APPLICATIONS OF GRAPHICS DEVICES AT THE METEOROLOGICAL OFFICE, LONDON AIRPORT

by

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Abstract

The Meteorological Office is at present extending its computing facilities in support of forecasting beyond the headquarters at Bracknell. The system at the Principal Forecast Office, London Airport is described, concentrating on the three types of graphical output device: pen-plotter, electrostatic matrix plotter and graphic visual display unit.

The Computer System (OASYS)

Although the Meteorological Office has made use of computer graphics at its headquarters installations (Bracknell) and at research establishments for over a decade, a recent innovation is the use of graphics in routine forecasting activities outside Bracknell. As part of the Outstation Automation project a computer system called OASYS (Outstation Automation SYStem) became operational at the Principal Forecast Office (PFO), London Airport on 19 January 1981. It is the first of a planned series of OASYS installations at major forecasting offices.

OASYS consists of a pair of Digital Equipment Corporation (DEC) PDP 11/60 minicomputers driving 2 pen-plotters, 2 electrostatic matrix-plotters and (by the end of 1981) at least 2 colour graphic visual display units (GVDUs) (see Figure 1). The observational and forecast data on which the PFO depends are transmitted from Bracknell along a dedicated line at medium speed and are stored on each of two 67-megabyte disks. These data form an indexed data base which is accessed by all graphics application programs. 24-hour operation is assured by duplication of all the major hardware components and by the ability to switch the essential peripheral devices between processors.

Pen-plotters

In order to provide high-quality plotted charts of observations pen-plotters were included in the configuration. Although there is a time-penalty, as compared with electrostatic plotters, in producing, say, a chart covering half the Northern Hemisphere, it was felt that the advantages of being able to plot in up to four colours, to use pre-printed stationery (cartridge paper), to erase pencilled-in isobars without erasing the plot and to add later observations to a partially-plotted and analysed chart were worth waiting for.

The Benson 5342 plotter, of which OASYS has two, is one of the fastest available, having a top speed of 80 cm/sec axially and an acceleration of 4g. For plotting of meteorological observations consisting mainly of small characters or symbols composed of short vectors, the top drawing speed is seldom reached. High acceleration is the more critical factor determining the time taken to plot a chart. The top speed setting was designed for use with fast-flowing liquid ink cartographic pens, and slower speed and acceleration setting are provided for ball-point and fibre tip pens. However, since the observation plotting application avoids large drawing speeds, it is possible to use the fast setting with Pentel (ball-point, water-based ink) pens, thereby taking advantage of maximum acceleration, a fast pen-up speed when traversing between observations and, of course, the relative cheapness of Pentel pens.

The graphics software supplied by Benson provides the basic facilities (set origin, draw vector, change pen, move with pen up, etc) required for chart-plotting as well as extra facilities (label axis, etc) that are not used. Although the software is supplied as low-level source code with a FORTRAN skin, OASYS application programs are written in CORAL 66 and call low-level graphics routines as required. Some characters may be generated in the plotters themselves, ie hardware generated. The normal character set supplied is designed in the continental style, but on request Benson supplied a special set with an English "1", a flat-topped "3" and uncrossed "7" and "0". Extension of the character set to include meteorological plotting symbols is now under consideration: this would take some load off the host computer.

The pen-plotters are used exclusively for plotting synoptic observations on to pre-printed charts. A range of chart areas, scales and projections can be accommodated by a single program through the use of a plotting control file (PCF) which describes the chart to be plotted, its particular station list together with precomputed (x,y) station positions and flags to indicate whether each station has been plotted. This last facility enables the program to be re-run at a later time to add more recently received observations ("retards") without replotting the whole chart. The retards are usually plotted in green, rather than the conventional red/black, so that the forecaster's attention is drawn to them.

Ships' positions cannot be precomputed, so they are calculated from projection information in the PCF. In order to avoid overplotting neighbouring ships, the PCF also contains a two-dimensional bit-array in which each bit represents a small rectangular area element of the chart. The bit is set if the area element is on land, if it is normally used to plot a coastal observation, or if it has been used to plot a ship observation. Only those ship observations that fall into an empty area of the chart are plotted. An observation plot covers nine elements. Any ship observation that cannot be plotted in place is either plotted in a special box at the edge of the chart or is written to an "unplotted" file that can be printed out at will.

