BUILDING THE 1/2 V.W.ENGINE

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DISCLAIMER: The user of this manual and the associated three drawings assumes all liability in the construction and operation of this engine.

"Outrageous" you say? "Cutting an engine in half"? In these days of nearly out-of-reach flying costs, such claims for a reliable engine, even an aircraft engine are enough to invoke the raised eyebrows of aviation buffs everywhere. As bizarre as it may seem, it is possible to cut an engine in half and end up with something that will give aircraft reliability. Even the outlay of $500 - $600 is enough to make most ardent flyers regard you as some kind of nut and the coup de force will come when you casually mention that the gas consumption is just 1.8 US gallons per hour.

ENGINE SELECTION

Generally, look for a 1600 cc engine from a 1970 VW or later. The engine should have dual-port heads and case savers for the cylinder hold-down studs. VW engines with serial numbers beginning with AE or AK are excellent choices but don't discard other engines because they fail to meet the above criteria. Case-saver studs can be added to a case and single-port heads which convert with slightly more difficulty than dual-port heads, are quite satisfactory. The only parts that you will use from the original engine are the crankcase, heads, crankshaft, connecting rods, and oil pump. Everything else is discarded.

SPECIAL TOOLS/SERVICES NEEDED

- 6" outside dial caliper
- dial gauge
- access to a metal lathe
- access to a welding equipment
- a copy of HAPI'S book "How to build a reliable VW aero engine" will be quite helpful but is not mandatory.

If this list is scaring you off, don't panic. If you have to buy the caliper and dial gauges, the outlay can be as low as $100. Before you resort to this, check around and maybe you can borrow or rent them. Access to a lathe may not be as difficult as you might think and again, ask around. You will probably have to pay for the welding required but in so doing, you'll be able to seek out a competent welder and the piece of mind from this expenditure is well worthwhile.

NEW PARTS REQUIRED

- 1/2 set (2), 92mm pistons and cylinders:
- 1 - C-20 camshaft: SCAT or Great Plains' equivalent
- 2 - exhaust valves: be sure to specify face and stem diameter
- 2 - intake valves: " " " " " " " "
- 4 - valve pushrods:
- 4 - pushrod tubes:
- 1/2 set (4), cam followers (lifters):
- 1 - main bearing set (specify O/D & brg journal size):
- 1 - rod bearing set (specify O/D & journal sizes):
- 1 - cam bearing set
- 1 - tapered prop hub and faceplate: Great Plains Aircraft
- 1 - prop hub seal: Garlock model 63x1114 21128, or CR Indust. 19852
- 1 - POSA 26mm super-carburetor (mixture adjustable):
- 1 - Fairbanks Morse magneto model FMP1-2B10: Morry Hummel
- 2 - NGK B6HS sparkplugs, set gap to .016"

Suggested Suppliers - Write for Catalogue

Great Plains Aircraft
P.O. Box 545,
Boystown, NE.,
USA 68010
Phone: (402) 493 6507
Fax: (402) 333 7750

SCAT Enterprises, Inc. (ask to speak with Pat)
1400 Kingsdale Ave.,
Redondo Beach, CA.,
USA 90278
Phone (213) 370 5501 FAX (213) 241 2285

CRANKCASE

After the engine has been completely disassembled and studs removed, clean the case with a solvent and have it bead blasted (like sand blasting but with glass beads).

Inspect the case carefully for cracks and for bearing saddle wear. The #2 bearing saddle (middle main bearing) seems to wear more than the others as evidenced by a ridge around the surface of the saddle near the oil gallery. If this ridge is more than .001" high, have your case line-bored. Otherwise, the new bearings will not be held in place with the proper "squeeze" which will allow too much clearance between the bearing and the journal even though the bearing is new.

Measure and record the bearing saddle diameter (O/D of the bearings) so that the proper size bearings can be ordered.

Standard size saddle: 2.565" (brgs 1,2,3), 1.965" (brg 4)
1st line-bored: 2.585" (brgs 1,2,3), 1.985" (brg 4)

It would be best to discard the case if it is beyond the figures shown above.

