Founded in 1872,
Vol. 167: No. 2

POPULAR SCIENCE
REG. U. S. PAT. OFF. Monthly

Mechanics and Handicraft
REG. U.S. PAT. OFF.

America's Leading New-Idea Magazine for 83 Years

AUGUST, 1955

(More features and departments are listed on page 4)

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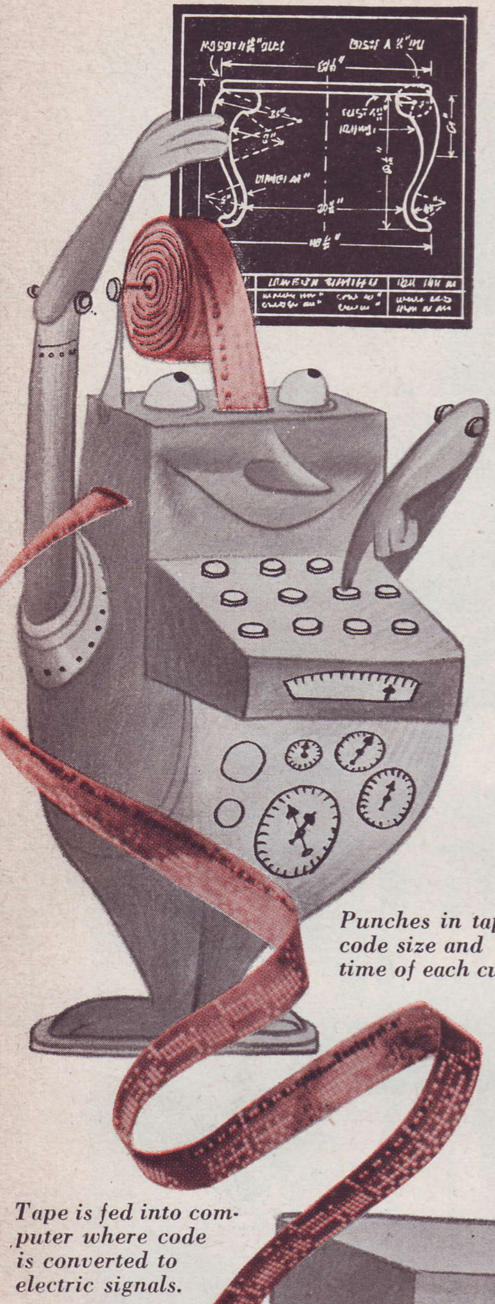
Published monthly at 353 Fourth Avenue, New York 10, N. Y., by Popular Science Publishing Co., Inc., Godfrey Hammond, Chairman of the Board; Ralph H. Flynn, President and Treasurer; Franklin E. Parker Jr., Secretary; Eugene Watson, Vice-President. Second-class mail privileges authorized at New York, N. Y. and Dayton, Ohio. Entered as second-class matter at the Post Office Department, Canada. Printed in U.S.A. Yearly subscriptions to United States, its possessions and Canada, $3.40 (2 years, $6.00; 3 years, $8.00); foreign countries $1 per year extra. Four weeks' notice is needed to change a subscriber's address. Please give both old and new addresses, including postal zone numbers.



Punches in tape code size and time of each cut.

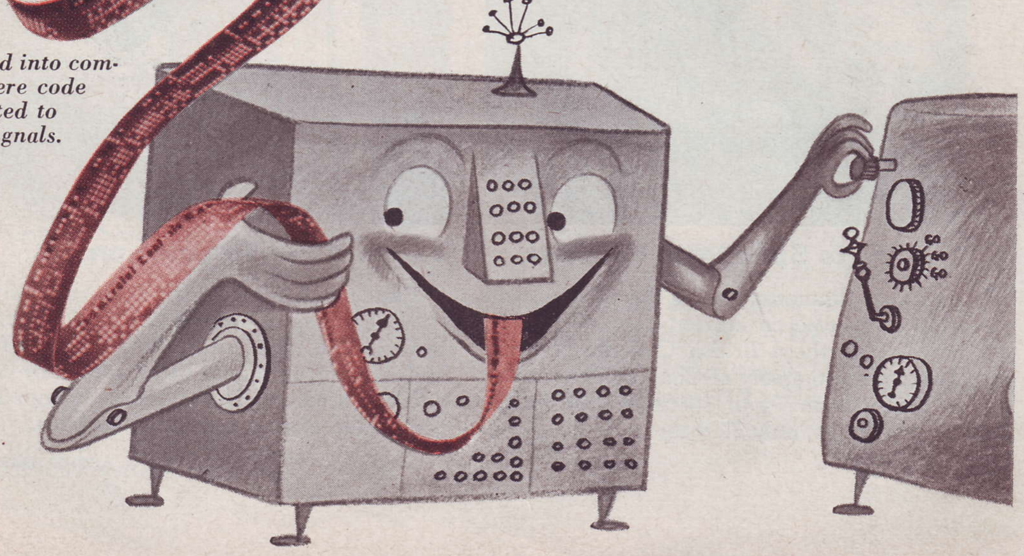
In an electronic lab at MIT, engineers now are

