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No. 020

MASSPLOT: A program for producing CALCOMP plots of ASSP-100 measurements

by

B J Conway

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Cloud Physics Branch (Met.O.15)

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Section

1 Introduction

MASSPLOT is a Fortran program which produces plots, on 35mm CALCOMP, of physical quantities derived from ASSP - 100 measurements. Time-histories, scatter plots and individual or mean droplet size spectra may be plotted. MASSPLOT uses as input the disk dataset created by D A Johnson's program PAX30678. This report describes, with examples, how MASSPLOT is used.

2 Control Cards

MASSPLOT is controlled by a series of data cards read in on input stream 5. The first of these is a title card. Any characters in columns 1 to 32 inclusive are used as the main title for the run and appear at the top of every CALCOMP frame produced. The title cannot be changed within a run.

Subsequent cards, of which there may be any number, determine the types of plot produced and the contents of each plot. Each card specifies a single plot. These "plot-cards" are completely independent of one another and may appear in the deck in any order.

Each plot-card may contain up to 10 control parameters specifying details of the frame to be plotted. Because of the provision of default values however, it is often only necessary for the user to code three or four of these parameters.

Table 1 summarises plot-card details for three types of plot available. These are discussed in the following sections of this report.

3 Time Histories

In this mode MASSPLOT plots a selected parameter (vertically) against time (horizontally). The plotting symbol is '+' and the points are not connected by a line.

To select this mode, KPY, KSTART and KSTOP (see table 1) must be coded and KPX must be zero (blank). All other control-parameters are optional. KPY selects the parameter to be plotted and must be in the range 1 to 11 inclusive. Table 2 is a list of the parameters selected by KPY.

ASSP records timed between KSTART and KSTOP (inclusive) are plotted. KSTART $<$ KSTOP. KPX = 0 causes the horizontal axis to be time.

Fig 1 is an example of a plot produced when only the above parameters are coded. In this example KPY = 2, KSTART = 90000 and KSTOP = 91500, ie liquid water content is plotted over a 15-minute interval. Both axes are automatically scaled and the axes are divided into 5 intervals (vertically) and 8 intervals (horizontally) by default. A caption at the bottom left shows the origin time (which is always KSTART) and the horizontal scale is elapsed time, in seconds, from KSTART. Note that in this case automatic scaling (using the CALCOMP subroutine SCALE) has resulted in a horizontal axis which extends 300 seconds beyond KSTOP. However MASSPLOT only plots records between KSTART snd KSTOP so that the extra space does not contain plotted points.

By coding other control parameters on the plot-card the user may force the scaling and number of subdivisions of either axis.

3.1 Vertical axis, forced scaling

The vertical axis will range from YAXMIN to YAXMAX if one or both of these parameters is coded such that YAXMAX $>$ YAXMIN. If YAXMIN = 0 is required this field is left blank. Fig 2 shows a case similar to that in fig 1 except that the parameter plotted is droplet concentration (KPY = 6) and the vertical axis limits have been forced by coding YAXMIN = 40.0 and YAXMAX = 200.0.

In fig 3 the same data are plotted as in fig 2 but the vertical scale has been forced to range from 50.0 to 200.0 and MYINT has been coded (= 3) to divide the axis into 3 intervals instead of the default value of 5. Note that MYINT can be used to set the number of axis-intervals regardless of whether forced scaling is being employed or not.

It is possible for the user to force axis limits such that some of the records lie outside the plotting area. Fig 4 is an example of this. Out of range points are projected onto the graph boundary and plotted using a different symbol (◇) to distinguish them from correctly placed points which happen to fall on or near the edge of the graph.

3.2 Horizontal axis, forced scaling

Horizontal axis limits corresponding to KSTART and KSTOP may be forced by coding any number in either XAXMIN or XAXMAX so that XAXMAX $\neq$ XAXMIN. The origin will be 0 (corresponding to KSTART) and the right-hand limit will be KSTOP - KSTART (in seconds). There is no provision for forcing horizontal axis limits other than these in time-history mode.

Independently, MXINT may be coded to force the number of subdivisions of the horizontal axis. If MXINT is not coded a default value of 8 is taken.

To produce the plot shown in Fig 5, XAXMIN was set $\neq 0$ to force a range of KSTOP - KSTART (= 900 seconds) and MXINT was set to 9 to make the axis intervals a convenient size.

4 Scatter plots

Coding $1 \leqslant$ KPY $\leqslant 11$ and also $1 \leqslant$ KPX $\leqslant 11$ causes a scatter plot of the parameters identified by KPY (vertical axis) and KPX (horizontal axis) to be produced, containing all the records found between KSTART and KSTOP. KPY, KPX, KSTART and KSTOP must all be coded. The remaining plot-card parameters are optional.

Fig 6 shows a scatter plot of liquid water content (KPY=2) against droplet concentration (KPX=6) for the period 90000 to 91500. Because only the four obligatory parameters were coded, the program has provided automatic scaling in both axes and divided each axis into 5 intervals.

Coding XAXMAX > XAXMIN forces the horizontal axis to run from XAXMIN to XAXMAX and coding MXINT > 0 causes the axis to be divided into MXINT intervals. Similarly, YAXMIN, YAXMAX and MYINT control scaling and subdivision of the vertical axis.

Fig 7 is the same scatter plot as Fig 6, but this time XAXMIN and XAXMAX have been coded 80.0 and 160.0 respectively, producing forced scaling in the horizontal axis. YAXMIN and YAXMAX were not coded so the vertical axis has been scaled automatically as in Fig 6. Note that values falling outside the forced range of the horizontal axis have been plotted on the boundary of the chart using the symbol '◇'. Within-range values are plotted using the symbol '+'. MXINT and MYINT were not coded in this example so each axis is divided, by default, into 5 intervals.

In fig 8, both axes use automatic scaling but coding MXINT = MYINT = 1 has removed subdivision of the axes.

The program does not limit the number of points that may be plotted in a single frame. Fig 9 shows a scatter plot which contains 3517 records found within a 3-hour data-period.

5 Drop size spectra

5.1 General

MASSPLOT produces plots of droplet size spectra (number of particles, vertically, vs droplet-radius, horizontally) if KPY is coded appropriately. A spectrum may be taken from a single ASSP record or may be the weighted mean of a number of records. Points are plotted at radii corresponding to the centres of ASSP channels 1 to 15 (these values depending on the range to which the ASSP was set). The plotted points are connected by staight line segments: the program does not smooth the curve.

First order correction for the effect of different ASSP channel widths (the lowest channels cover smaller radius-intervals) is made by multiplying the channel contents by factors involving the reciprocals of the channel widths.

Various vertical scaling options are available, including choice of log or linear scales. Selection from these basic scaling options is made by coding KPY appropriately.

When mean spectra are being computed, individual records may be included or rejected depending upon whether a chosen quantity (eg droplet concentration) falls inside or outside a range specified by the user.

There is no satisfactory way of combining size-spectra recorded on different ASSP range-settings. Therefore if, during the accumulation of a spectrum, the program encounters on ASSP range-change it plots the data accumulated so far and starts a fresh CALCOMP frame for records recorded on the new range. This is the only case in which a single plot-card may result in the production of more than one CALCOMP frame.

In general, KPY, KSTART and KSTOP must be coded on the plot card, other parameters being optional. If no other parameters are coded, all records timed between KSTART and KSTOP will be included in the mean spectrum. If KSTOP is not coded (only allowed in this MASSPLOT mode) it is set equal to KSTART and a single ASSP spectrum will be plotted, provided that a record timed at exactly KSTART exists on the PAX30678 dataset.

In order to select size-spectrum mode and a particular scaling option, the user codes KPY as a 3 digit number, kpy, as described below.

y = 0: spectrum is normalised such that sum of channel contents = 1.0
1: spectrum is normalised such that modal channel contents = 1.0
2: spectrum is unnormalised. Ordinates correspond to droplet concentration. Values are derived from y=0 (normalised) case multiplied by the mean value of the weighting function (droplet concentration)

p = 8: weighting factor ="CONGD" (Droplet concentration derived from ASSP inner volume)
9: Weighting factor = "CONTL" (Droplet concentration derived from ASSP total volume)
(mean spectra are calculated by summing individual spectra each weighted by droplet concentration).

k = 0 (blank): linear vertical scaling
5: log vertical scaling.

For example:

KPY = 592 ⇒ log scaling, weighting factor = CONTL, unnormalised spectrum.

KPY = 80 ⇒ linear scaling, weighting factor = CONGD, normalised sum of channel contents.

5.2 Scaling Options

Default Scaling.

Unless overridden by the user, the program provides preset scaling for normalised spectra and automatic scaling for unnormalised spectra. In the case of automatic log scaling, a maximum range of six decades is allowed, the top of the range always being chosen such that the largest data value is accommodated.

Figs 10 to 15 inclusive show normalised and unnormalised linear and log spectra which use the various default scaling options. The values of KPY in these examples were 90, 91, 92, 590, 591 and 592 respectively and all six plots correspond to the same group of ASSP records.

Forced Scaling.

If unnormalised spectra are being plotted the user can override the automatic scaling feature by using the parameters YAXMIN, YAXMAX and MYINT.

Forced linear scaling.

The user codes YAXMAX > YAXMIN to force the vertical scale to these limits. If MYINT = 0 (or blank) the vertical axis will be divided into 5 intervals. If MYINT > 0 the axis will have MYINT subdivisions. The plot shown in Fig 16 corresponds to KPY = 92, YAXMIN = 0.0 YAXMAX = 42.0, MYINT = 6

Forced Log scaling.

If KPY indicates log scaling is to be used and YAXMAX > YAXMIN is coded the vertical axis will range from 10^{YAXMIN} to 10^{YAXMAX}. Whole numbers should be chosen for YAXMIN and YAXMAX. The number of axis intervals is set by the program to be YAXMAX - YAXMIN. MYINT is ignored, if coded. In Fig 17 KPY = 592, YAXMIN = -1.0, YAXMAX = 2.0

Data points outside the range of the vertical axis are plotted on the graph boundary using the symbol '△'. (Values within range use the symbol '□'). However the connecting line on the graph joins only the within-range values and this can lead to the plotted spectrum having a misleading appearance if one or more of the highest spectrum ordinates exceeds the range of the vertical axis. (eg Figs 18 and 19). This cannot occur when automatic scaling is employed, but care must be taken when setting range limits in forced-scaling mode.

5.3 Conditional acceptance of records

Coding parameters MXINT, XAXMIN and XAXMAX enables the user to set criteria for the selection or rejection of individual records when mean spectra are being assembled. Note that these parameters have nothing to do with the scaling of the horizontal axis, which is fixed at 0 to 25 microns radius when MASSPLOT is used to produce drop size spectra.

If MXINT = 0 (uncoded) "unconditional mode" is selected and all records between KSTART and KSTOP will be included.

If $1 \leqslant$ MXINT $\leqslant 6$ the PAX30678 parameter identified by that number (see table 2) is examined in each record found. Its value is used to determine whether the spectrum contained in that record should be included when calculating the mean spectrum.

If $1 \leqslant$ MXINT $\leqslant 6$ the value of the selected parameter is compared with the user-defined values XAXMIN and XAXMAX. There is no restriction on the relative sizes of XAXMIN and XAXMAX. The region of acceptance values is shown shaded in the diagrams in fig 20 for the various distinct cases.

For example, if MXINT = 6, XAXMIN = 50.0 and XAXMAX = 100.0, only those ASSP records for which droplet concentration , CONTL (parameter 6) lies between 50 cm^{-3} and 100 cm^{-3} will contribute to the mean droplet size spectrum being assembled.

6 Printed output

MASSPLOT produces printed supplementary data associated with each CALCOMP frame. For time-histories and scatter plots these data are printed via output stream 4 and consist (Fig 21) of the plot number and title, the axis parameters, a list of the plot card parameters and the number of records included in the plot. Each line-printer page accommodates printed output for up to 5 of these plots.

In the case of drop size spectra the printed output is transmitted via output stream 7 at a density of 2 plots/page (fig 22). Alongside the plot number and title the weighting factor (CONTL or CONGD) is indicated. If records were accepted for inclusion conditionally, this is stated immediately under the title. The period requested (KSTART to KSTOP) is indicated as well as the times of the first and last records actually included in the mean spectrum and the total number of records included. When MASSPLOT is used in conditional mode, records found but rejected do not count towards these statistics.

On the next line, parameters describing the plotted spectrum are printed. These are mean radius (RM), mean areal radius (RA), mean volume radius (RV) and dispersion (standard deviation divided by mean radius).

Radius values are in microns. In the case of a spectrum derived from a single PAX30678 record it may be noticed that the values differ slightly from those appearing in the printout produced by PAX30678. This is because MASSPLOT adjusts the spectrum-shape to make first-order correction for the fact that the lowest ASSP channels are narrower than the others, whereas PAX30678 uses only the raw channel-counts. In practice, this difference is usually very small and depends on what fraction of the spectrum is contained in the lowest ASSP channels.

The printout then gives the ASSP range setting for all the records in the plot, followed by a table of ASSP channel widths, channel centre radii and channel contents, the latter presented as partial droplet concentrations (cm^{-3}) corrected for ASSP channel width differences.

Mean values of droplet concentration (both CONGD and CONTL, cm^{-3}) and of liquid water content (LWCGD and LWCTL, $g.m^{-3}$) are presented next. These means are derived from all the records used to form the mean spectrum. Rejected records (in conditional mode) do not contribute to them. The means are straightforward unweighted averages.

