UNIVERSITY OF ILLINOIS
DIGITAL COMPUTER

AUX.
LIBRARY ROUTINE Y4-236
By Roger Farrell

TITLE Input Routines to Drum Memory
TYPE Entire Program
NUMBER OF WORDS 249
DESCRIPTION

This routine reads and stores library routines on the drum. A sum check is computed and stored after each routine. During input a list of reference words is formed and stored on the drum. When SADOI is directed to bring a routine off the drum the list of reference words is searched. The right most eleven bits of the reference word tell SADOI the location of the first word of the routine on the drum.

Routines to be stored must not use symbolic addresses. The terminating symbols K,S,N,J,F,L may be used and are preserved. In general any routine so written for SADOI may be stored on the drum using Y-4. Directives and N-terminated jump instructions will be correctly interpreted and executed when SADOI brings a routine from the drum. Directives and N-terminated jump instructions may appear as left or right hand instructions. However, unlike reading a routine from tape, when a directive or N-terminated instruction appears as a right hand instruction an extra word is stored in the Williams memory when a routine is read from the drum by SADOI.

This routine is designed to read a series of routines and store them on the drum. The first location of each routine on the drum may be arbitrarily specified or may be automatically placed immediately after the preceding routine. The first routine of the series must be preceded by two ten character sexadecimal constants:

1st constant: A drum instruction of the form 8600S . . . . . .
The address used in this drum order determines how far Y-4 may store in the drum memory. For example "8600S003LL" restricts the addresses which may be used to lie below 1023.

If this constant does not appear on the tape an FF stop results. Similarly, if the limit is exceeded an FF stop results.

2nd constant: An address written in sexadecimal. For example 0000000064. This address is subtracted from each reference word before it is stored on the drum. It must equal the address of the first reference word (SADOI requires this equality).

Each routine must be preceded by a symbolic address (which names the routine) and by two decimal addresses which specify the storage locations for the reference word and routine. Each decimal address must be terminated by one of K,S,N,J,F, or L. For example (N12) 3000F 3010F says library routine N12, reference word at 3000, routine begins at 3010.

When zero rather than non-zero addresses are written, the reference word is placed immediately following the preceding reference word and the routine is placed immediately after the preceding routine. For example (R1)FF.

Each library routine must be followed by 00N. This directs Y-4 that a special termination should be stored on the drum. ILLIAC then stops on a 24 jump instruction. After 00N for the last routine, if a pair of parenthesis ( ) is written, Y-4 stops on an 0F instruction.

Example

```
8600S 00 3LL
00000 00 064
(N12) 1000F 1040F
 ..............
       00N
(P16) F F
 ..............
       00N
(R1) F F
       00N
       ( )
```

For each routine stored on the drum four lines of information are punched by ILLIAC. A typical example is

P16
0 - - 8
181800000+
0 - N2

The information is sexadecimal. It describes the operation of Y4. In the example P16 is stored with the first word at 0 - N2 and has reference word 181800000+ which is stored at 0 - - 8. When the last routine is followed by ( ) one plus the address of the last word stored is punched sexadecimally.

When routines stored on the drum are to be read by SADOI the reference words must be stored in consecutive locations. The 1st word of a library routine must be stored at a higher address than that of the reference word. SADOI determines that it has completely searched the reference word list when it reads -1 from the drum. During input -1 is automatically stored immediately following the last reference word. If a new reference word is received it over writes the -1 which is then restored immediately after the new reference word.

METHOD OF COMPACTING

Y4 reads instructions and forms blocks of 8 digits from them. When five blocks have been formed a 40 digit word is stored on the drum. Each instruction is represented by at least two blocks, one for the function digits and one for the address and terminating symbol. An instruction may, however, require as many as four blocks but never more than four. The address n of an instruction is read and decomposed into parts a, b such that $0 \leq a,b < 64$ and $n = 64a + b$. From a and b blocks of 8 digits are formed. Since $64 \times 64 = 4096$ each block has two extra digital positions which are used to give information about the termination. These are the left most 2 digits and have the following interpretations.

00: The part a of the address

01: The part b of the address, L termination

10: The part b of the address, F termination

11: K,S,N terminations.

In assembling blocks for storage on the drum the address blocks are to the right of the function digit blocks. They are interpreted first when SADOI reads a routine back from the drum. The following examples show in sexadecimal how various instructions are stored on the drum

	Instruction	Compacted Form
F	40 F	40 80
	40 3F	40 83
	41 1491F	41 93 17
L	L5 L	L5 40
	K5 2L	K5 42
	50 2240L	50 40 23
S	L5 S3	L5 N3
	40 3S7	40 N7 03
	J0 69S5	J0 N5 05 01
K	00 K	N1 00 80
	00 129K	N1 00 81 02
N	26 1N	N0 26 81
	26 64N	N0 26 80 01

The address block LL is used to indicate the end of the routine.

