the frame of the aircraft rather than floating— only the spinning spheres float. Although this greatly simplifies the mechanical arrangement, it exacts a price in increasing the complexity of the data-processing. In its present model, Rockwell is using a computer it developed, the D216, which has a MOS large-scale-integrated processor and 5-mil-plated-wire memory. However, production units are expected to use a semiconductor memory, ideally made of nonvolatile metal-nitride-oxide (MNOS) devices.

Initial efforts were aimed at a radiation-hardened navigator, with complementary-MOS circuits on sapphire substrates; hence, the use of the radiation-resistant plated-wire memory. But this requirement has now been eliminated, and the plated-wire memory is too expensive if the target production price is to be met.

Rockwell's brassboard unit occupies about 1 cubic foot in volume, compared to the 2½ ft^3 of the N-16 system. The goal for the final model is only 200 cubic inches (about 0.1 ft^3). Schwartz says, however, this figure may not be achievable, although the navigation system will still be exceptionally small. The final version will weigh about 10 pounds, also an order of magnitude less than the N-16.

The Anaheim, Calif., company is now in phase 2A of its contract, being supervised by Capt. Robert Warzynski of the Avionics Laboratory at Wright-Patterson Air Force Base, Ohio. Flight-testing and component refinement are the major efforts at present.

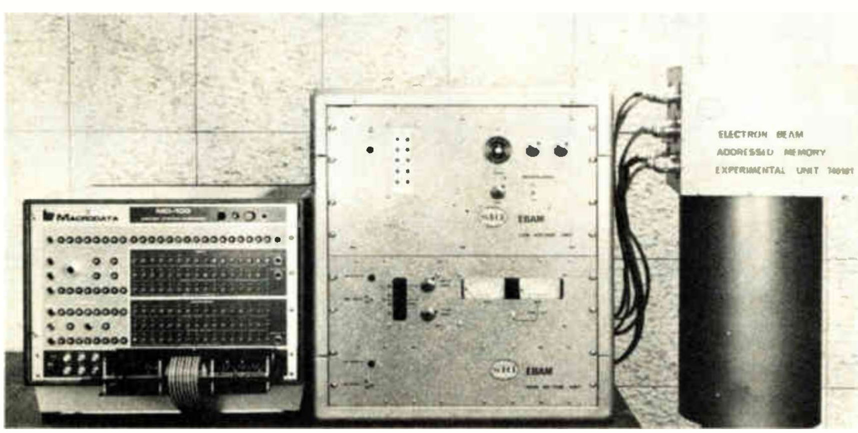
The next step in the Micron contract should begin early next year, when Autonetics is to develop 18 prototypes—eight for the Army and 10 for the Air Force. These could be delivered some time in 1977, Autonetics officials say. □

Memory

MOS target in a vacuum tube yields fast, compact memory

There's nothing unusual about the Air Force turning to solid-state MOS technology for fast, compact computer memory. Almost everybody is doing it.

What is unusual is that the Air Force is turning to vacuum tubes at the same time. The result so far looks extremely promising: Stanford Research Institute, Palo Alto, Calif., has delivered a working model of the electron-beam-addressed memory (EBAM) that in its final configuration could pack 64 million bits of information into a module occupying only two cubic feet. By contrast, 64 million bits is the largest main memory IBM supplies for its 370/168, the top-of-the-line computer in its 370 series. And this MOS memory occupies considerably more space.



EBAM. Electron-beam-addressed memory, right, was tested with a Macrodata MD 100 memory exerciser, left. Eventually, 64 million bits could fit in 2 cubic feet.

The prototype, delivered to the Memory Technology group of the Air Force's Avionics Laboratory's Advanced Electronics branch at Wright-Patterson Air Force Base, Ohio, is geared for an airborne memory system. E.A. Buvinger, Air Force project monitor for EBAM, says potential applications could be in airborne command posts where the Air Force is looking for higher speed and capacity. "The system conceivably could replace tape, disk, or drum systems," she says.

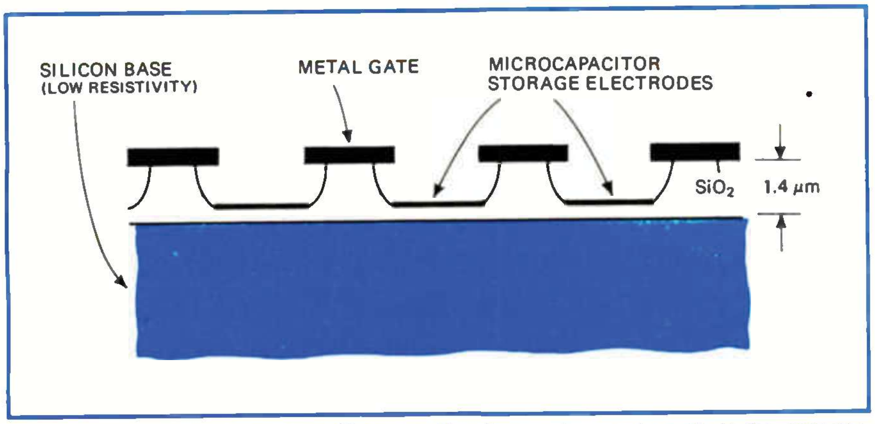
The experimental SRI system has a single EBAM tube, a 12-inch long, 2-inch-diameter device with an MOS storage target. The tube was exercised with a 65,000-bit capacity, but Stanford Research's memory-program director, John Kelly says more refined test circuitry would enable the tube to store 4 million bits; an operational system would consist of 16 tubes. Production could begin in 1976.

