FLANGE COUPLING SYNTHESIS ON AUTOCAD

by
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for
ME 600
Professor Panos Papalambros
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FLANGE COUPLING SYNTHESIS ON AUTOCAD

A program to design and fabricate flange couplings was developed at the Rapid Prototyping Laboratory of The University of Michigan as part of the ME 600 research under the supervision of Professor Panos Papalambros. This program, FLANGE, was developed on the Autocad/CAMM3 system using Autocad's resident language Autolisp. This program was designed to allow a user to create a standard sized safety flange coupling or custom design a flange coupling. The program creates the drawing of the flange coupling and stores it in Autocad. The program, also creates the tool paths needed to fabricate the flange coupling.
INTRODUCTION

A program to design and fabricate flange couplings was developed at the Rapid Prototyping Laboratory of The University of Michigan as part of the ME 600 research under the supervision of Professor Panos Papalambros. This program was developed on the Autocad/CAMM3 system using Autocad's resident language Autolisp. This program, FLANGE, was designed to allow a user to create a standard sized safety flange coupling or custom design a flange coupling. The program creates the drawing of the flange coupling and stores it in Autocad. The program, also, creates the tool paths needed to fabricate the flange coupling. The program is composed of five modules: 1) stuser, 2) fcuser, 3) drwflng, 4) machflng, and 5) FLANGE.

Module stuser prompts the user for standard sized safety flange coupling data. A table located in Appendix A provides the user with the data for standard sized safety flange couplings (Faires, 1937). Future versions of FLANGE will integrate the table into the program.

Module fcuser allows the user to custom design couplings. This module prompts the designer for the shaft diameter, the allowable shear and bearing stresses, the maximum allowable torque, the number of bolts, and the bolt diameter. The module, through a series of rules, develops the parameters needed to draw and fabricate a coupling. A copy of these rules can be found in Appendix B. It should be noted that the output from this module is of the same format as the output from stuser. This will allow FLANGE to be easily modified in the future.

Module drwflng takes the data from either stuser or fcuser and converts the parameters into a drawing in Autocad. Drwflng next sends the data to machflng. Currently, drwflng does not dimension the coupling drawings. The lack of dimensions can be attributed to the way Autocad dimensions circles. Future versions will support drawing dimensions.

Module machflng converts the data from drwflng into tool paths and generates the code needed by the CAMM3. The only data required from the user is the tool diameter and workspace length.

Module FLANGE is the link between the other four modules and Autocad. FLANGE also acts as the entry point for stuser and fcuser.
This report is divided into two sections. The first section is the users' manual for the program FLANGE and the second section is a documentation of the program. The users' manual takes the user on a guided tour of the operations of the FLANGE program from the MS-DOS level of the computer through final machining of the part. The documentation section of this report outlines the main points behind the code for the program FLANGE. This documentation should allow future users of FLANGE to correct untrapped bugs and to update and tailor the code to specific needs.
DISCUSSION

The program FLANGE is able to draw and fabricate a flange coupling on the Autocad/CAMM3 rapid prototyping system. Several specimens have already been machined using the FLANGE program. Functions stuser and fcuser have been used to create drawings and tool paths.

The small size of the CAMM3 limits the size and the material of the flange coupling. Currently, FLANGE does not check to determine if the CAMM3 is capable of making the flange coupling. Future versions of FLANGE should determine if the CAMM3 is capable of machining the part and also determine cutter size and material size for the user. Dimensioning of the part in Autocad is another feature that should be added in future versions. The dimensioning problem and the problem of creating layers could be bugs in the Autolisp and Autocad programs.

