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RESEARCH REPORT

No. 18

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THE PRODUCTION, IN REAL-TIME, OF A RAINFALL FIELD COVERING A LARGE AREA, USING DATA FROM SEVERAL WEATHER RADARS

MALVERN, ROYAL SIGNALS AND RADAR
ESTABLISHMENT, METEOROLOGICAL OFFICE
RADAR RESEARCH LABORATORY.

Research Report No.18.

The production, in real-time, of a rainfall field covering a large area, using data from several weather radars. By LARKE,P.R. and COLLIER,C.G.

Malvern,R.Signals Radar Est.,Met.Off. Radar Res.Rep.No.18,1980,30cm.Pp.14.App.22. 23 Refs.

An unofficial document - restriction on ~~first page~~ Front cover to be observed.

1 INTRODUCTION

One of the principal aims of the Meteorological Office Short-Period Weather Forecasting Pilot Project, which began in 1978, has been stated by Browning (1977) as:

> To establish and operate facilities to provide mesoscale observational fields of cloud and precipitation (albeit at first over only a part of the country in the case of some of the data); and, in the light of practical experience, to optimise the accuracy, reliability, and the clarity and timeliness of presentation of the data.

This report describes the software which has been written in order to go part way to achieving this Project aim by enabling a rainfall field covering a large area to be produced, in near real-time, using data from, initially, four weather radar sites. Collier (1980b) has described the data processing undertaken within the Pilot Project as a whole.

The use of radar to measure areal rainfall quantitatively has been established over many years (for a review see Browning, 1978). However, it was only in the last decade that techniques were developed enabling a network of weather radars to be operated economically, such that users of the data could receive it in near real-time in a form which might be easily assimilated. Improvements in two areas of primary importance opened the way for such a development,namely the increased flexibility produced by digital (as opposed to analogue) techniques of processing radar data, and improvements in digital communications and data display systems.

Taylor and Browning (1974) have discussed these changes in technological environment, and described their effect upon the design of a prototype weather radar network in the United Kingdom. The initial network was based upon a system of radar data processing carried out in a minicomputer at each of a number of radar sites, and was a form of dispersed packet switched network (Taylor 1975a,b). A central minicomputer situated at the Royal Signals and Radar Establishment, Malvern, controlled the minicomputer at each radar site via Post Office DATEL 2400 baud private telephone lines. An operator at the central location could pass radar control commands and data between the various radar sites and the network centre. The processing carried out at the radar sites, which was guided by the analysis work undertaken as part of the Dee Weather Radar Project (Harrold et al, 1974), has been described by Ball et al (1976).

At the same time as the work in the United Kingdom was being carried out, similar work was being undertaken in the United States (the D/RADEX Project) (McGrew, 1972), Canada (Try, 1972), Russia (Chernikov, 1976) and in several other countries. However, the emphasis in most of these countries was more on single radar site operation as opposed to truly network operation, one notable exception being West Germany. In that country Breuer (1973) proposed a radar network system similar to the one suggested for the United Kingdom (Bulman and Browning, 1971, Water Resources Board, 1973) at the beginning of the 1970s.

Experience in displaying the data from several radars in real time together on one picture is limited. Work is presently being undertaken in several countries with networks of weather radars(Collier 1980a). Most of the work to date has been concerned with the off-line processing of data sets obtained during detailed research programs (Wilson, 1975, Hudlow and Patterson, 1979, Patterson et al, 1979). Much effort has been devoted to applying corrections to the individual radar site data for the effects of variations in Z:R relationship and radar calibration, attenuation through rain, water vapour and atmospheric oxygen, and incomplete filling of the radar beam at far ranges. These types of corrections have been regarded as essential by Taylor and Browning (1974) and Patterson et al (1979) before any attempt is made to combine the data from individual radars. Accordingly in the Pilot Project such corrections are carried out at the radar sites (Ball et al., 1979, Collier, 1980b). Further near real-time quality control will be possible at some central location, designated a Mesoscale Analysis Centre by Browning (1980).

2. THE BASIS OF THE RADAR NETWORK SOFTWARE

The radar network software to be discussed here, occupies a central position within the overall system described by Collier (1980b). Only passing references will be made to the other parts of the system; these will be the subject of further reports. A computer network, based on the DEC PDP-11 series of minicomputers, enables radar data to be transferred to a network centre computer in near real-time (Figure 1). The software described later in this report (section 3) resides within the network centre computer.

In order to receive data from several radar sites in real-time, it has been necessary to develop interrupt-driven software using a computer disc for temporary data storage. Such a requirement arose from the need to be able to receive data at Malvern at variable times so allowing the radar sites to function independently. The early work at the Royal Signals and Radar Establishment (RSRE) (Taylor, 1975, Ball et al, 1979) had demonstrated the feasibility of this task using a dispersed packet switched network system. However, the communication protocols involved in the RSRE work were complex due to the need to pass control commands to any of the radar sites from a central location, and pass commands between any of the sites themselves. The Pilot Project network involves the reception of data from several independently maintained radars including one that is part of a separate radar project, the North West Radar Project (Figure 1) (Collier et al, 1980). Ball et al (1979) therefore suggested that it was inappropriate to have facilities in the network software for controlling centrally the various radar sites and hence that the communications part of the software could be simplified, such that the network computer only 'listened' passively for data. Therefore the system would be based, at least initially, on simplex communications, using an error checking technique structured around an automatic repeat transmission of the data. These suggestions have been adopted by the Met. O.RRL.

The construction of a surface precipitation field over a wide area involves the combination of data from several radar sites. Distance weighting techniques have been used by some workers (Taylor, 1975, Ziegler, 1978, Patterson et al, 1979), but the methods tend to obscure discrepancies between data from different radars. Such discrepancies are due to differences in radar performance resulting from both meteorological and hardware effects. There is a need to quality control the radar data in near real-time, as described in the FRONTIERS strategy proposed by Browning (1979). Therefore clear cut boundaries between radars have been chosen in the Pilot Project to highlight any discrepancies in radar performance so that quality control procedures may be used to adjust the data in an appropriate way. The boundaries between the coverage of each radar site under different conditions of radar site availability (section 3.3) have been subjectively assessed as discussed in section 3.3. This assessment has been based upon the height of the radar beam above the surface at any location (Figure 2), and subjective analyses of the overlap regions between radars (examples are shown in Figure 3).

Within each boundary data are used from one radar only and there is no blending of data from different radars across these boundaries. The boundaries between the different radar sites under different conditions of data availability are shown in Figure 4.

3. THE RADAR NETWORK SOFTWARE

3.1 Overview

The software consists of two basic modules (detailed flow charts are contained in Larke (1980)(internal Met. O.RRL Report, OAG Rep No.48), and Appendix A to the present report).

(i) the network set up program which creates data lists, mnemonics for peripheral registers, site names etc, and invokes the running section which initializes flag values, data lists, hardware and software error traps, and interfaces ready for the network task.

(ii) Network taskmaster which is the baseload program for the compositing task. Each part of the compositing task is initiated by network taskmaster when appropriate.

The software tasks controlled from the network taskmaster, which is initiated from the set up program, in the order in which they occur in time, are as follows:-

Stage I:

Data are transmitted at 15 minutes intervals at present (HH, HH+15, HH+30, HH+45 where HH is a clock hour) from remote sites and the data reception routine is activated at these same time intervals.

Successful reception and transfer to disk of each site is flagged, and the next stage entered as soon as (usually within 4 minutes) all expected sites are received free from error (see section 3.2 for the error checking procedure) or, in the event of non-receipt or reception error of an expected site, after a data search period of 6 minutes.

Stage II:

The formation of the data composite. The 8-bit data are retrieved from disk if they are free from error. A selection of these data, dependent upon the availability of the radar site data, is extracted for input to the 128 x 128 (5 km grid) composite data array. Before considering another radar site the data from the site currently in the computer core is zero packed (see section 3.5) and archived on magnetic tape.

Stage III:

Formation and transmission of data for display purposes. A data format suitable for transmission to a Jasmin store (3 bit intensity levels) is produced from the composite fields and the data are passed to a local TV display and to other users (Ball et al, 1976).

Stage IV:

Data packs zeroes in the data stream and archives the data composite on magnetic tape (see section 3.5).

Stage V:

Initiation of the transmission of the packed, composite data array from the Network computer to the non-contiguous Display computer where these data are used in real time by a small team of forecasters.

Stage VI:

At all times, whether or not radar data are being composited, satellite data may also be received in the Network Computer, and stored on disk in similar fashion to radar data from a remote site. These data are retrieved and archived on magnetic tape at a time when sufficient data are received for a block. This is to allow reception of a quick succession of satellite transmissions.

3.2 <u>Data reception and error checking</u>

Data are transmitted from remote sites in 14 blocks, plus a file header which contains information pertinent to the radar data (see Larke, 1980, internal Met. O.RRL report, OAG Report No.48). Each data block consists of six "lines" containing 84 bytes from the 84 x 84 5 km grid array. A summation into a store of size 3 bytes (henceforth referred to as Block Check Character-BCC) of the values of these six lines (ie 504 bytes total) is carried out at the remote site. Each data block is preceded by a sequence of 3 ASCII 'B' (Begin) characters, 3 block numbers (decimal value 0-13), 3 BCC (3 byte) characters, and followed by 3 ASCII 'E' (End) characters making a total of 522 bytes. The 128 byte file header is preceded by 3 ASCII 'B' characters and followed by 3 ASCII 'L' (Last) characters.

The reception routine (through synchronous DP11 or DUP11 interfaces) is interrupt driven, so that whilst an interrupt from one site is being serviced another may occur. Each site is designated a table. These tables contain pointers, counters, flags etc particular to the relevant site. On receiving an interrupt, a pointer is set to the beginning of the table required. The interrupt servicing routines are re-entrant, and are therefore common to all radar reception interrupts. A double buffering system is employed so that as soon as one buffer is full the data it contains are transferred to the computer disk. Data subsequently received are placed in the other buffer until that buffer is filled, and then the data in the buffer are transferred to the disk whilst the first buffer is filled again.

The routine carries out a 2 of 3 comparability check on 'B', 'E', 'L' and BCC characters. As the 504 byte blocks of radar data are received a summation is carried out and the resultant value compared with the BCC value transmitted from the remote site. A successful comparison is flagged and if all other checks are validated, a 512 byte block consisting of Block Number x 2 + BCCx2 + 504 data bytes is written to disk. The repeated Block number and BCC bytes are not used at present except to fill out the block to 512 bytes (the DEC RS64 disk currently in use is organised in 128 byte blocks), but could be used in the future. File headers are not transferred to disk or error checked. A repeat transmission from remote sites allows data blocks which are in error to be received, hopefully free from error.

3.3 The production of the radar composite

This is accomplished by considering the individual sites in a strict order, together with knowledge of which other sites are available, so that the selection of data from each site may be made (see Larke, 1980). Each site, with the exception of Camborne because it is considered first, and all its data are accepted, has a number of lookup tables which contain the following information for each required "line" of remote site data.

(i) the required "line" number
(ii) first required element number
(iii) last required element number

The choice of tables depends upon the position the individual site occupies in the strict order in which sites are considered, and upon the availability of other sites.

Camborne is considered first so all its data are used except those outside the composite area. Figure 5 illustrates how part of the Camborne area lies outside the 128 x 128 5 km grid. Subsequently, some of these data may be overwritten depending upon site availability. This method, though increasing the time taken to composite, reduces the number of lookup tables (and hence computer core storage) which would otherwise be required if a set of lookup tables were held for every possible permutation of site availability.

For each site considered, the start points are fixed by West-East and North-South offsets for both composite and remote site arrays. The amount of data used from each remote site is fixed by the number of "lines" required. Figure 5 is an example of the composite picture so formed, using data from the four radars operating in January 1980. It shows that part of the Camborne area lies outside the 128 x 128 5 km grid.

3.4 Data Outputs

a) Transmission to local colour monitor display and to other users eg Gloucester Met. Office

The data must first be arranged in a form suitable for display on the colour monitor through a so-called Jasmin store (see Ball et al, 1976 for a description of this display system) which necessitates conversion to a 3-bit format, and the insertion of a legend eg Date, time etc. A detailed description of this format has been given by Ball et al (1976, 1979).

The conversion to "3 bit", "picture" data is carried out and stored in a separate part of computer core so that the most recent "picture" may be constantly transmitted. This enables the most up-to-date picture to be received at the earliest possible time in the event of a hardware failure at the user location, and line transmission errors (~ 1 bit in 10^5 bits) to be removed by reception of subsequent repeated pictures. The data stream also contains character sequences which control the operation of an audio tape recorder at the user terminal. This facility allows the user to record long sequences of pictures for replay on the display system.

b) Transmission to the Display computer

Composite data are received in the Display computer by the Forecasting Techniques Group of the Met. O.RRL to develop the FRONTIERS procedures. A greater degree of accuracy is required than the 3-bit (7 nonzero levels only) data can provide. Therefore, composite data are transmitted in packed (see section 3.5) 8-bit data format. These data are sent once only as soon as archiving on magnetic tape is completed. The usual delay from the nominal time of data collection to receipt in the Display computer is about four minutes.

The Display computer also receives, every half-an-hour, IR and VIS satellite data about 15 minutes after the nominal observation times. With the present system sequences of radar, satellite or satellite with overlayed radar data may be replayed at speeds up to almost four frames per second.

3.5 Archiving on magnetic tape

Radar data from remote sites are archived as a backup to those archived at the radar sites. Data from each radar site are read from disk into core, provided that they are free from error, and are used in the production of the radar composite. In order to reduce the wastage of magnetic tape, a data packing scheme is carried out at this point before being archived. The contents of grid squares beyond the designated maximum range (210 km) are discarded, and the remaining data scanned for sequences of 10 or more consecutive zero data bytes. Any of these sequences are packed, and the resultant data archived in a single block on magnetic tape, preceded by a block containing file header information applicable to the particular site.