Teaching Power Tools to Run Themselves

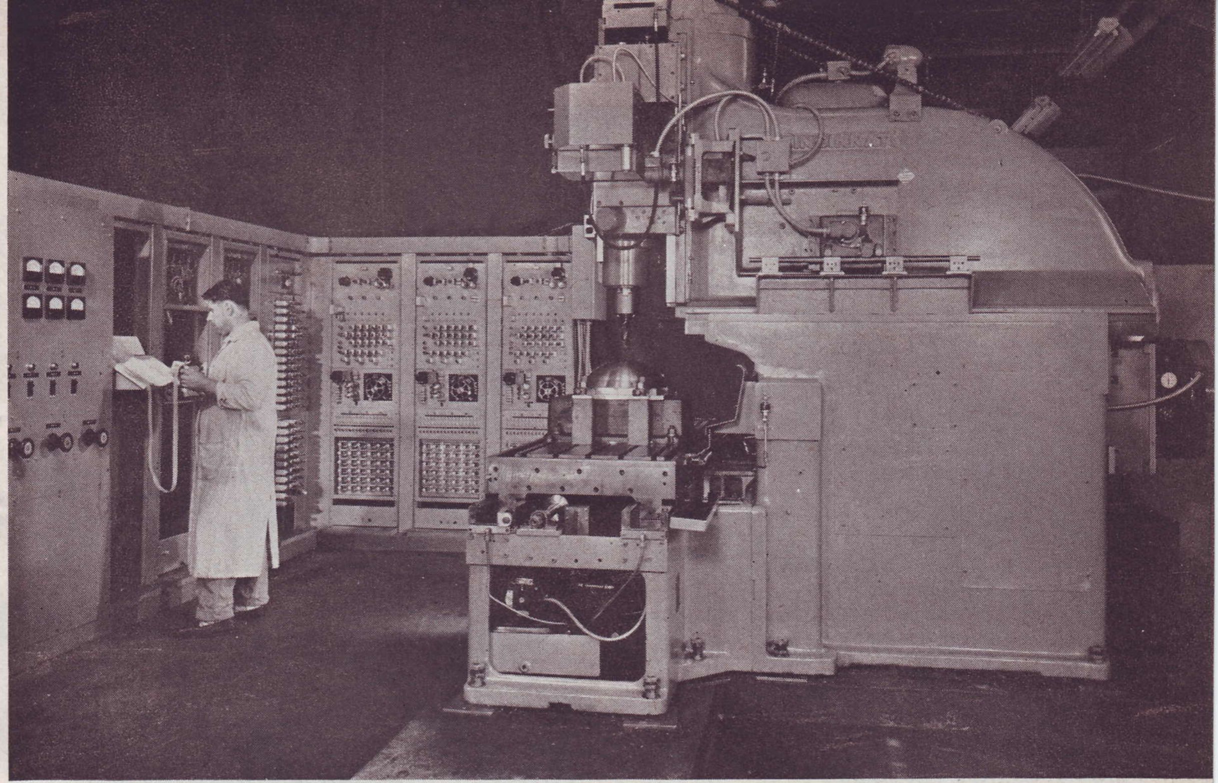
By Hartley E. Howe

SO JOE WORKSHOPPER figures he'd like to turn out a set of dining-room chairs—and at the same time break in his new Model 100 Super Tapemaster. Joe whips down to the hardware store and looks over photographs of different designs. He settles on a Swedish pattern popular 'way back in 1955—delicate and handsome, but full of difficult reverse curves.

That doesn't worry Joe. He plunks down $10 for a week's rental of a batch



Tape is fed into computer where code is converted to electric signals.



Too big yet for home shop, this MIT milling machine is run by computer-control at left.

of tapes—one each for legs, arms, back and seat.

