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\$1.00 ■ SEPT. 1977

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CORE MEMORIES

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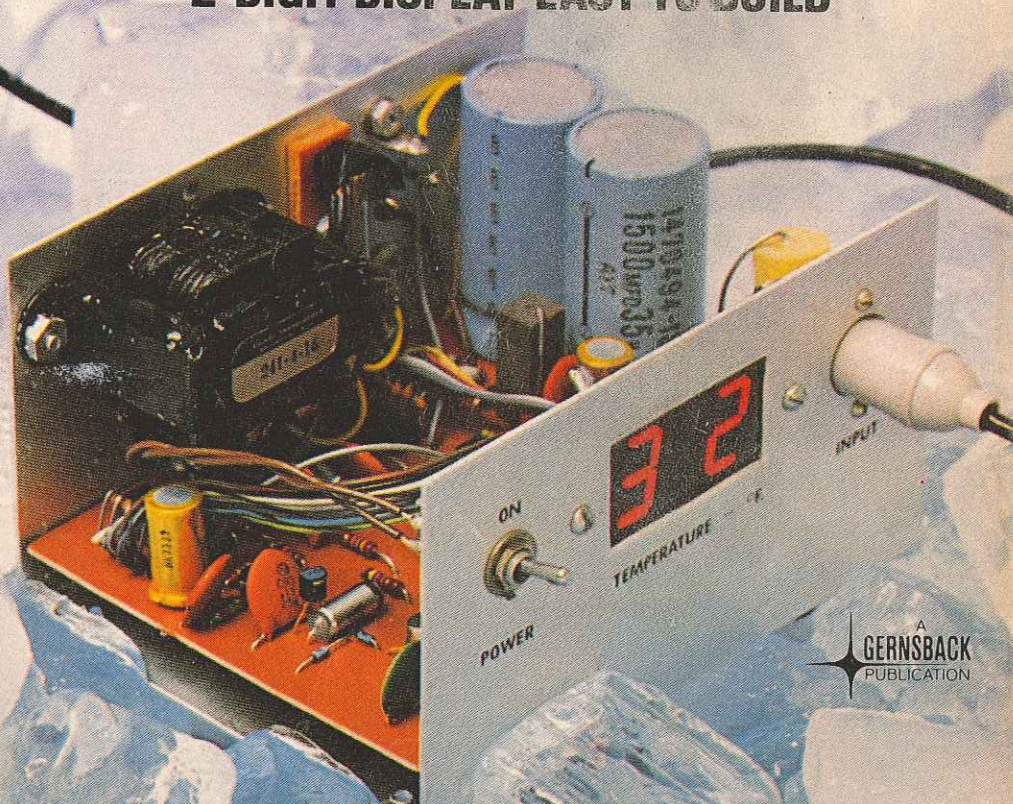
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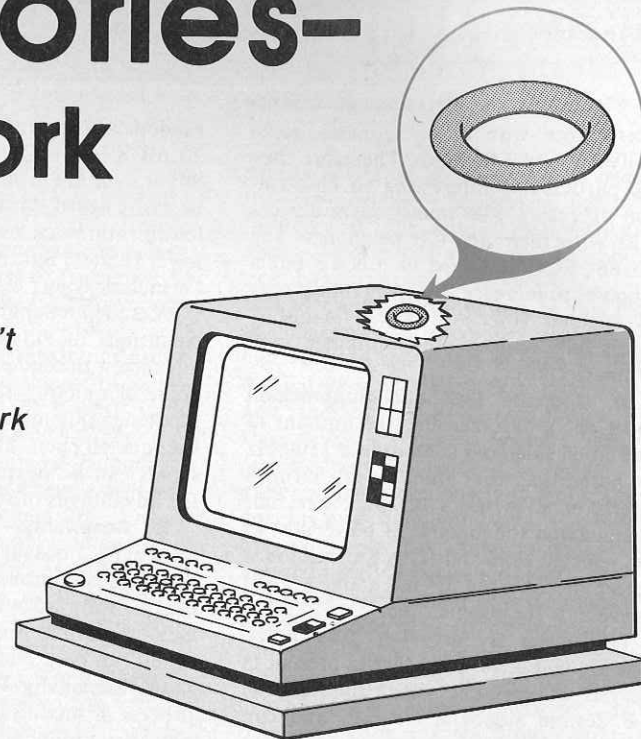


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Core Memories— How they work

With inexpensive core memories flooding the surplus market, it's a wonder that they haven't appeared in more hobby computer systems. Here's a look what they are and how they work

MARTIN A. SALA



THE MAGNETIC CORE IS ONE OF THE LEAST expensive and fastest means of storing data in a computer system. Magnetic core memories are *static*: they hold data when power is removed, don't have to be refreshed periodically and are usually of the random access (RAM) variety.

