Automatically Controlling Mach

Keyboard of Digimatic machine tool control. Dimensional information concerning the part to be produced is entered into high-speed computer by means of this keyboard.

By GILBERT C. CLOSE

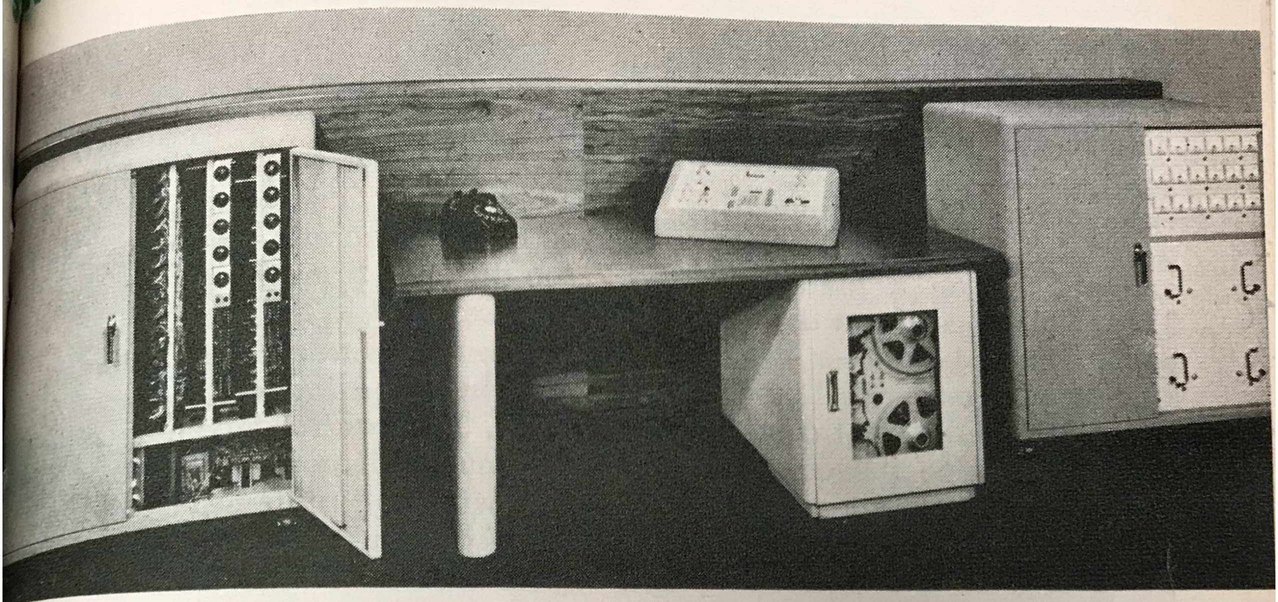
A control tape produced on a planning desk in one city could be duplicated by telephone anywhere in the world, placed in a machine control unit, and production of the part immediately started.

"Automation" and "push-button factory" mean the same thing to a lot of people. However, it will be a number of years before many factories enjoy automation in this fullest sense of its meaning. But during the interim, thousands of plants will begin to automate here and there, in spots along the production line, not necessarily removing an employee, but minimizing his chances to commit a human error.

It was this more rational aspect of automation that guided engineers at Electronic Control Systems, Inc., of Los Angeles, an affiliate of Stromberg-Carlson and a subsidiary of General Dynamics Corporation, when they began development of the company's recently announced "Digimatic" control device for shop machines. The "Digimatic" could be incorporated in a push-button factory control system, or just as handily used to control a single milling machine in the center of a large shop where everything else was done by hand.

