DIGITAL CENTRAL HEATING CONTROLLER

- ★ **Works with either gas or oil-fired central heating**
- ★ **Designed to work reliably and without adjustment over long periods of time**
- ★ **Eliminates wasteful standing losses within the boiler**
- ★ **Saves you money**

by Chris Bearman

Ever rising fuel costs are tending to make most of us seek ways in which to reduce our energy consumption, particularly in the home. Many firms offer us their wares with the promise of lower fuel bills in the future, usually these take the form of some type of insulation, be it draught exclusion, wall and loft insulation or double glazing. One area which has it's fair share of economy suggestions is the central heating system. At present there are thermostatic radiator valves, and zone control valves to name but two.

The digital central heating controller was designed with two basic views in mind. First, to help to make the system more economical, and second, to make the controls more convenient to operate. The controller was designed around a basic gas fired central heating system, but it could work just as well with an oil fired boiler. The controller directly activates two motor valves, a pump and a boiler. The 'primary' water route through the boiler should be pumped to allow the controller to operate correctly. Some types of heating system use what is called a 'gravity primary' which does not require a pump to heat the water in the hot water cylinder. This type of system probably has no motor valves in it either and so would need a few alterations to allow it to work successfully with the controller.

An example of a suitable system is shown in Figure 1. This diagram is obviously much simplified, and can of course be altered in many ways to suit the particular application.

Circuit description

It can be seen from the circuits (Figures 2, 3 and 4) that there are two sets of control buttons. One set is mounted on the control box (usually near to the pump and motor valves) and the other set is at a convenient remote location. In a two storey house the water cylinder is found upstairs, so the controller would be near to this, the remote control set is probably best mounted in the kitchen.

The remote switches S1-4 activate the LEDs in the opto-coupler D14, hence giving isolation to the logic inputs. Either the outputs of the couplers, or the operation of switches S5-9, act on the inputs of the latches in IC1. These inputs may also be acted on by the operation of the timer circuitry, IC2

