INTERSERVICE RADIO PROPAGATION LABORATORY
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PREDICTED LIMITS FOR F2-LAYER RADIO TRANSMISSION THROUGHOUT THE SOLAR CYCLE.

It is of interest in the consideration of design or purchase of high-frequency radio equipment to know the probable range of frequencies to be expected for reliable transmission on a world-wide basis, for all seasons, and all probable degrees of solar activity.

An estimate of this range may be made by means of the nomogram, Fig. 1, which represents the variation with solar activity, as measured by sunspot number, of the geographical and seasonal limits of monthly average F2-layer critical frequencies and maximum usable frequencies at 4000-km transmission distance.

Frequencies for E- and F1-layer transmission will be included within these limits. Transmission by sporadic-E ionization is in general rather erratic, and does not vary in the same manner with solar activity, reaching maximum values during periods of sunspot minimum. Frequencies for fairly reliable sporadic-E trasnmission at sunspot minimum do not, in general, exceed those for F2-layer transmission for a rather low sunspot maximum value, such as 80, for example.

The central area, A, and the line B, of the nomogram, Fig. 1, are the envelopes of the corresponding scales, A and B, on nomograms of the type of Fig. 2, for each ten degrees of latitude, making world-wide coverage, for the months of June, September, and December. These months, representing both summer and winter solstice, and typical equinox conditions, together, approximately include the extremes of seasonal variation in the ionosphere.

IRPL methods of predicting ionosphere characteristics are discussed in the reports IRPL-R4, "Methods Used by IRPL for the Prediction of Ionosphere Characteristics and Maximum Usable Frequencies," and IRPL-R11, "A Nomographic Method for Both Prediction and Observation Correlation of Ionosphere Characteristics," the latter also discussing the basis of construction for nomograms of the type shown in Fig. 2. The method of use of the nomogram, Fig. 2, is illustrated by the example thereon.

The method of use of the nomogram, Fig. 1, for obtaining the predicted limits of f^oF2 and F2-4000 muf, is as follows:

1. To obtain lower limit F2-layer frequencies (not to be confused with <u>lowest useful high frequency</u>, for which cf. IRPL Radio Propagation Handbook, <u>Part 1, p.5</u> and thereafter as given in index, p.105); These will correspond to a sunspot number of zero. Align a straightedge with the zero mark on the right-hand scale for sunspot number, with the uppermost boundary of the area

(over)

A, and read off the intersection on the left-hand scale for f^oF2. The lower limit of f^oF2 thus found is 1.4 Mc. Next, align this f^oF2 value with the lower end of the line B (which effects multiplication of f^oF2 values with those of M4000), and read the lower limit F2-4000 muf on the right-hand scale. This is 3.5 Mc. [During the period of sunspot minimum just passed, there have been recorded a very few cases, for other months, of f^oF2 lower than this, none being lower than 1.2 Mc.]

2. To obtain upper-limit F2-layer frequencies:

(a) Estimate the highest sunspot number during the time for which prediction is made. This estimation is far from precise by any methods known at present. As a guide for such estimation, the highest yearly average sunspot recorded is 159, in the year 1778, this number being of somewhat doubtful reliability since it was made long before the standard series of zurich observations were begun, and brought into line with them by estimate. The maximum yearly average of the last cycle was 121 in 1937, the preceding maximum, in 1917, being 106. Predictions for next maximum, by various astronomers, vary from 80 to above 145, the preponderance of them approximating the former figure.

(b) Align the estimated number for sunspot maximum with the lower boundary of area A, and read the f^oF2 on the left-hand scale. Values, for example, for sunspot numbers of 80, 90, 100, and 145 are, respectively, 16.4, 16.8, 17.2, and 19.0 Mc.

(c) Align the f^oF2 thus determined with the upper end of line B, and read the corresponding values of F2-4000 muf. These are, for the above cases, respectively, 62.0, 64.0, 65.2, and 72.2 Mc.

Since these values represent extremes of monthly average conditions, daily variation about these mean values may be covered for about 90% of the time by subtracting 15% from the lower limit frequencies, and adding 15% to the upper limit frequencies. Thus the lower limit for 90% of all cases would be f^oF2 = 1.22 Mc, and F2-4000 muf = 3.3 Mc, for zero sunspot number, and the values of probable upper limit at sunspot numbers of 80, 90, 100, and 145, respectively, are f^oF2 = 18.9, 19.3, 19.8, and 21.9 Mc, and F2-4000 muf = 71.3, 73.6, 75.0, and 83.0 Mc.

