

Constructing A  
**Turbocharger Turbojet Engine**

By  
**Edwin H. Springer**

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Published by  
**Turbojet Technologies**  
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The information contained in this guide is purely academic. Jet engines are potentially dangerous and should not be constructed or operated by anyone for any purpose whatsoever. The author and publisher disclaim all liability incurred in connection with the use of this information.

## **PREFACE**

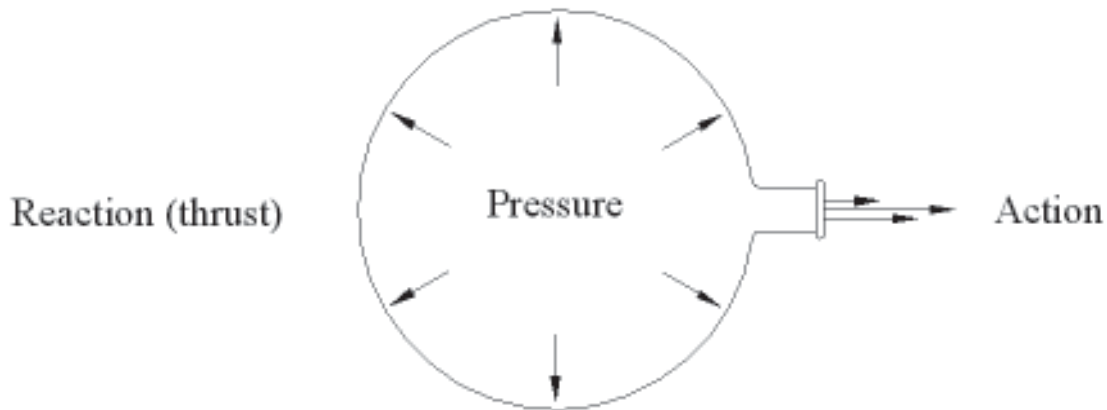
This publication is the result of a jet engine project started in 1996. After some trial and error and considerable thought, we successfully built a turbojet engine using an ordinary truck turbocharger, some exhaust tubing and materials found around most automotive repair shops. We constructed several turbocharger/turbojet engines that run on propane or diesel/jet fuel. We created an internet web site dedicated to our hobby and received so many questions that we decided a detailed construction guide would be appropriate.

We have tried to use as many pictures as possible. Oftentimes ideas can be communicated best with pictures. Many of the fixtures and mounting methods that we used are not the only way to do things. We are trying to show the major elements of a turbojet engine. You will likely find improvements to what we have done.

Although commercial and military jet engines are extremely expensive, a simple turbojet engine can be constructed utilizing a used turbocharger and other readily obtainable parts. The total cost should not exceed \$500.00. No special skills or engineering knowledge are required, however they help. If you can put a trailer hitch on a car or install a new bathroom sink, you should be able to build this jet engine. It should be noted, however, that this project is not for the faint of heart. Combustible liquids, high temperatures, fire and high rotational speed can be a formula for disaster. Utmost care should be taken in each step of the project. Take the time to check each connection and build some sort of protective cover for the turbocharger in case something comes apart at high speed. Think twice before doing anything! We hope you have as much fun building a turbojet engine as we have. Good Luck!

Chapter 1  
**Introduction to  
TURBOJET ENGINES**

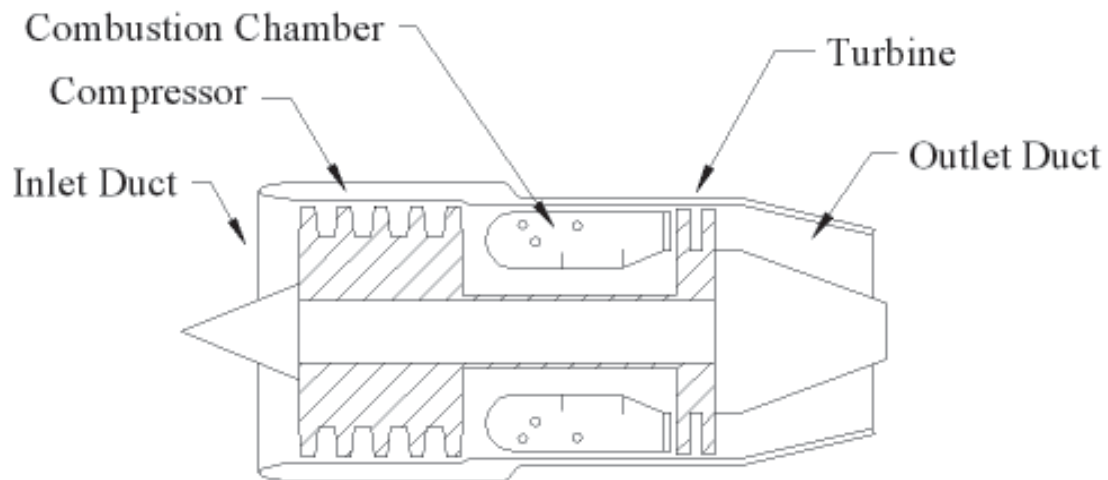
Before describing the construction of the turbocharger/turbojet engine, some basic principles should be understood. A turbojet engine can be broken down into five major subassemblies, the inlet duct, compressor, combustion chamber, turbine wheel, and exhaust outlet. When the engine is running, air is drawn into the compressor where it is compressed and the pressure is increased. It is then ducted to the combustion chamber where fuel is added and burned. The heat in the combustion chamber causes the air to expand before it exits through a nozzle and drives the power turbine. The turbine drives the compressor by means of a drive shaft. The remaining hot gasses are expelled out the exhaust nozzle. Forcing the large amount of air taken into the engine and expelling it out the exhaust duct at a much higher velocity creates thrust. This is the principle of operation of the turbojet engine. It is a reaction engine.



**Fig. 1  
Balloon Analogy**

A reaction engine can be illustrated by visualizing a balloon filled with air. If the stem of the balloon is held closed the pressure inside the balloon is equal on all parts of the interior surface. If the stem is released and the air is allowed to escape, the pressure in the area of the stem is lowered while the pressure remains the same on the side opposite the stem. The pressure is now unequal on the interior surface and the balloon is forced to move in the direction opposite the stem. The undisturbed air pressure in the balloon is potential energy that becomes kinetic energy when the air is allowed to escape. This movement is called reaction.

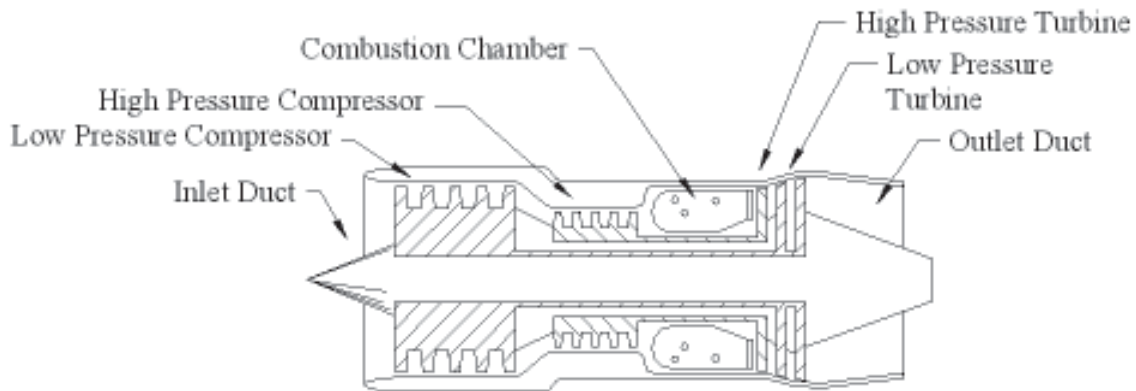
Another example of reaction is a man standing on a skateboard holding a bowling ball. As long as he holds the bowling ball (mass) the skateboard will not move. If he suddenly throws the bowling ball the skateboard will move in the opposite direction. The motion of the skateboard is reaction. The bowling ball represents mass and the act of throwing represents acceleration. When the bowling ball is thrown it accelerates from a steady state to a new state of motion. This is mass acceleration.



**Fig. 2**  
**Single Spool Turbojet Engine**

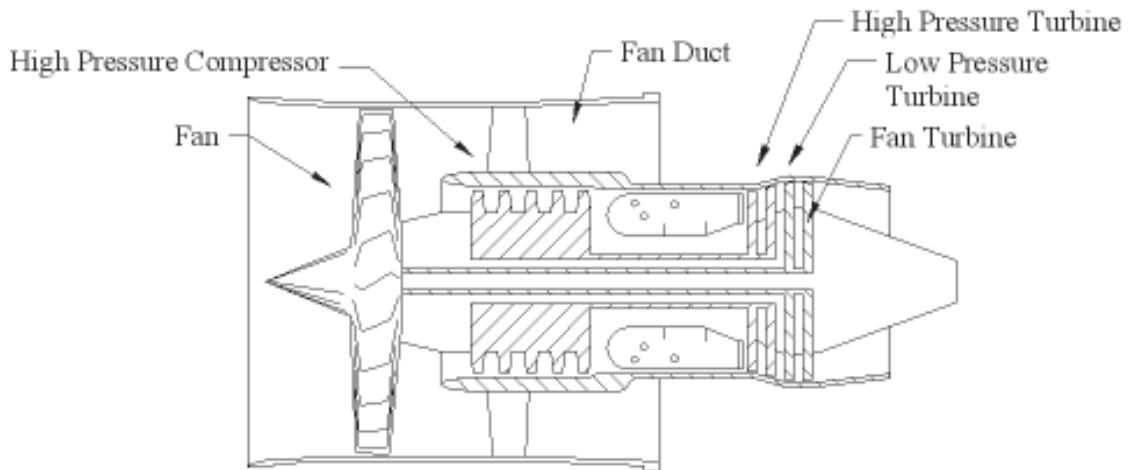
Fig. 2 shows a simple single spool turbojet engine. When the air in the combustor is heated, it expands and is forced through the turbine blades which, in turn, drive the compressor. Air is drawn into the compressor and the pressure is increased as it enters the combustion chamber. The cycle is continuous.

Approximately 90% of the energy produced by the expansion of air in the combustion chamber is used to drive the compressor and the remaining 10% goes out the exhaust nozzle to produce thrust. An engine that produces 1000 lbs. of thrust requires about 3,000 horsepower to drive the compressor. Most of the fuel burned in the engine is used to drive the compressor.



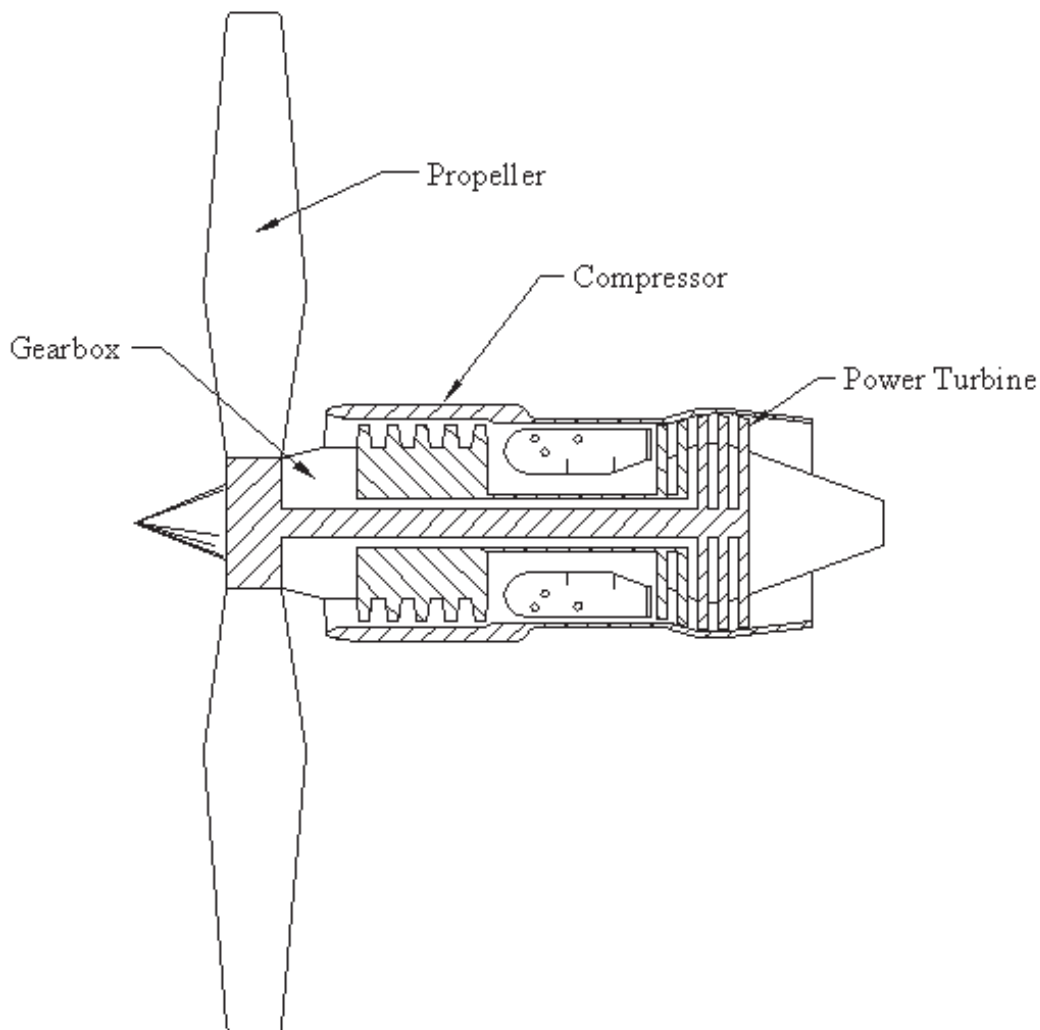
**Fig. 3**  
**Dual Spool Turbojet Engine**

Fig. 3 shows a dual spool turbofan engine. In this engine a turbine wheel is placed behind the primary turbine and is used to drive the first stage compressor. This engine has the advantage of being capable of producing much higher compression ratios since the first stage (low pressure section) forces a large amount of air into the high pressure section. This type of turbojet engine produces more thrust for a given diameter than a single spool engine and is desirable for fuselage-mounted engines.



**Fig. 4**  
**Triple Spool Turbofan Engine**

The sole purpose of the turbine in a turbojet engine is to drive the compressor. In a turbofan engine, a second turbine, behind the one that drives the compressor, is used to drive a ducted fan on the front of the engine. The fan rotates at a considerably slower speed than the core engine and is considerably larger in diameter. The thrust produced by the fan greatly increases the total thrust produced by the engine. Usually the fan on a high bypass engine will produce two to four times the thrust that the core engine produces. The efficiency of the fan is considerably higher than the core engine. (It is more efficient to move a large amount of air at low velocity than it is to move a small amount of air at high velocity.) Both the fan and the core engine produce thrust.

