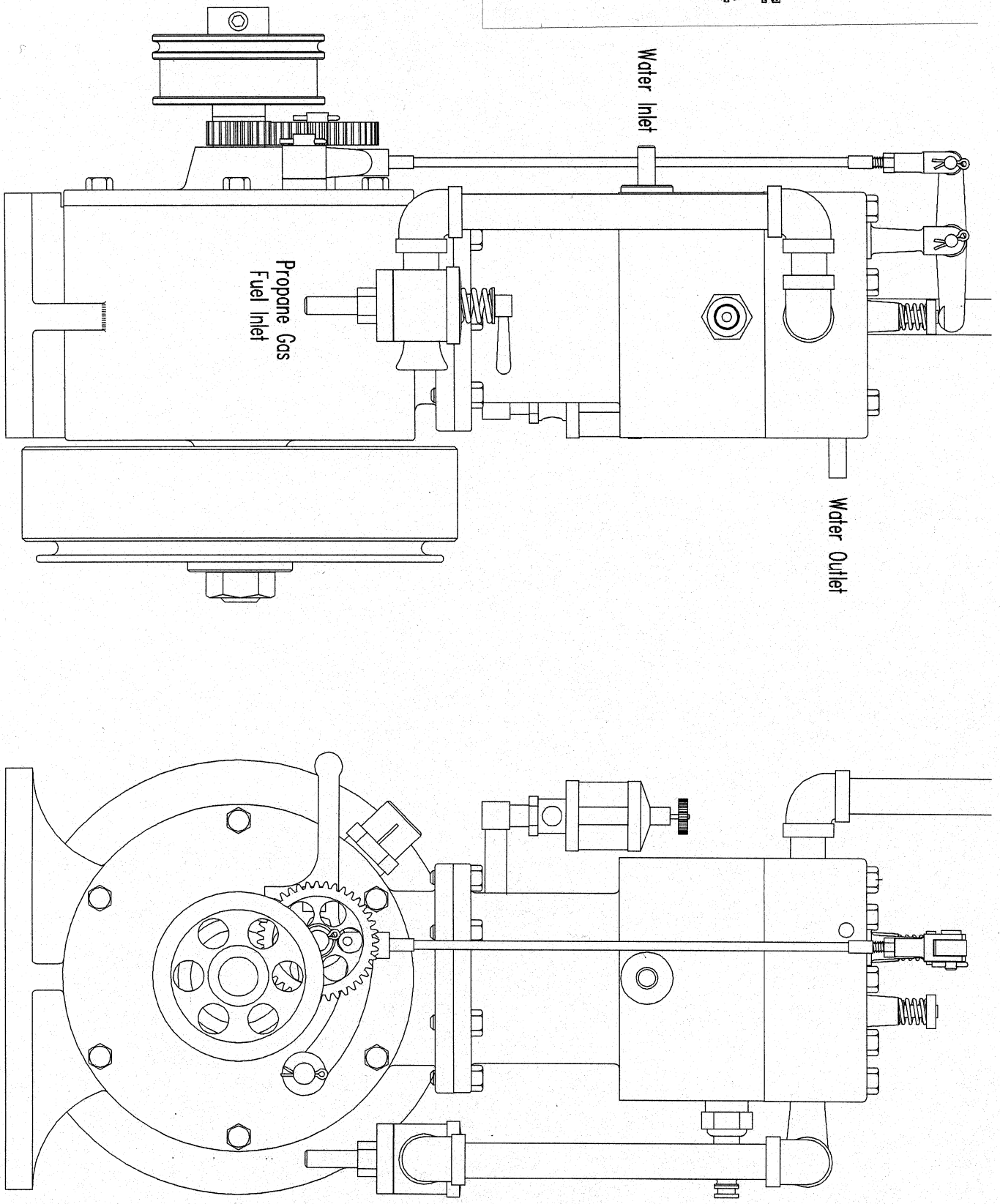


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Notice



Drawn Actual Size

Technical drawing of a mechanical part, likely a bracket or support, showing dimensions in inches. The drawing includes a top view and a side view.

Top View Dimensions:

- Overall width: 2.140"
- Overall height: 1.665"
- Inner width (dashed line): 1.025"
- Inner height (dashed line): .875"
- Top flange width: .495"
- Top flange height: .440"
- Top flange thickness: .560"
- Top flange radius: .720"
- Top flange hole diameter: .165"
- Bottom flange width: .188"
- Bottom flange height: .063"
- Bottom flange radius: .375"

Side View Dimensions:

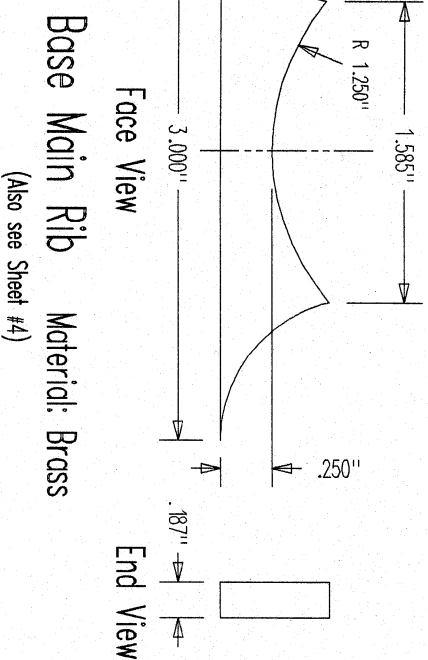
- Overall height: 1.251"
- Inner height (dashed line): .881"

The drawing also shows a cross-section of the part, indicating a threaded hole on the right side.

Technical drawing of a circular machine component, likely a bearing or housing, showing dimensions and features:

- Overall diameter: 2.500"
- Inner diameter: 2.240"
- Radial thickness of the outer ring: .42.000"
- Drill #43, .230" deep and top 4.40 on 2.270" bolt circle 6 places as shown.
- .125" end mill. (oil drain for oil that gets outside the bearing)
- Section A-A is indicated on both sides.

Crankcase Material: Brass



Crankcase Base Plate Material: Brass

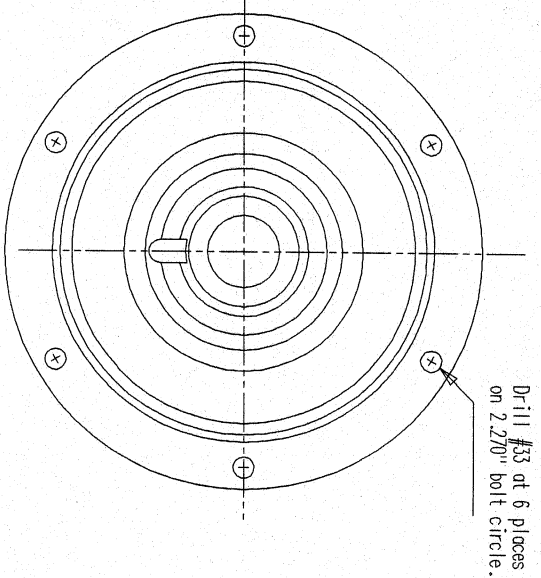
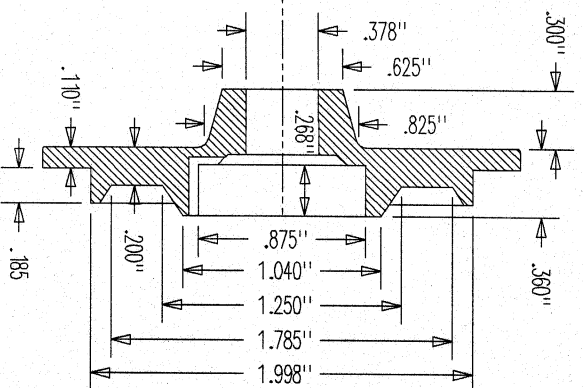
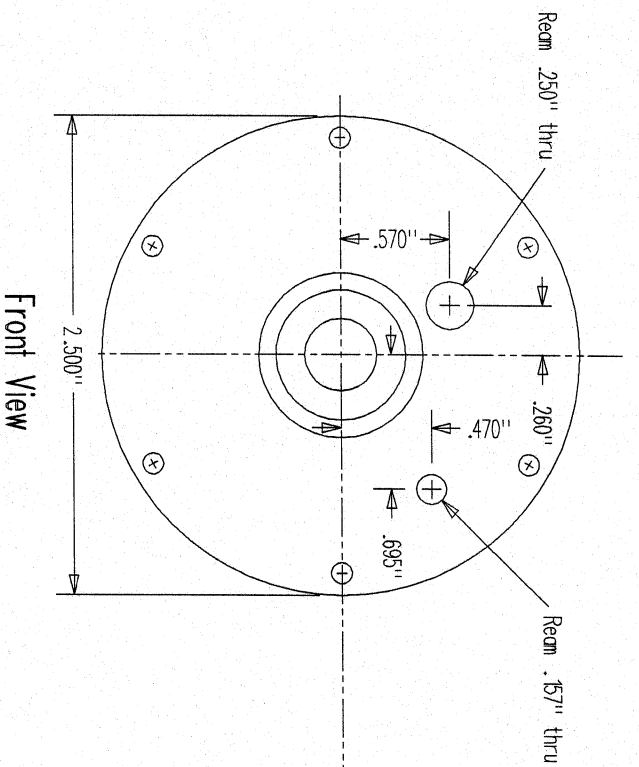
Crankcase Parts

Jerry E. Howell
3960 Backet Drive
Colorado Springs, CO 80906
Model Project Plans & Kits

