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DEVELOPMENTS IN DIGITISING AND VOICE RECOGNITION TO MEET THE REQUIREMENTS OF HYDROGRAPHY AND CARTOGRAPHY

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INTRODUCTION

Some 15 years have elapsed since the first theories regarding automated cartography were put forward and experiments begun in both universities and survey establishments. At this time the equipment used had been primarily designed for use in mechanical engineering in the manufacturing industry. The requirement to handle the large amounts of non-geometric data in hydrographic and cartographic applications has played a large part in the design of digitisers and plotters as they appear today. This paper will indicate how some of the techniques and facilities have been evolved and are now used, with particular reference to their application in hydrographic chart compilation.

Traditionally, the hydrographic chart compiler takes information from a number of sources : existing charts; data from survey ships, commercial services and harbour authorities; charts from foreign sources; and listings of wrecks and buoys. This information is collated and compiled into an accurate, but not fair drawn, sheet from which the published chart is ultimately produced by highly skilled cartographic draughtsmen.

When automated techniques are applied, the process tends to be split into three distinct operations :

1) Data entry — generally by the use of digitisers.
2) Computing and editing.
3) Plotting, or automated draughting.

DATA ENTRY BY DIGITISING

It is not necessary to describe a digitiser, as this was excellently done by MURT and ADAMS recently [1]. However, the techniques of data entry by digitising are extremely important. If a systems analysis is applied to the graphic data on a hydrographic chart compilation, the data can be split into a number of easily identifiable, but different, types with which the digitiser must cope, namely :

a) *Line data* — such as depth contours and coastlines; and roads, railways and contours where land information is also shown.
b) *Soundings* — comprising position data and text.
c) *Symbols* — for wrecks, buoys and lighthouses.
d) *Text* — names, labels.

It is perhaps not widely known that it was the requirement to handle the first of the above items which led to the development of the "free cursor" digitiser as it is known today (figs 1 & 2).

Digitising of line data

Prior to 1963, digitisers were generally of the manual gantry type, which were unable to trace random lines, such as coastlines, to any degree of accuracy. The breakthrough occurred when a cartographer enquired whether a device similar to the hand-held tripod scriber, in the use of which all cartographic draughtsmen are trained, could be used for handling line data. Hence, the principle used in the d-mac Pencil Follower was born, and this has simply changed to the solid state digitisers such as the Ferranti Freescan which are in common use today.

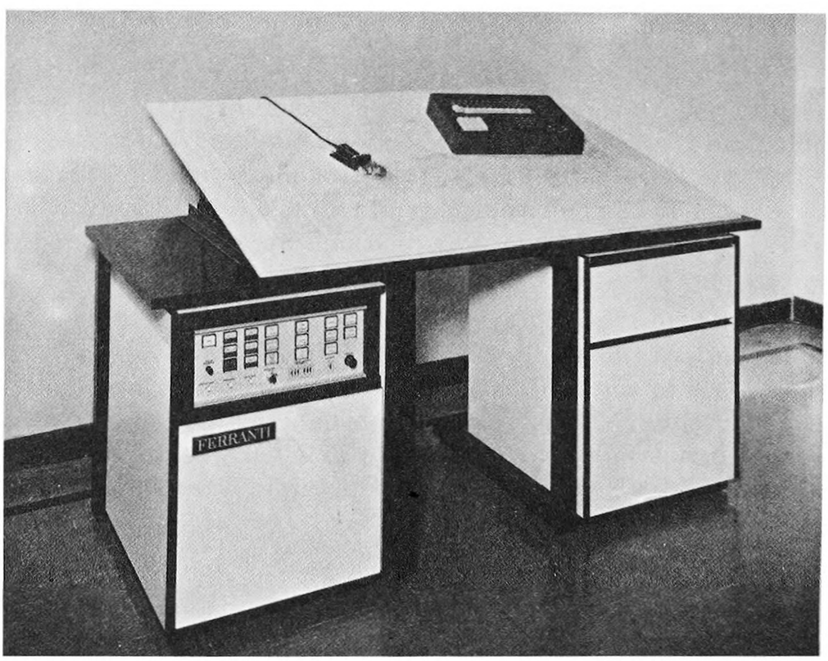


FIG. 1. — Ferranti solid-state Freescan Digitiser.

FIG. 2. — "Free" cursor.

