Report No. 19

<u>Title</u> Second Interim Report on Medium Frequency Sky Wave Measurements.

Prepared by J. M. Dixon - April, 1959.

D McDonald
(D. McDonald)
Director
Technical Services Division

Date of issue
20/10/1959

SECOND INTERIM REPORT ON MEDIUM FREQUENCY SKY WAVE MEASUREMENTS

1. Introduction

The success achieved by any Administration or broadcasting organization in planning a medium frequency service, depends upon the accuracy with which ground wave field strengths, sky wave field strengths and noise levels are predicted. This report deals with medium frequency sky wave field strength values, reliable estimates of which are needed to predict the extent of night time secondary service areas and also to determine the degree of interference caused by common channel and adjacent channel stations.

In order to ascertain the extent to which northern hemisphere medium frequency sky wave results(1) could be applied under Australian conditions, a series of measurements was begun at Melbourne in March, 1953, with weekly sky wave field strength recordings of several clear channel transmissions.

At the time it was known that sky wave field intensities varied over the sunspot cycle(2) but little information was available to show the extent of this variation in the southern hemisphere and the consequent effect on medium frequency service areas.

The first phase of these tests extended over the 1953-54 sunspot minimum period when average results were between 1 db and 7.5 db above those anticipated. Field strength recordings for a path of 400 miles showed peaks in the plot of weekly results occurring during periods of lowest sunspot activity while the results measured at 800 miles showed no significant correlation. Apart from this peculiarity the expected trend of decreasing field strength with decrease in sunspot number was evident in monthly average values, the monthly average sunspot number not exceeding 30.

Second Phase of Recording Programme

The recording programme was extended to Brisbane and Perth early in 1955, the results considered in this report being those obtained up to May, 1958.

Recordings made at Melbourne and Brisbane cover a three hour period from 1930 hours to 2230 hours E.S.T. while those made at Perth cover a two hour period from 1900 hours to 2100 hours W.A.T.. Values exceeded for 10% of the time over an interval of 1½ hours are taken centred whenever possible on the second hour after sunset. Table 1 shows the stations recorded.

..2/.

Table 1

Station	Power kw	Location	Frequency Kc/s	Recorded at	Period	Distance miles	Ed. mV/m. mile
2GZ	2	Orange	990	Melbourne	March 1953-April 1954 Jan. 1955-May 1958	392	245
2CR	10	Cumnock	550	Melbourne	March 1953-April 1954 Jan. 1955-May 1958	400	600
4AK	2	Oakey	1,220	Melbourne	March 1953-April 1954 Jan. 1955 -May 1958	820	272
4QR	10	Brisbane	590	Melbourne	Nov. 1956-Aug. 1957	875	712
4SB	2	Kingaroy	1,060	Melbourne	March 1955-Feb. 1956	890	256
4RK	10	Rockhampton	840	Melbourne	April 1956-May 1956	1,060	712
3KZ	0.6	Melbourne	1,180	Brisbane	April 1955-Feb. 1956	875	192
2GZ	2	Orange	990	Brisbane	April 1955-Feb. 1956	480	245
2CR	10	Cumnock	550	Brisbane	April 1955-Feb. 1956	460	600
4QR	10	Brisbane	590	Perth	March 1955-Oct. 1955 May 1956-Oct. 1956 March 1957-April 1957	2,260	712

3. Measuring Equipment

A ten metre vertical aerial, communications receiver type AR88, signal generator, DC amplifier and recording milliammeter comprised the receiving equipment used at the respective P.M.G. radio receiving centres. This equipment was calibrated for the transmission frequencies by measuring the noon field strength of selected stations which were as close to the transmission frequency as possible and gave the same order of field strength as the station being measured. R.C.A. field intensity set type WX2B was used to measure the field strength a short distance from the receiving aerial in order to calibrate the output of the signal generator, which when substituted for the receiving aerial, provided a calibration for the recordings.

4. Field Strength Variation with Sunspot Activity

Sky wave field strength may vary greatly even over as short a period as 2 minutes. The maximum values over an evening will usually be of the same order but may vary from week to week and from year to year.

Field strength values exceeded for 10% of the time have been plotted against sunspot number, and mean values obtained over sunspot number intervals of about 20. These mean values are given in figures 1 and 2 which show a common characteristic with a maximum mean 0.9 times the inverse distance value at a sunspot number of about 30.

Above sunspot number 80 there is in general little correlation between sunspot number and field strength, the mean 10% figure in this range being about 0.5 times the inverse distance value.

The following exceptions are to be noted -

(a) In the case of 2GZ recorded at Melbourne there is a second maximum with mean 10% values exceeding 0.75 times the inverse distance value between sunspot number 120 and 210.

(b) Results for the 2260 mile east-west path of 4QR recorded at Perth show a reduction of 20 db at sunspot number 100 from the maximum mean 10% value of 0.2 times the inverse distance value at low sunspot numbers.

Table 2 shows the spread of 10% values about the mean plotted in figure 1.

