AD-A009 109

RESEARCH IN MICROTERMINAL DEVELOPMENT AND NETWORK END-TO-END ERROR RECOVERY

Roland F. Bryan, et al

California University

Prepared for:

Advanced Research Projects Agency
Defense Supply Service

22 April 1975

134108

ARPA Order No: 2852
Program Code: 62706E
Grantee: The Regents of the University of California
Effective Date: 1 September 1974
Expiration Date: 30 June 1975
Amount of Grant: $124,962

Grant No: MDA903-75-G-2
Principal Investigator: Roland F. Bryan (805)961-3933
Title: Research in Microterminal Development and Network End-to-End Error Recovery
Date of Report: 22 April 1975
Period Covered in Report: January thru March 1975

Sponsored by
Advanced Research Projects Agency
ARPA Order No. 2852

CSL-50

SECOND QUARTERLY TECHNICAL REPORT
1/1/75 - 3/31/75

This research was supported by the Advanced Research Projects Agency of the Department of Defense under Grant No. MDA903-75-G-2.

i

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) University of California Santa Barbara, CA 93106	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

RESEARCH IN MICROTERMINAL DEVELOPMENT AND NETWORK END-TO-END ERROR RECOVERY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Second Quarterly Technical Report 1/1/75 - 3/31/75

5. AUTHOR(S) (Last name, first name, initial)

Bryan, Roland F.
Wells, Paul E.
McAfee, John H.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 22, 1975	~~21~~ 26	7

8a. CONTRACT OR GRANT NO. MDA903-75-G-2 b. PROJECT NO. c. ARPA Order No: 2852 d. Program Code: 62706E	9a. ORIGINATOR'S REPORT NUMBER(S) CSL-50 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES This research is supported by the Advanced Research Projects Agency.	12. SPONSORING MILITARY ACTIVITY Department of the Army Defense Supply Service-Washington Room 1D245, The Pentagon Washington, D.C. 20310

13. ABSTRACT

In Task I (Microterminal), we have pursued the implementation of a prototype terminal which will allow the direct replacement of new and more capable components as they become available. All prototype parts have been ordered except the housing and delivery of all parts should be complete by mid-April. A breadboard version is underway and the prototype is scheduled for completion before June.

Task II (End-to-End) work for this quarter has been absorbed by implementing the hardware for the processor pair which will be responsible for communication and error recovery. One processor is ahead of the other in fabrication and will be used for software development as soon as it is completed. Design of the first transmission program is already underway using another Network site.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Microterminal						
Portable Terminal						
Text Editing Portable Terminal						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ______________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ______________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ______________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

TABLE OF CONTENTS

COMPUTER SYSTEMS
LABORATORY--UCSB
15 April 1975

SECOND QUARTERLY TECHNICAL REPORT

RESEARCH IN MICROTERMINAL DEVELOPMENT AND NETWORK END-TO-END ERROR RECOVERY

I. SCOPE OF QUARTERLY TECHNICAL REPORT

Three separate subject areas make up the body of this quarterly report. These may be treated as the latest in a series of reports dealing with Task I of our project: Microterminal Research and Development. Included are:

1. Report #6 - Summary of Display Considerations, both past and through 30 March 1975.
2. Report #7 - Portable Intelligent Terminal Command Summary.
3. Report #8 - Prototype Power Sources, Specification and Diagrams.

Our Management Report for this same quarter conveys additional information as to Task II (End-to-End Error Recovery), project schedule, accomplishments, and major concerns.

II. REFERENCES

Previous reports which are supportive of material given in Section III include:

1. First Quarter Technical Report, Report #1, 12/9/74.
2. Prototype Terminal Display Selection, Report #2, 12/20/74.
3. Display for Prototype Vendor Summary, Report #3, 2/4/75.
4. Prototype Power Source, Report #4, 1/17/75.
5. Controller for Microterminal Prototype, Report #5, 2/26/75.
6. First Quarter Management Report, CSL-49, 2/28/75.
7. Second Quarter Management Report, CSL-51, 4/22/75.

III. REPORTS - Quarter ending 31 March 1975

COMPUTER SYSTEMS
LABORATORY--UCSB
Paul E. Wells
1 April 1975
Report #6

SUMMARY OF DISPLAY CONSIDERATIONS

OVERVIEW

An ongoing survey of display technologies applicable to the Micro-Terminal was started in the Fall 1974. The purpose of the survey being twofold:

1. Identify a company with a capability to supply a display within the time frame and cost constraint for the engineering model.

2. Monitor emerging display technologies which promised performance and/or cost advantages for future application.

The Micro-Terminal requires a multi-line display with a minimum of 40 characters per line. The 40 character line must not exceed 8 inches in length which dictates a maximum horizontal character pitch of 0.2 inches. The required vertical pitch is satisfied with the commonly used character aspect ratios based on the previously stated horizontal pitch.

Preliminary results indicated that a suitable display was not readily available as a standard product and must therefore be acquired on a custom basis. The preliminary results further suggested the following technologies as the most likely candidates:

1. Liquid crystals
2. Light emitting diodes
3. Gas discharge
4. Electroluminescent
5. Cathode ray tubes

LIQUID CRYSTAL DISPLAYS

The liquid crystal development effort encompasses varied approaches. The accompanying chart depicts the principal approaches with the associated company. Included in the chart are salient comments on each approach and the reason for rejection for incorporation in the engineering model. (See Appendix A chart for status of development as of the Fall 1974.)

