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# WASHING READY INDICATOR



TERRY DE VAUX-BALBIRNIE

*Has the washing machine finished?  
– Avoid those washday blues!*

**O**UR OLD washing machine gave long and faithful service. Unfortunately, when it did eventually fail, it was not possible to repair it economically.

## DREAM MACHINE

The replacement washing machine is a famous brand, renowned for its high quality and long life. However, after using it for the first time, it became apparent that something that “old faithful” had was lacking in its successor. This was a lamp that came on when it had completed the washing.

The only way of knowing whether it has finished or not is to look closely at the program switch or listen until the machine has not made a sound for some time. Taking the washing out promptly is important if you wish to re-load the machine or if you want to dry the laundry as quickly as possible.

A further point is that if the washing machine is situated in a garage or other place remote from the house, even a warning light will be of little help. You would have to visit it periodically to check whether it had finished its work.

## LAUNDRY DONE

The washing machine alarm circuit described here will give an audible signal (in the form of high-pitched bleeping) when the washing cycle has finished. If the machine has been left on a “rinse hold”

setting, it will give a signal when the program has reached this point.

This will prevent the user from forgetting about it and leaving the washing overnight in a machine filled with water. Readers may find the circuit useful for other similar appliances and it has been tested successfully with tumble driers.



Fig. 1. Block schematic diagram for the Washing Ready Indicator.

Being battery-operated, the circuit is safe to construct and in operation. Also, because no modifications are made to the appliance itself, using the device will not invalidate any manufacturer’s warranty.

The circuit consists of a main unit (see photographs) which is placed near the washing machine. This contains the circuit panel and a 6V battery pack. There is an on-off switch on the front of the case and a socket on the side which is used to connect a sensor. This is placed so as to make mechanical contact with some part of the washing machine.

The warning device (a small piezo buzzer) will normally be mounted on the circuit board with a hole drilled in the box to allow the sound to pass through.

However, if the washing machine is situated in some place remote from the house, the buzzer could be placed somewhere else – in the kitchen, for example. For this to be done, you would need to route a length of light-duty twin wire between the main unit and buzzer position.

While operating under standby conditions, the prototype required just 500µA, which may be regarded as negligible. While actually sounding, the current rises to a few milliamps depending on the

buzzer used. The internal 6V battery pack will provide several hundred operating hours and will probably give more than one year of service.

## OVERVIEW

The Washing Ready Indicator works by responding to the sound and/or vibration that occurs while the washing machine motor is operating. When correctly adjusted, other sources of sound have only a minimal effect unless they are particularly loud. Even if they do have some temporary effect, this should not prevent the circuit from giving a proper warning.

The sensor consists of an electret microphone insert (that is, the working part without the external case). While the motor is turning, this provides an electrical signal which is passed to the main unit.

While the machine vibrations continue, the warning does not sound. When it stops, the warning continues to be held off for a further preset time and after that the buzzer sounds.

## HOLD-OFF TIME

This hold-off time is necessary because the motor in a washing machine is not operating all the time during the washing cycle. The drum turns in alternate directions to prevent the clothes tangling and there will be several seconds of silence between each movement.

There may also be longer “quiet” times when the machine is filling with water. The hold-off time must be sufficient to take account of all these factors and will be set by the user for best effect at the testing stage.



## LONG SILENCE

To prevent the warning being given while the washing machine is not in use (obviously a long period of silence!), the unit must be switched on and off manually. The user is unlikely to forget to switch it off because the buzzer will continue to sound until this has been done. However, he or she will need to remember to switch it on at the beginning of the washing cycle whenever a warning is required.

## HOW IT WORKS

Basic operation of the Washing Ready Indicator is best illustrated by the block diagram shown in Fig.1. It will be seen that this comprises seven main parts: vibration sensor; audio amplifier; level detector; integrator; Schmitt trigger inverter; slow astable (low-frequency oscillator) and piezo buzzer.

The complete circuit diagram is shown in Fig.2. MIC1 is the electret microphone insert of the type specified in the parts list. This has an inbuilt f.e.t. preamplifier which requires its own power supply. This is derived from the 6V battery pack, B1, through resistor R1.

