COMMONWEALTH OF AUSTRALIA

# AUSTRALIAN BROADCASTING CONTROL BOARD
## TECHNICAL SERVICES DIVISION

REPORT No. 13

TITLE: INTERIM REPORT ON MEDIUM FREQUENCY SKY WAVE MEASUREMENTS.

*Issued by :—*
*The Chairman,*
*Australian Broadcasting Control Board,*
*Rialto Building,*
*497 Collins Street,*
*Melbourne, C.1.*

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REPORT No. 13

TITLE: Interim Report on Medium Frequency Sky Wave Measurements.

Report on a series of field strength recordings on three medium frequency broadcasting stations over a 12 month period ending April, 1954. The measurements were made by the Post Office Engineering Branch and analysed by J.M. Dixon. The measurements are continuing and a further report will be issued at a later date.

D McDonald

(D. McDonald.)

Director, Technical Services.

Date of Issue.

17/3/55

C O N T E N T S

Interim Report on Medium Frequency Sky Wave Measurements

# INTERIM REPORT ON MEDIUM FREQUENCY SKY WAVE MEASUREMENTS.

## 1. Scope of Recordings.

The prediction of sky wave field intensity is of prime importance to any medium frequency planning authority. Reliable sky wave estimates are needed to predict the extent of night time secondary service areas, and also to establish the degree of interference caused by adjacent and common channel stations.

F.C.C. sky wave curves(1) have been found useful but they were prepared from measurements made during the period Feb.-May 1935, and therefore apply only for a particular phase of the sunspot cycle at the location of the measurements and not for all frequencies in the medium frequency band.

Extensive measurements made from Oct. 1952-March 1953 in Europe and issued at the V11th Plenary Assembly C.C.I.R., London, Sept. 1953, suggested the procedure which has been adopted in making further measurements.

It was with this background that a rather modest series of recordings was commenced in March 1953 with the intention of establishing the validity or otherwise of the F.C.C. curves under Australian conditions but before receipt of the recommendations subsequently made from the European measurements(2).

Weekly sky wave field strength recordings of stations 4AK (1220 kC/s), 2GZ (990 kC/s) and 2CR (550 kC/s) were commenced in Melbourne by the Post Office and analysed by the Broadcasting Control Board. These recordings were continuous, commencing at 1930 hours and concluding at 2230 hours E.S.T., thus enabling the value of the field strength which was exceeded for 10% and 50% of the time over an interval of $1\frac{1}{2}$ hours to be determined. In order to eliminate the diurnal variation in field strength the centre of this period was selected as close to the second hour after sunset as the time of the recording permitted. Daily quasi-maximum 10% values for this interval are plotted in figs. 1, 1A, 3 and 5 for the 12 months period up to April 1954 for 2CR, 2GZ and 4AK respectively and these values are plotted against sunspot number in figures 2, 4, and 6. Figure 7 gives data on the variation with the time after sunset. Figure 8 gives the monthly averages and figure 9 the monthly averages plotted against sunspot number.

## 2. Analysis of data.

Sky wave field intensity 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 greatly from week to week and even more greatly from year to year. Daily field strength readings can be expected to vary in a random manner about a slowly varying mean but as a result of the European experiments(2) it was pointed out that to obtain this mean, little error would be introduced by recording sky wave field strengths every second day instead of every day. Although weekly samples are too infrequent in many cases to determine the mean, the results obtained in the case of the Melbourne recordings show that weekly samples yield uncertain results only during periods of greatly varying field strength.

### 2.1 The Influence of Solar Activity.

It is well known that sky wave propagation is influenced by the extent of ionization in the ionosphere, and that this ionization is largely caused by ultra-violet radiation from the sun, the persistance of ionization in some layers after sunset being as yet not fully understood.

An indication of the extent of ionization may be gained by observing the number of visible sunspots, or by measuring the critical frequency of reflecting layers. The accuracy of the former method depends upon the relation between sunspot numbers and the amount of ionization they produce, while the latter method gives a measure of the maximum electron density of a reflecting layer. Daily sunspot numbers are available(6) but only monthly average critical frequency values of the $F_2$ layer at Mount Stromlo are published(6).