In fact, Leonard Mautner, president of Electronic Control Systems,

Machine Operations



Planning desk of Digimatic numerical control device developed by Electronic Control Systems, Inc., for automatic control of machine tools. At left is high speed decimal computer which interpolates dimensional data into signals for controlling machine's servomotors. Pulses are recorded on magnetic tape by a recorder located in the right pedestal of the desk in center. Keyboard for entering dimensional data is mounted on the desk. The cabinet shown at the right contains the power supply for all units of the planning desk.

made the statement that the chief markets for the new device would undoubtedly be among smaller and medium-sized shops that wanted to approach automation cautiously and well within the limitations of their budget. "The Digimatic is a relatively low-cost installation, requires little space, can be maintained as easily as a television set, and any machine operator who can read a blueprint can be trained to use it in a few hours," Mautner said.

The Digimatic consists of two principal parts—the planning desk, including a high-speed decimal computer and tape recorder, and a control unit which governs the operation of a machine by transmitting the electrical impulses recorded on the tape into the operation of servomotors which in turn control the machine through its various axes of movement. The device checks itself throughout its operation. If an error occurs in the planning desk section, a light flashes to warn the operator. If an error occurs in positioning the machine on any one of its axes, delicate sensing instruments flash this information to the amplifiers in the control unit, and adjustments are made automatically. In fact, this sensing unit operates so swiftly that errors in machine movement do not have time to occur, but are kept at a zero level.

Briefly, this is how the Digimatic

"The number of channels any tape contains is determined by the design of the recording head . . ."

works. A coordinated reference point is established on the blueprint (either during its drafting, or on a print that has already been drafted). All distances on the blueprint are calculated from this reference point and entered on a planning sheet. These "distances from the reference point" may be either transverse, longitudinal, or vertical on a job involving three different directions or axes of machine movement. Thus, for a straight milling machine cut, the distance the machine would have to travel from the reference point, both longitudinally and transversely, would be calculated. Then the vertical travel to bring the cutter into the work would be calculated. If a circle rather than a straight line was to be cut, this fact would be noted on the planning sheet along with the distance from the blueprint reference point to the circle center.

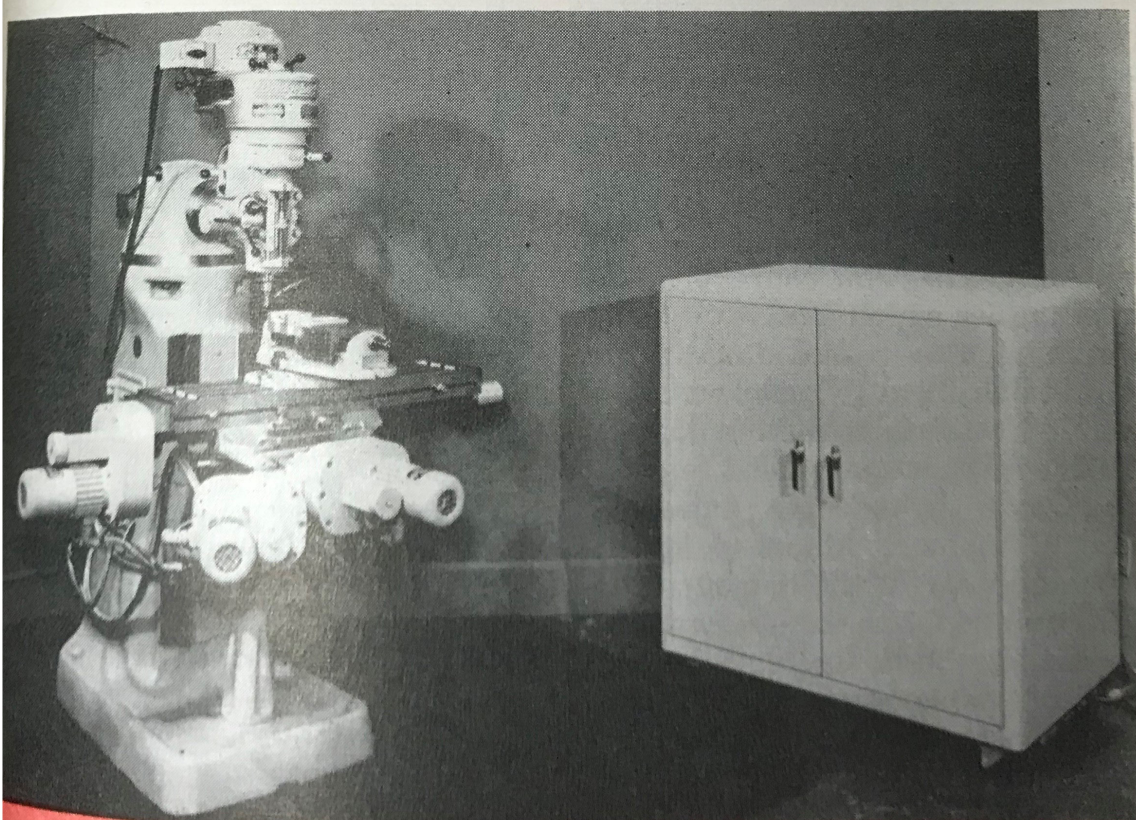
Next, it is necessary to impart this information to the control tape. The control tape used in the Digimatic demonstration was ⅝-inch wide and contained eight channels for eight different types of recorded information. (The number of channels any tape contains is de-