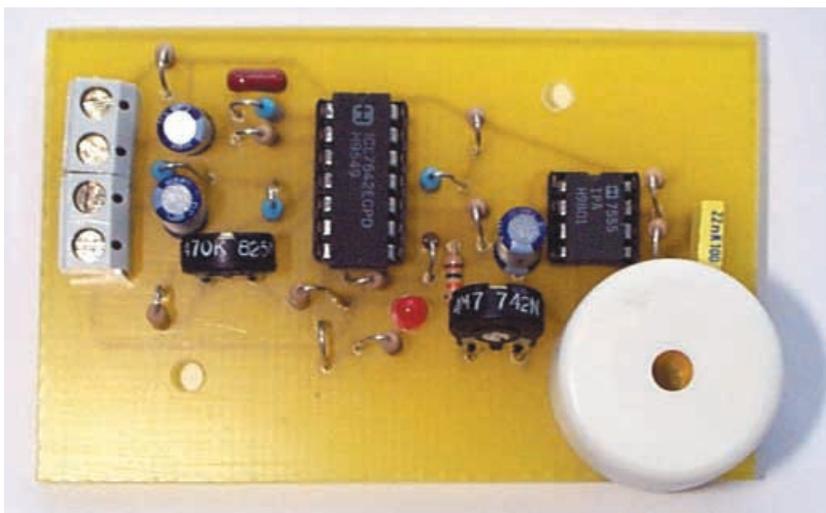
Operational amplifier (op.amp), IC1 is a quad device – it contains four identical units IC1a, IC1b, IC1c and IC1d (although only three of these are actually used). IC1a is used for the audio amplifier, IC2b for the level detector and IC1c for the Schmitt trigger inverter.

Taking IC1a first, this is used in a.c. inverting mode. For this, the signal arriving from the sensor MIC1 is applied, via coupling capacitor C1 and input resistor R2, to the inverting input (pin 2).

Capacitor C1 allows the alternating current (a.c.) component (that is, the signal) to pass while blocking the passage of direct current (d.c.) This prevents it interfering with the d.c. conditions of the op.amp.

## STANDING CONDITIONS

As far as d.c. is concerned, the op.amp non-inverting input (pin 3) is held at one-half of supply voltage (3V nominally) by the potential divider action of equal-value resistors R3 and R4. Regarding the a.c. signal, it is at 0V since the impedance of



Component layout on the finished circuit board.

capacitor C2 is very small at the audio frequencies involved. The standing d.c. voltage at the output (pin 1) is equal to that at the non-inverting input – that is, nominally 3V.

The gain of the amplifier is determined by the ratio of feedback resistance (R5) to input resistance (R2). In fact, the gain is *negative* but this has no practical consequence here.

With the values specified, the gain is therefore fixed at  $(-)\approx 220$ . The result is that a voltage of some 1V peak-to-peak will exist at the output, pin 1, and this will be superimposed on the standing d.c. voltage.

Capacitor C3, connected in parallel with the feedback resistor R5, provides a low impedance path at higher frequencies but a much higher one at the typical frequencies of vibration. It thus has little effect at the “intended” frequencies but the gain is much reduced at higher ones. The circuit is therefore less sensitive to much of the “normal” sound in the vicinity of the washing machine.

## ON THE LEVEL

The level detector based on IC1b “looks at” the voltages applied to its inverting (-) and non-inverting (+) inputs (pin 6 and

pin 5 respectively). If the voltage at pin 5 exceeds that at pin 6 the op.amp will be on with the output (pin 7) high. Otherwise it remains low.

The signal provided by the output of the audio amplifier (IC1a pin 1) is applied direct to IC1b inverting input (pin 6). A certain preset voltage is applied to the non-inverting input, pin 5, by the potential divider network made up of R6/VR1/R7.

Preset potentiometer VR1 will be adjusted at the end so that the voltage at pin 5 is slightly lower than that at pin 6 (that is, less than 3V) when no vibration is detected. The state of the level detector output (pin 7) will therefore be low when no vibration exists.

Fixed resistors R6 and R7 narrow the range of adjustment of VR1 to the middle one-third of the voltage range (nominally 2V to 4V) and this simplifies setting-up at the end.

## RAPID SWITCHING

When vibration is detected, the voltage at IC1b pin 6 rises on the positive half-cycles and falls on the negative ones. The former have no effect.

