REPORT CRPL-7-1

ISSUED JUNE 15, 1947

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
CENTRAL RADIO PROPAGATION LABORATORY
WASHINGTON, D. C.

PRELIMINARY INSTRUCTIONS FOR OBTAINING AND REDUCING MANUAL IONOSPHERIC RECORDS

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CONTENTS

I. STANDARD PRACTICES FOR MANUAL IONOSPHERIC OBSERVATIONS

The standard practices given herein have been prepared for ionospheric observations with manually-operated equipment. They are to be considered preliminary pending comments and criticism from the field; until such time as revision is made, it is expected that these practices will be followed at each Radio Propagation Field Station. A graph sheet similar to attached CRPL manual ionosphere recording form will be used for plotting observations.

1. Circumstances of Observations. - Complete information on the circumstances of observations must be given on each graph sheet, including time of beginning and ending, standard time meridian, date, station, observer, and serial number. Times and serial numbers of the observation must be actual, not anticipated. It is preferable to give the full last name of the observer. Script must not be used. If an observation is by more than one observer, the frequency at which the change was made must be given.

2. Time of Observation. - Observations are to be made hourly, commencing accurately at ten minutes before the hour. Ideally, daytime observations would be made in about fifteen minutes, nighttime records in about five minutes. More frequent observations must be taken when needed to clarify interpretation.

3. Frequency Intervals. - Each "run" is to be started at the lowest frequency giving echoes; the frequency will be increased in increments of about 0.2 Mc/s until the highest frequency-giving echoes are reached, except that in the vicinity of critical frequencies and of the point where the 3000 muf is read, the interval will be 0.1 Mc/s or less.

When the retardation in the F1-region is slight, this will mean observation at 0.1 Mc/s intervals in the range from approximately 0.3 Mc/s below the $f^{o}E$ to the $f^{x}F1$. At times when $f^{o}F2$ is much greater than $f^{o}F1$ and the observed height of F2 changes very gradually with increasing frequency, in order to speed up observation the observed height at each 0.2 Mc/s frequency-step need not be recorded individually, but rather 4 or more may be observed successively and recorded at one time.

4. Recording Procedure. - When the frequency interval is 0.2 Mc/s, observations are to be plotted on the nearest 0.1 Mc/s line on the scale of frequency. Only when the interval is 0.1 Mc/s or less is interpolation required. Heights are to be plotted to the nearest 5 km. Observed points are to be recorded in ink as dots which must always refer to the leading edge of echoes. A cross is to be marked in ink over erroneously plotted points.

When conditions of spread echoes are encountered, as evidenced by broad echoes with non-stationary splits, the practice is to draw a vertical line at the observed frequency extending from the height of the leading edge of the echo to the point where the echo is no longer distinguishable from background noise. Dots should be entered in the usual manner if stationary splits are also present. The width of an echo pulse should be marked at a frequency well below the critical, and below the point where scattering becomes obvious, in order to facilitate the determination of M3000 and M1500.

The second multiple; i.e., reflections at double the virtual height, need not be recorded except when it will help in the interpretation of a characteristic or when it will prevent ambiguity. Second multiples of Es should be recorded when at approximately the virtual height of the F1 layer.

Every effort must be made to obtain a complete record of both the o- and x-components of the h'f curve. Especial care is required

to distinguish F1 ordinary and F1 extraordinary traces. Incomplete traces may cause considerable error, not only in F1 characteristics but also in h'F2 and F2-M3000 and F2-M1500.

Remarks must be given if, for any reason, a complete and unambiguous record is not obtained.

5. Scaling Procedure. - Original interpretative lines are to be drawn in red pencil. Each record must be interpreted, scaled, and values recorded on the graph sheet by the observer immediately upon completion of observation. Ink or red pencil must not be used after the original recording and interpretation of the observations.

6. Checking. - The hourly graph sheets are to be checked and corrected for errors in scaling or interpretation by the engineer-in-charge of the station or his assistant. Criticisms of observation should be noted on the record when necessary and brought to the attention of the observer. The checker must use a soft black pencil and initial each record to indicate assumption of responsibility for recorded values.

If some of the observers making routine observations have not had scientific training at the college level and systematic training in the interpretation of ionospheric records, it will be found advisable to have them keep current graphs of all quantities scaled from the hourly records. These are for the current use of observers and supervisors in noting errors, trends, and unusual conditions that require closer examination.

