

## **General Disclaimer**

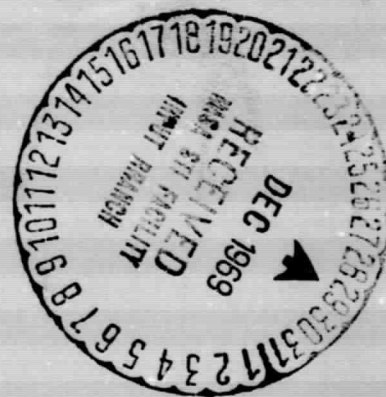
### **One or more of the Following Statements may affect this Document**

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

*X* *R. J. Lesniewski, 711*

FINAL REPORT

Contract Number: NAS-5-21012 ✓



**N70-13705**  
(ACCESSION NUMBER)

**23**  
(PAGES)

**CR-107306**  
(NASA CR OR TMX OR AD NUMBER)

**7**  
(CODE)

**09**  
(CATEGORY)

Prepared By:

*Robert Cook*

Robert Cook  
Project Engineer

Approved By:

*Robert Cook*

Robert Cook  
Project Manager

SOLID STATE SCIENTIFIC INC.  
MONTGOMERYVILLE, PENNA.

## TABLE OF CONTENTS

|                                              | Page |
|----------------------------------------------|------|
| INTRODUCTION .....                           | 1    |
| Study Program .....                          | 1    |
| C <sup>2</sup> PROCESSING .....              | 1    |
| PHASE I ELECTRICAL RESULTS .....             | 2    |
| PHASE II .....                               | 2    |
| BI-DIRECTIONAL DRIVER PERFORMANCE.....       | 2    |
| C MOS versus C <sup>2</sup> .....            | 2    |
| BUFFER CIRCUIT EVALUATION .....              | 3    |
| LOW VOLTAGE OPERATION.....                   | 4    |
| C <sup>2</sup> GEOMETRY CONSIDERATIONS ..... | 4    |
| CHIP AREA TRADE-OFFS .....                   | 5    |
| CONCLUSION .....                             | 6    |

## INTRODUCTION

This final report covers the accomplishments made during the performance of the investigation into the combination of Complementary MOS and Complementary Bipolar circuits on a monolithic silicon chip. The results of this effort clearly demonstrates feasibility. The data shows that enhanced electrical performance can be expected with this new technology.

### Study Program

The development program was divided into two work phases. Phase I consisted of the design and fabrication of a special engineering photo-resist mask set and an investigation of the wafer processing techniques required to determine initial feasibility. Phase II consisted of the fabrication of read/write buffer circuits using a second set of masks. This new technology has been named "Complementary-squared" or simply "C<sup>2</sup>".

### Complementary-squared (C<sup>2</sup>) PROCESSING:

The diffusion development effort centered around the fabrication of a compatible high beta PNP. Both a "lateral" PNP and a "substrate" PNP approach were eliminated as candidates for C<sup>2</sup>. The final structure used is the familiar vertical planar PNP. Additional investigations to determine the minimum fabrication steps and the processing reproducibility were also completed during Phase I. Figure #1 shows a cross-sectional view of the C<sup>2</sup> structure. The process requires only two additional steps versus that of C MOS only. The bipolar transistor process was specially designed to achieve the high emitter-base reverse breakdown voltages required for the read/write buffer circuits. Typical electrical characteristics are shown in Figure #2 for both the bipolar and C MOS devices.

### PHASE I ELECTRICAL RESULTS:

The mask set of Phase I was designated SD 5610. The first group of wafers completely processed using these masks clearly demonstrated the feasibility of  $C^2$ . The dynamic performance showed that with a capacitive load of greater than 470 pico-farad, speeds in excess of one megahertz could be achieved. The static power consumption achieved with these circuits was typically much less than 100 nano-watts.

The successful completion of Phase I marked the beginning of an entirely new and exciting technology.

### PHASE II

The circuits developed during phase II are shown in Figure #3 and #4. These devices are designated SD 5615-2 and SD 5615-3 respectively. A simple inverting output buffer was evaluated as shown in Figure #5 (SD 5615-1). Ten samples of each circuit have been furnished to NASA for further evaluation. The wiring diagrams are shown in Figure #6. Table I shows the data for the SD 5615-1 device.

### BI-DIRECTIONAL DRIVER PERFORMANCE:

The data collected on circuits #SD 5615-2 and SD 5615-3 is represented in tables II and III. The high leakage currents associated with these devices are a result of the low  $BV_{CEO}$  of the PNP devices. The  $BV_{CEO}$  values were a result of extremely narrow base-widths for these devices. It has already been shown in Phase I that these high leakage levels are not inherent in the  $C^2$  process, and identical dynamic performance for low leakage devices (nano-amperes) would be experienced.

### C MOS versus $C^2$

The evaluation of the dynamic characteristics clearly shows the advantages of  $C^2$  over that of C MOS.

### CMOS versus C<sup>2</sup> (Cont'd)

This is represented graphically in Figure #7. Here, the rise and fall times are plotted versus load capacitance for the case of  $V_{dd} = +10\text{Volts}$  (SD 5615-2). The C MOS inverter used for this graph has w/l ratio equal to 100 for both the N and the P channel devices. It is apparent from this data that a ten to one speed improvement can be realized by using the C<sup>2</sup> technology.

### BUFFER CIRCUIT EVALUATION

The two bi-directional driver circuits were compared dynamically in both the input and output modes of operation. In the output or driving mode the SD 5615-3 circuit exhibits extremely long fall times. This is due to the fact that the bases of the bipolar devices are not turned off thru MOS devices. Rather, the bipolar device that should be off (depending upon the input state), is left "floating" such that current can continue to flow until the device capacitances are discharged. The fact that only the fall time is affected indicates that the NPN charge storage time is much greater than that of the PNP. The SD 5615-2 circuit does not suffer from this problem due to the "push-pull" effect achieved by driving the bipolar bases from a common C MOS inverter. In the input or data acceptance mode the SD 5615-2 circuit has an undesirable property. This circuit loads down the output as expected due to the fact that the bipolar devices are not turned off as is the case with the SD 5615-3 device. The loading effects of both circuits were evaluated by using a C MOS inverter to drive into the bipolar output and then measuring transition times. These times were in turn translated into effective capacitances. The SD 5615-2 represented a load from 200 to 1000 pico-farads and the SD 5615-3 represented essentially zero load to the C MOS inverter.

### BUFFER CIRCUIT EVALUATION - Cont'd:

The circuit comparisons show that an optimum design can be achieved by combining the best aspects of these two circuits. This optimum design is shown in Figure #8, and it will result in the fastest switching response and minimum output loading.

### LOW VOLTAGE OPERATION

Circuit #SD 5615-2 was evaluated at a supply voltage equal to +5 volts. The results of these tests are extremely significant in that no degradation of dynamic performance was observed under high loading conditions in terms rise and fall times. Figure #9 shows a comparison of C MOS and  $C^2$  in terms of switching response versus supply voltage.

The fact that the  $C^2$  fall time increases at higher supply voltage indicates that the effective series collector resistance increases due to current saturation. However, the supply range from +5 to +10 volts is of prime importance. In this voltage range the speed advantage of  $C^2$  versus C MOS varies from a factor of ten (at 10 volts) to a factor of approximately twenty-five (at 5 volts).

The fact that the switching speed of C MOS at low voltage is quite poor, has inhibited its usefulness as an interface with standard TTL logic. The new  $C^2$  technology offers the user direct TTL interface at high speeds.

### $C^2$ GEOMETRY CONSIDERATIONS

Three MOS inverter geometries (w/l ratios) and two bipolar geometries were evaluated in terms of dynamic performance.

The SD 5610 device contained three C MOS inverter sizes, which were;  $W/L = 100$ ,  $W/L = 50$ , and  $W/L = 25$ . These devices were evaluated in terms of driving capability

for the bipolar outputs. The results of this investigation is shown in Figure 10. The plotted parameters are propagation delay plus transition time versus inverter size for both logic states. The conditions were  $V_{DD} = +10$  volts and  $C_L = 120$  pico-farads.

The results show that the larger inverter sizes increase the maximum operating frequency as expected. Thus, the minimum inverter size required of any new circuit designs will be a function of the requirements in terms of dynamic performance.

The bipolar devices were evaluated similarly using a constant inverter size of  $W/L = 100$ . The two bipolar sizes (total area for both the NPN and the PNP) were  $212 \text{ mil}^2$  and  $408 \text{ mil}^2$ . The results of this investigation is plotted (Figure #11) in terms of propagation delay plus transition time versus capacitive load for both buffer sizes, ( $V_{DD} = +10$  volts). The results show that there is very little difference in terms of maximum operating frequency. This suggests that perhaps even smaller bipolar sizes could be used in future designs.

#### CHIP AREA TRADE-OFFS

This study program shows that both a speed improvement and a chip size improvement can be achieved with the new  $C^2$  technology.

The area consumed by a typical output C MOS inverter ( $W/L = 100$ ) is  $176 \text{ mil}^2$ . The bipolar output buffer of the SD 5610 device is only  $212 \text{ mil}^2$ . The increase in area of the bipolar devices is very minimal considering the tremendous gain in dynamic response. This very small increase in area makes  $C^2$  very attractive for use as output buffers and also internal buffers such as clock line drivers.

#### CONCLUSION

The successful completion of this study program has lead to the following conclusions:

- 1) Both high speed and low leakage can be obtained using  $C^2$ .

