

NC SCIENCE

August 1973



**COMPUTERIZED
TAPE AND WAGE RATE
GENERATION**

NC SCENE

August 1973

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B/NC REPORT

Pay off begins at plug in.

That's what E. M. Machine & Tool Corp., Clifton, N.J., found out when it took delivery on a Bridgeport Series II N/C milling machine. Within days this shop was delivering completely acceptable blister

pack molds to a major customer, and already has a second Bridgeport NC machine on order.

Prototypes the first day

Fact is, Philip Moherrek, President of E. M. Machine & Tool, produced prototype molds the day after the N/C machine was installed. Although unfamiliar with N/C, programming and the Series II machine, Phil himself programmed the tape for the prototypes. Phil's shop has since produced several other parts, including right and left hand parts from the same tape program. (This is done simply by

reversing the X and Y axes).

Simple Programming, Setup, and Operation

Getting the Series II N/C into production this quickly is possible because the B/NC system requires no special operator skills. The operator uses familiar planning methods, so learning how to program and operate it is relatively easy. Simplified fixturing and qualified tooling make setup easier, too.

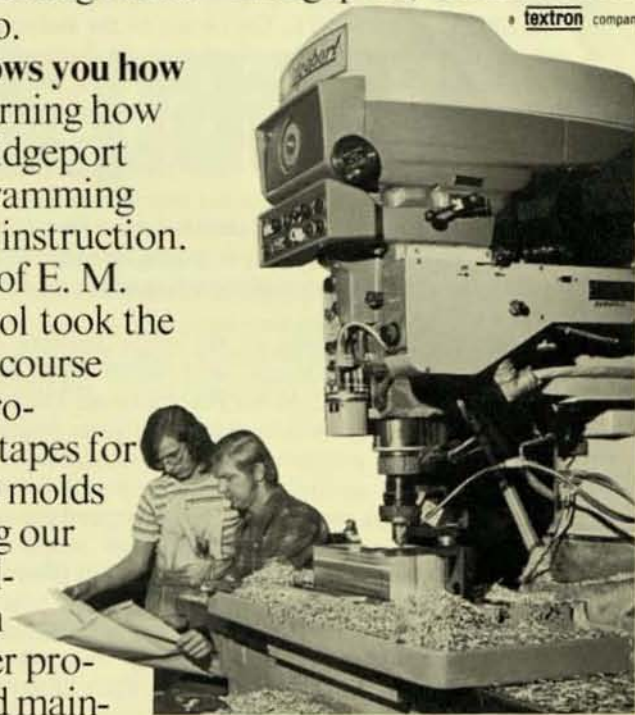
Bridgeport shows you how

To make learning how even easier, Bridgeport provides programming and operating instruction. Phil Moherrek of E. M. Machine & Tool took the programming course and finished programming the tapes for his production molds while attending our school. Specialized training in logic, computer programming, and main-

tenance is also offered. **E. M. Machine & Tool buys a second machine**

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EVALUATING PARTS PROGRAMMING LANGUAGES

JAMES J. CHILDS
Contributing Editor

With the increasing popularity of computer-assisted parts programming and the number of different parts programming languages, or systems, to choose from, questions arise regarding the relative merits, or demerits, of the various systems. Those most interested are the people that are searching to adopt a system, or those who feel that their present system is inadequate or perhaps unsatisfactory for their requirements.

For some time the Department of Defense, and particularly the Army, have been interested in determining the relative values of different computer parts programming systems that are being used at numerous government work centers, depots, and laboratories. This interest has developed to a deep concern as computer parts programming has increased, to a point where practically every installation is using some system. The concern centers around whether the Department of Defense is obtaining the best value for its programming dollar, and whether the proper system is being used for particular part configurations and environments.

In order to assess the situation, a contract was let to the Numerical Control Society by the U. S. Army (ECOM, Fort Monmouth, N. J.) which involves the investigation and evaluation of six different parts programming languages, or systems. These are: ADAPT, APT, COMPACT II, NUFORM, SPLIT, and UNIAPT. The object of the evaluation is not to determine which system may be better than another, but rather to determine which systems are most likely to be best suited under different conditions involving considerations such as part complexity, computer availability, and training requirements. The Numerical Control Society was selected for the contract award because of its expected impartiality and overt circumstance. One of the outputs of the study will be a public report of the evaluation; the anticipated completion date of the project is November 1973.

One of the key features of the study involves the programming of ten different parts which have been furnished by Army, Navy, and Air Force sources. The parts have been modified by NCS to reduce the parts programming effort and data processing costs to a reasonable level by eliminating most multiple cuts and random holes and multiple set ups. Data packages are being prepared for each of the ten parts which include operation sheets and sketches describing the cutter paths to be programmed. While the parts represent government hardware requirements, they are also felt to be representative of the industry spectrum. The complexity of the parts range from two-axis point-to-point to five-axis configurations. Each of the ten parts is to be programmed by a *proponent* and a *user* of the system, in consideration of the axes capability of the

continued on page 12

Readers are invited to submit new questions to the NC SCENE Q & A Department—as well as to submit replies and suggestions in response to already-published questions.

Q. Now that CNC equipment is becoming available at prices competitive with hard-wired controls, the way is clear for rapid expansion of its use by small- and medium-sized shops. Do you expect this to happen and what would be the benefits to the users?

A. I certainly believe CNC is headed for the smaller shops. CNC users find their controllers are more reliable because they use far less components. The CNC controller readily lends itself to system diagnostics which reduces maintenance time and makes it easier for small shops to do a lot of their own troubleshooting and repair.

Another benefit is simpler programming. Good examples are the control of turret punch press and the trochoid grinder. In the first case, the parts programmer can use a geometric definition tape to create parts directly instead of using it to generate an intermediate dimension tape and then in turn using the dimension tape for parts generation. In some cases, the user can get a parts programming capability integrated into his CNC system.

The Wankel engine has given us the opportunity to approach new machining problems with a new controller technology. Conventional NC grinding has always been a rather gray area. The shape of the part really determines the feasibility of using an NC grinder. However, most of the NC grinder problems have been solved using a computer controller. In the process, the programming has become a lot simpler too.

The results, over-all, are higher production and better quality per dollar investment for CNC systems. This is especially important for small operations.