7. Return of records and tabulations. - On or before the fifteenth of each month, the original graph sheets and completed tabulations of the previous month's observations should be forwarded to the CRPL. However, a copy of the tabulations should be retained at the station, in case the ones mailed to CRPL are lost enroute or otherwise destroyed.

II. STANDARD SCALING PRACTICES FOR USE BY CRPL RADIO PROPAGATION FIELD STATIONS

1. General. - The values of ionospheric characteristics for which regular tabulations should be kept are: f°F2, F2-M3000, F2-M1500, f°F1, F1-M3000, f°E, E-M1500, h'F2, h'F1, h'E, and fEs. The F2-layer and Es characteristics are scaled at all times of the day while values of F1-layer and E-layer characteristics are recorded during the daylight hours only.

Frequencies are scaled to the nearest tenth of a megacycle. If two consecutive values of frequency are equally good, the higher one is chosen, since the tendency in scaling critical frequencies

is to underestimate these values. The muf factors are scaled to the nearest tenth; when there is a choice of two values here, the lower one is selected, because division by a critical frequency is involved in computing factors.

Virtual heights are scaled to the nearest ten kilometers; when the measured height is midway between two ten kilometer steps, round to the nearest even multiple of kilometers.

2. Definitions. - The following abbreviations and nomenclature have been accepted internationally, and should be used on all reports, records and tabulations. Definitions of only a few of the more important terms used in this report are included.

F2 Layer (F2). The highest known ionized layer in the ionosphere existing between about 250 and 450 km above the earth's surface.

F1 Layer (F1). The lower of the two layers into which the night F2 layer usually separates over the intensely illuminated portion of the day hemisphere. It exists between about 200 and 260 km above the earth's surface.

E Layer (E). An ionized layer in the region of the ionosphere between about 90 and 140 km above the earth's surface. (See Es below).

Sporadic E (Es). The name given to the abnormally high ionized layer at about E-layer virtual heights. It is variable with respect to time of occurrence, geographic distribution, and penetration frequency.

Virtual Height (h'). The virtual height of an ionized layer of the ionosphere, is the height at which reflection from a definite boundary surface would cause the same time of travel as the actual reflection, for a wave transmitted at vertical incidence from the ground and reflected back. Due to the slower signal velocity in the ionized region the virtual height is always greater than the actual height of the layer. The value stated is the minimum observed for the layer.

Critical Frequency (f^o). The critical frequency of an ionized layer of the ionosphere is the highest frequency of waves reflected from the layer at vertical incidence. The value used is for the ordinary wave component.

Ordinary Wave Component ("o"). A plane polarized wave incident upon the ionosphere is split into two oppositely rotating elliptically polarized components by the earth's magnetic field. The one rotating to the left and having the lower index of refraction is called the ordinary or "o" wave component.

Extraordinary Wave Component ("x"). The second component of the plane polarized-wave, split by the earths' magnetic field, elliptically polarized and rotating to the right is called the extraordinary or "x" component. It has a higher index of refraction than the "o" component.

f^oF2, f^oF1, f^oE. The ordinary wave critical frequency of the F2, F1 and E layers, respectively.

f^xF2, f^xF1, f^xE. The extraordinary wave critical frequency of the F2, F1, and E layers, respectively.

fEs. Highest frequency reflected by sporadic E.

E2S. The higher of two sporadic E layers observed simultaneously.

F2-M3000, F1-M3000. The muf factors for the F2 and F1 layers, respectively, for 300 km distance.

F1-M1500, E-1500. The muf factors for the F1 and E layers, respectively, for 1500 km distance.

Muf. Maximum usable frequency; the highest frequency that will be refracted from a given layer to the receiver at the given distance. Higher frequencies will either be refracted beyond the receiver or penetrate the layer.

Muf factor. The ratio of the muf, for a given distance, to the critical frequency of the layer.

3. Explanatory Symbols. - Following is a complete list of the symbols to be used in conjunction with the tabulation sheets. Symbols are used with and without numerical values to identify ionospheric effects which are irregular, or to explain why measurements are listed as doubtful or are not entered at all for hours when they normally would be expected. An effort has been made to show exactly where each symbol should be used, since many have a very restricted meaning. Symbols A through K were established on an international basis by the International Radio Propagation Conference held in Washington in the spring of 1944. Their sense and interpretation have not changed. The remaining symbols have been introduced since that time and are being used at CRPL pending international agreement.

