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- Sensitivity 30 mV. Suitable for high output, high fidelity transformers.
- Designed for use with all types of speakers, stereo systems, and high quality speakers.
- Complete kit, built and fully guaranteed. Limited number to clear. £18 Gns.

MINI-8 HI-FI Loudspeaker Units Special Offer

- Teak or Afromosia veneered cabinets.
- 20-100 watts.
- 25 Gns. (Each). 

F.A.L. 'Phase Fifty' PUBLIC ADDRESS AMPLIFIER


BLACKPOOL AGENT APPOINTED

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/ vinyl, ideal for schools and Public Address. 15 ohm rating.
- Overall size approx. 10 x 14 x 15in. or 9 x 14 x 15in. 16 Gns.
- Complete kit, built and fully guaranteed. Limited number to clear. £7-19-11

R.S.C. HI-WATT SPEAKERS

Covered in two-tone Rexine/ vinyl, ideal for vocalists and Public Address. 15 ohm rating.
- Overall size approx. 10 x 14 x 15in. or 9 x 14 x 15in. 16 Gns.
- Complete kit, built and fully guaranteed. Limited number to clear. £7-19-11

R.S.C. 30 WATT HI-FI AMPLIFIER

For Vocal, Vocal or Instrumental Group A 2 or 4 input, 2 vol. control, HI-FI with separate Bass and Treble controls. Current Voltage Peak output rating.
- £819. 20 Gns. complete kit. £9.10. 20 Gns. complete kit.

F.A.L. 'Phase Fifty' PUBLIC ADDRESS AMPLIFIER


POWER PACK KIT

- Consisting of Mains transformer, Metal detector, Smiths types, and Smiths type, etc.
- Suitable for use in musical or public address equipment.

BLACKPOOL AGENT APPOINTED

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/ vinyl, ideal for vocalists and Public Address. 15 ohm rating.
- Overall size approx. 10 x 14 x 15in. or 9 x 14 x 15in. 16 Gns.
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POWER PACK KIT

- Consisting of Mains transformer, Metal detector, Smiths types, and Smiths type, etc.
- Suitable for use in musical or public address equipment.
The design that's based on PEAK SOUND "Cir-Kit"

- Simplified
- Unit
- Construction
- Fantastic Performance

This 12 + 12 watt integrated stereo hi-fi amplifier and preamp is proving one of the most successful P.W. designs ever. With good ancillary equipment, you will find it one of the best you have ever heard, and it is a delight to build and handle. Basically, the design of the “P.W. Double 12” as described in P.W. April, May and June demonstrates the value of using “Cir-Kit”. However, Peak Sound have contributed more besides to the success of this project. This includes the power amplifiers, the power pack and the ingenuous cabinet which almost assembles itself. Go right ahead and build this exciting new design now with authentic, exact-to-specification Peak Sound kits as recommended by the designers.

This is your PW Double 12 Shopping List

These are the Peak Sound units with which you can build this excellent design. Transistors included:

- 2 P.A. matrix boards
- 1 P.B.A.M. 40 volt power supply kit
- 1 Pack-flat aroamaks tone finished cabinet kit
- 5 Controls as specified
- 6/10

Total cost £53 5 6

Hardware Kit of knobs, plugs, sockets, switches, fuses, screws, wire, etc.

- 2 PA.12-15 Power Amplifier Kits
- 2 PA. Sink assemblies

P.W. Double 12 abridged specification

- Controls—Base and treble cut and lift based on Baxendall circuitry/Volume/Balance/Rotary selector.
- Input Sensitivity—Magentic P.U. (per channel) 2.8mV into 88k.
- Ceramic P.U.—28mV into 37k.
- Potentiometer—C.R. for 2.8mV into 110k.
- Output—12 watts per channel into 150 ohms, (62 speakers may be used).
- Negative Feedback—4/20 ft.
- Cabinet—Flat, aroamaks tone, finished cabinet, easy to build.
- Size 24 x 18 in., high x 18 in.
- Transistors—Ultra low noise in pre-amp and tone control stages.

GO TO YOUR DEALER NOW

for your authentic Peak Sound Kits. In case of difficulty, please send direct, giving the name and address of your usual supplier so that we may be able to assist you. 5/6 if without power pack.

TRADE ENQUIRIES INVITED

PEAK SOUND (HARROW) LTD
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SPEAKER SYSTEMS

All cabinets are new and speakers are mounted on 3/3, chin coated, baffle. All speakers are tested on 35 watt output of 1.5 watt.

- THE CAXTON COLUMN Cabinet in ash, 93 x 24 x 28 in., 3 per case.
- £23.50 Cm. Kit. Complete with alnico magnet, 2500 line, 1000 ohm, £6.50.
- THE MOLTON A. Hi-Fi Bookshelf Cabinet, 30 x 5 x 5 in., with all the fittings and fittings, £9.60
- THE IMP. Extension Speaker Cabinet, 7 x 1 x 1 in., fitted £3.50. Speaker.
- £23.50. Speaker fitted in three cloth with matching Vynair.
- THE IMP. Speaker Cabinet, 9 x 3 x 3 in., fitted £8.50. Speaker.
- £23.50. Speaker fitted in three cloth with matching Vynair.
- THE BROADWAY Electronics
92 MITCHAM ROAD, TOOTING BROADWAY, LONDON, S.W.17 Telephone 01-672 3934 (Closed all day Wednesday)

(Few minutes from Tooting Broadway Underground Station)

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As Britain's largest Specialists we have the most complete range of Hi-Fidelity equipment available. With a stock of over 30 Hi-Fi Systems, we are sure to have a system to suit your needs. For a full range of Hi-Fi Systems, visit our showroom today. Every system is complete with all leads, plugs, etc., fully guaranteed and backed by 100% NuSound after sales service. Illustrated literature and technical data sent on request.

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Add 3/- for post and packing on all orders.

AMPLIFIERS

DULC12077 Stereo Amplifier
DULC12078 Stereo Amplifier
DULC12079 Stereo Amplifier
GOODMANS Maxamp
New LEAK Stereo 30 Plus
New LEAK Stereo 30 Plus in teak case
New LEAK Stereo 70
LEAK 169 ST 45 Stereo Amplifier
QUAD 500 Series 22 Amplifier
QUAD 303 Stereo Main Amplifier
ROGERS Ravensbrook 50 watt Stereo
ROGERS Ravensbrook 50 watt Stereo
ROGERS Ravensbrook 50 watt Stereo
TELETON 30E
TRUVOX T5A200
WHARFEDALE GR-50
Markii P.A. Amplifier

Rec. Retail Price
£23 0 0
£27 6 0
£44 2 0
£54 0 0
£58 10 0
£63 0 0
£63 10 0
£64 2 0
£65 5 0
£65 6 0
£64 10 0
£70 5 0
£89 1 0
£81 9 0
£50 0 0

Comet Price
£10 0 0
£21 19 0
£24 19 0
£41 19 0
£48 14 0
£50 0 0
£50 0 0
£51 9 0
£56 4 0
£56 4 0
£56 4 0
£65 9 0
£74 19 0
£69 19 0
£52 0 0

TUNERS

ARENA 121 Stereo with Coax
DULC12097 FM Tuner
DULC12098 FM Tuners
DULC12099 FM Tuners
GOODMANS Stereome Sat FM/AM Tuner
LEAK Troubleshooter T.Tuner with Enhancements
QUAD 500 Series 22 FM Tuner
ROGERS Cadet Model 40V Tuner
ROGERS Ravensbrough Tuner with Decoder
TRUVOX FM 200/IC Tuner

Rec. Retail Price
£39 18 0
£82 2 0
£82 0 0
£82 0 0
£80 19 0
£65 11 4
£65 0 0
£65 0 0
£65 0 0
£52 0 0

Comet Price
£24 18 0
£19 0 0
£19 0 0
£19 0 0
£19 0 0
£19 0 0
£19 0 0
£19 0 0
£19 0 0

TUNER-AMPLIFIERS

ARENA 2400 with Decoder
AEG 2400 with Decorder
TELETON MX.990 Stereo Tuner with Diff/Multispeaker
LEAK 900X AM/FM Stereo Tuner/Amplifier 40 Watts RMS
TRUVOX F.2000/AM Stereo Tuner/Amplifier 2 x 5 watts RMS with silicon transistors
TRUVOX R.4000 AM/FM Stereo Tuner/Amplifier 2 x 5 watts RMS complete with 2 speaker boxes
TELETON TAT-1 Stereo Tuner Amplifier AM/FM 30 watts RMS, Stereo Deccoder and E.E.T.
TRUVOX CMS 48 AM/FM Multiplex Tuner/Amplifier with 2 speaker boxes and turntable

Rec. Retail Price
£60 0 0
£67 0 0
£64 13 2
£107 8 3
£43 0 0
£20 0 0
£133 0 0
£126 0 0

Comet Price
£19 9 0
£79 0 0
£19 0 0
£64 19 0
£90 0 0
£19 9 0
£90 0 0

BUDGET HI-FI STEREO SYSTEMS

GARRARD 3000 Turntable, Amplifier 8 watts per channel, VHF Tuner and all of the above components beautifully finished in teak, at a low price of £39 0 0

Rec. Retail Price
£35 0 0

Comet Price
£35 0 0

Hi-Fi Stereo Tape Decks and Tape Recorders

AKAI X-250D deck 4 track
AKAI X-360D deck 4 track
AKAI X-720D deck 4 track
AKAI X-500D deck 4 track
AKAI X-500D deck 4 track
AKAI X-450D deck 4 track
AKAI X-250D deck 4 track
AKAI X-250D deck 4 track

Price
£200 5 0
£250 0 0
£285 0 0
£300 0 0
£300 0 0
£285 0 0
£250 0 0
£250 0 0

Hi-Fi Tape Recorders

FIDELITY HF Play Master 2
FIDELITY HF Play Master 2
FIDELITY HF Play Master 2

Price
£25 0 0
£25 0 0
£25 0 0

Phillips Car Radio, Model 240T
Phillips Car Radio, Model 288
Phillips Car Radio, Model 380
Phillips Car Radio and Cassette Tape Recorder, Model 202

Price
£13 9 0
£19 5 0
£20 0 0
£35 0 0

Car Radios

GARRARD AP-75
GARRARD SL-55
THORDS T.D.17
THORDS T.D.17
THORDS T.D.17
THORDS T.D.17

Price
£15 0 0
£25 0 0
£25 0 0
£35 0 0
£35 0 0
£35 0 0

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DELIVERY. Comet guarantee that all prices quoted are genuine. All items offered available at these prices at the time this issue closed for press.

Add 3/- for post and packing on all orders.
Integrated Transistor Stereo Amplifier

The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.

Specification: R.M.S. power output: 3 watts per channel into 10 ohms speakers.
Input Sensitivity: Suitable for medium or high output crystal cartridges and turntables.
Crosstalk better than 30dB at 1Kc/s.
Controls: 4-position selector switch (2 mono and 2 pos. stereo)
dual ganged volume control.
Tone Control: Treble lift and cut. Separate on/off switch.
A preset balance control.

The new Duo general purpose 2-way speaker system is beautifully finished in polished teak veneer, with matching vynair grille. It is ideal for wall or shelf mounting either upright or horizontally.

Type 1 Specification: Impedance 10 ohms.
It incorporates Goodmans high flux 6" x 4" speaker and 2¹/₂" tweeter. Teak finish.
"12" x 6²/₃" x 6²/₃" 4 gns each, p & p 7/6.
Type 2 as Type 1. Size 17²/₃" x 10²/₃" x 6²/₃".
Incorporating Elac 10²/₃" x 6²/₃", 10,000 lines & 2¹/₂" tweeter. 3 ohms impedance.
5½ gns p & p 7/6

Garrard Changers from £7.19.6 p & p 7/6
Cover & Teak finish Plinth £4.15.0 p & p 7/6

The Classic

8½ Gns. + 7/6 p & p

Controls: Selector switch Tape speed equalisation switch (1½ & 7½ i.p.s.), Volume, Treble, Bass. 2 position scratch filter and 2 position rumble filter.

Specification: Sensitivity New for 10 watt output at 1kHz. Tape head: 3mV (at 31 i.p.s.).
Max. P.U.: 3mV. Car. P.U.: 60mV. Radio: 100mV. Aux.: 100mV. Tape/Rec. output: 100mV. Equalisation for each input is correct to within ± 2dB (R.I.A.A.) from 20Hz to 20kHz. Tone control range: Bass ± 13dB at 80 Hz, Treble ± 14dB at 10kHz. Total distortion for 10 watt output) < 0.5%; Signal noise: < 0.06dB, A.C. mains 200-250v.
Built and Tested. Size 15½" long, 4½" deep, 22" high. Teak finished case.

Goods not despatched outside U.K.
Terms C.W.O.
All enquiries stamped addressed envelope.
THE DORSET
(600mW Output)
7-transistor fully tunable M.W.-L.W. superhet portable — with baby alarm facility, Set of parts.
The latest modularised and pre-alignment techniques makes this simple to build. Sizes: 6 x 8 x 3.5in.
MAIN POWER PACK KIT: 9/6 EXTRA.
Price 5 GNS. + 7/6 p. & p. CIRCUIT 2/6 FREE WITH PARTS.

THE ELEGANT SEVEN
(350mW Output)
7-transistor fully tunable M.W.-L.W. portable. Set of parts. Complete with all components, including ready-stocked and drilled printed circuit board — back printed for foolproof construction.
MAIN POWER PACK KIT: 9/6 EXTRA.
Price £4.9.6 plus 7/6 p. & p. Circuit 2/6 FREE WITH PARTS.

THREE-IN-ONE HI-FI 10 WATT SPEAKER
A complete Loud Speaker system on one frame, combining three matched ceramic magnet speakers with a low cross over network. Peak handling power 10 watts. Impedance 15 ohms. Plus density 11,000 Gauss. Resonance 40-60 c/s. Frequency range 55c/s to 20kc/s. Size 13 x 9 x 4 1/4 inches. By famous manufacturer. List Price £7. Our price 7/6 plus 5/- P. & P.
Similar speaker to the above without tweeters in 3 and 15 ohms 44/6 plus 5/- P. & P.

X101
10W SOLID-STATE HI-FI AMP WITH INTEGRAL PRE-AMP
Specifications: Power Output (into 8 ohms speakers) 10 watts. Sensitivity (for rated output): 1mV into 3k ohms (0-33 microamp), Total Distortion at 1KHz at 5 watts 95-25%, at rated output 2-5% Frequency Response: Minus 3dB points are 30KHz and 40KHz. Speaker 3-4 ohms (15 ohms may be used). Supply voltage: 24V d.c., at 800mA. 0-35V may be used.
2. Treble: PRICE £5.
The above 3 items can be purchased for use with the X101.

CAR TRANSISTOR IGNITION SYSTEM
(by famous manufacturer)
For 6 volt or 12 volt positive earth systems. Comprising: special high voltage working hermetically sealed silicon transistor mounted in molded heat-sink, high output ignition coil, ballast resistor and hardwire (screws, washers etc.). PRICE £4.19.6. (post and packing 5/- extra.)

50 WATT AMPLIFIER A.C. MAINS 200-250V
An extremely reliable general purpose valve amplifier with six commercially mixed inputs, suitable for use with: mics, guitars, radios, turn-tables, organs, etc. Separate bass and treble controls. Output impedance 8, 8 and 15 ohms.

