Building A Pulsejet Engine Like The One On Scrapheap Challenge
By Bruce Simpson

Those who saw the Jet Racers episode of Scrapheap Challenge were probably as amazed as Robert Llewellyn when that hastily constructed collection of rolled metal and a U-bend successfully propelled The Destroyers' vehicle to victory over the quarter-mile.

In this document and with reference to the plans found elsewhere on this disc, I'll do my best to explain exactly how you can build your own powerful pulsejet engine, just like the one you saw on TV.

The engine we used was originally designed by an American called Ray Lockwood while he was working for the Hiller Aircraft Company in the 1960's.

Although it looks very different to the engine used on the German V1 flying bomb, it uses almost exactly the same principles. However, unlike the V1 engine, the Lockwood has no moving parts – not even the simple valves that the Germans used.

Obviously a simple engine that uses no moving parts was the ideal design for a challenge where time is limited and reliability is important.

The Lockwood is a very simple valveless pulsejet capable of being built in a wide range of sizes with a matching wide range of thrusts.

Perhaps the most distinctive thing about the Lockwood is its unusual shape – more like a trombone than a jet engine. The reason for its unique U-shape becomes obvious when you realize that it ejects exhaust gases out both tubes. If it were unbent then the gas-flows exiting from each end would largely cancel each other out resulting in little or no thrust being produced.

The great thing about these engines is that, unlike a valved engine, they require no machining. You won't need a lathe or milling machine – just something to cut the stainless steel sheet with, a MIG or TIG welder, and a set of slip-rolls to form the metal into cones and tubes.

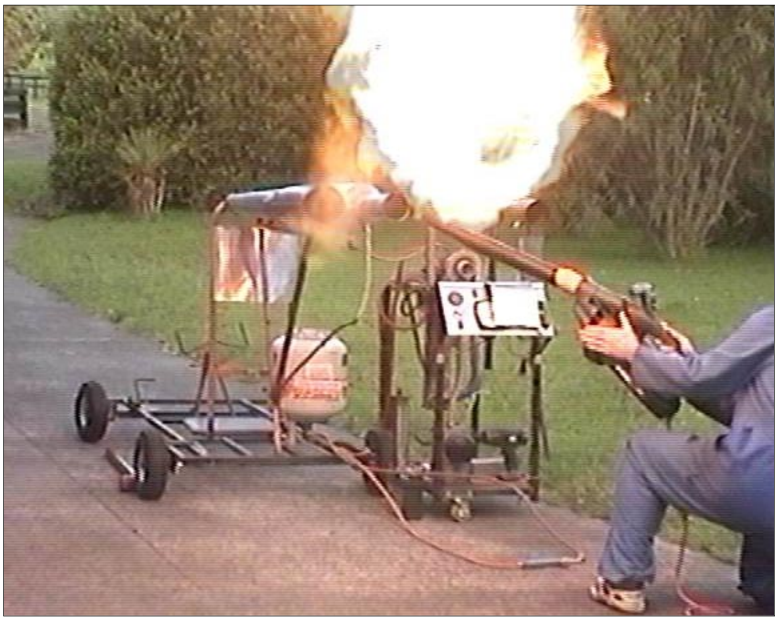
The mandatory words about safety
Yes, I'm going to bore you with a few words about safety before we get onto the meat of this document.

As you'll have seen on TV, these engines make a hell of a lot of noise – so you're going to need very good hearing protection. I'm not talking about cotton wool rammed into your earhole, no, I'm talking about at least grade 4 ear defenders, and preferably a set of ear-plugs as well.

When you're standing close to one of these engines you will be exposed to noise levels in excess of 140dB—that's many, many times the pain threshold and also sufficiently loud to cause permanent hearing damage in less than a second if your ears are unprotected.

As Robert Llewellyn put *it "the ground was shaking, the actual ground was shaking*", and the look on his face (grade 4 hearing protection and all) tells the entire story.

You'll also have seen that when running, these engines glow red-hot. Not only do the glow red hot but they also radiate a huge amount of heat. If you hold a piece of wood near one of these engines when it's running, it will smolder and actually catch fire pretty damned quickly.



Of course there's always the other risk that the engine will stop running unexpectedly. This results in a huge plume of flame that billows out of both pipes. If you're standing down-wind of this flame you run the very real risk of being badly burnt – so always make sure you have the wind to your back when you're starting or near one of these engines. Also make sure that the fuel-shut-off valve is always in easy reach. It's no good having such a valve if you can't reach it because flames from a stopped engine are licking all around it.

And finally, remember that propane or LPG is a flammable gas that can, when mixed with the right amount of air (as happens inside the engine) explode violently. You must always make sure that all your fuel fittings are tight and leak-free. Don't skimp on the quality of your fuel lines, hoses or fittings – a break or rupture could result in dangerous liquid propane spraying everywhere – and when it ignites – well don't even think about it.

Keep a fire extinguisher (dry powder or CO2) close at hand whenever you're using one of these engines – and also keep a big bucket of cold water within easy reach. When you burn your hand (and you will – I still do it occasionally even after four years of messing with these engines) you will find the soothing relief that's to be gained from such a bucket to be well worth the effort of filling it and placing it nearby.

On the bright side however – despite all the dangers I've just listed, you can have a lot of very safe fun with these engines – just don't let your commonsense fly out the door and always try to think ahead and plan for "what if" events.