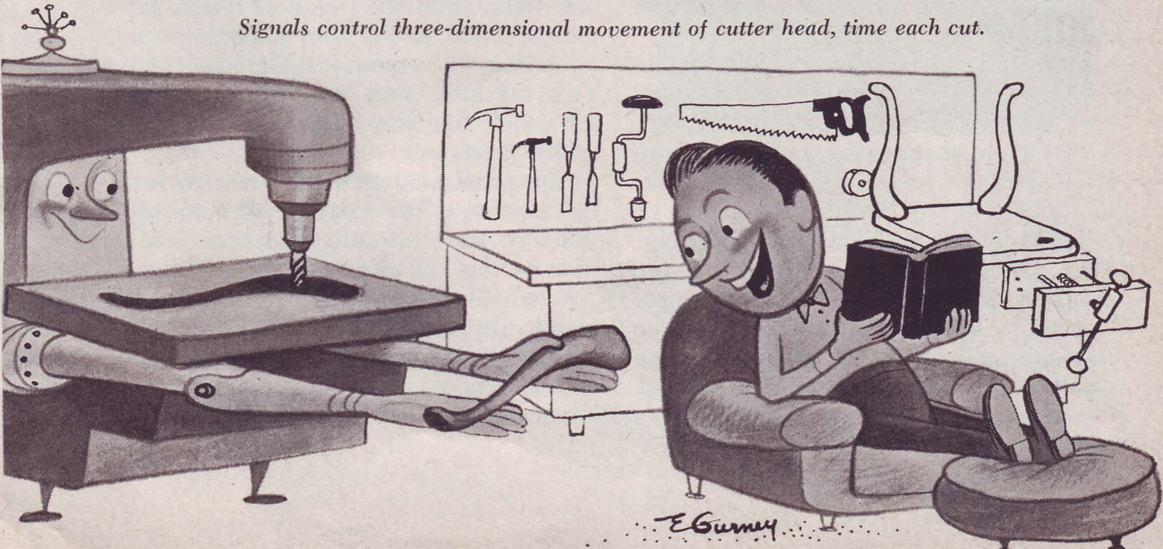
That night, he clamps a nice piece of birch into his Tapemaster, slips the tape into the control box, flips the switch, and sits back with his pipe and the new issue of *Outdoor Life*.

Forty minutes later, the rumble of the Tapemaster stops and Joe takes a look. One leg is finished. So he clamps on another piece of birch . . .

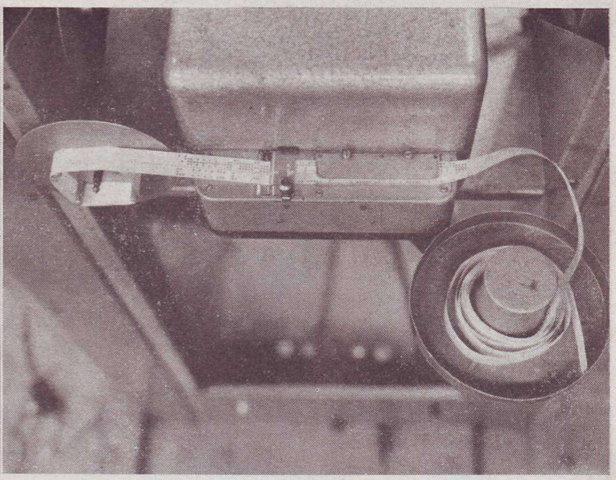
Sure it's a dream—in 1955. But the engineering basis for Joe's Tapemaster exists right now. Sitting up in the Servomechanisms Laboratory of the Massachusetts Institute of Technology in Cambridge, Mass., is a milling machine that will turn out any metal part at the command of a little roll of tape. Originally a standard, vertical 28″ Cincinnati Hydro-Tel, it now has hitched to it $50,000 worth of electronics.

To conceive, design and build the MIT machine took some quarter-million

Signals control three-dimensional movement of cutter head, time each cut.



PAPER TAPE is punched on standard equipment used in teletypewriters. Operator follows code directions, in which blueprint lines have been changed to column of figures.



TAPE READER pushes needlelike fingers against paper strip. Wherever there is a hole, steel finger goes through and completes an electrical circuit, sending a code signal.

dollars, 250 electron tubes, 280 pilot lights, 175 relays—and brilliant engineering on the part of Tech's Department of Electrical Engineering. As father of a whole new family of machine tools, it will earn its keep many times over.

What we can expect. Whether such industrial giants can be scaled down to home-shop size and price is anybody's guess. But it is no guess that these tape-eaters are going to bring a lot of eye-opening changes to industry. Someday, perhaps . . .

• A remote overseas base will be able to make a desperately needed part in a few hours by plugging a machine tool into a radio receiver.