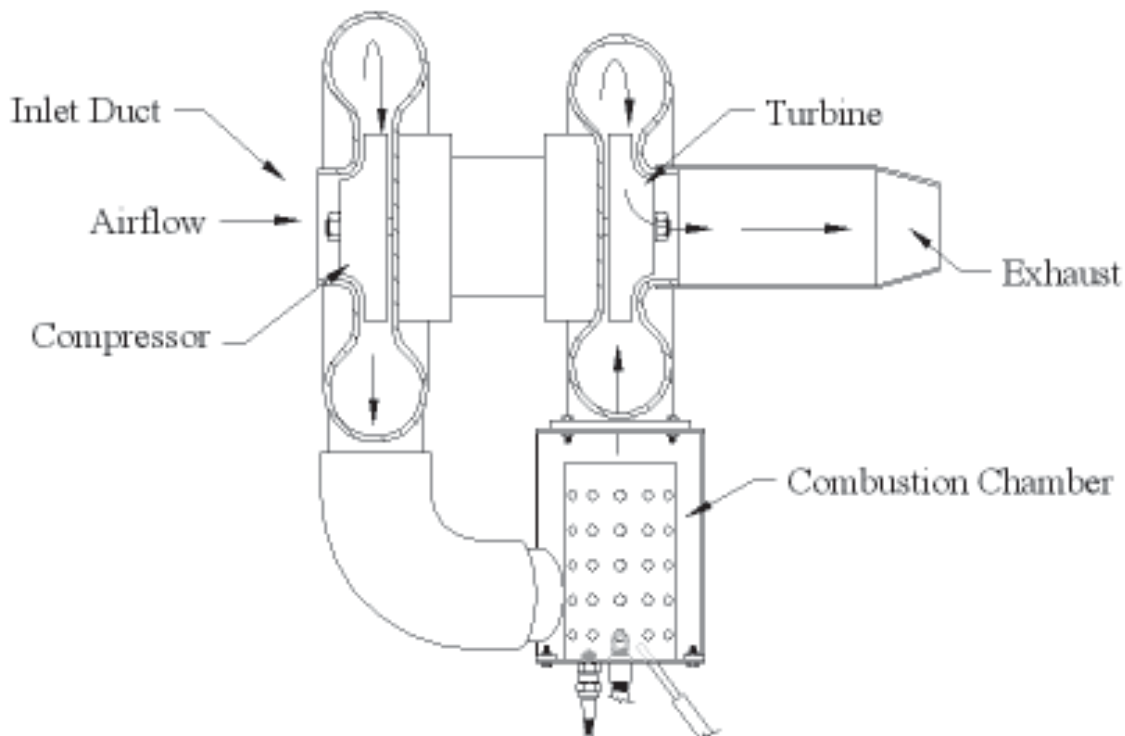


**Fig. 5**  
**Turbofan Engine**

The turboprop engine in Fig. 5 uses a turbojet engine as a core engine with the hot exhaust gasses directed toward a power turbine. The power turbine is connected to a propeller by means of a reduction gear. This system takes advantage of the relatively high efficiency of the propeller and the smoothness and light weight of the turbojet engine. In this configuration the thrust provided by the turbojet core engine is almost entirely used to drive the propeller. A gear reduction is required since most propellers do not exceed about 2,400 rpm. The core engine can be operating at 30,000 to 40,000 rpm.

Speed mismatch is a problem in the turboprop and turbofan engine design. The propeller is designed to operate at a speed less than the speed of sound (mach 1) while the core engine usually operates at a speed in excess of 30,000 rpm. A gear reduction is required to match speeds.

Propellers are designed to operate with a tip speed less than the speed of sound. Usually a design speed of around .8 mach is best. If the propeller is allowed to operate at a speed greater than mach 1, the efficiency of the propeller decreases dramatically. And since the speed of sound decreases with a decrease in temperature, the actual speed of sound at 25,000 feet may be several hundred rpm less than at sea level. Thus severe altitude limits are set on the turboprop powered aircraft.



**Fig. 6**  
**Turbocharger Turbojet Engine**



The turbocharger jet engine in Fig. 6 uses the compressor and turbine from a common turbocharger. The turbocharger compressor serves the same function as the compressor on a commercial jet engine. The turbine on the turbocharger drives the compressor and the excess energy is expelled out the exhaust nozzle to provide thrust. The lower portion of the drawing shows the combustion chamber attached to the turbocharger. The combustor liner (with the holes), does not go all the way to the bottom of the combustor. Enough air is allowed to go into the burner to allow the correct fuel to air ratio and the rest is used as cooling air in the turbine. Without this cooling air, the turbine would get too hot and melt the blades. The blades are generally made from Hastalloy, a nickel alloy, and can handle temperatures in excess of 2,000 deg. F. without damage.

### **Cost and efficiency**

Early turbojet engines consumed large amounts of fuel and did not produce high power output. Their weight to power ratio was poor. They would consume 1.2 to 1.5 pounds of fuel per hour for every pound of thrust they produced. Today's turbofan engines consume as little as .25 pounds of fuel for each pound of thrust produced. This is far less than the best piston engines in use. We estimate that the homebuilt turbojet engine will use about 1 pound of fuel for each pound of thrust produced. This is not high efficiency, but when you consider the construction cost compared to a commercial jet engine the result is remarkable. \$500.00 dollars would hardly buy an igniter for a commercial jet engine.

Chapter 2  
**Selecting a  
 TURBOCHARGER**

When selecting a turbocharger to build your turbojet, a large truck turbocharger is best. Large turbochargers move large amounts of air. More air equals more mass flow! More mass flow equals more fun!

The following table (T-1) can be used to estimate the static thrust produced by a small radial turbojet engine with a centrifugal compressor inducer diameter of 1.5” to 4.25”. Inflow air velocity is assumed to be .4 mach at sea level and standard conditions. It is assumed that enough fuel is used to produce a choked nozzle velocity of at least mach 1. Inflow air is calculated at a weight of 0.07647 lbs/cu.in. This is a theoretical approximation and requires that enough energy be provided to produce appropriate mass flow.

Inducer Diameter	Area (sq. in)	Area (sq. ft.)	Airflow (cu.in./sec.)	Airflow (cu.ft./min)	Massflow (lbs./sec)	Thrust (lbt)
1.5"	1.77	0.0123	12.27	736.31	0.94	37.89
1.75"	2.41	0.0167	16.70	1002.20	1.28	51.57
2.00"	3.14	0.0218	21.82	1309.00	1.67	67.35
2.25"	3.98	0.0276	27.61	1656.90	2.11	85.25
2.50"	4.91	0.0340	34.09	2045.31	2.61	105.24
2.75"	5.94	0.0412	41.25	2474.82	3.15	127.34
3.00"	7.07	0.0491	49.09	2945.24	3.75	151.55
3.25"	8.30	0.0576	57.61	3456.57	4.41	177.86
3.50"	9.62	0.0668	66.80	4008.80	5.11	206.27
3.75"	11.04	0.0767	76.70	4601.94	5.87	236.79
4.00"	12.57	0.0873	87.27	5235.98	6.67	269.42
4.25"	14.19	0.0985	98.52	5910.93	7.53	304.15

Note: The inducer diameter is the smallest opening inflow air must pass through to enter the compressor.

**T-1**

The following table (T-2) gives the approximate choked nozzle static thrust in pounds (lbt) for varying inflow velocities with a known inducer diameter.

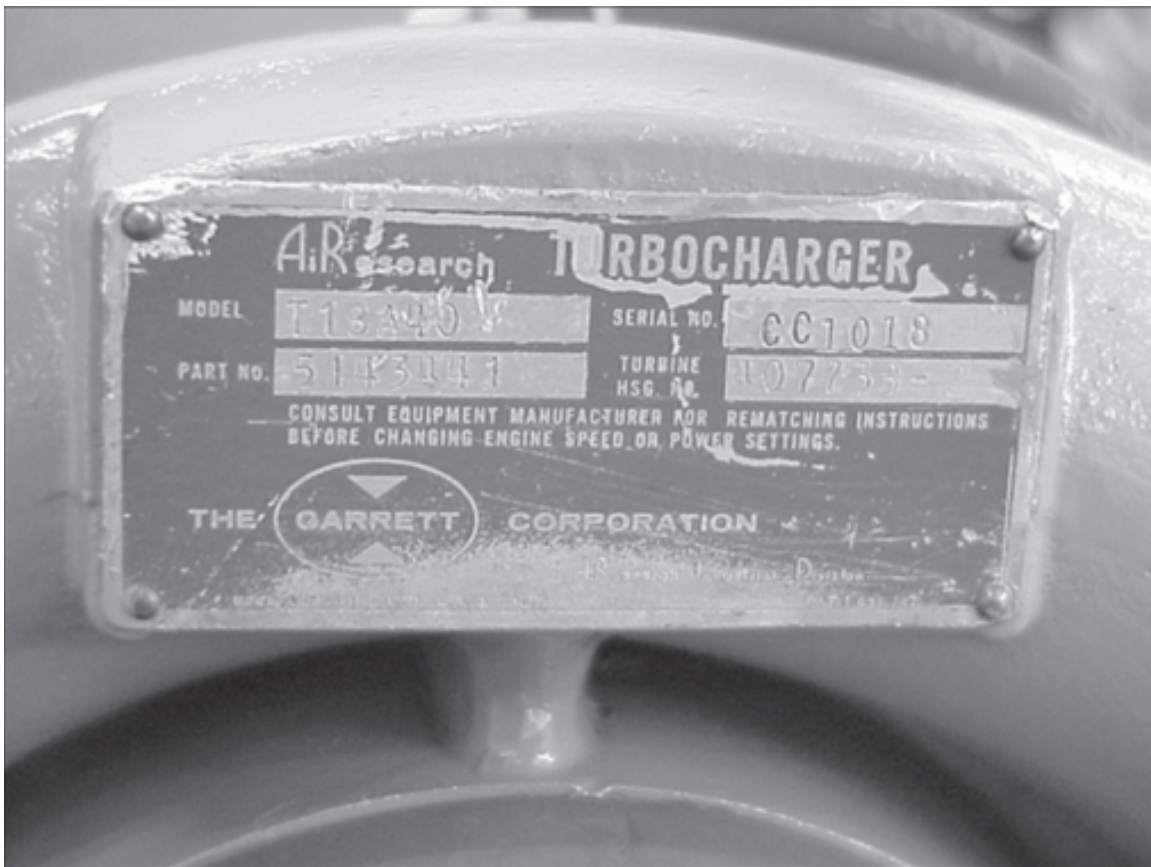
Inducer Diameter	600 fps	700 fps	800 fps	900 fps	1000 fps
1.5"	22.73 lbt	26.52 lbt	30.31 lbt	34.10 lbt	37.89 lbt
1.75"	30.94 lbt	36.10 lbt	41.25 lbt	46.41 lbt	51.57 lbt
2.00"	40.41 lbt	47.15 lbt	53.88 lbt	60.62 lbt	67.35 lbt
2.25"	55.15 lbt	59.67 lbt	68.20 lbt	76.72 lbt	85.25 lbt
2.50"	63.14 lbt	73.67 lbt	84.19 lbt	94.72 lbt	105.24 lbt
2.75"	76.41 lbt	89.14 lbt	101.87 lbt	114.61 lbt	127.34 lbt
3.00"	90.93 lbt	106.08 lbt	121.24 lbt	136.39 lbt	151.55 lbt
3.25"	106.71 lbt	124.50 lbt	142.29 lbt	160.07 lbt	177.86 lbt
3.50"	123.75 lbt	144.39 lbt	165.02 lbt	185.65 lbt	206.27 lbt
3.75"	142.08 lbt	165.75 lbt	189.43 lbt	213.11 lbt	236.79 lbt
4.00"	161.65 lbt	188.59 lbt	215.53 lbt	242.48 lbt	269.42 lbt
4.25"	182.49 lbt	212.90 lbt	243.34 lbt	273.73 lbt	304.15 lbt
4.50"	204.59 lbt	238.69 lbt	272.79 lbt	306.88 lbt	340.98 lbt

### T-2

Although there is no exact correlation between horsepower and thrust, one horsepower will produce approximately 2.5 lbs. static thrust.

We recommend a truck turbocharger such as the Garrett T-18A. These were used on trucks and large stationary diesel engines. They are common and usually can be obtained for \$100.00 or less. Check out the truck wrecking yards. Small automotive turbochargers are not as adaptable since they quite often have special flanges and strange configurations that make mounting the combustion chamber difficult.

Inspect the turbocharger carefully. Don't let a little rust discourage you. Look in the turbine end and notice the tips of the turbine blades. If they are burned or missing, the unit may be out of balance. Very slight burning will not have much affect on overall performance. Grab the compressor shaft and move it up and down. Some radial play is permissible. End play is critical and very little can be tolerated.



**Fig. 7**  
**Garrett Turbocharger**

Fig. 7 shows an AiResearch T-18A series turbocharger. They are large, very common and usually inexpensive. Truck wrecking yards usually have more than a few. Check the unit very carefully. Make sure that the turbine and compressor turn freely. If the unit has been overheated there will be signs of heat discoloration on the turbine wheel and turbine housing.

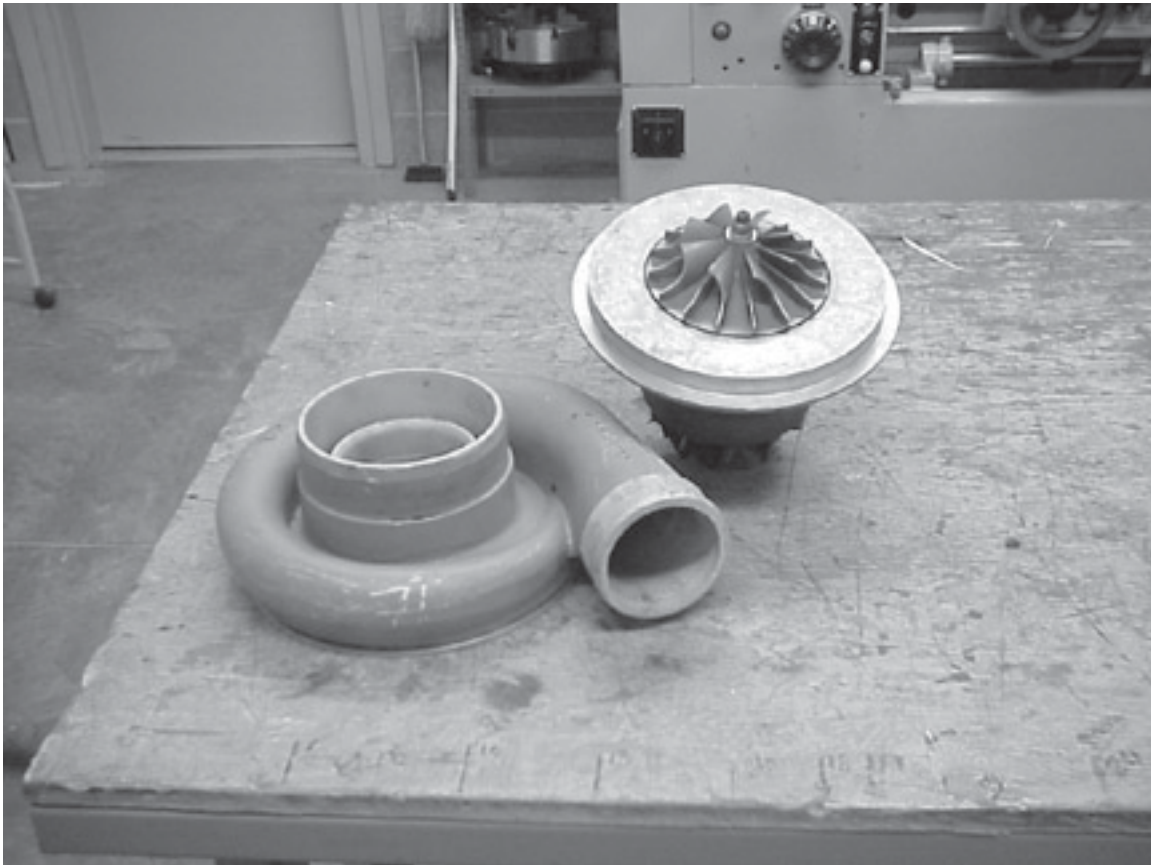
Check the castings for cracks or lumps. If a foreign object has entered the compressor and broken a blade, it will likely fly apart and damage the case. The compressor housing is made from aluminum alloy and is easily broken. The turbine housing is made from malleable cast iron and is quite tough. They are rarely damaged.