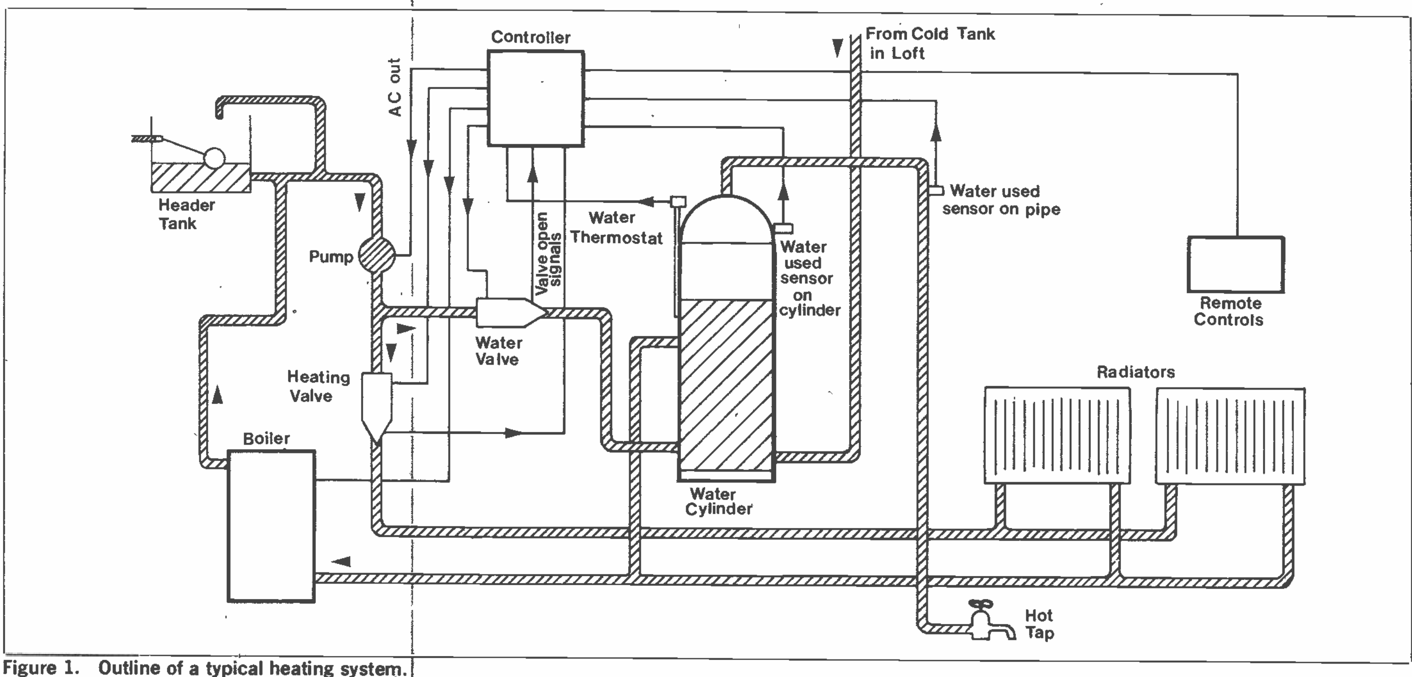


Figure 1. Outline of a typical heating system.

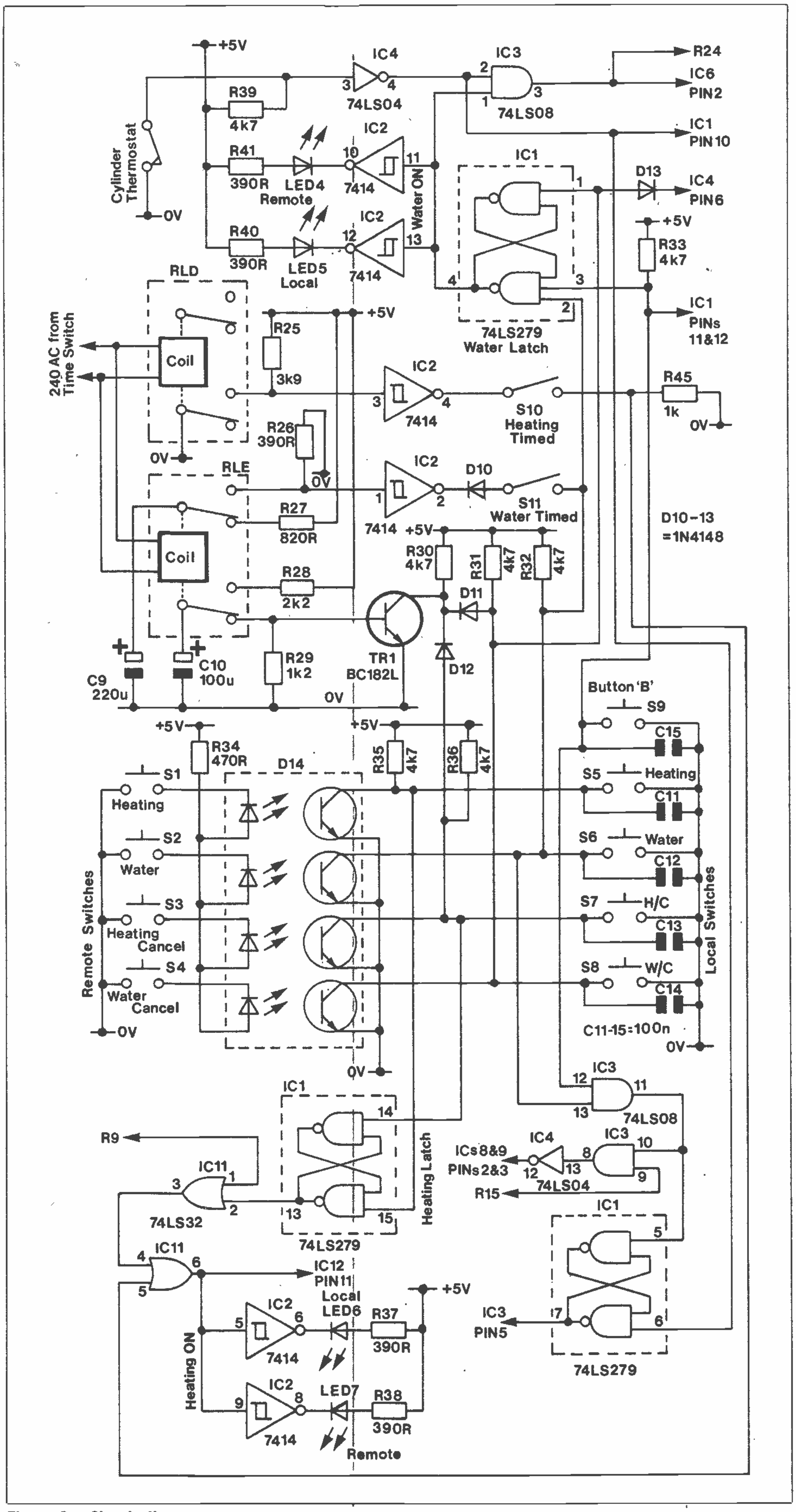
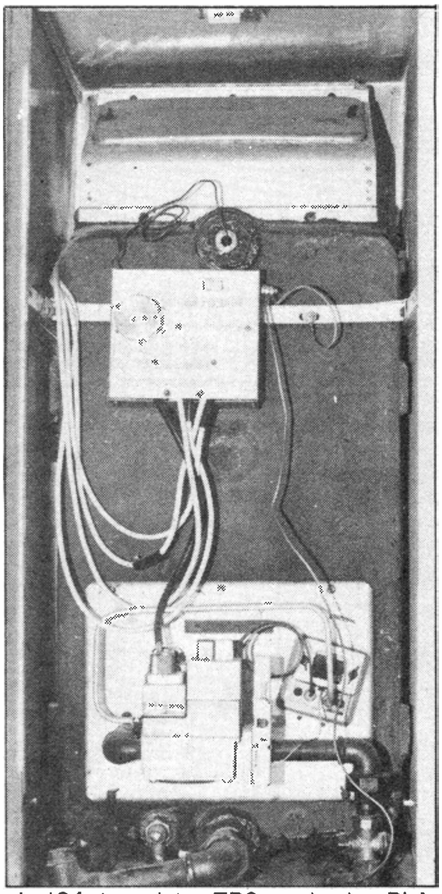