A. Characteristic not measurable because of blanketing by Es. A may be used logically for any of the tabulations, except of course, Es.

B. Characteristic not measurable because of loss of trace due to absorption, either partial or complete. A good indication of absorption, which often serves to distinguish it from other conditions of loss of trace, is a noticeable drop in interference level as well as in signal level. This symbol may apply correctly to any of the ionospheric characteristics.

C. Characteristic not measurable because of loss of trace due to equipment failure, operator's error, etc. This symbol may be used for any of the characteristics.

D. Characteristic higher than the upper frequency limit of the recorder. This symbol may be necessary, especially at the present time near the peak of the sunspot cycle, if the range of the apparatus is not sufficient, for values of $f^{o}F2$, F2-M3000, F2-M1500 or fEs. The upper limiting frequency of the recorder should be noted on the tabulation sheets when this symbol is used.

E. Characteristic less than lower limiting frequency of the recorder. This symbol is often necessary with tabulations of Es and sometimes with h'E but rarely with any other. The lower limit of the equipment should be stated on every sheet on which this symbol occurs.

F. Spread echoes (scattered reflections) present. This may occur in any layer, although it is by far most common in the F2 layer. Very occasionally, spread echoes are observed in conjunction with Es. Proper use of this symbol is important, and the discussion in Section II-4 of these instructions should be carefully considered.

G. $f^{o}F2$ less than $f^{o}F1$. G is used for entries of $f^{o}F2$, F2-M3000, F2-M1500 and h'F2, when during ionospheric disturbance the F2 layer is less densely ionized than the F1 layer and therefore is not observed. The "G phenomenon" is most often observed in the first few hours of daylight. Conditions may occur which make it impossible to recognize it until the reappearance of the F2 layer at great virtual heights.

H. Stratification within the layer. Stratification appears as a leveling off of the trace, or at least a distinct tendency to do so, before the actual critical frequency has been reached. At times it may even be so extreme as to produce a cusp or maximum in the curve. H may be appended to the minimum virtual height or critical frequency of any of the regular layers except the Es.

J. Characteristic derived by scaling the extraordinary trace. The symbol indicates when the critical frequency of any of the regular layers has been determined by the relationship.

$$f^{o} = f^{x} - \frac{fh}{2},$$

or, when the muf factor has been scaled from the extraordinary trace. This method, however, should be applied only when absolutely necessary.

K. Ionosphere storm in progress. This symbol should never stand alone as an entry on the tabulation sheets, but should always be accompanied by a numerical value or another symbol (as B^{k} or A^{k}). Fuller

explanation of the disturbance may also be advisable in the remarks column.

L. The F1-layer present (as evidenced by a distinct change in virtual height) but the inflection of the curve insufficient for scaling $f^{o}F1$. The use of this symbol is restricted to the $f^{o}F1$ and F1-M3000 tabulations. When used, numerical values must be given for both $h'F1$ and $h'F2$.

N. Unable to make logical interpretation. This symbol is occasionally necessary, especially for stations using manual operation, where the points do not fall into any coherent pattern; indiscriminate use must be avoided. It is only used where a characteristic cannot be derived numerically and where no other symbol correctly applies.

P. Trace extrapolated to a critical frequency. This is used as a subscript applied only to tabulations of $f^{o}F2$, F2-M3000 and F2-M1500. Use of this symbol is desirable at times, especially in operation of manual equipment.

Q. The F1 layer not present as a distinct layer. Use of this symbol is restricted to the daylight hours when the F1 layer is expected to occur, but where no evidence of it appears. Such a situation is occasionally encountered near the beginning and end of daylight hours at all stations and in the middle of the day during winter at stations in the temperate and polar zones. At NBS field stations, it is necessary that the station chief designate the hours of the day when this symbol may be employed for each month of the year. The symbol Q is correctly applied only to $f^{o}F1$, $h'F1$ and F1-M3000.

R. Curve becomes incoherent near the F2 critical frequency. This symbol is used where the curve is otherwise normal, but breaks near the $f^{o}F2$ into many traces which spread out in fan-like fashion. This phenomenon, although not common, seems to occur more frequently in temperate latitudes. R should only be used for tabulations of $f^{o}F2$, F2-M3000 and F2-M1500.

