EXPANSION PLANS FOR THE TELEMETERED NETWORKS

by

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SEISMOLOGICAL SERVICE OF CANADA

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1. Summary

This paper describes the plans to develop the Eastern Canada Telemetered Network (ECTN) and its western counterpart (WCTN) so that each can accommodate a maximum of twenty-four channels of data. Several other enhancements in performance are planned including on-line interaction by the seismologists with data to produce fast epicentres. It is hoped that data from conventional seismograph stations can be integrated into the new scheme which will lead to a more efficient method of processing data for the annual bulletin of earthquakes.

A change of operating system will permit two users to share the processor so that event detection, graphic output, epicentre determination and software development can run concurrently. In addition to providing for more incoming lines, the software being developed will permit considerable flexibility in the digital transmission format, so that remote data concentrators can be used where economic. Improvements in the outstation hardware will permit data to be telemetered by radio and the inclusion of a microprocessor at the remote stations will open the way to more on-site data editing and hence lower data transmission costs.

The new system will run in parallel with the existing four channel ECTN and changeover will occur when the new software is stable.

2. Background

The ECTN network was first established in 1973 as a four channel system using a DEC PDP11-15 processor with no disc storage. A 2.5Mbyte disc was added in 1974 and an event trigger algorithm added. The system has been in an operational mode since February 1974 and during 1977 for example, was on-line 95% of the time. A similar four station network (WCTN) was established on the West Coast during 1975 using a PDP11-40 computer.

The Ottawa PDP11-40 processor was purchased in 1974 as a replacement for the older DDP124 (1967 vintage). After three years of overlap the DD124 finally disposed of in 1977. Up to the present the PDP11-40 has been used for:

application software development,

editing ECTN event files,

playback of CANSAM files and velocity filtering

digitising analogue FM tapes and plotting of digital data files

formatting digital BAKPAK data,

regular fetching of the CANSAM log,

and other projects.

During 1977 a cooperative project with USNRC was considered in which the U.S. would fund about twelve additional stations in the Eastern network. A plan was developed based on a new PDP11-34 processor which would support up to 24 channels in conjunction with other new computer hardware, a new operating system and a rewrite of the ECTN program. The plan was budgeted at $180K with twelve new stations, and although it was accepted as technically desirable, other considerations have delayed the project, perhaps indefinitely.

In the meantime other agencies in Canada have requested assistance in the assessment of seismic risk and as a result the following new stations are to be added to ECTN system with funding by the agencies:

1. Glen Almond, Que. borehole, EPB
2. Gentilly, Quebec. Hydro-Quebec
3. Chats Falls, Ontario. Ontario Hydro
4. LG2 site 1. SEBJ
5. LG2 site 2. SEBJ

6. LG2 site 3. SEBJ

7. Bancroft. AECL - (less certain)

8. Chalk River. AECL - (less certain)

The four existing stations are:

1. Ottawa, EPB

2. Montreal, EPB

3. Maniwaki, EPB

4. Manicouagan, Hydro-Quebec

In addition two new stations have been budgeted for the WCTN in the Gulf Islands region using radio telemetry. The new system configurations are shown in figs. 1&2.

All of these factors have led to the conclusion that the essence of the proposal developed for the USNRC should proceed immediately but using our own funds, and by asking each of the cooperating agencies to contribute to the incremental cost of the Ottawa minicomputer system as well as the outstation costs.

The original proposal made to the USNRC provided for a new PDP11-34 and sufficient hardware to enable it and the 1140 to be capable of running the network, and in fact included provision for automatic changeover to the backup machine. Because of the limited funds in our capital budget, an alternate scheme has been prepared which will fully utilise the time sharing capability of the PDP11-40 and permit all jobs except the digitising of FM tapes to be done by a single machine. The PDP11-15 is not able to support time-shared operations.

When funds become available (perhaps in fiscal 79-80) it is expected that the PDP11-15 will be replaced with a newer machine and a redundant configuration adopted. In the meantime microprocessor backup of key channels

appears to be the way to achieve minimum reliability standards as described in more detail in section 4.4.

Since a minimum of six additional channels must be accommodated in the next six months, and since this represents a major work load, the option of stretching the existing system by one or two channels (2 man-month) would represent a diversion of effort which would delay the implementation of the other new stations. It is worth noting that SEBJ hope to have their three channels on-line by October 78 when filling of LG2 commences, and that the new system is essential to the decoding of data from the borehole seismometer.

3. Objectives

The general objective is to further develop the ECTN data acquisition system so that the Seismological Service can respond in a timely manner to requests for additional seismic monitoring and subsequent processing in both eastern and western Canada. These requests may be the result of:

a) planned network expansion by EPB

b) damsite monitoring,

c) nuclear power plant risk assessment,

d) radio active waste disposal: earthquake risk assessment,

e) any new application.

A second general objective is to improve the efficiency and speed with which Canadian earthquake data can be processed.

These general objectives lead to the more detailed plan below, which includes:

1. provision in the software for up to 24 channels of data,
2. provision in the short term (FY78-79) of hardware for 16 channels of data,

3. a smooth transition from the present 4 channel system to the new 16 channel system with both running in parallel during an evaluation period,
4. an improvement in system reliability from the present 95% level by the provision of a more reliable, but limited performance, analogue back up facility, (more microprocessors)
5. to configure the PDP11-15 system so that it can continue to run all (or most) of the user programs which currently run on the PDP11-40,
6. to provide multi-terminal, multi-user access to interactive programs,
7. to provide on-line graphic output of current event files,
8. to provide a terminal in the record reading room for direct viewing of data and phase picking and to permit phase data from conventional CSN stations to be entered and filed,
9. to provide an interactive time sharing version of the CANSESS epicentre determination program,
10. to provide an on-line file of phase data which will grow and be modified over a period of months (weeks) as data is received from more distant stations,
11. to continue to provide high quality digital data from the out-stations with extended dynamic range,
12. to provide software which can cater to an broad mix of digital data transmission formats so that opportunities to reduce line costs by multiplexing can be accommodated.
13. to make progress towards more data reduction at remote sites and hence lower data transmission costs.

4. System Description

The following sections describe the major changes required in the hardware and software to meet the objectives. The descriptions emphasise the differences between the existing system and the proposed new system and presuppose some knowledge of the established ECTN/WCTN.

4.1 Ottawa PDP11-40 (new ECTN)

The expanded ECTN system requires several new pieces of hardware. These are listed below with the expected installation date:

1.	14 Mbyte disc. (RK611)	May 1*
2.	16 channel line multiplexer (DZ11-E)	installed
3.	an additional 32K of memory	installed
4.	memory management	installed
5.	expansion box	installed
6.	floating point processor	May 1
7.	watchdog timer	budget 78-79
8.	large screen Tektronix terminal	installed
9.	small screen Tektronic terminal	installed
10.	expansion chassis ($2.5K)	not budgeted for

The proposed configuration for the PDP11-40 is shown in fig. 3. Note that the new configuration leaves the PDP11-15 as a viable configuration which can operate in parallel with the 11-40 using the original ECTN program. Since the FILEX utility under RSX11-M can read and write RT11 disc files, discs can be transferred easily between the two processors.

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*requires new data lab power source.

4.2 Ottawa PDP11-15

Because of its obsolescence the PDP11-15 will not support the RSX11-M operating system. However, it can be used as viable system operating with RT11 operating system with 24K of memory to support most of the current user programs, the digitiser and the VT11 plotting package. The LV11 plotter will be left on the PDP11-15 to work with the VT11 display as long as necessary. Later it can be moved onto the 11-40. The 11-15 will continue to be used as a digitiser, perhaps indefinitely. One of the two discs will be sent to Victoria for the WCTN. The revised configuration is shown in fig. 4.

4.3 WCTN PDP11-40

This system will be upgraded:

1. to support up to eight input channels,
2. to run the same programs as in Ottawa under RSX11M operating system,
3. to include 64K memory with memory management,
4. to include a graphics plotter,
5. to include more disc space,
6. to use the DZ11 line multiplexer.

During FY78-79 the objective will be to upgrade the WCTN program and provide a reasonable service to a single concurrent user (Weichert). More disc space is perhaps desirable, but the DZ11 is higher priority. Items 3,4, &6 are provided for in the FY 78-79 budget. Item 5 is from Ottawa. The proposed hardware configuration is shown in fig. 5. Note that the Tektronix graphics terminal (purchased by Geomag) is proposed. This would require an EIA/Data communications interface ($2,000), alternatively a new Tektronix 4006, dumb terminal could be purchased ($4,000).

