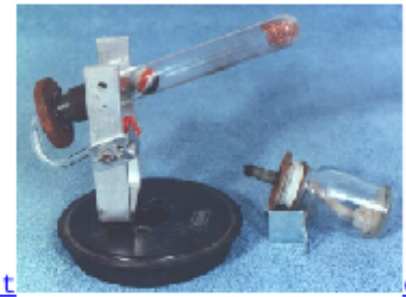
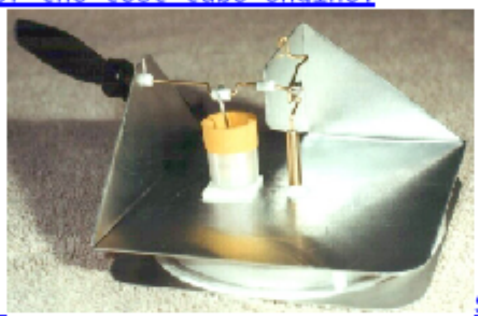
Simple Stirling Engines

One-moving-part, t  es  t-tube
Stirling engine.
Parts of the test-tube engine.

Simple  S  imon
Stirling engine.
Parts of the Simple Simon engine.

TEST TUBE STIRLING:

Our first Stirling was our redesign of the now-common test-tube version. The parts are a Pyrex test tube, cloth tape, two jumbo paper clips, two #2 single-hole stoppers, glass or copper tubing, a piece of metal strap, a corner brace, two bolts with wing nuts, three marbles, the end off of a balloon, a base of any sort, copper-wire ball, balance-weight "washer" and an alcohol burner.

Cloth tape holds the paper-clip pivot axle to the top of the test tube. The metal strap is bent and drilled 1/16" for the pivot bearings. The copper wire ball in the test tube acts as both heat exchanger and cushion. The glass tubing needs to be bent using a torch, or use copper tubing. The big "washer" is a counterbalance.

Adjusting: Balance it to tip counterclockwise. As the burner heats the air, the balloon expands out, pushing on the corner brace. This tips the test tube clockwise. The marbles roll to the right. The air is then forced to the left, and gets cooled. The cool air shrinks. The balloon is now sucked in. The test tube now tips counterclockwise. The marbles roll left. The air is pushed right, to the hot side. The balloon expands. And so on. It takes a little time to adjust everything right. The alcohol burner can be found in hobby/craft shops (jewelry-making) or in chemistry sets.

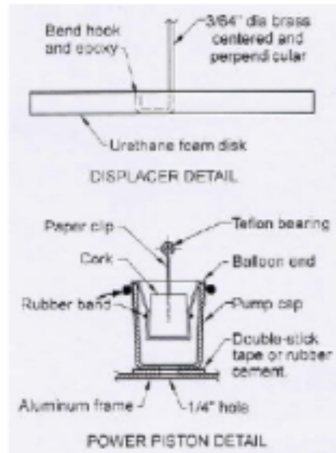
SIMPLE SIMON:

Simple Simon uses a displacer disk made of 5/16" foam 4" in dia. and a balloon-and-cork piston. The displacer cylinder is a piece of plexiglas tube 4 & 1/2" dia., 5/8" high with 3/16" wall. The piston and displacer have a 1/4" stroke, so the crank offsets are 1/8". They are 90 degrees apart, so when the power piston is neutral, for instance, the displacer is all the way up (or down). This offset determines the direction of rotation.

The power piston cylinder is the cap from a hairspray pump. All the brass wire is 3/64". The small white bearings are Teflon 5/32" O.D., 3/64" I.D., 1/4" long. The sheet aluminum is all .032". The brass guide tubing for the pushrod is 3/16" O.D., 5/32" I.D. x 1" long. The Plexiglas cylinder is caulked to the base aluminum and caulked to the upper aluminum. There is a tiny roller on the end of the crank that rides in the displacer pushrod slot. (The 1/8" offset of the crank is poorly visible.) The roller is a model-plane wheel without the tire.

