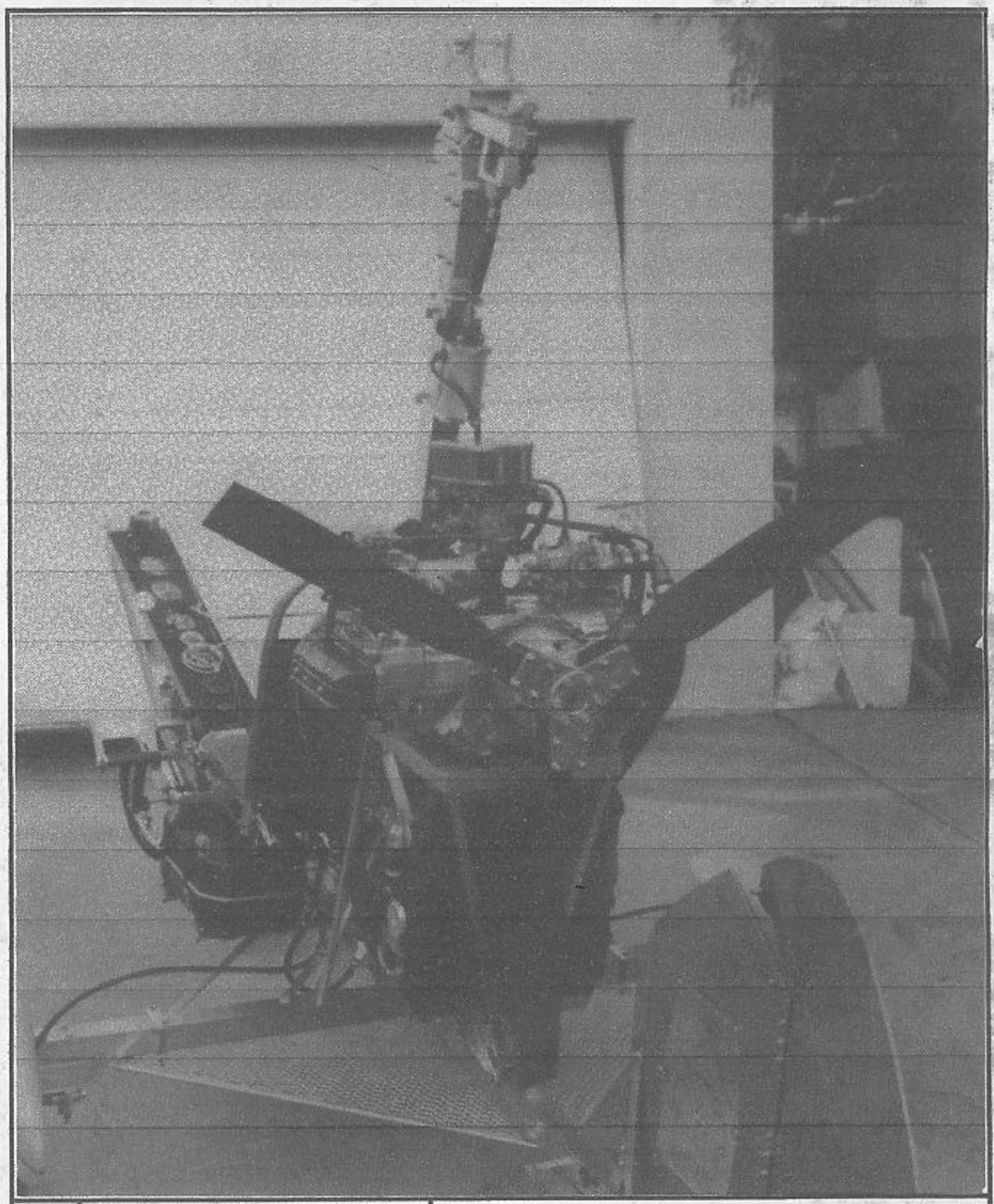
PLEASE NOTE:
The quality of these scans was optimized to the best possible finished output considering the poor quality of the originals.



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ROTARY
FLIGHT
INTERNATIONAL

EA81 SUBARU ENGINE CONVERSION MANUAL

FOR THE BENSEN AND BROCK GYROPLANE

FORWARD

This manual has been assembled in a rather hurried fashion in an attempt to disseminate information as soon as possible to those interested in building a reliable, inexpensive auto engine conversion. Due to the rush in getting the manual published there is always the possibility of errors; and, we may discover a "better way to build a mousetrap." As we gain new information or find errors, we will be mailing supplements to all purchasers of this manual. Updated drawings will also be forwarded with the appropriate revision level. A "-" indicates original issue and subsequent drawing revisions will be indicated by a revision letter, i.e. A, B, C, etc...

Please be aware that this engine conversion manual covers an experimental installation and although the design appears to be sound, Rotary Flight International (RFI) makes no guarantee as to performance or structural integrity. Performance may vary from one builder to another due to differences in construction and assembly technique.

ACKNOWLEDGEMENTS

We would like to thank Mr. Duane Engle for providing the majority of the information for this manual. Duane developed the conversion for his Phlying Phantom rough field gyrocopter and provided rough sketches, photos, and construction notes. Rod Zaedow built a similar Subaru conversion in parallel with Duane's development and actually had his ship completed first. A lot was learned in the process, and by working together and sharing information, a successful conversion has been developed that provides a reliable and inexpensive, four stroke aircraft powerplant.

A special note of thanks goes to Don Bouchard who we consider to be the pioneer of Subaru conversions, and as far as we know, was the first to fly a Subaru powered rotorcraft. Don was instrumental in providing a lot of the basic information for Duane Engle's conversion. In addition, Tony Stiles who is developing a similar conversion has been most helpful in sharing information and ideas.

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1.0 INTRODUCTION

This manual was published to provide the do-it-yourself experimenter with the knowledge to build an inexpensive, alternative powerplant for light aircraft. Although it was developed specificly for Bensen/Brock gyroplane airframes, the Subaru engine conversion is also applicable to other gyros and fixed wing aircraft. This conversion is for a direct drive application and is designed for a pusher configuration only.

DO NOT USE THIS CONVERSION IN A TRACTOR CONFIGURATION. The thrust from the propeller could possibly pull the flange off the crankshaft. The reduction drive version can be used in either tractor or pusher configuration. (See section 4.9 for details on modifying for a tractor configuration).

This conversion is also not designed as a replacement for an ultralight class aircraft engine since the weight of the Subaru engine is approximately twice that of the typical two stroke engines normally utilized in ultralights. A three cylinder, four stroke Subaru Justy engine is being considered for the ultralight class gyros and fixed wing aircraft. It will require a reduction drive to extract the necessary horsepower. A conversion manual and drawings will be available when time permits.

2.0 SCOPE

The scope of this manual does not include information on rebuilding the Subaru engine since there are several auto manuals available with the necessary information. We recommend the John Mier Publications Subaru manual if you acquire an engine that needs an extensive overhaul. Their address is:

John Mier Publications, P.O. Box 613, Santa Fe, NM 87504

Tel: (505) 982-4078.

FIGURE 1. Phlying Phantom with Subaru engine conversion

2.0 SCOPE

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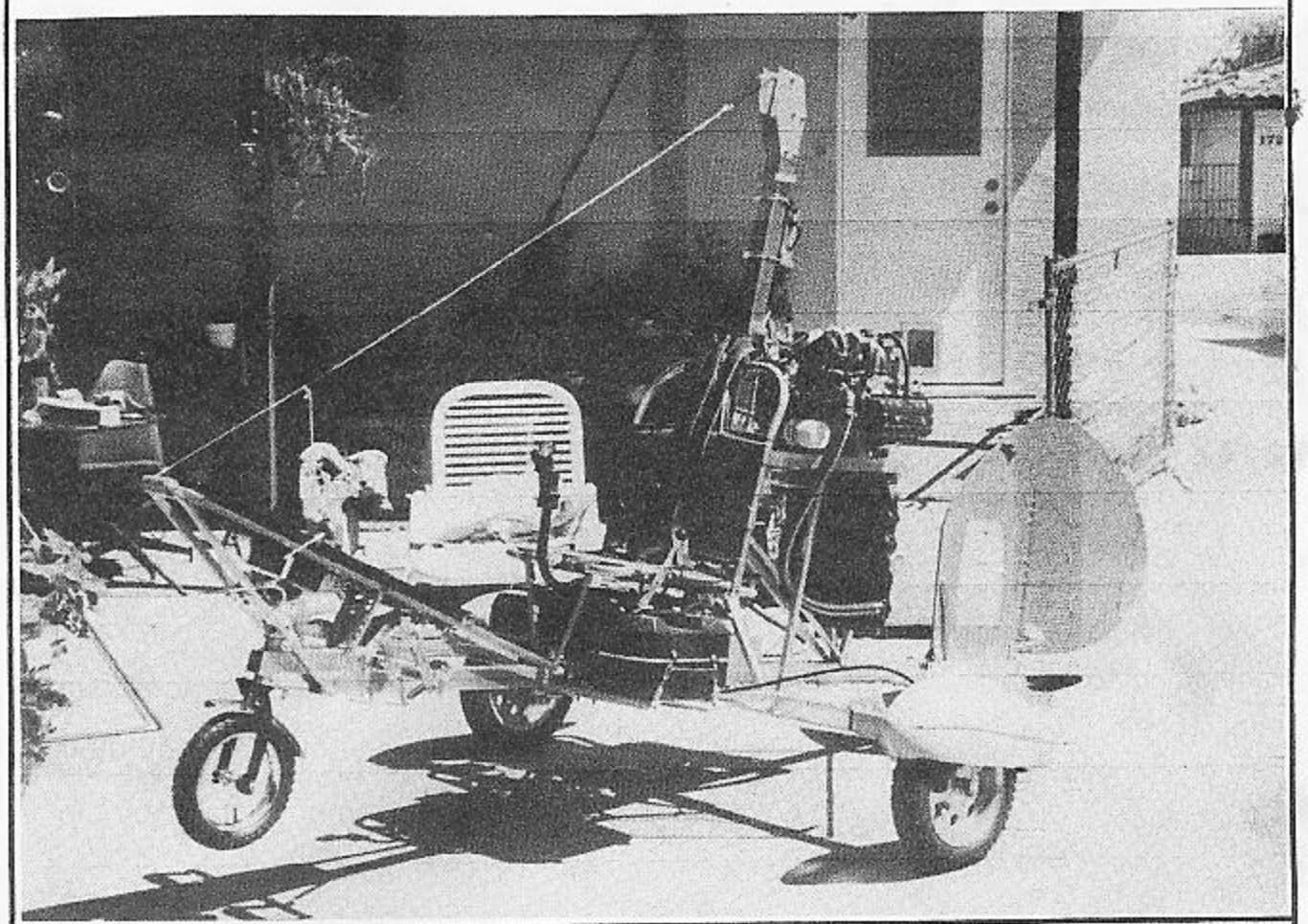
FIGURE 1. Phlying Phantom with Subaru engine conversion



3.0 ENGINE SELECTION

The engine selected for this conversion is a model EA81 which was manufactured from late 1981 through 1984. Earlier models were 1600 cc displacement or less, and later models are overhead cam versions that weigh more than the EA81 and cost considerably more. When selecting an engine check the model number on the accessory end of the engine. The model and serial number is stamped in the block on the left side when facing the accessory end of the engine. (Make sure it is an EA81 model).

If you have acquired an EA81 Subaru engine of questionable quality, have it rebuilt or get the shop manual and accomplish the rebuilding yourself. This engine will be "the heart and soul" of your gyroplane or fixed wing aircraft and its condition is contingent upon the safety of your ship.

A second choice is to buy a used engine (low milage) from a Subaru dealer or one of the used engine importers. There are plenty of auto salvage businesses that get Subaru engines direct from Japan that have less than 30,000 miles on them.

Regardless of what you buy (unless it is a totally rebuilt engine) you should pull the heads and have them reconditioned. While that is being done, check the cylinder bores for roundness as outlined in a shop manual.

If in doubt about the condition of the engine, dismantle it and install new bearings and rings (standard size). Use a

"total seal" 92 mm compression ring (VW hop up trick). Any further work required equals a total rebuild.

If your engine checks out okay, reassemble the heads with Felpros Premium head gaskets #8818B following procedures outlined in a good shop manual.

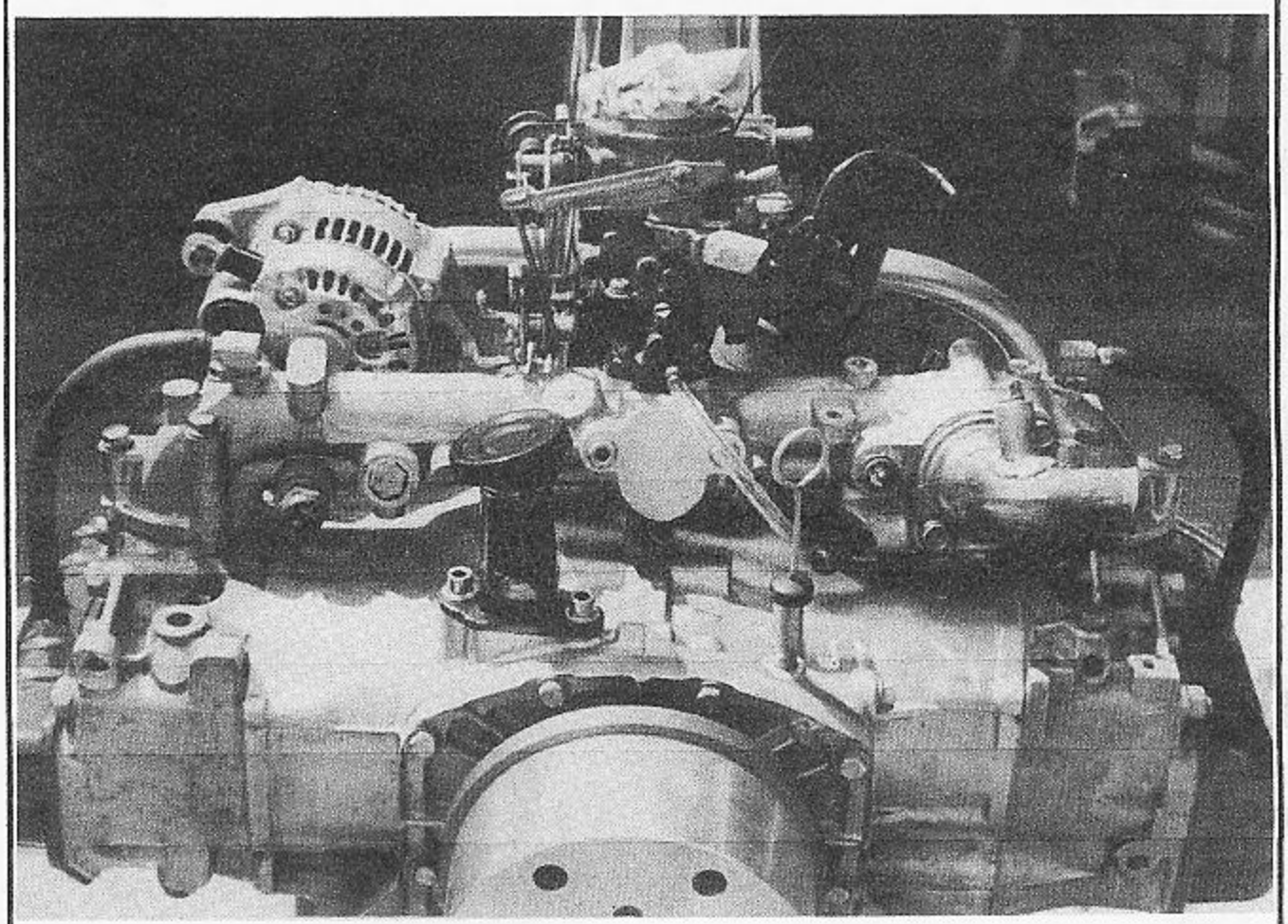


FIGURE 2. Top view of the converted engine. Carburetor is a Holly 5210. Alternator in upper left is a Japanese unit used on several Nisson autos. A smaller alternator can be used to save weight.

Table 3 ENGINE SPECIFICATIONS

	1800cc	1600cc
General		
Bore and	3.62 x 2.64 in.	3.62 x 2.36 in.
Stroke	92 x 67 mm	92 x 60 mm
Firing order	1-3-2-4	1-3-2-4
Piston displacement	109 cu. in. 1781cc	97 cu. in. 1595cc
Compression ratio	8.7	9.0
Cylinder bore service limits		
Wear limit	0.0197 in. (0.50 mm)	0.0197 in. (0.50 mm)
Taper limit	0.0020 in. (0.50 mm)	0.0020 in. (0.50 mm)
Out-of-Round	0.0020 in. (0.050 mm)	0.0020 in. (0.050 mm)
Piston (standard outer diameter)	3.6205-3.6216 in. (91.960-91.990 mm)	3.6205-3.6216 (91.960-91.990 mm)
Piston pin clearance		
Pin-to-piston	-0.00004 to 0.00067 in. (-0.001 to 0.017 mm)	-0.00004 to 0.00067 in. (-0.001 to 0.0017 mm)
Pin-to-rod	0.00020-0.00157 in. (0.005-0.040 mm)	0.00020-0.00157 in. (0.005-0.040 mm)
Piston ring gap		
Top ring	0.0079-0.0138 in. (0.20-0.35 mm)	0.0079-0.0138 in. (0.20-0.35 mm)
Second ring	0.0079-0.0138 in. (0.20-0.35 mm)	0.0079-0.0138 in. (0.20-0.35 mm)
Oil ring rail	0.0079-0.0354 in. (0.20-0.90 mm)	0.0079-0.0354 in. (0.20-0.90 mm)
Piston ring/piston ring groove clearance		
Top ring	0.0016-0.0031 in. (0.04-0.08 mm)	0.0016-0.0031 in. (0.04-0.08 mm)
Second ring	0.0012-0.0028 in. (0.03-0.07 mm)	0.0012-0.0028 in. (0.03-0.07 mm)
Oil ring rail	N A	
Connecting rod bearing oil clearance	0.0008-0.0028 in. (0.020-0.070 mm)	0.0008-0.0028 in. (0.020-0.070 mm)
Crankshaft		
Connecting rod journal outer diameter	1.7715-1.7720 in. (44.995-45.010 mm)	1.7715-1.7720 in. (44.995-45.010 mm)
Front and rear main	2.1636-2.1624 in. (54.955-54.970 mm)	1.9668-1.9673 in. (49.957-49.970 mm)
Center	2.1636-2.1624 in. (54.955-54.970 mm)	1.9674-1.9678 in. (49.970-49.982 mm)
Crank bearing oil clearance		
Center	0.0004-0.0010 in. (0.010-0.025 mm)	0.0004-0.0012 in. (0.010-0.030 mm)
Front and Rear	0.0004-0.0012 in. (0.010-0.025 mm)	0.0004-0.0014 in. (0.010-0.035 mm)
Camshaft inner diameter journal bore		
Front and center	1.2598-1.2605 in. (32.000-32.018 mm)	1.0236-1.0243 in. (26.000-26.018 mm)
Rear	1.4173-1.4180 in. (36.000-36.018 mm)	1.4173-1.4180 in. (36.000-36.018 mm)
Camshaft journal outer diameters		
Front and center	1.2582-1.2589 in. (31.959-31.975 mm)	1.0220-1.0226 in. (25.959-25.975 mm)
Rear	1.4157-1.4163 in. (35.959-35.975 mm)	35.959-35.975 mm (1.4157-1.4163 in.)
Journal/Bore clearance	0.0010-0.0023 in. (0.025-0.059 mm)	0.0010-0.0023 in. (0.025-0.059 mm)

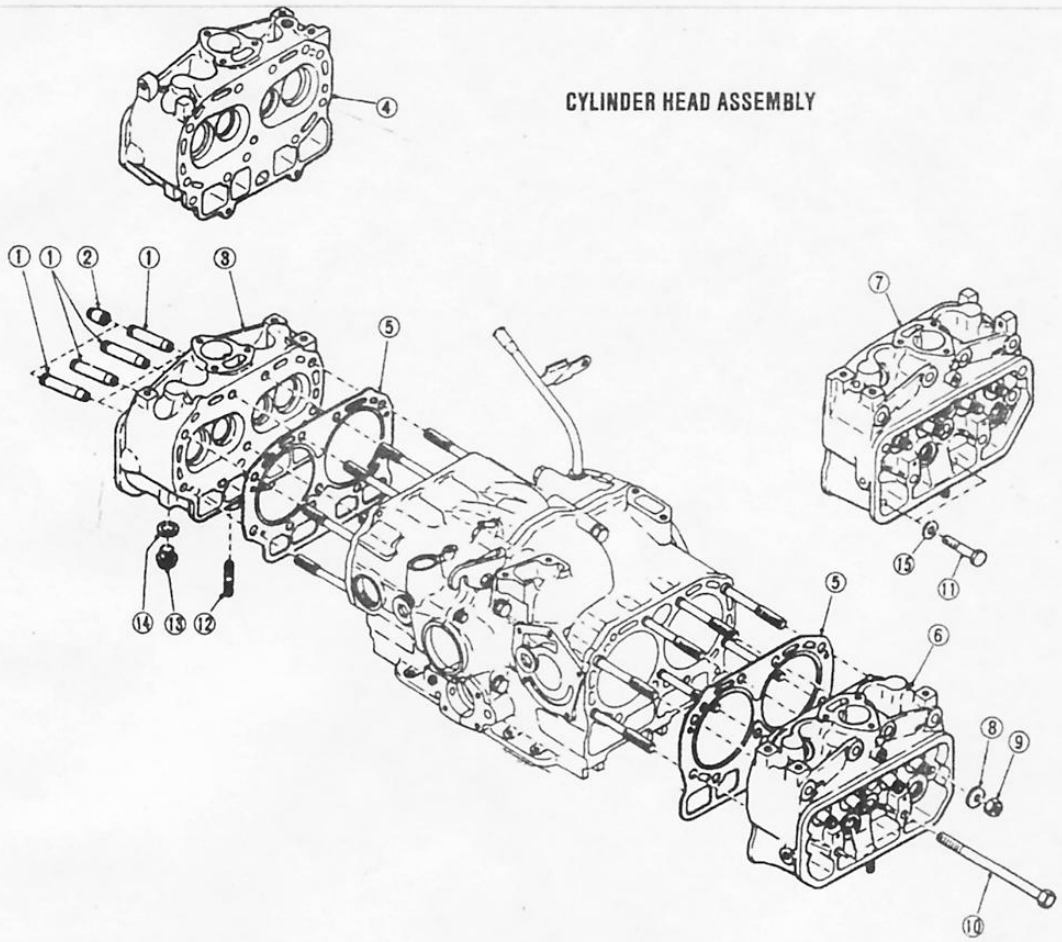
TUNE-UP SPECIFICATIONS

Firing order	1-3-2-4
Valve clearance (cold)	
Intake	0.010 in. (0.25 mm)
Exhaust	0.014 in. (0.35 mm)
Distributor air gap	0.012-0.020 in. (0.3-0.5 mm)
Spark plug type	
1980	
U.S.	NGK BP6ES; Nippondenso W20EP; Hitachi L45PW
Canada	Champion RN9Y
1981	
U.S.	NGK BPRES-11; Nippondenso W20EP-11; Hitachi L45PW-11
Canada	Champion RN10Y-4
1982	
U.S.	NGK BPR5ES-11 or BPR7ES-11; Nippondenso W20EPR-U11, W16EPR-U11 or W22EPR-U11; Champion RN9YC-4 or RN11YC-4
Canada	Champion RN9YC-4 or RN11YC-4
Spark plug gap	
1980	0.028-0.034 in. (0.7-0.9 mm)
1981-on	0.039-0.043 in. (1.0-1.1 mm)
Ignition timing*	8° BTDC @ idle speed
Idle speed*	
1980	
All 1800 cc, 1600 cc with manual transmission	900 rpm
1600 cc with automatic transmission	800 rpm
1981-on	
Manual transmission	700 ±100 rpm
Automatic transmission	800 ±100 rpm