LIQUID CRYSTAL DISPLAY TECHNOLOGY
Types: Dynamic Scattering & Field Effect
Modes: Reflective & Transmissive

Implementation Approaches

(1) Direct Addressed w/o Intrinsic Memory	(2) External Switch and Memory Element per Segment	(3) LSI Semiconductor Techniques/L.C. Electro Optical Elements	(4) Thin Film Semiconductor Techniques/L.C. Electro Optical Elements
Princeton Material Sciences Hughes	Princeton Material Sciences Itek	Hughes	Westinghouse
Advantages: 1. Simple Process. 2. Min. Associated Circuitry. 3. Potential for Low Cost. Disadvantages: 1. Requirement for exacting L.C. material properties. 2. Slow response time. 3. Requires Refresh. 4. Limited multiplexing capability	Advantages: 1. Requirement for exacting material properties reduced significantly from (1). Disadvantages: 1. Large number of high density interconnections. 2. Low character density.	Advantages: 1. High character density. 2. L.C. Material requirement same as (2). Disadvantages: 1. Complex batch process.	Advantages: 1. Potential for high character density 2. L.C. Material requirement same as (2). Disadvantages: 1. Complex batch process.
PMS - Delivery Hughes - Cost	PMS - Character Density Itek - Character Density	Cost & Delivery	Cost & Delivery

CURRENT STATUS OF LIQUID CRYSTAL DISPLAY DEVELOPMENT

Direct Addressed Type

Princeton Material Sciences--Indeterminate

Hughes--Development work in this area is being continued with the following significant results:

1. Multiplexing capability extended from 7 lines to 14 lines
2. Verbal expression of confidence in supplying a 2 line 40 character line module with an overall length of less than 5 inches and stackable in the vertical dimension.

External Switch/Memory Element Per Segment

Princeton Material Sciences--Indeterminate

Itek--The Itek effort is aimed at a particular display requirement apparently in the military area. Itek has considered extending the low end of the operational temperature range by incorporating heaters. Low power electroluminescent light sources have been considered for use in low intensity ambient light.

Itek personnel feel that they can now achieve a horizontal character pitch of 0.2 inches which satisfies our minimum requirement. The Itek approach is a solid one but affords little hope of a significant advance in character density.

LSI-Semiconductor Techniques/L.C. Electro-Optical Elements

Hughes--The work has been extended to include silicon or sapphire technology which affords the following advantages over the bulk silicon approach:

1. Increased element density
2. Reduced process complexity
3. Reduced light sensitivity
4. Transmissive mode of operation.

It is important to note that the main thrust of this effort is in the area of T.V. type displays.

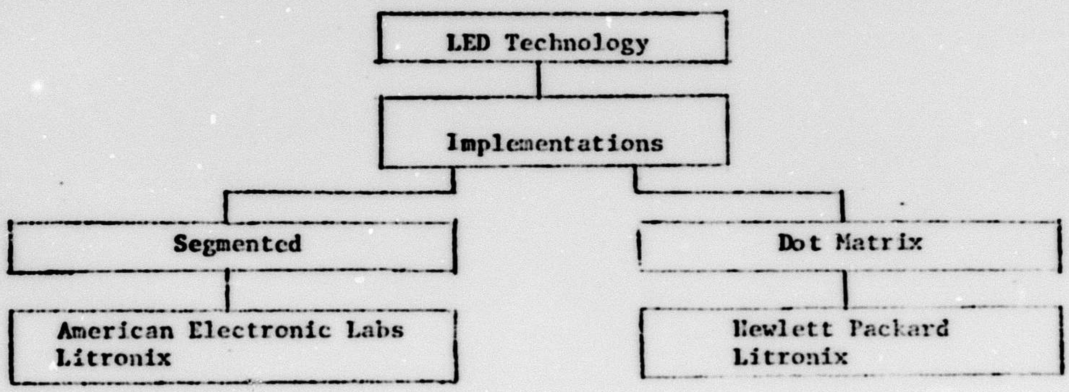
Thin-Film Semiconductor Techniques/L.C. Electro Optical Elements

Westinghouse--The Westinghouse Display Effort is being continued and has yielded an x-y addressable array of thin film transistors with intrinsic memory.

LED DISPLAY TECHNOLOGY

LED display technology is not in general use in large capacity displays due to the high power consumption of the LED display element. However for portable equipment requiring a modest number of characters as in the Micro-Terminal, the LED on balance competes rather favorably with presently available display technologies.

The accompanying chart depicts in very elemental fashion the findings of the survey in the Fall 1974.



The AEL device was selected for use in the engineering model for the following reasons:

1. The Micro-Terminal display requirement could be satisfied by modification of an AEL standard product
2. The display was acceptable in terms of power consumption, size, weight, form factor
3. The unit could be delivered within the required time frame and cost constraint.

