

Appendix D - UNIVERSITY HONORS PROGRAM
SENIOR PROJECT - APPROVAL

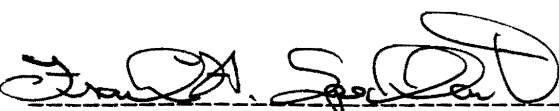
Name: Suzy Lavender

College: Engineering Department: Mechanical

Faculty Mentor: Dr. Frank Speckhart

PROJECT TITLE: Design of a Three-Function
Mechanism for an Inkjet Printer

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: , Faculty Mentor

Date: 5/9/2000

Comments (Optional):

Design of a Three-Function Mechanism for an Inkjet Printer

Senior Honors Project

Submitted by Suzy Lavender

Partners: Chris Bradley and Evan Quinley

Faculty Mentor: Dr. Frank Speckhart

Sponsored by Lexmark, Inc.

May 9, 2000

Abstract

The purpose of this project was to design and build a mechanism to perform three tasks during the print cycle of a Lexmark inkjet printer. Those three tasks involve the rotation of four shafts: one to raise the printhead carriage, one to lower the starwheels, and two to open the printer's batwings. The printhead and starwheel shafts are parallel to each other, but not to the two batwing shafts, which are also parallel to each other. Another design requirement was to control costs, mainly by using only one prime mover in the design. A goal of \$6 was given for all parts not including the motor and driver. Finally, the design had to fit within the space confines of the existing printer machinery.

After considering several options, the timing key method was chosen for this design. This method involves four pairs of elements mounted on a shaft that is coupled with a stepper motor. The smaller element of each pair is a tab that is fixed to the shaft and fits inside a counterbore in the larger element, which is free to rotate on the shaft. A spring steel connecting rod is attached to each of the larger elements, and each counterbore contains a notch or notches positioned in such a way as to interfere with the rotating tab at certain locations. When a tab is not in contact with a notch in its mating element, the tab can rotate without causing any motion in the other element. When a tab does contact one of the notches, the mating element also rotates, leading to motion in the connecting rod. The four connecting rods do the actual work to move the printhead carriage, starwheels, and batwings. The elasticity of the spring steel rods allows each of the operations to be overdriven slightly against a mechanical stop. This ensures accuracy of placement in the output motion, and bias springs guarantee the correct default position for each of the elements when the driving force is removed.

A model of this design was built using a stepper motor and driver, plastic parts from a three-dimensional printer, PVC sheets, metal shafts, springs, clips, and small spring steel rods. The model was tested and is able to meet the specifications given for required motions. The model was designed to fit within the given space restrictions of the printer, and the total cost of parts (excluding motor and driver) and labor for one of these mechanisms was estimated to be \$3.13, well within the \$6 goal given.

Table of Contents

Objectives and Specifications	1
Final Design Description	2
Other Designs Considered	4
Cost Analysis	5
Future Work	8
Conclusions	9
Appendix	10

Objectives and Specifications

The purpose of this project was to design and build a mechanism to perform three tasks during the print cycle of a Lexmark inkjet printer. The first task was to raise the carrier for the printhead by rotating 45° the shaft upon which the carrier rides. This rotation is accomplished by applying a force of 1.5 pounds to a cam at the end of the shaft. The second function was to lower the printer's starwheels by rotating 25° the shaft to which the starwheels are fixed. The printhead and starwheel shafts are parallel to each other, but the required rotations are in opposite directions. The last task was to open the batwings by rotating each batwing shaft 21° . The batwing shafts are parallel to each other, but not parallel to the other two shafts. The two batwings rotate in opposite directions in order to open. A complicating factor is that the printhead carrier should only be raised in the event that an envelope is being printed. If regular thickness paper is used, the printhead carrier must remain in its original position. Another design requirement was to control costs, mainly by using only one prime mover in the design. A goal of \$6 was given for all parts not including the motor and driver. The design also had to fit within the space confines of the existing printer machinery. The assumption was made that the motor, shafts, springs, and stops could be mounted anywhere within the free area of the printer. Finally, the project was to be completed by the end of the spring 2000 semester. A copy of the Gantt chart used to schedule the project progress is included in the appendix.

Final Design Description

After considering all the options, the timing key method was chosen for this design. This method involves four pairs of elements mounted on a shaft that is coupled with a stepper motor. The smaller element of each pair is a tab that is fixed to the shaft and fits inside a counterbore in the larger element, which is free to rotate on the shaft. A spring steel connecting rod is attached to each of the larger elements, and each counterbore contains a notch or notches positioned in such a way as to interfere with the rotating tab at certain locations. When a tab is not in contact with a notch in its mating element, the tab can rotate without causing any motion in the other element. When a tab does contact one of the notches, the mating element also rotates, leading to motion in the connecting rod. The four connecting rods do the actual work to move the printhead carriage, starwheels, and batwings. The elasticity of the spring steel rods allows each of the operations to be overdriven slightly against a mechanical stop. This ensures accuracy of placement in the output motion, and bias springs guarantee the correct default position for each of the elements when the driving force is removed.

A model of this design was built using a stepper motor and driver, plastic parts from a three-dimensional printer, PVC sheets, metal shafts, springs, clips, and small spring steel rods. See the appendix for drawings of the prototype assembly and all the components manufactured. The stepper motor and driver used in the model are much bigger than required; they were used because of availability. The stepper motor operates with a step of 1.8° , but a gear train could

be inserted into the design to accommodate a motor with any other step size. Refer to the appendix for the stepper motor specifications and a copy of the Visual Basic code written to drive the motor. The drive shaft employed in the model is a 1/4" diameter steel shaft, and the drive tabs are pinned in place. In the actual product, a D-shaped shaft should be used to ensure accuracy of radial placement, with simple spacers inserted between the elements to ensure lateral placement. The elasticity of the spring steel connecting rods allows each of the operations to be overdriven slightly against a mechanical stop. This overdriving guarantees the correct output position for each of the functions, even if there is some error in molding, irregularity in the shape of the D-shaft, or slippage of the tabs on the shaft. A plastic wheel was used in the model to approximate the printhead cam mechanism, and a new starwheel actuator was designed to incorporate a mechanical stop against a nearby shaft. The other plastic parts used were designed to be oversize due to the weakness of the rapid prototype plastic, but in a production environment the tabs and elements could be scaled down according to the strength of the molding plastic. This action would save space inside the printer and save money in the cost of the plastic medium. Scaling down the plastic elements would also require greater rotations in the drive shaft to bring about the desired output motions in the printhead, starwheels, and batwings. This is advantageous since it would result in greater control over the output positions without relying on the mechanical stops and springs.

The prototype was designed to fit within the space restrictions given. It was tested and was found to also meet all the known motion requirements.

Other Designs Considered

During the development phase of the three-function mechanism, two other major designs were developed but set aside in favor of the current design.

The first design was a cam system that still involved four major elements. The cam system operated on a 360° cycle that could be run clockwise or counterclockwise. The cycle was divided into two 180° sections that determined whether an envelope or regular paper was to be printed. The 180° cycle could run back and forth as many times as it needed in order to print multiple envelopes or multiple sheets. One problem with this design involved the expense associated with the cam followers. The followers would be part intensive and therefore cost intensive. Also, the printer would have to calibrate itself each time it was turned on to determine the current position of the cam.

A second design consideration was very similar to the present prototype. The major difference was the placement of the drive shaft added to the design. The current prototype uses a drive shaft that runs the length of the printer until it is coupled with a parallel motor. The original design utilized a drive shaft that ran from the printer's front to back in the free space allowed on the left side. This idea was abandoned because it was found to be easier and cheaper to drive the batwings from directly above as opposed to running a belt between the two batwing elements and driving them from the left side.

Cost Analysis

The cost to put the three-function mechanism into mass production should fit well within the parameters established by Lexmark. Much of the line item cost analysis is speculation based on established costs of similar equipment. Also, it was assumed that the printer would run at a minimum production rate of 200,000 units per year for two years. See Table 1 for a line item cost analysis.

Table 1: Cost Analysis on Individual Part Basis		
Part Description	Assumed Cost/ Unit	Factors Affecting Costs
Print head carrier element (10g)	\$0.215	\$50,000 Mold cost, Plastic weight
Star wheel element (10g)	\$0.215	\$50,000 Mold cost, Plastic weight
Batwing elements (2, [L,R], 10g ea.)	\$0.43	\$50,000 Mold cost, Plastic weight, Color Distinguishing
Timing key tabs (4, 3g ea.)	\$0.23	\$50,000 Mold cost, Plastic weight
Batwing tabs (2, [L,R], 10g ea.)	\$0.43	\$50,000 Mold cost, Plastic weight, Color Distinguishing
Star wheel shaft stop and actuator (10g)	\$0.215	\$50,000 Mold cost, Plastic weight
Coupling	\$0.05	Extruded Plastic
Alignment spacers	\$0.10	Extruded Plastic
D-Shaft	\$0.25	Machining
Bias springs (3)	\$0.12	Handling
Connecting rods (4)	\$0.20	Handling
Labor	\$0.67	Based on Asian wages
TOTAL COST ==>	\$3.125	

Since most of the mechanism's design calls for injection molded parts, the largest expense initially will be the creation of new molds. New mold costs were estimated at \$50,000 each. Typically it would take two years or 400,000 units to recover the costs of these molds. Another factor in the cost of plastic parts would be the plastic material and handling. Material cost was taken to be \$2/lb and this cost was doubled to include the handling costs. The prototype parts were weighed and the cost was determined on a per unit basis. Additional cost of the plastic parts could be incurred by using colored material to distinguish between the left and right types of the batwing elements and the batwing tabs.

Other non-plastic parts were estimated on an individual basis. The main shaft added to the printer is a D-shaft, taken at a cost of \$0.25/ ft. Bias springs and connecting rods are difficult to handle, so their costs will be slightly higher than usual.