Bolt the two halves of the case together and mark the cut-line as shown in the prints. Now drill a 1/4" hole as shown which will provide access for a new dowel pin. Make one from 1/4" steel rod (eg. drill rod). Remember, the original dowel pin on the top of the engine will be discarded when the case is cut. Separate the case halves and cut behind the marked line using a hacksaw or a bandsaw. The cut can be fairly rough but don't cut too close to the line. The case is made from magnesium alloy and cuts easily even with a cross-cut saw. Honest, it doesn't hurt the saw at all so don't be afraid to use it.

There are two ways to fill the unwanted holes left by the two cylinders cut off and to beef up the lower engine mounts so, each one will be described separately. In both situations, you will need to machine plugs from aluminum to fit in the front and rear main bearing holes (#2 & #3). Be sure to machine centers in each plug. These will allow the case to be mounted in a lathe so that the rear surface can be machined.

METHOD ONE - welding

Bolt the case together, complete with new dowel pin and using the previously-made plugs, mount the case in a lathe. Take a very light cut to even the rear surface. Now cut a piece of material from the discarded portion of the case to fit the hole left by the rear cylinder and bevel the edges for welding.

Blocks of magnesium for the lower engine mounts can be cut out of the discarded bearing saddle and should be filed for a snug fit. Again, bevel all edges to increase the weld surface. Clamp these blocks in place and drill and tap for the two 1/4"-20 bolts used to anchor the blocks.

Welders who can TIG-weld magnesium are scarce and when you do find one, instruct him to weld all pieces and to fill the holes/depressions left by the other rear cylinder with weld. Again, bolt the case together and put it in a lathe to make the finishing cut to the rear surface. As light a cut as possible should be made to preserve the integrity of the welds.

<u>METHOD TWO</u> - drill and tap
Cut a notch out of the rear of the case on either side of the rear cylinder hole so that a piece of 1/2"x 3/4" aluminum can be set into it. Drill and tap for #10-24 countersunk screws to secure it in place. This piece will actually form part of the rear surface flange that mates with rear cover plate. Make a cover plate for the hole left by the rear cylinder from 1/8" aluminum then drill and tap in place using 6-32 screws. Seal with silicon sealer/cement (RTV clear silicon rubber). On the other half of the case, cut and file a depression about 1/4" deep and 3 1/2" long to accommodate a piece of 1/4" thick aluminum. This will fill the hole left by the other rear cylinder and it's hold-down studs. Drill and tap for one #10-24 countersunk screw. Before any of these pieces are secured, coat all surfaces with silicon sealer.

Make blocks for the lower engine mounts from aluminum or magnesium and file for a close fit. Drill and tap for two 1/4"-20 bolts on the side of the case and for another, through the web inside the case and into the block. Seal the blocks in place with silicon and coat the threads of the bolts as well. These bolts should be safety wired. Now bolt the case together, complete with the new 1/4" dowel pin and place in a lathe to true up the rear surface.

Of the two methods, I prefer the latter since it requires less lathe work and eliminates the cost of welding (it cost me $50.00). As well, the case should end up being much stronger.

Plug the exposed oil galleries by drilling and tapping for short grub screws. Only tap as deep as required to cause the screws to bottom out so that the top of the screw is just below the rear surface of the case. Also make sure that the screws don't restrict the inner oil passages.

If you are going to use the 92mm cylinders which are larger than the stock 1600cc ones, then now would be a good time to have the cylinder holes in the case opened up. To preserve as much wall thickness as possible for the cylinder hold-down bolts, the cylinder bores should be opened up via a two-operation cut. Make the first cut at 3.700" to a depth of 1.125" followed by a second cut at 3.787" to a depth of .75".

Earlier cases (pre 1970 or so) were single-bypass, that is, there was only one spring and piston (located just to the left of the oil pump) to control engine oil pressure. Later cases contained an additional spring and piston located at the flywheel end of the case. Such cases were termed dual-bypass. If yours is a dual-pass case, then you must drill a 3/16" hole about 1 7/8" directly above the existing hole in the bypass adjacent to the oil pump. Examine the discarded portion of the case removed earlier and note the two holes in the bypass area. Basically, this extra hole drilled restores it's function to the portion of the case that we are using. Buy an adjustable oil relief valve assembly and set it for 60 PSI.