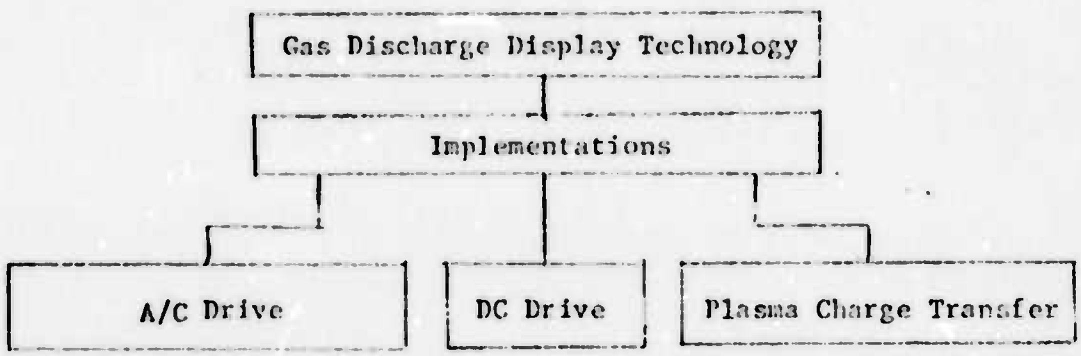
CURRENT STATUS OF LED DISPLAY DEVELOPMENT

No truly significant advances have been made in this area. HP will begin delivery of a 4 character stackable module on a sample basis within the next few months. Power consumption is estimated to be approximately 100 mw per character.

GAS DISCHARGE DISPLAY TECHNOLOGY

The primary characteristics of Gas Discharge Displays available in the Fall 1974 are summarized in Appendix B. The development effort in most companies was directed toward a standard product line exhibiting fixed formats and capacities. Companies expressed little or no interest in doing custom work.

The chart below depicts the basic implementations employed in flat panel alphanumeric Gas Discharge displays.



Gas Discharge Displays were eliminated for use in the engineering model on the basis of power consumption, character density (size), weight, and availability.

<u>Current Status of Development</u>

Recent work by National Electronics and Owens Illinois is directly applicable to the display requirements of the Micro-Terminal.

National has responded to a procurement enquiry. The information submitted was favorable in terms of power consumption of the display element but inadequate to determine power consumption at the system level. Additional information has been requested.

The recent work of Owens-Illinois will be described in a paper being presented at the U/M-SID Seminar at College Park, Maryland on Thursday, April 24, 1975. The title of the paper, "A Shift-Logic Plasma Display/Memory Unit." This technique will be evaluated against the specific display requirements of the Micro-Terminal.

Electroluminescent Display Technology

The work of interest in the above technology is being conducted primarily at the Westinghouse Research Laboratories. Westinghouse has been contacted and their effort is being monitored.

Their most recent effort combines electroluminescent phosphorus with thin film Cdse field effect transistors. The thin film transistor is a floating gate structure with intrinsic memory. The transistor provides both the selection and memory function yielding a simpler display from an operational viewpoint. This implementation can also be realized with liquid crystal electro optical elements.

The above implementation though attractive presents some tough process problems. The time frame for realization of this type of display is difficult to predict.

Cathode Ray Tube Technology

Cathode Ray Tube displays are clearly the best understood of the available display technologies in terms of capability as well as limitations. CRT displays exhibit a good figure of merit when viewed with regard to power consumption per character (estimated at 25-50 mw in a well designed system). Form factor is the key drawback for use in the Micro-Terminal.

Monitoring of this technology is being continued.

TECHNOLOGY LIQUID CRYSTAL, TYPE: DYNAMIC SCATTERING, MODE: REFLECTIVE --APPENDIX A--

AVAILABILITY	DELIVERY ≤ 4 MONTHS			DELIVERY ≤ 12 MONTHS	
COMPANY	ITEK	PRINCETON MAT. SCIENCE	HUGHES	HUGHES	PRINCETON MAT. SCIENCE
GENERAL CHARACTERISTICS:					
Display Organization					
Character Capacity	480	80	40	280	80
Display Format - Lines x Char/Line	10x48	2x40	1x40	7x40	2x40
Character Format	14 seg. starburst	14 seg. starburst	5x7 dot matrix	5x7 dot matrix	5x7 dot matrix
Character Size -WxH (in)	0.20x0.31	0.1x0.2	uns.	uns.	uns.
Character Linear Density - (H,V)/in	4.0,2.0	3.0,2.0	8,1	10,7	10,4
Optical Data					
Contrast Ratio - Typical	20:1	20:1	uns.	uns.	uns.
Color (Char)	Light Gold	Black	Black	Black	Black
Brightness	N.A.	N.A.	N.A.	N.A.	N.A.
Viewing Angle	45° Cone	uns.	uns.	uns.	uns.
ELECTRICAL CHARACTERISTICS:					
Interface					
Logic Levels	CMos-Type B	CMos, T^2L	CMos, T^2L	CMos, T^2L	CMos, T^2L
*Power Requirements	240-MW	40 MW	20 MW	140 MW	80 MW
Voltage Levels	+15.	+(2-8)	uns.	uns.	uns.
*Mili-Watts/Char-Typical	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5
Drive Requirements-IC Compatible	yes	yes	yes	yes	yes
PHYSICAL CHARACTERISTICS:					
*Dimensions - LxHxT (in)	14x5x2	13x2x1	6x1x1	4x2x1	4x1x1
*Weight (lbs)	3-4	≤0.75	≤0.5	≤0.5	≤0.5
ENVIRONMENTAL:					
Operating					
Temperature (°C)	0→50	(-5)→(+65)	uns.	uns.	uns.
Humidity	Mil. Stnd 202 Method 103	uns.	uns.	uns.	uns.
Storage					
Temperature (°C) & Humidity	Mil. Stnd 202 Method 103	uns.	uns.	uns.	uns.
PRIMARY FEATURES:					
Drive Electronics	Included	Can supply	Included	Included	Can supply
Modularity (H,V)	4-Char, 1-Line	3-Char, 1-Line	uns.	uns.	uns.
Potential for Further Development	Nil	Nil	Yes-Material properties improve: TSW, Threshold Dev. Material with Memory	Yes-Improve Process & Materials	Yes-Material Improvement
Potential for Reduced Cost	Moderate	Moderate	Good	High	Good
COMMENTS:					
Primary Problem Area	Interconnections: Drive Electronic to character segments	Interconnections: Drive Electronics to character segments	Requirement for exacting material characteristics	Complex batch process yield must be consistent with cost constraint	Requirement for exacting material characteristics