CONCLUSION - Cont'd

- 2) Only two additional process steps are necessary for the fabrication of  $C^2$  versus C MOS alone.
- 3) Both types of bi-directional buffer circuits functioned electrically and pointed the way to a newer optimum design.
- 4) The SD 5615-3 represented nearly zero load in the input mode of operation.
- 5)  $C^2$  offers a dynamic performance improvement from 10 to 25 times that of C MOS.
- 6) The observed high speed performance at +5 volts is compatible with conventional TTL circuits.
- 7) Chip area is not appreciably increased by using  $C^2$ .

SCL 5615-1

TABLE #1

STATIC CHARACTERISTICS:  $V_{DD} = 10.0V$ ,  $V_1 = 10.0V$ ,  $V_0 = 0.0V$

| <u>Units</u><br><u>Serial #</u> | $I_{DD} @ V_1$<br>$\mu A$ | $I_{DD} @ V_0$<br>$\mu A$ | $V_{OH} @ V_0$<br>Volts | $V_{OL} @ V_1$<br>Volts |
|---------------------------------|---------------------------|---------------------------|-------------------------|-------------------------|
| 1                               | 0.0005                    | 250                       | 9.41                    | 0.00                    |
| 2                               | 0.11                      | 0.003                     | 9.57                    | 0.00                    |
| 3                               | 3.0                       | 0.09                      | 9.58                    | 0.01                    |
| 4                               | 48                        | 0.45                      | 9.58                    | 0.46                    |
| 5                               | 6.4                       | 4.0                       | 9.54                    | 0.01                    |
| 6                               | 4.6                       | 4.6                       | 9.57                    | 0.01                    |
| 7                               | 60                        | 0.0003                    | 9.96                    | 0.55                    |
| 8                               | 0.0005                    | 0.0005                    | 9.56                    | 0.00                    |
| 9                               | 34                        | 47                        | 9.58                    | 0.01                    |
| 10                              | 2.1                       | 0.04                      | 9.57                    | 0.01                    |

DYNAMIC CHARACTERISTICS:  $V_{DD} = 10.0V$ ,  $V_1 = 0.0V$ ,  $C_L = 92\text{ pf}$

| <u>Units</u><br><u>Serial #</u> | $T_r$<br>n Sec | $T_f$<br>n Sec | $T_{p0}$<br>n Sec | $T_{p1}$<br>n Sec |
|---------------------------------|----------------|----------------|-------------------|-------------------|
| 1                               | 54             | 188            | 44                | 56                |
| 2                               | 60             | 218            | 46                | 60                |
| 3                               | 60             | 204            | 53                | 62                |
| 4                               | 52             | 272            | 37                | 58                |
| 5                               | 66             | 252            | 69                | 66                |
| 6                               | 60             | 182            | 55                | 62                |
| 7                               | 64             | 196            | 48                | 64                |
| 8                               | 60             | 146            | 38                | 62                |
| 9                               | 58             | 358            | 94                | 60                |
| 10                              | 63             | 218            | 47                | 62                |

TABLE II

STATIC CHARACTERISTICS:  $V_{DD} = 10.0 \text{ V}$ ,  $V_1 = 10.0 \text{ V}$ ,  $V_0 = 0.00 \text{ V}$

| INPUT<br>CONDITIONS | $I_{DD}$      | $V_1$         | $V_0$         | $V_1$         | $V_{OH}$ | $V_{OL}$ | Data<br>Write |
|---------------------|---------------|---------------|---------------|---------------|----------|----------|---------------|
|                     | $V_0$         | $V_0$         | $V_1$         | $V_1$         | $V_1$    | $V_0$    |               |
| Units               | $\mu\text{A}$ | $\mu\text{A}$ | $\mu\text{A}$ | $\mu\text{A}$ | Volts    | Volts    |               |
| Serial #            |               |               |               |               |          |          |               |
| 1                   | 6.7           | 2450          | 0.0008        | 0.003         | 8.53     | 0.01     |               |
| 2                   | 0.025         | 310           | 0.025         | 310           | 9.44     | 0.00     |               |
| 3                   | 1650          | 950           | 950           | 1000          | 9.58     | 0.07     |               |
| 4                   | 1300          | 1700          | 0.0003        | 0.0003        | 9.34     | 0.18     |               |
| 5                   | 0.60          | 730           | 0.0005        | 0.0005        | 9.38     | 0.00     |               |
| 6                   | 470           | 950           | 1100          | 0.0012        | 9.32     | 0.01     |               |
| 7                   | 510           | 2000          | 0.0002        | 0.0002        | 9.35     | 0.00     |               |
| 8                   | 0.0005        | 670           | 21            | 0.0011        | 9.37     | 0.00     |               |
| 9                   | 1.0           | 150           | 0.19          | 0.20          | 9.44     | 0.40     |               |
| 10                  | 30            | 270           | 34            | 34            | 9.99     | 0.50     |               |

DYNAMIC CHARACTERISTICS: @  $V_{DD} = 10.0 \text{ V}$

| CONDITIONS | $T_R$                                                              | $T_f$  | $T_{p0}$ | $T_{p1}$ | $C_{e0}$ | $C_{e1}$ | Data<br>Write<br>Output |
|------------|--------------------------------------------------------------------|--------|----------|----------|----------|----------|-------------------------|
|            | $\phi$                                                             | $\phi$ | $\phi$   | $\phi$   | $V_0$    | $V_0$    |                         |
|            | $V_0$                                                              | $V_0$  | $V_0$    | $V_0$    | $V_1$    | $V_{OH}$ |                         |
|            | $C_L = 1.4 \text{ pf} \leftarrow \rightarrow C_L = 1.4 \text{ pf}$ |        |          |          | $V_{OL}$ |          |                         |
| Units      | n Sec                                                              | n Sec  | n Sec    | n Sec    | pF       | pF       |                         |
| Serial #   |                                                                    |        |          |          |          |          |                         |
| 1          | 30                                                                 | 48     | 46       | 35       | 150      | 870      |                         |
| 2          | 29                                                                 | 56     | 50       | 34       | 380      | 740      |                         |
| 3          | 36                                                                 | 38     | 48       | 35       | 290      | 700      |                         |
| 4          | 30                                                                 | 48     | 54       | 38       | 350      | 740      |                         |
| 5          | 29                                                                 | 48     | 48       | 34       | 390      | 800      |                         |
| 6          | 23                                                                 | 40     | 44       | 35       | 200      | 870      |                         |
| 7          | 30                                                                 | 62     | 54       | 34       | 280      | 400      |                         |
| 8          | 33                                                                 | 46     | 52       | 46       | 360      | 860      |                         |
| 9          | 29                                                                 | 46     | 50       | 35       | 470      | 770      |                         |
| 10         | 35                                                                 | 42     | 50       | 45       | 260      | 550      |                         |
| CONDITIONS | 25pf                                                               | 25pf   | 25pf     | 25pf     |          |          | $C_L$                   |
| Units      | n Sec                                                              | n Sec  | n Sec    | n Sec    |          |          |                         |
| Serial #   |                                                                    |        |          |          |          |          |                         |
| 1          | 36                                                                 | 50     | 50       | 44       |          |          |                         |
| 2          | 36                                                                 | 80     | 56       | 43       |          |          |                         |
| 3          | 43                                                                 | 42     | 57       | 46       |          |          |                         |
| 4          | 37                                                                 | 54     | 58       | 47       |          |          |                         |
| 5          | 34                                                                 | 58     | 52       | 43       |          |          |                         |
| 6          | 40                                                                 | 46     | 48       | 45       |          |          |                         |
| 7          | 36                                                                 | 110    | 58       | 43       |          |          |                         |
| 8          | 39                                                                 | 52     | 56       | 56       |          |          |                         |
| 9          | 34                                                                 | 60     | 56       | 44       |          |          |                         |
| 10         | 45                                                                 | 70     | 58       | 56       |          |          |                         |

Continued.....

SCL 5615-2

TABLE II - Cont'd

DYNAMIC CHARACTERISTICS: Cont'd

| CONDITIONS      | 92pf | 92pf | 92pf | 92pf | C <sub>L</sub> |
|-----------------|------|------|------|------|----------------|
| <u>Serial #</u> |      |      |      |      |                |
| 1               | 47   | 90   | 60   | 59   |                |
| 2               | 52   | 140  | 72   | 59   |                |
| 3               | 61   | 92   | 62   | 65   |                |
| 4               | 48   | 100  | 68   | 62   |                |
| 5               | 44   | 112  | 66   | 57   |                |
| 6               | 52   | 78   | 56   | 62   |                |
| 7               | 47   | 220  | 84   | 57   |                |
| 8               | 55   | 94   | 68   | 72   |                |
| 9               | 47   | 126  | 72   | 60   |                |
| 10              | 72   | 156  | 78   | 35   |                |

---

| CONDITIONS      | 300pf | 300pf | 300pf | 300pf | C <sub>L</sub> |
|-----------------|-------|-------|-------|-------|----------------|
| <u>Serial #</u> |       |       |       |       |                |
| 1               | 91    | 228   | 108   | 96    |                |
| 2               | 88    | 50    | 154   | 92    |                |
| 3               | 107   | 240   | 127   | 103   |                |
| 4               | 87    | 240   | 127   | 95    |                |
| 5               | 80    | 296   | 142   | 89    |                |
| 6               | 93    | 200   | 96    | 97    |                |
| 7               | 83    | 600   | 216   | 89    |                |
| 8               | 99    | 235   | 128   | 113   |                |
| 9               | 85    | 350   | 160   | 93    |                |
| 10              | 132   | 430   | 192   | 122   |                |