Table 2

Station	Recordings made when sunspot number is less than 60		Recordings made when sunspot number is greater than 80	
	Relative 10% field strength exceeded by 10% of recordings	Relative 10% field strength exceeded by 90% of recordings	Relative 10% field strength exceeded by 10% of recordings	Relative 10% field strength exceeded by 90% of recordings
2GZ	1.44	0.35	1.17	0.30
2CR	1.33	0.40	0.83	0.17
4AK	1.33	0.42	0.75	0.24

5. Variation with E layer Critical Frequency

Although there is little correlation between sunspot number and sky wave field strength during the period of high sunspot activity, weekly skywave plots continue to show an orderly pattern suggesting a related variable. A search for this variable showed that during the period commencing February, 1956, there exists a significant correlation between sky wave field strength and E layer critical frequency(3). Noon values of the vertical incidence E layer critical frequency at Canberra a used since no information is available for f_oE after sunset.

The correlation coefficients obtained are -

2GZ - 0.49 for a sample of 60

2CR - 0.42 for a sample of 80

4AK + 0.38 for a sample of 69

The probability of such a correlation coefficient occurring by chance is less than 1%.

It is therefore concluded that the type of variation in field strength with change in E layer critical frequency depends upon the transmission distance, but the limited number of observations for different path lengths and frequencies does not permit a complete characteristic to be determined.

Despite this lack of data, likely combinations of the variables have been tested for a possible common characteristic on the assumption that the value of f_oE after sunset is partly related to the noon value. A plot of relative field strength as a function of $\frac{f}{f_oE \sec \phi}$ shows the results to be consistent with a common characteristic which gives a reflection coefficient varying in a cyclic manner. The data is also consistent with a common characteristic given by a plot of relative field strength as a function of $f_oE \sec \phi$ which is independent of transmission frequency except perhaps at short distances.

6. Conclusion

An analysis of the recordings made from March, 1953, to May, 1958, shows that for distances of 400 to 800 miles in the north south direction and frequencies in the range 550 kc/s - 1220 kc/s there is a common characteristic in relation to sunspot numbers in the range 0-80, but for sunspot numbers exceeding 80 there is in general little correlation between sunspot number and field strength. The mean value of the 10% sky wave field strength varies from 0.9 to 0.5 times the inverse distance value in the sunspot number range 0-80.

Recordings of field strength for transmission over a 2,260 mile path in the east west direction show a variation in the mean 10% sky wave figure from 0.2 to 0.02 times the inverse distance value in the sunspot number range 0-100.

Significant correlations have been found between the noon value of f_oE and the sky wave field strength when the monthly average sunspot number exceeds 80. The nature of this variation in field strength is found to depend upon the transmission distance.

References

1. Federal Communications Commission - Rules and Regulations Part 3 1956.

2. Changes in Ionization and Radio Reception during the Sunspot Period 1944-1947. Journal of Terrestrial Magnetism, 1948.

3. Ionospheric Predictions Series D and W Prepared by Ionospheric Prediction Service of the Commonwealth Observatory.

4. First Results of a Campaign of Field-Strength Observations Organized by the E.B.U.
Doc. 327E VIIth Plenary Assembly C.C.I.R. London 1953.

5. Interim Report on Medium Frequency Sky Wave Measurements - Report No. 13 Australian Broadcasting Control Board. (Also doc.77 C.C.I.R. Plenary Assembly Warsaw 1957)