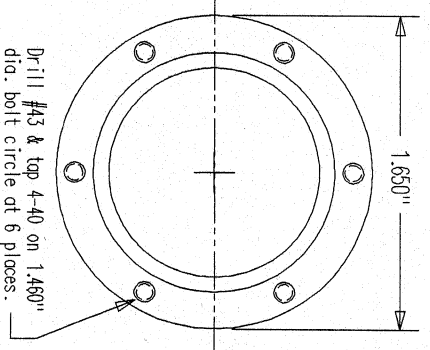
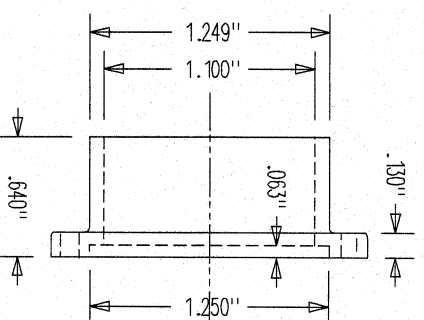
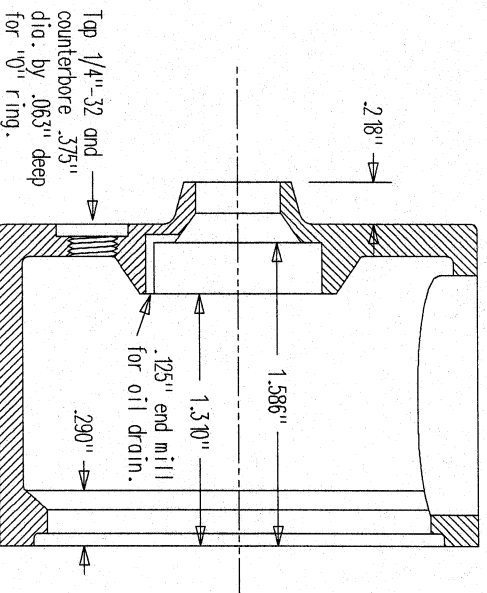
Project: **"Bill" - 1906 Four Cycle Gas Engine**

Sheet # 2	Date: 06/04/02	By: Jerry E. Howell
------------------	----------------	---------------------

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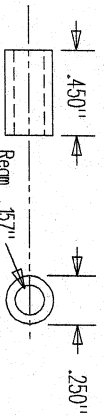
Crankcase End Cover Material: Brass



Crankcase Cylinder Flange Material: Brass

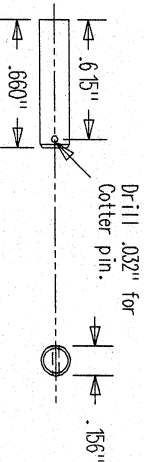
Crankcase Cover & Flange

Jerry E. Howell		Project: Bill - 1906 Four Cycle Gas Engine	
3880 Becket Drive Colorado Springs, CO 80906		Sheet # 3	
Model Project Plans & Kits		Date: 06/04/02 By: Jerry E. Howell	
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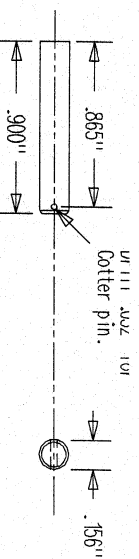
Side View End View

Cam Post Bushing Material: Brass



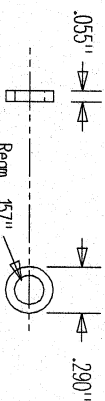
Side View End View

Tappet Arm Post Material: Drill Rod



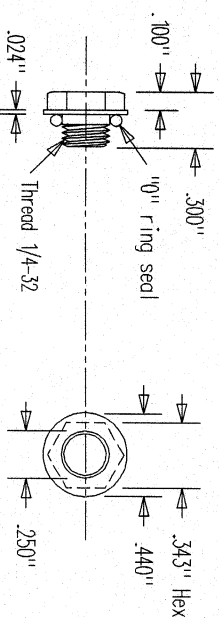
Side View End View

Cam Sleeve Post Material: Drill Rod



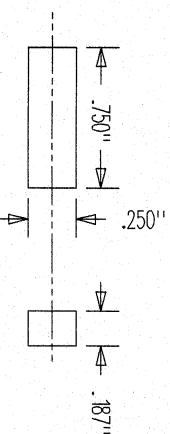
Side View End View

Tappet Arm Post Spacer Material: Brass



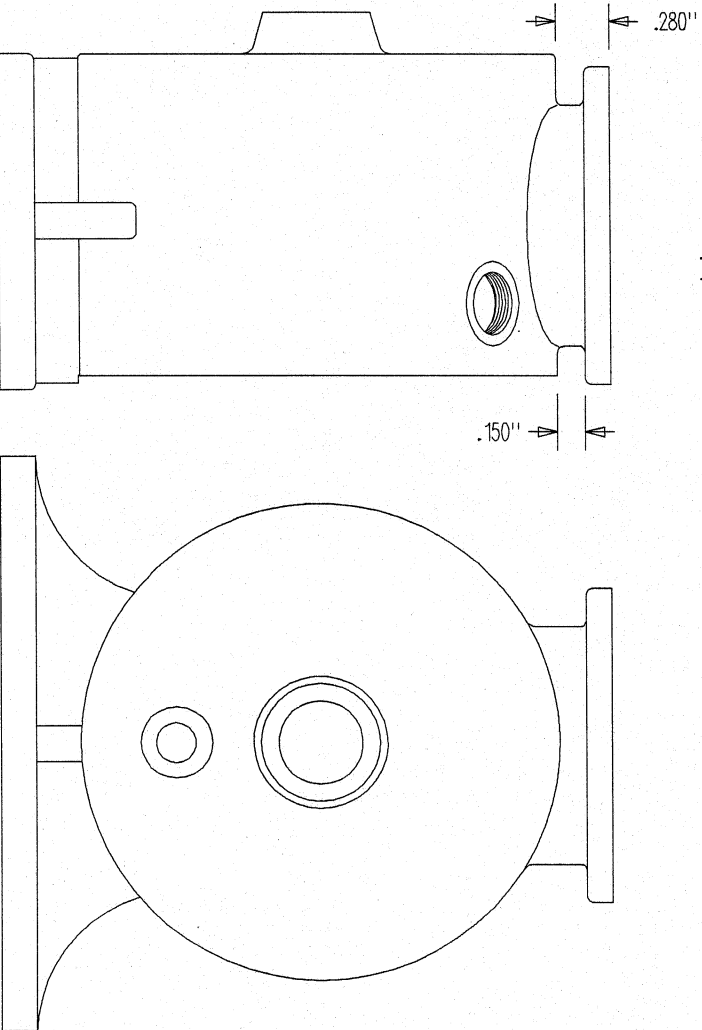
Side View End View

Oil Drain Plug Material: Steel



Side View End View

Base Rib (2) Material: Brass

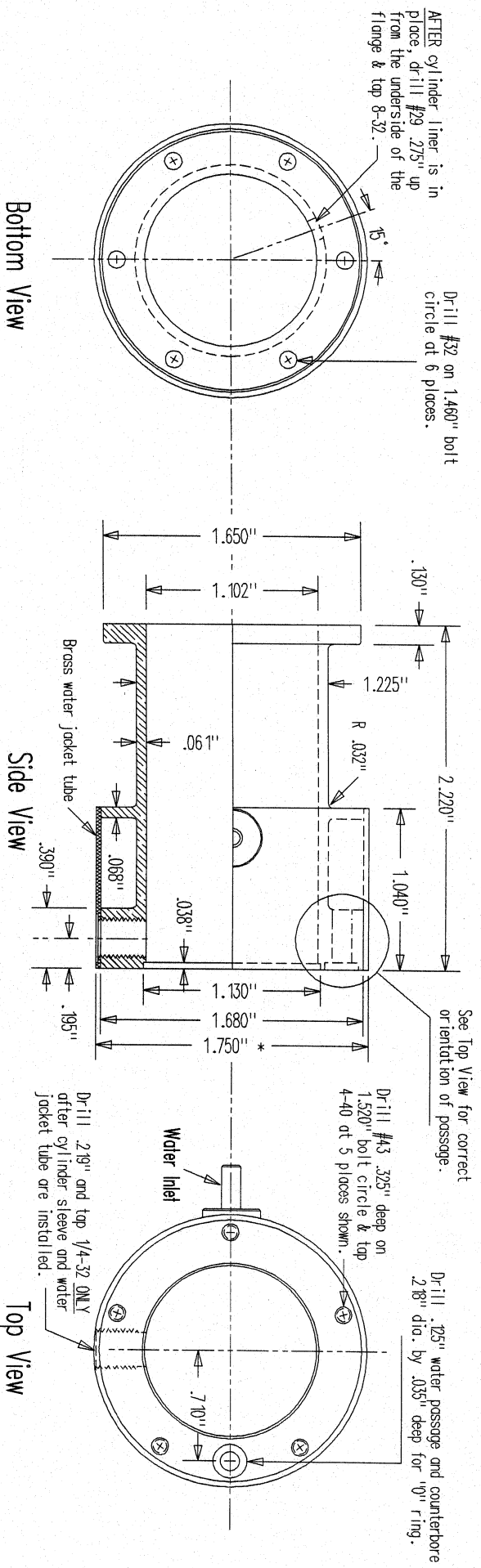


Right Side View

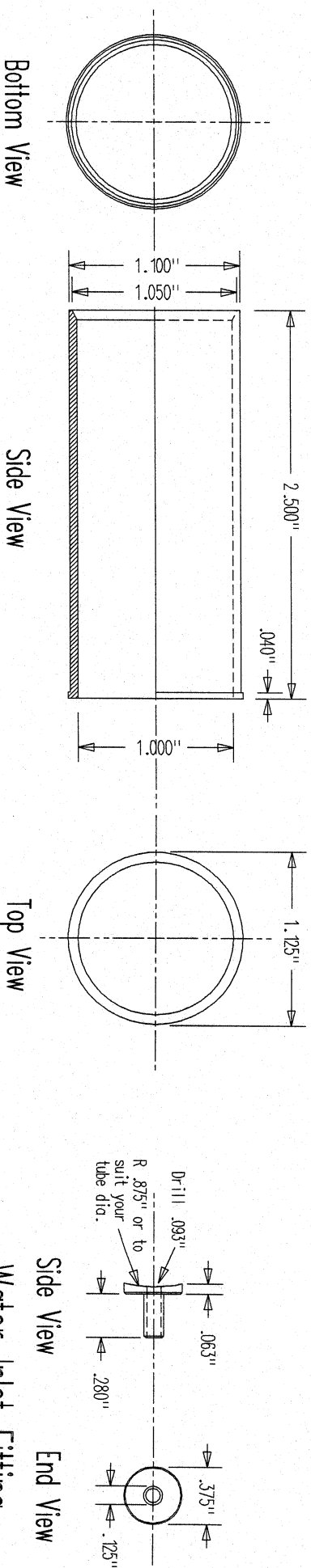
Front View

Crankcase Assy. Views & Parts

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Project: Bill - 1906 Four Cycle Gas Engine	Sheet # 4	Date: 07/06/02	By: Jerry E. Howell
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Cylinder Flange/Water Jacket Material: Brass

