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

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California University

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

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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.
Microterminal
Portable Terminal
Text Editing Portable Terminal

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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.

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:

2. Prototype Terminal Display Selection, Report #2, 12/20/74.
3. Display for Prototype Vendor Summary, Report #3, 2/4/75.
5. Controller for Microterminal Prototype, Report #5, 2/26/75.
III. REPORTS - Quarter ending 31 March 1975
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

<table>
<thead>
<tr>
<th>Approach</th>
<th>Company</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| 2. External Switch and Memory Element per Segment | Princeton Material Sciences Itek, Itek - Character Density | 1. Requirement for exacting material properties.  
2. Slow response time.  
3. Requires Refresh.  
4. Limited multiplexing capability | |
2. L.C. Material requirement same as 2. | 1. Complex batch process. |

---
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. It has considered extending the low end of the operational temperature range by incorporating heaters. Low power electro-luminescent 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 on 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.

```
  LED Technology
   | Implementations
   |    |      |
   |    |      |
   |    |      |
   |    |      |
  |      |
  |      |
  |      |
  |      |
  |      |
  |      |

Segmented
  American Electronic Labs
  Litronix

Dot Matrix
  Hewlett Packard
  Litronix
```

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 mA 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 Display Technology
- Implementations
  - A/C Drive
  - DC Drive
  - Plasma Charge Transfer

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

Current Status of Development

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.
### General Characteristics:
- **Display Organization:**
  - Tek: 480
  - Princeton Nat. Sci.: 80
  - Hughes: 40
- **Character Capacity:**
  - Tek: 2x40
  - Princeton Nat. Sci.: 1x40
  - Hughes: 2x40
- **Display Format - Lines x Char/Line:**
  - Tek: 10x48
  - Princeton Nat. Sci.: 14 seg. starburst
  - Hughes: 14 seg. starburst
- **Character Format:**
  - Tek: 14 seg. starburst
  - Princeton Nat. Sci.: 5x7 dot matrix
  - Hughes: uns.
- **Character Size - Width (In):**
  - Tek: 0.2x0.51
  - Princeton Nat. Sci.: 0.1x0.2
  - Hughes: 8.1
- **Character Linear Density - (H,V)/in:**
  - Tek: 4.0x2.0
  - Princeton Nat. Sci.: 3.0x2.0
  - Hughes: uns.

### Optical Data:
- **Contrast Ratio - Typical:**
  - Tek: 20:1
  - Princeton Nat. Sci.: 20:1
  - Hughes: uns.

### Electrical Characteristics:
- **Interface Logic Levels:**
  - Tek: CMOS-Type B
  - Princeton Nat. Sci.: CMOS,
  - Hughes: CMOS,

- **Power Requirements:**
  - Tek: 240 MW
  - Princeton Nat. Sci.: 40 MW
  - Hughes: 20 MW

- **Voltage Levels:**
  - Tek: +15
  - Princeton Nat. Sci.: +5
  - Hughes: ±0.5

- **Milli-Kratos/Char-Typical:**
  - Tek: 50.5
  - Princeton Nat. Sci.: 6.0
  - Hughes: yes

### Physical Characteristics:
- **Dimensions - LxWxT (In):**
  - Tek: 14x5x2
  - Princeton Nat. Sci.: 13x2x1
  - Hughes: 6x1x1

- **Weight (lbs):**
  - Tek: 3-4
  - Princeton Nat. Sci.: ≤0.75
  - Hughes: ≤0.5

### Environmental:
- **Operating Temperature (°C):**
  - Tek: 0-50
  - Princeton Nat. Sci.: (-5)-(+65)
  - Hughes: uns.

- **Humidity:**
  - Tek: MIL Stnd 202
  - Princeton Nat. Sci.: Method 105
  - Hughes: uns.

- **Storage Temperature (°C) & Humidity:**
  - Tek: MIL Stnd 202
  - Princeton Nat. Sci.: Method 105
  - Hughes: uns.

