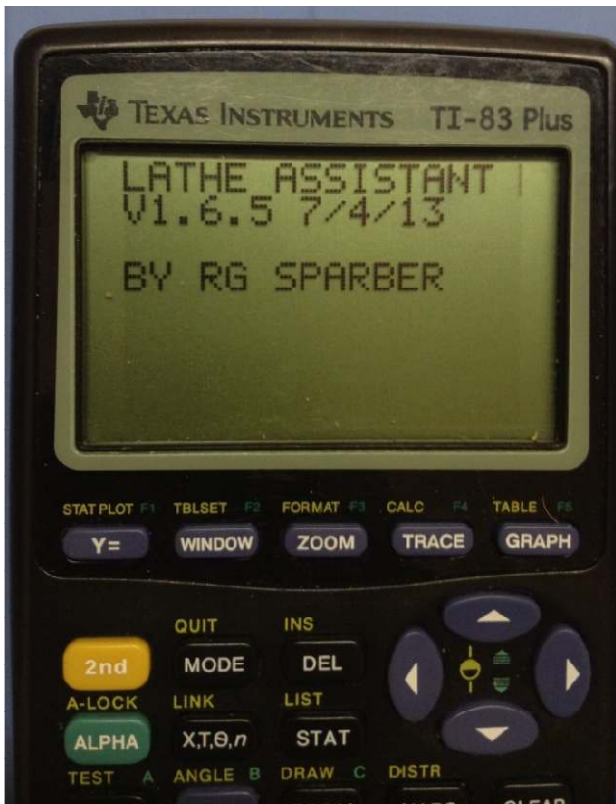# Lathe Assistant for a TI-83 Plus, version 1.6.1

By R. G. Sparber

Copyleft protects this document.[1]

Purpose

This program assists the lathe operator in turning inside and outside diameters. It runs on a programmable pocket calculator that is rather old and therefore easy to buy used for around $40. The program is large but if you own or have access to the TI-Graph Link USB cable and a PC, you can download the code[2] and then upload it into the TI-83 Plus.

User Interface

The user can customize the display to show all details or just enough information to get the job done. On the left here you see the details mode.

The user inputs the goal diameter and the present diameter. The program calculates and keeps track of the number of roughing cuts. If one or more passes is not recorded, the program detects the error. If one or more passes are taken but not recorded, the program attempts to detect that error. Then it calculates and keeps track of the finish cuts. Optionally, it will calculate the lathe's fixed error and use it on the final finish cut.

With Details turned off, a typical user dialog looks like this:

[1] You are free to copy and distribute this document but not change it.
[2] Contact me directly at rgsparber@AOL.com for the file.

When the program starts up, it offers the user the options of running, changing the set up parameters, viewing the log file of the previous session, exiting, or doing a one-time initialization. I have previously used SET UP to tell the program that my roughing depth of cut (DOC) is 50 and I want to make 1 outside diameter (OD) finish pass. It was also told that my in-feed dial has a maximum value of 100. My Surface Feet per Minute (SFM) was set to 80 for steel and 100 for aluminum.
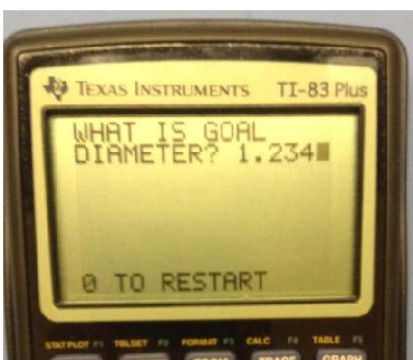
The user is then asked for the goal diameter. They can back space or move to any digit to correct the entry. When done the user presses ENTER. I have entered "1.234".
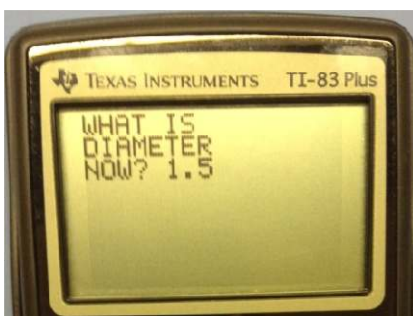
The user is next asked for the current diameter. I have said "1.5". The program now has enough information to know if this is an OD or inside diameter (ID) being turned plus how many roughing passes to make before measuring for the finish pass. Given a starting diameter of 1.5" and a goal of 1.234", I have to reduce the diameter by .266 so must feed the cutter in by .133 because my lathe is set up so dial movement is related to radius and not diameter.
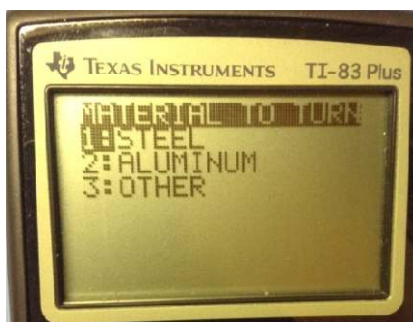
This screen will only show if the program is being run from the top. On subsequent restarts of the program, it is assumed that the same material is being cut. Run from the top by selecting "EXIT" on the first screen and then press "ENTER".

The program takes the average of the goal diameter and current diameter plus the specified SFM to calculate the RPM.

```
TEXAS INSTRUMENTS    TI-83 Plus
SET RPM
NEAR 220

PRESS ENTER NOW
```
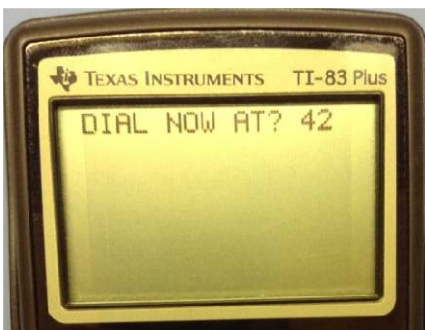
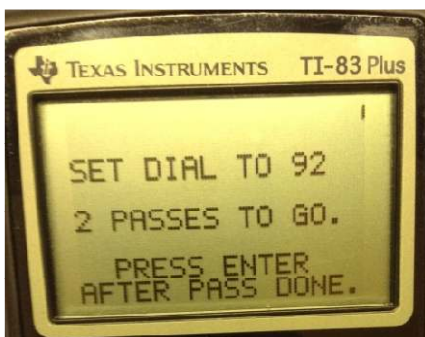The user moves the cutter until it contacts the workpiece. The program asks the position of the dial.

```
TEXAS INSTRUMENTS    TI-83 Plus
DIAL NOW AT? 42
```

My dial started at 42 so to make my first roughing pass I move the dial to 42 + 50 = 92 and that is what the program is telling us. This will ideally reduce the diameter from 1.5" to 1.4".

When done with this pass, I press ENTER.

```
TEXAS INSTRUMENTS    TI-83 Plus
SET DIAL TO 92

2 PASSES TO GO.

    PRESS ENTER
AFTER PASS DONE.
```
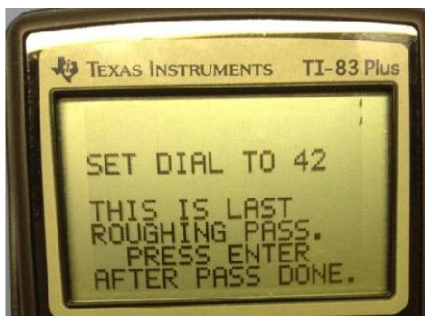
The program then says to turn the dial to 42 in preparation for the second roughing pass. This will ideally reduce the diameter from 1.4" to 1.3". If we took another roughing pass, our diameter would ideally be 1.2" and that is too small. So the program tells us that this is our last roughing pass[3]. When done with this roughing pass, I press ENTER.

```
TEXAS INSTRUMENTS    TI-83 Plus
SET DIAL TO 42

THIS IS LAST
ROUGHING PASS.
    PRESS ENTER
AFTER PASS DONE.
```

---

[3] The program has been modified so "THIS IS LAST ROUGHING PASS." will only display if "DETAILS" are turned on.
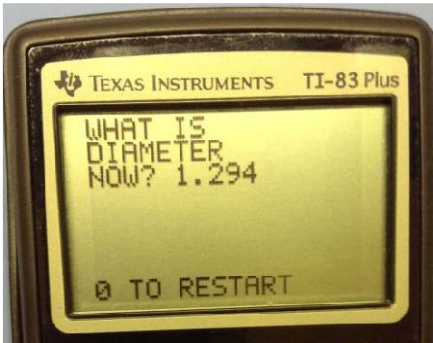
Ideally, our diameter is 1.3" but let's assume there was some error and the actual diameter is 1.294. This turns out to be exactly 60 thou larger than the goal. So we need to reduce the radius by 30 thou.
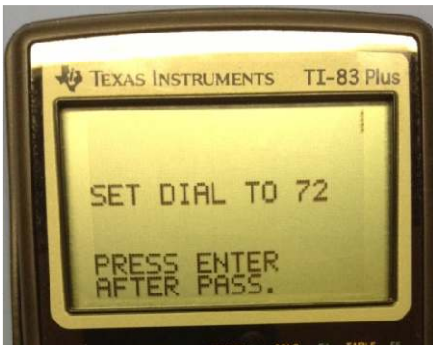
My dial was at 42 so advancing it 30 puts me at 72 which is consistent with what the program is telling us.
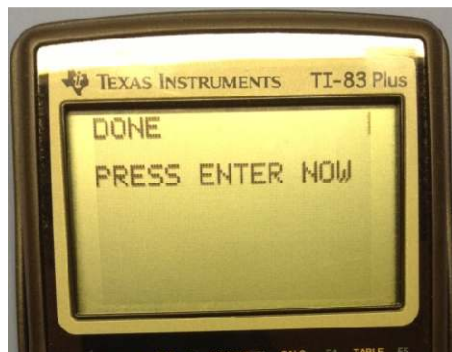
Since this was the one and only finish pass, we are now done. Our diameter will then be as close to our goal of 1.234 as the lathe accuracy will allow.

