Applications of Micro-computers in Small Businesses

An Honors Thesis (ID 499)

By

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The 1980's will be the decade of the micro-computer. According to Lawrence Fiedelman, approximately eighty percent of the computers sold in the next ten years will be sold to small businesses. Small business computers are expected to flood the market similar to the growth of the electronic calculator. (Infosystems, Je '79, p. 104+)

Businessmen are attracted by the small size, relatively low cost, small power consumption, speed and reliability of micro-computers.

One small businessman who was attracted by the features of micro-computers, John Maryan of Hiatt Metal Products Company Incorporated, recently purchased a Radio Shack TRS-80 micro-computer.

Hiatt Metal Products is a small tool and die shop located at 720 West Willard Street in Muncie, Indiana. The shop generally employs three office workers and ten to fifteen shop workers. There are presently five tool makers, two machinists, three lathe hands, two apprentices and one general laborer. The shop occupies approximately 5000 square feet but will expand to 10000 square feet in the near future. They presently serve ten to fifteen steady customers, including Broderick, Delco-Remy, and Warner Gear. Occasional walk-in business is also handled. Hiatt Metal Products manufactures tools, dies, jigs, fixtures and does precision lathe work as well as CNC (Computer Numerical Control) machining.

The shop consists of three mills, one horizontal
mill, two tracer lathes, five regular lathes, one radial
drill, two internal/external grinders, one external grind-
er, two surface grinders, and assorted files and sawing
machines. The shop also has one CNC Bridgeport mill as well
as a recently purchased CNC MAZAK lathe. These last two
machines are of particular interest because they are pro-
grammable via the TRS-80.

Mr. Maryan originally purchased the Radio Shack
micro-computer specifically to write programs for the CNC
Bridgeport mill. Mr. Maryan can compose and edit his pro-
grams on the micro-computer and when he is satisfied with
the program he can then produce a paper tape version of the
program which is fed into the CNC mill.

The first three programs in the following sections
are designed to prepare paper tapes for the Bridgeport mill.
The tapes are fed into the mill which then drills, bores,
mills or reams according to the given specifications. The
next two programs (4 and 5) are used to calculate certain
points which are needed to program the CNC mill. The sixth
program is used to create and update programs which will
be used by the CNC mill.

The remaining programs are used for office use. The
seventh program records the hours spent in each area of the
shop on a particular shop order. The eighth program figures
the cost of cylindrical or rectangular cold roll steel stock.
The ninth program adds up hours for each employee under
various categories. The tenth program computes the profit
or loss for the company each week. The eleventh program
creates data tapes to record information on the jobs done for each customer. Finally the twelfth program is used to update the data tapes created with the eleventh program. Once all of the data tapes for each customer are initially created the eleventh program is no longer needed unless Hiatt Metal Products begins to do business regularly with another customer. There are presently twelve data tapes which are updated at least once per month.

Since the TRS-80 is a recent addition to Hiatt Metal Products Mr. Maryan is constantly thinking up new programs to be written.
The Current System

Radio Shack TRS-80 Model I, Level II micro-computer
Memory Size: 16K RAM
Word Size: 8 bits
Printer Rate: 110 baud
Printer Output: 8½ inch paper or 8 hole ASCII paper tape
Language: BASIC
Total Cost: Approximately $1,000
Radio Shack BASIC I/O Statements

**INPUT**  
Input values through keyboard

**READ**  
Reads values from DATA statements—assigns values to specified variables

**INPUT#-1**  
Input values stored on cassette and assigns them to the specified variable names

**PRINT**  
Prints item(s) on the display

**PRINT USING**  
Allows programmer to specify a format for printing string and numeric values

**LPRINT**  
Prints item(s) on line printer
If paper tape function is on the LPRINT statement will also produce a paper tape (ASCII) version of the item(s)
Programs 5, 6, 11 and 12 were written by John Norris, the remainder were written by John Maryan.
Purpose: To prepare a paper tape for the CNC Bridgeport mill which will drill or counter bore any number of holes in any bolt circle.

