Subaru EA81-Turbo Conversion Manual

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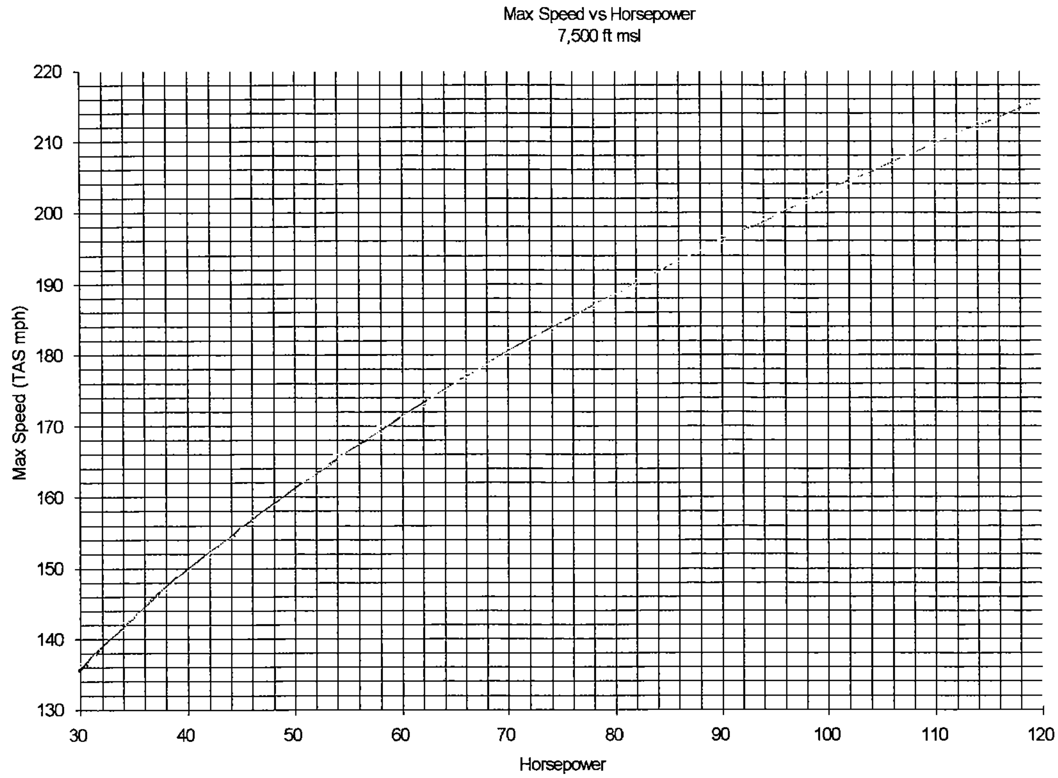
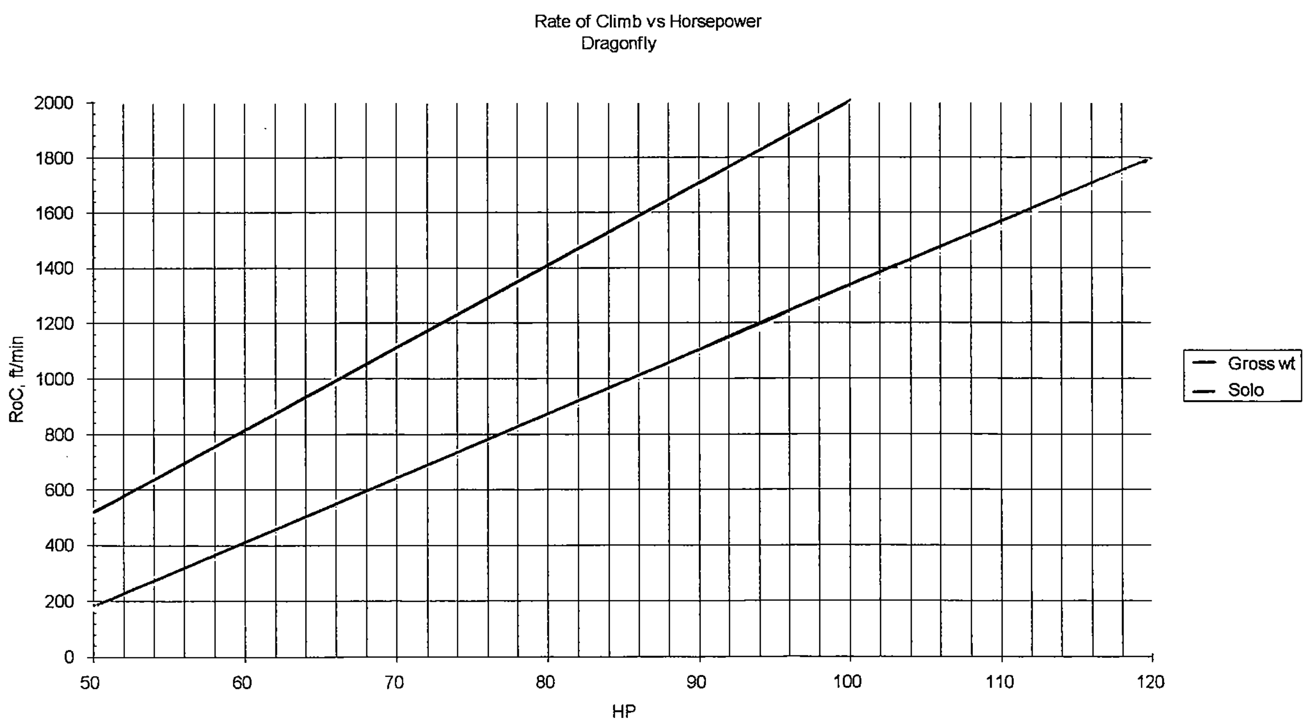
Introduction:

The Subaru EA-81 engine is a horizontally opposed four cylinder engine with pushrod actuated overhead valves. This design was used extensively during the early 1980's in Subaru sedans, wagons, and the Brat pickup. This engine has become a common choice for conversion for aircraft use where 75 to 100 hp is required.

Most engine converters in the industry incorporate a propeller speed reduction unit (PSRU) as part of the conversion to aircraft use. This allows the engine to be run at the high speeds necessary to generate the required horsepower, while turning the propeller at a reduced speed. Typical reduction ratios range from 1.6:1 to 2.2:1. These systems are suitable for installation in airframes that permit a large diameter propeller to be used. For aircraft like the KR-2, Q2, Dragonfly, Sonerai, etc, designed around the Volkswagen conversions, the propeller diameter is limited due to reduced ground clearance. PSRU based auto-conversions installed in aircraft like those above often have trouble absorbing the available horsepower in a small diameter, low speed propeller. The common solution is to increase the number of blades, thereby reducing propeller efficiency, and increasing cost.

This conversion manual describes the process of converting an EA-81 engine for direct drive use. Using a 54" two or three blade Warp Drive propeller, engine speeds up to 3800 rpm can be used, with typical cruise in the 3400-3500 rpm range. At this engine speed, a normally aspirated EA-81 can be expected to generate 60 - 65 hp. This conversion manual describes the use of the stock Subaru turbocharger to increase output to more than 90 hp. This increase is seen at stock boost levels (maximum 7.5psi, 45" Hg). This system is ideally suited to the aircraft types listed above, as they generally cruise at lower power settings. Surplus power is useful for shortening takeoff distances, and increasing rate of climb. Below are the 'Power Required Vs TAS' and 'Power Required Vs ROC' graphs for the test aircraft, Dragonfly . As can be seen from the charts, cruising at 50% power (45hp) with the turbocharged direct drive Subaru yields a cruise speed of 155 mph TAS. This is equal to running at full throttle with the normally aspirated 1835cc VW at 7500 ft.


