COLLECTION, STORAGE AND RETRIEVAL OF DATA BY COMPUTER AT THE HIGH FIELD MAGNET LABORATORY, CANBERRA.

EP-RR 28

R. G. SUTTON
R. L. McMURTRIE

October, 1972

Department of Engineering Physics
Research School of Physical Sciences
THE AUSTRALIAN NATIONAL UNIVERSITY
Canberra, A.C.T., Australia

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SUMMARY

This report describes a data collection and retrieval system for the High Field Magnet Laboratory at the Australian National University.

The computer used is an IBM 360/50 with an IBM 1827 Data Control Unit. An IBM 735 I/O typewriter connected to the 1827 is used for selecting programmes and for printing processed data.

1. INTRODUCTION

The High Field Magnet Laboratory in the Department of Engineering Physics contains two water cooled electromagnets which are powered by the Department's 500 megajoule homopolar generator. These magnets are used for fundamental research in solid state physics.

The smaller and older magnet was constructed on the "Bitter" principle in which the coils are constructed from laminated sheets of perforated copper. The maximum magnetic field strength of this magnet is 16 Tesla at 5 Megawatt power input.(1)

The larger magnet was designed and constructed by the Department. It has two coil units; the outer one being of the "Bitter" type and the inner one of a unique local design. This magnet is the most powerful of its type in the world, designed to produce field strengths of up to 30 Tesla at 30 Megawatts and requiring 120 litres per second water flow for cooling.

Approximately two hundred voltage signals emanating from the larger magnet represent temperatures, water flow, strains, pressures and voltages that occur during a normal 15 second magnet pulse.(2)

This report describes a data processing system, using an IBM 360/50 computer, that was developed to collect, store and process data from the 30 Tesla magnet during its initial testing period.

Work, which commenced in February 1969, brought the system to an operational condition in January 1971.

Included in this report are detailed descriptions of equipment interconnection, software, digital interfaces and a frequency modulated signal transmission system.

The method of storage, recovery and presentation of data, using a digital computer was chosen for the following reasons:

(1) most of the necessary hardware was already available in the Department;

(2) data reduction, using a computer, is more practical than manual reduction of data obtained from chart recorders;

(3) a computer system can be adapted to cater for the special needs of some solid-state experimenters who require fast data collection rates and on-line data processing.

Two multi-channel ultra-violet oscillographs complement the computer system. These are used to record selected analogue data.

The original specification for performance of the computing system is contained in Appendix 1. Briefly, it was to:

(1) Transmit and amplify 32 channels of analogue voltages from the Magnet Laboratory Control Room to the IBM 1827 Data Control Unit.

(2) Use the IBM 360/50 computer and the 1827 to sample the channels 10 times per second for 15 seconds at time intervals not less than 10 minutes. (Each 15 second scan may overwrite the previous one on temporary storage).

(3) Use an input/output typewriter (also connected to the 1827) to control the computing and to selectively print samples and/or maxima and minima.

At the outset, the Department owned an IBM 1827 Data Control Unit which was connected to the ANU Computer Centre's IBM 360/50 computer via the latter's multiplexer channel. Initially the 1827 was fitted with facilities for multiplexing 32 analogue voltages, converting the multiplexer output to digital and storing the results in the 360/50 main store.

To the above were added:

(a) Digital input and digital output facilities in the 1827.

(b) An IBM model 735 input/output typewriter, interfaced to (a).

(c) A 32 channel F.M. system for taking voltage signals from the Magnet Laboratory to the 1827.

(d) The computer software necessary to operate the system.

2. SYSTEM DESCRIPTION

2.1 Design Philosophy and Implementation

Three main considerations influenced the design of the system. These were:

(1) Electrical isolation of monitored devices from other circuits.

(2) Noise free transmission of analogue data, economically, over 200 feet of telephone cable.

(3) Most beneficial use of computer facilities with minimum interference to other computer users.

As illustrated diagrammatically in Figure 2.1, an IBM 360/50 computer and IBM 1827 data control unit provide the necessary computing support for the magnet laboratory's data acquisition equipment.

An IBM 735 electric typewriter, situated in the magnet laboratory, prints processed data and provides a means of operator interaction with the magnet laboratory's computer programmes. The typewriter is connected to the IBM 1827 digital-input and digital-output facilities via an interface situated in the IBM 1827 enclosure.

Analogue data from the magnet laboratory passes via a 32 channel frequency-modulation link to the 1827 which, under programme control, multiplexes and converts the data to digital form for processing by the computer.

2.1.1 Data Transmission

The first two considerations above led to the design of the frequency modulation system. This system is capable of driving up to one mile of telephone cable and of isolating input circuits with common-mode input voltages of up to 1000 volts with respect to ground.

Although originally designed for use by the magnet laboratory, the F.M. system may be readily adapted for use by other installations requiring the transmission of analogue signals from isolated voltage sources.

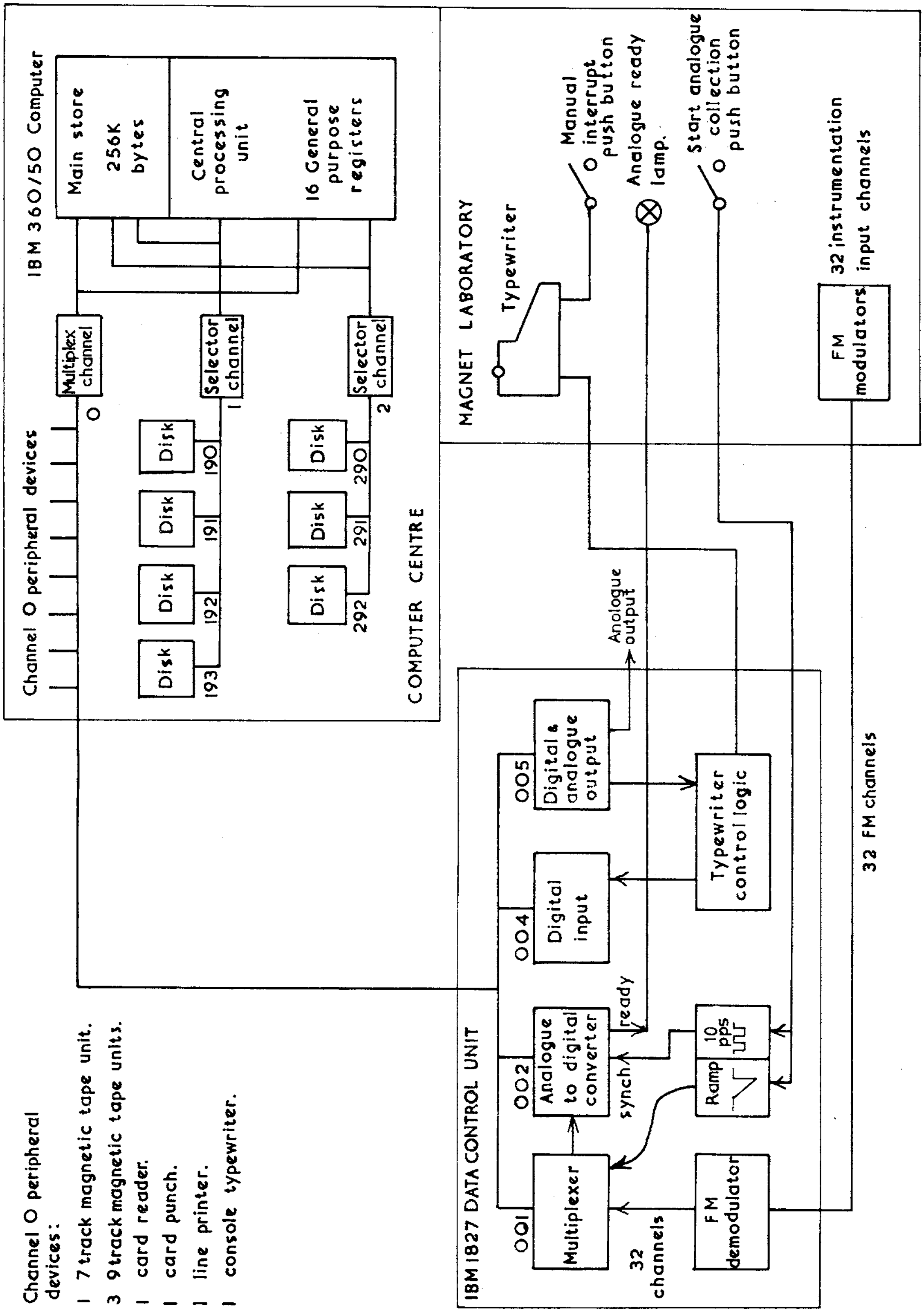


Figure 2.1 Overall Layout of Computing System

2.1.2 Programmes

Programmes for the magnet laboratory's computing system have been designed to provide an optimum system with regard to quantity of data collected, complexity of processing, ease of operator intervention, flexibility of operation, availability of suitable hardware and degree of interference to other computer users.

The system was designed specifically for the magnet laboratory and its capabilities can only be used elsewhere if the same type of computing equipment is available.

The programmes have been designed specifically for 32 channels of analogue input and would have to be altered considerably to accommodate any larger number of channels.

The number of samples collected per second and hence the duration of sampling, may be modified by simple programme changes. The sample collection rate may also be easily modified; this requires hardware, but not software, changes.

2.1.3 Programme Size

Under operational conditions, the magnet laboratory's computer system is required to be available for eight hours per day. Therefore, so that the ANU Computer Centre may provide optimum service to all IBM 360/50 users, the magnet laboratory's programmes must occupy as little of the IBM 360/50's main store as possible. The magnet laboratory's programmes are therefore required to operate in 8K bytes (1K = 1024) of main store, 8K being the smallest amount of main store that may be allocated for programme operation.

However, even using disk for temporary data storage, the programmes total about 10K bytes. Therefore, to fit the system into 8K bytes an overlay structure was formed in which all programmes are stored permanently on a resident disk pack.

When the magnet laboratory's programmes are started, the control programme and the tables referred to in section 2.6, are loaded into the main store then, as required, copies of the various programmes are loaded from the system disk. Each newly called programme, or group of programmes, overwrites previous programmes according to the overlay structure used.

The overlay structure and the choice of programming language (360 Assembler Language) are discussed in chapter 6.

2.1.4 Programme Response Time

Magnet laboratory programmes are selected for operation by typing code letters on the magnet laboratory typewriter. Programme response time is the time taken for a selected programme to become available after its code is typed.

Although other programmes are using the IBM 360/50 computer, minimum response times are assured for the magnet laboratory programmes because they are given the highest operational priority by the computer.

Highest priority also means that, once selected, a magnet laboratory programme will operate at the maximum possible rate; this is essential for the data collection programme as, once data collection commences, any delays in programme operation will cause loss of data.

However, even using highest priority, data collection may be impaired because of competition, between the IBM 1827's analogue-input facility and magnetic tape units, for use of the computer's multiplexer channel. If a tape unit is transferring a block of data at the time the analogue-input facility attempts to transfer data, the analogue-input's data transfer will be delayed until completion of the block transfer. Normally, magnetic tape data blocks are too small to adversely affect analogue-input operation. Occasionally however, large size blocks occur and cause loss of analogue-data.

2.1.5 Disk Storage Failure

Analogue-input data is stored on disk during operation of the data collection programme and is recovered from disk during operation of the data processing programme.

In the event of disk storage failure, user written routines prevent the computer from terminating the magnet laboratory programmes and cause subsequent disk input and output operations to be bypassed; however, data continues to be entered into a maxima-minima table in main store during the data collection programme and data from the maxima-minima table continues to be processed by the data processing programme.

2.1.6 Magnet Overload Conditions

A 200 millivolt signal at the input of an F.M. channel produces 5 volt at the F.M. demodulator output. 5 volt is also the level limit of the 1827 input channels. Therefore, it was decided to adjust the input levels to the F.M. channels so that, under normal operating conditions, the output levels will not exceed 1 volt. The ability is thus maintained to obtain information even if the signals from the magnet become abnormally large as might occur if some part of the magnet failed.

This allowance for overload made the specification for the F.M. system more stringent than it need have been had normal outputs gone to ± 5 volt.

In retrospect, it may have been better to have made the F.M. system transfer function sensitive and linear up to, say, 2.5 volt and somewhat less sensitive above that.

2.2 Computer

IBM model 360/50 Computer (32 bit words) with

256 K byte main store (1 byte = 8 bits)

7 x 7 disk pack drives

1 x 7 track tape drive

3 x 9 track tape drives

1 card reader

1 card punch

1 line printer

1 console input and output writer

1 1827 Data Control Unit with

(a) analogue input

(b) multiplexer

(c) digital input

(d) digital and analogue outputs

2.3 Frequency Modulation System

The main purpose of the F.M. system is to isolate the computing electronics from the signal sources that have, generally, superimposed common mode voltages of up to 150 volts.

This system also provides noise free transmission of analogue data from the magnet laboratory to the IBM 1827 Data Control Unit via 200 feet of telephone cable.

The specifications of the F.M. system are:

Number of channels	32
Input type	differential, with obligatory third wire driven from some point not more than 7 volts from either differential input
Differential input voltage range	400 mV peak to peak
Output type	single ended; one terminal commoned to 1827 ground
Output voltage range	± 4.5 V
Gain stability	less than 0.3% per day
Zero setting drift	less than 5 mV per day measured at the demodulator output

(The gain and zero specifications are for an air-conditioned environment).

Input common mode rejection	90 dB at DC
Modulator isolation from earth, power supply and F.M. output	1000 V
Modulator input impedance	100K ohms
Demodulator output impedance	2 ohms (approx.)
Linearity	better than 0.05% full scale

Maximum signal frequency	500 HZ
Modulator adjustments	none
Demodulator adjustments:	
zero	$\pm$ 100 mV
gain	$\pm$ 30%
F.M. centre frequency	5 KHz
F.M. carrier deviation	$\pm$ 36% ($\pm$ 1.8 KHz)
F.M. centre frequency stability	0.1% (5 Hz) per day 0.005% (0.255 Hz) per ^{o}C

2.4 Analogue Input

2.4.1 Summary of Operation

The 32 analogue output channels from the F.M. demodulators are multiplexed, then their signals are converted to digital data by the 1827 analogue-input facility; each sample voltage is converted to a 16 bit data word that consists of a sign bit, 14 data bits and an overload bit. The least significant data bit (i.e. the second least significant bit of the data word) corresponds to approximately 0.3 millivolts at the 1827 input. The overload bit, normally 0, is set to 1 and data collection ceases if the amplitude of any sampled voltage exceeds 5 volt.

Synchronization between 1827 analogue-input operation and magnet laboratory operation is achieved by a "READY" signal from the 1827 analogue-input facility to the magnet laboratory and by "SYNCH" pulses from a pulse and ramp generator to the 1827 analogue-input facility. The pulse and ramp generator is situated in the 1827 enclosure.

The "READY" signal indicates, by means of a lamp in the magnet laboratory, when the 1827 analogue-input facility is ready to accept data. A "SYNCH" pulse train will then cause the 1827's multiplexer to scan its 32 input channels, once per "SYNCH" pulse, until the 1827 becomes not "READY". The "SYNCH" pulse train can be initiated, either manually or automatically, from the magnet laboratory.

2.4.2 1827 Analogue Input Specification (Reference 3, p.75)

Number of channels	32
Input voltage range	± 5V
Maximum overload voltage	± 34V
Input type	Single ended
Input impedance	100K ohms
	1000 pF
Resolution	14 bits + sign
Single conversion time	50 μs
Maximum sampling rate	18K per s
ADC bit pattern	sbbbbbbbbbbbbbbx
where	s = sign bit
	b = data bit
	x = overload bit
"READY" signal (output)	
ready	0.0 to -0.5V
not ready	-12V @ 1000 ohms
"SYNCH" signal (input)	
synch	+0.5 to -0.5V
not synch	-6.0 to -18V
synch pulse width	2 to 15 μs

2.4.3 Pulse and Ramp Generator

"SYNCH" (output)	
synch	-0.2V
not synch	-15.0V
synch pulse width	8 μs
synch pulse rate	10 pulses per s
Ramp	-41.6 mV per s
Initiation of pulse train and ramp	contact closure
Duration of pulse train and ramp	adjustable
range	1.0 to 99.0 s
increments	1.0 s

Note: The duration of the pulse train as set by the pulse and ramp generator does not control the amount of data collected by the data collection programme.

2.5 Typewriter

The typewriter is used by the magnet laboratory staff to select required computer programmes, to update and print tables and to print processed data.

In the following, input refers to data transfer from the typewriter to the computer, output refers to data transfer from the computer to the typewriter.

Type	IBM model 735 "Selectric" input/output writer.
Line Length	131 character capacity.
Output rate	15 characters/second.
Typewriter Code	"Correspondence" 7 bits including parity.
Computer Code	"I/0 writer" 8 parallel bits (extra bit to code functions).
Type font	"courier 72".
Character set	
44 lower case	abcdefghijklmnopqrstuvwxyz 1234567890 -=!;',./
44 upper case	ABCDEFGHIJKLMNOPQRSTUVWXYZ ±@#$%[&*() _+]:",.?
8 functions	space, backspace, tabulate, carriage return, upper case shift, lower case shift, keyboard lock, keyboard unlock.
Manual interrupt	An external pushbutton labelled "manual interrupt" generates an input code the same as the output code for keyboard unlock. This facility is not required by the present system.
Case shift indication	A lamp is on when the typewriter is in upper case.
On and off-line	A toggle switch is provided to set the typewriter off-line or on-line. Switching to off-line ensures that the typewriter is in lower case.
Parity errors	Input and output parity errors raise audible and visual alarms which may be cancelled by a push button. Further output is automatically inhibited until the alarm is cancelled.

Automatic carriage return	When operating on-line and the carriage reaches the right hand stop, a carriage return is automatically generated.
Input line termination	When an input line has been typed according to the specified format, it must be terminated by typing an extra character or function. This terminator is not read into main store. Commonly, a space or carriage return is used.
Control logic	The typewriter control logic, manufactured mainly from DEC (Digital Equipment Corporation) modules, is located in the user space of the 1827 cabinet. It interfaces the typewriter to the 1827.
Digital input to 1827	The typewriter control logic simulates 8 switch contacts which are read by the 1827 digital-input facility. The 1827 digital-input facility and the typewriter input are synchronised by two control lines called "DI ready" and "DI synch".
Digital Output from 1827	The 1827 output to the typewriter is the states of 8 transistor switches. The 1827 digital-output facility and the typewriter are synchronised by two control lines called "DAO ready" and "DAO synch".

2.6 Programmes

The various magnet laboratory programmes are selected for operation by a control programme, MGLB, the basic flow diagram of which is figure 2.2. Programmes (options) are selected for use by typing, in lower case, the code letters shown at the top of the required programme's block. Magnet laboratory use of the computer is terminated by typing TRM.

Analogue data from the magnet laboratory is converted to digital data and stored on disk by the data collection programme, ANALIN, which is called by typing COL.

During data collection, groups of five multiplexer scans of the 32 channels alternately fill two buffers in the computer main store. While one buffer is being filled, the contents of the other are transferred to disk storage and are used to update a maxima-minima table, MAMITB, in main storage.

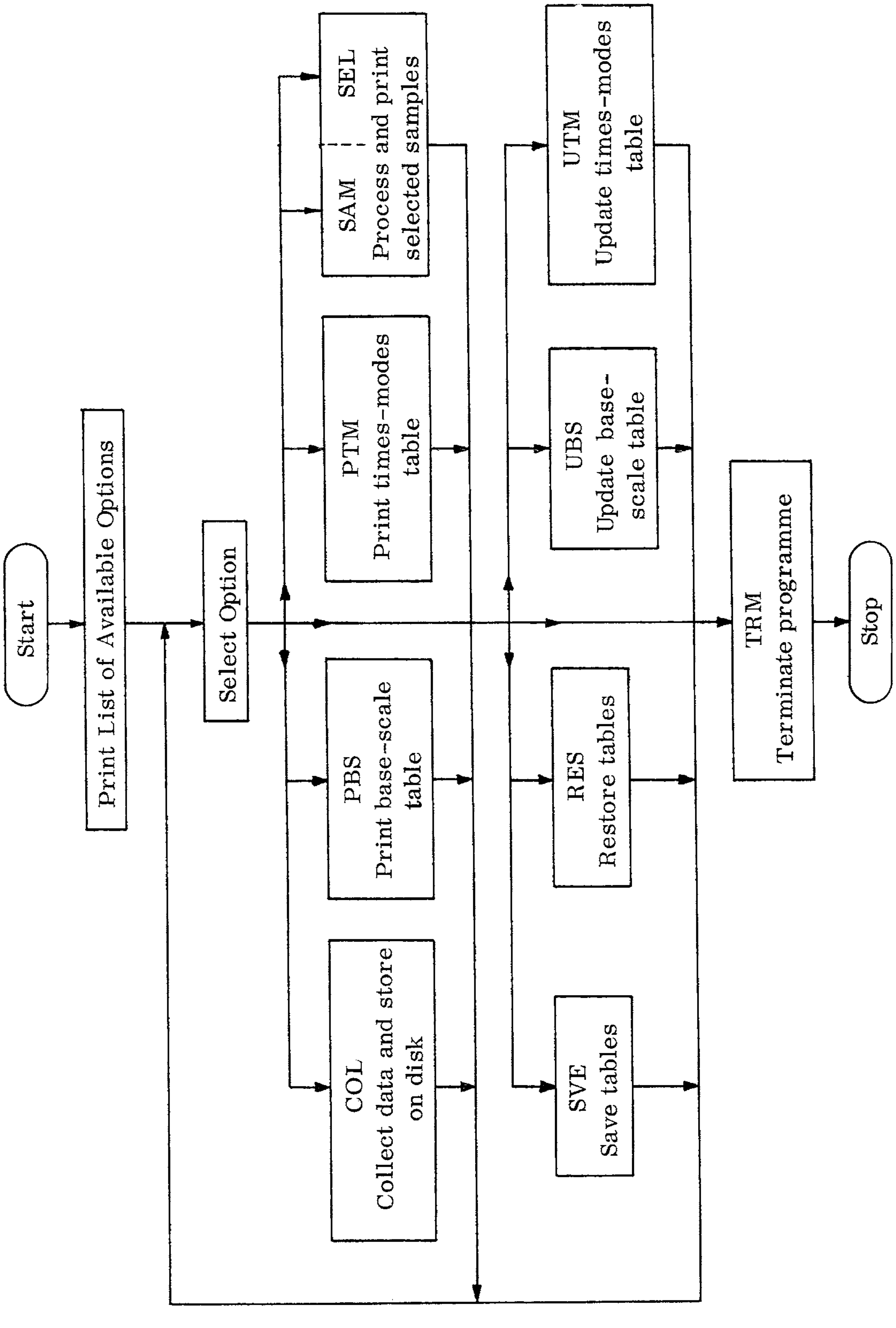


Figure 2.2 Computer programming - basic flow chart

The maxima-minima table contains the maximum and minimum sampled voltage values, for each channel, that occurred during the most recent data collection period. The times at which these voltages occurred are also stored in the table.

Computer evaluation of physical quantities assumes that each channel is calibrated up to the 1827 input and that the voltages there are linear functions of the physical quantities being measured.

The typed out value of a physical quantity, y, is given by:

$$y = y_o + k.x$$

where:

y_o is the value of the quantity (called the baseline value) that corresponds to zero volts into the 1827 channel representing the quantity.

k is the channel's scale value measured in physical units per volt into the 1827.

x is the sample voltage value representing the quantity as measured at the 1827 input.

A base scale-table, BSTAB, containing the baseline value, y_o, and the scale value, k, for each channel is contained in main store. This table is updated by the update-base-scale-table programme UDBS, which is selected by typing UBS. The updating procedure is described in section 9.2.5.

The contents of the base-scale table are printed by typing PBS; this selects the print-base-scale-table programme, BSPT.

A times-modes table, TMT, contains required sample times and printout modes for each channel. Its entries may be changed by typing UTM to call the times-modes table updating-programme, UDTM2. Required changes are made to TMT by typing updating information as described in section 9.2.6.

The contents of the times-modes table are printed by the typewriter after the operator types PTM. This selects the times-modes table printing programme PTM.

The programme SAVE stores the times-modes table and base-scale table in a special disk storage area when SVE is typed. The times-modes table and base-scale table stored in the special area replace the main store times-modes table and base-scale table when RES is typed. This facility relieves the magnet laboratory staff of setting up the tables each time the magnet laboratory programmes are started by the computer centre.

Samples are processed and printed by the programme SAM which is called directly by typing SAM or indirectly by typing SEL.

When SAM is typed, the contents of the times-modes table determine the mode in which samples are processed and printed.

When SEL is typed, the select-channel programme SELCHN is called before SAM. SELCHN enables the operator to select, via the typewriter, a required channel and mode of printout.

The available modes for each channel are:-

(1) maximum and minimum samples with corresponding times;
(2) selected samples and their times;
(3) all samples, without times;
(4) no samples.

The permitted combinations of options 1, 2 and 3 are: 1 and/or (2 or 3). An example of printout is contained in section 8.8. The quantity of printout after a 15 second pulse is limited by the speed of the typewriter. For example, it takes a minute to print 150 samples (without times) for a channel.

The expected range and accuracy of the physical quantities being recorded dictated the format for printing samples. The greatest quantities are hydraulic oil pressures of about 4000 p.s.i. whilst the smallest are strains, measured as displacements in thousandths of an inch. It was decided that positive baseline values and scale values would be expressed as four decimal digits ranging from 0.001 to 9999. Positive sample values are computed to four decimal places, rounded to four significant figures, and printed with a decimal point. Negative baselines and scales take on three decimal digits and range from -.001 to -999. Negative samples are computed as for positive samples but are rounded to three significant figures and a leading minus sign is added. Thus, -1.47 is -1.47 ± 0.005 whereas 1.470 is 1.470 ± 0.0005.

Printed output is normally expected to be positive, therefore, the reduction of one significant figure for negative samples should be of little importance.

Other magnet laboratory programmes and their uses are:-

MAGVRS identifies updated versions of the magnet laboratory programmes by date.

DECIN converts typed decimal numbers into binary numbers for use by other programmes.

READIN controls typewriter input operations

P130 controls typewriter output operations

Figure 2.3 is an example of printout obtained during a computer run of the magnet laboratory's data acquisition programmes. Upper case letters have been typed out from the computer whereas lower case letters have been typed by the operator.

The line "ADC CHN CC=7f, PCICT=041" was printed following a successful 20 second data collection period.

The second last line, commencing "290", is an example of a disk error message.

ADC channel completion codes (ADC CHN CC) and other error messages are described in section 9.4.

3. F.M. SIGNAL TRANSMISSION SYSTEM

3.1 Introduction

The frequency modulation signal transmission system about to be described was designed by Dr. K.J. Muirhead of the Department of Engineering Physics. As mentioned earlier, the system was designed for the magnet laboratory, keeping in mind its later possible use elsewhere.

From its specification given in the Chapter 'System Description' it may be seen that the requirements were rather stringent with respect to the stability of the output for fixed input. An output accuracy of 0.5% of normal full scale (1 volt) corresponds to a 5 mV change at the output. This, in turn, corresponds to a change in F.M. centre frequency of 1.8 Hz. Fortunately, temperature change effects are reduced by the modulators and demodulators being in air conditioned environments. It is perhaps worth repeating that a change in the lowest order bit of the A/D converter (when working at 14 bit accuracy) is equivalent to a 0.3 mV change at the F.M. demodulator output.

Frequency modulation was chosen as a means of signal transmission because it has good noise immunity and because the necessary d.c. isolation can be achieved. The specification called for isolation of 1000 V and common mode rejection of 90 db with respect to the modulator common. An example of the requirements for isolation is the recording of a signal from a thermocouple embedded in the magnet at some point which could rise to 150 V above earth. The

```
VERSION   7 JUN 72
ANU HIGH FIELD MAGNET LAB
FOLLOWING ROUTINES MAY BE USED:
"COL"  COLLECT ANALOGUE DATA
"PBS"  PRINT BASE, SCALE TABLE
"PTM"  PRINT TIMES, MODES TABLE
"SVE"  SAVE BASE, SCALE & TIMES, MODES TABLE
"SAM"  PRINT SAMPLES ACCORDING TO TIMES,MODES & BASE,SCALE TABLES
"RES"  RESTORE BASE,SCALE & TIMES,MODES TABLES
"TRM"  TERMINATE THIS JOB
"UBS"  UPDATE BASE,SCALE TABLE
"UTM"  UPDATE TIMES,MODES TABLE
TYPE ROUTINE DESIRED: utm
  TYPE NEXT
del all                      t   TYPE NEXT
add mod 26 27 28             t   TYPE NEXT
add sel 26 27 28             t  TYPE TIMES IN DECISECONDS
010 040 140                  1
TYPE ROUTINE DESIRED: ubs  OK  SEND NEXT
26 27 28  0.0,-3.15
 OK  LAST. TYPE ROUTINE DESIRED: col
 ADC CHN=7f, PCICT=041
TYPE ROUTINE DESIRED: sam SELECTED SAMPLES
26 MAX 15.4/14.87    MIN  0.0/-0.00
27 MAX 15.4/14.66    MIN  0.0/0.004
28 MAX 15.4/10.89    MIN  0.0/0.342
290,da,dskhld  ,read  ,no rec found  ,0000000e000ff,bsam
TYPE ROUTINE DESIRED: trm
```

Figure 2.3 Example of Printout

required isolation was achieved by coupling power into and F.M. signal out of each modulator printed circuit board by ferrite cored transformers, as illustrated in diagram 3.1.

Each modulator has a three wire input, the differential input takes two wires whilst the third wire is connected to the mid-point of the modulator board's own power supply. The third wire is used to define the mean voltage of the modulator and should be connected to some reference point whose potential is within 7 volts of the differential inputs.

The input power to each modulator board is from a common 25 KHz supply. This relatively high frequency permits physically small transformers and smoothing capacitors to be used. It also means that the transformer inter-winding capacitance is small, resulting in small currents when the third wire charges the circuits to the working voltage. Typically, the total capacitance to ground is 30 pF. For a voltage rise rate of 10^5 volts/sec (the peak rate of 50 Hz 240 V) the current is only 3 μA.

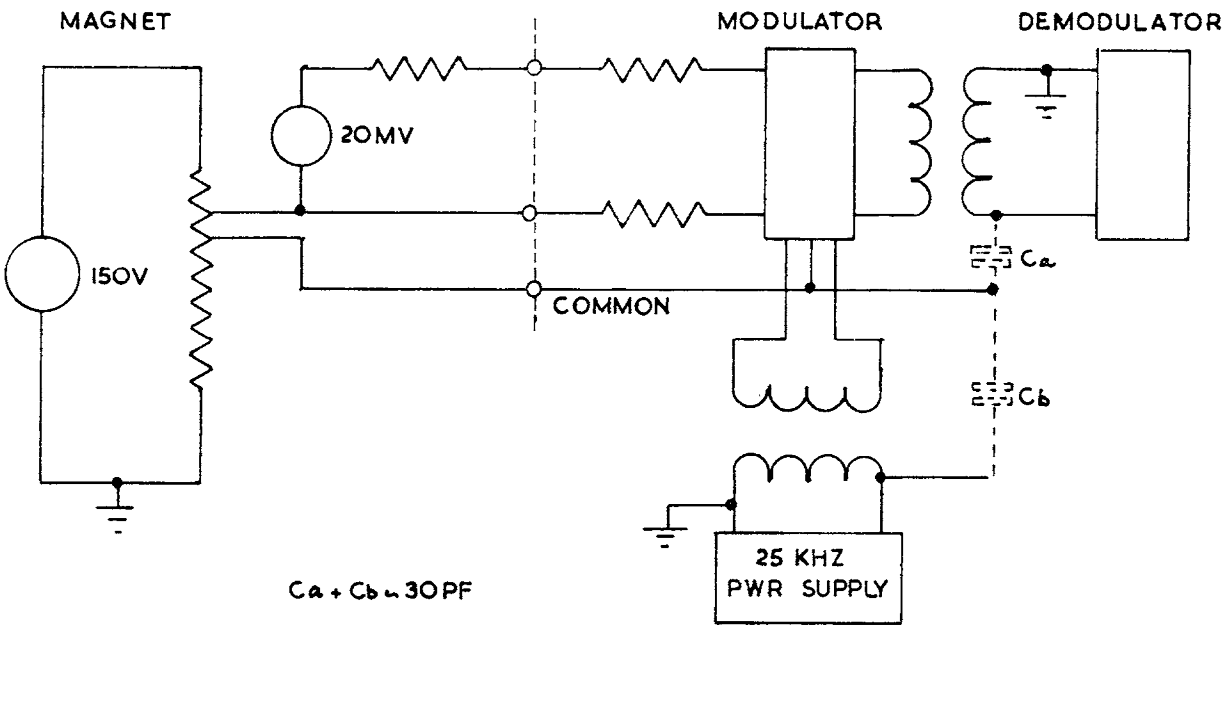


Figure 3.1 Modulator Isolation

The remainder of this chapter describes the modulator and demodulator circuits.

3.2 Modulator

Refer to the modulator circuit in Figure 3.2

The input amplifier has a voltage gain of about 20, raising the level of a normal maximum signal from 40 mV to 0.8V. Q5 is an emitter follower whose collector resistor prevents the emitter going more negative than -6V. This prevents the F.M. carrier deviating lower than 2.5 KHz, thus ensuring that lower side band frequencies do not enter the demodulator filter as intermodulation noise. Q6 to Q13 form a free running multivibrator whose frequency deviation is a linear function of the differential input voltage (360 Hz for 40 mV). Q12, Q13 and their emitter resistors form quasi-constant current sources which linearly charge the capacitors C12 and C13. 'Quasi-constant' means constant for constant signal input. Changes in V_{be} of Q12 and Q13 with temperature should be compensated by Q5. Q8 and Q9, speed-up switches for the collectors Q7 and Q11, ensure rectangular waveshapes. Q6 and Q10 form a starting circuit which prevents the astable (Q7 and Q11) from having any stable states. The square wave output of Q11 is low-pass filtered by R32 and C15 to reduce the harmonic content of the F.M. carrier signal. The F.M. signal passes to the telephone cable via the dual emitter follower Q14 and Q15 and isolation transformer T2.

Each modulator has its own regulated DC power supply that converts power from the 25 KHz supply, referred to in section 3.1, to $\pm$ 12 volt. Figures 3.3 and 3.4 are circuits of the $\pm$ 12 volt and 25 KHz supplies respectively.

3.3 Demodulator

Referring to the F.M. demodulation circuit (Figure 3.5), Q1 and Q2 comprise a zero crossing detector which triggers the demodulator monostable Q4, Q6 and Q7. Q3 and Q5 and Q5's emitter resistors form a constant current source which causes a linear negative ramp on the cathode of D2. Q6 speeds up the negative going output edge. The monostable's mark-space ratio depends upon the F.M. input frequency. The resulting deviation in mean d.c. monostable output level from 0 V is directly proportional to the deviation of the F.M. carrier (0.86 V for 360 Hz). The 500 Hz low pass filter removes the F.M. frequency components. Capacitor C10 produces further high frequency roll-off in the output amplifier. The low frequency gain of the filter amplifier is given by $\frac{1}{2} \cdot \frac{R17 + RV2}{R24}$. Diodes D5 and D6 serve to clamp the output excursion to $\pm$ 4.5 volt. One dual 12 volt power supply feeds the monostables whilst another feeds the output amplifiers.

3.4 Signal Transmission

Frequency modulated signals from the magnet laboratory are conducted to the demodulators in the 1827 cabinet by two 25 pair telephone cables.

Reflections along the cable pairs are minimised by terminating the inputs of the demodulators with 300 ohm impedance-matching resistors.

3.5 Inductance Winding Data

3.5.1 Modulator

Power transformers :

Core	Mullard LA2400 with no air gap

Primary

turns	60
wire guage	31 BS

Secondary

turns	200
wire guage	34 BS

Coupling transformers :

core	Mullard LA2400

Primary and secondary

turns	500
wire guage	38 BS

3.5.2 Demodulator

cores	Mullard LA2400
wire guage	38 BS

turns

L1	850
L2	922
L3	575

inductance

L1	353 mH
L2	418 mH
L3	162 mH

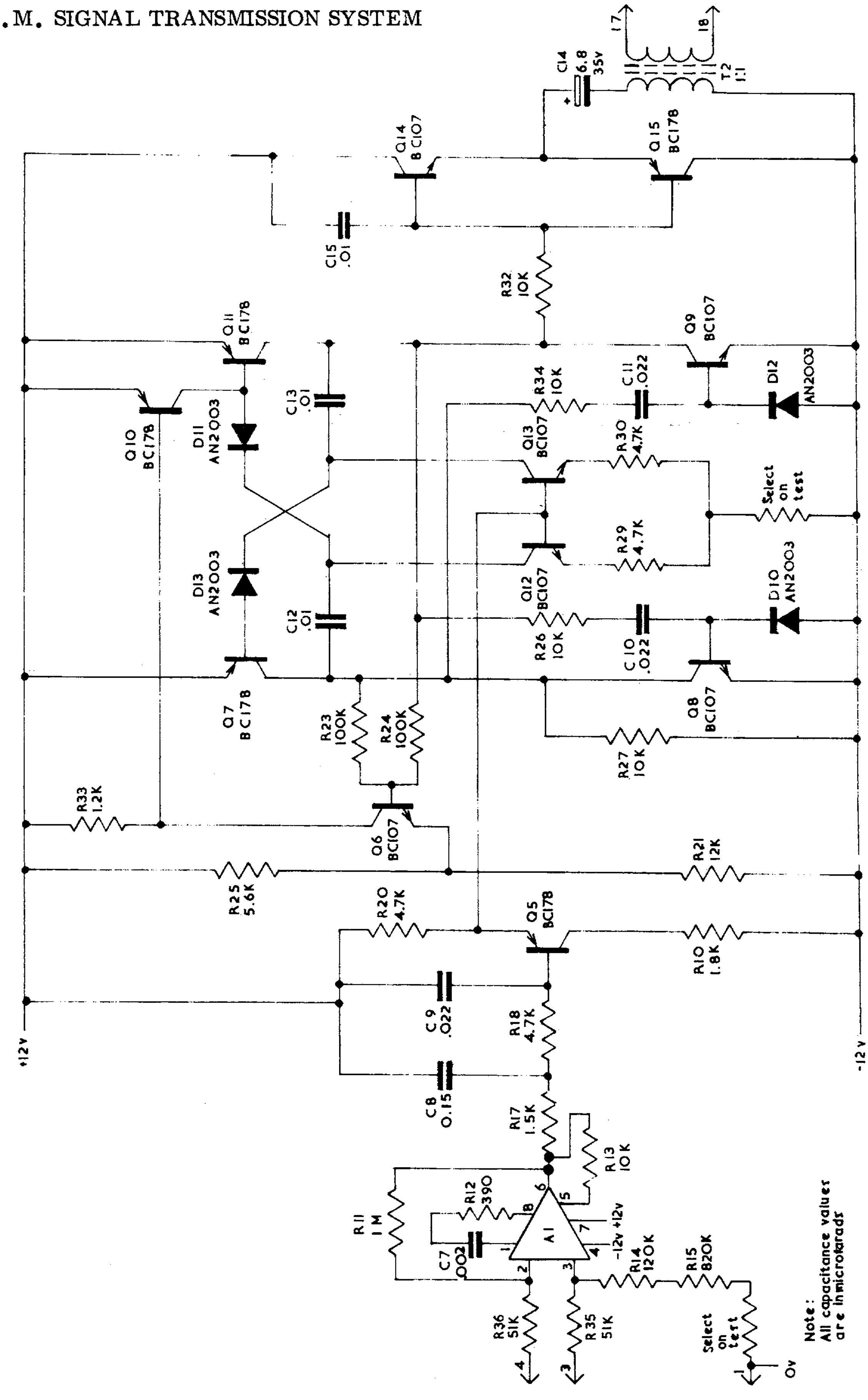


Figure 3.2 F.M. Modulator

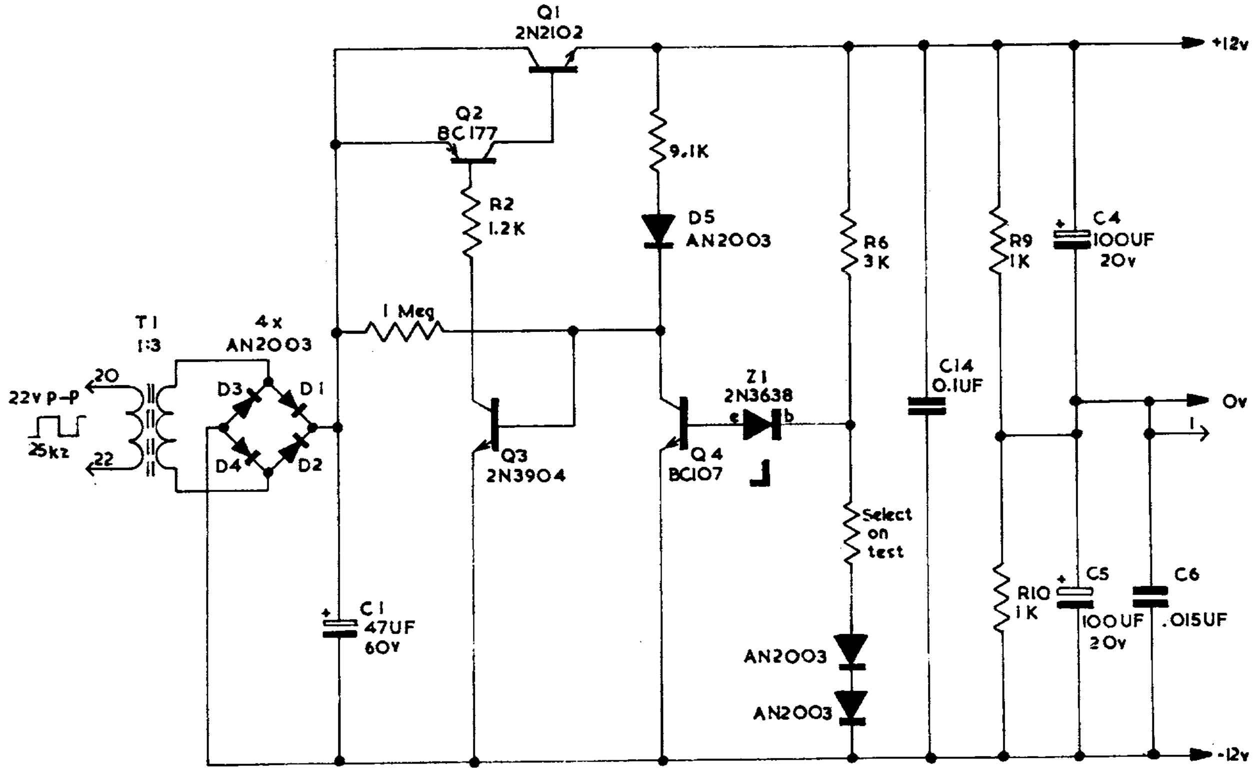


Figure 3.3 F.M. Modulator Card - Power Supply Circuit

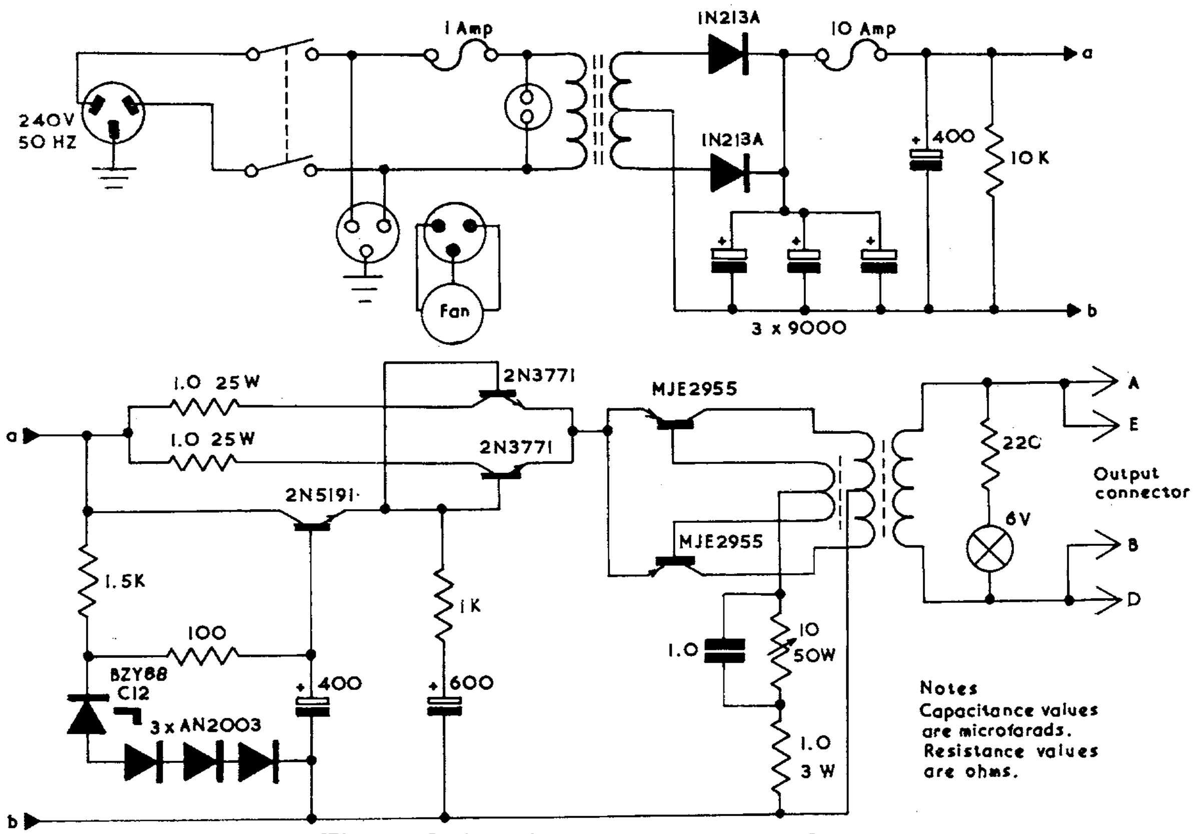


Figure 3.4 25 KHZ Power Supply

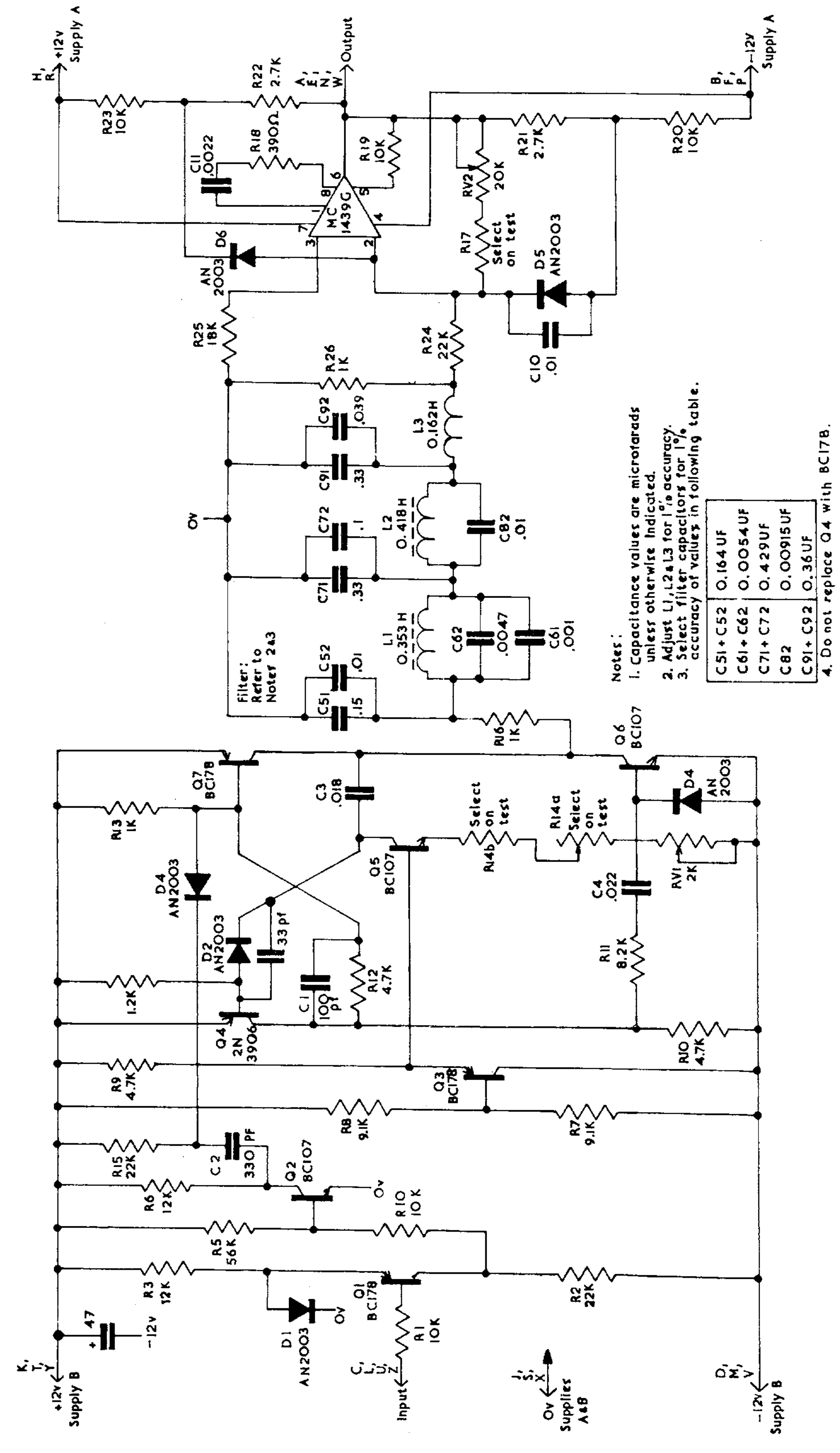


Figure 3.5 F.M. Demodulator

4. ANALOGUE INPUT

4.1 Introduction

The analogue input facility of the IBM 1827 data control unit consits of a 32 channel multiplexer, a sample and hold amplifier, and an analogue to digital converter (ADC).

Analogue input operation is controlled by the magnet laboratory's data collection programme ANALIN and by a pulse and ramp generator situated in the 1827 enclosure. The pulse output of this generator is connected to the analogue input facility's SYNCH terminals to provide timing and synchronism of analogue input with magnet laboratory operation. The ramp output provides a time base for data collection.

Interconnection of the various units involved with analogue input is depicted in figure 2.1.

General specifications for the IBM 1827 analogue-input facility are contained in section 2.4.2.

The data collection programme is described in section 8.7.

Section 4.2 describes the pulse and ramp generator. Section 4.3 describes the prototype pulse and ramp generator; this was used successfully until completion of the final version. The prototype is maintained in operational condition as a standby unit.

The ramp output of the pulse and ramp generator provides a time reference that is independent of computer operation. Such a reference is necessary because exact synchronism between synchronizing pulses and data is not possible as various input-output devices, including the analogue-input facility, compete for use of the IBM 360/50 multiplexer channel. Thus, data transmission between analogue-input and computer may not be possible immediately upon receipt of a synchronizing pulse. When this situation occurs, data transmission from the analogue input is delayed until the IBM 360/50 multiplexer channel becomes available. For example, if the analogue-input facility receives a synchronizing pulse while the IBM 360/50 multiplexer channel is being used to transfer a block of data from a magnetic tape to the computer's main store, analogue-input operation will be delayed until the block transfer from the tape has been completed.

4.2 Pulse and Ramp Generator

The following description refers to the pulse and ramp generator block diagram, figure 4.1, and to the schematic diagrams, figures 4.2 to 4.5.

Clock pulses, at the rate of 50 per second, are derived from the AC mains by an AC to pulse converter. Application of these pulses to the remainder of the circuit is controlled by an RS flip-flop that provides an inhibiting signal to the clock pulse gate in the reset state and provides an enabling signal in the set state. This flip-flop also controls operation of the integrating circuit that generates the voltage ramp. Thus pulse and ramp output occur only when the RS flip-flop is in the set state.

The RS flip-flop may be set by a remote contact closure or by the START pushbutton on the pulse and ramp generator's front panel. It is reset automatically by a pulse train duration circuit that operates under the control of front panel switches. These switches provide selection, in 1 second increments, of pulse trains with durations of from 1 to 99 seconds.

When the clock-pulse gate is enabled, clock pulses are applied to a digital divider that reduces the pulse repetition frequency from 50 to 10 pulses per second. These pulses are applied to an output flip-flop and to the pulse train duration circuit.

The output flip-flop, a monostable device, produces eight-microsecond pulses which are applied, via coaxial cable, to the SYNCH terminals of the IBM 1827 analogue-input facility.

The pulse train duration circuit controls the number of pulses generated before the RS flip-flop is reset. By means of digital dividers and BCD-to-decimal decoders, this circuit produces one second and ten second pulses that are applied to two front panel rotary switches. When the pulse train duration becomes equal to the desired duration, as set by the switches, the 'and'ed switch outputs reset the RS flip-flop thus terminating pulse generation and resetting the ramp output to 0 volt.

The voltage ramp is generated by an integrating circuit that has a gain of -41.6 millivolt per second. When the RS flip-flop is reset, a miniature reed relay connects a discharging resistor across the integrating capacitor thus resetting the integrator output to 0 volt. Setting the RS flip-flop causes the discharging resistor to be disconnected thereby enabling ramp generation.

The minimum ramp voltage, corresponding to a pulse train duration of 99 seconds, is -4.1 volt; therefore, the ramp cannot overload the analogue input circuit which has a full scale input voltage capability of $\pm$ 5.0 volt.

