

APPENDIX B

COMMON WORDS AS THEY RELATE TO PROGRAMMING THE BRIDGEPORT CONTINUOUS PATH CONTROL

ABSOLUTE DIMENSION. A dimension expressed with respect to a fixed point of origin. (See INCREMENTAL DIMENSION) For example, POINT/x,y,z coordinate values in an APT part program are expressed as distances from the X,Y,Z reference axes. NOTE: The x,y,z/i,j input values to the Bridgeport Continuous Path Control are incremental, not absolute, dimensions.

ACC/DEC. The ability of the control system to provide smooth changes in velocity when starting and stopping, and when changing from one feed rate value to another.

ACCELERATION OVERRIDE. The Bridgeport CP Control automatically provides ACC/DEC profiles at the beginning and end of each input move if the programmed feedrate is above 6 inches per minute. However, if consecutive moves are approximately tangential, it may not be necessary to decelerate at the end of the first move. The use of an "f-" code in a block of information overrides the deceleration logic. For example, and "f-" code can be used when an arcuate path crosses from one quadrant to the next.

ACTIVE STORAGE. Data registers which hold the data which is actively being processed. In the Bridgeport CP Control, this consists of the interpolation registers and the N, F, M function registers.

ADAPT. A computer-aided NC programming language and processor. It is a sub set of APT and is essentially limited to two axis contouring and three axis point-to-point work. Versions of ADAPT with the Bridgeport Series II postprocessor have been implemented and supported on the IBM 360 computer series, and are also available from GE Information Services on a Time Sharing basis.

ADDRESS. An identification for a control storage register. In the Bridgeport CP Control, the various registers are addressed by two distributors which, in the tape read mode, are incremented by "tab" codes.

ALPHANUMERIC CODE. A code whose set consists of letters, digits, and associated special characters. (see EIA STANDARD CODE).

APT. (Automatically Programmed Tools). An NC computer-aided programming language developed on a pooled fund basis by an organization of private companies and government agencies. It consists essentially of: (a) the input language, (b) the APT processor, (c) a Bridgeport APT postprocessor, and (d) a computer of sufficient size to run the APT program. The APT system is capable of 3, 4 and 5 axis contouring and point to point work. The Bridgeport APT postprocessor has

been implemented on the following series of computer systems:
IBM 360, GE/HONEYWELL 600, UNIVAC 1100, CDC 6000.

AUXILIARY FUNCTION. see MISCELLANEOUS FUNCTION.

AXIS. (1) A reference line of a coordinate system, for example, the x, y, and z axis of the Cartesian coordinate system.
(2) A direction along which a movement of the workpiece occurs.

AXIS INVERSION. The reversal of the sign (plus or minus) of the x and y input values, on a selective basis, to permit machining "left-handed" parts from "right-handed" part programs.

BATCH PROCESSING. Pertaining to the technique of executing a set of computer programs such that each is completed before the next program of the set is started. (see also TIME-SHARING).

BCD. (Binary Coded Decimal). A notation system in which the individual decimal digits expressing a number in decimal notation are each represented by a four bit binary number. For example, the decimal number 92 is represented by 1001 0010 in BCD notation.

BINARY. A numbering system utilizing a base of two. Binary Code is notated by 0 and 1's. For example, the number 92 is represented by 1011100. Control systems utilize binary logic because the switching components within them have two states: "on" and "off". In the Bridgeport CP Control, the decimal x,y,z/i,j dimensions which are input to the control in BCD notation are converted internally to binary values so that the arithmetic functions may be more conveniently implemented.

BLOCK. A group of words, on punched tape, that collectively provides a complete operating instruction to the control. The block of information is terminated by an End of Block character.

BUFFER STORAGE. Storage registers for x, y, z/i, j, f, m data which act as an intermediate storage area between the tape reader and active storage. This data is available for rapid transfer (9 micro-seconds) to active storage. Buffer storage is provided to prevent delays in the transfer of data due to tape reader speed.

