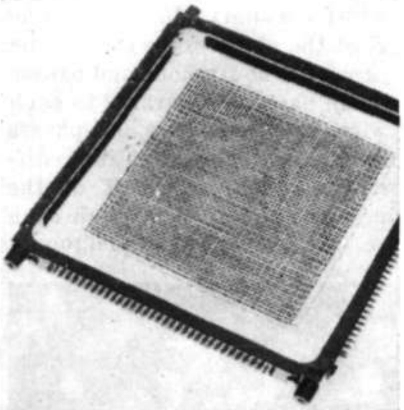
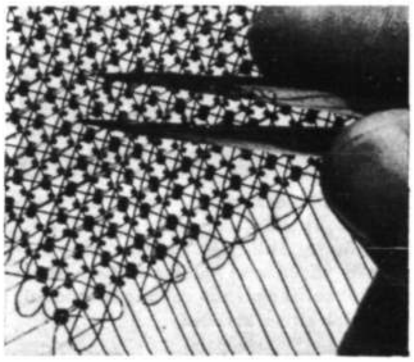
# Vacuum and Vibration Speed Assembly of Core Memory Planes



Assembly and wiring of this early 64 x 64 ferrite-core memory plane required 1 to 2 technician-weeks of tedious labor



Closeup of early memory plane design, showing how four wires pass through each core—for X, Y, digit and sense

Pouring ferrite cores on to fenced-in area of vibrating form while vacuum cleaners are pulling air at full speed down through flexible hose at lower left. During pouring, form may be tilted and rotated to get one core into each of the 4,096 pockets



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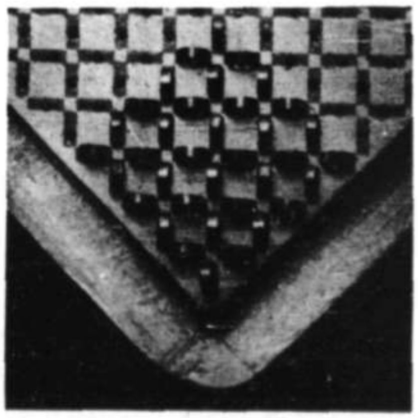
UNTIL RECENTLY, assembly of tiny ferrite rings into high-speed random-access memory arrays for digital computers has been an expensive and time-consuming process. As an example, assembly of a 64 x 64 (4,096-core) memory plane for the MIT memory test computer occupied a technician for between 1 and 2 weeks. The techniques to be described have resulted in over a 5 to 1 reduction of assembly time through the use of inexpensive, easily obtained fixtures.

▶ **Core Holder**—The first requirement for an improved plane-wiring procedure was a fixture capable of holding the cores in fixed alignment for the four wires which had to be passed through each of them. The earlier technique required that the cores be counted and threaded a row at a time. The cores would then be aligned and cross-wired.

A fixture to hold 4,096 cores in orientation is a complex machining job. For this reason, a male mold was machined from which plastic forms could be pressed as needed. The machining task was simplified by milling into the basic mold piece the shaped projections running in one direction and milling receiving slots for those running at right angles. The remaining projections were machined in strip form and later soldered into the slots.

Tests of various plastic compounds resulted in the selection of Plexiglas for the forms; several types of this material were successfully pressed in the mold and removed in one piece.

▶ **Bouncing and Vacuum**—A technique was devised to load one of these plastic forms with 4,096 individual cores in less than 15 minutes. The form, which has a hole in the bottom of each core pocket, is mounted as the cover of a metal box connected to a commercial vacuum cleaner. The cores are slowly poured onto the form



Corner of plastic form, showing 36 cores in correct orientation in the pockets. Air is sucked through hole in bottom of each core pocket at a high rate during core positioning and at a lower rate during wiring of a 4,096-core plane

