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DECUS NO.	8-297
TITLE	TRACE
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DATE	December 29, 1969
SOURCE LANGUAGE	PAL D

TRACE*

TRACE is a debugging program which combines many of the features of PALEX (DECUS 5/8-55) and DD T, as well as handling instructions to the floating point interpreter. It operates in a interpretative mode so that the user may obtain a complete record of the program steps if desired and so that TRACE cannot be destroyed by the users' program. Provisions are made for examining and modifying single word and also floating point entries. TRACE resides in field 1 and operates on a program in field 0.

Loading

TRACE is loaded in the normal fashion using the binary loader. The binary tape contains a field setting so that it will be correctly loaded into field 1. The program to be traced is similarly loaded into field 0.

Operation and Options

The starting address is 110200. This gives the instruction printout shown in Figure 1. The user supplies the upper and lower program limits and the starting location. The users program

* The development of this program was assisted by a grant from the National Science Foundation.

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TRACE PROGRAM
KEYBOARD INTERRUPTS ARE:
(XXXX IS TYPED BY THE COMPUTER AND NNNN IS TYPED BY THE USER)
A CARRIAGE RETURN IS INDICATED BY ,
TNNNN,    UPPER LIMIT IS SET TO NNNN
BNNNN,    LOWER LIMIT IS SET TO NNNN
ONNNN,    STARTING ADDRESS IS SET TO NNNN
FXXXX    FULL OUTPUT (INITIAL MODE), XXXX IS CURRENT ADDRESS
SXXXX    SHORTENED OUTPUT,          " "
JXXXX    OUTPUT ON JMS OR JMP ONLY, " "
PNNNN,    START PRINTOUT AT NNNN
AXXXX NNNN, C(AC) = XXXX; UNCHANGED IF FOLLOWED BY CR;
           CHANGED TO NNNN IF FOLLOWED BY NNNN AND CR
LXXXX NNNN, C(L) = XXXX; SEE A ABOVE
ENNNN XXXX NNNN, C(NNNN) = XXXX; SEE A ABOVE
YXXXX NNNN, C(FL. PT. AC) = XXXX (IN FL. PT. FORM);SEE A ABOVE
ZNNNN XXXX MMMM, C(NNNN TO NNNN+2) = XXXX (IN FL. PT. FORM)
           SEE A ABOVE
N,        GIVES NORMAL (OCTAL) OUTPUT
W,        GIVES SYMBOLIC OUTPUT FOR E
R,        READ SYMBOLIC TAPE ON HS READER
HNNNN MMMM, HUNT FOR NNNN IN MEMORY WHERE MMMM IS A MASK
UPPER PROGRAM LIMIT = 200
LOWER PROGRAM LIMIT = 7000
STARTING ADDRESS = 200

```

Figure 1 Initial typeout obtained by starting at 112000. This may be eliminated by starting at 110000. Then, the upper limit is set to 0, the lower limit is set to 7777 and the starting address is set to 200.

is then simulated beginning at the specified starting location.

The instruction printout may be suppressed by starting at 110000. In this case the upper and lower program limits are initially set to 0 and 7777, and the current address is set to 0200. The computer, on starting, prints the initially set upper location limit followed by an X. It then waits for the operator to type one of the following characters to designate the desired option.

While simulation is in effect, the operation of the TRACE program may be modified at any time by typing one of the following characters. The simulation may be halted at any time by typing X.

CharacterResult

C

The users program is traced starting at the next location in the program sequence, or initially at location 200 if no other starting location has been assigned. The printout is as follows:

current location	instruction	C(AC)	C(L)	ADD	C(ADD)	IADD
xxxx	xxxx	xxxx	x	xxxx	xxxx	xxxx

where C(AC) is the content of the accumulator, C(L) is the content of the link, ADD is the address specified by the instruction, C(ADD) is the content of the address and IADD is the address used for indirect addressing.

T xxxx

The upper end of the program limits is set to xxxx. The initial value is 0000 and need not be reset. If a program step leads to a jump to a location outside the program range, the trace operation is concluded and a & is typed.

B xxxx

The lower end of the program limits is set to xxxx. The initial value is 7777 and need not be reset.