Operator entering dimensions of part to be produced into Digimatic planning desk. Computer, in cabinet at left, interpolates dimensional information into pulse signals which are recorded on magnetic tape. Cabinet at right contains power supply for all units.

termined by the design of the recording head in the tape recorder.) Two of the channels on the demonstration tape contained information for right and left-hand longitudinal movements of the milling machine table in use; two more channels contained information for forward and aft transverse movements; two for upward and downward vertical movements. The remaining two channels were not used in the demonstration, but could have been used either for rotating or tilting movements if such had been possible or necessary.

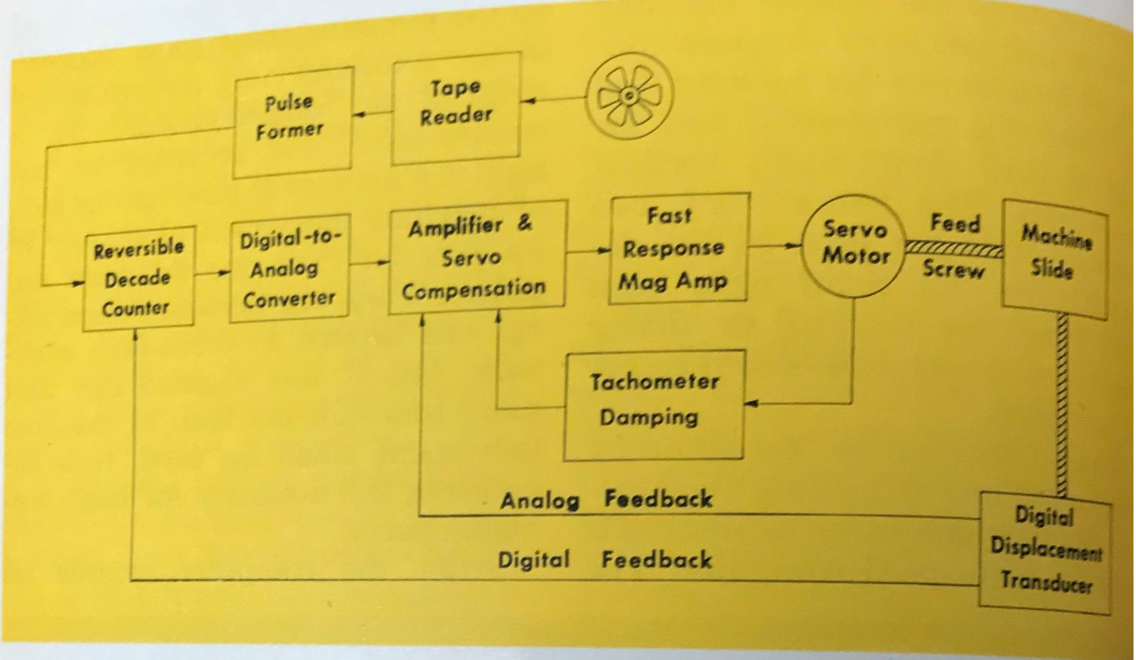
The information on the planning sheet is fed into an adding machine-like device which in turns transmits it to the high-speed computer. The computer "stores" this information until the operator has finished. The operator then presses a button marked "Compute," and the computer goes into action. All distances listed on the planning sheet (now "stored" in the computer) are automatically reduced to "one-thousandth inch components" and recorded on the tape in a manner to produce one inch of machine movement along any of its axes for each one thousand impulses. Thus, the demonstration set-up was limited to 0.001-inch accuracy, but it was pointed out that more impulses per inch of machine movement could be used, thus increasing the accuracy for high precision parts.

