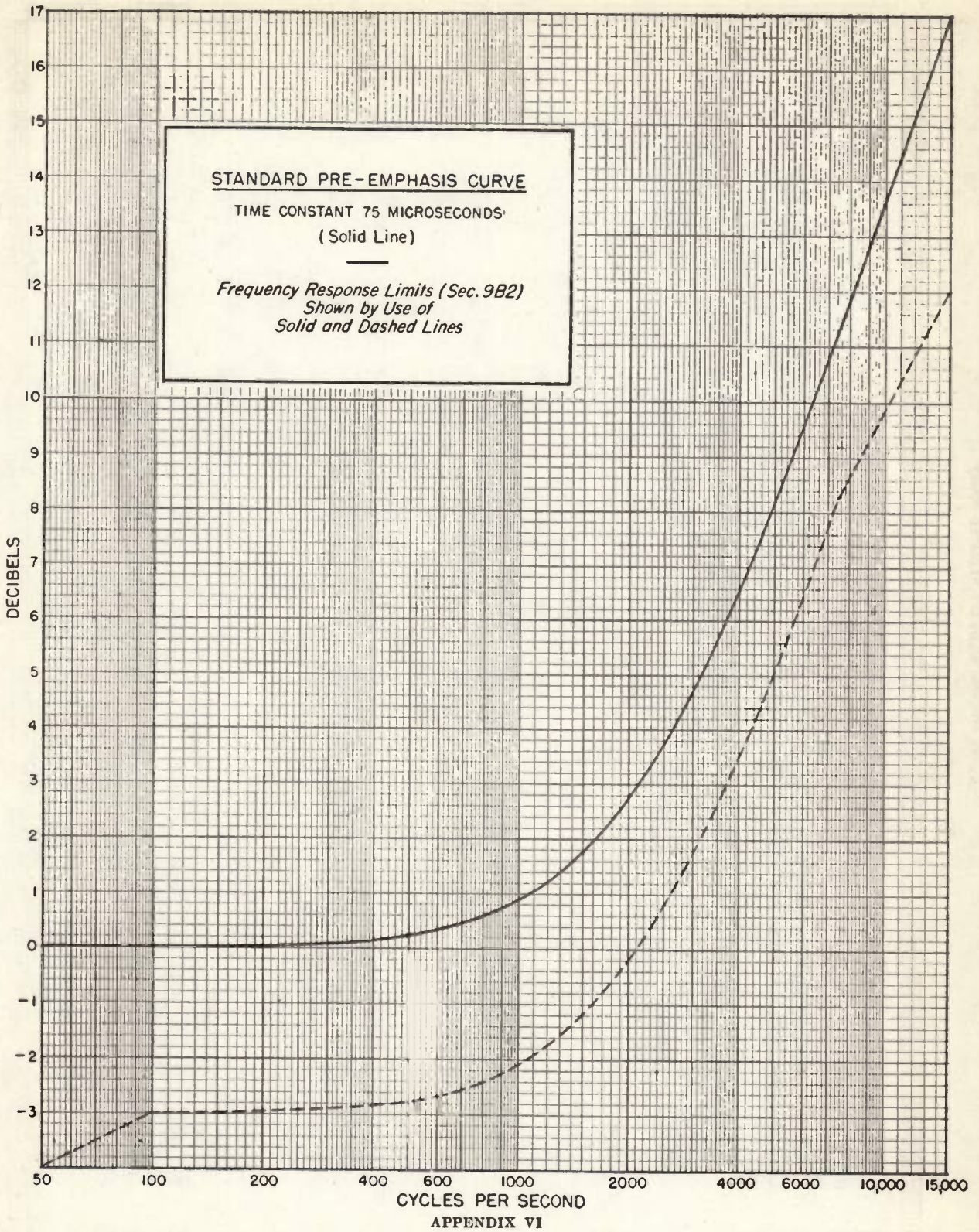
APPENDIX IV
FIGURE 8



GROUND WAVE SIGNAL RANGE FOR TELEVISION

195 mc, $\sigma = 5 \times 10^{-14}$ e.m.u., $\epsilon = 15$, RECEIVING ANTENNA HEIGHT 30 FEET
FOR HORIZONTAL (AND APPROX. FOR VERTICAL) POLARIZATION

APPENDIX IV
FIGURE 4



APPENDIX VI

U. S. GOVERNMENT PRINTING OFFICE: 1948