3.0 Use of Qualifying and Descriptive Letters

Letters are written exclusively in capital (block) letters. They are grouped into two classes, qualifying and descriptive. The distinction between these classes must always be kept clear and letters must be entered only in the appropriate position on the daily tabulation sheet (qualifying letters in the first letter column, descriptive letters in the second).

The old WWSC convention, with qualifying letter before the number and descriptive letter after it, was dropped for general use as it was found to cause trouble when the data were punched for computer use. This convention is convenient for manual work and is allowed where the data also exist in computer form. When letter symbols are printed above the number the convention is that the qualifying letter, if any, is placed above the first figure of the number and the descriptive letter above the third figure.

The letters A,D,E,M,O,T,Z are defined both as qualifying and descriptive letters and the meaning is made clear by the conventional position of the letter on the tabulation sheets.

Wherever doubt arises, the international definitions given under the appropriate letters in sections 3.1, 3.2, or 3.3 should be consulted.

When the data are tabulated by computer methods it is possible to compute the desired characteristic from a measured value for another mode. The International conventions for descriptive letters O and X have been modified to permit this. Thus, a tabulated value (fxEs)-X can then be read by the computer to give (fxEs-fB/2)JA. Similarly for fxI when no scatter is present, a tabulated value (foF2)-O can be read to give (foF2+fB/2)OX (no scatter but value deduced from o trace). It is very undesirable to use these conventions when tabulation is done by hand.

3.1 Qualifying Letters

The qualifying letters give an indication of the reliability of the measurement of a tabulated value. These letters cannot be used to replace a numerical value and must always be accompanied by a numerical value and by a descriptive letter.

Qualifying letters are used for two purposes: as algebraic symbols, and to show that the tabulated value has not been deduced directly from the trace which is normally considered.

When no qualifying letter is used, it is implied that there was no serious difficulty due to interference, noise or instrumental defects in making the measurement; that the interpretation of the ionogram is clear and unambiguous; and that the values tabulated are within the limits of accuracy required for the characteristic.

If no qualifying letter applies, the space provided on the tabulation sheet is filled with a dash (—) or left blank, as may be appropriate to avoid ambiguity and according to the format of the table.

The qualifying letters are: A,D,E,I,J,M,O,T,U,Z. They have the following meanings:

A - Less than. Used only when fbEs is deduced from foEs because total blanketing of higher layers is present. This must be ignored when computing medians - xxx AA is treated as xxx, i.e.fbEs = foEs (see section 4.6, p. 119).

D - Greater than.

E - Less than.

Letters D, E give maximum or minimum limit values. Such values must be moved to the top (D) or bottom (E) of the distribution when forming the second median (Section 8).

Letter A also implies a less than limit value but this value is expected to be abnormally large and hence should not be moved to the bottom of the distribution when forming the second median. The connotation "less than" is thus ignored in forming the medians.

D and E are used as qualifying letters when only limiting values are observed. Accuracy rules for the use of D and E are given in sections 2.2 and 2.7.

When D and E are used in conjunction with ionosonde limits (descriptive letters D,E,W) or limits due to fmin, foE, foF1, descriptive letters B,G, it is essential that the numerical limits should be readily available. Since data are often handled by computer, notes in station booklets can be lost. It is therefore recommended that limit values be written out in full, e.g. xxxEE, unless it is certain that the missing values are easily available. Since median tables are often separated from other data all median values should be written in full whenever a numerical value is available.

QUALIFYING AND DESCRIPTIVE LETTERS

I - Missing value has been replaced by an interpolated value.

Interpolations may be performed over a period not exceeding two hours provided that the sequence of records indicates that conditions are varying slowly. Interpolations should be done from an f plot or a diurnal curve since the characteristic need not vary linearly with time. If the gap in the observations is more than 2 hours, or if the characteristic is not believed to be smoothly and slowly varying, no interpolation is permitted.

Interpolation may not be used to provide a numerical value in the following cases: (1) when the observed value is replaced by D,E, F, G, L, N or W, (2) for any Es parameter, fmin for fxI.

Interpolation should be used whenever possible to provide a numerical value when the observed value is replaced by C, R or S. The same is true for B in the case of a SID but not in the case of polar black-out.

J - Ordinary component characteristic deduced from the extraordinary component.

This letter applies only to measurements involving critical frequencies and assumes fo = fx - fB/2 or when fo is near or below fB the appropriate value of fx-fo (section 1.04) [A1121, fig. 138, A114D]. Whenever the letter J is used, the reason for not scaling the ordinary trace must be indicated by the appropriate descriptive letter.

M(3000) may be obtained even when the ordinary critical frequency is deduced from the extraordinary, provided that the point of tangency of the transmission curve and the ordinary trace can be located. M(3000) is scaled using the deduced ordinary critical frequency, but is not qualified by J. The possible error in deducing fo is normally very small.

M - Mode interpretation uncertain.

This letter is used when there is not enough evidence from the ionogram or sequence of ionograms to show whether the mode was ordinary or extraordinary. It is mainly (but rarely) used with parameters fxI, foF2, foEs or fxEs (where tabulated). The reason for the difficulty is given by the most appropriate descriptive letter. The observed value is treated as if the interpretation was correct but M implies a possible error of fB/2 for frequency characteristics and an undefined error in height and factor characteristics.

O - Extraordinary component characteristic deduced from the ordinary component.

This letter applies whenever it is necessary to deduce the extraordinary characteristic from the ordinary wave trace. It can only be used with characteristic frequencies defined for the x trace, in particular fxI and fxEs. fx is deduced by assuming fx = fo + fB/2 or when fo is near or below fB the appropriate value of fx-fo (section 1.03, p 9).

When the qualifying letter O is used the reason is given by:

(a) The descriptive letter which best shows why the extraordinary characteristic could not be measured.
(b) The descriptive letter M, when there is doubt about whether the ordinary or extraordinary characteristic was measured. The characteristic is treated as O.
(c) The descriptive letter O, when there is no doubt that the ordinary wave characteristic was measured but the reason for the absence of the extraordinary characteristic is complex, doubtful, is near fB, or the x mode could be seen but was not used (see O under descriptive letters, 3.2).

T - Value determined by a sequence of observations, the actual observation being inconsistent or doubtful.

The letter T is applied only to numerical values obtained by 'smoothing' from the f plot and always shows that the actual ionospheric conditions differ from the representative value given in the table. Its use is mainly confined to high-latitude stations where the actual value may be found from the f plot. T is never used to replace a missing value. In such cases interpolations should be performed if possible. See section 6.9.

U - Uncertain or doubtful numerical value.

A tabulated value may be uncertain because the trace is obscured by interference, noise, instrumental defects, spread echoes, deviative absorption, etc., which make the ionogram difficult to interpret. See section 2.2 for the criteria for use of the letter U.

Z - Measurement deduced from the third magneto-electronic component.

The letter Z, used as a qualifying letter, is analogous to the letter J. It applies only to critical frequencies. Whenever Z is used the reason for not scaling the ordinary trace must be indicated by a descriptive letter. Letter Z is used also as a qualifying letter when the o-mode parameter is deduced from the z trace, e.g., foF2 = (fzF2 + fB/2)ZF. This is valuable when there is no main trace or a series of main traces (Fig. 3.35). Note h'z < h'o < h'x so it is not possible to use qualifying Z for height parameters. When fz is near or below fB the appropriate value of fo-fz (p 9) must be used.

Since the z component is reflected obliquely, except at the magnetic dip pole, there is always doubt whether or not conditions have changed with the position, and values based on deductions using this component are regarded as doubtful and are therefore qualified by qualifying letter Z.

M(3000) may be obtained even when the ordinary critical frequency is deduced from the third magneto-electronic component, provided that the point of tangency of the transmission curve and the ordinary trace can be located: M(3000) is scaled using the deduced ordinary critical frequency and is qualified by Z. The qualification is necessary because the z trace is always oblique except at the magnetic dip pole and therefore the deduced ordinary critical frequency is uncertain.

Additional qualifying letters are used in topside soundings and are given in section 5.65.

3.2 Descriptive Letters

Descriptive letters give the main reason for uncertainty in, or absence of, a numerical value or indicate the presence of certain phenomena. Although two descriptive letters may be used when the form provides space for three letter symbols, mechanical methods of analysis can handle only one descriptive letter. Therefore only the first descriptive letter can be recognized as an international parameter and it is most important that this letter be consistent with the rules.

The descriptive letters are: A,B,C,D,E,F,G,H,K,L,M,N,O,P,Q,R,S,T,V,W,X,Y,Z. The following selection rules should be invoked when two letters seem equally applicable:

(a) Always use the letter which most nearly represents the cause of the difficulty.
(b) Always use a letter with a restricted meaning in preference to one with a more general meaning. (This particularly applies to the ambiguity between C and S, or between E and G.)

The descriptive letters have the following meanings:

A - Measurement influenced by, or impossible because of, the presence of a lower thin layer, for example, Es. When an Es trace is such that foEs cannot be distinguished and must be deduced from fxEs letter A is used. foEs = (fxEs - fB/2)JA.

Historically, this case was treated using letters JX but this is misleading and obsolete. A is not used when foEs cannot be evaluated directly because of interference (use JS) or instrumental trouble (use JC).

This letter is used when a higher layer (such as the F layer) is 'blanketed' by a thin layer (such as Es). Blanketing occurs when an Es layer prevents the observation of echoes from a higher layer (Figs. 3.1, 3.2, 3.3).

Es can blanket the normal E trace also in which case foE, h'E are replaced by A (Fig.3.2).

When complete blanketing occurs (i.e. no reflections from higher layers appear at all), it is not possible to evaluate fbEs with certainty. However the statistics of fbEs lose much value if these high values are not numerical. The solution is to use fbEs = (foEs)AA in these cases. This can be misleading if foEs is deduced from a weak trace. When the Es does not vary with position, the top frequencies of the multiple order traces decrease slowly with order and the top frequency of the second order trace corresponds approximately with the frequency at which an F trace could have been seen. The first order Es trace is also often stronger below than above this frequency. When the Es is varying with position, the second order trace (or more seldom higher order traces) can be seen at frequencies higher than the top frequency of the first order trace. In practice when total blanketing is found, the difference between foEs deduced from the solid trace and fbEs is negligible compared with the variability of fbEs in space and time. Thus rule (a) below is usually applicable.

(a) If the trace is solid to foEs, tabulate foEs AA (Fig. 3.1).

(b) If the trace is not solid to foEs, or if two or more multiple traces are present with the value of the top frequency of the second order trace much smaller than foEs (Fig. 3.2) tabulate the top frequency of the second order trace qualification AA respectively. (Note: If these values have to be deduced from the x-mode trace, AA should be used in preference to JA in cases (a) (b).). Values of fbEs deduced using foEs deduced from the solid part of the trace and rule (a) should usually agree with the value deduced from rule (b) within the accuracy rules for limit values.

Es traces may blanket over the lower part of their frequency range and not over the higher part, Fig. 3.3, [A88I, Fig. 77; A96I, Fig. 87], [B IIB 54 Johannesburg noon, IIB 55 Dec., IIB 57 June, IIB 66 June]. This is called partial blanketing.

Blanketing differs from the occultation of a normal layer (e.g. F1) by a lower thick layer (e.g. E) in that the traces of the higher layer will not show any additional group retardation near the blanketing frequency [A88I, Figs. 76, 77, 78; A96I, Fig. 90]. Compare Fig. 3.3 and Fig. 3.4.

Normally a blanketing Es trace is strong but when the non-deviative absorption is great - fmin large - the trace may appear to be weak. Comparison of the Es trace with that of the higher layer shows clearly when blanketing is present, Fig. 3.5.

When the minimum frequency reflected from higher layers is greater than foEs, descriptive letters C, R, S or Y should be used to describe fbEs as appropriate. The use of A should be restricted to cases where blanketing is clearly indicated. Y is most commonly the most appropriate, Fig. 3.6. (see also section 2.75, Fig. 2.19).

A difficult situation to handle is when the only trace appearing on the ionogram is a weak Es echo over a rather small frequency range with a comparatively high value of fmin (Fig. 3.5). In such cases one should study the series of preceding and following ionograms to determine where the F-layer critical frequencies are likely to be, to decide whether the F-region characteristics should be scaled as missing because of blanketing (A) or absorption (B). Another helpful guide in this situation is a knowledge of the expected range of frequencies of the F-region echoes, obtained from the previous day's scaling or from monthly median values. If the Es echo first appears in a range of frequencies well above the expected range of F-region echoes, the letter B should be used. If the virtual height is below 95 km, the weak trace is Es type d, the absorption is great and letter B should be used for all parameters except Es type.

Frequently in equatorial regions and sometimes at higher latitudes, Es echoes overlap the normal E-layer trace so that h'E is obscured. This frequently occurs with q type Es and with the common weak forms of ℓ type Es. Though blanketing is not taking place the use of the letter A to describe this obscuration is permitted [A96I, Fig. 98].

Letter A is also used when a multiple order Es trace prevents accurate measurement of h'F or h'F2.

A special case occurs when particle E, Es-k, completely blankets the F trace. Logically this would imply the use of G but such use would cause difficulties with the F-layer medians. Also the distinction Es-r, Es-k is often difficult in this case. For simplicity particle E is regarded as an Es type for this purpose and the value of foF2 should be replaced by letter A. It is impossible to know whether foF2 was normal or not, so the accuracy rules do not allow E to be used. Thus total blanketing by Es or particle E are treated alike, use replacement letter A.

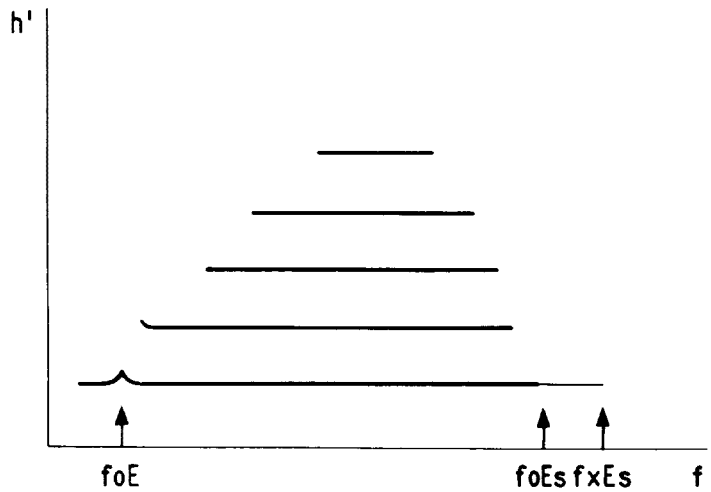

Fig. 3.1 Complete blanketing

(i) All F-layer parameters replaced by A.
(ii) If x trace distinct as shown here foEs can be read directly, fbEs = (foEs)AA.
(iii) If x trace not distinguished, foEs = (fxEs - fB/2)JA.
fbEs = (foEs)AA because of small difference in top frequency between first and second orders.
(iv) foE should be extrapolated if possible to give (foE)-A, otherwise use cusp value and UA, (foE)UA. (see section 2.4, p. 36, Fig. 2.2a).

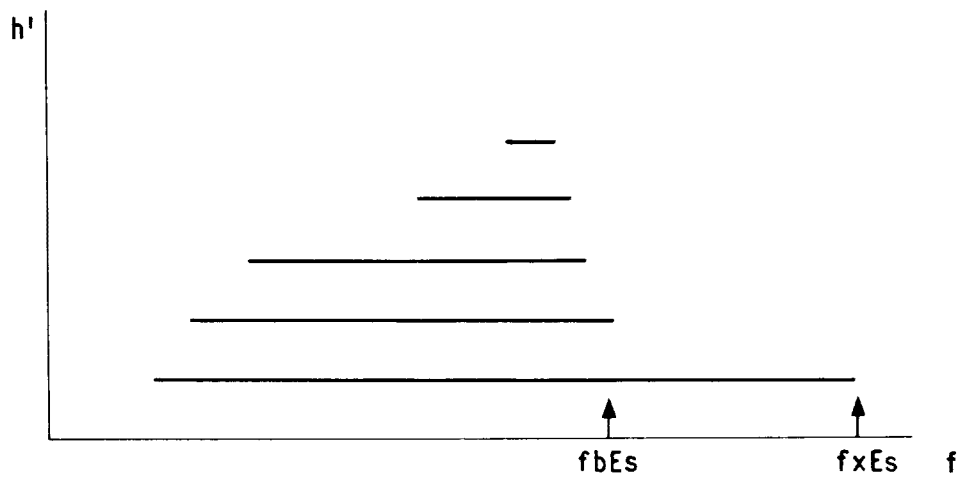

Fig. 3.2 Complete blanketing with consistent multiple traces

(i) All F-layer and normal E-layer parameters replaced by A.
(ii) Deduce foEs from fxEs, foEs = (fxEs - fB/2)JA.
(iii) Deduce fbEs from multiples, fbEs = xxxAA.

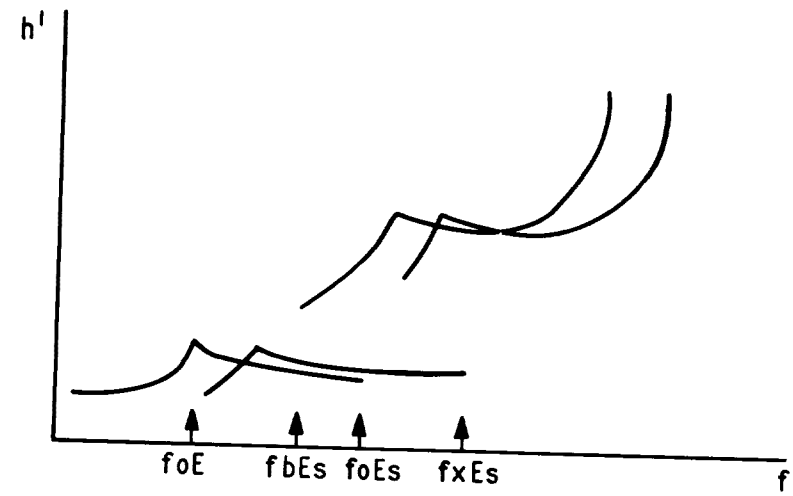

Fig. 3.3 Partial Blanketing

Note: If F trace nearly horizontal (see extrapolation, Section 2.4), use lowest value of h'F with EA, (h'F)EA. When extrapolation is not allowed, h'F is replaced by A.