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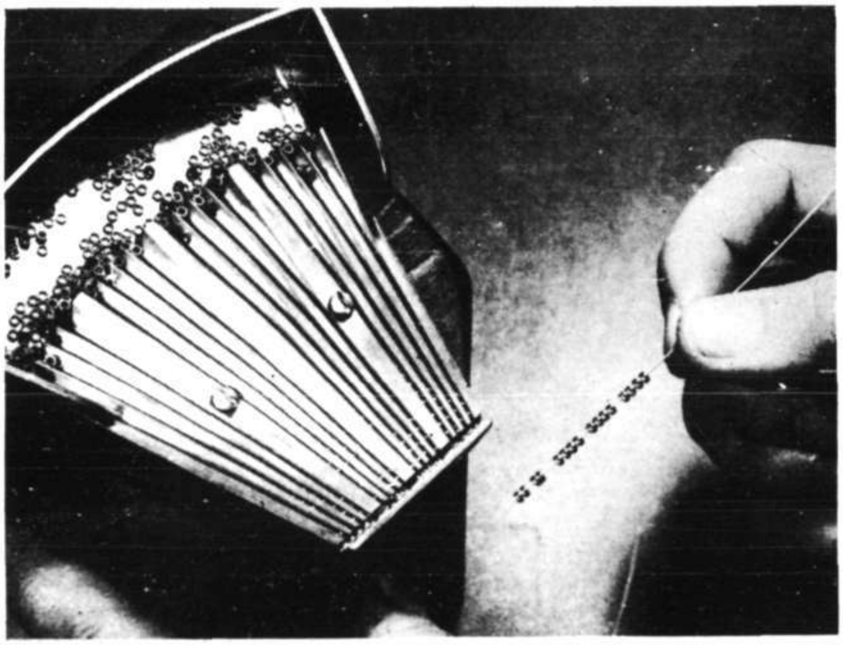
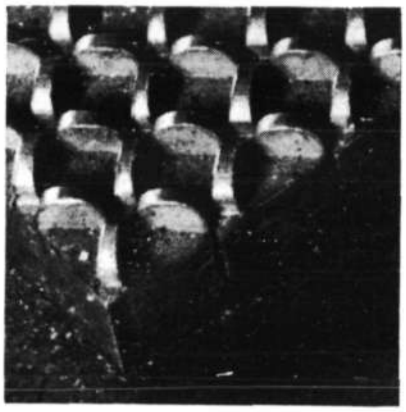
while a vibrator within the box shakes the entire fixture. As the cores are bounced, they are caught in the air stream and pulled into the pockets where they are held by the suction stream. When the form is filled with cores a thin plastic sheet, pulled down tightly against the tops of the cores by the suction, helps to hold them all in place for wiring. It is then possible to pass a needle through a row of cores without flipping any from their positions in the pockets.

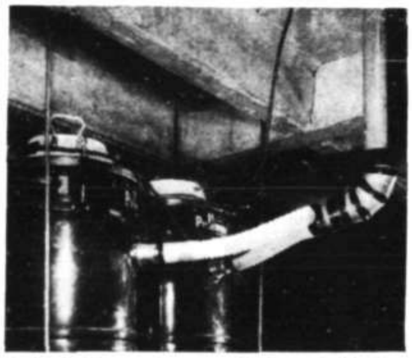
▶ **Threading**—The filled form is moved to another vacuum station for wiring; the first station is used for the positioning process only. Each core is threaded by an X wire, a Y wire, the digit winding and the sense winding. The X and Y wires are short and go from one edge of the plane to the other. The digit wire is continuous and passes through each core parallel to each Y wire. The sense wire also passes through each core, but in a different manner; one half of the winding is threaded through each core along alternate diagonals,



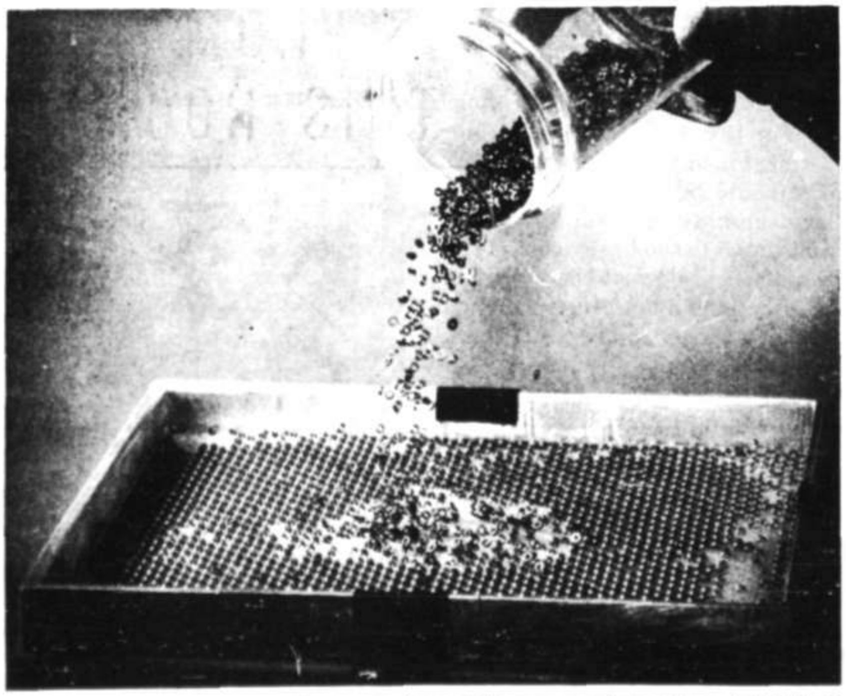
Older technique required that cores be threaded on a long needle and wired into large frame manually. The only significant mechanized aid was the counter-threader shown here, which presented 16 cores at a time to operator. Cores gradually turn to vertical position as they slide down contoured chutes to threading position at bottom