You can see a video of the program in action with Details enabled:

http://www.youtube.com/watch?v=xg10VuiUARo&feature=youtu.be

Lathe Assistant Quick Start Instructions

These instructions assume that only the Lathe Assistant program is loaded into the TI-83 Plus.

1. To Start Program
   - Press ON
   - Press PRGM
   - Press ENTER twice

2. When done and at the home screen, select EXIT before pressing OFF ("2nd" button and ON)

Shop Experience

Here are my experiences. In all cases I was turning aluminum at 100 SFM with cutting fluid. I use HSS for both and ID. My boring bar is ½" in diameter and cantilevered 4.5". **My worst case error is +/- .002".**

ID/OD	Goal	Final	Error
OD	.900	.902	.002
OD	.600	.5995	-.0005
OD	.250	.251	.001
OD	.800	.8015	.0015
OD	.600	.600	0
ID	1.200	1.200	0
ID	1.400	1.4005	.0005
ID	1.500	1.4995	-.0005
ID	1.800	1.8020	.002
ID	1.842	1.8435	.0015

I use a digital caliper to measure OD. For ID I use a telescoping T gage. The gage is first put into the bore at a slight angle. It is then tightened. Then the gage is straightened out in the bore which causes it to compress. Then it is removed and measured with the digital caliper.

Since I wrote the program to conform to my taste, it is impossible for me to judge how user friendly it is for others. Yet I have to admit that I enjoy being able to input my goal, current diameter, and then concentrate on running my lathe. No time is taken figuring my next DOC and the program never makes a (small) mistake. I do have to be careful to input all measurements correctly. Otherwise, it is just "garbage in/garbage out".

Strategy

The program is based on the strategy of taking as many roughing cuts as possible and then taking a user specified number of finish pass. If the user is using a very solid lathe and turning an OD, then it is reasonable to turn a single finish pass. I own a light-weight hobby lathe and have found it better to take 3 OD finish or 4 ID finish cuts. This reduces the DOC for each pass which reduces the distortion of the lathe which, in turn, causes error. It also lets me figure out any fixed error between

dialed-in DOC and actual change in radius. This ratio can be used to predict the best final finish cut.

The program calculates the number of roughing passes in order to leave at least 5 thou per finish pass but less than one roughing pass plus 5 thou per finish pass. See subroutine "RUN3" for details.

When boring an ID, the boring bar will deflect due to the cutting force. Say you start with the cutter zeroed on the inside bore's surface. The boring bar has no force on it so has no deflection.

When you dial in that first roughing cut, some of the out-feed is taken up by the bending of the boring bar. The rest is the actual change in radius. It is impossible to know how much of this out-feed goes for which phenomenon. But if you take another pass at this same out-feed, less additional bending of the boring bar occurs so more of the out-feed dial change goes into increasing the bore's diameter. After some number of equal DOC passes, the deflection of the boring bar stays constant and all of the change in in-feed is used to increase the bore's diameter.

The program knows how much radius would be ideally removed by the cutter if there was no bending, or spring, in the tool holder. It also knows the actual total change in radius during the roughing phase. From this data is calculates the actual spring. If this spring is more than half of the radius to be removed in the finish pass phase, the user is asked to re-establish touchdown. This will remove all spring. In this way we avoid the case where the spring released during the first finish pass causes us to blow past our goal.

The user may input a finish cut diameter that is unexpected by the program. If the diameter is more than 30% from the expected value, it restarts the finish cut process. A detailed example is given in the appendix.

My experience has taught me that 3 OD finish passes and 4 ID finish passes is enough for my machine. It is totally depends on your experience with the lathe, material being bored, and the boring bar.

The program lets you specify the number of ID and OD finish passes.

For more details on the strategy, see

http://rick.sparber.org/bbt.pdf

Program Index

Set Up

Before starting to use the program, the user must specify a few things:

1. Crossfeed settings (dial reads radius or diameter, the largest number on the in-feed dial or if the user has a Digital Read Out (DRO)
2. the desired roughing DOC,
3. the number of OD finish cuts
4. the number of ID finish cuts
5. automatic compensation feature on/off
6. details displayed on screen on/off
7. Surface Feet per Minute for steel and aluminum

On my lathe, my in-feed dial sets radius; the dial's maximum number is 100, I can handle a of roughing DOC of 50 thou, and I prefer to make 3 OD finish cuts or 4 ID finish cuts in order to establish the fixed error in the lathe. The user must also decide if they want the program to compensate for fixed error between dialed-in DOC and actual changes in radius. A feature was added after the first release to enable the user to turn off all details and just "git 'er done".

Program Notes

The program has been structured to have a main calling program, "LA" which in turn calls "Main", and specialized subroutines.

I tried my best to write what is called "defensive code" which means that I avoided narrow tests. For example, rather than test if A = 1, I test for A<2. In this way any tiny round off error does not cause random failures. All inputs are range checked. Where necessary, values are forced and then offered to the user.

The code is heavily commented in case someone wants to port it to another platform. I think it would be great to see it running on an Android Smartphone or an iPhone/iPod touch.

The calculator is intended to be brought into the shop and used with greasy fingers. A single wrap of thin plastic sheet over the keys protects the device.

The program maintains a log file so you can review what measurements were input during the finish pass phase. Dial values are for radius dial.

Internally, the program uses radius. If the user's lathe dial controls diameter, that is converted at the interface with the user. Roughing DOC, dial size, and dial movement are affected.

In TI Basic, variables are assigned values with the notation: $x \rightarrow A$. " x " can be a constant, another variable, or an equation.

Variables used by program

A	auto comp flag: A=1 is ON, A=0 is off
B	auto comp value: last dial divided by last actual
C	C = 0 means no roughing cuts made; =1 if 1 or more roughing cuts
D	dial size; if >0 means lathe cuts radius; if <0 means lathe cuts diameter. Abs(D) = 1000 means DRO being used
E	If dial used, E is the current dial setting which is the absolute position modulo the dial size. If DRO used, E is the absolute position
F	first roughing cut time duration
G	goal diameter, temporary flag for radius/diameter dial
H	= 1 if 1 or more roughing cuts done; 0 if none done
I	= 1 to turn brevity mode on; any other value turns it off
J	number of ID finish cuts
K	hold either OD or ID finish cut count
L	steel SFM
M	last measured diameter
N	number of OD finish cuts
O	aluminum SFM
P	number of roughing cuts
Q	next finish cut count
R	roughing DOC
S	= -1 means ID, +1 means OD; = 0 means fresh start of program
T	temp local variable
U	Total roughing cuts; next finish DOC
V	previous measured diameter
W	temp local variable
X	= 0 if finish cuts made; 1 if more roughing cuts needed
Y	chosen SFM
Z	roughing cut timer
Ө	data log line number
[A]	Matrix that holds log

The program

LA - top of program

```
ClrHome
DISP "LATHE ASSISTANT"
DISP " V1.7.1 8/1/13 "          version information
DISP ""
DISP "BY R.G. SPARBER"
 FOR(T,1,100)
END
0→S          set a flag to say this is a fresh start of the program
{20,3} → DIM([A])      define log file as matrix A with 1 row for each
                       finish pass and 3 columns:
                       finish pass number | measured dia. | dial setting

Prgm Main
RETURN                 use if program called by central menu
END
```

Main- operational manifold

Lbl A
0→X	initialize flag used to signal cut status
PrgmSUS	Start Up Screen
Prgm SL	initialize log file for finish cuts
Prgm RUN1	get goal diameter
Prgm RUN2	get diameter now
Prgm RUN7	calculate and suggest RPM; do not prompt for material if this is a restart of the program
Prgm NIR	calc dial direction (ID versus OD) and set S to + or - 1
Prgm MFC	select ID or OD finish cut count

Lbl C
Prgm RUN3	make all roughing cuts
IF H<1	H=0 means no roughing cuts done; skip dial and
THEN	new diameter prompts
GO TO B	
END	
Prgm SDIAL	begin finish cuts phase; give user chance to change present dial setting
Prgm RUN2	get new diameter, M, now after all roughing cuts
PrgmSU	if deflection stored in cutter holder more than half of radius to go, re-touchdown cutter to remove spring.

