Dual Motor Gear Switching Mechanical Assembly

The TechnoKats Robotics Team, a partnership between Delphi Automotive Systems and Kokomo High School in Kokomo, Indiana, is proud to be able to share their Drive Motor Assembly (DMA) from the 2001 FIRST Robotics Competition.

The DMA consisted of two motors and had the ability to switch between speeds, which we called low gear and high gear. This design shows the Fisher-Price Motor mounted inline to the back end of the Bosch Drill Motor. The Drill Motor's gearbox was still used, while the Servo actuated the lever arm to switch between low and high gear. This design uses a 12 tooth sprocket (35 type) and 3/8" dia. ball bearings from SPI or the FIRST kit.

We used two of these assemblies to drive our robot, TechnoKart. One assembly was used for each side of our robot, as we used tank-style steering with metal tank treads for superior traction.

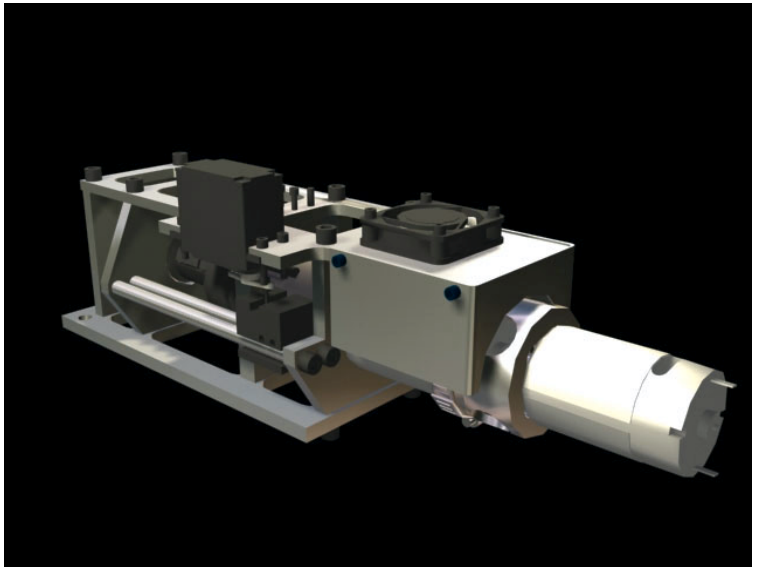
Advantages:
The obvious result of this design is the fact that it produced more power than simply using the Drill Motor. We did not perform any studies to show exactly how much more power this assembly generates versus just using the Drill Motor, but we estimate that a 40% increase in power was produced by the two motors working together. There are other drive train designs that use 4 motors, but this dual motor design uses one gear box that utilizes gear switching to get an optimal mix of power and speed. For the 2001 competition, this power, speed, and traction combination was valuable for us, as we consistently auto-balanced on the bridge (see "Auto-Balancing Gyro Code" White Paper).

Performance:
Once we started test driving our robot with these new DMA's, we realized more benefits than just more power. We were able to run these DMA's in high gear for a very long time (5-8 minutes) before they would over heat. Usually, when we design a drive system that has a high and low gear (see "Gear Switching with Servo" White Paper – to be released, summer 2001), we try to get our high speed to push our robot as quickly as possible. The problem with running a fast robot is that the electrical system gets overheated quickly, within 30-60 seconds. Our geartrain design for TechnoKart had a very aggressive ratio, at 3:1 from the Drill Motor Gearbox, driving 7.5" dia. wheels (treads, actually). At this speed, we

expected the circuit breakers to trip as the electrical system heated up under the high load, but it didn't. Once we thought about this, it made sense. Since 4 motors are used, the amps used to drive the robot were being distributed over 4 motors, distributing the current load more diversely compared to a 2 motor drive system. Again, we did not take the time to evaluate how much current was distributed to each motor. Maybe we will have time in 2002 to do some performance test on this assembly, if it is used again.

Our Experience:
We did experience some trouble with this mechanical assembly. All of the trouble was concentrated on the mechanical coupling area between the two motors. 6 or 7 times, the weld broke on the small hex shafts that were attached to the Drill Motor or the Fisher-Price motor. This happened more often on the Drill Motor, since the F-P motor shaft has some serrations that help keep the hex shaft fitted tightly. Luckily for us, these problems only happened during practice times, away from any FIRST Competitions. This design of press-fitting and welding the hex shafts onto the motor shafts needs to be improved for the 2002 season, but a solution is not designed yet. If you find something that works 100% of the time, please share your resulting design.

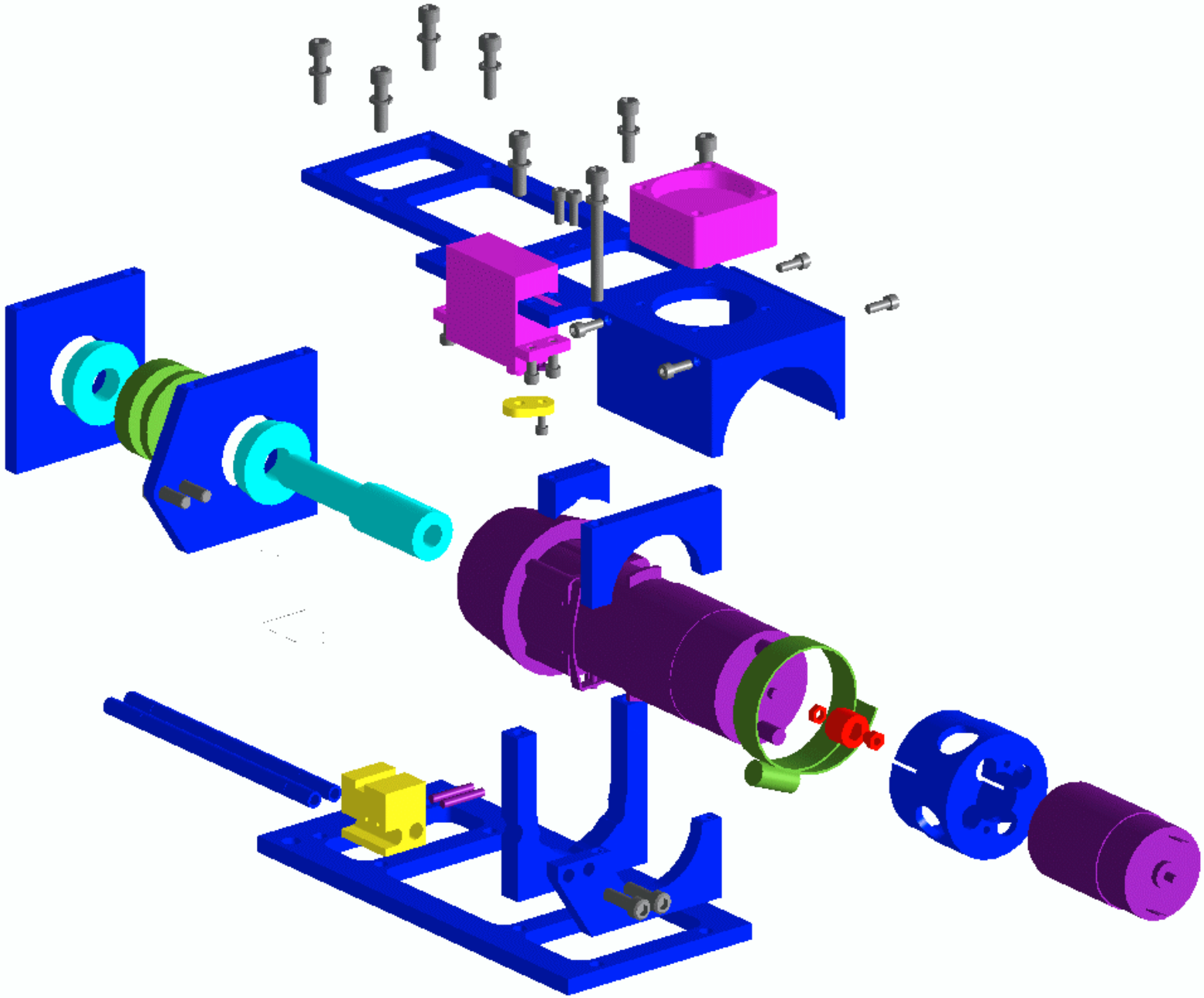
As for building your own assembly, use these designs as you wish. You will notice that there are a few prints that have four place decimal dimensions included, so be careful as you machine these high-tolerance parts. Getting +/- 0.0005" is definitely not easy to do. While this sort of accuracy is not absolutely necessary to get this assembly to work, performance will be affected. For instance, the Drill Motor will wobble if it's parts do not hold it in a concentric manner. It is suggested that these high-precision parts are to be fabricated on a CNC mill in order to get the accuracy needed.



