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SUBJECT: TESTS OF SOME MAGNETIC-MATRIX SWITCH OPERATING MODES

To: N. H. Taylor

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Abstract: There are two independent questions that must be answered when choosing a switch operating mode:

1. Should the "set" and "reset" windings take part in the selection operation?

2. Should the "bias" drivers be gated?

The tube counts indicate the "set" and "reset" windings should not take part in the selection operation. The duty factor requirements on the "bias" driver indicate the "bias" drivers should be gated. The experimental results obtained from two different operating modes show that the tube count should determine the operating mode.

Introduction

The magnetic matrix switch is being considered as a device to select and drive the "selection" planes in a magnetic-core memory, its main advantage being that it greatly reduces the number of tubes and other components required in a memory-address selection system. This advantage stems from the fact that the magnetic-matrix switch performs two jobs: it translates the address from the base 2 to the selection-coordinate base and it drives the memory selection planes with the desired current pulses. The fact that the switch is a dual-purpose device enables us to make tremendous savings in equipment over systems that use separate translators and drivers. For example a system using a crystal-matrix translator and vacuum-tube drivers requires 564 tubes and 768 crystals to operate a 4096-register memory, while a magnetic-matrix switch system requires only 104 tubes and 128 switch cores to drive the same memory.

A "n" position magnetic-matrix switch is made up of "n" magnetic cores threaded with three types of windings as shown in Fig. 1. There are a number of "bias" windings which, when excited, select the desired core by biasing off all but the selected core. In addition, there is a "set" winding and a "reset" winding; driving the set winding switches the selected core and causes this core to produce a voltage pulse; driving the "reset" winding resets the selected core to its original state.

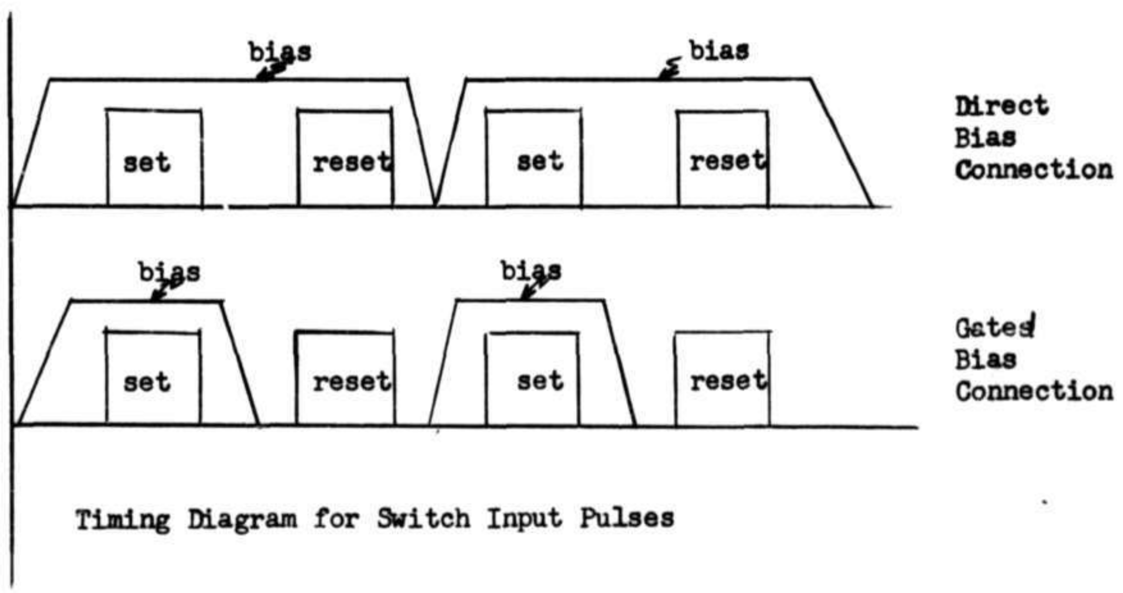
There are many different modes in which a magnetic matrix switch can operate; however, in this note only a few of these modes will be considered. In the discussion of the modes of operation, two independent questions arise:

1. Should the "set" and "reset" windings take part in the selection of the core?

The "set" and "reset" winding configurations can be arranged so that the only function of these windings is driving the selected core (the selection operation is performed by the "bias" windings), or the winding configuration can be arranged so that these windings not only drive the selected core, but also take part in its selection.