SPECIAL OFFER!
Complete stereo system comprising Balfour 4-speed autoplayer with stereo head, 2 duo speaker systems. size 12in. x 6 1/2in. x 5 1/2in. Plinth (less cover) and the Duett0 stereo amplifier. All above items 19 gns. plus 20/- p. & p.

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THE RELIANT
SOLID STATE GENERAL PURPOSE AMPLIFIER
Specifications:
Output: 10 watts Input: 0.1 mV into 10K ohms Frequency Response: -3dB at 1KHz at 50mW BASE control range +10dB at 100Hz Frequency Response — with tone controls central. Minus 3dB points are 30KHz and 40KHz Signal to Noise Ratio: better than —60dB. Transistor: 1 silicon PNP type and 5 germanium type. Mains Input: 200 — 250V A.C. Size of chassis — 10 x 4 x 3 1/2" A.C. Mains, 200-250V. For use with Std. or L.P. records, musical instruments, all makes of picks and tuners. Separate bass and treble L.F. control. Two inputs with control for gain, and mix. Built-in and tested. 8 x 8 x 3” speaker to suit price 12/- plus 1/6 P. & P. Crystal clock to suit 12/- plus 1/6 P. & P.
Reliant Mark 1. 51 gns. plus 7/6 p. & p.
As above less test case.
Reliant Mark II. 6½ gns. plus 7/6 p. & p.
In test finished case.

CYLDON
2 TRANSISTOR U.H.F. TUNER
Brand new. Complete with circuit diagram.
£21.00 plus 1/- P. & P.

EXTRACTOR FAN
AC Mains 230/240v, complete with pull switch. Size 6 x 6 x 4". Price 27/6 plus 5/- P. & P.

B.S.R. TD-2 TAPE DECK
This tape deck takes 8in. spools complete with two-track heads. Size 13in. long by 6in. wide. 240v plus 1/6 P. & P.

RECORD PLAYER SNIP
A.C. MAINS 240V
The “Pricer” 4-speed automatic record changer and player engineered with the utmost precision for beauty, long life, and trouble free service, will make up to ten recordings which may be played 10 to 16 or 16. Patent style tone arm design after each playback and at shut off, the pick-up locks itself into its recess, a most useful feature with portable equipment — other features include pick-up height adjustment and flux pressure adjustment. This unit as a fine instrument which you can purchase this month at only £21.8.6 complete with cartridge and ready to play. Post and Insurance 7/6 extra.

POCKET MULTI-METER
Size 5 1/2 x 2 1/2 x 1 1/2, Meter size 2 1/2 x 1 1/2. Sensitivity 1000 O.E.V. on both A.C. and D.C. volts. 0-10, 0-100, 0-1000 D.C. current 0-10mA. Resistance 0-100K. Complete with test probes, battery and full instructions. 2/6. P. & P.
3/- FREE GIFT for orders placed only. 30 watt Electric Roldering Iron free 13/- to every purchaser of the Pocket Multi-Meter.

FIRST QUALITY P.V.C. TAPE
5" Std. 850ft. 11/6 5" L.P. 850ft. 12/-
5" Std. 1200ft. 13/- 5" L.P. 1200ft. 13/-
5" L.P. 2400ft. 5 6 5" L.P. 2400ft. 34/-
6" Std. 850ft. 20/- 6" L.P. 850ft. 44/-
6" L.P. 2400ft. 20/- 6" L.P. 2400ft. 44/-
6" D. 1800ft. 10/- P. & P. on each 1/6.

MOTEK
3 Speed 2 track Tape Desk complete with heads, takes 7in. spool.
Incorporating 3 motors.
A.C. mains, 240 volts, listed at £21.0.0.
Our Price 29.18.6, plus 10/- P. & P.
If it's components you're after...

...you need the

**HOME RADIO CATALOGUE**

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Third Opportunity

During the heyday of the valve era, designers, constructors, equipment makers and service engineers were plagued with the vast proliferation of valve types. From a handful of basic types, valve manufacturers escalated production to the stage where a complete listing of all new, obsolete and replacement types became well nigh impossible due to sheer numbers.

With the advent of transistors, it seemed that a new era of rationalisation was dawning. Starting with a clean slate it was inconceivable that the same mistakes would be made with transistors as with valves. Alas, the result has been even greater chaos!

There must be tens of thousands of semiconductor devices now in the catalogues, or in replacement lists. Many of these are direct, or almost direct, equivalents, or else the parameters are sufficiently close to make duplication wasteful and frustrating, especially when one considers that there are cases of up to twenty variants of some basic types.

There has been little attempt to rationalise the type numbering system between different countries or even different manufacturers, nor any co-ordination in introducing new types to catalogues. And at this stage of the game, it is too late to remedy matters.

We are now on the threshold of yet another major opportunity for industry to work together for the common good. Integrated circuits are no longer a laboratory novelty and are poised to break into the domestic sphere in a big way. Unless industry can prevent itself—leming fashion—from making the same mistakes the third time, a situation even more chaotic will result. The possibilities (and the temptations) to proliferate will be greater than ever, for we are all set to be overwhelmed by an avalanche of IC devices within the next few years.

Today, ICs are an appetiser. Tomorrow, on the menu, it will be chips with everything. P.W. is preparing for this situation and will have something of great interest to say to constructors in the next issue.
**LATEST RADIO-3 STEREOPHONIC TRANSMISSIONS**

The unshaded part of this map shows areas where satisfactory stereo reception should normally be obtained. In places where field-strength is low, increased background noise or interference may be heard. Improvement in the sensitivity of the receiving aerial may enable the noise level to be reduced and a more directional aerial may discriminate against interference. Frequencies are: Brighton, 92-3MHz; Holme Moss, 91-5MHz; Kendal, 90-9MHz; Morecambe Bay, 92-2MHz; Northampton, 91-1MHz; Oxford, 91-7MHz; Scarborough, 92-1MHz; Sheffield, 92-1MHz; Sutton Coldfield, 90-5MHz; Swinage, 92-4MHz; Wrotham, 91-3MHz.

**MINI POTS**

Fitted with Cermet resistance elements, these potentiometers, Type S106, shown actual size, are immune to high humidity effects and chemical attack, making them very suitable for operation at elevated temperatures.

Wattage rating when mounted on a steel plate 100 x 100 x 1mm. is 2.5W, and when mounted on insulated material, 0-7W. These units are available in values from 100Ω to 1MΩ, linear only. Tolerance is ±20% and working voltage 250V d.c. Manufactured by Rosenthal Isolatoren GmbH, the sole UK distributors are: Radio Resistor Co. Ltd., 9-11 Palmerston Road, Wealdstone, Harrow, Middx.

**ASPIRING AMATEURS TAKE NOTE**

For the last three years at the Knaresborough Further Education Centre, Stockwell Road, Knaresborough, Yorks, they have offered Evening Courses (7-9 p.m.) leading to the City and Guilds Radio Amateurs' Examination and these have included tuition in Morse code.


Fees will be 30s. from September to March.

Local Radio—PO confirms policy on wavelengths

The Postmaster General, the Rt. Hon. John Stonehouse, M.P., has rejected Mr Hughie Green's view that 100 local radio stations could be provided on medium wavelengths. A team of Post Office experts has completed a detailed examination of his proposals and their conclusions were sent to Mr Green.

Mr Green submitted two feasibility studies to the Post Office. Both would have involved the use of directional aerals for some stations, including those for London and Manchester. They would also have involved the use of medium wave frequencies allocated to other countries, under the terms of Article 8 of the 1948 Copenhagen Plan. The Post Office conclusion is that, even by day, not all the stations Mr Green proposed would give satisfactory reception; and, that for the remainder service areas would in general be so reduced after dark as to be completely unsatisfactory. For example, the station proposed for London would cover only 10 per cent of the Greater London area after dark.

Post Office studies reaffirm the conclusions set out in the Government's White Paper on Broadcasting (Cmd. 3169 para. 32, December 1966) that "no general service of local sound broadcasting, which would be available during the hours of darkness as well as in daylight, can be provided only on medium wavelengths allotted to the United Kingdom."

WOW! A STRIPPER

Multicore's Model 3 Bib Wire Stripper and Cutter has been improved. This new one enables insulation to be removed without nicking the wire. The aperture setting for different diameters is adjusted by setting a sliding screw set in one handle.

In addition, this stripper features two cutting positions—one for normal flex cutting and the other on the tip of the unit, for cutting wire in a confined space. A good example is the removal of wire after it has been connected to a tag or bolt. This cutting tip is also suitable for separating extruded twin flex. Each stripper is packaged on an instruction card and costs 5s. 6d. from most hardware, electrical and do-it-yourself stores. Multicore Solder Ltd., Hemel Hempstead, Herts.
NEW RELAYS

The range of ITT’s PZ style relays for printed circuit boards has been augmented by a two-changeover version, the type PZ-2. Overall dimensions of this miniature relay are only 29 x 16 x 14mm. The connections are for direct soldering on to printed circuit boards.

The two-changeover contacts are of the twin type with a choice of silver/palladium or gold/silver contact alloy. Maximum switched power per contact is 12VA (1A at 100V a.c. or d.c.). The relay is for d.c. operation. ITT Components Group Europe, Standard Telephones and Cables Limited, Electro-Mechanical Product Division, West Road, Harlow, Essex.

TO BEAT THE THUGS

The Glasgow Corporation Transport Department, hard on the heels of the Edinburgh and Wolverhampton Transport Departments, has placed an order for 100 v.h.f. f.m. mobile radiotelephones for use by the city’s bus services. Hooliganism has resulted in the placing of this order and the Storno mobile units are to be installed in buses running on late-night routes and will enable the crews to establish immediate contact with transport control where a direct link to police headquarters will speed the police to any emergency.

PHILIPS SECOND GENERATION “AUDIO PLAN”

The new Audio Plan incorporates qualities gained from both experience and technical advances that have occurred over the past few years. Advances like the “touch tuning” facilities of the RH790 tuner amplifier where tuning is accomplished by applying a variable voltage to a varicap. This voltage is set by potentiometers; one coupled to the main tuning control and the other three to preset controls. The appropriate control (therefore appropriate voltage) is selected by means of transistor switches actuated by hand capacity, when the appropriate one of the four “touch tuning” panels is approached by the operator’s finger. The panel is then illuminated and the frequency selected is indicated by a meter which measures the voltage applied to the varicap. The meter is calibrated in MHz, the frequency selected being proportional to voltage applied. Price of this unit is £125.


JACKSONS’ NEW COMPONENTS

A new range of tuning capacitors is announced by Jackson Bros. Type TX5 are capacitors available in single-stator and split-stator versions and with capacitance swing values ranging from 30pF to 1,000pF. They have siliconed ceramic endplates and satin-finished aluminium vanes with radiused edges.

The company also manufactures the “Wavemaster” tuning capacitors with swings ranging from 10pF to 300pF.

New trimmers of the piston type with PTFE dielectric have also been introduced. Ten models are now made and the smallest, measuring 1 x ½ x ½ in. has a capacitance swing of ½pF to 8pF.

Completing the range of new products are two epicyclic ball-drives—the Mini which is designed to fit all makes of miniature variable capacitor with solid dielectric (4:1 ratio) and the Adjustable-Torque ball-drive which provides a reduction ratio of 6:1. On this unit, four spring-loaded screws effect adjustment.

Jackson Brothers (London) Ltd., Kingsway, Waddon, Croydon CR9 4DG.

Tape head cleaning kit

Bib Division of Multicore Solders have introduced a new compact “size J” Head Maintenance Kit. It comprises a 30c.c. bottle of anti-static, non-flammable Bib cleaner, or alcohol for removing oxide and dirt from the tape heads and all parts of the tape path, 10 double-ended, cotton-wool tipped sticks for access where the Bib tools will not reach, and four Bib tools together with a Hi-Fuster absorbent cloth for cleaning the soiled tools and sticks etc.

All these components are contained in a plastic wallet and the recommended retail price is 9s. 9d. including 1s. 11d. P.T. The size J kit is available from all leading stockists. Multicore Solders Ltd., Hemel Hempstead, Hertfordshire.

DATE TO REMEMBER

GB3WRA, operated by a group of local radio Amateurs from the Annual Wycombe Show on the Rye, High Wycombe, Buckinghamshire, will be on the air on Saturday, 6th September, 1969.

Operation will be on all bands 160-4 a.m., c.w., s.s.b. and visiting Amateurs will be especially welcomed. Further information may be obtained from A. C. Butcher, G3FSN, 70 Hughenden Avenue, High Wycombe, Buckinghamshire.
WHEN it comes to v.h.f., most fixed amateur stations use either a transceiver, a crystal controlled superhet converter (with the s.w. receiver as i.f. and a.f. amplifier), or a de-luxe triple conversion receiver.

However, these units are usually quite expensive or difficult to build and align, unless one has considerable experience of v.h.f. techniques.

This super-regenerative t.r.f. design will satisfy the needs of many s.w.l.s and prospective G8s, as there is only one tuned circuit to adjust; it can be easily built in one evening and is not difficult to set up. Having only one tuned circuit, it is also very easy to change the frequency coverage.

The f.e.t. tuner is the heart of the device and if so desired could be used on its own with a jack plug to feed into the input socket of a ready-made amplifier. In this case the tuner could be made quite small. This set-up was in fact used by a local G8 for his first QSO. It will not do for DX, but at least it’s a start. Many readers will have dabbled around with the regenerative t.r.f. type of receiver but in the super-regenerative design, feedback is introduced (via the source to drain capacitor C3 in the author’s design) beyond the point where oscillation just occurs, and the stage is in continuous oscillation until this state is disturbed by an incoming signal. The super-regenerative state brings about a condition of extremely high sensitivity to the circuit; there is also a high level of circuit background noise, commonly referred to as “slush”.

The complete circuit of the receiver is shown in Fig. 1. Even without an aerial the receiver has received good signals from aircraft, radio amateurs and other services up to a distance of approximately 6 miles. Because the prime purpose of building the receiver was to receive local amateur radio transmissions in the Taunton area, the extra encumberance of an elaborate aerial array has not been tried. It is suggested that for experimental purposes an 18in. length of 18 s.w.g. tinned copper wire is simply fitted to the centre of the coax socket. Vertical orientation of the aerial will normally bring forth optimum performance.

The author has built more than one version of this receiver, but that shown in the photograph was built into a wooden cabinet already on hand. This was approximately 8 x 8 x 4in. deep.

As an alternative to the loudspeaker, a low impedance (800) earpiece could be used.

**Layout and Construction**

Although layout is important at v.h.f., and the effects of extra-long wires and inter-electrode capacitances undesirable, the circuit allows considerable latitude, even on 2 metres. The original mock-up was in fact built up on a 1½ x 2½in. paxolin board. Layout will depend on the cabinet and components used, but VR1 should not be more than 6in. from the coil.

VC1 was actually an Eddystone 35pF variable with brass vanes in the prototype. All these were removed except for one stator and one rotor, but a 5pF C804 (Henry’s Radio) is a suitable ready made

---

**Fig. 1:** Circuit of the complete receiver. If only the tuner is required (as depicted in Fig. 2), the audio output should be taken from the slider of VR2. S1 should be shown wired in the +9V supply lead.
Tightly spaced this tinned copper direct soldered connections were component. The stator was cleaned and tinned, and direct soldered connections were made to it.

