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DECADE SWITCH FOR
SETTING MAGNETIC CORES

Gerald W. Kinzelman

20 May 1963

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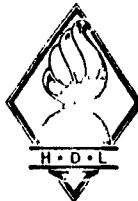
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FOR THE COMMANDER:
Approved by



Robert S. Hoff
Robert S. Hoff
Chief, Laboratory 400

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ABSTRACT

This paper describes the design of a special single-wafer decade switch that is intended to replace a conventional six-wafer 10-position switch for setting magnetic core circuits. The new switch is less than one-third the size of the older design and its reduced complexity makes it potentially more reliable.

1. INTRODUCTION

The Harry Diamond Laboratories has developed a particular design of magnetic core decade counter* for use in electronic timers. This counter reduces the number of wires that must be brought out from the projectile or missile for setting the desired time of flight. The proper interconnection of the setting wires requires six wafers in a conventional 10-position switch. This paper describes the design of a single-wafer switch which will perform all the required functions of the six-wafer switch. The new switch has a volume less than one-third that of the six-wafer design. Since the interconnections are made by the use of printed wiring rather than by many wire interconnections, the new switch is potentially more reliable.

Figure 1 shows the coils of the decade counter and the required direction of (momentary) current flow to set any core from 0 to 9. For example, to set core 7, terminals A and D must be connected, C and X1, X2 and G, and F and B. When the switch makes these interconnections, the current entering at terminal A will pass in the proper direction through the two coils (marked with the digit 7) now connected in series, and out through B. This switching can be accomplished for all 10 digits with a 10-position 4-wafer switch.

These switches will be used in groups with series connections of the decade counters to provide counts up to 999. Another requirement of the switch is to prevent the setting of a number smaller than 200 or larger than 919. An electrical interlock circuit that will provide this limitation is shown in figure 2. Terminals Z and Y of the hundreds switch connect to A and W of the tens switch.

The interlock circuit operates as follows—assume a setting, say 247 (within the allowed range). Setting current enters the hundreds switch at terminal A, passes through the appropriate hundreds cores, comes out at B, then out at Z, into A of the tens switch, through the tens cores, out at B, and into A of the units switch. If the setting is 199 or less, the circuit between B and Z of the hundreds switch is open and no setting current can flow. If the setting is 920 or greater, setting current must come out terminal Y of the hundreds switch, into W of the tens switch, where the circuit is open, and again no setting current can flow.

* HDL Report No. TR-1118, "A Magnetic Decade Demonstrator," Michael J. Katz, 20 May 1963.

One additional wafer on each of these switches and connected as shown will provide the interlock feature. To make both switches identical, two wafers will be required for each switch for the interlock feature. A total of six conventional wafers are thus needed for a complete switch for each digit.

2. SWITCHING CIRCUITS

All switching circuits required for each digit are shown in figure 3. We now desire to provide these circuits with one wafer; this objective has been accomplished by providing 13 fixed brushes--one for each different terminal letter in figure 3--and arranging them as shown in figure 4. The wafer circuit for providing the switching connections is also shown in figure 4. The wafer, which can be placed in any of ten positions, is shown in the position for setting core zero. Note that the digit visible in the switch window is the nine's complement of the core number being set, for reasons explained below. Photographs of the switch are shown in figures 5 and 6.

Figure 7 is a schematic diagram of switch interconnections for setting three decades of magnetic core counters. With the switches and counters connected as shown, the three ring counters can be set to any number from 200 to 919 inclusive, the series circuit being open for any number outside this range. The clear winding in each counter must be part of the circuit. (This winding clears all cores to the "zero" state. It is overridden by the set windings where "ones" must be set into specific cores.) The clear windings are connected in the circuit as shown in figure 7 to minimize the connections that must be brought out to the switching panel. The mode switch provides for the selection of B, L, and T signals discussed below.

3. NINE'S COMPLEMENT

Three decade ring counters can count from 0 to 999 inclusive. Let the output signal occur at count 999. When the three decades are each initially set to 0, 999 input pulses are required for the output signal to occur. For example, if the initial setting is 347, then 652 pulses are required for the output pulse to occur. In this application, the operator wants to set pulses required. This setting can be accomplished if the dials are marked with the nine's complement of the core number being set in the counter as in figure 4, thus eliminating the need for mental subtraction. (The cores are numbered for a forward counting operation to simplify the design of output circuits for more than one output, and to simplify the description of operation of the ring counters, particularly with respect to carries from one decade to another.) The electrical interlock circuit that limits setting to numbers between 200 and 919 (inclusive) thus limits counts remaining to numbers between 799 and 080 (799 and 080 sec remaining when the input is a 10-cps clock).