4.4 BACKUP

Experience has shown that a reliable backup system is essential. The microprocessor system used on the Manicouagan line has worked well and so five more of these units are highly desirable. The best method of achieving this would be to replace the microprocessors in the existing BAKPAKS with the MK II microprocessor and use the existing processors as backup units with the software from the MNQ backup. Since capital funds are tight, we might consider providing the additional backup fairly quickly and cheaply by borrowing them from the BAKPAKS (except during the spring & fall field experiments). The helicorders would then be connected directly to the microprocessors through a patchboard leaving the computer with the trigger algorithm (see fig. 1).

4.5 Outstation Hardware

The outstation design is being updated to include:

1. a local microprocessor (RCA 1802),
2. programmable dynamic range, making trade offs between speed (S/S) and dynamic range possible,
3. switch selectable bandpass and sample rate,
4. optional transmission by radio instead of phone lines,
5. a self contained waterproof enclosure that can be mounted directly on an antenna mast,
6. spare card slots so that more memory can be added at a later date, if required,
7. the possibility of adding a trigger algorithm at the remote station to further edit the data,
8. low power consumption so that the equipment can operate from primary batteries if required,

9. electronics identical to that in MKII BAKPAKS, excluding of course, the cassette module.

A block diagram of the outstation is shown in Fig. 6.

4.6 ECTN/WCTN Software

The new software package will permit any reasonable mix of sampling rates and components to be combined on a single communications channel. Information on the incoming data is stored in tables which can be easily updated to reflect a change in configuration. Since the output file structure must also vary as the input configuration, any file generated will include as part of its header, details of its own structure. Application programs will then access all data through the file header so that, for example, graphics programs can be written which will be independent of the current input configuration.

Calculations of the executing time of the key loops in the trigger algorithm have shown that provided floating point hardware is included, a maximum of 24 channels can be catered for.

The new RSX11-M operating system will permit many programs to time-share the processor capacity. Each program is allocated a priority so that the operating system can schedule jobs to run in order of priority.

The ECTN program is being completely restructured to take advantage of the new operating system and at the same time to ensure that smooth changes in job context are accommodated without loss of continuity in real time data processing.

Briefly, the data input section of the program, which runs at a fairly high hardware priority (which takes precedence over software priority) will format data into structured one second buffers which are

queued into the trigger algorithm. Thus all processing down-stream from this queue can run asynchronously.

During the initial phase of program development logical program structure and speedy results are being given priority over the achievement of maximum speed. Since in the short term only ten channels are planned no timing problems are expected. The program will then be tuned to run faster and meet the objective of 24 channels.

The argument above applies equally well to other application programs which run at a lower priority concurrently with the ECTN algorithm.

Fig. 7 shows the memory map for the PDP11-40 in the new configuration. The operating system and essential utilities occupy 22K (base 10) of memory. It is estimated that the new ECTN program will take 10K. We presently have 56K of memory so that other users can share 24K.

In the worst case one user can use all 24K, which is about 4K more than was available to him in the old RT11 system. In fact many of the system utilities will run in 8K (e.g. PIP, FORTRAN compiler, EDIT), but in addition the swapping algorithm permits two users to share the same 24K block of memory. To ensure an equitable distribution of CPU time amongst time sharing users, the operating system includes an optional 'round-robin scheduler' which gives all tasks of the same priority equal access to the CPU.

Since in many interactive programs much time is spent in deliberating 'what next' the operating system will be built to support three terminals (a typewriter and two Tektronix CRT terminals). One will be devoted to 'production' work (Wetmiller, Ruygrok), one to application development and one to system development.

It is recognized that at some stage the system may become CPU bound. When this point is reached and if it is worthwhile, some of the jobs can be transferred to a second processor (PDP11-34) using the same operating system.

Increases in reliability are expected since the operating system in conjunction with memory management hardware operates in a protected memory environment. The operating system is also continuously monitored by a hardware 'watch dog timer' which can detect a software or temporary hardware malfunction and initiate the complete reloading of the program followed by a hands-off restart.

A logical extension of the ECTN will be to install the same operating system in the WCTN to cater for additional channels on that system and to support multiple terminals.

4.7 Tektronix Graphics System

Our Tektronix graphics system consists of two parts, two storage tube terminals and a Tektronix software package. All were delivered in January 1978.

One terminal (4006) has a 19 x 14cm display area and the other (4014) has a 38 x 28cm display area. It is planned to put the latter in the record reading room.

The software package has been installed and will run in 24K of memory (just!). Further work is required to 'tune' the software package and to investigate the use of overlays to reduce the memory requirements.

Since data is stored on the screen, the new terminals will be able to plot a much greater volume of data than was possible using the DEC VT11 refreshed display processor.

5.2 Special Responsibilities (in addition to normal duties)

R. Hayman - coordination of activities

F. Kollar - design & evaluation of 3 channel amplifier
- modification to the design of a MKII outstation package to suit the special needs of the Borehole Seismograph
- design of digital radio links for WCTN and SEBJ outstations and repeaters.

F. Anderson - hardware design of microprocessor development system
- hardware design of ADC - TCXO module
- hardware design of micro-processor module
- outstation software design
- hardware design of outstation power supplies
- supervision of contracted PCB layout

J. Thomas - supervision of technicians assembly modules, etc.
- checkout of floppy disc system
- checkout of level II Floppy assembler
- assist others in software development

A. Vesa - hardware checkout of MK II microprocessor
- update & checkout of PDP11 hardware configuration
- keep systems operational through Datalab operations

R. Grogan - parts procurement, assembly and test 3 channel preamp.
- prepare detailed rack layouts, interconnection diagrams, wiring schedules & parts lists
- parts procurement

5 WORK PLAN

5.1 Schedules

A sketch showing the way in which the various activities interact is shown in fig. 8. The immediate need is for software to support the additional channel from Hydro-Quebec at Gentilly. There are indications that this channel may be operational by March 31. All of our equipment is on-site at Gentilly ready for connection as soon as the line has been installed and checked out. If the line does become operational, the Ottawa channel will be used until the system has been expanded.

Development of the new software is progressing and by April 1 the first version of the program will be operational. This will provide helicorder playback only. It will take a further seven weeks of development to provide a version with the SPZ trigger algorithm. The second version will also require additional disc space. This has been ordered and should be delivered by April, however installation will have to wait until additional mains power has been installed. This item is included in the contract for the Datalab alterations (and accounts for a significant part of the cost). The contract is to be let during the week starting March 5 and work should be completed by May 5 provided key parts are available within 8 weeks. Thus the multi-channel triggered system should be operational by the end of May. The six channel microprocessor backup system can be built within four to six weeks since most parts are from stock and can be operational by mid May.

Planning for the new outstations for AECL, WCTN and SEBJ is underway, detailed scheduling is being developed. These schedules will, of course, depend on getting the go-ahead from AECL and SEBJ, and on the satisfactory completion of the Datalab alterations.