CANNED CYCLE. A preset sequence of events initiated by a single command. For example, the Z axis canned drill cycle, initiated by a "m51" command (and "f" not equal "0") moves the knee up a stored distance at a stored feedrate and down at rapid traverse at the end of each XY axis programmed move.

CARTESIAN COORDINATES. A dimensioning system whereby the position of a point can be defined with reference to a set of axes at right angles to each other.

CHANNEL. (track, level.) A path parallel to the edge of a tape along which information may be stored by the presence or absence of holes.

CHARACTER. One of a set of symbols which may be combined to express information in a program. The characters used by the Bridgeport CP Control are the decimal digits 0 to 9, and the special characters "-", "tab", "end of block", and "rewind stop".

CIRCULAR INTERPOLATION. A mode of contouring control which uses the information contained in a single block to produce an arc of a circle.

CLDATA. (Cutter Location Data. CLFILE, CLTAPE). CLDATA is the output of the generalized numerical control programming processor (such as APT) and is the input to the postprocessor. For example, an APT output record has the form:

W1, W2, W3,..... Wn

where W1 = record sequence number

W2 = record type number

W3,...Wn = words with significance dependent on the record type as tabulated below: (only word types used by the postprocessor are given)

W2	W3,...Wn
1000	Source card number
2000	Postprocessor Auxiliary Command
3000	Surface Data
5000	Point coordinate values
14000	End of program

CODE. A system of characters in a predetermined fixed pattern representing information in a language which can be understood and handled by the control.

COMMAND. A signal, or group of signals, initiating one step in the execution of a program.

COMPUTER. A device capable of accepting information, operating on the information according to pre-programmed instructions and supplying the results of these operations. A typical computer consists of a CPU (central processing unit - control, arithmetic and logic, and register elements), main memory and I/O (input/output) devices.

COMPUTER LANGUAGE. The computer understands instructions coded as binary numbers. For example, a simple set of instructions coded in the binary number language the computer understands could be:

7200
7001
7440
5002
7402

Since programming in binary codes is very demanding, symbolic translator programs have been written which enable the programmer to express the problem not directly in the "MACHINE language" of the computer, but rather in a more powerful language, which will be translated into the basic language and encoded into the required binary format automatically. The symbolic translator is itself a computer program that operates on the format of the input (SOURCE) program and outputs it as machine language (OBJECT) code, ready to be executed. ASSEMBLY language is one of many such translators. It enables using mnemonic code sets rather than binary numbers to program a set of instructions. For example, the above program would be written:

START,	CIA	CLEAR ACC
A,	IAC	INCREMENT ACC
	SKA	SKIP NEXT INSTRUCTION
		IF ACC = 0
	JMP,A	JUMP BACK TO INSTRUCTION
		LABELED A
	HLT	STOP THE COMPUTER

FORTRAN is a still more powerful symbolic translator. It lets the user express the problem he is trying to solve in a mixture of English words and mathematical statements. Additionally, an attempt was made to make FORTRAN computer independent so that a program coded in FORTRAN does not have to run on a specific computer. The above program coded in FORTRAN would be written:

```
      A = 0
2     A = A + 1
      IF (A.NE.0) GOTO 2
      STOP
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CONSOLE. That part of the Bridgeport CP Control used for communication between the operator and the machine tool controller. The console can be used to control the machine manually, correct errors, determine the status of the "n" and "f" registers, and modify the contents of buffer storage.

CONTINUOUS PATH. The controlling of the motion of machine members so that the slides travel through the designated path at the specified rate. For example, a continuous path controller would be used to mill intricate shapes.

CUTTER RADIUS OFFSET. The distance from the part surface to the radial center of a cutter.

CUTTER PATH. The path described by the cutter in order to generate the desired part configuration.

CYCLE. A predetermined sequence of operations that is repeated regularly. In the Bridgeport CP Control, the "m51" command sets the various drill/tap/bore cycles.

DATA. A representation of facts or instructions in a formalized manner, particularly as they are input, acted upon, and/or output by a controller used for handling such information.

DIGIT. A symbol that is used to represent one of the integers of a numbering system. For example, in the decimal system, the integers 0 to 9 are digits; in the binary system, 0 and 1 are digits.

EIA STANDARD CODE. The two EIA Standards for N/C character coding are:

RS-244-A Character code for Numerical Machine Control Perforated Tape.

RS-358 Subset of the USA Standard Code for Information Interchange for Numerical Machine Control Perforated Tape.

NOTE: The Bridgeport CP Control conforms to RS-244-A. However, the following exceptions are taken to RS-358:

FUNCTION	ASCII character
Rewind Stop	+
Tab	;
End of Block	\$

END OF BLOCK CHARACTER. (EOB). A character that represents the end of a line or block of information contained in a machine control tape. (see EIA STANDARD CODE).

END OF PROGRAM. An "m02" code indicating completion of the workpiece. Stops spindle, coolant, and feed after completion of all commands in the block. The tape is rewound back to the rewind stop code at the beginning of the program.

FEEDRATE. A two digit code - denoted as the "f" number - which determines the machine slide rate of feed. In the Bridgeport CP Control, this number is coded directly in inches/minute.

FLOATING ZERO. A characteristic of a machine tool controller permitting the zero reference point on any axis to be easily established at any point in the travel.

FORMAT. A formalized arrangement of data. As applied to tape, the rules defining the character configuration. As applied to programs, the rules defining the structure of the information.

FORMAT CLASSIFICATION. An EIA shorthand system used to classify NC systems. The format for the Bridgeport CP Control is:

n2.x+24.y+24.z/i+24.j+24.f2.m2*

FORTRAN. (see COMPUTER LANGUAGE)

GENERAL NC LANGUAGE PROCESSOR. A computer program developed to operate on symbolic input data generated by a parts programmer in developing the mathematical representation of a geometric form, for example, APT.

INCREMENTAL DIMENSION. A dimension measured from the preceding point in a sequence of points.

INHIBIT. In the Bridgeport CP Control, an external signal which interrupts data processing until a peripheral auxiliary function has been completed.

INITIALIZE. To set the system logic at the beginning values.

INSTRUCTION. A command that specifies an operation. For example, a BLOCK OF DATA.

INTERFACE. That portion of the machine tool controller that connects the control system to the "outside" world. This can include a data link to a remote computer or connection to peripheral machine tool equipment. Special consideration has to be given in the interface design so that the control system is effectively isolated from externally generated electrical "noise" transients.

INTERPOLATION. Development of a path by means of determining the many intermediate discrete points which produce the desired smooth curve or straight line. The Bridgeport NC Controller is capable of 2 axis circular and 3 axis linear interpolation.

LINEARIZATION. A mathematical procedure whereby a path defining a shape is subdivided into many small linear segments that closely approximate the desired path, such that tool motion resulting from the consecutive subdivisions will machine the shape to a specified tolerance.

LOOP. A sequence of instructions that is executed repeatedly until a terminal condition exists.

MACHINE LANGUAGE. (see COMPUTER LANGUAGE).

MACRO. A subroutine consisting of a group of instructions which can be stored and then recalled as a group to solve a recurring problem.

MANUAL DATA INPUT (MDI). A mode on control that enables an operator to insert data into the control system. This data is identical to information that could be inserted by means of a tape.

MANUAL FEEDRATE OVERRIDE. A control that enables the operator to reduce the feedrate if the tape programmed rate is not optimum for the material being machined. This consists of a dial on the operator's console that enables the operator to adjust the programmed feedrate \pm 50%.

MANUSCRIPT. A listing which details manual or computer part programming instructions.

MISCELLANEOUS FUNCTION. A two-digit "m" code which sets a particular auxiliary machine function such as spindle/on-off, coolant/on-off, etc.

NUMERICAL CONTROL (NC). A method of controlling machine members and auxiliary equipment using an input media which consists of coded alpha numeric characters.

OCTAL. A number system of base eight. For convenience, binary numbers are usually read in octal. For example, decimal 92 = binary 1 011 100. This is equivalent to 134 in octal.

OPEN LOOP SYSTEM. In a closed loop system, the output is measured and fed back for comparison with the input. This difference causes an error signal which results in a motion that acts to reduce the error to zero. In an open loop system, such as the Bridgeport CP Control, the output motion is directly generated by input data. The advantages of an open loop system are: (1) fewer parts - the feedback resolvers and error amplifiers are not required, (2) no adjustments - a closed loop system requires specialized and critical adjustments to obtain maximum performance, (3) high stability - an open loop system does not hunt or overshoot, (4) maximum holding torque at commanded position - since a closed loop system requires an error signal to generate motion, once the machine members reach position (zero error), the signal into the drive motors is at a minimum value, (5) high accuracy - most closed loop systems operate with a lag between commanded position and actual position when the axes are in motion, causing a "following" error of approximately .001 inch per inch/minute of set feedrate.

PART PROGRAM. A specific and complete set of data and instructions written in one of the part programming languages for the purpose of machining a part on an NC machine. For example, an APT part program consists of the definition of workpiece geometry, axes motions and auxiliary equipment commands. This is input to the APT processor, the processor translates this input into CLDATA and the postprocessor in turn translates the data into machine tool controller code.

PERIPHERAL EQUIPMENT. Auxiliary equipment used with a computer's central processing unit, off line or on line, For example, card readers, paper tape punches, magnetic tape readers, disc storage units, high speed printers.

POINT TO POINT CONTROL. (Positioning System). An NC machine which provides control only of discrete positions at which a machine operation is performed. The path and rate of movement between points is not under continuous control. The most common application of point to point control is drilling. NOTE: The Bridgeport CP Control always follows a direct straight line when going from point to point.

POSTPROCESSOR. A computer program (software) which is the interface between a NC processor language and the specific machine tool controller. The postprocessor describes the features of the machine tool controller such as geometry, dynamics, peripheral equipment. It transforms the general output from the processor, such as APT, to the unique format required by the machine tool/controller. The Bridgeport CP Control postprocessor is written entirely in FORTRAN IV. (See COMPUTER LANGUAGE.)

PRECISION. All numbers in a computer are in binary. The largest number that can be represented is dependent on the size (number of bits) of a computer logic word. For example, the Bridgeport CP Control operates on a 24 bit word basis. The precision of the controller is 2 to the 24 power -1 = 16,777,215.

PROGRAM. The complete plan for the solution of a problem; more specifically, the complete sequence of machine instructions and routines necessary to solve a problem.

PROGRAMMING. Preparing a detailed sequence of operating instructions for a particular problem. This involves the analysis of the problem, preparation of a general scheme or flow diagram, preparing details, developing subroutines, specifying formats, etc.

PROGRAM STOP. An "m06" miscellaneous function command that stops the spindle, coolant, and feed after completion of other commands in the block and also electro-magnetically disconnects line power from the machine tool auxiliary functions. It is necessary for the operator to (1) enable system power by depressing the SPINDLE ENABLE pushbutton, (2) depress the CONTROL START pushbutton, in order to continue with the remainder of the program.

PUNCHED TAPE. A tape with holes produced in such a manner so as to represent a particular set of data.

QUADRANT. One of the four quarters of the rectangular coordinate dimensioning system.

REMOTE JOB ENTRY (RJE). The ability to access a system from a station distant from that system.

RESOLUTION. A measure of the smallest programmable value that a control system can execute. In the Bridgeport CP Control, the input resolution is .0001", the arithmetic logic resolution is .00001".

ROW. A path perpendicular to the edge of a tape along which information may be stored by the presence or absence of holes.

SEQUENCE NUMBER. A multidigit "n" number identifying the block or group of blocks on the NC tape. The last two digits of the sequence number are displayed on the operator's console.

SERIAL OPERATION. A controller operating mode in which all the bits of a data word are handled sequentially bit by bit.

SERVICE BUREAU. A company which offers software support service to owners of NC equipment. This support can range from simply supplying program tapes to a complete counseling and computer part programming service.

SETPOINT. The position established by a programmer or operator as the starting point for the program from which the first programmed move is made.

SLOWDOWN SPAN. A length necessary to allow the machine slide to decelerate from its present feedrate to a stop without losing position. For the Bridgeport CP Control, these values are:

FRN	SLOWDOWN SPAN
0-6	.0
6-10	.005
11-20	.025
21-25	.050
26-30	.075
31-35	.100
36-39	.125

SOFTWARE. Programs and related documentation, as compared to the computer or machine tool controller, which is hardware. Software can be modified by changing instruction sets, hardware must be modified by changing wiring.

SOURCE LANGUAGE. The original symbolic language in which a program is prepared for processing by a computer. It is translated into object language (see COMPUTER LANGUAGE) by an assembler or compiler.

STATEMENT. A meaningful complete expression.

STORAGE. A device into which information can be introduced, held, and then retrieved at a later date. For example, the paper tape used in NC is a storage device.

SUBROUTINE. A series of computer instructions to perform a specific task for other routines. It is distinguishable from a main routine in that it requires a location specifying when to return to the calling program after its function has been accomplished.

SURFACE.

A geometric shape used for controlling the location of a tool in space. As a cutter is directed along a path, it is guided by two surfaces from the programmer's viewpoint. One surface is called the DRIVE SURFACE and the other surface is called the PART SURFACE. Generally, the bottom of the cutter moves along the part surface while the side of the cutter is guided by the drive surface. A third surface, the CHECK SURFACE, is used to check or halt the movement of the tool in its progress along the DS-PS pair.

TAB SEQUENTIAL FORMAT. Means of identifying a word by a number of tab characters preceding the word in a block. The Bridgeport CP Control recognizes two word types, one consisting of n,f, m data, the other consisting of x,y,z/i,j data. Words in a given type must be presented in a specific order. n,f,m data may be omitted except for the tab character when the command represented by that word is not desired, x,y,z/i,j data must be represented by at least ".0" and a tab character.

TERMINAL. A point in a system or communication network at which data can either enter or leave.

TIME SHARING. The use of a device for multipurposes during the same overall time period, accomplished by interspersing component actions in time. In commercial NC timesharing, the computer's processing capability is shared on a real time basis with many other users. Normal access to a time

shared computer is by a data terminal in the user's plant connected via telecommunication link to the remote computer.

TOOL ASSEMBLY. A complete preset tool, usually consisting of the tool holder, the cutter, and, if applicable, the tool insert. The tool holder fits directly into the spindle nose of the machine. The tool insert, which connects the cutter and the tool holder, is adjustable and allows axial movement of the tool up to approximately 1 inch.

TOOL LENGTH COMPENSATION. A manual input which eliminates the need for pre-set tooling and allows the programmer to program all tools as if they were the same length.

VECTOR VELOCITY. The resultant speed of a particular combination of axes motion. The individual axes move slower than the programmed rate, but the resultant rate, or vector, is equal to the programmed rate.

WORD. An ordered set of coded characters used to cause a specific action of a machine tool.

XTABL. The APT vocabulary table containing the code numbers which are used to represent the vocabulary words of the APT language, as used internally by APT, and passed along to the postprocessor.

ZERO SHIFT. A characteristic of a machine tool controller permitting the zero point on an axis to be shifted readily over a specified range.

ZERO SUPPRESSION. In the Bridgeport CP Control, the elimination of non-significant zeroes to the left of the decimal point and non-significant zeroes to the right of the first digit after the decimal point.