Figure 2. Circuit diagram.

and TR1. A standard inexpensive plug-in type timer may be used to operate the A.C. Relays RLD and E, hence allowing timed operation of the water, the heating or both. Switches S10 and S11 enable the circuitry to the latches.

When Pin 2 of water latch IC1 is taken low, the two 'water on' indicators are activated, one on the control box and the other on the remote panel. If the cylinder thermostat shows the water temperature to be below the set level, the output of IC3 will go high, enabling TR4 and so operating the water valve via RLC. Once open, the inbuilt switch in the valve will take pin 11 of IC4 low, enabling input 3 of IC6. Pin 6 of IC6 then activates both the pump and the boiler



via IC4, transistor TR2, and relay RLA.

It can be seen that two thermistor sensors are attached to inputs 12 and 13 of Op Amp IC7. One of these is attached to the hot water pipe leaving the water cylinder, and the other is attached to the cylinder itself. These form the 'Water Used' circuitry. The preset RV1 is adjusted so that when the hot water pipe has cooled down, (in relation to the cylinder) i.e. no hot water has been run off for some time, the output on pin 14 will go high. This disables the reset lines of the counters IC8 and IC9. When the water in the cylinder is up to temperature IC4 pin 4 will go low thus forcing pin 7 of latch IC1 to go high. Clock pulses from the slow clock IC10 will now reach the input of the counter IC8. When no hot water is used for some time, the output of IC7 pin 14 will go high, thus allowing the counters to time out. After a period of about half an hour or so, assuming that the 'water' button is not depressed again, and that no hot water is used, pin 11 of IC9 will go high thus clearing down the water latch IC1; at this point the 'water' indicator will go out.

Heating may be turned on by pressing either of the two 'H' buttons. It may also be set to come on 'timed'. The buttons act upon input Pin 15 of the heating latch IC1 and cause output 13 to go high. This output is taken to Pin 2 of the 'OR' gate IC11. The other input of the 'OR' is from the frost-stat circuitry, IC7.

