NASA-CR-205084

Semiannual Technical Progress Report

Aeromover Systems Corporation
3045 Broad Street
Dexter, MI 48130

Contract # NAS1-20640

This report covers the third six month period of the subject contract from January 26, 1997 to July 26, 1997. The contract statement of work covers four specific applications of Aeromover's 'N'-output differential technology that are being developed in cooperation with industry and NASA. A quantitative description of work, project difficulties, proposed solutions, and a statement of the work that will be performed during the next six months has been included for each of the four projects.

Contract # NAS1-202640 development projects:

1. Robotic Gripper for industrial application
2. End-effector design for NASA application
3. Nut-runner for simultaneous torquing of multiple threaded fasteners
4. Multiple output drive for power auto seats

1. Robotic Gripper for industrial application

A four output differentially powered end-effector has manufactured and tested for use at our collaborating manufacture's facility (Variety Die and Stamping). During the past six months, the prototype device has gone through several small design adjustments and mechanical "tweaking" typical for this type of first-iteration equipment. Strain gauges used to test the torque at the output/fingers showed that drag coefficients at each differentiated output were inconsistent when measured at angles of incidence not parallel with respect to the ground plane. Our investigations revealed that this was primarily due to deficiencies in precision in bushing and bearing supports. Bearing supports were modified and these problems were overcome.

Because the chosen task for demonstrating our industrial end-effector does not require a particularly precise differential mechanism it is possible that the first iteration would have been sufficient for the chosen tasks without modification. However, the Principal Investigator, Mr. Srinivas Bidare' and Aeromover personnel felt that design refinements were necessary to gain a better hands-on understanding of ancillary issues effecting the performance the differential driving mechanism. Investigation has revealed that several specific areas where designers will need to focus attention if precision performance is to be attained. These areas include the following:

1 Overcoming the inertial load of the gear train, while supported at various angles. (Critical to driving motor/actuation).

2 Supporting bearings & bushings design/location (Necessary for gaining nearly equivalent drag co-efficients at each differentiated output).

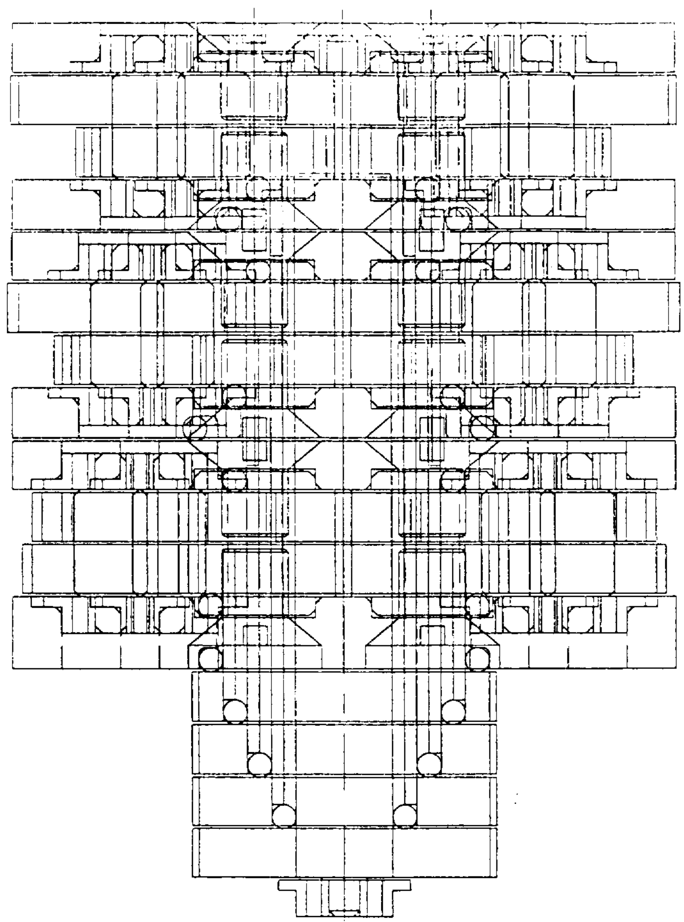
3. Design of consistent finger actuation mechanisms that are low mass and not subject to excessive drag. (Slide mechanisms designed for the current model are adequate, however, they prove to bulky for more precision applications).

Eastern Michigan University (EMU) has received a refurbished PUMA robot, which is being used to create a mock-up test sight that will simulate tasks in the manufacturing environment. The EMU test site is being used so that any unforeseen problems with the new robotic system can be resolved prior to actual system installation. The test site will also offer the opportunity to more easily collect cycling information. When the system has proven its readiness in the laboratory it will be brought to the manufacturing facility and installed. After installation the end-effector will be examined on a regular basis to monitor for any potential problems. The manufacture will be given the opportunity to evaluate performance of the new system for several months, using the EMU robot, before deciding whether or not a system will be permanently installed, at which time the EMU robot will be returned to the University. By the end of the contract period the system will been installed at Variety Die and they will be evaluating it's performance.

2. End-effector design for NASA application/design iterations

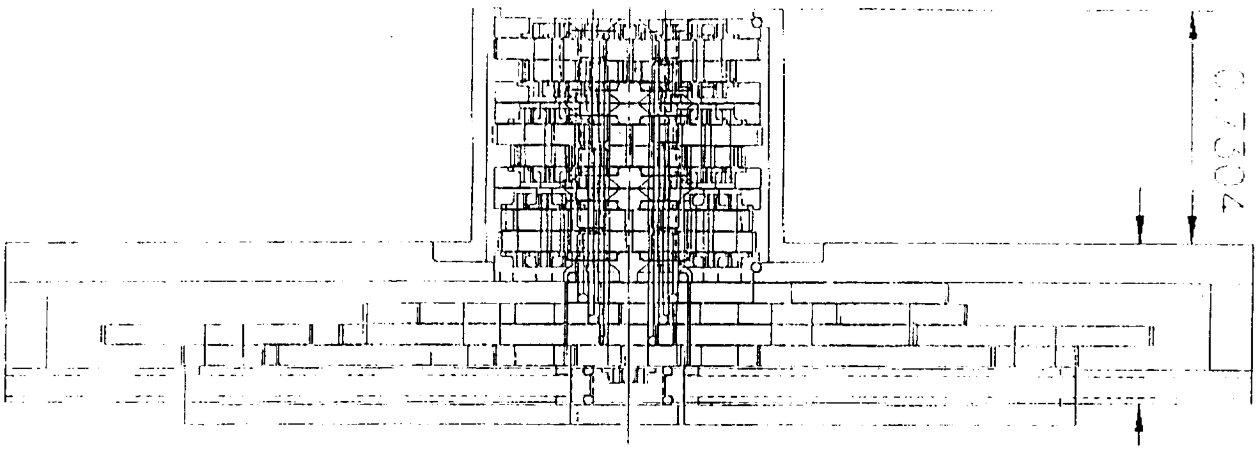
Discovering a specific NASA application for our differentially powered end-effector was delayed due to difficulties in breaking through to program end-users and designers and in receiving their specifications for automated tasks. Lack of progress in this area resulted in Aeromover requesting that project technical monitor, Walter Hankins, assist us in finding an appropriate contact within NASA, that could supply Aeromover with appropriate design specifications. Mr. Hankins supplied Aeromover with contacts at Johnson labs in Houston, with whom a dialogue has begun. By the end of the contract period Aeromover will supply a design to meet the design criteria of a specific NASA end-effector mission.

During the past six months, in lieu of having an actual specific application from NASA, the Principal Investigator began designing a "lightest weight" and "least massive" configuration of the "N-output" differential gear train. This gear train is seen as an extremely promising for application in prosthetic devices or in other applications where the miniaturization of component/mechanisms is critical. NASA's Johnson lab is primarily working with astronaut interface to specific "hand-like" functions being carried out in space. Our flexible, compliant, durable, and light weight mechanism could prove be very appropriate. The following drawing shows our most recent design iteration for a miniature high-speed four output differential.



The device shown is less than 1" in diameter and slightly more than 1" in total length.

The design shown here is capable of driving the four pounds of gripping force necessary for our current industrial application presuming that gear reductions are made at some point after the differentiated outputs. A generic rule in designing differentially driven mechanisms is that the gear train can be made smaller and lighter if the reduction is done at the end of the differential rather than before it. Therefore, handling heavier payloads with a small mechanism requires that greater gear reduction occur after differentiation. In applications such as a prosthetic hand, there are several opportunities to accomplish reduction after differentiation and this type of mechanism would be ideal. Specific task work loads and product design constraints will indicate whether or not the smaller scale differential will prove practical. The following drawing illustrates how the miniature gear train could be used to build an end-effector that could carry out our current industrial manufacturing task.



The drivetrain shown here offers a dramatic reduction in the size and weight vs. our current device. EMU Principal Investigator Prof. Max Kanagy has been concurrently carrying out design calculations with Mr. Bidare' to develop a slightly larger drivetrain, approx. 2" diameter and 2.5" height, that would not require post-differentiation reduction to accomplish our 4 pound workload requirement. Currently, Dr. Kanagy's work seems the most well suited to most industrial applications, while Mr. Bidare's seem best suited to more specialized applications such as "high-end" prosthetic devices.

In the last six months Aeromover has been weighing the benefits of different differential designs for potential applications at both Ford Motor Company and for Delphi automotive. (Both companies advanced Robotics departments have asked Aeromover to propose an end-effector developmental proposal). In the next six months we will make proposals to both corporations based on their specific design criteria. Similarly we will also obtain an appropriate set of specific design requirements from NASA Johnson and apply the most effective version of a differential mechanism to a their specific requirements.

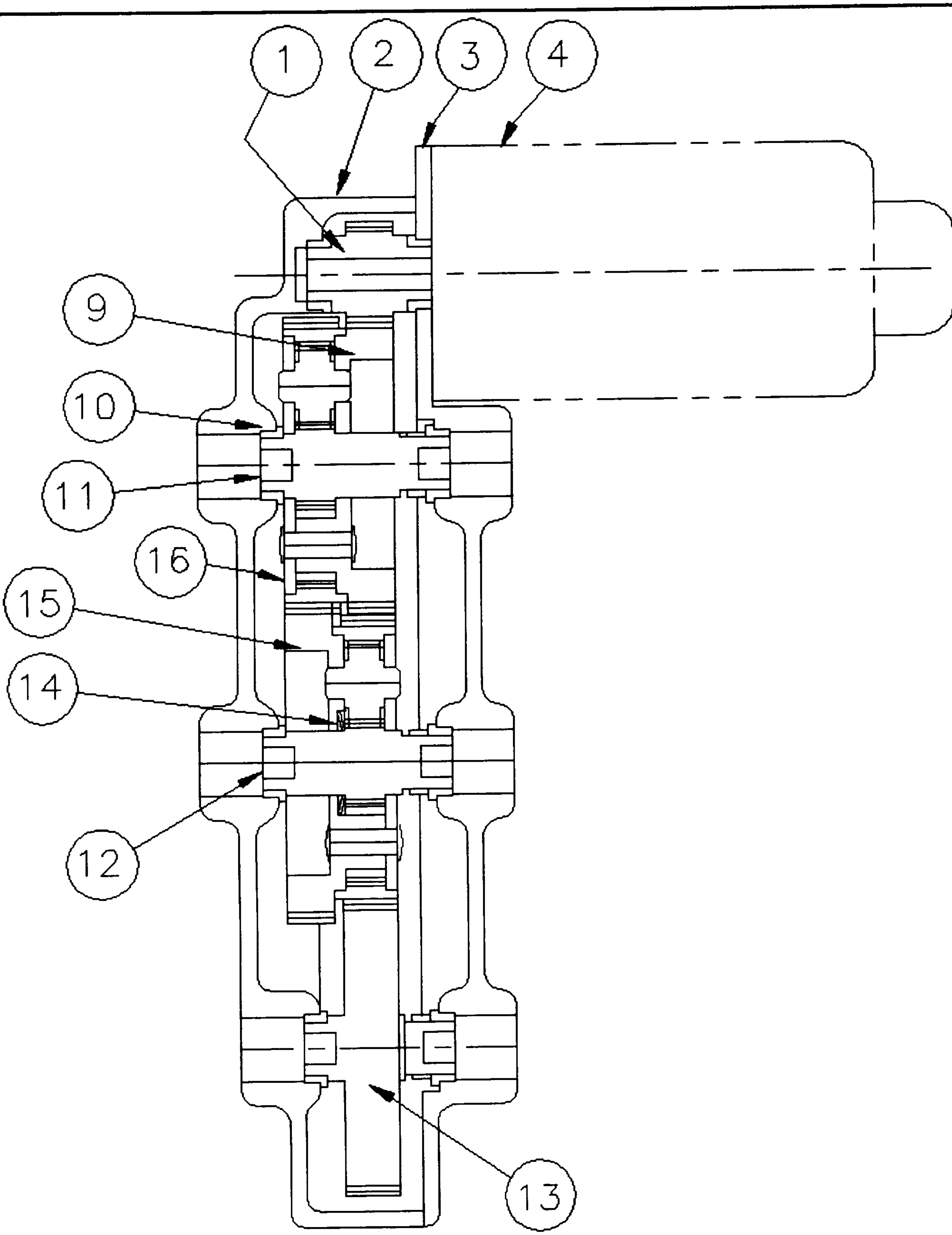
3. Nut-runner for simultaneous torquing of multiple threaded fasteners

Designs for an eight output nut-runner have been completed for use at Tecumseh products. A final design evaluation (outside engineering check) is being conducted by our design subcontractor, South Lyon Design. Tecumseh's existing nut-runner frame is being replicated, by Tecumseh, for Aeromover to use in testing the new machine. We expect delivery of the Tecumseh frame in from 6-8 weeks and completion of the differential drive mechanism within 10 weeks. Testing will then begin and take form 2-4 weeks. We expect to deliver the machine to New Holstein, Wisconsin within the next 16 weeks. Drawings for the nut-runner are attached at the end of this report.

4. Multiple output drive for power auto seats

Our originally proposed Industrial Collaborator for manufacturing a prototype six-way seat drive mechanism, Johnson Controls Inc. (JCI), has not responded to Aeromover proposals in a timely enough manner to meet the demands of our STTR schedule. Therefore, a second seat-drive manufacture, Delphi Automotive, has taken JCI's place as our industrial collaborator. Delphi has offered to fund the development of the prototype seat drive, contingent upon intellectual property agreements that would ensure that they would not pay royalty on any findings made during prototype developments which they help to fund, they also wish to hold exclusive rights to any new technologies developed for the next three years. Aeromover is planning to proceed with the Prototype development, but, has taken several steps to better ensure that our product/technology can not be "held-up" by our collaborator should they choose <u>not</u> to use the new technology. We want to ensure that the technology has the best possible chance of actually being implemented rather than being "sat-on" by a major manufacturer.

Aeromover has therefore completed designs for a seat mechanism to the industrial prototype level. Manufacturing processes and sources have been quoted and two potential manufacturers approached. (Drawings for the seat drive mechanism and assembly plans are attached at the end of this report.) Aeromover has now completed more work on this project than was originally proposed under NAS1-20640. We have taken these extra steps to ensure that the product we are developing actually has a reasonable chance for wide spread use. We anticipate that within the next six months that agreements will be finalized with Delphi and that a prototype device will be tested. (Build of this prototype is not overly complex or time-intensive). If, however, these developments would jeopardize our corporate position, we will contact NASA contracting officers and attempt to get exceptions made to the specific terms of the STTR.

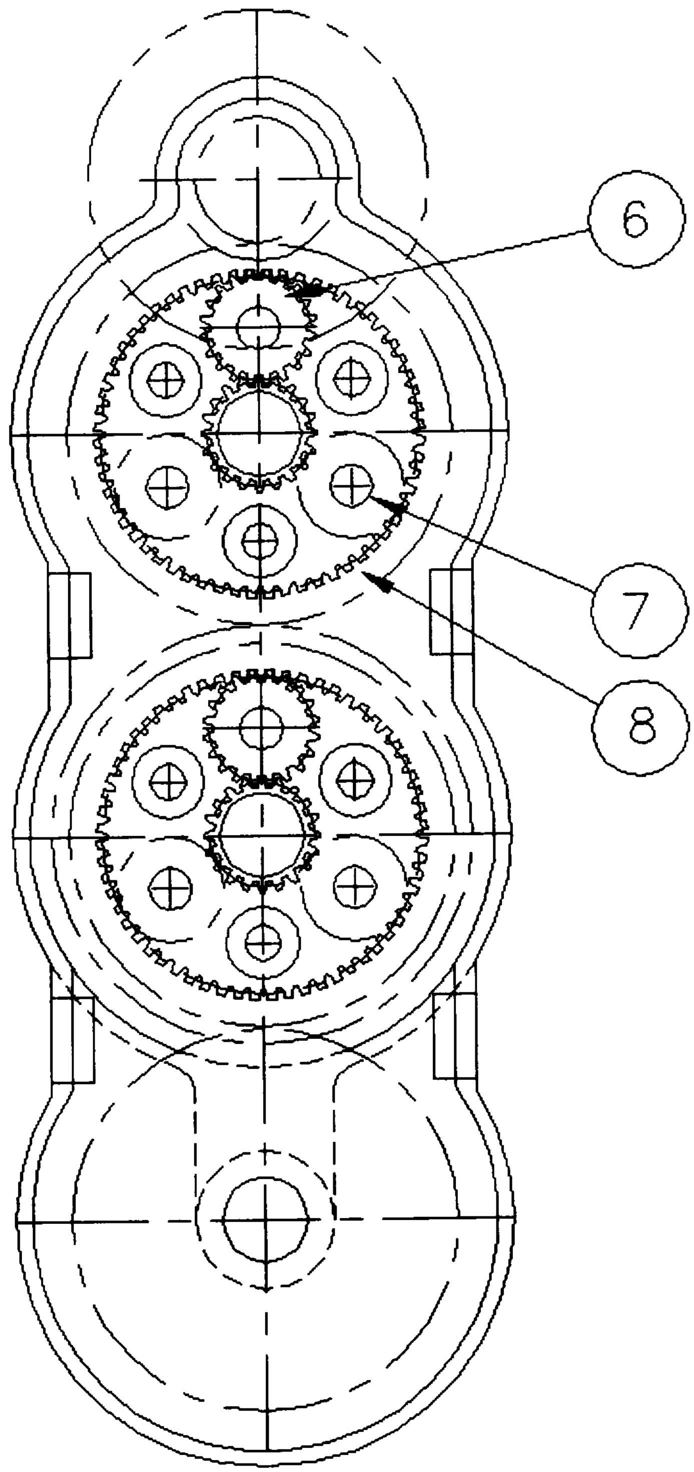


ENGINEER | DATE

AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT

SOUTH LYON DESIGN
REV. APR 12,1997



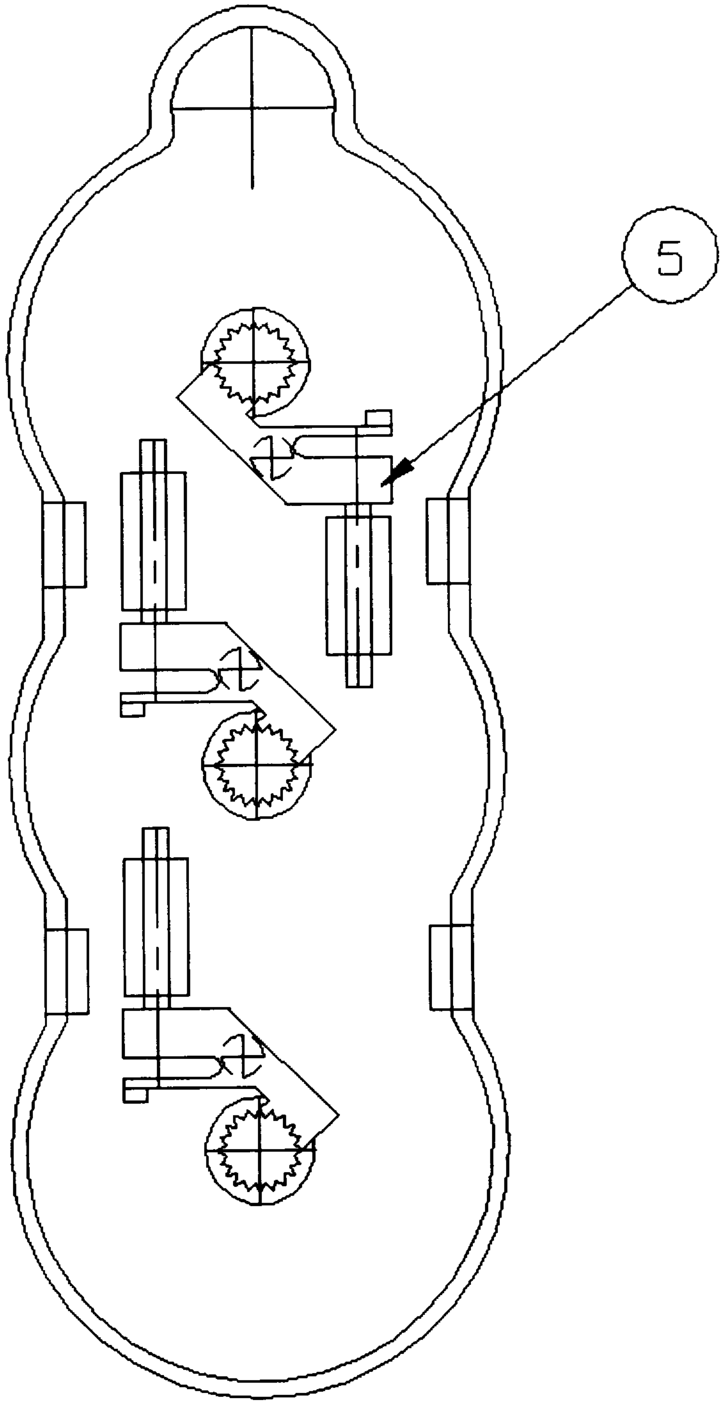
SOUTH LYON DESIGN

REV. APR 12,1997

ENGINEER | DATE

AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



SOUTH LYON DESIGN

REV. APR 12,1997

ENGINEER | DATE

AEROMOVER INC

BRAKE ASSEMBLY
FOR 3 OUTPUT SEAT ASSEMBLY

NOTES:
REVISION RECIEVED APR 9 1997
1 CHANGE GEAR 1 TO DOUBLE HUNG
2 ELIMINATE LEFT SIDE ALUMINIUM SUPPORT PLATE, INTEGRATE BUSHING INTO PLASTIC MOLDED HOUSING
3 BUSHING MADE OF HARDENED STEEL W/ GREASE PACKED DURING ASSEMBLY
4 SUN GEAR IS MADE OF POWERED METAL, INTEGRATED SHAFT AND HAS SQUARE HOLE FOR CABLE DRIVE
5 RING GEAR IS MADE OF POWERED METAL
6 PLANET GEARS MADE OF POWERED METALOR COLD HEADED STEEL OR INJECTION MOLDED PLASTIC, SHAFT IS INTEGRATED INTO GEAR
7 COVER PLATE OF PLANETARY CAN BE MADE OF HIGH CARBON STEEL STAMPING WITH HOLES THICKNESS MAY HAVE TO BE INCREASED TO REDUCE BEARING STRESS ON RING GEAR
8 ARM TO BE MADE OF POWERED METAL WITH LIGHTING HOLES OR PROFILE.
9 OLD PLATE 3 – SNAP FIT INTO MOLDED PLASTIC HOUSING
10 BRAKE LEVER MADE OF PLASTIC WITH INTEGRATED SHAFT AND SPRING – NO FASTENER
11 SOLENOID CAPTURED SNAP FIT AND HOUSED IN HOUSING
12 NO RIVETS, SHAFTS ETC TO CAPTURE BRAKE OR LEVER

NOTES:
AEROMOVER TO VERIFY TORQUE AND RPM OF ALL OUTPUT SHAFTS
AEROMOVER TO VERIFY GEAR SIZE AND CAPABILITY FOR PRODUCT REQUIREMENTS

SOUTH LYON DESIGN
REV. APR 12,1997

ENGINEER	DATE	AEROMOVER INC
		3 OUTPUT SEAT DRIVE FOR FLEX SHAFT 6 OUTPUT

SYM	DESCRIPTION	QTY	MATERIAL	SIZE / VOLUME	WEIGHT
1	GEAR INPUT	1	STEEL		
2	HOUSING MAIN	1	PLASTIC		
3	HOUSING SWITCH	1	PLASTIC		
4	MOTOR 500 RPM	1	COMMERICAL		
5	LATCH	3	PLASTIC		
6	GEAR	6	STEEL		
7	RIVET	6	STEEL	3/16 DIA X .65	
8	GEAR RING	2	STEEL		
9	ARM INPUT	1	STEEL		
10	BUSHING	8	STEEL		
11	SHAFT OUTPUT	1	STEEL		
12	SHAFT OUTPUT	1	STEEL		
13	SHAFT OUTPUT	1	STEEL		
14	SPRING	1	STEEL		
15	INPUT ARM	1	STEEL		
16	PLATE RETAINER	2	STEEL		