NOTES: *Indicated values were either computed or conservatively estimated on the basis of company furnished data.

Companies other than those appearing in the table were contacted. The companies shown in the table appeared to be in the best

CODE:
uns. = unspecified
N.A. = not applicable

TECHNOLOGY - Gas Discharge

COMPANY	BURROUGHS	BURROUGHS	OWENS-ILL	OWENS-ILL	NIPPON ELECTRONICS	IEE	NATIONAL ELECTRONICS	BECKMAN
GENERAL CHARACTERISTICS:								
Display Organization			80/33	512/60				
Char Capacity	256	36	336	4335	256	256	Custom	
Display Format	8 x 32	1 x 36			8 x 32	8 x 32		
Char Format	5 x 7	5 x 7	5 x 7	5 x 7	5 x 7	5 x 7	5 x 7	
Char Dimn	0.[illegible] x 0.28	0.14 x 0.28	0.135 x 0.195	0.077 x 0.112	0.180 x 0.267	0.213 x 0.3	0.130 x 0.190	
Char Linear Density(H,V)	3.6, 2.5	6, 2.5	6, 3.3	10, 6	4, 2.6		6.4, 3.3	
Modularity								
Optical Data								
Contrast Ratio	20:1	uns	20:1	20:1	30:1	uns	50:1	
Viewing Angle	113°	uns	160° max	160° max	120°		150°	
Color	Neon-Orange	Neon-Orange	Neon-Orange	Neon-Orange	Neon-Orange			
Brighness (nominal) (Ft-L)	25	Per Dot = 40						
ELECTRICAL CHARACTERISTICS:								
Interface Logic Levels	T^2L	T^2L	T^2L	T^2L	T^2L			
Power Requirements (Watts)	31.6	8.9	104	287.5	42.5			
Voltage Levels	5, 30, -12, -250	5, -12, -250	115 AC + Power Pack	115 AC + Power Pack	+12, +5, -12, -5, +145		200, 160, +5, ±12	(4 or 5)-250
Current (amp)	2.5, 0.040, 0.24, 0.05	0.16, 0.050, 0.030	0.9	2.5	0.15, 2.0, 0.1, 0.1, 0.2			
Mili-Watts/Char	123.5	247.0	297	72	166	71(?)		50 (display only)
I.C. Compatible	yes	yes	yes	yes	yes			
PHYSICAL CHARACTERISTICS:								
Dimensions (LxWxT)	11.8 x 6.5 x 3.75	8.5 x 2.25 x 1.34	11.8 x 5.44 x 4.12	16.5 x 15.5 x 7.12	14 x 7 x 3	11.7 x 5.4 x 4.3	(2 x 80) 4 x 40 12 x 2.0 x 2, 6 x 2.5 x 2.0	
Weight (lbs.)	uns		Display=7, P.Pac=5	Display=33, P.Pack=17			5	
ENVIRONMENTAL:								
Operating								
Temperature	0-50	0-50	0-50	0-50	0-50		(-5)-70	0-50
Rel. Humidity	0-85%	0-85%	uns	uns	0-85%		uns	
Storage								
Temperature	0-70	-40-85	(-62)-(+85)	(-62)-(+85)	0-70		uns	
Rel. Humidity	0-85%	0-85%	uns	uns	0-85%		uns	
PRIMARY FEATURES:								
Drive Electronics								
Modularity								
Potential for Further Dev.								
Life							>10,000 Hrs.	
Potential For Reduced Cost								
COMMENTS:			The second number given in the weight (7+5 or 33+17) is the weight of the Power Pack that comes with the display.				Would like to supply display without electronics.	Some experimental work in large A/N displays. Willing to do custom work. Major emphasis is on small numeric displays.

NOTE: For all sources except IEE - The dimensions for width, height, and thickness are for the display and its housing since all electronics are included.

COMPUTER SYSTEMS
LABORATORY--UCSB
1 April 1975
John H. McAfee
Report #7

PORTABLE INTELLIGENT TERMINAL COMMAND SUMMARY

PROM Bootstrap

T --Bootstrap up from cassette tape.

Ø --Run as an on-line terminal and bootstrap up from communications interface if escape character is received.

X --Execute program bootstrapped in or left in memory from previous run.

