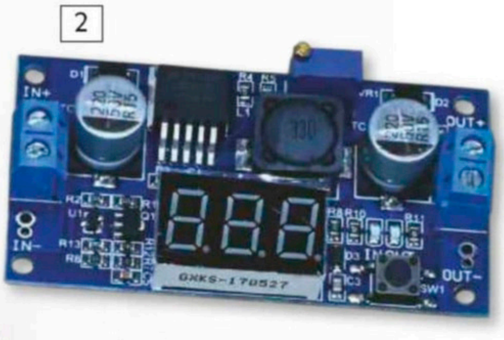
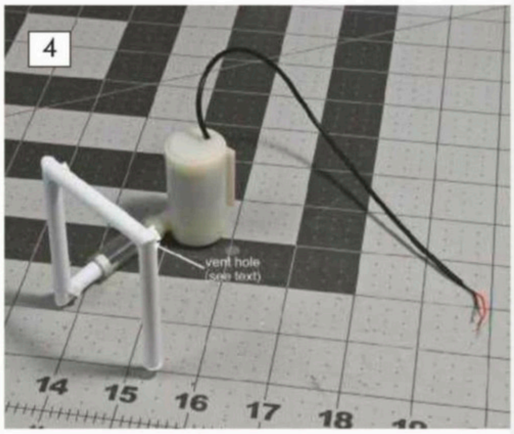


Smoke on the water

Roy F. Cheers provides a step by step guide to making your very own water-based smoke unit...



I don't know if the Steammaster units were the first on the market but they certainly made news in the model boating world. Their advantages over oil-based units set them apart, being environmentally-friendly, clean and with low power consumption. It appears they are available no longer, but similar devices are.

Water-filled smoke units are relatively simple devices, which can be built from readily available components. The 'heart' of the device is a nebuliser which uses ultrasonic vibrations to create a water mist. According to my research, these are only effective over a small depth range. The device I will be explaining how to create here, however, has an effective depth of 5-7cm.

One of the improvements my design has over the Steam Master unit is that it uses more of the water, i.e. more than that top 2cm represented by the operational depth range of the nebuliser. I typically enjoy a sailing session of 90 minutes or more, and I so I like the smoke to last that long.

Another feature of this unit that I wanted to design differently was the size and shape of the tank. I'd bought two Steammaster units for other models, only to find the tank did not fit, so I ended up discarding the supplied tanks and creating my own from styrene. In view of this, when it came to my next model, I decided to have a go at building something myself that would be better suited and more fit for purpose.

By following the instructions in this feature – and please note, these are based on using a 12V battery as the main power source – you can do the same. Ready? OK, it's full steam ahead...

Materials

The materials required for this project (which should be easy enough to source online or via eBay), are as follows:

1. Nebuliser, (See **picture 1**.)
2. Voltage increaser, variously described as voltage step-up, converter, etc. (See **picture 2**).
3. 2-wire 25mm 12V DC brushless computer fan, (See **picture 3**)
4. Mini submersible pump (See **picture 4**)
5. 47 or 56 ohm resistor, 2 watt minimum, to be fitted in series with the pump.
6. Styrene sheet and strip to make the tank.
7. Smoke output control, optional.

Other modellers have suggested using a plastic food container as a tank. This is a neat and simple solution if you can find one of a size that suits your model.