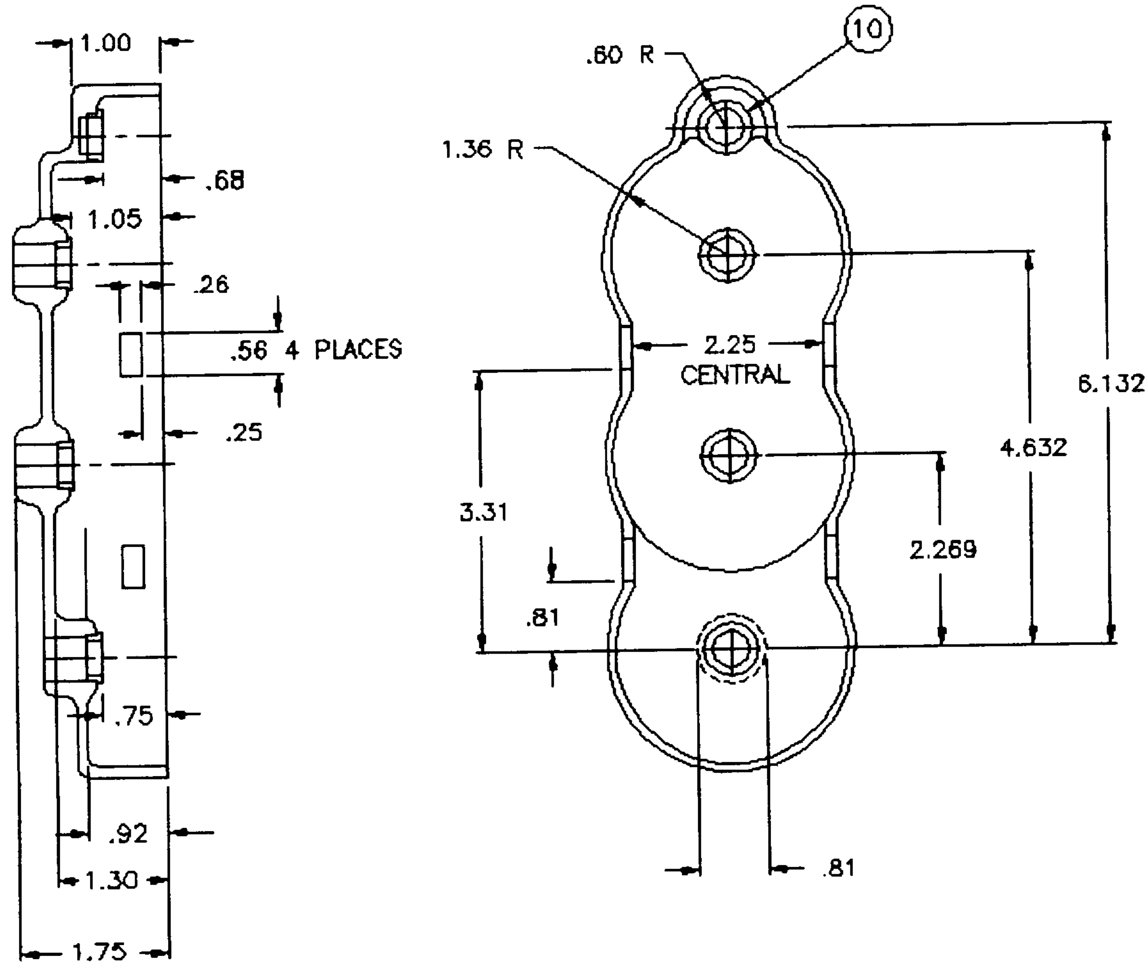
ENGINEER DATE

AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT

SOUTH LYON DESIGN

REV. APR 12,1997

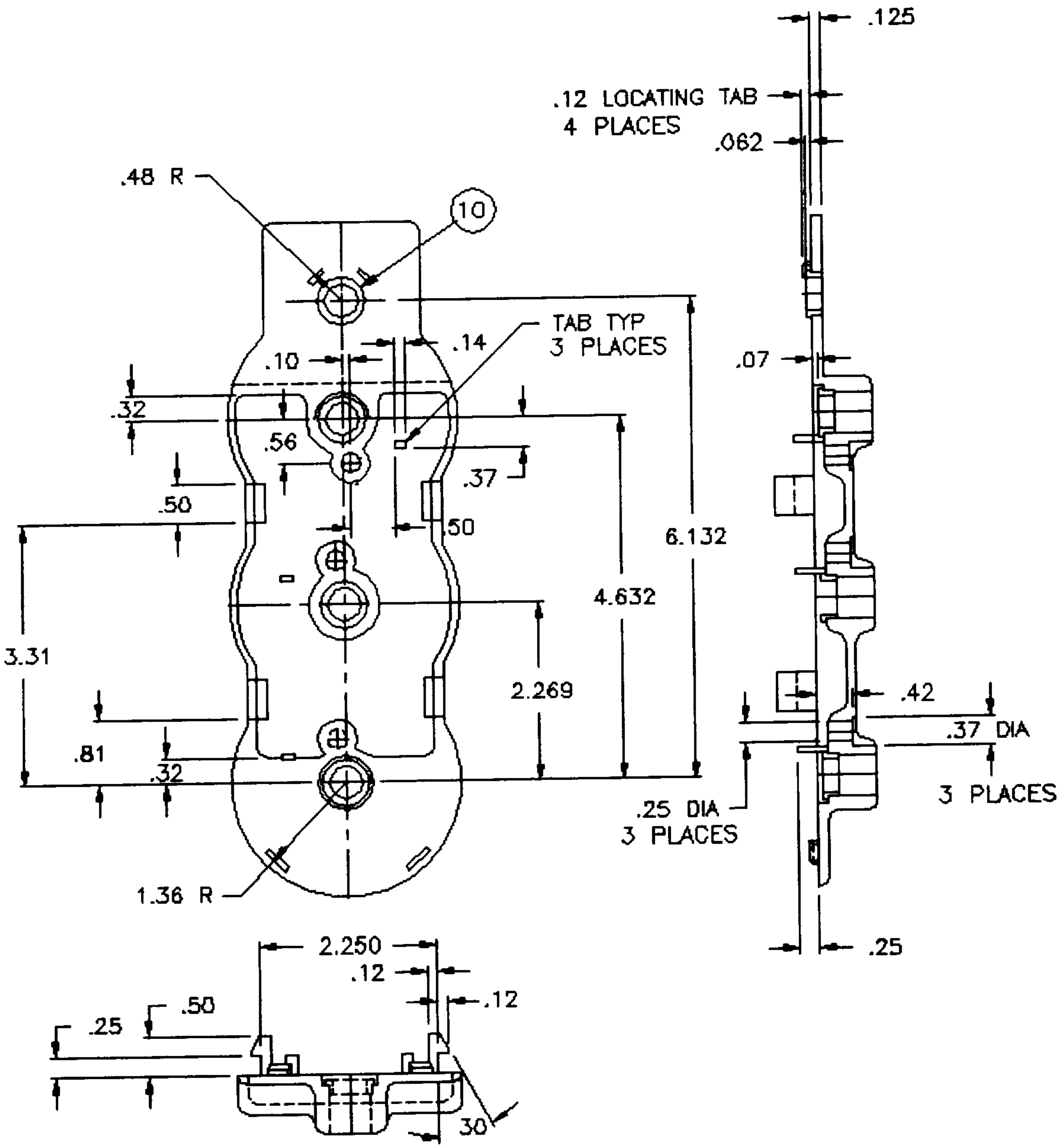


WALL = 1/8'
FILLET = 1/8"

(2) HOUSING MAIN
PLASTIC
QTY(1)

SOUTH LYON DESIGN
REV. APR 12,1997

ENGINEER	DATE	AEROMOVER INC
		3 OUTPUT SEAT DRIVE FOR FLEX SHAFT 6 OUTPUT



WALL = 1/8'
FILLET = 1/8"

(3) HOUSING SWITCH
PLASTIC
QTY (1)

ENGINEER	DATE	AEROMOVER INC
		3 OUTPUT SEAT DRIVE FOR FLEX SHAFT 6 OUTPUT

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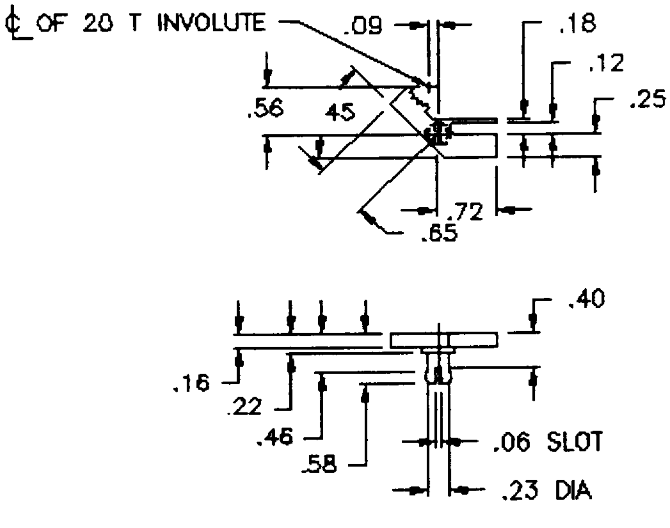
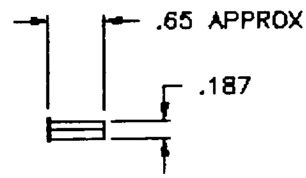


(5) LATCH
PLASTIC
MOLDED

QTY 3



(7) RIVET
QTY (6)

ENGINEER | DATE

AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT

SOUTH LYON DESIGN

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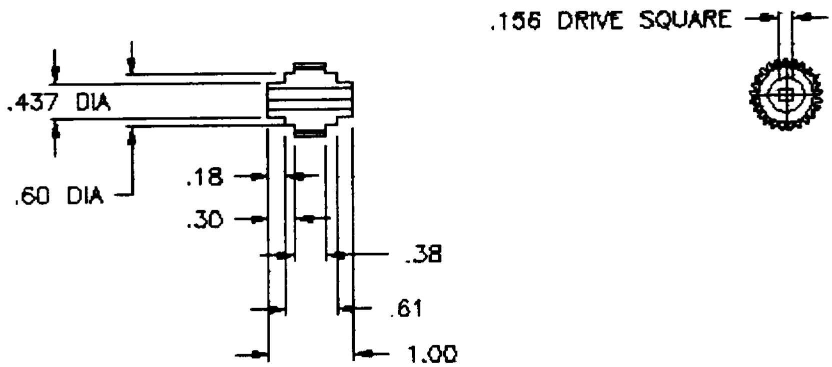
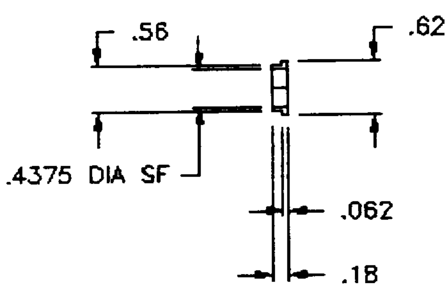
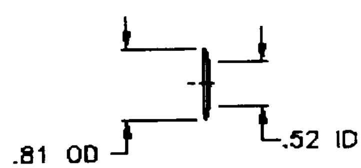


GEAR
NO OF TEETH 28
DIAMETRICAL PITCH 32
PITCH DIAMETER .875

(1) GEAR INPUT
STEEL
QTY (1)



(10) BUSHING
STEEL
MOLDED INTO HOUSING
QTY(8)



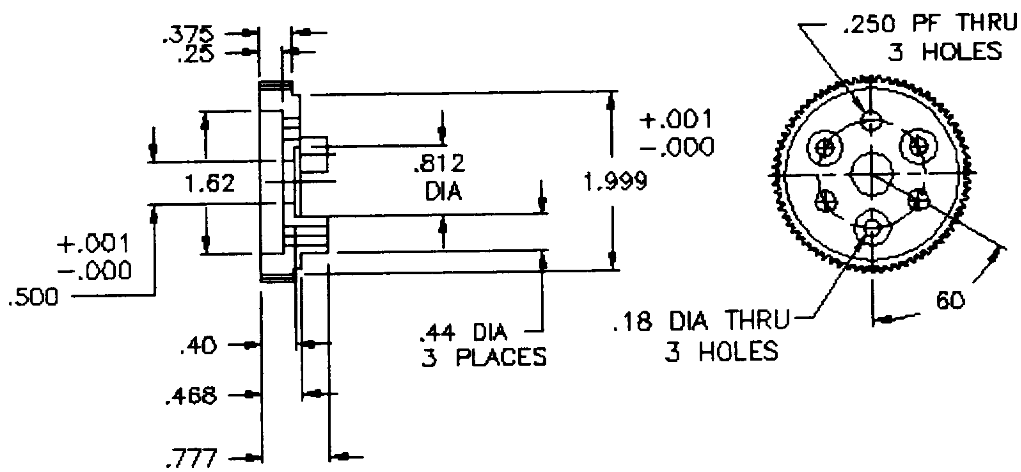
(14) SPRING BELLVILLE
STEEL
COMMERICAL
QTY (1)

SOUTH LYON DESIGN
REV. APR 12,1997

ENGINEER | DATE

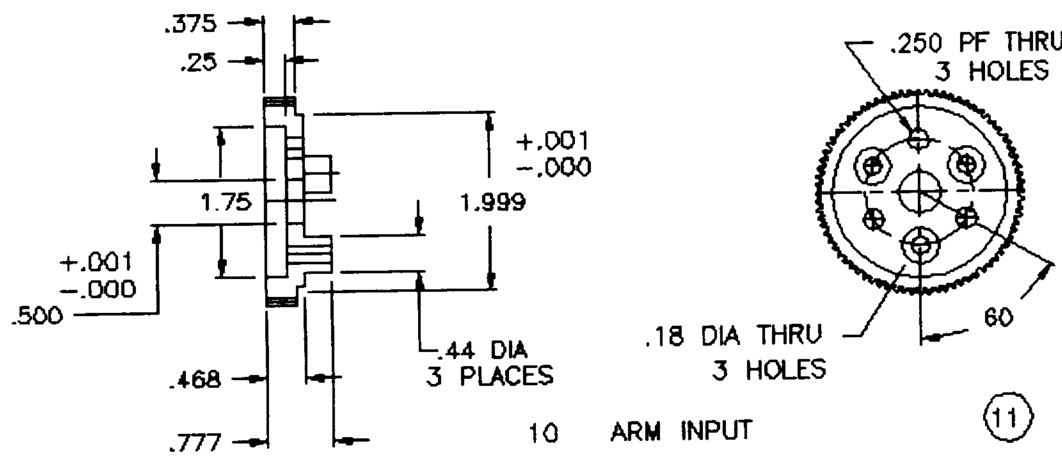
AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



GEAR
NO OF TEETH 68
DIAMETRICAL PITCH 32
PITCH DIAMETER 2.250

(15) ARM #2
STEEL
MOLDED
QTY (1)



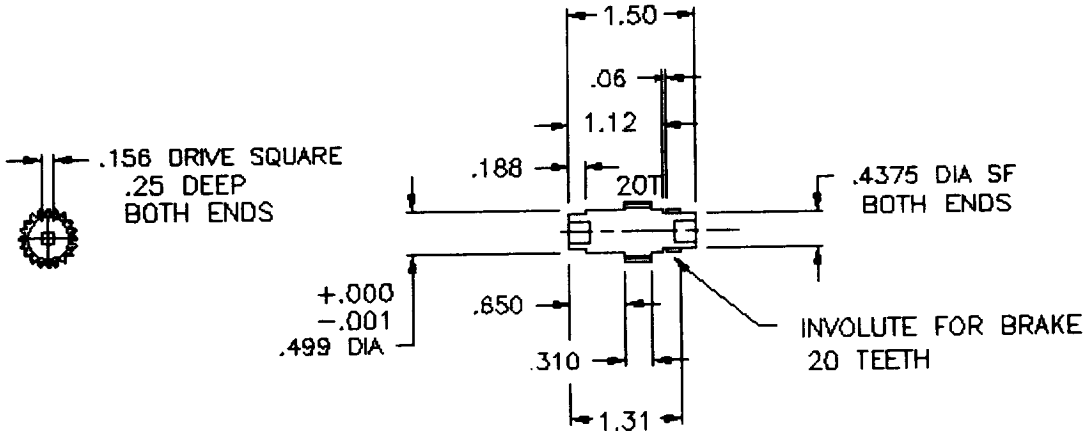
10 ARM INPUT

(11) ARM #1
~~NYLON~~ STEEL
MOLDED
QTY (1)

GEAR
NO OF TEETH 76
DIAMETRICAL PITCH 32
PITCH DIAMETER 2.375

SOUTH LYON DESIGN
REV. APR 12,1997

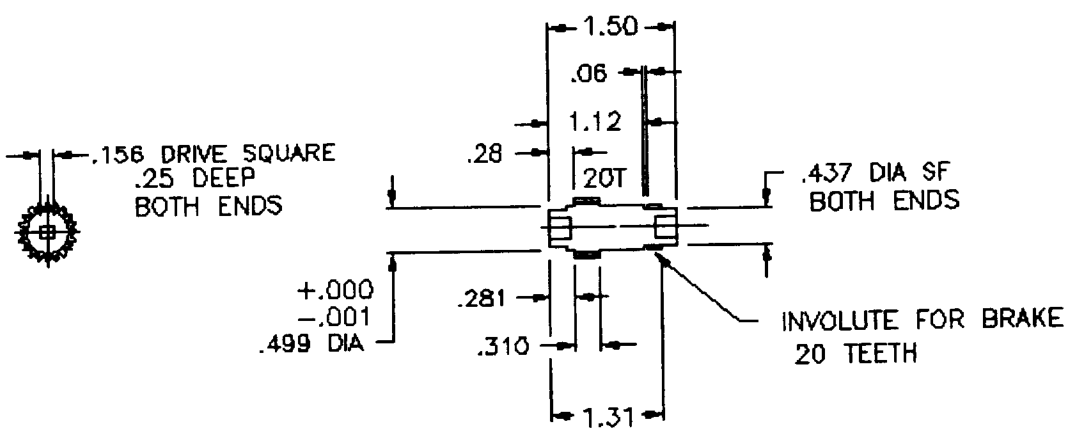
ENGINEER	DATE	AEROMOVER INC
		3 OUTPUT SEAT DRIVE FOR FLEX SHAFT 6 OUTPUT



GEAR

NO OF TEETH	20
DIAMETRICAL PITCH	32
PITCH DIAMETER	.625

(12) SHAFT OUTPUT
STEEL
QTY (1)



GEAR

NO OF TEETH	20
DIAMETRICAL PITCH	32
PITCH DIAMETER	.625

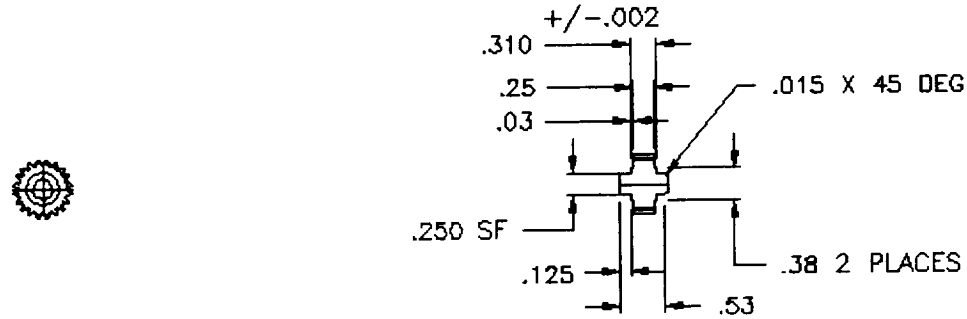
(11) SHAFT OUTPUT
STEEL
QTY (1)

SOUTH LYON DESIGN
REV. APR 12,1997

ENGINEER | DATE

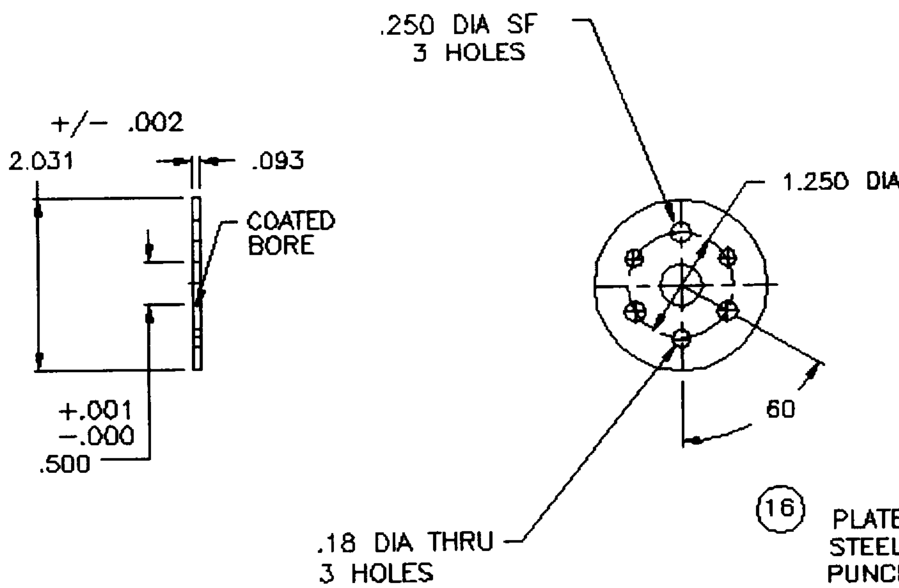
AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



GEAR
NO OF TEETH 20
DIAMETRICAL PITCH 32
PITCH DIAMETER .625

(6) GEAR
~~NYLON~~ STEEL
MOLDED
QTY (6)



(16) PLATE RETAINER
STEEL
PUNCH FROM STRIP
QTY (2)

SOUTH LYON DESIGN
REV. APR 12,1997

ENGINEER	DATE	AEROMOVER INC
		3 OUTPUT SEAT DRIVE FOR FLEX SHAFT 6 OUTPUT

AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT

OPER	DESCRIPTION	OPERATOR TIME	MACHINE TIME	MANPOWER #1	#2	#3
10	ASSEMBLY DIFFERENTIAL (12 SEC PER ASSEMBLY)	28	28	28		
20	ASSEMBLY LOWER HALF	16	*			
30	ASSEMBLY UPPER HALF	12	*		28	
40	JOIN HALF , PRESSS &GREASE	8	10			
50	MOUNT MOTOR	5	*			
60	TEST & MARK PART	8	19			
70	PACKAGE FOR SHIPMENT	7	*			28
	TOTAL LABOR TIME (SEC/UNIT)	84	28			
	PRODUCTION RATE (PC/HR)		128.57			
	ANNNUAL UNITS/SHIFT		257142.86			
	MANPOWER @ PROD. RATE	3.00				
	LABOR RATE		$50			
	LABOR COST PER PIECE		$1.17			

AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT

EQUIPMENT

MACH	DESCRIPTION	OPERATOR TIME	MACHINE TIME
10	INDEX PRESS & GREASE		
	INDEX 180 DEGREE	*	2.00
	ADVANCE PRESS		2.00
	PRESS COVER		1.00
	STAKE 3 RIVETS		4.00
	RETRACT PRESS		2.00
	MANUAL UNLOAD	2.00	
	ASSEMBLY		
	RIVET (3)	3.00	
	BASE	2.00	
	PLANETARY GEAR (3)	3.00	
	COVER	2.00	
	TIME (SEC)	12.00	11.00
40	PRESS HALF & GREASE		
	LOAD HALVES	4.00	
	PRESS TO POSITION		2.00
	INJECT GREASE (8 PLACES)		4.00
	UNLOAD	2.00	
	TIME (SEC0	6.00	6.00
60	TEST PRODUCT		
	LOAD ASSEMBLY	2.00	
	CONNECT LEADS	2.00	
	STALL TEST		3.00
	SOL 1 TEST		3.00
	SOL 2 TEST		3.00
	SOL 3 TEST		3.00
	SOL 2&3 TEST		3.00
	REV TEST		4.00
	DISCONNECT LEADS	2.00	
	UNLOAD	2.00	
		8.00	19.00