Explanation of Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tr>
<td>G00</td>
<td>(Modal) Rapid Traverse, point-to-point positioning</td>
</tr>
<tr>
<td>G01</td>
<td>(Modal) Linear Interpolation Feed</td>
</tr>
<tr>
<td>G02</td>
<td>(Modal) Circular Interpolation Arc CW</td>
</tr>
<tr>
<td>G03</td>
<td>(Modal) Circular Interpolation Arc CCW</td>
</tr>
<tr>
<td>G04</td>
<td>(Modal) Dwell</td>
</tr>
<tr>
<td>G17</td>
<td>(Modal) XY Plane</td>
</tr>
<tr>
<td>G18</td>
<td>(Modal) ZX Plane</td>
</tr>
<tr>
<td>G19</td>
<td>(Modal) YZ Plane</td>
</tr>
<tr>
<td>G30</td>
<td>(Modal) Cancel Mirror Image</td>
</tr>
<tr>
<td>G31</td>
<td>(Modal) Reverses Programmed Direction of X axis</td>
</tr>
<tr>
<td>G32</td>
<td>(Modal) Reverses Programmed Direction of Y axis</td>
</tr>
<tr>
<td>G40</td>
<td>(Modal) Cutter Diameter Compensation OFF</td>
</tr>
<tr>
<td>G41</td>
<td>(Modal) Cutter Compensation Left</td>
</tr>
<tr>
<td>G42</td>
<td>(Modal) Cutter Compensation Right</td>
</tr>
<tr>
<td>G70</td>
<td>(Modal) Select Inch Dimension System</td>
</tr>
<tr>
<td>G71</td>
<td>(Modal) Select Metric Dimension System</td>
</tr>
<tr>
<td>G72</td>
<td>(Modal) Transformation Off</td>
</tr>
<tr>
<td>G73</td>
<td>(Modal) Transformation On</td>
</tr>
<tr>
<td>G74</td>
<td>(Modal) Multiquadrant Circular Interpolation Cancel</td>
</tr>
<tr>
<td>G75</td>
<td>(Modal) Multiquadrant Circular Interpolation</td>
</tr>
<tr>
<td>G77</td>
<td>(Non-Modal) Facing Cycle</td>
</tr>
<tr>
<td>G78</td>
<td>(Non-Modal) Pocket Mill Cycle</td>
</tr>
<tr>
<td>G79</td>
<td>(Non-Modal) Rough Bore Milling Cycle</td>
</tr>
<tr>
<td>G80</td>
<td>(Modal) Fixed Cycle Cancel</td>
</tr>
<tr>
<td>G81</td>
<td>(Modal) Drill Cycle</td>
</tr>
<tr>
<td>G82</td>
<td>(Modal) Spot Facing Cycle</td>
</tr>
<tr>
<td>G83</td>
<td>(Modal) Deep Hole Drilling Cycle</td>
</tr>
<tr>
<td>G84</td>
<td>(Modal) Tapping Cycle</td>
</tr>
<tr>
<td>G85</td>
<td>(Modal) Boring Cycle</td>
</tr>
<tr>
<td>G86</td>
<td>(Modal) Boring Cycle</td>
</tr>
<tr>
<td>G87</td>
<td>(Modal) Chip Breaking Deep Hole Drilling Cycle</td>
</tr>
<tr>
<td>G89</td>
<td>(Modal) Boring Cycle</td>
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<tr>
<td>G90</td>
<td>(Modal) Absolute Programming Mode</td>
</tr>
<tr>
<td>G91</td>