Remove the oil pickup tube and cut a portion from the rear of the bell. Make a piece to weld up the open end of the bell. For the oil screen, clean up a used one and cut the flange flush with the rear cover. Bend over the screen to fit inside the bell.

REAR COVER PLATE

Make the rear cover plate from 1/4" aluminum as per the full scale drawing in the prints and trim to fit the outline of your particular case. Leave sufficient material on the bottom edge so that it can be filed flush with the sealing surface for the oil sump cover. Make a cardboard template of the rear cover marking all the holes to be drilled. Place this template on the rear surface of the case and transfer the hole positions to the case with a centerpunch (very lightly only). Now examine carefully each punch mark to ensure that it is located accurately and will not allow the bolt to fall too close to an edge or to restrict an oil gallery. This step is important since there are slight manufacturing differences in VW engine cases and a correct hole in one situation may be inaccurate for another. If you determine that all is okay, transfer the hole locations from the cardboard template to the rear cover and drill 1/8" pilot holes at all locations. Lay the cover on the rear surface of the case, position it properly and secure it with tape or whatever. Use it as a drill guide to drill the 1/8" pilot holes into the case. One way to do this, is to first drill two holes at opposite corners then drill out to size, and tap. Two mounting screws can be used to hold the cover in position while the rest of the holes are being drilled.

The two 5/16" holes on either side at the bottom are motor mount points. For these two holes only, drill and tap through the back cover as well as the crankcase to provide a little extra strength here. The top motor mount is made from a piece of 1 1/2"x 1 1/2"x .090" steel tubing, 6" long. One side is cut out to form a "U" channel that fits over the flange along the top of the crankcase. Make up as per the drawing.

Locate the center of the magneto on the rear cover and use a 2 1/2" or so, hole saw to make the initial hole. Now screw the cover to the case, mount everything in a lathe, and open up the hole to 3 1/4" for the magneto mounting flange. This step is necessary to ensure that the magneto will be on center with the crankshaft.

CRANKSHAFT CONVERSION (see note in last paragraph)

Completely disassemble the crankshaft by removing the snap ring at the pulley end and removing the cam-drive and distributor-drive gears. You'll need to use a gear puller for this. It would be advisable to have your crank magnafluxed to ensure that it is crack free, however, there is another simple test that will yield the same results. Insert the bolt in the pulley end of the shaft, the one used to secure the pulley, and use it to suspend the crank by wrapping a piece of wire around it. Holding the crank vertically in this fashion, strike it with a piece of wood and listen for a definite ring. If you hear a dull clunk or thud, the crank is defective and is not suitable.

Inspect the bearing journals for grooves and use a dial caliper or micrometer to measure them for size and out-of-round.

Standard size: 2.165" (brgs 1,2,3, & rod journals)
1.575" (brg 4)
First regrind: 2.155"
1.565"
Second regrind: 2.145"
1.555"

Often a used crank will show very little wear and if it is within one or possibly two thousandth's of spec, you can save yourself a regrind assuming of course, that there are no grooves and the journals are not egg-shaped. If necessary, there are many automotive machine shops that can regrind your crank to the next size down. If you already have a 2nd regrind or a first regrind that needs work, I would discourage going any further.

Next, cut the crank as shown and have the cut end machined as necessary. The 1/4" projection for the magneto drive can be milled if you have access to such machinery or you can use a hacksaw and carefully make the necessary cuts then file the projection to size. If you choose the latter method, mount the crank in a lathe and scribe a line 1/4" in from the cut-end of the crank. This will be used as a guide as you hacksaw. Once the projection has been formed, weld the exposed oil galleries shut and file the surface smooth.

Next, make the counterweights as shown and grind the crank as necessary for a good fit. Position them as accurately as possible using clamps and pieces of steel, then have them TIG welded in place. Before welding, preheat the crank to 450F and after welding, place back into the oven at 450F and gradually reduce the temperature over a period of eight hours. This last step is required to relieve the internal heat stresses built up from welding and to minimize the possibility of cracks forming.