Composite radar data are scanned for zero data byte strings, and packed (as above) before being archived on magnetic tape in as many 2048 byte blocks as are required, the last block less than 2048 bytes if necessary. The average saving of magnetic tape is about 70%.

4. FUTURE DEVELOPMENTS

At the time of writing, March 1980, four sites (Camborne, Upavon, Hameldon Hill and Clee Hill) are operating. Work is presently underway to optimize the boundaries between the radar sites used in producing the composite picture. The present suite of software would cater for up to six remote sites, and lends itself fairly easily to the addition of further radars up to about twelve. As sites are added some minor changes will be necessary, particularly to the information which is wholly site dependent eg West-East and North-South offsets and lookup tables for compositing. As more sites are added consideration will be given to increasing the area of the composite picture from 128 x 128,5 km squares to 256 x 256, 5 km squares.

The major constraints on further expansion ie beyond six radars and to a larger composite are:

a) Size of current computer disk: The DEC RS64 disk in use at present has a maximum capacity of 64 K words and it must store satellite as well as radar data. The present disk usage is as follows:

(i) Satellite data which are received in packed format,(but must allow for maximum) = 16K words

(ii) Data from each radar site = 4K words

Therefore the maximum possible number of sites which could be coped with under the present system = $\frac{(64-16)}{4}$ = 12 sites.

b) The timing of the interrupt routine controlling the reception of the radar data:

The maximum time taken in the interrupt routine, measured electronically, has been found to be 42Ø µsec, although a time as long as this occurred only rarely. At the reception rate of 2400 baud each byte takes $\frac{1000 \times 8 \text{ msec}}{2400}$ = 3.3 msec. Therefore assuming no delays because of higher priority interrupts elsewhere in the system, the maximum number of sites that the interrupt routine can cope with simultaneously when <u>all</u> the sites require the use of the interrupt routine for 420 µsec is about $\frac{3.3 \times 1000}{420}$ = approx. 8. Because the 420 µsec interrupt is only occasionally required it seems likely that a national network of say 12 radar sites could be adequately coped with for not less than about 99% of the time.

c) Size of computer core

At present the suite of software occupies all but 26440 bytes of the computer core. Therefore allowing 6440 (octal) bytes (ie 3220 words), say, for user stack and reserved vectors (ie system facilities) we may use 20000 (octal) bytes = 4K words for program expansion. At approximately 1K words per site, another 4 sites could be incorporated in the present computer ie a total of 10. It should be stressed however, that if the composite array is expanded (to 256 x 256, 5 km squares) to accommodate additional radar coverage then the following would be required:

(i) an additional 3 x 8K words computer core store for the 8-bit composite = 24K words

(ii) an additional 3 x 4K words computer store for 3-bit 'picture' data = 12K words.

A total of 36K words of extra core would thus be required to cope with a 256 x 256 composite array under the present software system, though savings could be made at the cost of some flexibility of the system, eg 3-bit 'picture' data could be stored in the same area as '8-bit' data, but could not be transmitted continually.

Individual radar site data are presently composited every 15 minutes. If it is demonstrated, in the future, that the radar site data need to be composited every 5 minutes, then only a few modifications will be required to the existing network software. However, if the additional data are to be archived such a change would reduce the length of time the archive magnetic tapes presently used last from about 48 hours to about 12 hours (assuming four radars). Non-trivial changes would also have to be made to the software at each individual radar site (except the Hameldon Hill site) in order to ensure that no radar data are input to the on-site computer during the transmissions to the network centre.

Also, software checks would have to be implemented to ensure that data which had been received at a time inappropriate to their nominal collection time would not be composited by the network computer. These changes to the radar site software would probably require at least an extra 4K words of computer core, and an accurate timing system independently powered from the rest of the radar site computer hardware.

5. CONCLUDING REMARKS

The software structure described in this report could form the basis of a future operational weather radar network. The present system has been running for about ten months (to March 1980) with almost 100% reliability of the networking aspects over the last three to four months. We conclude that it is possible to produce regularly, in real-time, a surface rainfall picture covering a wide area, from the data provided by several weather radars. The composite pictures produced are used in real-time by a team of forecasters, and used off-line for research involving detailed case studies. Experience during the Pilot Project will indicate where improvements ought to be made, and how the radar composite pictures should be combined with satellite and other more conventional meteorological data. Recently Browning (1980) has described one possible scenario regarding this data integration.

ACKNOWLEDGEMENTS

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REFERENCES

Ball, A.P., Clarke J.L., Davy B.D., O'Brien, M.J, Trigg, S.E, Taylor, B.C, and Voller T.A.	1976	"A system for the processing, transmission and remote display of data from a weather radar", RRE Memo. No.3020, RRE, Procurement Executive, MOD, August, unpublished report, 40 pp.
Ball, A.P, Clarke, J.L, O'Brien, M.J, Shaw, A.H, Trigg, S.E and Voller, T.A.	1979	"The design and implementation of an operational, computer-based weather radar system", RSRE Memo No.3151, RSRE, Procurement Executive, Unpublished report, 67 pp.
Breuer, L.J.	1973	"Weather radar as an important and economic meteorological sensor, and as a component of a future precipitation, Network", Offenback a.-M., D.Wettered. Ann. Met., N.F., Nr.6, pp121-129. (In German)
Browning, K.A.	1977	"The short-period weather-forecasting Pilot Project", Met.Office Radar Research Lab. Res.Report No 1, October, unpublished report.
	1978	"Meteorological applications of radar Rep.Prog.Phys., 41, No 5, May, pp761-806
	1979	"The FRONTIERS plan: a strategy for using radar and satellite imagery for very-short-range precipitation forecasting", Met. Mag., 108, pp161-184.
	1980	"Radar as part of an integrated system for measuring and forecasting rain in the UK: Progress and plans", to appear in the April issue of Weather.
Bulman, P.J, and Browning, K.A.	1971	"National Weather Radar Network" Unpublished Report, RRE, July 1971, 17pp.
Chernikov, A.A.	1976	"Progress in Radar-meteorology and the weather radar network", Moscow, Tsent. Aerol.Obs., T Vyp., 117, pp60-73. (In Russian) (Russian title: "Radar methods of observation and their prospects").

Collier, C.G. 1980a "A note concerning progress and plans for the establishment of operational networks of quantitative weather radars", Met. Mag. 181, pp 75-77.

1980b "Data processing in the Meteorological Office Short-Period Weather Forecasting Pilot Project", to appear in the June issue of Met. Mag.

Collier, C.G, Cole J.A, and Robertson, R.B. 1980 "The North West Weather Radar Project: the establishment of a weather radar system for hydrological forecasting", to appear in the Proceedings of the Int. Sym. on Hydrological Forecasting, 15-19 April 1980.

Harrold, T.W, English E.J. and Nicholass, C.A. 1974 "The accuracy of radar-derived rainfall measurements in hilly terrain", Quart, J.R. Met Soc., 100, pp331-350.

Hudlow, M.J. and Patterson, V.L. 1979 "GATE Radar Rainfall Atlas", NOAA Special Report, Center for Environmental Assessment Services, NOAA, US Dept of Commerce, Washington DC, 155 pp.

McGrew, W.H. 1972 "Project D/RADEX (Digitised Radar Experiments)" Reprints 15th Radar Met. Conf., Am Met Soc., Boston, pp101-106.

Patterson, V.L. Hudlow, M.D. Pytlowany, P.J., Richards F.P, and Hoff, J.D. 1979 "GATE radar rainfall processing system", NOAA Tech.Memo.ED15 26, Environmental Data and Information Service, NOAA, Washington DC, May, 34 pp.

Taylor, B.C. 1975a "A mini-network of weather radars", Proc. of 16th Conf. on Radar Met., Houston, Texas, Am Met Soc., Boston,pp361-363.

1975b "A system for real time processing and display of radar derived rainfall", Sym. on Weather Radar and Water Management, December, Paper 2, Water Research Centre, Medmenham.

Taylor, B.C. and Browning, K.A. 1974 "Towards an automated weather radar network", Weather, 29, pp202-216.

Try, E.F. 1972 "Remoting of CAPPI pictures by computer", Preprints of 15th Radar Met. Conf, Am Met Soc, Boston, pp189-192.

Water Resources Board 1973 "The use of a radar network for the measurement and quantitative forecasting of precipitation", Dee Weather Radar Project, Report by the Operations Systems Group, Water Resources Board, Meteorological Office, Plessey Radar Ltd.

Wilson, J.W. 1975 "Radar-gage precipitation measurement during the IFYGL", Final report to the Great Lakes Environmental Research Laboratory, NOAA, The Center for the Environment and Mon.Inc., Report 4177-540.

Ziegler, C.L. 1978 "A dual doppler variational objective analysis as applied to studies of convective storms", National Severe Storms Lab, Norman, Oklahoma, NOAA Environmental Research Laboratories, Tech. Memo ERL NSSL-85, November, 116 pp.

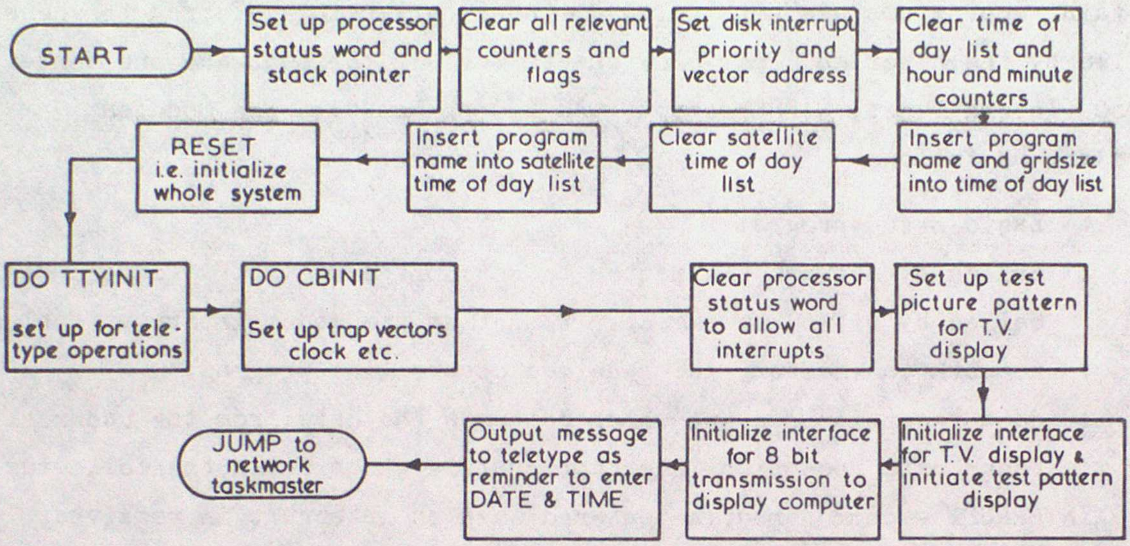
APPENDIX A

Software flow charts

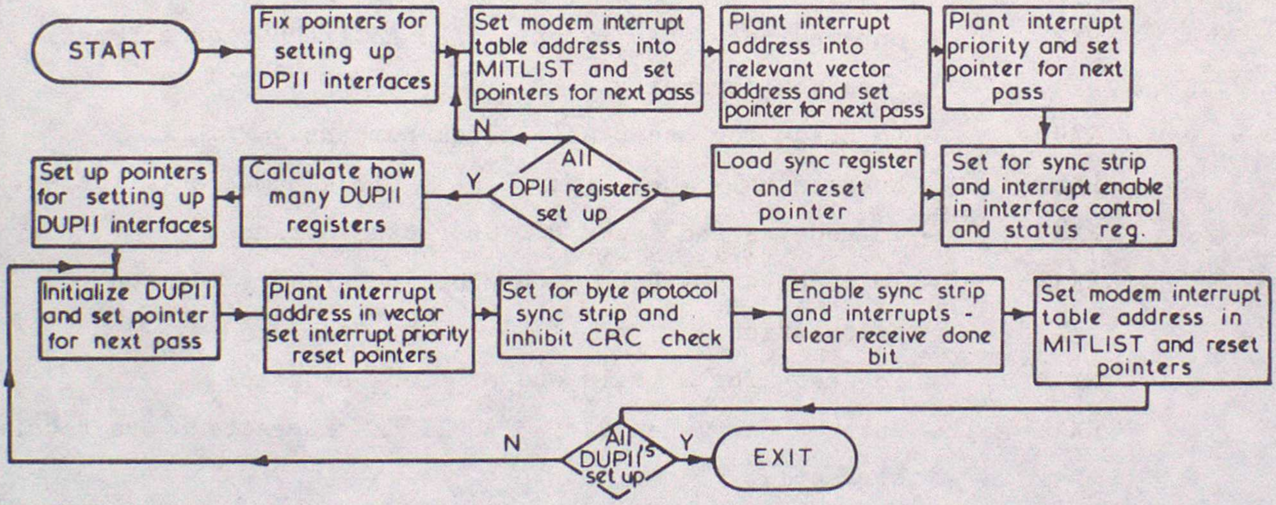
This appendix contains flow charts for the basic modules in the network software. However, certain subprograms are not included, these only being referred to where they are called by the other modules. Flow charts for all the software are contained in Larke (1980)(Internal Met. O.RRL report, OAG Report No.48). The modules included here are as follows:-

- NSETR : basic setup program
- RXINIT : called by network taskmaster to set up the DP11/DUP11 interfaces.
- RXSETUP : called by network taskmaster to set up the modem interrupt tables.
- NTASR : network taskmaster, the baseload controlling program.
- DATAIN : data reception routine which collects the data from the radar sites.
- NEXR : radar data reception interrupt routine which calls the following:-
  - RXINTERRUPT - common routine entered when an interrupt is received.
  - RXØ - to check for the validity of the beginning of the data block sequences.
  - RX2 - entered only when first 2 of 3 ASCII "B" characters received correctly.
  - RX4 - to check for acceptable block numbers.
  - RX6 - Entered only when first 2 of 3 block numbers validated.
  - RX8 - To receive and check BCC Character Strings.
  - RX1Ø - To receive 504 byte data blocks and carry out the BCC calculation.
  - RX12 - To check for a valid end of block sequence.
  - RX14 - Entered only when 2 of 3 ASCII "E" characters are received correctly.
  - RX16 - To receive file header.
  - RX18 - To check the last block sequence, and tidy up.
- NCOMR : primary compositing program.
- NETIR : secondary compositing program.