2. Should the "bias" drivers be gated?

The "bias" drivers can be connected directly to the outputs of the address flip-flops, or gate tubes may be interposed between the flip-flops and the drivers. By adding the gate tubes the duty cycle of the "bias" drivers can be reduced. A timing diagram showing the switch input pulse sequence for the two types of "bias" driver operations is shown below.



Timing Diagram for Switch Input Pulses

Description of Operating Modes

In the first mode of operation to be considered the switch has a "set" winding, a "reset" winding, and a full set of "bias" windings as shown in Fig. 1. The "set" and "reset" windings pass through all the cores and do not take part in the selection of the desired switch core.

In the second mode of operation the switch has two "set" windings, (which now take part in the selection process), a "reset" winding, and a set of "bias" windings minus two as shown in Fig. 2. Each "set" winding goes through half the cores, and the high-order selection is done by pulsing only one of the "set" windings. The highest-order address flip-flop determines which "set" winding is pulsed. The "reset" winding is the same as the previous case.

In the third mode of operation the switch has a "set" winding, and a full set of "bias" windings, as shown in Fig. 3. The "set" winding goes through all the cores and does not do any of the selection. One pair of "bias" windings does double duty, that is they supply both the "bias" and the "reset" pulse to the memory. This is possible because there is only one core in the switch that has to be reset. This core is always on the "bias" winding that is connected to the nonselected side of the flip-flop; in other words, the core is on the one of a pair of "bias" windings that was not driven during the set operation.

In the fourth mode of operation the switch has two "set" windings and a full set of "bias" windings minus two as shown in Fig. 4. The "set" operation is the same as in system number 2 and "reset" operation is the same as in the system number 3, described above.

The "bias" drivers can be connected directly to the memory-address flip-flops or they can be gated with any of the four above-mentioned systems. If the "bias" drivers are connected directly to the flip-flops the drivers must be able to operate at a 100% duty cycle; but, if gate tubes are interposed, the duty cycle can be reduced, and as a result the driver-tube specifications can be relaxed.

Estimated Tube Counts

The tube and winding counts shown in Fig. 5 are made on the following assumptions:

1. The gate tubes are independent units and are counted as such.
2. The "bias" winding drivers would be made up of two tubes, a buffer amplifier and a driver.
3. The "set" and "reset" drivers would be made up of 7 tubes, a 6-tube buffer amplifier and a driver tube. The large number of tubes is necessary for pulse shaping and current regulation.

After looking at Fig. 5, it is clear that no saving in the number of driving tubes is made by using one of the more sophisticated driving systems. The only saving is in the number of windings on the switch core, the maximum saving being two windings. The gates added between the address flip-flops and the "bias" drivers increase the total number of tubes required, but on the other hand, the duty cycle of the "bias" driving tubes will be reduced from 100% to about 50%.

Test Results

Memory Test Setup IV was built up so that a switch could be tested under two different modes of operation. The system consisted of two 16-position magnetic-matrix switches made up of MF 1118, F262 cores which drove a 256-register, 2-digit memory made up of MF 1326 B, F291 cores. Each switch selected and drove the "selection" planes along one co-ordinate axis. This switch was set up so that it could be operated with one "set" and one "reset" winding with the "bias" drivers connected directly to the flip-flops as shown in Fig. 1, or it could be operated with two "set" windings and combined "bias" and "reset" windings, with gate tubes controlling the "bias" drivers as shown in Fig. 4. The switch was driven with similar driving functions for both modes of operation, and every effort was made to keep the conditions similar for both modes of operation.

The first test made was a comparison of the selected and non-selected outputs of the switch core under the two different modes of switch-core operation. There was very little difference in the output pulse shapes from the selected switch core when the operation mode was changed. The slight differences could be attributed to the fact that the driver was working into different impedances depending on whether the driving winding passed through all the switch cores or one-half the cores. The outputs from the non-selected cores showed very little difference for the two modes. In both cases the largest non-selected output was about 9% of the selected output. As a whole, the non-selected outputs of the system shown in Fig. 1 were slightly smaller than those of the other system, but the difference was very small and could very well be attributed to measurement errors.

Various patterns were placed in the memory planes and the spreads of the outputs from the memory were compared under the two modes of switch operation. The outputs were observed with all "one"s in the memory, with all "zero"s in the memory, and with the "pairs checkerboard" pattern in the memory. The spreads were approximately the same for the three patterns for both operating modes. The post-write disturb pulse was removed and the output with the "pairs checkerboard" pattern in the memory was observed. Here again, no difference was detected in the output spread from the memory when the driving mode was changed. The effect of load changes on the output of the switch core was very small and did not change when the mode of operation changed. The test data was documented by R. S. DiNolfo in notebook #2.