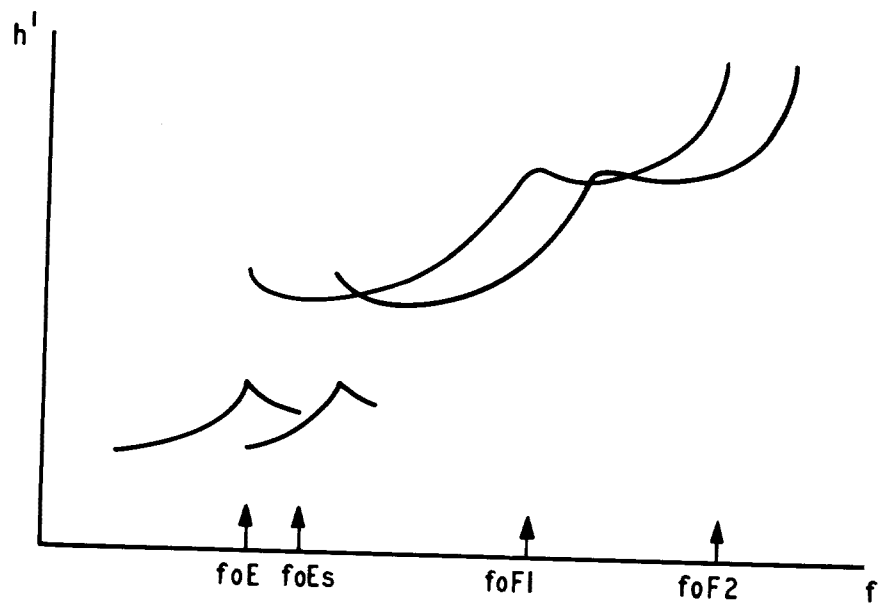

Fig. 3.4 Occultation of F by a thick E Layer

fbEs = (foE)EG
Note: In this case h'E is given as (h'E)EB
h'Es is given as (h'Es)EG

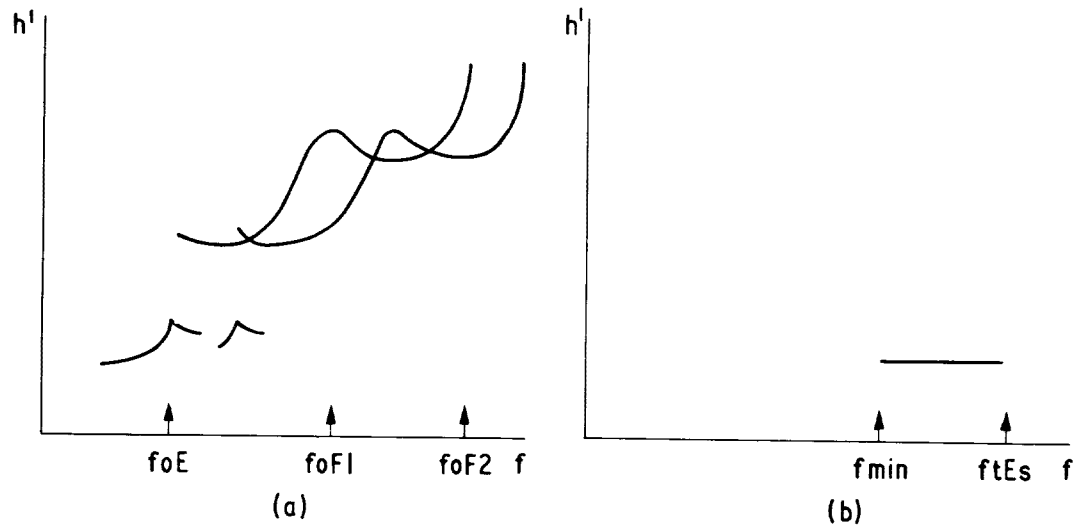

Fig. 3.5 Distinction between A and B

(a) absorption normal, corresponding time of day to (b)
(b) absorption high

(i) If in (b) fmin >foE in (a), h'E and foE replaced by B
<foE in (a), h'E and foE replaced by A

(ii) If in (b) fmin >foF1 in (a), h'F and foF1 replaced by B
<foF1 in (a), h'F and foF1 replaced by A

(iii) If in (b) fmin >foF2 in (a), h'F2 and foF2 replaced by B
<foF2 in (a), h'F2 and foF2 replaced by A

(iv) If there is little doubt that ftEs is foEs, i.e. that the x mode is absorbed foEs = (ftEs)-B
If doubt exists, for example if ftEs - fmin is large
foEs = (ftEs)MB
See section 4.3 for details.

In both cases fbEs = (ftEs)AA.

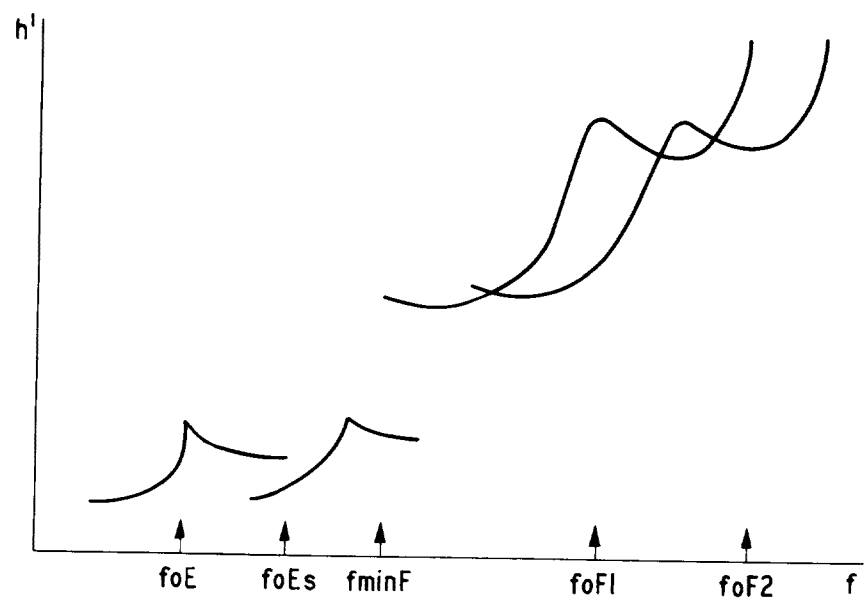

Fig. 3.6 Lacuna Case

fminF >foEs
fbEs = (foEs)EY

Note: Same convention applies if x trace is missing or if the F trace shows no retardation at lowest frequency.

B - Measurement influenced by, or impossible because of, absorption in the vicinity of fmin.

This letter applies only to the effects of non-deviative absorption. Absorption of this type is roughly measured by fmin (Figs. 3.5, 3.7, 3.8, 3.9) [A101I, Fig. 111; A112I, Figs. 128, 129, 144].

If the trace is well defined at lower frequencies and missing at a higher frequency, the letter B must not be used. In such cases the letters R or Y may be applicable (Fig. 3.9) [A112I, Fig. 137; A88I, Fig. 81].

When neither Es nor E echoes are observed but fmin is above the lower limit of the ionosonde and absorption is clearly indicated, foEs and fbEs are tabulated as less than the numerical value of fmin with descriptive letter B [A88I, Fig. 67]. h'Es is replaced by B (Fig. 3.7).

During total black-out or SID, use B for all characteristics including fmin. This is the only instance when letter B can be applied to fmin.

At stations using gain runs, it may happen that the medium-gain ionogram is blank because of absorption, so that fmin must be recorded as B. If traces appear on the high-gain record they should be scaled for all characteristics except foEs, fbEs and fxI despite the entry B in the fmin table.

When fmin is within about ± 10% of a critical frequency, the numerical value is perturbed by the relatively large retardation (deviative) absorption present. The fact that fmin is no longer a reliable measure of non-deviative absorption can be indicated using the convention (fmin) UR for these cases. This rule is used at stations where special care is taken to make fmin a quantitative measure of absorption.

Care should be taken to distinguish between high absorption at night (letter B) and absence of traces due to foF2 being below the lowest recorded frequency (letter E). The interference and noise level on the ionogram is usually detectably less than on normal ionograms in the former case but is unchanged in the latter. The time variation of foF2 also usually suggests when an E condition is likely to occur, Fig. 3.10.

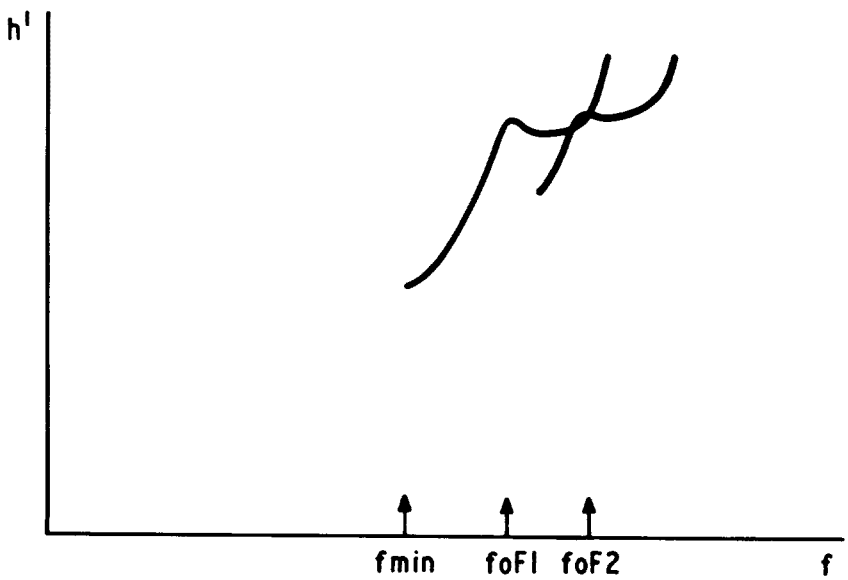

Fig. 3.7 High absorption in daytime

Use of B, foE, foEs, fbEs tabulated as (fmin)EB
h'E, h'Es replaced by B
h'F replaced by B unless within accuracy limit of normal value, then use (h'F)EB

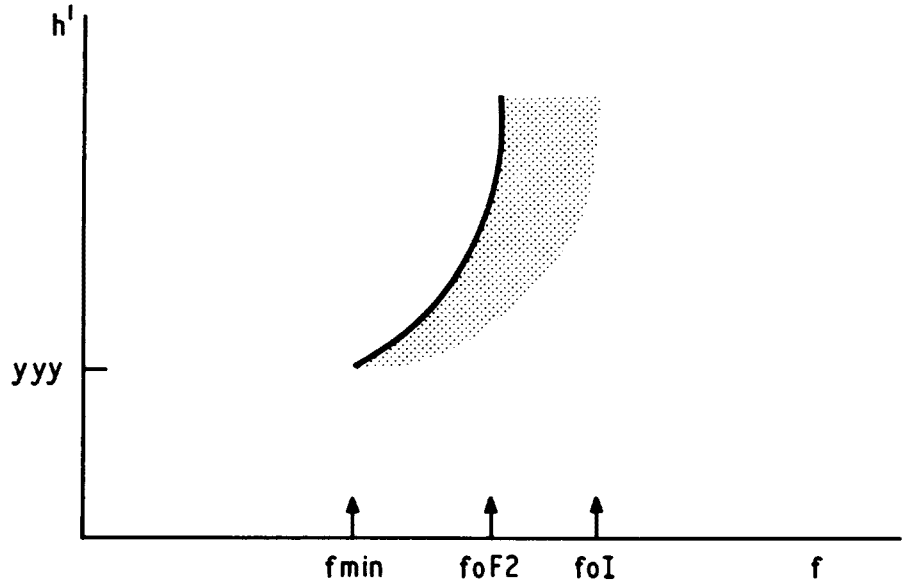

Fig. 3.8 High absorption at night

Use of B, foEs, fbEs tabulated as (fmin)EB
h'Es replaced by B
h'F tabulated as (yyy)EB
fxI tabulated as (foI + fB/2)OB

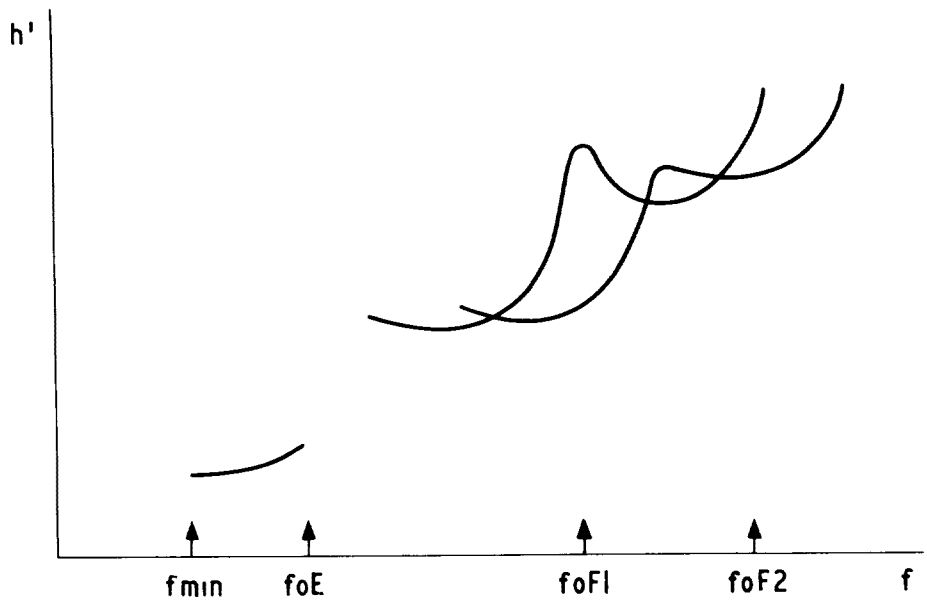

Fig. 3.9 Distinction B and R

foE is (foE)-R or (foE)UR depending on gap width (see accuracy rules).
Note: fmin determined by E not F trace.

C - Measurement influenced by, or impossible because of, any non-ionospheric reason.

C is used to explain missing records due to equipment or power failure, interference due to other local equipments (e.g. transmitters), or when it becomes necessary to take the ionosonde off the air to prevent interference with other installations. It is used to explain a doubtful measurement where there is uncertainty regarding the frequency or height scale (unusual expansion or compression of the record, poor identification of frequency markers, etc.) such that the measurement is in doubt by more than the nominal accuracy required of the measurement.

C is used to explain a doubtful measurement when there is uncertainty regarding the time of observation (poor legibility or absence of print-time, clock errors) such that the time of the record is uncertain by not more than 5 minutes. It may be used to explain a doubtful measurement due to poor equipment response in part of the frequency range. C is used to explain doubtful or missing values because of some failure or omission on the part of the operator (fogged or streaked film, out of film, etc.). Finally, C is used when interference is caused by rain or snow static (See letter S).

When part of the ionogram is unusable because of an instrumental fault, C, the rules for extrapolation or interpolation are the same as for letter, S.

D - Measurement influenced by, or impossible because of, the upper limit of the normal frequency range.

Care should be taken in the daily and monthly tabulations to distinguish the descriptive letter D from the qualifying letter D. When the upper limit is adjustable and is less than the published upper limit of the normal frequency range, the actual upper limit frequency, xxx, should be recorded, xxxDD.

E - Measurement influenced by, or impossible because of, the lower limit of the normal frequency range.

If foF2 is presumed to be at a frequency below the lower limit of the ionosonde, the replacement letter E is used in place of values foF2 and h'F. (Figs. 3.10 (a), (b). where no principal F trace was present and the f plot suggests foF2 is below the lower limit. The absence of the F trace is not in itself enough justification to use the descriptive letter E. Always judge from a sequence of records and from the noise and interference present on the ionogram; the letter A, B, or S is frequently the appropriate one [A112I, Fig. 135].

If foF2 is so close to the lower frequency limit of the ionosonde that the trace does not become horizontal, then the height of the echo at the lower frequency limit of the recorder is tabulated for h'F with the qualifying letter E (less than) and the descriptive letter E (Fig. 3.11). [A112I, Fig. 143].

During night hours when no Es echoes appear on the ionogram and fmin is below the lower frequency limit of the ionogram, the descriptive letter E alone is tabulated for foEs, fbEs, h'Es and fxEs where tabulated (Figs. 3.10 (b), 3.11). The descriptive letter E is not used in this way when a trace from a thick E layer is present on the ionogram (e.g. during daylight hours) (see letter G). The descriptive letter E may not be used if fmin is greater than the lower limit of the ionosonde.

When the lowest frequency of the ionosonde is changed at different times of day (as is usual for ionosondes employing switched bands), it is important that the actual lowest frequency in use be tabulated at least in the fmin tables whenever a limit value, (fmin)EE, is present; preferably this should be done for all parameters qualified EE.

When the critical frequency is lower than the lowest frequency of the ionosonde the appropriate symbol is E not G.

Care should be taken in the daily and monthly tabulations to distinguish the descriptive letter E from the qualifying letter E.

Where the ordinary characteristic is below the lower limit of the ionosonde but the corresponding extraordinary characteristic is present, this should be measured and the corresponding ordinary characteristic deduced and qualified by J and described by E.

