USER'S MANUAL FOR MILENG1/UTIL READ-ONLY MEMORY MODULE OF THE COMBAT ENGINEER PROGRAMMABLE HAND-HELD CALCULATOR

by

John M. Deponai III

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**Title:** User's Manual for Milengi/Util Read Only Memory Module of the Combat Engineer Programmable Hand-Held Calculator

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**Report Date:** September 1982

**Number of Pages:** 45

**Security Classification:** Unclassified

**Abstract:**
Six pilot combat engineering programs and ten programming utility sub-routines have been developed as part of an ongoing study to evaluate whether programmable hand-held calculators can increase the efficiency or military effectiveness of engineer troop units from platoon through brigade levels. This report describes the programs, explains how to use them, and gives example problems.
FOREWORD

This investigation was conducted for the Directorate of Military Programs, Office of the Chief of Engineers (OCE), under Project 4A762731AT41, "Design, Construction, and Operation and Maintenance Technology for Military Facilities"; Task D, "Combat Engineering Strategy"; Work Unit 049, "Programmable Calculator Technology for Engineer Troop Units." The applicable STO is 81-5.1:19. The OCE Technical Monitors were LTC John Howard and Dr. Clemens Meyer, both of DAEN-ZCM.

This work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (CERL). Mr. E. A. Lotz is Chief of CERL-FS.

The cooperation and contributions of many persons on the staff of the U.S. Army Engineer School are gratefully acknowledged. CPT Scott Loomer of the Defense Mapping School is especially commended for developing the Bridge Classification Program and all but two of the global utility routines described in this report.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.
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<td></td>
</tr>
<tr>
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<td></td>
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<th>Page</th>
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<td>17</td>
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<td>CPM Program Sequence</td>
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<td>CPM Program Problem Example</td>
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<td>CRATER Program Sequence</td>
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<td>11</td>
<td>DEMO Program Problem Example</td>
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<tr>
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<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>13</td>
<td>MINES Program Sequence</td>
<td>30</td>
</tr>
<tr>
<td>14</td>
<td>MINES Program Problem Example</td>
<td>32</td>
</tr>
<tr>
<td>15</td>
<td>MINES Program Examples (With Printer)</td>
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<td>WIRE Program Sequence</td>
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<tr>
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<td>WIRE Program Examples (With Printer)</td>
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1 INTRODUCTION

Background

Recent advancements in the state of the art of programmable calculators have indicated that these devices might help military engineers work more efficiently. To determine the potential of these systems, in March 1980 the U.S. Army Engineer School asked the U.S. Army Construction Engineering Research Laboratory (CERL) to see how hand-held programmable calculators could be exploited by combat engineers. To date, six pilot programs and ten utility routines have been developed for testing. Details of the study and comprehensive information on the programs and routines appear in CERL Technical Report P-134, Software Documentation for MILENGI/UTIL Read Only Memory Module.

This user's manual describes each MILENGI/UTIL program, explains how to use each program, and gives example problems.

Conventions

Only a few conventions must be learned to use the MILENGI/UTIL programs effectively.

Yes/No Input

When the program asks a question that needs a "yes" or "no" answer, the calculator will display an alpha string ending in (Y/N)?. To respond "yes", press two keys: Y and R/S. * To answer "no", press the N and R/S keys. Any other responses will be rejected by the program and the question will be displayed again. When the program asks this type of question, it automatically puts the calculator in the alpha mode, then awaits your response.

Numeric Input

When the program asks for numeric input the calculator displays an alpha string concatenated with a unit of measurement and an = ?. To respond, key in a numeric string, then press the R/S key. (Do not use the ENTER key.) If an alpha string were keyed in, it would be rejected and the question would be repeated. If the input is not within the allowable range specified in the program, one of the following messages will be displayed:

---

* When several letters/symbols are underlined, it means that as a group they identify the name of a single key on the calculator. Only key function names will be shown. Use of the shift key, if needed, is assumed. Single letters or numbers represent individual keys on the calculator.
MUST BE <= (some maximum value)

or

MUST BE >= (some minimum value).

Then, the original question will be repeated.

Output

All "MILENCl/UTIL" programs can run with or without a printer. If a printer is attached, the program stops only (1) when your input is required and (2) at the end of a program. If a printer is not attached, the program also will stop after each line of output. To continue execution, press the R/S key each time the program stops. If you use a printer, set it to the NORM mode.

Program Access

To access a particular program, you must "execute" the program name. For example, to call the MINES program, press XEQ ALPHAMINESALPHA and the program will begin execution.

Each program may be assigned to almost any key on the HP-41 calculator. For example, to assign the MINES program to the Y key, press ASN ALPHAMINESALPHA Y. Then, when the calculator is in the USER mode, the MINES program will be executed if the Y key is pressed. See the HP-41 Owner's Handbook and Programming Guide for more information on this "assign" feature.

Size Check

Before a program can be executed there must be enough data registers available to run the program. The minimum number of registers required for each program is:

<table>
<thead>
<tr>
<th>Program</th>
<th>Registers Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRDGCLS</td>
<td>52</td>
</tr>
<tr>
<td>CPM</td>
<td>*(2A+43)</td>
</tr>
<tr>
<td>CRATER</td>
<td>40</td>
</tr>
<tr>
<td>DEMO</td>
<td>41</td>
</tr>
<tr>
<td>MINES</td>
<td>53</td>
</tr>
<tr>
<td>WIRE</td>
<td>44</td>
</tr>
</tbody>
</table>

*A = Number of Activity Nodes

To set a program to the correct size, press XEQ ALPHASIZEALPHA. The calculator then will prompt for the number of registers required. A three-digit number must be entered; i.e., for the BRDGCLS program, enter 052. If the program is sized incorrectly, the program will immediately tell you to

RESIZE > (No. of Registers Required, minus one).
For example, if the BRDGCLS program was originally sized at 040, the BRDGCLS program would display the message RESIZE > 51. You would then press XEQ ALPHA SIZE ALPHA 052 (or greater), and then execute the program name again.

Register Use

Registers 00 through 19 are reserved for your use. These registers are not used by any of the programs on MILENV1/UTIL. However, the contents of registers 20 and above are affected, depending on which programs are executed.
THE BRIDGE CLASSIFICATION PROGRAM (BRDGCLS)

The bridge classification program is used with certain tables in FM 5-34 (September 1976) to help you determine bridge superstructure classification. This program may be used for both timber and steel stringer bridges. It first asks you for the basic dimensions of the bridge. At the appropriate times, it refers you to certain tables and figures in FM 5-34, tells you what entry values are needed, and asks for the value of the variables corresponding to those entry conditions. You extract the appropriate value from the manual's table (or figure) and input it to the calculator. The program determines the limiting classifications for one- and two-way traffic by wheeled and tracked vehicles. It determines the constraints imposed by moment capacity, shear capacity, deck thickness, roadway width, and also determines if additional braces are required.

General Program Information

Abbreviations used in BRDGCLS are listed in Table 1. Input variable operating limits are listed in Table 2.

Program Sequence

The typical sequence of events and the options you encounter when executing this program are shown in Figure 1.

BRDGCLS Program Example

Assume that a bridge reconnaissance was conducted to obtain the information below for a timber trestle bridge. Determine the final bridge classification.

Road Width = 23 ft
Nine Timber Stringers, each 8" x 18"
Deck = two layers of 3" x 12" plank
Springer Spacing = 35 in.
Span Length = 17 ft
Two Lateral Braces, 8" x 10" at midpoint and at one end of span.