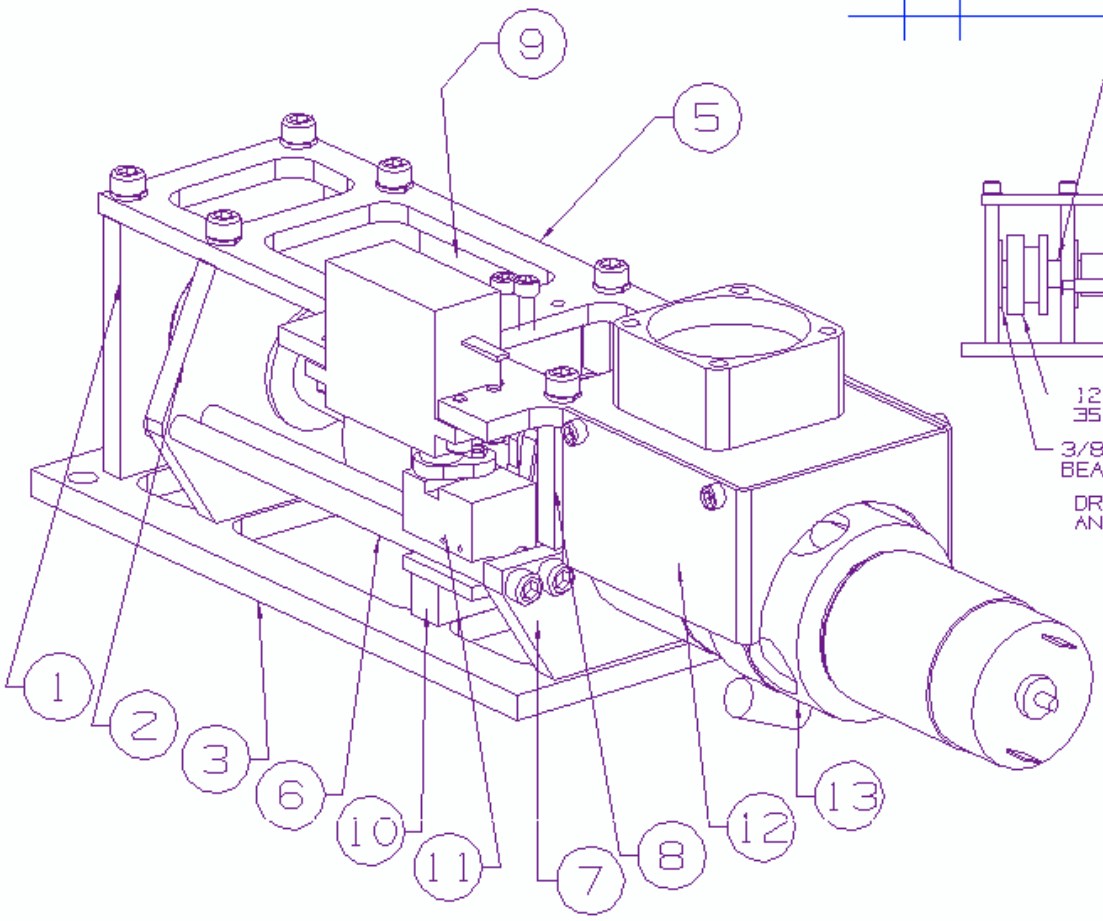
Feedback:
Your comments about the design are welcome, but you are on your own with regard to how this thing goes together and how it performs in Competitions. For questions/comments, you can email Andy Baker at andrew.r.baker@delphiauto.com.

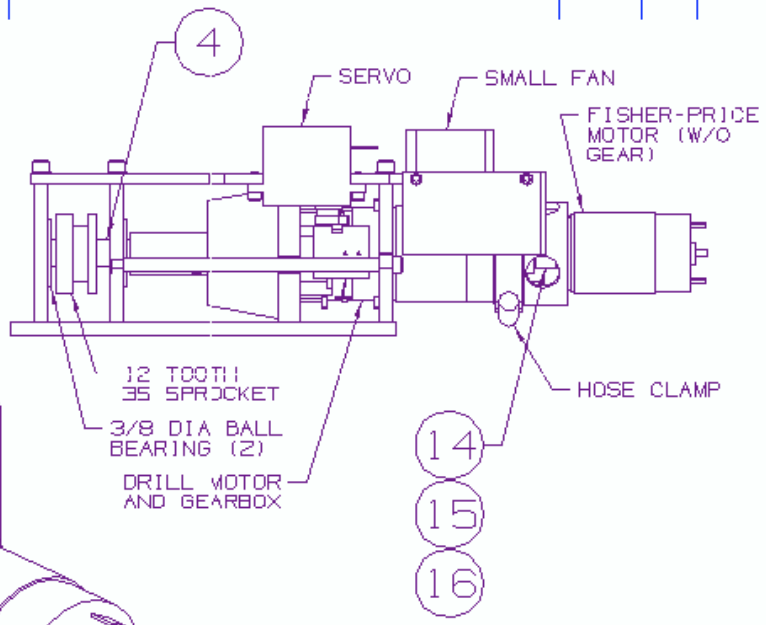
A Challenge:
For those of you who use this design, please consider publishing your own designs and technical work so that the rest of the FIRST Community can benefit as you have. The goal here is to raise the level of competition within FIRST, and provide resources to teams who do not have as much as other teams. Also, don't keep this design to yourself. Please share this resource with other teams in your area to show them how to increase their performance.

Print Package:
The following pages contain the prints for this design. The first two pages are assembly drawings, and the others are detail prints. These were made on 11"x17" sheets (B size prints), so the scale (Full Scale, 2x Scale, etc.) you see is not correct. Good luck, and we hope that this design provides your team with added performance.



CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE





PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--10--01
DESIGN ENGINEER Andy Baker	DETAILER ARB
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

ONE/ONE SOFTWARE
Unigraphics Solutions

CHANGE RESTRICTED

DELPHI
Automotive Systems

Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME 2001 TECHNOKATS ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

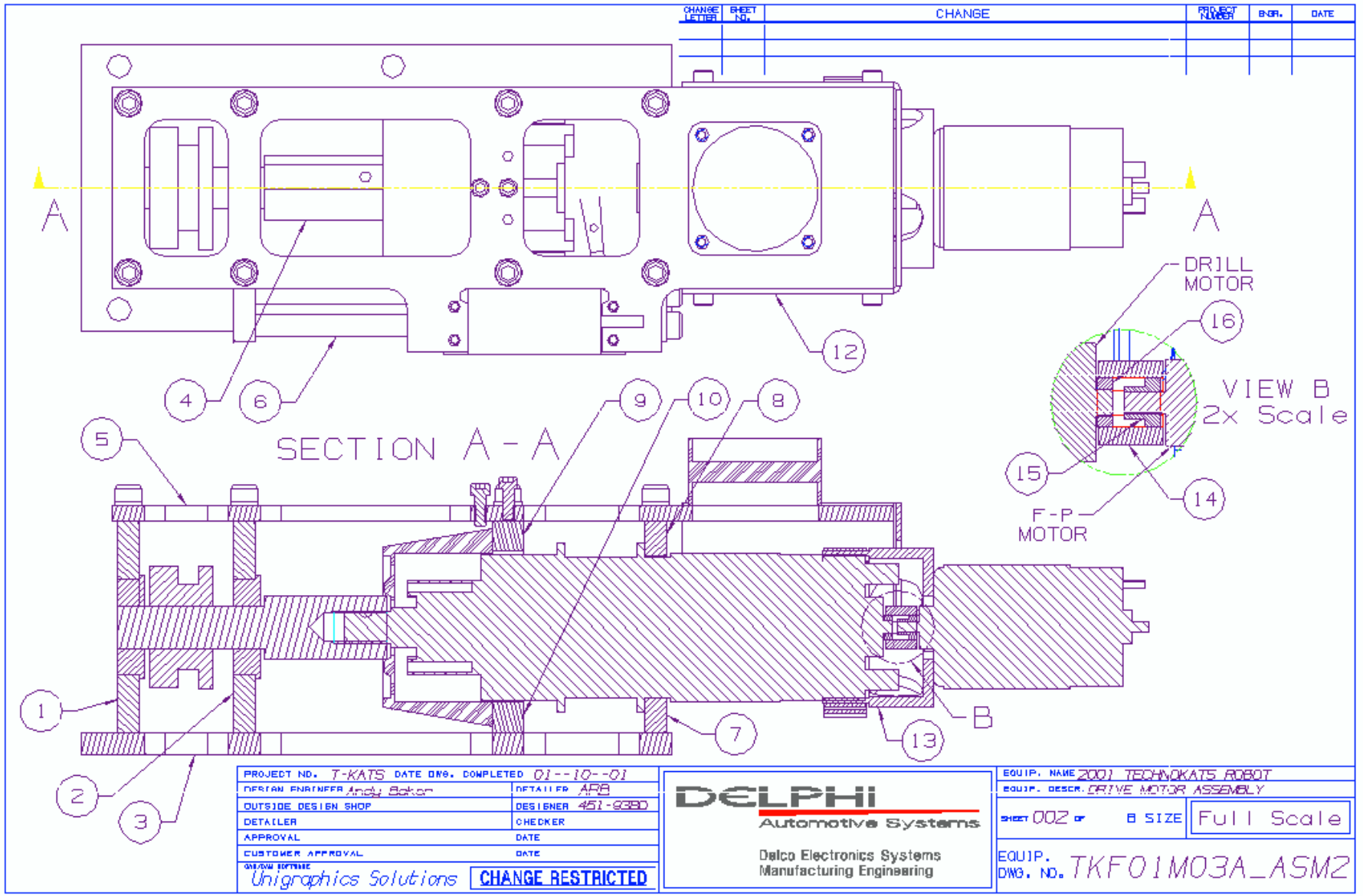
SHEET 001 OF | B SIZE | Full Scale

EQUIP. DWG. NO. TKF01M03A_ASM01

MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.


