3H/120

The Met. Office

A preliminary report on the exceptionally strong winds of 15/16 October 1987 over the south of England

Meteorological Office, London Road, Bracknell, Berks RG12 2SZ

INTRODUCTION

This combined report deals with the chain of events preceding and immediately following the night of the exceptionally strong winds over the south of England on 15/16 October 1987.

PART 1 (Pages 1 to 6 and Annexes 1 to 20) summarizes the observations received soon after the event and considers the exceptional nature of the wind speeds reported. Part 1 was prepared by Advisory Services for issue to the general public and therefore the information has been presented in appropriate terminology.

PART 2 (Pages 1 to 7 and Figures 1 to 13) relates to the sequence of weather events, model guidance used in the numerical weather prediction along with the short period guidance and forecasts issued.

JM

A PRELIMINARY SUMMARY OF INFORMATION ON THE EXCEPTIONALLY STRONG WINDS OF 16 OCTOBER 1987 OVER THE SOUTH OF ENGLAND

Part 1: The Observations (Prepared by the Met Office, Advisory Services, Bracknell)

Note: This summary has been prepared in haste to meet the immediate demand from the public for some facts about the exceptional winds of 16 October 1987 over the south of England. In order to meet this demand this summary is based on information which is immediately available to Advisory Services. The data have not yet been subjected to our usual careful scrutiny. Therefore the analyses shown and the values quoted may be reviewed in the light of later examination. However it is believed that the summary will give a good guide to the extreme events of 16 October 1987.

Weather Situation on 15/16 October (see Annexes 1 to 6)

On the evening of 15 October at 2100 GMT (see Annex 1) a depression (Low) of central pressure 972 millibars was centred over the north of East Anglia. From this depression, a frontal zone lay across the south of England to another depression which was believed to be centred over the western entrance to the English Channel with a central pressure believed to be less than 966 millibars.

To the south of the frontal zone the air was quite mild and winds were blowing from between south and southwest. The air to the north of the frontal zone was cooler and winds were from the northeast.

By 0001 GMT (Annex 2) the depression in the west of the English Channel had deepened, probably to about 959 millibars and was centred over the south coast of Cornwall. The associated front was being forced to move quickly northwards over the south of England. A broad band of quite heavy rain was associated with the frontal zone.

By 0300 GMT (Annex 3) the depression was over the county of Avon with a central pressure of about 956 millibars and it was moving rapidly northeastwards. By 0600 GMT it had already reached the area of Humberside, probably with a central pressure of about 958 millibars and by 0900 GMT the depression was already well out into the North Sea (see Annex 5).

Annex 7 shows a satellite image with the depression centred off the east coast of England at 0830 GMT on 16 October.

Details of the surface wind conditions (Annexes 8 to 16)

Annexes 8 to 16 show the details of the surface winds as reported by observing sites. These reports form part of the full weather observation made in the 10 minutes or so prior to the nominal hour of observation shown on the charts. Therefore the MEAN wind direction and speed refers to a 10 minute period preceding the time shown. However the gust speed is the highest observed speed in the past HOUR. A guide to the interpretation of the plotted data is given at the end of this section.

At 2100 GMT on 15 October (Annex 8) most of the south of England except the coast of Sussex and Kent, was covered by light to moderate winds from the northeast. Stronger winds from the southwest were already affecting the coast of Sussex and Kent.

By 0001 GMT (Annex 9) the stronger winds had spread quickly northwards over the south of England, backing somewhat to a direction from the southsoutheast. Gusts to over 40 knots (46 miles per hour) were already being reported over inland areas.

The sequence of charts shown as Annexes 10 to 14 show hour by hour how the strong winds developed between 0200 GMT and 0600 GMT, the period when most areas experienced their strongest winds. Note particularly the gusts of 80 knots (92 mph) or more reported on the charts for hours ending 0400 GMT and

0500 GMT over the area southeast of a line approximately London to the Isle of Wight. Gusts to 82 knots (94 mph) were recorded in London between 0200 and 0300 GMT.

By 0600 GMT a broad belt of very strong winds covered most of England south of a line from a Severn Estuary to the Wash. The direction from which the wind was blowing had veered to between southwest and west by this time, as the centre of the depression moved quickly away over Humberside. By 0900 GMT (Annex 15) winds had decreased in strength over most areas except the north of East Anglia.

Key to Wind Charts

1. The "arrows" show the direction FROM which the 10 minute mean wind was blowing.

2. The short "feather" represents a speed of 5 knots (6 mph); the longer "feather" represents 10 knots (11 mph); a "triangle" represents 50 knots (58 mph).

Thus  indicates a wind of mean speed 45 knots (52 mph) blowing from the southwest and  is a wind of mean speed 70 knots (81 mph) blowing from the west.

3. The maximum gust in the hour is shown as "Gnn". For example, G90 is a gust of 90 knots (104 mph). The direction of the gust is not given. Note that only gusts exceeding a speed of 33 knots are reported in the routine weather observations.

Annex 17 shows the Maximum Gusts in knots reported during the 24 hours 0001 GMT to 2300 GMT on 16 October 1987. Most of these maximum gusts occurred in the period 0001 GMT to 0900 GMT.

How unusual were the wind speeds on 16 October 1987?

Providing sufficient long term wind records are available from a weather station with sophisticated wind recording equipment, it is possible by statistical methods to estimate the average interval in years between the occurrence of wind speeds of given strength. This interval is known as the RETURN PERIOD. It must be stressed that the Return Period is only an average time interval. In reality extreme winds could occur more frequently than the Return Period. Also the estimation of the Return Period is greatly affected by the quality and quantity of available data used in the analysis.

Annex 18 shows for 19 sites the highest "10 minute" mean speeds and/or the highest gusts recorded on 16 October together with an indication of the approximate Return Periods where available. As can be seen in some areas the wind speeds were not exceptional, having Return Periods of 20 years or less. However in a few cases the Return Periods appear to be in excess of 200 years and even possibly as long as 500 years or more in one or two cases. Again it must be stressed that these are estimates and it does not mean that it has been 500 years since such an event occurred nor does it mean that it will be 500 years before such winds will occur again. Nevertheless it does suggest that in some area the wind speeds recorded on 16 October 1987 were exceptionally strong for those areas. Elsewhere in Britain, especially in western and northern coastal areas (and over mountains) such wind speeds occur much more frequently.

Annex 19 shows a copy of part of the anemogram (wind record) from the observing site at Shoeburyness (Essex) during the time 0001 GMT to 1100 GMT on 16 October. The upper part of the diagram shows the record of the direction from which the wind was blowing. The lower part records the speed of the wind.

Annex 20 shows the official Beaufort Scale of Wind Force used by the Met Office and other meteorological services throughout the world.

Note that the term "Hurricane" strictly applies only to the special structure of a revolving storm in tropical latitudes of the Atlantic and therefore is not used to describe weather systems near to the British Isles. However the term "Hurricane Force" is used to describe winds of sustained speeds of 64 knots or more. No instrumented records of sustained winds of this speed for this occasion had come to hand at the time that this summary was being prepared but many gusts exceeding 64 knots occurred on 16 October.

The term "Strong Gale" is used in the Beaufort Scale but in Shipping Forecasts and Gale Warnings issued by the British Met Office the term "Severe Gale" is used to denote mean speeds of Force 9.

Historical Note

Amongst previous exceptional gales which have caused extensive damage "within living memory" are:

Period	Area	Reason
5/8 January 1928	All UK	Gale with North Sea floods
14/15 January 1952	All UK	Severe gale; hurricane force winds over north of Scotland
30 January/1 February 1953	All UK	Severe NW gale; North Sea floods.
4 November 1957	All UK	Exceptional gale
27 January 1961	Scotland	Hurricane force winds over the north of Scotland
11/18 February 1962	All UK	Exceptional gales; Sheffield storm damage
14/15 January 1968	Scotland	Exceptional gales; much damage in the Glasgow area.

One of the most notable storms of history which was recorded in detail by the famous author Daniel Defoe was the "Great Storm" of November 1703 which caused extensive damage and large loss of life.

Accounts of these earlier storms may often be found in local libraries especially in the archives of old newspapers.

Summary

The winds over parts of the southeast of England on 16 October 1987 will undoubtedly be the subject of much more detailed analysis during the coming months especially as more information is retrieved from recording sites. This summary may well be amended by later data. Enquirers who need more detailed reports for insurance, commercial or scientific purposes, etc are advised to contact:

The Met Office
Advisory Services (Room 228)
London Road
Bracknell
Berkshire RG12 2SZ Telex 849801 WEABKA G
DocFax 0344-422907

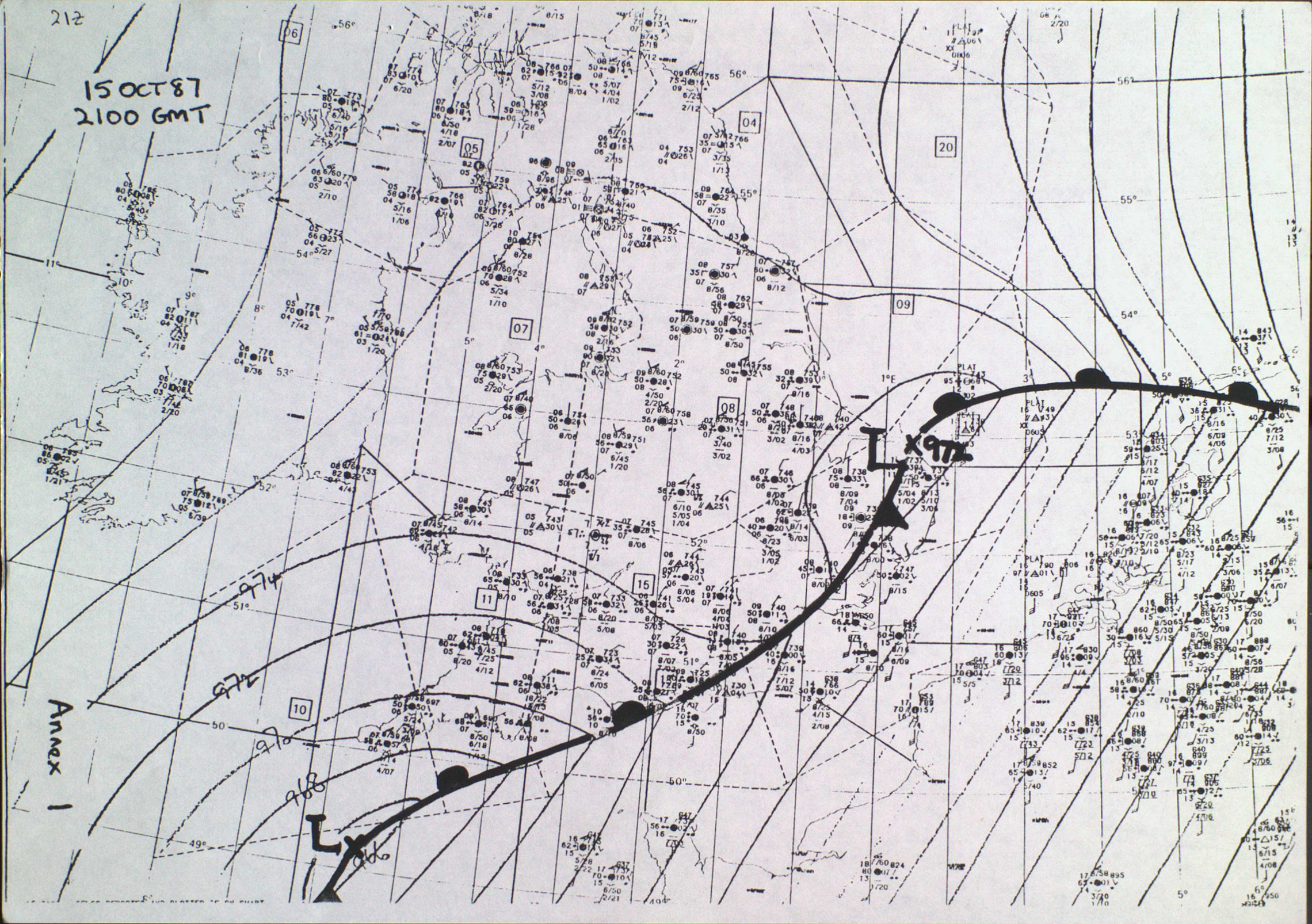
It is unlikely that detailed wind data from observing sites will be readily available to Advisory Services until mid-November following detailed quality control procedures. Potential enquirers are also reminded that the Met Office will make charges for responding to specific enquiries.

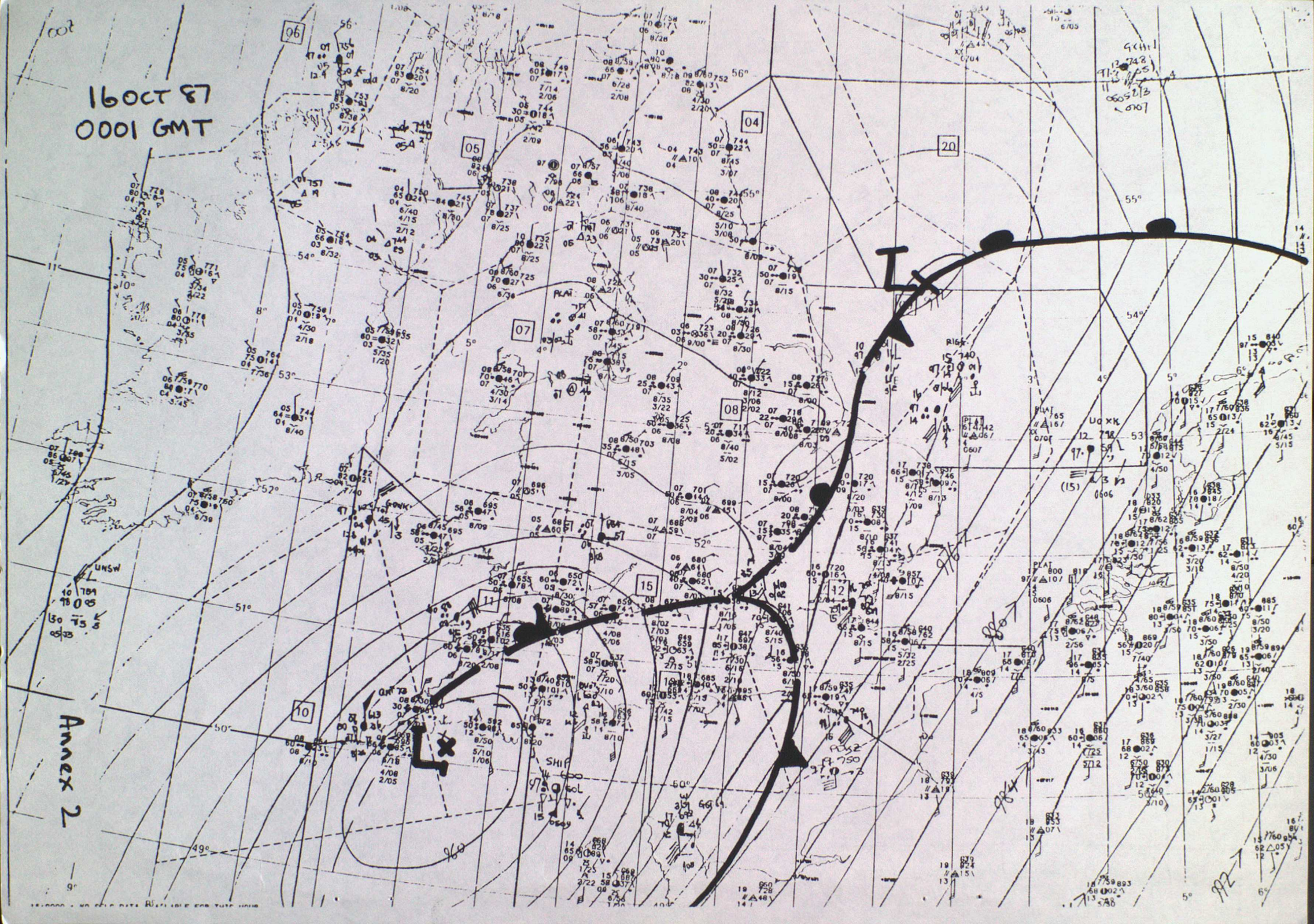
Note

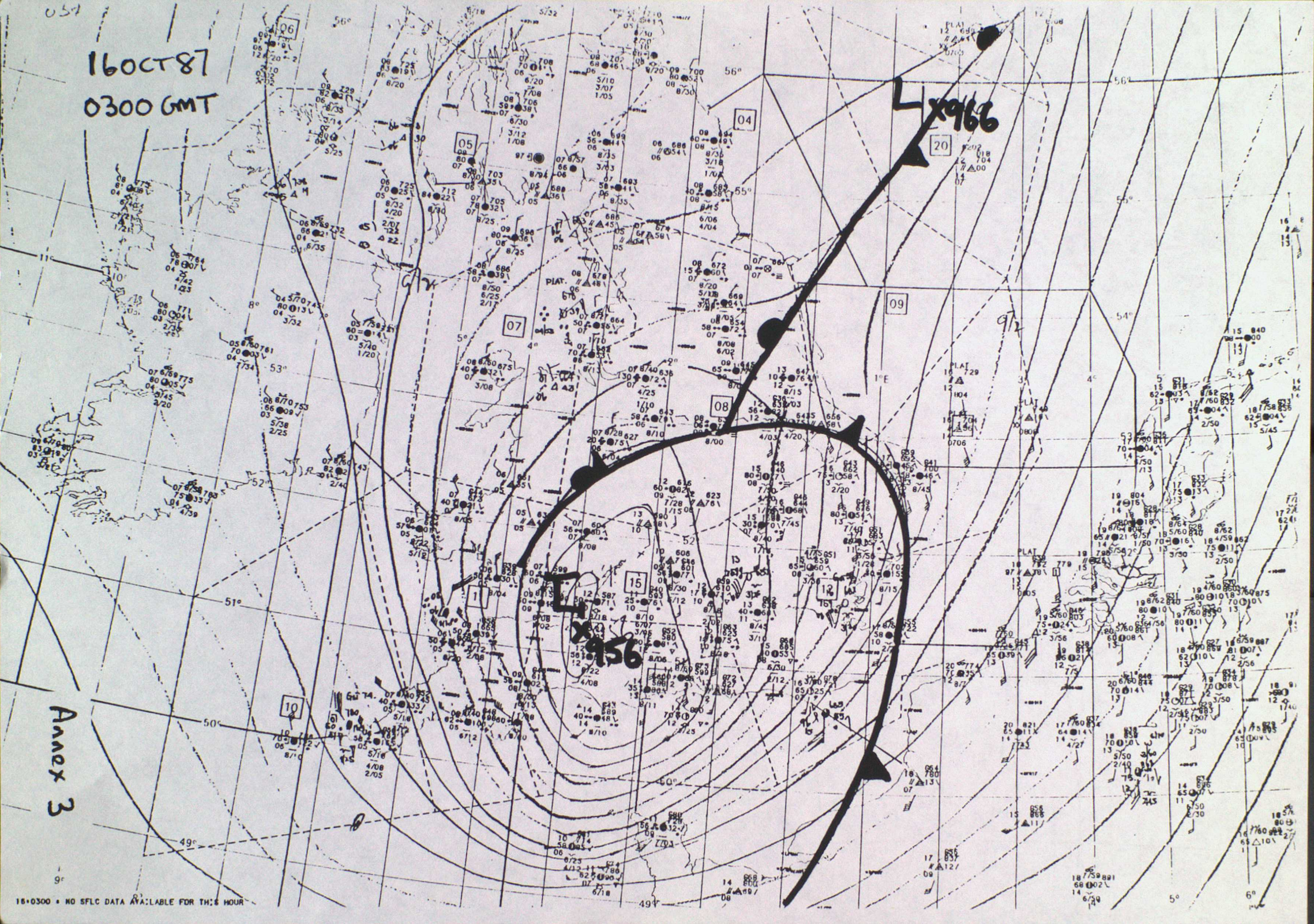
The contents of this summary have only been lightly bound to facilitate separation of the pages for ease of examination, display or copying especially for school projects and discussions etc.