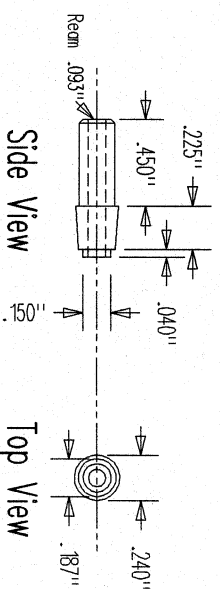
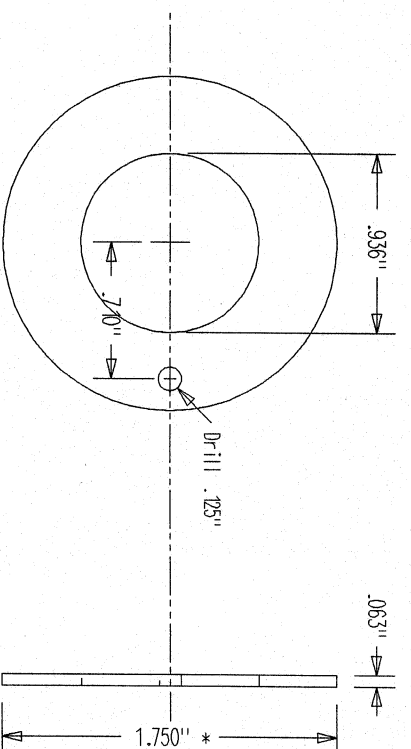
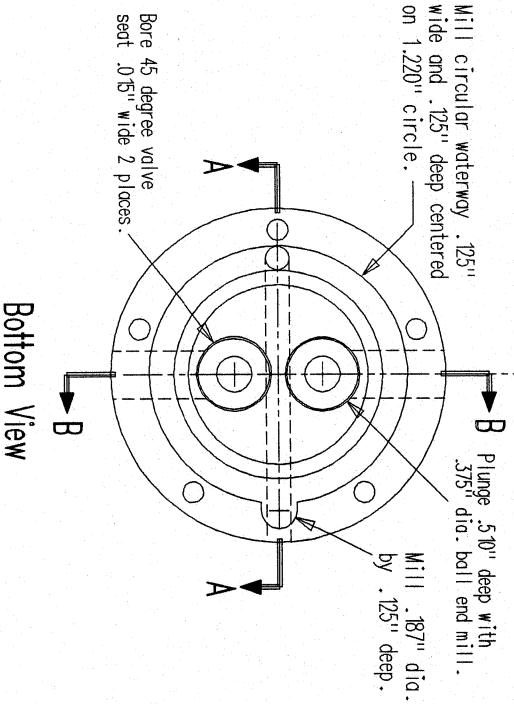
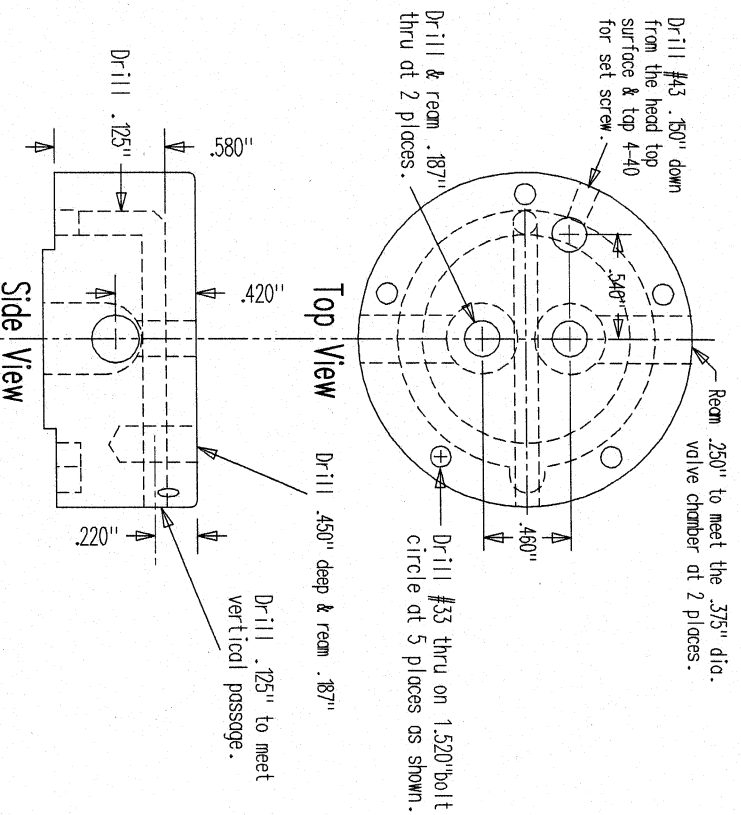


Cylinder Liner Material: Cast Iron

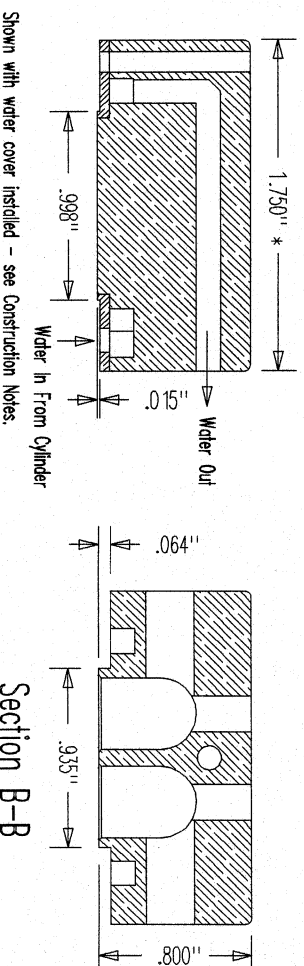
* See Construction Notes

Cylinder Parts

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Project: Bill - 1906 Four Cycle Gas Engine	Sheet # 5	Date: 06/07/02 By: Jerry E. Howell
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Valve Guide (2) Material: Bronze

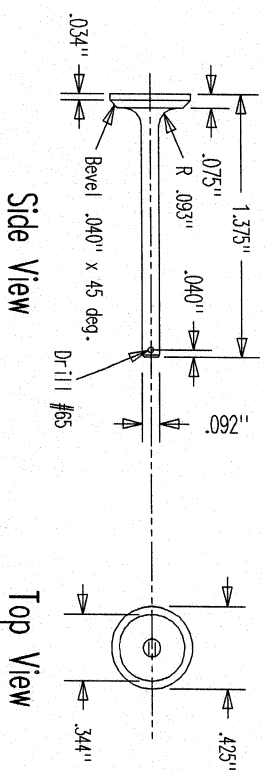


Shown with water cover installed - see Construction Notes.

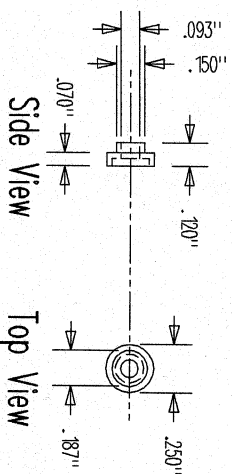
* Match outside diameter of Cylinder water jacket tube.

Cylinder Head Material: Brass

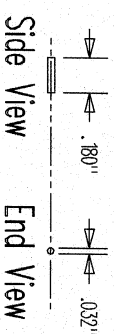
Jerry E. Howell		Project: Bill - 1906 Four Cycle Gas Engine	
3980 Beckel Drive	Colorado Springs, CO 80906	Sheet # 6	Date: 07/11/02 By: Jerry E. Howell
Model Project Plans & Kits		© Copyright 2002 by Jerry E. Howell - All rights reserved.	



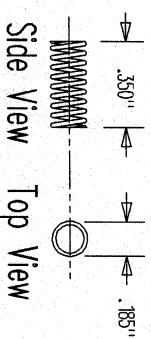
Intake/Exhaust Valve (2) Material: Stainless Steel



Valve Spring Keeper (2) Material: Stainless Steel

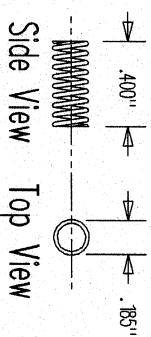


Valve Spring Keeper Pin (2) Material: Steel



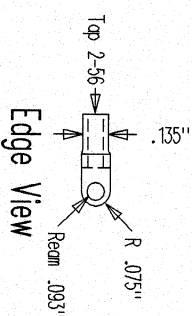
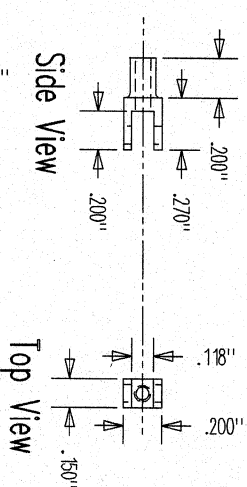
Wind 8 turns of .016" spring wire on .125" mandrel.

Exhaust Valve Spring

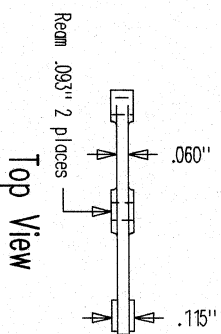
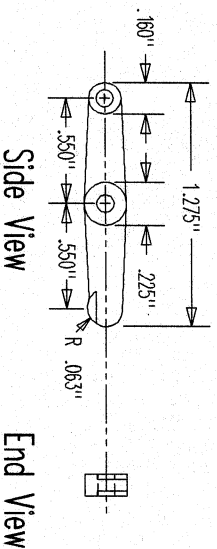


Wind 9 turns of .011" spring wire on .125" mandrel.