It is important to blow up the balloon and let it deflate several times before cutting the end off to make the power "piston" very flexible. It is also important to dust true talcum powder (not cornstarch) on the balloon and inside the cap and then blow off excess. This engine runs faster, is more fun to watch and more educational than the Test Tube Stirling.

The Simple Simon displacer and power piston.
The Simple Simon top aluminum pattern.



A complete construction article about Simple Simon is in "Machinist's Workshop" magazine, Oct./Nov. '03, published by Village Press.

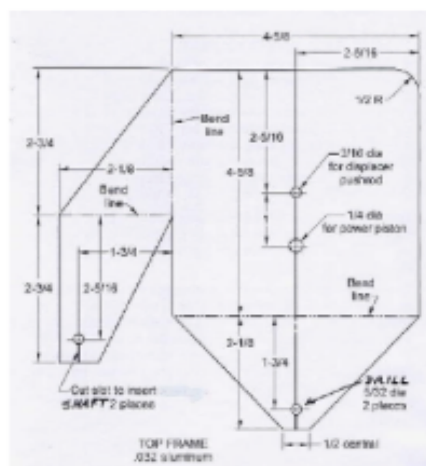
SIMPLER SIMON:
SimpleR Simon Stirling engine.

SimpleR Simon uses a flat rubber membrane instead of the balloon inside a plastic cap, but is otherwise the same as Simple Simon. This design requires less temperature differential. The balloon-rubber power piston and steel washers are rubber-cemented (not caulked) to the aluminum base. The cork piston is rubber-cemented to the balloon membrane. The opening for the balloon-rubber piston is 7/8", the wide end of the cork is 1/2".

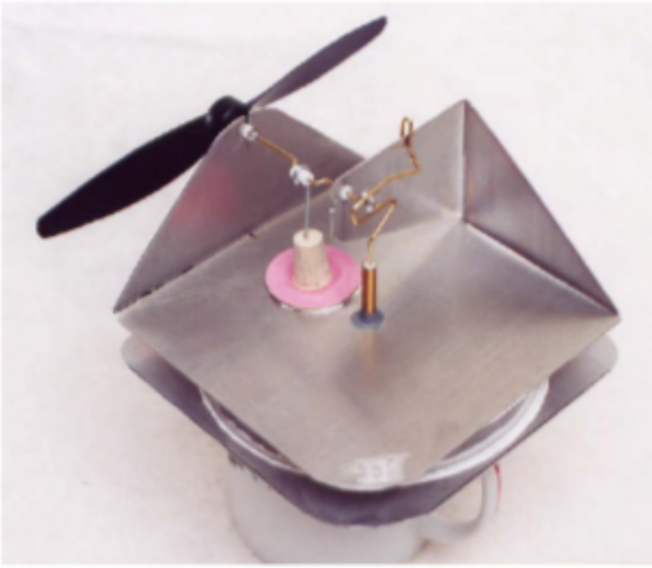
NOTE: Common foamboard, used for signs and posters, makes a good displacer. The casing over stacked CDs on a spindle makes a good cylinder, but the piston and sheet metal will have to be a bit wider.

BEARINGS:

There seems to be some difficulty obtaining the Teflon bearings for the crankshaft. Another option is to use Hot Wheels type car wheels. It is necessary to drill the rivets out and pop the car halves apart. The axles are 1/16" steel and the hole in the wheel is slightly larger. Drill the wheels out for the crankshaft that you use. The outside diameter of the wheels is 7/16". You can make the holes in the aluminum frame that size, or you can rubber-cement the wheels to the frame so that the holes align.



Typical Hot Wheels toy car.



How does a Stirling engine work?

Step 1 Characteristics of air

Let's fit a rubber to a can like Figure 1. You can understand easily that the rubber expands when the can is heated (Figure 2), and the rubber contracts when the can is cooled (Figure 3). It is caused that a pressure of the air in the can works to the rubber when the air is heated, shown in allows of Figure 2. Of course, you cannot see the pressure by your eyes.

