if the surface of a stove, for instance, is hot enough, drops of water falling on it form globules that, rather than evaporating immediately, may last for several minutes. The globules are insulated from the direct heat of the stove by a layer of superheated vapor.

Calculations by Dr. Alfvén on a similar phenomenon for matter and antimatter show that a thin, very hot layer of ambiplasma may provide an adequate insulating boundary.

The prediction of the existence of antiparticles was made by British Nobelist P. A. M. Dirac in 1927 and confirmed by the discovery of the positron, a positively charged electron, in 1932. To verify the existence of antiprotons, negatively charged protons, was an important reason for construction of the bevatron at Berkeley. The first clear-cut evidence for the existence of the antiproton came in 1955, soon after the bevatron started operating. The antineutron was found shortly after that.

The significance of these confirmation's lies in the very fundamental ideas behind Dirac's predictions that the universe should show complete symmetry between particles and antiparticles. Discovery of the antideuteron in 1965 further confirmed not only the terrestrial symmetry of elementary particles and their opposite numbers, but also made much more real the possibility of antiworlds made of atoms of antimatter.

The antideuteron was the first known antinucleus made up of two fundamental building blocks of antimatter, the antiproton and the antineutron.

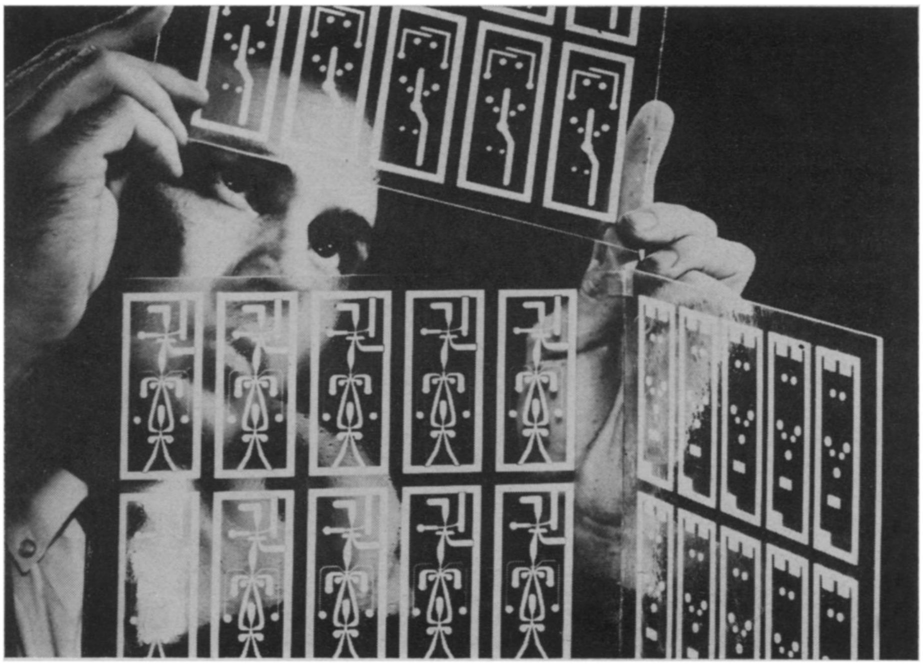
It was the first complex atomic nucleus of antimatter to be found, and is the antiparticle of the nucleus of the heavy hydrogen atom. Deuterium is the simplest possible complex nucleus, consisting of a neutron and a proton bound by the strong nuclear force.

Existence of the antideuteron means that all the properties of the strong nuclear force are closely mirrored in the antiworld, as had previously been expected but not proven. These properties determine the nature of the compound nuclei of heavier elements that are built up by adding neutrons and protons.

The discovery convinced many scientists that it is no longer possible to question the basic physics part of the cosmological conception of a literal antiworld populated by stars and planets." The antiworld would be made up of negative nuclei surrounded by positrons.

Some scientists have suggested that the Tunguska meteorite that shook Siberia in 1908 was actually an antimeteorite.

HYDRODYNAMICS



Corning Glass Works

Etched-glass amplifiers: one way to mass-produce fluid control circuits.

Fluidics Is Muscling In

Where electronics once ruled, new technology is making its way.

by Carl Behrens

Hydrodynamic theory has been around a long time. Now it is spawning a technology, fluidics, which is making inroads where reliable, rugged control and amplification are a must.