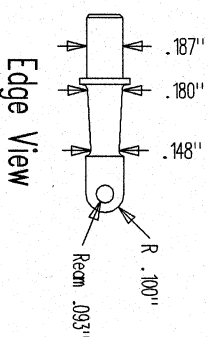
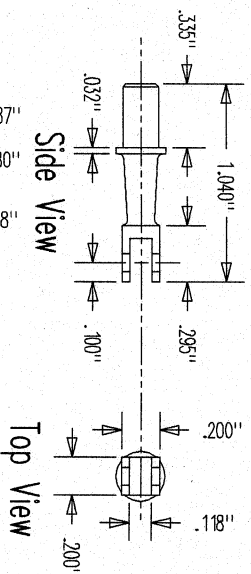
Intake Valve Spring



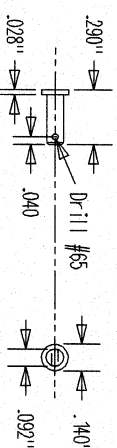
Exhaust Valve Push Rod Clevis Material: Stainless Steel



Exhaust Valve Rocker Arm Material: Brass



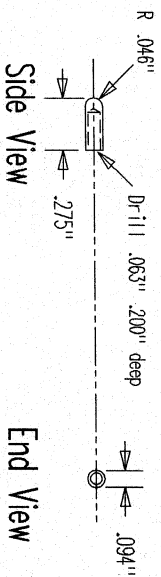
Exhaust Valve Rocker Arm Pivot Material: Stainless Steel



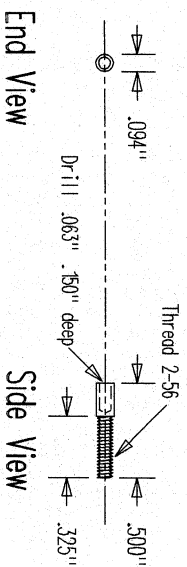
Rocker Arm Pin (2) Material: Stainless Steel

Valve Train Parts

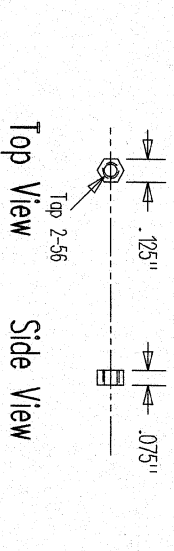
Jerry E. Howell 3980 Beckel Drive Colorado Springs, CO 80906 Model Project Plans & Kits			
Project: "Bilt" - 1906 Four Cycle Gas Engine	Sheet # 7	Date: 06/12/02	By: Jerry E. Howell
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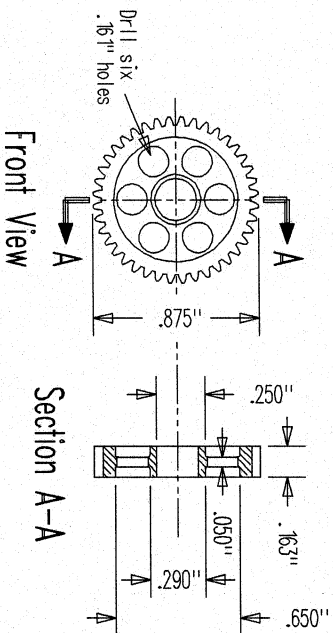
Bottom Push Rod End
Material: Stainless Steel



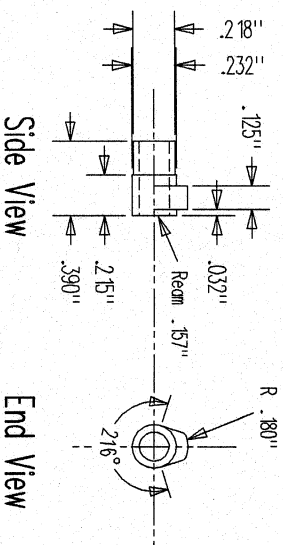
Top Push Rod End
Material: Stainless Steel



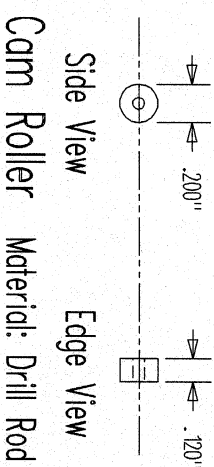
Push Rod Length Adjusting Nut
Material: Stainless Steel



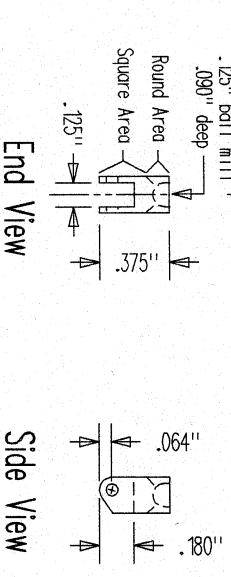
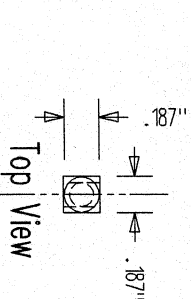
48 Pitch 40 Tooth Cam Gear
Material: Brass



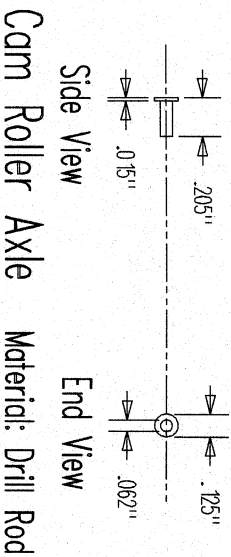
Cam Sleeve Material: Steel



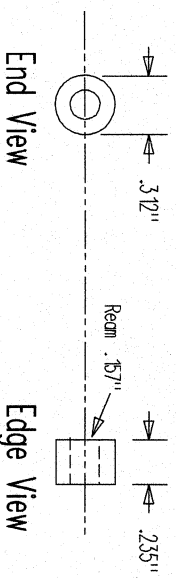
Cam Roller Material: Drill Rod



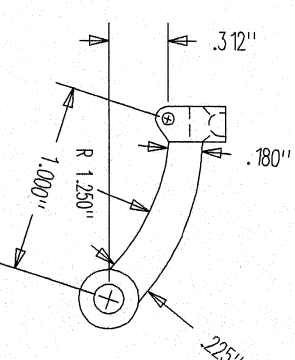
Cam Arm Roller End Material: Brass



Cam Roller Axle Material: Drill Rod

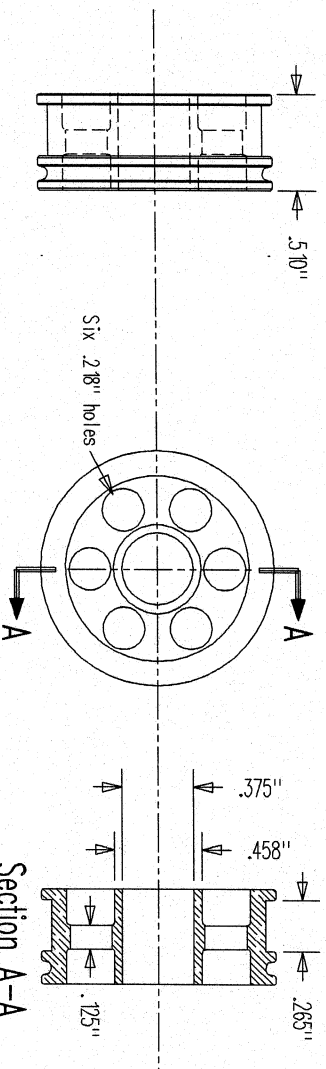


Cam Arm Pivot End Material: Brass



Cam Arm Assembly

See the "Construction Notes" for details of Cam Arm fabrication.



Edge View

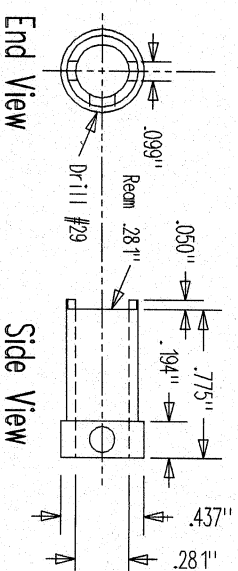
Pulley Material: Steel

Face View

Section A-A

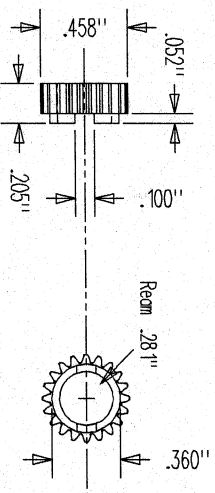
Pulley Hub

Material: Steel



End View

Side View

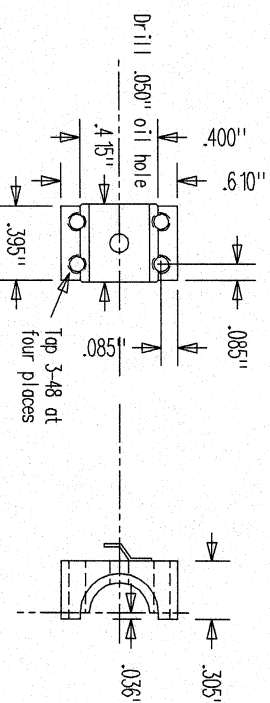


Edge View

Face View

48 Pitch 20 Tooth Crankshaft Gear

Material: Steel

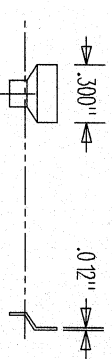


Top View

Side View

Connecting Rod Bearing Lower Half

Material: Bronze or Brass

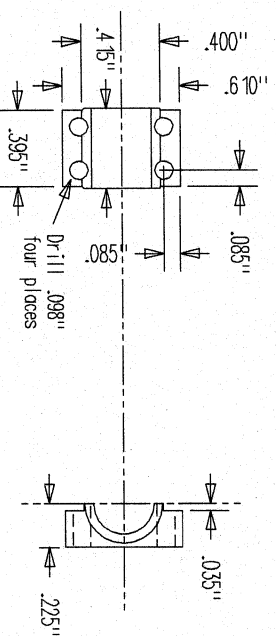


Bottom View

Side View

Oil Dipper

Material: Sheet Brass

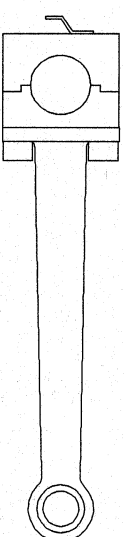


Bottom View

Side View

Connecting Rod Bearing Upper Half

Material: Bronze or Brass



Assembled Connecting Rod shown with oil dipper soldered to lower bearing half, the (4) 3-48 x .5" socket head screws and the small end bushing installed.