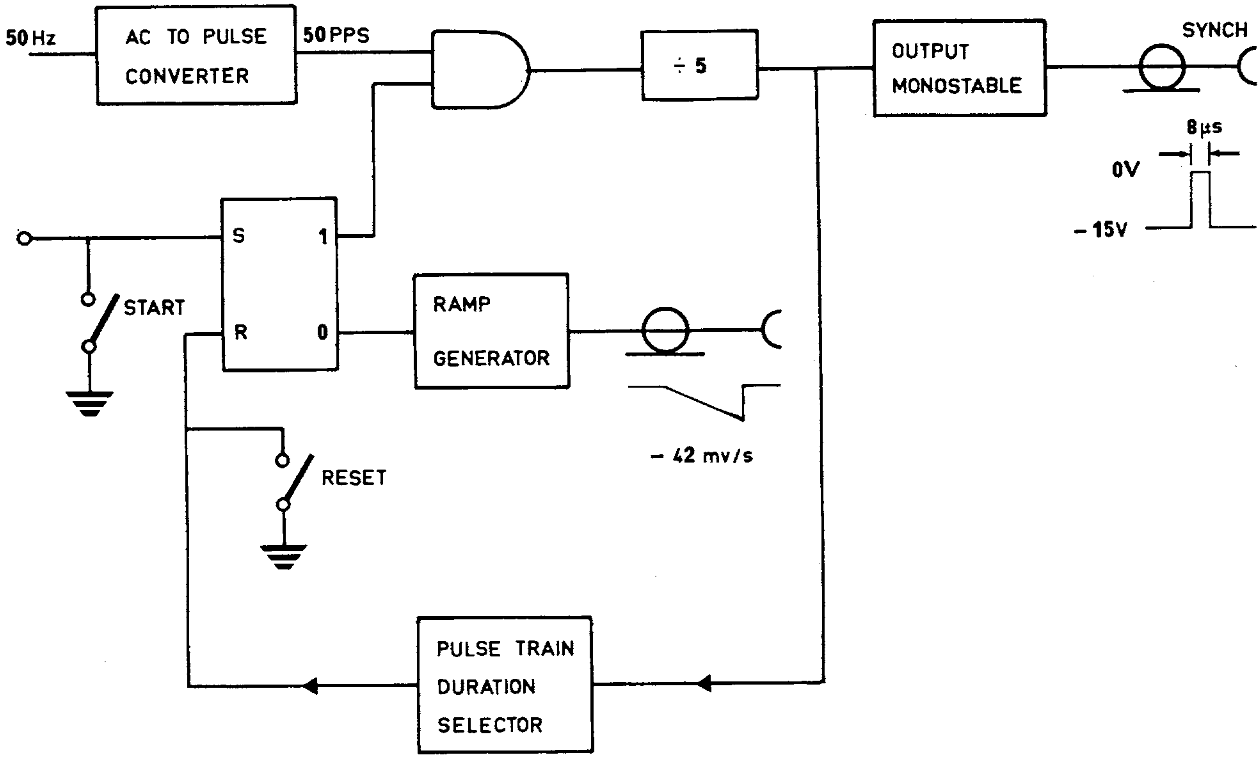


Figure 4.1 Pulse and Ramp Generator - Block Diagram

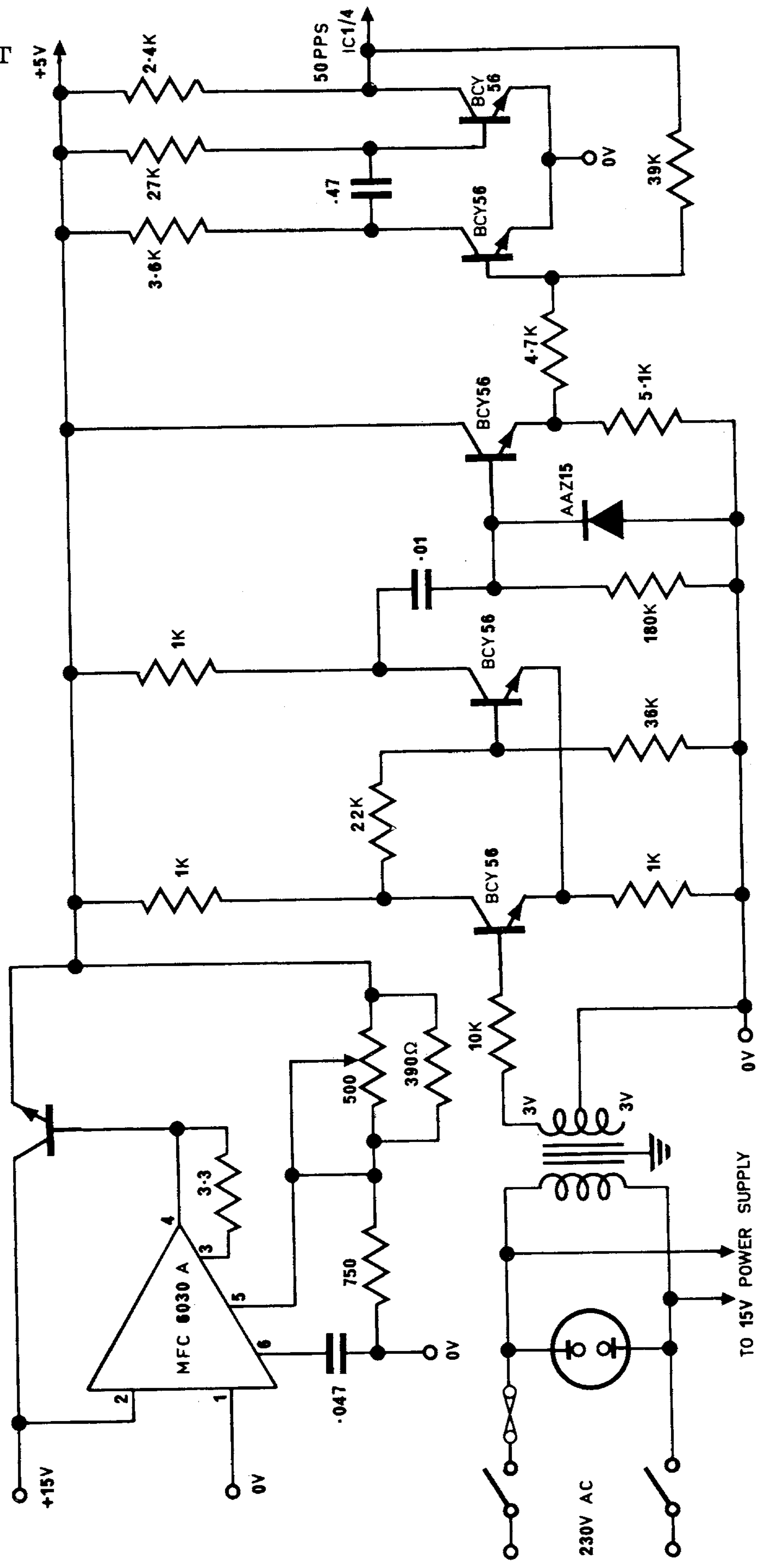


Figure 4.2 A.C. to Pulse Converter

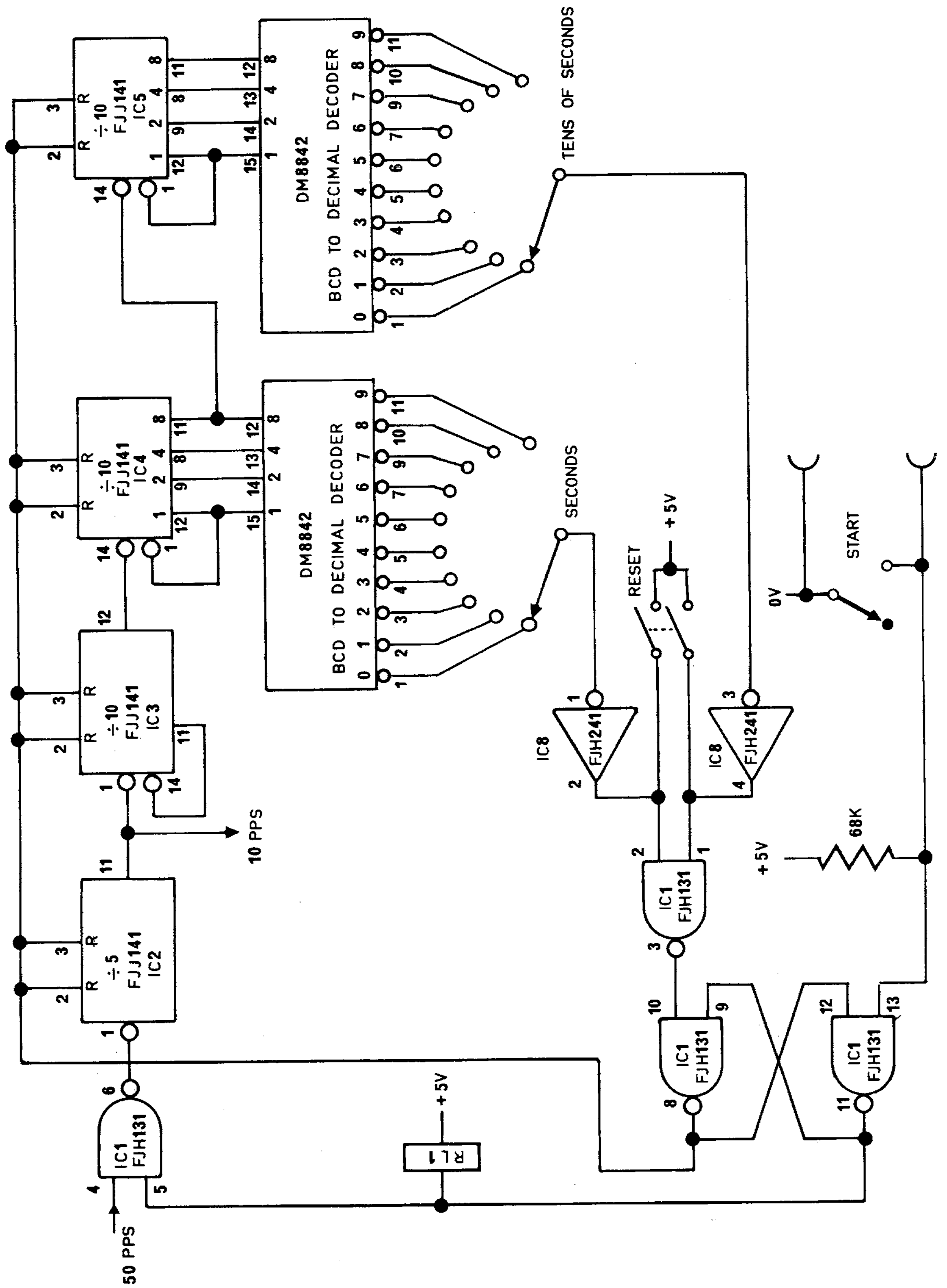


Figure 4.3 Divider and Duration Selection

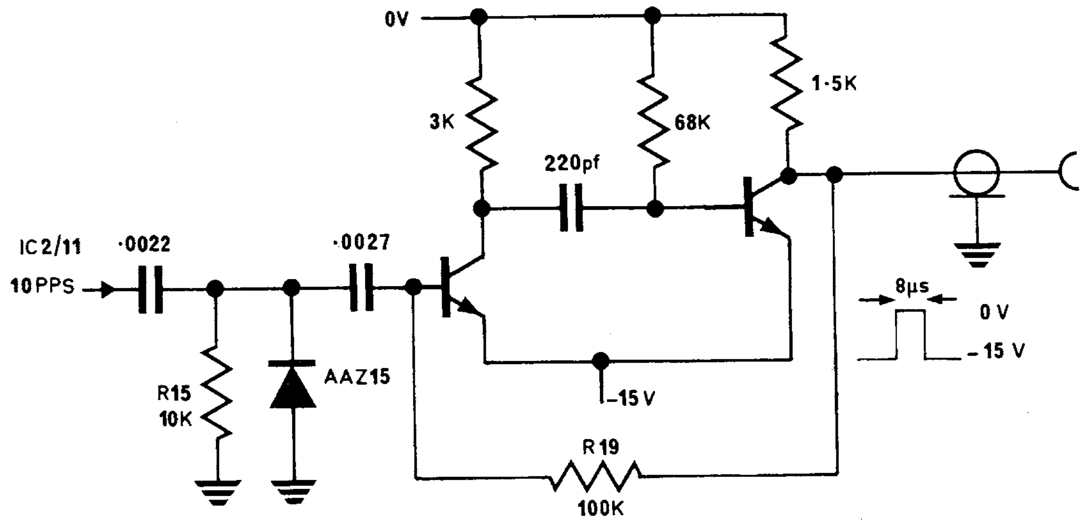


Figure 4.4 8 Microsecond Monostable

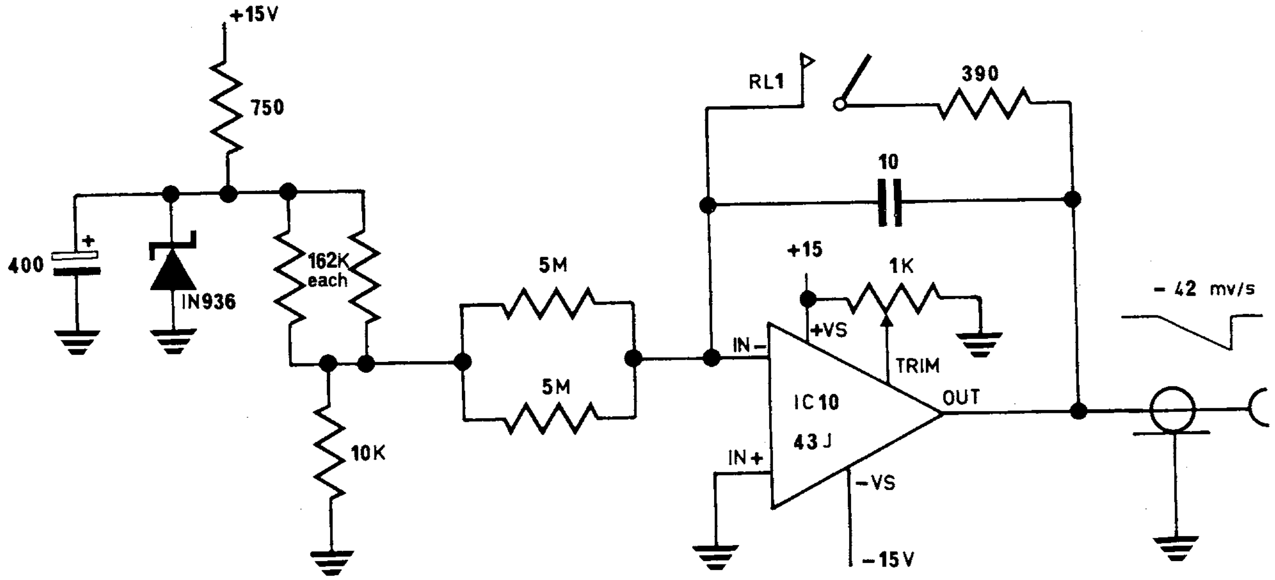


Figure 4.5 Ramp Generator

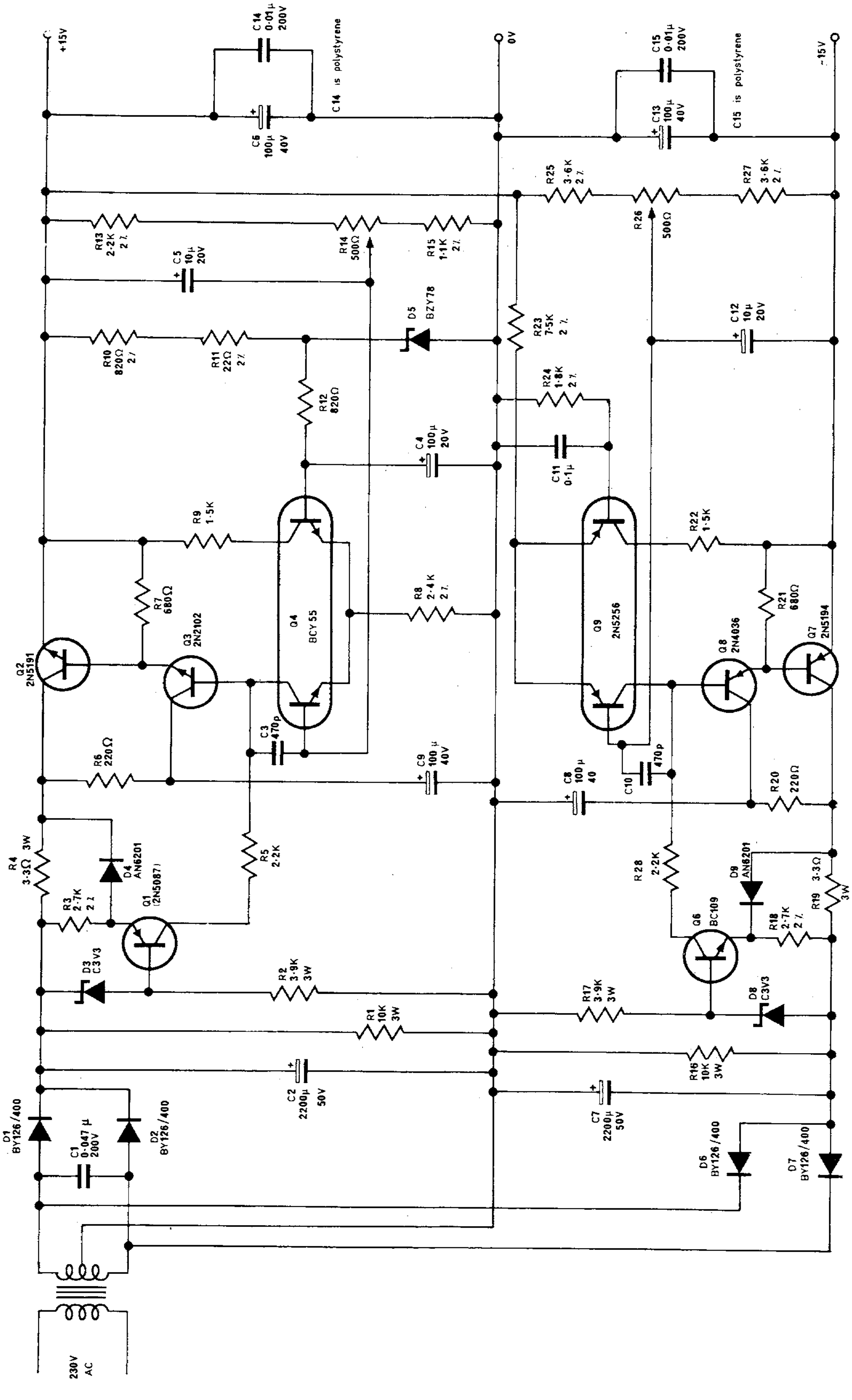


Figure 4.6 ± 15 Volt Power Supply

4.3 Prototype Pulse and Ramp Generator

The generator described below was used successfully until the presently used unit was commissioned. It is retained for standby use.

Figure 4.7 is a block diagram of the analogue input timing circuits. The logic symbols are the same as those for the typewriter circuits. The circuit diagrams are given in figures 4.9 to 4.13. The circuits between the 1827 and the magnet laboratory are carried by the 50 pair typewriter cable. Figure 4.8 is the analogue input timing chart.

Refer to figure 4.7. The dormant state is described by:-

(a) the flip-flop is reset so that its 1 output is low,

(b) the ramp generator relay is released, making the ramp generator output very close to zero,

(c) the 100 Hz square wave derived from the power mains is inhibited from reaching the decade counter,

(d) the decade counter is held reset to its 9 state,

(e) the analogue input synch line is held at -15 volts by the monostable.

If, at switch on, the flip-flop is set, it will initialise a cycle of the ramp generator which will reset it.

When either the 'start' or 'start collection' buttons is momentarily depressed, or the sequence controlled relay contacts close, the flip-flop is set. This releases the 'reset 9' on the counter, permitting it to count. The gate opens to allow the 100 Hz signal to reach the decade counter input. On the first negative transition of this input, the counter's output level falls, causing the monostable to fire. The 7 microsecond pulse from the monostable causes the 1827 analogue-input facility to read the 32 analogue channels sequentially at 50 microseconds per channel. The decade counter fires the monostable every 0.1 second.

The setting of the flip-flop also energises the ramp generator relay whose normally closed contacts open some 20 milliseconds later. The output level of the ramp generator starts falling at about - 0.3 volt per second. By the time it reaches - 5 volt the collection programme has finished. At $-7\frac{1}{2}$V (corresponding to about 25 seconds from start) the end-of-ramp switch resets the flip-flop and the relay releases, returning the ramp output to zero. Simultaneously the other circuits return to the dormant state.

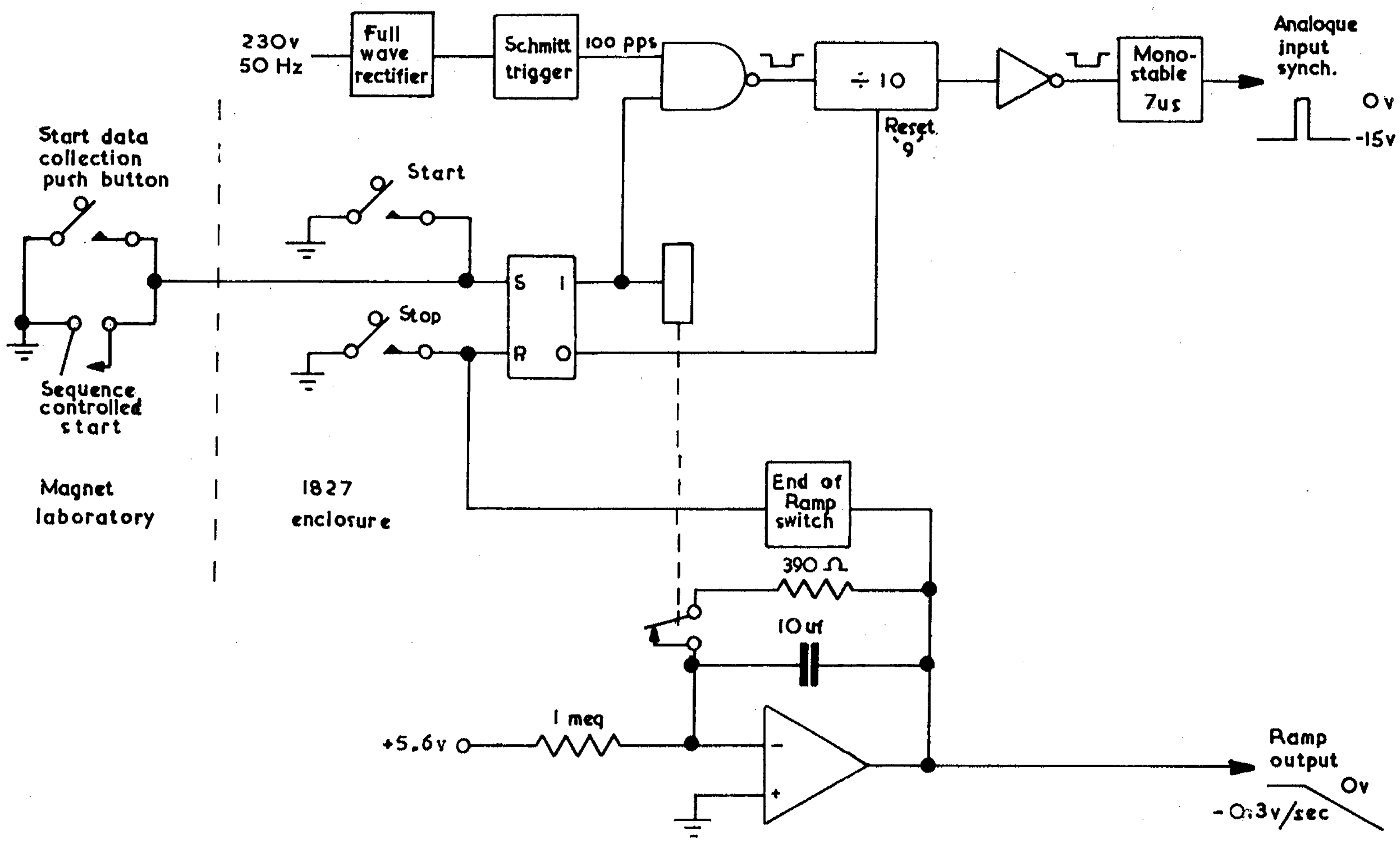


Figure 4.7 Prototype Pulse and Ramp Generator - Block Diagram

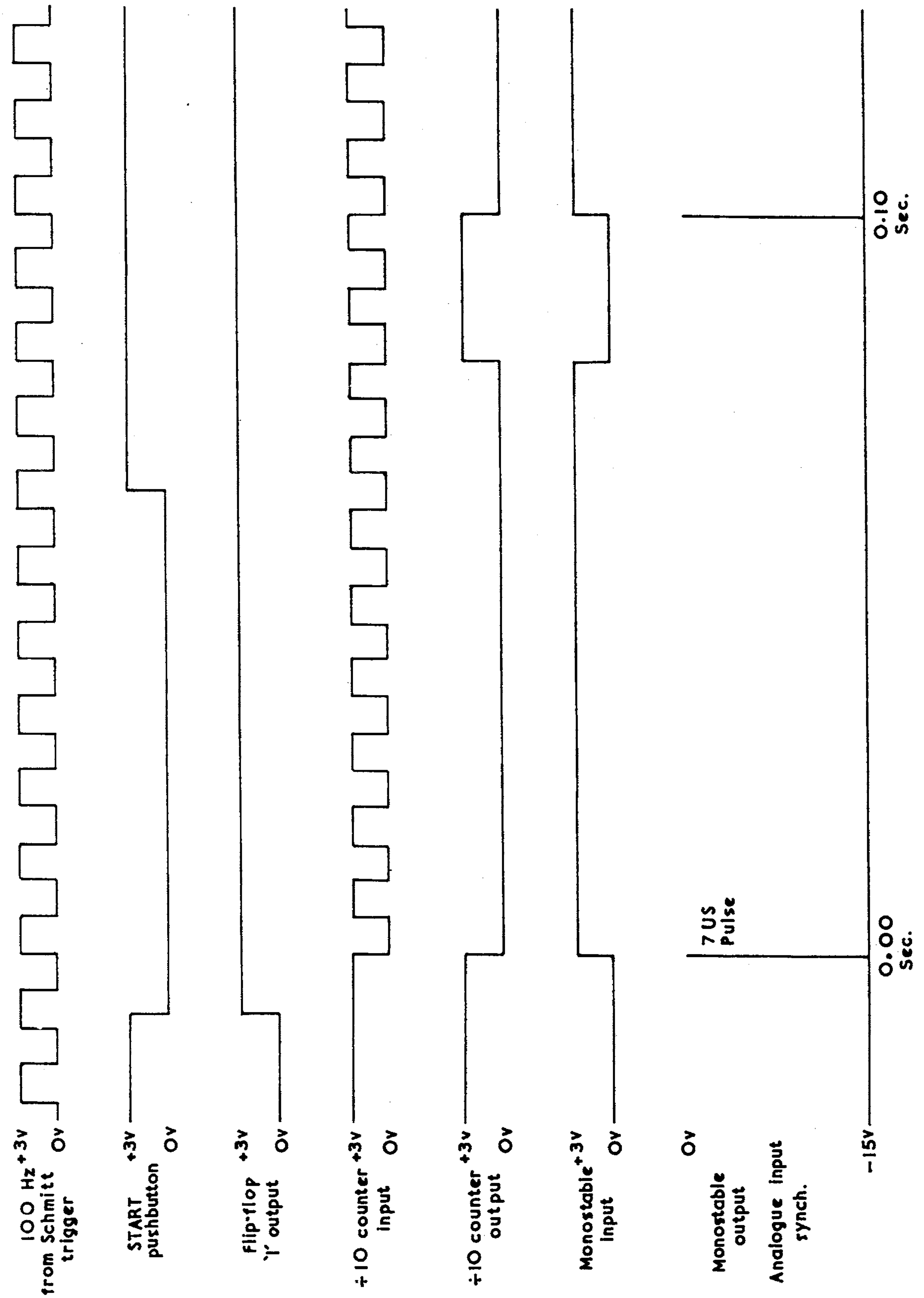


Figure 4.8 Prototype Pulse Generator Timing Diagram

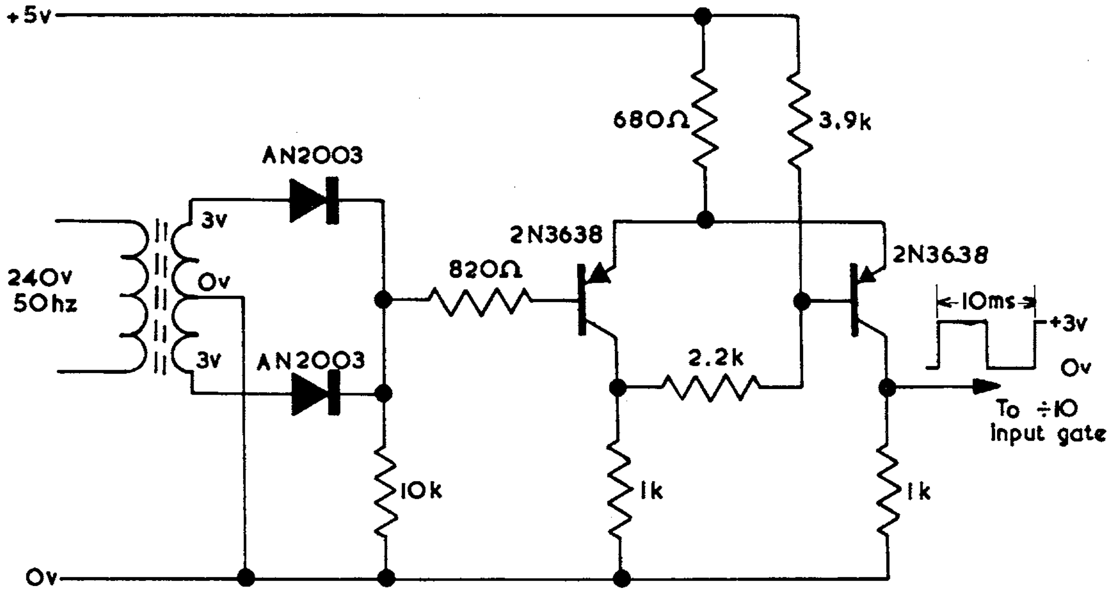


Figure 4.9 Prototype 100 Pulse Per Second Generator

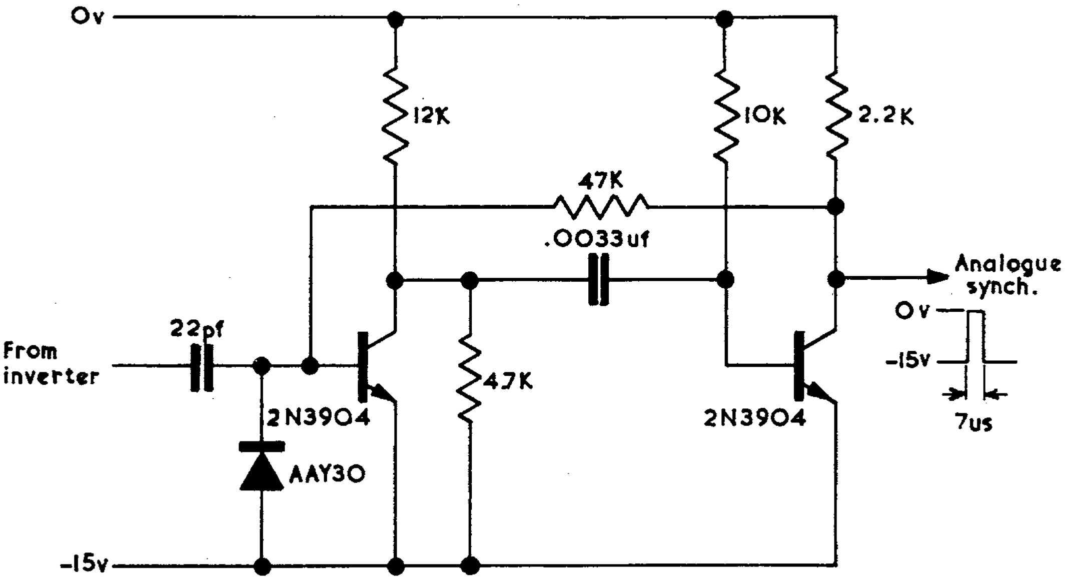


Figure 4.10 Prototype 7 Microsecond Monostable

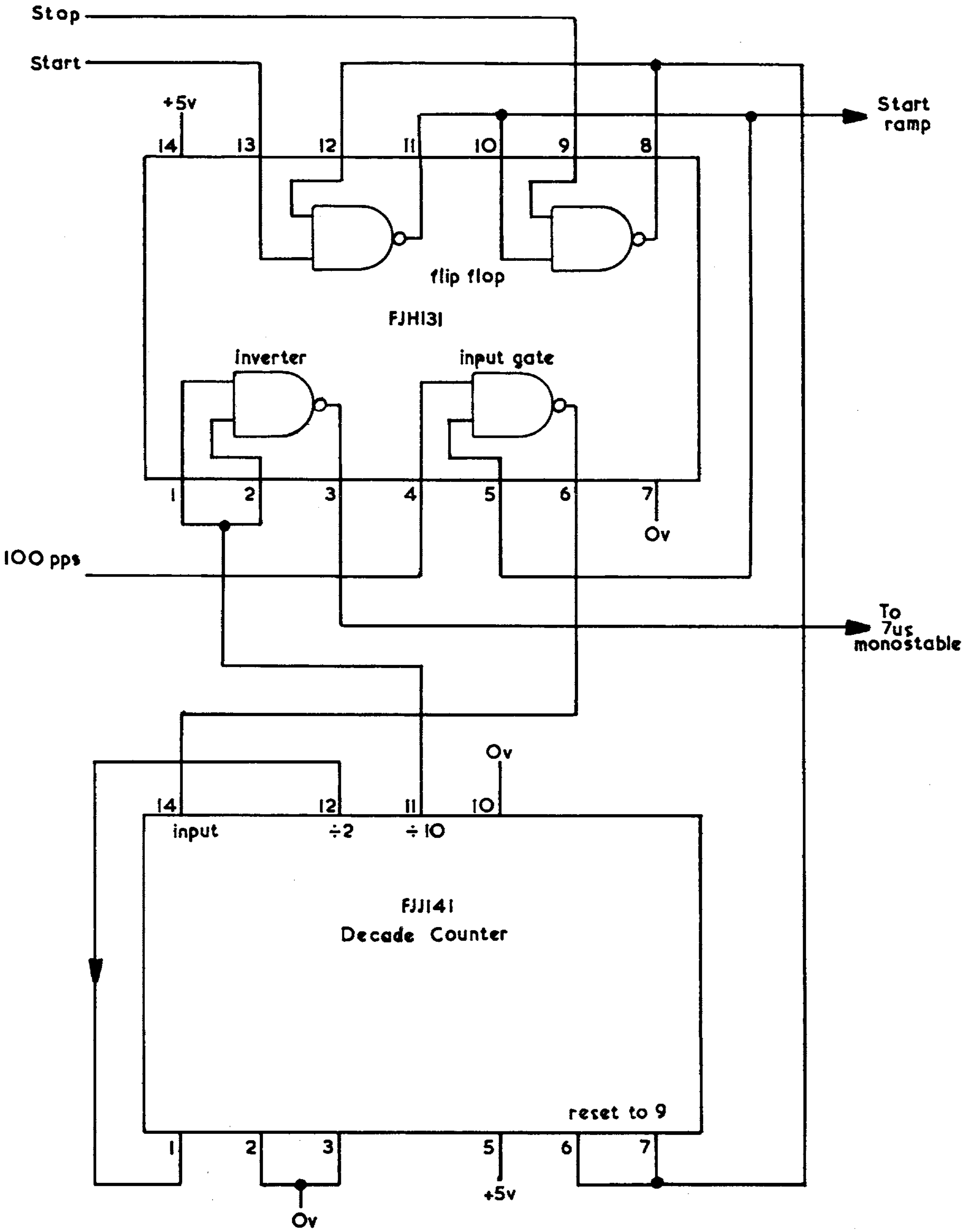


Figure 4.11 Flip-Flop Gate and Counter.

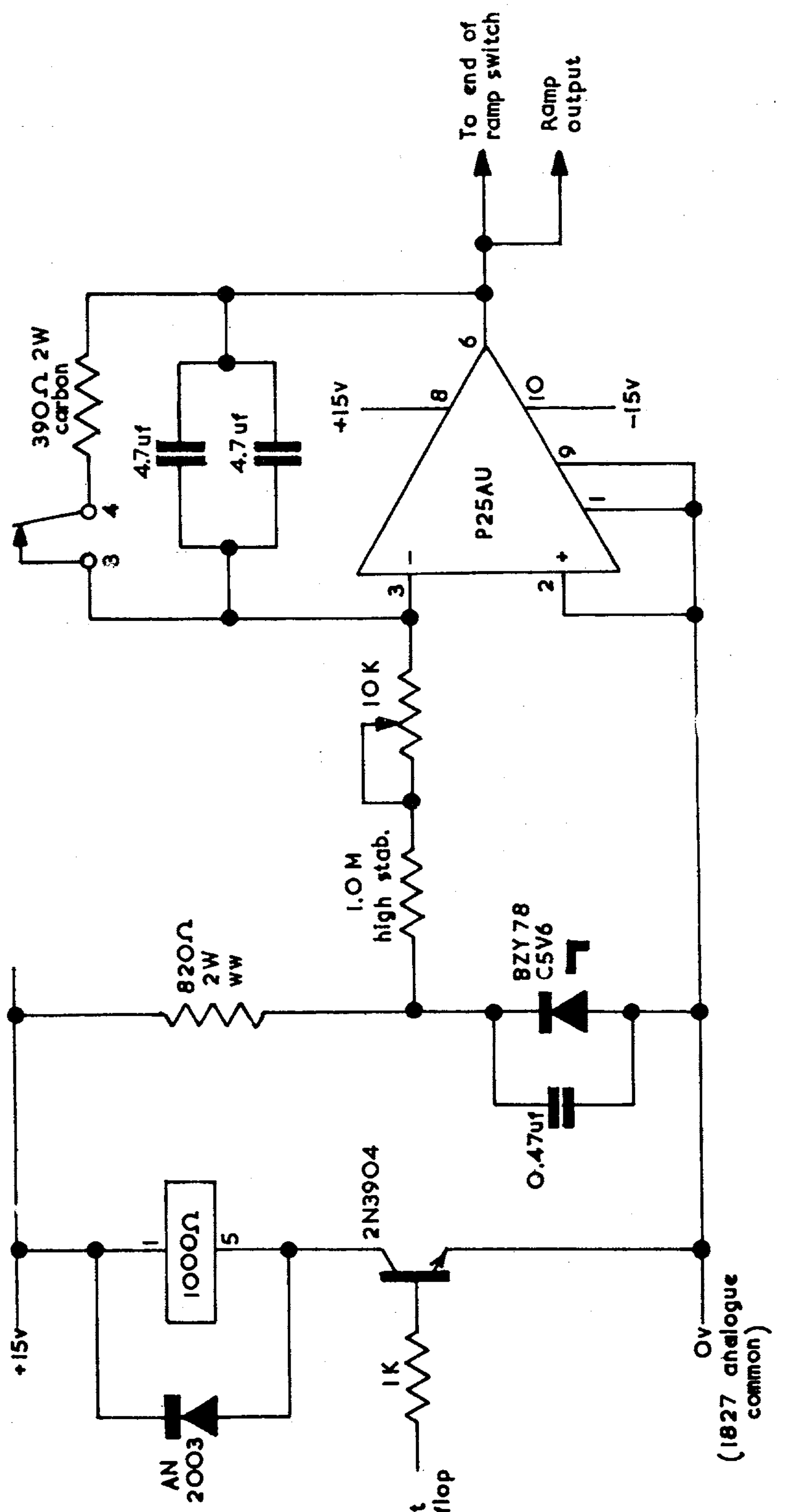


Figure 4.12 Analogue Input Ramp Generator

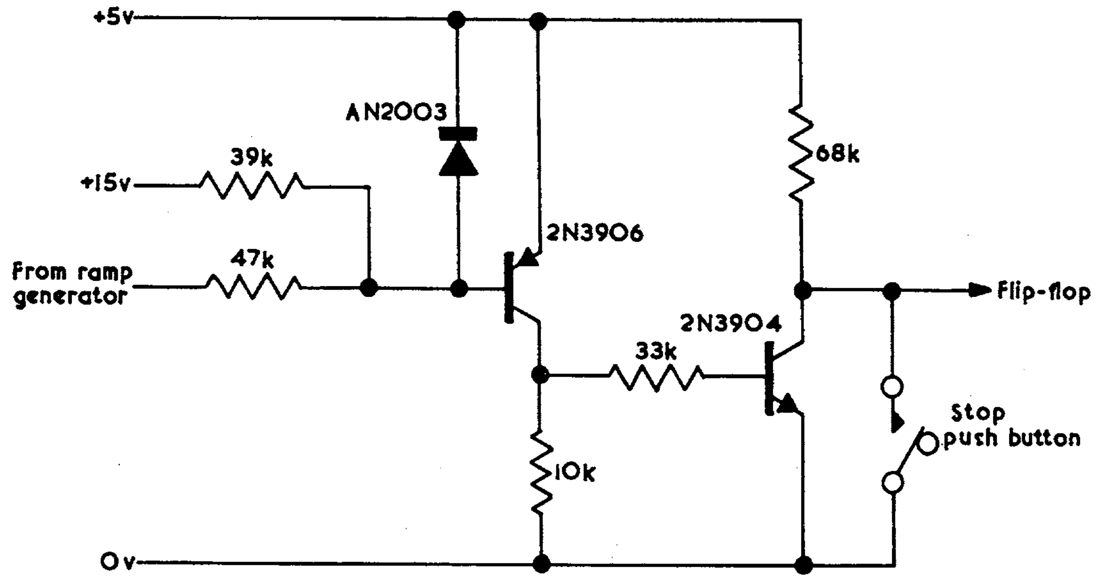


Figure 4.13 Prototype End of Ramp Switch

5. DIGITAL FACILITIES

5.1 Introduction

The typewriter, situated in the magnet laboratory is used to select computer programmes, to update tables, to print tables and to print processed data.

It is connected to the multiplexer input-output channel of the IBM 360/50 computer via control and interface circuits and the IBM 1827 digital-input and digital-output facilities, as illustrated in figure 5.1.

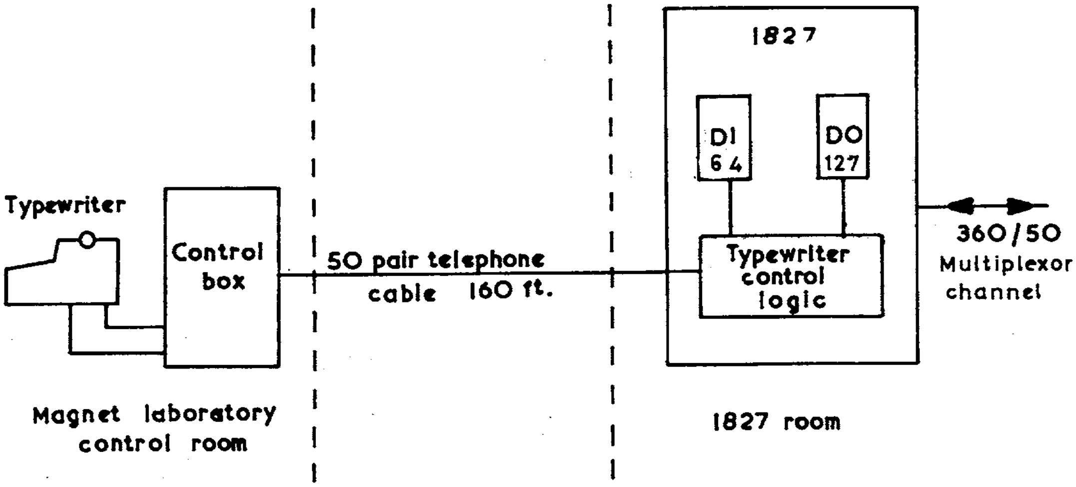


Figure 5.1 Typewriter Computer Interconnection

The control and interface circuits are constructed from Digital Equipment Corporation (DEC) modules.

Before the design of the typewriter control hardware had commenced, the ANU Computer Centre announced its intention to implement a Typewriter Consoles System using the IBM 360/50 and IBM 735 typewriters (see section 10). As the Department agreed to join the scheme it was sensible to co-operate with the Centre. Dr. Lawrence (Computer Centre) and R. G. Sutton designed logic for interfacing a typewriter to the Consoles System's multiplexer. The IBM recommendations for using the 735 typewriter were taken from the typewriter handbook(4). The circuits were then modified to interface the typewriter to the 1827 digital-input and digital-output facilities. This course of action was mutually beneficial since the typewriter circuits could be tried before production for the Consoles System started.

The interface circuits contain 8- bit input and output buffers which are unnecessary in the present configuration because the 1827 digital-input and digital-output have their own buffers. However, provision of interface buffers will enable the magnet laboratory to connect to the Consoles System with minimum of disturbance. The DEC logic slot will be prewired and the changeover will be made by existing logic cards and cables when all is ready.

In the following paragraphs 'character' refers to any symbol that may be printed by the typewriter, 'function' refers to any typewriter operation that does not involve printing. Examples of characters are: h ? 5 +. Examples of functions are: carrier return, space, upper case shift.

5.2 Component Description

5.2.1 1827 Digital-Input and Digital-Output (References: 3, p.47 and 5 pp.23, 29).

The 1827 digital-input and digital-output facilities provide groups of 16 terminal pairs. Each of these groups has a unique address that may be selected by a processing programme.

Each pair of input terminals is intended to operate in conjunction with an external pair of electrical contacts, a closed contact representing binary 1 and an open contact representing binary 0[3, p.51]. One terminal of each pair supplies +36 volt from the 1827 to the external circuit which, in the case of the typewriter interface, consists of a transistor switch instead of a a contact pair.

Each pair of output terminals of a group supplies +3 volt (binary 1) or 0 volt (binary 0) according to the contents of the group's digital-output register. One terminal of each digital-output pair is connected to the 1827 d.c. ground [3, p.55].

The magnet laboratory's typewriter is connected, via its interface circuits, to digital-input address 64 and to digital-output address 127 as shown in figure 5.1.

5.2.2 Synchronization (Reference: 3, pp.54, 57).

The 1827 analogue-input, digital-input and digital-output facilities each have one pair of READY and one pair of SYNCH terminals; one terminal of each pair is connected to the 1827 d.c. ground. These terminals permit the user to control the timing of data transfer between user device and the 1827.

As each 1827 facility has only one pair of READY terminals and one pair of SYNCH terminals, these terminals must be connected to the particular device addressed by a processing programme. For example, when the typewriter is addressed at digital-output address 127 the digital-output READY and SYNCH terminals must be connected to the typewriter control circuit and not to a device that uses another address.

An 1827 facility's readiness to execute data transfer is indicated by 0 volt at the facility's READY terminals; the 'not ready' condition is indicated by -12 volt at the terminals.

Upon receipt of a READY signal, the addressed device, if also ready for data transfer, sends a -12 volt synchronizing pulse to the facility's SYNCH terminals. This pulse initiates the data transfer and causes the READY signal to fall to -12 volt until the facility is ready for the next data transfer.

5.2.3 Typewriter [4].

The typewriter input-output components comprise contact sets and electromagnets that provide synchronized communication between the typewriter and the 1827 digital-input and digital-output facilities via the digital-interface circuits. These components are shown in the typewriter wiring diagram, figure 5.8.

Typewriter character keys operate a set of seven transmitting contacts that generate 'correspondence' code (figure 5.4) in the form of contact closures. The code generated includes an odd-parity check bit.

In addition to transmitting contacts, the character contact sets have checking contacts that are internally wired to provide an odd-parity check of contact set operation.

Individual transmitting contact sets are provided for each of the following typewriter functions: tab, space, index, backspace, carrier return, upper case shift and lower case shift.

Corresponding to each of the above character and function contact sets is an electromagnet that converts the electrical output from the interface into mechanical output. The character magnets operate the 'correspondence' code decoding mechanism to select and print characters, whereas, the function magnets operate their corresponding functions directly. Each magnet also operates its corresponding transmitting contact set thereby providing a feedback facility that is used, in this system, to check output characters for correct parity. A feature of the interface circuit prevents the feedback from initiating input to the computer during output operations.

Cam operated feedback and timing contacts C1 to C6 are used to synchronize typewriter mechanical operation with the interface. The cams, attached to the typewriter cycle shaft, revolve for the following input and output operations:

C1 and C2	all characters (but not functions)
C3	upper case shift only
C4	lower case shift only
C5	backspace, space, tab only
C6	carrier return, index only

In addition to the transmitting and cam-operated contacts, the following mode and interlock contacts are provided: upper/lower case, keyboard lock/unlock, end of line, tab interlock and carrier-return interlock. The interlock contacts are used to prevent further input-output operations during the mechanical functions that they represent.

5.2.4 DEC Logic

The typewriter control logic situated in the IBM 1827 enclosure consists mainly of DEC logic modules. Specifications of these and definitions of logic levels are contained in reference 6. Generally, logic level low (L) is less than 0.4 volt and logic level high (H) is about +3 volt.

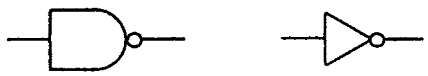
NAND symbols illustrated below may be replaced, in logic diagrams, by their equivalent NOR symbols.

e.g.

The following module types are used:

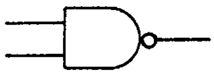
M111 containing 16 inverters

Inverter symbol:



M113 containing 10 dual input NAND gates

Dual input NAND gate symbol: A B



Output

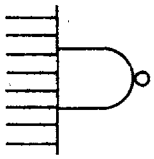
Dual input NAND gate truth table:

A	B	Output
L	L	H
L	H	H
H	L	H
H	H	L

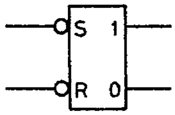
M116 containing 6 quadruple input NAND gates

Quadruple input NAND gate symbol: 

M117 containing 3 octal input NAND gates

Octal input NAND gate symbol: 

M203 containing 8 R/S flip-flops

R/S flip-flop symbol: 

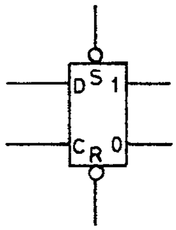
R/S flip-flop truth table:

R	S	1	0
H	L	H	L
L	H	L	H
H	H	U	U
L	L	H*	H*

U = Unchanged

* Prohibited state

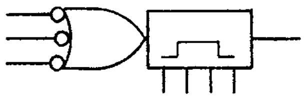
M206 containing 6 D flip-flops

D flip-flop symbol: 

D flip-flop operation:

Provided R and S are high, the information on the D input is transferred to the 1 output when the C input rises from low to high. The C input must return to low before any further information can be transferred. The R and S inputs may be used to over-ride the D input.

M302 containing 2 monostable flip-flops

Monostable flip-flop symbol: 

Monostable flip-flop operation:

The three inputs are normally high. Any input falling to low in 400 ns will cause a positive output pulse of duration determined by the external connections and internal trimming resistor adjustment. The input circuits are locked out until the output returns to low.

M602 containing 2 pulse amplifiers

Pulse amplifier symbol: 

Pulse amplifier operation:

The output pulse is at low level for a standard interval of 50 or 100 ns, otherwise the operation is the same as for the M302 monostable flip-flop.

5.3 Input Operation

5.3.1 Summary

Depressing one of the typewriter's character or function keys causes normal typewriter mechanical operation and presents a binary code, uniquely representing the character or function, to terminal pairs 0 to 7 of the terminal group having the IBM 1827 digital-input address 64.

A synchronising pulse from the digital interface to the 1827 digital-input facility's SYNCH terminals initiates transfer of the data from the digital-input group to the main store of the IBM 360/50 computer.

5.3.2 Circuit Operation

The following description is of the digital input interface and control circuits contained in figures 5.5 and 5.7. The various character codes referred to are contained in figure 5.4.

Typewriter character and function keys operate electrical contacts that control input voltage levels to the digital-input interface circuits. The contacts generate 'correspondence' code which is converted into 'I/O writer' code and then stored in the input-interface buffer. Provided that the 1827 digital-input READY signal is at 0 volt, a SYNCH signal generated 5 milli-seconds later, initiates transfer of data from the interface buffer to the

1827 digital-input register and causes the READY signal to fall to -12 volt until the 1827 is again ready to accept data.

The 5 millisecond delay is provided to allow the 1827 digital-input circuit to stabilize before data is transferred [3, p. 52].

Loss of data, due to the 1827 not being in a READY condition, is prevented by controlling the typewriter keyboard-lock solenoid with the digital-input READY signal thus preventing operation of the keyboard during 'not ready' periods.

As typewriter transmitting and checking contacts are bounce free during operation of their associated cam-operated contacts[4, p. 4], the cam-operated contacts are used to initiate loading of the interface input-buffer.

For character input, cam-operated contact set C1 sets flip-flop B24F2, C1 which triggers the monostable flip-flop A18T2. The trailing edge of the 5 millisecond pulse from A18T2 loads the data at the D inputs of the input buffer flip-flops.

The typewriter character contact-sets are checked for correct parity by NAND gate A21N1. Incorrect parity sets the parity flip-flop causing a parity alarm indication at the typewriter control box. Operating the Parity Cancel push button on the control box resets the Parity flip-flop thereby cancelling the alarm.

For functions, NAND gate B21V2 is enabled by B22V2 which is high when any function transmitting-contact is operated. Cam-operated contacts C3 to C6 operate for functions and provide a 'feedback' signal to the typewriter READY circuit (see figure 5.8), which then indicates typewriter BUSY at B22P2(figure 5.5). This results in a low at B21V2 which resets the FUNCTION flip-flop thereby triggering A18T2 and loading the input buffer.

The 10 microfarad capacitor at B22V2 prevents triggering of A18T2 by contact bounce when function transmitting contacts release.

Load pulses from A18T2 also set the INIT flip-flop which, after a 5 millisecond delay, sets the SYNCH flip-flop. The resulting SYNCH pulse causes the 1827 digital-input register to load from the input-interface buffer.

The Manual Interrupt button on the typewriter control box sets A20J2 which generates 'I/O writer' code X'7F' (X indicates hexadecimal representation of a binary code). This feature will be used in the consoles scheme to request the computer programme to unlock the keyboard. A20J2 also overrides any inhibit pulses from A18F2.

5.3.3 Input Example

This example describes the typewriter and digital-input operations that occur when an operator types the character 'c' followed by the function 'space'.

The description generally relates to the following figures:

5.2 Digital-Input Timing Chart;
5.4 Character and Function Codes;
5.5 Digital-Input Interface - Logic Diagram;
5.7 Typewriter Control Box - Wiring Diagram.

Where applicable, references are made to other figures.

The following conditions are assumed to exist before the operator types the character 'c':

(a) typewriter power is switched on;
(b) the typewriter is in lower case;
(c) the IBM 1827 digital-input facility is ready to accept input;
(d) the EOL (figure 5.6), PARITY, INT. REQ., INIT and SYNCH flip-flops are in their reset states.

When the typewriter key C is depressed, normal typewriter operation causes the character 'c' to be printed. At the same time the typewriter's R2A, R5 and T2 transmitting contact sets operate. These, in conjunction with the remaining unoperated contact sets, cause the following voltage levels at the D inputs of the interface input-buffer IN0 to IN7: HLLHHLHH.

When the cam-operated contacts C1 change over, bistable flip-flop B24C1, F2 changes state and triggers monostable flip-flop A18T2. The trailing edge of the resulting 5 millisecond pulse loads the interface input-buffer and sets INIT.

The 1 outputs of IN0 - IN7 control transistor switches in B16; high outputs cause these switches to conduct,thereby providing simulated contact closures to the 1827 digital-input facility.

INIT setting causes SYNCH to set 5 milliseconds later.

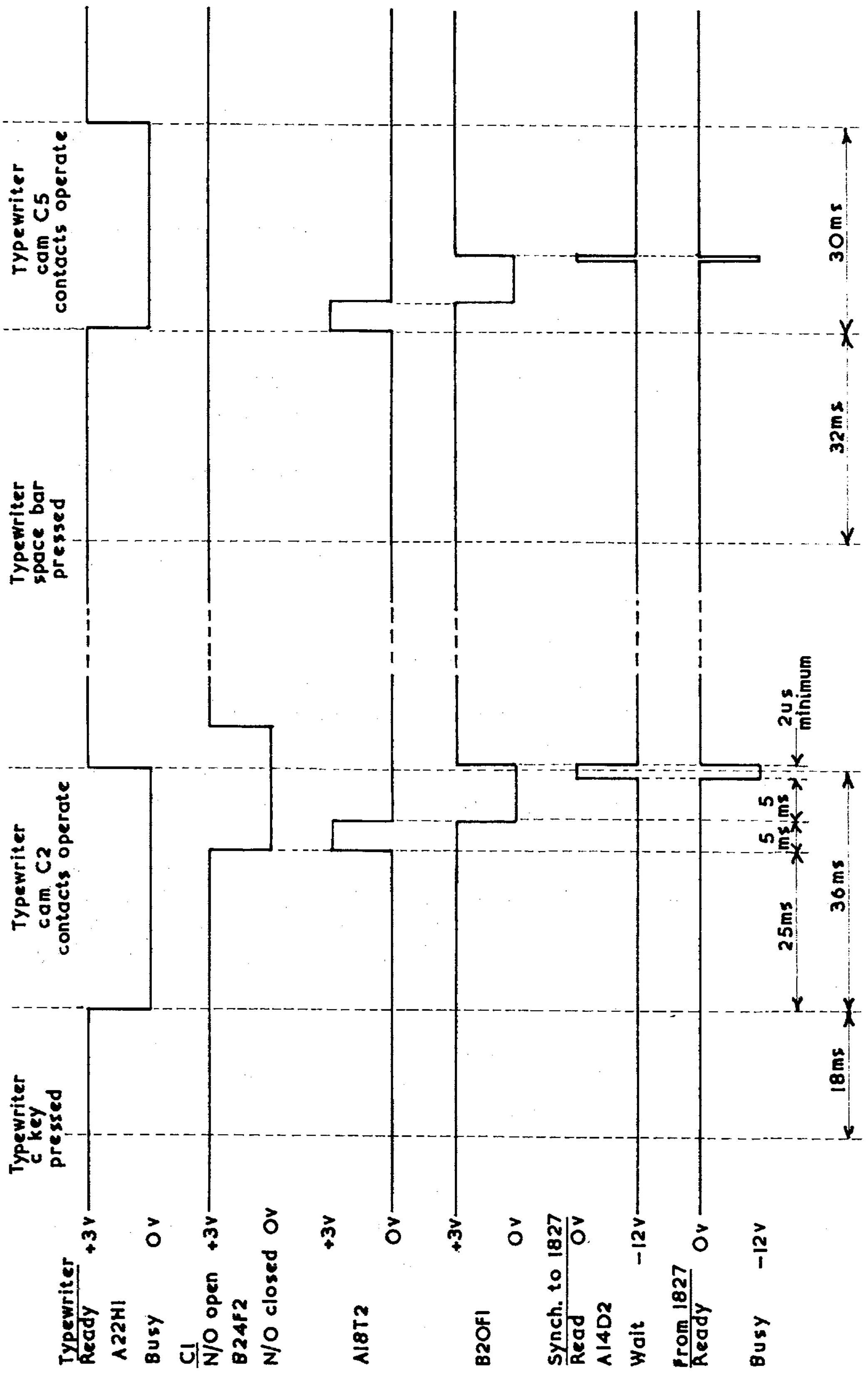


Figure 5.2 Digital Input Timing Chart

SYNCH set changes the digital input SYNCH signal from -12 volt to 0 volt, indicating to the 1827 digital-input facility that it may accept input.