However, on the negative excursions, the voltage at pin 6 will fall below that at

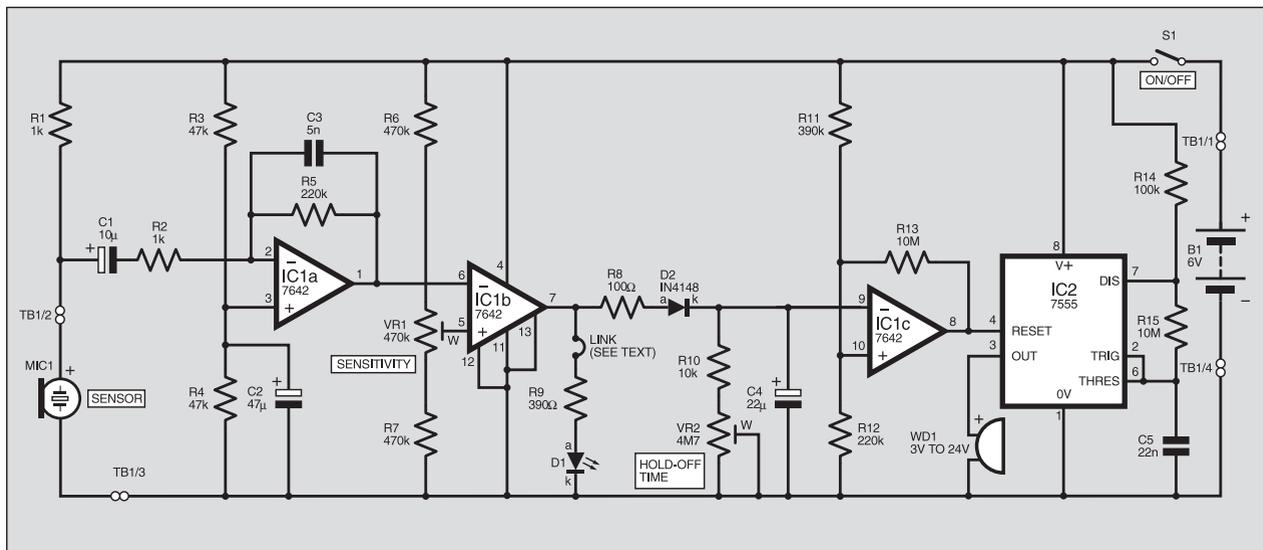


Fig.2. Complete circuit diagram for the Washing Ready Indicator. The battery pack B1 is made up of 4 x AA alkaline cells.

pin 5 and this will result in the output (pin 7) switching between high and low states at the frequency of vibration. The length of the *on* times will depend on how much the a.c. wave falls below the voltage at pin 5 as set by preset VR1. This preset therefore provides the Sensitivity control.

Note that, as the supply voltage falls in the process of battery ageing, this makes no difference to the operating point. This is because the voltages applied to both IC1b inputs vary in the same proportion.

Ignoring the connection from the output of IC1b at pin 7 to resistor R8 for the moment, the signal from the output of the level detector can be directed to the light-emitting diode (l.e.d.) D1 using a "jumper wire" on the circuit board. The operating current is limited to some 10mA by series resistor R9.

The l.e.d. is used to check operation of the circuit up to this point because it will flash when vibration is picked up. It is also used to make a reasonably correct adjustment to preset VR1. At the end of testing, the jumper wire will be cut to prevent the l.e.d. from working and so reduce the current requirement of the circuit.

## INTEGRATION

Returning now to the output from the level detector IC1b at pin 7, consider the current flowing through fixed resistor R8 and diode D2. This allows capacitor C4 to charge up and provides the "integrator" aspect of the circuit.

While pulses are given by IC1b output (pin 7), the relatively small value of resistor R8 allows the capacitor to charge to almost supply voltage in a very short time. In fact, it will not quite reach this value because it is being constantly drained by the network comprising fixed resistor R10 and preset VR2.

When the pulses stop, the capacitor gradually discharges in a time dependent on the adjustment of VR2. It cannot drain back into IC1b pin 7 because diode D2 is reverse biased.

Note that without R10 and VR2, capacitor C4 could only discharge by leakage and this would take a very long time. This is because the input resistance of op.amp IC1c (whose purpose will be explained presently) is extremely high.

## INVERTING EFFECT

Op.amp section, IC1c gives a Schmitt trigger inverting effect. It works like this. The voltage existing across capacitor C4 is applied to the inverting input (pin 9). The non-inverting input (pin 10) is maintained at approximately 2V by the potential divider action of resistors R11 and R12.

While pulses are detected, the inverting input voltage (which is close to supply positive voltage) will exceed the non-inverting one and IC1c output (pin 8) will be low. When the pulses stop and sufficient time has elapsed to discharge C4 below the 2V level, the conditions reverse and pin 8 will go high. Resistor R13 provides some positive feedback and sharpens the switching between the output on and off states.

