EE RADIO CONTROL SYSTEM

A COMPLETE 7 CHANNEL OUTFIT
PART 1—THIS MONTH

Special Offer
SOLAR ALARM DUAL—TIME WATCH

3 FUNCTION GENERATOR
BABY ALARM
MW & LW RADIO TUNER

Easy to build projects for everyone
Everyday ELECTRONICS

NOV 79
45p

Australa 85c South Africa 85c New Zealand 85c Malaysia $2.15
The perfect kit for miniature work!

**ANTEX**

**TCSU1 or 2 with CTC**

**NEW TCSU2 with visual temperature guide**

---

**Model TCSU1**

- Micro Soldering Station
- Model CTC-24volts: Priced at £6.75 (1/67)
- Model XTC-24volts: Priced at £9.75 (1/87)

Accurate point temperature control between 65° and 400°C. Heating element and sensor built in tip of the iron for fast response. Interchangeable slide-on bits from 4.7mm (3/16") down to 0.5mm. Zero voltage switching, no spikes. No magnetic field, no leakage. Supplied with miniature CTC (35-40 watt) iron or XTC (50 watt). TCSU1 soldering station with XTC or CTC iron £36 (6.44) Nett to Industry.

**Model TCSU2**

- Specification as TCSU1 except temperature range 200°-400°C. Visual temperature indicators by square LED at 270, 300, 330, and 360°C. Priced at £42.50 (7.50) Nett to Industry.

- Spare element Model CX230E

**Model SK3 Kit**

- Contains both the model CX230 soldering iron and the stand ST3. Priced at £5.70 (1.49)

- It makes an excellent present for the radio amateur or hobbyist.

**Model SK4 Kit**

- With the model X25/240 general purpose iron and the ST3 stand, this kit is a must for every toolkit in the home. Priced at £5.70 (1.49)

**Model SK1**

**Model MLX 12volts**

- This kit contains a 15 watt miniature soldering iron complete with 2 spare bits, a coil of solder, a heat sink and a booklet. How to Solder. Priced at £3.95 (1.53)

- The soldering iron in this kit can be operated from any ordinary car battery. It is fitted with 19 feet flexible cable and battery clips. Packed in a strong plastic envelope it can be left in a car, a boat, or a caravan ready for soldering in the field. Price £4.55 (1.14)

---

**Model X25 25 watts 230 volts**

A general purpose iron also with a ceramic and steel shaft to give you toughness combined with near-perfect insulation. Fitted with 1/8 bit and priced at £4.20 (0.98). Range of 4 other bits available. Also available in 24 volts.

- Spare element Model X25/240E

---

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Name

Address

Antex Ltd., Freepost, Plymouth PL1 1BR Tel. 0752 67377
Top value test equipment from TANDY

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Low-cost hand held digital multimeter with a full 3½ digit LCD display. 0.5% basic accuracy, auto polarity operation. 10 Mohm DC input impedance.

Reading to ± 1999.

**LOW-COST LCD MULTIMETER**
A portable, compact sized multimeter with a full 3½ digit LCD display. Auto polarity operation, low battery indicator. 10 Mohm Input impedance.

**COMPONENTS AND PARTS**

<table>
<thead>
<tr>
<th>CAT No.</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
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</thead>
<tbody>
<tr>
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<td>LED</td>
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<td>276-142</td>
<td>Infra-Red Emitter Detector Pair</td>
<td>£1.37</td>
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<tr>
<td>277-1003</td>
<td>12VDC Automotive Digital Clock Module</td>
<td>£17.52</td>
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<tr>
<td>276-9110</td>
<td>6-pin edge connector for 277-1003</td>
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<tr>
<td>276-1373</td>
<td>Power Transistor Mounting Hardware</td>
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<tr>
<td>276-1363</td>
<td>TO-220 Heat Sink</td>
<td>60p</td>
</tr>
<tr>
<td>276-1364</td>
<td>TO-223 Heat Sink</td>
<td>81p</td>
</tr>
</tbody>
</table>

**AC/DC 8 MHz OSCILLOSCOPE**
A new approved 8MHz version of last years' winner! The advance design features of this oscilloscope make it an absolute essential for industrial uses on production lines, in laboratories and schools. Ideal for Radio and TV servicing, audio testing, etc.

Specifications:
- Horizontal axis: Deflection sensitivity better than 250mV/Div. Vertical axis: Deflection sensitivity better than 10mV/Div (125V - 6mm). Bandwidth: 0.8MHz. Input Impedance: 1Mohm parallel cap 3pF. Sweep: 10mV - 100kHz (3 ranges). Synchronization: Internal (± 2 Div. 200x, 155x, 150x). Supply: 220/240/100Hz. 22-9501.

**Price**

**53.19**

**39.93**

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Everyday Electronics, November 1979
SEIKO MEMORY BANK
Calendar watch M324
Hours, mins, secs.
Month, day, day.
12 or 24 hour ore format.
Auto-calendar
Year and leap
Year and leap.
Automatic calendar.
Any desired date up to
2 years battery life.
Water resistant.
Memory bank function.

£79.50

M31

SEIKO Alarm Chronograph
With WEEKLY alarm.
Hours, mins, secs, month.
Date, day, am/pm.
Weekly alarm - can be set
for every day at designated
time e.g. 6.30 am on Mon.
Set for every day at
Wed and Fri.
Alarm set time displayed
above time of day.
Full stopwatch functions.
Laptime, split etc.

£89.95

M10

M32

SEIKO Melody Alarm Chronograph
Chiming Alarm,
plus chronograph.
Hours, mins, secs, date.
24 hour alarm.
12 hour chronograph.
1/100th secs.
Laptime. Back light.
Stainless steel, mineral
glass.

£92.95

M19

M33

SEIKO Calculator Watch
Full specification with
memory, plus multi
function watch.
Hours, mins, secs.
day, date, backlight.
Automatic calendar.
Long life battery.

£99.95

M27

CASIO CHRONO 950S-3LB
Stainless steel case.
Water-resistant to 66 feet.
Hours, mins, secs, am/pm.
Day, month, date, day.
Auto-calendar
Pre-programmed
until the year 2029.
12/24 hour.
Stopwatch function.
Range 7 hours.
1/1000 sec.
Model: Net time/ISO time./
1st-2nd place time.
Dual time function.
Accuracy 15 secs per month.
Battery life approx 4 years.

£22.95

M22

CASIO LADIES 86CL-238-1
Engage storm line.
Stainless steel bracelet.
Full sub-adjustable.
Hour, mins, 10 sec.
Second by flash.
Month, date, day.
Auto-calendar preprogrammed
for 38th day in Feb.
Accuracy per month 15 secs.
24 hour format.
Battery life approx 15 months.

£29.95

M35

CASIO F-200 Sports Chrono
Attractive black resin
in black resin with mineral
glass.
Hours, mins, secs, am/pm.
Month, date.
Alpha numeric day.
Auto-calendar set
28th Feb.
Stopwatch working
range 1 hour.
Units 1/100 sec.
Net Time/ISO time.
1/1000 sec.
Auto-calender set from
1901 to 2009.
Fully adjustable.
Russian optional.
12/24 hr display.
24 hour alarm.
User optional.
Battery life approx 3 years.

£34.95

M25

BELTIME Chronograph
(9 Functions)
Hours, mins, secs.
day, date, month.
Interchange feature.
Automatic calendar.
Backlight.
Alarm, lap/time.
Stainless steel bracelet.
Battery life 1 year.

£14.95

M34

BELTIME Multi Alarm
29 functions.
Hours, mins, secs.
date, day.
Alarm, chronograph.
Lights.
Watch functions.
Alarm 4 functions.
Chronograph 17.
Stainless steel bracelet.

£29.95

M35

M36

CASIO F-8C
3 Year Battery life.
Hours, mins, secs.
am/pm, date.
Auto-calendar set
28th Feb.
Stopwatch function.
Accuracy 15 secs per month.
Battery life approx 3 years.

£9.95

M36

PICOQUARTZ Microprocessor Alarm Chronograph
Multilingual - day of the week can be set to English, French,
German, Italian or Spanish.
Chime - every full hour
combined with a response signal.
Beeper at every pressing
of the functions.
Can be switched off.
12-24 hour format.
Back light.
Chime - 1, full scale chronograph with lap.
Hourly time measurement of two
competitors.
Stainless steel.
Mineral glass.

£37.95

M32

SEIKO CHRONOGRAPH
Hours, mins, secs.
day of the week.
Month, date.
1/100th secs.
Laptime.
24 hour format.
Chime.
2 Alarm systems.
Two time zones.

£66.00

M33

North & Midlands
67 High Street, DAVENTRY
Northamptonshire
Telephone: 03272 76645

South of England
327 Edgware Road
LONDON W.2
Telephone: (01) 723 4753

Metac ELECTRONICS & TIME CENTRES

Everyday Electronics, November 1979
**QUARTZ LCD 5 Function**
- Hours, mins, secs., month, day, auto calendar, back-light, quality metal bracelet.
- £6.65
- Guaranteed same day dispatch.

**SOLAR QUARTZ LCD 5 Function**
- Genuine solar panel with battery back-up.
- Hours, mins, secs., day, date, day of week.
- £8.65
- Guaranteed same day dispatch.

**QUARTZ LCD 11 Function**
- 6 digits, 11 functions.
- £10.65 thousands sold!

**SOLAR QUARTZ LCD ALARM 7 Function**
- Hours, mins., secs., month, date, day.
- £12.65
- Guaranteed same day dispatch.

**MULTI ALARM 6 Digits 10 Functions**
- Hours, mins, secs., month, date, day.
- £18.65

**SOLAR QUARTZ ALARM Chronograph with Alarm**
- £24.95

**ALARM CHRONO with 9 world time zones**
- £27.95

**FRONT-BUTTON Chronograph with Alarm**
- £22.65

**SOLAR QUARTZ LCD ALARM Chronograph**
- £13.65

**SOLAR QUARTZ LCD Ladies Day Watch**
- £9.95

**QUARTZ LCD Ladies Fashion Watch**
- £14.95

**HANIMEX Electronic LED Alarm Clock**
- £10.20

**EXECUTIVE ALARM WATCH**
- £14.95

**MACY QUARTZ ANALOGUE**
- £24.95

**OUTSTANDING FEATURES**
- Dual Time.
- Local time always visible.
- Current time in each zone.
SPARKRITE X5 is a high performance, top quality electronic ignition system designed for the electronics DIY world. It has been tried, tested and proven to be utterly reliable. Assembly only takes 1-2 hours and installation every direct to the petrols 'clip-on' every engine.

The superb technical design of the Sparkrite circulates the problems of the contact breaker. There is less friction due to contact breaker bounce which eliminated electronically by a pulse suppression circuit which prevents the firing of the points below-operating at high R.P.M. Contact breaker bounce eliminated by reducing the current by 30% of the normal.

There is also a unique extended dwell circuit which allows the coil a longer period of time to store energy before discharging to the plugs. This in turn is built into static timing light system function light and security clamp new switch will work up to five counters.

Fits all 12v negative-earth vehicles with coil/distributor ignition up to 8 cylinders.

THE KIT COMPRISES EVERYTHING NEEDED

Disc packed: Ready drilled aluminium extruded base and heat sink, coil mounting clips and accessories. All kit components are guaranteed for a period of 2 years from date of purchase. Fully illustrated assembly and installation instructions are included.

Roger Clark the world famous rally driver says 'Sparkrite electronic ignition systems are the best you can buy'.

Great for low B.P.M.

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NORTHERN BRANCH (PERSONAL SHOPPERS ONLY), 880 BURNAGE LANE, BURNAGE, MANCHESTER M18 1NA. PHONE (061) 432 4945.
### Capacitors

#### Polyether Capacitors: Axial lead types

<table>
<thead>
<tr>
<th>Value (µF)</th>
<th>0.01, 0.022, 0.047, 0.1, 0.15, 0.22, 0.33, 0.47, 0.68, 1.0, 2.2, 3.3, 4.7, 7.1, 10.0, 22.0, 33.0, 47.0, 71.0, 100.0, 220.0 µF</th>
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#### Polyether Capacitors: Round types

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</tr>
</thead>
</table>

### Resistors

#### Solid Resistors

- 0.1%, 0.25%, 0.5%, 1%, 5%, 10%, 20%, 50%, 100%, 200%, 500%, 1000%, 2000%, 5000%, 10000% Tolerance

#### Wirewound Resistors

- 0.1%, 0.25%, 0.5%, 1%, 5%, 10%, 20%, 50%, 100%, 200%, 500%, 1000%, 2000%, 5000%, 10000% Tolerance

### Inductors

#### Fixed Inductors

- 0.1 nH to 1000 µH

#### Tunable Inductors

- 0.1 nH to 1000 µH

### Diodes

#### Rectifier Diodes

- 1N4001 to 1N4007

#### Switching Diodes

- 1N5401 to 1N5408

### Transistors

#### Bipolar Transistors

- BC107, BC108, BC109, BC110, BC111, BC112

#### Field-Effect Transistors

- 2N3904 to 2N3906

### Other Components

#### Potentiometers


#### Switches

- SPST, DPST, DPDT, DP3T, DP4T

#### Connectors

- Jumper Wires, Banana Plugs, Jacks, Other

### Miscellaneous

- Capacitors, Resistors, Inductors, Diodes, Transistors, Potentiometers, Switches, Connectors

---

*Everyday Electronics, November 1979*
UK657
LOGIC CIRCUIT TEST PROBE
A very handy device for checking the state of Logic Circuits, red & green state indicators.
Power supply = 12V.D.C.
Q/C Current = 10 mA
Under Load Current = 0.5 mA
Dia. = 25mm 100mm

UK606
PORTABLE SIGNAL TRACER
This is a very useful instrument for tracing faults in radio's, television's 
and easily read check of the con-
dition of diodes and NPN & PNP transistors.
Powered by internal 9V D.C.
Diode -- 25mm 100mm
0/C Current --10 MA
Power supply -5 V.D.C.
green state Indicators.
the state of Logic Circuits, red &
white state Indicators.
F. M.
MICROTRANSMITTER
This small and efficient trans-
mITTER has many diverse uses, 
amongst which is use as a radio 
microphone, baby alarm etc. 
The range is approximately 200 feet. Complete with high sensitiv-
ty, dynamic microphone and telescopic antenna.
Supply 5V D.C.
Frequency range 88-108MHz 
Transmitters = BC205-B-81706
Bases = £1.00 & P & P 50p
Not licenceable in the UK

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TRADE AND EXPORT ENQUIRIES WELCOMED

UK233
AUTOMOBILE, ANTENNA AMPLIFIER
This unit very much increases the sensitivity of any car radio and 
improves stereo reception on VHF. It also compensates for mismating due to extra 
capacitance in a long antenna cable.
Supply 12V D.C. negative earth
Gain = L.W. - 11-12db M.W., S.W. - 15-16db VHF - 68- 
100MHz 14-15db Current drain - 5mA
Transmitter BF273
Kit £4.47 Inc. VAT
Wired & tested £7.38 Inc. VAT.
Post & packing 50p.

UK232
AM-FM ANTENNA AMPLIFIER
This unit increases the sen-
tivity of car radio and gives wide range of frequencies.
It also eliminates frequency
modulation broadcast.
In simple and economical way using a compact unit that is easy to install and 
non licenceable in the UK
Supply 12V D.C.
Gain = L.W. - 8-25db M.W., S.W. - 15-16db VHF - 68- 
100MHz 14-15db
Current drain - 5mA
Transmitter BF273
Kit £4.47 Inc. VAT
Wired & tested £7.38 Inc. VAT.
Post & packing 50p.
The opportunities in electronics, today, and for the future are limitless — throughout the world. Jobs for qualified people are available everywhere at very high salaries. Running your own business, also, in electronics — especially for the servicing of radio, TV and all associated equipment — can make for a varied, interesting and highly remunerative career. There will never be enough specialists to cope with the ever increasing amount of electronic equipment coming on to the world market.

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- BEGINNERS PRACTICAL COURSE.
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WE ARE AN INTERNATIONAL SCHOOL SPECIALISING IN ELECTRONICS TRAINING ONLY AND HAVE OVER 40 YEARS EXPERIENCE IN THIS SUBJECT.

All students enrolling in our courses receive a free circuit board originating from a computer and containing many different components that can be used in experiments and provide an excellent example of current electronic practice.

Free 32 page Colour Booklet.
Projects... Theory... 
and Popular Features...