CHANGE LETTER
SHEET NO.
CHANGE
PROJECT NUMBER
ENGR.
DATE
A
A
SECTION A-A
DRILL MOTOR
VIEW B
2x Scale
F-P MOTOR
B
1
2
3
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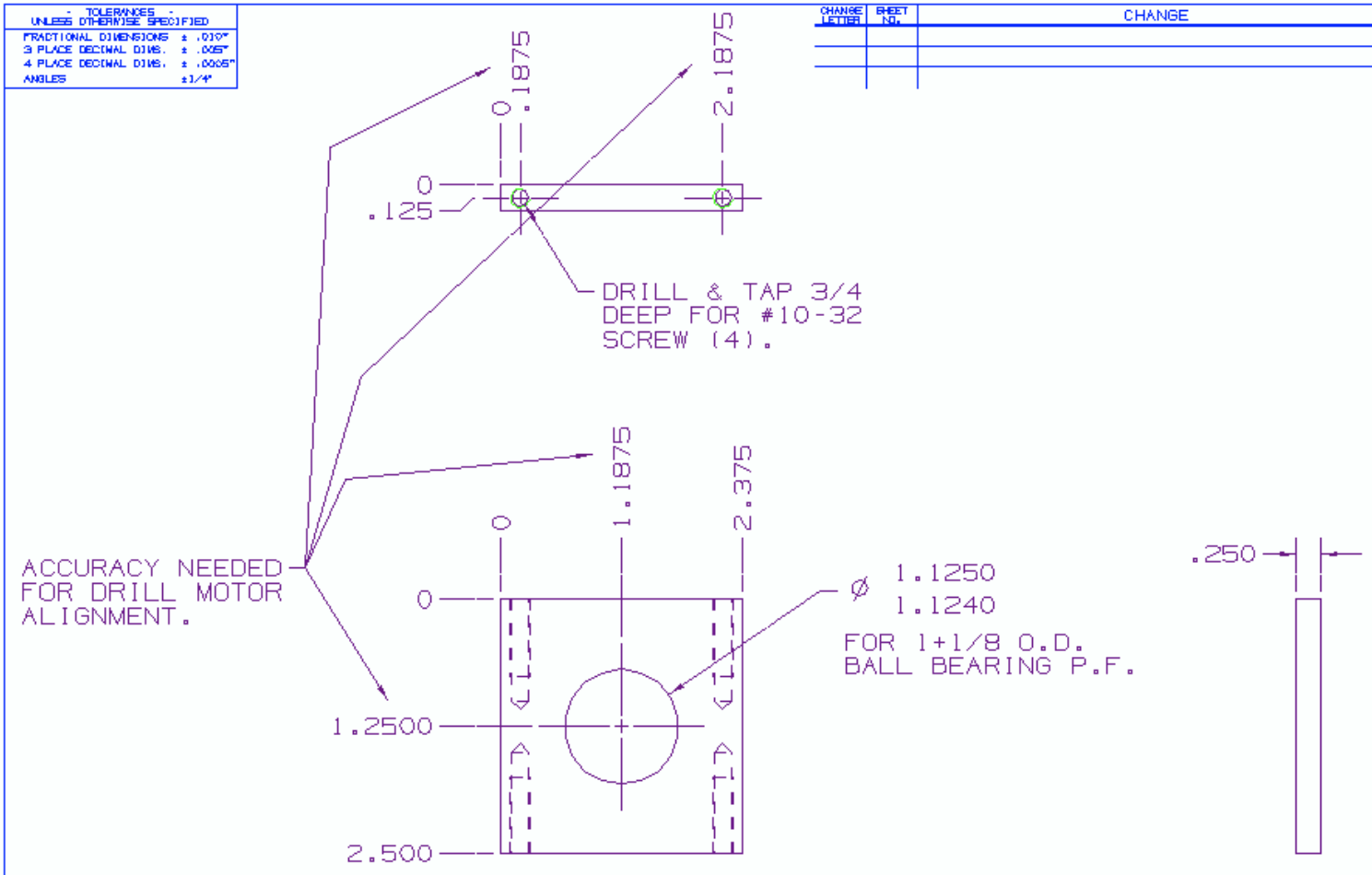
16
PROJECT NO. T-KATS DATE DWG. COMPLETED 01--10--01
DESIGN ENGINEER Andy Baker
DETAILER ARB
OUTSIDE DESIGN SHOP
DESIGNER 451-9380
DETAILER
CHECKER
APPROVAL
DATE
CUSTOMER APPROVAL
DATE
CAD/CAM SOFTWARE
Unigraphics Solutions
CHANGE RESTRICTED
DELPHI
Automotive Systems
Delco Electronics Systems
Manufacturing Engineering
EQUIP. NAME 2001 TECHNOKATS ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
SHEET 002 OF
B SIZE
Full Scale
EQUIP. DWG. NO. TKF01M03A_ASM2
MARK WITH DET.# AND DWG.#
JOB TAG PLACEMENT ABOVE
BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



MM DETAIL PART NUMBER

NAME SMALL BEARING PLATE

MATL. 1/4" ALUM. PLATE

NO. REQ'D 2

HT. TREAT

FINISH

PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01
DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

CAD/CAM SOFTWARE Unigraphics Solutions

CHANGE RESTRICTED

DELPHI Automotive Systems

Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT

EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

SHEET 001 OF | B SIZE | Full Scale

EQUIP. DWG. NO. TKF01M03A_D01

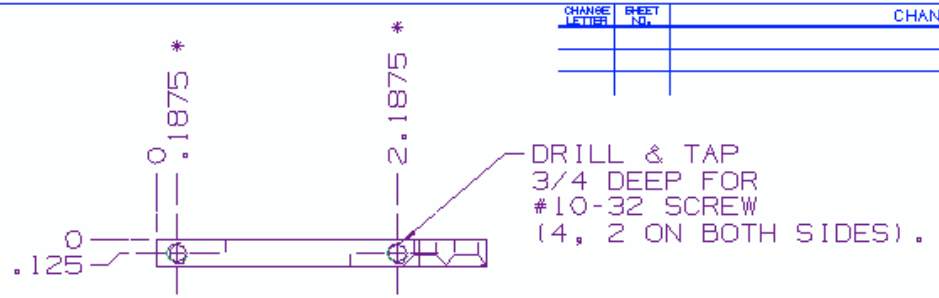
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

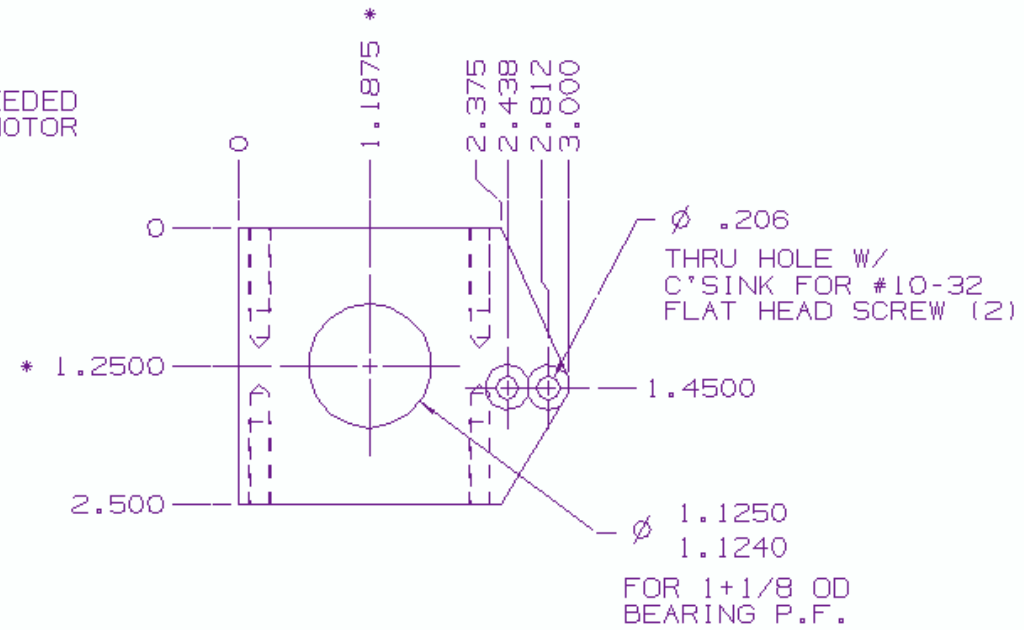
BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

