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NATIONAL INSTITUTE OF OCEANOGRAPHY

WORMLEY, GODALMING, SURREY

Winter Waves in the northern North Sea at 57°30'N 3°00'E

Recorded by M. V. "FAMITA"

by

L. DRAPER and J. S. DRIVER

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CONTENTS

Figures:

Waves have been recorded by a Shipborne Wave Recorder (Tucker, 1956) placed on M.V. FAMITA, a Norwegian rescue and meteorological vessel which is stationed in the North Sea in 40 fathoms of water 160 miles east of Peterhead at $57^{o}30'N$ $3^{o}00'E$. The records from one winter's operation, from October 1969 - March 1970 have been analyzed, mainly following the method of analysis developed by Tucker (1961) from theoretical studies by Cartwright and Longuet-Higgins (1956). The method of presentation is that recommended for data for engineering purposes (Draper, 1966).

Records were taken at three-hourly intervals, and the analysis yields the following parameters:

(a) H_1 = The sum of the distances of the highest crest and the lowest trough from the mean water level.

(b) H_2 = The sum of the distances of the second highest crest and the second lowest trough from the mean water level.

(c) T_z = The mean zero-crossing period.

(d) T_c = The mean crest period.

From these measured parameters the following parameters have been calculated, after allowing for instrumental response:

(e) H_s = The significant wave height (mean height of the highest one-third of the waves): this is calculated separately from both H_1 and H_2, and an average taken. The relationship between the parameters is $H_1 = f(H_s)$ where f is a factor related to the number of zero-crossings in the records (Tucker, 1963). A similar relationship is used for the calculation of H_s from H_2.

(f) H_{max} (3 hours) = The most probable value of the height of the highest wave which occurred in the recording interval (Draper, 1963).

(g) $\in$ = The spectral width parameter, which is calculated from T_z and T_c (Tucker, 1961):

$$\in^2 = 1 - (T_c / T_z)^2$$

The results of these measurements are expressed graphically divided into two seasons thus:

Autumn:	October	November	December
Winter:	January	February	March

For each season a graph (Figures 1 & 2) shows the cumulative distribution of significant wave height H_s, and of the most probable value of the height of the highest wave in the recording interval, $H_{max(3\ hours)}$.

The distribution of zero-crossing period is given for each season (Figures 3 & 4).

The distribution of the spectral width parameter is given for the six months (Figure 5).

Figure 6 is a scatter diagram relating significant wave height to zero-crossing period, for the six months.

Figure 7 is a persistence diagram for the six months.

Figures 8 & 9 are 'Lifetime' wave height prediction graphs.

Discussion of Results

From Figures 1 & 2 may be determined the proportion of time for which H_s or $H_{max\ (3\ hours)}$ exceeded any given height. For example, in the Winter the significant height exceeded 10 feet for 43 percent of the time, which is somewhat rougher than the winter data (1962) from Sevenstones, off Land's End (Draper and Fricker, 1965). It is considerably rougher than wave conditions at Smith's Knoll in the southern North Sea (Draper, 1968). The highest measured wave (H_1) of 61 feet with a zero-crossing period T_z on the record of 13.3 seconds occurred about 1500 hr on either 27 or 28 November 1969. The uncertainty in date is caused by inadequate labelling of the chart and discontinuities in the sequence of records. The record showing the high wave is a good one and its validity is not in doubt. There is little seasonal variation in either the wave period or spectral width parameter. The scatter diagram of Figure 6 relates the significant wave height to zero-crossing period, with the numbers of occurrences expressed in parts per thousand; for example, the most common wave conditions were those with a significant height of between 4 and 5 feet and a zero-crossing period of between 6.0 and 6.5 seconds, which occurred for 33 thousandths, or 3.3 percent, of the time. The rapid attenuation of the shorter waves with depth means that the pressure units, which are necessarily situated at about 3.7 feet below mean water level, do not record the lower period waves; this is a cause of the cut-off below that period.

A parameter which is sometimes of interest is the wave steepness, expressed as wave height: wave length; it may also be expressed as a decimal number. It should be noted that the steepness of a wave is not the same as the maximum slope of the water surface during the passage of a wave. Lines of constant steepness of 1 : 20 and 1: 40 are drawn on Figure 6. (In this case, steepness relates to significant wave height : wave length calculated from the zero-crossing period.)

A fairly well-defined limit of steepness is observed at
approximately 1:16 (0.06): this occurs in all stormy areas.
There is a theoretical limit for a progressive wave of
1:7 (0.14). From the persistence diagram, Figure 7, may be
deduced the number and duration of the occasions between
October and March on which waves persisted at or above a
given height. For example, if the limit for a particular
operation of a vessel is a significant height of 8 feet, it
would have been unable to operate for spells in excess of
10 hours on 46 occasions, or spells in excess of 20 hours on
32 occasions.