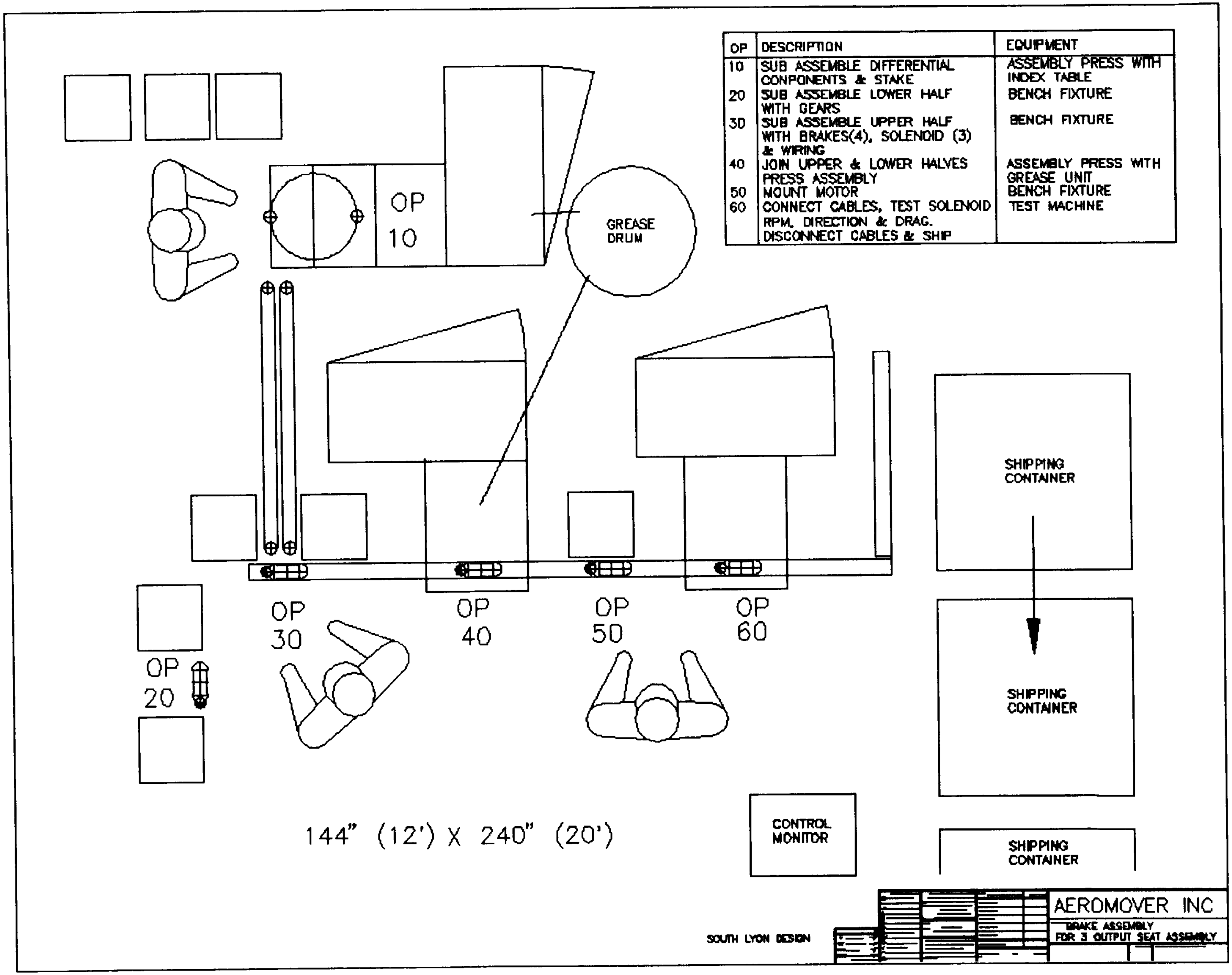
AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT

CAPITAL COST

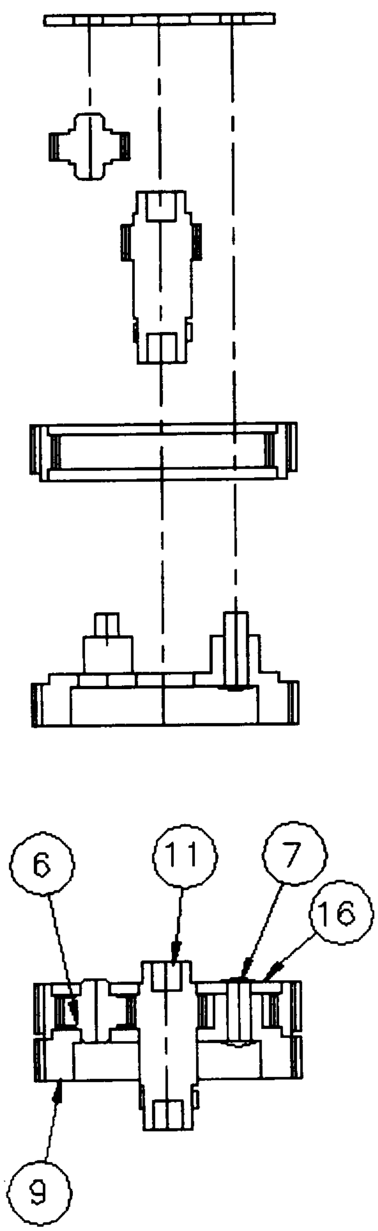
OPER	DESCRIPTION	
10	2 STA DIAL INDEX PRESS & STAKE MACHINE	
	CONPONENTS	
	BASE	
	INDEX UNIT	
	PRESS SLIDE WITH FORCE MONITOR	
	STAKE RAM (3) WITH DISTANCE MONITOR	
	FIXTURE (2)	
	PNEUMATIC SYSTEM	
	ELECTRIC CONTROLLER	
	TRACK SECTION (2) (6 FT)	
	ESTIMATE	$95,000
	BUILDER MARKUP	30.00%
	CAPITAL COST	$123,500
20	TRACK SECTION (6 FT)	
	ESCAPEMENT & LATCH	
30	FIXTURE	
40	ASSEMBLY PRESS & GREASE	
	CONPONENTS	
	CONPONENTS	
	BASE	
	LOWER RAM	
	UPPER RAM	
	LOWER RAM TOOLING	
	UPPER RAM TOOLING	
	ESCAPEMENT (2)	
	TRACK SECTION(6 FT)	
	PNEUMATIC SYSTEM	
	FORCE MONITOR	
	POSITION MONITOR	
	ELECTRICAL CONTROLLER	
	ESTIMATE	$105,000
	BUILDER MARKUP	30.00%
	CAPITAL COST	$136,500

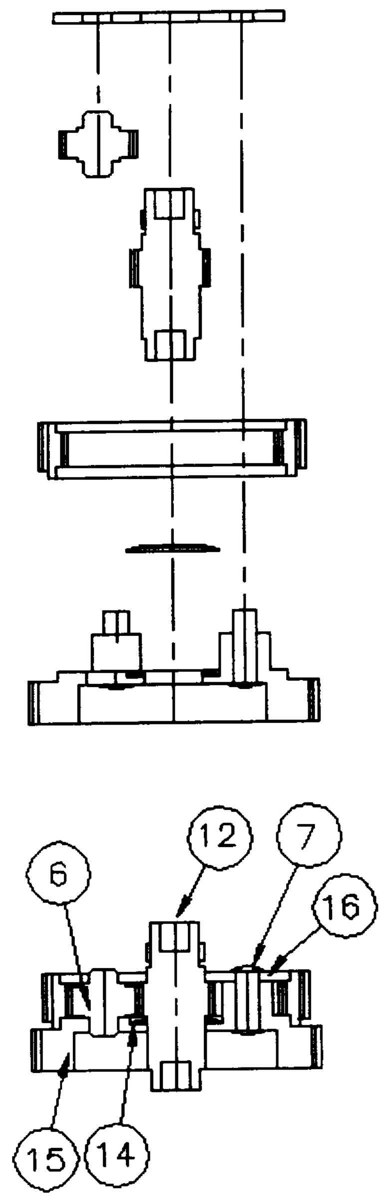
AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT

50	TRACK (6FT)		
	ESCAPEMENT & LATCH		
60	TEST MACHINE		
	CONPONENTS		
	BASE		
	LOWER SLIDE		
	SPEED OUTPUT DEVICES (4)		
	TEST MOTOR CURRENT & VOLT		
	BASE ELECTRICAL CONNECTOR		
	TORQUE BRAKE (1)		
	MARKING SYSTEM		
	PNEUMATIC SYSTEM		
	ELECTRICAL CONTROLLER		
	TRACK SECTION (6 FT)		
	ESTIMATE		$125,000
	BUILDER MARKUP		30.00%
	CAPITAL COST		$162,500
QUALITY CONTROL ITEMS			
	PC, STORAGE BACKUP, SPC, SHIP,		
	DATA HIGHWAY, ETC		$30,000
	CAPITAL COST		$452,500
	CAPITAL COST/UNIT		$1.76
FLOOR SPACE			
		40 X	60.00
			2400.00
			$12
			$28,800
	COST PER PIEC		$0.11
TOTAL COST PER PIECE			$3.04



OP	DESCRIPTION	EQUIPMENT
10	SUB ASSEMBLE DIFFERENTIAL CONPONENTS & STAKE	ASSEMBLY PRESS WITH INDEX TABLE
20	SUB ASSEMBLE LOWER HALF WITH GEARS	BENCH FIXTURE
30	SUB ASSEMBLE UPPER HALF WITH BRAKES(4), SOLENOID (3) & WIRING	BENCH FIXTURE
40	JOIN UPPER & LOWER HALVES PRESS ASSEMBLY	ASSEMBLY PRESS WITH GREASE UNIT
50	MOUNT MOTOR	BENCH FIXTURE
60	CONNECT CABLES, TEST SOLENOID RPM, DIRECTION & DRAG. DISCONNECT CABLES & SHIP	TEST MACHINE





OPERATION	SUB ASSEMBLE DIFFERENTIAL CONPONENTS AND STAKE RIVETS	
TIME CYCLE		PER ASSEMBLY
EQUIPMENT	ASSEMBLY PRESS WITH INDEX TABLE	
COST ESTIMATE		

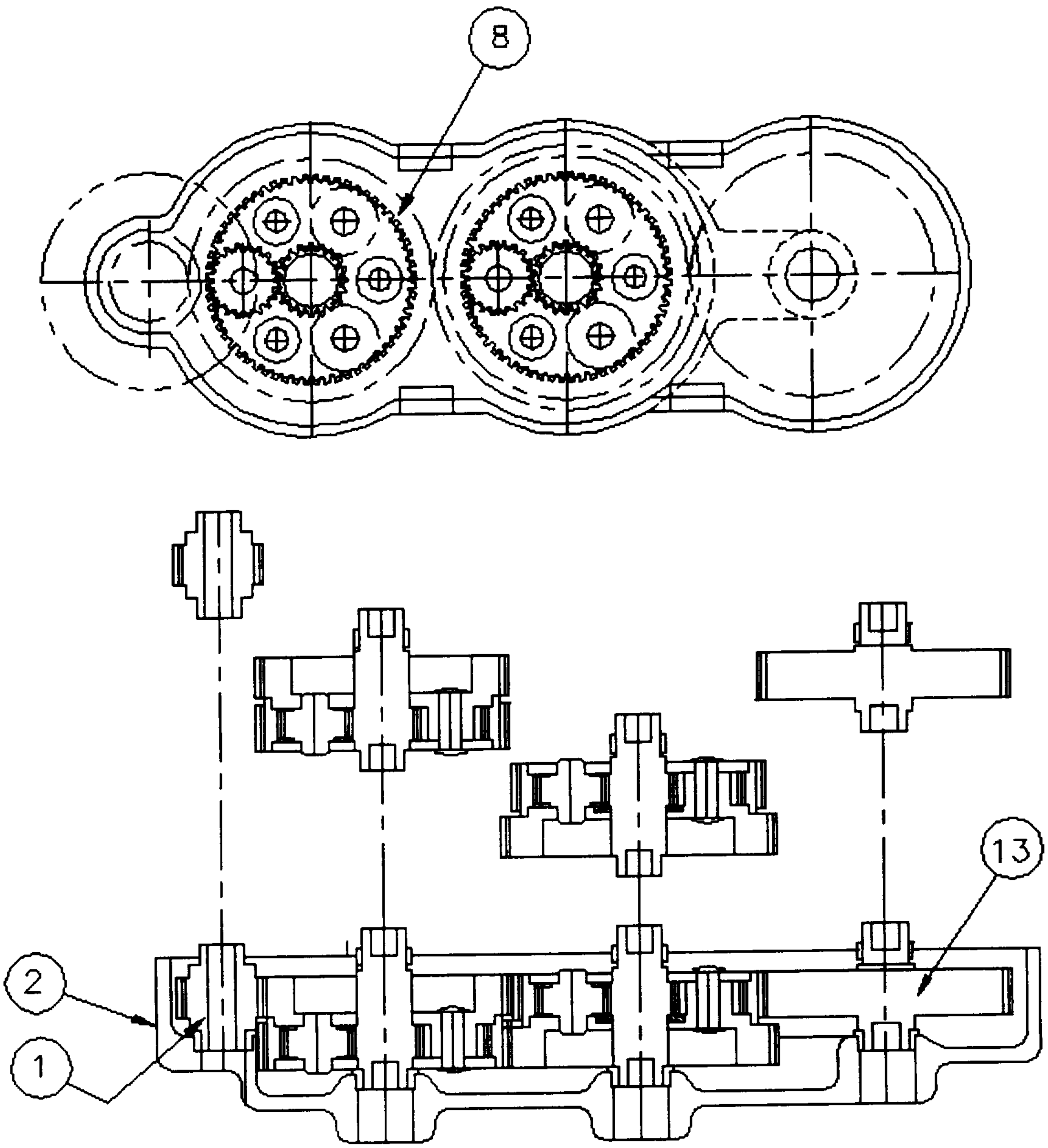
OPERATION NO
10

SOUTH LYON DESIGN

ENGINEER DATE

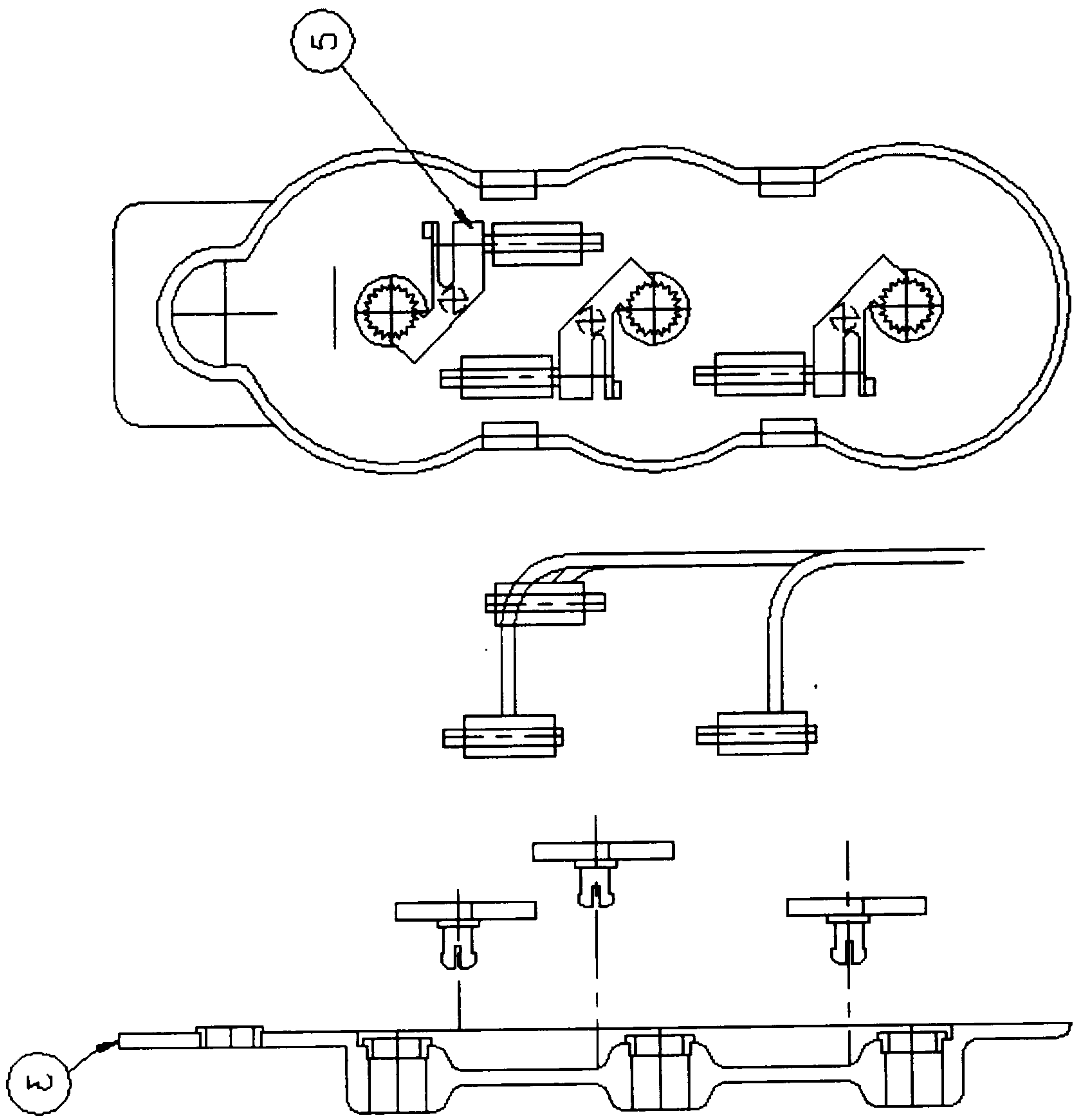
AEROMOVER INC

BRAKE ASSEMBLY
FOR 3 OUTPUT SEAT ASSEMBLY



OPERATION	SUBASSEMBLE LOWER HALF WITH GEARS	
TIME CYCLE		PER ASSEMBLY
EQUIPMENT	BENCH FIXTURE	
COST ESTIMATE		

OPERATION NO 20	ENGINEER	DATE	AEROMOVER INC
SOUTH LYON DESIGN			BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY



OPERATION	ASSEMBLY BRAKE (3), SOLENOID (3) & WIRING	
TIME CYCLE		PER ASSEMBLY
EQUIPMENT	BENCH FIXTURE	
COST ESTIMATE		

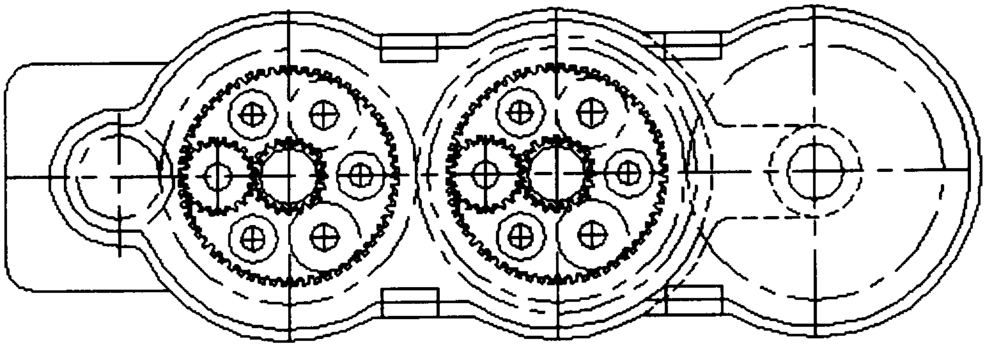
OPERATION NO
30

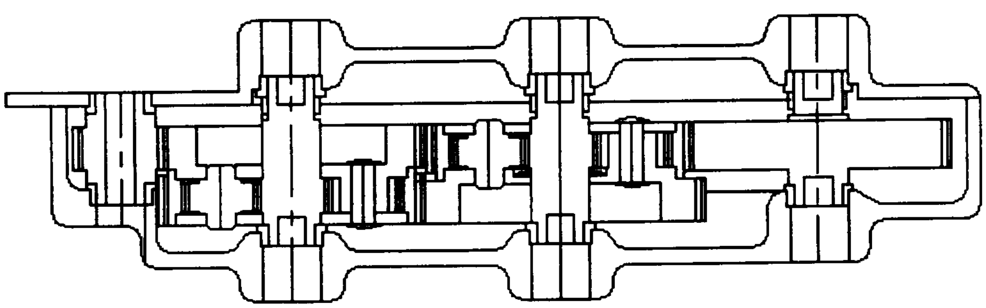
SOUTH LYON DESIGN

ENGINEER DATE

AEROMOVER INC

BRAKE ASSEMBLY
FOR 3 OUTPUT SEAT ASSEMBLY





OPERATION	JOIN TWO SUB–ASSEMBLIES AND LOAD TO PRESS PRESS TO POSITION
TIME CYCLE	PER ASSEMBLY
EQUIPMENT	PRESS WITH POSITION FEEDBACK
COST ESTIMATE	