D. Havelock - install RSX11M V3.01

- ECTN software development

B. Shannon - install tektronix graphics software and prepare libraries

- convert LV11 plotting package to RSX11M

- prepare CRT data display routines for RSX11M

M. Bone - site selection, path profiles & path loss calculation for new WCTN sites

- coordinate DEC hardware installation

- supervise new EPB chassis installation

R. Wetmiller - convert CANCESS to run under RSX11-M

- convert FILL to run under RSX11-M

D. Weichert - introduce RSX11M to Victoria

F. Lombardo - site tests where necessary

D.G. Instruments - PCB layout for microprocessor

- general assembly

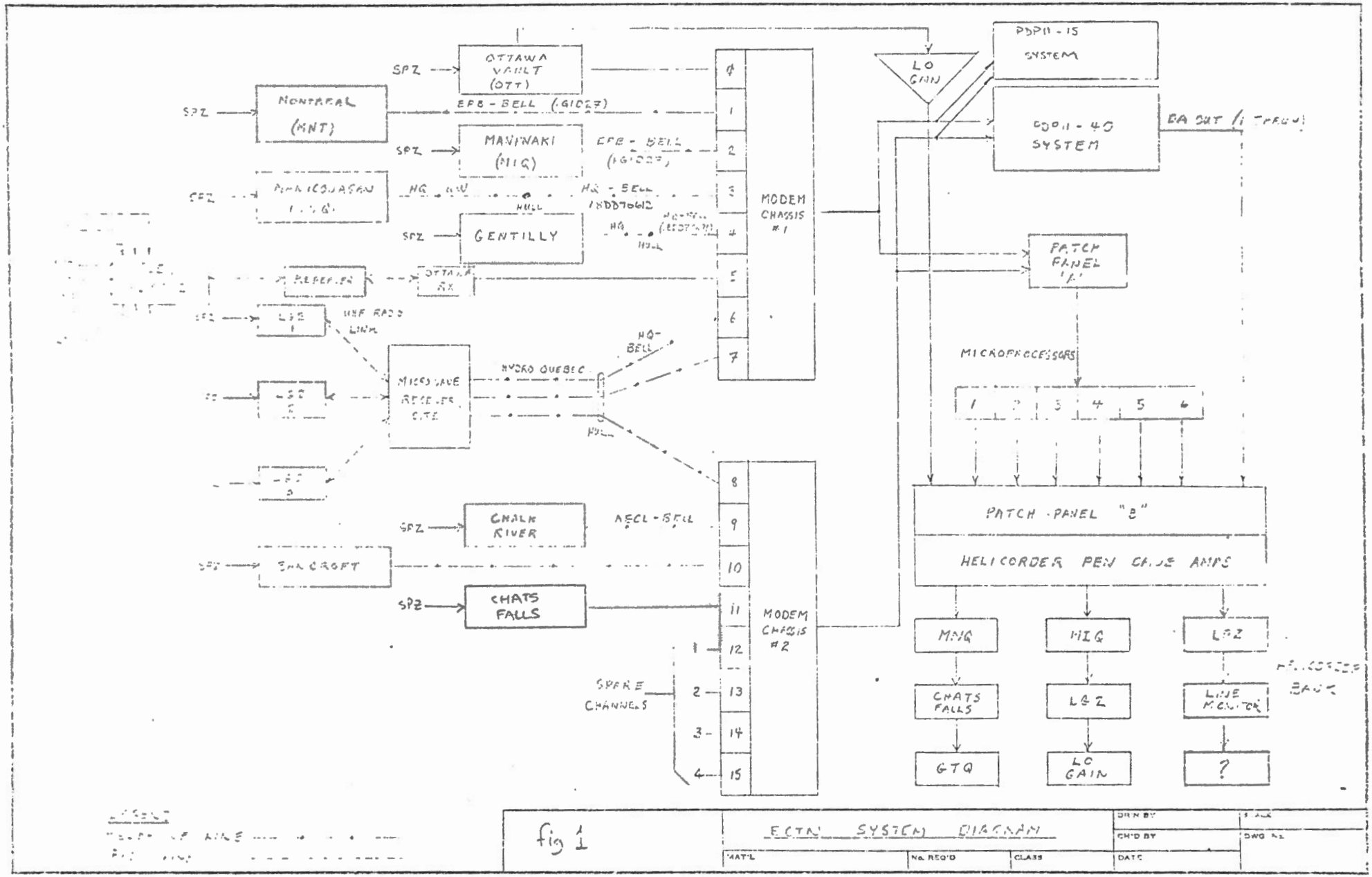
McGregor Electronics - assembly of 3 channel preamp.

Station Location	Funded By	Station Code	Component	Sample Rate S/S	Line Data Rate (Baud)	Input Channel	Order	Long. Code	Word Format
Ottawa vault	EPB	OTT	SPZ	60	1200	0	0	01	0
Montreal	EPB	MNT	SPZ	60	1200	1	0	01	0
Maniwaki	EPB	MIQ	SPZ	60	1200	2	0	01	0
Manicouagan	HQ	MNQ	SPZ	60	1200	3	0	01	0
Gentilly	HQ		SPZ	60	1200	4	0	01	0
Glen Almond	EPB		SPZ	30	1800	5	0	000001	1
Glen Almond	EPB		SPN	30	1800	5	1	000001	1
Glen Almond	EPB		SPE	30	1800	5	2	000001	1
Glen Almond	EPB		LPZ	1	1800	5	0	100010	1
Glen Almond	EPB		LPN	1	1800	5	1	100010	1
Glen Almond	EPB		LPE	1	1800	5	2	100010	1
Glen Almond	EPB		?	1/60	1800	5	0	010011	?
Glen Almond	EPB		?	1/60	1800	5	1	010011	?
Glen Almond	EPB		?	1/60	1800	5	2	010011	?
LG2-1	SEBJ		SPZ	60	1200	6	0	01	1
LG2-2	SEBJ		SPZ	60	1200	7	0	01	1
LG2-3	SEBJ		SPZ	60	1200	8	0	01	1
Chalk River	AECL		SPZ	60	1200	9	0	01	1
Bancroft	AECL		SPZ	60	1200	10	0	01	1
Spare 1						11			
Spare 2						12			
Spare 3						13			
Spare 4						14			
Spare 5						15			

TABLE 1: ECTN-STATION DATA TABLE

Station Location	Funded By	Station Code	Component	Sample Rate(S/S)	Line Rate(Baud)	Input Channel	Order	Long. Code	Word Format
Victoria	EPB	VIC	SPZ	60	1200	0	0	01	0
Alberni	EPB	ALB	SPZ	60	1200	1	0	01	0
Haney	EPB	HNY	SPZ	60	1200	2	0	01	0
Pender Is.	EPB	PIC	SPZ	60	1200	3	0	01	0
Gulf Is.	EPB		SPZ	60	1200	4	0	01	1
Gulf Is.	EPB		SPZ	60	1200	5	0	01	1
Spare 1						6			
Spare 2						7			

TABLE 2: WCTN: STATION DATA TABLE


SPZ
OTTAWA VAULT (OTT)
MONTREAL (MNT)
EPB - BELL (GIDE7)
SPZ
MANIWAKI (MIQ)
EPB - BELL (GIDE7)
SPZ
HQ - BELL
HULL
SPZ
GENTILLY
HQ - BELL (SECTRAN)
HULL
RECEIVER
OTTAWA RX
SPZ
L&Z
UHF RADIO LINK
MICROWAVE RECEIVER SITE
HYDRO QUEBEC
HQ-BELL
HULL
SPZ
CHALK RIVER
AECL-BELL
SPZ
CHALCROFT
SPZ
CHATS FALLS
SPARE CHANNELS
MODEM CHASSIS #1
MODEM CHASSIS #2
LO GAIN
PDP11 - 15 SYSTEM
PDP11 - 40 SYSTEM
PATCH PANEL "A"
MICROPROCESSORS
1 2 3 4 5 6
PATCH PANEL "B"
HELICORDER PEN CAGE AMPS
MNQ
MIQ
L&Z
CHATS FALLS
L&Z
LINE MONITOR
GTQ
LO GAIN
?
MICROCOMPUTER BANK
fig 1
ECTN SYSTEM DIAGRAM
DRN BY
CH'D BY
DWG No.
MAT'L
No. REQ'D
CLASS
DATE