Figure 8 enables an estimate to be made of the most
probable value of the height of the highest wave likely to
occur in various time intervals up to 100 years. For example
the most probable value in a 50-year interval is 90ft.

Figure 9 shows an alternative method of extrapolating
wave data to yield estimates of extremes. It is based on the
scatter diagram (Fig. 6) of significant height and zero-
crossing period, and has been calculated following an example
by Battjes 1970. The authors are indebted to their colleague
Mr. J.A. Ewing for the calculations on which this graph is
based. The values of extreme-wave heights yielded by this
method are the highest of several different methods of
estimating this parameter for this site.

Wind Conditions

The mean wind speed for the six months during which wave
measurements were made has been compared with the appropriate
ten-year mean speed. Two stations, Lerwick, Shetland and
Bell Rock, off the Firth of Tay were investigated by Mr. H.C.
Shellard of the Meteorological Office. At Lerwick the mean
speed for the 1969-70 winter was 15.1 knots whilst the
10-year mean was 15.3 knots. At Bell Rock the figures are
17.9 and 18.1 respectively. The differences from the 10-year
mean were quite small, being less than 1.5% in wind speed.
The higher values at Bell Rock are due to the winds being
recorded at the top of a tall lighthouse, and not at a
standard height above a land station.

It could be argued that to achieve 'average' conditions
the measured wave heights quoted in this report should be
increased by between 2 and 3 percent, depending on whether
in this area wave heights are related to the wind speed to
the power of 1.5 or 2. However, these differences are quite
small and are well within the errors inherent in the measur-
ing system. It is recommended that the heights (and periods
also) be used without modification.

Acknowledgements

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PERCENTAGE EXCEEDANCE OF HS AND HMAX