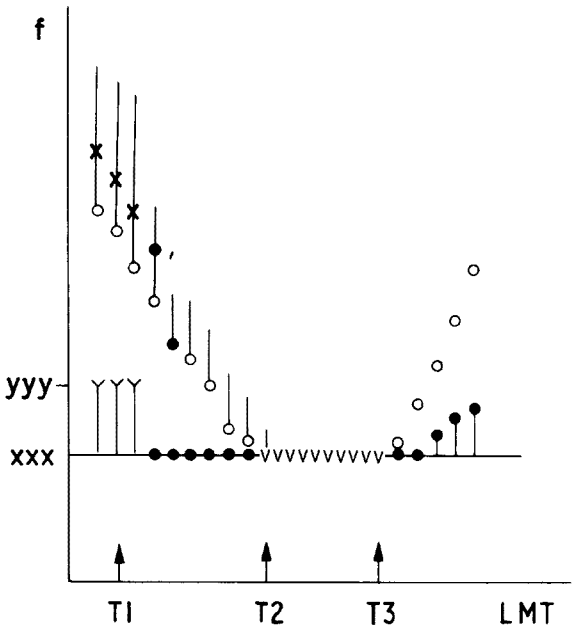

Fig. 3.10(a) Section of f plot showing use of EE

Lower limit frequency of ionogram xxx
Near T1 fmin is yyyES
foEs yyyES
fbEs yyyES
Between T2 and T3 all parameters replaced by E
(more accurately xxxEE)

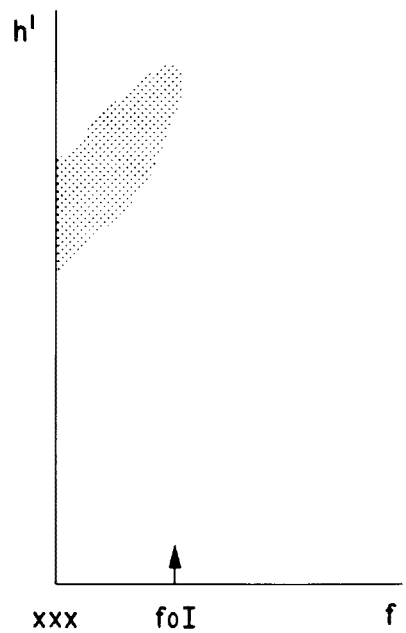

Fig. 3.10(b) Ionogram at time T2, Fig.3.10(a)

fxI = (foI + fB/2)OB.
All other parameters replaced by E
(more accurately xxxEE)

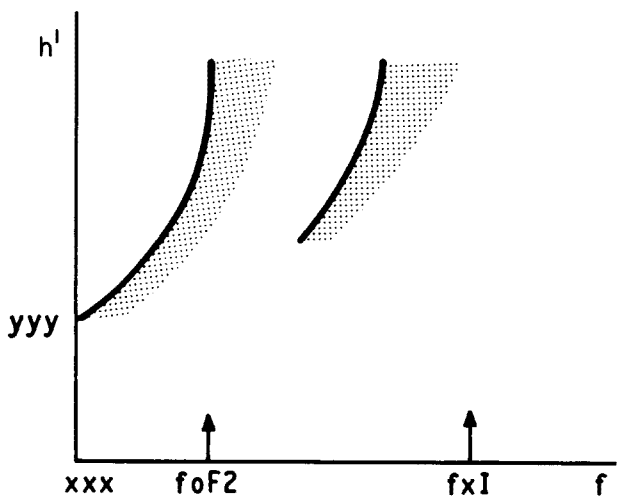

Fig. 3.11 Use of EE

Lowest frequency on ionogram is xxx
fmin (xxx)EE or less accurately E
h'F (yyy)EE
foEs, fbEs, fxEs and h'Es---E

F - Measurement influenced by, or impossible because of, the presence of spread echoes.

The critical frequency of a layer is usually modified by the presence of spread echoes, even when the reading accuracy of the characteristic is unaffected, and the descriptive letter F should be used in these cases. Whenever possible, a numerical value for the critical frequency should be tabulated, but caution should be used not to scale traces which are likely to be oblique (see section 2.7).

The procedures have been fully discussed in sections 2.7 and 2.8 and are therefore only summarized here.

The first step is to decide whether the main traces are due to a horizontal or a tilted layer, section 2.7, Figs. 2.6, 2.7, 2.8, 2.10. If the former, as is most usual except at high latitudes or during storms:

(a) the first choice is the principal trace (Figs. 3.12(a) and 2.10) [A98I, Fig. 101; A100I, Fig. 105; A104I, Fig. 122; A112I, Fig. 136].
(b) the second choice is guidance from the multiples (Figs. 3.12(b) and 2.11) [A104I, Figs. 123, 124].
(c) the third choice is a well-defined 'inside edge' of the spread (Fig. 3.12(c) [A40I, Fig. 29; A88I, Figs. 68-70].
(d) the fourth choice is a limiting value used with the qualifying letters D or E (see section 2.22, paragraph (d).
(e) the fifth choice is the descriptive letter F without any numerical value (Fig. 3.13) [A104I, Figs. 124 and 125]. For tilt cases see section 2.7.

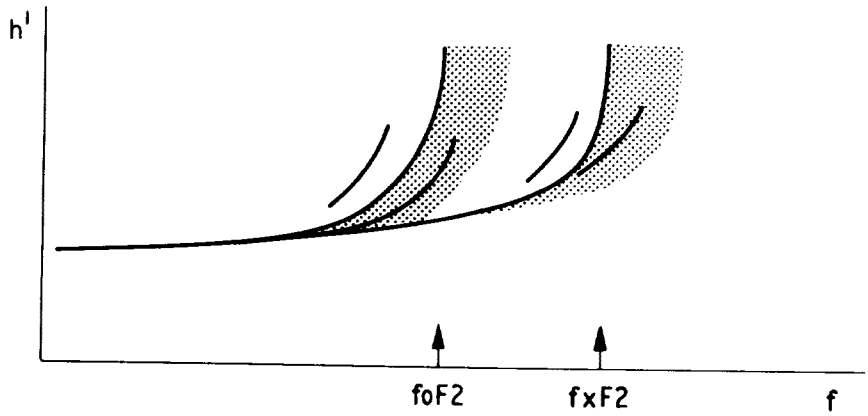

Fig. 3.12(a) Principal trace

(i) The principal trace is usually more solid than other traces.
(ii) For the principal trace fxF2 - foF2 = fB/2. This is not always true for subsidiary traces.

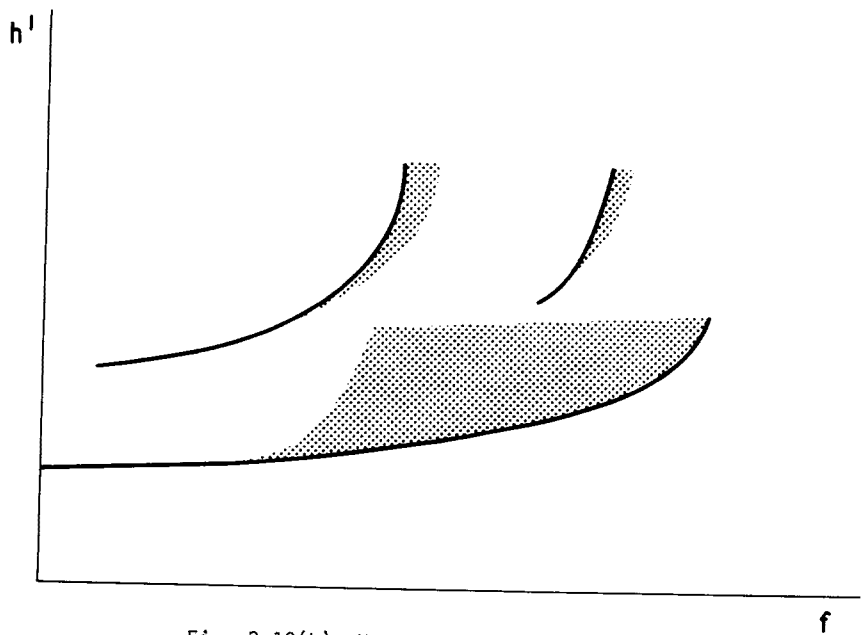

Fig. 3.12(b) Use of multiple orders

A principal trace can often be seen in the second or higher order when not visible on the first order. Again it is usually relatively solid and fxF2 - foF2 is often close to fB/2. The latter, when true, confirms the interpretation but is not essential.

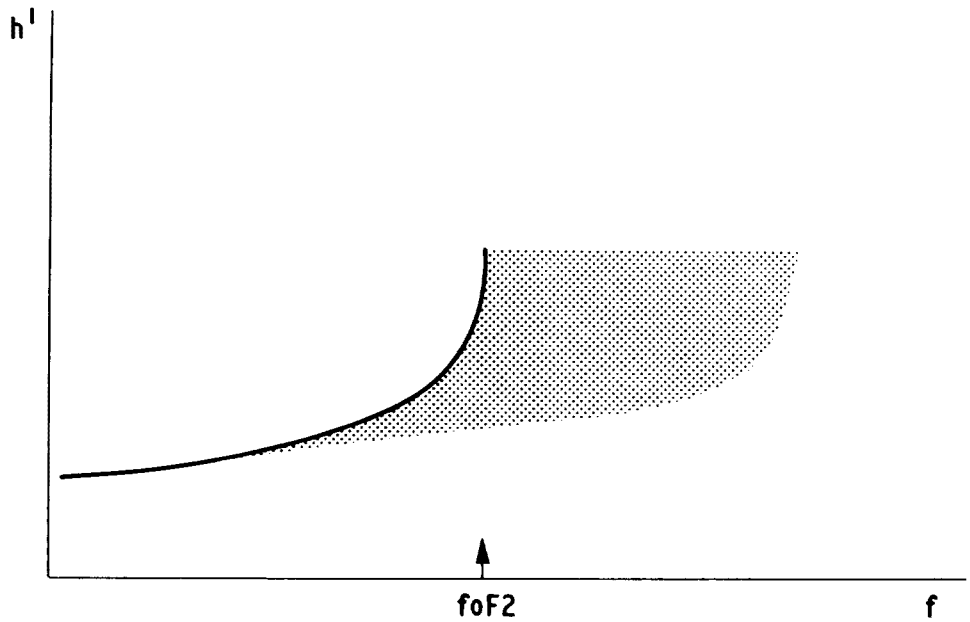

Fig. 3.12(c) Use of limit edge

When the main trace is due to a horizontally stratified layer, the lower frequency edge of the spread gives foF2. Very often a principal trace can be seen to define this edge. (see also Figs. 2.4, 2.11).

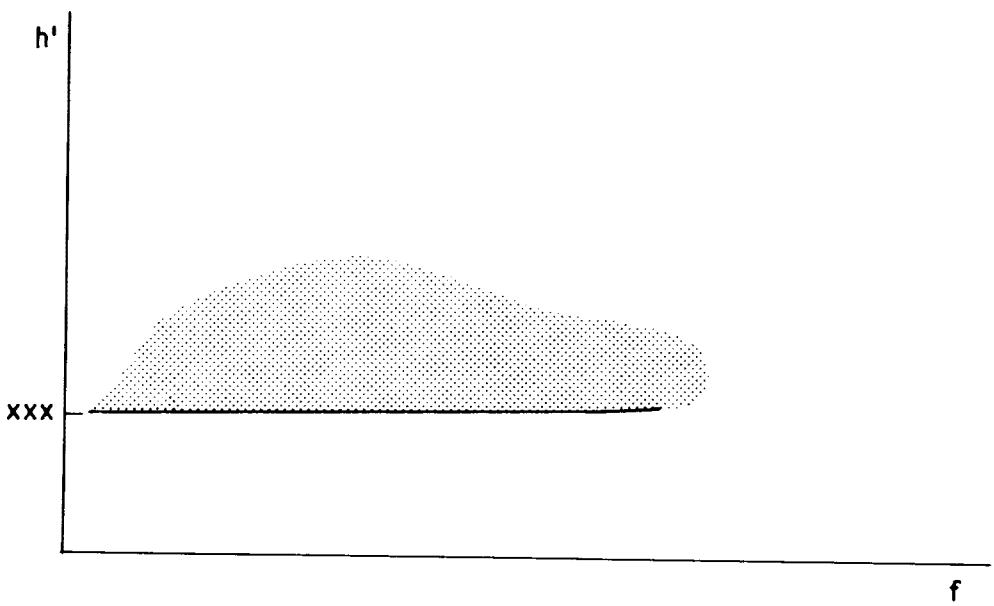

Fig. 3.13 No principal trace

Use of Q	foF2	replaced by Q
	h'F	xxx-Q or xxxUQ depending on whether or not lower edge clear.

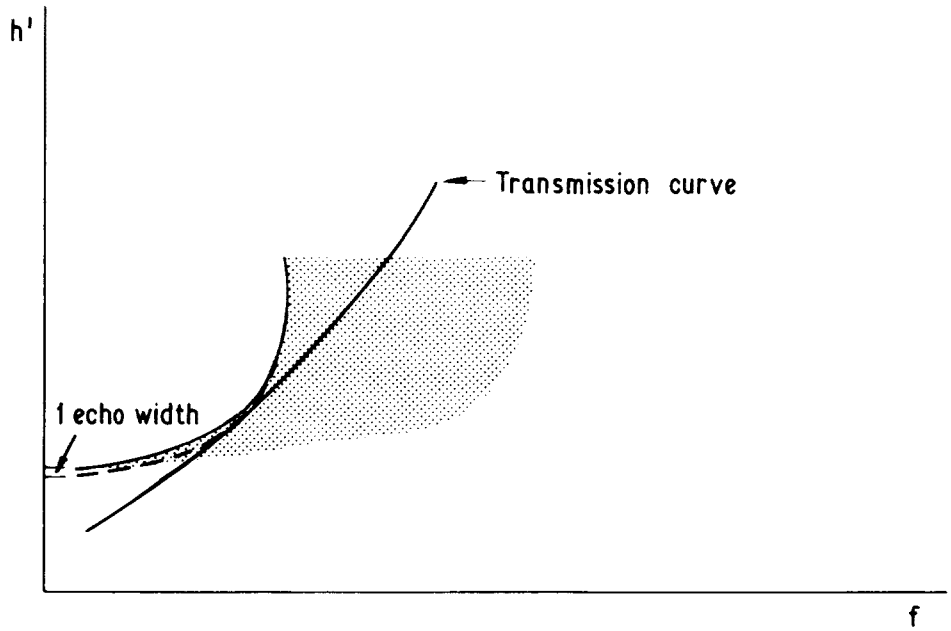

Fig. 3.14 Scaling of M(3000)

from Ionogram with well defined inner edge to scatter pattern

—— observed inner edge
- - -constructed trace edge

Procedures to be followed in scaling M(3000) when spread echoes are present are as follows:

(a) The first multiple echo may be used as a guide to help determine the location of the main echo.
(b) If there is a well-defined 'inside edge' to the trace, proceed as follows: construct a curve, each point of which is one echo width below the corresponding point of the inside edge. Scale the factor from the reconstructed trace, Fig. 3.14.
(c) If these methods fail, the descriptive letter F without any numerical value is tabulated.

Letter symbol F can never be used with parameters h'I, dfS, as these characteristics are used only when spread F is present. When F is used to denote spread F typing in foF2 or fxI tables, it takes precedence over all other descriptive letters (see section 2.8).

Letter F must be used whenever the frequency spread is equal to or exceeds 0.3 MHz and should not be used when it is less than this value. This rule enables the presence of spread F to be compared at different stations.

G - Measurement influenced or impossible because the ionization density of the reflecting layer is too small to enable it to be made accurately.

This letter is used when foF2 is equal to or less than foF1. In this case tabulate the numerical value of foF1 for foF2 and use the qualifying letter E (less than) and the descriptive letter G [A88I, Fig. 84; A100I, Fig. 108]. For M(3000) F2 and h'F2 tabulate the letter G with no numerical value (Fig. 3.15).

The letter G is used for Es characteristics in all cases when no Es traces are observed although normal E-layer traces are present (Fig. 3.16).

A numerical limit should always be given with EG and is helpful to the user when foE varies greatly in a month. Usually, however, the variability of foEs is so much greater than that of foE that a median foE is adequate and this minimizes work.

As all median and quartile values of foEs or fbEs should be numerical, the value of median foE is inserted if these would otherwise be G (Section 8).

If, because of interference, it is not possible to obtain numerical values for foE, yet the presence of the E trace is observable, it is proper to use G for the missing Es characteristics (Fig. 3.17).

G is used to explain a doubtful or limiting value of h'Es when the low frequency end of the Es trace is affected by group retardation and the trace does not become horizontal (Fig. 3.18) [A112I, Fig. 134]. This applies in the case of Es type c and Es type h.

For Es types ℓ and c, when foEs is less than foE, the numerical value of foEs and fbEs must be described by the letter G (Figs. 3.19 and 3.20). This is necessary for median determination.

Note: Two common difficulties concern the proper use of G or B and of G or E. For G to be used there must be positive evidence of the presence of a reflecting lower thick layer, i.e., any group retardation due to its critical frequency is visible on the ionogram. If the trace is missing because of high absorption the appropriate letter is B; if the critical frequency falls below the lowest limit of the ionosonde the associated characteristics are replaced by E. Stations making gain runs should use the high-gain sounding to determine whether the letter G applies.

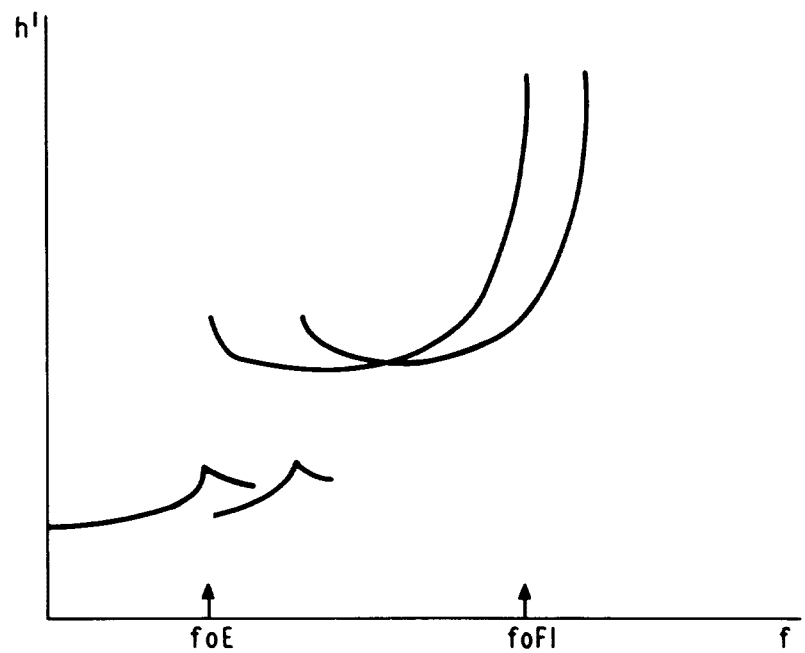

Fig. 3.15 G condition. No F2 trace visible

foF2 is given by (foF1)EG (less accurately by G)
h'F2 is given by G
M(3000)F2 is given by G
Note foF1/foE will be approximately given by the normal ratio when foF2 is present (Section 1.13).