<td>(Modal) Incremental Programming Mode</td>
</tr>
<tr>
<td>G92</td>
<td>(Non-Modal) Preset Absolute Registers</td>
</tr>
<tr>
<td>G99</td>
<td>(Non-Modal) Deceleration Override for 2.8 ipm and above</td>
</tr>
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</table>
INPUT: OPERATION NUMBER
DEPTH OF C. BORE + .05
C. B. RAD. - CUT. RAD.
PLUNGE FEED RATE
BORE FEED RATE

DATA CORRECT?

INDEX > # OF OPERATIONS

PUNCH/PRINT LINES
INCREMENT INDEX

END
1 CLS
2 CLEAR 1000
3 PRINT "ALL DECIMALS MUST BE ENTERED"
4 PRINT
5 INPUT "ENTER 1 FOR DRILL OR 2 FOR COUNTER BORE"; M
6 INPUT "ENTER NUMBER OF HOLES"; JL
7 INPUT "RADIUS OF BOLT CIRCLE"; JR$ 
8 INPUT "ANGLE OF FIRST HOLE"; JAS
9 INPUT "ANGLE BETWEEN HOLES"; JA2S
10 INPUT "HEIGHT OF HUB"; JHS
11 INPUT "HOW MANY OPERATIONS"; J C
12 PRINT
13 IF M=2 THEN GOT0 1000
14 FOR I=1 TO C
15 LET G$ = "Y"
16 INPUT "TOOL NUMBER"; TS(I)
17 INPUT "WHICH G CODE, 81 OR 83"; X(I)
18 INPUT "DEPTH OF HOLE +.05"; Z1S(I)
19 IF X(I)=81 THEN 120
20 INPUT "DEPTH OF FIRST PECK"; Z2S(I)
21 INPUT "DEPTH OF SECOND PECK"; Z3S(I)
22 INPUT "FEED RATE"; FS(I)
23 INPUT "IS THE DATA CORRECT Y OR N"; GS
24 PRINT
25 IF GS = "N" THEN GOTO 75
26 NEXT I
27 INPUT "ARE YOU READY TO MAKE A TAPE"; KS
28 LPRINT "Z"
29 FOR I=1 TO C
30 LPRINT "N"; TS(I); "G00G90X0.Y0.T"; TS(I); "R6"
31 LPRINT "R"; JR$; "10.W0."
32 LPRINT "A"; JAS; "Z0."
33 LPRINT "N100=N140/"; JSTR$ (I-1)
34 LPRINT "N110G0G91Z-"; J HS
35 IF X(I)=83 THEN 214
36 LPRINT "N120G91G61A0.Z"; Z1S(I); "F"; FS(I)
37 G0T0 220
38 LPRINT "N120G91G63A0.Z"; Z1S(I); "Z"; Z2S(I); "Z"; Z3S(I); "F"; FS(I)
39 LPRINT "N130G91G0Z"; J HS
40 LPRINT "N140G0G91A"; JA2S
41 IF X(I)=83 THEN 260
42 LPRINT "N140G0G91-"; J HS
43 LPRINT "G91G61A0.Z"; Z1S(I); "F"; FS(I)
44 G0T0 290
45 LPRINT "N290G91G63A0.Z"; Z1S(I); "Z"; Z2S(I); "Z"; Z3S(I); "F"; FS(I)
46 LPRINT "G00G90X0.Y0.Z0."
47 NEXT I
48 LPRINT "W2"
49 LPRINT "E"
50 END
51 PRINT
52 FOR M=1 TO C
53 IF M=2 THEN GOTO 1000
54 NEXT M
55 FOR I=1 TO C
56 IF M=2 THEN GOTO 1000
57 NEXT I
58 END
59 INPUT "OPERATION NUMBER"; TS(I)
60 INPUT "DEPTH OF C. BORE +.05"; ZS(I)
61 INPUT "C. B. RAD.- CUT. RAD."; J S(I)
Purpose: Prepares paper tape for Bridgeport mill. Mill will drill, counter bore, ream or bore any number of holes in any location.