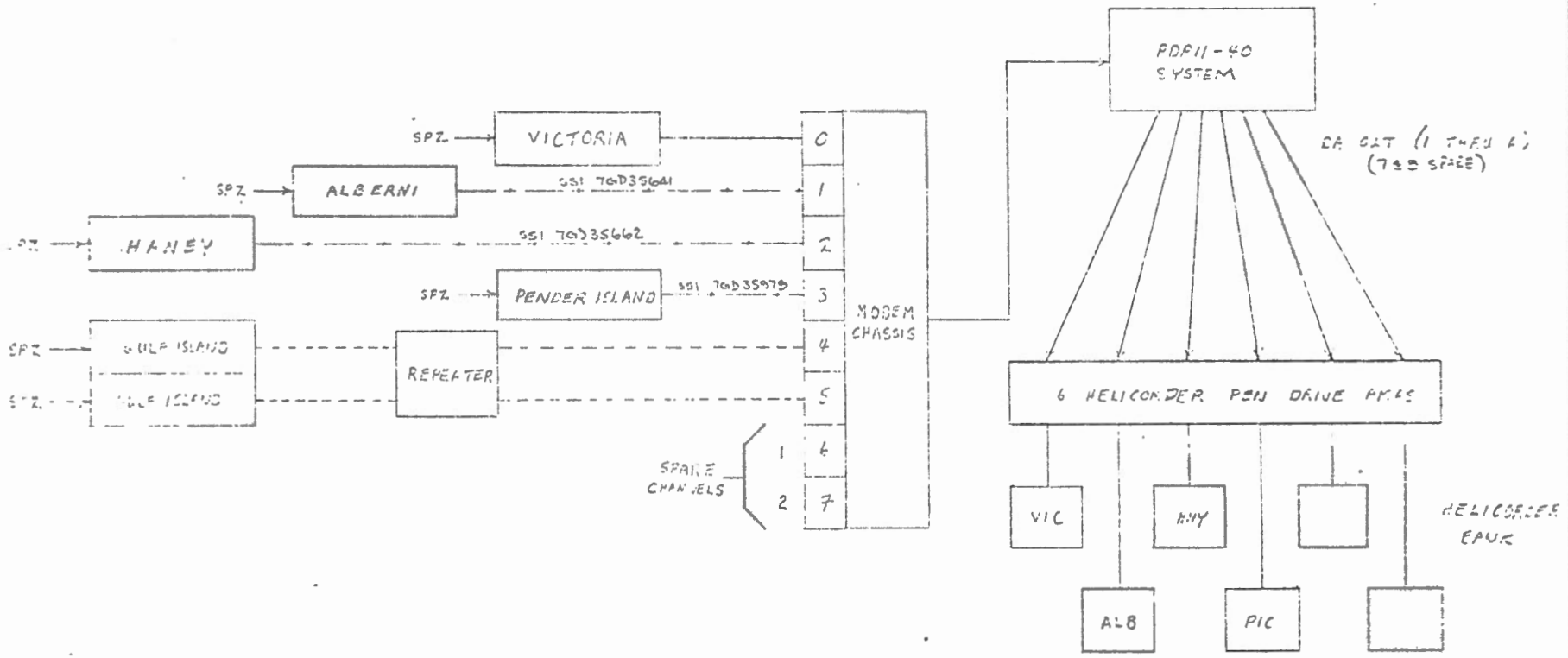


fig. 2.

WCTN SYSTEM DIAGRAM

DR'N BY		SCALE	
CH'D BY		DWG No.	
MAT'L	No. REQ'D	CLASS	DATE

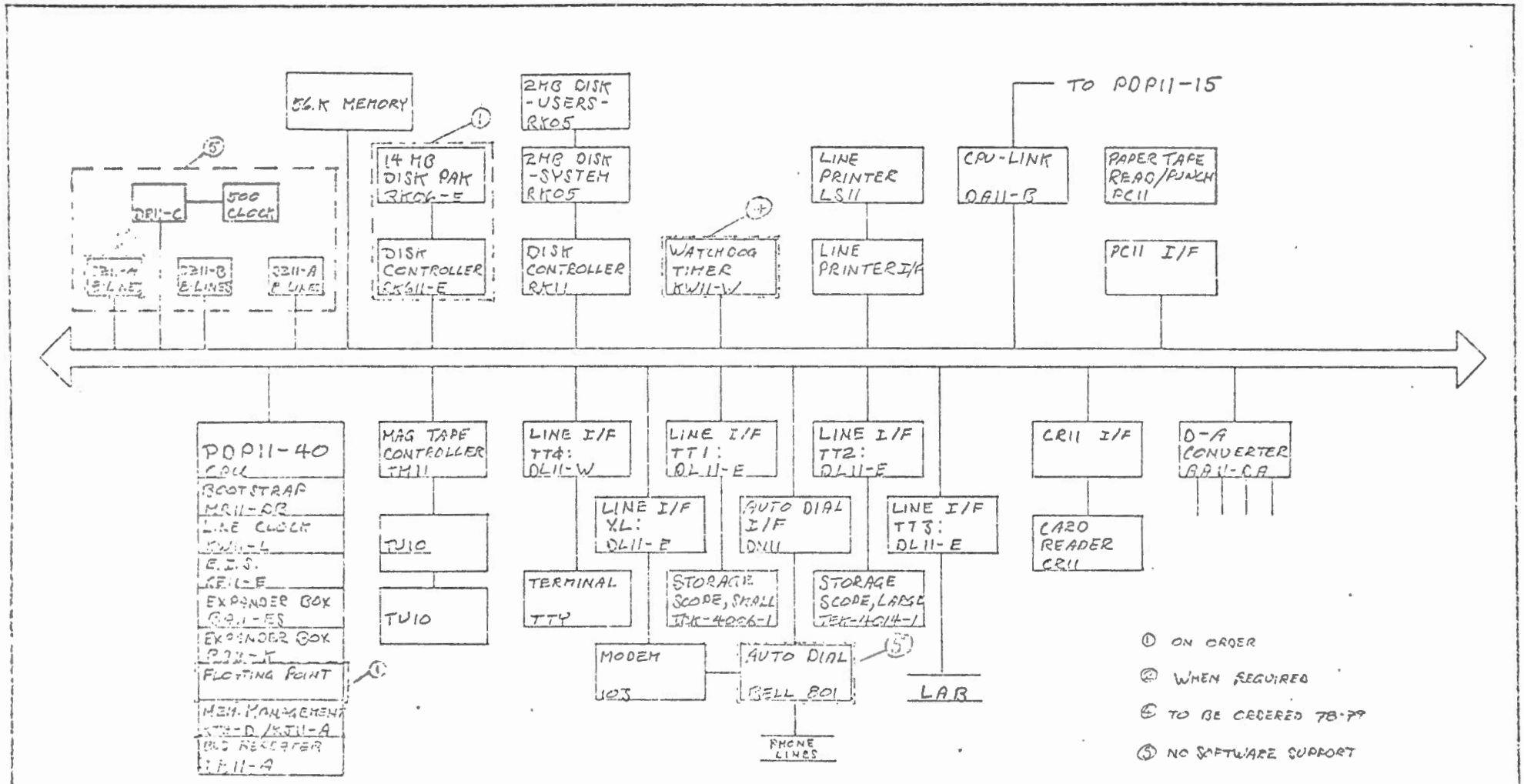


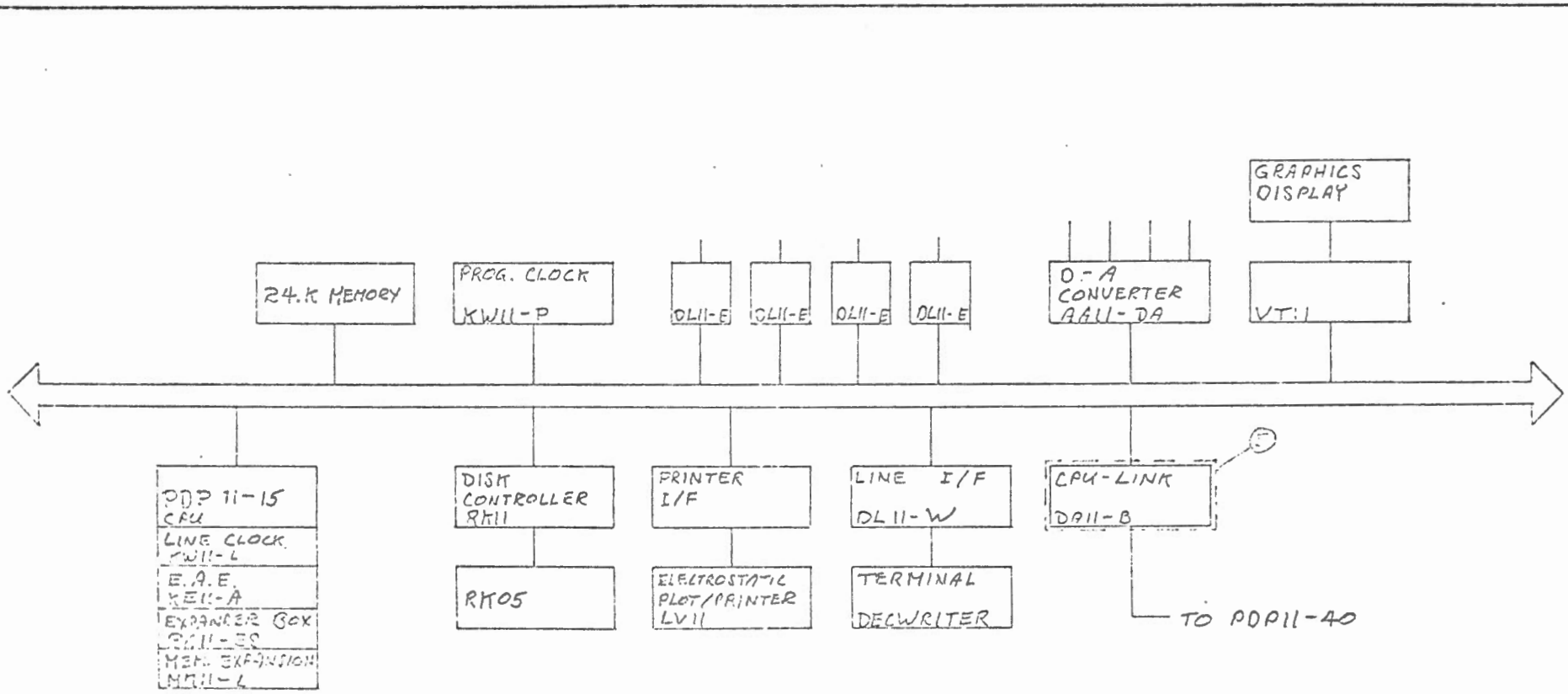
fig .3.