In operation Y-4 reads a pair of instructions, saving the terminating symbols. The resulting number is then split into function digits and addresses and stored on the drum together with the terminations. Thus cases

of drum orders and integer input in which the address must add to the function digits are taken care of. In case an instruction is J-terminated the decimal fraction is computed. The result (added to the function digits) is then split into function digits and addresses and stored on the drum. The fraction is computed by division with accuracy $\pm 2^{-40}$. As with SADOI any fraction 0 to .999 999 999 999 may be input without making special use of the function digits.

INTERLUDES

It is convenient to think of SADOI as using tape input and drum input. Bringing a routine from the drum is called drum input. The three types of interludes which may be written for tape input may also be used during drum input. Their operation is exactly the same as with interludes initiated during tape input, with one exception. Interludes initiated during drum input never require substitution of real addresses where inside symbolic addresses have been used.

Special interludes may thus be written for routines to be stored on the drum. The block of instructions to be used in the interlude is preceded by the customary 26 1000N instruction. SADOI has been written in such a way that if, during tape input, the beginning of a special interlude is marked by a 26 1000N instruction, and, if interior to this block of instructions drum input occurs which also uses a special interlude, the information about the tape input controlled special interlude is remembered. Thus drum input interludes in no way interfer with tape input.

COMBINATION LIBRARY ROUTINES

Library routine A6 consists of several routines which are individually useful (A1, etc) but which are sometimes wanted in the form of A6. By changing one word of SADOI it is possible to have one designator call several routines. The following shows how this was done for A6. Note that the fast interlude use instructions stored in 563 ff of the Williams memory. The fast interludes are preceded by the directive 00 600K so that as far as SADOI's bookkeeping is concerned these words do not overwrite locations which have inside symbolic addresses.

First Part of A6

```
     (A6) FF
          00 3K
3         00 F
          00 557F        Automatically preset
4         00 F
          00 559F        S parameters
5         00 F
          00 727F
6         00 F
          00 754F
7         00 F
          00 770F
8         00 F
          00 796F
9         00 F
          00 822F
10        00 F
          00 852F

          00 600K
563       L5 566F        Fast interlude written in fixed address. These
          40 319F        words are overwritten by A1 at next step.
564       L5 368F
          42 86F         The first instruction pair modifies the jump after
565       26 269F        the sum check is tested. The second instruction
          00 F           pair prevents these words from being stored on the
566       L3 1023F       drum.
          32 263F
          26 1469N
          00 559K        Set directive for A1
          00 N           Termination of A6
          (A1) FF
                         Begin A1.
```

Second Part of A6

```
        (A6) FF
        00 600K     FAST Interlude
563     L5 570F     Reset SADOI
        40 319F
564     L5 368F     Prevent overwriting
        42 86F
565     24 269F     Choice of DOI or
        L5 568F       SADOI by white or black switch.
566     40 1023F
        L5 569F
567     40 1F
        26 1008F    Start playback from drum to Williams Memory.
568     85 11F
        40 F
569     00 F
        26 1023F
570     L3 1023F
        32 320F

        26 1469N

        00 430K     Preset the directive

        00 N        Terminate A6
```

CALCULATION OF STORAGE SPACE

When a routine does not use J terminated instructions the exact space needed is easily determined. The space needed for J terminated instructions can be determined only by converting the fraction to an order pair representation. The following formula will often be exact and is always an upper bound on the space required. Let

a = the number of instructions
b = F,L terminations with addresses ≥ 64
c = S terminations, $0 <$ address < 64
d = S terminations, address ≥ 64
e = K,N terminations, $0 \leq$ address ≤ 64
f = K,N terminations, $64 \leq$ address
g = J terminations

Compute the fraction $s = \dfrac{2a + b + c + 2d + e + 2f + 2g + 6}{5}$

and round up to the nearest integer. For routine Y1, a = 80 b = 2 c = d = e = f = g = 0 $s = 33\frac{3}{5}$. 34 words are required (Sum check is included). For routine F1, a = 107 b = 7 c = d = 0 e = 1 f = 0 g = 3 and $s = 46\frac{4}{5}$. 47 words are required.

Dependence on this formula for determining space requirements is risky because mistakes can be made easily. The information printed by Y-4 allows exact determination of the space used. The sexadecimal drum order which heads the series of routines provides a means of preventing Y-4 from overwriting non-free locations.

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