4. MODE SELECTOR

A switch is required for mode selection in an arm programmer. Magnetic cores are set which provide B, L, and T signals independent of each

other. When a selected core is set with a current pulse in one direction, a selected signal will occur; if the setting pulse is in the other direction, the signal will not occur. The switch designed for setting the decade counters can also be applied here, if the connections to the mode selection coils are made as shown in figure 7. The arrows in the figure show the direction of current required to make the selected signals occur. If the pulse is in the opposite direction, that particular signal is omitted. Two L coils are required, but only one of them will be in the pulsing circuit at any one time. This requirement arises when the wafer used is the same as that designed to fulfill the requirements of the decade counter.

With the mode switch connections shown in figure 7, the control coding is determined from figure 1. When the switch is set for cores 8 or 9, the circuit is open and nothing will be set. Signal B will occur when the setting is 0, 2, 4, or 6; signal L will occur when the setting is 2, 3, 6, or 7; signal T will occur when the setting is 0, 1, 6, or 7.

This coding can be shown more clearly in the following chart. The third column in the chart shows the digit visible in the window for each of the conditions. For example, if only B and L outputs are desired, the mode switch setting must be numeral 7 (for core 2).

<u>Coding for core number</u>	<u>Signals</u>	<u>Coding for digit visible</u>
0	B T	9
1	T	8
2	B L	7
3	L	6
4	B	5
5	(none)	4
6	B L T	3
7	L T	2
8	(open)	1
9	(open)	0

A switch with any desired coding can be designed by changing the circuitry printed on the wafer. If further work is done on this type of system, it is suggested that a coding more suitable for the mode switch be designed to simplify field use. Below is shown the present code and a proposed code versus the switch digit visible (nine's complement of core number). When the letter is omitted, the corresponding output will not occur.

<u>Switch digit visible</u>	<u>Signals with present code</u>	<u>Signals with proposed code</u>
0	(open circuit)	B
1	(open circuit)	B L
2	T L	(open circuit)
3	B T L	B T
4	(none)	(open circuit)
5	B	(none)
6	L	L
7	B L	(open circuit)
8	T	T
9	B T	(open circuit)

The purpose of the proposed code is to group the B signals together, then to group the T and L signals in a pattern that is the same whether the B signal is present or not. The proposed code omits the L signal when the T signal is present because the T signal makes the L signal meaningless in a particular application. An additional improvement would be to design a six-position switch, eliminating the open-circuit positions.

ACKNOWLEDGMENT

T. F. Protz did the layout and art work required to develop this switch and supervised the fabrication of models, utilizing the components of a commercial switch.