The 1827 accepts data and the digital-input READY pulses to -12 volt, resetting INIT and SYNCH.

The typewriter is ready for the next input operation, in this case typing the function SPACE.

Pressing the SPACE bar causes low at B22M1 so that B22V2 goes high. When the typewriter cam C5 operates B22P2 goes high thus resetting the function flip-flop. This generates the code LLLLHHHH at the D inputs of the interface input-buffer, IN0 - IN7, and triggers A18T2. The trailing edge of the resulting 5 millisecond pulse from A18T2 loads the interface input-buffer.

As with character input, the same signal which loads the buffer sets INIT which in turn sets SYNCH 5 milliseconds later.

The 1827 accepts the input and resets SYNCH and INIT when ready for the next input operation.

5.4 Output Operation

5.4.1 Circuit Description

This description generally relates to the following figures:

5.4 Character and Function Codes;
5.6 Digital-Output Interface - Logic Diagram;
5.7 Typewriter Control Box.

Other figures are referred to as applicable.

Typewriter characters are selected for printing by seven magnets that are controlled by the digital-output interface. These magnets operate the typewriter mechanical-decoding mechanism to convert digital 'correspondence' code into printed characters. The magnets also operate their associated transmitting and checking contacts. In the magnet laboratory system, the checking contacts are used to check for odd parity; feedback from the transmitting contacts to the computer is inhibited by the digital-output interface.

Typewriter functions are selected by individual typewriter magnets operated by individual signals from the interface.

The following paragraph is a summary of the digital-output interface and typewriter output operation.

Loading of the 1827 digital-output register by the computer causes a Digital/Analogue Output (DAO) READY signal to be transmitted to the digital-output interface. This signal causes the interface output-buffer to be loaded from the 1827 digital-output register and causes the DAO SYNCH signal, from interface to 1827, to fall to the 'not DAO SYNCH' level. If the typewriter is in a READY condition, the decoded buffer-outputs are gated to the typewriter magnets which operate, thereby initiating a typewriter mechanical print-cycle. During the print-cycle, a typewriter BUSY signal is produced; this signal removes the signals from the typewriter magnets, inhibits input to the 1827 digital-input facility from the transmitting contacts and generates a DAO SYNCH pulse. The DAO SYNCH pulse causes a new character to be read into the 1827 digital-output register and the resultant DAO READY signal causes this character to be loaded into the interface buffer. This occurs during printing of the previous character by the typewriter so that when the typewriter again becomes ready for output, at the completion of the print cycle, fresh output is immediately available. Thus, during digital-output, the output buffer is loaded while the previous character is being printed.

A detailed description of the above operation follows.

When the 1827 digital-output facility is ready to transfer data, the DAO READY signal goes high. This transition, after a 15 microsecond delay in level changer A15, triggers B17F2 via the pulse shaping inverter, B15J2. The 15 microsecond delay allows the levels at the D inputs of the interface output buffer to settle before the buffer is loaded.

The 200 nanosecond pulse from B17F2 does three things:

1. it resets the INTO flip-flop;
2. its leading edge triggers B17T2;
3. its leading edge loads the data, at the D inputs of the output-buffer flip-flops, into the output-buffer.

The 1 output of the INTO flip-flop, now being low, causes DAO SYNCH to go low (i.e. 'not SYNCH') while B17T2 ensures that DAO SYNCH remains low for a minimum of 5 microseconds.

The 0 output of the INTO flip-flop, now being high, allows A19L2 to be controlled by the typewriter READY signal via A21F1. A21F1 thus synchronizes typewriter operation with interface operation.

Logically the typewriter has two states, READY and BUSY.

READY defines a period when the magnets may be energised from the interface's output-buffer. The typewriter is READY when all of the following conditions exist:

(a) none of the contact sets C2, C3, C4, C5, C6 are operated;

(b) neither the TAB interlock nor the END of LINE interlock is operated;

(c) the EOL flip-flop is in its reset state;

(d) the PARITY flip-flop (figure 5.5) is in its reset state.

BUSY defines a period when the typewriter magnets must not be operated. The typewriter is BUSY when any of the following conditions exist:

(a) any of the contact sets C2, C3, C4, C5, C6 are operated;

(b) either the TAB or END of LINE interlock is operated;

(c) the EOL flip-flop is in its set state;

(d) the PARITY flip-flop is in its set state.

For the first character or function of a sequence the typewriter will normally be in a READY condition whereas for later characters or functions the typewriter will be in a BUSY condition when INTO resets. Low at A21D1 indicates the READY condition whereas high indicates the BUSY condition.

Thus, for the first character or function of a sequence, the reset of INTO immediately causes high at A22L2 whereas for other characters or functions A22L2 remains low until the typewriter becomes READY at the completion of its current mechanical cycle. When A22L2 does go high the output gates are enabled via A21C1, A22F2 (for characters), or A21F2, A22D2 (for functions), thereby transmitting the decoded output-buffer states to the typewriter magnets via magnet drivers in the typewriter control box.

The operation of any typewriter magnet initiates a typewriter mechanical cycle that prints the character or executes the function indicated by the operated magnets.

Operation of any of the typewriter cams, C2 to C6, indicates a typewriter BUSY condition and causes the TYPEWRITER READY signal to go low thus resetting the TRDY flip-flop. Cam operation also causes either the FEEDBACK or the CR, TAB INTERLOCK signal to go HIGH so that a high is applied to the S input of TRDY. During carrier return or tab functions TYPEWRITER READY is maintained low by the carrier return interlock contacts or tab interlock contacts until the function is complete.

Provided that the PARITY (figure 5.5) and EOL flip-flops are reset, resetting TRDY produces BUSY (low) at A22H1 and low at A22L2.

A22L2 going low causes three things:

1. the output gates are disabled thus releasing all typewriter magnets;
2. A18J2 (figure 5.5) is triggered, inhibiting loading of the interface's input buffer;
3. A19L2 is triggered producing a pulse that sets the INTO flip-flop.

The 1 output of INTO, now high, produces DAO SYNCH, provided that the five microsecond pulse from B17T2 is completed.

DAO SYNCH causes the DAO READY signal from the 1827 to go low (not READY) and causes the computer to load the next character into the 1827 digital-output register. When the loading is completed the DAO READY signal again becomes high and a new cycle of digital-output interface operation commences.

At the completion of each typewriter print or function cycle TYPEWRITER READY goes high while CR, TAB INTERLOCK and FEEDBACK go low, thus resetting TRDY so that the next typewriter operation may begin.

If the output were a case shift and the typewriter were already in that shift, then the appropriate magnet would energise but no typewriter BUSY would be generated. Such a condition would prevent further output. To overcome this problem the case-shift magnet signals at A22N2 and A22R2 are gated with the signals from the shift-mode contacts to trigger pulse amplifier A19L2. This generates DAO SYNCH which causes the output buffer to be loaded with the next character. For example, if the LCS (lower case shift) gate A23V2 goes low and the typewriter is already in lower case, indicated by B21A1 low and B21E2 high, the 100 ns pulse amplifier A19L2 will be triggered by A22J2. This sequence of events takes less than 1 microsecond.

A similar situation exists with KEYBOARD LOCK and UNLOCK. Note that the signals which normally energise the magnets are used to set and reset the UNLOCK flip-flop (A20K1). Either LOCK or UNLOCK will fire the pulse amplifier through its input A19P2. As in the case of case shifts, this operation occurs in less than 1 microsecond.

Monostable flip-flop B17T2 ensures a DAO SYNCH pulse with a minimum length of 5 microseconds, even under the above conditions.

Figure 5.3 illustrates the timing conditions that occur for the following output sequence:

(a) the first character of the sequence;
(b) a character other than the first of the sequence;
(c) a case shift when the typewriter is already in the required shift;
(d) a carrier return.

5.4.2 Output Example

This example generally relates to the following figures:

5.4 Character and Function Codes;
5.6 Digital-Output Interface - Logic Diagram;
5.7 Typewriter Control Box - Wiring Diagram.

Where applicable, references are made to other figures.

The following conditions are assumed to exist prior to the operations described in this example:

(a) the typewriter power is switched on;
(b) the PARITY (figure 5.5), EOL, and INTO flip-flops are in their reset states.

This example describes the typewriter and digital-output operations that occur when output consists of the character 'd' followed by the function 'space'.

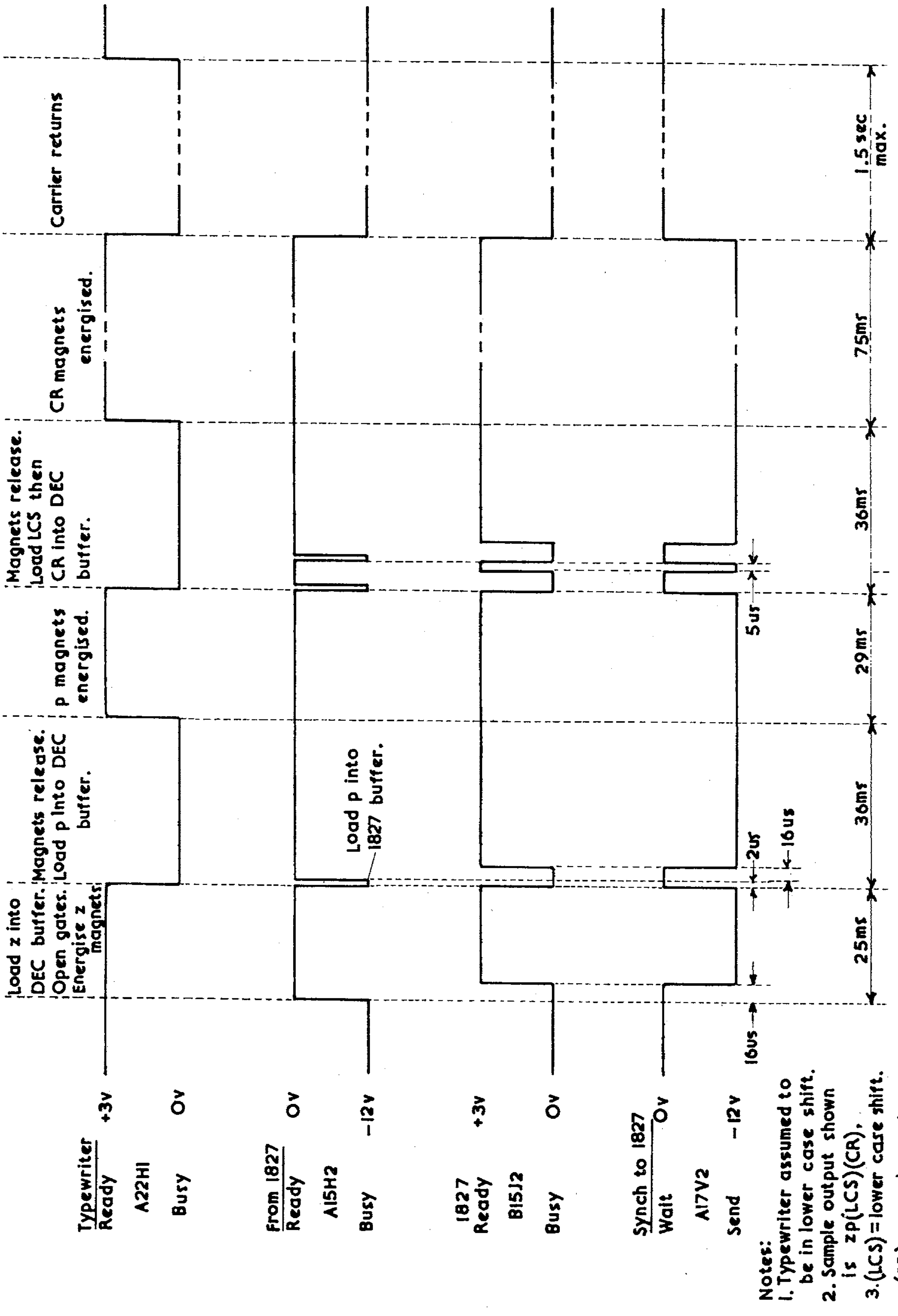


Figure 5.3 Digital Output Timing Chart

When the print programme commences, the IBM 360/50 computer loads bits 0 to 7 of the IBM 1827's digital-output register at digital-output address 127 with X '1A' which is the 'input-output writer' code for character 'd'.

The 1827's DAO READY signal then goes high (H) and the voltage levels LLLHHLHL are applied to the D inputs of the interface output-buffer flip-flops OUT0 to OUT7 via non-inverting isolators on board A16.

To allow the output-buffer D inputs to settle before loading the buffer, the positive-going leading edge of the DAO READY signal is delayed by 5 microseconds before triggering the monostable flip-flop B17F2.

The 200 nanosecond pulse, from B17F2, loads the output-buffer, resets INTO and triggers B17T2 causing the DAO SYNCH output to fall from 0 volt to -12 volt.

The 0 output of INTO, 'and'ed with the output of A22H1, enables the character output gates, thus causing the R1, R2A, R5, T2 and CK outputs to energise their associated typewriter magnets via magnet drivers in the typewriter control box.

This initiates a typewriter mechanical print cycle to print the character 'd'. After 10 milliseconds, in this case of a first print cycle, the normally open contacts of C2 close and cause TRDY to reset. This produces typewriter BUSY at A22H1.

At this point, the magnets must be de-energised and the interface output-buffer may be loaded with the code for the next output character or function.

Because INTO is reset, BUSY triggers the monostable flip-flops A19L2 and A18F2 (figure 5.5). The output pulse from A18F2 inhibits input caused by the printing of character 'd'. The output pulse from A19L2 sets INTO thus causing DAO SYNCH to rise from -12 volt to 0 volt. This transition causes the 1827 digital-output facility to load the interface output-buffer with X'0F', the 'input-output writer' code for the function 'space'.

The print cycle for 'd' continues for another 36 milliseconds then the normally closed contacts of C2 close causing TRDY to set. Provided that the PARITY (figure 5.5) and EOL flip-flops are reset, the setting of TRDY produces a high at A22H1 which, when 'and'ed with the high 0 output of INTO, enables the output gate for SPACE (B23J2) thus causing the typewriter's space magnet to operate.

During the resulting typewriter function cycle, the normally open contacts of C5 close causing TYPEWRITER READY to go low. TRDY then goes to its reset state thus disabling the output gates and de-energising the space magnet.

5.5 Digital Interface Test Box

A digital interface test box was developed so that the digital interface and typewriter could be tested independently of the IBM 1827 data control unit and IBM 360/50 computer.

When testing, cables between the test box and interface replace the cables that normally connect the IBM 1827 digital-input and digital-output facilities to the interface.

Figure 5.16 is a circuit diagram of the digital interface test box.

The test box provides simulated digital-input and digital-output READY signals, simulated digital-output contact closures and indicators that display the contents of the interface input-buffer. An external 36 volt power supply is required when using the digital-input display facility of the text box.

Typewriter Function	I/O writer code	EBCIDC
Space	0F	40
Backspace	1F	CA
Tabulate	4F	CD
Carrier return	5F	4A
Upper case	6F	CF
Lower case	2F	CB
Keyboard lock	3F	3F
Keyboard unlock	7F	7F

Figure 5.4(a) Function Codes

Character upper case	Character lower case	Correspondence code R1	R2	R2A	R5	T1	T2	CK	I/O writer code	EBCDIC
A	a			x	x	x			AB	C1
B	b						x		97	C2
C	c			x	x		x		9B	C3
D	d	x		x	x		x	x	1A	C4
E	e	x		x			x		92	C5
F	f		x	x	x				B9	C6
G	g	x	x	x	x			x	38	C7
H	h	x					x	x	16	C8
I	i			x		x		x	23	C9
J	j	x	x	x					B0	D1
K	k			x			x	x	13	D2
L	l	x			x		x		9E	D3
M	m	x	x	x	x	x			A8	D4
N	n		x	x			x		91	D5
O	o	x			x	x			AE	D6
P	p	x		x				x	32	D7
Q	q			x					B3	D8
R	r	x		x	x	x		x	2A	D9
S	s	x				x		x	26	E2
T	t	x	x	x			x	x	10	E3
U	u		x	x	x		x	x	19	E4
V	v		x	x	x	x		x	29	E5
W	w					x			A7	E6
X	x	x	x	x	x		x		98	E7
Y	y	x							B6	E8
Z	z	x	x	x		x	x		80	E9

x indicates contact-set or magnet operated.
R5 is normally open.
All others are normally closed.

Figure 5.4(b) Character Codes

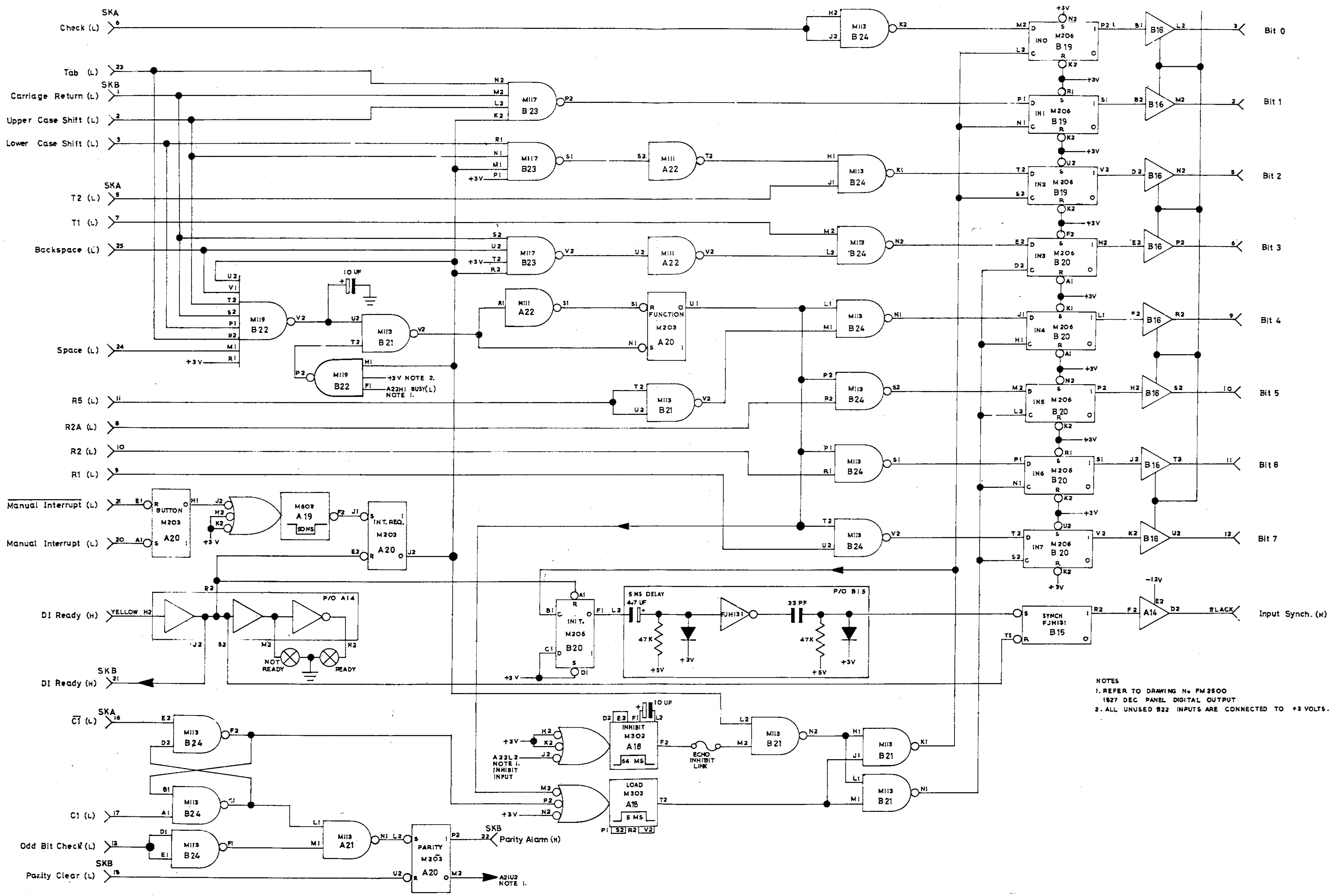


Figure 5.5 Digital-Input Interface - Logic Diagram

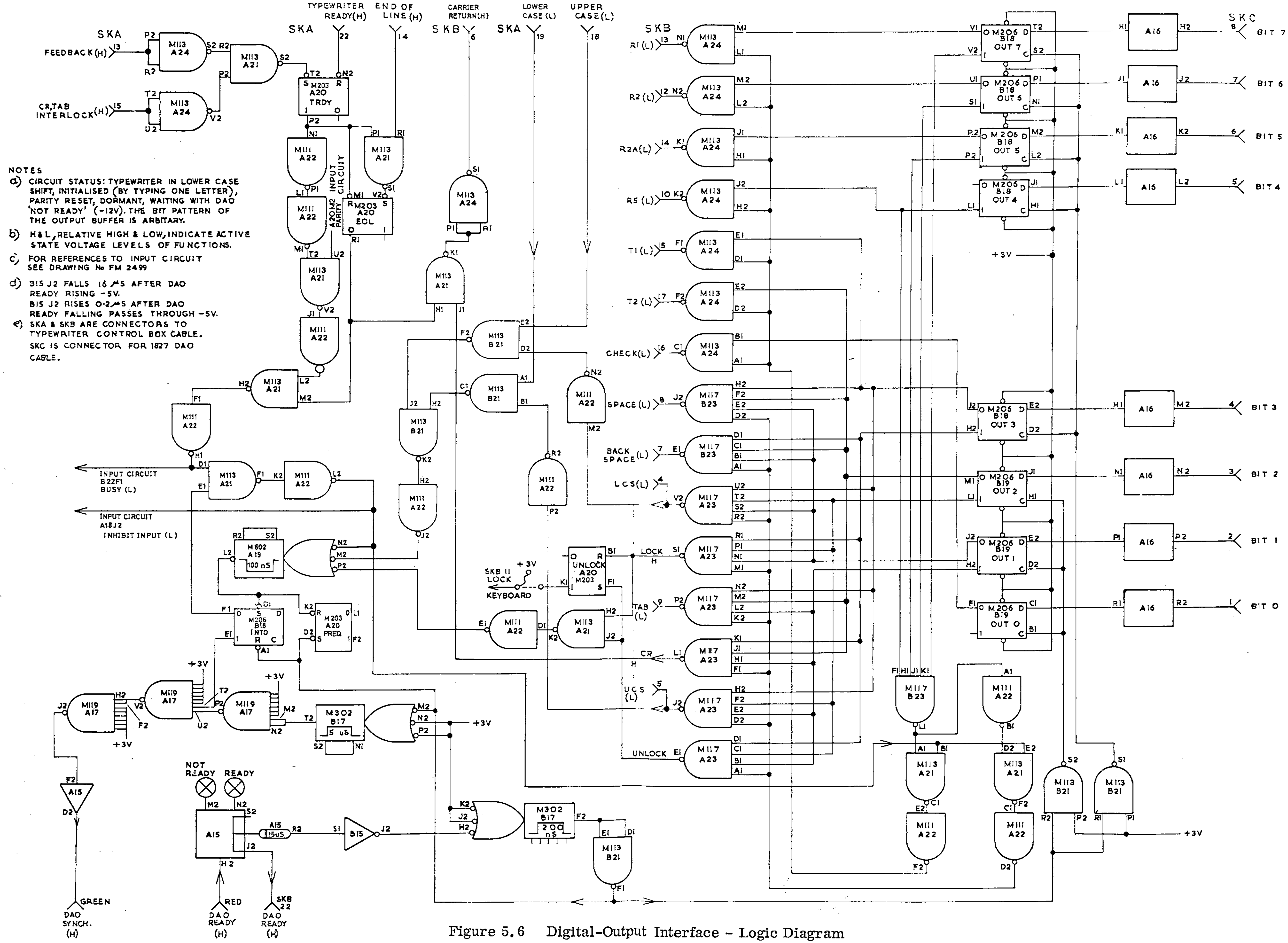


Figure 5.6 Digital-Output Interface - Logic Diagram

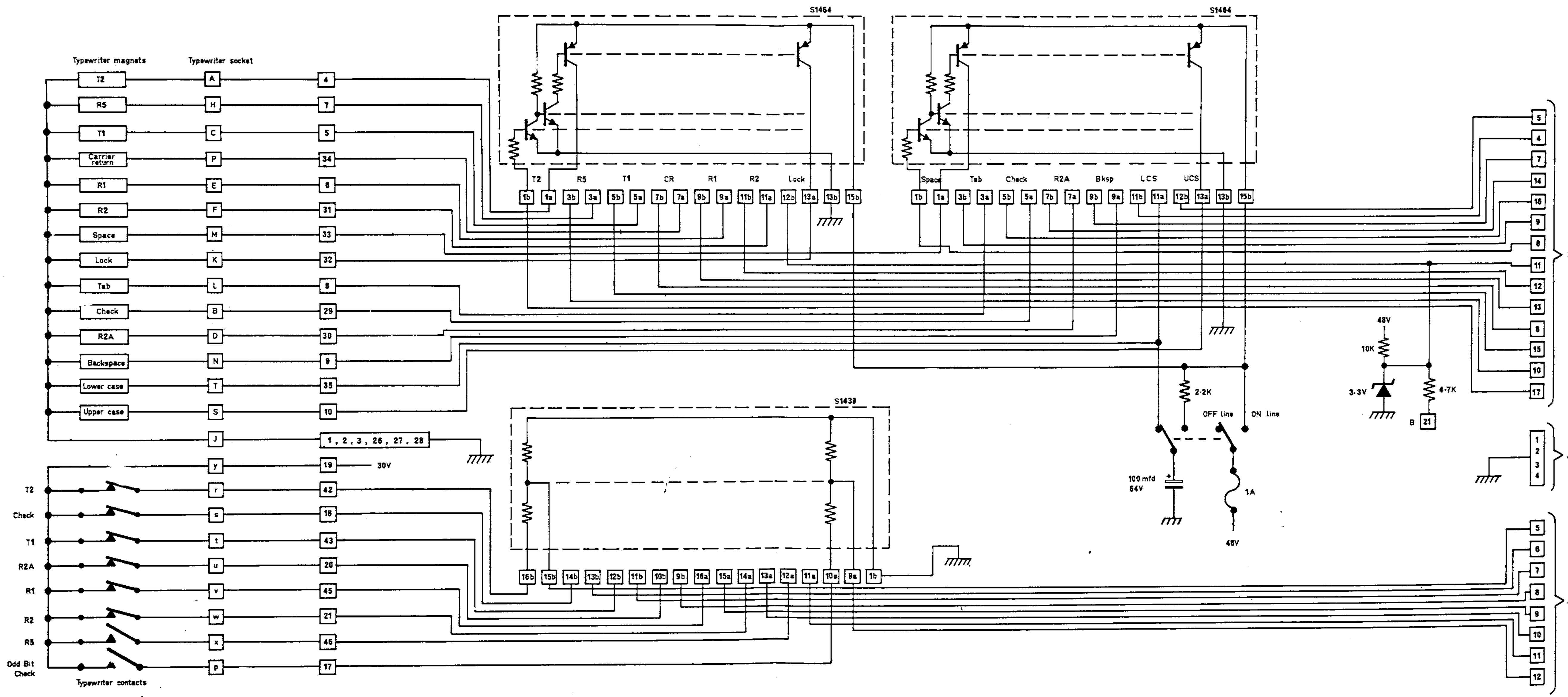


Figure 5.7(a) Typewriter Control Box - Wiring Diagram. Character Circuits

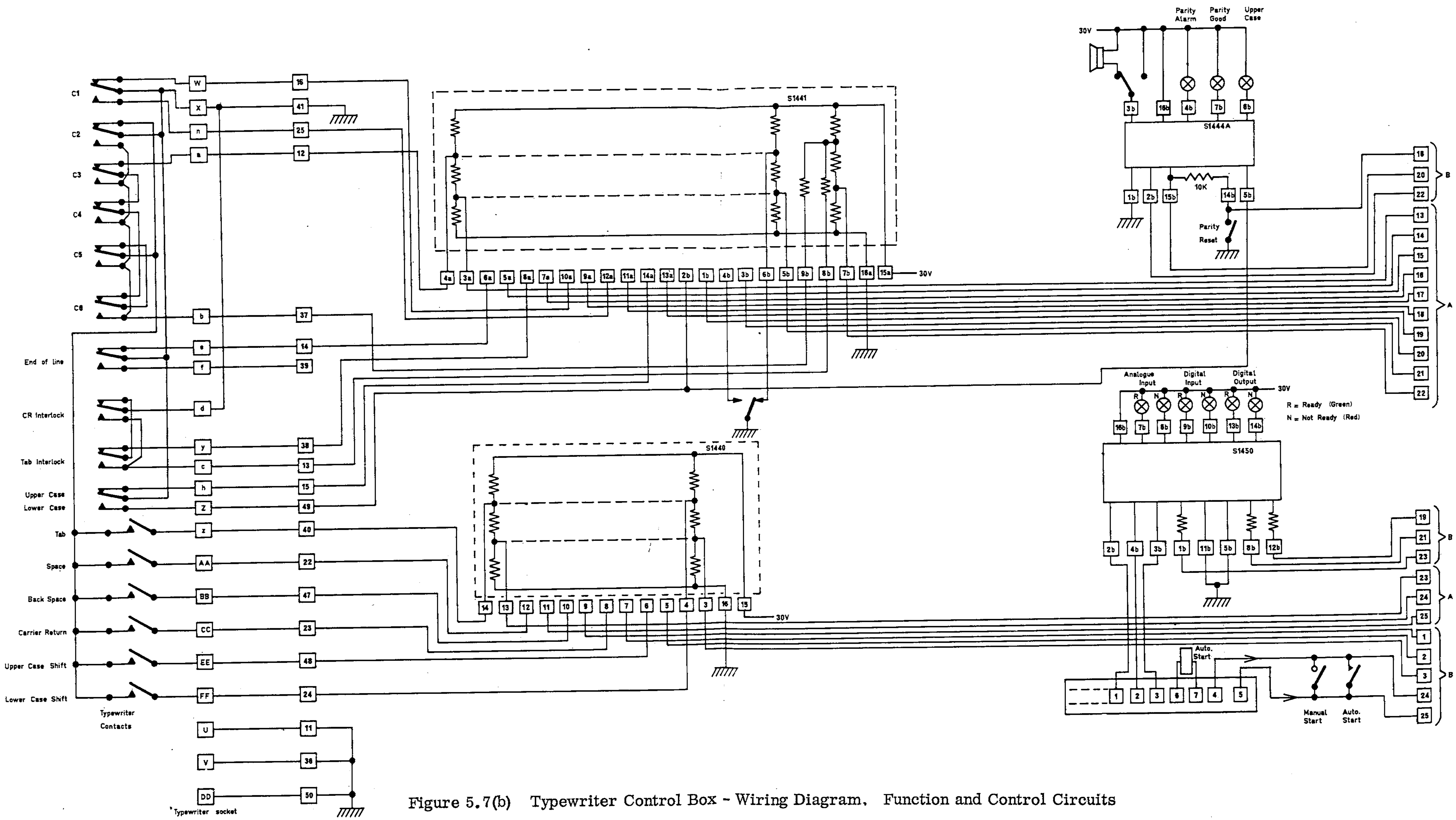


Figure 5.7(b) Typewriter Control Box - Wiring Diagram, Function and Control Circuits

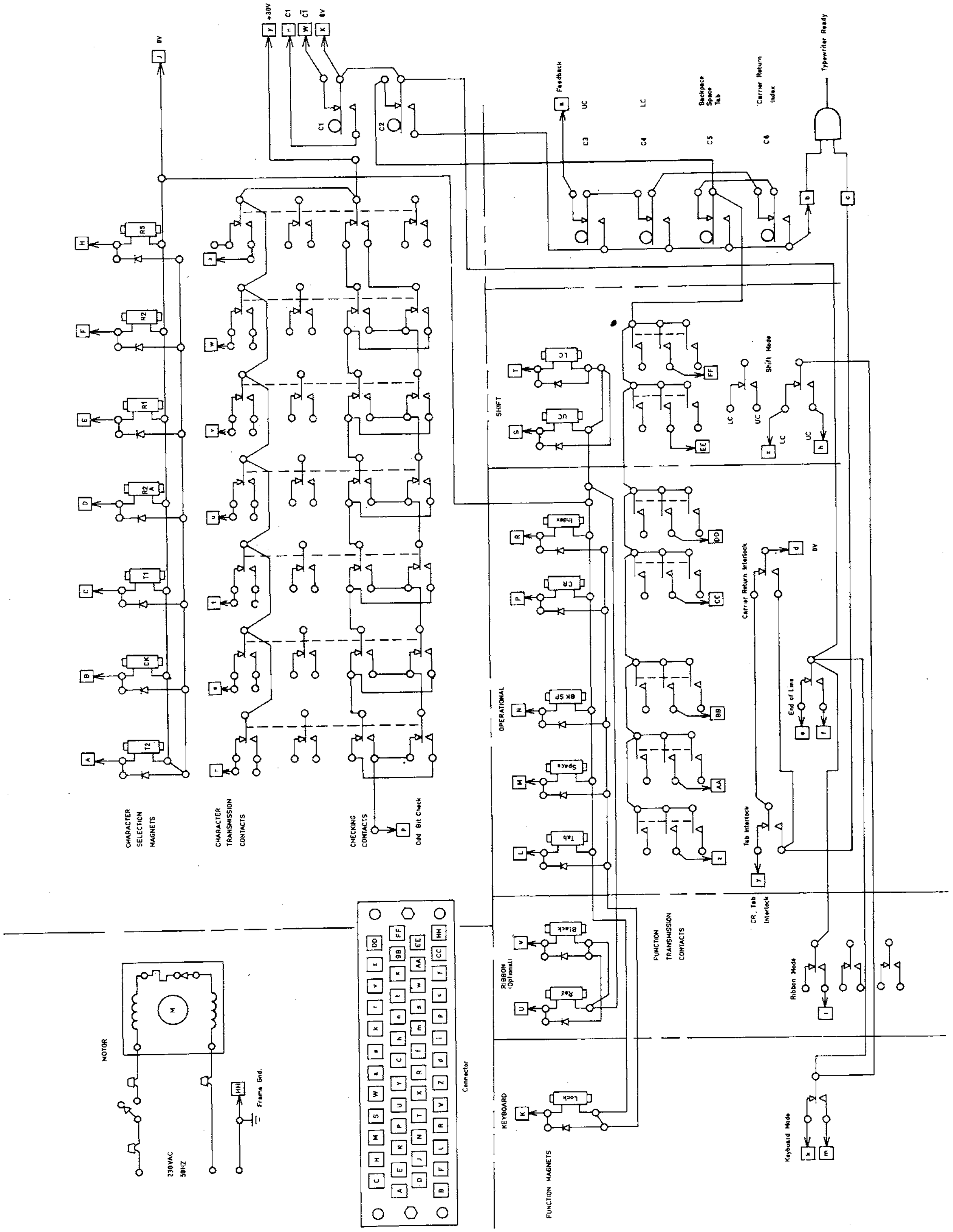


Figure 5.8 Typewriter Wiring Diagram

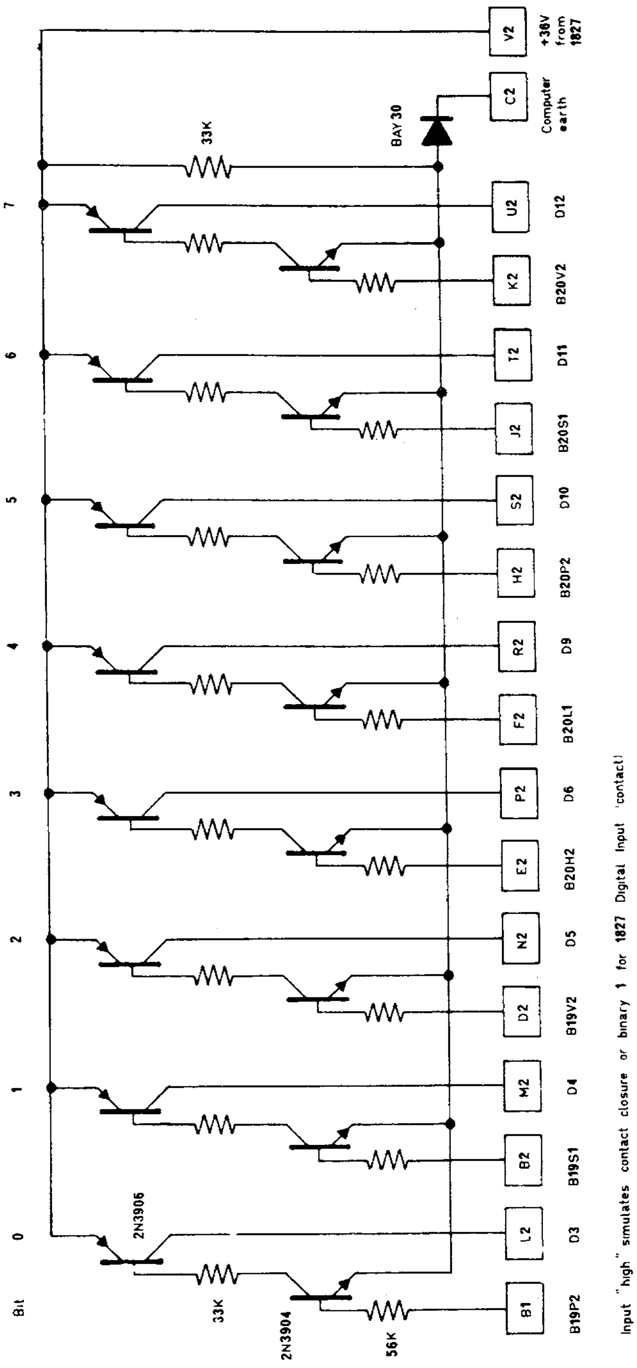


Figure 5.9 B16 Digital Input Switches

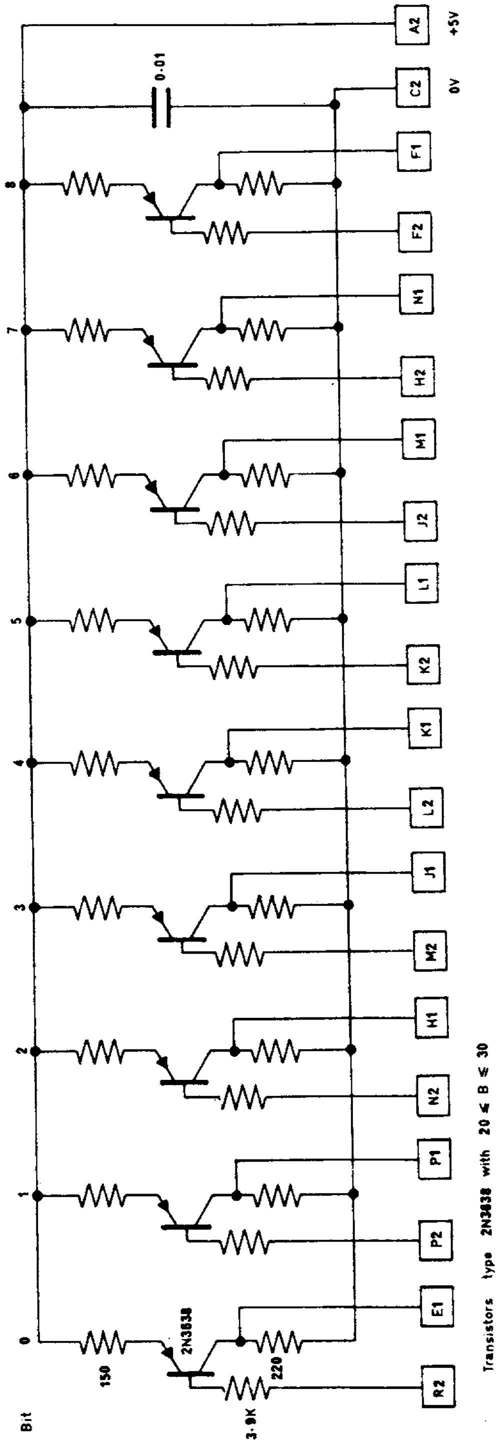
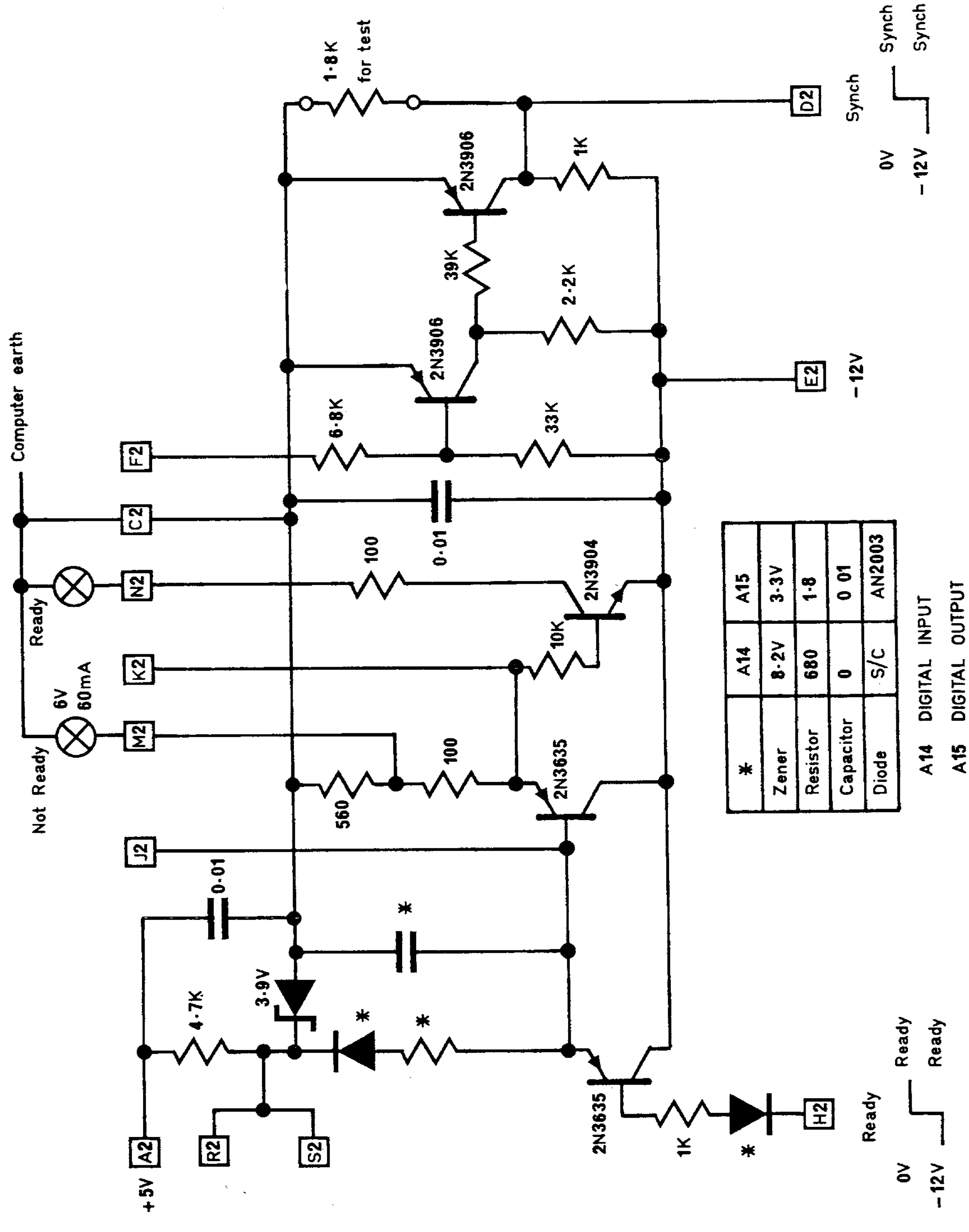


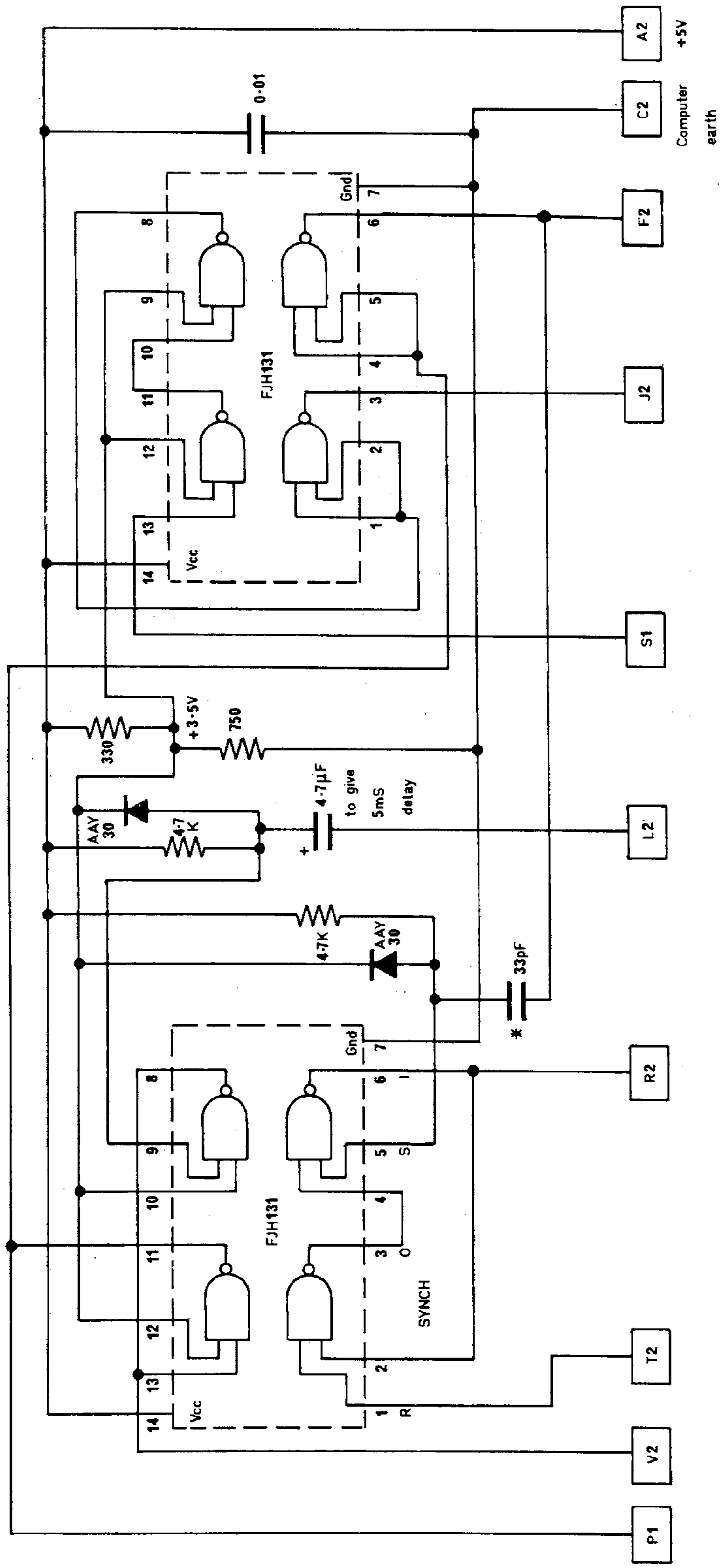
Figure 5.10 A16 Digital Output Level Converters



*	A14	A15
Zener	8·2V	3·3V
Resistor	680	1·8
Capacitor	0	0 01
Diode	S/C	AN2003

A14 DIGITAL INPUT
A15 DIGITAL OUTPUT

Figure 5.11 S1457 Computer Status Boards A14 and A15



* Capacitor chosen to be twice that which will just reset f/f or that which gives <0·8V for 0·1μS, whichever capacitor is larger