But it will probably be another three years or so before the smaller shops realize the full potential of CNC.

*Joe R. Frazier
Project Manager
Data General Corporation
Southboro, Massachusetts*

NUMERICAL CONTROL SOCIETY

Numerical Control Society (NCS) is a professional organization which provides opportunities to contribute to and learn about the application and technology of numerical control in all industries. NCS is affiliated with American Institute of Industrial Engineers (AIIE); Groupement Pour l'Avancement de la Mécanique Industrielle (GAMI); International Material Management Society (IMMS); and South African Numerical Control Society (SANCS).



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CALL FOR PAPERS

Numerical Control Society Eleventh Annual Meeting and Technical Conference

March 31-April 3, 1974
Royal York Hotel, Toronto

GUIDELINES FOR PAPERS

The papers to be presented will be separated into three groups and the international aspects of NC will receive considerable attention:

- I. Papers focused on solving today's cost-price problems. Special emphasis will be placed on how-to-do-it, practical guidelines, description of successfully operating facilities, from small shops to large concerns, and any other topics that will help end users in the audience to get into NC or to use their existing NC facilities more effectively;
- II. Papers on trends, techniques, new developments, new applications, etc., that will be broadly encompassed under the title "the state of the NC art"; and
- III. Tutorial papers on basics of NC economics, use, realization, and standards.

TOPICS

NC Programming and Software Development. Languages; Sculptured Surfaces; Special Macro Developments; Programming Techniques for Metalcutting and Nonmetalcutting Applications.

DNC and CNC. Hardware and Software Developments; Interpolation Techniques; Post Processing; Retrofitting; Adaptive Control.

NC System Applications. Leather; Textiles; Woodworking; Electronics; as well as Metalworking, including Robots.

CAM. Automated Factory Concepts; On-Line Computer Control of Groups of Machines; Scheduling of Machines,

Tools, and Materials; Integration of Management Function Within a Manufacturing System.

Maintenance for NC. Established NC Preventive Maintenance Systems; In-House vs. Contract Maintenance; Costing.

NC Graphics and Data Base. Data-Base Developments; New Approaches Using Graphic Displays.

Management Aspects of NC. Economics of NC, DNC, and CNC; Machine Tool Selection; Programmer Selection, Qualification, and Training.

Other Topics. Design; Inspection; NC Abroad; Any Other Topic Related to NC/CAM Not Specifically Listed Above.

DEADLINES

Abstracts: 6 copies of one- to two-page, double-spaced abstract, accompanied by biographical sketch, must be submitted by October 1, 1973 to the Technical Program Chairman, Dr. K. G. Adams, Mechanical Engineering Department, University of Waterloo, Waterloo, Ontario N2L3G1, Canada.

Papers: 3 copies of the final paper for presentation and publication in the conference proceedings, typed, double-spaced, and accompanied by supporting 8 x 10 glossies and/or slides, with drawings in pen and ink, are due December 1, 1973. Submit one copy to Technical Program Chairman, above address; one copy to National Meeting Coordinator George R. Gibson, Industrial Development Officer, Government of Ontario, 950 Yonge Street, Toronto, Ontario, Canada; and submit the original with original art and photos to Editor Mary A. De Vries, NCS, P. O. Box 26, Concord, N. H. 03301.

George R. Gibson, National Meeting Coordinator
Alan Mundy, Conference Chairman
K. G. Adams, Technical Program Chairman

Newsprint NC

By Carl Natoni

A San Diego Chapter Meeting report, presentation by Carlton R. Appleby, Escondido Daily Times-Advocate.

As the tenth largest industry in the United States and the fifth largest industrial employer, newspaper publishing once lagged badly in the matter of accepting technological improvements. For many years it was one of the least innovative of all industries, but this is rapidly changing, says Carlton R. Appleby, publisher of the Escondido *Daily Times-Advocate*. A growing daily in a fast developing southern California community, the *Times-Advocate* has just recently moved into a large, crisply color-coordinated and well-planned new building.

To streamline operations and reduce newspaper production time in their new home, Appleby sought to eliminate the rekeyboarding steps which are so productive of errors. The result: a unique numerically-controlled composing room featuring six minicomputers plus peripheral gear. A product of local talent and off-the-shelf components, the system has attracted attention throughout the western states. There has even been a query from Toronto, Canada where printing plant experts are seeking to squeeze dollars out of their news operations.

The items of most interest NC-wise are: a CompuScan Optical Character Recognition (OCR) device with an 8K Data General Nova minicomputer which scans typewritten copy at 100 characters per second. Featuring a small cathode ray tube (CRT), the OCR has keyboard entry for making corrections or deletions right at the machine as necessary. The OCR output tape, after being merged with other items in a 16K General Automation computer, motivates one of four Photon phototypesetters having either 2K or 8K minicomputers. The end product is a colorful, easy-to-read newspaper with a minimum of errors that reaches the public in the shortest possible time.

First used in the classified department (ads lent themselves to the format restrictions imposed by the OCR), the system has now been expanded to include reporter copy. Because the system is the result of local talent, the *Times-Advocate* created its own manuals which Appleby said he had to rewrite, because, "If a publisher can understand it, then anyone can."

The manuals provide the basics for computer interaction training received by the girls in classified. Want ads are regularly typed on the OCR form right from the telephoned request using the special type font of IBM Selectric IIs. Deletion of errors and addition of words, characters, or entire lines can be accomplished at first typing through the use of suitable code designations which the 8K OCR minicomputer can recognize and act upon.

Once all "glitches" were worked out of the classified operation, the reporters were brought into the system.



Composing department staff member at the *Daily Times-Advocate* (Escondido, Calif.) shown putting copy in stack feeder of Compu-Scan optical character scanner. Punch for paper tape output is at left.

"After all, if the classified ad girls could master the system, then obviously the college-educated reporters would have no problems," observed Appleby.

