SALES BULLETIN NO. 42 NC-1

1968 - THE YEAR OF NUMERICAL CONTROL

Information Systems

Time-Sharing Service

1-17-68

WHAT IS NC

Numerical Control is formally defined as "the direct control of a mechanism from prerecorded information in symbolic form." In simple language, NC is the control of a machine tool such as a drill, lathe, milling machine, punch press, etc. by an electronic controller instead of an operator. The electronic controller interprets digital instructions fed to it on punched tape and causes the machine tool to perform the actions required to produce a part. Preparation of the punched control tape requires a large number of calculations and is generally referred to as part programming.

WHY YOU SHOULD BE INTERESTED IN NC

There were 12,000 NC tools installed by year end 1967, and 4,500 more to come in 1968. Market research indicates an average of 130 control tapes prepared per year for each machine. Considering the multiple computer tests required to produce a debugged NC tape, we are looking at a parts programming market in excess of FOUR million computer shots per year.

A large portion of the parts programming is presently done by hand . . . . very slowly and with many errors. The remaining portion is done by computer . . . . batch computer, with parts programmers waiting in batch queues like engineers were before time-sharing. This is indeed a market ideally suited to General Electric Time-Sharing Service.

To help you capitalize on this prime market opportunity, a series of new products is being developed. These products are specifically designed to help you get a large segment of the numerical control parts programming market. The products are being developed for the GE-265 and the Mark II Time-Sharing Service.

You will receive the Users Guide and a sales promotion sheet on the first of these products this month.

PURPOSE OF NC BULLETINS

This NC Bulletin (#1 of a long series) provides you with a general outline of our NC plans and will introduce you to some of the basic terminology you will need for selling these products. Future NC Bulletins will include:

A. NC fundamentals - general workflow - reference sources.

B. Description of the features, benefits, and targeted market segment for each NC product as it is released.

C. User success stories for reference selling.

D. Results of our contacts with machine tool builders, distributors, and national trade associations.

SEQUENCE OF EVENTS

(Check the new terminology list on the last page if you find unfamiliar words)

1. The Users Guide and sales promotion sheet you receive this month will explain a series of three NC programs for the GE-265. These programs will prepare control tapes for two-dimensional, point-to-point NC tools. These programs have had excellent customer acceptance for the NC jobs which are normally manually programmed.

2. Later in the first quarter a more sophisticated program for point-to-point work will be released. Input to this GE-265 program will be a point coordinate file generated by the NCPTS program (part of the January release) and English-like statements of the actions the NC machine tool is to perform. Output is an EIA coded control tape which includes auxiliary tool commands. The program is flexible enough to permit the user to enter his own tool specification file into the post processor.

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3. The next product is the big one — the REMAPT parts programming language. This is an expanded, conversational version of the ADAPT language. Manufacturing Services has estimated that the REMAPT language can be used to prepare control tapes for 90% of the installed NC tools. REMAPT is for Mark II Service.

   Initially, REMAPT will include the GELATH generalized postprocessor for lathes. Postprocessors for milling machines and point-to-point tools will be added later in the summer. REMAPT will output a clean EIA tape which will run on an NC tool without modification.

4. One high point of our NC promotion will be the presentation of a paper on the REMAPT language to the Fifth Annual Meeting and Technical Conference of the Numerical Control Society in Philadelphia on April 4, 1968. As specific promotion plans are firmed up for each new product they will be communicated to you through the appropriate NC Bulletins.

WHAT NOW

This is the time to begin.
As you can see from this bulletin, there is a new set of "jargon" or "buzz words" for you to learn. The attached list of NC terminology will get you started speaking the NC language. The next NC bulletin will describe the general workflow in an NC shop and list some good references where you can gain a greater understanding of the NC business, and thus converse knowledgeably with your prospects.

Now is the time for you to establish contact with the Numerical Control Society chapter in your area. Learn which companies are members of the society. They represent first-class prospects for time-sharing service in 1968.

Prepare now — get in on the ground floor — The marriage of Time-sharing and Numerical Control will be big news in 1968.

Your contact at Headquarters, Marketing is Len Hendricks. Dial Comm 8*273-4473.

NUMERICAL CONTROL TERMINOLOGY

Numerical Control
Control of a machine tool such as a drill, lathe, milling machine or punch press by an electronic controller instead of an operator. Input to the electronic controller is usually punched tape which may be prepared manually or by a computer.

Control Tape
The punched tape containing the numerically coded instructions which will be interpreted by the controller and cause the NC tool to perform the actions required to produce a part.

Part Programming
The process of writing the symbolic instructions which describe the geometry and the sequential machine steps required to produce a part.

Point to Point
This describes one category of NC tools. These tools are two dimensional and normally move a workpiece in either of two directions, perform some operation, then repeat the cycle. Normally, there is no cutting while the workpiece is in motion. Drills are an example of point to point NC tools.

Contouring
The ability of a NC machine tool to move on two or more axes simultaneously. Cutting may be performed while the workpiece is in motion. Lathes and milling machine are examples of contouring machine tools.

Two Axis
Three Axis
Describe the number of axes along which the machine tool is capable of numerically controlled motion. Two axis tools usually move the workpiece side to side (the X axis) and forward and backward (the Y axis). Three axis tools include the ability to control up and down (the Z axis) motion.

Multi-axis
This term is commonly used when referring to large machine tools having 4 or 5 axes of motion. In addition to the normal X, Y and Z motions, these tools have a rotating table and can adjust the cutting head to different angles.

APT
A sophisticated computer program which accepts English-like statements defining workpiece geometry and machining operations; calculates required cutter locations and punches a NC tool control tape. These input statements are known as a parts program. APT is available only on large scale computers and handles the complete spectrum of machine tools.

ADAPT
A subset of APT for use on medium scale computers. It has complete two axis capability, limited three axis capability, and covers the majority of NC machine tools in use today. It is upward compatible with APT.

CL File or Point Coordinate File
Cutter location file. This is the output of the calculation phase of APT or ADAPT. It defines series of points which represent the location of the cutter at all times during the machining operation.

Postprocessor
A section of APT or ADAPT which converts the cutter location file into the specific commands required by a particular NC machine tool.

Generalized Postprocessor
A postprocessor designed to handle a broad class of related machine tools. In order to provide for differences between machine tools in a given class, it is necessary only to provide the generalized postprocessor with the parameters unique to the NC tool involved.

GECENT
A generalized postprocessor developed by General Electric for use with the APT language.

GELATH
A generalized postprocessor developed by General Electric for use with ADAPT. It covers a wide variety of lathes. & AND REMAPT

GEMILL - A GE MILLING-MACHINE P. PROC. FOR USE WITH REMAPT - ADAPT

GPOINT
A generalized postprocessor developed by General Electric for use with ADAPT. It covers a wide variety of drills.

GEPOINT SAME AS ABOVE, BUT FOR REMAPT.

EIA Code
Electronic Industries Association. This is the standard punched tape code recognized by most machine tool controllers.

IITRI
Illinois Institute of Technology Research Institute. This is the group responsible for maintenance and further development of APT.

Mark Century
The trade mark used by General Electric Specialty Control Department for a series of machine tool controls.

SALES BULLETIN NO. 42 NC-2

Information Systems

Time-Sharing Service

1968....
THE YEAR OF NUMERICAL CONTROL

DYNAMIC DUO

Numerical Control is frequently referred to as the one overwhelming metalworking development of this century. Now, that capability can be stretched even farther... by linking it with Time-Sharing. NC and Time-Sharing Service make a great team for hitting the manufacturing market.

Our first NC sales bulletin merely broke the ice by announcing our strong sales thrust planned for this big market in 1968. This bulletin (#2 in the series) explains the fundamentals of the NC process. As new NC programs are released, additional bulletins will discuss each of them specifically.

NC IS A HOT MARKET

The growth of NC has been very rapid. The number of NC tools installed is doubling every year, as the table below shows.

YEAR	TOTAL NC TOOLS INSTALLED
1960	629
1962	1,891
1964	4,236
1966	8,762
1968	16,700*
1970	28,600*
1972	47,000*

* Figures based upon forcast of shipments from the National Machine Tool Builders Association

To help you get up to speed in this key market area, read the article "Crank the Handwheel Eight Times." This is partially a pickup from American Machinist. It focuses clearly upon the general idea of NC. The second article called "Elements of the NC Process," is a more detailed discussion of NC. It will give you a good understanding of the NC process, the sequence of events, the work of the parts programmer, and the like. A list of references is included.

CRANK THE HANDWHEEL EIGHT TURNS

"Crank the handwheel eight turns, and thump the carriage once to make sure."

When a man does it, that's manual control. When a circuit triggers the action, that's numerical control.

That's how simple the NC concept really is.

In one instance, a man carries the numerical data in his head, and counts the turns as he transfers the data to the machine by hand.

In the other, the very same information is carried by holes in a tape. A controller does the counting, and the instructions are transmitted to the machine by a non-human agent.

Perhaps this is an oversimplification of NC, but it does make a valid point: There is nothing complicated about the idea of controlling metalcutting machines (and a great variety of other equipment) by feeding them numbers.

Numerical control is a method of automating machine tools while retaining the ability to switch to different jobs. It is accomplished by feeding a previously prepared tape, or other medium, with all commands in numerical form to a control system which directs the machine.

POINT TO POINT? CONTOURING?

Basically, there are two different degrees of control that can be handled numerically on machine tools: point-to-point and contouring.

In the simplest point-to-point control, as implied by its name, the tool and the workpiece are placed in the desired relationship, and then the tool is advanced. Drilling a pattern of holes would be a typical example: the NC table positions the work under the spindle, and then the drill is advanced. Tool advance might be under either manual or automatic control.

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The distinguishing feature of this type of control is that it is immaterial what route is taken to place tool and workpiece in the desired relationship. It might travel in a straight line, or it might zig and zag.

In contouring, on the other hand, the path of the tool must be controlled continuously, as in a profile milling job. This requires constant syncronization of the tool's motion in more than one spatial axis. Contouring is also referred to as continuous-path, while point-to-point is generally synonymous with positioning.

Note that the basic definitions of positioning and contouring apply whether the system operates in two dimensions or three. If you're just getting into numerical control, you've probably seen the terms "two-axis" and "three-axis" control. But you may not have encountered the term "multi-axis." This term is commonly used to refer to large machine tools having four or five axes of motion. In addition to the normal X, Y, and Z motions, these tools have a rotating table and can adjust the cutting head to different angles.

Other NC terminology that is commonly used is listed in the attachment to NC Bulletin Number 1. Make these "in words" a familiar part of your NC vocabulary before talking to your prospects.

FOR ADDITIONAL INFORMATION, HERE IS A LIST OF PUBLICATIONS OFFERING GREATER DETAIL ON NUMERICAL CONTROL.