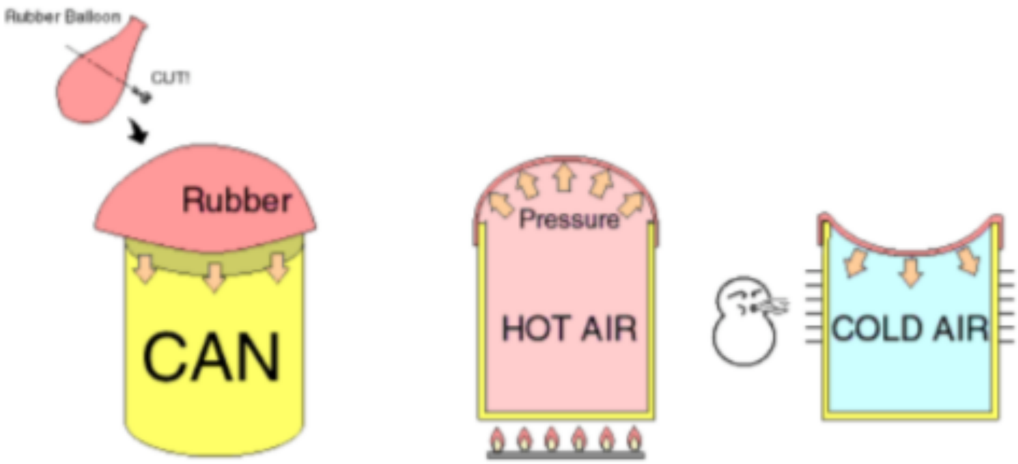


Fig. 1 Can and rubber Fig. 2 Air is heated... Fig.3 Air is cooled...

Step 2 What is a displacer piston?

Next, let's put in a piston into the can like Figure 4. A diameter of the piston must be somewhat smaller than that of the can, because the piston works to move (displace) the air up and down in the can. And, please heat the bottom side of the can and cool the upper side of the can. After it has enough temperature difference, move the piston up and down by your hand. When the piston is moved up, the rubber expands because there is a lot of hot air in the can (Figure 5). It corresponds to Figure 2. When the piston is moved down, the rubber contracts because there is a lot of cold air in the can. It corresponds to Figure 3.
In the case of the Stirling engine, this piston, which moves (displaces) the air and make the pressure changes is called a displacer piston.

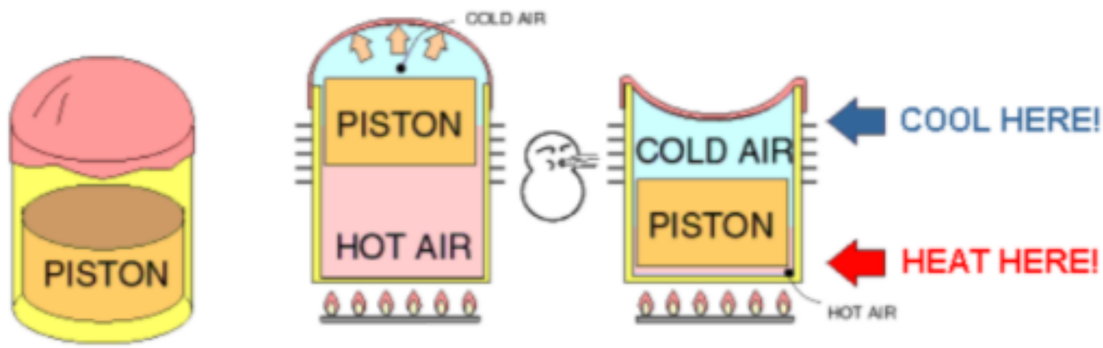


Fig. 4 Displacer piston   Fig. 5 Work of piston

Step 3 Crank mechanism ~ from piston motion to rotation ~

Do you understand about the characteristics of the air and the work of the displacer piston? They are very important to understand how does the Stirling engine work.
First, connect from the piston and a bent wire with a thread like Figure 6. When the bent wire is rotated, the piston is moved up and down. This is called a crank mechanism.
Please heat the bottom side of the can and cool the upper side of the can, similar to above description. When your hand rotates the bent wire, the piston is moved up and down, and the rubber expands and contracts repeatedly (Figure 7).

