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A METHOD OF DETERMINING THE MINIMUM ALLOWABLE DISTANCE OF POWER LINES FROM AIRPORT BOUNDARIES FOR NOISE-FREE RADIO RECEPTION

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SUMMARY

A definite and reliable method of obtaining standards regulating the location of high-voltage power lines in airport approach zones is essential when the construction of new airports and new transmission lines is considered or when the modernization of existing facilities is attempted. The amount of information available for the preparation of standards is very limited. This discussion, therefore, deals with a method of arriving at standards that will provide noise-free radio reception within the approach area rather than the establishment of requirements for immediate use. While the minimum allowable distance of 220-kilovolt lines from airport boundaries is shown, it is included only to indicate that reasonable conclusions may be reached.

INTRODUCTION

Considerable difficulty has been encountered in the preparation of standards and regulations relative to the location of power lines within airport approach zones in order to provide noise-free reception aboard aircraft within the approach zones. This difficulty is due to the fact that very little information is available relative to the noise radiation from various types of power lines and the actual radio signal strengths provided in the approach areas. Previous standards adopted by the Civil Aeronautics Administration regulated the placement of power lines according to the voltage of the line; that is, the higher the voltage of the line the farther it had to be located from the airport boundary. These standards are included in a Civil Aeronautics Administration pamphlet entitled, "Standards for Location of Overhead Transmission Lines in the Vicinity of Landing Areas and Radio Range Stations."

During tests made by the electrical industry, it was found that the voltage of the line was not the only factor to be considered in the regulation of power-line noise interference to radio reception. Actually, the modern high-voltage lines tested gave less interference than some of the lower voltage lines of different construction. One of the tests made on the Washington-Baltimore 220-kilovolt line was witnessed by members of the Civil Aeronautics Administration and the Federal Communications Commission. During this test, data were presented from this and other tests which proved that the amount of noise from power transmission lines was usually dependent on the type of construction used where all types of lines were considered. However, newly constructed lines incorporating all new materials and methods available to the art were all found to be extremely quiet. No tests, however, were made during precipitation, and further tests would be required to provide conclusive evidence.

A report by the electrical industry late in 1940 showed that power-line noise interference decreased rapidly with increasing

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radio frequencies and with increasing distances from the line. It was indicated in this report that the noise at ultra-high frequencies was not measurable on the equipment used. Although it was found that existing standards were not applicable and that noise from the newer type lines was very low, no method was suggested for future standards.

DISCUSSION

At the time the foregoing tests were made, it appeared that the proper method of arriving at the desired standards was to start with the actual field strength provided by the various radio facilities at various positions in the approach area. Accordingly, field strength curves were calculated and collected for the frequencies used for ground-to-aircraft communication and for aircraft guidance. Actual field strength measurements made by the Administration were available for airport traffic control facilities, and radio range attenuation characteristics were available in Technical Development Report No. 4 entitled, "Geographical Separation of Radio Range Stations on the Same or Adjacent Frequencies in the 200-400 Kc Band." Attenuation characteristics in the band from 3 to 5 megacycles were obtained from a paper by K. A. Norton, in the October 1936 issue of the Proceedings of the Institute of Radio Engineers entitled, "The Propagation of Radio Waves Over the Surface of the Earth and in the Upper Atmosphere." The characteristic of the instrument landing glide path facility was calculated from information contained in a paper by J. S. McPetrie and J. A. Saxton entitled, "An Experimental Investigation of the Propagation of Radiation Having Wavelengths of 2 and 3 Meters," in the August 1940 issue of the Journal of the Institute of Electrical Engineers.

All attenuation characteristics are plotted in figure 1. These curves show the attenuation that may be expected where poor ground conditions exist and with the transmitter power that is normally used for each facility. While the power of transmission may vary considerably under the various existing conditions throughout the country, the power for which the curves were computed is believed to be the nearest approach to average conditions. It is also known that the transmitting antenna characteristics vary widely in different installations in the aircraft communications band and that this condition will cause the attenuation characteristics to vary from those plotted. It is felt that consideration of the airline communications band is particularly important in this determination, since airline operators have reported more interference in this band than at any other of the frequencies used. Distances beyond ten miles were not considered, in order to eliminate the effects of substantial reflections from the ionosphere.