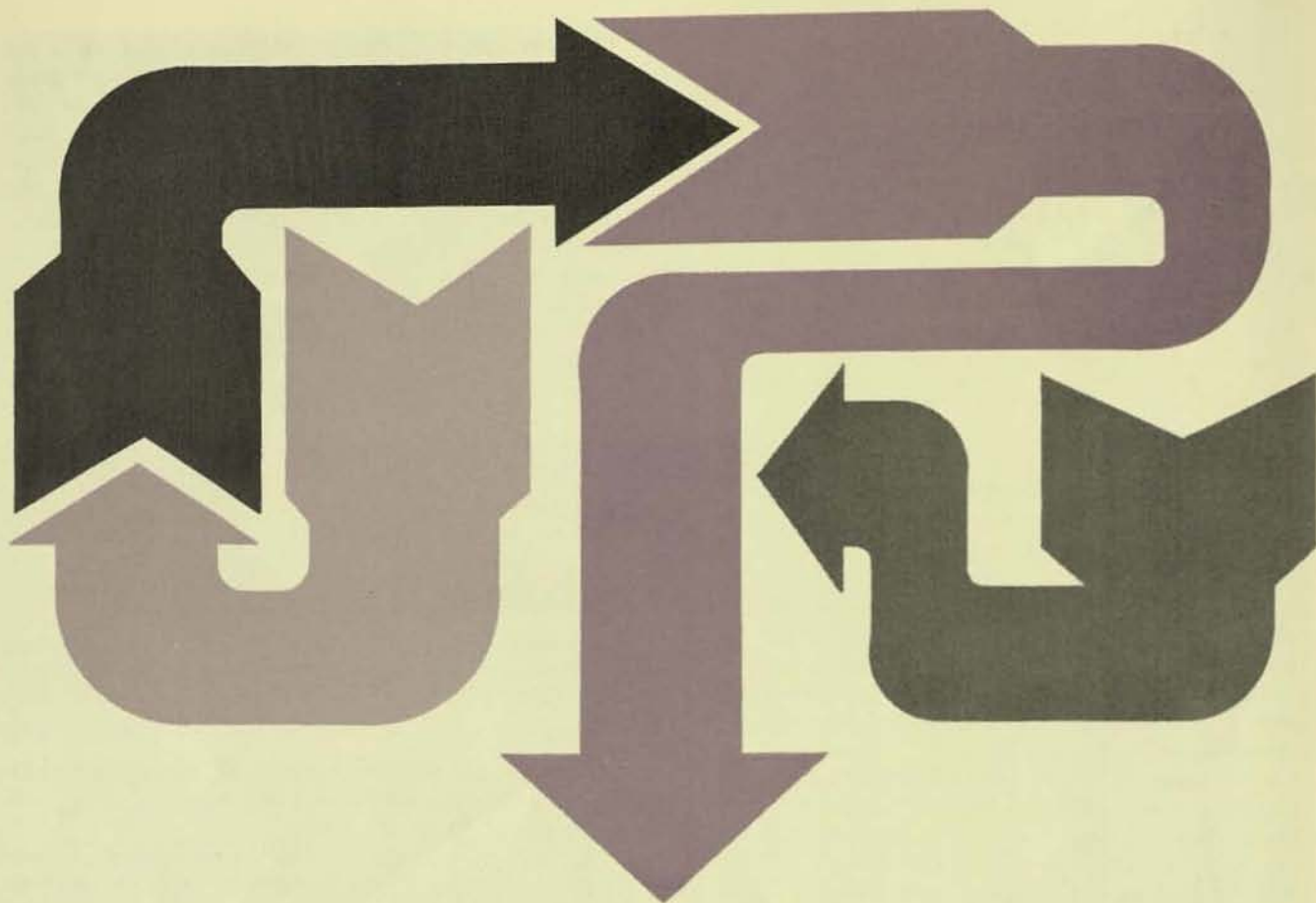
Successfully in operation now for six months, all news items are fed through the CompuScan OCR; the resultant tape activates a 2K Photon 713-5 to output column-width phototypeset copy. Even though the OCR output is nonjustified, justification information is programmed in the minicomputers inside the Photon 713-5 phototypesetters.

Photoset copy is pasted up into page format for photographing by an outsized camera. Processed through an automated developing system, the film is used to burn an impression onto the thin aluminum plate used on their offset presses. The aluminum plates in this process cost but a fraction of the normal zinc plate etchings ordinarily used elsewhere. It was the typographic labor disputes of 1947 that gave impetus to typewriter composing, paste up, photography, and etching of plates for multilith and offset printing which the *Times-Advocate* uses to such good effect with numerical control assist.

To emphasize the time value relationship, Mr. Appleby noted that a linotype is limited by an operator's skill to producing 8-to-10 newspaper lines per minute; punched tape input to the linotype increases the output to only 12-to-14 lines per minute. This small improvement is due to the inherent limitations imposed by the metal casting process itself. Thus, the much faster CompuScan Photon typesetting rates are just like money in the bank.

According to Appleby, the CompuScan OCR is the most reliable piece of equipment in the composing room: "We have backup for every piece of equipment except for the offset presses."

In the camera room, a Seiko S-310 table-top computer is used to evaluate color separation and composition of photographs. This translates a densitometer reading for use in GAM controls for exposure calculations. Eliminating the need for human judgment, the system ensures top quality color photos which are appearing ever more frequently, adding colorful appeal to an already attractive paper. □



A Special Technique for COMPUTERIZED TAPE AND WAGE RATE GENERATION

By T. D. Johnson and L. J. Hubacek

Anyone observing an NC machine operating, to all appearances by itself, would probably wonder who or what is controlling it. The *who* or *what* is a punched tape: A numerically-controlled machine obeys instructions coded into the perforations of a tape passing through the tape reader head in the control cabinet adjacent to the machine.

Efforts involved in making such a perforated tape (used to control punching operations in a Strippit NC Punch Press) and the tape's involvement in a wage incentive rate are examined below.

Wage Incentive Computation Procedures

Development of wage incentive computation procedures comes first. These procedures are the skeleton of a time standard, and all the time elements used in the procedures fill out the skeleton to complete the time stan-

dard. Thus, the procedures must be ready for the writing of a post processor, which is essential to create a tape.¹

Western Electric's industrial engineering group at Hawthorne has, for one of its functions, machine time standards. This involves the knowledge and use of existing standards and, if required, the creation of new standards.

After the decision to obtain a post processor for the Strippit NC Punch Press, they decided to include the necessary information to obtain all the required wage incentive rate calculation data. The data generated to ob-

tain the perforated tape could be used as a data source to calculate the rate; and in addition to the regular print-out, a wage incentive rate covering both manual and machine time could be printed.