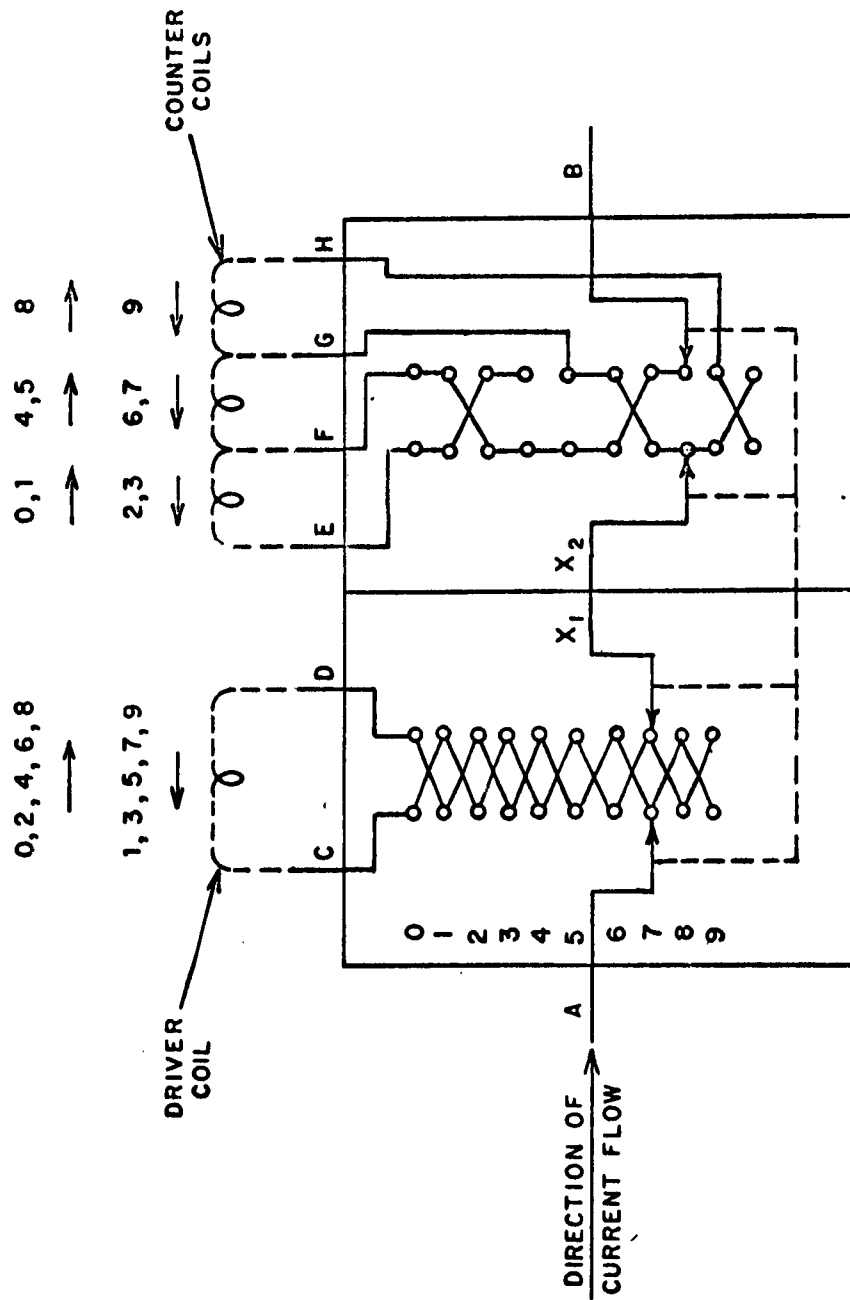


Figure 1. Core switching requirements.