There are several active pastimes that depend entirely upon electronics though the participants are not necessarily involved in or even concerned with the techniques employed, but only with the resultant effects produced by some action on their part. Radio control of models is a notable example. Its practice well demonstrates a marriage of technology and art. Anyone who has watched the adroitness with which an experienced and skilled operator manoeuvres a model aircraft in the air above and around him causing the model to enact the antics of a real lifesize craft, can be filled only with admiration... and envy.

So it is no wonder that radio control has a very large following and is backed by a sizeable industry catering for the special needs of these R/C enthusiasts—from models of all kinds through servo-mechanisms to complete transmitters and receivers.

Of the large numbers who participate in R/C perhaps the majority buy everything ready made and concentrate on the "real business" of operating their favourite kind of model. A fair number do however add further to their enjoyment by building their own model aircraft, boats or wheeled vehicles. And finally some, certainly a smaller proportion of the whole, actually build their own radio transmitting and receiving equipment.

To this latter group, as well as to the general electronics enthusiast, we shall be directing special attention over the next few months. The EE Radio Control System is an "entire" system and it uses a well proven circuit that is equally amenable to the needs and requirements of novice as well as experienced operator. The overall project is a result of teamwork: three designers have cooperated to produce this system which has been subjected to exhaustive field tests, culminating in the very creditable achievements by one of the trio during the Manx Soaring Championships on the Isle of Man last August.

We hope that through this project many of our readers will discover another fascinating pastime and have the additional pleasure of modestly remarking to admiring onlookers—"Oh yes, I built the electronics myself!"

And now for something quite different. Circuits simple, useful and all built on a standard size board. That sums up Uniboards, a new series of quick one-off's featuring commonplace discrete semiconductors that starts this month. Just the job for newcomers to cut their teeth on and assuredly worth more than a passing glance from older hands.

Our December Issue will be published on Friday, November 16. See page 740 for details.

Readers' Enquiries
We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.
We cannot undertake to engage in discussions on the telephone.

Component Supplies
Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.
All reasonable precautions are taken to ensure that the advice and data given to readers are reliable. We cannot however guarantee it, and we cannot accept legal responsibility for it. Prices quoted are those current as we go to press.
CONSTRUCTIONAL PROJECTS

3-FUNCTION GENERATOR  Valuable piece of test equipment  by F. C. Judd
MW LW RADIO TUNER  For use with headphone or amplifier  by F. G. Rayer
UNIBOARDS: 1—OPTO ALARM  Buzzer sounds when light falls on sensor  by A. R. Winstanley
BABY ALARM  For remote babysitting  by E. M. Lyndsell

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It must first be emphasised that this project requires the use of an oscilloscope for the adjustments necessary to obtain the correct mark-to-space ratio for each waveform and also the shape and purity of the sinewave. This cannot be done audibly, or with an audio signal reading meter.

An audio range signal generator of this nature is a valuable piece of test equipment and has dozens of applications in testing and performance measurement of both audio and other electronic equipment. It has a total frequency coverage of 15Hz to 100kHz in four ranges, see Table 1.

**Table 1. Band coverage of the 3-Function Generator.**

<table>
<thead>
<tr>
<th>Band No.</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (x1)</td>
<td>15 to 250Hz</td>
</tr>
<tr>
<td>2 (x10)</td>
<td>150 to 2,500Hz</td>
</tr>
<tr>
<td>3 (x100)</td>
<td>1,500 to 25,000Hz</td>
</tr>
<tr>
<td>4 (x kHz)</td>
<td>10 to 100kHz</td>
</tr>
</tbody>
</table>

The output is continuously variable with maximum signal levels as shown in Table 2.

**Table 2. Maximum output levels for the three functions.**

<table>
<thead>
<tr>
<th>Function</th>
<th>Level (volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinewave</td>
<td>1 (r.m.s.)</td>
</tr>
<tr>
<td>Square-wave</td>
<td>2.5 (pk-pk)</td>
</tr>
<tr>
<td>Triangular-wave</td>
<td>1 (r.m.s.)</td>
</tr>
</tbody>
</table>

The sinewave signal has a minimum harmonic distortion factor of about 2 per cent when correctly adjusted but lower than this is not possible as the sinewave is obtained by electronic shaping within IC1 and not by pure generation.

Although the sinewave is not suitable for harmonic distortion analysis with a t.h.d. meter it is quite adequate for all audio equipment frequency response measurements, audio amplifier power output and bandwidth measurement, frequency comparison, and so on. The triangle-wave is quite pure and also has numerous applications in electronics as well as audio, particularly as the "ramp" rise and fall is perfectly linear.

The square-wave has a rise time of only 2 microseconds and so can be used effectively for audio amplifier square-wave tests as well as for a "clock pulse" source with a 1-to-1 mark-space ratio at any frequency within the range of the generator.

**THE CIRCUIT**

The circuit diagram of the 3-Function Generator is shown in Fig. 1. Most of the work is carried out internally by the 8038 sine-square-triangle generator i.c. with external CR network-switching to provide the wide frequency coverage specified. The output signals from IC1 are coupled to an op-amp, IC2, with switched negative feedback to provide (a) a nominal output level of 1V r.m.s. from the sine and triangle waves within the range of IC1 and not by pure generation.

Although the sinewave is not suitable for harmonic distortion analysis with a t.h.d. meter it is quite adequate for all audio equipment frequency response measurements, audio amplifier power output and bandwidth measurement, frequency comparison, and so on. The triangle-wave is quite pure and also has numerous applications in electronics as well as audio, particularly as the "ramp" rise and fall is perfectly linear.

The square-wave has a rise time of only 2 microseconds and so can be used effectively for audio amplifier square-wave tests as well as for a "clock pulse" source with a 1-to-1 mark-space ratio at any frequency within the range of the generator.
calibration on the first three ranges \((\times 1, \times 10 \text{ and } \times 100)\) is uniform (since time constants are in decade ratio) so only the one scale is required. On the kilohertz \((kHz)\) range, 10 to 100kHz, the time constant deviates in ratio to the others to limit maximum frequency to 100kHz. Above this value the square-wave would be of little use and in any case the frequency response of the 741 op-amp (IC2) starts to fall off above this.

If the calibrated scale printed with this article is copied or cut out and used, all frequencies should be within about 10 per cent of true.

More accurate calibration would of course be possible with the aid of a high grade laboratory type signal generator and oscilloscope but this is hardly necessary for normal practical use. However, the generator is very stable and will hold continuously at any set frequency to within a few cycles.

Incidentally by splitting the frequency ranges into four, the calibration is spread out much more and so makes it easier to get close to intermediate frequencies.

**GENERATOR I.C.**

Returning to the circuit we have the basic generator IC1 which has three outputs that simultaneously provide the sine, square and triangle waveforms, hence the switched selection of these by the ganged pair S2a and S2b. Frequency ranges are selected by S1 which simply brings in the appropriate C value to operate with VR1 the frequency control and R1, R2, the range limiters. Note that VR1 is a log. potentiometer—do not use a linear potentiometer. The preset VR2, is adjustment for the mark-space ratio of the waveforms and setting this is the first reason why an oscilloscope is essential.

The presets VR3 and VR4, set the purity of the sinewave and again this cannot be done without an oscilloscope although adjustment could, in this case, be made with the aid of a distortion bridge but more of this later.

The potentiometer VR5 is the signal level output control although it actually controls the level of signals from IC1 into the 741 op-amp which is a basic amplifier configuration with negative feedback switched as appropriate to obtain a uniform output from the sine and triangle waves and a fast rise time from the square waves.

The output feed capacitor is kept large to obtain a flat topped square-wave down to 15Hz but in order to check this, an oscilloscope with a d.c. input on the Y-amplifier must be used. Scope amplifier input capacitors (a.c. coupling) are usually too small in value to obtain flat top square-wave displays at frequencies as low as 15Hz (see oscillograms in this article).

**POWER SUPPLY**

The circuit requires a smooth 30V d.c. supply. This is derived from the mains in a conventional manner. Mains voltage enters the unit via S3 and appears across the primary of T1; 24V a.c. (nominal) is produced across T1 secondary which is then full-wave rectified by the diode bridge D2 to D5, producing a d.c. level across C10 equal to the peak value of T1 secondary voltage (i.e. \(24\sqrt{2}\)) plus an over-voltage due to the regulation factor of the transformer.

The prototype used a transformer with a secondary current rating of 250mA, resulting in total voltage at C10 +ve of 41V. The current required by the circuit is 25mA. Therefore to obtain 30V at C11 +ve, 11 volts must be dropped across R19 when 25mA flows.
From Ohm's law, \( R_{19} = \frac{11}{0.025} = 440 \text{ ohms} \). The nearest preferred value above is chosen, i.e. 470 ohms.

To determine the value of \( R_{19} \) for other transformers that might be used, carry out the following.

With the power supply section not connected to the rest of the circuit, measure the voltage across \( C_{10} \), \( (V_m) \) and then calculate the value of a resistor, \( R_p \), to place in parallel with \( C_{10} \) to cause 25mA to flow:

\[
R_p = \frac{V_m}{0.025 \text{ ohms}}
\]

Measure the voltage now at \( C_{10} \) +ve, call this \( V_m' \). Remove \( R_p \). The value of \( R_{19} = \frac{(V_m' - 30)}{0.025 \text{ ohms}} \).

Calculate \( R_{19} \) wattage from \( (V_m' - 30) \times 0.025 \text{ watts} \).

The complete generator and its power supply will fit comfortably into a Verobox type 75-1412K which has aluminium front and rear panels. The generator circuit board and its controls are situated on the front panel with the rear panel holding the power supply board and transformer.

Drilling details for the front panel are shown in Fig. 2. The diameter of some of the holes, e.g. the on/off switch and the panel mounted neon may need to be changed to suit the components used.

The generator circuit is built on a piece of 0.1 inch matrix perforated board size 58 x 26 holes. The layout of the components and wiring details on both sides of the board and interwiring between the panel mounted controls is shown in Fig. 3. Although the generator circuit board layout is not critical, the constructor is advised to retain the position of all the components as closely as possible to avoid interaction and waveform cross-talk.

In the prototype the generator circuit board was mounted on the front panel using 30mm long plastic spacers and self-tapping screws.
Fig. 3. Above. The layout of the components and interwiring on both sides of the circuit board. Note that some wires pass through holes to make connections to components/wiring at other locations. Left. The internal face of the front panel showing component positions, interwiring and connections to be made to the board.
There is no particular order to be followed in the assembly of components on this board except perhaps to begin by inserting the Veropins, used for component anchorage, and the i.c. sockets. Some interconnecting wires use tinned copper wire and others use p.v.c. covered wire. Where there is any danger of a link wire touching another wire or component lead, the p.v.c. type is essential. Alternatively, tinned copper wire and sleeving may be employed.

When assembly is complete, sufficient lengths of flying lead should be attached to the board to reach the panel mounted components, and this wiring carried out. The board can then be screwed in place on its spacers.

**POWER SUPPLY SECTION**

As previously stated, the power supply board is fitted with the transformer on the back panel. The board is mounted on spacers to keep it clear of the metal back panel. The layout of the components is shown in Fig. 4 together with the interwiring on the underside. Note that this differs slightly from that in the photograph. The author used two 1,000µF 25V capacitors in series to form a 500µF 50V capacitor. This has been replaced in the text and diagrams by a single capacitor of this value.

Secure the transformer to the back panel remembering to place a solder tag on one of the fixings for earthing purposes. Make the connection between the board and T1 secondary and secure the board in place; R19 should not yet be connected, its value may need to be determined as explained earlier.

The two wires interconnecting the boards should not be connected until R19 is in place. In the prototype, a convenient method of connecting the mains cable to the transformer primary was to use a short length of plastic screw-terminal. The mains cable should of course be passed out through the rear panel via a rubber grommet or strain relief bush. Complete the wiring to S3 and LP1.

**CALIBRATED FREQUENCY SCALE**

A full-size copy of the calibrated frequency scale as used on the prototype is shown in Fig. 5. This can be cut out or photocopied and pasted on thin card. It is secured under the locknut of the frequency control VR1 but if a thin Perspex plate can also be made to cover it, so much the better.

A graticule type pointer, like that on the prototype is also worth while and not difficult to make from thin Perspex to the size shown in Fig. 6 and which is glued (Araldite) or screwed to the back of a plain control knob.

**CHECKING OUT AND ADJUSTMENT**

As already mentioned, an oscilloscope is necessary for adjustment of the presets VR2, VR3 and VR4. The oscilloscope Y-amplifier input is connected to the generator output socket and the output control set at maximum. A preliminary check with the frequency range switch S1 on X10 frequency scale pointer at 100 (1,000Hz) and waveform switch S2 set to “square”, will establish that the generator is operating, in which case first check the supply rail positive to ground voltage at the junction of R19 and C11 (power supply) which should be 30V ±1V. If not, it may be necessary to slightly change the value of R19 to obtain 30V as close as possible otherwise the output level and calibration of the generator may be affected. With this done, adjust VR1 to obtain a square-wave (still at 1,000Hz) with a uniform 1-to-1 mark-space as in the oscillogram Fig. 7b. Next, switch S2 to sine-wave output and adjust VR3 and VR4 together, each a little bit one
Fig. 4. Shows the power supply circuit board and transformer mounted on the internal face of the rear panel, and interwiring.

Fig. 5 (right). Full size copy of the frequency dial used in the prototype.

Fig. 6 (below right). Construction details for the frequency control pointer.

Prototype power supply board and interwiring. The two capacitors forming C10 have been replaced by a single capacitor.
way or the other, to obtain the closest possible replica of the sine-wave in oscillogram Fig. 7a. Each of the waveforms shown in this photo were taken from the prototype generator.

Now switch to triangle wave for which no other adjustment is necessary as its mark-space has already been established. It will appear as in the oscillogram Fig. 7c.

If an r.m.s. reading a.c. voltmeter is available check that the output level is appropriate from each waveform and over the whole frequency range. A reasonable assessment of this can of course be made with a calibrated oscilloscope.

If a distortion analyser is available, the sine-wave purity can be adjusted with VR3 and VR4 until the lowest possible distortion i.e., about 2 per cent at 1,000Hz is obtained.

Some further checks on square-wave outputs can be carried out with a calibrated oscilloscope and preferably one with a d.c. input to the Y-amplifier and a time base range in the microseconds region. On a fast time base range the rise time of the square-wave can be verified and this should be in the region of 2 microseconds for 90 per cent of the rise as shown in the oscillogram Fig. 8.

At 15 to 20Hz the square-wave should have an almost perfectly flat top as in oscillogram Fig. 9 but this will only be apparent with d.c. coupling into the 'scope.

USES

An audio range three waveform generator of this nature is a very desirable item of test equipment but its full use requires an a.c. (audio range) voltmeter and an oscilloscope at least to carry out tests and measurements on audio amplifiers, tape recorders and various kinds of purely electronic circuitry as mentioned earlier.

With the extra essential items of test equipment as above, one could measure frequency responses of audio amplifiers and tape recorders, responses of tone controls, filters and pre-amplifiers, carry out square-wave tests on amplifiers, check frequencies of other generators and oscillators and measure the power output of audio amplifiers etc.

Incidentally a quite good but secondhand oscilloscope is not difficult to get hold of at a reasonable price and is one of the most valuable of all the numerous items of test equipment to be found in workshops and laboratories.
A tuner to provide a.m. reception on medium and long wave bands increases the scope and entertainment value of an audio amplifier. This tuner has sufficient output for even insensitive amplifiers, while avoiding the relative complication of a superhet circuit. Coverage is approximately 1600 to 600kHz m.w., and 490 to 185kHz l.w., or 360 to 145kHz l.w.

CIRCUIT DESCRIPTION

The circuit diagram of the tuner is shown in Fig. 1.

The circuit comprises an r.f. amplifier, TR1, a diode detector, D1 and an audio amplifier TR2 with high output impedance.

Signals generated in the aerial are fed via SK1 into L1 primary and induced into L1 secondary to reach the gate of the r.f. amplifier, TR1. The potentiometer VR1 is the gain and volume control. As the wiper of VR1 is moved towards L1 pin 5, the source bias is increased thereby reducing the gain of TR1. The aerial signal in L1 primary is attenuated at the same time.

The drain terminal of TR1 is coupled to the primary of coil L2, pins 5 and 6, which is tuned by the second section of the ganged capacitor, C1b. Each section has its own trimmer, C2 and C5 respectively.

Note that a dual 500pF gang can be used but will require a little extra space.
Fig. 2. Layout and wiring of components on the top and underside of the plain perforated circuit board and interwiring to panel mounted components.