The Materials List

The bulk of the engine is built from stainless steel sheet. Ideally this would be 321 alloy but the chances are that you'll have problems tracking that down in the thickness (or thinness) that we'll be using for this engine. Alternatives (in order of preference) are 316 and 304 alloys. You may be asked what type of surface-finish you want – avoid a brushed finish and opt for one that is shiny or slightly dull.

A half sheet (ie: 4 foot-square) of suitable stainless sheet should be enough to build the basic engine. You should use metal that is at least 0.9mm thick and if your welding isn't all that good you'll probably find you're better off to go to 1.5mm sheet – it's much easier to weld.

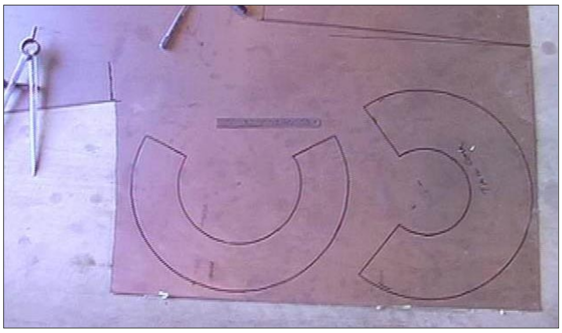
The other key component for this engine is a mandrel-drawn 180-degree U-bend made from 3-inch diameter (76mm) stainless steel tube. If you can't get a single 180-degree bend you can use two 90-degree bends and weld them together.

You'll also need about 24 inches of 8mm stainless tubing for the fuel system and a short (2-inch) length of quarter-inch by 1-inch (6mm x 25mm) stainless steel bar.

Various nuts and bolts, plus some gas-fittings and a needle-valve or old gas-torch should just about complete the materials list.

Marking up the Stainless

It's actually quite hard to mark out an easily visible pattern on stainless sheet with a regular scribe. The problem is that the metal is very shiny and also quite hard. The easiest way around this is to either use a very sharp felt-pen or give one side of the metal a light spray with black paint so that the shiny metal left by the scriber lines contrasts really well.



Note that some of the radiuses for the larger cones are actually quite long – you won't be able to use a compass or set of dividers to mark those curves.

What I do is either use a length of solid wire (not string or cord because it stretches) and have someone hold one end very firmly against what will be the center of the radius, while I prescribe the required arc by holding my scribe firmly against the wire at the desired radius.

Have a couple of practice goes first – you'll probably find that you need to be very careful to hold the pen or scriber perfectly vertical and you'll need to keep the wire very close to the metal. If it all turns to crap – don't worry too much. Just mark it as accurately as you can and tidy it up later with an angle-grinder after the metal is cut to shape.

Cutting the Stainless

While I have been keen enough to cut 0.7mm (0.035") stainless steel sheet using hand-shears in the past, using hand-tools on thicker stainless is not something I would recommend – it's damned hard work and even with good quality shears you'll end up with blisters.

While you can use power-shears to cut the straight lines and large-radius arcs, such tools won't do a very good job at all of handling the much tighter radiuses encountered when cutting out some parts such as the cones at each end of the combustion chamber.

The best option is to use a plasma cutter. If you don't have one of your own you can either pay for someone else to cut out the various parts or hire a suitable machine for the day. Make sure you hire suitable safety gear as well if you don't have it already.

Note that you can't use an oxy-acetylene cutting torch on stainless steel – it just won't work. This is because oxy-torches cut by actually forcing the steel to burn. Stainless steel will melt but it won't burn so trying to use an oxy-torch will simply result in a distorted, blobby mess rather than a clean cut.

If you use a hand-held plasma cutting torch you might find it much easier if you cut some plywood templates first and run the torch around them. This will also come in handy if you decide to build another engine later on – you can use the same templates and save the time of measuring again. Note that each plasma torch will have a slightly different tip and you have to allow for the distance between the actual plasma jet and the edge of the torch when marking and cutting your templates. For example – if the torch has a 24mm tip with a 1mm hole you'll need to cut your templates 11.5mm undersize all the way around in order to cut out a piece the right size.

Ask if you can measure up the tip of any plasma cutter you intend to hire so that you can calculate this "undersize" factor before cutting your templates.

Although a good quality plasma cutter in the hands of a practiced operator can produce a very clean cut, chances are that if you're a novice you might need to give some bits a light touch-up with an angle-grinder when you've finished. Boy, we really gave that angle-grinder a workout on Scrapheap – some of those plasma cuts were incredibly rough.

To get the best possible edge for welding (ie: dead straight) then you might want to use a jig like this one [PICTURE] which allows me to clamp a piece of stainless between two steel bars and then, using my angle-grinder, grind back the edge until it's perfectly straight (ie: flush with the steel bars).

And don't forget to make a hole for the sparkplug at this point. If you don't then you'll curse yourself later! I use a chassis punch but you can drill and file to the required size.

To locate the position of the sparkplug, just draw a diagonal from each corner of the sheet that will eventually be rolled into that chamber. Where the lines intersect in the middle is where you put your hole.

Rolling the Stainless
The various bits of stainless you've cut to size now need to be rolled into tubes and cones. This is done with the aid of a slip-roll but believe me – it can be damned hard work!

