

A simple air flow temperature regulator for small enclosures

1. Introduction

There are numerous instances when small volumes (typically ~1 litre or a few litres) need to be maintained at a fixed temperature above ambient. In biological science applications, the required temperature is typically at around 37 degC. While there are numerous commercial solutions for such applications, in general they are either very costly, 'not quite right' or, more often than not, are part of a more complex system and thus hard to obtain. We describe here a simple solution which may be of interest to others as it is made from readily available components and can be put together in a couple of days. It was originally developed to maintain small biological samples at a constant temperature within a microscope enclosure.

The system is 'closed' in the sense that air (or some other non-flammable gas) is continuously recirculated through a heater block. The enclosure which needs to be maintained at the constant temperature should of course be insulated as well as possible. The enclosure temperature is monitored with a thermocouple and heater power adjusted with a proportional-integral-derivative control system. The enclosure is connected to the controller with flexible pipes and air flow is provided by a small fan. Some heat losses are of course inevitable and indeed necessary so that the feedback system can operate properly and it is thus assumed that temperatures above ambient are required i.e. no active cooling is provided.

Heating is provided by readily available cartridge type heaters. The maximum heater power available is of the order of a few hundred watts and this dictates the insulation (i.e. heat loss) required. A heatsink designed for forced air cooling is employed and the cartridge heaters are embedded in it. Such a heatsink is convenient to use as it is straightforward to attach a fan to it; after all it just what the heatsink was designed for! A thermal cutout switch is of course essential in case of malfunction and this is placed close to the heatsink.

The circuit diagram of the controller is shown in Figure 1. The heaters are driven from the mains voltage through a solid-state relay which is in turn driven by a temperature controller which contains a thermocouple input and all required feedback circuitry. A small transformer and full-wave rectifier generates ~13 V DC which is regulated to a lower, adjustable voltage which drives the fan.

The thermocouple is attached directly to the controller and fed down one of the flexible hoses to the enclosure which is to be controlled.

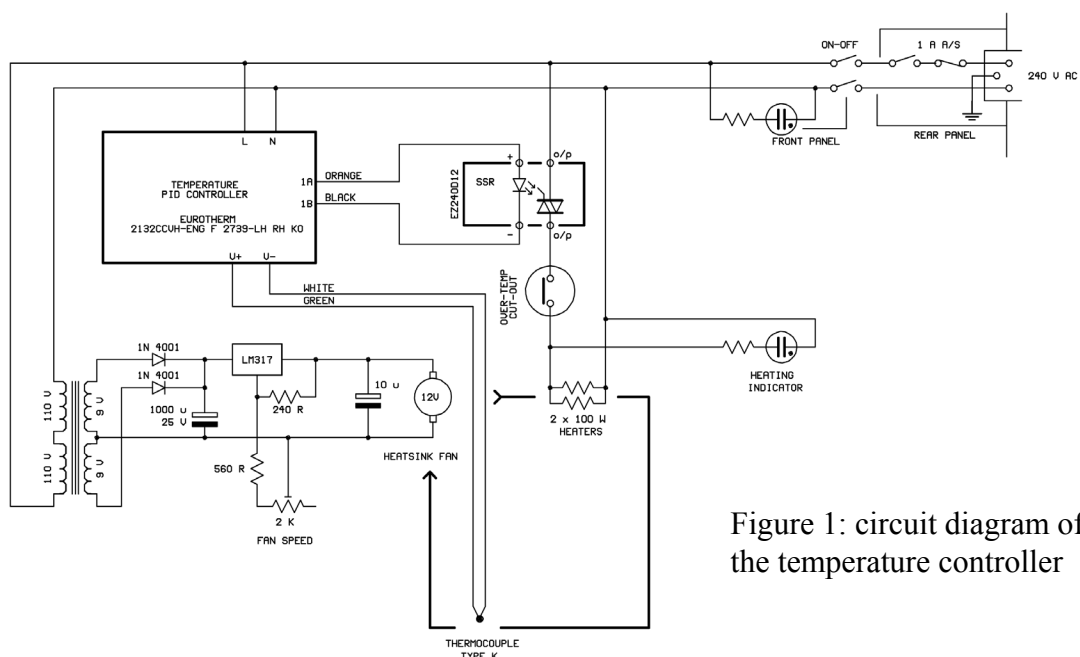
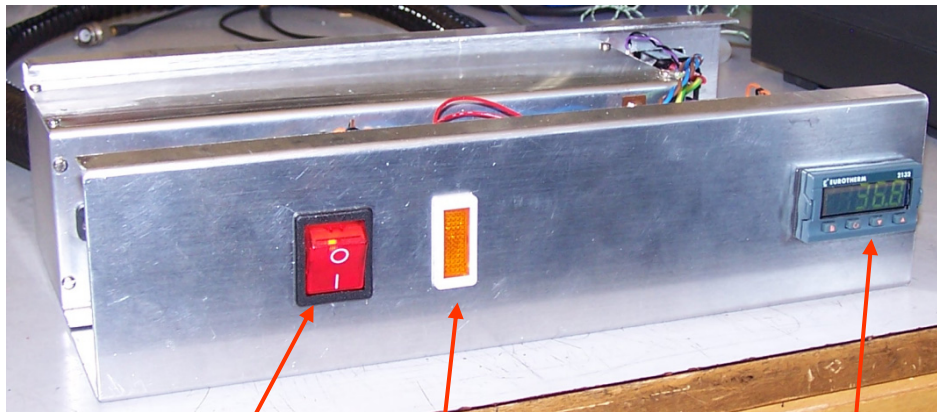