Figure 5.12 B15 Digital Interface Sundries

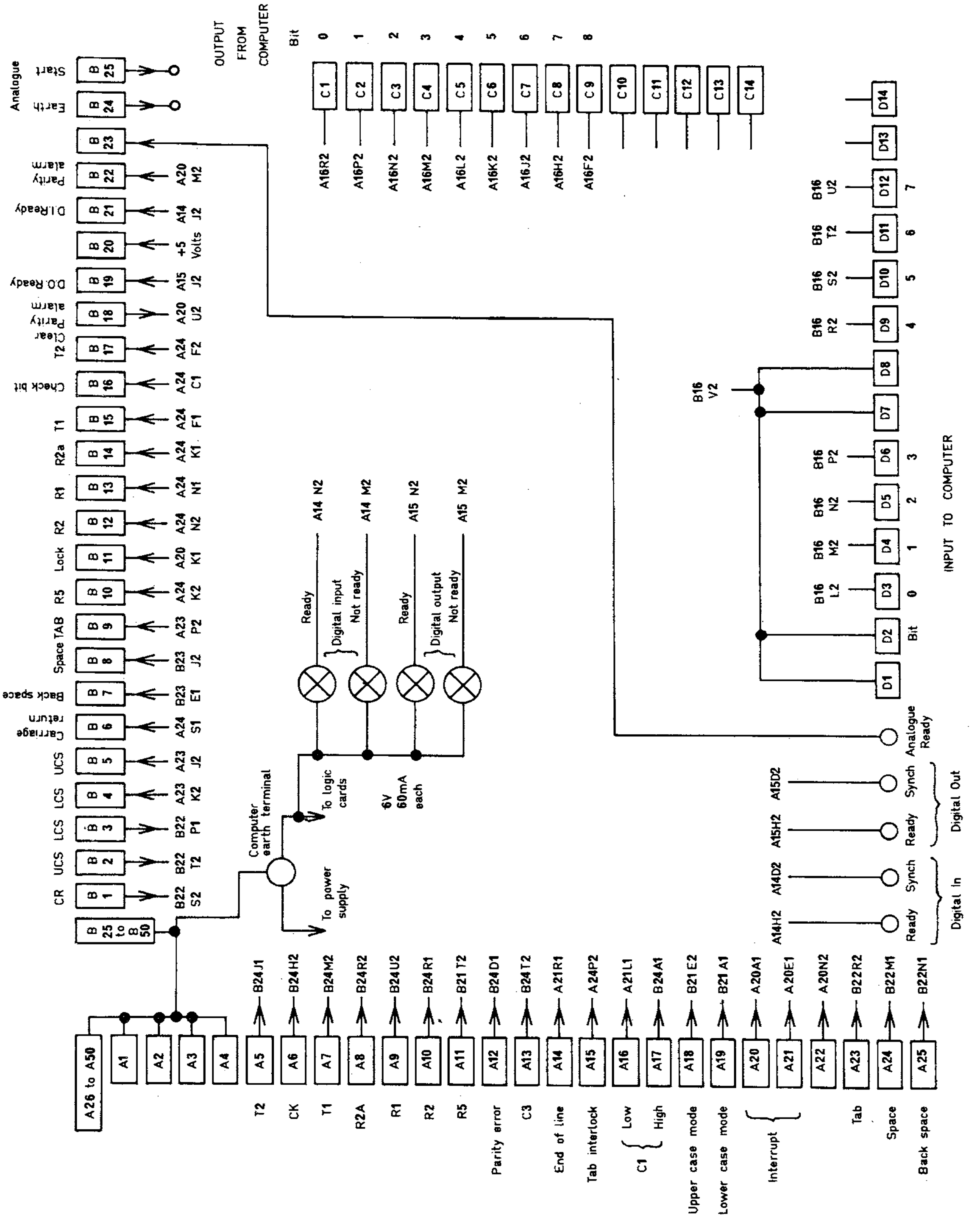


Figure 5.13 Digital-Interface Chassis

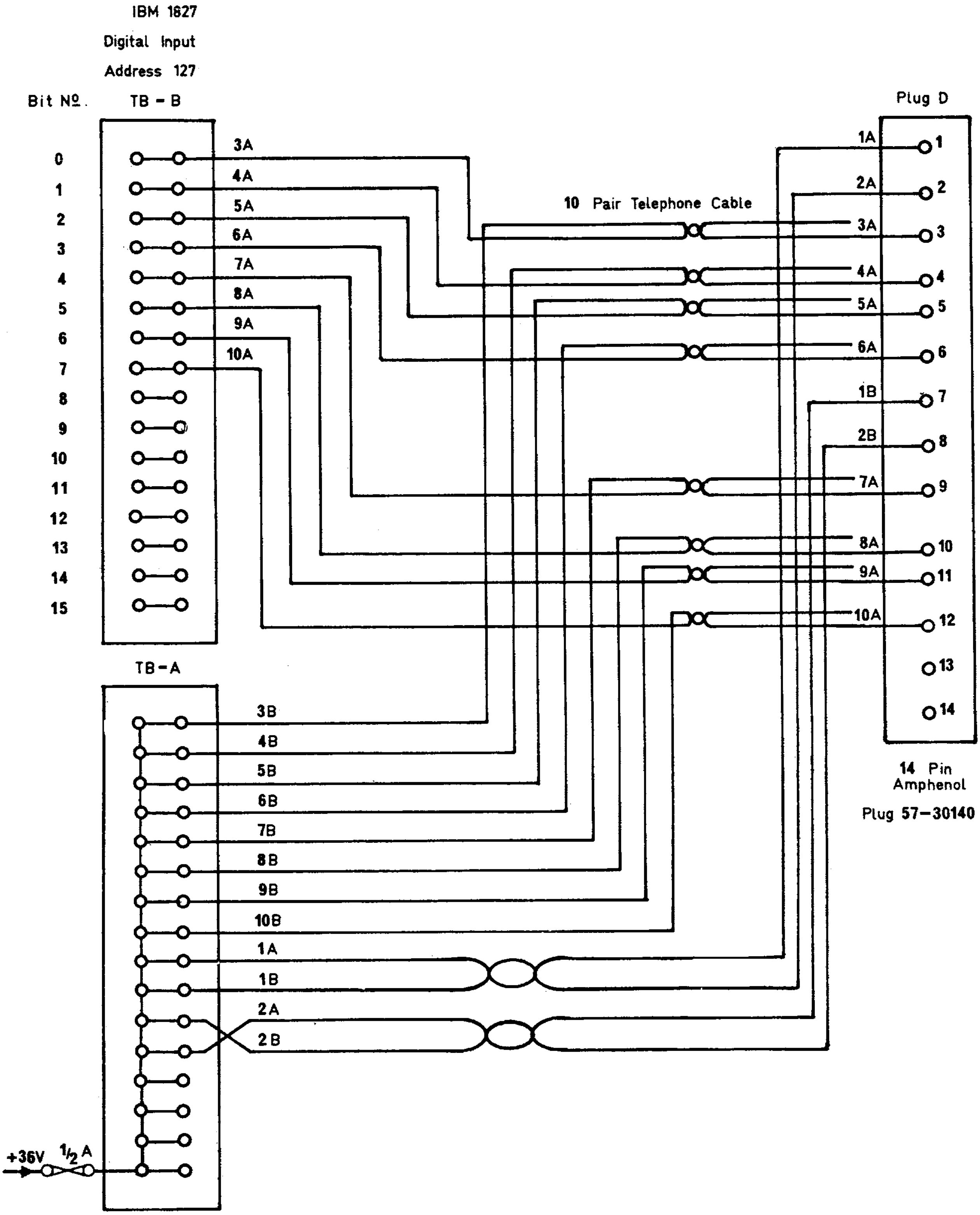


Figure 5.14 Digital Input Cable

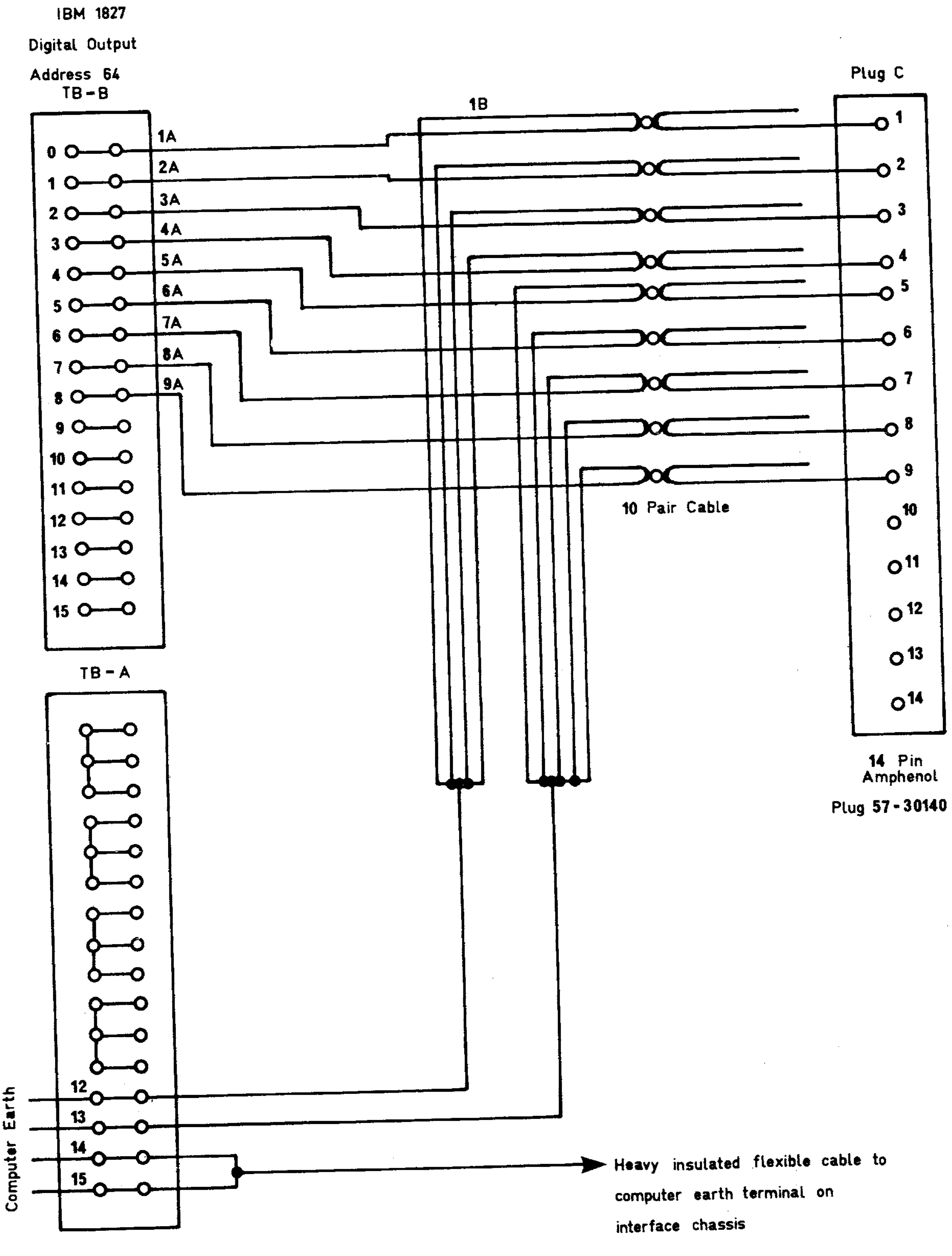


Figure 5.15 Digital Output Cable

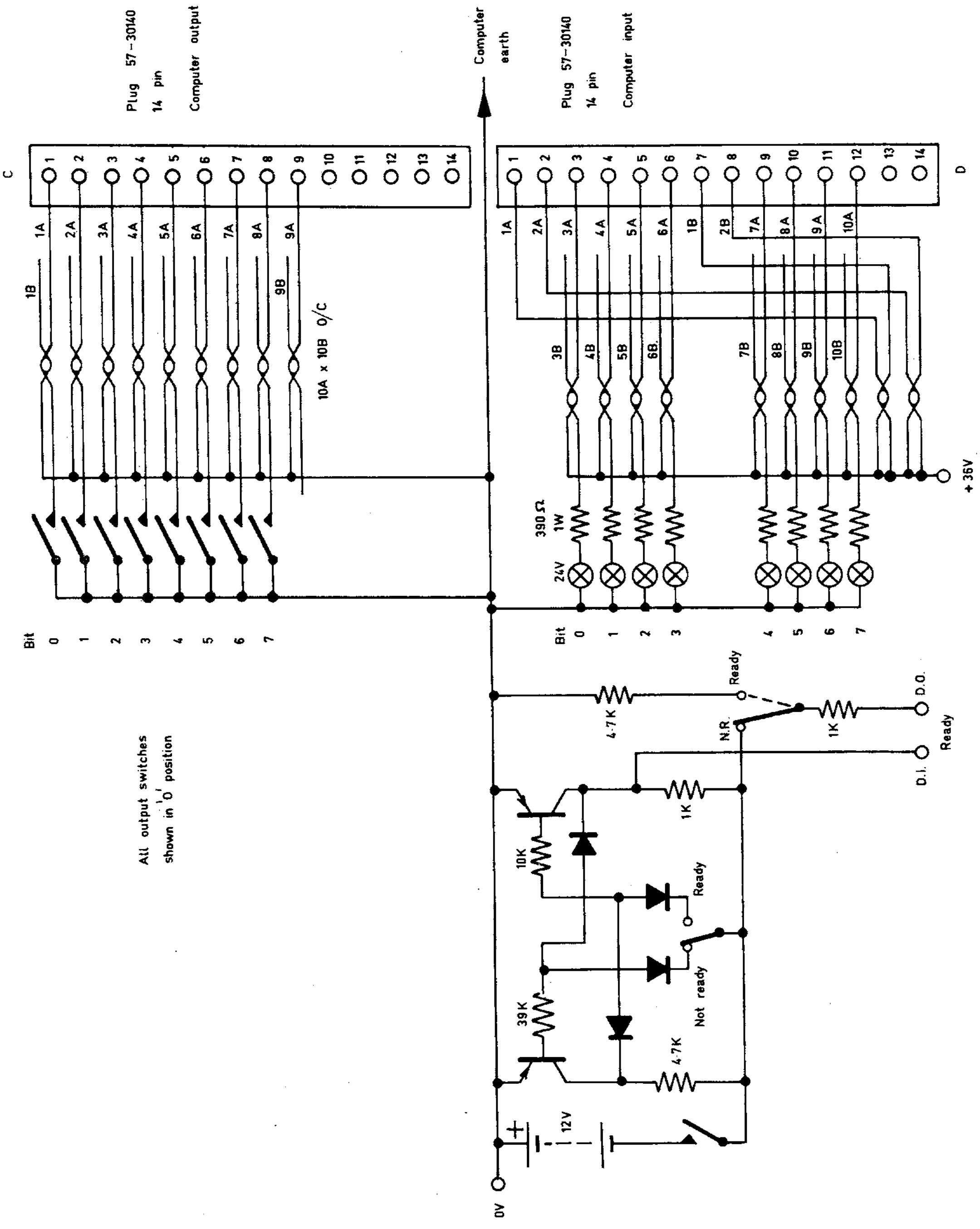
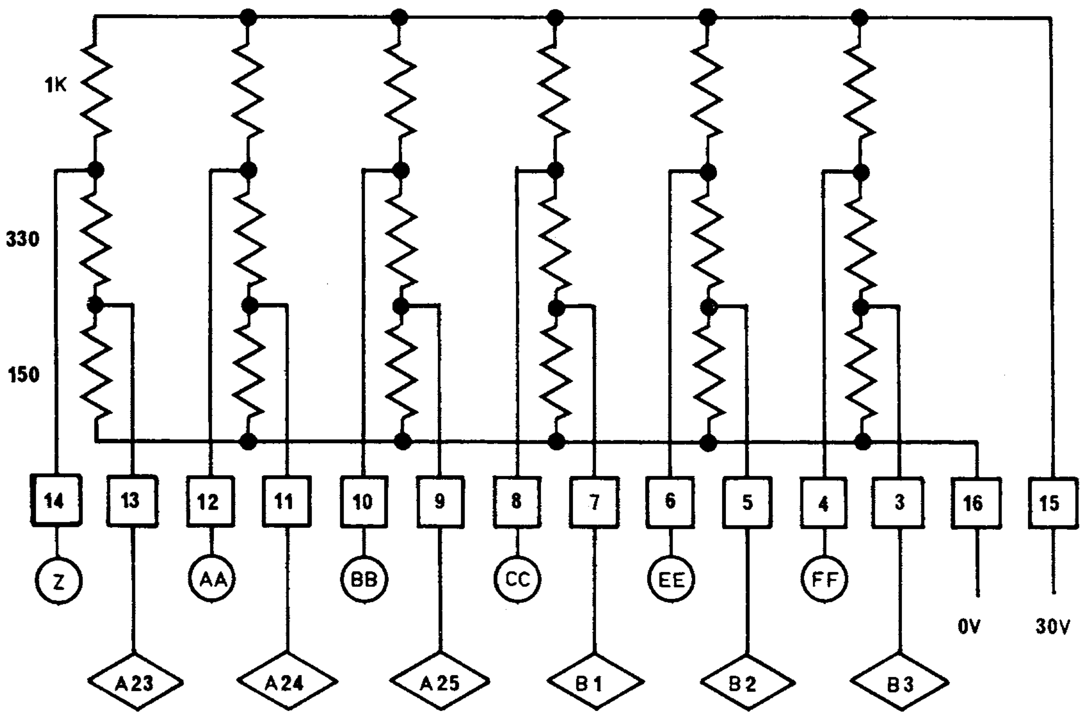
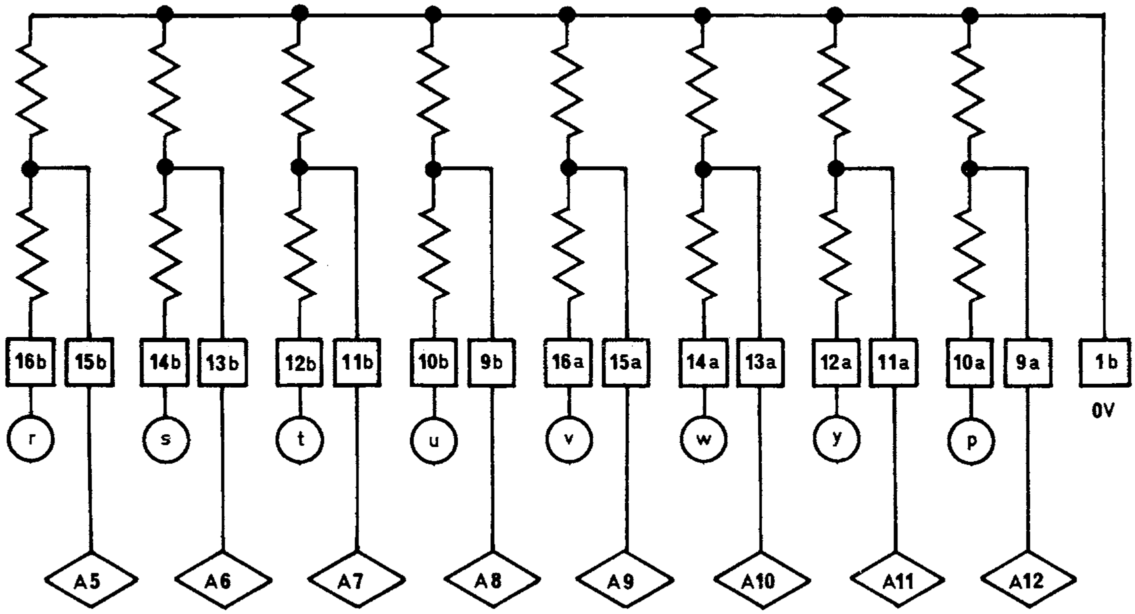


Figure 5.16 Digital Interface Test Box



S1440 Function Inputs



S1439 Character Inputs

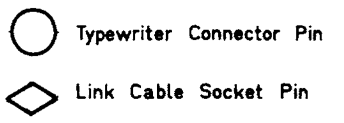


Figure 5.17 Typewriter-Input Level Converters

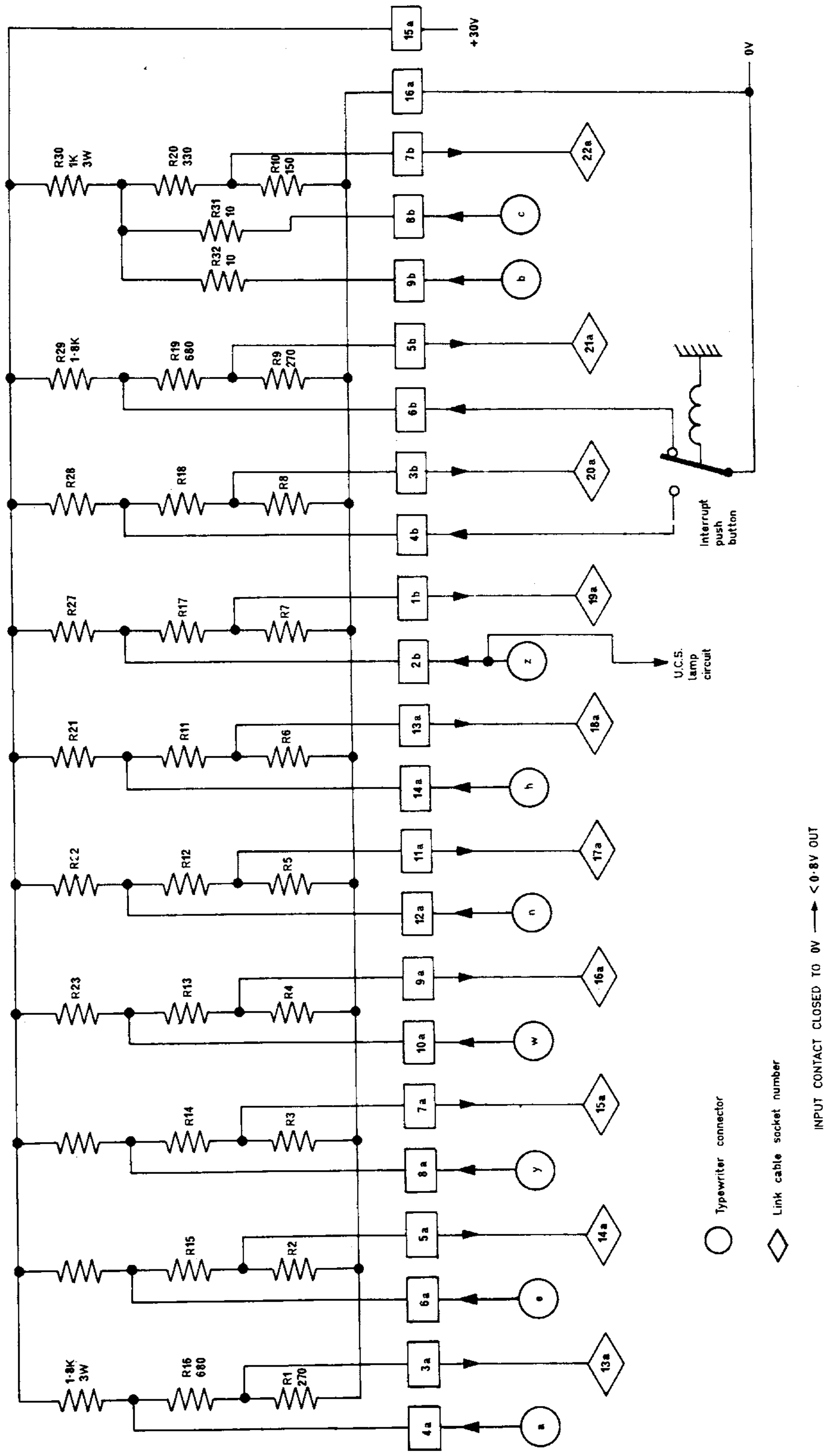


Figure 5.18 Typewriter-Control Level Converters

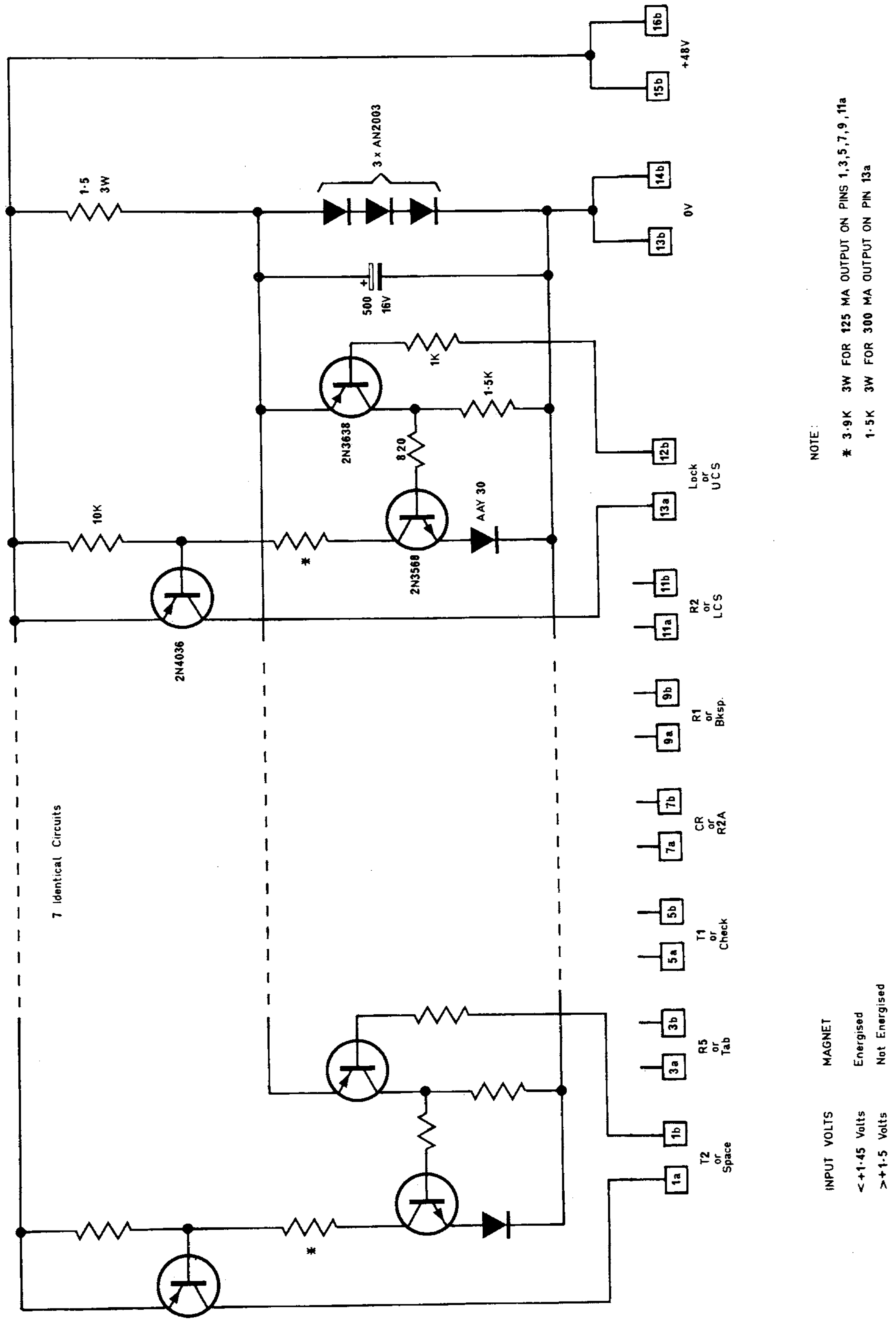


Figure 5.19 Typewriter Magnet Drivers

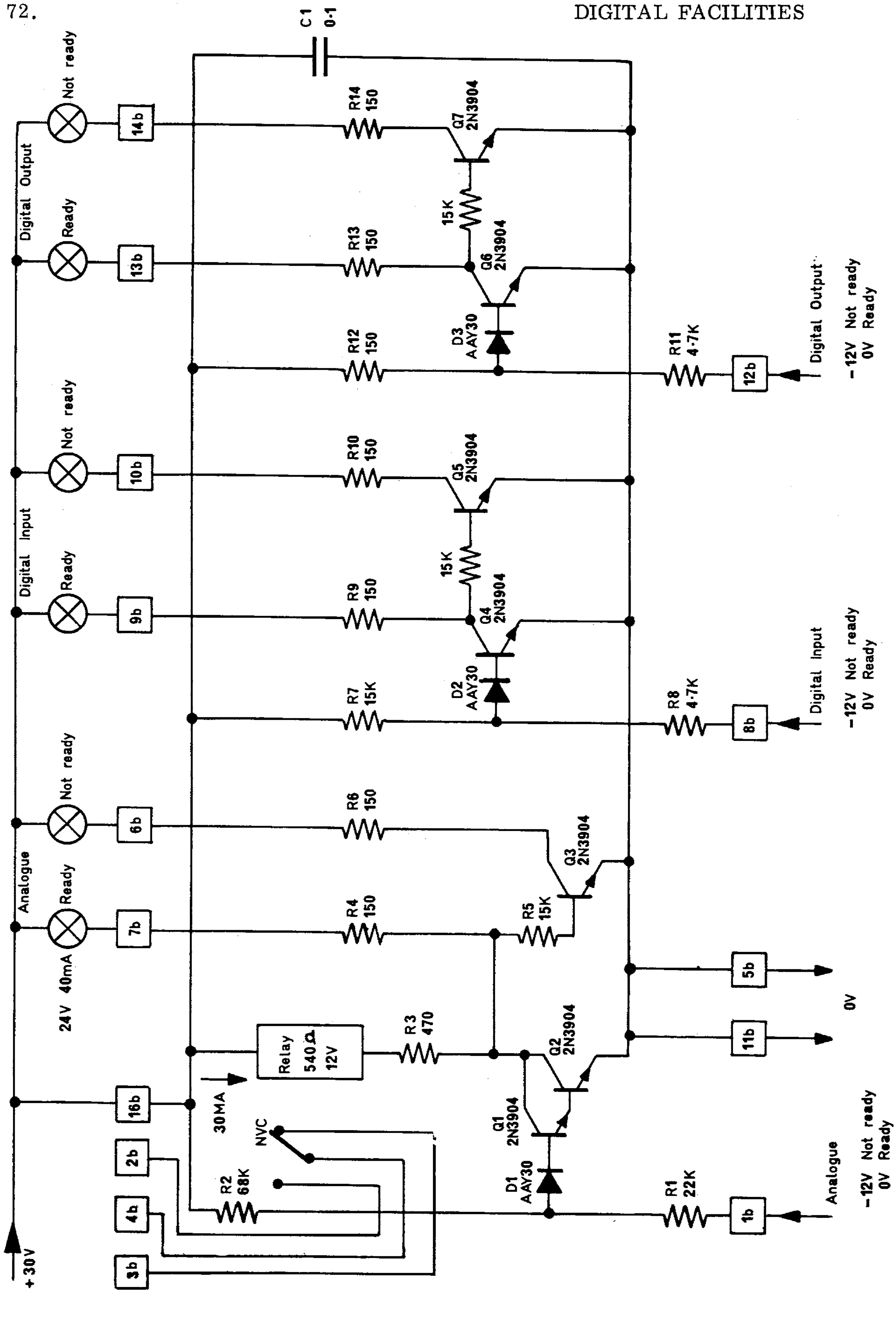


Figure 5.20 S1450 - Computer Status

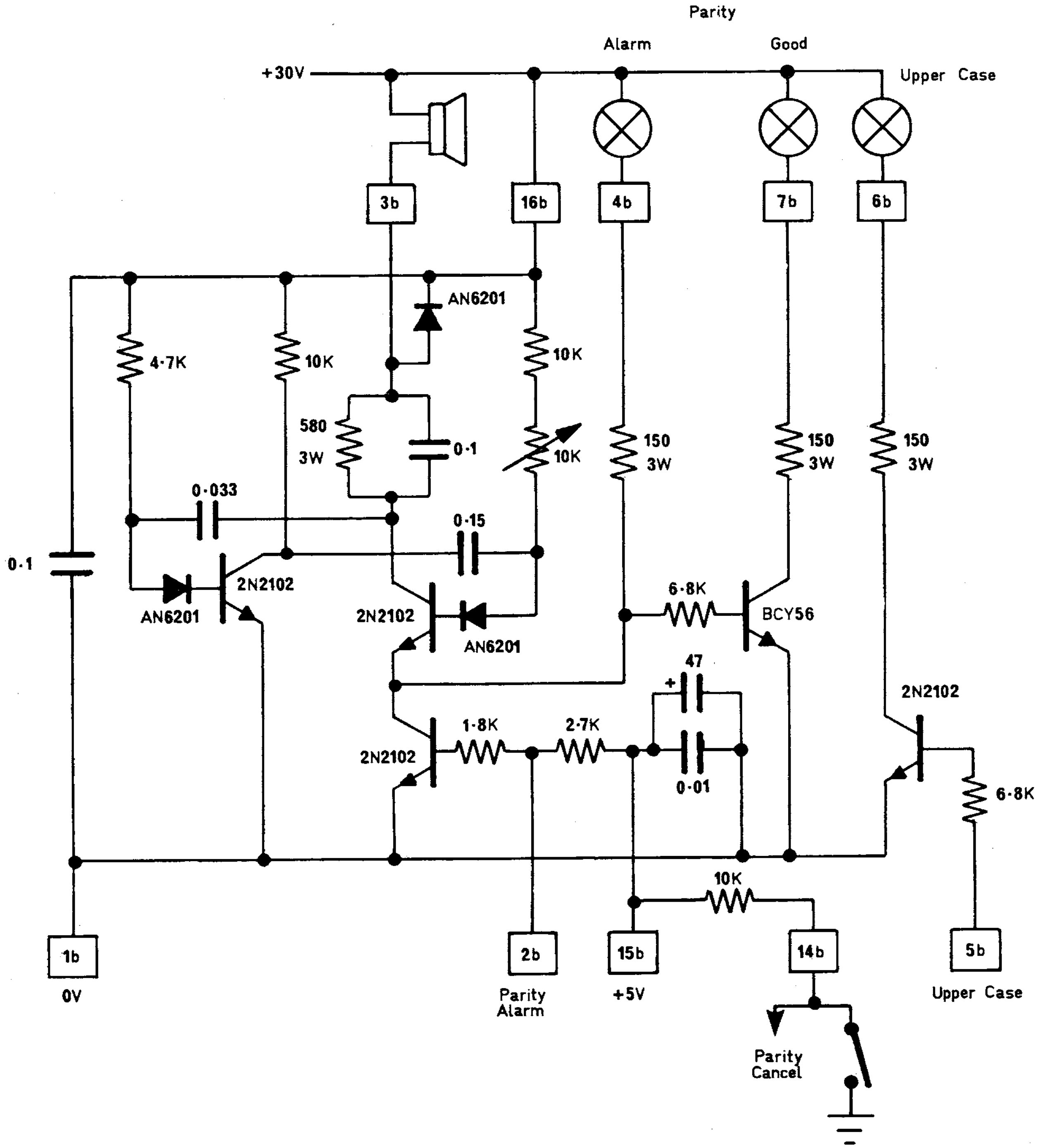


Figure 5.21 S1444A - Parity Alarm

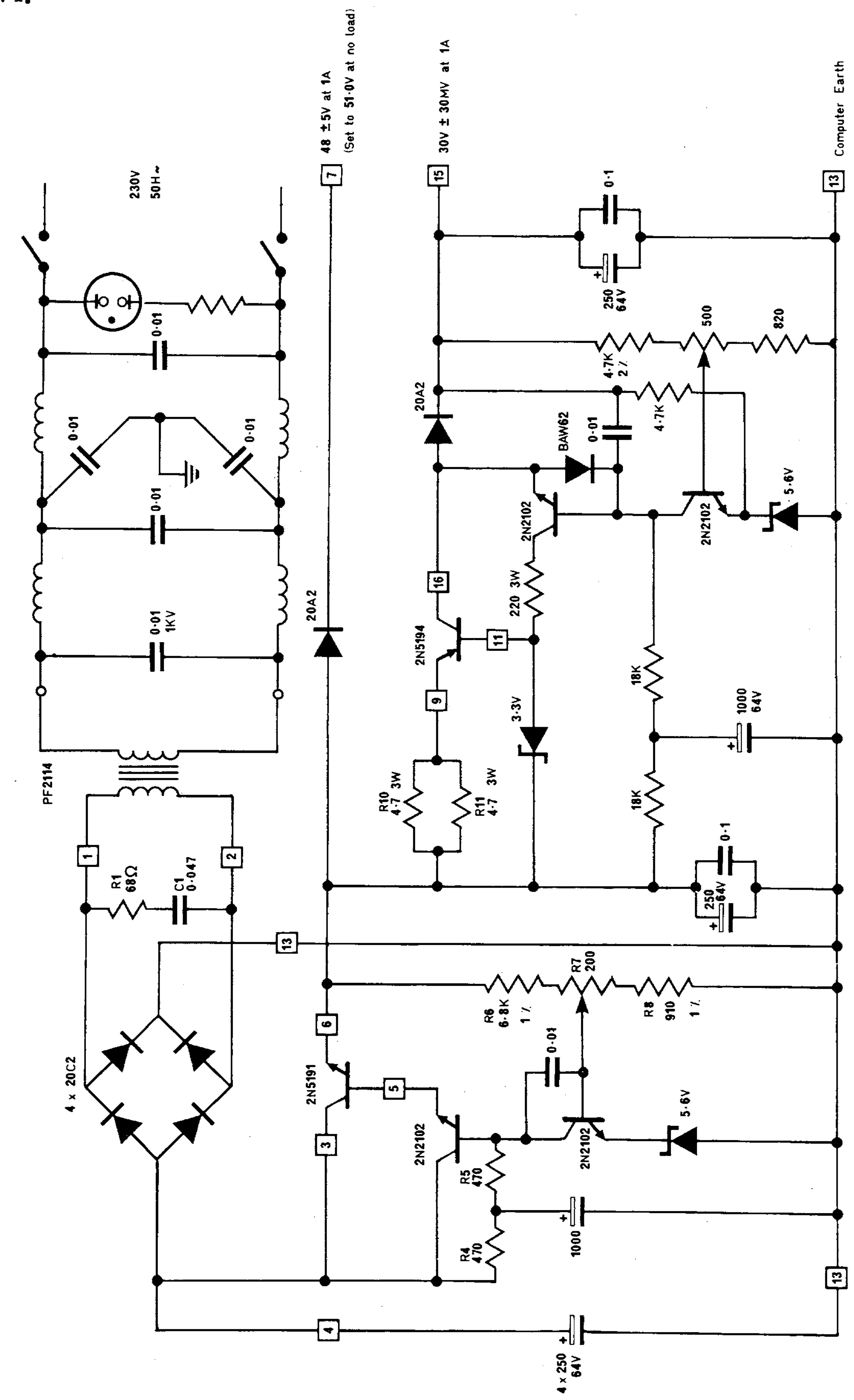


Figure 5. 22   Typewriter Control Box Power Supply

6. COMPUTER AND PROGRAMMING

6.1 Introduction

Rather than treat the computer and its general programming separately, it is covered here as one topic. The descriptions of magnet laboratory system programmes are contained in section 8. This present chapter introduces sufficient of the 360/50 concepts and terminology for the programmes to be understood. As each new term is introduced it is underlined. The reader is referred to various IBM handbooks for further details.

6.2 Computer

The components of the ANU's 360/50 computer are listed in section 2, and their interconnection is shown in figure 2.1. The heart of the computer is the Central Processing Unit (CPU). It responds directly to programme instructions to execute arithmetic and logical operations to request data transfer by the input-output (I/O) channels to branch to other parts of a programme, etc. The CPU contains 16 general purpose registers (numbered 0 to 15) with which it executes the various arithmetic and logic processes required by the programmes. There are three types of storage in this 360/50 system:-

(a) main store (fast access) - holds programmes being executed by CPU and data currently being referred to or processed;

(b) disk store (slower access) - holds other programmes and data;

(c) tape store (slower still) - not used by magnet laboratory.

The computer has three I/O channels to which various I/O devices are connected. The I/O devices consist of one or more units each of which has a unique address. Unit addresses provide the channel with a means of identifying units to or from which data is to be transferred.

Each channel may be considered as a special purpose computer for transferring data between I/O devices and main store.

The terms input and output refer to the movement of data (including programme code) relative to the main store. Thus, output data is written from main store to a disk, and input data is read from disk into main store.

Each 360/50 register is one word long (= 32 binary bits), but the smallest addressable unit in main store is a byte (= 8 bits). On the other hand the 1827 Data Control Unit operates only on 16 bit words. Therefore, data is always transferred between the 1827 and the 360/50 main store, two bytes (16 bits) at a time. The magnet laboratory computing system ignores the low order half of each 16 bit word when using the 1827 digital-input and digital-output facilities. Since the 1827 is an irregular addition to the 360/50, it has little software support. Hence, programmes using it must themselves provide certain information which otherwise would be provided by the 360/50's operating system.

6.3 360/50 Operating System (OS)

"The operating system is a comprehensive set of language translators and service programs operating under the supervision and co-ordination of an integrated control program" [7, p.1]. The operating system consists entirely of software and includes the FORTRAN IV, PL/1 and Assembler Language compilers, the LINKAGE EDITOR, the I/O device handlers, the programme SUPERVISOR, and other system programmes. These names are introduced to give some working concept of the OS. To the computer user there is his programme, other user programmes and "the System" (OS).

6.4 Main Store Usage

The particular form of the OS used at the ANU is called MFT (Multitasking with a Fixed number of Tasks). The main store is segmented into partitions. One programming task operates in each partition. Figure 6.1 shows typical partitioning:-

Partition number		Partition size in bytes
0	magnet laboratory programme	8K
1	job stream 1	104K
2	job stream 2	96K
3	resident system	48K

Figure 6.1 Typical Main Store Partitioning

The various tasks are allotted priorities for using the CPU. Usually task 0 is highest (next after the system), the others being in order below it. The programme in partition 2 is given the CPU only when tasks 0 and 1 are not using the CPU.

6.5 Instruction Set

The 150 or so standard user instructions to the CPU are described in Principles of Operation [8]. A further set of about 70 instructions are the (system) supervisor and data management macro instructions [9] (MACROs), to which a number of locally written MACRO instructions have been added. The MACROs generate sets of standard instructions and constants for the user programme. Instructions generated by MACROs are identified in programme listings by a +.

6.6 Choice of Language

From the outset it was obvious that at least the majority of the programming would have to be done in IBM 360/50 OS Assembler Language. FORTRAN IV was unsuitable because if it were used for I/O an additional 19K bytes of error handling routines would have been loaded into the partition. Recall that the partition size available is only 8K bytes.

Future sections of programmes could be written in FORTRAN, provided they do not use any of the FORTRAN OS subroutines (e.g. log, sine, etc.) or input-output.

Assembler Language was obligatory for the IBM 1827 data control unit, because, as mentioned earlier, the 1827 has little system software support.

6.7 Input-Output Operations

Because of the flexibility of the System 360/50 OS, even the simplest I/O operation is fairly complicated. The most fundamental level of coding available, involving the EXCP (execute channel programme) MACRO instruction, must be used to programme 1827 operation.

Disk I/O is handled using the higher level READ and WRITE MACROs. The highest level data handling MACROs, GET and PUT, are not used in these programmes. With increasing level of MACRO instruction the MACRO calls on the OS to carry out more of the work. Naturally the penalty for this is less flexibility and usually more space is taken up.

An important concept in understanding I/O is that of data set. IBM defines a data set as "The major unit of data storage and retrieval in the operating system, consisting of a collection of data in one of several prescribed arrangements and described by control information that is accessible by the system" (7, p. 68). 'Data' in this sense includes programme code.

In the description which follows, the term 'supervisor' will mean the OS programme and control information resident in the main store; the term 'programme' will mean the user written programme. To use the EXCP MACRO, the programmer creates the following in his partition (10, p. 135):-

(a) a channel programme, comprising suitably linked channel command words (CCW's) which are referenced by the channel;

(b) an event control block (ECB), which the system uses to synchronize the problem programme to the progress of the particular EXCP instruction;

(c) a data control block (DCB), which defines to the supervisor the modes of I/O and to where control should be transferred in case of error;

(d) an input/output block (IOB), used by the particular EXCP instruction to locate (a), (b) and (c).

When a programme processes a data set, the time sequencing of events is:-

(1) The programme issues an OPEN MACRO which prepares the DCB for use. If data has not been entered into the DCB by a DCB MACRO when the programme was compiled, then the supervisor looks to the data set's DD (data definition) card; this is included in the cards used to initiate programme operation. If the information is not there either, the supervisor inserts system information about type of device, mode of data, addresses of error routines, addresses of MACRO instruction routines, etc.

(2) The programme issues an EXCP instruction. This causes control of the CPU to be passed to the supervisor which requests the channel to execute the channel programme contained in the user's partition then returns control of the CPU to the user programme. The channel begins execution, independent of CPU control, transferring data to or from the addresses given in the programme CCW's.

(3) At the point where the user programme cannot continue until the data transfer has finished, a WAIT MACRO is issued. If the data transfer has finished the next instruction is immediately executed. If it is not finished, a bit in the ECB is set to indicate that the programme is awaiting completion of the channel programme. A binary bit is said to be 'set' or 'flagged' when its state is 1. The opposite (the 0 state) is called 'reset'.

(4) When the channel programme finishes, the channel interrupts the supervisor, which in turn resets the ECB's wait bit and sets its complete bit.

(5) When the last WAIT has been honoured, the data set is closed by issuing a CLOSE MACRO on the DCB. Logically the device (e.g. lineprinter) and the problem programme are then unconnected.

If the channel executes a channel command word in which the PCI (programme controlled interrupt) bit has been set, then the channel interrupts the supervisor [8, p. 109]. The supervisor transfers control to an appropriate user-written PCI appendage [10, p. 139], this having been loaded into the partition by the OPEN MACRO instruction.

The storage and retrieval of data from disk is achieved using the WRITE and READ MACRO instructions. These move blocks of data, 320 bytes at a time. The CHECK MACRO is used instead of the WAIT for testing the completion of the I/O operations. The OPEN and CLOSE MACROs are the same as used with the EXCP MACRO. A sequential method is used by magnet laboratory programmes when transferring data to or from disk. Thus, successive READs take blocks n, n + 1, n + 2, etc. The OPEN MACRO repositions the block pointer to block 0.

6.8 Job Steps

There are at least three computing job steps involved in the preparation and execution of a programme. The first of these, called compile, translates the programming language input (e.g. 360/50 OS Assembler) into relocatable machine code and tabulates any references to other programmes which may have been compiled separately. The next job step is usually an OS programme named the linkage editor which resolves unresolved references between the compiled input and other previously compiled programmes. It is also capable of structuring the programme sections into an overlay programme (described in section 6.10). The relocatable output of the linkage editor is loaded into the user's partition when required and is executed as the third job step.

The linkage editor output of the magnet laboratory's programmes is permanently stored on a system disk, SPOOL1, always ready for use.

6.9 Control Sections

A control section is defined as - "The smallest separately relocatable unit of a program; that portion of text specified by the programmer to be an entity, all elements of which are to be loaded into contiguous main storage locations" [7, p. 68].

The 16 control sections which comprise the magnet laboratory programmes are:-

TMT	times-modes table
BSTAB	base-scale table
MAGVRS	version data
MAMITB	maxima-minima table
MGLB	control programme
ANALIN	collection programme
SAM	print samples programme
SELCHN	print samples for a selected channel programme
UDBS	update BSTAB programme
PBS	print BSTAB programme
UDTM2	update TMT programme
PTM	print TMT programme
DEC	character to binary-number conversion programme
READIN	read a line on the typewriter programme
P130	print a line on the typewriter programme
SAVE	save TMT and BSTAB on disk, restore TMT and BSTAB from disk programme.

Note that the first four are not executable code.

If it were not for the overlay structure there would be no constraints on the location of any of these control sections in main store. This is because it is conventional to branch to a control section using the instruction BAL 14, CSectname which causes programme operation to branch to the instruction labelled 'CSectname'; the address of the next instruction in the calling programme, after the BAL instruction, is automatically stored in register 14. All that is needed at the end of the called control section to return to the calling programme is the instruction BR 14 (which causes the called programme to branch to the address in register 14). Of course, this assumes that register 14 has not meanwhile been altered. To guard against loss of data stored in registers, it is also conventional to save the contents of all registers in a save area provided by the calling control section when branching to another control section.

The address of the save area is always assumed to be in register 13. The registers are stored cyclically beginning with register 14 in location (R 13) + 12. Before returning from a called control section the registers are stored so that, as far as the calling programme is concerned, the action of branching to the called control section and back again leaves the contents of all registers except R15 unchanged.

If the called control section uses any of the system MACRO instructions or calls another control section, it should also provide a save area for the system or for the lower level control section respectively.

If a MACRO is used, then the contents of registers 14, 15, 0, 1 are unpredictable on completion of the MACRO. Therefore, these registers are only used transiently. To distinguish between the save areas of a called and calling control section, the calling programme's save area is called a higher save area while the called programme's save area is called a lower save area.

Throughout the magnet laboratory programmes the computer centre written MACRO instruction SUBR has been used. This MACRO instruction stores register contents in the higher save area, creates a lower save area and, on completion of the called control section, restores the registers 0 - 14 from the higher save area then returns control to the calling control section. register 15 is not restored because it is often used to return a code to the calling control section. SUBR assumes that the called control section was branched to by the instruction BALR 14,15.

The following example illustrates the use of SUBR in an Assembler language coded control section:-

```
FREDDIE  CSECT
         SUBR
           '
           '                    Body of
           '                    programme
         L       12,0(13)       These two instructions
         BR      12              cause control to be
                                 returned to the calling
                                control section via SUBR.
```

An example of coding used by another control section to call FREDDIE is:

```
                  '
                  '
          L       15, JILL
          BALR    14, 15
                  '
                  '
                  '
JILL      DC      V(FREDDIE)    This storage
                                location contains
                                the address of
                                FREDDIE
```

6.10 Overlay

As mentioned previously, the magnet laboratory programmes, which consist of at least 10K bytes must occupy only 8K bytes of main store. This is achieved by instructing the linkage editor to make an overlay structure(11, p.61) of the control sections.

The overlay structure used is illustrated in figure 6.2.

An overlay structure reduces main store requirements by loading into main store only those control sections that are required at any time. The complete magnet laboratory programmes are stored on disk, required control sections being loaded into main store when required and overwriting other control sections that are not required.

To illustrate the overlay, assume PTM has control and that it, and everything above it, is in main store. When PTM finishes, control returns to MGLB. Suppose that the next programme requested was UDTM2, MGLB would execute the instructions:-

```
L       15, = V(UDTM2)
BALR    14,15
```

Because of the overlay structure READIN, DECIN and UDTM2 would be loaded into store, overwriting PTM, before passing control to UDTM2. The overlay is structured so that any control section above the one required is also loaded, if it is not already in main store.

It is important to remember that any data sets that have been opened by a control section must be closed before that control section is overwritten, otherwise the supervisor may later try to close a non existent data set. This would cause an abnormal end to programme execution.

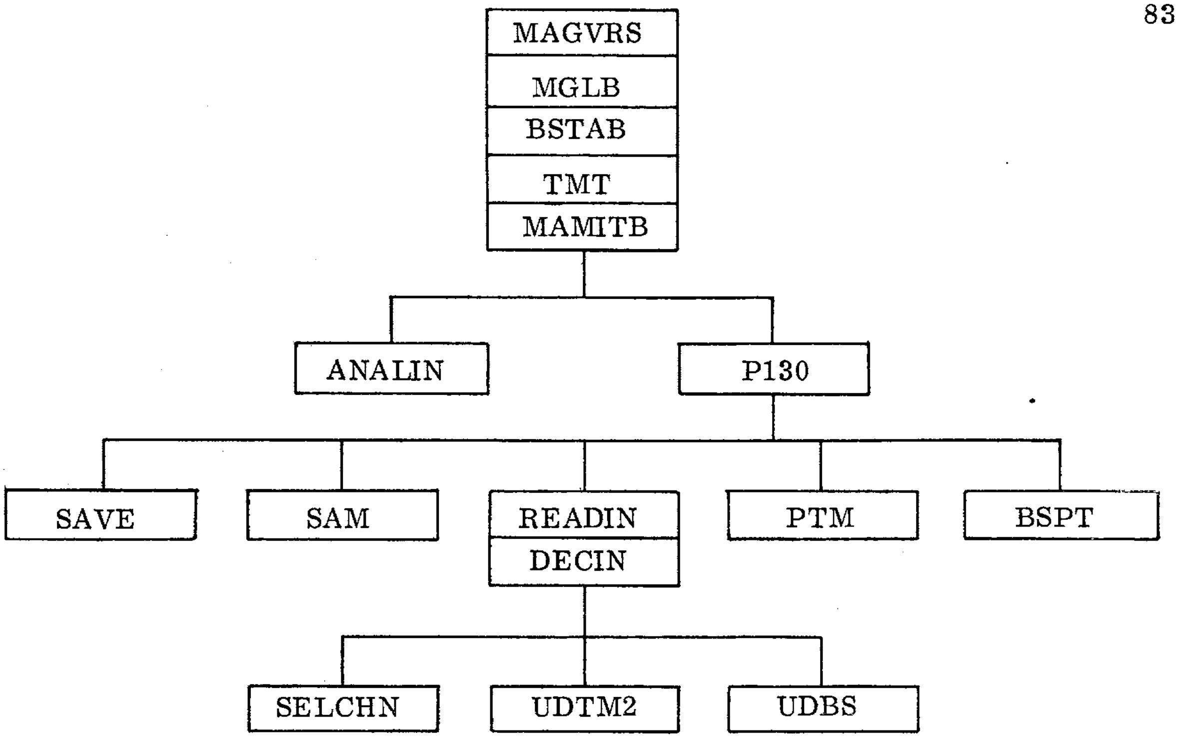


Figure 6.2 Overlay Structure

7. PROCESSING OF COLLECTED SAMPLES

7.1 Summary

Operation of the sample-processing sub-routine PROSAM is described in this section with the aid of two examples. As a knowledge of some system features and conventions is necessary for a complete understanding of the examples, paragraphs concerning applicable features and conventions are included. Use of the PROSAM flow chart (figure 8.8(i)), when following the examples is suggested.

7.2 IBM 360/50 Arithmetic

The IBM 360/50 uses twos complement arithmetic in its central processing unit. Binary numbers are represented in their normal binary form if positive, negative numbers are represented, in twos complement form, by reversing the bits of the positive form of the number and adding one to the result. Negative numbers, expressed in twos complement, may be converted to their normal binary form by the same procedure.

Thus, -00001010 (binary)
= 11110110 (twos complement)

Note that, with twos complement, the highest order bit will be 0 for positive numbers and 1 for negative numbers.

For convenience, binary numbers are generally expressed in hexadecimal form in this report. Binary numbers are identified by a B preceding the number, hexadecimal numbers are identified by an X, decimal numbers are not identified by a prefix.

Thus, -10 = B'11110110' = X'F6'.

7.3 Analogue-to-Digital Converter
(Reference: 5,p.11)

The following description of the analogue-to-digital converter (ADC) is limited to details that determine the processing requirements of the processing programme, SAM.

Input voltages are inverted by a sample-and-hold amplifier before being converted to digital values by the ADC. The ADC input voltage range is ± 5 volts; however, input filters reduce inputs to the multiplexer channels by 1%. The voltage range at the multiplexer inputs is, therefore, ± 5.05 volts. Voltages outside this range cause an overload bit in the ADC output register to be set and ADC operation is terminated, control being returned to the user's programme.

The digital number developed in the ADC's 16 bit output register consists of a 15 bit twos-complement number corresponding to the ADC input voltage and a low order overload bit that sets if the input voltage is outside the ADC input voltage range of ± 5 volts. The value of the 16 bit number, D, is given by:-

$D = 2Q$

where $Q = V/0.3051758$, rounded to units

where V is the ADC input voltage, in millivolts; 0.3051758 is the ADC resolution in millivolts per bit (of the 15 bit number)(5, p. 21).

Full scale ADC register values are:-

positive	0111111111111100	$= 2^{15} - 4 = 32764$
negative	1000000000000010	$= 2^{15} + 2 = 32770$

Conversion by the processing programme, of ADC register values to multiplexer input voltage values, is simplified if full scale

ADC register values are assumed to be 2^{15}. The maximum error of 0.01% introduced by this assumption, is negligible in this system.

ADC register output values are converted to multiplexer input voltage values by multiplying the output values by -5.05×2^{-15} where: - compensates for inversion by the sample-and-hold amplifier;
5.05 is the full scale input voltage at the multiplexer input;
2^{15} is the full scale digital output value.

7.4 Stored Base and Scale Values

Typed in base and scale values are multiplied by 10^4 and -5.05×10^4, respectively, before being stored in the base and scale table, BSTAB.

In both cases the factor of 10^4 scales the stored values for four decimal place fixed-point arithmetic operations.

The factor of -5.05 in the scale value is part of the conversion of ADC output described in section 7.3, the remaining conversion factor of 2^{-15} given in 7.3, is more conveniently carried out during the sample processing.

7.5 Sample Processing

Data from the ADC is stored by the collection programme, ANALIN, on disk and in the maxima-minima table, MAMITB.

The sample processing programme, SAM, retrieves this data, uses subroutine PROSAM to evaluate and edit the data, then prints the processed data.

PROSAM uses four decimal place fixed-point arithmetic to evaluate and edit each sample by:-

multiplying by the stored scale value;
dividing by 2^{15};
adding the stored base value;
converting to decimal;
rounding;
converting to character format (zoned decimal);
inserting decimal point and, if negative, minus sign.

Positive values are rounded to three decimal places if less than 1.0000 and to four significant figures if equal to or greater than 1.0000; negative values are rounded to two decimal places if greater than -1.000 and to three significant figures if equal to or less than -1.000.

7.6 Examples

The following two examples illustrate the procedure by which PROSAM evaluates and edits samples; the first example is confined to PROSAM operations whereas the second traces data flow from ADC input to printout.

7.6.1 Example 1.

Typed-in base	= 0.01 units
Typed-in scale	= -0.03 units per volt
Sampled voltage	= 2.50000 volts
Required printout	= 2.5 x (-0.03) + 0.01
	= -0.065
	= -0.07
Stored base	= 0.01 x 10^4
	= X'64'
Stored scale	= -0.03 x (-5.05) x 10^4
	= X'05 EB'
ADC input	= -2.5 x 100/101 volt
	= -2.47524 volt
ADC output:	
Digitised input	-2.47524 x 10^3/0.3051758
	= -8111
ADC output	= -8111 x 2
	= -X'3E 5E'
	= X'C0 A2'

Processing of the stored 16-bit ADC output value commences by loading it into a 32-bit general purpose register. The high order 16 bits of the register are automatically set to the same status as the high order bit of the stored ADC output value.

Processing continues as follows:

Register		X'FF FF C0 A2'	(-16222)
Multiply by scale		X'00 00 05 EB'	(1515)
Product		X'FF FF FF FE 88 FE B6'	(-24576330)
Divide by 2^{15}		X'00 00 80 00'	(32768)
Quotient		X'FF FF FD 12'	
Add base		X'00 00 00 64'	
		X'FF FF FD 76'	
Convert to decimal		00 00 65 0-	
Round	subtract	00 00 05 0+	
		00 00 70 0-	
Edit		-0.0700	
Load into output buffer		-0.07	

7.6.2 Example 2

Sample	25° Centigrade
Time	0.2 seconds from start of data collection
Channel number	3

Calibration of thermocouple, amplifier and F.M. channel:-

Base	65.56° C	
Scale	80.8° C per volt	
Stored base at location BSTAB+24	X'00 0A 00 F0'	(655600)
Stored scale at location BSTAB+23	X'FF C1 BC F0'	(-4080400)

1827 multiplexer, channel 3 input	-0.501980 (deduced from sample and calibration values)
ADC input	0.497009 volt
Digitised value	1629
ADC output	X'0C BA' (including overload bit)

During sample collection, the ADC output corresponding to the example data above is read into locations BUFA + 132 and BUFA + 133, and from there is stored on disk at location block 0, bytes 132 and 133. When this sample is to be processed, SAM reads block 0 from disk into location BUFI and, when the data for channel 3 time 0.2 seconds is to be processed, reads the half word consisting of BUFI + 132 and BUFI + 133 into general purpose register 1. The sample is then processed by PROSAM as follows:-

Register 1		X'00 00 0C BA'	(3258)
Multiply by scale		X'FF C1 BC F0'	(-4080400)
Registers 0 and 1		X'FF FF FF FC E7 9E 86 60' (= -13,293,943,200)	
Divide by 2^{15}		X'00 00 80 00'	(32768)
Quotient		X'FF F9 CF 3E'	(-405698)
Add base		X'00 0A 00 F0'	
		X'00 03 D0 2E'	
Convert to decimal		02 49 90 2+	
Round	add	00 00 05 0+	
		02 49 95 2+	
Edit		24.9952	
Load into output buffer		24.99	
Typewriter code		X'01 0E A1 07 07'	
Typewriter prints		24.99	

The error of -0.01 is due to the ADC resolution of 0.3 millivolt. The ADC output value of X'0C BA' actually corresponds to an ADC input of 0.49713 ± 0.00015 volts.

8. PROGRAMMES

The following sections describe the computer programmes used by the magnet laboratory's data collection, storage and retrieval system.

Each section contains a brief programme description and a flow chart of the particular programme's operation. Upper case characters in the flow charts identify corresponding locations in the programmes.

The complete programmes are contained in a separate publication [12].

8.1 Control Section MGLB

MGLB is the controlling programme. It is located in the overlay root segment along with the tables (TMT, MAMITB and BSTAB).

Figure 8.1 is a flow chart of MGLB operation.

After printing a title message, MGLB enters a loop which requests the operator to type in a 3 letter code to call a standard programme. If the code is not matched, an error message is printed and the programme loops to request the code again. When the code is matched, the appropriate programme is called. Each of the called programmes eventually returns to the point in MGLB which requests a new three letter code (see flow chart). As at October 1972, the codes and corresponding programmes are:-

COL	calls	ANALIN	which collects data and stores on disk;
PBS	calls	BSPT	which prints the base/scale table BSTAB;
PTM	calls	PTM	which prints the times/modes table TMT;
RES	calls	SAVE	which restores the base-scale and times-modes tables from disk;
SAM	calls	SAM	which prints processed samples as required by TMT or SELCHN;
SEL	calls	SELCHN	which enables the operator to select individual channels for sample processing by SAM;
SVE	calls	SAVE	which stores the base-scale and times-modes tables on disk;
TRM	terminates the job		
UBS	calls	UDBS	which updates the base/scale table BSTAB;
UTM	calls	UDTM2	which updates the times/modes table TMT.

Only the first two letters of the three letter code are tested. Hence PBZ would also call BSPT. Each of the three letter codes must be terminated by a fourth character (usually made a carriage return or space).

The P130 and READIN data control blocks, LNODCB and DIGIDCB, are opened and closed in MGLB.

Because of the overlay structure, P130 and READIN are overwritten during certain operations. Therefore, before either of these control sections is overwritten, the associated data control block must be closed. The subroutines MBGO and MCGO, in MGLB, close LNODCB and DIGIDCB as required before an overwriting control section is loaded into main store. When control is returned to MGLB from the called control section the overwritten control section is reloaded and its associated data control block is opened.