PDP11-40 COMPUTER SYSTEM OTTAWA

DR'N BY D.H | SCALE

CH'D BY | DWG. No

MAT'L | No. REQ'D | CLASS | DATE 24 FEB 78

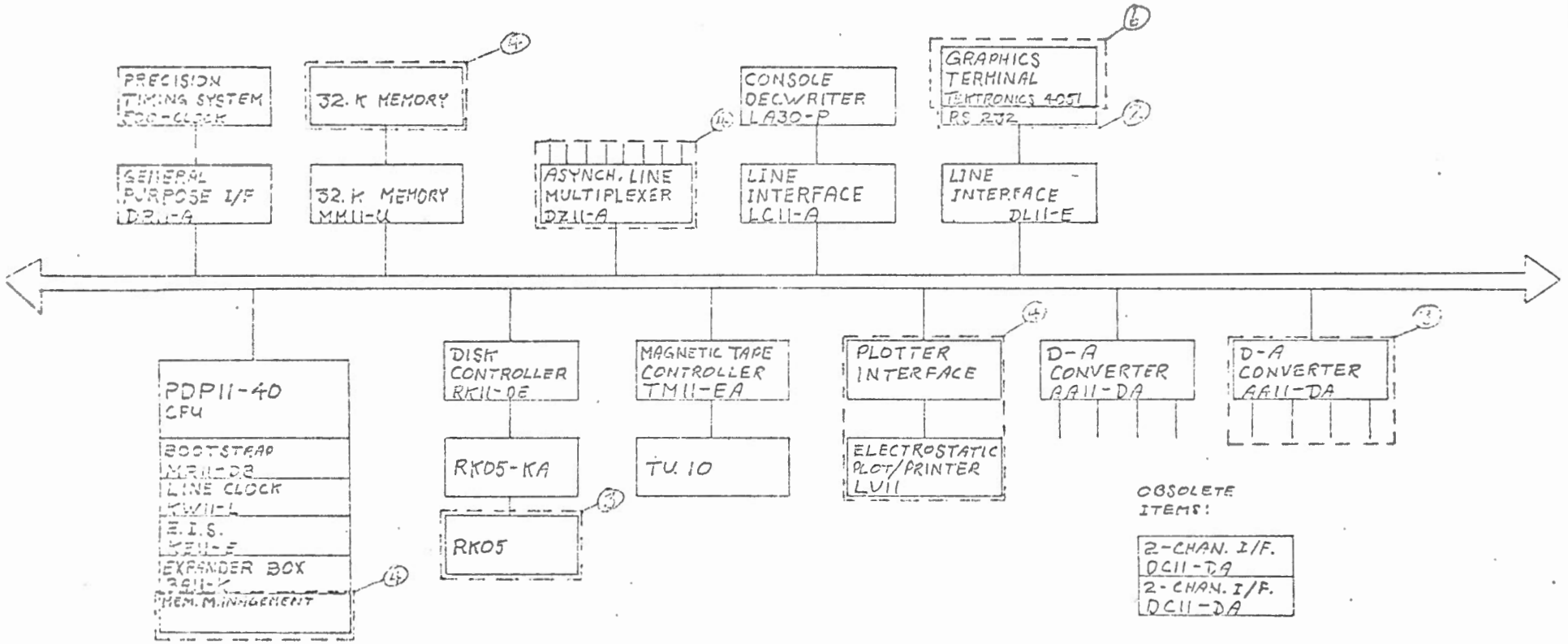


5 NO SOFTWARE SUPPORT

fig. 4.

PDP 11-15 COMPUTER SYSTEM
OTTAWA

DRN BY D. H.	SCALE
CH'D BY	DWG. NO.
MAT'L / No. REQ'D / CLASS	DATE 24 FEC 78



② WHEN REQUIRED

③ FROM OTTAWA

④ TO BE ORDERED 78-79

⑤ GECMAG

fig. 5.

PDP11-40 COMPUTER SYSTEM
VICTORIA

DR'N BY O. H.
CH'D BY
DATE 24 FEB 78
SCALE
DWG No.
MAT'L
No. REQ'D
CLASS

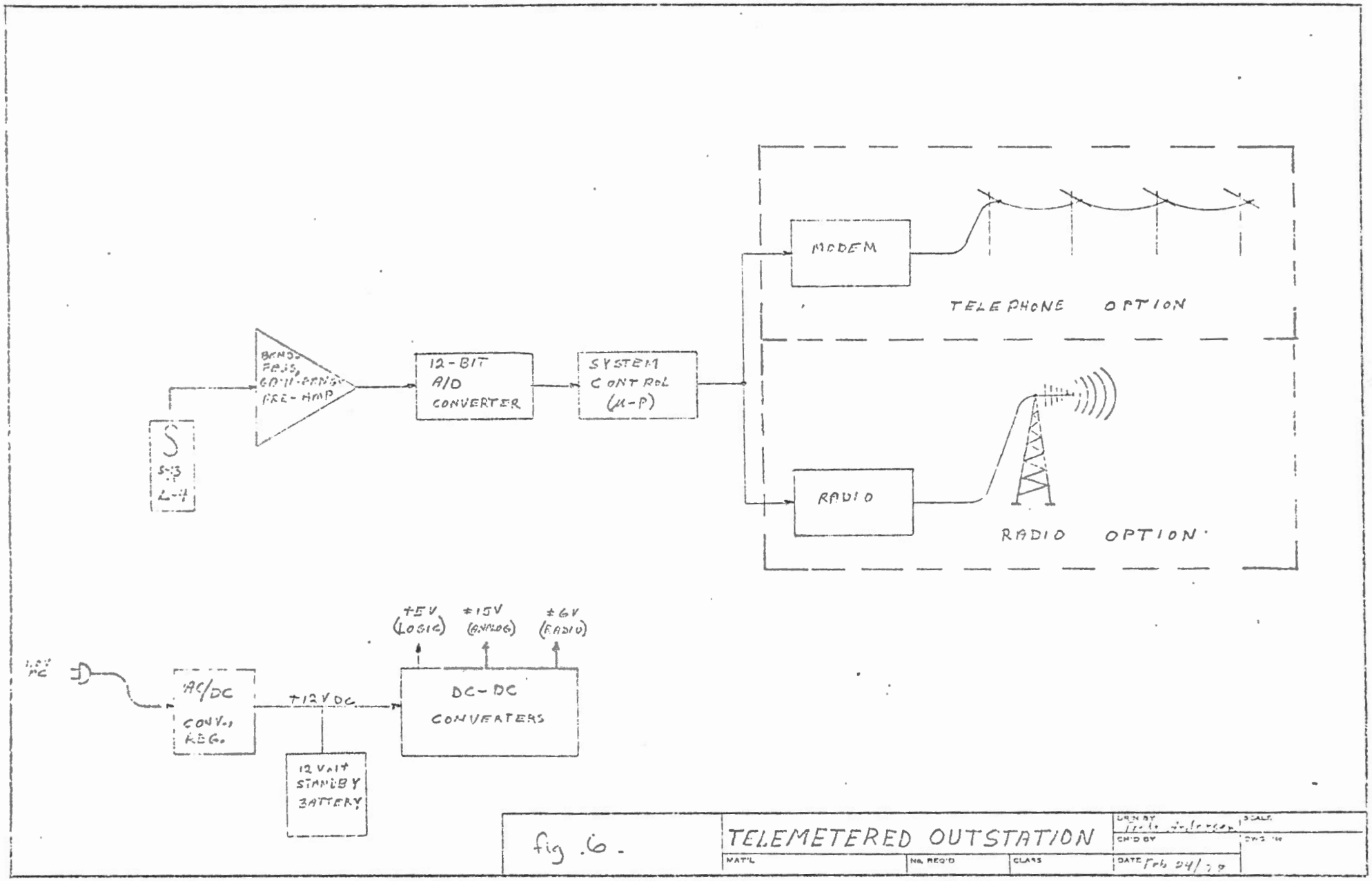


fig .6.

