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SUMMARY REPORT
ON-LINE LOGICAL SIMULATION (OLLS)

by

H. R. Howie, G. Schwartz,
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April 1969

INSTRUMENTATION
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E-2410

Summary Report

ON-LINE LOGICAL SIMULATION (OLLS)

ABSTRACT

This report is intended to summarize the progress in implementing the system described in an earlier document MIT/IL Report E-2265, ON-LINE LOGICAL SIMULATION (OLLS), written in May 1968. The topics discussed in that document will be reported here in the same order. It is assumed that the reader is familiar with the contents of E-2265 and no attempt will be made here to redescribe the technical makeup of the various subsystems. Results of computer test runs and the to-date status of the programs are presented.

by H. R. Howie
G. Schwartz
H. A. Thaler
April 1969

TABLE OF CONTENTS

1. INTRODUCTION

The possibility of using computers to aid designers has been recognized and exploited, in various ways, for the last several years. Designers can have mechanized help in small circuit design (ECAP, NET), and in some forms of mechanical design (SKETCHPAD). As SKETCHPAD showed, the implications of a cathode ray tube system whereby the designer and the computer interact, as opposed to the more prevalent processing systems, are many and exciting.

The possibility of using major data processing aids for logical designs became an important concern to those who had been engaged, for quite some time, in the development of medium-sized computer systems, especially if those systems could be made interactive. But interactive or not, accumulated experience in logical design indicated the near necessity of mechanized files, drafting aids, and simulations.

The initial objective of MIT/IL was not so much to demonstrate the power of a new approach (Computed Aided Design) as to develop and implement a practical system. We are still short of that goal in that we do not have an operational interactive system; we do have a batch system (MAC 360) and major portions of the more ambitious FILLIP List Processing System and the CRT Interactive System. Consequently, the present report is in part a demonstration of achievement and in part a blueprint of present and future developments.

MAC 360 is a card system, with very limited file capability, wherein the logical device models are an integral part of the program. It was written without recourse to a list-processing language, and has been in use for about six months.

In early 1967 a decision was made by the Digital Computation group (which runs the data processing system of Instrumentation Laboratory) to implement a major list-processing language called FILLIP, and it was decided then that OLLS/360 should be based on FILLIP. As of this writing, FILLIP is still under development for its overall system aspects, and, consequently, some of the FILLIP Card System remains untested. The major features of FILLIP, and its power, are described in The Users' Guide to FILLIP by Charles A. Muntz and J. Halcombe Laning, Jr.

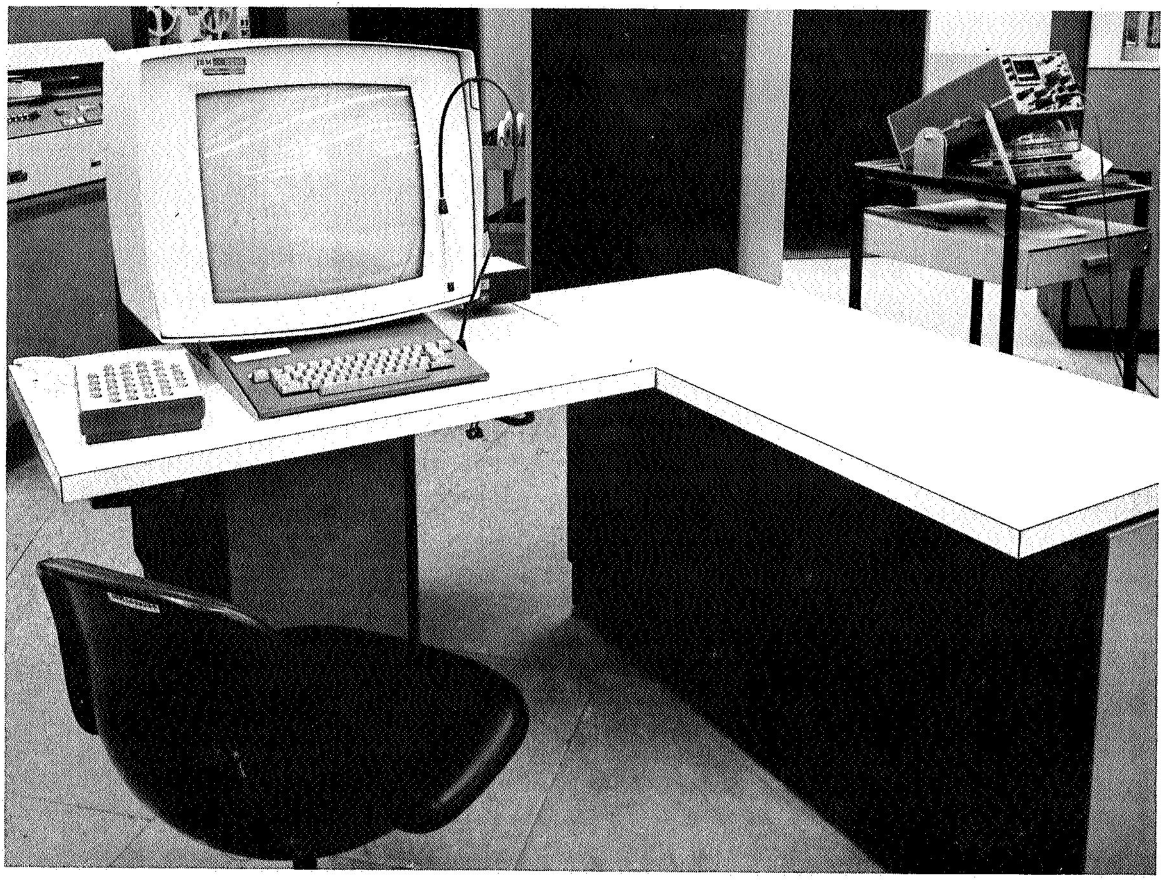


Fig. 1-1 OLLS/360 Installation

When it became apparent that the FILLIP language would not be operational before mid 1968, and FILLIP would not be able to handle difficult I/O such as the CRT interface or a plotter, we decided to implement a machine language version of the logic file specifically with an interactive CRT - operator interface in mind. While this version may lack some of the elegance present in the FILLIP version made possible by such FILLIP operations as "TREE", "SICS", and "MDUPL" which allow large file structures to be searched and manipulated by only a few lines of source coding, similar operations are not difficult to implement in machine language. The tradeoffs are much more source coding for speed, efficiency, and the ability to access any I/O device attached to the CPU.

2. THE MAC 360 WORKING SYSTEM

This system is very similar to the so-called H1800 system described in Chapter 2 of E-2265. The original programs (written in a language called MAC) were translated and expanded from the versions which ran on the Honeywell 1800 to be a useful design tool on the IBM 360. With the exception of a few input-output routines which are written in machine language, the IBM 360 version is also written in the language of MAC.

Many changes and improvements were made in the system.

a) The list of available device types was expanded to 34 devices.

b) The running time for a typical drawing was reduced to about 1.5 minutes of CPU time.

c) The REVISE mode was removed from DRAWSCHEMATIC and replaced by a separate program which can rename devices and signals if required.

d) The aesthetic quality of the output plots was greatly improved by the addition of a routine which puts a frame on the plot which conforms to standard drafting conventions. (See Fig. 2-1)

The MAC 360 system is in full production use at MIT/IL, and, although it was never intended to be used in production, we feel we have learned much from the experience.

a) Since most logic designers are unaccustomed to punching cards, a card input system can be a very frustrating experience for the designer at first. Too much time and energy is spent learning and conforming to card formats and trivial details, and too little time is spent in design.

b) A system with no immediate feedback to the designer is very slow and costly. Most drawings require 3 or 4 reruns before they become a finished part of the logic design. This implies a process time of about one week and a cost of about 6 CPU minutes per drawing.

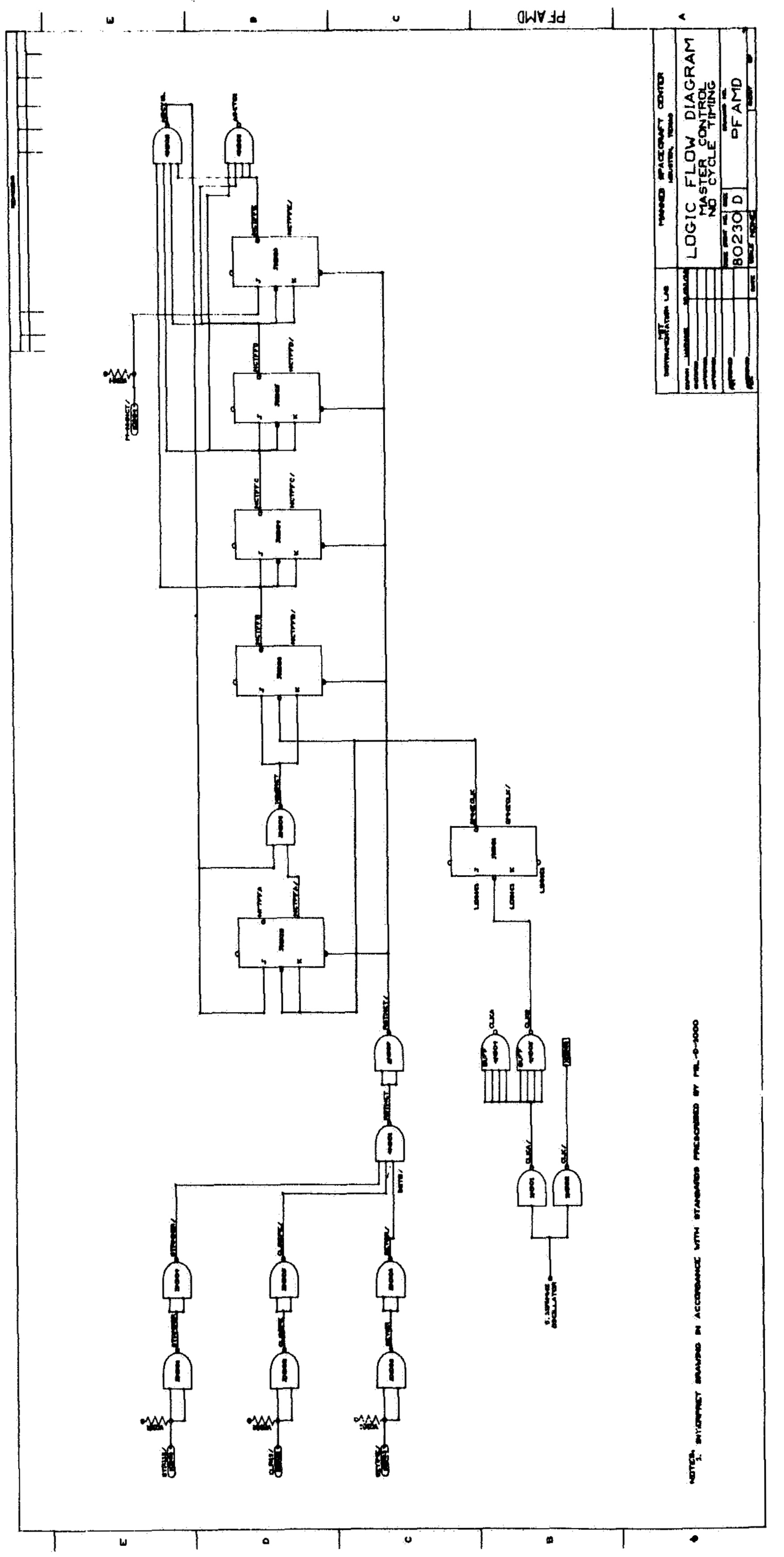


Fig. 2-1 Drawing Format

[illegible]

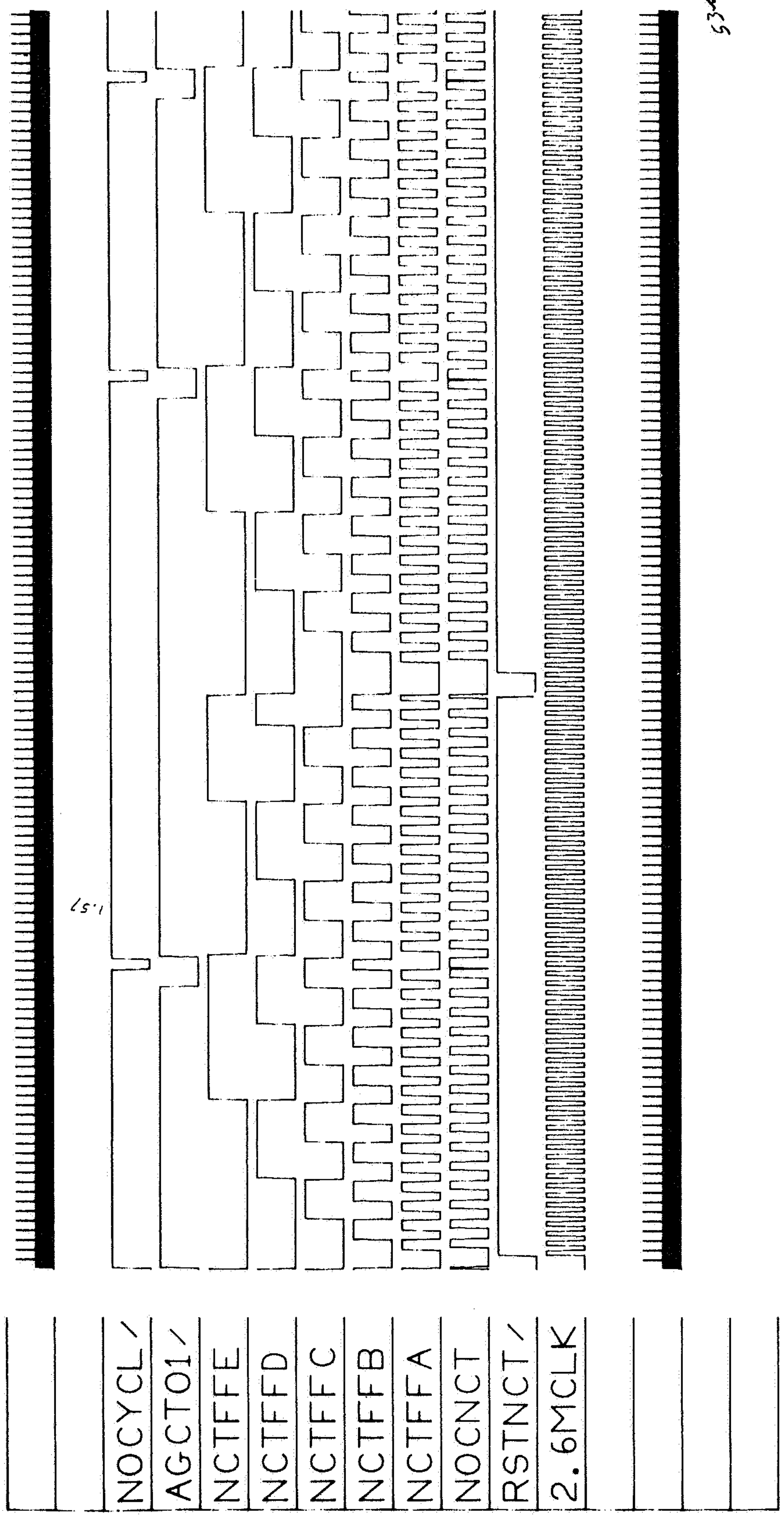


Fig. 2-2 PFAMD Simulation

For most logic systems which will have many such drawings, the effect on schedules and budgets is severe. Most of the difficulty is due to the fact that the entire drawing must be resubmitted in order to make even minor corrections. The former REVISE mode was no better since even though fewer input cards were submitted for a revision, the program still had to load up the entire old file to process a revision. An interactive system of even the most rudimentary type would be easier to learn, faster to operate (both CPU and real time), and place the designer in a position where he is not completely at the mercy of a batch program.

c) The inflexibility of this program keeps the designer in a very tight box. He is constantly faced by problems such as not enough device types, not enough space on the drawing, small logic file, etc.

What we learned most from this system is that designers dislike IBM cards. They also have little use for printed computer output except for finished signal lists (and even then only if someone else will be reading the list). Supervisors are uneasy about designers who must spend too much time doing non-design type clerical work, and they are especially uneasy about high costs and schedule bottlenecks.

The system does work however, and its main selling point is the ability to produce and maintain accurate signal lists and wire wrap control cards, and as such it will remain useful (if cumbersome and costly) until an interactive system is operational.

Figure 2-1 shows the new drawing format. We include it here for its own sake and to aid in the interpretation of the computer output for the creation and simulation of PFAMD shown in Section 3. (Figs. 3-1 through 3-16).

The simulation of PFAMD shown in Fig. 2-2 was obtained by injecting inputs to the circuit at "2.6MCLK" and "RSTNCT/". Note the appearance of a "sneak pulse" on signal "NOCNCT" coincident with the falling edge of signal "NOCYCL/". This represents an essential circuit hazard and is also discovered by the FILLIP simulation. (See Fig. 3-14 at time 297 and Fig. 3-15)

3. THE FILLIP CARD INPUT SYSTEM

3.1 General

The status of the OLLS card system is, as it has been in the past, closely related to that of the FILLIP language. A recent milestone in the development of this language was the implementation of a "stored file" capability, which allows for the creation, deletion, calling, and storage (on disc) of FILLIP files. Now it is possible to save data files between runs and to store programs, which correspond to OLLS asterisk cards, in separate files.

Of course, this state of FILLIP's development was not unexpected; we have always endeavored to write our programs in a way which would require no conversion when the "stored file" version of FILLIP became available. Only the CARDREAD program, which does the actual file manipulation, needed rewriting; this has been done, but the new program has not been debugged.

The new CARDREAD program treats a particular data file either as a read-only (henceforth called a "read") file or as a read/write ("write" or "working") file. There is nothing inherent to a FILLIP file which makes it a read or a write file; this distinction is made by OLLS to enable its users to use the same file for several asterisk instructions without repeating its name on each card, and to simplify the syntax of instructions which require several variables.

Figures 3-1 through 3-16 show the printer output from a recent FILLIP OLLS run in which a data file was created, three devices were defined, and a circuit, essentially the same as PFAMD shown in Fig. 2-1, was constructed and simulated. The simulation output from the printer corresponds to the plotted output from the MAC 360 simulation in Fig. 2-2.