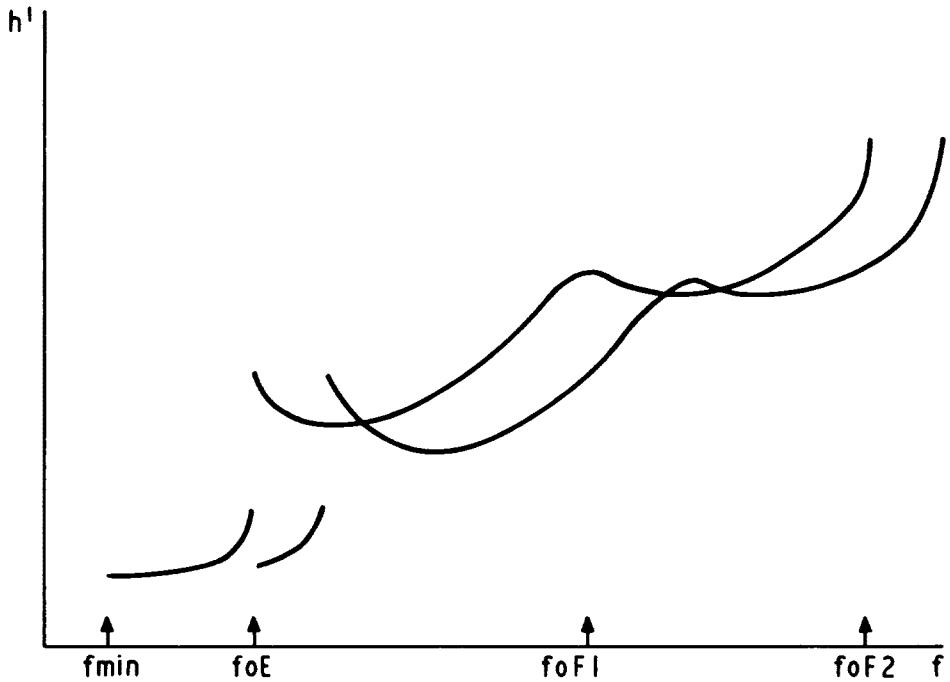

Fig. 3.16 G condition. No Es trace visible

foEs given by (foE)EG
fbEs given by (foE)EG
h'Es replaced by G

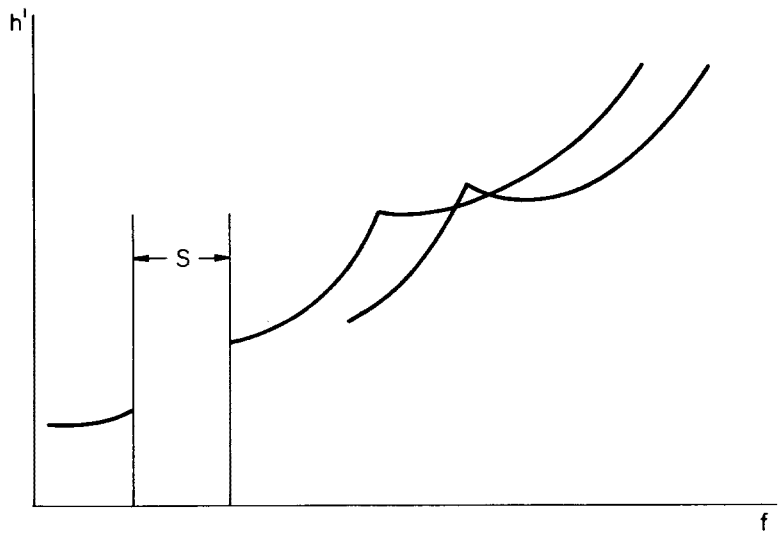

Fig. 3.17 Use of G,S when interference is present

foE = S, foEs = G, fbEs = G, h'Es = G

More accurately use median values of foE to give
foEs = (foE)EG, fbEs = (foE)EG.

A similar pattern due to instrumental fault would show C instead of S.

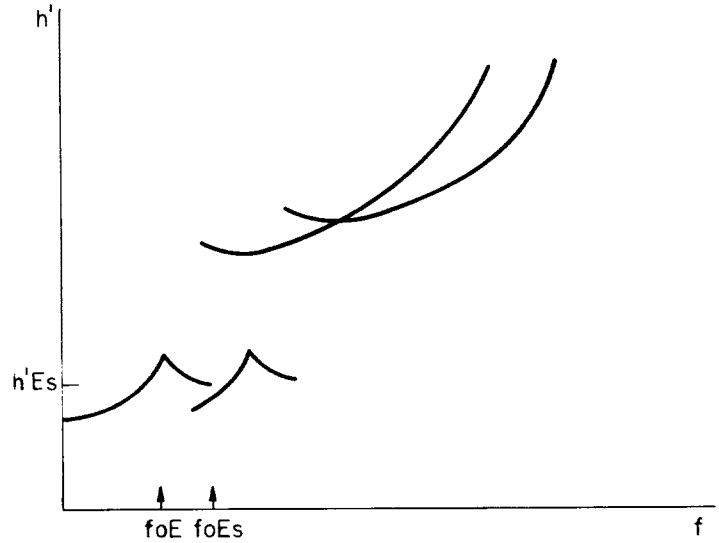

Fig. 3.18 Use of G with h'Es
h'Es = (h'Es)EG

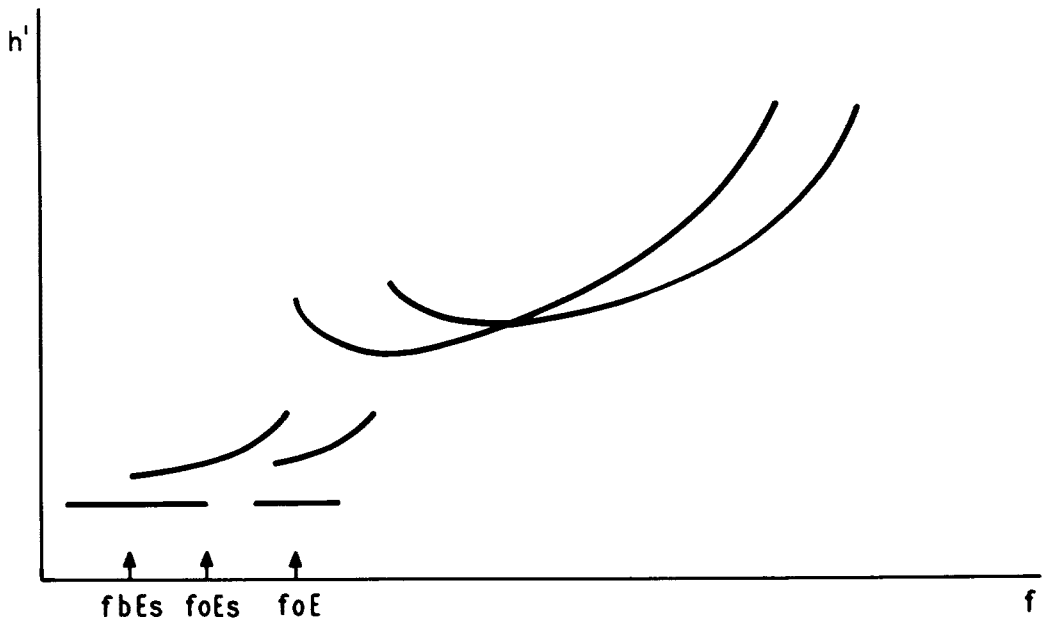

Fig. 3.19 Use of G to show foEs less than foE
foEs is written (foEs)-G
fbEs is written (fbEs)-G

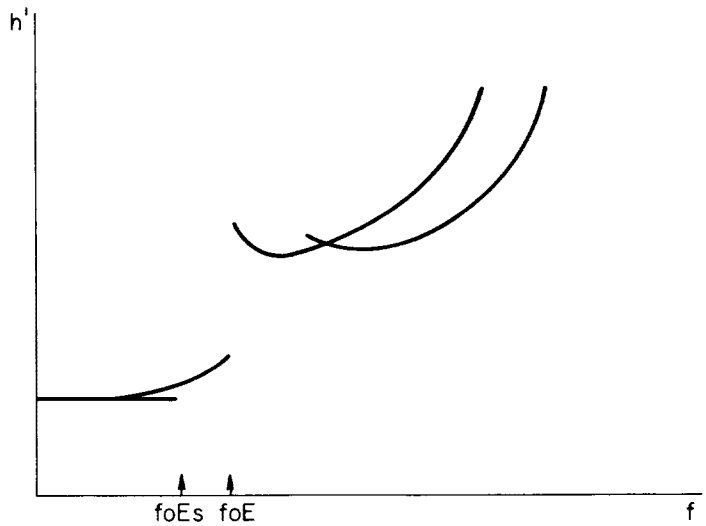

Fig. 3.20 Use of G to show fbEs less than foE

foEs is written (foEs)-G

In this figure fbEs is less than the lowest frequency recorded xxx.
fbEs is written (xxx)EG or, in approximate form, G

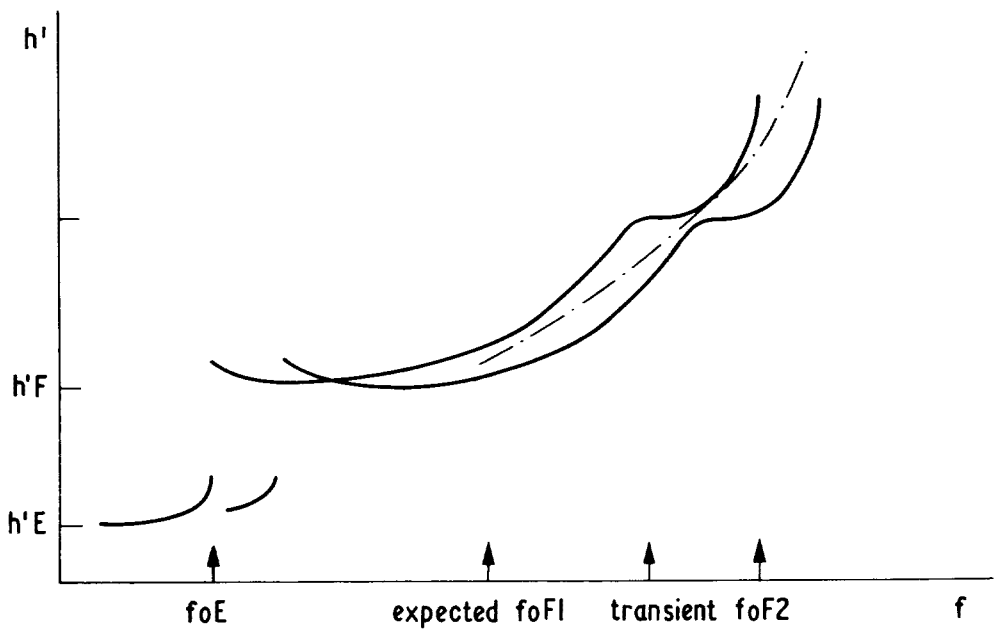

Fig. 3.21 Stratification H influencing foF2 and M(3000)F2

— · — · — · transmission curve touches abnormal trace
foF2 given by (foF2)-H
M(3000)F2 given by (M(3000)F2)UH
h'F2 is transient and not recorded

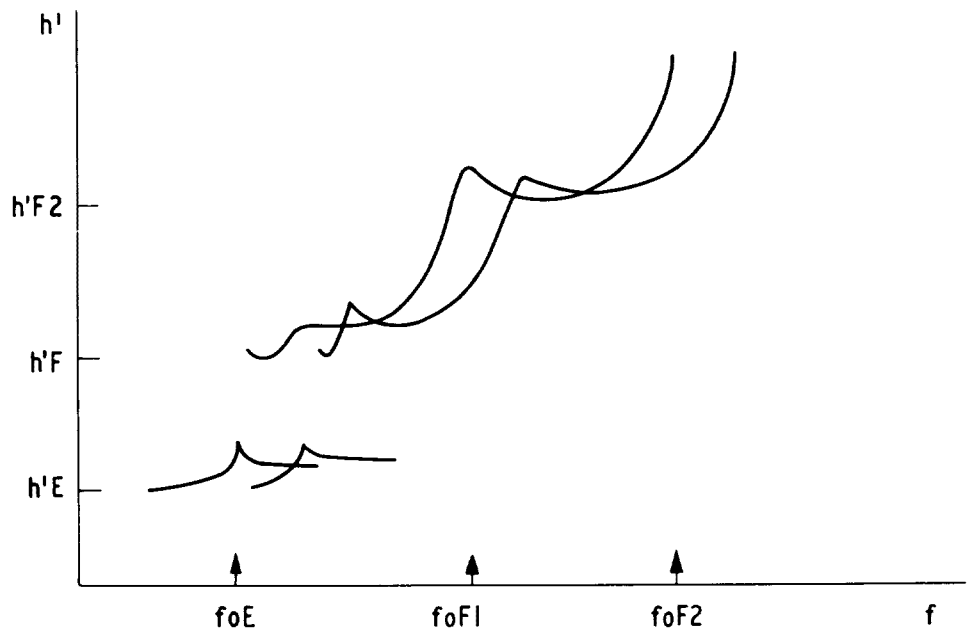

Fig. 3.22 Stratification influencing h'F

h'F given by (h'F)UH.
(when the transient can be easily seen U is needed.)

H - Measurement influenced by, or impossible because of, the presence of stratification.

This letter may refer to the traces of any regular layer. It is used when the trace shows a retardation cusp or point of inflection not normally scaled at the station (Fig. 3.21). In most cases the phenomena are transient [A88I, Figs. 81, 83; A98I, Fig. 91; A128I, Fig. 148]. In Fig. 3.21 the expected value of foF1 is at a much lower frequency than the stratification shown.

The presence of abnormal stratification usually modifies the critical frequency or virtual height of the layer, as can be seen from the f plots or h' plots respectively. The descriptive letter H is therefore necessary in these cases, even when the reading accuracy of the characteristic is unaffected, Fig. 3.22.

The qualifying letter U should be used when comparison of different components, orders of reflection or a sequence of ionograms shows that the uncertainty of interpretation exceeds the allowed limit. The definitions of the normal characteristics should be used to identify the appropriate value in doubtful cases. Thus, for the F2 trace, the highest critical frequency and lowest virtual height should be tabulated.

M(3000) should always be determined using the trace of the regular layer as a whole (e.g., F2, F1 or F1.5 when scaled systematically) (Fig. 3.21; point-dash line: transmission curve).

K - Presence of a particle E layer

This letter is used to distinguish cases where foE is determined by a particle E layer--a thick layer in the E region generated by particle precipitation and having a critical frequency significantly higher than the normal solar controlled E layer. This letter has been devised primarily to draw attention to particle-generated thick E layers found at hours when foE due to the normal E layer is also present; e.g., for low frequency ionograms and for stations at high latitude in summer months. The primary indication that particle E is present is the presence of group retardation at the low frequency end of the trace from the higher layer. (Fig. 4.2, p. 105). A possible physical definition of particle E is that it is a thick layer formed below the F layer directly or indirectly by the action of ionizing particles and having a critical frequency greater than that of the normal E layer. For scaling purposes the descriptive definition is quite adequate. Letter k is inserted in the Es-type table when particle E, Es-k, is present. Es-k takes precedence over all other Es traces present other than that giving foEs.

When the E trace is totally blanketing the distinction between a thick layer particle E or a thin layer with apparent retardation at the top frequency (Es type r) cannot be certain. In cases of complete doubt classify as Es type r. The following criteria should be used:

(a) When absorption is small, particle E gives both o and x modes and one or more multiple traces extending to near foE; whereas Es type r either shows no multiple traces or multiples which stop at a frequency appreciably lower than foEs. When any of the multiple traces are within the accuracy rule limits for use of U with foEs, the distinction type r or particle E is not significant; scale as particle E, foEs = fbEs = foE, entry (foE)-K.

(b) When absorption is high a solid trace is more likely to be due to particle E than to Es type r, and a weak trace or trace showing spread is more likely to be Es type r than particle E.

L - Measurement influenced by or impossible because the trace has no sufficiently definite cusp between layers.

The letter L is used for F-region characteristics (Fig. 3.24). The criterion for deciding the use of L is the relative slope of the F1 and F2 traces. (See also section 6.4 for detailed rules).

The conventions given below are intended to give a quantitative guide as to when L should be used by comparing the slope of the F1 trace with the slope of the transmission curve. If the latter always cuts the former L must be used. If a tangent point can be found (equal or greater slope of F1 trace relative to transmission curve) a numerical value is possible.

(a) The conventions for using L when scaling foF1 are:

(i) When the shape of the F trace shows that no F1 stratification is present no entry is made. (F traces never concave downwards) (Fig. 3.23).

(ii) When the transition from the F1 trace to the F2 trace is smooth and ill-defined, the probable error in estimating the true value of foF1 will exceed 20% and the numerical value is replaced by the letter L (Fig. 3.24). The M(3000) transmission curve will not give a point of tangency with the F1 trace in these cases, cutting the F1 trace at an angle, [A100I, Fig. 110], (Fig. 3.24).