Figure 2 shows how to solve this problem using the BRGCLS program. Figure 3 is an example of BRGCLS output with printer attached.
Table 1
BRIDGES Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLS,CLASS</td>
<td>Classification</td>
</tr>
<tr>
<td>DT</td>
<td>Deck Thickness</td>
</tr>
<tr>
<td>FIG</td>
<td>Figure</td>
</tr>
<tr>
<td>FT</td>
<td>Feet</td>
</tr>
<tr>
<td>IN</td>
<td>Inches</td>
</tr>
<tr>
<td>KP</td>
<td>Kip</td>
</tr>
<tr>
<td>L,M</td>
<td>Maximum Span Length</td>
</tr>
<tr>
<td>LAM</td>
<td>Laminated Lane</td>
</tr>
<tr>
<td>M</td>
<td>Moment Capacity</td>
</tr>
<tr>
<td>N,DL</td>
<td>Dead Load Moment</td>
</tr>
<tr>
<td>W,LL</td>
<td>Live Load Moment</td>
</tr>
<tr>
<td>M2</td>
<td>Effective Number of Stringers/Lane for a 2-Lane Bridge</td>
</tr>
<tr>
<td>ROCKM</td>
<td>Reconnaissance</td>
</tr>
<tr>
<td>S,S</td>
<td>Maximum Bracing Spacing</td>
</tr>
<tr>
<td>S,S</td>
<td>Stringer Spacing</td>
</tr>
<tr>
<td>STL</td>
<td>Steel</td>
</tr>
<tr>
<td>STM</td>
<td>Stringer</td>
</tr>
<tr>
<td>TAB</td>
<td>Table</td>
</tr>
<tr>
<td>TBR</td>
<td>Timber</td>
</tr>
<tr>
<td>THICK</td>
<td>Thickness</td>
</tr>
<tr>
<td>V</td>
<td>Shear Capacity</td>
</tr>
<tr>
<td>V,DL</td>
<td>Dead Load Shear</td>
</tr>
<tr>
<td>V,LL</td>
<td>Live Load Shear</td>
</tr>
<tr>
<td>W</td>
<td>Way</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>(Yes/No)</td>
</tr>
<tr>
<td>%</td>
<td>Percent</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
</tbody>
</table>

Table 2
BRIDGES Program Input Variable Operating Limits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road width</td>
<td>Feet</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>Span length</td>
<td>Feet</td>
<td>10</td>
<td>200</td>
</tr>
<tr>
<td>Stringer number</td>
<td>Each</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Stringer width</td>
<td>Inches</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Stringer depth</td>
<td>Inches</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Stringer flange thickness</td>
<td>Inches</td>
<td>7/8</td>
<td>2</td>
</tr>
<tr>
<td>Stringer spacing</td>
<td>Inches</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Deck Thickness</td>
<td>Inches</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>% laminated</td>
<td></td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Number of braces</td>
<td>Each</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Moment capacity</td>
<td>Kip-Feet</td>
<td>3</td>
<td>3100</td>
</tr>
<tr>
<td>Shear capacity</td>
<td>Kip</td>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>Maximum span length</td>
<td>Feet</td>
<td>9</td>
<td>135</td>
</tr>
<tr>
<td>Maximum bracing spacing</td>
<td>Feet</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Dead load moment</td>
<td>Kip-Feet</td>
<td>3</td>
<td>1200</td>
</tr>
<tr>
<td>Dead load shear</td>
<td>Kip</td>
<td>1</td>
<td>65</td>
</tr>
<tr>
<td>Wheel classification</td>
<td>Class</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>Track classification</td>
<td>Class</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>Classification</td>
<td>Class</td>
<td>0</td>
<td>150</td>
</tr>
</tbody>
</table>

Source Reference Notes:
FHM 5-34 (September 1976), pp 178-184 and 199-203.
EXECUTE "BRDGCLS"

ENTER ROAD WIDTH IN FEET
ENTER SPAN LENGTH IN FEET
ENTER NUMBER OF STRINGERS
DECIDE IF STRINGERS ARE STEEL
ENTER STRINGER WIDTH IN INCHES
ENTER STRINGER DEPTH IN INCHES
ENTER STRINGER FLANGE THICKNESS IN INCHES*
ENTER STRINGER SPACING IN INCHES
ENTER DECK THICKNESS IN INCHES

DECIDE IF LAMINATED

(DECIDE IF LAMINATED)

ENTER NUMBER OF BRACES
ENTER MOMENT CAPACITY (KIP-FT) FROM TAB. 7-1 OR 7-2, FM 5-34
ENTER SHEAR CAPACITY (KIPS) FROM TAB. 7-1 OR 7-2, FM 5-34
ENTER MAXIMUM SPAN LENGTH (FT) FROM TAB. 7-1 OR 7-2, FM 5-34
ENTER MAXIMUM BRACING SPACING (FT) FROM TAB. 7-2, FM 5-34*
ENTER DEAD LOAD MOMENT (KF-FT) FROM FIG. 7-4, FM 5-34
ENTER DEAD LOAD SHEAR (KIP) FROM FIG. 7-4, FM 5-34

PROGRAM COMPUTES/OUTPUTS DEAD LOAD MOMENT PER STRINGER, LIVE LOAD MOMENT PER STRINGER, EFFECTIVE NUMBER OF STRINGERS PER LANE ($N_1$), AND EFFECTIVE NUMBER OF STRINGERS PER LANE FOR A 2-LANE BRIDGE ($N_2$)

ENTER CLASS OF WHEELED VEHICLE FROM FIG. 7-3, FM 5-34
ENTER CLASS OF TRACKED VEHICLE FROM FIG. 7-3, FM 5-34

PROGRAM COMPUTES/OUTPUTS DEAD LOAD SHEAR PER STRINGER AND LIVE LOAD SHEAR PER STRINGER

ENTER CLASS OF WHEELED VEHICLE FROM FIG. 7-5, FM 5-34
ENTER CLASS OF TRACKED VEHICLE FROM FIG. 7-5, FM 5-34

PROGRAM COMPUTES/OUTPUTS WIDTH CLASSIFICATION

ENTER DECKING CLASSIFICATION FROM FIG. 7-7, FM 5-34

PROGRAM COMPUTES/OUTPUTS FINAL CLASSIFICATIONS

* (ONLY IF STEEL STRINGERS ARE USED)