## Chapter 3

### Examination of

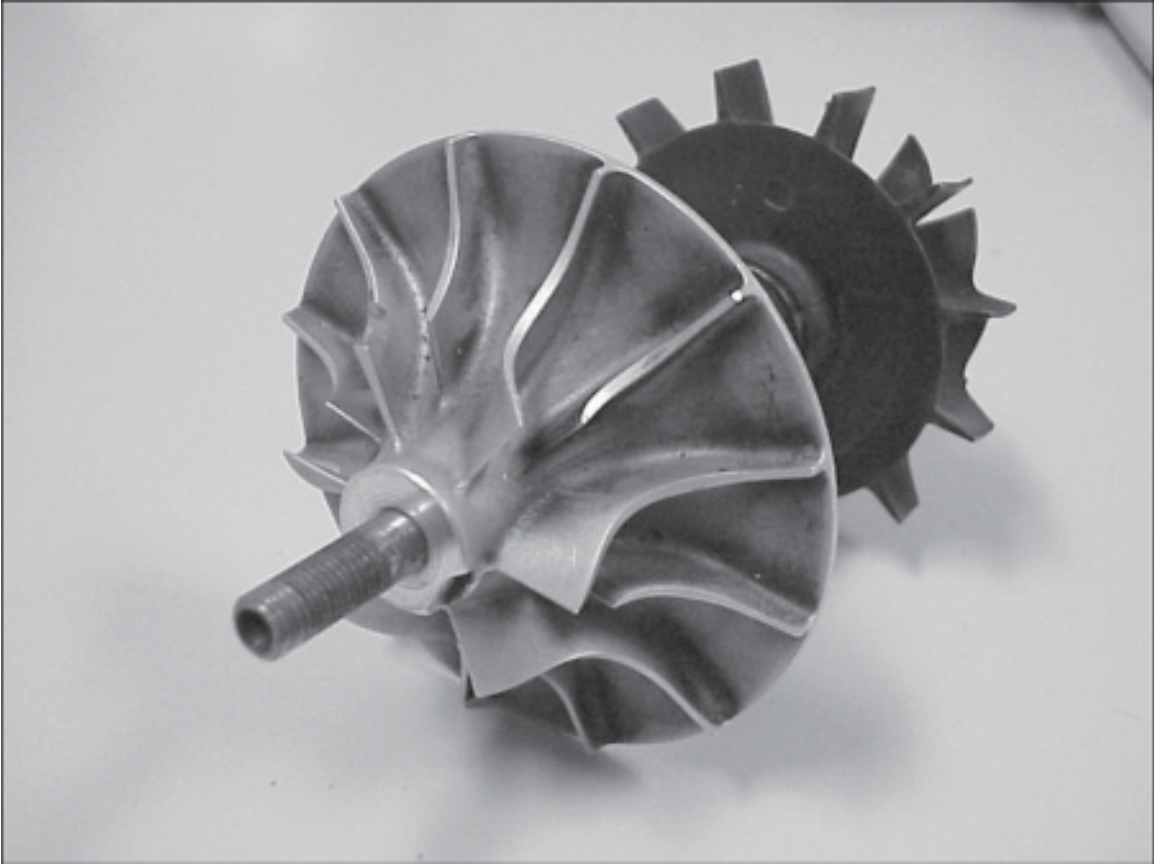
# THE TURBOCHARGER

Turbochargers, used on gasoline and diesel engines contain both a rotary air compressor and an exhaust gas driven turbine. The turbine is connected to the compressor by a drive shaft. Hot exhaust gasses from the engine drive the turbine wheel which, in turn, drives the compressor that forces pressurized air into the engine. By adding a turbocharger, the output of an internal combustion engine can be increased by 50%, or more.



**Fig. 8**  
**Turbocharger**

Fig. 8 shows a Garrett T-18A compressor with the housing removed. Notice the bent blades on the compressor near the center. These are the inducer vanes that draw air into the compressor inlet. Once air is drawn in, centrifugal force throws it to the outer edge where it is accelerated in the direction of rotation. It then moves to the outlet in the housing and passes on to the engine intake manifold.

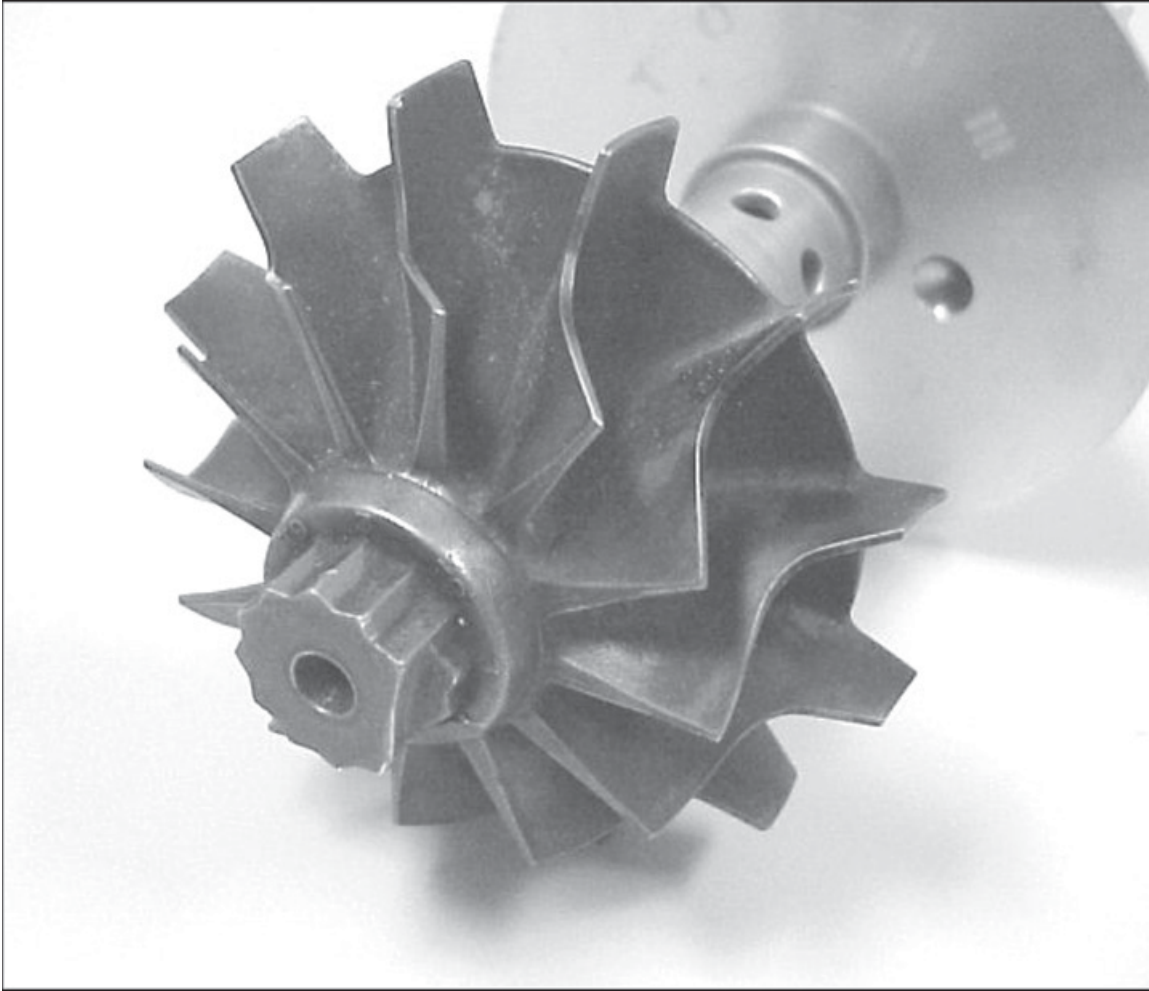


**Fig. 9**  
**Compressor**

### **Turbocharger Compressor**

The compressor on the turbocharger serves the same function as the compressor on the turbojet engine. It is used to compress a large amount of air into a small space and increase pressure. The compressor wheel turns at a very high speed; usually between 45,000 and 125,000 rpm. The larger truck turbochargers turn about 75,000 rpm. The compressor wheel is usually made from an aluminum alloy. It does not run at a high temperature so aluminum works fine. The temperature of the air will increase 200 to 400 deg. F. in the compressor. The compressed air exits the compressor into a diffuser. This is usually a casting that increases in area so that the air will be slowed down and the pressure will increase.

The compressor end contains the impeller. It is usually an investment casting of aluminum alloy. The blades should all be intact and not bent excessively. The curved portions of the blades near the center are called the inducer vanes and are used to draw air into the compressor where the radial blades accelerate it. The air then passes into the snail shaped housing called the diffuser.

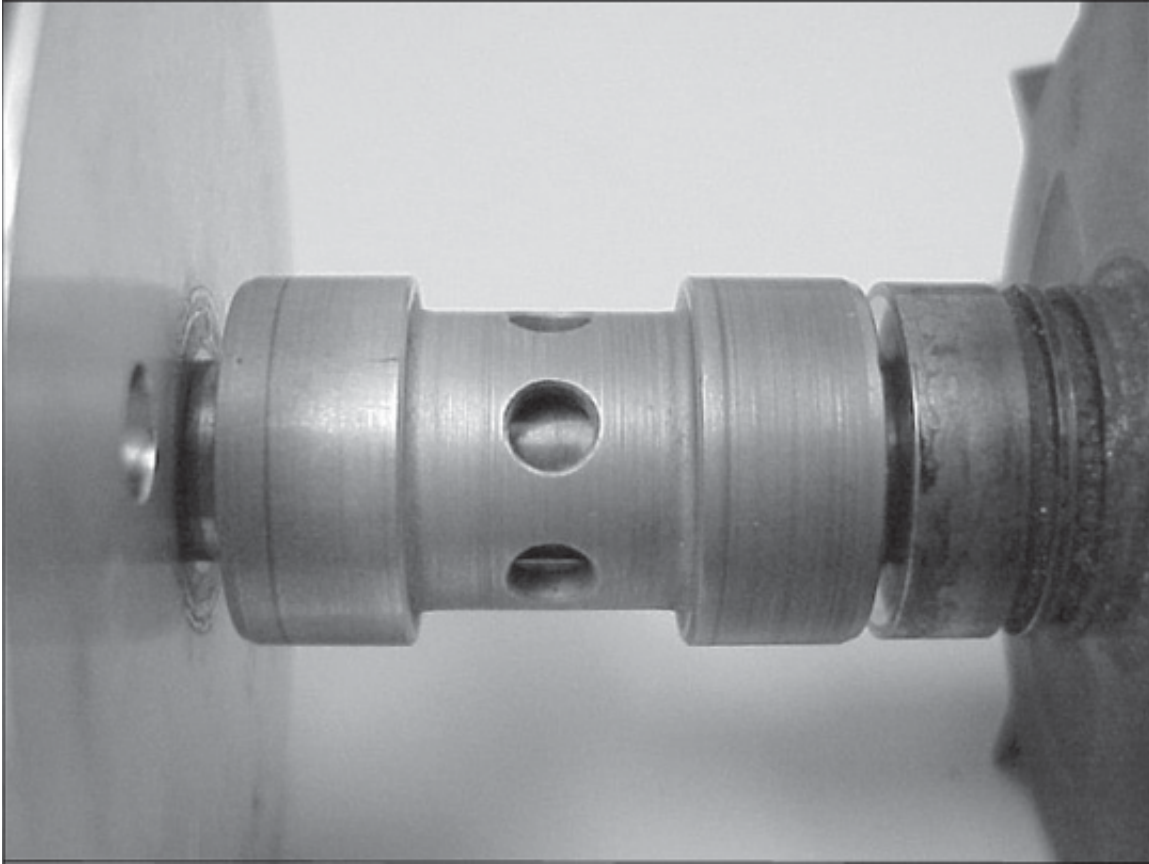


**Fig. 10  
Turbine**

### **The Turbine**

The turbine is located at the rear of the turbocharger inside a snail housing. The turbine is a radial inflow design. The snail housing is designed to increase the velocity of the inflowing air so that it strikes the turbine blades, at high velocity. The inflowing high speed air strikes the tips of the turbine blades causing the turbine to rotate at very high speed. The turbine wheel has angled blades near the outlet and is designed to exhaust the hot gases to the rear. Gas temperature at this point is about 1,800 deg. F. The turbine wheel is usually cast from Hastalloy or some other nickel alloy.





**Fig. 11**  
**Bearing**

### **The Drive shaft and Bearing**

The turbine drives the compressor by means of a drive shaft; usually a very short, small diameter shaft that is friction welded to the turbine wheel and bolted to the compressor. The shaft runs through an aluminum bearing.

Most modern turbochargers use hydrodynamic bearings as shown in Fig. 11. This is an alloy sleeve bearing with design tolerances that allow a layer of oil between the shaft and the bearing. When the turbocharger is running, the oil supply is under pressure and the shaft rides on a layer of oil and does not touch the alloy bearing. The shaft is suspended on a layer of oil. The thrust bearing on the turbine end rides on a layer of oil and is cooled by oil. The turbine end bearing runs extremely hot, usually about 1,800 deg. F. Large quantities of oil must be circulated to provide adequate cooling.