S. No observation obtainable because of interference. This symbol is used to indicate that interference caused so great distortion on the screen as to obliterate completely the ionospheric trace. This situation frequently occurs in operation of manual equipment. This symbol should not be used to excess.

V. Forked record. This symbol describes the situation when the F2-layer ordinary trace has two critical frequencies and only one minimum virtual height. Usually the forking appears in both the ordinary and extraordinary traces.

Z. Triple split near critical frequency. Especially at polar stations the h'f curve may sometimes show all three magnetic components, the "o", the "x" and the lowest frequency component the "Z". It is present practice to scale the middle trace, the "o", for the tabulation sheet.

( ) Doubtful value. If possible, a symbol should be added as a subscript to explain the reason for the doubt. This symbol should be used liberally but with care.

⌐ ¬ Interpolated value on diurnal curves. Interpolation in time may be carried out, with caution, when values are missing for not more than two consecutive hours. Periods when loss of records occur for more than two consecutive hours must not be interpolated under any conditions. This is not used on h'f curves.

4. Discussion of Ionospheric Characteristics. - $f^{o}F2$. - The F2 layer critical frequency is well determined when the trace has turned up enough to have very nearly vertical slope. The majority of records will show this condition. In many instances when the h'f curve of the F2 layer is not ideal or simple, a numerical value of $f^{o}F2$ can still be determined, the situation being described by one of the symbols C, F, H, J, P, R, V, or Z. In addition, the numerical value may be doubtful (parenthesized) for the reason given. If no value of $f^{o}F2$ can be determined, one of the following symbols will explain the situation: A, B, C, D, F, G, N, R, or S.

When the trace has enough turn up to indicate that it is near the critical frequency and yet is not near vertical slope, the critical frequency may be determined by extrapolation. Curves extrapolated more than 0.2 Mc/s are listed as doubtful and carry the symbol P. However, no extrapolations beyond 0.4 Mc/s should be undertaken for the $f^{o}F2$.

If spread echoes totally obscure the $f^{o}F2$ (equatorial-type spread) the proper entry is F. If, in the presence of spread, the envelope shows a definite turn up on the inside edge (polar-type spread), and indicates the o or x critical frequency, the critical frequency, $f^{o}F2$, is taken to be the frequency at which this "inner-edge" becomes effectively vertical. The symbol F of course, is added to the numerical entry on the tabulation sheet. When the spread is so extreme as to render the $f^{o}F2$ doubtful, the value should be put in parenthesis.

In the F2 layer, spread echoes are manifest in two different forms: (a) Blanket or Equatorial Type Spread, which totally obscures the critical frequency, is encountered more often in equatorial or tropical latitudes, although it may be observed elsewhere as well, and (b) Polar Type Spread, occurring in temperate or polar latitudes, where the spread echoes have a well defined "inner edge", whose curvature resembles that of a normal h'f trace, which inner edge may be scaled for values of $f^{o}F2$. This type of spread may also be observed infrequently at other than polar latitudes.

Care should be taken in using B to explain the failure to record $f^{o}F2$. Absorption generally is greatest at the low frequencies, diminishing with increasing frequency. Hence it affects the $f^{o}F2$ least of all. The only legitimate use of B for $f^{o}F2$ is when the entire trace has been absorbed. Unfortunately, in operation of manual equipment, the observation takes considerable time, and a sudden fadeout may occur in the middle of a sweep, causing the curve to stop abruptly. In such a case, the observer will go back and ascertain that the previous points have also been absorbed, before recording a fadeout.

Stratification in the F2 layer is a fairly common phenomenon at many of the stations. This appears as an inflection in the curve of the F2 layer trace, or in an actual cusp which shows the retardation from the lower strata. Usually such stratifications appear above the first split of the F2 trace, but since this is not invariably the case, care must be exercised not to confuse such stratifications with the normal F1-layer critical frequency. When stratification does occur in the F2 layer, the minimum virtual height of the lowest strata is recorded as $h'F2$, and the critical frequency of the highest strata as $f^{o}F2$.

Some mention should be made of storm effects peculiar to the F2 layer. During ionosphere storms the $f^{o}F2$ may drop below the $f^{o}F1$. In such cases, G should appear on the record. A tendency toward this condition is always evident in preceding or succeeding records. When the ordinary F2 trace is forked, scale the higher value and add the symbol V. Where a triple split occurs, the procedure is to scale the middle trace, adding a Z to the value entered on the tabulation sheet. In the case of an incoherent multiplicity of traces near the critical frequency such a situation may be recorded by an R on the tabulations. Occasionally it may be possible to select a doubtful value which most nearly suits the rest of the trace; R should still be entered on the tabulations, however.