Max Speed vs Horsepower
7,500 ft msl
Max Speed (TAS mph)
220
210
200
190
180
170
160
150
140
130
30
40
50
60
70
80
90
100
110
120
Horsepower


Rate of Climb vs Horsepower
Dragonfly
RoC, ft/min
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
60
70
80
90
100
110
120
HP
Gross wt
Solo

Weights:

The complete weight of this conversion is 181 lbs. This includes the following:

- Intake manifold
- Exhaust system with turbocharger and wastegate
- Carburetor and associated mounting flanges
- 45 Amp Chev. Sprint alternator with mounting brackets
- Starter and mount
- Water pump
- Oil pan
- All hoses and fittings
- Header tank
- Flywheel and prop extension
- Distributor and one ignition coil

<u>Not included:</u>

Engine mount brackets		~3 lbs
Radiator and mounts		~5 lbs
Fluids -	3.5 liters oil	7 lbs
	4 liters coolant	9 lbs

This gives a total wet weight, firewall forward, of 205 lbs. Note that this does not include the propeller. This compares well with the VW conversions, which come in between 160 to 170 lbs when similarly equipped. Before the conversion, had a firewall-mounted battery. This battery was moved to a position behind the passenger seat, which helps offset the extra weight in the nose.

Those planning a normally aspirated conversion can deduct the weight of the turbocharger and associated plumbing, which should save about 15 lbs. This gives a total weight ready to run of ~ 190 lbs.

flew with a gravity-feed fuel supply system during its VW-powered days. Because of the higher carburetor location with this conversion, a redundant fuel pump system was needed. This added approximately four pounds.

Ignition System:

The ignition system used on incorporates the standard Subaru distributor.

Two ignition pickup units were incorporated in the distributor housing. Due to the size of the standard Subaru pickup, two of this type would not fit into the housing. Two Mitsubishi units were used as they were dimensionally smaller. The units used were from 1985-1989 Dodge Colt/Hyundai Excel.

These two pickup units fire two separate ignition coils, purchased to match the ignition pickups used.

These high tension output of these coils are connected a 'Dual Coil Selector' product, supplied by MSD. This product takes two high tension inputs, and provides one high tension output. High voltage diodes are contained within this device to prevent feedback from one coil to the other.

The dual coil selector output is connected to the normal high tension coil input at the distributor. A wiring diagram of electrical system can be found in Appendix A.

The vacuum advance system was removed, and the rotating plate assembly discarded. A new plate was manufactured using 1/8" mild steel plate. This plate was drilled and tapped for the attach screws to fix the two ignition pickup modules.

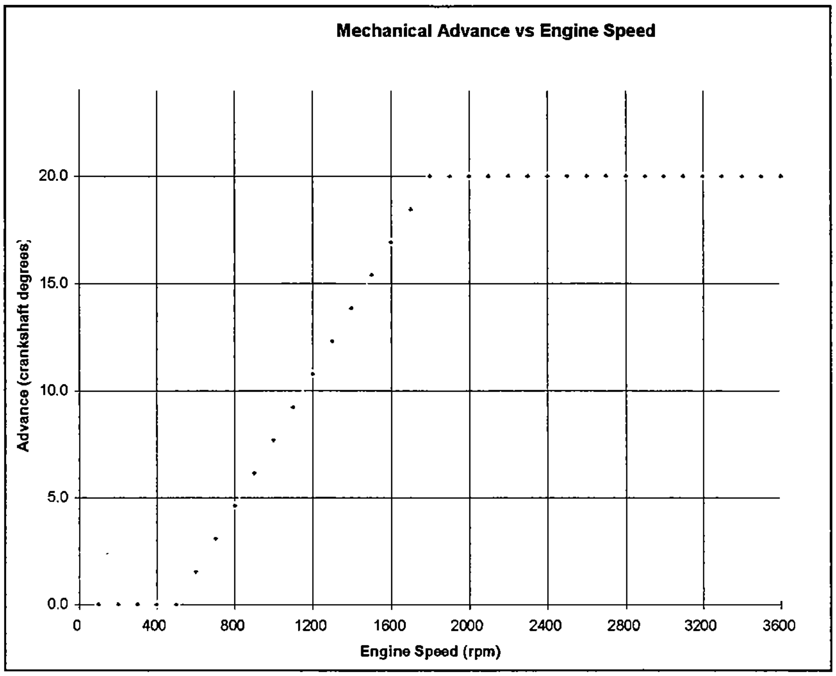
Accel 8mm high performance ignition leads were purchased. A universal set for a V8 should give enough leads for the complete ignition system.

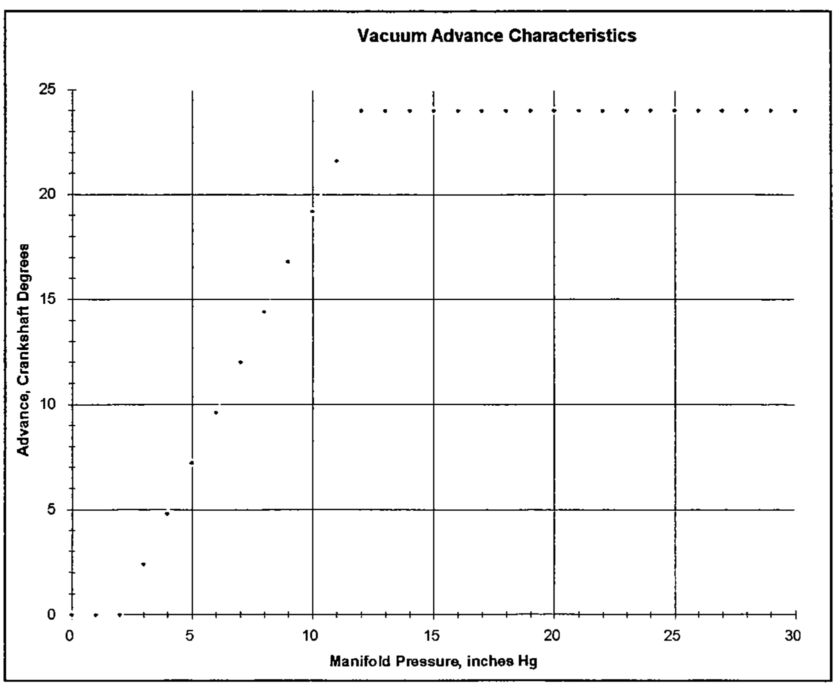
On , the ignition coils and MSD dual coil selector are mounted on behind the firewall, away from the heat of the engine. Only the signal wires from the distributor and the high tension output from the MSD DCS need penetrate the firewall.

