

# GE TIME-SHARING SERVICE MAKES NEWS

Field of Manufacturing



# AUTOMATION LOOK TO TIME-SHARING IN PREPARING n/c TAPES

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It is wise to attempt to plan manufacturing activities. It is also wise to recognize that planning cannot foresee all problems that will arise. Fast responses to the unforeseen are required. Increasingly in N/C machining, this requirement can be met only if a programmer has immediate access to a computer. Time-sharing of a computer via telephone hookup provides this immediate service to any size company, almost anywhere.

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AT ONE TIME it appeared that numerical control would be one of those "improvements" that created problems that are more difficult than the ones it solved. Early users of N/C found that once a tape was prepared the control could, in fact, guide a machine through its operations in a manner that outperformed a human operator. However, tape preparation was a problem. Major users were confronted with the problem of learning and using a special, complex "language" or code in order to communicate with each different machine and control they used. And this on top of the need of N/C to be fed great quantities of specially prepared, detailed data. It was necessary to describe how the centerline of a tool should be moved in order that its cutting edge would create a desired shape to a desired tolerance.

As described, the problem of tape preparation was most severe for early users of contouring controls—and those were primarily found in the aircraft industry. That industry was also well acquainted with the computer and recognized its potential as an aid in solving the tape preparation problem.

In 1956, the Air Force awarded a contract to Massachusetts Institute of Technology which was interpreted as a mandate to pursue automatic programming research for industrial applications. Since M.I.T. did not have the staff necessary to create a complete automatic computer program, its efforts were devoted to developing an overall program structure which could eventually be completed by a user. This approach resulted in Automatically Programmed Tool (APT) system.

The extensive time and personnel requirements necessary to develop computer-assist programs were still too great for one company. In view of the importance of N/C, the Aircraft Industries Association formed a numerical control subcommittee that decided to develop the APT general purpose computer program as a cooperative venture. In 1958, the first integrated APT II program for multiaxis contouring was released to AIA companies for field test. Subsequently, a further cooperative venture resulted in improvements and expansions—APT III.

To insure the continuing development of the APT system, the AIA committee formulated an APT Long Range Program (ALRP). The IIT Research Institute now has the basic responsibilities of coordinating and controlling APT activities—supported by AIA members and non-AIA member companies.

APT is, of course, but one of the variety of computer-assist N/C programs that are now available.

However, briefly recounting its particular history should make it apparent how complex a job it is to develop a program—and, by implication, that there must be a considerable advantage to using such programs.

### ► Generalized Programs

The various computer-assist N/C programs that have been developed are known by such names as REMAPT, AUTOSPOT, CAMP, PRONTO, ADAPT, SYMPAC, etc. Some are designed for N/C positioning systems, others for contouring. Each is generally written for use on a particular computer.

In some cases the programs have been developed by a computer manufacturer, in other cases by builders of the numerical controls or the machine tools, in a few cases by combinations of the three interests. As a result some of the programs are designed not only for a particular computer but also a particular machine tool model equipped with a particular control. However, this specialized approach has not proved too attractive because of the effort involved and the large number of possible combinations of machines and controls. The emphasis is on generalized programs.

Generalized computer-assist operations typically follow the pattern shown in Fig. 1. Some experienced person analyzes the engineering drawing and specifications for a workpiece and lists a *part program* that will be processed by the computer. This part program describes what operations the machine tool must perform to produce the part. Since it is destined as an input to a computer, it must be written in a language and transcribed to a form that can be handled by the computer. One of the key advantages of computer-assist programs is the provision for using English-like words as a computer input.

The computer is prepared for receiving the parts program by inputting a set of special instructions, i.e., it is programmed. This computer program is called the *main processor program* or *preprocessor program*. It translates the English-like language of the parts program, performs calculations, and manipulates the data. The output of the computer following these operations is, typically, a CL (cutter location) tape.

In addition to describing the coordinates of the cutter path, this tape also contains the various other instructions dealing with spindle speeds, feed rates, coolant, etc., that were listed on the parts program. However, the CL tape cannot be used to direct a machine tool. It is simply an intermediate stage—

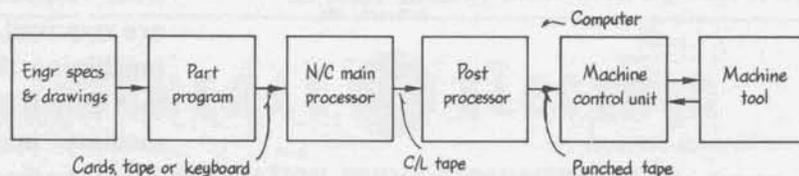


Fig. 1—Diagram indicates flow of data in translating engineering drawings into a part in a numerically controlled system. Essential requirement is that a coded tape be prepared for input to the machine control unit, using a language understood by the control. A computer can assist this task, allowing the part program to be created in English-like words which are subsequently translated into the necessary punched tape for machine control.

a fleshed-out version of the original parts program.