Both the frost-stat and the room thermostat share the same thermistor, sited to control the temperature of the heating in the house. The output of the thermistor is taken to pins 2 and 6 of the 3403 (IC7). One of the Op-amps is

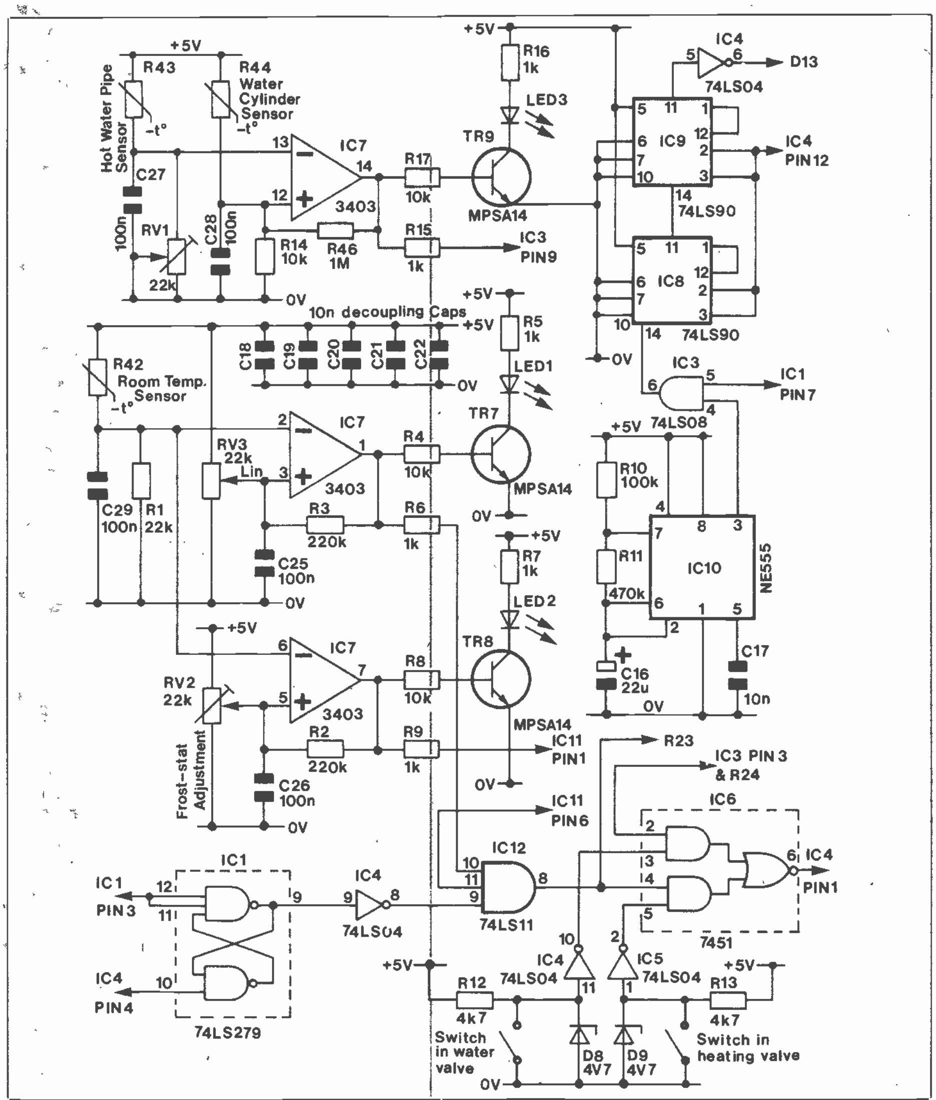


Figure 3. Circuit diagram.