Finally labor costs were determined. Labor costs were taken at \$10/ hour for each individual producing the mechanism. This labor rate would include the workers wages, managerial costs, and overhead costs. A reasonable time for a person to assemble one mechanism was assessed to be approximately four minutes. This would mean that 15 units could be produced in one hour. To get the desired output of 200,000 units per year with 260 working days, the operation would run for 16 production hours a day and have three workers building the mechanisms per shift. Using these numbers the unit cost of labor was determined to be \$0.67 per unit.

The total cost for parts and labor, excluding the motor and driver, was calculated to be \$3.13 per unit, so the actual cost of production is estimated to be between \$3.00 and \$3.50. This is well within the \$6.00 range established in the design parameters. A typical motor and the driver of the type currently used at Lexmark should add approximately \$6.00 to the total cost.

Future Work

While the Three-Function Mechanism prototype is fully functional, there are several things left to be considered.

The first important consideration is finding a more precise method to overdrive the star wheels and the batwings. The current prototype uses spring steel bent into a “U” shape in order to facilitate the overdriving. Experimental tests on other materials should be performed to determine the best shape and size of these connecting rods. Efficiency and uniformity should be the primary concern of these tests.

Next the motor should be sized down and a simple gear train developed to compensate for the new step size. This would save money without a loss of accuracy in the rotation of the motor.

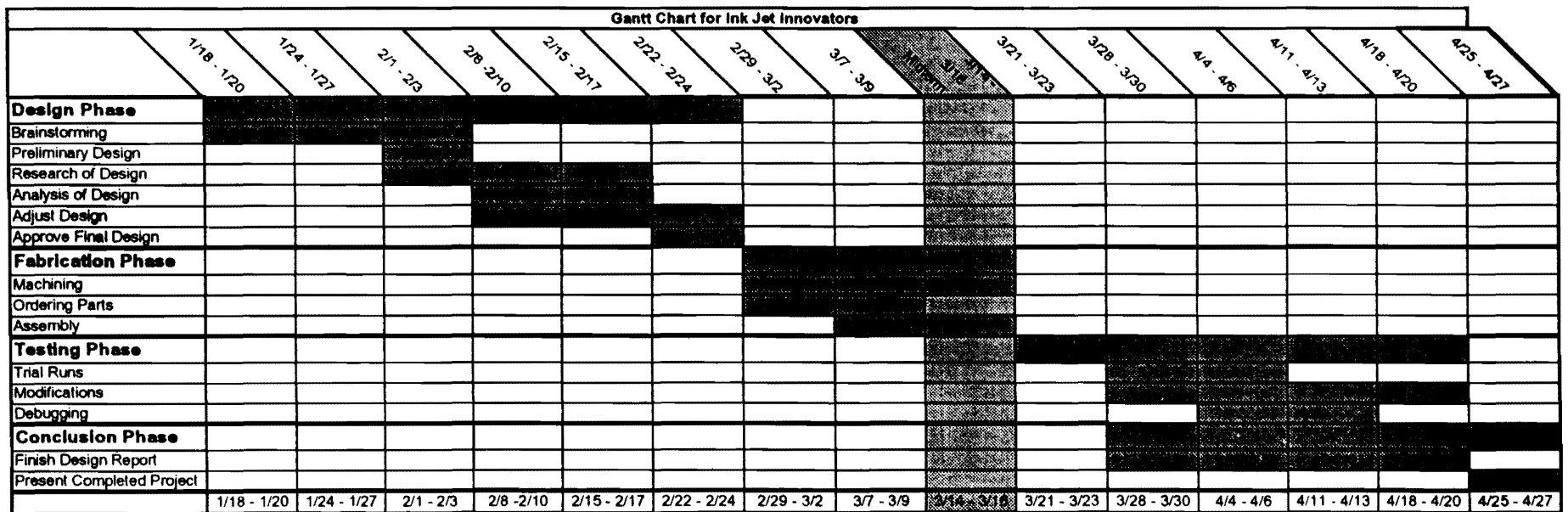
Another consideration for future work is to resize the timing keys and elements. Better tolerances and smaller size would make the mechanism a much more cost-effective design.

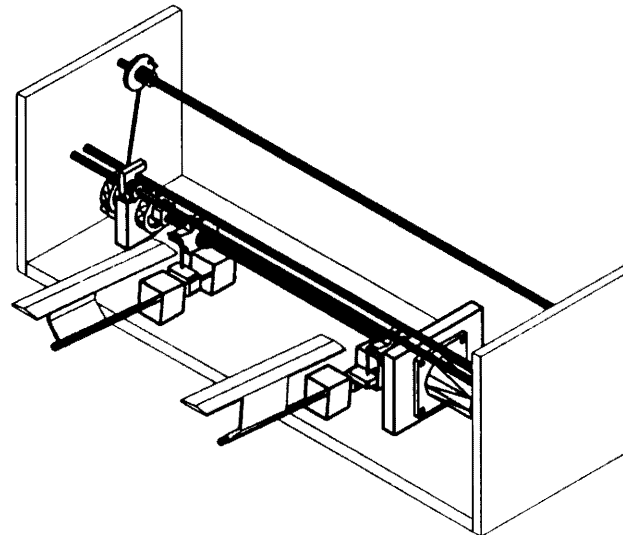
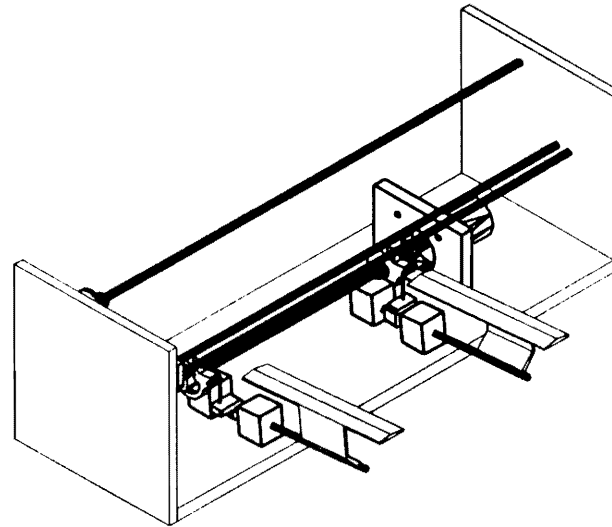
Finally, control over the mechanism would be much greater if the prototype’s current-bias springs were replaced with torsion springs placed directly on the shaft.

Conclusions

A prototype of this design was built and tested, and the design is able to meet the specifications given for required motions for each of the three functions. The model was designed to fit within the given space restrictions of the printer, and the total cost of parts (excluding motor and driver) and labor for one of these mechanisms was estimated to be between \$3.00 and \$3.50, well within the \$6.00 goal given. In conclusion, this design is functional, compact, and inexpensive, meeting or exceeding all given specifications.

Appendix

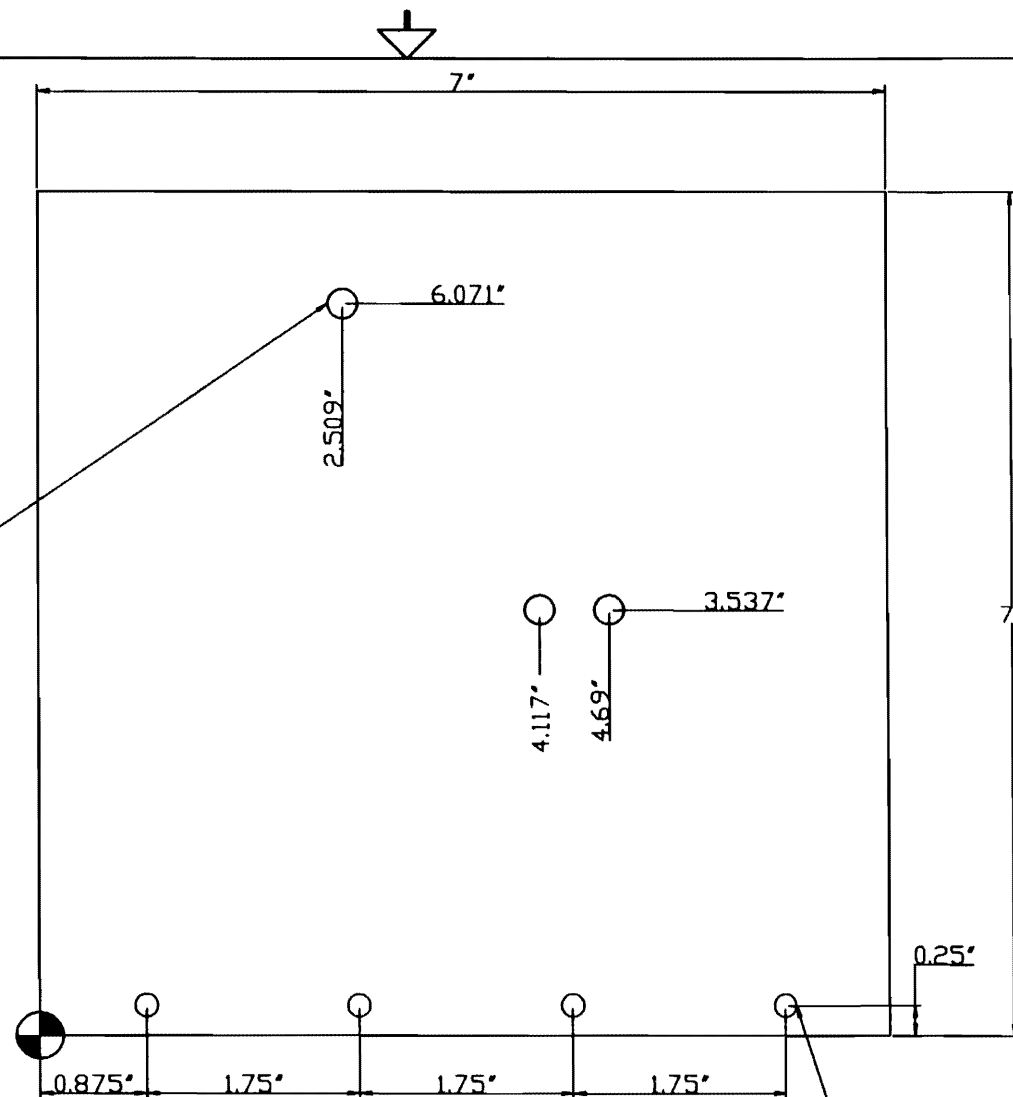




EVAN T. QUINLEY: 588-1857	COMMENTS:
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		FINAL ASSEMBLY	
SENIOR DESIGN PROJECT FOR LEXMARK, INC.		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE	
THE UNIVERSITY OF TENNESSEE, KNOXVILLE	SIZE A	DATE 5/2/2000	REV
	SCALE: NONE	REVIEWED BY:	DRAWN BY: CHRIS BRADLEY

DRILL "F" SIZE 3 PLACES
±0.001 ON ALL HOLE LOCATIONS



QTY X2

CONSTRUCT FROM LEXAN
3/8" THICK

CLEARANCE HOLES
FOR 10-24, 4 PLACES
MATCH HOLES TO BASE PLATE

IJI, INC.
INK JET INNOVATORS
CHRIS BRADLEY
SUZY LAVENDER
EVAN T. QUINLEY

SENIOR DESIGN PROJECT FOR
LED MARK, INC.