The coil L2 consists of 3½ turns of 18 s.w.g. tinned copper wire close wound to $\frac{3}{16}$ in. diameter. Tightly spaced this will get aircraft, and stretched over $\frac{3}{16}$ in. it will cover the 144 MHz Amateur Band. Naturally, the coil is sensitive to the effects of hand capacitance. The aerial coupling coil L1 should be a half turn of the same wire placed near to the earthy end of L2.

The 10 pF feedback capacitor C3, if preferred, can be replaced by a conventional tubular variable type, which would also provide a good anchorage for the drain and source of the f.e.t. Alternatively, the unconventional variable "twisted wire" variety may be used. About $\frac{3}{16}$ in. is sufficient to get the circuit "started".

The 1.8 $\mu$H r.f.c. in the prototype was filched from a turret-type v.h.f./u.h.f. tuner, but this may be difficult to obtain, and about 25 turns of very thin wire on a 1 megohm $\frac{1}{4}$ watt miniature resistor works equally well.

Wiring should be kept as short as possible, and the same tag should be used for all earth connections in the first stage.

Fig. 2: Layout of the tuner section of the receiver. The audio amplifier stages are not shown, C3 may alternatively be of the "twisted wire" variety (see text). The leads of L2 should be kept as short as possible, one end being soldered directly to the fixed plate of VC1 (5pF type C804 shown in the above diagram).

Distinguish carefully the leads of the f.e.t. and if using the 2N3819 remember that the lead-out is different from that of the MPF102. Although the f.e.t. is silicon and should stand up to about 10 seconds heat from a 15 watt iron, it is best to use a heat shunt when soldering, such as long nosed pliers with a rubber band wound around the handles. An earthed soldering iron should be used, as the f.e.t. can be damaged by mains-derive capacitive

---

**components list**

<table>
<thead>
<tr>
<th>Resistors:</th>
<th>Capacitors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 1kΩ</td>
<td>C1 1000pF ceramic</td>
</tr>
<tr>
<td>R2 10kΩ</td>
<td>C2 5pF ceramic</td>
</tr>
<tr>
<td>R3 15kΩ</td>
<td>C3 10pF (see text)</td>
</tr>
<tr>
<td>R4 220kΩ</td>
<td>C4 4700pF ceramic</td>
</tr>
<tr>
<td>R5 10kΩ</td>
<td>C5 0.01µF ceramic</td>
</tr>
<tr>
<td>R6 220kΩ</td>
<td>C6 0.1µF miniature</td>
</tr>
<tr>
<td>R7 1MΩ</td>
<td>C7 8µF 12V electrolytic</td>
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<tr>
<td>R8 220kΩ</td>
<td>C8 8µF 12V electrolytic</td>
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<tr>
<td>R9 470Ω</td>
<td>C9 0.1µF miniature</td>
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<tr>
<td>R10 620Ω</td>
<td>C10 50µF 12V electrolytic</td>
</tr>
<tr>
<td>R11 82Ω</td>
<td>C11 50µF 12V electrolytic</td>
</tr>
<tr>
<td>R12 All 10% 1W miniature</td>
<td>VC1 5pF variable (see text)</td>
</tr>
</tbody>
</table>

Semiconductors:

| Tr1 MPF102 or 2N3819 | Tr2 2N2926 |
| Tr3 OC44 | Tr4 OC71 |
| Tr5 OC81 |

Inductors:

| L1 ½ turn, near earthy end of L2, 22 s.w.g. insulated copper wire. |
| L2 3½ turns, 18 s.w.g. tinned copper wire, $\frac{3}{16}$ in. diameter, air cored. |
| r.f.c. 1.8 $\mu$H r.f. choke (see text) |

Miscellaneous:

VR1, VR2 5KΩ potentiometer, S1 single pole on/off switch (may be combined with VR2), 80Ω loudspeaker, paxolin board, tagstrip, coax socket, battery clips, PP9 battery, wire, solder, etc.

---

Fig. 3: Transistor lead connections.
voltages. As a further precaution, all the f.e.t. leads could be shorted together by the "heat shunt" whilst being fitted.

**Operation**

Check the polarity of the battery, and the wiring before switching on. If the circuit of Fig. 1 is used the current drain on a 9V battery should be about 35-40mA. Check that none of the f.e.t. leads are shorting and switch on, with VR1 at minimum. A lively background hiss will indicate that the f.e.t. is oscillating. If it is not, advance VR1 towards maximum. The hiss should be extremely loud, much louder than ordinary background hiss with which it should not be confused. Experiment with various settings of VR1 to produce optimum results.

The photograph shows the author's prototype.

When a station is tuned-in there will be a reduction in the circuit background hiss, this depending upon the strength of the received signal. It is usually best to adjust L2 for the desired band on Sunday mornings or evenings as radio amateurs are usually more active on v.h.f. at these times.

The only likely cause of trouble may be C1 working loose or fracturing as a result of the manipulation of L2.

The amount of radiated interference, once the scourge of this class of receiver, appears to be negligible.

**AUDIO SIGNAL GENERATOR**

This describes the construction of an audio generator, with both sine and square wave outputs. The design is based upon the popular Wien bridge oscillator and covers the frequency range of 15 to 100,000Hz. A mains power supply is built-in, but as an alternative, the generator could be run from a 12V 30mA battery supply.

Thermistor control ensures a constant amplitude output regardless of minor variations in supply voltage and temperature.

**PRINTED CIRCUIT DESIGN**

Many home constructed transistor designs are invariably built on some form of printed circuit, the tendency is to use ready available SRBP perforated board, or that with copper strip bonded to it. For those who prefer a tailor-made printed circuit, details are given on the preparation and etching of boards to one's own design.

A masking technique utilising adhesive tape gives a professionally finished product.

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IN Part 3 the methods of preparing a p-n junction diode were described. The basic p-n junction device is the best known example of the modern diode since it is used extensively in power rectification circuits.

These devices have taken the place of the thermionic diode in most applications. The obvious reason for this is the very significant increase in efficiency over the thermionic counterpart. The voltage drop across a semiconductor diode carrying one ampere is measured in fractions of a volt whilst the voltage drop across the valve is measured in volts. Also the valve requires a filament or heater supply which itself consumes several watts.

The earlier solid state diodes had one disadvantage, their low reverse breakdown voltage. The rectifier has to withstand a voltage several times the peak voltage and in many circuits this can amount to many hundreds of volts. However there are now available diodes with reverse breakdown voltages measured in thousands of volts.

Care has to be taken that this reverse voltage is not exceeded otherwise the diode will suffer irreparable damage. The damage is caused by the excessive heat dissipated by the large reverse current flowing across the high impedance junction.

**Point Contact Diodes**

The capacitance which a junction diode has between its terminals is dependent upon the area of the junction. For very high frequency applications and for fast switching it is necessary to reduce this capacitance to a minimum. This is achieved in the point contact diode by using a tungsten metal wire with a very fine point which is pressed against a small piece of semiconductor material. This constitutes the simplest type of point contact rectifier similar to the early “cats whisker” detector used in crystal sets.

A much improved performance is obtained when the device is “formed” by passing a short pulse of current through the diode in the forward direction. This produces a heating effect and changes the character of the contact region, although the exact nature of the operation of the device is not wholly clear.

**The Metal Rectifier**

Although not normally considered when talking about semiconductor diodes the metal rectifier which was used extensively in power rectification in the fifties and before is worth mentioning here. It consists of a metal to semiconductor junction as in the point contact device but a much larger area is used in order to reduce the series resistance of the diode. A layer of copper oxide, CuO, is produced on a piece of copper by oxidation. The oxide layer acts as a donor, or n-type semiconductor, and the equilibrium energy band diagram can be drawn as in Fig. 1.

![Fig. 1: Equilibrium energy band diagram for a metal-oxide rectifier.](image)

The Fermi levels of the oxide layer and the metal must coincide at distances from the junction as in the case of the p-n junction. However the carrier concentrations in the metal are such that the conditions in the metal are unaltered and the result is that electrons from the donor sites in the oxide layer diffuse into the metal leaving a wide region with a positive space charge. It can easily be shown, using the same arguments that were used in Part 3, that the device will act as a rectifier. When the n-type oxide layer is negative with respect to the metal the diode is biased in its forward direction. The opposite polarity is of course the reverse bias case. This form of diode is inferior to the junction or point contact diode in that its reverse current is much larger, it has a large parallel capacitance and its reverse breakdown voltage is low.

**The Gold Bonded Diode**

This type of diode is used in high speed switching circuits. It consists of an alloyed p-n junction with a very small area in order to keep the capacitance to a minimum. This is achieved by using a very fine gallium doped gold wire pressing against an n-type germanium base wafer. The p-type gold wire acts as an anode when it is alloyed to the germanium by passing a short pulse of current through to heat the junction.

A silicon version of the golded bonded diode is also made using an aluminium wire as the p-type
anode, with an n-type silicon wafer. This device gives a lower reverse leakage current than the germanium equivalent but the forward offset voltage is considerably larger; silicon devices typically have offset voltages of 0.6V compared with 0.3V for the germanium device. This is undesirable in many circuits as it leads to distortion when the diode is used to detect a low level signal. Consequently a compromise has to be adopted in most applications.

**Variable Capacitance Diode**

It was shown earlier that when the reverse voltage applied to a diode is altered the width of the depletion layer changes. This effect can be likened to separating the plates of a capacitor. This produces a change in capacitance; an increase in separation leads to a decrease in capacitance and vice versa. The same effect occurs in the diode, with some modification because of the presence of ionised atoms between the plates of the “capacitor”. This gives rise to the diode capacitance which changes as the reverse bias is altered.

In the case of the alloyed junction diode the capacitance varies as the inverse square root of the voltage, doubling as the voltage is divided by four. In the case of the diffused junction diode which has a built-in gradient of impurity ions the capacitance increases as the inverse cube root of the voltage, so that an increase in the reverse voltage by a factor of eight is required to halve the capacitance.

The variable capacitance diode is used extensively in circuits which would formerly have used variable reactance valves. Such applications are automatic frequency control of receivers, electronic tuning circuits and parametric amplifier circuits. Diodes are now available which have capacitance ranges of from 500pF with a reverse voltage of 1V to 75pF with reverse voltages of around 100V.

**Zener Diodes**

The reverse breakdown of a p-n junction has been shown to be due to one of two effects. Breakdown below 6V in due to the zener effect in which the field across the junction leads directly to ionisation; above 6V the breakdown is due to the avalanche process. In practical devices these effects can be made to occur at specific voltages by varying the doping levels and junction widths. A typical characteristic curve is shown in Fig. 2. This type of diode can be used to stabilise a voltage power supply either by using amplification and a series stabilising transistor or by simply using the zener diode as a shunt stabiliser. Breakdown diodes can be obtained with breakdown voltages of from 2V to several hundred volts, capable of controlling hundreds of watts of power.

Unfortunately the breakdown voltage varies with temperature. The temperature coefficient of the devices varies between ±0.1% per degree centigrade. The negative temperature coefficient applies to the zener diode, the positive to the avalanche diode. The dynamic resistance of the breakdown diode can vary from a few ohms for a good device to several thousand ohms for a low current device.

It is worth mentioning that reference voltages of less than 2V can be obtained by using the forward offset voltage of forward biased junction diodes. Several diodes can be connected in series to obtain voltages in steps of 0.3V using germanium devices.

**Photodiodes**

Another form of diode which is used in the reverse biased condition is the photodiode. The reverse current of a diode increases if light is allowed to fall on to the junction. It was explained in Part 3 that the reverse saturation current is due to the thermal generation of minority carriers near to the depletion region, these being swept across the junction by the internal field. If the junction region is illuminated electron-hole pairs are generated by the photoelectric effect. The minority carriers produced near the junction then increase the reverse current.

This effect occurs in any reverse biased junction and consequently care is normally taken to ensure that no light can reach the junction. However in the case of the photodiode a transparent encapsulation is used so that the junction can be illuminated. Sometimes a lens is used to focus the light to the most sensitive area. The lens is formed in the material of the encapsulation.

From Fig. 3 it can be seen that the dynamic resistance of the photodiode is large so that the reverse current is insensitive to the reverse voltage applied to it.

**Light Emitting Diodes**

Various semiconducting diodes emit radiation when they are forward biased. This is because the hole-electron recombination occurring in the junction...
region leads to the production under certain circumstances of radiation. Numerous light emitting diodes are now available, exhibiting laser action when very narrow beams of “in phase” or coherent light are produced.

Wavelengths of between 8,500Å and 500Å are available from the devices, giving radiation from the infra red to the ultra violet ends of the spectrum. Only relatively small amounts of light are yet available from the devices; suitable applications are in card reading machines for computers and short range communications systems.

The Tunnel Diode

It might be thought that if an electron meets an obstacle that requires a greater energy to surmount than the energy possessed by the electron, then the electron would be stopped. However the quantum theory of matter predicted that the electron would under these circumstances be able to penetrate a small distance into the barrier, and if the barrier were thin enough the electron could pass straight through it. This process is called tunneling.

If a diode is made with a very high level of doping the Fermi level will lie within the conduction band in the n-type region and within the valence band in the p-type region. Thus when the junction is unbiased the p- and n-type regions will have overlapping valence and conduction bands respectively, as shown in Fig. 4 (a). If a small reverse bias is applied the situation becomes that of Fig. 4 (b), where electrons in filled states in the p-type material are opposite empty states in the n-type material so that the conditions for tunneling apply. This results in a large reverse current flowing.

If a small forward bias is applied electrons from the n-type material will tunnel into the p-type material as long as the conduction and valence bands still overlap as in Fig. 4 (c). However when the forward bias is such that there is no overlap tunneling stops and only the normal diode forward current flows, this initially being smaller than the tunneling current.

![Fig. 4: Tunnel diode energy band diagram when in an open circuit state of equilibrium. (b) Tunnel diode with reverse bias, (c) with small forward bias.](image)

![Fig. 5: Tunnel diode characteristic curve.](image)

The important point in the characteristic above is the sloping region between a and b. This corresponds to a negative resistance region where an increase of the voltage across the device leads to a decrease in current through it. This enables the device to be used in oscillators and amplifiers.

A second point of importance is the fact that at a certain current there are three voltages at which the device can operate. For example the line cd in Fig. 5 cuts the curve at three points. This feature enables the tunnel diode to be used in switching applications.

Impatt Diodes

Various diodes have recently been constructed which are capable of producing oscillations at microwave frequencies. Examples are the Gunn and Read diodes. The theory of these devices is rather involved to discuss here but depends on the bunching of charge carriers as they move across a block of suitable semiconductor.

TO BE CONTINUED
OUR Scientific Correspondent in my daily paper is always quick to tell us that this is the age of automation. What with telecasts from lunar floorshows and David Frost jumping onto the rocket-wagon, anything so mundane as a hand-wired valve radio almost qualifies as an objet d'art. Modules are the order of the day.

Is it any wonder that the average chap begins to fear he will soon be made redundant by a robot? Orwell lurks around the corner. My uncle's pacemaker is a Mark II model and Bob Hope is said to hang a sign at the foot of his hospital bed: 'Just dozing—no transplants.'