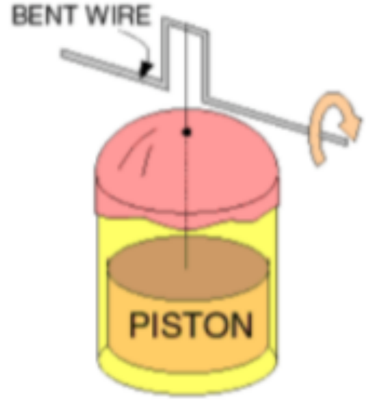


Fig. 6 Crank mechanism

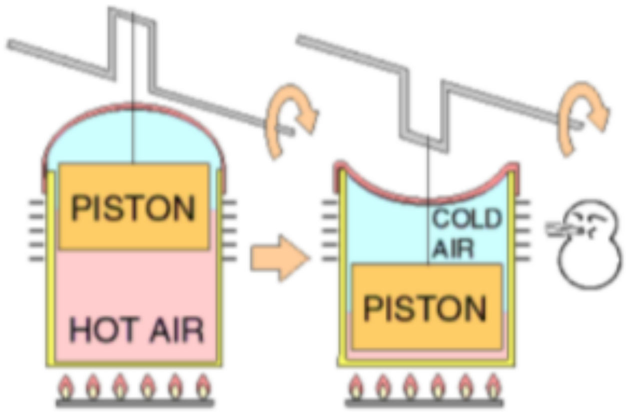


Fig. 7 Work of crank mechanism

Step 4 Power piston ~ function of the rubber ~

The Stirling engine converts from the motion of the rubber to the rotation of the bent wire. Please connect from the rubber to the bent wire with a rod. In this time, a force of the rubber (expansion and contraction) has to be the direction, which rotates the bent wire. In short, you must bend the bent wire the just right angle (90 degrees) from the piston like Figure 8 and 9.

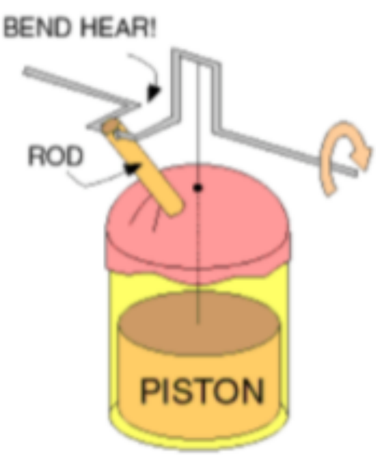


Fig. 8 Force of rubber

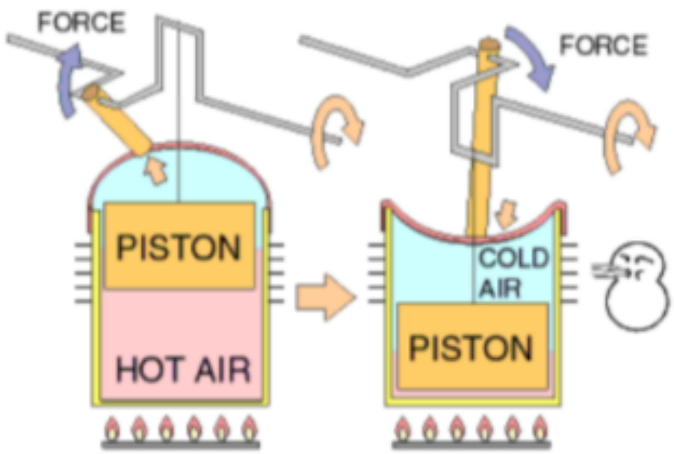


Fig. 9 Force for rotation

Step 5 Flywheel ~ for the smooth rotation ~

This engine has not worked yet. If you try to work this engine (Figure 8 and 9), the rubber keeps the most expansion or contraction. In order to rotate smoothly and repeatedly, you must fit a rotated mass with the bent wire. It is called a flywheel.
Generally, the flywheel is circular like Figure 10. But at this point, please bend the end of the

bent wire, and fit a mass at the edge of the wire like Figure 11. The mass works as the flywheel and to be balanced to the weight of the piston. So, you must fit the mass against the piston.