Figure 1: circuit diagram of the temperature controller

2. Construction

The unit is constructed in a simple folded aluminium enclosure, as shown in Figure 2. A separate folded enclosure is made up around the heatsink and fan and capped with two small aluminium end-plates. Cutting and drilling details for the various items are shown on subsequent pages; hopefully, these are self-explanatory!

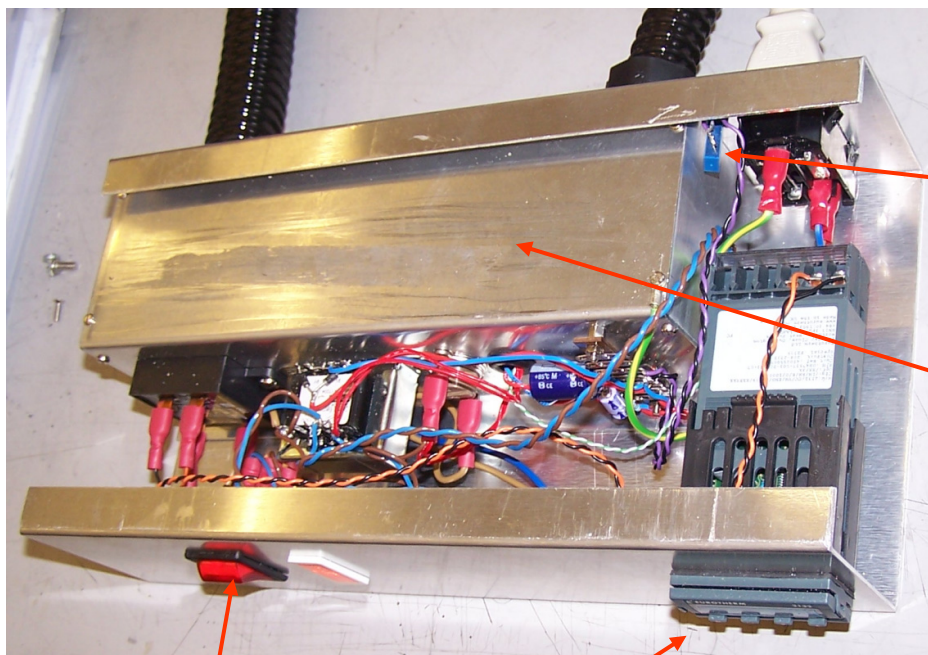
It is noted that several of the components operate at mains potential and appropriate construction techniques are essential. If you don't know how to do this, do not attempt to replicate this project!