When the "machine" vibration stops for a short time, the voltage across capacitor C4 does not fall sufficiently for IC1c output pin 8 to go high. When vibration is detected again, the capacitor rapidly charges to its former value.

## TIME ADJUSTMENT

The hold-off time can be adjusted using preset VR2 between limits of almost zero and two minutes approximately. The shortest timing is provided simply for testing purposes. The maximum timing could be extended if required by raising the value of capacitor C4.

A CMOS version of the 555 timer i.e., IC2, is configured as a low frequency astable. While vibration is detected, the low state of IC1c output (pin 8) applies a similar state to IC2 reset input (pin 4). This disables the device and it does nothing.

When the hold-off time expires, IC1c pin 8 goes high and, with IC2 reset input also high, a stream of pulses are passed to IC2 output at pin 3 and hence to buzzer WD1. The frequency of oscillation is determined by the value of fixed resistors R14 and R15 in conjunction with capacitor C5 and with the values used, this should be some 3kHz.

In fact, it appears to vary with operating conditions and was much slower in the prototype. This may be seen as a benefit because it reduces the current requirement. The buzzer connected to IC2 output, pin 3, therefore bleeps in sympathy.

## CONSTRUCTION

Construction of the Washing Ready Indicator is based on a single-sided printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 342. The topside component layout, interwiring to off-board switch and jack socket, and full-size underside copper foil master pattern are shown in Fig.3.

Begin construction by drilling the two mounting holes and soldering the i.c. sockets and p.c.b. mounting terminal block (TB1) in position. Solder the jumper wire to link points A and B. Follow with the resistors and capacitors (including preset potentiometers VR1 and VR2).

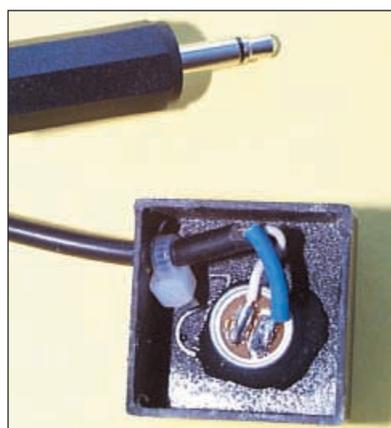
Now, add the polarity-sensitive components which are the electrolytic capacitors, l.e.d. D1, diode D2 and buzzer WD1 (if this is to be mounted on-board) taking care over the orientation of these components. Adjust preset VR1 to approximately mid-track position and VR2 fully anti-clockwise (as viewed from the bottom edge of the p.c.b.). This gives a near-zero hold-off time.

Finish construction of the circuit board by inserting IC1 (but not IC2 at this stage) into its socket taking care with the orientation. Since this is a CMOS component, it is vulnerable to damage by static charge which may be present on the body. To avoid any such problems, touch something which is earthed (such as a metal water tap) before removing the i.c. from its packaging.

## TESTING

It will be found convenient to make a basic test on the unit before the p.c.b. is mounted in its box. In this way, errors are more easily corrected and the preset potentiometers are more accessible.

Cut off a short piece of light-duty twin wire to connect the microphone insert sensor (MIC1) temporarily to the terminal block at points TB1/2 and TB1/3. Look carefully at the microphone connecting pads. The one which is connected to the metal case of the device must be taken to



Using screened audio cable to connect the electret microphone to the main unit.

## COMPONENTS

### Resistors

|          |              |
|----------|--------------|
| R1, R2   | 1k (2 off)   |
| R3, R4   | 47k (2 off)  |
| R5, R12  | 220k (2 off) |
| R6, R7   | 470k (2 off) |
| R8       | 100Ω         |
| R9       | 390Ω         |
| R10      | 10k          |
| R11      | 390k         |
| R13, R15 | 10M (2 off)  |
| R14      | 100k         |

All 0-25W 5% carbon film.