Fig. 3. Construction of a simple tuning pointer disc. Half of a brass spindle coupler is glued to a 70mm diameter Perspex disc with an engraved radial line.
common emitter amplifier providing considerable boost. The output is at the collector which is capacitively coupled to the output socket SK3.

**TUNING COILS**

The tuner uses two identical coils, having six tags, see Fig. 2. Count from the tag ring slot. Band-switches S1a and S1b are sections of a slide switch, and short out both of the longwave windings (pins 3 and 4) for medium wave reception.

The coils are of fixed inductance, and do not have adjustable cores. The only adjustment necessary will be to the trimmers C2 and C5. To do this, tune in a signal near the high frequency end of the m.w. band (ganged capacitor nearly fully open) and rotate C2 and C5 for best results.

**COMPONENT BOARD**

Most of the components including the dual-ganged capacitor are assembled on a piece of 0.15 inch matrix perforated board, 30 x 12 holes, as in Fig. 2. The 2-gang capacitor used has two threaded holes, so that the board can be fitted to it with short 4BA bolts.

First solder a lead to the capacitor rotor or frame tag, and bring it down through a hole in the board. This is the earthing point MC in Fig. 2. Extra washers or similar means of spacing about 3mm thick will be needed between this capacitor and the board.

Assemble and interconnect the board-mounted components according to Fig. 2. In many places the wire ends of components can reach to the required points. Elsewhere, 22swg or similar connecting wire is recommended.

Prepare the front panel to accept the panel-mounted controls and secure these and the board in position.

The ganged capacitor is fitted to the panel by means of three 12mm long 4BA bolts, with two nuts each, to lock against the capacitor and panel. This capacitor provides sufficient support for the board.

Should a capacitor without slow motion be fitted, then this can come nearer the panel as the spindle will be shorter. Take care that the bolts are not so long that they project inside the capacitor.

The aerial and earth sockets, SK1, SK2 are to be mounted on a small piece of Paxolin or similar material to be fitted to the rear of the case.

Complete the interwiring as shown in Fig. 2.

**Resistors**

| R1 | 100kΩ |
| R2 | 100kΩ |
| R3 | 220Ω |
| R4 | 22kΩ |
| R5 | 1.8MΩ |
| R6 | 4.7kΩ |

All ¼W carbon ±5%

**Capacitors**

<table>
<thead>
<tr>
<th>C</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>2 x 365pF dual ganged (Jackson type 0), slow motion (preferred)</td>
</tr>
<tr>
<td>C2</td>
<td>60pF compression trimmer</td>
</tr>
<tr>
<td>C3</td>
<td>0.01µF ceramic or plastic</td>
</tr>
<tr>
<td>C4</td>
<td>0.01µF ceramic or plastic</td>
</tr>
<tr>
<td>C5</td>
<td>60pF compression trimmer</td>
</tr>
<tr>
<td>C6</td>
<td>220pF ceramic or plastic</td>
</tr>
<tr>
<td>C7</td>
<td>0.47µF ceramic or plastic</td>
</tr>
<tr>
<td>C8</td>
<td>4.7µF 6V elect.</td>
</tr>
<tr>
<td>C9</td>
<td>100µF 12V elect.</td>
</tr>
</tbody>
</table>

**Semiconductors**

| TR1 | CA40673 or 3N201 dual gate silicon n-channel MOSFET |
| TR2 | BC108 silicon npn |
| D1 | OA81 or similar germanium diode |

**Miscellaneous**

| L1, L2 | Repanco type DRR2 (2 off) |
| VR1/S2 | 5 kilohm carbon linear with ganged switch |
| S1 | d.p.d.t. slide switch |
| SK1, 2 | 4mm insulated sockets or similar (2 off) |
| SK3 | 3.5mm jack socket |
| B1 | 9V PP3 or any other 9V battery |

Circuit board; 0.15 inch matrix perforated board, size 30 x 12 holes; battery connector to suit B1; knobs (2 off); 4BA and 6BA fixings; Perspex and bush (for dial); Paxolin or similar, 100 x 40mm (to hold SK1, SK2); case 150 x 100 x 100mm.
Trimmers C2 and C5 are soldered directly to C1a and C2b, and their second tags supported by a short, stout wire to the gang frame. They are almost vertical, so that they can be adjusted by means of a small screwdriver from behind, with the tuner in its case.

The case employed in the prototype had dimensions 150x100x100mm internally, and was made of metal; plastic or thin wood could also be used.

**POWER SUPPLY**

Current drain is small (3mA measured) and an internal 9 volt battery is therefore suitable.

The tuner may be operated from a well decoupled and smoothed supply obtained from the main audio amplifier, of about 9 to 12 volts, with negative earth.

**TRIMMING**

Initially set the trimmers to near maximum capacity. Subsequently adjust both for best reception of a medium wave transmission near the h.f. band end (say 1600 to 1400kHz) as mentioned. For optimum results adjust C2 with the actual aerial and earth which will be used, already connected.

For the alternative l.w. band mentioned, cores may be obtained which can be screwed to the l.w. winding ends of the coils. These are not necessary, however, for 200kHz reception.

The aerial can be a few feet of wire indoors, or a somewhat longer indoor wire carried along one (or possibly two) walls of the room, near the ceiling. Either a short or rather longer outdoor aerial may be used if available. It can be worthwhile to try one or two alternatives.

It is recommended that an earth connection be provided if feasible.

**IN USE**

The usual type of screened lead should be employed to feed the audio signals from the tuner to the main amplifier.

If the tuner is used for personal headphone listening, a high resistance headset approximately 2 kilohms will be most satisfactory.

Note that the values are so arranged that the maximum possible gain setting of VR1 brings the tuner to the point of regeneration, as this allows improved sensitivity. This was found to cause no difficulty with an earth provided, but with no earthing VR1 must be adjusted accordingly, or resistor R3 increased in value until it is just impossible to bring TR1 into oscillation. A resistor of about 1.5 kilohms should be suitable.

A tuning pointer can be made from a stout wire soldered to the capacitor spindle, or, as used in the prototype, a disc of thin Perspex about 70mm in diameter can be fitted to a bush with set screw, obtained from an old control knob with a line scribed along a radius of the disc. A 180 degree scale can be glued to the front panel behind the Perspex disc and later calibrated.

---

**BRIGHT IDEAS**

**I.C. SOCKET**

For sometime I have been using one of those T-Dec breadboards and to use a d.i.l. integrated circuit with this you need a special adaptor. This can cost between £2 to £2.50.

I first came up with the idea of an i.c. socket fitted with flying leads, but this proved to be a bit clumsy. Then I hit upon an idea of using a wirewrap i.c. socket, bending the pins as shown in the diagram and then snipping the ends level. The socket can then be plugged in and out of the T-Dec with ease.

The cost of the Wirewrap I.C. socket should be between 20 and 30 pence, which is a considerable saving on the original.

L. A. Privett, Barking.

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**The Adventures of Tanty Bead**

By Matthew Reed

OUT WALKING ...... AH, I SEE CONSTABLE DAI ODE HAS MADE AN ARREST

IT'S THAT YOUNG HOOLIGAN, SERGE VOLTAGE, HE TRIED TO COME THE WRONG WAY UP A ONE-WAY STREET AGAIN!

I THINK THAT'S A BIT DRASTIC, TANTY.

HELLO DAI, WHO'VE YOU GOT THERE?

GOOD SHOW DAI. IT'S TIME SOMEONE RAN HIM TO EARTH!

I'LL JUST LET HIM COOL HIS HEELS IN THE CADMIUM CELLS FOR A WHILE.
SEMIC conductors is a term that embraces a very important family of electronic devices. The most widely used, and best known, of such devices are the diode and the transistor.

The simplest semiconductor device is the diode. This functions as a oneway device (or “valve”) for electronic current. It has two terminals or lead - out wires. One connection is distinguished by a mark of some kind on the body of the component, and this is the cathode. For normal conduction this must be connected to the negative side of the circuit in which it is to be used. The other (usually unmarked) is the anode and goes to the positive side of the circuit. See Fig. 1.

There are a variety of diodes, varying size, shape and form. See Fig. 2.

One kind of device commonly encountered in electronic circuits is that generally known as a general purpose signal diode. Many of these resemble a small resistor in outward appearance and have a coloured band at one end of the body which identifies the cathode.

A SPOT OF CONFUSION

Other types of diodes have some other kind of mark adjacent to the cathode lead.

Perhaps somewhat confusing is the use of a + sign or a red band or tip to denote the cathode on certain diodes. This is a throw-back to earlier days when diodes were used chiefly for power rectification. The positive side of the direct current (d.c.) output from a power rectifying circuit comes from the cathode of the diode rectifier, and so this method of coding makes sense. But when the diode is employed in other circuit arrangements the basic logic of this method of identification is somewhat obscure and confusion is frequently caused.

CIRCUIT SYMBOL

The symbol normally used for a diode in circuit diagrams is shown in Fig. 3. (a) Diode forward-biased—conducts. Can be considered as a switch that is closed. (b) Diode reverse-biased—does not conduct. Can be considered as a switch that is open.

DIODE OPERATION

The diode conducts when the anode (a) is connected to the positive point of a circuit, and the cathode (k) to a more negative (less positive) point. See Fig. 1.

When connected the other way round, (or if the circuit voltages reverse) the diode will not conduct, but becomes a complete barrier to the flow of direct current. See Fig. 3b.

When the diode is used to rectify alternating current (a.c.) it behaves like a switch, “opening” and then “closing” as the a.c. changes direction, that is swinging from positive to negative. See Fig. 4.

The unidirectional output from the diode is a series of positive going pulses. The negative-going half of the a.c. input is suppressed.

Fig. 4. Diode used as a rectifier of a.c. T is a mains transformer. When “x” is positive, the diode will conduct, and d.c. (conventional current) flows from cathode back to other end of transformer winding. When “x” is negative, the diode will not conduct.
CIRCUIT DESCRIPTION

The circuit diagram of the Opto Alarm appears in Fig. 1. The photocell, PCC1 is an ORP12 light-dependent resistor which is located in the room to be protected, and is connected by means of PL1 and SK1. Together with R1, PCC1 forms a potential divider: the voltage at the junction of R1 and PCC1 varies with the amount of light striking the l.d.r. In absolute darkness the resistance of an ORP12 is at least 10 megohms, and so the voltage at the junction of R1/PCC1 is very nearly that of the supply rail, 9V. Transistor TR1 is therefore firmly switched off as its base is not biased.

When light falls on PCC1, its resistance drops (albeit relatively slowly) and this causes TR1 to switch on. A triggering pulse is therefore delivered to the gate of CSR1 and this component conducts. The audible warning device (WD1) will therefore sound. The thyristor will now remain in this low impedance state even if the triggering signal is removed. The only way to reset CSR1 and mute the alarm is in this case to switch off the mains power supply, or switch off the battery if dry cells are used instead. Resistor R5 will ensure that a minimum holding current is flowing in the anode-cathode circuit of the triggered thyristor, and so preventing any undesirable resetting.

BUZZER

It is important to note that conventional electromechanical buzzers should not be used in this circuit. They feature a very high current consumption normally, and apart from destroying the specified thyristor such a unit could greatly reduce battery life if the circuit is powered by conventional batteries. The miniature audible warning device used here has a current consumption of only 15-20mA.

Whilst the response time of the l.d.r. is relatively slow, experimentation with resistor values enabled a design to be produced which reacts quickly to a change in light: the alarm is triggered, for example, by a torch beam skimming over the photo-resistor in a darkened room. Finally, C1 and C2 decouple the power supply and prevent triggering of the thyristor during initial switch-on. A 9 volt supply is connected via SK2, the tip of the jack plug being +9V as usual.

LIGHT SENSOR

The photocell arrangement in the prototype is shown in Fig. 2. The ORP12 is mounted upon a small piece of tagstrip and connected to its respective jack socket using twin-core flex terminated with a 3.5mm jack plug. The length of the flex can be in excess of 5 metres.

No setting up is required, simply mount the l.d.r. in the room to be monitored. Obviously it should not be obscured by any object in the room.

One final point is to remember to connect up all jack sockets before switching on the power. If this is not done then there is the possibility that the "9 Volt Power Supply" (if used) could be shorted out when the jack plug connecting it is being inserted into the jack socket.

If battery operation is required, the power input socket SK2 should be replaced by an on/off switch located so as to allow a PP3 battery to sit in the case.
The completed Opto Alarm showing positioning of the circuit board and wiring to the jack sockets.

Fig. 1. The circuit diagram of the Opto Alarm. The dotted components replace SK2 for an integral battery version.

Fig. 2. The layout of the components on the topside of the stripboard and the breaks to be made along the copper strips on the underside and interwiring between board and panel mounted components. Left shows the l.d.r. fixed to a tag strip enabling the l.d.r. to be mounted and connected to a jack plug to suit SK1.
In the first part of this series, we looked briefly at the physics of conduction in solids. We will now look at the differences between materials that are good at conducting electricity, such as most metals, and those which can withstand extremely high fields without conduction, such as glass and most plastics.

The two types of material are called conductors and insulators respectively. There is, in fact, a third important class of materials, called semiconductors. These are normally reasonably good insulators but, under certain circumstances, they can be converted into fairly good conductors.

PHYSICAL MODELS

A physical model of the atoms in a metal considers them as having lots of free electrons which pass easily from atom to atom. The electrons move about so easily that they have been likened to the molecules of a gas.

An insulator, on the other hand, has atoms (or molecules) whose electrons are bound very strongly to the atom. It takes an extremely high field to move the electrons from atom to atom.

In semiconductors there is a different situation: all the electrons are held firmly to the atom so that there are not many free for conducting current. By supplying energy of the right kind certain electrons can be transformed into conduction electrons. There is not a gradual change but a sudden jump as the electron changes its character.

Materials which are semiconductors in their normal, unadulterated, state are called intrinsic semiconductors, examples being silicon, germanium, and carbon in the form of diamond.

OHM'S LAW

Many years ago it was noticed that a wire of given dimensions varied as to its conducting properties according to the type of material from which it was made. The effect can be summarised by saying that different materials have different resistance to current flow. Obviously, the term resistance needs a more precise definition.

The force with which conduction electrons are bound to the atom depends, as we have said before, on the type of atom. It is thus not surprising that the resistance, or, conversely, the conductance, of materials varies. What is more surprising is the fact that for a wide range of materials the current flow in a given conductor is directly proportional to the e.m.f. applied. Thus, if we know the current that flows when one volt is applied we can predict the current that flows when any other voltage is applied.

The ratio of the voltage to the current we call the "resistance". The mathematical way of defining resistance is by the equation

\[ R = \frac{V}{I} \]

where \( R \) is the resistance, \( V \) the voltage and \( I \) the current. We call this equation Ohm's Law after its discoverer.

The units of resistance are ohms, one ohm being the resistance which allows one ampere to flow when one volt is applied. Conversely we can say that one ohm produces a voltage drop of one volt when one ampere flows through it.

CURRENT VERSUS VOLTAGE GRAPH

Another way of visualising resistance is by plotting a graph of current against voltage in a given component. The resistance is then given by the slope of the graph.

A pure resistance gives a straight line current versus voltage graph—we say there is a linear relationship between current and voltage, see Fig. 2.1.

Other components may not give a straight line but we can still find the resistance at any point on the graph by drawing a tangent to the curve and then measuring the slope of this line.

SWITCHES

A switch can be defined as a two-state device—in one state it has extremely high resistance (it is an insulator), and in the other state it has very low resistance (it is a conductor).

The force which causes it to change state may be mechanical, as in an ordinary light switch, or an electric current or voltage, as in the case of a relay or an electro-mechanical solid-state switch.

Switches vary in their specifications as to how much voltage they can withstand in their insulating or "off" state, and how much current they can carry in their conducting or "on" state.

Switches can have more than just two contacts which are either open or closed. Mechanical switches with eight or more contacts are not uncommon.

A very useful type of switch is the changeover type where a moving contact, or wiper, makes contact with either one terminal or another. This type of switch can be used as a normally closed
Switch a normally open switch, or can be used to switch from one voltage to another.

The circuit symbols for various types of switch are shown in Fig. 2.2.

RESISTORS

Perhaps the most common circuit element is the resistor. Resistors come in a variety of shapes and sizes but they all have a common function—to accurately set current levels in a circuit when given voltages are present.

Resistors are somewhat taken for granted in electronic circuits but it is quite remarkable that a component can give such predictable behaviour over a vast range of applied voltages.