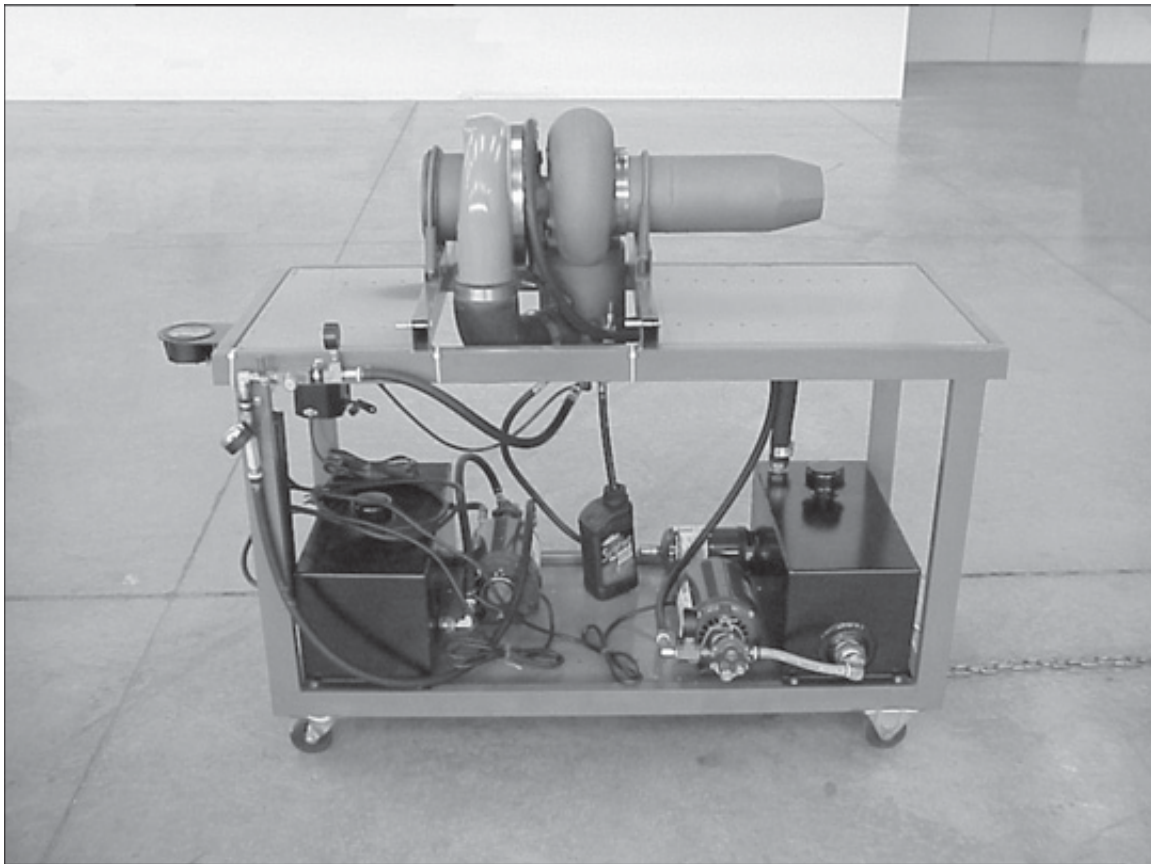
## Chapter 4

### **Constructing the TURBOCHARGER TURBOJET ENGINE**

Once you have chosen a turbocharger the next step is to plan how to build the combustion chamber and how to mount the turbocharger to the test stand. Since there is very little vibration, the turbocharger can be mounted solidly to the test stand.

Turbojet engines operate at high temperatures and produce considerable thrust. A test stand must be constructed in such a manner that it can be fastened to a solid anchor of some sort. We welded a chain to the exhaust end so that it could be fastened to the floor. A welded steel test stand that will support the engine at a reasonable working height and support it while running, is shown.

Some method must be used to mount the turbocharger to the test stand. We used a pair of muffler clamps from the truck repair shop. They are mounted to the test stand using 1" x 2" square tube. The turbo must be secure so it will not move when running.



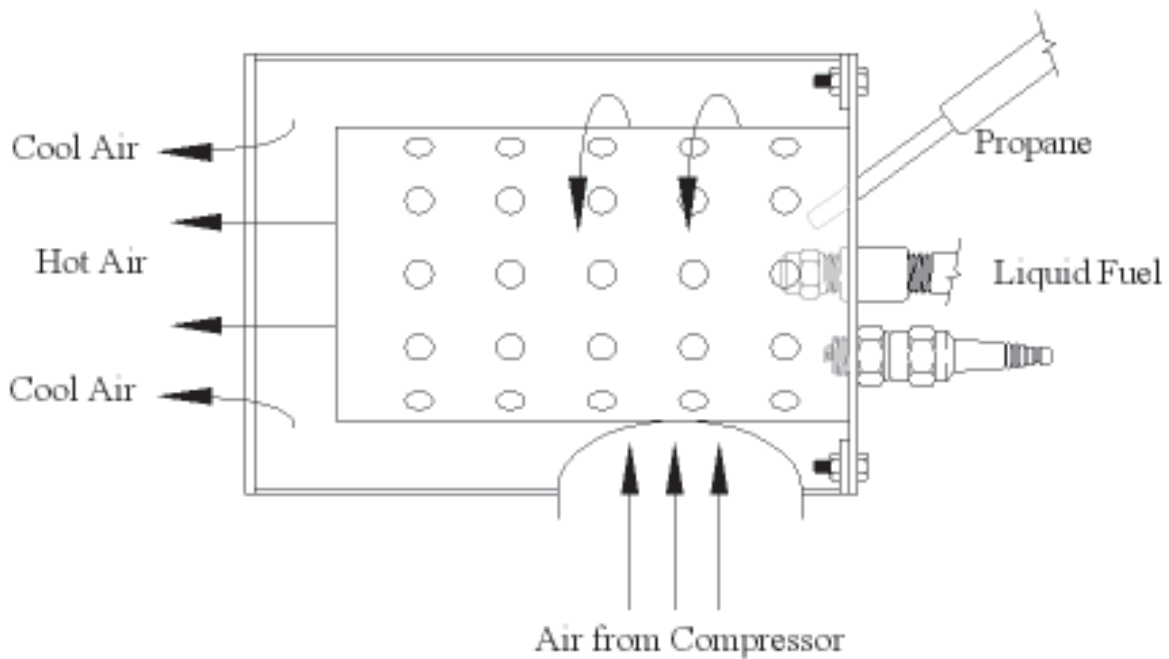
**Fig.12**  
**Jet Engine on Test Stand**

The stand is constructed from 1" x 2", .067" steel tube. The top and bottom steel trays are shelves from a steel shelving unit. Four casters are welded to the bottom corners. The lower shelf holds the oil and jet fuel tanks, as well as the pumps and motors. The important thing is that the stand be substantial and not collapse under stress. The exact dimensions are not important as long as it will hold all of the parts required. The stand shown in the picture works very well.

Chapter 5  
**Construction of the  
COMBUSTION CHAMBER**

The combustion chamber is the key element of the engine. This is where fuel is mixed with compressed air and burned, causing the air to expand and drive the turbine wheel. A shield called a “combustion liner” is designed to allow some air to mix with the fuel and burn, while the remainder of the air is used to cool the steel parts.

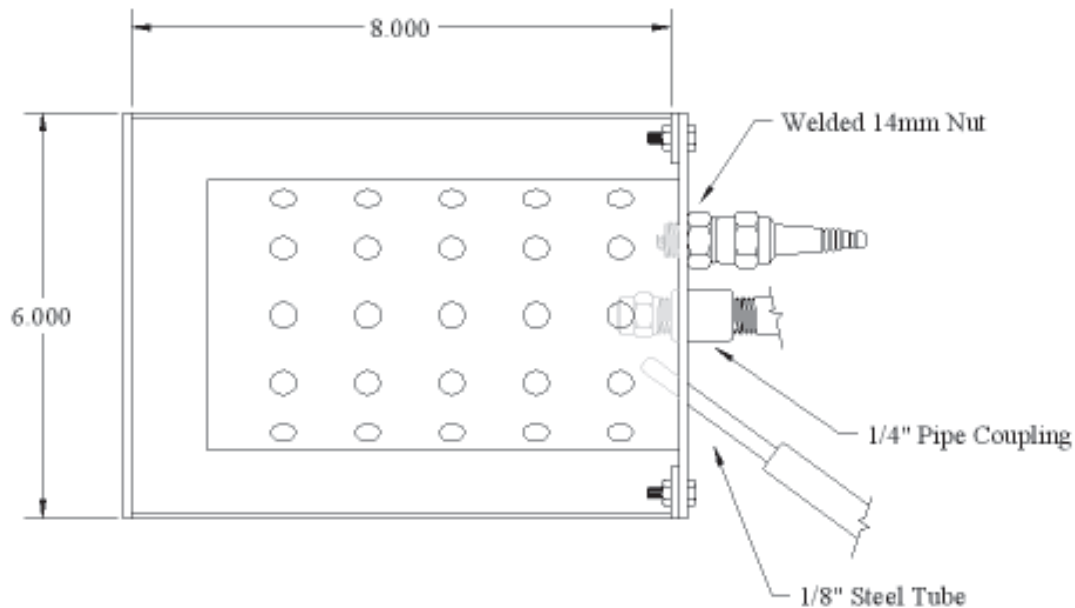
An analogy would be the windproof design of the Zippo lighter. The holes in the combustion liner are adjusted to allow the right amount of air to mix with the fuel so that combustion can occur. If the holes are too large, the incoming pressurized air will blow out the flame. If the holes are too small, there will not be enough oxygen to support combustion. If the holes at the fuel inlet end are too small, the flame will have to travel down the combustion liner until enough oxygen has entered to support combustion. This will cause the combustion to occur in the inlet to the turbine and overheat the turbine.



**Fig. 13**  
**Combustion Chamber Airflow**

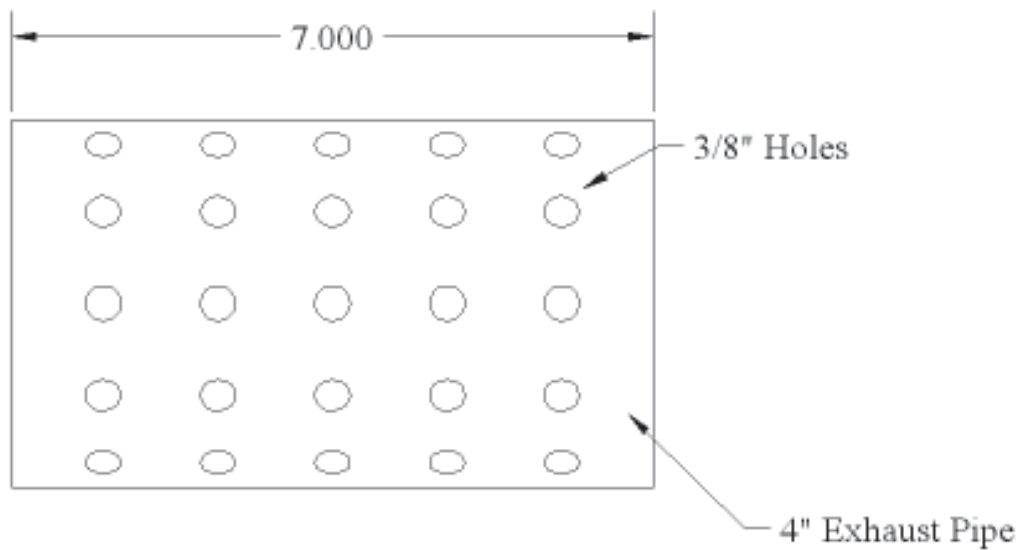
As you can see, the holes in the combustion liner are critical. They can best be determined by trial and error. The holes shown are what we used and are a good starting point. More holes can be drilled as needed.

The combustion liner does not extend to the bottom of the combustion chamber. Excess air passes around the liner and continues into the turbine housing. This forms a layer of cool air around the hot gas entering the turbine. We drilled a hole in the turbine housing and inserted a thermocouple. The air in the first 1/4" measured 250 deg. F., while the air near the center rose to nearly 2,000 deg. F.



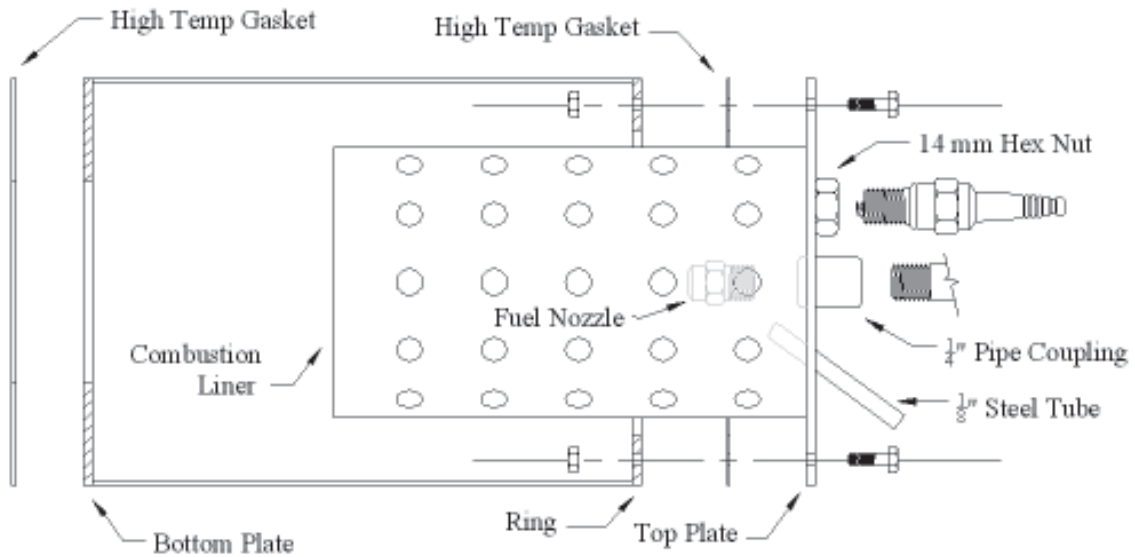
**Fig. 14**  
**Combustion Chamber Diagram**

The combustion chamber is constructed from truck exhaust tubing, which can be purchased at most truck repair shops. The outside of the chamber is 6" diameter tubing 8" long. A 1/8" thick ring is welded to the top end and a 1/8" plate to the other end. Fig. 14 shows the position of the parts.



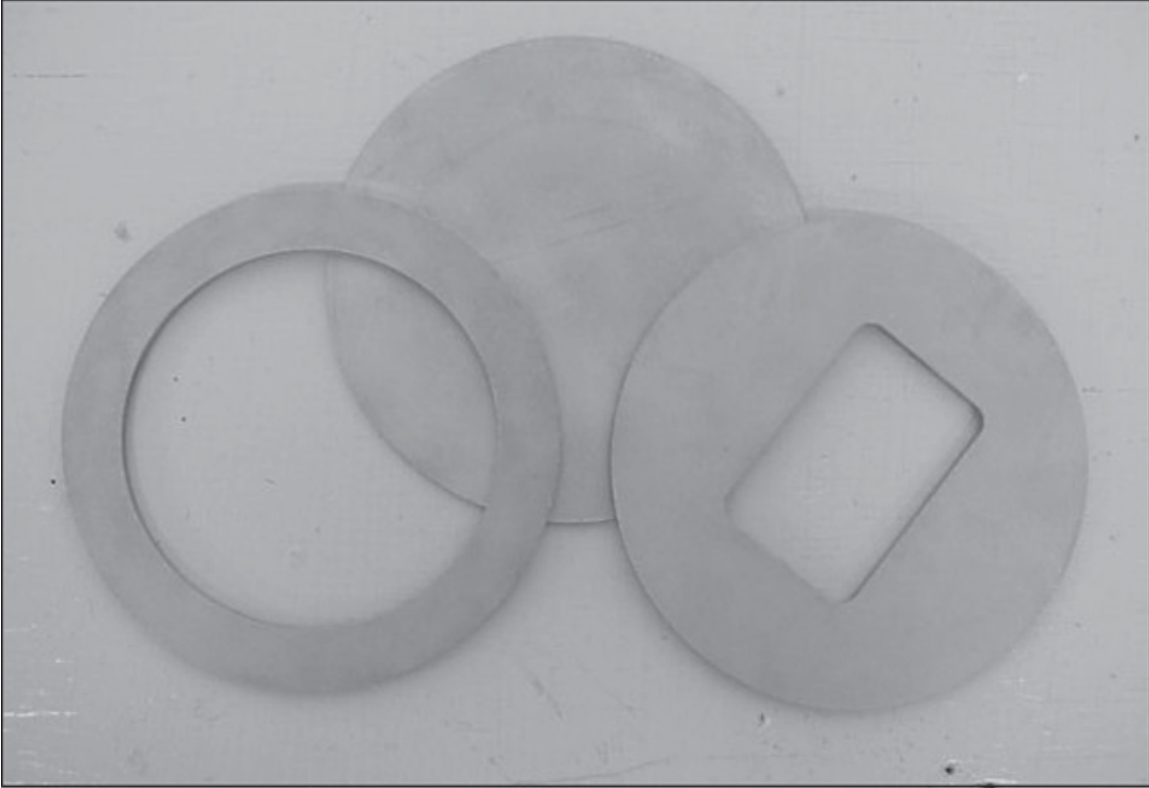
**Fig. 15**  
**Combustion Liner**

The combustion liner, shown in Fig. 15, is made from a piece of 4" diameter exhaust tubing 7" long with holes drilled as shown in the drawing. The holes should be drilled approximately 1 1/2" on center. Precise placement is somewhat determined by experimentation.