Figure 1. BRDGCLS program sequence.
<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>XEQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALFA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BRDGCLS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALFA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>R/S</td>
<td>BRIDGE CLASS</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>R/S</td>
<td>RECON:</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>23 R/S</td>
<td>ROAD WIDTH (FT) = ?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>17 R/S</td>
<td>SPAN LENGTH (FT) = ?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>R/S</td>
<td>STRINGERS:</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>9 R/S</td>
<td>STR. NUMBER = ?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>M R/S</td>
<td>STEEL (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>R/S</td>
<td>STR. WIDTH (IN) = ?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>18 R/S</td>
<td>STR. DEPTH (IN) = ?</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>35 R/S</td>
<td>STR. SPACING (IN) = ?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>6 R/S</td>
<td>DECK THICK. (IN) = ?</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>N R/S</td>
<td>LAMINATED (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>R/S</td>
<td>DECK LAYERED (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2 R/S</td>
<td># BRACES = ?</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>R/S</td>
<td>TAB. 7-1, FM 5-34:</td>
<td>See Note 1</td>
</tr>
<tr>
<td>17</td>
<td>R/S</td>
<td>8.0X18.0</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>R/S</td>
<td>M(KP-FT) = ?</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>86.40 R/S</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>14.40 R/S</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>21.50 R/S</td>
<td>FIG. 7-4, FM 5-34:</td>
<td>See Note 2</td>
</tr>
<tr>
<td>22</td>
<td>R/S</td>
<td>TBR, 2 LM, 17. FT:</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>R/S</td>
<td>M,DL(KP-FT) = ?</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>37.36 R/S</td>
<td>V,DL (KIP) = ?</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>8.75 R/S</td>
<td>M,DL/STR= 4.2</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>R/S</td>
<td>M,LL/STR=82.2</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>R/S</td>
<td>N1 = 2.71</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>R/S</td>
<td>N2 = 3.38</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>R/S</td>
<td>FIG. 7-3, FM 5-34:</td>
<td>See Note 3</td>
</tr>
<tr>
<td>30</td>
<td>R/S</td>
<td>17 FT. &amp; 223. M,LL:</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>R/S</td>
<td>CLS, WHEEL = ?</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>R/S</td>
<td>CLS, TRACK = ?</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>60 R/S</td>
<td>V,DL/STR = 1.0</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>40 R/S</td>
<td>V,LL/STR = 13.4</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>R/S</td>
<td>FIG. 7-5, FM 5-34:</td>
<td>See Note 4</td>
</tr>
<tr>
<td>36</td>
<td>R/S</td>
<td>17 FT. &amp; 52. V,LL:</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>R/S</td>
<td>CLS, WHEEL = ?</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>R/S</td>
<td>CLS, TRACK = ?</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>50 R/S</td>
<td>WIDTH CLS:</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>R/S</td>
<td>1 WAY = 100</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>R/S</td>
<td>2 WAY = 30</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>R/S</td>
<td>FIG. 7-7, FM 5-34:</td>
<td>See Note 5</td>
</tr>
<tr>
<td>43</td>
<td>R/S</td>
<td>DT = 4.0 &amp; 8.8 = 35.</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>R/S</td>
<td>CLASS = ?</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. BRDGCLS program problem example.
<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>12 R/S</td>
<td>FINAL CLASS:</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>R/S</td>
<td>ADD 1. BRACES</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>R/S</td>
<td>1 WY WHEEL = 12.</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>R/S</td>
<td>2 WY WHEEL = 12.</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>R/S</td>
<td>1 VY TRACK = 12.</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>R/S</td>
<td>2 WY TRACK = 12.</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>R/S</td>
<td>END PROGRAM</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. See Table 7-1, FM 5-34 for the properties of timber stringers.

2. See Figure 7-4, FM 5-34 to determine the dead load moment and shear.

3. See Figure 7-3, FM 5-34 to determine the wheel and track classification based on moment capacity.

4. See Figure 7-5, FM 5-34 to determine the wheel and track classification based on shear capacity.

5. See Figure 7-7, FM 5-34 to determine the classification based on decking thickness.

6. If a printer is connected and in the NORM mode, steps 46 through 51 will be output automatically.

Figure 2. (Cont'd).
Figure 3. BRDGCLS program example (with printer).
The CPM program provides an easy way to do the tedious calculations associated with using CPM project control. The CPM program uses activity-on-the-node logic. Up to 98 activities can be analyzed if the full HP-41cv resident capacity for data storage is used. Up to 20 activities can be done on the HP-41c model without memory modules.

The program computes the total float, the early start time, the early finish time, the late start time, and the late finish time for each activity. The "with printer" version prints out in boxes. These boxes can be cut out and pasted together to graph logical relationships. In the printer version, the preceding activities for each activity are noted to the left of each diagram, so the user will know how to connect the activities together. The "without printer" output must be copied as it is output. Then diagrams can be drawn by hand and annotated with the correct information.

General Program Information

Abbreviations used in the CPM program are listed in Table 3. Variable input operating limits are listed in Table 4.

Program Sequence

The typical sequence of events and the options you encounter when executing this program are shown in Figure 4.

EXECUTE CPM
ENTER TOTAL NUMBER OF ACTIVITIES
ENTER ACTIVITY NUMBER, DURATION, AND PRECEDING ACTIVITIES FOR EACH ACTIVITY
ENTER ENDING ACTIVITIES
ENTER STARTING ACTIVITY NUMBER
PROGRAM COMPUTES AND OUTPUTS EARLY START, EARLY FINISH, LATE START, LATE FINISH, TOTAL FLOAT AND CRITICAL PATH

Figure 4. CPM program sequence.
Table 3

CPM Program Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>Activity</td>
</tr>
<tr>
<td>CPM</td>
<td>Critical Path Method</td>
</tr>
<tr>
<td>EF</td>
<td>Early Finish</td>
</tr>
<tr>
<td>END</td>
<td>Ending</td>
</tr>
<tr>
<td>ES</td>
<td>Early Start</td>
</tr>
<tr>
<td>LF</td>
<td>Late Finish</td>
</tr>
<tr>
<td>LS</td>
<td>Late Start</td>
</tr>
<tr>
<td>PRED</td>
<td>Preceding</td>
</tr>
<tr>
<td>START</td>
<td>Starting</td>
</tr>
<tr>
<td>TF</td>
<td>Total Float</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>(Yes/No)</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
</tbody>
</table>

Table 4

CPM Program Variable Input Operating Limits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Activities</td>
<td>1</td>
<td>98</td>
</tr>
<tr>
<td>Activity Identification Numbers</td>
<td>1*</td>
<td>98</td>
</tr>
<tr>
<td>Duration</td>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>Preceding Activity Identification Numbers</td>
<td>1*</td>
<td>98</td>
</tr>
<tr>
<td>Starting Activity Number</td>
<td>1</td>
<td>98</td>
</tr>
</tbody>
</table>

*0 is also a valid input but tells the program that there are no more inputs for these variables.

The limits set for preceding activity numbers (i.e., the identification number) show that you can enter any activity between 1 and 98. However, the total number of preceding activities for a single activity cannot exceed five. The registers will be disrupted if more than five preceding activities or more than 25 ending activities are used. The CPM program is not designed to check these last two limits.
Given the following information, determine the early start, early finish, late start, late finish, and total float for each activity using the critical path method.

<table>
<thead>
<tr>
<th>Activity No.</th>
<th>Duration</th>
<th>Preceding Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>2,4</td>
</tr>
</tbody>
</table>

Figure 5 shows how to solve this problem using the CPM program. Figure 6 is an example of CPM program output with printer attached.
Table 3

CPM Program Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>Activity</td>
</tr>
<tr>
<td>CPM</td>
<td>Critical Path Method</td>
</tr>
<tr>
<td>EF</td>
<td>Early Finish</td>
</tr>
<tr>
<td>END</td>
<td>Ending</td>
</tr>
<tr>
<td>ES</td>
<td>Early Start</td>
</tr>
<tr>
<td>LF</td>
<td>Late Finish</td>
</tr>
<tr>
<td>LS</td>
<td>Late Start</td>
</tr>
<tr>
<td>PRED</td>
<td>Preceding</td>
</tr>
<tr>
<td>START</td>
<td>Starting</td>
</tr>
<tr>
<td>TF</td>
<td>Total Float</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>(Yes/No)</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
</tbody>
</table>

Table 4

CPM Program Variable Input Operating Limits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Activities</td>
<td>1</td>
<td>98</td>
</tr>
<tr>
<td>Activity Identification Numbers</td>
<td>1*</td>
<td>98</td>
</tr>
<tr>
<td>Duration</td>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>Preceding Activity Identification Numbers</td>
<td>1*</td>
<td>98</td>
</tr>
<tr>
<td>Starting Activity Number</td>
<td>1</td>
<td>98</td>
</tr>
</tbody>
</table>

*0 is also a valid input but tells the program that there are no more inputs for these variables.