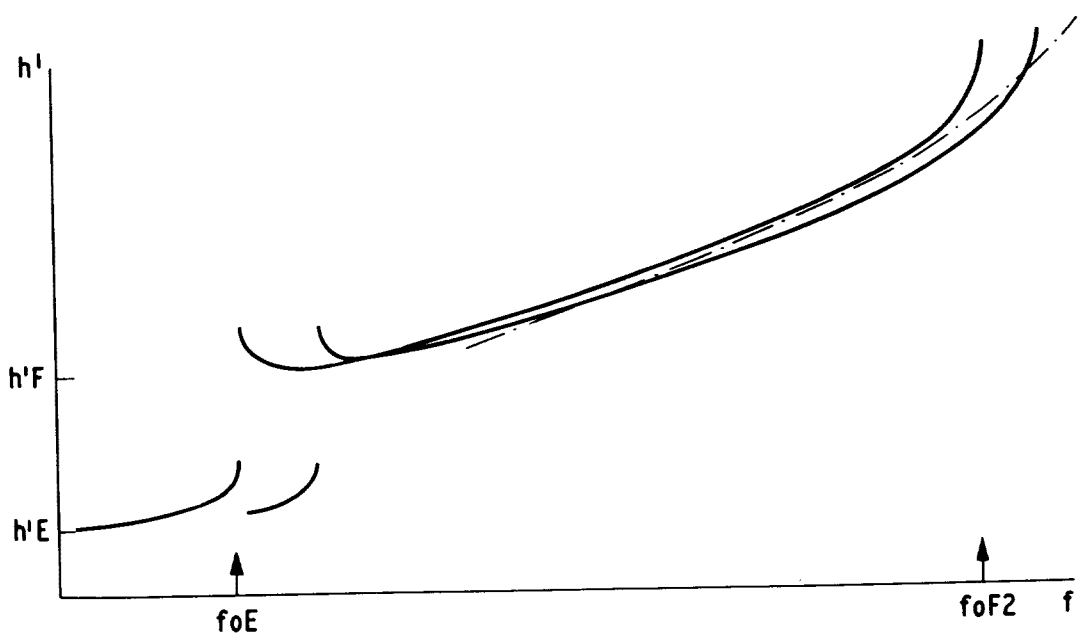

Fig. 3.23 Use of L

— · — · — · transmission curve touches o trace at one point only. foF1, M(3000)F1, h'F2 no entry in tables. foF1 no entry on f plot.

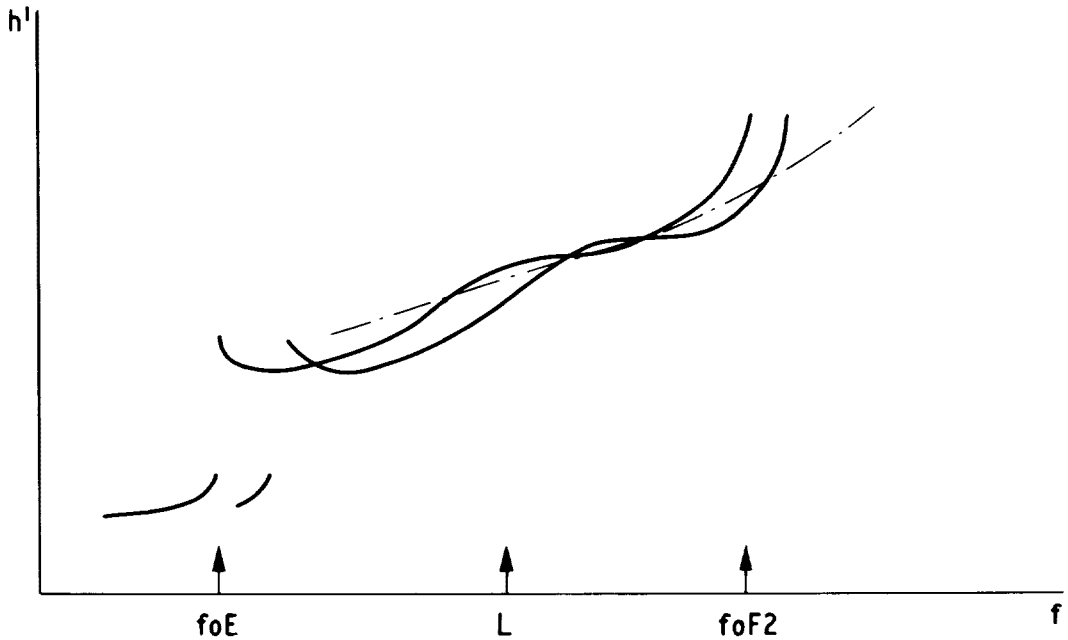

Fig. 3.24 Use of L

F2 trace not horizontal
foF1, M(3000)F1, h'F2 replaced by L
L is placed on f plot at frequency shown

(iii) When the M(3000) transmission curve gives a point of tangency with the F1 trace but the F2 trace does not become horizontal, scale with qualifying letter D and descriptive letter L [A100I, Fig. 109]. (Fig. 3.25a).

(iv) When the M(3000) transmission curve gives a point of tangency on the F1 trace and the trace shows an ill-defined maximum or one which is only clear on a multiple reflection, scale with the qualifying letter U and the descriptive letter L (Fig. 3.25(b)).

(v) When the cusp is sufficiently well defined for foF1 to obey the criteria for an accurate measurement do not use L.

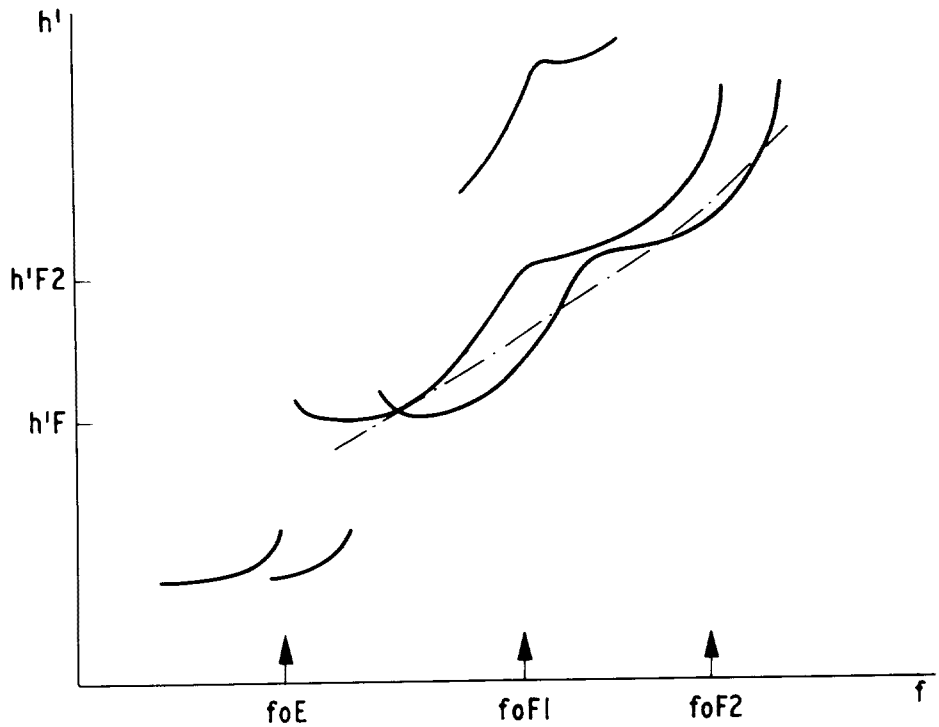

Fig. 3.25(a) Use of DL

F2 trace is not horizontal.
foF1 given by (foF1)DL measured at frequency at which F1 trace slope most rapidly decreasing (see section 6.4 for f-plot representation).
h'F2 given by (h'F2)EL, (h'F2)UL or by L depending on minimum slope of F2 trace.

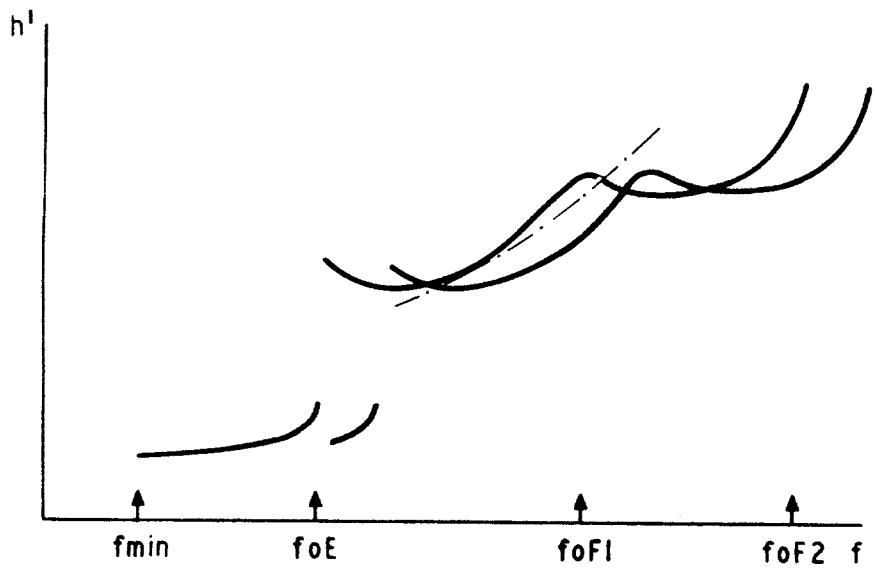

Fig. 3.25(b) Use of UL

For foF1 cusp equal to or less than that shown and transmission curve can be made to touch F1 trace use (foF1)UL.
Note when o-and x-mode traces less similar than that shown, (foF1)UH would be preferable.

(b) The conventions for determining M(3000)F1 are based on the fact that the main source of error is usually the determination of foF1. For this case, the five foF1 cases given above give:

(i) M(3000)F1 left blank
(ii) M(3000)F1 replaced by L
(iii) M(3000)F1 deduced at the numerical value of foF1 and qualified EL
(iv) M(3000)F1 deduced from the numerical value of foF1 and qualified UL
(v) M(3000)F1 unqualified. Do not use L.

(c) The conventions for using L when scaling h'F2 are:

(i) When the shape of the F trace shows that no F1 stratification is present, no entry is made (Fig. 3.23).

(ii) When the F2 trace does not show an almost horizontal section the numerical value is replaced by the descriptive letter L (Fig. 3.24) [A96I, Fig. 88; A100I, Fig. 109].

(iii) When the F2 trace is almost horizontal h'F2 may be tabulated with qualifying letter U and descriptive letter L [A96I, Fig. 86].

(iv) L is not used when the F2 trace has a horizontal tangent [A96I, Fig. 87].

Similar conventions may be used when additional characteristics are tabulated for local purposes, e.g., the intermediate layer F1.5 (Chapter 12).

It should be noted that there can be occasions when the appropriate letter symbols can be different for all four F1 parameters, e.g., h'F below fmin, entry V; M(3000)F1 tangent point blanketed by Es, entry A; foF1 a good cusp, unqualified entry; h'F2 hidden by interference, entry S. The appropriate letter symbols take precedence over L whenever they represent the more important source of inaccuracy or ignorance.

In most cases, M(3000)F1 and foF1 will show the same usage of L. In borderline cases, h'F2 will usually be more exact than foF1 or M(3000)F1 and the conventions are therefore given separately.

Letter L is used to denote the presence of spread F type mixed and is used in spread F type, foF2 or fxI tables only (section 2.8). The identification of spread F type L is voluntary but recommended by INAG as being valuable scientifically. When L is used in the foF2 or fxI tables for this purpose it takes precedence over all other descriptive letters.

M - Interpretation of measurement uncertain because ordinary and extraordinary components are not distinguishable.

Descriptive letter M is used to show that it was not possible to distinguish which component was present. It is mainly used when the presumption is that the required characteristic was not seen and the numerical value has been deduced. It is preferable to use M as a qualifying letter wherever possible giving the descriptive letter showing why interpretation was not possible.

This letter is used primarily for the characteristics foEs and fxEs. Its use for these is discussed fully in sections 4.4 and 4.5 (Es characteristics).

The letter can also apply to foF2 and fxI when there is real doubt of whether the o or x mode is observed. It should not be used if the doubt can be resolved by using a sequence of ionograms or by comparison with other ionograms. The most common case occurs when foF2 is varying irregularly in time and is close to or below the lowest frequency of the ionogram.

M should be used as a descriptive letter when a qualifying letter such as D, E, U is appropriate and the interpretation is also doubtful and may be used when there is no main reason for the doubt, e.g., ( )MM or ( )-M implies several causes with equal weight.

Letter M always implies an uncertainty of fB/2 in frequency characteristics, an uncontrolled uncertainty in height parameters, and M(3000) factors should not be computed for data described or qualified by it. It should be used as sparingly as possible.

N - Conditions are such that the measurements cannot be interpreted.

Use this letter as sparingly as possible. Be certain no other letter describes the difficulty. Usually a careful examination of a sequence of records will provide a logical interpretation [A88I, Figs. 66, 67; A96I, Figs. 91, 92; A104I, Fig. 115]. The most common use of this letter is when oblique echoes prevent unambiguous interpretation of the ionogram.

N is used when traces of different orders are superimposed so as to prevent an unambiguous interpretation of the traces. In general the reason for using N should be shown in the remarks column.

O - Measurement refers to the ordinary component.
(See section 4.5 for use when fxEs is tabulated.)

Descriptive letter O shows that an o-trace characteristic has been tabulated in an x-mode table without correction. Where suitable programs exist, the computation foX + fB/2 = fxX can be more accurately done than by hand. This should only be used when it is known that the final tabulation will include the correction. The most common application is when fxI = fxF2 and only foF2 is evaluated, use (foF2)-O. Note: O must take precedence over all other descriptive letters in this case and the procedure is therefore less useful than the direct measurement of fxI or its calculation from foI. Also this cannot be done when foI is not equal to foF2, i.e., spread is present; it is then necessary to calculate fxI manually using qualifying letter O and the appropriate descriptive letter. For example, with foI near the gyrofrequency fB, calculate fxI = (foI + fB/2) and tabulate (foI + fB/2)OB.

Similar rules apply for descriptive letter X. The qualifying letter corresponding to X has always been J. Section 1.04 gives more exact rules which should be used where necessary.

P - Man-made perturbation of parameters - Presence of polar spur traces.

P is used to show that the ionosphere has been modified by man-made pheonomena, e.g. heating experiment, injection of foreign substances.

Spread F types. P shows the presence of spur type spread F. When used for this purpose in fxI tables P takes precedence over all other desciptive letters. Many examples are shown in the High Latitude Supplement (UAG-50).

Q - Range spread present.

Q is used to show the presence of a range spread trace, see sections 2.74 and 2.8, Figs. 2.14, 2.17, 3.13 and see section 2.3. It is tabulated with the value of h'F and takes precedence over F when a distinct range spread structure is present. The main objective of this letter is to identify cases where a range spread structure is observed at oblique incidence and cases where no main trace or frequency spread is present. It is mainly used at high and low latitudes, but may be important anywhere during major ionospheric storms. Many examples are shown in the High Latitude Supplement (UAG-50).

R - Measurement influenced by, or impossible because of, attenuation in the vicinity of a critical frequency [A88I, Fig. 81; A112I, Fig. 129].

The letter R may be used to replace or describe a numerical value of any characteristic (example: see Fig. 3.26). The attenuation must be associated with retardation, the trace starts to move up towards the critical frequency and then disappears. Wide gaps in the trace which cover frequencies where retardation would be expected to be small are due to layer tilt, letter Y; to instrumental causes, letter C; or interference, letter S. When R is applicable the trace weakens gradually, when Y is applicable the trace is strong and stops suddenly (see Y).

R can only be used when there is evidence for the existence of a principal ray trace. The top frequency for a scattering layer cannot be a true critical frequency even when the scatter pattern rises in height near the top frequency; the proper letter to use in this case is F.

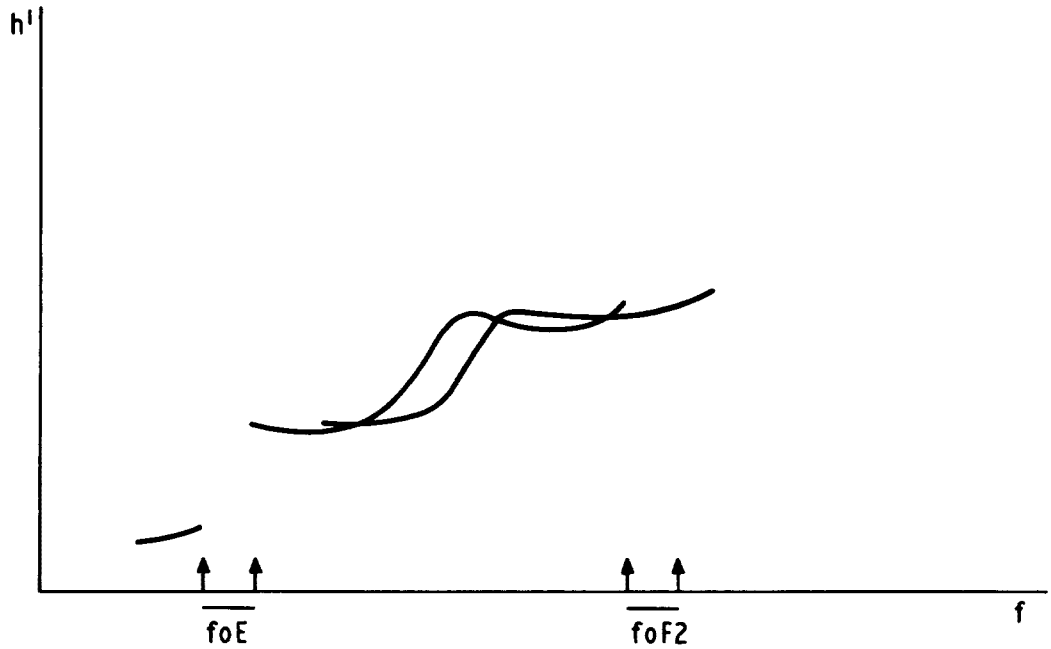

Fig. 3.26 Use of R

Traces show beginning of retardation near critical frequencies and then disappear. If no retardation is seen, Y is likely to be more appropriate (see letter Y).

The accuracy rules determine whether entry should be (foE)--, (foE)-R, (foE)UR, (foE)DR, (foE)ER or R, and (foF2)--, (foF2)-R, (foF2)UR, (foF2)DR or R.