3.2 Existing Programs

The following asterisk instructions are either working or are being debugged:

* OPEN	(3.2.1)
* DEFINE	(3.2.2)

```
* CREATE FILE PFAMO                                                  DAY=228  01:48  08/15/68  PAGE 114


  END OF STEP     * CREATE FILE PFAMO
```

Figure 3-1

```
* DEFINF DEVICE NAND                                          DAY=228  01:48  08/15/68  PAGE 115

      OUTPUTS A
      INPUTS B C D E
      ~~DEFAULT 1 1 1 1~~
      EQUATION A = ¬ ( B * C * D * E )
      FORMAT A B C D E


  END OF STEP    * DEFINE DEVICE NAND
```

Figure 3-2

```
* DEFINF DEVICE JK                                            DAY=228  01:48  08/15/68  PAGF 116

   OUTPUTS A B
   INPUTS J K T S R
   DEFAULT 1 1 1 1 1
   EQUATION A = ¬ S + T * ¬ T * ( J * ¬ A + ¬ K * A ) + ¬ ( T * ¬ T ) * ¬ B
   DELAY          1   2     1     1     1     1   1         2     1       1
   EQUATION B = ¬ R + T * ¬ T * ( K * ¬ B + ¬ J * B ) + ¬ ( T * ¬ T ) * ¬ A
   DELAY          1   2     1     1     1     1   1         2     1       1
   FORMAT A B J K T S R


END OF STEP    * DEFINE DEVICE JK
```

Figure 3-3

```
 * DEFINE DEVICE OSC                                                    DAY=228  01:48  08/15/68  PAGE 117

      OUTPUTS B
      INPUTS A
      EQUATION B = A * ¬ B
      DELAY 0 5
      FORMAT B A


 END OF STEP    * DEFINE DEVICE OSC
```

Figure 3-4

```
 * GET PFAMD                                                                      DAY=228  01:48  08/15/68  PAGE 118

      NAND 1 1 1 1 RSTNCT/ RSTNCT

      NAND 2 1 2 2 NOCNCT NOCYCL/ NCTFFA/

      NAND 3 1 3 3 NOCYCL/ NCTFFB NCTFFC NCTFFD NCTFFE

      NAND 4 1 4 4 AGCT01/ NCTFFC NCTFFD NCTFFE

      NAND 10 1 20 20 N10  N12

      NAND 11 1 21 21 N11 N10

      NAND 12 1 22 22 N12 N11

      JK 1 1 6 6 NCTFFA NCTFFA/ NOCYCL/ $  CLOCK $  RSTNCT/

      JK 2 1 7 7 NCTFFB NCTFFB/ NOCNCT NOCNCT CLOCK $  RSTNCT/

      JK 3 1 8 8 NCTFFC NCTFFC/ $ $ NCTFFB $  RSTNCT/

      JK 4 1 9 9 NCTFFD NCTFFD/ $ $ NCTFFC $  RSTNCT/

      JK 5 1 10 10 NCTFFE NCTFFE/ $ $ NCTFFD $  RSTNCT/



 END OF STEP    * GET PFAMD
```

Figure 3-5

```
      INITIAL1 RSTNCT

      INITIAL0 CLOCK

      INITIAL0 N10

      PROP

SIGNAL  N10      Became  Undefined  During  Propagation, Value Was  0
SIGNAL  N11                                                         1
SIGNAL  N12                                                         0
      PRINT SIGNALS


SIGNAL NAME    SOURCE GATE    TERMINAL    VALUE    TIME

RSTNCT/        1              A           0        -524 288
RSTNCT                                    1        -524 288
NOCNCT         2              A           0        -524 288
NCTFFA/        1              B           1        -524 288
AGCT01/        4              A           1        -524 288
NCTFFA         1              A           0        -524 288
CLOCK                                     0        -524 288
NCTFFB         2              A           0        -524 288
NCTFFC         3              A           0        -524 288
NCTFFB/        2              B           1        -524 288
NCTFFD         4              A           0        -524 288
NCTFFC/        3              B           1        -524 288
NCTFFE         5              A           0        -524 288
NCTFFD/        4              B           1        -524 288
NCTFFE/        5              B           1        -524 288
```

Figure 3-6

```
* SIMULATE PFAMD                                                                DAY=228  01:48  08/15/68  PAGE 120

NOCYCL/         3           A            1          -524 288
N10             10          A                       -524 288
N12             12          A                       -524 288
N11             11          A                       -524 288
UNUSED1                                  1          -524 288
     MINPULSE 3 3
     EVENT RSTNCT 0 0
     TRACE NOCNCT   CLOCK RSTNCT/ NCTFFA NCTFFB NCTFFC NCTFFD NCTFFE NOCYCL/
     C AGCT01/
     SEQUENCE CLOCK 1 10 0 5
     RUN 350
     PRINT SIGNALS

SIGNAL NAME     SOURCE GATE TERMINAL     VALUE      TIME

RSTNCT/         1           A            1             1
RSTNCT                                   0             0
NOCNCT          2           A            0           347
NCTFFA/         1           B            1           346
AGCT01/         4           A            1           308
NCTFFA          1           A            0           346
CLOCK           SEQINST     SEQOUT       1           350
NCTFFB          2           A            0           346
NCTFFC          3           A            1           347
NCTFFB/         2           B            1           346
```

Figure 3-7

```
* SIMULATE PFAMD                                                              DAY=228  01:48  08/15/68  PAGE 121

NCTFFD          4          A          0          308

NCTFFC/         3          B          0          347

NCTFFE          5          A          0          309

NCTFFD/         4          B          1          308

NCTFFE/         5          B          1          309

NOCYCL/         3          A          1          307

N10            10          A                 -524 288

N12            12          A                 -524 288

N11            11          A                 -524 288

UNUSED1                               1      -524 288

     PRINT LINTRACE 1
```

17

```
****************

        CLOCK    RSTNCT/   NCTFFA    NOCNCT    NCTFFB    NCTFFC    NCTFFD    NCTFFE    AGCT01/   NOCYCL/

      0   1
      1   1       1
      2   1       1
      3   1       1
      4   1       1
      5  0        1
      6  0        1         1
      7  0        1         1         1
      8  0        1         1         1
      9  0        1         1         1
     10   1       1         1         1
     11   1       1         1         1
     12   1       1         1         1
     13   1       1         1         1
     14   1       1         1         1
     15  0        1         1         1
     16  0        1        0          1         1
     17  0        1        0         0          1
     18  0        1        0         0          1
```

Figure 3-8

```
* SIMULATE PFAMD                                                              DAY=228  01:48  08/15/68  PAGE 122

      19  0        1       0       0         1
      20   1       1       0       0         1
      21   1       1       0       0         1
      22   1       1       0       0         1
      23   1       1       0       0         1
      24   1       1       0       0         1
      25  0        1       0       0         1
      26  0        1        1      0         1
      27  0        1        1       1        1
      28  0        1        1       1        1
      29  0        1        1       1        1
      30   1       1        1       1        1
      31   1       1        1       1        1
      32   1       1        1       1        1
      33   1       1        1       1        1
      34   1       1        1       1        1
      35  0        1        1       1        1
      36  0        1       0        1       0
      37  0        1       0       0        0         1
      38  0        1       0       0        0         1
      39  0        1       0       0        0         1
      40   1       1       0       0        0         1
      41   1       1       0       0        0         1
      42   1       1       0       0        0         1
      43   1       1       0       0        0         1
      44   1       1       0       0        0         1
      45  0        1       0       0        0         1
      46  0        1        1      0        0         1
      47  0        1        1       1       0         1
      48  0        1        1       1       0         1
      49  0        1        1       1       0         1
      50   1       1        1       1       0         1
      51   1       1        1       1       0         1
      52   1       1        1       1       0         1
      53   1       1        1       1       0         1
      54   1       1        1       1       0         1
      55  0        1        1       1       0         1
      56  0        1       0        1        1        1
      57  0        1       0       0         1        1
      58  0        1       0       0         1        1
      59  0        1       0       0         1        1
      60   1       1       0       0         1        1
      61   1       1       0       0         1        1
      62   1       1       0       0         1        1
      63   1       1       0       0         1        1
      64   1       1       0       0         1        1
      65  0        1       0       0         1        1
      66  0        1        1      0         1        1
      67  0        1        1       1        1        1
      68  0        1        1       1        1        1
      69  0        1        1       1        1        1
```

Figure 3-9

```
* SIMULATE PFAMD                                                    DAY=228  01:48  08/15/68  PAGE 123

  70  1     1     1     1     1     1
  71  1     1     1     1     1     1
  72  1     1     1     1     1     1
  73  1     1     1     1     1     1
  74  1     1     1     1     1     1
  75  0     1     1     1     1     1
  76  0     1     0     1     0     1
  77  0     1     0     0     0     0
  78  0     1     0     0     0     0     1
  79  0     1     0     0     0     0     1
  80  1     1     0     0     0     0     1
  81  1     1     0     0     0     0     1
  82  1     1     0     0     0     0     1
  83  1     1     0     0     0     0     1
  84  1     1     0     0     0     0     1
  85  0     1     0     0     0     0     1
  86  0     1     1     0     0     0     1
  87  0     1     1     1     0     0     1
  88  0     1     1     1     0     0     1
  89  0     1     1     1     0     0     1
  90  1     1     1     1     0     0     1
  91  1     1     1     1     0     0     1
  92  1     1     1     1     0     0     1
  93  1     1     1     1     0     0     1
  94  1     1     1     1     0     0     1
  95  0     1     1     1     0     0     1
  96  0     1     0     1     1     0     1
  97  0     1     0     0     1     C     1
  98  0     1     0     0     1     0     1
  99  0     1     0     0     1     0     1
 100  1     1     0     0     1     0     1
 101  1     1     0     0     1     0     1
 102  1     1     0     0     1     0     1
 103  1     1     0     0     1     0     1
 104  1     1     0     0     1     0     1
 105  0     1     0     0     1     0     1
 106  0     1     1     0     1     0     1
 107  0     1     1     1     1     0     1
 108  0     1     1     1     1     0     1
 109  0     1     1     1     1     0     1
 110  1     1     1     1     1     0     1
 111  1     1     1     1     1     0     1
 112  1     1     1     1     1     0     1
 113  1     1     1     1     1     0     1
 114  1     1     1     1     1     0     1
 115  0     1     1     1     1     C     1
 116  0     1     0     1     0     0     1
 117  0     1     0     0     0     1     1
 118  0     1     0     0     0     1     1
 119  0     1     0     0     0     1     1
 120  1     1     0     0     0     1     1
```

Figure 3-10

```
* SIMULATE PFAMD                                                    DAY=228  01:48  08/15/68  PAGE 124

     121  1     1     0     0     0     1     1
     122  1     1     0     0     0     1     1
     123  1     1     0     0     0     1     1
     124  1     1     0     0     0     1     1
     125  0     1     0     0     0     1     1
     126  0     1     1     0     0     1     1
     127  0     1     1     1     0     1     1
     128  0     1     1     1     0     1     1
     129  0     1     1     1     0     1     1
     130  1     1     1     1     0     1     1
     131  1     1     1     1     0     1     1
     132  1     1     1     1     0     1     1
     133  1     1     1     1     0     1     1
     134  1     1     1     1     0     1     1
     135  0     1     1     1     0     1     1
     136  0     1     0     1     1     1     1
     137  0     1     0     0     1     1     1
     138  0     1     0     0     1     1     1
     139  0     1     0     0     1     1     1
     140  1     1     0     0     1     1     1
     141  1     1     0     0     1     1     1
     142  1     1     0     0     1     1     1
     143  1     1     0     0     1     1     1
     144  1     1     0     0     1     1     1
     145  0     1     0     0     1     1     1
     146  0     1     1     0     1     1     1
     147  0     1     1     1     1     1     1
     148  0     1     1     1     1     1     1
     149  0     1     1     1     1     1     1
     150  1     1     1     1     1     1     1
     151  1     1     1     1     1     1     1
     152  1     1     1     1     1     1     1
     153  1     1     1     1     1     1     1
     154  1     1     1     1     1     1     1
     155  0     1     1     1     1     1     1
     156  0     1     0     1     0     1     1
     157  0     1     0     0     0     0     1
     158  0     1     0     0     0     0     0
     159  0     1     0     0     0     0     0     1
     160  1     1     0     0     0     0     0     1
     161  1     1     0     0     0     0     0     1
     162  1     1     0     0     0     0     0     1
     163  1     1     0     0     0     0     0     1
     164  1     1     0     0     0     0     0     1
     165  0     1     0     0     0     0     0     1
     166  0     1     1     0     0     0     0     1
     167  0     1     1     1     0     0     0     1
     168  0     1     1     1     0     0     0     1
     169  0     1     1     1     0     0     0     1
     170  1     1     1     1     0     0     0     1
     171  1     1     1     1     0     0     0     1
```

Figure 3-11

```
* SIMULATE PEAMD                                                    DAY=228  01:48  08/15/68  PAGE 125

        172  1       1       1       1       0       0       0       1
        173  1       1       1       1       0       0       0       1
        174  1       1       1       1       0       0       0       1
        175  0       1       1       1       0       0       0       1
        176  0       1       0       1       1       0       0       1
        177  0       1       0       0       1       0       0       1
        178  0       1       0       0       1       0       0       1
        179  0       1       0       0       1       0       0       1
        180  1       1       0       0       1       0       0       1
        181  1       1       0       0       1       0       0       1
        182  1       1       0       0       1       0       0       1
        183  1       1       0       0       1       0       0       1
        184  1       1       0       0       1       0       0       1
        185  0       1       0       0       1       0       0       1
        186  0       1       1       0       1       0       0       1
        187  0       1       1       1       1       0       0       1
        188  0       1       1       1       1       0       0       1
        189  0       1       1       1       1       0       0       1
        190  1       1       1       1       1       0       0       1
        191  1       1       1       1       1       0       0       1
        192  1       1       1       1       1       0       0       1
        193  1       1       1       1       1       0       0       1
        194  1       1       1       1       1       0       0       1
        195  0       1       1       1       1       0       0       1
        196  0       1       0       1       0       0       0       1
        197  0       1       0       0       0       1       0       1
        198  0       1       0       0       0       1       0       1
        199  0       1       0       0       0       1       0       1
        200  1       1       0       0       0       1       0       1
        201  1       1       0       0       0       1       0       1
        202  1       1       0       0       0       1       0       1
        203  1       1       0       0       0       1       0       1
        204  1       1       0       0       0       1       0       1
        205  0       1       0       0       0       1       0       1
        206  0       1       1       0       0       1       0       1
        207  0       1       1       1       0       1       0       1
        208  0       1       1       1       0       1       0       1
        209  0       1       1       1       0       1       0       1
        210  1       1       1       1       0       1       0       1
        211  1       1       1       1       0       1       0       1
        212  1       1       1       1       0       1       0       1
        213  1       1       1       1       0       1       0       1
        214  1       1       1       1       0       1       0       1
        215  0       1       1       1       0       1       0       1
        216  0       1       0       1       1       1       0       1
        217  0       1       0       0       1       1       0       1
        218  0       1       0       0       1       1       0       1
        219  0       1       0       0       1       1       0       1
        220  1       1       0       0       1       1       0       1
        221  1       1       0       0       1       1       0       1
        222  1       1       0       0       1       1       0       1
```

Figure 3-12

```
223   1    1    0    0    1    1    0    1
224   1    1    0    0    1    1    0    1
225   0    1    0    0    1    1    0    1
226   0    1    1    0    1    1    0    1
227   0    1    1    1    1    1    0    1
228   0    1    1    1    1    1    0    1
229   0    1    1    1    1    1    0    1
230   1    1    1    1    1    1    0    1
231   1    1    1    1    1    1    0    1
232   1    1    1    1    1    1    0    1
233   1    1    1    1    1    1    0    1
234   1    1    1    1    1    1    0    1
235   0    1    1    1    1    1    0    1
236   0    1    0    1    0    1    0    1
237   0    1    0    0    0    0    0    1
238   0    1    0    0    0    0    1    1
239   0    1    0    0    0    0    1    1
240   1    1    0    0    0    0    1    1
241   1    1    0    0    0    0    1    1
242   1    1    0    0    0    0    1    1
243   1    1    0    0    0    0    1    1
244   1    1    0    0    0    0    1    1
245   0    1    0    0    0    0    1    1
246   0    1    1    0    0    0    1    1
247   0    1    1    1    0    0    1    1
248   0    1    1    1    0    0    1    1
249   0    1    1    1    0    0    1    1
250   1    1    1    1    0    0    1    1
251   1    1    1    1    0    0    1    1
252   1    1    1    1    0    0    1    1
253   1    1    1    1    0    0    1    1
254   1    1    1    1    0    0    1    1
255   0    1    1    1    0    0    1    1
256   0    1    0    1    1    0    1    1
257   0    1    0    0    1    0    1    1
258   0    1    0    0    1    0    1    1
259   0    1    0    0    1    0    1    1
260   1    1    0    0    1    0    1    1
261   1    1    0    0    1    0    1    1
262   1    1    0    0    1    0    1    1
263   1    1    0    0    1    0    1    1
264   1    1    0    0    1    0    1    1
265   0    1    0    0    1    0    1    1
266   0    1    1    0    1    0    1    1
267   0    1    1    1    1    0    1    1
268   0    1    1    1    1    0    1    1
269   0    1    1    1    1    0    1    1
270   1    1    1    1    1    0    1    1
271   1    1    1    1    1    0    1    1
272   1    1    1    1    1    0    1    1
273   1    1    1    1    1    0    1    1
```