Given this type of digitiser, random curves such as coastlines and contours can be digitised in two ways :

1) by *stream digitising,* whereby a stream of coordinates (at intervals of either time or distance) is output. This method is widely used but, dependent on the application, may suffer from a number of disadvantages.
   a) An operator's accuracy tends to fall off after a period of continuous digitising since he cannot relax during the tracing of a line.
   b) If only one point is in error, when the curve is plotted, it can cause an unsightly glitch.
   c) If the data has to be plotted at a reduced scale, the problem of filtering large amounts of data has to be overcome.
2) by *point digitising.* This involves selecting salient points along the line and this method overcomes the disadvantages of streaming. It is more accurate, but operator training in the techniques takes longer and a more sophisticated curve fitting program is needed when the data is plotted. It is less tiring for the operator, and the selection of points creates job interest.

Whichever method is used, it is generally found that digitising is faster than manual scribing. In addition, the same data output can be used twice — both to draw a line and to cut a mask — and the accuracy of registration is guaranteed.

FIG. 3. — Keyboard with thumbswitches.

Digitising of soundings

A major part of hydrographic data is soundings, either from existing charts or from survey ships. Initially, keyboards (with which almost every digitiser is fitted) were used, but as draughtsmen are seldom trained typists, the data collected was error-prone. In addition the rate of output was low since, having digitised the position using the cursor, the operator had then to turn to the keyboard.

Other alternatives are available. Numeric thumbswitches, whilst having a built-in data check facility, still take time to set. Other approaches include raster scanning and displays with read-only memories. However the most appropriate solution to date appears to be voice recognition.

In the system developed by Ferranti and EMI Threshold, the operator places the digitiser cursor on the sounding's position and speaks the sounding values into a microphone, e.g. TWO, THREE, FIVE — for 23.5 metres. The value is displayed if required, for checking purposes, and the operator says "GO" or "NEXT", to output the sounding value and position coordinates. Throughput is increased, as is accuracy. There is no need for the operator to turn away from the cursor to a keyboard, and the error rate is negligible. In practice, the operator seldom uses the visual display for checking. The system is already in production use with the U.K. Hydrographic Department, and it should be noted that it is independent of language or dialect.

Symbols

Lighthouses, wrecks and buoys, all represented by symbols, abound on charts; and these must be recorded both by position coordinates and by a symbol shape (which in many cases includes text).

The menu card has come to be the recognised method for entering symbolic data and the speed of cursor movement in the present solid state digitisers, together with the lack of moving parts which could wear out, has made a significant contribution to the effective use of menu card techniques. The use of menus also partly caused the requirement for an additional button on the digitiser cursor — to repeat the last menu instruction — a simple way of improving the ergonomics of menu card usage. (It must be noted that the use of menu cards and symbol/macro techniques involves the use of software symbol libraries and menu decode programs at the computing stage).

Text

The biggest problem in "text" is accuracy. Any automated system is only as good as the data which is fed into it and, like soundings, text recording suffers not only from the fact that draughtsmen are not trained typists, but that "text" has an alphabet of 26 letters (52 if both capitals and lower case) and words of indefinite length. For this reason, the 32 character display was developed, so that text typed in from a keyboard could be verified and, if necessary, amended prior to output from the digitiser (fig. 4).

It may be noted that other items of data on a chart are borders and lattices. These are not normally digitised but are directly computed and then plotted.

It would not be right to leave the subject of data entry by digitising without some mention of digitising accuracies for point and line data. It is now generally accepted that a resolution of 0.025 mm and an accuracy of 0.1 mm is satisfactory for cartographic and hydrographic work.

FIG. 4. — Keyboard with 32-character display.