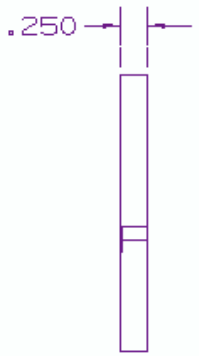
- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



* - NOTE:
ACCURACY NEEDED
FOR DRILL MOTOR
ALIGNMENT.





MM DETAIL PART NUMBER

NAME LARGE BEARING PLATE

MATL. 1/4" ALUM. PLATE

NO. REQ'D 2

HT. TREAT

FINISH

PROJECT NO. T-KATS DATE DWG. COMPLETED 01--11--01

DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

ONE/ONE SOFTWARE
Unigraphics Solutions

CHANGE RESTRICTED

DELPHI
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Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT

EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

SHEET 002 OF | B SIZE | Full Scale

EQUIP. DWG. NO. TKF01M03A_D02

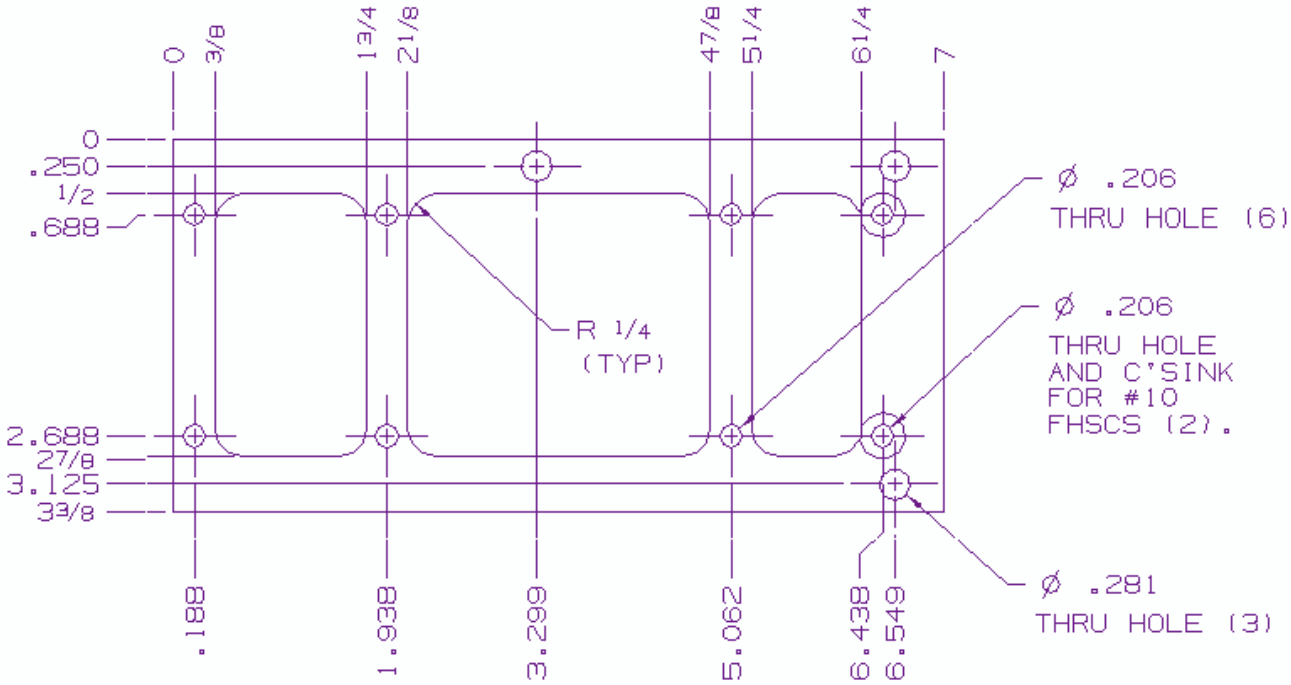
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



MM DETAIL PART NUMBER

NAME BASE PLATE

MATL. 1/4" ALUM. PLATE

NO. REQ'D 2

HT. TREAT

FINISH

PROJECT NO. T-KATS DATE DWG. COMPLETED 01--18--01

DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

ONE/ONE SOFTWARE
Unigraphics Solutions

CHANGE RESTRICTED

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EQUIP. NAME TECHNOKATS 2001 ROBOT

EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

SHEET 003 OF B SIZE Full Scale

EQUIP. DWG. NO. TKF01M03A_D03

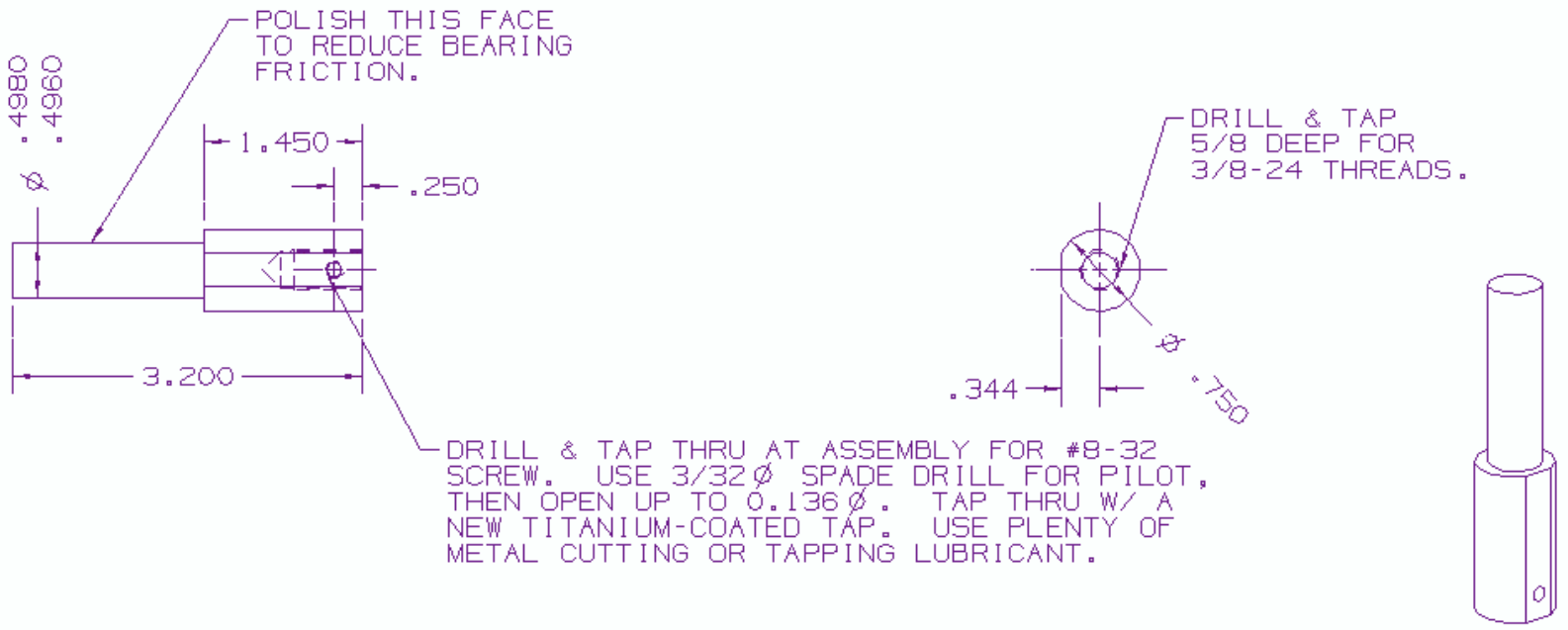
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