The actual method of storing ones and zeros in a core is simple. The basic core element is shown in Fig. 1. By passing conductors through the center of the ferrite cores and passing a current through the conductors in a set direction, a magnetic field is created that magnetizes the core. A logic 1 has then been written when the core is magnetized. (This process is similar to the one used in making permanent magnets.)

Just the opposite is done to read or clear a core. A current is sent through in the opposite direction, and consequently cancels any previous fields in the core. To read a core, an extra winding must be added: the *sense* winding.

When a core holds a logic 1 (is magnetized) the *read* current causes the magnetic flux to collapse and induce a voltage in the *sense* winding. If the core had held a logic 0 (been unmagnetized), no voltage would have been induced in the *sense* winding.

This method is basically the idea, but is much too simple to function in a real computer system. The type we shall be concerned with is known as the 3-D, 4-wire. Three-D means a three-dimensional array consisting of planes of cores arranged in an X-Y format in which the total number of words is equal to the number of cores per plane. (The number of bits per word is equal to the number of planes.) Four-wire signifies that four wires pass through each core. They are: *X Drive*, *Y Drive*, *Inhibit* lines and the *Sense* windings. (See Fig. 2.)

When a *read/write* (R/W) current passes through both X and Y drive lines, a core is magnetized (or demagnetized). If there is current on one drive line through one or many cores, those cores will not switch; it takes the sum of both

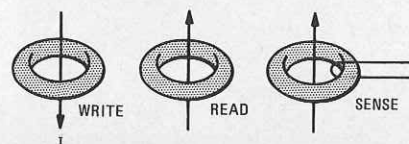


FIG. 1—ELEMENT OF CORE MEMORY. Current passing through the wire magnetizes the ring (core) when a strong enough current flows. A current in the opposite direction breaks down the magnetic field, producing a pulse of current in the Sense winding.

X and Y currents to switch a core. The current on one line is known as the *half current*.

This half current is used to write a logic 0 into a core, with the help of the *Inhibit* lines. As a core is selected, an equal but opposite current on the Inhibit line cancels out the current on the Drive line parallel to it and thus creates a half current. Remember, the drive lines only select the core to be written—it is the Inhibit lines that determine whether or not the core will be logic one or zero. During the read cycle,

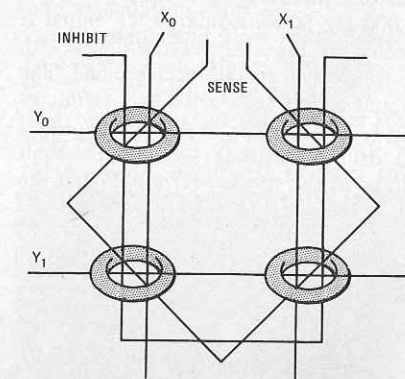


FIG. 2—HOW THE CORES ARE WIRED. The four wires are X-drive, Y-drive, Inhibit and Sense. There will be 64 X and 64 Y drive lines in a 4096-core plane (X₀ to X₆₃, etc.).