The first place to start would be to observe a machine in action. Since their machine was still crated, a trip to another plant was arranged to observe several similar Strippit Punch Presses operating, and to learn how the machines worked and what the operators did, during machine down time and running time.

The Strippit NC Punch Press is a perforated-tape-controlled, single-tool type machine. The tape has the machine punch all the holes of one tool, then move the work blank aside to clear the die, and stop. The tool change light on the control punch goes on to signal the operator for a tool change; and after this tool change, the machine is restarted to perforate with the new tool.

1. The processor computer program takes the programmer's manuscript data, translates it into computer numbers and nomenclature, and then performs the mathematical calculations required. The post processor translates this arithmetic solution into a tape format suitable to a particular machine and control system. Printed output results from both programs.

In considering what would be needed for the various sections of the time standard, they found areas with no known parameters, necessitating that they over-estimate the requirements. It was not known what various sizes the work blank would actually be, so they decided that all areas up to the machine's capacity would have to be covered. Types of work blank material and thicknesses to be punched were not known, so three material density groups were set up to include all possibilities in the calculation of the blank weight. The groups set up were nonmetals, light metals, and heavy metals. The load and unload values could then be determined by blank area and weight calculated from this information.

They knew that the tools came in groups of three sizes, but did not know how many subgroups would occur in each of the three sizes. They decided to provide for a total of fifteen subgroups, and these would be coded numerically as each was developed. Since the tool change specification would be "change tool code 1 to code 5," a 15 x 15 array of values had to be provided for. It later turned out that the tools fell into only nine groups, so six were labeled "future use." A similar 15 x 15 array was set up for tools changed in the holders during machine time. The actual number that was required turned out to be a 4 x 4 array.

Machine shift time was the more complicated of the unknowns. They did not have any idea what sizes or kinds of parameters would be involved. But they were able to obtain a graph from the manufacturer which showed that the machine would start, accelerate to *almost* full speed, and then decelerate in *three* steps to a stop in one inch. This indicated that the machine should accelerate to *full* speed and decelerate to a stop in a distance of more than one inch, but in less than an estimated one and a half inches. They decided to list the shift times in .100" increments for .100" through 5" shifts and use a formula for all shifts over 5". Not knowing if machine moves in +x, -x, +y, and -y directions were at equal speeds, they prepared for different time values for each of these directions. This gave a 4 x 50 array of time values to cover .100" through 5" shifts and a formula to cover all shift times over 5". Punch cycle time would be a single value.

Lubrication of the work blank would

be a constant plus a value per square inch of area.

This gave a time standard framework which, with instructions on how the values were to be obtained and used, was given to the writer of the post processor so he could start his program.

Once the machine was installed and operating, they made special machine tapes with specific movement patterns in the + and -x, and + and -y directions. Running the machine with these tapes and specially marked cardboard as the work-blank, high-speed movies were taken.

Analyzing these gave acceleration, deceleration, table movement speeds, and the punch cycle time. As the developed data worked out, the table speeds in the plus and minus direction for both x and y directions were close enough to use an over-all average. Since the .100" increment steps from .100" through 5" was left unchanged, the array became a 1 x 50 instead of the anticipated 4 x 50.

Based on the outside plant trip, observation of their regular machine operator, operation of the machine, analysis of the work elements, and use of predetermined time standard values, they worked up the payment time values for the manual work elements. The anticipated handling of work blanks from skids on the floor was changed to having the blanks on a table truck at machine table height. The operator could slide the blank from the truck to machine and, after processing, to a second truck, and not have to lift the blanks.

Once the machine time and manual work values were complete, they were submitted for insertion into the post processor to replace the dummy values which had been used up to then to fill out the time standard framework in the post processor.

This means that any part processed through the computer post processor program would have a complete machine operation wage incentive rate generated.

The data from which the output is developed comes from one basic source: the initial parts program submitted for processing.

With the time standard values now in, the post processor information had to be provided to the post programmer so that he could include the proper information in his program which would, in turn, generate the wage incentive rate.

Part of the information given to him was a listing of the tool code group numbers and a description of the tools in each code group. Where the tools are listed and described in his program, a tool code is also given. In the example illustrated below, P-47M891, tools 1, 2, and 3 are in the code 1 group; tool 4 is code 3, with the other five tools listed accordingly. The code number is the key in determining tool change time.

The program itself has "LOADTL" statements that both generate change commands for the tape and are used to determine the tool change time value for the rate. The first statement, LOADTL/1,1 states: load tool no. 1, code no. 1. The second, LOADTL/2,1 states: load tool no. 2, code no. 1, and the change time will be that of code no. 1 to another code no. 1. At the end of the program the change time from the last tool used, code no. 9 back to tool no. 1, code no. 1 is determined in order that all tool changes are paid for.

The machine time is derived after a series of steps take place in the processing computer. The data of the initial program defines points on a part, groups these points into patterns, then specifies the number of times in each direction these patterns are repeated. The computer program develops this data into the locations of each point moved to on the work blank. The post processor determination of inches traveled is made by subtracting the x and y coordinates (absolute dimensions of successive points disregarding the sign of the difference). Where there are simultaneous x and y axis movements, the larger move distance of the two is used with the time standard data to calculate the time for this move. This time determination pattern is followed from the first point location through to the last, to accumulate the total machine time. During this machine time determination, whenever a tool change occurs, a subtotal is started, to accumulate the first six machine times (shift plus punch cycle), and is shown on the output sheet as an observe time.

The manual time items are more directly given in the initial parts program as the CYCLE/TIMES and load tool (LOADTL) statements.

The first line of the program proper is the CYCLE/TIMES statement, which specifies: CYCLE/TIMES,1,48,

continued next page

TAPE AND WAGE RATE GENERATION continued

30,063,16. This statement gives the following data: material group no. 1 (heavy metals-steel), blank is 48" long, 30" wide, .063" thick, and there are 16 parts per blank. This will generate the blank area and weight for handling, lubrication, and time per part

values. The parts per blank are used to convert the total time per blank figures into a time per part, which is used in turn for the final payment factor of hours per 100 parts processed. The other items are used to obtain the area and weight of the blank to be handled by the operator. The handling method and time paid are determined by these items.