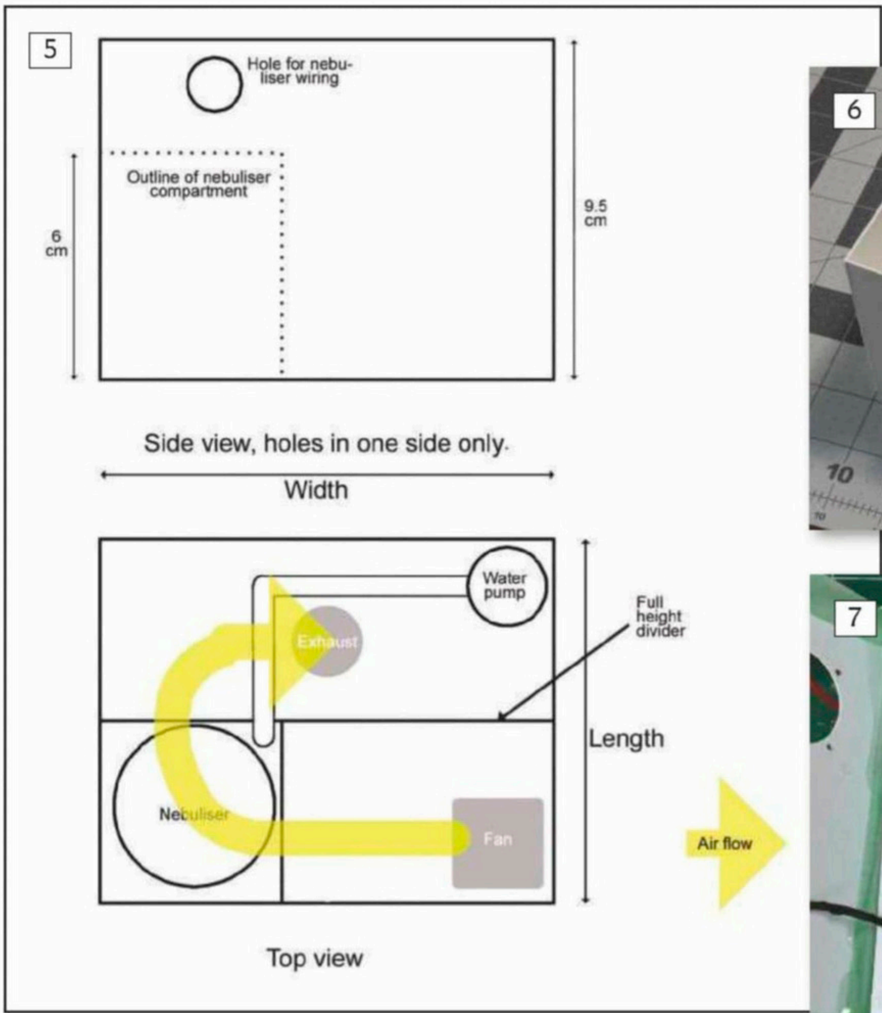
The nebuliser generates the water mist, i.e. 'smoke' and the voltage increaser steps up the voltage to the 24V that the nebuliser needs.

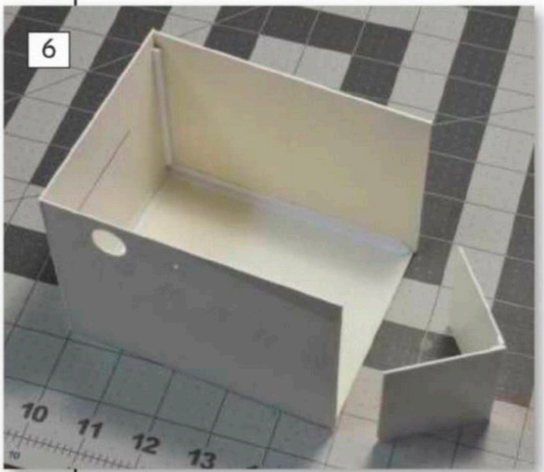
The fan creates pressure inside the tank to force the mist up the exhaust tube, i.e. funnel.

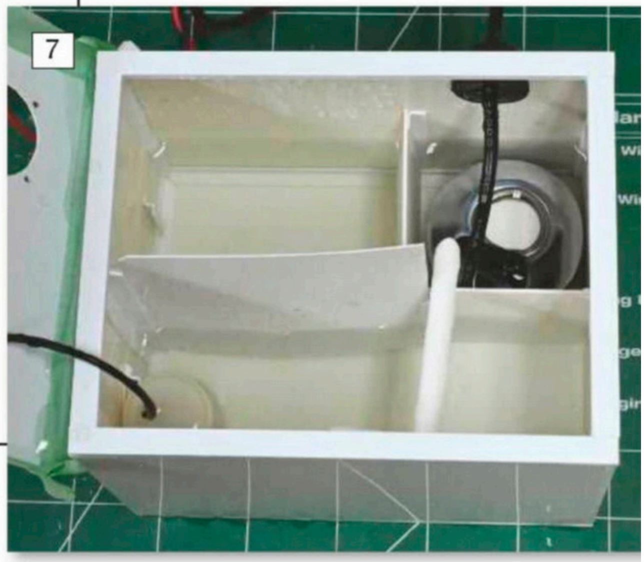
The pump maintains a constant depth of water over the nebuliser, pumping water continuously into an internal nebuliser compartment, drawing it from the main body of the tank. The slight surplus flows over the top of the compartment back into the main tank. The pump requires as little as 3V and 0.2A.