F2-M3000 and F2-M1500. - The muf factor for the F2 layer for distances of 3000 kilometers may be determined by use of the transmission curve slider as follows: Place the transparent slider over the record, align the ground trace on the record with the lower line on the slider, and keeping it so, shift it either right or left until the 3000 km transmission curve is just tangent, at some point, to the ordinary wave trace of the $h'F2$ curve. The F2-M3000 may then be read on the top line of the slider directly above the $f^{o}F2$ on the record.

The F2-M1500 can be determined in the same manner by using the 1500 km transmission curve on the transparent slider.

If there is no measurable critical frequency, the muf factor of course, cannot be measured. When this happens, the same symbol

which explains the absence of $f^{o}F2$ should be used for M3000 and M1500. Similarly, symbols or parentheses that qualify $f^{o}F2$ will also apply to M3000 and M1500.

It may be possible to obtain a reliable numerical value of $f^{o}F2$ and still not be able to determine the muf factor, as when the curve just below the critical frequency is obscured or missing. Here the proper entry is a symbol to explain the loss. More often, it is possible to interpolate the h'f curve through the missing frequency range and thus secure a doubtful or even, sometimes, a good value of the muf factors. Wherever possible this should be done.

A second method of scaling the factor may be resorted to if only the extraordinary trace is clearly presented. The factor may then be read directly, as it is measured customarily from the ordinary trace, and the letter J added to the value on the tabulation sheets, in parenthesis, because a small error is inherent.

If spread echoes are present in the F2 layer the problem of reading factors presents a special case. Where the spread is the equatorial or masking type, no factors may be secured and the proper entry if F. If the spread is of the polar type, a factor may be read from a line drawn at a pulse width, measured in kilometers, below the inside edge. This factor may or may not be doubtful, depending on symbols applied to the critical frequency, but in any case should carry the symbol F.

$f^{o}F1$. - It is rather difficult to describe the cases where a numerical value of $f^{o}F1$ may not be scaled. An actual cusp or peaked curve is always scaled, while a leveling off of the slope of the curve is not. The other cases lie somewhere in between the two extremes mentioned and the judgment of the individual observer must be relied upon to determine when the $f^{o}F1$ is clear, when it is doubtful, and when no value is to be scaled. The distinction between doubtful values and no values is, of course, the most difficult to make. However, by international agreement, no F1-layer critical frequencies are to be reported unless there is a definite and abrupt change in the slope of the h'f curve, either for the first reflection or one of the multiples.

Where a splitting or an inflection of a curve indicates the presence of a F1 layer, but no critical frequency can be scaled, the symbol L is used. During those daylight hours when the F1 layer is ordinarily separate from the F2 layer, the absence of the F1 layer is denoted by Q. To further clarify the data, other supplementary symbols should be used when they apply, such as A, B, or C; in manual equipment sweeps, S might be appropriately used also.

In cases where there is some doubt as to whether the critical frequency observed is actually the $f^{o}F1$ or whether it is a stratification in the F2 layer, the following test can be applied. Find the frequency that is approximately 83% of the critical frequency in question. Measure the virtual height at this frequency; if less than 270 km the doubtful critical frequency is probably the $f^{o}F1$; if higher than 270 km, the doubtful critical frequency is quite likely not the $f^{o}F1$ but is due to F2 stratification.

F1-M3000. - The F1 muf factor for 3000 km is found in a manner similar to that used in finding the F2-M3000 or F2-M1500. The 3000 km transmission curve is placed tangent to the h'F1 curve and the factor read opposite the critical frequency on the slider scale as described above for the F2 muf factors.

If no measurement of $f^{o}F1$ can be made for some reason, muf factors cannot be determined for the same reason. Any symbols or notes entered on the $f^{o}F1$ sheet for this time should be used on the F1-M3000 sheet.

It is possible to obtain the $f^{o}F1$ but sometimes difficult or impossible to find the factor, if the part of the h'f curve which would be tangent to the transmission curve is missing. It is important that the proper symbol is entered to explain why the factor was lost. Sometimes, when the tangent part of the h'f curve is missing, the factor can be scaled by using the extraordinary trace, as mentioned in regard to the F2 muf factors, the symbol J being used to indicate how the factor was obtained.