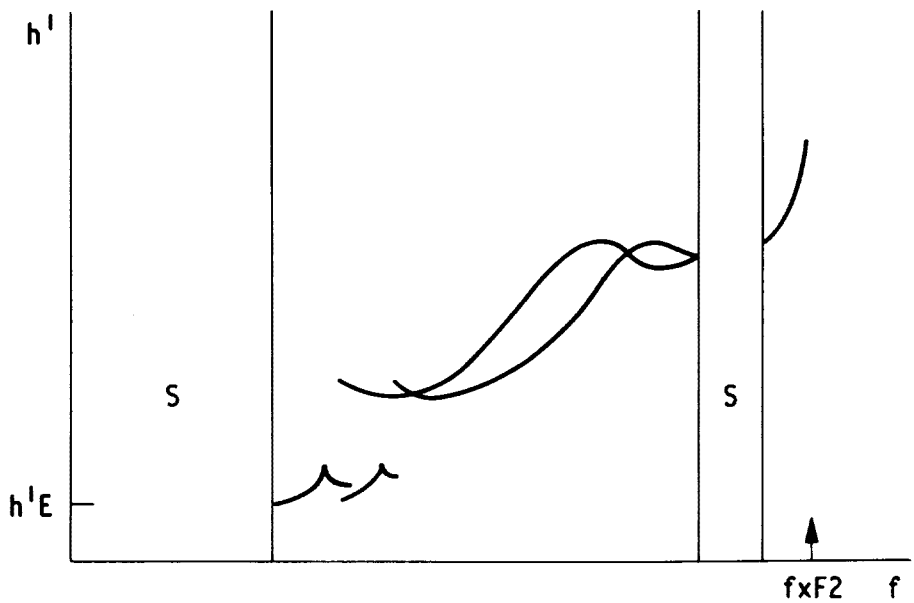

Fig. 3.27(a) Use of S

foF2 given by (fxF2 - fB/2)JS
h'E given by (h'E)ES

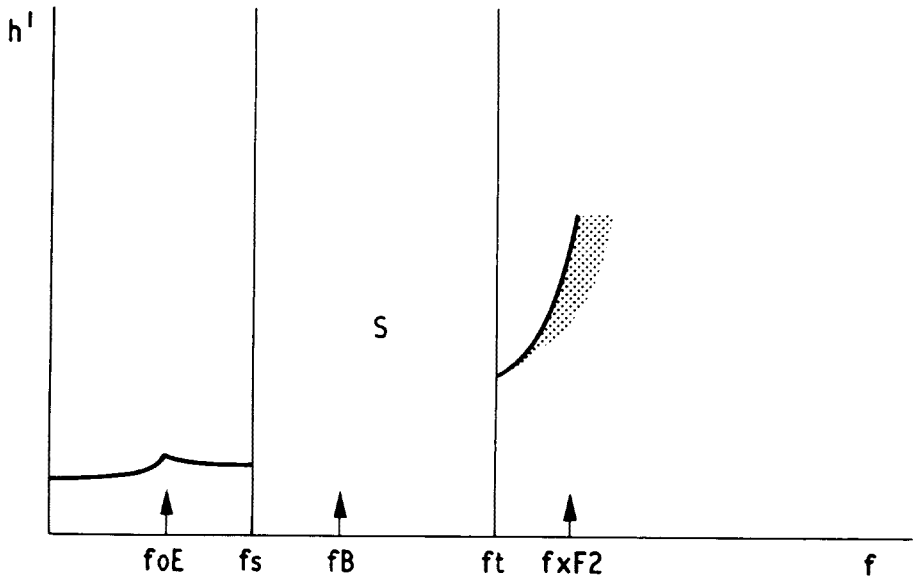

Fig. 3.27(b) Use of S on low frequency ionogram

foF2 given by (fxF2 - fB/2)JS
foEs and fbEs given by (fs)DS
h'F replaced by S as no ordinary ray trace is visible

Note: This should not be used if foEs is usually above ft at this time of day. Then (ft)ES is more useful. This is occasionally found in summer months.
If an F trace is seen below fs and no F traces above ft, foF2 is best given by (ft)ES.

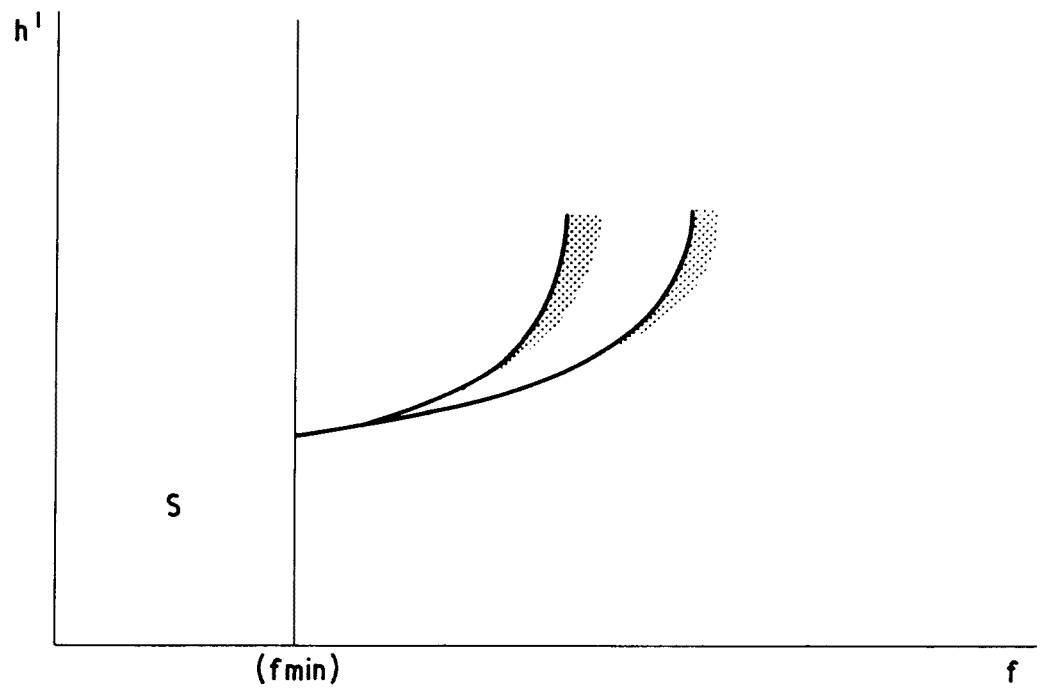

Fig. 3.28 Use of S at night

h'F is given by (h'F)ES
foEs, fbEs and fmin given by (fmin)ES
h'Es replaced by S

S - Measurement influenced by, or impossible because of, interference or atmospherics.

This letter should be used only when considerable difficulty from either of these causes affects the reading of the characteristic in question; i.e., only to explain a missing, doubtful, interpolated, or 'J' value (Figs. 3.17 and 3.27) [A88I, Fig. 81; A112I, Fig. 138; A113I, Fig. 145].

When the low frequency portions of the traces are obscured by broadcast band interference, the value of fmin should be tabulated, qualified by letter E (less than) and described by letter S (Fig. 3.28). Accuracy rules do not apply in this case.

A special difficulty arises with low frequency ionograms where there is often a wide band of broadcast interference present for many hours. As the limits of this are usually rather constant and clearly recognizable in the data, the accuracy rule can be relaxed without danger of confusion. When an E or Es trace disappears into this interference band and does not appear at the upper frequency limit, it is allowed to use (limit value) DS without applying an accuracy rule. In the case of F-layer traces, the corresponding rule is to take the upper limit of the missing band with ES. These values are usually abnormally small relative to the median for foF2 and abnormally high for Es, so that they add to the median count without greatly increasing the difference between first and second medians (Chapter 8).

During night-time hours when fmin is tabulated with the qualifying letter E and the descriptive letter S, and no Es is present, foEs and fbEs are tabulated in the same way as fmin, and h'Es is replaced by S (Fig. 3.28).

In general, interference known to be due to local causes, e.g., faulty generators, motors or lamps, snow or rain static, should be regarded as an instrumental fault (letter C rather than S).

T - Value determined by a sequence of observations, the actual observation being inconsistent or doubtful.

The descriptive letter T should only be used in those rare cases where an isolated numerical value is so unrepresentative that it has been replaced by an interpolated value from the smoothed f plot. Such values are qualified by the letter T also. This procedure is not allowed for fmin, fxI or for Es characteristics. Most stations ignore T.

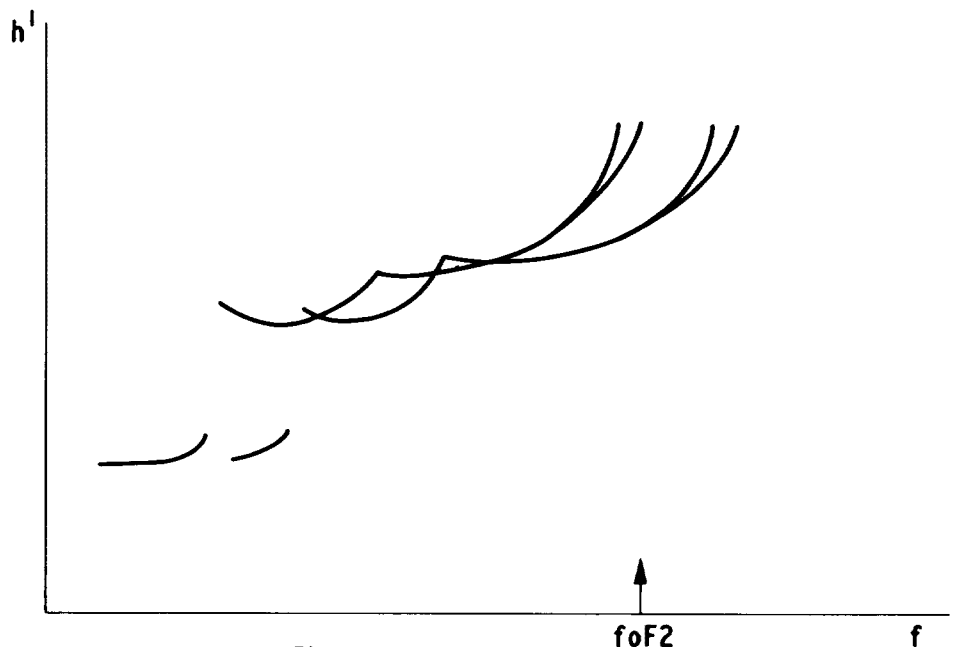

Fig. 3.29 Forked Trace

V - Forked trace, which may influence the measurement.

Scale the high frequency branch of the ordinary wave component (Fig. 3.29) [A128I, Fig. 149]. Do not confuse obvious oblique echoes, spread echoes or stratifications with forked trace [A88I, Figs. 66, 67, 70, 71; A96I, Fig. 91b; A100I, Fig. 105; A104I, Figs. 115, 122, 124].

W - Measurement influenced or impossible because the echo lies outside the height range recorded [A128I, Fig. 150].

With a normal height range (about 1000 km) cases where the letter W applies to any ionospheric characteristic are extremely rare. Care is needed to avoid using W for F2 characteristics when G is more appropriate. This can be best decided by examining a sequence of ionograms or from the f plot. In general if foF2 is close to foF1, G applies, whereas if the F2 trace moves bodily with little change of shape, W applies.

When W is used as a descriptive letter the numerical value may be qualified by D or U. W may also be used as a replacement letter when extrapolation is not allowed (Fig. 3.30).

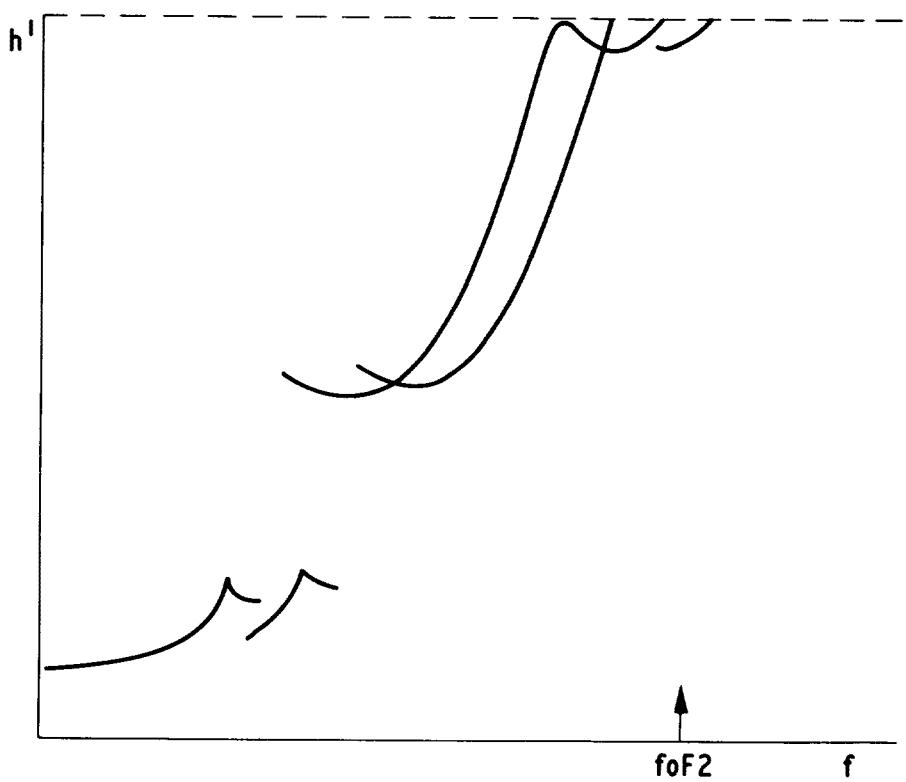

Fig. 3.30 Use of W

If h'F2 as shown but foF2 cannot be extrapolated, foF2 replaced by W.
If extrapolation possible, use (foF2)UW or (foF2)DW as given by accuracy values.
If h'F2 trace not seen and F1 trace goes above upper height limit, foF1 may need to be described by W, foF2 replaced by W, h'F2 replaced by W.

X - Measurement refers to the extraordinary component.

Letter X shows that the measurement was made using the x trace. It is mainly used to show the presence of an x-mode characteristic in an o-mode table and is analogous to descriptive letter O in an x-mode table.

Letter X is used in fxI tables to show that no spread was present, i.e. fxI = fxF2. (When more than half of the values are described by X the median of fxI must be described by X.)

Y - Lacuna phenomena-severe layer tilt.

Letter Y is used to show the presence of wide gaps in the trace pattern due to the Lacuna phenomenon (see section 2.75). When the parameter is missing, Y is used as a replacement letter. Examples of the use of Y when Lacuna is present are shown in Figs. 3.31, 3.32 which represent total F Lacuna and F1 or partial Lacuna, respectively. It is necessary to distinguish the proper use of Y from that of A, B, F, G and H.

The accuracy rules are, as usual, followed; use replacement letter Y, DY, UY, or -Y as given by the rules. This holds for all cases where Y is used, both Lacuna and severe layer tilt cases.

The rules are:

A - When blanketing sporadic E appears to be present always use A.

B - The distinction between the presence of high absorption (B) and Lacuna (Y) is based on the fact that absorption causes greater weakening on the low frequencies than on the high and affects the x trace to a greater extent than the o trace, whereas Lacuna causes an abnormal weakening of traces reflected from a given range of heights only.

(a) If fmin is given by an E trace and there is a wide gap in the traces at higher frequencies or they are missing, Lacuna is present, use letter Y (see H below).

(b) If fmin is approximately equal to foF1 and any of the following conditions are obeyed, Lacuna is present.

(i) The x-mode trace is visible.
(ii) The second order o-mode trace is visible.
(iii) fm2, the value of fmin for the second order F trace is the same as fmin within the accuracy rule for an unqualified reading, (strong confirmation).

In this case -

All E parameters are replaced by B
h'F and M(3000)F1 are replaced by Y
fmin is given by (fmin)EY
foF1 is given by (foF1)UY.

(c) If no traces are seen use letter B even when sequence suggests Y may be present.

F - When weak scattered F layer traces are seen but there is evidence that Lacuna is present Y should be preferred to F:

(a) If the upper end of the E trace is suddenly cut off below the normal value of foE and the F traces simultaneously become weak and scattered use Y not F.

(b) If the F2 trace is normal but the F1 trace is weak and scattered use Y not F. The E trace is most likely to be cut off but may be nearly complete.

(c) If part of the F1 trace is missing, fmin being given by an E trace, and the remainder is weak and scattered use Y not F.

(d) The presence of slant Es with any of above conditions confirms that Y should be used.

G - (a) When the ionograms before and after the Lacuna event show G conditions for the F2 layer, G should be used in preference to Y.

(b) When the ionogram sequence shows F2 before and after the Lacuna event and this trace disappears in the event, F2 parameters are replaced by Y.

H - When there is a gap between the normal E trace and the F trace, Fig. 2.13(c), the lower part of the F trace showing retardation, use H not Y. (This restricts the use of Y to cases where large tilts are present and may be reconsidered later by INAG).

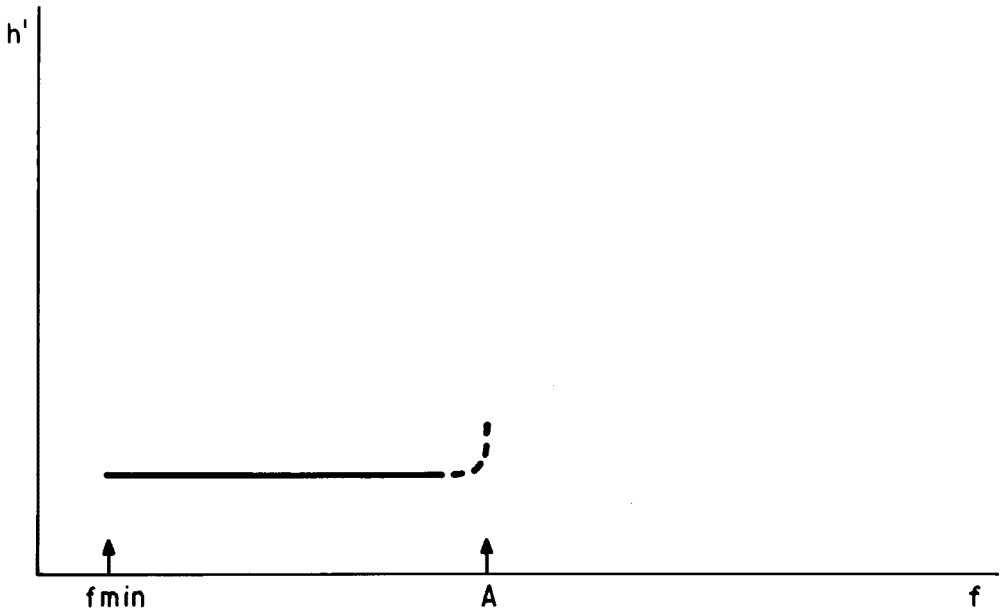

Fig. 3.31 Total F Lacuna

The F1 and F2 traces are missing.

fmin is given by an E trace
foE would be expected at A
h'Es: G. foEs, fbEs: G (preferable (foE)EG)

All F parameters replaced by Y. foE replaced by Y

Note similar pattern can occur with group retardation on E trace as shown by dots in which case foE is tabulated as (foE)UY.