Figure 3-13

```
274  1    1    1    1    1    0    1    1
275  0    1    1    1    1    0    1    1
276  0    1    0    1    0    0    1    1
277  0    1    0    0    0    1    1    1
278  0    1    0    0    0    1    1    1    0
279  0    1    0    0    0    1    1    1    0
280  1    1    0    0    0    1    1    1    0
281  1    1    0    0    0    1    1    1    0
282  1    1    0    0    0    1    1    1    0
283  1    1    0    0    0    1    1    1    0
284  1    1    0    0    0    1    1    1    0
285  0    1    0    0    0    1    1    1    0
286  0    1    1    0    0    1    1    1    0
287  0    1    1    1    0    1    1    1    0
288  0    1    1    1    0    1    1    1    0
289  0    1    1    1    0    1    1    1    0
290  1    1    1    1    0    1    1    1    0
291  1    1    1    1    0    1    1    1    0
292  1    1    1    1    0    1    1    1    0
293  1    1    1    1    0    1    1    1    0
294  1    1    1    1    0    1    1    1    0
295  0    1    1    1    0    1    1    1    0
296  0    1    0    1    1    1    1    1    0
297  0    1    0    0    1    1    1    1    0    0
298  0    1    0    1    1    1    1    1    0    0
299  0    1    0    1    1    1    1    1    0    0
300  1    1    0    1    1    1    1    1    0    0
301  1    1    0    1    1    1    1    1    0    0
302  1    1    0    1    1    1    1    1    0    0
303  1    1    0    1    1    1    1    1    0    0
304  1    1    0    1    1    1    1    1    0    0
305  0    1    0    1    1    1    1    1    0    0
306  0    1    0    1    0    1    1    1    0    0
307  0    1    0    1    0    0    1    1    0    1
308  0    1    0    0    0    0    0    1    1    1
309  0    1    0    0    0    0    0    0    1    1
310  1    1    0    0    0    0    0    0    1    1
311  1    1    0    0    0    0    0    0    1    1
312  1    1    0    0    0    0    0    0    1    1
313  1    1    0    0    0    0    0    0    1    1
314  1    1    0    0    0    0    0    0    1    1
315  0    1    0    0    0    0    0    0    1    1
316  0    1    1    0    0    0    0    0    1    1
317  0    1    1    1    0    0    0    0    1    1
318  0    1    1    1    0    0    0    0    1    1
319  0    1    1    1    0    0    0    0    1    1
320  1    1    1    1    0    0    0    0    1    1
321  1    1    1    1    0    0    0    0    1    1
322  1    1    1    1    0    0    0    0    1    1
323  1    1    1    1    0    0    0    0    1    1
324  1    1    1    1    0    0    0    0    1    1
```

Figure 3-14

```
* STIMULATE PFAMD                                                    DAY=228  01:48  08/15/68  PAGF 128

     325  0       1       1       1       0       0       0       0       1       1
     326  0       1       0       1       1       0       0       0       1       1
     327  0       1       0       0       1       0       0       0       1       1
     328  0       1       0       0       1       0       0       0       1       1
     329  0       1       0       0       1       0       0       0       1       1
     330   1      1       0       0       1       0       0       0       1       1
     331   1      1       0       0       1       0       0       0       1       1
     332   1      1       0       0       1       0       0       0       1       1
     333   1      1       0       0       1       0       0       0       1       1
     334   1      1       0       0       1       0       0       0       1       1
     335  0       1       0       0       1       0       0       0       1       1
     336  0       1       1       0       1       0       0       0       1       1
     337  0       1       1       1       1       0       0       0       1       1
     338  0       1       1       1       1       0       0       0       1       1
     339  0       1       1       1       1       0       0       0       1       1
     340   1      1       1       1       1       0       0       0       1       1
     341   1      1       1       1       1       0       0       0       1       1
     342   1      1       1       1       1       0       0       0       1       1
     343   1      1       1       1       1       0       0       0       1       1
     344   1      1       1       1       1       0       0       0       1       1
     345  0       1       1       1       1       0       0       0       1       1
     346  0       1       0       1       0       0       0       0       1       1
     347  0       1       0       0       0       1       0       0       1       1
     348  0       1       0       0       0       1       0       0       1       1
     349  0       1       0       0       0       1       0       0       1       1
     350   1      1       0       0       0       1       0       0       1       1


    PRINT HAZARDS


 TYPE1 HAZARD ON SIGNAL  NCCNCT    AT TIME       298.   PULSE VALUE WAS  0


 END OF STEP     * SIMULATE PFAMD
```

Figure 3-15

```
 * EXIT
                                                                    DAY=228  01:48  08/15/68  PAGE 129

 DLLS EXECUTION COMPLETED
```

Figure 3-16

* SIMULATE	(3.2.3)
* CHANGE	(3.2.4)
* OUTPUT	(3.2.5)
* EXIT	(3.2.6)

3.2.1 OPEN

This instruction has the form,

* OPEN DATAFILE filename

Its function is twofold; it establishes the existence of a working file, and it replaces the ADD instruction.

The data file specified by the variable "filename" becomes the working file, replacing any previously named working file; if there is no file which has this name, one is created.

In the example, Fig. 3-1, "CREATE FILE" would now be replaced by "OPEN DATAFILE".

If an OPEN instruction is followed by data cards, they are assumed to be of the form described for the ADD instruction described in E-2265 (Section 3.5.5). "OPEN DATAFILE" replaces "GET" in Fig. 3-5. The first device being added to the file is a NAND gate (which was defined in Fig. 3-2) with identification "1", and it is placed on drawing "1" at coordinates (1, 1), its output pin A is the source of signal "RSTNCT/", and its input pin B is connected to "RSTNCT".

3.2.2 DEFINE

The DEFINE instruction (See E-2265, 3.2, 3.3.1) is in working condition. It has the form,

* DEFINE type

where the variable "type" is the name given to the device which is defined by the subsequent data cards. The new device definition is added to the glossary of the working file.

Figures 3-2 through 3-5 show three devices being defined, a 4-input NAND gate, a J-K flip-flop, and an oscillator.

3.2.3 SIMULATE

The SIMULATE instruction has the form,

* SIMULATE (filename)

The parentheses indicate that the variable "filename" is optional. If present, "filename" is the name of the (read) data file to be simulated; if missing, the file simulated is the current working file.

The following subinstructions are available:

EVENT	(3.3.2,b; 3.3.3,a41)**
SEQUENCE	(3.3.2,b)
TRACE	(3.3.2,cl)
SAMPLE	(3.3.2,c2; 3.3.3,a4a)
RUN	(3.3.2,d; 3.3.3,a4b)
INITIAL0	(3.3.3,c)
INITIAL1	(3.3.3,c)
PROP	(formerly PROPAGATE: (3.3.3,c)
MINPULSE	
PRINT	

The MINPULSE instruction is used to define the minimum number of time units a signal must either be 0 or 1 for a hazard not to exist.

A sample simulation is shown in Figs. 3-6 through 3-15. The PRINT instruction is used in Figs. 3-6 and 3-7 to obtain the lists shown, and in Fig. 3-8 to obtain the linear trace. Thirteen other PRINT options are available at this time.

3.2.4 CHANGE

The operations which can now be performed with the CHANGE instruction,

* CHANGE

are (1) the identification of a drawing, signal, or device may be changed, and (2) a device may be moved to a different drawing or to a different location on the same drawing. Other functions have been coded, but not debugged.

3.2.5 OUTPUT

This instruction,

* OUTPUT (filename)

is used to generate signal lists and other useful data from either the file "filename" or, if this variable is missing, from the current working file.

3.2.6 EXIT

An EXIT card is needed at the end of each OLLS run to insure a normal FILLIP termination. Its format is simply,

* EXIT

**Numbers in parentheses are references to sections of Report E-2265.

3.3 Contemplated Programs

The following asterisk instructions are planned for future implementation:

DELETE	(3.3.1)
DELETE TYPE	(3.3.2)
COPY	(3.3.3)
ASSEMBLE	(3.3.4)

3.3.1 DELETE

The function of the asterisk card

```
* DELETE
```

is described in the report (Section 3.5.9)

3.3.2 DELETE TYPE

The instruction

```
* DELETE TYPE type
```

will be used to remove the definition named "type" from the glossary of the working file (See Section 3.5.10 of the report).

3.3.3 COPY

The COPY instruction, which will have the format

```
* COPY FROM filename
```

will be used to duplicate into the working file useful device definitions or entire drawings. The source of these definitions and drawings is the file "filename".

3.3.4 ASSEMBLE

The ASSEMBLE instruction,

```
* ASSEMBLE type
```

will be used to create a device definition named "type" in the glossary of the working file; data following the asterisk card indicates several instances to be combined to form this definition. (See Section 3.2.4 of the report).

4. THE CRT INTERACTIVE SYSTEM

This section was called Section 3.6 in E-2265 but because the CRT programs now operate as a stand-alone system and because it is this system which we feel has the most promise for the future, we present here a new section with the included figures which illustrate our progress to date.

The CRT system is written in IBM machine language. A data structure very similar to that used by the FILLIP system (See E-2265 Section 3) was implemented by machine language subroutines which allow the program to operate on a file which is much larger than the available CPU core capacity. These routines can rapidly follow pointers to data which is not currently in core if so required by the operator at the CRT.

As described in E-2265 our design philosophy for the CRT system has been to relieve the logic designer of the burden of learning detailed card formats and conventions and in general to show him the way as much as possible. Instructions to the designer appear prominently on the screen when appropriate. Options which are logically available for him to select at any time are indicated by a "#" to the left of the option. We call this character a "light button", and, to select it, the designer merely points the light pen at it and depresses the tip switch in the pen. When the designer has selected a particular option, he is given feedback from the program by changing the "#" to the character "X" to indicate selected. This not only reminds him of what option he is currently operating, but it should help prevent him from "fat fingering" the light buttons accidentally with the light pen (which is somewhat similar to a blunderbuss).

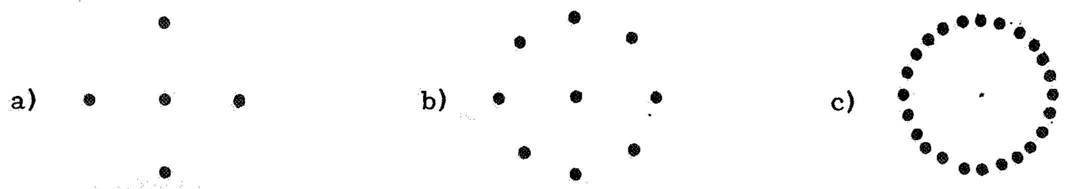
We have tried to avoid use of the alphameric keyboard except where absolutely necessary, i.e., when creating new names for files, devices, signals, etc. Again this is to relieve the designer of any opportunity to do any thinking except on his design problem. We have provided a parallel set of light buttons to those on the screen with the programmed function keyboard (PFK). We found that after a designer has had some hours of experience operating the CRT system, he can work slightly faster by using the PFK if he learns by memory the assignments of the buttons. One important factor which we found essential to consider is the time and trouble required to hang up the light pen in order to type a character or press a button. This may seem trivial, but experience has shown us the opposite.

4.1 Light Pen Tracking

One area where both "light-buttons" and the keyboard are inadequate is in describing lines and shapes to the logic file. Since the light pen is only a light detector, the only way in which the program can know the X, Y coordinates of the pen on the screen at any time is for the pen to detect light from some symbol which is already on the screen at coordinates known to the program. The program can then take logical action to move the symbol to a new set of coordinates and add the new X, Y point to the line segment currently being drawn. Basically the program must display a tracking symbol which traps the light pen within its light boundaries. Thus whenever the designer moves the light pen, the program receives an interrupt from the light pen detect and moves the tracking symbol in the direction of the detect.

Although there are many possibilities in the design of tracking symbols such as the static display of a circle, square, cross, spiral, etc., or a dynamic display of a random pattern of points or a regularly scanned area of the screen, only a few are well suited to a particular application. Dynamic patterns require local hardware able to update the display continuously and handle a very high interrupt rate.

Static patterns must be of just the right shape, size, light intensity, and light sensitivity to provide the user with sufficient degrees of freedom to accomplish his task. In the three tracking symbols shown below, we have combined the characteristics of our available hardware with the requirements of OLLS to produce a very flexible facility for light pen tracking. (Each symbol is about 1/2 inch in diameter.)



Symbol a) encourages long straight lines since the pen can detect light only from a point which is vertically or horizontally related to the center. Symbol b) can be used to draw lines at 45^{o} as well as vertically or horizontally. Symbol c) has enough points around the center so that smooth curves can be drawn.

The basic symbols above have been augmented by providing the designer with some frills which are available for him to select such as tracking magnification for very detailed work, a means of moving the symbol unattached from the line segment he is drawing, and a means of turning the symbol on and off while tracking. (Remember the pen is trapped by the symbol and if the symbol could not be turned off, the designer could not even pick up the pen without leaving a light smear on his work.) The point in the center of each symbol is used as an alternate action switch which causes the program to sensitize (enable) or desensitize (disable) the points around the center for light per detects. We have found that with these frills, light pen tracking can be very easy and effective. (See Fig. 4-25)

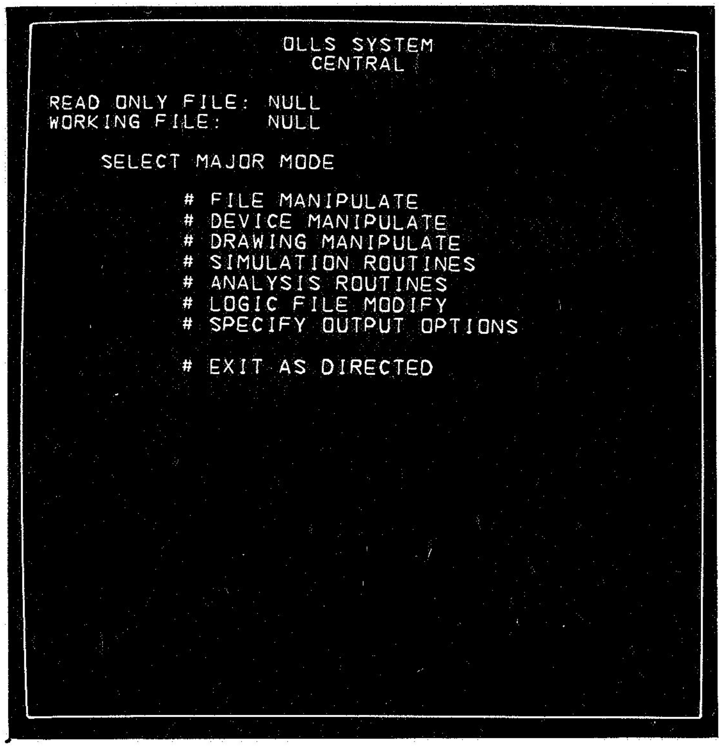
Two things are essential to economical light pen tracking. One is software designed with the user in mind and the other is hardware which allows interrupts to be processed rapidly without tying up too much CPU. For a time sharing environment this would be impossible without a small dedicated computer to buffer interrupts and update the display. In a multiprogrammed environment such as ours, interrupts can be handled more readily by the CPU since the programs to handle them are in core when needed. In either environment a display unit such as the IBM 2250 Model 3 which can execute buffer subroutines would be better than the Model 1. The buffer subroutine can update the position of the tracking symbol and add points to the segment being drawn interrupting the CPU only when the operator wishes to transmit a complete line segment.

The following figures are reproductions of photographs taken at the IBM 2250 CRT console as the designer uses almost as much of the system as is operational to date. As of this writing two important sets of menus, DRAWING MANIPULATE and OUTPUT OPTIONS, are in the final stages of debugging.

Figure 4-1

When the system first comes on, we see the major options available and that we have neither a Read Only File nor a Working File.

The designer selects FILE MANIPULATE by touching "#" with the light pen.



```
                    OLLS SYSTEM
                      CENTRAL

READ ONLY FILE: NULL
WORKING FILE:   NULL

    SELECT MAJOR MODE

          # FILE MANIPULATE
          # DEVICE MANIPULATE
          # DRAWING MANIPULATE
          # SIMULATION ROUTINES
          # ANALYSIS ROUTINES
          # LOGIC FILE MODIFY
          # SPECIFY OUTPUT OPTIONS

          # EXIT AS DIRECTED
```

Figure 4-2

The File Manipulate menu shows the list of available files and the options available.

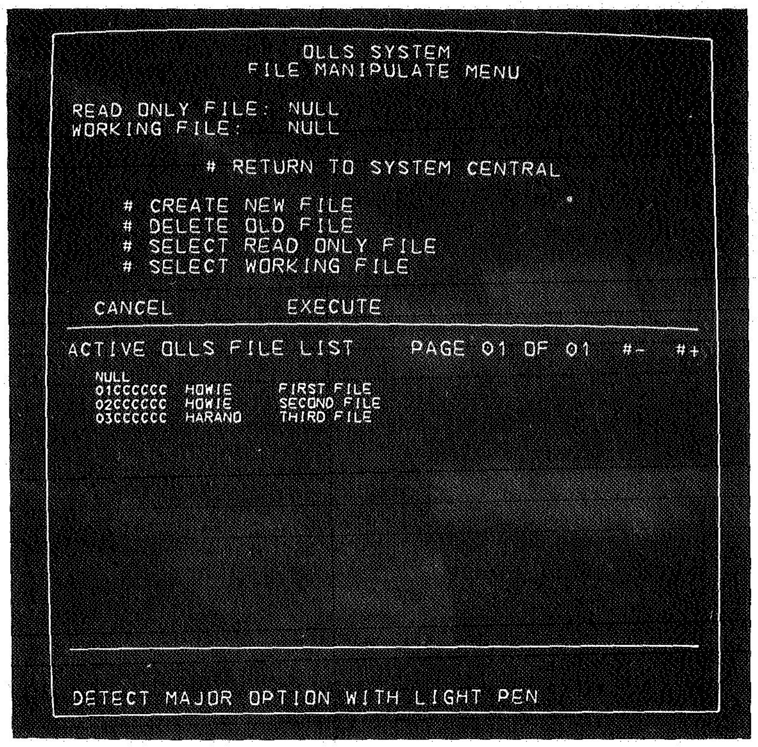
Directions or messages to the designer appear on the screen (usually at the bottom) when appropriate.