NUMERICALLY CONTROLLED MACHINE TOOLS, *GE Computer Equipment Dept., No. CPB 343 A*

GE 400 SERIES ADAPT PART PROGRAMMING, *GE Computer Equipment Dept., No. CPB 1155*

PRINCIPLES OF NUMERICAL CONTROL, *James Childs – Industrial Press*

APT PART PROGRAMMING, *McGraw Hill Book Co.*

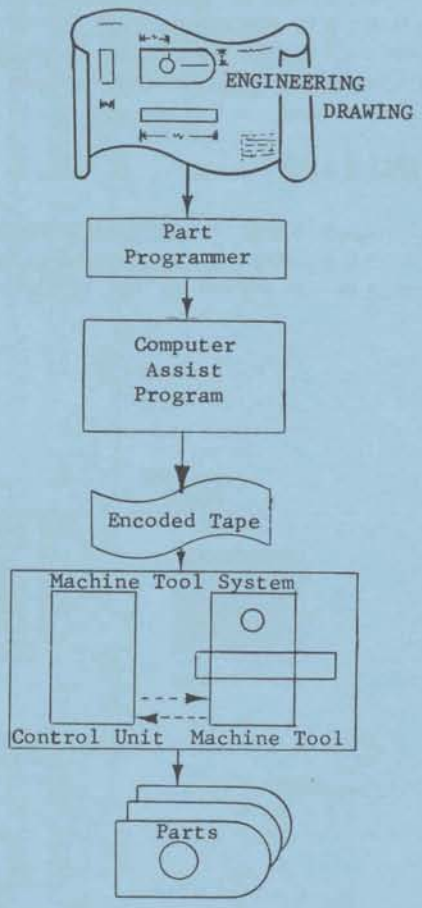
THE LANGUAGES OF TAPE, *Special Report No. 545 from American Machinist Magazine (The article originally appeared in the January 6, 1964, issue.)*

APT – ADAPT, *Special Report No. 554 from American Machinist Magazine (The article originally appeared in the June 22, 1964, issue.)*

NC TODAY, *Special Report No. 579 from American Machinist Magazine (The article originally appeared in the November 22, 1965, issue.)*

ELEMENTS OF THE NC PROCESS

The "part" is the final goal of any machining activity, numerically controlled or conventional. In NC, the process begins with an engineering drawing and ends with a machined part, as shown below.



ELEMENTS OF A NUMERICALLY CONTROLLED PROCESS

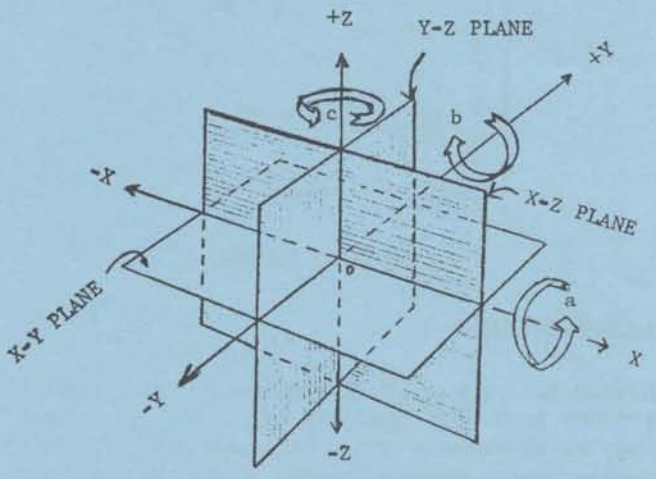
PARTS

Parts machined by numerical control will usually have a lower manufacturing cost than a conventional process. This becomes particularly true as parts complexity increases. In conventional machining, an increase in parts complexity results in a sharp rise in corresponding manufacturing costs, primarily attributable to the extensive time required by the operator in providing the control function (that is, the operator must work cautiously to ensure dimensional accuracy and avoid the possibility of scrapping an expensive workpiece that has taken hours of machining to develop). It was this potential savings in machining complex parts that initially spurred the development of numerical control. The numerical control technique was later extended to simpler machining problems such as drilling operations, resulting in productivity ratios of 3 to 1 (or more) over conventional equipment.

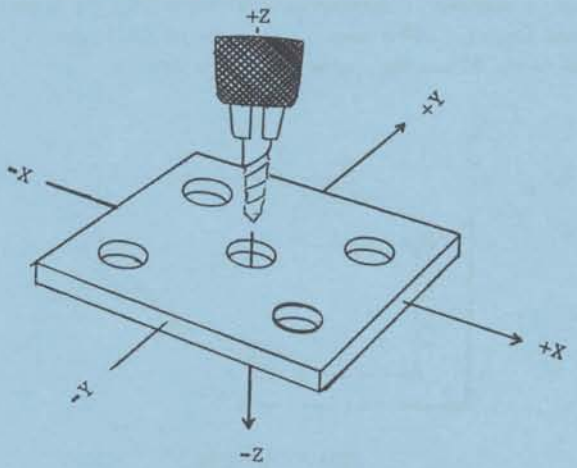
MACHINE TOOL SYSTEM-PROGRAMMED MOTIONS

The complexity of the parts to be machined dictates the particular machine tool and control system used. Each system can, however, be described in common terms of the number of axes along which motion can be taken as well as the number of axes about which rotation is possible as shown below in the Cartesian-Coordinate System.

Some numerical control systems position the table to changing X and Y coordinates but do not directly control the movement of the spindle or Z axis (see sketch below). This type of equipment is classed as a two-axis (X-Y) machine tool system. When the program media also controls the movement along the Z axis, (the depth the tool penetrates the material) it is called a three-axis (X-Y-Z) machine tool system. (This axis terminology does not include rotation of the cutting tool.)



CARTESIAN COORDINATE SYSTEM



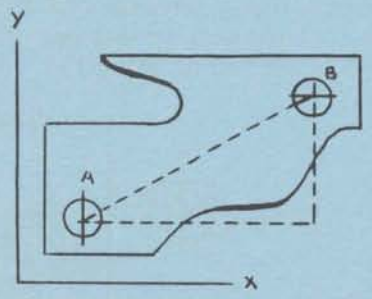
RELATIONSHIP OF A MACHINE SPINDLE TO THE WORK SURFACE

The number of programmed motions possible and the associated accuracy is a function of the total machine tool and control system. The two general machining methods, point to point and contouring are discussed below.

POINT-TO-POINT

Consider an operation requiring machining in discrete part locations, for example, drilling two holes in a given part. (See figure). In this example, we are not concerned with the path the tool will take in going from one point to the other since the tool does not perform work during the positioning movement. Here work is performed at point A, the tool withdrawn, the table moved, and then the work is again done at point B.

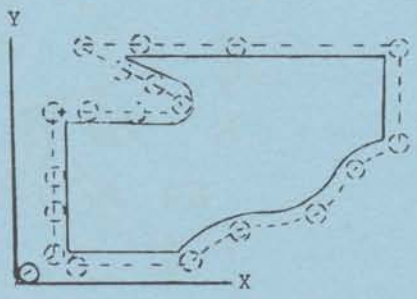
Approximately 80 percent of the numerically controlled machines presently installed are of this type. Typical prices for this equipment range from $10,000 to $100,00.



POINT TO POINT

CONTOURING

Continuous path or contouring machine tool control systems have the capability of cutting curves and complex three-dimensional contoured shapes. The machine tool, under direction of the control unit, positions minutely to new coordinate values such that a smooth, continuous cutting path is generated. (See figure). The tool is in continuous contact with the work while the table is in motion.



CONTOURING

The continuous path tool control uses one of the following interpolation methods for moving the tool through a curved pattern:

Circular Interpolation — A curve is described by a series of circular arcs.

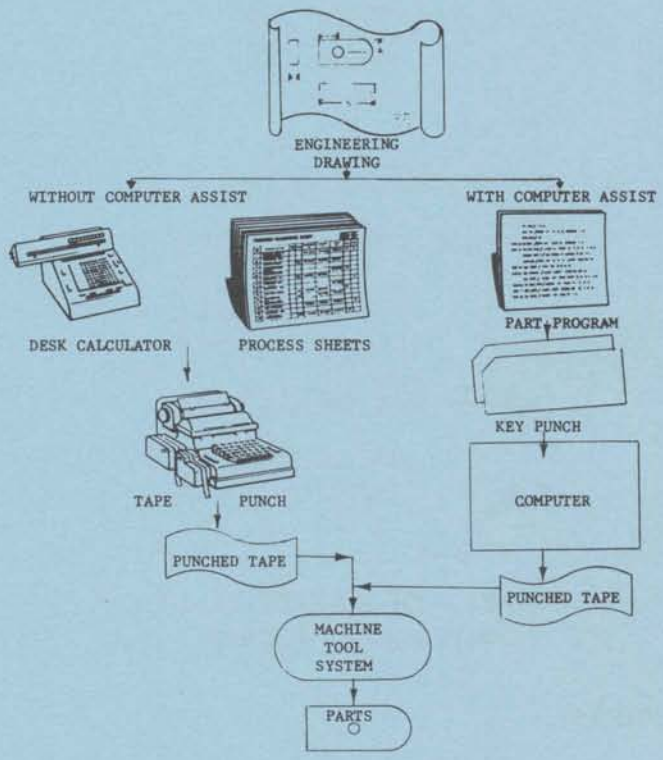
Linear Interpolation — A curve is described by a series of straight lines.

Parabolic Interpolation — A curve is described by a series of parabolic curves.

Most of the contouring controls manufactured by the leading control builders feature circular interpolation because the majority of parts surfaces are dimensioned as arcs of circles. The tool control generates all points on the arc when given the end points of the arc, the radius, and the center of the arc circle. Typical contouring machine tool investment begins at $75,000 and extends upward to $1,000,000. or more.

ENCODED TAPE

Punched tapes used to instruct numerically controlled machine tools are usually prepared by one of the processes illustrated in the following diagram:



PUNCHED TAPE PREPARATION--WITH AND WITHOUT A COMPUTER

With a noncomputer-assist approach, the parts programmer directly codes parts process instructions in a format understandable by the machine tool system. This is equivalent to programming a computer in machine language. These instructions are then converted to a tape-coded format with a tape punch. All calculations are made by the programmer. In a computer-assist program, a language similar to English is used to describe the parts and the required tooling operations. These statements, called a parts program, are keypunched and entered in a computer which performs all required computations and converts the parts program to coded information understandable by the machine tool system. With General Electric Time-Sharing Service, the parts

programmer prepares his tape right at his teletypewriter. By so doing, he eliminates the many errors inherent in the manual technique, and avoids the tremendous delay inherent in batch computer approaches.

PARTS PROGRAMMER

The parts programmer, through the media of numerical control, has the same capability for creating machined parts as the skilled machinist using conventional equipment. Essentially, the parts programmer or planner instructs the machine tool system in the sequence of operations to be performed. The machine tool system does not have "ears" to hear the programmer's words, but the system does have "eyes," in terms of its ability to read punched tape. The programmer communicates with the machine tool system in a written form which can be converted to punched tape.

In a noncomputer-assist program, the parts programmer is required to use a language which is directly understandable by the machine tool system. (See figure). In addition, he must perform all necessary computations by hand.

In a computer-assist program, the programmer uses a language similar to English rather than one which is machine-oriented. (See figure). In addition, the computer performs all the computations required to translate the programmer's statements into a machine tool system language.

Instruction	Description
m03	(Spindle on, clockwise)
717	(Spindle speed, 1700 rpm)
m08	(Coolant on)
560	(Feedrate, 60 inches/min.)