### Primary Features:
- **Drive Electronics Modularity (V, H):**
  - Tek: 4-Char, 1-Line
  - Princeton Nat. Sci.: 3-Char, 1-Line
  - Hughes: N/A

### Potential for Reduced Cost
- **Moderate**
- **Moderate**
- **Good**
- **High**

### Comments:
- **Primary Problem Area**
- **Interconnections:**
  - Tek: Drive Electronic to character segments
  - Princeton Nat. Sci.: Drive Electronics to character segments
- **Requirement for excising material characteristics**
- **Complex batch process yield must be consistent with cost constraint**

### 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 position with regard to the specific requirements.
<table>
<thead>
<tr>
<th>COMPANY</th>
<th>BURROUGHS</th>
<th>BURROUGHS</th>
<th>OWENS-ILL</th>
<th>OWENS-ILL</th>
<th>NIPTON ELECTRONICS</th>
<th>IIE</th>
<th>NATIONAL ELECTRONICS</th>
<th>ECKMAN</th>
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<tr>
<td><strong>GENERAL CHARACTERISTICS</strong></td>
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<td>Display Organization</td>
<td>256</td>
<td>36</td>
<td>20/33</td>
<td>512/60</td>
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<td>Custom</td>
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<td>Char Capacity</td>
<td>8 x 32</td>
<td>336</td>
<td>4335</td>
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<td>8 x 32</td>
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<td>Display Format</td>
<td>3 x 7</td>
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<td>5 x 7</td>
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<td>Char Format</td>
<td>3 x 7</td>
<td>9 x 17</td>
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<td>5 x 7</td>
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<td>Char Dims</td>
<td>0.7 x 0.28</td>
<td>0.14 x 0.28</td>
<td>0.133 x 0.195</td>
<td>0.197 x 0.267</td>
<td>0.180 x 0.267</td>
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<td>Char Linear Density(M, V)</td>
<td>3.6, 2.5</td>
<td>5.2, 2.5</td>
<td>5.2, 2.5</td>
<td>10, 6</td>
<td>6, 2.6</td>
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<td>Modularity</td>
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<td>Contrast Ratio</td>
<td>20:1</td>
<td>uns</td>
<td>20:1</td>
<td>30:1</td>
<td>uns</td>
<td>50:1</td>
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<td>Viewing Angle</td>
<td>130°</td>
<td>uns</td>
<td>130°</td>
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<td>130°</td>
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<tr>
<td>Color</td>
<td>Neon-Orange</td>
<td>100° max</td>
<td>Neon-Orange</td>
<td>Neon-Orange</td>
<td>Neon-Orange</td>
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<tr>
<td>Brightness (nominal) (ft-L)</td>
<td>25</td>
<td>uns</td>
<td>uns</td>
<td>uns</td>
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<td><strong>ELECTRICAL CHARACTERISTICS</strong></td>
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<td>Interface Logic Levels</td>
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<td>T7L</td>
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<td>T7L</td>
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<tr>
<td>Power Requirements (Watts)</td>
<td>31.6</td>