COMPRESSION PRESSURE LIMITS

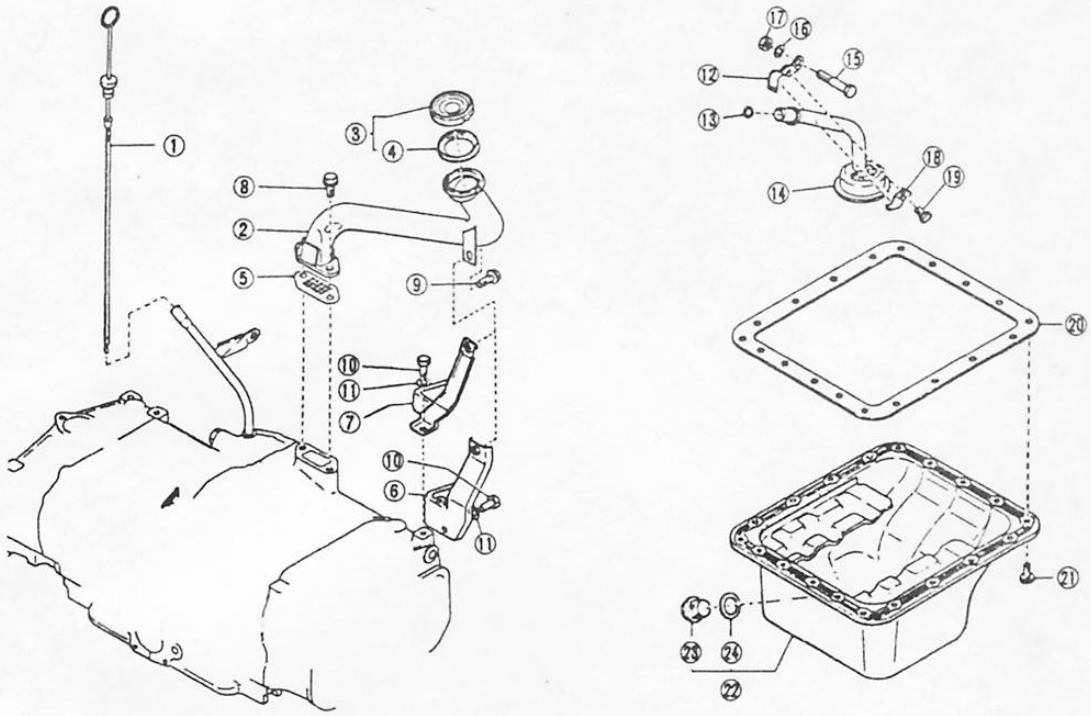
Pressure (psi)		Pressure (psi)	
Maximum	Minimum	Maximum	Minimum
134	101	188	141
136	102	190	142
138	104	192	144
140	105	194	145
142	107	196	147
146	110	198	148
148	111	200	150
150	113	202	151
152	114	204	153
154	115	206	154
156	117	208	156
158	118	210	157
160	120	212	158
162	121	214	160
164	123	216	162
166	124	218	163
168	126	220	165
170	127	222	166
172	129	224	168
174	131	226	169
176	132	228	171
178	133	230	172
180	135	232	174
182	136	234	175
184	138	236	177
186	140	238	178

CYLINDER HEAD ASSEMBLY

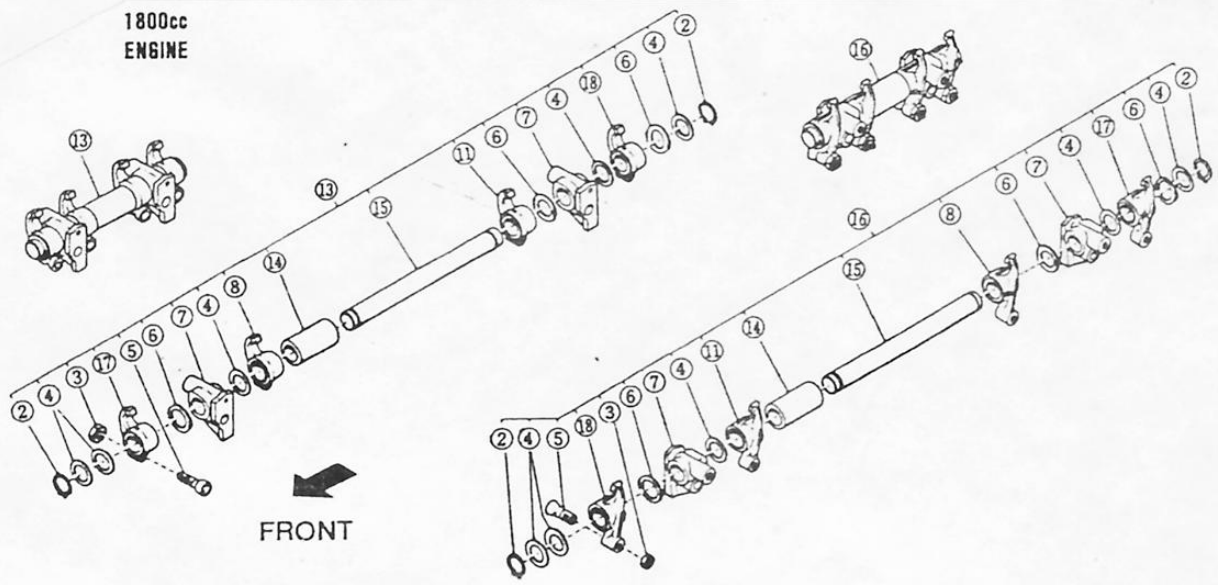


1. Valve guide
2. Oil seal
3. Cylinder head (1600 cc)
4. Cylinder head (1800 cc)
5. Cylinder head gasket
6. Cylinder head 2 (1600 cc)
7. Cylinder head 2 (1800 cc)
8. Washer
9. Nut
10. Bolt (11 x 162 x 34)
11. Bolt (6 x 66 x 16)
12. Stud bolt
13. Plug
14. Gasket
15. Plain washer

OIL PAN



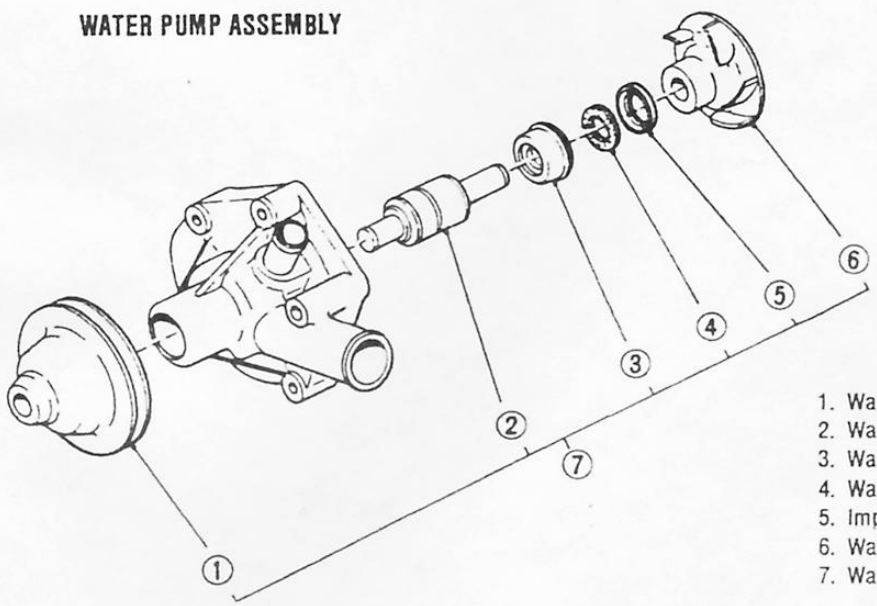
1. Oil level gauge
2. Oil filter duct
3. Oil filler cap complete
4. Gasket
5. Air breather duct gasket
6. Oil filler duct stay
7. Oil filler duct stay
8. Bolt and washer
9. Bolt and washer
10. Bolt
11. Spring washer
12. Oil strainer stay
13. O-ring
14. Oil strainer
15. Bolt
16. Spring washer
17. Nut
18. Oil strainer stay 2
19. Bolt and washer
20. Oil pan gasket
21. Bolt and washer
22. Oil pan complete
23. Plug
24. Gasket



VALVE ROCKER

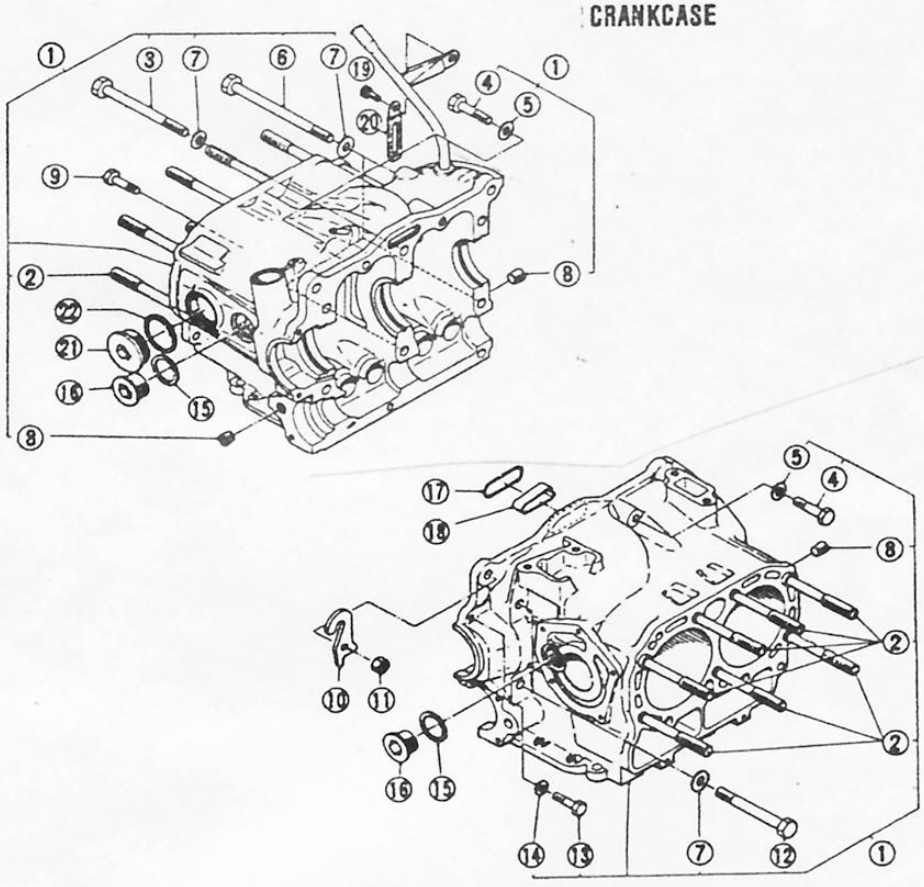
1. Valve rocker assembly (R.H.)
2. Snap ring
3. Nut
4. Washer
5. Valve rocker screw
6. Rocker shaft spring washer
7. Rocker shaft supporter
8. Valve rocker arm complete
9. Rocker shaft spacer
10. Valve rocker shaft
11. Valve rocker arm complete 2
12. Valve rocker assembly (L.H.)
13. Valve rocker assembly (R.H.)
14. Rocker shaft spacer
15. Valve rocker shaft
16. Valve rocker assembly (L.H.)
17. Valve rocker arm
18. Valve rocker arm 2

WATER PUMP ASSEMBLY



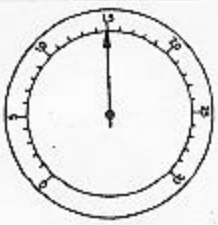
1. Water pump pulley
2. Water pump shaft
3. Water pump mechanical seal
4. Water pump impeller plate
5. Impeller plate seat
6. Water pump impeller
7. Water pump

CRANKCASE

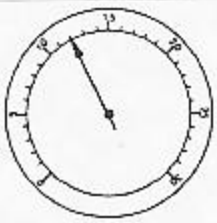


1800cc
ENGINE

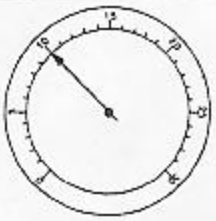
1. Crankcase assembly
2. Stud bolt
3. Bolt (10 x 108 x28 mm)
4. Bolt
5. Washer
6. Bolt (10 x 145 x 28 mm)
7. Washer (10.5 x 18 x 2 mm)
8. Main gallery plug
9. Bolt
10. Crankcase front hanger
11. Nut
12. Bolt (10 x 70 x 28 mm)
13. Bolt
14. Washer
15. Gasket (26.2 x 31.5 x 1 mm)
16. Crankcase plug
17. Crankcase O-ring
18. Back up ring
19. Bolt and washer (6 x 13 x 13 mm)
20. Clip
21. Crankcase plug
22. Gasket (36.2 x 44 x 1 mm)
23. Crankcase assembly
24. Nut (10 x 8 mm)
25. Bolt (10 x 135 28 mm)
26. Stud bolt (10 x 120 x 26 mm)
27. Bolt
28. Crankcase hanger



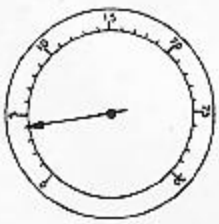
1. NORMAL READING
Reads 15 in. at idle.



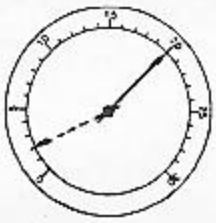
2. LATE IGNITION TIMING
About 2 inches too low at idle.



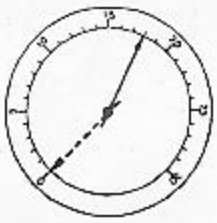
3. LATE VALVE TIMING
About 4 to 8 inches low at idle.



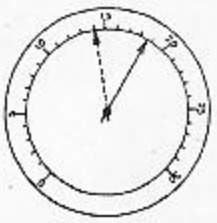
4. INTAKE LEAK
Low steady reading.



5. NORMAL READING
Drops to 2, then rises to 25 when accelerator is rapidly depressed and released.

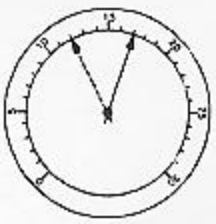


6. WORN RINGS, DILUTED OIL
Drops to 0, then rises to 18 when accelerator is rapidly depressed and released.

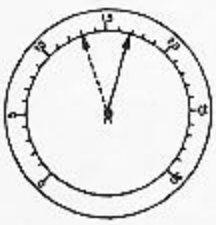


7. STICKING VALVE(S)
Normally steady. Intermittently flicks downward about 4 in.

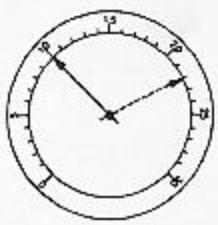
8. LEAKY VALVE
Regular drop about 2 inches.



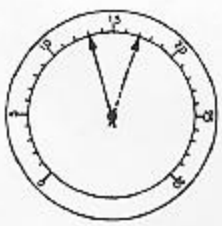
9. BURNED OR WARPED VALVE
Regular, evenly spaced down-scale flick about 4 in.



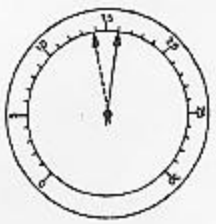
10. WORN VALVE GUIDES
Oscillates about 4 in.



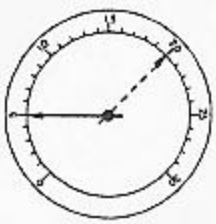
11. WEAK VALVE SPRINGS
Violent oscillation (about 10 in.) as rpm increases. Often steady at idle.



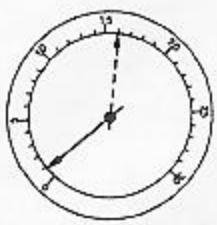
12. IMPROPER IDLE MIXTURE
Floats slowly between 13-17 in.



13. SMALL SPARK GAP or DEFECTIVE POINTS
Slight float between 14-16 in.



14. HEAD GASKET LEAK
Gauge floats between 5-19 in.



15. RESTRICTED EXHAUST SYSTEM
Normal when first started. Drops to 0 as rpm increases. May eventually rise to about 16.

SPARK PLUG CONDITION

NORMAL

- Identified by light tan or gray deposits on the firing tip.
- Can be cleaned.

GAP BRIDGED

- Identified by deposit buildup closing gap between electrodes.
- Caused by oil or carbon fouling. If deposits are not excessive, the plug can be cleaned.

OIL FOULED

- Identified by wet black deposits on the insulator shell bore electrodes.
- Caused by excessive oil entering combustion chamber through worn rings and pistons, excessive clearance between valve guides and stems, or worn or loose bearings. Can be cleaned. If engine is not repaired, use a hotter plug.

CARBON FOULED

- Identified by black, dry fluffy carbon deposits on insulator tips, exposed shell surfaces and electrodes.
- Caused by too cold a plug, weak ignition, dirty air cleaner, defective fuel pump, too rich a fuel mixture, improperly operating heat riser, or excessive idling. Can be cleaned.

LEAD FOULED

- Identified by dark gray, black, yellow, or tan deposits or a fused glazed coating on the insulator tip.
- Caused by highly leaded gasoline. Can be cleaned.

WORN

- Identified by severely eroded or worn electrodes.
- Caused by normal wear. Should be replaced.

FUSED SPOT DEPOSIT

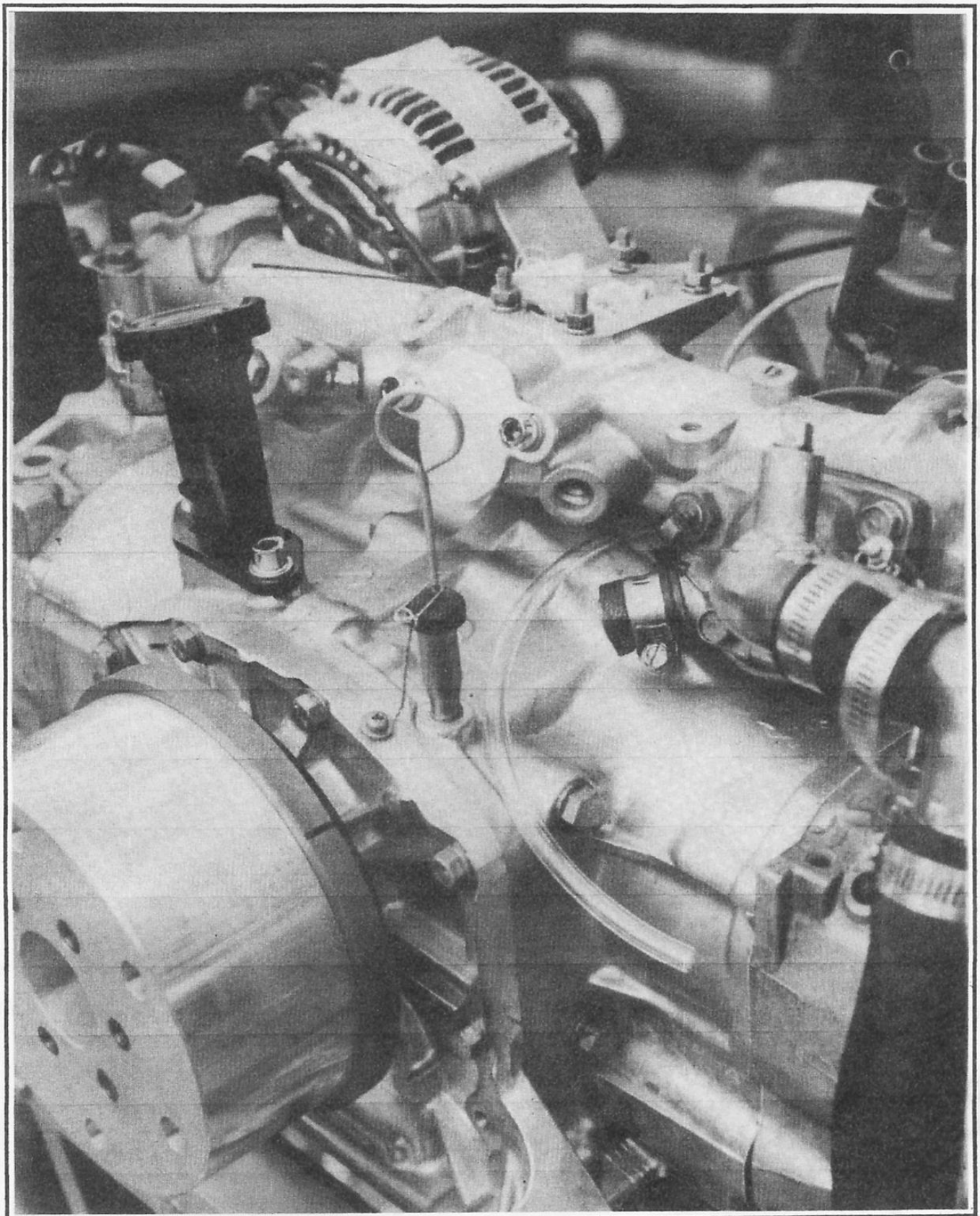
- Identified by melted or spotty deposits resembling bubbles or blisters.
- Caused by sudden acceleration. Can be cleaned.