Editing Monitor

Ø --Open tape file (displays name of file).

C --Close file (tape or memory file).

E --Edit file (go to editor level). If no file open, creates null memory file.

T --Transfer files over communications link (Go to on-line level.)

P --Purge tape file.

R (record #) --Retrieve tape record (page of tape file).

S (record #) --Store memory file on tape. (Updates old or creates new page of tape file.)

Editor

↑C--Go back to Editing Monitor.

↑A--Delete previous character.

↑B--Delete next character.

↑U--Delete back to beginning of line.

↑V--Delete forward to end of line.

UP--Scroll cursor up, towards beginning of file (display scrolled down).

DØWN--Scroll cursor down, towards end of file (display scrolled up). (Note: UP and DØWN scroll a single display line, not necessarily a full text line, when button first pressed. If button held down longer than a short delay, begins scrolling at a fixed readable rate. ↑UP and ↑DØWN provide rapid scrolling capability.)

Shift UP--Scroll cursor left on current display line.

Shift DØWN--Scroll cursor right on current display line. (Note: Shift UP and Shift DØWN move cursor a single character position when first depressed. If button held down longer than a short delay, begins continuous scrolling to beginning or end of the display line.)

<u>ØN-LINE Terminal</u>

Sends keys out to communications interface and displays incoming information. The details for the file transfer have not been worked out yet. An escape key from the keyboard will allow for local commands (such as half or full duplex, jumping back to Editing Monitor, or possibly beginning file transfer in or out). Also, an escape character being received may delimit file transfer operations.

Two alternatives are currently being considered for the file transfer:

1. An escape key followed by local commands may initiate the transfer which will then be controlled by the local process.
2. Commands sent to the remote process initiate the transfer which is then controlled by the remote process (communicating with the local process via an escape code).

Note: The single button commands may be changed or replaced by multiple key mnemonics.

COMPUTER SYSTEMS
LABORATORY--UCSB
23 April 1975
Microterminal Report #8
Paul E. Wells

PROTOTYPE POWER SOURCES- SPECIFICATIONS AND DIAGRAMS

1.0 SYSTEM POWER ALLOCATION PROTOTYPE UNITS

SUBSYSTEM	POWER-(WATTS)	LEVEL-(V)	CURRENT-(AMPS)	TOTAL SUBSYSTEM POWER-(WATTS)
Terminal Controller				13.895
Micro-Processor	1.000	+5	0.200	
Memory	1.000	+5	0.200	
Control & I/O	0.500	+5	0.100	
	1.200	+12	0.100	
Display	9.000	+5	1.800	
	0.600	-12	0.050	
Keyboard	0.175	+5	0.035	
	0.420	-12	0.035	
Tape Unit				4.000
Logic	1.000	+5	0.200	
Servo	1.750	+5	0.350	
R/W Circuits	1.250	-5	0.250	
Acoustic Coupler				4.900
	2.500	+5	0.500	
	1.200	+12	0.100	
	1.200	-12	0.100	

Note: The allocated power levels are not a true measure of equipment average power consumption.

2.0 POWER-PACK IMPLEMENTATION

The implementation of the Power-Pack is based on components which are available within a practical time frame. The development effort of commercial manufacturers in the battery area, and NASA in the converter area, suggests the possibility of substantial improvement in future power-pack designs.

2.1 DESIGN CONSIDERATIONS

The following Power-Pack implementation options were considered:

1. Single battery in combination with a series regulator and a multiple output DC/DC converter supplying all subsystems.
2. Separate power-packs, implementation as stated above, for each major subsystem.

Option 2 was selected for the following reasons:

1. DC/DC converter required for option 1 was not available.
2. Relaxed packaging constraints.
3. Allows independent testing of each major subsystem

Block diagrams are shown below. The indicated current is a capability level.

The series regulator design is quite straightforward and the efficiency should be approximately 80%. The high conversion efficiency is the result of the small difference between Vin and Vout over the usable portion of the battery discharge curve. (See Typical Discharge Characteristic of Ag-Zn Cell.) The converters are available as off-the-shelf items. The reflected ripple from the converters is of some concern, but should present no problem if the units conform to published specifications.

Considerable engineering effort has been expended in the space program toward the development of high efficiency power converters. In the 3 watt range the pseudo-saturating core technique is quite effective. Efficiencies of approximately 80% were achieved over the power range of 0.7 to 3.0 watts. Since either option requires a converter, some engineering effort in the converter area is probably warranted in order to optimize the design of the power-pack (future work).

A minimal effort was expended in the area of switching type regulators. Switching type regulators are more complex than the conventional series regulator and offer no significant advantages in low power systems where Vin-Vout is $\leq 1.5V$.

2.2 BATTERIES

The batteries are manufactured by the Yardney Electric Corporation. Each battery is comprised of four rechargeable high energy density silver-zinc cells.

Terminal Controller

Cell Capacity-(A-Hr @ 10 Hr Discharge Rate)	:	20
Battery Capacity-(Avg. W-Hr)	:	121
Battery Size - (in.)	:	4.94x9.24x0.80
Battery Weight - (lbs.)	:	2.5
Battery Discharge Curve	:	See Typical Discharge Characteristics*

Tape Unit

Cell Capacity -(A-Hr @ 10 Hr Discharge Rate)	:	6
Battery Capacity - (Avg. W-Hr.)	:	36.6
Battery Size - (in.)	:	1.72x3.36x0.59
Battery Weight - (oz.)	:	14.4

Acoustic Coupler - same as Tape Unit

2.3 DC/DC CONVERTERS

The converters are off-the-shelf commercial grade units. The units incorporate current limiting. Overvoltage protection must be added to each voltage level.