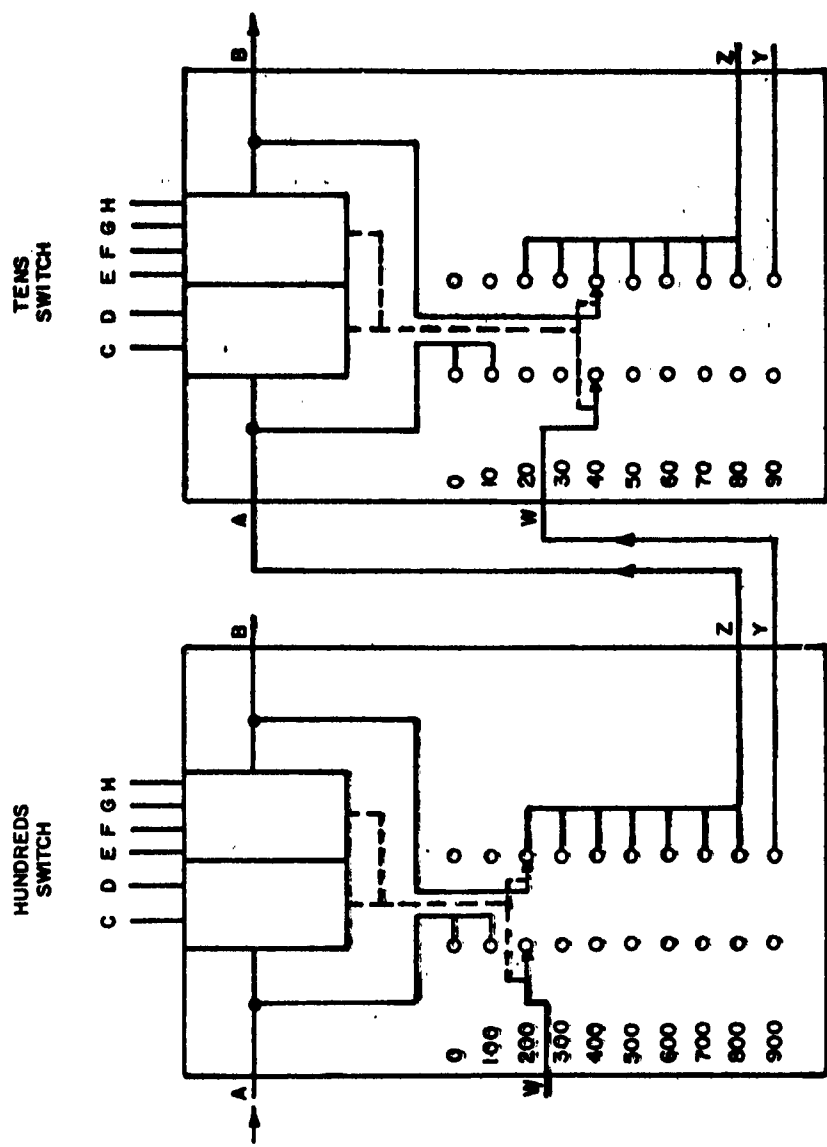


Figure 2. Interlock requirements

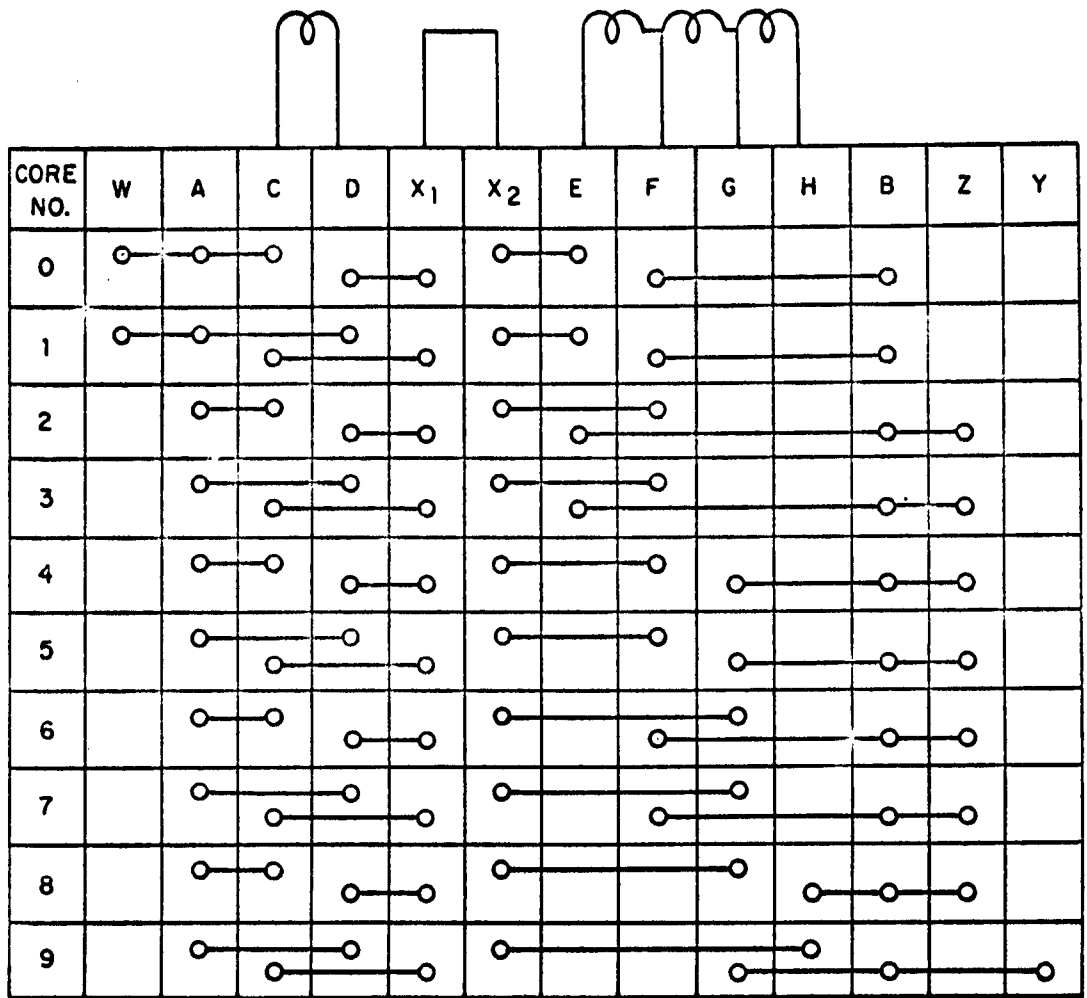


Figure 3. Switching circuit for one decade.