THE UNIVERSITY OF TENNESSEE,
KNOXVILLE

SIDE PLATE HOLE PATTERN

TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE

SIZE	DATE	DWG. NO.	REV
A	3/2/2000	SIDE_HOLE_PATTERN.DWG	
SCALE: NONE	REVIEWED BY:	DRAWN BY: ETQ	

EVAN T. QUINLEY: 888-1857

SUZY LAVENDER: 544-7143

CHRIS BRADLEY: 833-9820

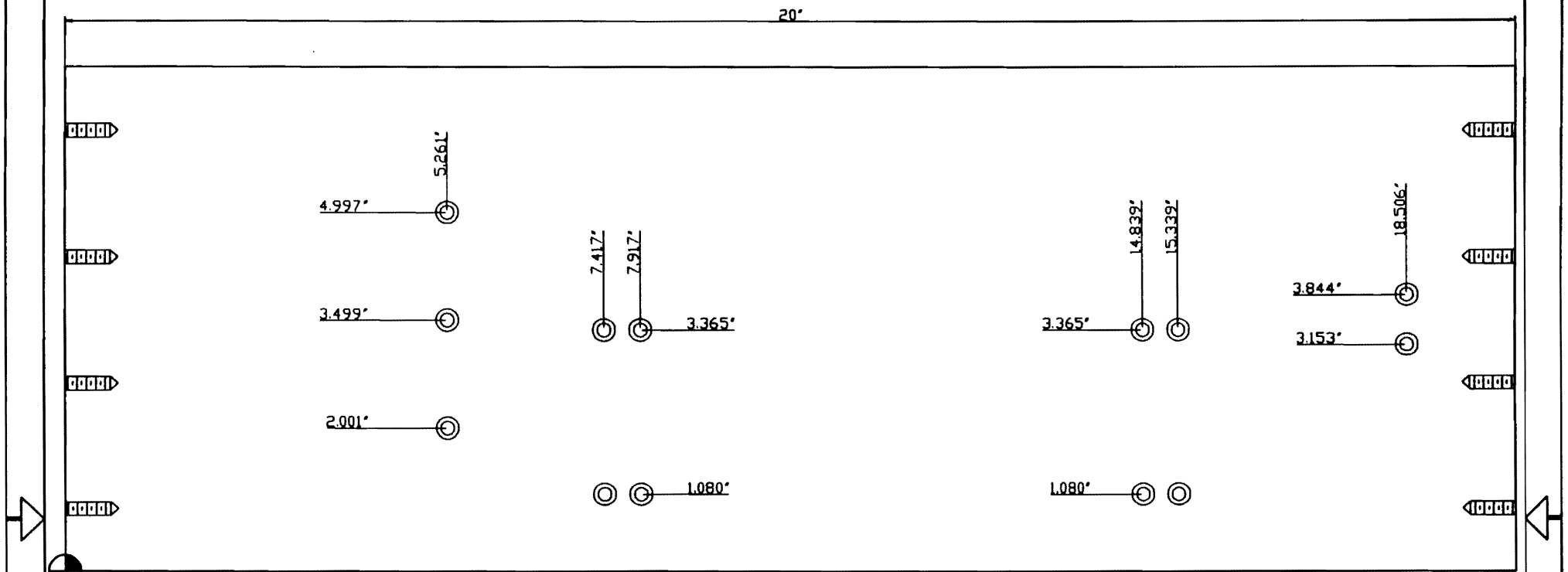
COMMENTS:

SIGNED:

DATE:

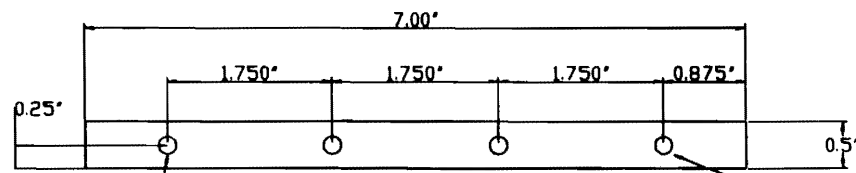


20'



BOTTOM VIEW

ALL HOLES CLEARANCE FOR 10-24,
COUNTERBORE 5/16 X 0.2 DEEP,
±0.001 ON ALL ABOVE HOLE LOCATIONS



DRILL & TAP FOR 10-24,
7/8" DEEP 8 PLACES

SIDE VIEW

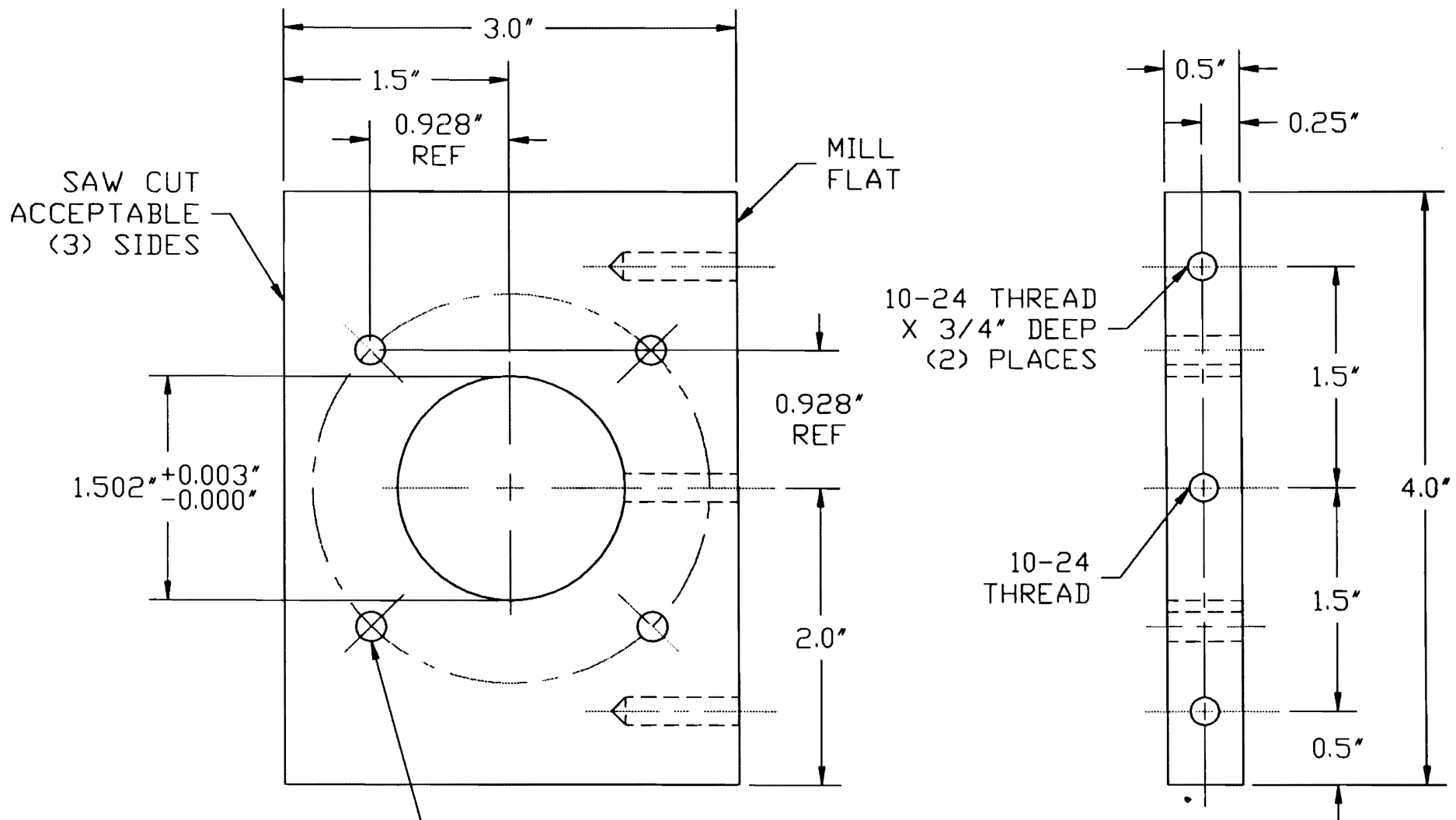
8 HOLES TO FIT SIDE PLATES

CONSTRUCT FROM PVC 1/2" THICK

EVAN T. QUINLEY: 588-1857	COMMENTS: CONSTRUCT FROM PVC
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC.
INK JET INNOVATORS
CHRIS BRADLEY
SUZY LAVENDER
EVAN T. QUINLEY
SENIOR DESIGN PROJECT FOR
LEXMARK, INC.
THE UNIVERSITY OF TENNESSEE,
KNOXVILLE

BASE PLATE HOLE PATTERN			
TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE			
SIZE A	DATE 3/2/2000	DWG. NO. BASE_HOLE_PATTERN.DWG	REV
SCALE: NONE	REVIEWED BY:	DRAWN BY: ETO	



MATERIAL: 1/2" PVC
QUANTITY: 1

CLEARANCE FOR 10-24
(4) HOLES EQ SP
ON A 2.625" DBC

LJI, INC.
INK JET INNOVATORS
CHRIS BRADLEY
SUZY LAVENDER
EVAN T. QUINLEY

SENIOR DESIGN PROJECT FOR
LIDMARK, INC.