Mains on-off

Heating indicator

Controller and temperature indicator



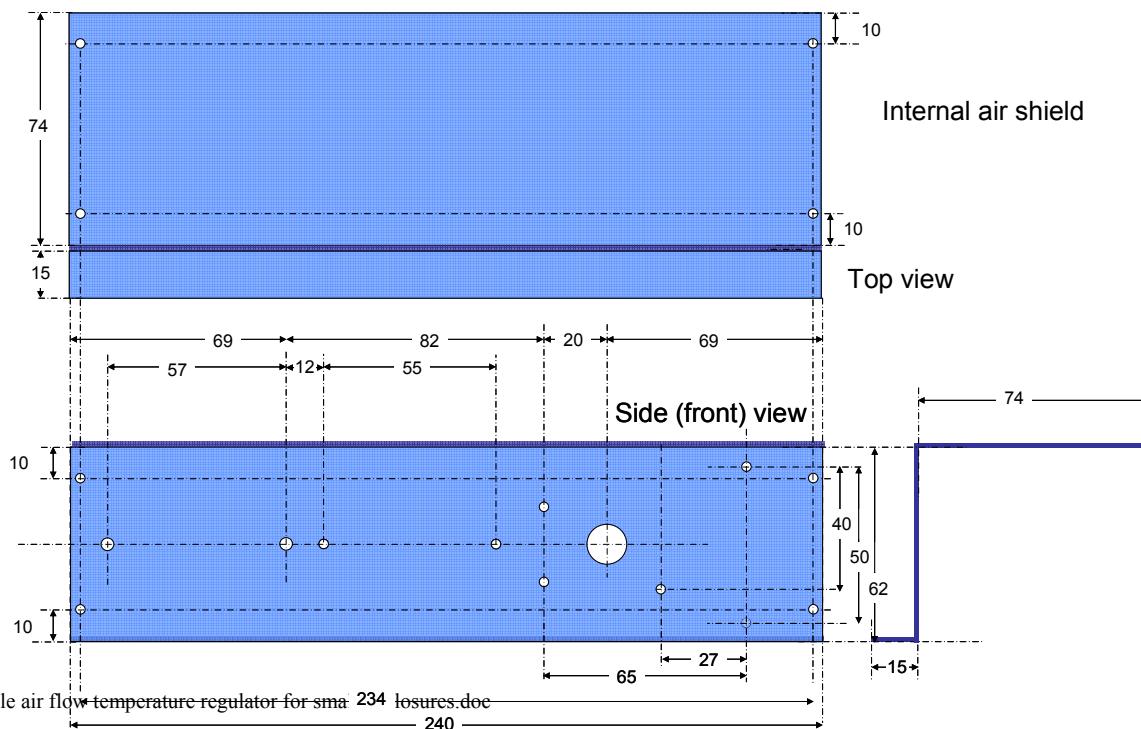
