News and Views

650  EDITORIAL—A Logical Step?

651  NEWS . . . NEWS . . . NEWS

658  PW READER'S PCB SERVICE—Prices and details of the PCBs available

670  HOTLINES—Recent developments in electronics ................................. Ginsberg

671  PRACTICAL WIRELESS—Pre-view of our next issue

676  STRAY SIGNALS ................................................................................... Point Contact

677  KINDLY NOTE—Jubilee Organ

677  TELEVISION—Details of the January issue

693  ON THE AIR—Amateur Bands ............................................................. Eric Dowdeswell G4AR
SW Broadcast Bands ............................................................................. Charles Molloy G8BUS
MW Broadcast Bands ............................................................................. Charles Molloy G8BUS
VHF Bands ............................................................................................... Ron Ham BR515744

For our Constructors

652  DIRECT CONVERSION RECEIVER ......................................................... Mike Tooley BA, G8CKT

665  THE PW 'JUBILEE' ELECTRONIC ORGAN—5 ................................. M. J. Hughes MA, C.Eng, MIERE

672  PROPORTIONAL POWER CONTROLLER ........................................ C. Toms

678  AERIAL PERFORMANCE TEST SET ................................................. F. C. Judd

685  DESIGN YOUR OWN PROJECTS—5 ................................................... Toby Bailey and Bob Whitaker

General Interest

659  SO YOU WANT TO PASS THE RAE?—5 ............................... John Thornton-Lawrence GW3JGA and Ken McKoy GW8CMY

690  POTENTIAL BREAD

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Practical Wireless, January 1978
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- Smoother running
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Sparkrite Mk.2 is a high performance, high quality capacitive discharge, electronic ignition system in kit form. It is professional, proven, reliable and complete. It can be assembled in two or three hours and fitted in 15/30 mins.

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- 100w R.M.S. Amp, incorporating a fabulous Fane Crescendo 12" 100 watt speaker for really superlative results with Lead Guitar. Curr. £197.95 or Dep £177.95 & 18 f'tnly payments £6.69 (Total £385-97).

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Signature

N.B. The CHROMA-CHIME is also available, fully assembled, price £24.95 inc. VAT and post and packing.

Please allow 7-21 days for delivery.

The Chroma-Chime is the world's first electronic musical door chime which uses a pre-programmed microcomputer chip to generate tunes. Instead of boring old buzzes, dings or dongs, the Chroma-Chime will play one of its 24 well known tunes from its memory using its tiny 'brain' to all the music synthesizing! Since everything is done by precise mathematics, it cannot play the notes out of tune.

The unit has comprehensive built-in controls so that you can not only select the 'tune of the day' but the volume, tempo and envelope decay rate to change the sound according to taste.

Not only visitors to the front door will be amazed, if you like you can connect an additional push button for a back door which plays a different tune!

This kit has been carefully prepared so that practically anyone capable of neat soldering will have complete success in building it. The kit manual contains step by step constructional details together with a fault finding guide, circuit description, installation details and operational instructions all well illustrated with numerous figures and diagrams.

The CHROMA-CHIME is exclusively designed by

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**HY5 Preamplifier**

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (line, Cartridge, tuner, etc.) are catered for internally. The designed function is achieved via a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease new construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: Complete pre-amplifier in single pack—Multi-function equalization—Low noise—Distortion: High overload—Two simply combined for stereo.

APPLICATIONS: Hi-Fi—Mixers—Disco—Guitar and Organ—Public address

SPECIFICATIONS:

- INPUT: 10mV; L.R.M.S.; Cooper-Ceramic Ceramic Pickup 33mV; Tuner 200mV; Microphone 1mV; Aux (1kHz) 3V
- OUTPUT: 10V; L.R.M.S.; Main output 300V R.M.S.

ACTIVELY TONE CONTROLS: Treble ±10kHz at 10kHz; Bass ±10kHz.

OVERLOAD: 0.1% at 1kHz, Signal Noise Ratio 65dB.

Price £5.22 + 8% VAT P/P free.

**HY30 15 Watts into 8Ω**

The HY30 is an exciting new kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, and mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

FEATURES: Complete Kit—Low Distortion—Short, Open and Thermal Protection—Easy to Build.

APPLICATIONS: Updating audio equipment—Guitar pre-amp—Hi-Fi amplifier—Audio restoration

SPECIFICATIONS:

- OUTPUT POWER 5W R.M.S. into 8Ω—DISTORTION 0.1% at 5W.
- INPUT SENSITIVITY 30mV, FREQUENCY RESPONSE 10kHz—85dB.
- SUPPLY VOLTAGE ±15V.

Price £5.22 + 8% VAT P/P free.

**HY50 25 Watts into 8Ω**

The HY30 is an exciting new kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, and mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

FEATURES: Low Distortion—Integration—Heatsink—Only one connection—No external components.

APPLICATIONS: Medium Power Hi-Fi systems—Low power disco—Guitar amplifier

SPECIFICATIONS:

- INPUT SENSITIVITY 50mV.
- OUTPUT POWER 25W RMS into 8Ω—LOAD IMPEDANCE 4-16Ω—DISTORTION 0.04% at 25W at 1kHz.
- SIGNAL/NOISE RATIO 96dB—FREQUENCY RESPONSE 10kHz—45kHz—85dB.
- SUPPLY VOLTAGE ±25V SIZE 114 50 85mm

Price £12.50 + 8% VAT P/P free.

**HY120 60 Watts into 8Ω**

The HY120 has been designed to give an output of 60 Watts which has been designed to meet the most exacting requirements—3 terminal and thermal protection this amplifier sets a new standard in modular design.

FEATURES: Very low distortion—Integration—Thermal protection—Five connections—No external components.

APPLICATIONS: Hi-Fi—High quality disco—Public address—Monitor amplifier—Guitar and organ

SPECIFICATIONS:

- INPUT SENSITIVITY 90mV.
- OUTPUT POWER 90W RMS into 8Ω—LOAD IMPEDANCE 4-16Ω—DISTORTION 0.04% at 60W at 1kHz.
- SIGNAL/NOISE RATIO 96dB—FREQUENCY RESPONSE 10kHz—45kHz—85dB.
- SUPPLY VOLTAGE ±25V SIZE 114 50 85mm

Price £18.99 + 8% VAT P/P free.

**HY200 120 Watts into 8Ω**

The HY200 is a new high power range. Designed to meet the most exacting requirements—3 terminal and thermal protection this amplifier sets a new standard in modular design.

FEATURES: Very low distortion—Integration—Thermal protection—Five connections—No external components.

APPLICATIONS: Hi-Fi—Disco—Monitor—Power slave—Industrial—Public address

SPECIFICATIONS:

- INPUT SENSITIVITY 50mV
- OUTPUT POWER 120W RMS into 8Ω—LOAD IMPEDANCE 4-16Ω—DISTORTION 0.01% at 120W at 1kHz.
- SIGNAL/NOISE RATIO 96dB—FREQUENCY RESPONSE 10kHz—45kHz—85dB.
- SUPPLY VOLTAGE ±25V SIZE 114 50 85mm

Price £32.32 + 8% VAT P/P free.

**HY400 240 Watts into 4Ω**

The HY400 is an exciting new kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, and mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

FEATURES: Low Distortion—Integration—Heatsink—Only one connection—No external components.

APPLICATIONS: Medium Power Hi-Fi systems—Low power disco—Guitar amplifier

SPECIFICATIONS:

- INPUT SENSITIVITY 50mV
- OUTPUT POWER 240W RMS into 4Ω—LOAD IMPEDANCE 4Ω—DISTORTION 0.1% at 240W
- SIGNAL/NOISE RATIO 94dB—FREQUENCY RESPONSE 10kHz—45kHz—85dB.
- SUPPLY VOLTAGE ±25V SIZE 114 100 85mm

Price £42.17 + 8% VAT P/P free.

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- Top line components throughout.

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<tr>
<th>Watts</th>
<th>Mono</th>
<th>Stereo</th>
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<tr>
<td>30W</td>
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<tr>
<td>240W</td>
<td>£74-25</td>
<td>£99-95</td>
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Combined stereo pre-amp and active tone control unit. Input sensitivity 80mV for 1kHz output, bass ±15dB at 1kHz; treble ±15dB at 1kHz; balance control; volume control. For ceramic p.l.c., radio or tape inputs, with FREE CONTROL PANEL FASCIA.

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Practical Wireless, January 1978

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Practical Wireless, January 1978
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- BP18 Boys and Beginners Book of Practical Radio and Electronic Construction
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- BP27 Radio, TV and Electronic Colour Code Handbook for Beginners
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- 120 Several Generalised Speed Indicator
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- 161 Radio, TV and Electronics Data Book
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- 231 Electronic Projects
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- 282 Build Your Own Solid State Hi-Fi and Audio Accessories
- 283 How to Build Hi-Fi Loudspeaker Enclosures IC Projects
- 284 How to Build High Quality Audio IC Projects
- 286 How to Build Advanced Stereo Receiver
- 287 RCG Resistor Colour Code Disc Calculator

### THYRISTORS

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<th>Code</th>
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### SLIDER PAKS

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<tr>
<td>S1</td>
<td>6 slider potentiometers mixed values</td>
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<td>S2</td>
<td>6 slider potentiometers, all 470 ohms</td>
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<td>S3</td>
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<td>6 slider potentiometers, all 100k ohms</td>
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<td>S6</td>
<td>6 slider potentiometers, all 47k ohms</td>
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### CERAMIC PAK

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<td>miniature ceramic capacitors, 3 of each value 10pf, 150pf, 220pf, 27pf, 10pf</td>
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</tbody>
</table>

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A Logical Step?

MICROPROCESSORS, as those of you who read our competitor magazines will know, are all the rage. As so often happens with modern developments in electronics (and, to a certain extent, in other fields) much thought has been devoted to finding new applications for this answer to all our problems.

The replacement of electro-mechanical control systems in things like cars, sewing machines, washing machines, etc., is a fairly logical step, giving great scope for improvement in reliability, and some reduction in cost. Other applications, such as the "computerised door-chime" reviewed last month, for things which were simply not practicable before, are also obviously valid.

When we get into the realm of the replacement of ranks of logic packages by a microprocessor and its memory, the advantages become more questionable. On a production line, considerable savings in assembly time are possible, though for the home constructor this is not quite so important. Systems can become more flexible, providing you can afford the memory required to store all the different programs—but what are you going to use this flexibility for? For control systems in a space capsule, or for some of the newer and more interesting TV games, all well and good. But for domestic control systems, I wonder.

If you are talking about central-heating controllers, burglar and fire alarms and the like, most of the cost and complexity is in the input/output devices and the sensors and controls, and these remain the same, by and large, whatever form the central processing unit takes. The idea of one box of electronics in a house, controlling a multiplicity of appliances and systems, doesn't really seem to be the answer. Even some microprocessor experts are now admitting that a separate processor in each application is likely to be a better solution. So what price flexibility? Each appliance and system will contain a single microprocessor chip with the necessary memory built in, dedicated to that one purpose and incapable of doing anything else.

For these reasons, we do not think that microprocessors have much application for the home constructor as yet, though obviously they are of interest, especially for anyone also involved professionally in electronics. We will not be ignoring them; one thing for sure, they aren't going to go away. But what do you, our readers, think about the subject? We would love to hear.

Geoffrey Arnold

PLEASE NOTE

We do not operate a Technical Query Service except on matters concerning constructional articles published in PW. We do not supply service sheets or information on commercial radios, TV's or electronic equipment.

All queries must be accompanied by a stamped self-addressed envelope otherwise a reply cannot be guaranteed.
Catalogue with a Plus
Available now from Plustronics, is their latest catalogue containing all the
information on the latest range of portable radios, radio/cassette recorders, tape
decks, headphones, in-car units, digital watches and electronic calculators.
Many of the products in the catalogue are listed under the "Plustron" brand name, including the recently announced MC1500 Music Centre, which is featured on the front cover. Other brand names handled by Plustronics include Fair mate, Roxy, Aiko and Dansk.

For a copy of the Plustron catalogue which is called "A World of Entertainment", contact Plustronics Ltd., Hempstalls Lane, Newcastle, Staffs. ST5 0SW. Tel: 0782 615131 or call at their London showroom at 235-241 Regent Street, London, W1.

Showtime
Aiwa, one of the fastest growing Japanese HiFi manufacturers have recently opened a new London Showroom. Growth of the company has continued since Aiwa were first marketed and distributed by Johnsons of Hendon and continued growing when Aiwa decided to do their own marketing by opening up a new office, warehouse and distribution complex at Leeds.

Well known for their pioneering work in the compact cassette market, Aiwa were first with such innovations as automatic cassette loading; oil-damped ejection; full automatic stop; synchronised recording between cassette and turntable; and the first full HiFi music centre. Another 'First' by Aiwa, is a unique insurance scheme whereby the company offer, free of charge, insurance against fire, theft and accidental damage on every HiFi separate or music centre sold between November 1st 1977, and October 31st 1978. Insurance cover lasts for two years and costs purchaser absolutely nothing. The full range of Aiwa products can be seen, inspected, heard and whatever else you need to do, at the new showroom which is sited at the New Brunswick Shopping Precinct, a short stop from Tottenham Court Road and an even shorter stop from Russell Square tube station.

Aiwa Sales and Service (UK) Ltd., 56-58 Brunswick Centre in Bloomsbury, London WC1. Tel: 01-278 2081.

Stocking-up?
As the old saying goes "stock is as good as money", and by the look of the latest stock list published by Watford Electronics, they would appear to be potential millionaires considering the extensive and varied range of components included in the list. Now available to PW readers, this stock list contains just about everything for the electronic enthusiast, is clearly set out with components under headings and listed by type number. Ratings, where applicable are also shown, together with the type of package and the cost per unit. As the list is about 201 x 300mm in size, please enclose an SAE.

Watford Electronics, 33 Cardiff Road, Watford, Herts. Tel: Watford 40586

Light work
A new family of Silicon Photovoltaic Cells are now available from National Semiconductors Ltd., and are accompanied by claims of good stability, high efficiency and excellent short circuit current linearity over wide ranges of illumination.

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National Semiconductors Ltd., Stamford House, Stamford New Road, Altrincham, Cheshire. Tel: 061 928 3477.

Keep-it-clean!
You've heard what they do to old warships to stop the elements getting to them—they 'mothball' them. Although the 'mothballing' material differs slightly, you can now protect your records in a similar manner, with a new product called 'Sound Guard'.

Originally developed for NASA, as a dry lubricant for the moving parts of space craft, it can now be obtained in a Hi-Fi form which is sprayed onto the surface of records. When buffed up immediately following application it leaves a five-millionth-of-an-inch thin-film solid lubricant of low shear strength bonded to the record groove.

Other advantages are that while Sound Guard bonds to record surfaces, it will not bond to itself, so re-application will not cause a build-up of the coating. Also it contains an anti-static property, which all goes towards keeping the groove clean and free from dust.

Marketed in the UK by Pyser Ltd, a 2oz bottle with a pump sprayer and buffer pad (sufficient for 25 LP's) costs around £4.99.
Short wave listening can be an interesting and absorbing pastime. High performance SSB/CW short wave receivers do however tend to be very complex and rather expensive; it is unfortunate that the complexity of a receiver which has all the desirable features can be somewhat daunting to anyone but the most experienced constructor.