THE UNIVERSITY OF
TENNESSEE, KNOXVILLE

RIGHT MOUNT FOR DRIVE SHAFT

TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE

SIZE A DATE 3/2/2000 DWG. NO. DRIVESHAFT_RIGHT_MOUNT.DWG REV

SCALE: FULL REVIEWED BY: DRAWN BY: BML

EVAN T. QUINLEY: 505-1657

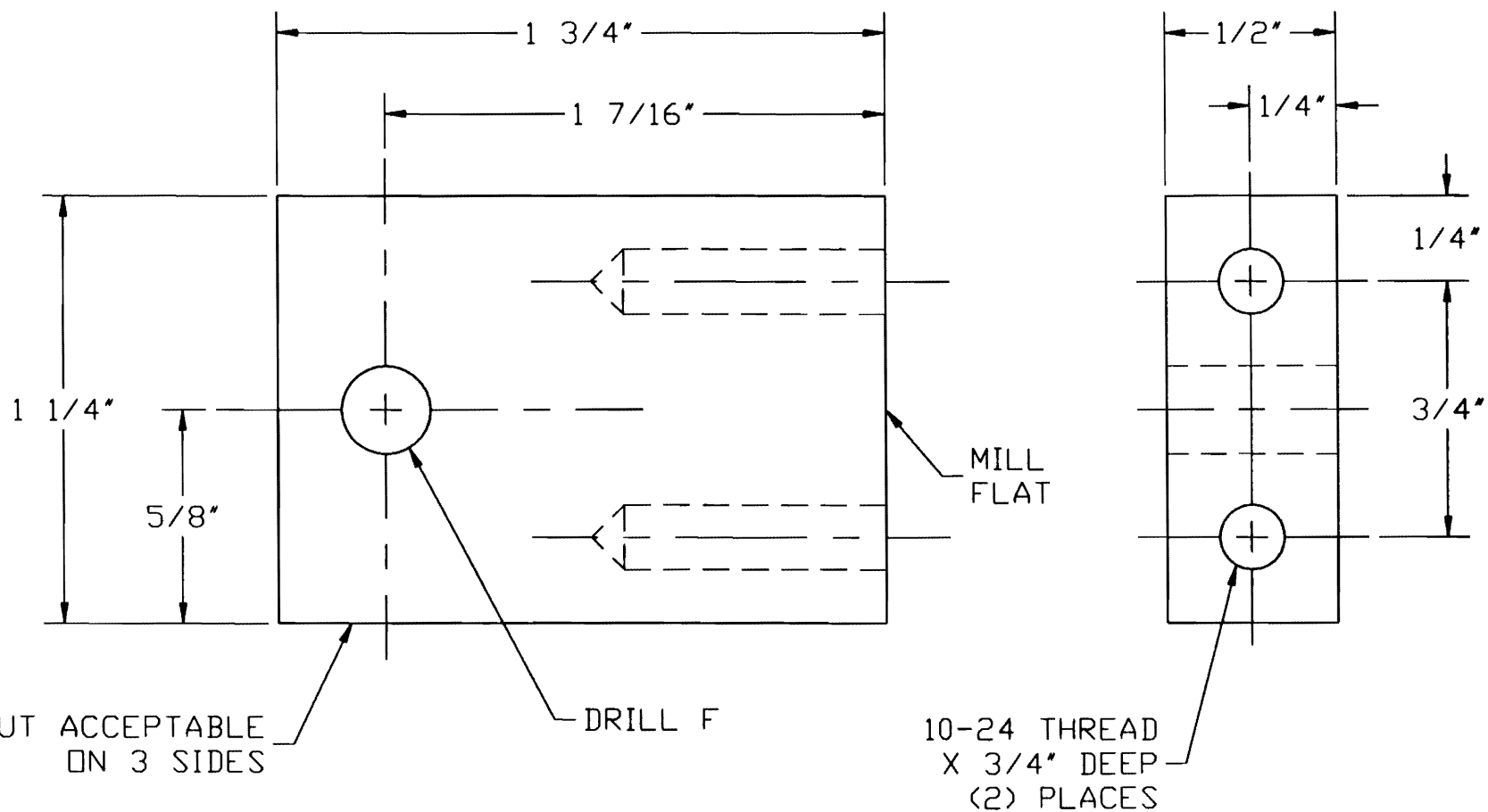
SUZY LAVENDER: 544-7143

CHRIS BRADLEY: 633-6630

COMMENTS:

SIGNED:

DATE:



SAW CUT ACCEPTABLE
ON 3 SIDES

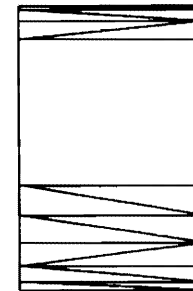
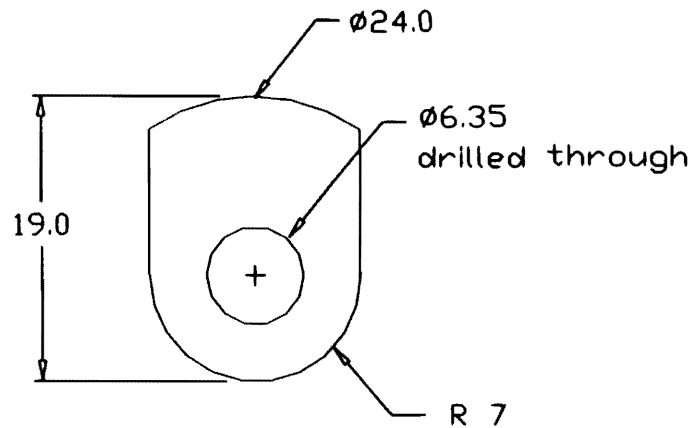
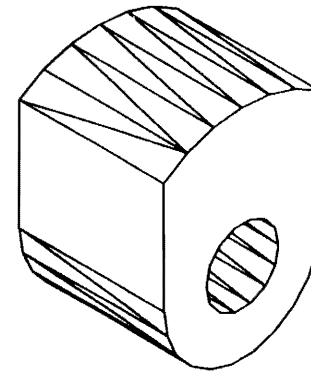
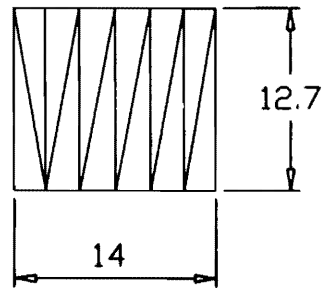
DRILL F

10-24 THREAD
X 3/4" DEEP
(2) PLACES

MATERIAL: 1/2" PVC
QUANTITY: 1

EVAN T. QUINLEY: 888-1857	COMMENT:
SUZY LAVENDER: 844-7143	
CHRIS BRADLEY: 633-8830	
SIGNED:	DATE:

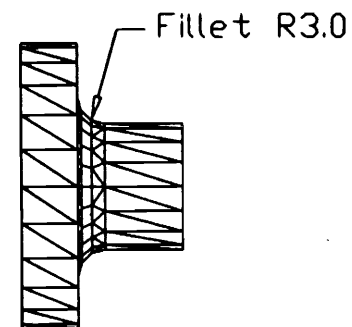
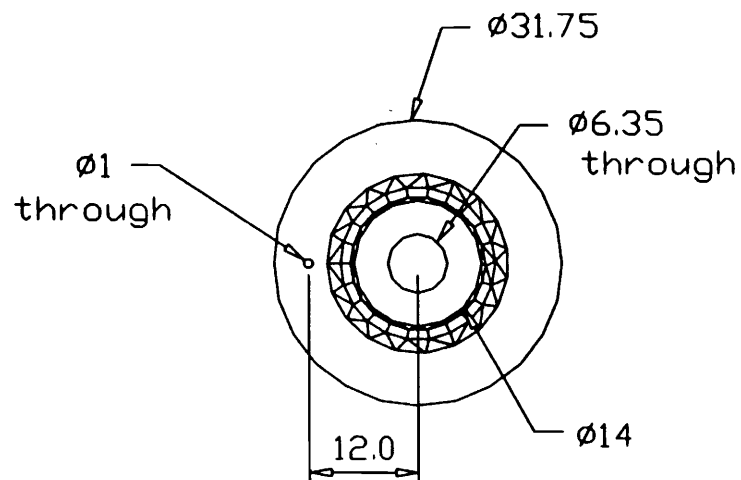
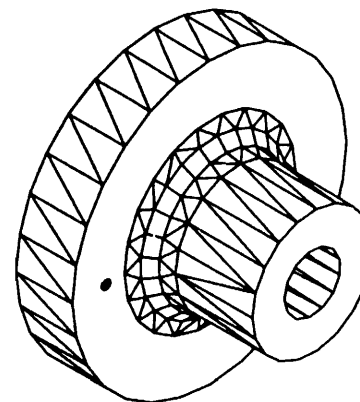
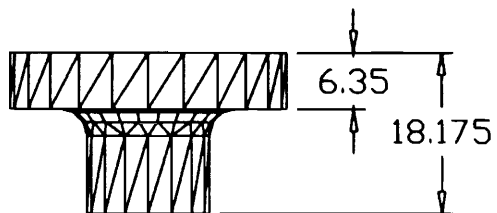
LI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		LEFT MOUNT FOR DRIVE SHAFT		
SENSOR DESIGN PROJECT FOR LIDMARK, INC.		TYPE ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE		
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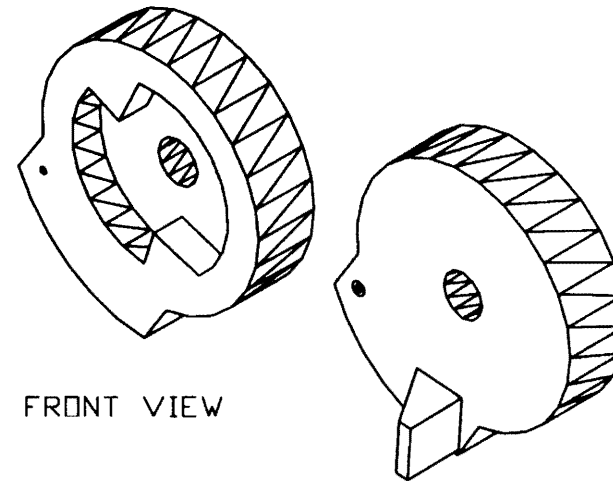
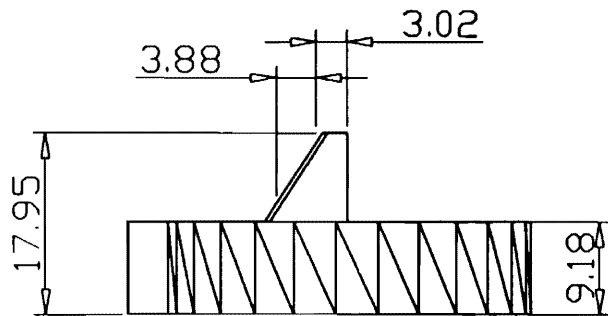
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SUZY LAVENDER: 644-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		DRIVE TAB		
SENIOR DESIGN PROJECT FOR LEXMARK, INC.		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE		
THE UNIVERSITY OF TENNESSEE, KNOXVILLE	SIZE A	DATE 5/2/2000	DWG. NO. TAB.DWG	REV
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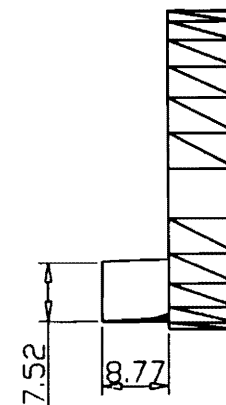
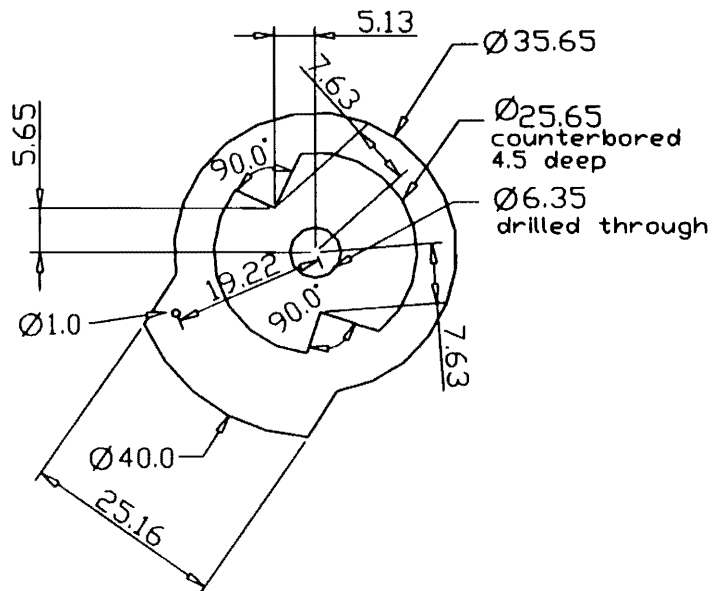
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CHRIS BRADLEY: 623-8820										
SIGNED:							DATE:			
			THE UNIVERSITY OF TENNESSEE, KNOXVILLE		SCALE: NONE		REVIEWED BY:		DRAWN BY: SML	



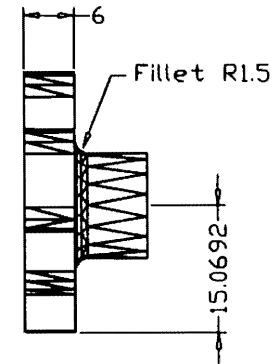
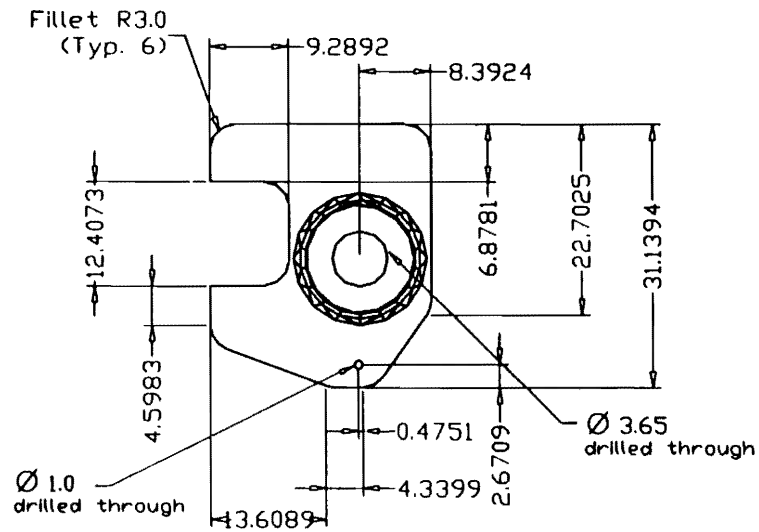
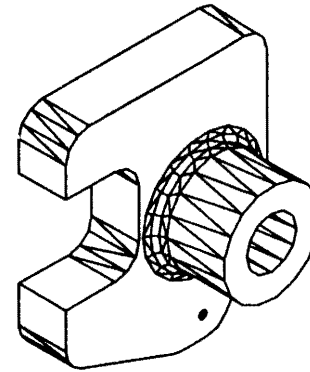
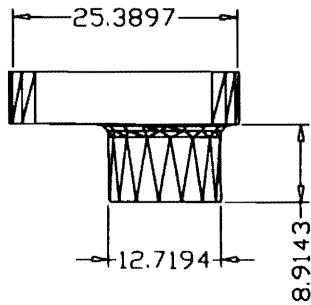
FRONT VIEW

BACK VIEW



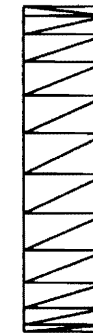
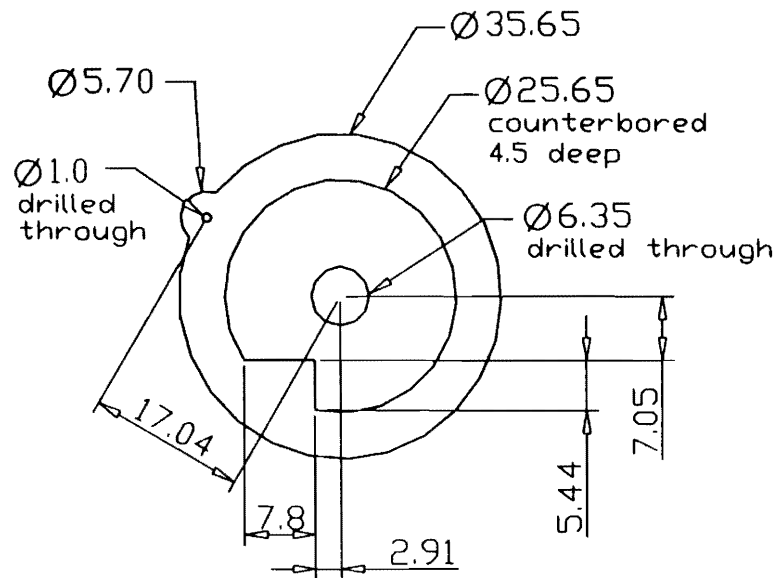
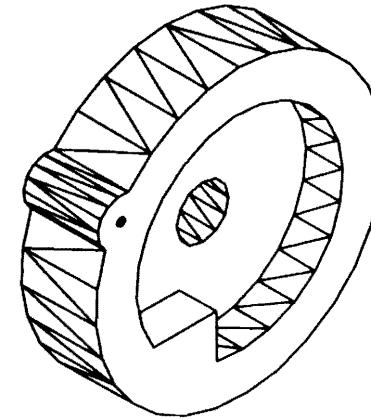
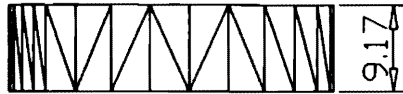
EVAN T. QUINLEY: 588-1857	COMMENTS:
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		STARWHEEL DRIVER			
		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE			
SENIOR DESIGN PROJECT FOR LEXMARK, INC.		SIZE A	DATE 5/2/2000	DWG. NO. STARWHEEL DRIVER.DWG	REV
THE UNIVERSITY OF TENNESSEE, KNOXVILLE		SCALE: NONE		REVIEWED BY:	DRAWN BY: CHRIS BRADLEY



EVAN T. QUINLEY: 588-1857	COMMENTS:
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		STAR WHEEL ACTUATER/STOP		
SENIOR DESIGN PROJECT FOR LEXMARK, INC.		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE		
SIZE A	DATE 5/2/2000	DWG. NO. STARWHEEL.DWG		REV
THE UNIVERSITY OF TENNESSEE, KNOXVILLE		SCALE: NONE	REVIEWED BY:	DRAWN BY: EVAN T. QUINLEY



IJI, INC.
 INK JET INNOVATORS
 CHRIS BRADLEY
 SUZY LAVENDER
 EVAN T. QUINLEY

STARWHEEL DRIVER

TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE

SENIOR DESIGN PROJECT FOR
 LEXMARK, INC.