Figure 4-3

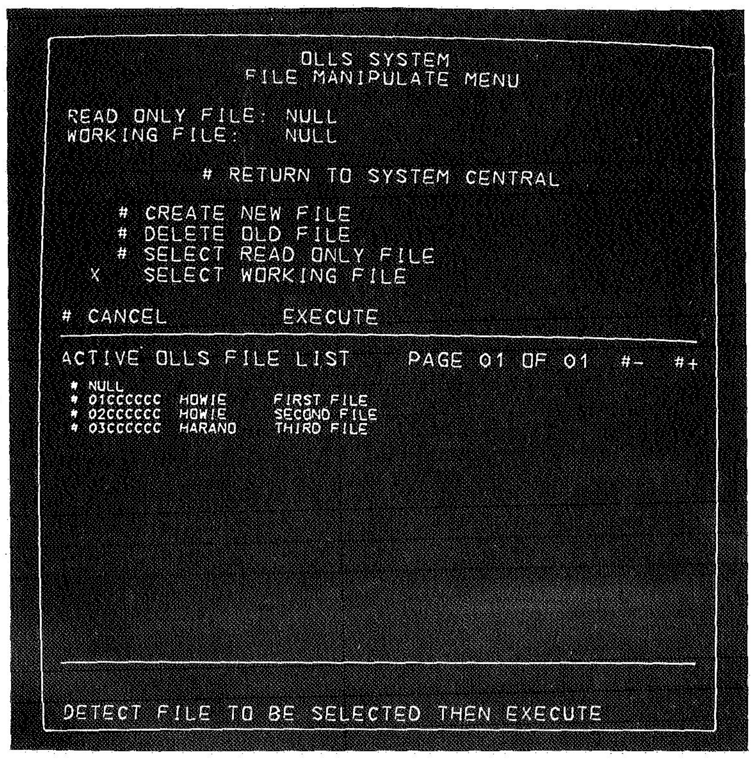
The designer detects

# SELECT WORKING FILE.

An "X" always appears in place of the "#" which the designer detected. This shows him positively what he is currently doing lest he forget or blunder with the light pen.



```
                    OLLS SYSTEM
                FILE MANIPULATE MENU

READ ONLY FILE: NULL
WORKING FILE:   NULL

          # RETURN TO SYSTEM CENTRAL

    # CREATE NEW FILE
    # DELETE OLD FILE
    # SELECT READ ONLY FILE
    # SELECT WORKING FILE

  CANCEL           EXECUTE
ACTIVE OLLS FILE LIST      PAGE 01 OF 01   #-   #+
  NULL
  01CCCCCC  HOWIE     FIRST FILE
  02CCCCCC  HOWIE     SECOND FILE
  03CCCCCC  HARANO    THIRD FILE

DETECT MAJOR OPTION WITH LIGHT PEN
```



```
                    OLLS SYSTEM
                FILE MANIPULATE MENU

READ ONLY FILE: NULL
WORKING FILE:   NULL

          # RETURN TO SYSTEM CENTRAL

    # CREATE NEW FILE
    # DELETE OLD FILE
    # SELECT READ ONLY FILE
  X   SELECT WORKING FILE

# CANCEL           EXECUTE
ACTIVE OLLS FILE LIST      PAGE 01 OF 01   #-   #+
# NULL
# 01CCCCCC  HOWIE     FIRST FILE
# 02CCCCCC  HOWIE     SECOND FILE
# 03CCCCCC  HARANO    THIRD FILE

DETECT FILE TO BE SELECTED THEN EXECUTE
```

Figure 4-4

The designer detects

# 03CCCCCC to be his working file. This file was created by

# CREATE NEW FILE on an earlier run.

Figure 4-5

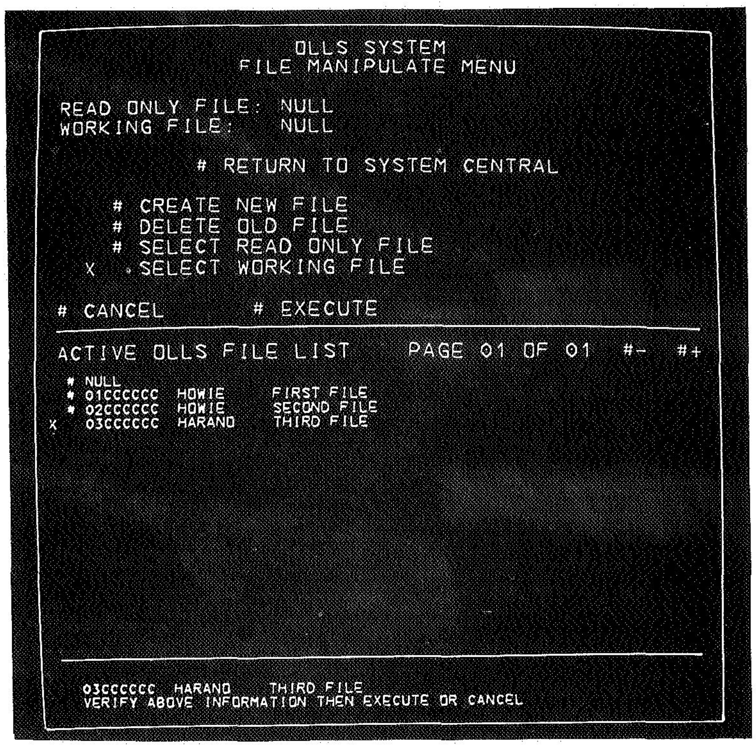
After the designer detects

# EXECUTE

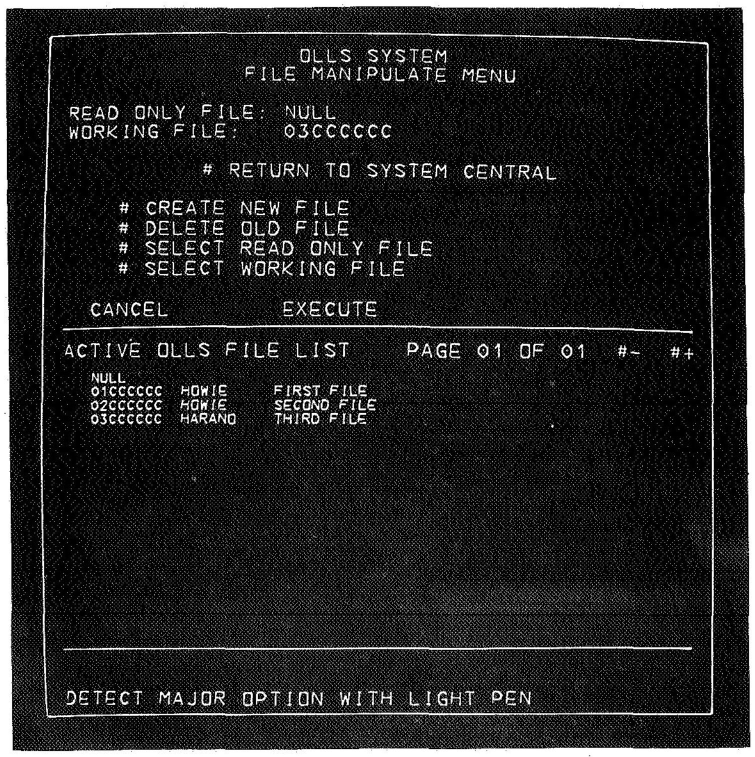
we see that the WORKING FILE is

# 03CCCCCC as requested. (In fact the entire file is moved from the IBM 2314 disk pack where all the files are stored to the IBM 2301 drum. The drum operates much faster than disk and protects the old copy of the file in case of some system disaster.)

NOTE: The actual selection of which storage devices will be allocated to the various files is determined at execution time by the Job Control Language statements which invoke OLLS. The JCL can also select a different "ACTIVE OLLS FILE LIST" for different runs thus providing complete flexibility to run OLLS in any IBM 360 environment or to transport an OLLS file or the OLLS System to a different computing facility.



```
                 OLLS SYSTEM
           FILE MANIPULATE MENU

READ ONLY FILE:  NULL
WORKING FILE:    NULL

          # RETURN TO SYSTEM CENTRAL

      # CREATE NEW FILE
      # DELETE OLD FILE
      # SELECT READ ONLY FILE
   X  . SELECT WORKING FILE

# CANCEL          # EXECUTE

ACTIVE OLLS FILE LIST       PAGE 01 OF 01    #-   #+
 # NULL
 # 01CCCCCC  HOWIE     FIRST FILE
 # 02CCCCCC  HOWIE     SECOND FILE
X  03CCCCCC  HARANO    THIRD FILE

   03CCCCCC  HARANO    THIRD FILE
   VERIFY ABOVE INFORMATION THEN EXECUTE OR CANCEL
```



```
                 OLLS SYSTEM
           FILE MANIPULATE MENU

READ ONLY FILE:  NULL
WORKING FILE:    03CCCCCC

          # RETURN TO SYSTEM CENTRAL

      # CREATE NEW FILE
      # DELETE OLD FILE
      # SELECT READ ONLY FILE
      # SELECT WORKING FILE

  CANCEL          EXECUTE

ACTIVE OLLS FILE LIST       PAGE 01 OF 01    #-   #+
  NULL
  01CCCCCC  HOWIE     FIRST FILE
  02CCCCCC  HOWIE     SECOND FILE
  03CCCCCC  HARANO    THIRD FILE

DETECT MAJOR OPTION WITH LIGHT PEN
```

Figure 4-6

The designer has detected

SELECT READ ONLY FILE
02CCCCCC and
EXECUTE

to check out a read only file.

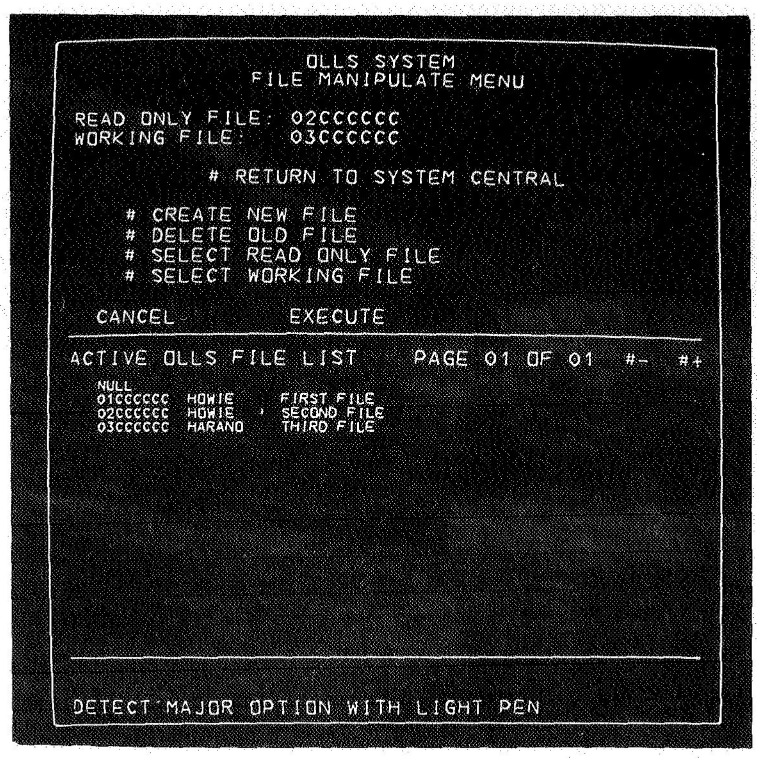
Since he is now finished with this menu he detects

RETURN TO SYSTEM CENTRAL

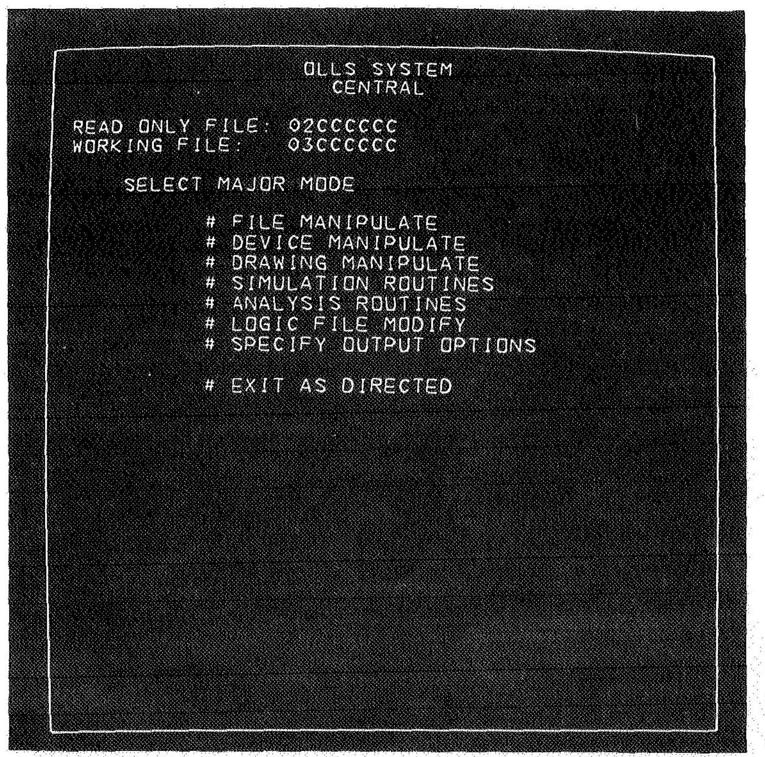
Figure 4-7

Again we see the major options available, but now we have an active working file and can set out to do some useful work:

DEVICE MANIPULATE



```
                 OLLS SYSTEM
             FILE MANIPULATE MENU

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

          # RETURN TO SYSTEM CENTRAL

    # CREATE NEW FILE
    # DELETE OLD FILE
    # SELECT READ ONLY FILE
    # SELECT WORKING FILE

  CANCEL          EXECUTE

ACTIVE OLLS FILE LIST     PAGE 01 OF 01   #-   #+

  NULL
  01CCCCCC  HOWIE     FIRST FILE
  02CCCCCC  HOWIE   , SECOND FILE
  03CCCCCC  HARANO    THIRD FILE

DETECT MAJOR OPTION WITH LIGHT PEN
```



```
                 OLLS SYSTEM
                   CENTRAL

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

    SELECT MAJOR MODE

          # FILE MANIPULATE
          # DEVICE MANIPULATE
          # DRAWING MANIPULATE
          # SIMULATION ROUTINES
          # ANALYSIS ROUTINES
          # LOGIC FILE MODIFY
          # SPECIFY OUTPUT OPTIONS

          # EXIT AS DIRECTED
```

Figure 4-8

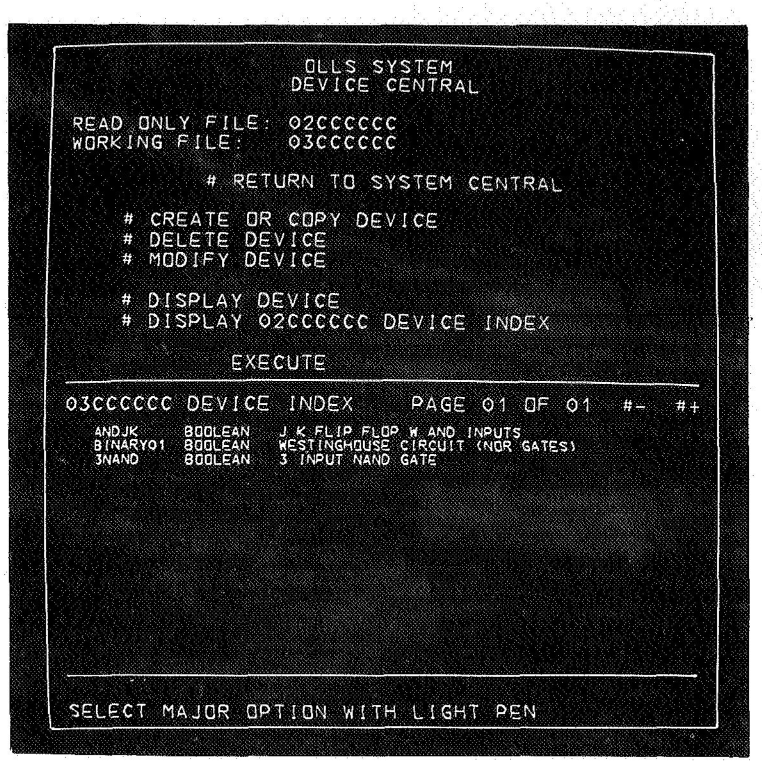
The DEVICE CENTRAL menu shows the list of available devices in the designer's working file (03CCCCCC). These devices are his to copy, delete, or modify (at his own peril) to suit his design needs. It is from this list that he chooses devices for his drawings.

Figure 4-9

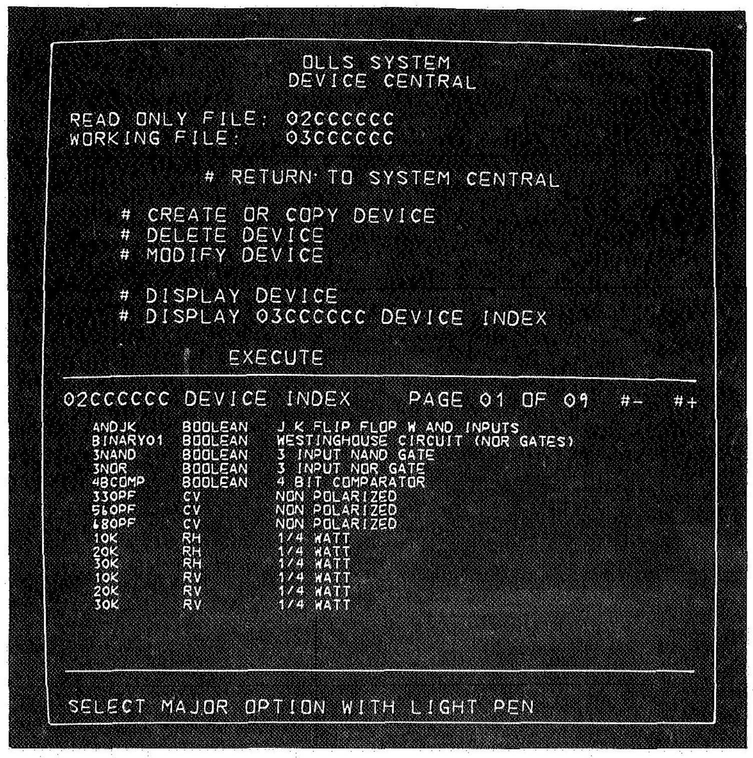
The designer has detected

```
                # DISPLAY 02CCCCCC DEVICE INDEX
then            # EXECUTE
```

to display the list of devices in the read only file (02CCCCCC). These devices are available only for the designer to display or to copy to save him the time and trouble of redefining a useful device himself.



```
                    OLLS SYSTEM
                   DEVICE CENTRAL

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

          # RETURN TO SYSTEM CENTRAL

     # CREATE OR COPY DEVICE
     # DELETE DEVICE
     # MODIFY DEVICE

     # DISPLAY DEVICE
     # DISPLAY 02CCCCCC DEVICE INDEX

              EXECUTE

03CCCCCC DEVICE INDEX      PAGE 01 OF 01    #-   #+
  ANDJK      BOOLEAN   J K FLIP FLOP W AND INPUTS
  BINARY01   BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
  3NAND      BOOLEAN   3 INPUT NAND GATE

SELECT MAJOR OPTION WITH LIGHT PEN
```



```
                    OLLS SYSTEM
                   DEVICE CENTRAL

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

          # RETURN TO SYSTEM CENTRAL

     # CREATE OR COPY DEVICE
     # DELETE DEVICE
     # MODIFY DEVICE

     # DISPLAY DEVICE
     # DISPLAY 03CCCCCC DEVICE INDEX

              EXECUTE

02CCCCCC DEVICE INDEX      PAGE 01 OF 09    #-   #+
  ANDJK      BOOLEAN   J K FLIP FLOP W AND INPUTS
  BINARY01   BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
  3NAND      BOOLEAN   3 INPUT NAND GATE
  3NOR       BOOLEAN   3 INPUT NOR GATE
  4BCOMP     BOOLEAN   4 BIT COMPARATOR
  330PF      CV        NON POLARIZED
  560PF      CV        NON POLARIZED
  680PF      CV        NON POLARIZED
  10K        RH        1/4 WATT
  20K        RH        1/4 WATT
  30K        RH        1/4 WATT
  10K        RV        1/4 WATT
  20K        RV        1/4 WATT
  30K        RV        1/4 WATT

SELECT MAJOR OPTION WITH LIGHT PEN
```

Figure 4-10

The designer wishes to examine a particular device (4BCOMP) in the read only file perhaps to pirate a good idea or to decide if he wants to copy it to this working file.