Note: See #1 for explanation of codes
10 CLEAR 2000
12 DIM X$(25), Y$(25)
20 CLS
30 PRINT "INSTRUCTIONS FOR DRILLING, REAMING, BORING, AND COUNTER BORING HOLES IN ANY POSITION"
40 PRINT
50 PRINT "1 ALL DECIMALS MUST BE ENTERED"
60 PRINT "2 ALL QUESTIONS MUST BE ANSWERED"
70 PRINT "3 1=YES AND 0=NO"
80 PRINT "4 FIRST MOVE AFTER T.C. IS ALWAYS IN THE G90 MODE"
90 INPUT "HAVE YOU READ THE INSTRUCTIONS"; B
100 IF B=0 THEN 30
110 CLS
120 INPUT "HOW MANY OPERATIONS"; J
130 INPUT "CLAMP OR HUB CLEARANCE"; H$
140 INPUT "X LOCATION AT T. C."; X$
150 INPUT "Y LOCATION AT T. C."; Y$
160 INPUT "HOW MANY HOLES"; C
170 INPUT "ENTER G CODE 90 OR 91"; G$
180 IF G$="90" OR G$="91" GOTO 190 ELSE 190
190 INPUT "IS THE DATA CORRECT"; B
200 IF B=0 THEN 110
210 FOR J=1 TO C
220 PRINT "HOLE NUMBER"; J
230 INPUT "X VALUE"; X$(J)
240 INPUT "Y VALUE"; Y$(J)
250 INPUT "IS THE DATA CORRECT"; B
260 IF B=0 THEN 220
270 NEXT J
290 FOR I=1 TO C
300 PRINT "OPERATION NUMBER"; I
310 INPUT "ENTER G CODE 79 OR 81 THRU 89"; A$(I)
320 IF VAL(A$(I))<79 OR VAL(A$(I))>89 THEN 310
330 INPUT "TOOL NUMBER"; T$(I)
340 IF A$(I)="82" OR A$(I)="89" THEN 360 ELSE 350
350 INPUT "DETER MINIMUM DEPTH"; Z$(I)
360 INPUT "DEPT HOLE"; Z(I)
370 PRINT "DEPTH +.05 ="; Z(I)+.05
380 INPUT "TOTAL DEPTH"; Z$ (I)
390 IF A$(I)="79" THEN 400
400 IF A$(I)="83" OR A$(I)="87" THEN GOTO 420 ELSE 410
410 PRINT "DEPTH OF FIRST PECK"; Z1$(I)
420 PRINT "DEPTH OF SECOND PECK"; Z2$(I)
430 GOTO 435
440 INPUT "DI A OF THE CUTTER"; CU
450 INPUT "DI A OF THE C. BORE"; CB
460 PRINT "TOOL PATH RADIUS"; (CB-CU)/2
470 INPUT "ENTER T. P. R."; J$(I)
480 PRINT "VERTICAL FEED RATE"; F$(I)
490 IF A$(I)="79" THEN 500 ELSE 490
500 PRINT "HORIZONTAL FEED RATE"; F2
510 PRINT "C. BORE FEED RATE" ="((CB-"(CB-CU)/CB)*F2
520 INPUT "ENTER C. B. FEED RATE"; F2$(I)
530 INPUT "IS THE DATA CORRECT"; B
540 IF B=0 THEN 300
550 NEXT I
1000 INPUT "IS THIS THE START OF YOUR PROGRAM"; B
1010 INPUT "IS THIS THE END OF THE PROGRAM"; BB
1020 INPUT "ARE YOU READY TO MAKE TAPE"; AB
1030 IF AB = 0 THEN 1020
1040 IF B = 0 THEN 1060
1050 LPRINT "%"
1060 FOR I = 1 TO C
1070 LET K = VAL(TS(I) * 100)
1080 LPRINT "N"; JK; "G90X"; XS(J); "Y"; YS(J); "T"; TS(I); "M6"
1090 IF AS(I) = "82" OR AS(I) = "89" THEN 1100 ELSE 1110
1100 LPRINT "G04"; "S";
1110 LPRINT "N"; JK+1; "X"; XS(I); "T"; TS(I); "ZO."
1120 BS = XS(I)
1130 IF GS = "91" THEN XS(1) = "0."
1140 IF AS(I) = "79" THEN 1150 ELSE 1190
1150 LPRINT "N"; JK+2; "G916Z-"; JS(I); "F"; FS(I)
1160 LPRINT "N"; JK+3; "G79J"; JS(I); "F"; F2S(I)
1170 LPRINT "N"; JK+4; "G0G91Z-"; JS(I)
1180 LPRINT "N"; JK+5; "G0G90Z+"; HS
1185 GOTO 1250
1190 IF AS(I) = "83" OR AS(I) = "87" THEN 1200 ELSE 1220
1200 LPRINT "N"; JK+2; "G"; JS(I); "G"; AS(I); "X"; XS(I); "Z"; JS(I); "Z"; JS(I); "F"; F2S(I)
1210 GOTO 1230
1220 LPRINT "N"; JK+2; "G"; JS(I); "G"; AS(I); "X"; XS(I); "Z"; JS(I); "F"; F2S(I)
1230 XS(I) = BS
1240 LPRINT "N"; JK+3; "G0G90Z+"; HS
1245 IF CC = 1 THEN 1440
1250 FOR J = 2 TO CC
1260 IF AS(I) = "79" THEN 1270 ELSE 1340
1270 LPRINT "N"; JK+4; "GOG"; JS(J); "X"; XS(J); "Y"; YS(J);
1280 LPRINT "N"; JK+5; "G0G90ZO."
1290 LPRINT "N"; JK+6; "G916Z-"; JS(I); "F"; FS(I)
1300 LPRINT "N"; JK+7; "G79J"; JS(I); "F"; F2S(I)
1310 LPRINT "N"; JK+8; "G0G91Z-"; JS(I)
1320 LPRINT "N"; JK+9; "G0G90Z+"; HS
1330 GOTO 1420
1340 LPRINT "N"; JK+2; "GOG"; JS(J); "X"; XS(J); "Y"; YS(J);
1350 LPRINT "N"; JK+3; "G0G90Z+"
1355 LET CS = XS(J)
1360 IF GS = "91" THEN XS(J) = "0."
1370 IF AS(I) = "83" OR AS(I) = "87" THEN GOTO 1380 ELSE 1440
1380 LPRINT "N"; JK+4; "GOG"; JS(J); "G"; AS(I); "X"; XS(J); "Z"; JS(I); "F"; F2S(I)
1390 GOTO 1410
1400 LPRINT "N"; JK+4; "GOG"; JS(J); "G"; AS(I); "X"; XS(J); "Z";
1410 LET XS(J) = CS
1415 NEXT J
1420 LET XS(J) = CS
1430 NEXT I
1440 NEXT I
1450 IF BB = 0 THEN 30
1460 LPRINT "N"; JK+CC+4; "G0G90X"; XS(J); "Y"; YS(J); "M2"
1470 LPRINT "E"
1480 END
#3