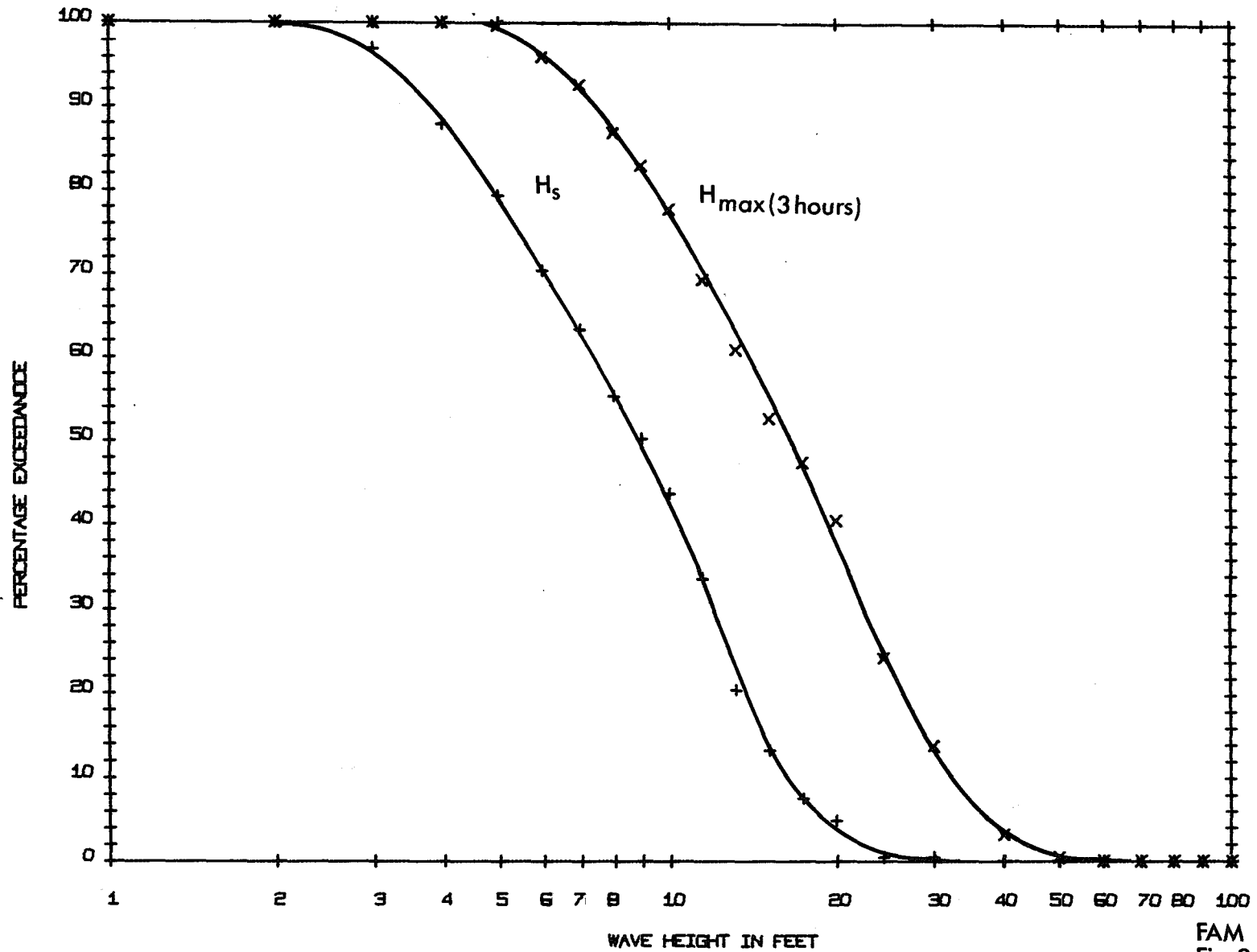AUTUMN – OCTOBER TO DECEMBER

H_s

H_{max} (3 hours)
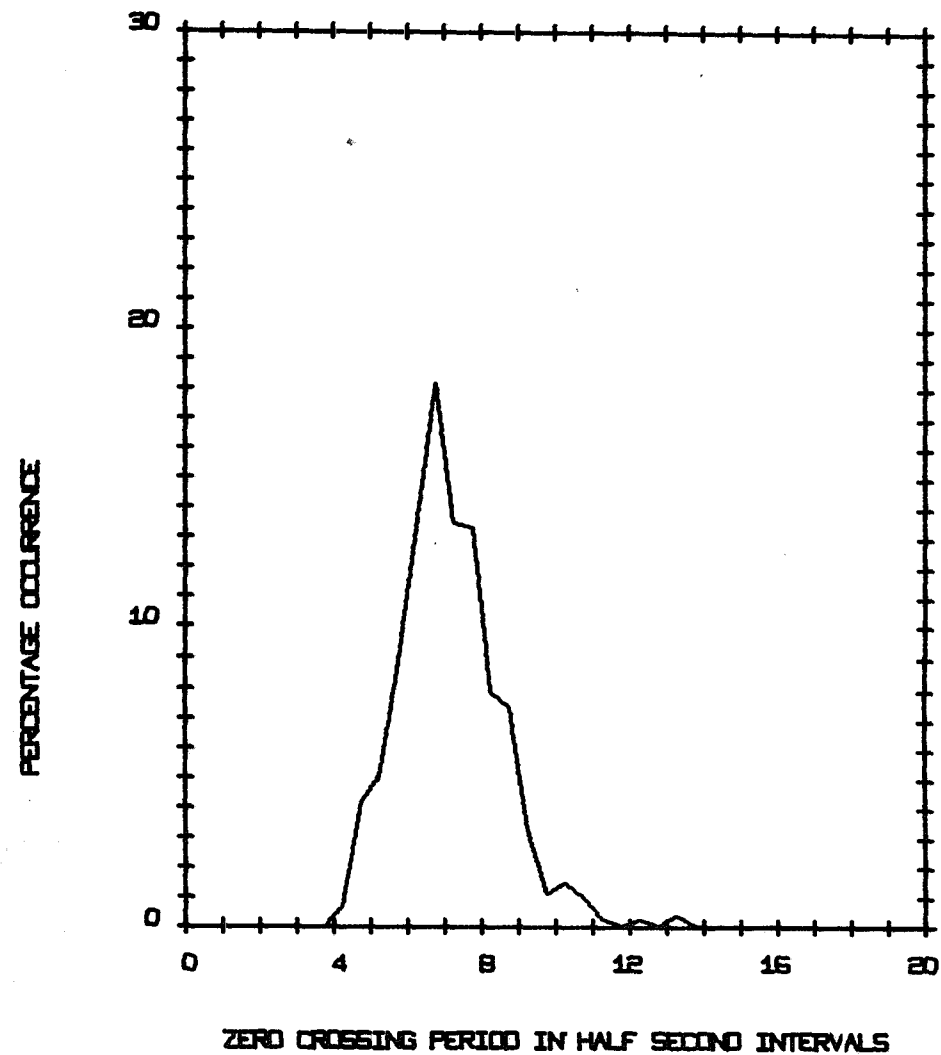
PERCENTAGE EXCEEDANCE

WAVE HEIGHT IN FEET