The limits set for preceding activity numbers (i.e., the identification number) show that you can enter any activity between 1 and 98. However, the total number of preceding activities for a single activity cannot exceed five. The registers will be disrupted if more than five preceding activities or more than 25 ending activities are used. The CPM program is not designed to check these last two limits.
<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>XEQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ALPHA</td>
<td>TOTAL # ACTIVITIES = ?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACTIVITY # = ?</td>
<td>See Note 1</td>
</tr>
<tr>
<td>3</td>
<td>5 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>15 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>20 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>18 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>4 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>18 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>3 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>5 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>20 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>4 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0 R/S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0 R/S</td>
<td>ANY CHANGES (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>N R/S</td>
<td>ENTER ENDING ACTIVITIES</td>
<td>See Note 2</td>
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<tr>
<td>25</td>
<td>5 R/S</td>
<td>END ACT. # = ?</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>0 R/S</td>
<td>START ACT. # = ?</td>
<td>See Note 3</td>
</tr>
<tr>
<td>27</td>
<td>1 R/S</td>
<td>ACT # = 1.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>R/S</td>
<td>DURATION = 15.</td>
<td>See Note 4</td>
</tr>
<tr>
<td>29</td>
<td>R/S</td>
<td>ES = 0.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>R/S</td>
<td>EF = 15.</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>R/S</td>
<td>LS = 0.</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>R/S</td>
<td>LF = 15.</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>R/S</td>
<td>TF = 0</td>
<td></td>
</tr>
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<td>ACT # = 2.</td>
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</tr>
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<td>35</td>
<td>R/S</td>
<td>DURATION = 20.</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>R/S</td>
<td>PRED. ACT = 1.</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>R/S</td>
<td>ES = 15.</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>R/S</td>
<td>EF = 35.</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>R/S</td>
<td>LS = 31.</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>R/S</td>
<td>LF = 51.</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>R/S</td>
<td>TF = 16.</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>R/S</td>
<td>ACT # = 3.</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>R/S</td>
<td>DURATION = 18.</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>R/S</td>
<td>PRED. ACT = 1.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. CPM program problem example.
<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>R/S</td>
<td>ES = 15.</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>R/S</td>
<td>EF = 33.</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>R/S</td>
<td>LS = 15.</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>R/S</td>
<td>LF = 33.</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>R/S</td>
<td>TF = 0.</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>R/S</td>
<td>ACT # = 4.</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>R/S</td>
<td>DURATION = 18.</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>R/S</td>
<td>PRED. ACT = 3.</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>R/S</td>
<td>ES = 33.</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>R/S</td>
<td>EF = 51.</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>R/S</td>
<td>LS = 33.</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>R/S</td>
<td>LF = 51.</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>R/S</td>
<td>TF = 0.</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>R/S</td>
<td>ACT # = 5.</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>R/S</td>
<td>DURATION = 20.</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>R/S</td>
<td>PRED. ACT = 2.</td>
<td></td>
</tr>
<tr>
<td>61</td>
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<td>PRED. ACT = 4.</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>R/S</td>
<td>ES = 51.</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>R/S</td>
<td>EF = 71.</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>R/S</td>
<td>LS = 51.</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>R/S</td>
<td>LF = 71.</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>R/S</td>
<td>TF = 0.</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>R/S</td>
<td>END PROGRAM</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. Activity numbers must be positive integers, beginning with 1. The numbers must be consecutive, but need not be entered sequentially.

2. Ending activities are those activities that do not precede any other activity.

3. The starting activity number will tell the program where you want to begin to output the results.

4. If the printer is connected and in the NORM mode, lines 28 through 67 will be output automatically. You do not have to press the R/S key.

Figure 5. (Cont’d).
Figure 6. CPM program example (with printer).
The road crater program computes the amount of explosive, number of cratering charges, and the number and depth of holes needed to produce hasty, deliberate, or relieved-face road craters for lengths of crater you specify.

**General Program Information**

Abbreviations used in the CRATER program are listed in Table 5. Input variable operating limits are listed in Table 6.

**Program Sequence**

The typical sequence of events and the options you encounter when executing this program are shown in Figure 7.

**CRATER Program Example**

Determine how much TNT, how many boreholes, and how many 40-lb cratering charges are required to blast a 41-ft-long deliberate crater.

Figure 8 shows how to solve this problem using the CRATER program. Figure 9 gives three examples of CRATER program output with printer attached.

```
EXECUTE CRATER

ENTER CRATER LENGTH

INDICATE IF CRATERING CHARGES ARE TO BE USED

SELECT TYPE OF CRATER

ENTER CRATER DEPTH
(for "hasty" option only)

PROGRAM COMPUTES AND OUTPUTS RESULTS
```

Figure 7. CRATER program sequence.
### Table 5

**CRATER Program Abbreviations**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG</td>
<td>Charge</td>
</tr>
<tr>
<td>EXPLO</td>
<td>Explosive(s)</td>
</tr>
<tr>
<td>FT</td>
<td>Feet</td>
</tr>
<tr>
<td>LBS</td>
<td>Pounds</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>(Yes/No)</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>Sum of (Total)</td>
</tr>
</tbody>
</table>

### Table 6

**CRATER Program Input Variable Operating Limits**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crater Length</td>
<td>Feet</td>
<td>12</td>
<td>999</td>
</tr>
<tr>
<td>Crater Depth</td>
<td>Feet</td>
<td>7.5</td>
<td>15</td>
</tr>
</tbody>
</table>

Source Reference Notes:

FM 5–34 (September 1976), pp. 28–32
FM 5–35 (February 1971), pp. 3–21 through 3–25

---

**Step 8 Press Resulting Display Comments**

1. **END**
2. **ALPHA CRATER**
3. **ALPHA**
4. **EXPLO**
5. **LBS**
6. **(Y/N)**
7. **(Y/N)**
8. **(Y/N)**
9. **(Y/N)**
10. **(Y/N)**
11. **(Y/N)**
12. **(Y/N)**
13. **(Y/N)**

**Notes:**

1. Crater-type Menu Order: Rasty, Deliberate, Relieved-Face
2. If a printer is connected and in the NORMAL mode, Steps 7 through 13 will be output automatically.

**Figure 8.** CRATER program problem example.
Figure 9. CRATER program examples (with printer).
The demolition program determines the amount of explosive required, the number of explosive units, the number of charges, and the minimum safe distance for the following engineer activities: cutting timber, cutting steel, and breaching walls. A menu of explosive types to be used is also presented. The program has three timber cutting options: internal charge placement, external placement, and abatis. The steel cutting options cover four application areas: railroad rails, round steel sections, structural steel sections, and carbon steel rods. The breaching applications are used in conjunction with applicable tables in FM 5-34.

General Program Information

Abbreviations used in the DEMO program are listed in Table 7. Input variable operating limits are listed in Table 8.

Program Sequence

The typical sequence of events and the options you encounter when executing this program are shown in Figure 10.

DEMO Program Example

Determine the amount of explosive required, the number of explosive units, the number of charges, and the minimum safe distance required to breach

EXECUTE DEMO

SELECT TYPE OF EXPLOSIVE

CHOOSE APPLICATION

ENTER APPROPRIATE DATA FOR THE CHOSEN APPLICATION

PROGRAM COMPUTES AND OUTPUTS:
POUNDS OF EXPLOSIVE REQUIRED
NUMBER OF EXPLOSIVE UNITS
NUMBER OF CHARGES (for BREACHING APPLICATION)
"IN OPEN" SAFE DISTANCE