Estimation of the precision of prediction is difficult inasmuch as the prediction entails extrapolation of a number of approximately linear trend curves relating f^oF2 and sunspot number for a large number of locations corresponding to ionosphere observing stations, and interpolating such trends between stations. It is believed, however, that there is rather little likelihood of their being in error by as much as 20%.

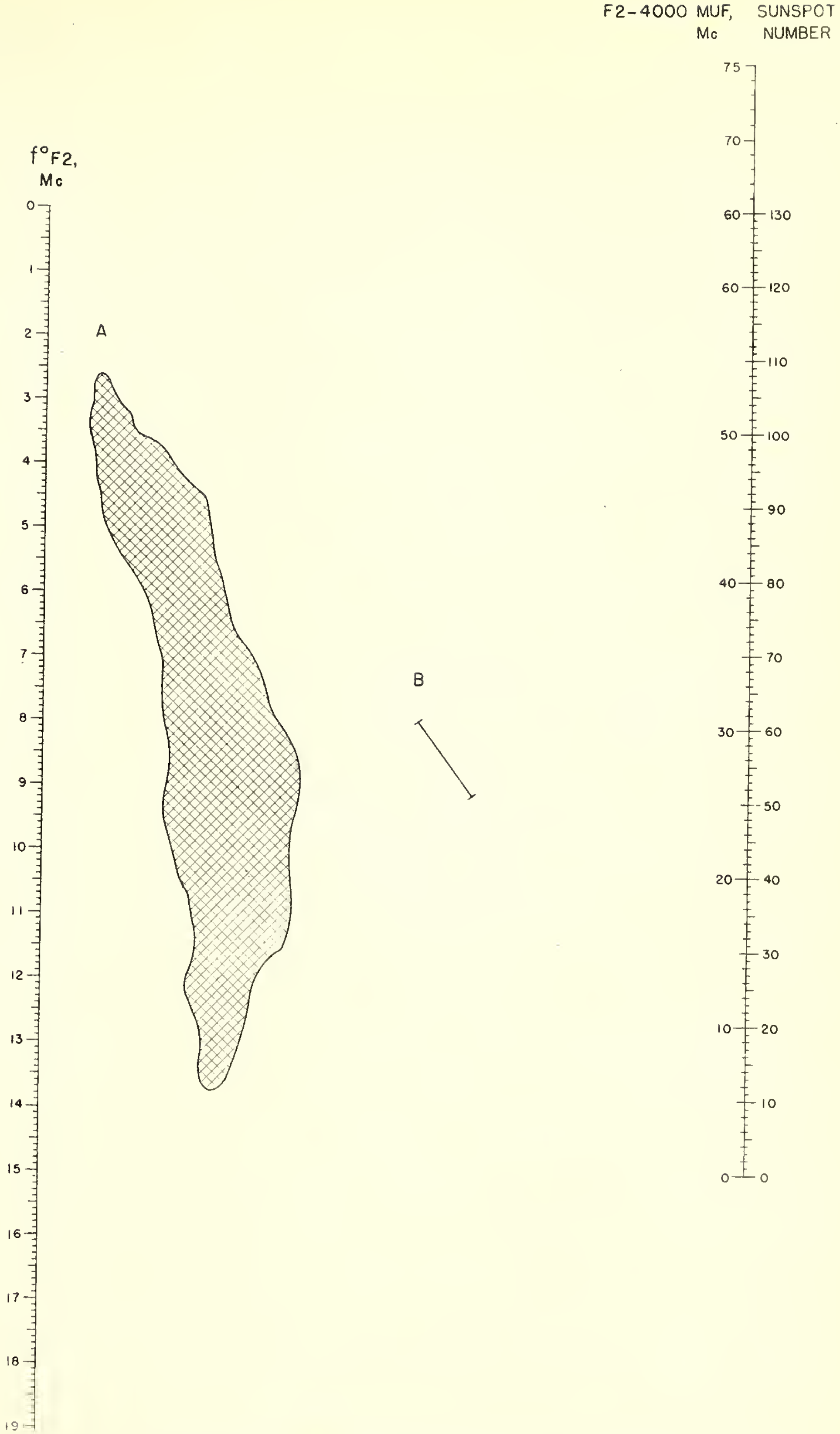

Fig 1. NOMOGRAM FOR OBTAINING LIMITS FOR f°F2 AND F2-4000 MUF THROUGHOUT THE SOLAR CYCLE.