OVERHEATING

- Identified by a white or light gray insulator with small black or gray brown spots and with bluish-burnt appearance of electrodes.
- Caused by engine overheating, wrong type of fuel, loose spark plugs, too hot a plug, low fuel pump pressure, or incorrect ignition timing. Replace the plug.

PREIGNITION

- Identified by melted electrodes and possibly blistered insulator. Metallic deposits on insulator indicate engine damage.
- Caused by wrong type of fuel, incorrect ignition timing or advance, too hot a plug, burned valves, or engine overheating. Replace the plug.



provide a good test of your blood pressure and heart rate! The prototype model has a lot of torque and it is a handfull to hold the centerline on the take-off roll.

4.1 BELL HOUSING

You will need to trim the bell housing if you intend to build a direct drive version. Use the bell housing gasket as a template since it follows the curves of the engine block. Leave the lower ears for added strength and they also provide rear mounting points.

4.2 INTAKE MANIFOLD

The next large project is the intake manifold. Remove everything from the manifold except the water temperature sending unit. If you have access to a welder and grinder there are a number of holes to fill and flanges to remove. If not, study the photos and plug or cap everything you don't need.

The developer of the prototype engine conversion chose to run the P.C.V system into the intake manifold. You can use existing plumbing for a more simple hook-up. DON'T cap those valve covers. You will create tremendous back pressure in the crankcase and performance will suffer. Refer to photos #6 and #7.

4.3 CARBURETOR

The carburetor used on the prototype is a Holley 5210 from

a 1971 Chevy Vega. Any of the Holley 5200/5210 models from 1971-1975 are an excellent choice for a low cost performance carburetor. You will need a Weber #99004-110 adapter for the 1600/1800 CC Subaru engine. You can purchase a new high performance Weber carburetor if you are willing to spend the bucks. Another possible selection is a Posa or Ellison throttle body injector. Posa carburetors are used quite frequently on large displacement VW conversions. The Ellison throttle body injector is available for all types of aircraft engines up to 180 HP.

4.4 AIR FILTER

A low restriction air filter should be used in this installation. A K&N #1951 microweb air filter is a good choice. Some trimming of the base of the filter is necessary to fit the carburetor. Refer to photo # 3 for placement and hook-ups.

4.5 FUEL PUMP

An electric fuel pump for imports is utilized in this installation. Working pressure is 2.5 to 4.0 PSI at 30 gallons per hour flow. Peak current is 1.2 Amps. A Bosch fuel filter is used between tank and pump to ensure a clean fuel supply to the carburetor.

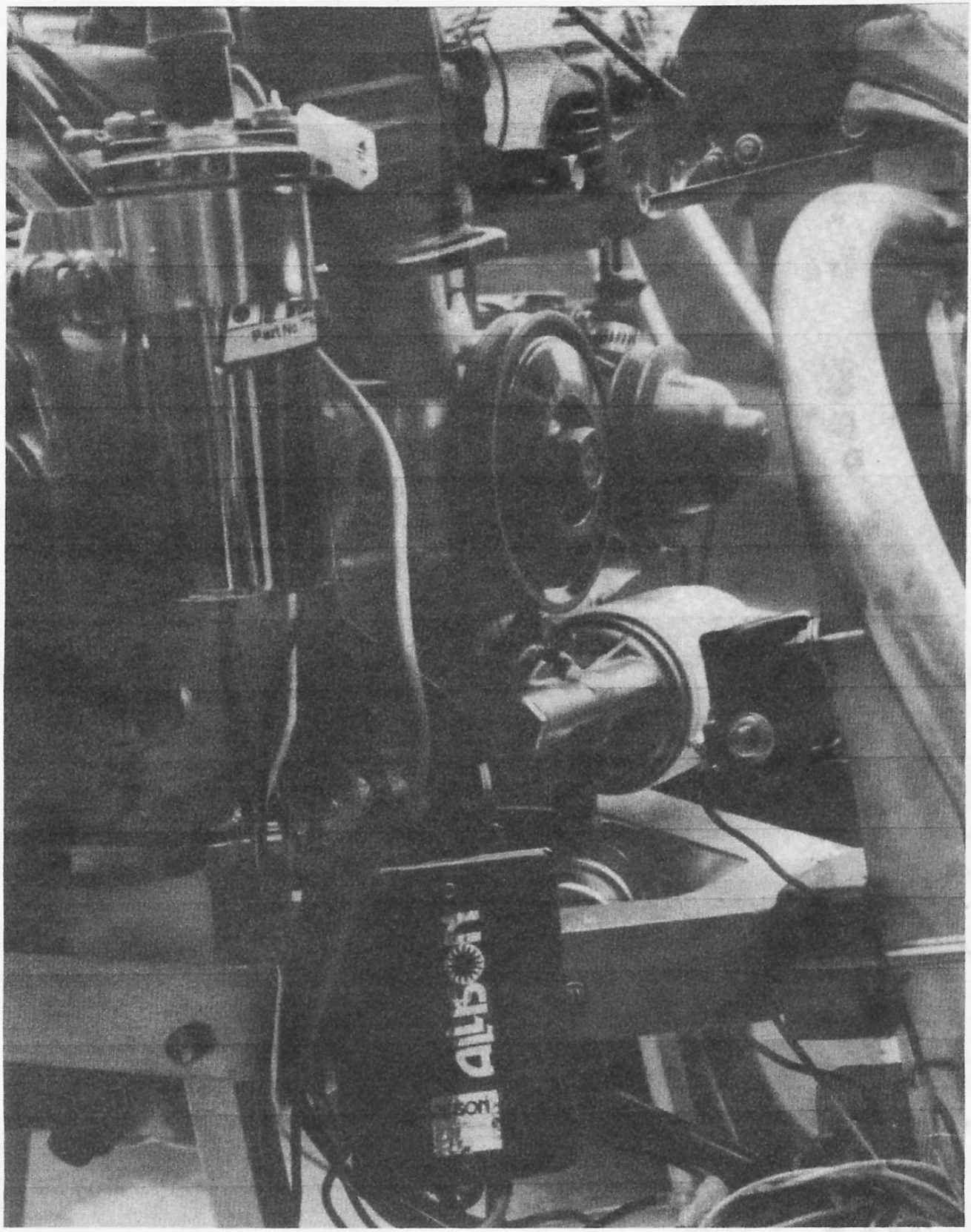
4.6 IGNITION SYSTEM

An Allison optical ignition system was chosen for simplicity, reliability, and ruggedness. It is a high-tech, basic ignition system with no hook-ups for oxygen and exhaust senders or other smog equipment. Use the "Plain Jane" model (XR-700). Allison systems can be procured at speed shops, PepBoys, J.C. Whitney, etc. A Whitney catalog is invaluable for locating all sorts of auto accessories. Their address is: J.C. Whitney & Co., 1917-19 Archer Ave., P.O. Box 8410, Chicago, IL 60680. Tel: (312) 431-6102.

4.7 COOLANT SYSTEM

When performing the radiator modifications and fabricating the mounts, remember to isolate any chafing points with rubber sheet material. The coolant capacity is one gallon + of a 50/50 mix of water and anti-freeze. The builder used the best grade of 1 inch i.d. radior hose that he could find. Two long pieces, plus two stubs amounted to a total of about five feet.

A note is in order concerning radiator caps and pressure. The prototype uses a 13 psi cap with an overflow return bottle. A non-pressure coolant flow system can work with the threaded fitting in the thermostat housing. Use a hose from the fitting into a coolant return bottle ... this will take care of expansion and contraction of the coolant.


Part No
ALLISON

If the engine has not been run for a year or so or has had the coolant system drained, plan on replacing the water pump. The original seal shrinks and cracks when dry and after it has been subjected to heat and pressure for a lot of heating/cooling cycles.

On page 4-7A there are exploded drawings of the water pump and fittings. Remove the following items:

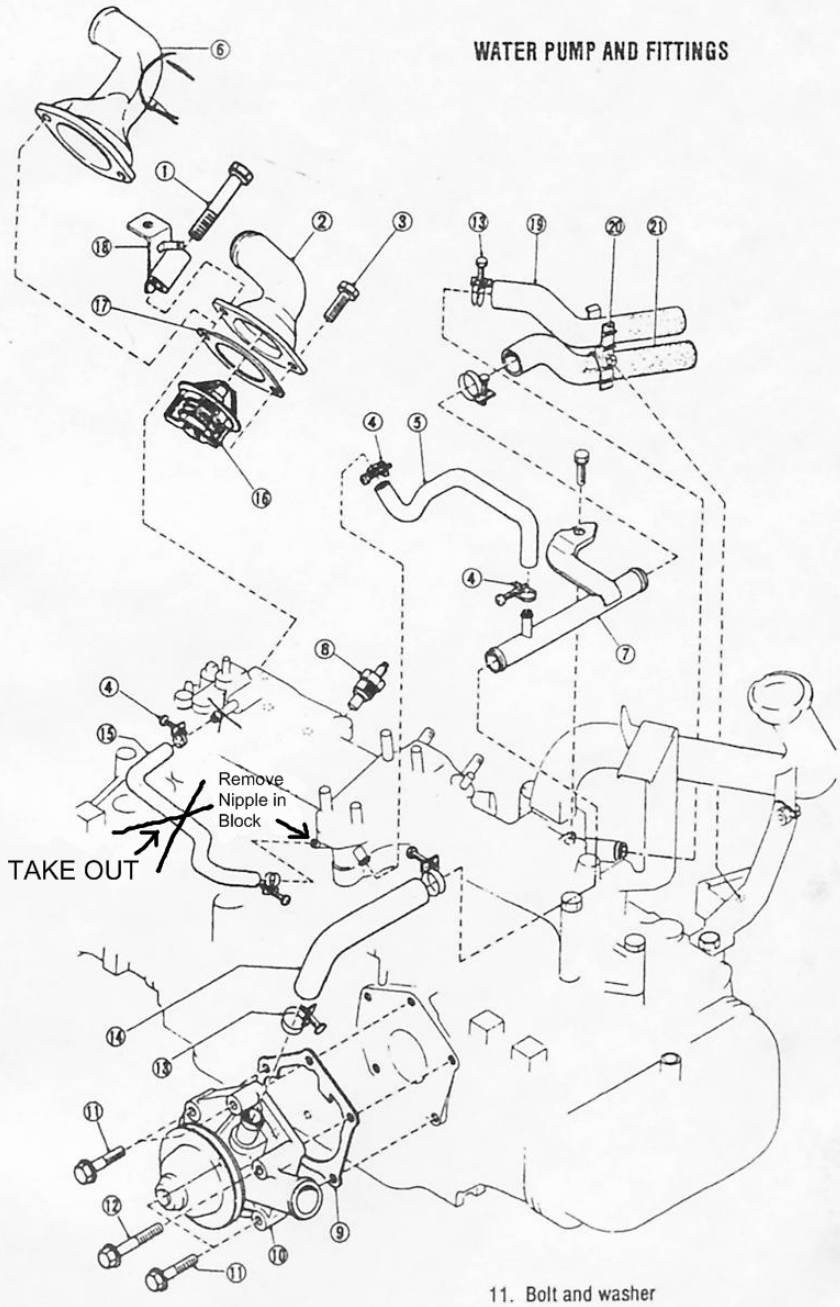
#1, (replace with another #3 bolt),
#4,
#5 (cap or weld carb preheat nipple),
#7,
#13,
#14 (cap or weld shut on water pump)
#15 (remove nipple in block) NOTE: Nipple in manifold can be used as a cooling system pressure sender. Cap or weld shut if not used.

#18,
#19,
#20, and
#21

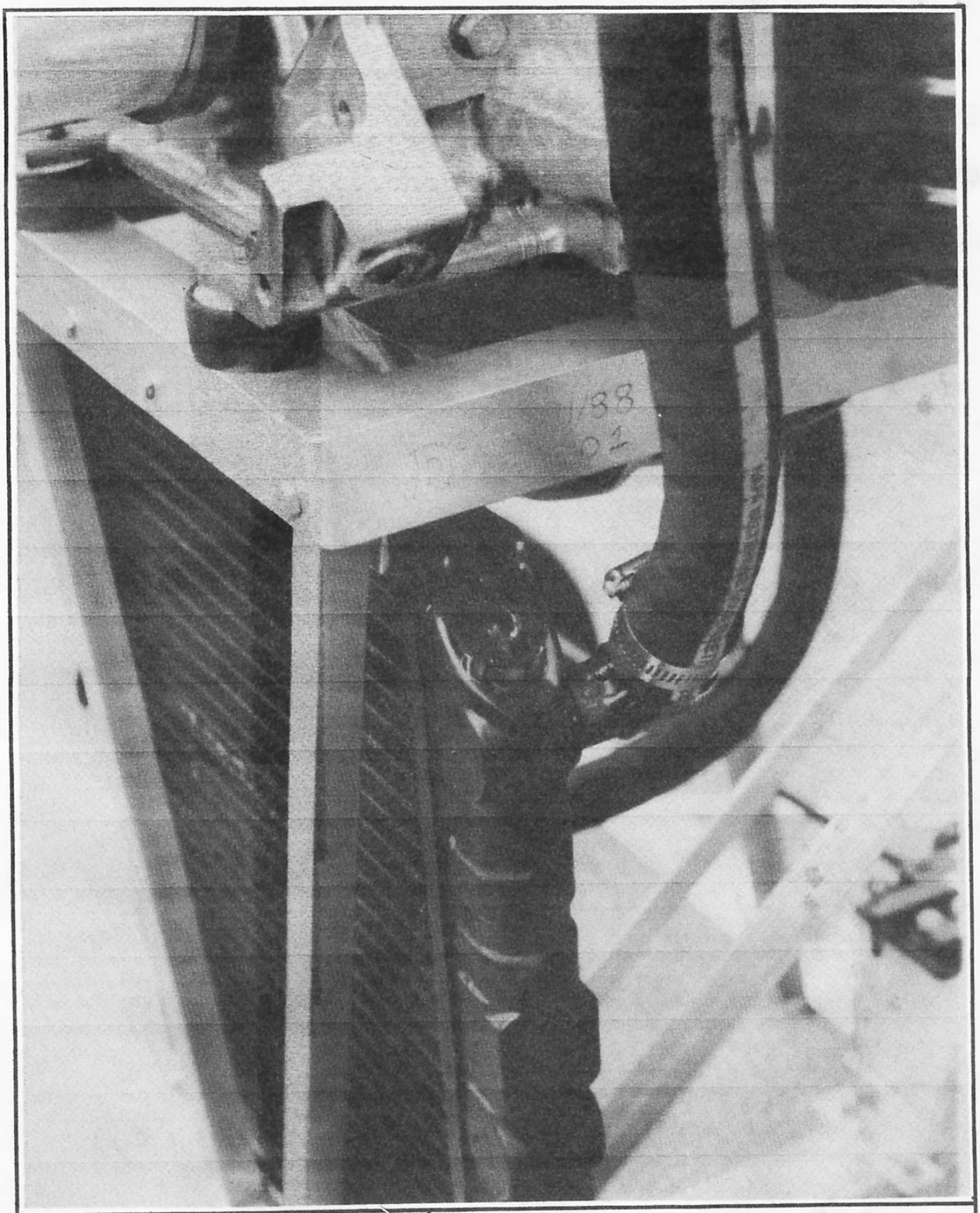
Apply gasket sealer to both sides of a new gasket and install it between the plate and water pump. Install the water pump on engine and secure with bolts.

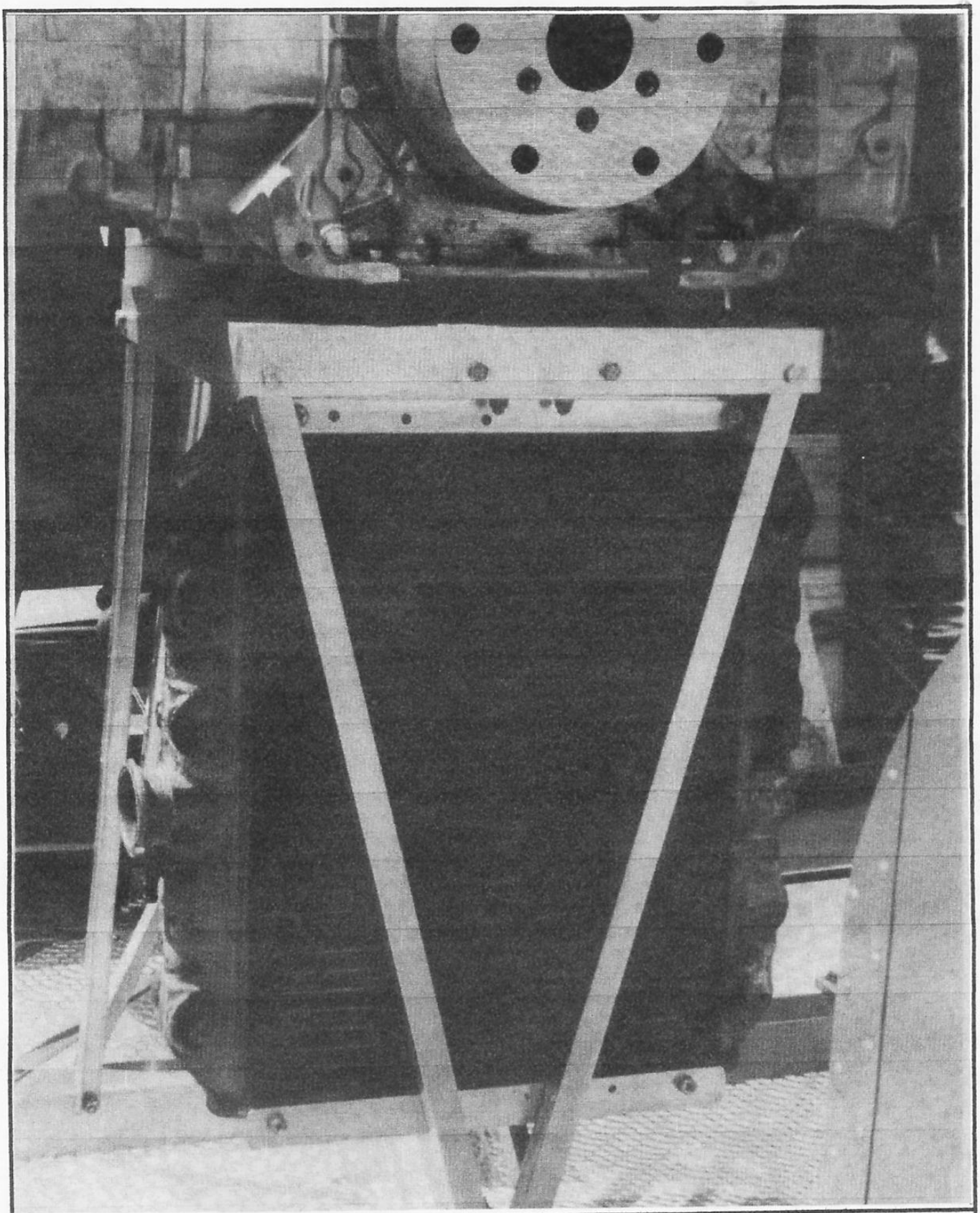
The thermostat is of the wax pellet type (the valve opens and closes with the expansion of sealed wax). The temperature characteristics of this type of thermostat do not vary as conventional bellows type thermostats do. Therefore, the cooling system pressure can be raised to make the boiling point of the coolant higher without affecting the thermostat.

WATER PUMP AND FITTINGS



1. Bolt and washer
2. Thermostat cover
3. Bolt and washer
4. Hose clamp
5. Hose
6. Thermostat cover (for power steering)
7. Water by-pass pipe
8. Thermometer
9. Water pump gasket
10. Water pump
11. Bolt and washer
12. Bolt and washer
13. Hose clamp
14. Hose
15. Hose
16. Thermostat
17. Thermostat cover gasket
18. Solenoid valve bracket
19. Hose
20. Heater hose clamp
21. Hose





4.8 LUBRICATION SYSTEM

The oil pressure sending unit and the Hobbs switch (on at 4 psi) were fastened into a brass "Tee" with a short nipple threaded into an adapter which threads into the oil pump. Fittings are standard 1/8 inch pipe thread. TIP: Put 3 in 1 oil into the orfices of both the oil pressure sending unit and the Hobbs switch. This procedure will eliminate air pockets and false readings.

On the crankshaft assembly there is an orange colored gasket that fits in a recess around the crankshaft ent. USE IT! This will eliminate any oil seepage from the gear. This crankshaft gear is pressed on the keyed crankshaft with about 500 kilos of force to withstand a clutch or torque converter for 200,000 miles. If you are concerned about losing your hub and prop, weld the modified flywheel to the crankshaft after bolt-up. Our advice is: don't weld it, leave it alone...

Use a new crankshaft oil seal in the trimmed clutch housing. Upon crankcase assembly, use Never-Seize on bolts threaded into aluminum cases. Leave off #10, 11, 19, and 20. Use torque values in Clymer's engine re-assembly section. On the double crankshaft pulley, machine or cut away the outside pulley and use the inside pulley for alternator and water pump. A six to seven inch diameter, 1/4 inch steel circular plate can be bolted on to drive a Wunderlich pre-rotator.