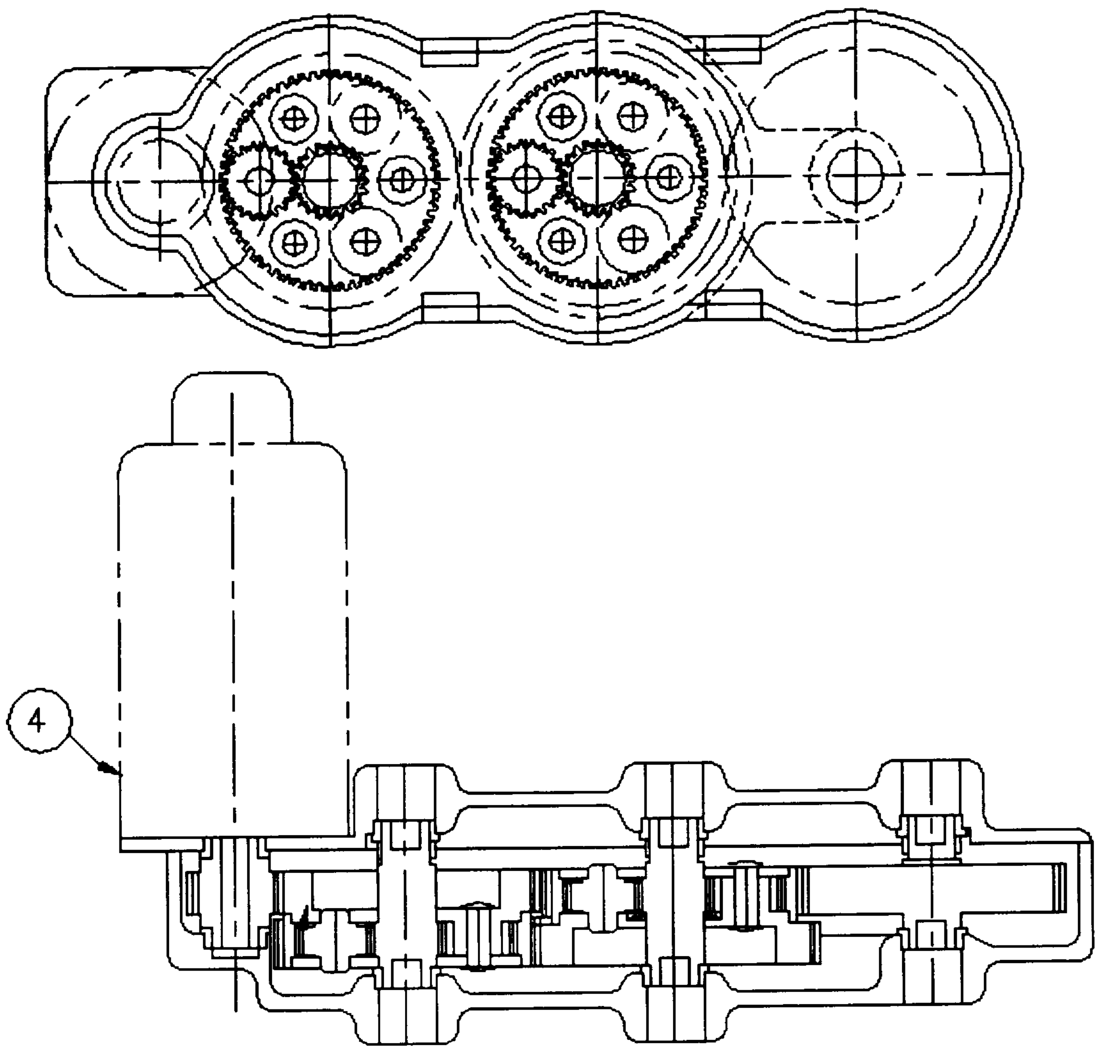
OPERATION NO
40

SOUTH LYON DESIGN

ENGINEER | DATE

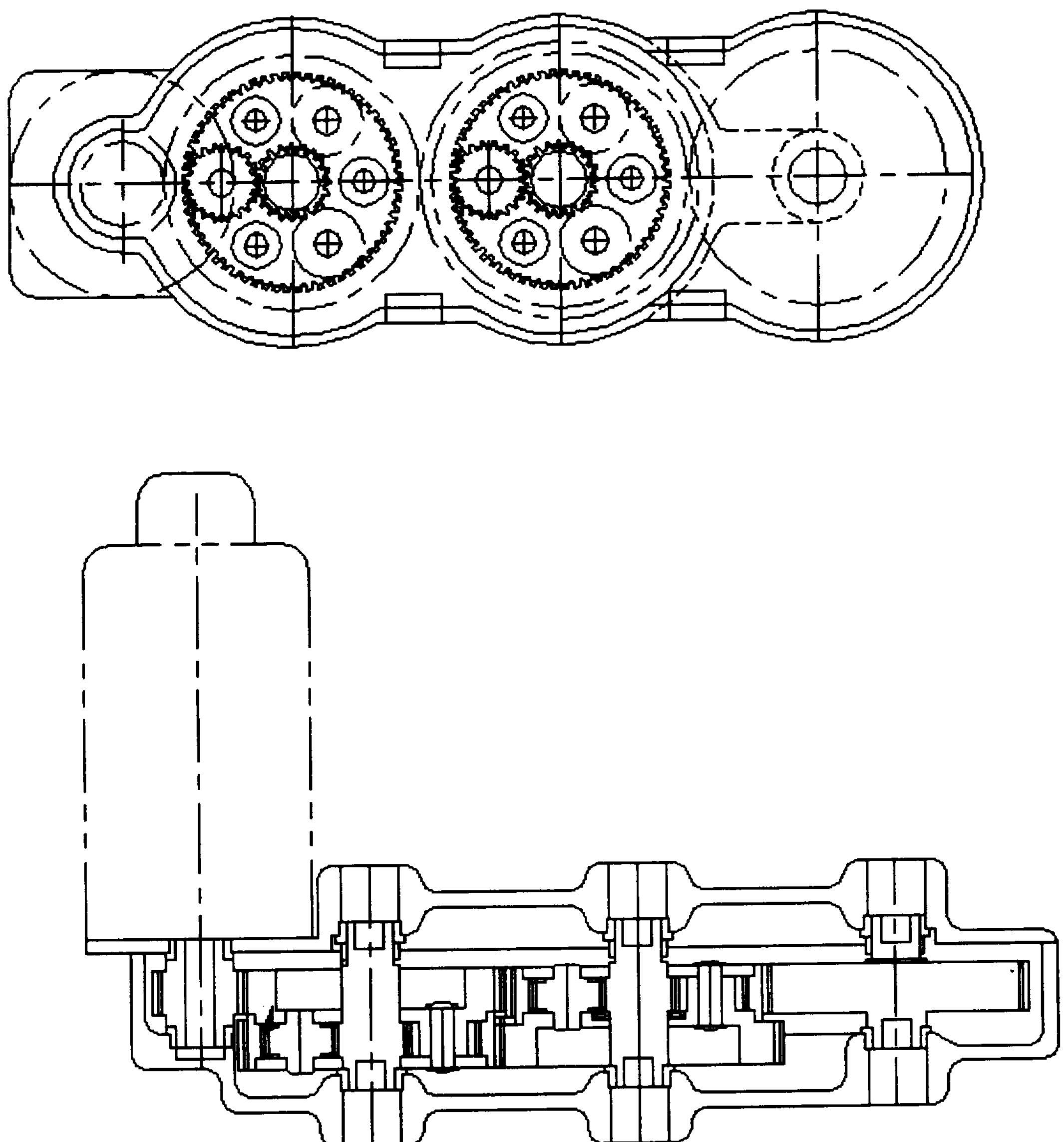
AEROMOVER INC

BRAKE ASSEMBLY
FOR 3 OUTPUT SEAT ASSEMBLY



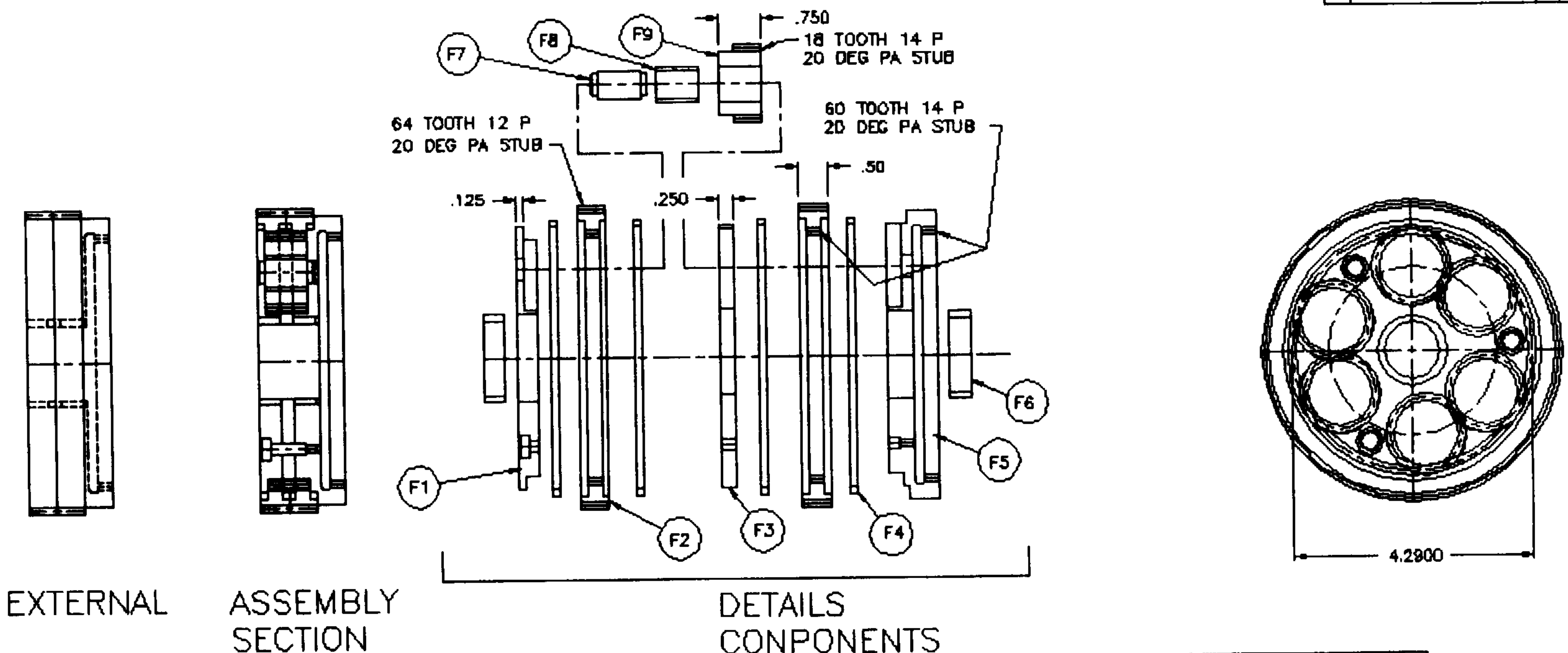
OPERATION	MOUNT MOTOR
TIME CYCLE	PER ASSEMBLY
EQUIPMENT	BENCH FIXTURE
COST ESTIMATE	

OPERATION NO 50	ENGINEER	DATE	AEROMOVER INC
SOUTH LYON DESIGN			BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY



OPERATION	CONNECT CABLES TEST SOL., RPM, DIRECTION, & DRAG DISCONNECT CABLES & SHIP
TIME CYCLE	PER ASSEMBLY
EQUIPMENT	TEST MACHINE
COST ESTIMATE	

OPERATION NO 60	ENGINEER	DATE	AEROMOVER INC
SOUTH LYON DESIGN			BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY

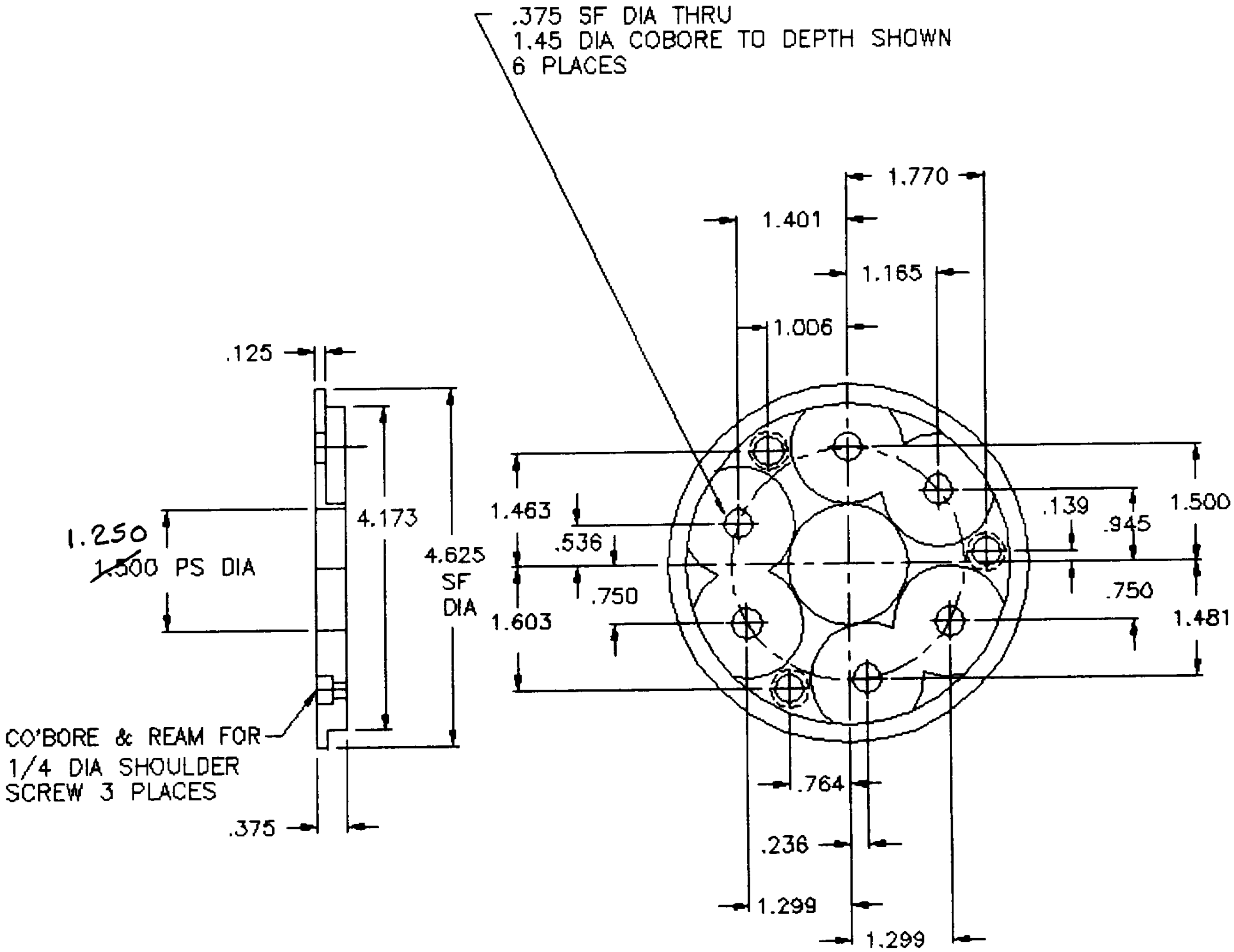


FINAL DIFFERENTIAL ASSEMBLY

SYM	QTY	DESCRIPTION
F1	1	HSG OUTER
F2	2	GEAR ANNULUS
F3	1	SUPPORT CTR
F4	4	BRG OUTER
F5	1	HSG INNER
F6	2	BRG INNER
F7	6	SHAFT
F8	6	BEARING PINION
F9	6	PINION PLANETARY
F10	3	3/8 SHOULDER SCR

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



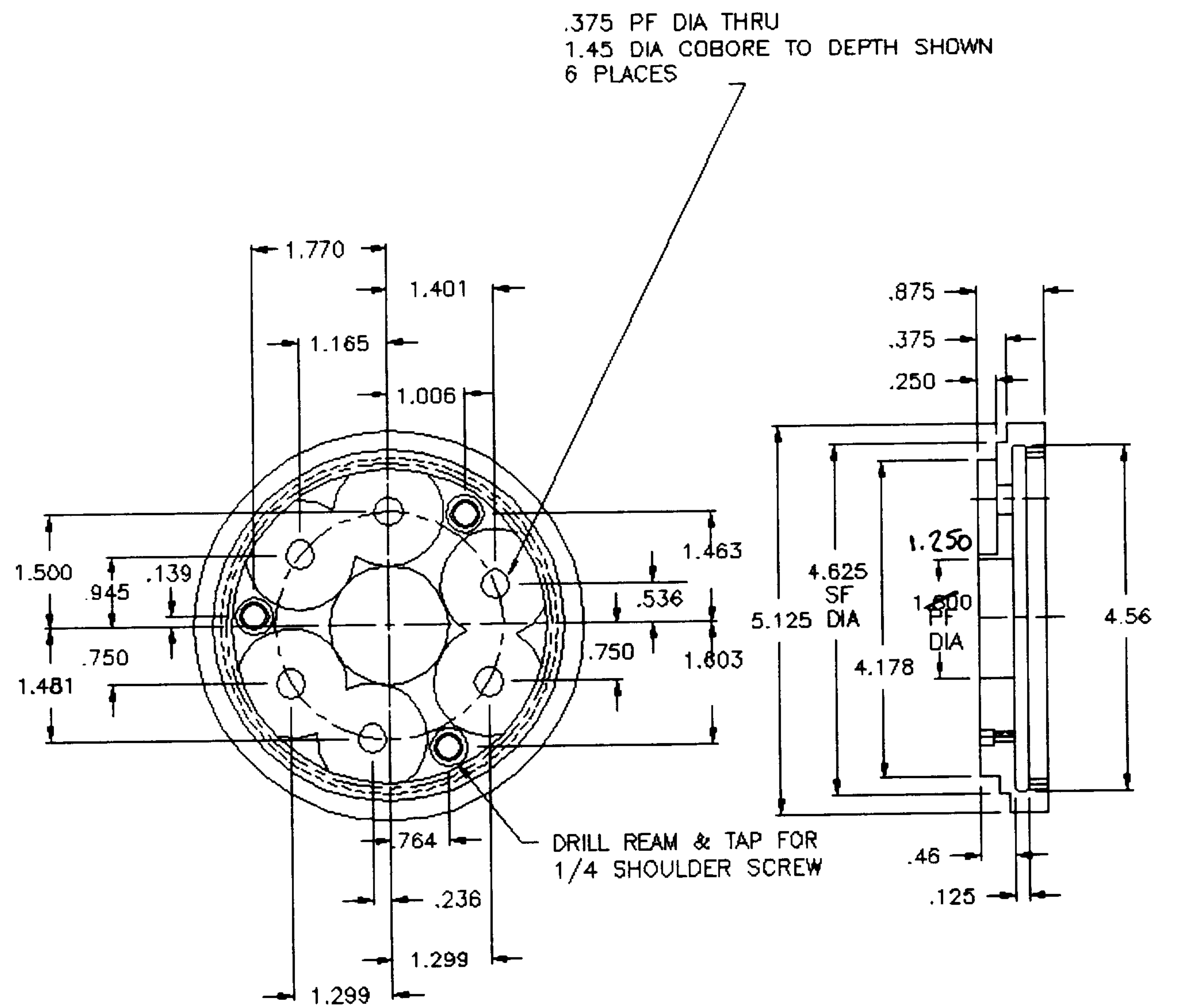
F1

HSG OUTER
STEEL 1045
4-3/4 DIA X3/4
QTY 1 PER DIFFERENTIAL
4 2 DIFFERENTIAL REQUIRED

ENGINEER	DATE
	SLD 4/17/97

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



F5

HSG INNER
STEEL 1045
5-1/4 DIA X1
QTY 1 PRE DIFFERENTIAL
4 2 DIFFERENTIAL REQUIRED

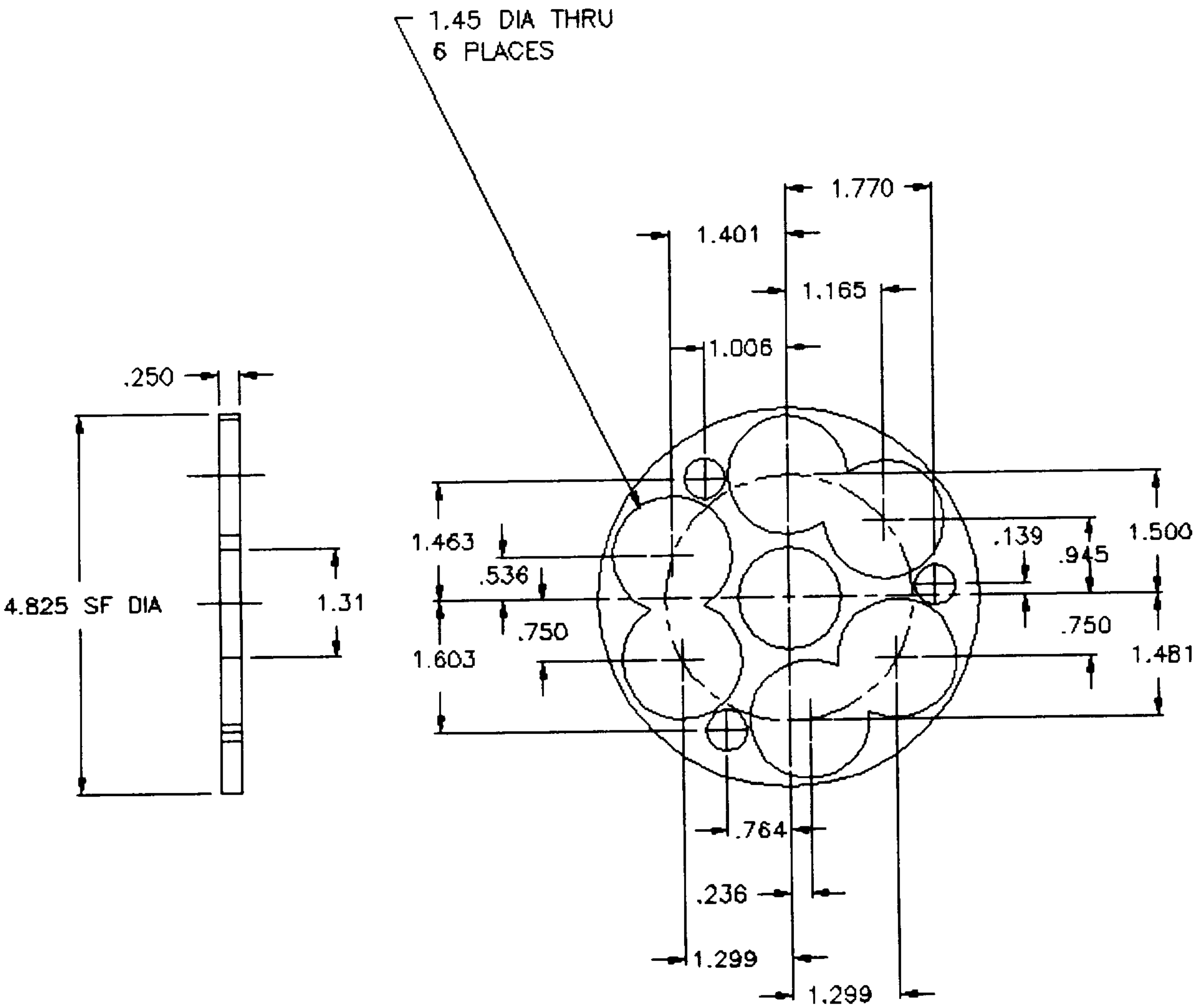
GEAR INFO

	INTERNAL
NO OF TEETH	60
DIAMETRICAL PITCH	14
PITCH DIAMETER	4.286

ENGINEER	DATE
	SLD
	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



(F3) SUPPORT CTR

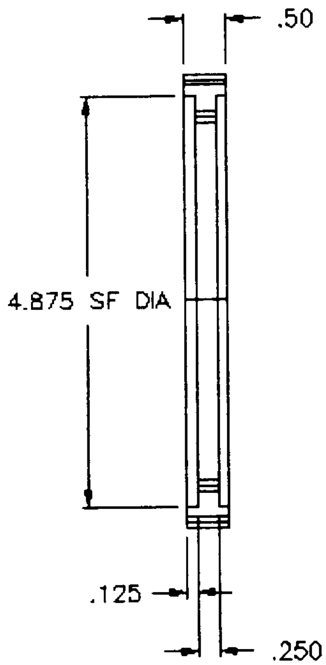
STEEL 1045
4-3/4 DIA 3/8
QTY 1 PER DIFFERENTIAL
4 ~~8~~ DIFFERENTIAL REQUIRED

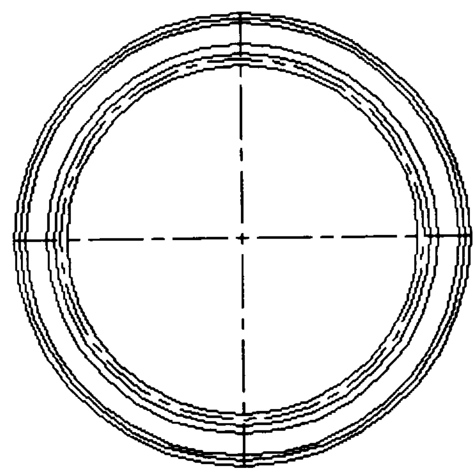
ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

64 TOOTH 12 P
20 DEG PA STUB





GEAR INFO	OUTER	INNER
NO OF TEETH	64	60
DIAMETRICAL PITCH	12	14
PITCH DIA	5.333	4.285

(F2)

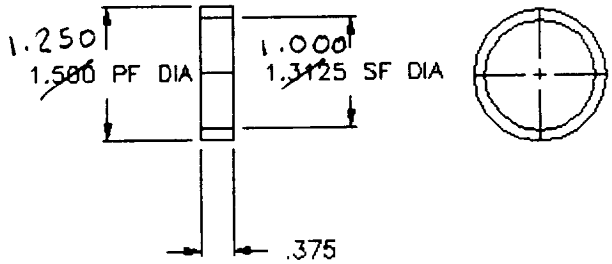
GEAR
GEAR ANNULUS
STEEL 1045
HARDENED
5-1/2 DIA X 3/4
OR TUBE 5-1/2 OD X 4-3/4 ID X 3/4

QTY 2 PER DIFFERENTIAL
4 2 DIFFERENTIAL REQUIRED

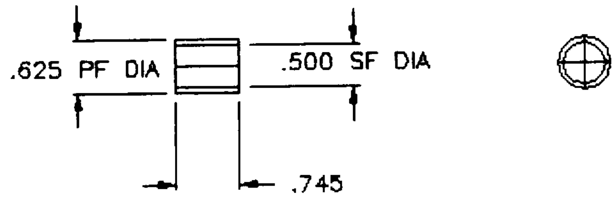
ENGINEER	DATE
	SLD
	4/17/97

AEROMOVER INC.

