SECTION III

TAPE CODES AND FORMATS

3.1 CONTROL TAPE

The input medium to the control system is one-inch width punched tape with dimensions conforming to EIA Standard RS-227. (See Figure 3-1). A number or letter is expressed as a combination of "holes" and "no-holes" across the tape. There are two standard formats for the tape-coded combinations which represent characters. One format was established by the Electronics Industries Association (RS-244) and is commonly referred to as EIA Standard. The other format is known as the American Standard Code for Information Interchange and is abbreviated as ASCII. The Bridgeport N/C system accepts either tapes coded in the EIA or ASCII format. A switch is provided in the rear of the logic compartment for the selection of the format to be used in any particular run. The codes used are shown in Figure 3-2. Note that for numeric values, both the EIA and ASCII codes are similar for channels 1 through 4.

For numeric codes, these channels are assigned weighted values of 1, 2, 4, 8 respectively. A "seven" is a combination of holes on channels 1, 2, 3. A "nine" is a combination of holes on channel 4 and 1. This method of individual digit coding is known as Binary Coded Decimal (BCD).

A row of "holes" and "no-holes" punched across the tape represents a character. A string of characters may be combined to form a word. An example of a word could be the X-dimension command to the control. Or, it could be a y-dimension command, a sequence number, a feedrate code number, or an auxiliary function code. A group of words may be combined to form a block. A block of information is one complete instruction to the control system. The Bridgeport N/C system requires that words within a block of information be separated by tab codes and that the last word in a block be punctuated by a end of block (EOB) code.

This method of tape formatting is known as tab sequential. Figure 3-3 shows a short block with a sequence number N=1; XYZ commands X=1.25, Y=.75, Z=.5; a feedrate code of F=0; and an auxiliary function code M=57.

Thus: 1, 1.25, .75, .5, 0, 57$

The tape codes used by the Bridgeport N/C system are as follows:

NOTE: The use of any code other than those listed below can cause faulty operation.

LEADER

It is recommended that the leader before and after the tape-coded program be a strip of tape having only drive sprocket holes. Twenty-four inches (24") of leader should be used before and after punched information to enable insertion of tape in the reeler hubs.

REWIND STOP (+) RWS

This code is normally placed in front of the first block of information. During rewinding, the tape reader will stop at the rewind stop code.

TAB (,)

This code separates words within a data block. Two sequential registers are used to decode the input tape - one register advances each time a non-decimal word (n, f, m) is read within a block, the other register advances each time a decimal word (x, y, z/i, j) is read within a block. To advance the non-decimal word register without entering information, consecutive tab codes are used:

,,m enters information into the m register without updating either the n (sequence number) or f (feedrate) storage registers.

MINUS (-)

The minus code indicates travel in the minus direction. If motion is positive, the plus sign must be omitted with ASCII (optional EIA). Conventional travel direction of the tool relative to the workpiece is shown in Figure 1-3.

NUMERALS, DECIMAL POINT

Data words consist of numeric codes and are of two types:

Words not containing a decimal point (n, f, m) and consisting of up to two numeric codes,

Words containing a decimal point (x, y, z/i, j) and consisting of up to six numeric codes.

END OF BLOCK ($)

This code separates blocks of information on tape. It initiates action by the control system on information received.

DELETE

The delete code is used to delete tape punching errors. It is ignored by the control system. Incorrect characters anywhere on the tape can be punched over with the delete code.

3.2 TAB SEQUENTIAL FORMAT

Typically, in using the tab sequential format, words in a block of information have to be in a fixed sequence. Each time a tab code is read, the control enters the word preceding the tab code in a register and then a distributor advances so that the next word is entered sequentially in the next register. The following registers can be commanded by tape instructions in the Bridgeport N/C system:

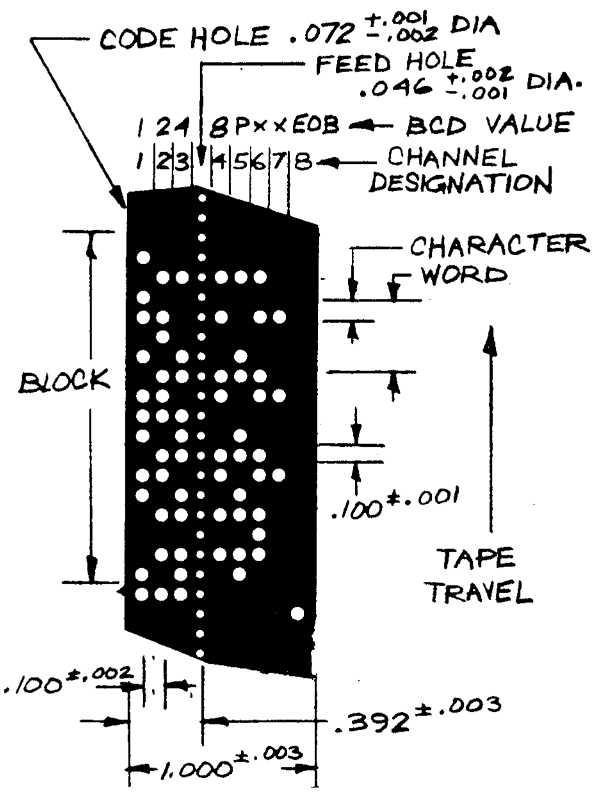

FIGURE 3-1.
Punched Paper Tape
(EIA Std RS-244)

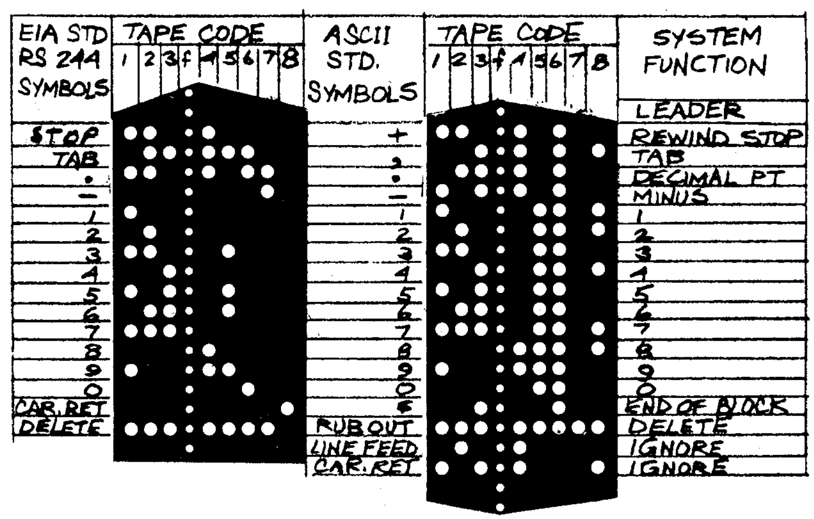

FIGURE 3-2.
Bridgeport NC Codes

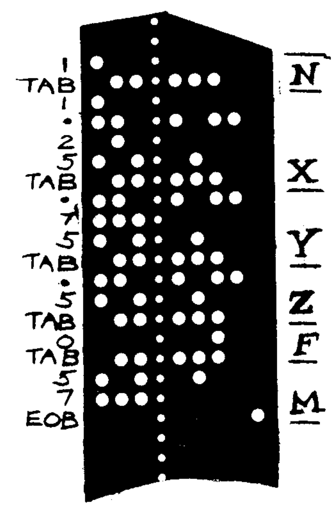

FIGURE 3-3.
Typical Block of
Information (EIA Code)
1, 1.25, .75, .5, 0, 57$
described above in ASCII
Code conforming to the text
of this manual (see para-
graph 3.4)