4.9 FLYWHEEL AND PROPELLER HUB

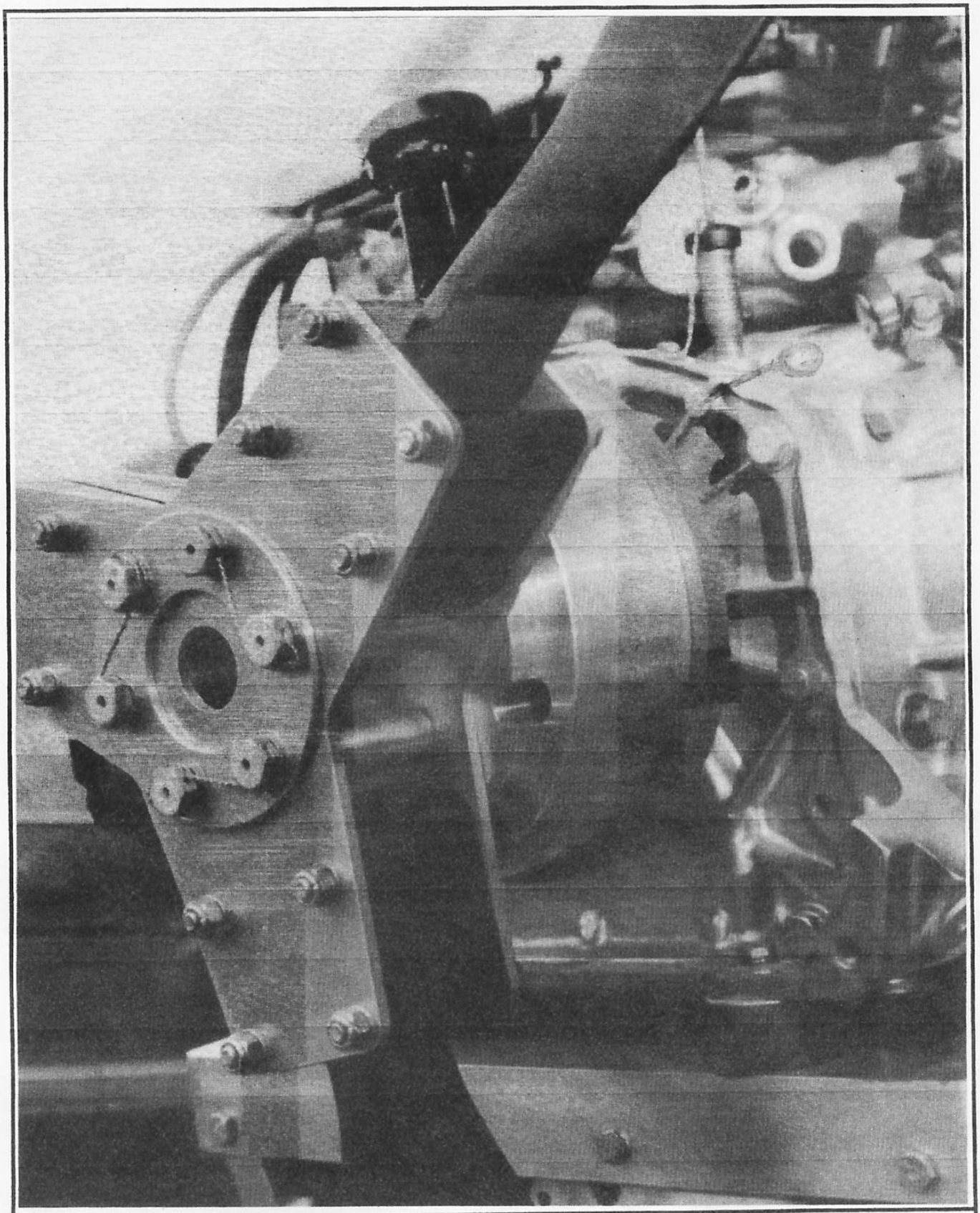
The original manual transmission flywheel is modified and used in this engine conversion. One of the reasons for utilizing the original flywheel was to maintain enough inertia to provide a smooth idle at around 1000 RPM.

The flywheel is cut down (see drawing # EA81-DD-XX) and mounted on the crankshaft flange with the original bolts. The aluminum prop hub/adapter is then bolted to the flywheel. The weight of the modified flywheel, prop hub, and a composite IvoProp weigh the same as the original flywheel and provides approximately the same inertia.

Another reason for this approach is that the bolts used to attach the flywheel to the crankshaft flange (9mm X 1 pitch) are an oddball size and are not available from any bolt house; and, the original bolts are not long enough to attach the prop hub directly to the crankshaft flange.

The 9 mm holes can be bored out and tapped to accept a 3/8 inch bolt.

Another point of interest is that the bolt pattern on the crankshaft flange is not symmetrical. One bolt hole is off slightly to prevent the flywheel from being mounted in any but one position. The difference in the spacing of the single bolt hole is ever so slight and very subtle. During the fabrication of the lower sprocket for the reduction drive the slight difference was overlooked by the designer and also by our machinist. Fortunately, we were able to elongate the



holes on the sprocket for adequate clearance since a boss is milled into the sprocket for accurate centering and the bolts simply clamp the sprocket to the flange.

Another prop hub configuration which was developed by Tony Stiles consists of a prop flange connected directly to the crankshaft flange. A hole is bored through the center of the crank and a bolt and washer is used to secure the flange to the crankshaft. Tony is producing parts for this modification and you may opt for his prop flange in lieu of the one presented in this manual.

In the original automobile setup the flange is press fit over the end of the crankshaft and secured with a key which is sufficient in a pusher configuration; but, if a tractor setup is desired some means to securely attach the flange has to be used. If a reduction drive is used these precautions are not necessary since there is no thrust load on the end of the crankshaft.

4.10 EXHAUST SYSTEM

The prototype Phlying Phantom engine uses a motorcycle Super-Trapp steel muffler (about $45.00) with a crossover exhaust tube exiting to the right of the gyro. The steel system was used for ease of welding. Also, back pressure can be tuned with the addition of plates (decreases pressure) or eliminating plates (increases back pressure). It is a durable system that will keep the noise down to a purr while balancing out the exhaust pulses and provide a smoother running engine. Make sure that the end of the muffler DOES NOT extend past the rear engine frame braces in the gyro airframe installation (Refer to the exhaust system drawings for details).

An alternative (and less expensive) muffler is a resonator from an automobile exhaust system. Some autos use a main muffler and a second, smaller unit near the end of the tail pipe. A resonator is less expensive, but does not have the feature of being able to tune the exhaust system.

Do not run straight pipes (with no muffler). The Subaru engine requires a certain amount of back pressure to run properly. The absence of back pressure could damage the valves.

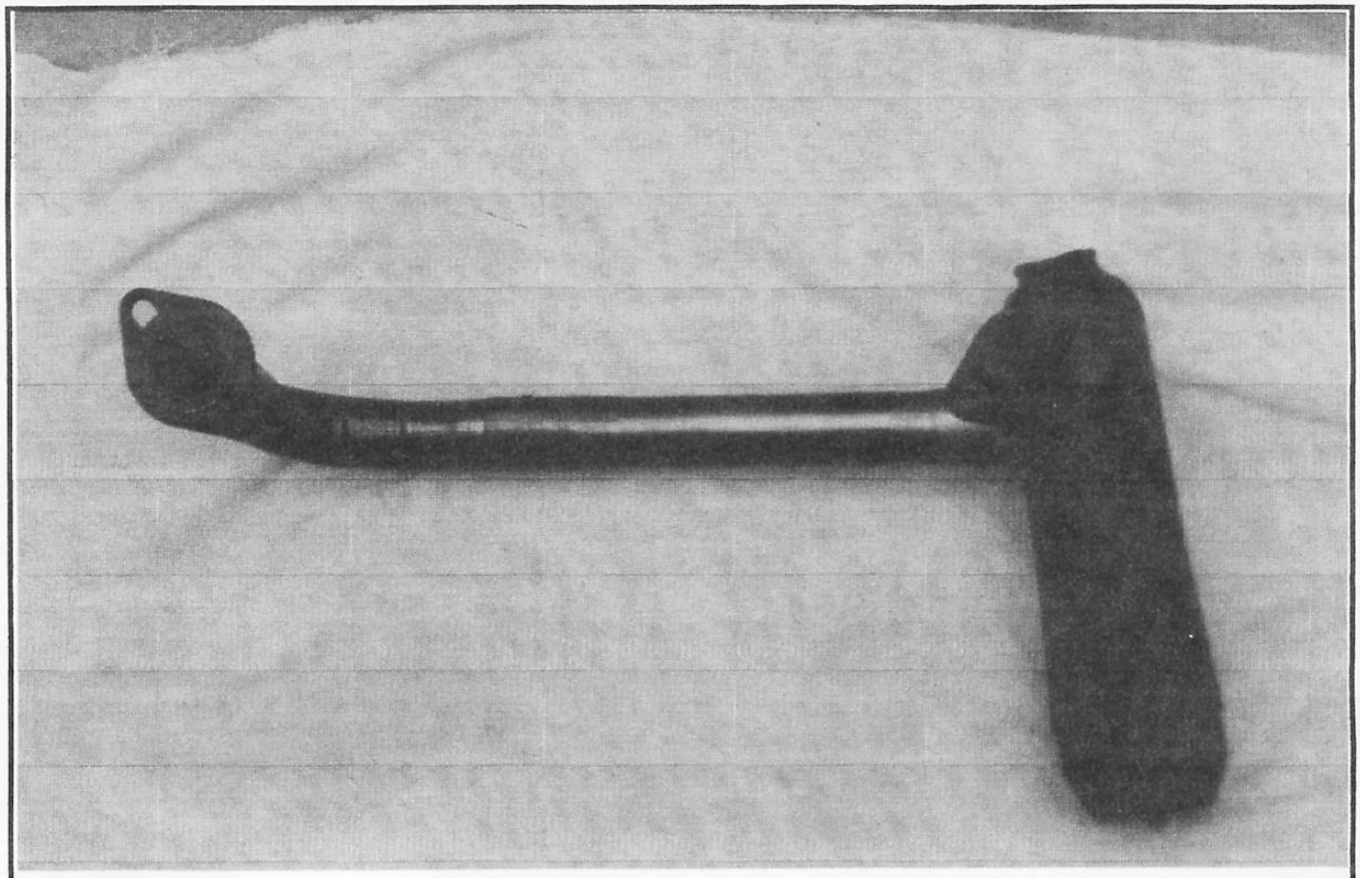
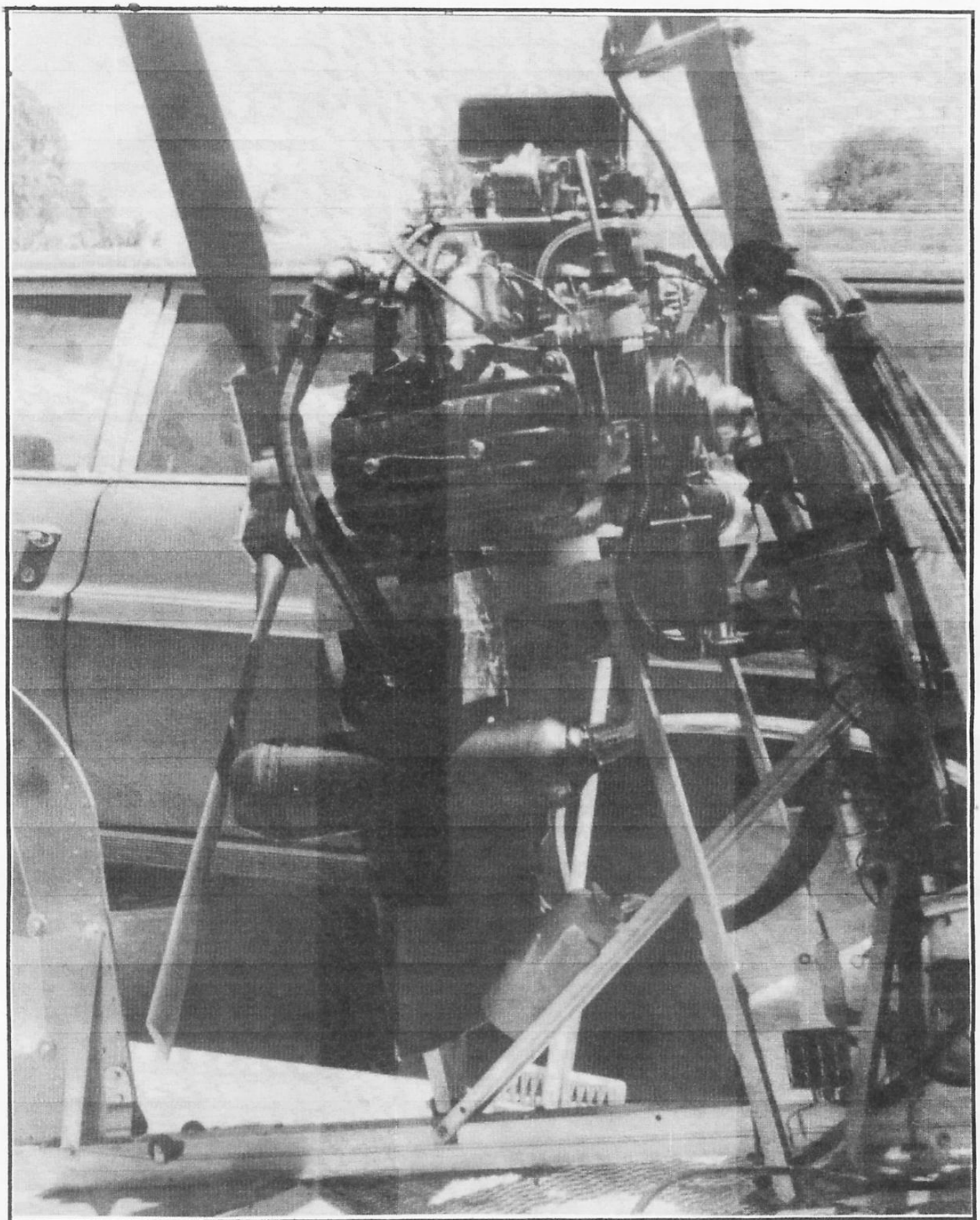


FIGURE 9 - Subaru exhaust system. A Super Trapp motorcycle muffler is used in this installation. It has adjustable baffles so the exhaust system can be tuned for optimum performance. Unit is steel construction. An alternate muffler that could be used is a resonator from an automobile exhaust system. The muffler is angled out at the rear to allow clearance around radiator.

5.0 ENGINE BREAK-IN

Perform a two hour break-in at various power settings. A totally rebuilt engine should be broken in for at least four hours. After the break-in period, change the oil and filter. We recommend using Slick 50 oil treatment after the break-in period. Slick 50 has been used in auto engines with excellent results and is approved for aircraft engines. Tests conducted in a Cessna 172 that had the Lycoming O-320 engine treated with Slick 50 produced almost unbelievable results. A quick-drain fitting was installed in the crankcase and after the aircraft was at altitude, the engine oil was drained, the Cessna was flown for an additional 30 minutes with no substancial increase in oil temperature. After a second round of the same senario, the engine was torn down and no appreciable wear could be found.

Another point on breaking in a rebuilt engine: A newly rebuilt engine may be difficult to near impossible to start by hand propping. It may be necessary to turn the engine for several hundred revolutions to get it "loosened up" to the point where it will run on its own, especially if you have a lightweight, composite prop. There is not as much "flywheel" effect as there would be in an auto configuration, since the stock flywheel has been turned down to around six inches, so the centrifugal force of a lightweight prop may not pull the engine through between power impulses.



6.0 PROPELLER SELECTION

For the new Warp Drive props with aluminum hub, use the modified hub adapter specs to provide clearance of the inner blade clamps. Refer to drawing EA81-DD-01 for details of the 3 inch prop pattern. 4-3/4 inch bolt patterns or the original composite hub Ivoprop do not need this hub modification.

Any number of propellers may be used for this engine conversion, but an adjustable prop is a definite advantage. Since actual horsepower will vary as a function of carburator and exhaust system used, optimum thrust can be achieved with adjustable blades.

The Warp Drive or Tech 3 (three blade props) will provide good performance in a pusher gyroplane configuration.

Duane Engle's prototype utilizes a 54 inch IvoProp with 3/8 inch prop bolts. Props that utilize the Rotax prop flange pattern normally have 1/4 inch or 8 MM holes. Engle chose to use 3/8 inch AN prop bolts that could be safety wired. His prop was ordered from Warp Drive with 3/8 inch holes pre-drilled. If you use a Rotax bolt pattern it is suggested that when you order your prop, you specify 3/8 holes. They will be drilled at no extra cost. Safety wired 3/8 prop bolts will eliminate the need to retorque the bolts at regular intervals and will provide a safer installation. Engle used 12 degrees of pitch in the Warp Drive prop. If you

fly from high elevation airports

more pitch may be required for optimum thrust, but 12 degrees is a good starting point. Static thrust at full throttle should be around 2500 - 2600 RPM.

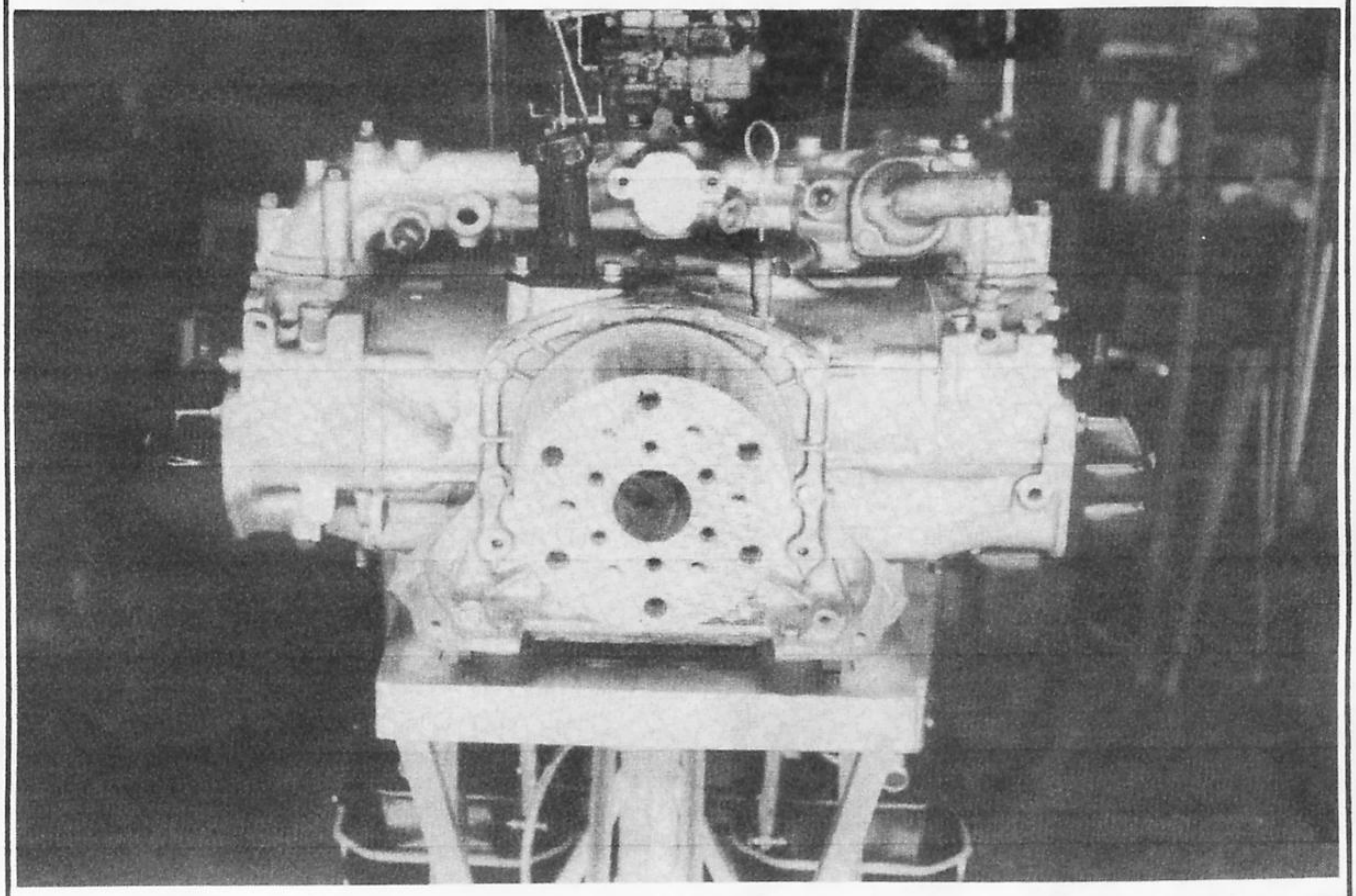


FIGURE 11 - Completed engine with prop hub installed. The hub is bolted to a modified standard transmission flywheel. Three inch (approx) Rotax prop hub bolt pattern is the inner ring bolt holes. An S.A.E. five inch bolt pattern is also drilled in the hub adapter. Outer hole pattern is for attaching adapter to flywheel. Center bore allows visual inspection of crankshaft flange attach bolts.