The basic receiver described here covers the popular 20m (14MHz) amateur band. This band offers a considerable long distance (DX) potential. This project is equally suitable for the beginner who requires a simple yet effective design, and the experienced short wave listener who requires a second, highly portable receiver. The unit may also be used in conjunction with a 2m converter having an intermediate frequency (IF) of 14 to 16MHz. The receiver will then cover the bottom end of the 2 metre band (144-0 to 144-4MHz) in which there is a great deal of VHF signal sideband (SSB) activity. Component changes and circuit modifications are also provided for coverage of the other amateur bands between 3-5MHz and 30MHz.

Single band design makes for considerable simplicity as regards coil winding and calibration; it also avoids problems associated with multi-band construction. Furthermore, the direct conversion technique ensures that the receiver is less prone to spurious signals, such as image channel interference, which can often be a problem with conventional superheterodyne receivers using single conversion and a low intermediate frequency.

The receiver uses a minimum number of semiconductor devices and is assembled using a single printed circuit board. The receiver may be built for a modest outlay of around £10 to £15 and alignment can readily be carried out using a signal generator or a second receiver.

Why direct conversion?

The vast majority of amateur activity in the HF bands is either single sideband (SSB) or morse (CW). Conventional receiver designs fall into two main categories. These are tuned radio frequency (TRF) and supersonic heterodyne (superhet). TRF receivers are relatively insensitive and unselective and thus some form of regeneration is needed. A TRF receiver cannot receive SSB or CW signals unless the regeneration is increased to a level which allows the receiver to oscillate continuously. This arrangement lacks frequency stability. The level of regeneration must also be frequently varied according to the strength of the incoming signal.

Superhet receivers, although selective and sensitive, tend to be complex and difficult to align. Furthermore, if SSB or CW signals are to be received using a superhet, it is necessary to incorporate a beat frequency oscillator (BFO) stage and a suitable detector.

The direct conversion receiver is halfway between a TRF receiver and a superhet. The incoming signal is mixed with a local oscillator signal operating on the same frequency. This should be clearly distinguished from the arrangement in a superhet where the local oscillator and signal frequencies differ by an amount equal to the intermediate frequency of the receiver. Thus the direct conversion receiver can be thought of as a superhet receiver with zero intermediate frequency. This may sound rather odd but it simply means that the incoming signal mixes with the local oscillator signal to produce an audible beat frequency. When SSB signals are to be received, the local oscillator is tuned to exactly coincide with the incoming carrier frequency. The result is correctly demodulated audio regardless of whether upper or lower sideband is being used. When a CW signal is to be received, the local oscillator is tuned to a very slightly different frequency from that of the incoming carrier.
Thus the CW signal is converted to a beat note within the audio frequency range.

The basic form of direct conversion receiver is shown in Fig. 1. This incorporates a separate local oscillator stage. A worthwhile improvement in sensitivity can be achieved by the addition of a radio frequency amplifier stage. This offers the further advantage of providing a degree of isolation between the local oscillator stage and the aerial, thus helping to minimise the amount of local oscillator radiation from the receiver. The block schematic of the receiver is shown in Fig. 2. The AF amplifier has a tailored frequency response and is important in setting the selectivity characteristic of the receiver.

Balanced Detector

There is nothing new in the concept of a receiver which uses a phase synchronous detector. The technique is used in both colour TV receivers and in stereo decoders. In order to provide best results, the local oscillator (or reference) should be phase locked to the incoming signal carrier. This is necessary for the reception of AM signals where even a small phase error can be disconcerting due to the presence of an audio image which is unavoidable when a double sideband signal is demodulated. In advanced receivers, a frequency reference is derived from the signal by means of a threshold gate and PLL but this is not necessary for reception of single sideband and CW signals. Furthermore, provided that the detector exhibits a high degree of linearity, the selectivity of the receiver is determined solely by the frequency response of the audio stages. This eliminates IF filters which are found in superhet receivers.

![Fig. 3: Balanced detector circuit.](image)

The simplified circuit of the balanced detector is shown in Fig. 3. It should be noted that, in practice, the reference provides a much greater voltage than that of the signal applied to the detector. D1 and D2 are effectively alternately switched “on” and “off” at the frequency of the reference oscillator. D2 conducts on positive going half cycles and D1 on negative half cycles. $R_s$ represents the source impedance of the reference oscillator circuit amounting to a few hundred ohms. $T_p$ provides signal voltages which are supplied to D1 and D2 in antiphase. $C_i$ is chosen so that it has negligible reactance at the reference frequency and a very high reactance at audio frequency and thus behaves as a high pass filter. $L_1$ and $C_2$ form a low pass filter preventing both the reference output and signal input from reaching the audio stages.

![Fig. 4: The upper trace shows SSB signal 100% modulated by a square wave. Note the phase reversals. Without the reference carrier inserted by the receiver local oscillator (middle trace) speech would be received at double the natural frequency and hopelessly distorted. Square wave modulated SSB signals would not be resolved in any form. The lower trace depicts the recovered modulation from the upper trace.](image)

When the signal and reference voltages are in phase, the balance of the detector is preserved and the output voltage after the low pass filter is zero. When a constant phase error exists between the signal and reference voltages the detector no longer remains balanced and a constant DC output voltage is produced. This may be positive or negative depending on the relative phase. When the phase error is not constant but changing, a corresponding alternating output voltage will be produced. Finally, if the signal and reference voltages differ by a constant frequency, say 1kHz, an audio signal is produced at this frequency. Fig. 4 shows a 100% modulated SSB signal applied to the detector.

Circuit description

A dual gate FET is used as the RF amplifier. The gain of the stage is made variable by adjusting the bias voltage applied to gate-2 of the transistor. The input tuned circuit, $L_1/C_1$, is damped by means of

*Practical Wireless, January 1978*
R13 to broadly tune to the 14MHz band. Its "Q" is however kept sufficiently high in order to reduce strong out of band signals. The RF stage is followed by a balanced detector arrangement using two germanium diodes, D1 and D2. Coupling from the RF amplifier stage to the detector is via a broadband transformer arrangement with damping provided by R4. Adjustment of the balance of the detector stage is provided by RV1. This compensates for any variation in the characteristics of the two diodes and is adjusted for maximum rejection of breakthrough from strong amplitude modulated signals which may otherwise be demodulated in a conventional manner.

The local oscillator uses a junction gate field effect transistor. Silicon diode, D3, provides automatic negative bias for the gate of the transistor. The supply voltage for the oscillator is stabilised by means of the zener diode, D4. The complete circuit diagram is shown in Fig. 5. The oscillator frequency is varied by means of VC1. The initial adjustment of operating frequency is carried out by means of the ferrite dust core of L2.

The demodulated audio signal is passed to the AF pre-amplifier. RFC2 and CI1 operate as a low pass filter. CI2 and CI3 are used to define the operating frequency range of the pre-amplifier stage, Tr3. The audio power amplifier stage is straightforward and uses an LM380. It produces ample output from a 6V supply.

**Construction and layout**

With the exception of the controls, VR1, VR2, VC1 and S1, the battery holder and sockets SK1, all components are mounted on a printed circuit board. The component layout is fairly important and the use of a printed circuit board is highly recommended. Other forms of construction (matrix board, Veroboard or point-to-point wiring) may give rise to poor performance or instability unless great care is taken. Where a printed circuit board is not used, a good common earth connection to all parts of the circuit is essential.

The input circuit, comprising L1 and associated components, must be screened from the rest of the circuit. This is accomplished by using a small piece of 20 SWG tinplate cut out and bent as shown in Fig. 6. The printed circuit board (copperside) is shown in Fig. 7, the corresponding component overlay is shown in Fig. 8.

Care should be taken to keep all the internal connecting leads short. The leads to the volume control, VR2, should be screened. The loudspeaker is mounted on the lid of the case and, when the lid is in place, care should be taken not to trail the loudspeaker leads across the circuit board. The aerial and converter input socket, SK1, is mounted on the rear panel of the chassis. The tuning capacitor, VC1, is mounted on a small aluminium bracket. The bracket is secured to the front panel of the receiver by means of the same two screws and nuts which retain a vernier drive mechanism. The "live" connection from VC1 to L2 on the printed circuit board should be made using stiff wire, preferably 18 or 20 SWG; this helps improve the frequency stability. The earth tag of VC1 is returned to the common rail on the printed circuit board by means of a short length of copper braid. The outer conductor removed from a short length of 50 ohm or 75 ohm coaxial cable is ideal for this purpose. The lid of the case should also be earthed to the common rail. This prevents hand capacitance effects.

In the prototype, the printed circuit board is held in place by means of four 25mm spacers which are
secured to the bottom of the chassis by countersunk screws. The battery holder is made from suitably bent aluminium and then lined with a strip of foam rubber. The battery holder fastens to the back of the case by two nuts and bolts.

**Coil winding details**

Both coils, L1 and L2, are wound on 7mm diameter coil formers fitted with dust cores. L1 comprises a main tuned winding of 20 turns of 26 SWG enamelled copper wire closewound with an aerial winding of 4 turns 30 SWG enamelled copper wire as in Fig. 9a. A thin layer of PVC tape is used to hold the main tuned winding in place while the aerial winding is completed.

L2 consists of a single tuned winding of 24 turns of...
26 SWG enamelled copper wire closewound as in Fig. 9b. After winding, both coils are liberally coated with a quick setting epoxy resin adhesive. This seals the winding in place and provides a very effective protective coating.

The interstage coupling transformer is wound according to Fig. 10. The transformer is wound on a miniature ferrite ring of approximate diameter 12mm. The drain winding (primary) consists of 10 turns 30 SWG enamelled copper wire. The mixer winding (secondary) consists of 5 turns 30 SWG enamelled copper wire. The transformer is similarly sealed with quick setting epoxy resin adhesive. If a ferrite ring is not available, the transformer may be wound using a 17mm x 8mm diameter dust core. The thread on the core facilitates a guide in which the transformer may be wound. The drain winding (primary) consists of 12 turns 26 SWG enamelled copper wire. The mixer (secondary) consists of 6 turns of 30 SWG overwound in the centre of the core. The transformer should be sealed with quick setting epoxy adhesive. The performance of the receiver is slightly better when a ferrite ring is used for the interstage transformer.

**components**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Value</th>
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<tbody>
<tr>
<td>R1</td>
<td>10kΩ</td>
</tr>
<tr>
<td>R2</td>
<td>33kΩ</td>
</tr>
<tr>
<td>R3</td>
<td>330kΩ</td>
</tr>
<tr>
<td>R4</td>
<td>2.2kΩ</td>
</tr>
<tr>
<td>R5</td>
<td>470Ω</td>
</tr>
<tr>
<td>R6</td>
<td>47kΩ</td>
</tr>
<tr>
<td>R7</td>
<td>330Ω</td>
</tr>
<tr>
<td>R8</td>
<td>10kΩ</td>
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<tr>
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<tr>
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<tr>
<td>R11</td>
<td>1kΩ</td>
</tr>
<tr>
<td>R12</td>
<td>22kΩ</td>
</tr>
<tr>
<td>R13</td>
<td>10kΩ</td>
</tr>
<tr>
<td>All</td>
<td>1W 5% carbon</td>
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<table>
<thead>
<tr>
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<th>Value</th>
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</thead>
<tbody>
<tr>
<td>C1</td>
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</tr>
<tr>
<td>C2</td>
<td>10nF</td>
</tr>
<tr>
<td>C3</td>
<td>100nF</td>
</tr>
<tr>
<td>C4</td>
<td>100nF</td>
</tr>
<tr>
<td>C5</td>
<td>47pF silvered mica</td>
</tr>
<tr>
<td>C6</td>
<td>68pF</td>
</tr>
<tr>
<td>C7</td>
<td>100pF</td>
</tr>
<tr>
<td>C8</td>
<td>10nF</td>
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<td>C13</td>
<td>1µF 63V</td>
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<tr>
<td>C14</td>
<td>100µF 10V</td>
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<tr>
<td>C15</td>
<td>1µF 63V</td>
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<td>C16</td>
<td>1000pF</td>
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<tr>
<td>C17</td>
<td>100F</td>
</tr>
<tr>
<td>C18</td>
<td>100µF 10V</td>
</tr>
<tr>
<td>C19</td>
<td>100µF 10V</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Semiconductors</th>
<th>Type</th>
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<tbody>
<tr>
<td>Tr1</td>
<td>4067</td>
</tr>
<tr>
<td>Tr2</td>
<td>2N3819</td>
</tr>
<tr>
<td>Tr3</td>
<td>BC108</td>
</tr>
<tr>
<td>IC1</td>
<td>LM380N</td>
</tr>
<tr>
<td>D1</td>
<td>OA90</td>
</tr>
<tr>
<td>D2</td>
<td>OA90</td>
</tr>
<tr>
<td>D3</td>
<td>1N4148</td>
</tr>
<tr>
<td>D4</td>
<td>BZY88   C3V9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potentiometers</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR1</td>
<td>10kΩ lin</td>
</tr>
<tr>
<td>VR2</td>
<td>5kΩ log</td>
</tr>
<tr>
<td>VR3</td>
<td>5kΩ preset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC1</td>
<td>15pF Jackson type C604, S1 SPDT miniature toggle switch.</td>
</tr>
<tr>
<td>RFC1 RFC2</td>
<td>1nH RF chokes.</td>
</tr>
<tr>
<td>T1</td>
<td>miniature ferrite ring or dust core, two coil formers 7mm diameter fitted with dust cores, vernier dia. 50mm, loudspeaker 50mm B0.5W. Case 127mm x 152mm x 89mm, 14 pin low profile dual-in-line IC socket, battery holder for 4 x HP7 1.5V cells plus snap connector to suit.</td>
</tr>
<tr>
<td>Mounting pillars</td>
<td>Double sided push fit pins. Coax socket for aerial and jack socket for 'phones.</td>
</tr>
</tbody>
</table>
Initial checks and alignment

After completing the wiring and assembly of the receiver, a careful visual check should be made for any faults. A 6V battery (4 x HP7) should be connected and the current consumption measured. If the receiver is working correctly, the supply current should be approximately 12mA. A slight variation should be noticed when the RF Gain control, VR1, is adjusted.

Alignment of the receiver can be carried out by using either an RF signal generator or an existing short wave receiver. The signal generator should be set for an unmodulated output at 14MHz. The tuning capacitor, VC1, should be set to maximum capacitance. L2 should then be varied until a beat note is heard. Carefully adjust L2 for zero beat (i.e. the apparently dead spot at the centre of the two ranges in which an audible beat is heard). Note that it should not be necessary to have the signal generator directly coupled to the receiver for this purpose. Stray coupling, using a short throw-out aerial, should be sufficient to produce a strong beat signal. After locating the zero beat position corresponding to 14-0MHz, re-set VC1 to minimum capacitance. Vary the signal generator frequency until a zero beat is found and note the new frequency. This will be approximately 14-4MHz; it should extend to 14-55MHz if the whole of the 20 metre band is to be covered.

To align the RF amplifier stage, adjust L1. Switch the signal generator to give a modulated carrier at 14-2MHz but leave the setting of VC1 at minimum capacitance (do not search for a beat note). A tone should be heard in the receiver's loudspeaker. If this is not the case, increase the output level of the signal generator accordingly. Note that the tone should not vary in frequency as VC1 is adjusted. Now adjust L1 for maximum loudspeaker output. If necessary, reduce the output level of the signal generator as resonance is approached. Finally adjust VR5 for minimum output—it should be possible to pull the tone out almost completely. The alignment procedure should be repeated once again after which the cores of L1 and L2 should be sealed. An antenna may then be connected to the receiver and its "on-air" performance can be checked.