The resistor in series with the pump reduces the 12V to approx 3V at the pump.

If you wish the volume of smoke to vary with model speed you can also make the output control.







Tank

The tank dimensions I show in **Picture 5** are selected to fit my model, and you can adjust most of these to suit your own build. They must, however, take into account the operational depth of the nebuliser. I chose to make the height equal to the maximum depth for the nebuliser, plus 2.5 cm, making it 9.5 cm. I made the tank approx 13 cm by 10 cm. The maximum volume of water in the tank is thus 13 x 10 x 7 = 910 ml. The nebuliser can generate 350ml/hr of mist, which gives over two hours of operation from one fill.

A small compartment within the tank is created to house the nebuliser. The height of this compartment's walls is selected to suit the operational depth of the nebuliser. The range of mine was 5-7cm, so I chose 6cm as the internal wall height. (7cm will be the maximum depth of water in the tank.) This compartment should be well sealed but does not need to be 100% watertight.

Styrene is one of the best choices for making the tank because it is impermeable and watertight joints are easy to achieve. I used strips that I had on hand to reinforce the joints.

Unlike steam, the water vapour created by the nebuliser will not naturally rise up the exhaust by convection. The water vapour is heavier than air and will tend to 'float' above the water. The fan is required to push it up the exhaust. Also, the fan and nebuliser should be spaced apart so that the fan does not push the mist from the nebuliser back down but instead creates a draught which pushes the mist away from the nebuliser and up the exhaust pipe.

The pump can be placed anywhere convenient, and the exit holes for the pump and nebuliser wires can be positioned anywhere in the walls or on the cover.

Because my tank is wide and almost fits the width of the hull, I fitted a swash plate down the axial centre. It has holes in the bottom corners to let the water levels on each side equalise, but which minimise the water sloshing to one side in a turn or when heeled by the wind.

A discharge line built up from styrene tube connects the pump discharge to the nebuliser compartment (see **Picture 4**). Use a short length of ¼ in plastic tube to connect tube and pump. The tube discharge hole is positioned at the bottom corner of the nebuliser compartment so that it does not disrupt the stream of vapour bubbles rising from the nebuliser. You will need to blank off the end of the tube and drill a hole in its side so that the water flow is directed around the side of the nebuliser. I tested a 1.3mm hole to limit water flow from the pump to 80-90ml/min, a little more than needed to keep the nebuliser compartment full.

It is recommended that you first drill a hole of 1mm diameter in the tube and measure the amount of water pumped out in one minute. Increase the size of the hole until you reach a satisfactory surplus. Too little water being pumped will result in the water level above the nebuliser decreasing until no water vapour is created, even though there is water still remaining in the main tank. Too much simply means that the pump will draw a few extra milliamps and increases the surplus that overflows from the nebuliser compartment back into the main tank.

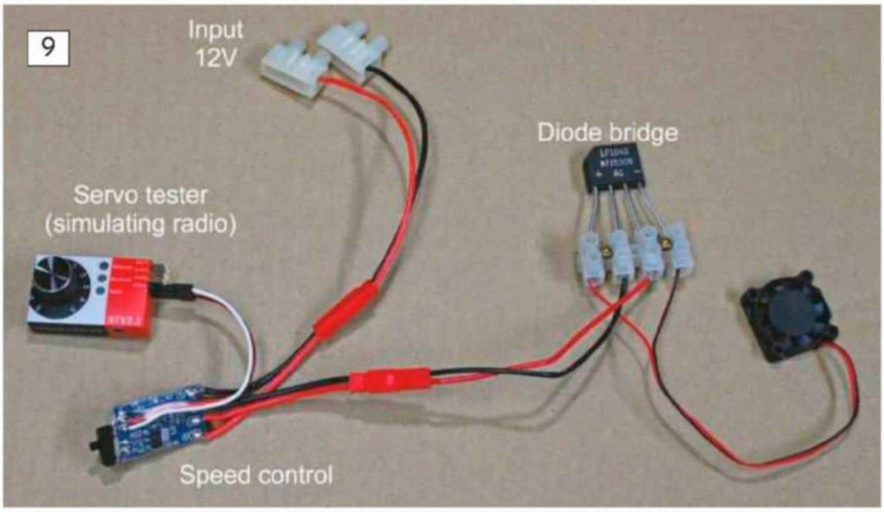
There are options for the cover. It can be made from opaque or clear styrene. It is recommended that you add flanges to the tank and a lip projecting down from the tank cover inside the flanges. These lips should be a close fit to the flanges. You can then screw the cover down.