<td>8.9</td>
<td>104</td>
<td>397.5</td>
<td>397.5</td>
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<td>200, 160, 45, 212</td>
<td>(4 or 5)-250</td>
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<td>Voltage Levels</td>
<td>5, 30, -12, -250</td>
<td>5, -12, -250</td>
<td>115 AC + Power Pack</td>
<td>115 AC + Power Pack</td>
<td>12, -45, -12, -5, 445</td>
<td>12, -45, -12, -5, 445</td>
<td>12, -45, -12, -5, 445</td>
<td>12, -45, -12, -5, 445</td>
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<tr>
<td>Current (mA)</td>
<td>2.5, 0.040, 0.24, 0.070</td>
<td>0.16, 0.050, 0.020</td>
<td>1.5, 2.0, 0.1, 0.2</td>
<td>2.5</td>
<td>0.15, 2.0, 0.1, 0.2</td>
<td>2.5</td>
<td>0.15, 2.0, 0.1, 0.2</td>
<td>12, -45, -12, -5, 445</td>
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<tr>
<td>Mill-Watts/Char</td>
<td>128.5</td>
<td>267.0</td>
<td>189</td>
<td>166</td>
<td>71(7)</td>
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<td>50 (display only)</td>
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<td>I.C. Compatible</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<td><strong>PHYSICAL CHARACTERISTICS</strong></td>
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<tr>
<td>Dimensions (LxWxH)</td>
<td>11.0 x 8.5 x 3.75</td>
<td>8.5 x 2.25 x 1.34</td>
<td>11.0 x 5.44 x 1.24</td>
<td>16.5 x 13.5 x 7.12</td>
<td>14 x 7 x 3</td>
<td>11.7 x 5.4 x 4.3</td>
<td>12 x 2.0 x 2, 6 x 2.3 x 2.0</td>
<td>3</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>uns</td>
<td>Display=7, F.Pack=5</td>
<td>Display=33, F.Pack=17</td>
<td>174</td>
<td>166.6</td>
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<td><strong>ENVIRONMENTAL</strong></td>
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<td>Operating Temperature</td>
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<td></td>
<td>(-5)-70</td>
<td>0-50</td>
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<td>Rel. Humidity</td>
<td>0-85%</td>
<td>0-85%</td>
<td>uns</td>
<td>0-85%</td>
<td>uns</td>
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<td>Storage Temperature</td>
<td>0-70</td>
<td>40-85</td>
<td>(-62)-(-45)</td>
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<td>(-62)-(-45)</td>
<td>(-62)-(-45)</td>
<td>uns</td>
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<td>uns</td>
<td>0-35%</td>
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<tr>
<td><strong>PRIMARY FEATURES</strong></td>
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<tr>
<td>Drive Electronics</td>
<td>Modularity</td>
<td>Potential for Further Dev.</td>
<td>Life</td>
<td>&gt;10,000 Hrs.</td>
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<tr>
<td><strong>COMMENTS</strong></td>
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<td></td>
<td>The second number given in the weight (745 or 33-17) is the weight of the power pack that comes with the display.</td>
<td></td>
<td>Would like to supply display without electronics.</td>
<td>Some experimental work in large AFR displays. Willing to do custom work. Major emphasis is on small numeric displays.</td>
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</tbody>
</table>
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**