MM DETAIL PART NUMBER	PROJECT NO. T-KATS DATE DWG. COMPLETED 01--12--00	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME DRILL SHAFT	DESIGN ENGINEER Andy Baker / DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. STEEL ROD	OUTSIDE DESIGN SHOP / DESIGNER 451-9380	SHEET 004 OF / B SIZE / Full Scale
NO. REQ'D 2	DETAILER / CHECKER	
HT. TREAT	APPROVAL / DATE	
FINISH	CUSTOMER APPROVAL / DATE	
	ONE/VIEW SOFTWARE Unigraphics Solutions — CHANGE RESTRICTED	EQUIP. DWG. NO. TKF01M03A_D04

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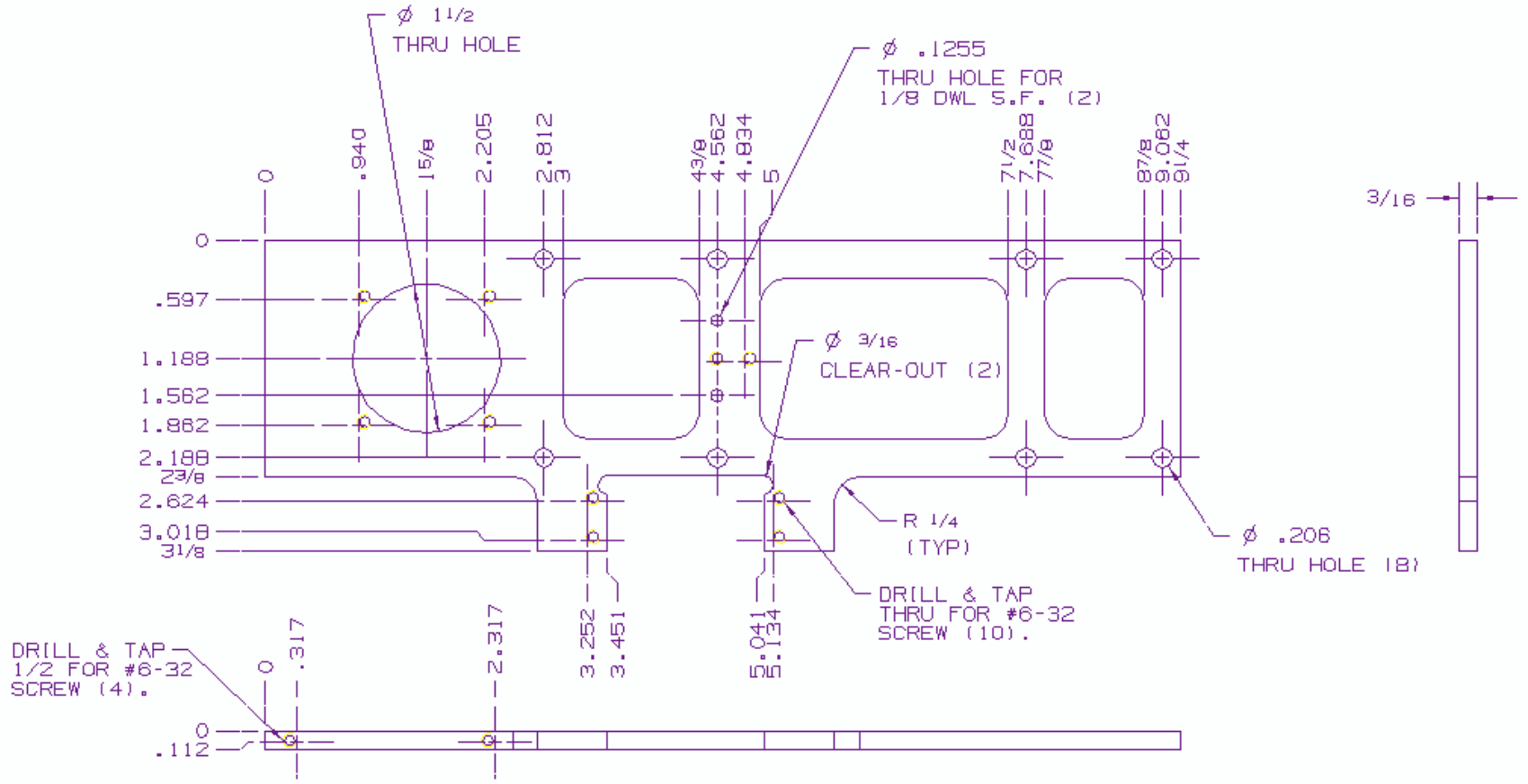
MARK WITH DET.# AND DWG.# — JOB TAG PLACEMENT ABOVE — BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



MM DETAIL PART NUMBER	PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME TOP PLATE	DESIGN ENGINEER Andy Baker	DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. 3/16" ALUMINUM	OUTSIDE DESIGN SHOP	DESIGNER 451-9380	SHEET 005 OF — B SIZE — Full Scale
NO. REQ'D 2	DETAILER	CHECKER	
HT. TREAT	APPROVAL	DATE	
FINISH	CUSTOMER APPROVAL	DATE	

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EQUIP. DWG. NO. TKF01M03A_D05

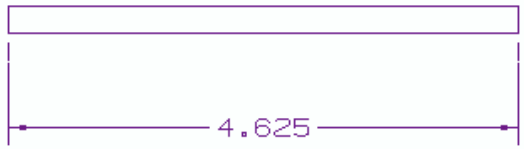
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



USE SPI ALUMINUM TUBING,
PART #U-LAT-49/4
(0.25 OD, 0.152 ID)

MM DETAIL PART NUMBER

NAME SLIDER SHAFT

MATL. 1/4" ALUM. TUBE

NO. REQ'D 4

HT. TREAT

FINISH

PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--12--01
DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

CAD/CAM SOFTWARE
Unigraphics Solutions

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EQUIP. NAME TECHNOKATS 2001 ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

SHEET 006 OF | B SIZE | Full Scale

EQUIP. DWG. NO. TKF01M03A_D06

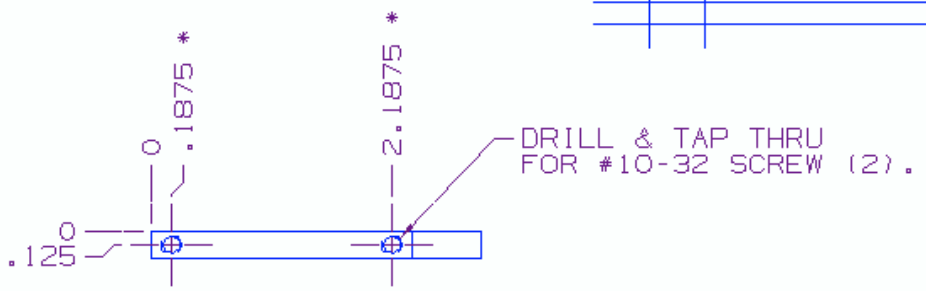
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

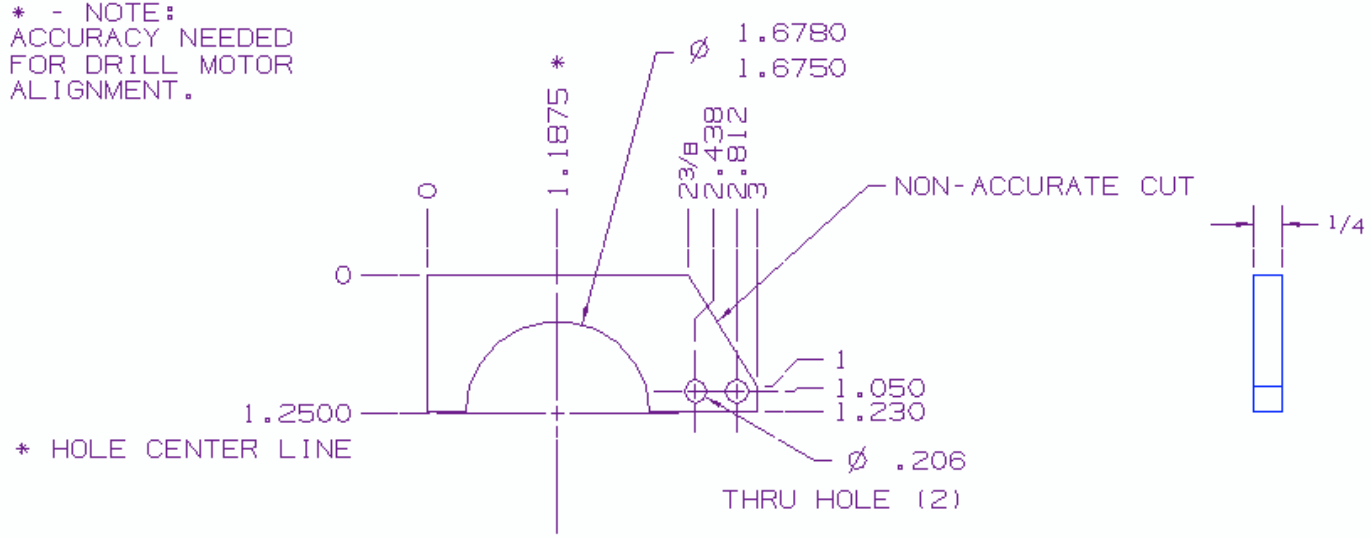
BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



* - NOTE:
ACCURACY NEEDED
FOR DRILL MOTOR
ALIGNMENT.