Henry has heard it all before. Dire predictions that progress would soon make radio engineers a drug on the market have sounded with every innovation. The Jeremys welcomed transistors with grim warnings that sets-to-be would never go wrong. Printed circuitboards were heralded similarly. Integrated circuits, in theory, should make fault-finding as archaic as the Morris dance. Modules, I repeat, are the in thing.

Funny thing is that I remember somewhat similar remarks when the double-diode-pentode first appeared. 'A complete output...'' one advertisement trumpeted. Lee deForest should have lived to see the day!

It was when television receivers first broke out in a rash of modules that big business took up the cry. Service departments were reorganised to cope with module-changing techniques. We were told that a small stock of P-C boards held by each field engineer would whittle down servicing time. And men, we wondered? Bench engineers surreptitiously studied plumbing between module transplants. Diagnosis, it was whispered, would become a dying art.

Bench engineers perforce began servicing modules, and soon it became a habit. It was cheaper than packaging them, returning them for replacement and hoping a good one would come back.

More important, it was a blow to the pride of a bench engineer to have to send back to the makers a simple printed circuit with a few components, when a modified fault-tracing technique quickly proved where the trouble lay.

In the trade magazines, 'Service Gen' articles began to appear, with C33 and R21 spotlighted as persistent failures. Before the modules had been sculling around long enough to outrun their guarantee, service was back to normal: just a little more difficult because testing a module in situ was not so easy as probing around a tag board.

Biggest joke of the lot was—and still is—the attitude of the copywriters. To read them seriously, one would imagine a setmaker was the engineer's favourite uncle. 'Plug-in modules for easy servicing' claim the blurs. If you believe that, you'll fall for anything.

Plug-in modules do make for easier fault-finding, true, if all you are concerned to do is swap around willy-nilly. In practice, when half our equipment is... what is the word? modulated, modulated (no, can't be that)... any shop carrying sufficient replacements would have too much capital tied up in spares.

So we are back to square one, but this time complicated by the hazard of inaccessibility.

Have you ever looked closely at these modular designs? The method of construction keeps the actual circuit out of reach when it is operating. To test many modern modules, one has first to make a multi-plug jumper lead. Every plug and socket differs.

In one tuner-amplifier I recently serviced, nine dinky modules, completely shielded, plugged into what looked like conventional valve-bases. Good, we thought, what an excellent way of using up old stock. Until we peered a little more closely and discovered that the pin formation of these ceramic bases was like nothing BVA had ever envisaged.

A blow to the bench engineer's pride.

I saw a service instrument once, a magnificent piece of apparatus with more tentacular probes than a Portuguese Man-o'-War. It hooks into a receiver and feels its pulse all over. Could PW please have a constructor's project for such a Henry de-moduliser, Mr. Editor?
LOOKING at the circuit I bet that several of you are doubting last month's claim that our project would fulfil several functions. In fact it will test p-n-p and n-p-n transistors for leakage and comparative gain, test both silicon and germanium diodes, test its own battery and other batteries up to 9V, measure resistance between about 470Ω and 47kΩ and check electrolytic capacitors.

TRANSISTORS

With the switch in the leakage position and a transistor connected in the correct way around (as shown in the circuit), 9V is applied between the emitter and the collector. A meter in the circuit will indicate the current passed—by definition this is the leakage current.

If the switch is then made to the appropriate position a 330Ω resistor is connected between the base and the collector providing the necessary bias allowing the transistor to conduct. If the transistor under test is O.K. the current passed should increase thus indicating gain. By noting the leakage and gain of good transistors it will be possible to get an idea of what the acceptable readings are. It will be found that the most common faults of the transistors in the surplus packs are either short or open circuit or high leakage while some have low gain. Don't worry if no leakage is indicated as this is so low in silicon transistors that this instrument will not measure it.

DIODES

Diodes are tested by clipping the leads between the emitter and collector contacts and then reversing them—one way round a negligible current will be measured, the other way a substantially higher one. As with transistors the readings are comparative.

BATTERIES

If R3 is chosen so that when the emitter and collector clips are shorted the meter will read full scale deflection (f.s.d.) it will follow that when the battery voltage is low, f.s.d. will not be achieved. Other 9V batteries can be substituted and the deflection compared; in fact this test is better than using a sensitive multimeter as, instead of drawing a few dozen microamps, it will test the battery under a 3mA load. Lower voltage batteries will give smaller deflections and the scale can be calibrated for 1-35V (mercury cells) 1-5V, 3V, 4-5V, 6V and 9V.

RESISTANCE

The tester will measure (if not very accurately) resistance between about 470Ω and 47kΩ by clipping the resistor between the emitter and collector contacts. If much use is to be made of this facility it would be a good idea to make R3 variable so that the meter can be “zeroed” each time to compensate for battery voltage variation. The scale will have to be calibrated using close tolerance resistors.

ELECTROLYTICS

If an electrolytic capacitor is connected with its positive to the p-n-p emitter and its negative to the collector clip, the meter should kick over and fall slowly. Note that electrolytics with working voltages of less than 9V should not be tested in this manner.

ADJUSTMENT

The meter in my prototype is a tiny one from an old tape recorder but almost any meter with a sensitivity better than 3mA can be used. Build a mockup of the circuit in Fig. 1 and substitute a 1kΩ pot, initially set at minimum resistance, for Rx and connect a multimeter set on a scale to read 3mA between the emitter and collector contacts. A 5kΩ pot should be substituted for R3. The switch R1 and R2 can be ignored.

First adjust the 5kΩ pot so that the multimeter reads 3mA then adjust the 1kΩ pot so that your meter reads f.s.d. Trim the two pots so that f.s.d. on your meter coincides with 3mA on the multimeter. Finally remove the multimeter and short out the emitter and collector connections and adjust the 5kΩ pot to give f.s.d. again. Measuring the values of the two pots will give you Rx and the exact value of R3.

Next month's project will be a one transistor radio which operates a loudspeaker without the use of an external aerial.
PART 5—MATCHING & RADIATION

THIS is the final part in this series describing transmitter and receiver aerial principles. Most aspects have been covered in sufficient detail, but two important details that have been ignored up to now are aerial matching and radiation patterns. These two subjects will be described in this article, and although the treatment does not pretend to be comprehensive, there should be enough information to be of interest to the beginner and experimenter.

Matching circuits

The most convenient and common impedance matching device for coupling an aerial feeder to a transmitter or receiver is a high frequency transformer using conventional coils and capacitors. If, for example, a 75 Ω coaxial line is to be connected to a transistor receiver, an impedance step-up is required, and this can be achieved with the circuit in Fig. 5.1. L1 C1 form the input tuned circuit, with the aerial feeder tapped up the coil, and L2 is the output coil wound to suit the base input impedance. Under these circumstances, there would be an impedance ratio step-down between the feeder part of L1 and L2, and a step-up ratio between the feeder section of L1 and the whole winding of L1 to avoid damping the tuned circuit severely.

Fig. 5.1: A tuned impedance matching circuit for a coaxial feeder to a transistor.

Another way of achieving the same result is shown in Fig. 5.2, where a transformer input is used instead of the tapping on the tuned circuit. The coaxial cable is connected to its own winding, the tuned circuit is completely independent, and the output to the base again has its own winding. A typical transformer for a receiver working over the range 1.6MHz to 3MHz would have 6 turns for L1, 40 turns for L2 and 4 turns for L3. The physical dimensions of the transformer would be determined by the capacitor used.

Matching transmitter aerial

One of the most practical ways of matching a transmitter to an aerial feeder is to use a tapped transformer or coil. Figure 5.3 shows one way of doing this.

The end-fed Marconi Aerial is tapped into L1 at a convenient point. L1 is also tapped to match the 40 ohm aerial to a 600 ohm feeder line. This couples to a distant transmitter and is tapped into the tank circuit at 600 ohms, the turns ratio so being arranged to match the feeder to 15k ohms of the tank (typical figures).

The turns ratio is given by \( T_2/T_1 = \sqrt{\frac{600}{40}} = 1 : 4 \)

and \( T_2/T_3 = \sqrt{\frac{15,000}{600}} = 1 : 5 \).

Figure 5.4 shows one method of connecting a coax feeder to a transmitter.

The 75 ohm coax is fed into a balanced input transformer which matches this to the tank circuit. Assuming the feeder to be 75 ohms and the tank circuit typically 15k ohms the turns ratio would be

\( L_2/L_1 = \sqrt{\frac{15,000}{75}} = 1 : 14 \).

Where it is desired to use one aerial system for transmitting or receiving as in the usual amateur or professional set-up it is usual to employ an aerial change-over switch. This is commonly a relay remotely operated.

Polar diagrams

The behaviour of an aerial system in space may be expressed by polar diagrams. As the aerial length becomes commensurate with the wavelength in use, current variations along it become pronounced and phase differences appear, causing interference effects between radiation components from different parts of the aerial. These may reinforce the signal radiated in some directions and cancel the radiation in others.

Figure 5.5 depicts an aerial slightly longer than \( \lambda \). At the point Y radiation may arrive via the direct path XY or by incident path XEY. Provided the radiation arriving at Y via each path is similarly polarised, cancellation may occur when the difference in the length of the path is equivalent to an odd number of half-
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The earth acts as an imperfect mirror to electromagnetic waves. If the reflecting area is damp soil or the sea, over 80% of the energy in the wave will be reflected, but dry sand or wooded countryside are poor reflectors of radio waves. The hilliness of the terrain will also affect radio waves especially at h.f. where a hill may become comparable with the wavelength in use. Furthermore, the earth is a much better reflector of long waves than short waves. Peat is also a poor reflector. During the war the author was in charge of a transmitting station sited on peat (Lochar Moss, Tinwald Downs, Dumfriesshire), where an earth mat of copper strip had to be laid down around the station and aerial system to form an effective counterpoise. This extended beyond the plan view of the aerial system by a distance equal to the height of the aerial masts.

Aerial reactance
When the frequency is low, the length of the aerial is a fraction of a wavelength and acts as a capacitance. As the frequency is increased the capacitive reactance decreases and the aerial becomes resistive at a quarter wavelength. If the frequency is increased further still the aerial becomes inductive and tends towards infinite inductive reactance at half wavelength. The aerial next becomes infinite capacitance and follows through the same cycle approaching zero for three-quarter wavelength aerial and on to infinite inductive reactance at a full wavelength.

Figure 5.6 is the vertical polar diagram of an earthed 1/4λ aerial. The full line occurs when the earth is a perfect conductor. The dotted curve is what happens in practice owing to a poor conducting earth.

The effect of raising the aerial above the ground is to cause the radiation to break up into beams. Figure 5.7(a) is of the 1/2λ dipole suspended 1/4λ above the ground.

Figure 5.7(b) shows the state of affairs when the aerial is raised a full wavelength above the ground (λ = wavelength).

The narrow beams of radiation caused by raising the height of the aerial above the ground are concentrated at definite angles increasing as the aerial height is increased. Use is made of this in the design of aerial systems for low-angle radiation. For instance, by stacking arrays of dipoles either in a horizontal or vertical plane and raising these above the ground, usually 1/8, the desired polar diagram may be achieved. The Koomans Array is a practical example of this, and the general form is given in Fig. 5.8 below.

Note the stub matching arrangements and the method of terminating the 600 ohm feeder.

---

**Fig. 5.5:** How the image of an aerial affects its radiating properties.

**Fig. 5.6:** An earthed 1/4λ aerial produces a 55° lobe (theoretically) and a 10° lobe (in practice).

**Fig. 5.7(a):** The radiation patterns from a 1/2λ aerial 1/2 above ground.

**Fig. 5.7(b):** The 1/2λ aerial one wavelength above ground produces a much more satisfactory pattern.

**Fig. 5.8:** The Koomans multi-element aerial array produces a much more predictable pattern than single 1/2λ aerials.
The horizontal Rhombic aerial

The Rhombic or horizontal diamond shaped aerial is substantially aperiodic when correctly terminated and may be operated over a 2/1 frequency band. Its principle of operation is attributed to the fact that a wire in free space carrying travelling waves produces a cone of radiation around it. Figure 5.9 shows the form of such a system with the lobes of radiation around the wires.

For h.f. aerials the sides should be $5\lambda$ and the terminating resistance 900 ohms, while for l.f. aerials the sides should be $4\lambda$ with a terminating resistance of 600 ohms.

As a transmitting aerial the Rhombic wires carry travelling waves and become in effect a special type of transmission line arranged to radiate. The input or characteristic impedance varies between 900 ohms at I.F. (30-300kHz) and 600 ohms at h.f. (3-30MHz). The terminating resistance is usually made up of three carbon rods in watertight tubes dissipating 30-60% of the power input to the system.

Rhombics may be made more efficient for transmitting purposes by grouping two or three either in series or parallel and in such a way that their combined directivity is maintained and the radiation efficiency may exceed 90%.

For the radiation or reception of ultra short waves (i.e. 17cm.) aerial arrays based on optical principles are employed. These take the form of a paraboloid reflector (usually made of aluminium) with the aerial, a half-wave dipole, fixed at the focus. The aperture of the reflector is typically $18\lambda$ across. Figure 5.10 shows the general arrangement of this system.

The gain of this arrangement is in the order of 30dB. The sharpness of the radiated beam is such that turning the dish reflector through $3^\circ$ reduces the received signal by 10dB (i.e. about 3/1).

To conclude this series on aerials details are given below of a practical power indicator (Fig. 5.11). This practical low-power meter for indicating line or aerial current may be made up from a 0-5 milliammeter. A silicon diode type NKT914 is used as the rectifier. Sufficient coupling can be achieved by fixing the coupling wire close to the feeder, aerial or one wire of a balanced feeder. By this method of coupling a deflection of several mA can be recorded on the meter. This instrument may be used for aerial tuning or for checking standing waves on a feeder.

The general constructional details are left to the constructor. The few components used may be grouped through the back of the meter on a piece of Veroboard and the assembly then mounted in a suitable wood or metal box.

Aerials for amateur use

The most suitable aerial system for amateur use will be determined largely by experience and inspired guesswork, as it is seldom possible to predict with any accuracy the performance of a particular system adopted for the frequency in use. It can be shown that the best height of an aerial is 0.625$\lambda$ for maximum power efficiency to produce a given field strength at a distant point. Aerials erected at a height of 0.5$\lambda$ are the usual practice.

References
Radio Communication Handbook, R.S.G.B.
Short wave Radio communication, Ladner & Stoner.
Admiralty Handbook Wireless Telegraphy.

CORRIGENDA

A Comprehensive Audio Mixer. Andrew Dicks
The author has drawn our attention to the following errors in his article. VR1, VR2, VR4 and VR6 should be 250k$\Omega$ log. and the wiring of S2, S4, S6 and S9 must be ignored. In Fig. 5, VR3/VR4 and VR5/VR6 should be interchanged; the last hole on the front panel is for Sk8 (not Sk7). In Fig. 3, R22 should be 27k$\Omega$.

Transistor Output Stages. I. Sinclair
At the foot of the second column on page 118 (May issue), the first formula should read Power out = $V^2/R_{load}$, and the second should be Power Dissipated = $A \times V^2/R_{L}$.