He detects

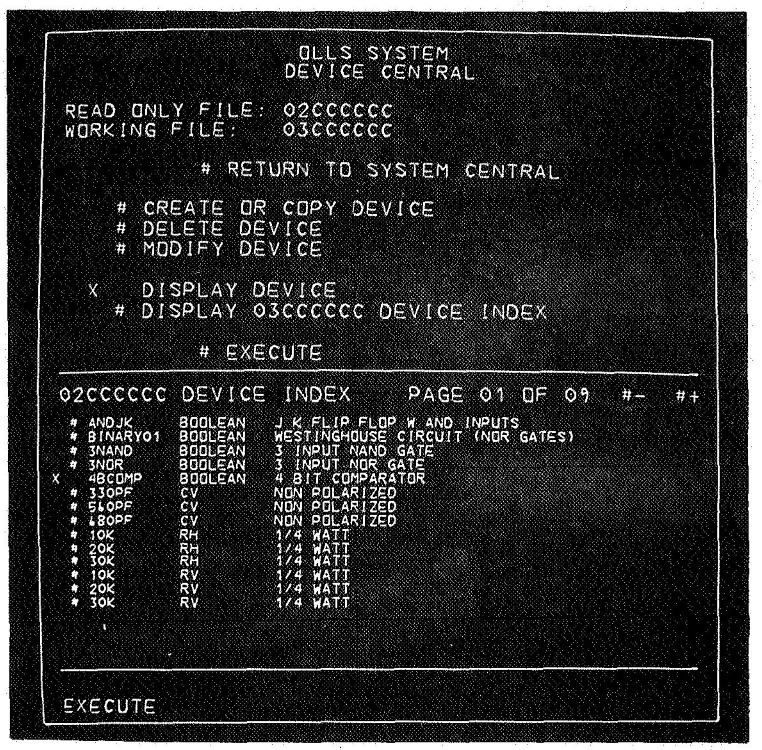
# DISPLAY DEVICE
# 4BCOMP

followed by

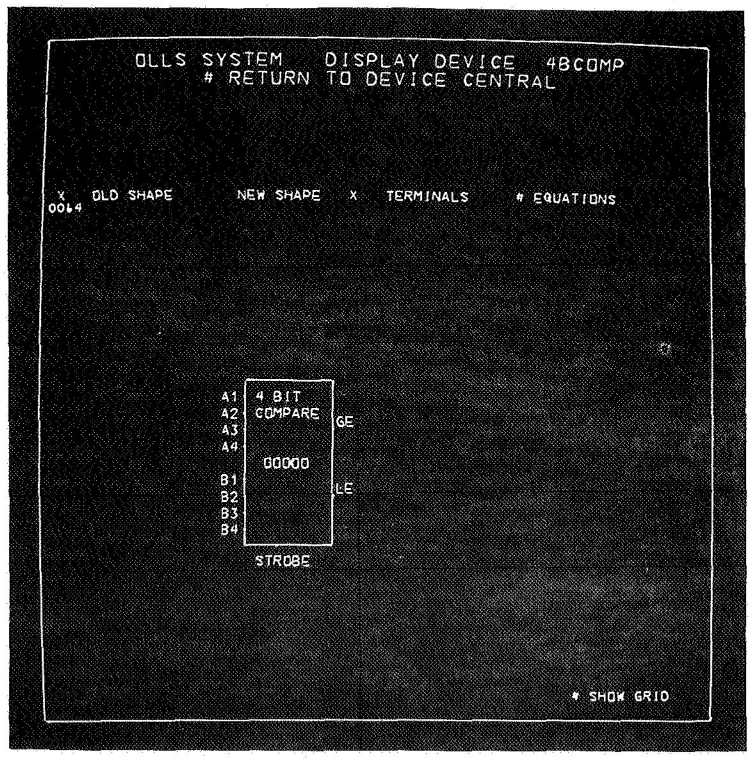
# EXECUTE

Figure 4-11

The DISPLAY DEVICE menu allows the designer to examine the device shape, terminals or equations. (He is now looking at shape and terminals.)



```
                    OLLS SYSTEM
                   DEVICE CENTRAL

READ ONLY FILE:  02CCCCCC
WORKING FILE:    03CCCCCC

          # RETURN TO SYSTEM CENTRAL

    # CREATE OR COPY DEVICE
    # DELETE DEVICE
    # MODIFY DEVICE

  X   DISPLAY DEVICE
    # DISPLAY 03CCCCCC DEVICE INDEX

          # EXECUTE

02CCCCCC DEVICE INDEX      PAGE 01 OF 09   #-   #+

  # ANDJK      BOOLEAN   J K FLIP FLOP W AND INPUTS
  # BINARY01   BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
  # 3NAND      BOOLEAN   3 INPUT NAND GATE
  # 3NOR       BOOLEAN   3 INPUT NOR GATE
X   4BCOMP     BOOLEAN   4 BIT COMPARATOR
  # 330PF      CV        NON POLARIZED
  # 560PF      CV        NON POLARIZED
  # 680PF      CV        NON POLARIZED
  # 10K        RH        1/4 WATT
  # 20K        RH        1/4 WATT
  # 30K        RH        1/4 WATT
  # 10K        RV        1/4 WATT
  # 20K        RV        1/4 WATT
  # 30K        RV        1/4 WATT

EXECUTE
```



```
        OLLS SYSTEM    DISPLAY DEVICE  4BCOMP
                 # RETURN TO DEVICE CENTRAL

X
0064  OLD SHAPE       NEW SHAPE   X   TERMINALS     # EQUATIONS
```

```
                                              # SHOW GRID
```

Figure 4-12

The designer has detected

# EQUATIONS

(and has turned off the terminals display for some reason by detecting

X ..... TERMINALS)

The equation list shows the two output equations and lists the inputs.

# RETURN TO DEVICE CENTRAL

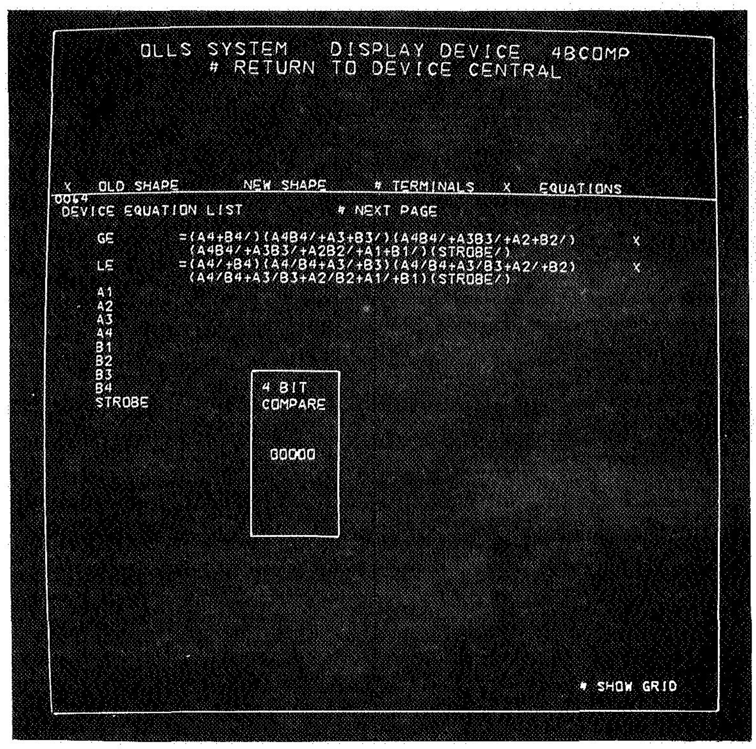
Figure 4-13

The designer wishes to display yet another device so he detects

# DISPLAY DEVICE

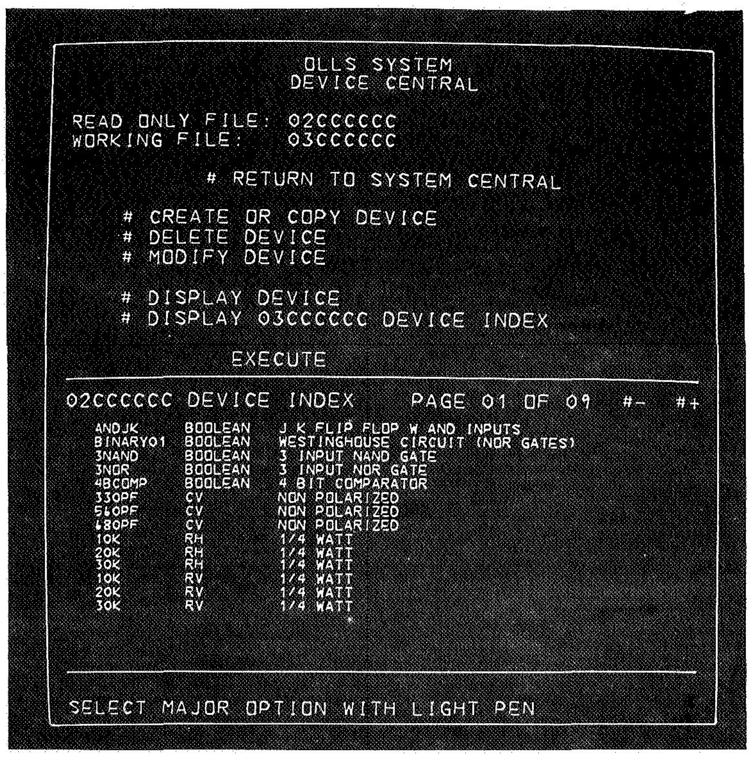
# BINARY01

# EXECUTE



```
      OLLS SYSTEM    DISPLAY DEVICE  4BCOMP
           # RETURN TO DEVICE CENTRAL

X   OLD SHAPE        NEW SHAPE      # TERMINALS   X   EQUATIONS
0064
DEVICE EQUATION LIST               # NEXT PAGE

   GE         =(A4+B4/)(A4B4/+A3+B3/)(A4B4/+A3B3/+A2+B2/)       X
               (A4B4/+A3B3/+A2B2/+A1+B1/)(STROBE/)
   LE         =(A4/+B4)(A4/B4+A3/+B3)(A4/B4+A3/B3+A2/+B2)       X
               (A4/B4+A3/B3+A2/B2+A1/+B1)(STROBE/)
   A1
   A2
   A3
   A4
   B1
   B2
   B3
   B4
   STROBE
```

```
                                                   # SHOW GRID
```



```
                     OLLS SYSTEM
                    DEVICE CENTRAL

  READ ONLY FILE:  02CCCCCC
  WORKING FILE:    03CCCCCC

             # RETURN TO SYSTEM CENTRAL

     # CREATE OR COPY DEVICE
     # DELETE DEVICE
     # MODIFY DEVICE

     # DISPLAY DEVICE
     # DISPLAY 03CCCCCC DEVICE INDEX

             EXECUTE

02CCCCCC DEVICE INDEX      PAGE 01 OF 09   #-   #+
    ANDJK      BOOLEAN    J K FLIP FLOP W AND INPUTS
    BINARY01   BOOLEAN    WESTINGHOUSE CIRCUIT (NOR GATES)
    3NAND      BOOLEAN    3 INPUT NAND GATE
    3NOR       BOOLEAN    3 INPUT NOR GATE
    4BCOMP     BOOLEAN    4 BIT COMPARATOR
    330PF      CV         NON POLARIZED
    560PF      CV         NON POLARIZED
    680PF      CV         NON POLARIZED
    10K        RH         1/4 WATT
    20K        RH         1/4 WATT
    30K        RH         1/4 WATT
    10K        RV         1/4 WATT
    20K        RV         1/4 WATT
    30K        RV         1/4 WATT

SELECT MAJOR OPTION WITH LIGHT PEN
```

Figure 4-14

This shows an example of what we consider about the limit of complexity of a single component device. A more complicated device would better be defined as a "drawing" in its own right and built up from smaller component devices.

Figure 4-15

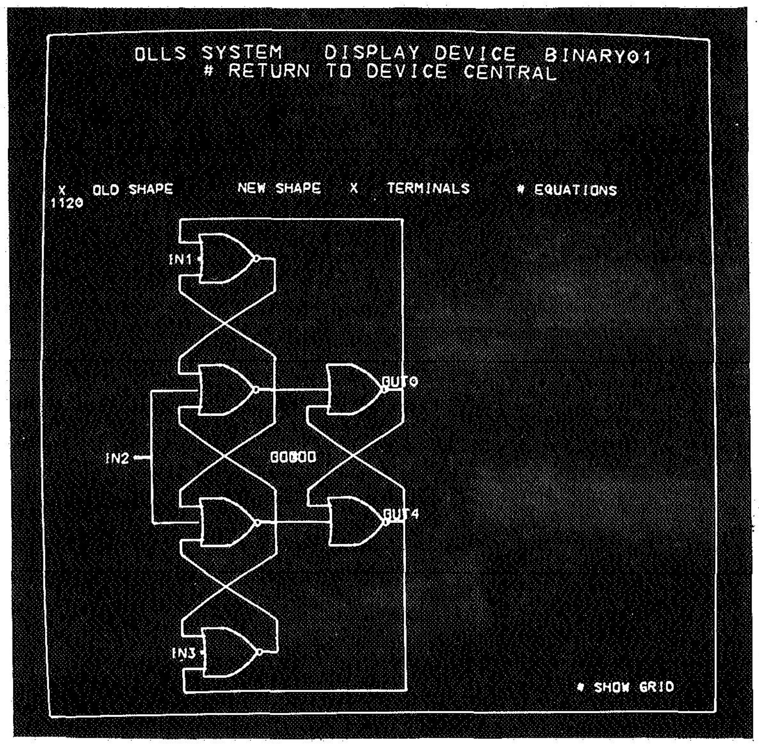
To create a new device he detects

# CREATE OR COPY DEVICE

and begins typing in:

```
FLOP01    BOOLEAN    FLIP FLOP    (3NAND GATES)
```

This new device will be added to his working file when he presses the END KEY after typing.


```
OLLS SYSTEM   DISPLAY DEVICE  BINARY01
      # RETURN TO DEVICE CENTRAL

X    OLD SHAPE      NEW SHAPE  X   TERMINALS     # EQUATIONS
1120
```

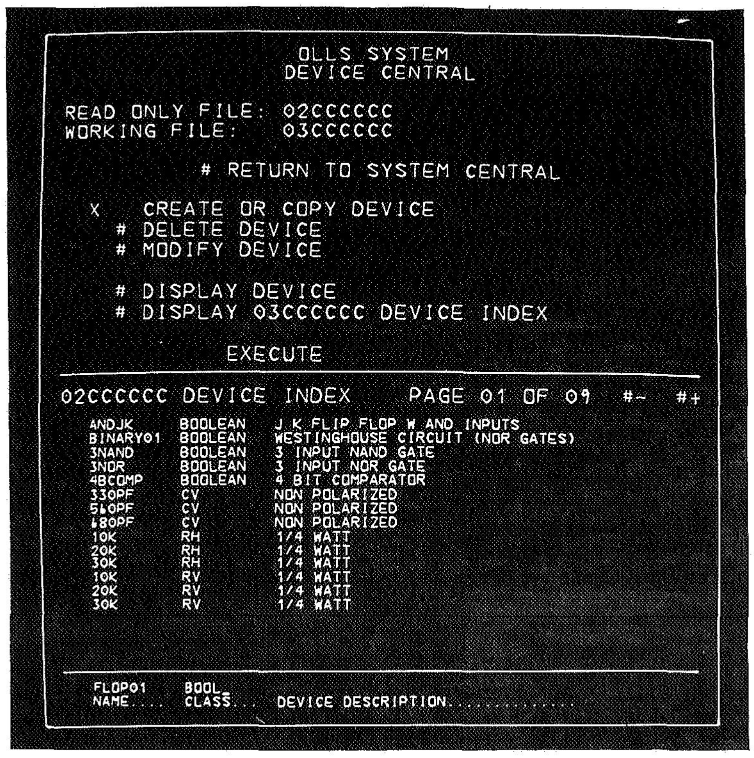

```
                  OLLS SYSTEM
                 DEVICE CENTRAL

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

           # RETURN TO SYSTEM CENTRAL

  X   CREATE OR COPY DEVICE
    # DELETE DEVICE
    # MODIFY DEVICE

    # DISPLAY DEVICE
    # DISPLAY 03CCCCCC DEVICE INDEX

            EXECUTE

02CCCCCC DEVICE INDEX    PAGE 01 OF 09   #-   #+

  ANDJK     BOOLEAN   J K FLIP FLOP W AND INPUTS
  BINARY01  BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
  3NAND     BOOLEAN   3 INPUT NAND GATE
  3NOR      BOOLEAN   3 INPUT NOR GATE
  4BCOMP    BOOLEAN   4 BIT COMPARATOR
  330PF     CV        NON POLARIZED
  560PF     CV        NON POLARIZED
  680PF     CV        NON POLARIZED
  10K       RH        1/4 WATT
  20K       RH        1/4 WATT
  30K       RH        1/4 WATT
  10K       RV        1/4 WATT
  20K       RV        1/4 WATT
  30K       RV        1/4 WATT

  FLOP01    BOOL_
  NAME....  CLASS...  DEVICE DESCRIPTION.............
```

Figure 4-16

If the designer wishes his new device to be initially a copy of some other device, he detects that device, i.e.

```
# 3NAND     BOOLEAN     3  INPUT NAND GATE
```

in this case before he detects

```
# EXECUTE
```

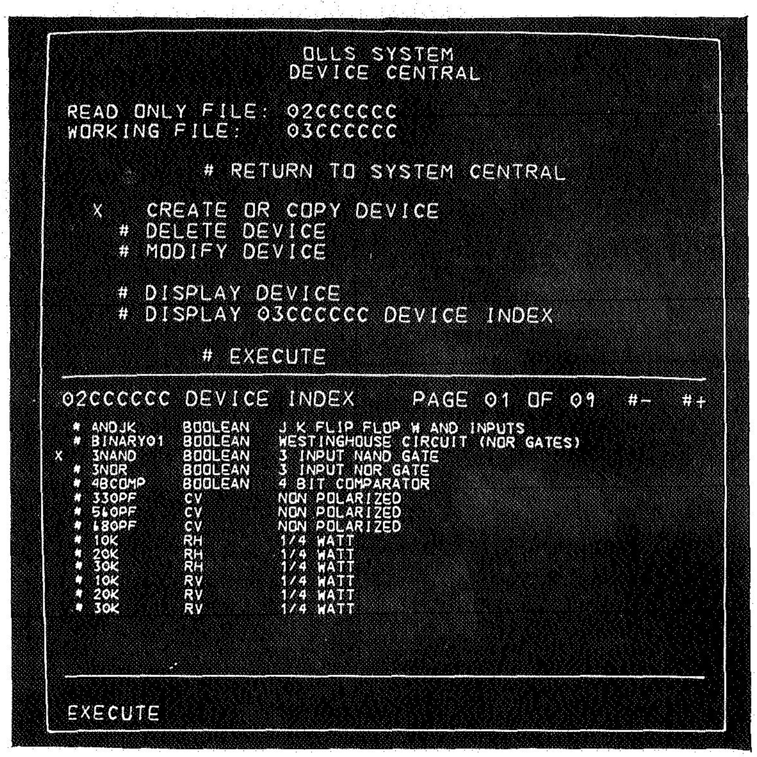
(A more appropriate message at the bottom of the screen has been incorporated since the photograph.)