Early resistors tended to be large rods of carbon even for quite low power dissipations. This was because internal heating was a problem in the solid type of construction. Modern resistors use sophisticated techniques to give very high performance and stability combined with small physical size.

The circuit symbols for various types of resistors are given in Fig. 2.3.

TYPES OF RESISTOR

The actual resistive part of a resistor can be carbon, a thin film of metal or metal oxide, or a wire made of a suitable alloy. The cheapest and probably the most widely used are carbon type but often, especially in precision instruments, the shortcomings of this type of resistor necessitate the use of more expensive metal film or metal oxide resistors.

The quality of a type of resistor can be judged in two ways: its tolerance and its stability with changes in temperature, humidity, etc. The concept of tolerance is, perhaps, a new one and therefore requires some elaboration.

TOLERANCE

When resistors (or any component for that matter) are actually produced, the manufacturer cannot ever make his components exactly match the nominal specification of that component. He must compromise between accuracy and cost so he does not attempt to make resistors of exactly the resistance required but, instead, specifies a band of values around the nominal within which the component is acceptable. In general, the closer the limits of acceptance are to the nominal value, the higher the cost.

The band around the nominal value is usually specified in terms of a percentage. A “ten ohm, five per cent” resistor is therefore a resistor whose real value can be anything from 9.5 ohms to 10.5 ohms.

Typical tolerances for resistors are 20 per cent, 10 per cent, 5 per cent, 2 per cent and 1 per cent. Tolerances of one per cent or better make the resistor what is called a “precision” resistor.

In general, the designer likes to produce circuits where low tolerance (high percentage) resistors can be used since this keeps down costs. However, there are many instances where close tolerance (low percentage) resistors are essential.

The concept of tolerance has led to the formulation of a range of values for resistors which all manufacturers now follow. These values are called preferred values and the way the actual values have been arrived at is quite interesting.

PREFERRED VALUES

Since manufacturers cannot make a resistor of every value imaginable, they have arrived at a set of values which the designer can choose from. This obviously puts constraints on the circuit which the designer must be aware of.

We said earlier that a “ten ohm, five per cent” resistor could take any value up to 10.5 ohms. There is thus no point in making a resistor whose nominal value is less than this. So, what is the next highest value that he should make?

The lower limit of the tolerance band of the new resistor should not overlap with the upper limit of the “ten ohm” resistor. A little calculation shows that the next value is 11 ohms (to the nearest whole number). Using the same principle we can find the next highest value which turns out to be 12 ohms.

Continuing in the same way, a whole string of values can be found up to 100 ohms. Above this the values are simply ten times the previously calculated values.

It turns out that for five per cent resistors there are 24 values between 10 and 100 ohms. We call any set of values where the upper limit is ten times the lower limit
Everyday Electronics, November 1979

POWER RATING

When we looked at conduction in solids we saw how electrons move—bouncing around in a random manner but with an overall drift against the field. The collisions which occur generate heat and the greater the current the more collisions occur.

Each collision therefore means that the electron loses some of its energy as heat. We say that power is dissipated when current flows in a resistive element.

The amount of power dissipated is proportional to the current flowing through, and the voltage across the resistor. Thus

\[ P = IV \]

Heat will be dissipated in any resistive element in a circuit whether it be an actual resistor or a piece of wire, since this is bound to have some resistance at normal temperatures.

When resistors are designed, the manufacturer tests how much power the type of resistor can dissipate without any damage. If too much current is passed through a resistor it will get hot and eventually burn out. Thus when a resistor is given a power rating it is really a summary of the maximum voltage and current which the resistor can withstand.

To calculate these two quantities from the power rating and the value of the resistor, we must return to Ohm’s Law.

If a voltage \( V \) is placed across a resistance \( R \) then the current \( I \) is given by

\[ I = \frac{V}{R} \]

Now we have seen that

\[ P = IV \]

so, substituting in this equation we get

\[ P = \frac{V^2}{R} \]

Rearranging we get

\[ V = \sqrt{PR} \]

Let us look at a real case. What is the maximum voltage which we can safely apply across the 100 ohm, one watt resistor?

\[ V = \sqrt{(1)(100)} = 10 \text{V} \]

We can find the maximum current by substituting

\[ \frac{V}{R} = \frac{10}{100} = 0.1 \text{A} \]

Again, let us look at a real example. What is the maximum current that we can pass through a 1/2 watt, 47 ohm resistor?

\[ I = \sqrt{(1/2)/(47)} = 0.029 \text{A} \]

In transistor and other semiconductor circuits, currents are usually very low, rarely rising over a few tens of milliamps. In these cases we will rarely find resistors over 1/2W and usually not more than 1W. It is only where large currents are flowing (as in power supplies or the output stages of amplifiers) or high voltages are present (as in valve circuits) that we encounter high wattage resistors.

COLOUR CODING

Resistors are usually marked with their values using three coloured stripes on the body of the resistor. The first two indicate the two digits in the value and the third the multiplier. Thus, for instance, red red orange is 22 followed by three noughts, which implies 22,000 ohms.

A fourth band is used to indicate the tolerance of the resistor.

The colour code is summarised in Table 2.2.

<table>
<thead>
<tr>
<th>Colour</th>
<th>1st/2nd digits (A/B)</th>
<th>Multiplier (C)</th>
<th>Tolerance (D) ±%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>10^2</td>
<td>-</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>10^3</td>
<td>3</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>10^4</td>
<td>4</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>10^5</td>
<td>-</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>10^6</td>
<td>-</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>10^7</td>
<td>-</td>
</tr>
<tr>
<td>Grey</td>
<td>8</td>
<td>10^8</td>
<td>-</td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td>10^9</td>
<td>-</td>
</tr>
<tr>
<td>Gold</td>
<td>10</td>
<td>10^10</td>
<td>-</td>
</tr>
<tr>
<td>Silver</td>
<td>10-2</td>
<td>10^11</td>
<td>5</td>
</tr>
</tbody>
</table>

**Example:** A resistor colour coded as orange-white-red-silver, would have a value of 3.9kΩ ±10%.
POTENTIOMETERS

In electronic circuits the requirement often arises to be able to change a certain parameter (volume, brightness, tone, etc.) under manual control. The cheapest and most readily available variable component is the variable resistor or, in its usual form, the potentiometer.

A potentiometer is a three-terminal device and has quite a simple internal construction (Fig. 2.4). It consists of a resistive track either of carbon or similar material (though sometimes it is a coil of wire) with electrical contacts at either end brought out to two terminals. Electrical connection is also made to a third terminal but this can make contact anywhere along the track, the actual position being set manually either by a rotating shaft to which the wiper is mechanically but not electrically connected or, in the case of slider potentiometers, by a linear movement.

To use the potentiometer as a variable resistor, the movable contact and one of the other terminals are used. With the wiper at one end of the track there will be virtually zero resistance between the two terminals; with it at the other end, the full resistance of the track will be seen. At intermediate positions a resistance dependent on the position of the wiper will be seen (Fig. 2.5a).

The most commonly used type of potentiometer has a linear relationship between wiper movement and resistance. In other words if wiper movement is plotted against resistance a straight line is seen. However, the need sometimes arises for a potentiometer with a non-linear characteristic. The most common type of this sort is the logarithmic type. The relationship between the wiper position and resistance being shown in Fig. 2.5b.

Such potentiometers are used where the parameter to be varied does not have a linear relationship to any easily varied circuit parameter. For instance, sound output power is a logarithmic function of electrical power so varying electrical power with a linear potentiometer would give large changes in volume at one end of the potentiometer and small changes at the other. Using a logarithmic potentiometer evens out the adjustment over the range of the potentiometer.

MEASUREMENTS USING POTENTIOMETERS

The name “potentiometer” sometimes gives rise to confusion as it does not appear to be any sort of “meter”. However, with suitable calibration and the use of the simplest of meters it can indeed be used for measuring.

If a voltage is placed across the resistive track then the wiper of the potentiometer can be used to tap off a proportion of this voltage (Experiment 2.1). If a simple meter is placed in the wiper of the potentiometer then it will indicate when current flows out of or into that wiper.

An unknown voltage (which must be less than that across the potentiometer track) can now be measured by connecting it across the wiper and one end of the potentiometer. Providing the knob is calibrated we can simply adjust the wiper until no current flows and this can only occur when the unknown voltage exactly equals that across the potentiometer.

LIGHT DEPENDENT RESISTORS

Ordinary resistors are designed so that external influences such as light, heat and mechanical stress have very little effect on the nominal resistance. There are, however, special resistors which exhibit marked changes in resistance with these influences.

Light dependent resistors (l.d.rs) are made of a special material which produces more conduction electrons when exposed to light. They should not be confused with solar cells which are sources of e.m.f. not completely passive as l.d.rs are.

Experiment 2.2 shows a simple light meter using a readily available l.d.r.

THERMISTORS

Another type of resistor called a thermistor exhibits large changes of resistance with temperature. Any heating tends to increase conductivity since electrons get "knocked off" as the heat agitates the atoms. However, in thermistors, the materials are specially chosen so that the changes are large.
EXPERIMENT 2.1:
A SIMPLE VOLTMETER
Components needed: 100kΩ resistor

To use a potentiometer as a voltmeter, the scale of the potentiometer needs to be calibrated. Because the track is linear, we know that equal divisions on the scale will represent equal changes in resistance. Thus it is simply necessary to divide the scale into ten equal increments using for instance a protractor.

Note that the rotation of the knob is restricted to 270 degrees (three quarters of a full rotation) so only this part needs to be divided up (see Fig. 2.6(c)). Each of the ten divisions can be further subdivided into two or maybe ten if it is intended to try to make more accurate measurements but since the battery voltage is not known to a high degree of accuracy this is not really a practical proposition.

The circuit of the simple voltmeter is shown in Fig. 2.6(a) and the board layout in Fig. 2.6(b). Note the 100kΩ resistor in series with the meter. This is not really part of the voltmeter but serves to protect the meter should the wiper of the potentiometer be at 0V and the positive end of the meter connected to a voltage.

Each division of the scale represents one tenth of the voltage across the potentiometer, in this case 9V. Connect say a 1.5V torch battery across the "voltmeter" terminals (note the polarity). Adjust the potentiometer until the meter reads zero, that is mid-scale. Read off the scale.

The reading should be about 1.7 corresponding to a voltage of approximately 1.5V. Note that the "meter" cannot read more than the voltage across the potentiometer—in our case 9V.

![Fig. 2.6. A simple voltmeter which can be built on the Tutor-Deck. (a) shows the circuit diagram and (b) the component layout on the deck. (c) shows the potentiometer scale.](image)

EXPERIMENT 2.2:
A SIMPLE LIGHT METER
Components needed:
- ORP12 light dependent resistor
- 10kΩ resistor
- 100kΩ resistor

The change in resistance of a light dependent resistor (L.D.R.) with illumination can be measured using the simple voltmeter described in the preceeding experiment. In order to convert the change in resistance into a change in voltage we need to pass a current through the L.D.R. Our voltmeter can only measure up to 9V so the voltage across the L.D.R. needs to be about a few volts in normal light to make a useful light meter.

The data tells us that the resistance in sunlight is about 3-5kΩ so placing a 10kΩ resistor in series with it and connecting the combination to the 9V supply used for the potentiometer should produce a reading of about 3V.

The complete circuit of the simple voltmeter is shown in Fig. 2.7(a) and the board layout in Fig. 2.7(b).

Adjust the potentiometer until the meter reads zero and note the reading. Now vary the light that falls on the L.D.R. either by shading it or by taking it closer to the light source. Adjust the potentiometer to bring the meter back to zero. For decreased light the scale reading should fall indicating that the resistance of the L.D.R. has risen. With increased light the meter reading should rise indicating a fall in the resistance of the L.D.R.

![Fig. 2.7. A simple light meter using a light dependent resistor. (a) shows the circuit and (b) the component layout.](image)
Since current through any resistive element tends to produce heat, these resistors tend to exhibit a resistance which goes down as current goes up.

In older types of television receivers one could find thermistors in the heater circuits of the valves. These valve heaters tend to have very low resistance when cold so a thermistor was used to limit the initial current but to allow the right current to flow once the heaters warmed up.

The thermistor just described has a negative temperature coefficient, this is indicated by the sign \(-t^\circ\) (see Fig. 2.3c). There are also available positive temperature coefficient \((+t^\circ)\) thermistors. In the case of these devices, their resistance increases when the current increases beyond the "normal" working current.

**PART 2 QUESTIONS**

2.1. A resistor of 10 ohms has 5mA flowing through it. What is the voltage across it:
   a) 0.5 volts 
   b) 5 volts 
   c) 0.05 volts?

2.2. 250 volts is applied across a 10,000 ohm resistor. How much current will flow:
   a) 2.5 amps  
   b) 25mA  
   c) 250mA?

2.3. How much power is dissipated by the resistor in the previous question:
   a) 6.25 watts  
   b) 0.825 watts  
   c) 25 watts?

2.4. What value is a resistor with the colour code yellow, violet, red:
   a) 47 ohms  
   b) 4700 ohms  
   c) 270,000 ohms?

2.5. What colour code will a resistor of 150,000 ohms have:
   a) brown, green, yellow  
   b) brown, green, orange  
   c) yellow, green, black?

**PART 1 ANSWERS**

1.1. b) 1.2. d) 1.3. c) 1.4. b) 1.5. b) and c)
THE BIRTH of electronic sound generation was probably around the time of the early valve-operated radios, which succeeded the old “cat’s whisker” crystal sets. The use of electronic vacuum tubes, or valves, brought with it the property of amplification, which is the boosting of the minute signals from the radio aerial. With amplification came the possibility of feeding back a boosted signal in order to further boost the overall result. An adjustable control was provided so as to allow accurate feedback to be set such that the maximum boost would occur, without overdoing it and causing over-feedback which resulted in oscillation.

Over-use of the “reaction control” as it was known, caused all manner of squeaks and whistles to emerge from the then-popular horn loudspeaker! Enter the new age of electronically-produced “music”, as the earlier version of the audio oscillator was born.

ELECTRONIC ORGANS

It was not long before oscillators were used to produce the basic tone generators of the first valve electronic organs. These used a bank of twelve such oscillators, each of which produced one note of the top twelve notes of the organ keyboard. (Twelve notes comprise one chromatic octave, i.e. including sharps and flats or “black” notes). The remaining octaves were derived, note for note, by dividing the frequency from each oscillator by a factor of two to produce a note exactly one octave lower. For instance, top C frequency would be divided by two to produce the note C one octave lower.

So the tone generation section was built up to include twelve oscillators and one divider per oscillator for each octave below which the keyboard or keyboards spanned. The oscillators and divider stages were left powered and running at their own particular frequencies continuously, and their various outputs selected as required by the depression of a key or keys on the keyboard. This requires at least one wire per key and often more in some designs.

A basic organ schematic is shown in Fig. 1.1, in which it will be seen that the oscillators feed signals to their respective dividers, from which a large number of individual signals emerge, one for each note of the keyboard (or keyboards). Sometimes these signals are switched direct by the keyboard, but in this example gating circuits are shown which do the switching electronically, which is more common nowadays.

The signals “chosen” by the depressed keyboard keys are commoned on to a single line in the diagram, but often these are fed out on a separate line per octave for reasons we need not worry ourselves at this point. The selected notes are fed to a Tone Forming circuit. The purpose of this block is to add the desired quality of sound which would be absent were we to listen to the “raw” signals produced by the oscillators and dividers.

In actual fact, the waveform of the dividers and oscillators is normally a squarewave, which is the shape shown in the diagram. If this shape is amplified and reproduced in a loudspeaker, it is similar to the sound of a clarinet. Obviously, it is not desirable for our organ to sound like a clarinet all the time, or any other single instrument, for that matter. So the squarewave signals are passed to the Tone Forming circuits for modification.

The circuits in this block perform various forms of modification on the signals fed into it. Each circuit is designed to modify a squarewave to produce a more complex waveform which will resemble a different instru-
SYNTHESISER PRINCIPLES

So much for the very basic principles of electronic organs. Now for the very different philosophy of synthesiser design. For the purpose of this series we shall restrict our dealings with the monophonic synthesiser, which is the design which is played one key at a time only. The polyphonic types are currently very expensive and use many of the electronic organ principles.

One of the most striking differences between the electronic organ and the monophonic synthesiser is the latter's comparative simplicity of design; at least so far as a comparison of the schematic diagrams of the two instruments is concerned. The actual circuit design of the component blocks of the synthesiser are by no means simple, as very high accuracy of performance over wide ranges of use must be maintained.