7.0 ENGINE MOUNT INSTALLATION

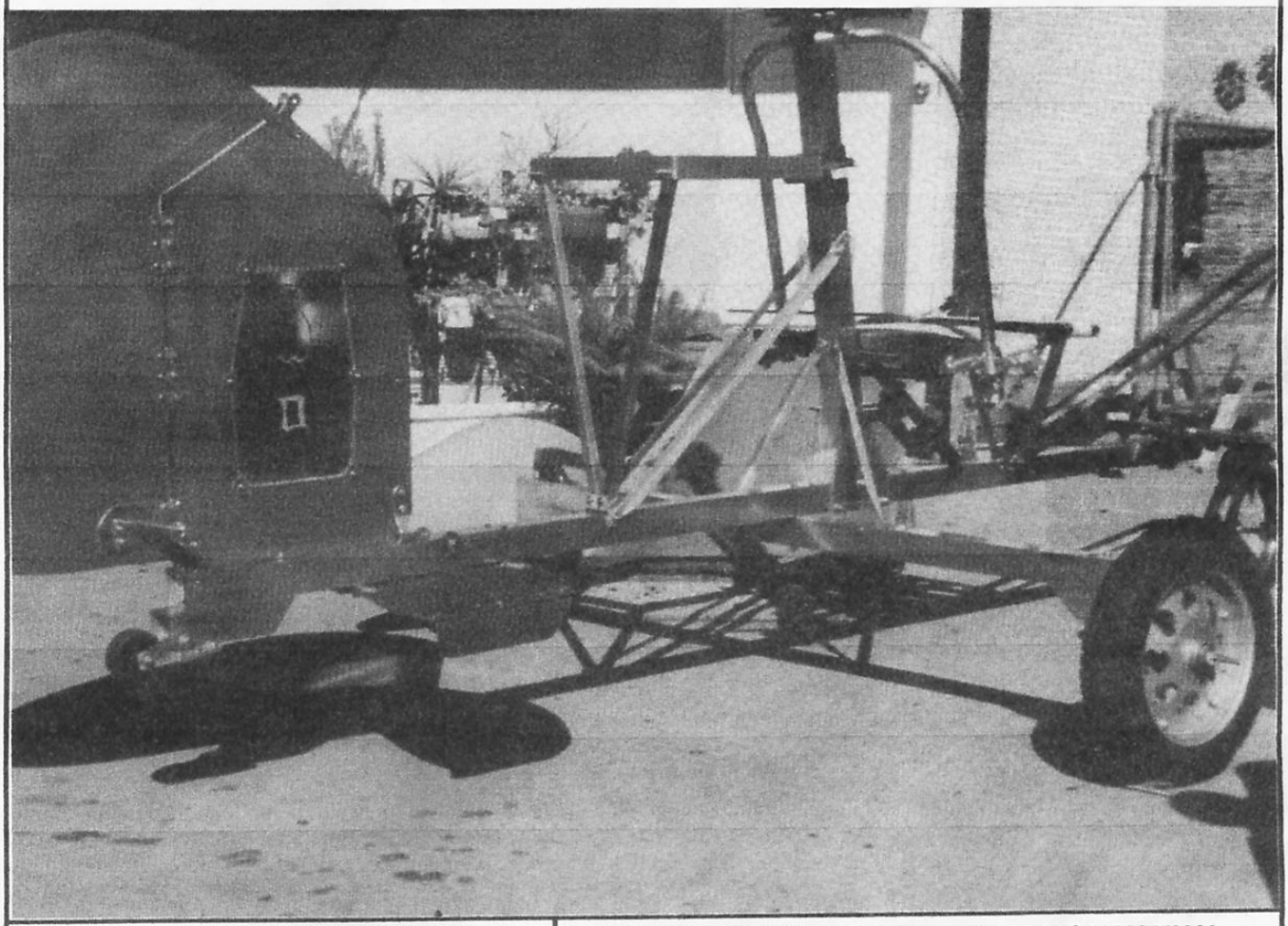
The engine mount used in the Phlying Phantom conversion is constructed from mild steel angle. It can be installed on a standard Bensen/Brock type airframe with very minor modifications to the airframe.

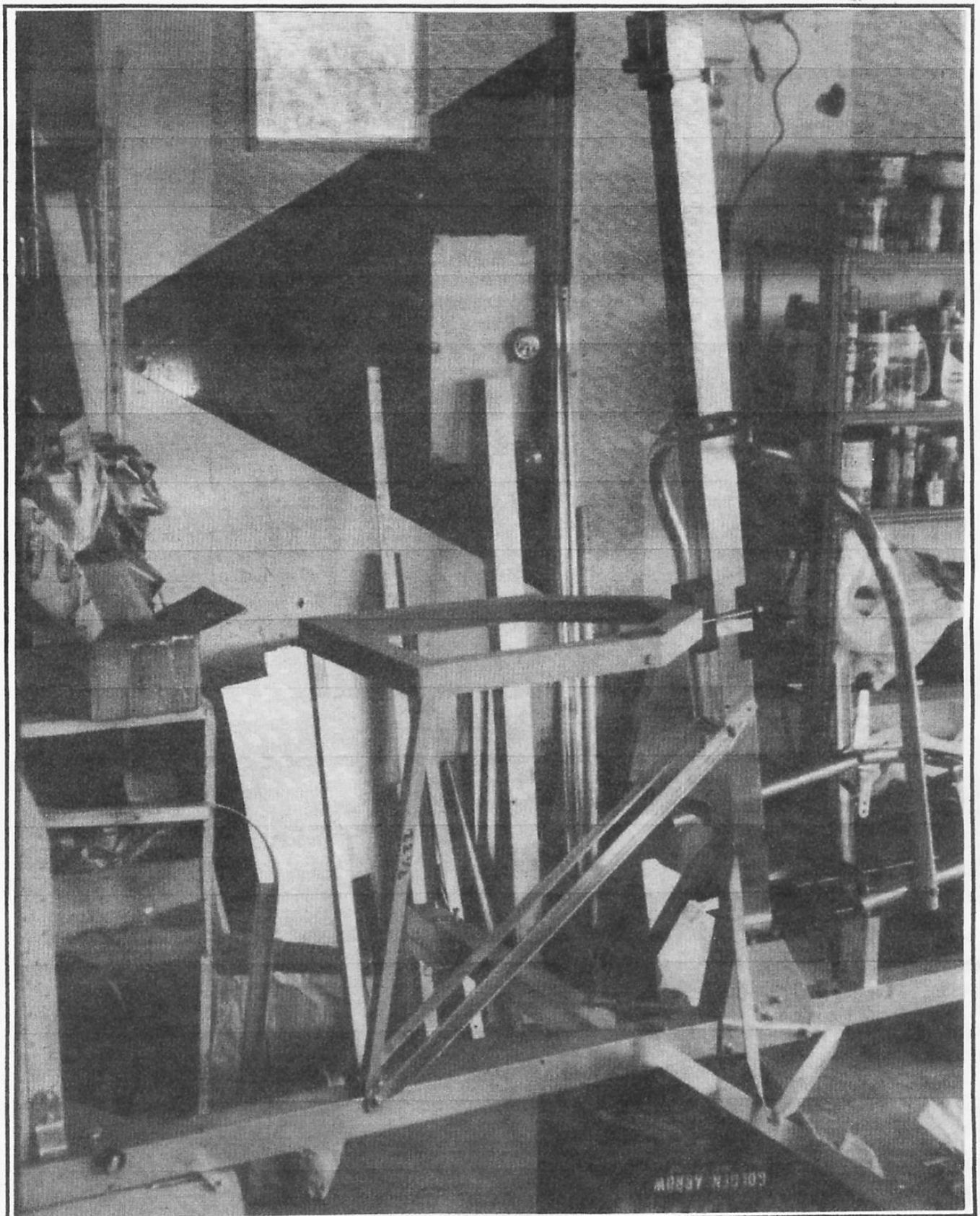
Drill holes in the engine mount as indicated in drawing EA81-DD-01. Enlarge the 7mm holes in the trimmed bell housing to 5/16 inch diameter to allow clearance for 1/4 inch bolts that serve as torque snubbers. Use Lok-Tite on 10 mm bolts used for mounting engine to frame.

Measure and mark 21 inches up from the keel on the mast and lay a two inch bead of RTV on both seat-side edges of the mast. Press the two 3/4 X 3 inch pieces of steel angle to the edges of mast. Drill holes in the third piece of angle material and install on the seat-side of the mast. Install the rubber buffer between mast and front of engine mount with 1/4 inch AN bolts. (The rubber buffer has notches in each side to prevent it from slipping out during assembly). Steel locking nuts should be used on the 1/4 inch AN bolts that clamp the engine mount to the mast to eliminate any possible fatigue due to heat. Leave the mast clamp lightly attached until front and rear braces have been installed to allow for proper alignment of the engine mount; then, tighten the mast clamp bolts until the nuts STOP turning. This will pre-load the buffer.

Cut all aluminum braces as indicated in drawing EA81-DD-05. Drill holes in the front braces and bolt braces to engine mount. Attach the braces to the axle with 1/4 inch AN bolts using existing holes in axle.

Attach the bottom of the rear braces to the steel saddle clamp with rubber shim material between the braces and saddle clamp. Install the rear braces to engine mount and keel. Use a rubber shim between clamp and keel and attach the saddle clamp through existing hole in keel.





ROTARY FLIGHT INTERNATIONAL	EA81 SUBARU ENGINE CONVERSION MANUAL FIGURE 13

9.0 ELECTRICAL SYSTEM

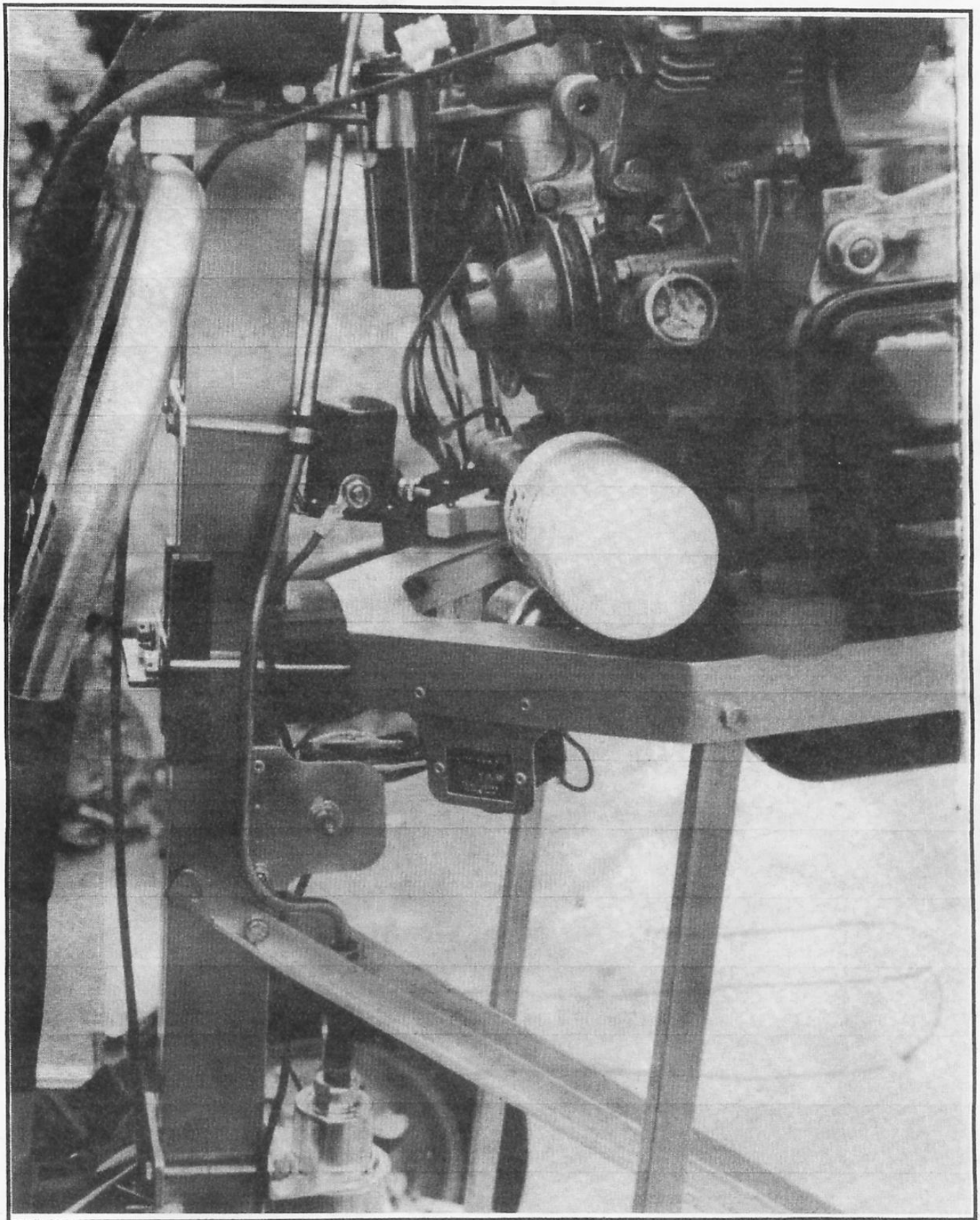
A schematic of the electrical system is located on drawing EA81-DD-09. Provisions were made in the prototype to prime the engine via the electric fuel pump instead of using a squeeze bulb primer. An electric pre-rotator is also utilized in the Phlying Phantom which you may or may not wish to install. No engine starter motor is used in order to save weight. The Subaru engine can easily be propped by hand. BE VERY CAUTIOUS WHEN HAND PROPING ANY ENGINE. The fuse block provides electrical feed for engine gauges, radios, and other accessories.

The master switch is a DOUBLE POLE - DOUBLE THROW - CENTER OFF type. The switch used on the prototype is a military grade switch, but a good commercial grade unit is satisfactory. The voltage rating is 240 Volts and current rating is 30 amperes.

A description of the master switch is as folows:

CENTER - OFF (all battery power is removed)

PRIME - In the "PRIME" position the common (C) terminal is connected to terminal 1 on both A and B sides of the switch. Battery power is applied from terminal 2A to terminal 1B (through jumper wire) to 2C which applies power to the fuel pump. (Note that no power is applied to the electrical system or fuse block.) Once the engine has been primed the switch is moved to the "ON" position for starting.



ROTARY FLIGHT INTERNATIONAL	EA81 SUBARU ENGINE CONVERSION MANUAL FIGURE 14

ON - When the switch is placed in the "ON" the common terminals on both A and B sides is connected to position 2. Battery power is then applied to the ignition system and to the fuse block. Note that the Hobbs switch is open at this point so power is removed from the fuel pump. This is a safety feature to prevent fuel from being dumped into the carburetor if the engine is not running. Once the engine is running and sufficient oil pressure is obtained (4 psi), the Hobbs switch closes and applies power to the fuel pump and hour meter.

A "kill switch" is installed between the negative (-) side of the coil and the ignition module to stop the engine in an emergency situation. The kill switch is wired so that it is "hot" in the normal position (push button). You may opt for a toggle switch instead of a push button type.

As mentioned earlier in this manual an Allison optical ignition system is used in the Phlying Phantom. Other systems can be used; in fact, the original ignition system is satisfactory if you want to save some money, but a performance type system is superior to the original equipment system. If you use the Allison ignition system, make sure that you use a coil with a built-in 2 Ohm ballast resistor.

An 80 AMP Nippondenso alternator is used in the prototype installation to provide an abundance of electrical power. The unit is used in several Japanese model automobiles. If

you do not wish to utilize the electric pre-rotator a small, 10 AMP Mitsubishi unit is sufficient to power the ignition system and a minimal amount of radio equipment.

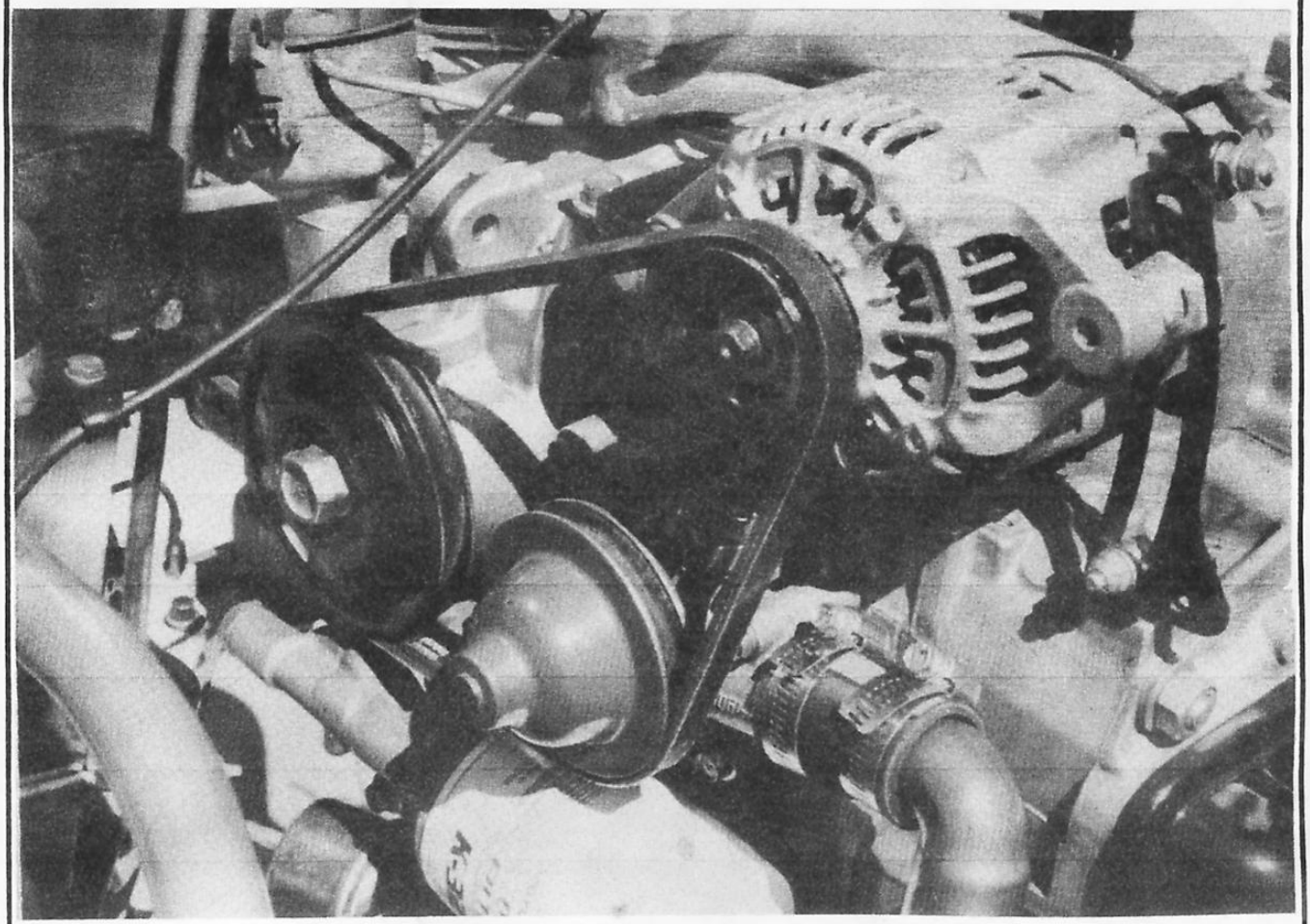
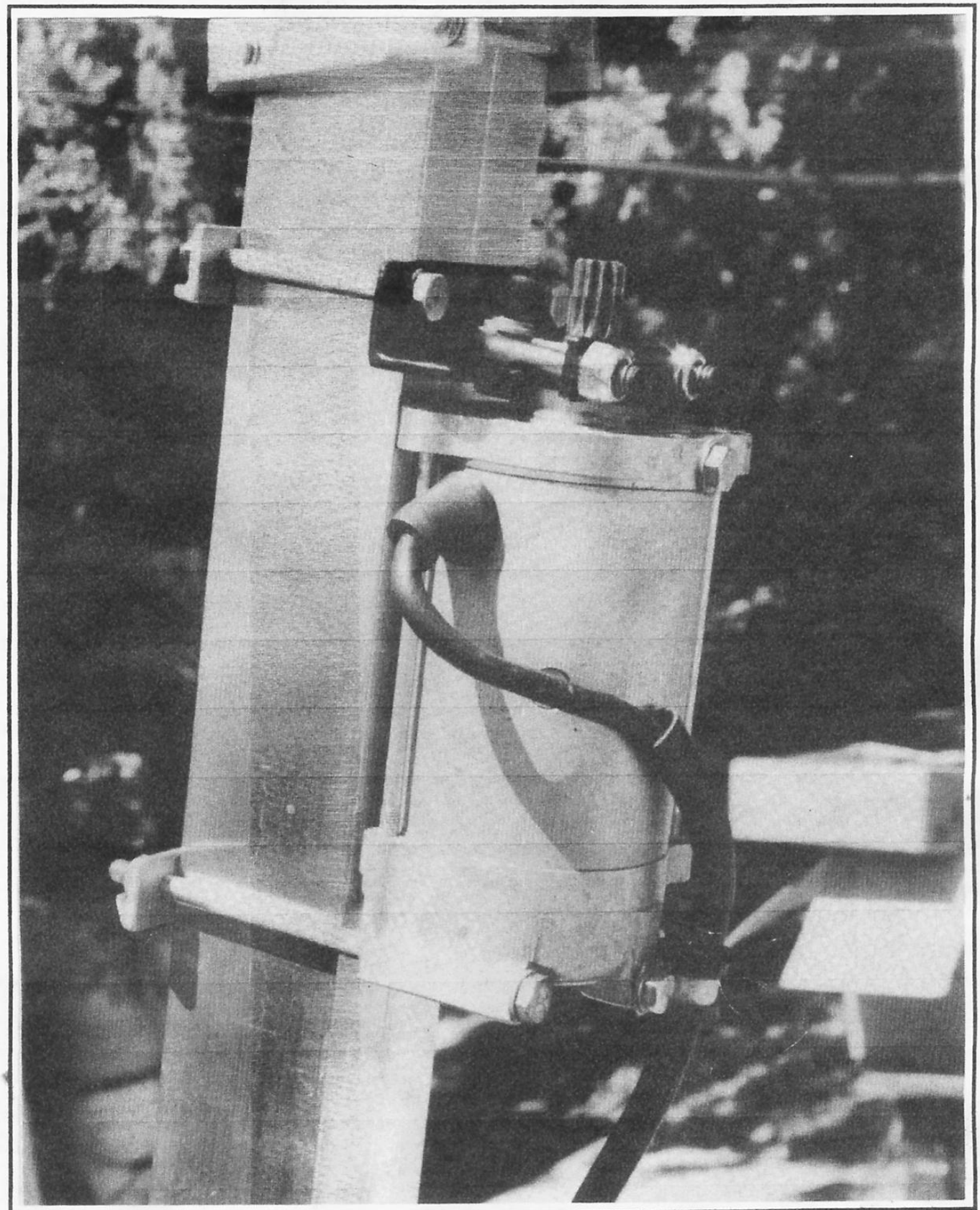


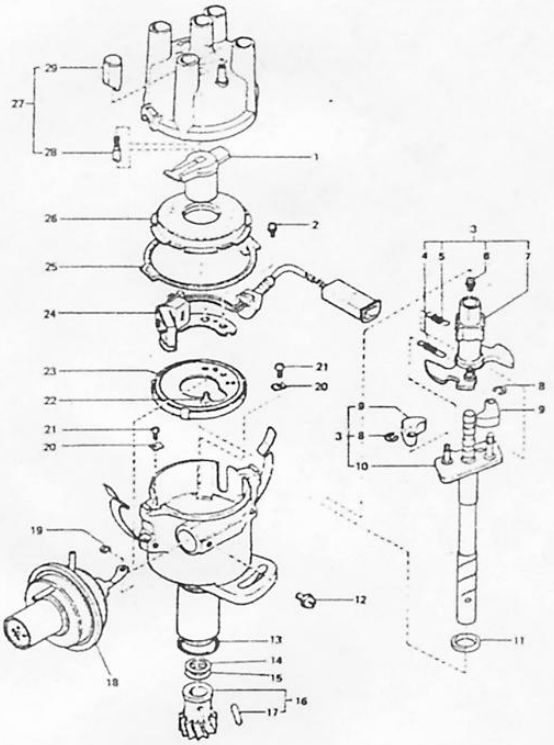
FIGURE 15. Close-up of alternator installation. Alternator bracket was fabricated by builder. No dimensions are given on the bracket drawing since you may choose to use another alternator. Outer pulley on crankshaft was removed to save weight.