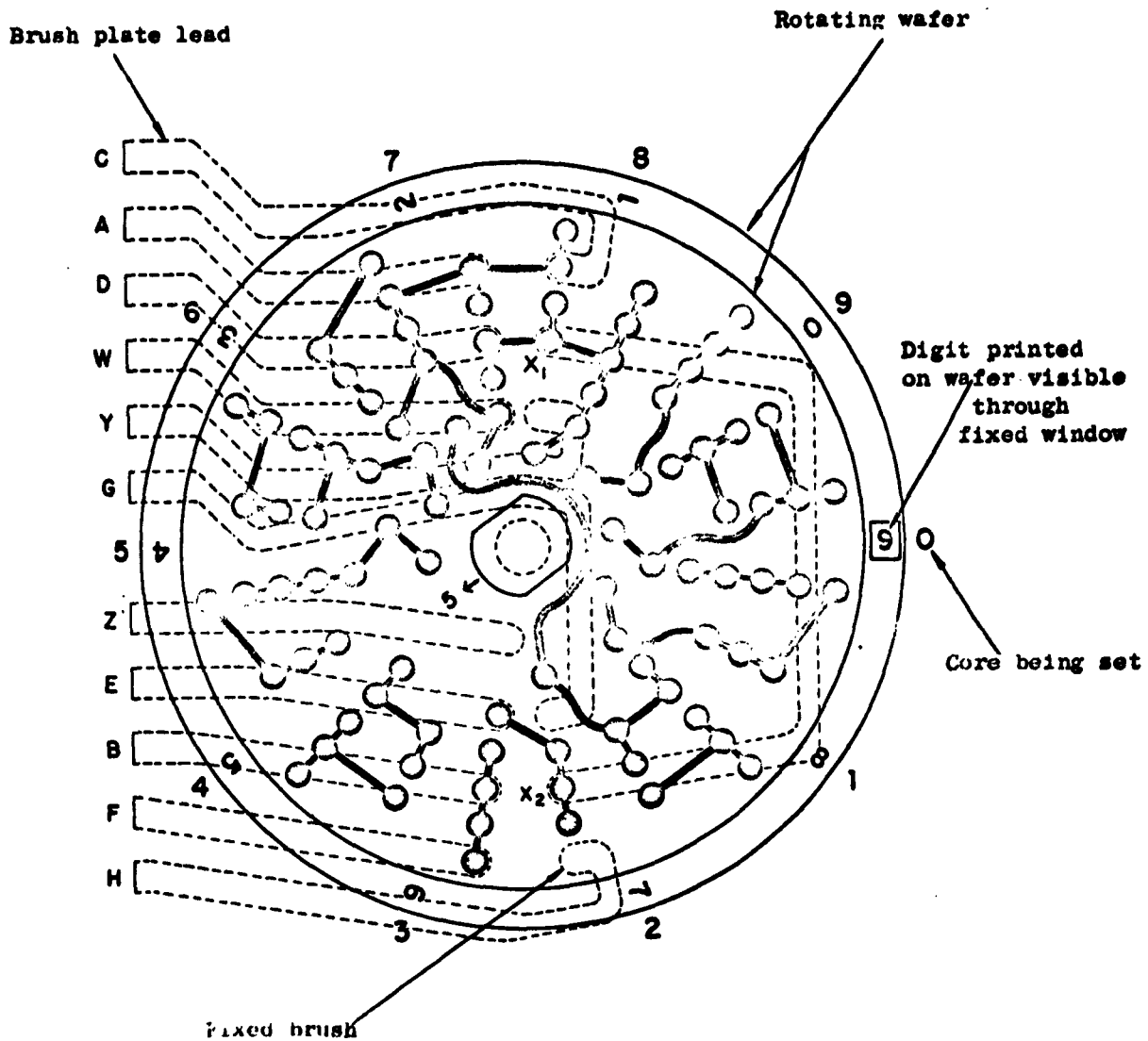
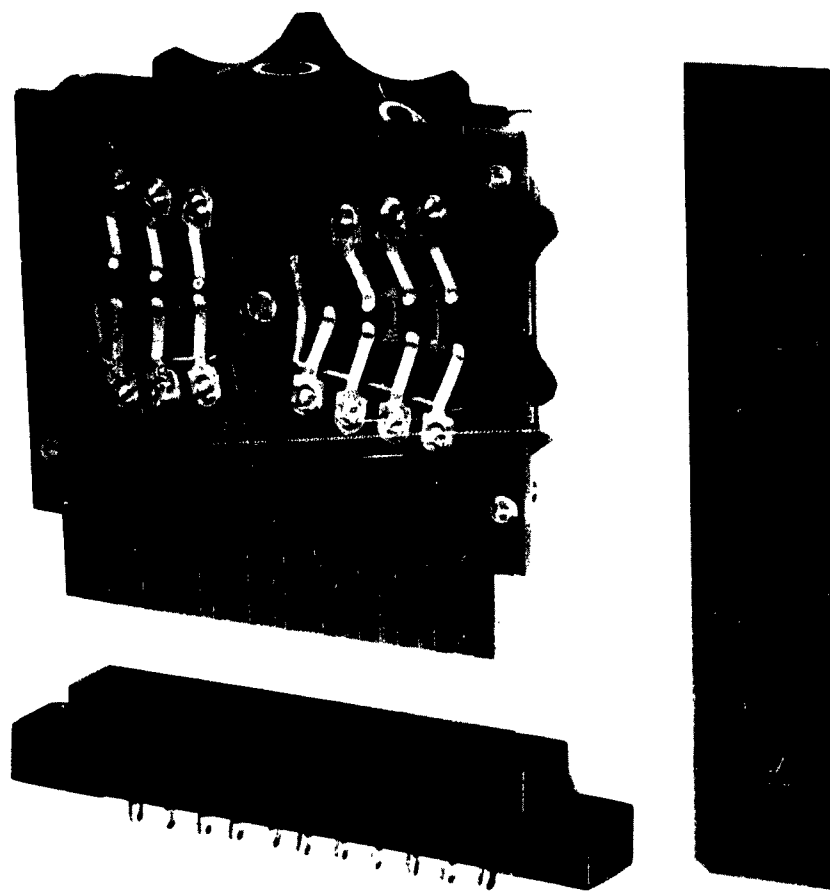