Register Name	Description of Contents
n	Sequence number
x	x axis incremental move
y	y axis incremental move
z/i	z axis incremental move or i arc offset value
j	j value arc offset value
f	feedrate number
m	auxiliary function number

This means that ordinarily it would take 6 tab codes to update the "m" register. However, the Bridgeport N/C system separates the above words into two kinds - those that contain decimal points (x, y, z/i, j) and those that do not contain decimal points (n, f, m). The control has two distributors, one that is initially set at "n" and advances sequentially through n, f, m every time a non-decimal point word is read (including successive tab codes), and a second distributor that is initially set at "x" and advances sequentially through x, y, z/i, j every time a decimal point word is read. Thus, to enter an "m" 50 auxiliary function code by itself, the following block of data must be used:

(tab) (tab) 50 (end of block)

Using a tab code that is not preceded by numeric information has the effect of skipping over a non-decimal point register without updating it.

To enter a Z move of +.5", the following block of data must be used:

.0 (tab) .0 (tab) .5 (end of block)

If either the x, y, z/i or j word equals zero, it must be entered preceding a tab code as ".0". (The "+" code is optional in EIA code, and should not be used in ASCII except for use as a Rewind Stop Code).

A block of information many contain 1 to 7 words. The alphabetic characters (x, y, z/i, j.n.f.m) are used for purposes of register identification only and must not be contained on tape.

The tape coded numeric characters 0 through 9 are shifted sequentially into the reader input buffer register as they are read off tape. For decimal point words, a counter counts the number of digits to the right of the decimal point, and, if the number of digits is less than four, fills up the remaining digits with zeros when a tab or end of block code is read. This adjusted value is then distributed out of the reader input buffer register into the proper decimal point word storage register. At least one digit must be to the right of the decimal point word. If the z value is .0 it need not be programmed. If the y value is .0 and the z value is .0, neither the y value nor the z value need be programmed.

For non-decimal point words, only the last two digits are transferred from the reader input buffer register into the designated n, f, m storage register. Thus, the number 870053914 will be recognized by the control as 14. Delete codes are ignored by the control. If, in the preceding 9-digit number, the 9 and 1 were over-punched with delete codes, the control would recognize the number 34. Zeros in the tape can be over-punched with any other numeric (1 through 9) code.

The programming format for the Bridgeport N/C contouring control, in accordance with EIA Standards RS-274B, is as follows:

n2.x±24.y±24.z/i±24.j±24.f2.m2.EOB

3.3 PROGRAMMING SHEETS

The prepared programming sheet is an aid to program writing in that it enables the part programmer to follow a uniform format. The standardized form enables programmers to communicate with each other more easily and with the machine operator. Figure 3-4 shows a reproduction of the Bridgeport N/C Part Program sheet.

Each line of information on the programming sheet contains a block of data. A block of data is one complete instruction to the control system. Each column in the programming sheet represents a word of information. A word of information updates the contents of a particular register in the control. A block of data may contain from 1 to 7 words.

The order of columns from left to right is the recommended sequence that words be entered into the control. Following the preparation of the programming sheet, the data must then be processed and punched on a tape. The tape must have essentially all the data on the programming sheet in the form of perforated code equivalents to the written symbols.

3.4 BLOCK OF DATA DESCRIPTION

Specific information describing the characteristics of the various words used in a block of data follows:

NOTE: The following symbolic conventions are used in this manual:

SYMBOL	MEANING
,	"Tab" Code
$	"End of Block" Character
*	"Multiplied by" Symbol

Bridgeport machines®

• textron company 500 LINDLEY STREET, BRIDGEPORT, CONN. 06606

CONTINUOUS PATH CONTOURING CONTROL PROGRAM

PREPARED BY DATE	REMARKS	JOB NO.	PART NO.
CHECKED BY DATE			PART NAME
SHEET OF			COMPANY NAME
TAPE NO. DEPT.			ADDRESS

N SEQ. NO.	T OR E	X	T OR E	Y	T OR E	Z/I	T OR E	J	T OR E	F FEED RATE	T OR E	M MACHINE FUNCTIONS	E	REMARKS

F-101A 1273 50M

Sequence Number (N)
Each block of information may be assigned a sequence number. The last two digits used in the sequence number word is displayed on the BCD coded STATUS lamps. Controls are provided on the console to search the tape (in the forward direction) for a particular sequence number code (SEARCH mode).

X Increment (X)
If the X increment is to be in the minus direction, a minus sign is entered. No sign must be used if the increment is to be in the plus direction. Zeros to the left of the decimal point and to the right of the first digit following the decimal point may be omitted. NOTE: A 1.0000 increment must be entered as at least 1.0 (or 1.00, 1.000, 01.0000). The maximum X increment input is 99.9999".

Y Increment (Y)
The direction and increment for the desired movement along the Y axis is entered in the same manner as previously described for the X axis. The maximum Y increment input is 99.9999".

Z Increment (Z) /I Arc Offset (I)
This word is either the direction and increment for the desired movement along the Z axis as described above, or in the case of circular interpolation, it is the signed distance from the center of the circle to the startpoint of the arc, measured along the X axis. The maximum Z increment /I Arc Offset value is 99.9999".

J Arc Offset (J)
(Circular Interpolation). The signed distance from the center of the circle to the startpoint of the arc, measured along the Y axis. The maximum J Arc Offset value is 99.9999".

Any arc with a radius of 99.9999 inches or less which falls in one quadrant can be programmed with a single block of data. Arcs which lie in more than one quadrant require two or more blocks of data. Positioning information which must be supplied to the control includes the X and Y axis increments to the final point on the arc and the location of the initial cutter position in relation to the center of the arc. The latter two values are the I and J arc offsets - the distance from the arc center to the starting point, measured respectively along the X axis and Y axis. See Figure 3-5.