**Fig. 16**  
**Combustion Chamber Assembly Schematic**

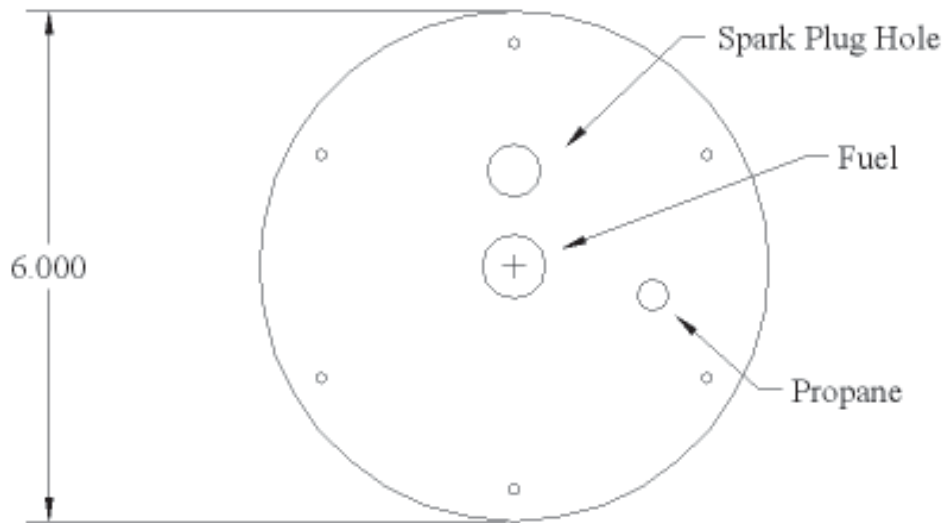
Fig. 16 is an assembly schematic of the combustion chamber. The bottom plate and the ring are welded to the 6" diameter exhaust tubing. The liner is spot welded to the top plate. Be very careful when welding not to warp the top plate. It must seal with a gasket or pressurized fuel and air will escape. Both the top and bottom gaskets can be high temperature gasket material from an automotive store. The 1/4" pipe coupling allows the fuel nozzle to be screwed into the lid. A 1/4" pipe nipple can be screwed into the other end. A 14mm nut is welded where you want the spark plug. This will allow the electrode to project through the lid just about the right amount. The 1/8" steel propane tube can be welded in place near the spark plug.



**Fig. 17**  
**Ring, Top Plate, and Bottom Plate**

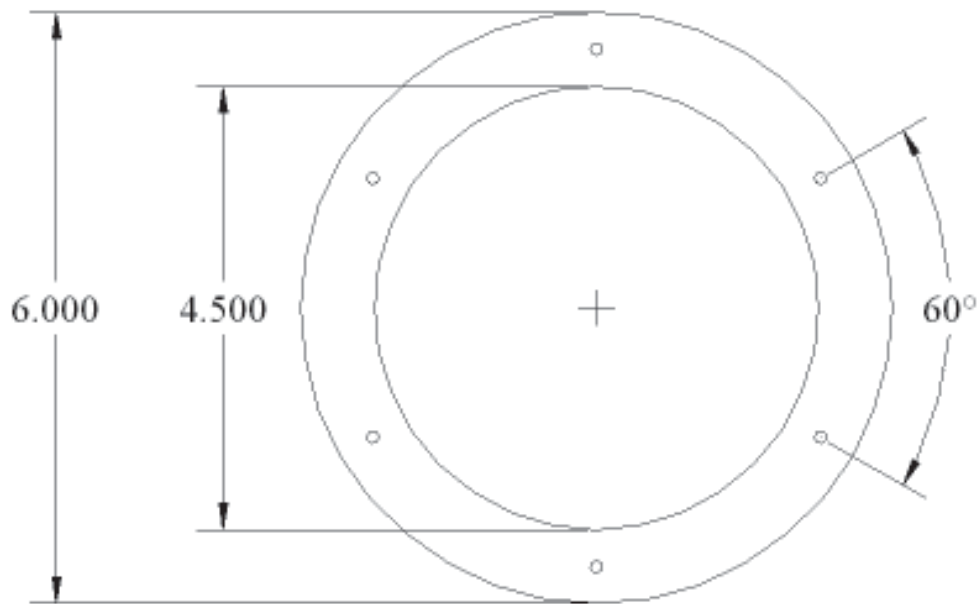
Fig. 17 shows three major components of the combustion chamber, the ring, top plate, and bottom plate. They are cut from 1/8" mild steel. The easiest way to make these is to take the drawing to a shop with a laser cutter or a plasma torch. They can be cut on a metal band saw, but this is a lot of work. If you do decide to cut them by hand don't use a torch, it may cause them to severely warp and not seal correctly. The combustion chamber is designed in such a manner that the top plate is held on by six 10-32 Allen head screws.





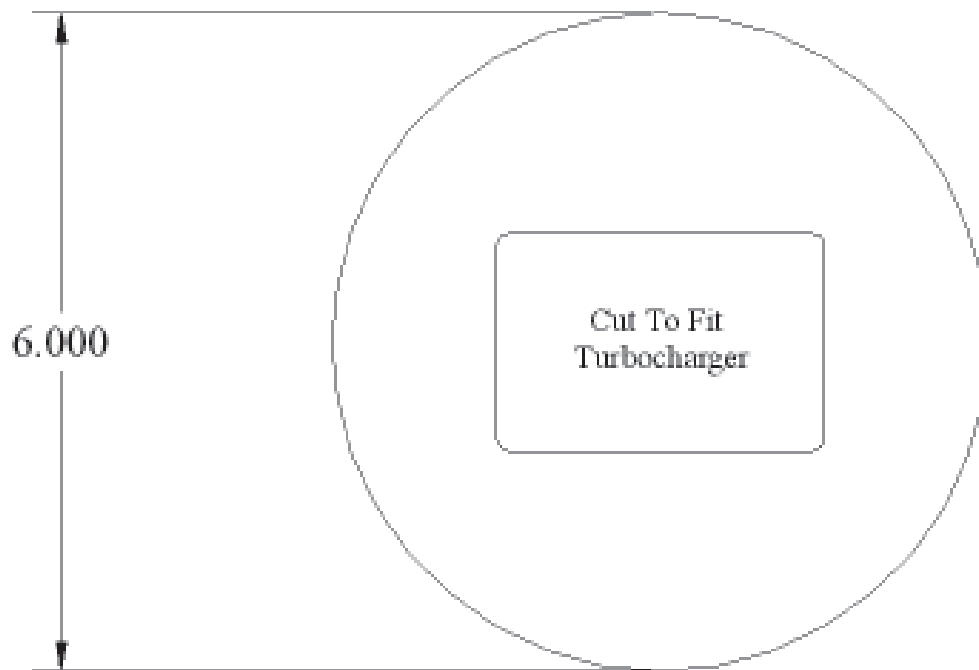
**Fig. 18**  
**Top Plate**

The top plate in Fig. 18 is drilled to accommodate the fuel inlet, spark plug, and propane inlet.



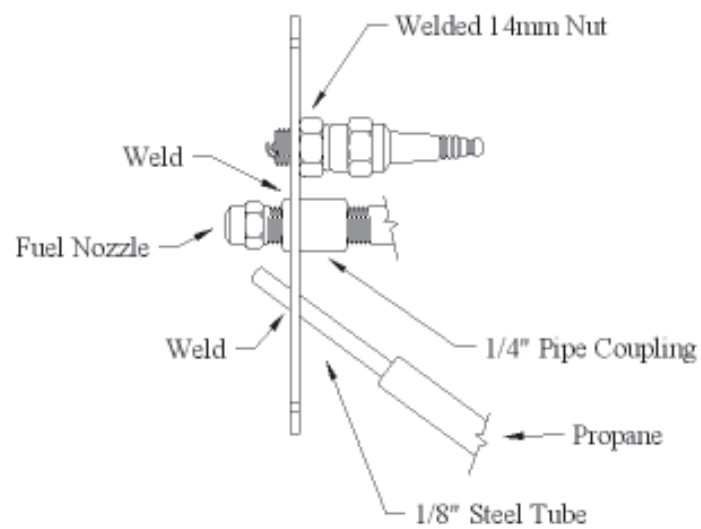
**Fig. 19**  
**Ring**

The combustion chamber top ring is shown in Fig. 19. Be sure to clamp the top plate and ring together when drilling your six holes to assure perfect alignment.

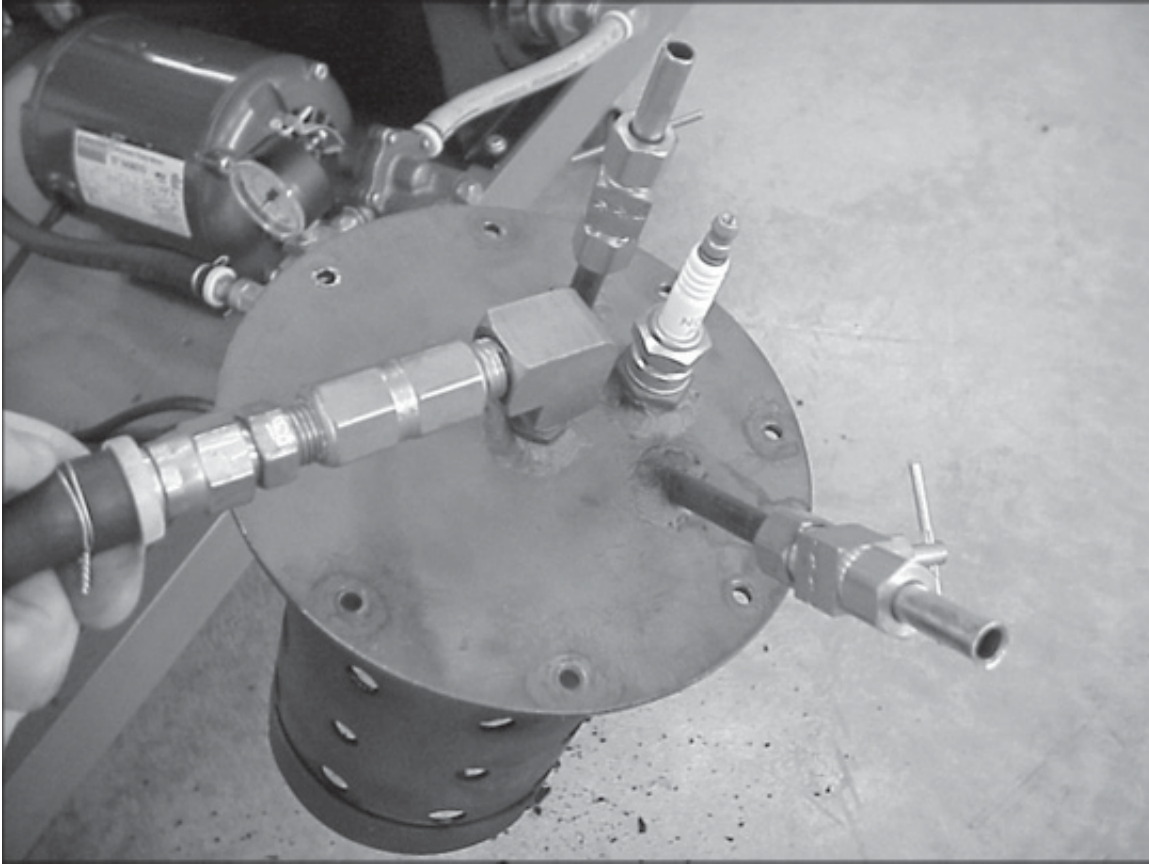


**Fig. 20**  
**Bottom Plate**

The bottom plate shown in Fig. 20 is cut to fit your particular turbocharger.



**Fig. 21**  
**Side View of Top Plate**



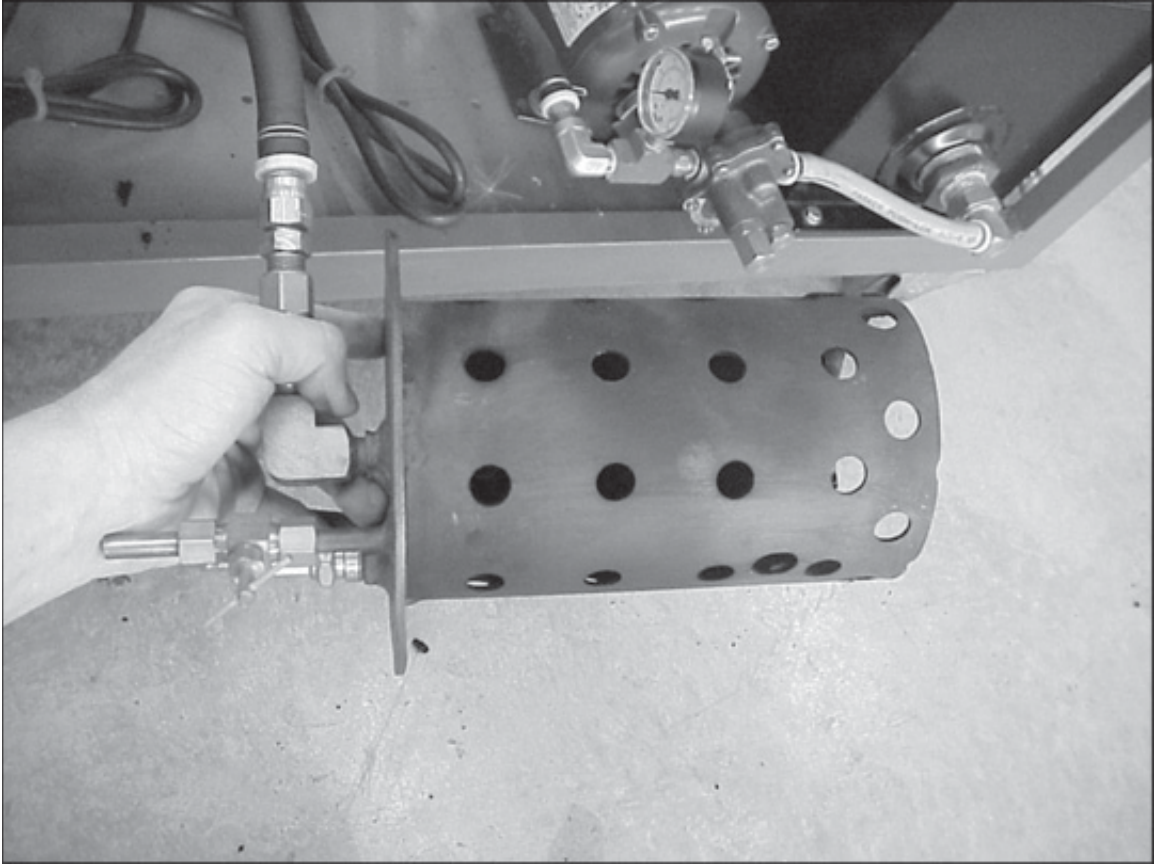
**Fig. 22**  
**View of Top Plate**

Fig. 22 shows the configuration we have use for the top plate. We have added a drain tube with a shut off valve to the bottom of the combustion chamber so that any fuel that accumulates can drain off. The exact position is not important just as long as it is near the low point. Too much fuel in the combustion chamber will create a lot of white smoke. It could also cause an uncontrolled startup. The propane allows a pilot flame to be used, which makes starting easier. Notice the check valve between the 90 deg. Fitting and the hose connector. This is used so that when the fuel is shut off, it will not dribble into the combustion can. When the fuel pressure is above 10 psi, the valve will open and fuel can flow to the nozzle. Fig. 21 shows a detailed side view of the components.