The plotting models in use conform to international recommendations, except that on upper air charts the 50-knot pennant has been expanded to an equilateral triangle for enhanced visual impact of jet streams (see Figures 2 and 3, which are reproduced in monochrome). The new recommended model corresponding to the new surface reporting codes provides an opportunity to present more detailed information to the forecaster. However, the users have indicated that they prefer not to clutter charts with inessential detail (eg, extra precision of temperatures). Therefore the old model will continue in use.

Matrix-plotters

The use of pre-printed stationery is worthwhile when the manual effort of mounting the paper is relatively small. However in producing diagrams of upper air ascents , which have typically less than 100 vectors, use of the pen-plotter is inappropriate. For this reason, and because a large number of monochrome contour charts would be required, two electrostatic dot-matrix plotters were included in the configuration.

The Varian 9222A matrix plotter was chosen. It has a resolution of 200 dots per inch (1 inch = 2.54 cm), the dots overlapping slightly to produce high quality lines. It accommodates 22-inch wide paper rolls, so that products traditionally received by facsimile can be generated. It also has an advanced system for applying toner fluid to the paper so that charts and diagrams are dry enough for immediate use. The take-over of Varian by Benson in 1979 provided a welcome opportunity to simplify maintenance arrangements.

Apart from its non-graphical use as an occasional line printer, the matrix plotter produces three types of output.

Firstly, every 12 hours approximately 80 diagrams of upper air ascents, mainly from European stations, are produced. Each ascent is represented as a temperature curve and a dewpoint curve on a grid with axes t, temperature and Ø (phi), dry-bulb 1000mb potential temperature. These diagrams are known in the UK as tephigrams. If the ascent from 12 hours earlier is available, it too is plotted, in dashed lines. A version of the diagram showing ascents up to 700mb at a larger scale can be generated on request (see Figure 4).

Secondly, monochrome plotted charts may be produced, either as an emergency procedure when a pen-plotter is out of action, or when a second copy is required. The plotting programs have been written so that a file of vectors is produced on disk. As a separate second stage, a program is run to interpret the file as plotting instructions either for a pen-plotter or for a matrix-plotter. In the latter case it is necessary to do some extra work, because the machine has to handle vectors in top-to-bottom order. The vector file has to be sorted (a time-consuming process, since the vectors cannot all be accommodated in main memory) and then merged with a pre-sorted chart background file. The subsequent task of converting sorted vectors to raster information (ie, which dots of a particular horizontal line or "raster" should be written) is undertaken by a microprocessor based "Graphware" unit associated with each plotter. This device is essentially an array processor, which relieves the host processor of a substantial task. It will process up to 640 vectors crossing a particular raster.

The third type of output is still under development. A contouring package called CMAPA has been developed for use on both mainframe and small computers (described by P Cockrell in another presentation to this seminar). It will be used on OASYS to display as contours various fields of output from the operational numerical model. Winds and temperatures at grid points may be superimposed (see Figure 5).

A particular disadvantage of matrix plotted output arises in connection with the second type of output. Plotted charts are intended to be drawn up by forecasters using pencil and eraser. Unfortunately the machine plot can also be erased unless special action is taken. Several solutions to this problem were proposed, including the use of a hair-lacquer aerosol spray to coat the paper. In the end, heat treatment was preferred, and a photographic glazer, modified to process a chart in 30 seconds rather than 4 minutes, has been provided.

Graphic Visual Display Units

At the time of writing, GVDUs are on order from Gresham Lion (PPL) Limited, and are due to be delivered in November 1981. Obviously not much software development has taken place, but certain intentions are clear.