Crankshaft Gear / Connecting Rod

Jerry E. Howell 3880 Becket Drive Colorado Springs, CO 80906 Model Project Plans & Kits			
Project:	Bill - 1906 Four Cycle Gas Engine		
Sheet #	10	Date: 06/27/02	By: Jerry E. Howell
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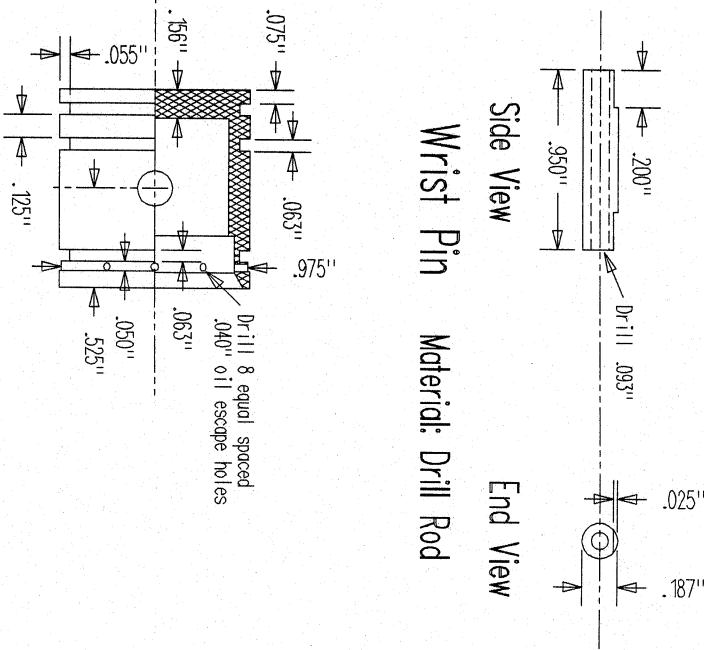
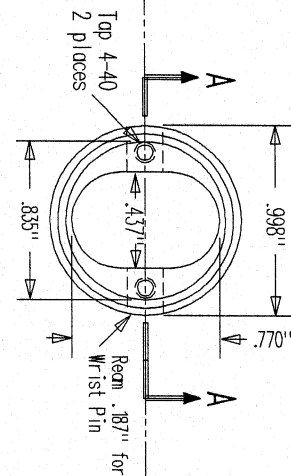
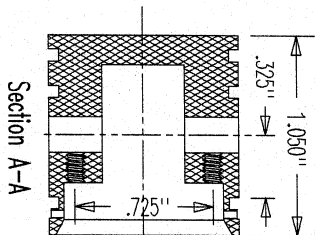
Piston Ring Options

Information on making your own high quality piston rings was printed in Strichly I.C. magazine 1989, Vol. 2, issues #7, #8 & #9. Back issues are available as of this date.

Strichly I.C. Magazine
24920 43rd Avenue S.
Kent WA 98032
E-mail: strictlyic@earthlink.net
Web Site: strictlyic.com

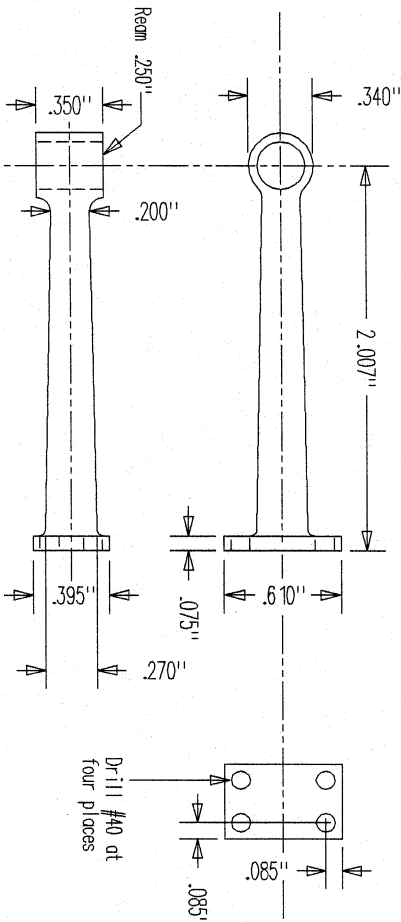
By increasing the piston ring width and depth to suit their rings, high quality and reasonably priced piston rings 3/32" in height can be purchased from:

Otto Gas Engine Works
2167 Blue Bell Road
Elkton, MD 21921
E-mail: otto@dol.net
Phone (410)-398-7340



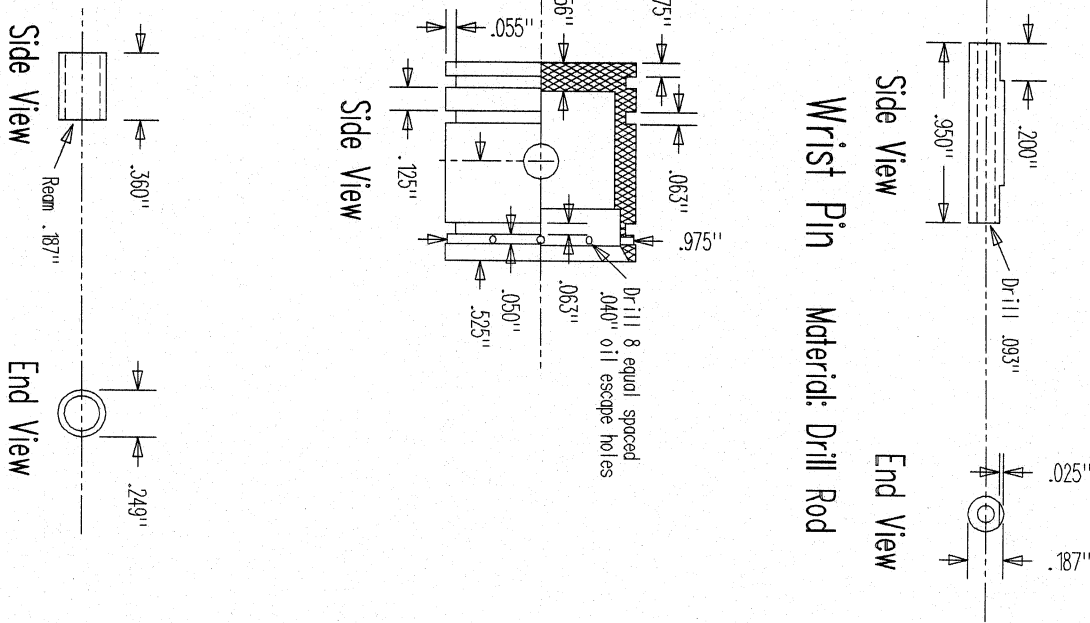
Bottom View

Piston Material: 6061 T6 Aluminum Alloy



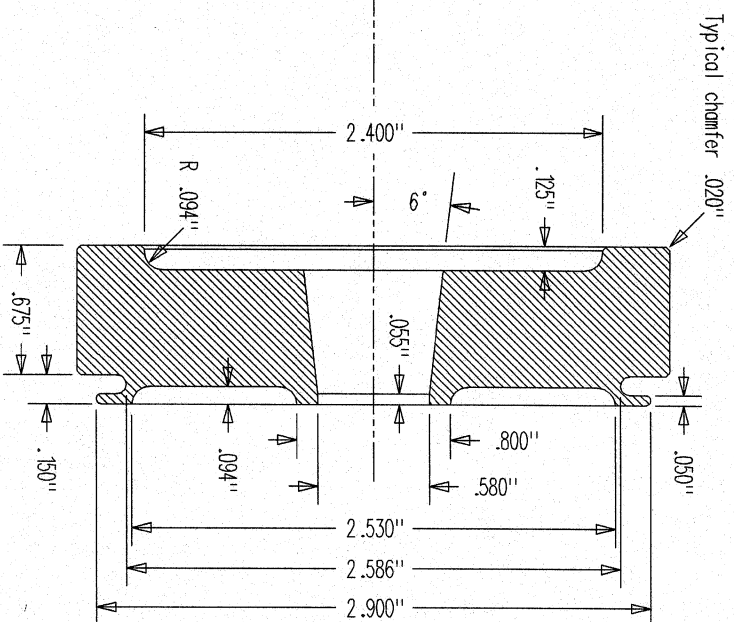
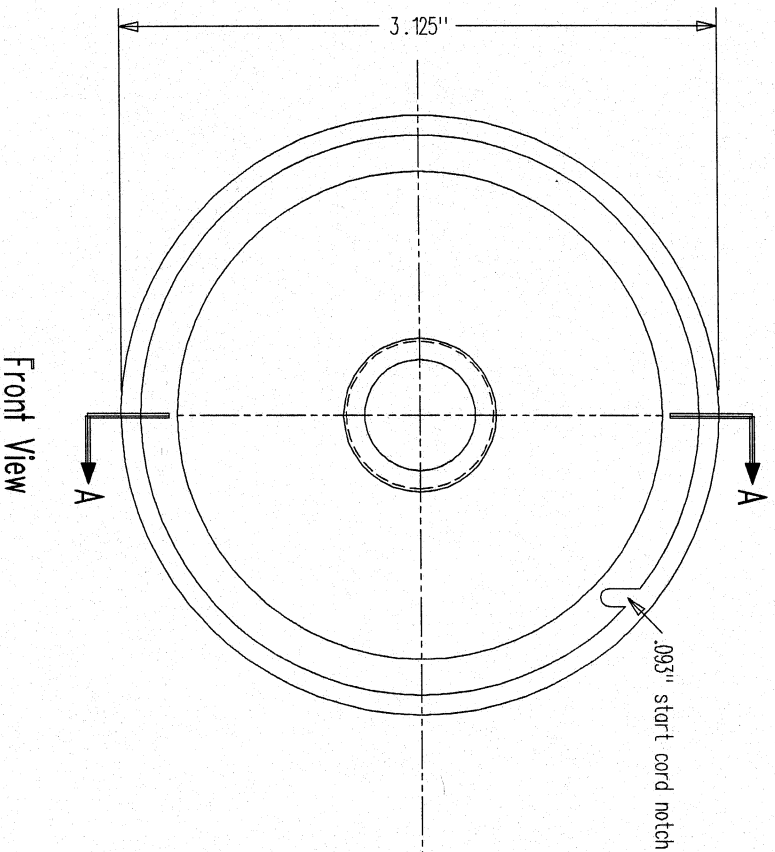
Connecting Rod Material: Steel

Piston / Connecting Rod



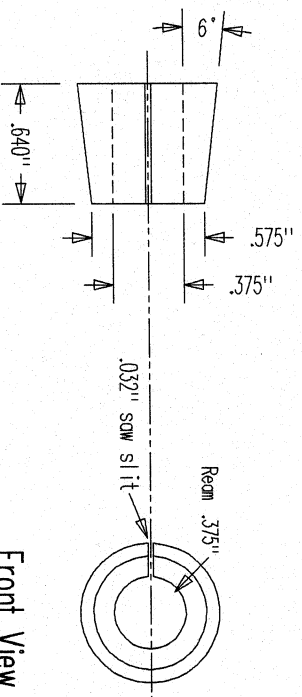
Connecting Rod End Bushing
Material: Bronze or Brass