The first LOADTL statement will specify tool no. 1 and the code group in which this tool fits. The second LOADTL will specify tool no. 2 and the code group. The program will locate, in the table of time values, the time to change from tool no. 1 to no. 2, depending on the tool code groups involved. After the last tool has punched its last opening, a change

```

1 PARTNO P-47M891 CHASSIS 2-10-69 RJR 001
2 MACHIN/WALES,1 003
3 CLPKNT 005
4 LFRIGIN/1, 007
5 LEADPT = POINT/2.5,16 009
6 P1 = POINT/1.577,6.12 011
7 P2 = POINT/2.132,5.52 013
8 P3 = POINT/1.892,6.75 015
14 P9 = POINT/1.892,6.75 029
15 P10 = POINT/1.5 031
16 P11 = POINT/9.477,5 033
17 P12 = POINT/15.122,6.85 035
18 V1 = VECTOR/1, 037
19 V2 = VECTOR/1, 039
20 PAT1 = PATTERN/LINEAR,P1,V1,INCR,3.46,2.24,8.86 041
21 PAT2 = PATTERN/LINEAR,P1,V2,INCR,21.136,1.154,21.136 043
22 PAT3 = PATTERN/PARALLEL,PAT1,PAT2 045
23 PAT4 = PATTERN/PARALLEL,P2,V1,INCR,1.60,7.1,7.86 047
24 PAT5 = PATTERN/PARALLEL,PAT3,PAT4 049
25 PAT6 = PATTERN/PARALLEL,PAT3,PAT5 051
54 PPRINT * * * * * TOOLS REQUIRED * * * * * 113
55 PPRINT * * * * * 115
57 PPRINT * TOOL 1 = .375 DIA.RO.PUNCH TOOL CODE 1 * 117
58 PPRINT * .381 DIA.RO.DIE * 119
59 PPRINT * TOOL 2 = .127 DIA.RO.PUNCH TOOL CODE 1 * 121
60 PPRINT * .133 DIA.RO.DIE * 123
61 PPRINT * TOOL 3 = .145 DIA.RO.PUNCH TOOL CODE 1 * 125
62 PPRINT * .149 DIA.RO.DIE * 127
63 PPRINT * TOOL 4 = .281 X .281 SQ.PUNCH TOOL CODE 3 * 129
64 PPRINT * .287 X .287 SQ.DIE * 131
65 PPRINT * TOOL 5 = .75 X .625 OBRROUND PUNCH TOOL CODE 4 * 133
66 PPRINT * .81 X .631 OBRROUND DIE * 135
67 PPRINT * TOOL 6 = SPECIAL SHAPE PSD C-985472 TOOL CODE 4 * 137
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87 GOTO/PAT6,INVERS 177
88 GOTO/PAT9 179
89 LOADTL/3,1 181
90 * * * * * 183
104 GOTO/PAT36,INVERS 211
105 END 213
106 FINI 215

```

Figure 1

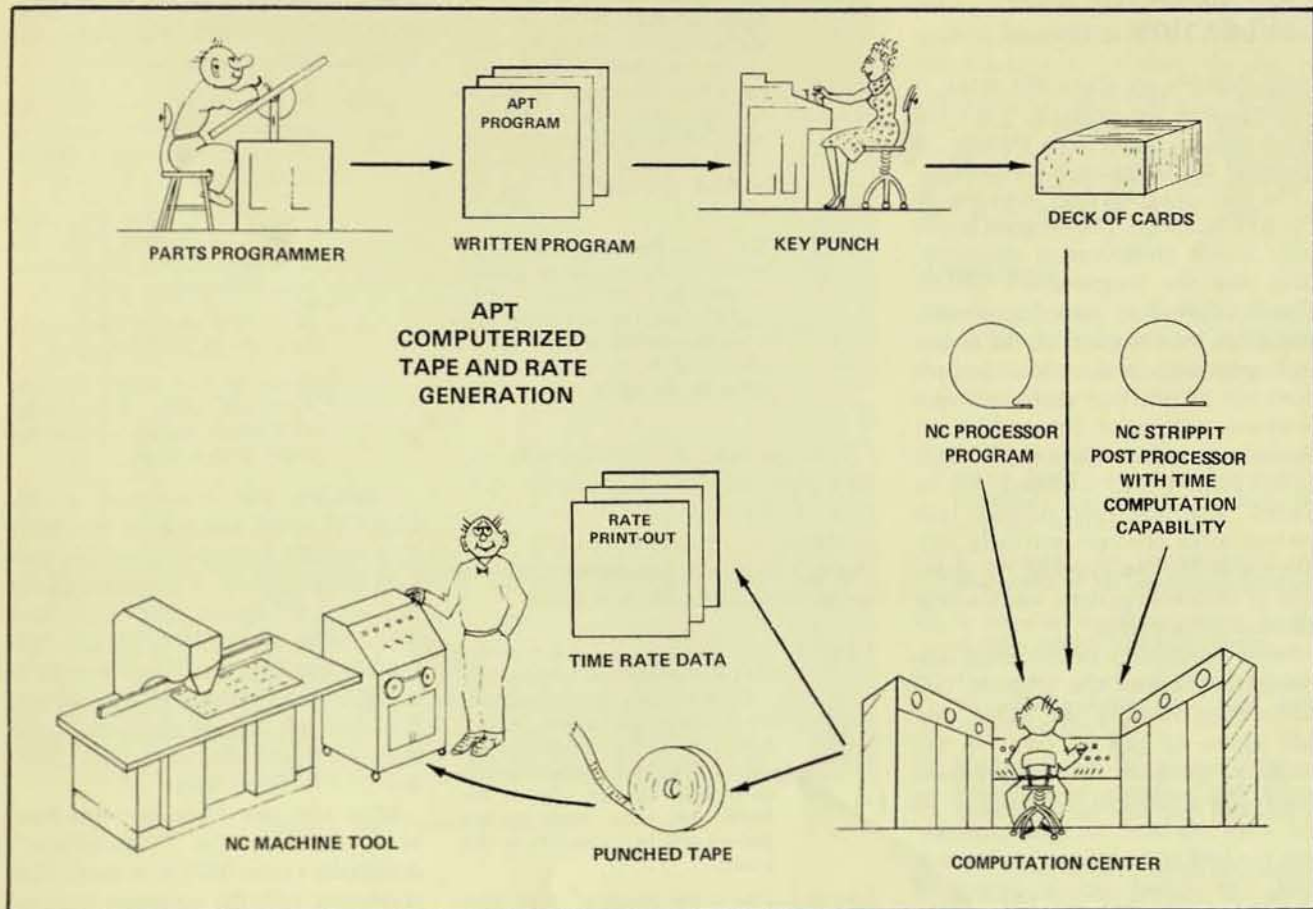


Figure 2. Basic APT Program.

from this tool back to tool no. 1 is derived in order to pay the full cycle of tool changes. Each tool change and the change time is shown in the printed output.