Figure 10. DEMO program sequence.
Table 7

DEMO Program Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREACH</td>
<td>Breaching</td>
</tr>
<tr>
<td>C</td>
<td>Tamping Factor</td>
</tr>
<tr>
<td>CONCR</td>
<td>Concrete</td>
</tr>
<tr>
<td>DEMO</td>
<td>Demolition</td>
</tr>
<tr>
<td>DIA</td>
<td>Diameter</td>
</tr>
<tr>
<td>DIST</td>
<td>Distance</td>
</tr>
<tr>
<td>EXPLO</td>
<td>Explosive</td>
</tr>
<tr>
<td>EXTERN</td>
<td>External</td>
</tr>
<tr>
<td>FT</td>
<td>Feet</td>
</tr>
<tr>
<td>HT</td>
<td>Height</td>
</tr>
<tr>
<td>IN</td>
<td>Inches</td>
</tr>
<tr>
<td>INTERN</td>
<td>Internal</td>
</tr>
<tr>
<td>K</td>
<td>Material Factor</td>
</tr>
<tr>
<td>LB</td>
<td>Pound(s)</td>
</tr>
<tr>
<td>M</td>
<td>Meter</td>
</tr>
<tr>
<td>MIN</td>
<td>Minimum</td>
</tr>
<tr>
<td>REINF</td>
<td>Reinforced</td>
</tr>
<tr>
<td>REQD</td>
<td>Required</td>
</tr>
<tr>
<td>RR</td>
<td>Railroad</td>
</tr>
<tr>
<td>SECT</td>
<td>Section</td>
</tr>
<tr>
<td>STL</td>
<td>Steel</td>
</tr>
<tr>
<td>STR.STL.</td>
<td>Structural Steel</td>
</tr>
<tr>
<td>SQ. IN</td>
<td>Square Inches</td>
</tr>
<tr>
<td>TAB</td>
<td>Table</td>
</tr>
<tr>
<td>X-SECT</td>
<td>Cross-Sectional</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>(Yes/No)</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
</tbody>
</table>

Table 8

DEMO Program Input Variable Operating Limits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber Diameter</td>
<td>Inches</td>
<td>0.5</td>
<td>180</td>
</tr>
<tr>
<td>Rail Height</td>
<td>Inches</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Bar Diameter</td>
<td>Inches</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>X-Sect Area</td>
<td>(Inch)²</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>Section Diameter</td>
<td>Inches</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>Material Factor, K</td>
<td>Inches</td>
<td>0.07</td>
<td>1.76</td>
</tr>
<tr>
<td>Tamp Factor, C</td>
<td></td>
<td>1</td>
<td>3.6</td>
</tr>
<tr>
<td>Barrier Width</td>
<td>Feet</td>
<td>0</td>
<td>999</td>
</tr>
<tr>
<td>Breaching Radius</td>
<td>Feet</td>
<td>0.1</td>
<td>99</td>
</tr>
</tbody>
</table>

Source References:

FM 5-34 (September 1976), pp 24-29
FM 5-29 (February 1971), pp 1-6 and 3-20
a reinforced wall 7-1/2 ft thick and 42 ft long, using ground placed, tamped charges.

Figure 11 shows how to solve this problem using the DEMO program. Figure 12 gives three examples of DEMO program output with printer attached.

<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>XEQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td>DEMO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td>EXPLOSIVE TYPE:</td>
<td>See Note 1.</td>
</tr>
<tr>
<td>2</td>
<td>R/S</td>
<td>TNT (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>N R/S</td>
<td>M112 C4 (1.25 lb) (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>N R/S</td>
<td>M5A1 C4 (2.5 lb) (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N R/S</td>
<td>DYNAMITE, M1 (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Y R/S</td>
<td>APPLICATION:</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>R/S</td>
<td>CUT TIMBER (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>N R/S</td>
<td>CUT STEEL (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>N R/S</td>
<td>BREACH (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Y R/S</td>
<td>TAB. 2-3, FM 5-34: See Note 2.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>R/S</td>
<td>MATERIAL FACTOR, K = ?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>.54 R/S</td>
<td>TAB. 2-4, FM 5-34: See Note 3.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>R/S</td>
<td>TAMP FACTOR, C = ?</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>2 R/S</td>
<td>BARRIER WIDTH, (FT) = ?</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>42 R/S</td>
<td>BREACH. RADIUS, (FT) = ?</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>7.5 R/S</td>
<td>REQD. EXPLO, LBS = 1,486.5</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>R/S</td>
<td># EXPLO. UNITS = 2,973. See Note 4.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>R/S</td>
<td># CHARGES = 3.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>R/S</td>
<td>OPEN, SAFE DIST, M = 1.141.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>R/S</td>
<td>END PROGRAM</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. Explosive Type Menu Order: TNT, M112 C4 (1.25 lb), M5A1 C4 (2.5 lb), Dynamite, Tetrytol, M118 Sheet (0.5 lb), M186 Roll (25 lb)

2. See Table 2-3, FM 5-34 to determine the material factor, K

3. See Table 2-4, FM 5-34 to determine the tamp factor, C

4. If a printer is connected and in the NORM mode, steps 17 through 20 will be output automatically.

Figure 11. DEMO program problem example.
Figure 12. DEMO program examples (with printer).
6 THE MINEFIELD PROGRAM (MINES)

The minefield program computes the logistical requirements for installing a standard pattern minefield given the field density, the irregular outer-edge cluster composition, the field length and depth, and conditions under which the work is to be done.

General Program Information

Abbreviations used in the MINES program are listed in Table 9. Input variable operating limits are listed in Table 10.

Program Sequence

The typical sequence of events and the options encountered when executing the MINES program is shown in Figure 13.

MINES Program Example

Determine the logistical requirements for a minefield, 400-m long and 400-m deep, with an AT-APF-APB mine density of 1-1-0, and an AT-APF-APB mine Irregular Outer Edge (IOE) cluster composition of 1-2-2.

Figure 14 shows how to solve this problem using the MINES program. Figure 15 gives two examples of MINES program output with printer attached.

EXECUTE MINES

ENTER MINE DENSITIES

ENTER IOE CLUSTER COMPOSITION

INDICATE IF NIGHT WORK IS TO BE DONE

INPUT MINEFIELD LENGTH IN METERS

PROGRAM COMPUTES LOGISTICAL REQUIREMENTS

RETRIEVE RESULTS

Figure 13. MINES program sequence.
### Table 9
MINES Program Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>APB</td>
<td>Anti-Personnel Blast</td>
</tr>
<tr>
<td>APF</td>
<td>Anti-Personnel Fragmentation</td>
</tr>
<tr>
<td>AT</td>
<td>Anti-Tank</td>
</tr>
<tr>
<td>IOE</td>
<td>Irregular Outer Edge</td>
</tr>
<tr>
<td>M</td>
<td>Meter(s)</td>
</tr>
<tr>
<td>MAX</td>
<td>Maximum</td>
</tr>
<tr>
<td>MMF</td>
<td>Main Minefield</td>
</tr>
<tr>
<td>RL</td>
<td>Reel(s)</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>Yes/No</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
</tbody>
</table>

### Table 10
MINES Program Input Variable Operating Limits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine Densities:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT Mines/M</td>
<td>Mines/M</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>APF Mines/M</td>
<td>Mines/M</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>APB Mines/M</td>
<td>Mines/M</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>IODE Cluster Composition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of AT Mines</td>
<td>Each</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No. of APF Mines</td>
<td>Each</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>No. of APB Mines</td>
<td>Each</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Minefield Length</td>
<td>Meters</td>
<td>0</td>
<td>5000</td>
</tr>
<tr>
<td>Minefield Depth</td>
<td>Meters</td>
<td>0</td>
<td>999</td>
</tr>
</tbody>
</table>

Source Reference Notes:

FM 5-34 (September 1976), pp 54-59
FM 5-20 (November 1976)
<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>XEQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MINES</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td>ENTER MINE DENSITY:</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>R/S</td>
<td># AT/M = ?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>R/S</td>
<td># APF/M = ?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>R/S</td>
<td># APB/M = ?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>R/S</td>
<td>IOE CLUSTER COMPOSITION:</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>R/S</td>
<td># AT = ?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>R/S</td>
<td># APF = ?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>R/S</td>
<td># APB = ?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>R/S</td>
<td>DO AT NIGHT (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>R/S</td>
<td>FIELD LENGTH, (M) = ?</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>400 R/S</td>
<td>FIELD DEPTH, (M) = ?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>400 R/S</td>
<td>TOTAL MINES:</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>R/S</td>
<td># AT = 1,370.</td>
<td>See Note 1.</td>
</tr>
<tr>
<td>14</td>
<td>R/S</td>
<td># APF = 1,859.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>R/S</td>
<td># APB = 3,619.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>R/S</td>
<td>IOE MINES:</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>R/S</td>
<td># AT = 45.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>R/S</td>
<td># APF = 90.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>R/S</td>
<td># APB = 90.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>R/S</td>
<td>MMF MINES:</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>R/S</td>
<td># AT = 1,200.</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>R/S</td>
<td># APF = 1,600.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>R/S</td>
<td># APB = 3,200.</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>R/S</td>
<td># IOE CLUSTERS = 45.</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>R/S</td>
<td># STRIPS = 9.</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>R/S</td>
<td>2-STRAND, 4-SIDE FENCE:</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>R/S</td>
<td># WIRE (RL) = 13.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>R/S</td>
<td># SIGNS, PICKETS = 165.</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>R/S</td>
<td># SANDBAGS = 3,780.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>R/S</td>
<td>MANHOURS = 962.</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>R/S</td>
<td>END PROGRAM</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. If a printer is connected and in the NORM mode, steps 13 through 31 will be output automatically.