The GVDUs each have a Supervisor 214 controller which is based on a DEC LSI 11/23 microprocessor. The display consists of two pages of 512 x 512 elements (pixels) of which one page is visible. The two-page facility enables zooming and animation. Four bits are assigned to each pixel of the display buffer, and these can be used flexibly, eg for:

a. 16-colour graphics
b. 8-colour graphics with monochrome overlay (eg chart background)
c. 8-level images in monochrome or pseudo-colour with monochrome overlay
d. 16-level images in monochrome or pseudo-colour.

The colours may be selected by look-up table from a pallette of 4096 colours.

The workstation consists of a monitor, a keyboard and a digitising tablet. The monitor has a 20-inch diagonal, and avoids unpleasant visual effects through use of long persistence phosphor (to reduce interlace flicker) and a neutral density polarising filter over the screen (to reduce reflected light). The 11-inch square digitising tablet is used to control a graphics cursor and was originally intended for menu selection and for interactive modification of contour charts. The need for the latter facility is under review at present, but the capability to input graphic information, ie to "draw" pictures on to the screen, remains. Since the display buffer can be transferred back to the host computer, the results of drawing on the digitising tablet can be processed or reproduced (in monochrome) on a matrix plotter.

Supervisor 214 software for the LSI 11/23 is down-line loaded from the host when the GVDU controller is initialised. Thereafter, application programs running in the host send commands to the controller to generate the required display. The controller software includes an alphanumeric VDU emulator which allows the GVDU to be operated as an ordinary terminal. A split-screen facility allows graphics programs to be initiated and controlled through this emulator.

As a new type of device, the GVDU will be largely experimental for a year or so, as the first programs will prompt from the users many ideas for improvements to the design of displays or for manipulation facilities. However, as a starting point four application programs (chosen by the users) will be written.

Firstly, as a paper saving exercise, the display of tephigrams on GVDUs will be provided as a "quick-look" facility, with the ability to select particular diagrams for printing on the matrix plotter. The routine production of hard-copy tephigrams could then be reduced substantially.

Secondly, a static display of several recent observations from one station will be provided. Plotted observations are more readily assimilated than coded ones, and simultaneous viewing of a sequence of observations will give the forecaster information on weather trends.

Thirdly, the occurrence of particular weather types (eg fog, snow, thunderstorms) at a given time will be displayed as weather symbols on a map background. By calling for these for a sequence of times, the progress of, for example, belts of snow could be monitored. The sequence could be expressed either by overlaying different colours or by semi-animation (ie, one or two pictures per second).

Fourthly, it is planned to provide a "quick-look" facility for forecast charts in the form of contours against a map background. Use of different colours will allow two or more sets of contours to be superimposed.

The GVDUs also have the capability for displaying images, since the application program can take control of individual pixels. Assuming that OASYS can acquire the data, it is intended in the longer term to be able to display satellite pictures or composite rainfall radar and satellite pictures, such as those described in other contributions to this seminar by J Ponting and Dr K Carpenter. Semi-animation of these pictures would be possible and would enhance their usefulness to the forecaster.

Summary

The OASYS system being introduced at major Meteorological Office outstations relies heavily on graphical output for presentation of information to forecasters. The variety of graphical devices allows full advantage to be taken of the most appropriate device for each application: the pen plotters providing quality hardcopy; the matrix plotters providing large quantities of hard-copy quickly; and the GVDUs providing quick looks at observations and forecasts in readily assimilable form. The software has been arranged so that most products can be generated on alternative devices, to cover hardware failures. The project is at an early stage: much programming remains to be done to provide the users with all the facilities of which the system is capable.