O xxxx

The starting address is set to xxxx and the trace operation is begun. xxxx may be an octal number or a symbolic address (provided the latter has been defined using R, see below).

S

A shortened output is now provided which leaves out ADD, C(ADD) and IADD.

J

Only the results of JMS and JMP instructions are typed, the rest are carried out but not typed.

F

Return to full output mode.

P xxxx

Starting printing when location xxxx is reached.

N

Return to normal octal mode for location output.

S

Give location output in symbolic form (symbol tape must have previously been read in using R). Input to E and Z may be a number or symbolic in any case.

R

Read symbol table using high speed reader. Additional symbols may later be entered by preparing a tape containing:

as many sets
as necessary { some columns of leader (200)
rubout (377)
carriage return (215)
line feed (212)
six symbol characters (fill in with
blanks if necessary)
a blank
the octal equivalent
carriage return
line feed
end of tape (204)
rubout (377)

and reading it in using the R command.

A total of 134 user defined symbols may be read. When this number of entries has been accepted, the reading of the tape is terminated, and the computer waits for another command symbol.

H xxxx yyyy

Search (hunt) in memory for xxxx after applying yyyy as a mask. If yyyy is not entered, it is taken as 7777. xxxx may be either a number or a symbol (or set of symbols). Each of the entries between the previously specified Top and Bottom locations will be examined for the designated entry, and when found it (they) will be printed out. H ∅ ∅ will result in list of the instructions between T and B in octal (N) or symbolic (W) form.

E xxxx yyyy zzzz

Examine the contents of xxxx (which may either be a number or a symbolic address). The C(xxxx) is typed as yyyy. A carriage return after yyyy leaves C(xxxx) unchanged. The number zzzz, (if typed) replaces C(xxxx). A carriage return is the normal terminator.

A line feed typed either after yyyy or zzzz will lead to examination of the next sequential location. When xxxx or zzzz are symbolic, they should be terminated by a comma or carriage return, and not be a blank which is interpreted as an OR instruction. If the symbolic output mode is used, the octal equivalent of yyyy may be obtained by typing =.

Y n. nnnnnn Emm

When a Y is typed, the contents of the floating point accumulator is typed in normal floating point form. If terminated by carriage return, the FL AC is unchanged. If a new number is typed, it replaces the C(FL. AC).

Z xxxx n. nnnnnn Emm

A Z followed by xxxx (as a number or a symbolic location) leads to the C(xxxx to xxxx+2) to be typed in floating form. If terminated by a carriage return, the number is unchanged. If a new number is typed it replaces the previous one. If a line feed is used as a terminator, the next sequential floating point number will be typed.

A yyyy

When A is typed, the content of the accumulator is typed as yyyy. If the line is terminated by a non-numeric character, the C(AC) is unchanged. If a number is typed followed by a terminator, the C(AC) is changed to the value typed.

L yyyy

When Y is typed, the content of the link is typed as yyyy. If the line is terminated by a non-numeric character, the C(L) is unchanged. If a number is typed followed by a terminator, the C(L) is changed to 0 or 1 depending on whether 0 or some other number was typed.

U

Transfer to binary punch routine. The computer halts. The number of blocks to be punched is entered in the switch register and CONT is pressed. Then the initial and final addresses of each successive block is entered in the same way.

All ION operations are carried out in the normal fashion except those which reference the teletype. When the sequence

```
TSF
JMP. -1
TLS
```

is found, the set of instructions are typed by a separate subroutine, and then the content of the AC is typed. When the sequence