The next step is to cut the 3 degree taper to accommodate the prop hub. Do not proceed until you have your prop hub because it is virtually impossible to guarantee a good fit unless you can first accurately measure the taper on the hub. It is best to seek out a good machinist to do this work since accuracy is paramount. When the taper has been cut, lap in the prop hub to the crankshaft using fine, valve-grinding compound. Be sure to clean off all traces of the compound. Install the prop hub but do not tighten the end bolt to any degree. Take the crankshaft with the prop hub to an automotive machine shop and have it balanced. If so required, it may be necessary to add a small weight to the rear of the hub (secured by the propeller mounting bolts) to achieve a good balance. Your machinist doing the balancing will be able to give you the required weight and position.

Advanced Balancing Method: Even though the above method will produce an acceptably smooth running engine, it can still be improved upon but with some extra effort. Weld up a jig to hold the crankshaft firmly then drill 7/8" holes through the rod journals. the center for these holes is 11/16" from the surface of the main bearing journal. Make the counterweight as before but use 1/2" thick steel instead of 3/8". Taper the back to reduce the thickness down to 3/8" where it is welded to the crank. If you have already made your counterweights from 3/8" steel, then make pieces from 1/8" steel and TIG-weld them to the inside face (connecting rod side) of the counterweight.

Make two "bob-weights" from strips of lead or solder, each weight equal to 55% of the combined weight of the piston, wrist pin, and connecting rod. After you've figured out what the bob-weight should weigh (it should be around 700 grams), wrap it around each rod journal making sure that the weight is distributed evenly. Use screwclamps to secure them and be sure to weigh each screwclamp ahead of time and include it in your calculations. Now your crankshaft is ready to be balanced and these "bob-weights" represent part of the connecting rod and piston mass which is a necessary consideration for good balancing of an "opposed-two" engine. Remember that accuracy in your calculations and fitting the bob-weights is very important to achieving a well balanced crankshaft so take your time and double check often.

The dual flanged bearing is used at the #3 bearing position (next to the small bearing at the prop hub end). Both flanges are used as thrust bearings to control the endplay of the crank (about .008"). The first step is to machine the thrust surface of the crankshaft so that it is true and smooth. One of the original thrust washers (removed when the engine was disassembled) will be used here but first, the inside diameter of the washer must be increased with a file to allow it to fit over the #3 bearing journal and any radius between the journal and the thrust surface. Make sure it fits flat against the trued-up thrust surface. Measure the distance from the thrust surface to the forward edge of #3 journal. Subtract the flange to flange distance of the bearing from it. This is the amount (plus allowance for three thrust washers and the required endplay of .008") that must be removed from the face of the gear that drives the camshaft so make your measurements carefully and double check.

For Example: Thickness of all thrust washers = .010" each
Width of flanged bearing (between flange surfaces): = 1.060"
Width of #3 bearing journal: = 1.030"
Amount to be removed from width of camdrive gear
= (1.060 - 1.030) + 3x .010 + .008 = .068"

Place this gear in a lathe and remove the required amount from the face, starting at the outside diameter down to a diameter of 2.115". While the gear is still in the lathe, cut a groove in the center of the teeth about 1/8" deep to allow the gear to be pulled off during any future crankshaft work.

Place the camshaft in the lathe and remove a similar amount from the rearward facing side of its mating gear plus a little extra (say .010") to allow for end play of the camshaft.

CAMSHAFT

Cut the camshaft on the rearward side just after the middle bearing journal. There really is no need to have the cut surface machined. Note the timing mark on camshaft gear. It is a little "o" on the forward side of one of the teeth. When assembling, this little "o" goes between the two punch-marked teeth on the forward side of the cam drive gear.

HEADS

Completely dismantle the used head and have it bead-blasted to remove all dirt and scale. Inspect it closely for cracks particularly on the inside from the spark plug hole to one of the valves and in the boss where the exhaust valve ends. That part of the head is scrap if there are any cracks but maybe the other side can be salvaged when the head is cut in two. Discard the original valves replacing them with single-piece, stainless steel units. When ordering the valves, measure the face and stem diameters of the old ones and include these figures in your order. Note too, that the intake valve is larger than the exhaust. Consult a VW engine manual and check the valve guides for excessive wear (valve rocking method). If the wear is outside the allowable limits, you'll need new valve guides in which case you would be better off just scrapping the head. Lap in the new valves into the valve seats with fine, valve-grinding compound. The original valve springs and keepers are probably okay, however, the cost for new ones is quite small.