A survey of figure 1 indicates that the minimum signals encountered for distances up to 3.6 miles will be those of the airport traffic control facility on 278 kilocycles. Beyond this point the minimum signals will be those of the aircraft communications facilities, particularly on the higher frequencies in the neighborhood of 5 megacycles. There is a possibility that in some cases

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where the radio range installations are located at some distance from the airport these signals may be lower in intensity than those of the airport traffic control. However, this condition has never been observed in actual flight.

In figure 2, the curve labeled "minimum signal encountered" has been plotted as a combination of the signals from either traffic control or aircraft communications facilities, whichever provide the lower signal. From this curve, another similar curve has been plotted which is 20 decibels lower than the minimum signal obtained, and shows the maximum noise of any nature that is allowable for good aircraft reception. A third curve has been plotted allowing one-half of the amount permitted by this maximum noise curve for power-line noise.

The maximum allowable power-line noise characteristic has been replotted in figure 3 against distance from the airport boundary rather than from the transmitter station as in figure 2. In making this transfer it was considered that the transmitter would always be located at least one mile from the approach boundary. This condition, of course, will not actually hold for all approaches at any one airport but will at least provide minimum operating conditions.

It was considered that the maximum power-line noise obtained from figure 3 would be that allowed along the lowest glide angle that could be used at any airport. Since the lowest possible glide is considered to be at instrument landing approaches where a clearance of 40 to 1 is available, this condition was chosen and plotted in figure 4.

A combination of figures 3 and 4 will provide data to show the maximum noise that can be permitted on the glide path. However, it would be difficult to measure this noise, since the distance from the power line is continually changing. In order to clarify this situation, a group of curves were plotted in figure 5 which show the actual noise that could be allowed at a horizontal distance of 50 feet from lines of three different heights. It was considered that a low-voltage line could be placed very close to the ground (less than 20 feet high) and this curve is labeled "ground line" on figure 5. Although the data obtained from these curves will be the allowable noise at a horizontal distance of 50 feet from the line, the actual angular distances from the lines would be 50 feet, 70.7 feet, and 112 feet from the ground line, the 50-foot line and the 100-foot line respectively. These values were used in the preparation of the information shown in figure 5. In making the corrections for the 50-foot distance, it was assumed that the actual power-line noise varied as $1/d^2$. This is a close approximation although actual measurements seem to indicate varying degrees of attenuation. Actual noise conditions on the Conowingo-Plymouth 220-kilovolt line are shown in figure 6, as reproduced in the report of the electrical industry.

From the data available it was estimated that the amount of noise radiated from a 220-kilovolt power line 50 feet in height would be approximately 200 microvolts per meter at a horizontal distance of 50 feet from the line. Similarly, it was estimated that the noise radiated from a 220-kilovolt line 100 feet in height would be approximately 80 microvolts per meter as measured at a horizontal distance of 50 feet from the line, the difference in radiated noise being due to the difference in actual distance from the 50-foot point to the line, because of the different elevations. Three lines having identical construction details were considered in making the estimates of noise radiation. These estimated values are somewhat lower than the value of noise radiation as measured on the Powerton-Crawford 220-kilovolt line which passes near the Chicago Airport. Measurements made on this line are shown in an article by Oldacre, Wollaston and Grosser entitled, "Powerton-Crawford 220-Kv. Line, Part II," in the February 1941 issue of Electrical World.

CONCLUSION

The curve shown in figure 7 was obtained from the estimated values of noise radiation. This curve shows the minimum distance from airport boundaries of 220-kilovolt power lines with regard to the area within the approach zone. With more data on the various types of lines it is believed that a family of curves similar to the one shown in figure 7 may be plotted to show the restrictions for all types of lines now being used. Only 220-kilovolt lines have been considered in figure 7, because this is the only type of line for which noise data are available. However, curves for other types of lines may quickly and easily be added to figure 7, as data become available.

It should be pointed out that the data used in arriving at the results shown in figure 7 are principally calculated or estimated values. It is concluded, however, that the restrictions resulting from the application of existing power-line noise radiation data to the maximum allowable noise curves of figure 5 are reasonable and that the method is suitable for the preparation of regulatory standards when sufficient noise and signal radiation data are obtained.