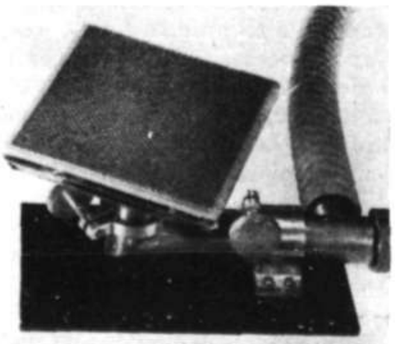
Corner of brass master mold used in producing plastic assembly forms. Vertical rows of half-disks are machined out of solid sheet with milling cutter, after which parallel slots are cut and individual horizontal strips inserted



Method of mounting two Pullman industrial vacuum cleaners on platform below assembly area and coupling to single stovepipe duct running up to assembly benches



Appearance of plastic frame when most of the 4,096 cores are in position. Artist's hairbrush and tweezers are used to place the last few cores in the empty pockets, after which the assembly is covered with Saran-wrap. Core-positioning takes 15 minutes

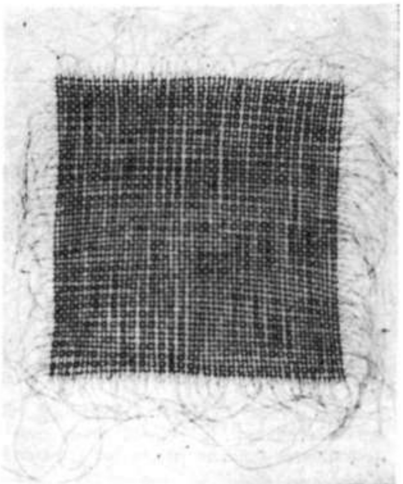


Holding fixture, showing cores in position on plastic form ready for wiring with aid of hypodermic needle. Saran-wrap covering is left in position during wiring while the other half is rotated 90 degrees and passed similarly through each of the remaining cores.

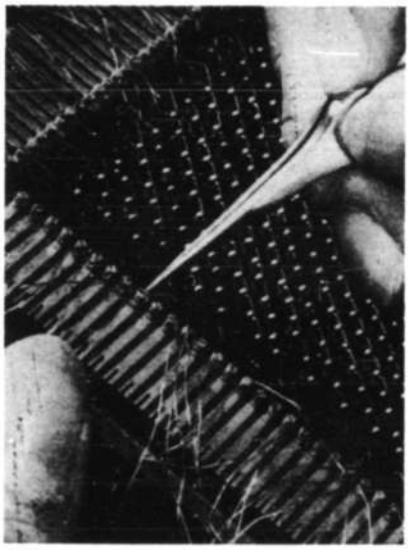
▶ **Finishing**—The wired assembly of 4,096 cores, called a mat, may be removed from the plastic form and connected to a simple frame. After

Wiring station, showing operator threading wire through cores held by frame of work fixture on bench. Core-positioning station at right is acoustically treated to reduce noise from vibrating jig

Method of using X-Var chemical stripper in test tube for stripping Formvar or Formex insulation from wires to be used in mat. Spaghetti tubing with tape seal at one end prevents stripper from creeping up too high. Squares of laminate bolted over spaghetti control depth of immersion when wire is dropped

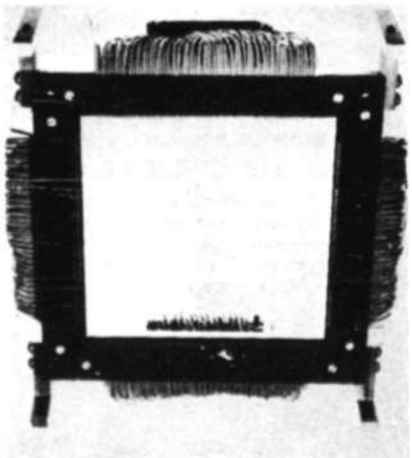


Appearance of completed mat when removed from wiring form, ready for connecting to a frame. Each mat now is produced in only 4 to 5 technician-hours, using quadruple-Formex No. 32 and No. 34 wire. Four of these wires go through each core