Conclusions

To minimize the number of tubes required to operate the switch, there should be one "set" winding, one "reset" winding, and a full set of "bias" windings. The "bias" drivers should probably be gated in spite of the fact that the gated system used 12 gate tubes that are not needed in the direct-connected systems; this allows the driver duty cycle to be reduced by a factor of about one half, a considerable reduction when the driver tube must supply 400 ma.

In the actual operation of the two systems that were tested, we were not able to detect any significant difference in the characteristics of the two systems. The outputs of the switch and the operation of the memory were similar for both modes of operation. As a result, it seems that the winding and tube count should be used to determine the operating mode.

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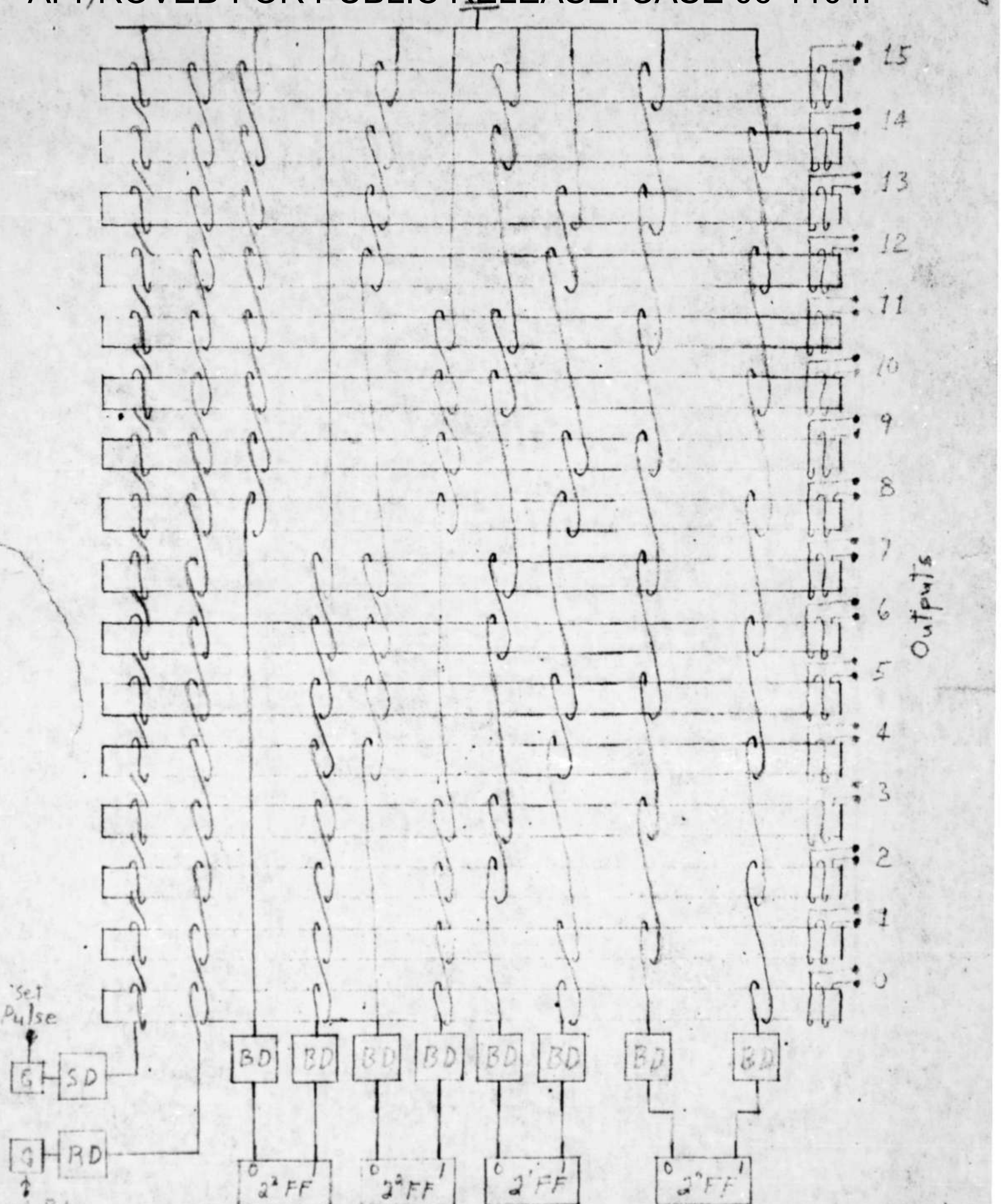
Drawings attached: SA 55290
SA 55291
SA 55292
SA 55293
SA 55294



