*Proceedings of the Institute of Radio Engineers*
*Volume 23, Number 5* *May, 1935*

# SOME DATA CONCERNING THE COVERAGE OF THE FIVE-MEGACYCLE STANDARD FREQUENCY TRANSMISSION*

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***Summary***—*Beginning in January, 1931, the Bureau of Standards has transmitted a standard frequency of 5000 kilocycles per second each Tuesday for two hours during the day and two hours at night. These transmissions have for their purpose the furnishing of an accurately known frequency to the public. They are used especially for calibrating the frequency standards of the field offices of the Federal Radio Commission and engineering and testing laboratories. At the request of the Bureau reports were sent in showing how satisfactorily the transmissions were received at many places in the United States. A study of about 2900 reports was made, covering a period of about two years during which a 1-kilowatt transmitting set was used. This transmitter has since been replaced by a more powerful one. The weekly reports indicated that at some time during the weekly transmission periods, satisfactory reception was obtained at all localities reporting, except when prevented by electrical storms or electrical interference.*

## I. INTRODUCTION

FOR more than ten years the Bureau of Standards has transmitted standard frequency signals. Beginning January 6, 1931, the Bureau has transmitted a standard frequency of 5000 kilocycles per second each Tuesday for two hours during the day and two hours at night. The endeavor has been to furnish this service so that frequency standards located at any place in the United States might be checked conveniently by comparison with these transmissions. One purpose among others was to furnish standard frequency service to the Federal Radio Commission's radio inspectors located in a number of the large cities. In order to find out how well the transmissions were received throughout the country, in 1931 requests were made of several Government departments and others to send reports to the Bureau describing reception of these transmissions. About 2900 reports were received, covering reception of the small 150-watt transmitter used at first and the 1-kilowatt transmitter used until April, 1933. A 30-kilowatt transmitter[1] has been used for the transmissions since April,

* Decimal classification: R555. Original manuscript received by the Institute, March 26, 1934. Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

[1] The radio transmitting sets used for the transmissions are described in the paper, by L. Mickey and A. D. Martin, "Development of standard frequency transmitting sets," *Bur. Stan. Jour. Res.*, vol. 12, p. 1; January, (1934). RP630.

1933, but this paper includes data only on the transmissions with the earlier 150-watt and 1-kilowatt transmitters.

The most widespread set of reports were those submitted by the former Airways Division, Bureau of Lighthouses, Department of Commerce, as furnished by the radio operators at the various Airways radio stations. The Airways Division reports cover a period from February, 1931, through March, 1932, except for the months of May and June, 1931. Many reports were received from Army and Navy stations located at various points in the United States. The reports, including some from commercial organizations and from individuals, give considerable data on the reliability of reception and the distance range of reception for the 5000-kilocycle transmissions when a transmitter with a power output of not more than 1 kilowatt was used.

The data which have been assembled cover a period from January, 1931, to December, 1932, during which time the standard frequency station was located at College Park, Maryland, eight miles northeast of the Bureau's main laboratory. While the data do not cover this period as completely as might be wished, yet taken as a whole they give interesting information. During the period covered there were 180 transmissions of two hours each.

The hours of transmission were changed somewhat during this period. The transmissions were made at the following times:

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|---|---|
| January to June, 1931, | 1:30– 3:30 P.M.<br>8:00–10:00 P.M. |
| July to October, 1931, | 2:00– 4:00 P.M.<br>10:00–12:00 midnight |
| October, 1931, to April, 1932, | 2:00– 4:00 P.M.<br>8:00–10:00 P.M. |
| April, 1932, to October, 1932, | 2:00– 4:00 P.M.<br>10:00–12:00 midnight |
| October, 1932, to April, 1933, | 10:00 A.M.–12:00 noon<br>8:00–10:00 P.M. |

The interpretation of the hundreds of reports received was difficult, in that no two observers described the reception conditions in the same way. Some observers gave comments on weather conditions, for example, and omitted an estimate of the relative intensity of the reception. Such reports were accordingly of no value in determining even the relative intensity of reception for that date at that location. The reports were tabulated after an effort was made to express them in the

same terms. In order to do this a method similar to the FRAME quality-of-signal code of the Radio Corporation of America was used, with some changes and additions.

## II. Results

1. *Relative Intensity.* Approximately 2900 reports were received from 80 points in the United States. In many cases the reports were not complete or numerous enough to furnish full data for the 23-month period. The reports were assembled and the relative received intensity for day and night reception, on a scale of 1 to 9, were plotted for each locality for all transmissions reported. In this manner it was usually evident whether a day transmission or a night transmission was received with greater intensity. In some cases the two transmissions were received equally well. These data, when plotted on a map of the United States, showed some sections reporting best reception in the day, other sections reporting best reception at night, and other sections reporting no difference in day and night reception. Reports were not received from enough localities, however, to determine these different areas with any exactness.

The data indicate that the following general statements may be made. The strongest daytime reception was observed in an area having a radius of about 500 kilometers (or 300 miles), although reception suitable for frequency measurements was obtained during the day up to a distance of about 800 kilometers (500 miles). Points beyond obtained best reception at night.