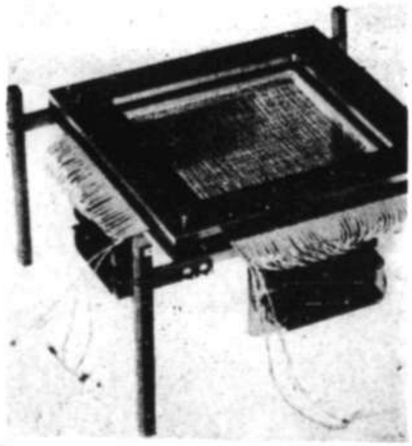


Method of using tweezers to aid in placing second loop of a Y wire in slot of subminiature lug on etched-wiring frame of memory plane. Between 2 and 3 hours are required to make these connections, straighten out lines of mat and clip off surplus wire

Method of using long 26-gage hypodermic needle to pull wires through 50-mil inside diameter of cores. An X wire and the Z winding are being pulled simultaneously



Test fixture without plane



Test fixture for completed memory plane, with plane in position dip-soldering the connections at the four edges, the plane is complete and ready for testing. The cores may be immobilized to prevent future possible abrasion damage to the wires by pouring a dilute solution of electrical dope or cement over the mat.

The 64 × 64 memory plane is a complete unit ready for stacking in a 4,096-word memory array. More than this, however, it is designed so that several units may be conveniently joined to form a larger plane. For example, 16 may be joined to form a 256 by 256 plane. These large planes may then be stacked in a 65,536-word memory array.

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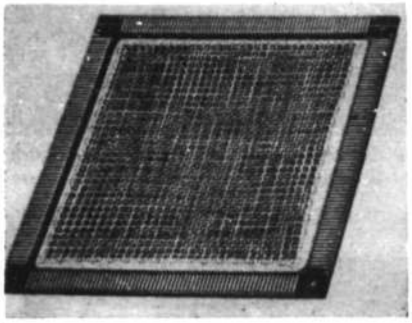
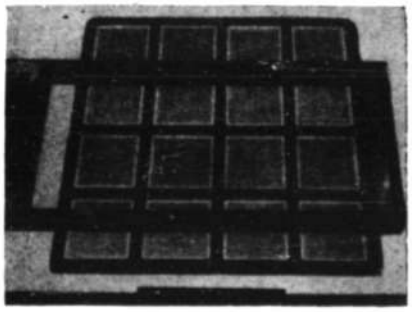


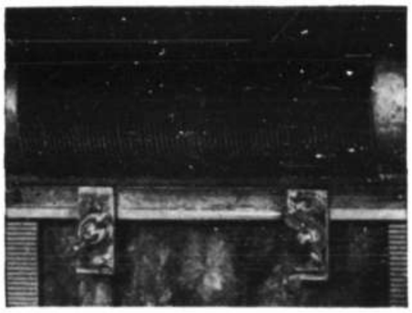
Complete memory plane ready for dip soldering of leads wrapped around lugs positioned over etched-wiring terminals

After dip soldering each of the four edges of the plane in turn, unit is ready for inspection and test

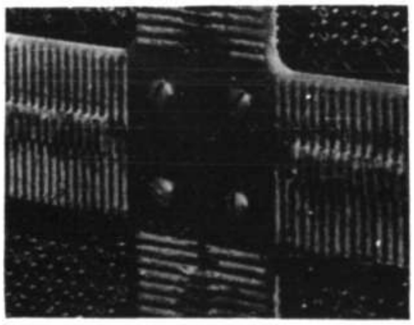
Pouring diluted Amphenol Polyweld over dip-soldered mat to cement each core at its four-wire junction below for later use



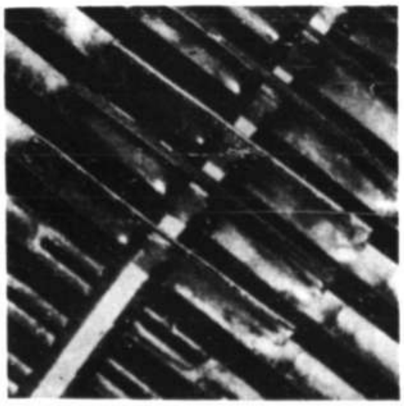
Array of 16 memory planes, interconnected by copper shims to give 256x256 memory plane. Complete random-access memory under development will have 38 of these large planes



Use of gang saw to slot etched-wiring terminals of memory plane, in preparation for insertion of interconnecting shims



Junction of four memory plane units, showing use of interconnecting shims



Shims are soldered to etched wiring terminals all at once by induction heating or by heating each shim individually with a soldering iron