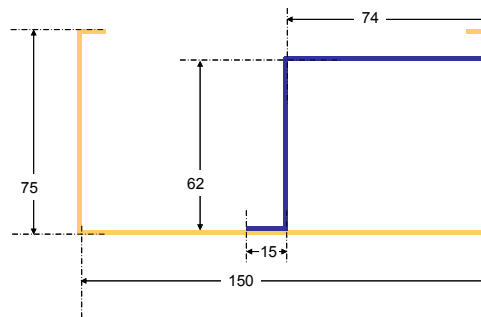
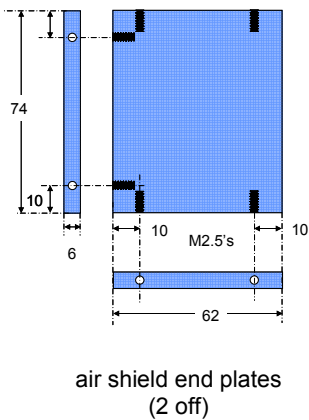
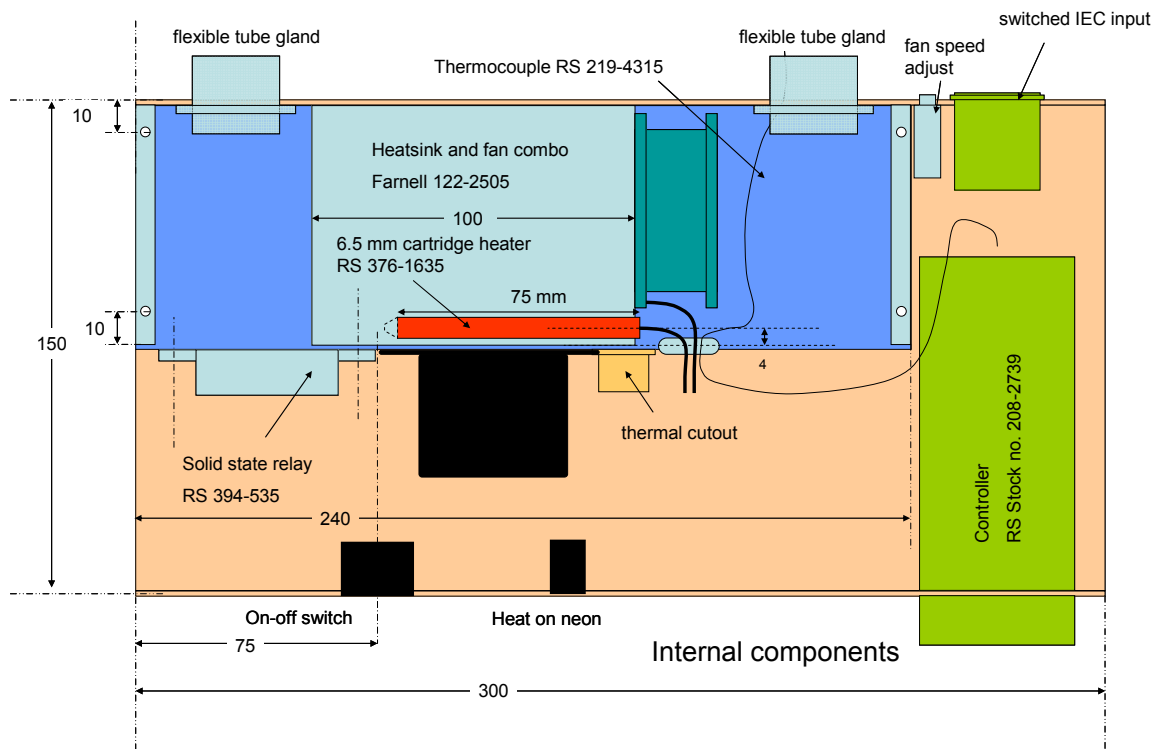
Mains on-off