MM DETAIL PART NUMBER		PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME THIN MOTOR MOUNT PLATE		DESIGN ENGINEER Andy Baker	DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. 1/4" ALUM. PLATE		OUTSIDE DESIGN SHOP	DESIGNER 451-9380	SHEET 007 OF B SIZE Full Scale
NO. REQ'D 2		DETAILER	CHECKER	
HT. TREAT		APPROVAL	DATE	
FINISH		CUSTOMER APPROVAL	DATE	EQUIP. DWG. NO. TKF01M03A_D07
		UNIGRAPHICS SOFTWARE Unigraphics Solutions	CHANGE RESTRICTED	

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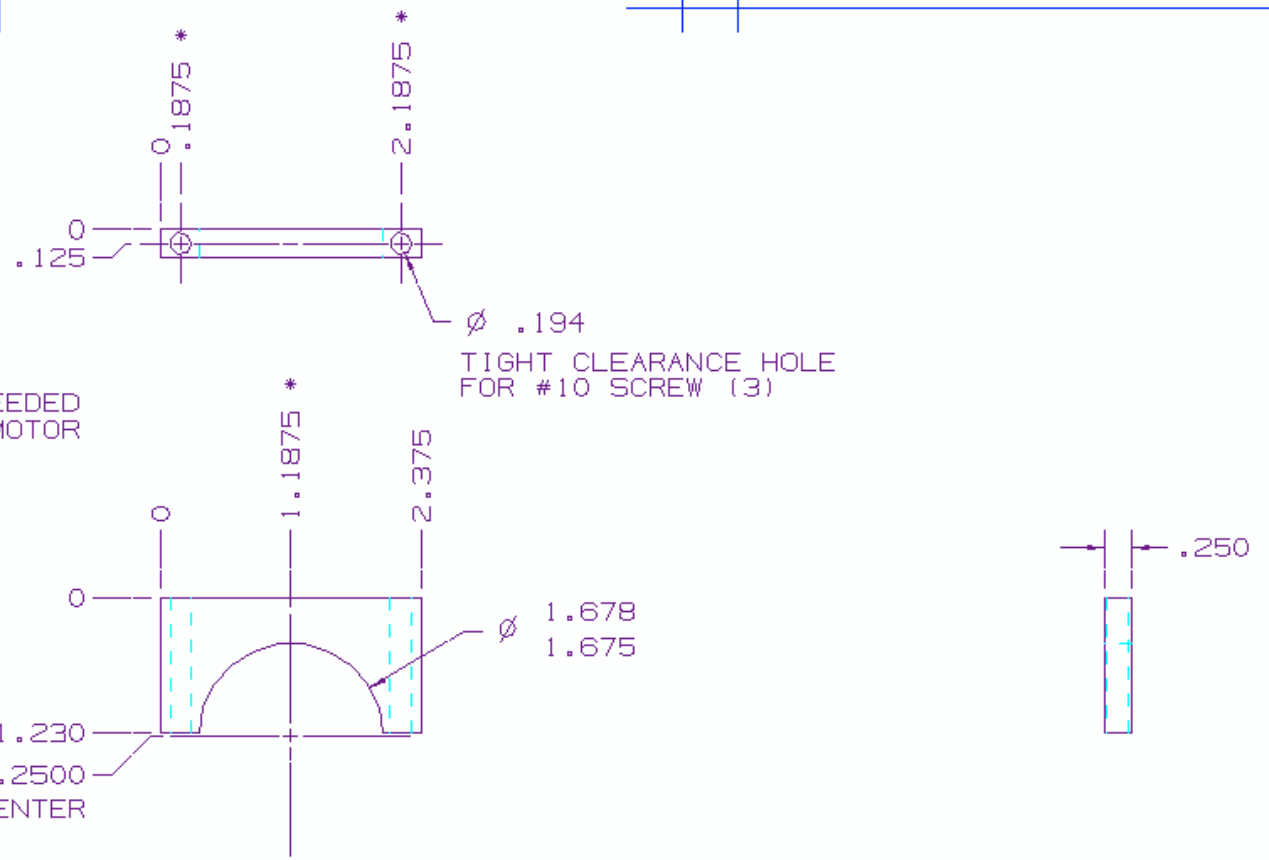
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



MM DETAIL PART NUMBER	PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME THIN MOTOR MOUNT TOP PLATE	DESIGN ENGINEER Andy Baker	DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. 1/4" ALUM. PLATE	OUTSIDE DESIGN SHOP	DESIGNER 451-9380	SHEET 008 OF — B SIZE — Full Scale
NO. REQ'D 2	DETAILER	CHECKER	
HT. TREAT	APPROVAL	DATE	
FINISH	CUSTOMER APPROVAL	DATE	EQUIP. DWG. NO. TKF01M03A_D08

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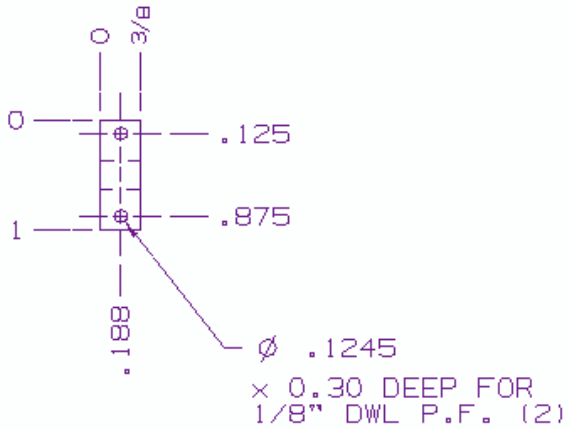
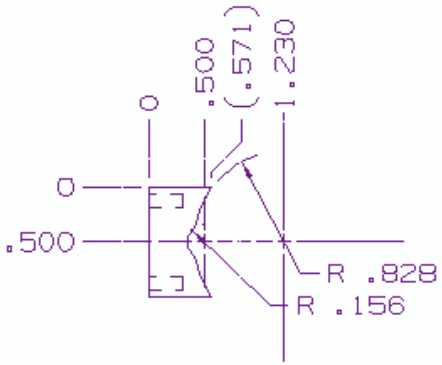
JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE





MM DETAIL PART NUMBER	PROJECT NO. T-KATS DATE DWG. COMPLETED 01--18--01	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME GEARBOX CLAMP	DESIGN ENGINEER Andy Baker / DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. 3/8" ALUM. PLATE	OUTSIDE DESIGN SHOP / DESIGNER 451-9380	SHEET 009 OF / B SIZE / Full Scale
NO. REQ'D 2	DETAILER / CHECKER	
HT. TREAT	APPROVAL / DATE	
FINISH	CUSTOMER APPROVAL / DATE	
	ONE/ONE SOFTWARE Unigraphics Solutions — CHANGE RESTRICTED	EQUIP. DWG. NO. TKF01M03A_D09

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MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