Lbl B
Prgm RUN6	make all finish cuts unless too much radius left because user missed 1 or more roughing cuts
IF X<1	X=0 means finish cuts made
THEN	so have reached goal; do full
Prgm LA	restart of program for new goal.
ELSE	X=1 means one or more rough cuts needed before
GO TO C	finish cuts can start because user decremented rough cut count but forgot to actually make pass.
END	

SL - set up log file

FILL(0,[A])   initialize finish cut log with all zeros

2→Θ   initialize row counter to second line because first
                               line hold goal and dial position before first pass

RETURN

SL - set up log file

SU - spring unload

U-abs((M-V)/.002) $\rightarrow$ T	U is ideal total DOC from roughing; in thou
	V is diameter before roughing phase
	M is diameter after roughing phase
	So T is the deflection stored in the cutter holder
Abs((G-M)/.004) $\rightarrow$ W	W is half of the radius to go
IF T > W	if stored deflection is greater than half of the radius to go, reset cutter to surface to remove spring

THEN
ClrHome
OUTPUT(1,1,"RE-TOUCHDOWN")
OUTPUT(2,1,"CUTTER TO")
OUTPUT(3,1,"SURFACE TO")
OUTPUT(4,1,"REMOVE ALL")
OUTPUT(5,1,"SPRING IN")
OUTPUT(6,1,"TOOL HOLDER.")
OUTPUT(8,1,"PRESS ENTER NOW")
PAUSE
ClrHome

IF abs(D)=1000	if using a DRO, change text

THEN
INPUT "DRO READS?",E
GO TO A
END

INPUT "DIAL IS? ",E	prompt user to enter dial position

LBL A

Abs(E) $\rightarrow$ E	defensive: remove sign

IF D>0	if dial sets radius, just return

THEN
RETURN

ELSE	if dial sets diameter, divide dial reading by 2 so internally it is for a dial setting radius

E/2 $\rightarrow$ E
RETURN
END

Program note: if user missed a roughing pass it will look like excessive spring so a re-touchdown will be performed. But RUN6 will catch the error and ask for more roughing passes.

SUS - Start Up Screen

```
LBL A
    ClrHome
    OUTPUT(1,3,"PRESS ENTER")
    OUTPUT(2,2, "TO RUN PROGRAM")
    OUTPUT (4,1, "1) SET UP")
    OUTPUT (5,1," 2) RESTART")
    OUTPUT(6,1,"3) LOG FILE")
    OUTPUT(7,1, "4) EXIT")
    OUTPUT(8,1,"5)INITIALIZE"          run only once
    WHILE 1
    GetKEY → T
    While T=0
    GetKEY→T
    END
    IF T=105               "ENTER" detected so run program
    THEN
    RETURN
    END
    IF T=92                "1" detected so go to SET UP
    THEN
    PrgmSTU
    GO TO A
    END
    IF T=93                "2" detected so restart program from top
    THEN
    Prgm LA
    END
    IF T=94
    THEN                   "3" detected so display log file
    PrgmLOF
    RETURN
    END
    IF T=82                "4" detected so exit
    THEN
    ClrHome                any other non-control key detected causes EXIT
    PrgmA            exit back to main menu
    END
```

```
IF T=83              initialization selected; define all variables that are not
                     defined by program
THEN
PrgmSIP
GO TO A              then return to main menu
END
END
```

SIP - initialize all variable used by program

If more than the Lathe Assistant program run on the calculator, this will restore all set up parameters to default values. The user can change these values to their preferred defaults.

```
ClrHome
OUTPUT(1,1, " REVIEW VALUES")
OUTPUT(2,1," FROM SETUP")
OUTPUT(3,1," INDIVIDUAL")
PrgmWP
100 → D              dial and since positive, radius dial; negative is diameter dial; a
                     value of 1000 means DRO and can be + or -
50 → R               roughing DOC
3 → N                number of OD finish passes
4→ J                 number of ID finish passes
1→ A                 auto comp on /off flag: 1 = on, 0 = off
1→I                  details on/off flag: 0 = on, 1 = off
80→ L                steel SFM
100 → O              aluminum SFM
RETURN
END
```

LOF - Log File Output

```
ClrHome
OUTPUT(1,1,"LOG FILE LAYOUT"
OUTPUT(3,4,"GOAL ON ROW 1")
OUTPUT(4,1,"COLUMNS")
OUTPUT(5,1,"1 - PASS NUMBER")
OUTPUT(6,1,"2 - DIAMETER INPUT")
OUTPUT(8,1,"PRESS ENTER")
PAUSE
ClrHome
DISP [A]                              dumps log file to screen
OUTPUT(8,1,"PRESS ENTER")
PAUSE
RETURN
```

MFC - Finish Cut Count Selection

```
IF S>0                    if S= +1, it is and OD cut
THEN
N→K                       set K to OD finish cut count
ELSE
J→K                       set K to ID finish cut count
END
```

STU - Set Up Screens

LBL K
ClrHome
MENU("SET UP VALUES", "ALL", H, "INDIVIDUAL", I, "EXIT", J)

LBL H

PrgmSDI1	set crossfeed parameter
PrgmSRD	set roughing DOC
PrgmSON	set number of finishing OD passes
PrgmSIN	set number of finishing ID passes
PrgmSAC	set auto compensation on/off
PrgmSDE	set details on/off
Prgm SFM1	set SFM
GO TO K	

LBL J
RETURN   return to SUS

LBL I
 ClrHome

 MENU ("SET UP VALUES"," CROSSFEED ", A, "ROUGHING DOC", B,
 "OD FINISH CUTS", C, "ID FINISH CUTS", D, "AUTO COMP", E,
 "DETAILS", F, "SFM", G)
LBL A
 PrgmSDI1   set ~~dial~~ crossfeed parameter
 GO TO K
LBL B
 PrgmSRD   set roughing DOC
 GO TO K
LBL C
 PrgmSON   set number of finishing OD passes
 GO TO K
LBL D
 PrgmSIN   set number of finishing ID passes
 GO TO K
LBL E
 PrgmSAC   set auto compensation on/off
 GO TO K
LBL F
 PrgmSDE   set details on/off
 GO TO K
LBL G
 Prgm SFM1   set SFM
 GO TO K
END

RD - radius/diameter parameter

Note: this must run before dial size, D, set by user; I use temporary flag since D may not be defined yet

ClrHome
IF D>0
THEN
MENU("SET RADIUS ","KEEP",A,"MAKE DIA.",B)
END
MENU("SET DIAMETER",KEEP",B,"MAKE RADIUS",A)
LBL A
1→G   temporary flag to indicate dial set radius
RETURN
LBL B
-1→G   temporary flag to indicate dial set diameter
RETURN

SDI1 - set all parameters related to crossfeed

Labels used: A, B, C, D,E, F

LBL A   radius/diameter flag

IF D=0   defensive check for D = 0; force to radius dial of size 100
THEN
100→D
END

IF D>0   if readout is radius
THEN
Menu("RADIUS SET","KEEP",B, "MAKE DIA.",C)
ELSE   readout is diameter
Menu("DIAMETER SET","KEEP",B,"MAKE RADIUS",C)
END
LBL C
-D → D   invert sign of D to change between radius and diameter.
GO TO A   give chance to review change

LBL B   drop/dial flag

IF abs(D) = 1000   if crossfeed set by DRO
THEN
Menu ("HAVE DRO", "KEEP", D, "MAKE IT DIAL",E)
ELSE
Menu("HAVE DIAL", "KEEP", D, "MAKE IT DRO",F)
END

LBL E
(Abs(D)/D)*100 → D   make D = something other than +/- 1000 to say it
                                     is a dial; transfer sign from previous value
GO TO B   give chance to review change
LBL F
(Abs(D)/D)*1000 → D   take sign of previous value of D and put it on 1000 to
                                     indicate it is a DRO. The sign indicates diameter if
                                     negative vs radius if positive
GO TO B   give change to review change

LBL D

IF abs(D) = 1000   if crossfeed set by DRO
THEN
RETURN
ELSE   else, get size of dial
3 → T   set units to blank
"DIAL SIZE" → Str1   load title for WP1 subroutine
PrgmWP1   subroutine will return with new dial size in W
abs(W) → W   defend against negative dial size since sign is a flag for
                  dia/radius
(abs(D)/D)*W → D   take sign from previous value of D and put on new dial
                  Size