To provide documentation of the time standard values, the machine and manual time elements were organized, written up, and the standard issued.

The standard was unique in that there would be no worksheet designed for its use. While it could be used for a manual calculation of a rate, the intended purpose was computer usage.

After several test runs had been made, the decision was made to change from a 100 per cent operator attention time basis to an attention time only basis. This would pay only for the operator work required per blank, with the operator leaving the machine area to perform other work. This did not rule out the need for the machine time since it was specified that after loading a tool and restarting the machine, the operator was to stay and watch the first six shift and punch cycles to be sure that the punch pattern had started correctly.

The generation of the 100 per cent attention time rate was left in the

process with the thought that it might be needed. Several parts run turned up to have six or eight tools used with a small number of punches to each tool. The walking time to and from the machine was longer than the machine time for these parts, so it was more economical for the operator to stay at the machine, and 100 per cent attention time was paid on these parts.

The regular attention time only payment would pay for the following items of work during machine run time: observe six punch cycles per tool, one half the walk time (from machine), gaging, lubrication of work blank, and bench tool change time. Work items during machine down time paid for: tool changes, one half the walk time (to machine), load and unload work blank, and empty parts blanked whenever this occurs.

Using the post processor to generate rates from the point of view of work involved is ideal since the amount of work on their part is zero.

It does depend on one condition: If the prove-in run of the tape is unsuccessful and corrections must be made, the job must be rerun through the post processor in order to have a correct

wage incentive rate. All of the jobs requiring corrections have been rerun.

Parts Program

To generate the data necessary to operate the Strippit NC punch press, and to develop the applicable wage incentive rates, it is necessary to write the parts program. Figure 1 shows a basic program written in the APT language for a specific piece part, P-47M891. The APT program is then converted to a deck of punched cards which is processed by the computer to provide a punched machine control tape, a processor print-out, and the wage incentive rate print-out for the specific piece part. This sequence of events is shown in the block diagram, figure 2.

The parts program, figure 1, starts with the piece part drawing. This drawing, P-47M891, is analyzed for such things as raw material, size and shape of holes required, size of part (including developed length of formed part), and direction of grain if part will be formed. Using the estimated annual requirements as a guide, the approx-

continued next page

TAPE AND WAGE RATE GENERATION continued

imate number of parts per blank is planned, and the order in which the holes will be punched is planned to minimize the changing of tool holders.

The parts program itself is written in the APT language. The program begins with a part identification statement, date, and the programmer's initials. This is followed by several statements that guide the computer to the proper post processor, plus various instructions and information about making a print-out, the point from which all dimensions originate, and the location of the point where the blank will be loaded. The first hole of each hole pattern is described geometrically, vectors are defined to establish the direction of each hole pattern, and the hole patterns are described.

Before proceeding to the actual motion statements of the program, two information sections are added that will appear in printed form on the computer print-out. The first of these two sections contains the listing of all the tools required to make the part and the tool code designation for each tool. The second section consists of miscellaneous information about the raw material and the part.

The last part of the program is composed of the motion statements. It is from this section that the computer gets the information for the wage incentive calculations, and the directions required to process the various patterns previously described in the first section.

Using piece part P-47M891, the various steps can be followed in detail. Starting with the piece part drawing, the first step is to calculate the developed length, lay out the configuration of the part in the flat stage, and determine the order in which the holes will be punched.

The parts program manuscript, figure 1, is written after the preliminary planning is completed. The first part of the program (Lines 001 through 009), numbered in the right column of the sheet, contains the information required by the computer to process the program.

Line 001—The part identification statement.

Line 003—Identifies the post processor required to process the program.

Line 005—Directs the computer to make a punched tape for use on the machine.

Line 007—The "Origin" is the point from which all holes in the program will be located. The 0,0 portion of the statement indicates the point is at the center of the die opening. This means that the upper left-hand corner of a blank loaded in the normal way would be over the center of the die opening.

Line 009—The "Load Point" is the location where the blanks will be loaded. In this case, the blanks will be loaded with the left-hand edge 2.5 inches to the right of the die center and the top edge 16 inches above the die center.

After the identification and information statements are complete, the location of the first hole in each hole pattern is described (Lines 011 through 033) and the required vectors are defined (Lines 035 and 037).

Line 011—This statement locates the first hole in the first hole pattern. The .577, 6.12 portion of the statement places the center of this hole .577 inches from the left edge of the blank and 6.12 inches down from the top edge of the blank. All other holes in this pattern will be located from this point.

Line 013—This is the location of the first hole in the second pattern; 2.182 inches from the left edge of the blank, and 5.52 inches from the top edge of the blank. As in the example above, all other holes in this pattern will be located from this point.

The explanation for Lines 015 through 033 would be similar to those above, except for Line 029, which differs slightly from the others. The zero for the x coordinate locates the centerline of the hole on the left edge of the blank.

Referring to the layout sketch, it can be seen that hole number 10 is a rectangle .500" x 2.250". Therefore, by programming the center of this hole on the edge of the blank, the result will be a rectangular notch, .500" x 1.125" in the edge of the blank.

The two vectors required are defined in Lines 035 and 037. Line 035 defines a vector along the y coordinate which runs from the top edge of the blank to the bottom edge. Line 037 defines a vector along the x coordinate which runs from the left edge of the blank to the right edge. The hole patterns are described in lines 039 through 113.

These statements contain the information required by the computer to calculate all the hole locations on the

blank. An explanation of several pattern statements will show how this information is arranged.