Cut the head in half as shown. Cut the hole in the side for the 1 1/4" aluminum tube. Now, cut the part necessary from a discarded head to build up the severed side for the valve cover and make plugs from aluminum to cover the original intake holes. Have all this welded in place using normal aluminum welding procedures.

If a single-port head is used, again, cut it as shown but note that it will require a little more work to cover the exposed intake passage. Use pieces of aluminum angle 1/8" thick to accomplish this.

Again, if the 92mm cylinders are being used, the opening in the head must be enlarged to 3.865" which should allow about .005" clearance for the fit. Don't worry if you get a little close (or even cut through) to the holes for the hold-down studs.

To make the valve covers for this engine, use the original ones if they are not rusted through or buy new ones. Remove a section from the middle of the cover sufficient to allow a good fit then weld (or braze) the two halves together. Do the same for the cover hold-down spring. Make new gaskets from 1/8" cork material and use silicon sealer on both sides when assembling.

Take the original rocker arm shaft and cut it down to suit. Drill a new mounting hole 5/16" in diameter at the cut end and make sure that it is parallel with the existing one. Mount the rocker arms on the shaft and place this assembly on the head securing it with the existing stud. When the rocker arms are positioned properly over the valve stems, drill using the 5/16" hole as a guide, through the bottom of the head to locate the hole for the other rocker arm shaft support. Make a spacer from aluminum to fit between, then use an AN5 bolt and locking nut to secure the other end of the shaft. Make spacers from steel tubing to maintain rocker arm position then drill and tap the end of the shaft for an AN4 bolt and large washer.

CRANKSHAFT ASSEMBLY

Lightly oil all bearing journals and fit the first thrust washer and flanged bearing over the #3 journal. Be sure to note the position of the dowel pin (to keep the bearing from turning) that the bearing mates with when it is placed in the saddle. Place the cam-drive gear, spacer, and distributor-drive gear (also used as a spacer) in an oven at 450F for 15 minutes. When hot, these components will slide easily into position on the crankshaft. Make sure the other two thrust washers are in place on the cam-drive gear and secure with tape to keep them from sliding off the fairly small shoulder as the gear is being tapped into position. With all this done and the snap ring in place, check the clearance for end play with a set of feeler gauges If you end up anywhere between .006" and .013", you're okay.

Place the each half of #2 bearing (#1 bearing is not used) in the #2 bearing saddle of both crankcase halves. Note carefully the position of the dowel pin and make sure each half is seated firmly in it's saddle. Install the #4 bearing (the smallest one) on the crankshaft noting the dowel position. Modify the oil slinger as per the drawing and install. Slide the prop hub seal on the hub making sure that the open end of the seal faces rearward. Install the prop hub and only lightly tighten the bolt at this time (it will be torqued later to 85 ft.-lbs.). Then insert the whole assembly in the right-hand half of the crankcase paying particular attention to seat each bearing properly in it's dowel pin. Make sure the crank turns freely. You will probably have to use a grinder on the inside of the crankcase to allow adequate clearance for the counterweights as the crank is rotated by hand. Place the crank into the left half of the case and remove any material for proper clearance as required.

With the crank now properly positioned in the right half of the crankcase, balance the pistons and connecting rods per HAPI'S manual and install the connecting rods on the crankshaft. Note that the forging mark on the rod faces upward. Make sure that the connecting rod nuts are torqued to 23 ft.-lbs. (in steps of 8, 20, & 23 ft.-lbs.), then locked.

Before you start assembling the crankcase, use an air hose to blow out all the oil galleries. The idea is to remove all the metal chips that may have become lodged inside. If you eliminate this step, you stand a good chance of doing some serious damage when you first start the engine.

Install the valve lifters and the camshaft bearings then place the camshaft in position making sure the timing marks on both gears are lined up properly. When installing the camshaft bearings, the narrow set is not used. The wide set with the flanged half, goes in place next to the cam gear; the flanged half is installed in the right half of the crankcase. Install the valve lifters in the other half of the crankcase and secure them temporarily with string. Oil the lifter faces and camshaft lobes . Coat the mating faces of the case with a thin layer of silicon sealer then assemble both halves.