Stainless steel is far stiffer than mild steel for a given thickness and you'll need good quality rollers and a strong arm if you intend to do this job yourself. If you can find someone with a suitable set of motorized rollers that can form the main tailpipe cone in a single piece then you're well advised to pay the money and have this done for you.

However, as you can see from my own engines, it’s still quite possible to roll up to 1mm thick stainless in a set of hand-operated rolls then weld the 600mm (2 foot) sections together to make a single cone.

Rolling cones, especially those with a sharp angle such as the ones at each end of the combustion chamber, takes a little practice but I’ve included a short video [VIDEO] that shows how you “slip” the metal around as you roll it. The idea is to make sure that that the rollers always pass through a point which would be the center of the arc.

Note that when using a three-roller slip-roll, it pays to turn the metal through 180 degrees after each pass through the rollers. This helps eliminate the small flat-section that will otherwise form at one end of the curve you’re creating.

Now I should state that it is possible to form these cones and tubes without using a slip-roll – but it’s even harder work. If you can find a suitably long length of thick steel pipe that is close to the diameter of the tube or cone you want to roll you can, with the aid of much sweat, effort and swearing, often coerce the metal into a curve that approximates a round(ish) shape.

As you can see, the engine The Destroyers’ built didn’t have perfectly round tubes – but it worked.

I don’t really recommend this method but, if you’re determined and too poor to pay a few bucks to the local engineering workshop, then you can give it a go. If worst comes to worst you can always bash it flat(ish) again and then take it down to the local workshop – just tell them that it’s dented because your dog ate it or something. Once they run it through their rollers most of those ugly dents will come out anyway.

Welding the Stainless
There are really only two welding options when it comes to joining al the pieces together:

- TIG (tungsten inert gas)
- MIG (metal inert gas)

The ideal welding process is TIG, since this allows total control over the amount of heat used and how much (if any) extra filler metal is added to the weld seam.

However, since TIG welders are more expensive than simple MIG units, and most people find MIG welding much easier than TIG, I’ll describe both processes.

Welding with MIG
I won’t turn this into a welding tutorial so I assume you’ll already be moderately competent with a MIG welder. Instead, I’ll focus on the points specific to welding the various parts of these engines together.

It is important to use the right filler-wire. If you’ve cut and rolled the parts out of 304 stainless steel then you can use 308 or 316 stainless filler wire. If you’ve cut your parts from 316 stainless then use 316 filler rather than 308.

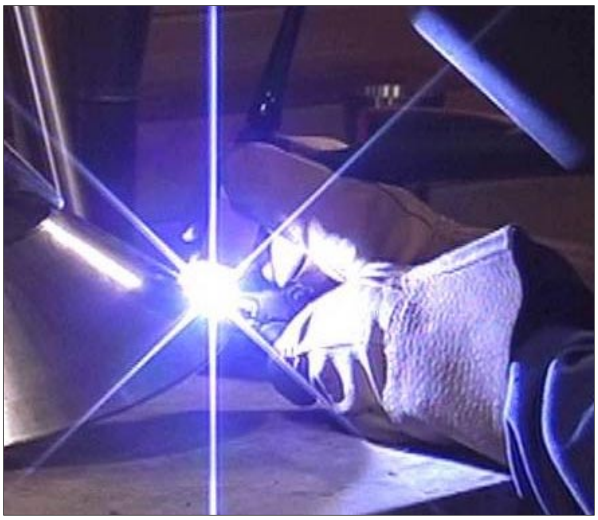
I've found that 0.8mm (0.032") wire is about the right thickness and you should only need a small spool to build an entire engine.

While you can use plain steel wire, the resulting weld will rust very quickly and become weak, so it's not recommended. Stainless steel also has a much higher rate of thermal expansion than plain steel so you'll get additional stresses set up as the engine heats and cools.

When welding, adjust the current, wire-speed and stickout used to try and get the flattest weld bead you can without burning through.

I find when working with very thin material (< 1mm/0.040")that sometimes it's easier to overlap the material along the weld-seam. If you plan to do this then don't forget to allow for that overlap when marking and cutting your pieces to size.

It also helps to have a "chill bar" behind the weld seam whenever possible. A length of 25mmx25mm (1"x1") aluminum bar does a good job here, with a length of 12.5mmx25mm used along the top surface to ensure intimate contact between the two sides. A pair of two C-clamps can be used to hold everything together as in this picture.



Welding with TIG

TIG welding thin stainless is not as easy as you might think. The use of a chill-bar (as described in the MIG welding section above) is absolutely essential. Without this, the stainless will tend to sag and form ugly black "danglers" on the back-side of the weld. This not only produces a weaker weld but those danglers will also interfere with the gases that flow at very high speed through these tubes.

Unfortunately, unless you want to go to the bother of turning up conical chill-bars to match the radius of each circumferential weld, you'll have to just do your best without one. Backpurging the weld with argon will certainly help here, as will making sure that the fit-up of the pieces is as near to perfect as you can get it.

Another option is to use a special high-temperature flux paste designed for use with stainless welding. This usually comes as a powder that is mixed with methyl alcohol then spread on the backside of the weld to stop oxidation during the welding process. The brand I've used with some success is "Solar".

Unless you've turned up those conical chill-bars, you're probably going to have to overlap the cones slightly to get a good fit-up, since the rolling process combined with the stresses produced when welding the length-wise seam, will almost certainly mean that the cones themselves are not perfectly circular in cross-section.