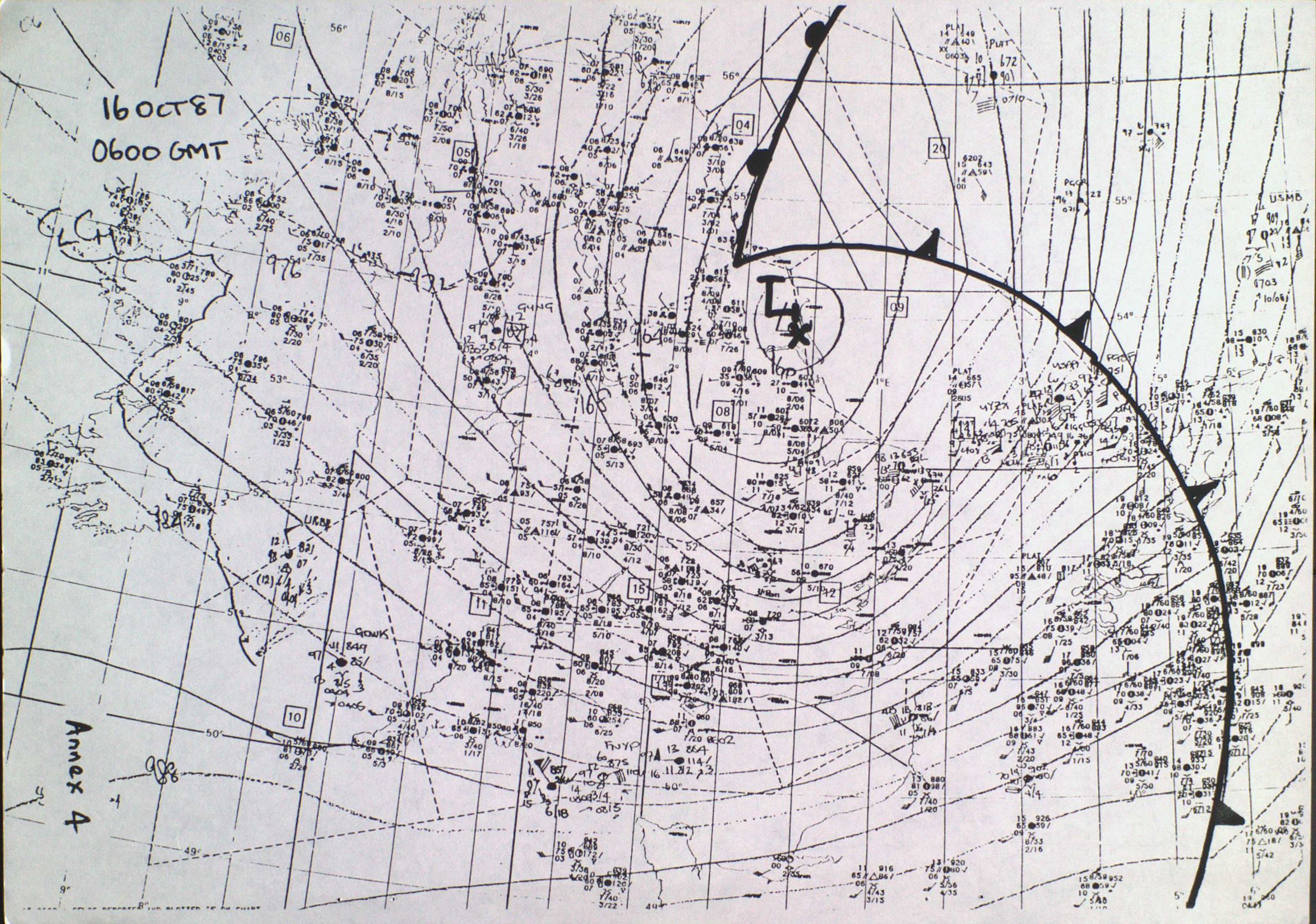
October 1987

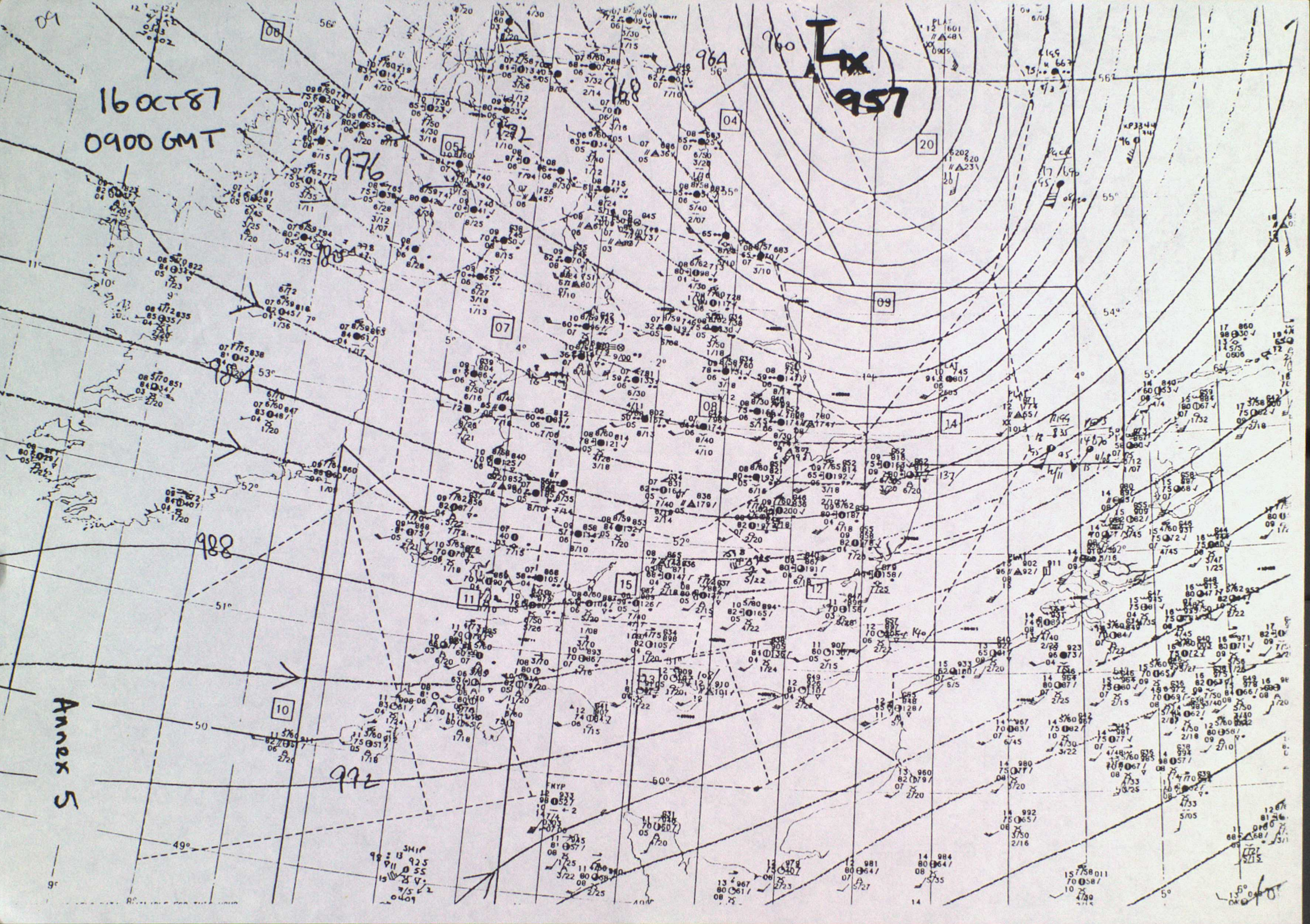
Advisory Services
Met Office, Bracknell

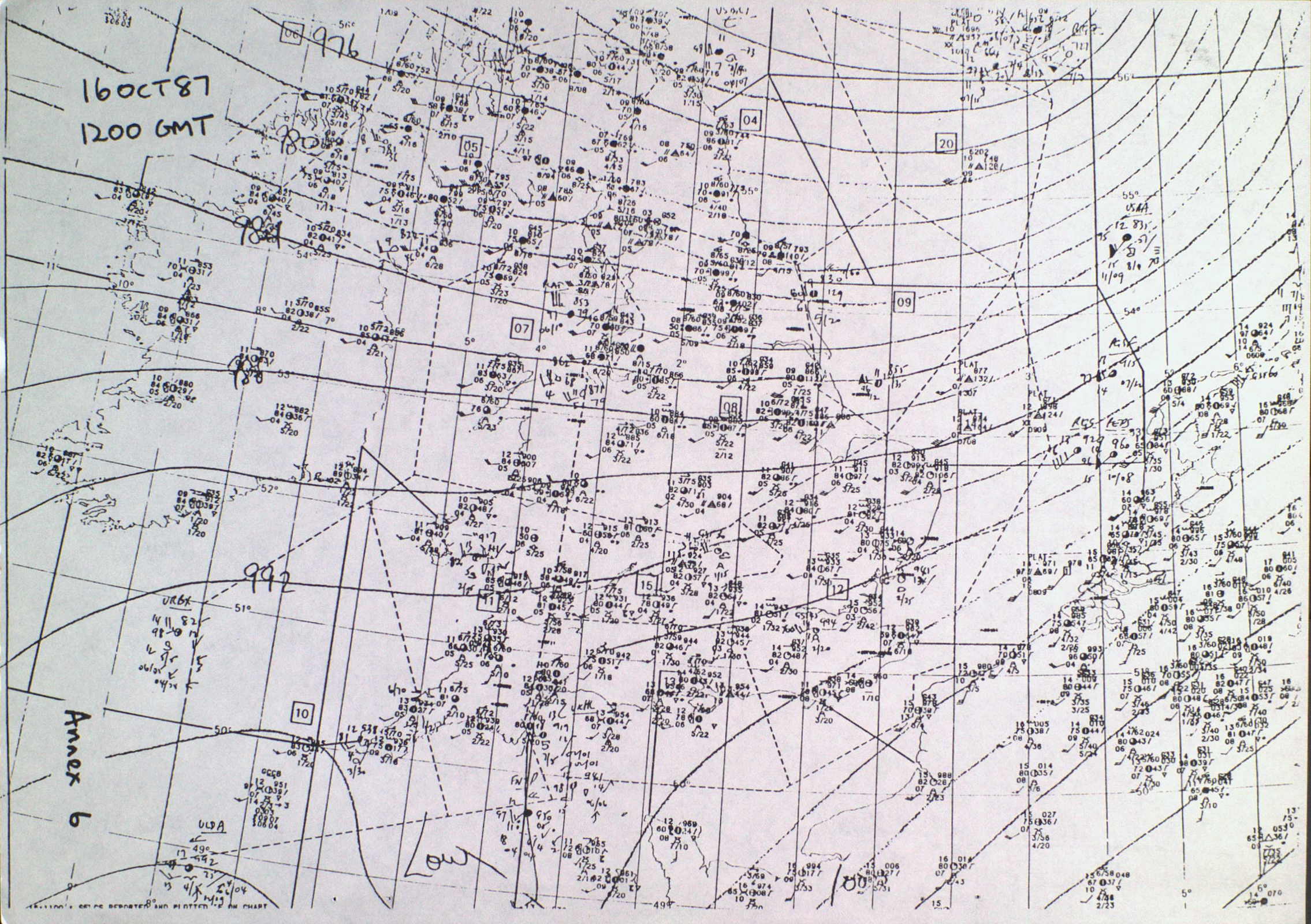

212
15 OCT 87
2100 GMT
Annex 1
974
972
968
966
L
X977


16 OCT 87
0001 GMT
Annex 2


16OCT87
0300 GMT
X966
X956
Annex 3
18+0300 = NO SFLC DATA AVAILABLE FOR THIS HOUR

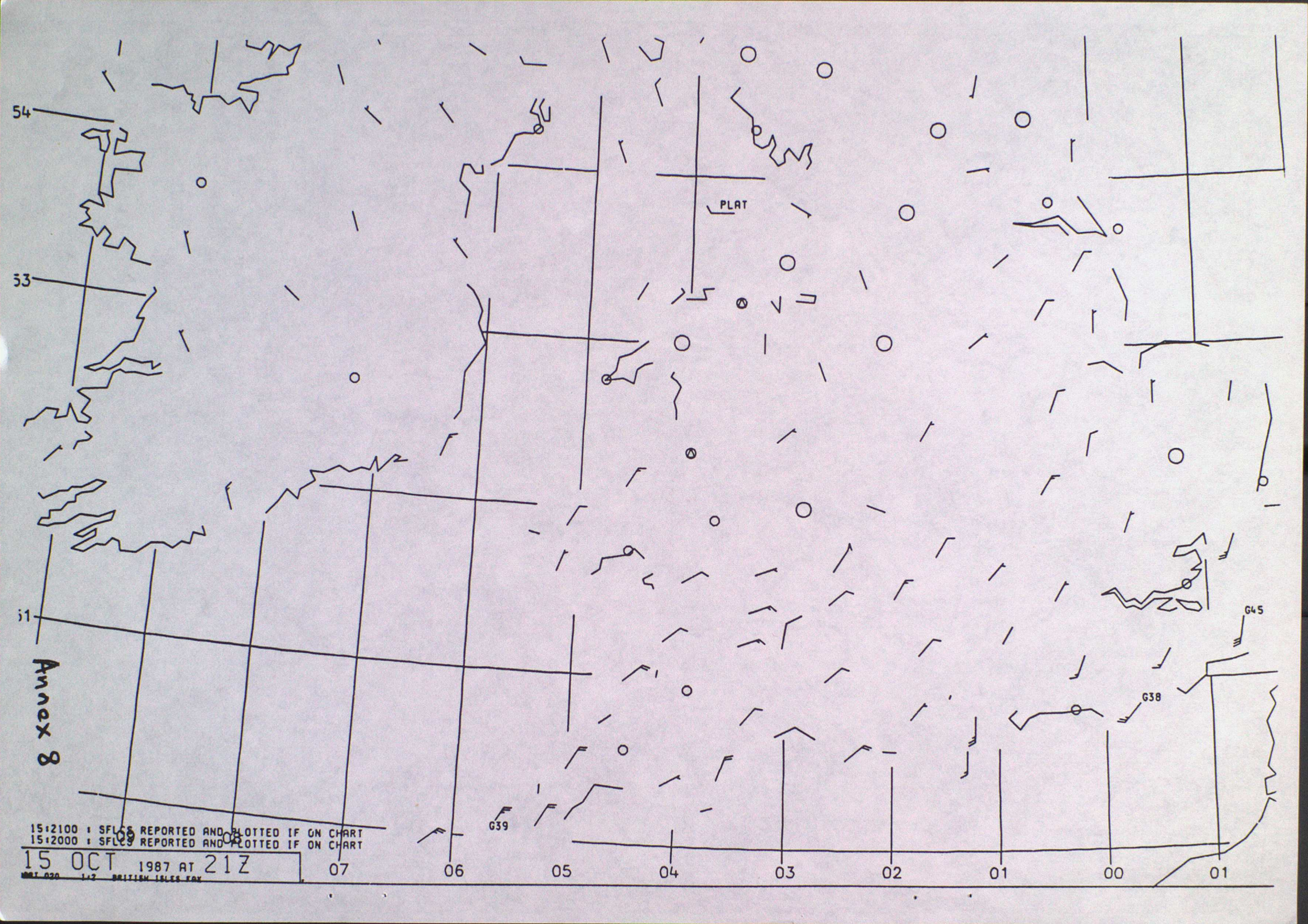

16 OCT 87
0600 GMT
Annex 4


16 OCT 87
0900 GMT
Annex 5

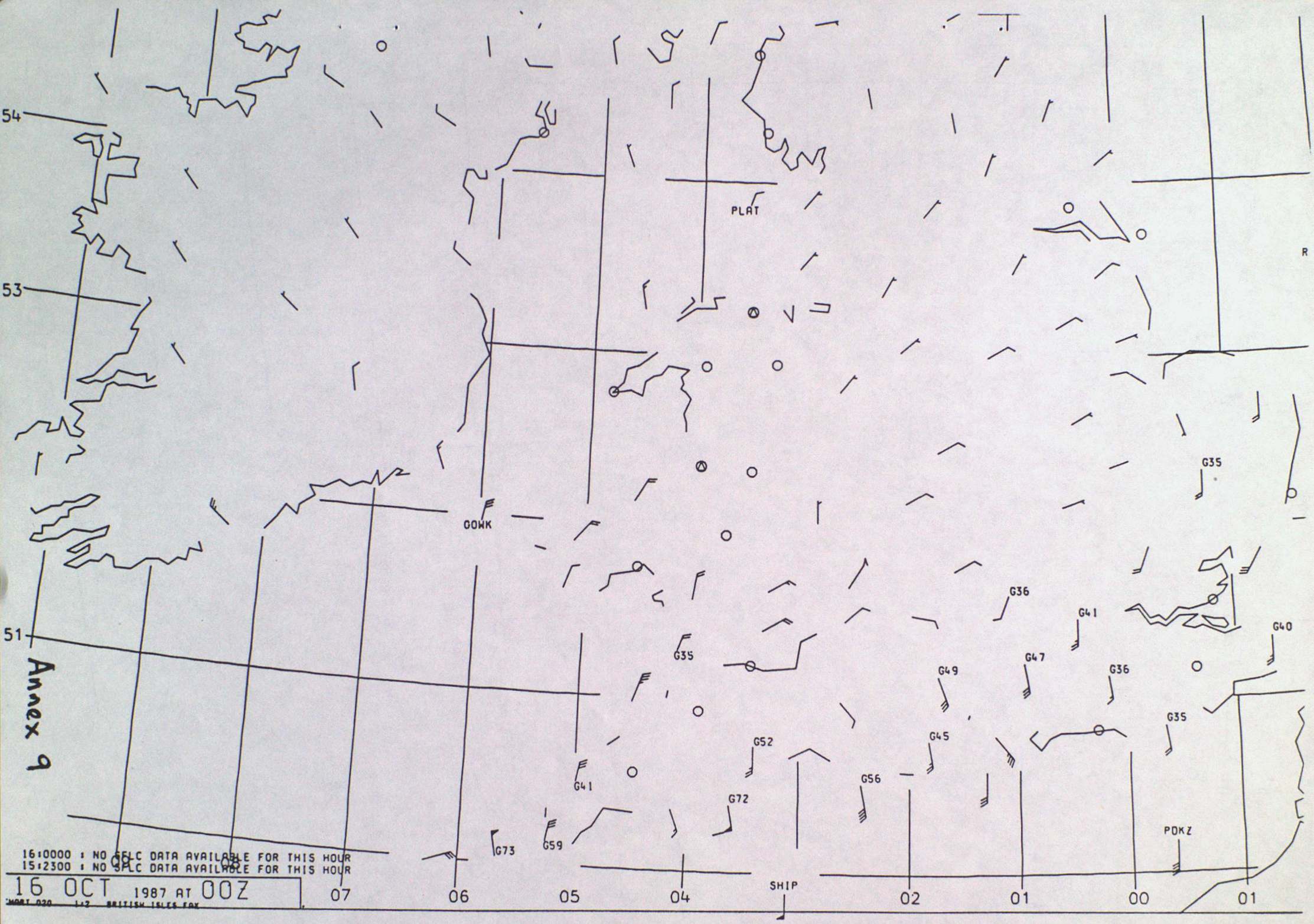

160CT87
1200 GMT
976
984
980
992
Low
Annex 6

Annex 7

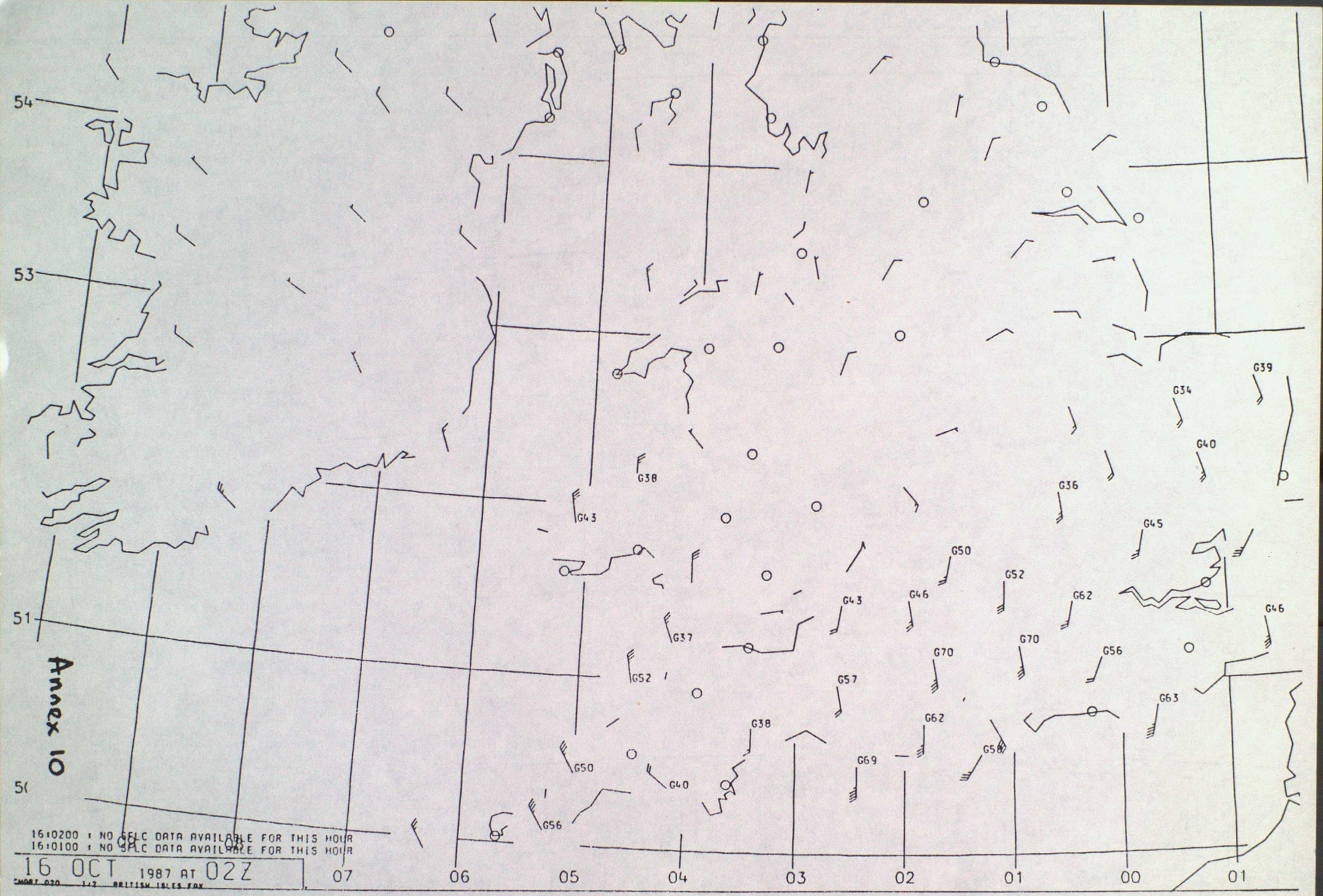
SATELLITE IMAGE FOR 0830 GMT ON 16 OCT 1987.

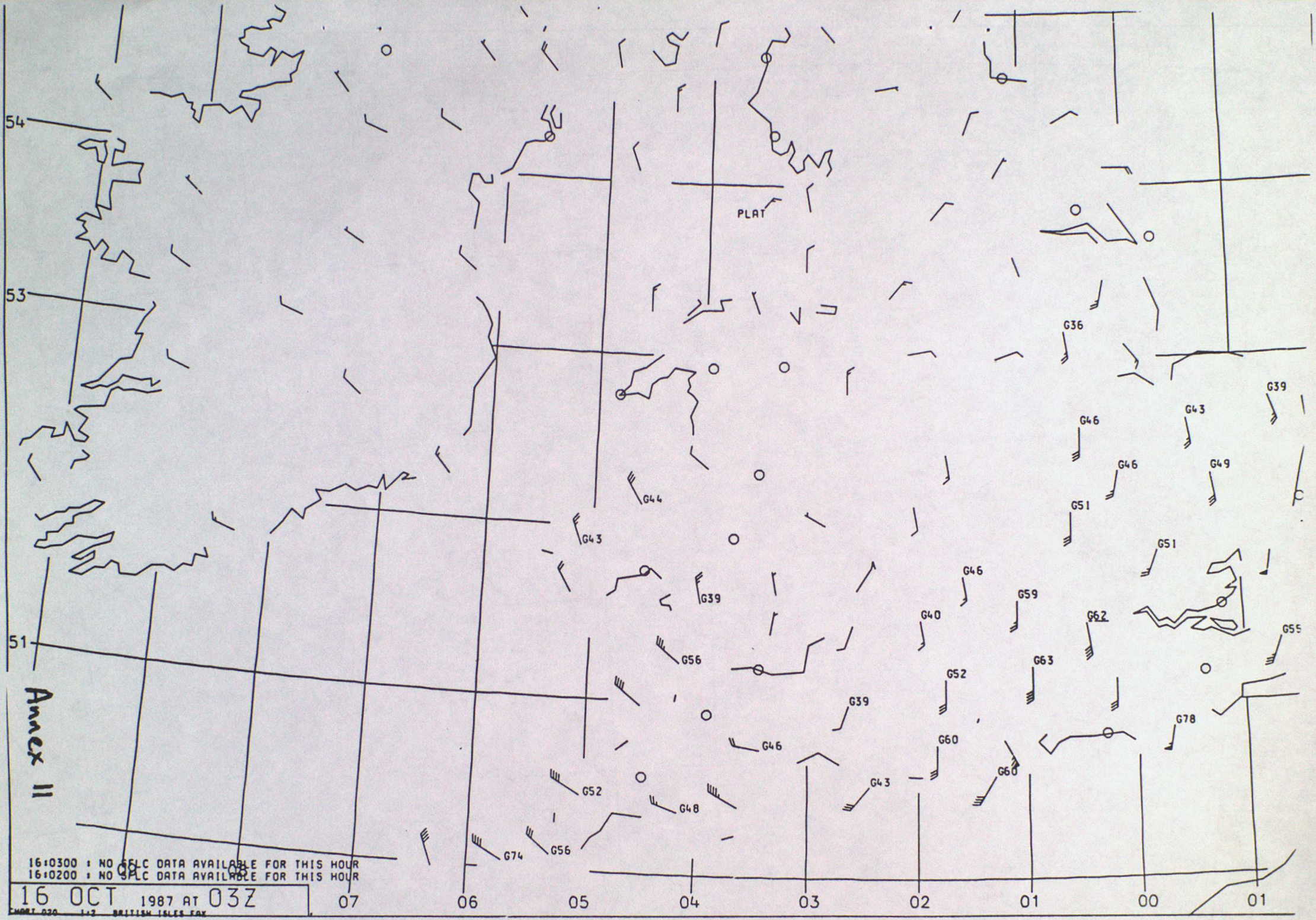

54
53
51
PLAT
G45
G38
G39
08
07
06
05
04
03
02
01
00
01
15:2100 : SFLCS REPORTED AND PLOTTED IF ON CHART
