TECHNOLOGY

Printing Replaces Wiring

Radios, TV sets and phonographs without internal wiring will soon be coming off the mass production line. They will use printed circuits instead of conventional wiring.

By SCIENCE SERVICE

➤ SPAGHETTI is definitely on the way out, engineers agree.

They are not referring to Italian cuisine, but to the jumble of spaghetti-like wiring they have to contend with in today's electronic equipment.

Your radio and TV sets have their share of this spaghetti inside the chassis. More advanced electronic devices have wiring systems that look very much like a course from an over-generous Neapolitan kitchen.

This tangle of wires can be and is being eliminated by a fast-growing automatic production method called printed circuitry. In the system, a metallic pattern that looks somewhat like a printed maze is stamped or engraved onto a plastic card. The pattern replaces the wiring completely. Electric current courses through the printed lines just as it does through wires.

The system eliminates the tedious, time-consuming job of the solderer, who must connect each wire in a radio to the proper terminals. It may take him hours to wire up a complex electronic device like a radar set, but with printed circuit techniques, scores of similar devices could be run off by machine in the time it takes him to complete one.

Lower Costs Foreseen

To the consumer, the high-speed production that printed circuits imply should mean far lower cost for common household devices. Printed circuit radios and TV sets, when mass produced, will also be more dependable and easier to maintain.

Smaller size of printed circuits, which lie flat on a card and do not bulge with tangled wires, can make wrist watch radios, television sets that you can hang on the wall like a picture and pint-sized electronic "brains" available at reasonable costs.

Once the circuit is printed on the card, machines drop the electronic components, like vacuum tubes, diodes, resistors, coils and the other electronic paraphernalia into place, completing the device's electronic works.

Thus the whole process for manufacturing the myriad of electronic devices can be handled by machine, a major step toward automation.

Engineers today are refining the technique. They are working hard to develop sub-miniature components to go with the printed circuits. Some components, such as resistors and capacitors, can actually be printed onto the card with the wiring.

Designers envision the day when today's bulky components will be so small that the entire circuit for a radio or TV set would lie nearly flat on a card.

The invention of the transistor, a pea-sized semiconducting device that can replace the bulky vacuum tube, has given great impetus to printed circuitry. The marriage of the transistor and the printed circuit promises devices of extremely small size that cost far less and use less power.

To cut down further on size, engineers have developed sub-miniature parts that could be used with the transistor to complete the circuit.

A promising application of the new printed circuit technique is in the so-called electronic "brains." These digital computers, which can calculate in minutes what might take a skilled mathematician years, are made up in part of hundreds of identical switching units, called "flip-flops."

They have that name because they can register only two electronic reactions, corresponding to "yes" and "no." If a flip-flop cell, which in a sense corresponds to a human brain cell, could be reduced to the surface of a card, the size of the computer could be cut immensely.

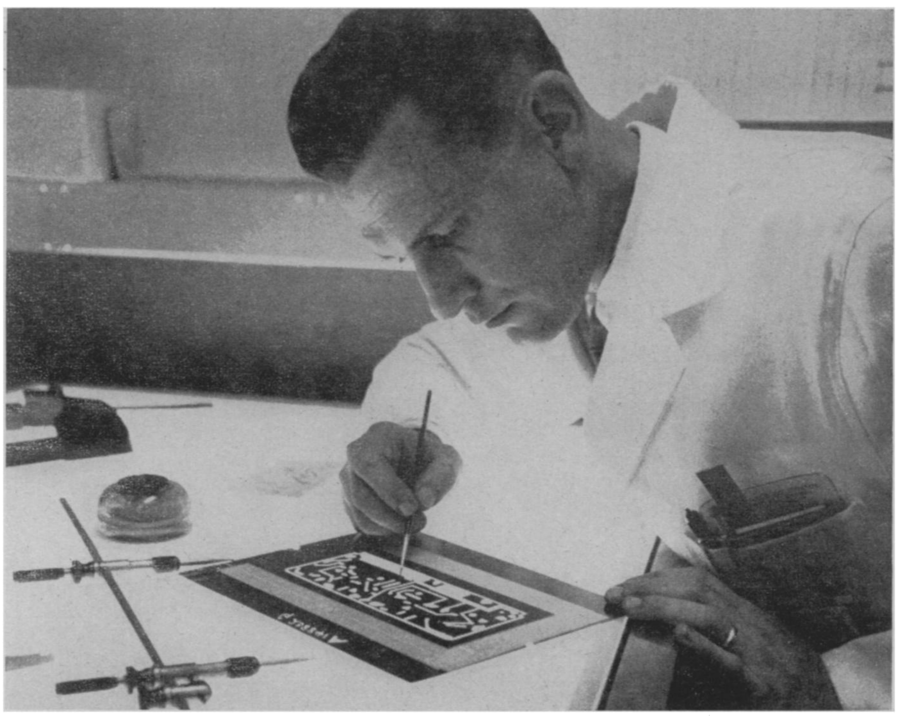
DYSEAC, the National Bureau of Standards' newest digital computer, has about a thousand such circuits, each of which is partially printed.