### 2.2 Results.

The relationship between sunspot numbers and the received field strength over this period of observations is rather obscure. In the case of 2CR, the appearance of sunspots is more frequently accompanied by a decrease in field strength, while peak field strength values usually occur during periods of zero or low sunspot numbers. This is clearly shown in figs. 1, 1A and 2.

Field strength values for 2GZ exhibit slightly different characteristics. Fig. 4 shows that the peak field strength readings usually occur during periods of low or zero sunspot numbers as in the case of 2CR, but the reduction of field strength with the appearance of sunspots is not so clearly evident.

Over a period of one year, figs. 1, 1A, 3, 8 and 9 show that the general effect is one of decreasing field strength with decrease in sunspot activity. This is illustrated fairly well in fig. 4 if field strength values at or near peak sunspot numbers are taken as a guide. Results given in ref. 3 for low sunspot numbers agree with this observation showing a value of sunspot number of about 33 for which field strength is a maximum. Above this value the field strength decreases with increasing sunspot activity.

As the centre of the chosen 1½ hour period does not always fall on the second hour after sunset and as some seasonal variation may be expected, the mean of five summer and five winter recordings is plotted (fig. 7) for 2CR and 2GZ. This shows that for the period of observations there is no appreciable seasonal effect which would influence the results. In the case of 2CR the field strength reached 84% of the maximum for the evening one hour after sunset in summer. Sunspot minimum was reached in November 1953 and was still very low in May 1954 although day to day sunspot numbers are only available up to April 1954.

It may therefore be expected that in cases similar to 2CR and 2GZ, there will be a period of high field strength when sunspot numbers begin to increase, although this period should be shorter than that when sunspots were on the wane as there is a tendency for the rate of increase of sunspot numbers to be more rapid after leaving the period of minimum activity than the rate of decrease when approaching this period.

The characteristics of the field strength values for 4AK bear little resemblance to those of 2GZ and 2CR. There appears to be a tendency for field strength peaks to coincide with peaks of sunspot numbers as shown in fig. 5. Fig. 6 shows there is little tendency for sky wave peak values to be confined to regions of low or zero sunspot numbers. The dispersion of readings around the yearly mean value is more uniform and less extensive in the case of 4AK, although in both figures 6 and 9 there is slight evidence of increase of field strength with sunspot activity.

The following table compares the results of the Melbourne observations with the expected field strength using the F.C.C. curves(1):-

| Station | Frequency kC/s | Distance Miles | 10% quasi-maximum field strengths | | | | |
|---|---|---|---|---|---|---|---|
| | | | F.C.C. Feb-May 1935 for 100 mV/m at one mile | A.B.C.B. Aug-Nov. 1953 | A.B.C.B. March 1953-Feb.54 | A.B.C.B. Aug-Nov. 1953 | A.B.C.B. March 1953-Feb.54 |
| | | | | for 100 mV/m at 1 mile | | Relative to F.C.C figures | |
| 4AK | 1220 | 820 | 0.054 mV/m | mV/m 0.14 | mV/m 0.13 | 8.5 db. | 7.5 db. |
| 2GZ | 990 | 392 | 0.16 " | 0.29 | 0.26 | 5 db. | 4 db. |
| 2CR | 550 | 400 | 0.16 " | 0.18 | 0.18 | 1 db. | 1 db. |

The small amount of data in this table is consistent with an increase in field strength with frequency not included in the F.C.C. data as well as the decrease with decreased distance.

## 2.3 The relation between quasi-maximum and median value.

The relation obtained between 10% and 50% values is as follows:-

| Station | Minimum ratio | Maximum ratio | Mean ratio |
|---|---|---|---|
| 4AK | 1.3 | 2.7 | 1.79 |
| 2GZ | 1.3 | 2.8 | 1.88 |
| 2CR | 1.1 | 2.8 | 1.85 |

### 2.4 Possible explanation of the observed characteristics in the case of 2GZ and 2CR.

Two factors which influence the received field strength in the propagation of medium frequency sky waves are the amount of reflection and the amount of absorption the wave undergoes on its path.