15:2000 : SFLCS REPORTED AND PLOTTED IF ON CHART
15 OCT 1987 AT 21Z
BRITISH ISLES FAX

Annex 8

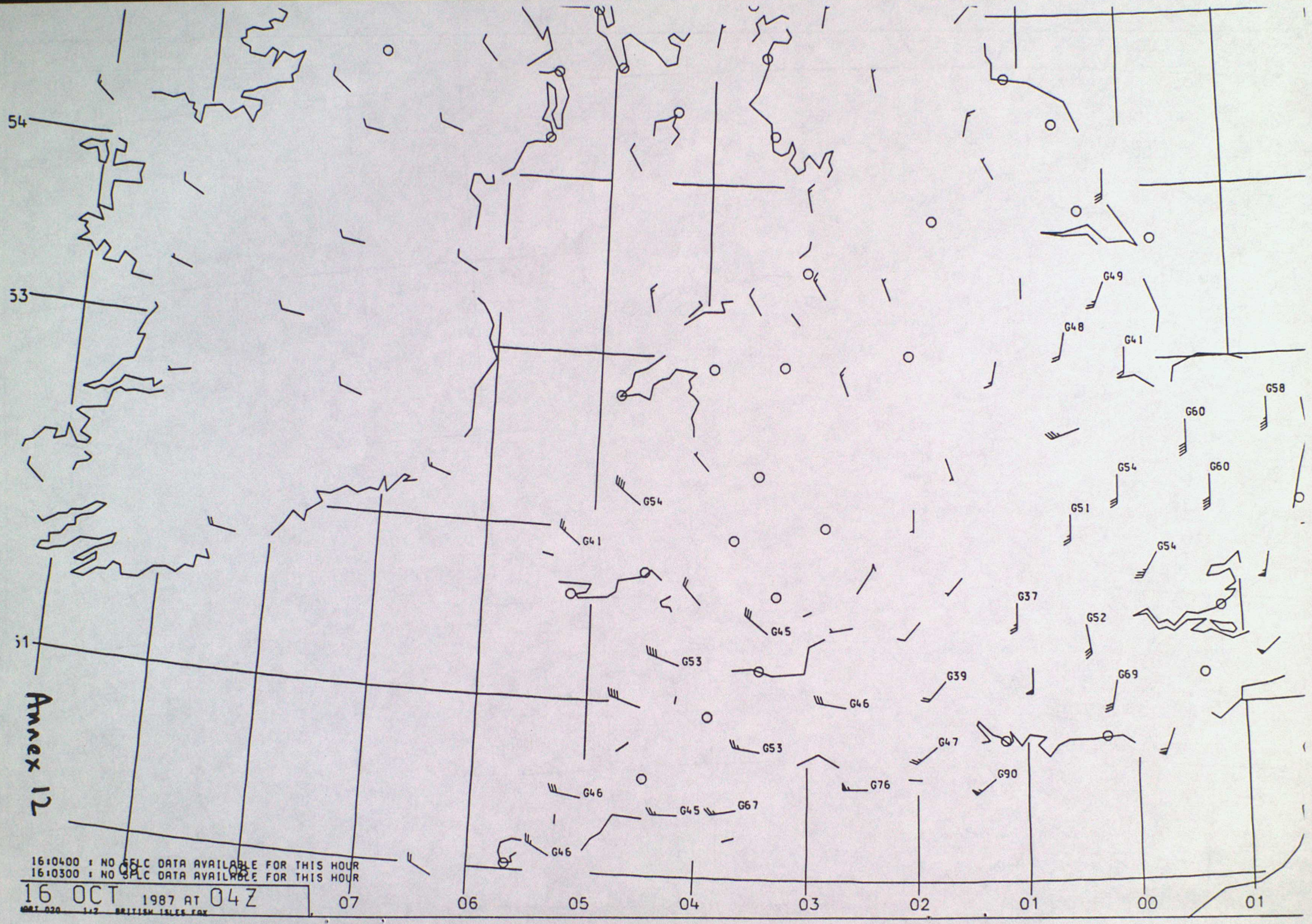

54
53
51
PLAT
GOWK
R
G35
G36
G41
G40
G47
G49
G36
G35
G35
G52
G45
G41
G56
G72
G73
G59
PDKZ
SHIP
08
07
06
05
04
02
01
00
01
16:0000 : NO SFLC DATA AVAILABLE FOR THIS HOUR
15:2300 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16 OCT 1987 AT 00Z
MORT 030 1+2 BRITISH ISLES FAX

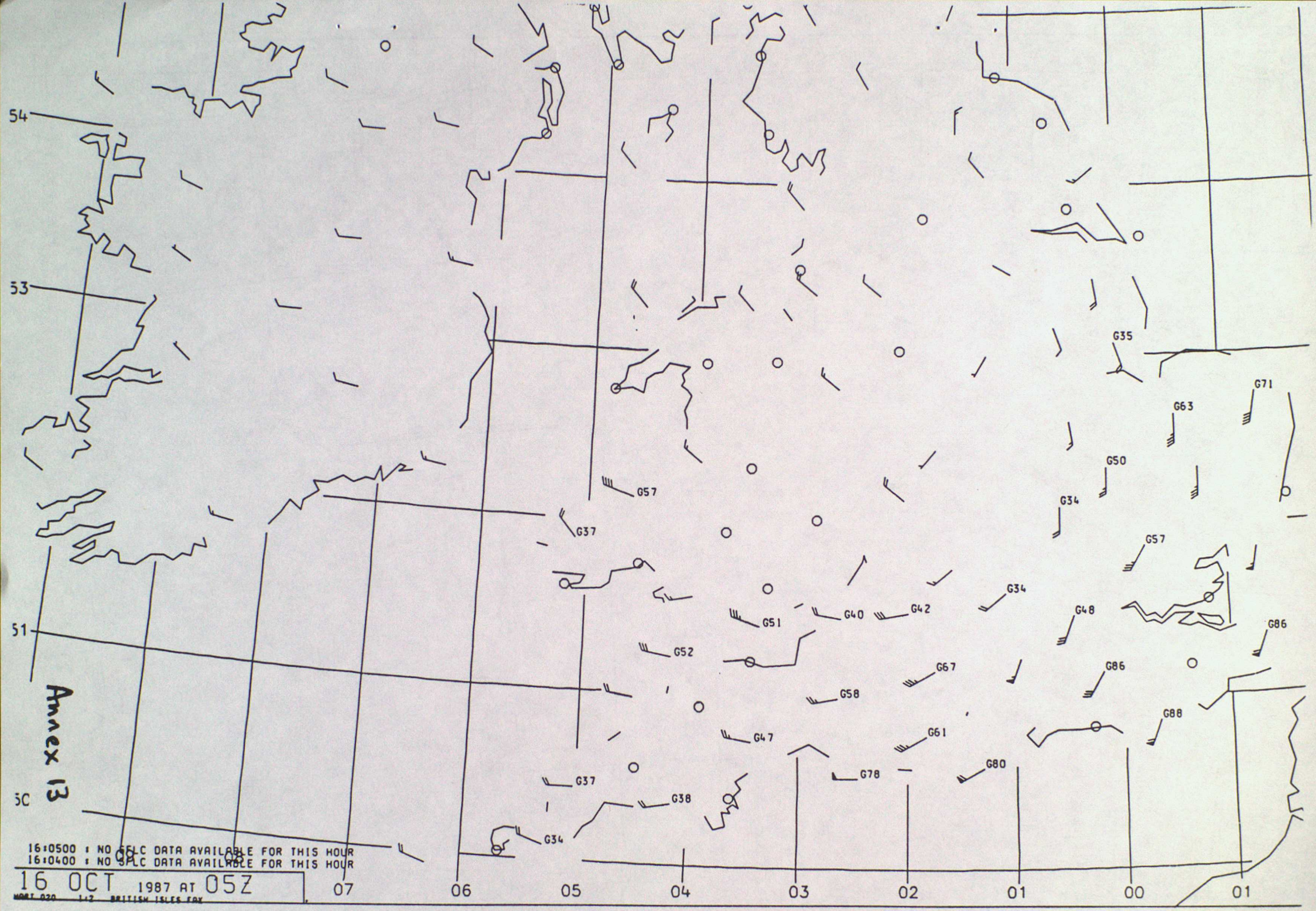
Annex 9


54
53
51
Annex 10
G39
G34
G40
G38
G36
G43
G45
G50
G52
G46
G62
G43
G37
G70
G56
G57
G63
G38
G62
G69
G50
G40
G56
16:0200 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16:0100 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16 OCT 1987 AT 02Z
08
07
06
05
04
03
02
01
00
01