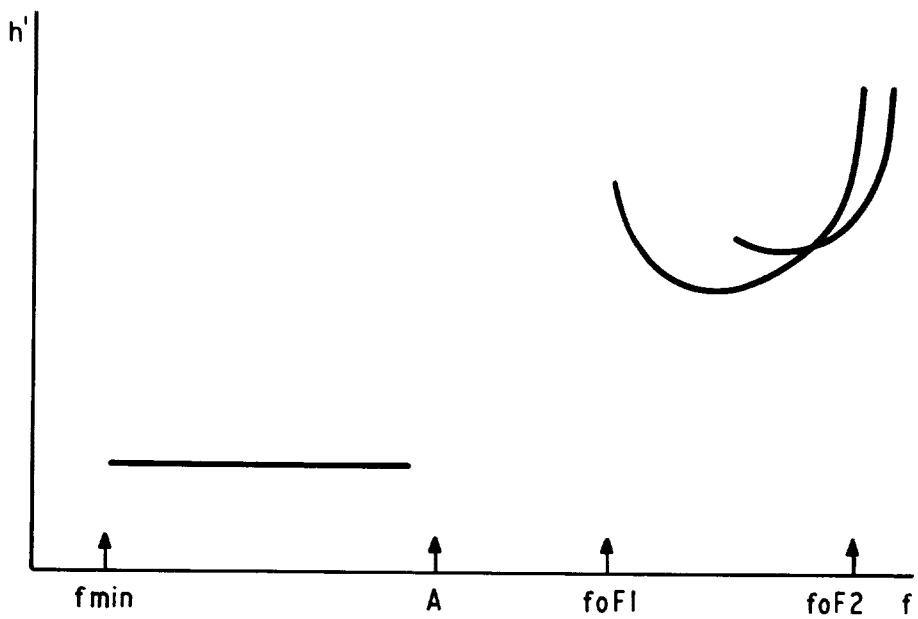

Fig. 3.32 F1 or partial Lacuna

F1 trace is missing
fmin given by E trace
foE would be expected at A
(if foE is observed use (foE)UY).

foE replaced by Y (unless observed)
h'F replaced by Y
foF1 given by (foF1)UY
M(3000)F1 replaced by Y

Note: F2 trace appears suddenly at approximately foF1.

Note Lacuna is often accompanied by Es-s, and this is also often seen when the Lacuna is about to develop or is dying away. The presence of slant Es is a clear distinction between layer tilt and plasma instability which causes Lacuna phenomena.

When Lacuna is present with Es-s the two phenomena are treated independently for scaling (see section 4). Es-s can arise from a normal E trace, a particle E trace (Es-k), or from a blanketing Es trace (usually f, but h, c, ℓ also possible). For convenience the rules are summarized below:

(a) foEs is deduced from the top frequency of the Es pattern from which the slant Es rises, foE is deduced ignoring the slant trace.

(b) Slant Es cannot blanket.

(c) If the Es trace is of a blanketing type, characteristics below the estimated value of fbEs should be replaced by A.

(d) For experts, the distinction between G and Y (Section 2.75) when no F2 traces are visible is easy and should be made. Where Lacuna phenomena are rare, missing F2 traces are treated as G condition.

(e) If parts of the F1 trace are missing, the missing F1 parameters are replaced by Y. (See accuracy rule note.)

(f) If both F1 and F2 traces are missing use G rules given above.

(g) If the E region trace is Es, the problem of whether Y should be used depends on whether foEs is likely to be influenced by the Lacuna phenomenon. For low, flat or auroral types of Es this is improbable. For particle E or retardation Es the appearance of the ionogram sequence will suggest when Y is needed, i.e., when the nose of the trace is missing. If there is no evidence suggesting that foEs is affected by the Lacuna, it would appear best not to use Y - we know Lacuna is present from the F-layer tables.

(h) Although slant Es frequently accompanies Lacuna and is usually present at some stage in a Lacuna sequence, its presence is not essential on a particular ionogram. If the F traces are missing, Y should be used for the missing parameters except where G above applies. It is accepted that slant Es is highly gain sensitive, and, therefore, its presence depends on the ionosonde sensitivity.

Severe layer tilts present

There are two important cases:

(a) Large tilts affecting apparent value of fbEs: If fbEs is greater than foEs, as in Fig. 4.22 use accuracy rule to give appropriate use of Y. When in doubt use replacement letter Y.

(b) Abnormal pattern near foF2: When the F2 layer is very tilted, the trace rises in the normal manner to a frequency near the expected value of foF2 (as shown by sequence) and then turns over so as to run horizontally, Fig. 3.34. When the signal-to-noise ratio is good it stops suddenly. In this case the wave has been reflected at oblique incidence and the value of foF2 overhead is certainly less than the limit frequency observed. This is probably true in all cases when the trace is concave downwards: the residual doubt is less important than obtaining a numerical limit. Use the top frequency observed qualified by E and described by Y. These conditions may last several hours but are usually short lived. This procedure can only be used when there is independent evidence of tilt or curvature (section 2.7). Convex or linear traces are more likely to be normal traces which are absorbed, UR, DR or R, when tilt is not present. A similar effect can be caused by inadequate antennas or ionosonde, letter symbol C, and this possibility should be considered if the condition is seen regularly. Note the use of Y to identify severe layer tilts is restricted to tilts in the F2 layer for physical reasons. Tilts near F1 are better described by H. Only tilts giving the type of ionogram illustrated in Fig. 3.34 should be identified by Y. H is more appropriate in other cases.

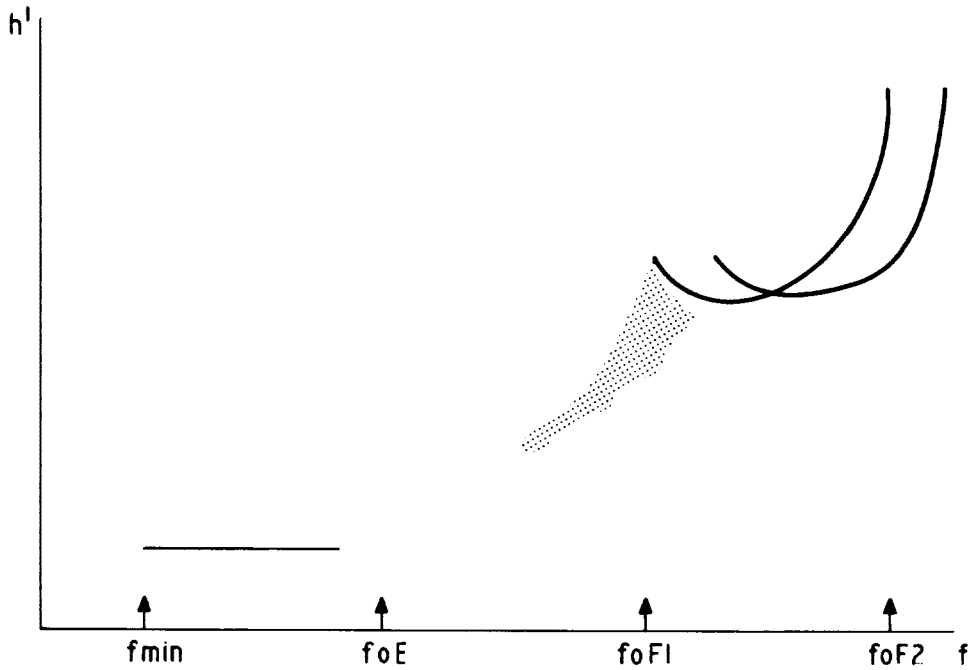

Fig. 3.33 Weak F1 Lacuna

The F1 trace becomes weak and scattered but is still visible.
fmin given by E trace
foE cusp not seen — foE replaced by Y
foE seen — foE given by (foE)UY
h'F replaced by Y
foF1 given by (foF1)UY
M(3000)F1 replaced by Y
Note: F1 trace often shows spurs in these conditions.

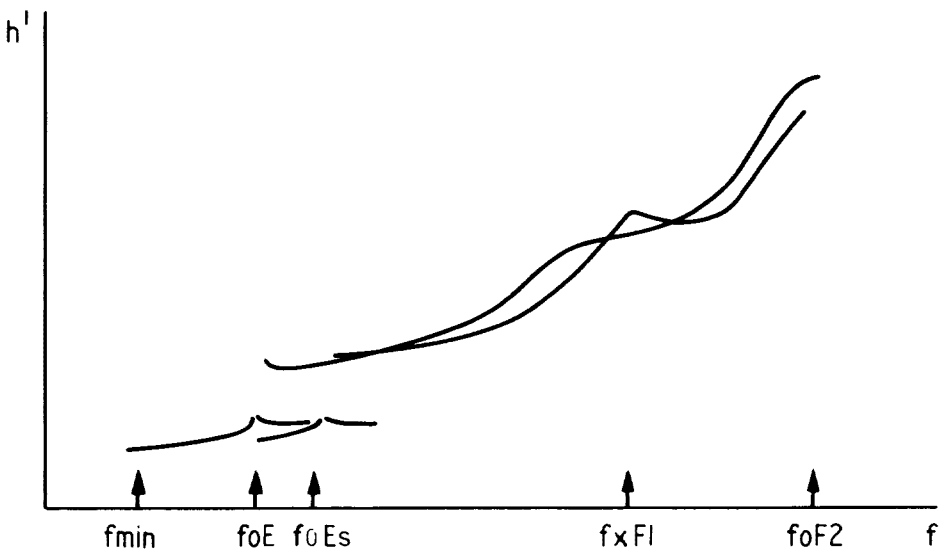

Fig. 3.34 Tilted layer, critical frequency increasing rapidly with distance. Use of Y.

foF2 is (foF2)EY — foF1 is (fxF1 - fB/2)JL
fxF2 is (foF2 + fB/2)OY — h'F2 is L; fbEs = (foE)EG

Note: x-mode trace can be similar to o mode or not, depending on whether tilt is E-W or N-S.

Z - Third magneto-electronic component present.

The critical frequency or height parameter is described by Z or a note made in the remarks column of the daily worksheet (Chapter 7), Fig. 3.35, 3.36. Descriptive letter Z is preferred to F when either are appropriate, since Z is usually seen only when spread is present. This is not appropriate if spread-F scaling is being used.

When a z-mode trace extends to or below fmin, the value of fmin should be described by Z. This applies to all coupling cases (Section 1.05).

Letter Z is used also as a qualifying letter when the o-mode parameter is deduced from the z trace, e.g., foF2 = (fzF2 + fB/2)ZF. This is valuable when there is no main trace or a series of main traces (Fig. 3.35). Note h'z < h'o < h'x so it is not possible to use qualifying Z for height parameters. When fz is near or below fB the appropriate value of fo-fz (p.9) must be used.

M(3000)F2 can be deduced if, with the aid of the z-mode trace, an o-mode trace can be identified at the point of tangency of the transmission curve.

The z- and x-critical frequencies differ by the gyro-frequency and the o-critical frequency is approximately half-way between them (Fig. 3.35). In general, the z trace is less spread than the other components (Fig. 3.35) [A38I, Figs. 23, 24; A104I, Fig. 118a,b,c]. It is most commonly observed at high-latitude stations, and may appear in all layers showing magneto-electronic splitting -- F2, F1, E, (Fig. 3.36) and certain types of Es.

The letter Z should be recorded as a descriptive letter with the frequency characteristic of the appropriate layer. At high latitudes, the critical frequency fzF2 should be plotted on the f plot whenever observed.

The low frequency end of the F region z trace is often mistaken for stratification in F1, resulting in erroneous scaling of h'F (Fig. 3.37) [A104I, Fig. 118a,b]. Sometimes it is also confused with multiples of the E or Es layers.

Since the z component is reflected obliquely, except at the magnetic dip pole, there is always doubt whether or not conditions have changed with the position, and values based on deductions using this component are regarded as doubtful and are therefore qualified by qualifying letter Z (section 3.1).

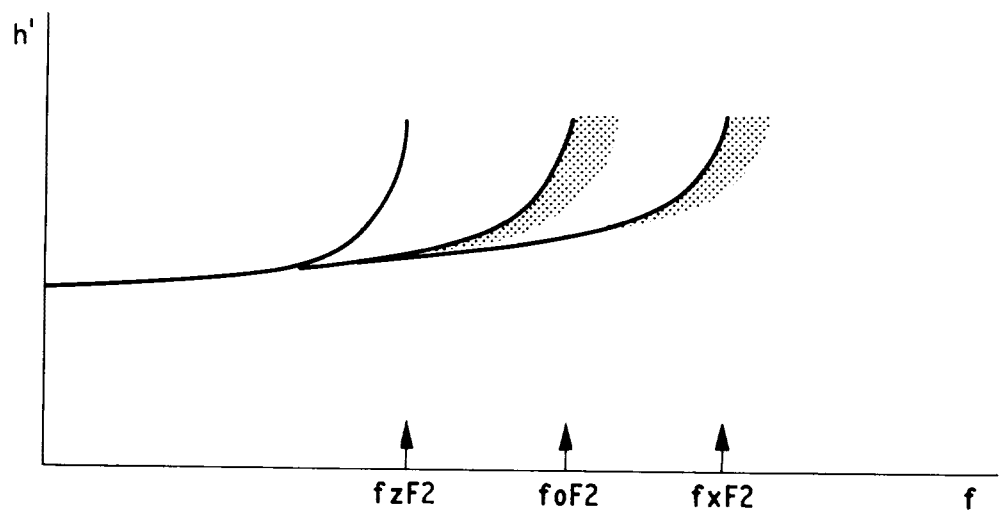

Fig. 3.35 z mode in F region

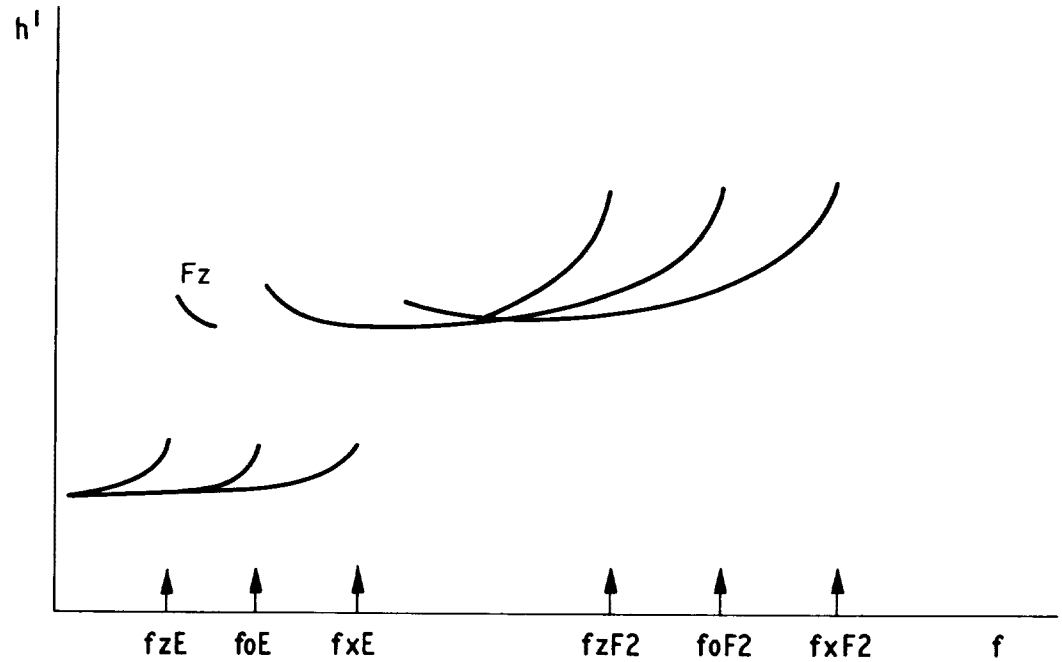

Fig. 3.36 z, o, and x modes in E and F regions

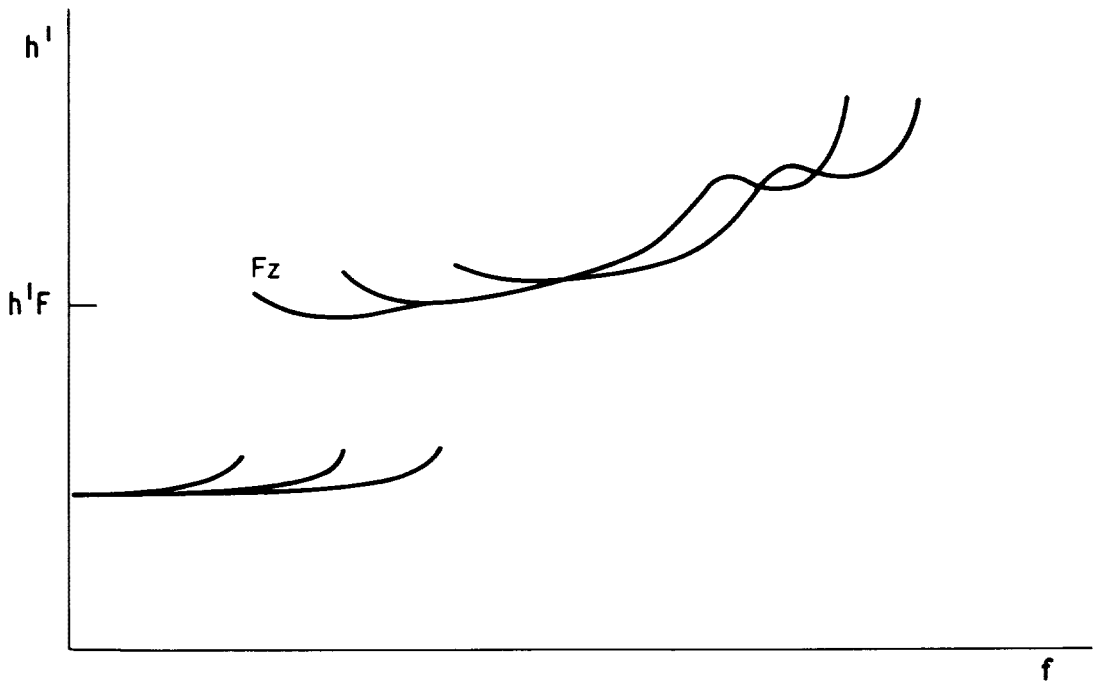

Fig. 3.37 z mode on low frequency end of F trace

3.3 Rules for the Analysis of fxI

3.30. Definition: The parameter fxI is defined as the highest frequency on which reflections from the F region are recorded, independent of whether they are reflected overhead or at oblique incidence. Thus, fxI is the top frequency of spread F traces including polar or equatorial spurs, but not including ground backscatter traces.