---

STATIC CHARACTERISTICS:  $V_{DD} = 10.0V$ ,  $V_1 = 10.0V$ ,  $V_0 = 0.00V$

| INPUT<br>CONDITIONS | $V_0$<br>$V_0$ | $I_{DD}$ |         | $V_0$<br>$V_1$ | $V_1$<br>$V_1$ | $V_1$<br>$V_0$ | $V_{OH}$ | $V_{OL}$ |
|---------------------|----------------|----------|---------|----------------|----------------|----------------|----------|----------|
|                     |                | $V_1$    | $V_0$   |                |                |                | $V_0$    | Data     |
|                     |                | $V_0$    | $V_1$   |                |                |                | $V_0$    | Write    |
| Units               | $\mu A$        | $\mu A$  | $\mu A$ | $\mu A$        | Volts          | Volts          |          |          |
| Serial #            |                |          |         |                |                |                |          |          |
| 1                   | 0.0017         | 3500     | 500     | 500            | 9.30           | 0.00           |          |          |
| 2                   | 0.020          | 900      | 200     | 200            | 9.36           | 0.00           |          |          |
| 3                   | 100            | 600      | 100     | 100            | 9.37           | 0.00           |          |          |
| 4                   | 0.001          | 2200     | 0.001   | 0.001          | 9.31           | 0.00           |          |          |
| 5                   | 0.0006         | 200      | 0.0055  | 0.0055         | 9.42           | 0.00           |          |          |
| 6                   | 6.0            | 650      | 6.0     | 6.0            | 9.40           | 0.00           |          |          |
| 7                   | 15             | 3500     | 600     | 600            | 9.33           | 0.00           |          |          |
| 8                   | 0.0011         | 4000     | 0.001   | 0.001          | 9.26           | 0.00           |          |          |
| 9                   | 4.0            | 300      | 110     | 110            | 9.40           | 0.00           |          |          |
| 10                  | 110            | 110      | 110     | 110            | 9.58           | 0.00           |          |          |

DYNAMIC CHARACTERISTICS: @  $V_{DD} = 10.0V$

| CONDITIONS | $T_r$ | $T_f$ | $T_{p0}$ | $T_{p1}$ | $C_{e0}$ | $C_{e1}$ | Data<br>Write<br>Output |
|------------|-------|-------|----------|----------|----------|----------|-------------------------|
|            | O     | O     | O        | O        | $V_0$    | $V_0$    |                         |
|            | $V_0$ | $V_0$ | $V_0$    | $V_0$    | $V_1$    | $V_1$    |                         |
| $C_L$      | 1.4pf | 1.4pf | 1.4pf    | 1.4pf    | $V_{OL}$ | $V_{OH}$ |                         |
| Units      | n Sec | n Sec | n Sec    | n Sec    | pf       | pf       |                         |
| Serial #   |       |       |          |          |          |          |                         |
| 1          | 24    | 2000  | 630      | 34       | 0        | 0        |                         |
| 2          | 22    | 2400  | 720      | 32       |          |          |                         |
| 3          | 30    | 1100  | 80       | 34       |          |          |                         |
| 4          | 30    | 1200  | 90       | 34       |          |          |                         |
| 5          | 22    | 1500  | 70       | 34       |          |          |                         |
| 6          | 20    | 2600  | 590      | 28       |          |          |                         |
| 7          | 20    | 2600  | 870      | 30       |          |          |                         |
| 8          | 44    | 1300  | 270      | 36       |          |          |                         |
| 9          | 26    | 1800  | 350      | 34       |          |          |                         |
| 10         | 20    | 1600  | 70       | 30       |          |          |                         |

| CONDITIONS | 25pf  | 25pf  | 25pf  | 25pf  | $C_L$ |
|------------|-------|-------|-------|-------|-------|
| Units      | n Sec | n Sec | n Sec | n Sec |       |
| Serial #   |       |       |       |       |       |
| 1          | 28    | 2000  | 660   | 40    |       |
| 2          | 24    | 2300  | 670   | 36    |       |
| 3          | 32    | 1100  | 100   | 38    |       |
| 4          | 32    | 1200  | 100   | 38    |       |
| 5          | 24    | 1300  | 70    | 38    |       |
| 6          | 22    | 2500  | 550   | 34    |       |
| 7          | 22    | 2700  | 850   | 34    |       |

SCL 5615-3

TABLE III Cont'd

CONDITIONS

| Cont'd          | 25pf  | 25pf  | 25pf  | 25pf  |
|-----------------|-------|-------|-------|-------|
| Units           | n Sec | n Sec | n Sec | n Sec |
| <u>Serial #</u> |       |       |       |       |
| 8               | 38    | 1300  | 260   | 41    |
| 9               | 30    | 1800  | 340   | 40    |
| 10              | 22    | 1600  | 90    | 36    |

---

| CONDITIONS | 92pf | 92pf | 92pf | 92pf |
|------------|------|------|------|------|
|------------|------|------|------|------|

Serial #

|    |    |      |      |    |
|----|----|------|------|----|
| 1  | 38 | 2000 | 1000 | 48 |
| 2  | 32 | 2300 | 590  | 45 |
| 3  | 40 | 1100 | 130  | 48 |
| 4  | 44 | 1200 | 130  | 48 |
| 5  | 34 | 1300 | 100  | 48 |
| 6  | 32 | 2500 | 410  | 42 |
| 7  | 30 | 2700 | 750  | 42 |
| 8  | 48 | 1300 | 250  | 52 |
| 9  | 40 | 1800 | 290  | 50 |
| 10 | 32 | 1700 | 130  | 44 |

---

| CONDITIONS | 300pf | 300pf | 300pf | 300pf |
|------------|-------|-------|-------|-------|
|------------|-------|-------|-------|-------|

Serial #

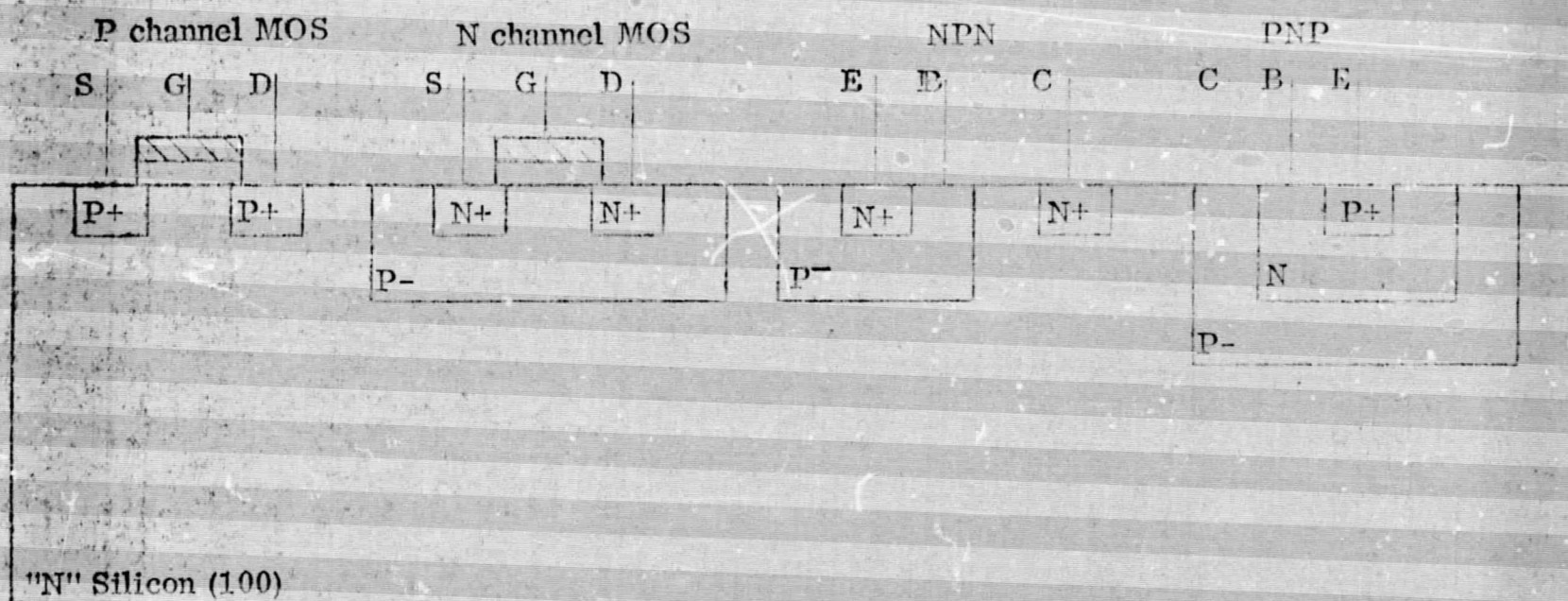
|    |    |      |     |    |
|----|----|------|-----|----|
| 1  | 60 | 2100 | 240 | 72 |
| 2  | 56 | 2500 | 230 | 66 |
| 3  | 66 | 1200 | 210 | 70 |
| 4  | 68 | 1300 | 230 | 72 |
| 5  | 58 | 1700 | 200 | 70 |
| 6  | 54 | 2800 | 480 | 62 |
| 7  | 50 | 3200 | 770 | 62 |
| 8  | 72 | 1400 | 300 | 76 |
| 9  | 66 | 1900 | 310 | 74 |
| 10 | 56 | 2100 | 290 | 66 |

---

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.



| REVISIONS |      |             |      |          |
|-----------|------|-------------|------|----------|
| ZONE      | LTR. | DESCRIPTION | DATE | APPROVED |



A cross-section view of one fabrication approach of complementary MOS and complementary bipolar on the same substrate.