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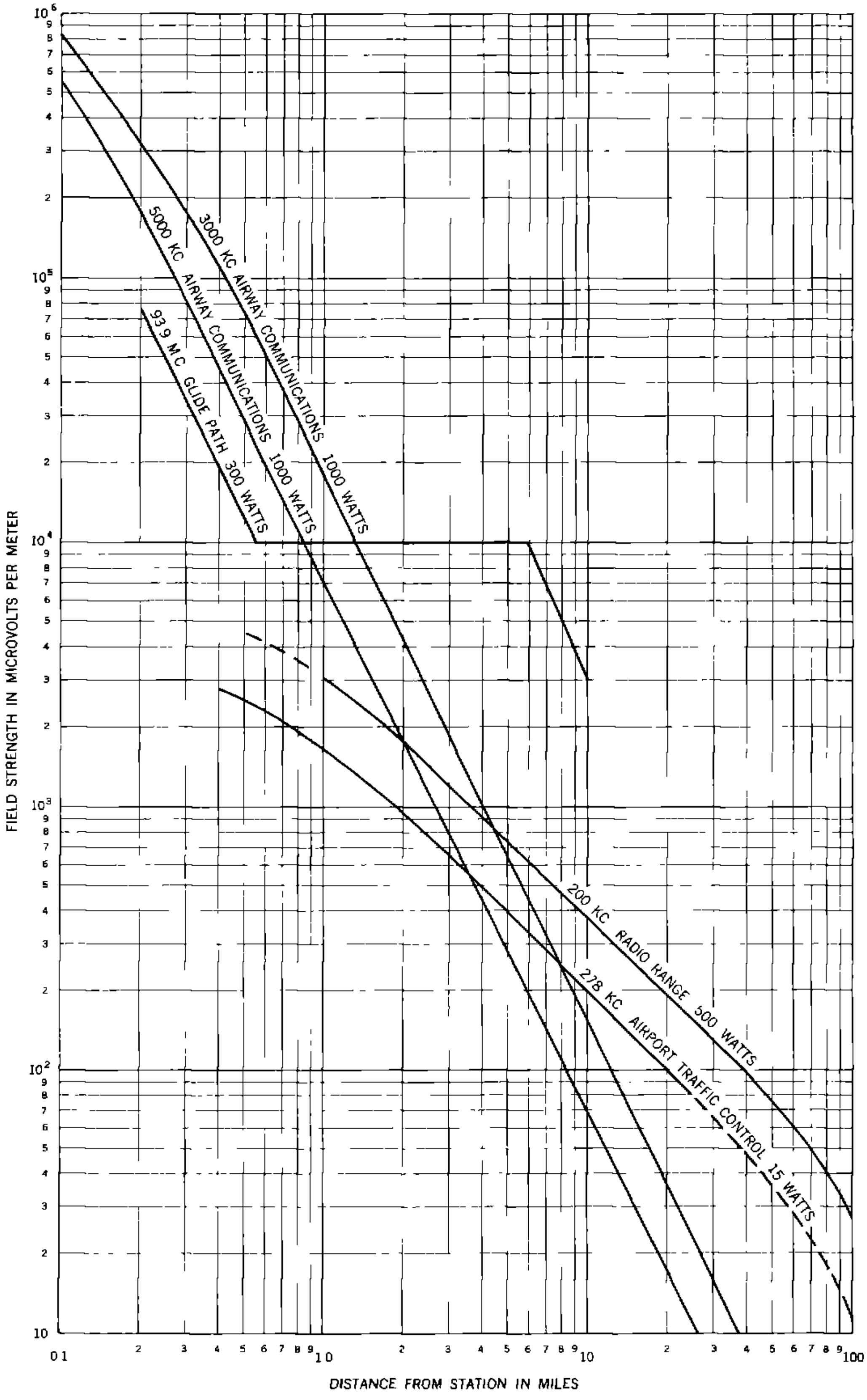