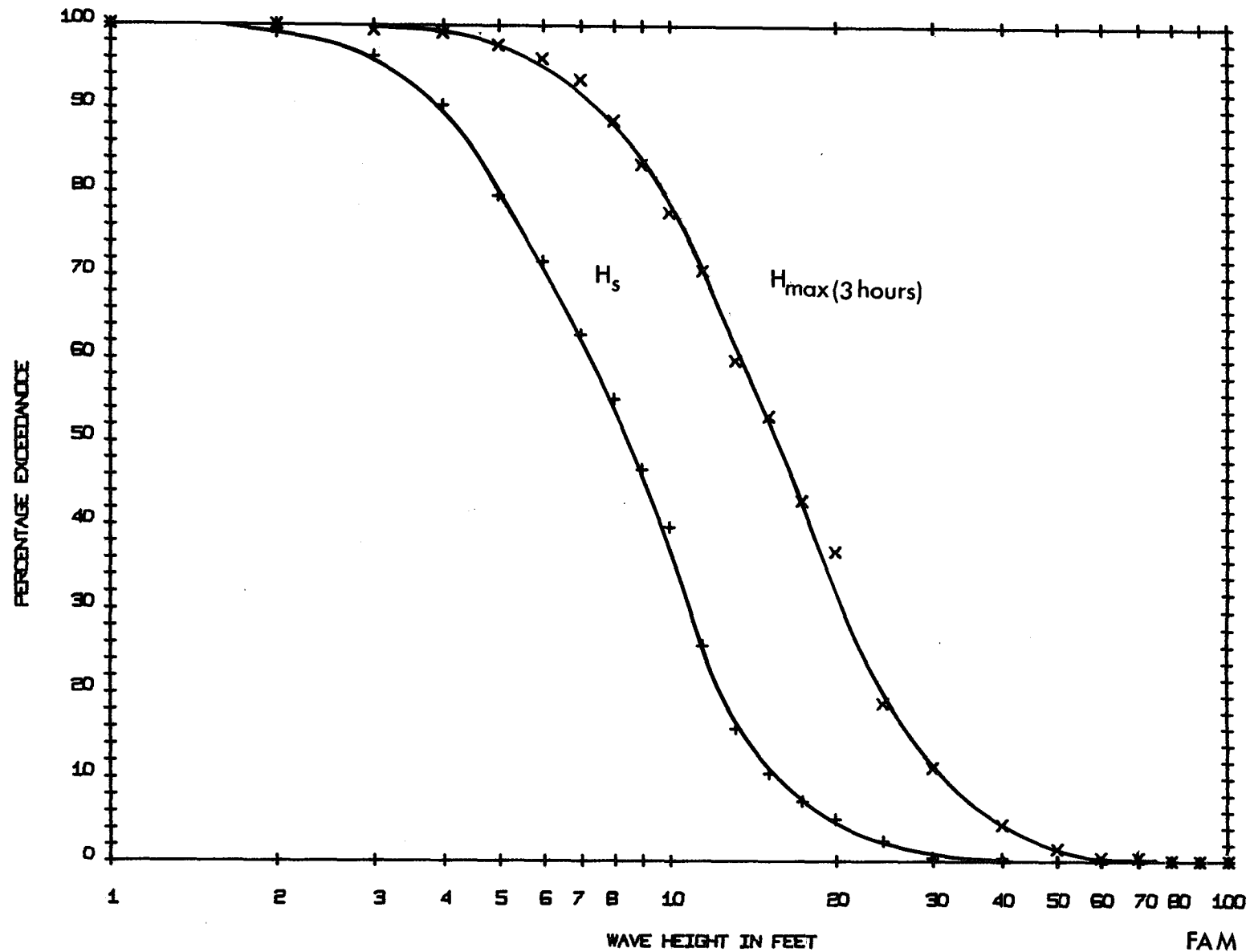
FAM
Fig.1

PERCENTAGE EXCEEDANCE OF HS AND HMAX

WINTER – JANUARY TO MARCH

FAM
Fig.2

GRAPH OF PERCENTAGE OCCURRENCE OF TZ

WITHIN HALF-SECOND INTERVALS