OSCILLATORS

In the synthesiser we do not use twelve oscillators, running all the time irrespective of whether they are being used at any one time. Instead, we use one or more (generally two or three) oscillators, which are designed to be very versatile. Each oscillator is made to respond to a certain voltage applied to its "voltage control" input.

The frequency, or pitch of signal created by the voltage controlled oscillator is accurately related to the voltage applied. In order for this to be possible, it is necessary for the oscillator to be widely variable, instead of being fixed at one pitch, as in the case with each oscillator in the organ.

RESISTOR LADDER

In Fig. 1.2, it is shown how the voltage controlled oscillator is controlled by the keyboard. A chain or ladder of resistors is connected in series between the positive and negative terminals of a source of direct current voltage. A current flows through each resistor, and a portion of the total supply voltage appears across the ends of each resistor. If each resistor is the same ohmic value (same resistance value), then the voltage developed across each will be the same.

Suppose the voltage across each resistor were 0.1 volt, then, starting from the bottom resistor, the first junction of resistors would have 0.1 volts on it, the next one up would have 0.2 volts, the next 0.3 volts and so on.

To each junction of resistors is attached one end of a pair of switch contacts operated by one key of the keyboard. The other ends of the contacts are commoned together and taken to the voltage control input line of the voltage controlled oscillator.

Now, if the bottom keyboard switch is operated, the voltage control line of the v.c.o. (voltage controlled oscillator) is connected to the first resistor junction and 0.1 volts is applied. Similarly, the operation of any of the other keyboard switches will result in a different voltage being applied. Hence, for each key, a different voltage, and a different pitch from the v.c.o.

Notice the outputs from the v.c.o. Three different outputs are shown in Fig. 1.2, though in some designs others are possible. The shape of the waveform differs at each output, but its pitch or frequency does not.

The pitch of all three outputs depends, as stated earlier, upon the voltage applied at the v.c.o. input, but the shape, or tonal quality of the three outputs are different.

The smooth-looking shape at the top output gives a mellow tone, and its shape is known as sinewave. The second output shape, known as triangular, gives a less smooth sound, as may well be expected from its appearance, and is similar, but not identical to the effect on organs known as "diapason". The third output shape is a square-wave, and, as we have mentioned before, this sounds rather like a clarinet.

Already, another difference has appeared between organs and synthesisers; we do not derive our effects from a single waveform, but can have three or more at our disposal, at root, i.e. direct from the oscillators. This is not to say that we do not use any form of tone forming circuits in a synthesiser, but simply that we start with a wider base on which to create our various effects.
ENVELOPE SHAPING

Even if we are not musicians, we are able to distinguish one instrument from another, even if the same note is played on each. Why?

Well, already we have touched upon differences in quality of tone, or waveshape. This is only one way by which sounds are distinguished. Another way is the way in which the note commences, sustains, and dies away or decays. These qualities are collectively known as the envelope of a sound.

Consider first, the sound of a piano note. As the internal hammer strikes the strings (there are more than one per note, each tuned to the same pitch), the sound commences almost explosively, and decays away gradually if the key is held down or the sustain pedal is pressed as depicted in Fig. 1.5a. But throughout the length of the audible note period the same pitch is created. The volume or amplitude of this pitch, however, starts large, and diminishes with time. If, on the other hand, the piano key is struck and immediately released, a damper is applied to the strings and the note starts abruptly as before, but ends almost as suddenly as shown in Fig. 1.3b.

Already, we have met two different shapes of envelope. One has an abrupt beginning or attack, and a slow decay, and the second has abrupt attack again, but also abrupt decay. A third example, for good measure, would be the bowed note of a violin.

ENVELOPE GENERATION

In synthesizers, we produce envelopes, as with other effects, electronically. This involves the use of special circuits which have variable parameters with respect to time. We will consider this in more detail later.

In order that the envelope shaper circuit can perform its task, it must be informed when it is to do so. This is the instant that a key is pressed on the keyboard, a signal is sent to the envelope shaper to tell it a note is being played. The envelope shaper will have built into it the controls required to set the attack and decay rates. When a key is pressed, the attack of the envelope will be commenced from this instant. If a long attack is required, the signal from the v.c.o. will be gradually allowed to pass through the envelope shaper with increasing amplitude until full strength or volume is reached. If short attack is set, the full signal will be passed immediately through the envelope shaper.

But what about decay? Attack is easy, as we have just seen, but if we press a key in Fig. 1.2 and release it, we see that immediately the release occurs, the contacts of the key separate and the voltage on the v.c.o. input line disappears! So, with the best envelope shaper in the world, if there is no signal to apply a decay shape to, we cannot shape it.

What we need is some way of telling the v.c.o. to stay oscillating after any key is released, and to remain sounding that note for some time afterwards, but to change its pitch immediately any other note is pressed. This circuit is not an unduly complicated device, thanks primarily to the facilities offered by the v.c.o. design. The circuit, known by function as pitch memory is called in electronic terms a "sample and hold" circuit. It is placed electronically between the keyboard pitch selection line and the input of the v.c.o., and its basic function is to use a capacitor which charges up to the voltage selected by a keyboard switch. When the switch is released, the capacitor charge remains, and, via a special circuit, holds the v.c.o. input line at the same voltage until it is "told" to change to a new value by the depression of another key.

PORTAMENTO

A useful spin-off from the use of the sample and hold circuit is the simple inclusion of another valuable function, known in musical terms as Portamento. When portamento is applied, instead of the pitch memory changing the voltage at the v.c.o. from one value to another as a new note is pressed, the change is made variable in velocity, i.e. the note will "slide" from the last note played to the next played.

Fig. 1.4 shows a schematic of all the facilities discussed so far. The envelope shaper is triggered simultaneously with the application of a voltage to the pitch memory, by means of a second contact on each key of the keyboard. These contacts...
are known as the envelope control contacts. In Fig. 4 they are connected to the positive voltage line and are all commuted at each end, so that operation of any one will connect the envelope control line to the positive rail, telling the envelope shaper circuit when to start shaping, and when to start decaying the signal. Other refinements can be incorporated into the envelope shaper, such that the decay can start before a key is released, but the same basic principle applies.

FURTHER COMPARISONS

Having considered the basic circuits in a synthesizer, a further comparison with electronic organs would not be out of place. Our simple organ circuit did not consider envelope shaping. This is because few organ manufacturers find it economical to provide very much in the way of shaping.

Sustain is often supplied, but in a conventional organ design, this means providing a separate decay circuit for every note of the keyboard! Admittedly, the circuit is not as complex as our envelope shaper in the synthesizer, but it must be provided in bulk!

Again, attack can be provided in organs, but where provided it is generally either present or absent, as set by a switch, and attack is normally restricted to a very short relative time.

Portamento on organs is rare or non-existent. Sometimes a glide facility is provided, which gives a smooth flattening of the played music, of at best about a semitone. Portamento in a simple synthesizer can be applied simply by making the pitch memory capacitor charge slowly through a variable resistor!

Another feature offered by most organ manufacturers is vibrato. This is the continual variation in pitch of all notes, and is achieved in organs by applying a relatively slow sinewave to each oscillator to change its pitch up and down alternately by about half a semitone each way. In the synthesizer this is achieved in much the same way by applying a low-frequency sinewave to the keyboard resistor ladder such that it is varied or “wavered” up and down by a small amount. In fact, it may be made more than a small amount if desired, so as to give special effects.

In short, the use of oscillators which are voltage controlled allows many things to be done. As will be seen later, oscillators are not the only circuits which can be voltage controlled, and the use of this principle in synthesizers has created the tremendous versatility which we associate with them.

To be continued
There have in the past been a number of articles published in the model and home electronics press on the subject of radio control, these have always tended to be either parts of the system or ideas on which a constructor can base a system. These systems have then suffered a further disadvantage in that they are not usually suitable for model aircraft.

What is to be described during the next few months is a radio control system of up to seven channels complete with all the necessary trimmings, which will be capable of being used in aircraft, cars and boats to name the three basic sides to R.C. modelling. Technically the system should be comparable with, and in some cases should be superior to, anything available on the market both in kit and ready-built form and therefore if constructed correctly should give many years of good service.

The EE Radio Control System is constructed mechanically around parts which are commercially made for the R.C. industry and are also readily available to the home constructor. Electrically the system is constructed on printed circuit board and makes use where possible of integrated circuits to make construction as "fool-proof" as possible. All these components should be available from sources advertising in this magazine.

The equipment comprises the following units:

- Transmitter
- Receiver
- Servos
- Speed Controller
- Field Strength Meter
- Battery Charger

Total cost for entire system: £170 approx. A comparable commercial equipment would cost £225 plus.

LICENCE
Before going on any further the constructor should be made aware of the law concerning the use of radio-control equipment. As in the case of all transmitting apparatus a licence is required before the equipment can be used, this can be obtained from: The Home Office, Radio Regulatory Dept., Waterloo Bridge House, Waterloo Bridge, London S.E.1, and costs £2.80 for five years which at 56p a year is cheap at twice the price!

SYSTEM CONCEPT
When designing an R.C. system there are many considerations to make, especially concerning the transmitter, as to the type of circuit to be used. Amplitude or frequency modulation (a.m. or f.m.) for instance. In this case a.m. was chosen because of its longer development and "track" record.

For radio control purposes f.m. is still very young and has not as yet, in the opinion of the authors, lived up to manufacturers' claims in terms
PART ONE

INTRODUCTION & TRANSMITTER DESCRIPTION

THE TRANSMITTER

The complete circuit of the transmitter appears in Fig. 1.3. It will be seen that this is composed of four sections: Channel Switching, Encoder, R.F. Stage and Power Supply.

CHOICE OF ENCODER

The object of the encoder is to 100 per cent modulate the r.f. circuit with a series of pulse widths varying from 1ms to 2ms dependent upon the position of the sticks on the transmitter.

In starting to design the encoder many things were taken into consideration and it was decided to make the encoder as versatile as possible. Two functions were considered vital: (i) the ability to easily reverse the effect of stick movement on the pulse width, for example increasing instead of decreasing pulse width when the
stick is moved in one direction; (ii) the ability to easily reduce the pulse width variation with stick movement. Although this second feature was not put on the prototype details are given on how to facilitate the feature.

This second consideration is very useful when learning how to fly because a novice always tends to over-steer at first which always ends up in the initial and usually expensive crash. Another useful use for the reduced throw is in cars and boats where during a race a minimum amount of movement is required to complete a course at speed, yet at slow speed a lot of movement is required to manoeuvre around.

Most existing commercial systems use a multivibrator driving a series of half-shots the pulse widths of which are controlled by the stick positions. This type of encoder is very difficult if not impossible to arrange such that the two main facilities now required can be incorporated. The half-shot method is also vulnerable to temperature and supply voltage changes and is also non-linear due to it relying upon a $CR$ charging curve, the curve being its disadvantage.

With the advent of cheap integrated circuits it now becomes possible to design a very versatile encoder which will now be described in detail.

**LINEAR RAMP ENCODER**

Fig. 1.2 is a schematic diagram of a linear ramp encoder. This is a simplified version of the final circuit (Fig. 1.3) and uses identical component references. The eight-position switch $S$ however is in reality an electronic device (IC1) as explained later. This switch scans around the potentiometers attached to the control sticks, remaining at each position until the pulse is complete. IC5a forms an
inverting buffer amplifier between these potentiometers and the comparator IC3c.

The capacitor C6 is allowed to charge up from the constant current source I until the voltage is the same as that at the output of IC3a which in turn, as explained, is dependent upon the stick position. This voltage is detected by IC3c and inverted by IC3d causing TR2 to turn on and discharge C6.

Once the voltage on the capacitor drops below the output of IC3a, TR2 is turned off and C6 allowed to charge up again. The time delay through IC3c and IC3d is long enough to ensure that C6 is fully discharged before TR2 turns off. The capacitor therefore is constantly discharged and allowed to charge up to a voltage dependent upon the stick position: thus as this voltage varies so the voltage to which C6 charges varies and as a result the time between discharge pulses varies.

Each time C6 is discharged the switch S is caused to step on to the next position. It can be seen therefore that the time between successive discharges will depend upon the voltage on each successively selected stick potentiometer, thus producing a series of pulses the widths of which are governed by all the control stick positions in sequence.

SYNCHRONISING PULSE

In order to synchronise the receiver (described later) it is necessary to have a long pulse between each set of control pulses. This is produced by arranging an eighth position to S which switches in a voltage such that the output of IC3a goes very high causing the capacitor C6 to charge to a much higher voltage, so producing a much longer pulse than the normal control pulses.

IC3b detects when C6 is discharged and produces a narrow pulse at its output. This pulse is used to both sequence S and drive the r.f. modulator to produce a correctly coded radio signal.

CAPACITOR TYPE

In practice the type of capacitor used as C6 was found to have a great deal of effect on the circuit performance. After looking at a variety of types, both electrolytic and non-polarised, the best performance was found to be from polyester capacitors, so for best effect a capacitor of this type should be used.

Fig. 1.4 shows the waveforms to be expected at various points in the encoder.

ELECTRONIC SWITCH

The switch used to look at each voltage in turn is a CMOS analogue switch IC1. This is a device which is dependent upon the digital binary code appearing on pins 9, 10 and 11, will present the signal appearing on one of the inputs on to the output "A" (pin 3) with an effective resistance of 300 ohms.
The code appearing on pins 9, 10 and 11 is changed by the counter in IC2 being clocked as already mentioned by the output of IC3b so as to present the next channels in sequence on to the output.

VR1-VR6 represent the six stick potentiometers whilst R1, R2 and R3 form the resistive network required for the switch channel (S1). R11 is the resistor used to set the sync pulse width wider than the remaining channel pulses.

**CONSTANT CURRENT SOURCE**

The capacitor C6 is charged from the constant current source formed by TR2, TR4, R21, R22, VR7, D2 and C7. The reference Zener diode D2 is an accurate voltage source over wide temperature and current variations and forms the heart of the current source. TR4 is used purely to cancel out any effects caused by the Vbe of TR2. VR7 varies the current to enable the centre pulse width to be set up on all channels.

**STICK POTENTIOMETERS**

As mentioned previously one requirement of the system is to be able to change round the potentiometers on the sticks without affecting the neutral position. This is achieved by arranging that the pot wiper is in the centre of the pot. when the stick is in the neutral position, thus causing no change in the voltage on the wiper of the potentiometer when the connections are reversed and therefore maintaining the same neutral pulse width whichever way round the pot. is connected.

The second requirement was to be able to reduce the effect of the stick movement on the pulse width. The change in pulse width with stick position is governed by the gain of IC3a. The gain is the ratio of R14 to R13. R13 ensures that when the pot. is in the neutral position the output of IC3a is at the same potential as the pot. wiper.

**REGULATED SUPPLY**

To ensure the accuracy of the voltage seen at the wiper of the stick pots the sticks have to be set across an accurate voltage supply. This is achieved by the shunt regulator D1, R17 and C5. Again this uses an accurate Zener reference D1 to maintain a good performance over temperature and supply voltage changes. This regulated supply is also for the reference voltages on IC3a and IC3b.

Because of the possibilities of r.f. being picked up on the encoder there is a buffer stage made up of TR1, L1 and R18 to block any stray r.f. Point "C" then becomes the output to the modulator section.

**MODULATOR**

TR6 is the modulator transistor which is used to 100 per cent modulate the P.A. stage; it is driven by the signal "C" from the encoder section. C9 slows down the edges of the modulation envelope thus reducing spurious radiation caused by sharp switching of r.f. signals.

**R.F. SECTION**

The requirement of the r.f. stage is to produce a stable 27MHz signal capable of operating on 25kHz spacing between channels with as little as possible (and preferably none at all) radiating interference on other r.f. bands. This r.f. signal then needs to be modulated with the relevant encoded information from the encoder section.

The stable 27MHz signal is produced by the crystal oscillator TR5, R4, R25, R26, C6 and L2. The output of the oscillator is then tuned by VC1 and L5. This series-tuned circuit serves a second function in tuning the input of the power amplifier TR7 and so making for a more efficient stage.

The power amplifier TR7 is a standard Class C r.f. amplifier with L4 as a collector load. R31 is introduced to reduce the Q or "goodness" of the load L4, thus avoiding any instability in the P.A. stage.

**TUNED OUTPUT**

The T network of the P.A. stage formed by L5, L6 and VC2 serves two purposes. First it enables the output impedance of the P.A. stage to be matched to the impedance of the aerial in use; second it filters out any harmonics which may be present in the r.f. signal. C10 is introduced to provide a d.c. block to the aerial to avoid excessive d.c. currents flowing should the aerial become accidentally shorted to the transmitter case or even ground, for instance when the transmitter is left switched on on damp grass.