Where a signal generator is not available, the frequency of the local oscillator can be set using a calibrated receiver. The receiver should be set to 14-0MHz and VC1 adjusted to maximum capacitance. L2 is then adjusted until a strong signal is heard in the main receiver, this will of course appear as an unmodulated carrier. The two receivers should be in fairly close proximity for this purpose and, if necessary, a short length of wire can be used to link the two aerial sockets so that sufficient coupling of the local oscillator signal is obtained. If more than one signal is heard on the main receiver (corresponding to two different positions of the core of L2) make sure that the stronger of the two is selected. This phenomenon is due to the image channel of the main receiver. Re-set VC1 to minimum capacitance and find the new local oscillator frequency by re-tuning the main receiver. This should be above 14-35MHz. Next connect an aerial to the unit and adjust VC1 to a signal which is fairly strong and continuous. A teleprinter signal is ideal for this purpose. Carefully adjust L1 for maximum output from the loudspeaker. If necessary, reduce the RF gain control accordingly. VR3 should be set to mid-position, but if break-through from strong amplitude modulated broadcast signals on adjacent frequencies is subsequently experienced, the preset should be adjusted for a null to minimise the effect.

If the local oscillator frequency coverage is found to be too low even after adjustment of L2, C5 should be replaced by a 33pF silver mica capacitor. If the local oscillator frequency coverage is found to be too high, C5 should be similarly replaced by a 68pF silver mica capacitor or alternatively a 15pF silver mica capacitor can be wired directly in parallel with VC1. If adequate screening is not used between the oscillator and RF circuits, a form of RF instability may occur. This is due to local oscillator radiation entering the RF amplifier and may only manifest itself when the RF gain control is turned fully up. Detuning L1 will usually cure this problem; however, the best solution is to ensure that a screen is fitted and that the lid of the case is adequately earthed (this is usually accomplished by the four securing screws).

Should audio frequency instability be noticed, particularly when not using the recommended printed circuit layout, a 100nF miniature polyester capacitor in series with a 4-7ohm 1/4W carbon resistor should be wired directly between pin 8 and the integrated circuit holder and the common earth rail. Also, when not using a printed circuit board, C19 should be wired as closely as possible between pin 14 of the integrated circuit holder and the common earth rail.

Instability may also occur which manifests itself as a howling at maximum gain settings when headphones are being used. This can be cured by using an RF choke, consisting of 6 turns 30 SWG (or 8 turns 26 SWG on a ferrite ring) wired directly between the loudspeaker output on the PCB and the headphone jack socket, SK4. However, few problems should be experienced if the recommended layout and printed circuit board is used.

Using the receiver

The performance of any short wave receiver depends greatly on the quality of the aerial system with which it is to be used and on the expertise of the user. This design gives acceptable results with a short "throw-out" aerial (15ft of flexible wire is ideal for this purpose). A good earth may improve performance further. If a dipole is available (this should be approximately 35ft in length and fed in the centre) results should be excellent.

Tuning an SSB receiver often presents difficulties to the uninitiated. The newcomer to short wave listening will however find that his ability to resolve SSB signals will improve considerably with practice. The

Practical Wireless, January 1978

657

www.americanradiohistory.com
signal needs to be slowly tuned through until the speech appears normal. An incorrectly tuned signal will make you think that you are listening to Donald Duck. This is, of course, due to a shift in the frequencies of the speech components. With a little practice, the correct tuning point will easily be found. When incoming signals are very strong, the RF gain control should be backed off. This will assist in resolving signals.

In the first few days of use, and with a very modest aerial, over twenty countries were logged with the receiver. These included DK, EA, EI, F, G, GW, HB, I, K, OE, ON, PA, SM, UA, UB, VE, W, YU. Propagation conditions on 20 metres vary considerably during the day and night. Seasonal variations are also noticeable. Thus do not expect instant long distance (DX) reception! A few days listening will soon tell constructors when and where to listen.

This simple receiver was developed with low cost and portability in mind. It will not outperform a complex communications receiver. However, when used with an efficient aerial system, it gives an extremely good account of itself.

appendix

Table of component changes for alternative frequency coverage

<table>
<thead>
<tr>
<th>RF TUNED CIRCUIT</th>
<th>Turns on L1</th>
<th>C1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sec. SWG</td>
<td>pri. SWG</td>
</tr>
<tr>
<td>3·5-3·8 MHz</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>7·0-7·1 MHz</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>21·0-21·5 MHz</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>28·0-30·0 MHz</td>
<td>12</td>
<td>26</td>
</tr>
</tbody>
</table>

Oscillator circuit modification for lower frequencies (see note below).

Oscillator tuned circuit

<table>
<thead>
<tr>
<th>Band</th>
<th>Turns on L2</th>
<th>SWG</th>
<th>VC1</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>3·5-3·8 MHz</td>
<td>30</td>
<td>see note 30</td>
<td>100pF</td>
<td>220pF</td>
</tr>
<tr>
<td>7·0-7·1 MHz</td>
<td>22</td>
<td>see note 26</td>
<td>15pF</td>
<td>100pF</td>
</tr>
<tr>
<td>21·0-21·5 MHz</td>
<td>16</td>
<td>26</td>
<td>15pF</td>
<td>47pF</td>
</tr>
<tr>
<td>28·0-30·0 MHz</td>
<td>10</td>
<td>26</td>
<td>15pF</td>
<td>47pF</td>
</tr>
</tbody>
</table>

*Note: Use modified circuit for oscillator shown in Fig. 11. Also increase the primary turns on T1 to 20 (30 swg) and secondary to 15 turns (30 swg). The use of a ferrite ring as the core of T1 is strongly recommended for the 3·5 MHz and 7 MHz bands.
Before we consider the behaviour of alternating current and voltage in circuits containing inductors and capacitors, we will have a look at the phenomenon of capacitance.

**Capacitance**

If we place two metal plates close to one another and separate them with a piece of insulating material, we have an arrangement which will store electricity in the form of a charge. The capacitance of the arrangement depends on a number of factors:—

i. Area of the plates
ii. Distance between the plates
iii. The nature of the insulating material occupying the space between the plates (specifically the Dielectric Constant or relative permittivity).

The unit of capacitance is the farad—an uncommonly large unit for the purposes we require—so that the values found in radio work are micro-farads ($10^{-6}$), nanofarads ($10^{-9}$) and picofarads ($10^{-12}$).

**Dielectric Constant**

If we measure the value of capacitance of two metal plates, separated by a certain insulating material, and repeat the measurement keeping area of plates and distance apart the same but having a vacuum separating them, then the ratio between the two values of capacitance will be equal to the dielectric constant of the insulating material. This constant is usually denoted by the letter K and the capacitance of a capacitor is given by the relationship:—

\[ C = \frac{K A}{d} \]

where \( A \) is the area of the plates and \( d \) the spacing between them.

A capacitor is classified by the material used as the dielectric and the table below shows some types of dielectric used together with their dielectric constants.

<table>
<thead>
<tr>
<th>Material</th>
<th>Dielectric Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1</td>
</tr>
<tr>
<td>Dry paper</td>
<td>2.5 approx</td>
</tr>
<tr>
<td>Polyester</td>
<td>5 approx</td>
</tr>
<tr>
<td>Mica</td>
<td>5-7 approx</td>
</tr>
<tr>
<td>Aluminium oxide</td>
<td>7.5 approx</td>
</tr>
<tr>
<td>(electrolytic)</td>
<td></td>
</tr>
<tr>
<td>Ceramic (Lo K)</td>
<td>up to 20</td>
</tr>
<tr>
<td>Ceramic (Hi K)</td>
<td>up to 10,000</td>
</tr>
</tbody>
</table>

The Dielectric Strength is the voltage at which the dielectric breaks down and this and its thickness determines the maximum safe working voltage which may be applied to the capacitor.

**Capacitor Ratings**

The two most important practical ratings of a capacitor are its capacitance and its working voltage and these are almost invariably marked on the capacitor. The required value of capacitance depends on the purpose for which it will be used and the voltage rating on the maximum voltage that will be present across the capacitor under all operating conditions.

The required accuracy or tolerance of the capacitance value depends on how critical the circuit is to this. For example, the capacitance of an electrolytic capacitor, providing the smoothing in a power supply, could be greater or less by 20 per cent of its stated value without causing any significant change in performance, but a silvered mica capacitor in the oscillator tuning circuit of a communication receiver would cause serious tuning errors if its value was in error by this amount. In some applications therefore, the tolerance is also an important factor.

There are other factors too, such as insulation resistance, temperature stability, physical size, etc., which affect the suitability of a particular type of capacitor for a particular use.

**Air Dielectric Capacitors**

These are usually in the form of variable capacity tuning capacitors having a set of fixed plates with a set of moving plates that swing into mesh between the fixed plates. This enables the effective area of the plates, and so the capacitance, to be varied.

Air dielectric tuning capacitors for use in receivers, where the maximum voltage may be only a few volts, can have very close spacing between the plates; but types for use in transmitters where high voltages are present, must have significantly greater spacing to avoid voltage breakdown or flashover. The breakdown voltage of air is about 25,000V/cm and the spacing between the plates of a tuning capacitor for a receiver would be about 0.2mm (mainly limited by the mechanical accuracy) and for a 150W HF transmitter about 1.5mm.

**Mica Capacitors**

The mica capacitor uses thin sheets of mica as the dielectric and offers the best electrical properties possible but for a given capacity it tends to be large and fairly expensive. Mica is a very stable material naturally, after all it has been lying in the ground stabilising for millions of years, so the capacitor using it as a dielectric will also have excellent stability. The mica capacitor is therefore, ideal for use in tuning or other critical circuits.

The silvered mica capacitor has the electrodes deposited as a film of silver on the surfaces of the mica and so enables very thin blades of mica to be used. The blades are stacked with interconnecting foils and are then clamped or riveted together which gives them their characteristiclly flat “postage stamp” shape. Silvered mica capacitors are available in values from 1pF to about 10,000pF and usually
have a voltage rating of 250 to 500V although higher voltage ratings are available for use in transmitters. They are very suitable for use in RF tuned circuits up to several hundred MHz and will carry appreciable RF currents in transmitter applications.

Some “compression type” trimmer capacitors use mica as a dielectric and in these the mica is sandwiched between spring foil electrodes. The capacitance is varied by squashing the sandwich with an adjusting screw and so changing the dielectric from partly air and partly mica to just mica. These capacitors, which were once seen only in radio receivers are now being used in transistor VHF and UHF transmitters where their very low inductance and low losses make them ideal.

**Ceramic Capacitors**

Ceramic capacitors are made in various forms, the most popular being the tubular and disc types. The tubular type consists of a small ceramic tube which has silver deposited on the inside and outside surfaces, the capacitance being determined by the area of the surface, the tube wall thickness and the ceramic dielectric constant. The disc type consists of a flat disc of ceramic with silver deposited on each side of the disc. Ceramic dielectric material can be made to have particular characteristics by adjusting the proportions of the ingredients.

The low K ceramic material usually used in the tubular capacitors provides good stability with a fairly low and a predictable temperature coefficient (change of capacitance with temperature) so that in some circumstances they can be used with advantage in a tuned circuit to compensate for the opposite temperature effects in other components in the circuit. Their small physical size and low inductance makes them suitable for use in receivers and low power circuits in the VHF and UHF range.

Tubular ceramic capacitors are also made in a lead-through form for decoupling supplies passing through a screening box or plate and they have a soldering flange or screwed bush for mounting. Variable tubular ceramic capacitors have the internal silvering replaced by a concentric adjusting screw and these are suitable for operation up to several hundred megahertz.

Disc ceramic capacitors are usually of the Hi K ceramic type and have the advantage of very high capacity with small physical size and very low inductance. Hi K ceramic material has a high temperature coefficient which makes these capacitors unstable in value and so unsuitable for use in tuned circuits. They suffer from losses at high frequencies but can be used successfully in bypass and decoupling applications up to 1,000MHz.

**Wound Capacitors**

Polystyrene, polyester, polycarbonate and paper capacitors are made by winding two strips of metal foil into a roll, insulated by two strips of dielectric film or paper. Connection strips or edges are brought out to form suitable lead-out connections. Polystyrene is a high-grade dielectric having characteristics approaching those of mica; polystyrene capacitors are used in LF, MF and HF circuits where stability is important. Polyester and polycarbonate capacitors are suitable for most LF and MF applications up to a few MHz. Paper capacitors are mainly used in LF applications and for high voltage power supply use where working voltages up to several thousand volts are available. Capacitors of this type are usually hermetically sealed in a can with special high voltage terminals.

Polystyrene capacitors are available in values from 10pF to 1µF and polyester, polycarbonate and paper capacitors from 1,000pF to 10µF approximately.

Now follows the last major theoretical section, but a very important one, leading up to the resonant tuned circuit, an essential part of every transmitter and receiver.

**Inductors and Capacitors in series and parallel**

(i) **Inductors** (not mutually coupled)

Series

\[ L_{\text{total}} = L_1 + L_2 \]

Parallel

\[ \frac{1}{L_{\text{total}}} = \frac{1}{L_1} + \frac{1}{L_2} \quad \text{or} \quad L_{\text{total}} = \frac{L_1 L_2}{L_1 + L_2} \]

(ii) **Capacitors**

Series

\[ \frac{1}{C_{\text{total}}} = \frac{1}{C_1} + \frac{1}{C_2} \]

Parallel

\[ C_{\text{total}} = C_1 + C_2 \]

**AC Circuits**

**Resistors in an AC Circuit.**

In this case both voltage and current are “in phase” with one another, i.e. they both reach maximum or minimum values at the same instant of time. When calculating current and voltage, the r.m.s. values are used, thus \( I_{\text{rms}} = V_{\text{rms}} / R \)

*Practical Wireless, January 1978*
Capacitors in an AC circuit (Capacitive Reactance).

When an alternating current is applied to a capacitor it will charge it, first in one direction and then in the other. The maximum current will be flowing in or out of the capacitor when the applied voltage is changing most rapidly (i.e. as it goes through zero volts) and the current will fall to zero when either peak of the cycle has been reached and the voltage is virtually steady for an instant.

Since the current is at a peak \( \frac{1}{4} \) cycle before the voltage it is said to "lead" the applied voltage by 90° (one full cycle being 360°—see section on sine waves). The energy which is stored in the capacitor during the \( \frac{1}{4} \) cycle charging period is returned to the circuit in the following \( \frac{1}{4} \) cycle. The current flowing is known as Wattless Current as no power is dissipated in the conventional FR sense.

![Fig. 24: The voltage and current in a resistive circuit are in phase.](image)

If the relationship between voltage and current is investigated, the frequency of the alternating current must be taken into account, together with the value of the capacitance in the circuit. In fact, the current flowing is proportional to capacitance, frequency and voltage. By arranging these factors we can extract a quantity which is akin to resistance in a DC circuit. This quantity is known as Capacitive REACTANCE and its unit is the ohm.

Capacitive REACTANCE \( (X_C) \) = \( \frac{1}{2\pi fC} \) where

\( f \) = frequency of alternating current, \( C = \) Capacitance and \( \pi = 3.142 \).