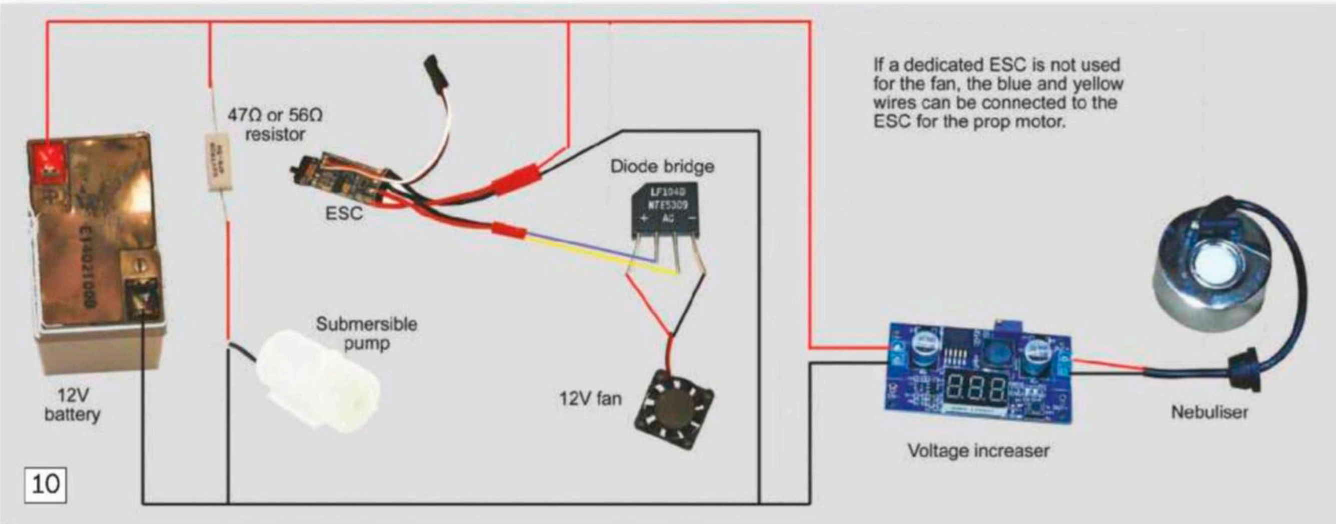
These features should be enough to ensure smoke and water do not escape between tank and cover but, if necessary, you can also take a 'leaf' out of the practices of the modellers of fast electrics and simply tape the cover to the tank.

The exhaust tube is not shown. The Steammaster unit used 20mm tube for the exhaust and this may be the optimum size. It is best to avoid the use of corners in the exhaust.

Picture 6, shows partial construction of the tank and **Picture 7** affords a top view.

Nebulisers are typically supplied with a 5.5mm female connector. The simplest way to connect to this is to use of a male connector (see **Picture 8**). If you decide to cut off the connector and hard wire it, then be sure to check which of the two wires connects to the centre pin, which is positive.





Flow Volume Control

There are two solutions to choose from here....

Solution 1 - Fan Speed Control

The simplest way to control the smoke volume is to power the fan through an ESC and a diode bridge. A diode bridge will ensure that the fan always receives the correct polarity to make it run, whatever polarity comes out of the speed control. So, whether the model is moving ahead or astern, the fan will run. The fan can be connected in parallel with a propulsion motor to the same ESC, or it can be powered by a separate ESC using a Y-connector to the radio's throttle channel (See **Picture 9**).

I must add a technical caveat here. The fan motors are brushless and designed to operate on steady DC voltage, as from a battery, not the pulsing DC from an ESC. I have not been able to establish conclusively that the electronics inside the fan motor will not be harmed by this pulsing DC. The fans are cheap enough if one has to be replaced, but be aware.