One of the first beneficiaries of the booming new control systems industry will be the U. S. Navy. And the Navy really needs boiler control help.

At any one time, according to Cdr. J. C. Kaune of the Naval Shipping and Engineering Center in Philadelphia, "over half the boiler automatic control systems in the fleet are partially or wholly inoperative." Main culprits in the breakdown of control systems, he says, are dirty air, rough treatment, and improper adjustment.

To improve this situation, a new control system, using fluidic circuits, is currently undergoing test use at the Philadelphia Naval Shipyard. The new system, built by Bowles Engineering Corp., whose founder, R. E. Bowles, is a fluidics pioneer, is unaffected by dirt in the air, requires little adjustment, and since it has no moving parts, is practically breakdown-proof.

The boiler regulator is a prime example of the kind of precise, rugged fluidic control systems that are now being developed for a wide variety of industrial and military uses. Faster, more reliable, and cheaper than the conventional systems of valves and motors, these fluidic devices are able to perform the functions of electronic circuits under conditions that would destroy transistor or vacuum tubes.

The similarity between electronic circuits and fluidic systems is startling. In an electronic device, signals are carried by a flow of electrons, which is controlled by various components such as resistors, capacitors, vacuum tubes and transistors. A fluidic signal is carried by a flow of some liquid or gas, usually air, and controlled by strangely-shaped pathways and channels that have exactly the same regulatory effect on the fluid flow as resistors and tubes have on electron flow.

Since fluidic systems use air instead of electrons, and channels instead of elaborate vacuum tubes, and hydrodynamic theory is, if anything, older than electronic theory, it is only chance that fluidic devices weren't developed first. It happened because electronic engineering was developed to meet the needs of long-distance communications not for switching and controls.

Once an electron flow has been turned into a signal and amplified, it is converted, in an antenna, into an electromagnetic wave, which carries the signal over long distances. Fluidic systems can make an air flow carry a signal, and they can amplify that signal, but they can't transmit it for any distance. So fluid systems had to wait for the world to need them.

It did when automation found new uses for electronics, and the new applications didn't need long-distance transmitters.

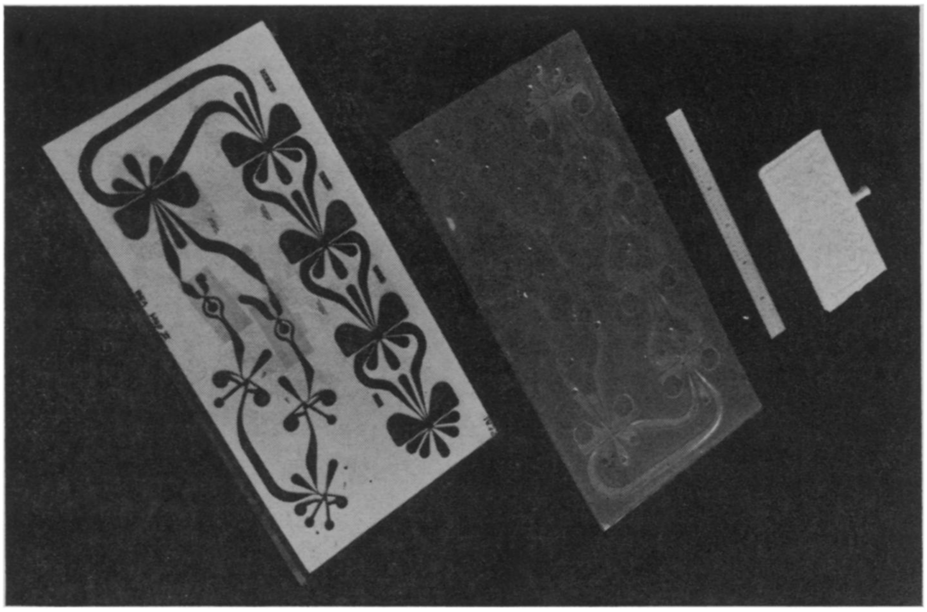
In a manually operated machine, someone reads a gauge or watches an operation and then turns on a motor or opens a valve. Automatic systems have to read the gauges and open the valves themselves. It is here that fluidic systems can fulfill many of the functions that are now being met with electronic circuits.