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YOU should be familiar with the Morse key, which is the simplest device that can be satisfactorily used to operate a transmitter. The key is usually connected in such a way that it causes the output from the transmitter to be interrupted, and all that is needed is some dexterity in manipulating the Morse key in accordance with a recognised code, such as the Morse Code. Quite high keying speeds can be attained—25 w.p.m. (words per minute) are not out of the way—but to better this figure considerable practice is demanded.

There is a way to improve one’s speed more easily, fortunately, and this involves using a semi-automatic keyer, preferably of the electronic variety. An electronic keyer, unlike a straight Morse key, has a “paddle” which moves in a horizontal plane between contacts on each side so that moving it to the right produces a succession of, say, long pulses (dashes), or moving it to the left produces short pulses (dots). This is a keyer of the simplest type which forms the subject of this article, but it should be noted that there are many improvements which can be made such as the addition of circuitry to avoid breaking up the last dash if the “paddle” is moved prematurely to the opposite contact (self-completion of characters), and circuits to make sure that all character spacing is perfect, even during the transition from dot to dash and vice-versa. It is even possible to build a simple memory into the more sophisticated keyers.

To gain practice, however, the simple transistorised keyer which the author has designed is ideal, and cheap to build. The contact assembly uses commonly available components, and the electronic circuitry comprises three multivibrators plus a relay amplifier. Describing the electronics first, the heart of the keyer is a couple of multivibrators Tr1/Tr2 and Tr3/Tr4 (Fig. 1), which are operated by taking their supply lines to the differential key. The first multivibrator, Tr1/Tr2, produces a square wave output at the collector of Tr2, and is used as the dot generator. The rate is controlled by VR1, and the mark-to-space ratio is governed by VR2. This multivibrator operates when the key is moved to the left. The second multivibrator Tr3/Tr4 produces the dash signal. As before, the overall speed is controlled by VR3, and the mark-to-space ratio by VR4. By juggling the settings of VR1, VR2, VR3 and VR4 the correct ratio of dot to dash and a constant interval between characters can be achieved for any speed. Unfortunately, with this simple circuit it is not possible to incorporate an overall speed control which would preserve the pre-set ratios.

The outputs from the multivibrators are combined and fed to Tr5, the relay current amplifier. The relay RLA is in the collector circuit of Tr5, and in parallel with it is connected a diode which protects the transistor from high back-e.m.f.s resulting from the interruption of current through an inductor. One set of contacts is used to key the transmitter, while a second set operates a higher frequency multivibrator Tr6 and Tr7, which is used as a keying monitor in conjunction with the headphones. This circuit is particularly useful if the keyer is to be used by an unlicensed enthusiast for practice, but do
THE title of this article is not to be taken too seriously. The instrument to be described is a skin resistance meter or "psycho-galvonometer", which operates by measuring the resistance between two electrodes held in a person's hands or taped to the wrists by passing a negligibly tiny current through. The resistance is found to vary erratically over a range of about 1 to 50kΩ brought on by perspiration which causes large, slow resistance changes, muscle contractions which produce small, slow variations that are hard to detect or sudden changes of emotional mood which can produce large, very fast changes and oscillations of resistance. These form the basis of the uncertain claims for "lie detector" devices.

The circuit of the instrument is shown in Fig. 1. It consists of a two transistor direct coupled current amplifier which drives a 0–1mA moving coil meter. Tr1 is normally non-conducting because R2 holds the base at emitter potential. Tr2 is normally conducting because current flows from emitter to base and through R3. Full collector current flows through R4 and the 1mA meter which indicates full-scale deflection.

When skin resistance electrodes are connected to terminals T1 and T2 a small current flows from Tr1 emitter to base through R1, VR1 and the subject's skin resistance. Tr1 starts to conduct and passes collector current through R3. The potential at Tr1 collector becomes less negative so that Tr2 passes less base current. The collector current therefore decreases also and the meter needle moves towards zero.

VR1 is used to adjust the meter to half-scale deflection (0.5mA) or slightly above. Any slight change in skin resistance will now produce a large swing of the needle to left or right. Half-scale deflection is regained by readjusting VR1. This control should be fitted with a fairly large knob as it will be in constant use and its adjustment is fairly critical. The meter can be brought to half-scale deflection for any resistance up to about 40 to 50kΩ (depending on component tolerances) between T1 and T2. Changes of resistance of as little as 10Ω can be seen on the meter. In view of this the instrument might find use in comparing high tolerance resistors and particularly in finding matched pairs of resistors.

The instrument can be constructed in any kind of cabinet and component layout is not critical. The author used a "Norman" aluminium chassis as a cabinet. The components were mounted on a tiny piece of Veroboard as an enjoyable exercise in miniaturisation and the layout is shown in Fig. 2. There is no need to build so small unless one has the inclination (and the patience) as there is plenty of room in the cabinet. It is easy to convert the layout in Fig 2 to a larger piece of Veroboard by (say) disregarding alternate holes.

Tr1 and Tr2 were OC71 in the prototype but any small signal transistors with current gains of 40 or more, such as the surplus "red spot" variety will work. They should be soldered as quickly as possible to avoid heat damage. The higher their current gains, the more
sensitive will be the instrument to small skin resistance changes. M is a 1mA d.c. moving coil unit and should be as large as possible to show up small deflections, but the calibration is unimportant and any surplus type is suitable. If the instrument is switched on without the electrodes connected a current of almost 3mA flows through M. This causes the meter needle to bang against the pin alarmingly but should not harm the movement. However, a meter required for other accurate measurements should not be used. A little protection can be provided for the meter by wiring one or two germanium diodes, or the junction of a germanium transistor, across it in the forward direction. If M has an internal resistance of about 100Ω the current through it will be limited to about 2mA, but if this is still considered excessive an additional 100 to 130Ω resistor (R5) in series will give further limiting of the maximum meter current but causes some loss of sensitivity. Note that the red or positive (cathode) ends of the diodes are connected to the negative terminal of M.

Suitable skin resistance electrodes for connection to terminals T1 and T2 are shown in Fig. 4. The hand-held electrodes give best results provided they are not 

... 

Fig. 4: Skin resistance electrodes; (a) for holding in each hand, (b) for holding in one hand and (c) for taping to wrist.

SIMPLE ELECTRONIC KEYER

remember that if a licence is aspired to, the GPO will require the test to be taken using a conventional Morse key. A relay with more contacts could be used, of course, if other outputs are required; for receiver muting, for example.

Construction of the key should be reasonably self-explanatory from Fig. 2. The whole assembly is mounted on a wooden block measuring 4in. x 2in. x 2in. Three brackets about 1in. high with a ¼in. lip for securing them to the base should be cut from a sheet of 18swg aluminium, the widths of two being about ½in. and the rear support, which needs two screws in line, should be about 1in. wide. The “paddle” is easily made from a 5in. metal nail file, drilled with a couple of holes at the narrow end for securing it to the rear bracket. Adjustable contacts are merely screws in the front brackets, each locked with a couple of nuts. Wires can be taken from the bracket mounting screws to the electronic circuitry. Any conventional form of construction is suitable for the electronics, such as Veroboard, Cir-Kit, pin-board or tagstrips. Details have not been given because the wiring is really quite simple.

This unit does demand care when switching from dot to dash and vice versa, to maintain correct element spacing. Nevertheless, with some practice

... 

Fig. 3: Appearance of the instrument.
A MINIATURE T.R.F. RADIO COVERING THE M.W. BAND WHICH CAN BE BUILT FOR LESS THAN 25s. AND ITS SIMPLICITY MAKES IT AN IDEAL PROJECT FOR THE BEGINNER.

EVER since transistors first became available on the amateur market constructors have been building radio sets smaller and smaller and these never lose their fascination to a large proportion of both new and established constructors.

The author is not claiming that the one described here is the smallest yet but it uses readily available components and case (always a problem for such sets) and should cost under 25s. to build. Even though the set is very small things are not so tight that building it is a problem. None of the component valves are critical, which is a common fault with many designs of this type and also the circuit is very stable, very important since the effects of handling some simple designs can send them way off tune.

Choice of transistors

Since the physical size of the set is small, obviously the aerial must be very small and consequently a very high gain is required from the transistors used; also, if very high gain transistors are used it will mean fewer stages are needed. There are on the market several transistors with very high gains but amongst the cheapest and highest gain is the BC109, now being replaced by the BC169 which is identical apart from being plastic encapsulated and cheaper. The BC169 costs under 2s. 6d each and two of these are used in the circuit.

In the prototype very cheap near-equivalents were tried with a large measure of success, these being the transistors sold in the 10s. packs, but the component values had sometimes to be altered slightly and consequently such substitutions are not recommended for those building the set straight up without first bread-boarding.

The circuit

Among designs of this type reflexing is very popular, that is, making the r.f. transistor do two jobs, but this was rejected since closer tolerance component values are needed and problems with stability are often encountered.

It is also common practise to bias one of the transistors in such a way that it will detect, but here again a straightforward detector diode is used, as accurate and individually chosen components would be required.

The basic circuit that we are left with is a high gain r.f. amplifier with a limited amount of regeneration provided by VC2 consisting of two lengths of wire twisted together followed by a detector and a high gain a.f. amplifier. The detailed circuit operation is described separately for those interested, the circuit is shown in Fig. 1. It is common to use a high impedance magnetic earpiece acting as the collector load of the second transistor but these cost two or three times the price of crystal types and the performance between the two types was identical.

Choice of components

About the smallest and cheapest method of tuning a coil is by means of a 250pF trimmer costing about 2s. and one is used here. Batteries are a problem and for sets of this sort there is a limited choice. The one chosen was the Ever Ready B154, a 15V battery costing 2s. 9d. This is available from Boots' or other chemists and is used for hearing aids among other things. The current consumption of the radio is only 1·5mA and will power the radio for months.

Since space is limited, a 2·5mm rather than 3·5mm jack and socket are used and the crystal earpiece should be bought with this size. As far as the author is aware, ready wound coils of the size used in the set are not available but it is a relatively easy matter to wind one's own on a 1½in., ¾in. diameter ferrite rod. Details of this are shown in Fig. 2.

The majority of the components are mounted on 0·1in. matrix Veroboard, 13 × 9 holes. To save sawing it to this size, this matrix is easily broken to the correct size along the holes.

The detector diode, OA81, is available in a miniature size and one of these should be used as the larger version will be a tight fit.
circuit operation

The radio waves are picked up on the aerial coil, L1, which has its own inductance and signal pickup qualities greatly increased by the ferrite rod. In combination with VC1, L1 forms a tuned circuit at a particular frequency depending on the position of VC1. The overwind on the coil, L2, considerably transforms the very high impedence of the tuned circuit thus preventing Tr1 from damping the tuned circuit; C1 is a d.c. blocking capacitor. Tr1 greatly amplifies the r.f. signal and part of this is fed back to the tuned circuit through VC2 providing a regenerative action.

The remainder of the signal is passed through C2 and is detected by D1 which is connected directly to the base of Tr2 which further amplifies the audio signal and applies it across the crystal earpiece. R1 and R3 provide the correct bias current for the transistors and R2 and R4 provide the loads across which the r.f. and a.f. signals are developed. As there is always a certain amount of detection in the first transistor, C2 is made large to feed this to Tr2. If it was necessary only to pass an r.f. signal C2 could be considerably reduced.

Constrution

The aerial coil should be wound first using 80 turns of 34 s.w.g. enamelled copper wire. A narrow band of adhesive tape should be wound around one end trapping the end of the wire in this. Eight turns of similar wire should be wound on top of the original windings approximately in the middle.

Only one break is needed in the Veroboard strip and this can be made using a 3/32in. drill. The components should then be mounted on the Veroboard as shown, taking note of the transistor connections, note that the lead arrangements on this type of case (TO92) positions the collector in the middle.

After mounting the components on the board, solder in the wires which will lead to the battery, the earphone socket and the tuning capacitor; finally feed the aerial wires through the appropriate holes, pull tight and solder. The aerial should be pulled close to the board as there is no other means of supporting it.

The tuning capacitor should next be modified. Remove the screw used for compressing the "vanes", screw the fixing nut underneath up tight and saw off the surplus thread. Remove the fixing nut and place the trimmer in position inside the box pressing to mark the position for the hole. Using a 3/32in. drill make the hole for the trimmer, fitting it in right into the corner. A 3/32in. 6BA round-headed screw should next be fitted through the tuning knob and locked with a nut. This can now be screwed through the trimmer and, allowing for the correct amount of movement, fix two locking nuts on the screw. The tuning knob is available as a replacement for some Japanese miniature volume controls.

The battery connections should be soldered, for, although spring contacts could be used these are not as reliable and the battery will have to be changed so rarely that it will be no chore.

The on/off switch is incorporated in the earphone socket by bending the switch section so that instead of being normally on it will be normally off. The jack, when inserted will automatically switch the set on. A 3/32in. hole should be drilled in the side of

---

**components list**

**Resistors:**
- R1 180kΩ
- R2 10kΩ
- All miniature 1/2 watt, 10% tolerance

**Capacitors:**
- C1 0.01µF (miniature disc types, 12V)
- C2 0.01µF (minimum disc types, 12V)
- VC1 250pF trimmer (Radiospares, available from most component suppliers)
- VC2 See text

**Semiconductors:**
- Tr1 BC169B Electrovalue Ltd.
- Tr2 BC169B
- D1 OA81, subminiature type

**Miscellaneous:**
- L1, L2—see text: Crystal earpiece with 2.5mm jack plug; 2.5mm socket; B154, 15V battery; Veroboard, see text for size; Plastic case—see text; Tuning knob (Henry's Radio).
the case to take the earphone socket, this fits inside the case beside the trimmer. The actual case used is widely available, sold holding 30 hairgrips (which may be of use to our longer haired friends to avoid singeing whilst soldering or for the closer cropped section to give to their good ladies!) “Kirbigrips” are the manufacturers of these hair grips and box, and they cost 1s. 6d.

The only setting-up necessary in this radio is adjusting VC2 which is made up by twisting 2in. lengths of insulated wire together. If the set fails to break into oscillation reverse the connections of the overwind. This design, together with the transistors used makes for an “overlap” in oscillation, that is, once oscillation starts it is necessary to reduce VC2 (by untwisting the wires) quite a bit before stability is achieved again. Because of this only a limited amount of regen is possible but it is sufficient to increase sensitivity and selectivity appreciably.

On two prototypes Radios 1, 3, and 4 were received well and under favourable conditions Radio Luxembourg and one or two other continental stations were heard with good volume.
No one knows

I was extremely pleased at first, to read B. R. Meredith's letter (March 1969) on the subject of those elusive fictional holes. I thought that at last people were beginning to understand the work of the theoretical physicist, but I was shattered by the next paragraph, which showed that he had not got the point at all—for he still believes in the fantasy world of the electron. I might even venture to suppose that he regards an atom as consisting of solid spheres of negative charge flying through space round a fixed set of positive and neutral spheres. I dare say many readers believe this as well—but this is where a fundamental misapprehension arises and this belief, I am sorry to say, is fostered by even the best text-books.

The atomic model and the electron-hole theory are not supposed to be, and were never intended to be, taken as literal representations. In each case, what the physicists said was: "We can understand how an atom works and we can do our sums on it, by pretending that it consists of particles having mass, charge, momentum etc., in certain fixed relations. The model, for such it is, is only useful for us in so far as it enables us to explain the results we observe." In a similar way, the physicists have never said that the positive hole exists—all they have said is that we can explain semiconductor action most effectively by pretending that such holes exist and that they move like electrons but in the opposite sense.