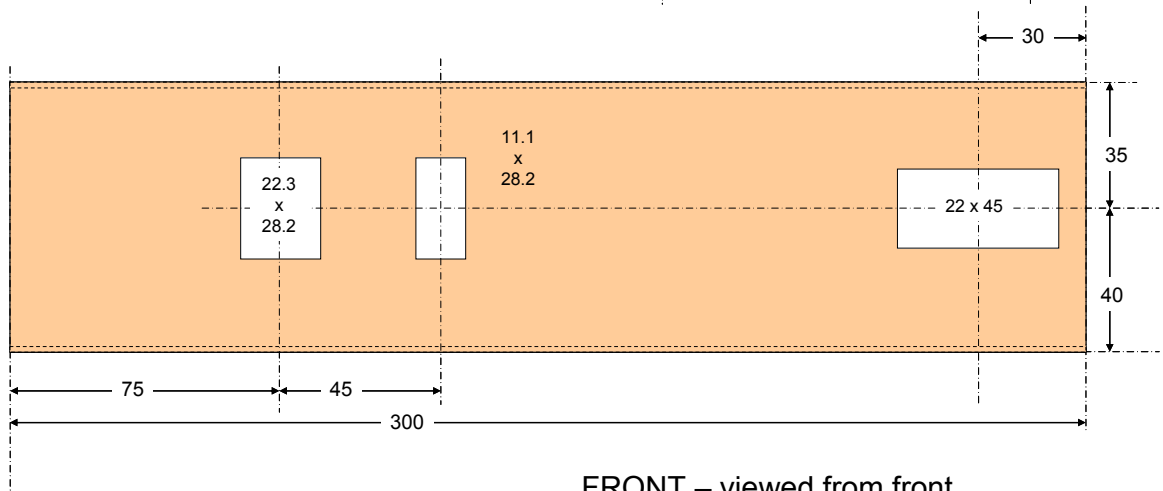
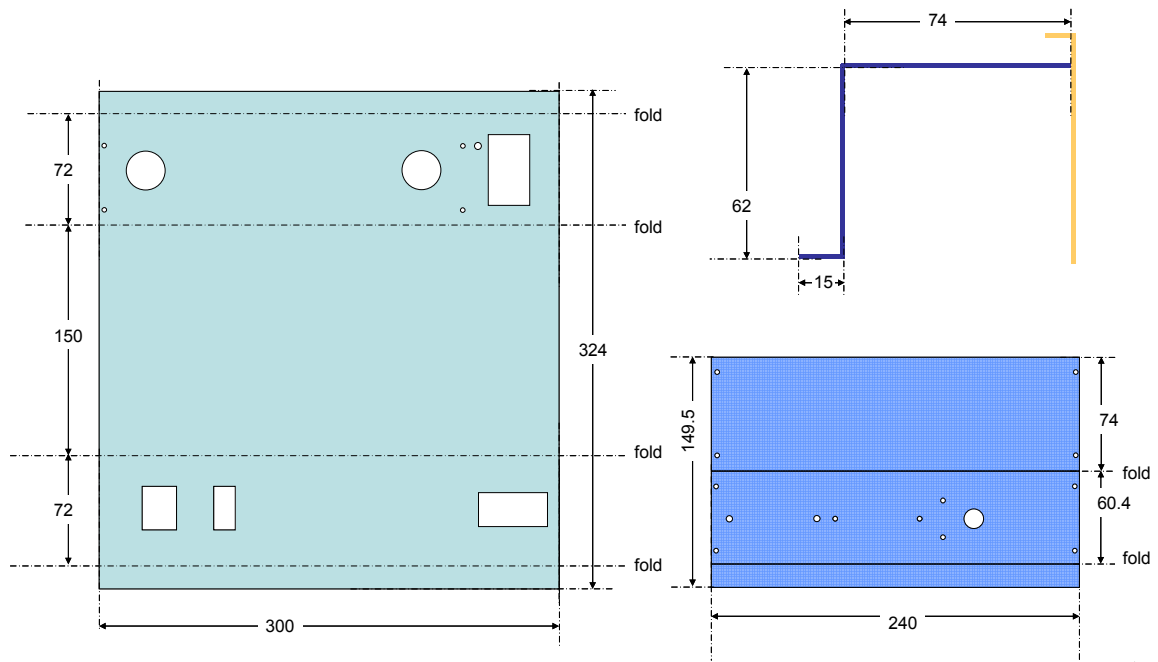
Controller and temperature indicator