TELEMETERED OUTSTATION

DRN BY
CH'D BY
SCALE
DWG NO
MAT'L
NO. REQ'D
CLASS
DATE Feb 24/78

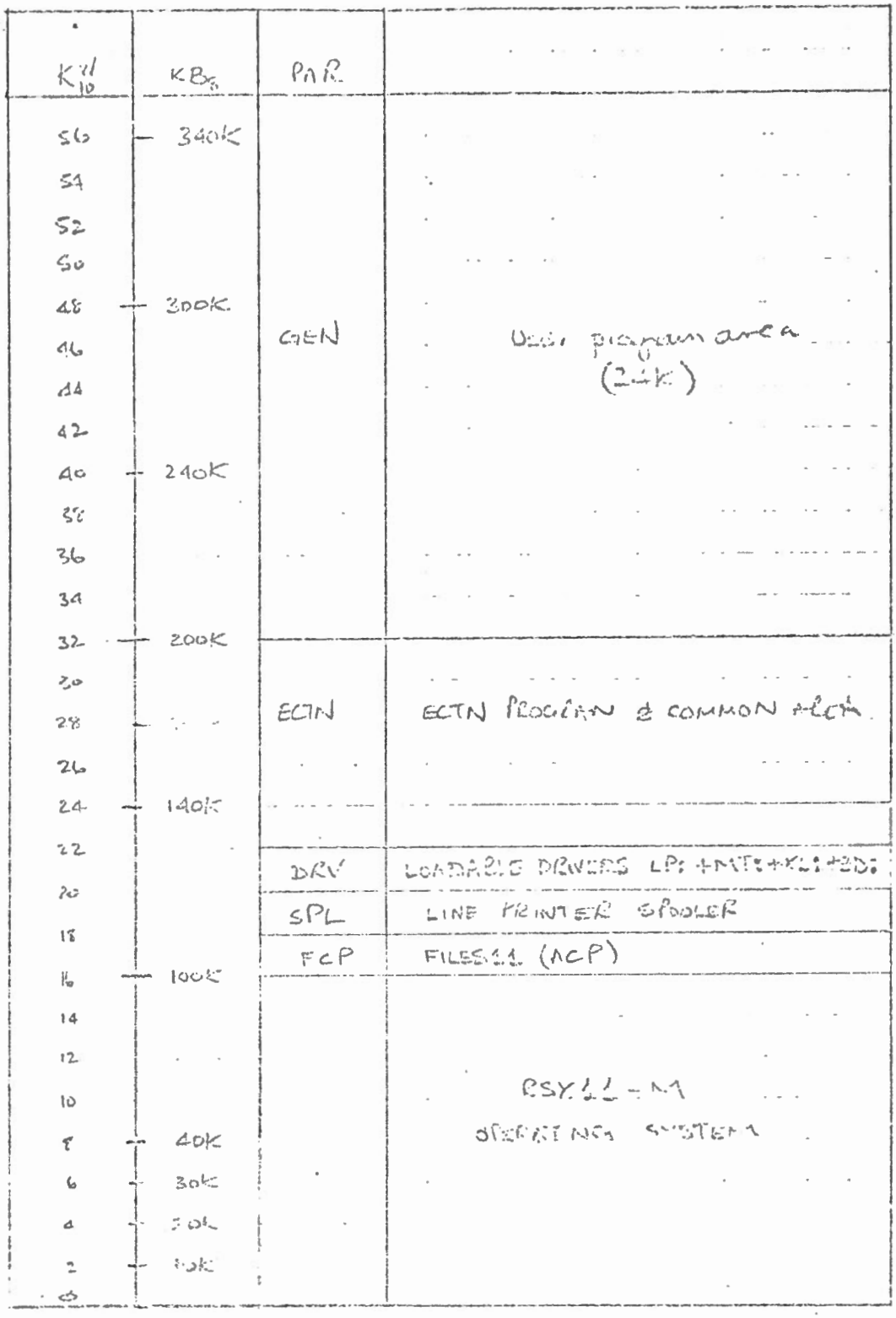


Fig. 7 MEMORY MAP: OTTAWA PDP11-40

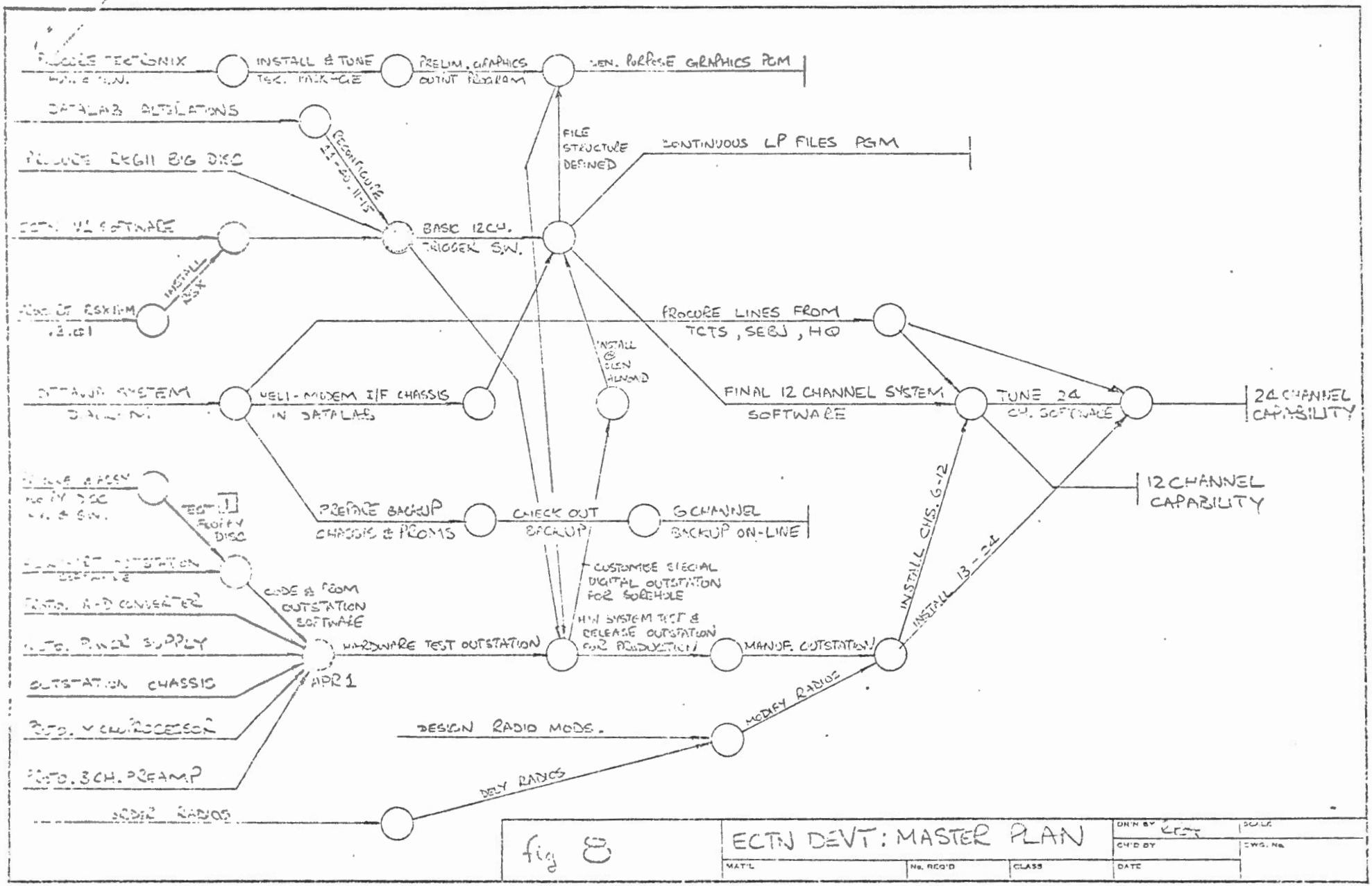


fig 8

ECTN DEVT: MASTER PLAN	DR'N BY ECET	SCALE