The major electronic firms are now racing to be the first to make a small-sized computer with high versatility. The advantage, again, would be not only in size, but in production speed and low cost.

Maintenance, too, would be cheaper, since the flip-flop units would be cheap. If one went bad, a new one could simply be put in its place.

In your TV set of the future, the printed circuit could be used in conjunction with the newly developed flat TV tube and a flat electrostatic speaker to make a self-contained picture-like unit. Just hang it on any nail, plug it in and tune in your favorite television show.

One system is the National Bureau of Standards' "Tinkertoy" method. Identically shaped, notched ceramic wafers containing different printed circuits are stacked one upon the other to obtain the desired electronic effect. As in junior's erector set, the pieces must be assembled individually,



2-D CIRCUIT—The master pattern for a printed circuit is touched up by a Bell Laboratories engineer. From the negative, metallic imprints of the pattern that can replace wires will be mass produced. Bright lines on the master sheet indicate where the printed wiring will be engraved.

but machines can whip almost any type of device together very quickly.

Another system is provided by the Signal Corps and General Electric's new automated printed circuit system now being completed at Ithaca, N. Y., designed to serve as the heart of an automatic factory. This is the automatic phase of the "Auto-Sembly" system developed by the Fort Monmouth laboratories shortly after World War II. Pilot production is tentatively planned on selected Signal Corps equipment.

Complete circuits for a wide variety of devices can be assembled automatically in one step. Printed circuit cards are fed into the machine, which connects all the components in the proper place. The completed unit is then dipped into a solder bath where all the parts are securely fastened at once.

System Very Flexible

One advantage of this system, worked out by the Army Signal Corps, is extreme flexibility. The machine can be set to make almost any type of electronic circuit, one right after the other. Circuit revisions can be made in the master pattern with very slight delay, the change being automatically accommodated through the system. Such a factory is seen as very important to national defense, for in a short time it can be converted to producing urgently needed electric and communications units.

The basic system allows mass production, miniaturization and reduction in cost.

Wiring errors are eliminated, and completed units are tested and rejected automatically if faulty.

One of the first applications of the printed circuit was the proximity fuse, needed by the thousands in World War II. These electrical triggers for artillery set off the charge in a shell when it reached a specified distance from the target. Speed of production, accuracy and small size were essential, making the printed circuit ideal for the application.

Printed Proximity Fuses

To produce them in such large quantities would have been a difficult chore indeed, but printed fuses filled the bill.

The proximity fuse gave the printed circuit its first big push. As the war progressed, more applications were found. Today many guided missiles, modern jet planes, radar beacons and other communications equipment employ the printed circuit.

The consumer is now benefiting from this military experience. A 1955 model Admiral television set was developed with its wiring printed on a plastic card on the chassis. Some radio sets employ these new 2-D circuits and the Webster-Chicago Corporation recently announced it has applied printed circuits to phonographs for the first time.

Printing has even invaded telephone communications. Tubes that pipe many conversations at a time over long distances can be replaced by a printed microwave tube that has many of the properties of a coaxial cable.

New and important as it is, printed circuitry is an old art, borrowing techniques used for centuries in the manufacture of china and for decades in the engraving industry.

The most popularly used method of etching printed circuits uses essentially the same process that makes the metal images for the pictures and cartoons that appear in newspapers and magazines. The image of the circuit is printed photographically onto the surface of a metallic coated sheet of plastic. The areas where the printed wires are desired are protected by an anti-corrosive chemical. The plate is then immersed in a solution that eats away the unprotected metal, leaving the desired pattern. It has been estimated that about 75% of the printed circuits used today are produced in this way.

Most of the rest of the circuits are manufactured in very much the same way as china is decorated. Machines print or silk-screen the wiring pattern on a ceramic surface with metallic paint. The slab is then baked to fuse the paint to the surface.

In the third common method, a heat press stamps out the circuit on a plastic card coated with an adhesive-backed sheet of copper. The excess metal is then stripped off.

Printed wiring is primarily a production tool, Gustav Shapiro, chief of the engineering electronics section of the National Bureau of Standards, said. Nothing can be done with printed circuits that cannot be done with ordinary wiring, but the technique lends itself ideally to automation, the coming trend in industry.

Automation, or automatic assembly, has been described as the second industrial revolution, and printed circuits are destined to play an important part in it.

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• Books of the Week •

For the editorial information of our readers, books received for review since last week's issue are listed. For convenient purchase of any U. S. book in print, send a remittance to cover retail price (postage will be paid) to Book Department, Science Service, 1719 N Street, N.W., Washington 6, D. C. Request free publications direct from publisher, not from Science Serivce.

CANCER OF THE LUNG: Pathology, Diagnosis and Treatment—Milton B. Rosenblatt and James R. Lisa—*Oxford University Press,* 330 p., illus., $15.00. Correlation between clinical and pathological findings has been stressed throughout to provide a more basic understanding to the problem of early diagnosis.