An error in P130 or READIN causes MGLB to print 'TYPEWRITER ERROR, TELL MAGLAB' on the 360/50 console and abnormally terminate the job (ABEND). Failure of LNODCB or DIGIDCB to open properly will also cause ABEND. The most likely cause of abnormal terminations is programmer error when making modifications.

In the case of disk input-output errors, MGLB uses P130 to print a disk error message passed to it by SAM or ANALIN.

Location MES begins a storage area in which messages are placed by the collection programme (ANALIN) or the samples printing programme (SAM). The message descriptions are contained in the descriptions of those programmes.

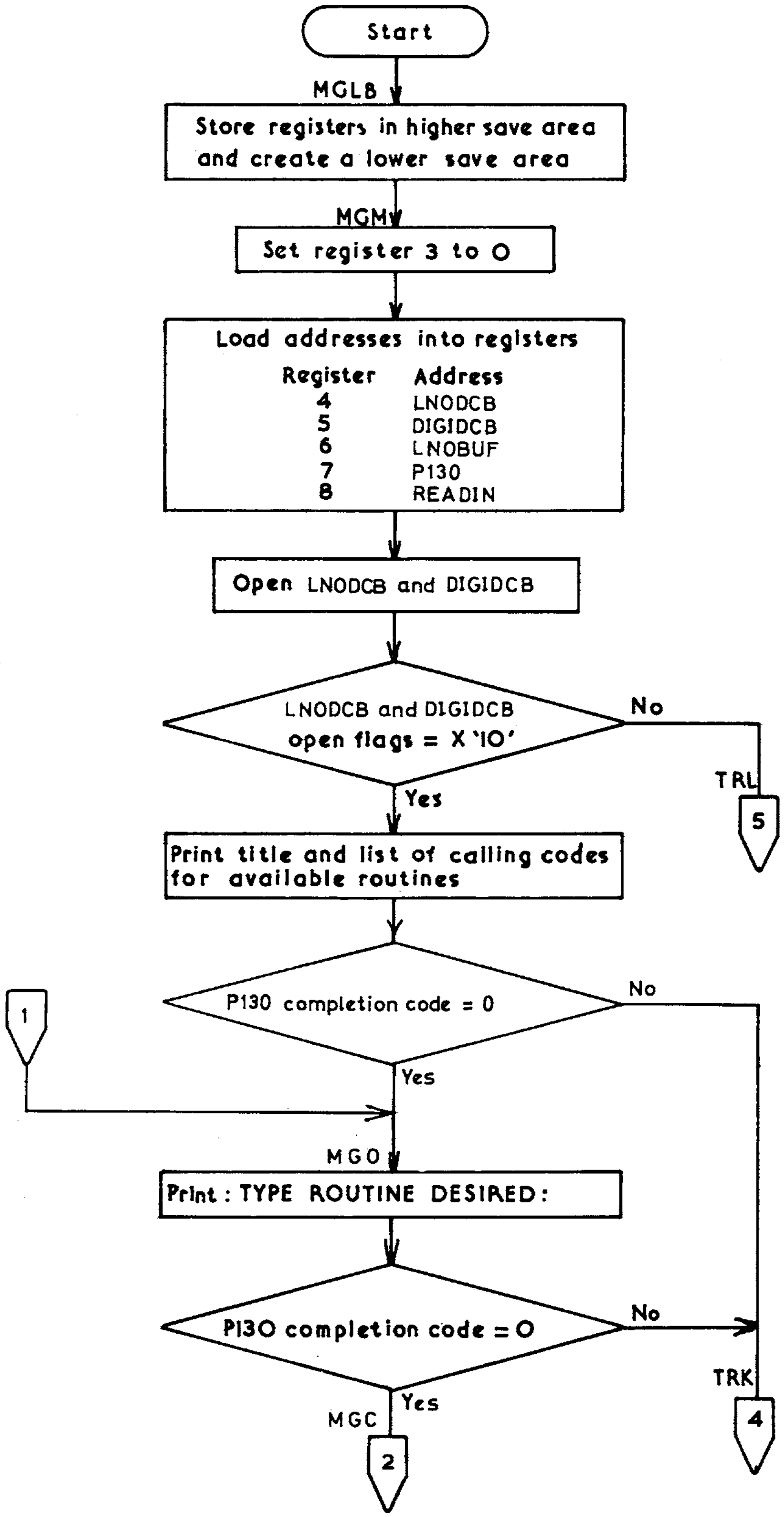


Figure 8.1(a) MGLB Flow Chart

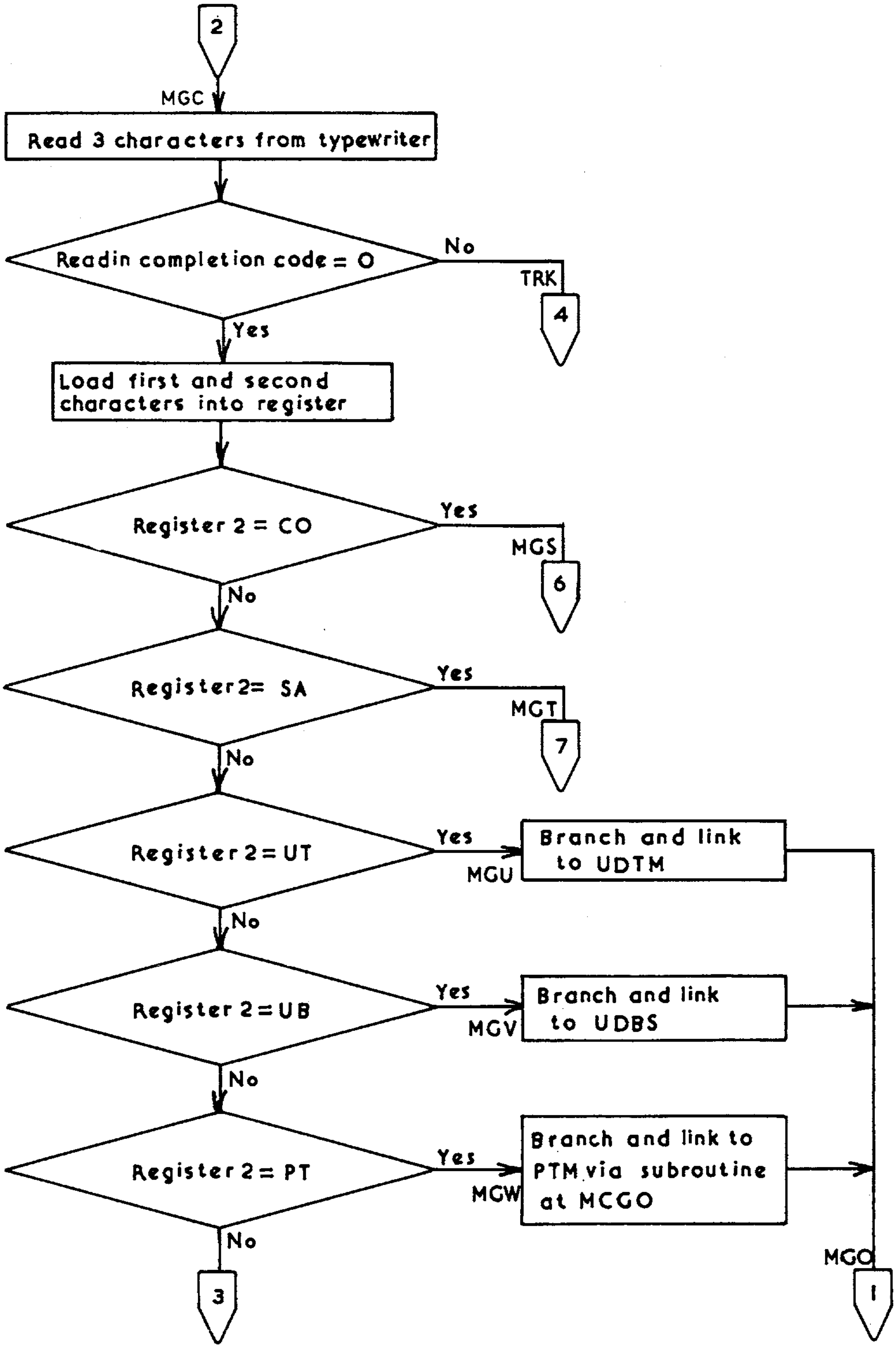


Figure 8.1(b) MGLB Flow Chart (continued)

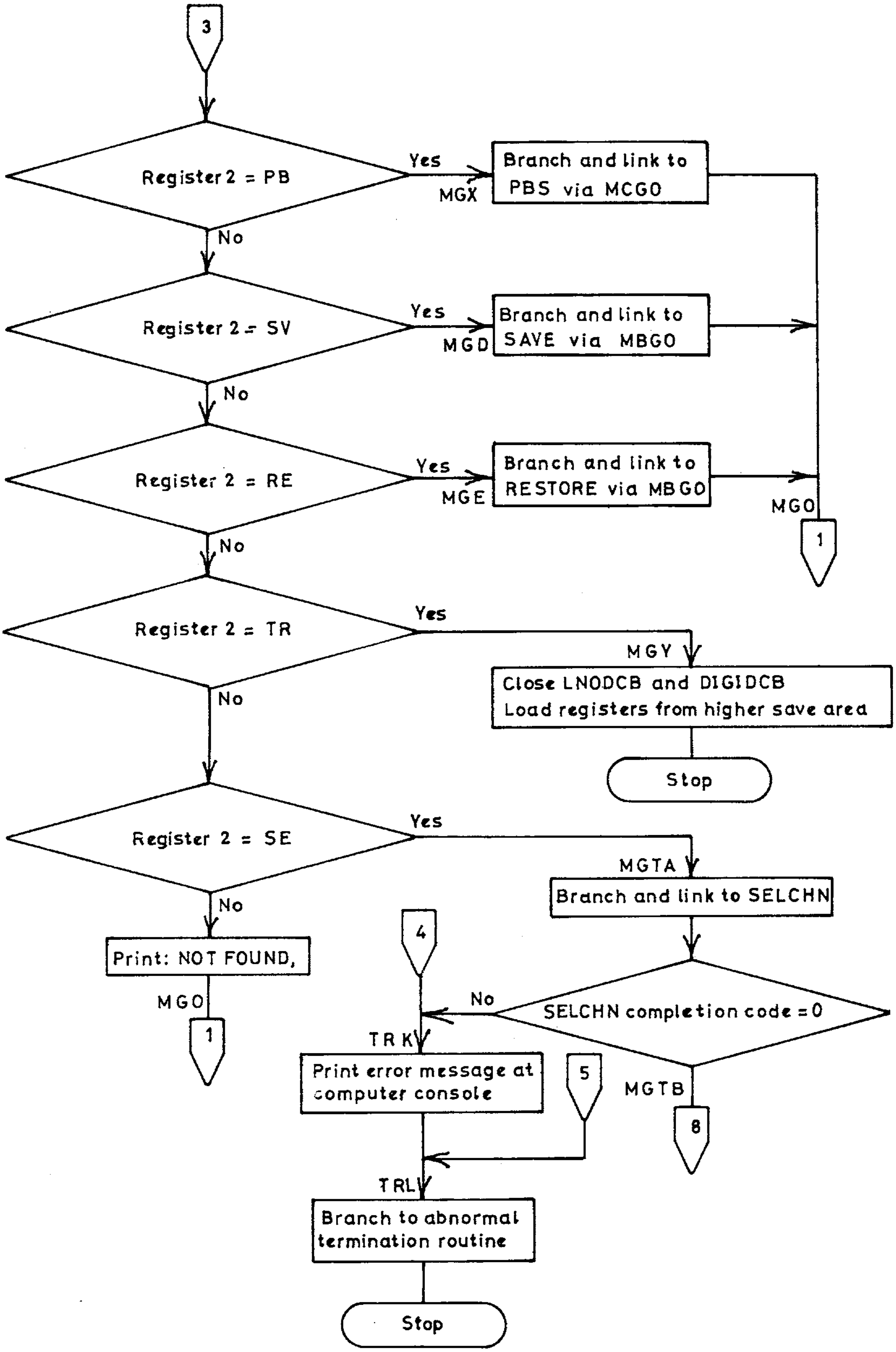


Figure 8.1(c) MGLB Flow Chart (continued)

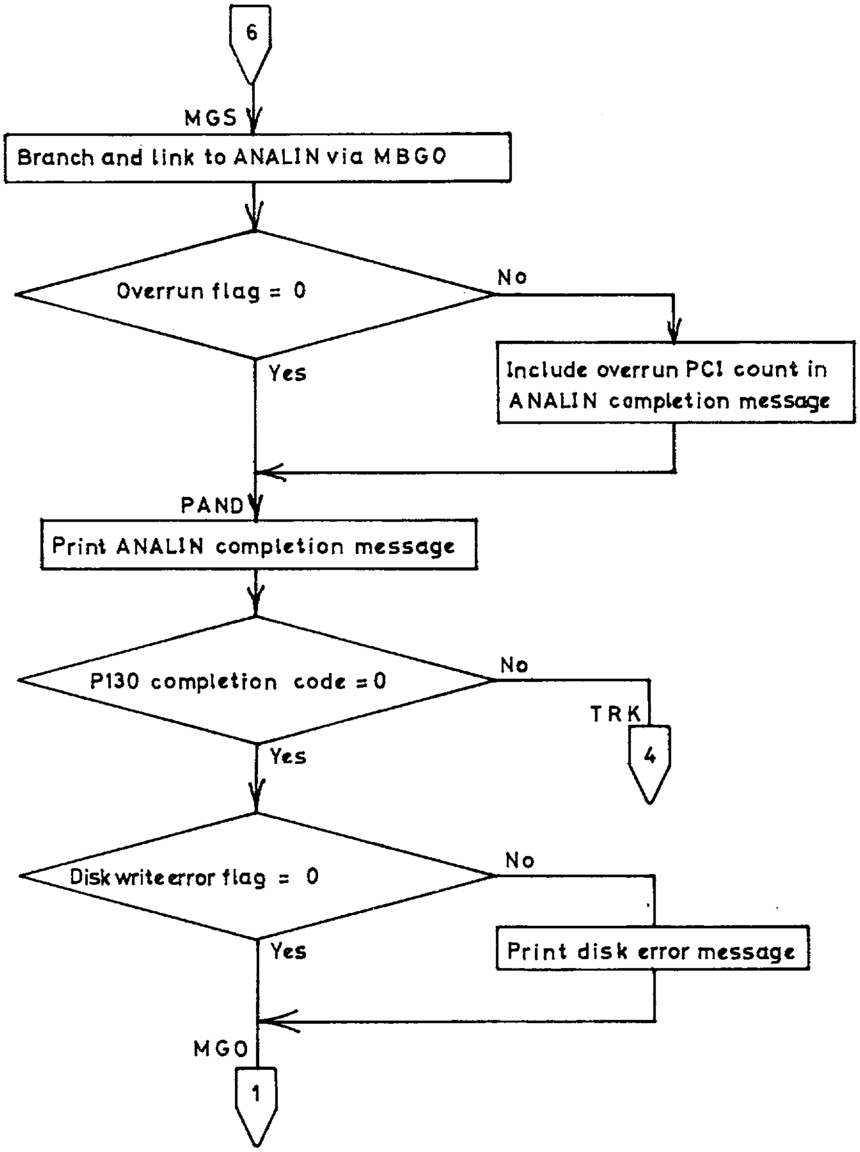
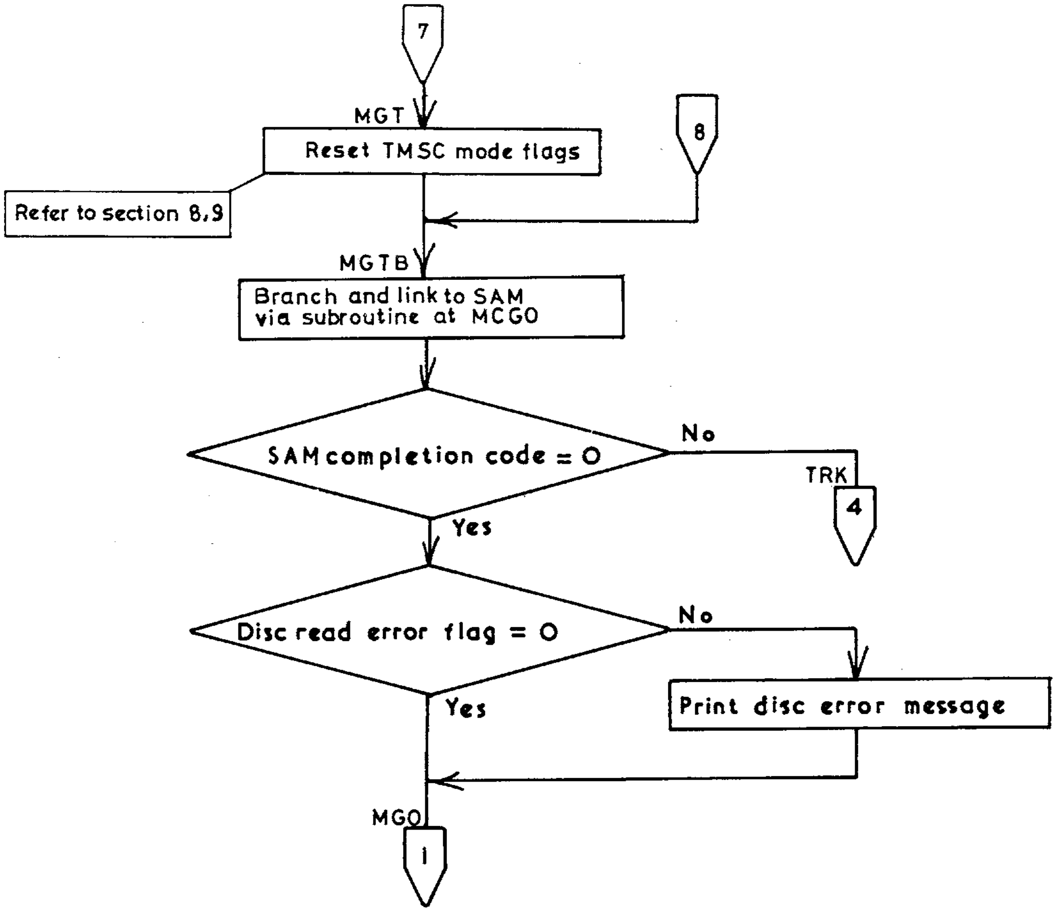


Figure 8.1(d) MGLB Flow Chart (continued)



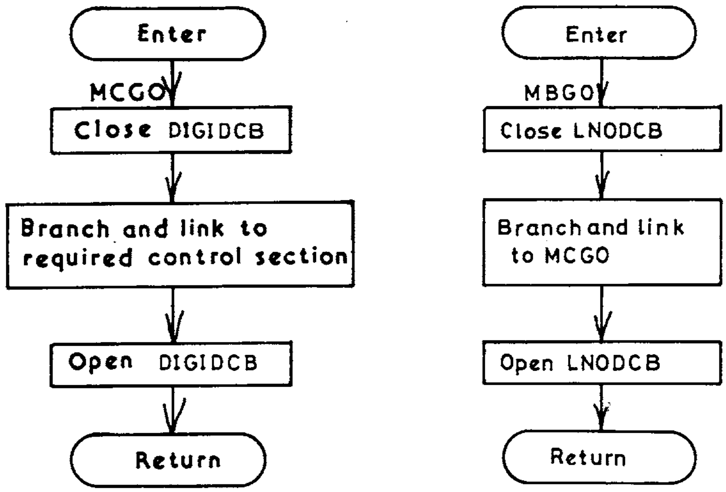


Figure 8.1(e) MGLB Flow Chart (continued)

8.2 Control Section BSTAB

BSTAB is the table of baseline and scale values used to evaluate samples prior to printing; its organisation is illustrated in figure 8.2.

Byte addresses of storage locations within the table are given relative to BSTAB + 0, the first byte of the table. This method of referring to storage locations is used throughout this report.

Each value contained in BSTAB, occupies a full word, making a double word entry for each channel. The table proper is preceded by an identifier (BLSV) and a full-word, containing the number of channels that is referred to by programmes to determine when their processing of channels is complete.

Addresses	+0	+4	
BSTAB + 0	BLSV	32	Identifier and number of channels
+ 8	Base 1	Scale 1	Channels
+ 16	Base 2	Scale 2	
+ 24	Base 3	Scale 3	
	⋮	⋮	
+ 256	Base 32	Scale 32	

Figure 8.2 Base-Scale Table

For reasons of computational efficiency, the typed-in base and scale values are multiplied, respectively, by 10000 and -50500 before being stored in the base scale table.

The base multiplier, 10000, enables base values to be used in four-decimal-place, fixed-point arithmetic operations.

The scale multiplier consists of the following factors:-

-1 x 5 x 1.01 x 10000 = - 50500 where:-

-1 compensates for the inversion of input voltages by the sample and hold amplifier that precedes the analogue to digital converter (ADC);

5 provides part of the conversion factor for the ADC output, the full scale value of which corresponds to 5 volts at the ADC input;

1.01 compensates for a one percent input voltage reduction that occurs in the multiplexer input filters;

10000 provides for four-decimal-place fixed-point arithmetic processing.

When BSTAB is read into main store from disk, all base and scale values are set to 0 and to -50500, respectively, corresponding to actual base and scale values of 0000 and 1.0000. These values may be changed by the base-scale updating programme, UDBS, or by the restore part of the tables saving programme, SAVE.

The comparator value can only be changed by recompiling BSTAB with the required comparator value in BSTAB+4.

The typed-in values to which the base and scale entries correspond may be printed by means of the print base-scale-table programme, PBST.

8.3 Control Section TMT

TMT is the table of the times and the modes of printout the operator desires when he calls the printing programme, SAM. Four printout options are available for each channel. They are:-

(1) maximum and minimum with corresponding times,

(2) selected samples and their times,

(3) all samples (without times),

(4) no printout.

The permitted combinations of options 1, 2 and 3 are 1 and/or (2 or 3).

The organization of the times-modes table is illustrated in figure 8.3.

The table is headed by a half-word identifier, TM, and a half-word equalling the maximum number of times samples that may be printed for each channel. Thus, if samples are taken every 0.1 second for 15 seconds, the latter is 151. It also equals the number of times words in TMT. Programmes refer to this number to decide when processing has finished for a channel.

Addresses	+0	+2	
TMT + 0	TM	151	Identifier and number of times words
+ 4	Modulus Word		Option 1
+ 8	Some Word		Option 2 & 3
+ 12	All Word		Option 3
+ 16	Time Word 0.0 sec		
+ 20	Time Word 0.1 sec		
	⋮		
	Time Word 15.0 sec		
TMSC	Single Channel Word		

Figure 8.3 Times-Modes Table

Each of the thirty-two bits of a modulus, some, all or time word corresponds to a particular IBM 1827 multiplexer channel. For example, bit 0 corresponds to multiplexer channel 1.

The contents of the single channel word, TMSC, are provided by the single channel programme, SELCHN, as described in section 8.9.

Channels for which data, measured at particular times, is to be printed, have their corresponding bits in the Some word set to 1.

Channels for which all data is to be printed have their corresponding bits in the Some word and the All word set to 1.

Selection of required times is accomplished for each channel by setting the channel's bit in each Time word that corresponds to a required time.

When TMT is read into main store from disk, all bits of the Modulus word are set to 1 and all bits of the Some, All and Times words are reset to 0. Thus, if no changes are made to TMT, modulus values for all channels will be printed when the sample printing programme, SAM, is called.

The status of all bits in TMT, other than those of TMT + 0 and of TMSC, may be changed by use of the update times-modes-table programme, UDTM2, and by use of the restore part of the save-tables programme, SAVE.

The comparator half-word, at TMT + 2, can only be changed by recompiling TMT.

The status of the times-modes-table may be determined by means of the print times-modes-table programme, PTM.

8.4 Control Section MAMITB

MAMITB is a table of maximum and minimum values that have been read from the IBM 1827's ADC output register during operation of the data collection programme ANALIN.

As illustrated in figure 8.4, the table consists of thirty-two double words, one double word per channel. Each double word consists of four half-word entries:-

(1) maximum value;
(2) time (in deciseconds) of occurrence of maximum value;
(3) minimum value;
(4) time (in deciseconds) of occurrence of minimum value.

Before data collection commences, the collection programme initialises the table by setting the maxima to the most negative half-word number, X'80 00', and setting the minima to the most positive number '7F FF'.

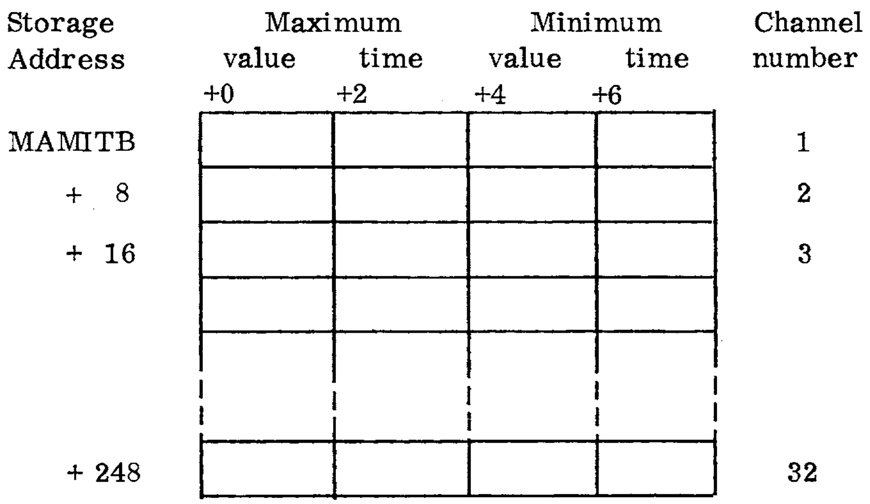


Figure 8.4 Maxima-Minima Table (MAMITB)

8.5 Control Section P130

P130 is called by other magnet laboratory programmes to print messages of up to 130 characters on the magnet laboratory typewriter.

Figure 8.5 is a flow chart of P130 operation.

Before P130 is entered, the calling programme loads the message to be printed into the buffer at location LNOBUF in P130 and loads the message length, in bytes, into register 0.

The message in LNOBUF is coded in EBCDIC, the character code normally used within the IBM 360/50 computer. P130 translates the message from EBCDIC to an 'I/O writer' code that is compatible with the magnet laboratory's typewriter. The relationships between EBCDIC, 'I/O writer' code and typewriter operation are given in figure 5.4.

After translation, successive bytes of the message are transferred from LNOBUF to the high order bytes of successive half-words of the output buffer at location PRNTBUF. Conversion from bytes to half-words is necessary because data can only be transferred from the IBM 360/50 computer to

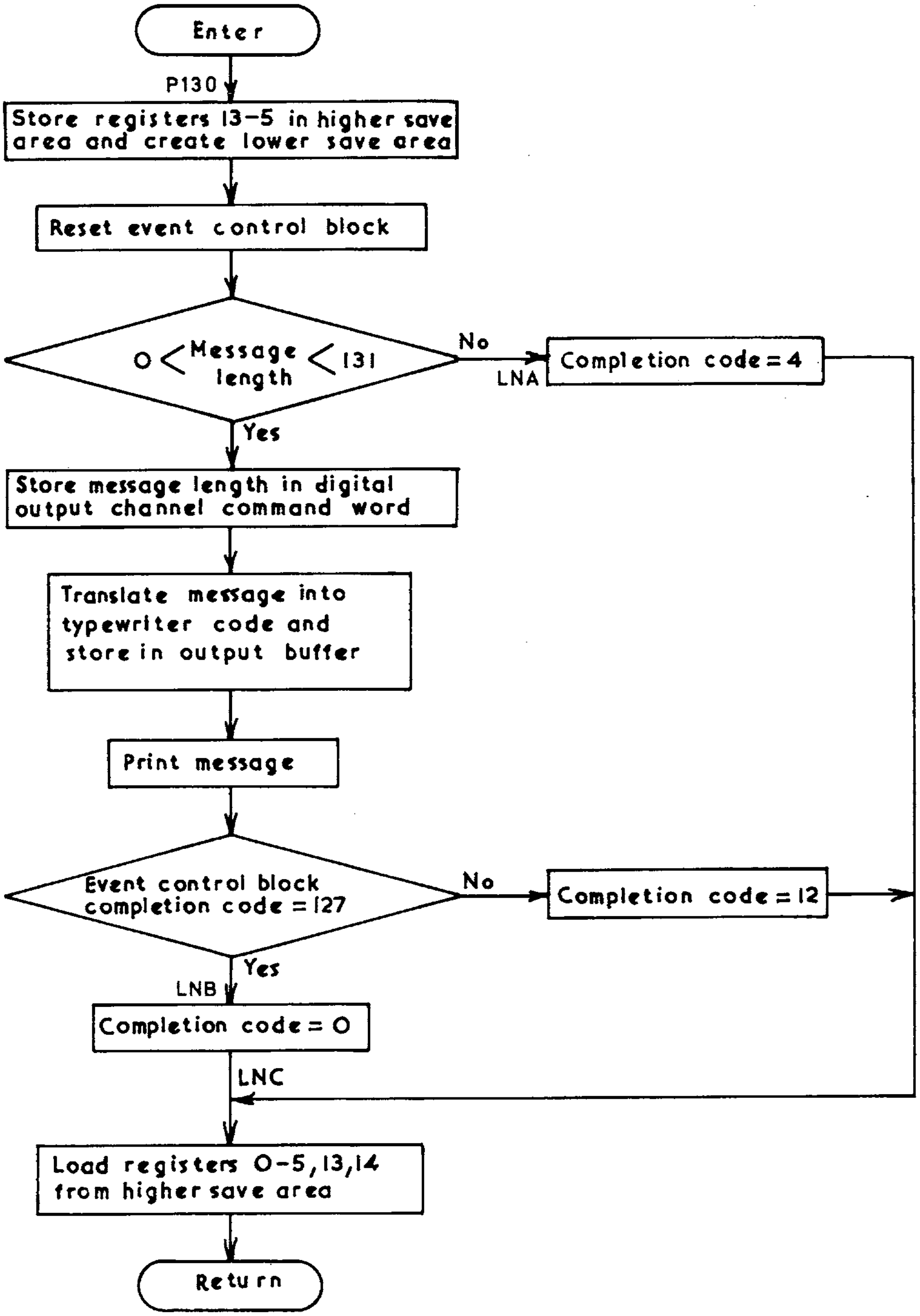


Figure 8.5 P130 Flow Chart

the 1827 digital-output facility in half-words; the contents of the low order bytes of these half-words are meaningless and are ignored by the typewriter and its interface.

Because of the manner in which the 1827 digital-output facility operates, the last half-word of a transferred message is not available at the 1827 digital-output terminals[5, p. 35]. Therefore, the message loaded into LNOBUF must contain one character in addition to the required message; if this is not provided the last character of the message will be lost.

When control is returned from P130 to the calling programme, R15 contains one of the following completion codes:

0 successful completion
4 out of limits line length
8 channel programme terminated with error.

The data control block, LNODCB, is opened and closed by the control programme, MGLB.

P130 provides a save area for registers 14, 15, 0 and 1 only. Therefore, it is conceivable that there could be trouble using the EXCP or WAIT MACRO instructions with later releases of the IBM 360/50 operating system, as any attempt to use a full save area would overwrite some P130 instructions. If such trouble does occur, it can be overcome by providing a full save area in P130.

8.6 Control Section READIN

This routine reads a line of up to 32 characters from the typewriter into a buffer in main store. As read, each character occupies the first byte of a half-word. The buffer is blocked (giving two characters per half-word) and translated into EDCDIC code by READIN. On return to the calling programme the address of the first character is left in register 1. Register 14 is left with one of the following completion codes:-

'0' successful
'4' out of limits line length given
'12' channel error

READIN stores and uses registers 14 to 5. Except for R15 these are restored before returning to the calling programme.

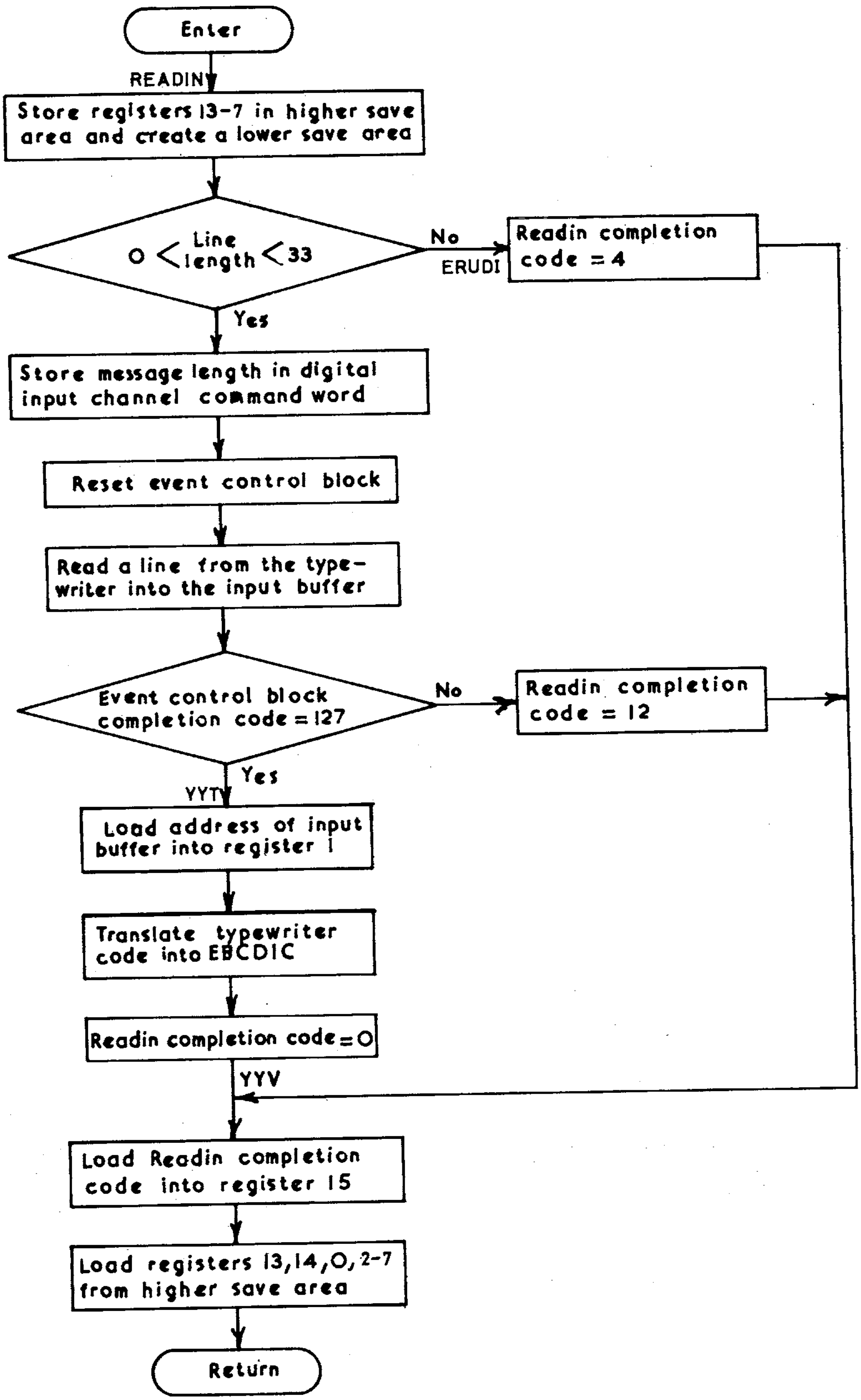


Figure 8.6 READIN Flow Chart

As a convention, all typewriter input to the computer is in lower case. Generally, output messages are in upper case.

READIN's data control block, DIGIDCB, is opened by the control programme, MGLB.

As with P130, there could be trouble with later releases of the 360/50 operating system because a full lower save area is not created in READIN. This may be rectified by providing a full save area.

8.7 Control Section ANALIN

This programme collects data from the 32 multiplexer inputs, updates the table of maxima and minima, MAMITB, and stores the data on disk for later retrieval. Figure 8.7 is a flow chart of ANALIN.

Two 360/50 channel programmes are used to collect the data. One writes addresses to the multiplexer and the other reads data from the analogue to digital converter into main store. The 1827 synchronises these automatically. The 360/50 channel programmes scan the 32 multiplexer inputs once for each user supplied synchronising pulse. These pulses, derived from the power mains, occur at 0.1 second intervals.

Two input buffers, BUFA and BUFB, are alternately filled from the analogue-to-digital converter's output register by the analogue-input channel programme, ADCCHN, contained in ANALIN. Each input buffer has a 320 byte capacity. Therefore, as the analogue-to-digital converter's output register contains two bytes of data, five scans of the thirty-two 1827 multiplexer channels fill a buffer. While the analogue-input channel programme is filling one input buffer, ANALIN transfers data to disk from the other buffer and updates the maxima-minima table.

Each time a buffer is filled, a programme controlled interrupt (PCI) generated by the analogue-input channel programme initiates execution of the PCI appendage IGG019WB described in section 8.15. This appendage increments a programme-controlled-interrupt counter, in ANALIN, and sets the event completion flag in the event control block of the buffer just filled. This synchronises ANALIN with data collection.

From the end of filling (say) BUFB till the time BUFB starts filling again is 0.5 second. In this time ANALIN must process BUFB's contents. If it does not an overrun situation arises. If, after processing the contents of one buffer, the alternate ECB indicates that the other buffer is filled, then a bit is set in MGLB to indicate possible overrun. The present PCI count is then stored, remaining unaltered until ANALIN is next entered. When control is returned to MGLB, the overrun bit is tested and, if set, the overrun PCI count is printed following the normal completion message, thus indicating the first data sample that may be in error because of overrun.

The number of scans of the analogue input channels depends upon s, the number of samples required. s is taken from the second half-word of the times-modes table (at TMT + 2). The desired PCI count S, is therefore given by

$$S = \frac{s}{5} \quad \text{(rounded up if there is any remainder).}$$

When the PCI count equals S - 1, ANALIN removes command chaining from the PCI channel command word that follows the BUFA channel command words. Thus, if s = 156, S = 32. S - 1 = 31 would indicate that BUFA had just been filled with the 155th sample and command chaining would be removed from the BUFA PCI channel command word. Ten more samples would be collected before the 360/50 channel stopped, giving 165 samples total. Had s = 154, then the total samples would have been 155.

The disk storage area is defined by the code DDNAME=DSKHLD. Blocks of length 320 bytes are alternately written to it from BUFB and BUFA. The blocksize equals 5 (number of scans) times 32 (number of channels) times 2 (bytes per channel). The data is stored sequentially; BUFA in Block 0, BUFB in block 1, BUFA in block 2, etc. When ANALIN is next called it overwrites the previous contents of DSKHLD.

Any error in writing to disk from which the 360/50 cannot automatically recover causes a routine, within ANALIN, to be executed. This routine writes a 60 character error message into MGLB and sets the disk write error flag. When control is returned to MGLB the error message is printed by the typewriter, along with the normal completion message.

Once a write-to-disk error has been detected, no further WRITES must be attempted. To ensure this, the disk write error flag is inspected before every WRITE. If on (flagged), the WRITE is bypassed. In such instances ANALIN will continue to update MAMITB until the data collection stops. ANALIN should not be called again until the error has been rectified.

The normal completion message printed by MGLB takes the form:- ADC CHN CC=kk, PCICT=yyy. kk is the ADC channel completion code, taken from the ADC event control block. Normally kk= 7f. For other codes see section 9.4.1. yyy is the final PCI count; for example, PCICT=041 for a 20 second data collection period.

If, for example, the 360/50 channel programmes had terminated prematurely due to a voltage overload of the analogue-to-digital converter, then the PCI count would be less than expected. This condition would also return an abnormal ADC channel completion code.

If the overrun bit is set, then the following message is added:- ' OVERRUN PCICT=zzz; zzz being the PCI count at the time the first overrun was detected. Overrun might be expected if:-

(a) the sampling rate was greatly increased above 10 per second;

(b) if the 360/50 operator had failed to give this job top priority with the CPU;

(c) if tape jobs with long blocks were being run.

ANALIN opens and closes the three data control blocks it uses.

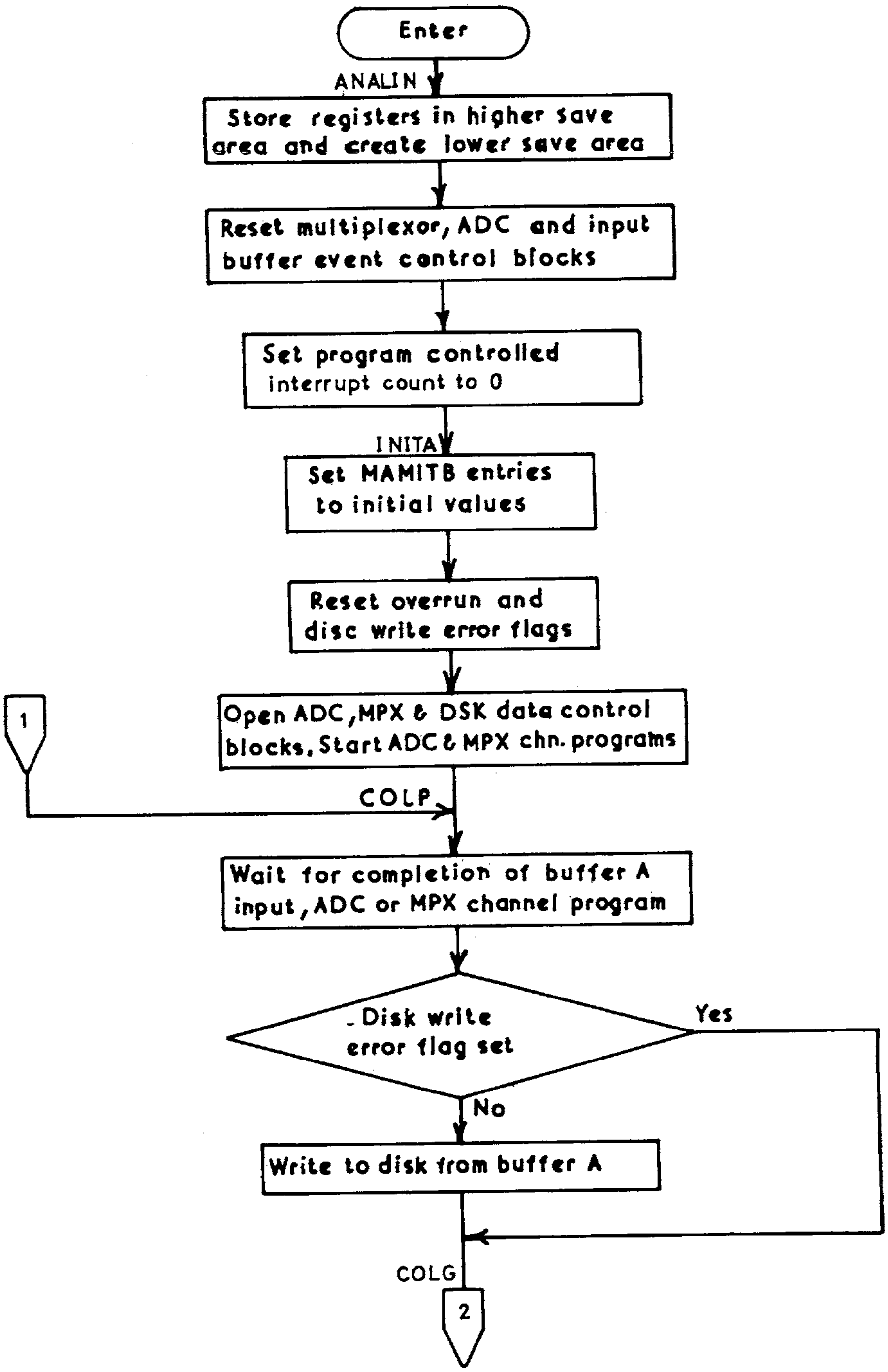


Figure 8.7(a) ANALIN Flow Chart

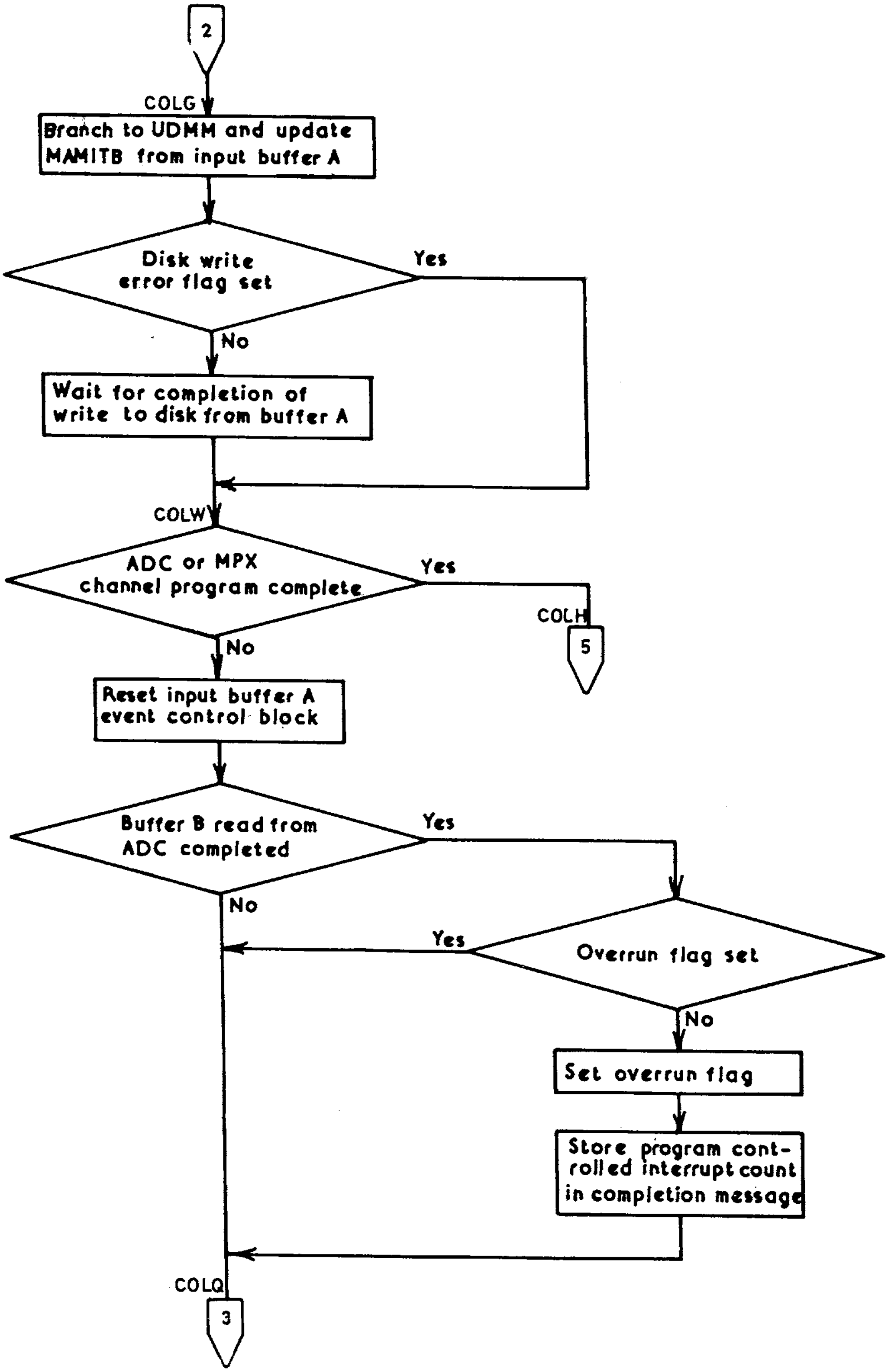


Figure 8.7(b) ANALIN Flow Chart (continued)

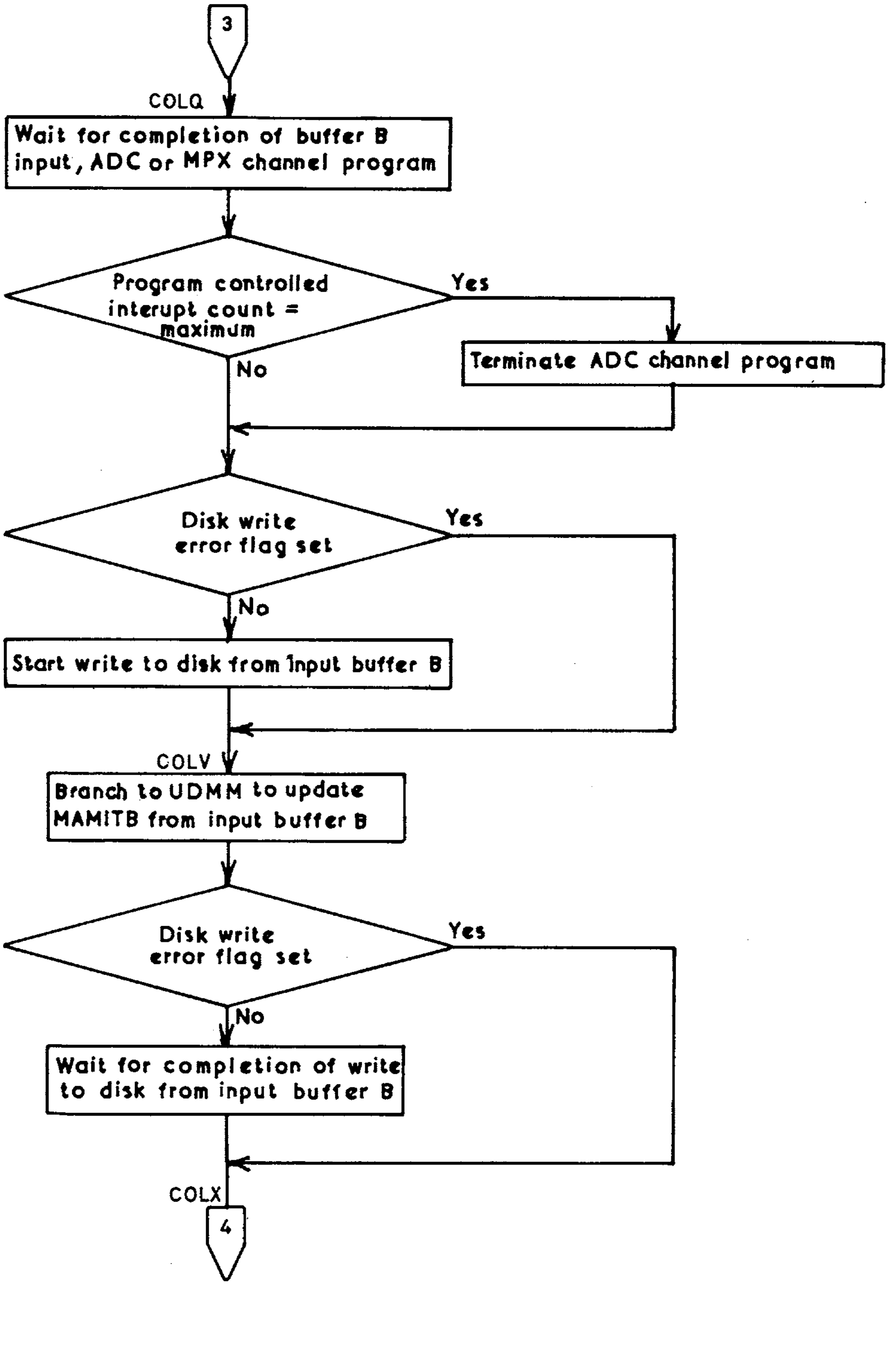


Figure 8.7(c) ANALIN Flow Chart (continued)

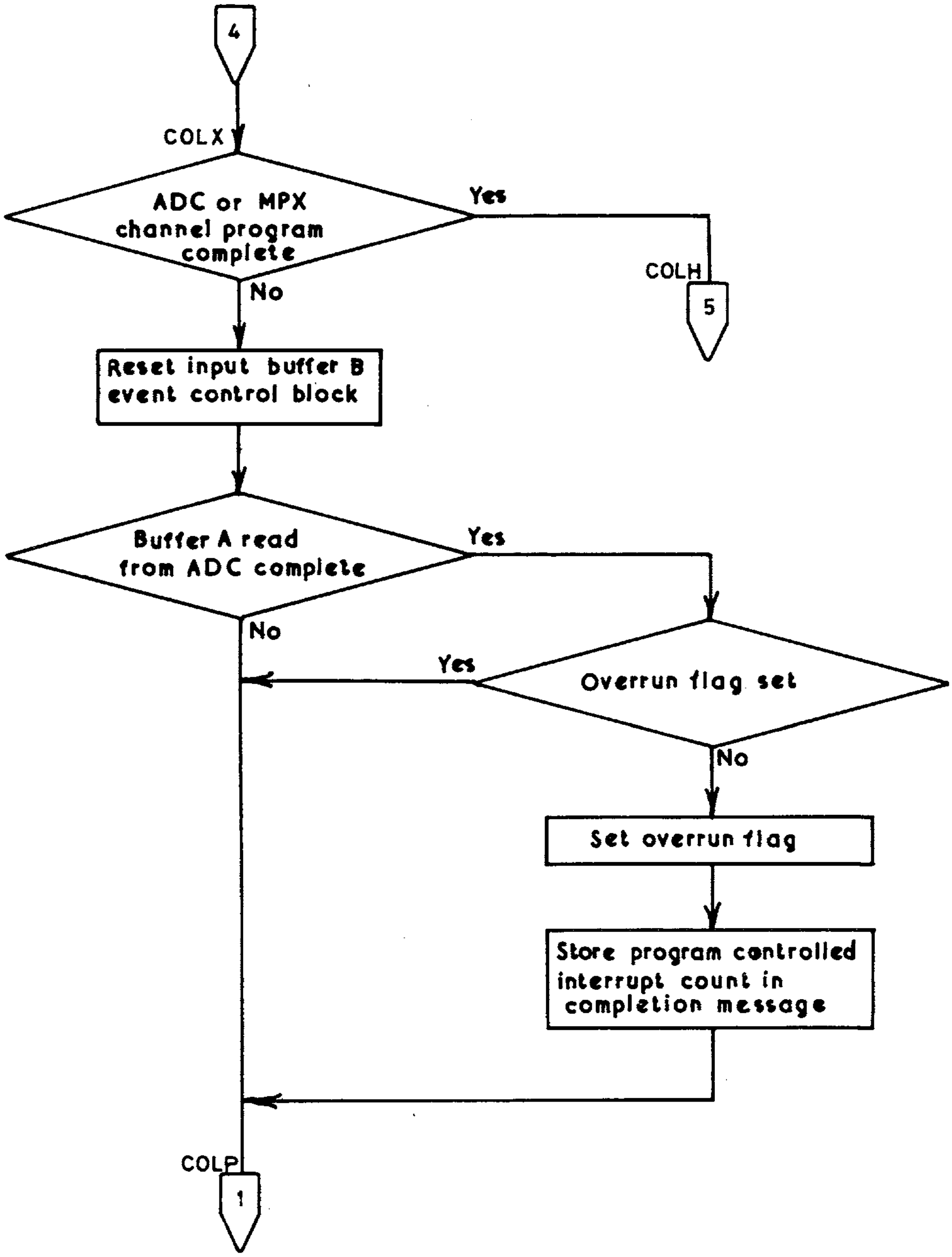


Figure 8.7(d) ANALIN Flow Chart (continued)

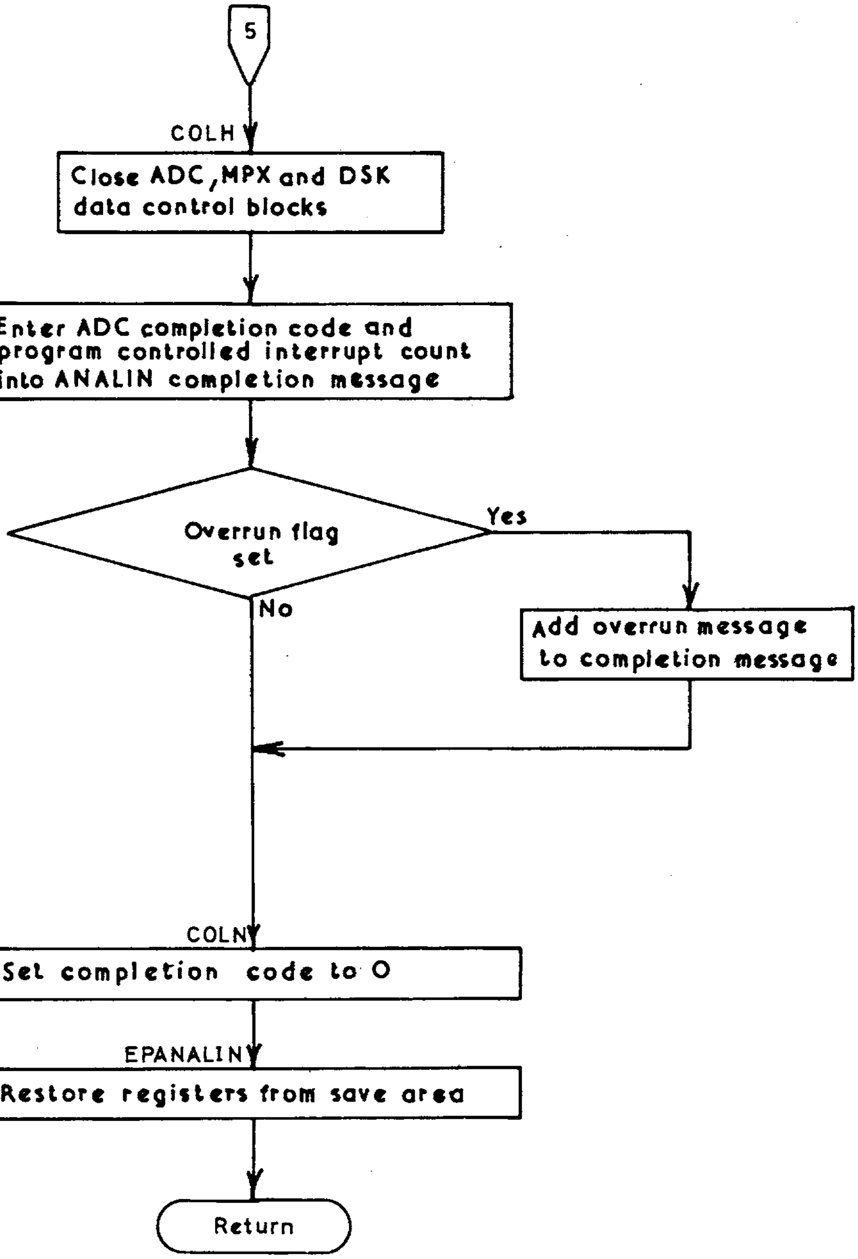


Figure 8.7(e) ANALIN Flow Chart (continued)

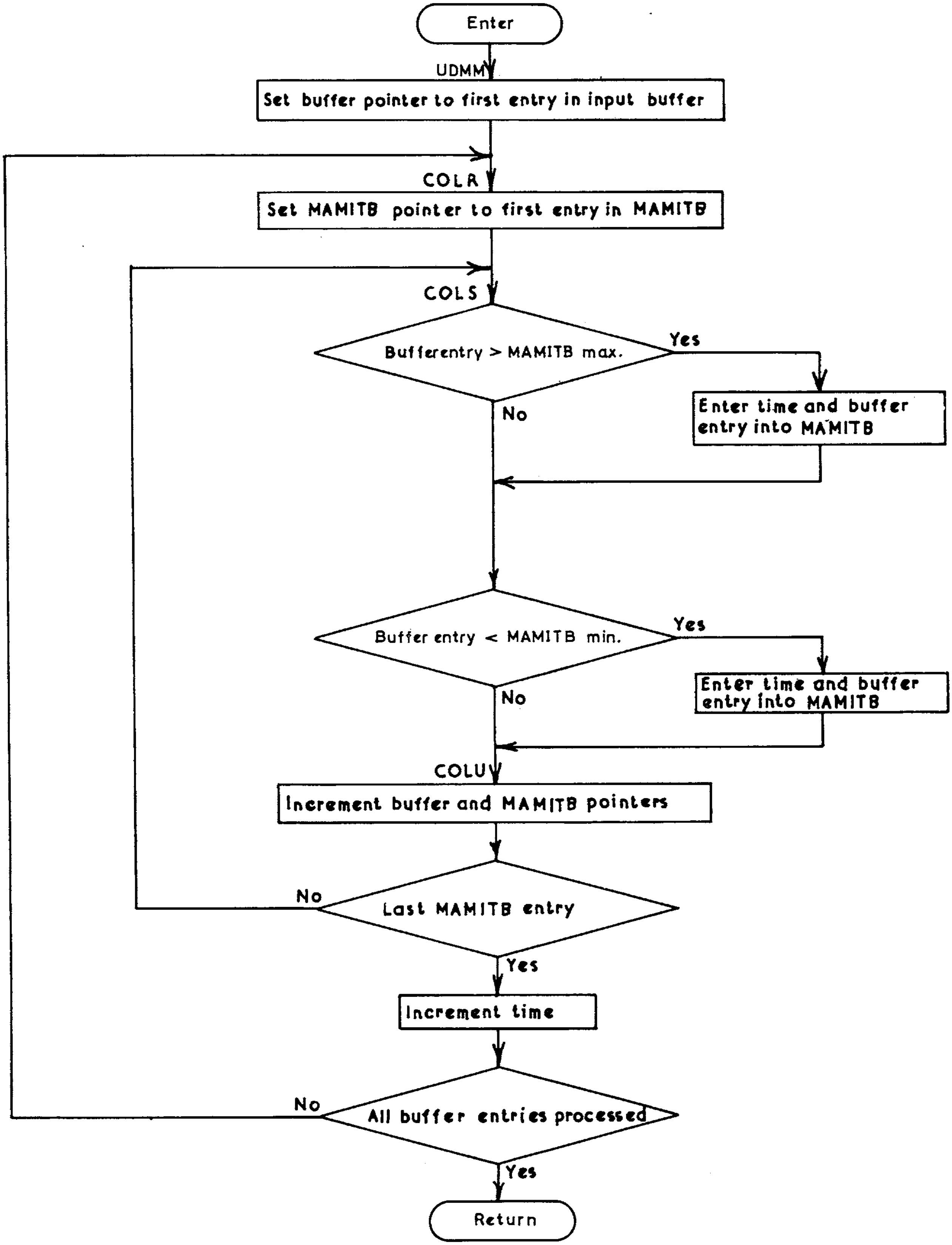


Figure 8.7(f) Update MAMITB Flow Chart

8.8 Control Section SAM

SAM processes and prints the samples stored on disk and in the maxima-minima table, MAMITB. It refers to the times-modes table, TMT, to select the samples to be printed and to the base-scale table, BSTAB, for the appropriate baselines and scales with which to process the samples.