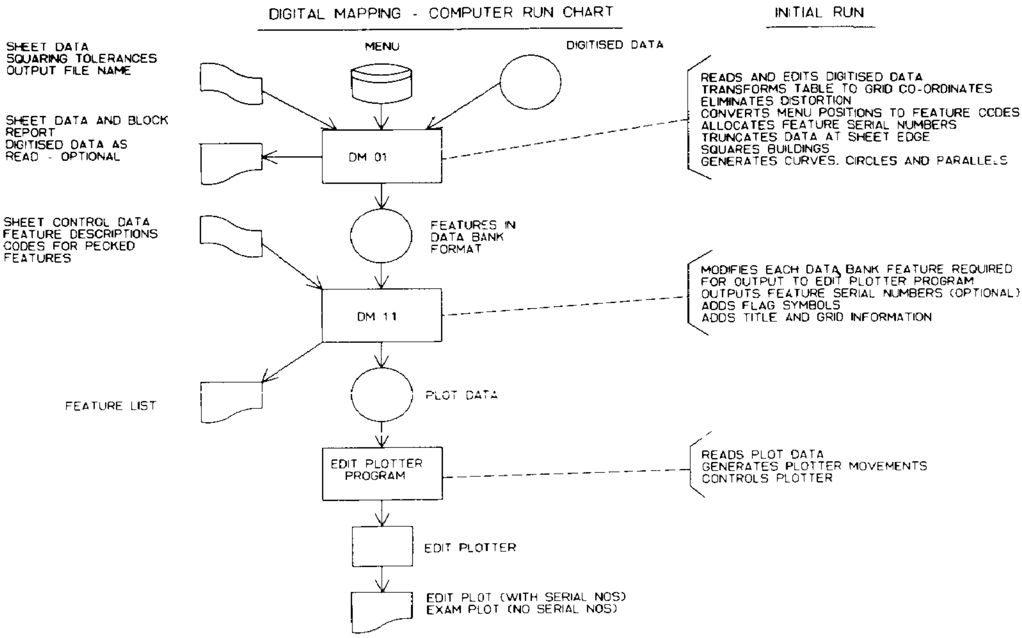


FIG. 5. — Ordnance Survey Digital Mapping System (UK).
Simplified diagram — Initial run.

COMPUTING

GARDINER-HILL [2] of the British Ordnance Survey has given four reasons for digital mapping :

1) It is easy to up-date any part of the information without destroying the remainder and without destroying any of the user's own information which has been added to the databank.
2) Within reason the data may be drawn at any scale.
3) For any particular map or chart only those classes of detail which are relevant to the specific purpose need be drawn.
4) The user has the facility to draw out a map of the exact area he requires, independent of sheet lines.

A fifth reason might well be the compact storage of map data : e.g. up to 40 sheets of 1:1250 scale maps on a single magnetic tape.

The Digital Mapping System of the Ordnance Survey is an excellent example of a flow-line production system using batch data-processing techniques and based on a central main-frame computer. It utilises off-line editing, where the plotter output is overlaid with the original sheet. Feature serial numbers, given to each feature automatically by the computer, are used for the identification of features to be edited. A three-part database concept is used whereby any feature is given :

a) a feature code or codes — which can be used for data selection for various types of map drawn at the same scale, and for filtering of data for derived mapping at smaller scales;

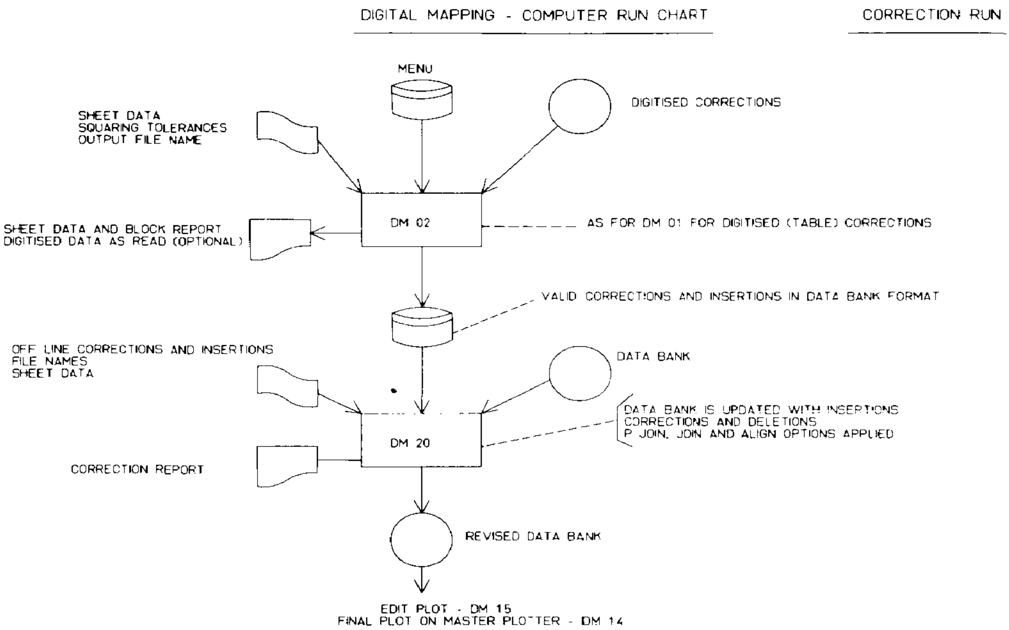


FIG. 6. — Ordnance Survey Digital Mapping System (UK). Simplified diagram — Correction run.