Purpose: Prepares paper tape which will drill any number of holes in any number of rows

Note: See #1 for explanation of codes
10 CLEAR 2000
12 DIM C(50), CC(50), X$(50), Y$(50), XS(50), YS(50), X2S(50)
20 CLS
30 PRINT "INSTRUCTIONS FOR MULTIHOLE ROW DRILLING, RREAMING, OR BORING"
40 PRINT
50 PRINT "1 ALL DECIMALS MUST BE ENTERED"
60 PRINT "2 ALL QUESTIONS MUST BE ANSWERED"
70 PRINT "3 YES AND 0=NO"
80 PRINT "4 FIRST HOLE POSITION ALWAYS IN ABSOLUTE MODE"
82 PRINT "5 IF X POSITION OF LAST HOLE KNOWN USE G90"
84 PRINT "6 IF DISTANCE BETWEEN FIRST AND LAST HOLE KNOWN USE G91"
86 PRINT
90 INPUT "HAVE YOU READ THE INSTRUCTIONS"; B
100 IF B=0 THEN 30
110 CLS
120 INPUT "HOW MANY OPERATIONS" ; C
130 INPUT "CLAMP OR HUB CLEARANCE" ; HS
140 INPUT "X LOCATION AT T. C." ; X$
150 INPUT "Y LOCATION AT T. C." ; Y$
160 INPUT "HOW MANY ROWS" ; CC
170 INPUT "ENTER CODE 90 OR 91" ; G$
180 IF G$="90" OR G$="91" GOTO 190 ELSE 170
190 INPUT "IS THE DATA CORRECT" ; B
200 IF B=0 THEN 110
210 FOR J=1 TO CC
220 PRINT "ROW NUMBER" ; J
230 INPUT "X VALUE" ; XS(J)
235 INPUT "Y VALUE" ; YS(J)
238 IF G$="90" THEN 240 ELSE 243
240 INPUT "X LOCATION OF LAST HOLE IN THE ROW" ; Xin(J)
242 GOTO 244
243 INPUT "TOTAL DISTANCE BETWEEN FIRST AND LAST HOLES" ; X1$(J)
244 INPUT "DISTANCE BETWEEN EACH HOLE" ; X2$(J)
250 INPUT "IS THE DATA CORRECT" ; B
260 IF B=0 THEN 220
270 NEXT J
290 FOR I=1 TO C
300 PRINT "OPERATION NUMBER" ; I
310 INPUT "ENTER CODE 79 OR 81 THRU 89" ; AI$(I)
320 IF VAL(AI$(I))<79 OR VAL(AI$(I))>89 THEN 310
330 INPUT "TOOL NUMBER" ; TI$(I)
350 IF AI$(I)="82" OR AI$(I)="89" THEN 360 ELSE 370
360 INPUT "Dwell TIME" ; TS$
370 INPUT "DEPTh OF HOLE" ; Z(I)
380 PRINT "DEPTh + .05" ; Z(I)+.05
390 INPUT "TOTAL DEPTH" ; ZI$(I)
410 IF AI$(I)="83" OR AI$(I)="87" THEN GOTO 420 ELSE 480
420 INPUT "DEPTh OF FIRST PECK" ; Z1S(I)
430 INPUT "DEPTh OF SEConD PECK" ; Z2S(I)
435 GOTO 480
480 INPUT "VERTICAL FEED RATE" ; FS(I)
485 INPUT "IS THE DATA CORRECT" ; B
490 IF B=0 THEN 300
550 NEXT I
Purpose: Calculates all tangent points, center of circle and cutter compensation for two lines tangent to a circle
5 CLS
10 REM *CIRCLE TAN TO TWO LINES*
30 IF R=0 THEN 2000
40 B=R
50 GOSUB 3000
60 D=.01745329
70 E=COS(A1*D)*C/2
80 F=SIN(A1*D)*C/2
90 G=SIN(A2*D)*C/2
100 H=COS(A2*D)*C/2
110 INPUT "IS X LARGE(L) OR SMALL(S)"; CS
120 INPUT "IS Y LARGE(L) OR SMALL(S)"; DS
130 IF CS="L" AND DS="L" THEN 3500
140 IF CS="L" AND DS="S" THEN 4000
150 IF CS="S" AND DS="S" THEN 4500
160 IF ES="N" THEN 360
170 IF C>0 THEN 7200
180 X1=U-S2
190 Y1=V+S3
200 X2=U+S5
210 Y2=V+S4
220 I=U+(S5+S7)
230 J=V-(S3+S6)
240 GOTO 5000
250 IF I>0 THEN 7400
260 X1=U+S3
270 Y1=V+S2
280 X2=U+S4
290 Y2=V+S5
300 I=U+(S3+S6)
310 J=V-(S5+S7)
320 GOTO 5000
330 B=1/2*C
340 GOTO 90
350 B=R+(1/2*C)
360 GOTO 90
370 A3=.5-((A1+A2)/2)
380 S1=TAN(A3*.01745329)*B
390 S2=SIN(A1*.01745329)*S1
400 S3=COS(A1*.01745329)*S1
410 S4=SIN(A2*.01745329)*S1
420 S5=COS(A2*.01745329)*S1
430 S6=SIN(A1*.01745329)*B
440 S7=SIN(A2*.01745329)*B
450 RETURN
460
3500 INPUT "IS THE TOOL MOVING X+? (Y OR N)"; HS
3510 IF HS= "Y" THEN 3710
3520 IF C>0 THEN 6200
3540 X1=U+S3
3550 Y1=V-S2
3560 X2=U-S4
3570 Y2=V+S5
3580 I=U+(S3+S6)
3590 J=V+(S5+S7)
3600 G0T0 5000
3710 IF C>0 THEN 6000
3720 X1=U-S2
3730 Y1=V+S3
3740 X2=U+S5
3750 Y2=U-S4
3760 I=U+(S5+S7)