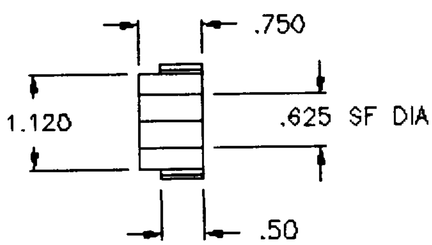
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



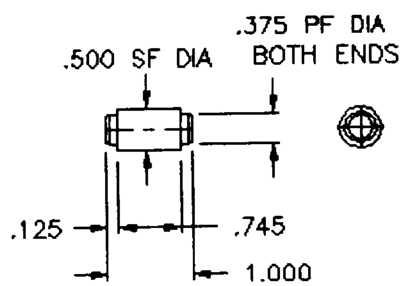
F6 BEARING INNER
NYLON
1-5/8 XDIA X 1/2
QTY 2 PER DIFFERENTIAL
4 X DIFFERENTIAL REQUIRED



F8 BEARING PINION
NYLON
3/4 DIA X 1
QTY 6 PER DIFFERENTIAL
4 X DIFFERENTIAL REQUIRED



F9 PINION PLANETARY
STEEL 1045
HARDENED
1-3/8 DIA X 1
QTY 6 PER DIFFERENTIAL
4 X DIFFERENTIAL REQUIRED



F7 SHAFT
STEEL 1045
HARDENED
5/8 DIA X 1-1/8
OR DRILL ROD
QTY 6 PER DIFFERENTIAL
4 X DIFFERENTIAL REQUIRED

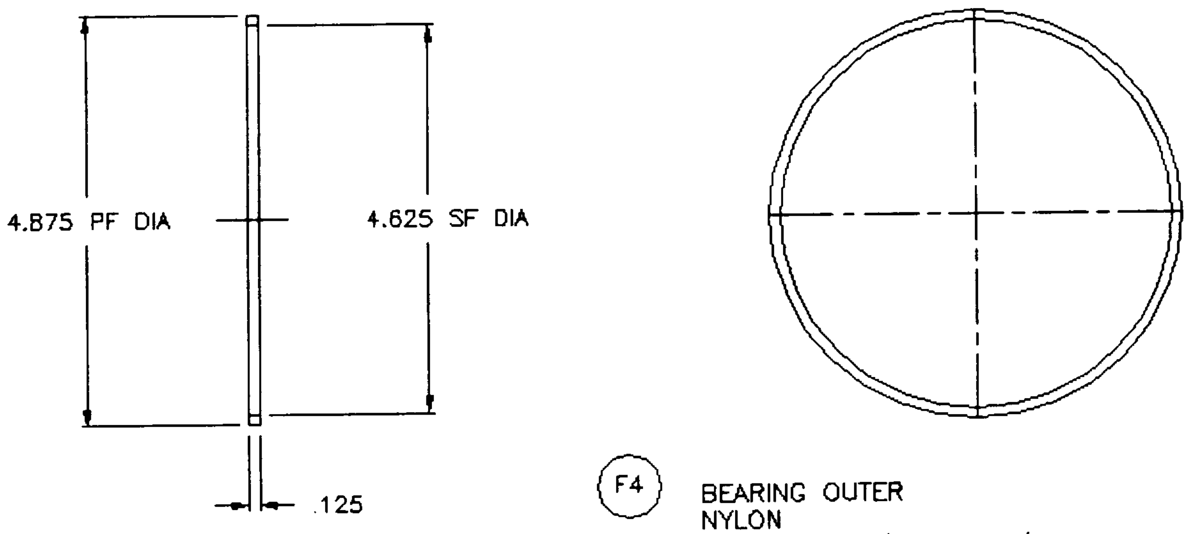
GEAR INFO

NO FO TEETH	18
DIAMETRICAL PITCH	14
PITCH DIA	1.285

ENGINEER	DATE
	SLD
	4/17/97

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



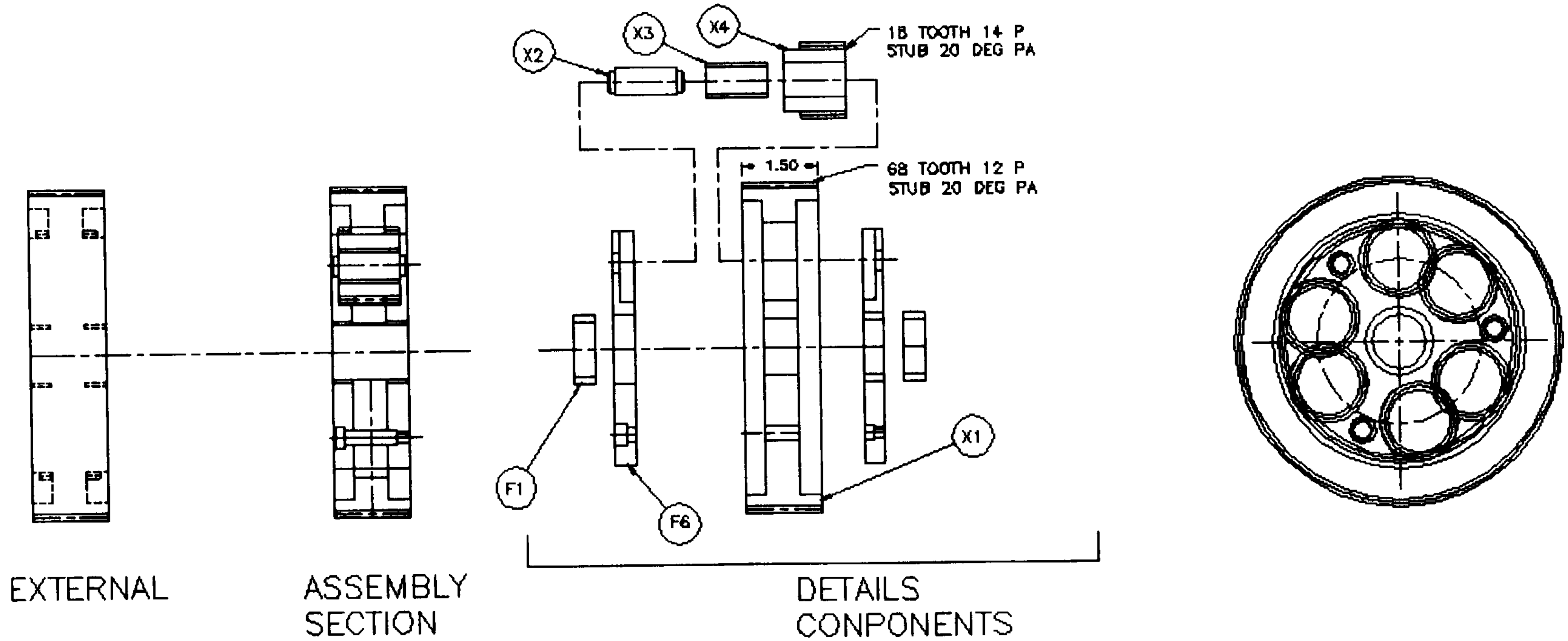
F4

BEARING OUTER
NYLON
5 OD X 4-1/2 ID X 1/4
QTY 4 PER DIFFERENTIAL
4 ~~2~~ DIFFERENTIAL REQUIRED

ENGINEER	DATE
	SLO
	4/17/

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



INTERMEDIATE DIFFERENTIAL ASSEMBLY

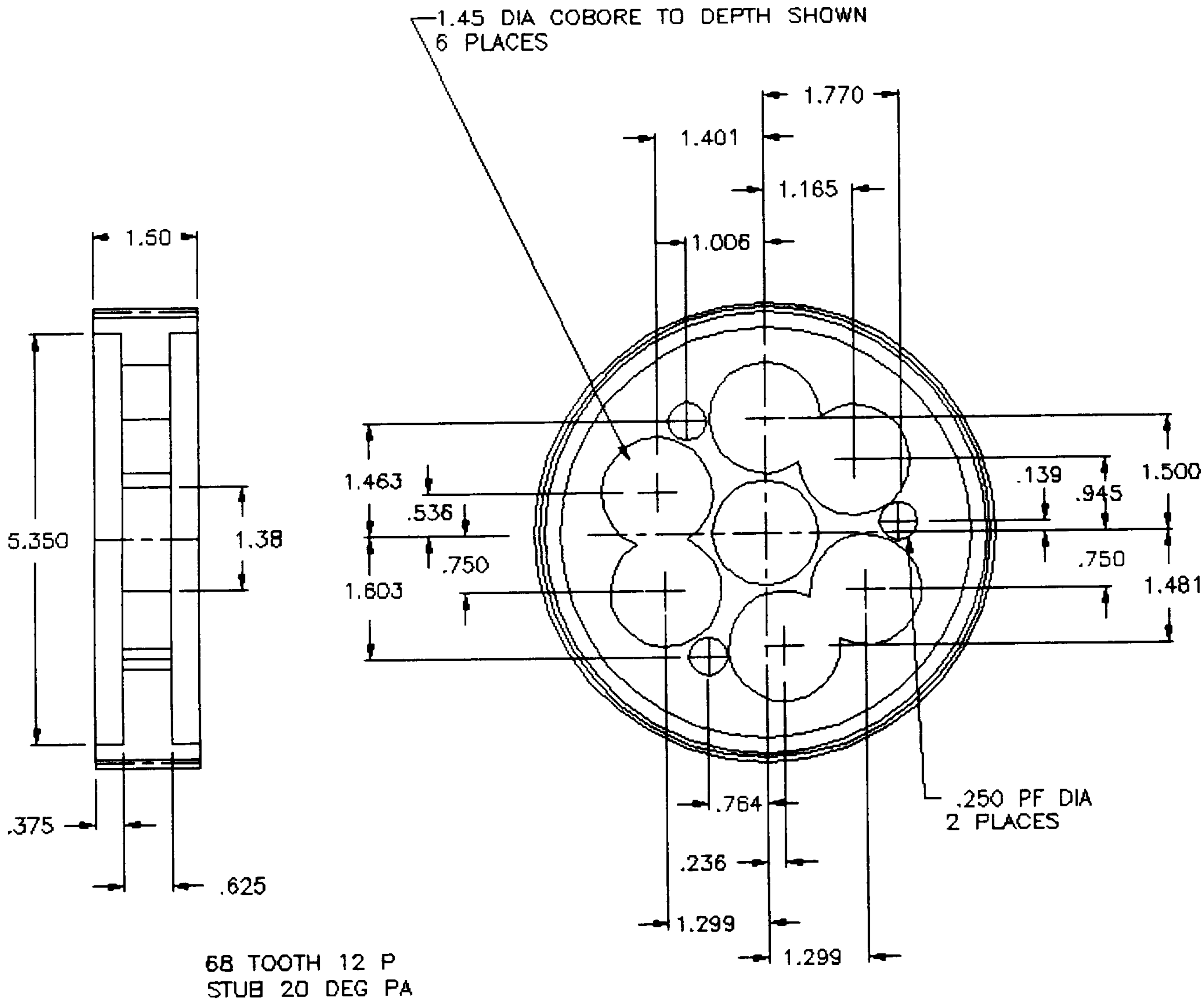
SYM	QTY	DESCRIPTION
X1	1	GEAR CENTER
X2	6	SHAFT
X3	6	BEARING PINION
X4	6	PINION PLANETARY
X5	3	3/8 SHOULDER SCR
F1	1	HSG OUTER
F6	2	BRG INNER

QUANTITY (2)

SLD 2/21/97

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



GEAR INFO

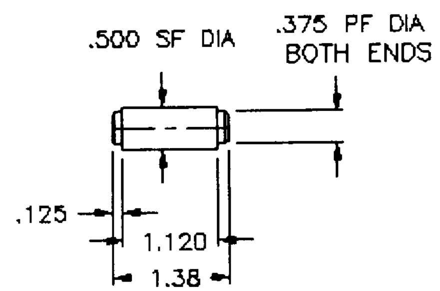
NO OF TEETH	68
DIAMETRICAL PITCH	12
PITCH DIAMETER	5.666

(X1) CENTER GEAR
STEEL 1045
HARDENED
6 DIA X 1-3/4
QTY 1 PER DIFFERENTIAL
2 DIFFERENTIAL REQUIRED

ENGINEER	DATE
	SLD 4/17/97

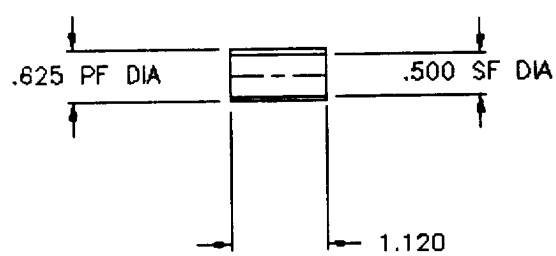
AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



(X2)

PINION SHAFT
STEEL 1045
OR DRILLL ROD
1/2 DIA X 1-1/2
QTY 6 PER DIFFERENTAL B
2 DIFFERENTIAL REQUIRED



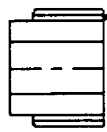
(X3)

BEARING PINION
NYLON
3/4 DIA X 1-1/2
6 REQUIRED PER DIFFERENTIAL
~~1 DIFFERENTIAL REQUIRED~~
2 DIFFERENTIAL REQUIRED

ENGINEER	DATE
SLD	4/17/97

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



18 TOOTH 14 P
STUB 20 DEG PA

(X4)

PINION PLANETARY
STEEL 1045
HARDENED
1-1/2 DIA X 1-1/2
QTY 6 PER DIFFERENTIAL
2 DIFFERENTIAL REQUIRED

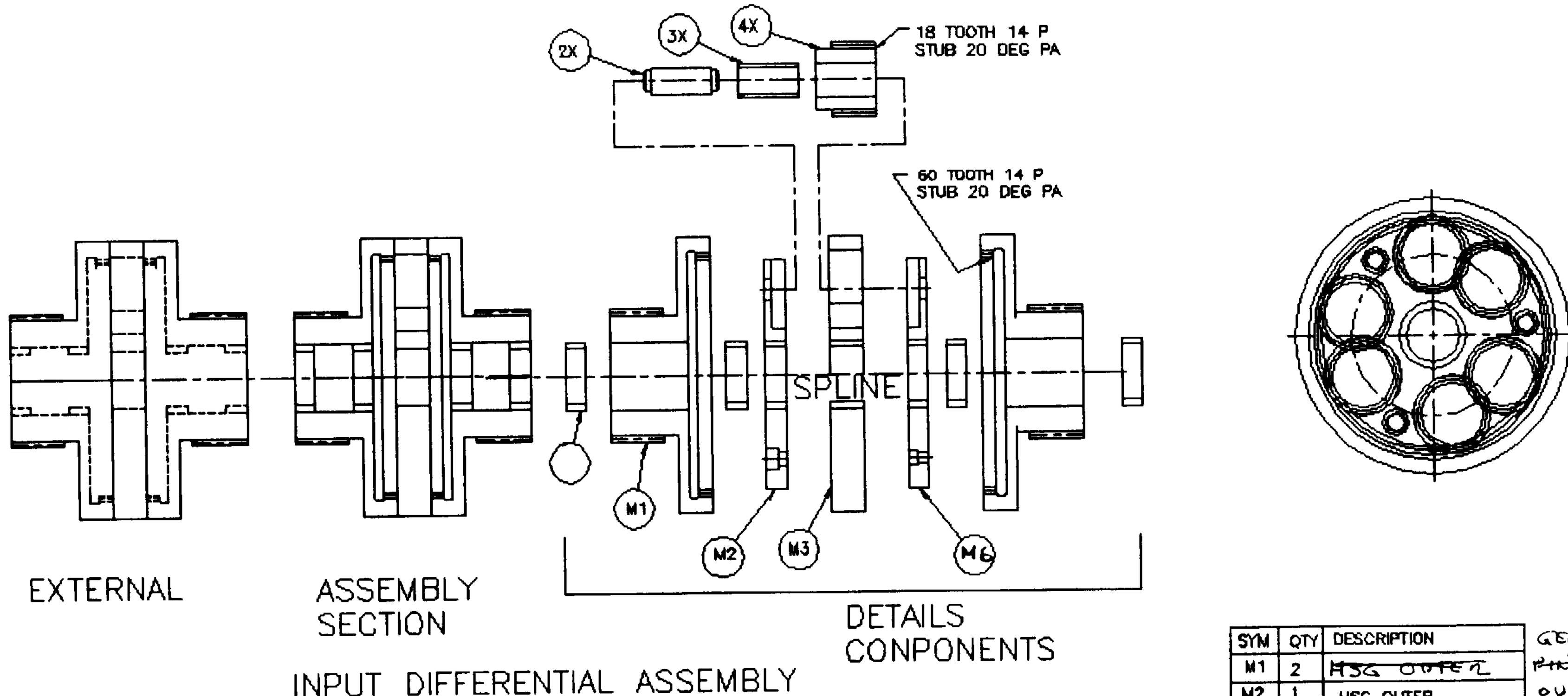
GEAR INFO

NO OF TEETH	18
DIAMETRICAL PITCH	14
PITCH DIAMETER	1.285

ENGINEER	DATE
SLD	4/17/97

AEROMOVER INC.

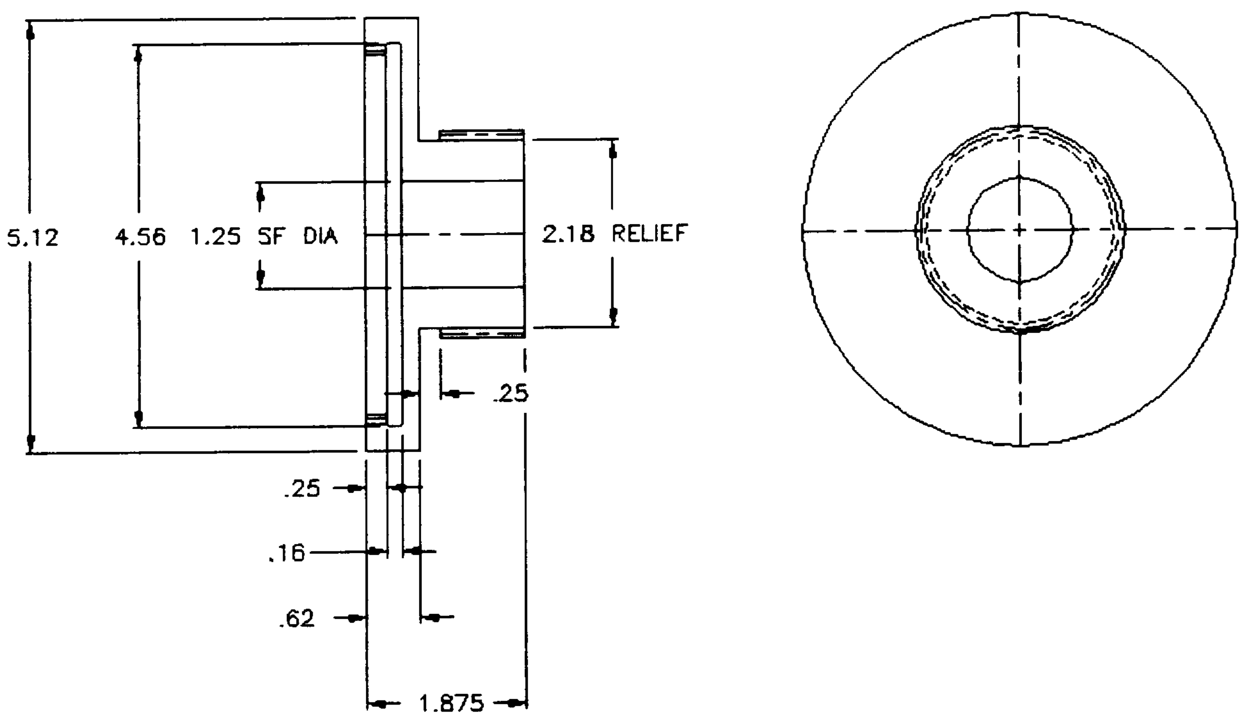
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



SYM	QTY	DESCRIPTION
M1	2	~~HSG OUTER~~ GEAR PINION OUTPUT
M2	1	HSG OUTER
M3	1	CENTER
X2	6	SHAFT
X3	6	BEARING PINION
X4	6	PINION PLANETARY
M4	3	3/8 SHOULDER SCR
F6	4	BRG INNER
M5	1	HSG OUTER

AEROMOVER INC.

8 SPINDLE NUT RUNNNER
300 IN LB CAPACITY

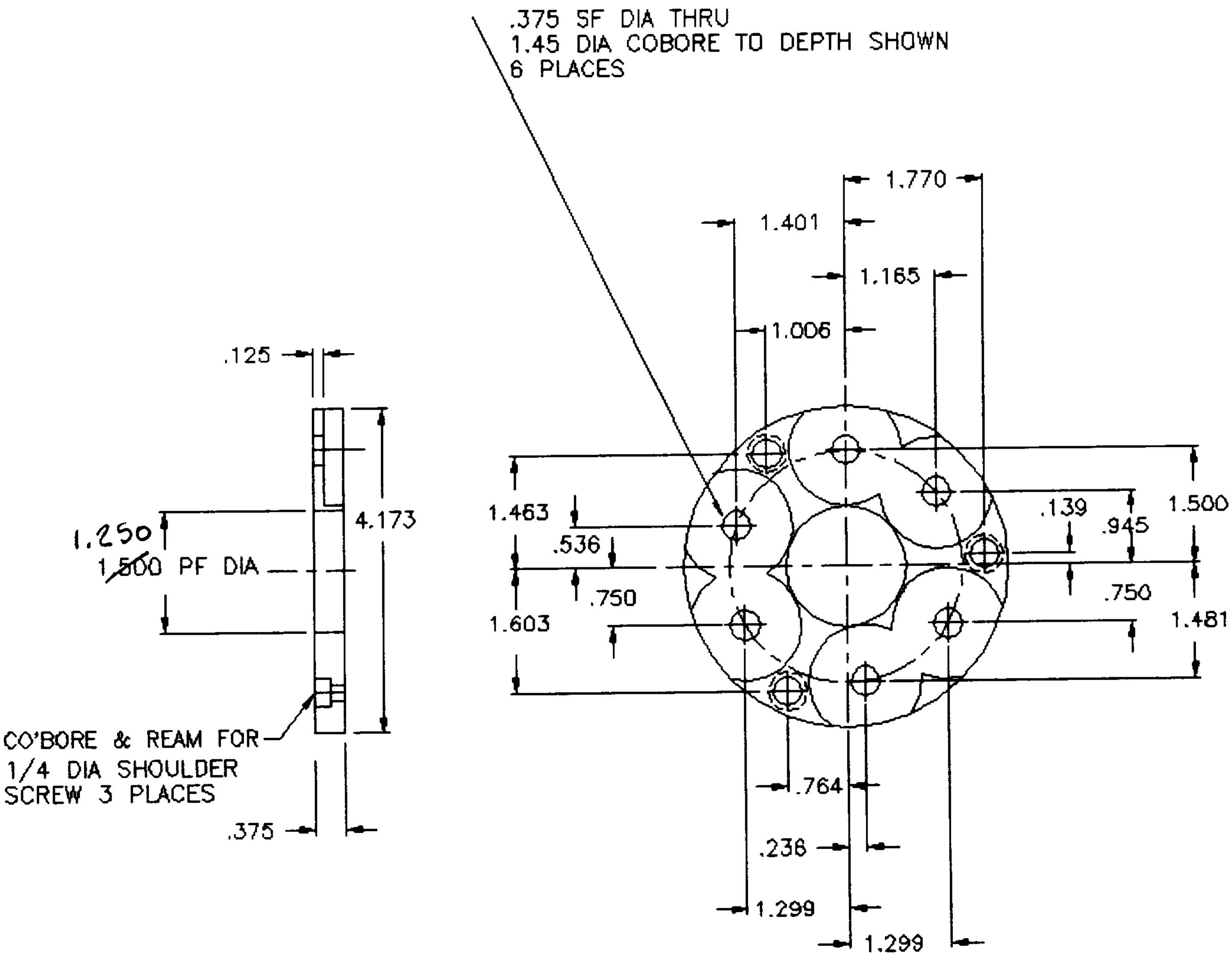


(M1) ~~PINION MTR~~ GEAR OUTPUT
STEEL 1045
HARDENED
5-1/4 DIA X 2
QTY 2 REQUIRED PER DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

GEAR INFO

	INTERNAL	EXTERNAL
NO OF TEETH	60	28
DIAMETRICAL PITCH	14	12
PITCH DIAMETER	4.285	2.333

ENGINEER	DATE	
	SLD 4/17/97	AEROMOVER INC.
		8 SPINDLE NUT RUNNNER 300 IN LB CAPACITY



CHANGE TO PLANET CARRIER

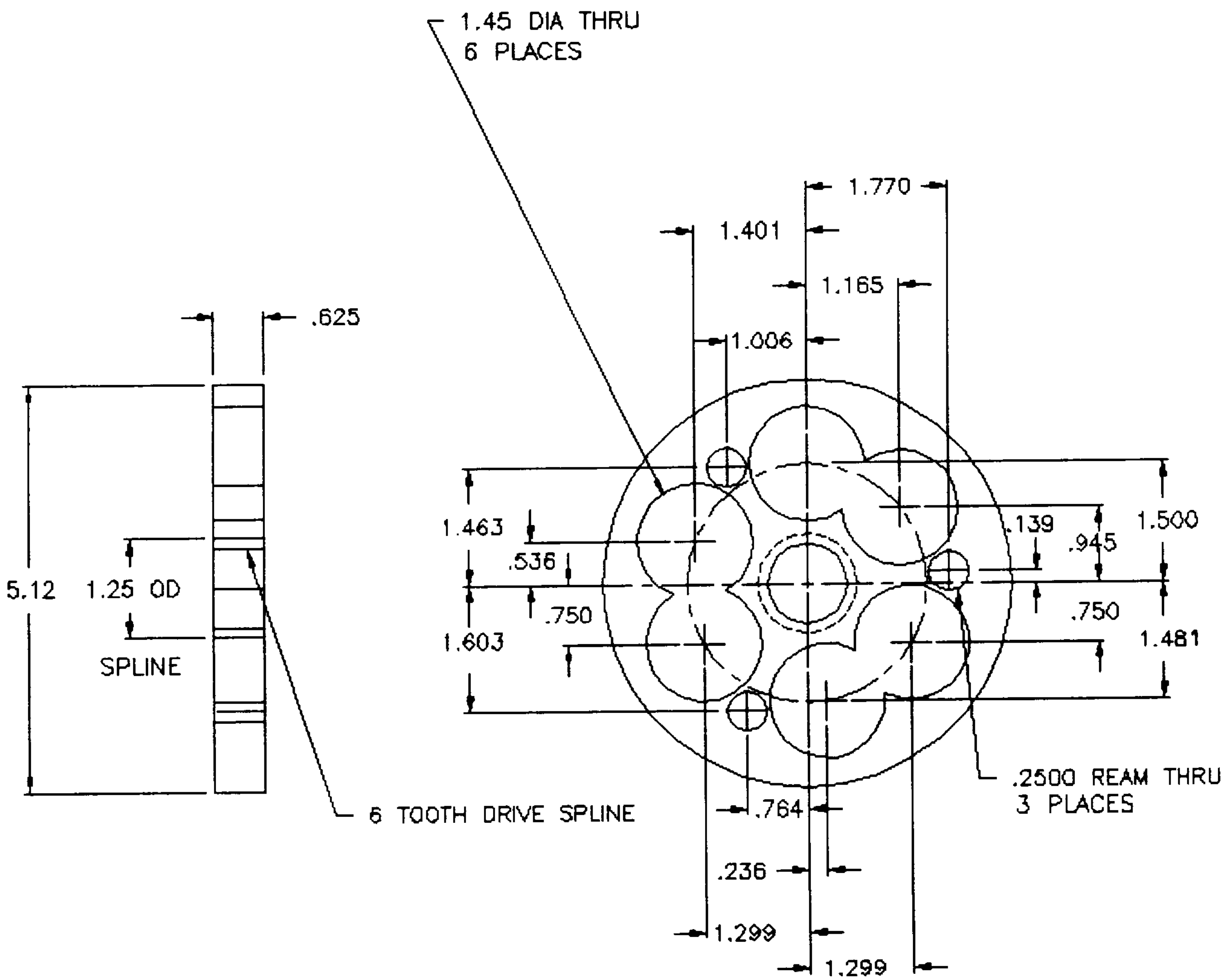
M2

HSC OUTER ~~HSG OUTER~~ CARRIER
STEEL 1045
4-1/4 DIA X 3/4
QTY 1 PER DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

ENGINEER	DATE
SLD	4/17/97

AEROMOVER INC.