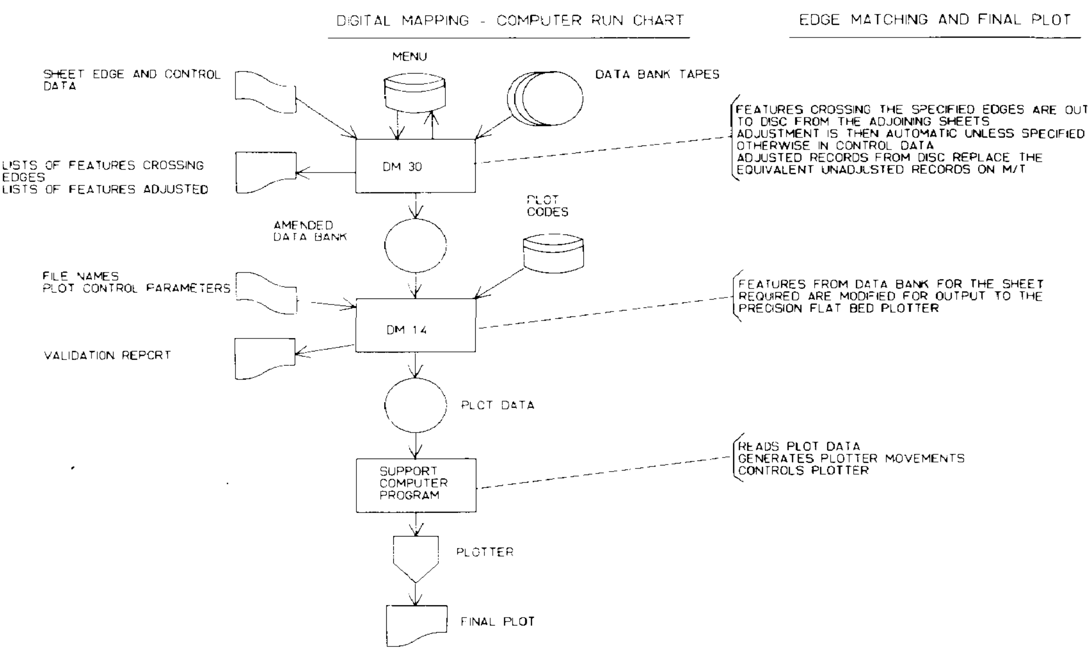


FIG. 7. — Ordnance Survey Digital Mapping System (UK). Simplified diagram — Edge matching and Final plot.

b) a feature serial number — used in editing and identifying a specific instance of a feature;
c) the graphical coordinate data of the feature.

This system produces both a "clean" database and selective output for plotting. Up-dating is similar to editing and is carried out by identifying the serial number of the feature to be changed and substituting new data for old in a separate computer run.

However, in some cases editing with a long turnround, due to main frame computer processing, is unacceptable and this, together with the need to input data at different scales and visually verify, edit and compile the data, has created the need for the Interactive Work Station.

INTERACTIVE COMPUTING AND EDITING

An interactive work station, such as the Ferranti Freedraft System (figs 8-11), generally consists of a digitiser, a mini-computer with both core and disc storage, and a graphics controller and display. It is able to accept input from its own digitiser, an off-line digitiser (via the medium of paper or magnetic tape) or from an existing database tape.

Facilities generally available include :

i) general graphics facilities such as scaling, rotation, macro and symbol libraries, various types of line patterns (e.g. dotted, dashed, solid, chain dotted), software text and windowing of data;
ii) mathematical facilities such as de-skew (to compensate for paper stretch); an input transformation to handle squareness and change coordinates to lat/long or other coordinate systems; curve fitting, and hatching.

However, its main ability is to Edit. Earlier in this paper it was stated that databases generally contain data in the form of features. The basic principle of editing a feature takes place by the operator displaying the features to be edited on the display screen. A flashing cursor on the display is positioned, using the digitiser cursor, on to any drawn part of the feature. On probing a point on the feature, the system searches the computer file until the feature is found and then a marker is placed on the screen to show it has been detected. The feature can then be deleted or amended.