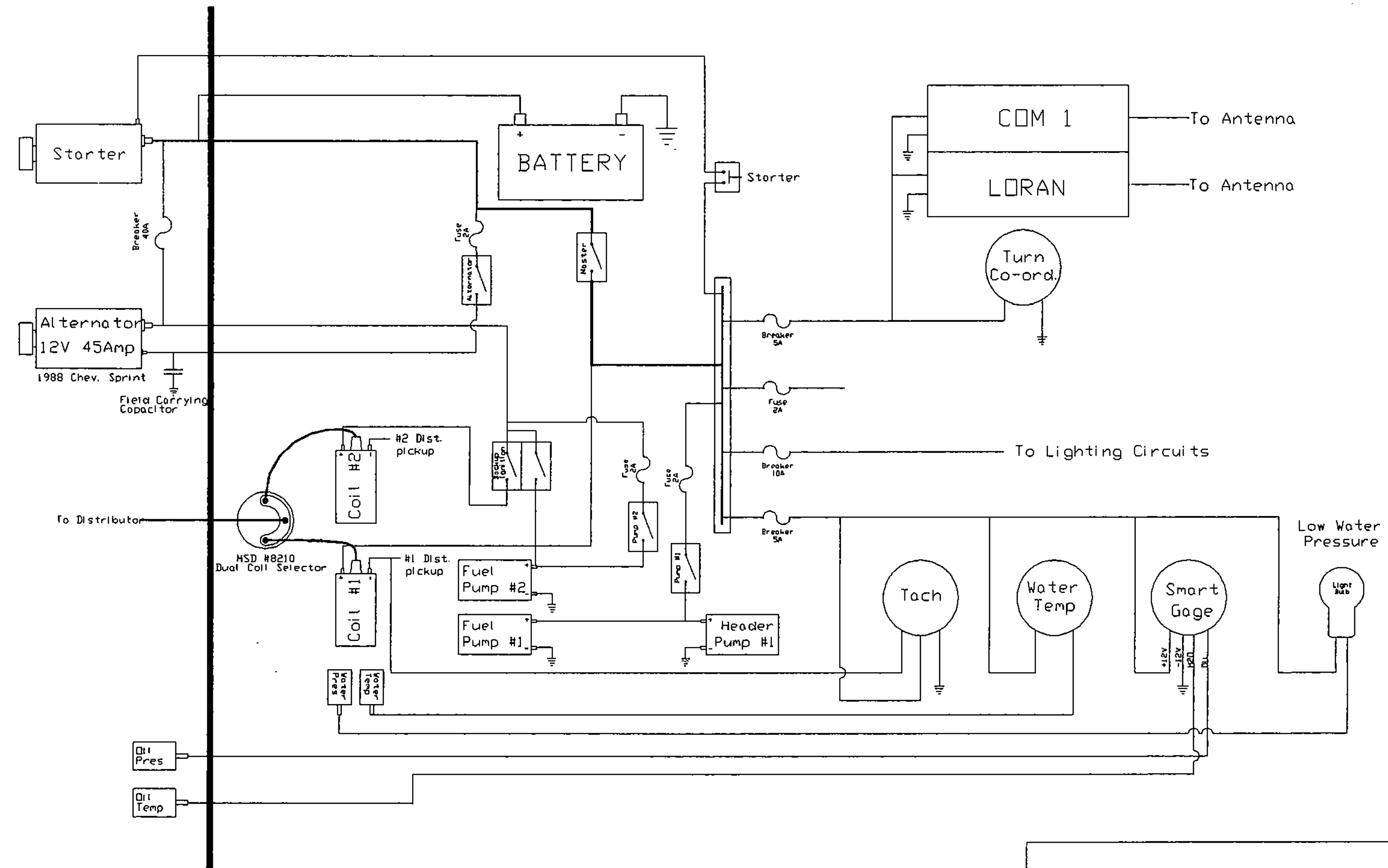
The standard Subaru mechanical advance was retained. It provides for 10 distributor degrees of advance, which translates into 20 crankshaft degrees. We have selected 24 degrees BTDC as our full advance position for operation with our turbocharged engine. This provides a static timing of 4 degrees BTDC, allowing easy starting, both with a starter and hand-propping. A graph showing the advance curves of the stock EA81 mechanical and vacuum advance systems can be seen below. Normally aspirated versions should be able safely use a higher advance, perhaps in the 30 - 32 degree BTDC range.

The Soob shop manual states that the standard mechanical advance mechanism starts at 500 rpm, and proceeds in a linear fashion to provide full advance (20 crank degrees) at 1800 rpm. In most cases it would be recommended to remove the vacuum advance, as it only affects timing during high vacuum (low manifold pressure) operation. In aircraft applications low manifold pressure operation commonly occurs only during taxi and possibly descent.

To find the correct position for TDC marks on the flywheel, a stop plug was made to fit the spark plug hole. The insulator and center conductor were removed from a stock spark plug, and a wood dowel extending 1" from the bottom of the spark plug was pressed into the bore of the plug. An indicator was made of light aluminum angle, and fastened to two top bellhousing attach bolts. An indexing wheel was attached to the prop hub, and a wire indicator extended from the engine to the wheel. With the modified spark plug carefully installed into cylinder #1, the engine is slowly turned over until the piston top contacts the wood dowel. The reading from the indexing wheel is recorded, and then the crankshaft is rotated slowly in the other direction. When contact is again made with the wood dowel, a second recording of the indexing wheel is taken. The exact midpoint of the indexing wheel is then the TDC position for cylinder #1. From this point, reference marks can be made for the intended static and full advance positions.







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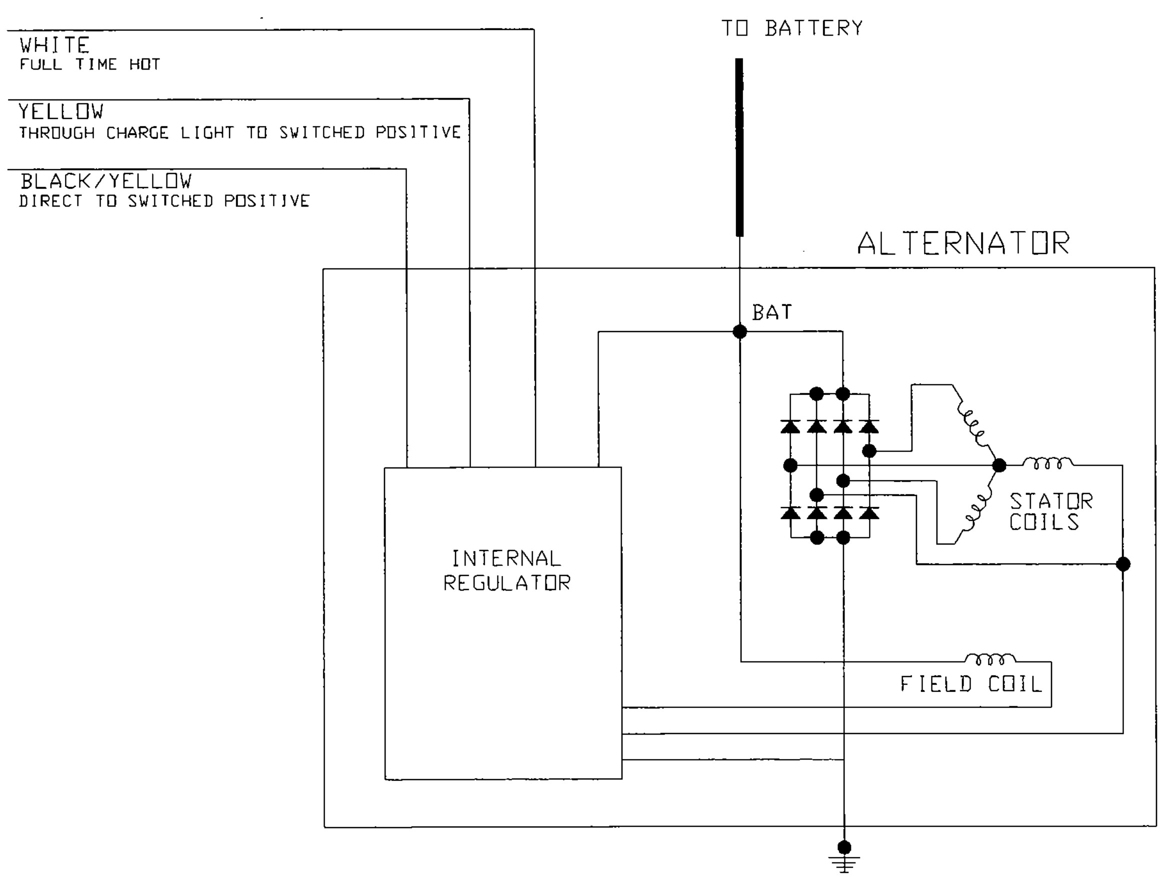
DATE: Nov. 15/95		REVISED BY:
WIRING SCHEMATIC DRAGONFLY SUBARU EA-81		
SCHEMATIC		

Charging system:

A 1988 Chev. Sprint (3 cyl) 45 amp alternator was adapted to the Soob. It is a Nippondenso model #31400-83010. This alternator is substantially lighter than the stock Subaru alternator. It has an internal voltage regulator, so only two connections are required, one for the field activation, and one for the output to the system. 2x2x1/4 aluminum angle was used to fabricate mount brackets for the alternator. The stock Subaru crankshaft pulley was removed, and re-machined to remove the second pulley. This second pulley is used to drive the power steering pump. A 10mm x 735mm accessory belt was found to suit our installation. The output terminal is a 6mm threaded stud. The other three connections accept a special plug. It is recommended that this plug be cut from the wiring harness, and purchased with the alternator.