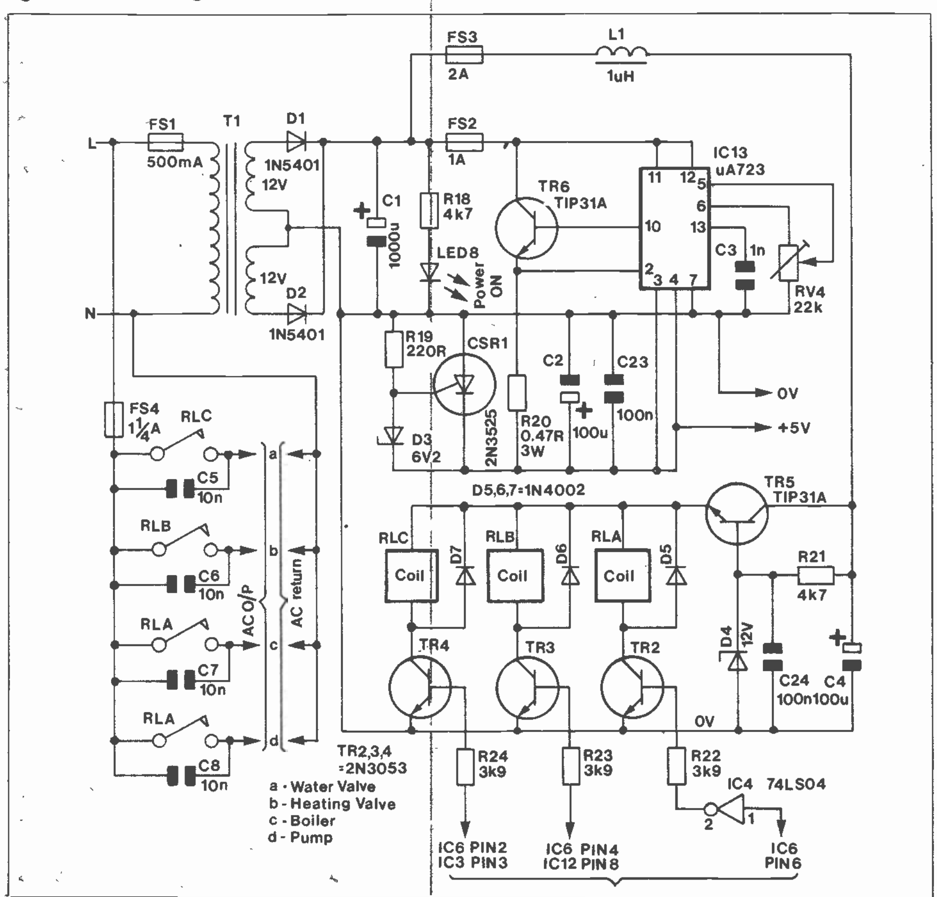


Figure 4. Circuit diagram.

adjusted by an external knob on the control-box (RV3) for the desired room temperature. The other is adjusted by a pre-set (RV2) to the desired lower-level temperature which will activate the heating. It will be noticed that the heating does not have to be on for this to operate, hence the premises may be left unoccupied with no fear of frozen pipes during a cold spell.

The output of the 'heating timed' circuitry is taken to Pin 5 of the next 'OR' gate (IC11) and so to the 74LS11 (IC12), on Pin 11. If the other inputs 10 and 9 are high, the output on Pin 8 will activate the heating motor valve via TR3 and relay RLB. Input 10 of the 74LS11 is taken from Pin 1 IC7 which is acting as the room thermostat. The other input, Pin 9, is fed from the output of latch IC1.

The 'B' button is found only on the control box and is used to give a priority to water heating when the central heating is also being used, for instance when a bath is needed. Switch S9 (B) causes the water latch to operate via Pin 3 of IC1. Pins 11 and 12 of IC1 are also taken low, thus causing the output IC4 pin 8 to go low. This has the effect of shutting down the heating on a temporary basis (as it does when the room-stat is up to temperature). It is restored eventually when the cylinder thermostat reaches the desired temperature, so taking Pin 10 of the latch low and re-activating the heating.

It will be noticed that the system design eliminates 'standing losses' with the boiler, which occur in the majority of central heating systems. This is when the boiler 'short cycles' by itself on it's own thermostat even when no heat is required by the radiators or the hot water.