AUTUMN – OCTOBER TO DECEMBER

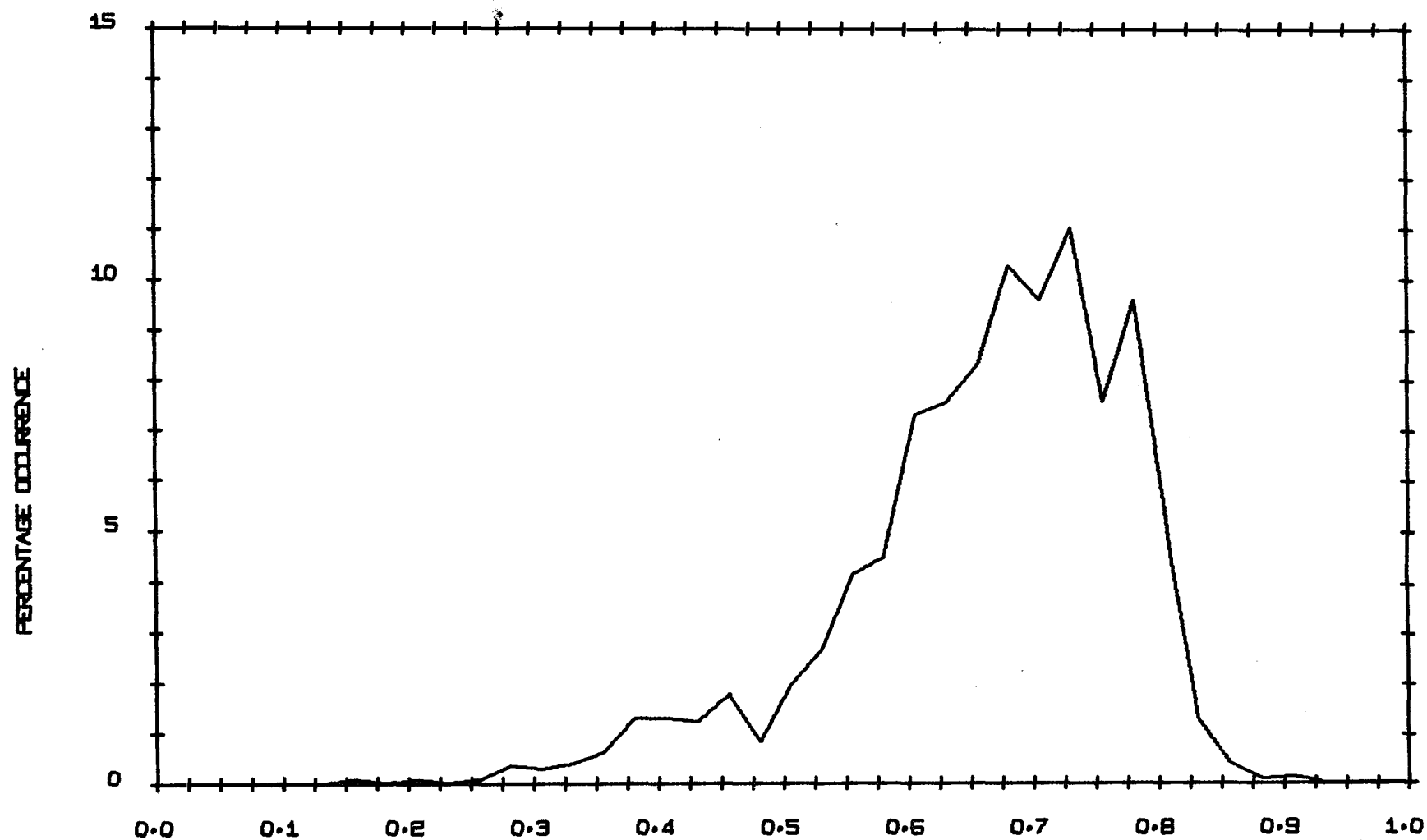ZERO CROSSING PERIOD IN HALF SECOND INTERVALS

CALM = 0·00 PER CENT

FAM
Fig.3

GRAPH OF PERCENTAGE OCCURRENCE OF TZ