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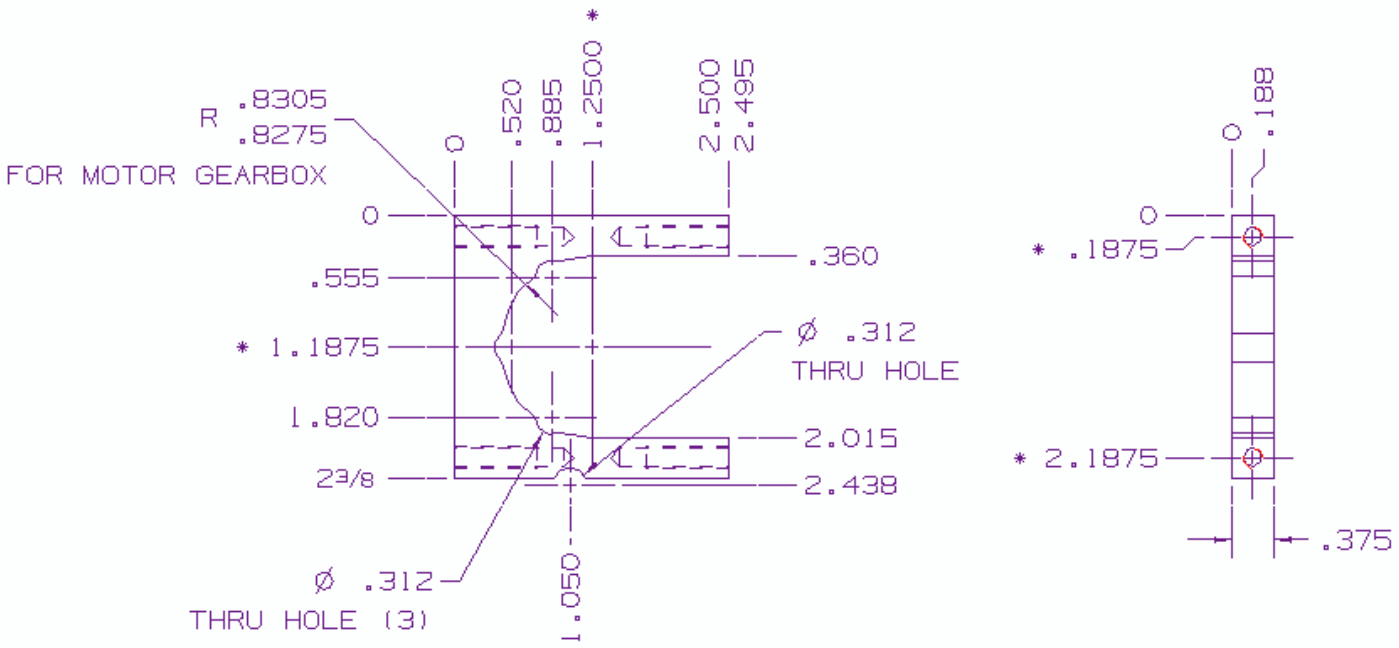
- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



* - NOTE:
ACCURACY NEEDED
FOR DRILL MOTOR
ALIGNMENT.

MM DETAIL PART NUMBER	PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME OUTSIDE MOUNT PLATE	DESIGN ENGINEER Andy Baker	DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. 3/8" ALUM. PLATE	OUTSIDE DESIGN SHOP	DESIGNER 451-9380	SHEET 010 OF — B SIZE — Full Scale
NO. REQ'D 2	DETAILER	CHECKER	
HT. TREAT	APPROVAL	DATE	
FINISH	CUSTOMER APPROVAL	DATE	EQUIP. DWG. NO. TKF01M03A_D10
	ONE/VIEW SOFTWARE Unigraphics Solutions	CHANGE RESTRICTED	

DELPHI Automotive Systems
Delco Electronics Systems
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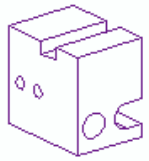
MARK WITH DET.# AND DWG.#

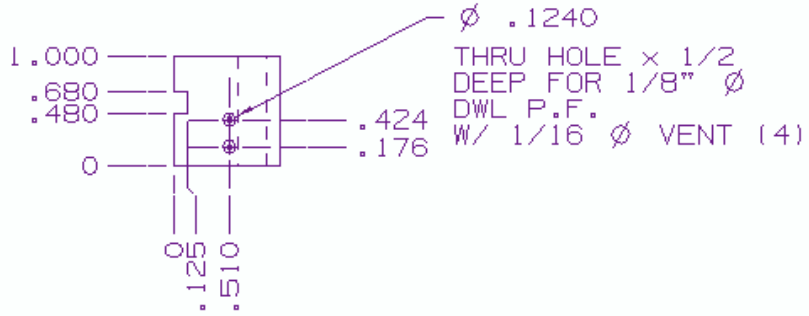
JOB TAG PLACEMENT ABOVE

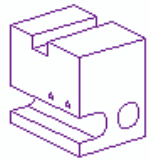
BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

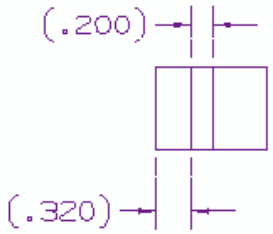
- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

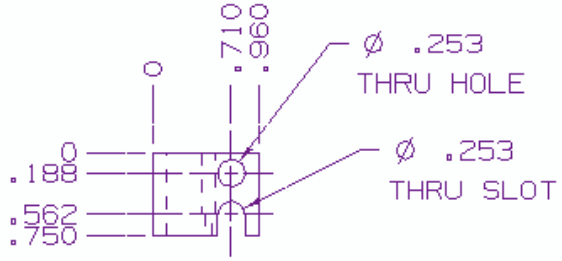
CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE











MM DETAIL PART NUMBER	PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01
NAME SLIDE BLOCK BLOCK	DESIGN ENGINEER Andy Baker	DETAILER A.B.
MATL. H.D.P.E.	OUTSIDE DESIGN SHOP	DESIGNER 451-9380
NO. REQ'D 2	DETAILER	CHECKER
HT. TREAT	APPROVAL	DATE
FINISH	CUSTOMER APPROVAL	DATE
	CAD/CAM SOFTWARE Unigraphics Solutions	CHANGE RESTRICTED

DELPHI Automotive Systems

Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
SHEET 011 OF B SIZE Full Scale
EQUIP. DWG. NO. TKF01M03A_D11

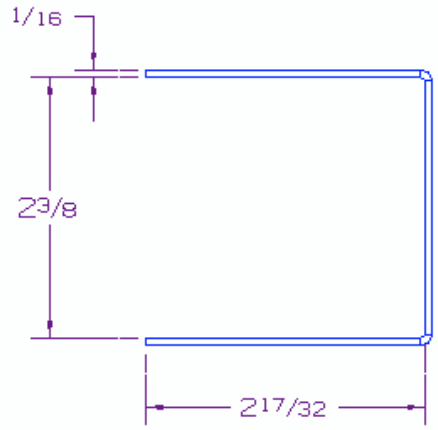
MARK WITH DET.# AND DWG.#

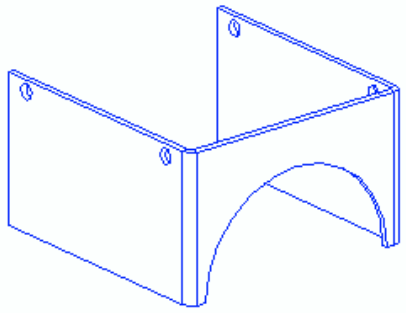
JOB TAG PLACEMENT ABOVE

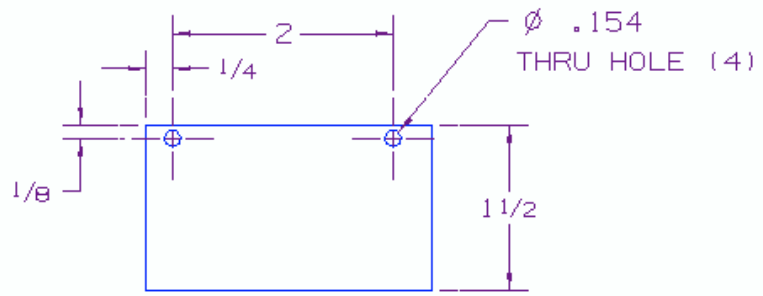
BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

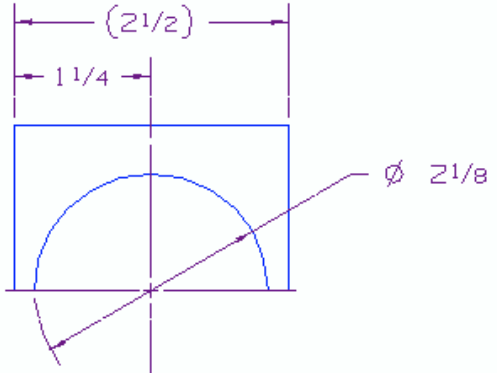
- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE









MM DETAIL PART NUMBER

NAME MOTOR COWLING

MATL. 1/16" ALUM. SHEET

NO. REQ'D 2

HT. TREAT

FINISH

PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01
DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

CAD/CAM SOFTWARE Unigraphics Solutions

CHANGE RESTRICTED

DELPHI Automotive Systems

Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT

EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

SHEET 012 OF | B SIZE | Full Scale

EQUIP. DWG. NO. TKF01M03A_D12

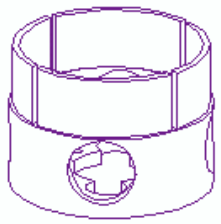
MARK WITH DET.# AND DWG.#

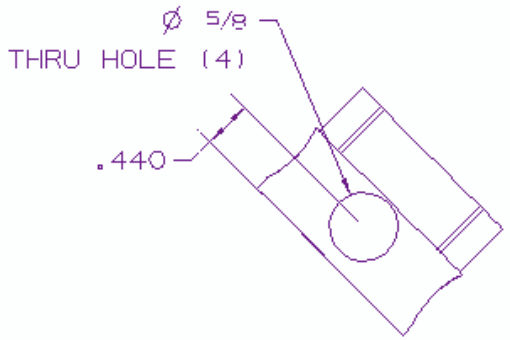
JOB TAG PLACEMENT ABOVE

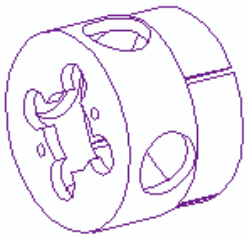
BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