RETURN
END

WP1 - prompt with titles(also used by ball program)

```
IF T=1                          T indicates inches, thou, or blank after value
THEN
"INCHES."→Str2
END

IF T=2
THEN
"THOU."→Str2
END

IF T=3
THEN
""→Str2
END

LBL C
ClrHome
1 + iPart((16-length(Str1))/2)→Q     center title held in string 1
OUTPUT(1,Q,Str1)
DISP ""
DISP "PRESENT VALUE IS"
OUTPUT(3,1,W)                         value is passed to subroutine in W
OUTPUT(3,7,Str2)
DISP ""                               blank DISP commands move line pointer
                                      Along because OUTPUT does not do it

DISP ""
DISP "1)KEEP  2)CHANGE"
WHILE 1
GETKEY → Q                            scan for 1 or 2 being pressed. Ignore all else
WHILE Q=0
GETKEY→Q
END

IF Q=92
THEN
```

```
RETURN
END

IF Q=93
THEN
GO TO B
END

END
LBL B
DISP ""
DISP "NEW VALUE="
INPUT W
GO TO C          after getting new value, restart dialog
END
```

SRD - Set Roughing DOC

```
LBL A              Roughing DOC
    IF R<10            defensive check: if roughing DOC less than 10, force it to
                       10
    THEN
    10→R
    END

    IF D>0             if dial sets radius, set temp variable to D
    THEN
    R → T
    GO TO Q
    ELSE
    2*R → T            convert radius roughing DOC to diameter roughing DOC
    END

LBL Q
    ClrHome
    OUTPUT (2,1," ROUGHING  DOC ")
    OUTPUT(3,1,"PRESENT VALUE IS")
    OUTPUT (4,1,T)
    OUTPUT (6,1, "1) KEEP")
    OUTPUT (7,1," 2) CHANGE")
    OUTPUT(8,1,"3) EXIT SET UP")

    WHILE 1
    GetKEY → T
    While T=0
    GetKEY→T
    END
    IF T=92
    THEN
    RETURN             return to STU
    END
```

```
        IF T=93
        THEN
LBL C
        ClrHome
        INPUT " ROUGHING  DOC =",R
        Abs(R) → R                    defensive move: force R to be positive
                IF D>0                if dial sets radius, move on to range check
                THEN
                GO TO B
                ELSE                  else this is a diameter dial so
                R/2 → R               convert diameter roughing DOC to radius
                                      roughing  DOC and store
                GO TO B
                END
        END

        PrgmMAIN        any other key returns us to MAIN

LBL B
        IF R<10
        THEN
        ClrHome
        OUTPUT(1,1," ROUGHING  DOC ")
        OUTPUT(2,1,"TOO SMALL")
        Prgm WP
        END
        GO TO A         give user another look at present value
        END
```

SON - Set OD Finish Cuts

```
LBL A                   Number of OD Finish Cuts
      IF N<1            if # of  OD finish cuts less than 1, force it to 1
      THEN
      1→N
      END

      ClrHome
      OUTPUT (3,1," NUMBER OF OD")
      OUTPUT(4,1, "FINISH CUTS IS ")
      OUTPUT (4,16,N)
      OUTPUT (6,1, "1) KEEP")
      OUTPUT (7,1," 2) CHANGE")
      OUTPUT (8,1," 3) EXIT SET UP")
      WHILE 1
      GetKEY → T
      While T=0
      GetKEY→T
      END

      IF T=92            keep number of OD finish cuts; move on to ID
      THEN
      RETURN      return to STU
      END
```

```
        IF T=93
        THEN
        ClrHome
        INPUT " OD FINISH CUTS =",N      get new OD count


        Abs(N) → N                        defensive move: force N to be
        positive


                IF N<1
                THEN
                ClrHome
                OUTPUT(1,1,"OD FINISH CUT ")
                OUTPUT(2,1," COUNT TOO SMALL")
                Prgm WP
                END
GO TO A                          let user see new value and decide if OK
END


PrgmMAIN        any other key returns us to MAIN
END
```

SIN - Set ID Finish Cuts

```
LBL K                    Number of ID Finish Cuts
    IF J<1               if # of ID finish cuts less than 1, force it to 1
    THEN
    1→J
    END

    ClrHome
    OUTPUT (3,1," NUMBER OF ID")
    OUTPUT(4,1, "FINISH CUTS IS ")
    OUTPUT (4,16,J)
    OUTPUT (6,1, "1) KEEP")
    OUTPUT (7,1," 2) CHANGE")
    OUTPUT (8,1," 3) EXIT SET UP")
    WHILE 1
    GetKEY → T
    While T=0
    GetKEY→T
    END

    IF T=92              keep ID count; move on to auto comp state
    THEN
    RETURN               return to STU
    END
```

```
IF T=93
THEN
ClrHome                              for any other key value, take as change
INPUT " ID FINISH CUTS =",J
Abs(J) → J                           defensive move: force J to be positive

        IF J<1
        THEN
        ClrHome
        OUTPUT(1,1,"ID FINISH CUT ")
        OUTPUT(2,1," COUNT TOO SMALL")
        Prgm WP

        END
GO TO K         give user chance to see new value and decide if OK
END

PrgmMAIN        any other key pressed sends user back to MAIN
END
```

SAC - Set Auto Compensation

```
LBL C              Auto Compensation On/Off
     ClrHome
     IF A>0
     THEN
     MENU("AUTO COMP IS ON","KEEP",F,"TURN OFF",E,"EXIT SET
UP",N)
     ELSE
     MENU("AUTO COMP IS OFF","KEEP",F,"TURN ON",G,"EXIT SET
UP",N)
     END
LBL G
     1→A        turn AUTO COMP on
     GO TO C         give user another look at set value
LBL E
     0 → A      turn AUTOCOMP off
     GO TO C         give user another look at set value
LBL F
     RETURN     return to STU
LBL N
     PrgmMAIN        return to STU
     END
```

SDE - Set Details On/Off

```
LBL F              Details On/Off
      ClrHome
      IF I=1        if I=1 it means brevity has been turned on
      THEN
      MENU("DETAIL OFF","KEEP",J,"TURN ON",I,"EXIT SET UP",N)
      ELSE
      MENU("DETAILS ON","KEEP",J,'"TURN OFF",H,"EXIT SET UP",N)
      END
LBL H
      1→I           this turns brevity on
      GO TO F          give user another look at set value
LBL I
      0→I           this turns brevity off
      GO TO F          give user another look at set value
LBL N
      PrgmMAIN
      END
LBL J
      RETURN
      END
```

SFM - Set SFM

```
LBL J                      SFM Values
     ClrHome
     OUTPUT(1,1,"SURFACE FEET")     display SFM for steel and AL first
     OUTPUT(2,1,"PER MINUTE")
     OUTPUT(4,1,"STEEL SFM= ")
     OUTPUT(4,12,L)
     OUTPUT(5,1,"AL SFM = ")
     OUTPUT(5,11,O)
     OUTPUT(7,1,"PRESS 1 NOW")      actually, any key will do
     WHILE 1
     GetKEY → T
     While T=0
     GetKEY→T
     END
     ClrHome                        give user ability to change SFM
     MENU("SFM"," KEEP ALL", N, CHANGE STEEL",L,"CHANGE
ALUM",M)
LBL L
     INPUT "STEEL SFM= ",L
     Abs(L) →L              defensive: remove sign

     GO TO J                        if steel changed, give ability to change both
LBL M
     INPUT "AL SFM= ",O
     Abs(O) →O             defensive: remove sign

GO TO J                            if AL changed, give ability to change both
LBL N
     RETURN                when nothing changed, we are done with setup
     END
```

SFM1 - replacement subroutine

3→T   no units on variable
"STEEL SFM"→Str1   title
L → W   load current value of steel SFM into temp variable
PrgmWP1   prompt, record, and confirm variable
Abs(W) → L   defensively remove sign; store value back in original place

"ALUMINUM SFM"→Str1   title
O → W   load current value of aluminum SFM into temp variable
PrgmWP1   prompt, record, and confirm variable
Abs(O) → Ldefensively remove sign; store value back in original place
RETURN
END

Run1 - Prompt for goal diameter

```
ClrHome
OUTPUT (8,1,"0 TO RE-START")
DISP "WHAT IS GOAL"
INPUT "DIAMETER?", G
Abs(G) → G        defense against negative input
IF G= 0           if user inputs 0 or a negative number,
                  restart program

THEN
Prgm MAIN
END
RETURN
```

Run2 - Prompt for current diameter

```
ClrHome
OUTPUT (8,1,"0 TO RE-START")
DISP "WHAT IS"
DISP "DIAMETER"
INPUT "NOW?", M
Abs(M) →M         defenses against negative value
IF M= 0           if user inputs 0 restart program

THEN
Prgm MAIN
END
RETURN
```

NIR - determines ID or OD and sets + or - 1

M -G $\rightarrow$ T

IF T=0   if goal and current diameters equal, complain about it
THEN
ClrHome
OUTPUT(1,1, "NOTHING TO DO")
OUTPUT(3,1,"PRESS ENTER NOW")
PAUSE
Prgm MAIN
END

Abs(T)/T $\rightarrow$ S   extract sign of M -G: if - this is an ID cut, + is OD
RETURN

Run3 - roughing cuts

Labels used: A, B,C, D, E, F, G, H, I, J, R, Z

LBL C

ClrHome

IF X>0   if more roughing cuts needed after Finish cut phase started, skip first prompt for DIAL NOW AT?