Figure 4-17

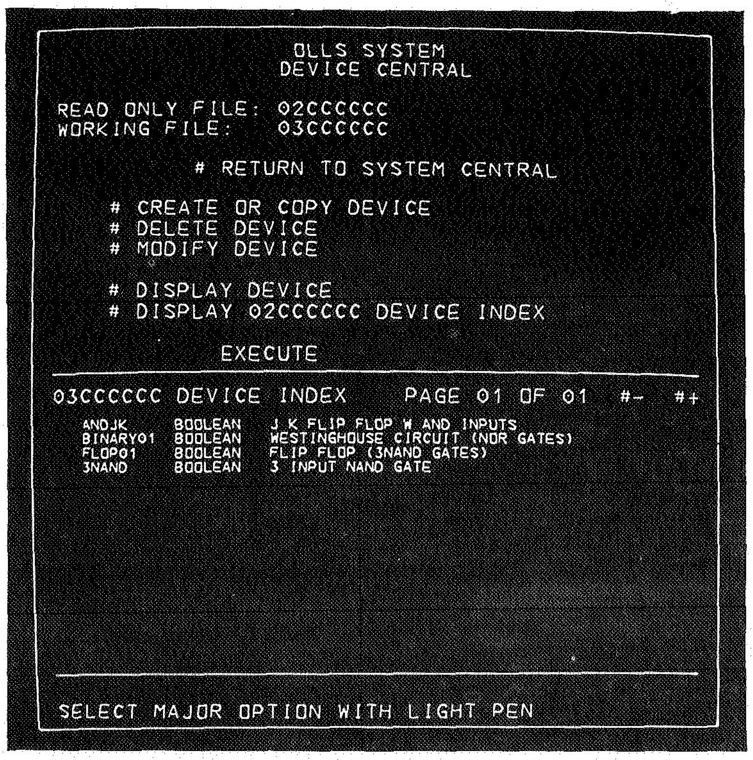
When the designer detects

```
# DISPLAY 03CCCCCC DEVICE INDEX
        (his working file)
# EXECUTE,
```

he sees that FLOP01 has indeed been added to the list. It is identical to the 3NAND he copied. Had he not elected to copy another device, a so-called NULL device would have been created.



```
                         OLLS SYSTEM
                        DEVICE CENTRAL

READ ONLY FILE:  02CCCCCC
WORKING FILE:    03CCCCCC

            # RETURN TO SYSTEM CENTRAL

   X    CREATE OR COPY DEVICE
      # DELETE DEVICE
      # MODIFY DEVICE

      # DISPLAY DEVICE
      # DISPLAY 03CCCCCC DEVICE INDEX

            # EXECUTE
-------------------------------------------------------------
02CCCCCC DEVICE INDEX       PAGE 01 OF 09    #-    #+

  # ANDJK      BOOLEAN   J K FLIP FLOP W AND INPUTS
  # BINARY01   BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
 X  3NAND      BOOLEAN   3 INPUT NAND GATE
  # 3NOR       BOOLEAN   3 INPUT NOR GATE
  # 4BCOMP     BOOLEAN   4 BIT COMPARATOR
  # 330PF      CV        NON POLARIZED
  # 560PF      CV        NON POLARIZED
  # 680PF      CV        NON POLARIZED
  # 10K        RH        1/4 WATT
  # 20K        RH        1/4 WATT
  # 30K        RH        1/4 WATT
  # 10K        RV        1/4 WATT
  # 20K        RV        1/4 WATT
  # 30K        RV        1/4 WATT
-------------------------------------------------------------
EXECUTE
```



```
                         OLLS SYSTEM
                        DEVICE CENTRAL

READ ONLY FILE:  02CCCCCC
WORKING FILE:    03CCCCCC

            # RETURN TO SYSTEM CENTRAL

      # CREATE OR COPY DEVICE
      # DELETE DEVICE
      # MODIFY DEVICE

      # DISPLAY DEVICE
      # DISPLAY 02CCCCCC DEVICE INDEX

              EXECUTE
-------------------------------------------------------------
03CCCCCC DEVICE INDEX       PAGE 01 OF 01    #-    #+

    ANDJK      BOOLEAN   J K FLIP FLOP W AND INPUTS
    BINARY01   BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
    FLOP01     BOOLEAN   FLIP FLOP (3NAND GATES)
    3NAND      BOOLEAN   3 INPUT NAND GATE
-------------------------------------------------------------
SELECT MAJOR OPTION WITH LIGHT PEN
```

Figure 4-18

In order to make a flip-flop out of his FLOP01 which is now a single 3NAND gate, he detects

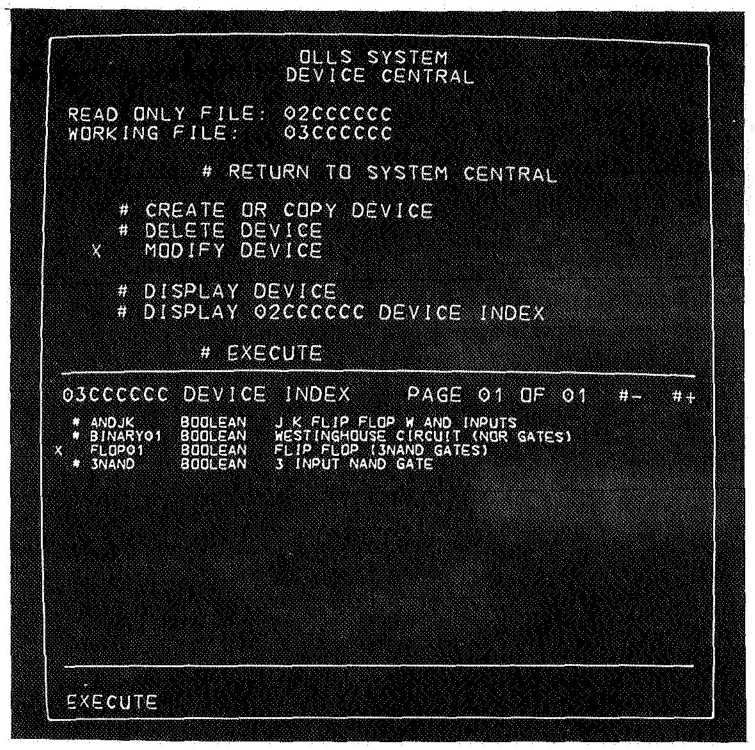
```
# MODIFY DEVICE
# FLOP01
```

followed by

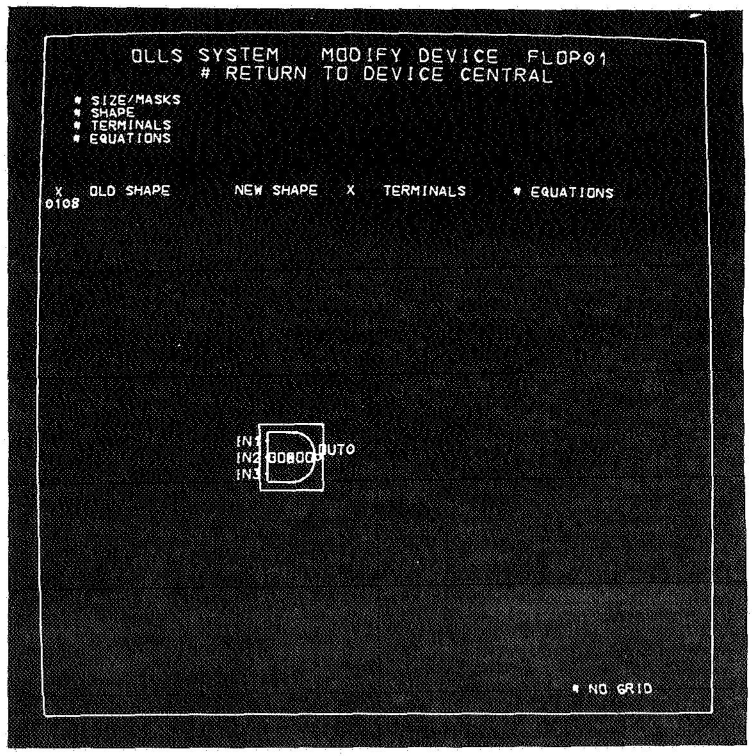
```
# EXECUTE
```

Figure 4-19

The MODIFY DEVICE menu is initially very similar to the DISPLAY DEVICE menu with the addition of the four options which allow the designer to modify the device size, shape, terminals, or equations.



```
                    OLLS SYSTEM
                   DEVICE CENTRAL

READ ONLY FILE:  02CCCCCC
WORKING FILE:    03CCCCCC

          # RETURN TO SYSTEM CENTRAL

   # CREATE OR COPY DEVICE
   # DELETE DEVICE
 X   MODIFY DEVICE

   # DISPLAY DEVICE
   # DISPLAY 02CCCCCC DEVICE INDEX

          # EXECUTE
---------------------------------------------------------
03CCCCCC DEVICE INDEX     PAGE 01 OF 01   #-   #+
  # ANDJK      BOOLEAN   J K FLIP FLOP W AND INPUTS
  # BINARY01   BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
X   FLOP01     BOOLEAN   FLIP FLOP (3NAND GATES)
  # 3NAND      BOOLEAN   3 INPUT NAND GATE
---------------------------------------------------------
EXECUTE
```



```
     OLLS SYSTEM   MODIFY DEVICE  FLOP01
          # RETURN TO DEVICE CENTRAL
 # SIZE/MASKS
 # SHAPE
 # TERMINALS
 # EQUATIONS

 X  OLD SHAPE       NEW SHAPE   X   TERMINALS     # EQUATIONS
0108
```

```
                                               # NO GRID
```

Figure 4-20

A flip-flop is larger than a 3NAND gate so the designer first detects

# SIZE/MASKS

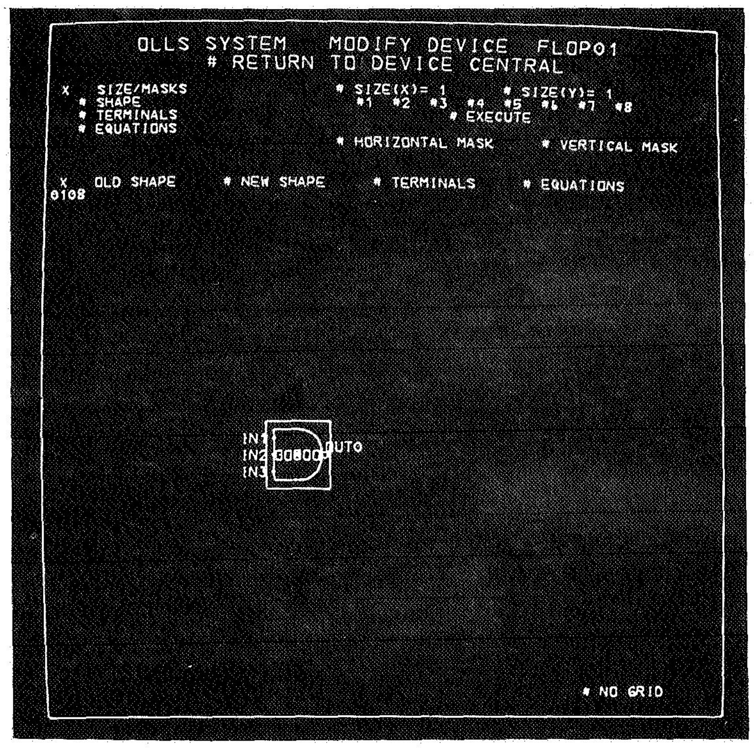
and a sub menu appears which allows the designer to alter the size. (MASKS will be explained later.)

Figure 4-21

The designer detects

# SIZE(Y) = 1
3
# EXECUTE

to change the vertical size to 3 units. (The #NO GRID - #GRID option at the bottom of the screen controls the display of the size outline.)


OLLS SYSTEM MODIFY DEVICE FLOP01
# RETURN TO DEVICE CENTRAL
X SIZE/MASKS
# SHAPE
# TERMINALS
# EQUATIONS
# SIZE(X)= 1 # SIZE(Y)= 1
#1 #2 #3 #4 #5 #6 #7 #8
# EXECUTE
# HORIZONTAL MASK # VERTICAL MASK
X OLD SHAPE # NEW SHAPE # TERMINALS # EQUATIONS
0108
IN1
IN2
IN3
G0800
OUT0
# NO GRID

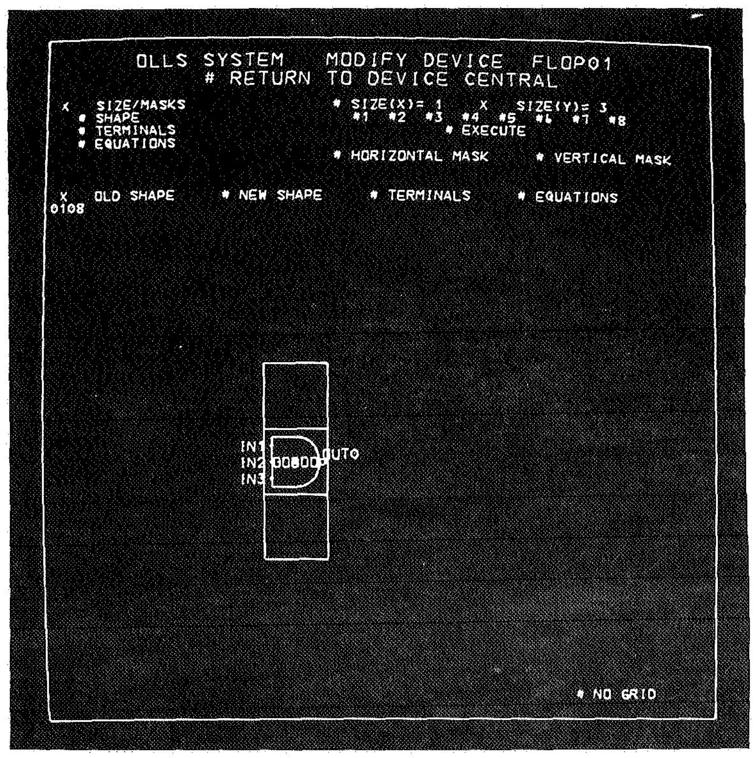

OLLS SYSTEM MODIFY DEVICE FLOP01
# RETURN TO DEVICE CENTRAL
X SIZE/MASKS
# SHAPE
# TERMINALS
# EQUATIONS
# SIZE(X)= 1 X SIZE(Y)= 3
#1 #2 #3 #4 #5 #6 #7 #8
# EXECUTE
# HORIZONTAL MASK # VERTICAL MASK
X OLD SHAPE # NEW SHAPE # TERMINALS # EQUATIONS
0108
IN1
IN2
IN3
G0800
OUT0
# NO GRID

Figure 4-22

The designer detects

SHAPE

to cause this sub menu to appear. The options shown affect the NEW SHAPE only and the OLD SHAPE (the permanent copy for the file) is not updated until # KEEP NEW SHAPE is detected.

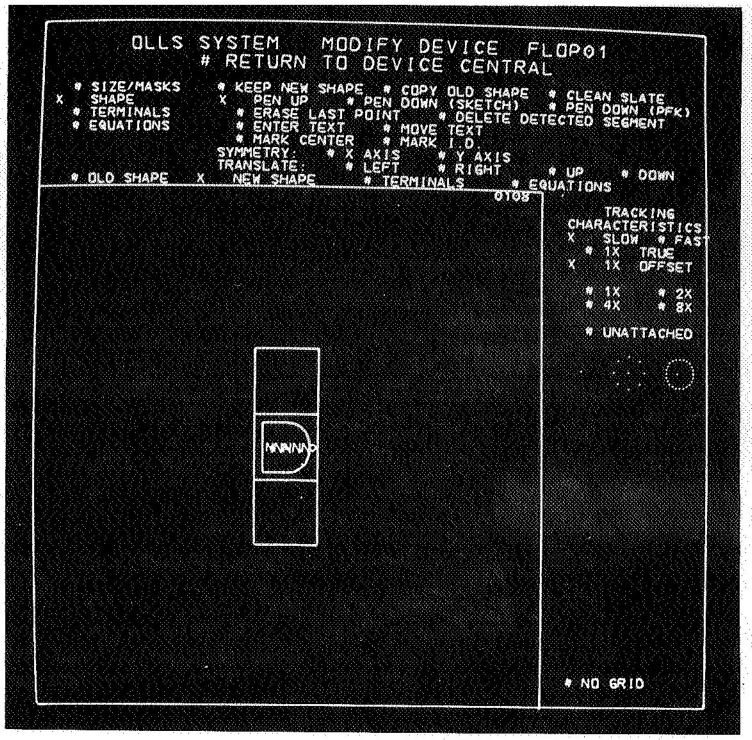
Figure 4-23

The designer rotates the center device to each of the two outer positions as shown by

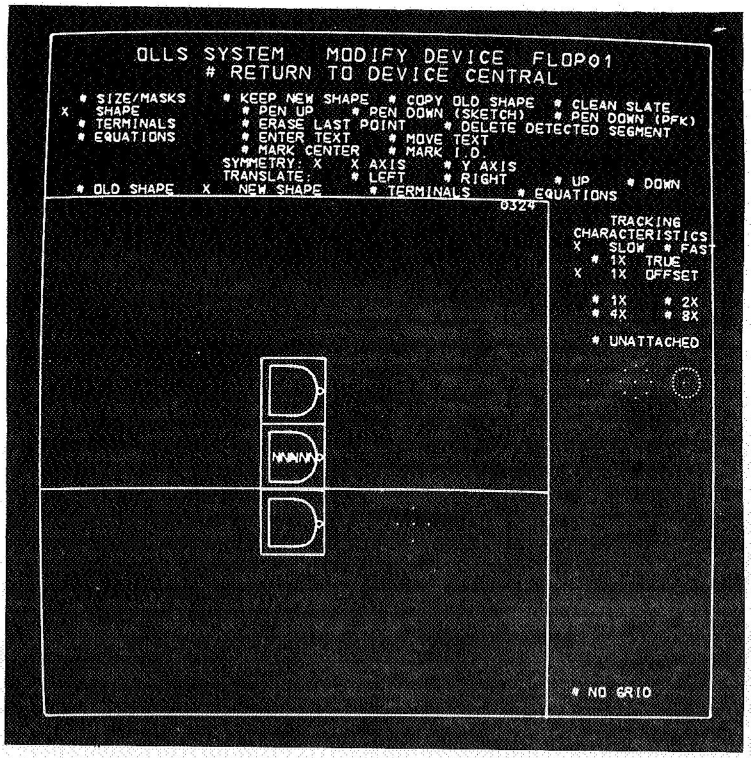
a) # X AXIS, Symmetry
b) Move line of symmetry with tracking symbol,
c) detect segments of center device,
d) move line of symmetry again
e) detect segments of center device.