ROTARY FLIGHT INTERNATIONAL

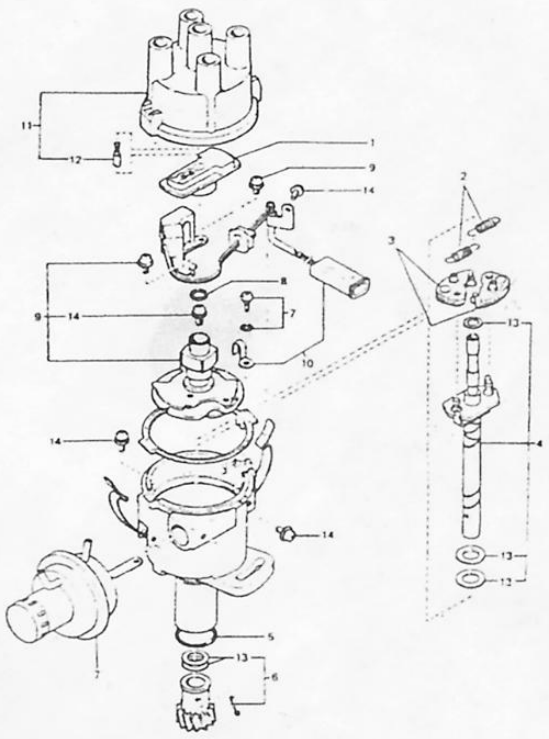
EA81 SUBARU ENGINE CONVERSION MANUAL

BREAKERLESS DISTRIBUTOR



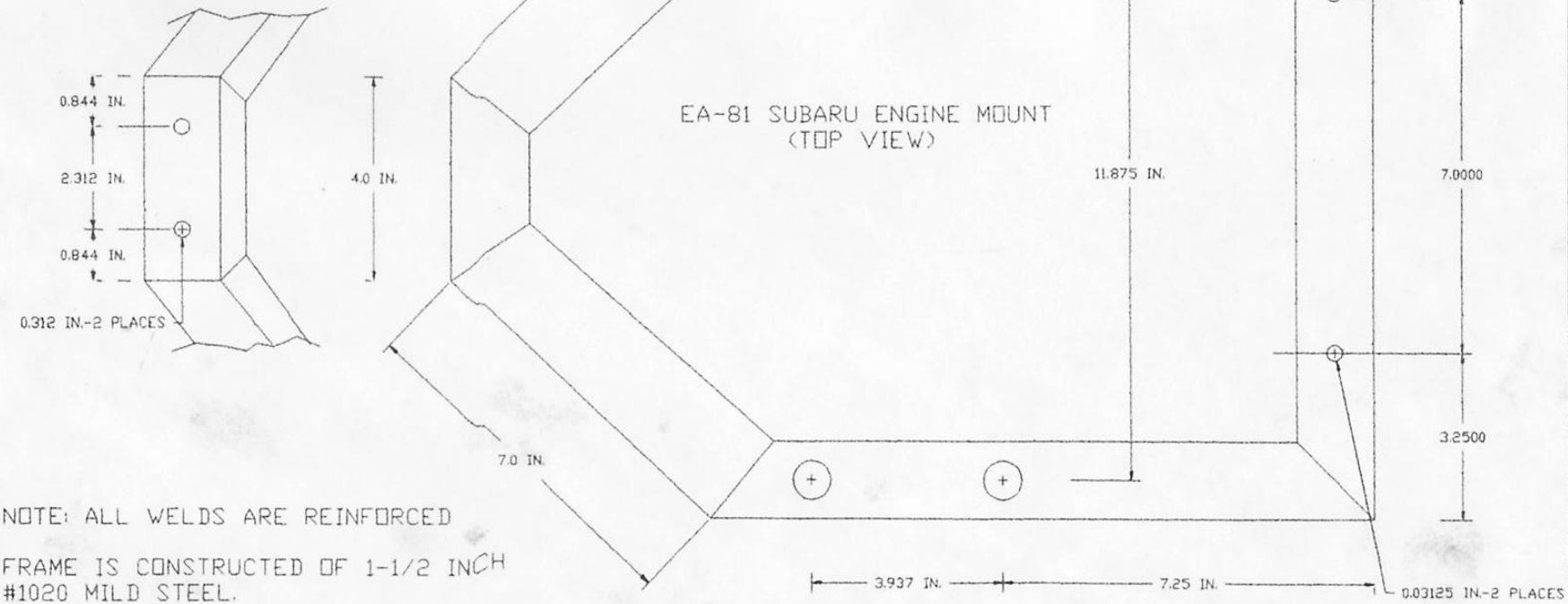
MANUAL TRANSMISSION

1. Distributor rotor
2. Screw and washer
3. Shaft and governor assembly
4. Governor spring B
5. Governor spring A
6. Screw and washer
7. Signal rotor subassembly
8. Snap ring clip
9. Governor weight
10. Distributor shaft assembly
11. Washer
12. Screw and washer
13. O-ring
14. Thrust washer (0.1)
15. Thrust washer (0.3)
16. Distributor pinion set
17. Straight pin (5 x 20)
18. Vacuum controller assembly
19. Snap ring clip
20. Plate
21. Round head screw
22. Screw and washer
23. Contact breaker plate complete
24. Pick-up coil set
25. Dust proof packing
26. Dust proof cover
27. Distributor cap assembly
28. Carbon point complete
29. Rubber cap



AUTOMATIC TRANSMISSION

1. Rotor
2. Governor spring set
3. Weight
4. Shaft and governor assembly
5. O-ring
6. Point set
7. Vacuum controller assembly
8. Dust proof packing
9. Contact breaker plate complete
10. Pick-up coil set
11. Cap
12. Carbon point
13. Thrust washer
14. Screw kit



NOTE: ALL WELDS ARE REINFORCED

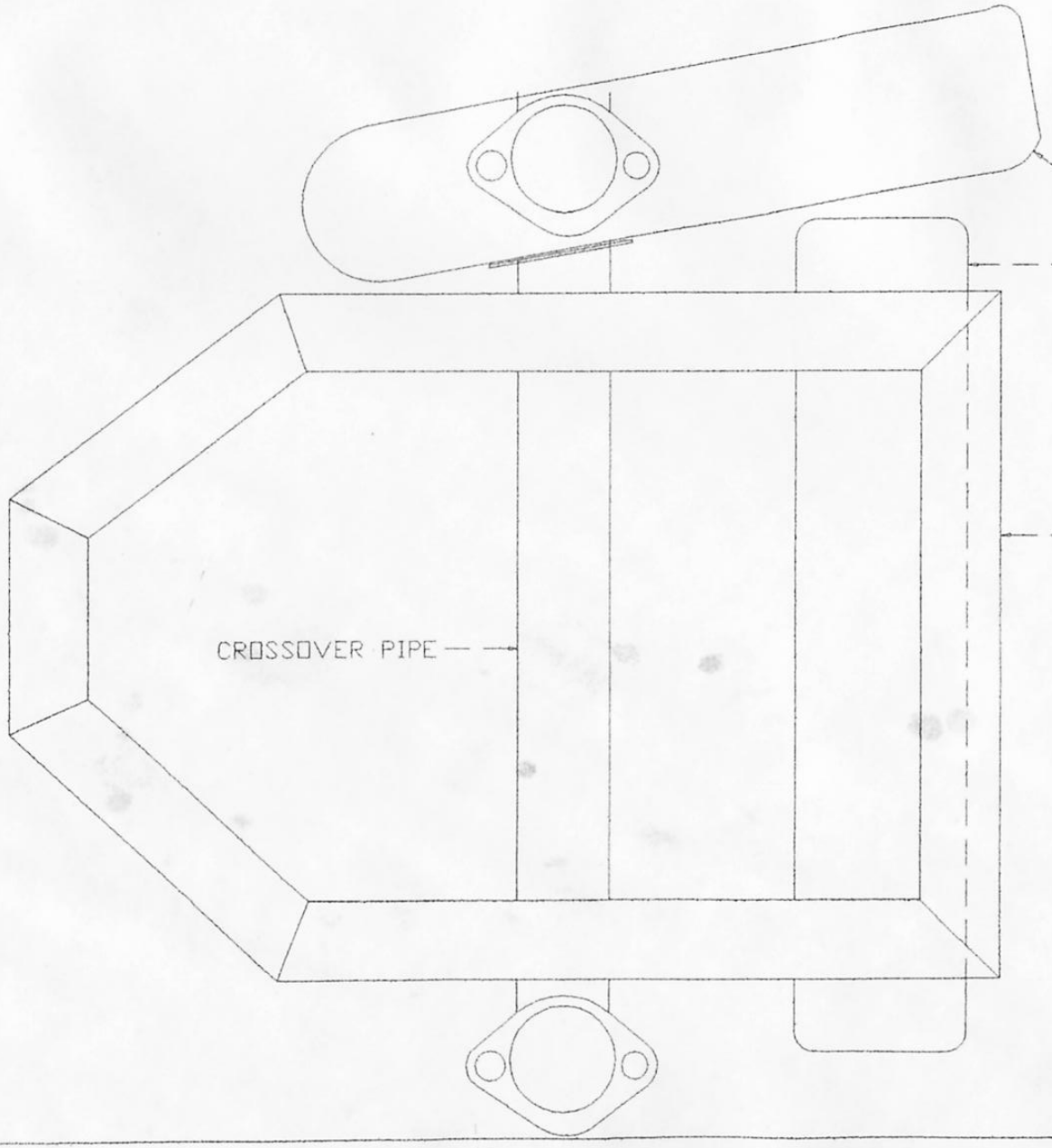
FRAME IS CONSTRUCTED OF 1-1/2 INCH #1020 MILD STEEL.

		DATE
DRAWN	D. PARHAM	2-03-90
CHECKED	V. LOCKYER	2-05-90
DESIGNER	D. ENGLE	8-15-89
SHEET#	OF	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

EA-81 SUBARU ENGINE MOUNT FOR GYROPLANE

DWG# EA81-DD-01 REV —



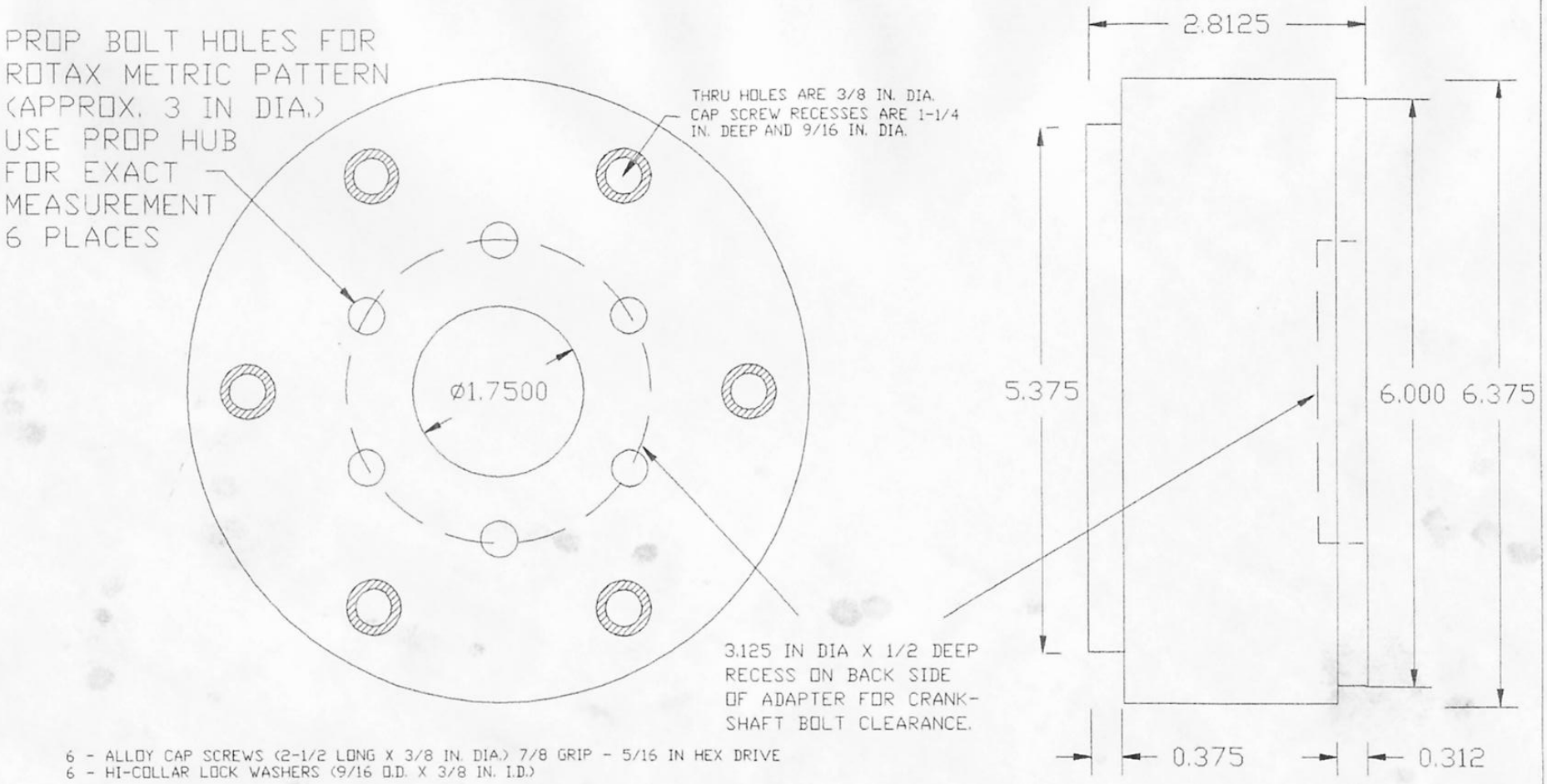
		DATE
DRAWN	D. PARHAM	2-03-90
CHECKED	W. LOCKYER	2-05-90
DESIGNER	D. ENGLE	7-14-89
SHEET#	1 OF 1	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

EA-81 SUBARU
EXAUST MANIFOLD

DWG# EA81-DD-02 REV --

ALUMINUM PROP ADAPTOR (Machine from 2024 or 6061 T3)



6 - ALLOY CAP SCREWS (2-1/2 LONG X 3/8 IN. DIA.) 7/8 GRIP - 5/16 IN HEX DRIVE
6 - HI-COLLAR LOCK WASHERS (9/16 O.D. X 3/8 IN. I.D.)

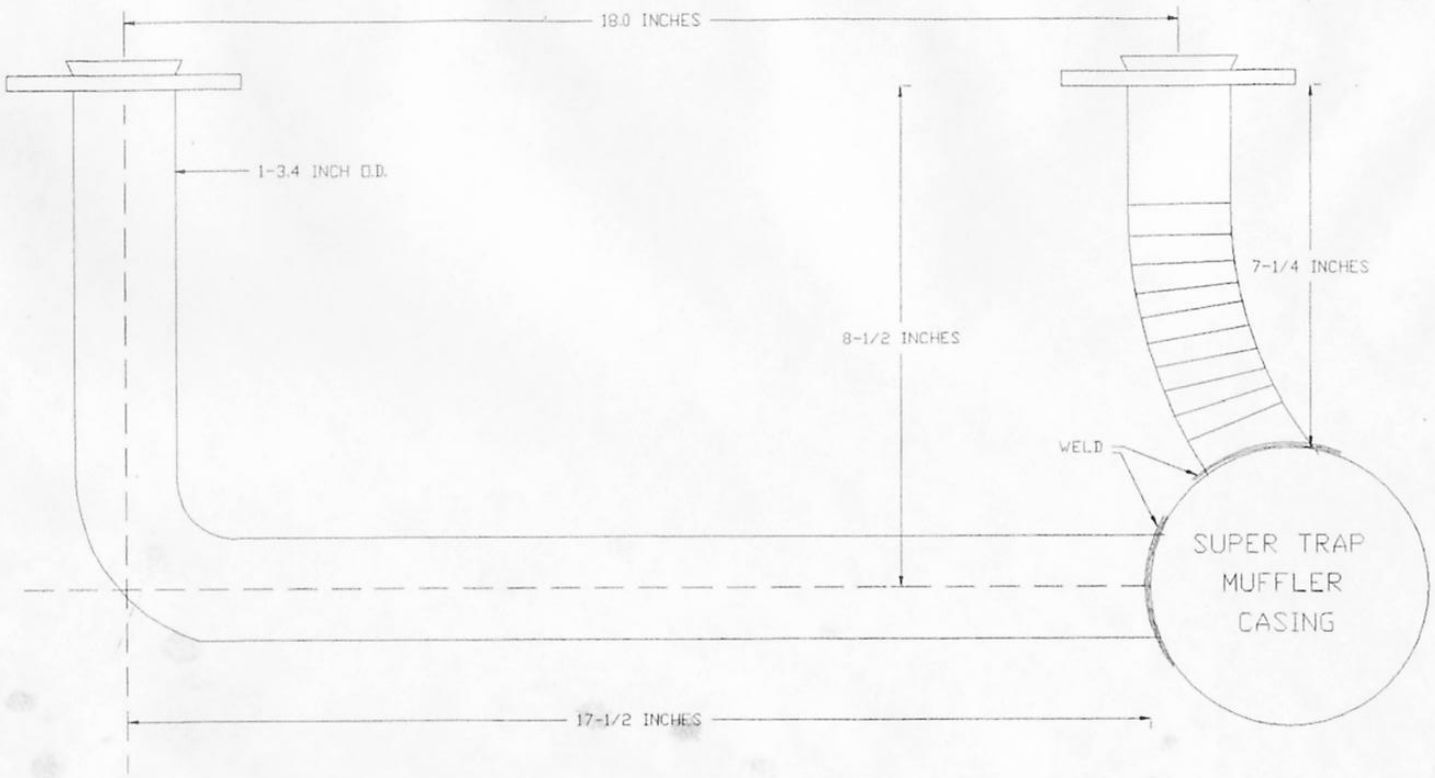
NOTE: HOLES FOR CAP SCREWS ARE 60 DEGREES APART ON A 4.875 IN. DIA. CIRCLE
HOLES FOR ROTAX PATTERN ARE 60 DEGREES APART ON APROX. 3 INCH DIA. CIRCLE
BETWEEN CAP SCREW HOLES. BOLT HOLES ARE 3/8 IN. DIA. (USE AN-76-32 BOLTS WITH
HELICOIL INSERTS)

		DATE
DRAWN	D. PARHAM	2-10-90
CHECKED	W. LOCKYER	2-12-90
DESIGNER	D. ENGLE	6-30-89
SHEET#	1 OF 2	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

PROP HUB ADAPTER
FOR ROTAX PATTERN

DWG# EA81-DD-04 REV -



STUBS OF EXHAUST ARE SWEDGED TO FIT THROUGH FLANGES WITH A CEREAMIC EXHAUST GASKET FOR SEALING. THIS PROCESS ALLOWS THE SYSTEM TO "FLOAT" AND CENTER DURING BOLT-ON SO THAT NO CRACKING OF EXHAUST PIPES OCCUR. REFER TO PHOTO OF EXHAUST SYSTEM TO CLARIFY.