System power

The electronics are supplied with the necessary +5 volts from a 723 voltage regulator, IC13, and a series pass transistor TR6. A separate feed is taken off the bridge rectifier to a simple regulator TR5, D4, to give around 12 volts for the operation of the relays. This supply is isolated to a degree by means of the choke L1 and the capacitor C4. The +5 volts is protected from over-voltages by an ordinary cro-bar circuit, D3 and CSR1. Three fuses are used to give protection to the low voltage supplies, these are FS1, FS2 and FS3.

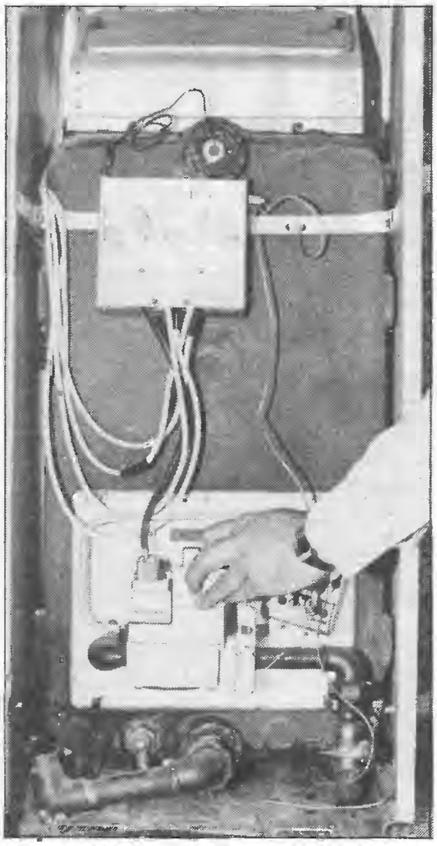
It is preferable to run a separate lead from the mains plug to the relay contacts which supply the voltages to the external devices, this is to reduce the likelihood of mains-originated interference problems. If mains interference poses a serious problem (this all depends on the other devices using the ring main supplying the controller) then the best solution will probably be found in a small mains filter.

When constructing the controller, the logic must be assembled away from the mains transformer and the relays. Transistors TR5 and TR6 must be mounted on adequate heatsinking; TR2, TR3 and TR4, each need only be fitted with a small cooling fin. The cable from the remote controls should not be run alongside of any mains cabling to reduce the possibility of any noise being induced onto the supply rails.

Setting up

It will be noticed that at various places in the circuitry, indicators have been fitted. These are invaluable for setting up the unit, and are of future use when adjustments to the settings are required.

Before first powering up the unit, the +5V adjustment should be set to it's midway position, along with all of the other pre-sets. Now apply power to the unit and adjust RV4 to give +5 Volts. To calibrate the room thermostat, an ordinary thermometer is required. Set the thermometer up close to where the room thermistor (R42) is mounted, and after allowing ten minutes or so for it to stabilise, note the reading on it. Now turn the room thermostat (RV3) adjustment fully counter-clockwise and note that the room-stat indicator LED 1 is on. (It matters not whether any of the buttons have been pressed). The control should be now rotated clockwise till the indicator goes out. This point on the scale should be marked with the temperature on the thermometer. It will be necessary to turn the heating on (H button) after the thermostat control has been turned up to check for the correct operation of the heating valve, the pump, and the boiler. When the room temperature has risen by a few degrees, it will be possible to add another value onto the thermostat scale using the same method as before. It should be possible to add further points to the scale by dividing the distance between the two points by the number of degrees rise in the room temperature.



An immersion heater type thermostat may be used to sense the temperature in the water cylinder. It should be firmly attached in an upright position to the top of the hot water cylinder (inside of the insulating jacket) and set to the temperature required by means of the adjusting control at the top. To adjust the 'water used' pre-set RV1, it will be first necessary to bring the water in the cylinder up to temperature by depressing the 'W' button. Check for correct operation of the motor valve, the circuitry and indicators, and when up to temperature note the position of the pre-set RV1 which causes the time out enable indicator LED 3 to extinguish. Run out half a sinkful of hot water and note the new setting of the pre-set. The final position will be somewhere between the two of these marks. Initially set the pre-set two thirds of the way back to the first mark and observe that if no further hot water is used, the indicator comes on after a period of five to fifteen minutes. The longer it takes for the indicator to come on after the last water was used, the longer before the start of the timeout.

