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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

INTEGRATED CIRCUIT SWITCHING DESIGN FOR A 1280-LAMP MATRIX

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ABSTRACT

This report describes the manner in which digital integrated circuits and silicon-controlled rectifiers are used to control and switch the currents through selected lamps of a 1280-lamp matrix that was chosen by the National Design Council of Canada as one of the items in a traveling display.

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INTEGRATED-CIRCUIT SWITCHING DESIGN

FOR A 1280-LAMP MATRIX

- T.H. Shepertycki -

INTRODUCTION

One of the items selected by the National Design Council of Canada for a traveling display is a 1280-lamp matrix, Plate I, which was built by the Radio and Electrical Engineering Division in 1963 for checking the wired program boards that are used for pre-launch ground control of rocket instrumentation [1]. To highlight the aesthetic appearance of the display, the lamps were to be switched on and off according to a 56-step program, Fig. 1, suggested by the National Design Council.

This report describes the basic switching circuitry in sufficient detail to permit diagnosis and repair of faults.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
A	1		45		45																				46		46												46	
B																																								
C	1		3		3		5																46		46		46		46										46	
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N										45																										42				
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P										45																										43				
Q						29			45	15		17		17		19		20		20		23		46		46									43			36	36
R										45																													
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T										45																													
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V										45																													
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X										45																													
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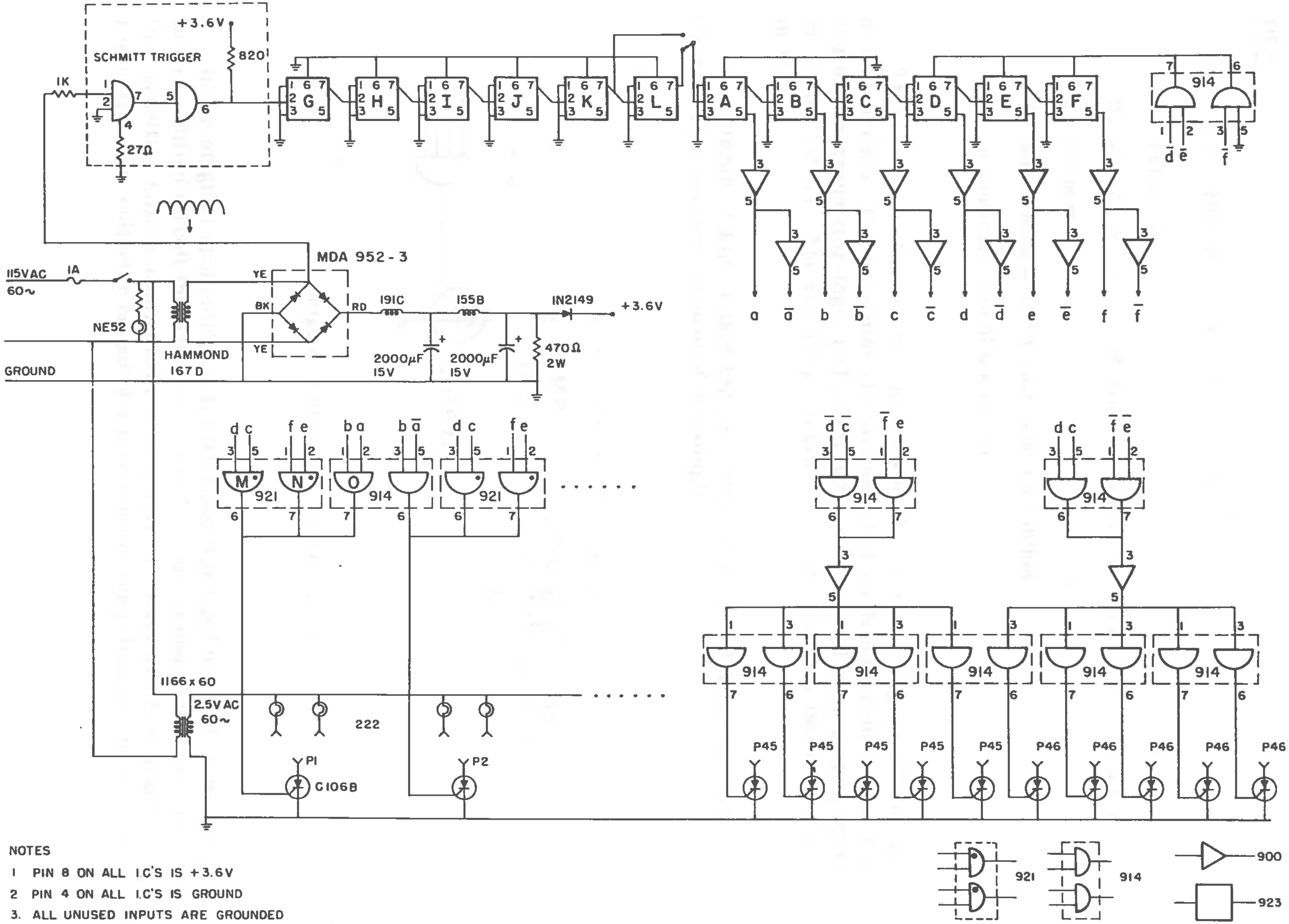
AD	28		28							45	44																											46	
AE										45															45		45													
AF											44												33		33		35		35										46	