THEN
GO TO D
END

IF abs(D)=1000   if using DRO, change prompt text
THEN
INPUT "DRO NOW AT?", E   since DRO, this is absolute position

GO TO I
END

                           otherwise,
Input "DIAL NOW AT?",E   get current dial setting

LBL I

Abs(E) →E   defensive: remove sign

IF D>0   if dial sets radius, no change
THEN
GO TO H
ELSE
E/2 → E   dial sets diameter so change to radius
END

LBL H

M → V   save starting diameter in V

LBL D

iPart ((abs(G-M)/.002-(5*K))/R) →P   calc # of roughing cuts; will leave at least K finish cuts of 5 thou each and no more than K finish cuts of 5 thou each plus a roughing cut. For

		K=3 and R=50, min is 15 thou and max is 65 thou

	IF P<1	if less than 1 roughing cut,
	THEN	
	0→H	set flag to say no roughing cuts done
	RETURN	don't do any roughing cuts
	END	
	P*R → U	total ideal DOC from roughing phase stored as U
	1→H	set flag to say 1 or more roughing cuts done
	0→C	set flag: no roughing cuts made yet

LBL A

	IF D>0	if this is a radius setting dial, continue
	THEN	
	R → T	
	GO TO R	
	ELSE	
	2*R → T	user expects diameter dial value so double
	END	

LBL R

	ClrHome	
	IF I=1	if I=1 it means brevity has been turned on
	THEN	
	GO TO E	
	ELSE	
	OUTPUT(1,1 "MAKE ROUGHING ")	
	OUTPUT(2,1, " PASS OF ")	
	OUTPUT(2,9,T)	R is user specified rough DOC
	END	

LBL E

	E+(S*R) →T	take present absolute or modulo position plus DOC to find new absolute or modulo position for either ID or OD (S handles ID/OD sign)

```
            IF ABS(D)=1000   if using a DRO, just display absolute position
            THEN             after modifying for radius/diameter
            GO TO K
            END


LBL B                        condition dial position to be between 0 and
                             max dial value
            IF T<0           if dial position negative, add dial size
            THEN             must strip off sign of variable D
            T+ Abs(D) → T
       GO TO B               and test dial position again
            END


            IF T> OR = Abs(D)   if dial position > or = dial size
            THEN
            T- Abs(D)  → T        subtract dial size
       GO TO B               and test dial position again
            END


LBL K
            T→E              when dial position in range, save to dial
                             position register E; for DRO just save it

            IF D>0           if dial sets radius, no change
            THEN
            E → T            prepare dial value for output
            GO TO G
            ELSE             if dial sets diameter, convert to diameter
            2*E → T          but only to display
            END
LBL G

            IF ABS(D)=1000   if using a DRO, just display absolute position
            THEN
            OUTPUT(3,1, "SET DRO TO")
            OUTPUT(3,12,T)
            GO TO J
            END

            OUTPUT(3,1, "SET DIAL TO ")
            OUTPUT(3,13,T)
```

```
LBL J
IF P<2
THEN
        IF I=1                  if brevity is on, skip display of text
        THEN
        GO TO Z
        END
OUTPUT(5,1,"THIS IS LAST")              last roughing pass
OUTPUT(6,1,"ROUGHING PASS.")
LBL Z
ELSE
OUTPUT(5,1,P)                          P>1  is current roughing cut
                                       count
OUTPUT(5,3,"PASSES TO GO.")
END

OUTPUT(7,3, " PRESS ENTER")
OUTPUT(8,1,"AFTER PASS DONE."
1→Z             initialize roughing cut timer
WHILE 1
GetKEY → T
While T=0
GetKey→T
Z+1→Z           advance the rough cut timer
END

IF T=95         this is undo for the rough cut pass count: "+"
                detected
THEN
P+1→P           so add 1 to rough cut count
ELSE
P-1→P           press any other key non-control key to decrement
                rough cut count; user told to press "ENTER"
END

IF C<1          if this is the first roughing cut,
THEN
Z→F             save first roughing cut Time, Z, in F
1→C             at least one roughing cut now made so set flag
ELSE
```

Z-(1.5*F) → W   this is not the first roughing cut so

        IF W>0   I am assuming that if subsequent roughing
                             cuts are more than 50% longer in time than
                                 the first one, a decrement might have
                             been missed

       THEN
       ClrHome
           IF I=1   if I=1 it means brevity has been turned on
           THEN
           GO TO F
           ELSE
           OUTPUT(1,1,"POSSIBLE MISSED")
           OUTPUT(2.1, "DECREMENT.")
           OUTPUT(4,1,"PRESS ENTER NOW.")
           PAUSE
           END
           LBL F
       RETURN   if it is suspected that a decrement was
                              missed, return to MAIN where finish cut
                              logic will figure out more roughing cuts are
                              needed
      END

    END   if all subsequent roughing cuts are less
                     than 50% longer than first roughing cut, continue
    IF P<1   if done with roughing cuts, return
    THEN
    RETURN
    END

GO TO A   otherwise, proceed to make next roughing cut

Run5 - one finish cut (is called by Run6)

Labels used: D, B, R, C, A,E

LBL D

Q→[A](Ɵ,1)   finish pass number to log file, column 1. Starts out with the value of K which is number of ID or OD passes and decrements by 1 each pass unless there is a restart of the finish pass process. Then Q is reset to finish pass number.

abs((G-M)/(.002*Q))→T   calculate next finish DOC using goal (G), current diameter (M) and number of passes left to do (Q). This is based on a radius dial.

Alternate finish DOC:

IF T<5   If next DOC is less than

THEN   5 thou, spread across fewer passes.

abs((G-M)/(.002*5))→W   Calculate number of passes that give DOC of 5.

iPART(W) → W   Then round down to next smaller integer. DOC will then be greater than or equal to 5 thou for this number of passes.

     IF W=0   If rounded down number of passes is 0, force to 1

     THEN
     1→W
     END

abs((G-M)/(.002*W))→T   using alternate number of passes left to do, W, calculate next DOC

END

     IF Q<K AND A=1   if after first finish cut and auto comp enabled, then use DOC Compensation Factor (DCF); must take at least one finish cut to insure that at least one sequence of

measure/cut/measure has been done. If no roughing cuts were done, I could not calculate a valid DCF.

THEN

 T*B→W   DOC times DOC Correction Factor gives better estimate of DOC set on dial

 Round(W,1)→U   U is next finish DOC , round to nearest tenth

 IF I=1   if I=1 it means brevity has been turned on

 THEN

 GO TO B

 ELSE

  ClrHome

  OUTPUT(1,1, "DOC CORRECTION")

  OUTPUT(2,1, "FACTOR OF")

  OUTPUT(2,11, B)

  OUTPUT(3,1," WAS APPLIED.")

  OUTPUT(5,1,"PRESS ENTER NOW")

  PAUSE

 END

LBL B

 ELSE

 Round(T,1)→U   round to nearest tenth and save as Next finish DOC

 END

 ClrHome

 IF I=1   If brevity turned on, skip text and give dial setting

 THEN

 GO TO C

 END

 IF Q>1   if brevity turned off and if not at final finish cut

 THEN

 OUTPUT(1,1, "MAKE FINISH CUT ")

```
        ELSE                          if at final finish cut, say so
        OUTPUT(1,1,MAKE FINAL CUT")
        END

        OUTPUT(2,1, "WITH A DEPTH ")
        OUTPUT(3,1, "OF ")
        IF D> 0
        THEN
        U → T        user has radius dial so no change in dial change value
        GO TO R
        ELSE
        2*U → T      user has diameter dial so double dial change value
        END
LBL R
        OUTPUT(3,4 , T)
LBL C
        Abs(D)→ W                use only magnitude of dial size for
                                 dial
                                 position calculations
        E+(S*U) →T               take present absolute position plus DOC
                                 To find new absolute position for radius.

        IF abs(D)=1000    if using a DRO, skip modulo dial calc
        THEN
        GO TO E           and add radius/diameter multiplier
        END
```

```
LBL A                          if dial, convert new radius position to modulo dial
                               value
          IF T<0
          THEN
          T+W → T
          GO TO A
          END

          IF T> OR = W
          THEN
          T-W →T
          GO TO A
          END
LBL E

          T→E
          IF D<0                    if this is a diameter dial,
          THEN
          2*T → T                   double the radius value
          END                       if radius dial, do no change
          T → [A]( Ө,3)             new dial position to log file
          Ө + 1 → Ө                 log row complete so advance to next row

          IF abs(D) = 1000   if using a DRO, use different text and return
          THEN
          OUTPUT(4,1,"SET DRO TO")
          OUTPUT(4,12,T)
          OUTPUT(7,1,"PRESS ENTER")
          OUTPUT(8,1," AFTER PASS.")
          PAUSE
          RETURN
          END

          OUTPUT(4,1,"SET DIAL TO ")        if using dial, use this text
          OUTPUT(4,13,T)
          OUTPUT(7,1,"PRESS ENTER")
          OUTPUT(8,1," AFTER PASS.")
          PAUSE
          RETURN
```