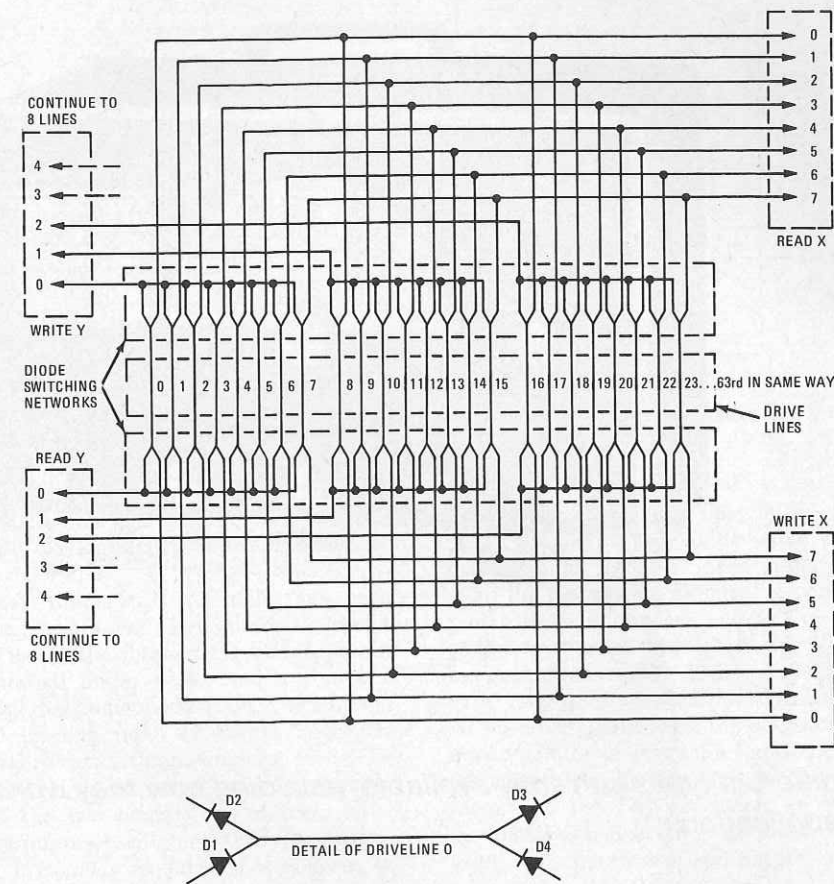


FIG. 3—A MEMORY CORE ASSEMBLY. There are no less than seven pieces of equipment in the circuitry shown here; the core stack itself, the two diode steering units and four switching units.

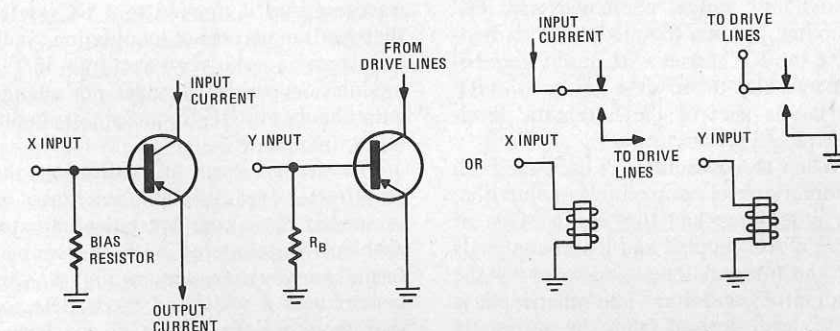


FIG. 4—TWO SWITCHING SYSTEMS. The actuating signals come from the address decoder, the output is to the drive lines.

the drive currents are reversed and cause the magnetic field stored in the core to collapse and create a voltage on the *Sense* winding.

Core memory design

Memories of the core type are basically easy to design. Circuitry is usually straightforward, with simple timing methods. All that one needs to service a core memory is an oscilloscope, a VOM and sometimes a signal generator.

One can start a core system with a stack of core planes with the desired

number of bits and words. Try to obtain the core stack parameters (current values for the Drive and Inhibit lines, etc.). Input/output designations for the core stack are also necessary—the experimenter will be lost if he doesn't know what all the leads on the package are for.

Mount the core stack in a place relatively free from magnetic fields (away from motors, generators, solenoids and the like) and where cool air may circulate freely—continued use heats the Drive lines.

In the 4096-core unit partially illus-

Switching a core

It takes a specific amount of current to switch a core. This current is switched on and off at the diode decoders desired by the X and Y circuits. They are usually made up of single transistors biased so that they turn on and off at logic 1 and 0. Logic 1 is normally 4 volts, logic 0 is 1.4-volts TTL (transistor-transistor logic) levels. See Fig. 4.

There are two sets of X and Y circuits. One sends current down the drive lines in one direction to write; the other in the opposite direction for the read operation. While transistors are most commonly used, one may use any desired technique: relays, switches, diodes, even vacuum tubes (all have been used) and need not incorporate the TTL methods described here.

So far the cores, mounted in their planes and assembled into stacks, the diode decoders and the switch and sink circuits have been discussed. How the cores receive their signals, how they are directed to certain cores in the stack, how they are called for and how information is restored to a core after it is destroyed by reading are still to be learned.

R-E