This method of editing is perhaps the main advantage of the Freedraft system, as the operator is able to edit data without having to either refer to listings or have a knowledge of computer files. This is particularly important as draughtsmen tend to think graphically and will show a better accuracy if they don't have to worry about non-graphical items.

The ability to detect and edit a feature is, however, only the starting point, and several facilities of specific use in chart compilation have been added. These are :

Relocate :	which amends the absolute position of the feature. Useful if, for example, a buoy's position but not type has been changed.

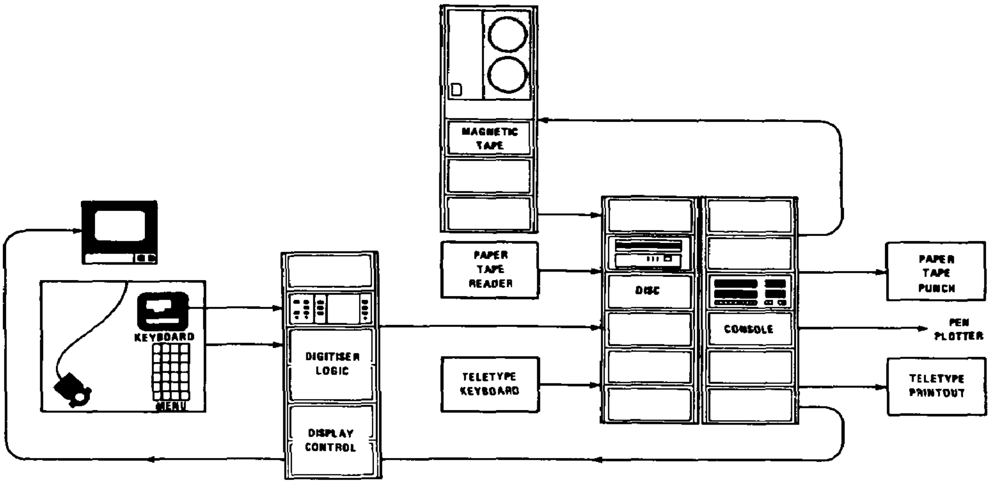


FIG. 8. — Ferranti Freedraft — System configuration.

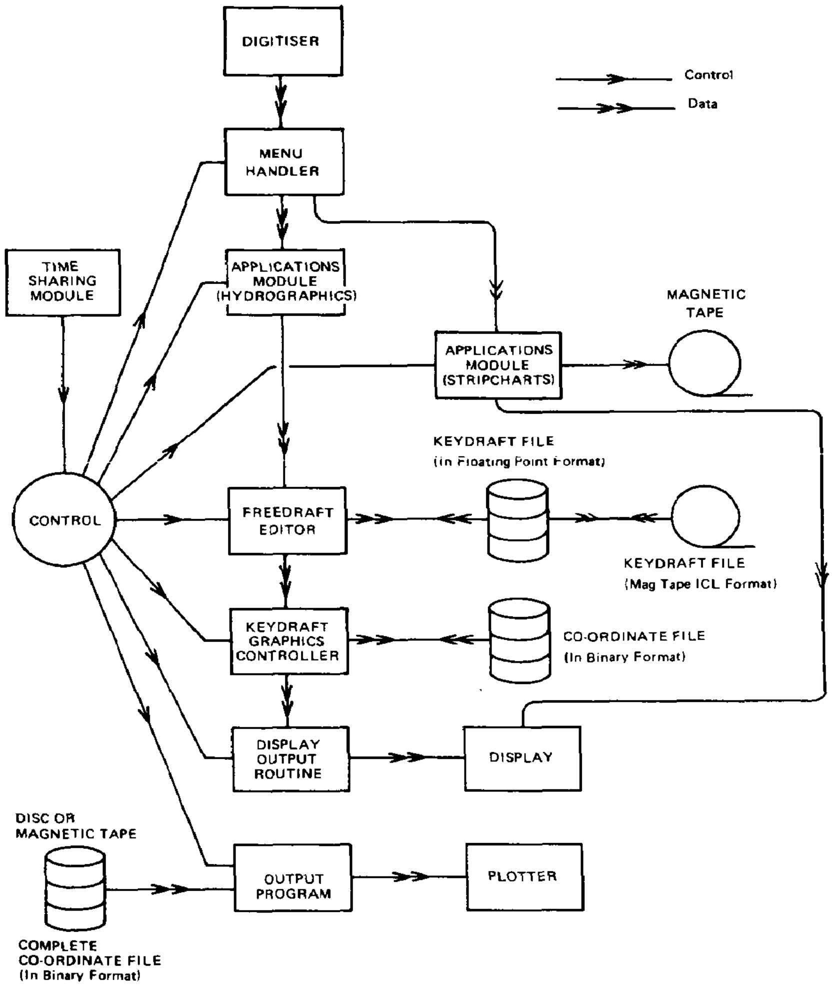


FIG. 9. — Ferranti Freedraft — System flowchart.