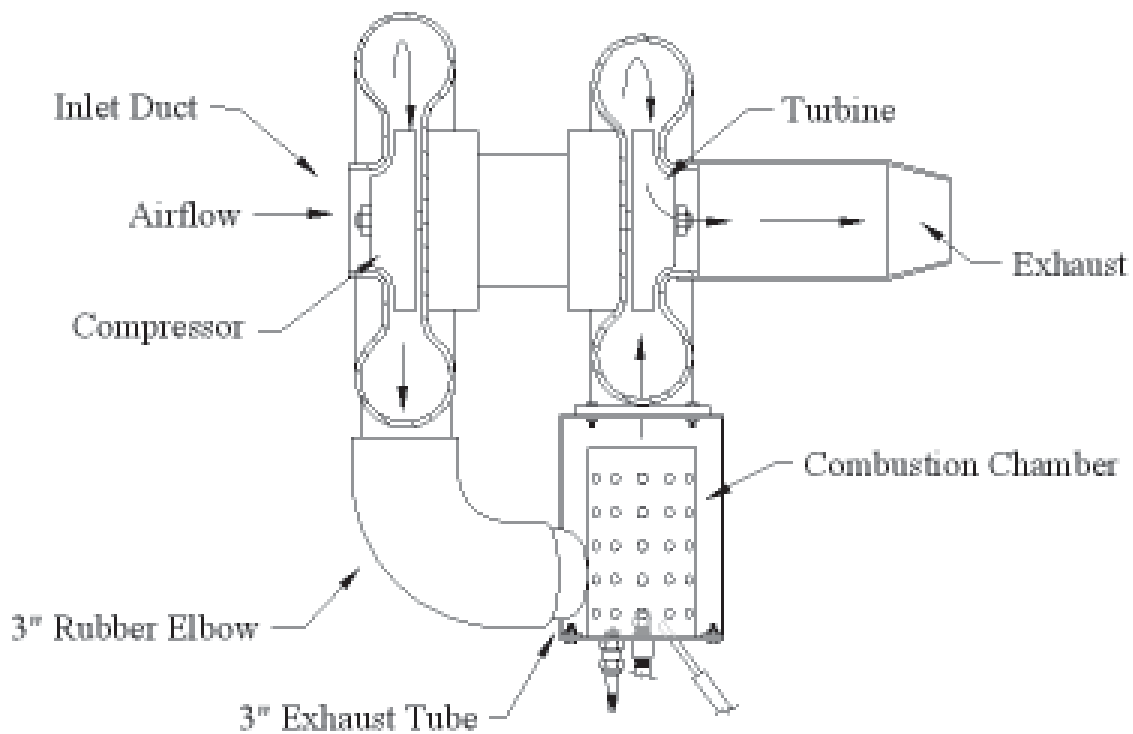
**Fig. 23**  
**Propane Pilot Flame**

Fig. 23 shows the propane pilot flame system. A piece of rubber hose is attached to a propane torch. The spark plug will ignite the propane. The small flame will assure the ignition of the fuel.



**Fig. 24**  
**Inspecting the Combustion Liner**

The holes can be adjusted after you have run the engine a few hours. Look for hot spots or carbon buildup. As you can see in Fig. 24 we added extra holes as necessary.

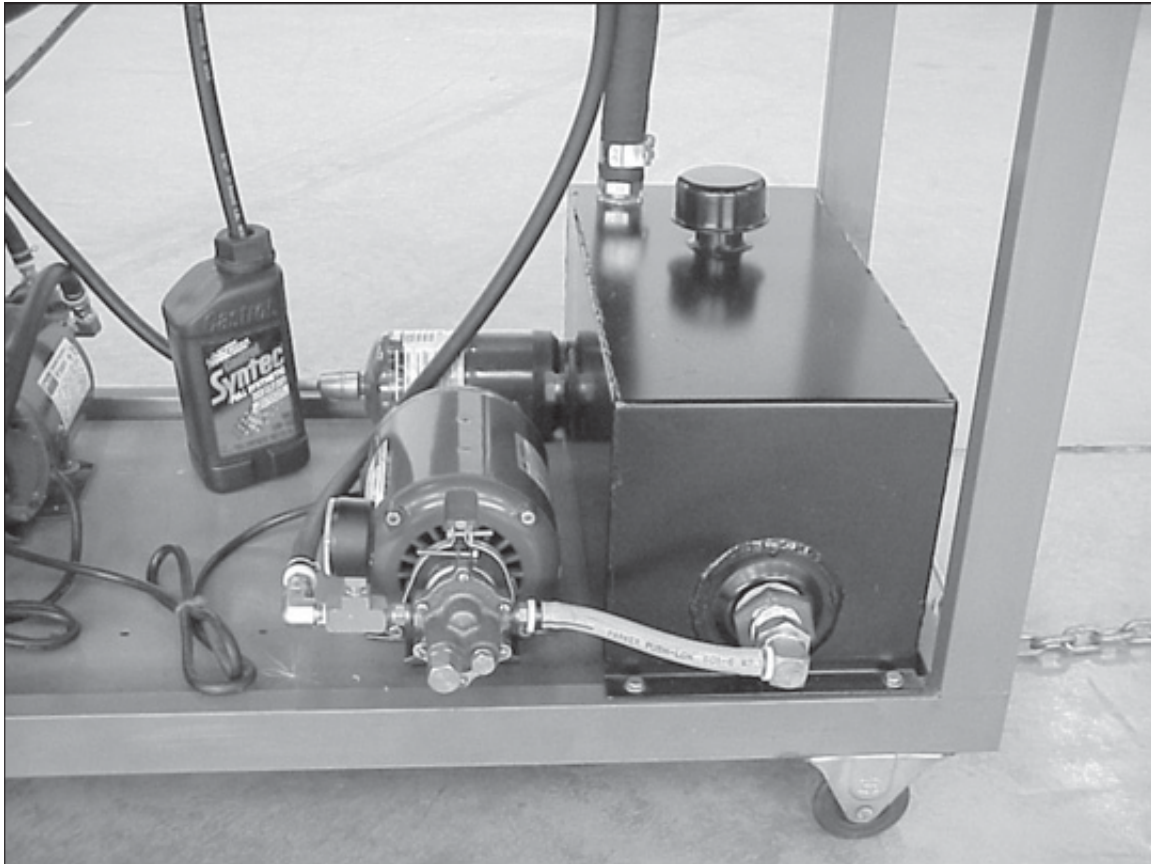


**Fig. 25**  
**Turbocharger Turbojet Engine Detail**

Fig. 25 shows the configuration of the turbocharger turbojet engine. Notice the three-inch exhaust tube welded to the side of the combustion chamber. This is the air inlet for the combustion chamber. A three-inch rubber elbow is attached to the exhaust tube, and compressor outlet by stainless clamps. These items are available at a local truck supply store. It is recommended that you mount the combustion chamber on the bottom of the engine. This prevents forgotten objects, such as bolts, nuts, etc. from falling into the turbine blades.

## LUBRICATION SYSTEM

Most turbochargers are equipped with hydrodynamic bearings. The bearing itself is a sleeve made from an aluminum alloy. The bearings are designed to have an excess of clearance on the turbine shaft. The bearing is flooded, under pressure, with light oil. The oil provides lubrication as well as cooling. When the turbocharger is running, the oil fills the gap between the bearing and shaft and the metal parts do not touch. This is an excellent bearing for this particular application since the turbine runs at extremely high temperatures and some sort of mechanism is needed to carry the heat away from the bearings. The oil gets very hot though.



**Fig. 26**  
**Lubrication System**



The oil pump, motor and tank can be seen on the right side of Fig. 26. Notice the large diameter oil return hose. The oil goes into the turbocharger bearings under about 45 lbs pressure and returns by gravity. The outlet cannot have any restriction and the oil must flow freely. Oil in the tank will get to several hundred degrees in about 15 minutes of running time.

The tank is a hydraulic tank from W.W. Grainger, which fits well and comes with a vented cap. It holds 5 gallons of oil. We used the same tank for the fuel. W.W. Grainger has a wire mesh filter for the large hole in the end.

We used a 5 gallon tank filled with Chevron Turbine Oil #GST ISO 32. The turbine oil will operate at high temperatures without producing excess carbon deposits. It will become quite hot after a half hour of running. This oil can be obtained from any oil distributor in 5 gallon cans.

The oil reservoir is from W.W. Grainger. It is a Dayton, 5 gallon hydraulic reservoir, Model 4Z980, with a vented cap. We used the same model tank for the jet fuel also.



**Fig. 27**  
**Oil Pump Tag**

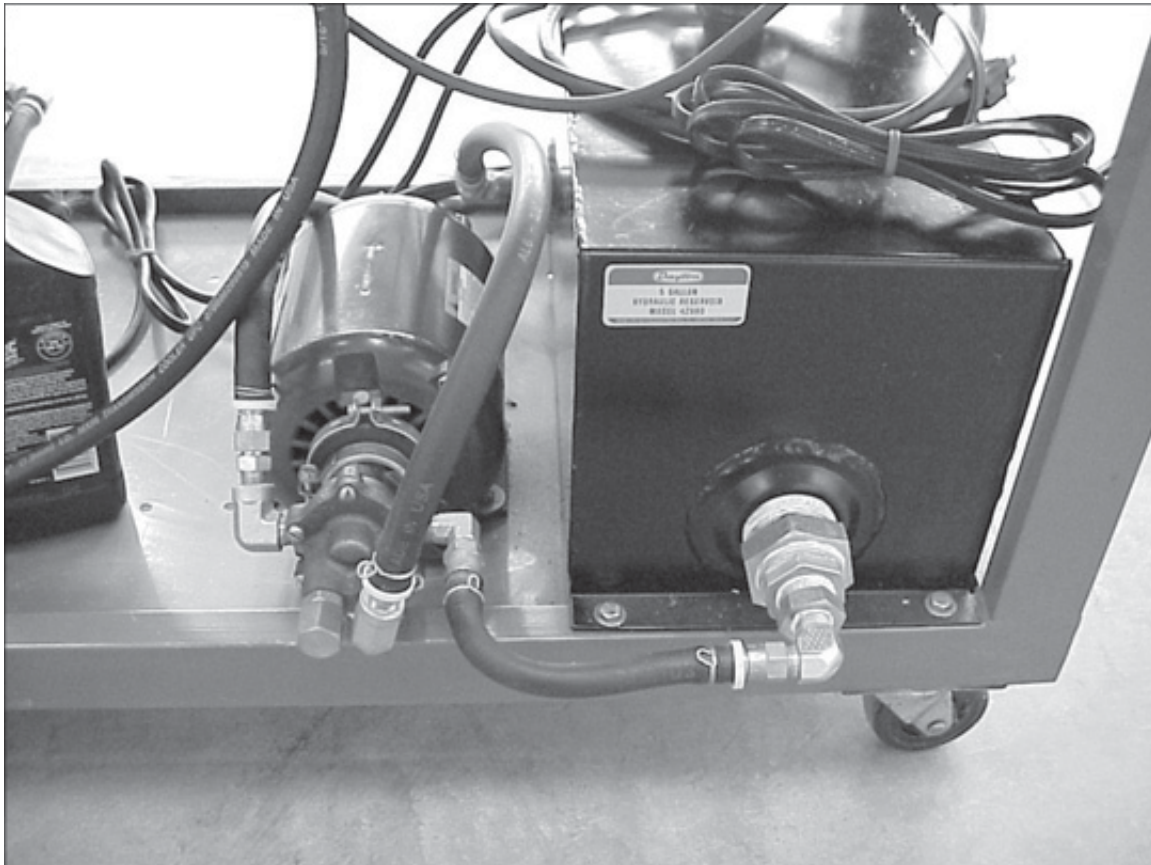
An oil pump that will produce about 25-45 lbs of pressure is required. We chose to use a Dayton Carbonator Pump and Motor Model #5K887D, which is equipped with a 1/3 hp 125 volt AC motor. The pump is normally used to dispense soda fountain products and pumps the oil very well in this application.

The same pump and motor are used for the fuel system. The pump is positive displacement and has a relief valve which needs to be adjusted. The instructions that come with the pump show how to do it.



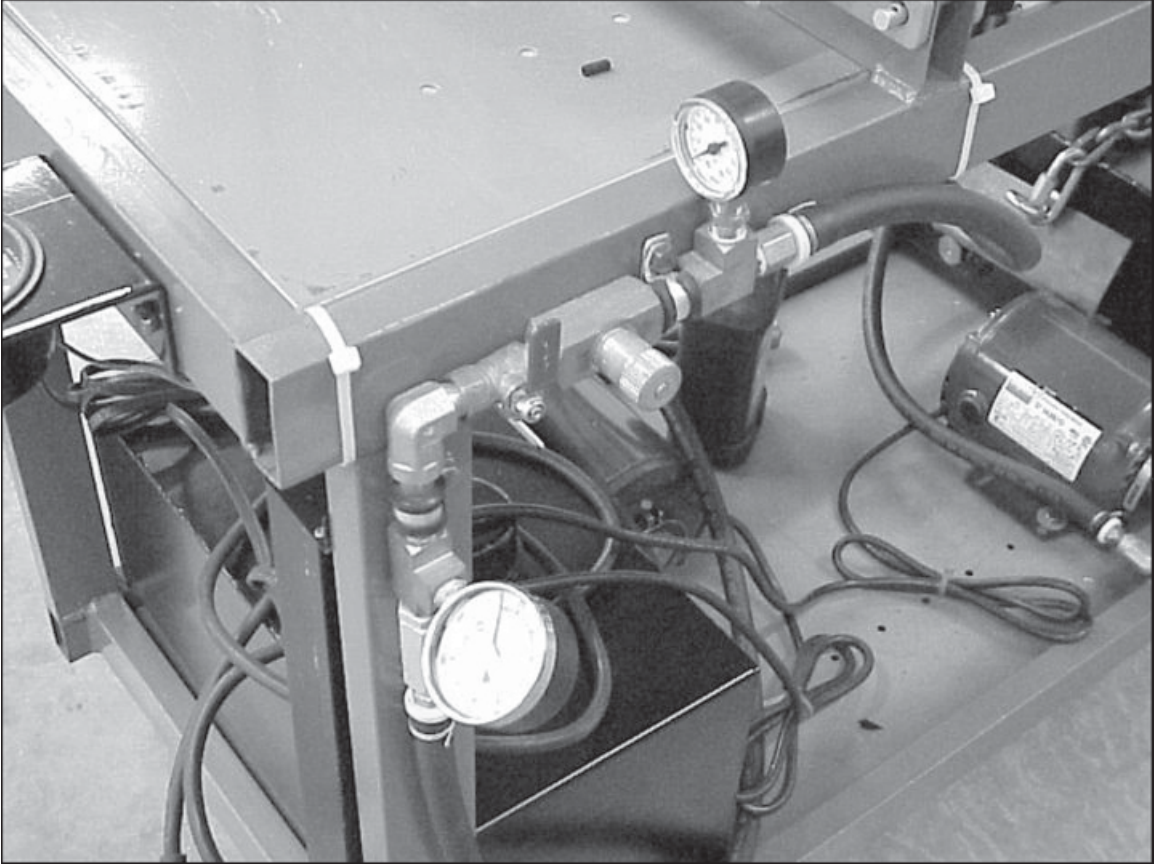
Chapter 7  
**FUEL SYSTEM**

The fuel system consists of a 5-gallon fuel tank, a gear driven fuel pump, a metering valve and a fuel nozzle.