A typical printout is:

```
SELECTED SAMPLES
26  MAX  15.4/160.3            MIN  0.0/-0.00
27  MAX  15.4/15.99            MIN  0.0/-0.00
        0.0/-0.00     1.0/0.995         2.0/2.002
30  12.12  12.23  12.33  12.43  etc.
```

The leading two digit numbers are the channel numbers.

For clarity of reading, the channel number is omitted for the second and subsequent lines of each channel.

MAX and MIN label the maximum and minimum processed sample values obtained during a sampling period.

The first of each pair of numbers separated by a / is the time in seconds from the start of a sampling period at which the second number, the processed sample value, occurred.

If all samples of a channel are printed, they are printed in sequence without times as shown above for channel 30.

Printed samples are formed from

$$y = y_o + k.x$$

where y_o is the baseline value from the first word of the channel's double word in BSTAB;

k is the scale value from second word of the channel's double word in BSTAB;

x is the voltage sample collected.

Dimensionally: [units] = [units] + [units/volt] · [volt]. Typically, "units" correspond to units of pressure, flow, displacement, temperature, voltage, etc..

Valid positive values of y are printed, after rounding, as four digits with a decimal point. Valid negative values are printed, after rounding, as three digits with a decimal point and leading minus sign.

Printed values that are less than -999 or greater than 9999 may be invalid; if they occur, they will consist of five digits if positive or four digits and a minus sign if negative. A decimal point will not be included with such values.

SAM is entered via a BALR 14,15. All registers are stored and a full lower save area is created. On normal completion register 15 is set to '0'.

SAM calls P130 to print on the typewriter. Any error from P130 returns to SAM R15 ≠ '0'. SAM returns this register unaltered to its caller (MGLB).

SAM retrieves data from MAMITB or the disk data set, DDNAME = DSKHLD, or both. When samples are retrieved from DSKHLD, all blocks are read sequentially, whether or not a sample in each block is required.

When printing all samples for a channel, the processing continues until DSKHLD is exhausted. Thus the number of samples printed for the channel can exceed the number stored in the times/modes table header at TMT + 2.

When printing samples with 'times' (e.g. 13.4/-0.09), processing ceases when either DSKHLD or TMT is exhausted. DSKHLD for the run could be small if there had been:-

(a) an error in writing to DSKHLD
or (b) a voltage overload on any analogue input.

If DSKHLD is prematurely terminated, SAM continues to process and print required maxima and minima but bypasses any further read-from-disk instructions.

A permanent error in reading from DSKHLD causes control to be given to the error routine at SMSYN. SMSYN flags a local (within SAM) error indicator, writes a 60 character error message into MGLB for later printing and flags bit 1 of MES (also in MGLB). SAM opens and closes the data control block, DSKIDCB, for the data set containing the samples, but assumes that the typewriter output data control block, LNODCB, is always open.

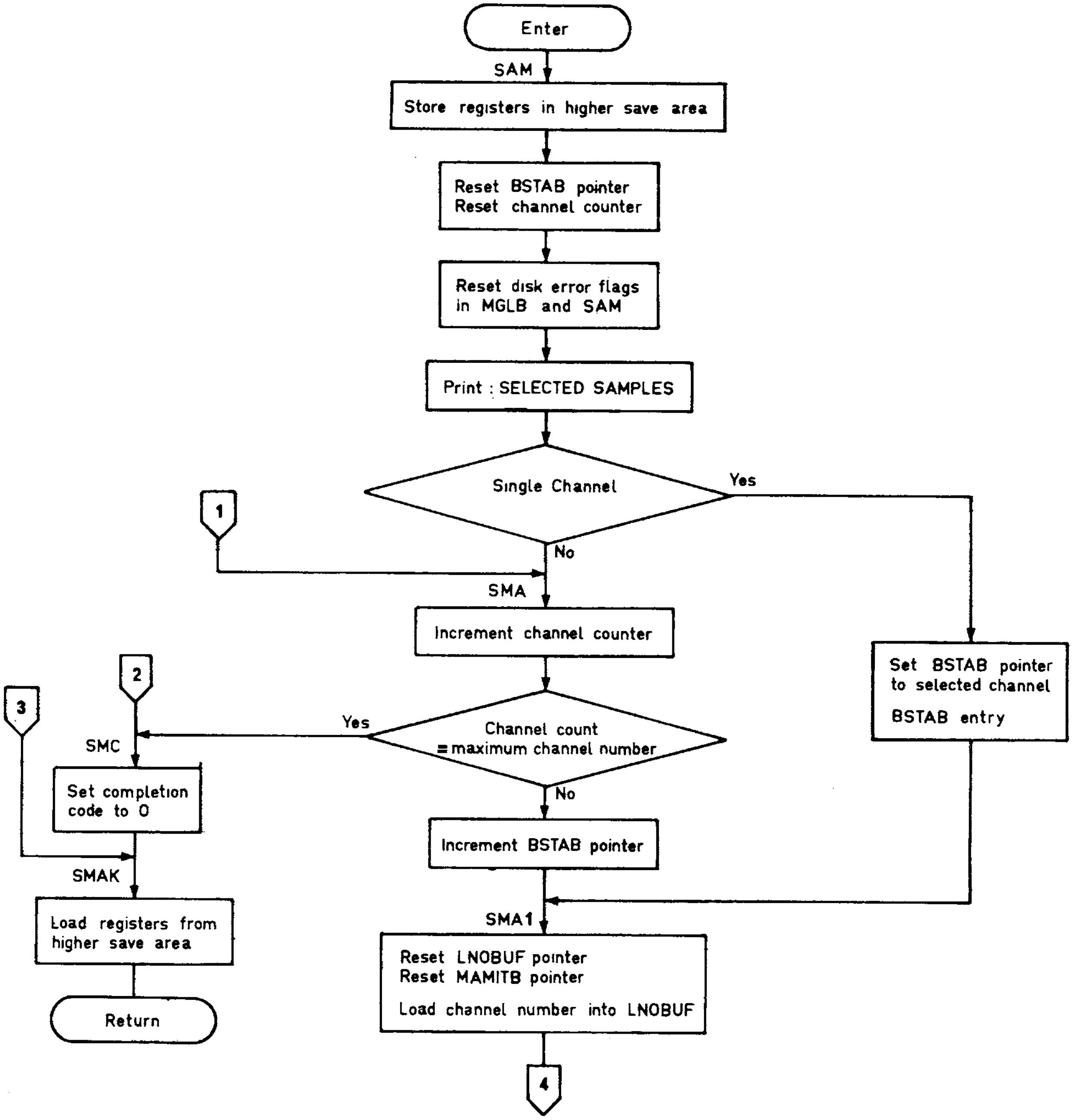


Figure 8.8(a) SAM Flow Chart

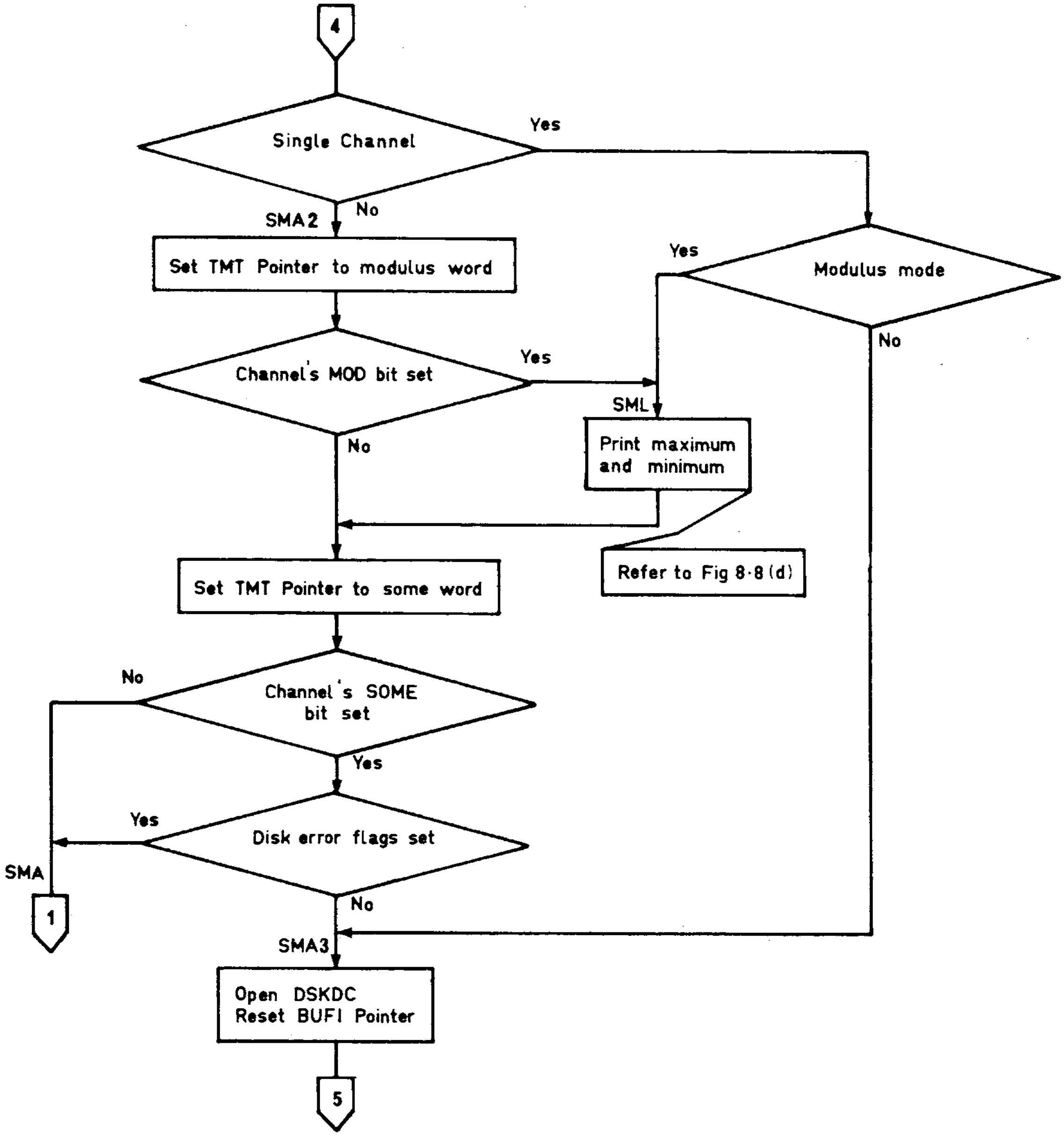


Figure 8.8(b) SAM Flow Chart (continued)

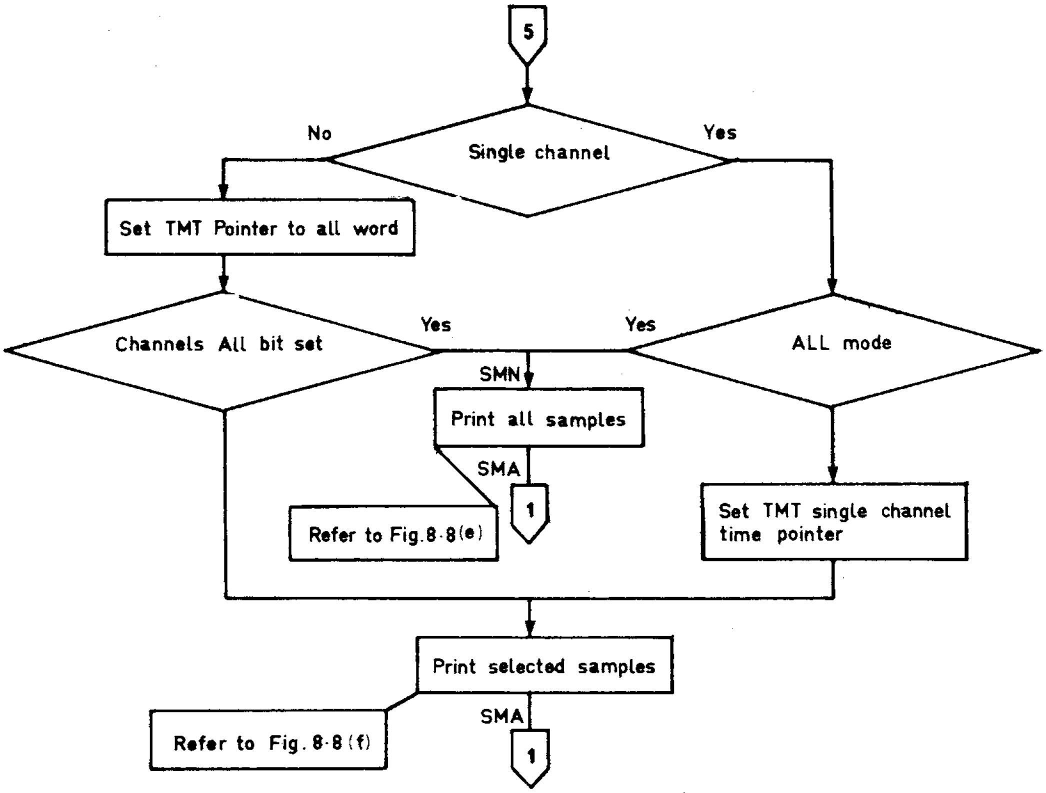


Figure 8.8(c) SAM Flow Chart (continued)

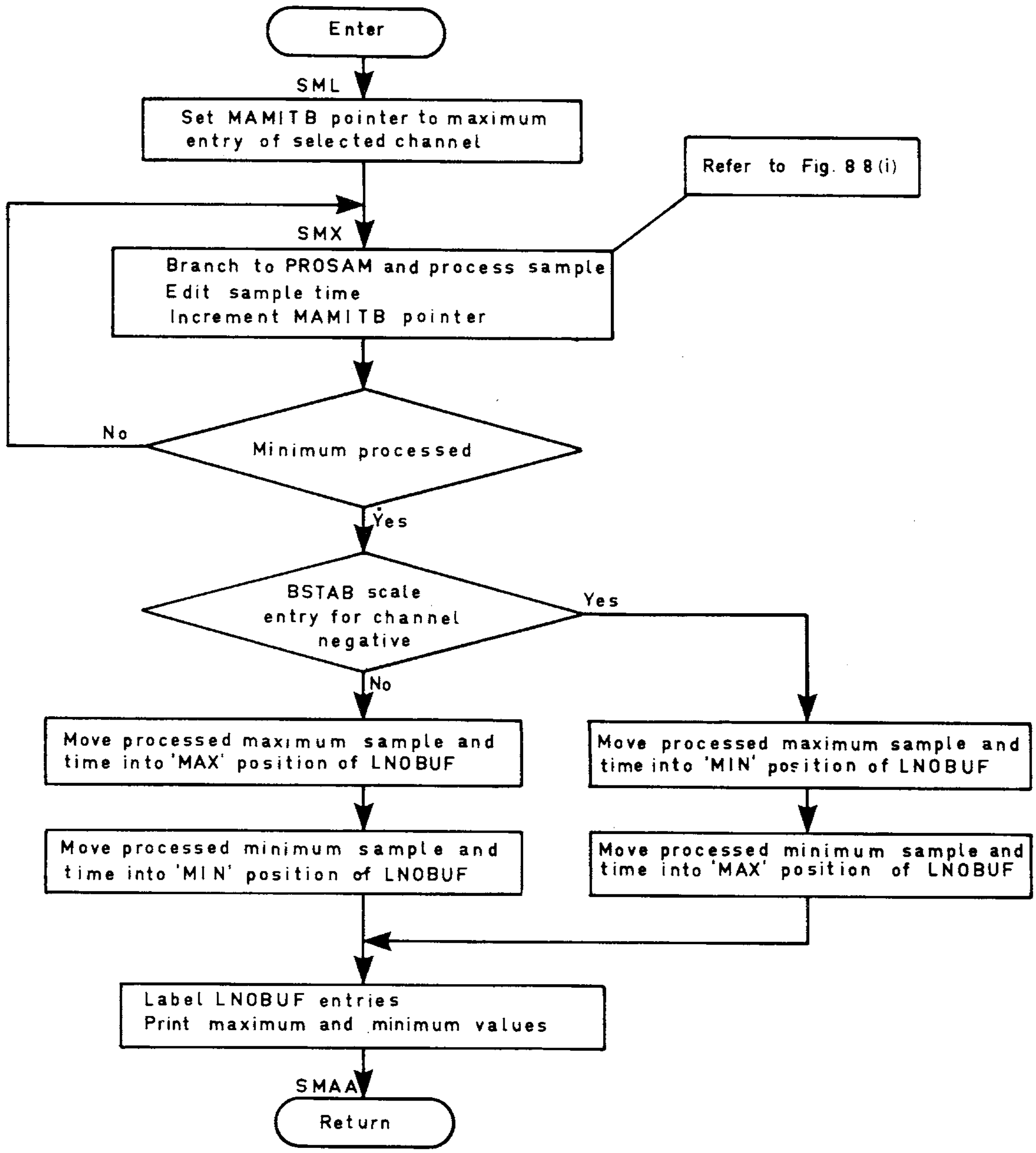


Figure 8.8(d) Process Maxima and Minima

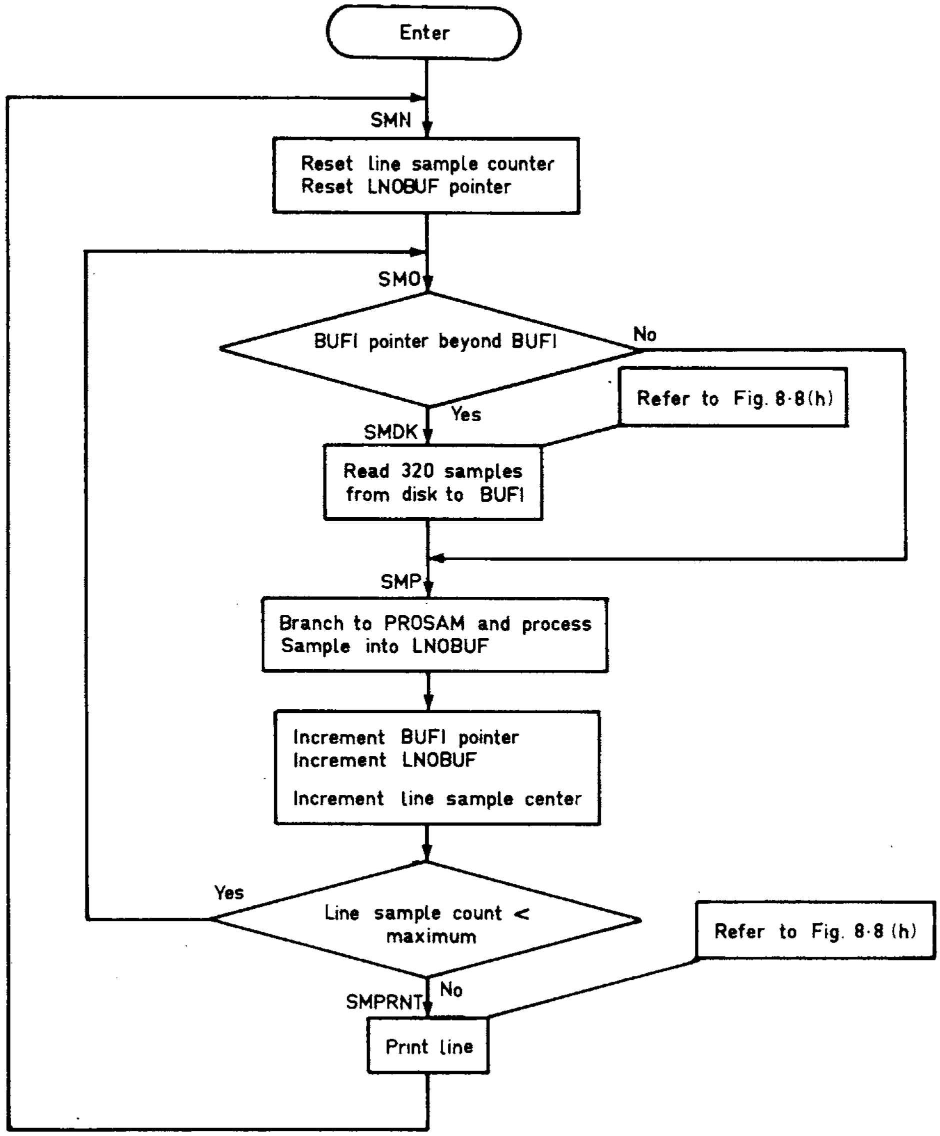


Figure 8.8(e) Process All Samples

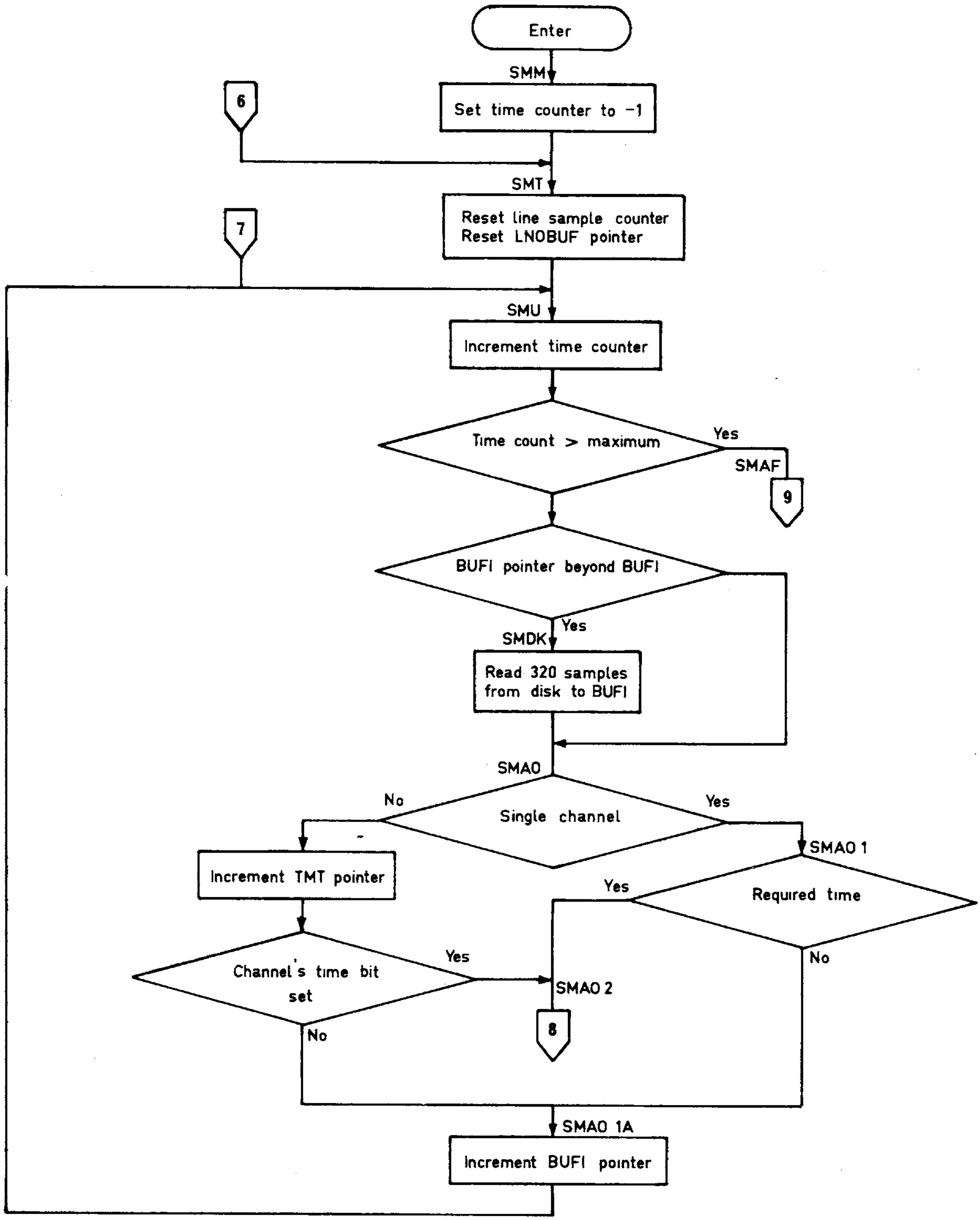


Figure 8.8(f) Process Selected Samples

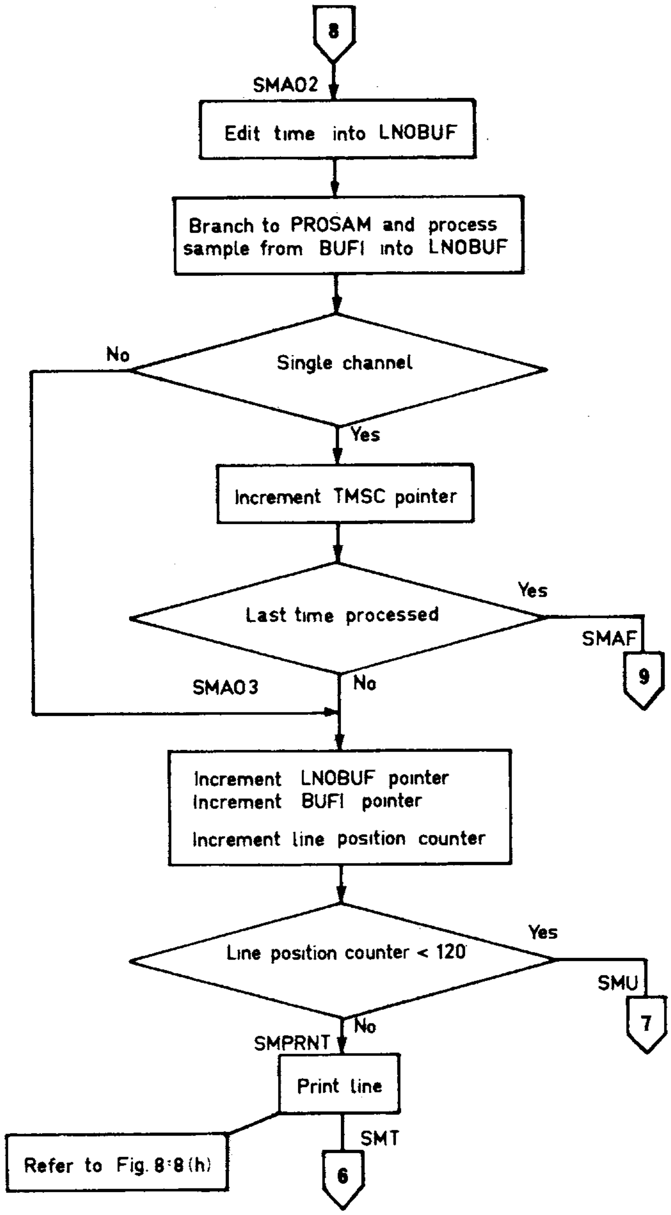
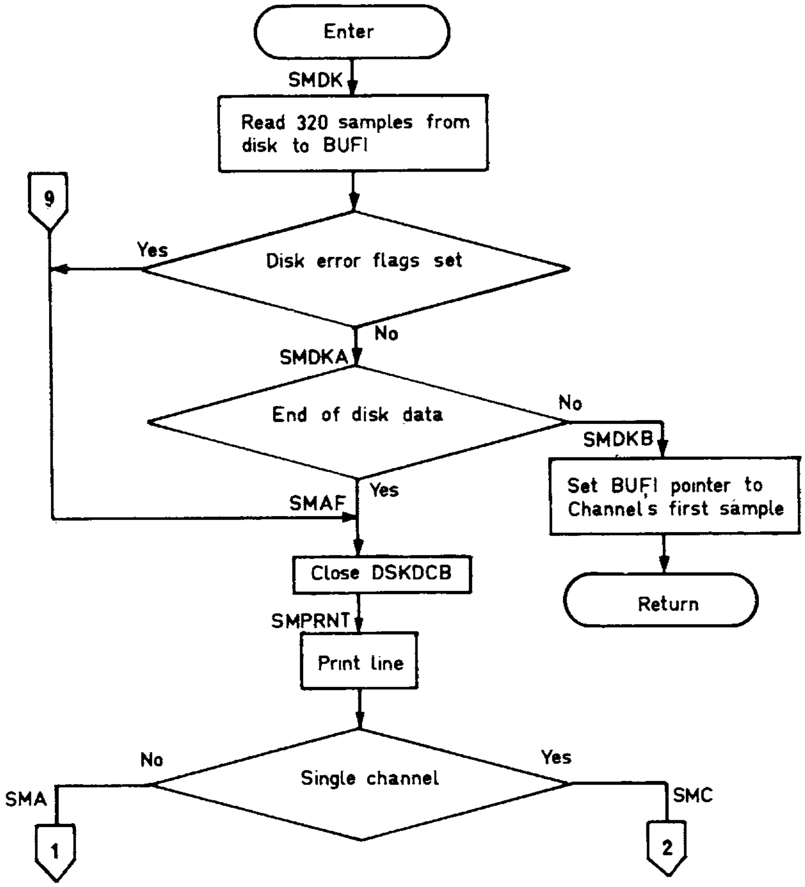


Figure 8.8(g) Process Selected Samples (continued)

Read Routine:



Print Routine:

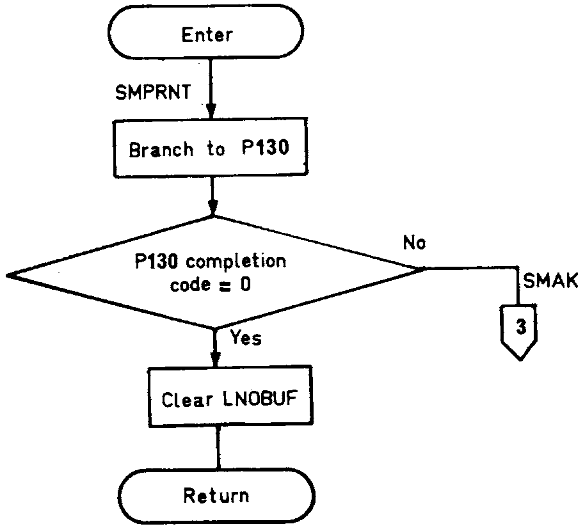


Figure 8.8(h) SAM Print and Read Routines

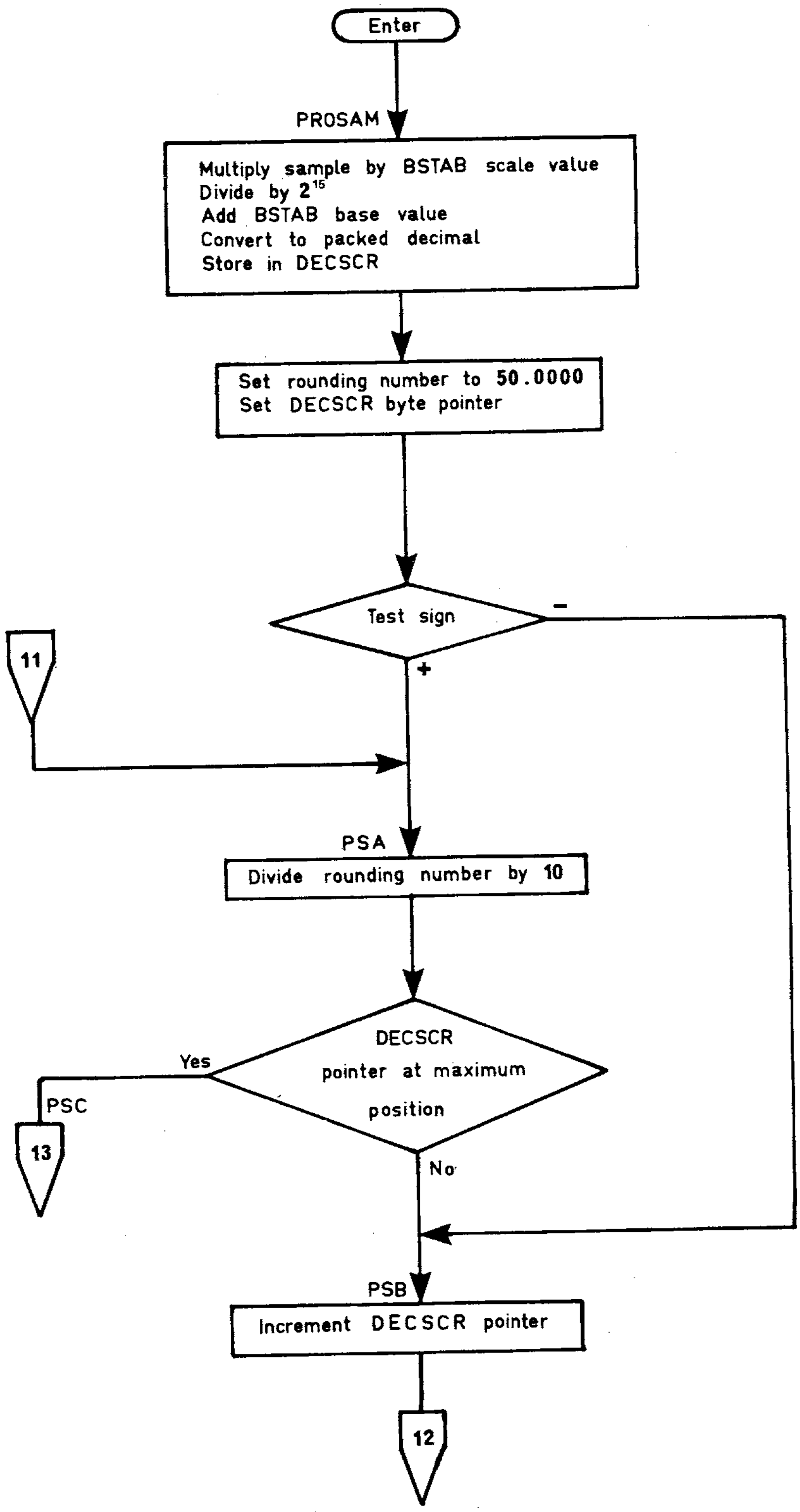


Figure 8.8(i) PROSAM - Flow Chart

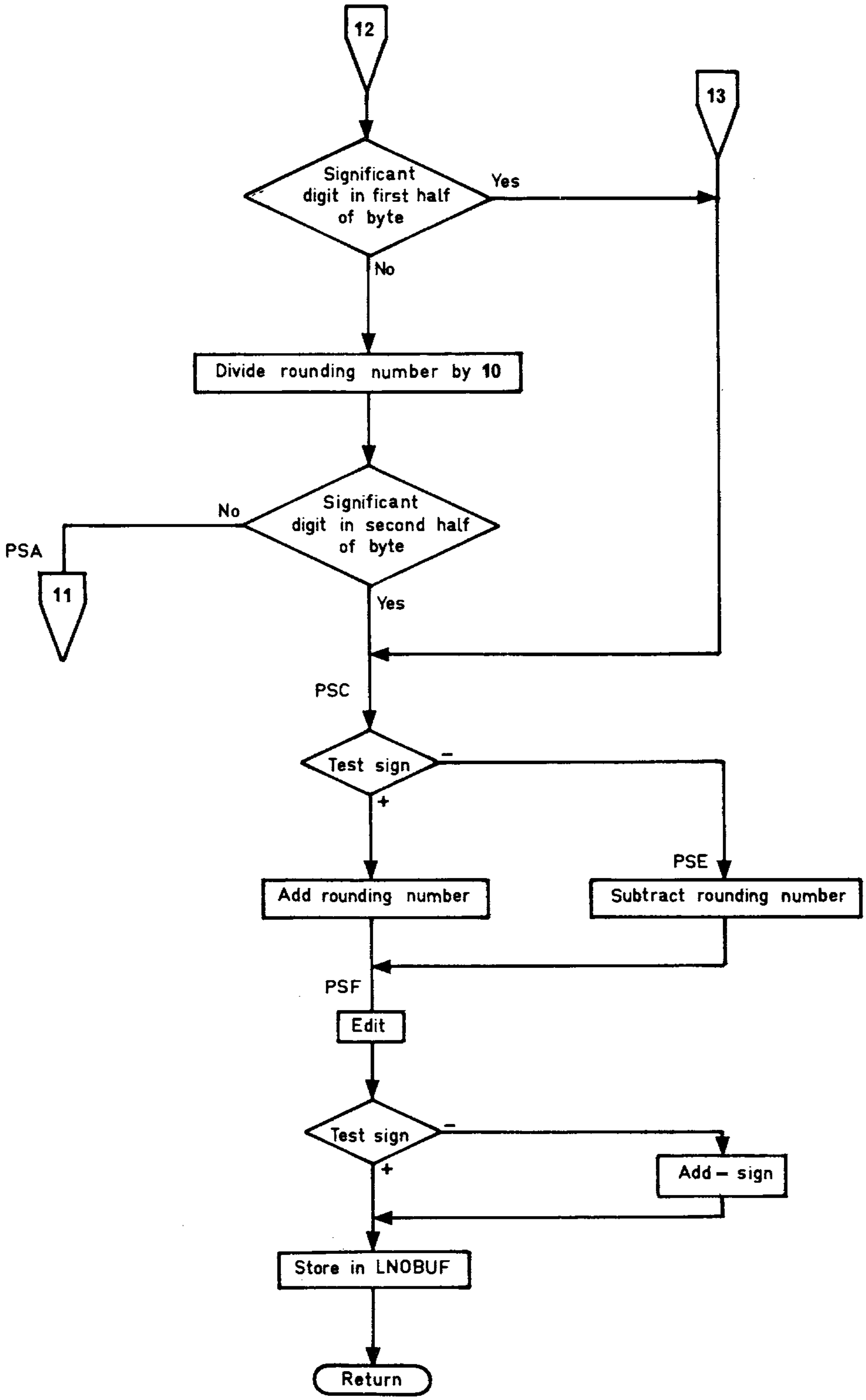


Figure 8.8(j) PROSAM - Flow Chart (continued)

8.9 Control Section SELCHN

SELCHN enables the sample processing programme, SAM, to process and print data for a single channel without the modes and times words of TMT being updated.

During single channel operation, SAM is controlled by TMSC, the last word of TMT. TMSC has the following format:-

byte 0	mode	00	multichannel
		01	single channel, all samples
		02	single channel, modulus
		03	single channel, selected times
byte 1	channel number		
bytes 2-7	selected times		

The mode byte is set to 00 when SAM is requested by the typewriter operator and to one of the other codes during SELCHN operation.

When the code is 00, SAM operates under control of the modes and times words of TMT, otherwise SAM operates under control of the single channel word, TMSC.

The setting of TMSC bytes, during single channel operation, is determined by information typed by the operator. This information is typed in the following format:-

characters 1-2	channel number	
3	space	
4-6	all	all samples mode
	mod	modulus mode
4-26	list of three-digit times (in deciseconds), separated by spaces	
29	t or l	accept this line and branch to SAM

SELCHN applies validity tests to all input data and provides appropriate error messages when invalid data occurs.

READIN and P130 are called by SELCHN; their associated data control blocks are open when SELCHN is entered.

DECIN is called to convert channel numbers and times to binary.

On completion of SELCHN, control is transferred, via MGLB, to SAM and the requested single channel operation is executed.

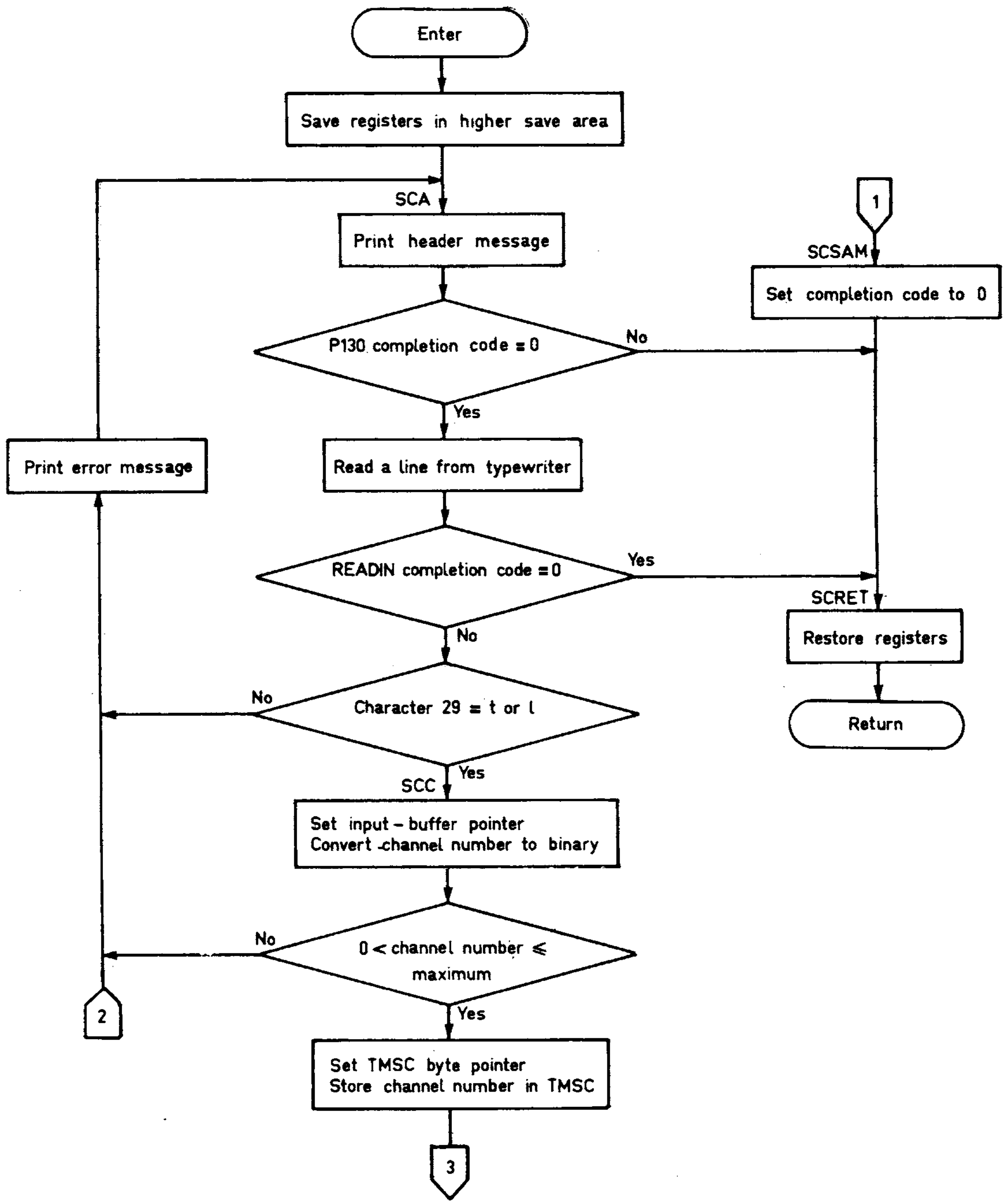


Figure 8.9(a) SELCHN Flow Chart

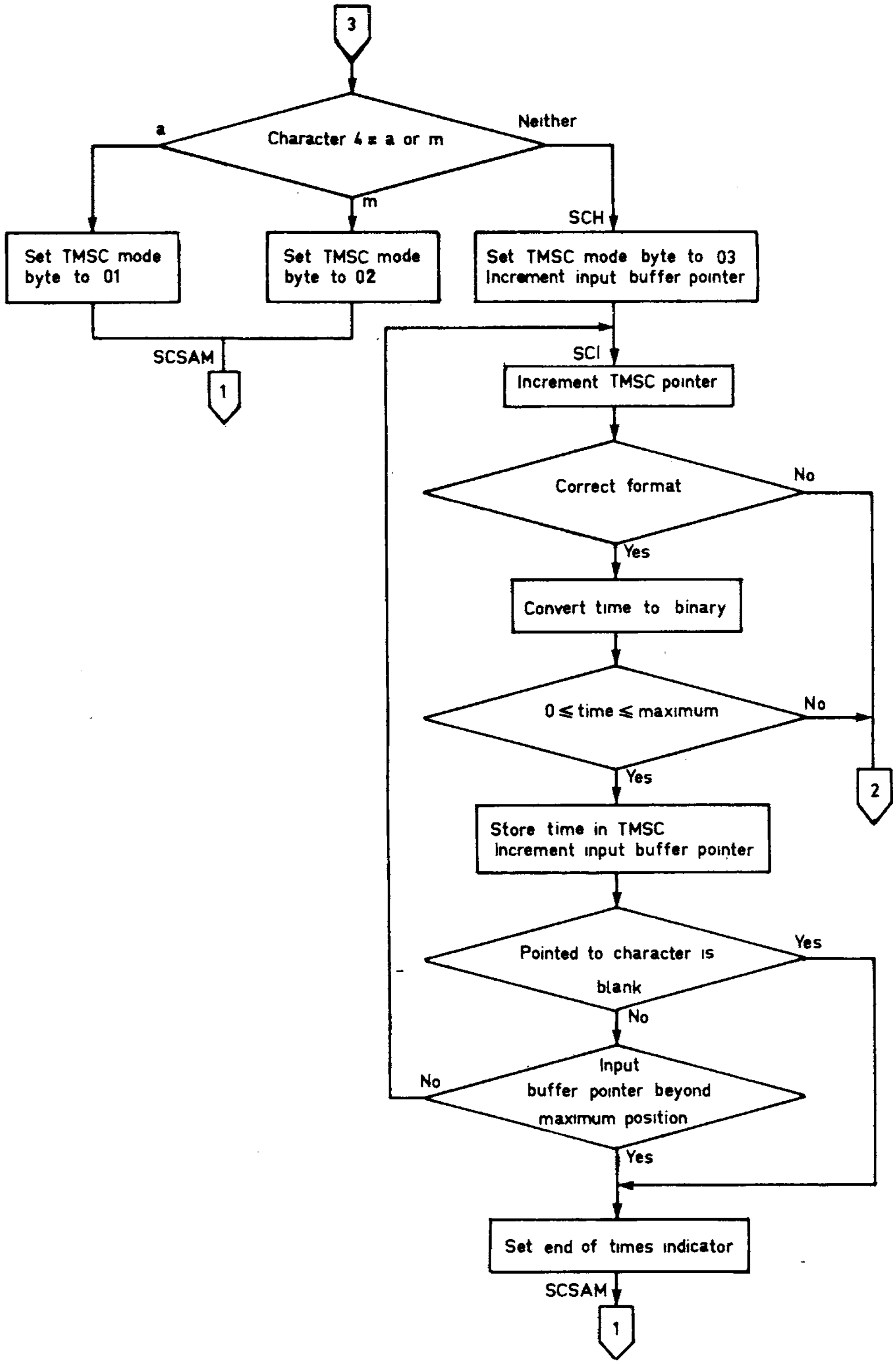


Figure 8.9(b) SELCHN Flow Chart (continued)

8.10 Control Section DECIN

DECIN is a short routine used by UDBS and UDTM to convert 1, 2 or 3 digit unsigned positive integers to binary. The integer must be delimited by a trailing space. The calling programme places the address of the first EDCDIC digit in register 3. DECIN returns the number converted to binary in register 3.

However, if there is an error, the number '-1' is returned in register 3. An error is detected when the number either exceeds three digits or contains non-digits.

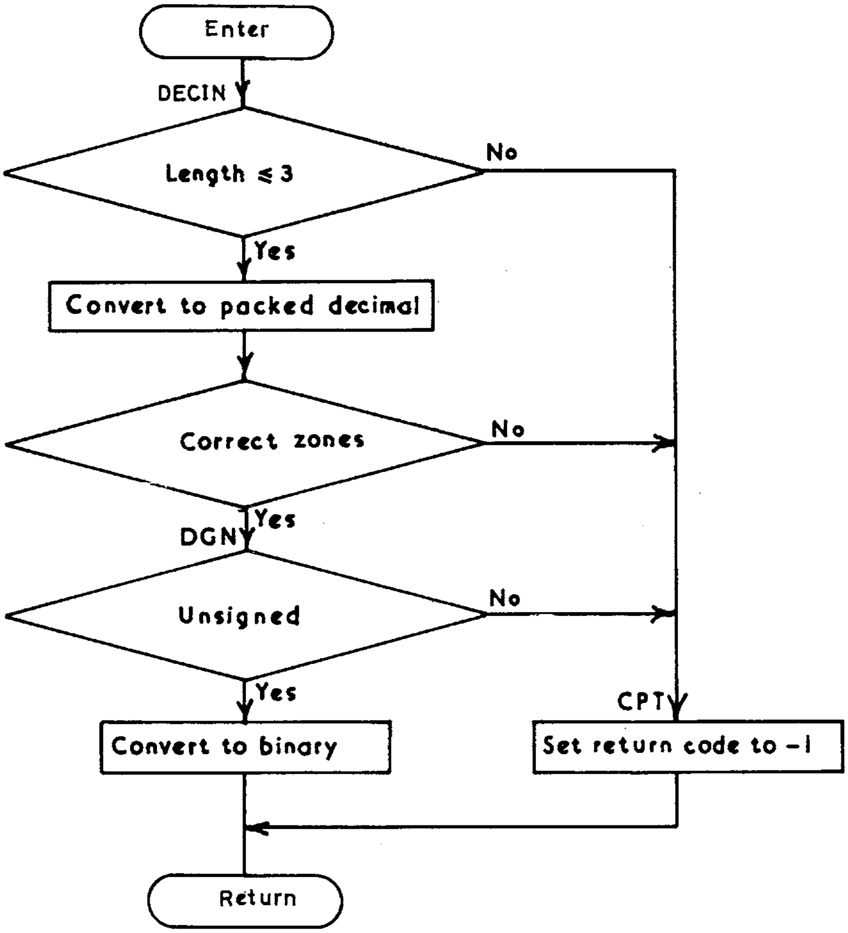


Figure 8.10 DECIN - Flow Chart

8.11 Control Section UDBS

UDBS reads lines of 29 characters from the typewriter to update the table of baseline values and scale values (named BSTAB) . The stored baseline and scale each take a full-word (4 bytes) per channel. See the description of BSTAB for further details. The updating line format is:

line position	(equals byte position plus one, e.g. line position 29 = byte 28);
1 - 9	list of single or double-digit channel-numbers separated by single spaces;
10	space;
11 to 21	baseline value, comma, scale value, delimited by a space;
22 to 28	ignored;
29	't' - take this line; 'l' - take this line, it is the last; other - ignore this line;
30	terminator (any character), not read into store.