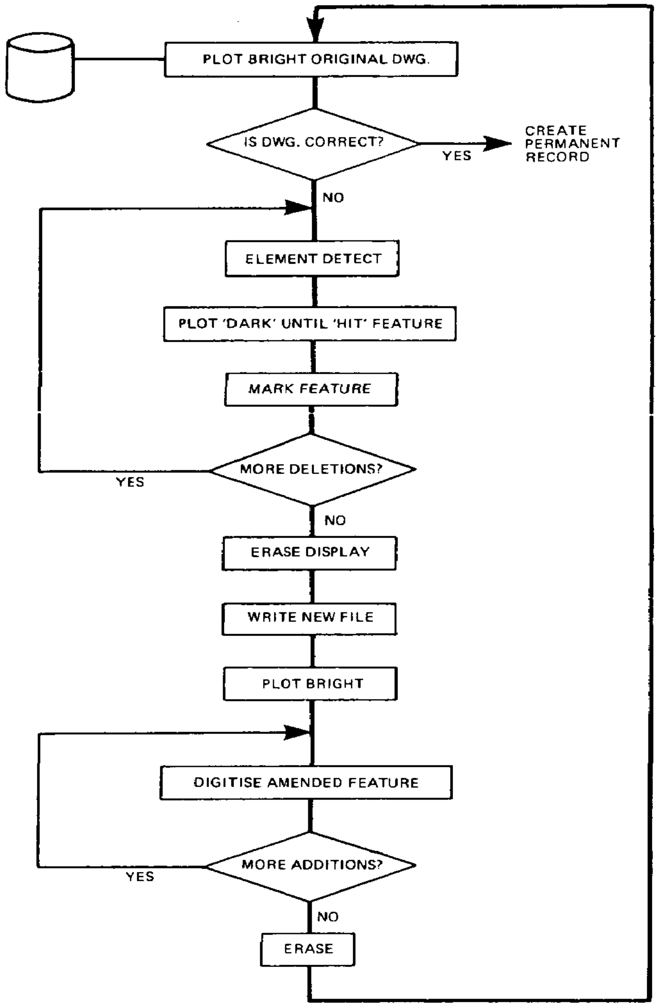


FIG. 10. — Ferranti Freedraft — Editing flowchart.