Figure 14. MINES program problem example.
XROM "MINES"

ENTER MINE DENSITY:
@AT/ N= 1.00 RUN
@APF/ N= 1.00 RUN
@APB/ N= 2.00 RUN

IEO CLUSTER COMPOSITION:
@AT = 1. RUN
@APF = 1. RUN
@APB = 1. RUN

DO AT NIGHT(Y/N)?:
Y RUN
FIELD LENGTH, (N)= 400. RUN
FIELD DEPTH, (N)= 100. RUN

TOTAL MINES:
@AT = 490.
@APF = 990.
@APB = 930.

IEO MINES:
@AT = 45.
@APF = 45.
@APB = 45.

MNF MINES:
@AT = 408.
@APF = 408.
@APB = 808.

IEO CLUSTERS=45.
#STRIPS=3.
2-STRAND,4-SIDE FENCE:
#WIRE(RL)=9.
#SIGNS,PICKETS=109.
#SANDBAGS=1,930.
#MANHOURS=436.

END PROGRAM

XROM "MINES"

ENTER MINE DENSITY:
@AT/ N= 3.00 RUN
@APF/ N= 4.00 RUN
@APB/ N= 6.00 RUN

IEO CLUSTER COMPOSITION:
@AT = 1. RUN
@APF = 2. RUN
@APB = 2. RUN

DO AT NIGHT(Y/N)?:
N RUN
FIELD LENGTH, (N)= 400. RUN
FIELD DEPTH, (N)= 400. RUN

TOTAL MINES:
@AT = 1,378.
@APF = 1,869.
@APB = 3,619.

IEO MINES:
@AT = 45.
@APF = 98.
@APB = 98.

MNF MINES:
@AT = 1,200.
@APF = 1,600.
@APB = 3,200.

IEO CLUSTERS=45.
#STRIPS=9.
2-STRAND,4-SIDE FENCE:
#WIRE(RL)=13.
#SIGNS,PICKETS=165.
#SANDBAGS=3,700.
#MANHOURS=962.

END PROGRAM

Figure 15. MINES program examples (with printer).
The WIRE obstacle program computes the logistical requirements for installing any of seven common wire obstacles: double apron fence, 4- and 2-pace; double apron fence, 6- and 3-pace; high wire; low wire; 4-stand fence; triple standard concertina; and general purpose barbed tape obstacle. The program can also be used to compute the effective length of the obstacle according to its function and location on the battlefield. If you already know the effective length, you can input the effective length directly.

General Program Information

Abbreviations used in the WIRE program are listed in Table 11. Input variable operating limits are listed in Table 12.

Program Sequence

The typical sequence of events and the options encountered when executing this program are shown in Figure 16.

WIRE Program Example

Determine the effective length, the number of 300-m sections, the amount of material, the number of manhours, and the number of truckloads required to construct a triple-standard concertina obstacle. The entanglement is for protecting an area on the FEDB which has 100 m of actual front. Only one belt of wire is to be used. The construction is done at night with experienced troops.

Figure 17 shows how to solve this problem using the WIRE program. Figure 18 gives two examples of WIRE program output with printer attached.
Table 11
WIRE Program Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBL.</td>
<td>Double</td>
</tr>
<tr>
<td>EFF.LEN.</td>
<td>Effective Length</td>
</tr>
<tr>
<td>FEBA</td>
<td>Forward Edge of the Battle Area</td>
</tr>
<tr>
<td>GPBTO</td>
<td>General Purpose Barbed Tape Obstacle</td>
</tr>
<tr>
<td>M</td>
<td>Meter(s)</td>
</tr>
<tr>
<td>MED</td>
<td>Medium</td>
</tr>
<tr>
<td>T</td>
<td>Ton(s)</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>(Yes/No)</td>
</tr>
<tr>
<td>3-STD</td>
<td>Triple standard</td>
</tr>
<tr>
<td>#</td>
<td>Number</td>
</tr>
</tbody>
</table>

Table 12
WIRE Program Input Variable Operating Limits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camp Perimeter</td>
<td>Meter</td>
<td>0</td>
<td>50,000</td>
</tr>
<tr>
<td>Length of Front</td>
<td>Meter</td>
<td>0</td>
<td>50,000</td>
</tr>
<tr>
<td>Unit Depth</td>
<td>Meter</td>
<td>0</td>
<td>5000</td>
</tr>
<tr>
<td>Effective Length</td>
<td>Meter</td>
<td>0</td>
<td>2,250,000</td>
</tr>
<tr>
<td>Number of Belts</td>
<td>Each</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

Source Reference Notes:

FM 5-34 (September 1976), pp 105-109
FM 5-15 (June 1972), pp 6-10, 6-22, and 6-23
Execute WIRE

Is Effective Length Known?

NO

YES

Select Type of Troop Development

(Base Camp) (FEBA)

Select How Wire Is To Be Used

Enter Unit Depth in Meters if Wire Use Is Supplemental: FEBA, REAR

Program Computes Effective Length in Meters

Select Special Conditions From Menu

Select Barrier Type from Menu

Program Computes Logistical Requirements

Retrieve Results

Figure 16. WIRE program sequence.
<table>
<thead>
<tr>
<th>Step</th>
<th>Press</th>
<th>Resulting Display</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>XEQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td>WIRE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALPHA</td>
<td>KNOW, EFF, LEN (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>N R/S</td>
<td></td>
<td>ON. FEBA (Y/N)?</td>
</tr>
<tr>
<td>3</td>
<td>Y R/S</td>
<td></td>
<td>FRONT LENGTH, (M) = ?</td>
</tr>
<tr>
<td>4</td>
<td>100 R/S</td>
<td></td>
<td># BELTS = ?</td>
</tr>
<tr>
<td>5</td>
<td>1 R/S</td>
<td></td>
<td>WIRE USE:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>See Note 1.</td>
</tr>
<tr>
<td>6</td>
<td>R/S</td>
<td>TACTICAL (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Y R/S</td>
<td>EFF. LEN, M = 125.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>R/S</td>
<td></td>
<td>USE BARBED TAPE (Y/N)?</td>
</tr>
<tr>
<td>9</td>
<td>N R/S</td>
<td></td>
<td>EXPERIENCED TROOPS (Y/N)?</td>
</tr>
<tr>
<td>10</td>
<td>Y R/S</td>
<td></td>
<td>USE DRIVEN PICKETS (Y/N)?</td>
</tr>
<tr>
<td>11</td>
<td>N R/S</td>
<td></td>
<td>DO AT NIGHT (Y/N)?</td>
</tr>
<tr>
<td>12</td>
<td>Y R/S</td>
<td>BARRIER TYPE:</td>
<td>See Note 2.</td>
</tr>
<tr>
<td>13</td>
<td>R/S</td>
<td>DBL APRON 4+2 (Y/N)?</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Y R/S</td>
<td>300M SECTIONS = 0.4</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>R/S</td>
<td>PICKETS, LONG = 42.</td>
<td>See Note 3.</td>
</tr>
<tr>
<td>16</td>
<td>R/S</td>
<td>PICKETS, SHORT = 83.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>R/S</td>
<td></td>
<td># WIRE REELS:</td>
</tr>
<tr>
<td>18</td>
<td>R/S</td>
<td>USING U-PICKETS = 6.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>R/S</td>
<td>USING PICKET, SCREW = 6.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>R/S</td>
<td>USING PICKET, WOOD = 7.</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>R/S</td>
<td>MANHOURS = 25.</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>R/S</td>
<td># 2.5T LOADS = 0.3</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>R/S</td>
<td>END PROGRAM</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. Wire Use Menu orders: Tactical, Protective, Supplemental