```
KSF
JMP. -1
KRB
```

is found, the first two instructions are typed by a separate subroutine, and the computer then cycles without printing until the desired character is typed. When it is typed, the last instruction is typed along with the content of the AC (which contains the character typed).

This feature permits programs containing input and output statements to be simulated correctly. Using the P option, it is possible to simulate a program from its beginning up to the desired point for initiating printing of program information. As an example, Fig. 2 shows the simulation of the first order kinetics program (DECUS 8-133) up to location 0563 , and a detailed printout following this point.

After the program has been corrected and is operating properly, it may be punched by typing U, the entry to the binary punch routine. The number of blocks to be punched, and the initial final addresses of each block, are entered via the switch register in the same fashion as for DIGITAL 8-5-U. The normal output is via the high speed punch, but this may be changed to the teletype punch by changing the following

0200 X initial printout when starting at 110000
 P 563 start printout at location 563
 C continue (if a starting location other than 200 was desired, 0nnnn would have been typed)

FIRST ORDER KINETICS
 DATA IN ABSORBANCE, M = 1
 DATA IN TRANSMITTANCE, M = 2
 DATA IN VOLUME, M = 3
 M = 1
 N IS THE NUMBER OF DATA POINTS
 N = 4
 THE INFINITY VALUE = 0.1
 NOW TYPE OBSERVED VALUES AND TIMES
 0.9 0
 0.8 10
 0.7 22
 0.6 36

here, the program, including input and output, is simulated

ALL DATA HAVE BEEN ACCEPTED 0563
 0564 1124 2200 1 0124 2200
 0565 3015 0000 1 0015 2200
 0566 1121 3000 1 0121 3000
 0567 3012 0000 1 0012 3000
 0570 1120 3200 1 0120 3200
 0571 3011 0000 1 0011 3200
 0572 1122 2600 1 0122 2600
 0573 3013 0000 1 0013 2600
 0574 1123 2400 1 0123 2400
 0575 3014 0000 1 0014 2400
 0576 5777 0000 1 0600 7200 0577
 0600 7200 0000 1
 0601 1117 0004 1 0117 0004
 0602 7041 7774 1
 0603 3142 0000 1 0142 7774
 0604 4407
 0605 5150 0150 +0.0000000E+00
 0606 6111 0111 +0.0000000E+00
 0607 6114 0114 +0.0000000E+00
 0610 5415 2200 +0.8999999E+00
 0611 2126 0126 +0.7999999E+00
 0612 6156 0156 +0.7999999E+00
 0613 0000
 0614 7200 0000 1
 0615 1157 3146 1 0157 3146
 0616 7510 3146 1
 0620 7200 0000 1
 0621 1147 0001 1 0147 0001
 0622 4535 0001 1 4355 0623 0135
 4356 3045 0000 1 0045 0001
 4357 3046 0000 1 0046 0000
 4360 1366 0013 1 4366 0013
 4361 3044 0000 1 0044 0013

7200 0000 1
 location 563 is reached and printout begins

a floating point interpreter jump causes switch to a special subroutine

instruction, address and content of floating point accumulator

exit from floating point interpreter - return to main program