Torque up the four large bolts first to 10 ft.-lbs., then again to 14 ft.-lbs., then to 20 ft.-lbs., then finally to 25 ft.-lbs. Torque up the smaller bolts around the outside of the case to 14 ft.-lbs. in two stages; first to 10 ft.-lbs. then to 14 ft.-lbs. Now check the rotation of the crankshaft. It should turn with little resistance, maybe a little tight in some situations, but it definitely should not require the use of a wrench or any other tool to turn the crank. If it won't turn at all or seems very tight, better open up the crankcase and check for proper seating of the bearings in the bearing saddles or some case obstruction.

Install 1/4"-28 nutplates (3), on the inside of the rear cover plate to secure the magneto. Use a thin layer of silicon sealer to coat the mating surfaces of the rear cover. Install, tighten all bolts and lockwire the heads.

Install the oil pump and use silicon sealer on the mating surfaces of the cover. Torque the nuts to 14 ft.-lbs.

MAGNETO ASSEMBLY

Before the fibre-block coupling can be fitted, it is necessary to make some important measurements to ensure that the magneto drive shaft will not be thrusted by the crankshaft. In fact, aim for a minimum of .010" end clearance. Now, turn the crankshaft pushing it endwise toward the rear of the engine until it seats against the thrust bearing. This is the rearward limit of the crank end travel. Use a depth gauge or that provision on your dial calipers to measure the distance from the outer surface of the rear cover plate to the face of the crankshaft end (not the face of the 1/4" projection itself). Then measure the distance from the face of the magneto drive (again, not the face of it's projection) to that part of the flange that is in contact with the face of the rear cover. The difference between these two measurements, less .010" for clearance, will be the required thickness of the fibre-block coupling. If you are using a ready-made coupling that is thicker than that calculated above, make a spacer to fit between the magneto flange and the rear cover. Again, check your calculations to ensure that the minimum magneto shaft clearance is .010".

The fibre-block coupling can be made from a material known as "Micarta" and is available from electrical motor repair shops. You can cut it out with a hole saw and form the grooves for the projections using an electrical router. Just make sure that the grooves are concentric; that is, the centers of both grooves are in line and not staggered.

As a final check for proper end clearance, mount the magneto on the rear cover plate with the fibre coupling in position. Push and pull the crankshaft from end to end and measure the end play with a dial gauge. It should agree with your measurements taken earlier with the feeler gauges. If it is less, then maybe the minimum end clearance for the magneto is nonexistent.

MAGNETO TIMING

The magneto must be set to fire the sparkplugs at 22 degrees before top dead center (BTC). Before this can be done, you must first identify TDC by placing a scribe mark on the prop hub that lines up with the case split line at TDC. Use a dial guage set up at the sparkplug hole to determine the spot where the piston reaches it's top-most position as the crankshaft is rotated. At this position, scribe a line on the prop hub to line up with the case-split line just above it. Now turn the crank backwards 22 degrees by using a protractor taped to the prop hub. Scribe another mark on the hub and identify it as "22 BTC".

Place the magneto in position on the rear cover making sure that the fibre-block coupling is in place as well. Make sure that the crankshaft is at the 22 BTC position. Remove the black phenolic cover from the rear of the magneto to expose the points and use an ohmmeter across the points to determine when they are opened or closed. Now rotate the magneto body CCW (to prevent engaging the impulse coupling) until the points just open. Secure the magneto in place by tightening the clamps on the rear cover. You may want to run through this procedure a couple of times to ensure the timing is in fact, correct.

CYLINDER DECK HEIGHT

By definition, this is the distance between the top of the cylinder and the surface of the piston at TDC. For a given compression ratio, this distance must be established by calculation and then set by adding shims at the base of the cylinder during assembly. The compression ratio is 8.5 to 1 for this engine which means that the maximum volume at BDC is compressed to 1/8.5 of that value at TDC. In order to find the maximum volume, we need to know the displacement volume (DV - depends on bore & stroke) and the minimum volume at TDC which is comprised of the head's combustion chamber (CCV) and any portion of volume remaining in the cylinder when the piston is all the way up (deck height volume or DHV).