When welding, try at all times to keep the weld bead the same thickness as the sheets being joined. It's obvious why you would not want the weld to be too thin – but read the piece on heat-stress later in this section to find out why a thick weld bead is just as bad.

Getting a Good Fit-up

A good fit-up is essential to the success of any welding job and there are some simple methods of getting a good fit-up when assembling these engines.

Butting a cone up to a matching tube in such a way that the edges match perfectly so as to ensure a good weld is a very difficult (some would say impossible) task when using very thin material – but fortunately there are alternatives.

I always flare or flange edges of my cones to ensure the maximum contact area between the two parts and to ensure that the springiness of the stainless steel actually works to keep the two surfaces in intimate contact for welding.

There are two ways of flaring and flanging – you can use a rotary machine (sometimes called a "jenny") or you can just beat the snot out of it with a hammer and dolly.

If you've got a jenny then you're probably already aware of the techniques used to create flares and flanges – but if you don't, here's how you do things the manual way:

First you'll need a good hammer (or two) and a dolly. Although I use the term "dolly", I use nothing more than a 100mm (4 inch) long piece of 25mm (1 inch) steel bar. I've ground a fairly large (6mm - ¼ inch) radius onto one end and a small recess onto the other [PICTURE].

This piece of metal is then used as a backstop as you beat the stainless into submission, carefully working around the edge of the cone until the desired flare/flange is obtained.

If you do a good job, the cones and tubes should stay together before they're welded without the need for clamps or other mechanical devices.

Assembly sequence:

The normal welding sequence is:

- all the length-wise seams in the various cones/tubes and combustion chamber
- the circumferencial welds joining the tailpipe cones together

Before you go any further, mount the sparkplug in the combustion chamber. Once the engine is together you won't be able to get at the back so you'll really kick yourself if you forget. Tighten the plug up **REALLY** well otherwise it will come loose when it gets hot and you'll kick yourself again. Also note that you should open up the gap to about double the normal spacing to get a good long spark for easy starting.

Do not be tempted to weld the nut to the combustion chamber. The reason for this will be explained later.

- weld the intake flare tube to the intake tube
- weld the intake tube to the **matching** combustion chamber end-cone.
- weld the short straight tailpipe section to the **matching** combustion chamber end-cone

at this point you should clean up the inside surfaces where the intake tube and exhaust tube join to the cones that will ultimately be welded to each end of the combustion chamber.

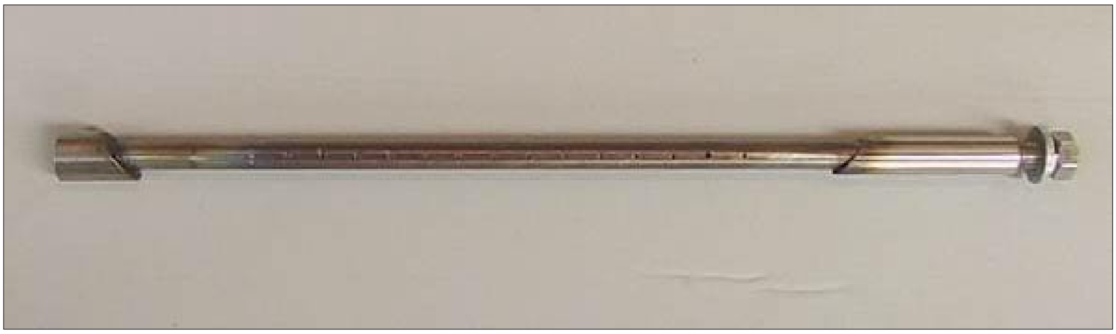
Any rough edges or "danglers" at this stage will significantly impede the flow of gases when the engine is running so get stuck in with a good file and/or die-grinder to mane sure everything is nice and smooth here. Note that you don't have to radius the point where the cones and tubes meet – just take the sharp edge off it – a 1mm (0.040") radius there is fine.

The fit-up between the two cones that go on the ends of the combustion chamber and the chamber itself should now be worked on. I've found that the easiest way to do this is by cutting these cones slightly oversize and then flanging a small edge using a rotary machine (jenny) or a hammer and dolly so that the combustion chamber fits snugly inside. [DIAGRAM]

- weld the cone with the intake tube already attached to the narrow end of the combustion chamber
- weld the cone with the short straight section of the exhaust tube to the larger end of the combustion chamber
- if you are using two 90 degree bends, weld them together into a 180 degree bend
- weld the mounting tab to the inside of the U-bend (this must be a **strong** weld)
- weld the U-bend to the short straight section of tailpipe tube already welded to the combustion chamber cone
- weld the U-bend/cone assembly to the combustion chamber
- weld the tailpipe cone assembly to the other side of the U-bend