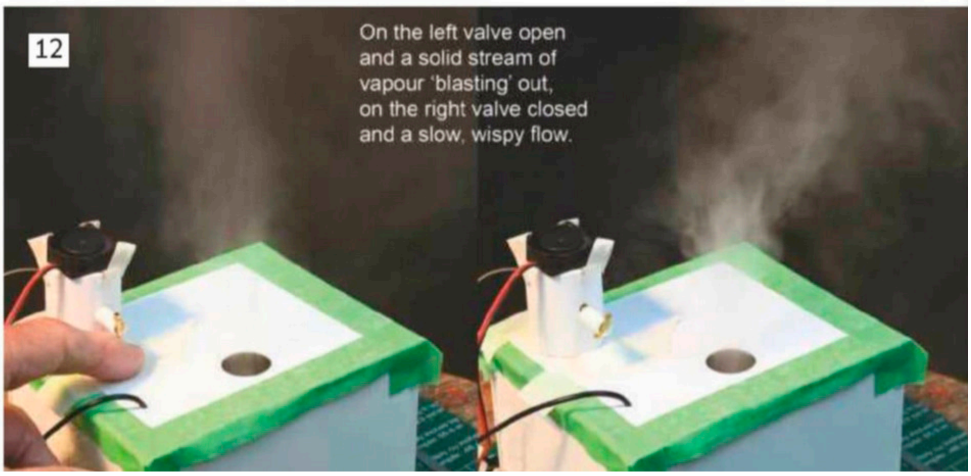
The wiring layout for this set up is illustrated in **Picture 10**. A fuse is recommended, but not shown.

I noticed while testing this arrangement that when I moved the throttle from full ahead to full astern the fan slowed, stopped, then immediately sped up again. When I tried the other way, the fan stopped and remained stopped. To go from full ahead to full astern I had to pause in the 'stop' position and then move to full ahead. It's not a significant problem, but it's an indicator that there may be other quirks in operating these fans from an ESC.

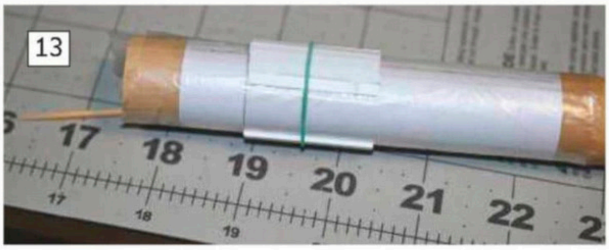
Solution 2 – Direct Flow control

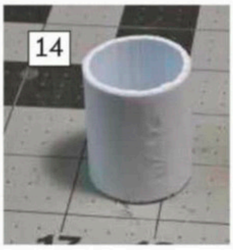
The second solution is a mostly mechanical one and involves fitting a damper in a duct between the fan and the tank. **Picture 11** shows an industrial size example. At maximum flow the valve disc is in line with the flow, and this is the position for the model's maximum speed. When the valve rotates 90° it blocks the flow, as it would when the model is stationary. Rotate another 90° degrees and it's fully open again. The valve does not completely stop the flow but reduces it considerably (see **Picture 12**). To achieve the 180° rotation a servo stretcher (see **Picture 17**) must be connected before the servo.

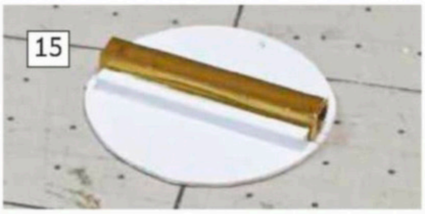
The fans are an inch in diameter so, to fit the valve, a tube of this same diameter is required. If you are unable to find a suitable piece of 1-inch diameter tube, this is how I made mine... Draw two lines at right angles on a piece of paper. Wrap the paper around a piece of 1-inch diameter dowel so that the two ends of one line overlap and are in line. This line marks one end of the tube. The other line will lie



On the left valve open and a solid stream of vapour 'blasting' out, on the right valve closed and a slow, wispy flow.







on the axis of the dowel. Wrap a piece of thin clear plastic film around on top of the paper. Tape both paper and film down with clear tape. Cut 25 pieces of 0.06 in x 0.125 in styrene. Place two strips axially on the dowel, glue their ends together, and then place a rubber band on them to hold them in place. The plastic film will prevent the glue from sticking to the paper and wood. Add more strips, a few at a time, gradually forming a tube. You might need a couple of pieces of 0.02 in x 0.06 in strip to close the final gap. Once you have the complete ring in place you can remove the rubber band and glue the whole length of the strips. Glue a piece of 0.01in sheet around the tube to add strength (see **Pictures 13** and **14**).

To make the disc for the valve, draw a circle on a piece of 0.030 in thick styrene to a diameter a little smaller than the inside diameter of your tube. I do this by cutting off the outside of the circle to make a square. Then I cut off the corners and continue to cut off the corners until I can make it circular with a little sanding or filing. Cut a length of $^1/_8$ in square brass tube a couple of millimetres shorter than the disc diameter. Then glue the tube to the disc across the centre point (see **Picture 15**).