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Project: "Bill" - 1906 Four Cycle Gas Engine	Sheet # 11	Date: 07/05/02	By: Jerry E. Howell
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Flywheel

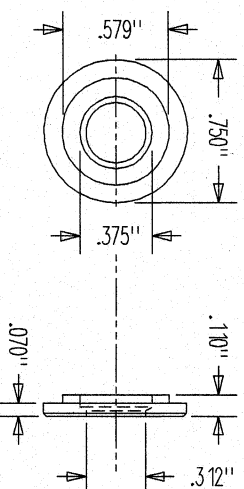
Material: Stainless Steel



Side View

Flywheel Collet

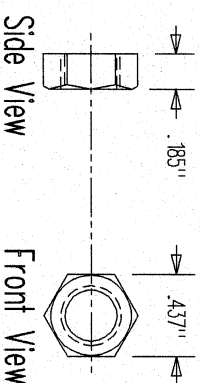
Material: Steel



Edge View

Flywheel Washer

Material: Stainless Steel



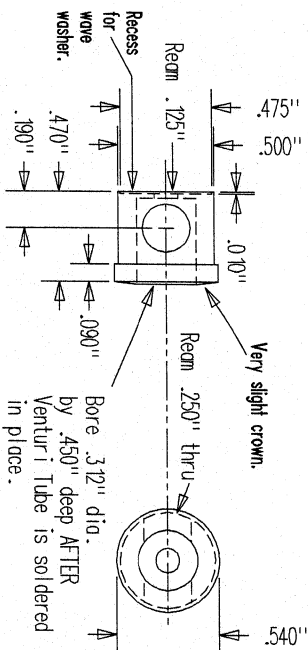
Front View

5/16-24 Steel Hex Nut

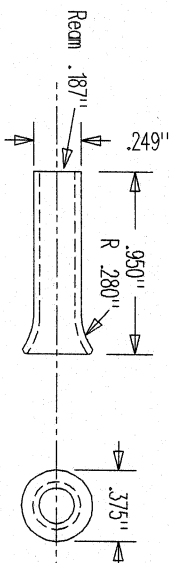
Flywheel Assembly

Jerry E. Howell
3880 Becket Drive
Colorado Springs, CO 80906
Model Project Plans & Kits

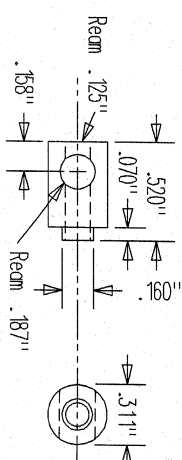
Project: **3111 - 1906 Four Cycle Gas Engine**
Sheet # **12** Date: **06/20/02** By: **Jerry E. Howell**
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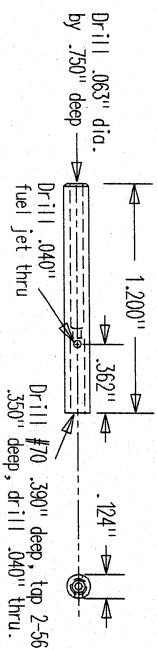
Throttle Body



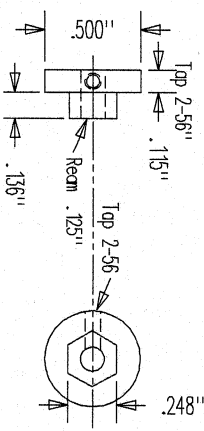
Venturi Tube



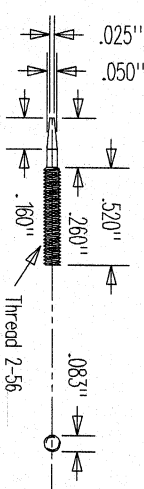
Throttle Barrel



Gas Jet Tube

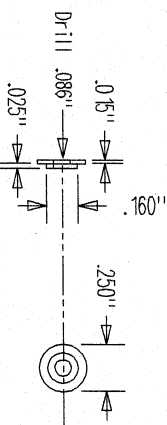


Jet Tube Retainer

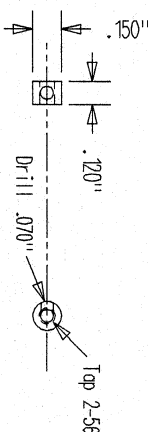


Fuel Metering Needle

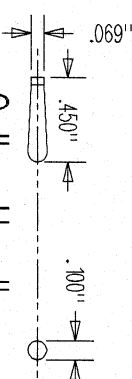
Material: Steel



Spring Washer

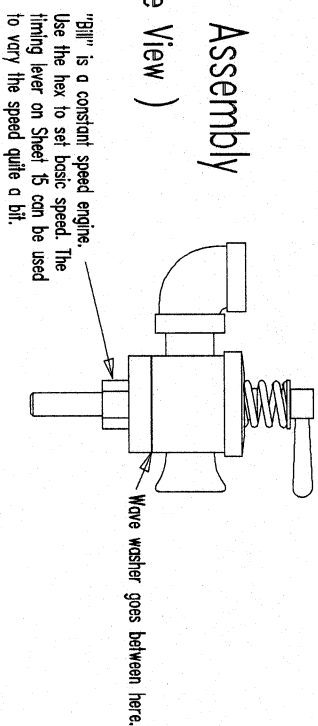


Needle Collar



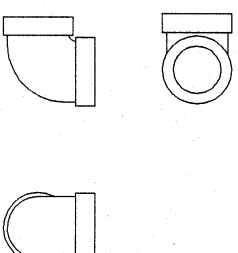
Collar Handle

Throttle Assembly (Side View)



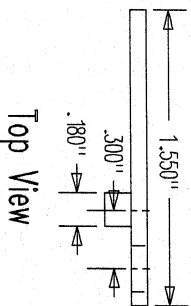
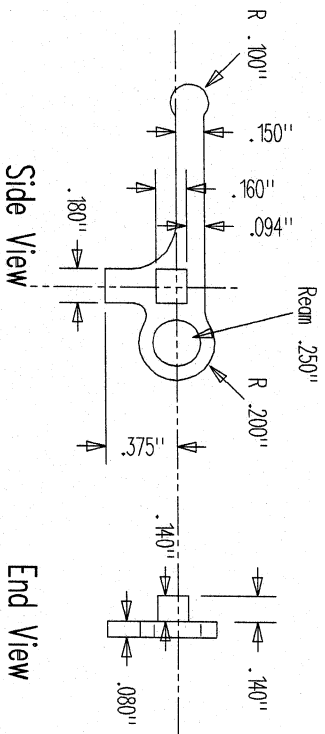
Intake and exhaust cast bronze elbows are available from:
P.M. Research
Department 15M
4110 Niles Hill Road
Wellsville, NY 14895
www.pmrsearch.com

OR
Superscale Locomotive Co.
367-A Beckett Place
Grover Beach, CA 93433
FAX 805-473-4774



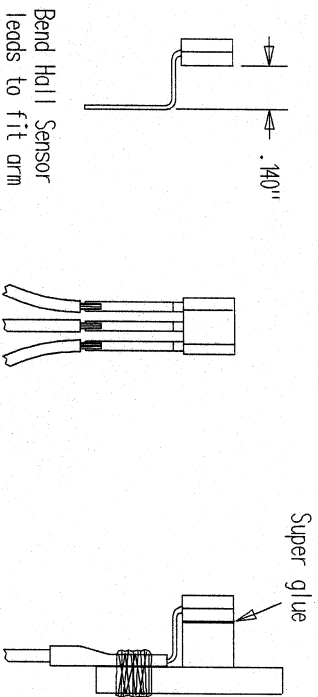
Throttle (all parts brass unles otherwise stated)

Jerry E. Howell 3390 Becket Drive Colorado Springs, CO 80906 Model Project Plans & Kits			
Project: "Bill" - 1906 Four Cycle Gas Engine	Sheet # 13	Date: 07/08/02	By: Jerry E. Howell
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Top View

Timing Advance Arm Material: Delrin



Bend Hall Sensor leads to fit arm

Solder wires to the Hall sensor leads

Install heat shrink tubes and bind Hall leads to arm tab with thread and soak with your favorite glue.

Use the smallest stranded wire you can get.

The "Bill" engine was designed to use the TIM-6 transistor ignition module and a Hall Effect sensor magnetic pickup. If you have aversions to electronics, you can use mechanical contacts of your own design instead. In that case I would recommend the mounting of a tiny arm type micro switch such that the arm is activated by the cam lobe. Keep the dwell time as short as possible with this set up. I am sure you will be able to take it from here. You will still need the TIM-6 circuit because micro switch contacts can't handle the current draw of an ignition coil and will not last long before they fail. TIM-6 takes care of that problem though.

Use super glue or epoxy to mount the magnet in place on the cam gear. As noted below, the center of the cam lobe is 4 gear teeth clockwise of the magnet. The drawing is looking at the cam gear from the engine side.

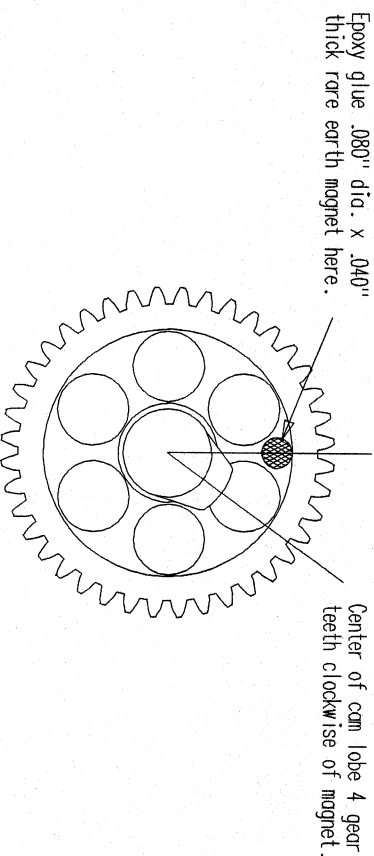
Spread the leads of the Hall sensor apart in crows foot fashion to solder the wires to them. Use as small a stranded wire as possible and hold each lead with needle nose pliers or heavy tweezers as heat sinks during soldering to prevent heat damage to the sensor. The wire I use is .016" diameter and is .028" diameter over the teflon insulation. Radio Shack or other electronic stores should have this.