The data do not show any changes in the above general statement with respect to season. This may be due in part to the method of averaging the data for the two-hour periods, and to the fact that some of the data submitted cover only a portion of the two-hour period. For example, the transmission may have been observed for fifteen minutes, during which time a strong signal was heard and was reported accordingly; an hour later the signal might have been much weaker, which if taken into account would have given a lower signal intensity number to plot for that transmission. However, all the data submitted were used, in order to have as complete a picture as possible of the peculiarities of these transmissions noticed at various points.

2. *Fading.* The data submitted regarding the fading experienced on the 5000-kilocycle transmissions were averaged in the same manner as the data on relative received intensity. The data were then plotted, on a scale of 1 to 9, for day and night for the various transmissions. These charts were then examined to see which localities showed less fading in the daytime, and which at night. A few localities were found

where the data indicated no marked difference in fading between day and night. These various points, when plotted on a map, showed even less definite area boundaries than those for relative intensity previously mentioned.

Most of the eastern quarter of the United States experienced less fading during the day transmissions than at night. Less fading was experienced at night in the Mississippi River Valley and west thereof (although very scant data were available from farther west because the signals could not be heard during the day). The locations from which the most data were submitted showed no variation in fading with respect to season.

3. *General Discussion.* The other information sometimes given in the reports, regarding musicality of note, atmospheric disturbances, interference, and use for measurement, amplified the reports and in some cases explained why the transmission was not successfully heard.

A number of interesting features were brought out in the study of the data. In the western part of the country the received intensities increase as the two-hour evening period progresses. During part of the year the beginning of the transmissions sent from 8 to 10 P.M., E.S.T., reached the west coast about the sunset hour there, with the result that during the first half hour of the transmission the standard frequency signals could not be identified, but the intensity of the signals increased to a maximum during the remainder of the time. This result would be expected. In the eastern part of the country, in general, the received intensity is approximately constant during the two-hour evening period. In a few cases, however, the intensity decreased in the latter part of the period, the reverse of the condition noted in the western part of the country; this may perhaps be attributed to a combination of circumstances including changes in the ionosphere layers, and differences in the angles of incidence of the waves on these layers.

The data show no evidence of a "skip" distance for the times at which the transmissions took place. This is in agreement with most previously published information on the subject,[2,3] although Ladner and Stone[4] present curves showing a skip distance for 5000 kilocycles of about 500 kilometers (300 miles) for late night. Data were available from six cities at distances between 465 and 528 kilometers from the transmitter. Night transmissions were not heard at Williamsville, N.Y. (480 kilometers), one evening in October, one evening in No-

[2] Chester W. Rice, "Short-wave radio transmission and its practical uses," *QST*, vol. 11, p. 8; July, (1927); vol. 11, p. 36; August, (1927).
[3] "The Radio Engineering Handbook," p. 442, (1933).
[4] "Short-Wave Wireless Communication," p. 48, (1933).

vember, 1931, and one evening in March, 1932. Serious interference was responsible for the latter failure to hear the transmissions from 8 to 10 P.M. Some interference and atmospherics were present on the other two evenings. Observations were made but one day per month there. Reports received for March and July, 1931, from Williamsville, showed that the night transmissions were received with greater intensity than the day transmissions.

Weekly reports from Columbus, Ohio (528 kilometers), indicated that with but few exceptions the day transmissions were received with greater intensity than the evening transmissions. The failure of two evening transmissions to be heard satisfactorily could be attributed to atmospherics. Reports from Albany, N.Y. (490 kilometers), were similar to those from Columbus. A limited number of reports from Buffalo, N.Y. (465 kilometers), showed little difference between night and day transmissions, while reports from Schenectady, N.Y. (495 kilometers), and Cleveland, O. (483 kilometers), showed better night reception than day reception.

There is accordingly little evidence in the data to substantiate a skip distance for 5000 kilocycles.

## III. Conclusions

An analysis of the reports shows that the transmissions from the 1-kilowatt transmitter were not receivable at all times throughout the whole of the United States, but that during some portion of the transmission periods reception was possible at each locality except when prevented by unusual atmospherics or electrical interference. The latter condition prevails in some of the large cities and adds to the difficulty of any radio reception. This emphasizes the value of the higher powered transmitter installed by the Bureau of Standards subsequent to the period covered by these tests.

A section of the country within about 500 kilometers (or 300 miles) of the 1-kilowatt transmitting station was found to receive the strongest signal during the day. The greater part of the country received the strongest signal at night. Most of the eastern quarter of the United States experienced less fading during the day than at night.

No clear evidence of a skipped area was found.

## IV. Acknowledgment

This opportunity is taken to thank the many observers who sent reports on the reception of the 5000-kilocycle transmissions, thus assisting in making the transmissions more useful. Thanks are particu-

larly due to the following organizations for the large number of reports submitted: the American Telephone and Telegraph Company; the Radio Corporation of America; the former Airways Division, Bureau of Lighthouses, Department of Commerce; the former Radio Division, Department of Commerce; the Navy Department, and the War Department.