NONCOMPUTER-ASSIST LANGUAGE

Instruction	Description
SPINDL/1728, CW	(Spindle on at 1728 rpm, clockwise)
COLONT/ON	(Coolant on)
FEDRAT/60	(Feedrate, 60 inches/min.)

COMPUTER-ASSIST LANGUAGE

COMPUTER-ASSIST PROGRAMS

Numerous calculations are required to instruct continuous path control equipment. The volume of work required makes computer-assist programs virtually mandatory for this type of application. A large number of users still manually prepare NC instructions for positioning equipment. The trend, however, is to increased computer utilization. Tailored computer-assist programs have been written for specific control machine tool combination. Since the variety of control and machine tool combinations is very broad, this approach requires an extensive programming effort. To offset this problem, generalized computer-assist programs have been developed for given classifications of control and machine tool combinations. Some subsequent programming effort is then required to tailor the output of the generalized program to the specific machine tool system. These two programming efforts (that is, "generalized," and tailored") are referred to as the "main" or "preprocessor" program and the "postprocessor" program. The generalized main processor, written only once, typically does editing, translating of the source language, calculations, and merging of tool information. It produces an intermediate output which is read by the postprocessor program and which tailors the information to a specific control-machine tool combination.

ENGINEERING DRAWINGS

In general, the application of Numerical Control does not require a unique drafting system. However, there are a certain noncomputer-assist tape preparation methods that require restricted drafting practices. With computer-assist programs, parts have been produced accurately from sketches on the "back of an old envelope." There is no question, however, that the parts programmer's task of describing the part to the computer is facilitated when good engineering drawing techniques are utilized.

SUMMARY

Numerical Control is a technological innovation which controls the movement of machine tools through numerically encoded instructions. This innovation provides manufacturing managers with highly efficient, versatile, automatic production devices. Preparation of instructions for NC tools involves precise definition of where the tool head is to be at any given instant and the great number of mathmatical calculations required to determine these points. In the past, the capability of NC tools frequently exceeded the ability of man to do the calculation and provide the input. General Electric Time-Sharing Service solves this problem. Now NC programing can be done conveniently, efficiently, and at a relatively small overall cost.

SALES BULLETIN NO. 42 NC-3

1968....

THE YEAR OF NUMERICAL CONTROL

Information Systems

Time-Sharing Service

2-13-68

THREE QUICK POINTS ON NC-

1. We promise not to send anymore long, detailed, frightening, full of strange words, dissertations on NC. However, NC Bulletin #2 and the references attached to it give you a good background for discussing NC with your prospect's technical people. Perhaps now is the time to reread it.

2. Enclosed (with salesmen's copies of this bulletin only) is an excellent report prepared by Arthur D. Little, Inc. This report is non-technical and provides a good overview of the history, status, and potential of the NC industry. It provides the broad perspective you need for discussing NC with your prospect's top management.

3. Are we gaining any revenue from these piles of paper we send you??? If the answer is yes, we can get more resources applied to the NC project and release new products faster.

   How about letting me know of any new contracts you receive, or any significant increases in revenue from existing customers, due primarily to our NC programs. Phone calls, TTY messages, letters, hand-scratched notes are all fine. Just let me know your name, the customer's name and whether it is a new contract or a revenue increase.

   In return – we will publish this information in future NC Bulletins and try to get more NC products into the 1968 pipeline.

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GENERAL ELECTRIC
INFORMATION SERVICE DEPARTMENT

SALES BULLETIN NO. 42 NC-4

1968

THE YEAR OF NUMERICAL CONTROL

Information Systems

Time-Sharing Service

2-29-68

NC IS EASY TO SELL

What Do We Sell Today?

Right now there are three programs available that are very attractive to NC users.

NCPTS$ - for calculating part geometry
NCTAP$ - for formatting the data to the user's specific NC tool
NCEIA$ - for punching the tape at the terminal

You already have promotional sheets and user guides that describe these programs. Take a few minutes and run the programs to become familiar with them.

Who Are The Prospects?

Most NC programming is done in a company's Manufacturing Engineering Group. This is the group that is responsible for the way the product moves through the production cycle. Start looking for the decision-maker here.

There are two basic types of parts programming:

A. Using a calculator or some other manual method

B. Using an in-house computer or a batch computing service

A prospect is usually all one or the other. Each type has a different base of knowledge and will need to be approached differently. Your first step, once you have an indication of interest, is to qualify the prospect as one or the other type.

A. Those Prospects Using Manual Methods

The programs we now have are most attractive to this kind of prospect. Why? Here are three real benefits:

1. The programs eliminate doing a great number of tedious calculations manually or with a desk calculator.
2. These people are not conversant with the many automatic features of a full-blown parts programming language so are not expecting elaborate built-ins.
3. These programs allow better utilization of some 2-axis tools because they easily handle 2-axis contouring work. Many tools have this capability but it is not presently being used because manual programming is too complex

How Do We Pitch To These Prospects?

Easy ---

1. To emphasize the first benefit, high-light the speed and accuracy of time-sharing---particularly with reference to complex parts. The parts programmer's productivity is immensely increased.
2. On the second, make a strong case for simplicity, convenience, and reliability. These points are important because NC prospects are generally from a manufacturing background and probably have an instinctive fear of the "big complicated computer up in Finance."
3. When it comes to discussing 2-axis contouring, tell your prospect how he simply defines more points very close together and does not instruct the tool to be withdrawn during movement of the work table - NCPTS does all the point calculations.

B. Those Prospects Now Using Computers

We have a strong story to tell here too. Here's a few pluses for the prospect using an in-house computer or a batch computing service.

1. Our fast turnaround. The quick response of time-sharing helps to meet tight production schedules. No more waiting for days to get a program back from the computer room.

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And parts programs are like all others--they rarely run right the first time. No more delays waiting for program re-runs. With time-sharing service a parts programmer can correct and re-run as many times as he needs to--without interruption or delay.

2. All facets of NC tape preparation are under direct control of the parts programmers. No more sparring with Finance or the in-house data processing manager to get keypunching and computer time. With time-sharing the parts programmer talks directly to the computer, and the time-sharing terminal produces his paper tape. He controls the whole process.

3. Immediate availability of tapes permits better use of expensive NC equipment. Machine idle time is reduced simply because more tapes can now be produced quickly and accurately.

4. Tapes can be corrected quickly if an error is discovered after a tool is "set-up" for production. The manufacturing engineer no longer has to either (1) let the tool sit idle, or (2) tear down an expensive set-up until a corrected tape is prepared. With time-sharing service he is able to quickly correct his program, rerun his tape, and keep his machine going.

Beware!

No matter whom you talk to, you will probably have to field this one. Prospects will raise one question consistently— "What are you doing about post-processors" or expressed another way, "Do you have a postprocessor for my Model X Drill with a Model Y controller?"

Here's Your Reply

Our current programs do not need a postprocessor per se. The programs create a point coordinate file and provide the structure into which a user enters the machine tool commands necessary to machine a specific part. The program NCTAP actually performs some of the work normally done by a postprocessor. NCTAP modifies its output to fit a specific machine system according to the user's answers to the questions asked by NCTAP. The programs, in effect, produce a tape ready for use without the need for the conventional postprocessor.

Modification of NCTAP

In several centers the Customer Application Specialists have been changing NCTAP to make it more suitable for a specific tool/controller combination. If you need to make a change, have your CAS call Wayne Hanners in Operations Engineering - 8*273-4468.

How Do We Clinch The Sale?

It's the old story -- sock it to them with a demonstration. The sample programs in the Numerical Control Programming Users Guide (Pub. No. 712222) are good workhorses. Particularly the one on page 25. It focusses clearly on how one or two variables can easily be changed in the program and a whole new set of points immediately produced. It will really impress a man who is used to endless manual calculations.

Lastly, swing them our way by mentioning the man who owns one. The list sent to each office last week mentioned 27 enthusiastic users of our NC programs. As NC time-sharing catches on, we will give you more names and testimonies.

After you have a signed contract, make arrangements with the local phone company to disable the EOT function on any MOD 33 TTY's. This is required because one of the standard EIA characters is the same as an ASCHII EOT and will turn the TTY off.

OK - FAST TURNAROUND, CONVENIENCE, LOW COST. YOU KNOW WHY PEOPLE LIKE GE TIME-SHARING SERVICE. TELL THE STORY NOW TO THE NC MARKET. YOU'LL NEED LOTS OF BLANK CONTRACTS!

SALES BULLETIN NO. 42 NC-5

NC ROUNDUP

Information Systems

Time-Sharing Service

4-24-68

There is a lot of action in the NC market. To help you keep up, this bulletin summarizes activity to date, results, and future plans.

The Market

Market potential is excellent. The facts are:

2,260 companies now use NC tools
400 new companies taking delivery in 1969
16,400 machine tools installed
28,300 by 1970
46,700 by 1972

The number of NC tools installed will triple in the next four years. And they are ripe for Time-Sharing Service!

Results to Date

They like it. That's right. Already there are over 40 customers making tapes the GE way. Big companies and small ones. Check the attached list. It's not complete because new customers are added every day. But it tells us clearly that we have a winning combination: an excellent product and superior salesmen.

Latest Selling Tips

Seminars

Offices in the heart of the NC country are finding that a 2 or 3 hour seminar is more than worth the time invested. Your sales manager has already received agendas and other details.

Distributors

The machine tool distributors are a powerful "in group" with our prospects. Make a concerted effort to get them enthusiastic about our service. They can really extend your selling power. A copy of the Directory of Members of the American Machine Tool Distributors Association was recently sent to all offices. Look up the distributors in your area and get to know them.

One-Program-At-A-Time Approach

A surprising number of customers get hooked by one particular facet of our NC package. The Machine Tool Description file concept is proving to be a really powerful innovation for many users. And others find that NCPTS is the answer to their prayers. As you talk to your prospects, be alert to this kind of special interest.

Non-Computer Users

Focus your selling effort here first. Our NC programs are easier to sell to the man who is not already tied into a programming language.

Competition

Yes, there is some. But nothing as attractive as our service

Comshare

Features a version of the "split" language called Compact. Pricing is on a sliding scale based upon usage. Except at the extreme high-usage end of the scale we compare favorably. Main disadvantage is that the user requires a "machine link" that is basically a postprocessor and that costs him approximately $2,000 per NC tool.

CDC

Offers remote-batch APT with a CDC-6600 in L.A. But the user requires a very expensive CDC-6030 or 6040 terminal.

GENERAL ELECTRIC
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Univac

Offers remote-batch APT on an 1108 in New York. Here also a very expensive terminal (1004-1005) is required.

Product Information

Re-read the Sales Bulletins No. 42 series.
NC-1 sums up the plans and gives you the "buzz words". Review them to be sure you feel at home with them.
NC-2 gets you into point-to-point, contouring, and the NC process with and without computers.
NC-3 included an excellent booklet published by Arthur D. Little that gives an overview of the NC industry. It provides the broad perspective that you need for discussing NC with your prospects' top management.
NC-4 tells you how to find the prospects, gives you the main points to hit in your pitch, and includes some tips for closing the sale.
Other literature that tells our story and works hard for you includes:
Green promotional sheet, NC Point-to-Point Processor (No. 132127A)
Green "Customer Testimony" sheet just off the press (No. 114048)
Numerical Control Programming Manual (No. 712222)
Numerical Control Point-to-Point Processor Manual (No. 802208)
Pink list of where local service is available.