FIGURE 1 Attenuation of Airway Radio Facility Signals

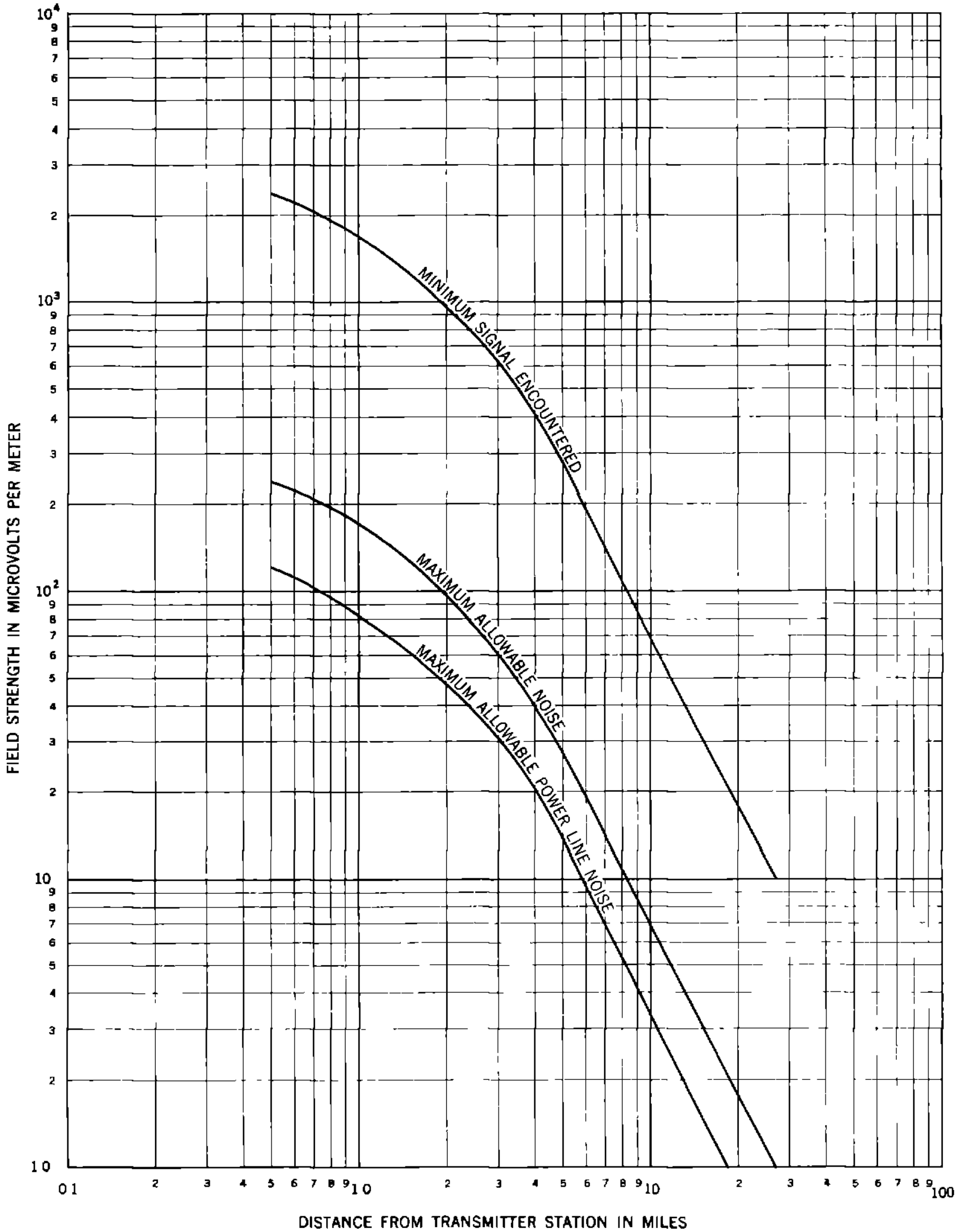

FIGURE 2 Minimum Signal Encountered and Maximum Allowable Noise

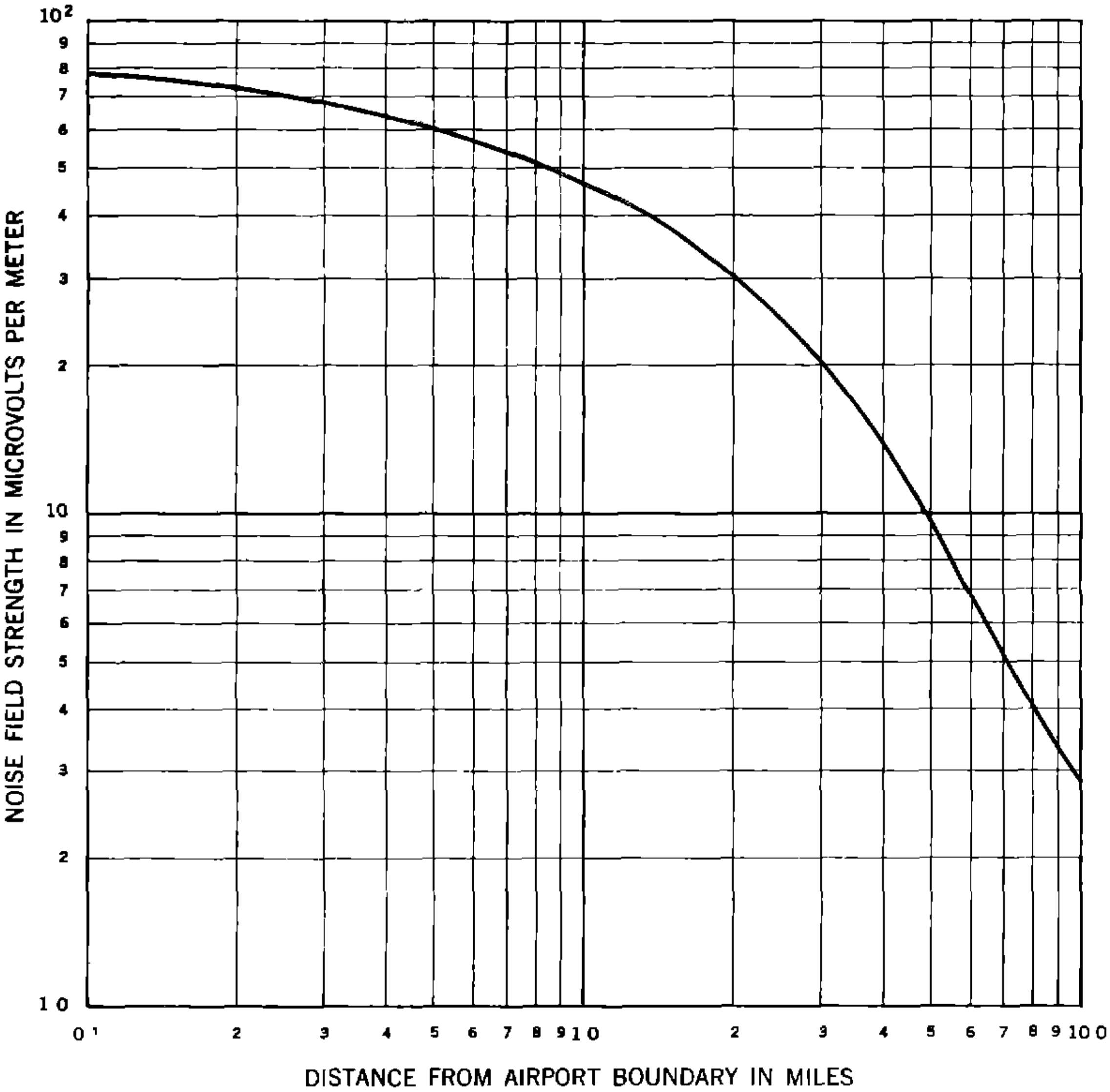

FIGURE 3 Maximum Allowable Power-Line Noise Along a 40 to 1 Glide Angle.