• Machines in factories spotted across the country will all be controlled from one central headquarters.

• Little machine shops will be able to do big jobs by buying or renting control tapes.

• Automobiles may change design more often—perhaps even seasonally—thanks to tapes that cut tooling-up costs.

Three things make all this possible: First, blueprints can be converted into numbers (hence the name "Numerical Control"). Second, the numbers can be converted into a perforated paper tape which generates electric signals. Third, the signals can operate controls of a machine tool—to make the part on the blueprint.

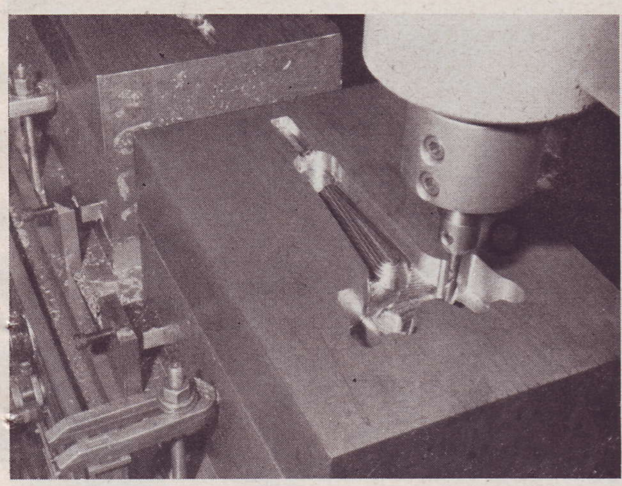
Turning a blueprint into holes in a tape—"programming," they call it—requires a man who knows machining, tools and metals. He has to break up every curve in the design into straight lines. The automatic machine cuts straight lines only—but they can be as short as .0005 inch. A series of such lines is a curve for all practical purposes.

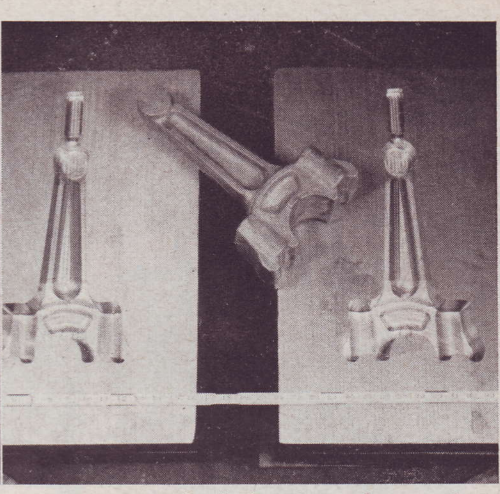
The programmer next translates each straight line into numbers. Three numbers represent distance of cut in each direction: up or down, back or forth, sideways. A fourth number tells the time the cut will take.

Typing out a pattern. The programmer then codes the numbers into a pattern of holes in the slim paper tape by operating a typewriter-like machine. This machine, and the tape it makes, are much like the ones used for high-speed Teletypes.

The programmer's final job is to feed the tape into the machine director, essentially an electronic computer. From now on the machine is on its own.

When the tape is run through the director, tiny steel needles finger the holes and read the numbers, changing them into electrical signals. These signals can be recorded, transmitted by radio or wire,





DIE BLOCK for master piston rod of a radial aircraft engine was cut automatically in solid steel, using tape controls. Run was continuous except for halt to change cutter.

PAIR OF DIES is checked against a dummy piston rod molded in dies made in earlier run. Exact fit showed complete duplication resulting from re-use of the same control tape.

and reproduced anywhere in the world.

From these signals, the computer figures the rate of feed and orders servomechanisms to adjust the speed controls of the machine's three hydraulic feeds.

The actual movement of the cutter through the metal may be momentarily slower or faster than expected because of variations in metal hardness and dulling of the cutting edge.