To add some redundancy to the system, we included a capacitor connected across the field wire connection to the alternator. The switch supplying power to the field connection is a DPDT switch, with the second pole controlling the power source for the secondary ignition. When the switch is on, power for the ignition comes from the battery. When the switch is off, power for the ignition comes from the dedicated alternator. The output of the alternator is now powering the system without a battery. This system needs to be properly tested on the ground before committing to the flight. It has been proven on many systems, but each combination of electrical components has different characteristics, and should be tested accordingly. Special care should be taken to ensure that the voltage regulator is able to maintain proper supply voltage without a battery load present. A sample wiring schematic of this particular alternator can be found below:



Starting System:

A Nippondenso starter from a Mazda pickup was selected, as it was of the gear reduction type, and offered correct rotation (cw viewed from gear end). If a starter is selected from an auto wrecker, ensure the correct rotation is offered by turning the pinion. It should freewheel in one direction. That is the direction of rotation when power is applied to it.

The starter was fit underneath the intake runner tube, and mounted to a 3/8" aluminum plate. This plate was bolted to front bellhousing. In order to give a true flat mount position, the bellhousing, after being trimmed to match the engine case profile, was milled flat in the area where the starter plate mounts. This ensures the axis of the starter pinion is parallel to the crankshaft. In order to mount the starter as low as possible, the engine oil filler tube was removed, and the cast mounting flange for said tube was cut off with a hack saw. The shoulders of this hole were then filed flat, and an aluminum plate was cut and fit to it. Four holes were drilled and tapped for 10-24 machine screws to retain this cover plate. With this port removed, the starter fits nice a close to the crankcase. As for oil filling, the existing oil filler tube was cut short, and brazed in place on one of the valve covers. The crankcase ventilation in the opposite valve cover is maintained, connected to the airbox in automotive fashion.

Depending on the type of aircraft, judicious grinding of the top of the starter may be required to suit the upper cowling profile. This can be done with a hack saw. Cleaning and polishing with a wire wheel installed in a bench grinder gives good results.

In the case of , the intake tube had to be cut and lowered in order to fit the stock cowling. This required that the starter installation be modified somewhat. Out of desperation to match the existing cowling, the starter solenoid was removed, and the housing for it shortened substantially. This required a mechanical lever be attached to the starter to push the pinion to mesh with the ring gear on the flywheel. Also, an older style separate solenoid was installed on the backside of the firewall. A new electrical cable was created to run directly from the starter motor to the solenoid output, and the starter signal wire from the starter button was rewired to actuate the new separate solenoid.

The battery, a standard motorcycle type, was relocated behind the seat. Welding cable, size #4, was run from the battery, along the side of the fuselage, to the bulkhead. The ground cable was terminated at this point, with an 8mm brass bolt directly through the firewall. A ground strap from the firewall to the engine case ensures a proper ground. The positive lead terminates at the primary solenoid input connection.

Intake System:

The intake system was fabricated from scratch, eliminating the stock aluminum Soob casting. Some weight savings can be found by eliminating it, as well allowing further options for carburetor mounting. Also, if the crosspipe is manufactured high enough (about 4" above engine case) then the starter will fit underneath it, making for a nice clean installation. Fitting a starter in this position is difficult with the stock intake.

A central collector was manufactured using an old propane canister cut in half and shortened somewhat. This 'mixing chamber' accepts the fuel/air mixture from the compressor outlet. A larger diameter tube 2" perhaps, may also be suitable for this application. 1 1/2" tubing was used to fabricate the intake runners from the mixing chamber to the intake ports.

Intake port flanges were manufactured of 1/8" steel plate, cut using an old gasket as a template. 5/8" OD tubing was used to create hose attach points for the coolant passages. It is recommended that the elbows be welded to the 1/8" plate first, using the same method as described in the exhaust fabrication chapter. Then the two runners with flanges can be fit to the central mixing chamber, and welded with the assembly bolted down to the engine. This ensures proper alignment. After the system is completed, it is recommended that one of the runners be split with a hacksaw, and about 1/8" removed. A silicone hose with two clamps can then secured across this opening, allowing some movement between the two parts. Do not be tempted to use radiator hose for this application. The rubber used in the manufacture of most radiator hoses is not compatible with gasoline. Short lengths of silicone hose can be purchased at the local industrial supply house.

Exhaust System:

1 5/8" OD tubes were used to fabricate the exhaust runners which wrap around the back of the oil pan, and join into one 1 3/4" tube which runs vertically behind the engine, to the turbine inlet on the turbocharger.

The exhaust from the turbine is carried through a 2" OD tube, which exits at the bottom corner of the cowling.

All flanges were manufactured of 1/4" mild steel plate. The most successful method is to use a holesaw to cut a hole in the flange to just fit snugly over the OD of the tube in question. The tube is then welded from the inside, minimizing the chance of burning a hole in the tube while welding, and giving a smooth, weld-free intersection of the tube and flange. It has been stated from other sources that after welding such a connection, it is helpful to braze a fillet around the outside intersection to give added support to the tube to resist future cracking.

During removal of the stock Soob exhaust system, some of the bolts sheared off flush with the cylinder head. The casting has provision for four bolts per exhaust port, so even if both existing bolts break, the two unused holes can be used. In this application they were drilled and re-tapped 7/16" NF, to convert to more common inch size hardware.

Mandrel bent tube sections of various diameters were purchased from JC Whitney. These tubes were all of .050" wall thickness. Another excellent source of mandrel bent steel tubing is from motorcycle dealers. Headers from crashed or retired motorcycles are usually wrinkle-free, and contain many useful bends that can be salvaged for use.

Turbocharger Details:

A turbocharger from a 1988 EA82 engine was selected, as it suits the same engine displacement as the EA81, but uses a water-cooled housing. The older turbochargers used in 1984 with the EA81 engines require that the engine oil providing lubrication for the bearing also carry away the heat from the center section. In aircraft applications, an oil cooler would be a necessity with this type of turbocharger. With the water cooled turbocharger, it is possible to operate without an oil cooler.

The standard banjo fittings used on the oil inlet and water lines can be reused. Note that the turbine and compressor housings can be rotated to face whichever direction is best suited for your application. What is critical is that the center section remain vertical, so as to allow proper gravity feed of the oil back to the sump. In this case a hole was drilled and tapped 3/8" NPT in the crankcase, just above the oil pan, beside the oil pump. The oil return line from the turbocharger is routed directly to this port. Note that it is critical that the oil return be above the oil level in the sump.