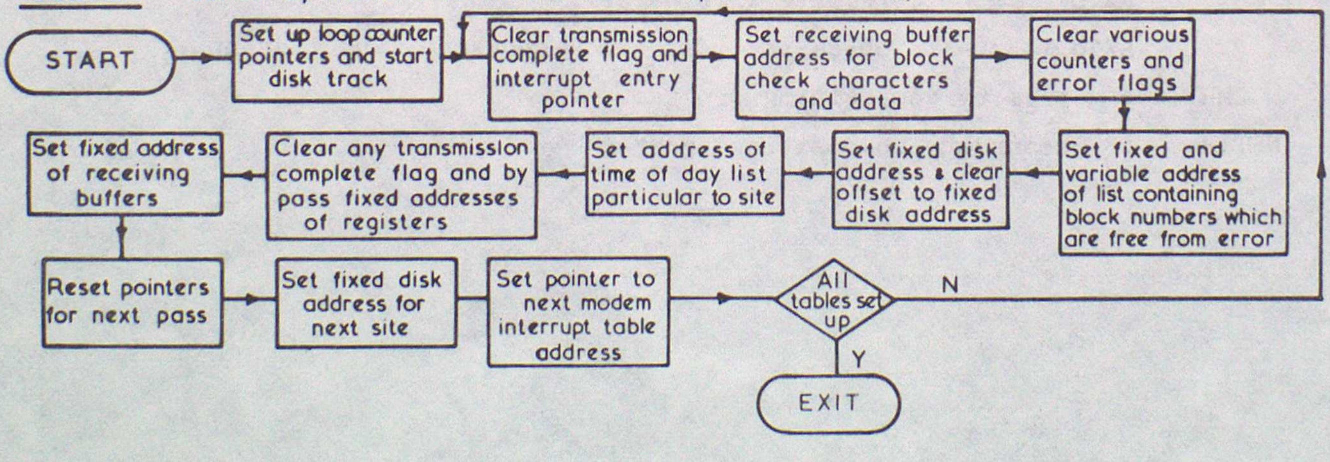
NETWORK SETUP PROGRAM NSETR



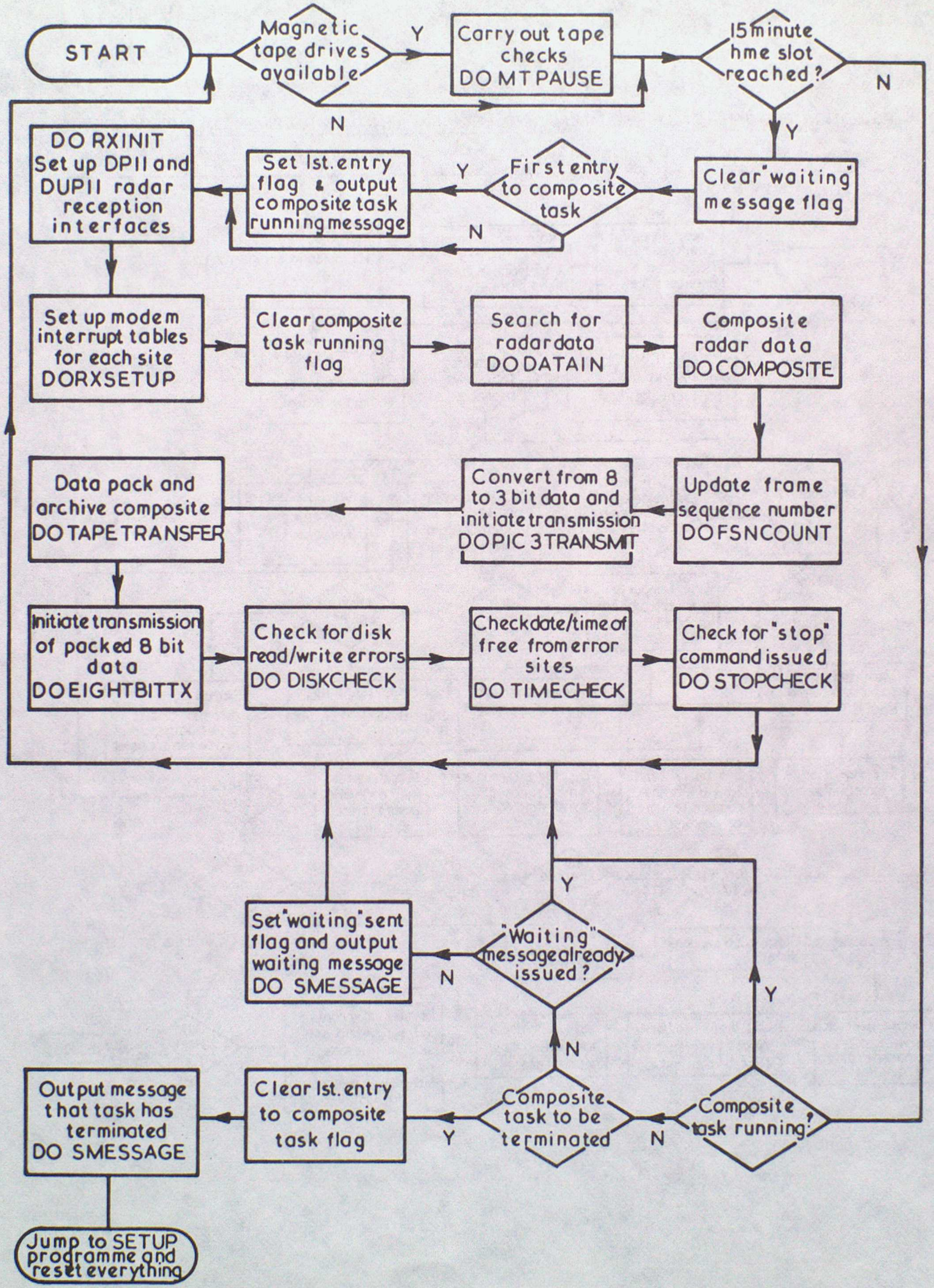
RXINIT: called by network taskmaster to set up for DP11 and DUP11 interfaces used for radar data reception



RXSETUP: called by network taskmaster to set up modem interrupt tables

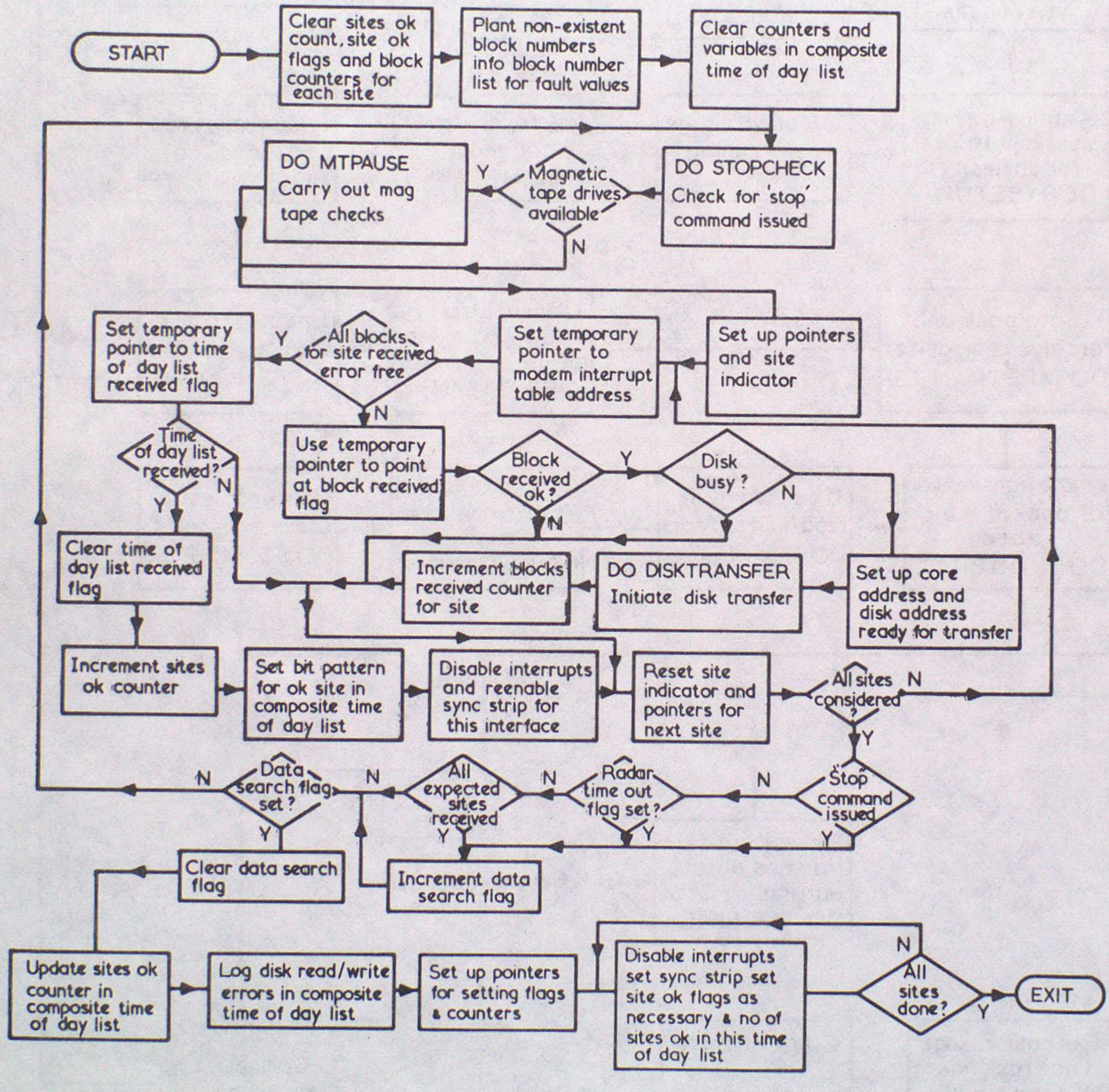


NETWORK TASKMASTER NTASR BASELOAD CONTROLLING PROGRAM



RECEPTION ROUTINE – CALLED BY TASKMASTER. LOOPS WHILST DATA RECEIVED ON INTERRUPT

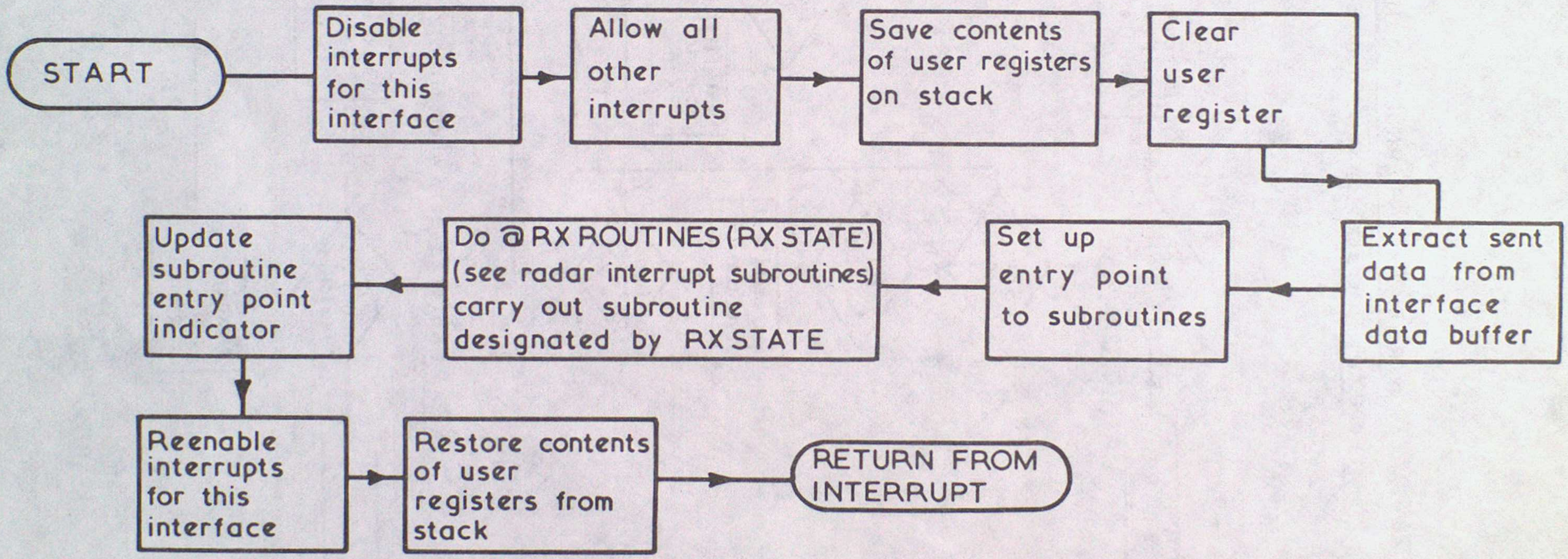
DATAIN:



RADAR RECEPTION INTERRUPT ROUTINE NRXR

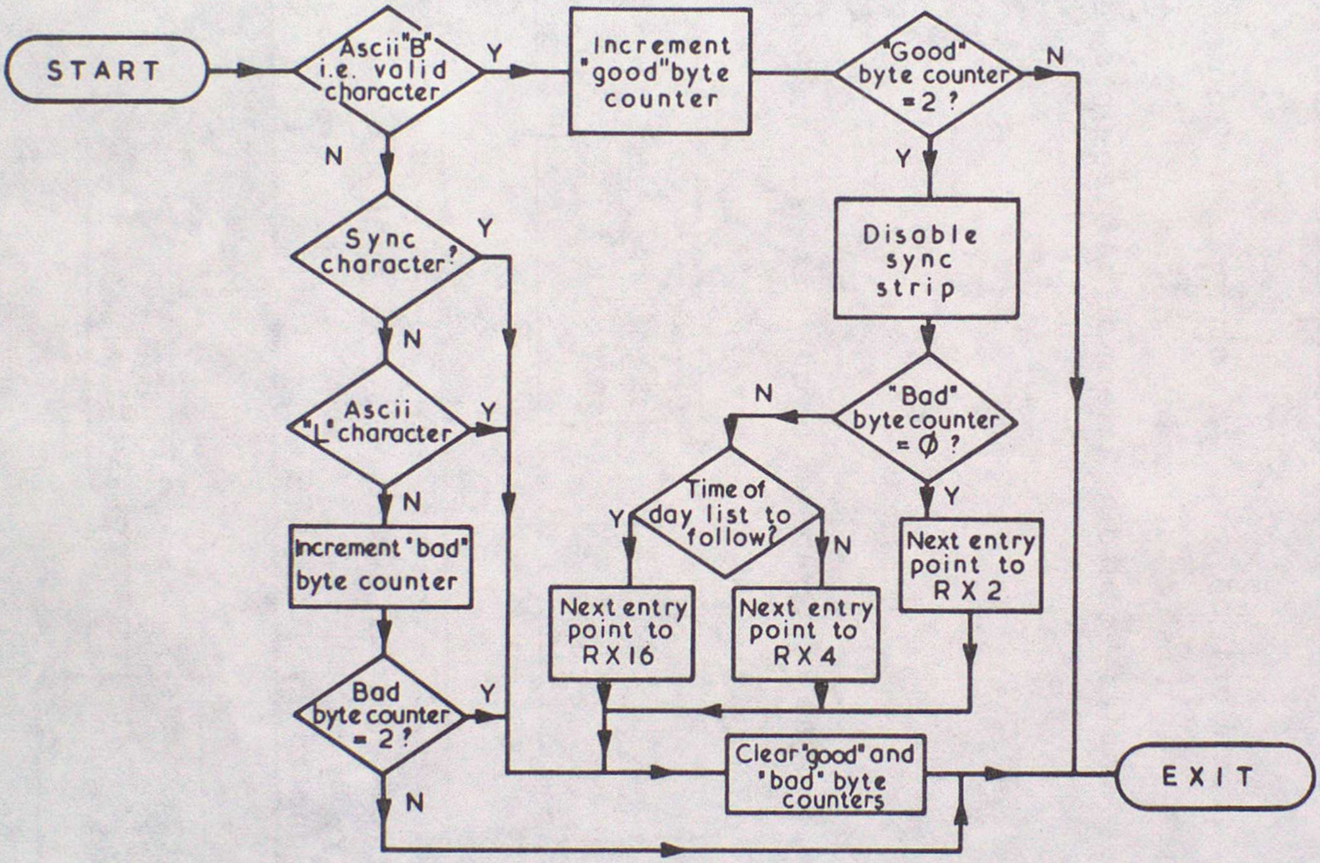
Entered at varies points dependant on site. A common reentrant section of code is then entered with a pointer set to a site dependant address - i.e. modem interrupt table start address. Modem interrupt tables contain information required by interrupt routine.

RX INTERRUPT: Common routine entered upon any receive interrupt

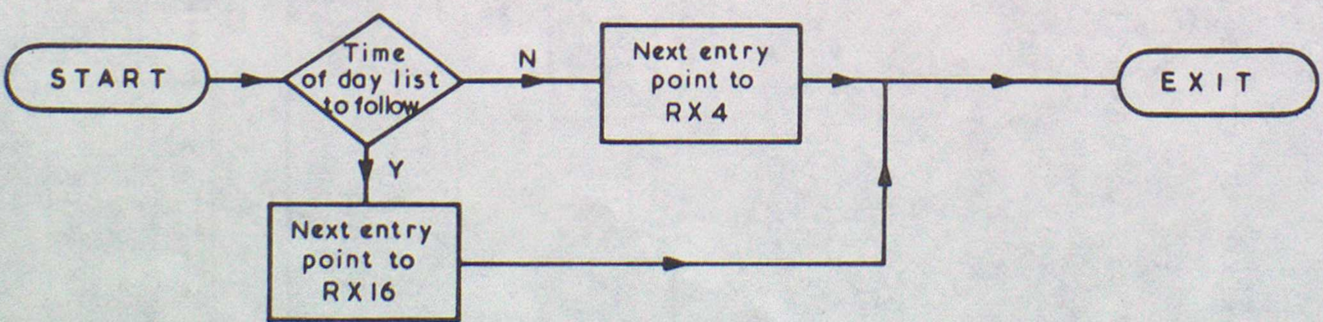


RADAR INTERRUPT SUBROUTINES

RXØ: To check for valid beginning of block sequence

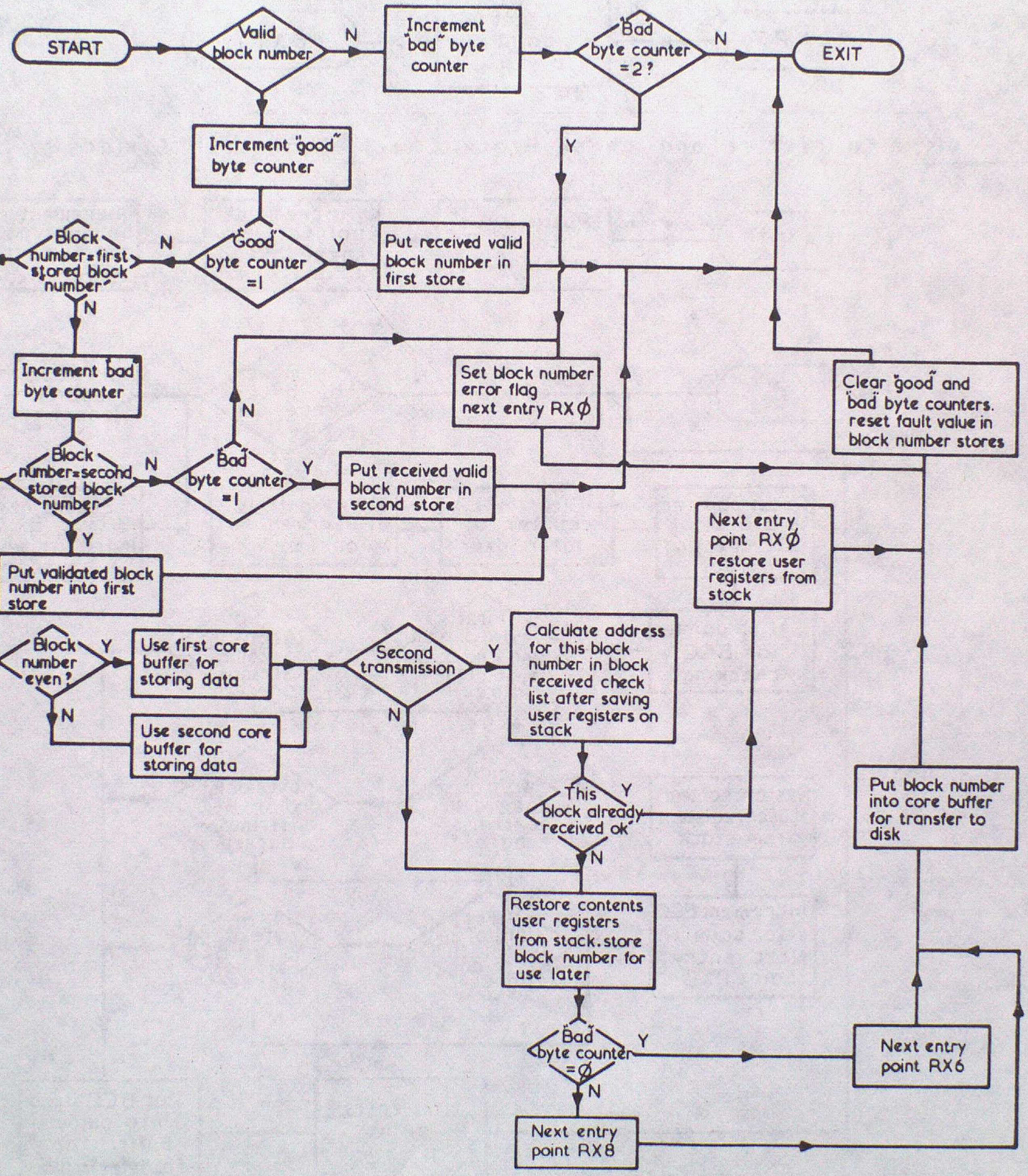


RX2: Entered only when first 2 of 3 Ascii received O.K.



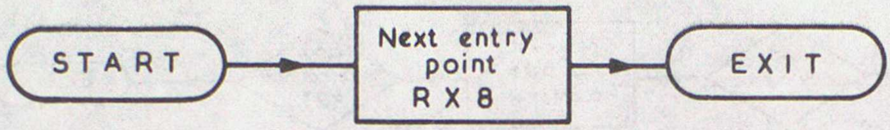
RADAR RECEPTION INTERRUPT SUBROUTINES cont.

RX4: To check for acceptable block numbers

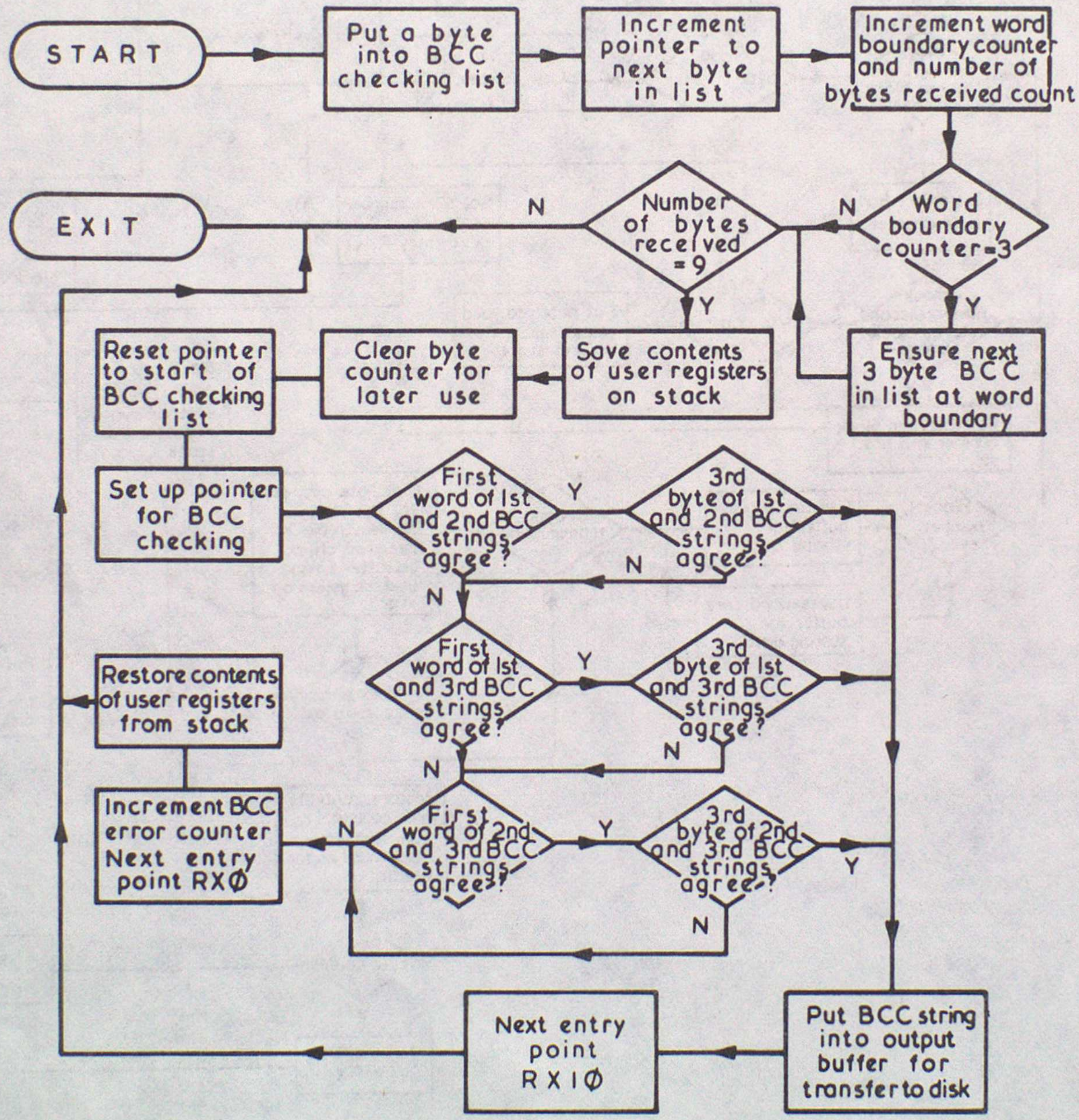


RADAR RECEPTION INTERRUPT SUBROUTINES cont.