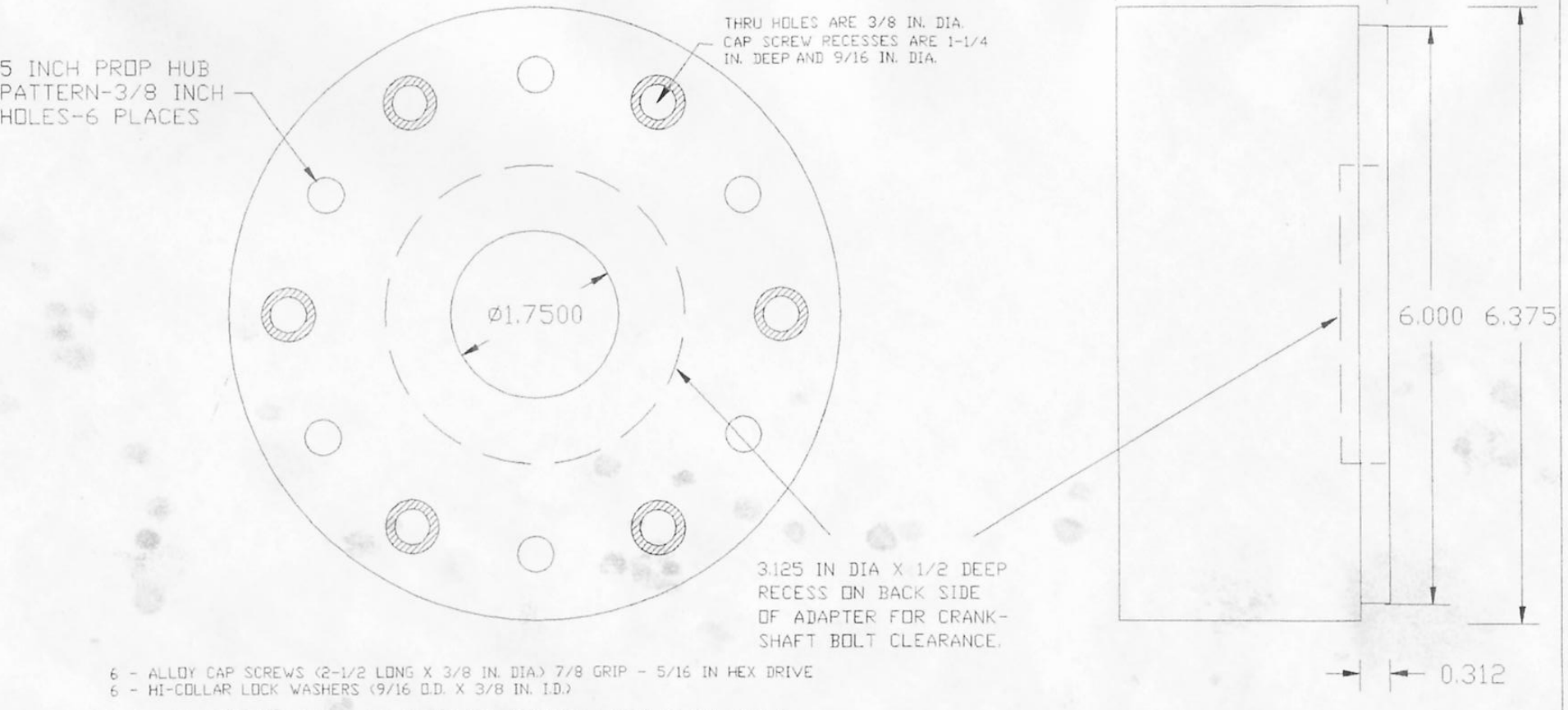
		DATE
DRAWN	D. PARHAM	2-03-90
CHECKED	V. LOCKYER	2-05-90
DESIGNER	D. ENGLE	10-06-90
SHEET#	1 OF 1	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

EA-81 SUBARU
EXHAUST SYSTEM

DWG# EA81-DD-03 REV -

ALUMINUM PROP ADAPTOR (Machine from 2024 or 6061 T3)



6 - ALLOY CAP SCREWS (2-1/2 LONG X 3/8 IN. DIA.) 7/8 GRIP - 5/16 IN HEX DRIVE
6 - HI-COLLAR LOCK WASHERS (9/16 O.D. X 3/8 IN. I.D.)

NOTE: HOLES FOR CAP SCREWS ARE 60 DEGREES APART ON A 4.875 IN. DIA. CIRCLE. HOLES FOR S.A.E. BOLT PATTERN ARE 60 DEGREES APART ON A 5.000 INCH DIA. CIRCLE. BETWEEN CAP SCREW HOLES. BOLT HOLES ARE 3/8 IN. DIA. (USE AN-76-32 BOLTS WITH HELICOIL INSERTS)

		DATE
DRAWN	D. PARHAM	2-10-90
CHECKED	W. LOCKYER	2-12-90
DESIGNER	D. ENGLE	6-30-89
SHEET#	2 OF 2	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

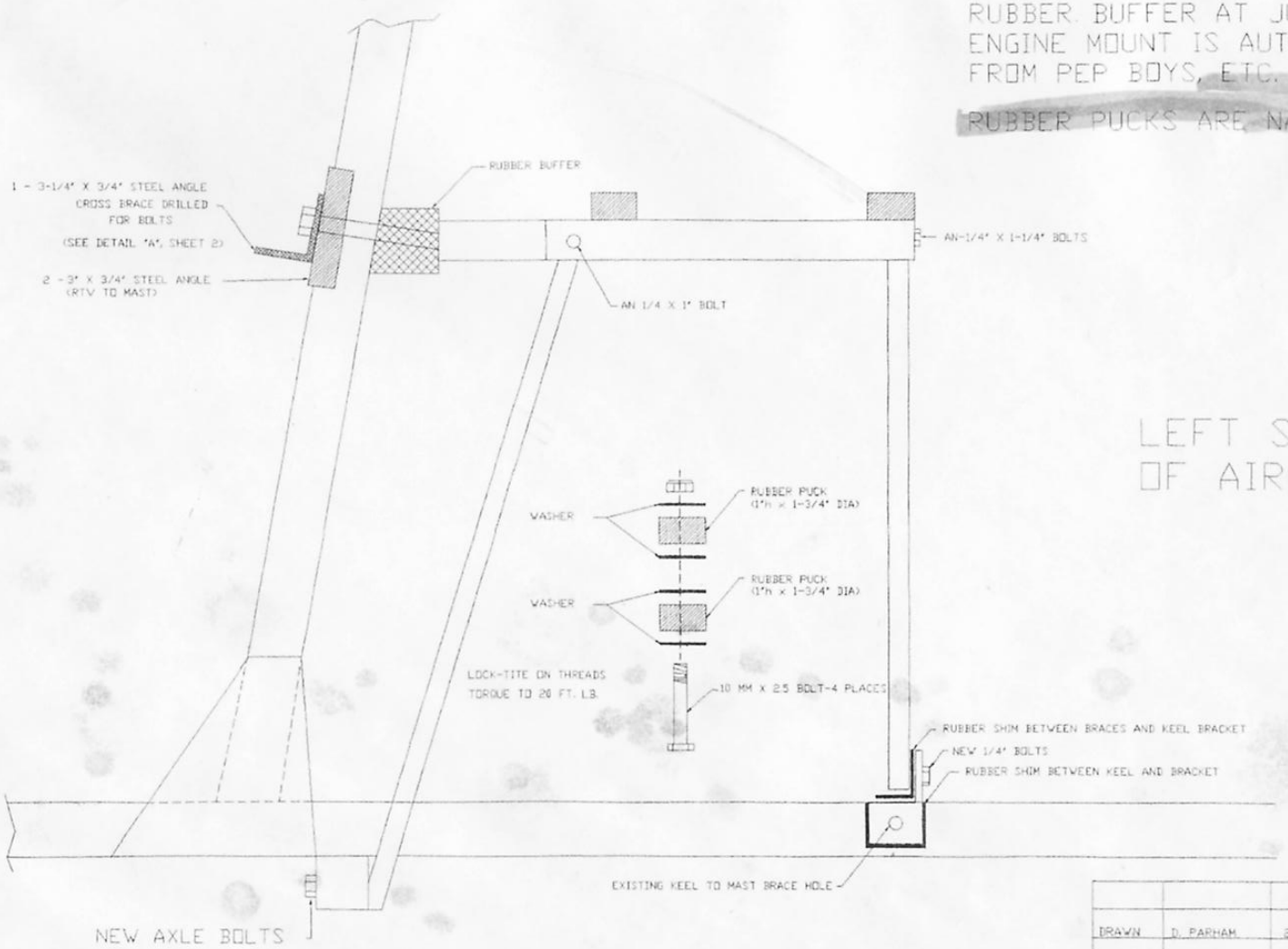
PROP HUB ADAPTER FOR 5 INCH PATTERN

DWG# EA81-DD-04 REV -

NOTES: ENGINE MOUNT FOR BENSEN/BROCK AIRFRAME.

RUBBER BUFFER AT JUNCTION OF MAST AND ENGINE MOUNT IS AUTO COIL SPRING HELPER FROM PEP BOYS, ETC. (3" DIA.)

RUBBER PUCKS ARE NAPA #602-1045



LEFT SIDE VIEW OF AIRFRAME

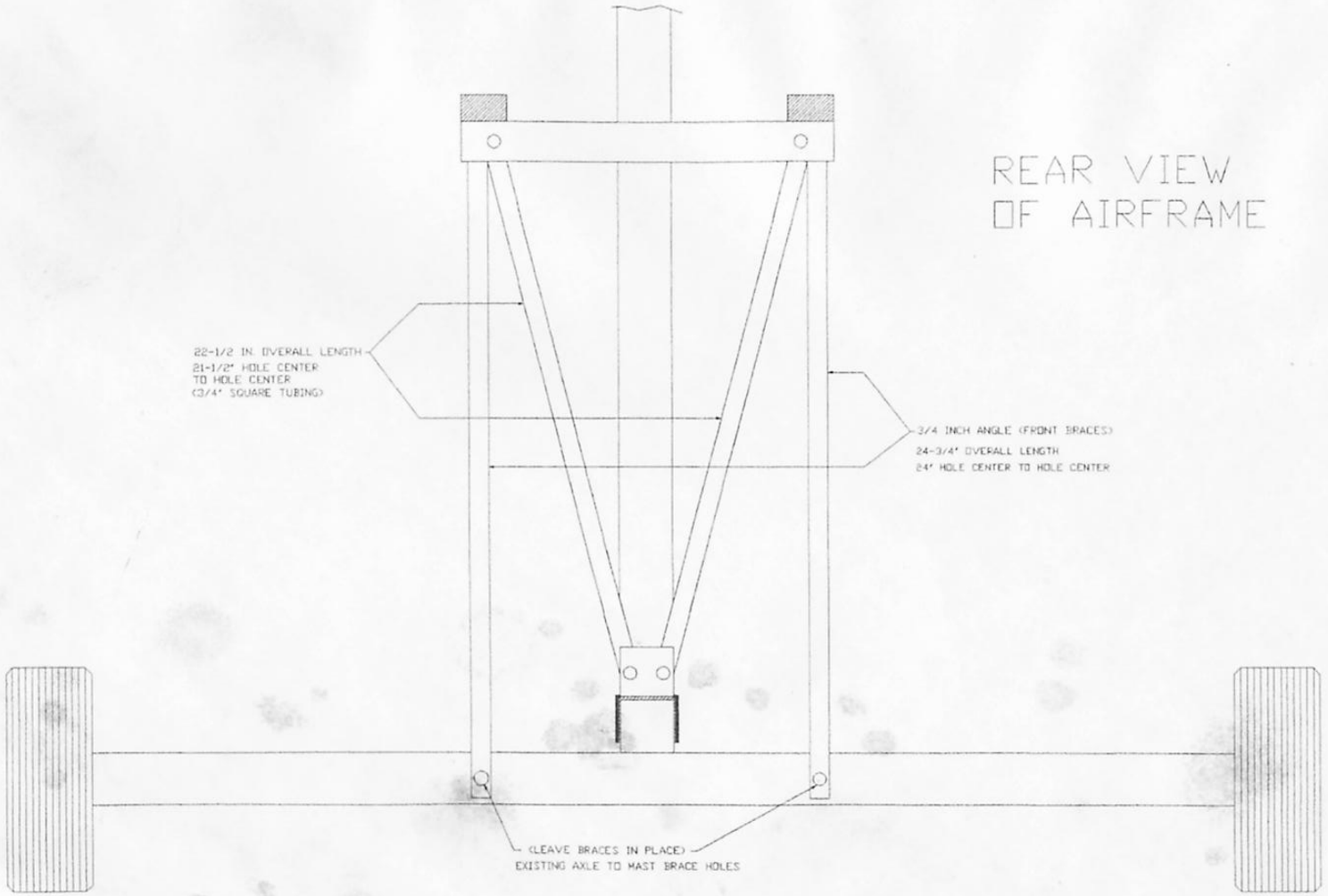
		DATE
DRAWN	D. PARHAM	2-04-90
CHECKED	W. LOCKYER	2-06-90
DESIGNER	D. ENGLE	9-06-89
SHEET#	1 OF 4	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

ENGINE MOUNT AND AIRFRAME DETAILS

DWG# EA81-DD-05 REV A

REAR VIEW OF AIRFRAME



		DATE	ROTARY FLIGHT INTERNATIONAL SUITE 281 5555 ZUNI S.E. ALBUQUERQUE, NM 87108	
DRAWN	D. PARHAM	2-04-90		
CHECKED	W. LOCKYER	2-06-90		
DESIGNER	D. ENGLE	5-06-89	ENGINE MOUNT AND AIRFRAME DETAILS	
			DWG#	EA81-DD-05 REV -
SHEET#	2 OF 4			

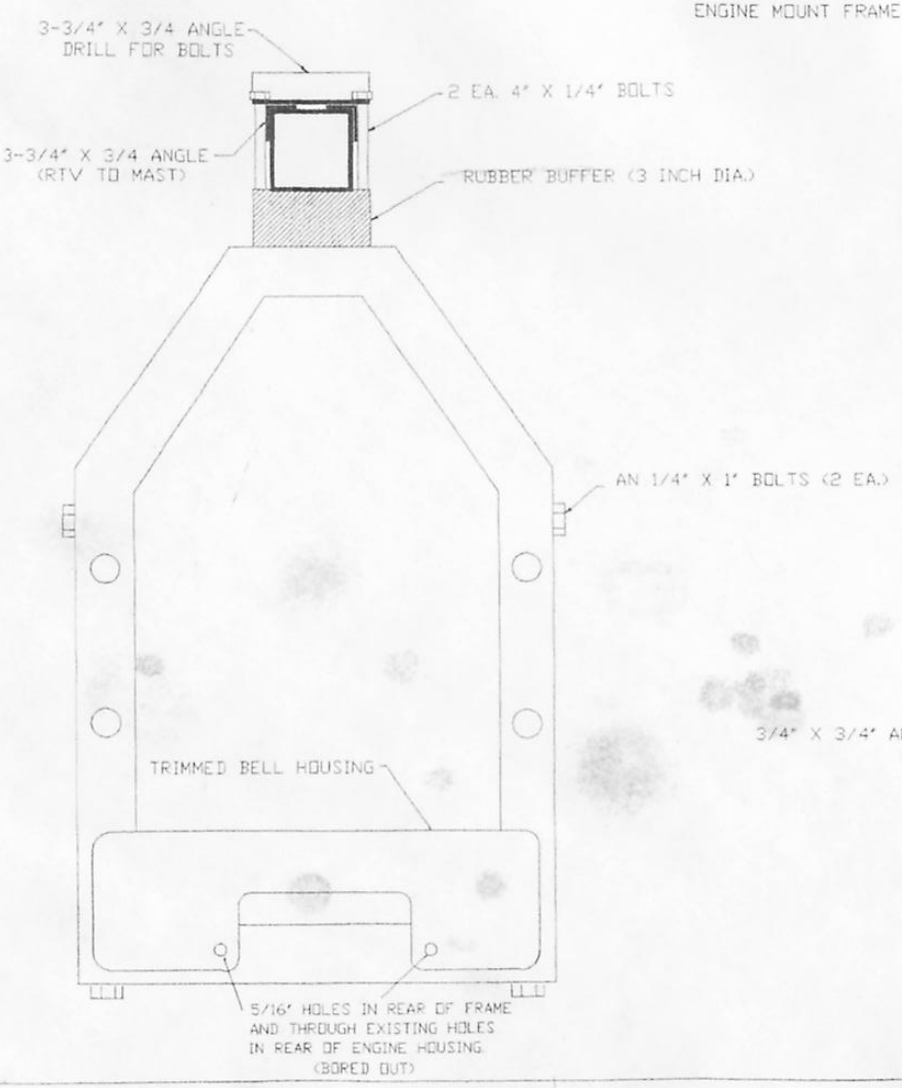
		DATE
DRAWN	D. PARHAM	2-04-90
CHECKED	W. LOCKYER	2-06-90
DESIGNER	D. ENGLE	5-06-89
SHEET#	3 OF 4	

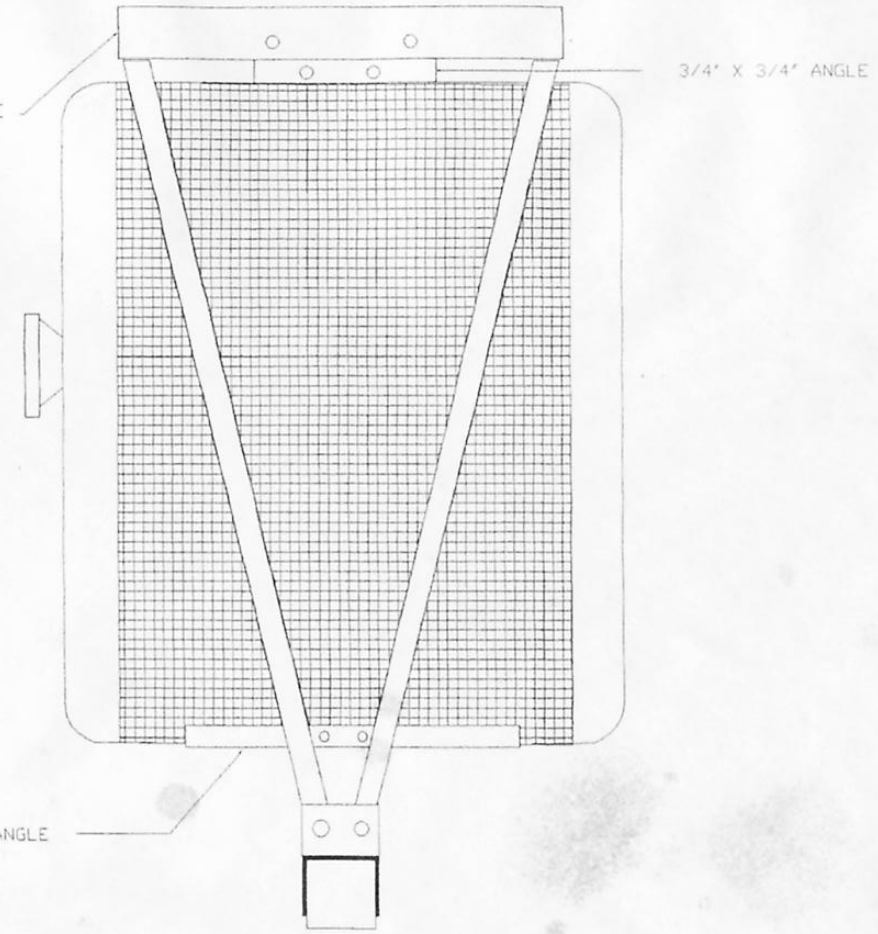
ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

ENGINE MOUNT AND AIRFRAME DETAILS

DWG# EA81-DD-05 REV A

NOTES: ENGINE MOUNT FOR BENSEN/BROCK AIRFRAME.



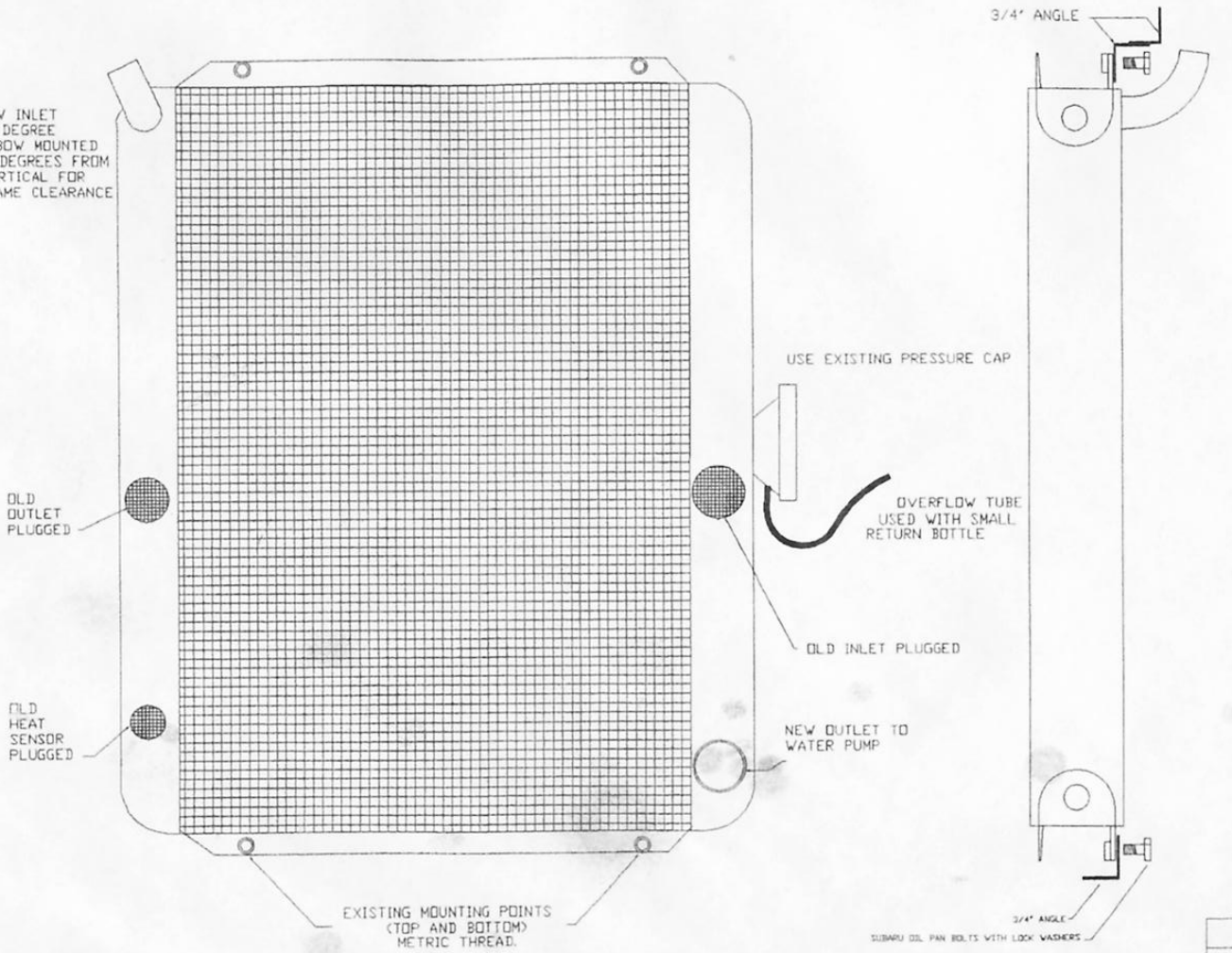


		DATE
DRAWN	D. PARHAM	2-04-90
CHECKED	W. LOCKYER	2-06-90
DESIGNER	D. ENGLE	5-06-89
SHEET#	4 OF 4	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