Terminal Controller

Semiconductor Circuits, Inc. Model No. 30C5-12D125

Capacity - (Watts)	:	3
Weight - (oz.)	:	3
Size - (in.)	:	1.5 x 2.0 x 0.4

Tape Unit

Technetics Model 1305-105

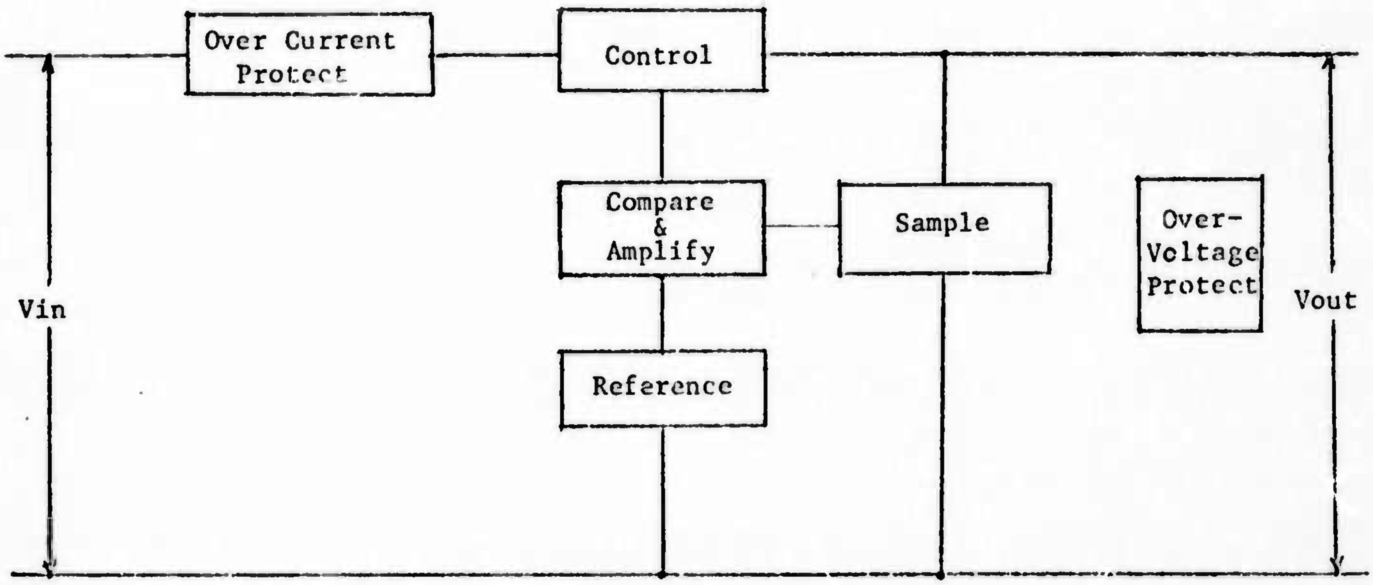
Capacity - (Watts)	:	3
Weight - (oz.)	:	6
Size - (in.)	:	2.125x2.35x0.812

Acoustic Coupler - same as Data Terminal

*See Report #5.

2.4 D-C VOLTAGE REGULATOR

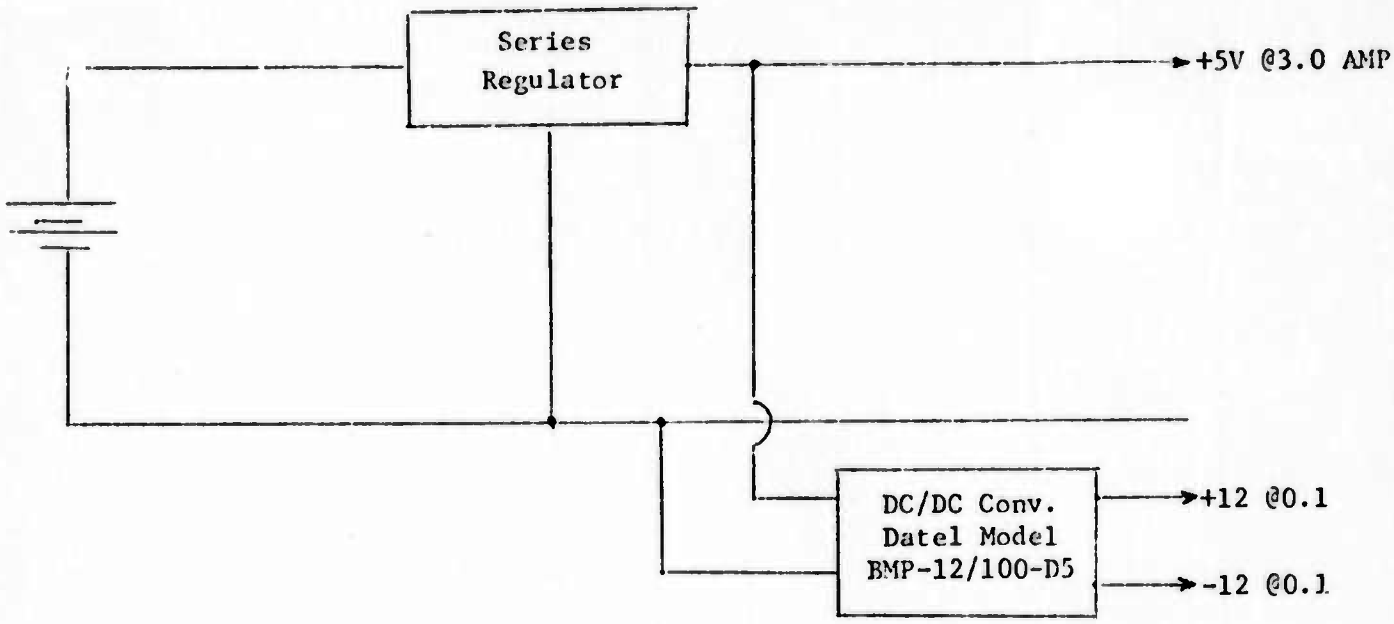
The D-C Voltage Regulator is a conventional Series Type regulator. (See block diagram.)