RUN6 - finish cuts

Labels used: F, B, C, D, A, E, G

$0 \rightarrow [A](1,1)$	top row's finish pass number set to 0 because this row is before first pass and contains goal diameter and initial dial position
$G \rightarrow [A](1,2)$	top row's diameter is the goal diameter
$E \rightarrow [A](1,3)$	top row's dial is position before first pass starts

LBL F

$K \rightarrow Q$	initialize finish cut count

Lbl B

$M \rightarrow [A](\Theta, 2)$	Put last diameter input in column 2.
$S*(M-G)*500 \rightarrow T$	calc radius to go in thou; figures in ID or OD so <0 is a miss

IF T=0   If remaining radius = 0, we have reached
the goal so DONE

THEN
 GO TO A
END

IF T<0   if remaining radius < 0, we have missed the goal so give
warning.

THEN
GO TO E
END

$R+(5*K) \rightarrow W$ otherwise, take more roughing or start finish cuts; max
diameter to go with finish cuts is one roughing cut plus 5
thou times the number of finish cuts (ex: 50 + 5*3 = 65
thou)

IF T>W   if remaining radius > expected max, it
may be because user missed 1 or more roughing cuts

```
          THEN               Then make 1 or more roughing cuts rather than starting
                             finish cuts
          1→X                set flag to say more rough cuts needed and return to Main
          RETURN
          ELSE               otherwise
          0→X                set flag to say no more rough cuts needed
          M→V                    save newest diameter, M,  as last diameter, V
          Prgm RUN5          make a finish cut



          IF Q<2             if Q is 1, we are done with finish cuts
          THEN
          GO TO G
          END

    Lbl C
          Prgm RUN2          get new diameter, M,   after a finish cuts
                IF V-M = 0        avoid divide by zero error
                THEN
                GOTO D
                END

          Abs((U*.002)/(V-M))→B        use last DOC, U, current diameter and last
                                       measured diameter to calculate Doc Correction
                                       Factor (DCF), B . Multiply by next needed change
                                       in radius to get better dial setting if function
                                       enabled via variable A. Use on all but first  finish
                                       cut and auto correct enabled
          1/B → T
          IF (T<.7 OR T>1.3)           if 1/DCF is more than 30% from ideal,
                                            restart finish pass sequence
          THEN
                IF I=0       if brevity turned off, output the following
                THEN
                ClrHome
                DISP " MEASUREMENT"
                DISP " FAR FROM"
                DISP " EXPECTED."
                DISP " RESTART"
                DISP " FINISH PASSES."
```

```
                DISP"PRESS ENTER NOW"
                PAUSE
                END
        GO TO F
        END
        Q-1→Q                   decrement finish cut count
GO TO B                         take next finish cut
Lbl D
        ClrHome
        DISP "NO CHANGE IN"
        DISP "DIAMETER"
        DISP "RECORDED,"
        DISP "MEASURE AGAIN."
        DISP" "
        Prgm WP
        GO TO C
Lbl A
        ClrHome
        DISP "WOW,"
        DISP "NAILED GOAL."
        Prgm WP
        RETURN


LBL E
        ClrHome
        DISP "MISSED GOAL BY "
        OUTPUT(2,3, -T)
OUTPUT(3,3,"THOU")
        Prgm WP
        RETURN


LBL G
        ClrHome
        DISP "DONE. "
        Prgm WP
        RETURN
```

Run7 - SFM calculation

```
        IF L<0 OR O<0           defensive check for negative SFM
        THEN
        ClrHome
        DISP "SFM NOT SET "
        DISP " UP RIGHT."
        PrgmWP                  user presses ENTER and calculations skipped.
        RETURN
        END
        IF S does not equal 0   if this is the first pass through program, S=0 so
                                prompt for material being machined. Otherwise,
                                just calc RPM
        THEN
        GO TO D
        END
        ClrHome
        MENU( "MATERIAL TO TURN","STEEL", A,
        "ALUMINUM",B,"OTHER",C)
LBL A
        L→Y
        GO TO D


LBLB B
        O→Y
        GO TO D


LBL C
        INPUT"SFM =?",Y             if not turning steel or AL, user specifies
                                    SFM
        Abs(Y) →Y                   defensive: remove sign
```

LBL D

    0.1*Y/(.2618* ((G+M) /2)) → T   calculate RPM based on average of goal and starting diameters; round to nearest 10

    10*ROUND(T,0) →T
    ClrHome
    OUTPUT(1,1,"SET RPM")
    OUTPUT(2,1,"NEAR ")
    OUTPUT(2,6,T)
    Prgm WP
    RETURN

SDIAL - Dial position prompt before finish cuts

```
        IF I=1                 if brevity is on, skip messages and return
        THEN
        GO TO A
        END

        IF D>0                 if lathe has radius setting dial, prep for output
        THEN
        E → T                  if DRO, E is absolute radius position; if dial, E is
                               modulo dial size

        GO TO B
        ELSE
        2*E → T                lathe has diameter setting dial or DRO so double
                               Internal value which is for radius

        END

LBL B
    ClrHome
    OUTPUT(1,2,"FINISH PASSES")
    OUTPUT(2,4 "NEXT")

    IF abs(D) = 1000           if using a DRO, use different text
    THEN
    OUTPUT (4,1," IS DRO AT")  space before "I" so there is only one space
                               between text and T value
    GO TO C
    END

    OUTPUT (4,1," IS DIAL AT ")
LBL C
    OUTPUT (4,12,T)
    OUTPUT (6,1, "PRESS ENTER")
    OUTPUT(7,1,"FOR YES")
    OUTPUT (8,8," 1 FOR NO")
    WHILE 1
    GetKEY → T
    While T=0
    GetKEY→T
```

```
        END
        IF T=105
        THEN                                yes, dial or DRO correct
        GO TO A
        ELSE                                any non-control key pressed = no
        ClrHome               so get new value for dial or DRO


        IF abs(D) = 1000      have DRO
        THEN
        DISP "DRO IS AT?" ,E
        GO TO D
        ELSE
        INPUT " DIAL IS AT? ",E
        END


        LBL D
        Abs(E) →E             defensive: remove sign


        IF D>0                if lathe has radius setting dial, just save in log
        THEN
        GO TO A
        ELSE
        E/2 → E               lathe has diameter setting dial so halve current dial
                              setting on diameter dial so it matches internal
                              radius dial

        END

LBL A
        E→[A](1,3)            initial dial setting at start of finish cut phase stored
                              in log file at (1,3)

        RETURN
```

WP - Display utility

```
OUTPUT(8,1,"PRESS ENTER NOW")
PAUSE
RETURN
```

Regression Testing Cases

These test cases were used to verify the program was working correctly after each change. If you decide to recode the program in another language, these test cases will be useful.

The key parameter for this program is the difference between goal diameter and present diameter. When this difference is zero, the program will tell the user there is nothing to do. If either the starting diameter or current diameter is zero, the program will restart.

When the starting diameter is larger than the goal diameter, the program understands that this is an OD being turned and will take as many roughing passes as possible while leaving at least enough material to make the number of finished passes specified by the user and still have at least 5 thou per pass. Similarly, when the starting diameter is smaller than the goal diameter, the program understands that this is an ID being turned.

Each test case exercises a different logical path in the program. Run INITIALIZE to set: DIAL (not DRO), DIAL SETS RADIUS, DIAL SIZE = 100, ROUGHING DOC IS 50; NUMBER OF OD FINISH CUTS IS 3; NUMBER OF ID FINISH CUTS IS 4, AUTO COMP IS ON except as noted. Details are OFF. Steel surface feet per minute is 80 and aluminum is 100. Given 3 finish cuts and my personal choice of a minimum DOC of 5 thou per finish pass, the minimum change in diameter during the finish cut phase is 3*5 = 15 thou.