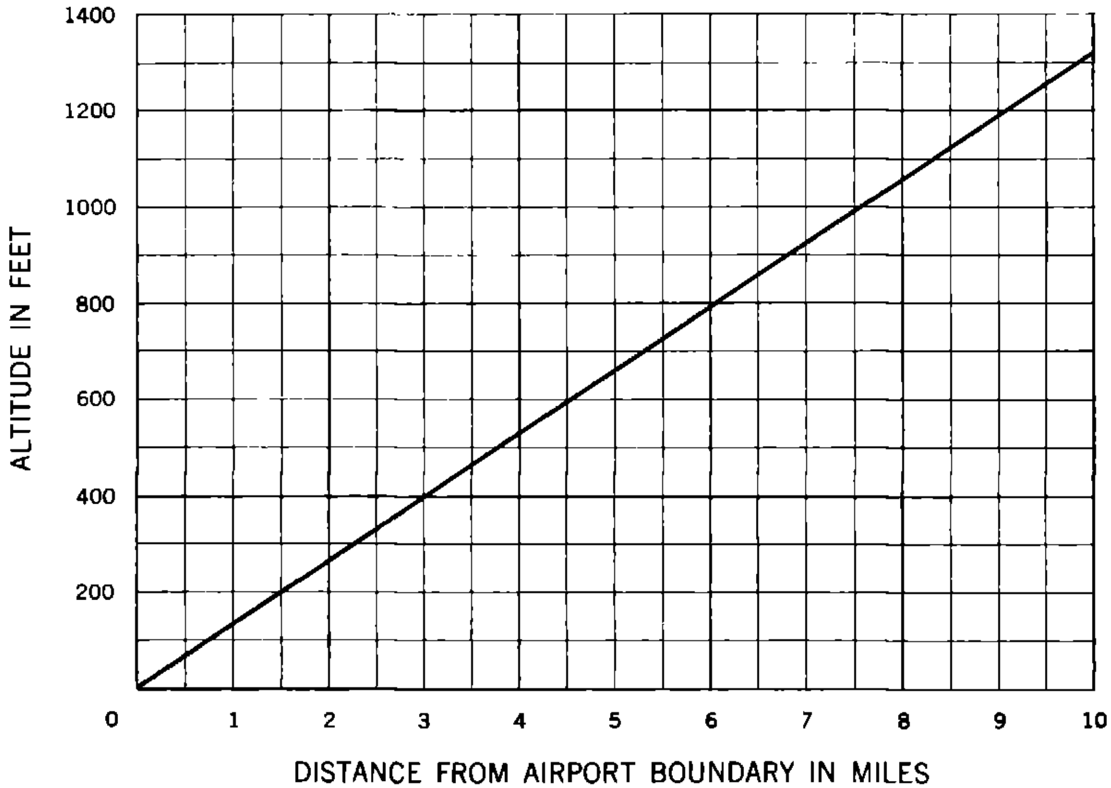

FIGURE 4. Minimum Glide Angle.