WITHIN HALF-SECOND INTERVALS

WINTER - JANUARY TO MARCH

ZERO CROSSING PERIOD IN HALF SECOND INTERVALS
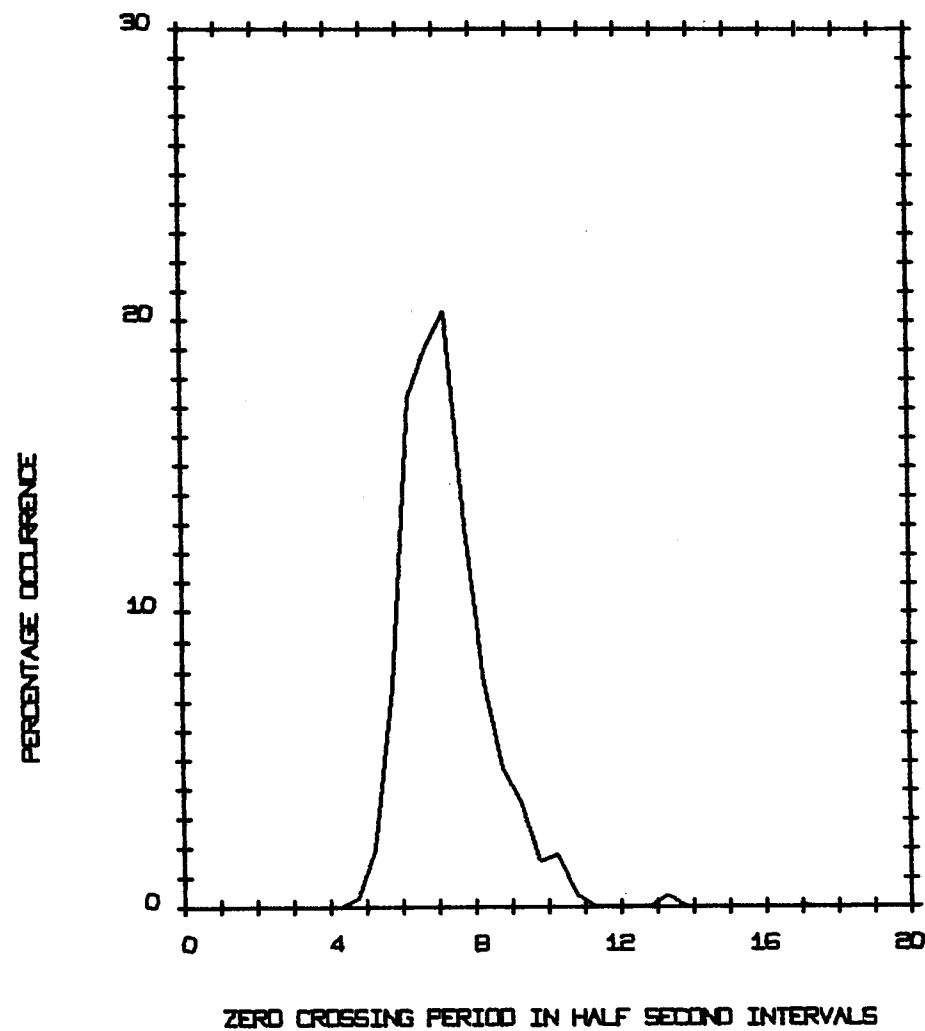
CALM = 0·00 PER CENT

FAM
Fig·4

GRAPH OF SPECTRAL WIDTH PARAMETER

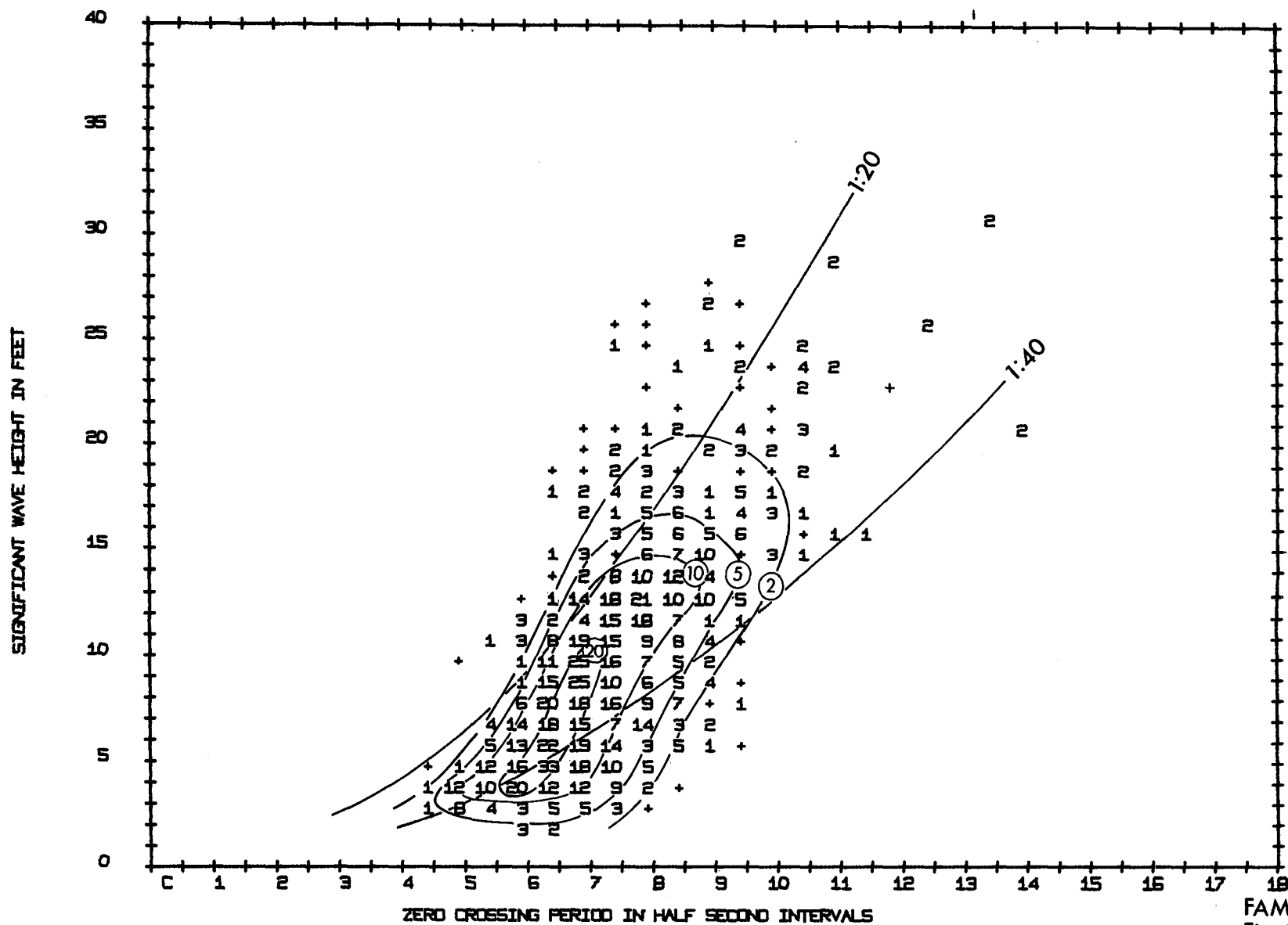SPECTRAL WIDTH PARAMETER IN TENTHS WITHIN INTERVALS OF 0·025
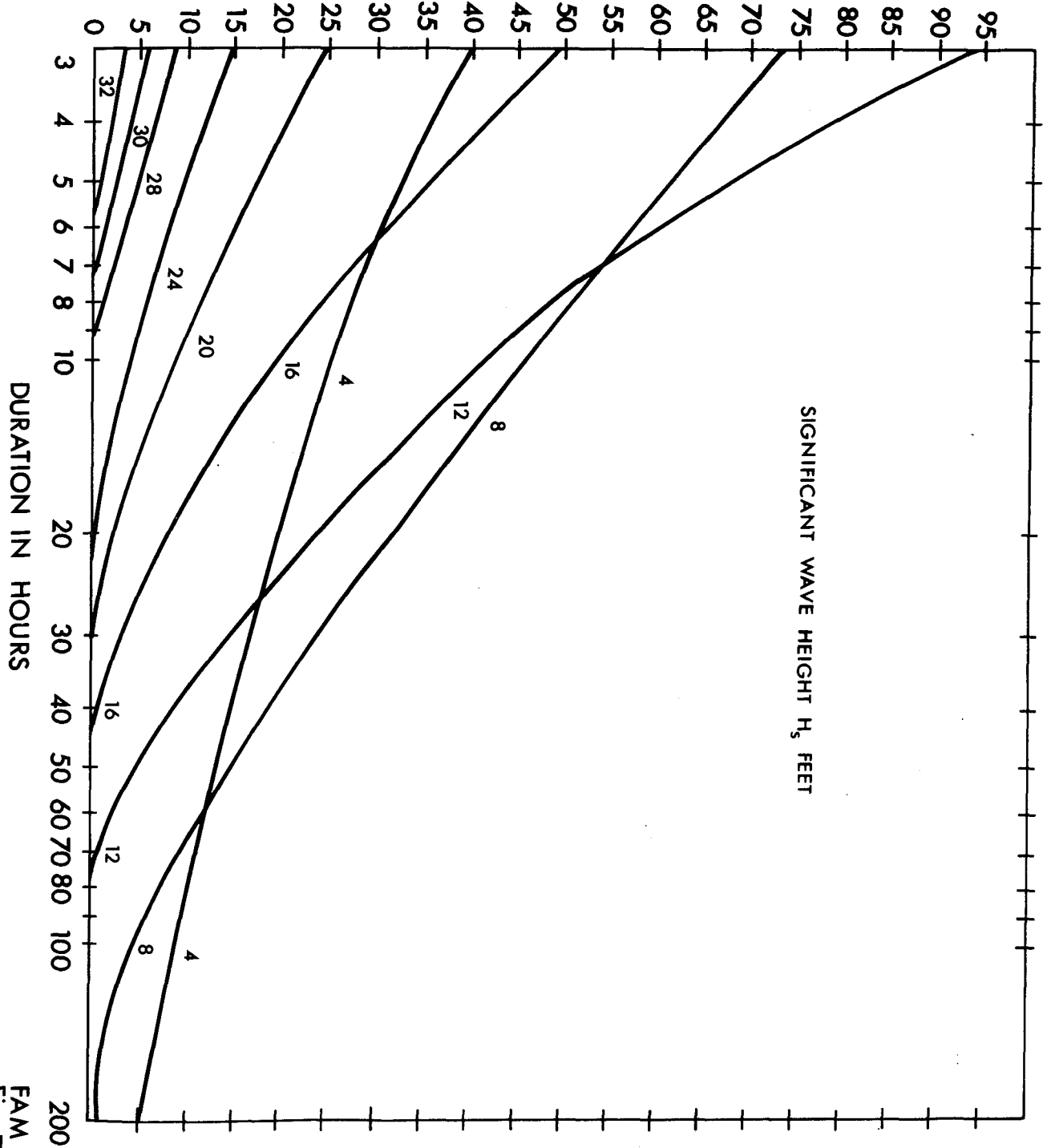
CALM = 0·00 PER CENT