Fig. 1 Switching pattern for lamp matrix



NOTES

1 PIN 8 ON ALL I.C'S IS +3.6V

2 PIN 4 ON ALL I.C'S IS GROUND

3. ALL UNUSED INPUTS ARE GROUNDED

4. ALL INTEGRATED CIRCUITS ARE FAIRCHILD MICROLOGIC 900 SERIES

Fig. 2 Diagram of switching circuitry for lamp display

DESIGN

The five major design objectives were

1. reliability
2. simplicity; i.e., minimum modification to existing circuitry
3. economy
4. small size — to fit into existing cabinet
5. acoustically silent operation

These requirements were best satisfied by the use of digital silicon integrated circuits; the particular circuits selected are from a commercial line of resistor-transistor-logic (RTL) circuits encapsulated in an epoxy package (modified TO-5). The resulting integrated circuit switching design is shown in Fig. 2.

The circuit of Fig. 3 used for switching the current through the lamps is of particular interest because of its simplicity.

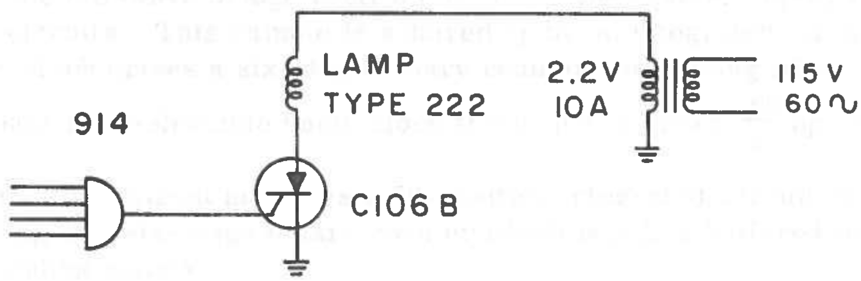


Fig. 3 Current switching circuit

In the original application, a transformer was used to supply lamp current. In the modified circuit this current, from the same transformer, is controlled by a sensitive silicon-controlled rectifier (type C106B) which is triggered directly from the collector output of a gate circuit, operating at a nominal +3.6 V dc.

Since the chosen SCR is capable of switching 2 amperes, it can control the current through eight parallel 250 mA lamps.

The operating life of the lamps used in the matrix is only 5 hours at the rated voltage of 2.2 V and a current of 250 mA. For economical reasons, lamp sockets were not used in the original display; this makes replacement of failed lamps a tedious procedure. This was not a serious problem in the original application since lamps are on for only short periods of time during check-out of program boards. However, this short lifetime is unacceptable for continuous duty operation. Operating them at lower than rated voltage offers considerable increase in lamp life at the expense of illumination intensity. Note that in the chosen circuit, the one-volt drop across the SCR when it is conducting lowers the lamp voltage.

Since the effect of switching on lamp life was unknown, a life test was conducted on six Type 222 lamps. They were divided into three pairs and operated continuously in the circuit of Fig. 3 for a month at switching rates of 1 Hz, 4 Hz, and 8 Hz. No failures were experienced and it was concluded that little trouble should be expected due to premature lamp failure in the display operated at less than 2 Hz for 6 months.

The system clock frequency is derived from the stable line frequency as follows. A rectified sample of the line voltage waveform is obtained from one arm of the full-wave bridge rectifier in the +3.6-V power supply for the integrated circuits. This sample is squared up by an integrated circuit Schmitt trigger which drives a six-stage binary counter comprising flip-flops G-L (Fig. 2). The result is a selectable basic clock frequency of either $\frac{60}{2^6}$ pps or $\frac{60}{2^5}$ pps.

This clock signal advances a 56-position integrated-circuit stepping switch consisting of a six-stage binary counter which supplies buffered timing signals to a decoding matrix.