Using Ohm's Law and reactance we can calculate the voltage or current in an AC circuit containing a capacitor:

\[
I = \frac{V}{X_C} \quad X_C = \frac{V}{I} \quad V = IX_C
\]

(note that \( V \) and \( I \) are r.m.s. values.

Inductors in an AC Circuit (Inductive Reactance)

When an alternating voltage is applied to an inductor the resultant current causes a back or induced e.m.f. to be generated which is proportional to the rate of change of the current. In the inductor, as in the capacitor, the maximum current occurs when the voltage is changing most rapidly (as it goes through zero), except that in the case of the inductor the current "lags" the voltage by \( \frac{1}{4} \) of a cycle or 90°.

It will be realised that if the frequency of the alternating current increases, so will the rate of change of current; thus the value of the e.m.f. generated in the inductance will be proportional to the frequency and the current flowing inversely proportional to the frequency. From this we can extract a quantity known as the Inductive REACTANCE, unit—again the ohm.

Inductive REACTANCE \( (X_L) = 2\pi fL \) where \( f = \) frequency, \( L = \) inductance and \( \pi = 3.142 \).

![Fig. 25: In a capacitive circuit, the current which flows leads the applied voltage by 90°.](image)

Reactances in Series and Parallel

Reactances of the same kind, Inductive OR Capacitive can be treated similarly to resistors:—

Series

\[
\frac{1}{X} = \frac{1}{X_1} + \frac{1}{X_2} + \frac{1}{X_3}
\]

Parallel

\[
X = X_1 + X_2 + X_3
\]

Reactances of opposite kinds, Inductive and Capacitive:—

Series

\[
X = X_L - X_C
\]

Parallel

\[
X = \frac{-X_L X_C}{X_L - X_C}
\]

This follows because when reactances of opposite kinds are combined in a circuit, the currents lag and lead the voltages, in the inductive and capacitive sections respectively, by 90° and consequently they must first be subtracted from one another to find the total reactance. For this purpose, Inductive reactance is normally considered 'positive' and Capacitive reactance 'negative'.

Impedance

In any circuit containing reactances there will be some resistive element in the wires, for example, in the inductor windings thus when we consider the resistance to current flow presented by reactances we must add that presented by the ohmic resistance of the circuit. When we consider all these elements together, inductive reactance, capacitive reactance and resistance, it is known as IMPEDANCE. The resistive element of the impedance may be either in series or in parallel with the reactance.

Practical Wireless, January 1978
Series

The impedance $Z$ in this case is $Z = \sqrt{R^2 + X^2}$, where $Z =$ Impedance (ohms), $R =$ Resistance, and $X =$ Reactance (inductive or capacitive).

Parallel

$$Z = \frac{R \cdot X}{\sqrt{R^2 + X^2}}$$

In circuits which contain impedances, Ohm's Law can be applied as follows: $I = \frac{V}{Z}$ and $V = IZ$ and $Z = \frac{V}{I}$. (use r.m.s. values of $V$ and $I$).

Resonance

The next characteristic of the AC circuit, that we are going to examine, is RESONANCE. This is a most importance effect which is employed many times over in every radio transmitter and receiver. As the AC frequency, applied to a circuit containing inductance and capacitance, is increased, the value of the inductive reactance increases, whilst that of the capacitive reactance decreases, as shown in the graph below:

![Resonance Graph](image)

From this it is apparent that at a certain frequency, $f_r$, the capacitive reactance equals the inductive reactance.

Series Resonant Circuit (Acceptor Circuit)

If the frequency of $V$ changes between $f_1$ and $f_2$, then the current flowing in the circuit will rise to a maximum at $f_r$. The impedance, on the other hand, falls to a value equal to $R$. To summarise this in an expression:

$$X_L = 2\pi fL$$ and $$X_C = \frac{1}{2\pi fC}$$

at $f_r$ $2\pi fL = \frac{1}{2\pi fC}$

$$f_r = \frac{1}{2\pi \sqrt{LC}}$$

Where $f =$ frequency in Hz, $L =$ Inductance in henries, $C =$ Capacitance in farads and $\pi = 3.142$.

The value of the current flowing in the circuit is found as follows:

$$I = \frac{V}{Z} = \frac{1}{\sqrt{R^2 + (X_L - X_C)^2}}$$

Thus, at resonance, the impedance of a series resonant circuit is equal to the resistive component $R$, $X_L$ and $X_C$ having cancelled each other out.

Parallel Resonant Circuit (Rejector Circuit).

This arrangement is awkward for the purposes of investigating the variation of current and impedance with frequency, so an equivalent parallel circuit is used in which a perfect inductor and a perfect capacitor are in parallel with an assumed resistance, known as the dynamic resistance $R_D$, $R_D$ being equal to $\frac{L}{C_r}$ at resonance. The expression for the resonant

continued on page 669
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The main differences between this and the calculator keyboard version are the cabinet details, the keyboard wiring loom, and the use of external foot switches to select Minor and Seventh chords. There are one or two minor layout differences.

The accompaniment keys (bottom octave of the 4 octave keyboard) require two separate busbars. One commons together the poles of C, CS, D, DS, E and F while the other commons FS, G, GS, A, AS and B. Use the wiring instructions shown in Fig. 1 to connect between the board pins and the contacts of each key (note) switch—not forgetting the three busbar connections. Use lacing cord to neatly tie the keyboard loom into a bundle.

The rear panel wiring is slightly different from the calculator key version. A stereo jack plug and socket is used to route the Minor and Seventh select wires (together with their common connection) to an external "push to make" pair of foot switches. Although expensive, an electronic piano "Soft/Sustain" pedal pair worked well.

A single pole toggle switch was put in series with the internal loudspeaker connections so that the internal speaker can be muted. The output for the external Phono lead is connected via an extra stereo jack socket. This enables an external foot controlled volume control (swell pedal) to be used. The wiring is such that the control (which should be 10kΩ log) can be plugged into the jack socket if needed but, if unplugged, the signal is left unaffected at the DIN socket.

Practical Wireless, January 1978
Adjustments for both versions

The most obvious problem will be caused by constructors trying to get too much out of the internal amplifier. Remember— it is only capable of putting out about 1W (about the same total volume as a portable radio). When playing a single melody note, it is possible to turn up the gain of the melody pre-amp and produce a very loud sound but as soon as you introduce a chord from the accompaniment, the internal amplifier overloads and produces distortion. This is made even worse by the drums— particularly the bass drum. The secret is to turn all the front panel volume controls to maximum and then switch all the voicing switches to their “on” position. Put the vamp switch in the “off” position and select a rhythm— say “Waltz”. With one hand, depress bottom “C” of the melody keyboard and the chord of “G” from the accompaniment. Adjust the preset gains of the three preamplifiers (VR6, 14 and 16) to get a good balance between melody, accompaniment and drums respectively and set the levels so that the sounds are as loud as possible without distortion. It might be necessary to adjust VR15, 16 and 19 to get the best compromise between level and tonal quality of the cymbals, snare drum and bass drum respectively. Listen, particularly, to the bass drum sound. This is very low frequency and might not be very prominent when heard over a small loudspeaker but it could have a high electronic amplitude driving the drums preamplifier and the internal power amplifier into clipping. Having set the maximum level, do not expect very loud signals if you select the melody string voice unaccompanied.

The “brightest” cymbals sound is heard when VR15 is near its earthy end; likewise for the snare drum control (VR16). The best bass drum setting for VR19 is just before the onset of oscillation; take care, however, not to have too long a decay on the latter otherwise it will sound more like a percussive tone rather than a deep “thump”.

Melody sustain length is increased by increasing the value of C6 by a small amount. Conversely, reducing the value shortens the period. If you get no melody sustain, D2 may be short circuit. Check that D2 is in the right way round and the VR5 wiper is making good contact with the track.

Sustain length of the alternating bass is set by C16. Failure of the bass note to cut off completely is an indication that D3 is faulty, the wrong value or inserted the wrong way round.

Chord sustain is set by the value of C20 (which must be a polyester type). If the chords do not die away completely Tr5 probably has very low gain and it might be best to replace it. Alternatively you can reduce the value of R44 but if you do this you will have to increase the value of C20 to keep a reasonable sustain time constant. If the chords do not sound at all, D5 may be the wrong way round or Tr5 faulty.

Clicks on the attack of the bass note and melody notes can be removed by careful adjustment of VR10 and VR5 respectively. A hesitation on a cymbal stroke is caused by Tr8 having too high a gain and this can be rectified by reducing the value of R58 to 4.7k.

If you wish to alter the amplitude balance between the cymbals, snare and bass drum without changing their tonal quality (the two parameters are linked to some extent) you can change the values of R61, R75 and R86 respectively. Reducing the value by a small amount will increase the volume for that instrument.
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SEVEN SEGMENT DISPLAYS

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<th>0.33 - 0.35 Orange</th>
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STANDARD 150V DC AUXILIARY VOLTAGE REGULATORS
Two 150V, 20mA, 1000V, 20mA, 500V, 20mA, 50V, 20mA, 10V, 20mA, 1V, 20mA, 0.5V, 20mA. £7.50 each (Data supplied with Spec. display only)

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Trouble shooting

We have already mentioned that the master oscillator operates from a lower supply rail than the dividers and during the constructional tests this was likely to give trouble. Generally the loading on the un-stabilised +15V rail—when all the ICs have been inserted—will clear this problem but it is possible, in some instances, that some instability remains (diagnosed by an irregular or distorted quality of some notes. This can be overcome by increasing the value of +15V rail dropping resistor (R95) to 10 ohms. Remember this must still be a \( \frac{1}{2} \) watt device!

In the unlikely event of total failure you must check the system carefully in a systematic manner. Total failure is most likely to be associated with the power supply, internal amplifier, or master oscillator. Test procedures have been dealt with in previous issues.

It is difficult to decide whether the AY-1-0212 is faulty (IC2) without using an oscilloscope; if you can be certain that the master oscillator is working with no audio tones from the output pins of this IC, there is a high chance that the integrated circuit is faulty. In the absence of a 'scope there is a simple, but effective, test to check the master oscillator. Place a medium waveband transistor portable radio very close (within an inch or two) to Tr1 and Tr2. If you tune over the band, you should hear heterodyne whistles at several points. These may be identified from the master oscillator by turning up the Vibrato Depth control. The whistles turn into chirrups.

Failure of the vibrato oscillator is most likely to be due to incorrect setting of VR2.

As with any printed circuit board project most problems are caused by poor soldering giving rise to dry joints, connections that have been missed—particularly under the large integrated circuits—solder blobs bridging conductor tracks, components put in the wrong holes and components inserted the wrong way round.

It is very unusual for components to be faulty—provided they have not been misused or abused. Remember that it is easy to damage MOS integrated circuits by handling them wrongly. In a complicated design such as the Jubilee Organ, there are bound to be occasions where a component on the extreme end of its tolerance can effect the final performance.

Postscript

Some people might wish to carry out a simple modification which enables the accompaniment section to memorise the last key that was depressed. If this is done, the rhythm and accompaniment sections will continue to repeat the same vamp without the player having to keep his finger on the key. To change the key of the vamp requires a single depression of the next key which is then memorised. Only major chords can be memorised. The modification requires a two pole change-over switch and a break in the printed wiring on the pcb at pins 5 and 35 of IC13 (the Chord Generator). Normally both these pins are strapped to ground 0V. Connecting them to the +15V rail through the switch activates the latch circuitry associated with each chord select key.

SO YOU WANT TO PASS THE RAE?

---continued from page 662---

frequency of the parallel tuned circuit is, in practical terms, the same as for the series tuned circuit,

\[
f = \frac{1}{2\pi} \sqrt{\frac{1}{LC}}
\]

![Fig. 32: A parallel resonant circuit.](W5275)

![Fig. 33: The equivalent circuit of Fig. 32.](W5380)

![Fig. 34: In a parallel RLC circuit at resonance, the impedance is at a maximum, and the current is a minimum.](W5861)

Magnification Factor "Q"

In the circuit shown in Fig. 30, at resonance, the voltage across the inductor (or the capacitor) can be considerably greater than the applied voltage V. As we have seen, the current at resonance is defined by the value of the resistor R, but the voltage across the inductor (or the capacitor) is given by the product of the current and the reactance in question, which is usually very much greater than R. The ratio of the voltage across the reactance to that across the resistor is called the Magnification Factor or "Q" of the circuit.

The "Q" of a practical tuned circuit depends mainly on the quality or "goodness" of the coil as the capacitor normally has very low losses associated with it. A high "Q" tuned circuit has the ability to respond to one frequency whilst rejecting others. In a receiver, this would imply "selectivity", the ability of the receiver to select a wanted signal and reject unwanted ones.

An example of the practical use of a simple resonant circuit is in an Absorption Wavemeter. In this device the resonant frequency of a tuned circuit is used to check the output frequency of a transmitter.

In the next section we will be dealing with diodes, transistors and valves, also block and circuit diagrams.

Practical Wireless, January 1978

669
Pocket-it

With "in" words like Teletext and Oracle commonly in the news these days, one tends to be on the lookout for anything new in this field. The most exciting piece of news this month is that a manufacturer is concentrating its efforts on producing a Teletext receiver which will fit into the coat pocket. Although the company (in Germany) has primarily aimed at producing a portable radio size unit, the pocket version is hot on its heels. It is planned that the unit should be complete i.e. you do not need to plug it in or connect it to a TV receiver in any way. The coat pocket version (it is planned) will have its own aerial and tuner, IF amplifier and Teletext decoder. This will feed a display of LEDs (for the mains version) or liquid crystal cells (battery model) and thus avoid using a conventional cathode ray tube. For anyone following the stock market, this looks a good bet—as and when it becomes available.

After remembering using the old PO 3000 type relays for early model control, I am pleased to note that a new DPDT relay, housed in a dual in-line package and standing only 0.38in high, has appeared on the American market. It fits standard 16-pin DIL sockets which is very useful, constructionwise. Even nicer is the extreme sensitivity of these little beasts: the coil requires 200mW maximum to pull in. On the business side, the contacts will switch a resistive load of 1A at up to 28V DC and will carry 5A. It is amusing to note that the manufacturers of this little relay have the address: 100 Relay Road! Clearly an address which should click with those who are really switched on.

Smart alices!

It seems that we will have to live with the word microcomputer for a while longer—until something even more wondrous takes its place, no doubt. The newest and most interesting development in this field comes from Japan. One of the electronics giants over there is to market a mini-computer-type kit which is aimed at school children between 12 and 14 years old. With a starting production schedule of producing some 4,000 kits a month, the company seems confident it can sell a large number. The price (converted very roughly) would be around £65—£95. Costly, perhaps, but the kit does contain quite a lot. There's a microprocessor (you know of a home without one?), a random access memory and a read-only memory, arithmetic/logic unit, 8-bit latch, audio amplifier, two static RAM chips, keyboard, displays and drivers, and even a loudspeaker. One of the exercises for users is to become an electronic composer. You can compose a tune and enter it into memory. At the touch of a button your masterpiece will be played back using oscillators (yes, these are included in the kit) Tunes of up to 127 notes are possible and are restricted to a maximum of three octaves. This takes in most if not all of the popular melodies for those who might prefer to stick to known tunes. I can see the time when a hush will descend on the Royal Albert Hall, and the soloist will emerge, tuck a 16-pin DIL under his chin and "give forth". Ah, come back Lionel Hampton, all is forgiven!