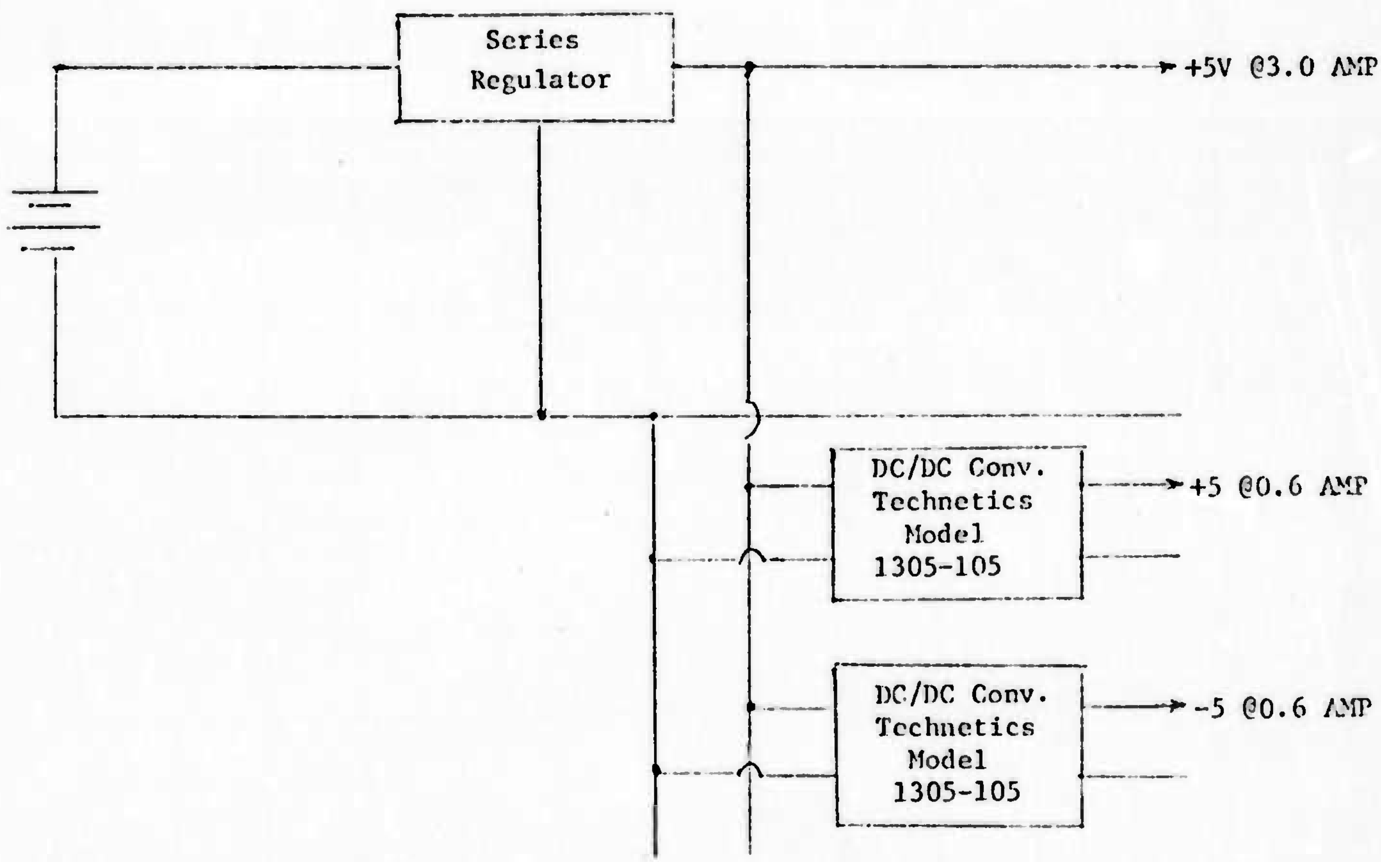
Block Diagram - Series Regulator

3.0 CROSS-REFERENCE TO ALTERNATE BATTERIES

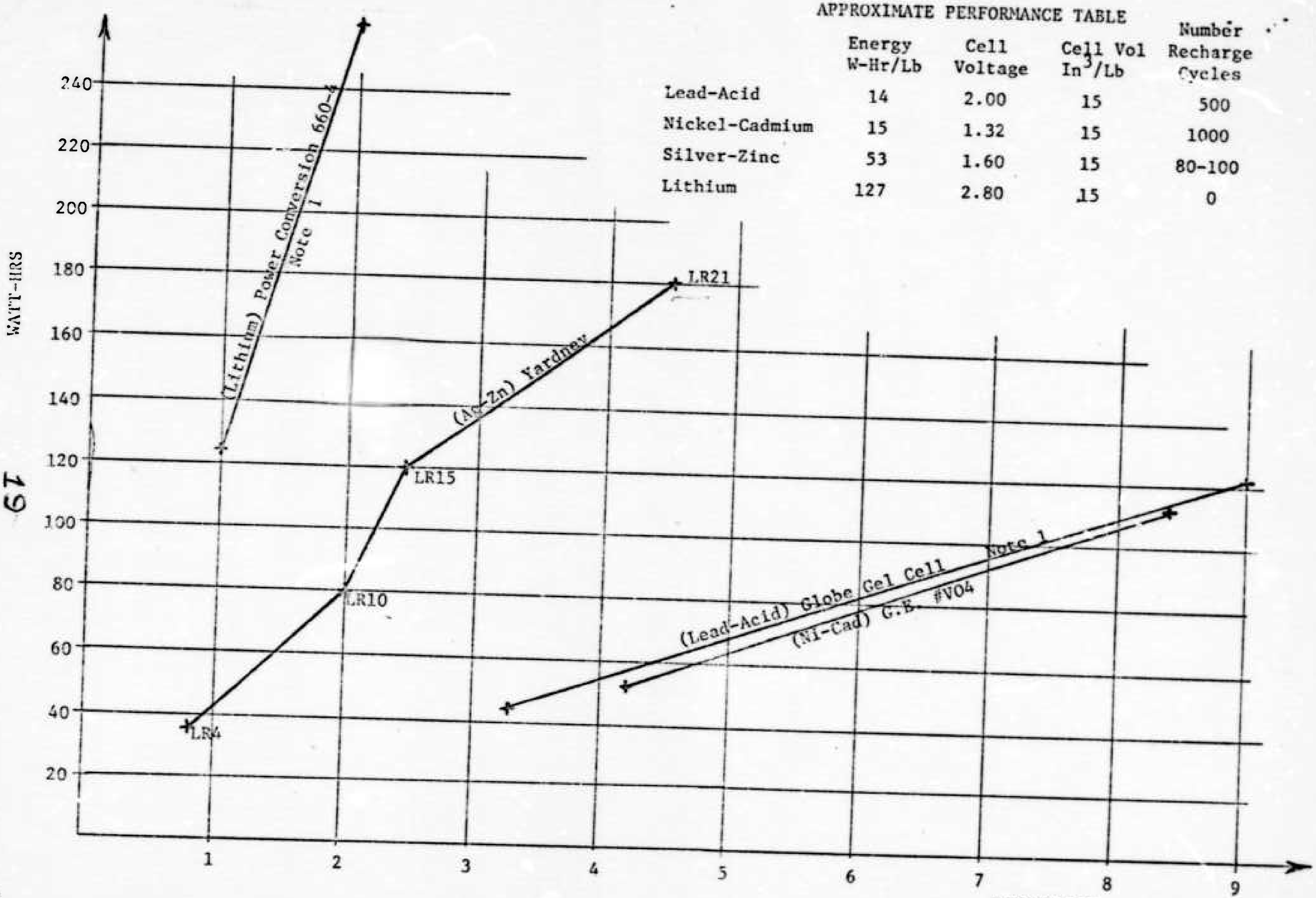
The chart (next page) illustrates the differences in Watt-Hr. to Weight for various types of batteries. In the prototype we employ Yardney Silver-Zinc cells (Type LR15). As power requirements diminish, in later versions of the micro-terminal, we may be able to use nickel cadmium which is cheaper and trouble-free.



Power-Pack Configuration: 1 ea. Data Terminal & Acoustic Coupler



Power-Pack Configuration: Tape Unit



APPROXIMATE PERFORMANCE TABLE

	Energy W-Hr/Lb	Cell Voltage	Cell Vol In^3/Lb	Number Recharge Cycles
Lead-Acid	14	2.00	15	500
Nickel-Cadmium	15	1.32	15	1000
Silver-Zinc	53	1.60	15	80-100
Lithium	127	2.80	15	0

Note
1 Lithium and Lead-Acid capacity shown for low discharge rates.

BATTERY - QUICK COMPARISON CHART

electron delocalisation brought about by d_π–d_π overlap between tin and the transition metal. This reduces ΔE in equation (1) so that the paramagnetic contribution is larger and the total shielding is decreased. This effect is offset by heavy atoms so that shifts to high field are observed when a third-row transition element is present, and intermediate results are obtained for the second row metals.

We thank the S.R.C. and the United States Army (European Office) for support.

[4/1525 *Received, 23rd July, 1974*]