In the case of , an oil inlet block 3/4" x 3/4" x 2" was fabricated, to adapt the oil pressure line to the pressure port, and also allow for a pressure gauge port. A 10mm hole was drilled through the block, allowing the banjo bolt to pass through. One end was drilled and tapped 1/8" NPT for the pressure line input from the pump, and the top was drilled and tapped 1/8" NPT for a pressure gauge sending unit.

This combination was designed to provide a power increase in the lower engine speeds, as the vehicle it is used in (typically 4x4 sedan or wagon) is not your typical high speed Autobahn cruiser. According to the Soob shop manual, full boost pressure is available at engine speeds as low as 2400 rpm. This makes it perfect for the 2800 - 3600 rpm direct drive engine speeds.

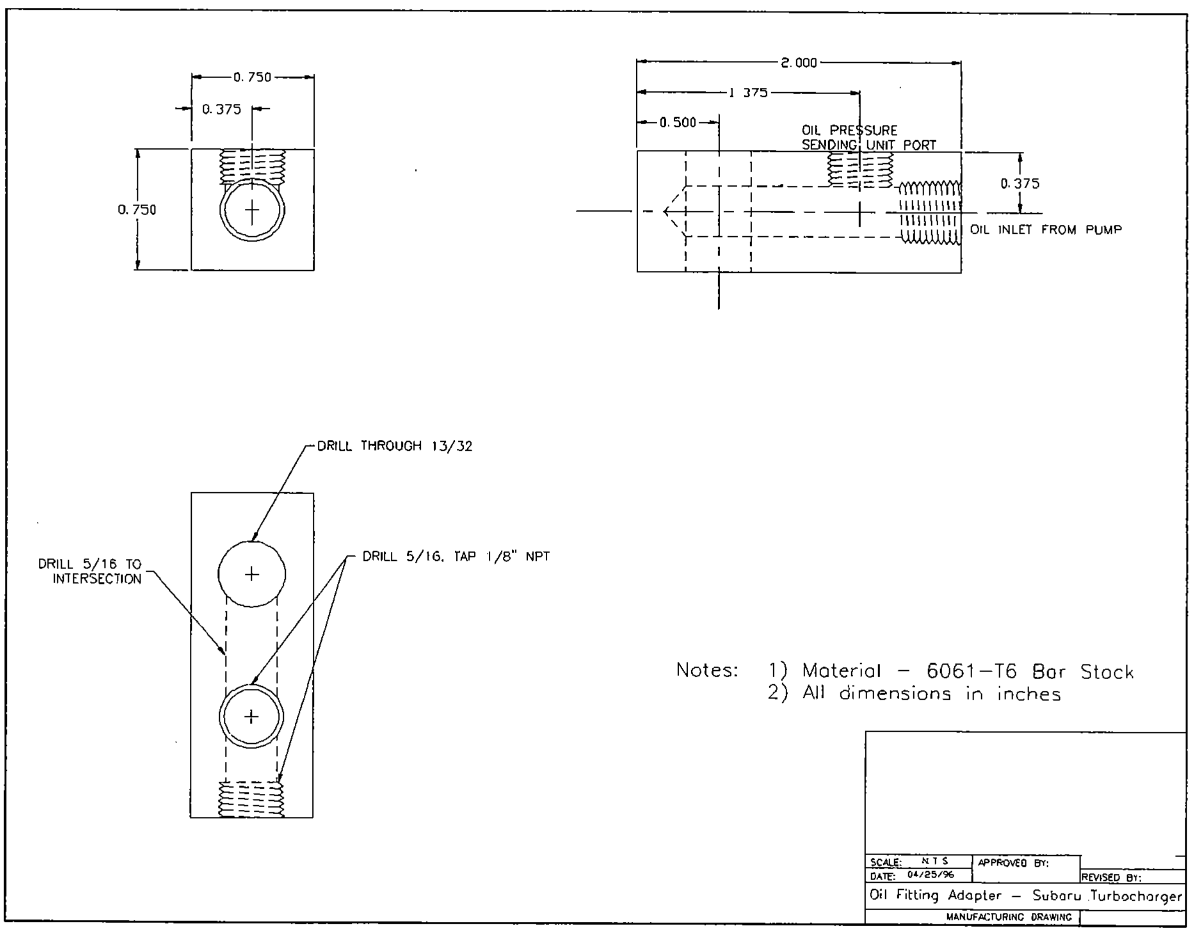
This turbocharger is equipped with an automatic wastegate, limiting manifold pressure to approximately 7.5 psi gauge (above ambient). This means that this that this turbocharger/wastegate combination will provide sea level pressure at altitudes greater than 20,000 ft. Retaining this wastegate ensures the engine should never be operated in an overboosted situation. The disadvantage of retaining the stock system is the fact that in part throttle conditions, the turbo may be working only to restore pressure lost due to the pressure drop across the partially closed throttle. Ideally, the turbocharger should only be employed after WOT has been reached. This minimizes intake air, oil and water temperatures. To control the turbo in this fashion, the wastegate should be held open, and pulled shut with a separate control lever. A slick method would be to incorporate the throttle and wastegate into one control lever, moving first the carburetor to WOT, and then pulling the wastegate shut. A warning is required here in that the manifold pressure limiting features of the automatic wastegate control are gone. The only manifold pressure control is the operator, so temptations may be there to run in grossly overboosted situations for short periods of time. (If 40 inches MAP is good, 50 inches should be great!!)

The turbine housing of the turbo gets very hot during operation. Be sure to keep water and oil lines well clear. A heat shield or insulating wrap may be considered to keep radiative heat transfer to a minimum.

Lubrication System:

The stock oil pump is retained. To fit a turbocharger to a non-turbocharged engine, it is necessary to find suitable oil pressure and return sources. The oil pressure sender is removed from the oil pump, and that port is tapped to 3/8" NPT, to allow the use of standard North American fittings. It is then bushed with a 3/8" NPT - 1/8" NPT bushing. A 1/8" NPT male to #4 flared 90 degree fitting is inserted. This allows for the use of a standard aircraft hose assembly. On the turbo, a banjo fitting is used at the oil inlet. A special fitting was designed to adapt the banjo to standard aircraft hoses, and also to provide a location for the oil pressure sending unit. A drawing of this fitting can be seen below.

An oil return port is created by drilling and tapping a 3/8" NPT port into the side of the engine case, left of the oil pump, just above the oil pan. This will ensure that the oil return is always above oil level. A 3/8" NPT to 1/2" barb fitting is installed here. This allows for a 1/2" return hose to be connected between the turbo and the engine case.



Cooling System:

A 1979 VW Rabbit Diesel radiator was selected for use with this conversion. This radiator was selected for three reasons:

1.) Aluminum with plastic end cap construction makes it lighter than comparable brass radiators.