Valve size?!

New things are often labelled "best" or "biggest" etc. A new semiconductor just released looks as though it could fairly claim to be the biggest transistor in the world. It will handle a peak current of 200A with voltage rating of 550V. These devices have a gain of 15 at the 50A mark and could doubtlessly do nasty things to loudspeakers in disco systems where power is all. Transistors have certainly come a long way since those "red spot" semiconductors I bought in the Edgware Road many summers ago (and they cut off at about 800kHz).

Sunset strip

The recent Energy Exhibition in London highlighted (for me) just how sadly inefficient solar cells are. Manufacturers get excited at anything which exceeds 10% efficiency. While it is almost certain that newer and better materials and techniques will come, there is some work in hand to maximise what is already available. For example, one American company is aiming to get the costs down to fifty cents per watt of power produced. The approach here is to perfect further the technique of "pulling" a ribbon of silicon to get as wide a strip as possible. Up until now, 1in and even 2in wide strips have been produced. Now, the aim is to get 8in widths. The thickness involved is around half a millimetre but by using improved techniques it is hoped to get this down to less than 8 thou.

The strip itself is produced by touching the surface of a molten pool of silicon with a little "seed" bar of silicon. The seed is then very slowly withdrawn. As it rises it "pulls" silicon with it rather like pulling the surface layer of a bowl of hot chewing gum! The cooling length is pulled slowly through a die to form a strip and the silicon allowed to cool at a controlled rate from over 1,200°C down to 600°C. When it is completely cool, it is scribed and broken up into individual cell sizes.

A filter for all occasions

Readers interested in audio filters—particularly electronic music enthusiasts, will find the new SSM 2040 DIL device of interest. It comprises a voltage-controlled monolithic filter and it can be made to synthesise almost any kind of active filter from low-pass to high-pass, band-pass or notch. The manufacturer is offering samples only at the moment and these are quite expensive. Like most things, the price should drop once production increases and the devices would then probably become available to the home constructor. At present, I am waiting further information but it seems possible to use just the one, single filter and to "switch" it to get numerous effects in an electronic musical instrument. Watch this space.
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tune up your car with the PW
ECONOMY TIMING STROBE

A very simple design which uses an a.c. mains power supply to drive the Xenon strobe tube. This provides a really bright flash, allowing easy checking of ignition timing even in full daylight. This unit is suitable for conventional or electronic ignition systems.

Also:
Active Tone Control

Medium Wave Tuner/Amplifier

A three-transistor circuit based on the well-known Baxandall tone control, ideal for use in disco or public address systems. A wide variety of source and load impedances can be accommodated.

This unit is designed to provide preamplifier input facilities plus medium wave AM broadcast coverage for feeding into an existing power amplifier, which also furnishes the necessary power supply. Prealigned IF transformers ease the setting-up procedure.
Due to the ever increasing cost of electricity the need was seen for a reliable and efficient method of controlling an electric fire by reference to temperature. It was thought that the control should be the same, if not better than, that of a gas fire. It should be proportional and automatic, i.e. adjusting to a preset level room heat. When switching large currents of 12-15 amps for up to 3 kilowatt fires, radio frequency interference can be a problem when using thyristors or triacs. With this in mind advantage was taken of the fairly new zero voltage switch integrated circuit, which will give very good proportional control with minimum interference. This is the basis of the circuit shown in Fig. 1.

**Zero Voltage Firing**

With zero point firing the current in the load is turned on at the zero voltage point; this has the effect of reducing radio frequency interference. The power in the load is controlled by the number of half cycles reaching the load in a given period. This technique can only be applied to certain loads, but is particularly suited to heater elements, which have a slow thermal inertia. The type of system described allows just sufficient bursts of power to reach the load, to make up system losses. This is achieved by using an internal generated ramp voltage (see Fig. 2 diagram). The result is very accurate control of the power produced in the load and hence, in this case, the temperature of a room.

**Circuit Description**

The principle of the operation of the zero voltage switch integrated circuit can be seen in Fig. 2. Here a ramp voltage is generated and used to turn on bursts of current in the load at the control voltage which is determined by, and related to, the temperature of the room, detected by the thermistor's resistance. This reference voltage, set up by the control circuitry, is fed into an operational amplifier. R1, R3, R4 and TH1 form the control circuit to give

![Fig. 1: The circuit diagram of the power controller.](image-url)
a means of controlling the related voltage. The width of the ramp voltage is set using the external components R1 and C1. When Pin 2 is at a lower voltage than the bottom of the ramp voltage, the heater is on, and when the voltage is higher than the top of the ramp the heater is off. Therefore voltages lying between the top and bottom of the ramp produce bursts of power to the load thus maintaining the temperature set by the control. The values of VR1, R4, TH1 type, have been chosen to give a temperature range in the region 40°F to 80°F. The output pulse width is controlled by C2, and was chosen to suit the type of triac used, and is therefore fairly critical to ensure that the triac fires correctly. The economy part of the circuit is effected by R8 and S2, R8 being lower in value than the minimum resistance of the thermistor at the high temperature. This ensures a very low load current at low or high temperatures.

**Practical Operation**

The load can be any electric heater up to 3 kilowatts, with the exception of those using electric motors, i.e. fan heaters. Due to the values of R1, C1, used for good control of an element (bar type), the motor will operate in bursts, and not run smoothly. The 3 kilowatts could be extended using a larger triac and modifications to the gating circuitry. But 3 kilowatts was thought to be adequate. The sensing ele-
ment is a miniature bead type thermistor, which in the prototype was mounted in a miniature jack plug, using epoxy resin.

When the room temperature is low the heater will be turned on. When the temperature of the room has reached the required level, that set by the position of VR1, just sufficient current is applied to the heater to maintain the temperature constant. When the temperature rises, the thermistor value drops and so the current is reduced. Figs. 5 and 6 show some graphs of the performance. In Fig. 6 it can be seen that the temperature, with the control in the mid-position, was kept quite even over a period of some 3 hours. It was found, in fact, that once 70°F was reached, and the control left in the central position, the temperature varied only 1°-2°F in 8 hours.
Fig. 5: Graph showing relationship between consumption and temperature.

**components**

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<td>C2 68nF</td>
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<td>C3 100µF 25V electrolytic</td>
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<td>R4 27kΩ ½W</td>
<td>C4 100µF 25V electrolytic</td>
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<td>R5 6.8kΩ 10W</td>
<td>C5 33nF Polyester</td>
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<td>R7 10kΩ ½W</td>
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<td>Semiconductors</td>
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<td>T1 2N5574</td>
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<td>IC1 305/800</td>
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Miscellaneous: mains voltage neon, 2 SPST miniature toggle switches, miniature jack plug and socket, 13 amp plug and socket, 13A fuse, fuseholder or fuse clips (20mm), 100mA fuse (20mm), PCB (Readers PCB Service), suitable case.

Fig. 6: Further graph indicating stable temperature level at mid-control position.

**Construction**

Reference to Figs. 3, 4 and 7 will show the method of construction. First and foremost it must be mentioned that mains voltages are being dealt with and a reasonable amount of care must be taken during construction. To ease the construction it is recommended that the approved P.C.B. is used i.e. Readers P.C.B. services, to minimise wiring errors. The assembly of the P.C.B. should be carried out first. The I.C. should be mounted in an I.C. socket. The case of the prototype was made out of aluminium extrusion, as used in shop fitting work, but any metal box of rigid construction and adequate size could be used. The unit could in fact be mounted flush to the wall, the brickwork giving added heatsinking to the triac. All leads should be kept away from the 6-8k 10 watt resistor. When mounting the triac, it should be fastened to its own heatsink, using the correct insulating kit. Figs. 7a and 7b show the mounting. The sense element in the prototype was mounted in a miniature jack plug, using epoxy resin, see Fig. 7d. There is no reason why the sense element should not be remote from the unit, say in its own small box. This however could possibly interfere with the fact that the unit is normally a portable accessory to an electric fire. If all the correct components are used there is no setting up of the unit to be done, but emphasis must be made here on checking wiring to the P.C.B. to eliminate damage to the I.C. Short circuits around the triac should be checked for, and also to make sure the case is adequately earthed.

*Practical Wireless, January 1978*

675
Were the summers sunnier, the blooms bigger and life more exciting when you were younger? Was the beer better, were the steaks juicier and the girls prettier? However that may be, I truly believe that the inhabitants of Research and Development Laboratories were more eccentric. In many instances the pranks they got up to were frankly crazy.

In his youth Point Contact spent varying amounts of time in laboratories which were only concerned with electronics in an oblique way, the immediate object of interest being some kind of material, a dielectric or semiconductor for example. Consequently, they were staffed by a motley mixture of Physicists, Chemists and that invaluable oddity, the Tame Mathematician, as well as the occasional Electronic Engineer. PhDs were two a penny, almost every other person had a higher degree except for yours truly and one or two other undergraduates. Whether as vacation students or student apprentices we were privileged for a period to participate in the work of this or that laboratory—and in the play too!

Some of the antics which people got up to were relatively harmless, some were fairly hazardous to the prankster and some potentially dangerous to others. In the first category I remember the Plasticene ploy. Plasticene (like Meccano) is a valuable laboratory aid with a thousand and one uses, like instant mounting for a specimen, plugging material for pipework etc. It was used again and again until it dried out and was thrown away and replaced. If you wanted some you had only to look around and there on the nearest shelf, in the cupboard, on the bench was a lump just waiting to be used. Of course, first of all it had to be well kneaded to make it soft and pliable again—and here care was necessary. The unwary were caught out by the prankster who had carefully fashioned a hollow lump and filled it with water, usually coloured with red ink, before smoothing over the hole and leaving it on the shelf.

Much more spectacular was the party trick of a certain Dr. K, which with a little prompting he would demonstrate. Pouring some liquid air from the Dewar flask of a vacuum-trap into a 50 ml beaker, he would then solemnly take a sip and roll it round and round his mouth. If one held up a smouldering taper he would breathe on it and it would burst into flame. (As liquid nitrogen boils at a lower temperature than liquid oxygen, it boiled off first, so unless replenished from a new delivery, vacuum-trap Dewars usually contained mainly liquid oxygen, as one could see at a glance from the pale blue colour.) He would then spit out the remainder, which vapourised in a flash on hitting the floor. Despite his assurances that it was quite safe if one kept the liquid on the move with one's tongue, I recount this stunt only to illustrate the
further time before failure) for cycle I am board used for or 61.03515Hz. This divides fourteen four as nited. Device clocked 1.01296376 1MHz output frequency, so being available, solar device clocked 1MHz and one cycle at the output would reach completion in 1-01296376 × 10¹⁴ years.

This is a good bit longer than Point Contact is capable of imagining, in fact if just four CD4020s had been switched on in the year AD0, then given a long-life battery and assuming a rather good MTBF (mean time before failure) for all the components including the 1MHz clock oscillator, there would still be another 305 years to go before the output of the last i.c. clocked over!

The said colleague came back the next day with the further useful (?) information that there is a Motorola device number MC14521 which is a 24-stage ripple counter and that a boardful of 35 of these would have an output period (when clocked at 1MHz) of 10³ divided by 7-331559403 × 10²⁹ seconds or approximately 2.3 × 10²⁹ years. A suitable long-life battery not being available, solar cells wouldn’t help much either, he assured me, as the sun is expected to have burnt out in the odd 10⁴⁴ years or so. Figures like these are so meaninglessly incomprehensible that the only thing to be said of them is that they do demonstrate the ample capacity of my informant’s all-singing all-dancing scientific pocket calculator.

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**THIRTY-CHANNEL REMOTE CONTROL**

Remote control of channel changing has been a feature of some TV sets for many years, sometimes along with remote control of sound, brightness and colour. More recently however fifteen and thirty channel remote control systems have been featured on some imported sets and some export models. These are based on a set of CMOS i.c.s, and the use of these more elaborate systems is likely to spread in the near future since they can accommodate the functions required for teletext page selection. The operating principles of this type of remote control will be described, and examples of typical peripheral circuitry given.

**DECODER SERVICING**

A general guide to the operation of PAL decoders, the faults that occur in them and trouble-shooting procedures, also mentioning some of the more important variations between different designs.

**TELETEXT EYEHEIGHT**

What? Well, the transmission of digital teletext signals involves many differences from the well known problems of transmitting and receiving normal TV picture signals. For example, with a conventional TV signal the picture worsens gradually with reduction in signal strength, whereas with teletext reception there is an abrupt transition from correct reception to the decoder producing “scribble”. It’s important therefore to be able to assess the quality of a teletext signal, and for this purpose the BBC now inserts teletext test signals on lines 20 and 330. These can be scoped, and the eyeheight of the digits observed. Harold Peters explains.

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**KINDLY NOTE!**

Jubilee Organ Part 3 — November 1977

Page 506: In describing the interim keying tests a mistake was in the text. When the flying lead is connected to the +12V point (positive end of C3) the note is inhibited. It is when the lead is removed from this point that the note will sound and it is under this condition that VR5 should be adjusted. Re-applying the 12V will terminate the tone according to the sustain setting of VR6. When S2 is open the tone burst will occur when the flying lead is REMOVED from the 12V point. The same reversed logic would apply to testing the repeat percussion effects.

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**Television**

- THIRTY-CHANNEL REMOTE CONTROL
- DECODER SERVICING
- TELETEXT EYEHEIGHT

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Practical Wireless, January 1978
Transmitting and receiving aerial performance is difficult to measure with any degree of accuracy particularly when the operating frequency is low and the aerial is, of necessity, very large. At frequencies as high as 28MHz (10m band) one would find it physically impossible to plot the vertical angle radiation pattern, or indeed the plane polar pattern, with the aerial operating in either vertical or horizontal polarisation mode. At 145MHz (2m band) the problem is eased somewhat since the aerials are physically small but even then they need to be mounted very high in order to obtain true “free space” radiation patterns. Further, the transmitted signal source must be a large number of wavelengths away and/or the receiving point must be at a similar distance if the aerial being tested is radiating.

It is usual to test an aerial under receiving conditions; the final result is the same. The writer has in use a 60ft high mast that can be lowered to half way so that 2m aerials for testing can be mounted on a special rotator system that will turn the aerial through 360° as well as from horizontal to vertical mode. The system is remote controlled from the measuring instrument position and the distant transmitters normally used are G8VHF for horizontally polarised signals and GB3PI, or local amateur stations for vertically polarised signals. Even so, the process of carrying out polar pattern and gain measurements is laborious to say the least, and indeed somewhat hazardous, especially when large beams (a recent one was a 12-element ZL Special) have to be hoisted to a small platform about 30ft above ground before being raised to full height for tests. On new designs there is the added problem of making modifications, so an aerial may have to be hauled up and down several times before the design can be approved.

The Theory of Similar Structures

It is well known that aerials scaled down in frequency behave in exactly the same way as they would at the original frequency. At one time the writer used a frequency of 10000MHz to operate a model aerial system capable of obtaining quite accurate polar patterns of both plane and vertical radiation fields. At such a high frequency however, impedance matching, with any degree of accuracy, becomes very difficult indeed.