```

4362 4407
4363 7000 0000 +0.10000000E+01
4364 0000
4365 5755 0000 1 0623 4407 4355
0623 4407
0624 6075 0075 +0.10000000E+01
0625 0000
0626 5233 0000 1 0633 4407
0633 4407
0634 5415 2200 +0.89999999E+00
0635 5415 2200 +0.89999999E+00
0636 2126 0126 +0.79999999E+00
0637 3075 0075 +0.79999999E+00
0640 0007 0075 -0.2231438E+00
0641 6412 3000 -0.2231438E+00
0642 0000
0643 2012 0000 1 0012 3001
0644 2012 0000 1 0012 3002
0645 2012 0000 1 0012 3003

```

P 1167 typing P causes simulation to halt - 1167 requests timeout to

THE RATE CONSTANT IS +0.1303005E-01

THE INTERCEPT IS -0.2244370E+00

THE RMS ERROR IS +0.1187311E-02

R = +0.9999773E+00

THE PERCENT ERROR IN K IS +0.2842379E+00

resume at 1167

program output resumes

T	Y	YCALC	DIF
+0.0000000E+00	-0.2231438E+00	-0.2244370E+00	-0.1293182E-02
+0.1000000E+02	-0.3566750E+00	-0.3547375E+00	+0.1937508E-02
+0.2199999E+02	-0.5108256E+00	-0.5110982E+00	-0.2726316E-03
+0.3600000E+02	-0.6931471E+00	-0.6935189E+00	-0.3718137E-03

IF PLOT IS DESIRED, RAISE KEY 1, PRESS CONTINUE

1167 7402 0000 0 location 1167 is reached, printout resumes

1167 X instruction is a halt-simulation is halted. It may
be continued by typing C.

Figure 2. Typical printout from TRACE routine.

locations:

location	normal content	revised content for teletype punch
773	6021	6041
775	6026	6046

If an incorrect entry is made while using the trace program, a diagnostic symbol is typed. A list of these symbols is given in Table I.

It may be noted that programs which are largely input-output limited, or which use mainly the floating point interpreter, will be simulated with only a slight increase in execution time prior to the point at which printout occurs. On the other hand, programs which carry out a large amount of fixed point arithmetic will be simulated with a marked increase in execution time prior to initiation of printout.

Table I

TRACE PROGRAM
ERROR DIAGNOSTICS

<u>Indication</u>	<u>Location</u>	<u>Error</u>
Halt simulation	232	CIF or CDF cannot be processed
Halt simulation	342	ION cannot be processed
X	431	Invalid Command character
X	547	5 Numbers for octal input
#	1126, 1133, 1140	Illegal entry to input list question
&	1106	Current address outside of limits
#	1442, 1451, 1457	Illegal entry to T, B or O
@	1722	5 Numbers for octal input
!	2005, 2060, 4310	Invalid input to E or Z
Q	7637, 7651, 7643	Incorrect character on symbol tape
?	4745	Instruction not on current page or page zero
?	4675	Symbolic entry not in symbol table

Example of Use of Examine Options

E 400 1511 CLA CLL — Examine location 400 - it is 1511, change it to CLA CLL
0401 7650 TAD I 115 — previous line terminated with line feed gives
0402 3117 DCA 423 contents of next location
0403 7100 TAD I 123
0404 7450 DCA 437
0405 7240 ISZ 127
0406 1023 ISZ 144
0407 3016 TAD 225 — Attempt to reference off-page location
? — error indicator
E 407 3016 TAD I 177 — location is unchanged, try again
0410 1416 JMP I 577

W — give content of locations in symbolic form (see text for use of R prior to this)

E 400 CLACLL — check locations which were changed above
0401 TAD I 0115 (an easier way is to use the H option)
0402 DCA 0423
0403 TAD I 0123 — line terminated with carriage return for exit.

T 400 — set upper search limit

B 410 — set lower search limit

H 0 0 — H option with a 0 mask - gives contents of all locations
0400 CLACLL in search range
0401 TAD I 0115
0402 DCA 0423
0403 TAD I 0123
0404 DCA 0437
0405 ISZ 0127
0406 ISZ 0144
0407 TAD I 0177
0410 JMP I 0577

A 0000 1234 — Examine accumulator, change it to 1234

A 1234 — Check accumulator

L 0000 22 — Examine link, change it

L 0001 — Content of link is 1 if any non-zero value is given

Y +0.0000000E+00 89.6 — Examine fl.pt. accumulator, change it to 89.6

Y +0.8960001E+02 — Check it

Z 144 +0.9132150E+47 — 10.67 Examine fl.pt. contents of 144-146, change it
to 10.67
Z 144 +0.1066999E+02 — Check it, terminate with line feed to

0147 -0.3402720E+39 0.0 examine next location, change it to 0

0152 +0.1548485E+599 0.0 ditto

Special Notes

The location following E or Z may be given in either octal or symbolic form. However, if it is to be given in symbolic form, the symbol table generated by PAL-III or PALD must first be read using the R command.

The content of locations specified by an E command may be given either in octal or symbolic form. The initial mode is octal. It may be changed to symbolic by typing W and may be changed back to octal by typing N. A symbol table must be read before using the W option. This may either be the symbol table produced along with the binary program to be tested by the PAL-III or PALD assemblers, or if this is not available, it may be a dummy symbol table made up as follows

```
some leader-trailer (200)
rubout (377)
carriage return (215)
line feed (212)
end of tape (204)
rub out (377)
```

The new content (if any) of a location specified by an E command may be given in octal or symbolic form regardless of which output mode is used. Thus, if TEST=105, one might type

```
4105
JMS 105
JMS TEST
```

If the appropriate symbol table had been read, all of these would lead to the same result. If only the dummy symbol table had

been read, the last would be invalid, but the first two would still be equivalent.

It must be noted that an I always specifies indirect. Thus, if INDEX=77,

TAD INDEX

would not be accepted and one would have to type

TAD 77

However, TAD I INDEX would be interpreted correctly.