If Mr. Meredith knew anything of the results of Quantum Mechanics, he would be utterly confused to say the least. Using this system it is easier to explain atomic spectra and other effects by considering the electron as a smeared-out spherical charge distribution around a hypothetical nucleus. But even this is only a model, for the quantum mechanical electron is in fact a wave in space. However the wave is not a wave as we understand it! So you can see how confusing it gets!

The main point of my argument is that the scientist invents a model which will explain his results and gradually, mainly through the influence of badly written beginners' books, people begin to associate the model with the real thing. I would like to state categorically, here and now, no one knows, or will ever know, exactly what an atom or electron looks like. The nearest we can ever get is to invent a model system which explains all known phenomena.

I must admit, Mr. Meredith's remarks about current flow in paragraph 5, puzzled me somewhat until I realized that he apparently has not yet sorted out the difference between electron flow and conventional current flow. For his benefit and that of his students, I might just point out that for historical reasons the conventional current flow is directly opposite to that of electron flow. I find that authors and "experts" tend to deal in either convention to about an equal extent, depending on which system they were educated in. The advice he gives his students ("What are the electrons doing") is very sound but then it is always very useful if one can appreciate the other point of view.

Incidentally, I believe that it is impossible to explain p-n-p action without the use of "hole theory" and I should be very interested to hear how Mr. Meredith does this.

Finally, as for Hiattitis Pungens, I don't think it ever existed, except perhaps in a confused mind.—K. H. J. Rainbow (Surbiton, Surrey).

Rhodian mod.

With reference to the "Rhodian Tape Recorder" design by Julian Anderson (P.W. March-April 1968), I have a suggestion which may be of help to other constructors of this unit.

In an otherwise excellent design giving very good results, I have found two difficulties, and after some experimenting I have improved one of these—the record level indication. I found the DM70 indicator was not giving any indication until the level, was so high as considerably to over-modulate the tape.

To make the "line" on the DM70 shorten appreciably, the grid must be several volts negative with respect to the cathode. I therefore decided to amplify the bias signal before it was applied to the grid, and for simplicity and small size. I used transistors, powered by a 4 1/2 volt battery the doubler from the heater line—only 7 components are involved. A super-alpha pair is used to match the impedance of the bias signal.

With this arrangement, a short line shows with no signal, and lengthens with increasing amplitude. The only precaution necessary is to keep the unit away from heat, as this alters the d.c. characteristics of the transistors. R1 can be chosen to give a full-length line when recording level is optimum.

This circuit gives a good indication of level, but I should be interested to know whether other constructors have had this problem, and how they have tackled it: also any comments on my other problems, whistles on recording from an a.m. radio, due to radiation from the oscillator coil. Perhaps this is due to building the unit on a printed circuit rather than a metal chassis? I would be glad to hear from other constructors "in any case!"—W. Wright (Muirpark House, Tranent, East Lothian, Scotland).

---

![Diagram](image-url)

Fig. 1: The "Rhodian" modification. The original circuitry is shown in dotted form.
It was desired at one stage to add an extension from the shed to the main unit in the kitchen but to provide such an extension would have proved expensive using a three-wire connection. Consequently a two-wire extension was devised but having the disadvantage that only one such extension may be parented on to a main unit, see Fig. 6. The operation of the extension is somewhat different from usual in that receiving a call at the main from the extension (announced by a bell) requires that the extension selector on the main unit be operated before communication can be established. A call to the extension from the main unit is made in the normal way.

The original extension unit consisted of a GPO type non-dial telephone with a press-button switch added just in front of the receiver rest for ringing purposes.

It was found that if the two-wire extension parent was unattended, calls to it were fruitless and since the extension has no outgoing selector keys, no connection could be made to the basic network. To overcome this problem, a night extension facility was added to the parent unit so that calls to it could be re-directed to any unit present on the main unit.

This arrangement is shown more clearly in the block diagram in Fig. 7 and the circuit in Fig. 8. The setting-up operation is to lift the receiver, operate the three keys or buttons simultaneously for "night extension", "shed extension" and the selector switch for the unit to which it is desired to extend the call. A call incoming from the extension to the parent will cause the buzzer to ring at the extended unit.
which can receive the call in the usual way. Note that outgoing calls cannot be made from the extended unit to the extension and the parent cannot be used to receive incoming calls (which will be announced by a buzzer in the usual way) unless the night extension facilities are first cancelled by momentarily depressing the receiver, rest switch. Note also that the receiver must be left off the parent unit so that the keys or buttons hold locked. The unit used by the author to parent the two-wire extension was a seven key unit and it was thus a simple matter to use one of the spare keys for the night extension facility.

**Auto-Transfer of Two-Wire Extension**

It will be seen from the description of the night extension that if a call originating from the extension cannot be dealt with at the parent unit, it can be extended to any of the other units by setting up a "temporary night extension" arrangement. The procedure is as follows: On hearing the bell (announcing a call from the extension) lift the receiver, operate the extension key or button and speak to caller. If the caller wishes to be connected to another unit, release the caller by temporarily depressing the receiver rest key and call the desired unit. On answering, the extension key and night extension key must be operated whilst holding the selected station key so that all three lock down. Since the receiver of the main unit is cut out of circuit, it will be difficult for the operator of the main unit to know when the conversation is over, hence an automatic transfer arrangement was devised having the following facilities:

(i) A call from the extension to the parent operates the bell.

(ii) The operator answering is then asked to transfer the call to another unit.

(iii) The auto-transfer key or button is operated (biased off) and the unit required is dialled (1 to 0 for up to ten extensions) and the ring key operated a few times to call the dialled unit.

(iv) The receiver is replaced and a "doll's-eye" indicator remains held whilst the transfer is in operation.

(v) At the termination of the call, the called unit rings the parent in the usual way. This causes the doll's-eye to drop out and the equipment to reset to normal without the intervention of anyone at the parent.

The circuit diagram is shown in Fig. 9.

**Auto-Transfer Circuit**

After ascertaining the unit required, the "transfer set" key or button is operated. This applies the earth at CN1 to the relay TRF, which latches via TRF2 and CN1. The doll's-eye indicator operates and the indicator lamp lights from the 24V supply via TRF3. The selector magnet, SR is now disconnected from its self-interrupt springs and homing arc by TRF6. The speech path is set up via TRF1 and TRF4. The incoming wire is switched to the 4.5V relay CN by TRF5 in preparation for cancelling the transfer. It is necessary to isolate the main unit buzzer as this will otherwise interfere with transmission being coupled in parallel to the extension receiver; this is achieved by TRF7. Dialling now steps the selector to the required outlet. On completion of dialling the ring key or button is operated which applies 4.5V battery voltage to the dialled unit via TRF4 and SR1 returning via the common return wire. When the dialled unit answers, the call is announced and the receiver is replaced. At the termination of the call, the called unit rings to the parent and in so doing applies 4.5V across the relay CN via TRF5, CN1 operates to disconnect the earth from TRF which releases. TRF6 deoperates, connecting the selector magnet to the earth on the homing bank via the self-interrupt contacts, SRdm, the magnet now steps successively to home. All other TRF contacts restore to normal causing the doll's-eye to release and the indicator lamp to extinguish. Calls may now be made to and from the parent unit without the further operation of any keys or buttons.

The power supply for the transfer unit is derived from a 20V transformer (or any other suitable voltage so long as it is sufficient to operate the relay, selector and doll's-eye indicator) and a silicon rectifier to give approximately 18V r.m.s.

All the apparatus can be housed in a wooden box containing the dial and doll's-eye indicator or the equipment may be housed with the transformer/rectifier separately from the dial and doll's-eye indicator. No details are given for the construction of the auto-transfer equipment since these will vary with the apparatus of the constructor.

A normally made "transfer cancel" key is connected in series with the relay should it be necessary to cancel a call from the parent unit (e.g. if there is no reply from the call deunit). This takes the form of a key switch (in practice the other "side" of the "transfer set" key).

**TO BE CONTINUED**
TRANSDUCERS are components which convert physical effects such as temperature, light intensity, mechanical movement, pressure etc. into electrical quantities. Since a number of types of transducer can be used for each physical parameter it will be convenient to consider each group separately.

Temperature

Most electronic components are affected by temperature variation and consequently a wide variety of transducers are available for temperature measurement. Among the most popular are thermostats, thermistors, thermocouples and temperature dependent resistors.

Thermostats

Thermostats are widely used for temperature control where critical operation is not required. The basic construction of a thermostat is illustrated in Fig. 1. Essentially it consists of a bimetal element formed by laminating two metals together. The metals used have radically different coefficients of linear expansion with temperature and consequently when the temperature is changed one element expands more than the other, which results in the strip bending to accommodate the separate requirements of each material. When the strip is heated or cooled the bending occurs and is used to make or break a contact.

The actual temperature at which this occurs is determined by the contact to strip spacing and can be adjusted by moving the contact position. Because of the variation in strip characteristics and the relatively small movement there is a large variation from one unit to another and individual setting of each thermostat is often required.

Thermostats are effective devices for sensing one particular temperature value within a margin of error of 2-5°C and can only be used for a single temperature due to the ON-OFF characteristic of their operation. Consequently they are widely used as control elements in domestic and industrial temperature control applications but are not generally used for temperature measurement and indication.

Applications

In electronic circuits thermostats are used as delay elements and for miniature circuit breaker applications. Components with delay times of 10-100secs are available and are used for valve applications where the application of h.t. potentials are delayed until after the heaters have warmed up. Both normally-open and normally-closed contact configurations are available and generally the bimetal strip is indirectly heated with a coil. The heating coil is wound around the bimetal strip and is electrically isolated from the contact. The coils are generally wound to match heater voltage ratings of 4, 6 and 27V and require current levels of 200-750mA. Contact ratings vary from 0.5A to 2A and depend largely upon size and construction. A typical low cost delay element is shown in Fig. 2; such devices vary in price from £1 to £3. Valve configurations are also available to suit many standard valve bases at prices from £1 to £3.

![Fig. 2: Miniature thermostat delay element.](image)

Miniature thermostat circuit breakers are used for over current and over power protection. Because of the time-lag inherent in the device due to thermal delay they are insensitive to transient conditions. The operation is similar to the delay elements except that the contact is normally closed. The current at which the contact opens is determined by the thermostat and a delay of 5-20secs is inherent. It should be noted that the maximum coil current for operation is dependent upon ambient temperature and reduces as the ambient increases; consequently these devices cannot be regarded as accurate for over current protection applications. They have the advantages of positive switching action and automatic restarting (as the coil cools) and are very cheap at prices from £3 to £5.

Thermistors

Thermistors are temperature sensitive resistors and the circuit symbol is shown in Fig. 3. They are
NEW PRICES ON NEW COMPONENTS

ELECTROLYTIC CAPACITORS (Mullard).—10% to + 50%.

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RESISTORS
High stability, carbon film, low noise. Capless construction, molecular

Dimensions (mm.): Body: 1W: 8 x 2.8

10% tolerance. 100 Volt Watt.

Prices—per Ohmic value.

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CAPACITORS
Subminiature Polyester film, Modular for P.C. mounting. Hard epoxy
resin encapsulation. Radial leads.

Prices—per Capacitance value (µF).

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JACK PLUGS

JACK SOCKETS

SEMICONDUCTORS: OA5, OA81, 1/9, OC44, OC45, OC71, OC81, OC82D, OC82, 2/5, OC70, OC72, 2/5, AC107, OC75, OC170, OC171, 2/5, AF115, AF116, AF117, AC19, ACY21, 3/5, OC410, 4/3, OC200, 5/3, OC19, 5/3, OC25, 7/3, OC35, 8/3, OC23, OC28, 8/3.


SWITCHES (Chrome body).

PRINTED CIRCUIT BOARD (Vero).

| 0.1in. Matrix: 3in. x 2in., 3/5, 3in. x 2in., 3/5, 3in. x 3in., 3/5, 3in. x 3in., 5/3 |
| 0.1in. Matrix: 5/3, 3in. x 2in., 4/3, 3in. x 2in., 4/3, 3in. x 3in., 4/3, 6in. x 3in., 5/3 |

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generally available with negative temperature coefficients. They are manufactured from semiconductor material and are consequently robust and reliable.

The resistance falls logarithmically with increase in temperature and a typical thermistor characteristic is shown in Fig. 4. Since the characteristic is continuous they can be used both for control and indication and are particularly useful for power measurement especially in the r.f. to microwave frequency range. Where a linear characteristic is required this can be achieved by shunting the thermistor with a resistor as shown in Fig. 5(a). This results in the modified characteristic shown in Fig. 5(b).

**Applications**

In electronic circuits thermistors are used for automatic gain and amplitude control and for surge suppression whilst as transducers they are used for measurement, indication and control. Three basic forms of construction are used to suit the varied design requirements and these forms are illustrated in Fig. 6. Bead thermistors are used for amplitude control and the bead is small in order to reduce the thermal delay. Consequently they are fast acting and suitable for direct control. Indirectly heated types in evacuated or gas filled glass encapsulations are also available. Disc thermistors are larger but are not protected except by the end connections. They are therefore more useful for power applications in control and compensation. Rod thermistors have a large surface area for heat dissipation and are particularly useful for surge suppression.

**Parameters**

Thermistor operating temperatures are wide but generally between 0-300°C. Resistance values vary considerably and are available from 100kΩ to 0.5MΩ at 20°C ambient temperature. The tolerance on thermistors of a particular type is usually ±20% of the ambient 20°C level. At maximum temperature or dissipation the resistance value is usually between 103 and 1kΩ depending on type. Disc and rod thermistors have lower ambient resistance values and are supplied to closer tolerances, usually ±10% or ±5%. Power dissipation levels vary from 20-100mW for bead thermistors to 1-5W for disc thermistors.

Prices vary between 7s. and 20s. for disc thermistors of wide tolerance to 15s. to 35s. for close tolerance devices, whilst bead thermistors vary from 10s. to 50s. depending on tolerance and construction. Generally directly heated bead devices are available in the range 10s. to 25s. for general purpose application. Whilst these prices apply for standard thermistor specialist r.f. and microwave power measurement devices are considerably more expensive.

Thermistors have a number of advantages when compared with thermostats for control purposes. These include the ability to both measure and control, and also non-mechanical operation which results in reduced size and increased reliability and stability. They are also robust and unaffected by high vibration levels. However they do require additional circuitry for control applications and generally are destroyed by high overload values. This is a particular problem in low power measurement at v.h.f. and u.h.f. frequencies.

**Thermocouples**

Thermocouples are widely used for temperature measurement and control but rarely as components in electronic equipment. Thermocouples are junctions of dissimilar metals and many combinations are used including cromel/alumel, copper/constantan, iron/constantan, and platinum/rhodium to cover the various temperature ranges. They operate by generating a small voltage in the region of mV when the temperature of the junction is raised but have very low source resistances. However when used in conjunction with high input impedance amplifiers rather than galvanometers the lead conditions are not critical.

Temperature ranges vary with the type of metals used for the junction. Commonly copper/constantan (Cu/Con) is used for temperatures from -200°C to +300°C since these are generally available in wire form, whilst cromel/alumel (Cr/Al) is widely used for more critical applications to 1000°C. Platinum/platinum rhodium is used for the range 0-1800°C where exceptional accuracy and stability are required.