RX6: Entered only when first 2 of 3 block numbers are validated.

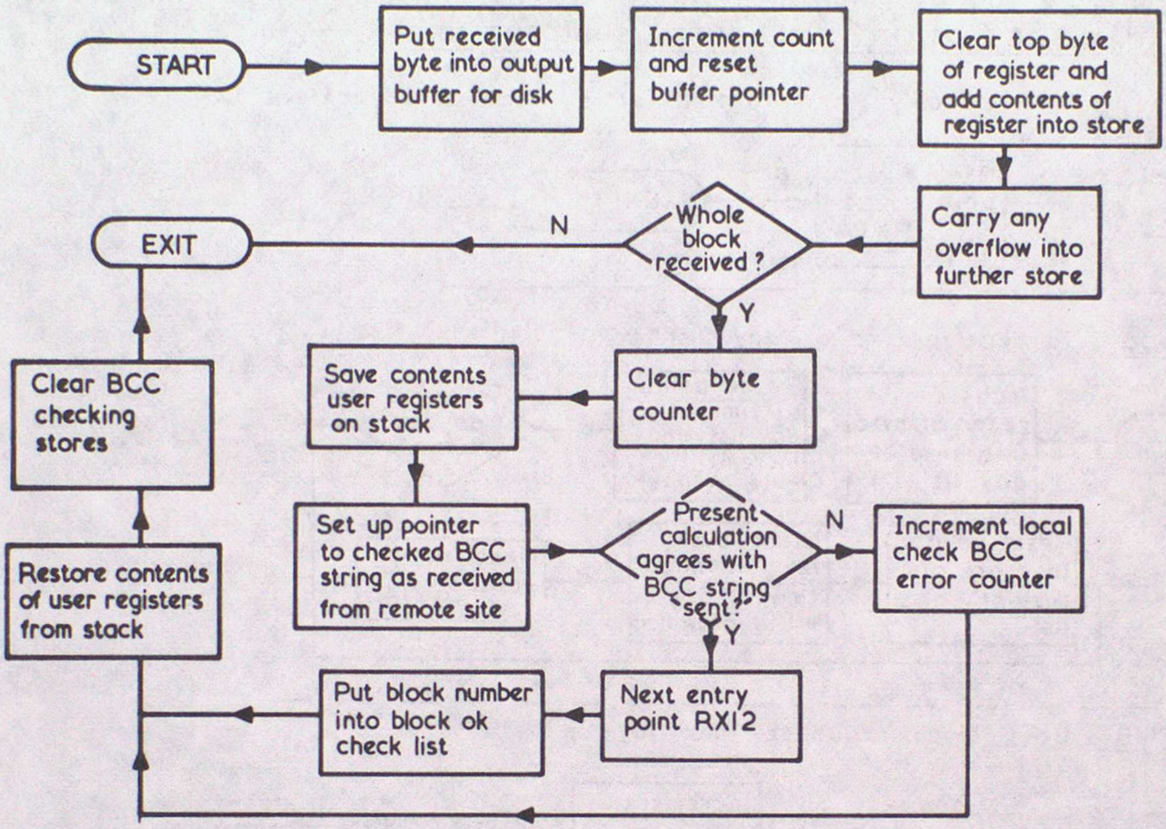


RX8: To receive and check Block Check Character Strings

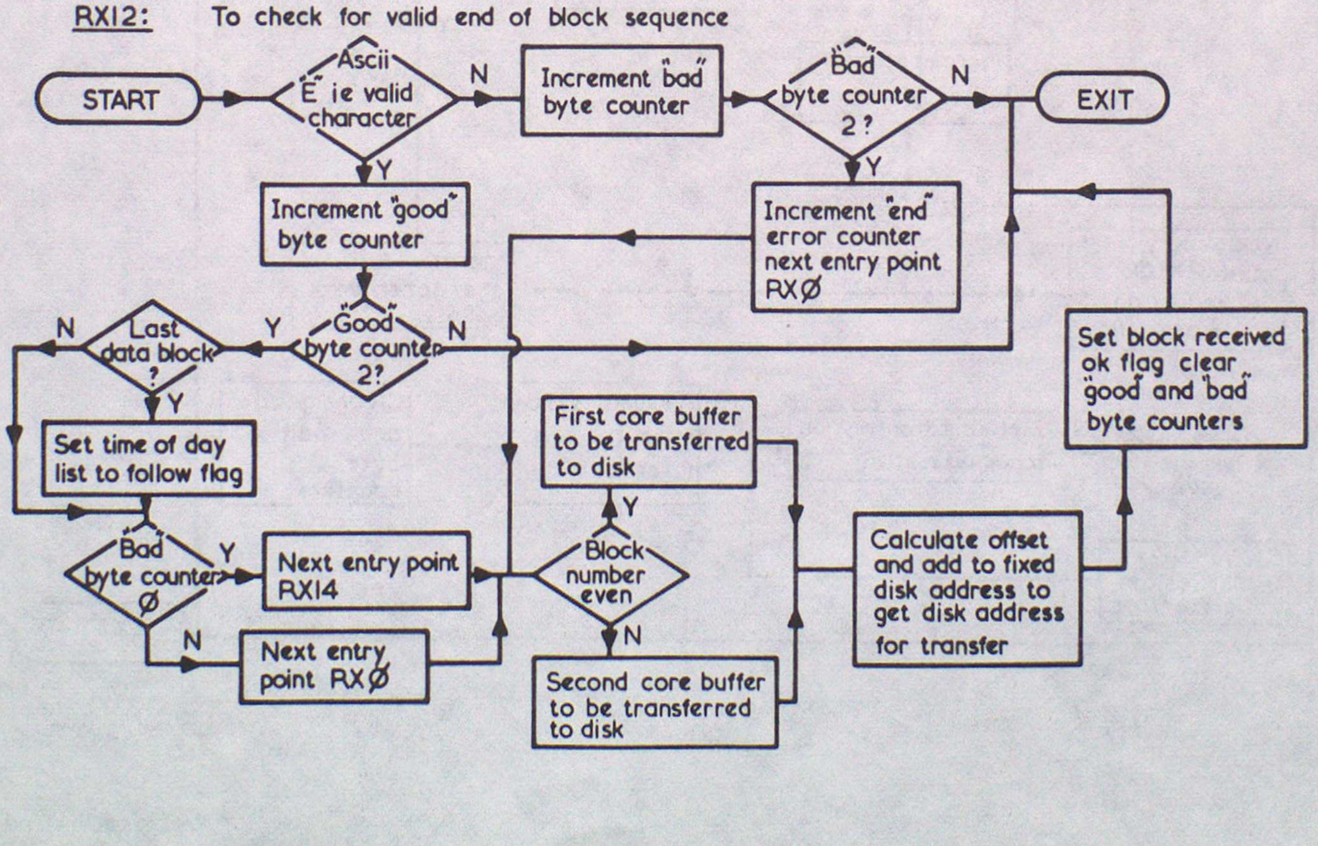


RADAR RECEPTION INTERRUPT SUBROUTINES cont.

RX10: To receive 504 byte data block and carry out BCC calculation

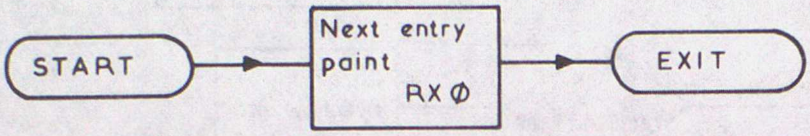


RX12: To check for valid end of block sequence

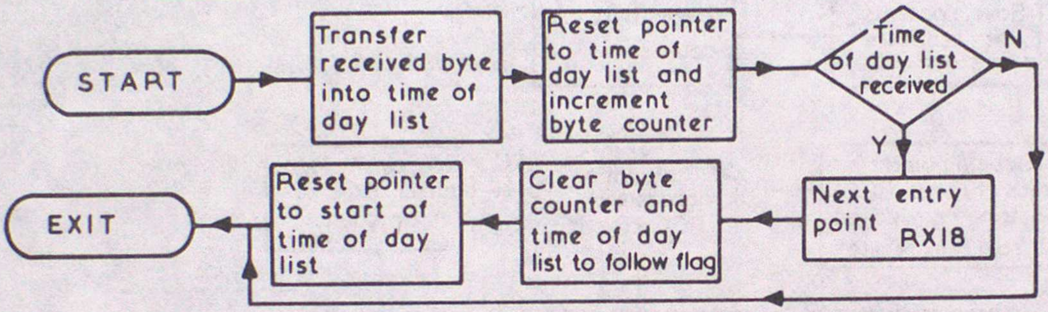


RADAR RECEPTION INTERRUPT SUBROUTINES

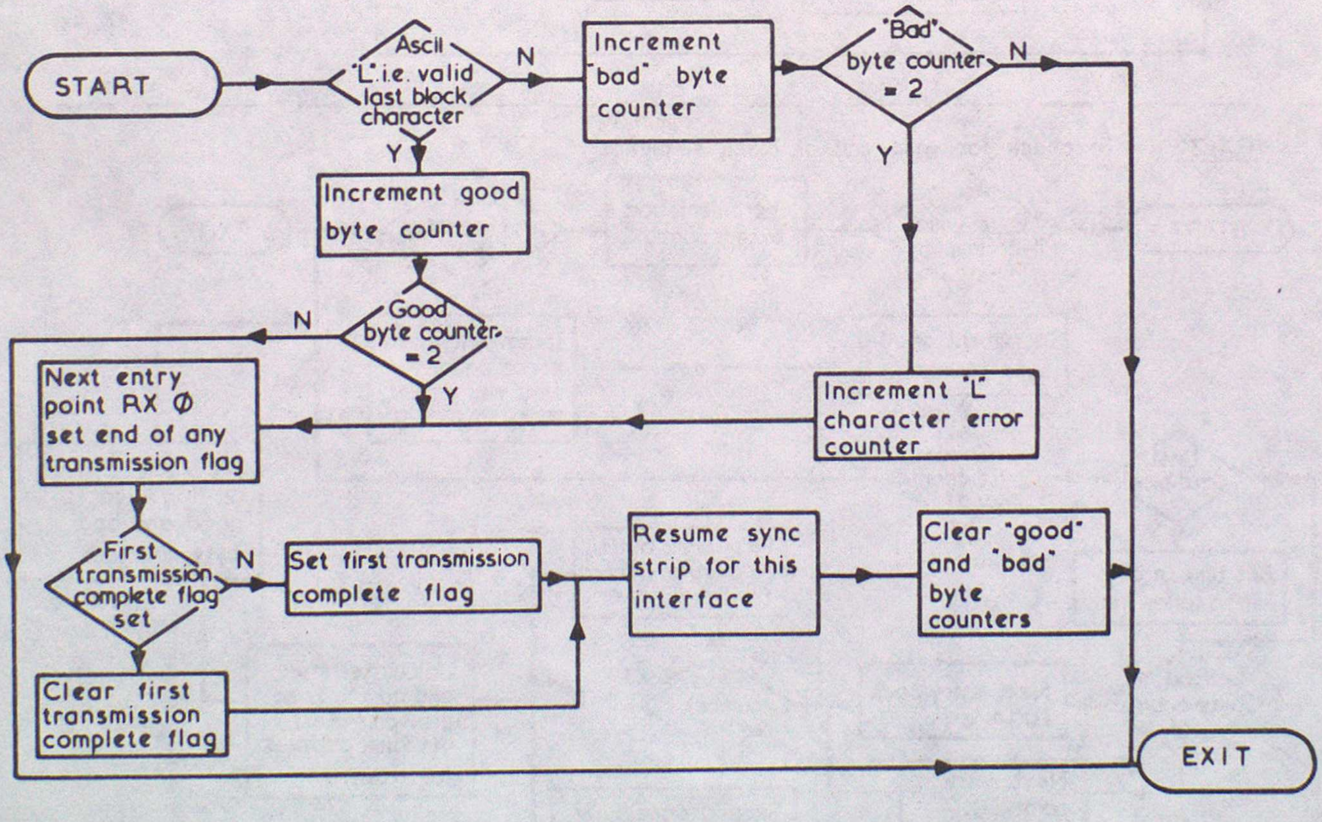
RX14: Entered only when first 2 of 3 Ascii "E"'s received O.K.