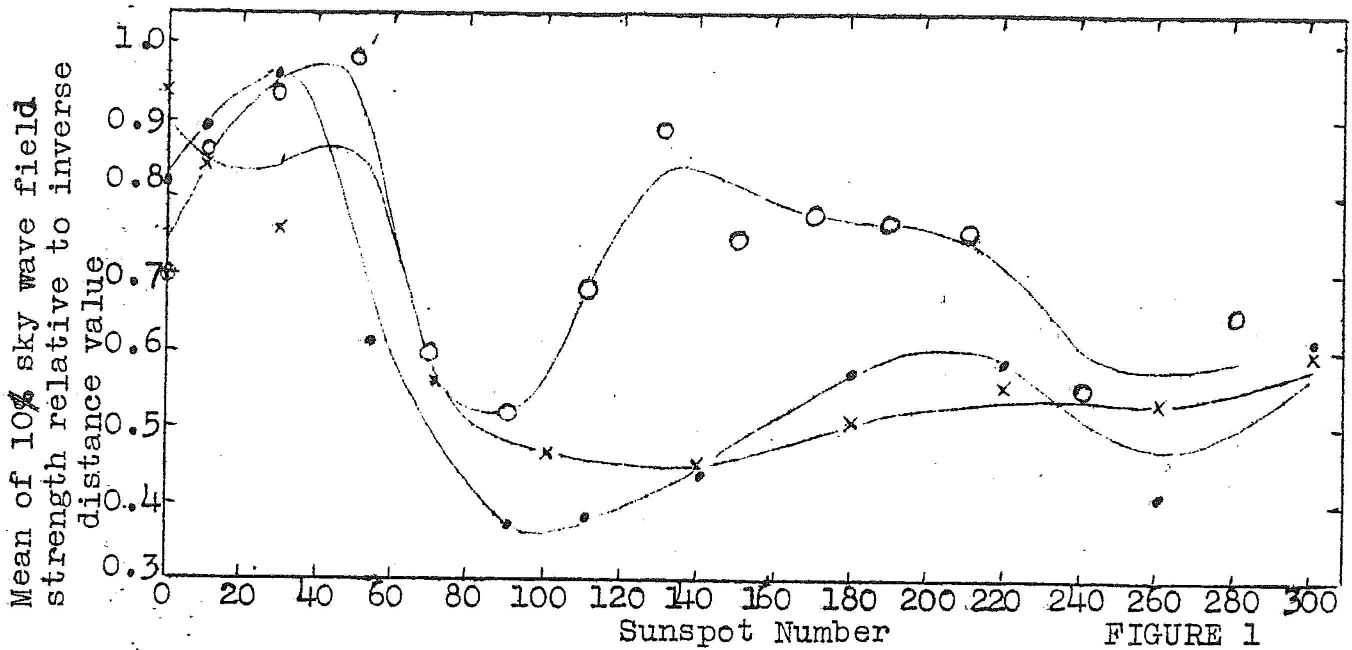

FIGURE 1

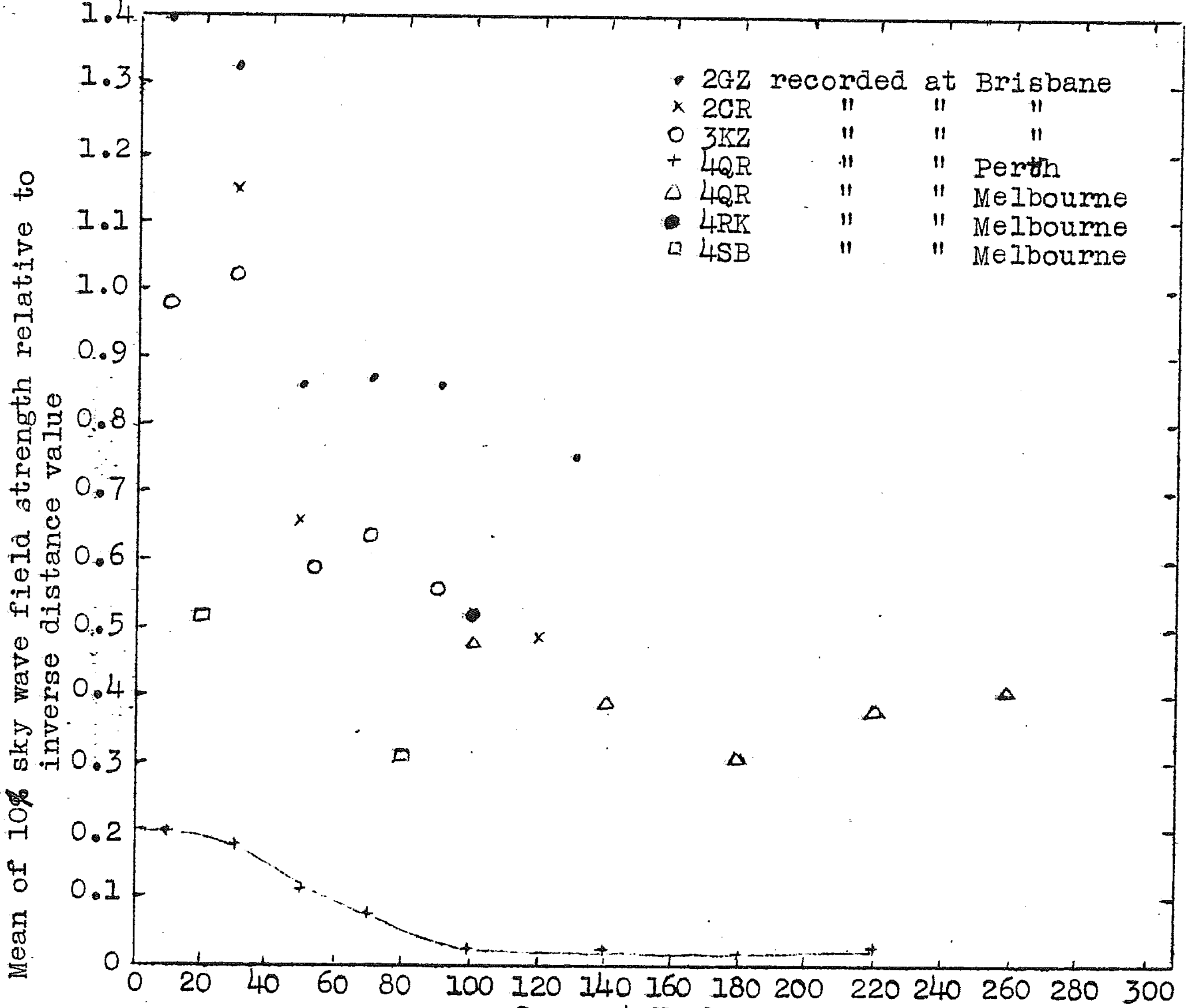

FIGURE 2