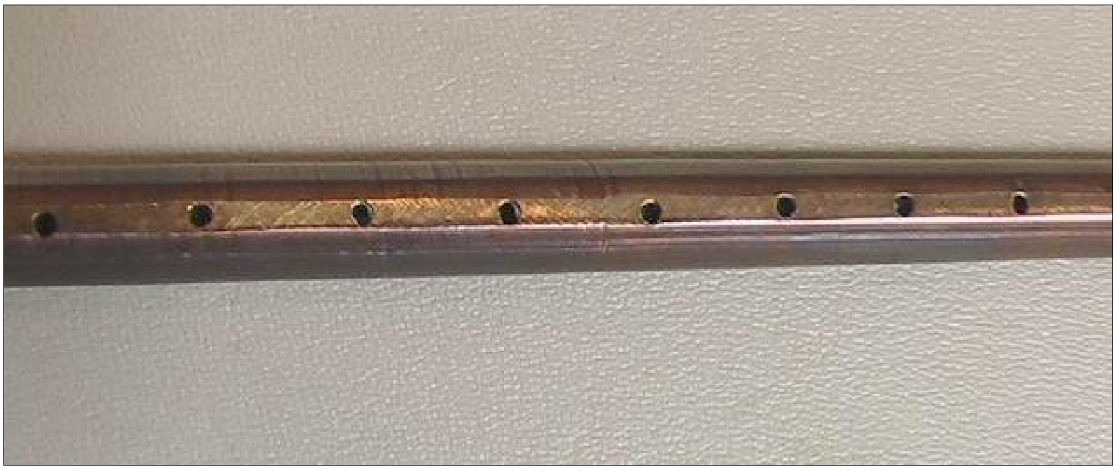
Now your engine will be assembled and you're ready to install the fuel injector.

Making the Fuel Injector
Using the dimensions given on the plans, thread the ends of the stainless fuel injector tube to the specified distance.



Now grind a flat along each side of the tube. This can be done with an angle-grinder or bench grinder but I prefer the former because it allows you to grip the tube in a vice while grinding. By gripping the tube securely, it becomes easier to make sure that the flat you're grinding is consistent and even along the section where the cross-holes will be drilled.

One you've ground two parallel flats on the tube, mark the spacing of the holes as per the plans.



Now here's some bad news. You're going to need a good supply of small drill-bits to drill all the holes in this piece of pipe.

Stainless steel is difficult to work with at the best of times but drilling very small holes in it is extraordinarily difficult – especially when you're dealing with tubing.

The reasons for this are manifold:

- stainless work-hardens very easily – this means that if you're not aggressive enough when drilling the area against which the drill-bit is rubbing becomes extremely hard, so hard in fact that it will instantly blunt the drill bit. With a larger drill bit this simply means that you'll have to resharpen the bit and try again to break through this work-hardened layer. With these tiny bits however, it probably means you'll break the end off the bit.
- Because, when you break through the top part of the tube, there'll be nothing underneath to support the drill bit, there's a chance that the drill-bit will catch and break This effect could be reduced by sliding a suitably sized piece of plain steel or even aluminum up the center of the tube so that the drill bit is supported as it breaks through, you'll probably find it very difficult to then extricate that piece of aluminum – although you could heat the whole thing up until the aluminum melted and let it run out.

- Stainless steel is just damned tough and puts a lot more stress on drill-bits than most other materials. Tiny drill bits have only minimal strength to start with so it's very easy to accidentally break one.

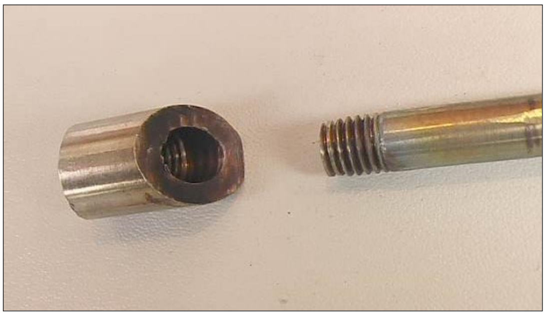
Here are some tips for avoiding, or at least reducing the number of broken drill bits:

- use the most rigid drilling setup you can. Using a drill press with the tube gripped firmly in a vice is far better than trying to drill these holes with a hand-drill. An even better option is a milling machine equipped with a drill-chuck.
- Use a high quality cutting lube designed for stainless alloys, and don't be miserly in its application.
- Practice on some scrap tube until you feel happy that you know just how much pressure to apply
- Use a new drill bit regularly. I find that after as few as four or five holes these tiny drill bits start to dull markedly. The duller the drill-bit the more likely you are to break it because it will require more force to cut.
- If a bit breaks off inside a partially drilled hole (so you can't get the fragments out) then don't try and drill it out (you'll just break another bit) – just move 2 drill diameters to the side and start from scratch.

As I suggested above, buy at least ten bits of each size – they're not expensive and you'll soon get annoyed if you run out or are forced to try and use a blunt bit.

And I can't stress highly enough the need to wear good eye-protection when doing this (or any) form of drilling. When/if a drill-bit breaks, it can shatter into a myriad of tiny razor-sharp fragments which fly out in all directions. If one hits your eye it will almost certainly embed itself and cause major damage – to say little of the extreme pain. You only get two eyes, don't waste them on something as trivial as drilling a hole!