Several problems occur while machining flange coupling. First, the shaft opening is a deep, cylndrical slot in which chips become trapped. The chips are then pushed into the wall of the shaft opening by the cutter. This has reduces the quality of surface finish. Alternative means of boring this hole must be examined. Second, the tool paths are not optimized to shorten cutting time. Future work on FLANGE should focus on adding dimensions and layer creation, and repairing the machining problems.
I. MS-DOS LEVEL COMMANDS

Two very important commands for using the FLANGE program occur at the MS-DOS level. These two commands set the lispheap and lispstack to the values needed to execute FLANGE. At the MS-DOS prompt enter the following:

C:>  SET LISPHEAP=25000 <return>
C:>  SET LISPSTACK=10000 <return>

II. ACTIVATING AUTOCAD

After setting the lispstack and lispheap Autocad can be opened and the FLANGE program can be loaded into Autocad:

C:>  ACAD <return>

When Autocad is running it will prompt you for the type of operation. Type "1" and <return> to start a new drawing. At this point Autocad asks you to name the new drawing. An appropriate name is "flange". After entering the new drawing name, type <return>. Autocad enters the drawing editor and provide you with the prompt

COMMAND:

III. LOADING THE PROGRAM FLANGE

The next step is loading the program FLANGE into Autocad. A second program, named CAMM3, must also be loaded at this time. CAMM3 contains the commands needed to set the depth of cut on the CAMM3 milling machine. CAMM3 was developed by Mr. Paul Wallich, a Michigan Journalist Fellow. Load the files in the following manner:

COMMAND: (LOAD "FLANGE") <return>

COMMAND: (LOAD "CAMM3") <return>
IV. INITIALIZE LAYERS

The fourth step is the initialization of the work layers. Autolisp does not have the ability to create work layers so they must be created manually. At the Command prompt enter LAYERS <return> and at the next prompt enter MAKE 1,2,3,4,5,6,7,8,9 <return>. The layers have now been created.

V. CAMM3 SETUP

The fifth step is to setup the CAMM3 to make the flange coupling. The CAMM3 is not a toy and should be treated with respect. Always wear safety glasses when operating the CAMM3 and keep fingers out the workspace when the mill is running. If any instruction is not clear do not operate the machine until you get help from a qualified operator.

i. Turn on the CAMM3. The switch is located on the right, rear, lower side panel.
ii. Press the "home" button on the CAMM3 control panel. The table moves to its home position.
iii. Put a ball nose endmill of known diameter in the CAMM3 tool collet and tighten the collet. A ball nose endmill is required to cut the deep shaft pocket in the flange coupling.
iv. Put a block of wax, with known dimensions, in the vise. Tighten the vise.
v. Press the "manual" button on the CAMM3 control panel. Using the table movement buttons on the control panel, move the cutter to a position about 2 inches above the surface of the wax. Press the "sensor" button on the control panel. Place the brass position sensor on the wax right below the cutter. Lower the cutter, using the "-Z" button onto the sensor. Turn off the sensor and raise the cutter. Press Z0 to lower the cutter to the surface of the wax. Move the cutter to the (0,0) position on the wax workspace. See figure 1.
vi. Press "enter" and "home" on the control panel to locate the (0,0) position. Press "manual" once again to set the CAMM3 for operation. Clear the workarea!

VI. RUNNING THE FLANGE PROGRAM

Enter FLANGE and <return> at the Autocad command prompt. This executes the FLANGE program. The FLANGE program responds with the question:

Standard Flange Coupling <Y or N> ?

Reply "Y" <return> if you wish to use the standard sized safety flange coupling menu or "N" <return> if you want the user designed flange coupling menu. According to your request, FLANGE responds with that menu. Enter the data requested by FLANGE followed with a <return>. Remember, enter tool diameter in millimeters; that is, if the tool is a 300, enter 3. The table of input data for the standard sized flange coupling is found in Appendix A. Autocad draws the coupling and stores the image on layers 1, 2, 3, and 4. Sample plots are in Appendix C.