Absorption occurs in the reflection region and also during the passage of the wave through lower ionized regions. The fact that in many cases the appearance of sunspots coincides with a drop in field strength suggests that increased absorption is occurring due to a greater ionization of layers. No figure of E layer critical frequencies at night are available but $F_2$ layer critical frequencies for the period which this report covers do not suggest a corresponding increase in the maximum electron density of this layer.

The fact that this drop in field strength is followed by an increase (when sunspot activity has died down) suggests that ionization in the lower regions traversed by the wave has decreased while that in the reflecting region has been maintained. The present long term effect of decreased sky wave with decreased sunspot activity suggests a reduction in the amount of reflection with lower ionization of the reflecting region.

## 3. Conclusion.

In the case of 2GZ and 2CR.

The 10% quasi-maximum results give a yearly average value between 1 and 4 db. above the calculated value using the F.C.C. curves. The highest field strengths during the period of recordings were 8 to 10 db. greater than the F.C.C. figures and usually occurred during periods of low or zero sunspot numbers. There is a general trend towards lower field strengths as sunspot activity decreases at the low sunspot activities involved which is in agreement with a previous investigation (ref.3).

In the case of 4AK.

The 10% quasi-maximum results give a yearly average which is 7.5 db. above the F.C.C. figure. The general level of the quasi-maximum readings remained constant throughout the period of observations.

The results are consistent with an increase in field strength with frequency, as well as a decrease with increasing distance.

References.