The frost-stat is the most difficult to adjust in that the temperature of the thermistor has to be reduced to around five degrees C. The setting may be obtained by adjusting it two thirds of the way down the scale and waiting for the colder weather. Two settings at the lower end of the scale should enable a similar calibration to be carried out as was done with the room-stat.

*Note that a lot of the components have been very conservatively rated, this being felt necessary to ensure that the unit will run cool and reliably as it is likely to be left switched on for very long periods of time.

CENTRAL HEATING CONTROLLER PARTS LIST

Resistors: All 0.4W 1% metal film unless specified

R1	22k		(M22K)
R2,3	220k	2 off	(M220K)
R4,8,14,17	10k	4 off	(M10K)
R5,6,7,9,15,16,45	1k	7 off	(M1K)
R10	100k		(M100K)
R11	470k		(M470K)
R12,13,18,21,30, 31,32,33,35,36, 39	4k7	11 off	(M4K7)
R19	220R		(M220R)
R20	0.47R (3W wirewound)		(W0.47)
R22,23,24,25	3k9	4 off	(M3K9)
R26,37,38,40,41	390R	5 off	(M390R)
R27	820R		(M820R)
R28	2k2		(M2K2)
R29	1k2		(M1K2)
R34	470R		(M470R)
R42,43,44	VA1055S Thermistor	3 off	(FX21X)
R46	1M		(M1M)
RV1,2,4	22k Hor-sub min preset	3 off	(WR59P)
RV3	22k lin pot		(FW03D)

Capacitors

C1	1000uF 63V axial electrolytic		(FB84F)
C2,10	100uF 25V axial electrolytic	2 off	(FB49D)
C3	1nF polycarbonate		(WW22Y)
C4	100uF 63V axial electrolytic		(FB51F)
C5,6,7,8	10nF suppression cap.	4 off	(FF53H)
C9	220uF 16V axial electrolytic		(FB61R)
C11,12,13,14,15, 23,24,25,26,27, 28,29	100nF disc ceramic	12 off	(BX03D)
C16	22uF 25V axial electrolytic		(FB30H)
C17,18,19,20,21, 22	10nF disc ceramic	6 off	(BX00A)

Semi-conductors

D1,2	1N5401	2 off	(QL82D)
D3	BXY88C6V2		(QH09K)
D4	BXY88C12V		(QH16S)
D5,6,7	1N4002	3 off	(QL74R)
D8,9	BXY88C4V7	2 off	(QH06G)
D10,11,12,13	1N4148	4 off	(QL80B)
D14	Quad Opto-Isolator		(YY63T)
CSR1	2N3525		(QR25C)
TR1	BC182L		(QB55K)
TR2,3,4	2N3053	3 off	(QR23A)
TR5,6	TIP31A	2 off	(QL15R)
TR7,8,9	MPSA14	3 off	(QH60Q)
L1	1uH choke		(WH29G)
IC1	74LS279		(YH01B)
IC2	7414		(QX46A)
IC3	74LS08		(YF06G)
IC4,5	74LS04	2 off	(YF04E)
IC6	7451		(QX83E)
IC7	3403		(QH51F)
IC8,9	74LS90	2 off	(YF38R)
IC10	NE555V		(QH66W)
IC11	74LS32		(YF21X)
IC12	74LS11		(YF09K)
IC13	uA723 (14 pin)		(QL21X)

Miscellaneous

T1	12V toroidal		(YK10L)
FS1	Fuse 500mA anti-surge		(WR18V)
FS2	Fuse 1A		(WR03D)
FS3	Fuse 2A		(WR05F)
FS4	Fuse 1.25A anti-surge		
LED 1-8 inc.	LED red	8 off	(WL27E)
RLA,B,C	5A mains relay	3 off	(YX98G)
RLD,E	2-pole changeover relay (coil 240V AC)	2 off	(FX49D)
S1-9 inc.	SP make push button switch	9 off	
S10,11	SP make min toggle/slide switch	2 off	