The final line of the printout gives the reason for terminating the plot. The normal case is "end of specified period reached", meaning that the program encountered a record timed later than KSTOP. Alternative messages are "end of dataset encountered", ie KSTOP was set later than the time of the last record on the PAX30678 dataset, and "ASSP range changed". Neither of these occurrences prevents a frame being produced in the normal way or invalidates any of the printed data. In the former case the program proceeds to the next plot-card and in the latter it starts a new frame, obeying all the parameters on the current plot-card but starting from the first record after the range-change. Further ASSP range-changes generate further additional frames until the program encounters the end of the dataset or a record timed later than KSTOP.

7 Pitfalls

There exist (at least) a couple of problems, connected with the way MASSPLOT interprets PAX30678 data.

7.1 Weighting factor

When forming an average drop-size spectrum, MASSPLOT weights each record only by the droplet concentration value taken from that record. Clearly however, an ASSP sample taken over 5 seconds should be given more weight than one indicating the same droplet concentration but taken over only one second, since the former will contain measurements of five times as many droplets. Unfortunately, PAX30678 records do not include information specifying the periods over which the ASSP counts were collected. The possibility of MASSPLOT deducing the ASSP sample period from the times of consecutive records was considered. However, such a procedure is complicated by factors such as the provision in the ASSP data logger of means of introducing gaps between sample periods, as well as by such things as missing records. In the end it was decided to weight individual records according to droplet concentration but without reference to sample collection period.

7.2 Flagged records on PAX30678

When calculating droplet concentrations etc, PAX30678 applies a correction to the measured values in an attempt to compensate for the effects of deadtimes within the ASSP instrument (see references 1 and 2). If measured droplet concentration is too high, PAX30678 is unable to make the correction and instead substitutes the droplet concentration (and consequent values of liquid water content and transmission) which it calculates to be the highest physically realisable value based on the instrument's characteristics. This action is indicated in the PAX30678 print out by symbols # or @ placed next to the droplet concentration. Unfortunately such dubious records are not flagged on the corresponding disk dataset and so cannot be distinguished by programs such as MASSPLOT.

The best way to remedy this situation would be to modify PAX30678 to change the sign of such flagged values before storing them on disk, since negative values of these quantities do not otherwise occur. This would enable the offending records to be recognised without the need to change the structure of the PAX30678 output record. For convenience all the affected quantities in a record (droplet concentration, LWC, transmission) should be flagged in this way. MASSPLOT has been designed to accommodate such a change in PAX30678, if it should be made. As the program stands, the absolute values of such records would be taken, so they would be included as genuine records in any plot. This response may be changed by the following modifications to MASSPLOT. (eg use MASSPLOT source and run METMERGE as a first step):

(a) Time-histories and scatter plots:- Delete lines 35440 and 35450 in the source. This will result in the negative sign on the flagged records being retained. They can then either be plotted (in which case they will be clearly distinguishable) or omitted from the plot (though appearing as out-of-range values on the graph boundary) by forcing the axes to cover only positive values.

(b) Drop-size spectra:- Delete line 68602. This will cause all flagged records to be rejected.

Note that (a) and (b) above are independent changes. Either or both may be carried out.

8 Running MASSPLOT

MASSPLOT exists as a Fortran Source on disk USER01 as a member of M15.SOURCLIB. It also exists in load module form as M15.PKNOLOAD (MASSPLOT) on Met 056.

M15 .PKNOLOAD contains load modules of all the programs in the usual ASSP processing chain. If MASSPLOT is run frequently it may be worthwhile to copy the load module onto an online disk.

Fig 23 shows typical JCL to run MASSPLOT:

(a) from the source module, in which case the appropriate CALCOMP routines must be added at the LINKED stage, as shown.

(b) From the load module.

Notes

In both cases the job-dependent code in Fig 23 has been framed.

Stream FT20 is from the PAX30678 disk dataset. In the example shown this is M15 .MF14579H on disk USER01.

//*INFORM MAIN CARDS=999 is coded to avoid encountering the system's normal CALCOMP output limit.

Output streams FT06 and FT60 carry diagnostic messages which are normally suppressed as shown to avoid wasting paper.

REGION=256K should be coded to avoid the job failing with error 240.

9 References

1. A J Lapworth: "Knollenberg ASSP" - Met O 15 unofficial document, c 1976.
2. W T Roach: "Performance assessment of the Knollenberg Axially Scattering spectrometer, Model ASSP-100." Met 015 Internal Report No 8.

Table 1: PLOT CARD PARAMETERS

Parameter Name	Col Nos	Format	MEANING AND/OR RANGE OF ALLOWED VALUES		
			TIME HISTORIES	SCATTER PLOTS	DROP-SIZE SPECTRA
KPY	1 - 3	I3	Identifies y - axis parameter ($1 \leqslant$ KPY $\leqslant 11$)		Specifies normalised/unnormalised " log or lin ordinates See Section 5 for allowed values
KPX	5 - 7	I3	Must be uncoded or 0	Identifies X - axis parameter ($1 \leqslant$ KPX $\leqslant 11$)	Ignored
KSTART KSTOP	9 - 14 16 - 21	I6 I6	Records timed earlier than KSTART (hh mm ss) not accepted Records timed later than KSTOP (hh mm ss) not accepted. (Signals end of plot)		
MYINT	23 - 24	I2	Forces number of subdivisions of y - axis. Default = 5		(MYINT ignored if log ordinates)
YAXMIN	26 - 33	F8.3	Y - axis minimum value if forced scaling employed (YAXMIN $<$ YAXMAX)		(minimum power of 10 if log ordinates used)
YAXMAX	35 - 42	F8.3	Y - axis maximum value if forced scaling employed (YAXMIN $<$ YAXMAX)		(maximum power of 10 if log ordinates used)
MXINT	44 - 45	I2	Forces number of subdivisions of x - axis Default = 8	Default = 5	Places program in conditional mode (see section 5) and identifies parameter to be tested (table 2) $1 \leqslant$ MXINT $\leqslant 6$ for conditional mode.
XAXMIN	47 - 54	F8.3	If XAXMAX $\neq$ XAXMIN, x - axis limits are forced to 0 and (KSTOP - KSTART)	X - axis minimum value if XAXMAX $\neq$ XAXMIN	Threshold values for parameter selected by MXINT. (conditional mode). See section 5 and Fig. 20
XAXMAX	56 - 63	F8.3		X - axis maximum value if XAXMAX $\neq$ XAXMIN	

Parameter Index No	MASSPLOT/ PAX30678 abbreviation	Parameter
1	LWCGD	Liquid water content value ($g.m^{-3}$) derived from ASSP "inner volume"
2	LWCTL	Liquid water content value ($g.m^{-3}$) derived from ASSP "total volume"
3	TRANSGD	Transmission (m) derived from ASSP inner volume.
4	TRANSTL	Transmission (m) derived from ASSP total volume.
5	CONGD	Droplet concentration (cm^{-3}) derived from ASSP inner volume.
6	CONTL	Droplet concentration (cm^{-3}) derived from ASSP total volume.
7	RM	Mean droplet radius, $\overline{r}$ (microns)
8	RA	Mean areal radius, $\sqrt{\overline{r^2}}$ (microns)
9	RV	Mean volume radius, $\sqrt[3]{\overline{r^3}}$ (microns)
10	SD	Standard deviation of radius spectrum (microns)
11	DISP	Dispersion of radius spectrum

Table 2. Index of parameters available for time-histories and scatter plots. (Parameters 1 to 6 inclusive may be used for selection of records for inclusion in mean drop-size spectra - see section 5.3)

Fig	KPY	KPX	KSTART	KSTOP	MYINT	YAXMIN	YAXMAX	MXINT	XAXMIN	XAXMAX
1	2		90000	91500						
2	6		90000	91500		40.0	200.0			
3	6		90000	91500	3	50.0	200.0			
4	6		90000	91500		100.0	150.0			
5	6		90000	91500				9	1.0	
6	2	6	90000	91500						
7	2	6	90000	91500					80.0	160.0
8	2	6	90000	91500	1			1		
9	2	6	73000	103000						
10	90		90000	91500						
11	91		90000	91500						
12	92		90000	91500						
13	590		90000	91500						
14	591		90000	91500						
15	592		90000	91500						
16	92		90000	91500	6		42.0			
17	592		90000	91500		-1.0	2.0			
18	92		90000	91500			30.0			
19	592		90000	91500		-2.0	1.0			

Table 3. Plot card parameters used to generate figures 1 to 19.

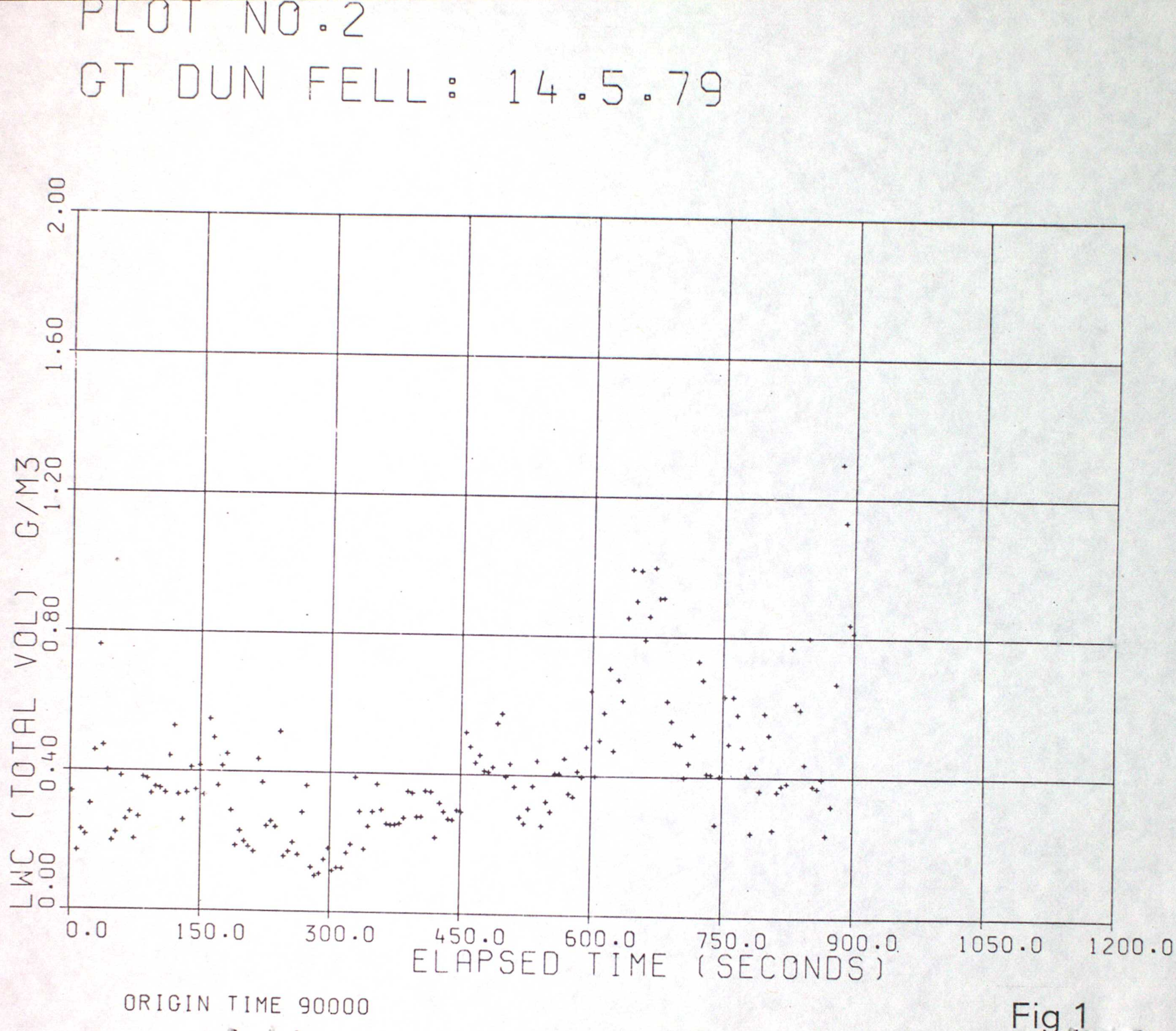

PLOT NO.2
GT DUN FELL: 14.5.79
LWC (TOTAL VOL) G/M3
0.00
0.40
0.80
1.20
1.60
2.00
0.0
150.0
300.0
450.0
600.0
750.0
900.0
1050.0
1200.0
ELAPSED TIME (SECONDS)
ORIGIN TIME 90000