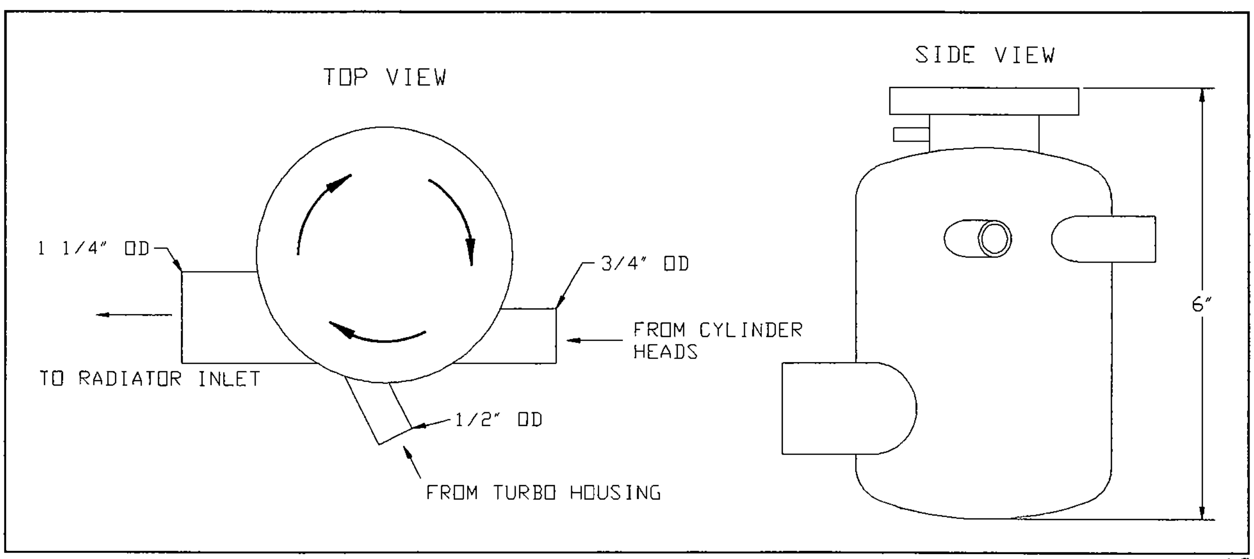
2.) The VW diesel radiators are designed for an external header tank, and do not have an integral radiator cap provision. This make it suitable for our applications, since the rad is located below engine level.

3.) The overall width allows the rad to fit between the stock DF engine mount points (old design).

The coolant path is as follows:

Water flows out of pump, through engine, and exits at four points. The two main coolant exit points are through the 5/8" tubes beside the intake ports. For turbocharged applications a 1/2" coolant line also is connected from the drain plug in cylinder head 1-3 to the turbo center section. The fourth coolant outlet is the small vent tube coming from the engine case, at the high point of the coolant passage. A matching port is brazed to the 5/8" line exiting the x-x cylinder head. This allows the air trapped within the engine case to be carried out.

The two 5/8" engine coolant lines and the 1/2" coolant line from the turbocharger are connected with a header tank. This reservoir has a port at the bottom, connected to the radiator inlet, and a radiator cap attached to the top. This allows any air in the coolant to collect in the header tank, and be vented through the radiator cap to the overflow bottle as the engine temperature (and system pressure) increases. During cooldown, a slight vacuum is formed drawing coolant from the overflow bottle. This eliminates any air within the system. This reservoir can be welded from a used propane bottle. A brass radiator cap flange can be purchased from any radiator re-build shop. It can be brazed to the steel bottle top by working carefully from the inside of the bottle.

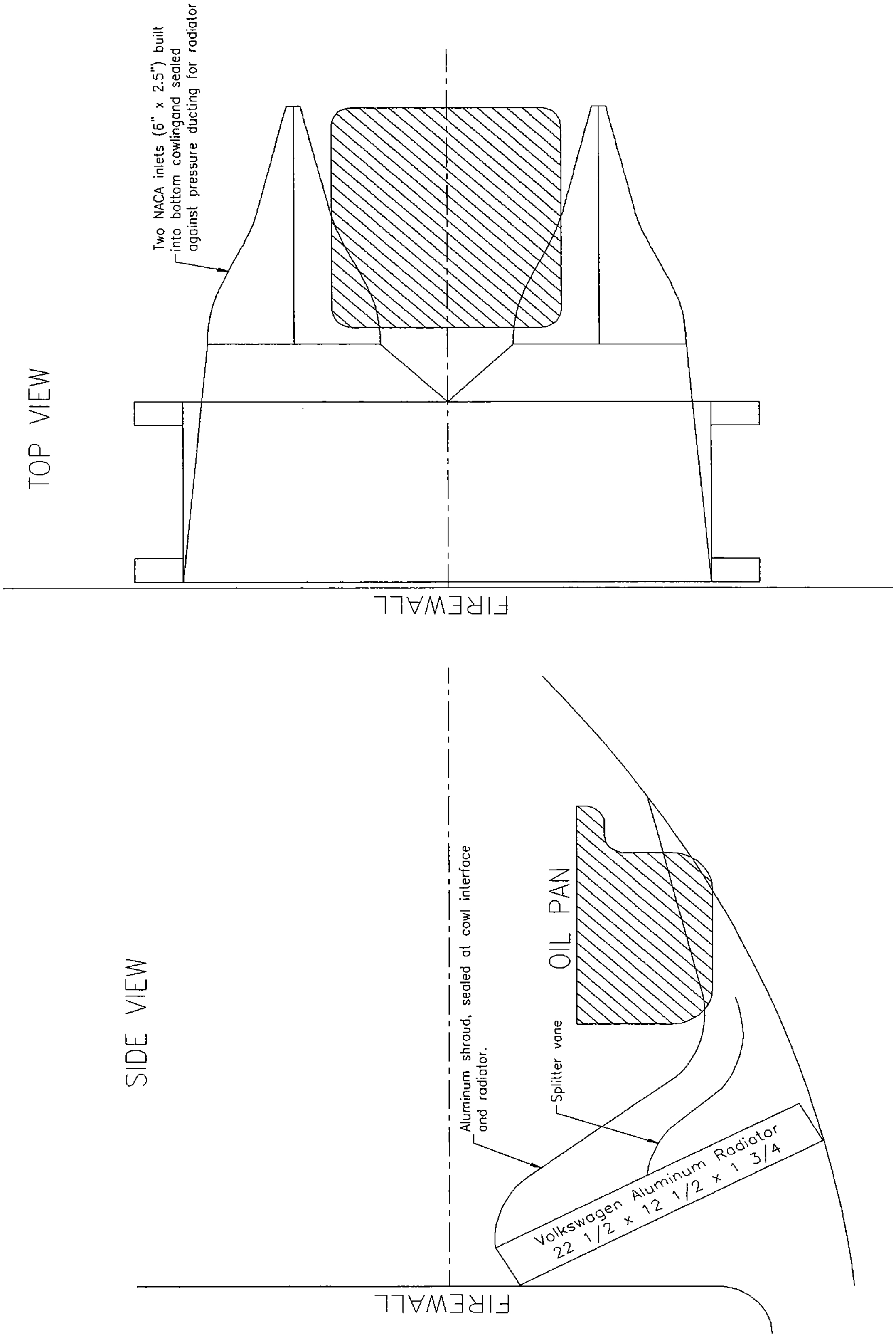


The stock water pump is used. This system uses no thermostat. There are arguments for and against the use of a thermostat, so the decision is yours. The bypass inlet port in the water pump is drilled and tapped 3/8" NPT, and plugged. This port could be plumbed through a heater core to provide cabin heat. On this installation, the firewall was cut open behind the radiator, and a swivel door mounted to it. This allows the use of outside air passing over the radiator to be used for cabin heat.

The top of the radiator is mounted against the firewall. The radiator slopes 70 degrees from horizontal, extending forward towards the bottom of the oil pan. A complete shroud was manufactured to duct air from dedicated NACA air inlets in the bottom cowling to through the radiator, and out the normal air exit between the rear of the bottom cowling and the lower edge of the firewall. To prevent the airflow from passing directly through the bottom of the radiator, a splitter vane was installed at the air inlet by the cowl. The vane carries part of the inlet air up to the top half of the radiator. See the drawing below for further details. Each NACA inlet has an entry area of 7" x 2 1/2", for a total inlet area of 35 in^2. The radiator exit is of dimensions 19" x 3", for a total exit area of 57 in^2. The cheek inlets used with the VW were retained, with the intention of reducing them in size when time allows for a new cowling design.