See  
**SHOP  
TALK**  
page

### Potentiometers

|     |   |
|-----|---|
| VR1 | 470k sub-min. enclosed carbon preset, vert. |
| VR2 | 4M7 sub-min. enclosed carbon preset, vert.  |

### Capacitors

|    |                       |
|----|-----------------------|
| C1 | 10μ radial elect. 16V |
| C2 | 47μ radial elect. 16V |
| C3 | 5n ceramic            |
| C4 | 22μ radial elect. 16V |
| C5 | 22n ceramic           |

### Semiconductors

|     |                       |
|-----|-----------------------|
| D1  | 3mm red l.e.d.        |
| D2  | 1N4148 signal diode   |
| IC1 | ICL7642 quad op.amp   |
| IC2 | ICM7555IPA CMOS timer |

### Miscellaneous

|         |  |
|---------|--|
| WD1     | miniature solid-state buzzer – 3V to 24V operation at 10mA maximum |
| TB1     | 4-way p.c.b. screw terminal block – 5mm pin spacing                |
| MIC1    | miniature two-terminal electret microphone insert                  |
| SK1/PL1 | 3.5mm mono panel mounting jack socket, with plug                   |

Printed circuit board available from the *EPE PCB Service*, code 342; plastic box, size 143mm x 82mm x 44mm; 8-pin i.c. socket; 14-pin i.c. socket; battery holder and four AA size alkaline cells; PP3 type battery snap (or as required); light-duty screened wire; multistrand connecting wire; solder, etc.

Approx. Cost  
Guidance Only

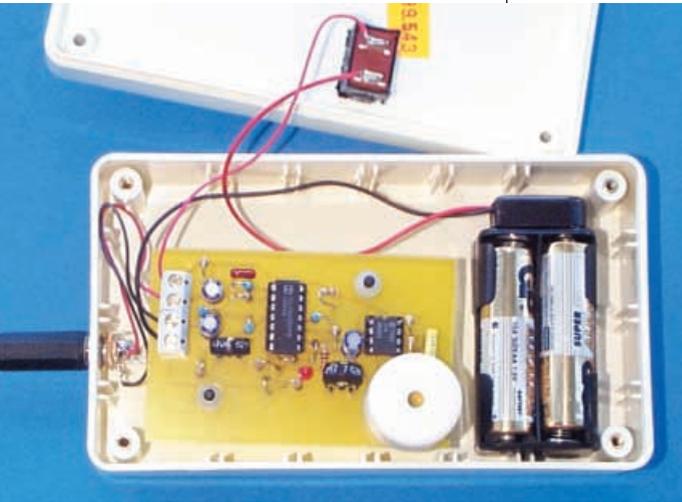
**£20**  
excluding batt

the negative (0V) of the supply – that is to TB1/3. The other one is connected to TB1/2.

Connect the PP3 battery snap (or as appropriate) to TB1/1 and TB1/4 taking care over the polarity. Insert the cells in their holder, apply the battery snap and switch on.

Adjust Sensitivity preset VR1 to the point where the “test” i.e.d. D1 is just off. If the microphone is touched, or the table top is tapped, the i.e.d. should flash momentarily. Adjust VR1 so that this happens reliably.

The battery should now be disconnected and IC2 inserted into its socket observing the anti-static precautions mentioned earlier for IC1. It is best to leave the i.e.d. in circuit for the moment.



Positioning of components inside the plastic case.

With no sound detected, buzzer WD1 should operate. Sound should make the buzzer stop but begin again as soon as it stops. This might not work properly unless preset VR2 is adjusted slightly clockwise to give a small hold-off time. If that works, adjust VR2 to provide a longer hold-off time of, say, 30 seconds.

Check that if sounds are made periodically within this time, the sound is held off. This will provide an approximate setting but final adjustments to the presets can only be made with the unit under actual operating conditions.

### BOXING UP

Remove the temporary sensor wires from terminal block TB1. Place the p.c.b. and battery holder on the bottom of the box to find their best positions. If the unit is to be wall-mounted, remember to allow space for the holes which will be used to attach it.

Mark through the holes for the various parts, also mark positions for on-off switch (S1) and the 3.5mm mono jack socket which is used for sensor MIC1 connection. Measure the buzzer position and drill a hole in the lid directly above this. If the buzzer is to be mounted remotely, mark the position for a further socket (say, a small “power-in” or a 2.5mm mono jack type) for this to be connected.

Remove all these parts, drill the holes and attach them. Use plastic stand-off insulators for p.c.b. mounting to bring the buzzer up to level of the hole in the lid.