ENJOYING MODERN SCIENCE—Victor C. Smith and W. E. Jones—*Lippincott,* 2nd ed., 466 p., illus., $3.32. Science in readable form for the eighth grader.

EXPLORING MODERN SCIENCE—Victor C. Smith and W. E. Jones—*Lippincott,* 2nd ed., 353 p., illus., $3.12. The seventh grade textbook in the Science for Modern Living series.

GUIDE TO INSTRUMENTATION LITERATURE—W. G. Brombacher, Julian F. Smith and Lyman M. Van der Pyl—*Govt. Printing Office,* National Bureau of Standards Circular 567, 156 p., paper, $1.00. To assist research investigators, instruments users and others interested in utilizing the extensive and scattered literature on instrumentation.

LOST COST HI-FI—Donald Carl Hoefler—*Arco,* 132 p., illus., $2.00 Containing hundreds of hints for budget high fidelity.

MODERN SURVEYING: For Civil Engineers—Harold Frank Birchal—*Philosophical Library,* 2nd ed., 528 p., illus., $15.00. Dealing with the subject of surveying in a practical manner to aid the engineer working in the field or on a definite project. Including photographic and aerial surveying.

NINETEENTH SEMIANNUAL REPORT OF THE ATOMIC ENERGY COMMISSION—Lewis L. Strauss, Chairman—*Govt. Printing Office,* 200 p., illus., paper, 60 cents. Reporting the activities of the past six months, with a special section on the International Conference on the Peaceful Uses of Atomic Energy. (See SNL, Feb. 11, p. 95.)

101 ATOMIC TERMS: And What They Mean—*Esso Research and Engineering Co.,* 20 p., illus., paper, free upon request direct to publisher, 15 W. 51st St., New York 19, N. Y. A popular-type glossary defining terms used by atomic scientists, many of which are peculiar to atomic energy.

THE POWER TO GO — Merrill Denison — *Doubleday,* 324 p., illus., $5.00. The story of the automotive industry in America.

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY: Volume 14, General Aspects of the Use of Radioactive Isotopes: Dosimetry—*United Nations (Columbia University Press),* 305 p., illus., $6.50. Describing production, handling and distribution of radioisotopes, as well as techniques that have been developed for the measurement of detailed properties of the various radioisotopes, including monitoring in industrial situations.

ROCKS AND MINERALS—Richard M. Pearl—*Barnes & Noble,* 275 p., illus., $1.95. Explaining how rocks and minerals are classified, how they can be recognized and identified, and how they should be collected and displayed. Including some color plates to aid identification.

SCIENCE ACROSS THE LAND—Victor C. Smith and Barbara Henderson—*Lippincott,* revised ed., 223 p., illus., $2.24. Giving suggestions for experiments for the fourth grader to do to help explain the new things he is learning about science.

SCIENCE ALONG THE WAY—Victor C. Smith and Katherine Clarke—*Lippincott,* revised ed., 128 p., illus., $1.72. Introducing the first grader to science.

SCIENCE AROUND THE CLOCK—Victor C. Smith and Katherine Clarke—*Lippincott,* revised ed., 160 p., illus., $2.00. A textbook for the third grade student.

SCIENCE BENEATH THE SKIES—Victor C. Smith and Barbara Henderson—*Lippincott,* revised ed., 352 p., illus., $2.48. Included in this textbook for the sixth grade students is a section on science fairs.

SCIENCE THROUGH THE SEASONS—Victor C. Smith and Barbara Henderson—*Lippincott,* revised ed., 352 p., illus., $2.36. For the fifth grader.

SCIENCE UNDER THE SUN—Victor C. Smith and Katherine Clarke—*Lippincott,* revised ed., 160 p., illus., $1.88. Science for the second grader.

SOURCES OF INFORMATION AND UNUSUAL SERVICES—Raphael Alexander, Ed.—*Informational Directory Co.,* 4th ed., 64 p., paper, $2.00. A guide to information, pamphlets and services available from organizations and agencies in the United States. The fourth edition contains 170 new entries.

TERRACOTTA FIGURINES FROM KOURION IN CYPRUS—John Howard Young and Suzanne Halstead Young—*University Museum,* Museum Monographs, 260 p., illus., paper, $5.50. A study of the mass of figurines uncovered by the excavations at Kourion, on the island of Cyprus, undertaken by the University Museum of Philadelphia between the years 1934 and 1948.

THROUGH THE MATHESCOPE — C. Stanley Ogilvy—*Oxford University Press,* 162 p., illus., $4.00. In other sciences, such as astronomy, scientists have instruments like the telescope to aid them in their study. Although the mathescope is not a physical instrument, it should help to "view" this introduction to some of the more interesting elements of mathematics "through the mathescope," a term invented by Watson Davis, director of SCIENCE SERVICE.

USING MODERN SCIENCE—Victor C. Smith and W. E. Jones—*Lippincott,* 2nd ed., 654 p., illus., $3.96. A general science textbook for ninth grade students.

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