2. Barrier Type Menu Order: double apron, 4- and 2-pace; double apron, 6- and 3-pace; high wire; low wire; 4-wire fence; triple standard concertina; general purpose barbed tape obstacle

3. If a printer is connected and in the NORM mode, do not press the R/S key for Steps 15 through 23. The results will be output automatically.

Figure 17. WIRE program problem example.
Figure 18. WIRE program examples (with printer).
The global subroutines are used by the six main application programs stored on MILENG/UTIL and can be used by you to write your own programs. The subroutines can also be used by other military engineering programs that may one day be stored on ROMs designed to be used concurrently with the MILENG/UTIL ROM. This convention will save a lot of room on future ROMs and in user-developed programs — room that would otherwise be needed to store similar subroutines. If programmers adopt these subroutines, the military engineer community should find it easier to understand each other's programs.

Conventions

The following information on register use applies to all global utility subroutines. Registers 20 through 29 are reserved for existing and future global utility subroutines. Registers 20 through 23 are used to store temporarily up to 24 characters of a message that will be presented as a prompt of some sort to a program user. Each register stores up to six characters. Register 24 is an indirect storage register for a "pointer" to show where the next input value will be stored. Registers 25 and 26 store the minimum and maximum limits, respectively, of the current input variable. Registers 27 through 29 are reserved for global subroutines that may be developed in the future.

The following flag conventions are also used. Flag "10" records the results of a yes/no question. The flag is set if the response is "Y" (yes) and cleared if the response is "N" (no). Flag "9" is programmed into subroutine *I (numeric input) and *A (alpha input) to allow an answer already stored somewhere to be used instead of the user-defined values (alpha or numeric) that usually result when the *I and *A subroutines are invoked. Although this option is not used in any of the six main application programs on MILENG/UTIL, the potential to bypass the normal user-input route and to use a value already in the system is available in these two subroutines. This flexibility may be useful in future applications.

Flag "8" was not used in the MILENG/UTIL programs. It is reserved for future use as a "global use" flag, which "jumps over" certain parts of a program that do not have to be executed each time on repetitive runs. Flags "0" through "7" are reserved for application program use and are cleared each time the *F subroutine is invoked.

Global Subroutine *S

Running global subroutine *S should always be one of the first steps in any program; this insures that adequate data registers have been allocated for the program being executed. If enough registers are available, the subroutine returns to the main program and continues execution; if not, a user is prompted to resize the memory. The program must then be restarted.

Before using the subroutine, the entry condition must first be satisfied. The number of data registers required for the program is first loaded into the
X register. Note that this is the actual number required, not the number of the highest register, which would be one less because register 00 counts as one register. *S is then executed.

The following exit conditions are observed: *S returns to the calling program if adequate registers are available; otherwise, *S prompts to resize. Assume that the stack contents are destroyed upon the return.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Instruction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>Loads &quot;61&quot; into X register; says that 61 registers (0 through 60) are required for this particular program;</td>
<td></td>
</tr>
<tr>
<td>XEO &quot;*S&quot;</td>
<td>Calls the *S subroutine</td>
<td></td>
</tr>
<tr>
<td>xxxxxxxxxx</td>
<td>Resume with main program</td>
<td></td>
</tr>
</tbody>
</table>

Note that *S also uses global subroutines *0 and *D.

**Global Subroutine *F**

This subroutine clears flags "00" through "07"; it should be used to initialize a program and to "clean up" at the end of each application program.

To use the subroutine, simply execute *F. *F returns to the calling program once flags "00" through "07" have been cleared.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Instruction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>XEO *F</td>
<td>Calls the *F subroutine</td>
<td></td>
</tr>
<tr>
<td>xxxxxx</td>
<td>Resume with main program</td>
<td></td>
</tr>
</tbody>
</table>

**Global Subroutine *I**

Global subroutine *I prompts for numeric input; a single tone will signal that input is required. If the input provided is not numeric, the prompt will be presented again.

The input value must pass a range check. If the input is out of range, a user is informed of the maximum or minimum acceptable value and reprompted. Global subroutine *I has a built-in option; if a user presses only the R/S key, he will be prompted with the current value.

To use *I, the indirect register pointer in register 24 must be set to the data register the input is to be stored in. This pointer is incremented
during each input call and has to be set only once if sequential input is to be stored in sequential registers. A prompt line and maximum and minimum acceptable value for the input are passed to the subroutine from the main program. The subroutine will not return to the main program until an acceptable value has been input. A "=?" is automatically appended to the prompt. If flag "9" is set, an "=" sign, the current value in the specified register, and a "?" are added to the prompt and displayed.

Entry conditions when calling *I are as follows: register X must contain the minimum acceptable value, register Y must contain the maximum acceptable value, register A must contain the prompt. Register 24 must contain the address of the register that the input is to be stored in.

The exit conditions from *I occur when an acceptable value has been entered; *I then returns to the calling program. (If flag "9" is set and R/S is pressed without numeric entry, the current value is used.) The input value is stored in the specified register and in the X register. The rest of the stack should be considered destroyed.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Instruction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF 09</td>
<td>Optional: used if &quot;current value&quot; of variable is to be presented to user for verification.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Identifies register address where input is to be stored.</td>
<td></td>
</tr>
<tr>
<td>STO 24</td>
<td>Stores indirect register address in register 24.</td>
<td></td>
</tr>
<tr>
<td>123</td>
<td>Specifies maximum acceptable input value</td>
<td></td>
</tr>
<tr>
<td>ENTER</td>
<td>Places maximum value in Y register</td>
<td></td>
</tr>
<tr>
<td>-37</td>
<td>Specifies minimum acceptable input value and puts in X register</td>
<td></td>
</tr>
<tr>
<td>&quot;HEIGHT&quot;</td>
<td>Specifies prompt to be presented to user</td>
<td></td>
</tr>
<tr>
<td>XEQ &quot;*I&quot;</td>
<td>Calls subroutine *I</td>
<td></td>
</tr>
<tr>
<td>CF 09</td>
<td>Used only if SF 09 option is used</td>
<td></td>
</tr>
<tr>
<td>xxxxxxxx</td>
<td>Resume with main program</td>
<td></td>
</tr>
</tbody>
</table>

Note that if input is sequential, the second two instructions only have to be programmed before the first variable is input. Also, if the current value option is used, make sure the calculator is FIX’d to the desired setting before calling *I. Note that *I also uses global subroutines "O and "D."
Global Subroutine *0

This subroutine displays labeled output. A label is passed to the subroutine, and an "-" and the value in the X register are appended. A two-tone sequence signals output. The routine then displays the labeled answer. If a printer is attached, the output display is printed and the program continues execution after a pause. If no printer is attached, program execution stops until the the R/S key is pressed.