ENGINE MOUNT AND AIRFRAME DETAILS

DWG# EA81-DD-05 REV A

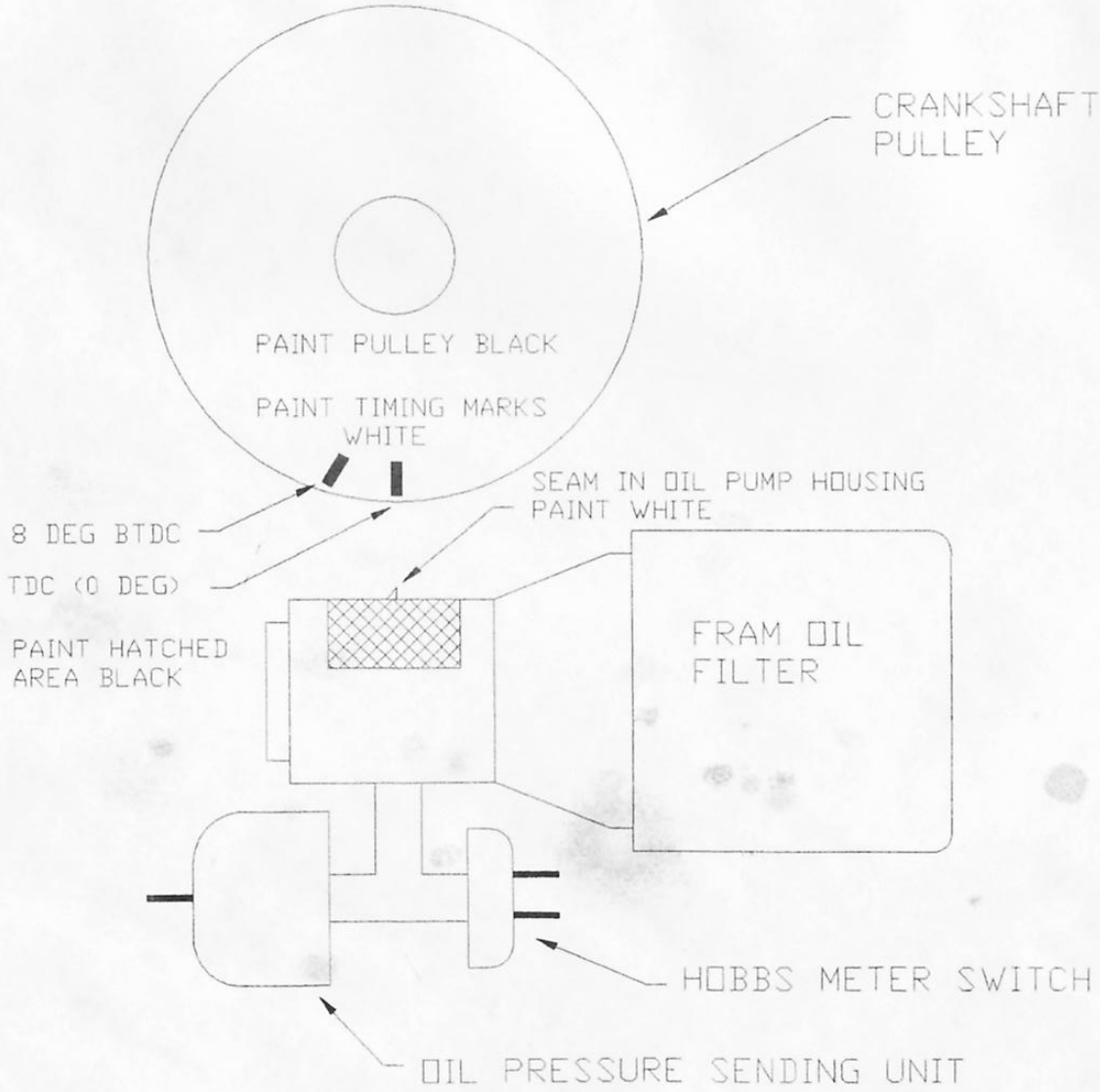


		DATE
DRAWN	D. PARHAM	2-04-90
CHECKED	W. LOCKYER	2-06-90
DESIGNER	D. ENGLE	5-06-89
SHEET#	OF	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

MODIFIED HONDA
CIVIC RADIATOR

DWG# EA81-DD-06 REV -



PAINTING PULLEY BLACK AND TIMING MARKS WHITE WILL GIVE GOOD VISIBILITY FOR ACCURATELY SETTING ENGINE TIMING. NORMAL SETTING IS 8 DEGREES BEFORE TOP DEAD CENTER (BTDC).

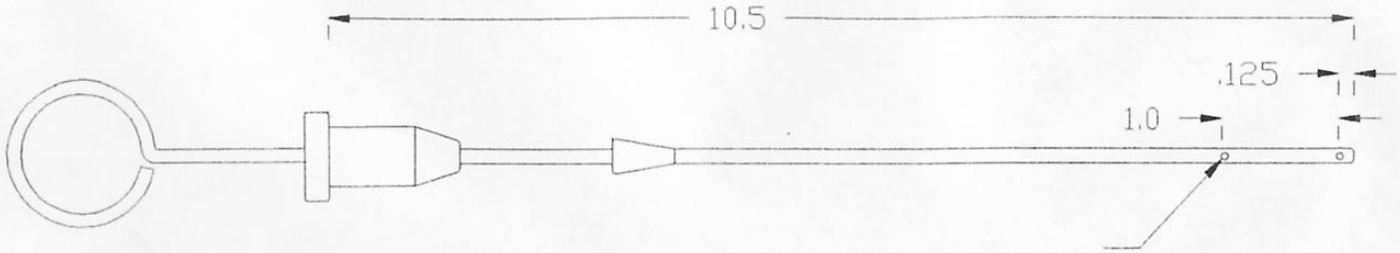
FRONT VIEW OF ENGINE IN PUSHER CONFIGURATION

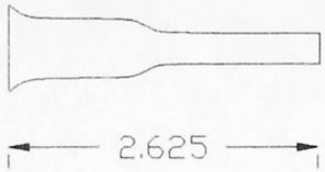
		DATE
DRAWN	D. PARHAM	3-12-90
CHECKED	W. LOCKYER	3-14-90
DESIGNER	D. ENGLE	9-20-89
SHEET#	1 OF 1	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

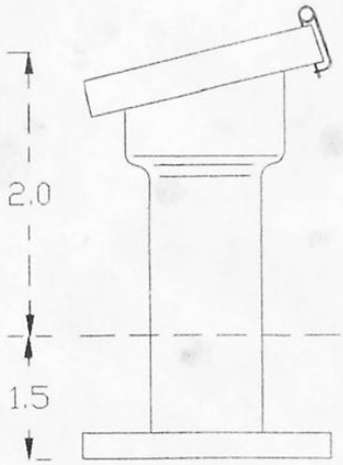
ENGINE TIMING MARK DETAILS

DWG# EA81-DD-08 REV -





DO NOT SCALE
MODIFY DIPSTICK AND TUBE AS SHOWN
TOP OF TUBE SHOULD BE 1.5" ABOVE BLOCK
INSTALL TUBE USING GASKET SEALER



MODIFY OIL FILLER PIPE AS FOLLOWS:
CUT PIPE APPROX. 1.5" ABOVE BASE OF FLANGE AND APPROX. 2.0" BELOW THE CENTER OF THE CAP SOME BLACKSMITHING MAY BE REQUIRED AT THIS POINT TO GET A GOOD FIT UP OF THE TUBES. WELD OR BRAZE THE PARTS TOGETHER.

PLACE CAP TIGHTLY ON PIPE AND DRILL .0625 DIA HOLE FOR SAFTEY PIN. IF YOU HAVE A FREE FLOATING GASKET ON YOUR CAP GLUE IT TO THE CAP BEFORE DRILLING PIN HOLE WE RECOMEND PUTTING A LANYARD ON TH CAP AND ON THE PIN TO PREVENT LOSS OF PIN OR INGESTION OF CAP BY THE PROP IN PUSHER INSTALLATIONS
MAKE SAFTEY PIN A PRE ENGINE START CHECK LIST ITEM.

		DATE
DRAWN	W. LOCKYER	2-18-90
CHECKED	D. PARHAM	2-18-90
DESIGNER	D. ENGLE	6-12-89
SHEET#	OF	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

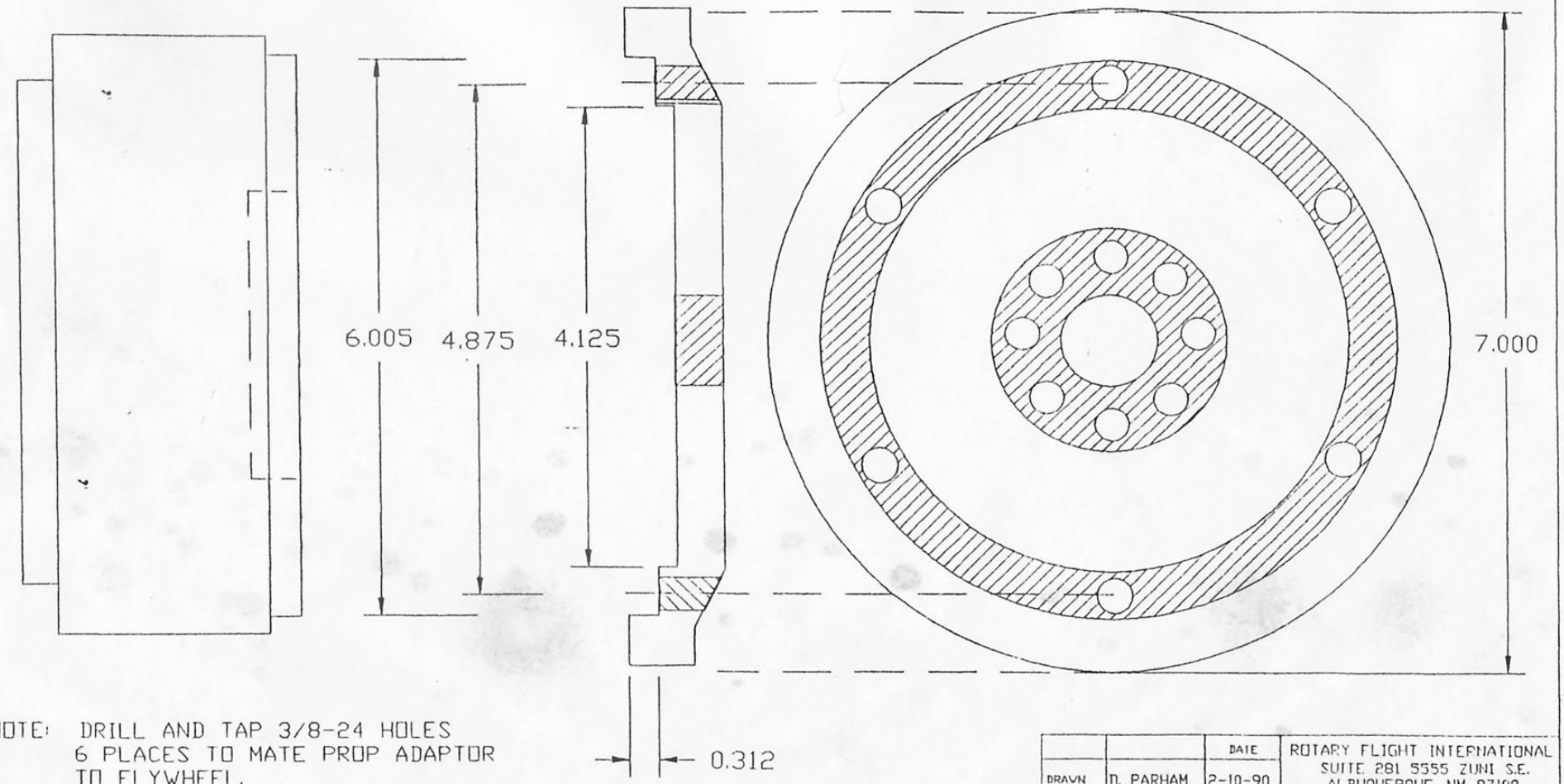
OIL DIPSTICK TUBE & FILLER TUBE MODS.

DWG# EA81-DD-09 REV -

PROP HUB
ADAPTOR

SIDE VIEW OF
MODIFIED FLYWHEEL

PROP HUB SIDE
MODIFIED FLYWHEEL



NOTE: DRILL AND TAP 3/8-24 HOLES
6 PLACES TO MATE PROP ADAPTOR
TO FLYWHEEL.

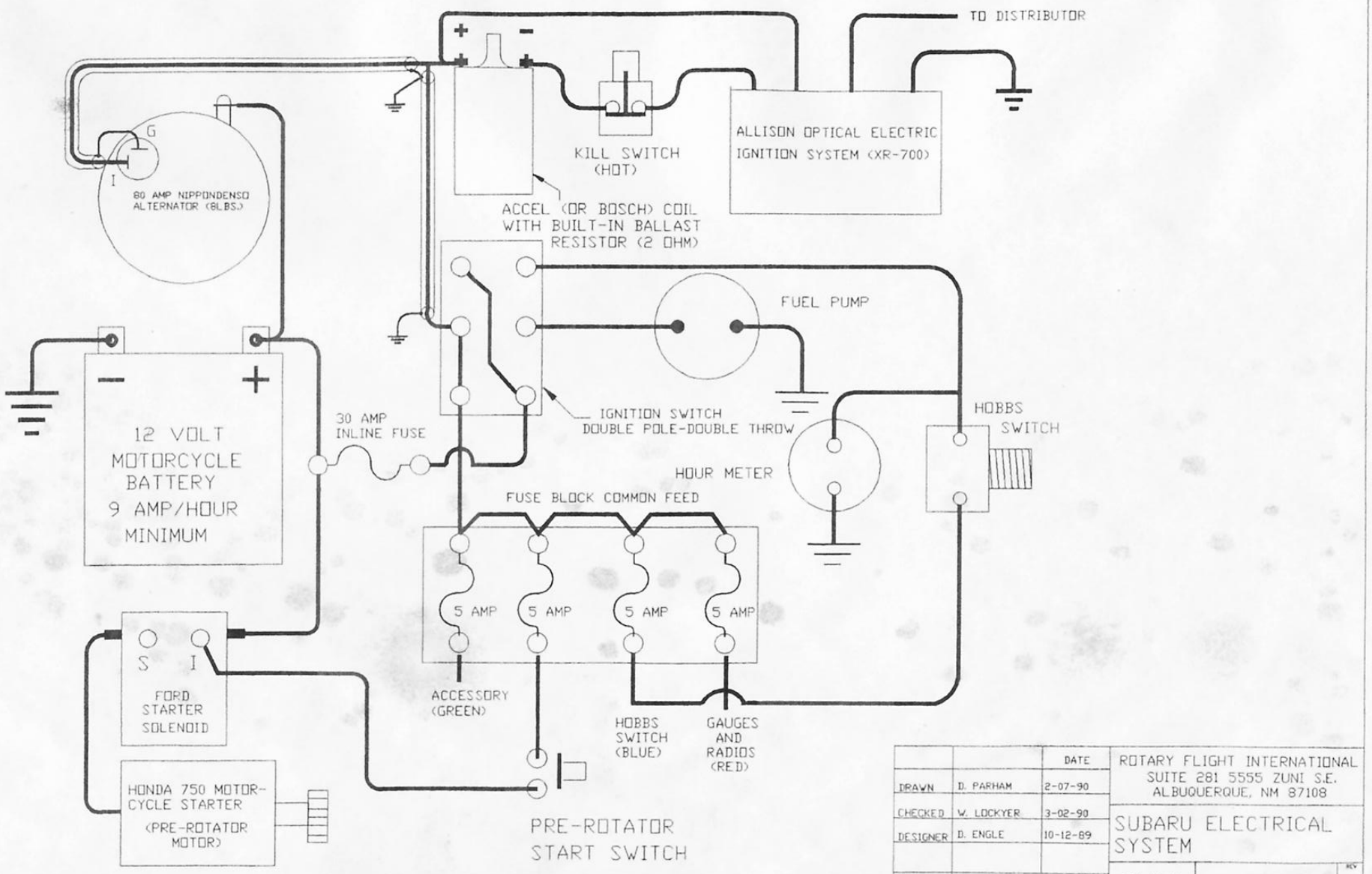
TURN DOWN FLYWHEEL TO MINIMUM
DIAMETER OF 7 INCHES (NOT CRITICAL).

		DATE
DRAWN	D. PARHAM	2-10-90
CHECKED	W. LOCKYER	2-12-90
DESIGNER	D. ENGLE	6-30-89
SHEET#	1	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

STOCK EA81 FLYWHEEL
MODIFICATION

DWG# EA81-DD-10



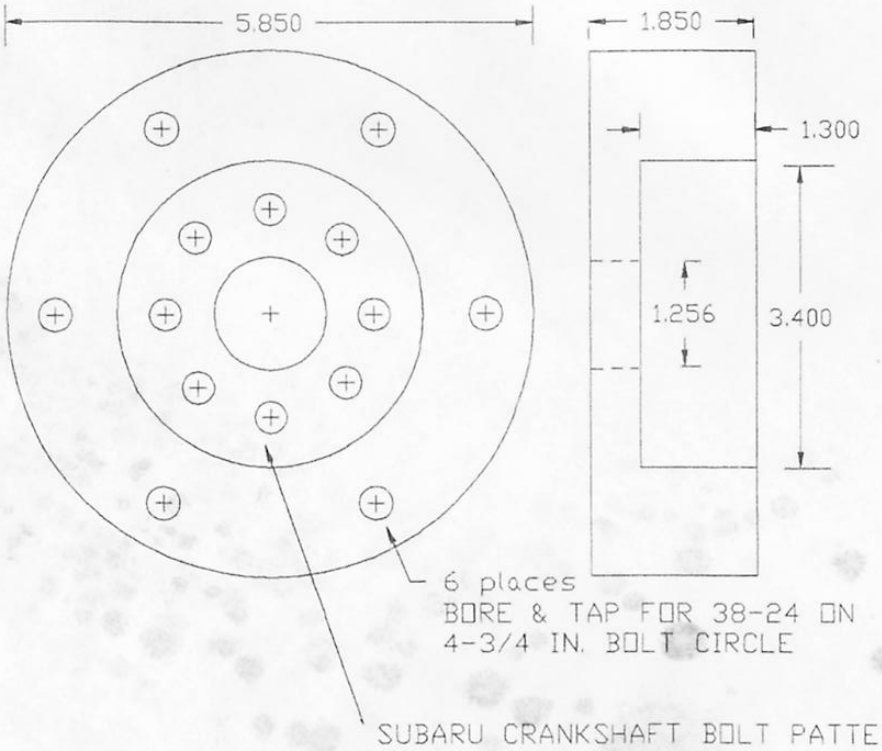
		DATE
DRAWN	D. PARHAM	2-07-90
CHECKED	W. LOCKYER	3-02-90
DESIGNER	D. ENGLE	10-12-89
SHEET#	1 OF 1	

ROTARY FLIGHT INTERNATIONAL
SUITE 281 5555 ZUNI S.E.
ALBUQUERQUE, NM 87108

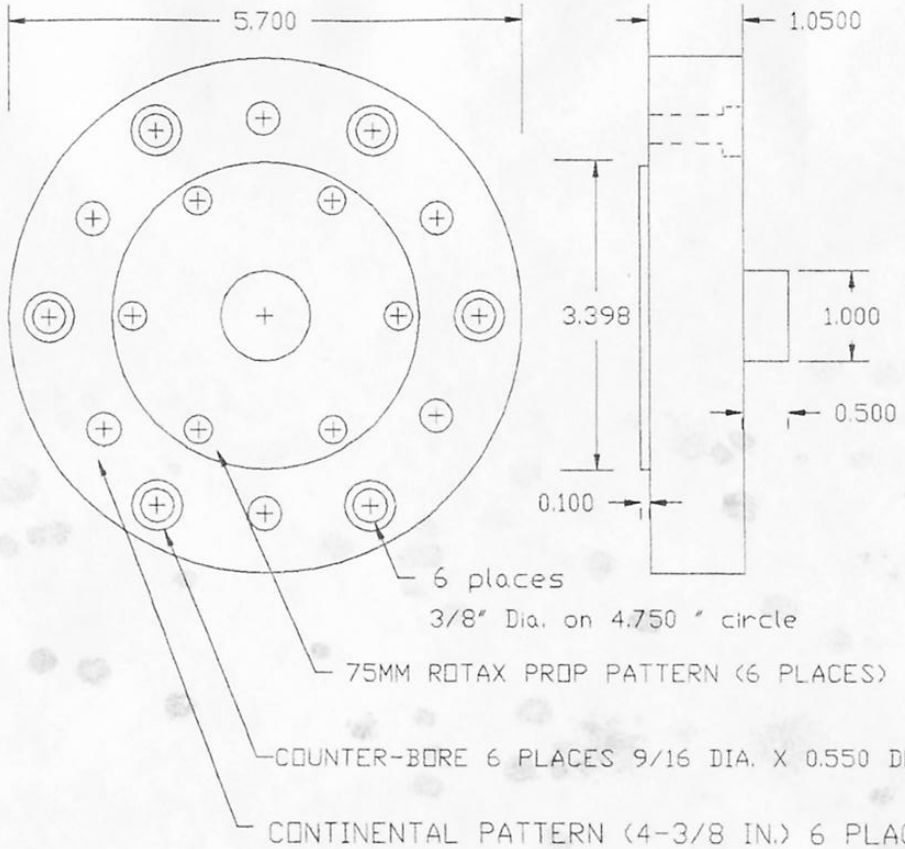
SUBARU ELECTRICAL SYSTEM

DWG# EA810DD-12 REV –

FLYWHEEL



PROP ADAPTOR



NOTE: 1) ATTACH FLYWHEEL TO CRANKSHAFT WITH STOCK SUBARU 9MM FLYWHEEL BOLTS.

2) ATTACH PROP ADAPTOR TO FLYWHEEL WITH 3/8-24 X 1-3/4" ALLEN HEAD CAP SCREWS

		DATE	ROTARY FLIGHT INTERNATIONAL SUITE 281 5555 ZUNI S.E. ALBUQUERQUE, NM 87108
DRAWN	D. PARHAM	9-18-92	
CHECKED			EA81 FLYWHEEL & PROP ADAPTOR
DESIGNER			
SHEET#	1 OF 2		DWG# EA81-DD-15 REV