The “theory of similar structures” is applied in many spheres of engineering. For example, for proving ship’s hulls by using scaled-down models in wave tanks, models of aircraft in wind tunnels and models of bridge structures etc. It is readily adaptable to transmitting aerials and if we take a dipole for example, its familiar figure-of-eight radiation pattern is exactly the same whether the aerial is cut to operate on 2MHz or 200MHz, or any other frequency. This applies, of course, to aerials of all other configurations and to directivity, gain and polarisation as well.

Scaling down makes the aerials much smaller, easier to construct and handle, reduces the distance between the source of transmission and the aerial being tested, and brings the “free space” position much nearer the real earth. If the effect of earth is required as part of the measurement then a metal ground plane of several square wavelengths extent is no great problem. As mentioned however, if the scale frequency is too high matching the aerial to its feed point becomes a problem and to overcome this frequencies of between 600 and 1000MHz are commonly used.

Some years ago the writer used 800MHz for the original design of the “ZL Special” end-fire beam for operation on 14 and 28MHz and which was described in PW recently for 2m operation. At frequencies around those mentioned quite accurate matching is possible, materials for constructing the aerials can be scaled down, as can transmission lines, matching stubs and baluns etc. Even “miniature” co-axial cable, with little loss up to around 1000MHz, is readily available.
A Model Aerial System

A system recently built by the writer and described here operates at a frequency of 650MHz and, as with virtually all systems of this nature, aerials being tested are operated in receiving mode. The transmitter is normally placed at a distance of 10 wavelengths, in this case 4-6m, and it is equipped with a three-element (flat plane reflector) beam aerial to concentrate the radiation forward, to provide a sufficiently large illumination area and to reduce reflected signals to a minimum.

The "receiver" consists basically of a simple diode detector to provide a DC voltage from the RF signal picked up by the aerial being tested and which is used (a) to operate a pen chart recorder to obtain either polar co-ordinate or Cartesian co-ordinate plots of radiation patterns or (b) a continuous direct display of a radiation pattern in polar or Cartesian coordinates on an oscilloscope screen.

The Transmitter

The transmitter is a simple self-excited oscillator using a Mullard TD1-100A valve to provide an RF output at 650MHz of about 2W. Any similar UHF valve would do and frequency stability is not critical provided drift is not more than a few MHz. Audio tone modulation can be applied for quick checks and for demonstration, in which case the model is made to radiate and the space around explored with a single dipole and diode receiver the signal from this being fed to an audio amplifier and speaker. The transmitter must, of course, be completely screened and its output (loop coupled) matched as closely as possible to the transmitting aerial. The circuit used is shown in Fig. 1 and may serve as a guide to anyone interested in embarking on a similar project.

The Measuring System

This system is rather complex in view of the facilities it provides but could be simplified by using a meter to obtain readings for plotting patterns and checking gain, in which case the receiver need consist only of a diode detector, the DC output from this being fed to a micro-ammeter via a simple attenuator.

One of the most important factors in aerial performance measurement is the "reference" to be used and this is normally a dipole. For example, in gain measurement the dipole is first set up and the signal level from this noted. It is then substituted for the aerial to be tested and the level from this ascertained. If the readings are in terms of voltage then the usual formula $20 \log_{10} \frac{V_2}{V_1}$ is used to obtain the gain in dB.

In the system described here a rather more sophisticated reference system is employed, particularly in connection with continuous oscilloscope displays and this uses an "electronic dipole" to be described later.

The block diagram Fig. 2 gives some idea of the complexity of the system, which begins at the aerial being tested, picking up the signal from the transmitter. This is coupled by a rotating loop to the detector and the received signal is rectified, the output being switched to obtain positive or negative (with respect to earth) DC which is fed to a calibrated attenuator. From here the signal goes to a pen-recorder for Cartesian or polar plotting, to a meter for making initial adjustments, or to the oscilloscope DC "Y" amplifier for direct display of Cartesian plots (see various photos). The aerial and polar plotting table are turned by either of two synchronous motors with suitable pulley and/or gear reduction to obtain (a) a slow rotation at about 1 revolution per 30 seconds for pen chart plots or a fast rotation for oscilloscope displays at between 5 and 8 revolutions per second. Directly coupled to the aerial turning shaft are (a) a system for obtaining a sync pulse for each 360° of rotation and pulses for each 10° of rotation which are used for Z modulation (scope "bright up") pulses and (b) the components for generating the electronic dipole signal. The sync and 10° marker pulses are obtained by a light shining through small holes in a perspex disc (painted black).

Fig. 1: Circuit diagram of the author's 650MHz transmitter.

The 650MHz test transmitter with its 3-element aerial mounted above it.
on to photo transistors, the outputs from which are amplified and shaped into short duration pulses. The disc contains 36 holes for the 10° markers and one for the 360° sync pulse.

The electronic dipole signal is obtained by shining light through a rotating disc of Polaroid material and a fixed piece of Polaroid simultaneously on to a photo transistor. As the light fluctuates sinusoidally the transistor generates two "sinusoidal" DC voltages per revolution, the equivalent of the radiation pattern from a dipole in Cartesian co-ordinates, see Fig. 3. The signal is coupled to the Y2 DC amplifier on the oscilloscope via an attenuator so that the level can be set against that from a real "reference" dipole and, of course, retained and displayed simultaneously whilst an aerial is being tested.

An additional feature in progress of being developed is to provide the oscilloscope (an Advance model O5250) with a controllable circular time base; controlled, that is, from the aerial signal to provide continuous display of patterns in polar form as depicted in the block diagram.

Examples of Pattern Plotting

First some examples of plots from the oscilloscope in Cartesian co-ordinate and, apart from the dipole, I have taken one or two of the aerials described in my articles in the PW July 1976 and May 1977. The pattern from a real dipole is shown in Fig. 4 and, as can be seen, compares very favourably with the "electronic dipole" readout in Fig. 3. Each bright spot represents 10° of rotation, through 360°. Now examine the scope readout, Fig. 5, from the "ZL Special" end-fire beam described in PW May 1977, operating in horizontal mode. The two minor rear lobes are displayed to the right and left respectively. Compare this with the polar co-ordinate plot in Fig. 6 taken from the same aerial and with the same equipment.

The $\frac{1}{4}\lambda$ ground plane is a very popular aerial but it is not as efficient as one would suppose due to its high-angle radiation. It is omni-directional and, ideally, maximum radiation should be parallel to the ground. As the vertical angle pattern Fig. 7 shows, maximum radiation is at an angle of about 30° and although some gain is obtained from this aerial over a conventional $\frac{1}{4}\lambda$ ground plane it is wasted in an upward direction. In fact the "gain" on a line parallel to the ground is negative with respect to a vertical dipole. The oscilloscope readout Fig. 8 shows the same pattern in Cartesian co-ordinate.

Performance Defects

With this system of testing all kinds of defects in performance can be seen readily. Taking again the $\frac{1}{6}\lambda$ ground plane, its normal omni-direction pattern

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*Aerial under test*

[Diagram of test setup including aerial, detector, markers, etc.]

A 15-element "ZL Special" mounted on the rotator system atop the author's 60ft mast.

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Practical Wireless, January 1978
Fig. 3: Oscilloscope Cartesian plot of the "electronic dipole". (See text)

Fig. 4: A Cartesian plot of the response pattern of a real dipole.

Fig. 5: Cartesian plot of the response pattern of a "ZL Special" array, operating in the horizontal mode.

Fig. 6: A polar co-ordinate plot of the aerial of Fig. 5, plotted using the pen chart recorder.

Fig. 7: Vertical radiation pattern of a \( \frac{1}{2} \)-wave ground plane aerial.

Fig. 8: Oscilloscope Cartesian plot of the response of the aerial of Fig. 7.
should be a circle if the aerial were behaving perfectly. If a mismatch exists, or the aerial is off resonance, the pattern can become distorted i.e., not a perfect circle. The presence of other resonant conductors will also produce this effect. The oscillogram Fig. 9 shows this quite clearly. The lower trace (B) is a reference dipole pattern. The upper trace should be a straight line, therefore there is a loss of radiated power in some directions. The result is perhaps more clearly illustrated by the polar coordinate plot in Fig. 10 of the same aerial with the dipole pattern again for reference.

A 12 element “ZL Special” mentioned earlier, has been developed for operation on 2m and is now operational at G2BCX, the home station. This aerial started out as a 650MHz model and after adjustment and a few modifications to director spacing and length, yielded a gain (over a dipole) of 14dB. The 2m version is physically much smaller than a Yagi array having the same gain. Its radiation pattern, actually plotted operating on 2m is shown in Fig. 11 by comparison with the pattern obtained from the 650MHz model, which is shown dotted.

**Slim Jim**

Another aerial designed and developed with the aid of the model system is an omni-directional “free space” aerial for 2m known at the moment as the “Slim Jim”. It has no ground plane radials and is vastly superior to a 5/8λ ground plane, due to the radiation being almost parallel to the ground. The vertical angle radiation from the full scale 2m version is shown in Fig. 12. Compare this with vertical angle radiation from a 5/8λ ground plane shown dotted in the illustration. Details of both these 2m aerials will be published in the not too distant future.

To anyone contemplating setting up a test system of this nature I must emphasise that the task is not an easy one, but the results, if they are reasonably accurate, are highly rewarding.
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In part one of this series of articles we mentioned that many of the circuits that we would be describing were going to be "one off" affairs. By this we meant that every circuit built to our specification may not necessarily work first time, without some playing about with component values. In fact this is also true of designs which are far more "respectable" than our examples! The audio amplifier in part 4 should work every time whereas the courtesy light extender of the previous month probably needs different values of timing capacitor to cater for the spread in gains of the transistors.

In passing we would recommend that if you don't spend a reasonable amount of time experimenting with simple circuits like this one, then now is the time to start. It's one of the best ways of learning about electronics in practice, as of course is reading this series!

Perhaps it's time now to stop philosophising and get down to business. The circuit for this month stems from the problem of finding which wire is which in wiring harnesses and cables. Wires always seem to end up being coated with nasty mixtures of dust and gunge and usually end in the most inaccessible places. The result of this is that "colour coded" wires can appear identical to one another and that you sometimes need to be a contortionist to hold the meter probes and simultaneously look at the meter needle. To put an end to this ritual we are going to go through the design of an audible continuity tester as this month's project.

A little while ago we saw a design for such a device which pointed out the merit of using a low testing voltage (about 0·2V) so as to avoid seeing forward biased semiconductor junctions as short circuits. Although this seems a good idea the circuit was implemented with five transistors and a Zener diode—we felt that this was rather excessive so this month we will start from scratch and "design our own".

**Specification**

We want to use a 4·5/5V supply, so that we can either use batteries or the 5V supply which we use for driving most of the instruments on our test bench. The device should use a low testing current—certainly no more than about 5mA—and should treat a forward biased germanium junction as an open circuit. The standby current should be as low as possible so that when the tester is left on for a few hours/days/weeks it doesn't precipitate a major energy crisis.

**Design**

The major problem we have to deal with is the magnitude of the voltages we have to sense. To push three or four milliamps through a forward biased germanium junction is going to need around 0·4V—we realise that the "turn on point" is usually stated to be around 0·2-0·3V but at 4mA it will be a bit more. Now sensing 0·4V is going to be quite difficult and the best solution seems to be to use the sensitivity of a transistor, at the point where it is switching on, to "catch" the small voltages in which we are interested. By far the most convenient way to do this is to work out a way of converting the input signal of a fraction of a volt into a signal of several volts, which we can then use to switch an oscillator on or off.

**Early ideas**

Initially all our thoughts were directed towards putting the sensing circuit in the supply to the base of the transistor. Fig. 1 shows one of our first circuits.

![Fig. 1: The start of the design.](image)

The idea is that the diode turns on a little before the transistor so that if the test probes are shorted together then the diode steals all of the base current...
from Tr1 and turns it off. If however there is a significant resistance or a junction between the probes then Tr1 will keep its base current and stay turned on.

Now this circuit has all sorts of problems in reality, but the one which caused us to abandon this circuit is that it will gobble up current at an alarming rate during standby. If the collector load resistor R1 is made large so as to reduce the quiescent current then Tr1 will be heavily saturated and hence difficult to switch off.

![Fig. 2: A possible development using a Zener diode.](image)

An alternative solution is to play around with Zener diodes, which alleviates the current problem (see Fig. 2). We don’t like this idea since, by the time you have allowed for the +5% Zener tolerance (+0·2V) and for about half a volt difference between a full battery and a half empty one, the build up of tolerances will produce a bit of a mess.

Anyway, whilst we were thinking about this method, we had a bright idea: why not put the sensing element in the emitter and stabilise the base voltage—which can be done roughly with a couple of diodes? Fig. 3 shows the sort of idea we are getting at—it seems altogether a lot better. The current consumption with

![Fig. 3: A more effective modification involving two diodes.](image)

the probes open circuit need be little more than the base current required to turn on Tr1—only a microamp or two. We will have to decide about the diodes by experiment but doubtless we can trim up the final circuit with a preset potentiometer. To check that this circuit is feasible suppose that we achieve an emitter voltage of 0·3V and that Rc is say 1kΩ: if we short the probes and ensure that Rb is sufficiently small then Tr1 will saturate, whilst if we connect a 200Ω resistor across the probes then a current of about 0·3/200=1·5mA will flow which means that Rc should drop only 1·5V. This all looks very promising.

At stage in the proceedings we can make intelligent noises about how, since we want voltage gain and aren’t particularly fussed about the current gain, a common base circuit (which this is in essence) is going to be at least as useful as a common emitter circuit (which the others were). We feel that whilst this sort of observation may be quite interesting it is not particularly useful and we certainly will not follow the scientific tradition of covering up the luck and inspiration involved by pretending that the circuit was arrived at in this way.

**The Oscillator**

Having got so far perhaps we should turn to the design of the oscillator. Some sledgehammer solutions spring to mind, such as using a transistor or two to amplify the current available and use this to supply a multivibrator or something. With a bit of thought we can do better than this. What about using the output of Tr1 to control the bias supply to a one-transistor oscillator—something like Fig. 4.

![Fig. 4: Here the circuit has grown into a Hartley-type oscillator.](image)

This may well work but we have a solution which we think is even better. The complementary pair type oscillator in Fig. 5 works as follows. Assume that both transistors are turned off—then C will start charging up via R and the speaker. Soon Tr1 will begin to turn on; this turns Tr2 on and the current through the speaker raises the voltage at that end of C.

![Fig. 5: An oscillator involving a complementary pair.](image)

Now it is one of the fundamental principles of electronic circuitry that you cannot change the voltage across a capacitor instantaneously. This means that the voltage at the other end of C is pushed up even higher and so even more current flows. Eventually the capacitor loses all its charge and the current through the transistors starts to drop. Provided that the component values are within a certain range (which is very wide and we won’t worry about it here) the capacitor will drag the base of Tr1 down sufficiently far to turn off both transistors again. The cycle can then be repeated. The current through the loudspeaker, which should be a low impedance type, flows in short pulses but is of sufficient magnitude to make a fair noise.

The major point of interest that this circuit holds for us is that the resistor acts merely as a charging source for the capacitor. If we take the supply-rail end of R and connect it to a variable voltage source, the oscillator won’t run when the voltage is zero and will oscillate as before when the voltage is equal to that of the supply rail. Somewhere in between these two extremes it will struggle into life and a little experimentation with the circuit on a T-Dec showed that this occurred with R=1MΩ and C=1800pF at around 1·5V.