	CH'D BY	DWG. No.
MAT'L	No. REQ'D	CLASS / DATE

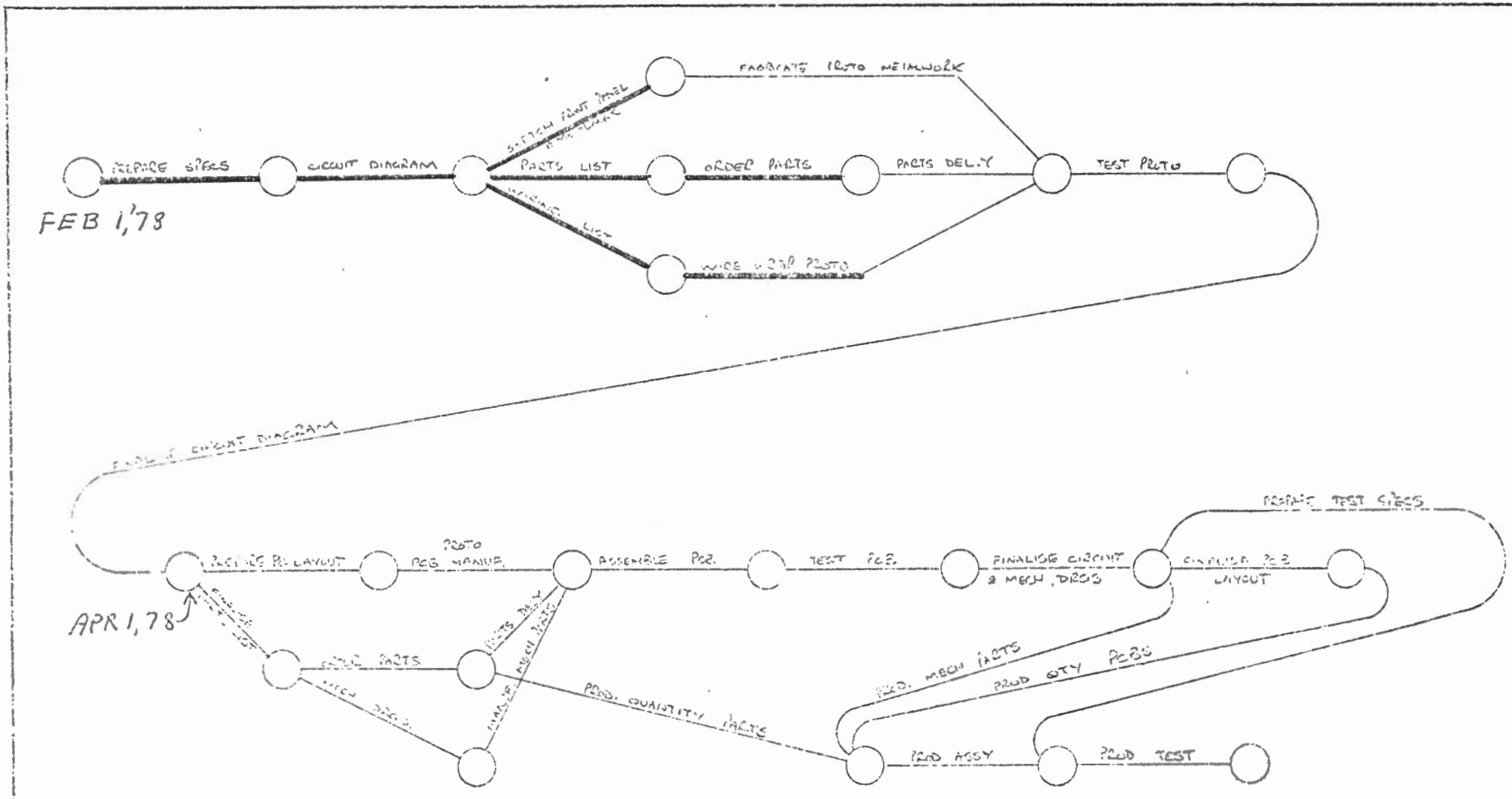


fig 10

CPU MODULE

MAT'L	No REQ'D	CLASS	DATE

DRN BY

CHK'D BY

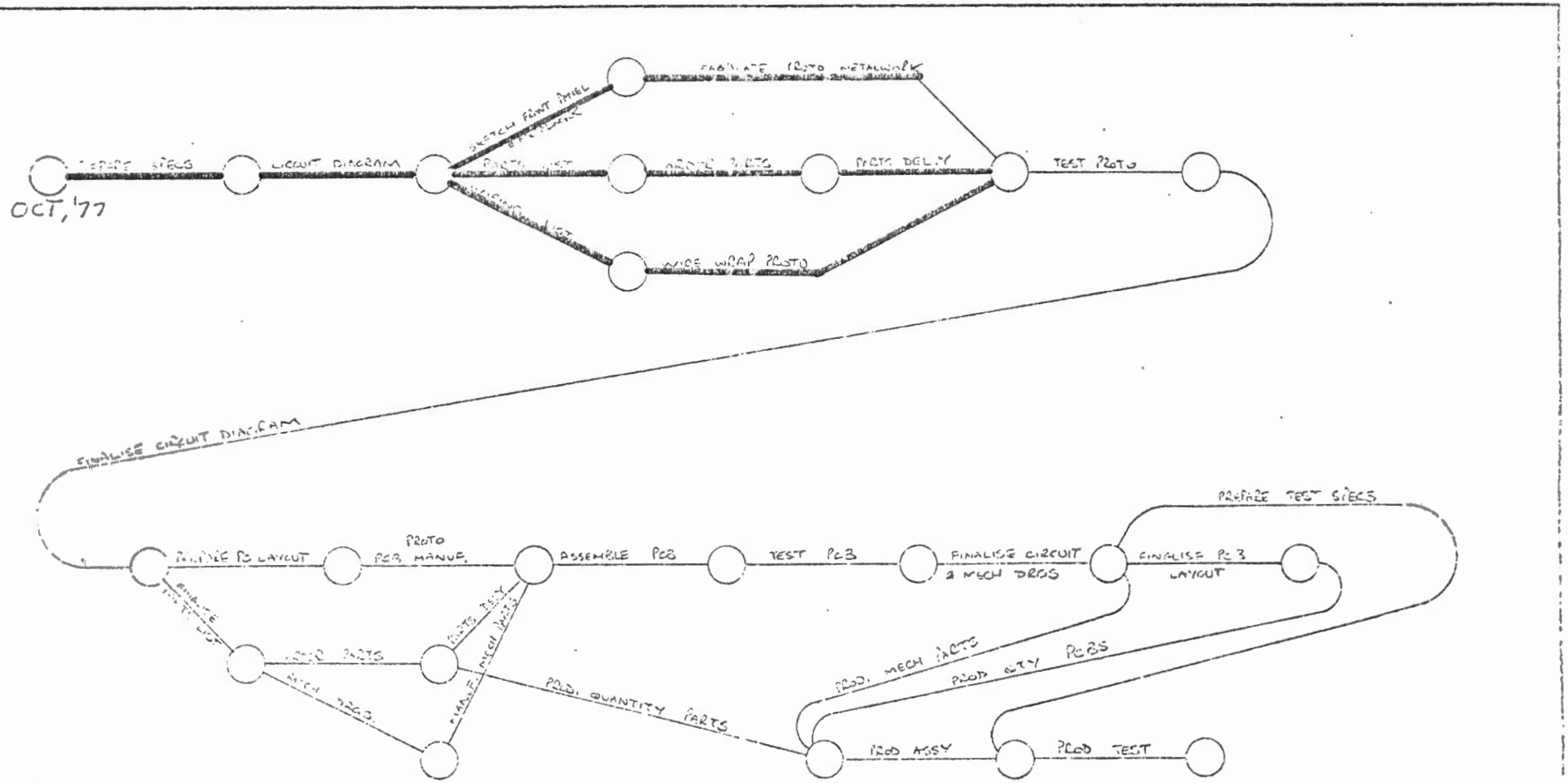


fig 11

ADC MODULE

MAT'L	No. REQ'D	CLASS	DATE

DR'N BY

CH'D BY

SCALE

NO.