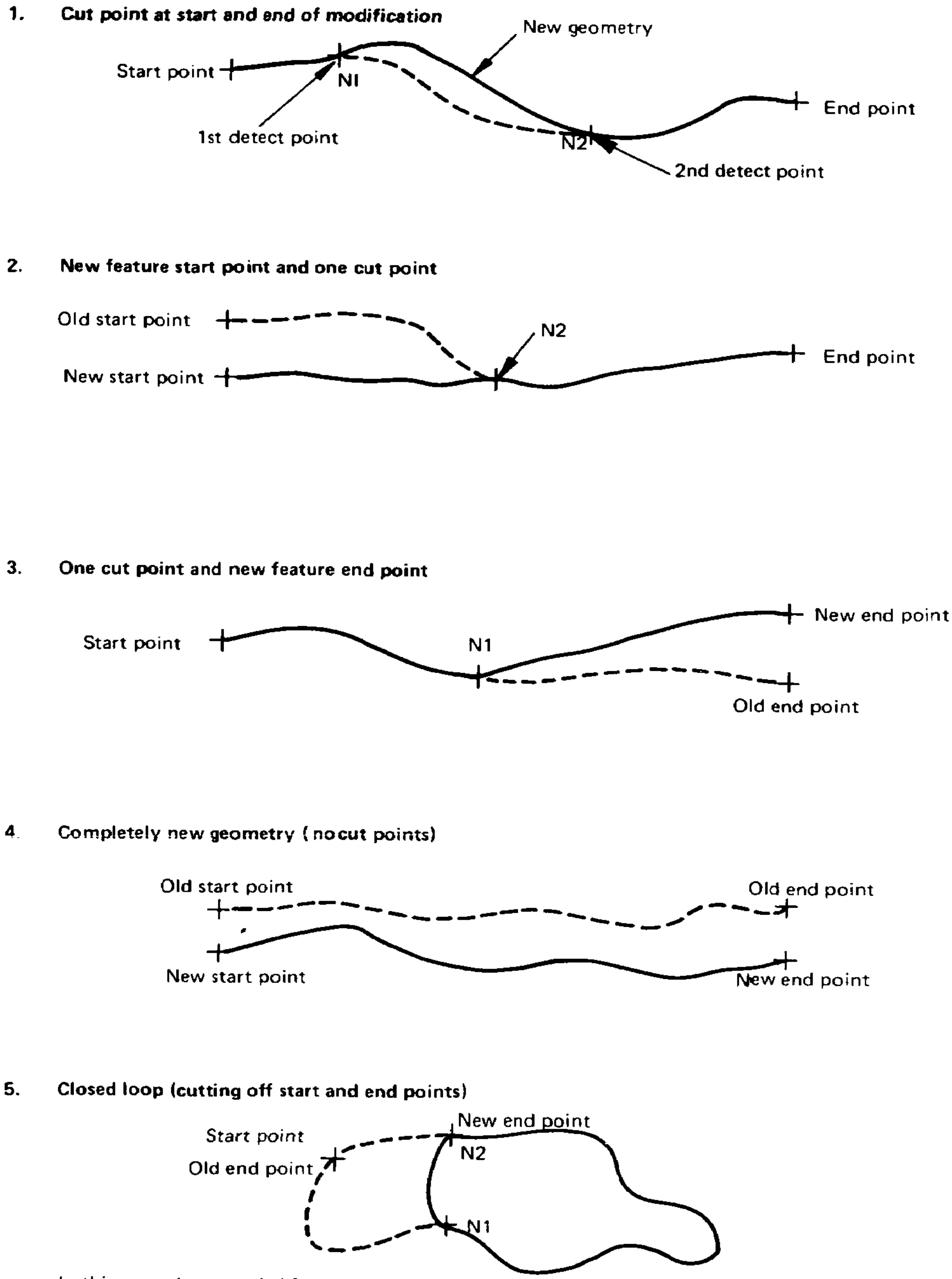
RELOCATE RELATIVE : which allows one feature to be located relative to a second feature. If, subsequently, the second feature is moved, the first will move with it.

MODIFY : which has several facilities on the menu card, as shown in fig. 3 of [1].

It will be noted that the above facilities all deal with position or coordinate data. What happens, for example, if a buoy is replaced by another with different characteristics ? The REDEFINE facility enables the feature code pertaining to a particular feature to be displayed on a message area on the screen (with any associated text) and the code can then be amended without altering the position data.

Of particular interest should be the fact that in the system supplied to the U.K. Hydrographic Department, the feature codes and qualifiers are those used in the "Standard List of Symbols and Abbreviations" of the International Hydrographic Bureau.

A further facility in the use of the interactive system is its ability to WINDOW ("zoom") data to a greater size than the original, which assists enormously in closing loops and edge matching.



In this case, the amended feature will be located at the original start point but will include, as the first element, a dark move to the new start point.

FIG. 11. — Ferranti Freedraft — Editing facilities.

PLOTTING

It will be noted that both data collection and interactive editing are operator dependent. It is true to say that the plotting side of digital mapping and charting is much more automatic and less dependent on human intervention. Over the years both the mechanical and electronic facilities on automated draughting machines have become extremely reliable, and at some establishments it is usual to leave the plotter working into the night completely unattended.

One of the main developments which enabled this to happen was the multi-aperture light spot projector, which draws with a light beam on photographic film (fig. 12). This gets over the problems of pens running dry and swarf removal if scribing. Facilities are also available for flashing symbols, text (if non-monoline), symbol rotation and tangential steering.