Fan speed preset

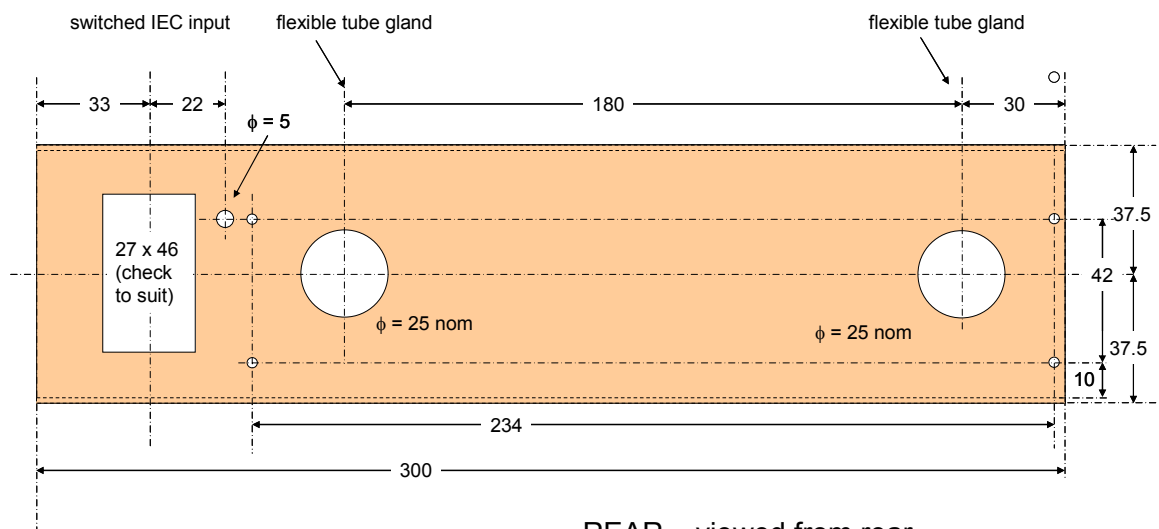
Fan, heater, heatsink assembly with inlet and outlet hoses

Figure 2. Construction of the controller unit. Two folded aluminium assemblies make up the chassis and the heating/fan assembly. The solid-state relay, the transformer, regulator and other sundry components are attached to the inner folded assembly, while switches, indicators and the controller are mounted to the front of the chassis. The rear of the chassis holds the mains input socket, the fan speed control and the inlet and outlet flow pipes.

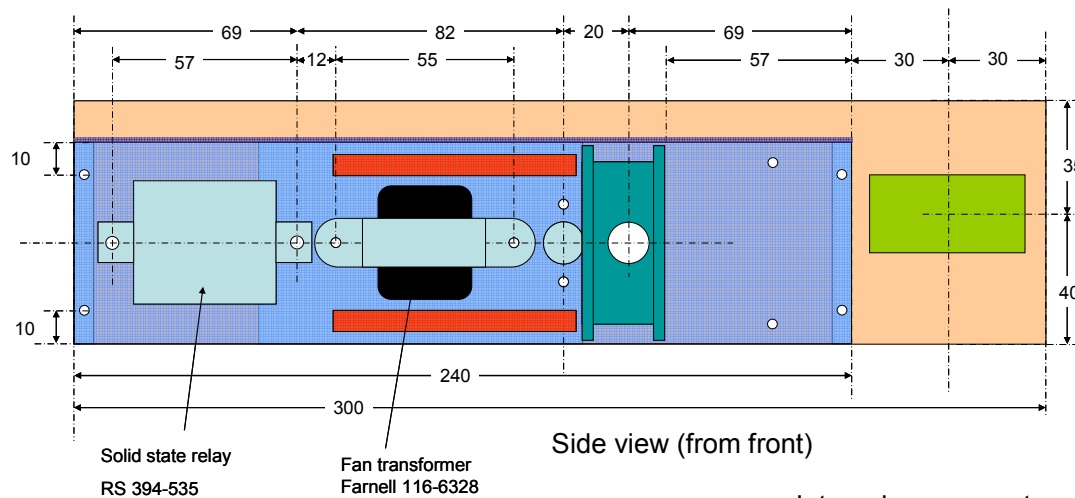
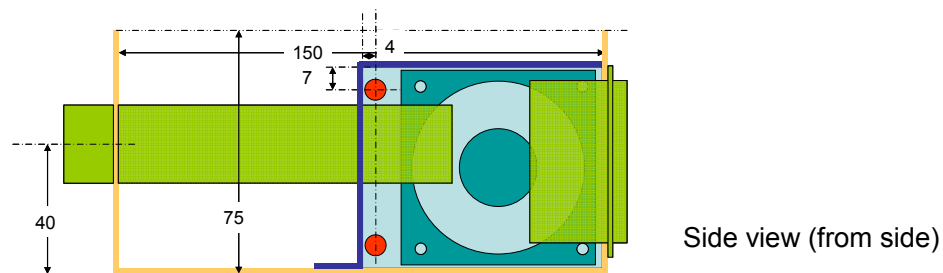