Fig. 10 Circular type Flywheel

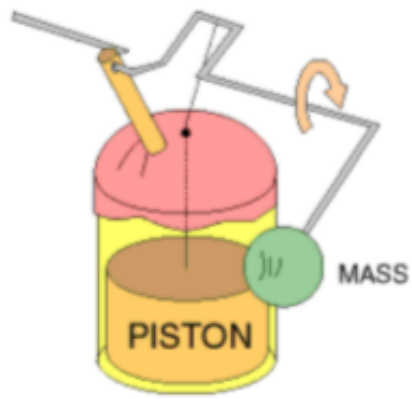
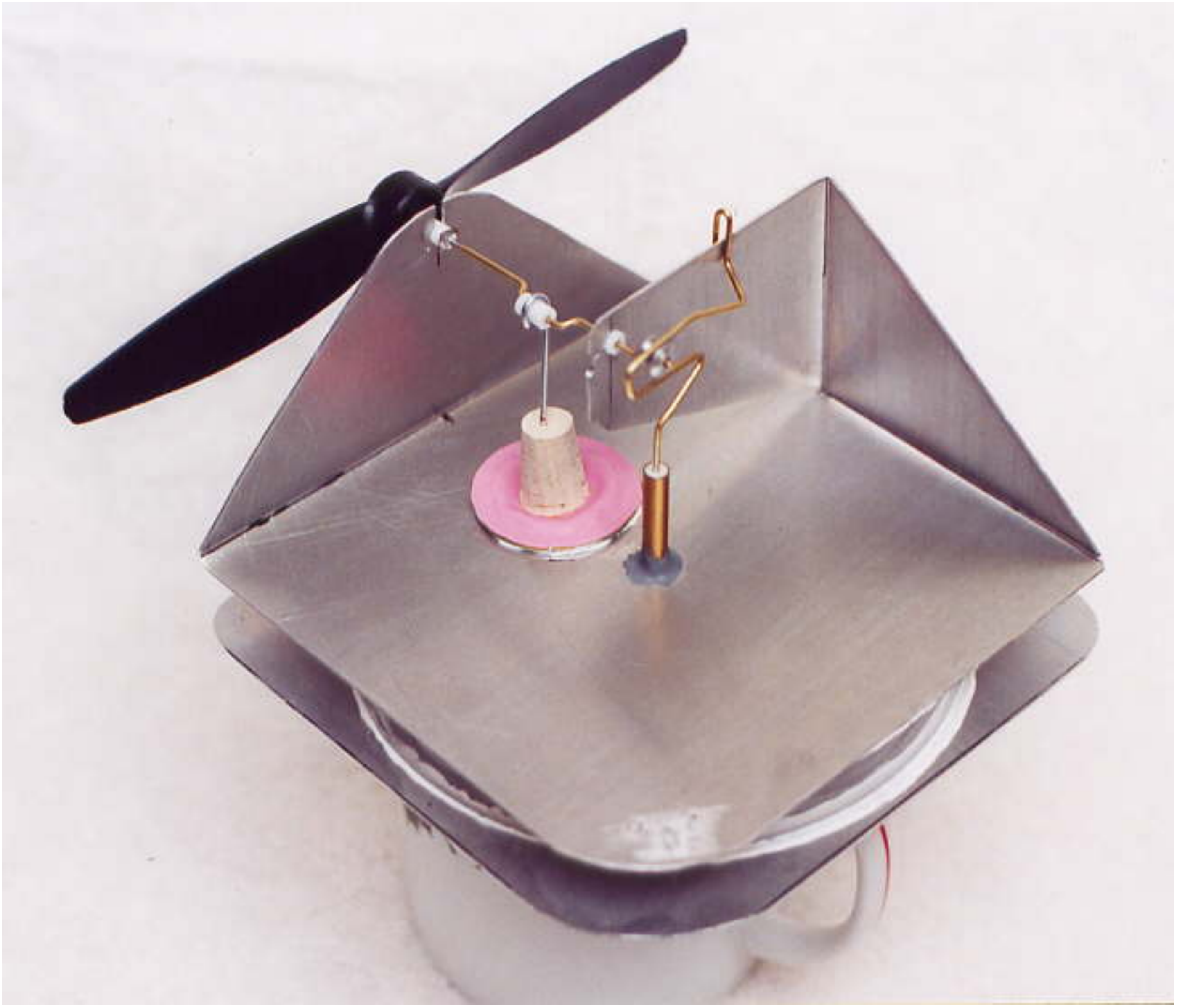
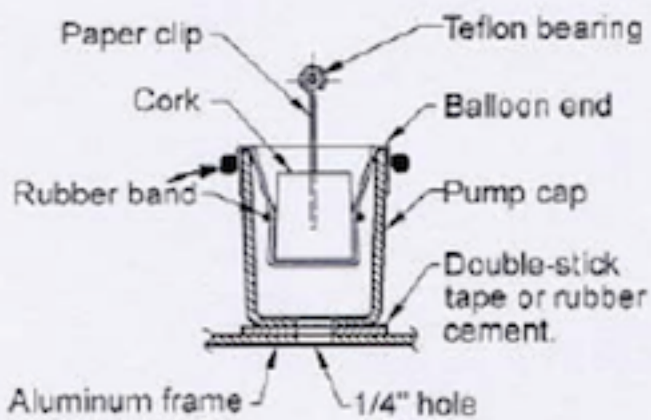