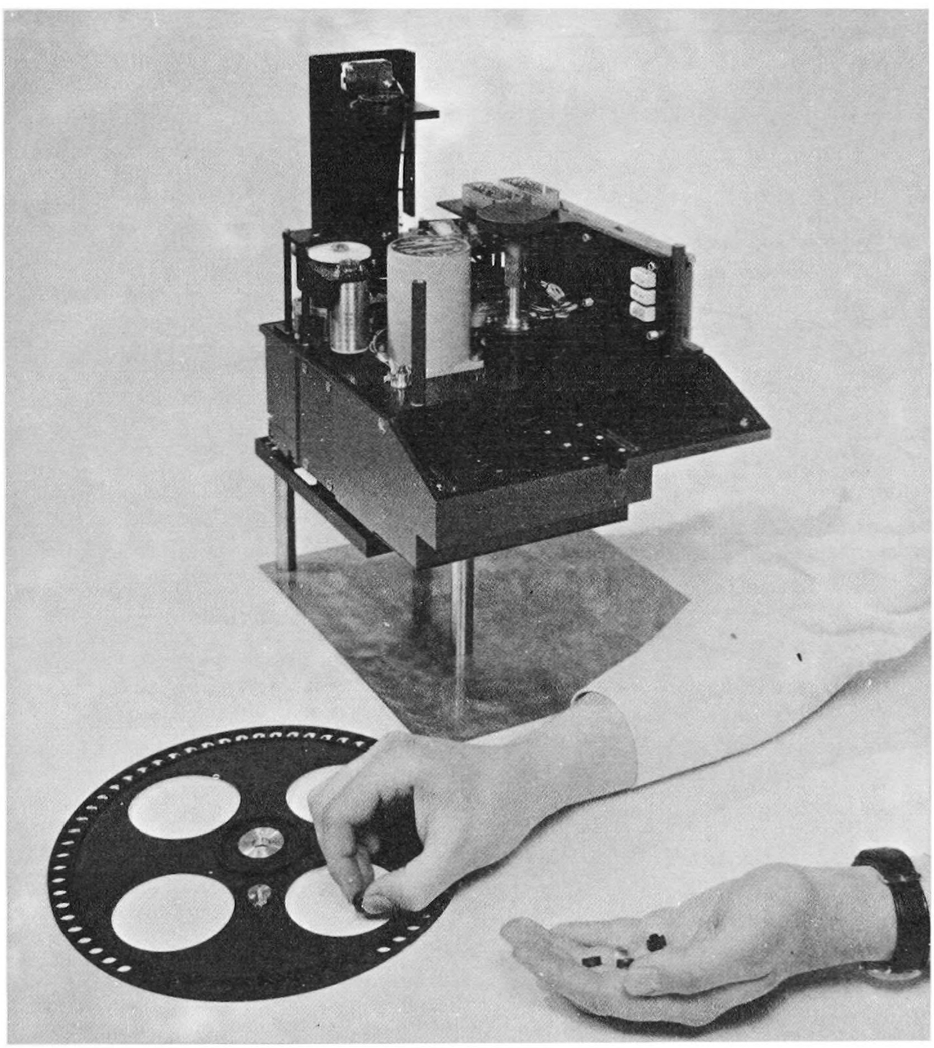


Fig. 12. — Light spot projector.

Use of a plotter in this manner implies that input data will be "clean", i.e. error free, which should be no problem if the editing facilities previously described are in use.

The other main step forward in plotting is in the use of a support computer close to the plotter. Current database thinking in computer graphics is that a database should contain data, not drawing parameters and instructions. Using a support computer makes this possible, as drawing instructions can be decided at run time. With the use of a powerful software package such as Ferranti Modular Plotting Software, the following advantages are obtained :

a) The concept of a data tape with local plot control means that it is not necessary to reprocess through a main frame computer to produce a series of map masters from one set of data;
b) In general, the data is processed in real time, and in a single pass;
c) The mechanical characteristics of the system are such that a high throughput of very high quality masters is obtained;
d) It is unnecessary to consider all map drawing specifications at time of basic data input. Provided features can be identified, drawing specifications can be drawn up just prior to plotting;
e) As the system handles drawing specifications, it is not necessary to store expanded data for text, interpolated curves, etc. i.e. only real data need be contained in the data base;
f) Changes in drawing specifications can be implemented without disturbing the database;
g) Direct input from digitisers and photogrammetric stereo-digitisers is possible without intermediate computing being necessary.

Additional advantages accruing are :

a) Simplification and time saving in coding before digitising;
b) Reduction in the volume of the digital database;
c) Easier implementation of changes in drawing specifications.

CONCLUSION

The various developments in hardware, software and techniques, some of which are described in this paper, illustrate that the use of automated methods in map and chart compilation has now passed the experimental phase and can be entered into with confidence.

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