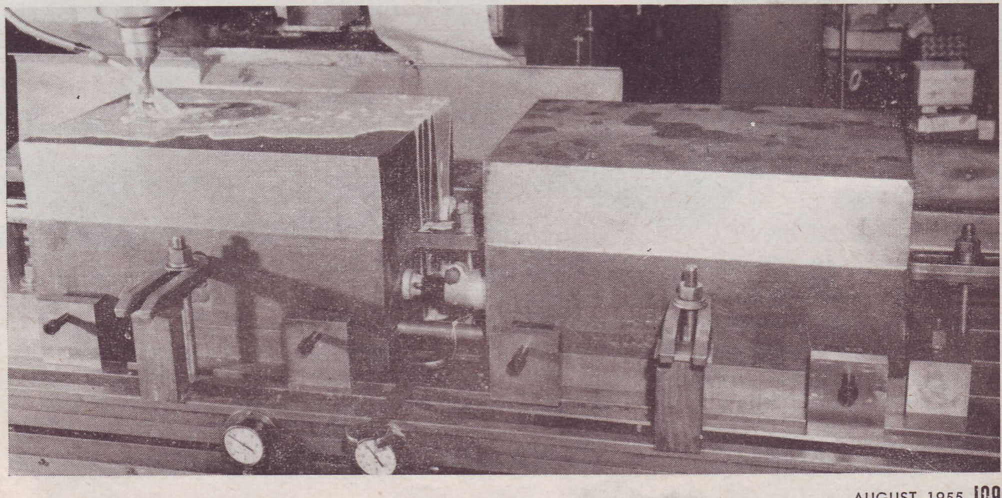
To catch such errors, the computer constantly inspects both the orders received by the servos and the actual movement of the cutting tool. If either differs from that on the tape, the computer automatically sends corrections.

These "feedback" inspections do a good job. The control system is accurate to .0005 inch, much more precise than the .002-to-.004-inch tolerance of the machine itself.

Despite its complexity, the numerically controlled machine is dependable. If anything goes wrong in the controls or machine, alarm circuits stop everything before the work can be damaged. In thousands of hours of operation, the elec-

[*Continued on page 222*]

NO HUMAN OPERATOR had to watch work, so blocks were covered with wetting agent during die cutting. This speeded work, reduced cutter wear. Note next block ready on table.



Teaching Tools to Run Themselves

[*Continued from page 109*]

tronic director has been down only three percent of the time. Much of this was due to a design defect now corrected.

Remote control, repetition of operations, saving in skilled manpower—these advantages of the MIT control system are important. But what makes the industry really happy is that it can do a run-of-the-shop job faster and better.

Up to now, automatic machine tools have been either very expensive special machines that make one part and no other or general-purpose machines that must follow a costly model or template. A skilled operator must still handle some controls and determine running speed.

Makes any part. The tape-controlled machine can be used for any part, not just one. There is no expensive process of modelmaking. And the final run is at high speed, completely automatic and completely accurate.

Making a particular airplane part by conventional methods requires 27 hours for set-up and a 169-minute milling operation. Making the same part with tape controls requires 16 hours for tape preparation, two hours for set-up, and a 39-minute run. For any re-run the tape preparation would be eliminated, and the saving would be 27 hours and 10 minutes!

Standardized components and circuits can be expected to trim the cost of the MIT system sharply on production models. Even so, the computer for the director is unlikely ever to become exactly cheap. Fortunately, however, one director can control as many machines as desired—and at any distance. Thus a director is not needed for each tool.

But what really takes Numerical Control out of the millionaire brackets is the fact that the electronic signals produced by the director can be recorded magnetically. Any machine fitted with the necessary servocontrols—far less costly than a director—can use this magnetic recording to direct its movements. Thus a machine owner who can obtain record-

[*Continued on page 224*]

Teaching Tools to Run Themselves

[Continued from page 222]

ings doesn't even have to own a director.

And soon it will be possible to convert ordinary non-automatic machines to tape controls at minimum cost. Work tables will be made with all three feed mechanisms, and all servocontrolled. The cutting head itself can be fixed in place.

Thus the uses of automatic controls are not likely to be limited to the big boys of industry. Medium-sized concerns that don't want to make a big investment in a director-computer will be able to send a blueprint to a computer service center. Back will come a custom-made recording of the product that can be plugged right into a machine. Such computer service centers already exist.

Big mass-production industries like auto making will find plenty of uses for Numerical Control. It can mean more frequent changes in models—and more specialized types such as sports cars and sportsman's wagons. Today the body dies for each model require an expensive process that starts with clay models, proceeds through a series of carved wooden replicas, and is climaxed by a steel die practically worth its weight in gold. With Numerical Control, there will be a far smaller investment to be paid off.

Plane makers have long been eager to utilize automatic machines, but the production run of a typical aircraft part is too short to pay off the big cash investment needed for the specially built, one-purpose type. Tape controls provide automatic machines that can do many different jobs. A whole family of such machines is being developed by aircraft builders and machine-tool companies.

Some experts predict that rocket-plane parts of the near future will be beyond the ability of human machine operators to turn out. It will be automatic tools or nothing. END

Auto-Suggestion

The sign which contributes most to safe driving is the one on the side of the car that reads "Police."—*Hudson Newsletter.*