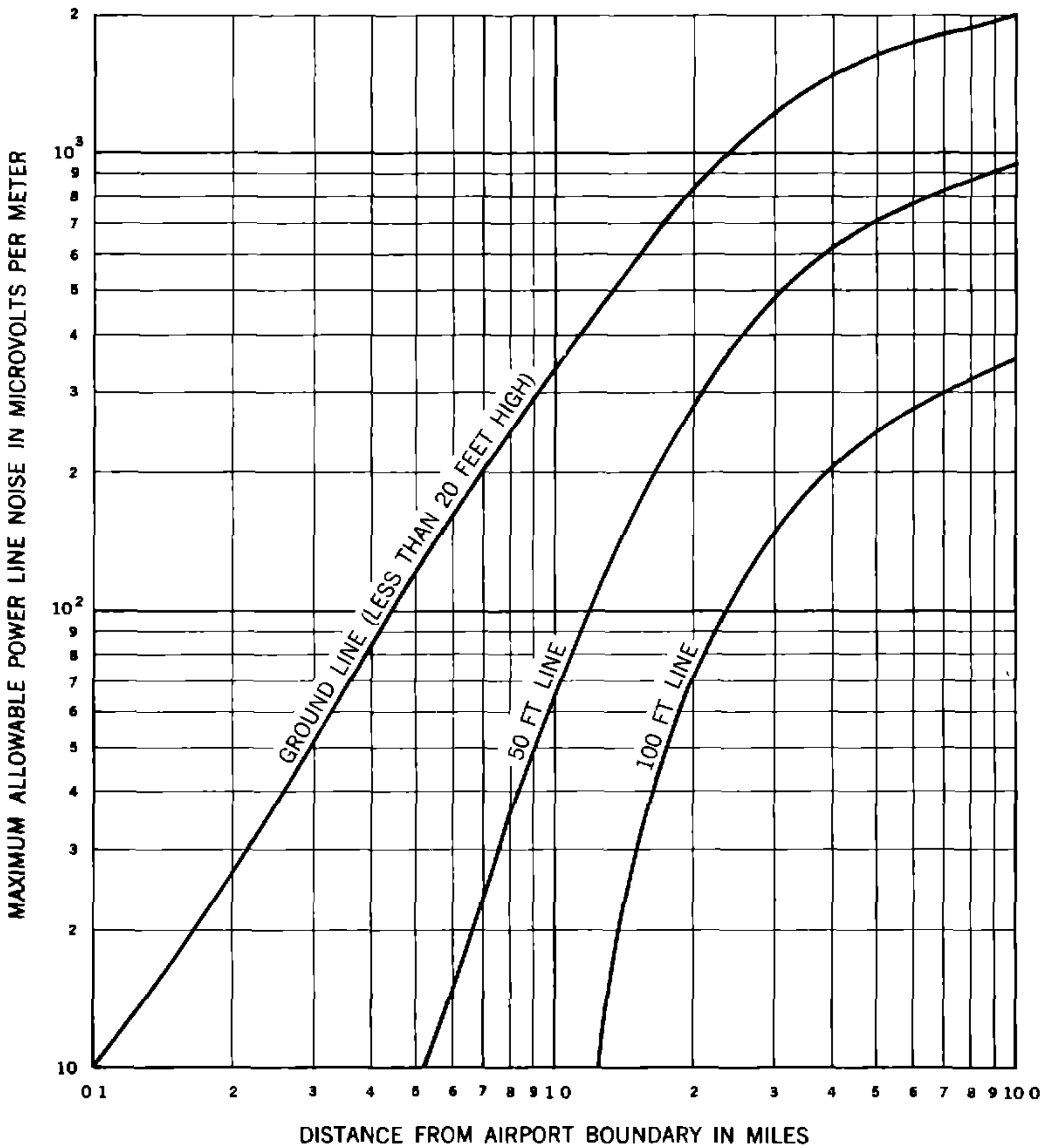

FIGURE 5. Maximum Allowable Power-Line Noise in Approach Areas at a Horizontal Distance of 50 Feet Measured Perpendicular to the Power Line.