    A. CROSSFEED SET UP - select SET UP from home menu. Select INDIVIDUAL.
1. Select CROSSFEED
2. If necessary, change to radius
3. If necessary, change to dial
4. Change dial size to 101
5. Select INDIVIDUAL again
6. Select CROSSFEED
7. Change to "MAKE DIA."
8. Change to "MAKE IT DRO"
9. Select INDIVIDUAL again
10. Select CROSSFEED again
11. Change to radius
12. Change to dial

13. Verify dial size is 101 and then change dial size to 100
14. Select EXIT

B. Difference between goal and initial diameters is zero or one value is zero.
  1. goal diameter of 0 should restart the program.
  2. goal diameter of 1, diameter now set to 0 should restart the program.
  3. goal diameter of 1, diameter now of 1, "NOTHING TO DO"; then the program restarts.

C. Difference between goal and initial diameters is minimum finish depth of 15 thou. Start from program LA.
  1. **goal diameter of 1, diameter now of .96** (so ID), select steel; RPM = 310; dial 0, dial is set to 95; the resulting diameter is .97, dial is set to 90; diameter now .98; dial is 85; diameter now .99; dial set to 80; DONE. **Data log test:** Select "LAST USE DATA" from menu and should see a matrix with 0,4,3,2,1 in column 1 and 1, .96, .97, .98, .99 in column 2. In column 3 you should see 0, 95, 90, 85, 80.
  2. **goal diameter of 1, diameter now of 1.03** (so OD), select steel; RPM = 300; dial 0, dial is set to 5; the resulting diameter is 1.02, dial is set to 10; diameter now 1.01; dial set to 15 , DONE.

  3. Diameter Dial: Go to SET UP and change from RADIUS DIAL to DIA DIAL. Dial size should now be 200, roughing DOC should be 100, exit set up. **goal diameter of 1, diameter now of 1.03** (so OD), select steel; RPM = 300; dial 0, dial is set to 10; the resulting diameter is 1.02, dial is set to 20; diameter now 1.01; dial set to 30 , DONE. Select LOG FILE from menu. In column 1 you should see 0, 3, 2, 1. In column 1 you should see 1.03, 1.02, 1.01. In column 3 you should see 0, 10, 20, 30. Go back to SET UP and change DIAMETER DIA to RADIUS. Dial Size should be 100, roughing DOC should be 50. Exit set up.

D. Difference between goal and initial diameters is (maximum finish depth of roughing DOC + 3*5 -1 thou = 50+15 -1=) 64 thou for OD and 50+20-1=69 for ID. Go to Set Up and turn off auto comp (DCF) and details.
  1. **goal diameter of 1, diameter now of .862** (so ID), select steel, RPM 330; dial 0; dial is set to 82.7; the resulting diameter is .8966, dial is set to 65.5; diameter now .931; dial is 48.2; diameter now .9656; dial set to 31.0, DONE.

2. **goal diameter of 1, diameter now of 1.128** (so OD), select steel, RPM 290; dial 2; dial is set to 23.3; the resulting diameter is 1.0854; dial is set to 44.7; diameter now 1.0426; dial set to 66 , DONE.

E. Difference between goal and initial diameters is (minimum that will give one roughing cut and minimum finish cuts: finish of roughing DOC + 3*5 thou = 50+15 =) 65 thou. Start from program LA. ***Go to Set Up and set number of finish cuts for ID to 3 plus turn off auto comp (DCF) and details.***
   1. **goal diameter of 1, diameter now of .87**, select steel; RPM 330; dial 0, dial set to 50; resulting diameter is .97; dial is set to 45; the resulting diameter is .98; dial is set to 40; diameter now .99, final finish pass has dial set to 35; DONE.
   2. **goal diameter of 1, diameter now of 1.13**, select steel; RPM = 290; dial 0; dial at 50; resulting diameter is 1.03; first finish pass has dial set to 55; the resulting diameter is 1.02; dial set to 60; diameter now 1.01, final finish pass has dial set to 65 , DONE.

F. Difference between goal and initial diameters that will give three roughing cut and maximum finish cut depths is (3*50 + (49 + 15) = 150+64 =) 214 thou. ***Go to Set Up and set number of ID finish cuts to 3 plus turn off auto comp and details.***
   1. **goal diameter of 1, diameter now of .574**, select aluminum; RPM = 490; dial 0; dial at 50; dial at 0; dial at 50; resulting diameter is .874; dial at 29, resulting diameter is .916; dial is 8; resulting in a diameter of .958; dial at 87. Done
   2. Repeat last test but with **DRO** rather than dial. Go to SET UP, INDIVIDUAL, CROSSFEED, keep RADIUS, change to MAKE IT DRO, EXIT.
      i. **goal diameter of 1, diameter now of .574**, select aluminum; RPM = 490; DRO NOW AT? 1; SET DRO TO -49 SET DRO TO -99; SET DRO TO -149; resulting diameter is .874 SET DRO TO -170, resulting diameter is .916; SET DRO TO -191; resulting in a diameter of .958; SET DRO TO -212. Done.
      ii. Go back to SET UP, INDIVIDUAL, DETAILS and turn them on. Verify no text is unreadable or extra characters present while performing the following: **goal diameter of 1, diameter now of .574**, select aluminum; RPM = 490; DRO NOW AT? 1; SET DRO TO -49 SET DRO TO -99; SET DRO TO -149; resulting diameter is .874 SET DRO TO -170, resulting diameter is .916; SET DRO TO -191; resulting in a diameter of

.958; SET DRO TO -212. Done. Go back to SET UP, INDIVIDUAL, DETAILS and turn them off. Go back to SET UP, INDIVIDUAL, CROSSFEED and change from DRO to DIAL Change dial size to 100. EXIT.

3. **goal diameter of 1, diameter now of 1.428**, select steel; RPM = 250; dial 0; dial at 50; dial at 0; dial at 50; resulting diameter is 1.128; dial at 71.3, resulting diameter is 1.0854; dial at 92.7 resulting in a diameter of 1.0427; dial at 14.1. Done

G. SET UP tests
1. Verify Auto Comp State Operationally: Go to SET UP and set number of finish cuts for ID and OD to 3 plus turn off auto comp and details: **goal diameter of 1, diameter now of .872**, select steel; RPM= 330; dial 0; dial set to 78.7; diameter is .913; dial is set to 56.9; diameter now 0. Go to SET UP and turn auto comp on. Start new cycle with **goal diameter of 1, diameter now of .872**; select steel; RPM= 330; dial 0; dial set to 78.7; the resulting diameter is .913; dial is set to 56.1; diameter now 0.
2. Verify Details can be turned on and off via operations : Verify values and state are RADIUS DIAL, 100, 50, 3, 3, ON, OFF. Restart program. Go to SET UP and turn on DETAILS: **goal diameter of 1, diameter now of .872**, Ignore RPM; dial 0. You should see "MAKE FINISH CUT WITH A DEPTH OF 21.3 plus SET DIAL TO 78.7". Press ENTER and then input a diameter of 0 to return to home screen. Go back to set up and turn DETAILS OFF.
H. Roughing Cut Count Monitor. Turn DETAILS ON.
1. Missed recording of a pass: (3*50 + (49 + 15) = 150+64 =) 214 thou; **goal diameter of 1, diameter now of .574**; ignore RPM; read over test before starting.
    i. dial 0; press ENTER
    ii. wait 5 +/- 1 seconds and then press ENTER.
    iii. wait 11 +/- 1 seconds and then press ENTER; program should say POSSIBLE MISSED DECREMENT, jump to finish passes, and prompt for diameter. Enter 0 to exit test.
    iv. Input .774 and dial is at 0. Program says to make one last roughing cut by setting dial to 50. Diameter should then be .874. First finish cut is 21 so dial is 29. Input diameter of 0 to restart program.

2. Extra recording of a pass that was not taken: (3*50 + (49 + 15) = 150+64 =) 214 thou; verify ID finish passes = 3; **goal diameter of 1, diameter now of .574**, dial 0, 50,0,50 diameter.774; it then asks for one more roughing pass and prompts for dial position verification. Should be 50. It then asks for diameter. Input 0 to restart program. (Note: this case requires the operator to somehow miss a pass yet turn the dial the correct amount. Doesn't seem possible.)

I. Possible error in a finish cut measurement like transposed digits that make input data more than 30% more or less than expected **(setup: radius dial, 100, 50, 3, 4, auto comp is on, details are off)**: **goal diameter of 1, diameter now of .96** (so ID), select steel; RPM = 310; dial 0, dial is set to 95; the resulting diameter is 31% low at .9669; dial is set to 89.5; the resulting diameter is 31% high at .9813, set dial to 80.1 (DOC is 9.4 because at restart, it can't get a DOC of 5 until it goes down to a single pass). Diameter is 0 to restart.