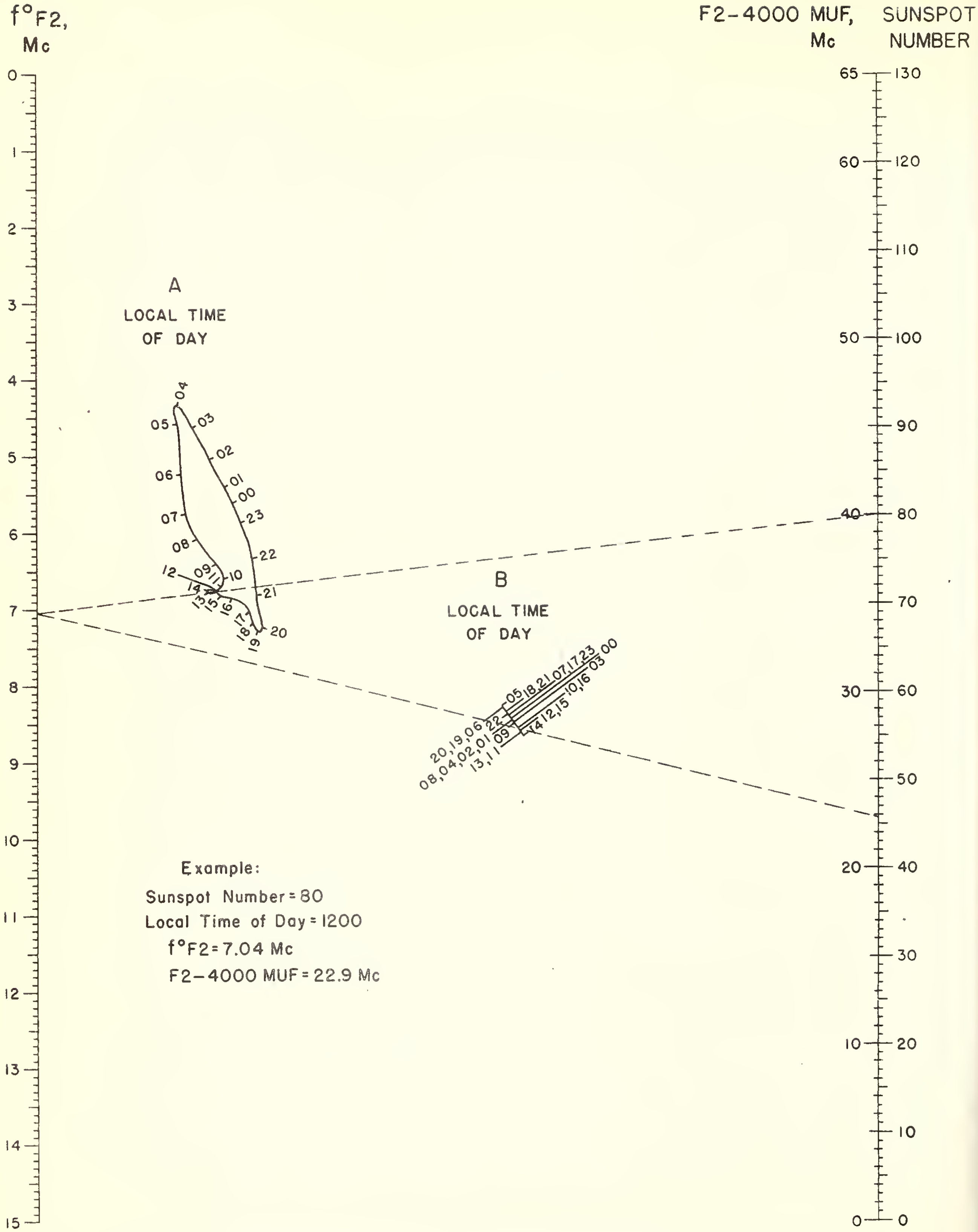

Fig.2. NOMOGRAM FOR OBTAINING f°F2 AND F2-4000 MUF THROUGHOUT THE SOLAR CYCLE.

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