Magnetic Matrix Switch with One Set and One Reset Winding; Direct Bias Driver Connections

figure 1

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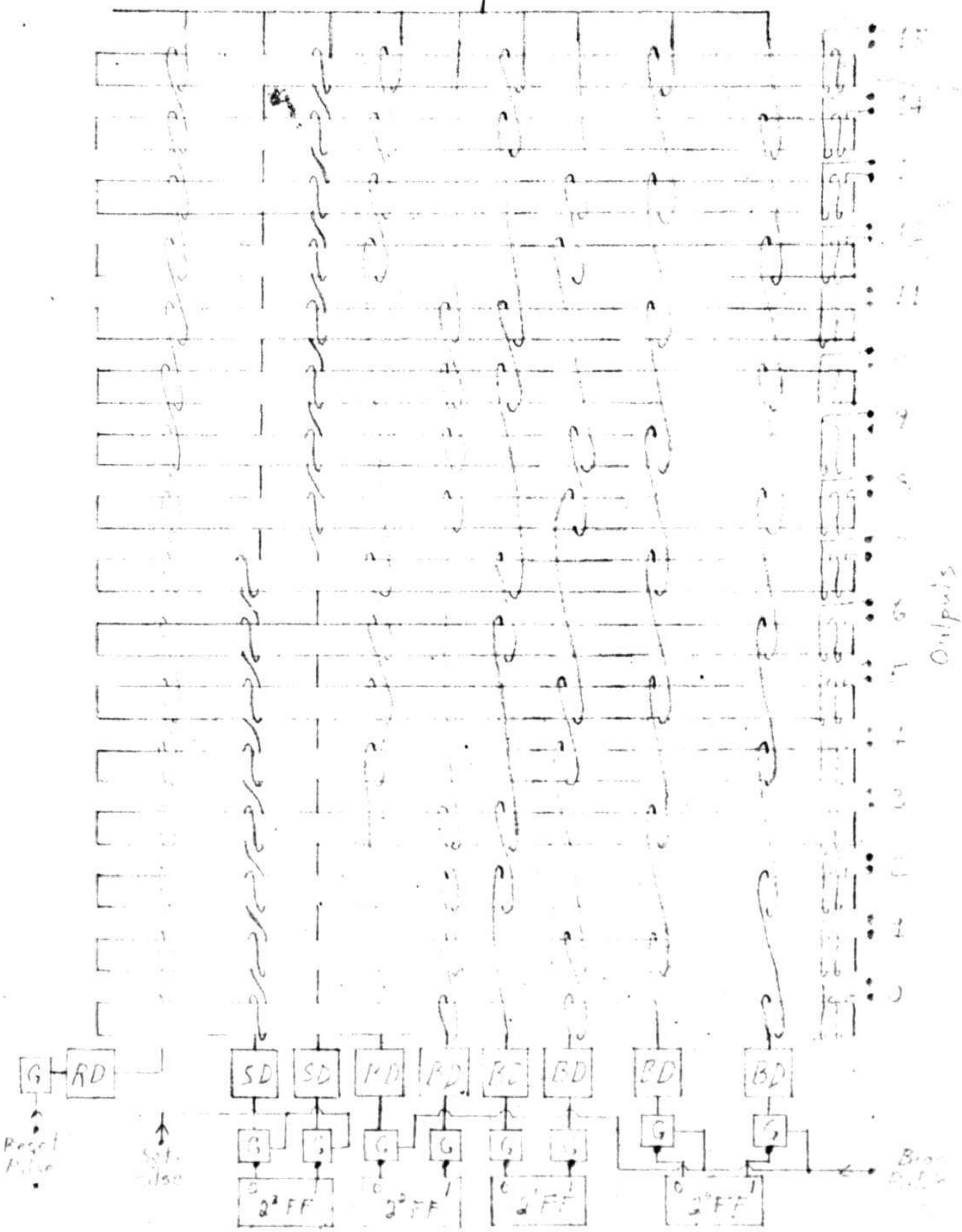