3770 J=V+(S3+S6)
3780 G0T0 5000
4000 INPUT "IS THE TOOL MOVING X+? (Y OR N)"; KS
4010 IF KS= "N" THEN 4210
4030 IF C>0 THEN 6400
4040 X1=U-S3
4050 Y1=V-S2
4060 X2=U+S4
4070 Y2=U+S5
4080 I=U-(S3+S6)
4090 J=V-(S5+S7)
4100 G0T0 5000
4210 IF C>0 THEN 6600
4220 X1=U+S2
4230 Y1=V+S3
4240 X2=U-S5
4250 Y2=V-S4
4260 I=U-(S5+S7)
4270 J=V+(S3+S6)
4280 G0T0 5000
4500 INPUT "IS THE TOOL MOVING X+? (Y OR N)"; KS
4610 IF KS= "N" THEN 4710
4620 IF C>0 THEN 6800
4640 X1=U-S3
4650 Y1=V-S2
4660 X2=U+S4
4670 Y2=V-S5
4680 I=U-(S3+S6)
4690 J=V-(S5+S7)
4700 G0T0 5000
4710 IF C>0 THEN 7000
4720 X1=U+S2
4730 Y1=V-S3
4740 X2=U-S5
4750 Y2=V+S4
4760 I=U-(S5+S7)
4780 J=V-(S3+S6)
4790 G0T0 5000
5000 IF C>0 AND R>0 THEN 5025
5020 END
5025 INPUT "F(O)";F(0)
5030 IF QS="N" OR RS="N" OR SS="N" OR TS="N" OR U$="N" OR VS="N" OR WS="N"
5060 F(1)=F(0)*((R-C/2)/R)
5070 GOTO 5090
5080 F(1)=F(0)*((R+C/2)/R)
5090 PRINT "X1";X1: PRINT "Y1";Y1: PRINT "X2";X2: PRINT "Y2"; Y2: PRINT
5095 END
6000 INPUT "IS THE TOOL INSIDE? (Y OR N)"; QS
6010 IF QS="N" THEN 6070
6020 X1=(U+S2)+E
6030 Y1=(V+U3)+F
6040 X2=(U+S5)+G
6050 Y2=(V+S4)+H
6060 GOTO 3760
6070 X1=(U-S2)-E
6080 Y1=(V+S3)-F
6090 X2=(U+S5)-G
6100 Y2=(V+S4)-H
6110 GOTO 3760
6200 INPUT "IS THE TOOL INSIDE THE LINES? (Y OR N)"; RS
6210 IF RS="N" THEN 6270
6220 X1=(U+S3)+F
6230 Y1=(V-S2)+E
6240 X2=(U-S4)+H
6250 Y2=(V+S5)+G
6260 GOTO 3580
6270 X1=(U+S3)-F
6280 Y1=(V-S2)-E
6290 X2=(U+S4)-H
6300 Y2=(V+S5)-G
6310 GOTO 3580
6400 INPUT "IS THE TOOL INSIDE? (Y OR N)"; SS
6410 IF SS="N" THEN 6470
6420 X1=(U+S3)+F
6430 Y1=(V-S2)+E
6440 X2=(U+S4)+H
6450 Y2=(V+S5)+G
6460 GOTO 4080
6470 X1=(U+S3)-F
6480 Y1=(V-S2)-E
6490 X2=(U+S4)+H
6500 Y2=(V+S5)-G
6510 GOTO 4080
6600 INPUT "IS THE TOOL INSIDE? (Y OR N)"; TS
6610 IF TS="N" THEN 6670
6620 X1=(U+S2)+E
6630 Y1=(V+S3)+F
6640 X2=(U-S5)-G
6650 Y2=(V-S4)+H
6660 GOTO 4260
6670 X1=(U+S2)+E
6680 Y1=(V+S3)-F
8080 RETURN
6690 X2 = (U - S5) + G
6700 Y2 = (V + S4) - H
6710 GOTO 4580
6800 INPUT "IS THE TOOL INSIDE? (Y OR N)"; US
6810 IF US = "N" THEN 6870
6820 X1 = (U - S3) - F
6830 Y1 = (V + S2) - E
6840 X2 = (U + S4) - H
6850 Y2 = (V - S5) - G
6860 GOTO 4580
6870 X1 = (U - S3) + F
6880 Y1 = (V + S2) + E
6890 X2 = (U + S4) + H
6900 Y2 = (V - S5) + G
6910 GOTO 4580
7000 INPUT "IS THE TOOL INSIDE? (Y OR N)"; VS
7010 IF VS = "N" THEN 7070
7020 X1 = (U + S2) - E
7030 Y1 = (V - S3) - F
7040 X2 = (U - S5) - G
7050 Y2 = (V + S4) - H
7060 GOTO 4760
7070 X1 = (U + S2) + E
7080 Y1 = (V - S3) + F
7090 X2 = (U - S5) + G
7100 Y2 = (V + S4) + H
7110 GOTO 4760
7200 INPUT "IS THE TOOL INSIDE? (Y OR N)"; WS
7210 IF WS = "N" THEN 7270
7220 X1 = (U - S2) + E
7230 X2 = (U + S5) - G
7240 Y2 = (V + S4) + H
7250 Y2 = (V + S4) - H
7260 GOTO 230
7270 X1 = (U - S2) - E
7280 Y1 = (V - S3) + F
7290 X2 = (U + S5) - G
7300 Y2 = (V + S4) + H
7310 GOTO 230
7400 INPUT "IS THE TOOL INSIDE? (Y OR N)"; XS
7410 IF XS = "N" THEN 7470
7420 X1 = (U + S3) + F
7430 Y1 = (V + S2) - E
7440 X2 = (U - S4) - H
7450 Y2 = (V - S5) - G
7460 GOTO 410
7470 X1 = (U + S3) - F
7480 Y1 = (V + S2) + E
7490 X2 = (U - S4) + H
7500 Y2 = (V - S5) + G
7510 GOTO 410
Purpose: To compute the center of circle 2, \( P_1 \) - line 1, circle 1 tangent point, \( P_2 \) - line 2 circle 1, \( P_3 \) - circle 1, circle 2 tangent point and \( P_4 \) - circle 2, line 2 tangent point.