VII. FABRICATING THE FLANGE

Autocad and FLANGE automatically creates the tool paths needed to fabricate the flange coupling. Remember wear safety glasses and keep fingers clear of the workspace when the
CAMM3 is operating. When the toolpaths have been created, Autocad will prompt you with a Command: prompt. Type <return>. This is a safety device to make the operator aware that the CAMM3 is ready to begin. The Command: prompt returns after each tool path has been completed. Type <return> to continue to the next tool path.

VIII. COMPLETION

When fabrication is completed, turn off the CAMM3 and remove the part from the mill. Note: the part is still attached to the base and a band saw is needed to remove the part from the base. Clean up around the CAMM3. FLANGE returns control back to Autocad.
PROGRAM DOCUMENTATION

Function stuser

The function stuser queries the user for standard sized safety flange coupling input parameters. Lines 16 - 20 ask the user for data on tool diameter and work space size. This section also processes data to ease the transition into the drwflng function. The final line of this function calls the drwflng function.

(defun stuser ()
  ; INPUT OF STANDARD SIZE COUPLING PARAMETERS
  (setq A (getreal "\nDiameter of shaft-A-: "))
  (setq B (getreal "\nHeight of flange coupling-B-: "))
  (setq C (getreal "\nDiameter of collar-C-: "))
  (setq D (getreal "\nDiameter of coupling-D-: "))
  (setq E (getreal "\nHeight of safety flange-E-: "))
  (setq F (getreal "\nThickness of hub-F-: "))
  (setq K (getreal "\nThickness of safety hub-K-: "))
  (setq KD (- D (* 2.0 K)))
  (setq H (getreal "\nDiameter of bolt pattern-H-: "))
  (setq HR (/ H 2.0))
  (setq NI (getint "\nNumber of bolts-N-: "))
  (setq N (float NI))
  (setq BD (getreal "\nDiameter of bolts-BD-: "))
  (setq BL (getreal "\nLength of block: "))
  (set BLP (/ BL 2.0))
  (setq P1 (list BLP BLP))
  (setq CD (getreal "\nTool diameter: "))
  (setq TR (/ CD 50.8))
  (drwflng)
  )

Function fcuser

The first section (lines 25 - 36) of function fcuser queries the user for data on creating a user-defined flange coupling. Lines 25 - 31 ask the user for material properties, loading
conditions, and bolt size and number. Lines 32 - 36 ask the user about tool diameter and workspace size.

The second section (lines 38 - 46) are the rules FLANGE uses to determine the coupling size from the inputted data. Line 47 calls the function drwflng. Fcuser sends the data to drwflng in the same format as sttuser.

```
(defun fcuser ()
  ; ACQUIRE INFORMATION FOR USER DESIGNED FLANGE COUPLING
  (setq A (getreal "nEnter shaft diameter: "))
  (setq BD (getreal "nDiameter of bolts: "))
  (setq NI (getint "nNumber of bolts: "))
  (setq N (float NI))
  (setq SS (getreal "nAllowable shearing stress: "))
  (setq SB (getreal "nAllowable bearing stress: "))
  (setq T (getreal "nApplied maximum torque: "))
  (setq BL (getreal "nLength of block: "))
  (setq BLP (/ BL 2.0))
  (setq P1 (list BLP BLP))
  (setq CD (getreal "nTool diameter: "))
  (setq TR (/ CD 50.8))
  ; CALCULATE THE FLANGE DIMENSIONS
  (setq H (sqrt (/ (* 8.0 T) (* SS N pi BD))))
  (setq HR (/ H 2.0))
  (setq F (/ (* 2.0 T) (* SB N BD H))
  (setq C (sqrt (/ (* 2.0 T) (* SS pi F))))
  (setq D (* 4.0 A))
  (setq K (+ (* 0.0625 A) 0.1875))
  (setq KD (- D (* 2.0 K)))
  (setq E (+ (* 0.3125 A) 0.75))
  (setq B (* 1.75 A))
  (drwflng)
)
```

Function drwflng
The function drwflng is totally dedicated to the drawing of the part. Drwflng does not process the data sent to it from either stuser or fcuser; drwflng merely takes the data sent to it and passes it on to Autocad commands to draw, display and store the part images.