Line 039—(Pattern/Linear) This tells the computer the type of pattern—in this case linear, or in a straight line.

(P1)—This specifies the point where this pattern originates. (The location of P1 was previously defined in Line 011.)

(V1)—This specifies the vector to be used with this pattern.

(Incr.) An APT word that means increment (8.86, 2.24, 8.86). This is the spacing between the holes in this pattern.

Following the explanation above, Line 039 would translate to: A pattern in a straight line, starting at P1, running from the top of the blank to the bottom and spaced 8.86, 2.24, and 8.86 inches apart. Similarly, Line 041 would translate to: A pattern in a straight line, starting at P1, running from the left edge of the blank to the right edge and spaced 21.136, 1.154, and 21.136 inches apart.

After the two linear patterns have been defined, the "Patern/Parlel" statement (Line 043) is written. This statement tells the computer to combine the two linear patterns named in the statement. The computer will arrange the hole locations into a sequence to be followed by the machine. This sequence will be based on the distance between holes specified in the linear patterns and the order that the linear patterns appeared in the parallel statement.

After the pattern statements have been completed, a listing of the tools required and the tool code of each tool appears (Lines 117 through 149). The tool code number is obtained from a standard, and is based on the size and/or shape of the tool. The size of the tool and the order in which it will be used will have a bearing on the rate.

A short section of miscellaneous information follows the tool listing (Lines 153 through 163). This section contains information about the blank size, raw material, part size, number of parts per blank, etc. The tool listing and this section will be printed on the computer print-out. A copy of this section of the print-out is given to the shop for the machine operator's use.

The last part of the program (Lines 167 through 215) contains the information and directions the computer required to calculate material handling

STRIPPIT N/C PUNCH PRESS

THIS PART NUMBER IS ** P-47M891 CHASSIS 2-1-69 AJK

LENGTH 48.000 WIDTH 30.000 THICKNESS .063 MATERIAL GROUP 1

PARTS 16 TOOL CODES 1 1 1 3 4 5 8 9 10 11 12 13

BLANK AREA 1440.000 SQ. IN. GAGE TIME .9523 MIN. LUBE TIME .2652 MIN.

BENCH TOOL CHANGE TIME 0.2211 MIN. OBSERVE TIME 2.4402 MIN.

WALK TIME 4.2228 MIN. LOAD-UNLOAD TIME 0.4512 MIN.

100% ATTENTION TIME PAYMENT MINUTES

TOTAL MACHINE TIME PER BLANK	= 16.7209
TOTAL MANUAL DOWN TIME PER BLANK	= 4.3987
TOTAL MANUAL TIME DURING MACHINE TIME	= 14.4786
WAIT TIME PER BLANK	= 14.5423
NUMBER OF PARTS PER BLANK	= 16
MACHINE TIME PER PART	= 1.0451
TOTAL TIME PER BLANK + INCID. ALLOW.	= 21.1300
TOTAL TIME PER PART	= 1.3210
MACHINE CONTROL 75.0% PER CENT	
BASE HOURS PER 1.0 PARTS	= 2.40300
END PARTS	= 41.700

OPERATOR ATTENTION TIME ONLY PAYMENT MINUTES

* MANUAL TIME PER BLANK INCL. WALKING-MACH. DOWN	= 6.5101
* MANUAL TIME PER BLANK INCL. WALKING-MACH. RUN	= 6.9352
* ATTENTION TIME PER BLANK INCL. INCID. ALLOW.	= 12.7500
* ATTENTION TIME PER PART INCL. INCID. ALLOW.	= 0.7965
* BASE HOURS PER 1 PARTS	= 1.45000
* EHMO BLANKS	= 2.580
* ATTENTION TIME PER HOUR	= 32.9900

** END OF POST PROCESSING **

ELAPSED TIME IS 1.32267 MINUTES

Figure 3. Wage Incentive Print-Out.

time, tool loading stops and positions and the order in which the patterns will be processed. An explanation of several statements from this section will illustrate how this information is incorporated into the program.

Line 167—This statement supplies the material specifications used to establish the material handling time. The "CYCLE/TIMES" portion of the statement is an APT code word that identifies this information for the computer. The "1" is the material classification for steel; 48 is the length of the blank in inches; 30 is the width of the blank in inches; .063 is the thickness of the material; and 16 is the number of parts per blank.

Line 169—"LOADTL" is the APT word for "Load Tool." The first "1" is the code for tool 1, and the second "1" is the tool code designation.

Line 171—"FROM/LOADPT" is the APT word for "From Loadpoint." This is the statement that starts the motion.

Line 173—"GOTO/PAT 3" means "Go to Pattern 3." This statement directs the computer to process the coordinates for Pattern 3.

Line 175—"LOADTL/2,1" means "Load Tool Number 2, which has a tool designation of 1."

Line 177—"GOTO/PAT 6, INVERS" means

"Go to Pattern 6, Inverse." This tells the computer to process the coordinates for Pattern 6, but to list them in an inverse order on the print-out, and to punch them in an inverse order on the machine control tape.

Lines 179—through 211 would be similar to 169 through 177.

Line 213—"END" is the statement that ends the parts program. This statement will cause the machine to return to the load position specified in Line 009.

Line 215—"FINI" is the last statement in any parts program. It signals both the APT system and the parts processor that the parts program is finished.

Upon processing through the computer, the information involved in this parts program will develop first the machine control tape, which will directly control the machine to produce piece part P-47M891, and second the complete wage incentive rate for both 100 per cent attention time payment and operator attention time only payment. Figure 3 is the wage incentive portion of the print-out associated with this specific piece part.

In summary, the APT parts program, upon processing through the computer, will develop all the necessary

information to produce the machine control tape which in turn will control the machine to produce the desired piece part automatically. The program will also develop all the time data necessary for the complete wage incentive rate for any piece part produced on this particular NC Punch Press.

Advantages

There are many advantages associated with the use of this technique. Some of the more obvious advantages are:

- (1) It eliminates the manual effort necessary to develop each individual x and y coordinate required to produce the piece part machine control tape.
- (2) It eliminates the manual typing and production of the master control tape.
- (3) It virtually eliminates errors in the machine control tape development.
- (4) The clerical effort necessary to produce the wage incentive rate from work sheets is eliminated.
- (5) Management can have an immediate and complete cost analysis, before manufacture, for any piece part produced in this manner.
- (6) In a matter of days, all the information necessary to produce a piece part can be available.
- (7) All the information associated with a piece part is documented and received in a dated print-out available for future use.