SIZE A
 DATE 5/2/2000

DWG. NO. STARWHEELDRIVER.DWG

REV

THE UNIVERSITY OF TENNESSEE,
 KNOXVILLE

SCALE: NONE

REVIEWED BY:

DRAWN BY: CHRIS BRADLEY

EVAN T. QUINLEY: 588-1857

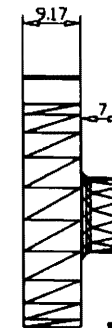
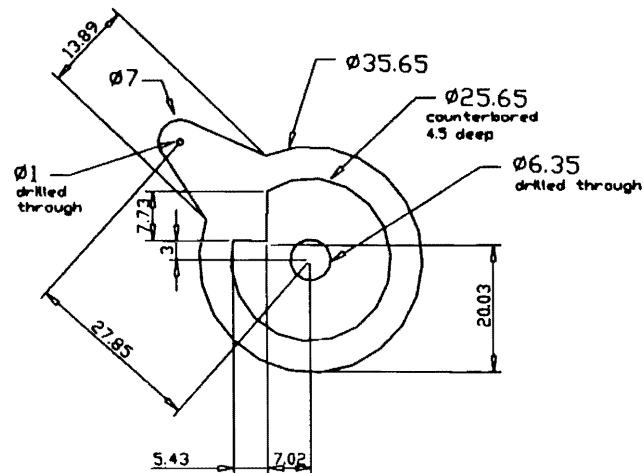
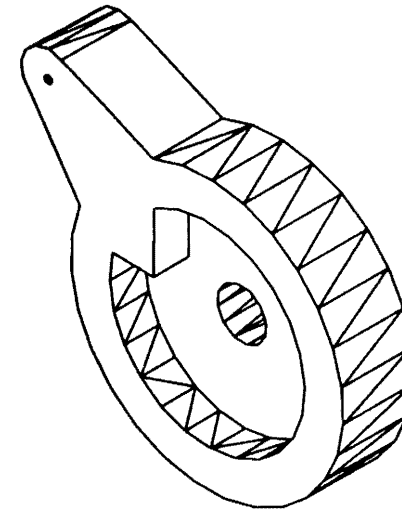
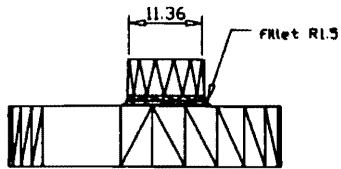
SUZY LAVENDER: 544-7143

CHRIS BRADLEY: 633-9820

COMMENTS:

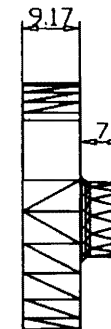
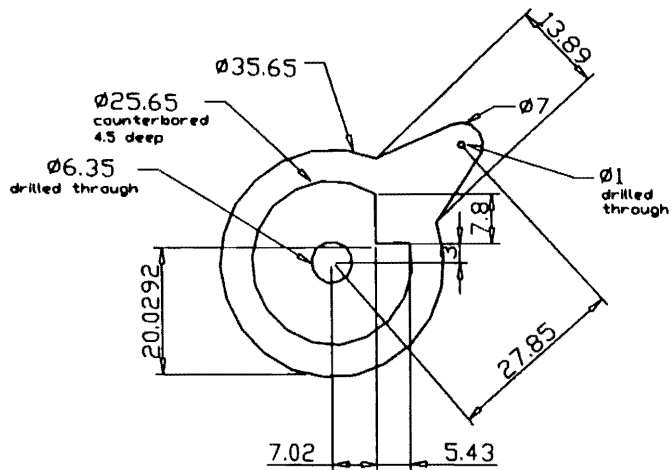
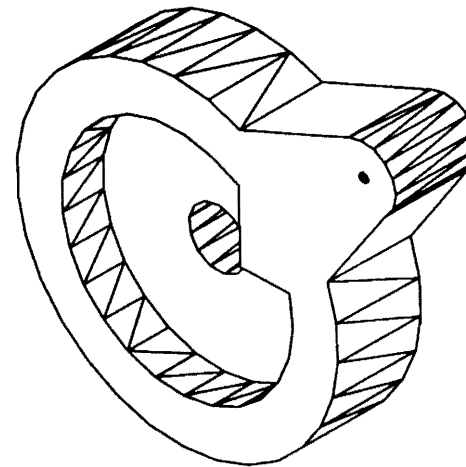
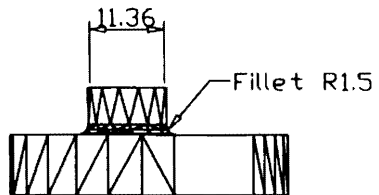
SIGNED:

DATE:



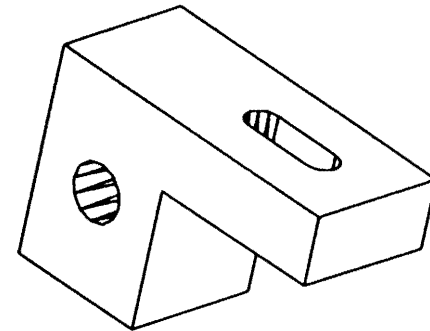
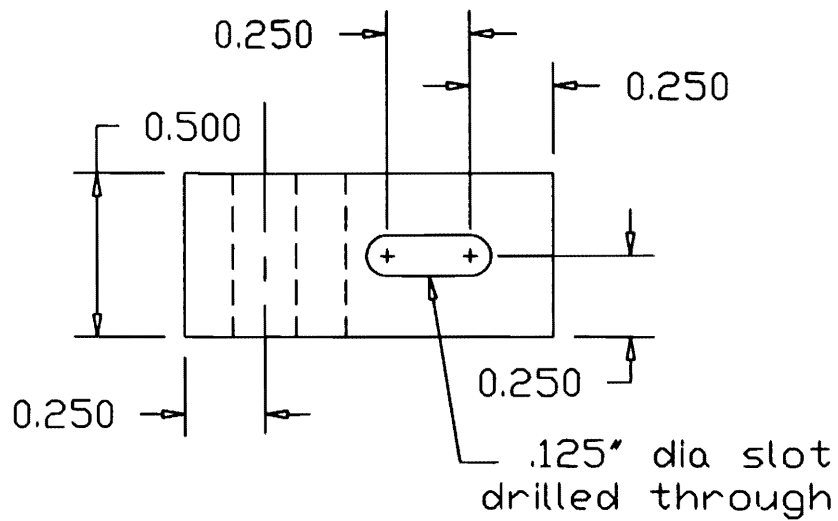
EVAN T. QUINLEY: 588-1857	COMMENTS:
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		RIGHT BATWING DRIVER		
SENIOR DESIGN PROJECT FOR LEXMARK, INC.		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE		
THE UNIVERSITY OF TENNESSEE, KNOXVILLE		SIZE A DATE 5/2/2000	DWG. NO. RIGHTBATWING.DWG	REV
		SCALE: NONE	REVIEWED BY:	DRAWN BY: CHRIS BRADLEY

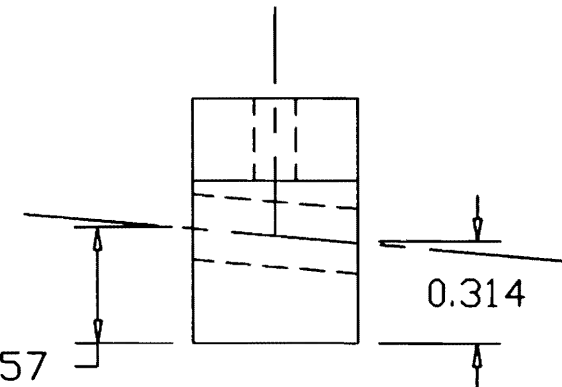
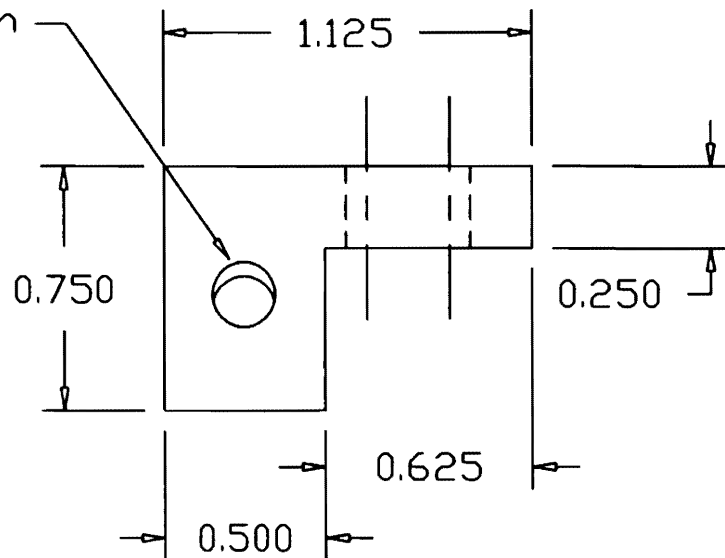


EVAN T. QUINLEY: 508-1857	COMMENTS:
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS		LEFT BATWING DRIVER		
CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE		
SENIOR DESIGN PROJECT FOR LEXMARK, INC.		SIZE A	DATE 5/2/2000	REV
THE UNIVERSITY OF TENNESSEE, KNOXVILLE		SCALE: NONE	DWG NO. BATWINGDRIVER.DWG	REVIEWED BY:
		DRAWN BY: CHRIS BRADLEY		