These points are necessary to program the CNC Bridgeport mill to cut an S-curve (red line) given the radius of circle 1, the angle \( \alpha_1 \), the angle \( \alpha \), the angle \( \alpha_2 \), and the radius of the second circle.

Circle C2 is tangent to 12. 12 given by P2 (from ) and \( \alpha_2 \)
Given: Circle 1, radius of circle 1

Line 11 specified by angle \( \theta_1 \) and tangent to circle 1

Equation 11: \( \cos(\theta_1 + 90^\circ)X + \sin(\theta_1 + 90^\circ)Y - r_1 = 0 \)

Point of tangency P1: \((r_1 \cos(\theta_1 + 90^\circ), r_1 \sin(\theta_1 + 90^\circ))\)

Given: Point \( P_2 = (X_2, Y_2) \) on circle 1

Given by angle \( \alpha \)

\[ X_2 = r_1 \cos \alpha, Y_2 = r_1 \sin \alpha \]

Line 12 through \( (X_2, Y_2) \) and has angle \( \theta_2 \)

Equation of 12: \( (\cos(\theta_2 + 90^\circ))(X - X_2) + (\sin(\theta_2 + 90^\circ))(Y - Y_2) = 0 \)

To find: Circle C2, whose radius is \( r_2 \), which is tangent to line 12, circle C1

To find: \((X_C, Y_C)\) center of circle C2

(+) \( (\cos(\theta_2 + 90^\circ))(X_C - X_2) + (\sin(\theta_2 + 90^\circ))(Y_C - Y_2) = r_2 \)

expresses tangency of 12 to C2

(++) \( (r_1 + r_2)^2 = X_C^2 + Y_C^2 \)

expresses tangency of C1 with C2

Method: Solve (+) and (++) simultaneously for \( X_C, Y_C \)

Other Quantities:

\[ P_3 = \frac{r_1}{(r_1 + r_2)} (X_C, Y_C) \]

\[ P_4 = (X_C, Y_C) - r_2(\cos(\theta_2 + 90^\circ), \sin(\theta_2 + 90^\circ)) \]
Variable Dictionary

R1#  Radius of circle 1
T1#  Theta 1 - the angle from horizontal of line 1
AI#  Alpha - the angle of circle 1 which produces P2
T2#  Theta 2 - the angle from horizontal of line 2
R2#  Radius of circle 2
X1#  X value of P1
Y1#  Y value of P1
X2#  X value of P2
Y2#  Y value of P2
XC#  X value of center of circle 2
YC#  Y value of center of circle 2
X3#  X value of P3
Y3#  Y value of P3
X4#  X value of P4
Y4#  Y value of P4
10 INPUT"GIVE R1";R1#
20 INPUT"GIVE THETA1";T1#
30 INPUT"GIVE ALPHA";AL#
40 INPUT"GIVE THETA2";T2#
50 INPUT"GIVE R2";R2#
60 LET P# = 4 * ATN(1.0)
70 LET X1# = R1# * COS((T1# + 90) * P#/180)
80 LET Y1# = R1# * SIN((T1# + 90) * P#/180)
90 LET X2# = R1# * COS(AL# * P#/180)
100 LET Y2# = R1# * SIN(AL# * P#/180)
110 LET T# = (T2# + 90) * P#/180
120 LET A# = X2# + (1/COS(T#)) * (R2# + Y2# * SIN(T#))
130 LET B# = -SIN(T#) / COS(T#)
140 LET A1# = B#(2+1)
150 LET B1# = 2*A1#B#
160 LET C1# = A1#(2-(R1#+R2#))I2
170 LET YC# = (-B1# - SQR(B1#(2-4*A1#C1#)) / 2*A1#)
180 LET XC# = A1# + B1#YC#
190 LET X3# = (R1#/R1# + R2#)*XC#
200 LET Y3# = (R1#/R1# + R2#)*YC#
210 LET TH# = (T2# + 90) * P#/180
220 LET X4# = XC# - R2# * COS(TH#)
230 LET Y4# = YC# - R2# * SIN(TH#)
240 PRINT :PRINT XC#;"";YC#;"" CENTER OF CIRCLE 2"
250 PRINT XI#;"";YI#;"" P1, LINE 1, CIRCLE 1, TANGENT POINT"
260 PRINT X2#;"";Y2#;"" P2, LINE 2, CIRCLE 1"
270 PRINT X3#;"";Y3#;"" P3, CIRCLE 1, CIRCLE 2, TANGENT POINT"
280 PRINT X4#;"";Y4#;"" P4, CIRCLE 2, LINE 2, TANGENT POINT"
290 END
Purpose: To create and update programs for use on the CNC Bridgeport Mill