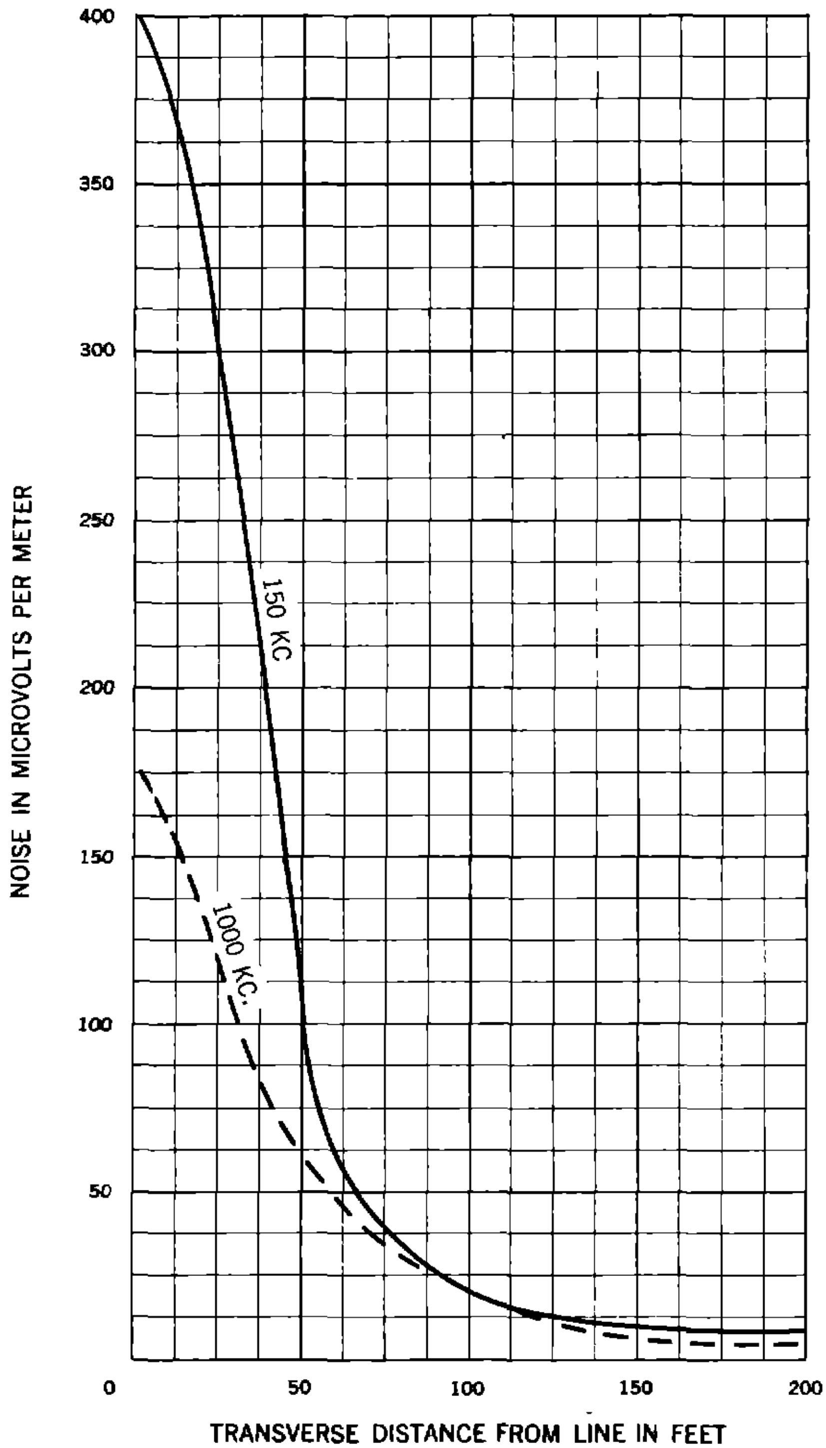

FIGURE 6. Attenuation of Power-Line Noise at 150 and 1000 Kilocycles on the Conowingo-Plymouth 220-Kilovolt Transmission Line.