(Figure #1)

|                                                                                                |          |                |                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------|----------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAWN    | DATE           |  <b>SOLID STATE SCIENTIFIC CORP.</b><br>MONTGOMERYVILLE, PENNSYLVANIA 10936 |
|                                                                                                | CHECKED  |                |                                                                                                                                                                 |
|                                                                                                | APPROVED |                |                                                                                                                                                                 |
|                                                                                                |          |                |                                                                                                                                                                 |
| MATERIAL                                                                                       |          |                | <b>C<sup>2</sup> - CROSS SECTION</b>                                                                                                                            |
|                                                                                                |          |                |                                                                                                                                                                 |
|                                                                                                | APPROVED |                |                                                                                                                                                                 |
|                                                                                                | APPROVED |                |                                                                                                                                                                 |
|                                                                                                | SIZE     | CODE IDENT NO. |                                                                                                                                                                 |
|                                                                                                | A        |                |                                                                                                                                                                 |
|                                                                                                | SCALE    | WEIGHT         | SHEET                                                                                                                                                           |



# COMPLEMENTARY-SQUARED

## ELECTRICAL CHARACTERISTICS

### BIPOLAR devices

| DEVICE | $BV_{CBO}$<br>@ 10 $\mu A$ | $BV_{EBO}$<br>@ 10 $\mu A$ | $BV_{CES}$<br>@ 10 $\mu A$ | $V_{CE}$<br>$I_C = 1 \text{ mA}$<br>$I_B = 0.1 \text{ mA}$ | BETA<br>$I_C = 10 \text{ mA}$ |
|--------|----------------------------|----------------------------|----------------------------|------------------------------------------------------------|-------------------------------|
| PNP    | 60V                        | 30V                        | 60V                        | 0.5V                                                       | 150                           |
| NPN    | 80V                        | 50V                        | 80V                        | 0.15V                                                      | 50                            |

### MOS devices

| DEVICE    | $V_T$<br>@ 10 $\mu A$ | $BV_{DSS}$<br>@ 10 $\mu A$ | $I_{DSS}$<br>@ 10 V |
|-----------|-----------------------|----------------------------|---------------------|
| P Channel | 2.3V                  | 50V                        | 1 nA                |
| N Channel | 1.9V                  | 30V                        | 1 nA                |

FIGURE #2

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.



| REVISIONS |      |             |      |          |
|-----------|------|-------------|------|----------|
| ZONE      | LTR. | DESCRIPTION | DATE | APPROVED |

Data Input

Write Command

+V

Output

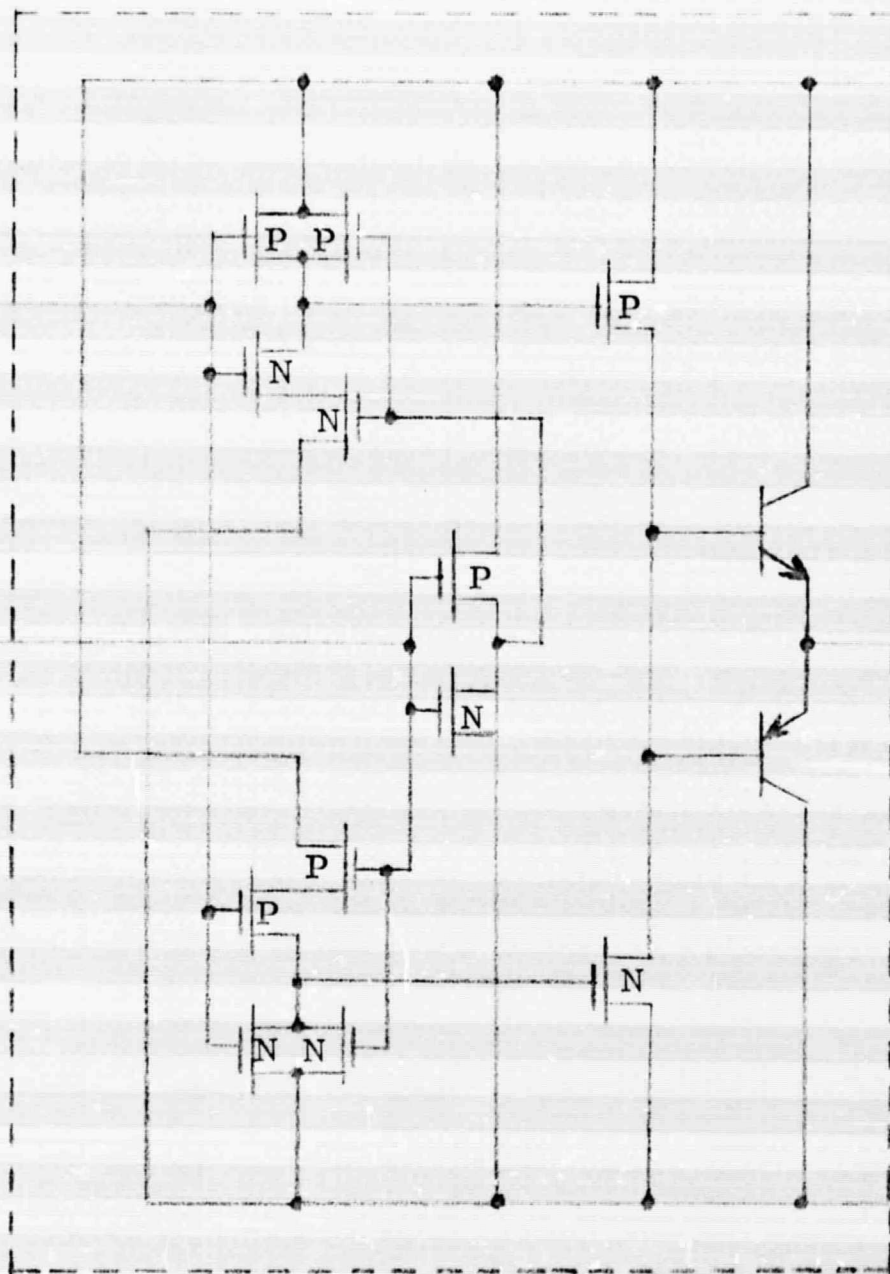


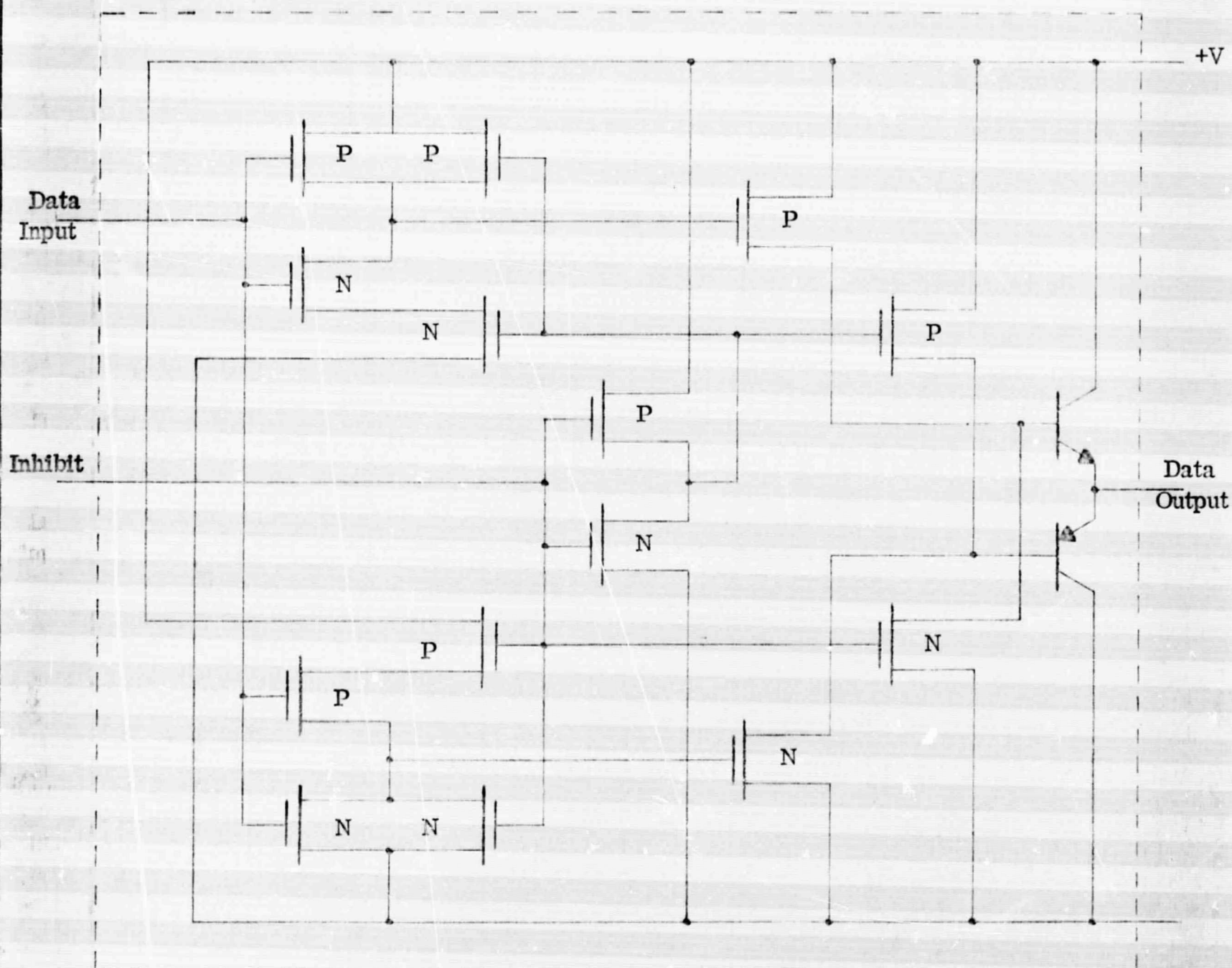
Figure #3

|                                                                                                |                       |                |                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------|-----------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAWN                 | DATE           |  <b>SOLID STATE SCIENTIFIC CORP.</b><br>MONTGOMERYVILLE, PENNSYLVANIA 18936 |
|                                                                                                | CHECKED               | 10/24/69       |                                                                                                                                                                 |
|                                                                                                | APPROVED              | 10/27/69       |                                                                                                                                                                 |
|                                                                                                |                       | 11/2/69        |                                                                                                                                                                 |
| MATERIAL                                                                                       | BI-DIRECTIONAL DRIVER |                |                                                                                                                                                                 |
|                                                                                                | SD 5615 - 2           |                |                                                                                                                                                                 |
| APPROVED                                                                                       | SIZE                  | CODE IDENT NO. |                                                                                                                                                                 |
| APPROVED                                                                                       | A                     |                |                                                                                                                                                                 |

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.



| REVISIONS |      |             |      |          |
|-----------|------|-------------|------|----------|
| ZONE      | LTR. | DESCRIPTION | DATE | APPROVED |



NOTE: The output is open circuited when Inhibit is high.