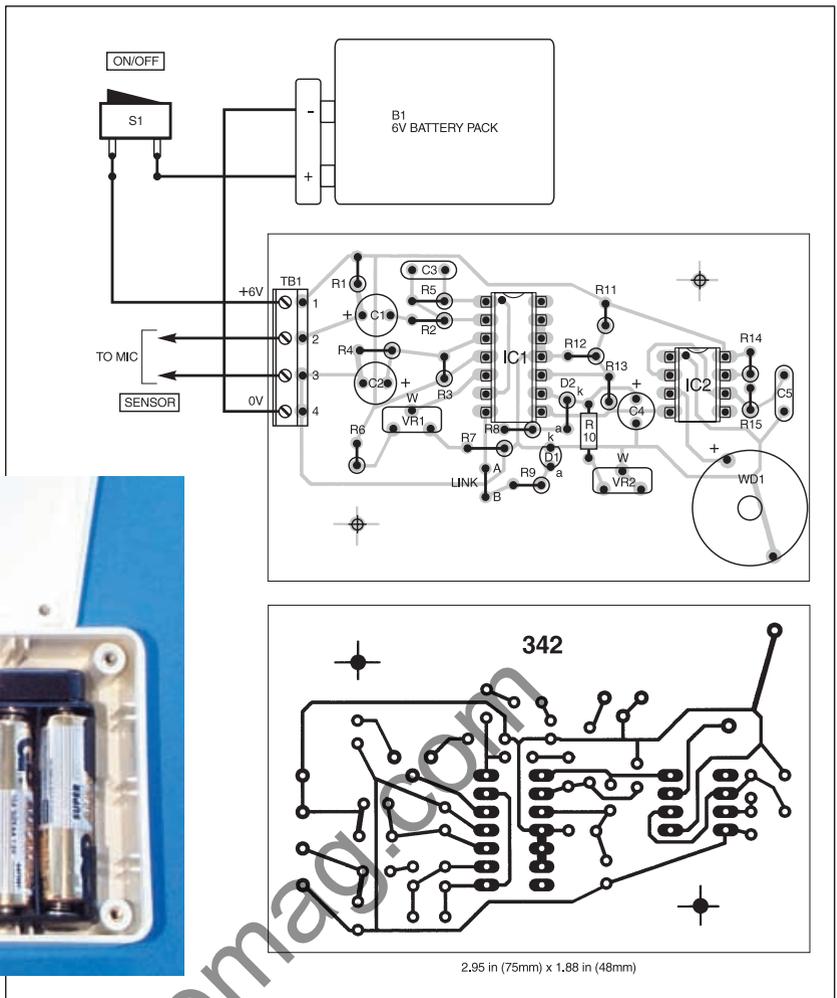


Fig.3. Printed circuit board component layout, full-size copper foil master and wiring to off-board components.

Refer to Fig.3 and complete the wiring using light-duty stranded connecting wire. If buzzer WD1 is mounted remotely, connect the buzzer pads on the p.c.b. to the buzzer output socket taking account of the polarity.

### SITING THE UNIT

Decide on a suitable position for the main unit. This should be placed fairly close to the washing machine (say, within 4 metres). Make the sensor connection using light-duty single screened wire (microphone cable). This is because ordinary wire could pick-up stray mains “hum” and could result in the injection of unwanted signals into the circuit. It is possible that this could hold off the warning in the absence of any vibration. When connecting the jack plug to the sensor wire, solder the outer (sleeve) terminal to the screening.

Mount the microphone insert inside a small plastic box (a potting box was used in the prototype). To do this, drill a hole to make a push fit for the microphone insert. Secure it using a little quick-setting adhesive.

Drill a further hole in the side of the box for the connecting wire to pass through. Pass the wire through the hole and, allowing a little slack apply a tight cable tie to provide strain relief.

Twist and sleeve some of the screening braid and solder the wires to the microphone pads. The pad which is connected to the

metal case of the microphone should be the one which is connected to the screening.

If the buzzer is to be mounted remotely, the connecting wire may be of any convenient length and be of any light-duty stranded twin type.

### FINAL TESTS

With the main unit in position, route the screened sensor wire between it and the washing machine and plug it in. Make some tests with the sensor in various positions observing the i.e.d. A suitable place should be found where the drumming noises of the washing machine case cause the i.e.d. to flash brightly. When satisfied about this, make further adjustments to preset VR1 as required.

In some cases it will not be found necessary for the sensor to touch the washing machine at all – just placed close enough for it to pick up the noise. However, if doing this, you may need to set the sensitivity somewhat higher and this may make the unit more susceptible to the pick-up of stray random noise.

Make some tests under real operating conditions. Adjust preset VR2 for a suitable hold-off time so that the buzzer is prevented from operating under all “silent” conditions on all washing programs. When satisfied about all aspects of operation, cut the jumper wire on the p.c.b. to prevent the i.e.d. operating.

Happy washday!