The decoding matrix consists of 44 six-input and 2 four-input NAND gates. The six-input NAND gates are obtained by using a 4-input expander to increase the fan-in of a 2-input gate. A typical six-input NAND gate is labeled M, N, O in Fig. 2. The SCR gate terminals are driven directly by these units. The state diagram for the stepping switch is shown in Fig. 4. During steps 45-48 and 49-52, it was necessary to switch on 34 and 38 lamps, respectively. To accommodate this number of lamps, eight extra inverters were required to handle the additional SCR's. Note also that the lamps labeled 45 and 46 are on for four clock cycles instead of the normal one. Allowing the six-stage binary counter to cycle through its complete sequence results in a dead-time of 12 seconds at the end of a cycle, during which time all lamps are off.

TIME	f e d c b a	
1	000000	LAMPS LABELLED 1 ON OURING THIS INTERVAL
2	000001	LAMPS LABELLEO 2 ON DURING THIS INTERVAL
3	000010	" 3 "
4	000011	" 4 "
5	000100	
6	000101	
7	000110	
8	000111	
9	001000	
10	001001	
11	001010	
12	001011	
13	001100	
14	001101	
15	001110	
16	001111	
17	010000	
18	010001	
19	010010	
20	010011	
21	010100	
22	010101	
23	010110	
24	010111	
25	011000	
26	011001	
27	011010	
28	011011	
29	011100	
30	011101	
31	011110	
32	011111	
33	100000	
34	100001	
35	100010	
36	100011	
37	100100	
38	100101	
39	100110	
40	100111	
41	101000	
42	101001	
43	101010	
44	101011	
45	101100	LAMPS LABELLED 45 ON DURING THIS INTERVAL
46	101101	
47	101110	
48	101111	
49	110000	LAMPS LABELLED 46 ON DURING THIS INTERVAL
50	110001	
51	110010	
52	110011	
53	110100	
54	110101	ALL LAMPS OFF
55	110110	
56	110111	
57	111000	RESET TO 0 POSITION

Fig. 4 Decoding sequence

This was decreased to 4 seconds by presetting flip-flops D, E, and F at the beginning of step 57. This is adequate to provide a definite starting point for the cycle.

A total of 101 integrated circuits and 54 SCR's were used in the design. The circuits are mounted on seven identical printed-circuit boards, one of which is shown in Plate II. The SCR's are mounted on an aluminum strip for heat sinking, which, along with the +3.6 V power supply, is secured behind the pin-jack panel shown in Fig. 5.

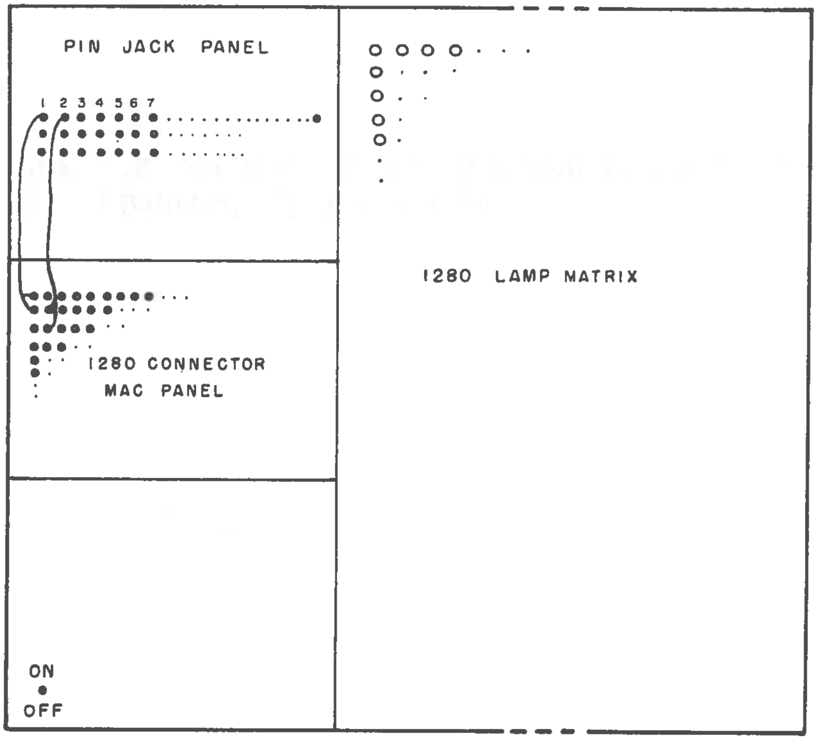


Fig. 5 Front view of display board

The anode of every SCR is brought out to a pin on the pin-jack panel while one terminal of each lamp is brought out to a pin on a patch-panel. By using wire jumpers between these two panels, any group of eight or fewer lamps can be turned on during any step in the cycle. During steps 45-48 and 49-52, any group of 40 or fewer lamps can be switched on. Should any lamp fail in service, it can be programmed out of the sequence easily by changing the interconnections between the pin-jack and the patch-panels.