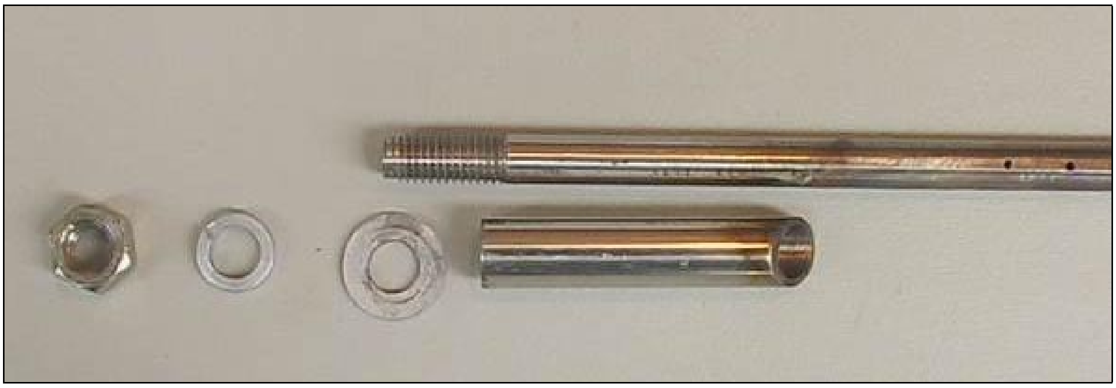
My own safety glasses have many little chips and scratches where pieces of metal that would otherwise have hit my eyes have been deflected – it's very sobering.



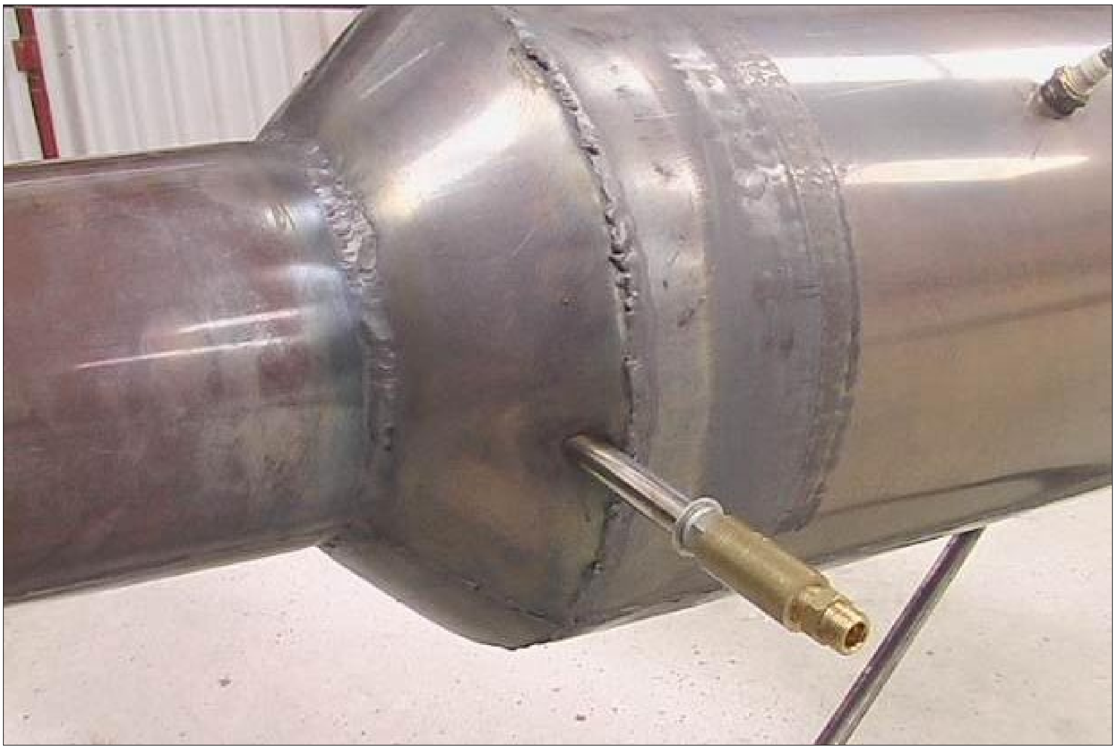
Now make the end-piece. This is done by cutting a piece of stainless steel rod to length then drilling and tapping it as per the plans.

Once it's been drilled and tapped, cut the angle on the end with the threaded hole.

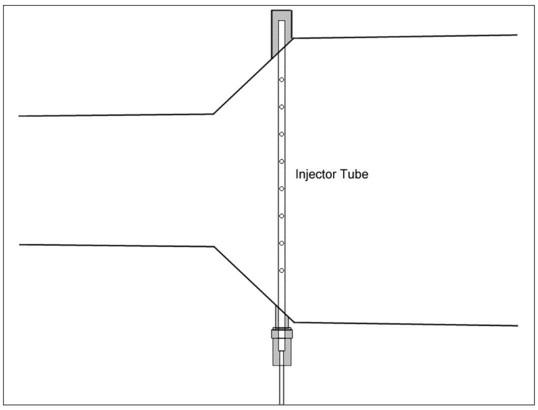
The other end of the tube is similarly threaded and another piece of larger stainless tube is cut so that it slips over this end and will be held in place by a nut and washers. Note that one end of this sleeve is cut at an angle to match that of the combustion chamber cone.



Once the tube is installed, this sleeve will push up against the combustion chamber cone as in the picture below – thus holding it firmly in place.