Magnetic Matrix Switch with Two Set and One Reset Winding; Gated Bias Driver Connection

figure #2

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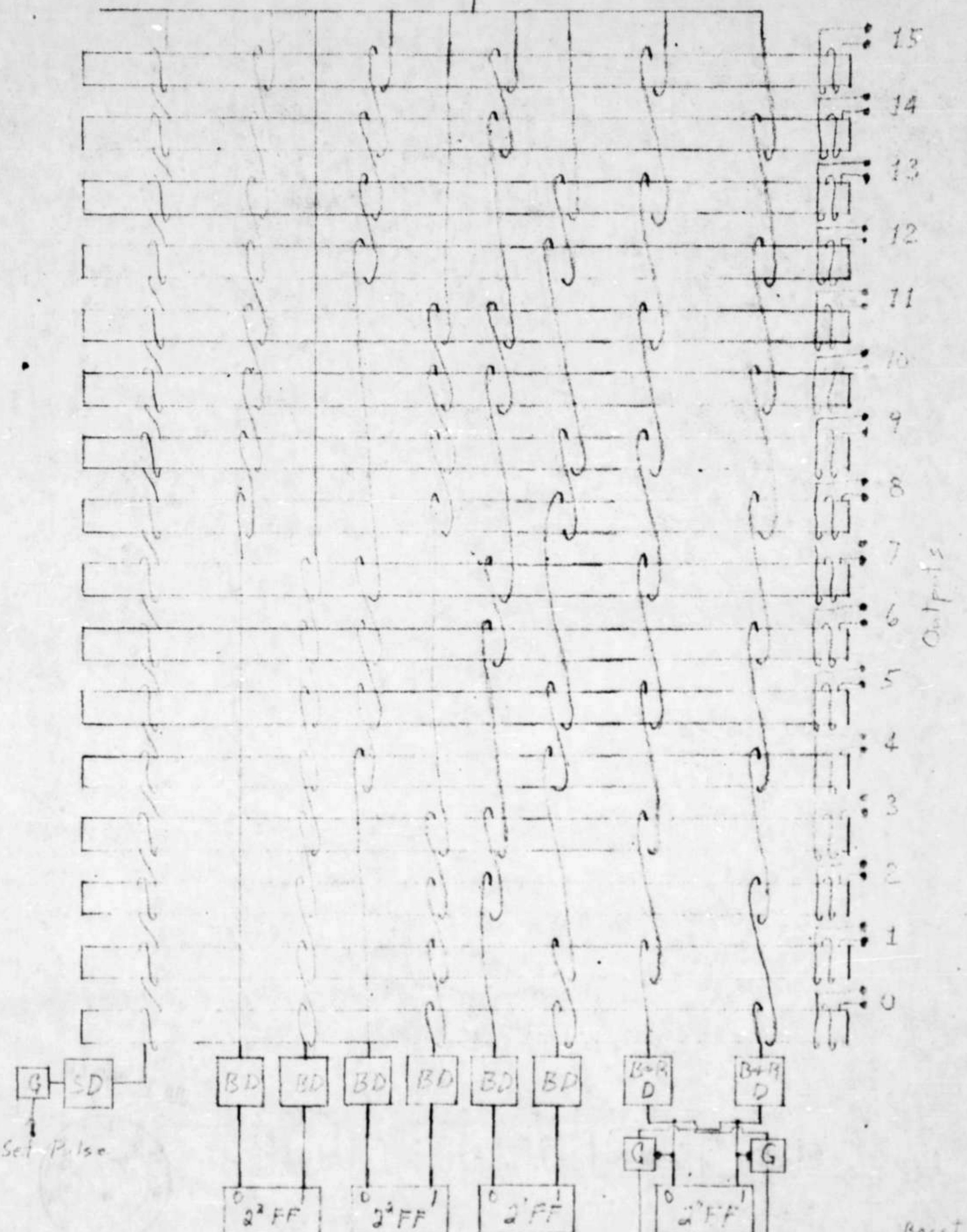
5-21-53



Magnetic Matrix Switch with One Set and Combination Bias and Reset Windings; Reset Bias Driver Connections