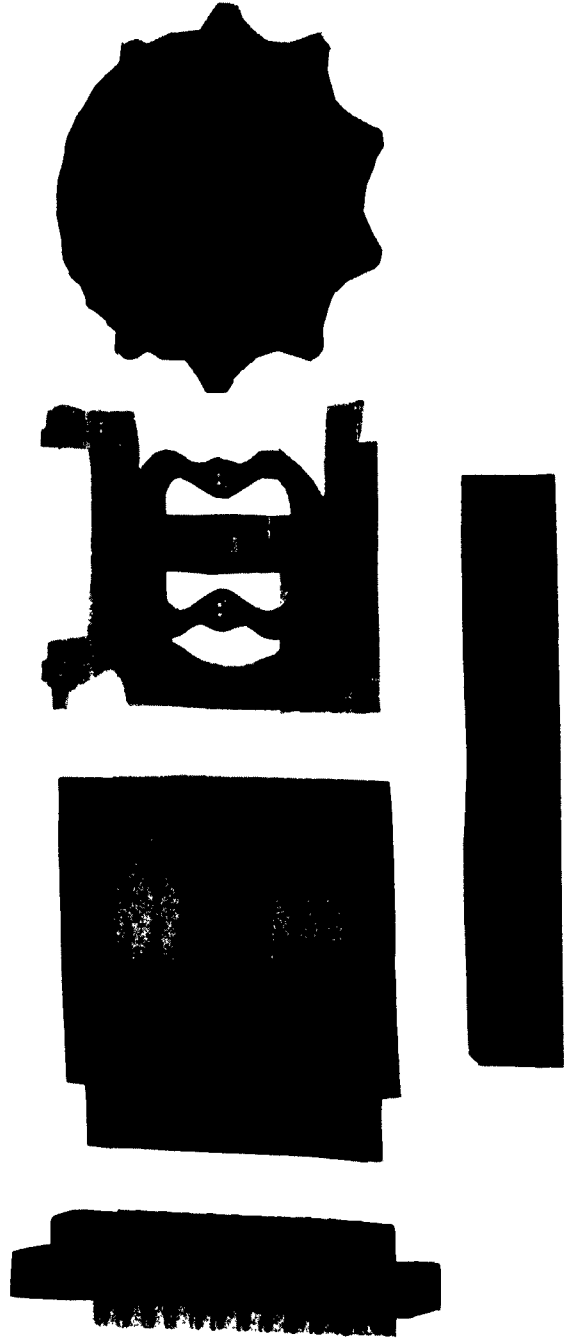