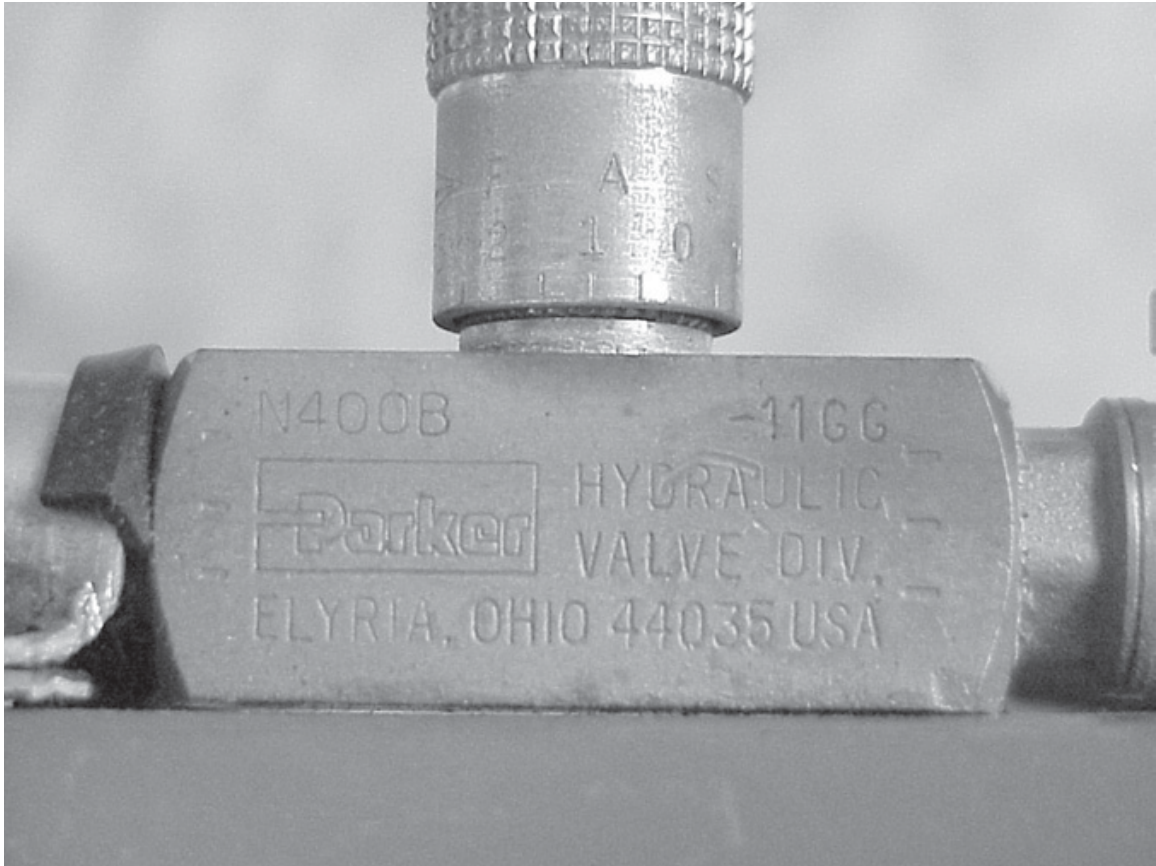
**Fig. 28**  
**Fuel System**

Fig. 28 shows the fuel pump and the fuel tank. Fuel is drawn from the tank into the pump. The pump has a return line to the tank since it is a positive displacement pump and is moving fuel all the time it is running. Any fuel that is not used by the engine is returned to the tank. The hose on the left side of the tank goes to the fuel control valve. The pump, motor, and tank are the same models used in the lubrication system. They can be purchased from W.W. Grainger.



**Fig. 29**  
**Fuel Regulating Circuit**

Fig. 29 shows the fuel regulating circuit. Note the ball valve right ahead of the needle valve. This allows quicker shutoff in case of disaster. The needle valve is the main speed control. The fuel pressure gauge can be seen in the photo. It is a good idea to monitor all of the fluids.



**Fig. 30**  
**Needle Valve**

The fuel control valve is shown above in Fig. 30. This is a needle valve that can be purchased at any hydraulic supply. You can get the hose and fittings at the same hydraulic supply.



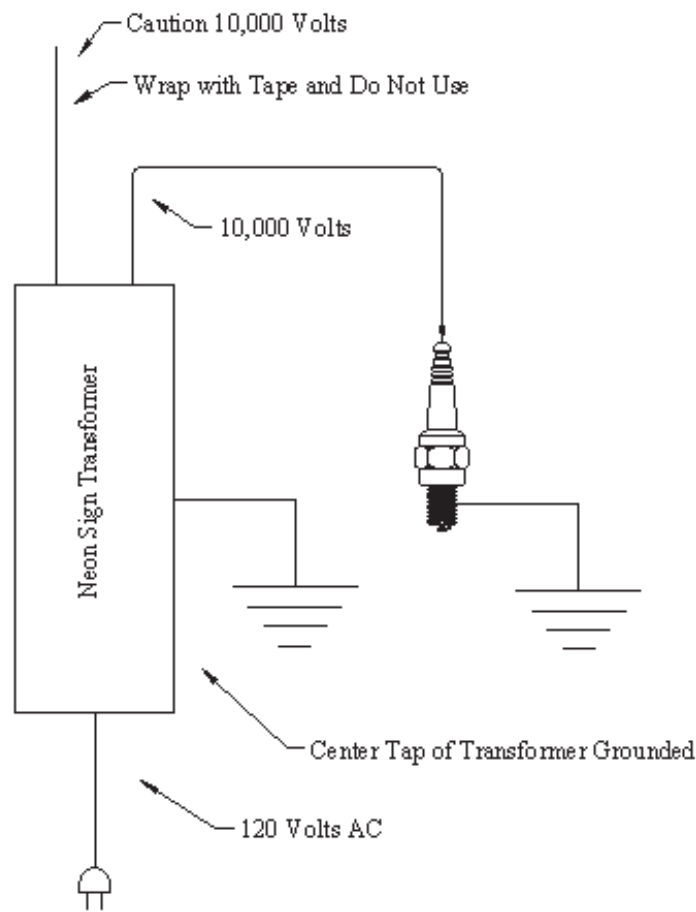
**Fig. 31**  
**Fuel Nozzles**

The fuel nozzles are sized to the combustion chamber. The nozzles shown are from Spraying Systems Inc. They are Number ¼ M SS. They have a ¼" pipe thread, full circle pattern and 3 gallons per minute flow. It is possible to substitute furnace nozzles. Furnace nozzles have a different thread and you will have to improvise.

If you find a substitute nozzle, be sure that the spray pattern is as wide as possible. If the spray shoots too far into the combustion chamber, the flame will be too close to the entrance of the turbine and will overheat.

Chapter 8  
**IGNITION SYSTEM**

The ignition system consists of a neon transformer, some ignition wire and a spark plug. An old neon transformer from a discarded beer sign works well. We found one that puts out 7,500 volts across the output leads. The transformer, however is center tapped and grounded so you can only use one half of the output. One of the high voltage leads needs to be cut off and wrapped with electrical tape. Wrap it good because this is very high voltage.



**Fig. 32**  
**Ignition System**



The diagram in Fig. 32 shows how the transformer is connected in the circuit. Be careful to use good automotive spark plug wire and do not touch anything when this unit is plugged in.

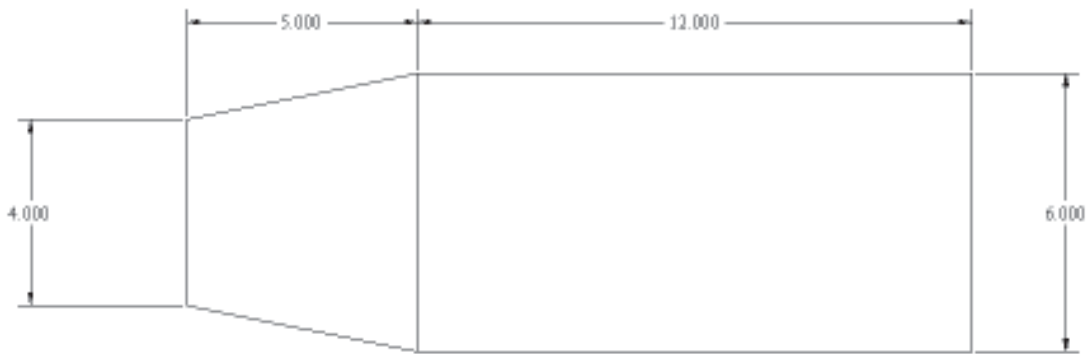
Adjust the gap on the spark plug for the best spark. With AC on the transformer, the spark will be continuous. Once the engine is running the ignition system can be shut off. The flame in the burner will continue to burn without assistance.

The transformer we found had an on-off switch already on it. Which most neon sign transformers have.

## Chapter 9

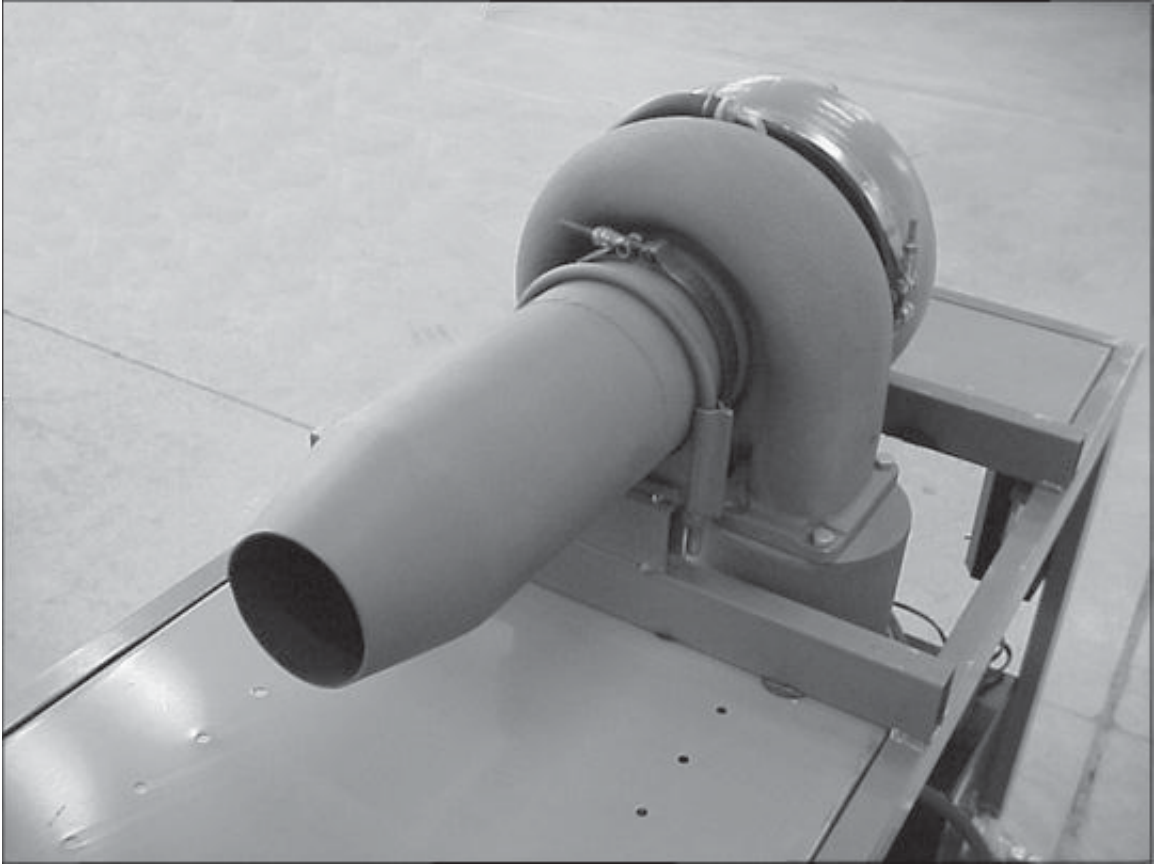
### Construction of EXHAUST OUTLET AND AIR INTAKE

Turbojet engines produce thrust by accelerating mass out the exhaust nozzle. The exhaust outlet is reduced to accelerate the gas molecules. The nozzle is designed to accelerate the hot gasses to a speed just slightly below the speed of sound. When the velocity exceeds the speed of sound, the efficiency decreases rapidly.