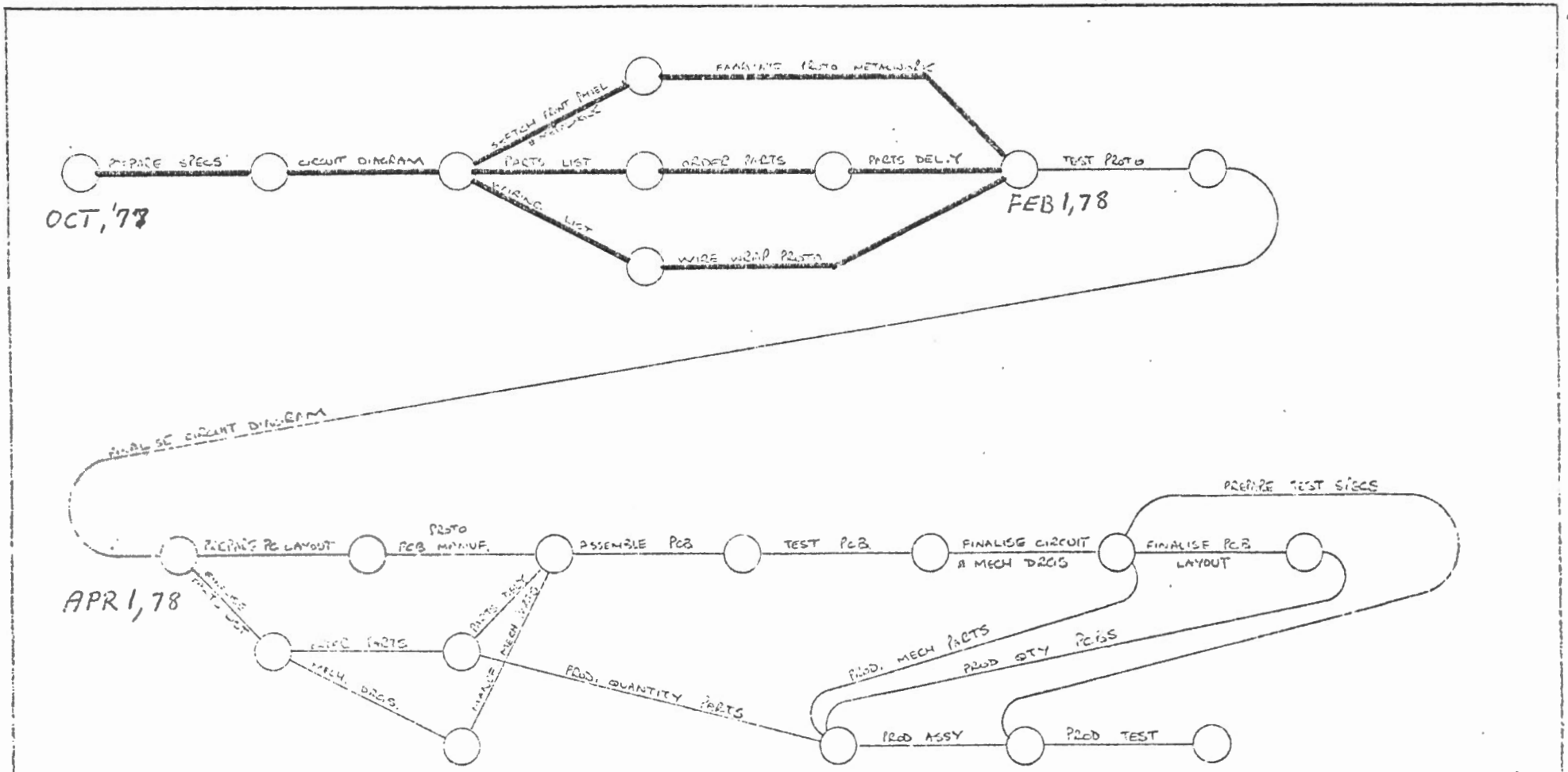


fig 12

KEYBOARD & DISPLAY

MAT'L	No. REQ'D	CLASS	DATE

DR'N BY

CH'D BY

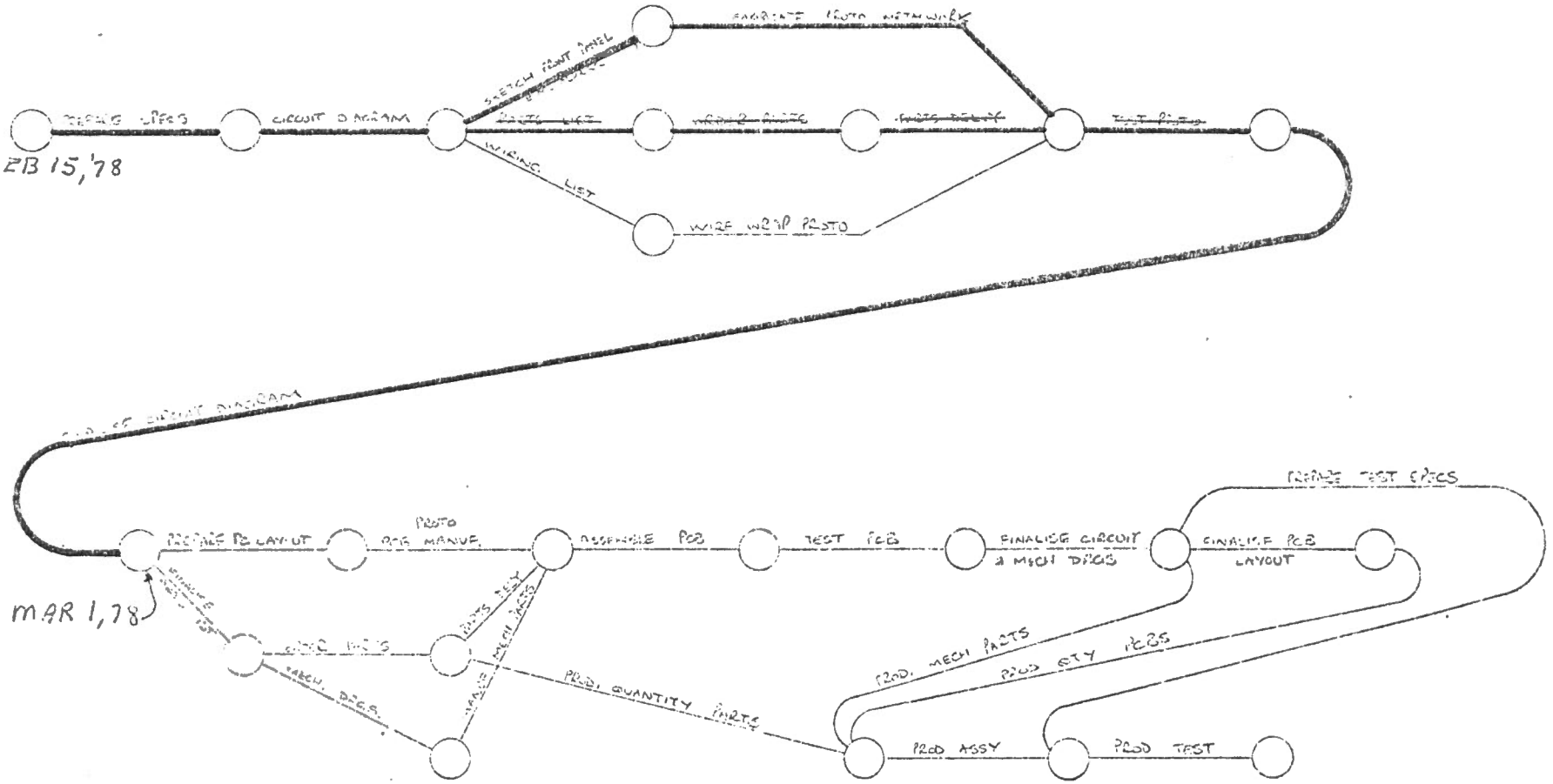


fig 13

PWR. SUP. MODULE

MAT'L	No. REQ'D	CLASS	DRN BY	SCALE
			CHKD BY	
			DATE	