As an introduction to the next remarks, it must be understood that the standard convention used in N/C programming is that all angles originate from a line passing through the center of a circle and parallel to the X axis in the +X direction of the tool relative to the center. Increasing angle is defined by a vector rotating counter clockwise from zero. Note also that quadrants are described with this convention as follows:

First Quadrant	----------------------	0 - 90 degrees
Second Quadrant	----------------------	90 - 180 degrees
Third Quadrant	----------------------	180 - 270 degrees
Fourth Quadrant	----------------------	270 - 360 degrees

For example, an entire 2.0" radius circle starting at 0 degrees and traveling counterclockwise to 360° would be programmed as follows: (n,x,y,i,j)

```
1,-2.0,2.0,2.0,.0$ ------------------- (arc from 0 to 90 degrees)
2,-2.0,-2.0,.0,2.0$ ------------------ (90 to 180 degrees)
3,2.0,-2.0,-2.0,.0$ ------------------ (180 to 270 degrees)
4,2.0,2.0,.0,-2.0$ ------------------- (270 to 360 degrees)
```

A 2.0" radius circle starting at 360 degrees and traveling clockwise to 0° would be programmed as follows:

```
1,-2.0,-2.0,2.0,.0$        (360 to 270 degree arc)
2,-2.0,2.0,.0,-2.0$        (270 to 180 degrees)
3,2.0,2.0,-2.0,.0$         (180 to 90 degrees)
4,2.0,-2.0,.0,2.0$         (90 to 0 degrees)
```

Figure 3-6 summarizes the sign values of X, Y, I, J in each quadrant for (a) clockwise rotation arcs, and (b), counterclockwise rotation arcs.

Figure 3-7 shows typical examples of misprogrammed circles. For a quick check:

I + X cannot exceed R, the radius of the toolpath arc.
J + Y cannot exceed R
X*(X+2*I) must equal Y* (Y-2*J)
R=SQRT (I*I+J*J)

NOTE: Positive values are used in the above equations for X, Y, I, J.

Feedrate Number (F)

The feedrate can be programmed on tape directly in inches per minute (ipm) as a number from 1 to 39. A feedrate code of 0 will set the system in rapid traverse. If the system is in rapid traverse and a -Z move is programmed (and even if an X and/or Y move is concurrent), logic in the control system will limit the rapid traverse to 24 ipm, if a +Z is programmed, rapid traverse will be 40 ipm. (This only applies if the major axis of motion is Z.) For X and Y moves (in data blocks without Z motion), the rapid traverse will be 80 ipm.

Logic is provided to maintain constant vector velocity in the feed ranges. Additionally, the Z axis feedrate can be entered directly without adjustment for

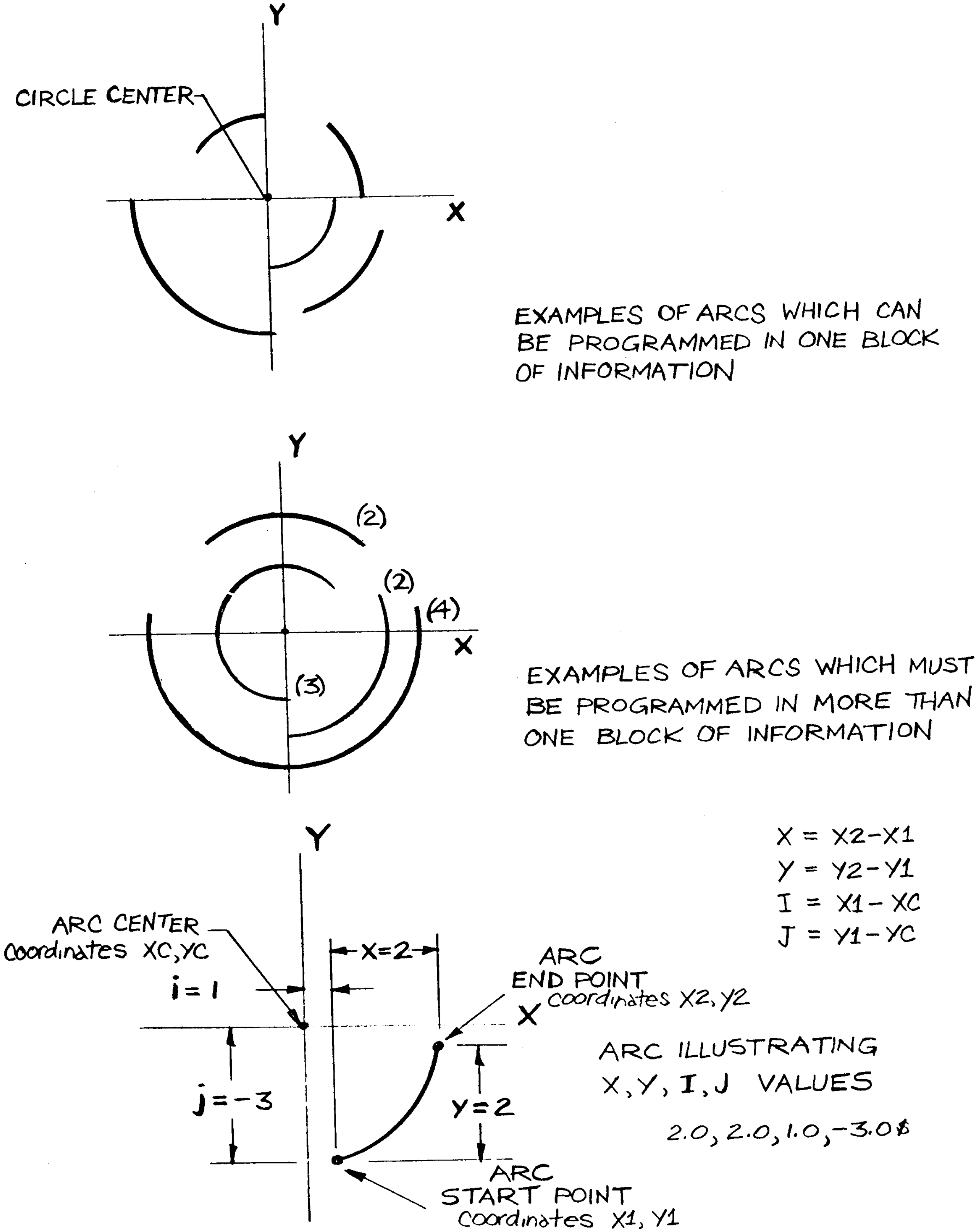

Figure 3-5. Arc Programming Examples

M CODE	TYPE	TRDR	CYCLE	QUILL	SPDL	COOL	STATUS	OPERATION
00	A	STOP					/ E	SPINDLE SPEED CHANGE
02	V	STOP	OFF	UP /	OFF	OFF	R / EI	END OF PROGRAM
04	C				ON			SPINDLE ON
05	B				OFF /			SPINDLE OFF
06	V	STOP	OFF	UP /	OFF	OFF	/ EI	TOOL CHANGE OR MOVE CLAMPS
07	C					ON		COOLANT ON
09	C					OFF		COOLANT OFF
50	B		OFF	UP /				CYCLE/OFF
51	A		DRILL	/ DN UP				CYCLE/DRILL (QUILL OR KNEE)
52	C							AUX FUN 'A' ON
53	C							AUX FUN 'A' OFF
54	B							ADVANCE TURRET
55	A			/ DN UP				KNEE BORE CYCLE
56	B							AUX 'B' ON RESET
57	B			DN /				QUILL/DOWN
		A	B	B / A	B / C	C	C / A	FUNCTION IN BLOCK