A simple fluidic switch, for example, is a Y-shaped channel with one very small channel coming in from either side just below the fork of the Y. The air, or other fluid, comes into the switch at the base of the Y. When it reaches the fork, a characteristic of fluid flow called the Coanda effect comes into play.

According to this effect, fluids tend to attach to one wall of an enlarging channel. As a result, all the flow goes into one arm of the Y and none flows through the other. If a jet of air is sent into the switch through one of the small side channels, the main flow is detached from one wall of the Y and flipped over to the other. A jet from the other side channel causes the main flow to switch back again.

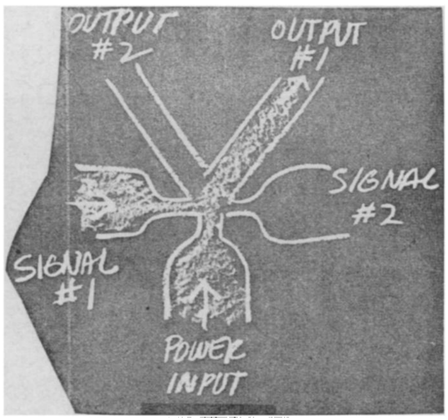
Switching circuits are the brains of any automatic control system; they do the job that would be done by the man who operates a non-automatic machine. But two other functions are also needed: sensing, which corresponds to the man reading the gauge, and activiting, which opens the valves or turns on the motor.

Electronic switching circuits are extremely efficient, sophisticated and fast, and recent advances in transistors and integrated circuits have made them very cheap and compact. In sensing and activating, however, electronic systems can be rather clumsy, particularly where valves have to be opened and closed to control the flow of a fuel or operate a hydraulic machine. Here fluidic control systems, which operate on the fluid directly, are much more efficient, entirely eliminating the valves with their slow-moving, wear-susceptible parts. In many cases, the relative slowness of fluidic logic signals, which move at the speed of sound instead of the speed of light as do electrical signals, is more than made up by the speed with which the signals are converted into action.



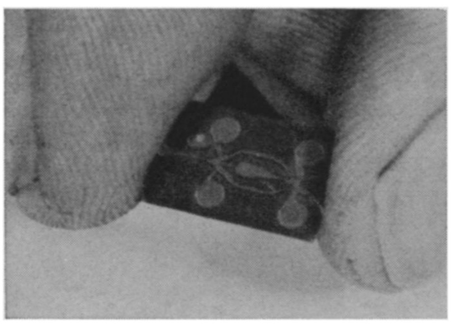
Bowles Engineering Corp.

Control channels may also be made of molded plastic.



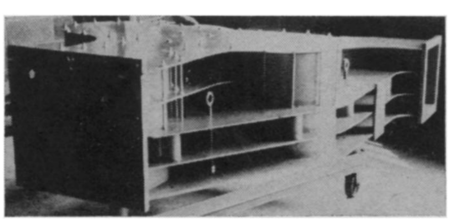
Industrial Research

How a fluidic switch works.



Bowles Engineering Corp.

Fluidic switches, small and . . .



Bowles Engineering Corp.

. . . large: 15,000 gallons/minute.

Fluidic devices are not only switches; they can also be amplifiers.

An amplifier is a device that accentuates the fluctuations in a variable signal, whether it be electronic, audial or whatever.

In fluidic devices, the variation in input from the control channels causes a proportional but larger change in the main channels, thereby amplifying.

Despite their basic simplicity, the strange, artistic whorls and channels that make up a fluid control circuit are requiring a whole new language to describe and analyze their properties. Some of the basic concepts are taken over from electronics—qualities such as resistance, capacitance, bias and gain. The meanings of these words, however, and the formulas that express them, are entirely different, as are the relations between them. In fluidics, Ohm's law, that basic of electrical engineering, is gone forever.

In its place, new formulas and new characteristics are being developed and defined so that design engineers can know just what a particular component will do by reading its specificatons.

As one engineer put it: "We are now at the point where we can design on paper a control system with components which we have on the shelf now, put the system together and be pretty sure it will work without a lot of changes." Having reached this stage, the fluidics industry is well on the way to maturity and mass production. Its proponents say that, on the basis of cost and reliability, they will take over a jumbo share of the automated control field.