Fig. 1.5 shows the relationship of the modulator envelope to the incoming encoded signal "C".

**POWER SUPPLY**

The whole of the transmitter circuits run off a 9.6V nominal voltage battery supply. To enable the state of
HOW IT WORKS

The EE Radio Control System is a pulse proportional system utilising the 27MHz radio band. Like all forms of remote control the idea is to transmit information from one place to another in order to control some function and in this case control model, whether it is a car, boat or aircraft.

The information starts out as a voltage across a potentiometer connected to the control sticks. This voltage is then converted into a digital pulse whose width is proportional to the voltage. Several of these pulses are grouped together into a series pulse train, one for each function to be controlled, and the whole train is repeated 50 times each second to enable changes in information to be quickly transferred to the model.

With the information now in digital form, it is then transmitted by the radio waves to the receiver by the switching on and off of the carrier wave (amplitude modulation). The radio waves are received by the receiver in the same way as a normal domestic receiver and then the pulse train is fed into a decoder where the pulses are split up into their individual channels. Each pulse now goes into a servo which converts this variable pulse width into the physical movement of a control arm which can then be used to move a particular control function of the car, boat or aircraft.

CHARGING

Charging is accomplished by connecting to pins 2 (earth) and 3 (+ve) of the DIN socket, when the set is switched off, and passing a constant current through the cells. More details of this will be given when the charger is described later in the series.

Another facility on the set is to be able to use an external power source by connecting to pins 2 (earth) and 1 (+ve) on the DIN connector. This was used by the authors to enable the transmitter to be used for long days on the flying field where the five hours to be expected from the internal batteries was not sufficient.

Switch S2 must be set to “off” when using an external power supply, otherwise the internal battery will be “on-charge”.

HOW MANY CHANNELS

The system as already described has seven channels, so the components list shows the components required for all seven channels. However, depending upon your requirements (and pocket) you can in fact build any size of system from two channels up to the full seven channels.

Next month we will be describing how to construct a transmitter covering from two to seven channels. In the intervening period you can make up your mind on your system size and purchase the required parts.

In order to help you Table 1.1 shows some of the many channel configurations available and the required sticks. When deciding upon the system size do not just judge upon your present requirements but try and plan for the future as modifications later on can be very messy and untidy. We ourselves strongly advise the full system as this should see you through a good few years service and give you good value for money.

Next Month: Building the transmitter

TABLE 1.1.

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<th>No. of Channels</th>
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</table>

Everyday Electronics, November 1979
LETTERS

Great Interest
I am writing this letter to express my thanks to your great magazine (EE). I started to buy EE two years ago, and when I received my copies I read them with great interest but deep down I didn't understand a word of the scientific jargon, but within the two years of reading EE I have become familiar with most of the Electronic World. Including the Microprocessor and I have already built a Labcentre designed to my needs. So I thank you for the knowledge I now possess.

S. Barton, Spalding, Lincs.

Sound Division
I have built your Sound-to-Light Unit with 3 Channels.
I thought that you may be interested to see how I divided my frequencies; bass, middle and treble, see Fig. 1. Thank you for a most interesting magazine.

M. A. Garty, Bristol.

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JACK'S WATER LEVEL INDICATOR IS A GREAT SUCCESS!

WE ALWAYS KNOW WHEN THE LEVEL OF THE WATER HAS REACHED...

...THE WINDOW SILL

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Crossword No. 21—Solution

I live in an area of strong signal strength, but the radio still gives a poor performance. I decided, therefore, to use an external aerial—30ft piece of gash co-ax cable. This can be plugged in to the radio when it is used in my bedroom. (A 0.1 to 0.22µF capacitor was placed between the aerial and the tuning capacitor). The radio now gives a much better reception than before. I hope this information may prove useful to other readers.

K. P. Holohan Preston, Lancs.

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Crossword No. 21

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<td>TUSK</td>
<td>20</td>
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<tr>
<td>FLAP</td>
<td>21</td>
</tr>
</tbody>
</table>

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Hot Ferric
I have just read the excellent article on making Printed Circuit Boards (January 1979) and while I cannot fault it, I think a word of warning might not be out of place.
A year or two ago we produced our own Etching Kits and in the process I learnt quite a lot about Ferric Chloride. Judging by the picture in the article the Ferric Chloride used by the writer is a fairly weak commercial type, rock hard and not too easy to dissolve but it has the advantage of having no heat problems.
There is on the market to-day quite a big quantity of Ex-Government, pure anhydrous Ferric Chloride which is almost a different substance. It is usually double packed in thick plastic and double sealed. It has the appearance of dark brown ground coffee and it is much stronger. About one half a desert spoonful (plastic or course) would make enough etching solution for several boards. Its one drawback is that it produces intense heat in contact with water. We advise custumers always to add the crystals to the water a little at a time, and not the other way round.
To give you a rough idea of the heat generated, if you add something less than two desert spoonfuls to a jam jar, one third filled with water, by the time the last of the crystals has been added the water is very hot to pick up. Another odd side effect we found, and that is, if you make the solution a little too strong, no etching will take place.
Although it is always looked upon as poisonous and corrosive and should always be treated as such, you may be surprised to learn that it was used for water purification by the American forces.

M. A. Garty, Bristol.

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Better Reception
I have just completed the construction of your Pocket Radio, shown in the June 1979 issue. I have found the performance was very poor, the volume control having little effect on the volume being produced.
I narrowed this problem down to C4, value 10µF, this takes several seconds to charge up and therefore is too large. I replaced it with a smaller 0.1µF non-electrolytic capacitor. This enables the volume control to be used to the best of its ability.
76 College Road, Bromley, Kent BR11DE.
BIG REWARDS FOR MICRO IDEAS

Three announcements this month (September) help to highlight the efforts being made to get to grips with the microelectronics revolution.

BRITISH MICROPROCESSOR COMPETITION

Suddenly everyone can get into the microprocessor scene, yes even amateurs, by entering the British Microprocessor Competition organised by its joint sponsors—the National Research Development Corporation (NRDC) and the National Computing Centre Limited (NCC). Their aim—to stimulate and encourage British innovation in the use of microprocessors in any type of product, process or service. This is a competition for the best invention incorporating a programmable microelectronic device.

Prize money totalling £20,000 will be awarded to entries, with working models, and those without a working model. First, second and third prizes in the working model category are £10,000, £5,000 and £2,000 respectively, whilst first and second prizes in entries without working examples are £2,000 and £1,000.

The competition is open to all individual residents in the UK, including UK registered companies, and other organisations located in the UK such as universities, polytechnics and other institutions engaged in education or research. The NRDC and NCC staff will judge the competition with 4 main criteria in mind—the degree of novelty, its potential commercial value, the technical and commercial viability and the standard of documentation. Although the winners names will be announced next year their ideas will be protected; publication only taking place when patent protection exists. All rights are protected for the designer and there is no obligation for further involvement by either party.

The NRDC, which this year celebrates 30 years of idea development, have indicated their willingness to look at non-winner ideas along with the winners inventions with a view to offering financial support to develop them. A sum of half a million pounds has been allocated to provide just this backup!

The closing date of the competition is Friday, 14 December 1979 and official Entry Forms and details are freely available from The National Computing Centre, Oxford Road, Manchester M1 7ED.

International Prestel

The British Post Office is to test-market an international Prestel service for travelling businessmen and government officials.

The trial is planned to last a year and will cover selected users in up to six countries. If there is sufficient interest the international service will be additional to the UK national Prestel service.

YOUNG ENGINEER FINALS

HRH The Prince of Wales will present the "Young Engineer for Britain 1979" awards at the national final to be held at the Wembley Conference Centre on October 25.

A record entry of over 300 youngsters with some 180 projects joined the trail to become "Young Engineer for Britain 1979". Following regional finals which were held around the country during June and July, 38 projects have been selected to appear at the national final. These cover a wide range of applications from a wind tunnel to a leaf raking machine and from a signature reproducing machine to an emotionally active robot.

NATIONAL MICROELECTRONICS COMPETITION

A rent-free £30,000 factory for one year is one of the inducements being offered by the Peterborough Development Corporation in the National Microelectronics Competition.

The aim of the NMC is to find ideas which are simple to manufacture and have got a ready market. Top prize is £4,000 and the only restriction is that no company with a turnover in excess of £2 million may enter. The challenge is to prove that the application is technically sound and that it can be produced and sold at a profit.

The Corporation, with the sponsorship of Barclays Bank and Finance for Industry, offers apart from the new factory, the prospect of £250,000 venture capital from Finance for Industry.

Closing date for the National Electronics Competition is 31 January 1980.

REGIONAL HELP

Another local authority promoting interest in microelectronics is the Lothian Regional Council of Scotland. They plan to fund a micro aid plan to the tune of £350,000 over the next five years, which they hope will bring microelectronic technology to companies in the area.

This initiative will bring the Edinburgh University Wolfson Microelectronic Institute directly into contact with local firms regardless of their level of technical knowhow. They also hope that local schools and polytechnics will become involved.

Part of the £700,000 per year investment will go towards setting up a new professorship of microelectronics at Edinburgh University and also to fund three high level engineers, who will seek potential applications of microelectronics. The engineers will approach companies rather than wait for potential micro users to make the first response.

On the Air

Europe's largest supplier of mobile radio, Pye Telecommunications Ltd., recently made known its views on the subject of CB radio.

In the event of the Government deciding in favour of CB, they feel that the U.H.F. frequency band would be the most appropriate. They argue that U.H.F. is more suitable for the high population density of the UK.

The use of U.H.F. prevents interference with hi-fi, television, radio and other electronic devices. It will also avoid harmonic interference into other users of the spectrum, police, fire, ambulance services etc.

Predictable range and channel re-usability is possible with U.H.F. Using U.H.F. gives high quality transmission and reception.

Finally, selection of the U.H.F. band would avoid the problem of the reallocation of existing users, model control, which would make 27 MHz CB slow and costly to implement.

Boss sells Boss

Having built up Boss Industrial Mouldings Ltd., into one of Europe's largest manufacturers of enclosures, indicators, breadboarding systems and other hardware products, Ian Boss has formally sold all his interest in the organisation which now becomes part of the Pistor Elektrotechnik Group of West Germany.
The Engineering Famine

Despite relatively high unemployment figures there is a serious shortage of engineering staff. Earlier this year GEC alone had vacancies for 1,600 engineers, 1,100 technicians and 800 craftsmen. Those training now for the electrical and electronics professions and trades need never be out of work.

The Filling in the Sandwich

There are many big producers who are not mass producers, but batch producers of many different products. A batch may be half a dozen units or fifty or so. They may be for specific customers with different delivery dates. Individual finished units may need to be married up into a system and tested as such before shipment. The number of different units being made at any one time may run into hundreds.

This is the sort of manufacturing operation undertaken at Hewlett-Packard's minicomputer factory at Grenoble, France. Cyril Yansouni, the plant's general manager, had quite a problem in getting the right mix of skilled hands. He already had those two indispensables, computer technicians and 800 craftsmen.

GEC alone had vacancies for 1,600 engineers, 1,100 technicians and 800 craftsmen. The demand for technicians, assembly and testing.

Over 1,200 products a week pass through the production lines. Each is given a traveller card which stays with it at every stage. The terminals have two slots, one for a badge reader which identifies the person using it, the other for the traveller card which carries data about the product, what it is, who has ordered it etc. Date and time of arrival in a department is automatically transferred with the rest of the data to the central computer.

The result of the exercise is that production is speeded up and bottlenecks eliminated. At the same time the cost of components being worked on along the lines has been cut by about £1 million despite the factory output having doubled in two years.

Nobody is working any harder than they did before. And nobody is losing his job. In fact they are planning to expand the work-force from 500 to 800 people in the coming year.

Of this increase is due to the data capture terminal which H-P is now marketing. Over a thousand will have been made and shipped to other manufacturers with similar problems by the end of this year.

Brian G. Peck.

Video News

Firm evidence of the growth of electronic news gathering and associated technologies in Europe is provided in the latest contracts placed with Sony Broadcast Ltd.

During the past six weeks orders totalling some £255,000 have been placed for Sony video recording equipment by the State Broadcasting organisations of Austria, Italy, Poland and Switzerland.

A specialist Viewdata Exhibition for information providers and others professionally engaged in using and operating viewdata and teletext systems is to be held at the West Centre Hotel, London, on November 7-8.

UK-USA Phone Cable Gets Green Light

The final seal was placed on an international agreement recently for a new £100 million telephone cable between Britain and the USA that will boost Britain's transatlantic cable links by more than 50 per cent.

At present more than 20 million phone calls are made each year between the UK and USA, and more than half go by cable. The demand for telephone service between the two countries has been growing by a steady 15-20 per cent a year throughout the 1970s and shows no sign of slackening.

Called TAT 7, this giant submarine system, with a capacity of 4,200 simultaneous connections, will carry phone calls, computer data and telex messages between Europe and the USA and Canada. A sizeable part of its cost will be spent in Britain on cable manufacture.

The new system is due to come into service in 1983. It will run some 5,400 nautical miles between Porthcurno (Land's End) and Tuckerton, New Jersey. At the British end it will continue for some two miles inland, terminating at the Post Office's Land's End repeater station.

The cost of the project is being divided equally between North America and Europe. On the European side, Britain is partnered by 17 other participants and her share—22 per cent of the total—is the largest of all those. There are seven participants in the project on the North American side, including the American Telephone and Telegraph Company which has the largest single share in the system, amounting to some 40 per cent of the total.

Manufacture of the new system will be shared between the USA, Britain and France. About 2,700 miles of cable will be made in Britain by Standard Telephone and Cables Ltd, under a contract worth some £30 million.

Looking Back

A 20 page booklet to mark the 50th anniversary of the formation of Pye Radio Ltd., is now available, free of charge, to readers on application to Pye Ltd., Publications Dept, 137 Ditton Walk, Cambridge.

The Story of Pye Wireless traces the history of Pye Receivers from when they were originally produced by W. G. Pye & Co. Written by Gordon Bussey the publication is illustrated with photographs of receivers from 1922 onwards and scenes in the Pye factory early years.

Breadboard '79

This year's Breadboard '79, the kits and bits show for the home electronics enthusiast, has moved to larger premises.

The venue is the Royal Horticultural Halls, Elviroton Street, Westminster, London, SW1, from 4 December to 8 December inclusive.

Over 90 exhibition stands will feature micromercomputer systems, analysers, logic test accessories, hi fi amplifier kits, as well as a varied range of construction kits and TV games.

Everyday Electronics will be there.

MOBILE JAM

Mobile radio channels have become so congested that the Home Office is to conduct trials with single sideband transmission with 5kHz channel spacing. Present channel spacing with frequency and amplitude modulation is 12-5kHz or 25kHz.

SSB could double the number of channels usable with no interference, thus allowing for considerable expansion of the mobile services used by businessmen and other organisations.
This piece of equipment has been devised to allow sounds generated in one place to be heard in another. In particular, from one room where a baby or child is situated to another, such as the bedroom or lounge occupied by the parents or baby sitter. The unit uses a microphone to pickup the sounds and these signals are amplified to produce the same sound in a loudspeaker mounted in the control box.

The Baby Alarm is completely safe, and the child is in no danger if he/she “acquires” the unit. The alarm is powered by a single PP3 9V battery and is economical, quiescent current being approximately 2.5 milliamps.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Baby Alarm is shown in Fig. 1. Signals generated in the crystal microphone insert MIC1 are passed to a high impedance buffer amplifier TR1, and f.e.t. wired as a source follower. This stage provides no amplification, but is included to provide low loading on the crystal microphone which is essential for a flat frequency response.

The effect of high loading on such a microphone is to provide a very "tinny" effect. Not entirely essential for specified application, this stage does however allow the circuit to be used in other applications where clear speech is required, e.g. an intercom.

The output from the source follower appears across VR1 used as a volume control, and from here to IC1, connected as a non-inverting amplifier. Resistors R6 and R7 provide the necessary biasing for an op-amp operating from a single power supply. Gain is approximately equal to the ratio of R5 to R4 i.e. 1000. The output signal is fed to and heard in LS1.

CONSTRUCTION

The prototype unit used a piece of 0.1 inch circuit board size 20 strips x 30 holes. The uppermost five strips are not used electrically but provide space for mounting screws. The prototype used self-adhesive horizontal mounting strips in preference to fixing nuts and bolts.

The layout of the components on the topside of the board and the breaks to be made along the copper strips on the underside are shown in Fig. 2.

Begin by soldering in the wire links followed by the resistors and capacitors. Take care when soldering in the f.e.t.s as these can be easily damaged when being soldered. Use of heat-shunts is recommended. F.e.t.s can also suffer damage by "leaky" irons. A couple of turns of tinned wire wrapped around and shorting all leads during soldering will prevent such damage. Remember to remove the wire afterwards. Finally position and solder in IC1.

Sufficient lengths of flying leads should next be connected to the board. A short length of
Fig. 2. The layout of the components on the stripboard and the breaks to be made on the underside of the board; also shown are components mounted to the case and position of battery and circuit board on base panel and full inter-wiring. Bottom right shows mounting of microphone in case and connection to phono plug via screened cable.
screened lead to connect to the input socket SK1 was used in the prototype, but this is not essential.

CASE

The author used a plastic box to house the unit, approximate dimensions 150 × 75 × 45mm. The case was used “inverted” so as not to show any panel fixing screws. The intended front panel is used for the base panel to which the circuit board and battery are fixed. The latter was secured with a self adhesive foam pad.

Prepare the box to accommodate Si, VR1 and SK1 and drill a pattern of holes above where the speaker is to be positioned to allow the sound to escape and reach the user.

In the prototype the speaker was glued in position using a polystyrene glue. Fix the components and wire up to the board as shown in Fig. 3.

The base panel (lid) can now be secured, and rubber feet fitted for good measure.

MICROPHONE

The microphone is mounted in a smaller plastic box (inverted as before). Drill a pattern of holes above MIC1 position and glue the latter in place. Solder sufficient lengths of screened cable to MIC1 to join the two boxes in their final positions. The cable should pass out through a gripping (or strain relief) grommet and terminate in a plug to match SK1.

TESTING

Plug the two units together and switch on. A click should be heard in the loudspeaker. Turn up the volume control. If the two boxes are less than about a couple of metres apart, a feedback howl will be heard. With the microphone at a distance from the control box, a sound source such as a portable radio placed near the microphone will be heard in LS1. Turning VR1 clockwise should increase the volume.

Remove the sound source. A small amount of hissing may be heard with VR1 fully advanced. Hum was absent on the prototype. Handling the cable will produce noise; for this reason the cable should be firmly secured when the unit is finally fitted.

If all is well the units may be fitted in their respective rooms and can either stand on any flat surface or be mounted on the wall, the latter suiting the microphone, keeping it out of reach. A single “keyhole” cutout on the back panel will allow single screw fixing.

By a suitable switching arrangement, two microphones and two speakers, the Baby Alarm can be converted to function as a two-way intercom.

COMPONENTS

- Resistors
  - R1 4.7MΩ
  - R2 390Ω
  - R3 10kΩ
  - R4 100Ω
  - R5 100kΩ
  - R6 10kΩ
  - R7 10kΩ
- Capacitors
  - C1 470µF 10V elect.
  - C2 0.1µF plastic or ceramic
  - C3 0.1µF plastic or ceramic
  - C4 47µF 10V elect.
  - C5 33µF 6V elect.
  - C6 470µF 10V elect.
- Semiconductors
  - TR1 2N3819 n-channel f.e.t.
  - IC1 741 differential op-amp 8-pin d.i.l.
- Miscellaneous
  - MIC1 crystal microphone insert
  - S1 d.p. on-off rotary switch
  - VR1 22kohm carbon log. law
  - SK1 phono socket
  - LS1 miniature loudspeaker 80Ω 70mm diameter
  - B1 9V (PP3)
  - PL1 phono plug
  - Stripboard: 0.1 inch matrix, 20 strips × 30 holes; PP3 battery connector; knobs (2 off); board mounts; screened cable; grommet; cases (2 off).
SUPER PHOTODETECTOR

It is clear, on looking at prices of photodetectors (photo emissive types, photo transistors, I.d.r.s, etc.) that these devices are by no means cheap; the least expensive component I have found is the 2N5777 photo Darlington at 60p. With a little care, it is possible to produce one's own photo transistors, at a fraction of the cost.

Take a transistor in a TO5 or TO18 can, such as a BC107, and, using a fine razor saw carefully remove the top of the transistor, taking care not to squash the can (see Fig. 1). Carefully shake out any particles of metal which may have fallen inside the transistor. You will find that the innards of the transistor are now exposed to the environment, and if light is allowed to fall onto the chip, you have a photo transistor. If desired, a few drops of cold setting, clear plastic resin may be poured into the can to afford some protection, but this is not essential.

Leaving the base unconnected, in fairly bright sunlight I found that a BC107 would pass 200µA. This sensitivity may easily be increased by using another BC107 transistor, the two being connected as a super-alpha pair (see Fig. 2). There should now be enough sensitivity to drive a relay without further amplification.

By this method, either npn or pnp silicon photo transistors can be made, much cheaper than the cost of a ready made device. Also, the response is very fast, better than some I.d.r.s.

Peter F. Vaughan, Lynton.

BUTTON STOP

When using twin-core (figure of 8) cable, I bind the separated ends of the cable with a small 4-holed button. This stops the split in the cable from lengthening, see Fig. 1.

A. A. Moore, Preston, Lancs.
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**CHRONOGRAPH**
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Best Electronics (Slough) Ltd., Unit 4 Farnburn Ave., Slough, Bucks SL1 4XU
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Marshall, 65 West Regent Street, Glasgow G2
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Everyday Electronics, November 1979
Test Case

Knowing the pride constructors take in the appearance of their finished projects, we make no excuse for returning to the subject of cases again this month.

Ideally suited to housing test gear accessories such as signal injectors, logic probes, small counters, voltage and resistance probes, and continuity checkers, the CTP-1 probe case from Continental Specialties Corporation comes complete with associated hardware.

Based on the case used in their LPK-1 logic probe kit it is supplied complete with a 3ft length of two-wire connecting lead with a moulded strain reliever and terminated with "croc clips", a nickel-plated screw-in probe tip, a mating tapped hex probe-tip connector, assembly screws, and a cut to size blank printed circuit board.

Also available from CSC is their latest 32-page product catalogue which features their range of circuit breadboarding equipment, logic testing devices and test instrumentation. Products featured include a range of solderless breadboards and breadboard assemblies, test clips, instrument cases, pulse and function generators, frequency counters and accessories, logic probes, logic monitors and a digital pulser.

Copies of the catalogue and further details of the CTP-1 probe case can be obtained from Continental Specialties Corporation, Dept EE, Shire Hill Industrial Estate, Saffron Walden, Essex, CB11 3AQ.

Teach-In '80

For those readers about to order components for the EE Tutor Deck and Teach-In '80 experiments, we have just heard that due to increase costs Home Radio have had to increase the price of the complete kits of parts for this project and experiments up to Part 6, to £22.50. (List A—£19.50, B—£4).

However, we understand that Greenweld and A. Marshall (London) Ltd have no plans, at the present time, to increase their published prices. Also, the following advertisers are able to supply complete kits of parts: Ace Mailtronix, Electrovalue, Magenta and Watford Electronics.

Tool sets

More renowned for their top grade soldering equipment, Light Soldering Developments Ltd. are now marketing four handy miniature tool sets.

Each set comes in a plastic case with transparent lid and the tools have chrome plated brass handles. The kits are made up of screwdrivers, open and socket spanners and cross-point screwdrivers.

The set of six instrument screwdrivers (Model. 1113), have hardened and tempered steel blades ranging in width from 0.8 to 3.8mm and retail at £2.93 including VAT. The 19 piece combination set, type 37228, consists of open and socket spanners, 5/64in to 5/16in across flats, socket head, cross head and plain screwdrivers, and a scriber and is priced at £5.12.

A set of five metric box spanners, model 37227, with a Tommy bar with hardened and tempered steel ends come in a range of sizes from 3 to 5mm at £2.93. The fourth tool set, model 37305 comprises two cross point screwdrivers, three hexagonal key wrenches (1.5, 2 and 2.5mm A.F.) and Tommy bar at £3.93.

CONSTRUCTIONAL PROJECTS

EE Radio Control System

Our star project this month is part one of the EE Radio Control System series and obviously will call for some special components. These will be described fully in the various articles.

Apart from the special electromechanical items, the majority of components should be generally available. The special components are usually stocked by local radio control shops, but any readers experiencing difficulties can order them from S.L.M. (Model) Engineers Ltd., Dept EE, Chiltern Road, Prestbury, Cheltenham, Glos, GL52 5JQ.

3-Function Generator

The only item likely to cause concern in the 3-Function Generator is the integrated circuit IC1.

We have found that the 8038 is only available from Maplin Electronic Supplies or through R. S. Components dealers.

MW/LW Radio Tuner

For the MW & LW Radio Tuner, the slow motion (Jackson '0' gang type) tuning capacitor is listed in the Maplin, Watford and Home Radio catalogues. However, the specified coils seem to be rare and only stocked by Home Radio Components.

Baby Alarm

The 741 integrated circuit used in the prototype model of the Baby Alarm was a TO-5 can type with preformed leads. The 8-pin d.i.l. plastic package is more common and readily available and can directly replace the can type.

Quite a number of readers will already possess a high impedance microphone so therefore the mic. insert could be omitted and SK1 chosen to suit your mic. plug.

The use of a rotary switch for S1 is optional and any double-pole toggle switch will suffice.

Opto Alarm

The first in our Uniboards series is a simple Opto Alarm.

There are numerous solid state buzzers on the market at the moment and it is worthwhile looking around for this item as prices seem to vary quite considerably.

The thyristor type MCR102 would appear to be only available from Maplin but the 2N5060, 2N5061 and 2N5062 types are suitable replacements.

Addresses of nearest stockists can be obtained from Light Soldering Developments Ltd., (Dept. EE), 97-99 Gloucester Road, Croydon, Surrey.
## Everyday Electronics, November 1979

### CASES—Boss Industrial

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### OPTO ELECTRONICS

#### Light Emitting Diodes, Individual

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#### Macrophone Clip 3

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### D.I.L.

#### 8 Pin Socket Set

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### MINIATURE VOLTAGE REGULATORS

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### RACK MOUNTING KITS

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<tr>
<td>BK006</td>
<td>6 Bay Kit</td>
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### SEMICONDUCTORS

#### N-Channel Power Mosfet

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### MAINS TRANSFORMERS

#### Low Voltage Regulators

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### SWITCHES

#### Single Pole Single Throw

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### ISOLATION TRANSFORMERS

#### 230V/50Hz, 2VA

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### INTEGRATED CIRCUITS

#### Capacitors

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### ELECTRICALS

#### Moulded Box and Close Fitting Flanged Lid

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- Mains Accessory Kit 1 contains 1mm, 2mm, 125” twist drills, 5 burrs and 2.4mm collet. £2.48
RUMMAGING AROUND
with Keith Cadbury

USEFUL SUCKER

O
ne of my main sources of high-quality components for stock is the “Goody Bag”. Whenever I visit my local electronics shop, I rummage in his “junk” bins and usually select a bag or two of assorted “goodies”.

Until recently the various p.c.b.’s that I had collected from these bags of components had been gathering dust. Most of the components on the boards had led too short to cut, and removing them with a soldering iron proved to be one hell of a laborious task, resorted to only in emergency, when a particular component has been needed that was not available from another source.

A recent acquisition has resulted in all the boards being stripped of 75 per cent of their components, and at a very fast rate. I now have a stock of several hundred close-tolerance resistors, items which have previously been bought only as required.

The acquisition that made it all so easy was a device called a “Soldersucker”. A sort of suction device with a Teflon nozzle, it can be primed and discharged with one hand easily, while the other hand is used to apply the soldering iron to the soldered component. The Soldersucker draws away molten solder with fantastic force that has to be seen to be believed, and after repeating the operation at each of the joints, the component can be lifted out, sometimes without the need to heat the “de-soldered” joints again.

So simple and so quick, I just didn’t realise how easy its use makes the removal of components. I would not have considered spending over a fiver on the tool, but as I have now had the chance to prove its worth at, relatively speaking, no cost (it was amongst a large “job lot” I was fortunate enough to obtain for a few quid recently) I have no hesitation in recommending its worth.

It would soon cover its cost. I have recovered, in good order, something like eighty pounds’ worth of transistors, 1 per cent resistors, integrated circuits and capacitors, with the aid of the Soldersucker.

I DREAM of an electronic house, where everything is controlled from a central position. Heating, lighting, ventilation, entertainment, security, cooking, washing and so on.

To sit in a Captain Kirk-type of armchair and to be in complete control of one’s immediate environment seems to me to be quite possible, given today’s State of the Art. And given the time and the money to make it all!

A robot to take the dog for a walk; three VTR’s always recording all TV output, recalled by ultrasonic instruction at a moment’s notice for replay on one of the many colour televisions around the house; similar audio recorders for five or six radio programmes to listen to automatically during the tending of the garden. What bliss, but for how long, before the whole caboodle becomes an absolute bore? You would get no exercise ever, and you would possibly die of a heart attack brought about by the effort of rising from your control chair to go to bed.

Nevertheless, those readers who dream of more electroney will realise the necessity of a patchboard, to alter various parameters that may need adjustment—how long grandma is allowed in the bath before the water automatically drains away; grilling times for the T-bone steaks; securing the fridge and freezer when hungry teenagers go prowling.

Even more modest projects will benefit from a patchboard—it would be an additional item of equipment that could prove very useful to the enthusiast’s audio set-up, especially where creative tape-recording is undertaken.

The patchboard described here is adequate for all projects the writer has worked on to date, and can be made at a fraction of the cost of a “bought” item.

There are many projects where a patchboard would be a useful part of the circuitry—given one hell of a lot of money to spend! For example, the Maplin catalogue price quoted for a 30 x 30 hole patchboard is £59-36p. It seems to me that my very-cheap alternative would suffice in nine out of ten applications.

Chassis mounting phono sockets are available on Paxolin boards containing numbers of sockets from one to eight, from Maplin, and work out at under 6p per socket in most cases. For example, to make an alternative to Maplin’s 10 x 10 hole board costs under a fiver, using twenty of the five-socket boards, compared with £19-55p.

I used single strands of copper wire, about 14mm thick, from a length of electricians’ heavy-duty cable, which was soldered as shown in the illustration. Careful drilling and mounting of the boards is needed to make the finished job look neat—but then care is needed with all electronic work anyway!

And that’s not all—the plugs are much less expensive also. Ordinary phono plugs cost under 10p, and can either be shorted out, or small resistors or capacitors can be connected across the terminals, inside the cover. Use plastic plugs (which are the cheapest) and devise your own colour code so that you can tell at a glance whether the connections are shorted or joined through a component. The wireable component plugs listed by Maplin for their 10 x 10 board cost 59p each, compared with 9p for my alternative!

Yer pays yer money and takes yer choice—for me, Mr Hobson dictates, prompted by the bank manager, tax collector, starving children and shoeless wife.
The legality of remote and radio control understandably confuses many people. Here are the facts in a nutshell. The Wireless Telegraphy Act prohibits the use of any unauthorised radio station. This wording covers both transmitters and receivers. So it is not only illegal to transmit any radio frequencies (such as CB radio) without authorisation, it is also illegal to receive them.

It follows that it is also illegal to use a radar speed trap detector in a car. These devices pick up police radar speed check signals and convert them into an audible alarm.

Under the Wireless Telegraphy Act it is also illegal to use a radio controlled model boat, car or aeroplane. But whereas no authorisation and licences are available to transmit pirate radio programmes or receive police radar signals, licences are available for the transmission of non-speech radio remote control signals to models and toys.

The penalty for any illegal transmission or reception, whether Citizens Band chat, radar trap avoidance, pirate radio pop music transmission or radio remote control of a toy, is the same: a fine of up to £400 and/or 3 months in jail. It is, of course, highly unlikely that anyone using a remote control toy would be fined as much as someone transmitting a pirate radio programme, but the penalty is available to a court.

Direct Link

Fortunately, because the Wireless Telegraphy Act covers only radio frequencies, it does not cover the use of ultrasonic, or infra red, or visible light, or laser light, links for remote control or other communication, even of speech and music. Thus it is perfectly legal to use links of this type without a licence. The snag is that such links are far more directional than radio links.

In Japan it is now possible to buy a gramophone turntable that contains a built-in high quality stereo radio transmitter which operates on a v.h.f. f.m. band. The gramophone signal can thus be picked up by a v.h.f, f.m. receiver anywhere in the house. So the user can install a turntable in one room and an amplifier and hi fi system in the other without any cable links. This would be illegal in the UK.