Everytime the Bridgeport mill is used to manufacture a part a new program must be written. Many times these programs may be very similar except for a few lines, where some specification is different. This program would allow someone to edit an existing program without having to retype the entire program. Since many programs written for the Bridgeport may be over a hundred lines this editing program would save much time in reprogramming instructions for the Bridgeport mill.

This program creates new programs for the CNC mill and stores them on tape. Once a program has been created it can be edited. If a program is to be edited the old program tape is read in. The operator can then:

(1) Display the entire file
(2) Display a single line (referenced by M-number)
(3) Insert a new line (placed in correct sequence)
(4) Change an old line
(5) Delete an old line (lines renumbered)
(6) Create a new file (stored on tape)
(7) Get a printout of the program
(8) Exit from the editing program

Variable Dictionary

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A$(I)</td>
<td>Array of N-numbers</td>
</tr>
<tr>
<td>B$(I)</td>
<td>Array of code numbers for each N-number</td>
</tr>
<tr>
<td>C</td>
<td>Line Counter</td>
</tr>
<tr>
<td>E</td>
<td>Interval between N values</td>
</tr>
<tr>
<td>K</td>
<td>N values</td>
</tr>
<tr>
<td>N</td>
<td>Temporary N-number -- used for insertion</td>
</tr>
<tr>
<td>N2$</td>
<td>Temporary partial line -- used for insertion</td>
</tr>
<tr>
<td>Q$</td>
<td>Purpose of tape</td>
</tr>
</tbody>
</table>
START

CLEAR STRING SPACE

OLD OR NEW TAPE

OLD

NEW

PRINT INSTRUCTIONS

INPUT: PURPOSE STARTING N-VALUE INTERVAL BETWEEN N'S

INDEX > 275?

YES

No

ENTER LINE

DATA CORRECT?

YES

NO

DONE?

YES

NO

INCREMENT N-NUMBER

INCREMENT INDEX

COMPUTE # OF LINES IN PGM

X1

Allows programs up to 275 lines
X1

RECORD PURPOSE & # OF LINES

INDEX > # OF LINES

YES

B

NO

RECORD LINES

INCREMENT INDEX
A

PRINT INSTRUCTIONS

READ PURPOSE & # OF LINES

PRINT PURPOSE

CORRECT TAPE?

YES

NO

PRINT ERROR MESSAGE

READ FILE

B
If end of array is reached then the number to be inserted is larger than any of the numbers presently in the file.

Search for correct insertion position for new line to maintain proper numerical ordering of lines.

Renumber the indices for the lines in the file after the new inserted line.

CLEAR SCREEN
ENTER LINE
DATA CORRECT?
YES
END OF ARRAY?
NO
N-NUMBER INSERTION POINT FOUND?
NO
INCREMENT INDEX
 INDEX < TEST VALUE ?
NO
RENUMBER LINES
DECREMENT INDEX
INSERT NEW LINE
INCREMENT LINE COUNTER

ANOTHER INSERTION?
YES

E

CHANGE OLD LINE

Sequential search for N-number

CLEAR SCREEN

ENTER N-NUMBER

END OF ARRAY?

N-NUMBER FOUND?

INCREMENT INDEX

PRINT LINE

ENTER CORRECTED LINE

ANOTHER CORRECTION?

PRINT ERROR MESSAGE

F

B
DELETION OLD LINE

G

CLEAR SCREEN

ENTER N-NUMBER

END OF ARRAY?

YES

PRINT ERROR MESSAGE

NO

N-NUMBER FOUND?

YES

NO

INCREMENT INDEX

PRINT LINE

DECREMENT LINE COUNTER

INDEX > LINE COUNTER

YES

NO

RENUMBER LINE

INCREMENT INDEX

PRINT MESSAGE

ANOTHER DELETION?

YES

G

NO

B

N-number for line to be deleted

Renumber lines following deleted line
CREATE NEW FILE

H

CLEAR SCREEN

PRINT INSTRUCTIONS

RECORD PURPOSE & LINE COUNTER

END OF ARRAY?

YES

NO

RECORD LINES

INCREMENT INDEX

PRINT MESSAGE

B
PRINTOUT OF FILE

I

PRINTER ON?

YES

J

NO

PRINT ERROR MESSAGE

PRINT MESSAGE

END OF ARRAY?

YES

B

PUNCH/PRINT LINES

INCREMENT INDEX

J

DONE

END