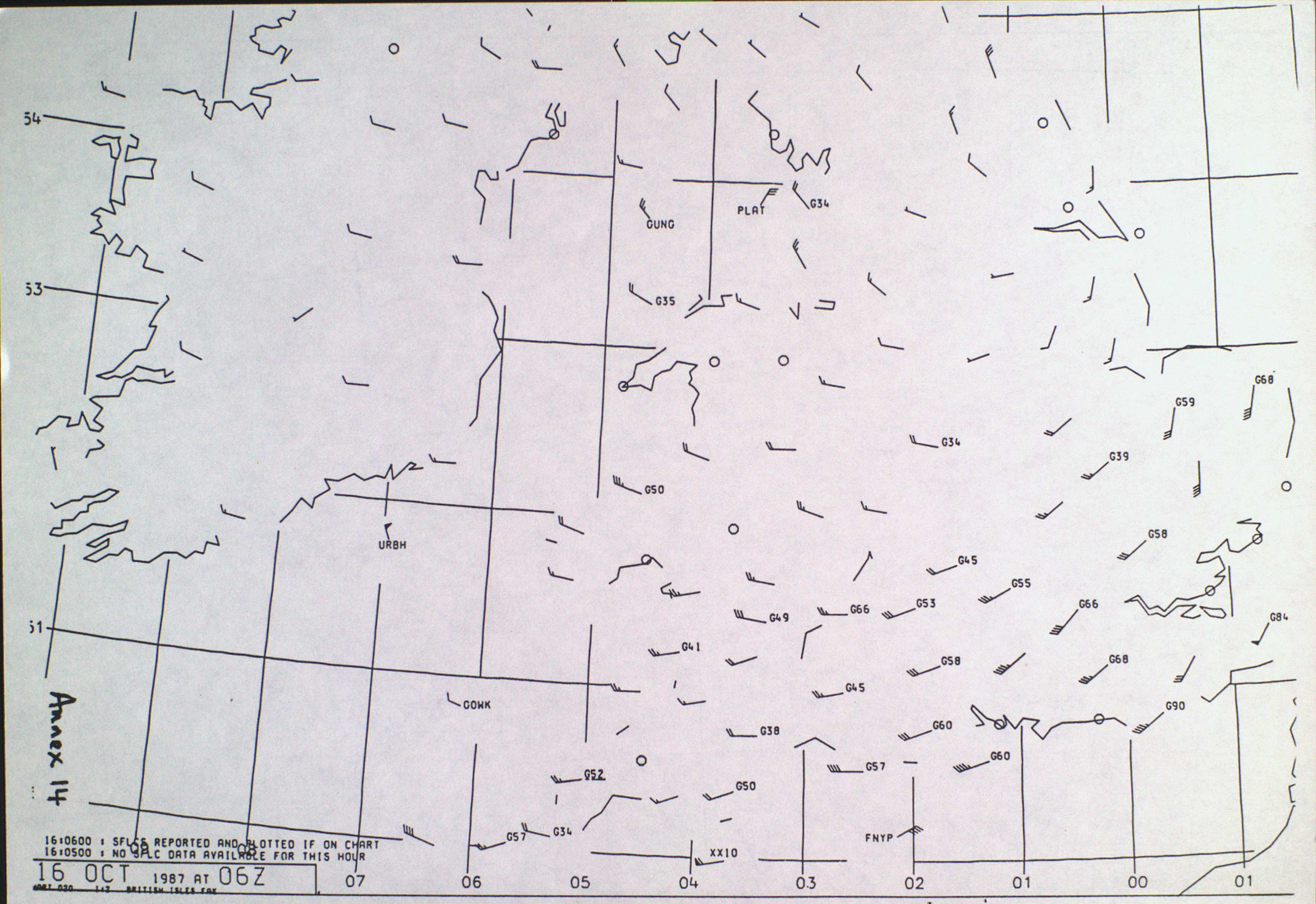

54
53
51
PLAT
G36
G39
G43
G46
G49
G44
G43
G51
G39
G46
G59
G40
G62
G55
G56
G63
G52
G39
G46
G60
G52
G48
G43
G60
G74
G56
G78
08
08
07
06
05
04
03
02
01
00
01
16:0300 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16:0200 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16 OCT 1987 AT 03Z
CHART 030 1:2 BRITISH ISLES FAX

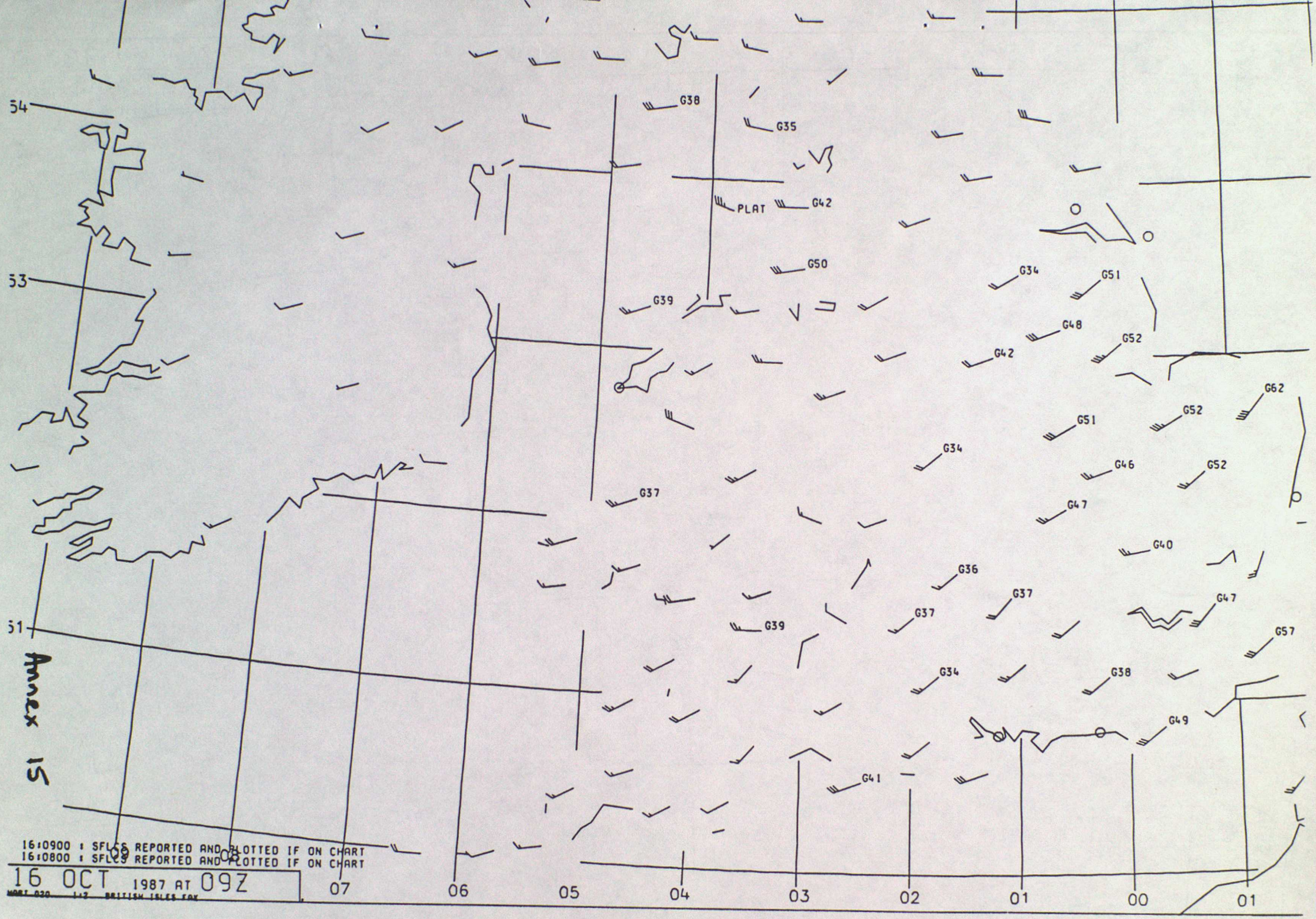
Annex II


54
53
51
G49
G48
G41
G58
G60
G54
G60
G51
G54
G37
G52
G69
G39
G47
G90
G76
G54
G41
G45
G53
G46
G53
G46
G45
G67
G46
07
06
05
04
03
02
01
00
01
16:0400 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16:0300 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16 OCT 1987 AT 04Z
Annex 12

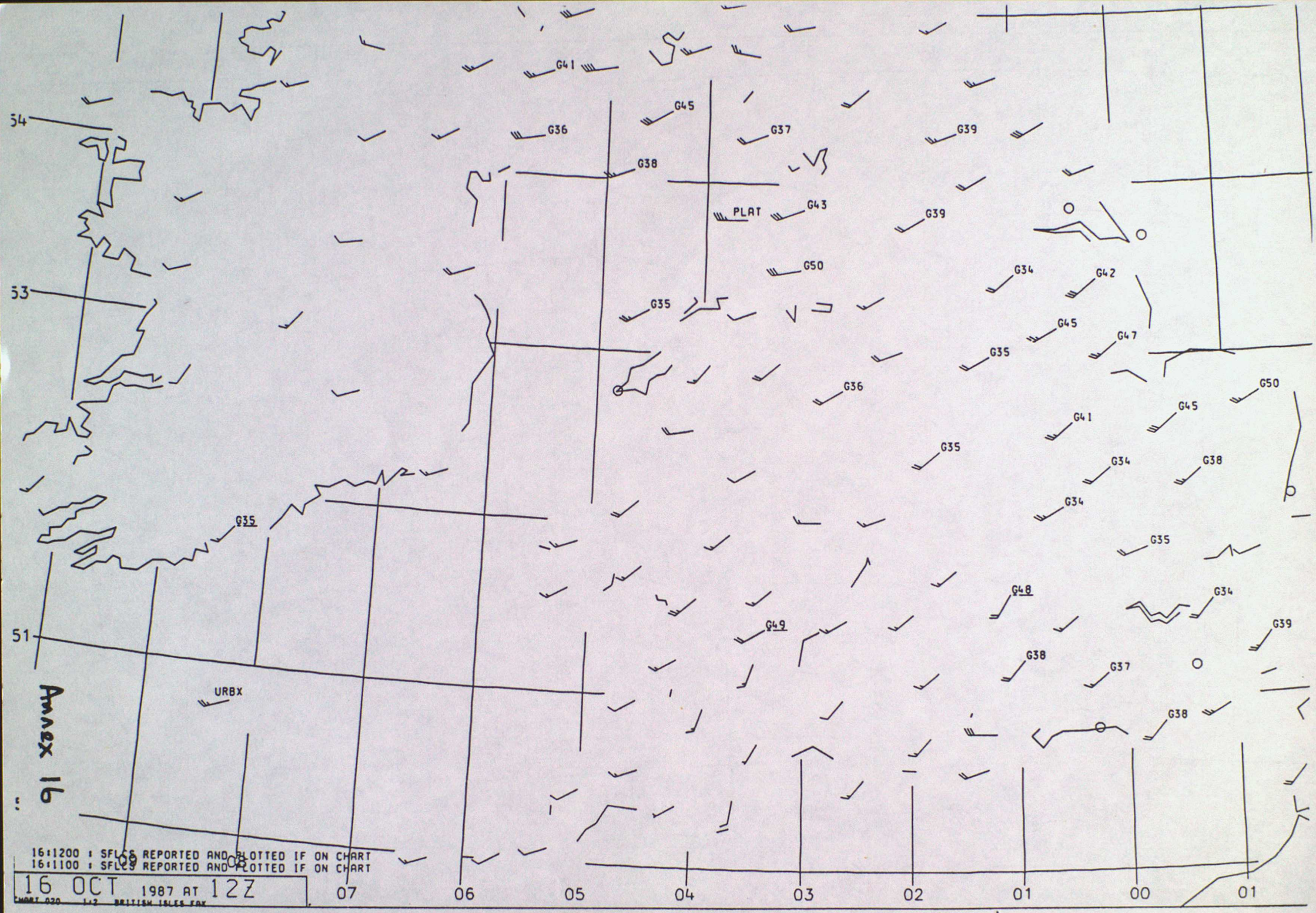

54
53
51
50
G35
G71
G63
G50
G34
G57
G37
G57
G34
G51
G40
G42
G34
G48
G86
G52
G67
G86
G58
G88
G47
G61
G37
G78
G80
G38
G34
08
07
06
05
04
03
02
01
00
01
16:0500 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16:0400 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16 OCT 1987 AT 05Z
WORT 020 1:2 BRITISH ISLES FAX

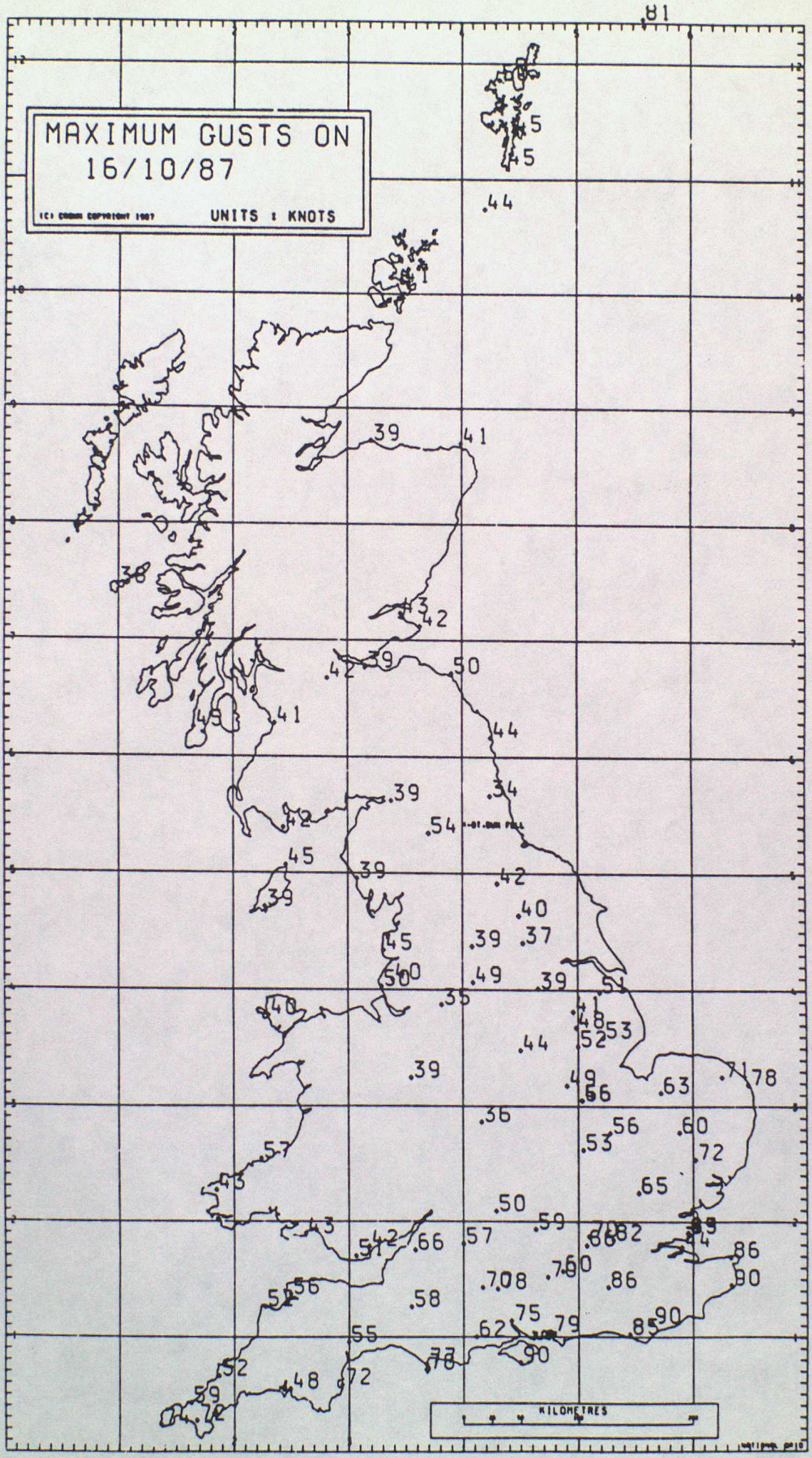
Annex 13


54
53
51
GUNG
PLAT
G34
G35
G50
URBH
G34
G68
G59
G39
G58
G45
G55
G66
G53
G49
G66
G84
G41
G58
G68
G45
GOWK
G90
G60
G38
G57
G60
G52
G50
G57
G34
XX10
FNYP
09
08
07
06
05
04
03
02
01
00
01
16:0600 : SFLOS REPORTED AND PLOTTED IF ON CHART
16:0500 : NO SFLC DATA AVAILABLE FOR THIS HOUR
16 OCT 1987 AT 06Z
Annex 14


54
53
51
G38
G35
PLAT
G42
G50
G39
G34
G51
G48
G52
G42
G62
G51
G52
G34
G46
G52
G37
G47
G40
G36
G37
G37
G47
G39
G57
G34
G38
G49
G41
09
08
07
06
05
04
03
02
01
00
01
16:0900 : SFLOS REPORTED AND PLOTTED IF ON CHART
16:0800 : SFLOS REPORTED AND PLOTTED IF ON CHART
16 OCT 1987 AT 09Z
WORT 020 1:2 BRITISH ISLES FAX