$f^{o}E$. - No value of $f^{o}E$ should be recorded unless there is a very evident increase in the slope of the E trace, representing an increase of virtual height of at least 10 km. Normally, the turn up is much greater, and if less than 20 km, the $f^{o}E$ scaled should be listed as doubtful.

The most common reasons for the loss of the $f^{o}E$ are those corresponding to the symbols A, B, C or F. In the case of F, the spread echoes usually arise in the abnormal E layer and obscure the regular E trace at the $f^{o}E$.

In equatorial regions it is not uncommon to see the E-layer trace often return to the E-layer height after passing the $f^{o}E$, thus producing a complete cusp in the curve (no break) in place of the usual turn up. In extreme cases, the cusp is not apparent and the trace appears concave downward. An $f^{o}E$ may be scaled at the highest point of the trace providing it agrees within 0.3 Mc/s of the predictions; otherwise, no value of $f^{o}E$ is entered.

fE-M1500. - The muf factor for the E layer is obtained as described for the other layers.

fEs. - In all cases, record as fEs the highest frequency observed at approximately the normal E-layer height (90 to 120 km) though there may be one or more breaks in the curve below that point. If, as sometimes happens, the first reflection is not present or clear, record the value of the highest frequency observed on the multiple, provided however, it is not an M- or N-type reflection.

In the rare cases where there are spread echoes present in the Es layer indicate it by the letter F, as is done for the F2 layer. When there are indications that the Es recorded is not the highest actually present, due to C or S, enclose the value in parenthesis to show it is doubtful. Also, when no Es is observed enter the symbol E in the tabulations. Whenever this is done the lower frequency limit of the recorder should also be given.

5. Medians. - Medians are computed monthly for all the characteristics recorded for each hour of the day. The process of selecting the median value for the month for a given characteristic consists of arranging all the values for the hour in order of magnitude and selecting the number which has as many values above it as below. If the total number of observations is odd, the median is simply the middle value. When the number of observations is even, the median is taken as the average of the two middle values.

The following conventions are used in determining the medians for hours when no measured values are tabulated because of equipment limitations and ionospheric irregularities.

a. For all ionospheric characteristics:

Values missing because of A, B, C, or F are omitted from the median count.

b. For critical frequencies and virtual heights:

Values missing because of E are counted as equal to or less than the lower limit of the recorder.

Values missing because of D are counted as equal to or greater than upper limit of the recorder.

Values missing because of G are counted:

(1) For $f^{o}F2$, as equal or less than $f^{o}F1$.
(2) For $h'F2$, as equal or greater than the median $h'F2$.

Values missing for any other reason are omitted from the median count.

c. For sporadic E (Es):

Values of fEs missing because no Es reflections appeared, the equipment functioning normally otherwise, are counted as equal to or less than the median $f^{o}E$, or equal to or less than the lower frequency count of the recorder.

Values of fEs missing for any other reason, and values of hEs missing for any reason at all are omitted from the median count.

The following conventions are used to determine whether a median value is doubtful:

a. If any four values or less are available, no median is computed as the data are considered insufficient.

b. For the F2 layer, if only five to nine values are available, the median is parenthesized. The E and F1 layers are so regular in their characteristics that as long as there are at least five values, the median is not considered as doubtful.

c. For all layers, if more than half the values used to compute the median are doubtful, the median is considered doubtful.

6. References for Scaling Procedures. - Report of International Radio Propagation Conference, IRPL-C61, issued by IRPL, NBS.

Report of Subcommittee of Committee A on "Reduction of Ionospheric Records", Item 3, IRPL-C46, issued by IRPL, NBS.

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Instructions for Manual Ionosphere Observations - H. W. Wells, issued by DTM, CIW, 1944.

Standard Practices for Manual Ionosphere Observations - A. H. Shapley, issued by DTM, CIW, 1945.

Observers' Instruction Book for Canadian Ionospheric Stations, CRWPC, Canada, 1946.