A=AFTER B=BEFORE C= COINCIDENT
E=EMPTY I=INHIBIT R= REWIND V=VARIOUS

ARC MOTIONS

CLOCKWISE ARC (90°)

QUADRANT		X	Y	I	J
1		+	–	.0	+
2		+	+	–	.0
3		–	+	.0	–
4		–	–	+	.0

COUNTERCLOCKWISE ARC (90°)

QUADRANT		X	Y	I	J
1		–	+	+	.0
2		–	–	.0	+
3		+	–	–	.0
4		+	+	.0	–

Figure 3-6. Summary of Sign Values for CW and CCW Arcs

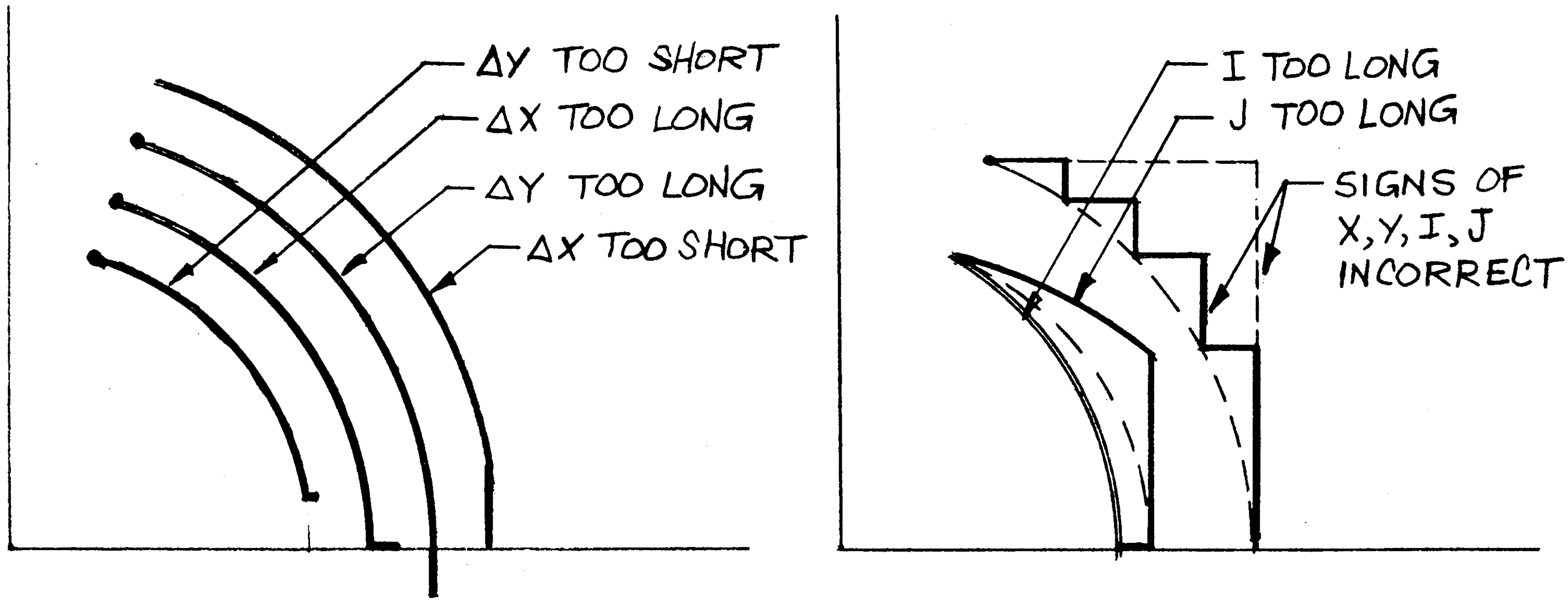

Figure 3-7. Misprogrammed Circles

the difference in the Z drive ratio (4 to 1), and the X and Y drive ratio (2 to 1). The maximum Z axis feed allowable is 20 ipm.

The optimum feedrate for an operation may depend on variables such as hard spots, cutter condition, etc., that cannot be foreseen by the programmer. The control system has a manual feedrate override which enables the operator to increase or decrease the programmed feedrate by up to 50%

Acceleration/Deceleration

If the feedrate is greater than 5 ipm, the table accelerates/decelerates from 5 ipm to the programmed value during each block of information. Figure 3-8 shows typical acceleration/deceleration curves.

The deceleration logic has 4 discrete steps with the following breakpoints:

RAPID & D.LT	0.2"	set f=24 ipm
V.GT. 18 & D.LT.	0.1"	set f=16 ipm
V.GT. 9 & D.LT.	.025"	set f= 9 ipm
V.GT. 6 & D.LT.	.003"	set f = 5 ipm

Where:

V = input feedrate + override value
D = Distance left to be traveled
GT = greater than
LT = less than

If a series of blocks contain moves of no greater than .025", the feedrate will not exceed 9 ipm, regardless of the programmed feedrate, except if acceleration/deceleration override is used.

CAUTION: The input feedrate + override must not exceed 40 ipm.

Acceleration/Deceleration Override.

Deceleration in a particular block of information can be eliminated by programming a minus (-) sign in the "f" word:

,2.0,-2.0,.0,2.0,39-$

Move along a circle from 90 to 0 degrees at 39 ipm without decelerating. This can also be written as:

,2.0,-2.0,.0,2.0,-$

In this case, the feedrate number previously in effect will be used and no deceleration will occur.