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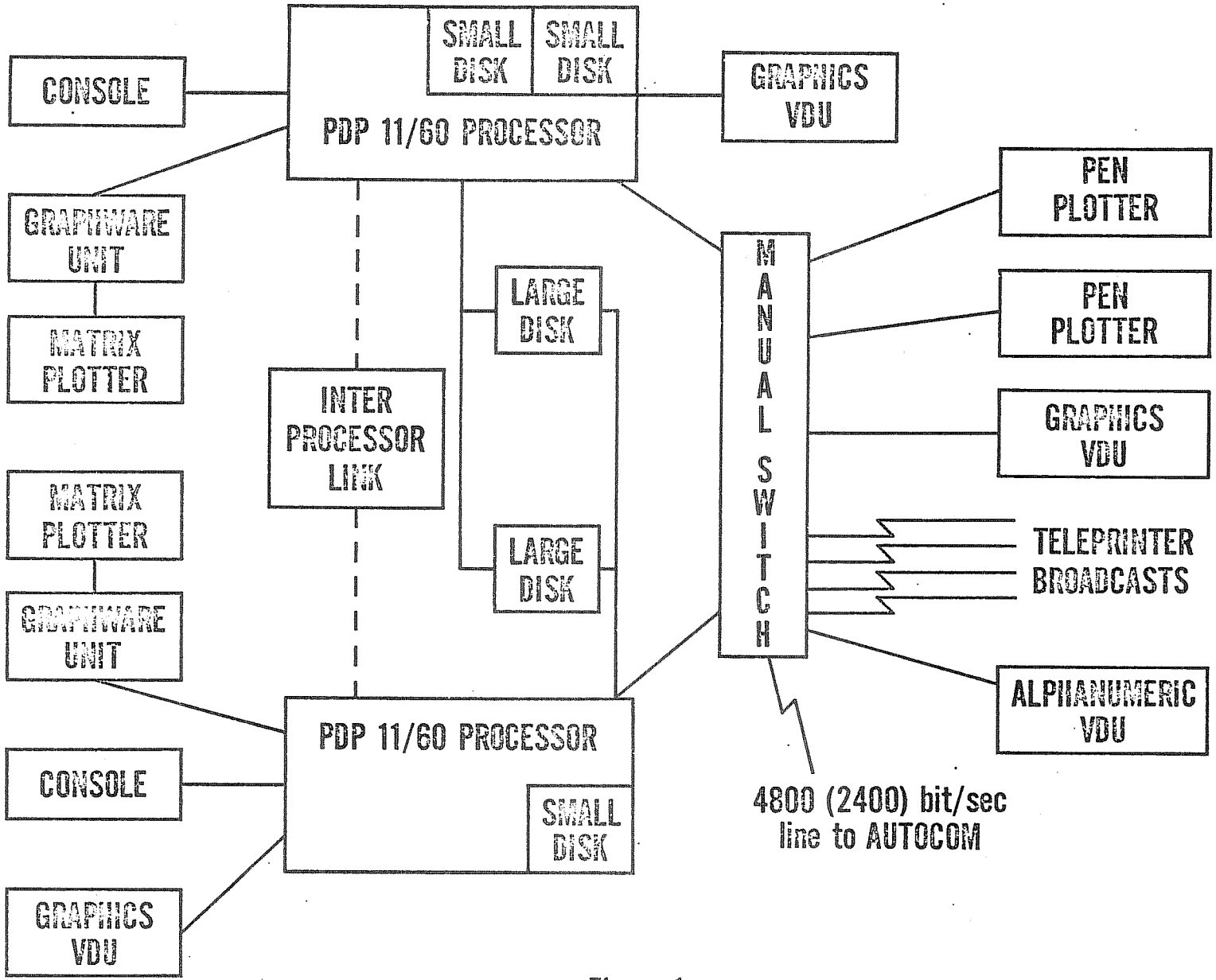

CONSOLE
SMALL DISK
SMALL DISK
PDP 11/60 PROCESSOR
GRAPHICS VDU
GRAPHWARE UNIT
MATRIX PLOTTER
INTER PROCESSOR LINK
LARGE DISK
LARGE DISK
MANUAL SWITCH
PEN PLOTTER
PEN PLOTTER
GRAPHICS VDU
TELEPRINTER BROADCASTS
ALPHANUMERIC VDU
MATRIX PLOTTER
GRAPHWARE UNIT
PDP 11/60 PROCESSOR
CONSOLE
SMALL DISK
GRAPHICS VDU
4800 (2400) bit/sec line to AUTOCOM