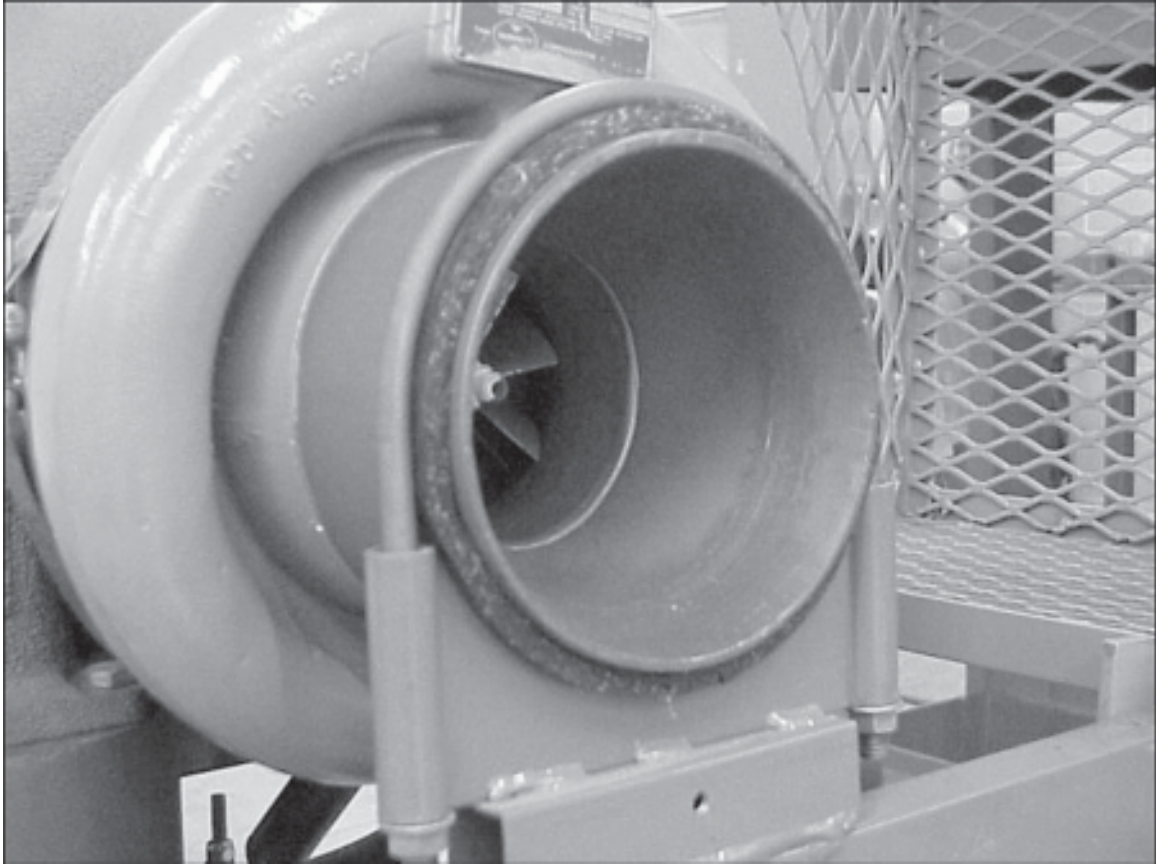
**Fig. 33**  
**Exhaust Duct Plan**

Fig. 33 shows the exhaust duct. It is constructed of six-inch truck exhaust tubing, and exhaust reducer. Both are available at a local truck supply store. You can adjust the dimensions to the turbocharger you are using. Some trial and error is required in determining the exact size of the outlet. Too small an outlet will produce a large amount of back pressure and the temperature of the turbine will increase proportionately. The turbine temperature should not exceed 1,850 deg. F. Adding a temperature gauge to the exhaust outlet is highly recommended.



**Fig. 34**  
**Exhaust Duct**

Fig. 34 shows the exhaust duct. Notice the method used for mounting the engine to the stand, a six-inch exhaust bracket. The exhaust duct and inlet are held the turbocharger by stainless steel clamps. Both are available at a truck supply store.



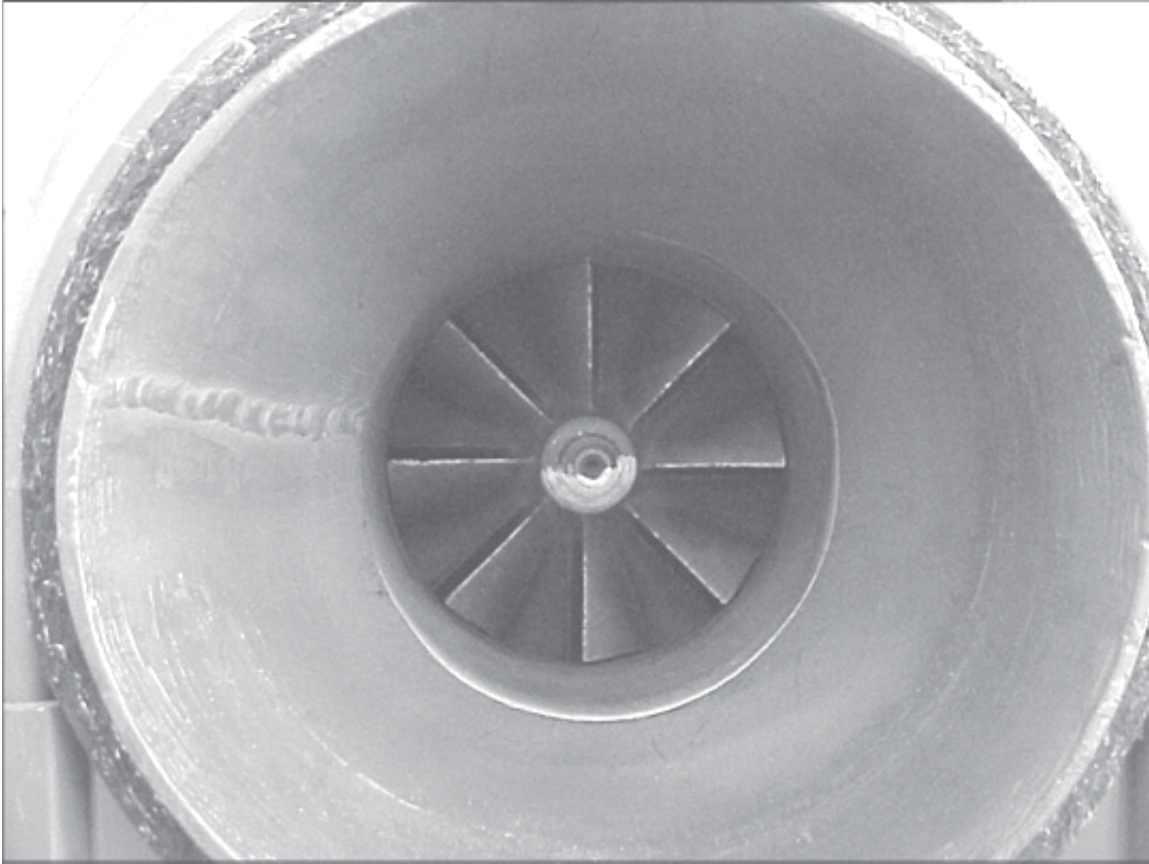
**Fig. 35**  
**Mounting**

Fig. 35 shows the method of mounting that we chose. The material between the exhaust clamp and the inlet is a piece of truck mud flap from a local truck wrecking yard. It allows a certain amount of flexing. As you can see in the picture, we fabricated an inlet nozzle for the turbo. This is optional. It makes it easier to attach the blower when starting the engine.



**Fig. 36**  
**Blower**

Designing an independent starting system for turbocharger turbojet engines is an engineering challenge. Operational speed for this engine is 75,000 rpm. In order to achieve start-up, the engine must be brought up to 20% of operational speed, or 15,000 rpm. This could be accomplished with an electric motor, but mounting would be difficult. Through trial and error, we discovered that a Black and Decker Super Vac “n” Mulch electric blower, as depicted in Fig. 36, could be utilized. It is portable, fully independent and relatively economical. We also found that, when using a blower, we only had to achieve 10% of operational speed, or 7,500 rpm, because of the additional airflow that is generated. The adapter on the front of the blower is a transmission filler funnel that has been cut off. This allows the blower to be held to the inlet and all of the air directed into the turbocharger. We also made a funnel shaped inlet for the engine as shown in Fig. 37.

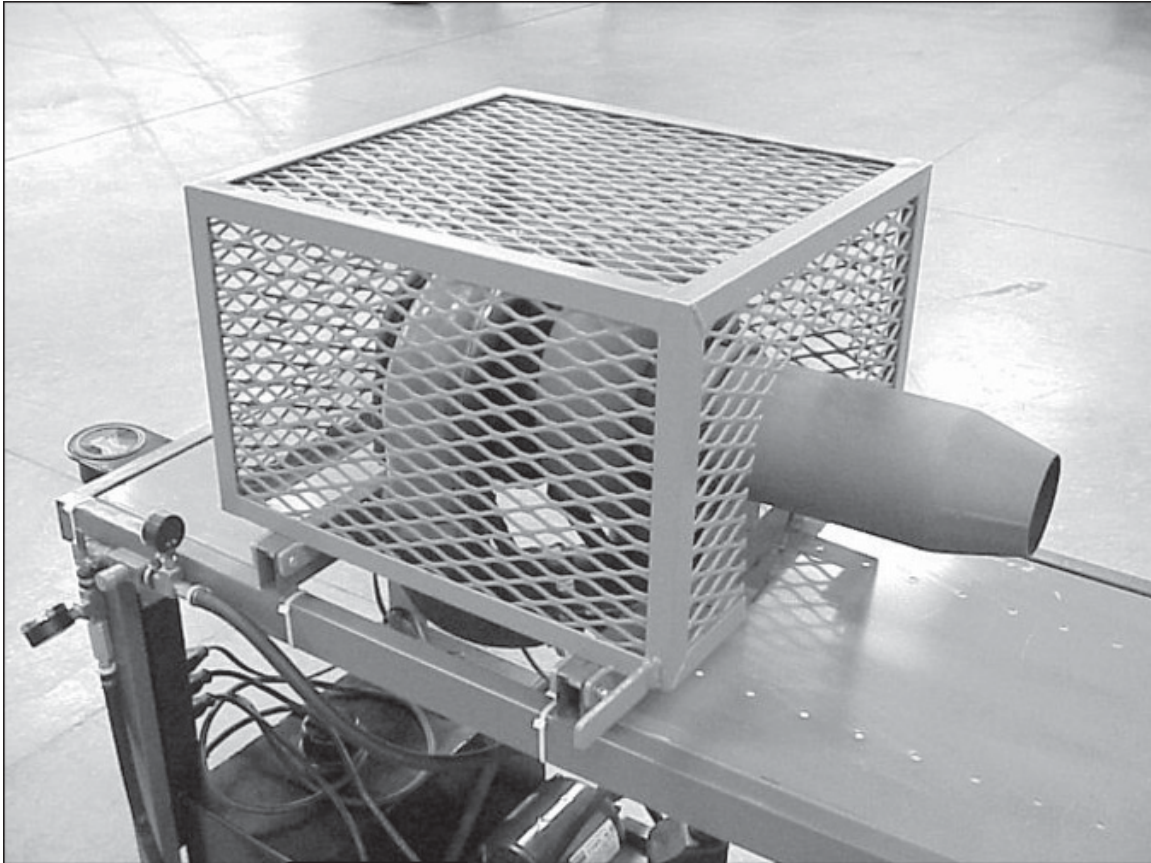


**Fig. 37**  
**Intake**

The inlet in Fig. 37 is constructed from a piece of six-inch truck exhaust tubing and the left over reducer piece from the exhaust duct.



## OPERATION AND STARTUP PROCEDURE



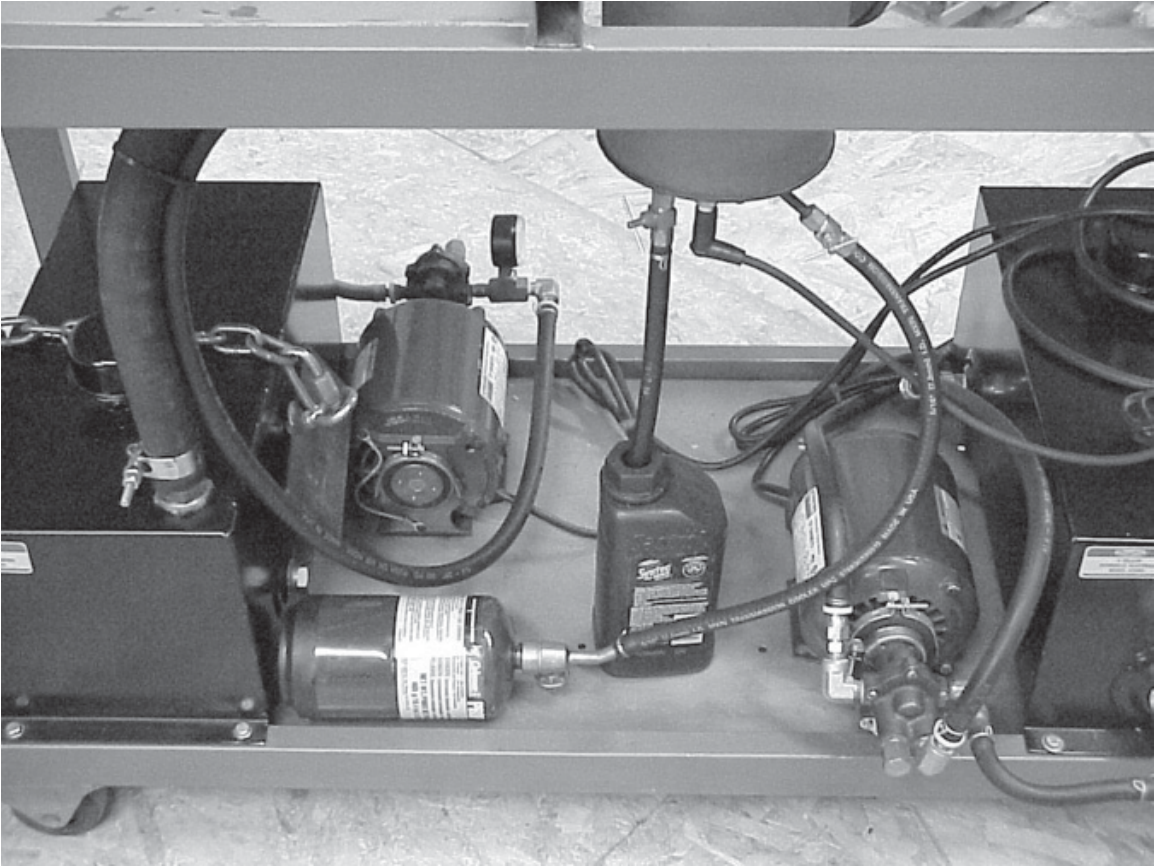
**Fig. 38**  
**Safety Cover**

It is a good idea to install a safety cover as shown in Fig. 38. The cage is an angle iron frame, with expanded metal welded to the inside. It should be designed to keep fingers, hands, etc. out of the inlet. The inlet has a lot of suction and could pull hands and fingers in. This could ruin your whole day!

Before starting the engine be sure you are in a location where the noise and jet blast won't bother anyone. If you are in a garage, open the door and aim the exhaust outside. Securely anchor the test stand to the floor, the engine creates a considerable amount of thrust.

Be careful handling diesel, or jet fuel. It is not as flammable as gasoline but you should still use caution. Remember, this is a real jet engine and it makes a lot of noise. Wear ear protectors when you are running it.





**Fig. 39**  
**Oil and Fuel Supply Tanks**

Fig. 39 shows the oil supply tank on the left, and the fuel supply tank on the right. The small propane tank is used for a pilot flame, and the oil can is used to hold excess fuel drained from the combustion chamber during startup.

Engine starting procedure:

- 1) Start oil pump and confirm 45-psig-system pressure.
- 2) Start fuel pump and confirm 100-psig-system pressure.
- 3) Place blower into inlet and allow turbine to accelerate (about 1 minute).
- 4) Open combustor drain to purge any residual fuel in combustion chamber (usually empty).
- 5) Turn igniter on. Allow engine to accelerate until no further acceleration can be achieved with the leaf blower.
- 6) Open propane valve to pre-ignite cold engine. You will here a rumbling sound like a furnace.
- 7) Turn fuel idle valve on (25 pounds nozzle pressure). Confirm fuel ignition. DO NOT remove blower yet.
- 8) Close propane valve. If the turbine outlet temperature exceeds 1,100 deg. F., shut fuel off IMMEDIATELY.
- 9) Allow engine to accelerate until it tries to pull the blower into the engine.
- 10) Remove blower from inlet. Turn igniter off.
- 11) Allow engine to accelerate to idle speed (approximately 25,000 rpm).
- 12) Open throttle to 80-100 psig for full power.
- 13) The engine can be accelerated, reduced, or idled with the fuel control. Combustion temperature should be around 850-875 deg. F.