(Figure #4)

UNLESS OTHERWISE  
SPECIFIED DIMENSIONS  
ARE IN INCHES  
TOLERANCES ON  
FRACTIONS DECIMALS ANGLES

DRAWN

DATE

CHECKED

APPROVED



**SOLID STATE SCIENTIFIC CORP.**  
MONTGOMERYVILLE, PENNSYLVANIA 18936

MATERIAL

BI-DIRECTIONAL DRIVER

SD 5615 - 3

APPROVED

SIZE

CODE IDENT NO.

| REVISIONS |      |             |      |          |
|-----------|------|-------------|------|----------|
| ZONE      | LTR. | DESCRIPTION | DATE | APPROVED |

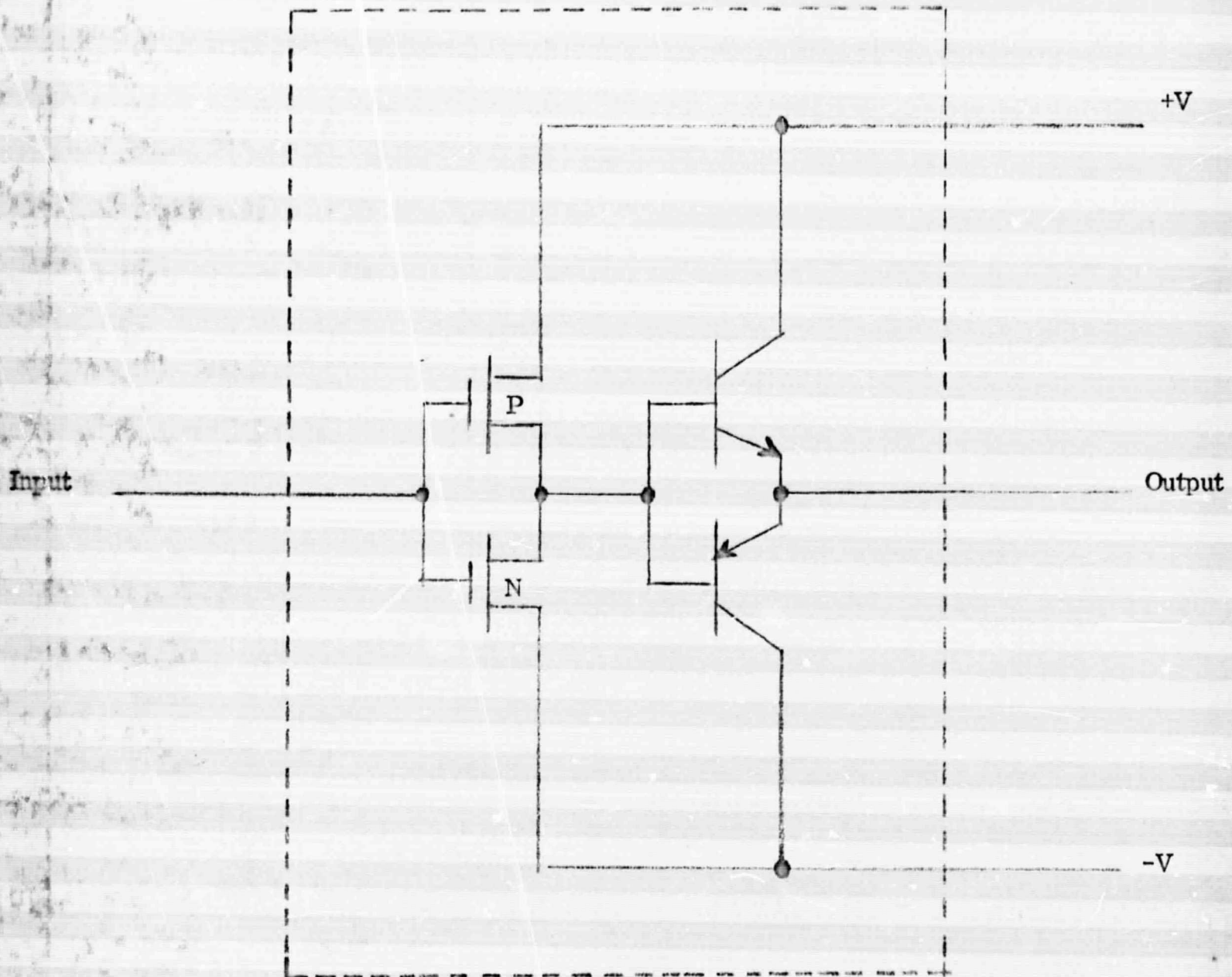


Figure #5

UNLESS OTHERWISE  
SPECIFIED DIMENSIONS  
ARE IN INCHES  
TOLERANCES ON  
FRACTIONS DECIMALS ANGLES

DRAWN *Rae*

DATE

*10/24/69*

CHECKED *Rae*

*10/26/69*

APPROVED *Rae*

*10/27/69*



**SOLID STATE SCIENTIFIC CORP.**  
MONTGOMERYVILLE, PENNSYLVANIA 18936

MATERIAL

APPROVED

SIZE

**A**

CODE IDENT NO.

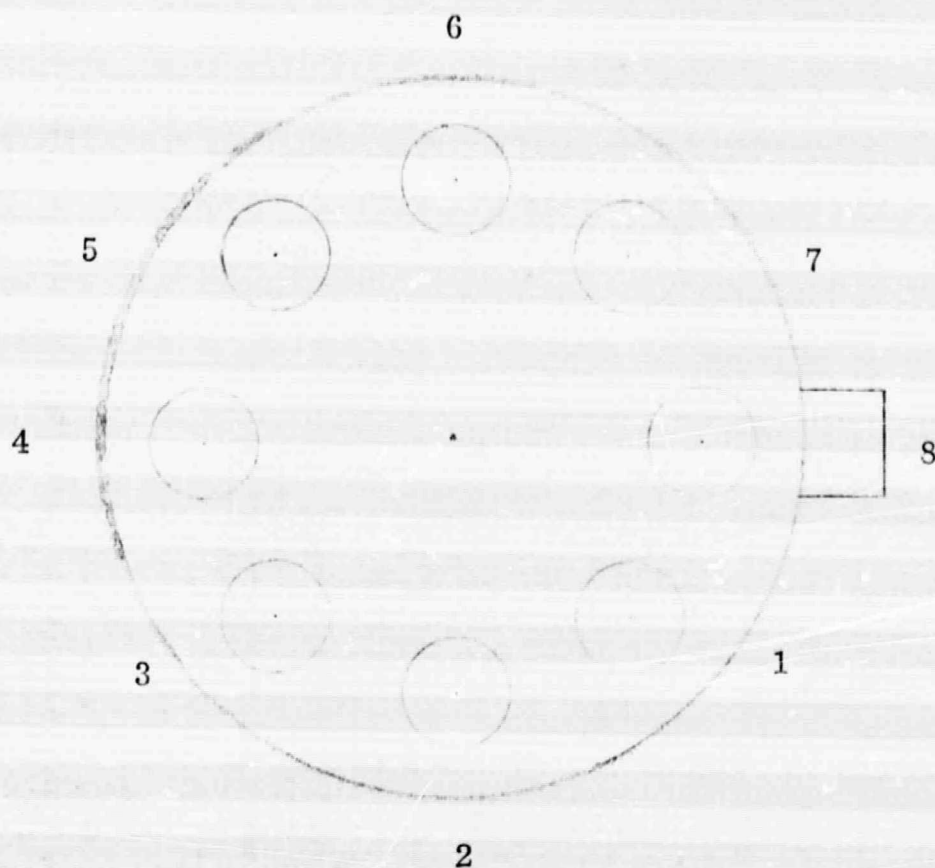
APPROVED

SCALE

WEIGHT

SHEET

INVERTING BUFFER  
SD 5615-1



BOTTOM VIEW

| <u>PIN #</u> | <u>SCL 5615-1</u> | <u>SCL 5615-2</u> | <u>SCL 5615-3</u> |
|--------------|-------------------|-------------------|-------------------|
| 1            | INPUT             | +V                | +V                |
| 2            | +V                | -----             | -----             |
| 3            | -----             | OUTPUT            | DATA              |
| 4            | OUTPUT            | -----             | -----             |
| 5            | -----             | WRITE             | WRITE             |
| 6            | -----             | DATA              | -V                |
| 7            | -V                | -----             | -----             |
| 8            | -----             | -V                | OUTPUT            |

FIGURE #6

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.