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*continued on page 347*
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In this modern age of the transistor, there is a wide range of small, portable equipment designed to operate from batteries, and modern power packs offer a very reasonable life. Considered long term, however, there are many cases where the economy of running this same equipment from a mains supply would be of great advantage.

Due to its small size, $4\frac{1}{2} \times 2\frac{1}{2} \times 1\frac{1}{2}$ in., the supply to be described is small enough to mount inside such equipment where the addition of a switch gives the versatility of mains/battery operation.

The supply has a current limit to protect against accidental short-circuit of the output, or overload, and in the form described has a nominal 18V stabilised output. A continuously variable output would not enable the circuit to keep its present advantage of simplicity. The 18V line may be used directly with decoupled line dropping resistors, or even further zeners if very accurate lower voltage lines are required. Alternately the actual output may be reduced to any desired lower level by small component modifications.

As an example of the economy of such a unit, compare, for instance, the requirement for an 18V line and a load current of 30mA. The most convenient method of obtaining this with batteries would be two series PP9's. Assuming a 12 hour/day operation, and allowing the supply to drop to 13V with the PP9's, lifetime would be about 80 hours for 7s. 6d. The cost of the miniature mains unit for the same period is less than two-tenths of a penny!

The circuit, including a sub-miniature mains transformer, is constructed on a piece of Veroboard, and this may be mounted inside the smallest of the Eddy-stone boxes. The supply can be used floating or with earth connected to either polarity. Output is taken from solder pins, and the supply box designed for use as a general purpose bench unit or for mounting inside equipment.

Regulation is better than could be achieved with a simple zener since zener current variation with load current variation has been minimised, thus achieving a 1% regulation.

Figure 1 shows typical output voltage against load current. It is pointed out that the absolute value of output voltage is dependent upon the spread of zener voltage, and will be about 0-7V less than a given zener voltage. For the BZY94 the spread is 16-9V to 19-1V.

**CIRCUIT DESCRIPTION**

A miniature mains transformer, T1, provides from a 240V mains supply a secondary of 24V r.m.s. This a.c. voltage is fed to a bridge rectifier formed by diodes D1, D2, D3 and D4. C1 is an initial reservoir capacitor tending to lift the full-wave rectified waveform to its peak value, and R1 and C2 provide further smoothing and ripple filtering. C1 and C2 should be capacitors suitable for this purpose, and capable of handling large ripple currents.

Resistor R3 provides zener bias current for D6, and the zener holds the base of Tr2 at a stabilised level, approximately 0-7V higher than the output voltage. The output is taken as an emitter follower and must therefore be tied to the zener voltage by the $V_{Be}$ of Tr2.

R4 provides a small bleed current to keep Tr2 just on when the supply is on open-circuit, and to further ensure that current variation in Tr2 base is minimised. The current through D6 should be kept as constant as possible to maintain accurate regulation of the output.

As shown in Fig. 1, the current limit comes into operation just above the working range of 40mA. This is necessary to ensure that the supply is not overloaded, and means that should an accidental short-circuit be applied to the output, the supply will be protected.

The current limit is provided as follows. The whole of the load current passes through R2, thus the voltage developed across it is proportional to the load current. In fact the circuit biasing current is also passed through R2, and this assists the switching-on action of Tr2, the current limiting transistor. When the voltage reaches a pre-determined level across R2, Tr2 is biased on. The voltage required to do this is the forward voltage across D5 plus the $V_{Be}$ of Tr1. This will be approximately 1-4V, but will vary slightly according to diode and transistor spreads. Because of this, slight adjustment of
R2 may be necessary to ensure that the circuit limits at the correct current. It should not be necessary to get to a lower or a higher resistance value than the next preferred values.

When the current increases to limiting value, the voltage across R2 brings on TR1 which, on short-circuit at the output, goes into saturation. The voltage at TR1 collector is thus made to fall, collapsing the reference voltage provided by the zener diode, and hence the output voltage. Vbe of TR2 must not exceed 0.7V or thereabouts or this transistor will be destroyed. Obviously a short circuit output reduces the emitter to OV, and hence the necessity to reduce the base voltage to something less than 0.7V relative to the 0V output.

After construction, a test should be made with a current meter and a variable load, such as a potentiometer. If the output voltage, which should also be monitored, does not start to drop just after 40mA is reached, R2 should be increased slightly. If the voltage falls suddenly before reaching 40mA decrease R2 slightly. (If two parallel resistors are required for good limiting at the right value, the second resistor may be inserted in the Veroboard layout between holes H11 and H12.)

For further smoothing a capacitor may be placed across the output. There is room for a moderately sized capacitor on the Veroboard between W4 and W11. The higher the capacitance (at appropriate voltage working) the lower the ripple.

Note that whilst a tempting place to put a smoothing capacitor is across the zener diode, this is not to be recommended. If this is done there is a danger of burning out TR2 if a short is applied to the output, since this capacitor will then discharge directly through the emitter-base of this transistor unchecked.

**COMPONENT NOTES**

All the transistors used are silicon types, and since germanium types behave very different thermally to silicon, and since Vbe's differ considerably, germanium components should not be substituted. It is also stressed that when alternative silicon components are used in the regulatory or limiting sections, the specification may not be achieved.

Small size, low cost silicon diodes may be employed throughout the circuit, including the bridge rectifier, since the supply is only providing limited power. Silicon alternatives to the OA200's may be freely employed.

With regard to the zener diode, the quality used relates to the degree of regulation with varying load current. Whilst zeners of the OAZ series may be used here, for a better regulation the newer BZY types give a superior performance with their sharper knees and smaller zener voltage variation with zener current.

If the constructor has any of the BZY88 range of silicon zener diodes, two of these might be used in series to give approximately 18V, for example, two BZY88 C91V1, giving a nominal voltage of 18-2V. If two such diodes are used in series, however, zener voltages under about 5V are not recommended since for lower voltages slope resistances generally are not as good and regulation will deteriorate. Of the transistors, any 800mW, 30V transistor will be suitable for TR2 with a reasonable gain, preferably greater than 60 (at 1mA). A wide variety of silicon transistors may be used for TR1 with a reasonable gain and Vce of about 30V. The BC107 is recommended for availability and low cost, with the TZX302 or BC167 as alternatives in plastic encapsulation.

The BFX85 or BFX86 are excellent transistors to use as TR2 for free-air mounting.

Note: if it is desired to use two zener diodes in series to provide the 18V reference, these may be mounted on the Veroboard as follows, where the zener shown between U1 and U11 is removed. Connect the cathode of the uppermost to U1 and the anode to U8. Connect the lower diode cathode to V8 and its anode to V11.

**OTHER OUTPUT VOLTAGES**

It is possible to modify the circuit to give output voltages from anything between about 6V and 18V. For simplicity in the circuit, because output voltage is not variable, the power dissipated by TR2 may be predicted accurately. It will be appreciated that with a variable control, when the power is not dissipated by the load at a high load voltage, the regulating transistor is required to take over on power dissipation. With a fixed output, this may be conveniently limited to a low value, and hence a free-air mounting used. For a lower voltage, it is possible to use a lower voltage zener, but this will reduce the maximum current that can be dissipated.

<table>
<thead>
<tr>
<th>Resistors:</th>
<th>R1 39Ω 10%</th>
<th>R3 2.7kΩ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R2 22Ω 5%</td>
<td>R4 18kΩ 10%</td>
</tr>
<tr>
<td></td>
<td>All 1W miniature types</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transistors and Diodes:</th>
<th>TR1 BC107, TZX 302, BC167, etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR2 BFX 85, BFX 86 etc</td>
<td></td>
</tr>
<tr>
<td>D1 D5 OA 200, OA 202</td>
<td></td>
</tr>
<tr>
<td>D6 BZY 94 C18</td>
<td></td>
</tr>
</tbody>
</table>

Miscellaneous: Transformer, Radiospares sub-miniature 12V type, Veroboard 12 × 24 holes, 0.15in. matrix.
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MT281 5 Amp Size 3 x 2 x 1. Jam Work 1/2 lb Price 3/-
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MT283 5 Amp Size 3 x 2 x 1. Jam Work 1/2 lb Price 3/-

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ventilation holes, design on this point should be conservative. Thus go for a $V_{ee}$ smaller than 12V, in fact as small as practically possible whilst still allowing for spreads. $R_3$ may then be increased to ensure that at this current the $V_{ee}$ selected is not exceeded. A zener current of 1-2mA is satisfactory. It may be necessary to reduce $R_3$ when the lowest voltage at $Tr_2$ collector is considered (i.e. at say 45mA load current), select $R_4$ to take about 1mA at the rated output voltage.

Other components will remain the same. For very low output voltages, the centre tap of the transformer may be employed to give full-wave rectification of 12V r.m.s. with two diodes, in the normal manner.

CONSTRUCTION NOTES

The Veroboard layout for the circuit is shown in Fig. 3. For safety reasons, the copper strips are removed over the whole area in the close vicinity of the mains ideally all the appropriate section of strip removed with a razor blade. Apart from clearing the copper tracks here, only one other break is made in the tracks, this being at hole E12.

Resistors $R_1$ and $R_2$ are vertically mounted; resistors $R_3$ and $R_4$ horizontally mounted. Since the capacitors are rather bulky, they should be the last components to be mounted, after a thorough check of the rest of the circuit has been made. Do not overlook the jumper bar between R2 and R10.

The complete unit may be mounted in the smallest Eddystone diecast boxes size $2\times 4\times 1\frac{1}{4}$ms, but great care must be taken to ensure that the box has plenty of ventilation holes and that, since mains is being applied to the unit, the insulation of the input is adequate. The box itself should be earthed.

No mains switch is provided as in many applications this would not be required since when mounted in equipment, this switch would be remote from the box itself. If desired, there are miniature toggle switches which might be fitted near the output sockets.

Needless to say, every care should be taken to ensure correct circuitry and insulation before switching on since this is a mains unit.

OTHER NOTES

The screen contact of the transformer should be wired to the mains earth lead.

Note that the supply is not intended for use as a constant current generator in the limiting mode as prolonged running on the limiting slope means excessive transformer dissipation. The current limit is intended solely as a protective device.

PW GUIDE TO COMPONENTS

---continued from page 340---

Great care is required when using thermocouples since the low voltage level requires sensitive sensing devices. Consequently they require calibration for a given length of lead and location and when used in remote positions special compensating cable is required.

Glass encapsulated and indirectly heated thermocouples are used for v.h.f. power measurement with standard output voltages of 7mV and 12-15mV, and a typical device is shown in Fig. 7. Prices vary but for this application are between 20s. and 60s.

TO BE CONTINUED
INDUCTORS FOR THE PROGRESSIVE SUPERHET

This receiver was described in the March 1969 issue of Practical Wireless and since then some difficulty has arisen in obtaining the specified inductors. Details for fitting alternatives are given here.

IF Stages
Denco Maxi-Q IFT11 465kc/s intermediate frequency transformers are suitable for all positions. Pin connections remain the same: 1—HT positive; 3—anode; 6—grid or diode; 4—A.V.C. or diode load. These i.f. transformers have the same base size and fixing.

The address is Denco (Clacton) Ltd., 357/9 Old Road, Clacton-on-Sea, Essex.

Oscillator Coils
These may be Denco “Red” (465kc/s) which have single hole fixing as for the original coils. Ranges are numbered from the i.f. band, and correct padders and pin connections are:

| Range 1 (l.w.) | 110pF | Pin 5 |
| Range 2 (m.w.) | 350pF | Pin 2 |
| Range 3 (s.w.) | 1,100pF | Pin 3 |
| Range 4 (s.w.) | 3,000pF | Pin 4 |
| Range 5 (s.w.) | None | Pin 6 |

With the highest frequency band Range 5, pin 6 is wired directly to chassis, no padder being used.

Other pin connections for these coils are: 1—C3; 8—C4; 9—chassis. With Range 1 only, pin 7 is taken to C3 and pin 1 is unused.

Aerial and Mixer Coils
For the receiver with r.f. stage, Denco “Blue” coils are suitable for the aerial circuit and “Yellow” coils for mixer grid. If the receiver is first built without the r.f. stage, but this is to be added later, use “Yellow” coils for the mixer grid (aerial). If the r.f. stage is not to be added “Blue” coils can be fitted here. Ranges and approximate band coverage is as follows:

| Range 1 (l.w.) | 150-500kc. | 2,000-750m. |
| Range 2 (m.w.) | 515-1,545kc. | 580-194m. |
| Range 3 (s.w.) | 1,675-3,5M. | 180-57m. |
| Range 4 (s.w.) | 5-0-15M. | 60-20m. |
| Range 5 (s.w.) | 10-5-31.5M. | 28-9.5m. |

Pin connections are: Blue, 8—aerial; 1 and 9—chassis; 6—tuning capacitor. Yellow, 9—r.f. stage anode; 8—h.t. positive; 1—chassis; 6—mixer grid.

Constructional Points

The Denco coils are slightly larger in diameter than those originally listed, but can be accommodated in the coil box made as in Fig. 3, p.830, March 1969 issue.

Connections to Range 5 and Range 4 in particular, including padder and chassis returns, must be as short as possible, so these coils are sited close to the wavechange switch.

Trimming

The original coils have trimmers incorporated. The Denco coils are without trimmers. No trimmers are needed in the aerial section because a panel trimmer is fitted.

The easiest way to secure maximum efficiency is to place a single beehive or high-stability trimmer across the oscillator section of the ganged capacitor, and to fit a 50pF variable trimmer for mixer grid.

The latter can be operated through an extension shaft so that it occupies the mixer grid section of the coil box. Then no pre-sets are necessary, and no holes for adjusting them are needed in the coil box cover. The mixer grid trimmer is peaked if necessary with very weak signals, in the same manner as the aerial trimmer.

The coil cores are adjusted by threaded rods which project above the chassis, and all normally need unscrewing somewhat as they are fully screwed in for packing. Nuts will lock the coil cores, alignment being as described.

The address of the supplier of the case, chassis, and side brackets is H. L. Smith & Co. Ltd., 287/9 Edgware Road, London, W2.

PRACTICAL TELEVISION

in the SEPTEMBER issue

★ CHIPS WITH EVERYTHING
Chips—trade slang for integrated circuits—are now starting to be used in TV receivers. Their increased use over the next few years is going to change TV receiver design to a far greater extent than any previous changes brought about by technological advance. In the September issue we shall be outlining what this will involve—how the use of integrated circuits will change TV receiver design and what effects this will have on performance and servicing. We shall also be outlining the basic properties of integrated circuits, their capabilities and the problems involved in their use in TV receivers.

★ TRANSISTOR IF STAGES
The servicing techniques needed in the i.f. sections of receivers have changed with the increased number of hybrid chassis in use. In this fault-finding feature, transistorised i.f. circuits are examined in detail and the servicing problems outlined.

★ TV NEWS
Of all TV features the News presents some of the most difficult production problems. In the September issue we take a look at the methods employed in bringing up-to-the-minute News to the TV screen and the organisations that make this possible.

★ TRANSISTORISED TIMEBASES
The line output stage with its high peak voltages is one of the most difficult to transistorise. In the second part of our Transistors in Timebases series the problems will be described and several successful designs that have overcome them illustrated.