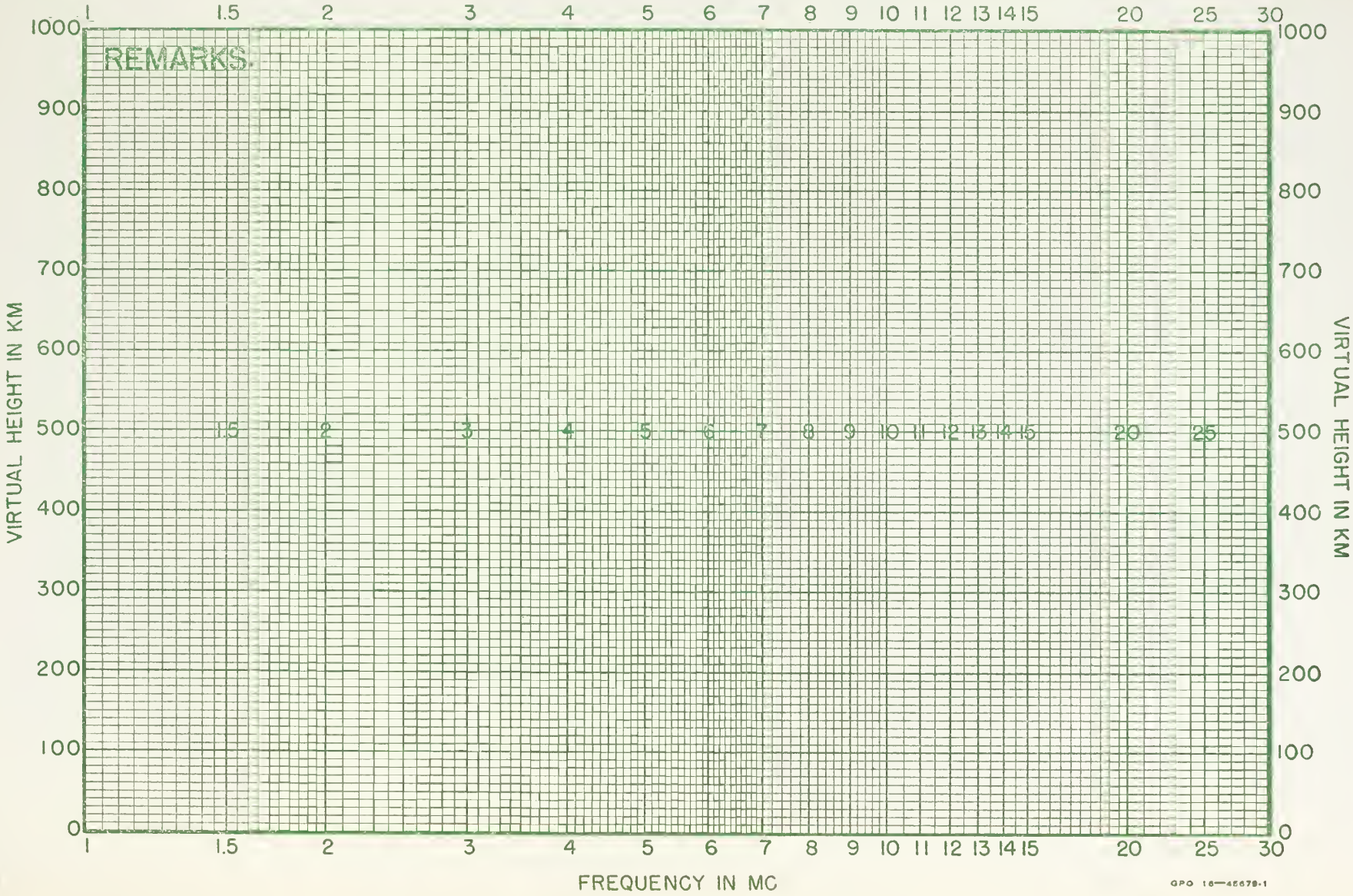
CRPL
NATIONAL BUREAU OF STANDARDS
JUNE 1947

STATION _____ **MANUAL IONOSPHERE RECORD** SERIAL NO. _____

BEGIN _____ END _____ MERIDIAN TIME _____ DATE _____ OBSERVER _____ CHECKED BY _____

$f°F_2$ _____ $f°F_1$ _____ $f°E$ _____ $f\,E_S$ _____ F_2-M3000 _____ F_1-M3000 _____

$h'F_2$ _____ $h'F_1$ _____ $h'E$ _____ $h'E_S$ _____ F_2-M1500 _____ E-M1500 _____



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