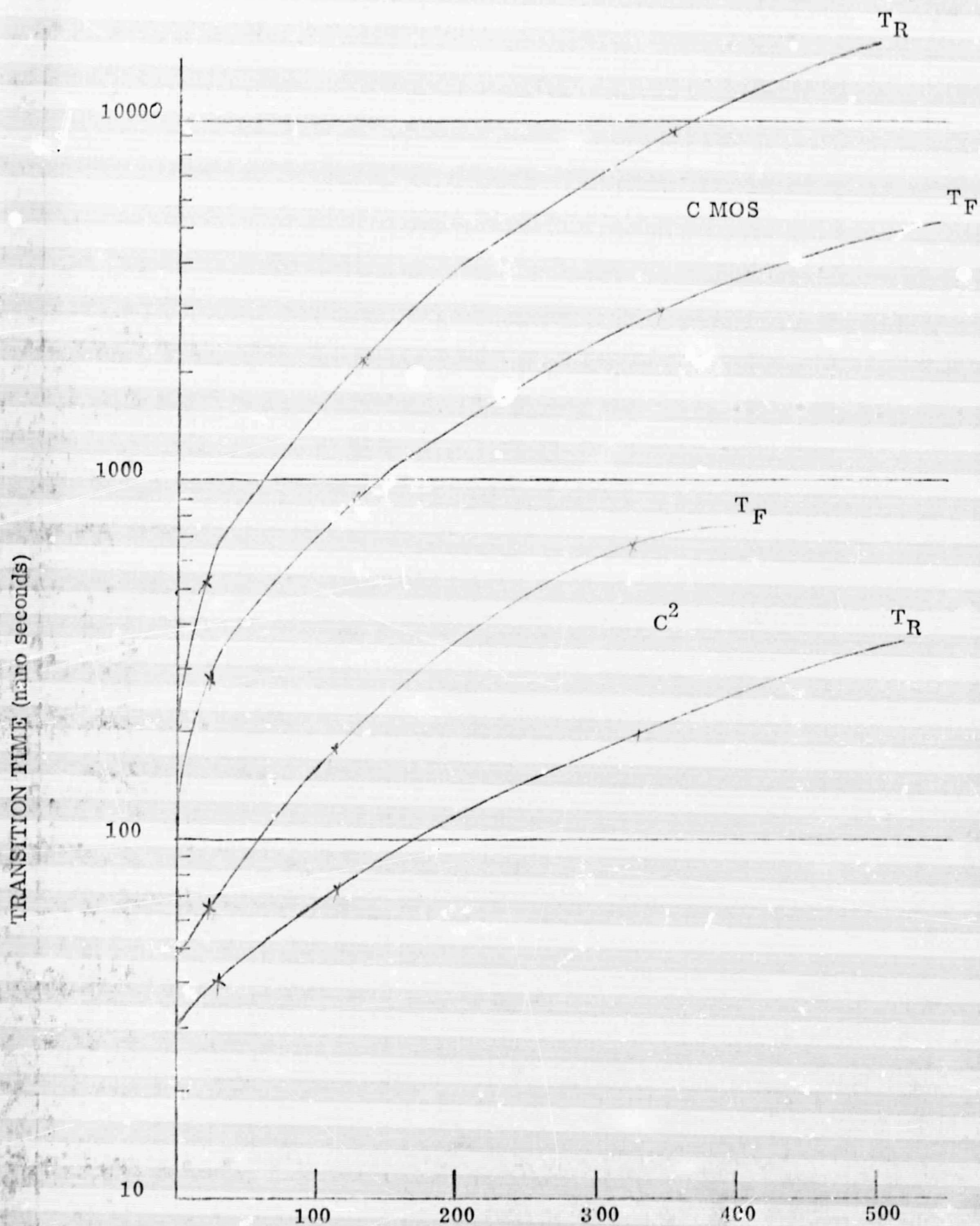


FIGURE #7

$C_L$  (pico farads)

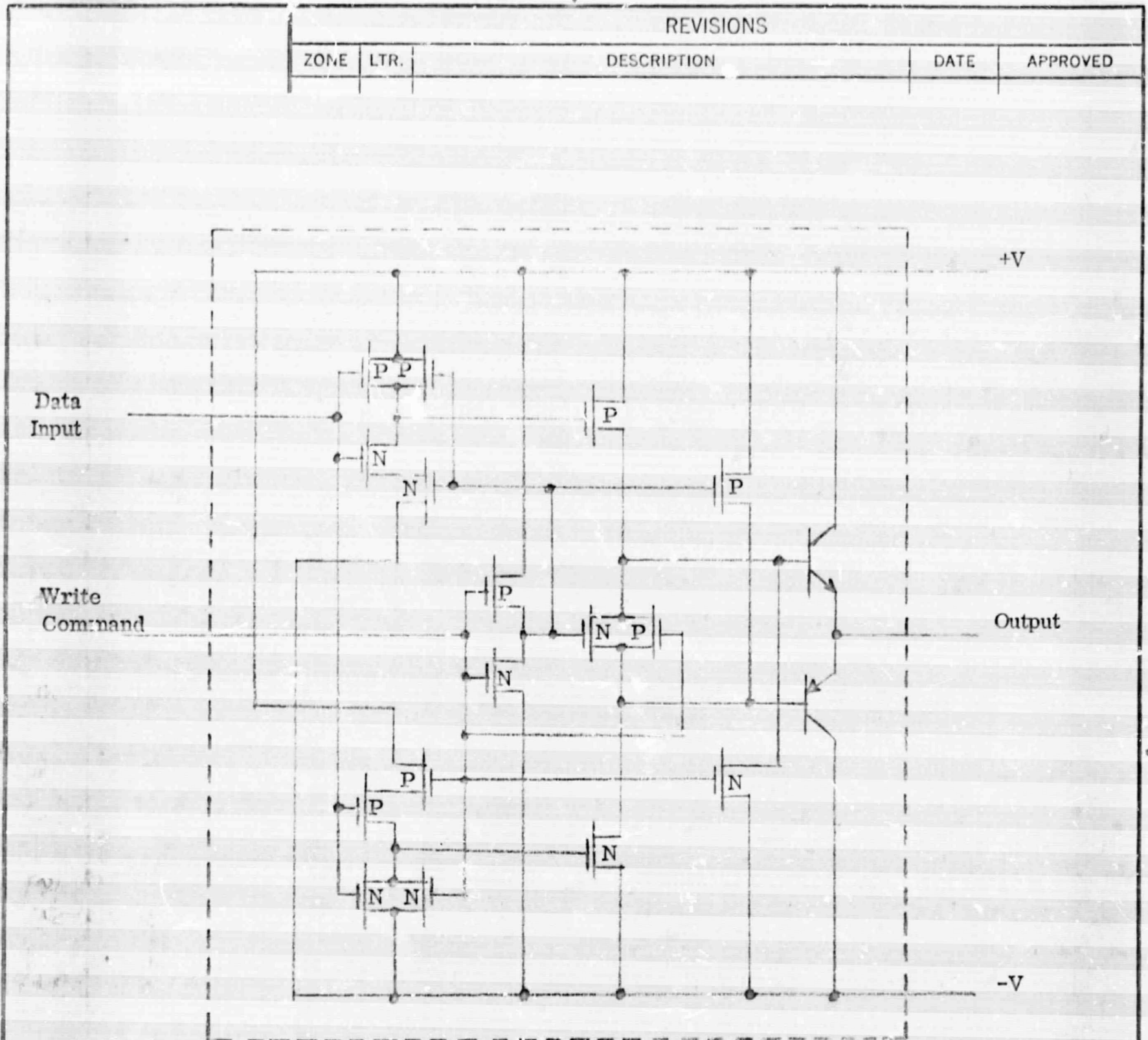


FIGURE #3

|                                                                                                |          |      |                                                                            |                                                    |       |  |
|------------------------------------------------------------------------------------------------|----------|------|----------------------------------------------------------------------------|----------------------------------------------------|-------|--|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAWN    | DATE | <b>SOLID STATE SCIENTIFIC CORP.</b><br>MONTGOMERYVILLE, PENNSYLVANIA 10936 | IMPROVED READ/WRITE OUTPUT BUFFER<br>WITH PULL-UPS |       |  |
|                                                                                                | CHECKED  |      |                                                                            |                                                    |       |  |
|                                                                                                | APPROVED |      |                                                                            |                                                    |       |  |
|                                                                                                | MATERIAL |      |                                                                            |                                                    |       |  |
|                                                                                                | APPROVED |      | SIZE                                                                       | CODE IDENT NO.                                     |       |  |
|                                                                                                | APPROVED |      | A                                                                          |                                                    |       |  |
|                                                                                                |          |      | SCALE                                                                      | WEIGHT                                             | SHEET |  |

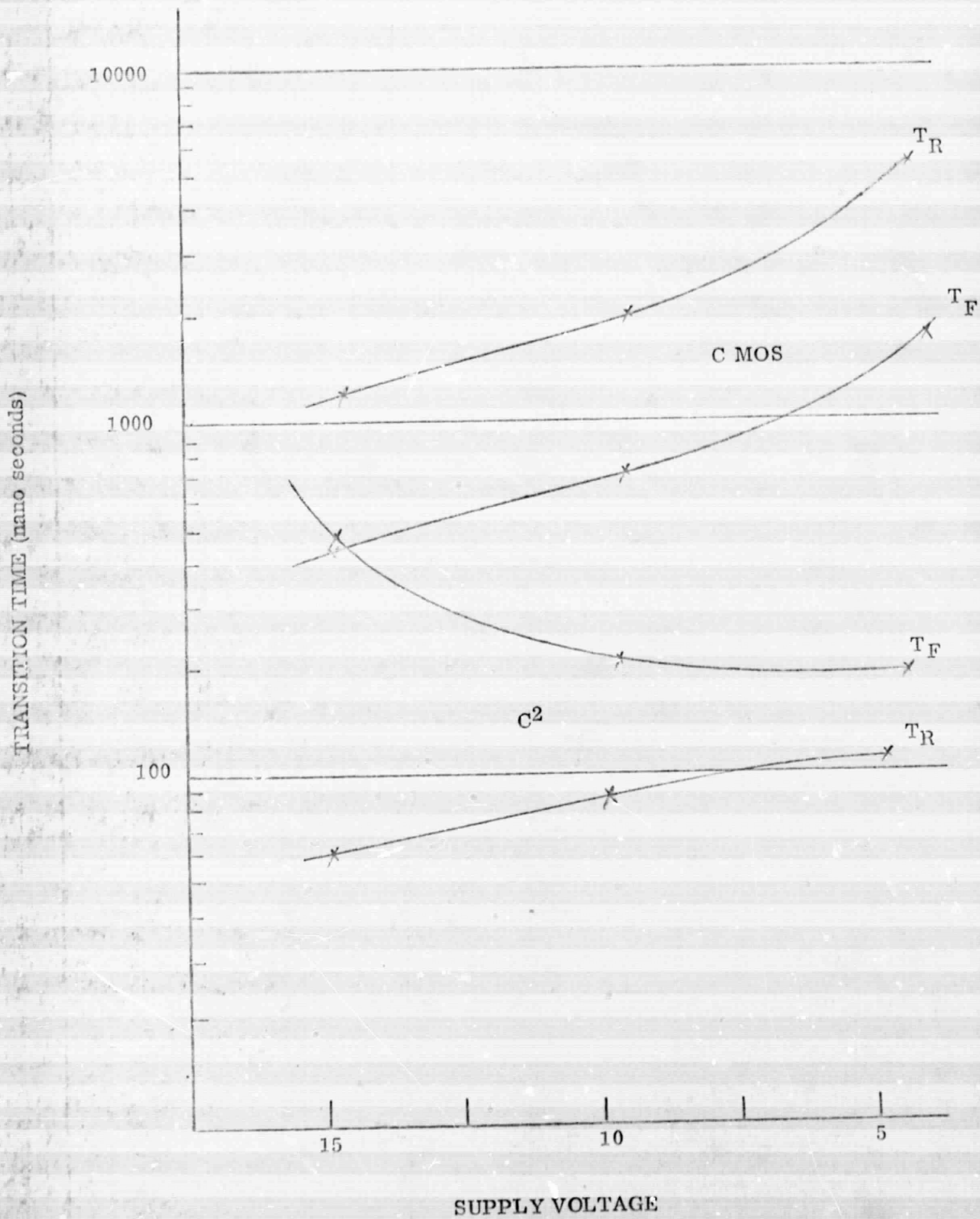


FIGURE #9

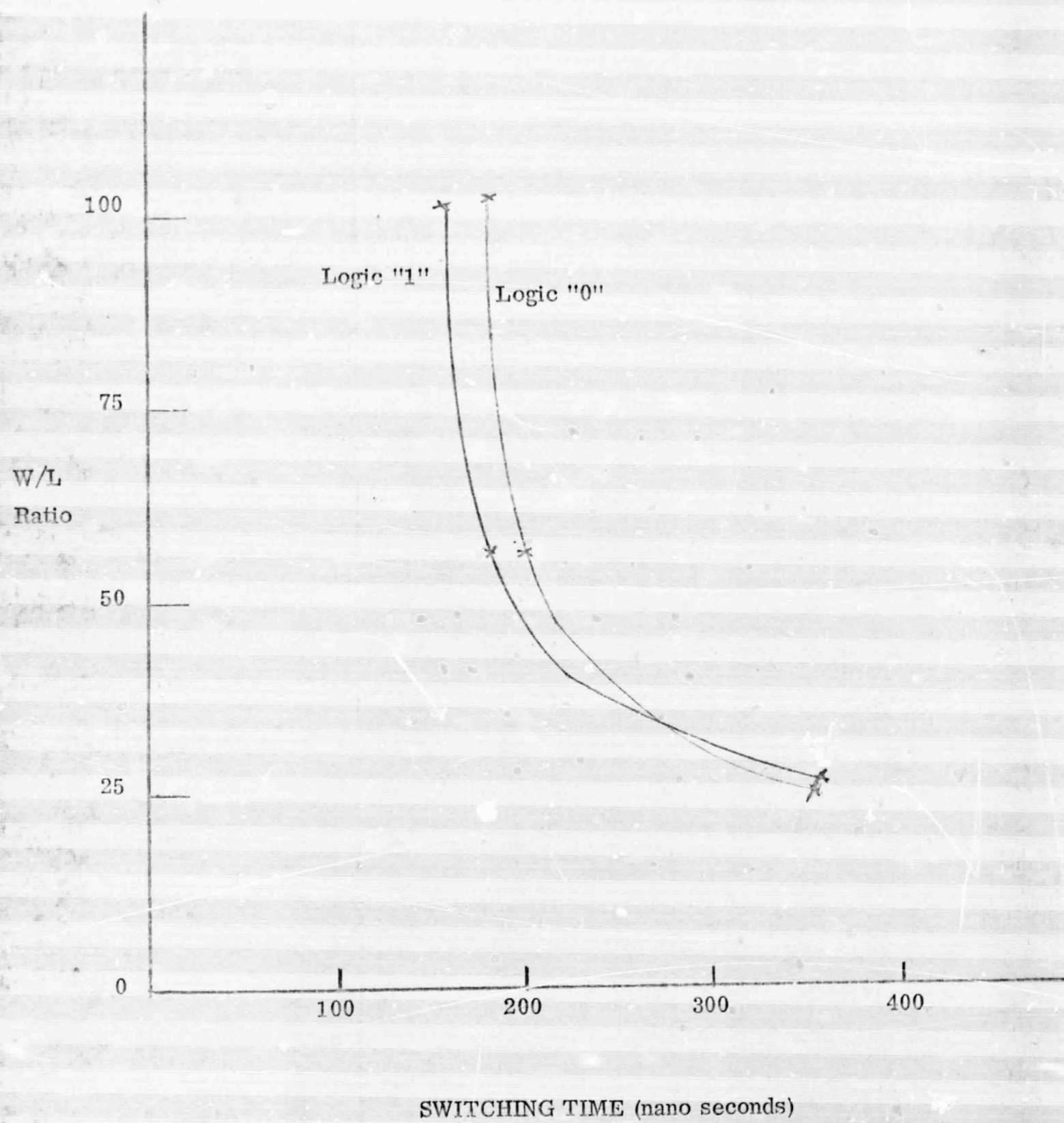


FIGURE # 10

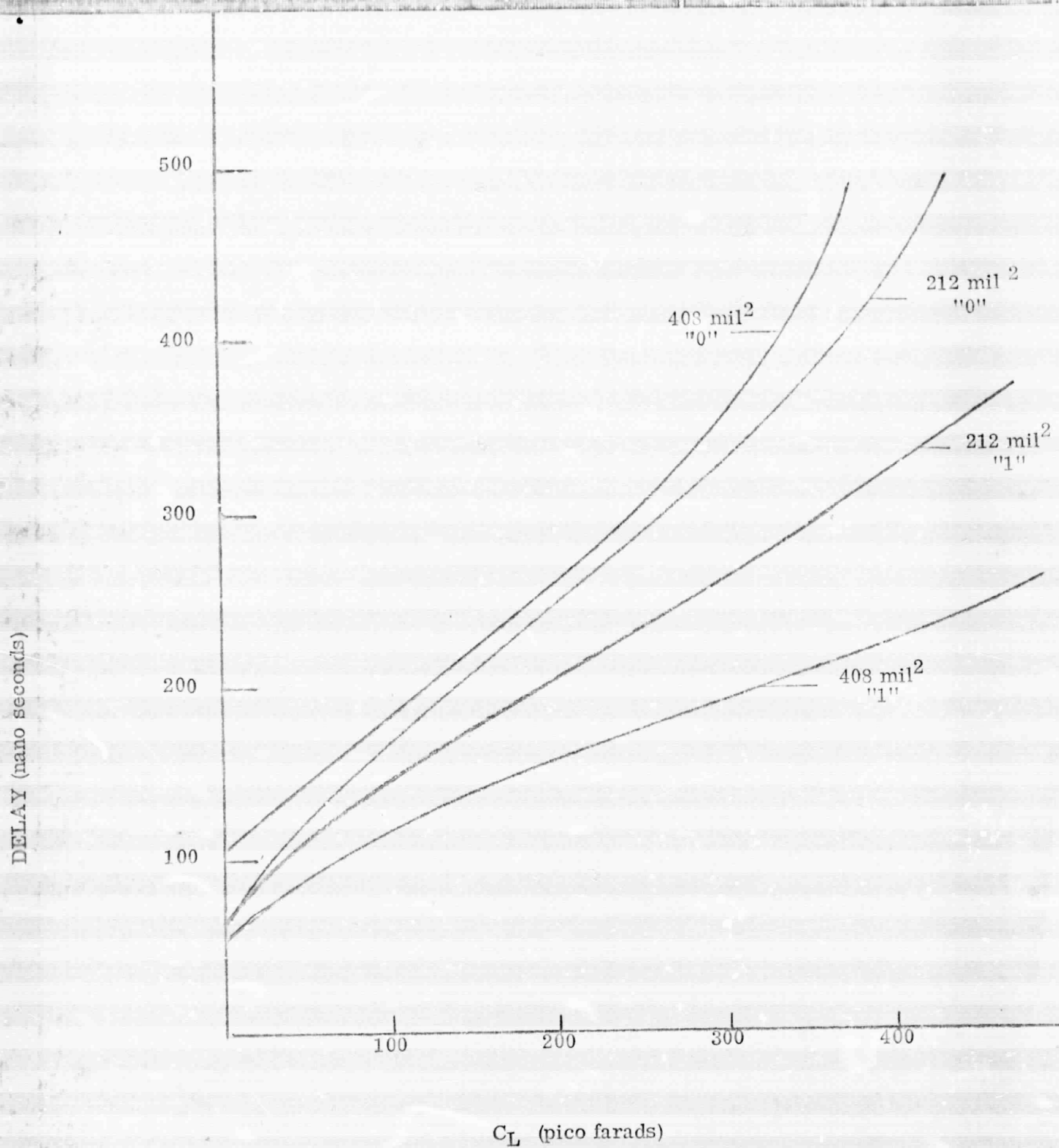
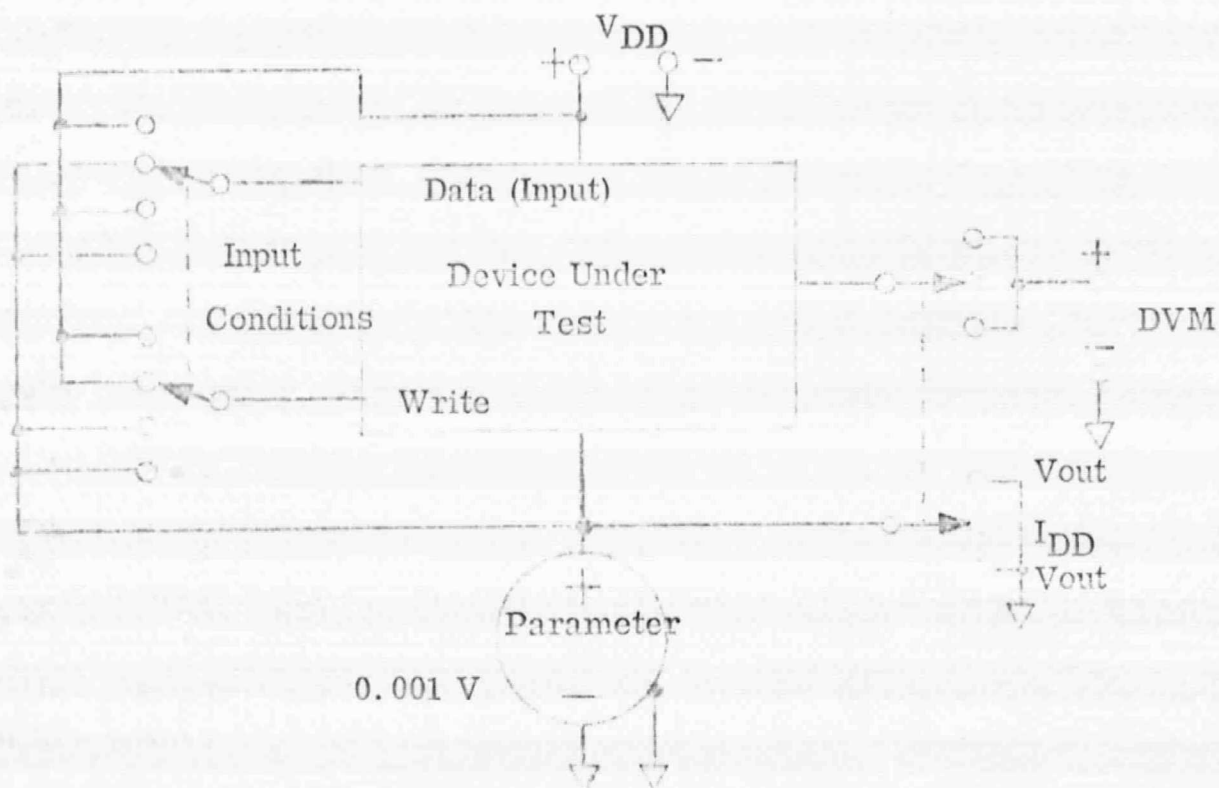
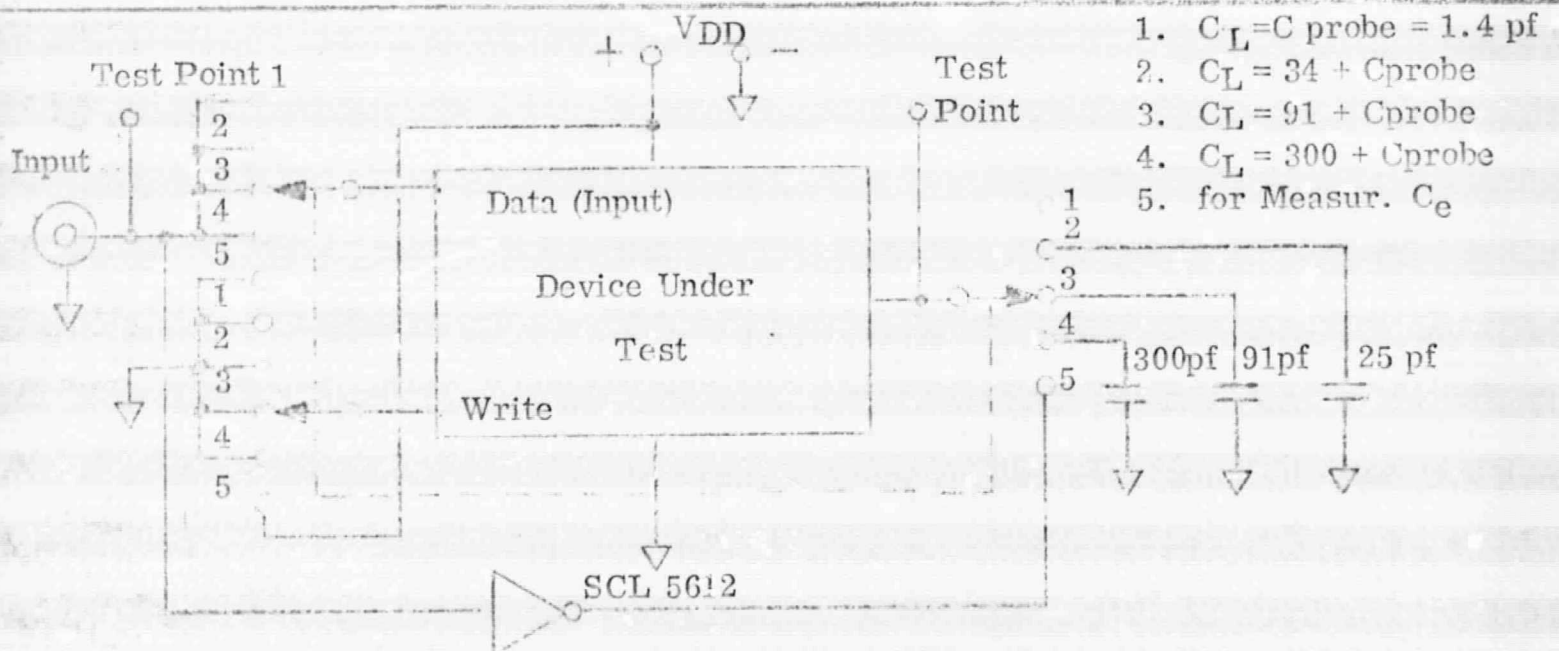


FIGURE # 11

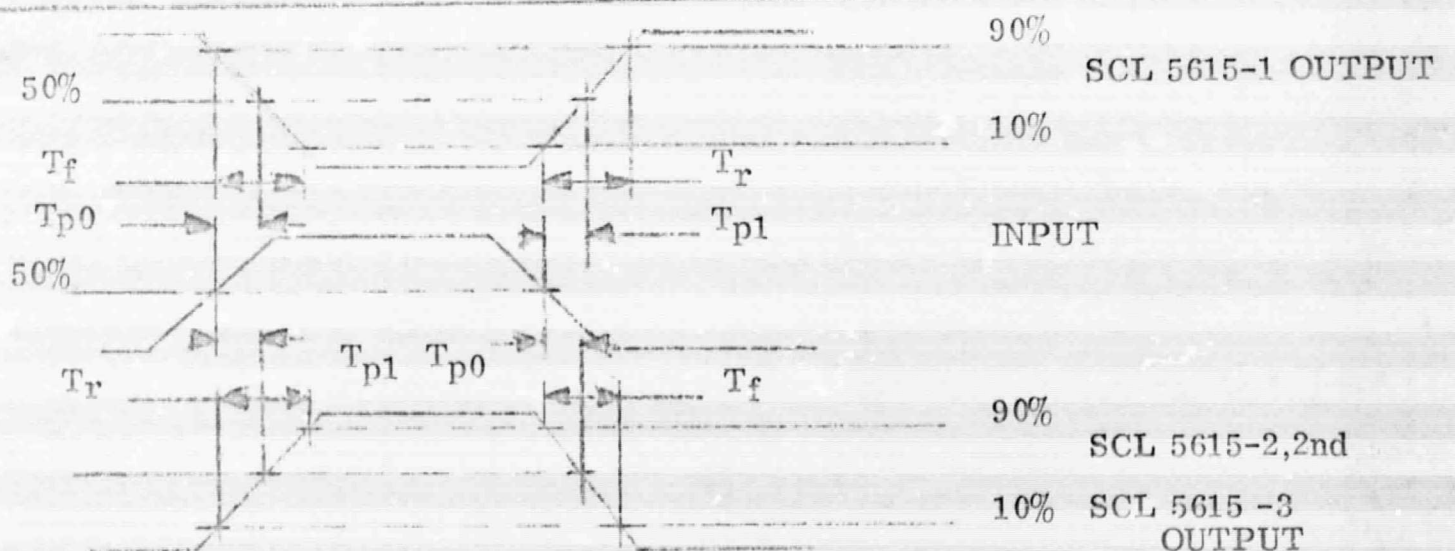
REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.



STATIC TEST SET



DYNAMIC TEST SET



TYPICAL DYNAMIC WAVEFORMS

FIGURE #12