Ultrasonic or Infra red links need something close to line-of-sight relationship, so cannot offer a comparable facility. Also infra red links can be disturbed or "broken" by direct sunlight, as the sun emits considerable infra red radiation.

I recall eyewitness tales of an impressive demonstration several years ago which was set up to show-off the prowess of a remote controlled fire fighting device. The robot-like gadget was designed to sense the infra red radiation. It would immediately activate a fire extinguisher.

The demonstration took place out of doors and a can of petrol was duly ignited. It was Summer, but a dull day. Then, just as the petrol burst into a ball of flames, the sun broke through the clouds. The robot's sensor picked up the sun's infra red radiation and latched onto its direction. The gadget stopped dead in its tracks, tilted back and foosed the contents of its fire extinguisher into the sky.

Take-away Car Radio

In-car-entertainment or ICE is now big business. It's easy to pay around £300 for a combined radio and cassette player; and that's excluding loudspeakers, and extras like booster amplifiers, graphic equalisers and exotic aerials.

Understandably many motorists are reluctant to install such expensive equipment because it's akin to leaving several hundred pounds laying in the dashboard pocket ready for a thief to grab. Even worse, the thief will probably smash the door, break a window or slit your sunshine roof to get access.

Burglar alarms are one answer, but by no means 100 per cent. Another answer is that offered by car radio firm Voxson.

The Voxson Tang radio receiver, now being fitted as standard to small Fiat cars, is protected against theft. The radio is a plug-in module that the driver removes every time the car is left unattended.

The really clever part of the scheme is that they have made the removable module small enough to fit into a pouch that hangs on a key ring along with the car keys. A socket is secured to the car dashboard and as this socket contains only a single chip audio amplifier it isn't worth stealing. The tiny plug-in module contains all the r.f. and i.f. circuitry, a tuning control and a volume control. There's a separate colour-coded module for longwave, medium wave and v.h.f. reception.

Provided you remember to pull-out the module when you park there's nothing left to encourage a thief.

War on CB

I learned recently how CB helped us win the war in Africa. Of course it wasn't called CB then, but the wavelength, 27MHz was the same.

Before World War II such frequencies seemed unreasonably high. But spurred on by the impetus of war the USA, Japan and Germany all made military equipment to work on this band.

One of the characteristics of "27 meg", and indeed one of the reasons why no one wanted it for CB in the UK, is that it can skip across Continents. A signal beams up into the sky bouncing off the upper atmosphere and down to earth again thousands of miles away.

In 1942 an amateur radio enthusiast in the USA heard German conversations on his experimental 27 meg receiver. He brought in a German speaking friend who reckoned the conversation sounded like military chat between tank commanders.

The American army moved in and discovered that the signals were skipping across the world from Rommel's tanks in North Africa. They could only be picked up within a radius of a few miles and night after night the army in the USA monitored the signals from Africa and sent them back to Field Marshal Montgomery in Africa. Thus, although Montgomery was out of range of Rommel's low power 27MHz transmitters, he soon knew everything the "Desert Fox" was saying to his troops.
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Radiation Non-hazards

Events at the Kensington fire station, where in August radiation meters appeared to detect harmful levels of ionizing radiation but where it was shown by staff of the National Radiological Protection Board apparently to have been caused by harmless non-ionizing radiation from the short-wave transmitters of the nearby Israeli Embassy, have underlined once again how difficult it is for the lay public (and even the experts) to judge just what levels and types of radiation are potentially harmful.

Most scientists and engineers accept that the present officially recommended levels for non-ionizing radiation from microwave and other radio transmissions, even though set empirically many years ago, have proved remarkably satisfactory, though there still remain doubts in some minds as to possible biological effects at levels too low to cause appreciable local heating.

Contrariwise there are some grounds for thinking that low levels of h.f. radiation may even have a beneficial, preventive effect in regard to certain diseases.

Microwave Bombardment

Part of the confusion in the public mind was brought about by the much publicised "bombardment" by microwaves of the US Embassy in Moscow some years ago. Many people rushed to the conclusion that this was all a deliberate attempt to affect the health of the American diplomats.

Less well known is that it has become clear since then that threats of this kind were raised not with a Russian attempt to prevent interception of their microwave telecommunications links by receivers in the Embassy, a practice that they were themselves doing in the USA. There is considerable evidence that their embassies and consulates contain microwave aerials and receivers which can intercept telephone traffic to and from Government buildings, using computers programmed to select automatically conversations likely to be of interest.

Many embassies, of course, have h.f. radio transmitters that enable the diplomats to communicate directly with their colleagues. My daily walk to work through Belgrade takes me past several large and very prominent "log-periodic" h.f. beam arrays, while even a casual look at levels and types of radiation are potentialiy harmful.

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Marking-Out

Last month I advocated the creating of a drawing, however elementary, of the required marking-out; I also explained the reason for doing this in reverse. Let us now look at marking out, cutting, and bending a fictitious front panel. In real life, of course, you will substitute your own requirements.

Let us agree on a front panel measuring 10in by 6in, and let us work in imperial since so many of us do so in our private lives, whatever measurements we may use at work. Let us also decide that the panel will be secured to the cabinet by means of flanges 3in wide, bent inwards, and at right angles to the panel. Immediately this gives us the overall size of 11in by 7in. We cut this from a larger sheet of aluminium, or obtain it cut to size.

All four sides will, naturally, be absolutely square. We must mark out our datum lines, commencing with the two centre lines. Set the combination square to 5in and scribe a small line; likewise at 3in. Using the square, now extend the datum lines until they intersect, bang in the centre of the panel, dividing the sheet into four exactly equal portions.

The position of every hole, top to bottom, side to side, is, in good engineering practice, referred back to these centre lines, whose exact positioning is critical. So too is every bending line. Errors are thus confined to one reference line.

Now if we happily start at one end and carry on, line to line to line, errors can accumulate, possibly disastrously. Say every line is out by 25 thou., in itself a wide or a narrow limit depending on applied criteria, then six holes, or lines, later on you will be out of position by 0-025in x 6 or 0-150in. That hole or line being out of position could completely ruin the panel.

Fixing Flanges

The fixing flanges require a somewhat different approach. If you mark the panel to precisely 10in by 6in it will not fit. Why? Well, you haven’t allowed for the thickness of the metal. For a precision panel you must subtract the thickness of the panel from the bending dimensions.

In round figures let us say the panel is 25 thou. thick. So you set your combination square to 5in and 3in from the centre lines, and then as well as you are able to, you subtract 25 thou. each time, top and bottom, and both sides. Then scribe the bending lines. With decent luck you will achieve a panel that is a perfect fit. When bent!

Now we can set about the holes required. Round holes are easy; at the intersection of appropriate horizontal and vertical datum lines use a centre punch and lightly "pop" the precise point. Then use engineers’ dividers to draw the circle required. Square or rectangular holes also use the horizontal and vertical datum lines. Locate the centre of the hole then, halving the width and length scribe its limits above and below, and to either side of the datum lines.

Let me reiterate that these lines will have been scribed on the reverse side of the panel so that the outer side is unblemished when the panel is completed. Got it wrong? So have I before, and I dare say, will again.

Cutting Out Holes

Having a panel marked out, we can commence cutting out the holes. There are various tools on the market designed to facilitate this chore. Let us however confine ourselves to easily and cheaply obtained hand tools. Of inestimable value is the Abrafle, available in various diameters. I have had mine for many years, and they range from 3in diameter to some that will fit a fretsaw; just the job for cutting holes in metal.

For round holes, drill a starting hole just inside the circumference of the required hole somewhat larger than the Abrafle, or other round file you propose using. Insert your file and away you go, all around the hole, just inside the scribed circle. Enlarge the hole to the required size, and remove all rough edges, by use of a smooth half round or round file. Smaller holes are simply enlarged in size by judicious use of a round file.

Square or rectangular holes are tackled in a similar manner. Again a starting hole is drilled, this time in one corner. Again you set off with your trusty round file, filing away just inside the scribed lines. Finally you square off the corners and straighten up the sides by use of a smooth Hand file or Flat file.

Alternatively, you can, particularly with large holes, drill several holes in a straight line, inside and parallel to each side of the hole. Then you use an padsaw with a length of hacksaw blade in it to cut out the hole. The four sets of holes you drill must, of course, all join up so that the hacksaw blade can be inserted. Finish off as before.

Bending

The scribed bending line must be accurately aligned with the angle iron, and just visible. This degree of visibility is important as it aids repeatability. The angle iron pieces are bolted together and clamped in the vice securely.

Use a piece of hard wood, place it in intimate contact with the aluminium sheet and the angle iron, and bend the sheet in the same direction as the scribed lines until it is flush with the angle iron; hopefully this will be square.

If necessary, tap the hard wood with a mallet, from end to end, and back, slowly and carefully. When the sheet lies on the angle iron, place the hard wood upon it and tap it down firmly to ensure a good tight bend. There should be no signs of damage on the sheet, or ripples; the hard wood used as an inter-face between mallet and sheet is a great aid here as it absorbs local blows.

With care, and practice, you will be able to manufacture your own cabinets; cabinets that will compete favourably with commercial products.

Panels have been dealt with at length since they are the most complex part of a cabinet, but the rest of it can be made in exactly the same way.
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<thead>
<tr>
<th>Model</th>
<th>Output Power R.M.S.</th>
<th>Distortion Typical at 1KHz</th>
<th>Minimum Signal/Noise Ratio</th>
<th>Power Supply Voltage</th>
<th>Size in mm</th>
<th>Weight in gms</th>
<th>Price + V.A.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY30</td>
<td>15 W into 8 Ω</td>
<td>0.02%</td>
<td>80dB</td>
<td>-20 -0 +20</td>
<td>105x50x25</td>
<td>155</td>
<td>£6.34 + 55p</td>
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<tr>
<td>HY50</td>
<td>30 W into 8 Ω</td>
<td>0.02%</td>
<td>90dB</td>
<td>-25 -0 +25</td>
<td>105x50x25</td>
<td>155</td>
<td>£7.24 + 1.09</td>
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<tr>
<td>HY120</td>
<td>60 W into 8 Ω</td>
<td>0.01%</td>
<td>100dB</td>
<td>-35 -0 +35</td>
<td>114x50x85</td>
<td>575</td>
<td>£15.20 + 2.28</td>
</tr>
<tr>
<td>HY200</td>
<td>120 W into 8 Ω</td>
<td>0.01%</td>
<td>100dB</td>
<td>-45 -0 +45</td>
<td>114x50x85</td>
<td>575</td>
<td>£18.44 + 3.77</td>
</tr>
<tr>
<td>HY400</td>
<td>240 W into 4 Ω</td>
<td>0.01%</td>
<td>100dB</td>
<td>-45 -0 +45</td>
<td>114x100x85</td>
<td>1.15Kg</td>
<td>£27.68 + 4.15</td>
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Load impedance – all models 4 - 16 Ω
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Input impedance – all models 100 K
Frequency response – all models 10Hz - 45KHz - 3dB

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<th>for 1 or 2 HY30’s</th>
<th>£8.10 + 1.22 VAT</th>
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<tbody>
<tr>
<td>PSU 50</td>
<td>for 1 or 2 HY50’s</td>
<td>£8.50 + 1.22 VAT</td>
</tr>
<tr>
<td>PSU 70</td>
<td>with toroidal transformer for 1 or 2 HY120’s</td>
<td>£13.61 + 2.04 VAT</td>
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<tr>
<td>PSU 90</td>
<td>with toroidal transformer for 1 HY200</td>
<td>£13.61 + 2.04 VAT</td>
</tr>
<tr>
<td>PSU 180</td>
<td>with toroidal transformer for 1 HY400 or 2 x HY200</td>
<td>£23.02 + 3.45 VAT</td>
</tr>
<tr>
<td>PSU 30</td>
<td>15V at 100mA to drive up to five HY5 pre-amps</td>
<td>£4.50 + 68p VAT</td>
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**SONOTONE 9THAC Diamond L3-73** Magneto, TOGGLE SWITCHES SP 30p, DPST 469. DPDT 511P - 14 x 5-44p; 12 x 12-41; 18 x 10-L1-16. 3-411p; 10 x 7-54p; 12 x 8-70p; 12 x 5-40; 16 x 6-76p; ALUMINIUM PANELS. 6 L1-441; 10 BLANK ALUMINIUM CHASSIS. 6 x 4-Np; 8 x 6- RELAYS. 12V DC Sip. 6V DC Up. 240V AC 613. HIGH STABILITY. OW 2% 10 ohms to 1 meg., 12p. RESISTORS. 100 to 10IA. OW, OW, 1W, 20% 2912W, 16p. ILLUMINATED ROCKER SWITCH. Single pole. Red Sop. 120pF TWIN GANG, Sep; 365pF TWIN GANG, 75p. TWIN GANG 25p1 slow motion asp. Up; 500V-0 001 10 0 05 12p; 0-1 15p; TRIMMERS 10pF, 30pF, 500F, Sp. 100pF, 150pF, 31p. MANY OTHER ELECTROLYTS IN STOCK. 50/503V 41.2/ 32/500V 73p 2500mF 50V Sip; 3000mF 25V 47p; 50V 63p. 1000mF 12V 17p; 25V Sip; 50V 47p; 100V 7110. 500mF 12V ISp; 25V 20p; 50V Sip; 16 ohm. 6 x 41n. £1-50. 7 x 41n. £1-50. 81n. £2.60. 8 ohm. Olin. L1 50. 3In. LI .50. 51n. L1 50. 10in. Li. 121n. G. 41.110. Bin. L2 60. 101 n. L3. 121n. L4. 3 ohm. 8 x **WIRE-WOUND RESISTORS** 5 watt, 10 watt, 15 watt lip. MANY OTHER TOGGLES IN STOCK. Please note.PICK-UP CARTRIDGES ACOS, GNI ES N. GPIM L2 U. BRIDGE RECTIFIER 200V Ply O amp Hp. 8 amp ELM. RADIO COMPONENT SPECIALISTS.

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2. Read, draw and understand circuit diagrams.
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3. Carry out over 40 experiments on basic circuits.
   We show you how to conduct experiments on a wide variety of different circuits and turn the information gained into a working knowledge of testing, servicing and maintaining all types of electronic equipment, radio, t.v. etc.

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Everyday Electronics, November 1979
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The compact, portable console can be set up to play on different levels of ability from beginner to expert, including four different levels of skill which can be varied at will. Each player must be verified by computer memory and can be changed at will. The computer can be played against itself or against another player, and the computer's programme can be changed at will.

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The compact, portable console can be set up to play on different levels of ability from beginner to expert, including four different levels of skill which can be varied at will. Each player must be verified by computer memory and can be changed at will. The computer can be played against itself or against another player, and the computer's programme can be changed at will.

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**SR-3A KIT**

(illustrated 16¼ x 10 x 2⅓)

Build over 100 projects including 3-TR reflex radio receiver, 3-TR radio receiver with RF amplifier, 3-TR reflex radio receiver, 3-TR amplifier for crystal microphone, 3-TR amplifier for speaker/amplifier, 3-TR signal traces, Morse Code trainer, 3-TR electronic organ, electronic multimeter, electronic bird, electronic cat, electronic alarm, electronic gun, 3-TR sleeping aid, high voltage generator, discontinuity warning device, water supply warning device, photoelectric alarm device, 3-TR burglar alarm, 3-TR water supply warning device, 3-TR water level warning device, 3-TR photoelectric alarm device, Morse Code trainer with sound & light, discontinuity warning device with sound & light, water level warning device with sound & light, electronic multimeter with sound & light, buzzer with sound & light, wireless mouse, wireless telegraph set, wireless discontinuity warning device, wireless water level warning device, wireless water supply warning device, wireless photoelectric warning device etc. etc.

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**£15.95**

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IF GOTO IF THEN INPUT LET

NEXT ON GOTO ON GOSUB POKE PRINT REAeq

REM RESTORE RETURN STOP

EXPRESSIONS

OPERATORS

1 NOT AND OR > < < > > <= RANGE 10^32 to 10^32

VARIABLES

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

The above can all be subscripted when used in an array. String variables use above names plus 5 eg AS

FUNCTIONS

ABS(X) ATN(X) COS(X)

ASIN(X) DEG(X) EXP(X)

ATN(X) DEG(X) EXP(X)

BREAK IN LINE XXXX is printed. In-

dicating line number of next statement to be executed or printed.

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