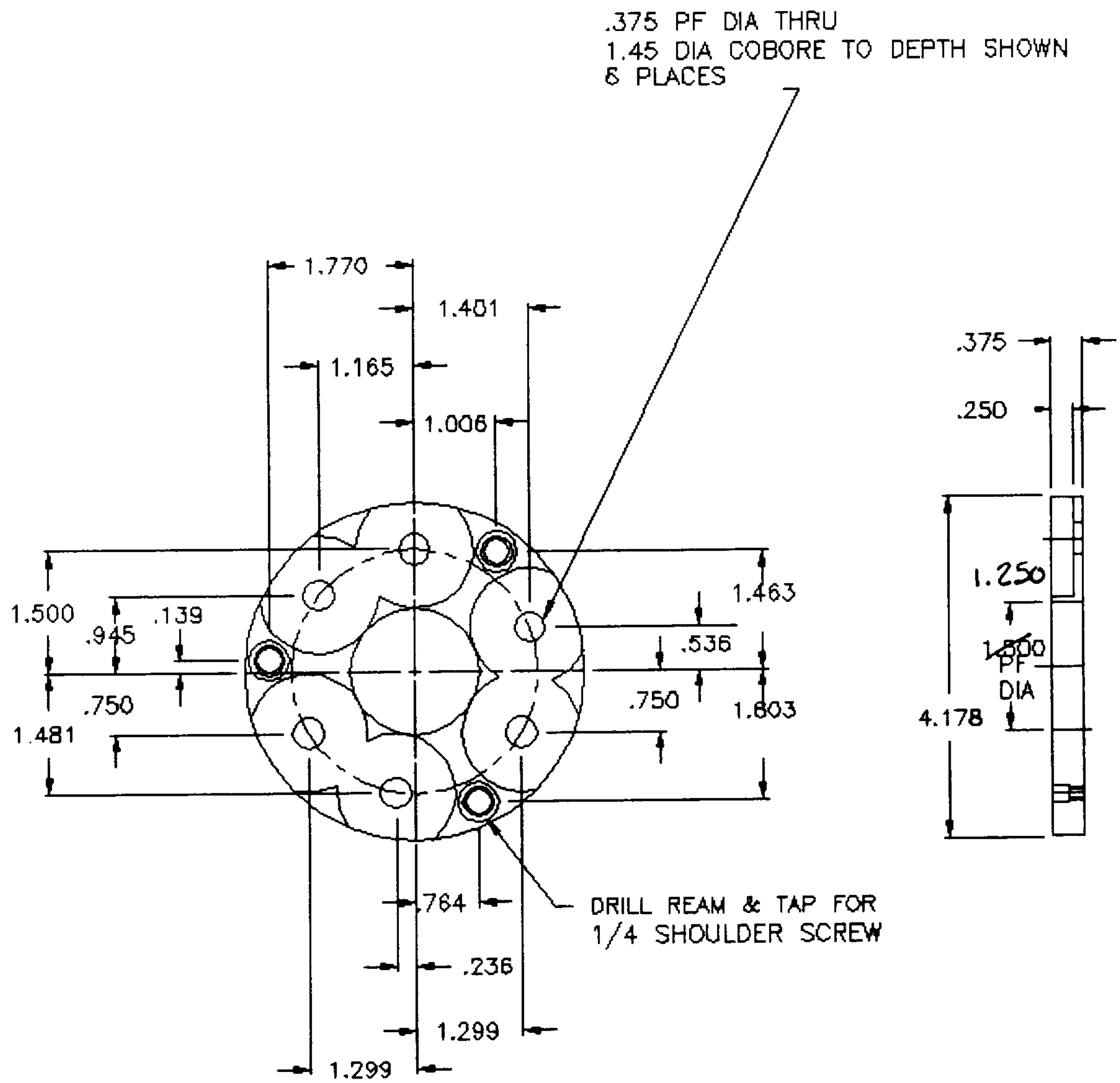
8 SPINDLE NUT RUNNNER
300 IN LB CAPACITY



(M3) SUPPORT CTR

STEEL 1045
5-1/4 DIA X 3/4
QTY 1 PER DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

ENGINEER	DATE	
SLD	4/17/97	AEROMOVER INC.
		8 SPINDLE NUT RUNNNER 300 IN LB CAPACITY



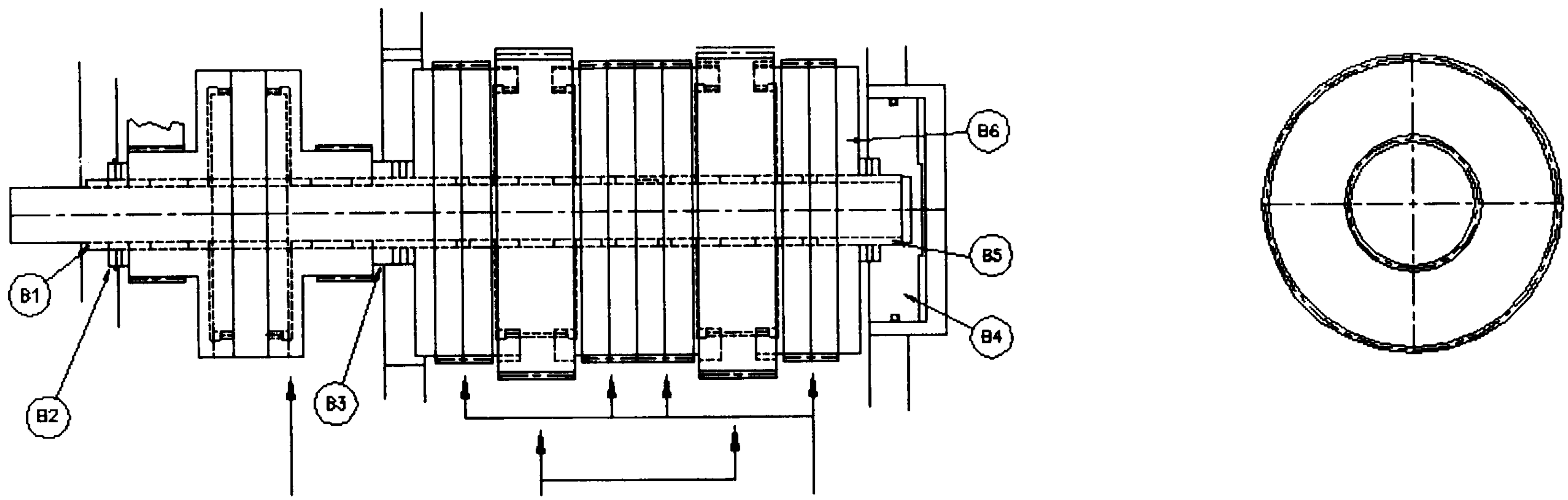
M5

HSG INNER
STEEL 1045
4-1/4 DIA X 1/2
QTY 1 PRE DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

ENGINEER | DATE
SLD | 4/17/97

AEROMOVER INC.

6 SPINDLE NUT RUNNNER
300 IN LB CAPACITY

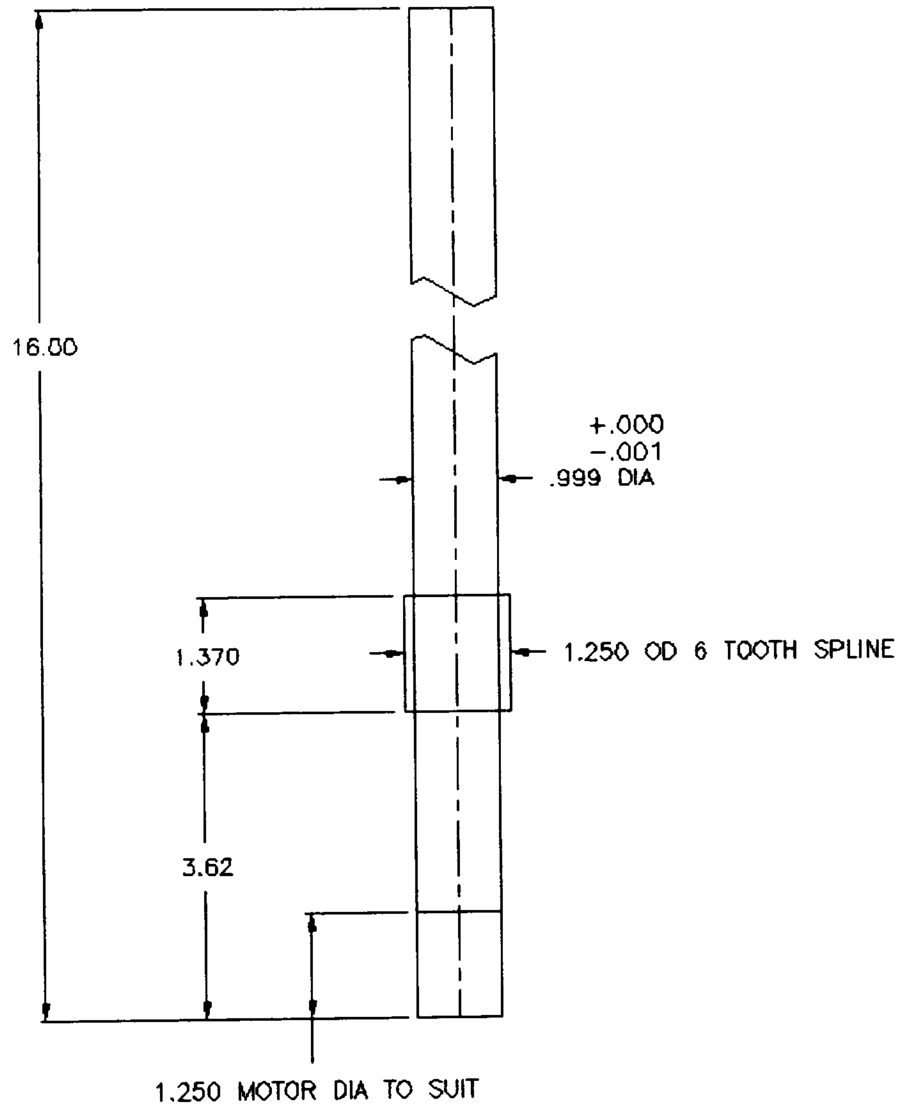


DIFFERENTIAL ASSEMBLY LAYOUT

SYM	QTY	DESCRIPTION
B1	1	SHAFT
B2	3	BRG THRUST
B3	1	SPACER
B4	1	PISTON
B5	2	BUSHING
B6	2	CAP
B7	1	O-RING

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



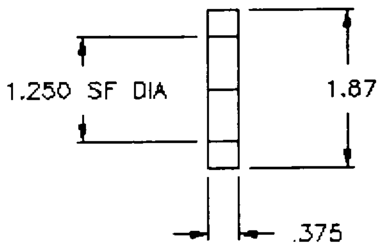
(B1) SHAFT
STEEL 1020
1-1/4 DIA X 16-1/4
QTY 1

ENGINEER	DATE
SLD	4/17/87

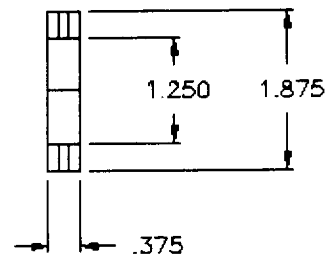
AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

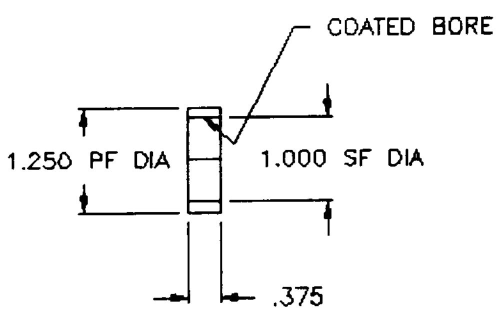
REVISIONS



(B3) SPACER
CRS
1-7/8 DIA X 1/2
QTY 1



(B2) THRUST BEARING
NEEDLE TYPE
COMMERICAL
QTY 3

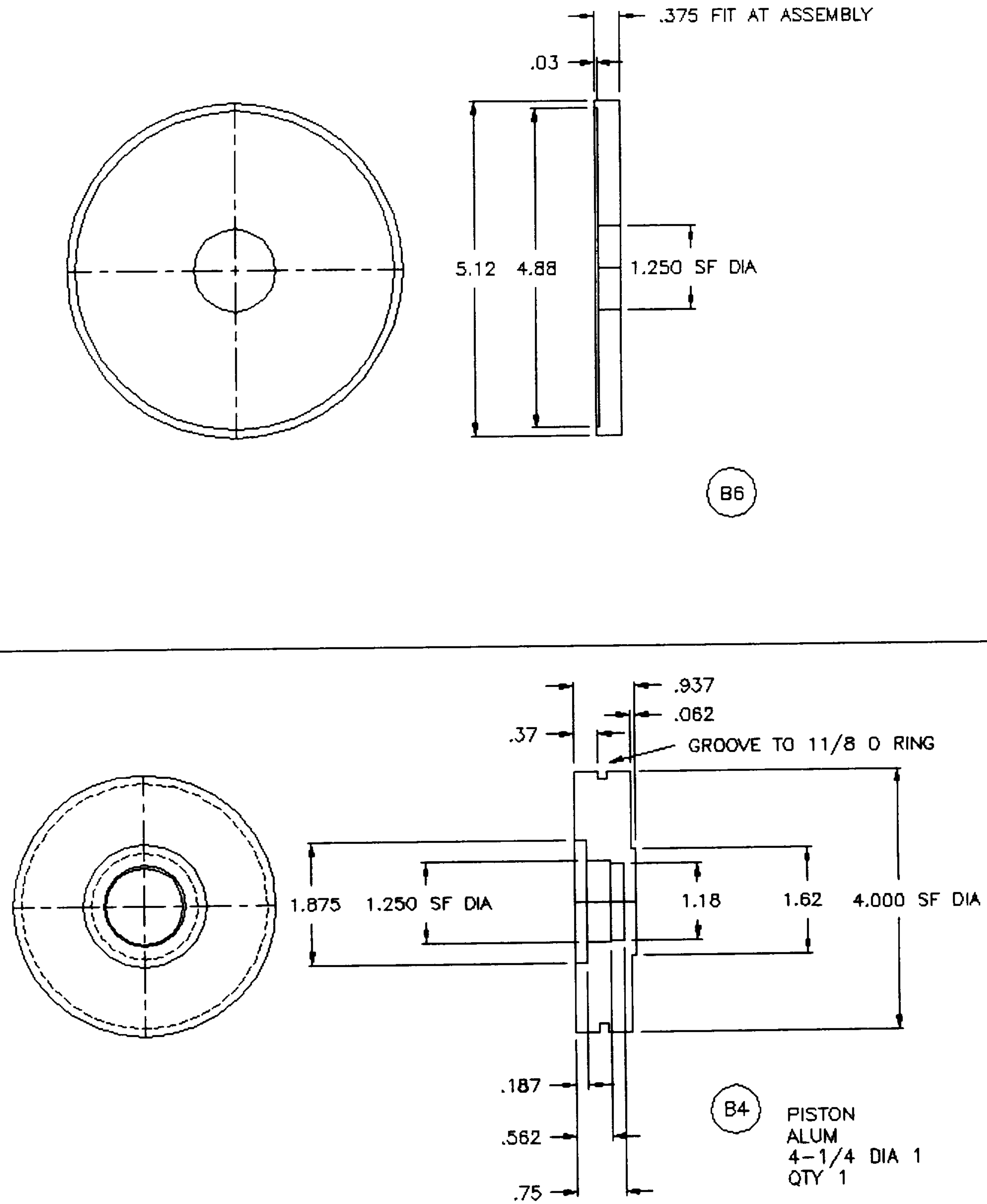


(B1) BUSHING
CRS
1-3/8 DIA X 1/2
QTY 2

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

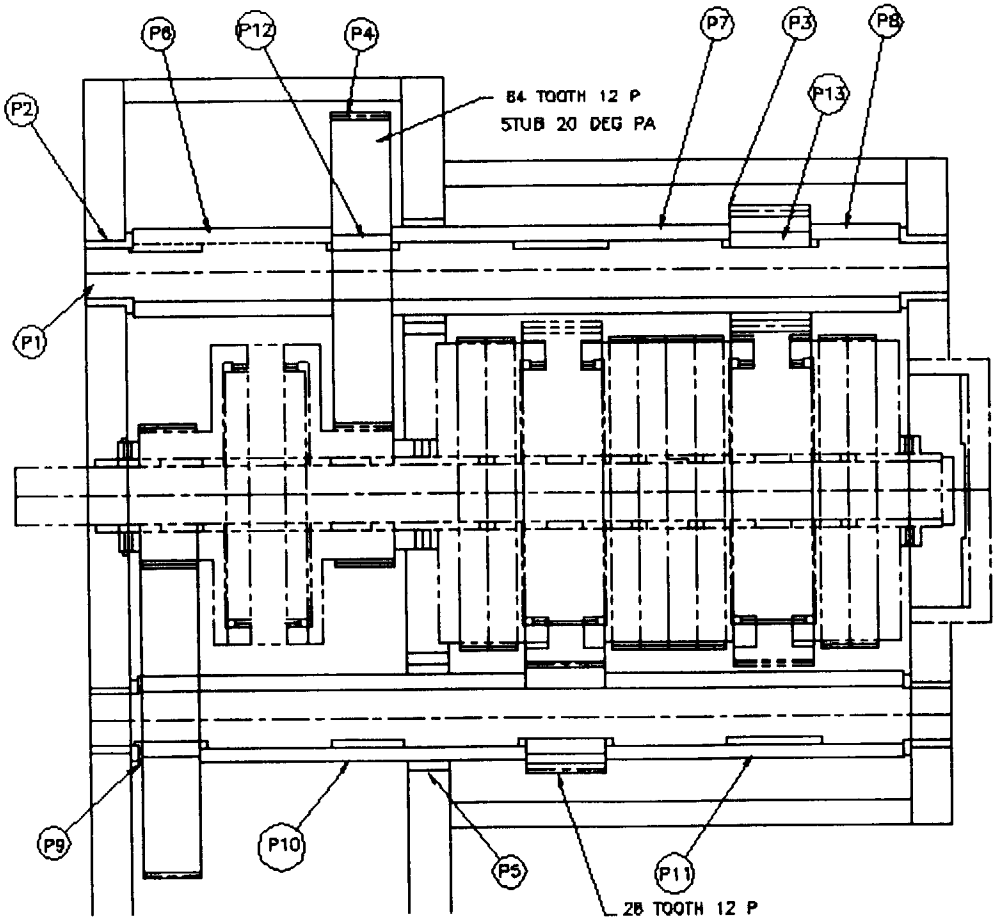


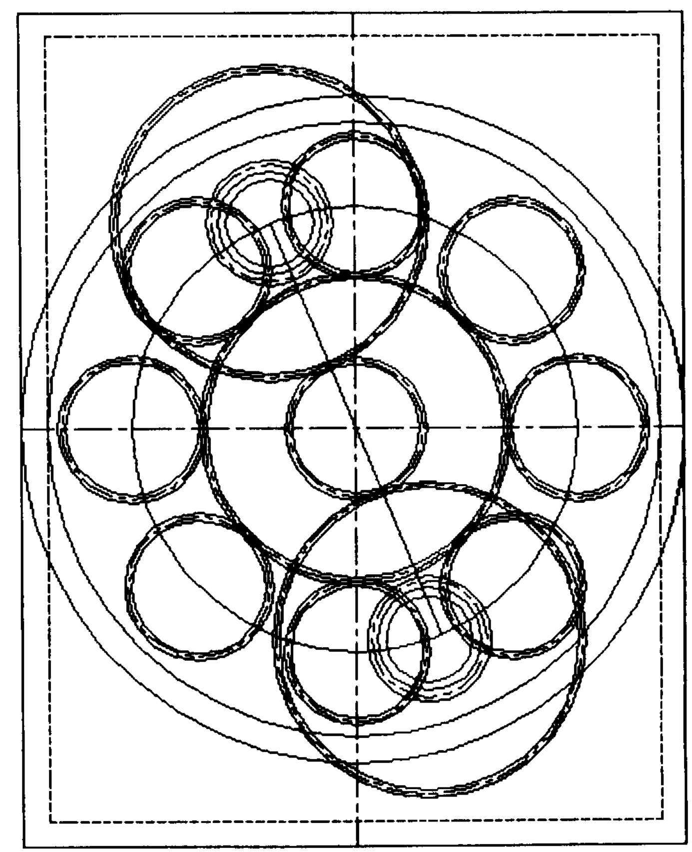
PISTON
ALUM
4-1/4 DIA 1
QTY 1

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



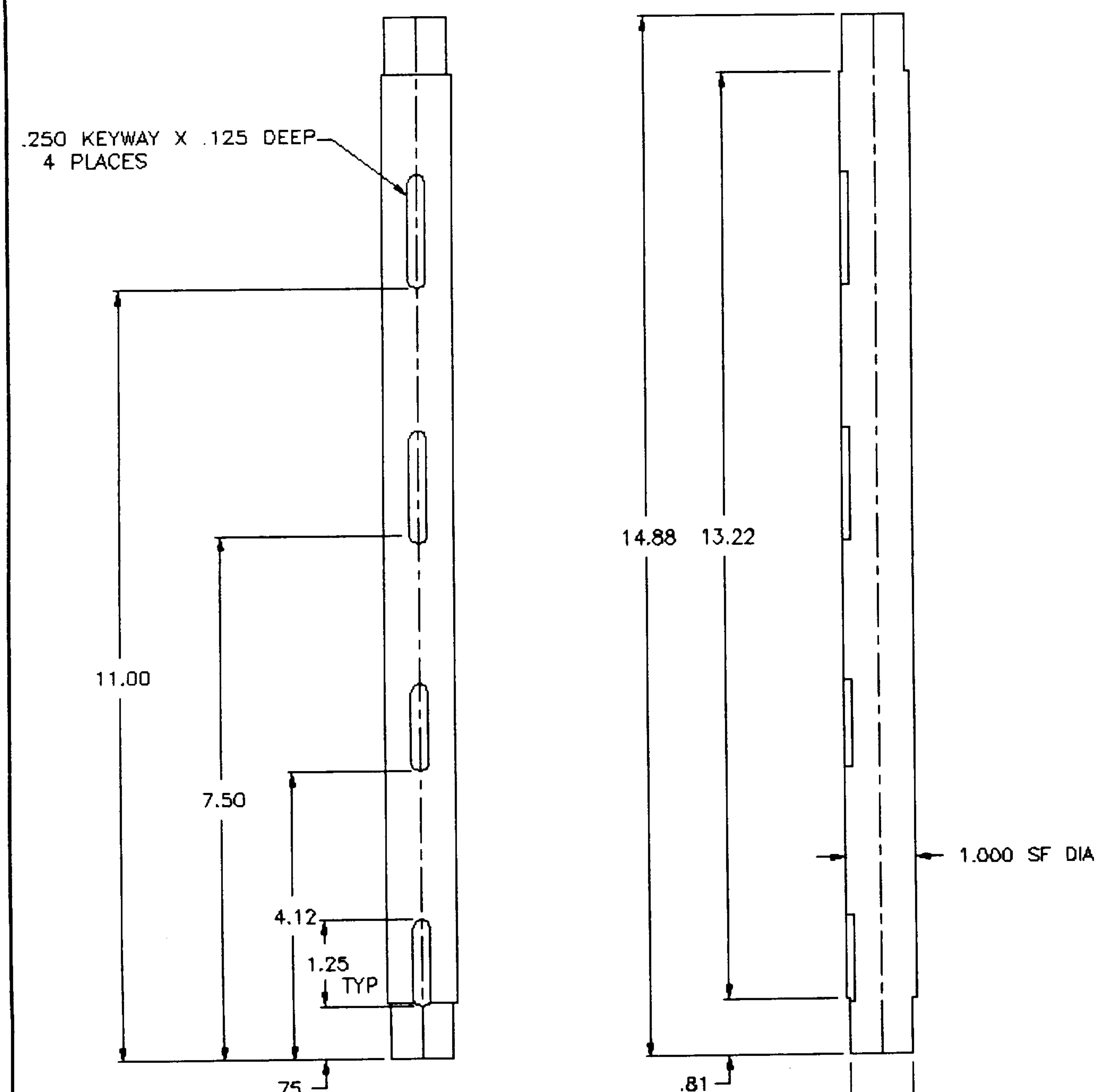


SYM	QTY	DESCRIPTION
P1	2	SHAFT
P2	4	BEARING
P3	2	PINION
P4	2	RING
P5	2	BEARING

SYM	QTY	DESCRIPTION
P6	1	SPACER LH M
P7	1	SPACER LH C
P8	1	SPACER LH S
P9	1	SPACER RH M
P10	1	SPACER RH C
P11	1	SPACER RH S
P12	2	KEY 1/8X1/8X1
P13	2	KEY 1/8X1/8X1-1/4

AEROMOVER INC.