Annex 15


G41
G45
G36
G37
G39
G38
PLAT
G43
G39
G50
G34
G42
G35
G45
G47
G35
G36
G50
G41
G45
G35
G34
G38
G34
G35
G48
G34
G49
G39
G38
G37
G38
URBX
54
53
51
09
08
07
06
05
04
03
02
01
00
01
Annex 16
16:1200 : SFLCS REPORTED AND PLOTTED IF ON CHART
16:1100 : SFLCS REPORTED AND PLOTTED IF ON CHART
16 OCT 1987 AT 12Z
CHART 020 1:2 BRITISH ISLES FAX

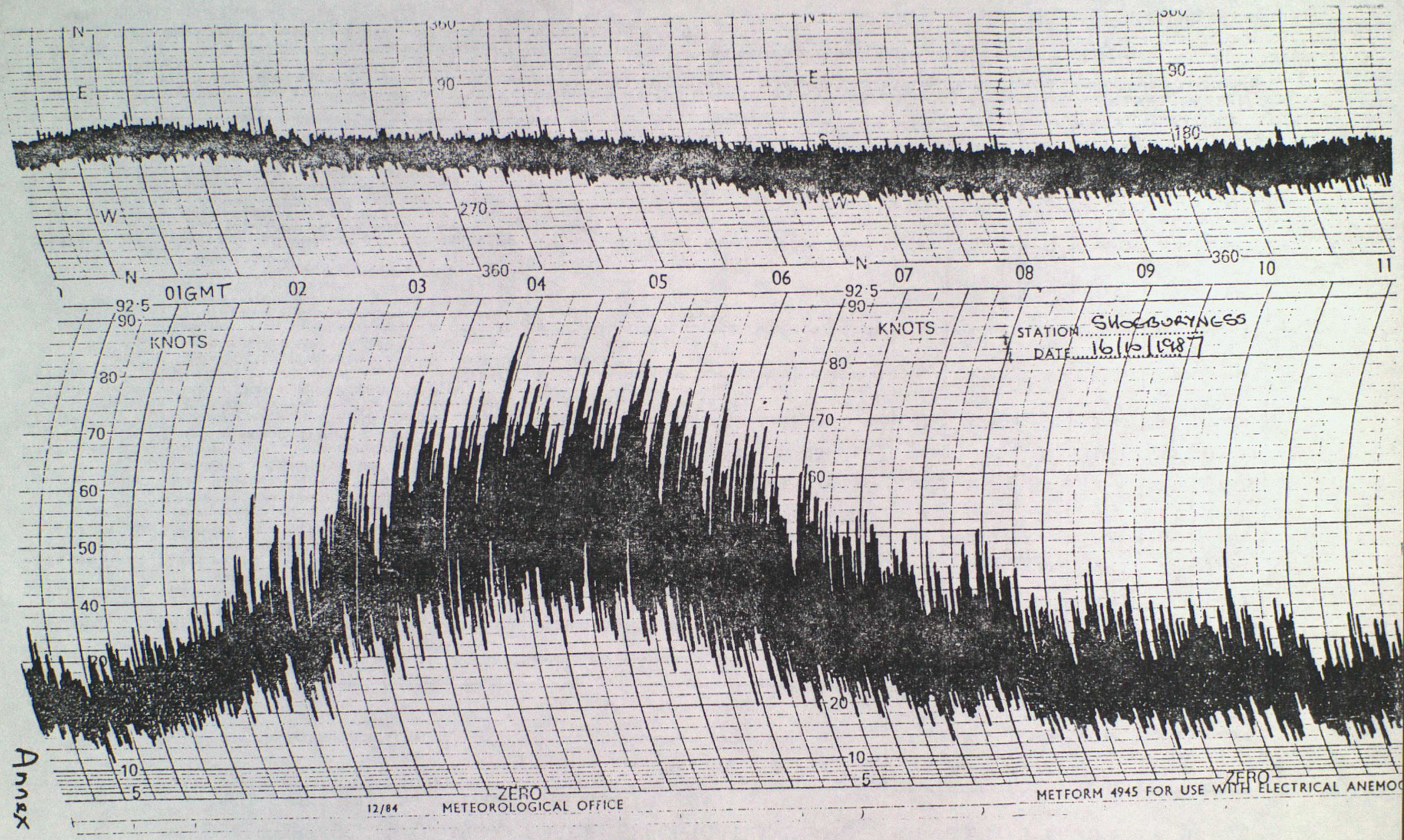


Annex 17

Station/Area	*Highest Reported 10 Minute Mean Speed during 00 to 13 GMT on 16 Oct 1987		*Approximate Return Period of Mean Speed	Highest Reported Gust Speed during 00 to 13 GMT on 16 Oct 1987		Approximate Return Period of Gust Speed
	Knots	Miles per Hour	in Years	Knots	Miles per Hour	in Years
Brize Norton (Oxon)	25	29	Less than 10	50	58	Less than 10
Oxford	35	40	Not available	62	71	Not available
Boscombe Down (Salisbury)	36	41	Less than 10	70	81	20
Hurn (Bournemouth Airport)	37	43	10	62	71	10
Southampton Weather Centre	48	55	Not available	75	86	Not available
St Catherines (Isle of Wight)	58	67	" "	90	104	" "
Jersey (Channel Isles)	55	63	10	85	98	15
Herstmonceux (Eastbourne)	60	69	Not available	90	104	Not available
Langdon Bay (Dover)	62	71	" "	90	104	" "
Manston (Margate)	61	70	Over 500	86	99	Over 200
East Malling (Kent)	37	43	Not available	74	85	Not available
Gravesend (Kent)	34	39	" "	74	85	" "
Gatwick (W. Sussex)	34	39	Less than 10	86	99	Over 300
London Airport	39	45	20	66	76	40
London Weather Centre	44	51	200	82	94	120
Stansted Airport	34	39	10	65	75	20
Shoeburyness (Essex)	55	63	Over 500	87	100	Over 500
Wattisham (Stowmarket)	48	55	45	72	83	10
Hemsby (Gt Yarmouth)	45	52	Not available	78	90	Not available

* Strictly the Mean Speed over 1 hour should be used to calculate the Return Period. However as such data are not yet available the '10 Minute' (synoptic) Mean Speed has been taken as the best available guide.

Annex 18



Annex 19

COPY OF THE ANEMOGRAM(WIND RECORD) FOR SHOEBURYNESS(ESSEX) ON 16 OCTOBER 1987.

Met. O. 917

Meteorological Office

BEAUFORT SCALE OF WIND FORCE: SPECIFICATIONS AND EQUIVALENT SPEEDS

(MEAN SPEEDS ONLY, NO EQUIVALENT FOR GUSTS)

Beaufort Number	Description of wind	Specifications for use at sea[1]	Specifications for use on land	Equivalent speed at 10 m above ground[2]						Beaufort Number
				Knots		Miles per hour		Metres per second		
				Mean	Limits[3]	Mean	Limits[3]	Mean	Limits[3]	
0	Calm	Sea like a mirror	Calm: smoke rises vertically	0	<1	0	<1	0·0	0·0–0·2	0
1	Light air	Ripples with the appearance of scales are formed but without foam crests.	Direction of wind shown by smoke drift but not by wind vanes.	2	1–3	2	1–3	0·8	0·3–1·5	1
2	Light breeze	Small wavelets, still short but more pronounced—Crests have a glassy appearance and do not break.	Wind felt on face; leaves rustle; ordinary vanes moved by wind.	5	4–6	5	4–7	2·4	1·6–3·3	2
3	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.	Leaves and small twigs in constant motion; wind extends light flag.	9	7–10	10	8–12	4·3	3·4–5·4	3
4	Moderate breeze	Small waves, becoming longer; fairly frequent white horses.	Raises dust and loose paper; small branches are moved.	13	11–16	15	13–18	6·7	5·5–7·9	4
5	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. (Chance of some spray.)	Small trees in leaf begin to sway; crested wavelets form on inland waters.	19	17–21	21	19–24	9·3	8·0–10·7	5
6	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere. (Probably some spray).	Large branches in motion; umbrellas used with difficulty.	24	22–27	28	25–31	12·3	10·8–13·8	6
7	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	Whole trees in motion; inconvenience felt when walking against wind.	30	28–33	35	32–38	15·5	13·9–17·1	7
8	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.	Breaks twigs off trees; generally impedes progress.	37	34–40	42	39–46	18·9	17·2–20·7	8
* 9	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.	Slight structural damage occurs (chimney-pots and slates removed).	44	41–47	50	47–54	22·6	20·8–24·4	9
10	Storm	Very high waves with long overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	52	48–55	59	55–63	26·4	24·5–28·4	10
11	Violent storm	Exceptionally high waves. (Small and medium-sized ships might be for a time lost to view behind the waves.) The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.	Very rarely experienced; accompanied by widespread damage.	60	56–63	68	64–72	30·5	28·5–32·6	11
* 12	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.	... ...	—	≥64	—	≥ 73	—	≥ 32·7	12

1 Where there is no swell and the fetch is not limited by proximity to land, the specifications describe the fully developed sea generated by steady winds of the forces indicated. There is always a lag in the response of the sea to wind speed changes, heavy rain appears to flatten the sea, and in shallow waters both water depth and tidal streams affect the sea state. Account should be taken of all these factors when estimating the wind force from the appearance of the sea.

2 Approximate corrections for wind speeds at other heights are: 2 m *subtract* 30 per cent; 3 m *subtract* 20 per cent; 6 m *subtract* 10 per cent; 15 m *add* 10 per cent; 30 m *add* 25 per cent.

3 For finding the Beaufort number corresponding to a recorded mean, or range of mean speeds, and *vice versa*.

*PLEASE REFER TO NOTES IN THE TEXT.

Annex 20

Dd 326062 1500 4/78 Ed (15163)

A PRELIMINARY SUMMARY OF INFORMATION ON THE EXCEPTIONALLY STRONG WINDS OF 16 OCTOBER 1987 OVER THE SOUTH OF ENGLAND

Part 2: The Forecasting

A. The Sequence of Weather Events

1. Part 1 of the summary contains a description of the conditions that obtained over England during the night of 15/16 October based upon information so far to hand. This paper provides a preliminary survey of the forecasting for the event starting with the first mention of it in the public forecasts on Sunday 11 October.

2. Detailed synoptic charts of the weather situation over Britain from 2100 on 15 October are included in Part 1. Figures 1 and 2 of this paper are copies of forecasters' working charts covering a wider geographical area for 1200 GMT and 1800 GMT on 15th respectively. It should be kept in mind that BST was in use at the time and public clocks were therefore one hour in advance of GMT.

3. From Figure 1 it is seen that pressure was already low on 15 October over the British Isles and a large area of the eastern North Atlantic. The secondary depression that was to bring the storm was present as a complex area of low pressure extending over several hundred miles to the west of Spain. By 1200 GMT (Figure 1) the position of the surface trough west of Biscay was reasonably well located by the available ships reports but they did not allow the position and depth of the depression to be fixed very exactly. The pressure gradient was weak on the northwestern flank of the depression but the strong pressure gradient analysed to the south of it was consistent with winds of 45-55 kt in that sector. The position of the centre at 1800 GMT (Figure 2) was not well fixed but pressure at its centre appears to have fallen by only a few millibars between 1200 GMT and 1800 GMT. Although the depression moved quickly over the British Isles it seems at no stage to have been a rapid deepener. There was evidence at 1800 GMT of increasing winds, however, with reports of 40 kts in the southwest sector behind the cold front and up to 60 kt in the southeast gradient. It should be borne in mind that the 1800 GMT senior forecasters working chart as shown in Figures 2 becomes available for analysis between 2000 GMT and 2045 GMT (i.e. between 2100-2145 BST. The interval between observation time and analysis time occurs because the observations must be collected from all over Europe, and the North Atlantic area after they are made and plotted on the charts, the time being minimised by automation to the extent possible of the communication, decoding and plotting functions.

4. From Annex 1 to part 1 of this report it can be seen that by 2100 GMT the low was estimated to be entering the English Channel. There are no reports to fix the centre, ships of the voluntary observing fleet reporting six-hourly. It was thought to be no more than 965 mbs or so at the centre, consistent with the previous slow deepening. By 0001 GMT (Annex 2 of part 1) on the 16th the depression was analysed to be located in sea area Plymouth with central pressure about 959 mbs. Observations at this time indicated that winds had reached 45-55 kts in the western and southern sectors of the depression and there were reports of winds of 45-55 kt also along the English Channel to the east of the centre. Winds reached gale force along parts of the south coast at about this time. Part 1 of this summary shows the evolution of the wind and pressure fields in detail after that.

5. After the depression crossed the English coast, around 0100, winds near the centre were not strong, neither were those to the north of it, and even for some distance, on the southern side. The very strong winds lay in a belt through the eastern, southern and western quarters, the highest and most damaging gust being experienced around 0500Z some 200 miles or so to the southeast of the centre. Some of those most affected by the gales noticed that their barometers had fallen off the scale on the stormy side and wondered why the forecasters had not noticed it too. But the crux of the forecasting problem was not simply that of forecasting that pressure would be very low, it was already low over the British Isles on 15th and expected to go lower over southern England. In many areas of the north and midlands where barometers were low there were no gales at all. The problem was not only that of forecasting the depression track, although that was relevant. The crux of the problem was the prediction of the location and severity of the belt of very strong winds, and that problem had exercised the forecasters minds from Sunday, 11 October onwards.

B. <u>The Guidance from the Models used in Numerical Weather Prediction</u>

6. To put the use of numerical weather prediction (NWP) models in perspective it should be recalled that thirty years ago, before they were brought into operational use, the public weather forecasts were given 'for the next 24 hours'. Beyond that, there was a further outlook, often of one or two words, perhaps 'continuing unsettled' or 'becoming drier'. Human skill, (for most of the work of preparing the forecast charts was done in the forecasters' heads), did not allow anything more. The development of ever-more complicated formulating of the physics of the atmosphere in the form of complex equations that can be handled only by the most powerful computers has enabled forecasts to be made with

tolerable degree of accuracy for up to a week ahead. It has also enabled forecasts to be made with much greater precision - better geographical definition and much less hedging of bets - within the first 24 hours. The public perception of forecasting and the level of public expectation have risen accordingly. The performance of the operational forecasters' models has been improved to the extent that a forecaster needs to have strong evidence that everything is not going to the model's plan before he will issue a forecast that differs very substantially from the numerical solution, especially in respect of the forecasting of the pressure and wind fields.

7. For periods beyond 24 hours, the forecaster is helped in his judgement of the likely reliability, for any occasion, of the numerical model forecasts by having available the results of global (or coarse-mesh) NWP models that emanate from more than one centre. In particular, in the Central Forecasting Office at Bracknell, he can compare the prediction in chart form out to seven days of the global model run at the European Centre for Medium Range Forecasting (ECMWF), an international centre which the Meteorological Office contributes to financially and scientifically, with those of an equally advanced but differently formulated model run on the COSMOS computer complex at Bracknell itself. On many occasions the two sets of model output tell similar stories, although there are nearly always significant differences in detail. However not infrequently the predicted evolution of the pressure systems differ, and the Senior and Medium Range Forecasters in the Central Forecasting Office (CFO) at Bracknell must make up their minds as to which solution is the most likely, on all considerations, in framing the guidance that he will give to forecasters at the regional Weather Centres throughout the country. For all practical purposes the overall success of the two is comparable. Both are run on what, over the past five years, have been state-of-the-art supercomputers. The ECMWF CRAY X-MP is faster than the Bracknell CYBER 205 for numerical weather prediction purposes by a small factor, but there is compensation for this in the more sophisicated programming and computing techniques in use at Bracknell. Mention is made of this here, and, in what follows, the output of the Bracknell and ECMWF models are described separately, largely to put the record straight on matters that have been misinterpreted in reports in the press and on radio and television.

8. Figures 3 to 8 show how the Bracknell model handled the development of the depression in the course of the week. The continuous lines are the forecast isobars for mean sea level. The pecked lines are isopleths of wet-bulb potential temperature for 850 mb, a level about 5000 ft above sea level. Figures 3 to 5 are forecasts made successively on Sunday 11, Monday 12, and Tuesday 13, based on mid-day data, all for mid-day on Thursday 15 when the low was poised west

of Spain to move northeastwards towards England. In each case a deep low was forecast to have reached the Southwest Approaches. It was moved there too soon but the accuracy is fairly typical of that achieved by the better global NWP models. The forecast made on Tuesday 13 (Figure 5) was particularly good as regards the general shape of the system - note the very strong gradient to the southwest of the centre, though largely over Biscay and Northern France. This forecast run was accurate in taking the centre subsequently, but at too early a time, into the North Sea (Figure 6). The model forecast made on Wednesday 14 based on mid-day data was even better (Figure 7) as far as the location and general shape of the low at 1200 GMT on Thursday was concerned. However, while the low itself was subsequently taken, in this model run, across southern England, winds there were kept light, the belt of very strong winds being kept well to the south of it over France, the Low Countries and Scandinavia, rather as shown in Figure 7 for the previous mid-day. The above forecasts were all based on mid-day data, but global model runs at Bracknell are made twice daily and, closer to the time, it is relevant to refer to the run made early (at 0320 GMT) on Thursday 15 October. This gave an excellent forecast for 0001 on 16 October as Figure 8 shows. It implied that stronger winds would occur closer to the centre of the depression than the previous model run (Figure 7) whilst retaining strong pressure gradients over northern France and the low countries.

9. Figures 9-12 show the ECMWF model forecasts for 1200 GMT on Thursday 15 made successively, in model runs from Sunday 11 to Wednesday 14 based on 1200 GMT data. The ECMWF model forecasts were not, during this period, better than those of the Bracknell model, the run on Tuesday 13 (Figure 11) for example, taking the low northwards to the west of Britain and the run on Wednesday 14 running a wave depression along the English Channel with strong winds on the 16 forecast well to the south over central France. The forecast shown in Figure 10, based upon 1200 GMT data for Monday 12 October looks much better but the low is shown as reaching southwest England 24 hours earlier than was the case.

10. It is necessary now to turn to the output of the Bracknell Fine-Mesh model. This has a resolution that is twice that of the global model and treats the weather situation in greater detail. Its level of accuracy is generally expected to be higher than that of the coarser-mesh global models. It enjoys a high reputation in Europe, including in Scandinavian countries and in Iceland, where it is particularly favoured for its ability to handle the evolution of the deep depressions that frequently come Iceland's way. British forecasters rely substantially on it in their rainfall forecasting. Figure 13 shows, amongst other things, the pressure distribution forecast at 6-hourly intervals from 0600 GMT on Thursday 15, based upon data for

0001 GMT on 15th. The depression appearing to the west of Spain at 0600 GMT is taken eastwards along the Channel and across the extreme southeast of England and the very strong southwesterly winds are forecast to be over northern France but not over southern England.