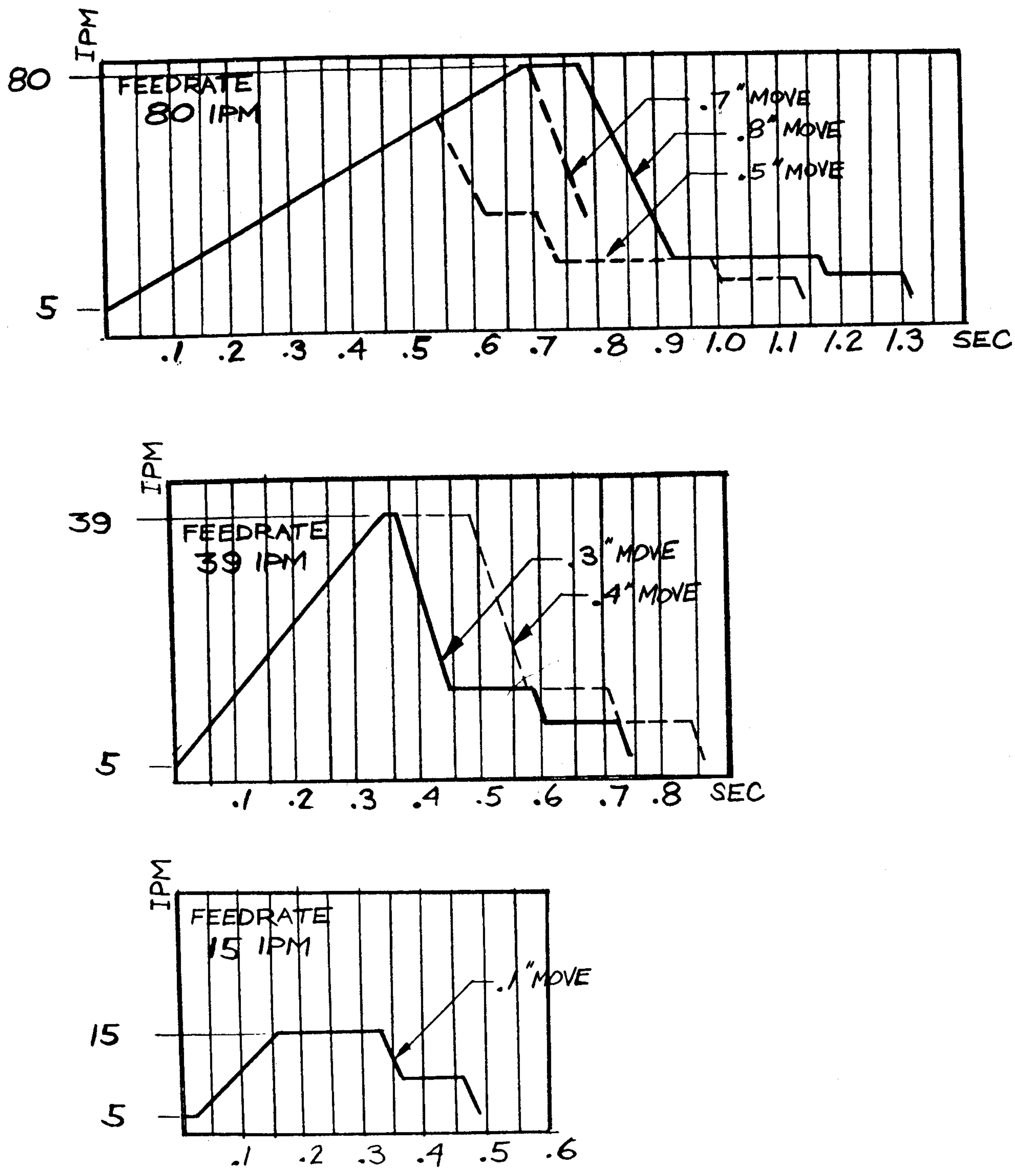

Figure 3-8. Typical Acceleration/Deceleration Curves

This technique is useful if subsequent motion is approximately tangential. To determine if f- can be used for non-tangent conditions, proceed as follows:

1. The major axis in a block of information is the axis with the larger move, the other axes are the minor axes. To use f- the major axis in the next move segment must be the same as the major axis in the move segment being tested and in the same direction.

2. The minor axis velocity (MAV) can be calculated approximately by:

   MAV = PFR * (MINOR AXIS MOVE/MAJOR AXIS MOVE)

   where PFR = programmed feedrate. The change in minor axis velocities between the successive moves should not exceed 5 ipm (X and Y) or 2.5 ipm (Z). For example, if XD1= .5, YD1 =.1, PFR1 = 25 IPM and XD2 = .5, YD2 = 0, and PFR2 = 25 IPM; the minor axis velocity for the first move is:

   MAV 1 = 25 * (.1/.5) = 5 ipm

   The minor axis velocity for the second move is:

   MAV 2 = 25 (0/.5) = 0 ipm

   The change in velocity is 5 ipm, therefore the first block of data output could be:

   ,.5,.1,-$ or (,.5,.1,25-$)

The acceleration/deceleration override is most useful when an arc is crossing over from one quadrant to the next at which point subsequent motion is always tangential.

The(f-) code must occur after the last X, Y, Z word in the block. This negative sign is not required at feeds of 5 ipm or less where there is no acceleration/deceleration.

CAUTION: Do not program any miscellaneous functions that demand a slide hold or external feedback signals in the block following a (f-) code. (Note that such operations as quill up or down will occur before the move takes place, demanding therefore, that the axis drive decelerate to a stop before actuating the external functions.) These codes are: 00 02 06 50 51 54 56 and 57.

An additional consideration in using f- is tape read dwell time. If tape read dwell time occurs, f- cannot be used or the table will misposition.

The standard tape reader supplied with the Series II control reads 150 cps. Assuming a typical 2-axis block consists of 12 characters (i.e., .0017, .009$) and a typical 3-axis block consists of 18 characters (i.e., .0017, .0009, .0013$.) it takes the tape reader 80 and 120 milliseconds respectively to read the blocks. At a programmed feedrate of 1 ipm, the table can move .0013" and .0020" respectively while the tape blocks are being read. If programmed moves are less than these distances, tape read dwell will occur - the table will get to position and wait for the tape reader to complete reading the block of data. Figure 3-9 plots the minimum major axis moves versus feedrates for no tape read dwell to occur. Several data block lengths are graphed. For major axis moves greater than the minimum value, no tape read dwell will occur.