Figure #3

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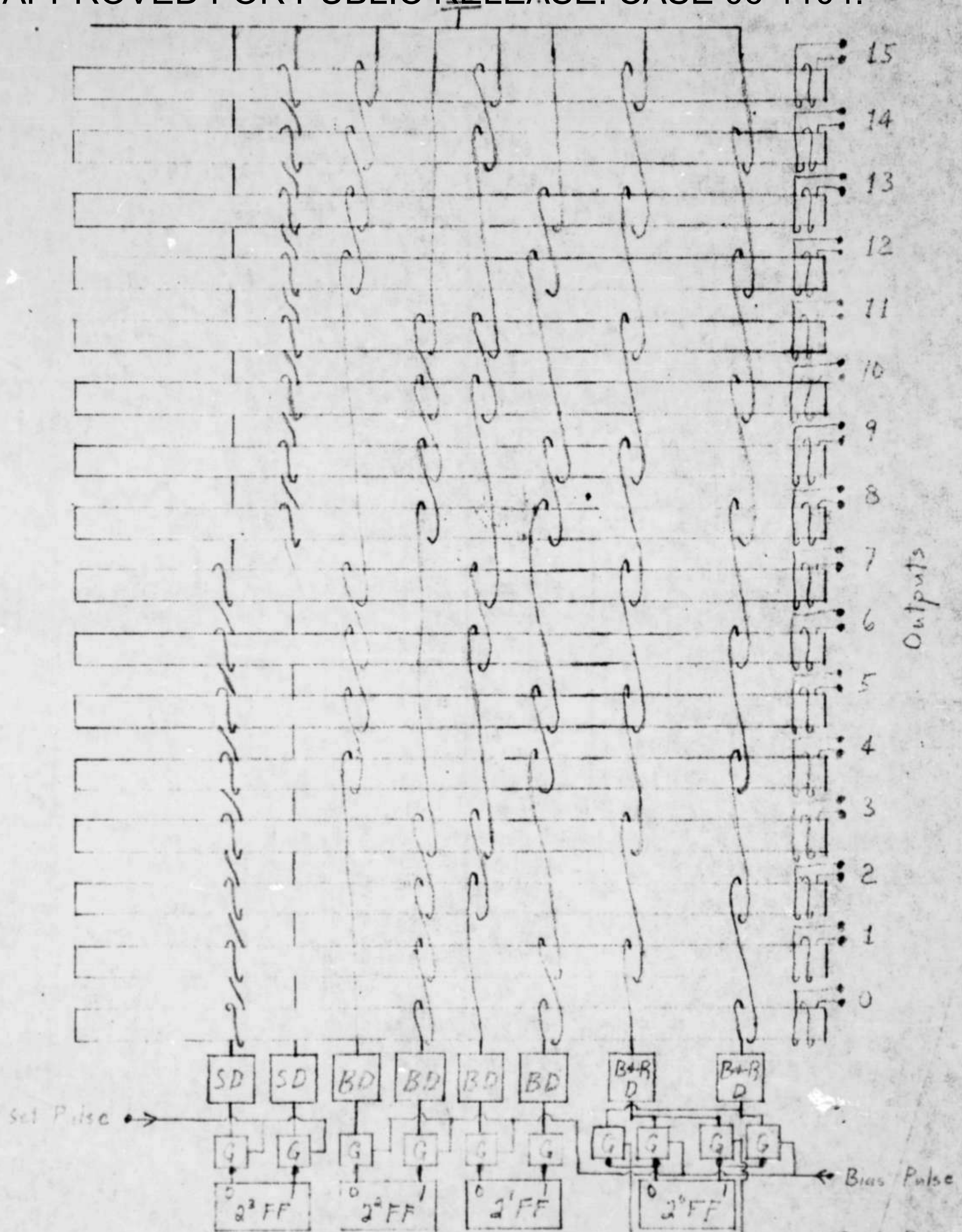

Magnetic Matrix Switch with Two Set Windings and Combination Bias and 'Reset' Windings; Gated Bias Driver Connections

Figure #4

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Winding and Tube Count

for a 64 position magnetic matrix switch
figure #5

Type of Bias Driver Connection to Address Flip-flops	Number of Windings on Each Core				Total Number of Windings on Entire Switch	Tube Count			
	Bias Winding	Set Windings	Reset Windings	Combination Bias and Reset Windings		Bias Driver Tubes	Set & Reset Driver Tubes	Gate Tubes	Total Tubes
direct	6	1	1	-	14	24	14	2	40
direct	5	1	1	-	13	20	21	3	44
direct	5	1		1	13	20	21	3	44
direct	4	1		1	12	16	28	4	48
gated	6	1	1		14	24	14	14	52
gated	5	1	1		13	20	21	13	54
gated	5	1		1	13	20	21	15	56
gated	4	1		1	12	16	28	14	58

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SA 55-94