11. Why the global model output was so much better than that of the fine mesh model on Thursday 15th is the subject of current investigation at Bracknell and the results of these will be included in the full report of the Director-General's investigation, but it was the fine mesh solution that was judged to be in keeping with the trend with time in the model output (including that from ECMWF) to run the critical depression eastwards close to the English Channel or across southwestern England, with the belt of very strong southwesterly winds, which then had at all times been expected, being confined to France, the low countries and at worst, the English Channel. The run of the Bracknell fine-mesh forecast based upon data 1200 GMT for 15 October, which became available to the forecaster at about 1500 GMT on 15th, improved upon the earlier run to the extent that the centre of the low was forecast to move over the Midlands and into the North Sea but it was brought up over the country too quickly, moving into the North Sea soon after 0001 GMT on Friday, 16th. The strongest winds were again expected over Northern France, the English Channel and over the North Sea, but winds of 30-35 kt were generated over eastern England for a short period around midnight.

C. Short period forecast guidance

12. The Senior Forecaster in CFO transmits guidance to outstation forecasters through the forecast charts and in writing through the medium of 'synoptic reviews'. The morning synoptic review (15th 1010 GMT) included a land gale warning for exposed parts of southern and eastern England. At about this time warnings of severe gale force 9 southwesterly winds were issued by CFO for the sea areas embracing the English Channel and southern North Sea. Storm force 10 was also predicted for Biscay. The mid-afternoon Synoptic Reviews (1535 GMT) included a land gale warning stating that the gales would become confined to Scotland tommorrow. This was amended at 1640 GMT in part 2 of the Synoptic Review to mention winds of severe gale force at times in exposed coastal districts during the evening especially in the southerly flow on the eastern flank of the depression in the extreme southeast part of the country. Part 3 (15th 1750 GMT) mentioned the possibility of rapid deepening of this surface circulation in the next few hours albeit with no specific mention of wind strengths. The 2225 GMT Synoptic Review spoke of gales or severe gales over exposed areas of the southeast with part 2, issued at 2235 GMT, saying that southerly gales over land could extend further westwards across southern Britain than thought

earlier. The 0345 GMT Synoptic Review predicted that severe land gales would extend across much of England and Wales during the first part of the day.

13. The shipping forecast issued at 1750 on Thursday 15th included warnings of severe gale force 9 south westerly winds over the whole Channel and southern North Sea. A warning of northerly gale force 8 was then in force also for the Irish Sea. The strength of the gales forecast for the English Channel were increased to storm forces 10 and 11 in the course of the evening, and warnings were issued.

D. Forecasts issued to the Press, Radio and Television

14. The afternoon issues to the national media from London Weather Centre for publication in the following morning's papers covered the rain but they did not make a feature of strong winds. The main TV forecast at 2128 displayed a map of the weather expected overnight with wind symbols of 50 MPH off the east coast and of 40 MPH off the south coast, but the wind over land was expected to be only 'fairly strong'. On the other hand both the Southern TV and TVS broadcast from Southampton mentioned strong winds, gales or even severe gales affecting southernmost areas during the night. Both these regional TV stations were briefed by Southampton Weather Centre, who in turn were briefed by London Weather Centre. These latter forecasts were of course consistent with the expectation of severe gales in the Channel.

15. The national Radio 4 broadcast at 1755 on the 15th mentioned strong winds affecting the southeast part of England during the evening and early part of the night. However none of the national media scripts i.e. the 30 word summaries and 100 word summaries which are read out by the announcers on BBC radio featured the strength of the wind. The Radio 4 0020 summary, which is broadcast live from London Weather Centre, was the first to warn boldly of severe gales overland in parts of the south during the night.

E. Other forecasts issued

16. FLASH messages are intended to give only a very short warning (1 to 2 hr at most) of the imminence of a severe weather hazard. A FLASH message was issued at 0120 GMT for very strong winds with possible structural damage over England and Wales. Warnings were issued to the fire brigade and police in southeast England between about 0001 and 0100 GMT; the warning to the fire brigade making a strong point about the unusual strength of the winds to be expected. Also at about 0120 GMT a message was issued to the MODUK duty officer warning of the possible need to provide assistance to the civilian community due to structural damage associated with the very strong winds.

17. In the early afternoon of the 15th the London Weather Centre issued a forecast of severe gale force 9 south westerly winds for the inshore waters of the Thames Estuary covering the region between the pool of London and Harwich. A warning of very strong winds was also passed to British Rail for the Romford region at 1730 GMT on the evening of the 15th. Thus some of the more specialised users received better warning than did the public at large, especially those close to the sea areas.