Figure 1

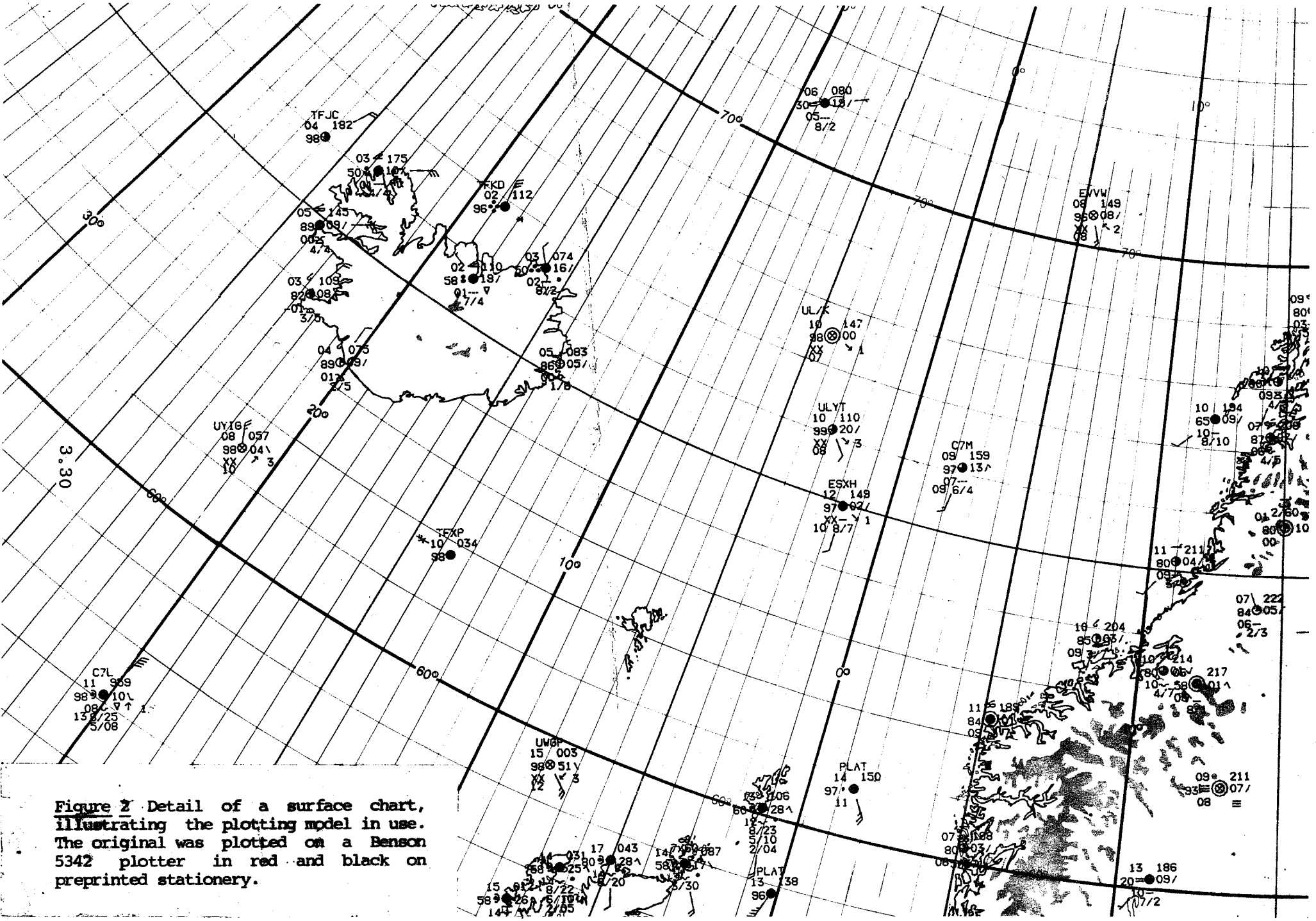


Figure 2 Detail of a surface chart, illustrating the plotting model in use. The original was plotted on a Benson 5342 plotter in red and black on preprinted stationery.