1. Federal Communications Commission - Standards of Good Engineering Practice.

2. V11th Plenary Assembly C.C.I.R. London, 1953, Doc. 327E.

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

4. National Bureau of Standards, Circular 462. Issued June 25th, 1948.

5. Radio Engineers' Hand Book - Terman.

6. Ionospheric Predictions, Series W. Prepared by the Ionospheric Prediction Service of the Commonwealth Observatory.

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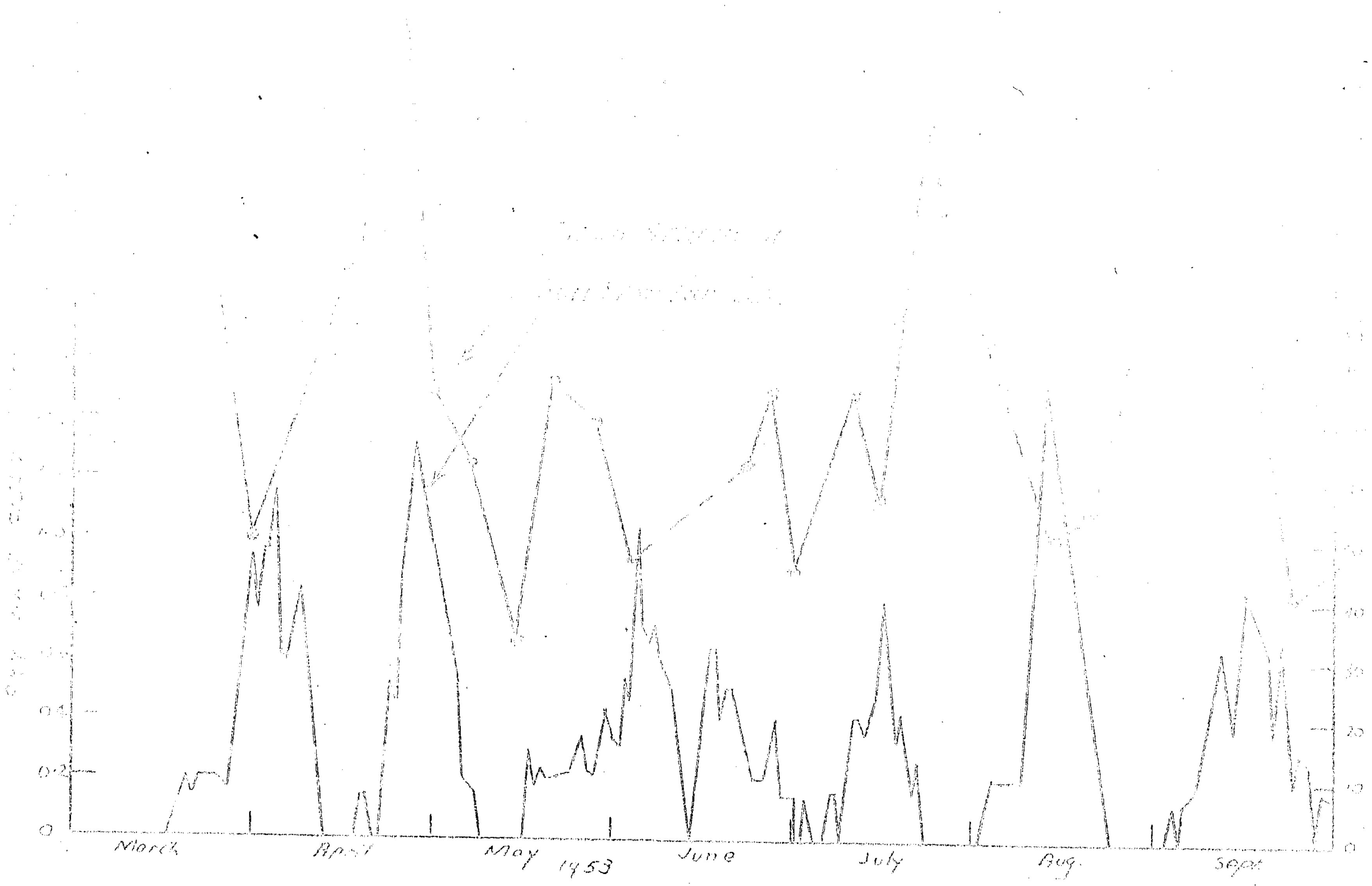
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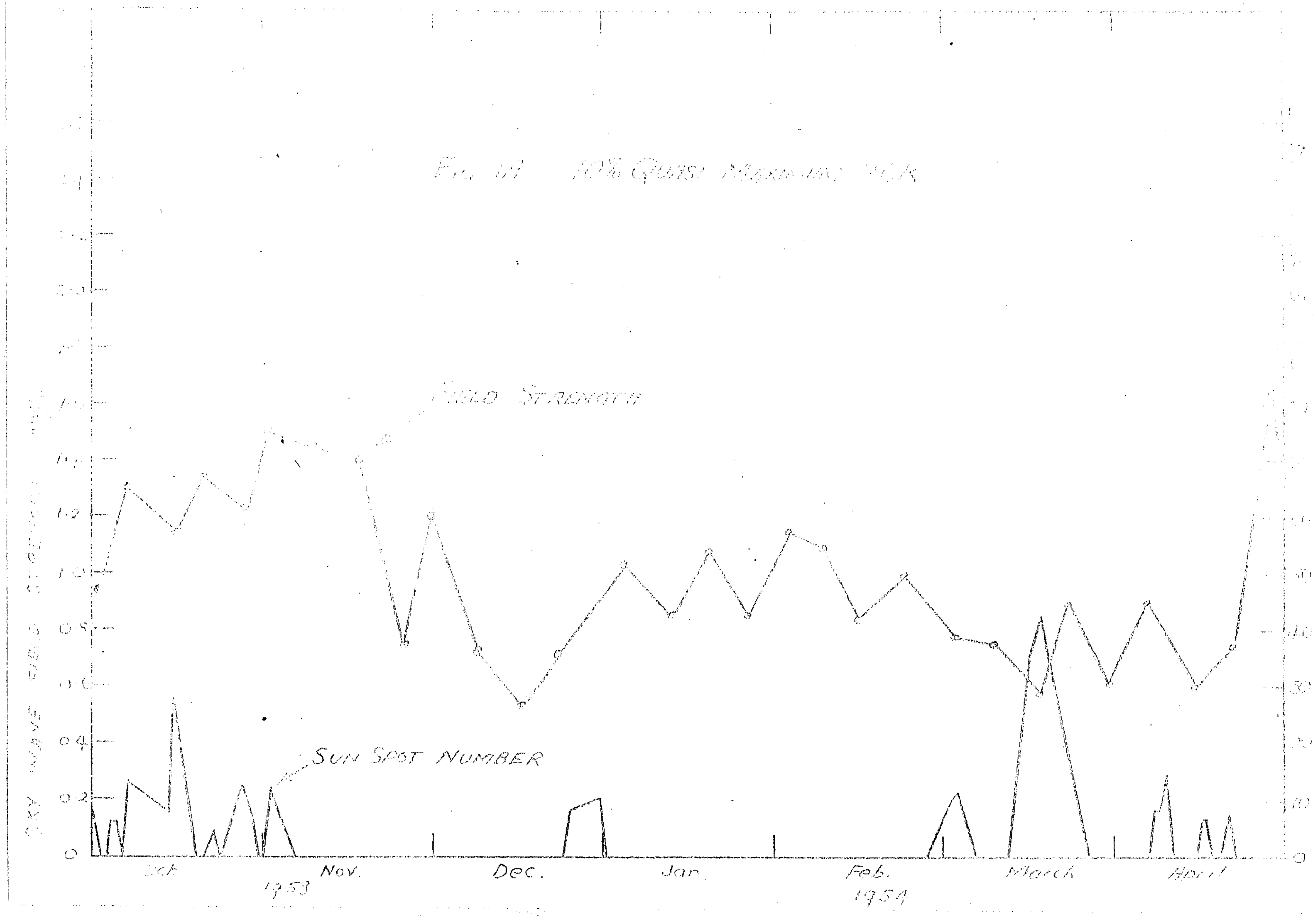