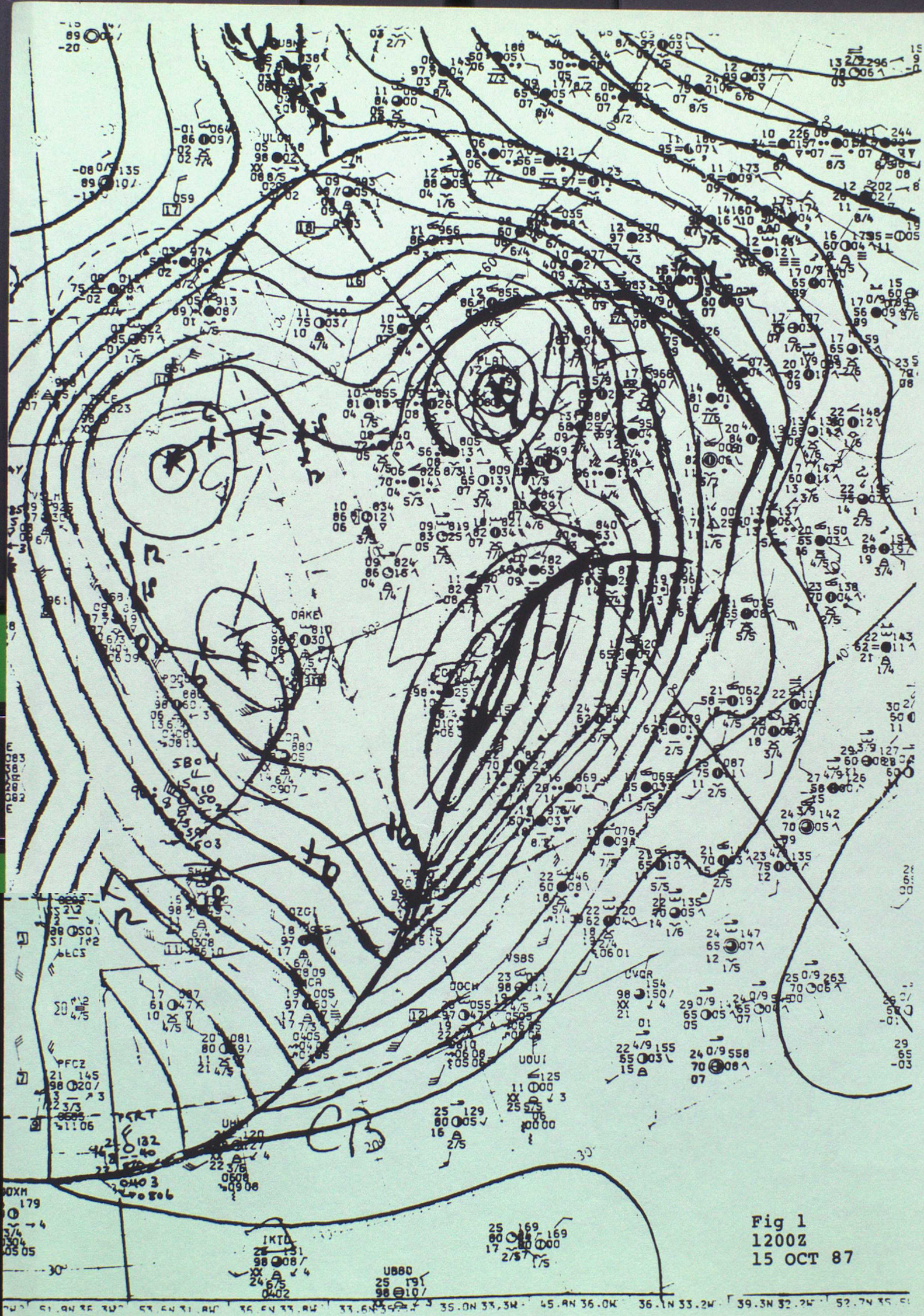


Fig 1
1200Z
15 OCT 87

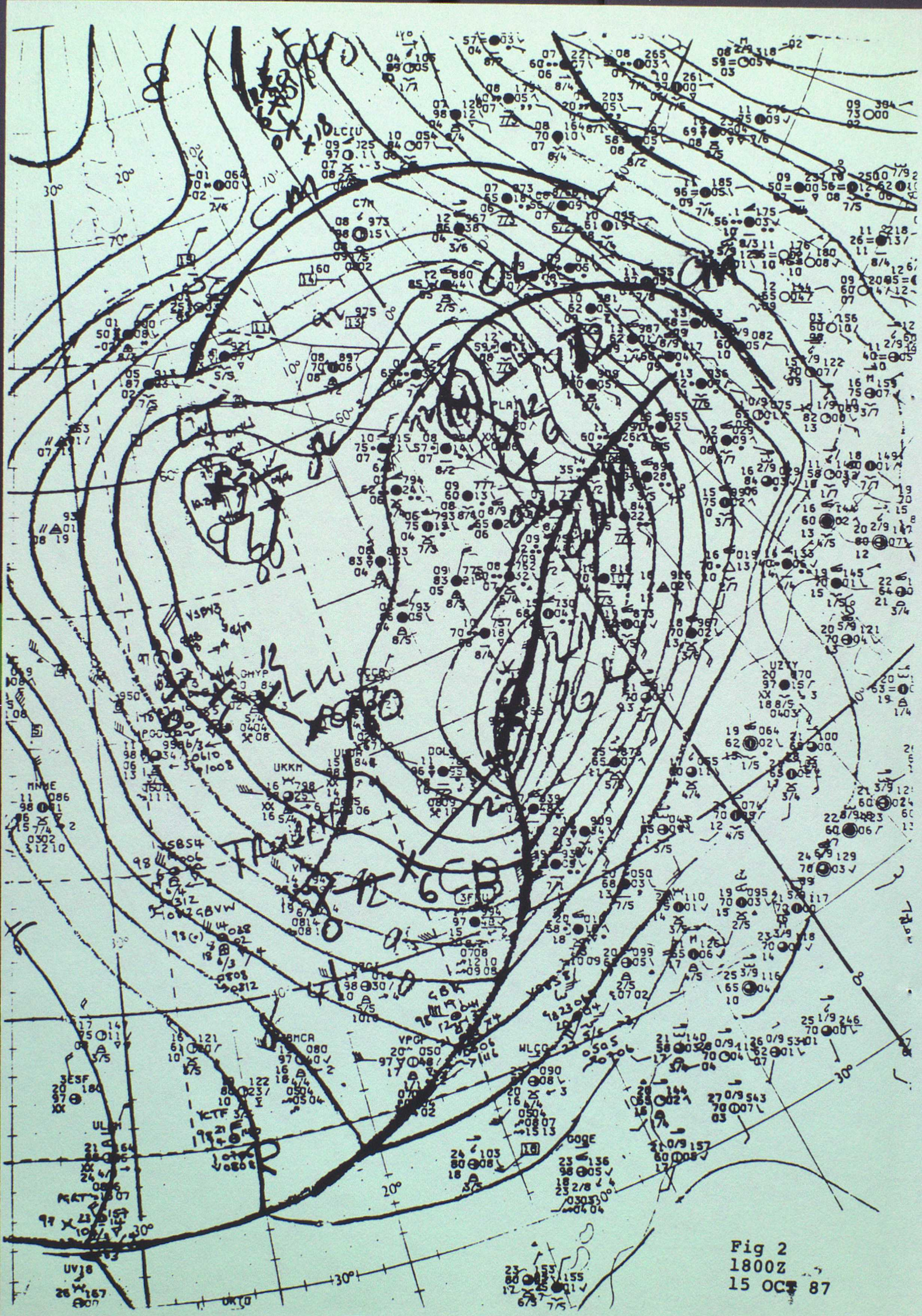


Fig 2
1800Z
15 OCT 87

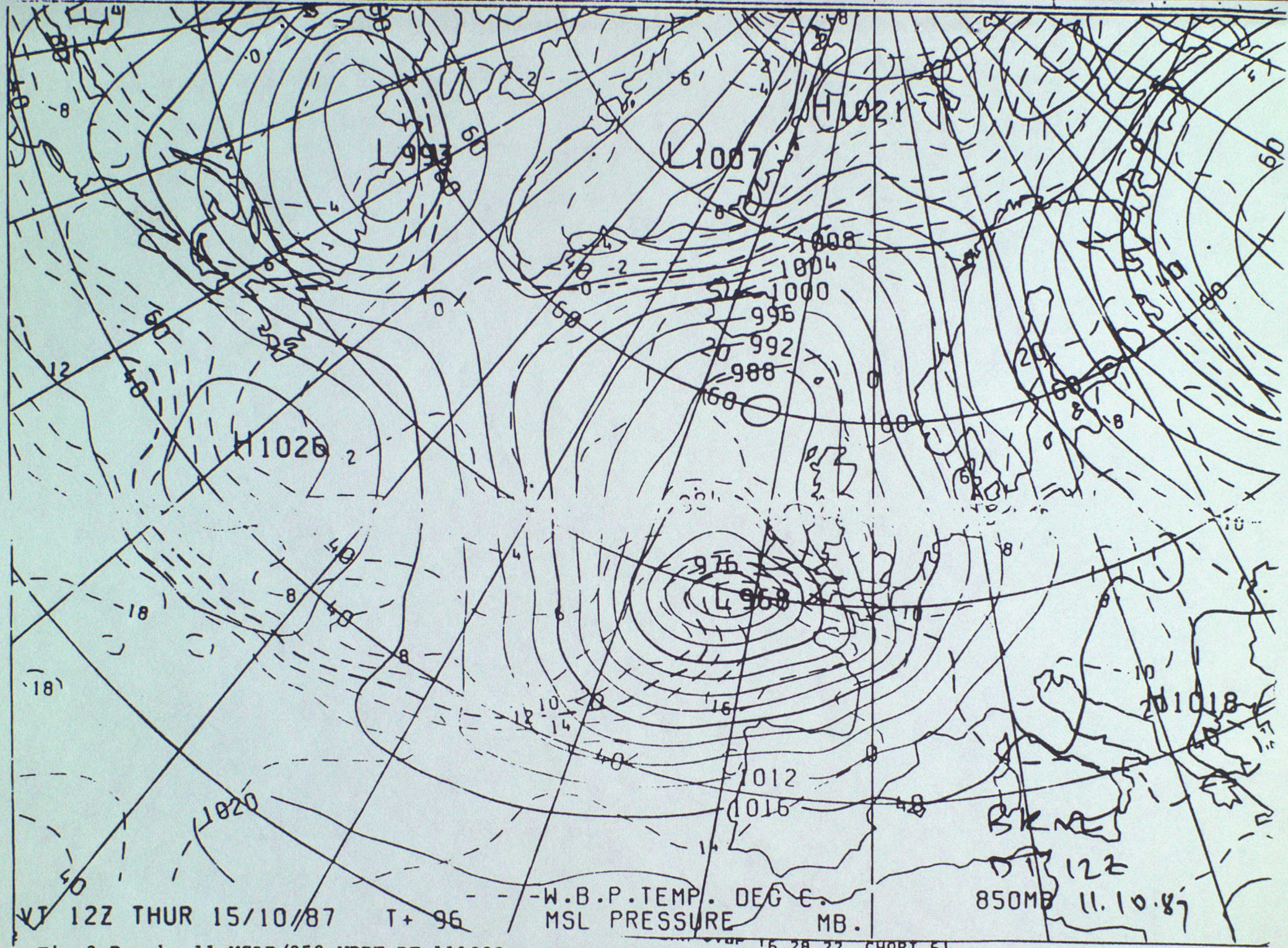


Fig 3 Bracknell MSLP/850 WBPT DT 111200Z T+96 VT 151200Z

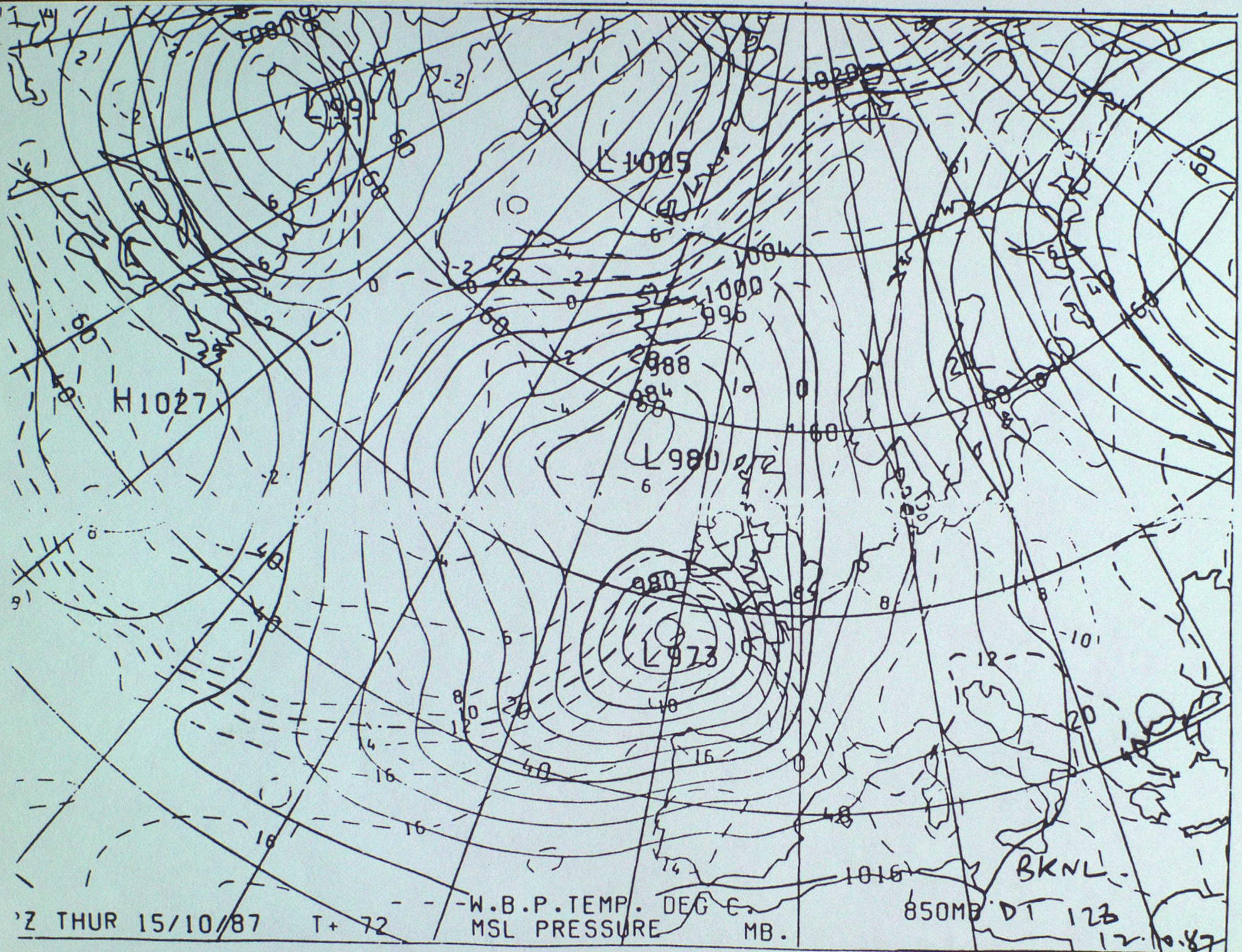


Fig 4 Bracknell MSLP/850 WBPT DT 121200Z T+72 VT 151200Z

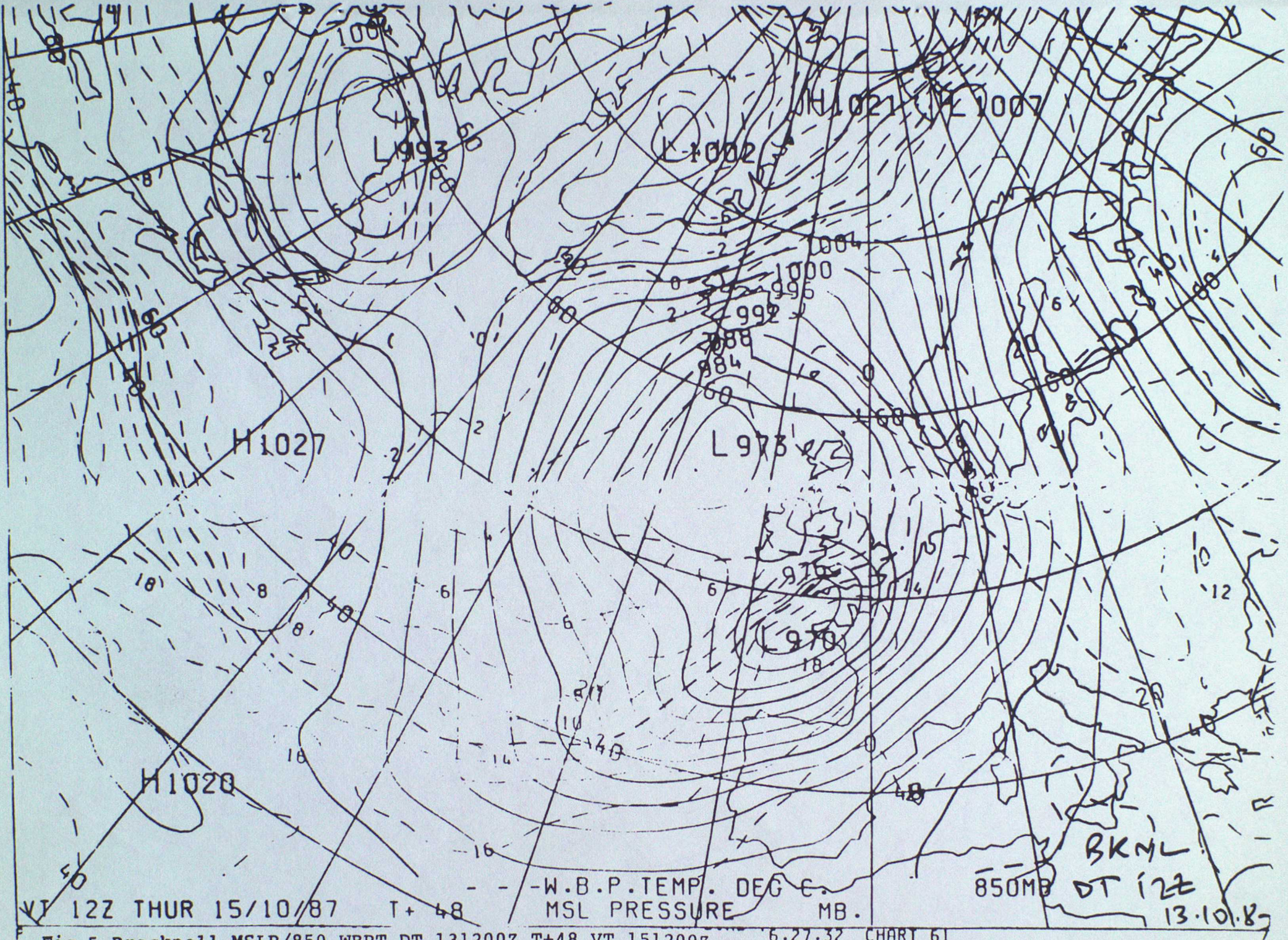


Fig 5 Bracknell MSLP/850 WBPT DT 131200Z T+48 VT 151200Z

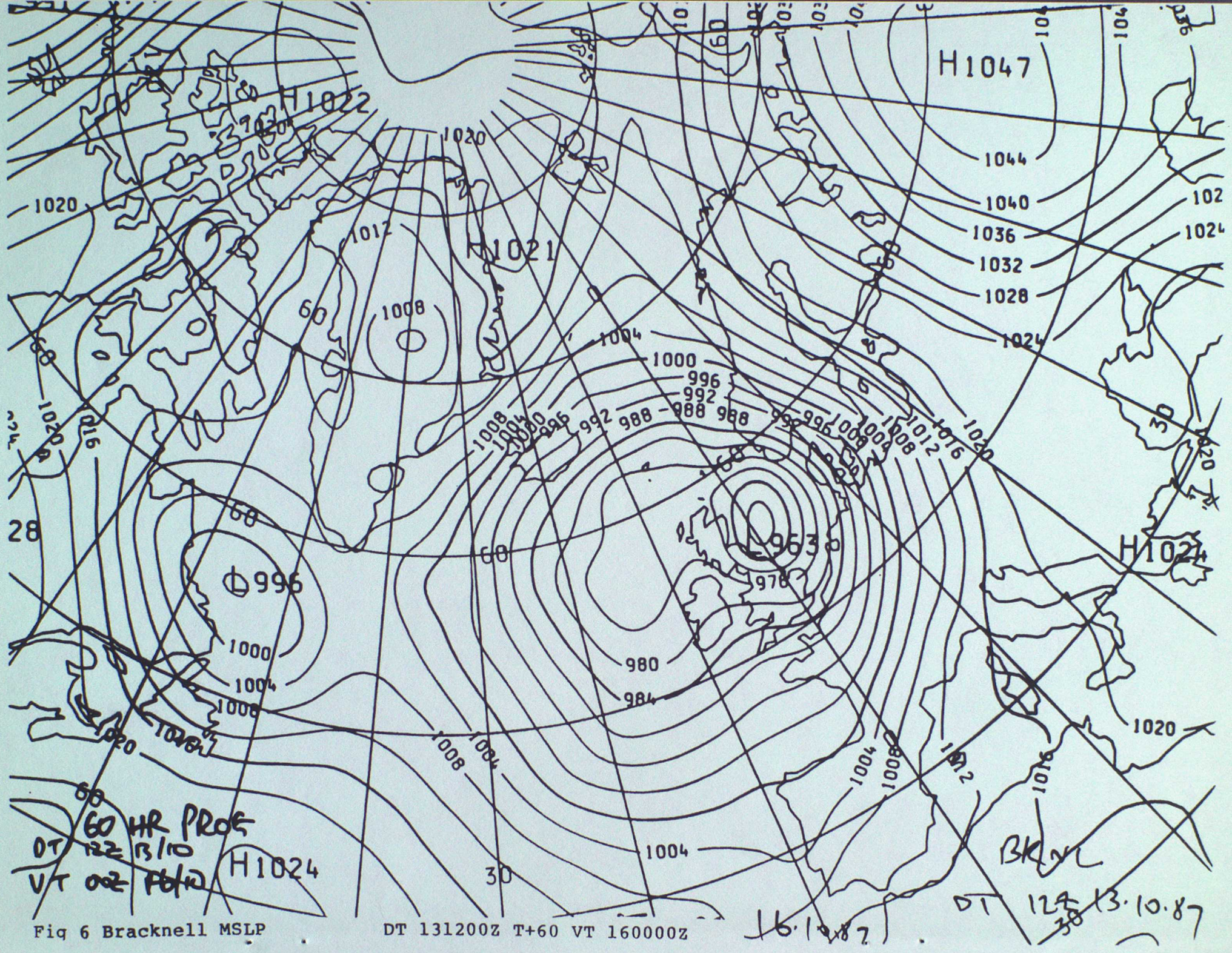


Fig 6 Bracknell MSLP DT 131200Z T+60 VT 160000Z

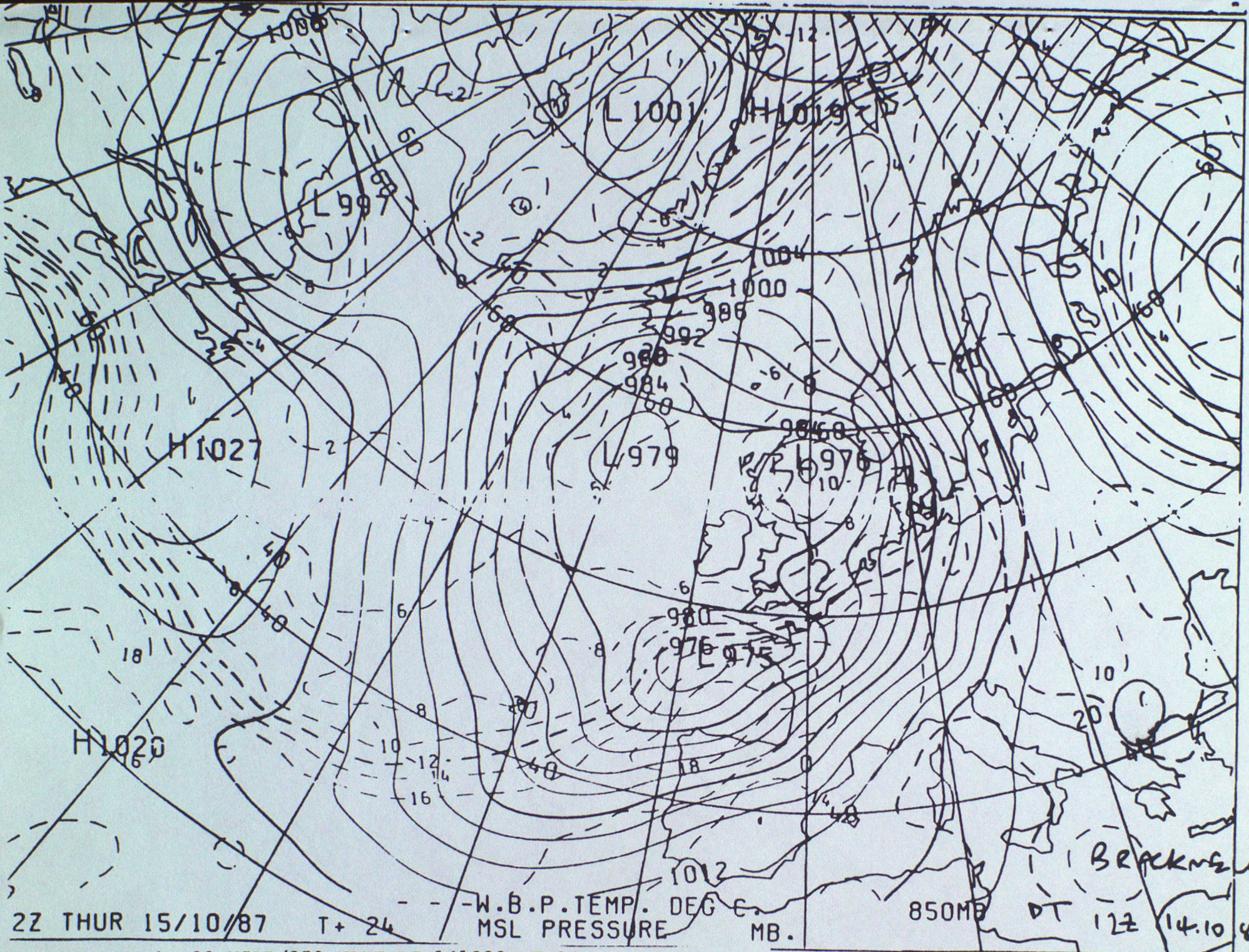


Fig 7 Bracknell MSLP/850 WBPT DT 141200Z T+24 VT 151200Z