Fig 1

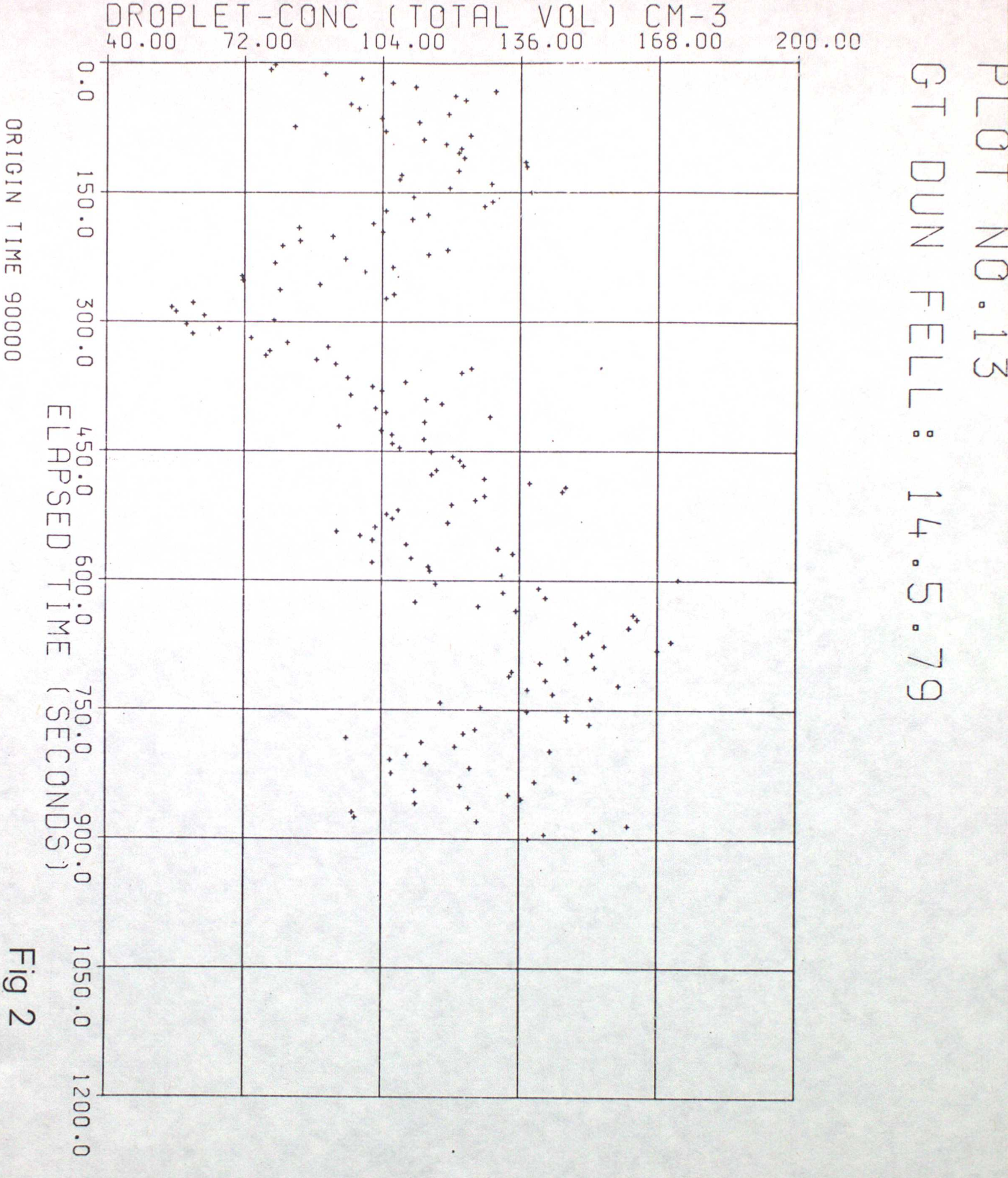
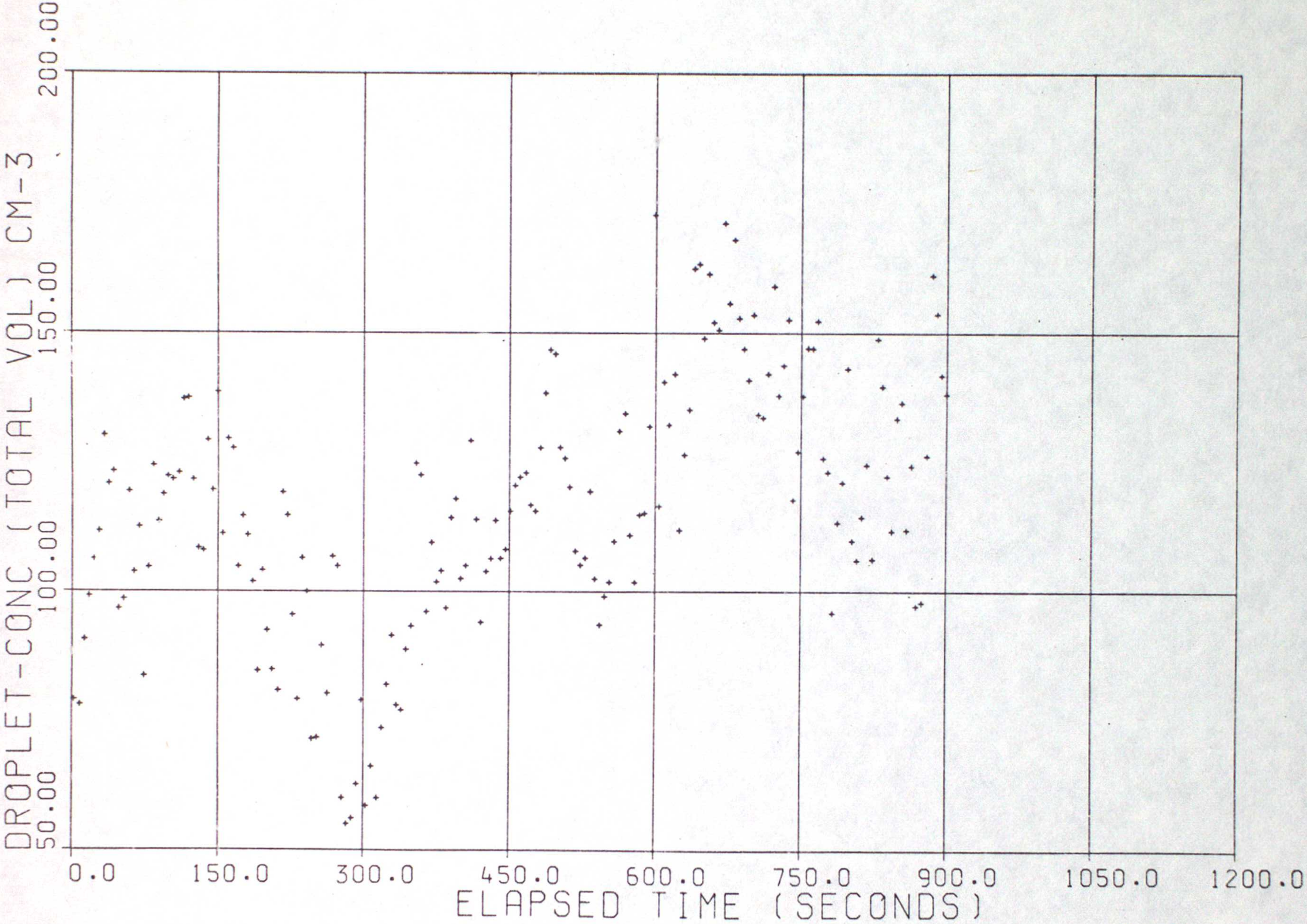

PLOT NO.13
GT DUN FELL: 14.5.79
DROPLET-CONC (TOTAL VOL) CM-3
40.00
72.00
104.00
136.00
168.00
200.00
0.0
150.0
300.0
450.0
600.0
750.0
900.0
1050.0
1200.0
ELAPSED TIME (SECONDS)
ORIGIN TIME 90000

Fig 2

PLOT NO.14

GT DUN FELL: 14.5.79



ORIGIN TIME 90000

Fig 3

PLOT NO.17

GT DUN FELL: 14.5.79

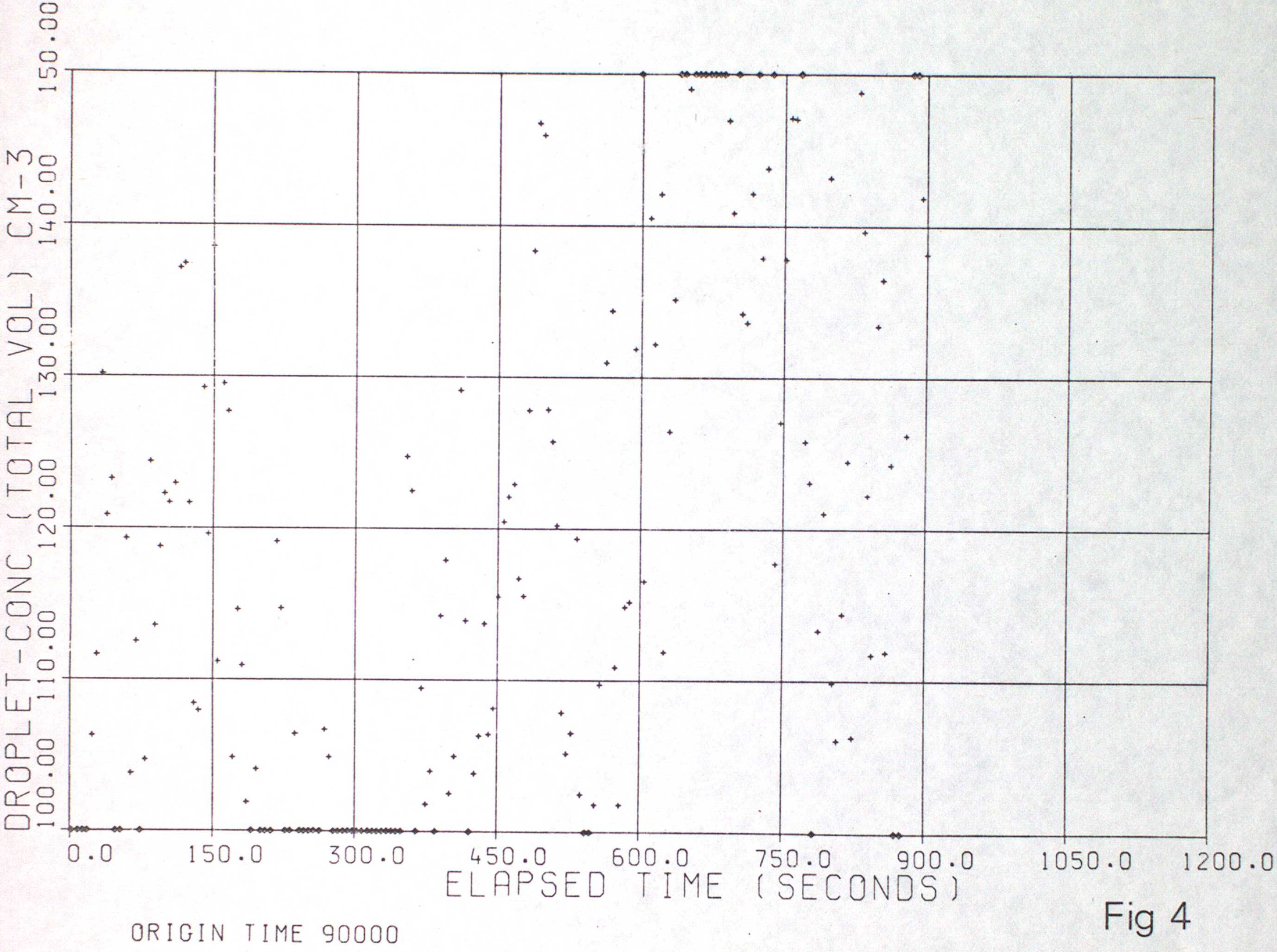


Fig 4

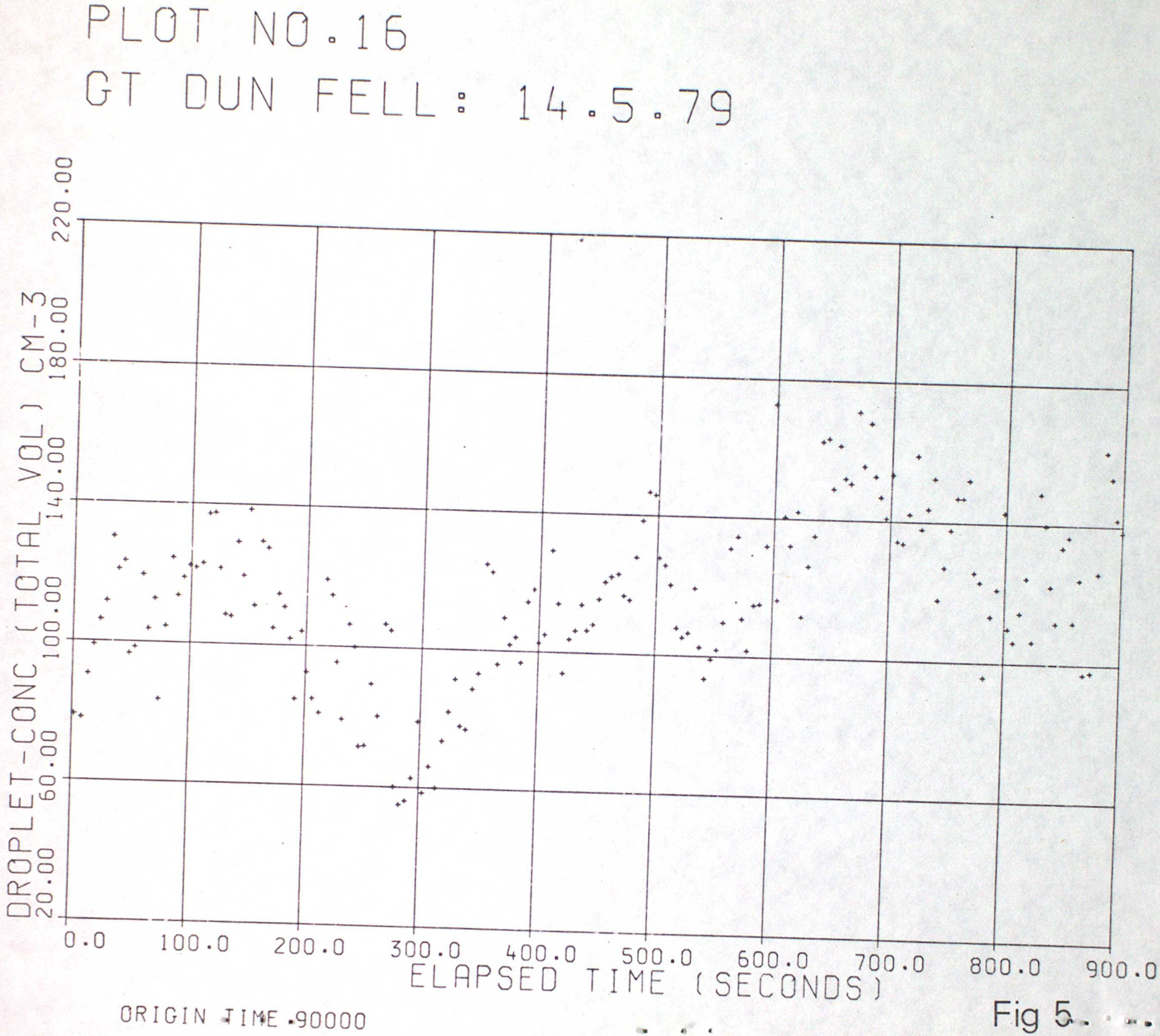

PLOT NO.16
GT DUN FELL: 14.5.79
DROPLET-CONC (TOTAL VOL) CM-3
20.00
60.00
100.00
140.00
180.00
220.00
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
ELAPSED TIME (SECONDS)
ORIGIN TIME 90000

Fig 5.