In a subsequent operation, the CL tape information is processed by a computer program tailored to a specific control/machine tool system. This computer program is called a *postprocessor program*. Its output is the actual control tape (typically, punched tape) that will be used at the machine tool.

### ► Advantages of Time-Sharing

For a number of years, generalized computer-assist N/C programs were applied essentially in the distinct steps that have been described. For most companies, this N/C support effort was but one of the many tasks that a computer facility (in-house or outside) was asked to perform. And whenever a facility has a number of different tasks to perform, to obtain efficiency traditionally the tasks are scheduled and run in batches. In effect, efficient facility operations are obtained by making man serve the machine. The only reason the delays of batch processing were acceptable to the manufacturing manager who must operate in a real-time, production environment was that his alternate tape preparation technique—manual coding—had even greater drawbacks.

Computer time-sharing has completely changed this picture. Computer-assisted N/C parts programming can now be made available in a real-time environment even to the smallest user of N/C equipment.

Computer time-sharing is a technique helping people at scattered locations to obtain immediate solutions to problems from a distant computer simultaneously. The computer, linked by ordinary telephone lines to teletypewriters in the user's office, operates so fast that the user thinks only he is using the computer.

Some of the more important advantages of computer time-sharing are:

- **Accessibility.** The computer is as accessible as the weather forecast. Just dial the right telephone number, and the computer will respond. The teletypewriter used to converse with the computer may be located in the part programmer's office. More than one teletypewriter can be installed, and each can have access to the same computer at the same time. This provides the capability of solving several separate problems simultaneously. Also, seldom does a line of users form at a teletypewriter.
- **Economy.** No capital investment in computer hardware is required. Teletypewriter rental and telephone charges together usually total less than \$100 per month. Computer charges are based on usage, and monthly minima, when applied, are in the neighborhood of \$10 per month. General Electric Co., which offers a worldwide computer time-sharing service, finds that a customer may spend as little as \$200 per month for the service, while using it to solve problems in several different application areas.
- **Simplicity.** Most time-sharing service companies have recognized that their users are not data processing experts. They are people with problems, people looking for solutions. To satisfy these people, time-sharing companies have established large pro-

gram libraries, so that solutions to common problems of industry are readily available. The informal conversational language required for programming is so simple it may be picked up in a couple of hours.

- **Capability.** Time-sharing users have access to modern, large and powerful general purpose computing systems, which are solid performers. However, to this author's knowledge, only two-axis contouring with third-axis positioning, and/or positioning (1-2-3 axes) programs are commercially available through time-sharing services. Because of the easy access and fast turnaround time provided by time-sharing, the part programmer does not need to work on several jobs in parallel to best utilize his time. Rather, the part programmer can work each job through from blueprint to tape without interruption. He may increase his efficiency, while the computer takes over the less creative, more tedious aspects of tape preparation. The immediate availability of the time-sharing computer is particularly valuable when errors or engineering changes require a remake of a tape.

### ► Working With Time-Sharing

The actual steps involved in producing tapes using computer time-sharing follow the traditional programming pattern. At a teletypewriter the user types in a series of statements which describe the geometry of the part and the steps required to machine the part, *Fig. 2*. When completed, these statements—which look like abbreviated English sentences—are executed at the remote computer by a geometric processor.

The function of the geometric processor is to compute the tool motions required to machine the part from the information contained in the part program. When the geometric processor has completed its job, it creates a part program of its own. However, this new program contains only a series of simple motion commands (GO TO x-value, y-value, z-value), and any special machining instructions (coolant, feedrate, etc.) previously included in the part program. This new program is ready for postprocessing.

As previously noted, a postprocessor is a computer N/C program that translates cutter location data and auxiliary information into the specific codes and commands required to operate an N/C machine tool in producing the part. The postprocessor must have specific information about the machine/controller characteristics. Sometimes, this information is written directly into the computer program, in which case the program is referred to as a specialized postprocessor. The alternative is to write a generalized postprocessor, which is then tailored to individual machine tools by entering the tool and controller characteristics into a machine parameter file.

Prior to using a generalized postprocessor for the first time, the user prepares a machine parameter file for his machine tool. In this effort, which can normally be completed in an afternoon, he can be assisted by one of the qualified N/C application specialists assigned by the computer time-sharing service company.