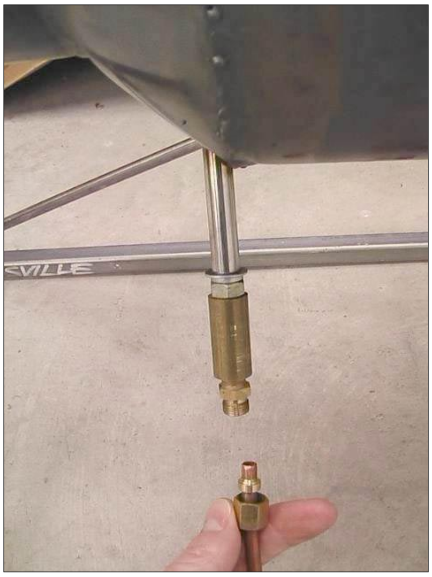


Now drill the injector mounting holes for the injector tube in the intake-end cone of the combustion chamber. These holes should be as close as practical to the weld seam where the cone joins the chamber and exactly 180 degrees apart (ie: the injector tube should run right through the center).



Drill these holes so that the drill is held at right-angles to the metal – note that drill-bit ground for sheetmetal drilling will be easier to work with. Second choice would be a step-drill, but if all you've got are regular twist-drills then get stuck in – but be prepared for the drill to try and screw its way in as it breaks through. You'll also find it easier to use a small pilot first.

Once you've drilled the holes right through, keep the drill running and angle it so that it's at right-angles to the intake tube and the axis of the combustion chamber (ie: in the same line as the injector tube will be when it's inserted. This will oval the holes (do each one in turn) so that the injector should fit perfectly and snuggly.



A standard pipe fitting can now be screwed onto the injector tube and at least 1m (3 feet) of copper tubing used before regular flexible propane hose is used.

It is essential that all fuel connections be secure and free from leaks. Use teflon (PTFE) tape if necessary to ensure that everything is gas-tight.

Screw the endpiece onto the end of the injector closest to the cross-drilled holes and then slide the assembly through the holes you've just drilled in the cone. Orient the endpiece so that it sits nicely against the cone and orient the tube so that the holes face the sides of the cone – ie: at 90 degrees to the flow of gas through the engine.

Now cut the sleeve from the specified diameter stainless tubing with a 45-degree angle on one end. This sleeve should come right up to, and just past, the threading on the injector tube.

A matching spring-washer and nut can now be screwed on to firmly secure the injector assembly. Don't over-tighten this or you'll bend the cone. Tighten it just enough to flatten the spring washer.

While you're tightening this all up, make sure that the injector tube itself isn't rotating – the cross-drilled holes must still be facing from side to side or the engine will not run properly.

Mounting the Engine

Now we have our basic engine completed but it must be connected to an engine mount before it can be fired up.

The first Lockwood I built failed spectacularly within seconds of being fired up because I hadn't bothered to calculate just how much it would expand as it got hot.

I had simply welded tabs to the intake and exhaust tubes and bolted the engine at three points to a mounting bar.

Of course, as soon as the engine began to get very hot (and they run at 850-1000 degrees C) the stainless steel from which it was made expanded by far more than I'd anticipated. And, since both ends were bolted to a steel bar and therefore immovable, the whole thing folded up like a concertina.

The secret to mounting a Lockwood therefore is to remember that these engines grow significantly in length when running.

To get around this problem I tend to use a single point of mounting through which all the thrust is transmitted. This is the tab welded to the inside of the U-bend. Do not use thinner material or a smaller bolt than specified in the plans here or you run the risk of your engine breaking free from its mountings.

The rest of the mount is simply designed to support the tailpipe and combustion chamber. Without these straps the engine would sag and distort unless you used much heavier stainless steel (more $, more weight).

The engine can be mounted vertically or horizontally and both methods are shown on the plans.

If you're mounting vertically the intake tube must be at the bottom or the engine will ingest hot exhaust gases and flame out when operated at low speeds or statically.

The throttle system
You can either use a high-flow needle-valve or a ball-valve to control the amount of fuel injected into the engine. Note that a needle-valve will provide a much finer degree of control and make it easier to set the required fuel levels.

The optimum system actually involves the use of two needle-valves and two ball-valves. One needle-valve sets the idle-flow and the other sets the full-throttle flow. Transition from idle to full-throttle is controlled by one of the ball valves, the other is used for shutting the engine down. These is setup is created by following this diagram:

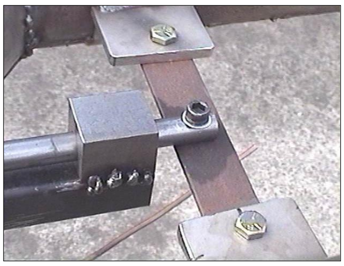
Mounting the Engine
One of the most difficult aspects to using these strangely shaped engines is that of actually mounting them.

While it might seem like a simple idea to weld a mounting bracket on the U-bend as shown in the plans, and then would a one on the intake tube and tailpipe tube then use these to bolt the engine to a metal bar or frame, that's not actually a good idea.

The reason is that stainless steel has a huge coefficient of thermal expansion – which is geek-speak for "it expands a lot when hot". Now, when you consider that this engine is going to reach temperatures of around 850-1000 degrees C when running, you can see that it will grow an awful lot in length.

Now just imagine for a moment what happens to an object when you mount it firmly at each end then heat it so that it expands. Have you ever seen the way that railway lines buckle during a heat-wave – well if you rigidly mount both ends of the engine then that's exactly what will happen to the pulsejet.