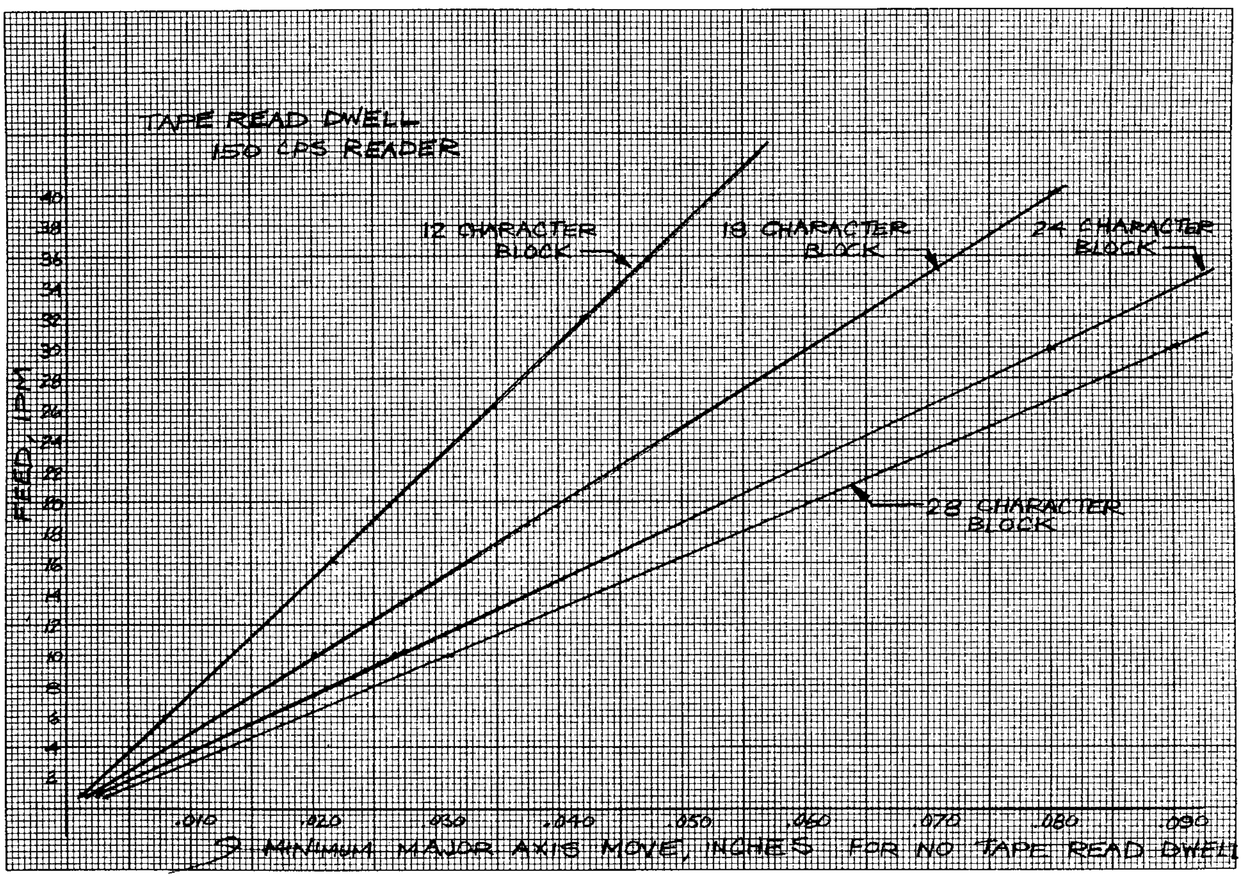

Figure 3-9. Minimum Axis Moves vs Feedrates

An additional consideration is that the last move in a sequence of linear moves in which deceleration override is used must exceed the minimum value given in the chart following, dependent on the feedrate used. The last move, which contains no "f-" code, must be of sufficient length to enable the control to decelerate to a smooth stop. The values following also represent the minimum radii which can be safely used with deceleration override for the various programmed feedrates:

FEED	MINIMUM DISTANCE OR RADIUS
0-6	.0
6-10	.005
11-20	.025
21-25	.05
26-30	.075
31-35	.1
36-39	.125

In programming feedrates for circular cuts, the ratio of the cutter tool path radius to the part surface radius affects the cutting rate since the vector velocity is that at the center of the cutter, not at the surface of the material. For cutting around the outside of a circle, the feedrate number should be increased by a factor of (R+r)/R. For cutting around the inside of a circle, the feedrate number should be decreased by (R-r)/R (where R is the part surface radius, r is the cutter radius.)

The feedrate code remains in effect until a new feedrate is entered. It is sometimes desirable to repunch the feedrate to change its value. This can be done by providing zeros (holes in channel 6) or spaces (holes in channel 5) on tape before the punched feedrate value. Delete codes can be used to blank out the punched feedrate code and the new value can be punched on top of the zeros or spaces.

Auxiliary Code Number (M)

The auxiliary function codes recognized by the control are as follows:

00 - Program Stop - complete all moves (if any) in the block of information in which it is entered. It stops the tape reader with the Buffer Register empty and it will not read or act on any information until the start button is activated again. If the quill is down and the spindle turning, these conditions continue.

Cycle/Off	(50)
Spindle/Off	(05)
Coolant/Off	(09)

02 - Rewind - will rewind the tape to the rewind stop code at the beginning of the tape and illuminate the Rewind lamp on the Control Console. This code also performs the following functions automatically:

Spindle/Off	(05)
Coolant/Off	(09)
Cycle/Off	(50)

04 - Spindle/On - turns on Spindle on Series II machines and will perform the same function on Series I machines fitted with Option J.

05 - Spindle/Off - see above.

06 - Tool Change - Similar to Program Stop (00) but will also perform the following functions:

Spindle/Off (05)
Coolant/Off (09)
Cycle/Off (50)

In addition, the (06) code will activate the SPINDLE INHIBIT condition. This removes auxiliary function power and lights the SPINDLE INHIBIT lamp on the Operator's Caution Box. The SPINDLE INHIBIT condition should be activated before tool changes or any other manual operation that causes the operator to handle controlled rotating equipment.

07 - Coolant/On - If the machine is equipped with the Coolant Option K, this would turn it on.

09 - Coolant/Off - see above.

50 - Cycle/Off - Quill up with Option Q. Also used to cancel the drill cycle (51) and raise the quill if it has been down (57). This code also cancels the Z axis Drill/Bore cycles (see below).

51 - Cycle/Drill - This code provides multiple hole machining routines. Two methods are available for machining holes: Automatic Quill Operation (Option Q), and Z Axis canned cycles.

If a Z Axis canned cycle has not been programmed, the control will automatically utilize the quill for machining holes at the end of each move following a data block coded with an m51, and including the move commanded by the data block which contains the m51 code, until a data block which contains an m50 code is executed, (or an m02, m06). The quill will not cycle after the move commanded by the data block which terminates the routine m50, etc.

Figure 3-10 shows the Automatic Quill Drive which is an Air-Hydraulic device which actuates the quill of the machine for automated milling, drilling, tapping and boring operations. It is controlled by manually operated switches or by tape coded instructions. There are three parts to this assembly: the quill drive unit, the quill stop bracket, and the depth post assembly.

A solenoid operated spring return 4-way pneumatic valve in the pneumatic system assembly permits air under pressure to enter or be exhausted from the air cylinder operator. The piston rod of the air cylinder drives a rack which rotates a pinion mounted on the quill pinion shaft.

Figure 3-11 shows the various quill cycles.

Mill (Drill) cycle: With air applied, the quill will move rapidly from its upstop to a point at which the quill stop bracket envelops the feed engagement pin on the depth post assembly. At this time, a switch in the bracket causes the hydraulic bypass valve to close forcing the hydraulic fluid in the tandem cylinder to pass through a flow control valve. This valve has a calibrated adjustment dial mounted on the front of the unit permitting feed rates of .5 ipm to 20 ipm to be selected. At the selected feedrate, the quill continues downward until the quill stop bracket meets the depth post. In this assembly is a microswitch, which indicates to the control system that the quill is fully down. If the initial command was "Quill Down", the quill will stay down, the INHIBIT lamp on the control STATUS DISPLAY will go off, and system operation will continue. If the control is in the quill hole machining routine (m51), the quill will rise to its upper limit at a rapid rate. When the quill is fully up and the UP LIMIT SWITCH is actuated, the INHIBIT lamp on the STATUS DISPLAY will go off and system operation will continue.

The feed engagement point and the down stop position must be preset manually. QUILL UP (m50) and QUILL DOWN (m57), will precede table motion if they occur in the same block as an XYZ command. The hole machining cycle will occur after table motion.

A timer potentiometer on the operator's Local Control Panel can be set to achieve approximately .1 to 6 seconds dwell time in the Drill cycle before the quill retracts. This is useful for spot facing and countersinking.