The VW radiator is provided with four integral mounting flanges, built into each end of the radiator housings. A small bracket was fabricated, which allows bolting the top flanges to the firewall. The bottom two flanges were removed using a hacksaw, to allow for a closer fit to the bottom cowling. A bleeder port for 1/4" hose is built into one end of the radiator. This port was also cut off, and the remaining hole plugged by inserting a screw with sealant.

Standard automotive radiator hoses were used between the high point reservoir, radiator and water pump. The hoses used were Dayco #71459 and Dayco 71299.

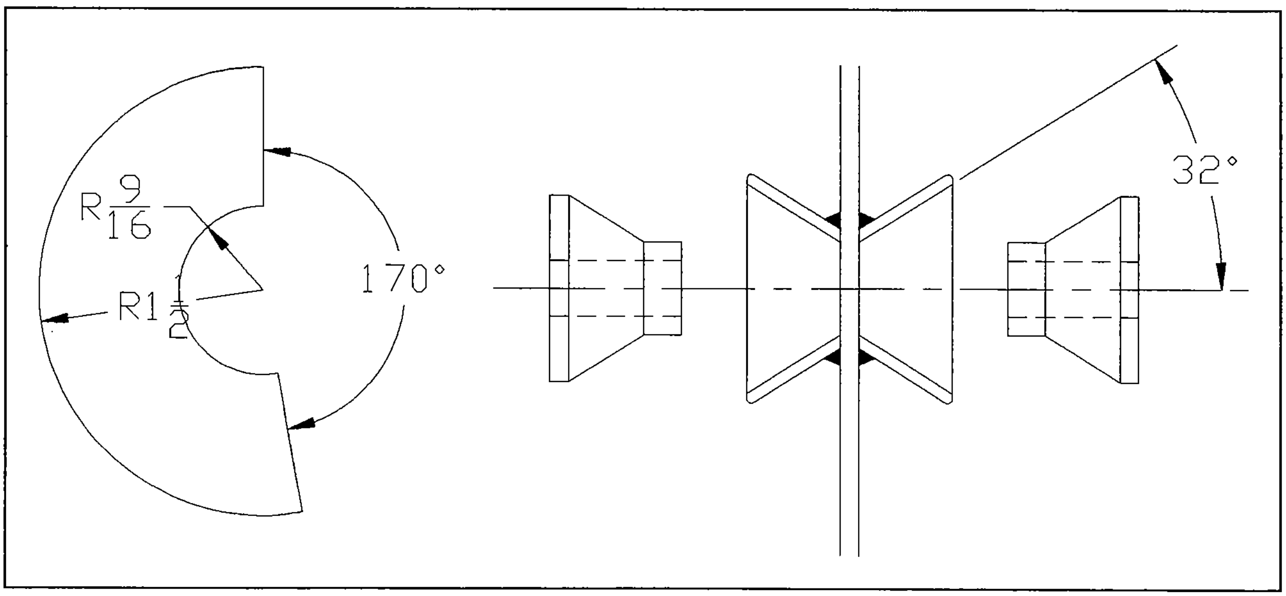

TOP VIEW
Two NACA inlets (6" x 2.5") built into bottom cowlingand sealed against pressure ducting for radiator
FIREWALL
SIDE VIEW
OIL PAN
Aluminum shroud, sealed at cowl interface and radiator.
Splitter vane
Volkswagen Aluminum Radiator
22 1/2 x 12 1/2 x 1 3/4
FIREWALL

Engine Mounts:

In order to fix the engine to a standard aircraft type engine mount, attach brackets were designed using the standard Continental isolation rubbers. All brackets were fabricated from 1/8" mild steel plate. Cones to fit the isolation rubbers were fabricated from 1/16" steel plate and welded to the plates. To fabricate the cones, the correct flat section was cut, and the formed around a male plug. Once properly formed, the seam was welded. See drawing below for details.

The bottom mounts use the four stock Subaru engine mount points on each side of the oil pan. The top mounts use the cylinder head bolts on each side. The cylinder head washers sit in a slightly recessed part of the casting. The edges of this recess will need to be removed with a file to allow the engine mount to pull tight against the cylinder head.

The tubular engine mount from the airframe to the mount points shown above were fabricated from 5/8 x .065 4130 steel tubing. In order to align the engine with the airframe properly, a mockup of the standard Dragonfly firewall was created, and mounted to the side of a workbench. This allowed test fitting of the engine, accessories, cowling, etc. This method is very beneficial if working on a conversion for a flying aircraft. All preliminary fabrication can be done on the bench, with the aircraft still in flying condition.



Engine Case Modifications:

This chapter summarizes all modifications made to the engine during the conversion. Many of these modifications may introduce contaminants into the engine, so it is recommended to perform these modifications with the engine disassembled. The engine should be disassembled for inspection regardless.

1. Cut oil filler attach to match surface of engine case. This may be required to properly fit the starter.

2. Drill and tap the oil pressure sending unit port to 3/8" NPT. This port is used as the oil source for the turbocharger.

3. Drill and tap a 1/4" NPT port on the left side of the oil pump, about 1" above the top of the oil pan. This port is used as the oil return from the turbocharger.

4. Drill and tap the water drain port on the 1-3 cylinder head 1/4" NPT. This port is used as the source for coolant to the turbocharger housing.

5. File the lips beside the rear two cylinder head attach bolts on each head. See engine mount installation for further details.

6. Weld a 1/2" long piece of 1/2" x .065" steel tube to the side of the oil pan. Drill the pan through with a 3/8" drill. Tap the tube to 3/8" NPT. An oil temperature sender will be inserted in this position.

7. Remove the bypass line from the water pump, and tap 3/8" pipe. Insert a socket-head pipe plug in this port to properly seal it.

Bill of Materials:

The lists below contain many of the components required to convert a stock naturally aspirated EA-81 for turbocharged aircraft use.