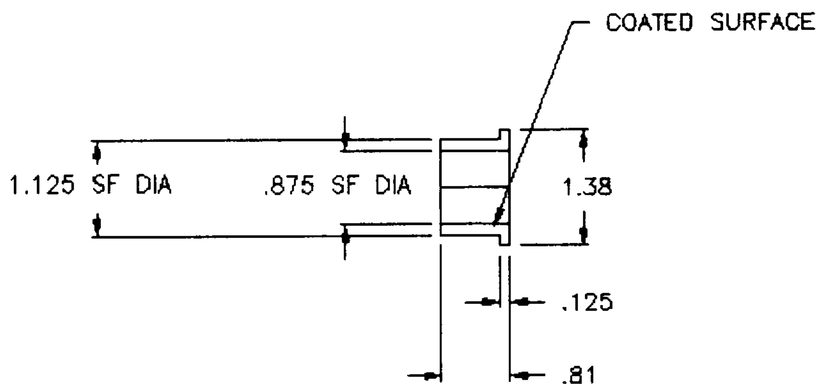
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



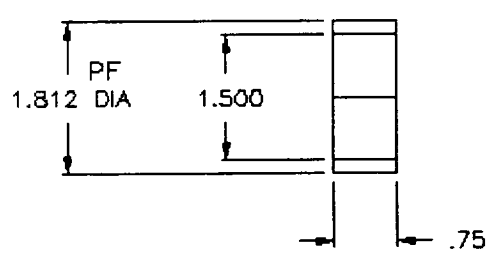
(P1)

SHAFT
CRS
1.00 DIA X 15
QTY 2

ENGINEER	DATE	
SLD	4/17/87	AEROMOVER INC.
		8 SPINDLE NUT RUNNER 300 IN LB CAPACITY



(P2) BEARING
CRS
1-3/8 DIA X 1
QTY 4

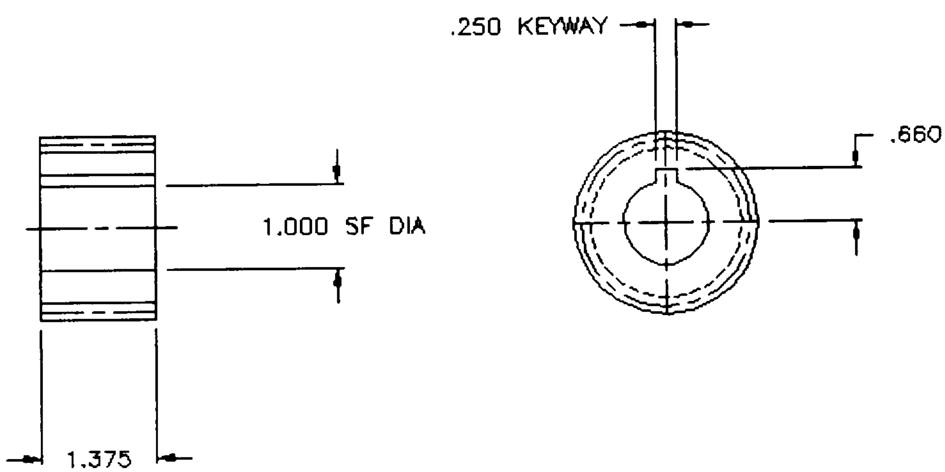


(P5) BEARING
CRS
2 DIA X 1
QTY 2

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



GEAR INFO

NO FO TEETH	24
DIAMETRICAL PITCH	12
PITCH DIAMETER	2.000

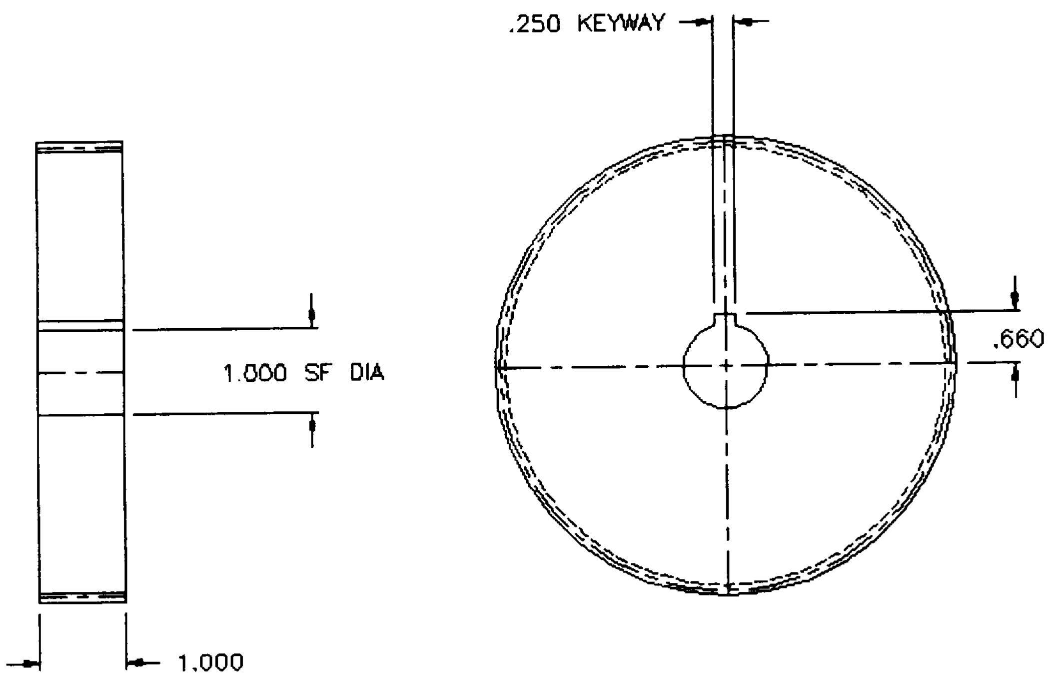
P3

PINION
STEEL 1045
HARDENED
2-1/4 DIA X 1-1/2
QTY 2

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



GEAR INFO

NO FO TEETH	64
DIAMETRICAL PITCH	12
PITCH DIAMETER	5.333

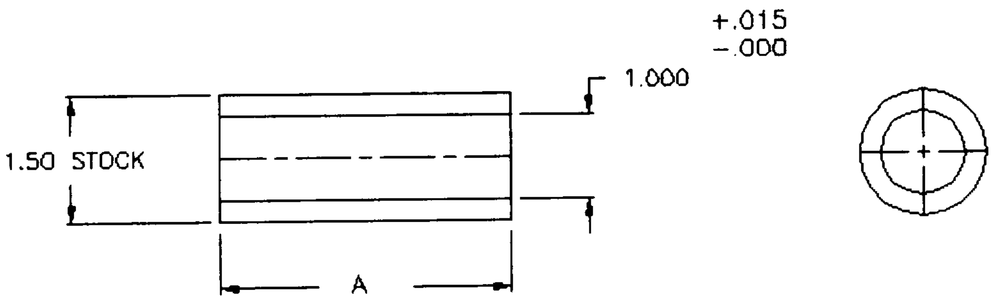
(P4)

RING
STEEEL 1045
HARDENED
5-3/4 DIA X 1
QTY 2

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

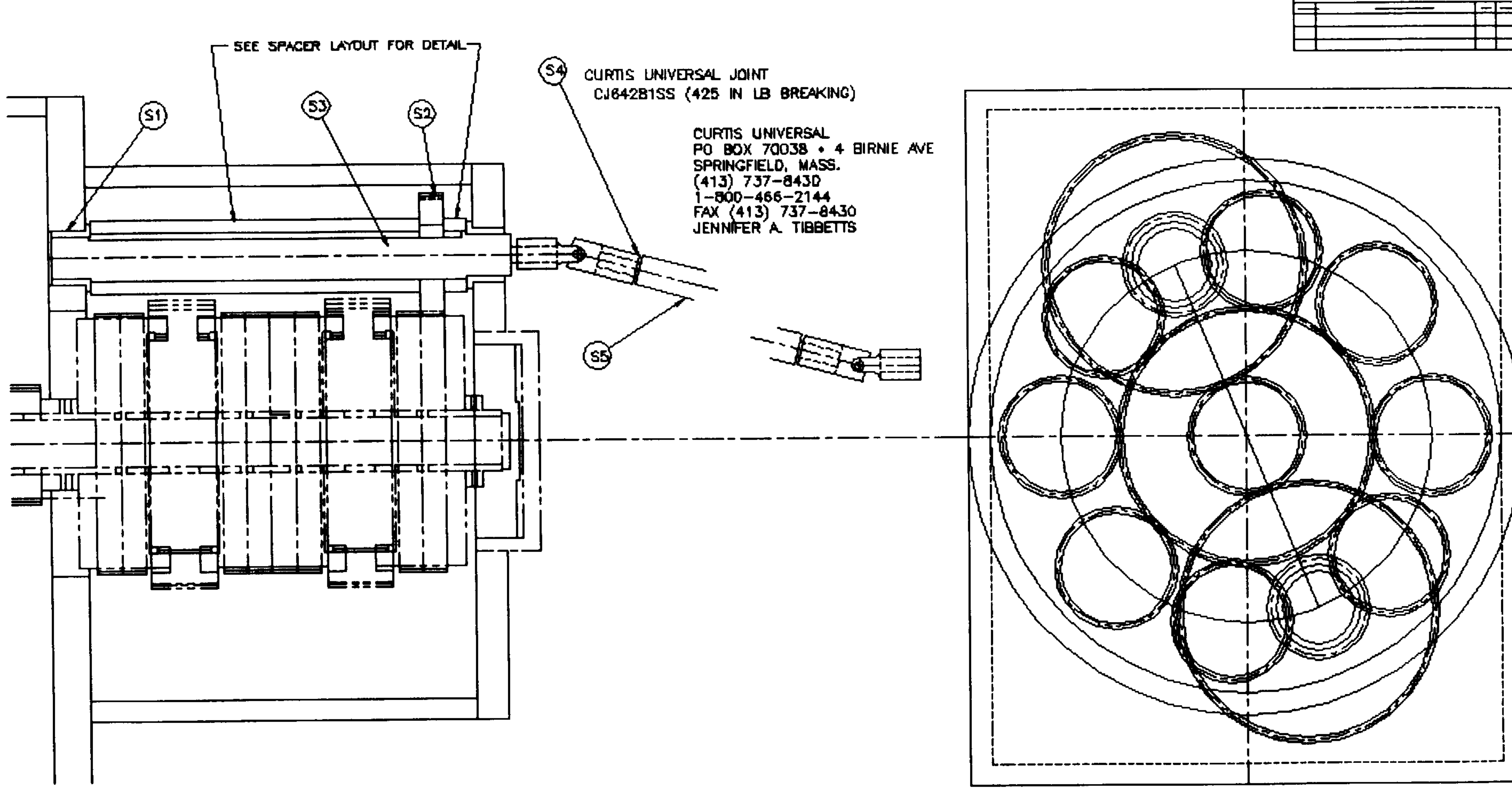


PART NO	DIM A
P6	3.437
P7	5.875
P8	1.562
P9	.062
P10	5.625
P11	5.187

ENGINEER SLD
DATE 4/17/87

AEROMOVER INC.

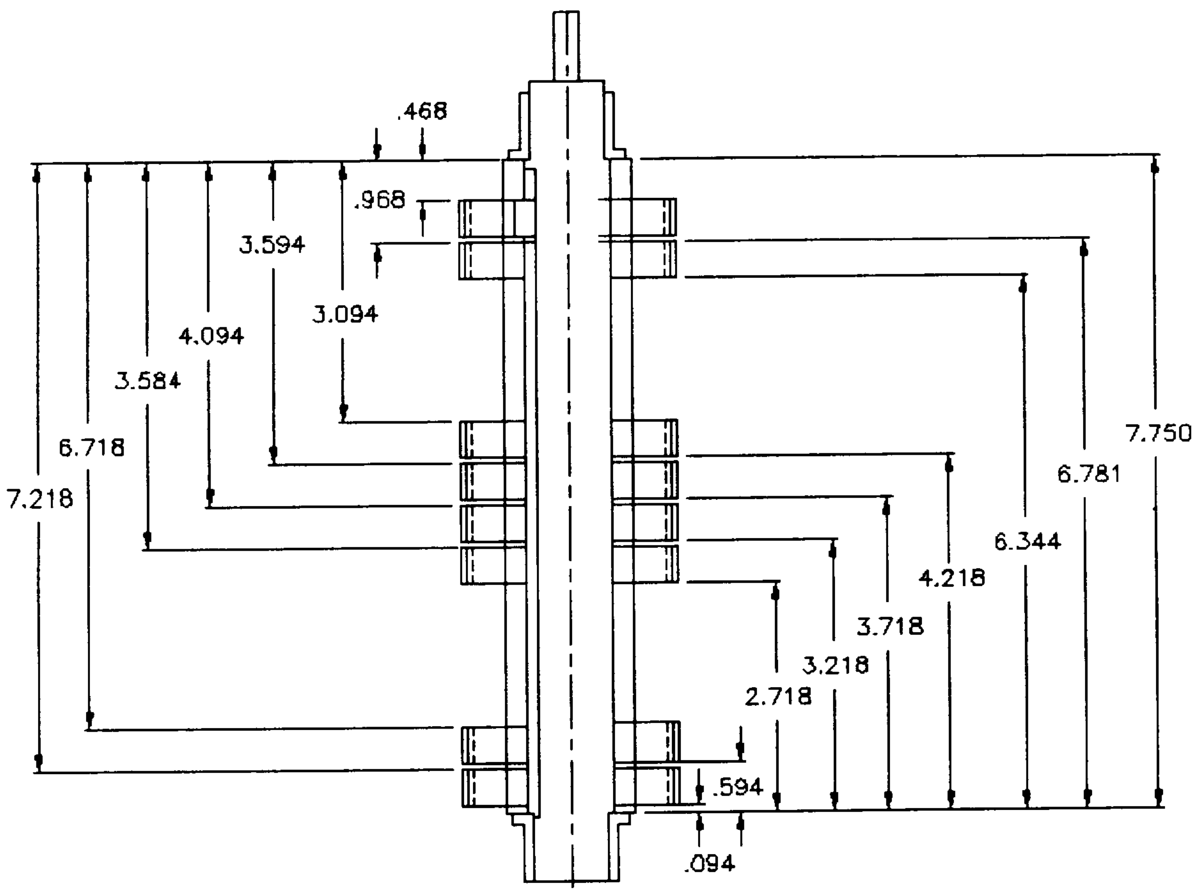
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



SYM	QTY	DESCRIPTION
S1	16	BUSHING
S2	8	GEAR
S3	8	SHAFT
S4	16	JOINT
S5	8	SHAFT TO SUIT APPLIC.

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

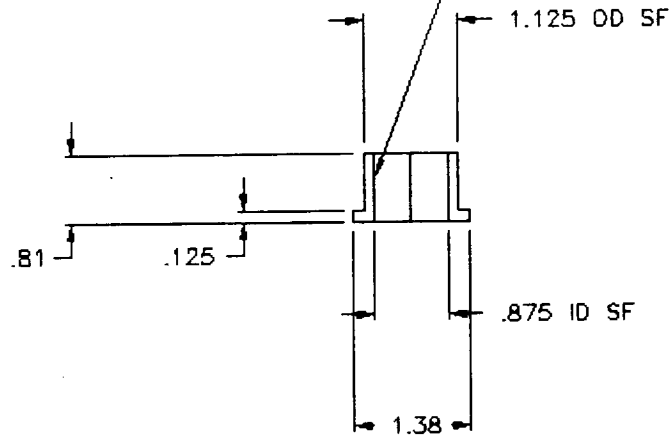


SPACER LAYOUT DRAWING

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



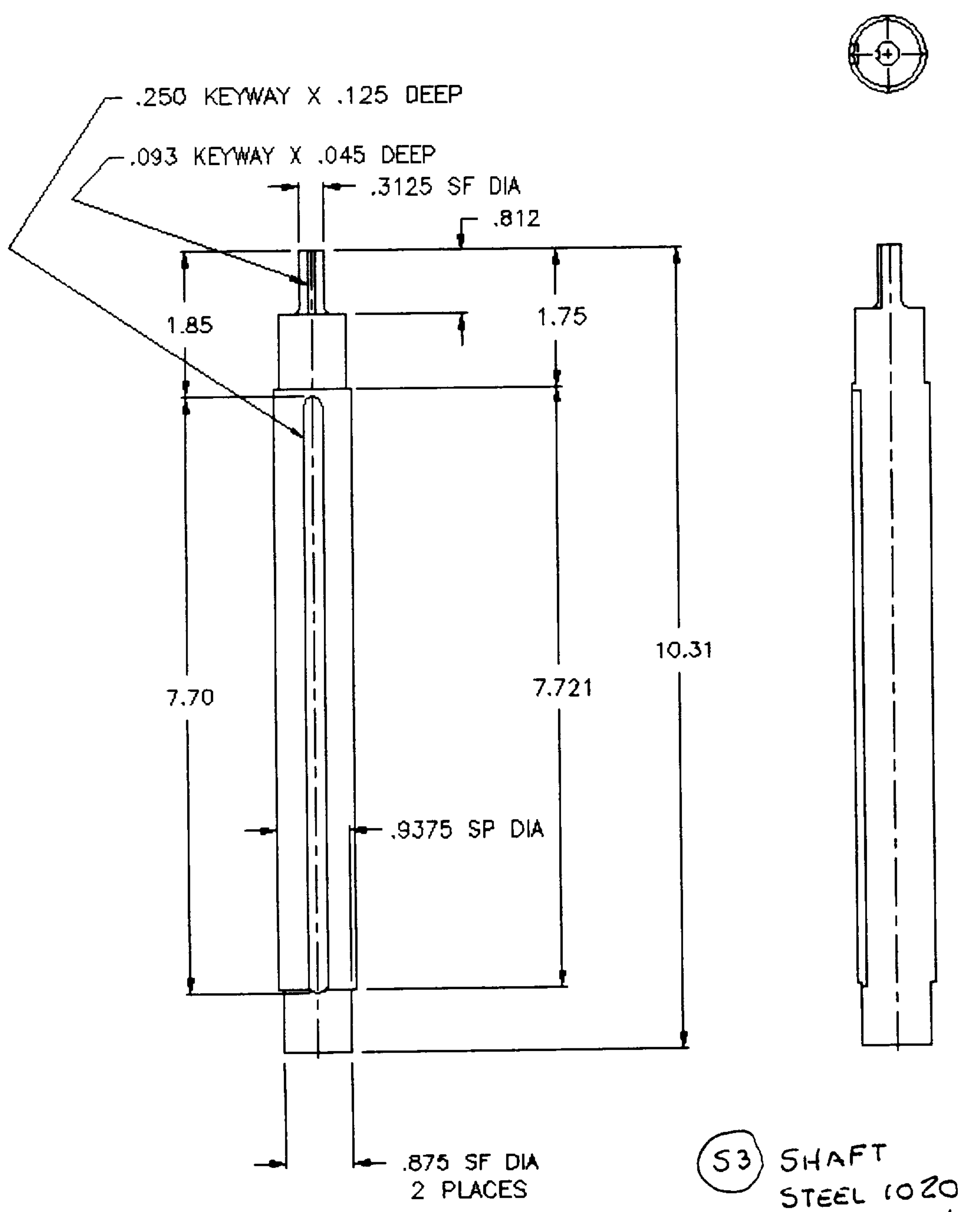
(51) BUSHING
CRS
1-3/8 DIA X 1
QTY 16

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

~~S3~~ ~~8~~ ~~SHAFT~~

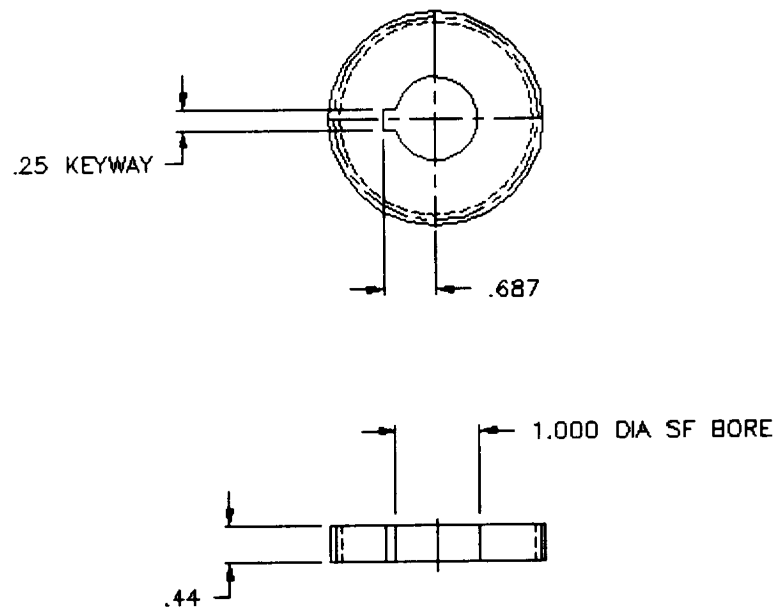


(S3) SHAFT
STEEL 1020
1 DIA x 10-1/2
QTY 8

ENGINEER	DATE
BLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



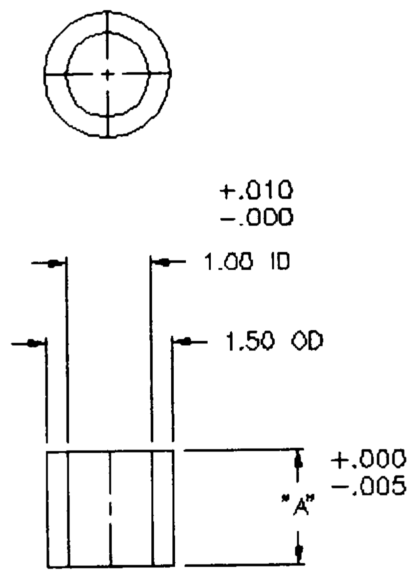
(S2)

GEAR
STEEL 1045
HARDENED
3.00 DIA X 9/16
QTY 8

ENGINEER	DATE
SLD	4/17/87

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



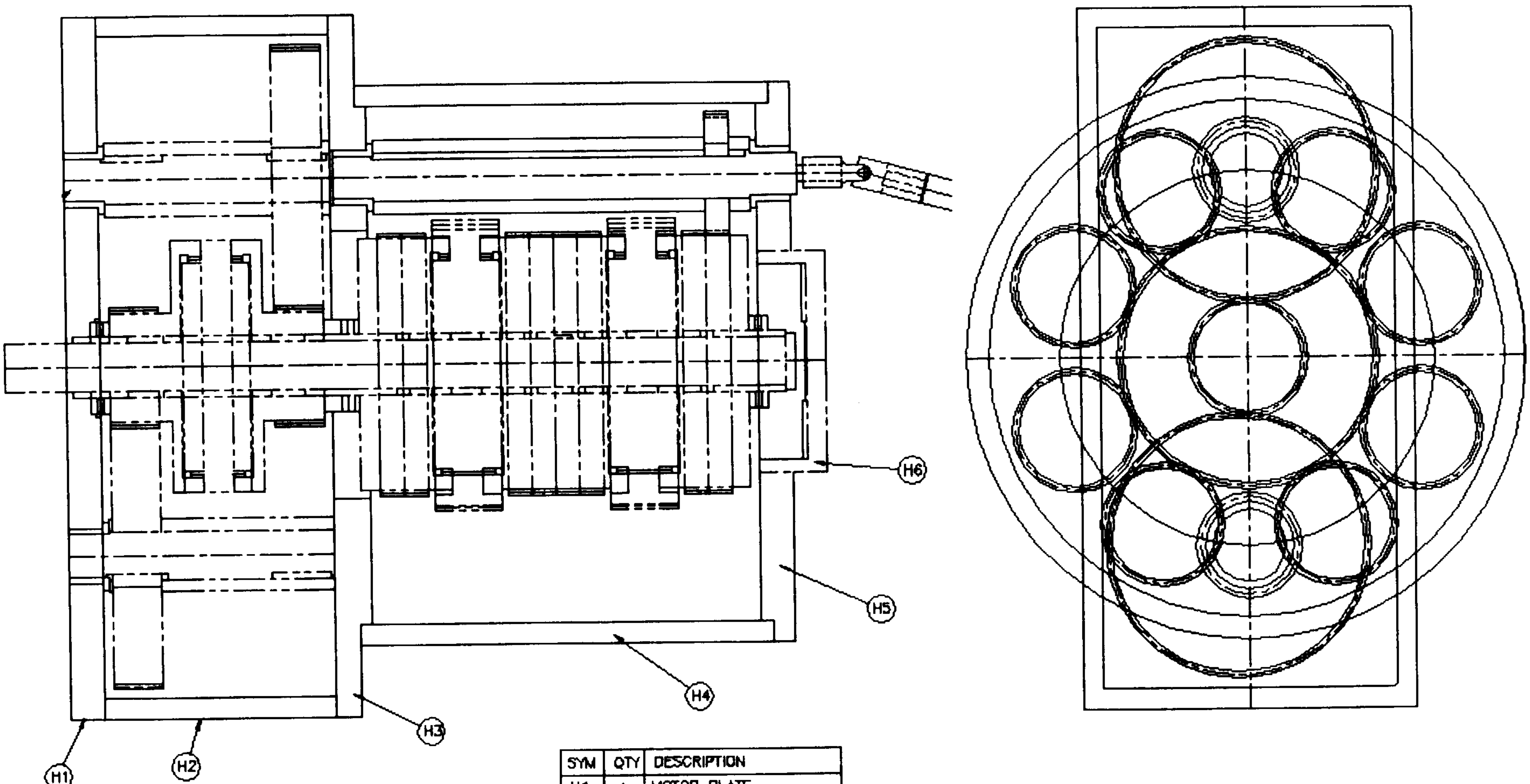
PART NO.	SPL#	F/R	DIM "A"
S6	1	F	.468
S7	1	R	6.344
S8	2	F	.968
S9	2	R	6.781
S10	3	F	3.094
S11	3	R	4.218
S12	4	F	3.594
S13	4	R	3.718
S14	5	F	4.094
S15	5	R	3.218
S16	6	F	3.584
S17	6	R	2.718
S18	7	F	6.718
S19	7	R	.594
S20	8	F	7.218
S21	8	R	.094

QUANTITY (1) FO EACH

ENGINEER SLD DATE 4/17/87

AEROMOVER INC.