Communications Campaign

A total campaign backs up your selling effort. Major events and activities that will help you find leads and sign contracts are covered below.

Press Conference

The formal public announcement in Philadelphia on April 3 was a resounding success. Editors from major metalworking and computer publications were excited about what they heard and saw. Stories are already appearing in STEEL, METALWORKING NEWS, and IRON AGE. The best ones will be reprinted and sent to you.

Mac's Speech at the NC Society

Mac McCleary gave a hard-hitting talk that really set the audience on fire. They stood in line to ask him questions. That evening the suite was packed with enthusiastic prospects. The speech has been sent to all sales personnel. The excellent supporting slides are available on loan from Jim Doyle (8*273-4391) for your local presentations.

ASTME Conference

Forty-thousand people are expected at this major tool machine conference. We will have a 100 square foot area featuring a new NC oriented exhibit and three terminals on which we will prepare control tapes for point-to-point machine tools. Details are:

Date ..... April 29-May 3
Place..... Philadelphia Civic Center—Booth 2629

Plans are to run these tapes on actual tools installed in tool manufacturers' exhibit areas at the show.

Space Advertising

A two-page, high-quality ad will appear in the June, July and August issues of the following metalworking magazines: AMERICAN MACHINIST, STEEL, PRODUCTION. Copies of the ads will be attractively covered and provided to you in quantity for your local use.

When the REMAPT Language and postprocessor programs become available, a follow-on ad will be run announcing these services. Copies of this ad will be sent to you in the same way as the first one.

Direct Mail

An eye-catching series of four mailing pieces will be sent to all companies now using NC equipment, and selected other potential users. The mailings will be sent every two weeks starting in mid-June. Each mailing will focus upon one of the benefits of NC Time-Sharing. To keep you posted, copies of the mailing pieces will be sent to each office just before the mailings go out to prospects. Plans are to make these mailing pieces available to you in quantity for your local mailings.

Inquiry System

The stories that result from the press conference, the ads in metalworking books, and the direct mail campaign will result in inquiries that you can convert into customers.

A complete, fast-reaction inquiry system is already in place to speed the inquiries directly to your office. Hot leads (those asking for demos, a sales call, specific information, etc.) will be sent to you within 24 hours. Brochures will go automatically to these hot lead addresses.

Other inquiries will be sorted and sent to you once a week. Brochures will be sent to these inquiries at the same time, along with a card on which the inquirer can request more information. When this second inquiry is received it will automatically be handled as a hot lead and sent to you within 24 hours. The rest is up to you.

GENERAL ELECTRIC TIME-SHARING SERVICE
NUMERICAL CONTROL CUSTOMERS

Customer	Location	Sales Rep
Akron Equipment Company	Akron, Ohio	Terry Troy
American International Aluminum Corp.	Detroit, Mich.	Ed Lansky
American Tool Works Company	Cincinnati, Ohio	John Schneider
Armco Steel	Houston, Texas	Frank McMordie
Avey Machine Tool Co.	Cincinnati, Ohio	John Schneider
Bell Telephone Labs	Allentown, Pa.	E. H. Weidberg
Brown & Sharpe	Providence R. I.	Al Boynton
Carlton Machine TooleCompany	Cincinnati, Ohio	John Schneider
Chrysler Corp.	Detroit, Michigan	Stan Freville
Cleveland Crane	Cleveland, Ohio	Joe Greene
Cleveland Twist Drill Company	Cleveland, Ohio	Joe Greene
Columbus Metals Corp.	Burlington, N.J.	Bill Minkoff
Digital Electronics	Seattle, Wash.	
Fosdick Machine Tool Company	Cincinnati, Ohio	John Schneider
GE DC Motor & Generator	Erie, Pa.	Ralph Gang
GE Flight Propulsion Division	Evendale, Ohio	Carl Fiorenza
GE Lamp Equipment Operation	Cleveland, Ohio	Ralph Gang
GE Lamp Glass Department	Cleveland, Ohio	Ralph Gang
GE Metallurgical Products	Detroit, Mich.	Stan Freville
General Motors (Allison Div., Cleveland Tank Plant)	Cleveland, Ohio	Joe Greene
Horsburgh & Scott Company	Cleveland, Ohio	Joe Greene
Hydromatics Inc.	Bloomfield, N.J.	L. W. Deuel
Information Development Corp.	Akron, Ohio	Terry Troy
R. K. LeBlond Machine Tool Company	Cincinnati, Ohio	John Schneider
Lear Siegler Inc.	Cleveland, Ohio	Joe Greene
Lodge & Shipley Company	Cincinnati, Ohio	John Schneider
Micro Pump	San Francisco, Cal.	Phil Moody
Midland Ross (Waldron-Hartig Div.)	Somerset, N.J.	E.W. Dooley
Moore Tool Co.	Bridgeport, Conn.	Ed Wingert
Mulhare & Bowie	S. Norwalk, Conn.	Ed Wingert
New York City Community College	New York, N.Y.	Stu Glick
Nu mac Company	Cleveland, Ohio	Joe Greene
Numerical Cutting	Buffalo, N.Y.	Bob Elliott
Ohio Crankshaft Company	Cleveland, Ohio	Joe Greene
Pacific Scientific	Anaheim, Cal.	Bill Babcock
Parker Hannifin Corp.	Cleveland, Ohio	Joe Greene
Quality Gage & Mfg. Inc.	Cleveland, Ohio	Ralph Gang
Raytheon Company	Santa Barbara, Cal.	Lacy Johnson
Research Design	Detroit, Mich.	Ed Lansky
Rocketdyne (Div. of NAA)	Canoga Park, Cal.	Jay Ackerman
Triton College	Chicago, Ill.	J. Munder
W. S. Tyler Inc.	Cleveland, Ohio	Joe Greene
Vulcan Mfg. Company	Cincinnati, Ohio	John Schneider
Westinghouse Electric Corp.	Bloombield, N.J.	L.W. Deuel

SALES BULLETIN NO. 42 NC-6

NC SELLING POINTERS AND SALES TIPS

Information Systems

Time-Sharing Service

6-14-68

SATISFIED CUSTOMERS

The number of NC customers is growing fast – it now numbers over 60. The attached sheet lists them all. Companies who have signed a contract since the last list we sent you (Bulletin 42 NC-5) are shown with an asterisk.

Sales Bulletins NC-4 and 5 contained some good selling tips for getting your NC prospect on the "sold" list. Here are a few more ideas.

SELLING POINTERS

Short vs. Long Runs

Look for the prospect who sets up for frequent short runs. They will have a frequent need for new tapes. Shops that set up for relatively simple, long runs may feel that their present method of preparing an occasional tape is satisfactory. NC job shops are ideal prospects.

Top-Level Selling

Try approaching the top-level decision maker, such as the manufacturing manager, who is concerned with dollars. Stress reduction of machine idle time, faster tape correction, better machine utilization. Also explain that he becomes more flexible to take new jobs and to switch jobs to different tools to ease scheduling problems. Another thought – when you go down to see the men on the job you have the added impetus of "being sent" by the VP.

ISD Team

The GE Industrial Sales Division has a real "in" with NC users. They can tell you who the decision maker is, what is important to him, and how to best approach him. They can also familiarize you with the type of equipment the prospect has, so that you can be prepared to discuss specifics. Listed below are the ISD Numerical Control Influence Men. Get to know the man who handles your area.

G. E. Troyak (Glenn)
Minneapolis – 8*326-1236

K. E. Kreh (Ken)
Detroit – 8*362-4265

T. G. Braly (Tom)
Dallas – 8*352-2223

H. E. Johnson (Harvey)
Los Angeles – 8*432-4328

G. U. Dautrich (George)
Hamden – 8*223-2313

W. M. McKenzie (Bill)
Philadelphia – 8*243-5322

J. W. Ellis (Jack)
Detroit – 8*362-4269

M. J. Swanson (Mal)
Syracuse – 8*256-7283

R. K. Mengel (Ron)
Chicago – 8*323-3603

D. G. Wallace (Dave)
Cleveland – 8*344-6069

The Shop with One or Two Tools

An excellent prospect, he knows the NC business and is over the "fear" of NC tools. Show him how he can simplify part programming and thus add more NC tools to increase output and reduce costs.

Control

Keeping the tape preparation job in-house, under direct control, is a good point to mention to those who go outside for tape preparation. With GE Time-Sharing Service he sets his own schedules and is able to make last minute changes without affecting his production schedule.

SALES TOOLS

Reprints

Enclosed is a copy of the American Machinist

Continued on reverse side

1 M (6–68)

GENERAL ELECTRIC
INFORMATION SERVICE DEPARTMENT

article "Can You afford Manual Programming?". It gives you some good ammunition for converting your prospects from manual programming techniques to GE Time-Sharing Service. These are available in quantity from the Schenectady Warehouse (order by No. 120058). Include one whenever you hand out a folder of NC material at NC Society meetings, our own NC seminars, etc.

Machine Tool Description Files

The information retrieval system for Machine Tool Description Files is now operational on the Washington "W" system. As mentioned in Operations Bulletin 16, you can access it with a W99 --- user number.

List MTDFL* for instructions and a catalog of tools for which MTDF's have already been written. Using the tool description file for your prospect's NC tool (or an existing one similar to his) makes a first class demonstration. Make this file even more useful by sending in your MTDF's; Wayne Hanners will get them into the Washington System to give you a bigger library to work with.

Get Ready to Handle Some More Hot Prospects

A lot of promotional activity is scheduled in the next few months. Highlights are:

- A composite of recently published magazine articles (Pub. No. GER-1948) was sent to all sales offices on June 12. These make excellent handouts to prospects because they are current and are filled with comments from enthusiastic NC users.

- A special mailing of NC literature will be made to all machine tool distributors on June 17. A copy of the cover letter is attached. It may give you some ideas for a local mailing cover letter.

- A two-page, four-color ad will run in key metalworking magazines starting in the July issues. The ad schedule is as follows:

Production	July 1 and 30
Iron Age	July 4 and August 1
Steel (Metalworking)	July 8 and August 5
American Machinist	July 15 and August 12

Advance copies of the ad will be mailed to Sales Representatives, CAS's, and managers on June 21, as well as to Industrial Sales and ISS&S Sales. On June 24, copies will be sent to key GE managers and NC personnel outside our Department and to NC distributors.

Copies of the ad will be stocked for your use starting in July. Order them by number 291-40. They make excellent handouts at meetings and seminars.

The first mailing of our NC direct mail campaign will go out on July 8. The orange mailer you received in the NC sales kit in the Poconos will be sent to 5325 manufacturing and engineering people throughout the U.S. and Canada. Schedule for the other three mailers in the series is July 22, August 5, and August 19.

Inquiries resulting from all of this promotional activity will be communicated directly to you. If they are hot leads (requests for sales calls, demonstrations, or specific application information) they will be teletyped to the applicable sales office each day. Other inquiries will be sent to you on a weekly basis. Make this promotion work for you! Follow up your leads!