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BLD
BLD FILE NAME--FRYMBLD
READY
LISTMH
100PARTNR 111A-/1B-R1000 HBLD PLUG 55-651773
110REMARK GENERAL ELECTRIC TIME-SHARING
130 3YN/C,C1RCL,GD,GBDLTA,GF,GBFWD,GL,GBLFT,GR,GBRGT,S
130 BT,GBTL,L,LINE,P,PARLEL,PT,PBINT,RAD,RADIUS,TT,TANTR
140 TL,TLLFT,TR,TLRGT,TN,TLON,XL,XLARGE,XS,S
150 XSMALL,R,RAPID,YL,YLARGE,YS,YSMALL
160 MACHIN/GFLATH,D,LINEAR
170 CLPINT
180REMARK BEGINNING OF VARIABLE INPUT DATA
190 CC =8-.28 8555-651773-1
200 DD =1.55 8555-651773-1
210 EE =10.05 8555-651773-1
220 FF =2-.33 8555-651773-1
230 JJ =10.81 8555-651773-1
240 AC =-.73 8555-651773-1
250REMARK END OF VARIABLE INPUT DATA
260 CL =L/O,0,1,0 SSCENTER LINE
270 VI =L/O,0,0,1 SBYAXIS
280 A1 =L/PT/O,((-JJ-.005)/2),ATANGL,2 SSTOLL
290 P1 =PT/FF/(-EE/2)
300 A2 =L/P1,ATANGL,47
310 A3 =L/P1,ATANGL,2
320 C1 =C/AC,0,CC
330 C2 =C/XL,A3,XL,IN,C1,RAD,1,01
340 C3 =C/XL,A2,YS,A3,RAD,.44
350 C4 =C/XS,A2,YL,A1,RAD,.38
360 PB=PBINT/XLARGE,INTOF,A3,C1
370 PC1 =PBINT/CENTER,C1
380 LB = LINE/PB,PC1
390 TLAR =3/84
400 TLAK =-5.255-1.25*TLAR
410 TLAY = R-1.75-1.8*TLAR
420 TLDEF/2,1,TLSET,TLAK,TLAY
430 SP =PBINT/32,-17
440 HBM/32,-17,0
450 FRM/SP
460 FEDRAT/20,1PH
470 SPINDL/300,RPM
480 CBOLNT/ON
490 CUTTFR/2,*TLAR
500 TURRET/2

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Fig. 2—Example shows the type of words and information that a programmer would use in creating a parts program. Example is based on General Electric's REMAPT system. Illustrated printout would be obtained at the teletypewriter in programmer's office. The underlined words in first few lines are programmer's typed in response to initial questions asked by computer when telephone contact is first established.

## ► The Computer Utility

The thrust of advancing technology is toward automated manufacturing control systems. This advanced technology is represented by smaller, less expensive equipment; by time-shared resources; and by communications networks in which machines are linked, pyramid fashion, to larger and more powerful machines.

The important point is that time-sharing is cost-sharing. Because of its effect on the economic feasibility of new techniques, cost-sharing will accelerate the adoption of new techniques. The time delay between the adoption of new technologies by the larger manufacturing companies and subsequent adoption by the bulk of the manufacturing community will be cut from the current five to ten years to a short two to three years. In short, broadly used automated manufacturing control systems are not nearly so far away as one might first suppose.

During the transition from the realities of today to the promises of the future, the manufacturing manager must be prepared to make effective use of those tools which do become available to him. One important such tool is the computer utility. The computer utility, as referred to here, is an information network capable of providing whatever computational power a user requires, from whatever communication device the user may have available.

A computer utility will be capable of operating in a time-sharing environment, but will more normally operate principally in a remote-batch environment. That is, the user will initiate processing of his problems in a time-sharing environment. The computer

will then check his input and issue any obvious error diagnostics for immediate correction and resubmission. Next, the user's job will be placed in a run queue to await the availability of the resources required to solve his problem, and the user will terminate his communication with the computer. When the computer has processed his job, it will re-establish communication with the user, and return the solution to his problem. Such a system is demonstrable today and will be commercially available in the near future.

For the manufacturing manager who requires the power of APT to produce tapes for his N/C machines, the computer utility will provide the convenience of an in-house facility at a fraction of the cost. On the low end of the cost scale, he may make an equipment investment no greater than the rental of a teletypewriter—the same device used to bring him the power of time-sharing. In this case, he would use the terminal as an input device and diagnostic report device. To obtain his output and paper tape, he would direct the computer to produce them on suitable equipment located in a computer service center located nearby. The service center would then mail or otherwise deliver the output to the user who requested it.

A larger user may find it economical to locate all or some of the equipment found in the service center in his own plant. Such is the flexibility of a computer utility.

Join the computer utility with on-line computer N/C, throw in adaptive control and other feedback devices, and you have tomorrow's promise—the automatic manufacturing control system.

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