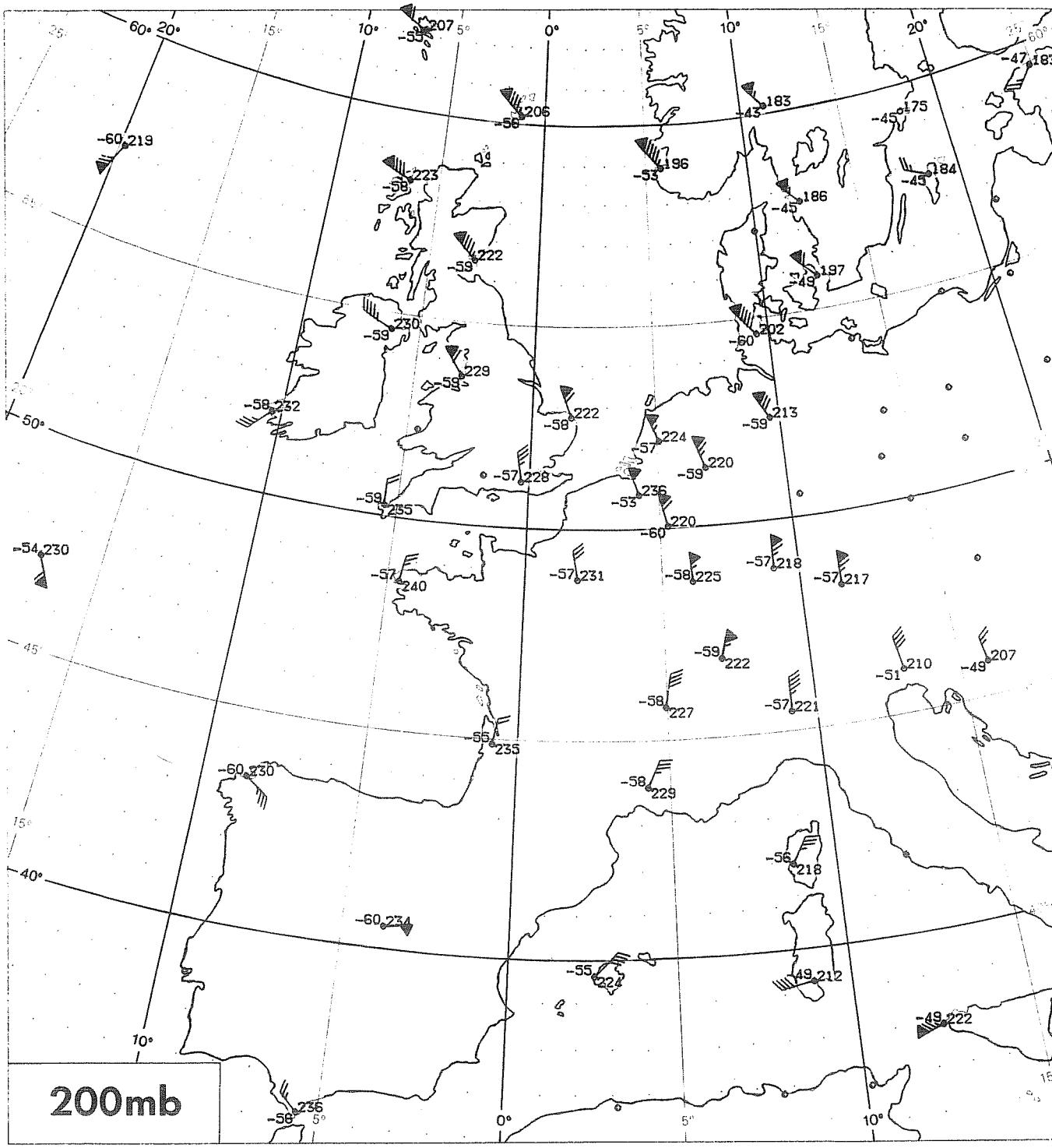


Figure 3 One panel of a 6-panel upper-air chart, illustrating the plotting model in use. The original was produced on a Benson 5342 plotter in black (early arrivals) and green (retards) on preprinted stationery. Other panels on the full chart show different levels and the maximum wind.