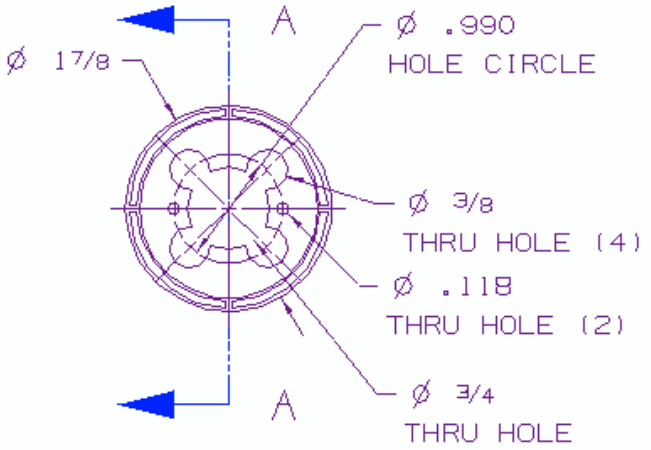
- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

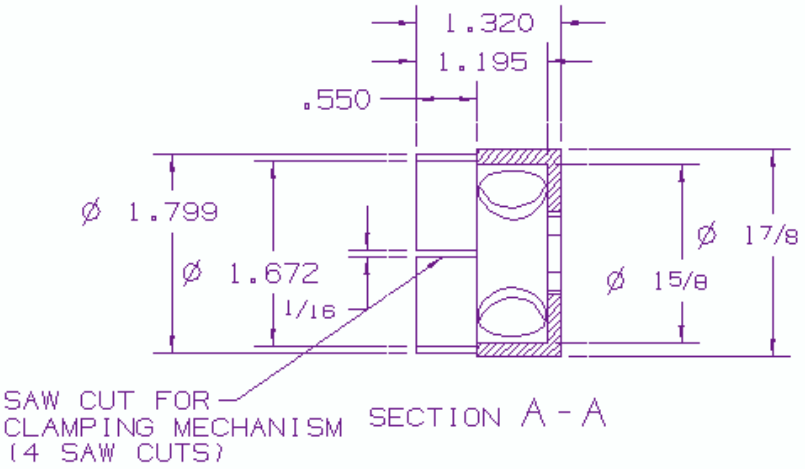
CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE











MM DETAIL PART NUMBER	PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01	
NAME F-P MOTOR MOUNT	DESIGN ENGINEER Andy Baker	DETAILER A.B.	
MATL. 2" ALUM. ROD	OUTSIDE DESIGN SHOP	DESIGNER 451-9380	
NO. REQ'D 2	DETAILER	CHECKER	
HT. TREAT	APPROVAL	DATE	
FINISH	CUSTOMER APPROVAL	DATE	
	CAD/CAM SOFTWARE Unigraphics Solutions	CHANGE RESTRICTED	

DELPHI Automotive Systems

Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
SHEET 013 OF | B SIZE | Full Scale
EQUIP. DWG. NO. TKF01M03A_D13

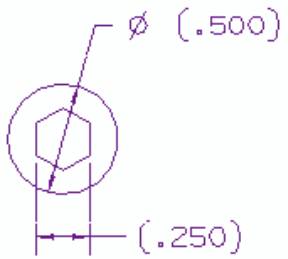
MARK WITH DET.# AND DWG.#

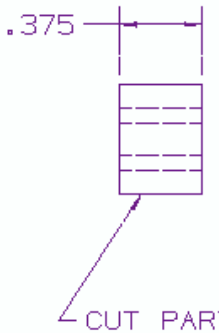
JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE





NOTE:
ALTERATION TO SPI
PART #: U-1000132

MM DETAIL PART NUMBER	PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--18--01	EQUIP. NAME TECHNOKATS 2001 ROBOT
NAME HEX COUPLING	DESIGN ENGINEER Andy Baker	DETAILER A.B.	EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
MATL. SEE NOTE	OUTSIDE DESIGN SHOP	DESIGNER 451-9380	SHEET 014 OF — B SIZE — 2x Scale
NO. REQ'D 1	DETAILER	CHECKER	
HT. TREAT	APPROVAL	DATE	
FINISH	CUSTOMER APPROVAL	DATE	EQUIP. DWG. NO. TKF01M03A_D14
	ONE/VIEW SOFTWARE Unigraphics Solutions	CHANGE RESTRICTED	

DELPHI Automotive Systems
Delco Electronics Systems
Manufacturing Engineering

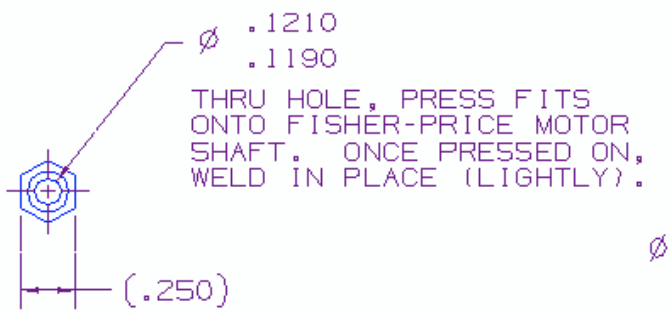
MARK WITH DET.# AND DWG.#

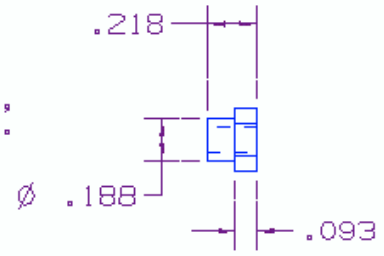
JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE





Full Scale

MM DETAIL PART NUMBER

NAME HEX SHAFT, F-P

MATL. 1/4 STEEL HEX SHAFT
NO. REQ'D 1
HT. TREAT
FINISH

PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--16--01
DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

CAD/CAM SOFTWARE Unigraphics Solutions

CHANGE RESTRICTED

DELPHI Automotive Systems

Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY
SHEET 015 OF B SIZE
2x Scale
EQUIP. DWG. NO. TKF01M03A_D15

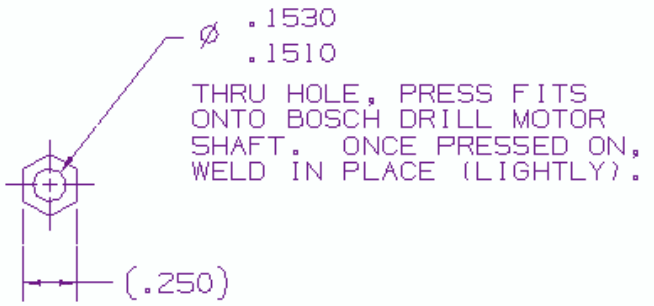
MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.

- TOLERANCES - UNLESS OTHERWISE SPECIFIED	
FRACTIONAL DIMENSIONS	± .010"
3 PLACE DECIMAL DIMS.	± .005"
4 PLACE DECIMAL DIMS.	± .0005"
ANGLES	±1/4°

CHANGE LETTER	SHEET NO.	CHANGE	PROJECT NUMBER	ENGR.	DATE



MM DETAIL PART NUMBER

NAME HEX SHAFT, DRILL

MATL. 1/4 STEEL HEX SHAFT

NO. REQ'D 1

HT. TREAT

FINISH

PROJECT NO. T-KATS	DATE DWG. COMPLETED 01--16--01
DESIGN ENGINEER Andy Baker	DETAILER A.B.
OUTSIDE DESIGN SHOP	DESIGNER 451-9380
DETAILER	CHECKER
APPROVAL	DATE
CUSTOMER APPROVAL	DATE

ONE/VIEW SOFTWARE
Unigraphics Solutions

CHANGE RESTRICTED

DELPHI
Automotive Systems
Delco Electronics Systems
Manufacturing Engineering

EQUIP. NAME TECHNOKATS 2001 ROBOT
EQUIP. DESCR. DRIVE MOTOR ASSEMBLY

SHEET 016 OF | B SIZE | 2x Scale

EQUIP. DWG. NO. TKF01M03A_D16

MARK WITH DET.# AND DWG.#

JOB TAG PLACEMENT ABOVE

BREAK ALL SHARP CORNERS EXCEPT CUTTING EDGES.