The photo shows the line of symmetry in position for steps d) and e) above.

The same result could have been obtained by TRANSLATE.



```
        OLLS SYSTEM    MODIFY DEVICE  FLOP01
              # RETURN TO DEVICE CENTRAL

  # SIZE/MASKS    # KEEP NEW SHAPE  # COPY OLD SHAPE  # CLEAN SLATE
X   SHAPE         X   PEN UP    # PEN DOWN (SKETCH)   # PEN DOWN (PFK)
  # TERMINALS       # ERASE LAST POINT    # DELETE DETECTED SEGMENT
  # EQUATIONS       # ENTER TEXT      # MOVE TEXT
                    # MARK CENTER     # MARK I.D.
                  SYMMETRY:    # X AXIS     # Y AXIS
                  TRANSLATE:     # LEFT     # RIGHT       # UP    # DOWN
  # OLD SHAPE   X   NEW SHAPE       # TERMINALS      # EQUATIONS
                                            0108
                                                   TRACKING
                                                CHARACTERISTICS
                                                X   SLOW   # FAST
                                                  # 1X   TRUE
                                                X   1X   OFFSET

                                                  # 1X       # 2X
                                                  # 4X       # 8X

                                                  # UNATTACHED

                                                # NO GRID
```



```
        OLLS SYSTEM    MODIFY DEVICE  FLOP01
              # RETURN TO DEVICE CENTRAL

  # SIZE/MASKS    # KEEP NEW SHAPE  # COPY OLD SHAPE  # CLEAN SLATE
X   SHAPE           # PEN UP    # PEN DOWN (SKETCH)   # PEN DOWN (PFK)
  # TERMINALS       # ERASE LAST POINT    # DELETE DETECTED SEGMENT
  # EQUATIONS       # ENTER TEXT      # MOVE TEXT
                    # MARK CENTER     # MARK I.D.
                  SYMMETRY: X   X AXIS     # Y AXIS
                  TRANSLATE:     # LEFT     # RIGHT       # UP    # DOWN
  # OLD SHAPE   X   NEW SHAPE       # TERMINALS      # EQUATIONS
                                            0324
                                                   TRACKING
                                                CHARACTERISTICS
                                                X   SLOW   # FAST
                                                  # 1X   TRUE
                                                X   1X   OFFSET

                                                  # 1X       # 2X
                                                  # 4X       # 8X

                                                  # UNATTACHED

                                                # NO GRID
```

Figure 4-24

The center device is deleted by

DELETE DETECTED SEGMENT

followed by detecting segments of the center device.

NOTE: The OLD SHAPE has not been affected by these operations. # OLD SHAPE will still display the original 3NAND and # COPY OLD SHAPE will restore the NEW SHAPE to the original 3NAND.

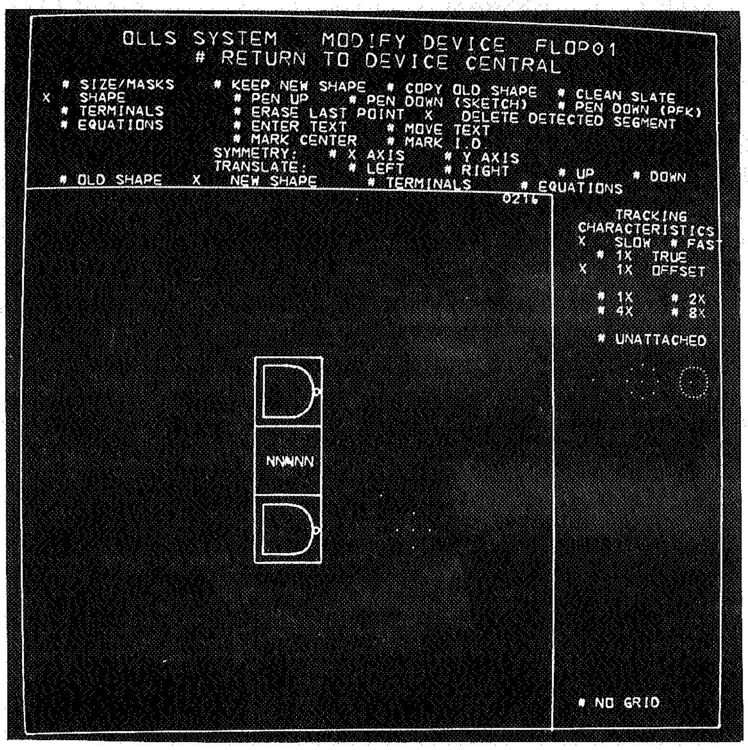
Figure 4-25

New segments are added to NEW SHAPE by

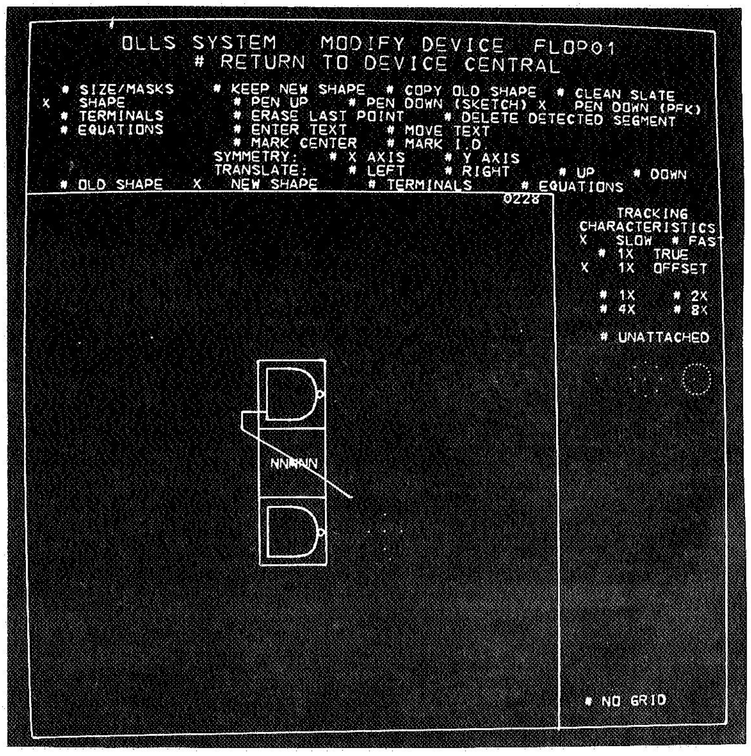
# PEN DOWN (PFK)

moving the tracking symbol to each new position and marking each point with the programmed function keyboard. This continues until # PEN UP. This mode is useful for drawing long straight lines.

NOTE: # PEN DOWN (SKETCH) operates the same except points are added for every tracking symbol detect. This is useful for drawing small curved segments.



```
OLLS SYSTEM   MODIFY DEVICE  FLOP01
        # RETURN TO DEVICE CENTRAL
  # SIZE/MASKS    # KEEP NEW SHAPE  # COPY OLD SHAPE  # CLEAN SLATE
X   SHAPE           # PEN UP   # PEN DOWN (SKETCH)   # PEN DOWN (PFK)
  # TERMINALS       # ERASE LAST POINT  X  DELETE DETECTED SEGMENT
  # EQUATIONS       # ENTER TEXT   # MOVE TEXT
                    # MARK CENTER   # MARK I.D
                  SYMMETRY:   # X AXIS    # Y AXIS
                  TRANSLATE:    # LEFT    # RIGHT     # UP    # DOWN
  # OLD SHAPE   X   NEW SHAPE      # TERMINALS     # EQUATIONS
                                                0216
                                                      TRACKING
                                                   CHARACTERISTICS
                                                   X   SLOW   # FAS
                                                     # 1X   TRUE
                                                   X   1X   OFFSET

                                                     # 1X     # 2X
                                                     # 4X     # 8X

                                                     # UNATTACHED

                      NNNNN

                                                   # NO GRID
```



```
OLLS SYSTEM   MODIFY DEVICE  FLOP01
        # RETURN TO DEVICE CENTRAL
  # SIZE/MASKS    # KEEP NEW SHAPE  # COPY OLD SHAPE  # CLEAN SLATE
X   SHAPE           # PEN UP   # PEN DOWN (SKETCH) X  PEN DOWN (PFK)
  # TERMINALS       # ERASE LAST POINT    # DELETE DETECTED SEGMENT
  # EQUATIONS       # ENTER TEXT   # MOVE TEXT
                    # MARK CENTER   # MARK I.D
                  SYMMETRY:   # X AXIS    # Y AXIS
                  TRANSLATE:    # LEFT    # RIGHT     # UP    # DOWN
  # OLD SHAPE   X   NEW SHAPE      # TERMINALS     # EQUATIONS
                                                0228
                                                      TRACKING
                                                   CHARACTERISTICS
                                                   X   SLOW   # FAS
                                                     # 1X   TRUE
                                                   X   1X   OFFSET

                                                     # 1X     # 2X
                                                     # 4X     # 8X

                                                     # UNATTACHED

                      NNNNN

                                                   # NO GRID
```

Figure 4-26

The final segment is added again by

X AXIS Symmetry
and
KEEP NEW SHAPE
is detected.

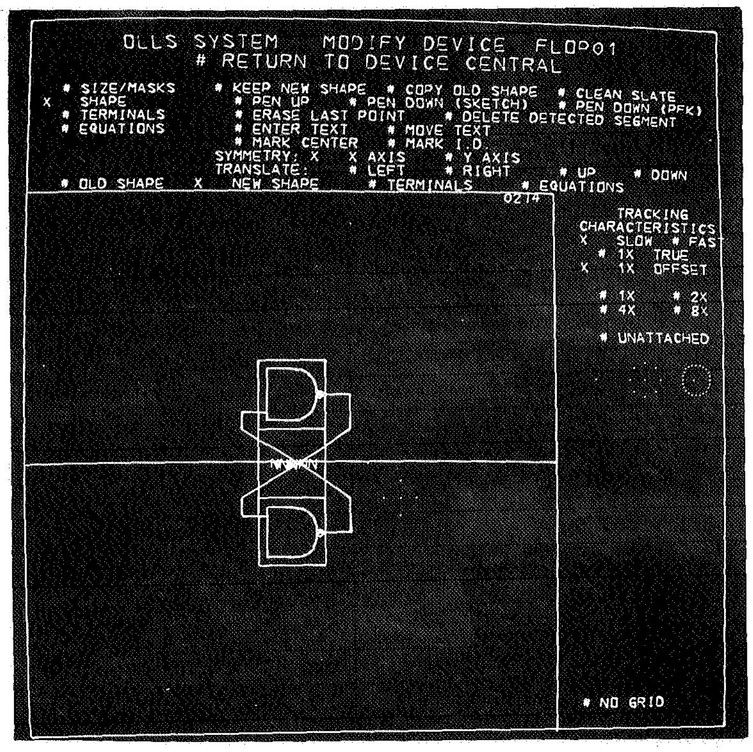
NOTE: Many useful features have not been shown (such as tracking magnification) since they do not lend themselves readily to still photography.

Figure 4-27

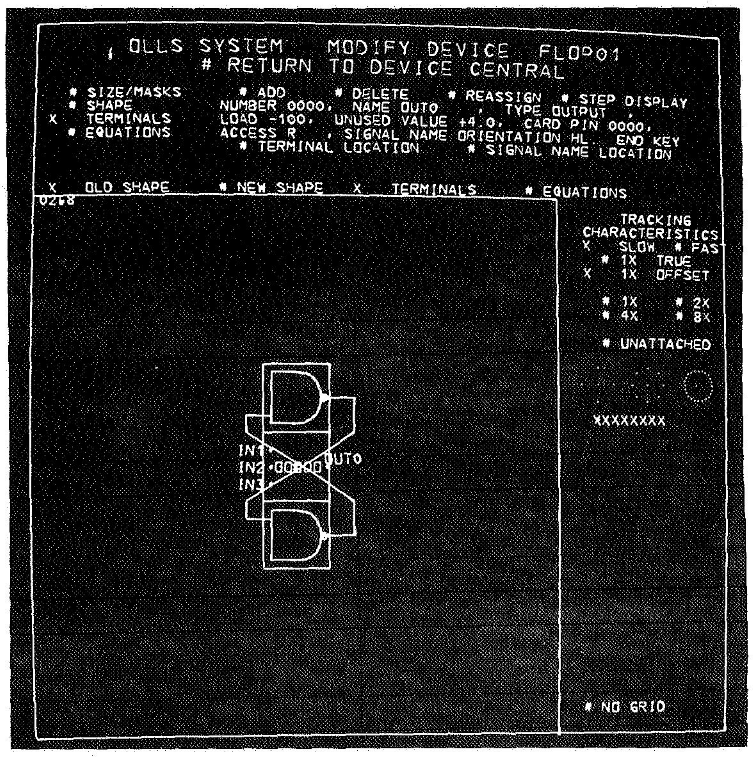
To modify the original 3NAND terminals, detect

# TERMINALS

to cause this sub menu to appear. The terminals shown are of the original 3NAND gate. We will delete IN3, move OUT0, IN1, and IN2, and finally add a new terminal OUT4.



```
        OLLS SYSTEM    MODIFY DEVICE  FLOP01
               # RETURN TO DEVICE CENTRAL
  # SIZE/MASKS     # KEEP NEW SHAPE  # COPY OLD SHAPE  # CLEAN SLATE
X   SHAPE             # PEN UP    # PEN DOWN (SKETCH)    # PEN DOWN (PFK)
  # TERMINALS         # ERASE LAST POINT    # DELETE DETECTED SEGMENT
  # EQUATIONS         # ENTER TEXT     # MOVE TEXT
                      # MARK CENTER    # MARK I.D.
                    SYMMETRY: X   X AXIS     # Y AXIS
                    TRANSLATE:    # LEFT     # RIGHT      # UP     # DOWN
  # OLD SHAPE   X   NEW SHAPE     # TERMINALS      # EQUATIONS
                                            0214
                                                      TRACKING
                                                   CHARACTERISTICS
                                                   X   SLOW   # FAST
                                                     # 1X   TRUE
                                                   X   1X   OFFSET

                                                     # 1X       # 2X
                                                     # 4X       # 8X

                                                     # UNATTACHED




                                                     # NO GRID
```



```
      OLLS SYSTEM    MODIFY DEVICE  FLOP01
              # RETURN TO DEVICE CENTRAL
  # SIZE/MASKS      # ADD      # DELETE      # REASSIGN   # STEP DISPLAY
  # SHAPE         NUMBER 0000,  NAME OUTO     ,  TYPE OUTPUT   ,
X   TERMINALS     LOAD -100,  UNUSED VALUE +4.0,  CARD PIN 0000,
  # EQUATIONS     ACCESS R    , SIGNAL NAME ORIENTATION HL   END KEY
                    # TERMINAL LOCATION       # SIGNAL NAME LOCATION

X   OLD SHAPE      # NEW SHAPE   X   TERMINALS      # EQUATIONS
0248
                                                      TRACKING
                                                   CHARACTERISTICS
                                                   X   SLOW   # FAST
                                                     # 1X   TRUE
                                                   X   1X   OFFSET

                                                     # 1X       # 2X
                                                     # 4X       # 8X

                                                     # UNATTACHED

                                                     XXXXXXXX



                                                     # NO GRID
```

Figure 4-28

Terminal IN3 was deleted by detecting

DELETE,

detecting terminal IN3 on the device, and pressing the END KEY.