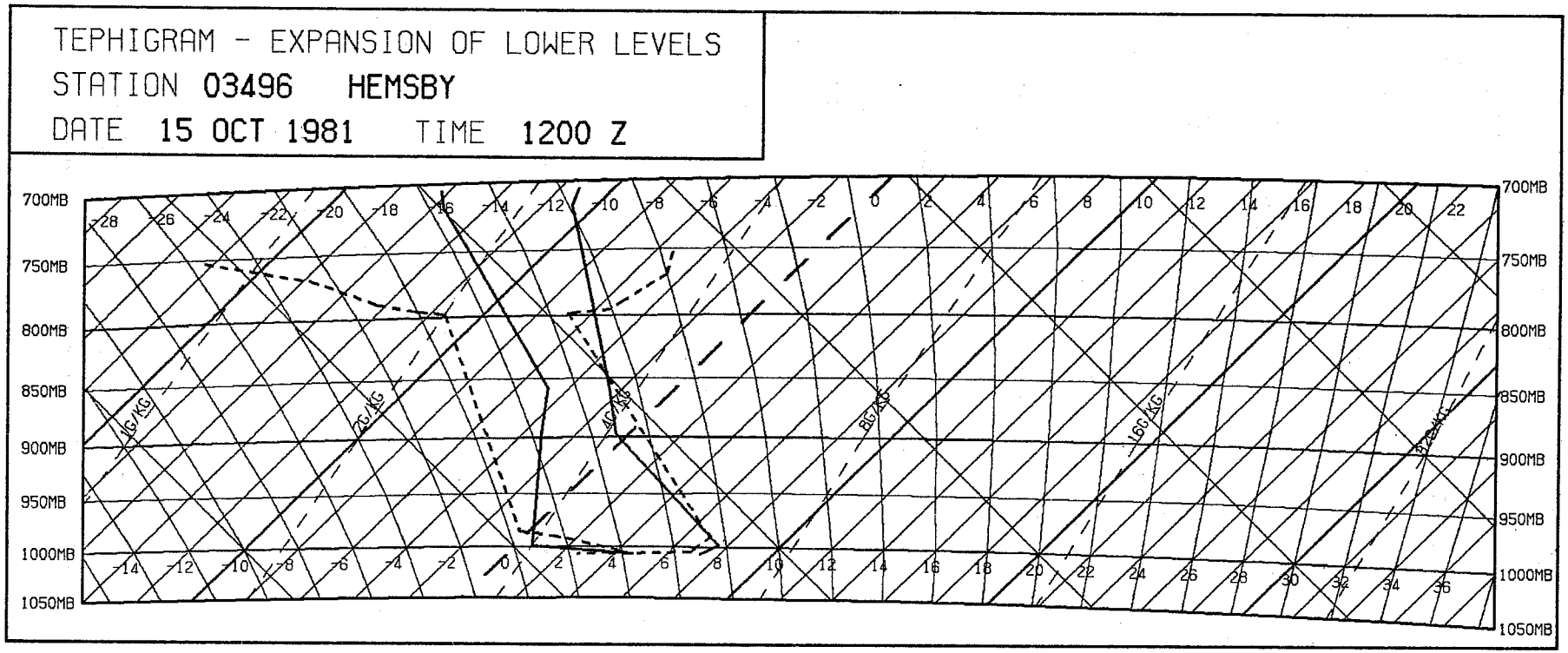
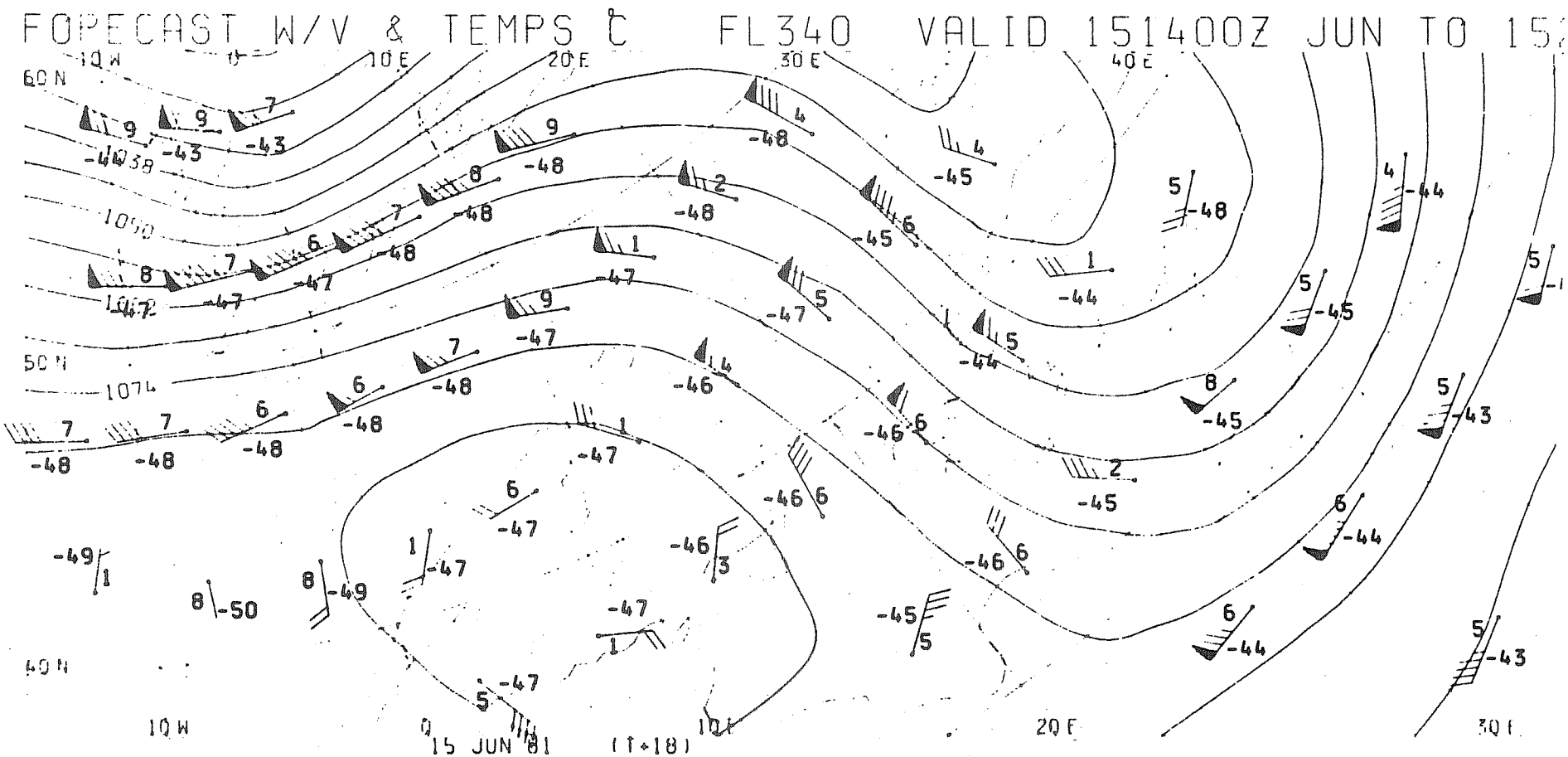


Figure 4 An expanded lower-level tephigram, produced on a Benson-Varian 9222A matrix plotter. The pair of full lines represent the current ascent; the pair of dashed lines represent the ascent made 12 hours earlier. Within each pair, the right-hand curve gives dry-bulb temperature and the left-hand curve gives dew-point. The origin (deg.C) of the diagram is the intersection of the heavy dashed line with the 1000mb line. The ϕ-axis is the heavy dashed line (ϕ is potential temperature). The temperature axis is perpendicular to the ϕ-axis. The slightly curved horizontal lines represent pressure levels, and the quasi-vertical curved lines are moist adiabats. Dry adiabats are parallel to the temperature axis. Temperature values are marked along the 1000mb and 700mb lines. Lightly dashed lines are isopleths of humidity mixing ratio.



3.33

Figure 5 An example of the kind of presentation of forecast information under consideration. Against a map background, contours or spot values or both will be possible. This diagram was not produced on OASYS.