The typed-in baseline and scale entries have identical formats. Each comprises at least a decimal point and one digit. There may be no more than four digits with no sign or three digits with a minus sign. The plus sign is not permitted. Positive values lie in the range .001 to 9999. Negative values range from -999. to -.001.

Error is indicated if:-

Character at line position 29 is not 't' or 'l';
the channel list is improperly terminated;
non-numerics are used;
incorrect formats are used;
any channel number exceeds the number of channels available.

The following is an example of updating BSTAB:-

```
TYPE ROUTINE DESIRED:  ubs   OK  SEND NEXT
1  2  3  20    0.0,-3.3        t  OK  SEND NEXT
04  05         -.3,925.2       t  OK  SEND NEXT
16  38         0.,-14.6        t  ERROR  SEND AGAIN
32             0.,-14.6        t  OK  SEND NEXT
10             -163.,1.0       l
 OK  LAST. TYPE ROUTINE DESIRED:
```

The third input line failed because there is no channel 38. The comments in capitals are printed by this programme. In processing a line, UDBS first converts the baseline (in milliunits) into binary, leaving it in register 8. The scale is similarly placed in register 9. These two registers are then multiplied by 10 and -50 respectively ready for updating BSTAB. The purpose of these multiplications is described in section 8.2.

The channel numbers are converted to binary and used to generate address displacements for updating the appropriate entries in BSTAB with R8 and R9. Channel numbers are processed one at a time so that the previous channel has been updated before an error may be discovered in the present one. Thus, in the example, when line three failed, channel 16 had already been updated.

UDBS has a subroutine named CONVB for converting the typed-in scales and bases to integer milliunits. UDBS calls CSECT DECIN to convert the channel numbers to binary.

UDBS uses READIN to read the lines from the typewriter and P130 to print the messages. Their data control blocks, DIGIDCB and LNODCB, are opened before entry to UDBS.

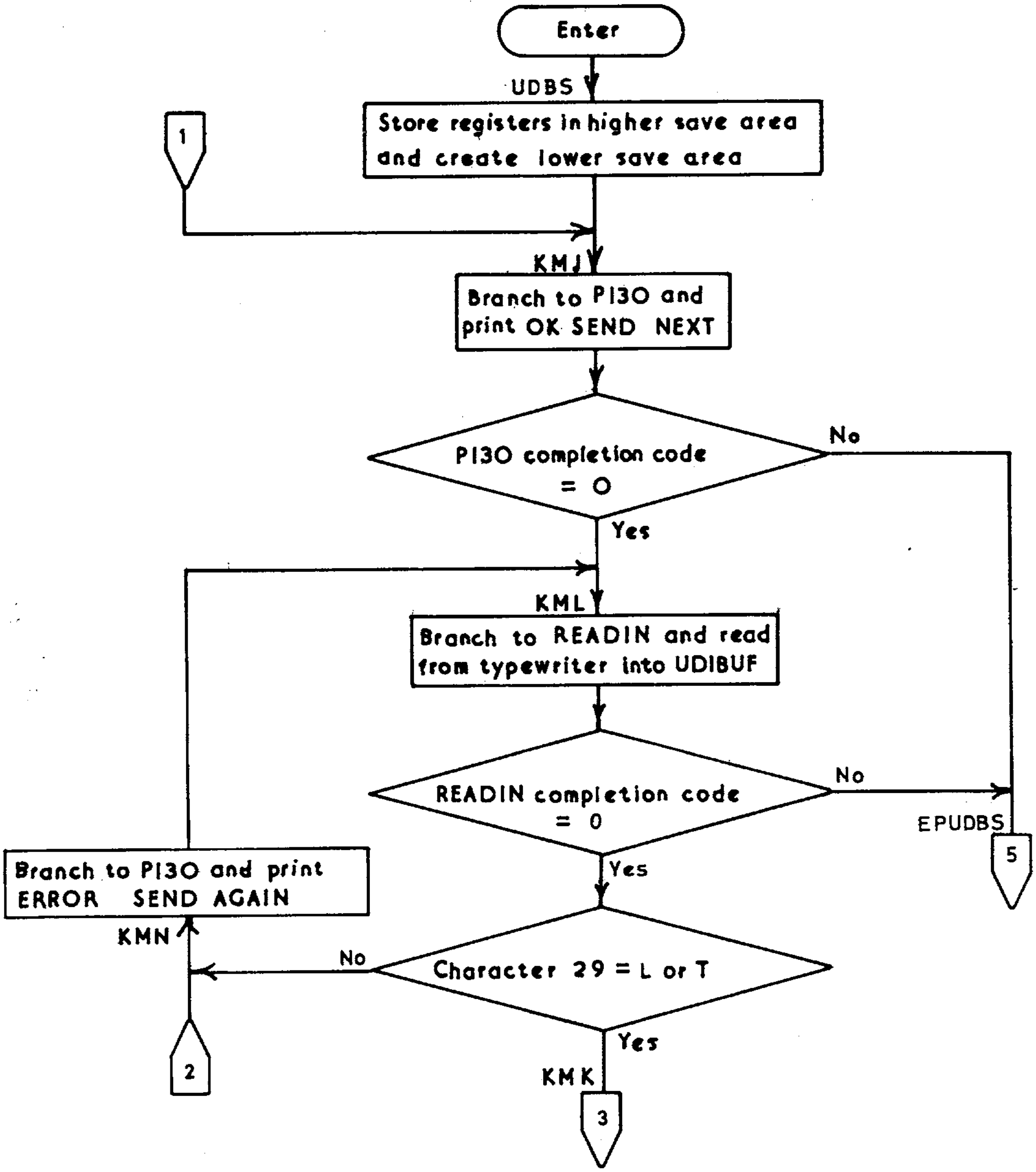


Figure 8.11(a) UDBS - Flow Chart

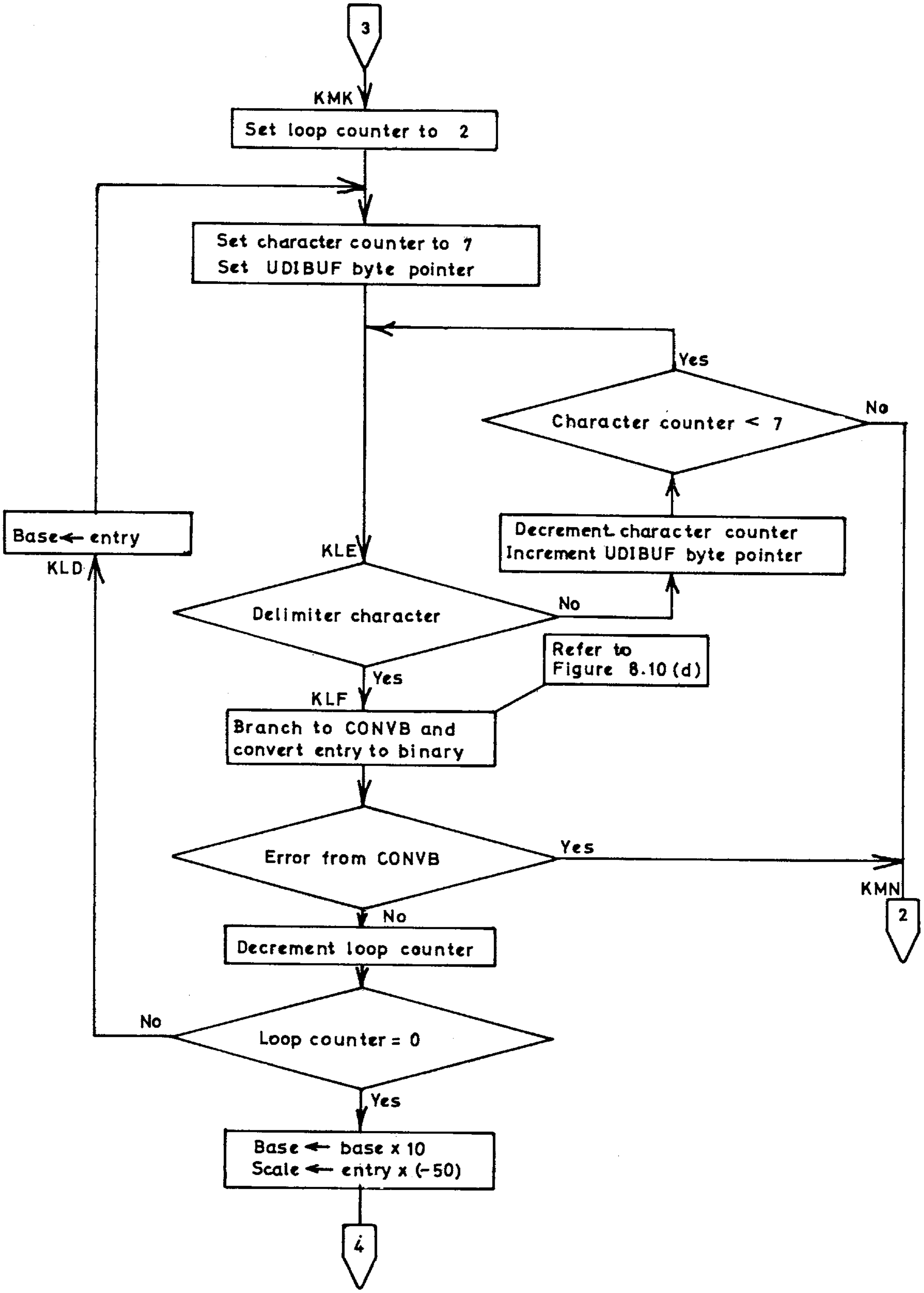


Figure 8.11(b) UDBS - Flow Chart (continued)

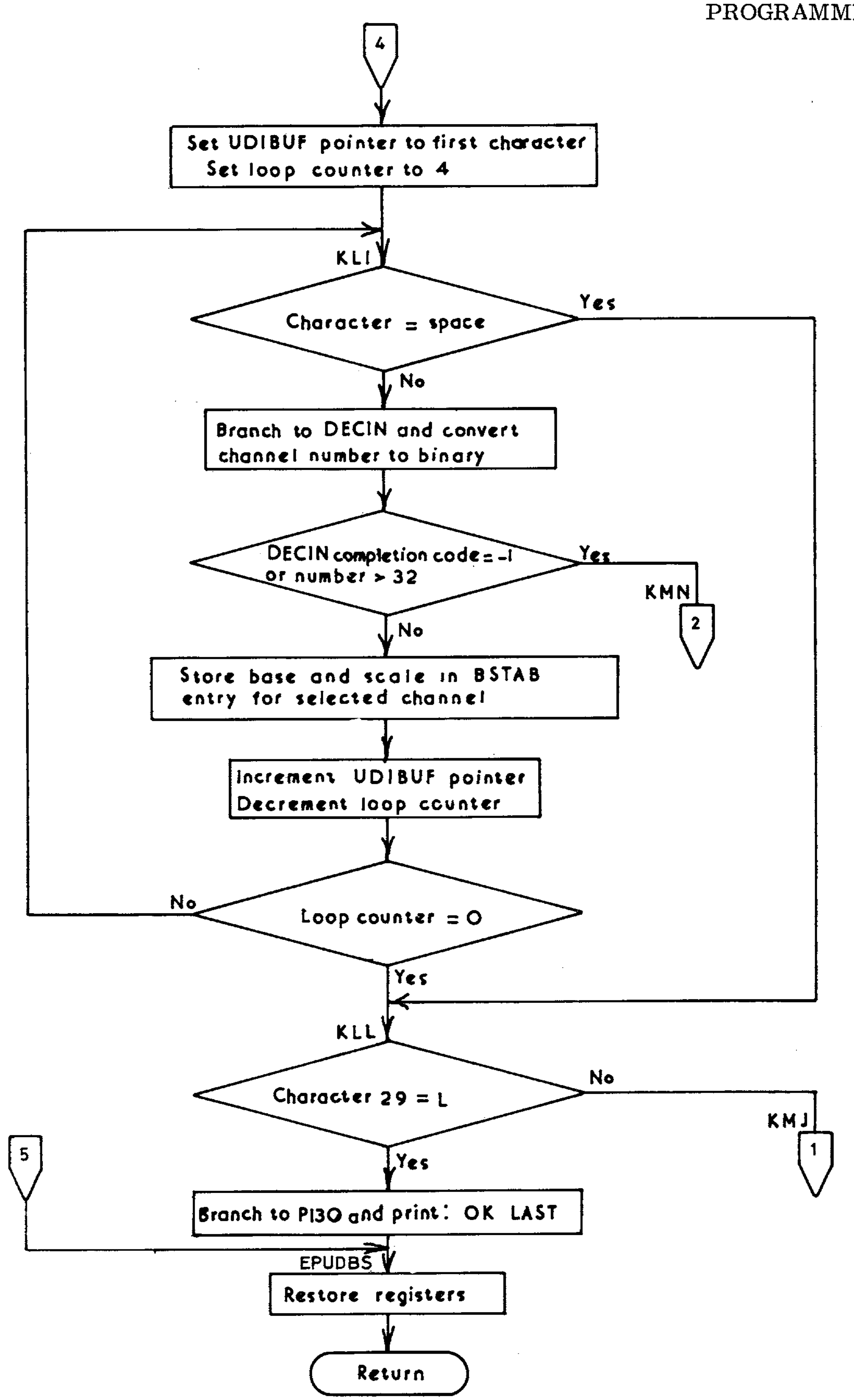


Figure 8.11(c) UDBS - Flow Chart (continued)

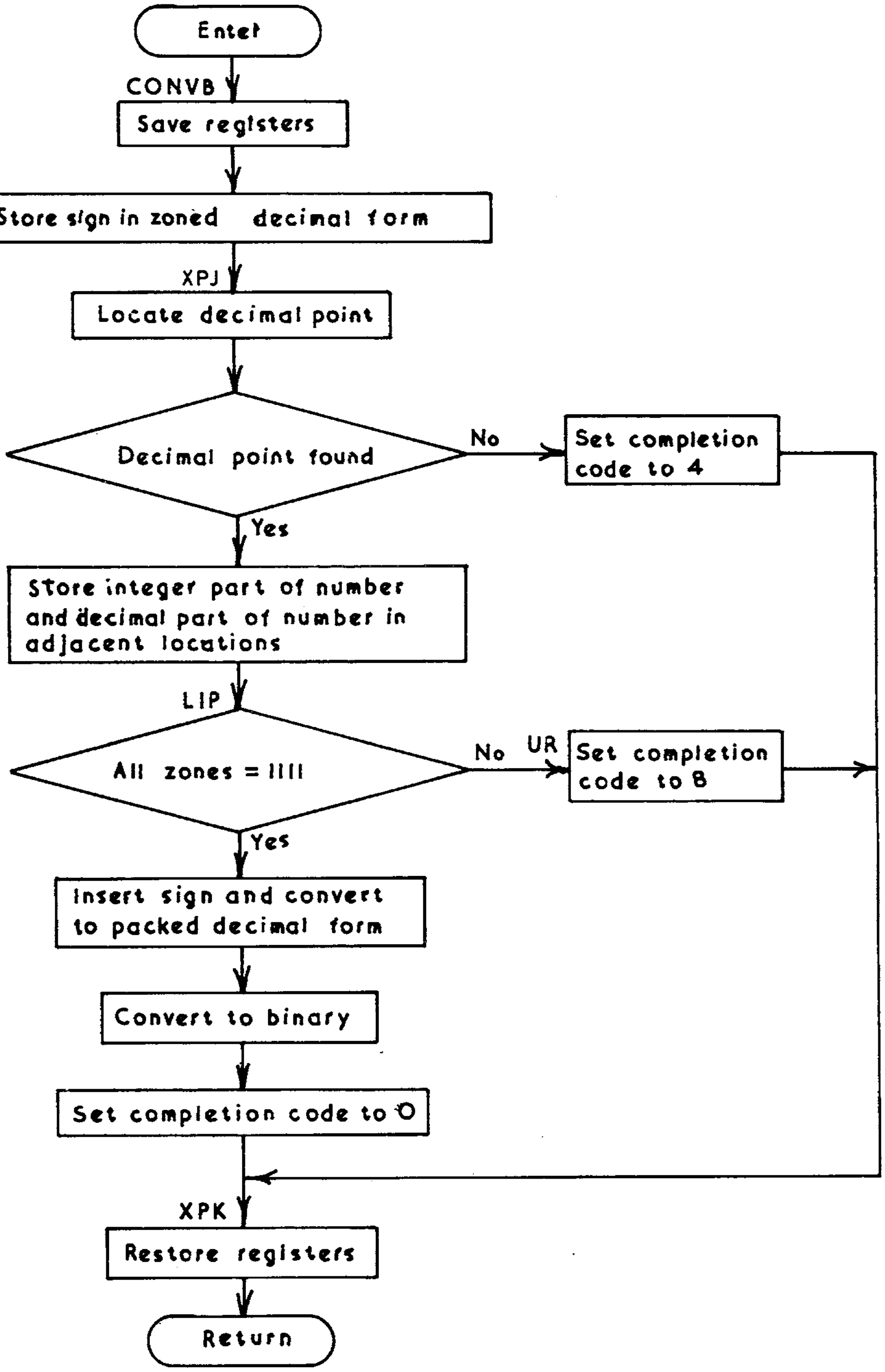


Figure 8.11(d) Convert to Binary - Flow Chart

8.12 Control Section BSPT

This programme prints a table of the baseline values and scale values by referring to BSTAB. The printed values are the same as those typed in to update BSTAB. The stored baselines are divided by 10,000 for printing, whereas the scales are divided by -50,500.

The printed values have three digits to the right of the decimal point and between one and four to its left. Negative values are preceded by a minus sign.

Examples:-

(1) base line stored as X'00 00 00 1E' = 30
prints as 0.003

(2) scale input -954.455
stores as X'02 DF 79 40' = 48200000 = +482 x 10^5
prints as -954.455

(3) typical printout (part of table)

```
BASELINE VALUES AND SCALEVALUES
CHN  BASELINE      SCALE
01      -0.000      1.000
02    9999.000    999.200
03    -452.000   -904.000
04      -0.060      0.001
```

Channel 1 contains the values in default of an entry by the updating programme UDBS.

No rounding of the values for printing is necessary since the values printed are either default values or values inserted by the updating programme, UDBS.

BSPT calls P130 to print the lines. The P130 data control block, LNODCB, is opened before entry to BSPT.

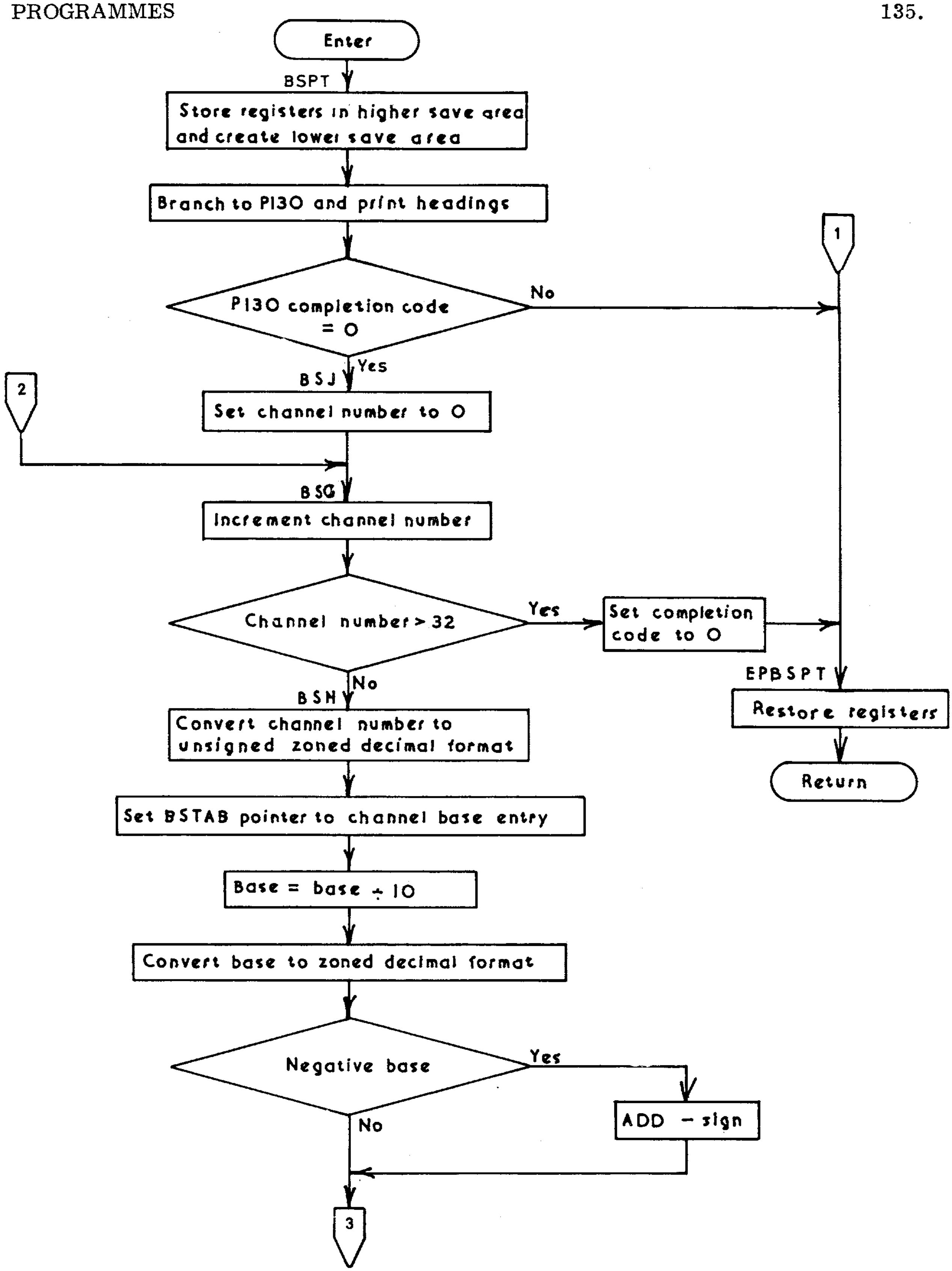


Figure 8.12(a) BSPT - Flow Chart

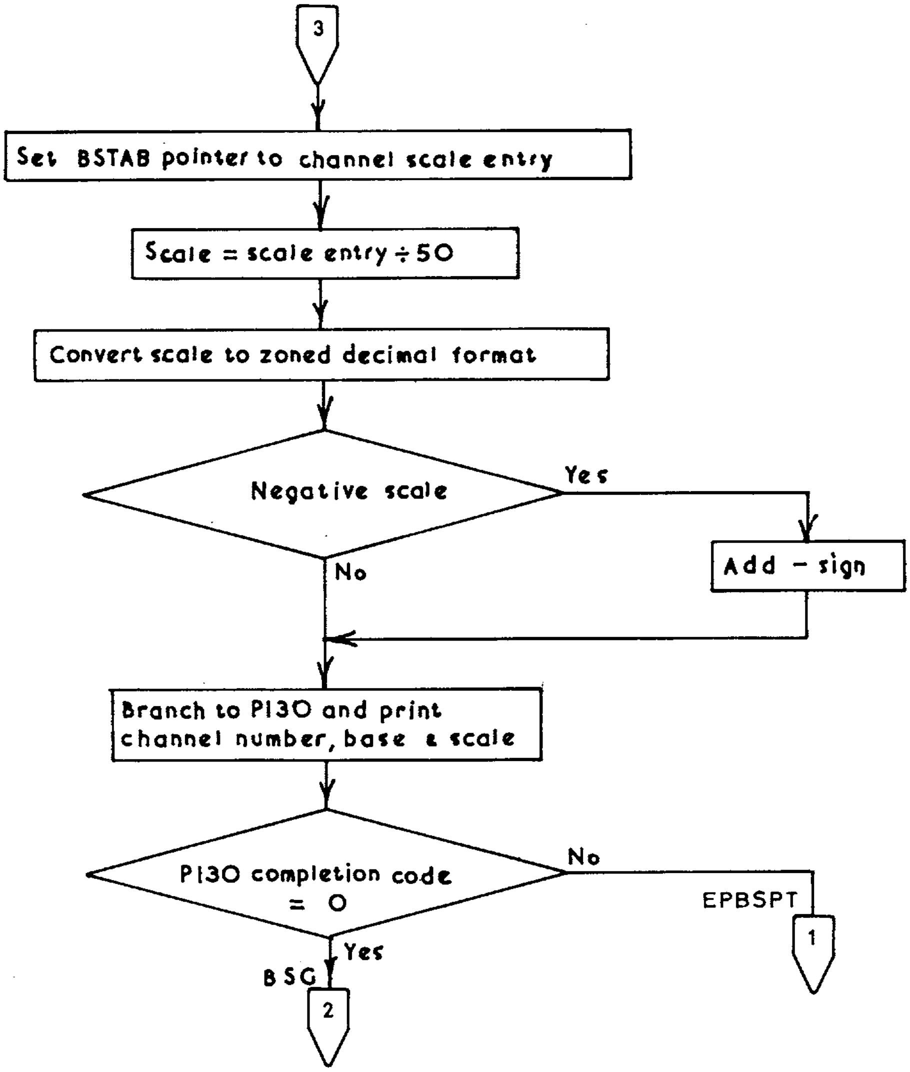


Figure 8.12(b) BSPT - Flow Chart (continued)

8.13 Control Section UDTM2

UDTM2 provides the operator with a facility to change the contents of the times-modes table, TMT.

Updating of times and modes words in the times-modes table is accomplished by means of a channel select word, TM2CS, the bits of which are set according to which channels are to be updated.

For delete operations, the complement of TM2CS is 'and'ed with each TMT word. This resets the bits corresponding to channels to be deleted without affecting the status of bits for other channels.

For add operations, TM2CS is 'or'ed with TMT words that are to be updated. This causes the desired bits to be set, without changing the status of other bits.

A replace operation consists of a delete operation followed by an add operation.

A variety of input-data validity tests and error messages is provided by UDTM2. Input characters that are in error are printed in their associated error messages.

To be accepted by UDTM2, input data must be in the following format:-

Characters 1 - 3	del	delete entries
	add	add entries
	rep	replace entries

For delete operations:

Characters 5 - 8	all	delete all channels
5 - 28	list of channel numbers whose entries are to be deleted.	

For add or replace operations:

Characters 5 - 8	mod	modulus mode
	sel	selected samples mode
	all	all samples mode

For all types of operations:

Character 29	t	accept this line then request another
	l	accept this line then request next routine desired
	c	accept this line then request another line of times
Character 30	any character or function; this is not processed but is required by the 1827 to initialise data transfer.	

If the add or replace selected samples function is requested, UDTM2 requests the operator to TYPE TIMES IN DECISECONDS. The list of times, typed in reply, must start in character position 1 and must consist of three-digit numbers, adjacent numbers being separated by single spaces.

READIN and P130 are called by UDTM2; their associated data control blocks are open when UDTM2 is entered.

DECIN is called to convert channel numbers and times to binary.

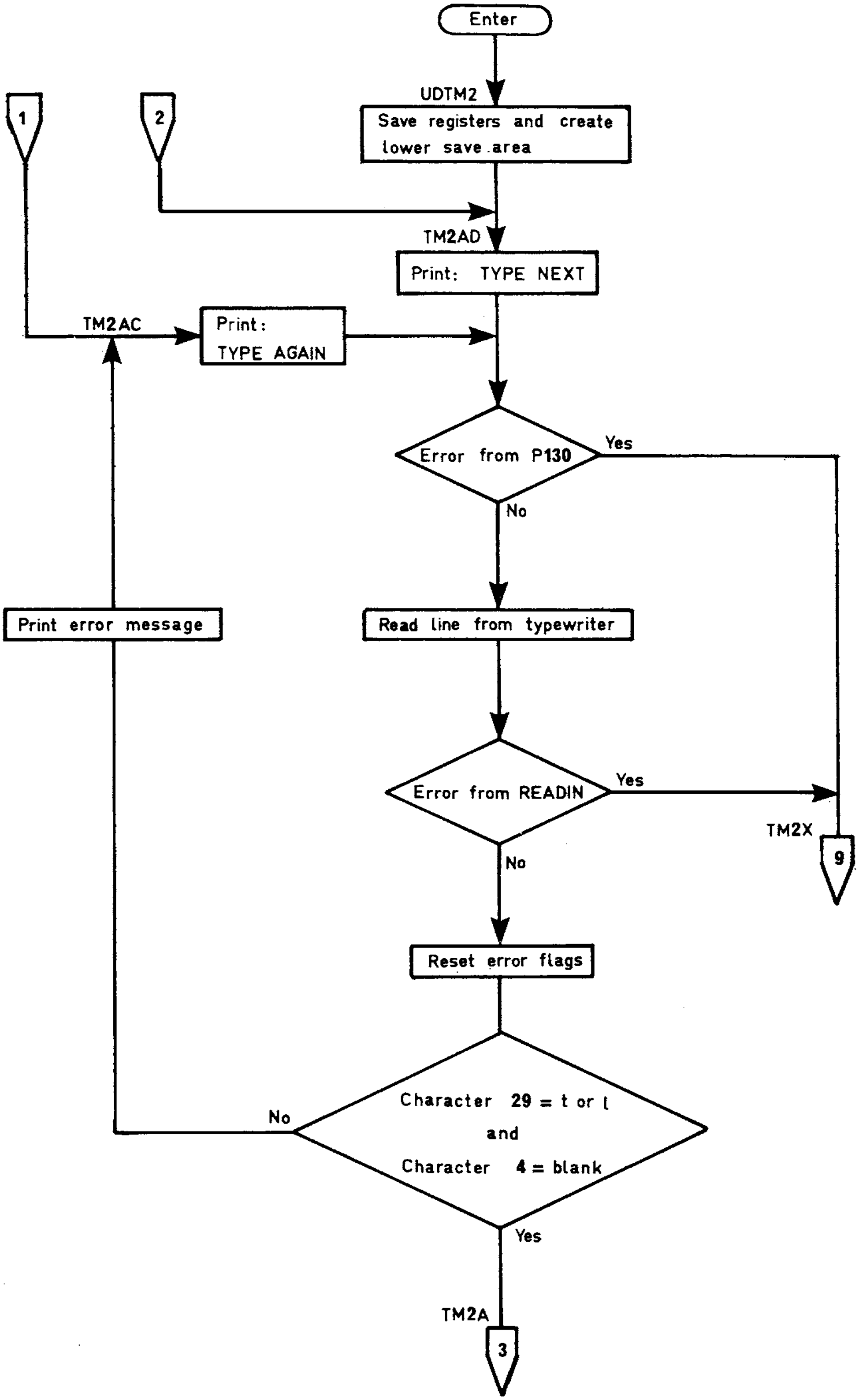


Figure 8.13(a) UDTM2 - Flow Chart

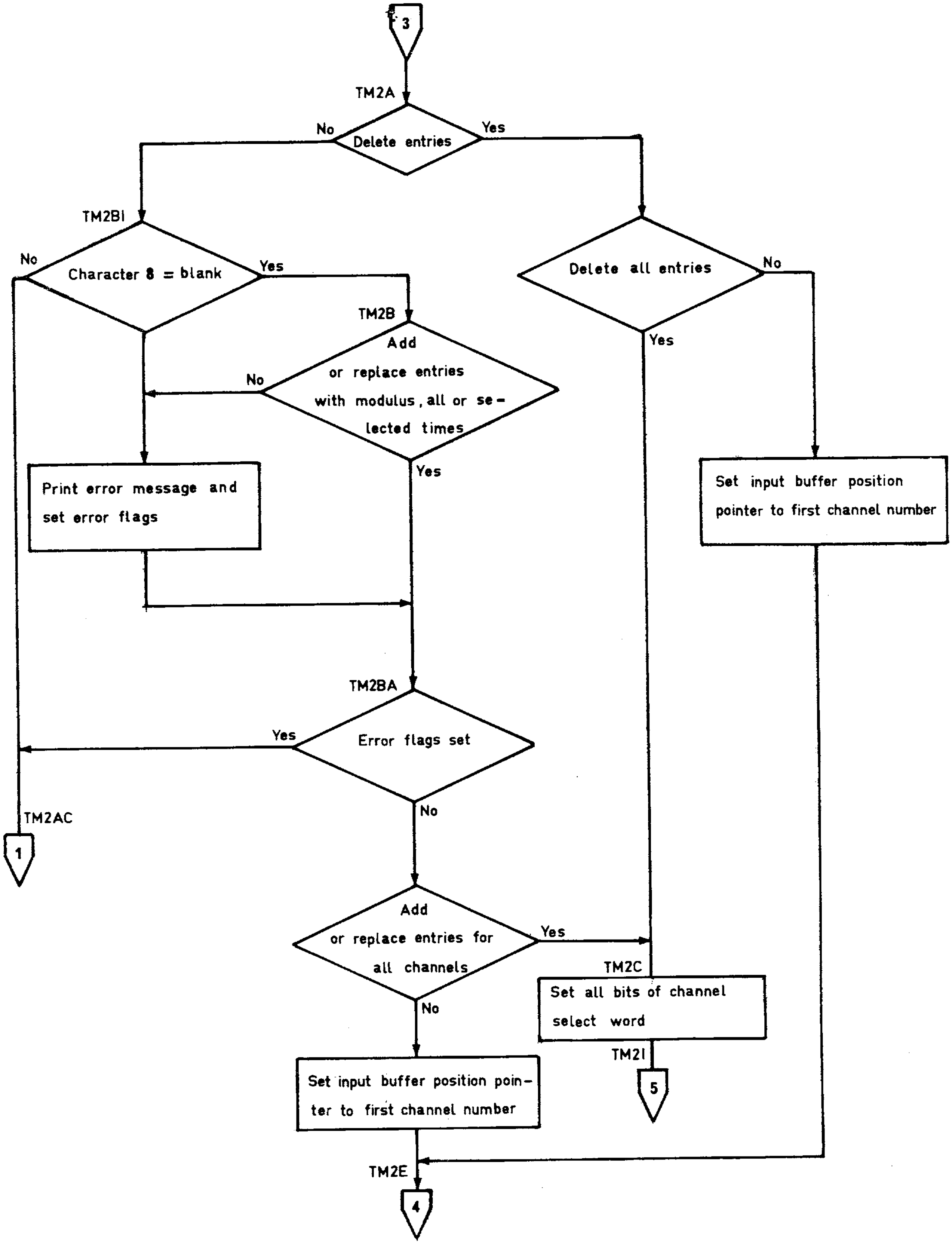


Figure 8.13(b) UDTM2 - Flow Chart (continued)

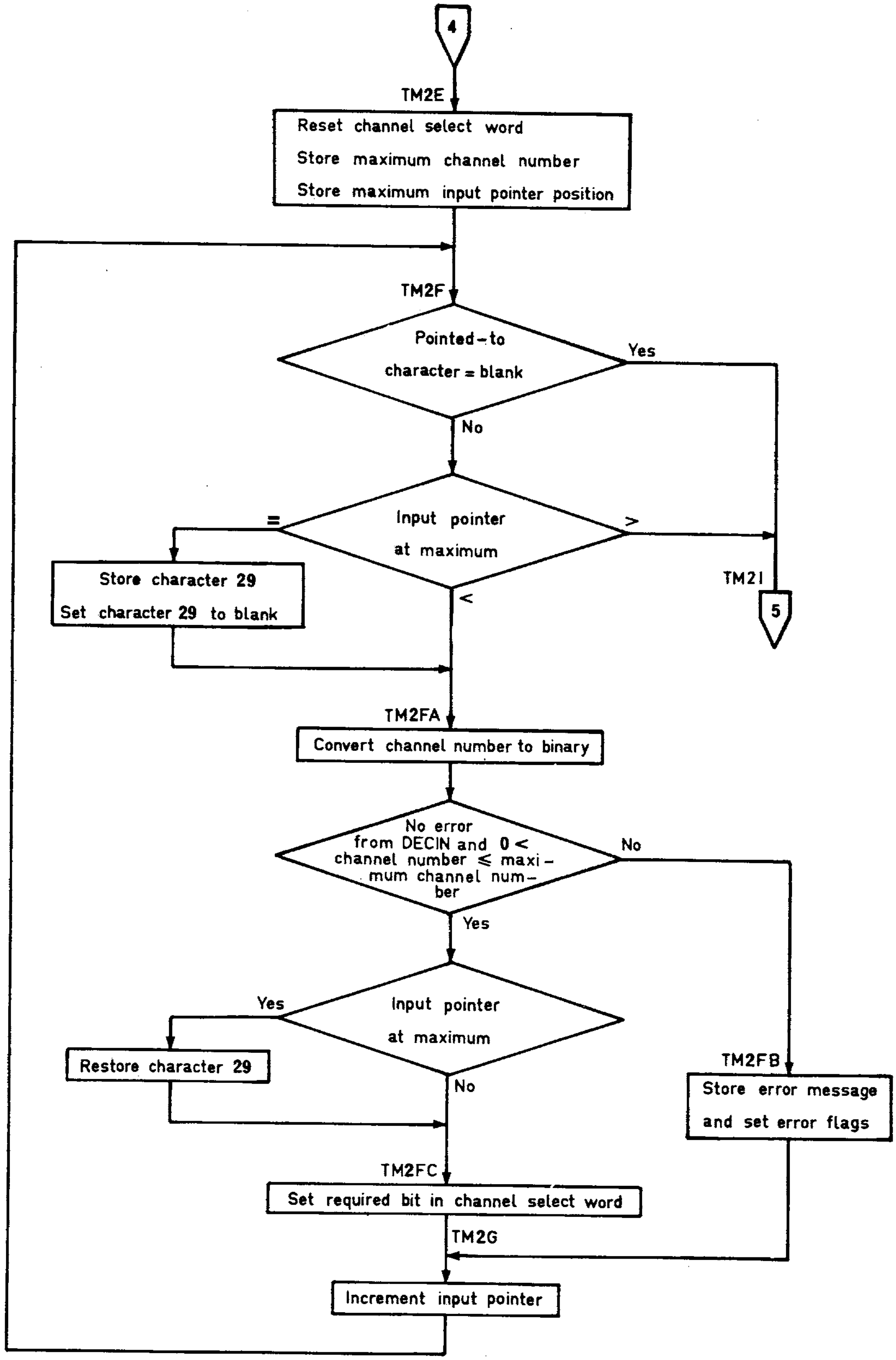


Figure 8.13(c) UDTM2 - Flow Chart (continued)

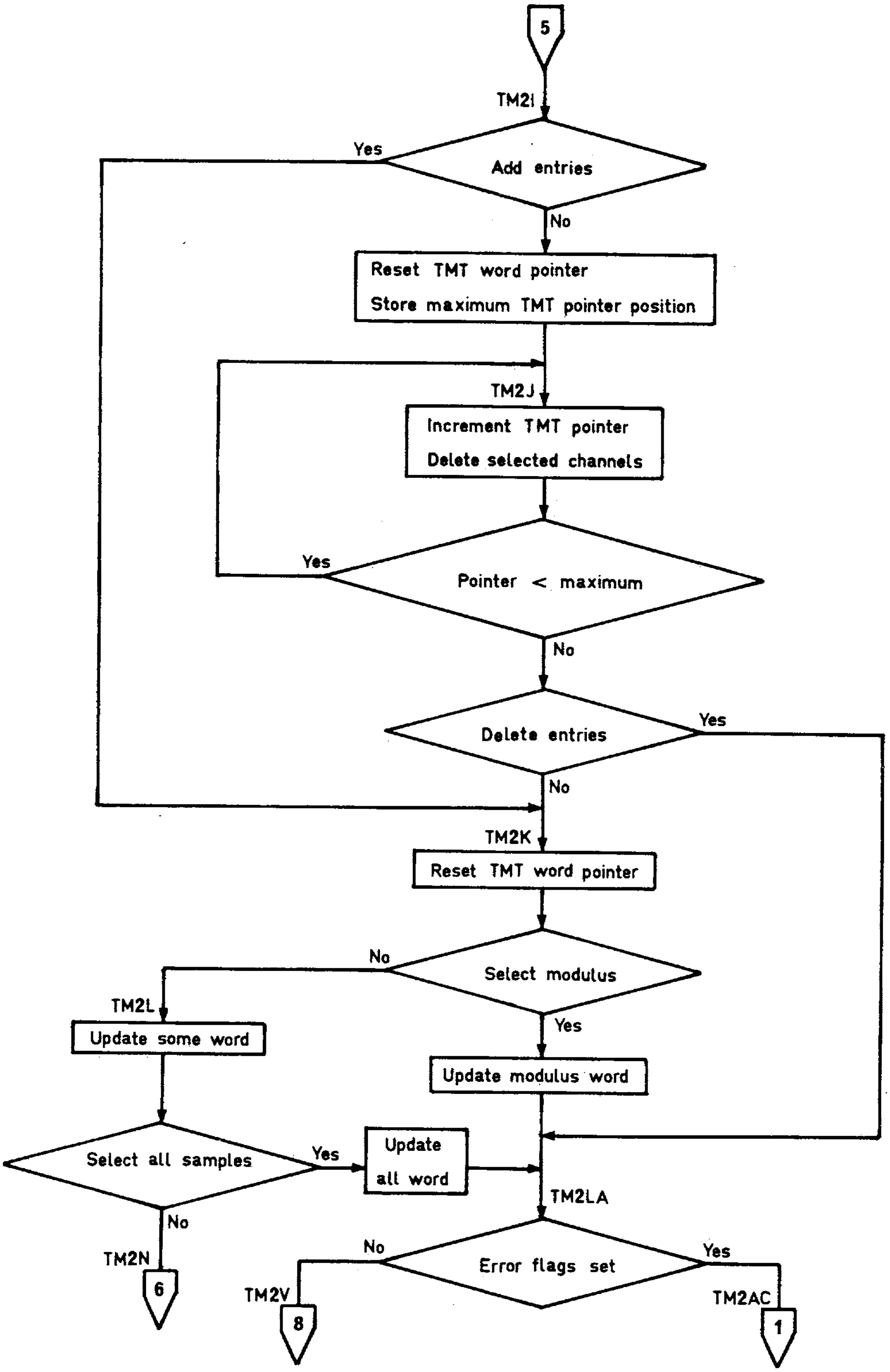


Figure 8.13(d) UDTM2 - Flow Chart (continued)

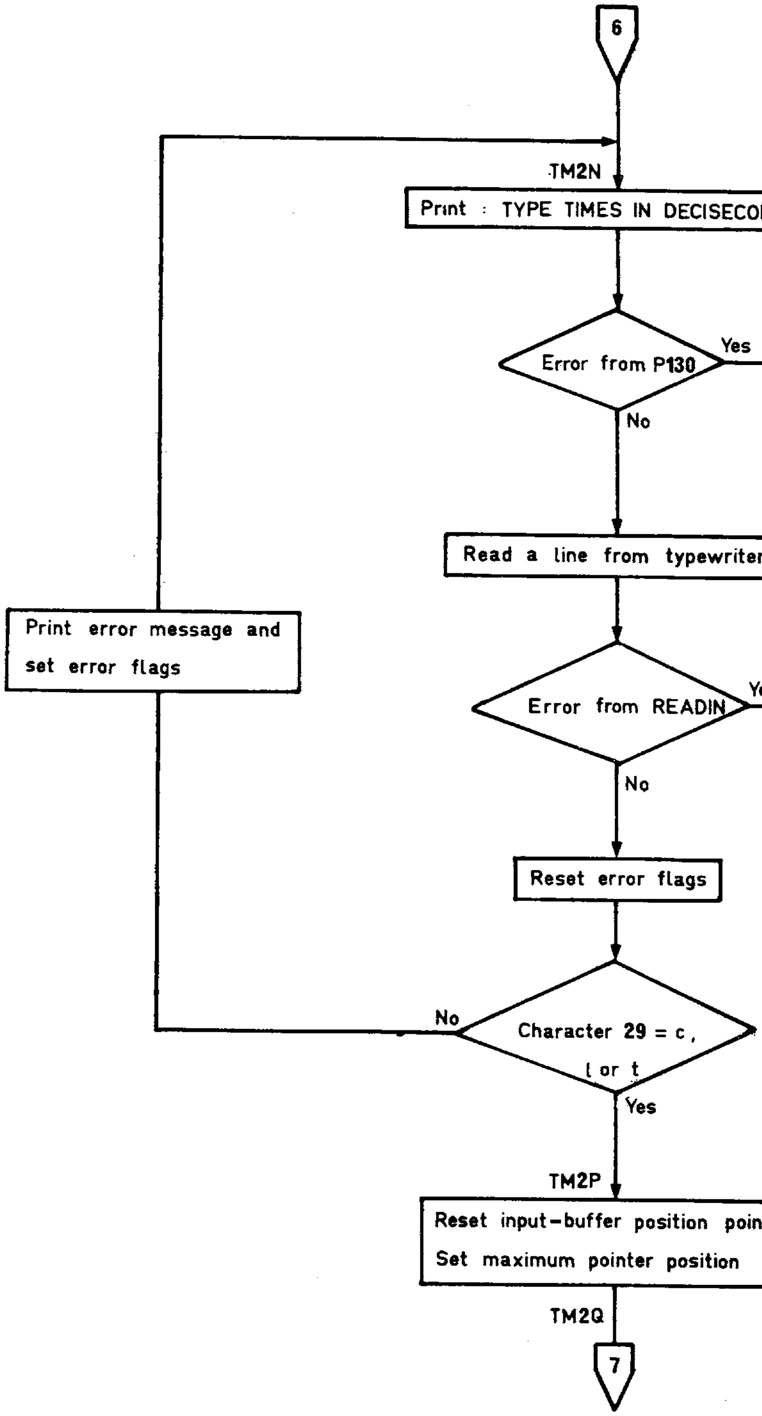


Figure 8.13(e) UDTM2 - Flow Chart (continued)

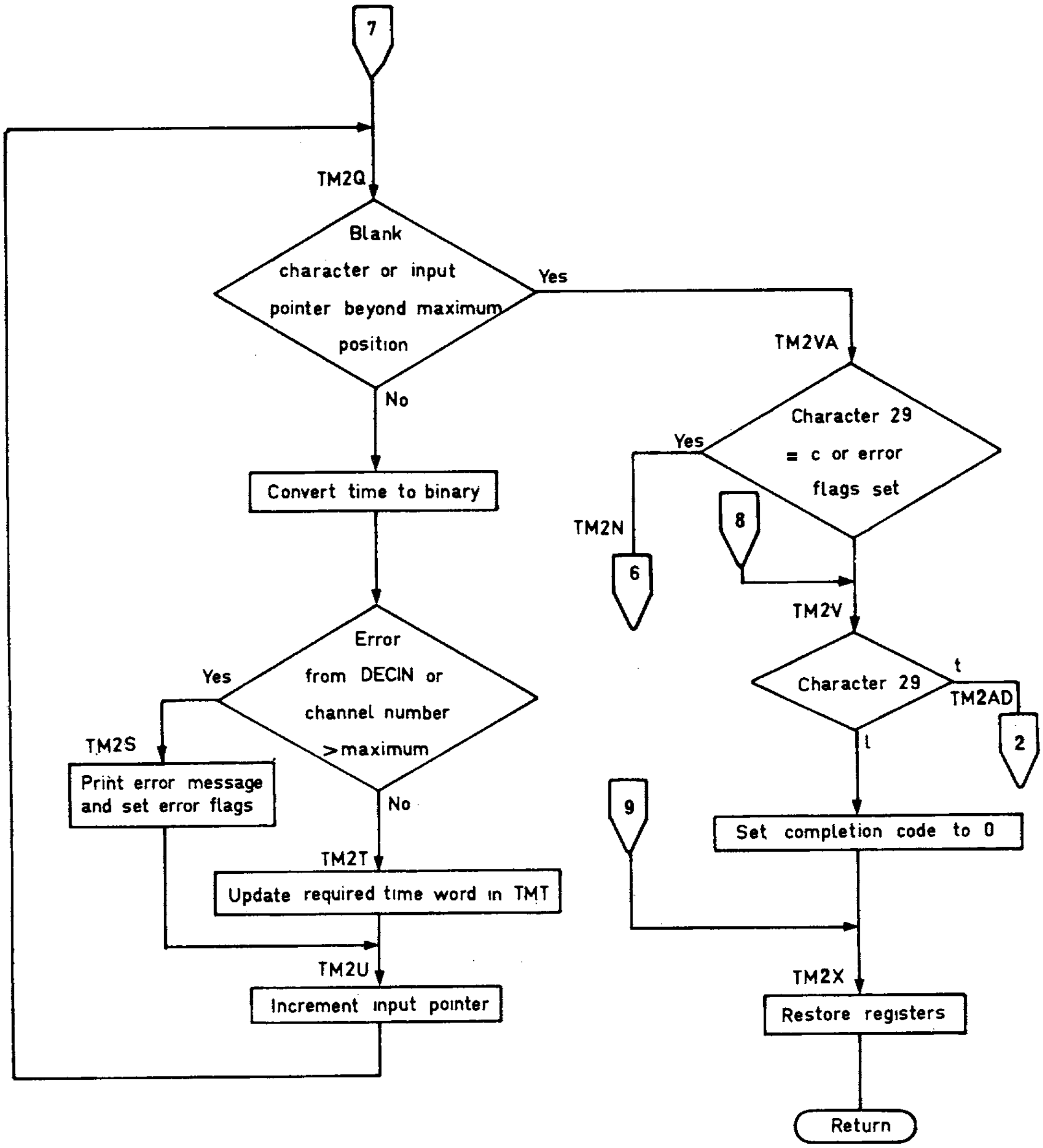


Figure 8.13(f) UDTM2 Flow Chart (continued)

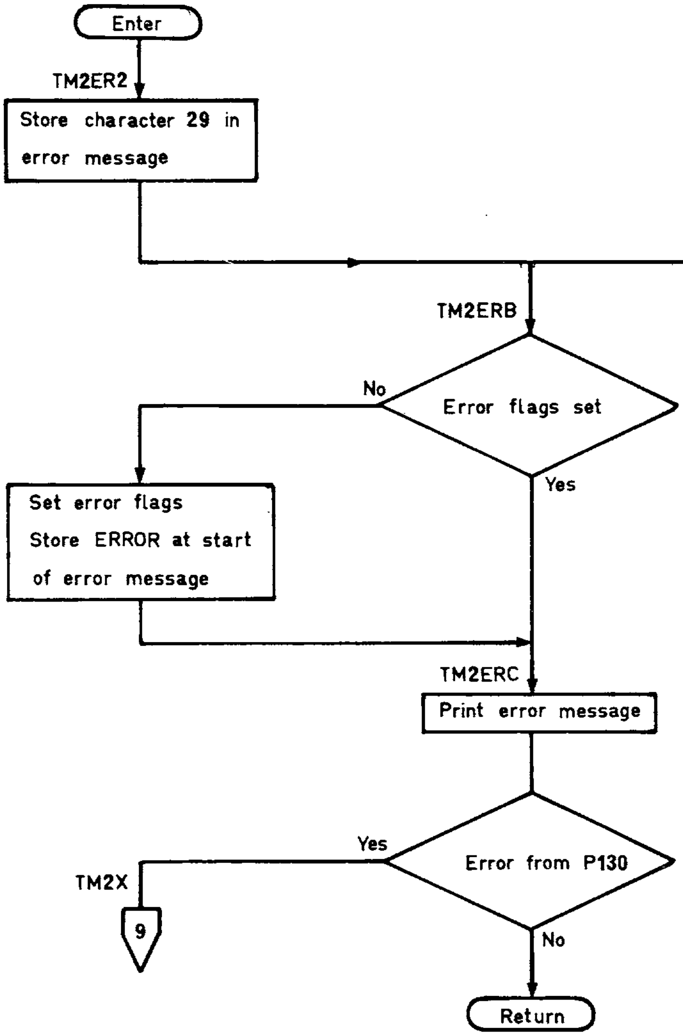


Figure 8.13(g) UDTM2 Error Routine - Flow Chart

8.14 Control Section PTM

PTM prints a copy of the times-modes table, TMT. Here is an example of the printout:-

```
TIMES MODES TABLE
26 mod all
27        0.0  0.3  10.8
         12.1 13.0
28 mod
```

A two digit channel number occupies bytes 0 and 1 of a line. Byte 3 is always blank. Bytes 4, 5 and 6 contain 'mod' or are blank. Bytes 7, 8 and 9 have 'all', if the all bit is set in TMT. Times bits that are set cause the appropriate times to be printed in the form 'XX.X', occupying 5 bytes each. These times entries always start at byte 7 and are printed at the rate of 20 per line. Times less than 10.0 seconds are preceded by two blanks.

The hexadecimal bit pattern in TMT causing the above printout example would be:-

Addresses	+0		+1		+2		+3		
TMT + 0	E	3	D	4	0	0	9	7	TM 151
+ 4	0	0	0	0	0	0	5	0	modulus word
+ 8	0	0	0	0	0	0	6	0	some word
+ 12	0	0	0	0	0	0	4	0	all word
+ 16	0	0	0	0	0	0	2	0	0.0 seconds
+ 20	0	0	0	0	0	0	0	0	0.1
+ 24	0	0	0	0	0	0	0	0	0.2
+ 28	0	0	0	0	0	0	2	0	0.3
									etc.

The table is processed channel by channel. If the 'some' bit for a channel is 0 then neither the 'all' nor the 'times bits' are inspected. The channel number is printed only on the first line for the channel.

A modes scratch byte is created in PTM for ease of processing and is overwritten for each channel. Bits 5, 6 and 7 of this byte duplicate the TMT 'mod', 'some' and 'all' bits for the channel. A test-under-mask instruction, recreated for each channel, is used to test the channel's bits in TMT.

PTM calls P130 to print the table. P130's data control block, LNODCB, is opened by MGLB before PTM is entered. Any error code returned by P130 to PTM in register 15 is passed unaltered to MGLB.