Bore (Tap) Cycle. The Bore Cycle is similar to the Drill Cycle, except that when the Quill goes up, the Quill retracts in slow feed until the feed pin is cleared. The quill then retracts to home position in rapid. A variable restriction adjustment located near the bottom of the Quill Actuator can cause the retract slow feed to be as much as 50% faster than the down slow feed. This is useful for some types of automatic tapping mechanisms.

Peck (Deep Hole) Cycle. The Peck Cycle is similar to the Drill Cycle, except that a timer starts as the feed engagement point is met. When the timed period ends, the quill returns to the top of the feed point in rapid traverse. The quill then starts down in rapid speed to within .10" of the last down position as detected by a peck memory rod and switch. At this time, the quill transfers to slow feed and a new timing cycle is initiated. The above sequence is repeated until the quill reaches the down position.

NOTE: The system will not operate properly if a quill actuator cycle is programmed without an X, Y or Z move. However, it is permissible to use a Z-axis cycle without an X, Y or Z move.

Z Axis "Canned" Cycles. Three axis control systems contain logic that enables using the knee for multi-hole machining. The basis of this routine is that certain repetitive information is retained in the control. The information stored is:

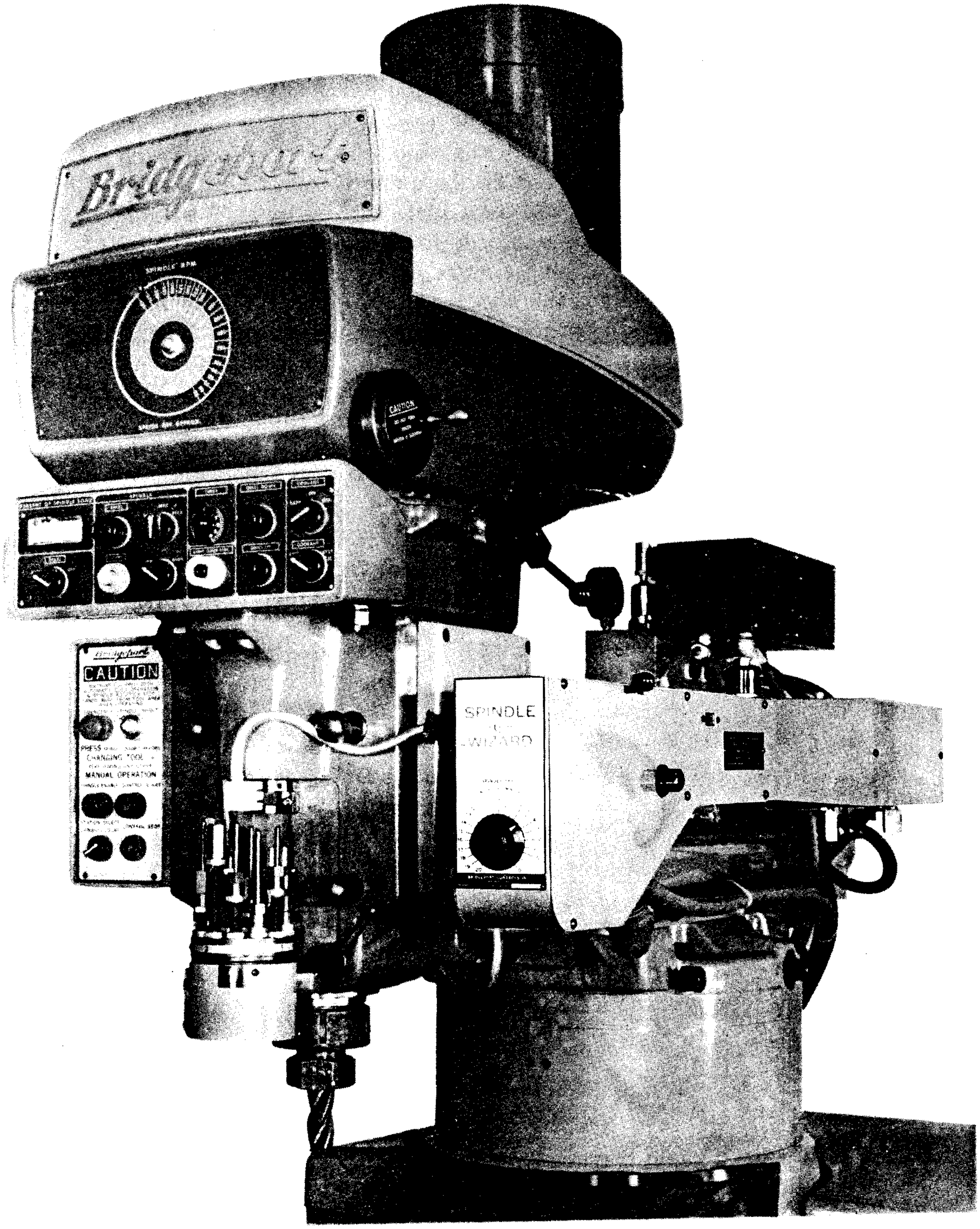

Figure 3-10. Quill Drive Unit

1. The depth of Z motion to be under feedrate control. This is entered in the Z increment column. Once entered, the Z increment need not be re-entered unless it changes.

2. The feedrate for the Z motion. After each move commanded by a data block including and subsequent to a data block which contains an m(51) code, and having a coded or retained feedrate of 39 ipm or less, a Z-axis cycle will occur until a data block which contains an m50 code is executed. The Z-axis cycle will not occur after the move commanded by the data block which terminates the routine (m50, etc.). Additionally, within a multi-hole routine utilizing the Z-axis, which commences with an m51 code and is terminated by an m50 code, the Z-axis cycle will not occur after any move commanded by a data block which has a coded or retained feedrate of f0, rapid traverse.

There are two Z-axis canned cycle routines:

1. Z-axis Drill cycle. The tool will move to the commanded XY position in rapid traverse, then advance the stored delta Z distance into the work at the stored feedrate, then retract the distance delta Z in rapid traverse.

   For example:

,,57$ -------------------	Bring the quill down
,1.5,.5,.5,12,51$---------	Set Z axis Drill Cycle. After moving X=1.5, y=.5, in rapid traverse move the Z into the work. 5" at a rate of 12 ipm, then move the Z.5" back to its initial location in rapid traverse.
,.5$---------------------	After each subsequent move,
,1.0,-.5$----------------	continue hole machining by raising and lowering the knee .5" at 12 ipm.
,.0,.0,1.5,0$------------	Move the knee +Z1.5" without a Z-axis cycle occurring.
,12.0,-.5,.0,0$----------	Move the table +X12.0", y=-.5" without a Z-axis cycle occurring.

NOTE: Following a rapid traverse move within a Z-axis cycle, both the feedrate and depth must be re-entered.