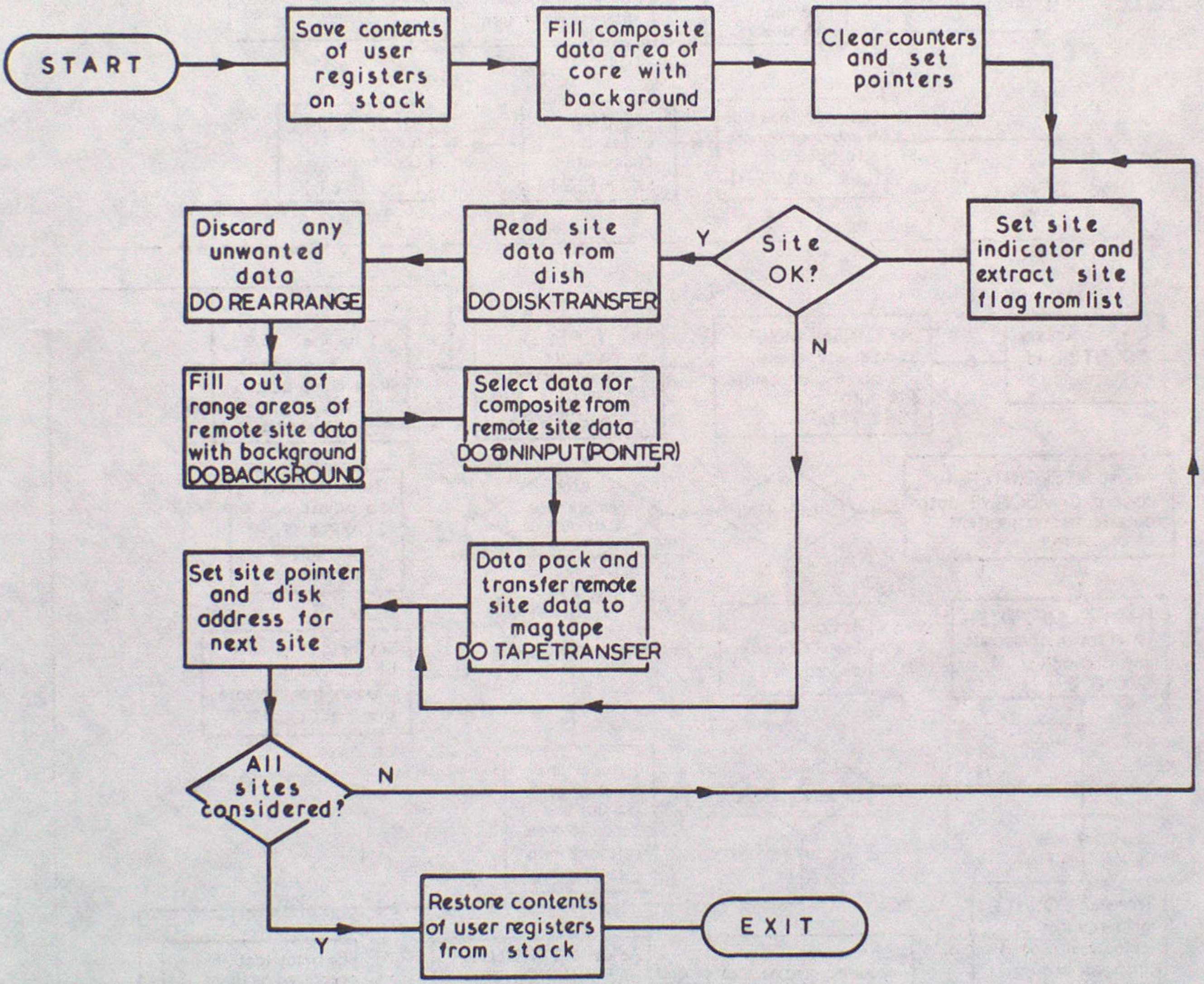
RX16: To receive time of day list.



RX18: Last block sequence and tidy up.

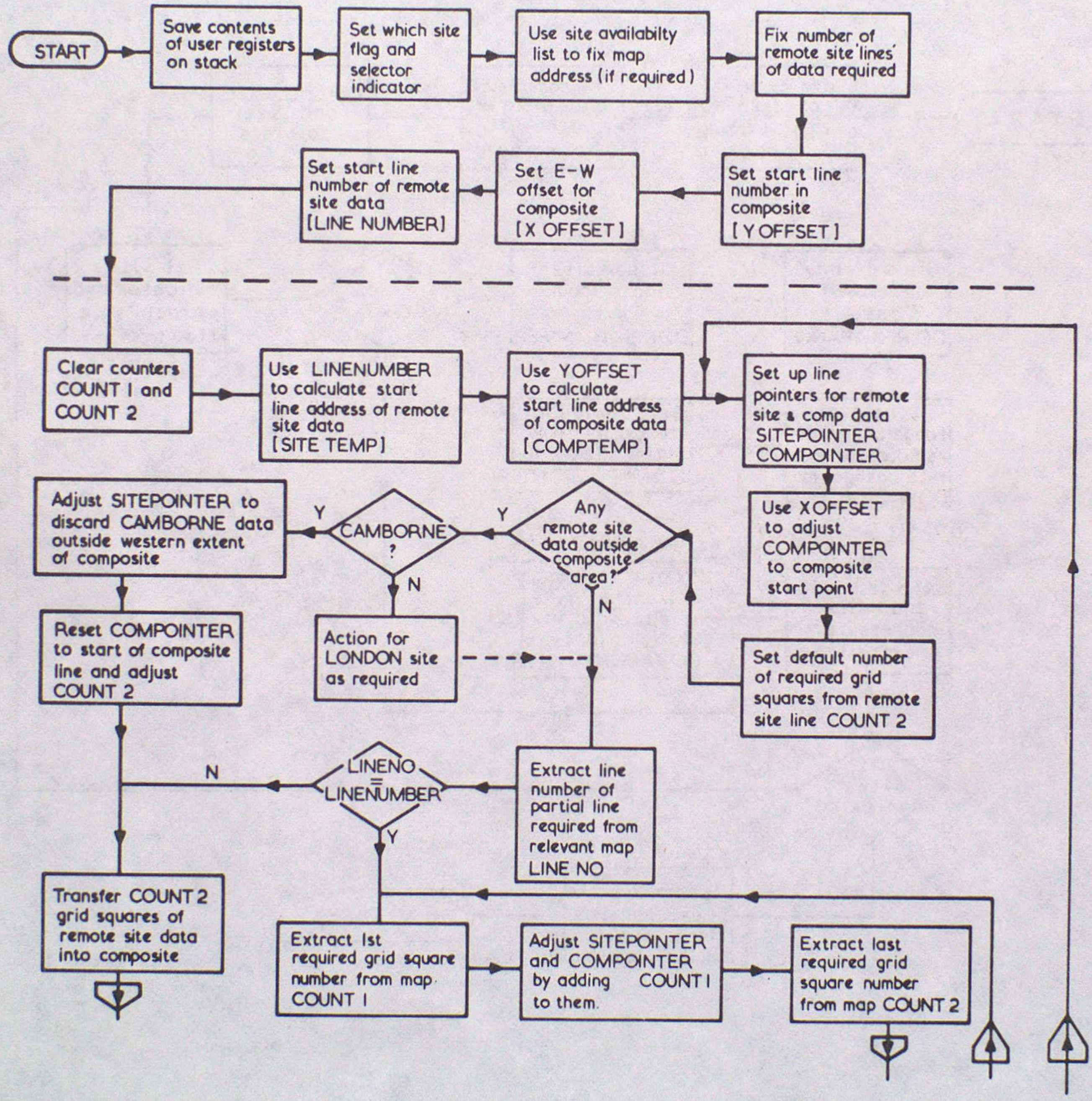


PRIMARY COMPOSITING PROGRAM NCOMR



SECONDARY COMPOSITING PROGRAM NETIR

Entered at a point dependent on value of site pointer calculated in primary program.
Carries out a set up procedure particular to each site (shown above pecked line) before continuing with common data selection routine (beneath pecked line)



SECONDARY COMPOSITING PROGRAM NETIR CONTINUED

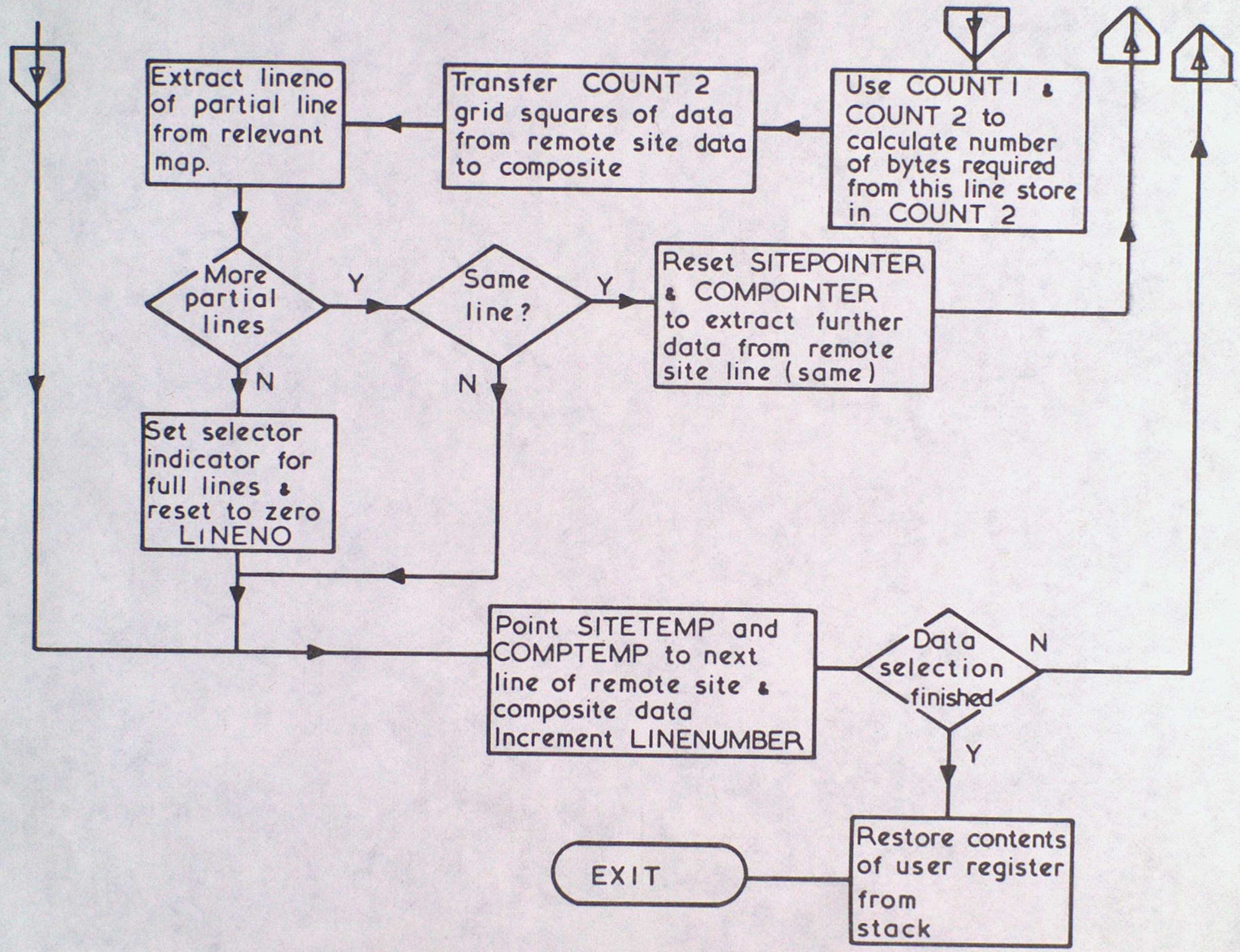
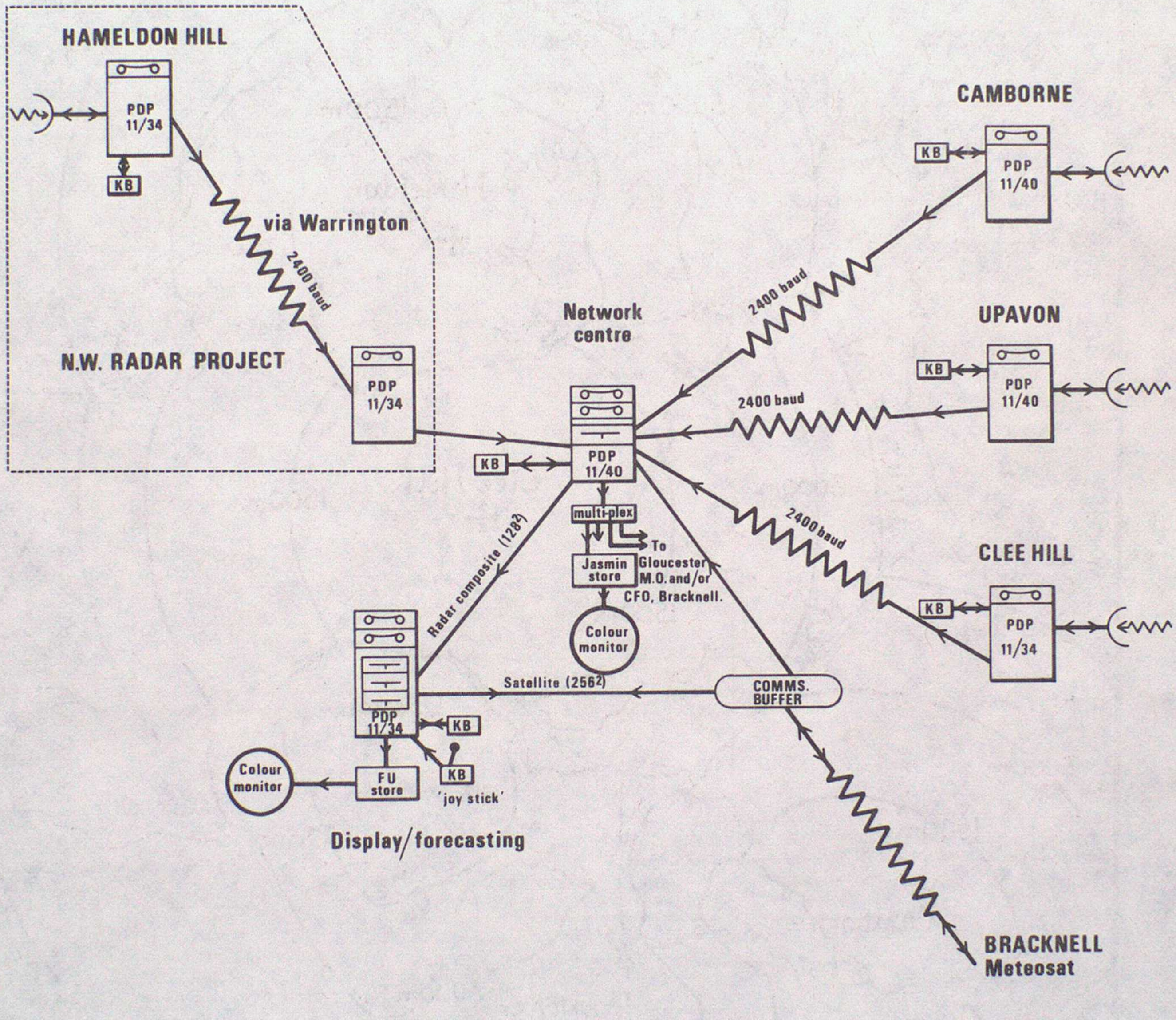


FIGURE 1

The type, location and interrelation of the minicomputers making up the computer network used to gather radar data in real-time.