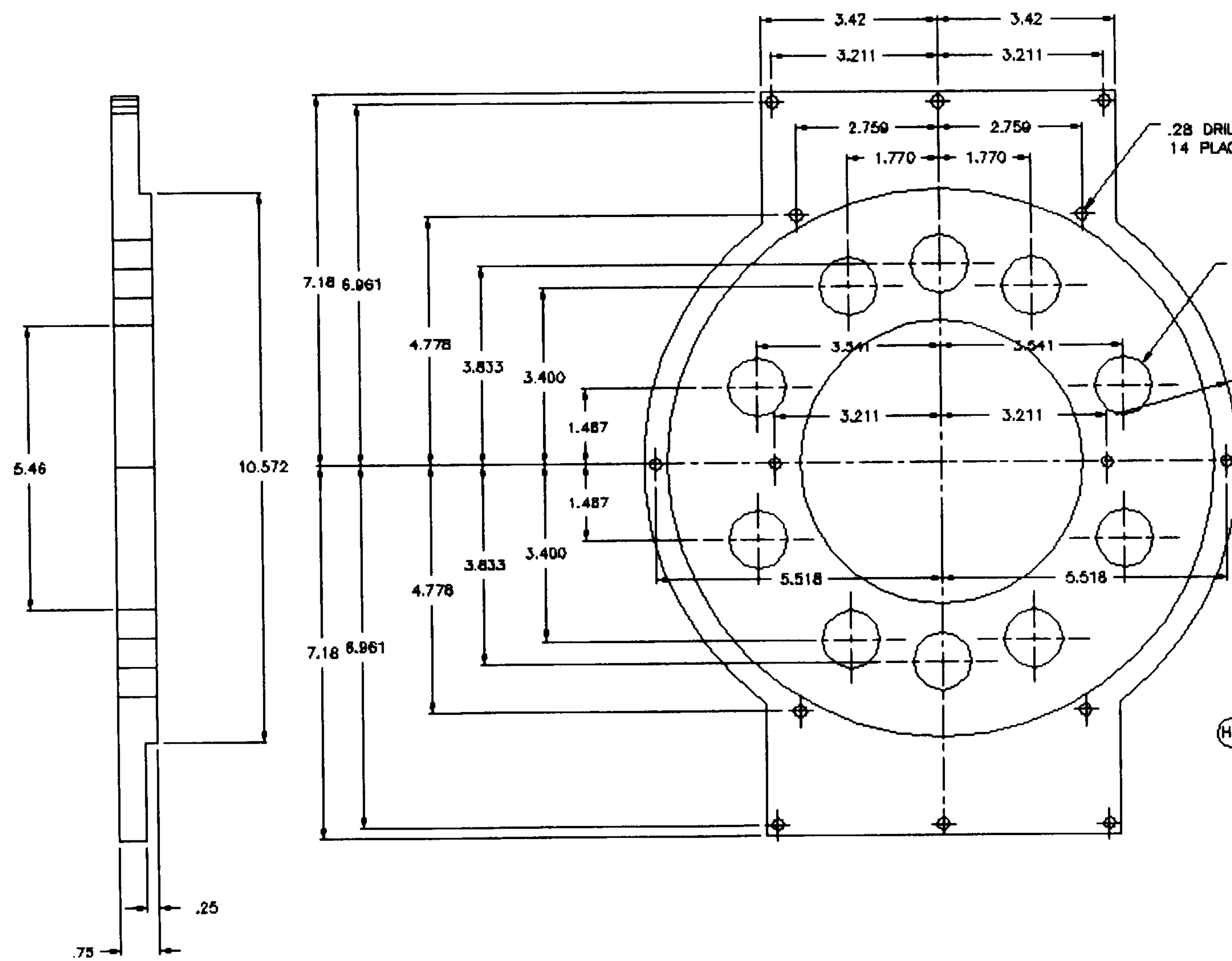
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



SYM	QTY	DESCRIPTION
H1	1	MOTOR PLATE
H2	1	MOTOR SPACER
H3	1	END PLATE
H4	1	CYLINDER
H5	1	END PLATE
H6	1	PISTON HOUSING

AEROMOVER INC.

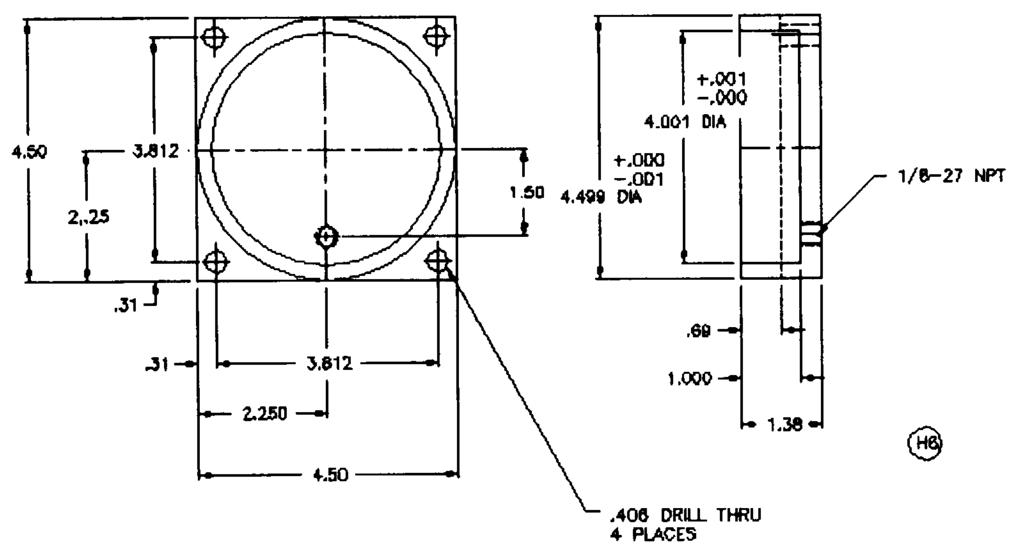
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



(H3) END PLATE
ALUM
3/4 X 11-1/2 X 14-3/8
QTY 1

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

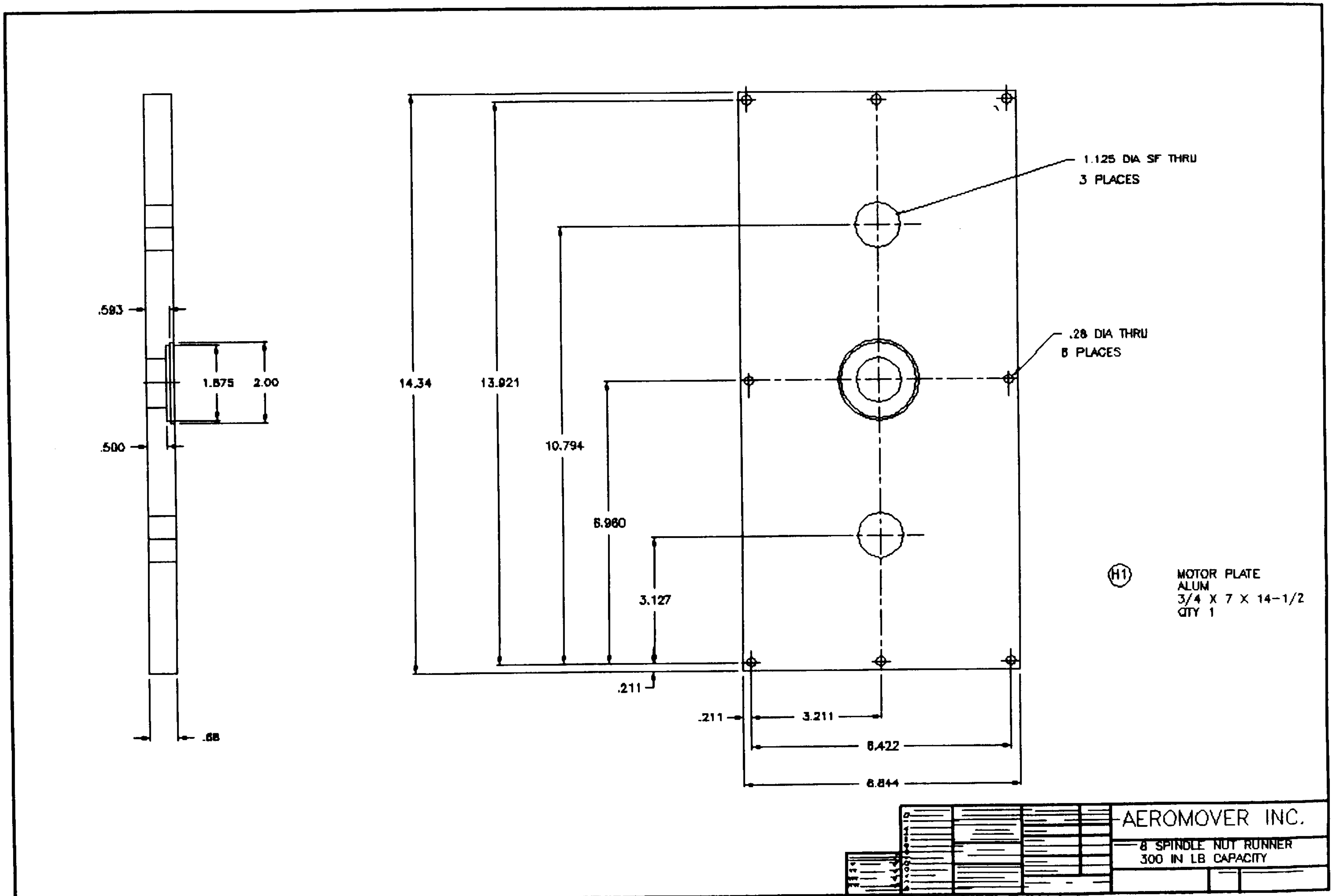


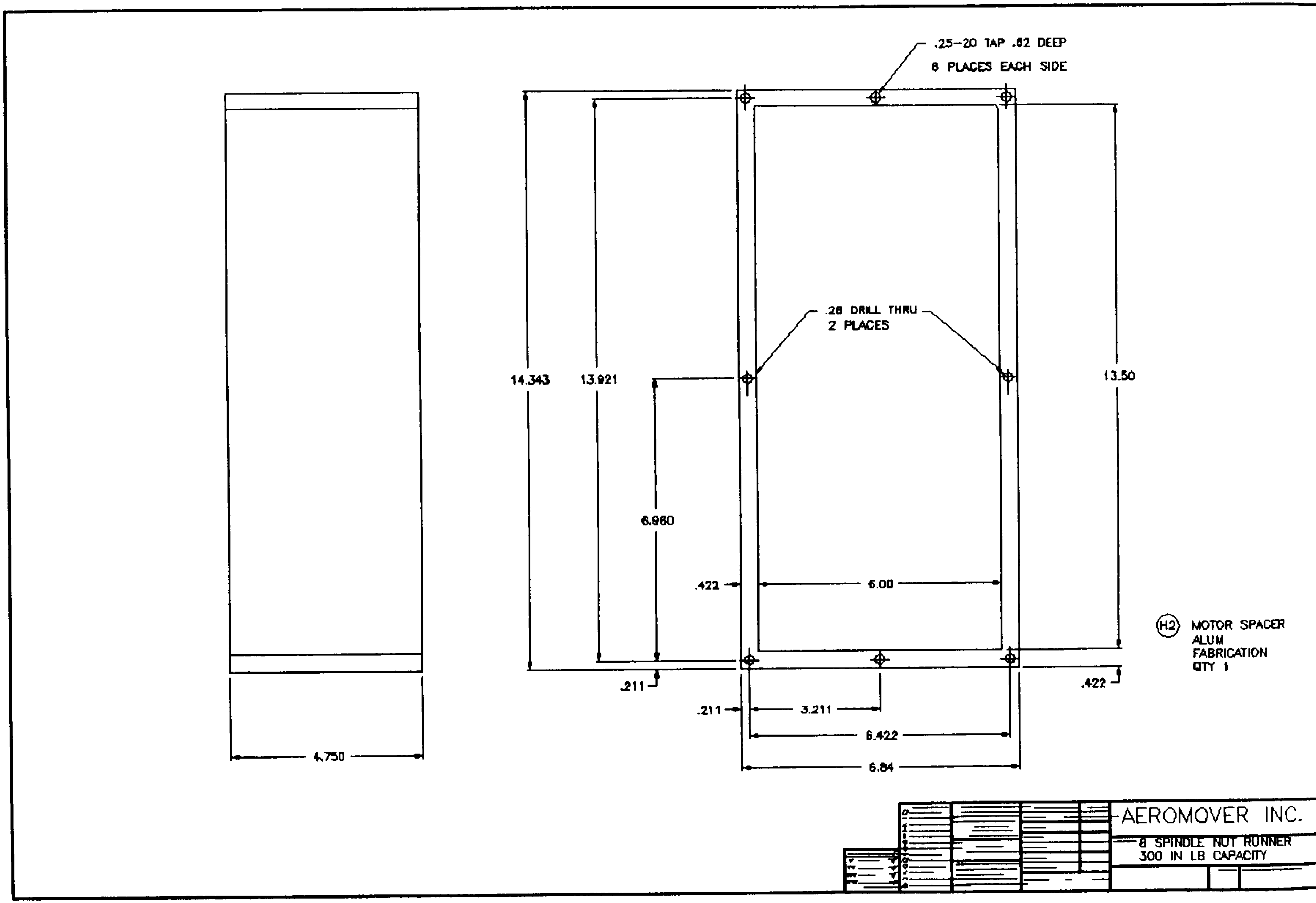
H6

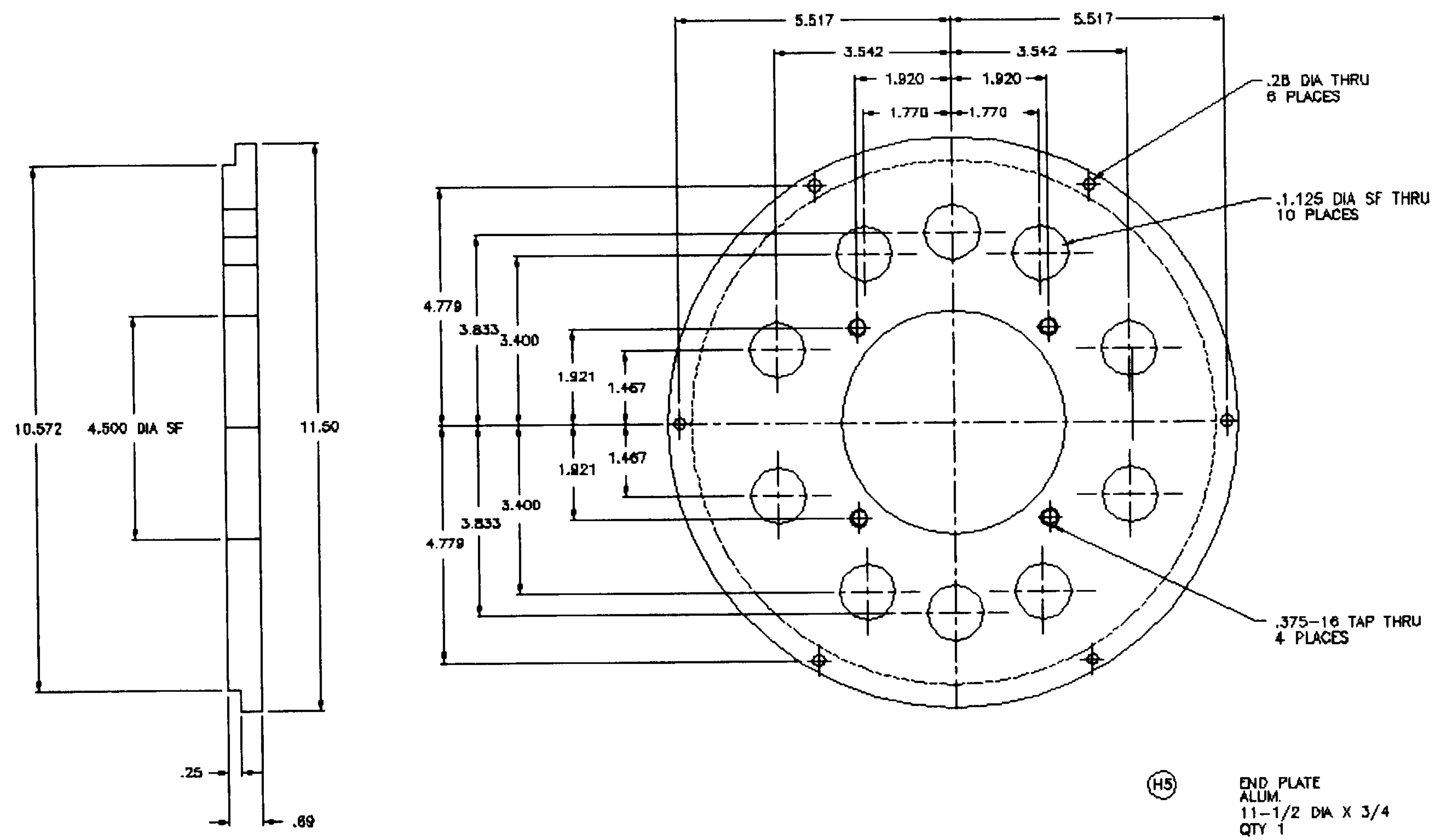
PISTON HOUSING
ALUM.
5 DIA X 1-1/2
QTY 1

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY


.593
.500
1.875
2.00
.68
14.34
13.921
10.794
6.960
3.127
.211
.211
3.211
6.422
6.844
1.125 DIA SF THRU
3 PLACES
.28 DIA THRU
6 PLACES
H1
MOTOR PLATE
ALUM
3/4 X 7 X 14-1/2
QTY 1
AEROMOVER INC.
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY


.25-20 TAP .62 DEEP
8 PLACES EACH SIDE
.28 DRILL THRU
2 PLACES
14.343
13.921
6.960
13.50
.422
6.00
.211
.211
3.211
6.422
6.84
.422
4.750
H2
MOTOR SPACER
ALUM
FABRICATION
QTY 1
AEROMOVER INC.
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY

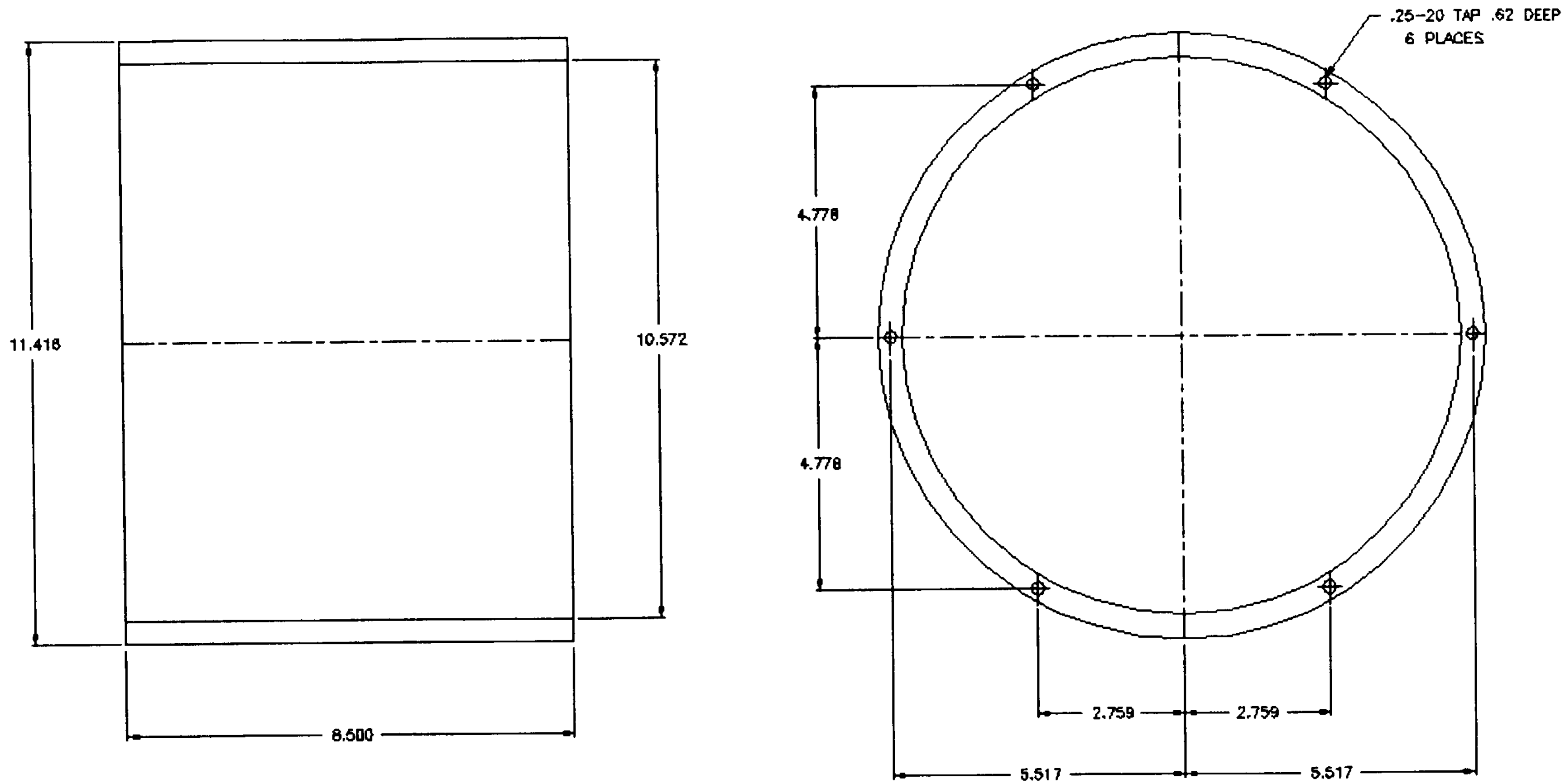


(H5)

END PLATE
ALUM.
11-1/2 DIA X 3/4
QTY 1

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



(H4) CYLINDER
ALUM
11-1/2 OD X 10-1/2 ID X 8-3/4
QTY 1

AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY