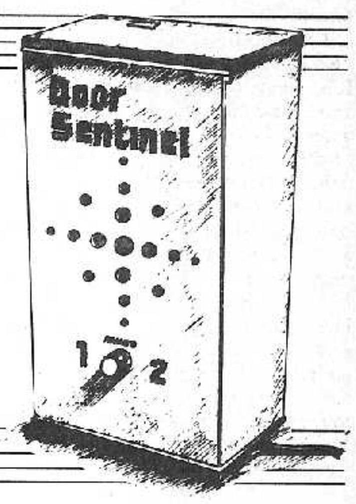
Constructional Project



DOOR SENTINEL

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If you have not already heard, the government is mounting a campaign to prevent crime. This low-cost security project will not prevent crime, but the "high power" siren should put any would-be criminal to flight!—Can be used in the home, office or shop.

THE DOOR SENTINEL is a small battery operated alarm unit which monitors doors or windows and sounds a piercing alarm when the door or window is opened.

FEATURES

- ***Automatic resetting after two minutes.***
- ***Hidden operating switches which are worked by a horseshoe magnet; tamperproof operation.***
- ***Normally-closed protection loop.***

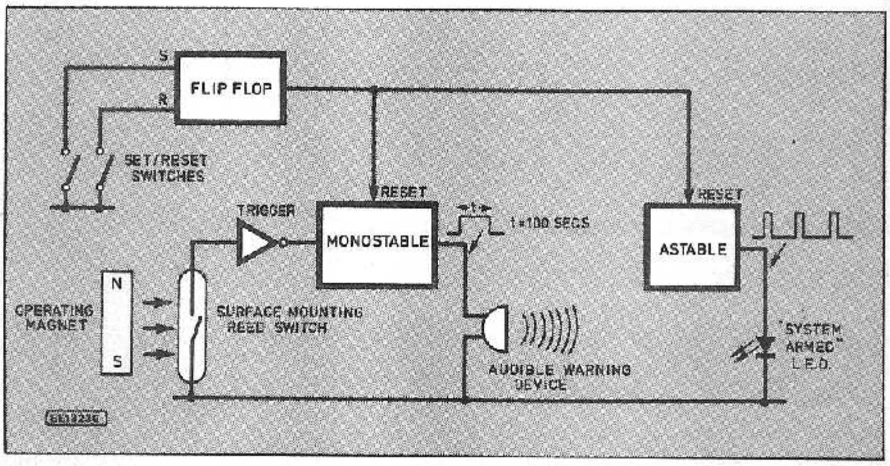


Fig. 1. Block diagram showing how the Door Sentinel operates.

With burglaries and break-ins seemingly on the increase, a widening variety of anti-theft devices is becoming available to help the householder to protect his property. Such countermeasures include window locks and alarm systems, and being economical and easily installed they are a worthwhile method of helping to combat the threat posed by opportunists and burglars.

More sophisticated electronic monitoring systems can also be installed to provide a comprehensive protection network which can be tailored to individual needs.

The *Door Sentinel* to be described here could form a useful adjunct to an existing system or can simply be installed as a totally independent deterrent to monitor any door or window. The Sentinel is a compact battery-operated alarm unit which provides closed-loop protection by means of a surface-mounting reed switch, and an outline of its operation follows.

OUTLINE DESCRIPTION

A reed switch with operating magnet is fixed to the desired door such that the reed is closed by the magnet when the door is shut, see Fig. 1. When the door is opened, the magnet is removed away from the reed, breaking the closed loop circuit, and this will trigger the alarm in the Sentinel.

This design incorporates a very piercing solid-state audible warning device, and once triggered, the unit will operate this alarm for approximately two minutes and will then automatically reset itself.

A further refinement is that there are no apparent switches showing on the unit, instead the Sentinel is either activated or turned off by built-in magnetic switches. The user turns the device on or off by touching a magnet to the appropriate place on the front panel. Therefore an intruder cannot easily disable the unit himself, since hopefully he won't have a magnet to hand at the time! Only someone with the appropriate know-how will be able to operate the alarm.

HOW IT WORKS

A flip-flop circuit interfaces two reed switches to the *Door Sentinel* circuit, the reeds being used to either "arm" or "reset" the alarm. The flip flop, when set, will enable both an astable and a monostable multivibrator. The astable flashes an l.e.d. which acts as a "power on" indicator, whilst the monostable timer drives an audible warning device through a transistor buffer.

A surface mounting reed switch is fixed to the door jamb and an operating magnet is positioned adjacently, such that when the door is closed, the magnet causes the reed switch to close also. This forms a "normally-closed" protection loop.

Opening the door will take away the magnet and this opens the reed. The signal so produced is inverted to trigger the monostable circuit, causing the audible warning device to sound for a pre-determined period. After the period has ended, the alarm will reset itself, unless the reed switch is still open.

Interfering with the normally closed loop in any other manner will also sound the alarm. Since hidden reed switches are also employed to set or reset the unit, this makes the Sentinel tamperproof to a limited extent, since it is necessary to use a magnet to switch the unit on or off. There are no visible controls otherwise

CIRCUIT DESCRIPTION

The circuit diagram of the unit appears in Fig. 2. This design employs the CMOS version of the popular twin timer chip, type ICM7556. One half IC2a is used as the alarm timer and IC2b is employed as an l.e.d. flasher. The CMOS version is utilised in order to reduce current consumption and so prolong battery life.

IC1a and IC1b are two CMOS NAND gates wired to form a bistable flip-flop. The inputs to the bistable are S1 and S2, two magnetic reed switches. Operating each switch in turn will cause the output of the arrangement to switch successively. The output is observed at pin 10 of IC1 and will switch between a high and low, or approximately +9V and 0V respectively.

The flip-flop output connects to the "Reset" terminals of both timers, so when IC1 pin 10 is low, both timers are disabled and cannot operate. By operating S1 with a magnet, both timers are enabled since their "Reset" terminals are biased high.

IC2a is connected as a monostable multivibrator circuit; this is a circuit which once triggered, will deliver one output pulse only and will then reset itself. The length of the output pulse (observed at pin 5) is determined by R5 and C1. Multiplying their values together produce a time period of 100 seconds—in theory! However, since C1 has an inherently large tolerance and also a high leakage current, you can expect to realise a much longer time delay of, say, 200 seconds. In a non-critical timing application like this, such inaccuracies are of no consequence.

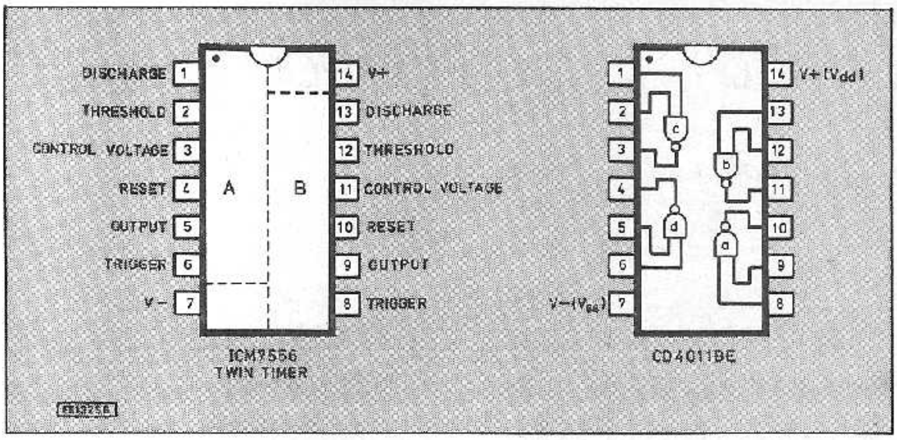


Fig. 3. Pin-out details for the twin timer and the quad NAND gate i.c.s.

L.E.D. FLASHER

Integrated circuit IC2b is wired to form an astable multivibrator which produces a steady stream of output pulses. D1 is a light-emitting diode connected to the astable output through a voltage- dropping resistor R6, and the l.e.d. will illuminate when the output is high.

The operation of the 556-type astable is well known but in brief it operates as follows. Assuming that the Reset terminal pin 10 is high, C2 will commence charging up through R7 and R8 until the voltage at pins 8 (trigger) and 12 (threshold) reaches two thirds the supply voltage. During this charge-up period the output is high.

When the capacitor is two thirds charged, the i.c. discharges the capacitor through an internal transistor via R8 until the potential across C2 drops to one third the supply voltage. The output is low when the capacitor is discharging but will switch high again when the voltage across C2 has dropped to one third supply voltage, at which point the capacitor starts to charge up again.

Basically then, C2 charges up to two thirds and then discharges down to one third the supply rail, switching the output high and low respectively.

However one drawback is the relatively long "on" time which in this application causes unnecessary power consumption, since the l.e.d. illuminates for longer than is really necessary. The inclusion of diode D2 across R8 greatly modifies the operational cycle of the astable: C2 will now charge up almost straight away through R7 and D2 (which shunts R8) so that the "on" time or "mark" is very short.

When the potential across C2 has reached two thirds of the supply, the output goes low and the capacitor discharges slowly through R8 into the i.c.—D2 now has no effect because it is reverse biased and so cannot conduct. The capacitor will charge quickly through R7 and D2 again, after it has discharged down to one third supply.

The result is that the l.e.d. will not so much flash on and off but will "strobe" in a manner which can be likened to a mini-stroboscope. Average current consumption is much reduced because the "on" time of D1 has been greatly shortened. Battery life will therefore be extended—all due to the addition of a diode costing a few pence! The addition of a shunting diode like D2 is not an uncommon method of modifying the mark to space ratio or duty cycle of 555-type astable multivibrators.

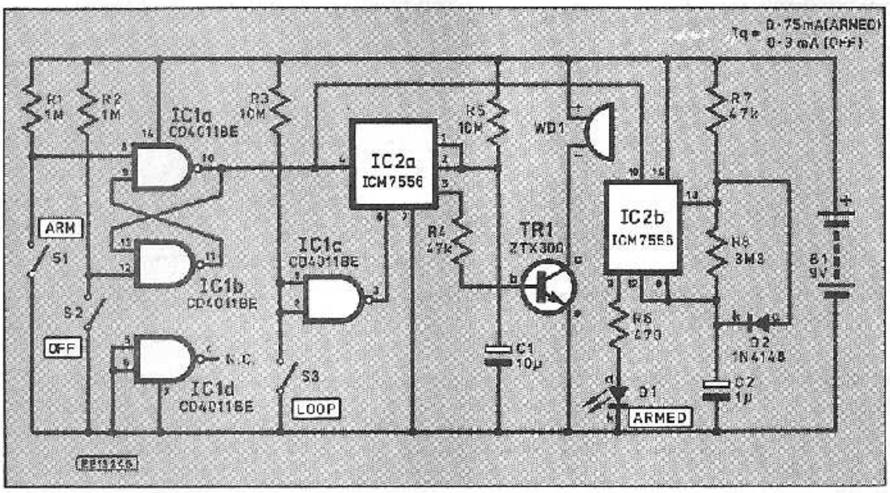


Fig. 2. Full circuit diagram for the Door Sentinel. Switches S1 and S2 are the glass reed types mounted in the circuit housing and S3 is the surface mounting reed which is attached to a door, window or cabinet together with a magnet.

ALARM CIRCUIT

NAND gate IC1c is connected as a simple inverter so that when S3 is closed, the two inputs of IC1c are both low, thus its output (pin 3) will be high. Therefore the trigger terminal of IC2a (pin 6) is high, so the monostable will not operate.

If S3 is opened, even for a fraction of a second, then IC1c input will be biased high through R3. The NAND gate inverts this to produce a low signal at the trigger terminal of the monostable. IC2a therefore triggers and its output—pin 5—goes high for a period of (R5 (Ohms) X C1 (Farads)) seconds, as previously described. Even if S3 is now closed again the monostable will remain triggered but resets itself after the time period has lapsed.

TRANSISTOR BUFFER

Transistor TR1 is a transistor switch and when IC2a output goes high, (the monostable having triggered), TR1 will turn on, thereby completing the circuit to WD1. The audible warning device will sound for the monostable period.

Transistor TR1 is included to counteract the output characteristic of CMOS 555-type timers whereby the output voltage drops noticeably as output current increases. Technically IC2a could drive WD1 directly but TR1 ensures that the buzzer is driven by the full supply rail voltage, not a reduced voltage which would be present at the timer output.

Regarding the audible tone generator

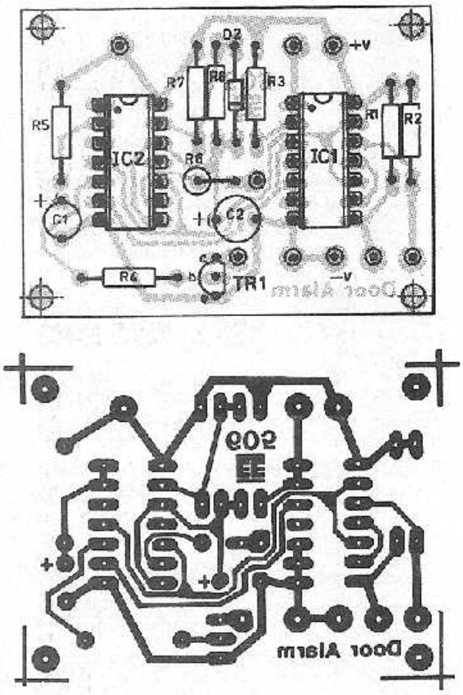


Fig. 4. Component layout and full size printed board copper foil master pattern for the Door Sentinel.

COMPONENTS

Resistors

R1, R2	1M (2 off)
R3	10M
R4	47K
R5	10M
R6	470
R7	47k
R8	3M3

Shop Talk
See page 295

All ¼W
5% carbon film

Capacitors

C1	10μ tantalum bead 16V
C2	1μ tantalum bead 16V

Semiconductors

IC1	CD4011BE quad NAND
IC2	ICM7556 dual timer
TR1	ZTX300 silicon *npn*
D1	0.2" red l.e.d.
D2	1N4148 silicon diode

Miscellaneous

S1, S2	miniature glass reed switch (2 off)
S3	surface mounting reed switch with magnet
WD1	piezoelectric warning device (high power type)
B1	9V PP3-type alkaline battery with clip

Box, TEKO Wall Housing 123×70×42mm, red/black; printed circuit board available from the *EE PCB Service*; 14-pin dil socket (2 off); l.e.d. lens-clip; interconnecting wire; mounting hardware; solder; etc.; small horseshoe magnet.

Approx. cost Guidance only **£15**

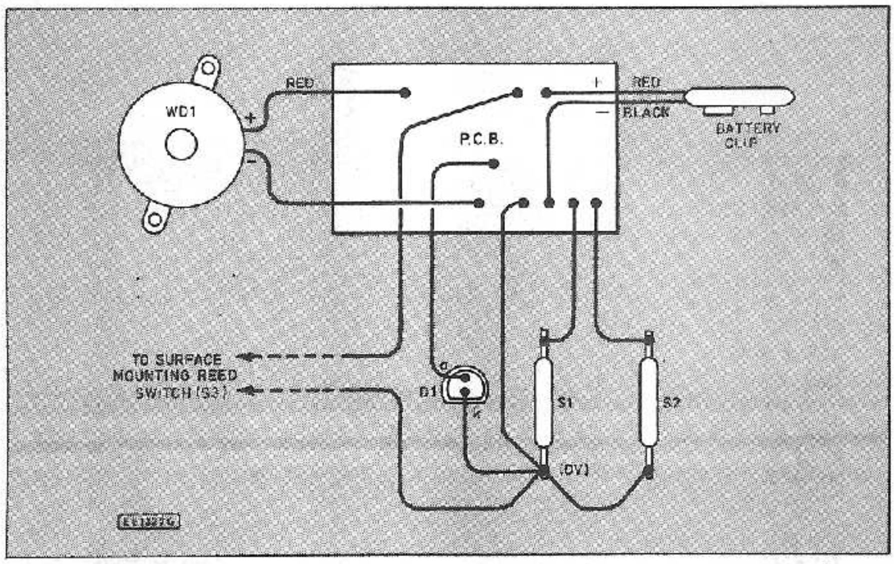
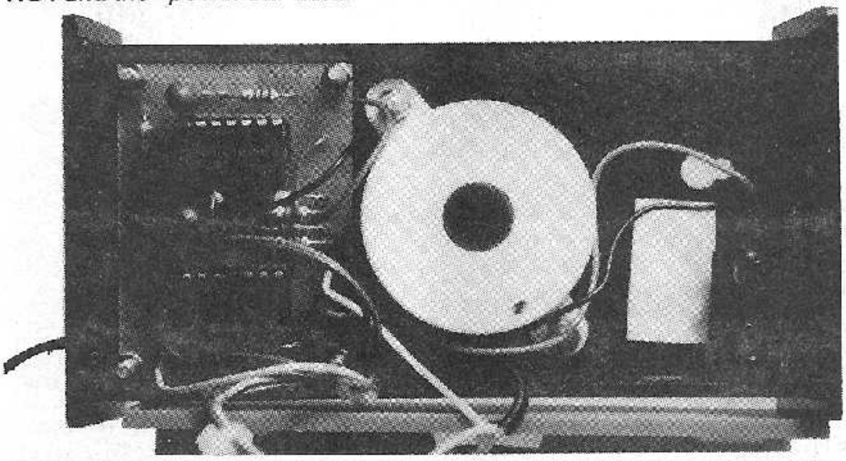


Fig. 5. Interwiring from the circuit board to the reed switches, warning buzzer WD1 and the "power on" l.e.d.



Positioning of the circuit board and warning buzzer in the bottom of the case.

itself, a piezo electric type has been selected for its clarity of output tone coupled with low current consumption. Ordinary electromechanical buzzers cannot be substituted in this circuit.

Since WD1 will sound for as long as IC2a is triggered, the alarm tone will automatically cancel at the end of the monostable period, unless the trigger signal is still present. The only way to cancel the alarm manually is to operate S2. This will reset the Sentinel completely.

Switch S3 itself is a reed switch which is affixed on the door jamb. The operating magnet is placed on the door itself such that when the door is closed, the reed is closed by the magnet; opening the door will open S3 and the alarm will be triggered.

The whole system operates from a PP3-type 9V battery. There is of course no apparent on-off switch since the unit is controlled through S1 and S2. When in a reset mode, the circuit consumes 0.3mA as measured on the prototype, most of this being drawn by the timer chip. The Sentinel draws 0.75mA (measured) when "armed". An alkaline battery is preferred for B1. Tests with the prototype would suggest a battery life of at least four months when the device is armed for a period of 12 hours per day.

CONSTRUCTION

The prototype unit was constructed in a TEKO Wall Housing moulded in red and black ABS plastic and measuring 123×70×42mm. It is a simple clip-together type and the two reeds S1 and S2 are fixed behind the removable cover, along with the light-emitting diode.

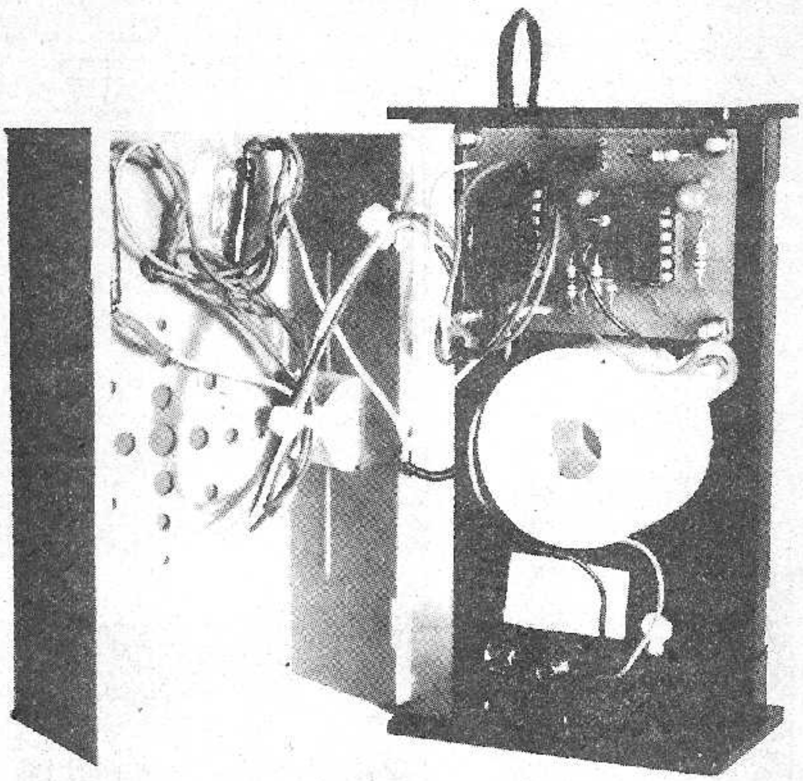
For greater security a screw-together plastic box of similar dimensions could be used, to make it more difficult for unauthorised people to gain access to the inner workings of the alarm.

The components themselves are mounted on a single-sided printed circuit board of dimensions 55×42mm, see Fig. 4. This can be manufactured by the home constructor in the normal manner, alternatively ready-made circuit boards are available from the *Everyday Electronics p.c.b. Service*.

Using a fine-tipped soldering iron, commence construction by soldering in the two 14 pin d.i.l. sockets to accommodate the integrated circuits. Follow on with all resistors, diodes and capacitors. Take care particularly to observe correct polarity of the diodes and tantalum capacitors. Also exercise caution when soldering the diodes and transistor as these are heat-sensitive semiconductors: if in doubt, employ a clip-on heat shunt to carry away excess heat which may be present during soldering.

The two CMOS chips are sensitive to excessive static electricity and must be retained in their anti-static packages until the last possible moment. Insert them—correctly orientated—only when all soldering has been completed.

The lid is prepared by carefully drilling a matrix of holes to permit sound from the internal audible warning device to pass through. The holes should be very carefully



The completed Door Sentinel showing the glass reed switches mounted on the inside of the case lid.

drilled with a hand-held drill: the resultant holes can be chamferred with a countersinking bit in order to "soften" the appearance. A few gentle twists with the countersink bit will make the appearance of the matrix more acceptable. A further hole is required for the l.e.d., which can be fitted into position with a lens-clip.

FINISH

Finally embellish the front panel with rub-down transfer lettering as required, and finish off by spraying on a light coat or two of protective transparent lacquer.

On the prototype, the two glass reed switches were fixed into place on the inside of the lid by carefully applying a drop of cyanoacrylate adhesive gel, e.g. "Super Glue Xtra". Some care is required when dealing with the reed switches since they are relatively fragile. Do not bend their lead-outs too close to the glass bodies or the whole reed switch will fracture. Ideally use a pair of round-nose pliers when bending and forming the lead-outs of the switches.

Interwiring is then completed with general purpose hook-up wire in accordance with Fig. 5. The use of different colours will assist with checking later on.

The trigger reed switch S3 is connected to the p.c.b. by a twin-core flying lead which passes through a hole in the case to the p.c.b. within the box. Complete construction by fitting the assembled printed circuit board to the base of the cabinet using 6BA or M3 hardware. A battery can be fitted to the battery clip and can be retained in place with a small piece of double-sided adhesive foam strip.

With the operating magnet positioned next to S3, the l.e.d. may or may not be flashing when the battery is connected. Operating S1 with a horseshoe magnet (see Notes) should arm the unit and the l.e.d. will blink.

TESTING AND INSTALLATION

Separating S3 from its closing magnet will cause the alarm to sound—be warned, it's quite piercing! The alarm should reset itself after a period of several minutes, but only if S3 is closed again with the magnet. In the interim the only way to silence the alarm is to close S2 temporarily with the horseshoe magnet.

With testing complete, the Sentinel can be installed in its final position. The keyhole slots in the base of the plastic box can be knocked through to fix the alarm to any suitable surface by using screws. S3 should be fitted to the door jamb and the operating magnet screwed into place adjacently on the door itself.

The twin-core wire linking S3 to the alarm unit can be several metres long if required, so it is quite feasible to place the Sentinel within earshot of the occupants of the house. Furthermore, if this connection wire is cut in an attempt to disable the alarm system, the alarm will sound continuously until reset: one of the advantages of closed-loop protection.

APPLICATION NOTES

Since a normally-closed loop is employed as the basis of detection, it is possible to use certain other devices in conjunction with the Sentinel to form a small monitoring system. For example, window foil could perhaps be used instead of a trigger reed switch, to warn of a broken window. Alternatively, several reed switches could be wired in series to extend protection to several doors. Obviously the device could further be used to monitor any window in a similar manner to its principal use as a door alarm. □

TRANSISTORS AS RECTIFIERS

IN LOW-VOLTAGE rectifier circuits the voltage drop across the silicon diodes in common use can be a problem. A typical diode wastes about 1V. This may be all right if the mains transformer delivers enough voltage. But occasions arise where an existing transformer can't quite do the job.

In this case, it is possible to squeeze an extra half volt of d.c. output by substituting silicon Schottky diodes for the ordinary types. Schottky diodes are expensive, however. Germanium power rectifiers would do the same job, but appear to be no longer made.

An alternative is to use germanium power transistors connected as diodes. These transistors can often be salvaged from old amplifiers, etc., and you may well have some in your junk box.

The diagram Fig.1 shows a typical push-pull voltage rectifier whose diodes D1 and D2 can be germanium power transistors connected as shown. Most audio power transistors are usable.

The main limitation is the reverse emitter-base voltage (V_{EB}). This is twice the d.c. output voltage. (2.8 times the r.m.s. a.c. input voltage). A maximum V_{EB} rating of 10V applies to many germanium power transistors and limits the r.m.s input voltage to about 3.5V.

Large pulses of current flow into capacitor C1. The peak collector current rating (I_{CM}) should be at least twice the d.c. output current. Fortunately, many germanium alloy power transistors have large I_{CM} ratings so the requirement is easy to meet. A transistor big enough to do the job is likely to drop about 0.5V.

In the circuit shown each "diode" has to deliver half the load current. Its dissipation is then calculable. For example, if the load current is 2A the dissipation is likely to be about 1A×0.5V=0.5W or 500mW. If the collector dissipation rating (free air, no heatsink) is more than this then no cooling arrangements may be needed.

Fig. 1. Arrangement for using Germanium power transistors as rectifier diodes in a low-voltage supply.