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686  *Practical Wireless, January 1978*
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If we connect R directly to the collector of the sensing transistor in Fig. 3 we will in fact have produced a resistance tester which will make a noise only when we haven't got continuity. Although this works it is not what we wanted when we drew up our specifications. Never mind, we can turn the circuit of Fig. 5 "upside down" if we reverse the polarity of both the transistors—the two circuits can then be fitted together as shown in Fig. 6. We have tapped the resistor to the oscillator from the potential divider of R2 and R3 so that we can arrange for Tr1 to be near saturation before the oscillator switches on. We have also put a preset potentiometer in the base of Tr1 to trim the circuit for maximum sensitivity. We could have put it in series with the probe leads, but let's leave it where it is for the time being.

![Fig. 6: The "combination" oscillator circuit.](image)

**Component values**

Perhaps we should justify some of the component values in Fig. 6 which have already been decided. R4 was chosen as 1MΩ because our experiments with the oscillator showed that this value worked well. C1 is 1800pF because this value made a nice noise. As for the transistor types: the 2N3702 and 2N3704 are simply cheap general purpose types and we chose a BC109C for Tr1 because it has high gain which will mean that we need less current in the R1-VR1 circuit and this in turn means lower standby current. What now? Well the best thing to do is to build the circuit on a T-Dec and experiment with the values of the other components.

![Fig. 7: The circuit of the completed design.](image)

on when the probes are shorted. Increasing the value of R1 to 470kΩ rectified this deficiency.

Having set the circuit to the correct operating point with a 4.5V supply we found that resistances of more than about 20Ω did not register as shorts, neither did a selection of germanium junctions in diodes and transistors. The 20Ω figure was rather better than we dared expect and even when the supply voltage was increased to 5V there was little degradation in performance. The complete circuit diagram is shown in Fig. 7.

Flushed with success we transferred the whole circuit directly from the Dec to a piece of Blob Board. A practical layout is shown in Fig. 8. If the transfer is done component by component then the whole process is very fast and you don't have the problem of losing the components among the general chaos of the work bench. We then attached a pair of old probes to the unit along with two leads for the battery.

Where do we start? We wanted a sensing current of three or four milliamps maximum so we want R2+R3 to be in the region of 1-5kΩ. We already know that we want about 1-5V drop across R3 when Tr1 is saturated, to drive the oscillator. A little experimentation showed that when R3=470Ω and R2=1kΩ the voltages were about right. Then we dug out a 500kΩ preset and soldered a couple of leads to it so that we could plug it into the Dec. R1 was chosen to be 270kΩ on the grounds that we can't possibly want more than about 70mA of combined base and diode current. The circuit was then tried without any diodes to make sure that the oscillator oscillated when the probes were shorted and stopped when they were open circuit.

We then experimented with the diodes. It turned out that with one silicon and one germanium diode in series the transistor could not be persuaded to turn on significantly at all, even with the VR1 on minimum. With two silicon diodes in series we couldn't turn the oscillator off when the probes were shorted. This is a disadvantage, as maximum sensitivity is obtained by adjusting VR1 so that the oscillator is just turned

![Fig. 8: A practical layout for the continuity tester.](image)

Practical Wireless, January 1978
In the January 1976 issue of PW we published an article entitled "Want Some Lolly?" which laid down the guidelines for budding authors. The response at the time, and for some time afterwards, was most encouraging so we feel that another similar, but updated, article could be of profit to magazine's readers alike.

First of all, don't imagine that just because you are a genius at developing and constructing electronic circuits you cannot possibly write them up as well. If you go about it in the right way, you can, and get paid for it! You have only to look at any copy of PW to see the style we use for technical articles and then copy that. What could be described as a PCB is to give an accurate account of what you are doing, from the word "go". Use a notebook and not odd bits of paper which are easily lost or used, inadvertently, for lighting your pipe!

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When experimenting with a circuit you are bound to make voltage or current measurements so put these values on the circuit diagram in your notebook. If using an oscilloscope to check waveforms draw these in at the appropriate point, together with their amplitudes, if these have been measured.

If you think that your brainchild is likely to be of interest to the readers of PW then drop a line to the Editor with a brief résumé of what it is and what it does. If its appearance is important then a colour snapshot of it can be very informative to the Editor. DO NOT SEND THE PRINT UNTIL REQUESTED!

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Practical Wireless, January 1978
Quite a few reports have accumulated since last month but pride of place must go as usual to a reader who has just got his nice new callsign. Andrew Work of Beverley, E. Yorks, often wrote to the column as A8091 but now he is G8NPT and has already been on the air on 2m with some borrowed gear. Regrettably, Andrew has quite rightly decided to forget the code test until his “O” level exams are out of the way next year. Andrew is full of praise for our new RAE series in P&W and feels sure it will bring on a new batch of licencers in due course.

Chas. Mason, subject of my November editorial is now GW4GDJ and active with a KW Vanguard on CW using a 132ft wire, plus an AR88. Chas. is in a very isolated spot in Pembroke, W. Wales, so the DX potential ought to be excellent. Simon Robinson (Stockfield, Northumberland) was on holiday on the Isle of Mull where he met local GM4EHE. Simon’s DX is still not too good, being stuck with an inside aerial around the lamp fittings!

Alan Doherty BR34668 of Portrush, Co. Antrim has not had too much time for DXing but nevertheless found something on all the HF bands. WB6NCO/VQ9 on Diego Garcia was a good find on 15m and FK8CR on Noumea (Both well known). Paul Pasquet reports that fellow listener Iain is now radio cadet with BP and away on a course, but Paul seems to have managed quite well on his own! Weirdest call of all time was 4079WARC which turned out to be in YU-land! Another of Paul’s weirdies was Z44N reported to be on an island near ZC4. A more familiar prefix was KS6 in the shape of KS6FL. A pretty good catch on 15m SSB.

It was good to hear from Dave Peck BR37621 of Cambridge once again with a short list of his RTTY finds on 20m. Dave happened to find out that his neighbour is an Ex-RAF radio op so Dave can now do about 12wpm! Better get him into the local club OM! In Brauntob, N. Devon, Paul Bradbeer now has a new FRG7 to feed from his V-3jr vertical aerial. Wisely, he has added earth radials rather than rely upon the natural earth. His favourite band is 15m although 20m and 40m get their share of his attention. First time writer John Stephen of Glasgow recently bought a Hallicrafters SX140 and is very pleased with results so far but would like to get hold of a manual for it, so if anyone can help write to John at 74 Shakespeare Street, Glasgow G20 8TJ.

Up in Dringhous, York, some CW has been copied by John Hague but he hopes to do better soon with a DX160 which is on the way. John mentions that he is taking his code test very soon but I am not sure that this is very wise. As far as I know the code test certificate is only good for a year so unless John gets his RAE in that time he might have to take the code test again. With the astronomical rise in the cost of taking the code test and the RAE it behoves every candidate to make quite sure that he is 100% ready for the exams before entering.

An interesting letter from 16-year-old Kevin Jones in Nuneaton, Warwick, who is working on communications in the Sea Cadet Corps where he has been able to play around with some of the gear. From Rotherham comes a first letter from Neil Clarke who has succeeded in copying SSB on 40m with two domestic receivers, using one as a BFO! Anyway I think that the bug has bitten Neil hard enough to ensure that he will be getting a set soon that is better suited to the job in hand! One callsign, a G8, caused Neil to ask why he was operating on 40m as he thought G8’s were confined to VHF and up. Well, this G8 was G8RY, an old-timer licenced around 1937/38, the other G8’s have three letters popularly known as G8-T’s. Similarly, my own call G4AR was issued in January 1933, the new licences are G4-T’s.

Old faithful Robin Bayley keeps going up in Shropshire with his EC10 and long wire aerial. Even in summer he still logs DX like HK0 and FP8 on 80m and a VK9 on 40m, with KH6 on 20 and 15m. From Redruth in Cornwall, Bill Caulfield tells me he has been reading PW for years but only now has taken the plunge and bought some gear for the SW bands. It is only what I would call a “glorified” domestic receiver but, like Neil Clarke mentioned earlier, I hope it will lead to better things before long. Bill admits to being 58 which gives him plenty of time to get his ticket and settle down to the greatest of all hobbies!

CLUB NEWS A new radio club for those of you in Devon, namely the Exmoor Radio Club which meets on the second and fourth Thursday each month at the South Molton Community College. They plan to start RAE courses based on the new PW series. Thanks for the compliment, hope it leads to a lot of new tickets. Contact Chairman Dave Stone, 47 Oakford Villas, North Molton, Devon or Secretary Ted Bruns, Loughrigg, East Street, South Molton, Devon.

Log extracts

R. Bayley:— 80m AP2AD CT2AP EA9CR FP8DA HKOCOP 40m DUDITB FP8DH JA1JKK J7W8K VK9XI 20m KH6BB TG9AD 15m HK0CAT KH0IP TG0TL
F. Bradbeer:— 20m VP2DLF VP8PM 15m HM11A HR5JJR KG6SS P29JS VP2GAI YBS5A 5T5JD 10m FMTAV VP8NO 8P6FX 9J2BO
A. Doherty:— 80m JA6BSM 5Z4DI 8P6GN 9GIAR 40m KA2BY TU2E2F 20m FK8CR KS6FL KG6BU 5T2A VP8MX V53XI YB7AAA 2K1DR 5B6DS 15m P29DU WB6MCO/VQ9 (Diego Garcia) ZD7PV VP8BC
P. Pasquet:— 20m KA6KN SN11M 15m J28AM KS6FL VP8NO ZD7S 807AD (Maldives)
D. Peck—RTTY 20m A9XXC EA5IY EA9FJ K8FD KG6FKG LU9CN PY2BIXA SL5LA VE3FQD YV77U 7X4MD
J. Stephen:— 20m CP1BP H55JR TR8JVC TU2GO 15m VP2SAG
B. Harrison:— 80m VP2LDJ 20m KC6BS 15m 8S8TH VR4DN 8Q7AD 10m VP8CZ VP8LP
All reports are SSB.

Practical Wireless, January 1978

693
MEDIUM WAVE DX
by Charles Molloy G8BUS

A useful log of MW DX comes from John McFadden of Belfast who has recently acquired a Yaesu FRG-7 communications receiver. When connected to a 35ft longwire aerial it pulled in CJOH in Halifax, Nova Scotia on 920kHz, CJYQ (ex-CJON) on 930 and three broadcasts from New York City, WINS on 1010, WNEW on 1130 and WQXR on 1560, all heard between 0100 and 0250 GMT. Other DX logged includes Ain Beida in Algeria on 529 at 0014, Istanbul on 1010 at 0216 and an American CBC Radio discussion programme on 650 at 0205. This could be CFCY in Charlottetown, Prince Edward Island which is occasionally heard in the UK. Although privately owned, CFCY may well have been relaying a programme from the CBC (Canadian Broadcasting Commission). Privately owned stations do this, a practice which can easily mislead the DXer.

John says he is interested in UK medium wave stations and asks if it is a good idea to concentrate on one area or just to browse around for anything that happens to be on. Surprise and the unexpected await those who browse around the medium waves. New stations are always appearing and propagation is sometimes favourable to quite unexpected parts of the world. On the other hand, DXing North Americans has an attraction of its own.

There are large numbers of stations, over 4000 in the United States. There is no trouble with identification or language and the majority of stations will QSL. Propagation as usual is the deciding factor on the medium waves. The North American specialist will sometimes find the band alive with stations that interest him while at other times 1010 on a Sunday afternoon is all heard. This occurs when he will have to "browse around" or pack in DXing until the North American path picks up again.

Neal Cartwright (London) who uses a Ecko A239 valve receiver, would like to know how to immobilise its AGC (automatic gain control). Locate the AGC line and connect it to the chassis of a valve or transistor amplifier as a switch can then be switched on or off as required. Although the AGC is useful when turning across the band, as it prevents the receiver from being overloaded by strong signals, it can be a disadvantage when one is trying to listen to a weak station that is close to a strong one. The AGC will respond to the strong signal, reducing the receiver gain and the weak station now appears to be weaker than it really is.

The usual technique to use when the AGC is ON, is to set the RF gain control to maximum and adjust the volume by means of the audio gain control. With AGC switched OFF then a different procedure is called for. Adjust the audio gain for a comfortable volume from the loudspeaker and follow the signal with the RF gain control, backing it off on strong signals to avoid overloading and crossmodulation.

Is there a book giving details of radio stations in North and South America including powers of transmitters, call signs, identifications and addresses, asks John Faulkener from Mansfield. The World Radio and TV Handbook, published annually and distributed in the UK by Billboard Publications, contains this information for the majority of broadcasting stations on the long, medium and short wave bands, throughout the world. The 1977 edition cost £5.50. John already possesses a copy of the World's Short Wave, Medium and Long Wave, FM and TV Listing which covers 1500 medium wave stations in the United States and another 300 in Canada. This paperback, which is published by Babani, costs 60p and is available from bookshops in the UK.

John does his DXing with a Trio 959D communications receiver, a Codar PR40 preselector and a 100ft longwire. North Americans heard with this setup are CFRB in Toronto on 1010 kHz, WBEL on 1080 kHz, WNEW on 1560 kHz and WOR on 1130 kHz. In Antigua the DXer , Charlie Robinson of Selby in Yorkshire is building a loop aerial. He has an unmarked variable capacitor and asks if it is possible to find out its value. An indication of the value can be obtained by substituting it for one of known value in a tuned circuit, such as the tuning capacitor in a radio receiver, though this may not be too easy to do in practice. The unknown capacitor will be lower in value than the known one if the tuned circuit resonates at a higher frequency than before, with the vanes fully meshed.

Why not try the unknown variable on the loop? With the vanes unmeshed, adjust the number of turns on the loop so that it resonates not lower than 1600kHz. When the vanes are fully closed the loop should tune to 540kHz. If it tunes to a higher frequency then the capacitor is too low in value. It can be increased by using a fixed capacitor to try 220pF. The outer 50pF is a switch and the band can now be covered in two ranges. DXers who find it difficult to cover the whole band even when using a 500pF variable, should try this method.

Harold Emblem (Mirfield, Yorkshire) has been busy during the evening with his Edystone 730/4 and loop. Stations heard include Riyadh in Saudi Arabia on 587kHz and Conakry, Guinea on 1070kHz. A loop is sometimes used in the UK and VQ5K, a DXCC specialist, has been heard from Nigeria on 1320kHz.

Harold mentions that all the stations in the CJON network, (610, 670, 880, 930, 1350) are now using the call CJYQ which is abbreviated at times to "CJ Radio". He has sent a reception report to St John's (830) which increased power recently to 50kW and the reply should indicate whether the callsign too has been changed from CJON to CJYQ.

Robin Harvey of Halesworth, Suffolk has heard the medium wave outlet of Mebo 2 under the Spanish station on 735kHz. It is on the air nightly between 1900 and 2300, in parallel with 6205 in the 45m band. Announcements are in English but very small and it is not known where the station is from a ship anchored in the harbour of Tripoli in Libya. During the day it relays the programmes of Libyan Radio. Reception was with a Telefunken TS101 portable and a telescopic aerial.

T. Cridge of Farndon, Cheshire recently purchased a CR100 and has a great deal of pleasure from it. "I have been experimenting with different aerials and at present have a half folded dipole. I don't really know what I am doing but it is great fun finding out". A loop is now under construction which should give some direction to the experiments.