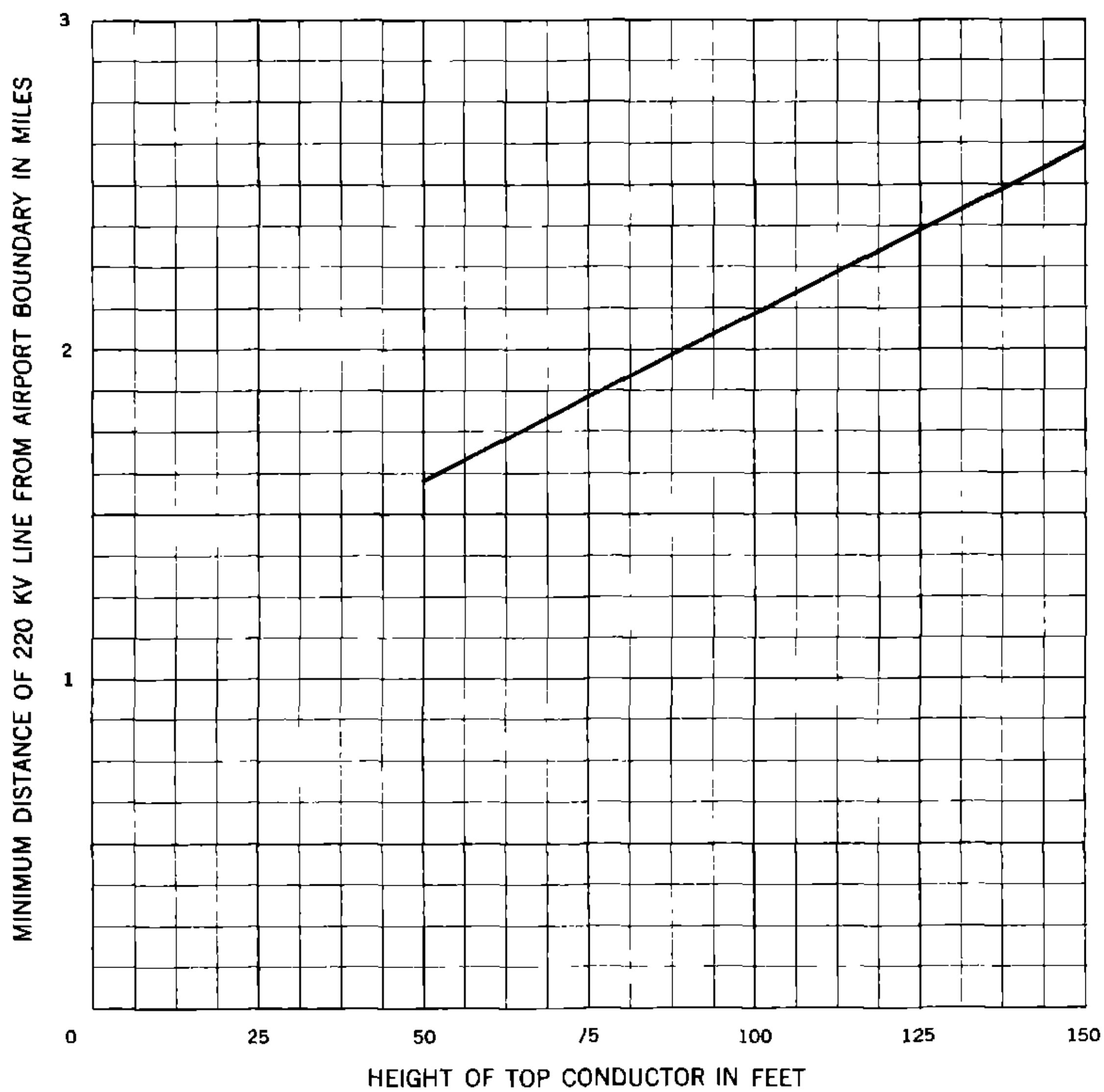

FIGURE 7. Minimum Distance of 220-Kilovolt Transmission Lines in Approach Areas from Airport Boundaries Based on Data Obtained on the Conowingo-Plymouth Line