To avoid this we only rigidly mount one end – the U-bend, using the tab that is welded to the engine at this point. The two pipes then only need be supported using some inch-wide strapping which can be cut from the same stainless sheet you used to build the engine itself.



Whatever method you use to hold the intake tube and tailpipe from waving around, be sure and leave things loose enough that the engine can expand and contract without restriction.

On my own cart I got all fancy and built a sliding mount that would expand as the engine heated up – but this was really an overkill.

Starting the Engine
To start the engine you're going to need to blow some air into the intake tube using a leaf-blower or similar high-volume air source. Remember that it's not pressure you want, it's volume so a tiny little compressor, even though it might put out 100psi, may not be ideal for this job.

Before I continue – a few words on safety are absolutely essential.

These engines not only run red-hot but also consume huge amounts of fuel – and this means there's a significant fire risk and the potential for inflicting significant, possibly life-threatening burns if they are not handled with caution.

At all times you should make sure you're wearing fire resistant clothing or at least garments made from natural fibers. Man-made fibers such as nylon, rayon, etc will melt and/or burn vigorously if exposed to raw flame and this can inflict horrendous burns on skin and flesh.

Always wear eye-protection when starting these engines. Although human skin is suprisingly resilient to a brief flash of flame, the eyes are not and can be badly scarred in an instant. Wear goggles or a face-mask.

Remember that flames are hot and therefore rise upwards. Keep your body low and to the windward side of the engine at all times when starting.

Make sure that the area around the engine is clear of flammable objects or materials. So much heat is radiated from the red-hot surface of the engine that materials such as wood, paper or plastic within several feet will char, melt or burn very quickly.

If you plan to fit one or more of these engines to a vehicle then some form of heat-shield is essential, not only to protect the driver but also the propane tank, fuel lines and any other flammable parts.

You can clearly see the rather crude heat-shield we fitted to the Scrapheap kart in this picture

It was made from stainless steel and the side closest to the engine was polished to a mirror-finish so as to make it more effective.

The usual starting procedure if you're on your own:

1. Start the spark – you should hear it crackling or ticking away inside the engine
2. Open the fuel valve slowly until you hear and see the engine "pop" – if you're lucky the engine will burst into life at this stage, although that only usually happens with very large engines or when there's a stiff breeze blowing directly into the tubes.
3. When lazy yellow flames start wafting from the engine, bring your leaf-blower up to the intake tube and blow air into the engine. The engine should pop and bang a few times before catching and starting to run. If it fails to do so, and the flames disappear then you can open the fuel valve a little wider.
4. Once the engine is running, turn off the spark and remove the spark-plug lead (or it will likely melt).

The Starting Procedure when you have some help

If you're lucky enough to have some help, or you can reach the fuel valve while still blowing air into the engine then:

1. Start the spark
2. Start blowing air into the intake tube
3. Slowly crack open the fuel valve – the engine should then burst into life

You can now throttle the engine by varying the fuel-flow using the needle-valve or ball-valve.

Remember however that there maybe some lag when throttling back because the liquid propane will begin to vaporize in the fuel line at lower throttle settings.

Once warm, this version of the Lockwood should idle right down to what is almost a gentle hum. If you throttle up slightly to a reliable yet still comparatively low-power idle setting then you can mark the position of your needle-valve or ball-cock and use this same setting for start-up.

If you've used the multiple valve fuel system described earlier then you can permanently leave the idle valve at this setting.

Troubleshooting

If your engine refuses to start or runs with only very low power no matter how much you open the throttle valve then it's likely that your propane tank is unable to provide a sufficient fuel-delivery rate. Make sure of course that you have a tank that can deliver liquid propane and not just gas.

Older 20-lb BBQ cylinders make good fuel tanks but ones made in recent years have a special valve fitted that prevents liquid propane from flowing. These tanks are not suitable at all. You can often tell if your tank is one of these by waiting until it is empty then quickly tipping it upside down. If you hear a click or clunk – that's the little valve designed to stop liquid being drawn from the tank so it will be of little use to you.

Alternative fuels

Although propane is the simplest fuel to use, requiring no fuel pump and offering easy starting, these engines will run on almost any liquid that burns. The big problem however is getting them started.

Propane vaporizes very easily at normal air temperatures and will therefore create an explosive mixture in the combustion chamber that is very easy to ignite.

Less volatile fuels such as gasoline/petrol, Jet A1, diesel or whatever will not vaporize nearly as well as propane in a cold engine, but they will work very well once the engine is up to running temperature.

This means that the easiest way to use these fuels is to use two separate fuel injector tubes installed at 90 degrees to each other so as to cross in the middle of the engine. One of the tubes is fed with propane for starting and, once the engine has been running for a few seconds, liquid fuel can be fed into the second tube, allowing the propane to be turned off.

That's about it – now get out there and build your own super-noisy, super-fun jet-powered vehicle!

Last revision: Nov 2003

Appendix:

The pulsejet engine plans are in the following files in the **/bruces/plans** folder of this CDROM

lh55lbs.pdf (Adobe format)
lh55lbs.dfx (CAD format)
lh55lbs.dwg (CAD format)

lh55lbsfuel.pdf (Adobe format)
lh55lbsfuel.dfx (CAD format)
lh55lbsfuel.dwg (CAD format)