(defun drwflng ()
  ; DRAW FIRST LAYER
  (Command "layer" "set" 1 "")
  (Command "elev" "" B)
  (Command "circle" P1 "D" A)
  (Command "circle" P1 "D" C)

  ; DRAW SECOND LAYER
  (Command "layer" "set" 2 "")
  (Command "elev" "" E)
  (Command "circle" P1 "D" A)
  (Command "circle" P1 "D" C)
  (Command "circle" P1 "D" D)
  (Command "circle" P1 "D" KD)

  ; DRAW FOURTH LAYER
  (Command "layer" "set" 3 "")
  (Command "elev" "" F)
  (Command "circle" P1 "D" A)
  (Command "circle" P1 "D" KD)
  (setq SA 0.0)
  (Command "circle" (polar P1 SA HR) "D" BD)
  (Command "array" "L" "" "P" P1 NI "" "")
  (machflng)
)

Function machflng

The function machflng is very similar in operation to the function drwflng. Machflng uses data from either stuser or fcuser to create tool paths using Autocad commands. In addition to Autocad commands, machflng uses the (setdep) command, stored in CAMM3.LSP and written by Mr. Paul Wallich, Michigan Journalist Fellow, to control machining depth. This function generates the tool path and the codes needed by the CAMM3.
(defun machfng () ; CLEAR SCREEN AND CREATE TOOL PATHS
  (Command "layer" "set" 5 "")
  (Command "layer" "off" 1 "")
  (Command "layer" "off" 2 "")
  (Command "layer" "off" 3 "")
  (Command "layer" "off" 4 "")

; PLOT FIRST TOOL PATH
  (setq TA (- A TR))
  (Command "circle" P1 "D" TA)
  (Command "hatch" "ANSI131" "0.6" "0.0" "L" "")
  (setq DB1 (/ B 4.0))
  (setq DBC (fix DB1))
  (setq DB (fix DB1))
  (setdepth DB)
  (Command "plot" "" "" "")
  (setq DB (+ DB DBC))
  (setdepth DB)
  (Command "plot" "" "" "")
  (setq DB (+ DB DBC))
  (setdepth DB)
  (Command "plot" "" "" "")

; PLOT SECOND TOOL PATH
  (setq TC (+ C TR))
  (Command "layer" "set" 6 "")
  (Command "layer" "off" 5 "")
  (Command "circle" P1 "D" TC)

; WORKSPACE DEFINED
  (setq P2 (list 0.0 0.0))
  (setq P3 (list BL 0.0))
  (setq P4 (list BL BL))
  (setq P5 (list 0.0 BL))
  (Command "pline" P2 P3 P4 P5 "cl")
(Command "hatch" "ANSI31,0" "0.6" "0.0" "W" P2 P4 ")
(setq DZ1 (- B E))
(setq DZ2 (/ DZ1 3.0))
(setq DZC (fix DZ2))
(setq DZ (fix DZ2))
(setdepth DZ)
(Command "plot" "" "" ")
(setq DZ (+ DZC DZ))
(setdepth DZ)
(Command "plot" "" "" ")
(setq DZ (+ DZC DZ))
(setdepth DZ)
(Command "plot" "" "" ")

; PLOT THIRD TOOL PATH
(Command "layer" "set" 7 "")
(Command "layer" "off" 6 "")
(setq TKD (- KD TR))
(setq TC (+ C TR))
(Command "circle" P1 "D" TKD)
(Command "circle" P1 "D" TC)
(Command "hatch" "ANSI31,0" "1.5" "0.0" "W" P2 P4 ")
(setq DE (fix E))
(setdepth DE)
(setq DF1 (- F E))
(setq DF (fix DF1))
(setdepth DF)
(Command "plot" "" "" ")