Oil System

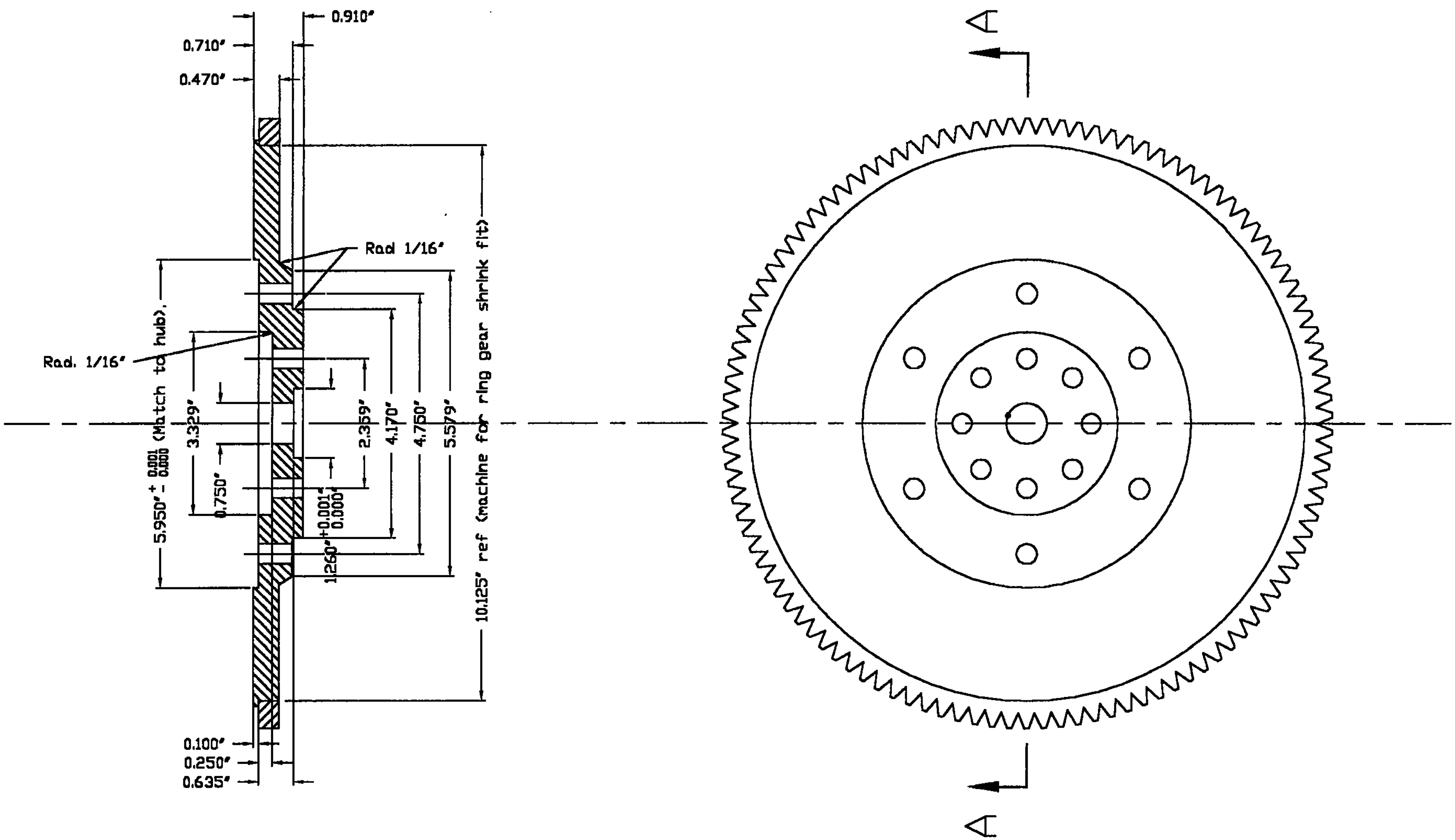
Part	Application
Oil fitting adapter	pressure line to turbo
3/8" NPT male to #4 90 deg. fitting	pressure line to turbo
1/8" NPT male to #4 90 deg. fitting	pressure line to turbo
1/4" NPT male to 5/8" barb straight fitting	return line from turbo
xxx" long #4 hose with straight swivel fittings	pressure line to turbo
xxx" length of 5/8" oil return hose	return line from turbo
firesleeve for 3/4" - 1" OD hose	pressure and return lines
1/4" NPT female weld fitting	oil temperature fitting in pan
Oil temperature sender	TBD
Oil pressure sender	TBD

Cooling System

1979 VW Rabbit Diesel radiator (19" x 12 1/2" Al core with plastic caps)
Header tank with 15 psi cap
1 quart overflow tank - Chevrolet Sprint has a nice one.
3 ft 3/4" heater hose
2 ft 5/8" heater hose
1 ft 1/2" heater hose
Dayco 71459 radiator hose (for radiator to header tank)
Dayco 71299 (for radiator to water pump)
3/8" NPT allen head plug

Electrical System

1982 Mazda pickup starter (Nippondenso starter)
1988 Geo Metro alternator (Nippondenso 45 amp)
Header tank with 15 psi cap
Alternator adj. mount bracket
Alternator pivot mount bracket
M8 x 1.25 x 40mm SHCS, 10 pcs
M8 flat washer, 10 pcs
M8 lock washer, 10 pcs
Starter mount plate



Section
A–A

Notes: 1.) All diameters must be concentric
2.) Break all sharp corners

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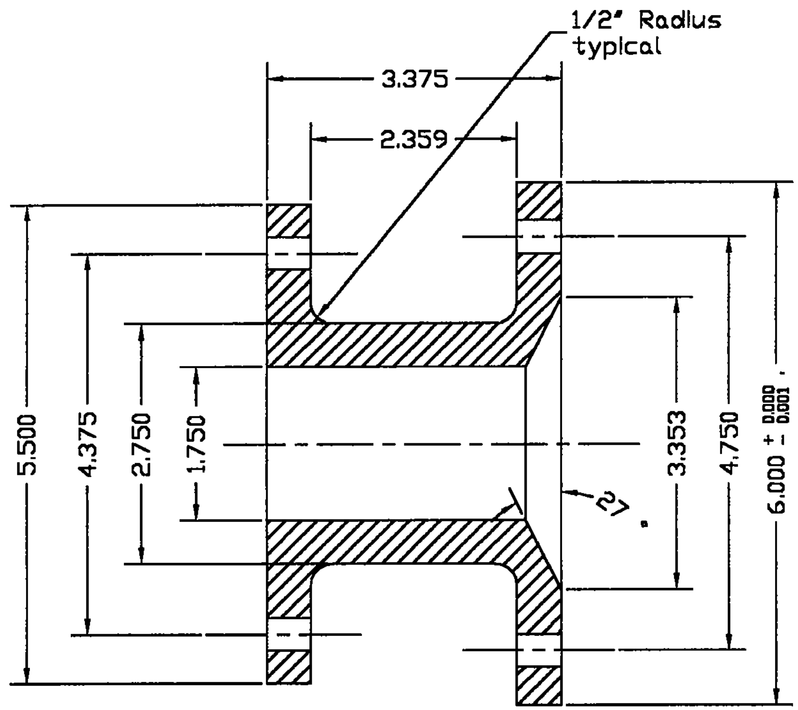
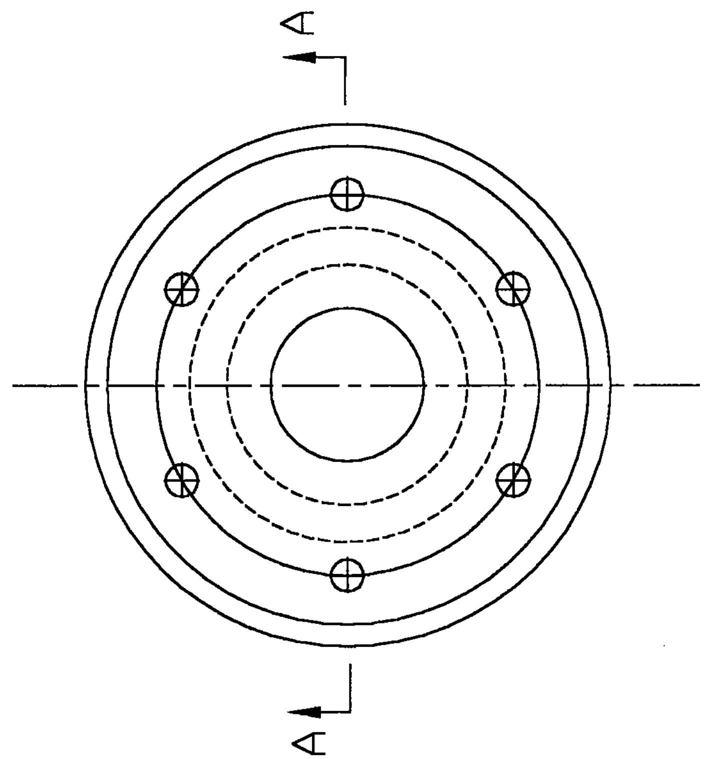
SUBARU EA–81 ALUMINUM FLYWHEEL		
MANUFACTURING DRAWING		



Section A-A



Notes: 1.) All diameters must be concentric
2.) Break all sharp edges
3.) Material - 6061-T6 6" round bar

SCALE: N.T.S.	APPROVED BY:	DRAWN BY:
DATE: 04/10/94		REVISED BY:
SUBARU EA-81 PROP EXTENSION CONTINENTAL PATTERN		
MANUFACTURING DRAWING		