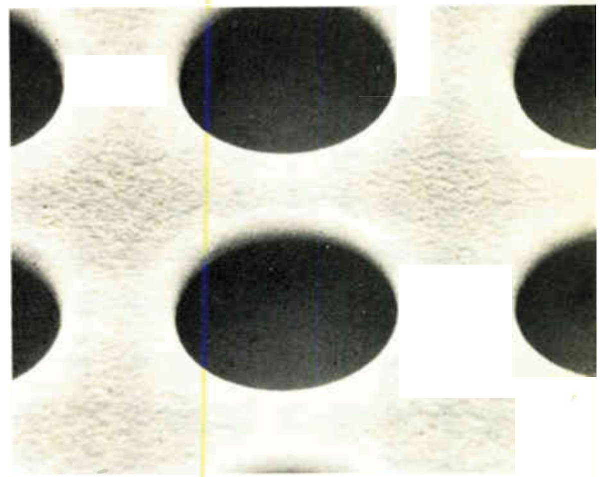
Besides its compactness, the EBAM memory is fast. Kelly says the prototype has a random-access time of 3 microseconds, a writing speed of 16 megabits per second and a reading time of 160 Mb/s.

"An electron beam can be switched at extremely high speeds from one memory location to another," he explains. "In fact, the only practical limit to the speed is the time to convert computer information from digital to analog form, and for the deflection amplifiers to settle. Random access times of 0.5 microsecond or less should eventually be possible.

Hole store. The EBAM storage target makes it all happen. Its half-inch-square surface is covered with millions of simple capacitors, which are able to store digital information having a very high density (about 70 million bits per square centimeter).

Holes are etched through the





Store. Microcapacitors formed on silicon are the charge-storage elements in the memory tube's target. Extreme magnification shows the capacitors formed into perfect circles, right.

metal gate of the MOS structure into the oxide by means of an electron lithographic technique developed at SRI. In each of these holes is deposited an isolated metal electrode, a microcapacitor. The holes measure about 6 micrometers in diameter on centers 9 μm apart. The oxide thickness atop the silicon base is about 1.4 μm.

Information is written by deflecting an electron beam in somewhat the same manner as a return-beam vidicon or a storage tube. The 2,000-electronvolt beam can be deflected to the target's edge by 26 volts. Binary ones are stored as a negative charge (typically -40 V with respect to the gate electrode) and zeroes as zero charge. Information is read from the beam by detecting the electrons—a function of stored charge—scattered from the target area and amplifying this into a usable signal.

Traditional deflection techniques were not precise enough for the tube, says Kelly. Instead, SRI developed an eight-pole deflector—eight electrodes arranged symmetrically around the beam axis. They share a common center of deflection and have equal sensitivities.

The single-tube prototype supplied to the Air Force is controlled by an off-the-shelf memory exerciser, which produces data-pattern addresses and read/write commands. Data, address, and operational commands are passed to an interface unit where all the timing is determined. From the interface, logic signals control the digital-to-analog converters for switching the beam, and provide the deflection voltages and the target bias for reading and writing. In the experimental system, says Kelly, it's the memory exerciser that limits the number of address locations usable in the tube. Later versions would use a larger-capacity exerciser.

Consumer electronics

TV-screen dot yields hard copy

Television sets have long offered the intriguing possibility of transposing the picture on the screen to a piece of paper that the viewer could carry away with him. Precisely what need this would fulfill is, however, another question—probably one of the reasons why, along with cost, such systems have not yet appeared on the market.

Atlantic Research Corp., Alexandria, Va., is taking a shot at the problem—but instead of making a hardy copy of the entire picture, it's satisfied to use the TV set as a receiver for digitally coded information that's piggy-backed onto the regular picture signal. This data can then be printed out.

The system, called Data-Dot, uses a photosensor that is attached to the TV screen by means of a rubber suction cup, similar to that found at the end of a toy arrow. The sensor picks up a small dot located in the corner of the TV screen that flashes on and off at the receiver's rate of 60 TV fields per second. This information can drive a low-speed thermal printer, developed by Atlantic, or it can be stored on a standard audio tape cassette recorder for printout later.

The company envisions a gamut of information that could be presented to viewers—news, stock market reports, weather, background information on programs, cooking recipes, and the like. Although marketing plans and cost estimates are not complete, Atlantic may end up franchising it to local TV stations, according to George Summers, ARC director of advanced programs.

Special. The TV studio would be equipped with a special-effects generator—a data insertion unit (DIU)—which comprises an attache-case-sized electronics package and a keyboard. The video signal is routed through the DIU, which adds the dot information to the signal, controlling the dot's shape, size, and location on the screen.

Up to 60 words per minute can be transmitted using ASCII code, up to 90 words per minute with a Baudot format. However, higher speeds could be attained with a multiplexing arrangement, Summers points out. On the TV screen, the system is quite tolerant of dot-sensor misalignments, he says. The printer uses a thermal print head with a 5 by 7