SHORT WAVE BROADCASTS
by Charles Molloy G8BUS

The reference in the October issue of Practical Wireless to Radio Australia's transmission on 21570kHz in the 13m band has brought an interesting reply from George Hew-

Practical Wireless, January 1978
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left of Torquay who is a Monitor to the Broadcasting Branch of Telecom Australia (Radio Australia and VNG). He refers to the antenna bearings which appear in Radio Australia's transmission schedule and in the World Radio Handbook. For British listeners, bearings of 308 and 325, both across the short route, offer the best reception while 110, 118 and especially 126 give the best reception over the long route across the Pacific. Reception of transmissions on other bearings can occur but are more difficult with much depending on time of year and day.

George refers to the Australian Time and Frequency standard VNG which can be heard on 12-0 and 7-5MHz between 0600 and 0800 and on 7-5 and 4-5MHz between 1600 and 2000. Reception is possible throughout the year, the morning times being latest and the evening times earliest, in mid-winter. Station announcements are given a few seconds before each hour, quarter hour, half hour and quarter to the hour. The transmission on 4-5MHz, which appears 30 minutes later than the one on 7-5 should be of interest in Tropical Band DXers as an Indicator of propagation conditions across S.E. Asia.

The International Short Wave Club is offering to send a free sample copy of their monthly bulletin to readers of Practical Wireless. The bulletin presents news and highlights of the short wave world and there is also a section covering the amateur bands. The October issue gives details of the International SWCW new leave station popularity poll. The voting, for 1977, favoured Radio Nederland in all six continents. Request should go to the President, Jim Malone, 19 Seventh Avenue, Manor Park, London E12 and return postage, although not asked for, would no doubt be appreciated.

Brian Steele (Sheffield) has recently purchased a Sony ICF 5900W receiver with which he pulled in the Voice of Turkey on 9515 and 11880kHz, Radio South Africa on 11900 and Radio Canada on 15325. Brian is very pleased with his new receiver which has a military style cabinet, a crystal calibrator and has DX/Local, BFO and bandspread controls.

Harold Emblem (Mirfield, Yorkshire) has been trying his Eddystone 730/4 on the short waves and he reports hearing Trans World Radio, Bonaira on 15275KHz (19m band) at 2215, Sri Lanka on 15425 at 0400, AFRTS on 15450 at 2255. On 16 metres he logged "WINB Red Lion on 17720 signing off at 2000 with announcement of this frequency which is not listed in the WRH, and WYFR Family Radio on 17045 at 2025. Harold Brodribb (St Leonards) has been busy again on the higher frequencies with his CR10 and longwire. On the 11m band he heard Radio Israel in Russian and Yiddish on 25605KHz between 1430 and 1630. On 15 metres, Radio RSA was heard on 21535 at 1435, Radio Australia on 21570 at 0840 with DXers Calling (also on 9570), Radio Israel on 21625 at 1640, BBC World Service on 21710 at 1405 and Radio Norway with Listeners Choice on 21730 at 1345.

Derek Taylor (Preston, Lancs) has been trying out his new Yaesu FRG-7 on the short waves. When connected to a 30ft longwire via an aerial tuning unit, it pulled in Radio Pyongyang on 9420 at 2000, The Voice of Vietnam on 12345 kHz (out of transmission) at 1200, 1850, ELWA Liberia on 11950 at 0625, Tokyo, Japan on 15320 at 0610 and Kinshasa, Zaire on 15350 at 2115. John Hill (Swindon) has a Realistic DX160 receiver which he uses either with a 40ft longwire or connected to the bedspring (not to be recommended with a mains operated receiver)! Stations logged include Radio Australia on 9570kHz at 0650. John, who is new to the short waves is not sure whether his conversion from MHz to kHz is correct. It is very easy to do, just shift the decimal point three places to the right; 9-57MHz is the same as 9570kHz.

Newcomers to the short waves may be confused by the reference to "bands" which are expressed in metres and to individual frequencies which are in kHz or MHZ. The conversion between the two is simple, especially if a pocket calculator is available. Divide 300,000 by the frequency in kHz to obtain the wavelength in metres, and vice versa e.g. Radio Australia on 9570kHz has a wavelength of 31-35 metres. The limits of the international short wave bands are:-

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency Range</th>
</tr>
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<tbody>
<tr>
<td>49 metre</td>
<td>5950kHz to 6200kHz</td>
</tr>
<tr>
<td>41mb</td>
<td>7100 to 7300</td>
</tr>
<tr>
<td>31mb</td>
<td>9500 to 9775</td>
</tr>
<tr>
<td>25mb</td>
<td>11700 to 11975</td>
</tr>
<tr>
<td>19mb</td>
<td>15100 to 15450</td>
</tr>
<tr>
<td>16mb</td>
<td>17700 to 17900</td>
</tr>
<tr>
<td>13mb</td>
<td>21450 to 21750</td>
</tr>
<tr>
<td>11mb</td>
<td>25005 to 26005</td>
</tr>
</tbody>
</table>

and this table should help readers whose receiver is marked in metres, to locate stations mentioned in this column which are in kHz.

Roy Patrick (Mackworth, Derby) sends news of WYFR Family Radio who expect to start testing the first 100kW transmitter from the new transmitting site at Okeechobee, Florida soon. The Scituate station will continue to broadcast until the middle of 1978 when it is scheduled to close down and all Family Radio programmes will then come from Florida. Roy used a Joystick antenna with ATU connected to a Trio 9R59D or a National 1400 portable. With this set-up he logged Radio Rumbos on 4970kHz at 0600, Malta and 0500 on Saturdays only, Radio Nova (Mebo 2) on 6205 with test transmissions in the evening, Radio Andorra on 6280 in French during the morning, the Voice of Iran 9022 from 2000 to 2030 in English, Voice of Turkey on 9515 at 2200 with DX tips nightly at 2230, WYFR on 11805 in Spanish at 1800, Kuwait on 12095 with a good signal from 1800 onwards, WINB 15270 with a good signal at 2130 and the Voice of Greece on 27700 in English at 1200. Thanks Roy for a very useful log.

The last word this month is from John Faulkener of Mansfield who mentions that the World DX Club has its own weekly programme in Adventist World Radio, broadcast over the 100kW station at Sines in Portugal. The programme is on a Sunday from 0835 to 0945 on 9670kHz on the 31m band and was received by John at a SINPO rating of 55555 with his Trio 9R59D receiver and 150ft longwire.

by Ron Ham BRS15744

Despite many overcast periods, Cmdr, Henry Hatfield, Sevenoaks, continues to produce valuable information about the sun's behaviour with his spectrohelioscope and his radio telescope. Frequently, during the latter part of September, John Smith, Cranleigh, Henry, and myself recorded radio noise from "active" events on the sun which were not suitably responsible for widespread isospheric disturbance, reported by the BBC World Service on the 24th, the auroral openings on the 22nd, 24th and 26th observed by John Branegan, Saline, Fife, and Charlie Newton, G2FKZ, London, and the good 10m conditions.

Henry identified 3 sunspot groups on October 2, 4 groups on the 5th and 5th, witnessed 6 bright plages on the 2nd, a spray of gas and a pillar prominence on the 5th, 2 "enormous" filaments on the 9th, and 4 plages and 16 filaments on the 18th. In view of this it is not surprising that John Smith, Henry and myself often recorded strong 'solar noise,' (156MHz), from the 1st to the 15th and severe noise on the 16th, 17th, and 18th. An ionospheric disturbance was reported by the BBC World Service during the early hours of the 19th.

During the auroral events, John Branegan heard 2m
signals from DL, EI, GM, GW, LA, and the UK beams from Lerwick, GB3LER, to Cowan, GB3CTC. Like other observers in the UK, confirmed by G2FKZ, RSGB auroral co-ordinator, John uses GB3LER, 144-955MHz, for early auroral warning. Readers reports will be passed on to G2FKZ and Ron Livesey, Co-ordinator for the British Astronomical Association.

It's good to hear the DX from both hemispheres on 10m again. On October 5, Henry Hatch, G2CBB, told BBC World Radio Club listeners that VK stations were currently being worked from the UK and at 0830 on the 8th I heard YB0ACP, and VK8CC/M. During the early mornings of the 10th and 14th I received strong signals from Japanese stations working into Europe. John Branegan heard stations from Italy, Portugal, South Africa, South East Asia, Japan, and FICL via GB3EM on the USSR on the 8th and 9th, and at 1600 on the 9th the US Citizens Band was wide open and tuned to 27-155MHz, USB, John heard signals from Brazil, California, Louisiana, Nova Scotia, Ontario and Texas.

Harold Brodribb, St. Leonards-on-Sea, Nigel Golds, BRS 36910, West Chiltington, Sussex Lawrence Hobden, Brighton, and myself frequencey heard strong signals from G4CYC, GB3QY, 28-220MHz, between the 8th and the 18th. At 0845 on the 10th I heard, amid QSB, the Bahrain beacon, A9XCl, 28-245MHz, and on the 11th, 14th, 16th, 17th and 18th I received signals around 28-330MHz from an experimental propagation beacon E2JZV. On the 15th, Lawrence Hobden heard the Florida beacon, 54RD, 28-207MHz, on his 1837 receiver which is still going strong, and Nigel heard several VP stations.

Around 1600 on September 27 and 28, Anthony Mann, Applecross, Australia, heard strong signals from the Bahrain beacon on 10m and on October 2 there was a strong opening toward UK and western Europe. During the early morning of October 4, and on several days after, the 10m band was open between Australia and the USA and some of the American CBers on 27MHz were almost at low strength.

Frank Luman, Donald Bassnet, John Thorburn, John McCarrn, from Glasgow and Fred Dinning, Dunlop, have formed a club called, The Scottish VHF AND SW DXers, and currently meet every first and third Saturday afternoons at Frank's home, 2, Ormonde Drive, Netherlee, Glasgow. New members are welcome: he, ed strong signals from Frank Luman. Frank, Donald and Fred have an early warning arrangement which was used on September 22 when 7 Norwegian stations, some in good stereo, were heard in Band II via what may have been the last event of the 1977 sporadic-E "season".

While on a hill some 800ft ASL Nr Dumfries, using a beam of about 16ft AGL, Mark Deutsch, G3VJG, Kettering, could not make any contacts on 2m SSB, so he moved down the hill, about 1 mile away, at 250ft ASL and worked G2HFC, Wigan, via the Welsh repeater, GB3MP, with a 5/8 whip aerial on his car. Mark could also hear the Central Scotland repeater, GB3CS, where there was no trace of its signals at the 600ft level.

Grange Zion, GB1TS, who, from his difficult location in the City of London, with his beam aerial fixed south on his balcony, has received his Four Metres and Down Certificate from the RSGB for 70cms. His achievement includes contacts with stations in northern G and his best DX was GW6CFQ, Wrexham. George now plans to do the same on 25cms.

On September 21, Alf Lee, GADDQ, Ilkworth, worked a GB station via the Irish repeater, GB3C, from his car in Haywards Heath car park. At 0930 on the 30th, Alan Baker, GB1LQ, Newhaven, heard FICIX working DCIWO via the German repeater, DB0UT.

Around 0800 on October 12 the atmospheric pressure began a gradual rise reaching 30-21in by noon on the 13th and at 0400 on the 14th it started to fall. True to form, a large auroral opening occurred and lasted until about 0500 on the 15th when the AP was levelling off at 30-05in. The event covered a wide range of frequencies.

Derek Knight, Storrington, and Harold Brodribb, both reported co-channel interference on UHF-TV and that both the BBC and IBA warned their viewers about the prevailing disturbance.

From midday on the 14th to mid-morning on the 15th I received strong signals from the Sutton Coldfield, GB3SUT, and Emley Moor, GB3EM, beams on 70cms, a good picture on Channel 8, 189MHz, from Lichfield, and several continental broadcast stations in Band II, with one on 40m the final station to fade to Frank. At 2035 on the 14th, Harold Brodribb, using a 2 element beam into his Bush VHF-80 heard French and Dutch stations in Band II and at noon on the 15th he counted 20 French stations between 88 and 101MHz, strong enough to obliterate the BBC signals.

During the morning of the 14th, Alan Baker worked several German stations on 2m via the Stuttgart repeater, DBOWR, on 250ft, and FICL via GB3EM on 2m and DEBUT on 7W7 while located on Beachy Head where both repeater signals were consistently 58. At 1700, Alan called on ERN Hoare, G6BDJ, Brighton, and they both watched Kojak on French TV via Ern's 70m beam. Around 0200 on the 15th, Alan worked G8LCK, London, via both the Birmingham, GB3BM, and Hampshire, GB3SN, repeaters on R5, at the same time. Alan suddenly realised what was happening when the Birmingham repeater signal faded out and he could still hear the 1J watt signal coming from G8LCK. At 1600 he heard the signal from a GM/M through the Kent repeater, GB3KR, and during the event he worked DG6TY, Cologne, about 500km on 2m SSB.

From 1800 until midnight on the 14th, John Heys, G8BDQ, Hastings, proved, the value of a morse key and worked a host of DXs on SW, 3 SPs, 4 OKs, 1 YO and a half hour stint between 1935 and 2005 he contacted 6 OKs on the trot, all on 2m. His best DX was more than 1000km, on a mainly overland path with OK3CDI/P. John said it was his best evening for 20 years and looks forward to another tropo-opening when he can go for YO, YO, HA, and 11.

During the August leg of the RSGB 5cm Cumulative Contest, Sam Jewell, G4DDK, Stone, worked GB8AXE/P on Winter Hill, Bolton, from Brown Clee, Shropshire, a distance of 124km with torrential rain at both ends which had little effect on the signals. Several days later, encouraged by this, G8AXE and G8AFC wanted to try for their Microwave Awards by working over 150kms. Sam set up his gear on the Long Mynd, Shropshire, and G8AXE, G8AFC, G5SMU and G4BBU climbed to the top of Fair Snape Fell in the Calder Fells, Lancs, to establish their stations. The two groups used their TR2200s for talk-back over the 151km path.

A signal on 3cms was received quickly from G6AXE/P but only a weak signal was received from G4DDK. The work began at 1200 and a strong sun set around 2045. A temperature inversion occurred and the signals came up at both ends allowing them to complete the formalities in relative comfort. On October 2, G8AFC and G4DDK set up their 3cm equipment on Axe Edge in the Derbyshire Peak District and exchanged signals over a 148km path with GW4BR5/P on Pumilumon Favre, near Aberystwyth.

Thanks to you all for your fascinating reports, best wishes for Christmas, and let us look forward to another interesting year above 28MHz.

Reports on the various bands are welcome and should be sent direct, by the 15th of the month; to -

AMATEUR BANDS Eric Dowdeswell G4AR, Silver Firs, Leatherhead Road, Ashtead, Surrey KT21 2TW. Logs for bands, each in alphabetical order.

MEDIUM and SW BANDS Charles Molloy G8BUS, 132 Segars Lane, Southport, PR8 3JG. Reports for both bands must be kept separate.

VHF BANDS Ron Ham BR51744, Faraday, Greyfriars, Storrington, Sussex RH20 4HE.

Practical Wireless, January 1978
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<td>4EP1 25.00</td>
<td>VCR132A 5.50</td>
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<td>VCR132B 8.00</td>
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<td>VCR132H 8.00</td>
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