Cut the heat shrink tubing that I include in the TIM-6 kit in thirds and slide them up the Hall sensor wires and over the solder joints and shrink them on with a little heat from a lighter flame while being careful not to allow the Hall sensor to get hot. Wind a layer or two of common sewing thread around the leads as shown and secure with super glue.

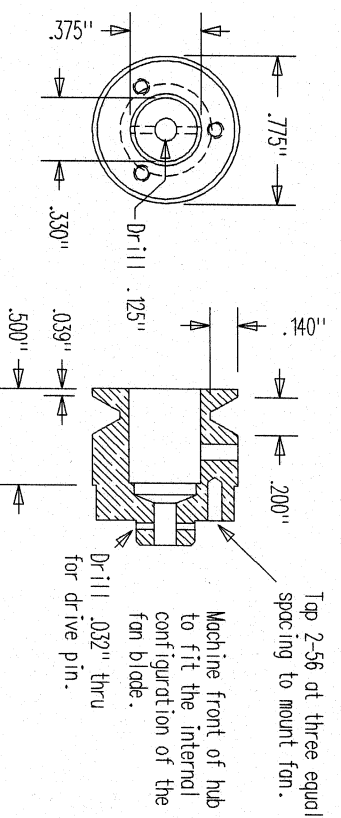
When Delrin is reamed, the hole will be a tad on the small side which will make the arm a friction fit over the Cam Post Bushing. Push it up against the engine crankcase. The arm requires no retainer or anything. It will stay put wherever you position it. Raising the arm advances the timing and lowering the arm retards it. Route the wires down and away from the engine and allow a small amount of slack in the wire for bending as the timing lever is moved and exit the wire through an appropriate hole in the engine base. Make sure the wire will not be able to get against the cam gear.

Don't forget to provide a ground wire from the engine frame to either the coil or the circuit board according to the directions included in the kit. Failure to do so will result in the high voltage of the coil spark to find its way back to the coil through the Hall sensor which will destroy it.

You will find that once properly installed, a Hall Effect sensor pick up will last almost forever and require no further adjustments.

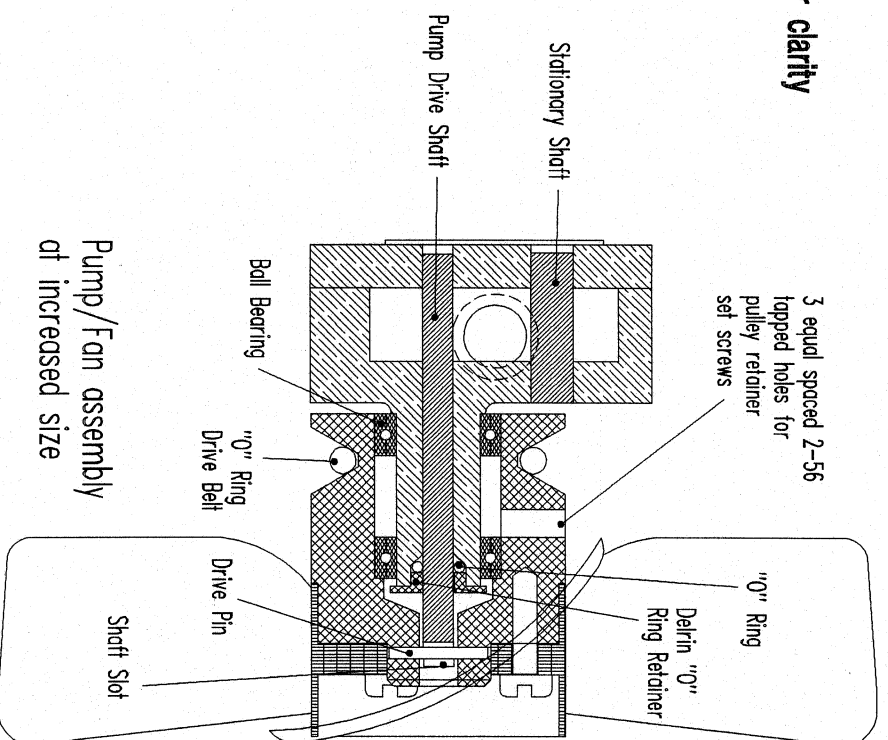
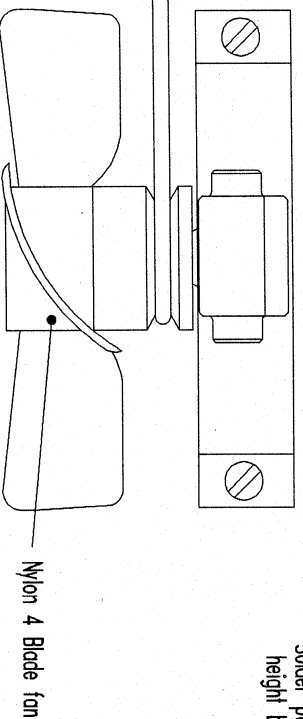
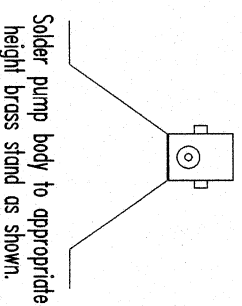


Hall Sensor/Timing Arm Assembly

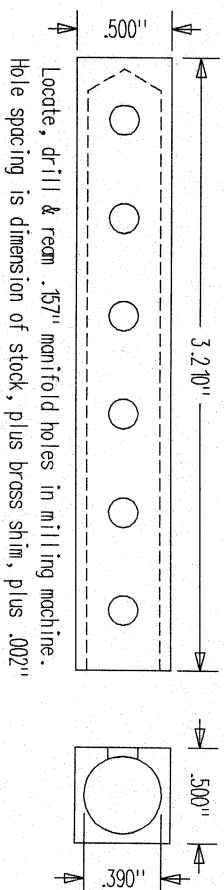


Some hidden lines omitted for clarity

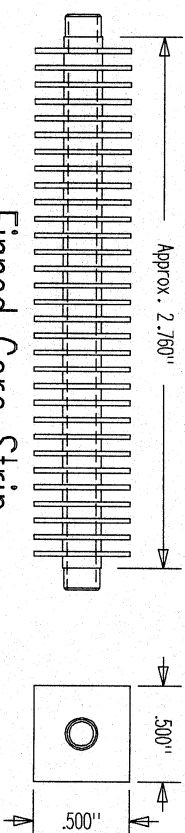
Solder .012" sheet brass cover to seal shaft holes after all other machining has been done.



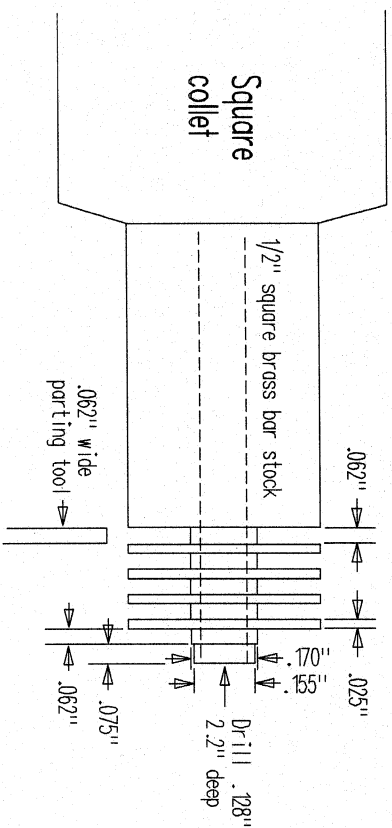
Pump/Fan assembly
at increased size



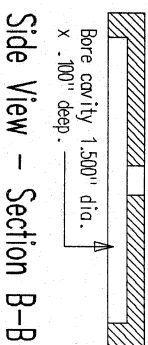
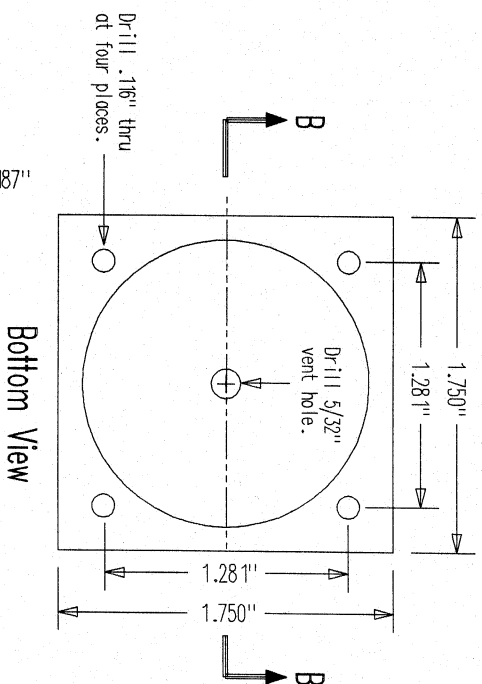
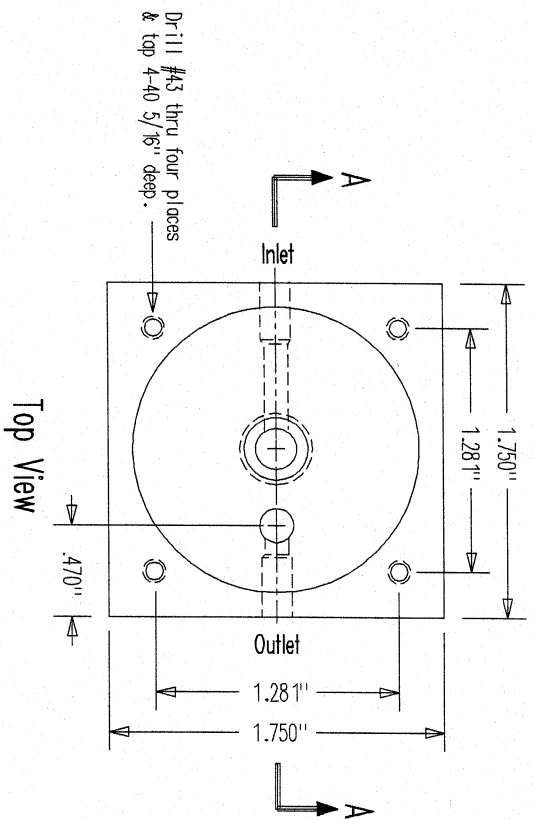
Finned Core Strip