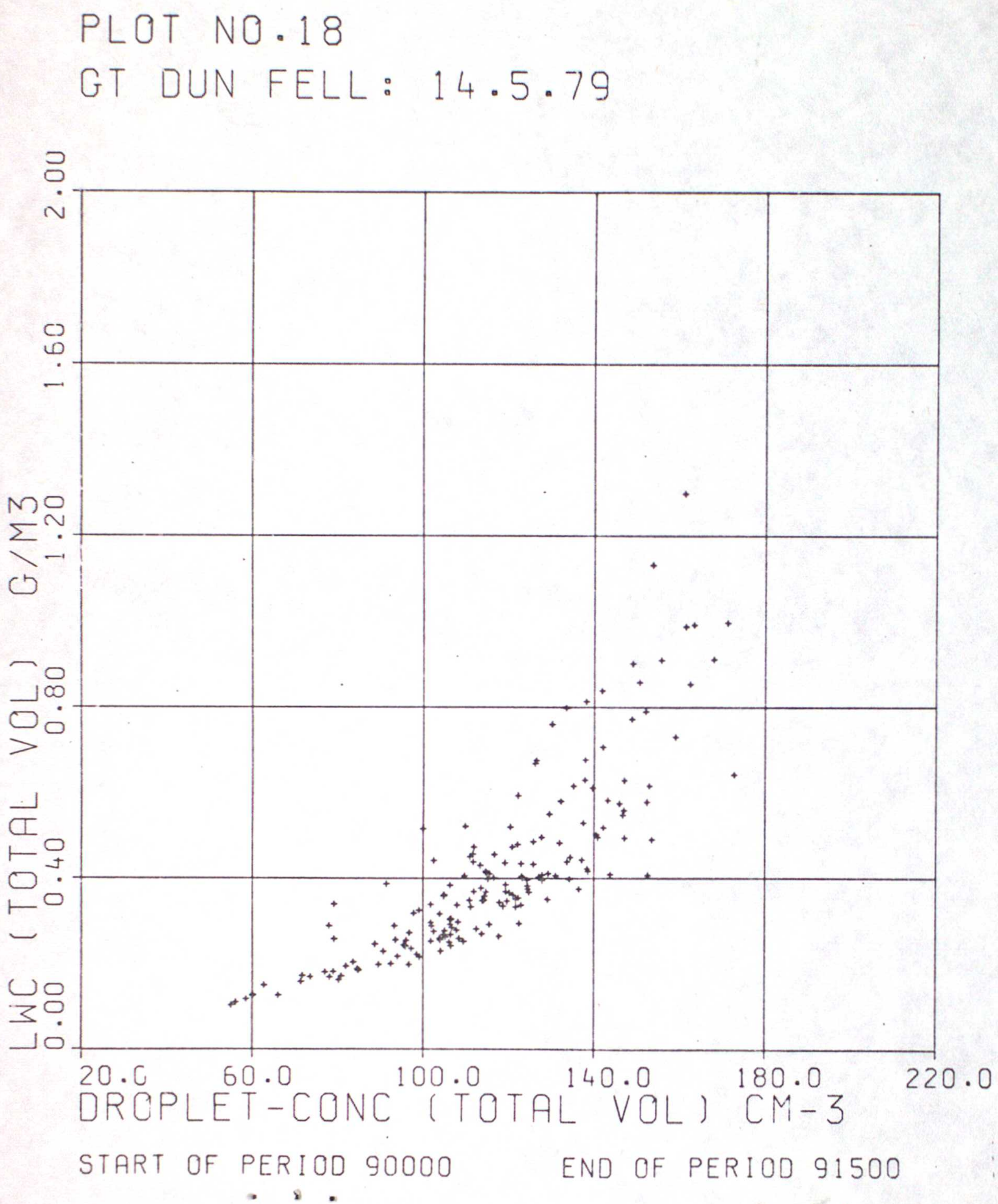

PLOT NO.18
GT DUN FELL: 14.5.79
LWC (TOTAL VOL) G/M3
0.00
0.40
0.80
1.20
1.60
2.00
20.0
60.0
100.0
140.0
180.0
220.0
DROPLET-CONC (TOTAL VOL) CM-3
START OF PERIOD 90000
END OF PERIOD 91500

Fig 6

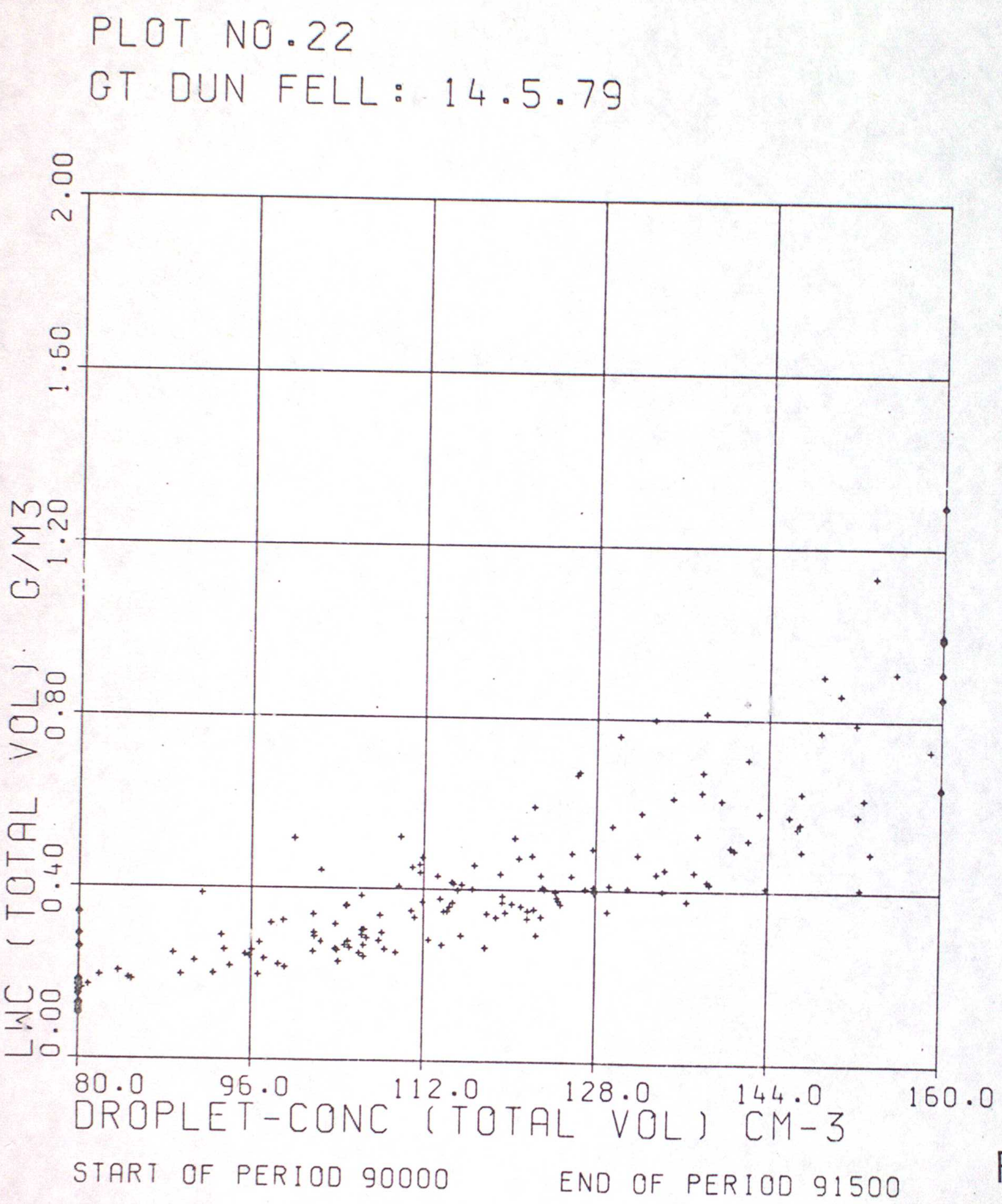
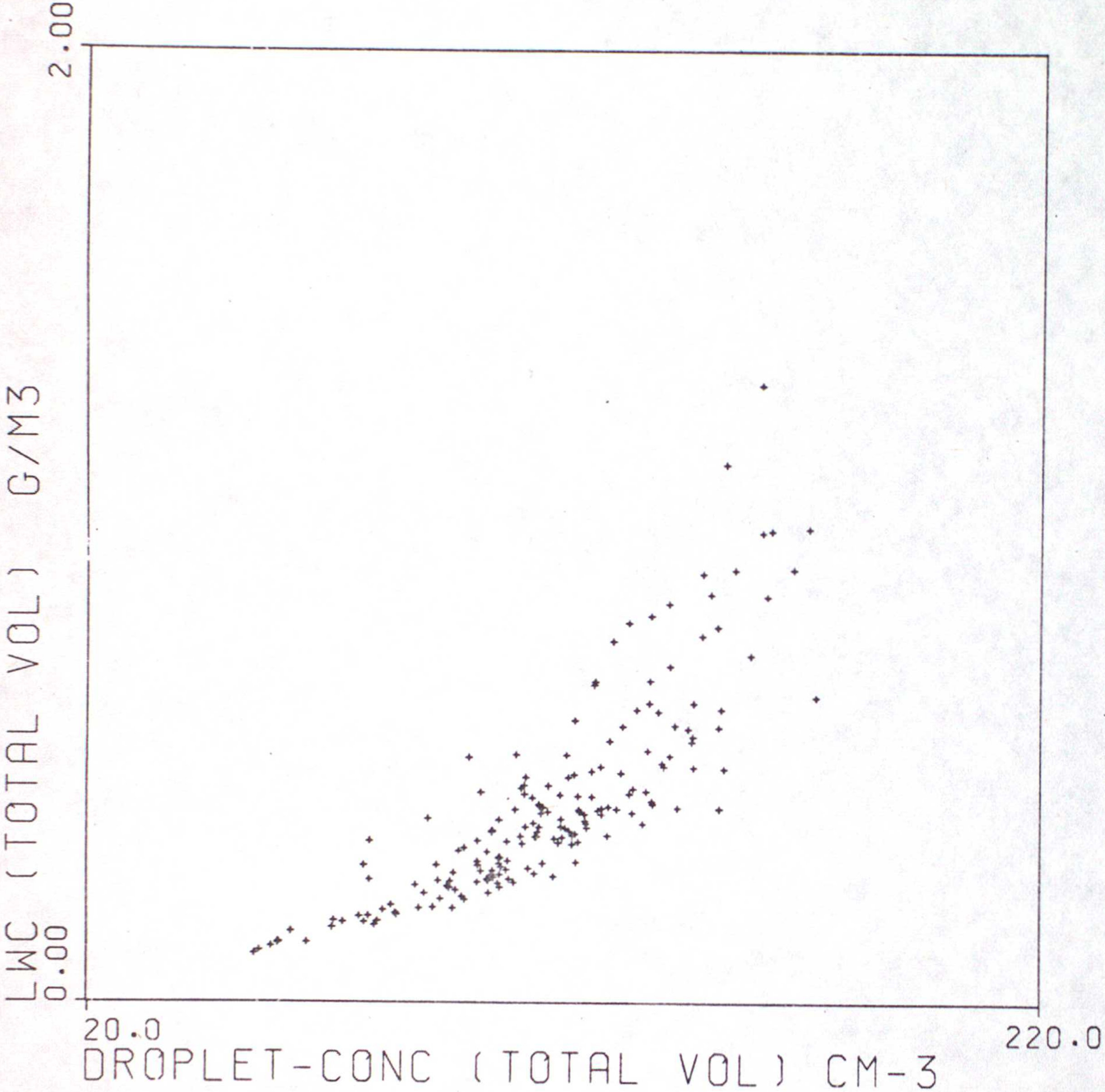

PLOT NO.22
GT DUN FELL: 14.5.79
LWC (TOTAL VOL) G/M3
0.00
0.40
0.80
1.20
1.60
2.00
80.0
96.0
112.0
128.0
144.0
160.0
DROPLET-CONC (TOTAL VOL) CM-3
START OF PERIOD 90000
END OF PERIOD 91500

Fig 7

PLOT NO.23

GT DUN FELL: 14.5.79



START OF PERIOD 90000 END OF PERIOD 91500

Fig 8

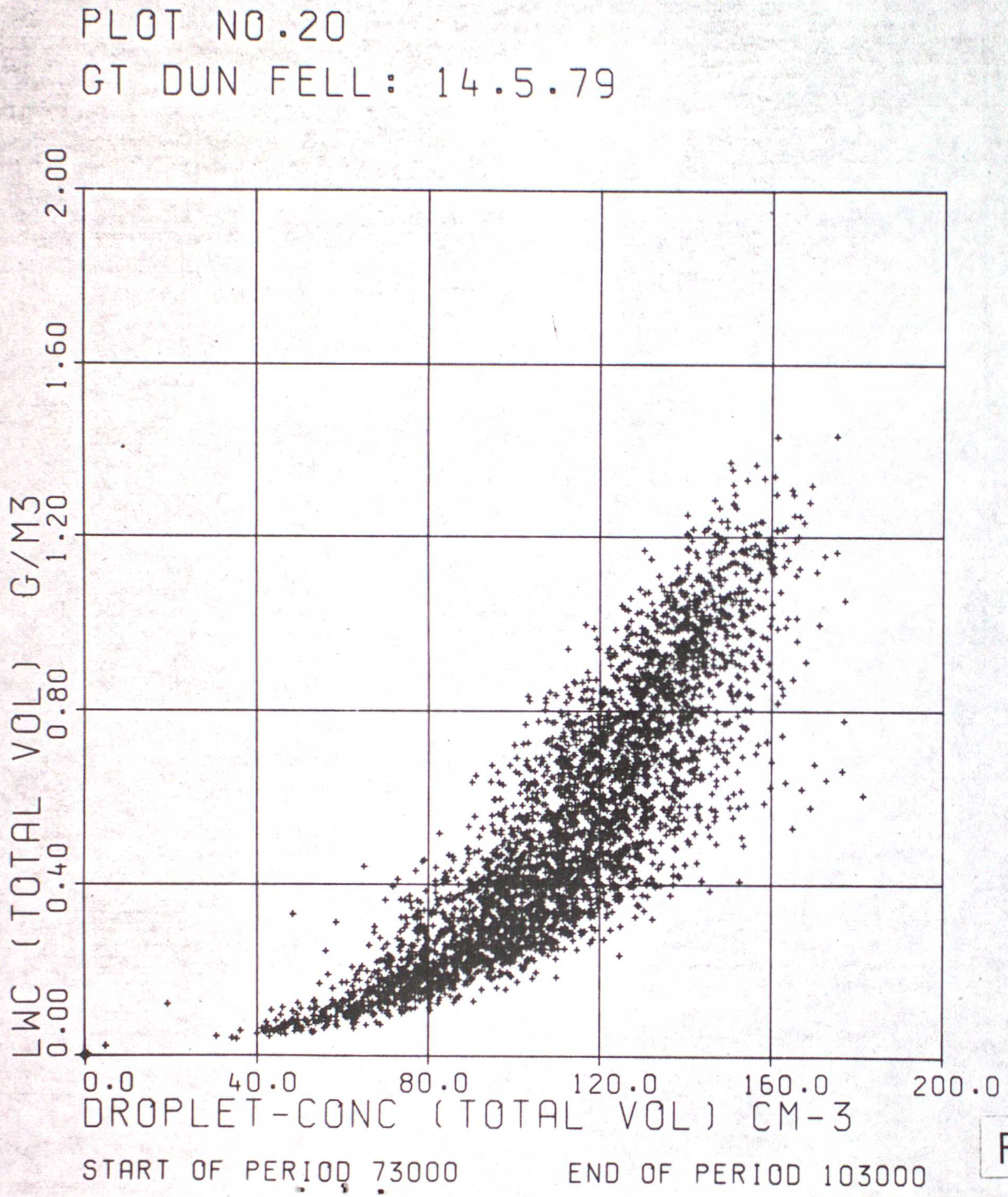

PLOT NO.20
GT DUN FELL: 14.5.79
LWC (TOTAL VOL) G/M3
0.00
0.40
0.80
1.20
1.60
2.00
0.0
40.0
80.0
120.0
160.0
200.0
DROPLET-CONC (TOTAL VOL) CM-3
START OF PERIOD 73000
END OF PERIOD 103000

Fig 9

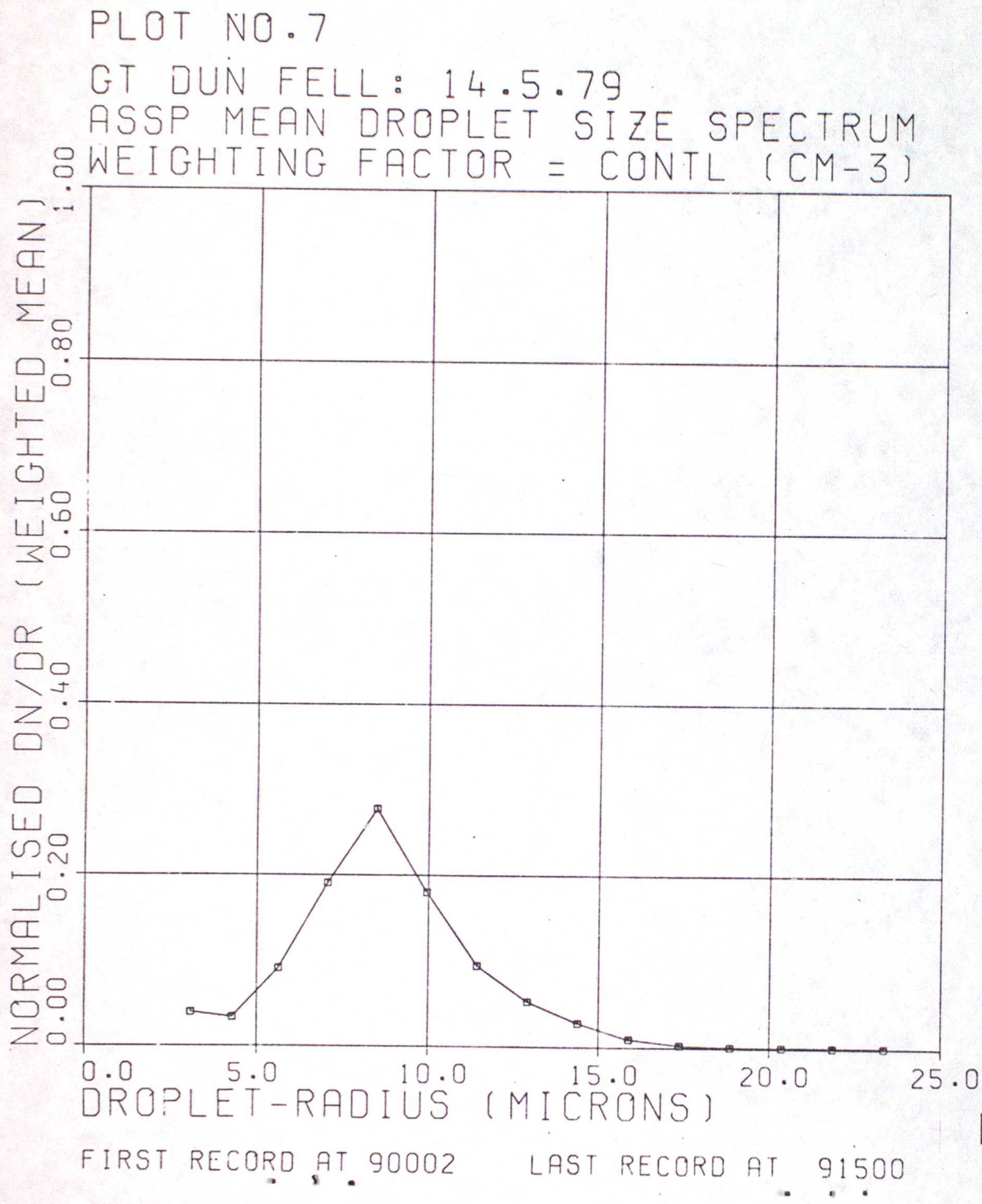
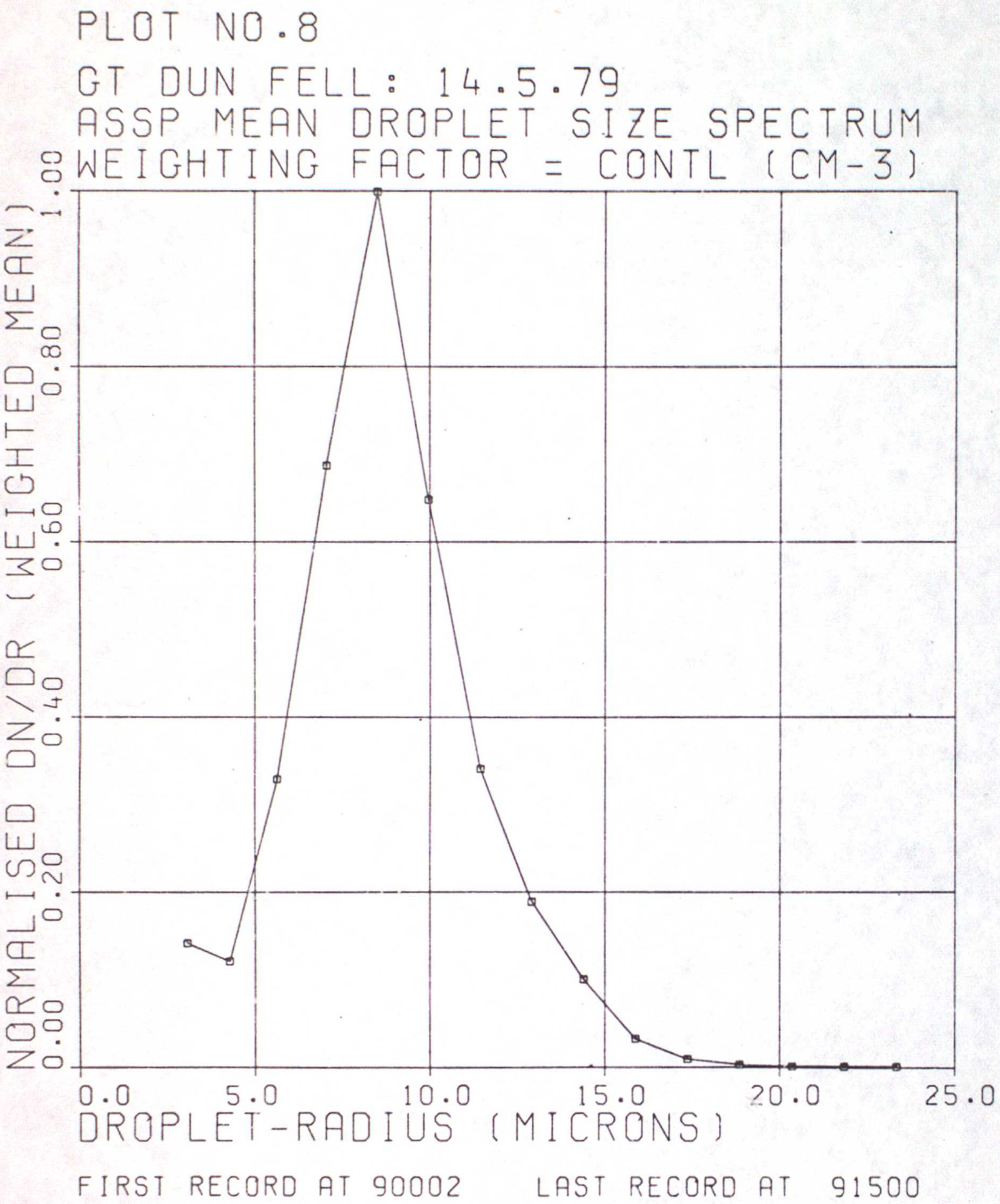

PLOT NO.7
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
NORMALISED DN/DR (WEIGHTED MEAN)
0.00
0.20
0.40
0.60
0.80
1.00
0.0
5.0
10.0
15.0
20.0
25.0
DROPLET-RADIUS (MICRONS)
FIRST RECORD AT 90002
LAST RECORD AT 91500

Fig 10



PLOT NO.8
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
NORMALISED DN/DR (WEIGHTED MEAN)
0.00
0.20
0.40
0.60
0.80
1.00
0.0
5.0
10.0
15.0
20.0
25.0
DROPLET-RADIUS (MICRONS)
FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 11