KEY:-

[tape symbol]	9 track, 800 bpi, 600 ft magnetic tape unit
[disc symbol]	Cartridge (2.4 megabytes capacity) or fixed head (~130K bytes capacity) discs.
KB	Keyboard: teletype or decwriter.
2400 [line symbol]	Post Office leased line DATEL 2412 service.

FIGURE 2

The height of the centre of gravity of the lowest radar beams at any location within the area of coverage of the radar network. The positions of the radar sites, of Malvern (indicated by the letter M), and the boundaries used in the network software are also shown. Data compiled by F.F.Hill, Met.O.RRL.

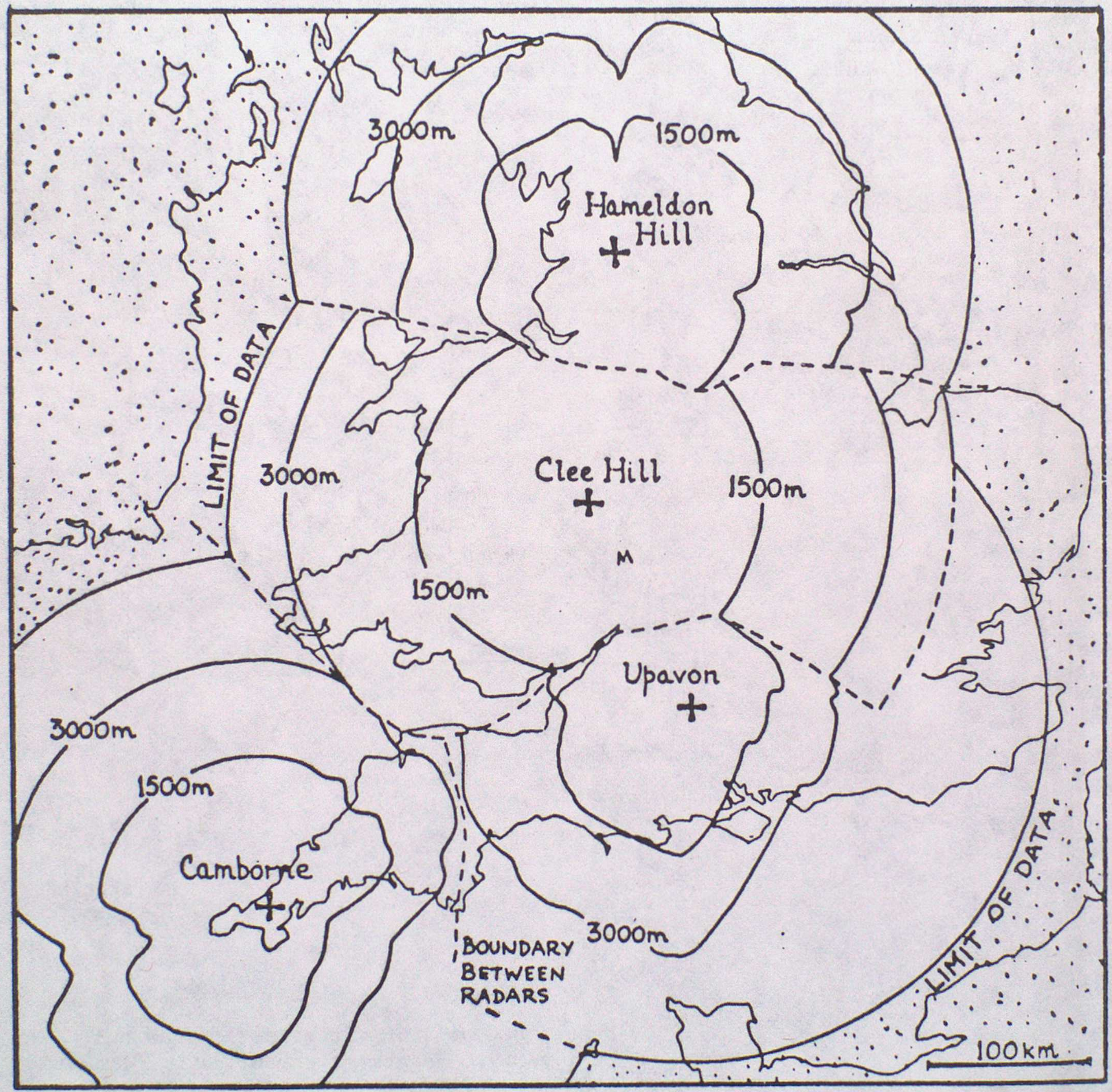


FIGURE 3

The mean boundaries (solid lines) between areas of data available from particular radar sites derived for analyses carried out using data from three days in January(21st), February(8th), and May(28th) 1980. The ratios of the radar values are plotted, and the optimum boundary taken as the position at which the ratio changes from being greater than 1 to being less than 1. The boundaries actually used are shown as dashed lines.

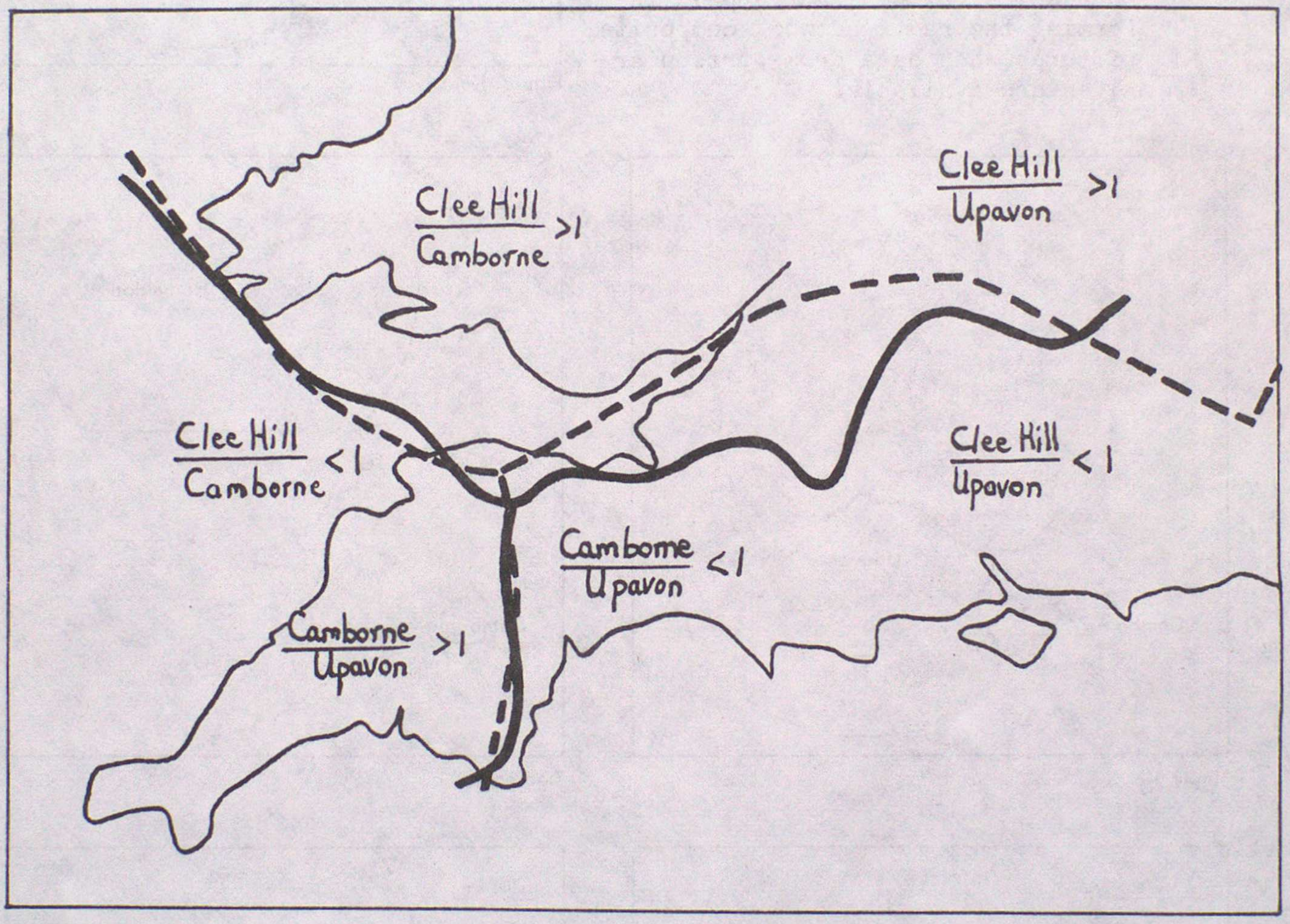


FIGURE 4

Key

.... Coastline

— — — Designated maximum range boundary for individual radar sites.

——— Designated data boundaries between individual sites.

\+ Positions of radar sites.

Boundaries between radars used in forming the radar network composite pictures when data from particular sites are available.