After the computer records all



ertical milling machine and Digimatic elec-onic control unit. Numerical instructions, au-matically computed by the planning desk and recorded on magnetic tape, control operation of the milling machine. Digimatic is development of Electronic Control Systems, Inc.

"The number of impulses received by the motor control determines how long the motor would operate . . ."



Machine tool control functional block diagram. Courtesy Electronic Control Systems, Inc.

data from the planning sheet on the tape, the tape is rewound and then "played back" into the machine control unit. This unit contains a power amplifier which receives the electronic impulses recorded on the tape and builds them to sufficient amplitude to operate a servomotor control. A servomotor is used to power each axis of machine movement. The Bridgeport Model J milling machine used in the demonstration was equipped with three servomotors for the longitudinal, transverse, and vertical movements of the table. Thus, each motor received right or left-hand rotational directions from the two tracks on the tape set up to control it. The number of impulses received by the motor control determined just how long the motor would operate, and thus how far it would drive the table in any direction of movement. If, for instance, the table had to move two inches to the right, two thousand impulses would be received from the tape channel controling that particular direction of movement along that particular axis.

Each servomotor is equipped with a delicate sensing device which tracks its movements. Whenever motor movement (interpolated in terms of machine movement) does not correspond with the number of impulses it is receiving from the tape, this information is flashed back to the amplifier and adjustments are made automatically. Thus, there is no chance for an error to occur between tape instructions and actual motor operation.

Dials are used on the Digimatic control keyboard for modifying the instructions imparted to the computer (and then to the tape). One dial can be set to speed up or slow down the sequence in which the impulses are recorded on the tape, thus eventually speeding or slowing the machine operation. Another dial is set when it is wished to machine a circle. When a circle is being machined, two of the servomotors are in operation at the same time, with their speeds synchronized in a manner to move the table in a circular motion, either through an arc, or through the complete circle.

While the above may sound somewhat technical, most of what has been said is in the province of the electronic engineer and has no direct bearing on the operational aspects of the Digimatic. From the standpoint of the machine shop operator, he merely establishes the reference point on his blueprint, measures the distance from the reference point to the machine positions necessary to cut the desired part, puts this information on a planning sheet, and then uses this planning sheet to impart the information to the computer by means of the Digimatic keyboard. From there on, the process is fully automatic, except that the machine operator has to place the blank material in the machine.

As the Digimatic has nothing to do with machine operation except control its movements along preselected axes, it is quite obvious that it could be adapted to almost any shop machine. While a machine control unit is required for each machine so adapted, a single planning desk can be used to prepare the tape for a number of machines. Tapes can be easily duplicated for production of the same part on different machines. In fact, a tape produced on a planning desk in Los Angeles could be duplicated by telephone anywhere in the world, placed in a machine control unit, and production of the part immediately started.

While exact cost figures are still not available, company officials estimate that the cost of the planning desk, including keyboard, computer, and tape machine, will be about $25,000. Cost of the machine control unit and servomotors will run about $5,000 per machine axis. Thus, it would cost about $15,000 to automate a three-directional milling machine plus the $25,000 for the planning desk setup. But as additional milling machines were added to the system, it would cost only $15,000 each because all machines could use the same planning desk.

"C. B. you old slave driver, guess who's rich uncle died leaving his favorite nephew a small fortune."