A few general rules can be applied to help in determining if this method of manufacture is the best for a specific piece part. Generally, the more expensive the standard type punch press tooling, the greater the savings available using the NC Punch Press. In conjunction with the tooling expense, any parts associated with low yearly requirements, where the higher cost standard tooling cannot be justified, are prime targets to be manufactured on the NC Punch Press. This method of manufacture is responsible for better quality, faster service, and reduced cost of the finished product.

Acknowledgement

The authors wish to acknowledge the contributions of R. J. Reznicek, engineering associate, who developed the parts programming information used in this article. □

Authors Johnson and Hubacek are associated with Western Electric Company's Hawthorne Works in Chicago.

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Technical creation within cost constraints imposed by a competitive environment will be a featured consideration during the 21st Annual Joint Engineering Management Conference (JEMC), October 25-26, at the St. Petersburg Hilton Hotel, St. Petersburg, Florida. Jay J. Newman, RCA Project Manager of the Atmosphere Explorer Satellite program and a practicing attorney, will touch upon this key issue when he discusses cutting costs for survival.

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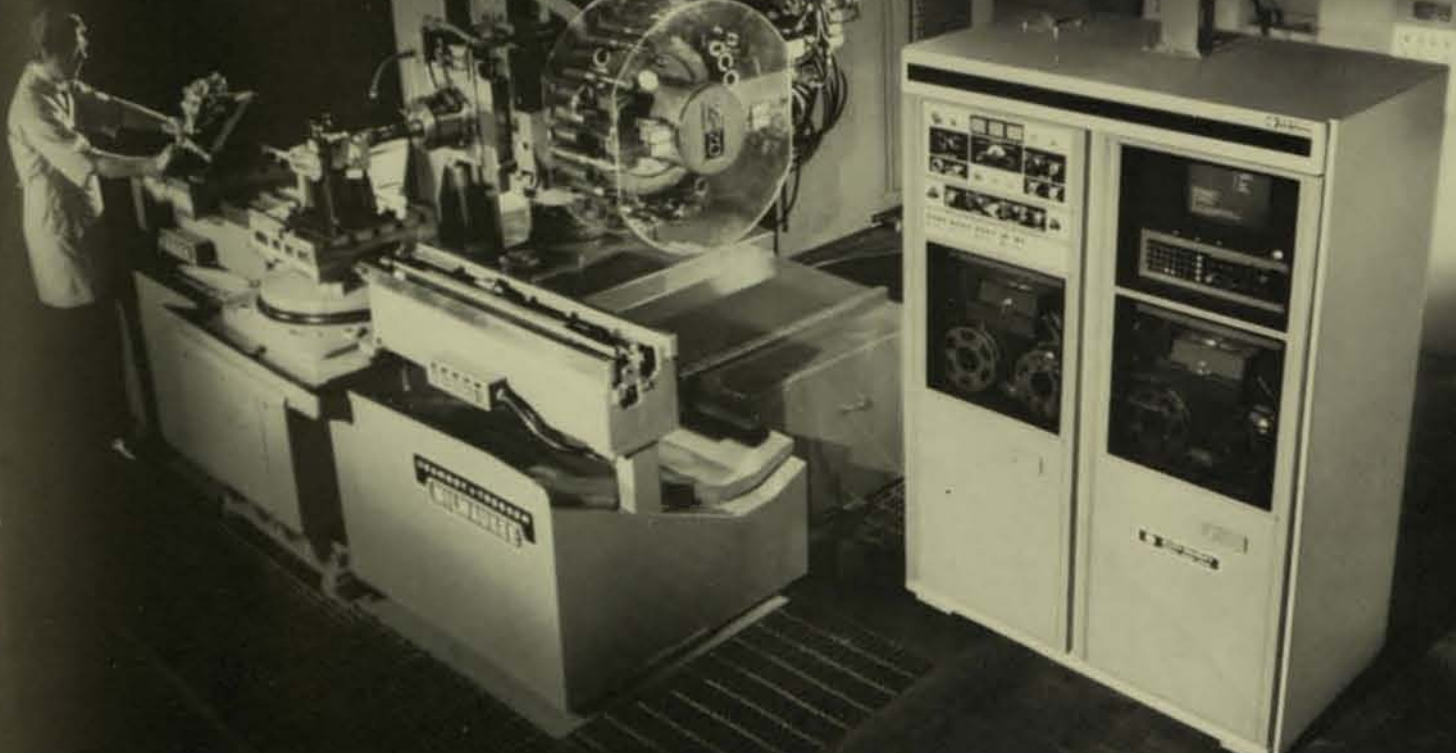
NC PANORAMA continued from page 2

system. Tapes are to be prepared which will be checked via a verifier or plotter. The verifier is being loaned to the Society on a no-charge basis by Tektronix, Inc.

To obtain a reasonable sample of parts programming sources, the Society has asked for volunteers. A number of industry and government organizations have been good enough to offer their services in exchange for an opportunity to obtain a first-hand feel and appreciation for the circumstances of the evaluation. While there are still a number of organizations that are considering participating, those that have offered to prepare parts programs are: Airesearch Manufacturing Company of Arizona, Black Hawk College, Bridgeport Machines, Cincinnati Milacron, DeVlieg Machine Company, DuPont (Wilmington, Delaware), General Electric Company, Hughes Aircraft Company (Tucson), Improved Machinery, Inc., R. K. LeBlond Machine Tool Company, Manufacturing Data Systems, Inc., McDonnell Automation Company, Monarch Machine Tool Company, National Bureau of Standards, Naval Air Rework Facility (Norfolk), Naval Ordnance Laboratory, Naval Ordnance Station (Louisville), Naval Research Laboratory, Numerical Control, Inc., Sundstrand Machine Tool, A. S. Thomas, Inc., United Computing Corporation, Western Electric, Westinghouse Tele'Computer Systems Corporation.

NCS would like to take this opportunity to publicly thank the companies and government organizations noted above, and others that will be participating, for their volunteer contributions to this language evaluation effort. □

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