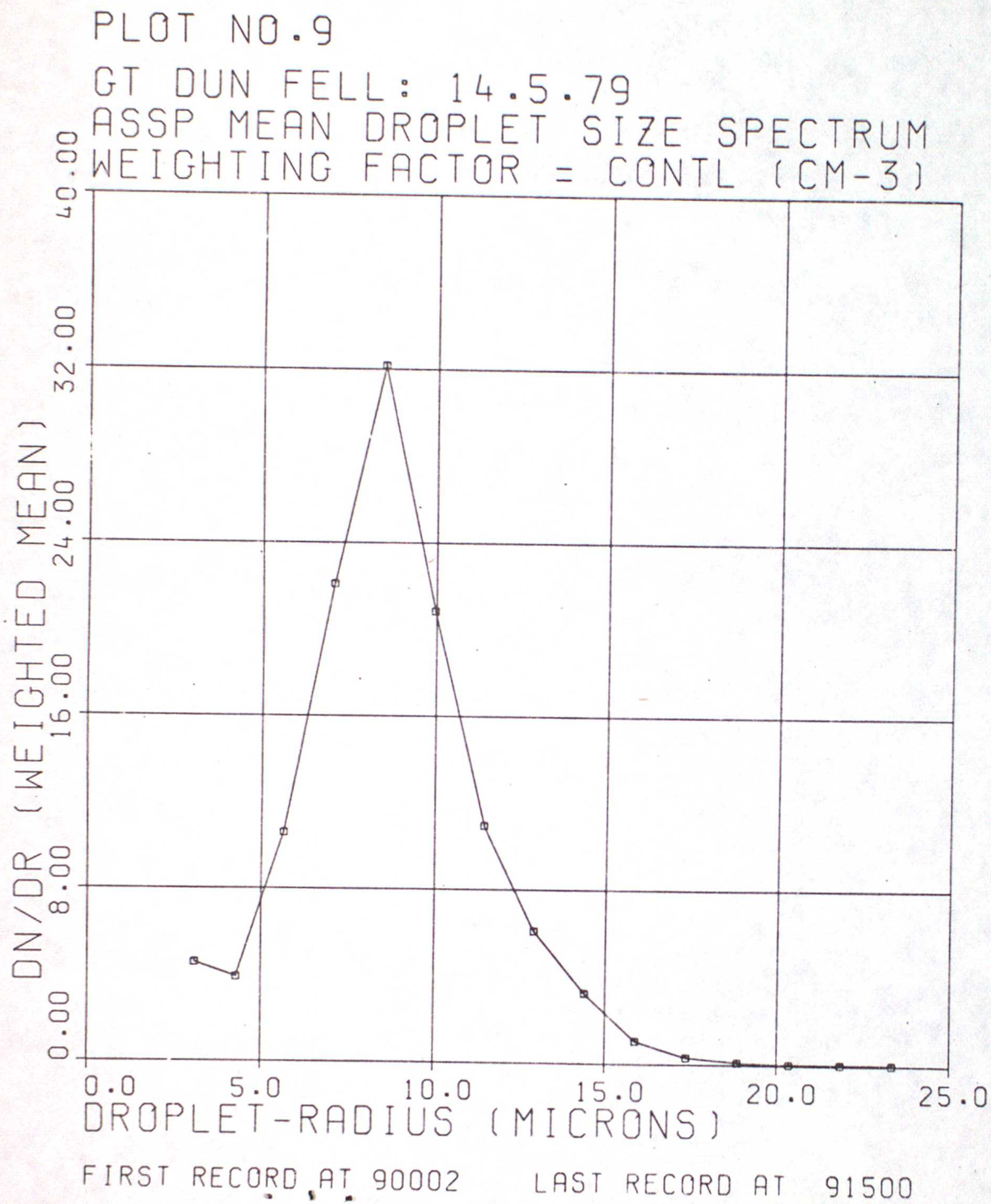
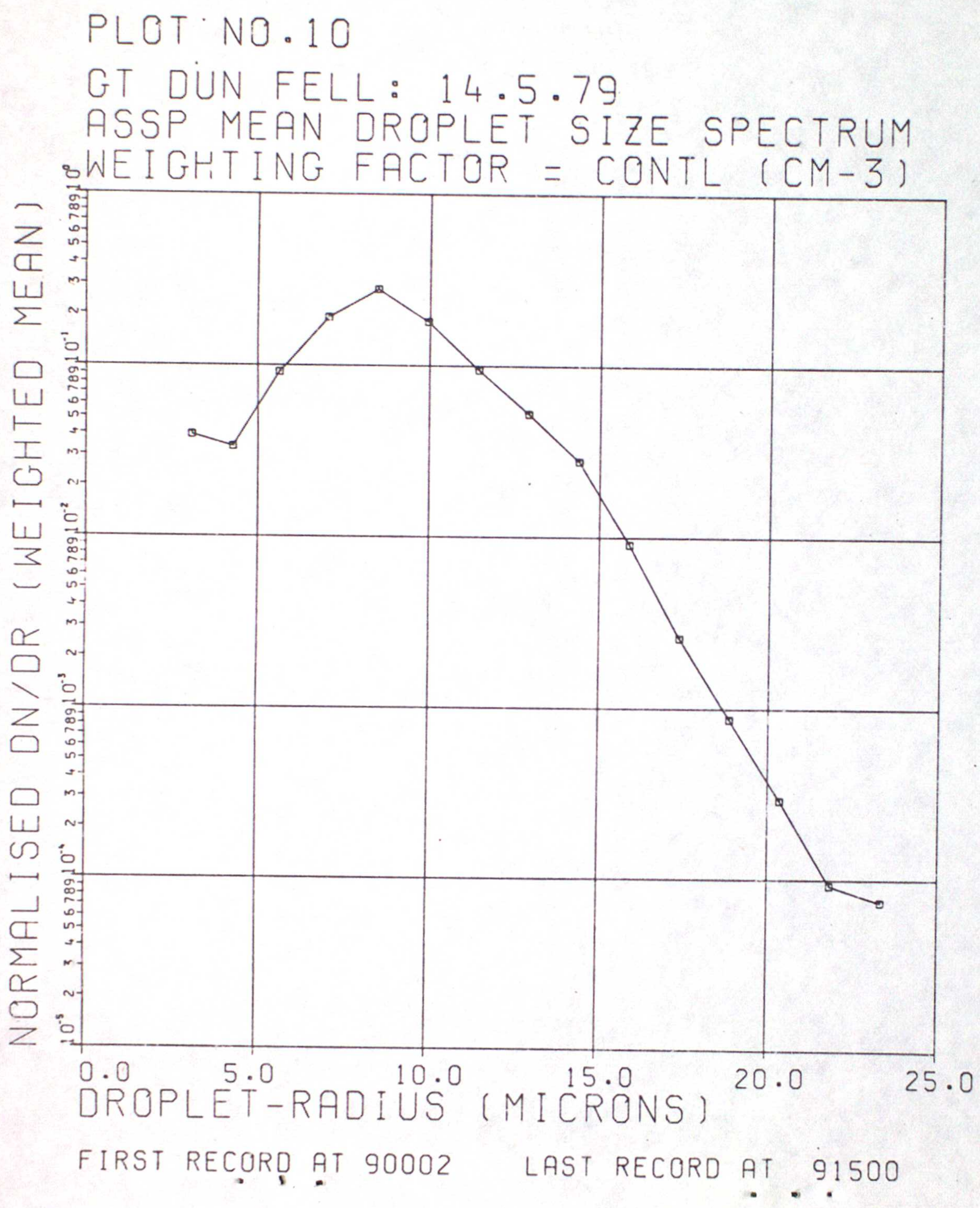

PLOT NO.9
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
DN/DR (WEIGHTED MEAN)
0.00
8.00
16.00
24.00
32.00
40.00
0.0
5.0
10.0
15.0
20.0
25.0
DROPLET-RADIUS (MICRONS)
FIRST RECORD AT 90002
LAST RECORD AT 91500

Fig 12



PLOT NO.10
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
NORMALISED DN/DR (WEIGHTED MEAN)
DROPLET-RADIUS (MICRONS)
0.0
5.0
10.0
15.0
20.0
25.0
FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 13

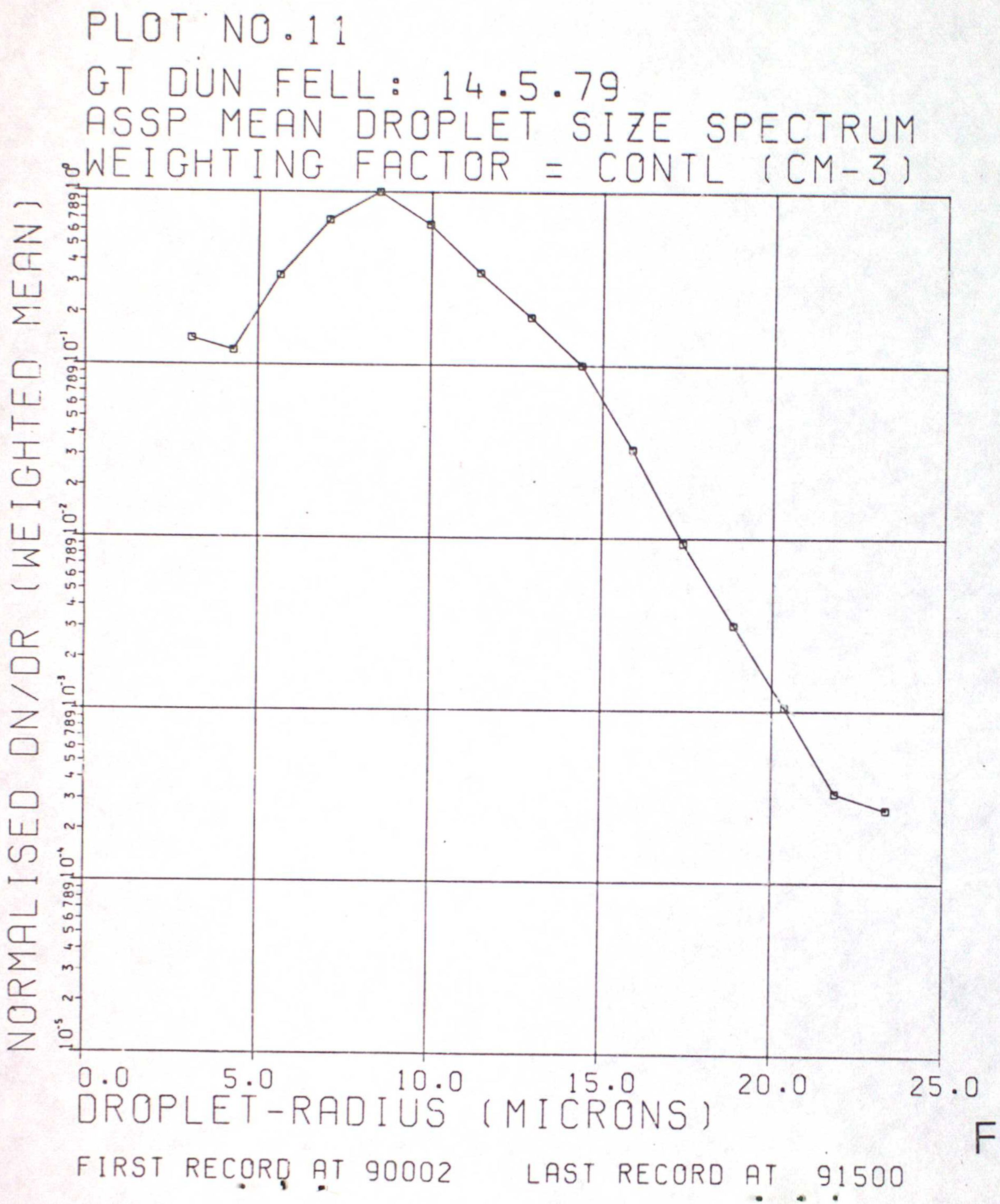

PLOT NO.11
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
NORMALISED DN/DR (WEIGHTED MEAN)
0.0
5.0
10.0
15.0
20.0
25.0
DROPLET-RADIUS (MICRONS)
FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 14