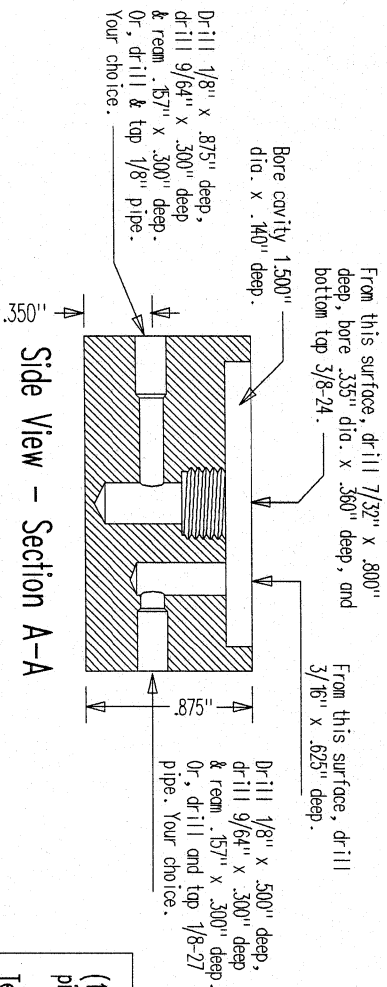
Note – All parts are brass stock



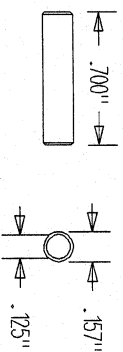
Radiator



Diaphragm Cover Material: Aluminum Alloy



Regulator Body Material: Aluminum Alloy



Hose Bib (2) Material: Brass Hobby Tube

Propane Demand Valve

(1) Pressure Regulator such as the Collipso Pneumatic MR1 or other miniature regulator for 1/8-27 pipe thread connection available from MSC, J&L or other industrial supply houses.

Tecumseh Engine Carburetor Parts:

- (1) Spring, Needle, Gasket & Seat Assy. #630932A.
- (1) Diaphragm and Gasket Set #630978.

Assembly: Install the hose bibs using Locite sealant. With the body upright, put the spring, needle & gasket in the center hole and screw in the brass seat. Lay the diaphragm on the body with the metal disk side down. The diaphragm gasket is readily not needed. That is up to you. Mount the diaphragm cover using four 4-40 screws. Pressurize the unit and submerge under water to check for leaks.

Operation: The pressure regulator MUST be mounted directly to a propane torch head such as the Bernz-O-Matic, Turner, etc. Using a pressure gauge, set the pressure regulator output to from 1 to 3 PSIA maximum. Silicone tubing with 1/8" bore available at most hobby shops can be used between the regulator and the demand valve and from the demand valve to the engine. Keep hose short.

Jerry E. Howell

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Colorado Springs, CO 80906

Model Project Plans & Kits

Project: **Bill - 1906 Four Cycle Gas Engine**

Sheet # **18** Date: 07/06/02 By: Jerry E. Howell

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Construction Notes

"1906 "Bill" - 4-Cycle Gas Engine

For a current full color catalog showing all of my model project plans and kits, visit my large web site at: www.jerry-howell.com

General - If you have never before built small engines, I recommend that you first gain some experience with a few bar stock steam (compressed air) engines and then castings kits.

These are notes of how I made some of the parts for my engine that may be of help to you in building your engine. This is not intended to be a complete step by step A to Z construction article.

Please read all these notes before making any parts. References to "Loccite" is the high strength 609 variety for sleeve, bearing and stud mounting.

The small zip lock poly bag with the plans contains: (1) 7/32" "O" ring to seal the water joint between the head and the cylinder, (1) crankcase vent check valve disk, (1) friction wave washer for the throttle.

Crankcase - 2 - I made my crankcase from a round solid. You could use heavy wall pipe with an end soldered in.

Two short base ribs are on Sheet #4. Soft solder the three ribs on the Base Plate. Machine the ribs to the dashed line to match the radius of the Crankcase. Then drill through the ribs using the base plate as a drill jig. Position that assembly on the crankcase and drill through the case at the front and rear holes only, for now. Tap these two case holes 4-40. Open up these two holes through the base assembly with a #33 drill. Mount the base assembly to the crankcase using two 4-40 panhead screws and do the same procedure for the two side screws. With the screws all in place, solder the base assembly to the crankcase. To prevent oil seepage at the screws, reinstall them with plenty of thread sealer (Loccite) on the threads.

Now, using the base as a reference you can accurately machine the hole for the Cylinder Flange. On a truly flat surface and with the crankcase on it's base, arrange two stacks of 1-2-3 blocks - parallels, etc. fore and aft of the crankcase so that two metal rails can be places across them - one on either side of the neck of the cylinder flange. The parallel stacks need to be adjusted in height so the top of the cylinder flange is the proper height during propane torch soldering. This procedure insures the cylinder flange is perpendicular to the base and the crankshaft.

Be careful drilling for the six 4-40 screw holes so as not to drill through to the inside. This prevents oil from seeping out along the screw threads. The drawing shows a 5/16-24 thread for the crankcase vent. If you have a finer pitch tap, use it. I had a 5/16-40 tap that I used on mine.

Cylinder - 5 - Before you machine the cylinder, be sure you can get some thin wall 1.750" OD brass tubing or you have brass stock large enough in diameter to make your own tube. The cast iron

cylinder liner is a slip fit inside the brass cylinder and is installed using Loccite. Solder the Water Inlet Fitting on the water jacket Tube. The water jacket tube is also installed using Loccite.

Cylinder Head - 6 - The Head Water Passage Cover is sweat soldered to the underside of the head and then the five bolt holes are drilled through the cover using the head as a drill guide. Get the water hole in the cover in the proper position before soldering. When drilling the horizontal water passage, be careful not to drill into the bolt hole!

Cam Arm Assembly - 8 - Turn the tapered arm with excess on both ends. Heat to red heat with a torch and bend the arc. Cut the arm to proper length and silver solder the Cam Roller End and the Pivot End onto the arm. Be particular that all is lined up properly with no twist. Upon assembling the roller pin (from the back side) a tiny amount of Loccite will keep the roller pin in place.

Crankshaft - 9 - Using the Crankshaft Balance Weights as drill guides, drill and tap the crankshaft cheeks 4-40 and mount them to the Crankshaft with two 4-40 socket head cap screws. For added insurance, drill the two .093" holes into the shaft cheeks about 3/16" and press in roll pins. Bill uses (2) .375" ID x .875" OD x .281" thick ball bearings on the crankshaft. These are known in the bearing industry as R6-ZZ bearings.

Pulley - 10 - Make your pulley to suit whatever it will be used for. Keep the hub thickness to the .510" dimension. The pulley is mounted onto the Pulley Hub with Loccite.

Connecting Rod Bearing -10 - Drill and ream the big end rod hole .312" after both halves are bolted together and being sure the hole is perpendicular to the bearing body.

Piston Rings - 11 - I make the piston rings for my engines based on the Strictly I.C. magazine article but limit heat treat to 900 degrees F. I used three .062" wide rings of .043" wall thickness and machined the ring grooves to suit. If you don't want to make your own rings, I would suggest that you use the very excellent and very reasonably priced rings from Otto Gas Engine Works.

Flywheel - 12 - My flywheel is stainless steel. If you are like many builders you don't like to machine stainless. If that is the case, I would suggest you use a leaded steel (12L14) because it turns almost as easy as brass. Don't use aluminum as it is not nearly heavy enough to carry the engine over compression at lower RPM's.

Throttle - 13 - The Gas Jet Tube is installed in the Throttle Barrel with Loccite. The fuel jet holes are centered in the air passage and with the jet holes 90 degrees to the air flow direction.

Dummy Lubricator - 14 - Again, the Dummy Lubricator is assembled using the ever popular Loccite!

Crankcase Vent - 14 - Lay the check disk (supplied) on the body and install the cap. If the cap is too loose a fit, squeeze the skirt together a tad at the saw cut.

Water Pump & Fan - 16 - Gear pumps are very good water movers - even at low speeds. This is a very good pump design and I have one engine using it that has over 800 running hours and the pump has never leaked a drop. The pump shaft is isolated from the side force of the drive belt and the axial load of the fan.

Radiator - 17 - My radiator design may be a bit more work to make than others, but the looks can't be beat, and it is a very efficient cooler. Use .010" or .012" brass shim strips between each core strip and .032" strips on the outside edge. Assemble the entire radiator using solder paste on every surface that will touch another one and mount it to a flat 1/4" thick aluminum plate that has a snug fitting fence on all four sides. This will ensure a square and flat radiator panel later. Heat the entire affair with a propane torch until the solder paste melts and flows.

The water inlet tube should be mounted near one end of the expansion tank and the outlet near the opposite end on the bottom as shown. That causes a diagonal cross flow to help all core tubes to work equally. A brass plug is Loccited into the end of the bottom header after all the flux is washed out of the inside. The filler neck is a press fit using the thin wall brass hobby tubing.

The fan will pull a lot more air through the radiator core if a shroud is made to fit around the blades. Pull the radiator cap up to clear the "O" ring during operation to prevent pressure build up. Use a 50-50 mixture of antifreeze and water which will keep the water pump shaft and gears lubricated.

Operation - The "Bill" engine is a long stroke, medium speed engine. Not a high speed bumble bee! It has quite a lot of torque and will easily power an appropriate size generator or water pump at around 1,000 RPM or so.

I can supply the 1/4-32 spark plug, the TIM-6 transistor ignition module kit and a model engine ignition coil. Check my web site at: www.jerry-howell.com

I use 6cc of 10w-30 motor oil in the crankcase. That is equal to about 5 full shots from an average medicine dropper. In any case, you want the oil level to be high enough to just not touch the crankshaft counterbalance weights. That allows oil to be picked up by the connecting rod, but not so much that the crankshaft will throw too much of it into the cylinder and also causes some oil to work out the crankcase vent check valve. Your engine may spit some oil out the exhaust and the vent until the rings seat. Until that occurs, keep an eye on the oil level so it don't get too low. The vent check valve, when working properly, allows air and blow-by to easily escape the crankcase as the piston moves down, but closes on the up stroke which causes a partial vacuum in the crankcase. That prevents oil from working out around the shaft. My engine quit spitting oil out the exhaust once the rings seated. I change the oil after every 10 hours of operation. Have fun! JEH

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Model Project Plans & Kits		Project: "Bill" - 1906 Four Cycle Gas Engine	
Sheet #	19	Date: 07/01002	By: Jerry E. Howell
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