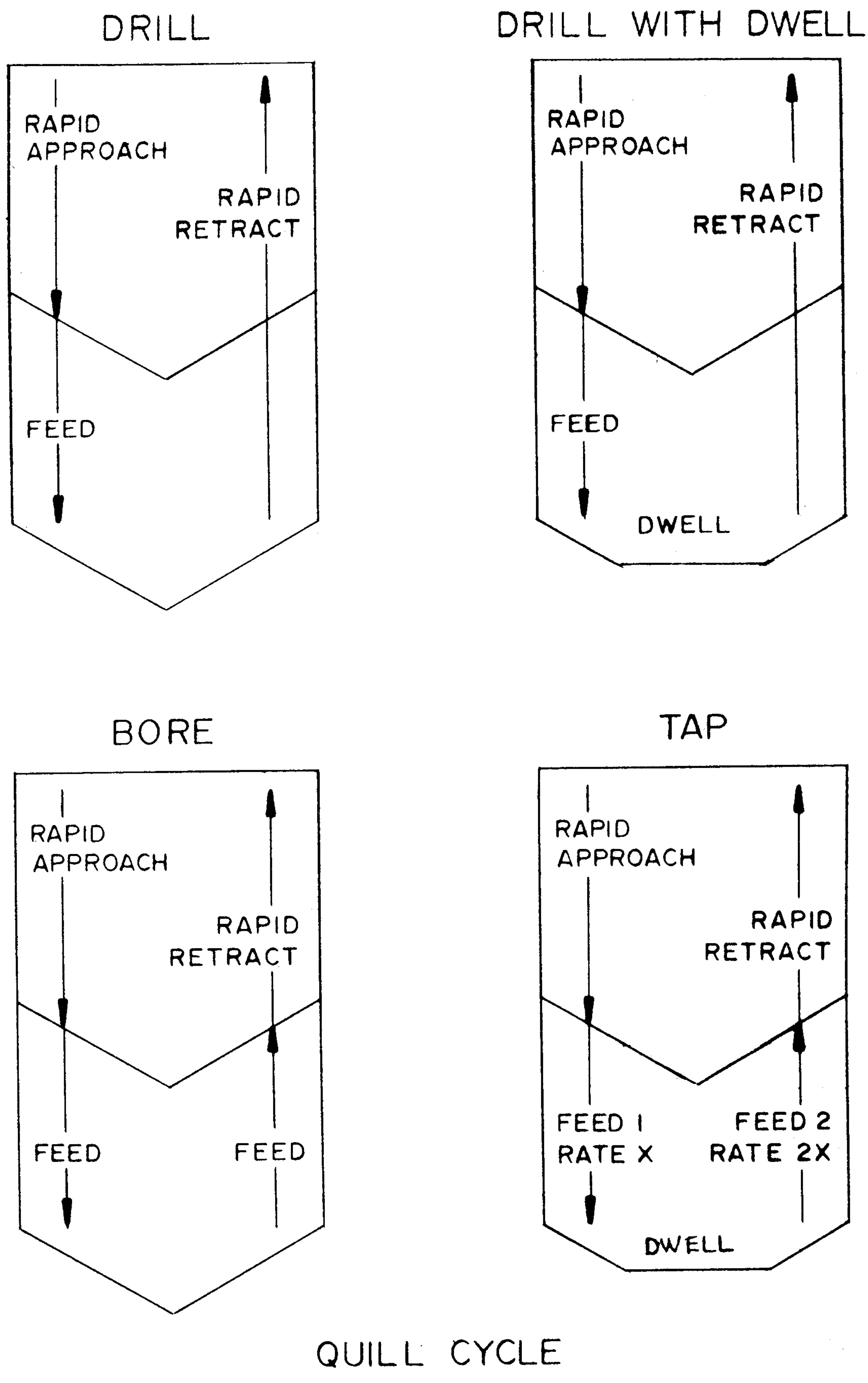

Figure 3-11. Quill Cycles

,1.5,1.5,.75,12$ ------------- After moving X=1.5, y=1.5 in rapid traverse, move the Z into the work .75" at 12 ipm, then move the Z out of the work .75" at rapid traverse.

NOTE: Both the Y and Z distances must be entered in a rapid traverse move within a Z-axis cycle even if they equal .0".

,.5$ -----------------------Move and drill.
,1.0,-.5,.5$ ----------------Move and drill .5" deep instead of .75".
,-18.0,-.5,.0,0,50$ -----------End the Z-axis cycle. No cycle will occur after this move. The quill will go up, then the X=-18.0", y=-.5" move will be made in rapid traverse.

NOTE: Both the Y and Z distances must be entered in the data block in which a code m50, 00, 02, 06 ending the Z-axis cycle is contained, even if they equal .0". The exception to this is if no motion command is contained in the data block terminating the cycle, in which case ,0,50$ will suffice. In both cases, however, an f0 code must be contained in the data block ending the Z-axis cycle.

2. Z-axis Bore Cycle. The tool will move to the commanded XY position in rapid traverse, then advance the stored delta Z distance into the work at the stored feedrate, then retract the distance delta Z at the stored feedrate (instead of at rapid traverse). An auxiliary function code m(55) programmed after auxiliary function code m(51) locks the system in the Z axis bore cycle. The above example would have been programmed as follows for a bore cycle:

,,57$
,,51$
,1.5,.5,.5,12,55$
,.5$
etc.

All the notes applying to the Z=axis drill cycle also apply to the Z-axis bore cycle.

Z-axis deep hole drilling can be simulated as follows:

,1.0,.5,.2,4,51$ ------------ Go to position, drill .2" deep at 4 ipm.
,.0,.0,.5$ ------------------ Redrill in position .5" deep.
,.0,.0,.75$ ----------------- Redrill in position .75" deep.
,.75,.25,.2$ ---------------- Go to new position, drill .2" deep.
,.0,.0,.5$ ------------------ Redrill in position .5" deep.
etc.

52 - Auxiliary Function "A" On - will cause contact closure of a relay (supplied by Bridgeport when requested) for the operation of other customer supplied equipment.

53 - Auxiliary Function "A" Off - see above.

54 - Advance Turret Stop with Option T - If machine is equipped with Option T. This would advance turret one stop for each time it is entered.

55 - Z Axis Bore Cycle - See above description, Z=axis multi-hole routine.

56 - Auxiliary Function "B" On - will cause contact closure of a relay (supplied by Bridgeport when requested) for the operation of other customer supplied equipment. The latter equipment must be supplied with a contact closure to reset this function. (Typical application is an indexing table.)

57 - Cycle/Mill, Quill/Down - with Option Q - if the machine is equipped with Option Q, it will actuate this operation and the quill will remain down until called up by Cycle/Off (50).

NOTE: Miscellaneous codes 50, 54, 56, 57 actuate external equipment and require external feedback signals to reset the system logic so that operation can continue. If the feedback switches are not in their proper position, the system will be INHIBITED. (INHIBIT lamp "ON"). These auxiliary functions are before functions, they must be reset before table motion can occur. For example, the block of information:

,1.5,.5,,57$

will cause the quill to come down (Auxiliary Function 57) before the table moves 1.5" in X and .5" in Y.