+G -- Go back to Editing Monitor.
+M -- Delete previous character.
+U -- Delete next character.
+D -- Delete back to beginning of line.
+V -- Delete forward to end of line.
UP -- Scroll cursor up, towards beginning of file (display scrolled down).
DOWN -- Scroll cursor down, towards end of file (display scrolled up).
(Note: UP and DOWN 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 +DOWN provide rapid scrolling capability.)

Shift UP -- Scroll cursor left on current display line.
Shift DOWN -- Scroll cursor right on current display line.
(Note: Shift UP and Shift DOWN 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.)
ON-LINE Terminal 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.
1.0 SYSTEM POWER ALLOCATION PROTOTYPE UNITS

<table>
<thead>
<tr>
<th>SUBSYSTEM</th>
<th>POWER-(WATTS)</th>
<th>LEVEL-(V)</th>
<th>CURRENT-(AMPS)</th>
<th>TOTAL SUBSYSTEM POWER-(WATTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terminal Controller</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-Processor</td>
<td>1.000</td>
<td>+5</td>
<td>0.200</td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>1.000</td>
<td>+5</td>
<td>0.200</td>
<td></td>
</tr>
<tr>
<td>Control &amp; I/O</td>
<td>0.500</td>
<td>+5</td>
<td>0.100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.200</td>
<td>+12</td>
<td>0.100</td>
<td></td>
</tr>
<tr>
<td><strong>Display</strong></td>
<td>9.000</td>
<td>+5</td>
<td>1.600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.600</td>
<td>-12</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td><strong>Keyboard</strong></td>
<td>0.175</td>
<td>+5</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.420</td>
<td>-12</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td><strong>Tape Unit</strong></td>
<td></td>
<td></td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>Logic</td>
<td>1.000</td>
<td>+5</td>
<td>0.350</td>
<td></td>
</tr>
<tr>
<td>Servo</td>
<td>1.750</td>
<td>+5</td>
<td>0.350</td>
<td></td>
</tr>
<tr>
<td>R/W Circuits</td>
<td>1.250</td>
<td>-5</td>
<td>0.250</td>
<td></td>
</tr>
<tr>
<td><strong>Acoustic Coupler</strong></td>
<td></td>
<td></td>
<td></td>
<td>4.900</td>
</tr>
<tr>
<td></td>
<td>2.500</td>
<td>+5</td>
<td>0.500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.200</td>
<td>+12</td>
<td>0.100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.200</td>
<td>-12</td>
<td>0.100</td>
<td></td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Capacity - (A-Hr @ 10 Hr Discharge Rate)</td>
<td>20</td>
</tr>
<tr>
<td>Battery Capacity - (Avg. W-Hr)</td>
<td>121</td>
</tr>
<tr>
<td>Battery Size - (in.)</td>
<td>4.94x9.24x0.80</td>
</tr>
<tr>
<td>Battery Weight - (lbs.)</td>
<td>2.5</td>
</tr>
<tr>
<td>Battery Discharge Curve</td>
<td>See Typical Discharge Characteristics*</td>
</tr>
</tbody>
</table>

**Tape Unit**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Capacity - (A-Hr @ 10 Hr Discharge Rate)</td>
<td>6</td>
</tr>
<tr>
<td>Battery Capacity - (Avg. W-Hr.)</td>
<td>36.6</td>
</tr>
<tr>
<td>Battery Size - (in.)</td>
<td>1.72x3.36x0.59</td>
</tr>
<tr>
<td>Battery Weight - (oz.)</td>
<td>14.4</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model No. 30C5-12D125</td>
<td></td>
</tr>
<tr>
<td>Capacity - (Watts)</td>
<td>3</td>
</tr>
<tr>
<td>Weight - (oz.)</td>
<td>3</td>
</tr>
<tr>
<td>Size - (in.)</td>
<td>1.5 x 2.0 x 0.4</td>
</tr>
</tbody>
</table>

**Tape Unit**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technetics Model 1305-105</td>
<td></td>
</tr>
<tr>
<td>Capacity - (Watts)</td>
<td>3</td>
</tr>
<tr>
<td>Weight - (oz.)</td>
<td>6</td>
</tr>
<tr>
<td>Size - (in.)</td>
<td>2.125 x 2.35 x 0.812</td>
</tr>
</tbody>
</table>

**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.)
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 1.R15). 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

<table>
<thead>
<tr>
<th>Battery Type</th>
<th>Energy W-Hr/Lb</th>
<th>Cell Voltage</th>
<th>Cell Vol In³/Lb</th>
<th>Number Recharge Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-Acid</td>
<td>14</td>
<td>2.00</td>
<td>15</td>
<td>500</td>
</tr>
<tr>
<td>Nickel-Cadmium</td>
<td>15</td>
<td>1.32</td>
<td>15</td>
<td>1000</td>
</tr>
<tr>
<td>Silver-Zinc</td>
<td>53</td>
<td>1.60</td>
<td>15</td>
<td>80-100</td>
</tr>
<tr>
<td>Lithium</td>
<td>127</td>
<td>2.80</td>
<td>.15</td>
<td>0</td>
</tr>
</tbody>
</table>

Note 1: Lithium and Lead-Acid capacity shown for low discharge rates.
electron delocalisation brought about by $d_{x^2}-d_{y^2}$ overlap between tin and the transition metal. This reduces $\Delta E$ in equation (I) 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.

[4/1025 Received, 23rd July, 1971]