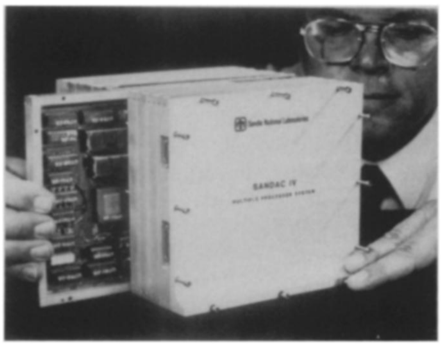
Supercomputer for rugged environments

Some mainframe computers are so fragile that they leave the factory packed in a carton with devices to record whether the contents have ever been turned over or tipped during transit; if it turns out they have been, the warranty is void. But not the little number-cruncher developed at Sandia National Laboratories in Albuquerque, N.M. It's been designed to "shake, rattle and roll," explains Edwin Barsis, manager of Sandia's Electronic Subsystem Department. If it weren't extremely rugged, this computer would never survive the send-off it is to get as part of the on-board navigator of a cruise missile or "smart" (maneuverable) munition.

It also handles rugged computations. The no-frills version of model IV — with three central processing unit boards—has the computing power of the well-known super-minicomputer VAX 11/780. But model IV is capable of taking up to 16 such boards, boosting computing speeds to 8 million instructions per second (mips). And the 16-processor prototypes of model V have demonstrated computational rates of between 24 and 40 mips — roughly the equivalent of a CRAY-1 supercomputer. Yet unlike the towering CRAY-1, these Sandia Airborne Computers (SANDACs) are about the size of a shoe box and weigh between 4 and 20 pounds.

Parallel processing is the key to the computer's speed. Most computers use "serial processing," breaking down a large computational problem into a series of small steps — like additions, multiplications or subtractions — and tackling each sequentially. Another way to handle the series of small steps is to assign each to a different microprocessor so that they can be computed simultaneously; this is parallel processing. "The big mainframes have very little parallel processing," Barsis says. "They have parallel access to memories and things like that, but none has the capability [as SANDAC does] to have 16 processors clunking away at once.

"For the problems it is optimized to solve," Barsis says, "SANDAC operates as fast as some of our best mainframes." But SANDAC is not a mainframe or a general-purpose computer. It's an embedded computer, meaning that it's designed to be part of something that is not primarily a computer. (One example of an embedded computer is the device that controls the timer and channel selector on a programmable videocassette recorder.)


Sandia

Six-processor (13.5-pound) version of SANDAC IV forms cube less than 7 inches on a side.

A special-purpose computer, SANDAC was specifically designed to handle navigation and guidance problems as an embedded part of a warhead-carrying reentry vehicle (such as a missile), attack helicopter or other such weapon. Not only can it survive the vibration and acceleration associated with such weapons, but it also will operate at temperatures as high as 190°F (nearly the boiling point of water).

Although SANDAC was originally expected to handle airborne navigation, Barsis notes that it appears to be equally applicable to ground navigation. And work is currently under way to make it capable of "expert vision identification," Barsis says. One such application might be used in the identification, targeting and destruction of a specific class of enemy aircraft. Alternatively, it might help industrial robots find and discard defective products from an assembly line, or permit automated analysis of blood products.

All of the components used in the computers are commercially available. Because existing SANDACs may have a number of civilian applications, Sandia has begun releasing drawings for the system to interested companies for commercial development. Part of SANDAC's appeal, Barsis acknowledges, is its small size. As computer chips get faster, the distance a signal has to travel becomes more significant. SANDAC's compact packaging keeps signal distances short. *—J. Raloff*

Microscope maps minuscule magnetism

Electron microscopes are a practical application of the principle that the waves associated with matter really do matter. Electron waves are very much shorter than light waves, so using electrons as probes instead of light reveals finer details, usually about the atomic and molecular structure of objects, than light can expose. Scanning electron microscopes (SEM) delineate the structure of a specimen's surface; transverse electron microscopes send electrons through the sample to find out about its interior. Now a group working at the National Bureau of Standards (NBS) in Gaithersburg, Md., has combined a polarization sensor and a SEM to produce an instrument that both delineates the surface structure of a sample and maps out its magnetic domains.

Magnetic domains are small sections of a metal, for example, in which the inherent magnetism all lines up the same way. Each atom has an inherent magnetism, produced mostly by the spins of its outer, or valence, electrons. In a given domain the magnetic fields produced by the atoms all line up the same way. In a nonmagnetized sample the magnetic fields of the different domains point in random directions, yielding generally no field overall. In a ferromagnetic sample the domains all point the same way and yield a net overall magnetism. (In an *anti*ferromagnetic sample the domains alternate pointing in opposite directions, making an orderly pattern but producing no net magnetism.) A knowledge of the locations, sizes and orientations of magnetic domains is important for the production and understanding of all manner of magnetic devices, particularly magnetic recorders and magnetic memories.

A SEM works by shooting a beam of electrons at the surface of the sample. Striking the surface, these electrons knock out "secondary" electrons, and the information gained from the secondary electrons is used to draw a picture of the surface structure. If the surface is magnetized, the secondary electrons carry information about the magnetization in their polarization. If one regards electrons as particles, polarization means that their spins are all oriented in the same direction; if one regards electrons as waves, polarization means that the waves all vibrate in the same direction. Whatever picture one uses, the polarization is related to the direction of magnetization in the part of the surface the given secondary electrons come from.

The new instrument, developed by John Unguris, Daniel Pierce and Robert Celotta of the NBS Center for Radiation Research and Gary Hembree of the NBS Center for Manufacturing Engineering, combines a SEM with a spin polarimeter to get the usual picture of the surface topography and at the same time a map of the magnetic domains. It is not the first attempt to do this, but it claims to be more practical. The work will be described in the September JOURNAL OF MICROSCOPY.

The first attempt to combine a SEM with a spin detector used a device called a Mott spin analyzer and an electron beam 10 microns in diameter. The Mott analyzer takes up about a cubic meter of space and operates at 100,000 volts, requiring special high-voltage protection. Unguris and colleagues developed an analyzer about the size of a human fist that operates at about 150 volts. It analyzes the electron spins by observing how the electrons scatter from a polycrystalline gold film. The way they scatter depends on their spin. This group also uses a narrower electron beam, one 10 nanometers in diameter.

With the device, they have mapped the