The other three terminals were repositioned using

TERMINAL LOCATION
and
SIGNAL NAME LOCATION

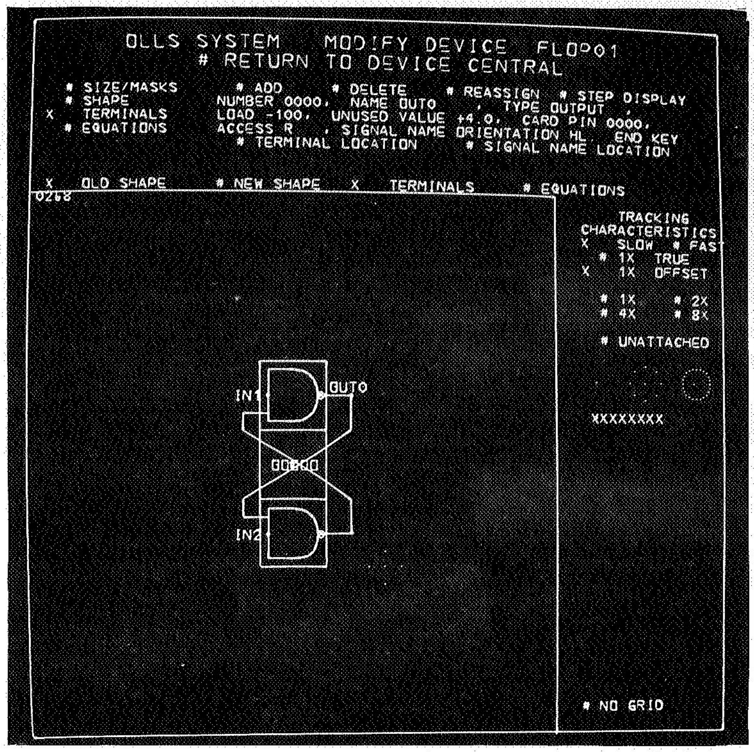
Figure 4-29

A new terminal OUT4 is added by detecting

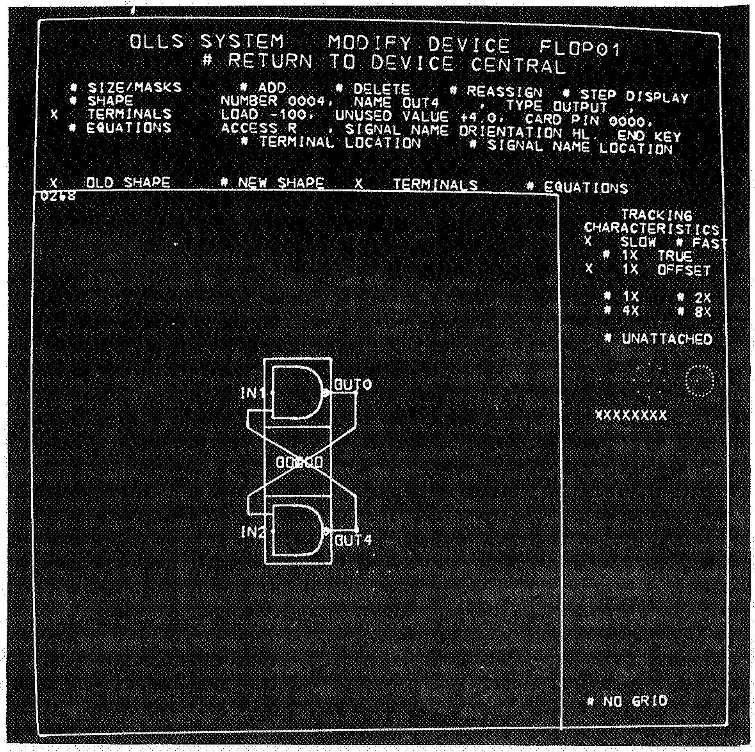
# ADD,

typing in the terminal characteristics as desired, and pressing the END KEY.

Some checks are automatically made in the background such as for non-unique terminal numbers or names etc.



```
      OLLS SYSTEM    MODIFY DEVICE  FLOP01
             # RETURN TO DEVICE CENTRAL

  # SIZE/MASKS      # ADD      # DELETE     # REASSIGN  # STEP DISPLAY
  # SHAPE          NUMBER 0000,  NAME OUTO     ,  TYPE OUTPUT  ,
X   TERMINALS      LOAD -100,  UNUSED VALUE +4.0,  CARD PIN 0000,
  # EQUATIONS      ACCESS R   , SIGNAL NAME ORIENTATION HL   END KEY
                     # TERMINAL LOCATION      # SIGNAL NAME LOCATION

X   OLD SHAPE      # NEW SHAPE   X   TERMINALS      # EQUATIONS
0268
                                                       TRACKING
                                                    CHARACTERISTICS
                                                    X   SLOW  # FAST
                                                      # 1X  TRUE
                                                    X   1X  OFFSET

                                                      # 1X    # 2X
                                                      # 4X    # 8X

                                                      # UNATTACHED

                                                    XXXXXXXX

                                                      # NO GRID
```



```
      OLLS SYSTEM    MODIFY DEVICE  FLOP01
             # RETURN TO DEVICE CENTRAL

  # SIZE/MASKS      # ADD      # DELETE     # REASSIGN  # STEP DISPLAY
  # SHAPE          NUMBER 0004,  NAME OUT4     ,  TYPE OUTPUT  ,
X   TERMINALS      LOAD -100,  UNUSED VALUE +4.0,  CARD PIN 0000,
  # EQUATIONS      ACCESS R   , SIGNAL NAME ORIENTATION HL   END KEY
                     # TERMINAL LOCATION      # SIGNAL NAME LOCATION

X   OLD SHAPE      # NEW SHAPE   X   TERMINALS      # EQUATIONS
0268
                                                       TRACKING
                                                    CHARACTERISTICS
                                                    X   SLOW  # FAST
                                                      # 1X  TRUE
                                                    X   1X  OFFSET

                                                      # 1X    # 2X
                                                      # 4X    # 8X

                                                      # UNATTACHED

                                                    XXXXXXXX

                                                      # NO GRID
```

Figure 4-30

To modify the original 3NAND equation, detect

EQUATIONS

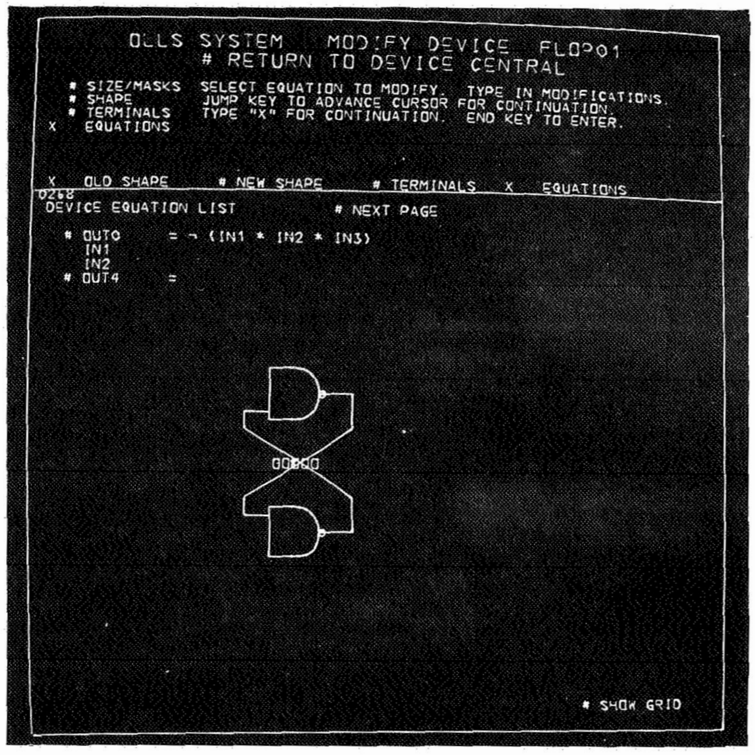
causes this sub menu to appear.

The equation for OUT0 is the original form from the 3NAND. Only terminals defined as "OUTPUT" or "INT. VAR." have a "#" and are alterable.

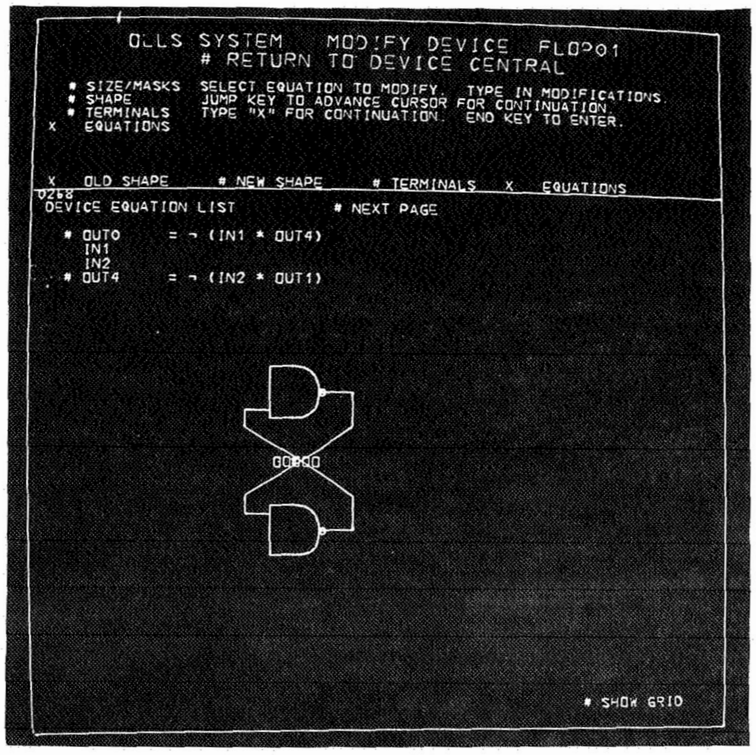
Figure 4-31

The new equations have been entered as per the instructions on the screen.
(Since no delays were specified, a delay of 1 unit is assumed.)

NOTE: It is at this point in time that the equations which describe a device can be compiled into machine code for the simulation routines. The manner in which the equations should be interpreted is decided by the "Device Class" field when the device was created. Equations for an analog device should perhaps be delivered to the FORTRAN Compiler while equations for a boolean device should be delivered to another compiler.



```
          OLLS SYSTEM    MODIFY DEVICE  FLOP01
                    # RETURN TO DEVICE CENTRAL

   # SIZE/MASKS  SELECT EQUATION TO MODIFY.  TYPE IN MODIFICATIONS.
   # SHAPE       JUMP KEY TO ADVANCE CURSOR FOR CONTINUATION.
   # TERMINALS   TYPE "X" FOR CONTINUATION.  END KEY TO ENTER.
 X   EQUATIONS


 X   OLD SHAPE     # NEW SHAPE     # TERMINALS   X   EQUATIONS
0268
 DEVICE EQUATION LIST              # NEXT PAGE

   # OUTO      = ¬ (IN1 * IN2 * IN3)
     IN1
     IN2
   # OUT4      =
```



```
          OLLS SYSTEM    MODIFY DEVICE  FLOP01
                    # RETURN TO DEVICE CENTRAL

   # SIZE/MASKS  SELECT EQUATION TO MODIFY.  TYPE IN MODIFICATIONS.
   # SHAPE       JUMP KEY TO ADVANCE CURSOR FOR CONTINUATION.
   # TERMINALS   TYPE "X" FOR CONTINUATION.  END KEY TO ENTER.
 X   EQUATIONS


 X   OLD SHAPE     # NEW SHAPE     # TERMINALS   X   EQUATIONS
0268
 DEVICE EQUATION LIST              # NEXT PAGE

   # OUTO      = ¬ (IN1 * OUT4)
     IN1
     IN2
   # OUT4      = ¬ (IN2 * OUT1)
```

Figure 4-32

Satisfied with the definition of FLOP01, our designer has detected

RETURN TO DEVICE CENTRAL

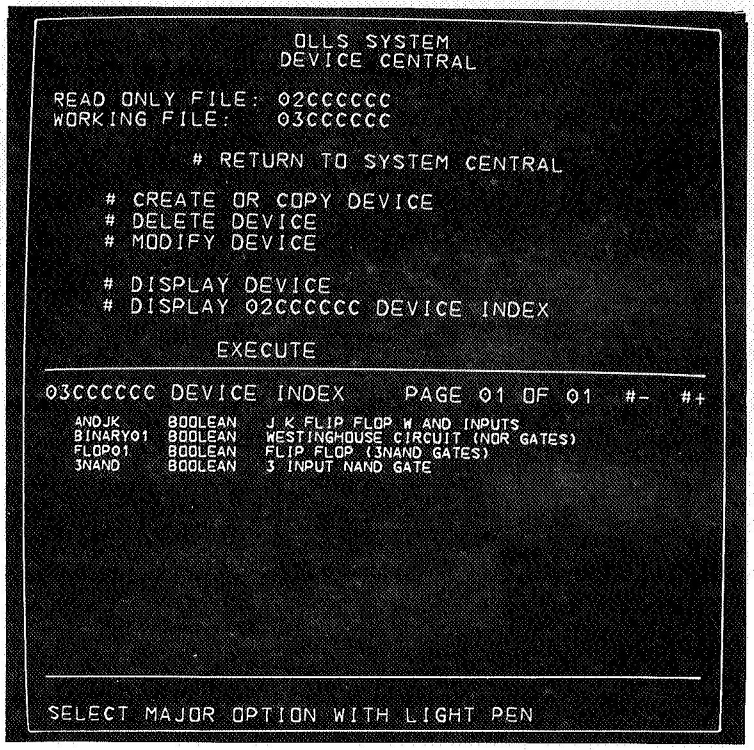
Satisfied with the list of available devices, our designer will detect

RETURN TO SYSTEM CENTRAL

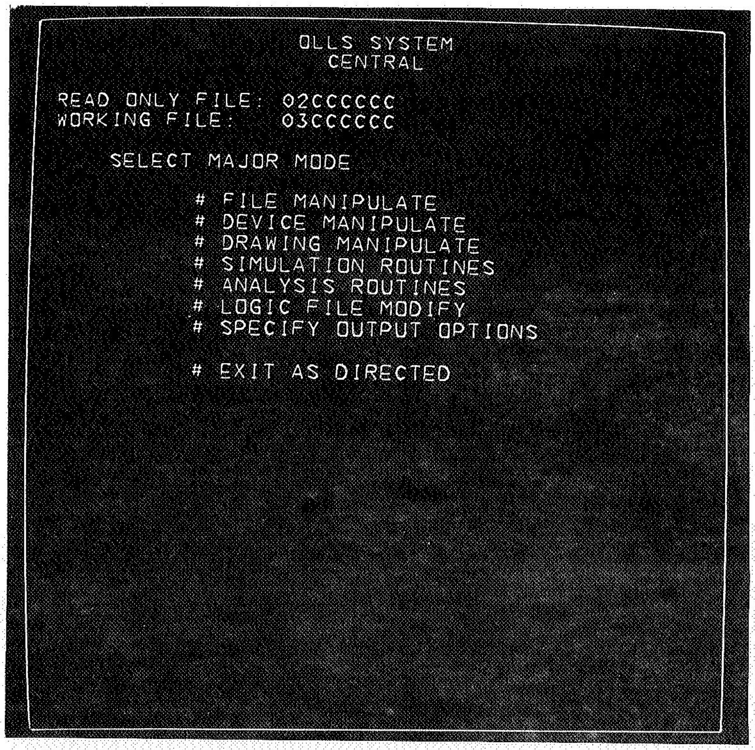
Figure 4-33

Again we see the major options available. We have a satisfactory list of devices so we can proceed to:

# DRAWING MANIPULATE



```
                      OLLS SYSTEM
                     DEVICE CENTRAL

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

           # RETURN TO SYSTEM CENTRAL

     # CREATE OR COPY DEVICE
     # DELETE DEVICE
     # MODIFY DEVICE

     # DISPLAY DEVICE
     # DISPLAY 02CCCCCC DEVICE INDEX

            EXECUTE
--------------------------------------------------------
03CCCCCC DEVICE INDEX     PAGE 01 OF 01   #-   #+
   ANDJK     BOOLEAN   J K FLIP FLOP W AND INPUTS
   BINARY01  BOOLEAN   WESTINGHOUSE CIRCUIT (NOR GATES)
   FLOP01    BOOLEAN   FLIP FLOP (3NAND GATES)
   3NAND     BOOLEAN   3 INPUT NAND GATE

--------------------------------------------------------
SELECT MAJOR OPTION WITH LIGHT PEN
```



```
                      OLLS SYSTEM
                        CENTRAL

READ ONLY FILE: 02CCCCCC
WORKING FILE:   03CCCCCC

     SELECT MAJOR MODE

           # FILE MANIPULATE
           # DEVICE MANIPULATE
           # DRAWING MANIPULATE
           # SIMULATION ROUTINES
           # ANALYSIS ROUTINES
           # LOGIC FILE MODIFY
           # SPECIFY OUTPUT OPTIONS

           # EXIT AS DIRECTED
```

Figure 4-34

As of this writing

DRAWING CENTRAL

has been fully implemented and checked out. It operates in much the same fashion as DEVICE CENTRAL shown earlier.

Figure 4-35

As of this writing

MODIFY DRAWING
DISPLAY DRAWING
and
OUTPUT OPTIONS

are in final stages of implementation.
(See Fig. 3-41 and Fig. 3-42 in E-2265.)

5. CONCLUSION

After almost three years of experimenting with different file structures (from the very earliest forms in Honeywell 1800 MAC to the very elegant forms possible in FILLIP), with different drawing and simulation algorithms, and with both interactive and non-interactive systems, we believe the following three points express the essence of our findings and our contributions to the area of computer aided design of logic circuits.

a) The nature of the OLLS project is of such complexity that the key to success in any implementation of the required goals is the structure of the data file. The means of the implementation of this structure will affect only the running efficiency and ease of coding. The data structure outlines in Section 3.1 of E-2265 embodies (we feel) most of the requirements of today's logic subsystems and has the ability to be easily expanded as future developments in this field require.

b) A card input system is almost unacceptable in a production environment. As an experimental tool, however, a card input system such as the FILLIP logical simulator can be a powerful engineering aid to understanding complex logic circuits.

c) Today's technology in the field of logic circuits is advancing too fast for a system which has not been designed to accommodate changes with ease. It is absolutely essential (especially in the area of defining devices) that there be a minimum of arbitrary constraints upon the user such as insufficient file size, limited number and variety of device terminals, shapes, or behavior, or input/output formats which are not completely flexible to suit the current application of the system.

We now have an operational facility (MAC 360) to produce logic flow diagrams, logical simulations, useful output lists, and a wrap deck compatible with existing wirewrap software. We have the complete FILLIP Card Input System almost operational as described in Section 3. We will continue our efforts at debugging some of the newer features of that system although at a reduced level since its production usefulness is not as apparent now as is the CRT system. Most of our effort in the near future will be toward making the interactive CRT system operational, at least to the point where we can produce logic flow diagrams, lists, and plots which are of superior quality and less expensive in terms of time and money than the MAC 360 system. We anticipate being in a position to phase out the MAC 360 system in early 1969.

For purely economic reasons we have fallen short of our goal: We do not have nor will we have an On Line Logical Simulator as the acronym OLLS suggests. We have instead two separate systems which if combined would do all that we initially set out to do. We have the on-line CRT system which has full drawing, file manipulating, and output capability but which cannot at this time perform logical simulations; and we have the FILLIP card input system which is not interactive, cannot produce any graphic output, but probably has the most powerful logical simulation capability available in the country today. Most of the difficult design work for an integrated system is complete, however, and we are now in a position where we require some external support for the implementation of the total system. The choice of whether it should be an all FILLIP implementation, a machine language implementation, or a combination, is not important. What is important is that we have shown the utility of such a system, have explored most of the alternatives which might be considered in implementing it, and have outlined a clear set of input, output, and internal structure requirements necessary for the computer aided design of logic systems.

E-2410

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