GENERAL ELECTRIC TIME-SHARING SERVICE
NUMERICAL CONTROL CUSTOMERS
(OVERSEAS NOT INCLUDED)

Customer	Location	Sales Rep.
Akron Equipment Company	Akron, Ohio	Terry Troy
American International Aluminum Corp.	Detroit, Mich.	Ed Lansky
American Tool Works Company	Cincinnati, Ohio	John Schneider
Armco Steel	Houston, Texas	Frank McMordie
*Automatic Metal Products	Brooklyn, N.Y.	Stu Glick
Avey Machine Tool Co.	Cincinnati, Ohio	John Schneider
Brown & Sharpe	Providence, R. I.	Al Boynton
*Brunswick	Muskeegon, Mich.	Ike Smith
Carlton Machine Tool Company	Cincinnati, Ohio	John Schneider
Chrysler	Detroit, Mich.	Stan Freville
*City Tool & Die	Muncie, Ind.	Bill Jackson
Cleveland Crane	Cleveland, Ohio	Joe Greene
Cleveland Twist Drill Company	Cleveland, Ohio	Joe Greene
Columbus Metals Corp.	Burlington, N.J.	Bill Minkoff
*Computerized Machining	Detroit, Mich.	Bill Reagan
*Cryton Optics	Brooklyn, N.Y.	Stu Glick
Digital Electronics	Seattle, Wash.	
*Dresser Industries (Oil Tool Div.)	Dallas, Tex.	George Bartosh
*Emerson	St. Louis, Mo.	Jim Theirl
*FMC Corp. (San Jose Ordnance Plant)	San Jose, Cal.	Bob Fuller
Fosdick Machine Tool Company	Cincinnati, Ohio	John Schneider
*General Dynamics	Dallas, Tex.	Harry Hearn
*GE Computer Department	Phoenix, Ariz.	Mike Schermer
GE DC Motor & Generator	Erie, Pa.	Ralph Gang
GE Flight Propulsion Division	Evendale, Ohio	Carl Fiorenza
*GE General Purpose Control	Bloomington, Ill.	J. Munder
GE Lamp Equipment Operation	Cleveland, Ohio	Ralph Gang
GE Lamp Glass Department	Cleveland, Ohio	Ralph Gang
*GE Mechanical Drives	Fitchburg, Mass.	Phil Ciolfi
GE Metallurgical Products	Detroit, Mich.	Stan Freville
General Motors (Allison Div., Cleveland Tank Plant)	Cleveland, Ohio	Joe Greene
*Hillyer Corp.	Mountainside N.J.	Larry Deuel
Horsburg & Scott Company	Cleveland, Ohio	Joe Greene
Hydromatics Inc.	Bloomfield, N.J.	L. W. Deuel
Information Development Corp.	Akron, Ohio	Terry Troy
R. K. LeBlond Machine Tool Company	Cincinnati, Ohio	John Schneider
Lear Siegler Inc.	Cleveland, Ohio	Joe Greene
Lodge & Shipley Company	Cincinnati, Ohio	John Schneider
Micro Pump	San Fran., Cal.	Phil Moody
Midland Ross (Waldron-Hartig Div.)	Somerset, N.J.	E. W. Dooley
Moore Tool Co.	Bridgeport, Conn.	Ed Wingert
*Motch & Merryweather	Cleveland, Ohio	
Mulhare & Bowie	S. Norwalk, Conn.	Ed Wingert
*National Water Lift	Kalamazoo, Mich.	Jim Mullenkamp
New York City Community College	New York, N.Y.	Stu Glick
*NRM Corp.	Akron, Ohio	T. Troy
Nu mac Company	Cleveland, Ohio	Joe Greene
Numerical Cutting	Buffalo, N.Y.	Bob Elliott
Ohio Crankshaft Company	Cleveland, Ohio	Joe Greene
Pacific Scientific	Anaheim, Cal.	Bill Babcock
Parker Hannifin Corp.	Cleveland, Ohio	Joe Greene
Quality Gauge & Mfg. Inc.	Cleveland, Ohio	Ralph Gang
Raytheon Company	Santa Barbara, Cal.	Lacy Johnson
Research Design	Detroit, Mich.	Ed Lansky
Rocketdyne (Div. of NAA)	Canoga Park, Cal.	Jay Akerman
*Size Control	Chicago, Ill.	
*Sperry Phoenix	Phoenix, Ariz.	Mike Schermer
*Stevens Engineering Co.	Phoenix, Ariz.	Mike Schermer
*Timken Corp.	Canton, Ohio	T. Troy
*Triangle Packaging	Chicago, Ill.	J. Munder
Triton College	Chicago, Ill.	J. Munder
W. S. Tyler Inc.	Cleveland, Ohio	Joe Greene
Vulcan Mfg. Company	Cincinnati, Ohio	John Schneider
Westinghouse Electric Corp.	Bloomfield, N.J.	L. W. Deuel

***Customers added since NC-5 list dated 4/24**
For use by General Electric Employees only.

6-14-68

REPRINTED FROM American Machinist

Can you afford manual programming?

A critical evaluation of computer-assisted versus manual NC parts programming shows that the cost of electronic assistance is lower than you might think

Can you afford to program your numerically controlled machines by hand? Yes, you can—if you're under no pressure to move fast, if you have a monopoly on your market, or if you pay your programmers about 2¢ per hour.

At first glance this may sound ridiculous, but the great majority of NC users today are actually practicing this approach. Numerically controlled machine tools are highly efficient, versatile, automatic production devices. Without the aid of computers, however, their capability quickly exceeds the ability of man to provide operating directions. Combined with computers, they become efficient extensions of man's creative abilities.

The problem

It is most unfortunate that our numerically controlled machine tools do not understand the spoken word, nor can they 'look' at a drawing and produce the part without any further instructions.

Since they do not have this capability, programmers must use a very rigid code and follow a format which the machine tool will accept. This code, which is foreign to human communications, must be learned, and, as with all codes, a rigid discipline must be enforced.

This is not to say that we have anything against manual programming, but certain conclusions are self-evident: it is slow, it is expensive, and it is definitely limited in its capability. This is true for the small shop and for the large one.

For the small manufacturer with simple point-to-point machines, and possibly, simple parts on engine lathes, any other technique may not seem worth the effort. However, a good case can be made for investigating the use of a computer as an aid to part programming. Even with simple machines, an early investment in this direction might be justified, and certainly a very handsome return can be foretold when additional or more complex equipment is added. Certainly, the capabilities of the programming group will be severely taxed if computer aid is not considered.

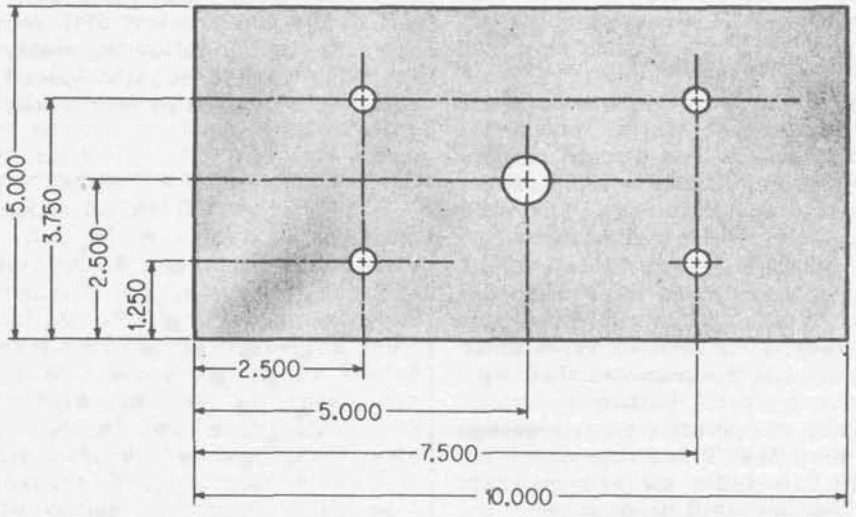
Much fear and confusion has been generated in the area of programming, particularly when computer-aided part programming is mentioned. Fear born of ignorance is unnecessary.

Do we fully comprehend what lies behind the telephone in that vast communication network that permits you to converse across the continent as easily as across the room? It is obvious that our ignorance of this specialized equipment does not prevent us from using it to its fullest advantage. Nor would you refuse to employ air transportation just because you yourself are not a licensed pilot.

Why, then, should we refuse to consider a new technology simply because we do not fully comprehend its innermost workings? It has already proven its worth for others. Therefore, let us examine the requirements of programming for NC machines and determine what advantages, if any, the computer might offer for us.

What is programming?

In its simplest form, programming (1) defines the location of



1. A computer offers no advantages in programming for parts such as this, but with a varied product mix many companies even do this type with computer aid

By Richard A Thomas
Automation software specialist
General Electric Co, Waynesboro, Va

the tool relative to the workpiece, and (2) describes the sequence of events which occur as the location of the tool changes.

The complexities of programming derive from the necessity of defining precisely where the tool is to be at any given instant and the great number of mathematical calculations required to determine these points. The degree of complexity spans the gamut from the simplest algebra to the most rigorous solid and analytical geometry. The time required for their manual execution is commensurate with the degree of effort required. And this can be both speeded and simplified with computer assistance.

The case for positioning

You have in your shop a numerically controlled drilling machine. The bulk of your work consists of drilling a few holes in flat plate stock, such as Fig. 1.

With only five holes to drill, you would seriously question the advisability of computer programming for such a part; and we might agree with you. In this simple program the coordinate dimensions can be read directly from the drawing with very few arithmetic calculations. The program can be developed almost as fast as the programmer can write it down. And, with only five holes to program, we would hardly expect him to make any error.

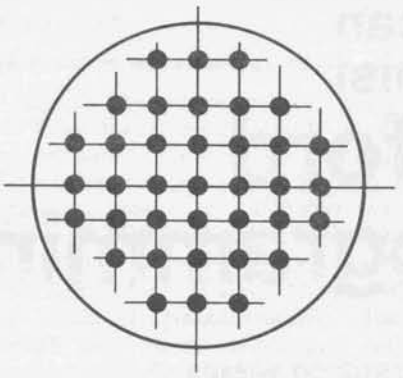
Certainly, a computer does not appear to offer any savings here. In this particular case, this may be true. But, before we make a decision based on this deliberately deceptive bit of evidence, let us consider another example or two.

A more complex part

The first example was very simple. Suppose we had a more complex part such as a printed circuit board, a micromodule board, or a rocket nozzle in which there are many holes, perhaps all of the same size and equally spaced (Fig. 2).

Not difficult, you say? Perhaps not, but what it lacks in difficulty, it makes up in tedious repetition. Our manual programmer may not find it a very challenging part. So much so that after programming the first few holes, his mind is likely to wander far enough that the first part will be scrapped unless the program is checked.

Could the computer help? But, of course! A few simple statements



2. Still simple, a pattern can cause problems because it's a dull job

defining the pattern, the number of holes in each row, the number of rows, and Big George, our friendly computer, takes over. In less time than it takes to write the name of the part on our work sheet, ol' George has all the answers calculated and arranged neatly, ready to use.

It is the computer's task to bring order from confusion, to bridge the communications gap between man and machine by accepting man's language and converting it into the language of the machine, and at the same time relieving man from the multitudinous mathematical manipulations.

To drive the point home further, let us assume the preceding pattern of holes is located in the plate shown in Fig. 3.

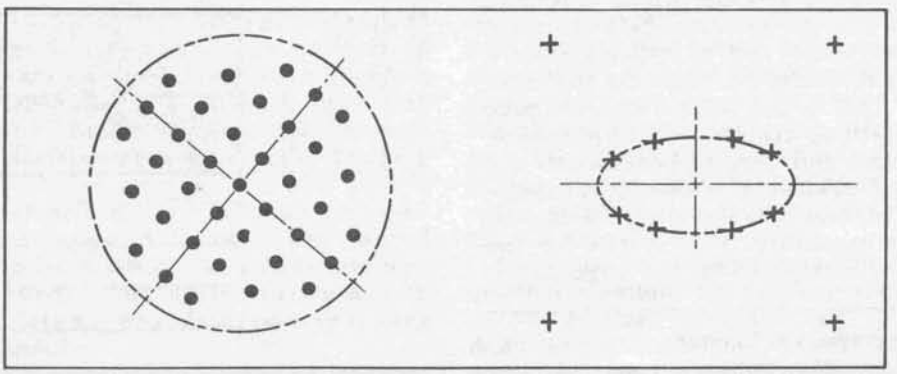
Our programmer is not only confronted with the relatively simple (but tedious) task of resolving each hole location into its axis coordinates trigonometrically (which could have been made more difficult if the angle were 57°, for example); but the drawing states that there are 12 equally spaced holes in an elliptical pattern whose equation is duly noted from the drawing. Outrageous? Yes. Impractical or improbable? Mmm. . . . maybe. Difficult? Yes, for the hand programmers, but our man George thrives on this sort of thing. And, we would guess that if you examine some of your own drawings, you will find some examples equally challenging.

This example is not particularly complex, but our programmer will find himself performing many calculations to determine point coordinates. Using a desk calculator, slide rule, or merely pad and pencil,, these will take him from 15 to 30 seconds each, and as the number of calculations increases we begin to add additional programming time and greatly increase the chance for human error. The computer can perform these calculations in one millionth of the time and continuously guarantee error-free work. It does not get tired, or confused, or distracted, or careless. It does what it is told—every time —perfectly.

Glance at the drawing once more. The computer is not concerned with the angle at which the matrix of holes is oriented. It will first calculate the coordinates of the holes in the reference shown, just as our hand programmer would do, and would then re-calculate their positions using the necessary trigonometry to put them in the proper reference for the machine's axes. The computer performs the same basic function of the hand programmer, but in about one-millionth of the time—and without error!

The problems of contouring

Programming for contoured parts is like entering a different world! The word 'contour' implies that we



3. Calculating rectangular coordinates for a tilted pattern is more complex and more time consuming. The elliptical array is worse. Call in the computer

are now dealing with a surface and not merely a point. We are interested in producing a continuous path and are therefore concerned with the location of the tool every step of the way, and not merely at isolated points. A contoured part is produced with a milling cutter or a lathe tool. It is not enough to program the surface of the work as described on the engineering drawing. No, indeed. These cutters have radii, and therefore, their centers must be offset from the work surface.

It is not the work surface that must be programmed, but the cutter center path that must be calculated and transformed into machine instructions. This will be the path the center of the tool must follow. Programming it may or may not be a simple task. It certainly is going to require a considerable knowledge of mathematics, and countless numbers of individual calculations. Look like a job for George? Very probably.

If yours is a simple part described in terms of straight lines and circles, you could probably program it by hand. After all, the offset of a circle is simply another circle, and control builders do supply control systems with circular interpolation. But, what if the surface is neither straight nor circular? Suppose it is a developed surface, not bounded by arcs of circles, what then? Or suppose it is defined by circular paths, but your control system has linear interpolation capability only.

How it's done

In this latter, much simpler case, the arc is segmented into chords which do not depart from the true circle by more than a specified tolerance (Fig 4).

Having calculated the coordinates of these individual segments (no mean task in itself), we must recalculate their equivalent offset. If the surface is not circular, a similar procedure must be followed, but the mathematics becomes considerably more complex.

So far, we have asumed only plane surfaces. Contoured parts are often not plane surfaces. Three-dimensional surfaces will bring problems to your hand programmer which would make even the strongest man blanch. And then, of course, there are those monstrous five-axis machining centers. It would be embarrassing to you and to your management if the effectiveness of these tremendously capable machines were solely limited by the inability of your hand programmers to write programs for them.

A contouring example

For purposes of example, we have chosen a valve seat (Fig. 5) which does not involve any circles except for a fillet or two and which is to be produced on a lathe. It's a very simple part, far less complex than some of the more exotic three-dimensional examples.

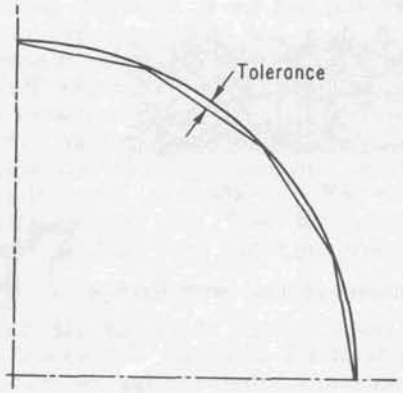
Let's assume the bottom surface is to be the reference plane. The part would be machined in two setups, one to establish the reference surface, and the second to complete the part. We would probably choose tooling with a 1/32 inch radius tip, as the print specifies fillets of this radius. In addition, we would need a boring bar and perhaps one or two form tools to do the grooves.

The methods planning, tool selection, fixturing, and determination of roughing and finishing cuts is a separate operation from the actual programming and would probably take the experienced planner less than 30 minutes.

We are not going to attempt to develop the complete program. Let us assume that we have completed our first setup, roughed the inside bore, faced and finished the reference surface, the groove and shoulder, and have rechucked the part to turn the outside, face the top, and do the angled internal surfaces.

Starting with the chamfered shoulder, and proceeding up the outside, we encounter no particular difficulty in programming as the surfaces are all either parallel or normal to the axis of rotation except for the 45° chamfers which are handled with simple trigonometric functions.

But, when we get to the inner surface, we face a problem of more than passing complexity. See Detail 'A' of Fig. 5 for an enlarged view of the area. Proceeding down the 45° slope and into the filleted pocket presents no particular problem, but getting back out on the second 45° slope does. Note that the draftsman has shown that the critical dimension of the second slope, which is parallel to the first, is 0.276 in. measured from the lower side of the tip. To relate this



4. Tolerances have to be figured when contouring with linear interpolation

to the axes of the lathe will require some trigonometry.

Next, you will notice that the second 1/32-in. fillet is tangent to the inner wall, which is parallel to the axis of rotation of the part, and to the 45° slope, but its center is not shown. Neither is the point of tangency between the fillet and the slope given. To locate these points so that the cutter path can be programmed will require some rather extensive construction.

Difficult? Not particularly; but detailed and tedious. We estimate it would take approximately 15-30 hours to program this part by hand at a cost of $200-$400, not including the time it would require to punch the tape. If George were here, he'd make short work of it. Isn't it time we call him?

Enter the computer

Meet George. A nice friendly fellow and a terrific worker. There's one thing you should remember at the outset! George cannot think, but he can do whatever you tell him to, and he has been programmed by the smartest brains in the business. Fact is, over 150 man-years of program development costing well over $6,000,000 have gone into the writing of George's program.

It's name? APT which stands for Automatic Programmed Tools. It is a program which nearly 100 companies here and abroad are using to help them part-program their NC machines. It is practically an internationally accepted standard by now. Dynamic, too. Member-companies put $750,000 a year into keeping it up to date and adding new capability to extend its usefulness.

Another thing to remember—George can do no more than a man

can do; but he is infinitely faster and does not get tired. He can work three full shifts a day if need be, and without coffee breaks. But, the best part is, he never makes a mistake! Oh, if some human programs him incorrectly, he will stop and tell you about it. More than likely, he will tell you exactly where you made your mistake, too.

Communicating with George

Does George speak—excuse me, understand English? Not exactly. You see, English has far too many words in its vocabulary. Some of the words are too big, and worst of all, some words have more than one meaning. George would get confused. So, we limit the vocabulary to a few hundred useful words or so, shorten all words to no more than six characters, and give each word only one meaning. The result is a Pidgin-English-like language that both of you can understand.

Of course, George is multilingual. He not only understands our language, but also that of any machine tool to whom he's been properly introduced. That's right. You can describe your part to him in the English-like language APT; and while you're catching your breath, he's done all those mathematical calculations and prepared a tape for your machine tool coded in the format that the tool will accept and understand.

George does more than that, too. He knows your machine tool better than you think he does. For example, if you have a long departure to make, George knows how much your machine can take in one step, and breaks it down into shorter segments if need be. Same thing about spindle speeds; if you call for a spindle speed that the machine can't produce, George finds one that will work. So it is with feedrate, too. George won't let you go too fast if the machine can't go as fast as you would like to. These are only a few of the things that George knows about your machine. Saves you having to remember yourself, or taking the time to look it up. George knows. Terrific memory.

Oh, and by the way, while you're getting your next part described, George is probably doing your payroll, keeping the books, checking inventory, scheduling jobs, running errands for the engineering department, and may even be designing some new products for tomorrow. George likes to keep busy.

How much does George cost?

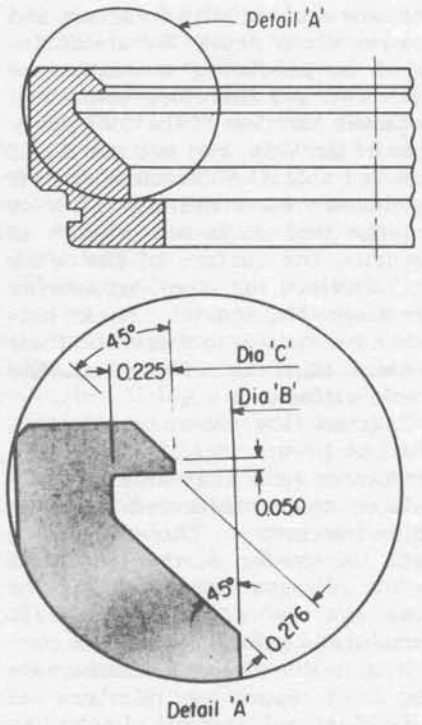
That's the wrong way to phrase it! How much does George save is much better. George can work like lightning. In one hour, he can do the equivalent of 1,000,000 man-hours of desk-calculator work. Yes sir, $600 worth of George's time is the equivalent of over $12,000,000 of manual programming. Let's break that down so we can get a better feel of it. For one cent (1¢) of computer time, we can buy over two 8-hour man-days, nearly three if you give a man a little coffee time. That means that for one dollar ($1), we can buy the equivalent of one whole man-year. Sounds like George is the best dollar-a-year man you ever had, doesn't it?

You think George isn't all that good? Let me tell you about a friend of mine. In the aircraft business, he is. He estimated that he would need about 400 mathematicians to do his programming—by hand, that is. Then, George offered him a deal. George and five other fellows did the whole job—all six billion calculations! Of course, George did all the work, but it kept those other five fellows hopping to keep up with him. What about the other 395 programmers? Didn't need them. Saved having to build a whole new plant to house them, too.

Incidentally, while we've been talking about George, our parts programmer was describing that valve seal problem to him. You remember, the one with the clever inside pocket that required all the trigonometry. It took him less than 4 hours to describe it, and George shot the answer back to him in less than 30 seconds. Total cost? Less than $50, including the tape ready for the machine.

Now that ol' George has proved his worth, how do we get him on your payroll? At $600 an hour, his wages come a little too high, you say. And you don't have enough work to keep him busy. That's a common remark, and you have a lot of company, so don't feel embarrassed. A lot of us can't afford to have George as a full-time employee. But, when there's a will, there's a way. And the way is very simple.

First, you find someone who has almost enough work to keep George busy. There are more of them than you think. Then you arrange to buy a few minutes of his time whenever you need it. This brings his cost well within the means of all of us. Now then, if you would like to have him as a part-time resident instead of having to mail or take your programs to some distant city for processing, we can arrange this, too.



5. Simple valve seat turning job calls for contouring control, and is much tougher to program than it appears

We have what is called a data terminal, a Teletype-like station from which we can send and receive your programs by telephone line. You set one next to your desk and George has one, too. This enables you and George to talk back and forth even though you may be hundreds of miles apart, or just in the next building. A data terminal can be rented for about $150 per month, plus your telephone charges. It's a pretty nice arrangement, don't you agree? In a way, it's almost like having a big public utility worth millions of dollars selling you a little bit of power when you need it. In fact, that's exactly what it is.

Let's see now, what was your original question? Oh yes, can you afford manual programming? I don't know about you, but if it were me, I'd pick up the Dataphone and let George do it! ■

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GENERAL ELECTRIC

LETTER TO NC DISTRIBUTORS

The enclosed information will help you get orders for NC tools. It describes General Electric's new method of preparing NC tapes.

Now you've got the answer when your prospect asks the question, "How do I program this NC tool if I buy it?". The answer is GE's Computer Time-Sharing Service. It's easy and economical.

GE's method of tape preparation is catching on fast. Take a minute to glance at the enclosed comments of satisfied users.

The price is right too. For as little as $200/month, your customer can use GE's computers and point-to-point programs. All he needs is a remote terminal installed wherever he wants it in his shop.

Like to know more about this new service? We would be happy to arrange a personal demonstration in your office or have you attend our next NC seminar in your area. Just fill out and return the enclosed reply card. You'll soon be ready to use this new sales tool to help you get more NC orders.

Very truly yours,

E. L. McCleary
Manager-Marketing

Enclosures: NC Point-to-Point Processor Sheet (132127A)
Customer Testimony Sheet (114048)
List of Locations
Time-Sharing Promotional Sheet (112065D)
Business Reply Card

SALES BULLETIN NO. 42 NC-7

Information Systems

Time-Sharing Service

NC STATUS REPORT

9-68

Three significant developments in NC will take place in the next few weeks:

I. NCPPX

A more powerful and versatile version of NC Point to Point Processor (NCPPP) will be loaded on Mark I Systems in October. The new program, NCPPX, is easier to use, and operates much faster than existing NC programs. NCPPX combines the functions of NCPTS, NCPPP and NCEIA for the most commonly used point patterns — circular and linear.

The major improvements provided by NCPPX are:

1 We can serve more NC tools, because the program will produce incremental or absolute coordinates.

2 Programming is greatly simplified for controllers without the optional extra of hardware "canned cycles," because NCPPX creates software "canned cycles." (A canned cycle is a macro type command to the Numerical Control Unit.)

3 NCPPX calculates coordinates, performs the post processing function and punches the EIA tape in one operation. This eliminates the time consuming file manipulations which some customers (and all salesmen) objected to with previous programs.

WHICH NC USERS WILL FIND NCPPX MOST ATTRACTIVE?

NCPPX handles a wide variety of NC Systems. However, it is especially powerful for the following:

- Milwaukeematic EA
- Milwaukeematic EB
- Cintimatics with Acramatic Controls
- Systems that require incremental coordinates

Watch the Operations Bulletins for the specific release dates.

II. NC ON THE MARK II

The three point to point programs NCPTS, NCPPX and NCEIA are being converted to the Mark II by Operations Engineering. The converted programs will produce a clean EIA tape (no need to run it thru a flexwriter anymore). Completion of this conversion is also scheduled for October.

III. REMAPT/GELATH

REMAPT is an NC part programming language which covers a wide variety of point to point and contouring applications. It is a subset of the widely used APT language. The first of a wide variety of post processors we are developing for use with REMAPT is GELATH. GELATH is a generalized post processor for use with NC lathes. GELATH is tailored to a specific NC tool by insertion of a "machine parameter file". This

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INFORMATION SERVICE DEPARTMENT

"machine parameter file" is actually a table of data on machine specifications.

Specific details regarding the selling of REMAPT/GELATH and preparation of the "machine parameter file" will be covered in the next NC bulletin.

REMAPT/GELATH is currently being field tested on the Cleveland Mark II System. It is scheduled to be commercially available on all Mark II Systems October 1, 1968. And, although we are still shaking a lot of bugs out of REMAPT, we have received very enthusiastic responses from the NC lathe manufacturers who are participating in the field test.

A variety of sales aids are being prepared to help you in your REMAPT/GELATH sales efforts.

Three prime aids working for you in October will be:

- Expansion of our NC direct mail campaign to include features and benefits of REMAPT/GELATH.
- A multi-page full color brochure covering our total NC service offering. The brochure will include specifics on REMAPT, a description of our point to point programs, and a packet for inserting the sales flyers which will be available as each post processor is released.
- A set of slides and suggested script describing the benefits of the REMAPT/GELATH system. These will be useful for presentations to your local NC Societies and for the NC seminars you have been conducting.

Three more reasons why 1968 is truly the year of NC Time-Sharing.

1. REMAPT/GELATH
2. NCPPX
3. NCPTS ON THE MARK II

SALES BULLETIN NO. 42 NC-9

Information Systems

World Leader in Time-Sharing Service

NUMERICAL CONTROL

Let's take a look at where we are and where we are going. In slightly more than a year, we have achieved a significant position in the Numerical Control market. The ever growing number of users and prospects for NC attests to the needs and potential of the market and the interest in GE's Time-Sharing Service. Why? Because the No. 1 company in the manufacturing of numerical control systems has the greatest knowledge and capacity in its NC Time-Sharing offering.

As you know, we have had our problems. These difficulties notwithstanding, the Regional Managers are unanimous in naming NC as the area in which the greatest revenue potential exists and the area in which the greatest support effort should be exerted.

Here are some of the early results of that endorsement:

- Joe Domonkos has been charged with sales responsibility for NC (as well as all manufacturing applications) in the Sales Programs Unit in Bethesda. He will be keeping you current and is the guy to call for sales assistance, programs and strategems (Dial Comm 8*271-1150, ext. 659).
- The Special Applications Section is responsible for all technical development and assistance. Contact Bud Studley (8*271-1150, ext. 622) for help in REMAPT—related problems and Nancy Lipman (8*271-1150, ext. 623) for all problems related to the Point-to-Point programs.
- The Schenectady group of Bob Rittenbury, one of REMAPT's creators, is now under contract to provide us with additional competency and resources.

In short, you and your customers are going to get better responsiveness and more service in 1969.

CLEANUP

A hard schedule for the cleanup of REMAPT is now in effect as follows:

Group A

Field Test — June

System Tape —July

- SFM (Proper spindle codes for surface feet per minute mode)
- Type 06 Spindle (D.C. Drive with computed spindle code)
- Type 07 Spindle (Table look-up to 300 value.)
- IN/OUT
- GO/TO, POINT
- Postprocessor error message format to include source program line number reference
- Relate CLL numbering of complex forms to the source program

Group B

Field Test — July

System Tape — August

- Section II of REMAPT (TANTO, THICK, 3 Surface start-up)
- PATTERN
- Symbol Table expansion

GENERAL ELECTRIC
INFORMATION SERVICE DEPARTMENT

GLATHE

A new version of this postprocessor is presently under test. It will embody the remedies in Group A and work with a new version of LATHEGEN. In addition, another new program will be available to update existing machine files for use with the new GLATHE.

ASSISTANCE

News about NC and assistance in solving problems are provided through programs in all MK II system libraries. Moreover, some of these programs are the means by which you can reach out to headquarters and the rest of the NC team at the same time. These programs are:

PROGRAM NAME:	AVAILABLE THROUGH:	PURPOSE:
TEXT 99***	Program Library	A status report of REMAPT errors and their solutions.
REMERR	GE NC specialists only.	A file of accessible programs which demonstrate newly discovered REMAPT problems. The file includes proposed work-arounds and identifies the author. This file is for your contributions as well.
NCDEMO***	Program Library	A part program for REMAPT demonstration use. It works and makes a nice handout. Significant features of the program are Macros for repetitive operations and detailed explanatory comments. Familiarize yourself with this program in the office and impress your prospect with a meaningful demonstration on the first call.
NCNEWS***	Cleveland Mark II System Library	A detailed explanation of Joe Schartman's (Senior CAS-Cleveland) newest Point-to-Point program now available for field test.
LIBNC***	Program Library	A listing of the documentation for all our NC programs and available and working machine files for use with REMAPT.
NC INFO***	Program Library	A supplement to the present Point-to-Point manual for Mark II usage with explanations and examples from J. Schartman's program.
NC LIST***	Program Library	A User's Guide to NCPPX for Mark II.
MAIL	GE NC specialists only	This is your forum, gang. Let everyone know of successes, failures, problems and needs. Headquarters reads the MAIL daily.
NEWS	GE NC specialists only	Headquarter's newsletter to you. We let you know what's happening as soon as possible. We also let you know when we need your help, and why!!!

USER'S GUIDES

A listing of the current User's Guides for NC follows:

Pub. No. 712222 A	Numerical Control Programming. Describes NCPTS$, NCPPX$ for Mark I. Supplement with information from NCLIST*** and NC INFO***.
Pub. No. 805220	REMAPT Describes the programming language and usage.
Pub. No. 805221	GELATH Describes the postprocessor for use with REMAPT.
Pub. No. FT808242	LATHEGEN Describes the technique and steps for creating a machine description file.

The Point-to-Point programs will get a detailed look in our next Sales Bulletin. Joe Schartman's super version of NCPPX$ will be the feature item.

Keep your TTY's tuned to NEWS and MAIL.

SALES BULLETIN NO. 42 NC-10

Information Systems

World Leader In Time-Sharing Service

INDUSTRIAL SALES DIVISION HELPS NC TIME-SHARING SALES

Valuable assistance in selling our NC time-sharing capability is available through numerical control field sales and application specialists in GE's Industrial Sales Division.

These other NC specialists in our Company are well established and respected by numerical control machine tool builders and users. Each of their offices has files of information on every piece of NC equipment with GE controls in their area. It's their job to know what's happening in NC locally, to be where the action is, to influence people to buy General Electric NC equipment and service... and they do this job very well.

They are willing to share this knowledge and expertise with us. In fact, a mutual-help relationship has the blessings of their Manager of Metalworking Industries Sales, Mr. W. R. King. To back that up, Mr. King has furnished the names, addresses, local phone numbers, and Dialcom numbers of his NC specialists.

A good working relationship between ourselves and Industrial Sales Division people can provide mutual benefits for both sales teams. Benefits for you include...

- . . . Knowing the location of every machine tool with GE numerical controls in your sales territory.
- . . . Knowing "in-house" problems and political climate of prospects.
- . . . Knowing who the prospect's decision-makers are.
- . . . Knowing what future NC plans are brewing in your sales area.
- . . . Being introduced to prospects by someone already established and respected.
- . . . Being identified as a representative of General Electric, the No. 1 company in NC controls.

How do you get this team sales effort started? Here are some suggestions:

1. Look at the list(at the back of this sales bulletin) of Industrial Sales Division District Managers in the machine tool market and Sales Engineers with NC user influence. Jot down the name and phone number of their people in your sales area.

2. Arrange to meet your local Industrial Sales Division manager and his people, perhaps over lunch. Extend the invitation yourself or ask your manager to do it.

3. Brief the Industrial Sales people on our capabilities and operation. They may not know a great deal about us, so start off simply.

4. Set up a demonstration, at their office or yours. Have the most knowledgeable NC time-sharing specialist on your local staff demonstrate our depth and competence in numerical control.

5. Show the Industrial Sales people how you can help them — by giving their customers a means for preparing NC tapes faster and more economically, resulting in higher production from NC machines. Point out our local training classes and capabilities.

6. Emphasize the fact that, by working together, General Electric can supply the NC market with a more complete package. Not only will users get top quality numerical controls, but fast accurate tape preparation capability as well. The double-barrelled sales presentation that you and the Industrial Sales representative put together can have great impact on prospects.

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INFORMATION SERVICE DEPARTMENT

7. Ask to look at their file of NC customers and prospects, then set up your own prospect list. Review the list with your Industrial Sales counterpart. Together, set up a call schedule with best prospects at the head of the list.

We are supplying the Industrial Sales Division with our list of field offices and NC specialists. In addition, a copy of this Sales Bulletin is in the mail to each of their sales managers.

The Industrial Sales Division is as interested as we are in establishing communication and rapport for a joint approach to the NC market. They are expecting your call... so get on the phone today.

INDUSTRIAL SALES DIVISION DISTRICT MANAGERS – MACHINE TOOL MARKET

R. E. Pfeif
625 Delaware Avenue
P.O. Box 1087
Buffalo, New York 14240
(716)TT3-9210
8*252-2201

E. J. Rezabeck
840 S. Canal Street
Chicago, Illinois 60680
(312)663-4141
8*323-4130

R. H. Allen
2621 Victory Parkway
Cincinnati, Ohio 45206
(513)UN1-3400
8*333-2226

K. F. Culler
1000 Lakeside Avenue
Cleveland, Ohio 44114
(216)523-6000
8*344-6050

H. O. Mellem
700 Antoinette Street
Detroit, Michigan 48202
(313)TR2-2600
8*362-4235

H. Perlis
212 N. Vignes Street
P.O. Box 2830
Terminal Annex
Los Angeles, California 90054
(213)MA5-7381
8*432-4408

A. P. Wylie
1 Prestige Drive
P.O. Box 910
Meriden, Connecticut 06450
(203)238-0791
8*225-6240

J. W. Blaiklock
25 E. Willow Street
Milburn, New Jersey 07041
(201)376-9000
8*223-8231

W. J. Dorworth
615 E. Michigan Street
Milwaukee, Wisconsin 53202
(414)BR1-5000
8*326-5215

L. S. Brumgard
3 Penn Center Plaza
Philadelphia, Pennsylvania 19102
(215)LO8-1800
8*243-5280

C. N. Palmer
3532 James Street
P.O. Box 1021
Syracuse, New York 13201
(315)456-0123
8*256-7235

R. P. Grady
1 Washington Street
Wellesley, Massachusetts 02181
(617)237-2050
8*262-2300

INDUSTRIAL SALES DIVISION PRODUCTION MACHINERY SALES ENGINEERS (NC USER INFLUENCE)

Lee Hambrook
840 S. Canal Street
Chicago, Illinois 60608
(312)663-4141
8*323-4030

R. J. Gillham
2621 Victory Parkway
Cincinnati, Ohio 45206
(513)UN1-3400
8*333-2276

T. G. Braly
8101 Stemmons Freeway
P.O. Box 5821
Dallas, Texas 75222
(214)ME1-3110
8*352-2223

G. U. Dautrich
1 Prestige Drive
P.O. Box 910
Meriden, Connecticut 96450
(203)238-0791
8*225-6247

W. M. McKenzie
3 Penn Center Plaza
Philadelphia, Pennsylvania 19102
(215)LO8-1800
8*243-5322

E. Joseph
212 N. Vignes Street
P.O. Box 2830
Terminal Annex
Los Angeles, California 90054
(213)MA5-7381
8*432-4526

D. W. Cherry
700 Antoinette Street
Detroit, Michigan 48202
(313) TR2-2600
8*362-4322

H. E. Johnson
212 N. Vignes Street
P.O. Box 2830
Terminal Annex
Los Angeles, California 90054
(213)MA5-7381
8*432-4328

J. A. Blaeser
1000 Lakeside Avenue
Cleveland, Ohio 44114
(216)523-6000
8*344-6067

PARTIAL LIST
MARK CENTURY/LATHE USERS
NEW ENGLAND – EXCEPT CONN.

User	O.E.M.	Control Type
G.E. Co. – Everett, Mass.	1 – Bullard V.T.L.	M100V
G.E. CO. – Everett, Mass.	1 – American	M100L
G.E. Co. – Everett, Mass.	8 – Bullard V.T.L.	M102C
G.E. Co. – SAED – Lynn, Mass.	1 – Sundstrand	M102C
G.E. Co. – SAED – Lynn, Mass.	1 – Bullard V.T.L.	M100Y
G.E. Co. – SAED – Lynn, Mass.	6 – J and L	M100S
G.E. Co. – SAED – Lynn, Mass.	1 – Monarch	M100L
G.E. Co. – SAED – Lynn, Mass.	2 – LeBlond	M102C
G.E. Co. – SAED – Lynn, Mass.	1 – American	M100L
G.E. Co. – SAED – Lynn, Mass.	1 – American	M100S
G.E. Co. – SAED – Lynn, Mass.	1 – Bullard	M102C
G.E. Co. – SAED – Lynn, Mass.	1 – Springfield	M100S
G.E. Co. – SAED – Lynn, Mass.	1 – Springfield (Grinder)	M100S
G.E. Co. – SAED – Lynn, Mass.	7 – Match and Merryweather	M100S
G.E. Co. – SAED – Lynn, Mass.	7 – Monarch	M102C
G.E. Co. – Med. Steam – Lynn, Mass.	1 – Farrel	M100S
G.E. Co. – Med. Steam – Lynn, Mass.	1 – Bullard	M104P
G.E. Co. – Med. Steam – Lynn, Mass.	1 – LeBlond	M102C
G.E. Co. – Med. Steam – Lynn, Mass.	1 – Sundstrand	
Wyman Gordon – N. Groton, Mass.	2 – Bullard V.T.L.	M104C
Wyman Gordon – N. Groton, Mass.	1 – American	M100L
Raytheon – Lowell, Mass.	1 – J and L	M104C
Avco – Lowell, Mass.	1 – Farrel – Betts – V.B.M.	M105C
Avco – Lowell, Mass.	1 – Sellers – V.B.M.	M105C
Hansen Engineering – Lynn, Mass.	2 – VDF – (Germany)	M100S
Worthington – Norwood, Mass.	2 – J and L	M100S

MARK CENTURY N/C USERS
R. I., MASS., VERMONT, N.H., and ME.
(EXCEPT LATHES)

USER	O.E.M.	MACHINE	CONTROL
Electronics Fabricators Tewksbury, Massachusetts	2-Behrens	Turret Punch Press	M120
Utility Metal Products Beverly, Massachusetts	1-Behrens	Turret Punch Press	M120
Raytheon Company Wayland, Massachusetts	1-Behrens	Turret Punch Press	M120
Gloucester Machy. Company Gloucester, Massachusetts	1-Burgmaster	Turret Drill	M120
Improved Machy. Company Nashua, New Hampshire	1-Burgmaster	Turret Drill	7563
International Equipt. Co. Needham Heights, Mass.	1-Cleerman	Drill	M103P
Honeywell, Inc. Brighton, Massachusetts	1-K and T	Mach. Center	
Osley and Whitney Westfield, Massachusetts	1-Lucas	H.B.M.	7573
Lund Mfg. Company Saco, Maine	1-Lucas	H.B.M.	M103P

USER	O.E.M.	MACHINE	CONTROL
General Electric Company Burlington, Vermont	2-Lucas	H.B.M.	M103P
General Electric Company Fitchburg, Massachusetts	1-Lucas	H.B.M.	M103P
Electro Metals Company Chelmsford, Massachusetts	1-Behrens	Turret Punch Press	M120
General Radio Company Concord, Massachusetts	2-Behrens	Turret Punch Press	M120
General Electric Company So. Portland, Maine	2-W.P. Hill	Drill	M120
G.E. Co. – Instrument Dept. West Lynn, Massachusetts	1-Burgmaster	Turret Drill	M120
General Electric Company Springfield, Massachusetts	1-Burgmaster	Turret Drill	M120
G.E. Co. – Instrument Dept. West Lynn, Massachusetts	1-Cleerman	Drill	M103P
Raytheon Company Waltham, Massachusetts	1-Excellon	P.C.B. Drill	M120
G.E. Co. – Ord. Pittsfield, Massachusetts	1-Wiedemann	Turret Punch Press	M102P
K.L. and H. Res. and Dexel Cambridge, Massachusetts	1-NATCO	P.C.B. Drill	M120
Raytheon No. Dighton, Massachusetts	2-Prod. Improvement	Wire-Wrap	M120
Raytheon No. Dighton, Massachusetts	2-Universal	Comp. Insert.	M120
K.L. and H. Res. and Dexel Cambridge, Massachusetts	2-Universal	Comp. Insert.	M120
Hoglund Engineering Berkley Heights, N.H.	1-Moore	Jig Borer	M102P
Tippett, Inc. Chicopee Falls, Mass.	1-Moore	Jig Borer	M102P
G.E. Co. – SAED West Lynn, Massachusetts	1-Sundstrand	Omnimill	M105C
Raytheon Quincy, Massachusetts	12-Universal	Comp. Insert.	M120

CONTROL CODE

M120	2-Axis Positioning
M102P	2-Axis Positioning
M103P	3-Axis Positioning
M105C	5-Axis Contouring
7563	3-Axis Positioning – Integrated Circuit
7573	3-Axis Positioning – Integrated Circuit w/contouring option

MACHINE CODE

H.B.M.	Horizontal Boring Mill
P.C.B. Drill	Printed-Circuit-Board Drill
Comp. Insert.	Component Insertion Machine