Before executing the subroutine, insure that register X contains the numeric data to be displayed and that register A contains the label to be appended. When the subroutine is done, it returns to the calling program. No registers are affected.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program Instruction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.27</td>
<td>Puts value to be displayed in X register</td>
</tr>
<tr>
<td>&quot;ANSWER&quot;</td>
<td>Puts label to be used in alpha register</td>
</tr>
<tr>
<td>XEQ &quot;*0&quot;</td>
<td>Executes the *0 subroutine</td>
</tr>
<tr>
<td>xxxxxxxx</td>
<td>Resume with main program</td>
</tr>
</tbody>
</table>

Note that the calculator should be FIX'd to the desired accuracy before executing *0. Note that *0 also uses global subroutine *D.

Global Subroutine *D

This subroutine displays an alphanumeric text line. A two-tone sequence is used to signal the display; the routine then displays the contents of the alpha register. If a printer is attached, the output is printed and displayed; the program continues execution after a pause. If no printer is attached, program execution stops until the R/S key is pressed.

Before executing *D, insure that register A contains the alphanumeric text to be displayed. When *D is done, it returns to the calling program. No registers are affected.

An example calling sequence follows:

<table>
<thead>
<tr>
<th>Program Instruction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;SAMPLE&quot;</td>
<td>Puts text to be displayed in alpha register</td>
</tr>
<tr>
<td>XEQ &quot;*D&quot;</td>
<td>Execute the *D subroutine</td>
</tr>
<tr>
<td>xxxxxxxx</td>
<td>Resume with main program</td>
</tr>
</tbody>
</table>

41
Global Subroutine *Y

This subroutine takes a prompt that is passed to it and appends "(Y/N)?" to it. A user must then respond with "Y" or "N" or the routine will reprompt. The answer to the query is returned to the calling program as flag "10" status. For "Y" responses, flag "10" is set; for "N" responses, it is cleared. The routine automatically places the calculator in the alpha mode before prompting and turns off the alpha mode after a response is input.

Before executing *Y, insure that register A contains the query text. When *Y is done, it returns to the calling program. Flag "10" status is affected.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program Instructions</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;PRINT&quot;</td>
<td>Puts query text in alpha register</td>
</tr>
<tr>
<td>XEQ &quot;*Y&quot;</td>
<td>Executes the *Y subroutine</td>
</tr>
<tr>
<td>FS? 10</td>
<td>Tests response: set=yes; clear=no</td>
</tr>
<tr>
<td>xxxxxxxxx</td>
<td>Resume with main program</td>
</tr>
</tbody>
</table>

Global Subroutine *A

This subroutine prompts a user for alpha input. A maximum of 12 alpha characters are stored. A tone sounds to signal that input is required. A built-in option will allow you to prompt with the "current value" of the alpha variable. Under this option, if R/S is pressed, the "current value" of the text will be used when the program continues execution.

This subroutine requires that the indirect register address (pointer) stored in register 24 be set to the data register the alpha input is to be stored in. The alpha input is stored in two registers, six characters in each. The pointer in register 24 is incremented twice during each input call, so it only has to be set once if a string of input is to be put in sequential registers. A prompt line to label the input is passed to the subroutine, and a "-?" is added to this prompt by the subroutine.

To use the subroutine, the entry conditions must be satisfied. Register "A" must contain the prompt. Register 24 must contain the address of the register that the first six characters of the input will be stored in. If you set flag "9" before calling *A, the "current value" in the specified registers will be appended to the prompt and will be presented for verification. If a user agrees with the alpha value assigned, he would press the R/S key, and the program would use that alpha value for the variable. If a user elects to change the value, he would simply enter the correct alpha string (12 characters or fewer) and then press the R/S key. This new alpha value would then be used in place of the "current value."
The following exit conditions result: *A returns to the calling program, and the input value is stored in the specified registers. No other registers are affected.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Instructions</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF 09</td>
<td>(Optional) If current value of variable is to be presented to user</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>First register address where input is to be stored</td>
<td></td>
</tr>
<tr>
<td>STO 24</td>
<td>Stores first indirect register address in register 24</td>
<td></td>
</tr>
<tr>
<td>&quot;VARIABLENAME&quot;</td>
<td>Specifies prompt to be presented to user</td>
<td></td>
</tr>
<tr>
<td>XEQ &quot;*A&quot;</td>
<td>Calls the &quot;*A&quot; subroutine</td>
<td></td>
</tr>
<tr>
<td>CF 09</td>
<td>Used only with &quot;SF 09&quot; option.</td>
<td></td>
</tr>
<tr>
<td>xddddxxx</td>
<td>Resume with main program.</td>
<td></td>
</tr>
</tbody>
</table>

Note that if input is sequential, only the second and third instructions need to be programmed before the first variable is input.

Global Subroutine *C

This subroutine clears a specified range of registers by storing a "0" in them. This subroutine should be used instead of CLRG so that the contents of registers not used in the application program are preserved.

Before the subroutine can be used, the entry conditions must be satisfied. Register X must contain the range of registers to be cleared; the format is fff.111, where fff is the address of the first register to be cleared and 111 is the address of the last register to be cleared.

After the specified registers have been cleared, *C exits to the calling program. The stack should be considered destroyed.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Instructions</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.045</td>
<td>Specifies address of registers to be cleared (30 through 45)</td>
<td></td>
</tr>
<tr>
<td>XEQ &quot;*C&quot;</td>
<td>Calls the *C subroutine</td>
<td></td>
</tr>
<tr>
<td>xddddxxx</td>
<td>Resume with main program</td>
<td></td>
</tr>
</tbody>
</table>
Global Subroutine *R

This subroutine "rounds-up" a value and displays the integer portion of the number. The subroutine first adds 0.99 to the value stored in register X, then uses the integer portion of that value. Before entering the subroutine, insure that register X contains the value to be rounded. When *R is done, it returns to the calling program.

A sample calling sequence follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Instructions</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.49</td>
<td>Specifies value to be rounded; could also be a recall RCL instruction</td>
</tr>
<tr>
<td></td>
<td>XEQ *R</td>
<td>Calls the *R subroutine</td>
</tr>
<tr>
<td></td>
<td>xxxxxxxx</td>
<td>Resume with main program</td>
</tr>
</tbody>
</table>

Global Subroutine *P

This subroutine displays the "END PROGRAM" message in large type. A two-tone sequence alerts the user; *P then displays the message. There are no pre-entry conditions for *P. The subroutine is called directly with the instruction, "XEQ *P". When *P is done, it returns to the calling program; no registers are affected.
Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEH-ASI-L (2)
ATTN: DAEH-ZGM

FESA, ATTN: Library 22060

416th Engineer Command 60623
ATTN: Facilities Engineer

ENK/US Combined Forces Command 96301
ATTN: EUSA-HHC-CFC/Engr

US Military Academy 10996
ATTN: Dept of Geography & Computer Science

Engineer Studies Center 20315
ATTN: Library

AMREC, ATTN: DEKHM-FE 02172

USA ARCOM 61299
ATTN: DRCIS-WI-I
ATTN: DRCIS-IS

DLA, ATTN: DLA-WI 22314

FORSCOM
FORSCOM Engineer, ATTN: AFEN-FE

Fort Belvoir, VA 22060
ATTN: ATZA-DTE-EN
ATTN: ATZA-DTE-SW
ATTN: ATZA-FE
ATTN: Engineer Library
ATTN: Canadian Liaison Officer (2)
ATTN: IWR Library

Cold Regions Research Engr Lab 03755
ATTN: Library

EXL, ATTN: Library 22060

Waterways Experiment Station 39180
ATTN: Library

HQ, XVIII Airborne Corps & Ft Bragg 28307
ATTN: Library

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45 p. (Technical report / Construction Engineering Research Laboratory ;
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1. Military engineering. 2. Programmable calculators. 3. HP41c.
I. Title. II. Series: Technical report (Construction Engineering
Research Laboratory) ; P-136.