FRONT – viewed from front



REAR – viewed from rear



Internal components

The components used are listed below:

Item	Supplier	Stock #	Part #	Cost
Controller	RS	208-2739	Eurotherm Controls # 2132-CC-VH-ENG-F2739-LH-RH-K-0	£ 150.00
Cartridge heaters	RS	376-1635	# MS6.5-75 100W 230V	£ 12.92 each, 2 off
Thermocouple	RS	621-2158	K PTFE welded tip insulated thermocouple	£ 2.99
Solid state relay	RS	394-535	Solid state relay, 12A 24-280Vrms Crydom EZ240D12S	£ 11.81
Over-temperature switch	RS	339-308	NC thermostat, Open@70degC part 2455R 82-195 L70C	£ 1.85
Tagstrip	RS	433-781	Miniature tag strip, 194x16.7x4mm	£ 0.918
Tagstrip mounting posts	RS	606-670	M3 x 5mm post	£ 0.14 each, 2 off
AC input connector	Rapid	23-3211	IEC, AC fuse, switched	£1.45
Fuse	Farnell	112-3131	Multicomp MCF03C-1A Fuse, Anti-surge 1A	£ 0.173
Heatsink and fan combo	Farnell	122-2505	Fischer Elektronik LA 6/100 12V Heatsink 0.2°C/W	£ 38.47
System on-off switch	Farnell	242-834	Arcoelectric C1353ATNAN 16A	£ 2.27
Transformer for fan	Farnell	116-6328	Dagnall Electronics D3630 6VA 2 x 9V	£ 4.49
Rectifiers for fan	Farnell	956-4993	Multicomp 1N4001. Diode, 1A 50V	£ 0.043 each, 2 off
Smoothing capacitor	Farnell	812-6593	Rubycon 35RX301000MEFG12.5X25 1000µF 35V	£ 1.50
Fan regulator	Farnell	121-4459	ON Semiconductor LM317BTG	£ 1.07
Heating on neon OR	Farnell	143-020	Orange / white	£ 0.95
Alternative neon	Farnell	150-918	- black surround	£ 1.66
Speed-setting potentiometer	Farnell	----	2KΩ preset	£ 2.50
Reference resistor	Farnell	934-1587	Multicomp MF25 240Ω	£ 0.021
Limit resistor	Farnell	934-2052	Multicomp MF25 560Ω	£ 0.021
Decoupling capacitor	Farnell	114-4665	RUBYCON 35ZA10M5X7, 10 µF 35V Al electrolytic	£ 0.36
AC input cable	Farnell	112-4382	Volux X-285626A	£ 6.27
Airflow hose	Whitehouse	PVC	¾" Superflex, black	£ 1.30/metre
Airflow hose glands	Farnell	152-598	CRITCHLEY Part No: EF952022	£ 1.41 each, 4 off

The flexible tubing can be obtained from: Whitehouse Flexible Tubing Ltd
 Britten street, Redditch, Worcestershire, B97 6HD, Tel: 0152764036, Fax: 01527584165
<http://www.flexible-tubing.com/>

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