To find what the CCV is, a procedure known as CC'ing the heads must be done. This involves filling the combustion chamber with a measured amount of a fluid such as light oil. The amount of oil needed to just fill the chamber is usually expressed in cubic centimeters and represents the combustion chamber volume. For heads that have been machined out for 92mm cylinders, the CCV is approximately 50cc.

The displacement volume for a 92mm cylinder and 69mm crank is:

DV = 3.14 R5 x stroke;   R = 92/2 = 46mm or 4.6cm.

= 3.14 x 4.6 x 4.6 x 6.9 = 459cc

From the definition of compression ratio, we can now define the relationship:

$$\frac{DV + DHV + CCV}{DHV + CCV} = \frac{8.5}{1}$$

DV = 7.5(DHV + CCV)

DHV = (DV/7.5) - CCV

= (459/7.5) - 50

= 11.2cc

Deck height = 11.2/3.14 x R x R

= 11.2/3.14 x 4.6 x 4.6

=.168cm

or <u>.066"</u>

To include the effects of metal stretch, it is a good practice to use the value of .08" as a minimum deck height.

Now, install the piston on one connecting rod and set the cylinder in place without shims, in the crankcase hole. Note that the little arrow on the face of the piston must point toward the rear (firewall) end of the engine. This works best with the engine on it's side. Turn the crankshaft to TDC and use your dial gauge to determine this. Measure the distance from the top of the piston to the top of the cylinder (surface that mates with the head). Subtract your measurement from .08" and this is the thickness of the required shim. Repeat for the other cylinder.

HEAD AND VALVE ASSEMBLY

Before going any further, make one final check to ensure that the forging marks (projections on top of the arm) of both connecting rods face upwards and that the arrows on the piston faces point to the firewall. Install the cylinder hold-down studs using the method of two nuts jammed together. Both cylinders should be in place with the correct shim installed. Incidentally, both surfaces of the shim should be lightly coated with silicon sealer before the cylinder is seated in the crankcase. Coat the pushrod tube seals with silicon sealer and position them in the head and the crankcase. While holding the pushrod tubes in position, install the heads and tighten them down lightly with the nuts on the hold-down studs. Now, make sure that head sits squarely on the cylinder. Make sure that the hold-down studs are perpendicular to the crankcase and rotate the head if necessary (a double check: the top of the head should be parallel to the top of the case). Torque down the nuts in cris-cross sequence, to 18 ft. lbs. in steps starting at 7 ft. lbs., then 12 ft. lbs., and then finally to 18 ft. lbs.

Slide the rocker arms and the spacers into position on the shaft and mount the assembly into place after sliding the pushrods down the tube into position. Torque down the stud and the bolt (18 ft.lbs.).

To set the valve lash, rotate the crank to bring the piston to TDC on the <u>compression</u> stroke. Use your feeler gauge and set the gap between the rocker arm and the valve stem to .005" intake, and .007" exhaust.

Make a new gasket for the valve cover from 1/8" cork and coat both sides liberally with silicon sealer before installing.

MISCELLANEOUS

-- Carburetor: My preference is the POSA SUPER CARB because of it's simplicity and the ability to have a cockpit-adjustable mixture control. For this engine, a throat size of 26 to 29mm is about right. Others have used a Bendix-Zenith carb. with excellent results as well. There is a school of thought out there that says POSA carbs. don't require carb heat. <u>Don't believe it!</u> There have been situations where I have needed carb heat and was really glad that I had it available. Besides, the DOT will not issue a flight permit without it. Mount the carb underneath the engine and make a bracket to secure it using the bolts that fasten the cover plate for the oil screen. The carb heat box can be made up as shown or to suit your particular requirements and use the bolts along the bottom part of the crankcase flange to hold it in place.

-- Intake manifold / oil cooler: Buy two, 1 1/4" "P" trap tubes from the hardware store to join up with the 1 1/4" tube at the head. Weld up a "Y" section from 1 1/4" aluminum tube to join the other ends of the "P" tubes to the carb. Use pieces of 1 1/4" rubber hose and screw-clamps to join the tube sections together. The oil cooler consists of a 6' length of 1/4" O/D aluminum tubing wound around each "P" tube and held tightly in place with epoxy. The aluminum tubing can be purchased at an air conditioning or re-frigeration supply house.