; PLOT FOURTH TOOL PATH
(Command "layer" "set" 8 "")
(Command "layer" "off" 7 "")
(setq TBD (- BD TR))
(Command "circle" (Polar P1 SA HR) "D" TBD)
(Command "array" "L" "P" P1 NI "" ")
(setdepth DB)
(Command "plot" "" "" ")

; PLOT FIFTH TOOL PATH
(Command "layer" "set" 9 "")
(Command "layer" "off" 8 ")
(setq TD (+ D TR))
(Command "circle" P1 "D" TD)
(Command "pline" P2 P3 P4 P5 "cl")
(Command "hatch" "ANSI31,O" "0.6" "W" P2 P4 ")
(setq DE (fix E))
(setdepth DE)
(setq DBZC (- B E))
(setq DBZ2 (/ DBZC 2.0))
(setq DBZ (fix (DBZ2))
(setdepth DBZ)
(Command "plot" "" "")
(setdepth DB)
(Command "plot" "" ")
 Function C:FLANGE

The function C:FLANGE is the main program of FLANGE. It is the link between FLANGE and Autocad. It also is the entry points for stuser and fcuser.

(defun C:FLANGE ()
; MAIN PROGRAM
(setq flegmenu nil)
(setq flegmenu
  (getstring "nStandard Flange Coupling <Y or N> ? ")
(if (= flegmenu "y") (setq flegmenu "Y"))
(if (= flegmenu "Y")
  (stuser))
(if (/= flegmenu "Y")
  (fcuser))
)
The program FLANGE is completed coded in Autolisp and executable on Autocad on either version of the IBM P.C. located in the Rapid Prototyping Laboratory at The University of Michigan. Appendix D is a listing of the undisturbed code.
REFERENCES

Faires, Virgil Moring, "Design of Machine Elements",

Oberg, Erik, Jones, Franklin D., and Horton, Holbrook L.,
Table 1: Table of values for stuser

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>H</th>
<th>K</th>
<th>No.</th>
<th>Dia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.75</td>
<td>2.25</td>
<td>4.0</td>
<td>0.6875</td>
<td>0.3125</td>
<td>2.82</td>
<td>0.25</td>
<td>5</td>
<td>0.375</td>
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<tr>
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<td>2.1875</td>
<td>2.75</td>
<td>5.0</td>
<td>0.8125</td>
<td>0.375</td>
<td>3.1</td>
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<td>0.5</td>
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<tr>
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<td>7.0</td>
<td>1.0625</td>
<td>0.5</td>
<td>4.73</td>
<td>0.25</td>
<td>5</td>
<td>0.5625</td>
</tr>
<tr>
<td>2.0</td>
<td>3.5</td>
<td>4.5</td>
<td>8.0</td>
<td>1.1875</td>
<td>0.5625</td>
<td>5.32</td>
<td>0.25</td>
<td>5</td>
<td>0.625</td>
</tr>
</tbody>
</table>
1) Shear of bolts

\[ H = \sqrt{\frac{8}{SS \cdot N \cdot BD}} \cdot T \]

where \( H \) = diameter of bolt pattern,
\( T \) = applied torque maximum,
\( BD \) = Diameter of bolt,
\( N \) = number of bolts,
and \( SS \) = allowable shearing stress.

2. Bearing of bolts and flange

\[ F = \frac{2}{SB \cdot N \cdot BD \cdot H} \cdot T \]

where \( F \) = thickness of flange,
\( T \) = applied torque maximum,
\( N \) = number of bolts,
\( BD \) = bolt diameter,
\( H \) = diameter of bolt pattern,
and \( SB \) = allowable bearing stress.

3. Shear of flange

\[ C = \sqrt{\frac{2}{SS \cdot BD}} \cdot T \]

where \( C \) = coupling diameter,
\( T \) = applied maximum torque,
\( SS \) = allowable shear stress,
and \( F \) = thickness of flange.

4. Diameter of flange

\[ D = 4 \cdot A \]

where \( A \) = shaft diameter,
and \( D \) = diameter of flange.