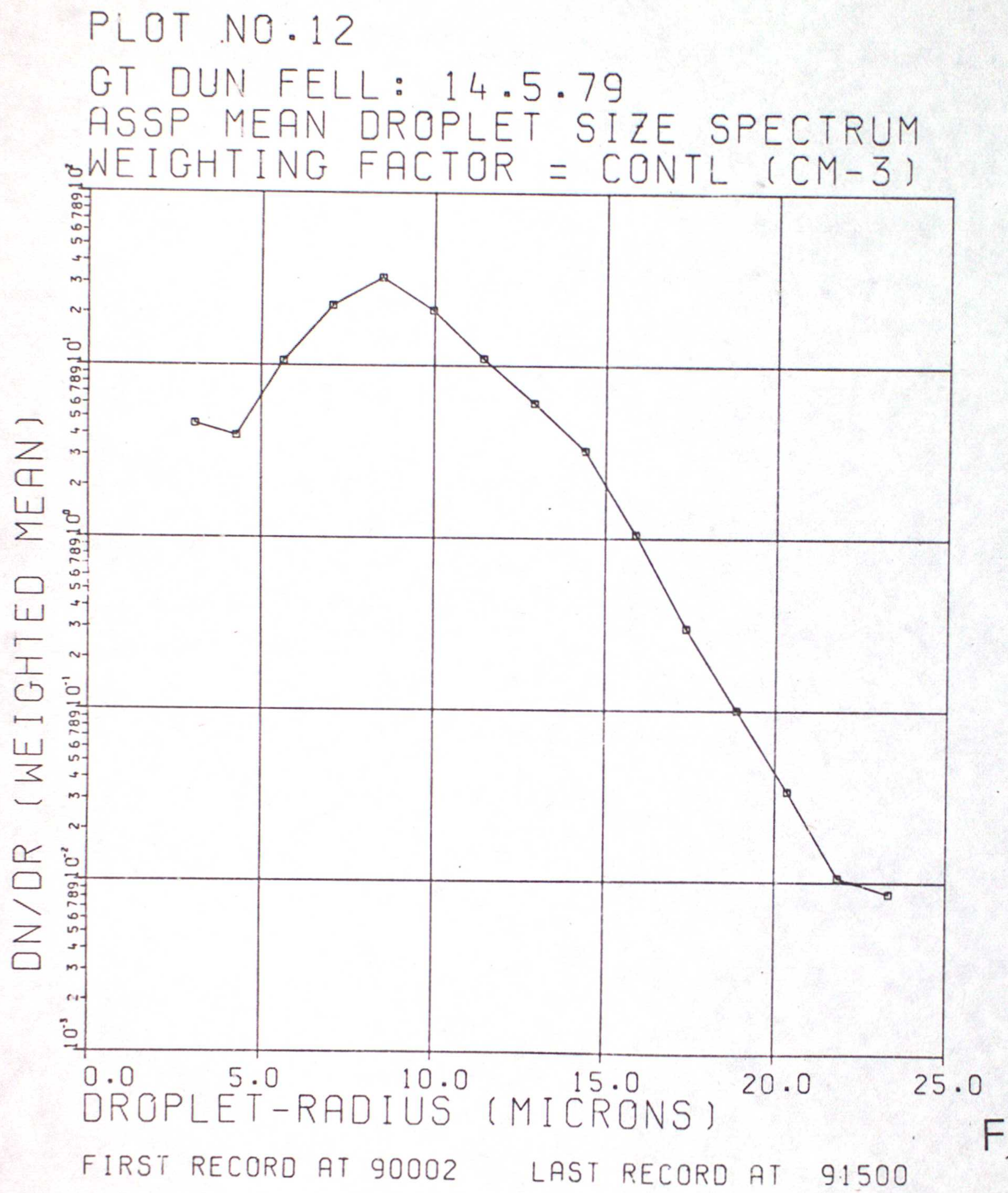
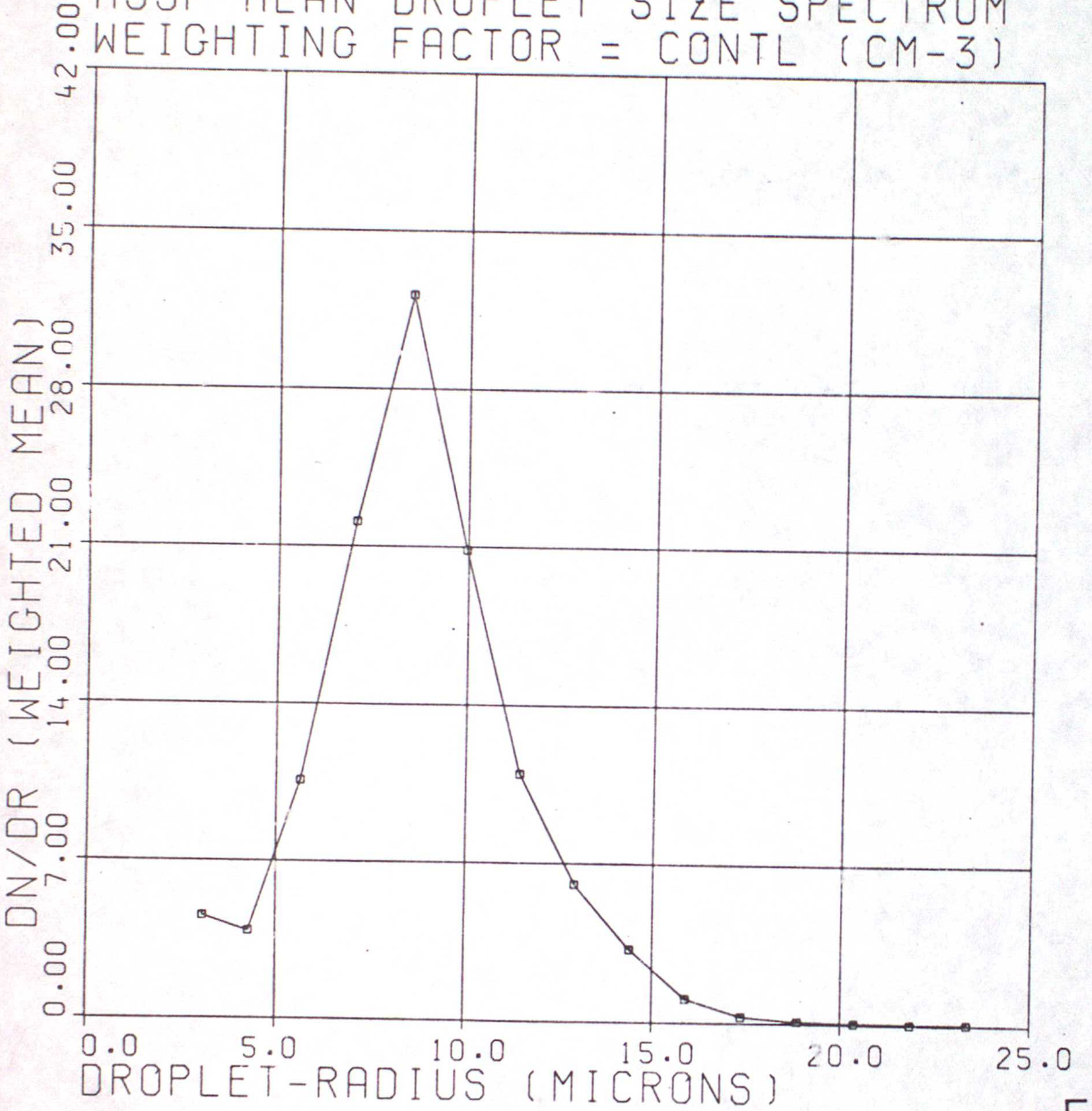

PLOT NO.12
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
DN/DR (WEIGHTED MEAN)
DROPLET-RADIUS (MICRONS)
0.0
5.0
10.0
15.0
20.0
25.0
FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 15

PLOT NO.22

GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)



FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 16

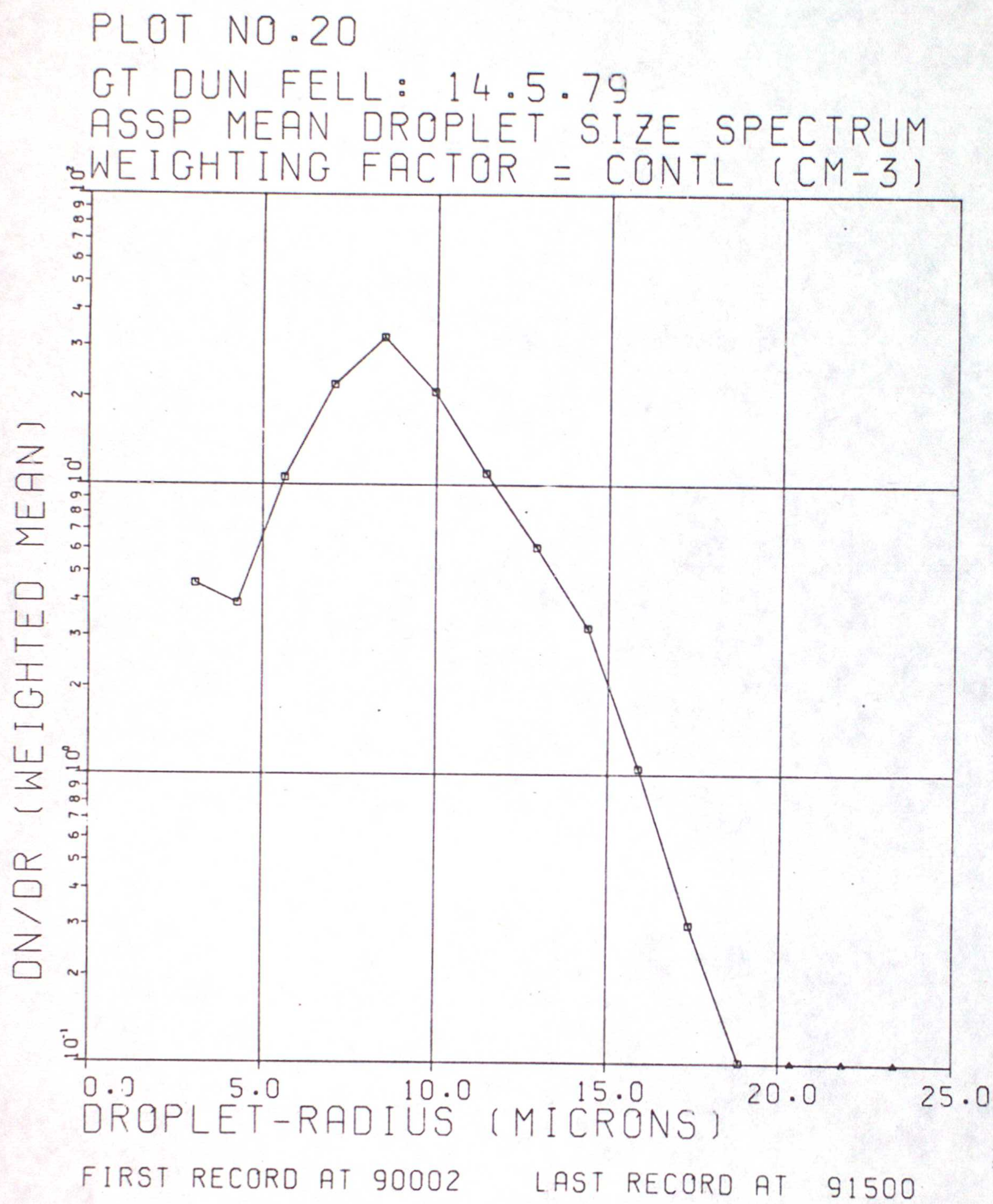
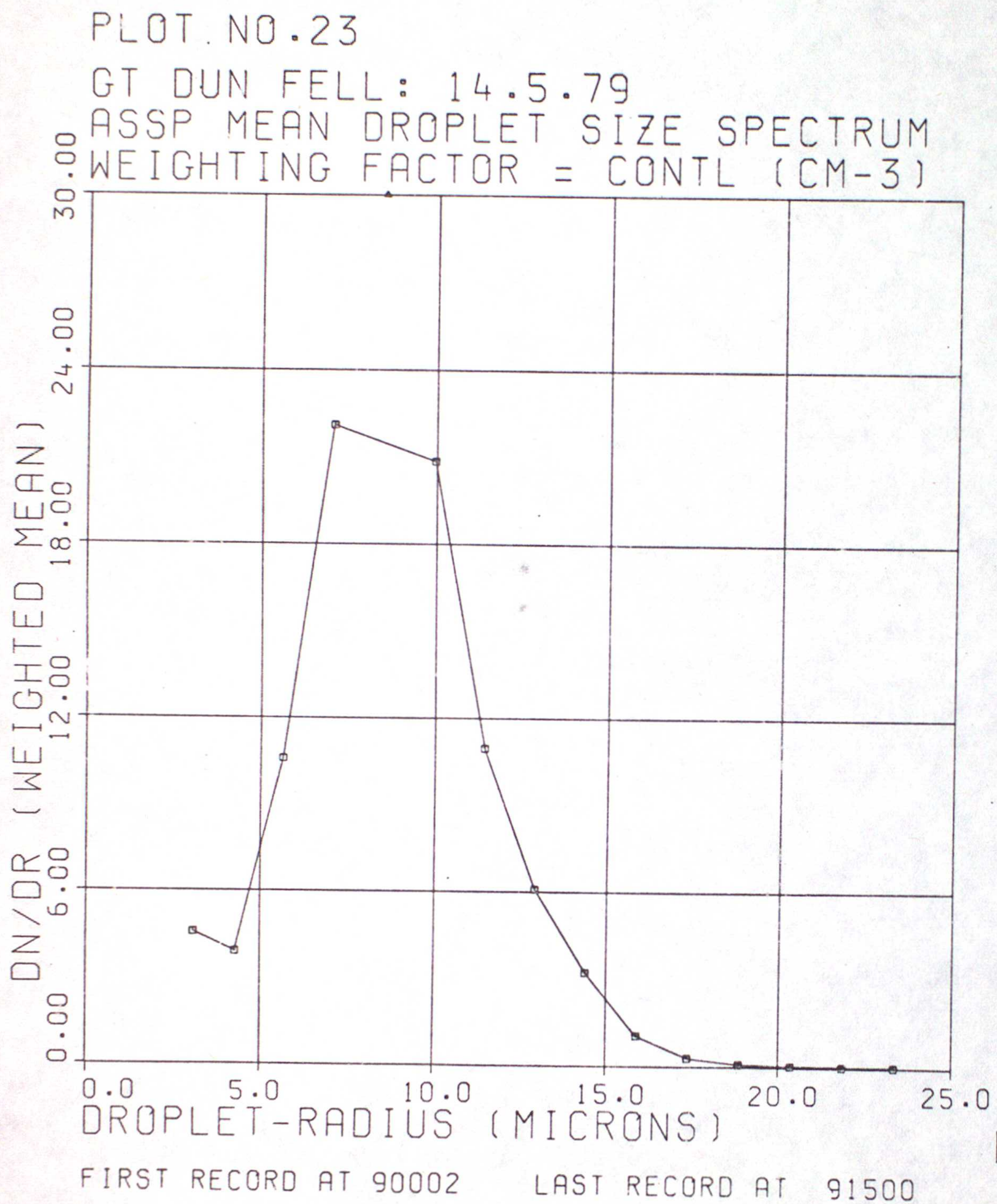
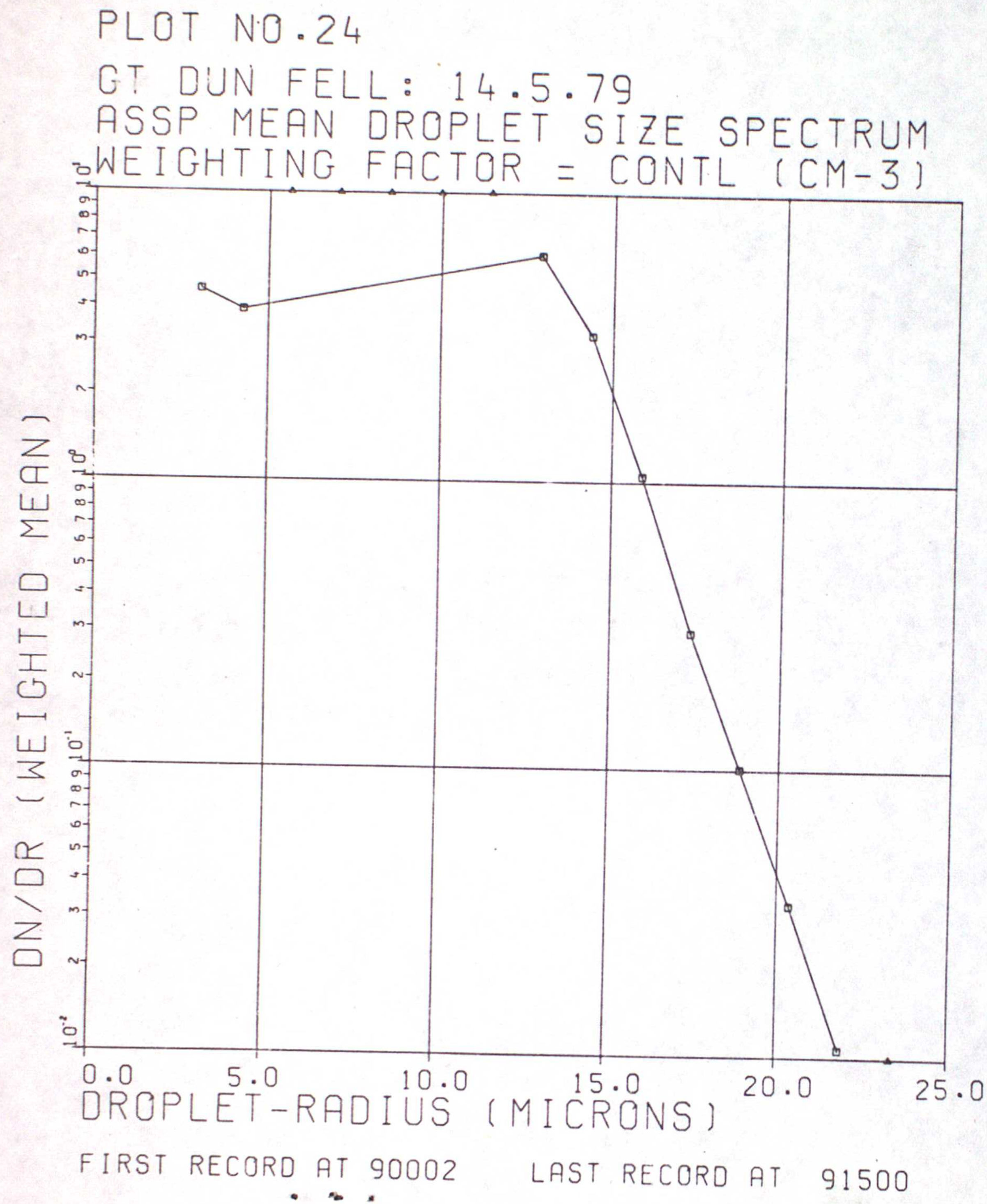