FAM
Fig. 5

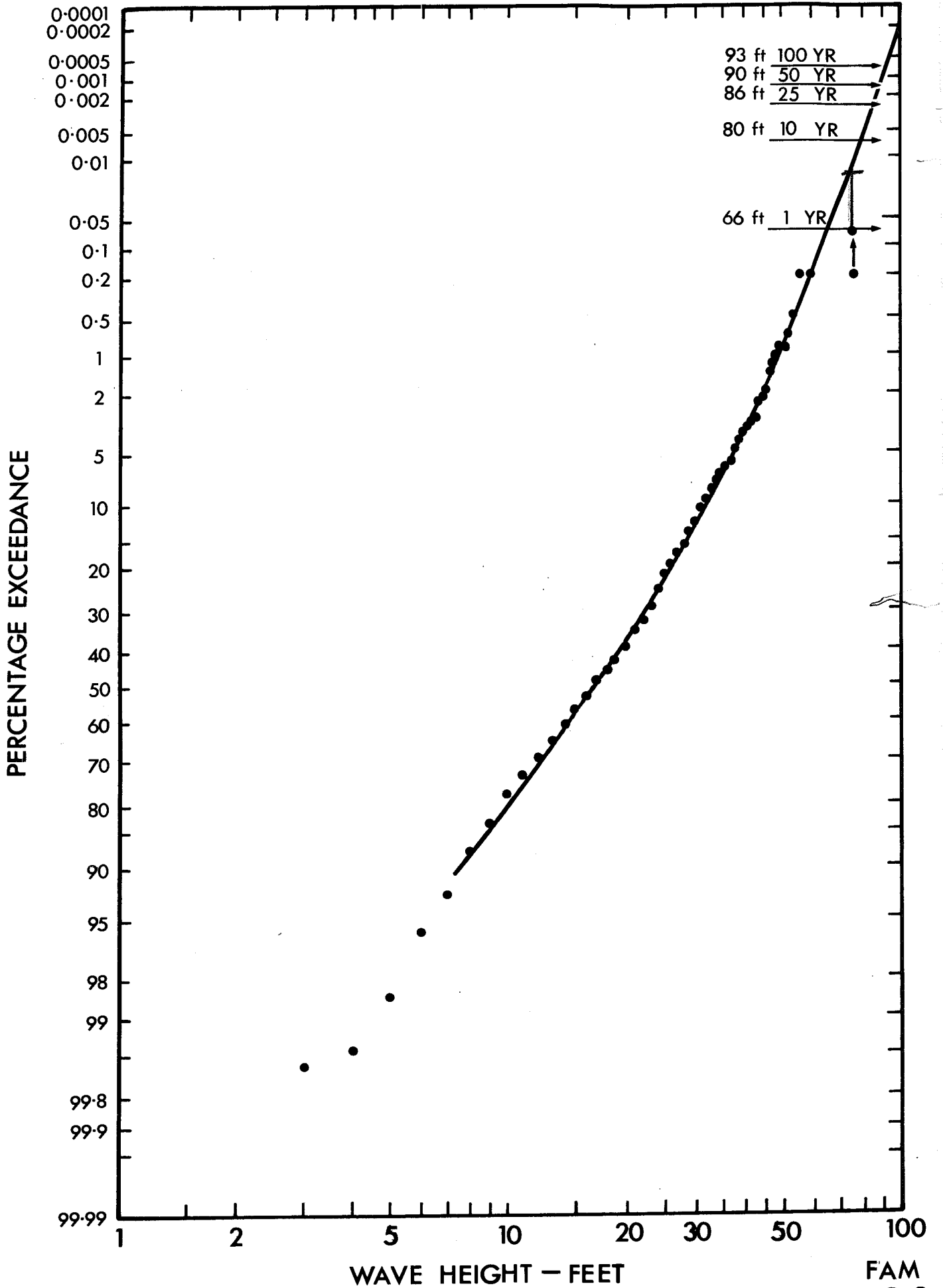SCATTER DIAGRAM

IN PARTS PER THOUSAND   + = 1 OCCURRENCE,

ZERO CROSSING PERIOD IN HALF SECOND INTERVALS

SIGNIFICANT WAVE HEIGHT IN FEET

FAM
Fig.6

NUMBER OF OCCURRENCES OF WAVE CONDITIONS EXCEEDING A GIVEN DURATION

FAM
Fig. 7

FAMITA WINTER (OCT→MCH INCL.) 1969—70

PERCENTAGE EXCEEDANCE

WAVE HEIGHT — FEET

93 ft 100 YR
90 ft 50 YR
86 ft 25 YR
80 ft 10 YR
66 ft 1 YR

FAM
FIG. 8.

FAMITA WINTER   Fig. 9