5. Thickness of safety flange

\[
K = 0.0625A + 0.1875
\]

where \( A \) = shaft diameter,
and \( K \) = thickness of safety flange.

6. Height of safety flange

\[
E = 0.3125A + 0.75
\]

where \( A \) = shaft diameter,
and \( E \) = height of safety flange.

7. Height of flange coupling

\[
B = 1.75*A
\]

where \( A \) = shaft diameter,
\( B \) = height of flange coupling.
APPENDIX C
(defun stuser ()
  ; INPUT OF STANDARD SIZE COUPLING PARAMETERS
  (setq A (getreal "nDiameter of shaft-A-: "))
  (setq B (getreal "nHeight of flange coupling-B-: "))
  (setq C (getreal "nDiameter of collar-C-: "))
  (setq D (getreal "nDiameter of coupling-D-: "))
  (setq E (getreal "nHeight of safety flange-E-: "))
  (setq F (getreal "nThickness of hub-F-: "))
  (setq K (getreal "nThickness of safety hub-K-: "))
    
  (setq KD (- D (* 2.0 K)))
  (setq H (getreal "nDiameter of bolt pattern-H-: "))
    
  (setq HR (/ H 2.0))
  (setq NI (getint "nNumber of bolts-N-: "))
    
  (setq N (float NI))
  (setq BD (getreal "nDiameter of bolts-BD-: "))
  (setq BL (getreal "nLength of block: "))
    
  (setq BLP (/ BL 2.0))
    
  (setq P1 (list BLP BLP))
  (setq CD (getreal "nTool diameter: "))
    
  (setq TR (/ CD 50.8))
    
  (drwflng)
  )

(defun fcuser ()
  ; ACQUIRE INFORMATION FOR USER DESIGNED FLANGE COUPLING
  (setq A (getreal "nEnter shaft diameter: "))
  (setq BD (getreal "nDiameter of bolts: "))
  (setq NI (getint "nNumber of bolts: "))
    
  (setq N (float NI))
  (setq SS (getreal "nAllowable shearing stress: "))
  (setq SB (getreal "nAllowable bearing stress: "))
  (setq T (getreal "nApplied maximum torque: "))
  (setq BL (getreal "nLength of block: ")))
(setq BLP (/ BL 2.0))
  (setq P1 (list BLP BLP))
(setq CD (getreal "nTool diameter: "))
  (setq TR (/ CD 50.8))

; CALCULATE THE FLANGE DIMENSIONS

  (setq H (sqrt (/ (* 8.0 T) (* SS N pi BD)))))
  (setq HR (/ H 2.0))
(setq F (/ (* 2.0 T) (* SB N BD H)))
  (setq C (sqrt (/ (* 2.0 T) (* SS pi F))))
  (setq D (* 4.0 A))
(setq K (+ (* 0.0625 A) 0.1875))
  (setq KD (- D (* 2.0 K)))
(setq E (+ (* 0.3125 A) 0.75))
  (setq B (* 1.75 A))
  (drwflng)

(defun drwflng ()
)

(defun drwflng ()

; DRAW FIRST LAYER

  (Command "layer" "set" 1 "")
  (Command "elev" "" B)
  (Command "circle" P1 "D" A)
  (Command "circle" P1 "D" C)

; DRAW SECOND LAYER

  (Command "layer" "set" 2 "")
  (Command "elev" "" E)
  (Command "circle" P1 "D" A)
  (Command "circle" P1 "D" C)
  (Command "circle" P1 "D" D)
  (Command "circle" P1 "D" KD)
; DRAW FOURTH LAYER

(Command "layer" "set" 3 "")
(Command "elev" "" F)
(Command "circle" P1 "D" A)
(Command "circle" P1 "D" KD)
(setq SA 0.0)
(Command "circle" (polar P1 SA HR) "D" BD)
(Command "array" "L" "" "P" P1 NI "" "")
(machflng)
)