PLOT NO.20
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
DN/DR (WEIGHTED MEAN)
DROPLET-RADIUS (MICRONS)
0.0
5.0
10.0
15.0
20.0
25.0
FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 17



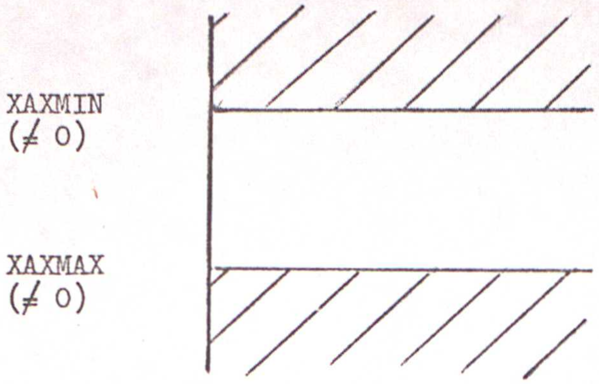
PLOT.NO.23
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
DN/DR (WEIGHTED MEAN)
0.00
6.00
12.00
18.00
24.00
30.00
0.0
5.0
10.0
15.0
20.0
25.0
DROPLET-RADIUS (MICRONS)
FIRST RECORD AT 90002 LAST RECORD AT 91500

Fig 18

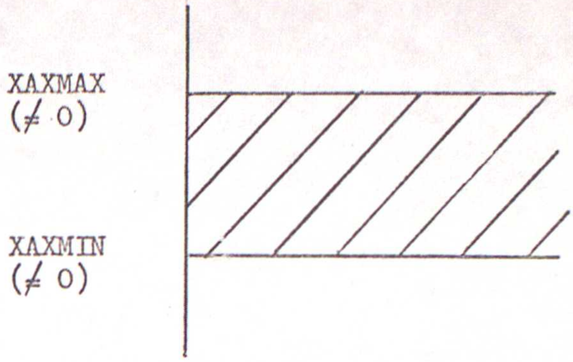


PLOT NO.24
GT DUN FELL: 14.5.79
ASSP MEAN DROPLET SIZE SPECTRUM
WEIGHTING FACTOR = CONTL (CM-3)
DN/DR (WEIGHTED MEAN)
DROPLET-RADIUS (MICRONS)
0.0
5.0
10.0
15.0
20.0
25.0
FIRST RECORD AT 90002   LAST RECORD AT 91500

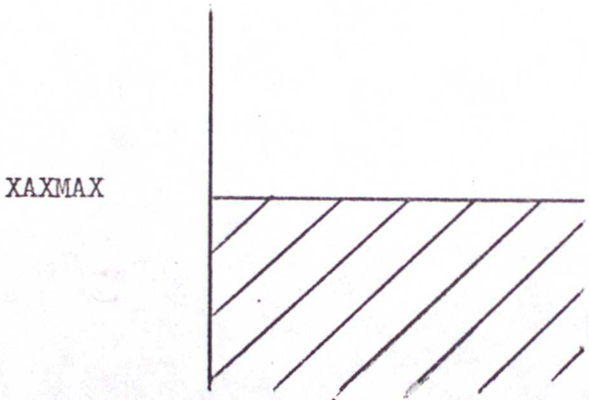
Fig 19



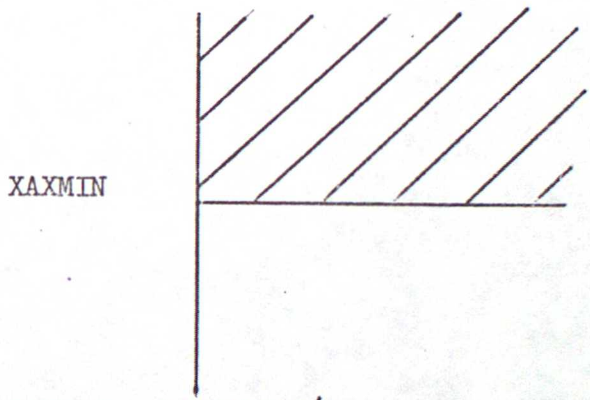
XAXMIN > XAXMAX
Accept record if test-parameter lies outside band



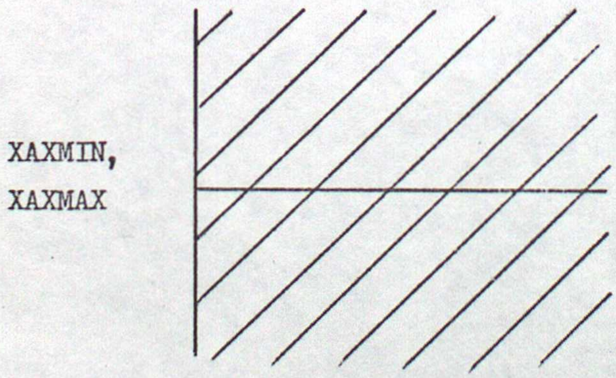
XAXMAX > XAXMIN
Accept record if test-parameter lies inside band



XAXMIN = 0, XAXMAX ≠ 0
Accept record if test-parameter ⩽ XAXMAX



XAXMAX = 0, XAXMIN≠0
Accept record if test-parameter ⩾ XAXMIN



XAXMIN = XAXMAX
Accept all records

Fig 20

MASSPLOT Drop size spectra (conditional mode)

A record is accepted for inclusion if the value of the selected test-parameter (see section 5.3) falls within the shaded region, relative to thresholds XAXMIN & XAXMAX, in whichever of the above cases applies.

```
GT DUN FELL: 14.5.79                     PLOT NO.   1
LWC (GOOD VOL)  G/M3                 VS ELAPSED TIME (SECONDS)

PLOT CARD PARAMETERS:

KPY  KPX  KSTART   KSTOP  MYINT   YAXMIN   YAXMAX  MXINT   XAXMIN   XAXMAX
  1    0   90000   91500    0       0.0      0.0     0       0.0      0.0

  177 RECORDS INCLUDED IN THIS PLOT

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

GT DUN FELL: 14.5.79                     PLOT NO.   2
LWC (TOTAL VOL)  G/M3                VS ELAPSED TIME (SECONDS)

PLOT CARD PARAMETERS:

KPY  KPX  KSTART   KSTOP  MYINT   YAXMIN   YAXMAX  MXINT   XAXMIN   XAXMAX
  2    0   90000   91500    0       0.0      0.0     0       0.0      0.0

  177 RECORDS INCLUDED IN THIS PLOT

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

GT DUN FELL: 14.5.79                     PLOT NO.   3
LWC (TOTAL VOL)  G/M3                VS MEAN VOLUME RADIUS (MICRONS)

PLOT CARD PARAMETERS:

KPY  KPX  KSTART   KSTUP  MYINT   YAXMIN   YAXMAX  MXINT   XAXMIN   XAXMAX
  2    9   90000   91500    0       0.0      0.0     0       0.0      0.0

  177 RECORDS INCLUDED IN THIS PLOT

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Fig 21

GT DUN FELL: 14.5.79 PLOT NO. 5. MEAN DROPLET SIZE SPECTRUM: WEIGHTING FACTOR = CONTL (CM-3)

PERIOD SCANNED= 90000 TO 91500. FIRST RECORD AT 90002 LAST RECORD AT 91500. 177 RECORDS INCLUDED
SPECTRUM PARAMETERS: RM= 8.6 RA= 9.0 RV= 9.4 DISPERSION= 30.5%
ASSP SET TO RANGE 1 THROUGHOUT THIS PLOT

CHNL #	WIDTH	CENTRE RAD	CHNL CONC (/CC)
1	1.10	3.07	4.567
2	1.31	4.28	3.895
3	1.40	5.63	10.582
4	1.44	7.05	22.091
5	1.46	8.50	32.156
6	1.47	9.96	20.854
7	1.48	11.43	10.960
8	1.48	12.91	6.088
9	1.48	14.39	3.220
10	1.49	15.88	1.051
11	1.49	17.37	0.299
12	1.49	18.86	0.101
13	1.49	20.35	0.034
14	1.49	21.84	0.011
15	1.49	23.34	0.009

MEAN VALUES OF OTHER QUANTITIES: CONGD= 83.0 CONTL=115.9 LWCGD=0.298 LWCTL=0.413

THIS PLOT WAS TERMINATED WHEN END OF SPECIFIED PERIOD WAS REACHED

++

Fig 22

```
//M15MNMT3 JOB (M15322,M),B.CONWAY.2586,REGION=256K,
// PRTY=8
//*INFORM PRINTDATA
//*INFORM MAIN CARDS=999
// EXEC FORTGCLG,PARM=(XREF,MAP,ID)
//FORT.SYSIN DD DSN=M15.SOURCLIB(MASSPLOT),DISP=SHR,
// UNIT=DISK,VOL=SER=USER01
//LKED.OBJ1 DD DSN=MET.CALCOMP,DISP=SHR
//LKED.SYSIN DD *
  INCLUDE OBJ1(OPENON35,AXIS,LINE,SCALE,LGAXS)
  ENTRY MAIN
/*
//GO.FT05F001 DD *
GT DUN FELL: 14.5.79
 90       90000  91500
 91       90000  91500
 92       90000  91500
590       90000  91500
591       90000  91500
592       90000  91500
/*
//GO.FT06F001 DD SYSOUT=Z
//GO.FT04F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)
//GO.FT07F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)
//GO.FT08F001 DD SYSOUT=K
//GO.FT20F001 DD DSN=M15.MF14579H,DISP=OLD,UNIT=DISK,VOL=SER=USER01
//GO.FT60F001 DD SYSOUT=Z
/*
//
```

(a)

```
//M15MNMTW JOB (M15322,M),B.CONWAY.2586,REGION=256K,
// PRTY=2
//*INFORM SETUP=YES,PRINTDATA
//*INFORM MAIN CARDS=999
// EXEC PGM=MASSPLOT
//STEPLIB DD DSN=M15.PKNOLOAD,DISP=SHR,UNIT=DISK,
// VOL=(,RÉTAIN,SER=MET056)
//GO.FT05F001 DD *
GT DUN FELL: 14.5.79
  1       90000  91500
  2       90000  91500
  2    9  90000  91500
 90       90000  91500                   0.4
591       90000  91500       -2.0
//GO.FT04F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)
//GO.FT06F001 DD SYSOUT=Z
//GO.FT07F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)
//GO.FT08F001 DD SYSOUT=K
//GO.FT20F001 DD DSN=M15.MF14579H,DISP=OLD,UNIT=DISK,VOL=SER=USER01
//GO.FT60F001 DD SYSOUT=Z
/*
//
```

(b)

Fig 23