-- Exhaust pipes: You should be able to pick up a curved section, 1 1/4" in diameter (often called "J" tubes), from a VW dealer or from a muffler shop. Make the flanges from 1/16" steel and weld them in place on the exhaust pipes. Weld or braze the end sections for the heat muffs at a suitable location along the straight portion of the pipe. Don't forget to install braces from the pipe to the head, otherwise, the pipes could develop cracks from vibration.

-- Crankcase breather: To the gasket/baffle plate used at the generator stand on the original engine, attach enough coarse mesh pot-scrubber or scouring pad (EG. Chore Boy) to the bottom so that it will extend into the engine about 2". Use safety wire to hold it in place on the gasket/baffle. Make up the breather cover as shown and fill it with the coarse mesh as well. The details for the oil separator are shown in the prints as well as the routing for the tubes and hoses that comprise the breather system. Note that for the first few hours of engine operation, some oil will escape to the atmosphere despite the measures taken to eliminate this. This is to be expected until the piston rings have seated themselves in place after which, the oil loss will cease. The oil return hose from the separator to the crankcase can be used to drain the engine oil just by removing the hose at the separator and routing it to an appropriate container. In this way, the carb., which is mounted below the oil screen cover, need not be disturbed.

-- Oil filter: Buy a remote filter adapter (Great Plains Aircraft) and mount it on the firewall. Use a small oil filter ('87 Toyota Corolla or MR2) and fill it with oil before installing. Secure it with a screw clamp around it's body to a bracket on the firewall to keep it from coming loose.

-- Prop hub seal: After torquing the prop hub, push the seal up against the front of the crankcase. Make sure you clean the area well to remove any trace of oil. Mix a batch of epoxy (Devcon Plastic Steel works well) and apply it around the outside of the seal body working it over to the crankcase. Build it up so that the seal is fully enclosed and smooth the surface to blend in with the front of the crankcase.

-- Connection of tachometer: If the specified tachometer is used with the Fairbanks-Morse magneto, then the positive terminal must be grounded. The negative terminal connects to the magneto "KILL" terminal.

-- Engine Shock Mounts: Make up as shown an SH #3. Suitable rubbers can be obtained from an automotive parts supply by asking for 2, stabilizer link kits for an 1976 Olds 98. Each kit provides 4 rubber donuts (6 in total will be needed) which can be adapted to suit. The cost for both kits should be less than $10.

INITIAL STARTUP

Fill the crankcase with 2 litres of 10W40 oil. Crank the engine via the propeller (fuel and magneto off), to allow the oil pump to fill all the oil galleries and oil filter lines. If a POSA carb. is used, open the throttle about 1/4" then prime by turning on the fuel for 5 seconds then off again. With the magneto on, pull the prop through until the engine fires. It should run long enough for you to turn the fuel back on. If it doesn't, repeat the priming sequence. Let the engine idle at an acceptable speed and immediately check the oil pressure (40-60 PSI cold).

OPERATION SPECS

- Oil pressure (hot, high RPM) 35-45 PSI
- Oil temp 200 degrees F max.
- Max RPM 3500
- Idle RPM 1100 or whatever you can get with minimum vibration.
- Approx horsepower 28 HP @ 3500 RPM

There you have it. The complete details for building your own engine. Routine maintenance takes the form of an oil /filter change every 40 hours or so, and new sparkplugs at the same intervals. Keep an eye out for any oil leaks and repair them if possible, as soon as you can. Inspect all hose connections and the engine mounts regularly. Happy and safe flying.

SOME ADDITIONAL THOUGHTS

This manual described the method for making up an aircraft engine in a most cost effective manner. However, if you wanted to increase the horsepower from 28-30 to something like 35 HP, you can purchase a stroked crankshaft (78mm) from SCAT. This crank is expensive ($500 US) but it is counter weighted and about the only thing you'd have to do is taper the end for the prop hub. Some extra case clearancing is necessary but fairly easily done. Also, you need to buy the pistons that are compatible with this crank (from SCAT) since the original connecting rods are used. This crank would be assembled in the same manner as described above for the crankshaft conversion.