CONCLUSIONS

This report has described the switching circuitry designed for controlling a 1280-lamp matrix that is part of a rocket instrumentation check-out board which was one of the items selected by the National Design Council of Canada for a traveling display. Switching of the relatively large lamp currents involved was simply and economically achieved by using digital integrated circuits to control sensitive silicon-controlled rectifiers.

ACKNOWLEDGMENTS

The author would like to express his gratitude to Mr. Frank Cairns for many helpful discussions and to Mr. G. Gibson who wired the circuitry.

REFERENCE

1. D.H. O'Hara, A.K. Scrivens. A control console for check-out of sounding rockets. REED Bulletin, 13(3): 1-4; 1963

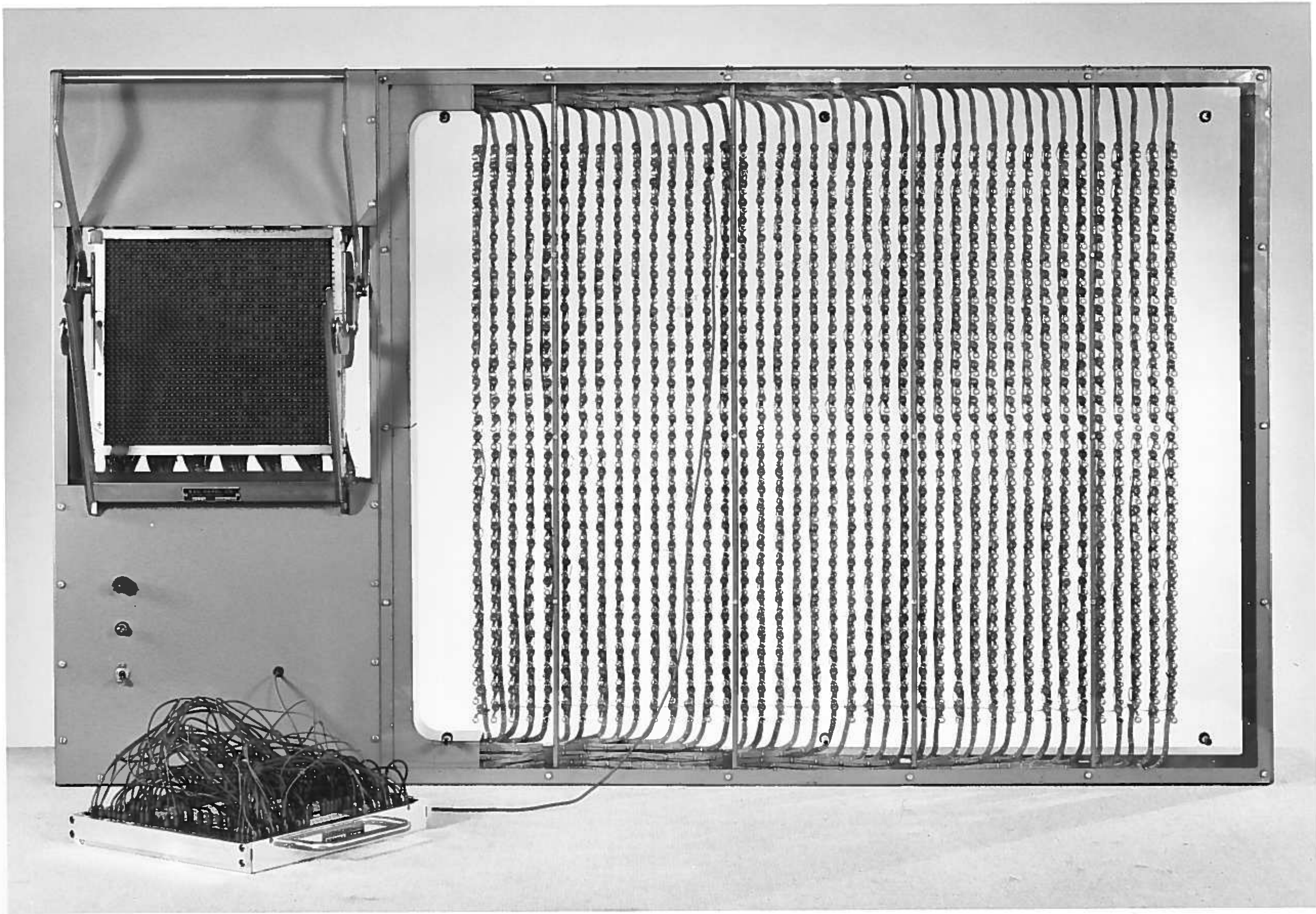


Plate I 1280-lamp matrix with connector panel on the left

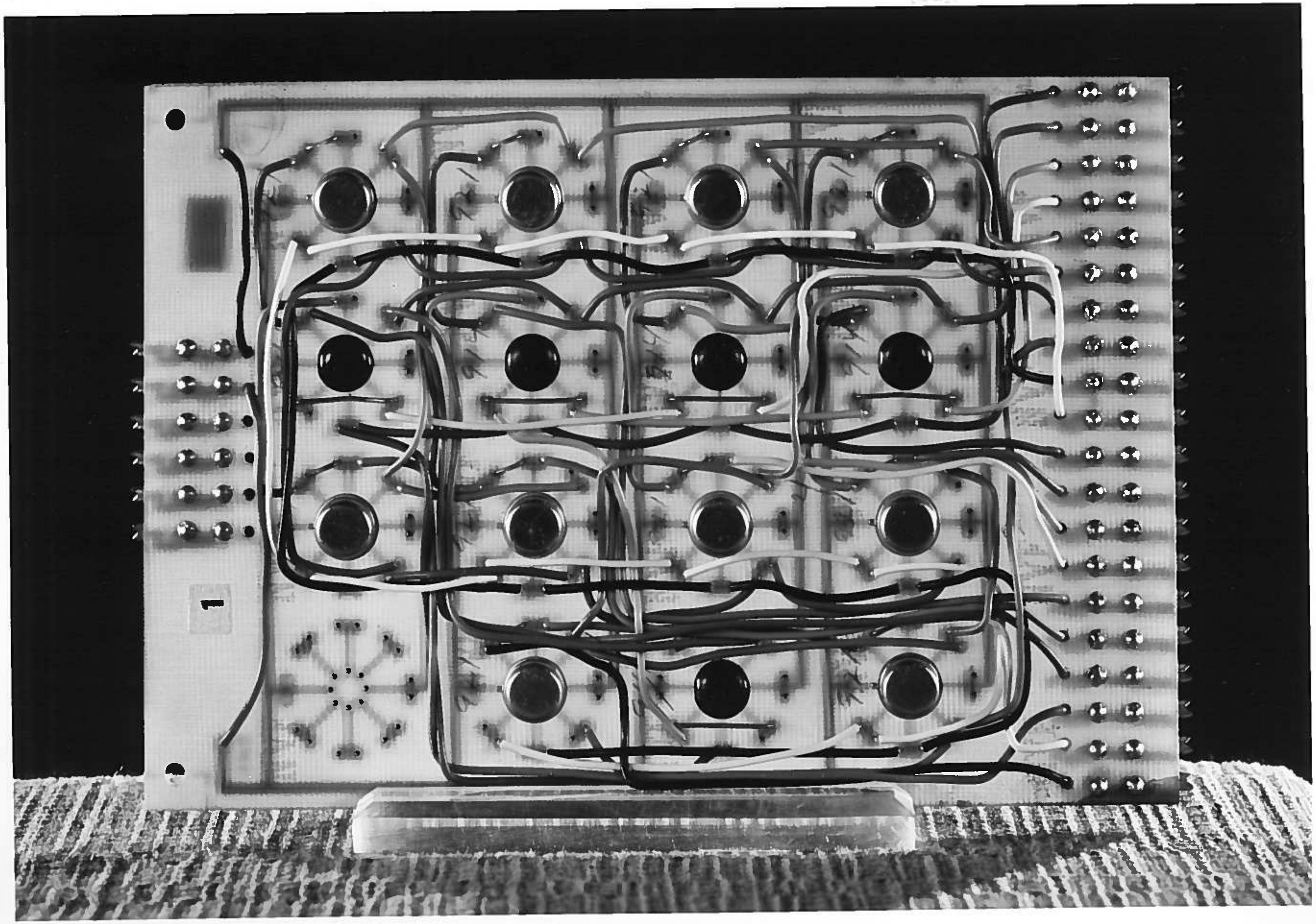


Plate II Typical printed circuit board showing portion of decoding matrix