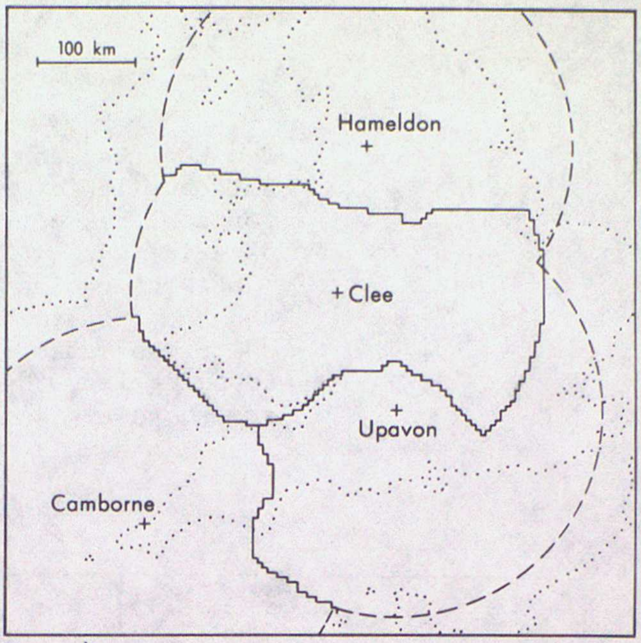


Figure 4a

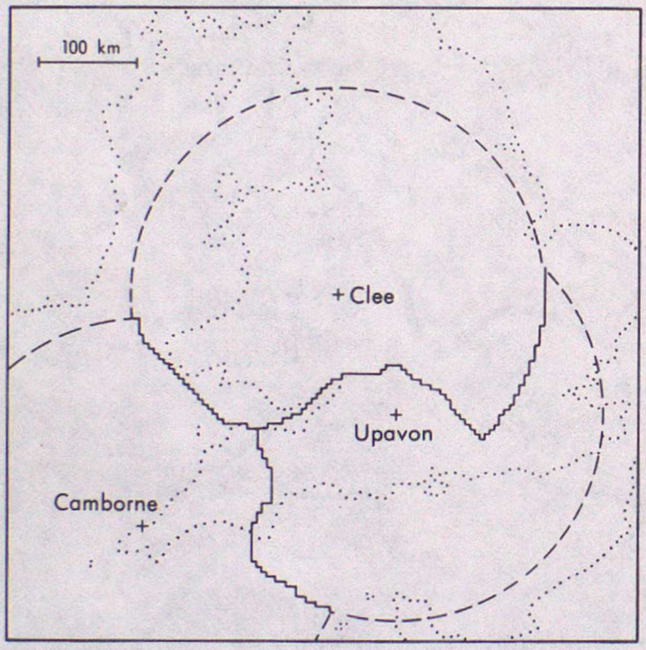


Figure 4b

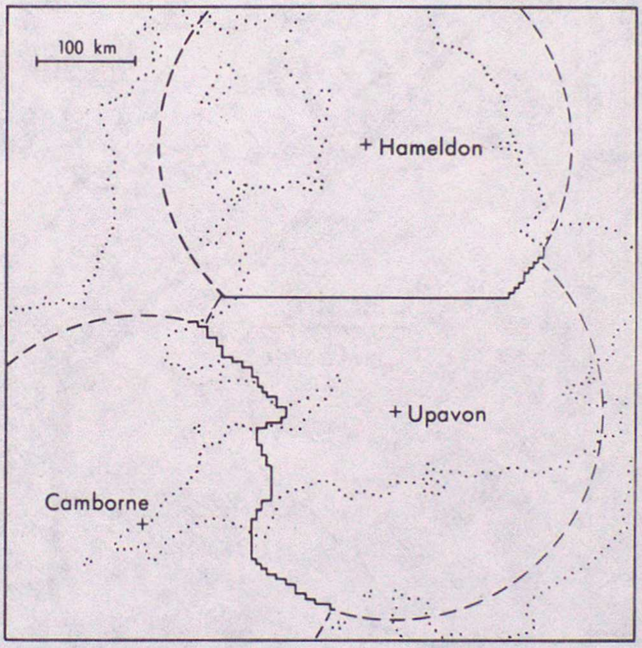


Figure 4c

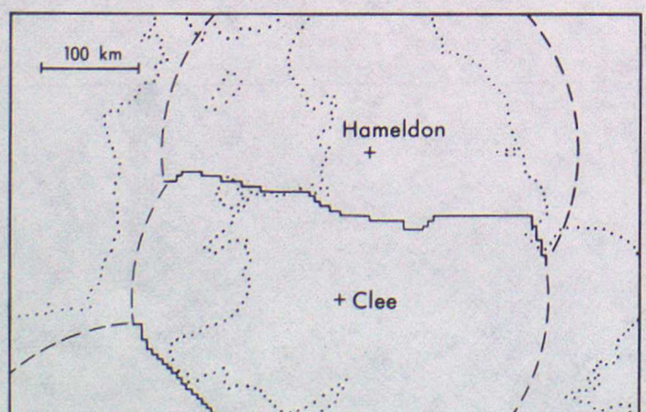


Figure 4d

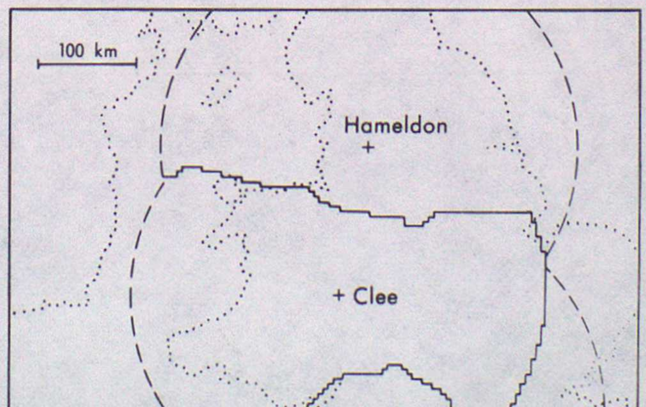


Figure 4e

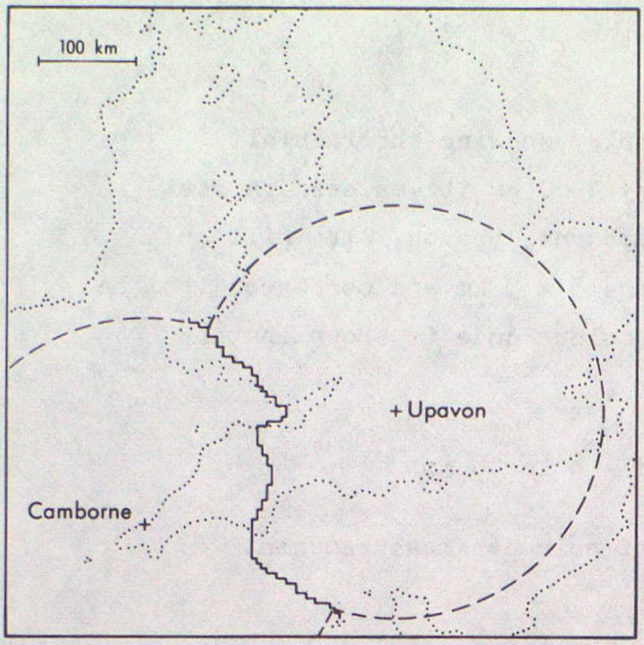


Figure 4f

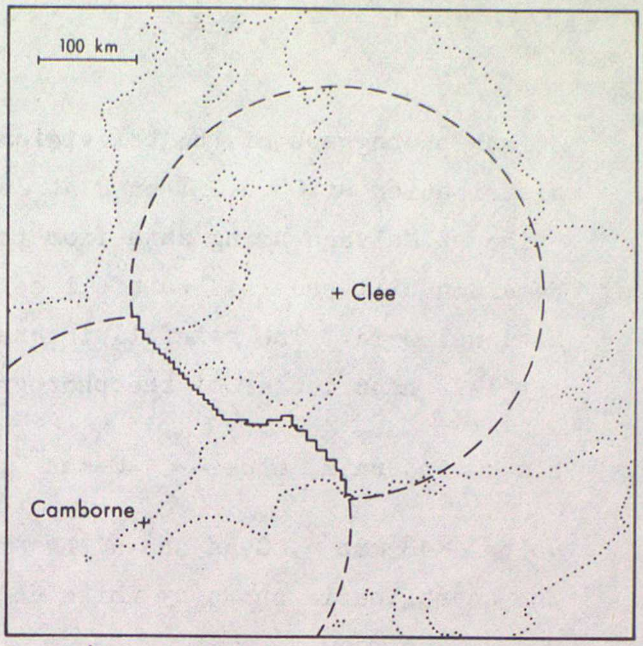


Figure 4g

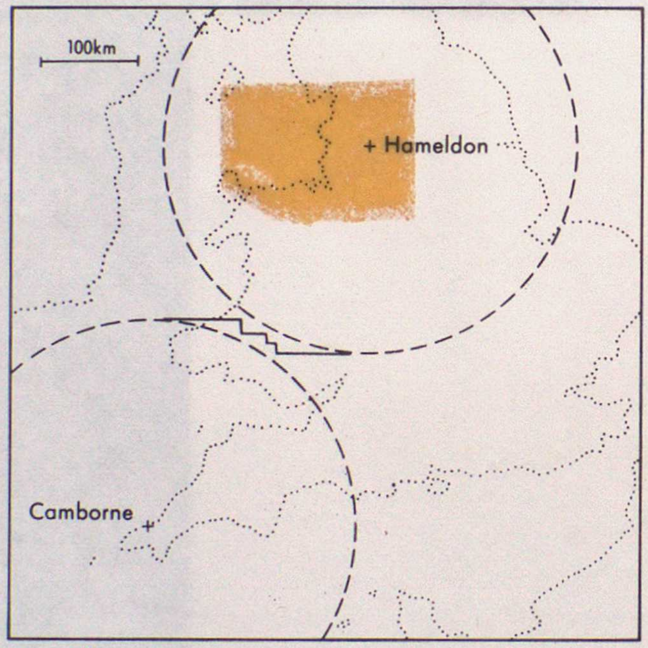


Figure 4h

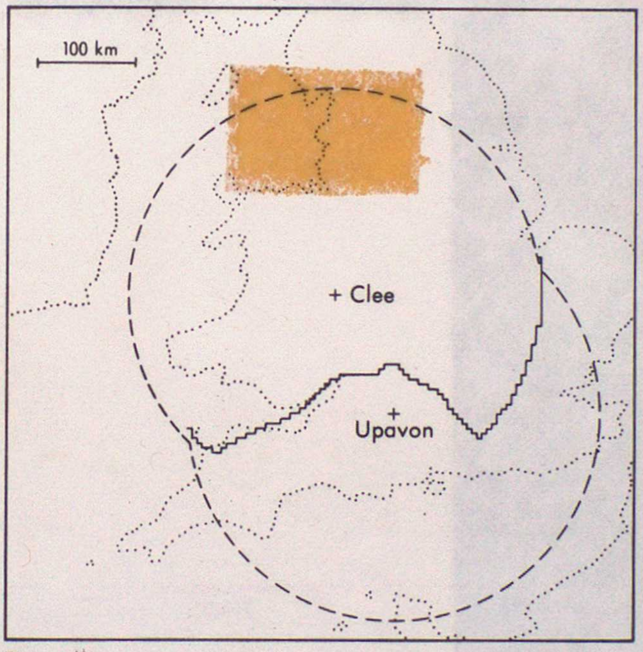


Figure 4i

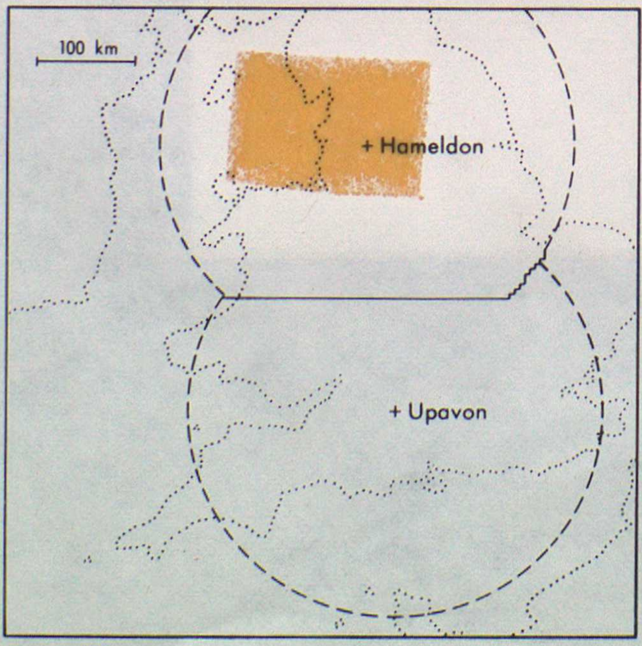


Figure 4j

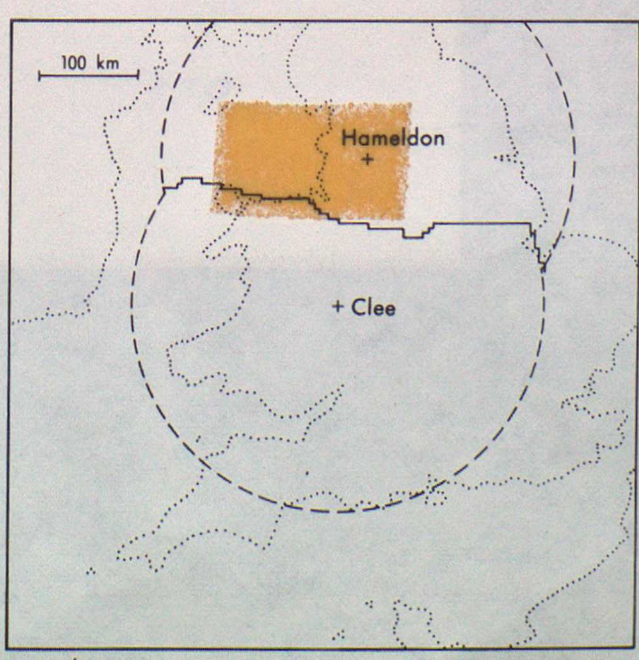


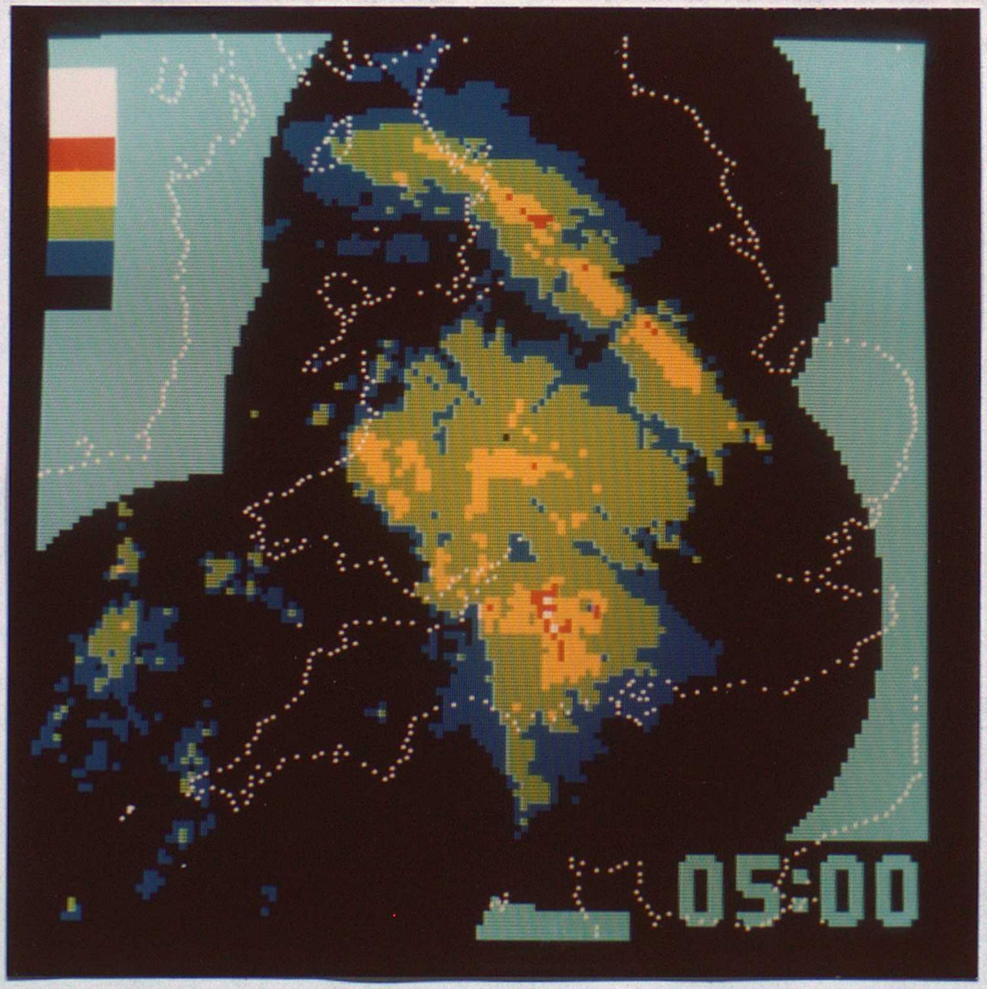
Figure 4k

FIGURE 5

Colour photograph of the television display showing the rainfall distribution at 0500 GMT on 21st January 1980 as it was seen in real-time at Malvern using data from the Camborne, Upavon, Clee Hill and Hameldon Hill radars. Rainfall cells are 5 x 5 km and correspond to the National Grid. The rainfall intensity colour code is shown on the top left hand corner of the photograph:

black - no rain, blue - < 1.0 mmh^{-1}, red - 8 to 16 mmh^{-1}

white > 16 mmh^{-1}. Cyan shows the area of no radar measurements. The coastline is shown by white dots.



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Research Reports