(defun machflng ()

; CLEAR SCREEN AND CREATE TOOL PATHS

(Command "layer" "set" 5 "")
(Command "layer" "off" 1 "")
(Command "layer" "off" 2 "")
(Command "layer" "off" 3 "")
(Command "layer" "off" 4 "")

; PLOT FIRST TOOL PATH
(setq TA (- A TR)
(Command "circle" P1 "D" TA)
(Command "hatch" "ANSI31" "0.6" "0.0" "L" "")
(setq DB1 (/ B 4.0))
(setq DBC (fix DB1))
(setq DB (fix DB1))
(setdepth DB)
(Command "plot" "" "" "")
(setq DB (+DB DBC))
(setdepth DB)
(Command "plot" "" "" "")
(setq DB (+ DB DBC))
(setdepth DB)
  (Command "plot" "" """)
(setq DB (+ DB DBC))
(setdepth DB)
  (Command "plot" "" "")

; PLOT SECOND TOOL PATH

(setq TC (+ C TR))
  (Command "layer" "set" 6 "")
  (Command "layer" "off" 5 "")
  (Command "circle" P1 "D" TC)

; WORKSPACE DEFINED

(setq P2 (list 0.0 0.0))
(setq P3 (list BL 0.0))
(setq P4 (list BL BL))
(setq P5 (list 0.0 BL))
  (Command "pline" P2 P3 P4 P5 "cl")
  (Command "hatch" "ANSI31,0" "0.6" "0.0" "W" P2 P4 "")
  (setq DZ1 (- B E))
  (setq DZ2 (/ DZ1 3.0))
  (setq DZC (fix DZ2))
  (setq DZ (fix DZ2))
  (setdepth DZ)
    (Command "plot" "" "")
  (setq DZ (+ DZC DZ))
  (setdepth DZ)
    (Command "plot" "" "")
  (setq DZ (+ DZC DZ))
  (setdepth DZ)
    (Command "plot" "" "")

; PLOT THIRD TOOL PATH
(Command "layer" "set" 7"")
(Command "layer" "off" 6"")
(setq TKD (- KD TR))
(setq TC (+ C TR))
(Command "circle" P1 "D" TKD)
(Command "circle" P1 "D" TC)
(Command "hatch" "ANSI31,O" "1.5" "0.0" "W" P2 P4"")
(setq DE (fix E))
(setdepth DE)
(setq DF1 (- F E))
(setq DF (fix DF1))
(setdepth DF)
(Command "plot" "" "")

; PLOT FOURTH TOOL PATH

(Command "layer" "set" 8"")
(Command "layer" "off" 7"")
(setq TBD (- BD TR))
(Command "circle" (Polar P1 SA HR) "D" TBD)
(Command "array" "L" "" "P" P1 NI "" "")
(setdepth DB)
(Command "plot" "" "")

; PLOT FIFTH TOOL PATH

(Command "layer" "set" 9"")
(Command "layer" "off" 8"")
(setq TD (+ D TR))
(Command "circle" P1 "D" TD)
(Command "pline" P2 P3 P4 P5 "cl")
(Command "hatch" "ANSI31,O" "0.6" "W" P2 P4"")
(setq DE (fix E))
(setdepth DE)
(setq DBZC (- B E))
(setq DBZ2 (/ DBZC 2.0))
(setq DBZ (fix (DBZ2))
(setdepth DBZ)
    (Command "plot" "" "" "")
(setdepth DB)
    (Command "plot" "" "" "")
)

(defun C:FLANGE ()

; MAIN PROGRAM

(setq flegmenu nil)
(setq flegmenu
    (getstring "\nStandard Flange Coupling <Y or N> ? ")
(if (= flegmenu "y") (setq flegmenu "Y"))
    (if (= flegmenu "Y")
        (stuser))
    (if (/= flegmenu "Y")
        (fcuser))
    )