J. Out of expected range of measured diameter received: **(setup: radius dial, 100, 50, 3, 4, auto comp is on, details are off)**: **goal 1, diameter now of 1.1** (so OD). Dial starts at 3. Dial set to 19.7; diameter now 1.0667; dial 36.4; diameter 1.0228; dial 42.1; diameter 1.0114, dial 47.8, diameter 1. Select log file and you should see

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

K. Excessive spring stored up in cutter support: **(setup: radius dial, 100, 50, 3, 4, auto comp is on, details are off)**: **goal 1, diameter now 1.43** (so OD). Dial starts at 0. Dial to 50, 0, 50, 0; Diameter now 1.080 (which reflects 25 thou of stored spring). Program prompts user to reestablish touchdown. Dial now 7. Dial to 20.3, diameter now 1.0534. Dial to 33.7, diameter now 1.0266. dial to 47, done. Log should show

Pass #	diameter	Dial set to	Notes
0	1	7	Goal is 1, dial at 7 after reestablishment of TD
3	1.08	20.3	Starting diameter is 1.08
2	1.0534	33.7	DCF is 1
1	1.0266	47	DCF is 1
0	0	0	

L. SET UP EXIT tests
1. From the start screen, select SET UP. Select INDIVIDUAL and then X-FEED DIAL; select RADIUS DIAL. At Dial Size, select option 3 to return to main page.
2. From the start screen, select SET UP. Select INDIVIDUAL and then ROUGHING DOC; select option 3 to return to main page.
3. From the start screen, select SET UP. Select INDIVIDUAL and then OD CUTS; select option 3 to return to main page.
4. From the start screen, select SET UP. Select INDIVIDUAL and then ID CUTS; select option 3 to return to main page.
5. From the start screen, select SET UP. Select INDIVIDUAL and then AUTO COMP; select option 3 to return to main page.
6. From the start screen, select SET UP. Select INDIVIDUAL and then OD CUTS; select option 3 to return to main page.
7. From the start screen, select SET UP. Select INDIVIDUAL and then DETAILS; select option 3 to return to main page.

M. SET UP range checks
1. From the start screen, select SET UP. Select INDIVIDUAL and then X-FEED DIAL; select RADIUS DIAL. At Dial Size, select CHANGE and input -1 and expect a "too small" warning followed by a dial size forced to 50;select CHANGE and input 49 and expect a "too small" warning followed by a dial sized forced to 50; input 50 and it should be accepted; select EXIT SET UP.
2. From the start screen, select SET UP. Select INDIVIDUAL and then select ROUGHING DOC: select CHANGE and input -1 and expect a "too small" warning followed by a forced value of 10; input 9 and expect a "too small" warning followed by a forced value of 10; input 11 and it should be accepted; input 50 and it should be accepted.
3. From the start screen, select SET UP. Select INDIVIDUAL and then select OD CUTS: input -1 and expect "too small" warning followed

by a forced value of 1; input 0 and expect "too small" warning followed by a forced value of 1; input 1 and it should be accepted; input 3 and it should be accepted

4. From the start screen, select SET UP. Select INDIVIDUAL and then select ID CUTS: change to -1 and expect a forced value of 1; input 0 and expect "too small" warning followed by a forced value of 1; input 1 and it should be accepted; input 4 and it should be accepted

5. From the start screen, select SET UP. Select INDIVIDUAL and then select AUTO COMP: you should be able to move between ON and OFF; select EXIT SET UP

6. From the start screen, select SET UP. Select INDIVIDUAL and then select DETAILS: you should be able to move between ON and OFF; select EXIT SET UP.

7. (SFM: since these numbers only set a suggested RPM, no tests needed other than what was done already.)

If you have read this far, my hat off to you. It has been a difficult journey. Fortunately, the user is shielded from all of this complexity.

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Appendix: A Finish Cut Example With A Restart In the Middle

I will be explaining regression test case "I" which is reproduced below.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

The first 3 columns and last 6 rows are the log file generated by the program.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

Row 1 shows the goal diameter, 1, and the initial value set on the dial, 3. The finish pass number is 0 to indicate that no chips have been made yet. As we move to the next pass number, the lathe is run.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

Row 2 is the start of the finish pass process starting with pass number 3 and counting down. The measured diameter is 1.1. Given that I have defined the number of OD finish passes as 3, the desired change in radius for this first pass is

$$\frac{(1.1-1)\times 1000}{2 \times 3} = 16.7 \text{ thou}$$

In this equation I first subtracted the current diameter from the goal diameter and divided by 2. This gives me the total radius to go. Then I divided by 3 to give me the desired change in radius per pass. And finally, I multiply by 1000 to convert to thou.

My dial was at 3 so in order to make this first cut, I must move the dial to 3 + 16.7 = 19.7. That number is shown on the second row, column 3. The cut is taken and I am then ready for pass number 2 shown in row 3.

All went perfectly so the diameter was reduced by
2 X 16.7 = 33.3 thou. 1.1 - .0333 = 1.0667. This value is shown as the starting diameter in pass 2. The DCF is 1.0030 which would be 1 if there was no round-off error for the dial setting.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

The program now calculates the DOC for finish pass number 2:

$$\frac{(1.0667-1)\times 1000}{2 \times 2} = 16.7 \text{ thou}$$

The dial is moved from 19.7 to (19.7 + 16.7 =) 36.4. This should cause the diameter to be reduced by 2 X 16.7 = 33.3 thou.

Consider, for a moment, what happens if all goes according to plan. With the dial at 36.4 I take my finish pass and would get a diameter of (1.0667 - 2 X .0167 =) 1.0333. This value would show up as the starting diameter of finish pass number 1.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
1	<mark>1.0333</mark>	53.1	DCF is 1.

The program now calculates the last DOC:

$$\frac{(1.0333 - 1) \times 1000}{2 \times 1} = 16.7 \text{ thou}$$

The dial would be moved from 36.4 to (36.4 + 16.7 =) 53.1 as you can see in row 4, column 3:

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
1	1.0333	<mark>53.1</mark>	DCF is 1.

If this was the result, the DCF would be 1 and after this last finish pass you would ideally arrive at a diameter of 1.

So now we see what happens when everything is perfect. Time to return to a more realistic case where something goes wrong.

Back to the original case where we got an unexpected diameter after completing finish pass 2:

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

Rather than measuring the ideal diameter of 1.0333 we get 1.0228. This is a change in radius of

$$\frac{(1.0667 - 1.0228) \times 1000}{2} = 22.0 \text{ thou}$$

So instead of causing a change of radius of 16.7 thou, we got 22.0. This is $\frac{22.0 - 16.7}{16.7} \times 100\% = 31.7\%$ more than expected. I have arbitrarily assumed that as long as the resulting diameter is within +/- 30% of expected, I will trust the DCF. But if more than that, I regroup.

This means starting the finish pass process over again making allowances for the fact that there will be less radius to go.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

At row 4, note that my pass number has been reset back to 3. I calculate my next dial setting:

$$\frac{(1.0228-1)\times 1000}{2 \times 3} = 3.8 \; thou$$

A DOC of 3.8 thou is too small on my lathe. I don't want to make any cuts under 5.

I rearrange this equation to give me the number of passes to make that insures a 5 thou DOC:

$$\frac{(1.0228-1)\times 1000}{2 \times 5 \; thou} = 2.28 \; passes$$

Rounding down to the next lowest integer I get 2:

$$\frac{(1.0228-1)\times 1000}{2 \times 2} = 5.7 \; thou$$

My dial was at 36.4so it will be turned to (36.4 + 5.7 =) 42.1.

I have chosen to keep the first finish pass number at 3 even though the program is actually planning to only make 2 passes. If I changed pass number 3 in row 4, column 1 to a 2, it would be confusing to see two consecutive pass number 2s. Hopefully, seeing the pass number jump back to the initial value will indicate that we are starting the process over again.

If all goes perfectly, the diameter will be reduced to (1.0228 - 2 X .0057) = 1.0114.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	`1.0114`	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

Assume that is what we get as shown in row 5, column 2. The program then calculates the last finish pass:

$$\frac{(1.0114 - 1) \times 1000}{2 \times 1} = 5.7 \text{ thou}$$

My dial was at 42.1 so it will be turned to (42.1 + 5.7 =) 47.8. If all goes perfectly, the diameter will be reduced to (1.0114 - 2 X .0057) = 1.

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	`1`	0	Final value of 1

Pass #	diameter	Dial set to	Notes
0	1	3	Goal is 1, dial at 0; expected to take 3 passes
3	1.1	19.7	Starting diameter is 1.1
2	1.0667	36.4	DCF is 1.0030
3	1.0228	42.1	Finish pass restart so finish pass number reset to OD finish pass count of 3
2	1.0114	47.8	DCF is 1. Only enough room for 2 passes
0	1	0	Final value of 1

Note that no finish pass number for row 6 which only shows the final diameter. This is similar to row 1 where the goal diameter is shown. No chips were made so no pass number is shown.