Fig. 18  10% Quasi Maximum

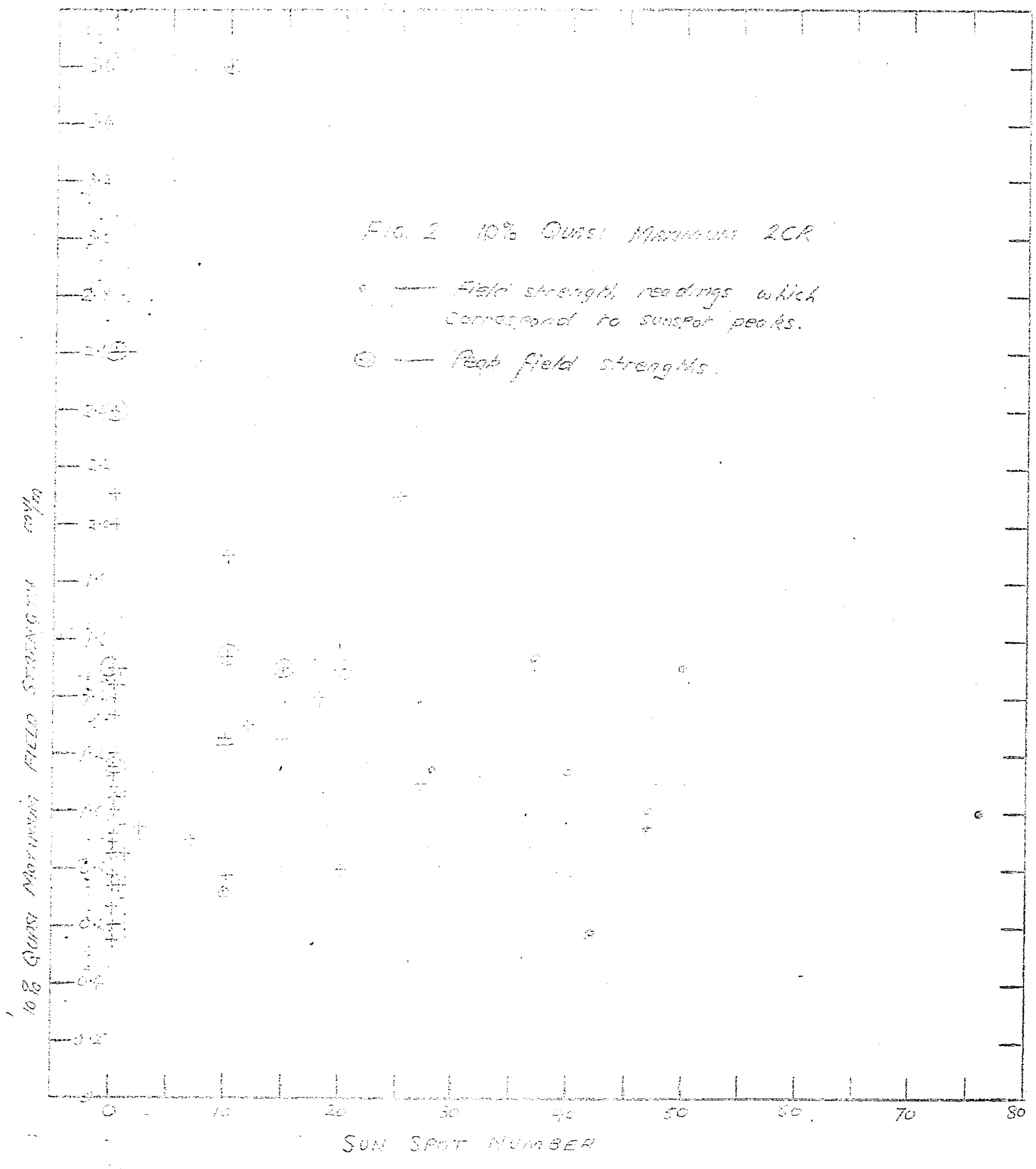
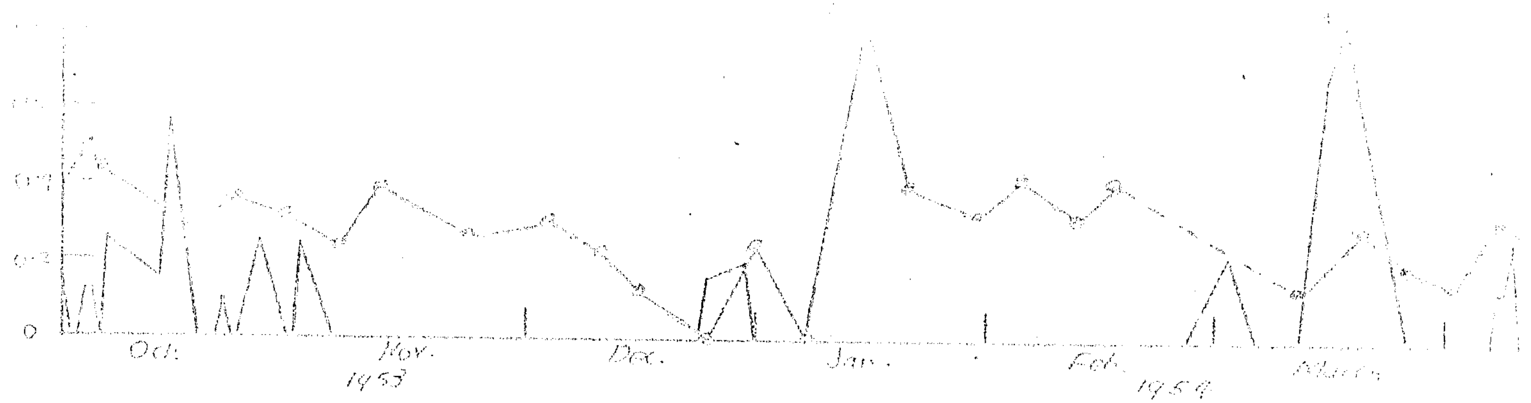



Fig. 2 10% Quasi Maximum 2CR



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