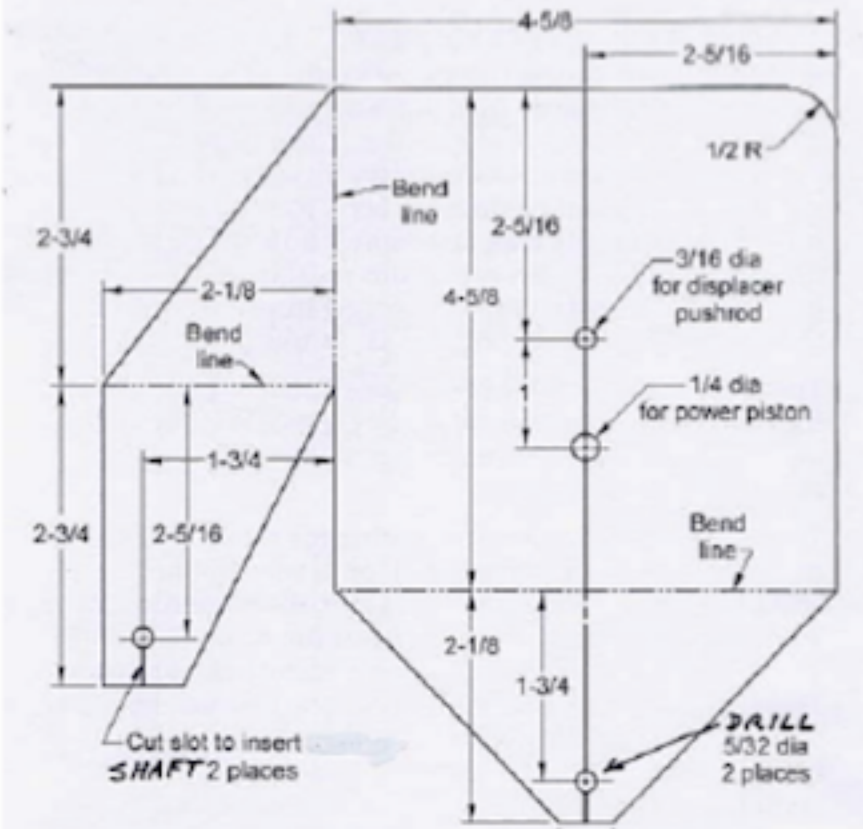
Fig. 11 Simple type Flywheel



DISPLACER DETAIL



POWER PISTON DETAIL



TOP FRAME
.032 aluminum