To make the shaft for the disc, cut a 2¼ in length of $^3/_{32}$ in square brass tube. At the drive end, glue a ½ in length of $^3/_{32}$ in round brass or styrene rod beside the square tube. Slide over it and glue a ½ in length of ¼ in round styrene tube, extending beyond the two $^3/_{32}$ in tubes by at least $^1/_{16}$ in. Cut a $^1/_{16}$ in wide slot crossways in the end of the ¼ in tube and glue in a $^3/_8$ in length of $^1/_{16}$ in square tube. The last step for the shaft is to make up a connector to the servo, as described below, for 180° rotation.

To make the shaft holes in the tube for the valve disc, position the disc with its shaft on top of the tube and mark out the positions of the shaft on the tube. From these marks draw lines down the side of the tube to the height selected for the location of the disc shaft. Drill $^1/_8$ in holes at these locations. Put it all together. Hold the valve disc in place and insert the shaft through the tube. Finally, put the assembly into its operating position. I suggest using a few drops of silicone or Goop to hold the fan in position. When setting up the connection to the servo, the disc should be in the closed position when the servo is in the zero-speed position. **Picture 16** shows disc, shaft and tube assembled.

Servo drive for a pot - 180° rotation

180° rotation requires a solution different from the usual servo linkage (see **Pictures 18** and **19**). A length of $^5/_{16}$ in outside diameter styrene tube has a slot cut crossways into one end, and this fits over the disc shaft. At the other end of the tube four 25mm lengths of $^1/_8$ in square tube are glued on the outside as spacers. Outside that is glued a piece of 17mm diameter tube. This came out of my 'bits box' and is the smallest diameter that will fit a Futaba standard servo horn. Slots are cut in the servo end of the 17mm tube so that the tube end fits over the servo horn. This makes a simple, if somewhat bulky, assembly. It can, however, be made more compact by shortening the tubes or using a micro-servo. As mentioned, the servo requires the use of a 'servo stretcher' (see **Picture 17**).

The wiring layout is similar that shown in Picture 10, except that the ESC and diode bridge are omitted, and the fan is connected to the 12V power.

Weight and stability

The trim and draft of the model will change as the water is used up, especially if you make a big tank. The weight of my prototype tank will change by almost 1kg from full to empty. In general, the stability will increase as the water is consumed and the weight decreases, because the height of the centre of gravity of both tank and model will decrease. Any change of fore and aft trim should be negligible.

Water

It is recommended that you use distilled water rather than pond or tap water in this unit, unless, of course, the latter is very soft, because any gunge or sediment may clog the pump or the small discharge hole. I have made it my practice to drain the water from the tank after every sailing session, simply refilling it next time around with a measured amount of water.

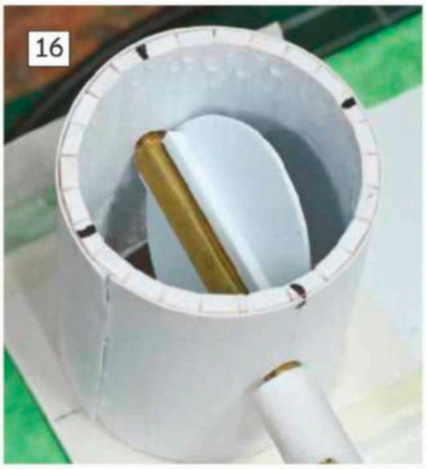
As the construction of the tank is described here, if you want to drain the tanks completely you will have to empty the main tank and nebuliser compartment separately. If you prefer, however, you can drill a small hole, say, 1mm in diameter, at the bottom of one of the walls of the nebuliser compartment. This will allow the compartment to drain into the main tank. Bear in mind, though, you will need to increase the size of the pump discharge hole to offset this amount.

Air

Filling the main compartment and allowing the pump to fill the nebuliser compartment should ensure that the air is expelled from the pump tube. Should you experience a problem, drill a very small hole at the nebuliser end of the top branch of the tube.

Steam team

If you decide to have a go at creating your own smoke unit, please let us know how you get on by sharing details of any problems encountered, solutions come up with and lessons learnt. ●



Take note!

If you intend to connect the fan wires using a terminal block, do not cut off the plug at the end. Instead cut off the tabs holding the connecting pins in place, then pull wires and pins out of the plug and leave them intact.