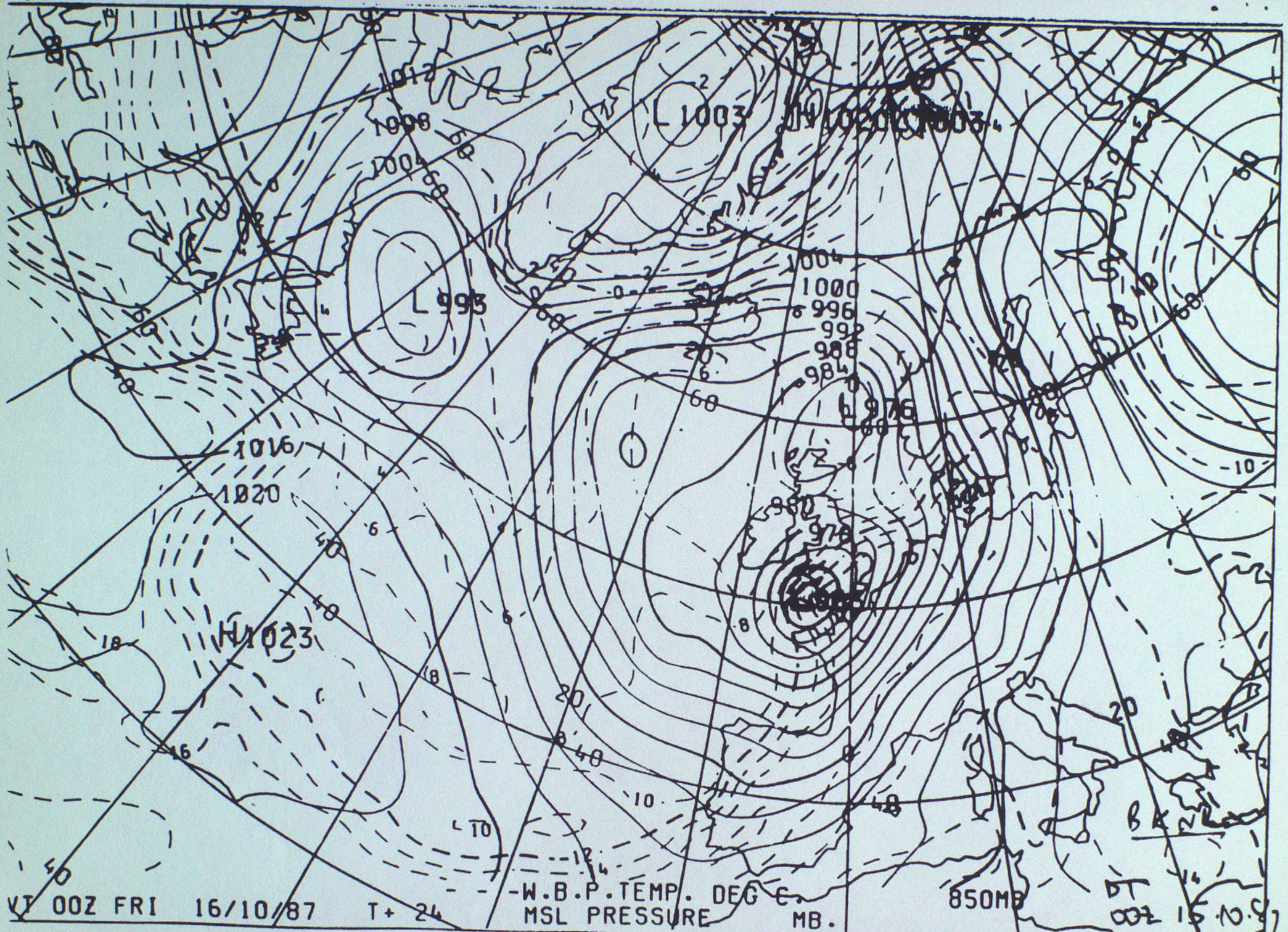


Fig 8 Bracknell MSLP/850 WBPT DT 150000Z T+24 VT 160000Z

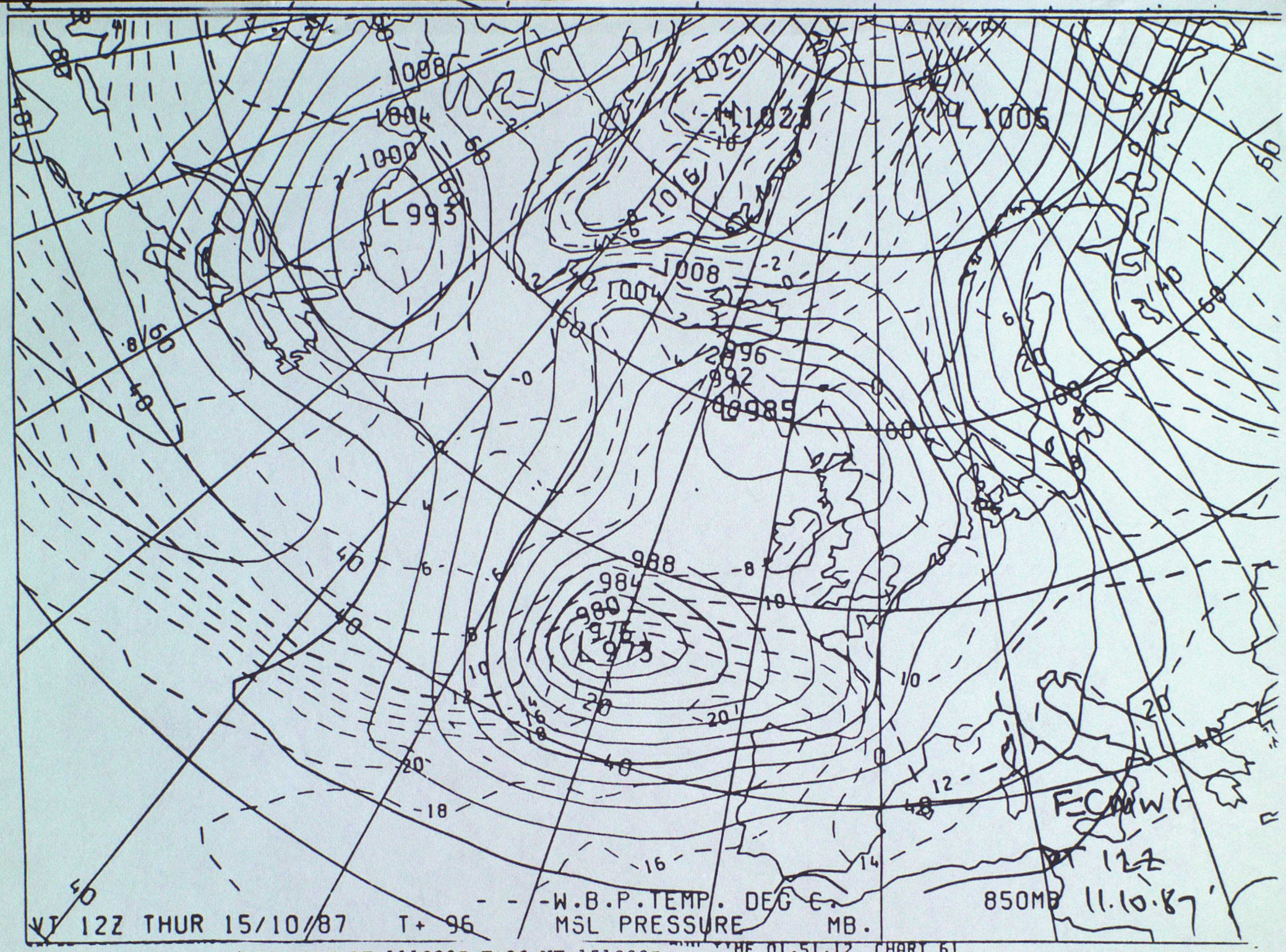


Fig 9 ECMWF MSLP/850 WBPT DT 111200Z T+96 VT 151200Z

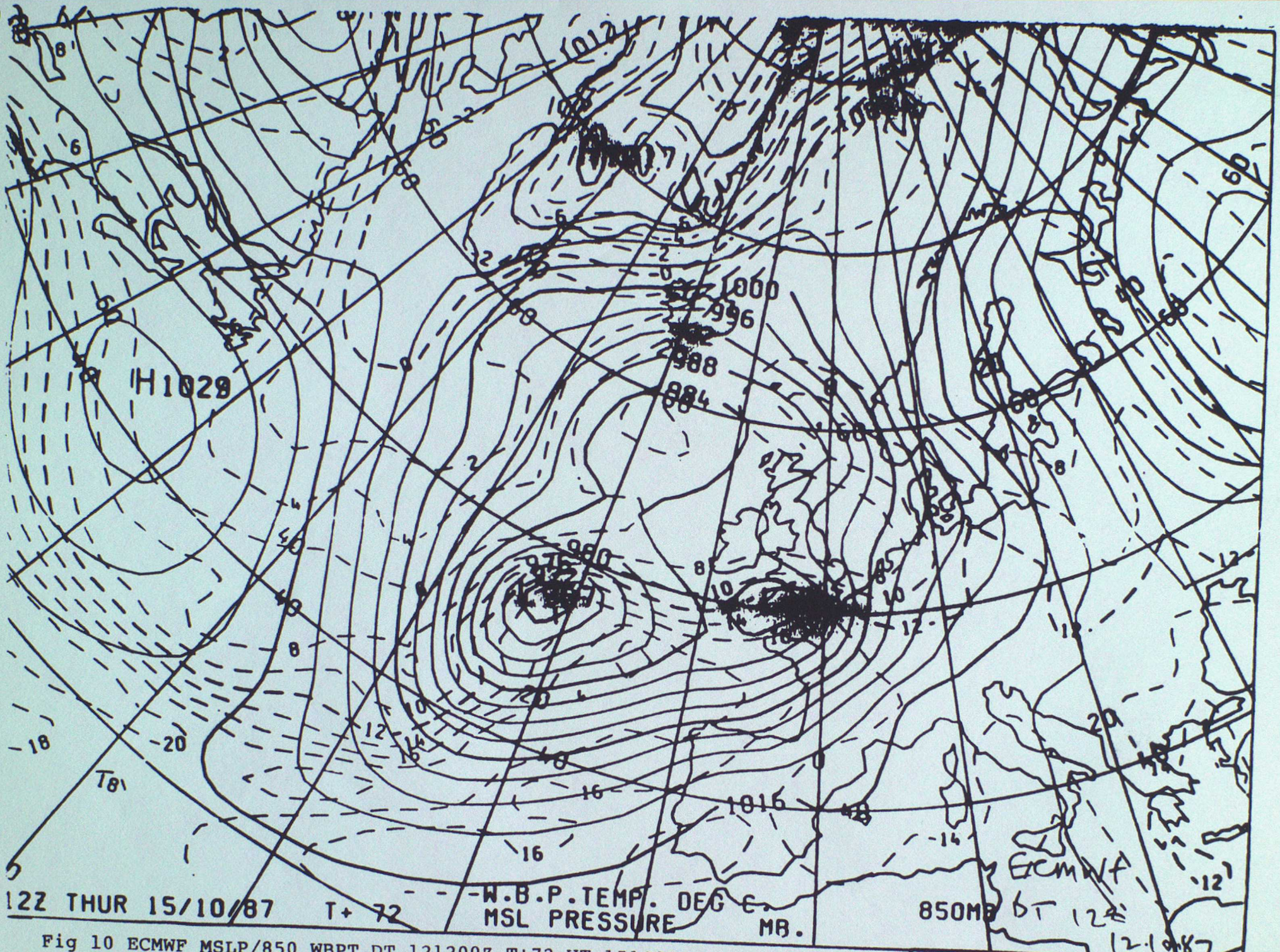


Fig 10 ECMWF MSLP/850 WBPT DT 121200Z T+72 VT 151200Z

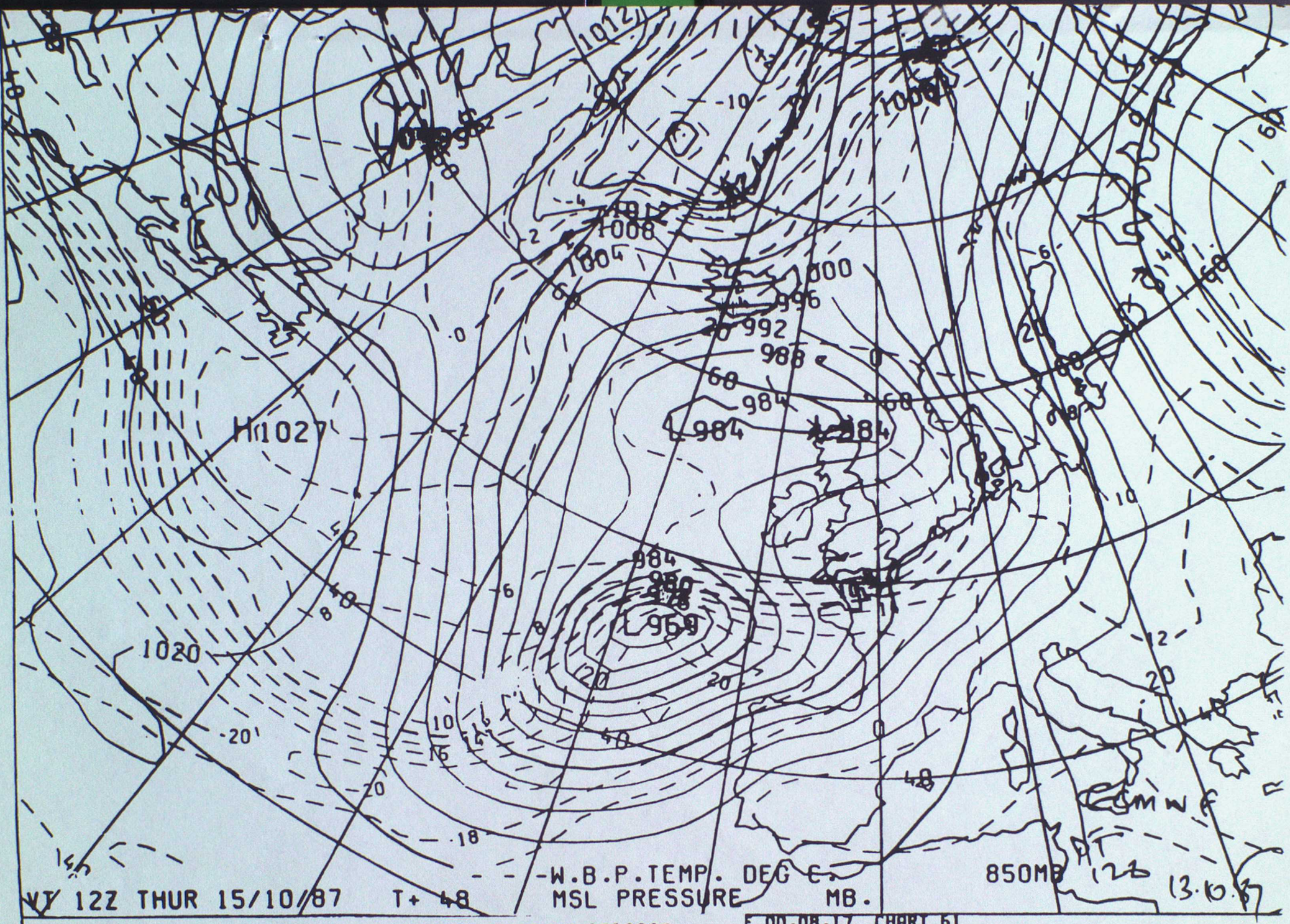


Fig 11 ECMWF MSLP/850 WBPT DT 131200Z T+48 VT 151200Z

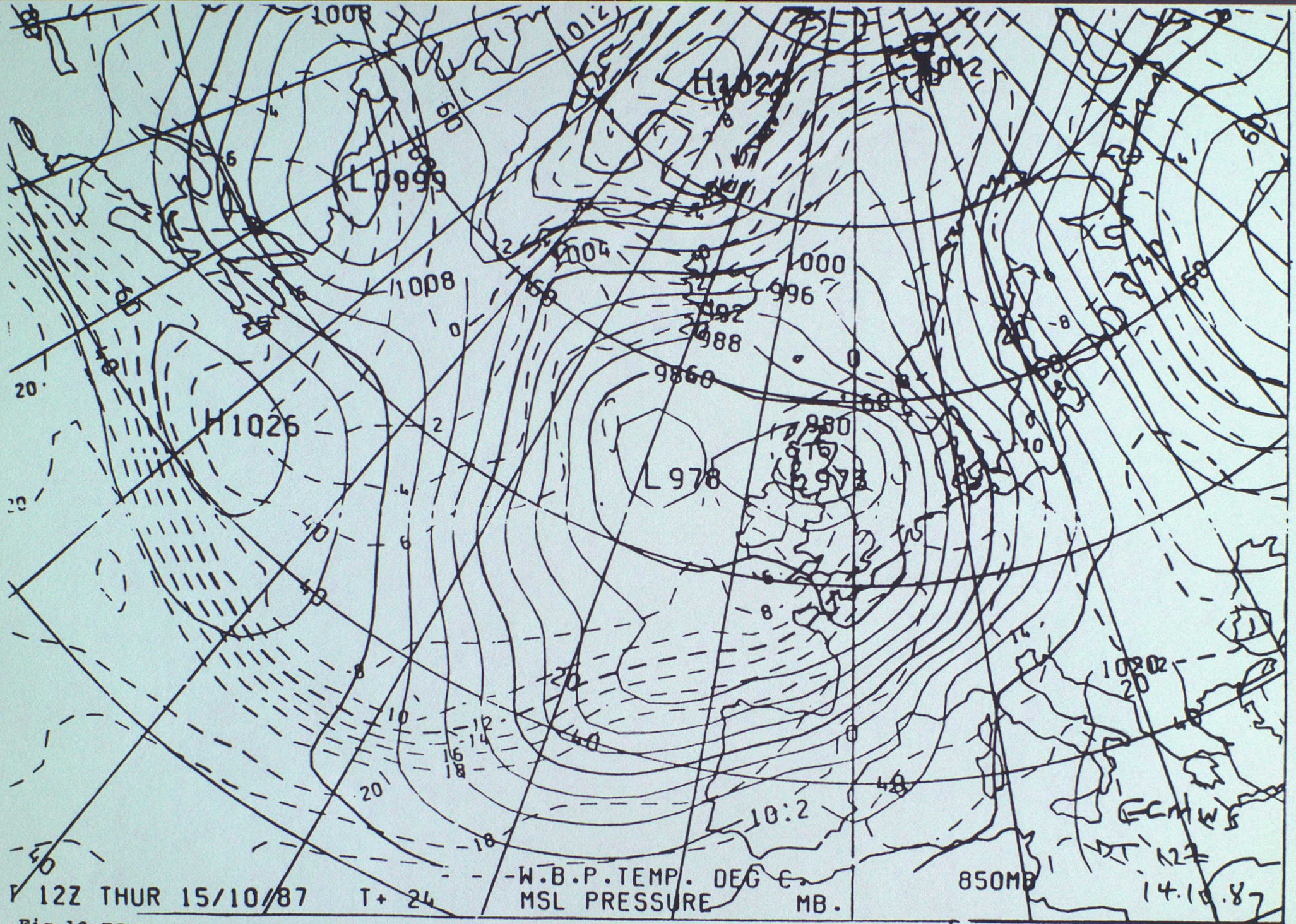


Fig 12 ECMWF MSLP/850 WBPT DT 141200Z T+24 VT 151200Z

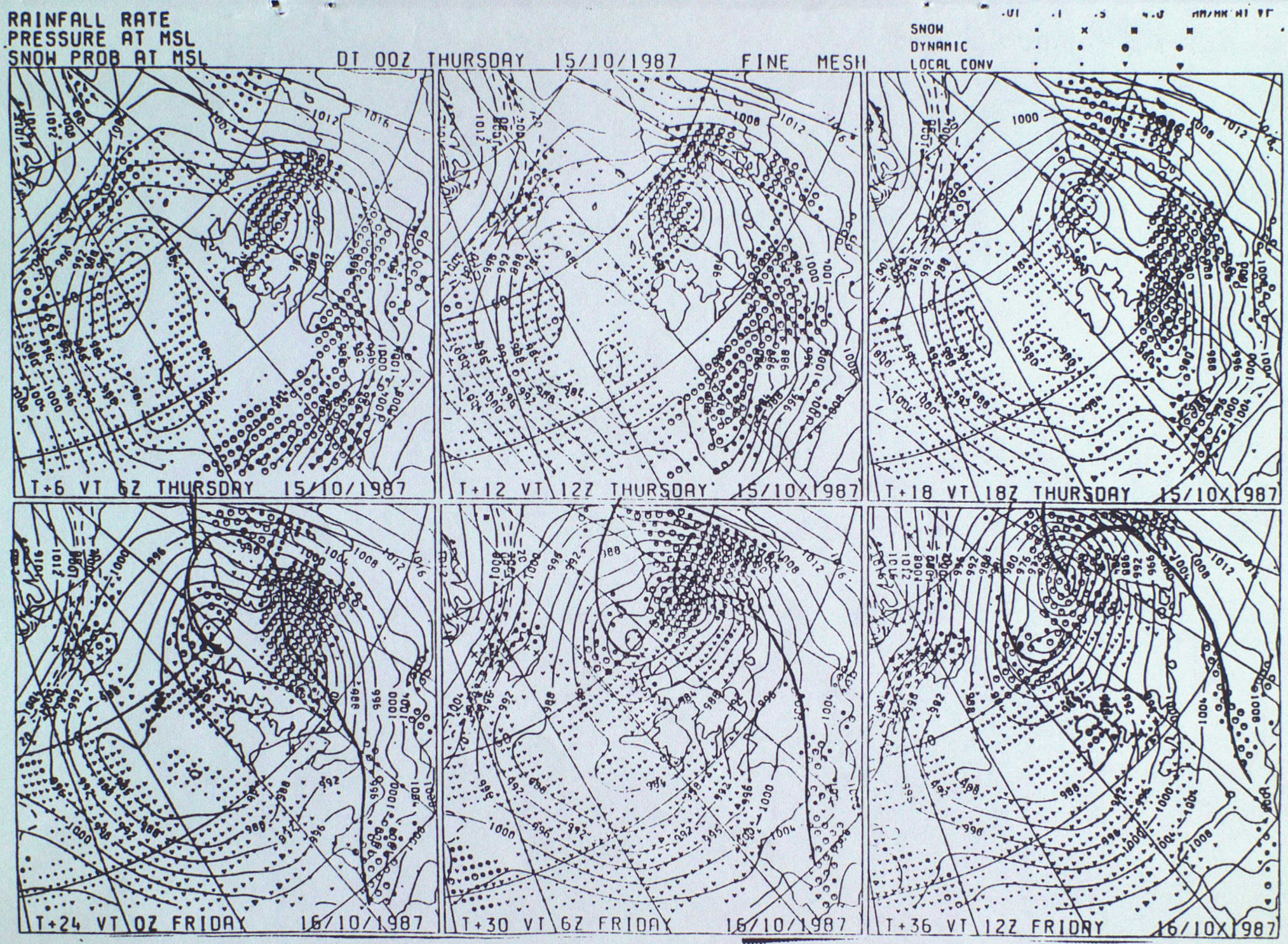


Fig 13 Bracknell Fine Mesh MSLP/RAINFALL DT 150000Z