BERNARDS No 221

28 Tested Transistor Projects

■ Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book.

■ Some of the circuits are completely new and, to the best knowledge of the author, unlike anything previously published while others may bear similarity to more familiar designs.

■ The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

■ Most of the circuits are very economical on the use of components and in many cases the semiconductors employed are non-critical, commonly available and inexpensive types.

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28 Tested Transistor Projects

R. TORRENS

28 TESTED
TRANSISTOR
PROJECTS

by

R. TORRENS

CONTENTS

INTRODUCTION

The constructor will find within this book many useful and interesting circuits. All of these have been designed and tested by the author. Some of the circuits are completely new and, to the best knowledge of the author, are unlike anything previously published. Others may bear similarity to more familiar circuits. Most of the circuits are very economical on use of components.

The projects themselves can be split down into simpler building blocks – these building blocks are shown separated by boxes in the circuits for ease of description and so that the constructor who wishes can combine boxes from different projects to realise his own ideas. Each 'box' is given a number of its own.

COMPONENTS

In most electronic circuits component values aren't very critical and the constructor should not be put off building because he doesn't have the exact component stated: try building with the nearest value you have.

Resistors Nowadays certain values of resistors are used most commonly – these are the E12 series (<u>10</u>, 12, <u>15</u>, 18, <u>22</u>, 27, <u>33</u>, 39, <u>47</u>, 56, <u>68</u>, 82 in each decade). This book uses only these values: indeed most circuits use only the values underlined in the E12 series above so that constructors who wish to acquire a stock of resistors only need a relatively small number to start with.

N.B. To help make resistor values clearer in diagrams and component lists $2 \cdot 2K$, $4 \cdot 7K$, $6 \cdot 8K$ etc are shown as 2K2, 4K7, 6K8 etc.

Capacitors are made in a far wider range than resistors – but no shop can stock every value. Modern tendency is to prefer the same values as the E12 series of resistors. Different values used in this book have been kept to a minimum and there is no harm in using a value close to that quoted, subject to the notes on the individual circuits. The type of capacitor (ceramic, polyester, mica, etc) is generally of no significance either.

Electrolytic capacitors in the parts lists have a voltage marked: the component used may be rated at a voltage greater than that quoted.

N.B. To help make capacitor values clearer in diagrams and component lists $1 \cdot 5nF$, $4 \cdot 7nF$, $4 \cdot 7uF$ etc are shown as 1n5, 4n7, 4µ7 etc.

Transistors are the cause of most confusion however, which is unfortunate since for most common circuits there are only two types of transistor: NPN and PNP. We have not therefore specified particular transistor types but label these TUN (general purpose NPN) or TUP (general purpose PNP).

Any good quality small signal (PNP or NPN as appropriate) transistor can be used for TUP or TUN, provided it is silicon, not germanium. The following is a short list of a few suitable types.

TUN: BC107/8/9, 182/3/4, 207, 383/4, 2N3711

TUP: BC157/8/9, 204, 212/3/4, 2N3702/3

Diodes as with transistors almost any type of diode can be used. DUS is silicon, such as 1N4149, 1N914, 1N4002, etc.

DUG is germanium such as OA90, OA91.

PROJECT 1

A SIREN

This circuit gives a piercing siren noise which rises and falls in a most insistent manner.

The circuit is designed for 12V operation, but will perform from 6V to 24V although the tone etc will vary slightly.

COMPONENTS

EP is a telephone-handset type earpiece – these are available cheaply from surplus shops and are very efficient in this circuit. It is of interest to note that this earpiece is a nice push fit into the end of a piece of 1½" diameter plastic waste-pipe, which can also hold a piece of board used to build the circuit on.

As an alternative other earpieces may be used – the circuit will even drive a small loudspeaker of not less than 15 ohms impedance. However in this case the circuit should be run off not more than 15V.

HOW IT WORKS

Box 1 generates on 'sawtooth' waveform – falling slowly from 2V to 4V then rising suddenly to 4V. This happens about twice a second.

Box 2 oscillates at a frequency which is determined by the voltage at point A. A change from 4V to 2V here alters the frequency between 1KHz and 2KHz or thereabouts.

Box 3 is a simple output stage to feed the earpiece unit.

VARIATIONS

The rate at which the siren works may be altered by varying C1 or R1: increasing C1 or R1 will slow the rate down, decreasing will speed it up.

The frequency of the siren itself can be altered by changing R6 and/or R7 or C3. Increasing R6 or R7 or C3 will decrease the pitch, whilst reducing the values will increase it.
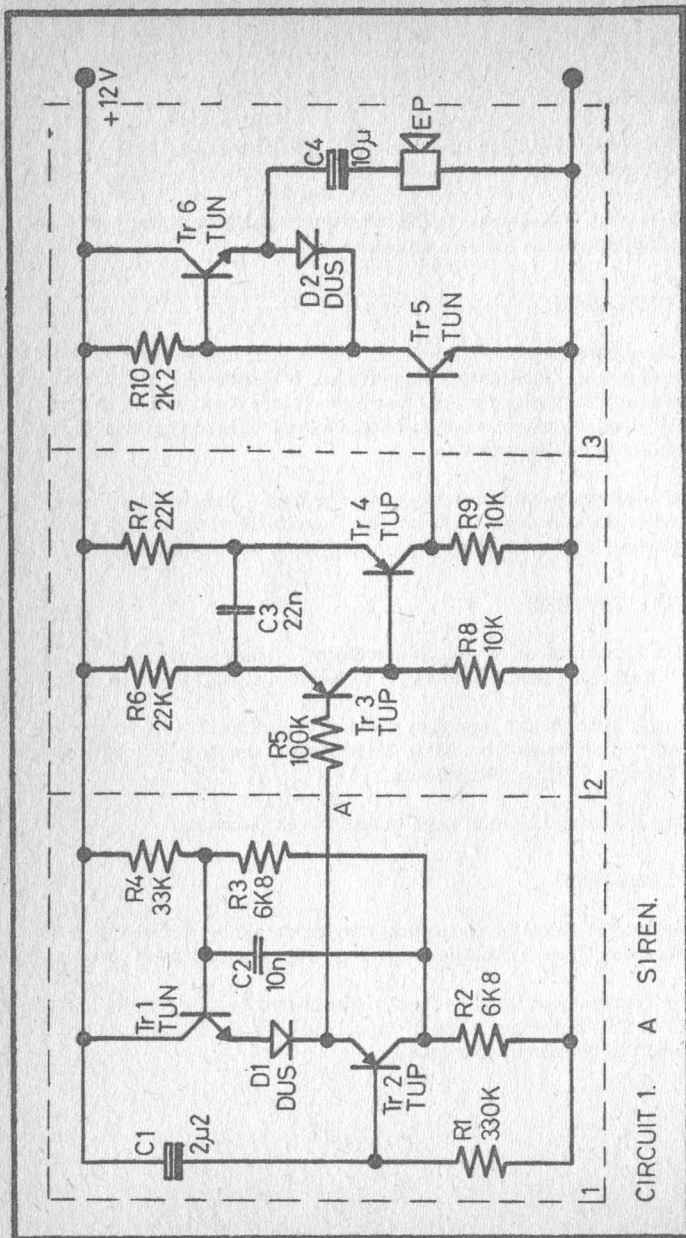
CIRCUIT 1. A SIREN.

PARTS LIST

BOX 1

Resistors:	2 x 6K8, 1 x 33K, 1 x 330K
Capacitors:	1 x 10n, 1 x 2µ2/16V
Semiconductors:	1 DUS, 1 TUP, 1 TUN

BOX 2

Resistors:	2 x 10K, 2 x 22K, 1 x 100K
Capacitors:	1 x 22n
Semiconductors:	2 x TUP

BOX 3

Resistors:	1 x 2K2
Capacitors:	1 x 10µ/16V
Semiconductors:	1 x DUS, 2 x TUN
Others:	one telephone type earpiece or small loudspeaker

PROJECT 2

A SENSITIVE A.C. RELAY

This circuit was originally designed for a central heating system which used fan assisted radiators. This circuit detected when a fan was switched on and then caused the boiler to heat up. Thus the fan heaters weren't used as a full time heating system, but more as if they were electric ones, switched on when needed.

The circuit is designed for 12-15 volt operation. For use from other voltages R3 may need to be altered: its value should be increased in proportion to the supply voltage, eg 2M2 for 24V use.

COMPONENTS

These are not generally critical and most can be altered.

RLA is a relay of suitable voltage for the supply voltage used — most 12 or 18V relays will work nicely on 15V with no problem. Box 31 (circuit 16) may be useful here.

D1 and D2 need only be low voltage types but must be able to handle the current which is being sensed. IN4001 will handle 2A in this circuit.

HOW IT WORKS

Current flows from +15V through R3 and R2, setting up a voltage on Tr1's base of about 0.25 volts: this is not enough to turn Tr1 on so current through R4 causes Tr2 to conduct and the voltage on the junction of R6/R7 is low so Tr3 cannot conduct.

Negative half cycles of sensed input current flow through D2 decreasing this bias voltage and having no effect on the circuit's state.

Positive half cycles flow through D1, which then has a voltage of about 0.6 across it. This 0.6 adds to the 0.25 volts across R2 turning Tr1 on. Tr2 turns off and its collector voltage goes high. C3 now charges up from Tr3's collector voltage allowing current to flow through R5 into Tr1's base holding Tr1 in conduction regardless of the state of the input current. Tr3 also conducts, activating the relay.

C1 takes a certain time to charge fully to a point at which the current through R5 is too small to hold Tr1 on. During a negative half cycle of the input current Tr1 will then turn off and Tr2 on. C1 will discharge very quickly through D4, so the circuit resets itself and senses whether the input is still present.

CIRCUIT 2. AN A.C. RELAY.
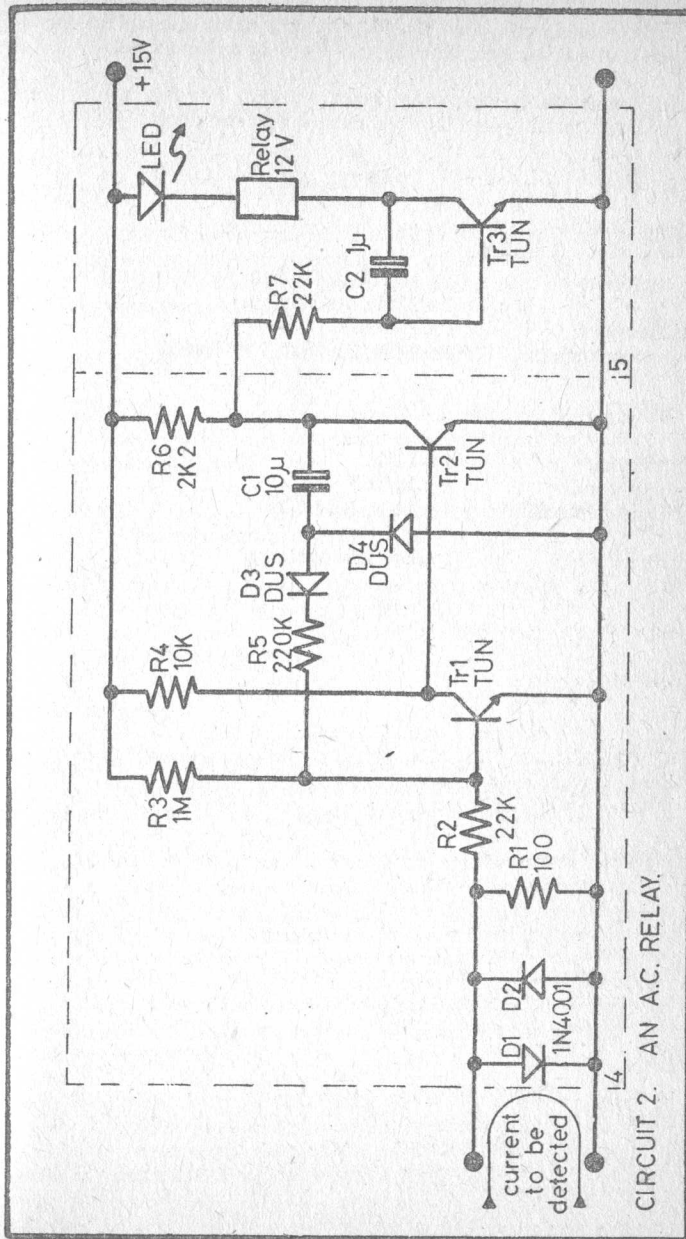
Circuit values shown allow the circuit to stay in the off state for only a couple of milliseconds, whilst it stays on for around a second.

C2 is present in the relay drive circuit to smooth out these small pulses since with certain relays they could allow it to switch off.

PARTS LIST

BOX 4

Resistors:	1 x 100 ohm, 1 x 2K2, 1 x 10K, 1 x 22K, 1 x 220K, 1 x 1M ohm
Capacitors:	1 x 10µ/16V
Semiconductors:	2 x TUN, 2 x DUS, 2 x 1N4002

BOX 5

Resistors:	1 x 22K
Capacitors:	1 x 1µ/16V
Semiconductors:	1 x TUN, 1 x LED
Others:	1 relay, 12V operating

PROJECT 3

A MAINS VERSION OF THE A.C. RELAY

This is very similar to the previous circuit, but uses a TRIAC to replace the relay so that it can switch mains direct.

Note that this circuit is operated direct from mains and it will therefore be at mains potential — this is potentially lethal so the circuit is not recommended to the less experienced constructor who is not used to working with mains voltage.

COMPONENTS

The TRIAC, Tr4, can be any one suitable for mains use, ie rated at 400V or more. Its current rating must be adequate for the motor or other devices being switched.

MBS is a Bi-Directional switch made by Motorola. Either MBS 4991 or 4992 will be satisfactory. For an alternative see Project 23.

C4 must be rated at 250V AC and must be a good quality one. It will probably be rated at a voltage in excess of 600 d.c.

R9 must be rated at 1W or more.

HOW IT WORKS

Box 6 is very similar to Box 4 in the previous circuit except that here Tr1 is normally biased just on and current through D2 turns it off. It is then held off by C1 discharging through D3 and R3.

Box 7 is the Triac drive circuit. The MBS is a device which is in effect open circuit at low voltages but above about 7V (positive or negative) it becomes a short circuit. Where Tr2's output is high Tr3 is turned on and it shorts the gate of MBS to zero so no current can flow into the Triac. However when Tr3 is off the MBS conducts into the Triac, firing it from C4. Tr3 is in fact working with either a +ve or a -ve voltage on its collector, so that in effect part of the time it is working with its emitter and its collector exchanged. All transistors can do this but they then have a very low gain.

Box 8 is simply to supply 14V to the circuit. Note that it uses a capacitor instead of a resistor to drop the mains voltage. The capacitor dissipates no energy so although this capacitor is quite expensive it will save its own cost in electricity within a year!
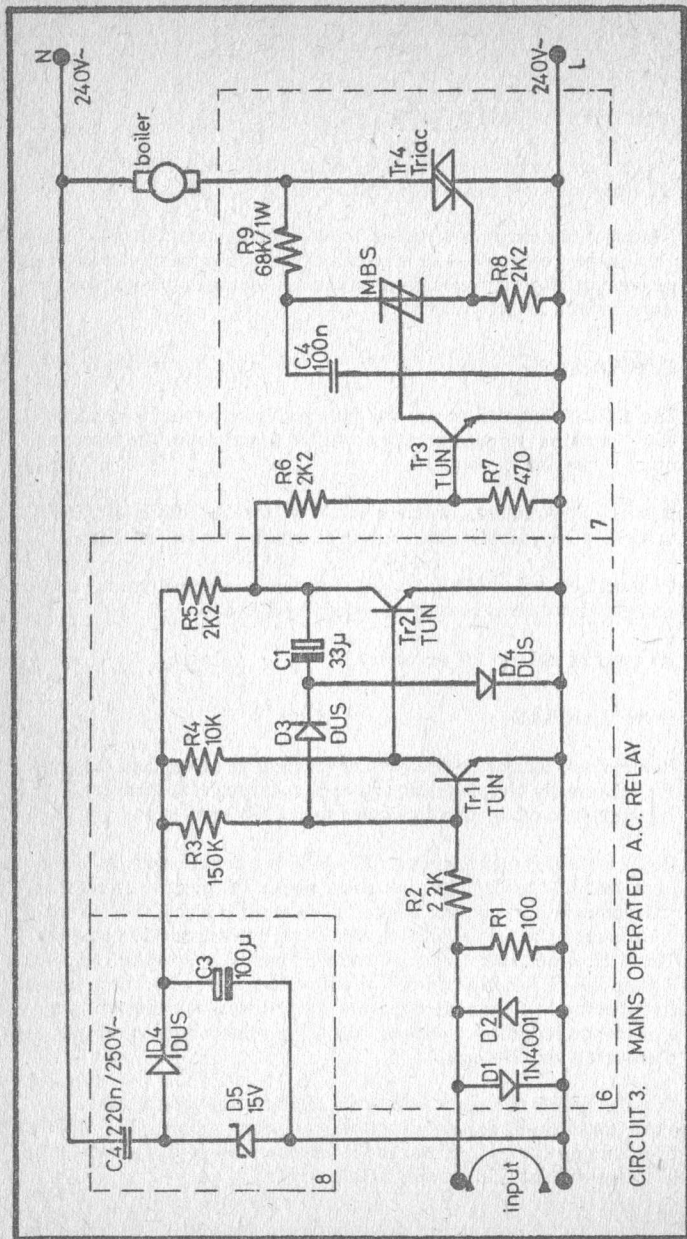
CIRCUIT 3. MAINS OPERATED A.C. RELAY

BOX 6

Resistors:	1 x 100 ohm, 1 x 2K2, 1 x 10K, 1 x 22K, 1 x 150K
Capacitors:	1 x 33μ/16V
Semiconductors:	2 x TUN, 2 x DUS, 2 x 1N4002

BOX 7

Resistors:	1 x 470 ohm, 2 x 2K2, 1 x 68K/1W
Capacitors:	1 x 100n
Semiconductors:	1 x TUN, 1 x Triac/400V, 1 x MBS4991 (or 4992)

BOX 8

Capacitors:	1 x 220n/600V d.c., 1 x 100μ/16V
Semiconductors:	1 x DUS, 1 x zener/15V

PROJECT 4

A LEAKAGE DETECTOR

This has many uses: it is basically a sensitive current detector and may be used as: a leakage checker for diodes and capacitors etc.

> a moisture detector
>
> a water level detector
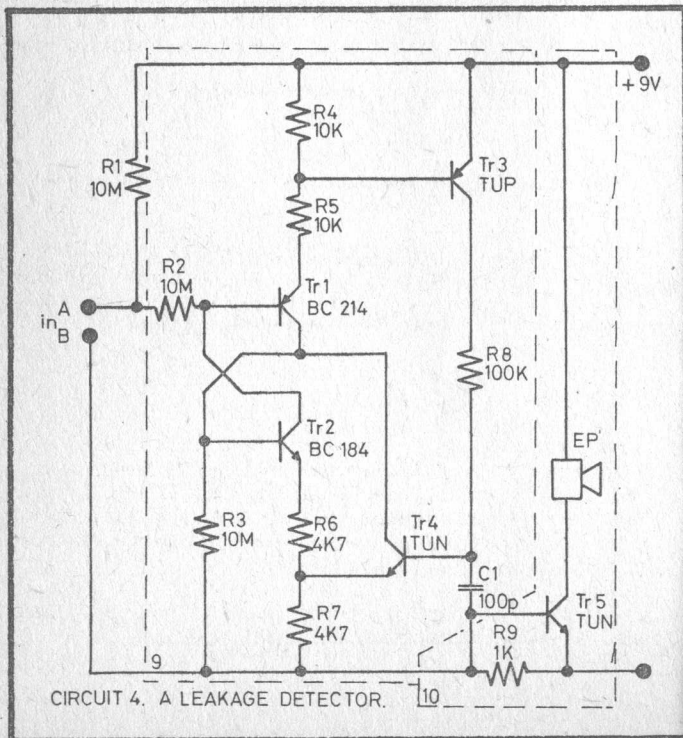
The circuit is designed for 9V operation and works nicely from a small battery such as a PP3.

COMPONENTS

Values are not critical and can be varied greatly.

EP is any earpiece or small speaker of 20 ohm or more impedance: a telephone receiver type earpiece is ideal — as mentioned in Project 1.

CIRCUIT 4. A LEAKAGE DETECTOR.

The same method of construction, in a piece of plastic wastepipe, can be used, and this will also accept the 9V battery, type PP3.

HOW IT WORKS

Tr1 and Tr2 are connected so that the output of each feeds to the input of the other so that when either transistor gets a small input both switch on together and also switch Tr3 on. C1 then charges up through R8 and turns Tr4 on. Tr4 turns Tr1 and Tr2 off again. C1 is very small so the circuit turns on giving a click in the earpiece and turns off again immediately. If a sufficient input current is present these clicks follow each other in quick succession and form a tone in the earpiece. The tone therefore gives an indication of the leakage.

The leaky component to be measured is connected across A & B: the resistor R1 desensitizes the input slightly and this resistor can be a very high value for maximum sensitivity. With 10M ohm here the circuit will oscillate with a leakage in the region of 200M ohm across the input. R1 can be omitted entirely but then, with some transistors, leakage may be enough in Tr1 itself to activate the circuit. However if it is good the circuit will indicate a leakage corresponding to perhaps 1,000M ohm or so. More information on this circuit follows later in this book (Project 12).

USES

The input device whose leakage is to be detected may be a capacitor, a diode (reversed) or a transistor junction.

It may be two terminals or wires touching something where leakage is to be measured; eg two wires may be taken to a piece of glass about 1" apart. Breathing on the glass will form a thin layer of condensation and will activate the detector.

Similarly the circuit could be used as a 'wet baby' detector, or as a water level detector.

A germanium diode can be connected across the input so that it is reverse biased (+ve to A) and R1 made variable (a 1M ohm preset is ideal). Germanium diodes have a leakage, in the region of a few microamps, which is very temperature sensitive. As the temperature increases leakage increases and at a certain temperature the circuit oscillates, giving an audible warning of the temperature.

The circuit is so sensitive that it should also work with a silicon diode although the author hasn't tried this.

BOX 9

Resistors:	2 x 4K7, 2 x 10K, 3 x 10M
Capacitors:	1 x 100p
Semiconductors:	1 x BC214 (low level PNP)
	1 x BC184 (low level NPN)
	1 x TUP, 1 x TUN

BOX 10

Resistors:	1 x 1K
Semiconductors:	1 x TUN
Others:	1 earpiece or speaker unit

PROJECT 5

AN AUDIO AMPLIFIER

The output stage, Box 3 in circuit 1, is fine for low output powers where distortion doesn't matter. However for high power use or where a good clean waveform is needed a better circuit is called for.

This circuit is one of the simplest available which will still give good results — distortion, working into 8 ohms, should be around 0.5% or better which is approaching hi-fi levels.

CIRCUIT 5. AN AUDIO AMPLIFIER
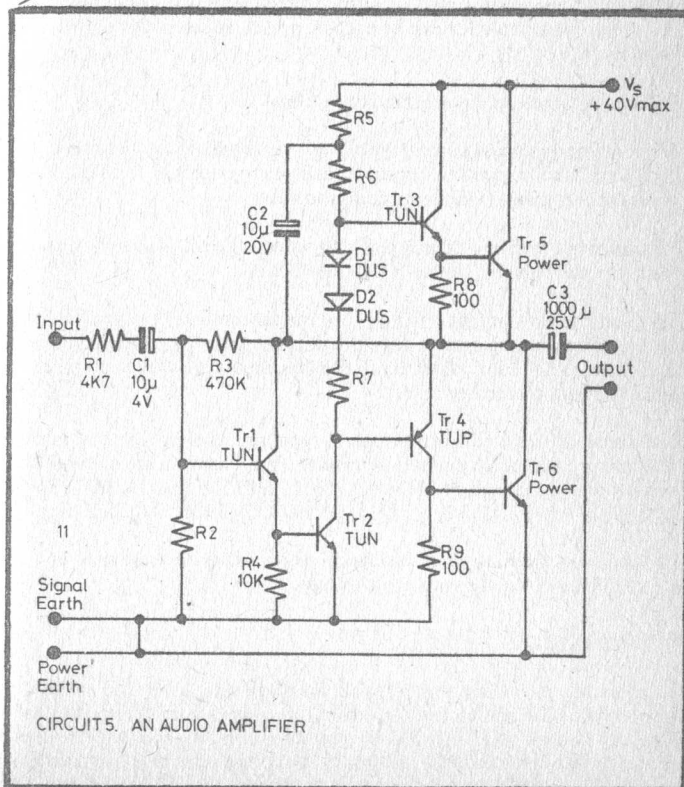
COMPONENTS

Since this is a simple circuit, values must be altered according to the supply voltage from which it is to be used, as in the table.

Vs	Output Power (8 ohms)	R2	R5 & 6	R7
12	1W	150K	470 ohms	82
18	3	100K	1K	82
24	6	47K	1K2	68
30	10	39K	1K5	47
36	15	33K	2K2	47

R2 controls the voltage at the positive of C3, which, for maximum output, should be around half the supply voltage with no signal present. If a meter is available R2 can be a 220K preset, adjusted for correct voltage.

R5 and R6 aren't in face particularly critical.

R7 controls quiescent current: too low a value will cause distortion, too high a value will cause the output transistors to overheat and fail. The values shown give a reasonable compromise.

R1 controls the gain — increase this to reduce the gain and vice versa. With the value shown gain is 100 times (40dB).

Transistors aren't in fact critical — but make sure that the type you use have a voltage rating greater than the maximum supply voltage you will use, thus for 40V operation the transistors should be able to stand at least 40V and preferably 60V.

Tr5 and 6 are NPN power transistors: type isn't critical but they must be rated at at least 5A collector current. The following are a few of the types which can be used: 2N3055, TIP41, TIP35, TIP3055, BD195, BD197, BD199, 2N5977, 2N5983, 2N5978, 2N5984, MJE205, etc.

The electrolytics have their minimum values shown — these may be higher either in capacitance or in voltage.

HOW IT WORKS

A transistor, operating normally, has a voltage of around 0.55 present between its base and emitter. Current is fed back from the emitters of Tr4 and 5 through R3 into R2. When the output voltage (with no signal) is at a certain level this current develops a voltage across R2 just sufficient to turn Tr1 and Tr2 on. Tr2 draws current through R5 and R6 and Tr3

and Tr4, Tr5 and Tr6 follow this voltage, transforming it to the output point (+ve of C3). This output point therefore takes up a stable voltage proportional to the value of R2. This voltage is adjustable by R2 to be about half of the supply voltage used.

For correct minimum distortion a small current should flow through Tr3, R8 and Tr4, R9. This is why D1, D2 and R7 are included: to set up a small voltage difference between Tr3 and Tr4 bases. If this voltage difference is too small Tr3 and Tr4 will both be off and crossover distortion occurs. If too high the current through R8 and R9 develops voltage high enough to turn the output transistor on: they will both conduct and quickly overheat.

A signal voltage is fed into the input causing a current to flow through R1. In order to maintain the same voltage as before in R2 the current in R3 must rise or fall to cancel out the current in R1. It can only do this if the output voltage rises and falls in exactly the same ratio (but reversed in phase) to the input signal as R3 is to R1.

When the output voltage rises near to the rail there would be little current through R5 and R6. This current would be too small to drive Tr3 and Tr4. C2 however couples the output voltage to the junction of R5 and R6: as the output rises so does this point so there is always plenty of voltage across R6 to allow current to flow into Tr3.

PARTS LIST

|	
Resistors:	2 x 100 ohm, 1 x 4K7, 1 x 10K, 1 x 470K
	Other resistors see text.
Capacitors:	1 x 10µ/4V, 1 x 10µ/20V, 1 x 1,000µ/25V
Semiconductors:	2 x DUS, 3 x TUN, 1 x TUP
	2 x NPN power transistors, see text.

PROJECT 6

A POWER SUPPLY

The circuits in this book work, for the most part, from voltages around 10 to 30. This is a simple stabilized power supply suitable for these circuits. It is completely safe in that a short circuit across its output will not damage it. The components of the power supply can be chosen to give any voltage up to 36.

ASSEMBLY AND COMPONENTS

First decide on the voltage you require the power supply to give (we will call this V_{cc}) and the maximum continuous current (I_{max}) you wish it to deliver. Various components can now be chosen:

CIRCUIT 6. A POWER SUPPLY.
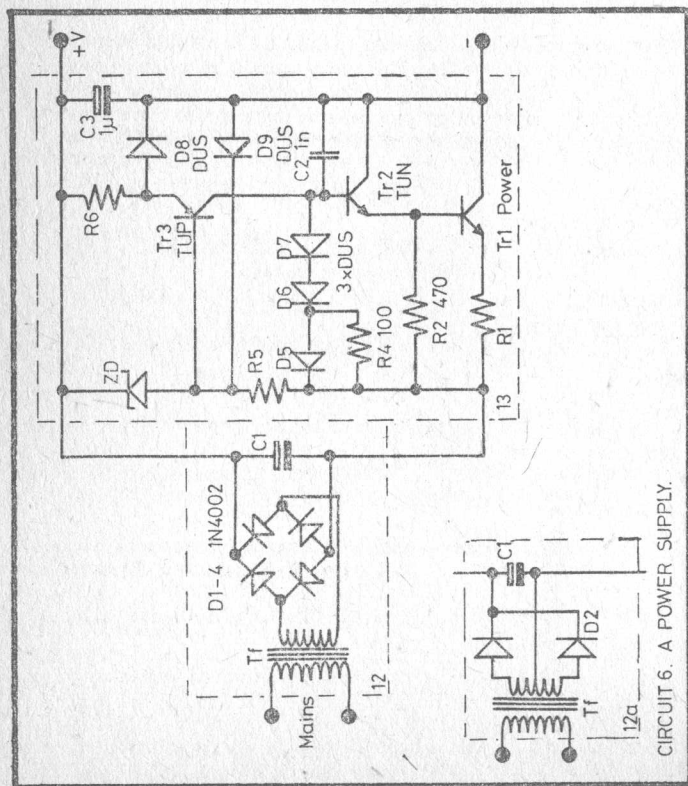
Transformer: this should give a voltage equal to or slightly higher than V_{cc} – thus for 20V output a 24V transformer would be fine – and capable of giving the required current. Some transformers have a double winding and may be quoted as, say, 24-0-24V. In this case use the transformer connections inset, (Box 12a), using only two diodes, may be substituted for Box 12.

C1: should be a large value of several thousand Microfarads – a reasonable choice is to use at least 2,000uF for every amp of current, so for a 2A power supply use 5,000uF and for a ½A power supply use 1,000uF. Larger values still give better results. C1's voltage should be nearly double the transformer's working voltage.

ZD: this is a zener diode of 400mW or more: its voltage should be the same as the required output voltage – use a 12V zener to get a 12V output and so on.

R5's value can now be worked out from the formula:

$$\frac{(V_T \times 1.4) - V_{cc}}{10} \text{ K ohm} \quad \text{where } V_{cc} \text{ is the required output voltage,}$$

V_T is the transformer's voltage. Chose a value near to that calculated, since this is not too critical. This for a 12V output from an 18V transformer the formula gives 1.3K – use 1K2 or 1K5 as convenient.

R6 is found by: $\dfrac{V_{cc} - 0.6}{5}$ K ohms.   Choose the nearest

convenient value: thus a 12V power supply gives a result of 2.2K for this.

R1 determines the maximum peak current the power supply can give: remember for an audio amplifier the maximum current on peaks is nearly three times the continuous value – so a 1A supply may be required to deliver 3A. If the maximum peak current drain is $\hat{I}$ then chose $R1 = \dfrac{0.6}{\hat{I}}$ ohms.

Thus 1 ohm ½W here will limit the current to 600mA – two 1 ohm ½W in parallel will limit to 1.2A etc. It is usually most convenient to use a piece of resistance wire or several 1 ohm resistors in parallel.

Tr1, 2 and 3 must all be able to stand up to twice the transformer's rated voltage.

Tr1 must be a power type capable of standing the full peak current – 2N3055 will be suitable. It will get hot so mount it on a good heatsink.

HOW IT WORKS

A.C. output from the transformer is rectified by D1-D4. C1 smoothes this rectified a.c. and itself will charge up to the peak voltage from the transformer (1.4 times its actual a.c. output voltage — which may in fact be higher than its rated voltage).

A current is then fed to ZD through R5. ZD therefore presents a reference voltage equal to its rated value.

Tr3 drives a current into Tr1 and Tr2 and the output then rises until D8 conducts — this tends to pull Tr3's emitter more negative thus cutting off Tr3. The circuit therefore balances itself so that the output voltage is equal to the zener voltage.

As the current drain increases Tr3 is called upon to deliver more current into Tr2. However there is a maximum value of current which Tr3 is allowed, by R6, to give. This is equal to $\frac{(V_2 - 0.6)}{R6}$ which has been

chosen as 5mA. If this is reached the circuit can give no more current and it limits. This drive current from R3 is reached when D5, 6 and 7 start to conduct because the voltage drop across R1 is too high and this is when R1 drops a voltage of 0.6 (equal to the drop across D5).

As the current limits the output voltage drops — D5 now becomes forward biased and tends to pull ZD's voltage down (towards the positive line). The current Tr3 can deliver therefore drops because there is now less voltage across R6. Into a short circuit Tr3 cannot conduct at all and the circuit delivers only 15mA or so and is completely safe.

PARTS LIST

Resistors:	1 length of resistance wire, see text.
	1 x 470 ohm, 1 x 47K, others see text.
Capacitors	1 reservoir, see text.
	1 x 1n, 1 x 1μ/50V
Semiconductors:	4 x 1N4002, 5 x DUS
	1 x zener of required voltage.
	1 x TUP, 1 x TUN
	1 x power transistor, see text.
Others:	1 x transformer to suit.

AN ULTRASONIC 'TRANSMITTER'

In radio books circuits are sometimes published for ultrasonic devices — remote control, burglar alarm or whatever. Invariably the sender uses an IC or an ordinary multivibrator whose frequency needs to be adjusted.

This circuit is simple, efficient and since its frequency is determined solely by the transducer used it needs no adjustment at all.

It will be noted that Box 3 is the output stage which was used with the siren — circuit 1.

CIRCUIT 7. AN ULTRASONIC TRANSMITTER.
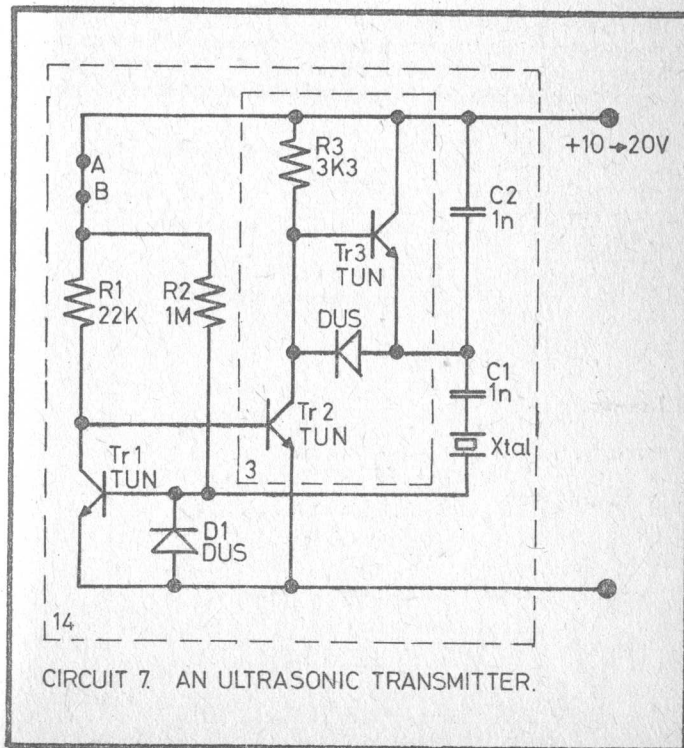
COMPONENTS

None of these are critical and near values are quite acceptable.

Xtal is an ultrasonic transducer (transmitter type) and virtually any of the commonly available ones are satisfactory. These transducers are normally sold in pairs – one for transmitter and one for receiver – working at around 40KHz.

HOW IT WORKS

At switch on R2 drives a small current into Tr1's base. C2 charges up and puts a voltage across Xtal: this behaves as a capacitor itself and more current flows into Tr1's base from this. Tr1 therefore switches on and switches Tr2 off, until C1 and Xtal have charged up when Tr1 switches off. The circuit is now oscillating with the output switching on and off in a good squarewave. D1 is included to cancel out the rectifying action in Tr1's base-emitter junction.

The circuit can be switched on and off by putting a switch in at points A and B: when this is open circuit the transmitter will draw no current (except leakage in Tr2 which is unmeasurable). This 'switch' can be electronic, as for instance a multivibrator which will then modulate the 40KHz signal – see circuit 8.

PARTS LIST

Resistors:	1 x 3K3, 1 x 22K, 1 x 1M ohm
Capacitors:	2 x 1n
Semiconductors:	3 x TUN, 2 x DUS
Others:	Ultrasonic crystal transducer

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PROJECT 8

ULTRASONIC TRANSMITTER MODULATED AT APPROX. 500Hz

For remote control applications reliability and stray response are improved if the receiver can recognise reliably the signal it is meant to pick up. This is done by modulating the transmitter and having the receiver recognise only this modulated signal. This is a circuit for modulating the transmitter of Project 7.
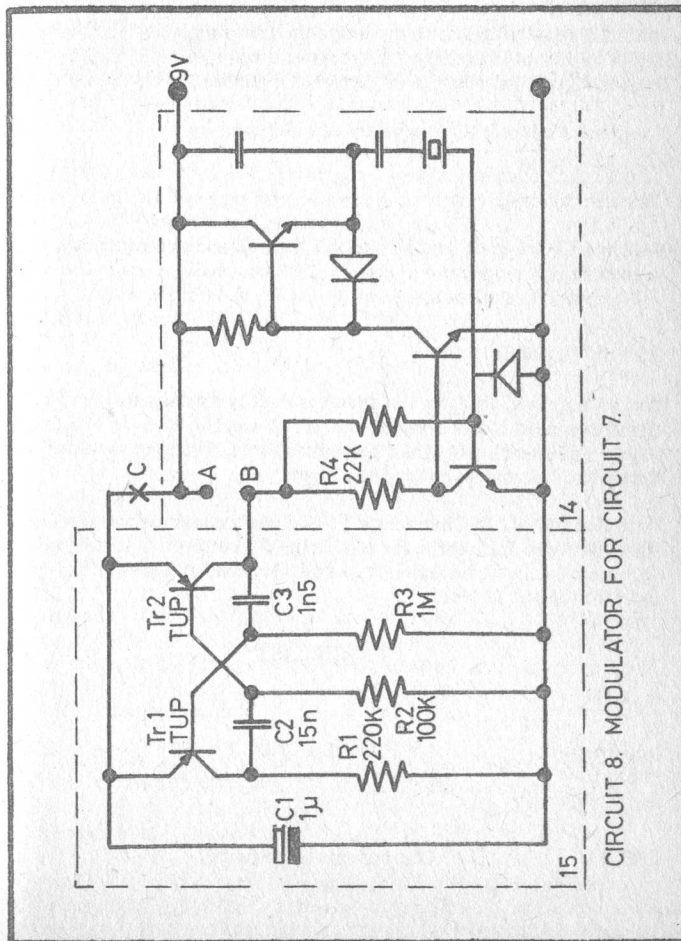
CIRCUIT 8. MODULATOR FOR CIRCUIT 7.

Note that this circuit is shown working from 9V. If it is used from a voltage higher than this the frequency will not be correct.

To overcome this a resistor may be incorporated at the point marked C: this resistor should be $\frac{V - 7}{0.6}$ K ohm, (where V is the desired working voltage) or the nearest value to that calculated.

COMPONENTS

The circuit in Box 14 is exactly the same as Project 7.

Box 15 is a multivibrator to modulate the transmitter and its frequency should be the same as that of the receiver used so R2, R3, C2, C3 should be good close tolerance (5% or better). Otherwise the circuit isn't critical.

If values are altered, the frequency can be found by

$$F = \frac{1.44 \times 1000}{C2 \times R3 + C3 \times R2}$$

If C2 and C3 are in nF and R2 and R3 in M ohms the frequency will be given in Hz.

HOW IT WORKS

Box 15 is a multivibrator: the circuit is slightly unusual since most vibrators published are symmetrical: if R2 was 1M, R1 was 22K and C2 was 1n5 this circuit would be conventional. Using an asymmetrical circuit like this gives a better wave form.

Note that R4 (R1 in Circuit 7) is Tr2's collector resistor and it is in effect between Tr2's collector and earth. By connecting it this way the ultrasonic oscillator becomes Tr2's collector load and is switched on and off at about 500Hz.

PARTS LIST

BOX 15

Resistors:	1 x 100K, 1 x 220K, 1 x 1M
Capacitors:	1 x 1n5, 1 x 15n, 1 x 1μ/12V
Semiconductors:	2 x TUP

BOX 14   Components as Project 7

PROJECT 9

AN ULTRASONIC RECEIVER

This receiver is built in stages (as indeed are most circuits) and the constructor has a choice of what to include and what to omit.

HOW IT WORKS

The basic circuit is shown in Circuit 9. Box 16 is a preamp with maximum gain at around 40KHz. Note that D1 is in effect in parallel with R2 (C3 is present only to block d.c. from D1). Now the effective resistance of a diode is dependant upon the current being passed through it — a typical diode has an impedance of 10K ohms at around 30μA which falls to around 1K at 60μA, 100 ohms at 300μA and around 30 ohms at 1mA.

Signal voltage and current however must be small or distortion results. So, in this circuit, the gain varies from 19, with no current through D1, to over 3,000 with one milliamp or so through D1.

Box 17 is a tuned 40KHz amplifier — although many writers claim a tuned amplifier is unnecessary, ultrasonic transducers do have a considerable response to other frequencies and if maximum gain is required then a tuned amplifier is needed. This circuit is efficient and tunes to a frequency f such that $f = \frac{10^6}{4\pi C_x \cdot R_x}$ where f is in KHz

C_x in pF
R_x is in K ohms

so that Cx of 100pF and Rx of 18K tunes to a frequency of 44KHz.

Capacitors Cx and resistors Rx should be close tolerance (1 or 2% preferred) and of course where there are two Rx in series a single resistor of double the value may be used (although 36K is not easy to obtain): similarly for the two Cx in parallel.

In chosing for other frequencies select the capacitor first, then calculate the required resistor since resistors can be bought or made from series parallel arrangement cheaper than capacitors can. If Rx is changed, R7 may also need alteration — it should be approximately 40·Rx. Box 18 is a detector stage.

Box 19 is a peak detector and AGC amplifier which feeds back to box 16 to alter its gain so that the detector stage never overloads. This is necessary for a modulated system but if the unmodulated transmitter is used AGC is not so necessary.

R19 is a gain control — it sets the maximum sensitivity level. If this control is set too high then the circuit responds readily to stray noises: it should be set so that the circuit just responds to the control signal.

The output from Circuit 9 is either d.c. or the low frequency modulation signal. If an unmodulated transmitter is used then this output is fed direct to a level detector (see Project 15).

With the modulated system it must feed to a modulation detector — a suitable circuit would consist of the preamp of Project 10 (box 21) and a peak detector (Project 10 box 22).

COMPONENTS

Generally these are not critical in value, with the exception of Rx and Cx which must be close tolerance types of the correct value: changing values will alter the frequency of this tuned stage.

CIRCUIT 9. ULTRASONIC RECEIVER.
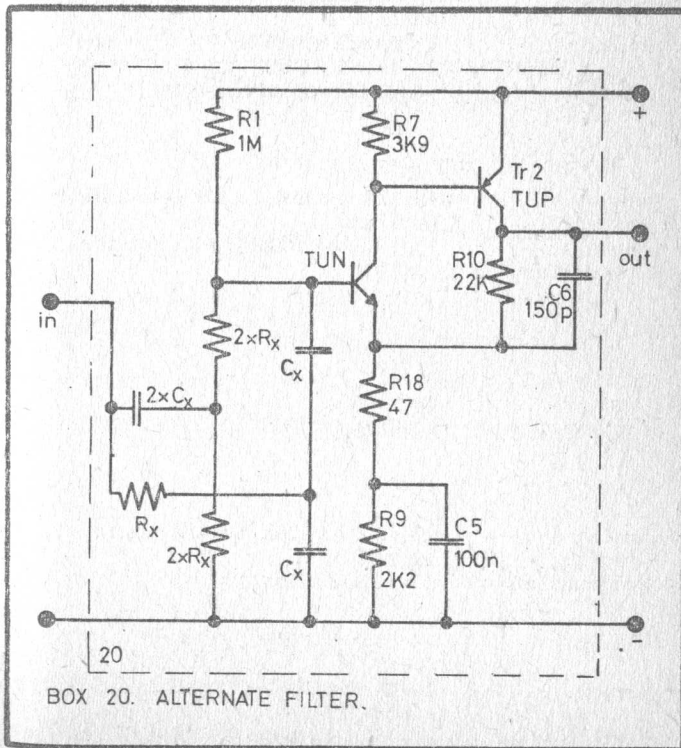
BOX 20. ALTERNATE FILTER.

VARIATIONS

Box 20 shows an alternative tuned amplifier – this is a higher gain one than Box 17. If it is used care must be taken with layout or instability can result from stray capacitance.

Use of this alternative is not an advantage with the modulated system but may be with an unmodulated system.

CONSTRUCTION

An ultrasonic system using these circuits will have high gain and a high Q: it must therefore be built carefully and preferably in a metal box to screen it from interference etc.

PARTS LIST

BOX 16

Resistors:	1 x 820 ohm, 1 x 10K, 1 x 100K, 1 x 180K, 1 x 220K
Capacitors:	1 x 100n, 2 x 1μ/6V
Semiconductors:	2 x TUN, 1 x DUS
Others:	1 Ultrasonic crystal transducer

BOX 17

Resistors:	1 x 1K5, 1 x 15K, 1 x 820K, 4 x 18K/1% (or to suit)
Capacitors:	1 x 150n, 4 x 100pF/1% (or to suit)
Semiconductors:	1 x TUN

BOX 18

Resistors:	1 x 12K, 1 x 22k
Capacitors:	1 x 1μ/20V
Semiconductors	1 x TUN, 1 x DUS

BOX 19

Resistors	1 x 3K3, 1 x 220K, 1 x 47K preset
Capacitors	1 x 1μ/20V
Semiconductors	1 x TUN, 1 x DUS

BOX 20

Resistors	1 x 47 ohm, 1 x 2K2, 1 x 3K9, 1 x 22K, 4 x 18K/1%
Capacitors	1 x 150p, 1 x 100n, 4 x 100pF/1% (or to suit)
Semiconductors	1 x TUN, 1 x TUP

PROJECT 10

A TUNED VARIABLE Q PREAMP AND PEAK DETECTOR

This circuit is designed for use with the modulated carrier ultrasonic control system: it would be possible to build several of these tuned preamps, each for a separate frequency, and to modulate with one of several frequencies to match the preamp.

CIRCUIT 10. TUNED AMPLIFIER AND DETECTOR.

HOW IT WORKS

Tr1, 2 and 3 form an op-amp with negative feedback via R6 and R7. At the same time positive feedback of a variable level through a Wein Bridge network consisting of both Cys and Rys (the second Ry is formed by R9 in series with R10 parallelling R11) which is tuned to 500Hz. R9 is a variable feedback control which determines the +ve feedback and hence the Q factor.

At the same time the amplifier is selective because of the feedback network R12, C3 and R7, C2.

The output of this can be fed into a level detector, such as Project 15.

The frequency determined by Cy and Ry must be the same as that of the modulator (Project 8) so if one is changed so must the other be.

The frequency may be calculated from the formula:

$$\text{Frequency (Hz)} = \frac{1}{2\pi Cy \cdot Ry}$$

The Peak detector detects the level of modulation and converts it unto a level suitable to feed the level detector (Project 15).

PARTS LIST

BOX 21

Resistors:	1 x 680 ohms, 2 x 1K, 1 x 2K2, 1 x 12K, 3 x 100K, 2 x 150K, 1 x 10K/5%, 1 x 22K/5%, 1 x 39K/5%, 1 x 22K preset
Capacitors:	1 x 1n, 2 x 10n/5%, 1 x 4n7, 1 x 10μ/12V
Semiconductors:	2 x TUN, 1 x TUP

BOX 22

Capacitors:	1 x 1μ/12V
Semiconductors:	2 x DUS

A DOMESTIC THERMOSTAT

Here is a method of replacing the normal thermostat used with central heating systems. The circuit uses a common germanium diode as a temperature sensor so it is very quick to respond, and cheap to build. With the normal thermostat there can be a considerable difference in temperature between the thermostat switching off and its coming on again. This 'hysteresis' is adjustable in this circuit.

Designed for 12V operation, the circuit can operate from 10-24V — although temperature setting is somewhat dependant upon the voltage.

CONSTRUCTION

The circuit of box 23 is the sensitive part and this should be built as a unit and positioned in the room to be sensed.

CIRCUIT 11. A DOMESTIC THERMOSTAT.

The relay circuit (box 10) and power supply can be remote. The circuit draws only 200µA in the off state and about 12mA when on and is low voltage so cheap twin bell wire can be used for interconnection.

D1 is the sensor itself. Note that most diodes are light sensitive, so this diode can with advantage be placed inside some thick black sleeving to protect it from light.

With any thermostat there are two temperatures: the first is the high level where the thermostat switches off. The room now starts to cool, until the second, low temperature is reached and the thermostat switches on.

There is a time lag between the heater's starting to work and the thermostat detecting this — this lag is partially due to the time taken for the radiators to heat, partially by the time hot air takes to circulate to the thermostat, and of course the time for the heat to flow through the glass case of the diode. All of these factors determine the hysteresis in a normal thermostat. The hysteresis in this electronic one is inherently low and can be increased by means of a preset adjustment, R9.

This is a factor for increasing fuel economy since the room can be held very near to a steady temperature, which can be lower than the average temperature in a normal system. It also makes the room more comfortable.

HOW IT WORKS

Germanium diodes, when reverse biased, are leaky: this leakage varies from one diode to another, but for any one diode at a fixed voltage, it is very dependant upon temperature.

D1 is the germanium diode. At high temperature D1 is leaky and turns Tr1 on. Tr1 pulls the potential on Tr2's base down, decreasing the voltage across the diode. The current needed to turn Tr1 on is determined by the setting of R1. For a particular setting of R1 therefore the emitter of Tr2 will be held at the correct voltage so that D1's leakage just turns Tr1 on. As D1 cools the voltage on Tr2's emitter necessary to maintain this leakage increases, until D2 conducts. The current through Tr2 now rises rapidly and turns Tr3 on. R7 provides feedback to speed up this switching action. At this point the current consumption increases from around 200µA to over 10mA, and this current illuminates the LED and switches the relay via Tr4.

As the LED turns on about 1.5 volts is dropped across it. A part of this is fed back via R9 and R10 to turn Tr1 off slightly, so D1 must cool further than it otherwise would. This 'hysteresis' is adjustable by R9.

If R9 is set to maximum resistance switching action is not very fast and the LED may extinguish slowly.

VARIATIONS

If R6, 7, 8, 9, 10, 11, Tr3, 4, D2 and 3 are omitted a voltage output can be taken from Tr2's emitter. This voltage swings between about 3V and 10V and is dependant upon temperature. This could be used as a thermometer or temperature alarm.

OTHER CONTROLS

Project 13 shows a touch operated switch designed for use with this thermostat: the author's own central heating system uses these!

Project 16 shows a remotely programmed version of this thermostat, where two or more different temperatures can be set externally.

PARTS LIST

BOX 23

Resistors:	1 x 68 ohms, 2 x 470 ohms, 1 x 1K2, 1 x 12K, 1 x 33K, 1 x 100K, 1 x 2M2, 1 x 10K preset, 1 x 1M variable
Capacitors:	1 x 22n
Semiconductors:	1 x BC184, 1 x TUN, 1 x TUP, 1 x LED 1 x DUG, 1 x zener/7·3V

BOX 10

|	
Resistors:	1 x 100 ohms
Semiconductors:	1 x TUN
Others:	1 x 12V relay

PROJECT 12

STATIC ELECTRICITY DETECTOR

This circuit is basically the same as number 4, but in a more sensitive form. Components and construction are therefore more critical.

The circuit is designed to work from a PP3 or other 9V battery.

HOW IT WORKS

Circuit action is the same as circuit 4, except that input desensitizing resistors are omitted and a diode included. Resistors R1 and R2 may be
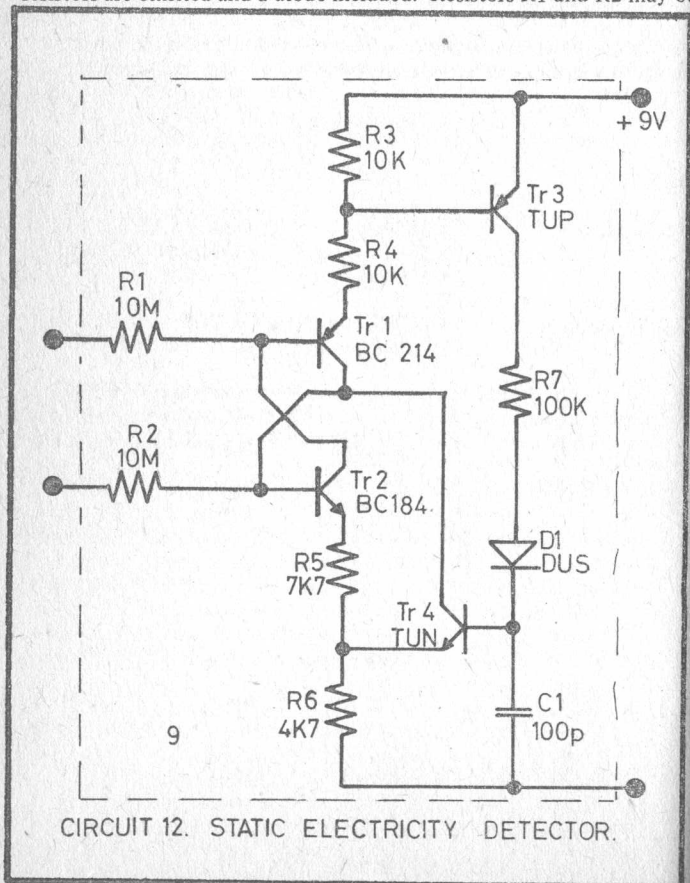
omitted — they are present simply to limit possible current in case a spark should ground to one input or other.

CONSTRUCTION

Components and construction are critical — a minute leakage between the input terminals is sufficient to set the circuit off, so good quality transistors must be used and assembly must be done in such a way as to minimise leakage. For this reason Veroboard, matrix board and PCB material may all cause trouble and perhaps the best way of building is onto a thick piece of polythene: a piece out of a polythene container or its lid is ideal: the components are mounted on one side as if on a printed circuit board and the appropriate leads are connected underneath. Holes can be made with a hot pin.

Transistors used must be good quality — especially Tr1, 2 and, to a lesser extent Tr3. Many different types are useable, provided they have a reasonable gain at low currents. Suitable NPN types are BC109, 149, 169, 184 and PNP types BC179, 159, 259 or 214.

Because of the circuit extreme sensitivity it is quite possible that the transistors will have to be selected for this circuit: it works at levels at which transistor manufacturers don't guarantee their products!

USE

In use the circuit can give an audible warning, when the earpiece and driver suggested in Project 4 (box 10) can be used. A short 'aerial' of wire a few inches long is connected to Terminal 1 or 2 (the wire can be insulated) and the unit held in the hand. If now the wire is brought up to some electric wiring the field around this will be picked up and a buzz will result in the earpiece. In this way it acts as a mains wiring detector.

Or the unit can be used in a static situation: it is put down somewhere and an item presented to the aerial. If the item is charged this will trigger the unit which will click.

Alternatively the circuit can be used as a static operated switch — one application of this is given in Project 14.

CIRCUIT 12. STATIC ELECTRICITY DETECTOR.

PARTS LIST

|	
Resistors:	2 x 4K7, 2 x 10K, 1 x 100K, 2 x 10M
Capacitors:	1 x 100p
Semiconductors:	1 x BC214 (low level PNP)
	1 x BC184 (low level NPN)
	1 x TUP, 1 x TUN, 1 x DUS

PROJECT 13

A TOUCH OPERATED ON-OFF SWITCH WITH MECHANICAL OPTION

The thermostat of Project 11 switches a relay to control central heating in one or more rooms. This central heating is controlled by a timeswitch.

This circuit integrates thermostat, timeswitch and a touch controlled manual over-ride.

The circuit is designed for 12V operation but should be useable up to about 24V.
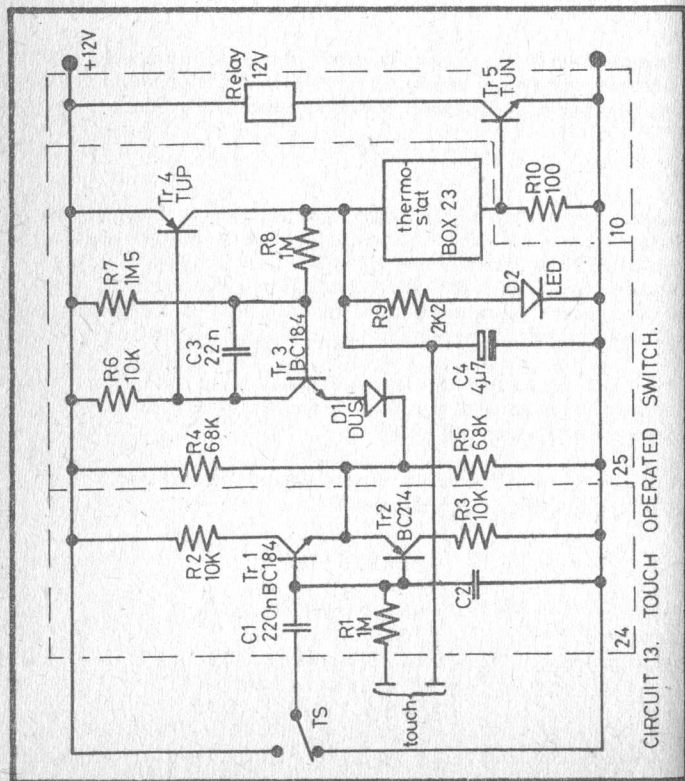
HOW IT WORKS

The switch is shown operating in conjunction with the thermostat of Project 11 (boxes 23 and 10). However the collector load of Tr4 could be a relay or any other circuit to be switched, drawing not more than about 20mA. R9 and the LED are put in solely to give a visual indication of the switch's state and may be omitted if not required.

Tr3 and Tr4 are arranged so that each switches the other on whilst Tr4 also switches power to the load.

In the on state a current of 170µA is available from the junction of R4 and R5 to Tr3's emitter to drive Tr4. The collector of Tr4 is nearly at +12V.

A finger applied to the touch terminals allows current to flow from Tr4's collector through R1 to charge C1 and C2. At a certain potential on C1 and C2, Tr1 conducts and robs current from Tr3, which switches off.

Tr4's collector voltage now falls to zero volts. If the finger is left on the terminals C1 and C2 discharge through the same path, until voltage falls low enough for Tr2 to conduct. Before it starts to conduct Tr3's base is held at +5V by R7 and R8 whilst R4 and R5 hold Tr3's emitter to +6V so Tr3 cannot conduct. The junction of R5 and R6 must then fall to +4V before the circuit turns on.

Thus a finger held on the touch control will cause the circuit to switch slowly on and off at a rate determined by C1 and C2 in parallel — in this case about ¾ second.

The timeswitch contacts controlling the circuit are TS shown in the on position. When they change over C1 will charge turning Tr1 on and switching the circuit off. If the circuit has been switched off manually then nothing will happen. When TS changes back C1 discharges, turns Tr2 on and the circuit on.

If power is removed as in a power cut then, when it is restored the arrangement of C1, C2 will cause the circuit to switch on to the state defined by TS.

C3 and C4 are to slow the circuit down and make it insensitive to interference pulses induced in the wiring.

CIRCUIT 13. TOUCH OPERATED SWITCH.

PARTS LIST

BOX 24

Resistors:	2 x 10K, 1 x 1M
Capacitors:	1 x 100n, 1 x 220n
Semiconductors:	1 x BC214, 1 x BC184 (low level PNP and NPN)
Others:	relay or micro switch to activate (TS)

BOX 25

Resistors:	1 x 2K2, 1 x 10K, 2 x 68K, 1 x 1M, 1 x 1M5
Capacitors:	1 x 22n, 1 x 4µ7/16V
Semiconductors:	1 x BC184, 1 x TUP, 1 x LED, 1 x DUS

BOX 10

| Resistors: | 1 x 100 ohms |
| Semiconductors: | 1 x TUN |
| Others: | 1 x 12V relay |

BOX 23   as circuit 13

PROJECT 14

A PERSON DETECTOR

This circuit is strictly for fun, but makes a great attention getter when friends call.

The circuit reacts to people, but not to everyone! When the right person passes near to the circuit it switches on and squeals at them. The squeal dies away in frequency after a second or so.

If the unit is built into an ornament it can be stood in a room and will 'talk' to people.

CIRCUIT 14. A PERSON DETECTOR.
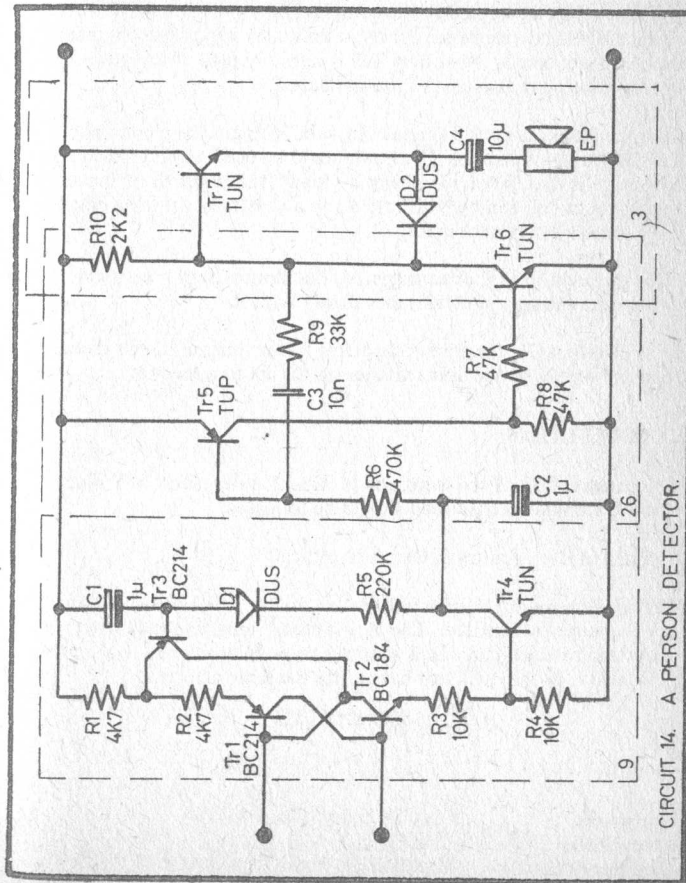
The circuit reacts to static electricity; whether it is triggered by a person depends upon how close they are, how fast they are moving and on their charge. Their charge depends upon the clothes they are wearing, their shoes and other factors, which in practice makes it appear fairly random; however it does appear to be a 'male', since women set it off more readily than men because of their nylon clothing etc!

The circuit works from a 9V battery, and draws no current when not howling so even when left on almost continuously an ordinary 9V battery will give a good life.

HOW IT WORKS

The circuit is an assembly of boxes mentioned earlier in this book: box 9 (Project 12), assembled in the complementary version (PNP transistors replace NPN and vice versa) drives an oscillator which incorporates the output stage, box 3. Note how Tr6 is not only part of the output stage in this circuit but also part of the oscillator.

Like the circuit of box 2 (Project 1), box 26 is a voltage controlled oscillator and indeed box 2's circuit could be used here. This circuit's advantage is that, when it receives no input it then draws no current so the whole circuit can be built into a toy and left on, drawing no current until someone approaches it.

C2 is included so that once triggered, the input voltage dies away slowly — the tone changes pitch and dies slowly with it.

Note also that C1, the timing capacitor is much larger in this circuit than previously so the unit switches on for about a second.

CONSTRUCTION

The construction of the front end is critical as described in Project 12, and the techniques described should be followed.

The rest of the circuitry is not at all critical.

The whole assembly can be built into a doll or other ornament and one or other aerial connected. The aerials are 6" long pieces of wire (insulated or bare) and one is sensitive to positive charges — the other to negative, so they will not have quite the same effects.

PARTS LIST

BOX 9

Resistors:	2 x 4K7, 2 x 10K, 1 x 220K
Capacitors:	1 x 1µ/12V
Semiconductors:	2 x BC214, 1 x BC184 (low level PNP and NPN). 1 x TUN, 1 x DUS

BOX 26

Resistors:	1 x 33K, 2 x 47K, 1 x 470K
Capacitors:	1 x 10n, 1 x 1µ/12V
Semiconductors:	1 x TUP

BOX 3

Resistors:	1 x 2K2
Capacitors:	1 x 10µ/12V
Semiconductors:	2 x TUN, 1 x DUS
Others:	1 telephone earpiece or speaker

PROJECT 15

A VOLTAGE LEVEL DETECTOR AND SWITCH

This circuit operates a relay when a pre-set input voltage is exceeded. It can be used with the ultrasonic receiver of Project 9. It could also be used with the variation of Project 11 described or with any other circuit where an indication must be given that a threshold voltage has been exceeded.

The circuit is designed for 24V operation but other voltages from 18-36 may be used.

HOW IT WORKS

The voltage level to be detected is set up on VR1. VR1 has a stabilized voltage across it, derived from ZD1 via Tr5. As soon as this voltage level is exceeded on input 1, Tr1 starts to conduct and passes current into Tr3. Tr3 turns Tr4 on.

R6 and C2 are included to make sure that Tr3 and 4 both turn hard on and remain on for a certain period regardless of the input level.

Closing SW feeds a signal back from Tr3 through R1 so that, once Tr3 turns on, it keeps Tr1 turned hard on.

D1 is included so that shorting input 1 to earth cannot turn the circuit off — it may be omitted if desired, or when used with circuit 10 which includes this diode in the output.

C1 is included to slow the input up so it does not respond quickly to transients and noise. C1 may have a resistor fitted across it to discharge it in some application.

Tr5 is an emitter follower stabilizing the 24V rail to 14 Volts or so to provide a reference level. It also slows a stabilized low current feed to be taken from+ve to drive the ultrasonic preamp or whatever input is used.

VARIATIONS

Box 30 shows an alternative input stage to box 28 which gives two inputs, 2 and 3. Input 2 is the same as input 1 in the original circuit whilst input 3, although less sensitive, responds not only to a voltage rise above the threshold setting but also to a fall below this value.

Box 31 shows a method of using a lower voltage relay, eg a 12V relay from a 24V supply. The values of Cx and Rx have to be found by

CIRCUIT 15. VOLTAGE LEVEL DETECTOR & LATCH

experiment since they depend upon the relay used: a 12V relay will usually operate at about 10V. If the voltage is now reduced the relay stays engaged until, perhaps, 6V. At this reduced voltage the relay of course draws much less current than at its full voltage. Rx is therefore selected to be as high as possible whilst still keeping the relay latched on from the voltage used. Cx is now chosen sufficiently large to ensure that the relay operates reliably when power is connected across d and e.

The input components D1 and C1 may be altered: D1 is only necessary if the unit connected to the input has a low impedance output, in this case its output falling to zero could switch the circuit off again even when set to 'latch'. C1 is to slow the input down so it does not respond to instantaneous peaks — for instance the ultrasonic control system can respond to a transient and can give momentarily a large output. C1 will absorb this without triggering the circuit, but will charge up quickly on a steady signal. Depending on requirements it is desirable to fit a resistor across C1 to discharge it — this resistor will be in the region of 10K to 1M ohms.

PARTS LIST

BOX 27 and 28

Resistors:	1 x 1K, 1 x 10K, 1 x 22K, 2 x 47K, 1 x 100K, 1 x 470K, 1 x 22K preset
Capacitors:	1 x 1µ/25V, 1 x 10µ/25V
Semiconductors:	3 x TUN, 1 x TUP, 1 x Zener/15V (1 x DUS)
Others:	1 x 24V relay, 1 x SPST switch

ADDITIONAL FOR BOX 30

Resistors:	1 x 4K7, 1 x 22K
Semiconductors:	2 x TUN

A PROGRAMMABLE THERMOSTAT

For certain applications a thermostat may be desirable where the temperature can be adjusted or switched to one of many levels at a point remote from the temperature sensor. This circuit does just that.

CIRCUIT 16. PROGRAMMABLE THERMOSTAT.
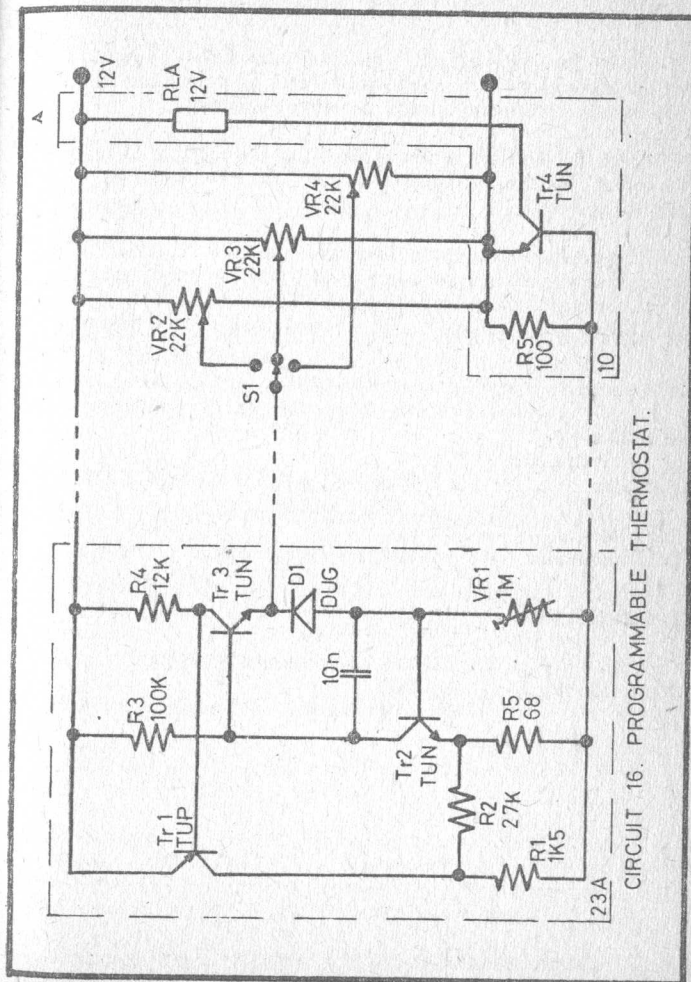
The circuit is designed for operation from around 12 volts, but, if suitable transistors are used, the same circuit will work from any voltage such that transistor and diode ratings are not exceeded.

HOW IT WORKS

The circuit should be compared with circuit 11 — it is basically the same, except that instead of using a zener diode inside the temperature sensing circuitry a voltage is fed to the circuit to define the switching level.

R3 and R6 have been left out — they may be included if desired but are only necessary in any case to limit the maximum current flow if transistors in the circuit fail: this is a remote possibility.

Note also that feedback is now applied from the collector of Tr3 via R9 to Tr1's emitter. With this circuit the LED may be omitted entirely as shown.

Switching voltage is set up on the potentiometers RV1, RV2, RV3 which are switched in as necessary by SW. This circuit, using a potentiometer to define switching point, does not give as sharp a switching action as circuit 11, but is acceptable for domestic use.

PARTS LIST

BOX 23A

Resistors:	1 x 68 ohms, 1 x 1K5, 1 x 12K, 1 x 27K, 1 x 100K, 1 x 1M preset
Capacitors:	1 x 10n
Semiconductors:	1 x TUP, 2 x TUN, 1 x DUS

CONTROLLER

Resistor:	22K presets as required, 1 x 100n
Semiconductors:	1 x TUN
Others:	1 x 12V relay

PROJECT 17

USING A CALCULATOR AS A TIMER

A writer needs to know how many words he has written: a simple method of counting this is by means of a calculator. Most calculators have a constant facility which can be set up to add 1 each time the = key is depressed. If the calculator is opened two wires can be soldered across the = key contacts. A reed switch can be fitted to the typewriter and the reed switch used to operate the = key on the calculator, such that each operation of the space bar on the typewriter adds 1 to the calculator, thus counting the spaces between words — which will effectively count the words.

The reedswitch is operated by a magnet — the magnet may be mounted on the space bar itself, or it may be more convenient to mount the magnet and the reed switch on the typewriter's chassis in such a position that the space bar comes between the two when operated, shorting out the magnetic field and opening the relay.

The addition of these two wires to the calculator, and the insertion of a socket in the calculator, so that connection can be made, also enables this circuit to be used. This circuit derives a 100Hz signal from the mains, divides it by 10 and operates a reed relay 10 times per seconds. If the calculator's constant is set to add on each operation the calculator is now turned into a timer counting in tenths of a second.

HOW IT WORKS

Box 12 is the power supply with a regulator (box 32) to give 5½ volts to drive the IC (7490).
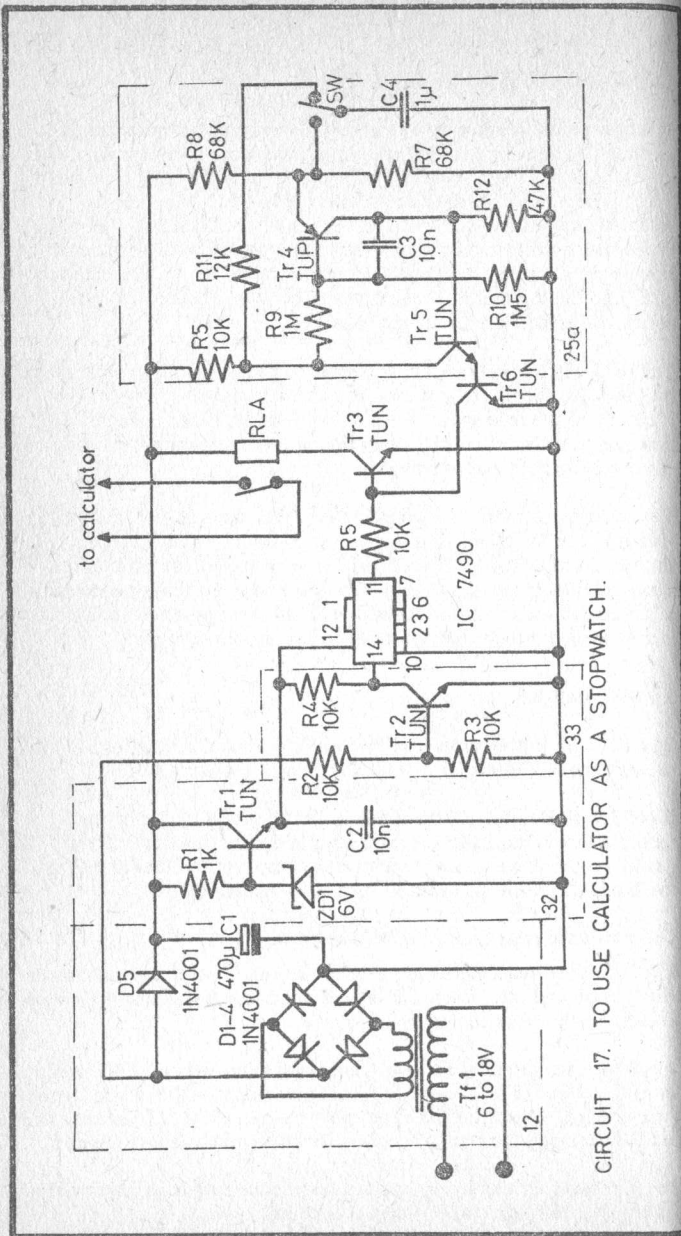
Box 33 with D5, detects the intervals between half cycles of the rectified low voltage a.c. and gives a pulse during this time. These pulses are therefore at twice mains frequency, i.e. 100Hz are fed to the input of the 7490 counter which is connected to ÷10.

Tr3 drives the relay from the 7490 output.

Box 25 is the circuit of Box 25 (Project 13) and is used as a bistable to turn Tr6 on and off. When Tr6 is on it conducts and shorts Tr3's base to earth so the relay cannot operate.

Box 25A is operated by SW — a changeover microswitch. C4 charges to the voltage on Tr5's collector (V_{cc} when counting or 0V when stopped), through R11. Operating SW applies the charges C4 to the junction of R7 and R8 changing the state of box and switches the counter on or off.

The Micro-switch therefore gives a good reliable stop-start motion to the timer just as if it is a conventional stopwatch.

CIRCUIT 17. TO USE CALCULATOR AS A STOPWATCH.

(circuit diagram — component labels: R8 68K, SW, C4 1µ, R7 68K, R12 47K, R11 12K, Tr4 TUP, C3 10n, R9 1M, R10 1M5, R5 10K, Tr5 TUN, Tr6 TUN, RLA, Tr3 TUN, R5 10K, IC 7490 (pins 12 1 11 9 7, 2 3 6, 14, 10), 25a, to calculator, R4 10K, Tr2 TUN, R3 10K, R2 10K, Tr1 TUN, C2 10n, R1 1K, ZD1 6V, D5 1N4001, C1 470µ, D1–4 1N4001, Tf1 6 to 18V, 33, 32, 12)

COMPONENTS

For the most parts are not critical — the transformer can be any suitable voltage between 6V and 18V. However C1 must be rated to stand nearly twice the transformer's output voltage and the reed relay must be capable of working from 1½ times the transformer's voltage.

A relay other than a reed relay could be used providing it is a fast one capable of operating reliably at 10 times per second.

Remember that 7490 can require as much as 40mA so Tr1 could with higher transformer voltage, be required to dissipate ¾ watt or so. A plastic power transistor or some such device is needed here.

Warning: the author has had personal experiences of many calculators used in this way: one or two models in particular won't work repeatedly in the + constant mode, but at some point in the operation tend to return the display to zero and start over again. Naturally a calculator that does this can only be considered to be faulty, but it does appear to be a fault common to certain models.

PARTS LIST

BOX 12

Capacitor:	470µ/25V
Semiconductors:	5 x 1N4002 or similar
Others:	Transformer to suit

BOX 25A

Resistors:	1 x 10K, 1 x 12K, 1 x 47K, 2 x 68K, 1 x 1M, 1 x 1M5
Capacitors:	1 x 10n, 1 x 1µ
Semiconductors:	1 x TUP, 1 x TUN

BOX 32, 33, etc.

Resistors:	1 x 1K, 4 x 10K
Capacitors:	1 x 10n
Semiconductors:	1 x 6V zener, 4 x TUN, 1 x 7490 IC
Others:	1 reed relay to suit

PROJECT 18

A DIODE TESTER

Unmarked, untested diodes are available very cheaply from various advertisers in the electronics press. If a suitable tester is available these are suitable for most of the DUS devices shown in this book. This circuit tests diodes for forward voltage drop.

The circuit operates from a.c. and the a.c. voltage may be any value provided the transistors and D1, D2 can handle one and a half time the input (a.c.) voltage.

CIRCUIT 18. DIODE TESTER.
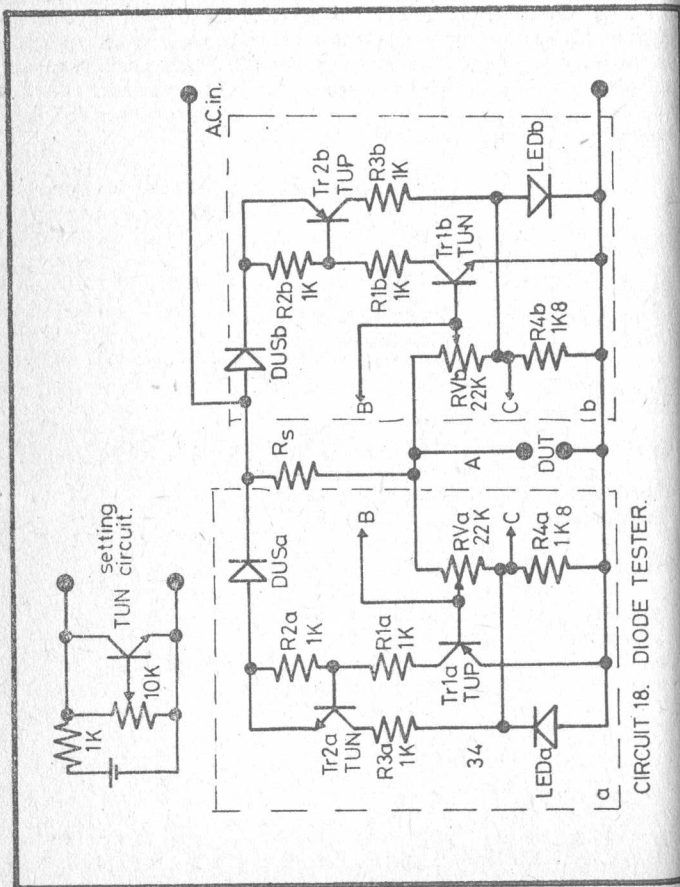
HOW IT WORKS

Notice that the circuit shown consists of two complementary halves. Box "a" is identical to box "b" except that PNP transistors replace NPN and vice versa and diode and LED are reversed.

In the absence of any connection to the D.U.T. (device under test) terminals the full a.c. voltage is present at point A.

Consider a positive half cycle: DUS b conducts feeding a positive voltage to the right hand circuit. The voltage, at the beginning of the half cycle, on point A is zero and rising. Current flows through Rs, RV2 and R4b. At a certain point on the half cycle the potential on the base of Tr1 b is sufficient to start Tr1 b conducting: it passes current into Tr2 which in turn passes current into LED b. The voltage on the junction of RVb and R4b therefore rises and is fed back to Tr1b's base turning it hard on. The LED stays on for the remainder of the positive half cycles and switches off on the negative half cycle when DUS b is reversed.

On negative half cycles the left hand half of the circuit operates.

If now a good diode is connected across the DUT terminals it will not conduct on one half cycle so one light will not be affected. On the other half cycle it will conduct – the voltage across it will be low and the other circuit won't turn on.

RV sets the threshold voltage at which the circuit turns on and the threshold is sharp so it can be set to select diodes where forward voltage drops are only a few millivolts different. The circuit also identifies the diodes polarity.

The circuit only shows that the diode is not shorted (a shorted diode will extinguish both LEDs) and that its forward voltage drop at the measured current is less than the threshold set up.

Rs controls the current through the diode – the maximum voltage across the diode will occur at the peak of the half cycle. At this point I, the current through the diode, will be equal to

$$\frac{1.4\,V_E}{Rs}$$

where V_E is the transformer's r.m.s. a.c. output voltage.

The circuit could be adapted for higher voltages (e.g. zener diodes etc.) by putting a zener diode in series with Tr1's emitter. The voltage threshold will then be raised to the zener voltage plus the transistor's base-emitter voltage.

To set the circuit up it can be set to accept some known good diodes, or the setting circuit shown can be used: the required pass voltage is set up on the meter and connected across the DUT terminals. One

circuit is set so the LED is just switching off. Reverse the setting circuit and adjust the other LED threshold.

Rs should be disconnected at this stage.

It is of interest to note an alternative possibility — if required points A-A and B-B may be connected in pairs. RVa and RVb are now in parallel, so one of them (RVa say) may be omitted and the single pot controls switching thresholds in both directions. This saves setting thresholds but means that the two thresholds are solely determined by the V_{be}'s of the two Tr1s. If these are well matched the difference is small.

As well as omitting RVa, R4a must also be left out.

PARTS LIST

FOR EACH HALF BOX 34

Resistors:	3 x 1K, 1 x 1K8, 1 x 22K preset, Rs to suit
Semiconductors:	1 x TUP, 1 x TUN, 1 x DUS, 1 x LED
Others:	1 transformer to suit

PROJECT 19

DIODE AND TRANSISTOR VOLTAGE TESTER

One specification quoted for a transistor is V_{cb} (max). This is the maximum allowable voltage at which the manufacturer guarantees that all transistors of the type will work safely. Thus for the BC184 Texas quote V_{cb} max at 45 volts. Yet if a batch of BC184s are measured V_{cb} will be found to vary — the occasional one will measure out at only 50V but most measure at around 120V! The transistor is in fact much better than the makers say. This circuit enables voltages of various devices to be measured at various currents. It also tests diodes for reverse voltage and zeners for their voltage.

R1	I d.u.t
10K	1mA
100K	100μA
1M	10μA

CIRCUIT 19. VOLTAGE BREAKDOWN TESTER.

The circuit is shown operating from 200 volts: a lower voltage may be used — or a higher one if suitable transistors are available.

HOW IT WORKS

The circuit is basically that of Box 23 (Project 11), with variations.

Current through the DUT (device under test) passes through R1. The circuit adjusts the voltage until enough voltage is present across R1 to turn Tr1 on. Tr1 causes Tr2 to conduct pulling the voltage on the base of Tr3 down. The voltmeter current flows from Tr3's emitter to the emitter of Tr2 so it does not affect the current through the DUT.

The circuit is therefore good for testing at very low currents, even when an insensitive meter (1mA) is used.

The circuit incorporates a voltage limit in D1, D2 and VRI which can be set so that the voltage across DUT terminals cannot exceed a certain level, thus reducing the risk of shock to the operator, and allowing a low voltage range to be switched on the meter without overloading it. R3 and ZD2 are included so that a low voltage transistor can be used in Tr1 position: low voltage transistors have better gains than high voltage types.

PARTS LIST

BOX 35

Resistors:	R1 as required, 1 x 100K, 1 x 220K, 1 x 220K preset
Semiconductors:	2 x BF258, 1 x BC184, 2 x DUS, 1 x zener/12V, 1 x zener/8.2V
Others:	1 meter

LIGHT CONTROLLED SWITCH

This circuit is ideal for car use: although the old fashioned parking light is no longer required (it is no longer legal) side lights are required by law if you park outside a 30MPH area. This circuit therefore uses a power transistor to switch up to 3 amperes of current to feed the side-lights.

HOW IT WORKS

LDR is a light dependant resistor such as RPY58A, but almost any type

CIRCUIT 20. LIGHT CONTROLLED SWITCH.

of LDR may be used in this circuit. These devices are like ordinary resistors except that their resistance is dependant upon the level of light falling on them — the brighter the illumination the lower their resistance.

Current passes through R1 and R2 into LDR: a voltage is developed across LDR which increases as darkness falls. At a certain level Tr1 starts to conduct and passes current into Tr2 where it is amplified and passed into Tr3. Tr3 turns the bulbs on and the voltage across the bulbs is sensed by R4 and fed back to Tr1 to turn the circuit quickly on.

Note the arrangement of R1, R2 and SW, which is shown in the off position. In the mid position R1 and R2 are connected in parallel and the circuit is fed off the +12V rail switched by the ignition switch. In this position it is impossible to drive the car away at night without lights since turning the ignition switch on at night will cause the circuit to switch on side lights.

The third position connects the circuit straight to the unswitched +12 volt rail, but only R2 is in circuit, so the light level at which switching occurs is delayed, saving battery, and the sidelights are switched on as parking lights.

Now the sidelights of a car draw perhaps 36W, or 3A from 12V — a resistance of 4 ohms. However, when the bulbs are cold their effective resistance is much less than 4 ohms — typically 0.15 ohms. If the transistor Tr3 was switched on direct into this low resistance a current of as much as 80 amperes could flow blowing the transistor immediately.

To stop this possibility protection circuitry can be fitted around Tr2 and Tr3 — this is shown in box 39. R5 senses the current through Tr3 and if this is too high Tr4 turns on reducing the drive to Tr2. R6 and R7 are included to reduce the current even further if there is a short circuit in the bulb wiring. In this case maximum current that is allowed to flow in Tr3 is very small since 12V across R7 will nearly turn on Tr4, shorting out the base drive to Tr3.

The circuit shown is for negative earth cars — for positive earth the circuit in box 38 is substituted for 37 or box 40 for box 39. Note that in any case the same power transistor is used.

For the positive earth version Tr1 must be PNP, and C1 must be reversed.

The light level at which the circuit switched can best be altered by the positioning of the LDR. It can also be altered by altering R1, R2 and R4. Increasing all of them will make the circuit more sensitive (so lights switch on later at night).

COMPONENTS

These are not critical — except for Tr3. R5 at the value shown sets a current limit of 5A and the transistor chosen must be able to handle at least that. 2N3055, TIP41 are two suitable types.

R5 itself can either be several 1 ohm resistors in parallel or it may be a length of resistance wire.

PARTS LIST

BOXES 36, 37 or 38, 39 or 40

Resistors:	length of resistance wire, 1 x 820 ohms, 1 x 1K, 1 x 15K, 1 x 220K, 2 x 470K
Capacitors:	1 x 1μ/16V
Semiconductors:	1 x TUN, 2 x TUP
	or
	1 x TUP, 2 x TUN
	1 power transistor,
	1 LDR (RPY 58 or ORP 12 or similar)
Others:	1 x 1 pole 3 way switch

PROJECT 21

A VOLTAGE CONTROLLED LIGHT DIMMER

Like most of the circuits in this book this circuit combines several new and unusual circuit techniques to make a practical circuit. This circuit was designed with Project 22 as a touch controlled light dimmer, but the two circuits can be used for purposes other than that for which conceived.
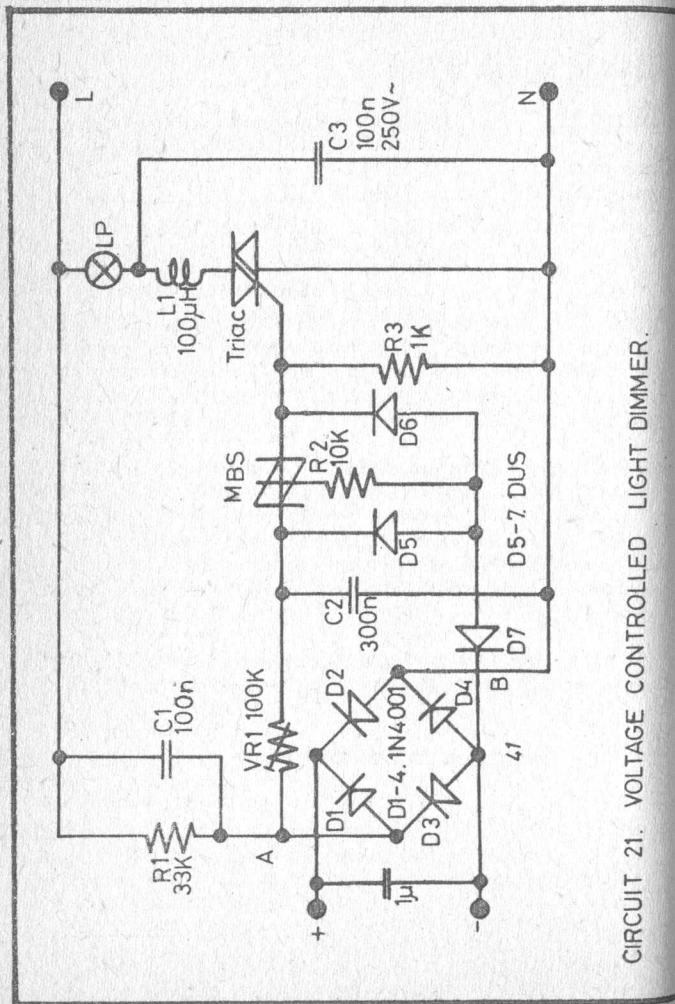
CIRCUIT 21. VOLTAGE CONTROLLED LIGHT DIMMER.

The circuit is mains operated: many of the components are live and the voltages are potentially lethal. Great care should therefore be taken in assembly. IEC safety regulations state that switches should not be included in neutral return lines, so to comply with this L & N on the circuit should be reversed from that shown. If this is done however the +ve & − inputs are at full mains potential and this should be borne in mind on the control system used.

HOW IT WORKS

Mains current passes through R1 in parallel with C1 through the bridge rectifier and load across + and - to neutral. Consider a 36V zener connected across the input: on positive half cycles current flows from A through D1 through the zener then through D4 to B, so that point A must be at +38V with respect to B (allowing 1V drop each in D1 and D3). On negative half cycles current flow from B through D2, the zener and D3 to A. A must be now at -38V. Note that in each case current in the load flowed from + to - so the load has a steady d.c. across it, whilst a 76V peak to peak (+38 to -38V) squarewave exists across A and B. If the voltage of the zener across + and - varies the amplitude of the square wave varies with it.

The squarewave charges C2 via VR1, so the charge rate of C2 is dependant upon the voltage across + and -.

MBS is a bi-directional switch (see also Project 23) with D5, D6 and R2 across it to reduce its switching voltage from 8V to around 2V.

C1 is connected across R1 to slightly advance the phase of the square wave, so it switches just before the mains input wave-from goes through the zero point.

As this squarewave switches from - to + voltage -ve terminal changes from - 37V to + 1V. This occurs at the end of the negative half cycle and if MBS has not discharged C2 by this time the + 1V level on D7 triggers it. On positive half cycles the gate of the MBS will of course always be more positive than -ve terminal so D7 cannot conduct.

D7 thus reduces the hysteresis effect that is present in light dimmers unless steps are taken to overcome it.

L1 and C3 are included to reduce interference which dimmers can otherwise cause.

COMPONENTS

C1 and C3 must be rated at 250V a.c. (at least 600V d.c.) R1 must be rated at 2W.

MBS is a Motorola Bi-directional switch type MBS4991, or 4992, or it is possible to use four transistors instead, see Project 23.

The triac type is not important provided it can switch the lamps with which it is to be used and can handle at least 400V.

PARTS LIST

BOX 41

Resistors:	1 x 1K, 1 x 10K, 1 x 33K/2W, 1 x 100K preset
Capacitors:	2 x 100n/250V A.C. 1 x 300n, 1 x 1uF
Semiconductors:	4 x 1N4002, 3 x DUS, 1 x MBS4992, 1 x Triac to suit
Others:	1 x 100µH choke (supressor type)

PROJECT 22

A TOUCH CONTROLLED VOLTAGE SOURCE

This is an unusual circuit where a signal input is applied to one of two terminals causing a voltage either to rise or fall, depending upon which

CIRCUIT 22. TOUCH CONTROLLED VOLTAGE SOURCE.
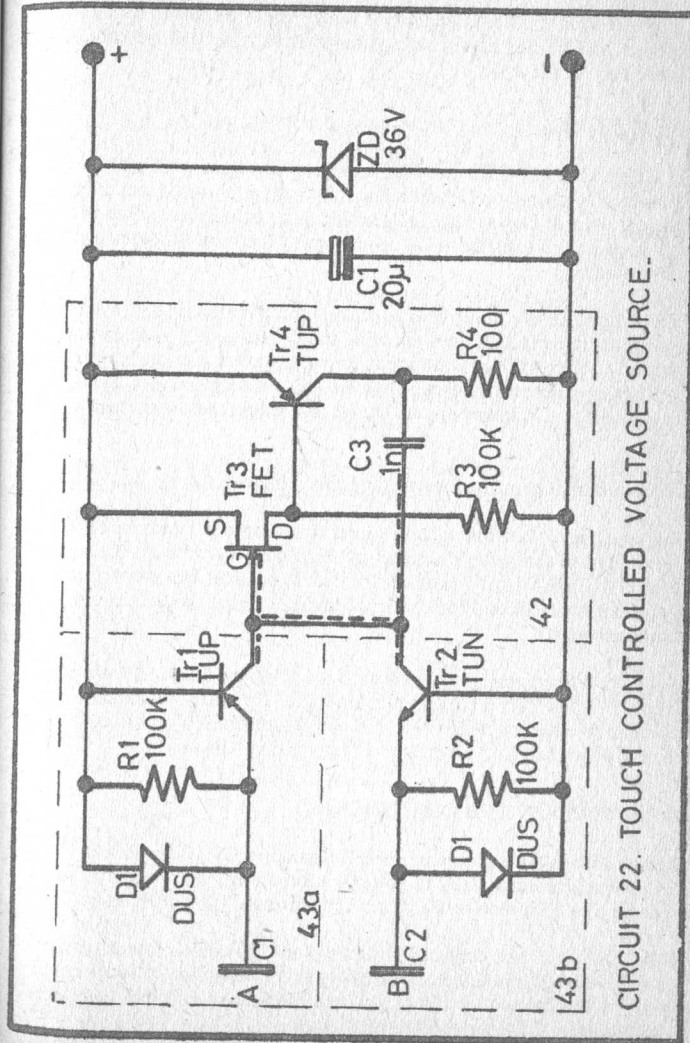
terminal is used. Rate of rise or fall depends upon circuit values, input frequency and amplitude.

Used as a touch controlled voltage source the input is of course hum. A capacitative input means that no direct finger contact need be made with the input and for mains use with Project 21 the input can be formed by two insulated touch areas on a printed circuit.

The circuit shown is designed for use with Project 21 for up to 30V. However the FET has nearly zero voltage across it, so voltage limit is entirely dependant upon Tr2.

HOW IT WORKS

Box 42 consists of a FET and PNP transistor arranged with 100% a.c. feedback: the charge on C3, therefore the voltage across it can only change if current flows from Tr1's collector or into Tr2's collector, or by leakage in Tr3 itself or in C3 or leakage in the mounting or mechanical arrangement.

If the voltage on the input tries to change, say positively, Tr3 is turned on more turning Tr2 off, and allowing the collector of Tr4 to fall more negatively. This will drop the input down, negatively, counteracting the initial change. However, if current flows into the input from Tr1, this must flow into C3, increasing its charge and therefore the voltage across it.

Similarly charge can flow out via Tr2, reducing the voltage across C3.

R4 is small so in fact the voltage across it will be small and the circuit tries to change the voltage across + and - to correspond with the voltage across C3. This part of the circuit therefore behaves like a constant voltage source to drive Project 21, with ZD defining the maximum voltage across it.

Boxes a and b are the same in effect but complementary. If hum is put on input "a" or "b", a current will flow into R1 and if its magnitude is sufficient +ve half cycles in box "a" will flow into Tr1's emitter, through the transistor into C3. Negative half cycles flow through D1.

CONSTRUCTION AND COMPONENTS

Construction of the circuit is critical: leakage in Tr1, Tr2, Tr3 or C3 will cause the voltage to drift, so only good quality components must be used: a polystyrene or polyester capacitor for C3 is necessary.

These components must be mounted so that the connection shown by the thick dotted line is well insulated – this connection is best kept in the air by bending collectors of Tr1 and Tr2 and gate of Tr3 to connect to each other. C3 joins to them in mid air.

If a voltage change of 1V across C3 in one hour is required, this corresponds to a leakage, i, such that

$$i = \frac{1n \times 1V}{1 \text{ hour}}$$

$$= \frac{10^{-9} \times 1}{60 \times 60}$$

$$= 3 \times 10^{-13} \text{amps}$$

$$= 0.3 \text{pA}$$

Although this sort of leakage is possible it is so only if care is taken, and it may well require selecting Tr1, Tr2 and Tr3.

Most likely sources of leakage are Tr1 and Tr2 so to check these short R1 and R2 and check drift: if voltage increases Tr1 or Tr3 is leaky, if it decreases Tr2 or C3.

As mentioned in Project 21, the whole of this circuit could be at mains potential: it should then be built on an insulated plastic box and "a" and "b" are formed by two areas of copper PCB, covered by good quality insulating tape. A finger is pressed to the tape to form the input plate of the capcitor C1 or C2: the harder it is pressed the greater the area, and the capacitance so the faster the rate of voltage change.

Alternatively double sided fibre glass PCB material can be used – one side is the input and the other side the emitter connector to Tr1 or Tr2. An area about 1" square should suffice.

PARTS LIST

BOXES 42, 43a, 43b

Resistors: 1 x 100 ohms, 3 x 100K
Capacitors: 1 x 20μ/36V, 1 x 1n polystyrene of mylar (low leakage type)
Semiconductors: 2 x TUP, 1 x TUN, 1 x FET, 2 x DUS, 1 x zener/36V

PROJECT 23

A BI-DIRECTIONAL SWITCH FOR USE WITH TRIACS

A bi-directional switch is an integrated circuit which does not conduct at low voltages but if the voltage across it becomes higher than around 8V it switches on and conducts with a voltage drop across it of around 1V.

If preferred the device can be assembled from four individual transistors as shown.

CIRCUIT 23.   A BI-DIRECTIONAL SWITCH
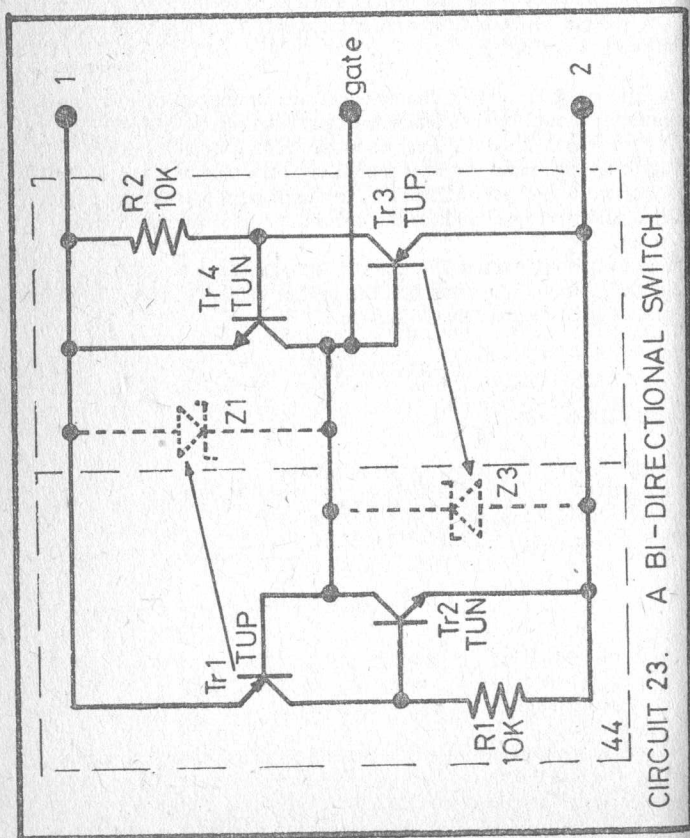
HOW IT WORKS

When subjected to a reverse bias the base-emitter junction of a transistor behaves like a zener diode, conducting at a voltage around 6 to 10 volts depending upon the individual transistor and its type.

On use one main terminal of the switch is connected to the gate of an SCR and the other to a capacitor which has an a.c. signal across it.

Consider a positive half cycle of voltage on terminal 1: at the start no current flows in the device. As voltage rises Tr3's base-emitter is reversed biased and behaves as the zener diode Z3 which starts to conduct at its breakdown voltage, passing current into Tr1 where it triggers Tr1 and Tr2 into immediate conduction: the device now switches hard on discharging the capacitor into the gate of the triac turning the triac on.

On negative half cycles Tr1 is reversed, behaving as Z1. Resistors R1 and R2 are to reduce the effects of leakage — their value is not critical.

If good symmetrical switching action is required of this circuit then Tr1 and Tr3 **must** be accurately matched for zener breakdown voltage: a suitable circuit is given in this book, Project 19.

Matching should be as close as possible — 0.1V or 0.05 if possible.

Since the circuit is entirely symmetrical, resistors R1 and R2 may be placed between Tr1, Tr3 bases and terminals 1 and 2 and the bases of the NPN's joined, instead of the PNPs, to gate. Then the zener action occurs in the NPN transistor rather than in the PNP.

PARTS LIST

BOX 44

Resistors:	1 x 10K
Semiconductors:	2 x TUN, 2 x TUP, matched for b-e zener effect

PROJECT 24

TOUCH OPERATED GAIN CONTROL

The circuits shown in boxes 16, 42 and 43 of Projects 9 and 22 may be combined (with slight variation) to make a preamplifier with

variable gain which is adjustable by a touch control.

Two supply voltage inputs are shown since the gain control itself will normally work off about 24V whilst the preamp needs a well smoothed voltage which will normally be less, around 15V probably.

HOW IT WORKS

The circuit consists of circuit 22 plus part of circuit 9. Boxes 43a and 43b are the same input stages for raising and lowering the control voltage as described earlier in Project 22. Box 42 is also basically the same as that of circuit 22 but values have been altered to reduce the currents in the transistors.

The output voltage from the circuit is transformed into a current in the emitter follower Tr5 and passed through D3 to vary the gain of box 16 in exactly the same way as was done in Project 9. No preset is included here as it is not necessary to set a minimum or maximum gain level.

CONSTRUCTION

The same care in construction must be taken as described in Project 22.

Box 6 will be handling a low level audio signal, less than 100mV, so normal care should be taken with this also.

PARTS LIST

BOX 16

Resistors:	1 x 820, 2 x 10K, 1 x 100K, 1 x 180K, 1 x 220K
Capacitors:	1 x 47p, 3 x 10µ, 1 x 33µ, 1 x 100µ
Semiconductors:	2 x TUN

42, 43 ETC

Resistors:	1 x 3K3, 1 x 10K, 2 x 100K, 1 x 220K
Capacitors:	1 x 1n Polystyrene (low leakage)
Semiconductors:	1 x FET, 2 x TUP, 2 x TUN, 3 x DUS

CIRCUIT 24. TOUCH CONTROLLED GAIN CONTROL.

PROJECT 25

A LIGHT FLASHER

This circuit was designed as a replacement for the thermal flasher used for a car's direction indicator: with the values shown it will flash lamps up to a total of 6A at 12V.

Designed for 12V operation the circuit unmodified should also be alright up to 24V.

CIRCUIT 25. LAMP FLASHER.

Component labels in diagram: +12, R1 10K, C1 100µ, D1 DUS, R4 8K2, R2 330, Tr2 TUP, D2 DUS, Tr1 TUN, C2 33µ, D3 DUS, R5 330, R7 100, R3 1K, R6 10K, C3 1µ, Tr3 TUN 38, Tr4 Power, A, R8 see text, 0
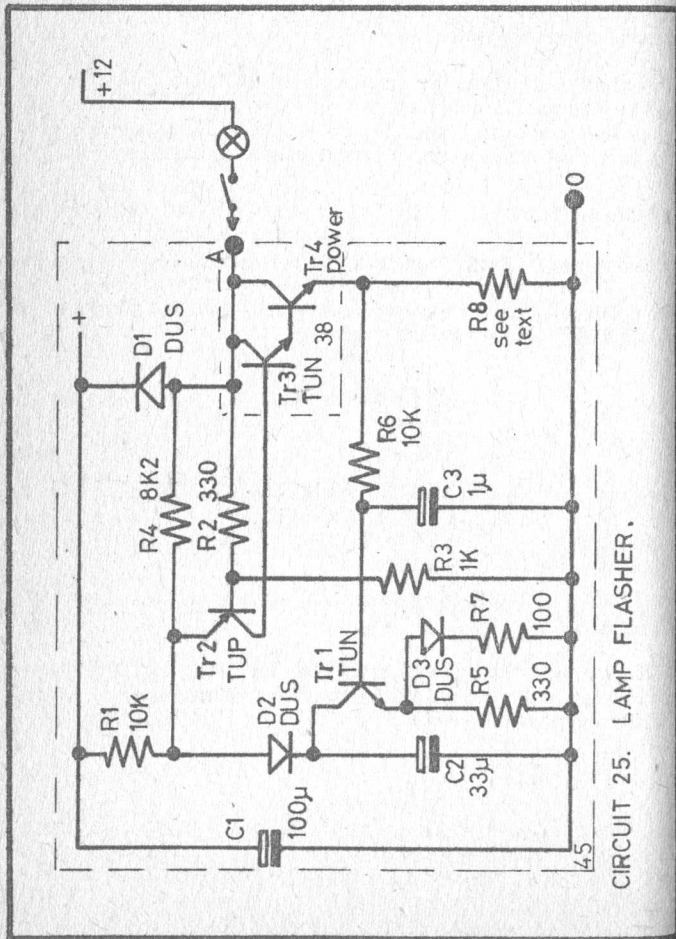
HOW IT WORKS

In the form shown the circuit only has two terminals, + 12V flows via the switch and bulb. At switch on a small current flows through the bulb and through D1 to charge C1. C1 holds a charge of 12V whilst the flasher is operating. Current also flows from terminal A (which is now at +12V) through R2 and R3, setting up a voltage of 9V on Tr2's base.

Current now starts to flow through R1 and D2 into C2 whose voltage starts to rise. With it rises the voltage on Tr2's emitter, until it exceeds the 9V set up on Tr2's base. Tr2 now starts to conduct into Tr3, turning Tr4 on and shorting terminal A to 0V. The voltage on the base of Tr2 also falls, turning Tr2 hard on. C2 is now isolated from Tr2's emitter by D2, so it does not discharge into Tr2. D1 is also reversed biased so C1 supplies the small drive current through R1 needed to keep Tr2, 3 and 4 conducting.

However, bulb current flowing through Tr4 flows through R8 whose resistance is chosen to drop 1V at the selected bulb current. This 1V turns Tr1 on and Tr1 discharges C2 at a constant current, until D2 again becomes forward biased. Tr1 now cuts off drive to Tr2 and the circuit switches off to start a new cycle.

If the bulb current is low, e.g. on a car if one of the two trafficator bulbs has failed, insufficient voltage develops across R8 to turn Tr1 on, so Tr2 never gets switched off and the bulbs don't flash but stay on continuously.

If the bulb current is high, say a wrong bulb is fitted or a short circuit is present the voltage across R8 is much higher than 1V so Tr2 conducts hard. If it is above about 1.2V then D3 starts to conduct also increasing further the current in Tr1 so C2 now discharges very rapidly indeed.

Thus the circuit not only gives a visible indication of a faulty bulb or wiring, but it also protects itself if a short circuit is present.

If desired C1 and D1 may be omitted entirely. In this case however the terminal marked + must be permanently connected to +12V. If this is done, there is no delay between operation of the flasher and the bulbs lighting since the circuit will hold in an on state with current flowing through R1 into Tr2 and Tr3. As soon as the bulb is connected current will flow.

CONSTRUCTION

The circuit is drawn conventionally for ease of understanding. However in a car one terminal of the bulb is always connected to chassis, so the +12V rail is infact chassis and the 0V rail is -12V. The circuit drawn is then for a positive earth car.

For a negative earth car all diodes must be reversed, so must all electrolytic capacitors. PNP transistors must replace NPN and vice versa. This means that the circuit needs a PNP power transistor.

If preferred however, the circuit in box 38 can be rearranged to that of box 37 as shown in Project 20.

PARTS LIST

Resistors:	1 length resistance wire
	1 x 100 ohm, 2 x 330 ohm, 1 x 1K,
	1 x 8K2, 2 x 10K
Capacitors:	1 x 1μ/16V, 1 x 33μ/16V, 1 x 100μ/16V
Semiconductors:	1 x TUN, 1 x TUP,
or	
	1 x TUN, 2 x TUP,
	1 x power transistor, 3 x DUS

PROJECT 26

ULTRASONIC INTRUDER ALARM

This circuit was designed to be used with the voltage level switch of Project 15. It draws power from the switch and ordinary three core cable is used to join the two circuits together.

CIRCUIT 26. ULTRASONIC INTRUDER ALARM

The circuit operates from 20V since that gives a squarewave output from the oscillator of 10V rms which is the maximum voltage allowable to drive most ultrasonic transducers. Other voltages may of course be used.

HOW IT WORKS

Box 14 is the ultrasonic transmitter circuit introduced in Project 7. It is situated in the same housing as the receiver circuit with the two transducers pointing in the same direction.

Ultrasound transmitted from X1 is received by X2. The resulting signal is amplifier by box 46, which has maximum gain around 40KHz but is not highly tuned. Note that this circuit is similar to box 16 in Project 9.

The resulting signal is fed to the base of Tr6. Fed to Tr6's emitter is a squarewave from the transmitter. The two signals, received and transmitted, are not identical, so Tr6 will be switched on and off at the transmitted frequency for a time determined by the received signal. The resulting current is smoothed by C6 so a d.c. level will be present across the potentiometer.

Now the signal from X1 is received by X2 in the form of reflection from the walls, floor, ceiling, furnishings and other objects in the room. So long as nothing moves the receiver sound will not change, but if any movement occurs then the reflections will alter and Tr6's switching will be affected. This will cause a change in the d.c. level across the pot.

The setting of the pot controls the circuit's sensitivity, and its output is fed to Tr7 where it is amplified. There is some slight residue of 40KHz still present at this stage — C8 is included to reduce this.

The amplified output from the circuit is fed into the detector of box 22. The resulting output is a positive rectified voltage whose maximum amplitude depends upon the setting of the sensitivity control and of course the movement in the room sensed.

USE

In the form proposed the setup will have two sensitivity controls — one on this part of the circuit and one on the level detector, Project 15. If both are set to maximum sensitivity (which corresponds to minimum voltage on circuit 15) the alarm is unduly sensitive and even air movements in the room may trigger the alarm. Initially both controls should be set midway and any major sensitivity change is best made on both controls.

In use the 'head', consisting of this circuit, can be installed in the protected room whilst the control box, circuit 15, will be mounted remotely in the seaparate room. The control box switch is set to open circuit so it doesn't latch and the room circuit adjusted for required sensitivity. The control box can now be adjusted for any last sensitivity change and switched to latch.

The relay will of course switch a bell or the siren circuit of Project 1.

The circuitry is so arranged that several 'heads' each consisting of one build of this circuit, can work into one control box so several rooms can be wired into one system.

This circuit cannot differentiate between movement of a human intruder and that of a cat, or mouse or even curtains, except that the human is larger and probably faster than other movements so will give a greater output. However a simple circuit such as this is not immune to false alarms and is really only suitable as a deterrent. It is however highly effective since most housebreaking is done by inexperienced youngsters and they are likely to be highly nervous, and the sound of a burglar alarm may well cause them to panic and run.

PARTS LIST

Resistors:	1 x 100 ohms, 1 x 1K, 1 x 1K8, 1 x 2K7, 1 x 3K3, 1 x 10K, 1 x 12K, 1 x 22K, 1 x 68K, 2 x 330K, 2 x 1M, 1 x 22K pot
Capacitors:	1 x 10p, 2 x 1n, 2 x 10n, 1 x 50n, 3 x 1µ
Semiconductors:	6 x TUN, 1 x TUP, 4 x DUS,
Others:	matched pair ultrasonic transducers

CAR WINDSCREEN WIPER CONTROL

Many circuits for windscreen wipers have been published. This is simpler than most yet has been thoroughly tested in a commercial production unit: it is trouble free, suits any car and gives excellent control range with a subjectively pleasing action. The circuit of the 'Variwipe' is published by kind permission of Scientronics.

The circuit shown is for a negative earth car: you may find the circuit
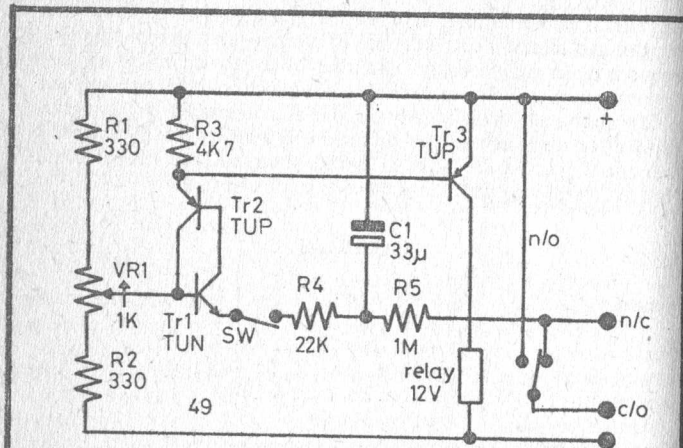
CIRCUIT 27. WINDSCREEN WIPER DELAY UNIT.
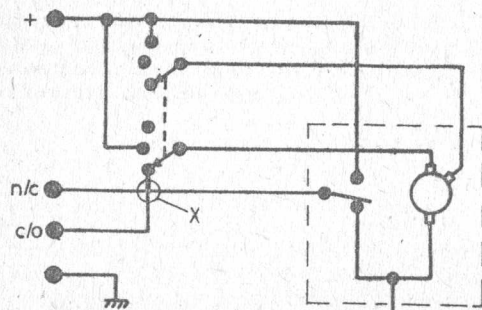
Connecting the unit to a car.

easier to understand by turning it upside down, so the negative is at the top.

INSTALLATION

Unfortunately the wiring diagrams supplied with most cars are often incomprehensible as they do not always indicate the internal connections of the various switches etc. However the wiper switch wiring on cars is almost completely standardised to that shown, +ve and earth are usually easy to identify, but the wire to the c/o contact on the motor's internal park switch is not so easy. If it is disconnected, the wipers will still operate properly when switched on, but when switched off the wipers will stop in mid-screen, wherever they were when the switch was operated. They may not stop suddenly but may grind to a halt. If they stop in mid screen re-connect the wire concerned — the wipers will restart and park properly.

This wire is now identified and must be cut, as indicated at part x, to connect in the 'Variwipe'.

HOW IT WORKS

When switched off, SW is open (SW is combined with VR1, the delay control, if desired), and there is a current path from n/c contact on the Variwipe through c/o and the dash wiper switch (shown switched off) through the motor to earth. C1 charges up through the path and R5.

If the dashboard switch is used it operates normally since the path from n/c to c/o contacts of the Variwipe restores the link that has been broken in installing it in the car's wiring.

If the Variwipe is switched on, C1 now supplies current via R4 into Tr1's emitter. Tr1 and 2 turn on delivering current into Tr3 to drive the relay. The n/o contact now makes to c/o supplying 12V to the motor via the dash switch. C1 discharges at a rate determined by R4 and the Variwipe switches off. The internal 'park' switch of the wiper motor now takes over and supplies power to the motor via n/c, c/o contacts of the Variwipe and the dash switch.

At the end of the wipe the park switch opens, the motor stops and n/c on the Variwipe now is not connected via the switches to +ve but via the motor to earth. C1 charges slowly via R5 until the voltage on Tr1's emitter falls below that set on Vr1. The circuit now fires and initiates another sweep.

The time for C1 to charge is naturally dependant upon the setting of VR1. C1 charges exponentialy so the time is nearly proportional to the log of the voltage or the log of the rotation of VR1. This gives a nice subjective feel to the control.

VR1 should be connected with the arrow corresponding to clockwise pot rotation. SW will therefore make when Vr1 is at maximum delay. C1 has charged so the circuit gives an immediate wipe. Wait now for a period corresponding to the required delay time before adjusting Vr1 to give just another wipe. The unit will now repeat wipes with the same delay.

COMPONENTS

These are not critical: however C1, R4 and R5 should be kept near the correct values since these give the most acceptable delay time and pulse lengths.

VR1 can be altered in value, but R1 and R2 should be about 1/3 the value of VR1.

The relay should be a fairly heavy duty one: most motors draw a current of about 2.5A but when the blades are stalled, or at switch on, the current can rise to 10A. If the relay is too light the contacts could burn out.

PARTS LIST

BOX 49

Resistors:	2 x 330 ohms, 1 x 4K7, 1 x 22K, 1 x 1M, 1 x 1K pot
Capacitors:	1 x 33µ
Semiconductors:	2 x TUP, 1 x TUN
Others:	Switch, 12V Relay

PROJECT 28

AN UMPIRE FOR SNAP AND MUSICAL CHAIRS

Snap and musical chairs are similar — except that in snap the first player to indicate wins but in musical chairs the last player looses. There is a whole family of games where either the first player or the last player wins or looses and these games can all benefit from an electronic umpire.

This circuit is in modules — a control module containing batteries and
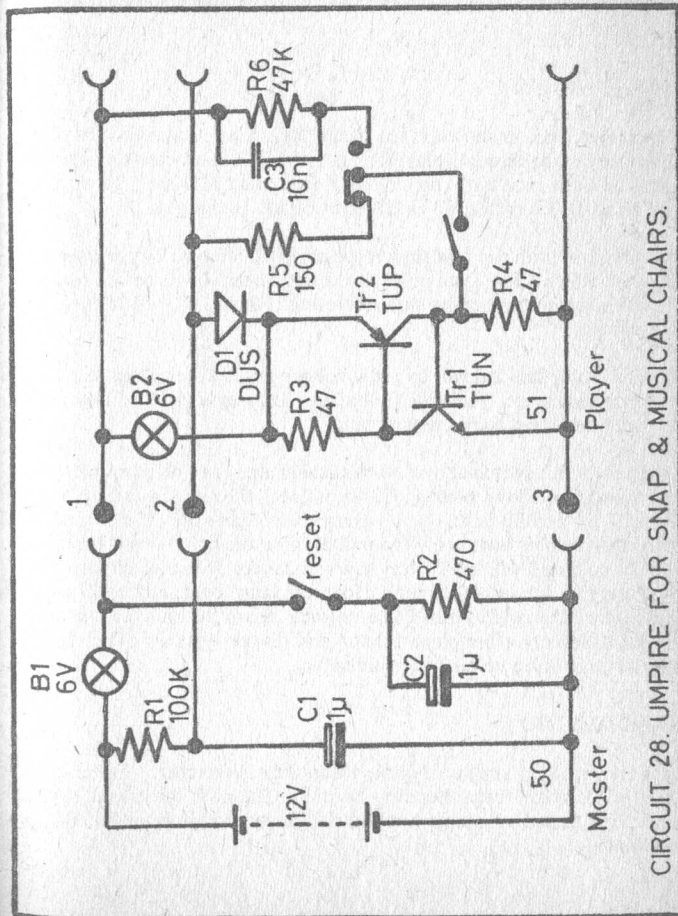
CIRCUIT 28. UMPIRE FOR SNAP & MUSICAL CHAIRS.

reset switch and any number of positions each of which has a prominent push switch on it: players push this switch to register action. Also on each player's box is a small hidden switch which selects the game to be played.

Each box has a 3 pin socket on it and also a flying lead with 3 pin plug. The first player plugs into the umpire's box and each other player plugs his box into the one next to him. Thus any number of players can play and the system expands to suit.

The system works off a 12V battery which is contained in the control module. An on-off switch is not needed, since no current flows in the control box and it is simply disconnected by unplugging player's boxes from it.

HOW IT WORKS

The player's box is shown in the "snap" position. Consider it in the off state (as are all other players). Tr1 and Tr2 don't conduct, line 1 has 12V on it via a bulb (no current flows) and line 2 has 12V on it fed via a 100K resistor, C1 in the control box is charged.

If the player with the box shown presses his button, C1 discharges through R5 and R4 — the pulse of voltage across R4 turns Tr1 on, Tr2 also turns on, drawing current through B1 and B2 which both illuminate.

D1 also holds line 2 down to a low voltage so no other player can activate his circuit. Thus the first player to press his button illuminates his bulb and locks other players out.

If the switch is switched over to musical chairs, then on pressing the button current flows through C3 from line 1 through R4 triggering the circuit. B1 and B2 light. Line 1 is now at roughly 6V. If a second player pushes his button 6V from line 2 fires his light — now his bulb will be cold and will have a very low resistance. When his circuit fires it shorts line 7 to earth through a low resistance bulb: any other player's bulb is switched off by this pulse, so each player pushing his button extinguishes any other player's lamp and his one goes on. Therefore the last button to be pushed is indicated.

CONSTRUCTION

Children are very rough on games when they get excited. The construction of the boxes must therefore be solid. The push buttons should also be operated by a large knob so the player can thumb it in his excitement.

CONTROL BOX

Resistors:	1 x 470 ohms, 1 x 100K
Capacitors:	2 x 1μ
Others:	1 x 6V bulb, 1 switch (push to make) battery, socket (3 pole)

EACH PLAYER'S BOX

Resistors:	2 x 47 ohms, 1 x 150 ohms, 1 x 47K
Capacitors:	1 x 10n
Semiconductors:	1 x TUP, 1 x TUN, 1 x DUS
Others:	1 push to make switch, 1 c/o switch, 1 bulb, 1 plug (flying lead), 1 socket (3 pole)

Notes

Please note overleaf is a list of other titles that are available in our range of Radio and Electronic Books.

These should be available from all good Booksellers, Radio Component Dealers and Mail Order Companies.

However, should you experience difficulty in obtaining any title in your area, then please write directly to the publisher enclosing payment to cover the cost of the book plus adequate postage.