In practice it is given by the highest frequency at which F traces are seen on the ionogram with two exceptions:

(a) Traces due to ground or sporadic-E backscatter are ignored, Fig. 3.38.

(b) When the top frequency is likely to be due to an o-mode reflection.

Typical examples of fxI measurement are shown in Fig. 3.39. In general the shapes of the patterns can change rapidly and considerably, e.g., in some cases there is no apparent retardation at fxI or near foF2 and h'I can be either greater or less than h'F2.

fxI should be scaled from the normal gain ionogram. When this shows total blackout, (fmin replaced by B); then replacement letter B should be used for fxI.

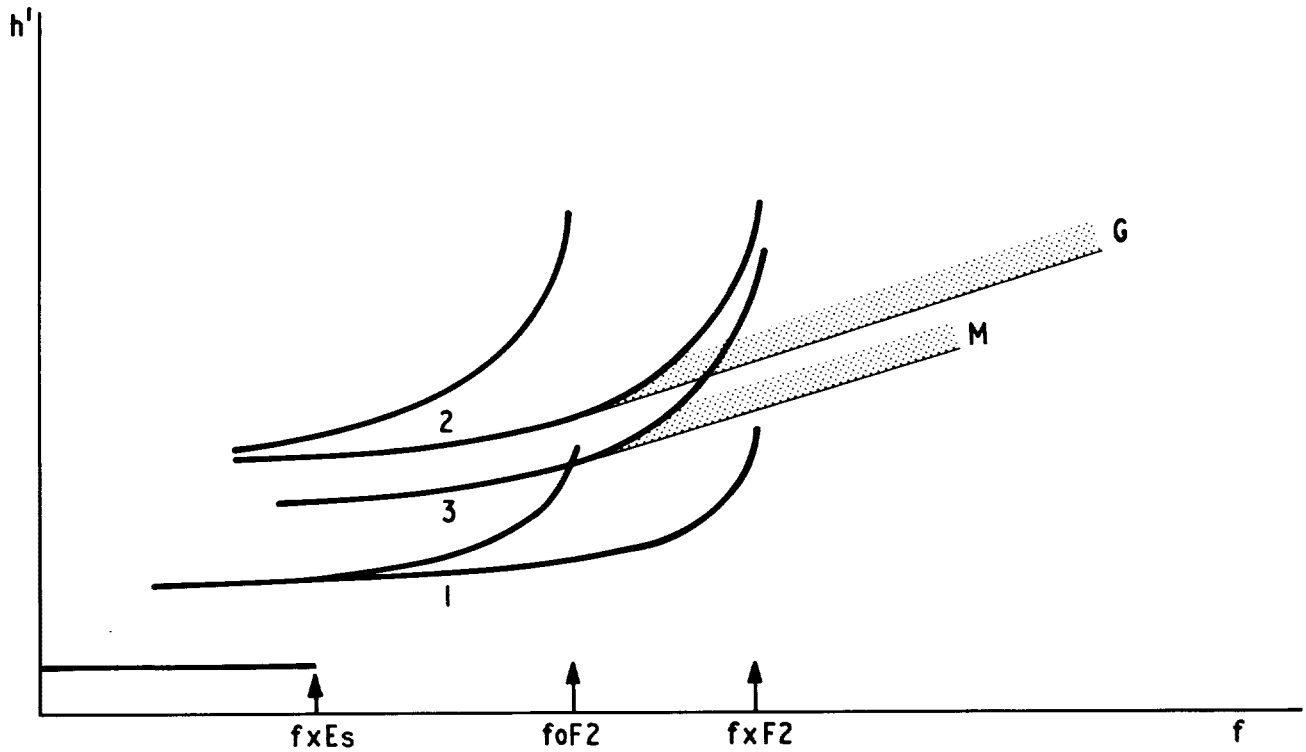

Fig. 3.38 Ground backscatter

The ground backscatter trace G is tangential to the second order x-wave trace (2). Es backscatter is tangential to the M (2F-Es) trace (3). In this case fxI is written (fxF2)-X.

3.31. Accuracy rules: Accuracy rules only apply to fxI for distinguishing between cases when D or E should be used instead of replacement letters C or S. If the possible error is less than 20% or 5Δ whichever is the greater use D or E as appropriate (see D, E) together with the descriptive letter. If the possible error is greater than this, use the descriptive letter as a replacement letter.

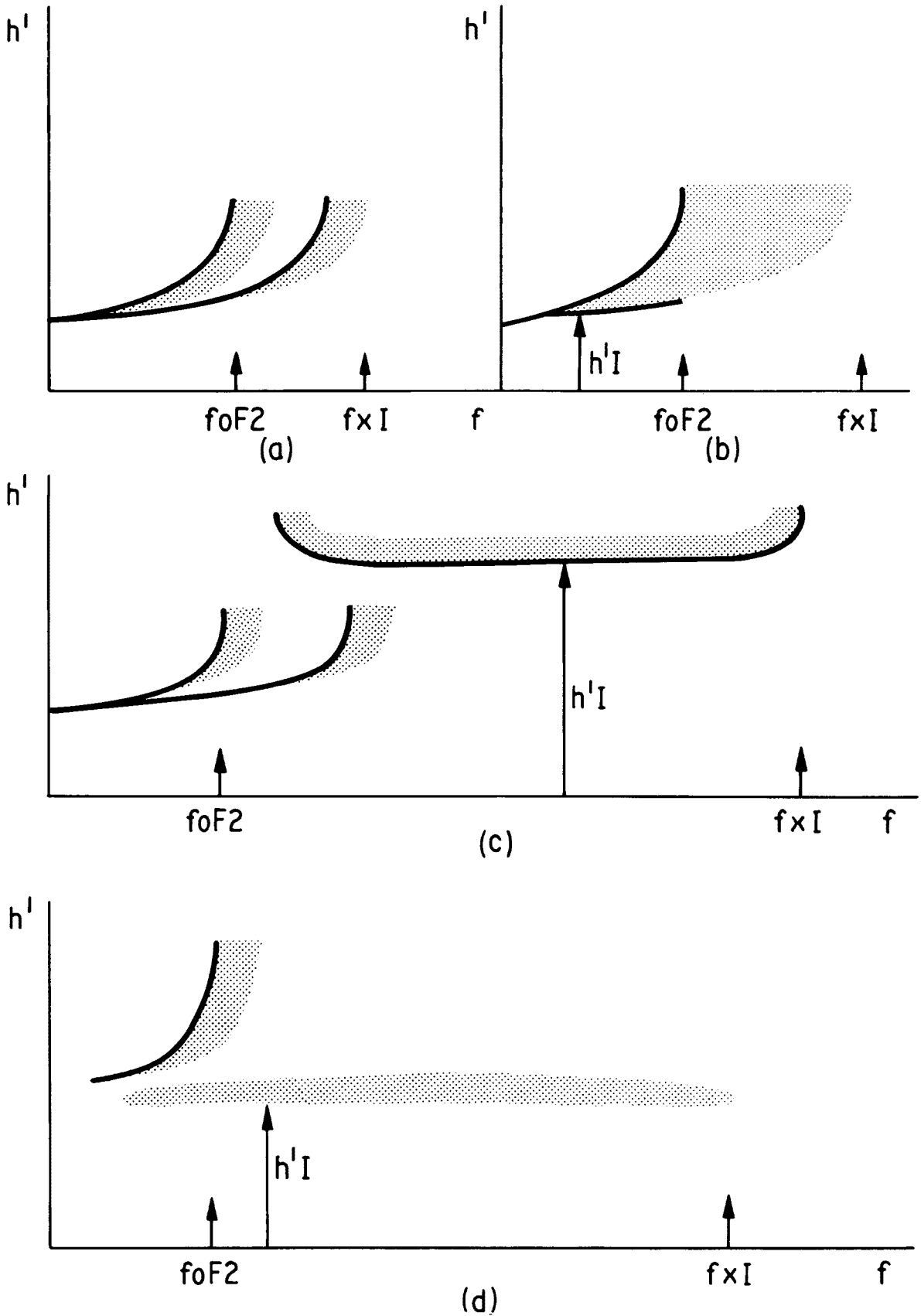

Fig. 3.39 Typical examples of fxI
100

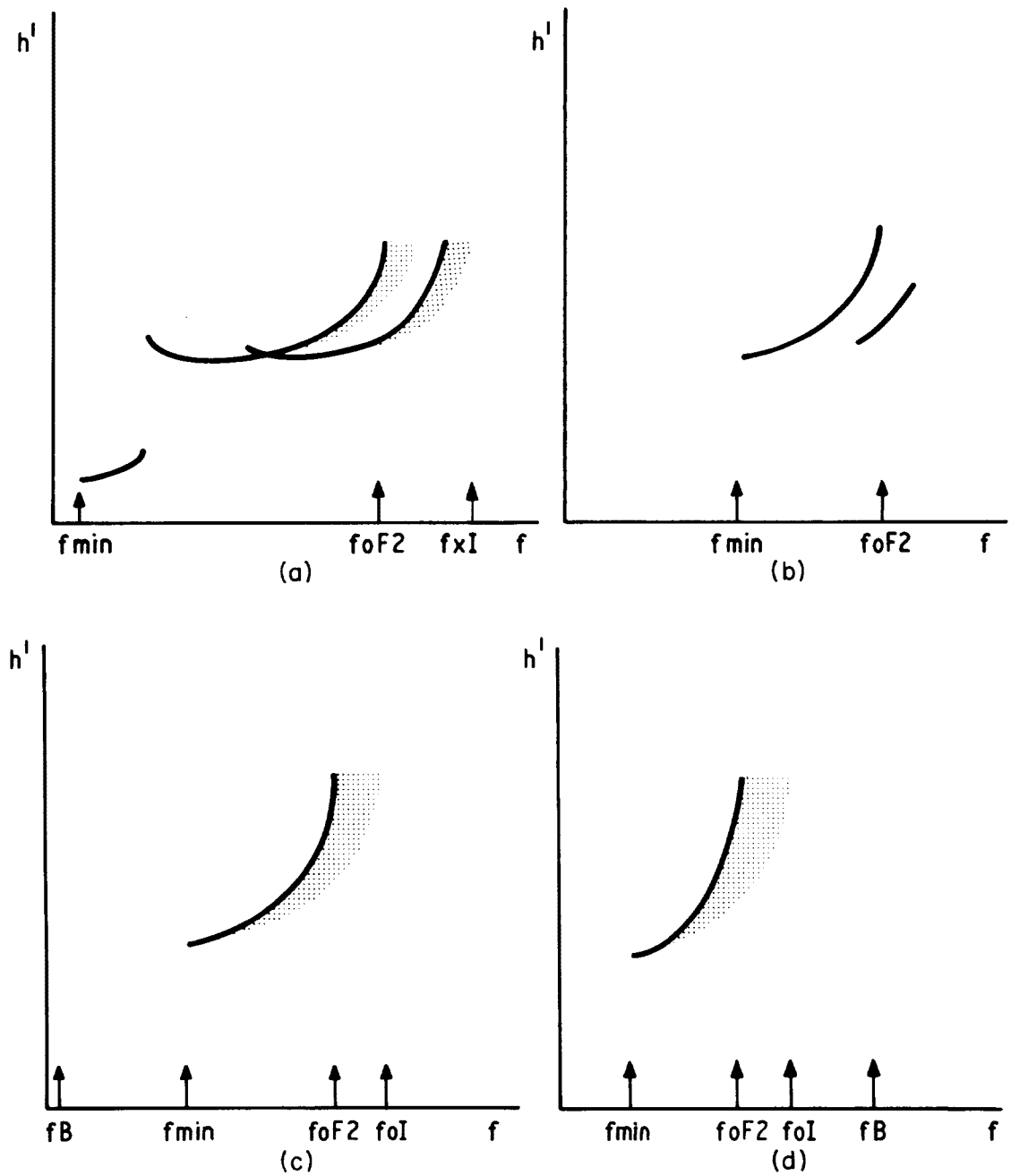

Fig. 3.40 High Absorption Conventions for fxI

(a) Normal fxI = (fxI)
(b) High fmin, only main traces visible
fxI = (foF2 + fB/2)DB
(c) High fmin, x traces missing
fxI = (foI + fB/2)OB
(d) foF2 near or below fB
fxI = (foI + fB/2) OB

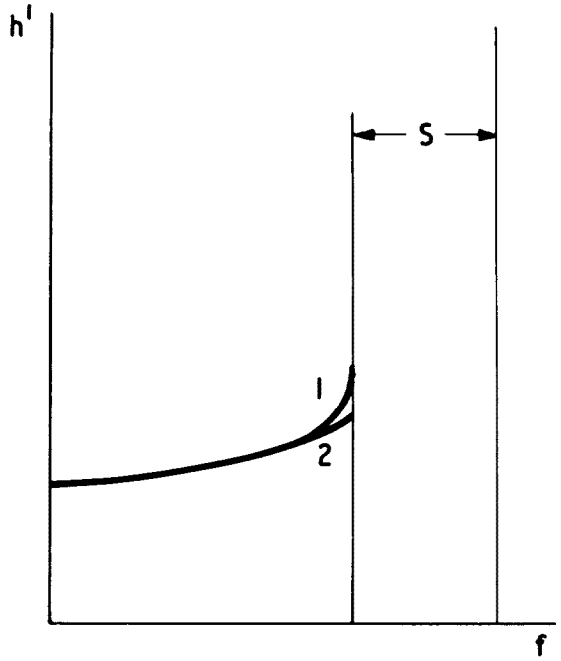

Fig. 3.41 Use of C and S with fxI

For foF2 more accurate than 10% and missing band less than 20% or 5Δ :
Use (foF2 + fB/2)DS.
For foF2 more accurate than 10% and missing band wider than 20% or 5Δ : Use S.
For foF2 more accurate than 20%, (foF2)DS entry; and missing band less than 20% or 5Δ : Use (top frequency of missing band)ES.
All other less accurate cases: Use S.
The rules for missing bands due to C are identical except that S is replaced by C.
Note: If the missing band is less than 10% or 3Δ wide, the characteristic is given by the middle value for the missing band with US (see accuracy rules).

3.32. Scaling rules:

(a) Measure the highest observed frequency of the traces directly reflected from the F layer, e.g., of spread F or polar spurs as shown on the medium gain ionogram. If closely spaced ionograms show the presence of a spread structure which is relatively gain stable, the top frequency of this structure is preferred. Use the ionogram which shows it most clearly.

(b) The normal descriptive letter symbols should be used to show the reasons for absent entries.

(c) Monthly tabulation sheets may be left blank for columns at hours for which spread F traces are seldom or never seen, as is the practice for E and F1 parameters. Most groups find it more efficient to ignore this point and tabulate fxI at all hours.

(d) When spread is absent, the numerical value of fxF2 (fxF2) is used with descriptive letter X: (fxF2)-X.

(e) When the spread F structure is not gain stable the value of fxI from the normal gain ionogram is recorded.

At some stations spread is found on the o trace but not on the x trace even when absorption is low. This is due to the fact that the two traces are reflected at different points separated by typically about 50 km in the magnetic meridian plane. A small movement of the station would, therefore, cause this situation to change. As fxI is intended primarily to show the existence of spread F near the station it is preferable to deduce the value from foI, fxI = (foI + fB/2)OF (F, if spread F typing is in use, otherwise B). This also makes the analysis simple -- always look at the o trace if the x trace is clean and deduce fxI from it.

3.33. Use of descriptive letters: Apart from the modified accuracy rule given above, the use of the following descriptive letters is the same as for other parameters: C, D, E, G, S, Y.

For letters A and B the following special rules apply:

A - The value of fxI is replaced by letter A when the presence of lower thin layers, such as Es, prevent observation of all F-layer traces.

B - There are a number of cases where descriptive letter B is appropriate. The principal rules are given first and then the particular cases.

(a) If all traces disappear as a result of absorption use replacement letter B. If traces can be seen on the high gain ionogram only, use rules (b) or (c), as appropriate.

(b) If the spread traces disappear as a result of absorption but the normal traces can still be seen, use (fxF2)DB. The numerical value (fxF2) can be deduced from foF2, Fig. 3.40(b).

(c) If the x-mode scatter traces are missing because of absorption, use the top frequency of the o-mode scatter trace, foI, plus fB/2 together with qualifying letter O and descriptive letter B : (foI + fB/2)OB, (Fig. 3.40(c)).

(d) If fmin is high, showing large absorption, and the value of fminx cannot be determined, use qualifying letter M (interpretation doubtful: reading may be foI instead of fxI) and descriptive letter B.

Note: When the signal/noise ratio is low, fxI is power sensitive; when high, it is usually independent of power as far as is known at present.

(e) If fmin is normal and foI is near or below fB, fminx will be greater than fB and fxI is given by (foI + fB/2)OB, Fig. 3.40(d). The probable value of fminx for this case can be deduced from ionograms having the same value of fmin but larger values of foF2.

3.34 Use of z-mode trace: At night in sunspot minimum years foF2 can fall into the medium wave broadcasting band and be hidden by interference. A missing value of fxI in these cases can be deduced from the z-mode trace using the relation:

$$fxI = fzI + fB$$

The value of fxI is given by (fzI+fB)ZS.

If the z trace is not spread in these circumstances this is most likely to be due to absorption. Use (fzF2+fB)DB.

This rule is only useful when an ionosonde operating to low frequencies is available (e.g., down to 0.2 MHz). In other cases this section should be ignored.

NOTES