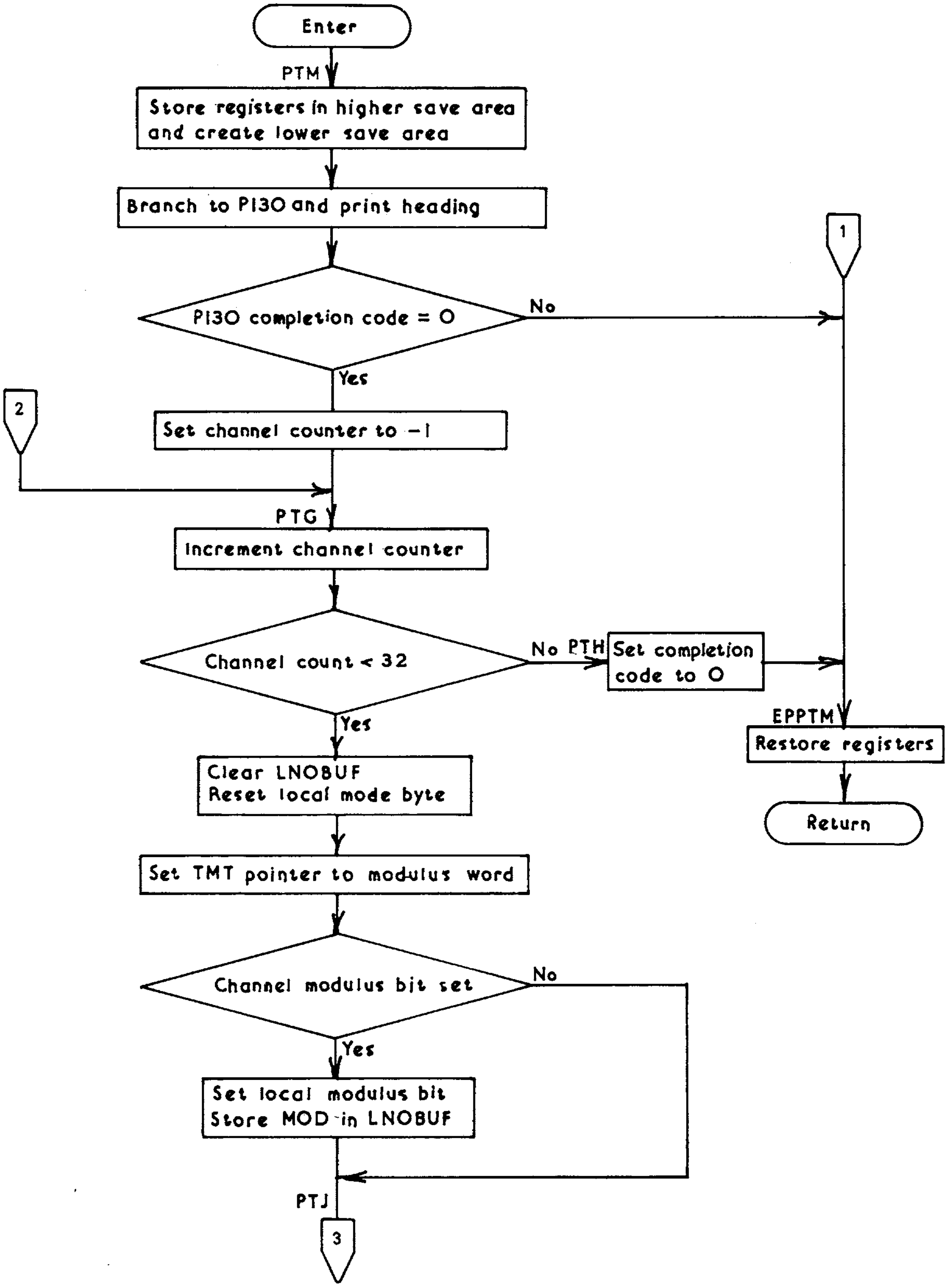


Figure 8.14(a) PTM Flow Chart

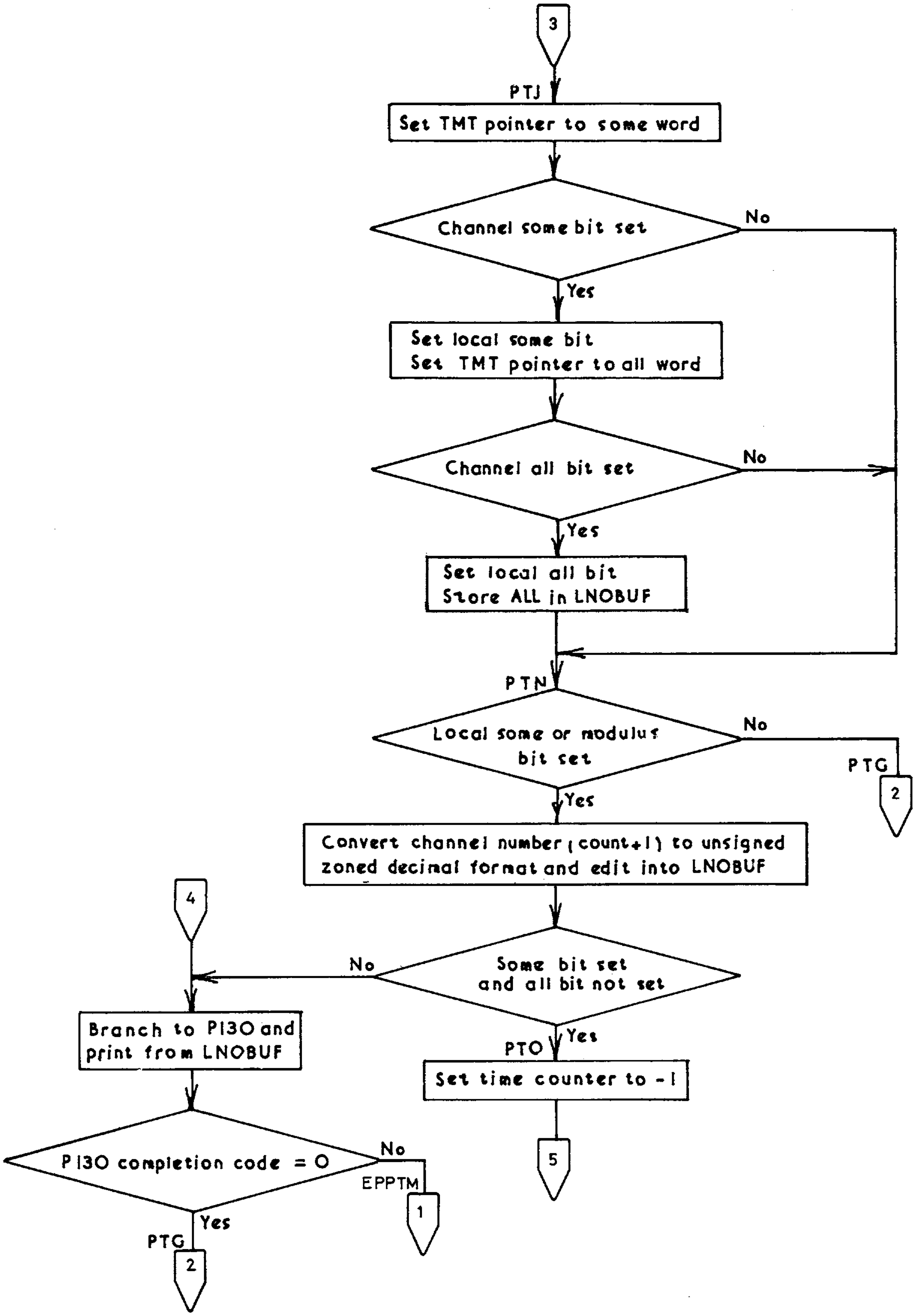


Figure 8.14(b) PTM Flow Chart (continued)

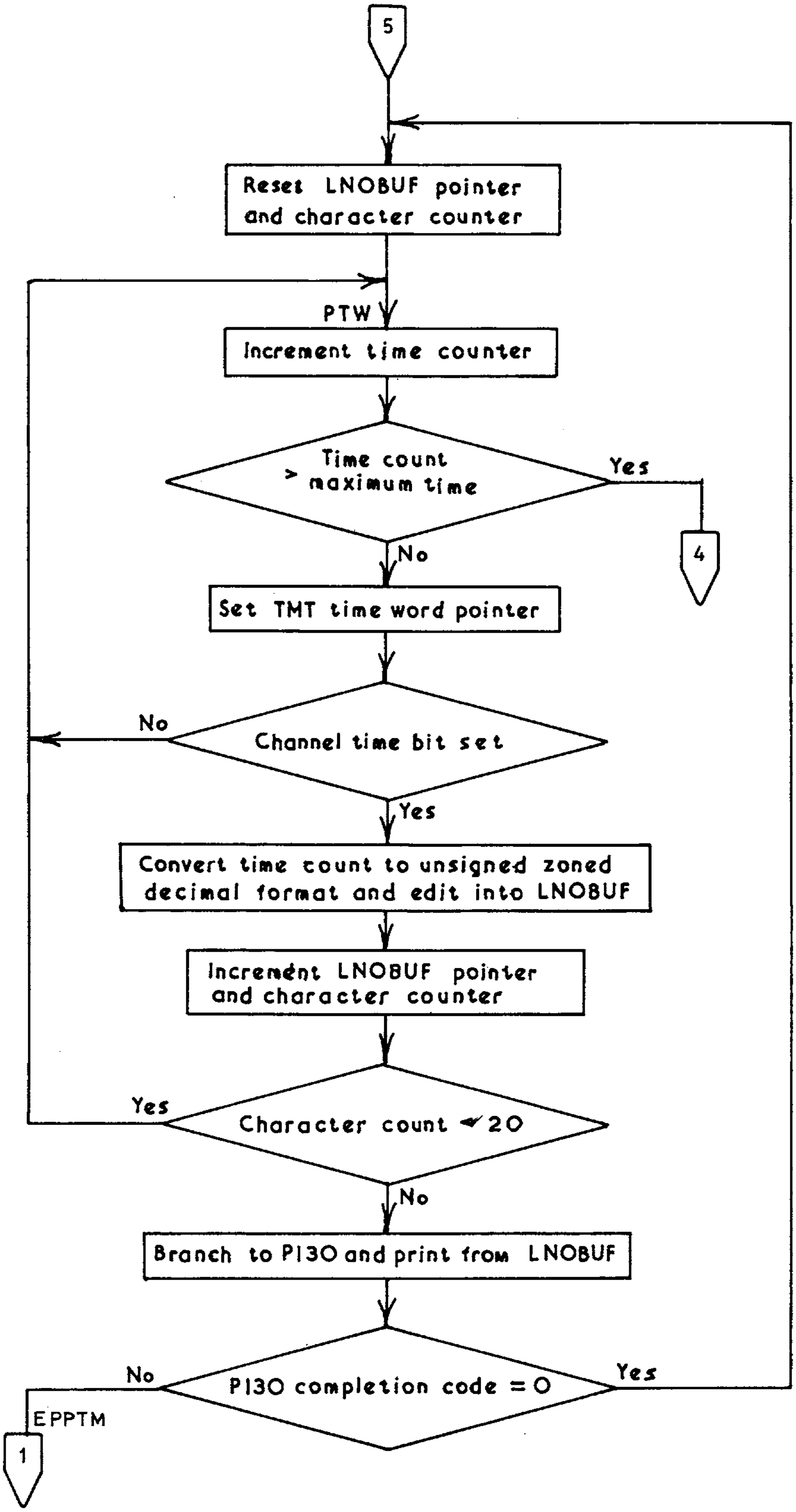


Figure 8.14(c) PTM Flow Chart (continued)

8.15 Control Section SAVE

Control section SAVE enables the base-scale table, BSTAB, and the times-modes table, TMT, to be transferred from main store to disk storage. When required, the stored tables may be transferred from disk to main store.

This facility allows tables, once constructed, to be used during different computer runs. Without this facility the tables have to be constructed at the start of each computer run, as part of the programme loading sequence reads the compiled tables into main store. The tables at the start of a computer run, therefore, contain the default information described in sections 8.3 and 8.4. If temporary changes are made to the tables during running the normal tables can be restored when the temporary changes are no longer required.

BSTAB and TMT are stored on disk by typing SVE which calls the SAVE part of SAVE. When the tables are saved they overwrite any previously stored tables.

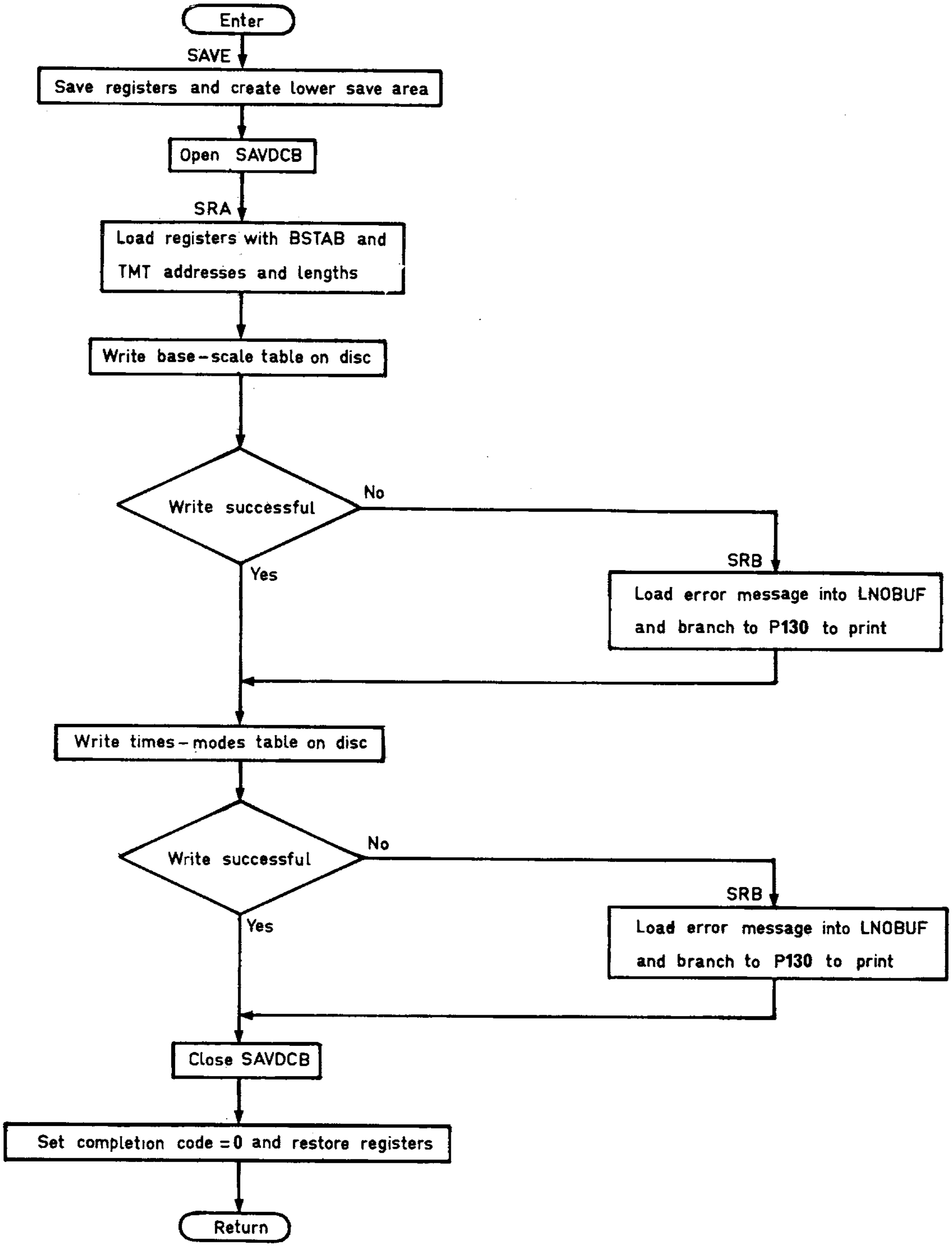
BSTAB and TMT may be replaced, from disk, by typing RES which calls the RESTORE part of SAVE.

Successful completion of these operations may be inferred when, after calling SAVE or RESTORE, the normal request for the next desired operation is printed.

The occurrence of a disk error is advised by a printed disk error message.

The data control block used in the SAVE and RESTORE operations, SAVDCB, is opened and closed in this control section.

This control section calls P130 if a disk error message is to be printed. The data control block used by P130, LNODCB, is opened before SAVE is entered.



The RESTORE flow chart is the same as the SAVE flow chart except:-

1. Entry point is named RESTORE;
2. Write to disk instructions are replaced by read from disk instructions;
3. "Write successful" tests are replaced by "Read successful" tests.

Figure 8.15 SAVE and RESTORE - Flow Chart

8.16 PCI Appendage IGG019WB

Operation of the data collection programme ANALIN is synchronised with analogue-input data collection by the programme controlled interrupt appendage IGG019WB. Figure 8.16 is a flow diagram of this appendage.

IGG019WB is stored in a system data set SYS1.SVCLIB and is automatically loaded into main store when the ADC data control block ADCDCB is opened by ANALIN. The appendage is executed each time a programme controlled interrupt is generated by the analogue-input channel programme ADCCHN contained in ANALIN.

Execution of this appendage increments a counter, PCICT, in ANALIN and alternately posts the analogue-input event control blocks ECBA and ECBB as successive programme controlled interrupts occur.

General information concerning PCI appendages is given in section 6.7 and in the IBM System Programmer's Manual [10].

A PCI appendage is generally executed in the supervisor mode of computer operation. Therefore, a more detailed knowledge of the IBM 360/50 operating system is required to write appendages than is required to write programmes that operate in the problem programme mode. Such knowledge may be obtained from various IBM System 360 Operating System Manuals.

9. OPERATIONAL INSTRUCTIONS

9.1 Normal Operation

9.1.1 Preliminary.

When the data collection system is used daily, the F.M. modulator and demodulator power supplies should be left switched on at all times to minimise drift in the F.M. channel zero-levels. The modulator power supply is situated in the magnet laboratory control room below the typewriter. The demodulator power supplies are situated in the 1827 enclosure.

The following procedure assumes that the F.M. modulator and demodulator power supplies are switched on. The pulse and ramp generator and the interface panel are normally on whenever the 1827 is on.

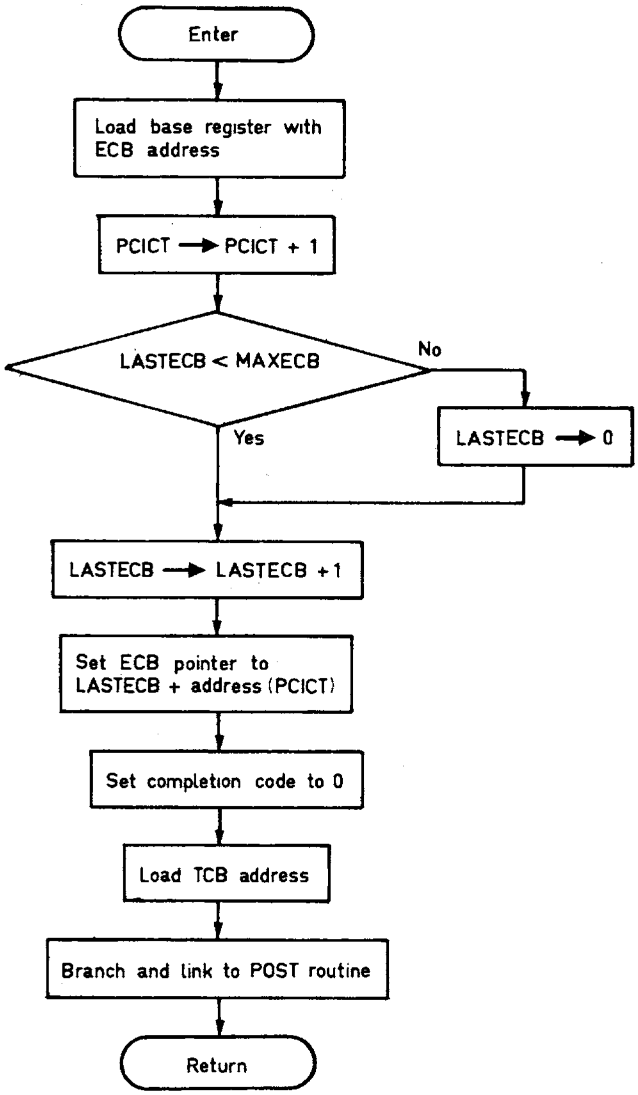


Figure 8.16 PCI Appendage IGG019WB

9.1.2 Starting the Programme.

1. Set the typewriter left-hand margin stop to position 11 on the printing position scale. Set the right-hand margin stop to position 120. Insert paper in typewriter.

2. Switch on the typewriter control box and typewriter; the control box switch controls power to the typewriter.

3. If a parity alarm occurs, operate the parity cancel push-button.

4. Switch the Line switch to Off and type a carrier return. This resets the typewriter control logic.

5. Return the Line switch to its On position.

6. At the 1827, check that the magnet laboratory "ready" and "synch" lines are connected to the "ready" and "synch" terminals at the left-hand rear base of the 1827.

7. Request the computer operator to start the magnet laboratory programme, MAGPGM, in 8K.

9.1.3 Using the Programme.

When the programme starts, the digital-output green lamp will glow and the programme heading with list of operations and calling codes will be printed on the typewriter.

TYPE ROUTINE DESIRED: will then be printed, the digital-output indication will return to red and the digital-input green lamp will glow. The typewriter operator may then request a particular operation by typing the appropriate calling code.

Normal procedure is to type RES, PTM and PBS to restore and print previously saved Times-Mode and Base-Scale tables. The data system is then ready for operation.

Printing may be stopped at any time by switching off the typewriter. When the typewriter is again switched on printing will be continued without loss of data.

9.2 Programme Selection and Operation

The following operations may be initiated by typing the appropriate code after the typewriter has printed TYPE ROUTINE DESIRED:

9.2.1 Data Collection.

The data collection programme, ANALIN, is called by typing col.

When ANALIN is ready to commence data collection the green analogue-input lamp will glow. Data collection may then be initiated either manually by operating the Start collection button on the typewriter control box or automatically by the magnet laboratory control system.

When data collection is complete, the analogue-input indication will return to red and a completion message will be printed on the typewriter.

Successful completion of a 20 second data collection period will be indicated by the following message:

ADC CHN CC=7f, PCICT=041

7f is the Analogue-to-Digital-Converter Channel Completion-Code for successful completion, other completion codes are listed in section 9.4.1.

The Programme Controlled Interrupt Count, PCICT, is equal to (0.2n + 1), where n is the total number of samples collected per channel. The above count of 041 is for 200 samples per channel, the samples having been collected at 0.1 second intervals for 20 seconds.

If the computer processing of collected data is delayed to the extent that some input data is not processed and is therefore lost, a condition of overrun is said to exist. This may occur, for example, if a tape drive takes control of the computer multiplexer channel for more than 0.1 second thereby preventing data transmission between 1827 and computer for that period.

Possible overrun during a data collection period is indicated by an additional message following the normal completion message. The additional message is of the form:

OVERRUN PCICT=xxx

where xxx is the programme controlled interrupt count at the time that the first overrun condition occurred. Data collected prior to the time represented by the overrun count will be correct. The timing ramp may be used to determine which data following the overrun is valid.

Failure to write data onto disk will be indicated by a disk error message. Although most data is lost because of this, maxima and minima data is not lost as the maxima-minima table is in main store and is updated directly from input data.

Disk errors should be reported to the computer centre. The disk error message format is contained in section 9.4.2.

9.2.2 Printing the Base-Scale Table

The base-scale table printing programme, PBST, is called by typing pbs. The table printed contains the values that were entered using the typewriter.

9.2.3 Printing the Times-Modes Table

The times-modes table printing programme, PTM, is called by typing ptm.

Each printed line consists of a channel number followed by the modes and times required for data printout. The table printed contains only those channel numbers for which there exist times-modes table entries.

Modes printed are mod (modulus) and all (print all samples). Times for which data will be printed are in seconds.

9.2.4 Printing Processed Data

The data processing and printing programme, SAM, is called by typing either sam or sel.

SAM uses the base-scale table entries when processing data.

When sam is typed, data is processed and printed as required by the times-modes table entries.

When sel is typed, the select-channel programme, SELCHN, is called before control is transferred to SAM. SELCHN enables the operator to select a required channel and mode of data printout.

An error in reading from disk will prevent data from being printed in the all or some modes; however, printing of maxima-minima data will not be affected. If a disk error occurs, a disk error message will be printed after processing and printing of maxima and minima is complete.

Disk errors should be reported to the computer centre. The disk error message format is contained in section 9.4.2.

The format required when using the select-channel facility is:

Line position		
11 - 12	channel number	
13	space	
14 - 16	mod	print moduli
	all	print all samples
14 - 36	list of three-digit selected times (in deciseconds), each pair of adjacent times being separated by a space.	
39	t or l	accept this line
40	any character or function	

Appropriate error messages are printed by the typewriter for the following error conditions:

1. incorrect format;
2. channel number less than 1 or greater than the highest available channel number (32);
3. selected time less than 000 or greater than the highest available time;
4. position 29 does not contain a t or an l.

When errors occur in a list of selected times, data corresponding to valid times in the list is processed and printed.

Example of selected channel operation:

```
TYPE ROUTINE DESIRED: sel

SELECT CHANNEL, MODE AND TIMES (IN DECISECONDS):
32 mod                        t
SELECTED SAMPLES
32 MAX 20.4/0.850    MIN  0.0/-0.01
TYPE ROUTINE DESIRED: sel
```

```
SELECT CHANNEL, MODE AND TIMES (IN DECISECONDS):
32 000 010 025 113          t
SELECTED SAMPLES
32   0.0/-0.01   1.0/0.034   2.5/0.096   11.3/0.467
TYPE ROUTINE DESIRED:
```

A description of SELECTED SAMPLES output formats is contained in section 8.8

9.2.5 Updating the Base-Scale Table

The base-scale table updating programme, UDBS, is called by typing ubs.

The following format is used to update the table:

Line position	
11 - 19	channel numbers
20	space
21 - 38	base and scale entries
39	t or l
40	any character or function

Channel numbers must be of one or two digits and must be separated by single spaces.

The base and scale entries must be separated by a comma.

Base and scale entries must be of from one to four digits if positive or of a negative sign and one to three digits if negative. A decimal point must be included in each entry.

Typing a t or an l in position 39 causes the typewriter line to be accepted by the programme when a character or function is typed in position 40. An l in position 39 indicates to the programme that this line contains the last updating information.

The line is checked by the programme before the table is updated. If the line satisfies the check, the table is then updated and the programme requests the next entry. If an error is detected in the line, the table is not updated and the programme requests that the line be typed again.

An error is indicated if:

1. incorrect format is used;
2. a channel number is less than 1 or greater than the highest available channel number;
3. the base or scale value does not contain a decimal point;
4. position 29 contains neither a t nor an l.

An example of updating the base-scale table follows:

```
TYPE ROUTINE DESIRED: ubs
 OK  SEND NEXT
1 2 15     0.0,20.54        t  OK  SEND NEXT
32         -1.5,-2.63       l
 OK  LAST.TYPE ROUTINE DESIRED:
```

9.2.6 Updating the Times-Modes Table

The times-modes table updating programme, UDTM2, is called by typing utm.

Note that when typing-in selected times, typing c in line position 39 will allow the list of times to be continued on the next line without repeating the function and channel numbers.

Formats used when updating the table are as follows:

Line position

to delete entries:

11 - 13	del	
15 - 18	all	delete entries in all channels
15 - 38	list of channel numbers whose entries are to be deleted	
39	t	accept this line and prepare for another
	l	accept this line then return to control programme
40	any character or function	

to add or replace entries:

11 - 13	add	add entries to current entries
	rep	replace current entries with new entries

15 - 18	mod	print moduli
	all	print all samples
	sel	print samples for selected times
20 - 28	all	update all channels
20 - 38	list of channel numbers to be updated	
39	t	accept this line and prepare for another
	l	accept this line then return to control programme
40	any character or function	

to select times (line following an add or rep line in which sel has been typed):

11 - 38	required times in deciseconds	
39	t	accept this line and prepare for another updating line
	c	accept this line and prepare for another line of times
	l	accept this line then return to the control programme
40	any character or function	

Notes concerning format:

1. channel numbers must be two digits with a single space between adjacent channel numbers;

2. selected times must be three digits with a single space between adjacent times;

3. if l is typed in position 39 of a line containing sel, the l will be treated by the programme as a t.

Errors:

The programme prints an error message, containing the error, for the following error conditions:

1. incorrect format;

2. channel number less than one or greater than the highest available channel number (32);

3. selected times less than zero or greater than the highest available time (150);

4. position 29 does not contain a t or an l in a modes updating line or does not contain a t, c or an l in a times updating line.

When errors occur in a list of channel numbers or times, valid values in the list are processed.

An example of updating the times-modes table:

```
TYPE ROUTINE DESIRED: utm
  TYPE NEXT
add mod 01 02 03 04 05        t    TYPE NEXT
add sel 10                    t    TYPE TIMES IN DECISECONDS
000 010 030 120 145           t    TYPE NEXT
del 20 09 24 28               t    TYPE NEXT
rep all 32                    l
TYPE ROUTINE DESIRED:
```

9.2.7 Saving and Restoring Tables

The base-scale and times-modes tables are stored on disk by typing sve which calls the table saving programme SAVE.

The base-scale and times-modes tables may be restored from disk by typing res which calls the table restoring programme RESTORE.

Disk error messages are the only information printed by these programmes. If a disk error message occurs, the computer centre should be informed. The format of disk error messages is contained in section 9.4.2.

9.2.8 Terminating Operations

Control of the computer by the magnet laboratory programmes is terminated by typing trm.

9.3 Emergency Facilities

9.3.1 Computer Operator Cannot Start Programme From Console.

This may be due to faults involving the library PARMLIB, in which the job control statements used in the loading of programmes, are stored.

This failure may be overcome by starting the programme with the following job control cards:

```
//RGS10434 JOB (11229,3,,300),name,CLASS=K,TYPRUN=HOLD
//JOBLIB DD UNIT=2311,DSN=RGS2,DISP=OLD,VOL=SER=SPOOL1
// EXEC PGM=MAGPGM
//DSKHLD DD UNIT=SPOOLSTD,SPACE=(TRK,5)
//DISKSAVE DD DISP=OLD,DSN=IRSMAG,VOL=SER=OS19L1,UNIT=2311
//DDMPX DD UNIT=001
//DDADCF DD UNIT=002
//DDIGIN DD UNIT=004
//DDLNO DD UNIT=005
//
```

The word - name - in the first statement should be replaced by the name of the person submitting the cards to the computer centre.

9.3.2 Programme Cannot be Started by the Method of 9.3.1

The magnet laboratory programmes are contained in the data set RGS2. Therefore, if RGS2 is lost the above methods will not be effective.

As RGS2 is stored on disk pack SPOOL1, any faults with SPOOL1 may cause RGS2 to be lost.

A backup data set, named MAGLIB, is stored on disk pack MAGLAB. If RGS2 fails, MAGLIB may be copied onto SPOOL1 to replace the failed RGS2. The following cards are used to carry out this operation:

```
//RGS10440 JOB (11229,3,,100),name,CLASS=J
// EXEC PGM=IEBCOPY
//SYSPRINT DD SYSOUT=A
//IN DD UNIT=2311,DSNAME=MAGLIB,DISP=OLD,VOL=SER=MAGLAB
//OUT DD UNIT=2311,DSNAME=RGS2,DISP=(,KEEP),VOL=SER=SPOOL1      *
//  SPACE=(TRK,(20,5,1),RISE)
//SYSUT3 DD UNIT=SPOOLSTD,SPACE=(TRK,(5,5))
//SYSUT4 DD UNIT=SPOOLSTD,SPACE=(TRK,(5,5))
//SYSIN DD *
         COPY   OUTDD=OUT,INDD=IN
         SELECT  MEMBER=MAGPGM
//
```

NOTES: The * in the fifth card above must be punched in card column 72.

There must be <u>two</u> spaces between // and SPACE of the sixth card.

The word - name - in the first statement should be replaced with the name of the person submitting the cards to the computer centre.

If this procedure is successfully completed, normal operations may be resumed.

9.3.3 Failure of RGS2 and MAGLIB

If both RGS2 and MAGLIB data sets fail, the programme will have to be recompiled and link editted from punched cards or from the data set MAGSRC which is stored on disk pack MAGLAB. The job control and linkage editor control cards required for this operation are listed in the listing of magnet laboratory programmes [12].

The disk pack OS19L2 must be mounted on a disk drive while the magnet laboratory programmes are being compiled.

9.4 Computer Error Codes and Messages

A complete description of the meanings of error codes and messages referred to in this section is not given as operators will normally require the assistance of computer centre personnel when seeking the cause of errors.

9.4.1 ADC Channel Completion Codes [10,p.157].

7F	Successful completion.
41	Channel programme has completed with permanent I/O error.
44	Channel programme has been intercepted because of a permanent error associated with device end for the previous request. Another attempt at operation may be taken.
48	Request element for channel programme has been made available after it has been purged.

9.4.2 Disk-Error Message Format [9,p.197].

Disk-error messages contain information printed out in the following order:

unit address, device type, ddname, operation attempted, error description, track address and block number in hexidecimal, access method.

10. ANU COMPUTING CENTRE TYPEWRITER CONSOLES

10.1 Introduction

Some time after the present computing system for the magnet laboratory had been specified and the ANU Computer Centre had agreed to reserve the 8K byte partition in main store, the Centre announced that is proposed to improve the computing service by providing a number of typewriter consoles. The purpose of this consoles system is outlined in an extract from the proposal report[13].

> "A conversational console system provides the user with the ability to prepare and test programs directly by the use of a typewriter console or display. This results in faster program development, and generally in less computing time used, as program errors may be observed and corrected as they occur.
>
> In addition console systems provide the user with program packages to solve a wide range of problems, as well as desk calculator and report editing facilities. By means of a command or series of commands the user is able to select any service program and type in data as requested and then receive the results on the typewriter."

One of the "programme packages" will be the magnet laboratory's system.

The Department has agreed to connect its IBM 735 typewriter to the consoles system when it becomes operational. Meanwhile, the magnet laboratory typewriter is connected to the 1827, keeping in mind its future connection to the consoles system multiplexor.

10.2 Consoles System Hardware

Figure 10.1 shows the proposed initial arrangement.

Access to the main store will be by the Direct Control feature connected to the CPU. This feature may be thought of as a channel which transfers data one byte (8 bits) at a time. The consoles multiplexer will initially serve three local typewriters and a special link to a typewriter in the Research School of Chemistry. Each typewriter will have control circuits similar to those already used by the magnet laboratory.

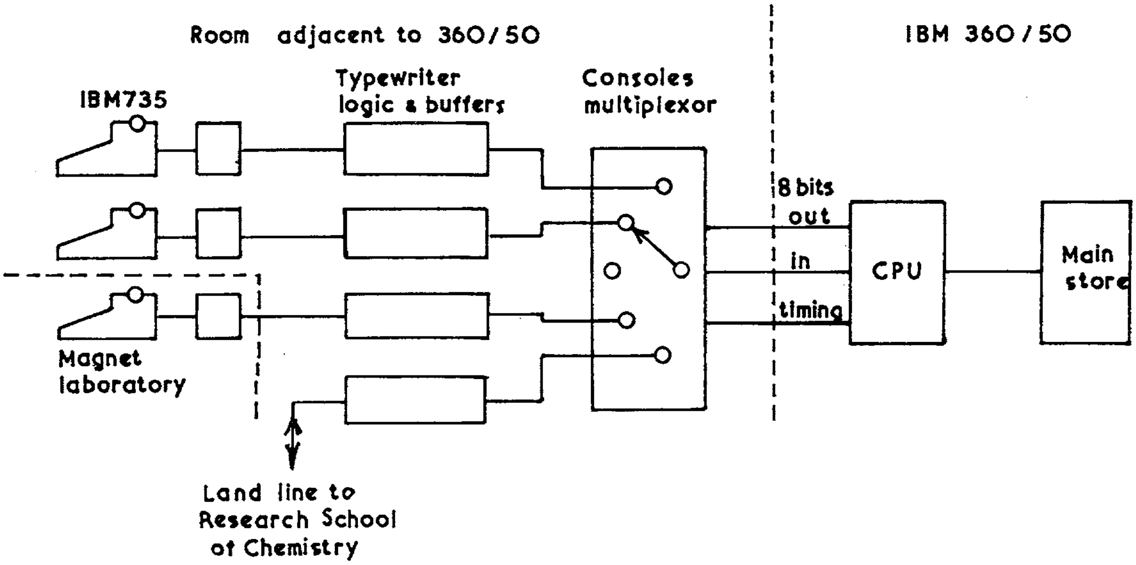


Figure 10.1 Consoles System

10.3 Consoles System Operation

The consoles system will occupy a 40 K byte partition of main store at such times during the day that it is in operation. A supervisor programme and 80 byte input and output buffers for each console typewriter will occupy 8 K bytes. The remaining 32 K bytes will be available for the user. User programmes will be handled using a "roll-in roll-out" or swapping system. Normally each user will use the 32 K area for about 0.5 second after which his programme will be transferred to disk store and the next user's loaded. This arrangement ensures reasonable response time to any user. Input and output with each typewriter will continue even when the appropriate user programme is not in main store. Characters will be passed from user programme with the case shift included in each 8 bit code. Figure 5.4 gives this code. It is up to the user to translate this code as he wishes.

Typed input lines will be variable length, each terminated by a carriage return. Backspacing on input will obliterate the preceding character.

The magnet laboratory's data collection programme, ANALIN, will be made an exception to the time-slicing just mentioned. It will have sole use of the consoles' user area for the duration of each data collection period (approximately 20 seconds).

If the times at which the consoles system is operating are insufficient for the magnet laboratory, then it may be possible to use the present set-up (with the 1827) during the off-periods. This would entail duplication of the digital-interface module cards and cabling.

10.4 Effect of Consoles System on Magnet Laboratory System

The necessary changes in hardware are restricted to those concerning the typewriter. These have already been mentioned in section 5.1. On the software side there will have to be significant, although straightforward, alterations. As the Computer Centre has not yet released details of user programme communication with the typewriter, the following list of points is intended as a guide only. Other changes besides those mentioned may be required. One assumes at this stage that the reader is familiar with the present magnet laboratory programmes.

The console system will differ from the present system in the following ways:

(a) the console system will not support an overlay structured programme;

(b) there will be no user defined data sets; all data sets will be defined by the console system and the data control blocks will be located in the 8 K supervisor area;

(c) typewriter input and output will be handled by the supervisor;

(d) the maximum length of a typewriter line will be 80 characters.

To make the magnet laboratory programmes compatible with console system operation:

(a) remove the overlay structure;

(b) define, to the computer centre, the multiplexer and analogue-to-digital-converter data sets used by ANALIN and the data set used by SAVE;

(c) remove references to the collected-data disk storage (DSKHLD) and store collected-data in main store;

(d) replace P130 and READIN with routines that call supervisor-controlled print and read routines;

(e) remove the P130 and READIN error routines from MGLB;

(f) ensure that the maximum output line length is not greater than 80 characters;

(g) remove the X'DD' from the end of all output lines.

11. REFERENCES

1. CARDEN, P.O. : "Features of the High Field Magnet Laboratory at the Australian National University, Canberra", the Australian National University, Department of Engineering Physics Publication EP-RR 19, January 1967.

2. CARDEN, P.O. and R.E. WHELAN : "Instrumentation of the Australian National University 300 Kilogauss Experimental Magnet", the Australian National University, Department of Engineering Physics Publication EP-RR 25, December 1969.

3. IBM 1800 Installation Manual - Physical Planning, Form A26-5922-5, 6th Edition, IBM Systems Development Division, Product Publications, San Jose, California, January 1969.

4. IBM "Selectric" Input-Output Writer, Form 543-0033-1, International Business Machines Corporation, Office Products Division.

5. IBM System/360 - Component Description : IBM 1827 Data Control Unit, Form A22-6868-2, IBM Systems Development Division, Product Publications, San Jose, California.

6. The Digital Logic Handbook, 1970 Edition, Digital Equipment Corporation, Maynard, Massachusetts.

7. IBM System/360 Operating System : Concepts and Facilities, Form GC28-6535-7, 7th Edition, IBM Corporation, Programming Systems Publications, Poughkeepsie, New York, June 1970.

8. IBM System/360 Principles of Operation, Form C28-6534-2, 9th Edition, IBM Systems Development Division, Product Publications, Poughkeepsie, New York, November 1970.

9. IBM System/360 Operating System : Supervisor and Data Management Macro Instructions, Order Number GC28-6647-4, 5th Edition, IBM Corporation, Programming Publications, San Jose, California, June 1970.

10. IBM System/360 Operating System : System Programmer's Guide, GC28-6550-8, 8th Edition, IBM Corporation, Programming Systems Publications, Poughkeepsie, New York, June 1970.

11. IBM System/360 Operating System Linkage Editor and Loader. Program numbers 360S-ED-510, 360S-ED-521, 360S-LD-547, Form GC28-6538-8, 9th Edition, IBM Corporation, Programming Publications, New York, November 1969.

12. SUTTON, R.G. and R.L. McMURTRIE, "Computer Programmes for the High Field Magnet Laboratory's Data Acquisition System", The Australian National University, Department of Engineering Physics Publication EP-CP2, October 1972.

13. LAWRENCE, D.E. and P.N. CREASY, "A Proposal for the Connection of Typewriter Consoles to the ANU IBM 360/50", The Australian National University Computer Centre Technical Report No. 34, December 1969.

14. MACLEOD, I.D.G., "Instrumentation and Control of the Canberra Homopolar Generator by On-Line Computer", The Australian National University, Department of Engineering Physics Publication EP-RR11, October 1966.

APPENDIX

COMPUTER-MAGNET LABORATORY LINK

SPECIFICATION FOR PERFORMANCE

DESIRED OF IBM 360 AND 1827

CONTENTS:

INTRODUCTION

The purpose of the system specified herein is to gather, store, and process data from an experimental magnet in the magnet laboratory and to print out the results of processing as required.

Data gathering will be during sampling periods of up to 15 seconds which may recur at intervals of not less than 10 minutes. The periodic recurrence of the sampling periods may extend for several hours but not usually beyond the 8 hours between 9 a.m. and 5 p.m. on normal working days and usually for not more than 4 days per week for about four consecutive weeks.

The complete system comprises instruments for the generation of analogue signals, FM modulation transmission and demodulation equipment, the IBM 1827 which is basically a multichannel analogue-to-digital-converter, the IBM 360/50 computer and an input output typewriter located in the magnet laboratory. Figure 1 is a diagram showing these components and their interfaces. This specification deals only with the performance of the 1827 and 360/50.

Each sampling period will be initiated by the magnet laboratory following the concurrence of several necessary pre-conditions, one of which is the availability of the computer. However, it would be impracticable if the availability of the computer were a deciding factor in more than 9 cases out of 10, that is to say, when all the pre-conditions other than the computer availability are concurrent, there should be at least a probability of .9 that the computer is available. The meaning of available in this context needs to be more carefully defined as will be done later in this specification. It is useful to note that there will be a period of five minutes or so after each sampling period during which it will be highly unlikely that another sampling period will be initiated. During this period the computer availability may drop to zero provided processing of the stored data has been completed.

COMPUTER AVAILABILITY

It is essential to ensure that no data is lost during or subsequent to the sampling period until it is deliberately erased by the magnet laboratory. A possible threat of such loss of data may come from other parallel operations carried on by the computer which may require the use of certain common facilities. Thus the no-loss requirement necessitates procedures involving the whole computer and includes the operating staff. A precise meaning must be given to the word available when used to describe the condition of the computer. It is defined as follows:

Available (now): in a condition to accept data with absolute certainty during a sampling period t_s long beginning t_d from now, to store this data safely and to process it for a time t_p immediately following the sampling period. t_d here is the time delay between the irrevocable initiation of a sampling period and the commencement of the sampling period; and t_p is the extra time after the sampling period necessary to complete safe storage of all data, plus an allowance by prior arrangement to perform minimum processing. The total time t_a is therefore $t_a = t_s + t_d + t_p$.

It follows that if the computer condition is switched from available to not available, by the computer staff, after a sampling period has been irrevocably initiated, the computer will in fact still gather data, store safely and implement minimum processing.

The availability of the computer should be preferably be protected by hardware or software modifications and should be communicated to the magnet laboratory by electrical signal.

Figure 2 is a logic diagram showing the ideal arrangement.

DATA CHANNEL DETAILS

Number of channels containing analogue information from FM System	32 (possibly 64)
Sampling frequency on each channel	10 c.p.s. min.
Period during which samples are to pass interface (i.e. t_s)	15 secs.

DATA PROCESSING PROGRAMME LIBRARY

Any of the following selected to process each channel. Not all channels need be processed.

(i) Samples at predetermined times or at times inputted from typewriter after the sampling period is over. Print out samples and times and some identifying information such as channel number and description of variable being recorded.

(ii) Select peak modulus of samples. Print out sample value, time and identifying information.

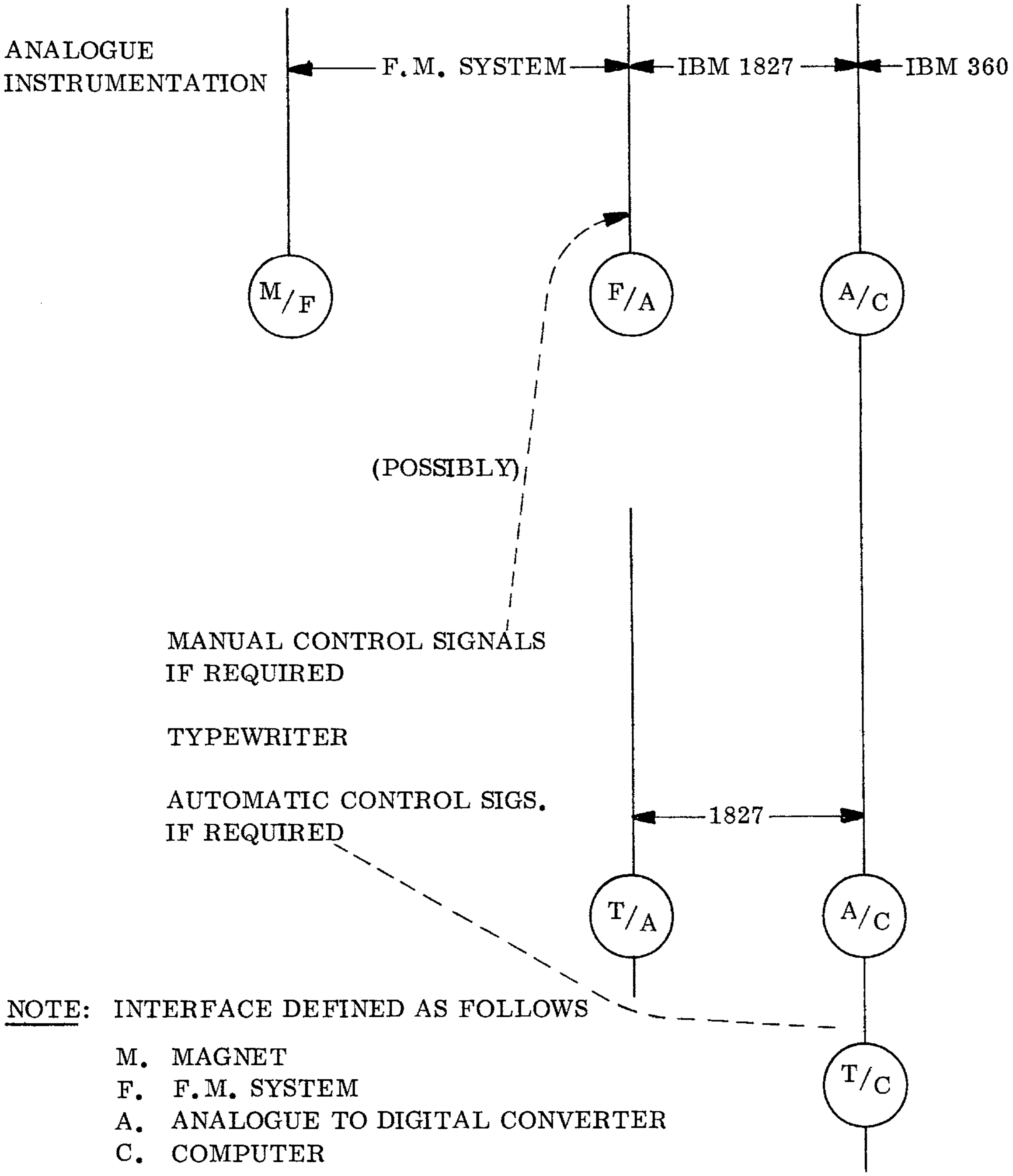
(iii) Print out all samples received and time.

In all the above, print-out would be required within a minute from the end of the sampling period.

TYPEWRITER

An IBM 735 typewriter, together with the necessary interface modules to the 1827 have been ordered. The typewriter is to be used for printing the results of all processing. It may also be used to communicate to the computer as required.

BLOCK DIAGRAM SHOWING INTERCONNECTION OF VARIOUS COMPONENTS AND INTERFACES



<u>NOTE</u>: INTERFACE DEFINED AS FOLLOWS

M. MAGNET
F. F.M. SYSTEM
A. ANALOGUE TO DIGITAL CONVERTER
C. COMPUTER

<u>THUS</u> M/F; MAGNET TO F.M. SYSTEM INTERFACE

FIG 1

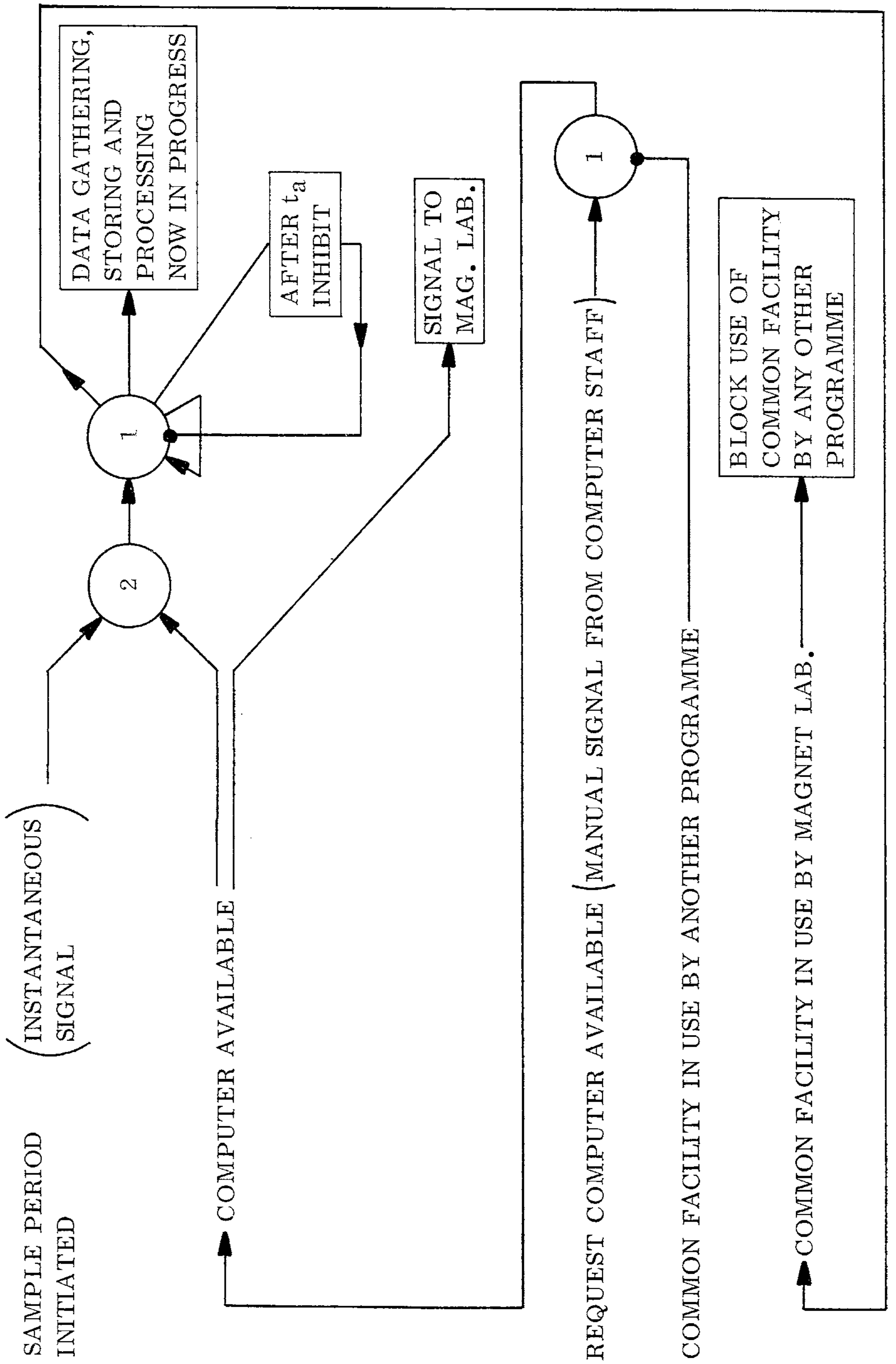

SAMPLE PERIOD INITIATED
(INSTANTANEOUS SIGNAL)
COMPUTER AVAILABLE
REQUEST COMPUTER AVAILABLE (MANUAL SIGNAL FROM COMPUTER STAFF)
COMMON FACILITY IN USE BY ANOTHER PROGRAMME
COMMON FACILITY IN USE BY MAGNET LAB.
2
1
1
DATA GATHERING, STORING AND PROCESSING NOW IN PROGRESS
AFTER t_a INHIBIT
SIGNAL TO MAG. LAB.
BLOCK USE OF COMMON FACILITY BY ANY OTHER PROGRAMME

FIG 2

Publications by Department of Engineering Physics

No.	Author	Title	First Published	Re-issued
EP-RR 1	Hibbard, L.U.	Cementing Rotors for the Canberra Homopolar Generator	May, 1959	April, 1967
EP-RR 2	Carden, P.O.	Limitations of Rate of Rise of Pulse Current Imposed by Skin Effect in Rotors	Sept., 1962	April, 1967
EP-RR.3	Marshall, R.A.	The Design of Brushes for the Canberra Homopolar Generator	Jan., 1964	April, 1967
EP-RR 4	Marshall, R.A.	The Electrolytic Variable Resistance Test Load/Switch for the Canberra Homopolar Generator	May, 1964	April, 1967
EP-RR 5	Inall, E.K.	The Mark II Coupling and Rotor Centering Registers for the Canberra Homopolar Generator	Oct., 1964	April, 1967
EP-RR 6	Inall, E.K.	A Review of the Specifications and Design of the Mark II Oil Lubricated Thrust and Centering Bearings of the Canberra Homopolar Generator	Nov., 1964	April, 1967
EP-RR 7	Inall, E.K.	Proving Tests on the Canberra Homopolar Generator with the Two Rotors Connected in Series	Feb., 1966	April, 1967
EP-RR 8	Brady, T.W.	Notes on Speed Balance Controls on the Canberra Homopolar Generator	Mar., 1966	April, 1967
EP-RR 9	Inall, E.K.	Tests on the Canberra Homopolar Generator Arranged to Supply the 5 Megawatt Magnet	May, 1966	April, 1967

No.	Author	Title	First Published	Re-issued
EP-RR 10	Brady, T.W.	A Study of the Performance of the 1000 kW Motor Generator Set Supplying the Canberra Homopolar Generator Field	June, 1966	April, 1967
EP-RR 11	Macleod, I.D.G.	Instrumentation and Control of the Canberra Homopolar Generator by On-Line Computer	Oct., 1966	April, 1967
EP-RR 12	Carden, P.O.	Mechanical Stresses in an Infinitely Long Homogeneous Bitter Solenoid with Finite External Field	Jan., 1967	
EP-RR 13	Macleod, I.D.G.	A Survey of Isolation Amplifier Circuits	Feb., 1967	
EP-RR 14	Inall, E.K.	The Mark III Coupling for the Rotors of the Canberra Homopolar Generator	Feb., 1967	
EP-RR 15	Bydder, E.L. Liley, B.S.	On the Integration of "Boltzmann-Like" Collision Integrals	Mar., 1967	
EP-RR 16	Vance, C.F.	Simple Thyristor Circuits to Pulse-Fire Ignitrons for Capacitor Discharge	Mar., 1967	
EP-RR 17	Bydder, E.L.	On the Evaluation of Elastic and Inelastic Collision Frequencies for Hydrogenic-Like Plasmas	Sept., 1967	
EP-RR 18	Stebbens, A. Ward, H.	The Design of Brushes for the Homopolar Generator at The Australian National University	Mar., 1964	Sept., 1967

No.	Author	Title	First Published	Re-issued
EP-RR 1[illegible]	Carden, P.O.	Features of the High Field Magnet Laboratory at the Australian National University, Canberra	Jan., 1967	
EP-RR 2[illegible]	Kaneff, S. Vladcoff, A.N.	Self-Organizing teaching Systems	Dec., 1968	
EP-RR 21	Vance, C.F.	Microwave Power transmission Ratio: Its Use in Estimating Electron Density	Feb., 1969	
EP-RR 2[illegible]	Smith, B.D.	An Investigation of Arcing in the Electrolytic Switch/ Test Load Used with the Homopolar Generator	Oct., 1969	
EP-RR 2[illegible]	Inall, E.K.	Use of the Homopolar Generator to Power Xenon Discharge Tubes and some Associated Switching Problems	Mar., 1969	
EP-RR 2[illegible]	Carden, P.O.	Pivoted Hydrostatic Bearing Pads for the Canberra Homopolar Generator	Dec., 1969	
EP-RR 2[illegible]	Carden, P.O. Whelan, R.E.	Instrumentation for the Australian National University 300 kilogauss Experimental Magnet	Dec., 1969	
EP-RR 28	Sutton, R.G. McMurtrie, R.L.	Collection, Storage and Retrieval of Data by Computer at the High Field Magnet Laboratory, Canberra	Oct., 1972	