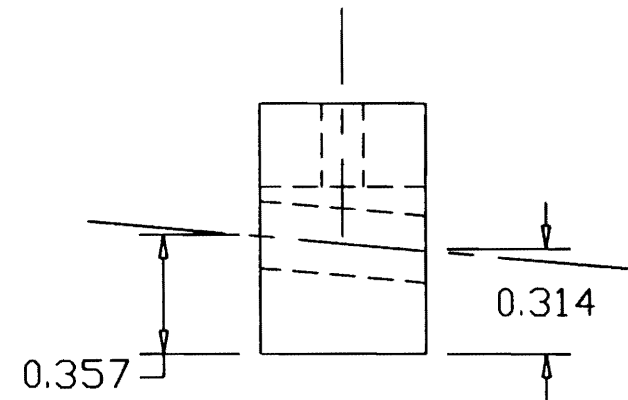
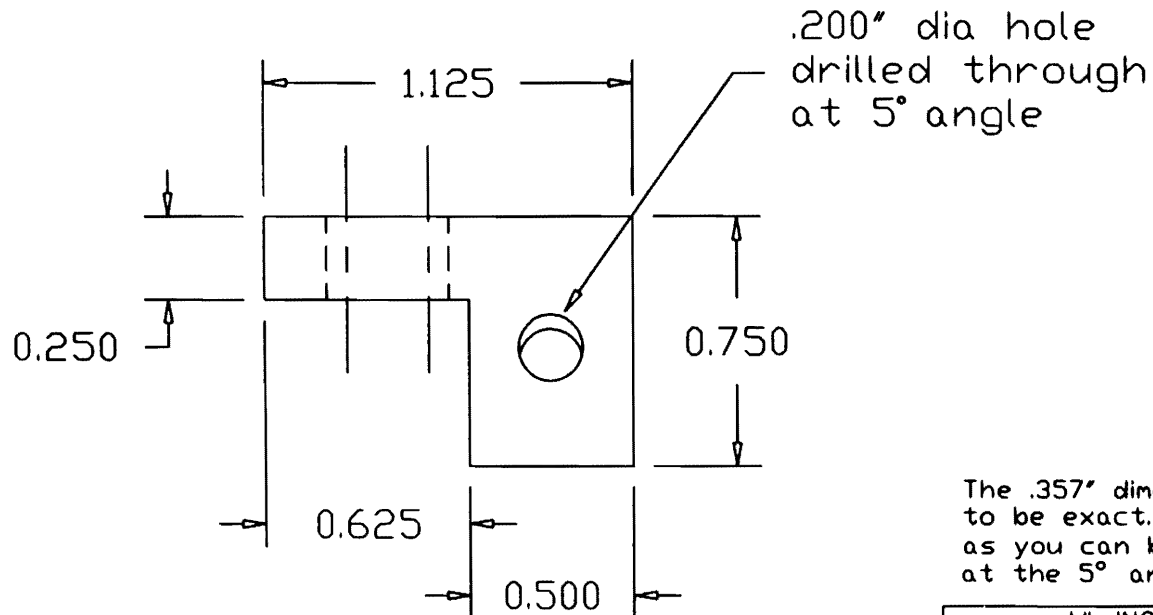
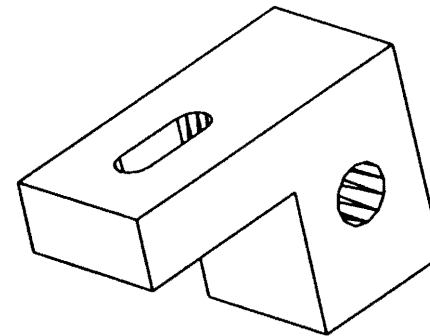
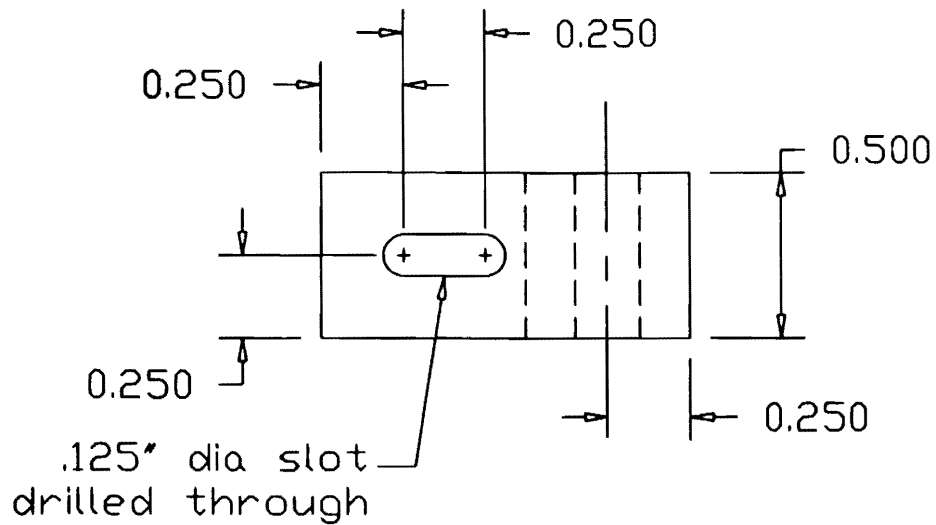
.200" dia hole drilled through at 5° angle



The .357" dimension doesn't have to be exact. Just get it as close as you can before drilling through at the 5° angle.

EVAN T. QUINLEY: 588-1857	COMMENTS: English Units
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-8820	
SIGNED:	DATE:

IJI, INC INC JET INNOVATORS		Left Bat-Wing Drive Tab	
CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE	
SENIOR DESIGN PROJECT FOR LEXMARK, INC.	SIZE A	DATE 3/10/00	DWG. NO. X00000X000.DWG
THE UNIVERSITY OF TENNESSEE, KNOXVILLE	SCALE: NONE	REVIEWED BY:	DRAWN BY: CHRIS BRADLEY



The .357" dimension doesn't have to be exact. Just get it as close as you can before drilling through at the 5° angle.

IJI, INC
INC JET INNOVATORS
CHRIS BRADLEY
SUZY LAVENDER
EVAN T. QUINLEY

SENIOR DESIGN PROJECT FOR
LEXMARK, INC.

THE UNIVERSITY OF TENNESSEE,
KNOXVILLE

Right Bat-wing drive tab

TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE

SIZE A DATE 3/10/00 DWG. NO. XXXXXX100L.DWG REV

SCALE: NONE

REVIEWED BY:

DRAWN BY:
ChrisBradley

EVAN T. QUINLEY: 568-1857

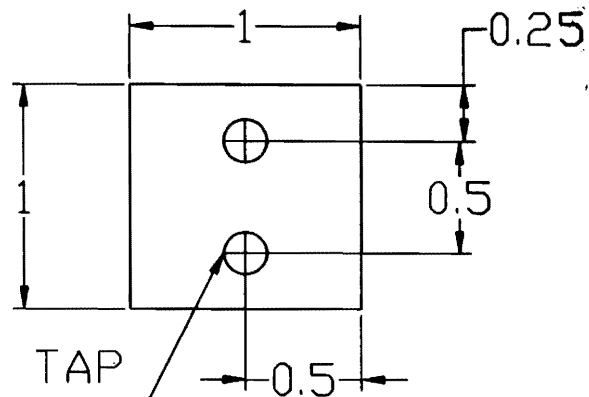
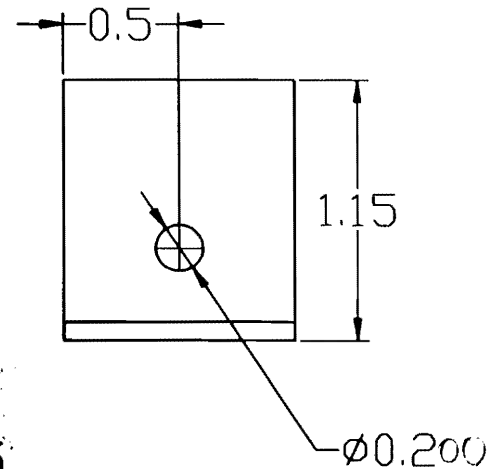
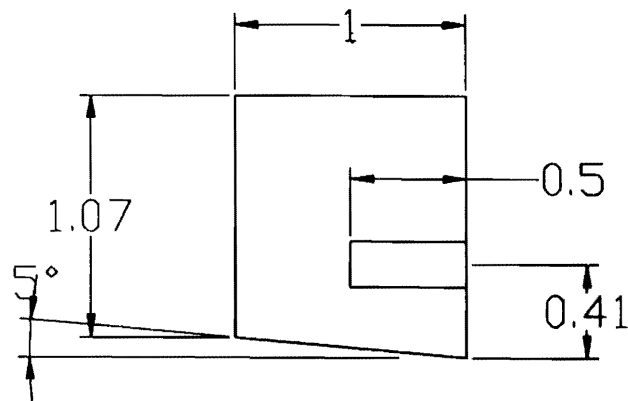
SUZY LAVENDER: 544-7143

CHRIS BRADLEY: 833-8820

COMMENTS: English Units

SIGNED:

DATE:



DRILL AND TAP
FOR 10-24, 3/4" DEEP

ALL TOLERANCES ARE
 ± 0.001

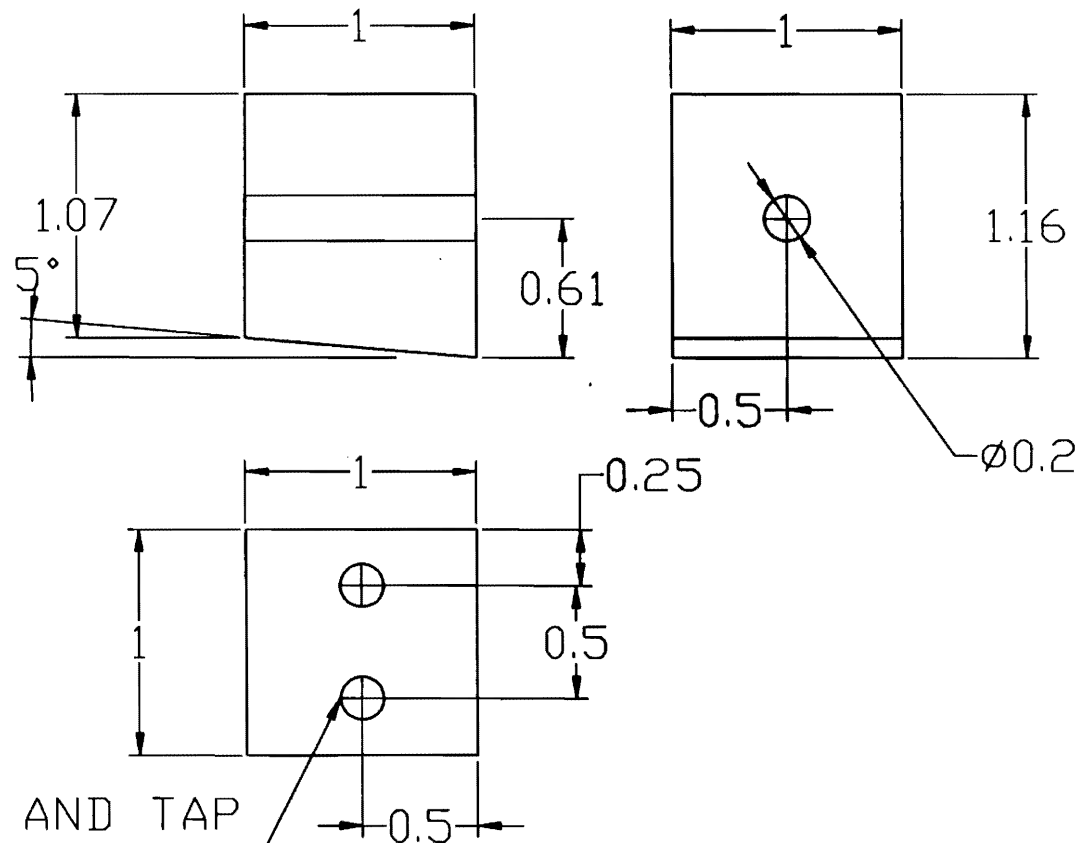
CONSTRUCT USING PVC
QUANTITY 2

EVAN T. QUINLEY: 688-1857	COMMENTS:
SUZY LAVENDER: 544-7143	
CHRIS BRADLEY: 633-8820	
SIGNED:	DATE:

IJI, INC.
INK JET INNOVATORS
CHRIS BRADLEY
SUZY LAVENDER
EVAN T. QUINLEY
SENIOR DESIGN PROJECT FOR
LEDMARK, INC.
THE UNIVERSITY OF TENNESSEE,
KNOXVILLE

BATWING MOUNT 1

TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE			
SIZE A	DATE 2/24/2000	DWG. NO. BATWING_MOUNTS.DWG	REV
SCALE: NONE	REVIEWED BY: <i>SML</i>	DRAWN BY: ETO	



DRILL AND TAP
FOR 10-24, 3/4" DEEP

ALL TOLERANCES ARE
 ± 0.001

CONSTRUCT USING PVC
QUANTITY 2

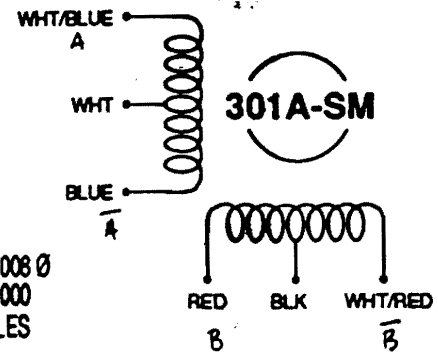
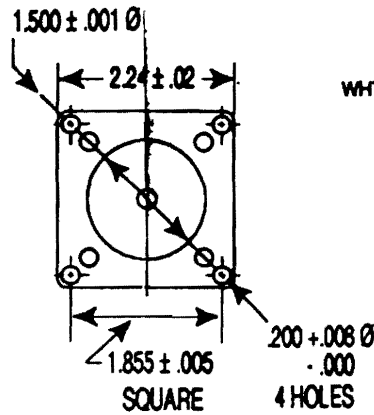
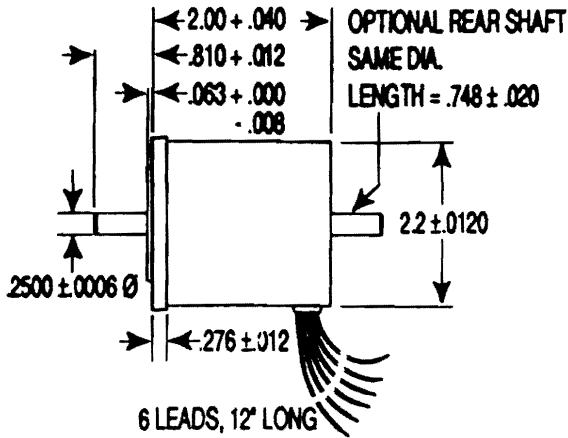
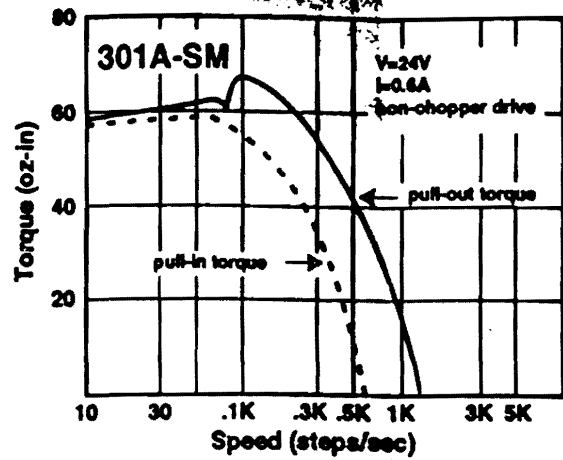
EVAN T. QUINLEY: 688-1867	COMMENTS:
SUZY LAVENDER: 644-7143	
CHRIS BRADLEY: 633-9820	
SIGNED:	DATE:

IJI, INC. INK JET INNOVATORS CHRIS BRADLEY SUZY LAVENDER EVAN T. QUINLEY		BATWING MOUNT 2		
SENIOR DESIGN PROJECT FOR LEIBNIZ, INC.		TYPE: ☐ ASSEMBLY ☐ SHOP ☐ REFERENCE		
THE UNIVERSITY OF TENNESSEE, KNOXVILLE		SIZE A	DATE 2/24/2000	DWG. NO. BATWING_MOUNTS.DWG
		SCALE: NONE	REVIEWED BY: <i>SM</i>	REV DRAWN BY: ETO

301A-SM

1.8°/step...12VDC...0.6A/phase...83oz-in max torque

D.C. Operating Voltage	12VDC
Step Angle	1.8°
Step Angle Tolerance	±0.1°
Holding Torque	83 Oz-In
Max. Rate. (on std. L/R drive)	395 steps/sec.
Resistance per Phase	20 ohms
Inductance per Phase	36 mH
Power Consumption	14.4 watts
Insulation Resistance	20 M ohms
Bearings	Ball Bearings
Operating Temperature Range	-10°C to +50°C
Weight	20 oz.



Visual Basic Code
To Run Stepper Motor
Ink Jet Innovators

```
Option Explicit
Dim counter As Integer
Dim counter2 As Integer
Dim x As Integer
```

```
Private Sub Form_Load()
'disable the motor
vbOut &H378, 8
End Sub
```

'the next two subroutines set the counters to perform an entire print cycle

```
Private Sub cmdEnvTest_Click()
    counter = 0
    counter2 = 1
    x = 289
    Runtest
End Sub
```

```
Private Sub cmdPaper_Click()
    'set counter2 to skip ph motion
    counter = 0
    counter2 = 193
    x = 289
    Runtest
End Sub
```

'the next 4 subroutines set the counters to perform only one task at a time

```
Private Sub cmdprinth_Click()
    counter = 0
    counter2 = 1
    x = 96
    Runtest
End Sub
```

```
Private Sub cmdstarw_Click()
    counter = 2
    counter2 = 97
    x = 215
    Runtest
End Sub
```

```
Private Sub cmdbatw_Click()
    counter = 2
    counter2 = 221
    x = 240
    Runtest
End Sub
```

```
Private Sub cmdhome_Click()
```

```
    counter = 0
```

```
    counter2 = 247
```

```
    x = 289
```

```
    Runtest
```

```
End Sub
```

```
Private Sub Runtest()
```

```
Do While counter2 < x
```

```
    Select Case counter
```

```
        Case 0
```

```
            'step clockwise
```

```
            vbOut &H378, 7
```

```
        Case 1
```

```
            'don't step clockwise
```

```
            vbOut &H378, 6
```

```
        Case 2
```

```
            'step ccw
```

```
            vbOut &H378, 5
```

```
        Case 3
```

```
            'don't step ccw
```

```
            vbOut &H378, 4
```

```
    End Select
```

```
    If counter2 < 96 Then
```

```
        'raise printhead carrier
```

```
        'by taking 48 steps cw
```

```
        If counter = 0 Then
```

```
            counter = 1
```

```
        Else
```

```
            counter = 0
```

```
        End If
```

```
    ElseIf counter2 = 96 Then
```

```
        'wait for 1 second
```

```
        Dim startTime
```

```
        startTime = Timer
```

```
        Do While Timer < startTime + 1
```

```
        Loop
```

```
    ElseIf counter2 < 220 Then
```

```
        'lower starwheels
```

```
        'by taking 61 steps ccw
```

```
        If counter = 2 Then
```

```
            counter = 3
```

```
        Else
```

```
            counter = 2
```

```
        End If
```

```
    ElseIf counter2 = 220 Then
```

```
        'wait for 1 second
```

```
        Dim startTime2
```

```
        startTime2 = Timer
```

```
        Do While Timer < startTime2 + 1
```

```
        Loop
```

```

ElseIf counter2 < 240 Then
    'open batwings
    'by taking 10 steps ccw
    If counter = 2 Then
        counter = 3
    Else
        counter = 2
    End If

ElseIf counter2 = 240 Then
    'wait for 1 second
    Dim startTime3
    startTime3 = Timer
    Do While Timer < startTime3 + 1
        Loop

ElseIf counter2 < 288 Then
    'return to home position
    'by taking 24 steps cw
    If counter = 0 Then
        counter = 1
    Else
        counter = 0
    End If

Else
    'disable the motor
    vbOut &H378, 8

End If

counter2 = counter2 + 1

DelayLoop

Loop

End Sub

Private Sub DelayLoop()
    'count to i
    Dim i As Integer
    For i = 0 To txtDly1.Text
        Next i
End Sub

```