Figure 4. Switch-design diagram.



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Figure 5. Switch.



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Figure 6. Switch disassembled.

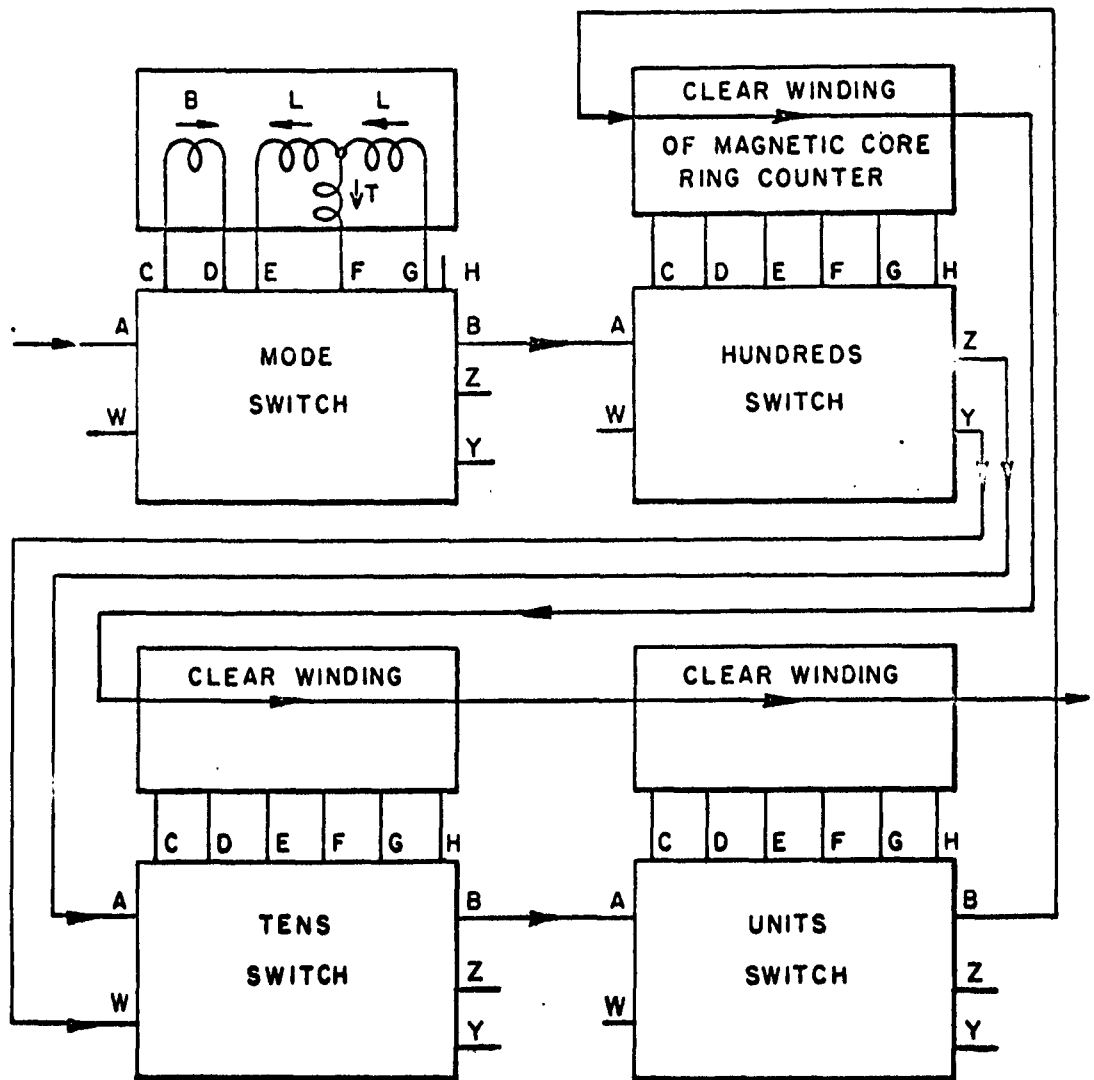


Figure 7. Schematic diagram of switch interconnections.

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2. Switches--Single wire
3. Electronic timers--Switch design
4. Decade counters
5. Switching techniques

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