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THE month of August seems to be the month when all or most of the DX-ers pack up and go on holiday. Many stay in the British Isles, some go abroad. The ones that travel into Europe want to visit the Radio station in that country. The best way to assure an interesting tour of the offices, studios and transmitter building is to write to the station well in advance of departure from this country and put down dates you would like to visit that station, don’t just go over and drive up to the station one afternoon and expect them to welcome you with open arms and show you around!

I must thank all readers of this column who have written in so far over my comments in the June issue, they have included some very good points and some very good logs which will be included under our “Heard and Noted” section which now follows.

HEARD and NOTED

Mr. Ray Read has certainly been having a right DX session in Monmouth, Wales, and heard these Latin American stations at fair to good strength between 0330-0400, 4,800 R. Yaracuy, 4,890 R. Diffusora Venezuela; 4,900 R. Juventud, 4,970 R. Rumbus, 4,980 Ecos del Torbes, 5,020 R. Nacional, 5,030 R. Continente, all in Venezuela and Ecos del Torbes has been heard as late as 0800. From Columbia he heard Radio Santa Fe on 4,965, R. Nacional on 4,955 and R. Sutalenza on 5,075 and 5,095. Another good log has come in from Vaughan P. Smith of Banbury, Oxon, Voice of Free China on 9,765 at 1715-1745 SINPO 33242, from Taipei, Formosa. Radio Diffusion Television Algerienne is giving good results with SINPO 44433 on 11,835 from 1700-2400. Radio Amman, Jordan, gives the best signals round about 1500 on 9,560 with SINPO 33333.

The Voice of Vietnam at Hanoi is being heard regularly on 15,018 with SINPO 45343 up until 2030 in Vietnamese, French and English after 1600.

Now from “Heard and Noted” here are some new summer schedule details just received direct from the stations.

EUROPE

Sweden: Radio Sweden, Stockholm is now on the following schedule for its English transmissions. From 1100-1130 on 15,315 and 9,625; 1200-1300 on 21,660 and 15,105, 1400-1430 on 21,575 and 15,316; 1600-1630 on 21,585 and 15,315; 1900-1930 on 15,240 and 11,860; 2045-2115 on 11,705 and 6,065; 2245-2315 on 15,155 and 11,705; 0030-0100 on 11,950; 0200-0230 on 11,950; 0330-0400 on 11,705 and 0515-0545 on 17,840.

CARIBBEAN AREA

Bonaire: Trans World Radio has dropped its transmission to Europe from 2000-2215 for the present, but they hope to resume this service in the future.

NORTH AMERICA

Canada: Radio Canada, Montreal is now on their Summer Service, here is the latest schedule. 0715-0800 on 11,765 and 9,625; 0830-0930 on 9,625 and 5,970; 1100-1212 on 17,820, 15,325 and 11,720; 1217-1313 on 15,325, 11,720 and 9,625; 1315-1343 on 17,820, 15,325 and 11,720; 1345-1830 on 21,595, 17,820 and 15,325; 1832-2152 on 21,595, 17,820 and 15,320; 2200-2250 on 17,720, 15,190 and 9,625; 0100-0400 15,190, 11,720 and 9,625; 0400-0555 on 11,720 and 9,625; 0555-0630 on 11,765 and 9,625; 0631-0706 on 11,720 and 9,625.

PACIFIC AREA

New Zealand: Radio New Zealand is now on its Winter schedule. From 1700-1945 to the Pacific Isles on 9,520 and 6,080; 2000-2145 to Australia and 2200-2400 to Pacific Isles on 15,110 and 11,780; 2200-2400 to Australia on 15,280. From 0015-0545 to Australia on 15,110 and to the Pacific Isles on 15,280; 0600-0800 daily to the Pacific Isles on 9,540 and 6,080; 0800-0845 weekdays only to the Pacific Isles on 9,540 and 6,080; 0800-0845 on Sundays to the Pacific Isles on 9,540 only. On Sundays from 0815-0845 there is a special transmission to the Antarctic on 6,080. Finally from 0900-1145 there is a Daily Service to Australia on 9,520 and 6,080.

Any of our readers who are good writers may be interested in writing a short talk for Radio New Zealand as part of their 21st anniversary they are asking listeners to write a talk of up to 400 words about New Zealand, a talk which might be broadcast. If any of you are interested write in to me immediately for details as the closing date is the 30th August 1969.

ASIA

Israel: Kol Israel has added a new frequency and transmission to its summer schedule. Now from 2015-2044 to Africa on 9,009 and to Europe on 9,725 and 9,625; 2045-2100 on 9,725, 9,625 and 9,009 to Europe. That was the new schedule for the evening English transmission. There is also a test transmission daily to North America in English from 0400-0415.

Japan: Radio Japan now transmits to Europe daily from 0645-0845 on 21,535 and 17,825 and 1930-2100 on 15,195 and 11,960. The English programmes are heard daily from 0800-0830 and 2030-2100.

Due to various problems which arose at the last minute this column could not appear last month, so I hope that this month’s column will make up for that. Please note that on September 7th stations will change to their Autumn or Spring schedules, so information in this column will be liable to alteration from that date onwards. Until next month good listening and 73s.
IT'S been a hard month for the DX enthusiasts. Those goodies have been a bit harder to come by, mainly because conditions were so variable. Going without sleep and meals allowed the really keen types to log the world, but for the less fanatical it's been a case of listening whenever possible and hoping that a nice hole would appear from which our undernourished logs could gain a little sustenance.

Owls and somnambulists (St John's probably) have had quite a time on twenty which has been opening up in the evenings and bubbling away happily, often until long past breakfast time. Generally though, it's been rather unreliable and sometimes more a matter of luck that one managed to listen at the right time.

Similar remarks apply to fifteen which has varied from remarkably good to just plain 'orrible. Oceana has been noticeably absent most of the time while very short skip conditions have had fun with the uninitiated.

If you find the summer months rather heavy going, why not try and plot yourself some propagation maps which you can then compare with those you make next summer? Log all the stations you can hear with as accurate a signal report as you can manage. Log the time too, and by this means you can make up a map of conditions. The final map can take any form you like. You might note the percentage or numbers of stations with, say, reports of 5 & 7 (or better), or you might compare signals from one Continent with those from another.

This is quite a serious task and requires vigilance and concentration. You will need to listen to the QSO in order to hear not only the QTH, but the reports exchanged (compare these with your own report for the stations involved) and you will need to know the power the stations are using. Go on, forget the mini-skirts just this once and become a proper little boffin.

As most readers are aware, these seasonal variations are mainly due to the state of the ionosphere. Interest in the ionosphere is on the increase and enthusiasts will be pleased to hear that a great deal of research is going on. One of the latest methods is to use intensely powerful radar beams to measure the electron density at different heights. I don't suppose this will make the DX any easier to hear, but it may well explain, when all the results are sorted out, why and how the bands do what they do when they do—if you switch on and hear nothing, at least you'll understand why!

LOW HAPPENINGS
Stand smartly to attention with headphones on backwards, we are going to salute the brave few who dared QRX on 7MHz. Persistence, patience plus Palmer, D. Palmer of Lancashire, to be precise. This combination plus a modified 19 set and a 3ft. ground plane at 20ft. raised this lot on 7MHz s.s.b.—CE3FRR, CN8AW, CP8EN, HP1JC, IS1DMN, OY2A, OY2X, PY1NBF, PY2DL, PY4ABH, PY6VZ, PY7ARJ, TF3TF, TF5TP, UA9EU, UV9KAG, VP9M1, YV11IB, ZC4HS, ZP3AB, ZP4MO, 4X4UF, 9H1BL, 9M2DQ. Why don't I hear things like that on 7?

Alan Mercer (Lancashire), 9-transistor Ferguson and 7ft. end fed also reckons that 7 is worth a listen. Alan hooked—BY1QA, EA4JK, F6AGE (running 5W), GW3WJ/MM (lottering in the Bay of Biscay with 25W), HB9AL, HB9BR, I1ROY, LA6OL, OA8NO, ON4PA (running 800mW), PAØSLR, WZOP.

John Mostram (Somerset), really puts me to shame. His log for 3.5MHz shows just what can be done if you're really determined (and don't mind losing the sleep). The rx is an SR200, the antenna a 40ft. end fed, the ears are standard issue and came with the body. Eighty metre c.w. produced—CN8AW, CR6IK (I'm jealous already), CR6IV, CR6LX, HBØ2JG, HB9T/J/P, HV3S1, LA2PH/MM (near Ascension Is.), OD5BA, OH0NC, PY1CAD, PY1NBF, PY2DGB, PY7ASA, V01FX, VP2AA, VP8FL, VP8HZ, VP8KO, WA1JOG/LA, 4X4MR, 5A1TK, 5A2TR, 5Z4KL, 8P6CC, 9H1J. It's no good, I'll have to get a new cats whisker for the front end.

"Why don't more people listen to topband DX?" writes Paul Tomes whose last known address was Swanage, Dorset. A B40 and 165ft. of wire produced—GM3YAC, GW3XRX, HB9CM, HB9NL, OK1DAG, OK2PCN, OL2AKS, OL6AKP, PAØRTT, WI1B/J, ZB2AY.

HIGH HAPPENINGS
High's the word too. Paul Knight built the 2 metre converter described in the November 1967 P.W. His aerial is a dipole built from a pruned "X" Band I TV antenna duly pokéd out of the bedroom window. This set up produced—F1RR, F1A0Y, F4ZK, F6AGF, F8WE, F9PL, PAØCML, PA2CMR, PAØMOT. Paul also logged G2XV (Cambridge) running 500mW to a three ele beam. He also reports hearing FN9J/T receiving TV transmission from G6ADZ/T on 70 cm.

Down to 21MHz where J. East (Worcestershire), has been listening with his 1475 plus RF2B4 converter and dipole. Signals a la s.s.b. loud and clear from—AP2MR, CN5EM, CR6JA, DU1RH, EA9AQ, WA8HWP/HC2, HS1AF, JA1E6F, JA6KCY, JA8DTD, JA9BE, JH1ECQ, KG4DO, KG6ALY, KR6MH, KR8EA, KX6GS, MP4BFO, OX3LP, VE8YJ, VK2BNS/MM (Sea of Japan), VK9X/L (Christmas Is.), VP2AW, VP8KL, V56AL, 9S5M6, XV8AL, YAIAR, YAIJS, ZS3JJ, 457PB, 5A1TL, 5L2BI, 3L2BH/MM (Libera), 5LØ/X/MM, 79RN, 9H1R, 9M2BO, 9V1OE, 9N1MM, 9X5AA.

FUTURE HAPPENINGS
Lots and lots of activity in August. August 4th, 144MHz s.s.b. contest; 10th, 432MHz contest; 16th, R.S.G.B. mobile rally at Woburn Abbey; 17th, 70MHz c.w. contest; 17th, Derby mobile rally; 24th, Torbay mobile rally; 24th, ARMS/RSARS mobile rally, Dorset; 24th, Swindon mobile rally; and a rare one August 9th-23rd, G3JDG/P on 160 metres a.m./c.w. from near Mersea Is. (look it up on the map).
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GR-64

354
Pulse Circuits in Operation

I. J. Kampel

The bistable is closely related to both the astable and the monostable circuits but, as its name suggests, the bistable has two stable states. It is incorrect terminology to call the bistable either a multivibrator or a flip-flop, these terms being reserved for astable and monostable circuits respectively. The bistable is sometimes referred to as the Eccles-Jordan Circuit named after the original valve circuit described in 1919 by Eccles and Jordan.

The bistable will rest in either of its two stable states until an external influence causes it to change states. If the output is taken from one collector, therefore, two input pulses are required for every single output pulse at that collector. A series of bistable circuits can thus be used to count input pulses. If there are, for example, four bistable circuits connected such that the output from each feeds the input of the following through to the end of the chain, for every output pulse at the fourth bistable there must be two output pulses from the third bistable, four from the second bistable, and eight from the first bistable. The last bistable will then serve as a counter to a base of 16. By more or less bistables, and by feedback within the chain where necessary via delay lines, counters to bases of 10 or any other number may be designed.

The basic bistable is similar to the multivibrator, where the capacitors are replaced by resistive couplings. This is shown in Fig. 4.1, where the coupling resistors R3 and R4 are shunted by small value speed-up capacitors. Upon switching on, due to unbalance in the circuit, one of the transistors will draw more current than the other, and this transistor will switch on in one of its stable states. We shall assume that Tr1 goes into the ON state, Tr1 bottoms, and under saturation conditions with only about 0.1V at Tr1 collector, Tr2 cannot switch on since the base would have to be supplied with approximately 0.7V, with the extra voltage across R3 also to be taken into account. The circuit will thus stay in this state. If negative pulses are available, a negative pulse at input B will not affect the circuit since as Tr2 is already cut off, the pulse can do no more than drive the base more negative. If, however, the negative pulse is directed to the base of the transistor in the ON state (Tr1) it will cut off this transistor. Tr1 collector will rise towards the positive rail, and as it does so base bias will be provided for Tr2 via R3. C1 provides extra current during the switching transient to drive Tr2 into hard saturation, easing off to just holding it in saturation when the switching has been concluded. As Tr2 goes on, its collector voltage drops down to the saturation level cutting off the supply to Tr1 base. Tr1 can thus not switch on again, and the circuit settles in its second stable state. Only a negative pulse will switch the circuit back to its original state, and this pulse must now be directed to input B. Since there are no large capacitors in this circuit, and the speed-up capacitor may be ignored as far as this is concerned, a fast rise time should be achieved as well as a sharp fall time, unlike the multivibrator, or one side of the monostable.

As in the case of the monostable, it is better to cut the transistor in the OFF state completely off, that is, by reverse bias on the base. Figure 4.2 shows the way to do this by adding a further negative supply rail. If Tr1 is switched on, the potential divider formed by R4 and R6 is adjusted such that the voltage at Tr2 base is

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Fig. 4.1: The simplest form of bistable circuit, which rests in either of two stable states, changing only on application of trigger pulses. C1 and C2 are speed-up capacitors for improving switching times.

Fig. 4.2: An adaptation of the simple bistable to ensure that the non-conducting transistor is completely cut-off.
PART 4 — THE BISTABLE

of $V_{cesat}$ now rises to $+V_{cc}$, and the potential divider provides a biasing potential on Tr2 base which switches on Tr2. The potential divider formed by R3 and R5 now takes Tr1 base to a small negative potential which keeps Tr1 off until the circuit is triggered again.

Now it has been shown that the triggering pulse must be steered to the correct input for the bistable to change states, i.e., the input negative pulse must be directed to the transistor in the OFF state to have any effect. In most circumstances there is only one trigger source, and in such a case it is necessary to introduce further circuitry to direct the incoming pulses to the correct bases. This circuit is known as the steering circuit, and Fig. 4.3 shows this steering circuit added to Fig. 4.2.

The steering circuit operates as follows. Assume initially that Tr1 is bottomed, and Tr2 cut off. Now $V_{ce} = V_{cesat} \approx 0.1V$, and $V_{cb} \approx 0.7V$. This means that there is a small voltage across D1 in the forward direction, being $V_{cesat} = V_{cesat} = 0.7 - 0.1 = 0.6V$. The voltage dropped by R3 may be regarded as negligible since it will only slightly reduce the forward voltage across the diode.

Now considering D2, $V_{c2} = +V_{cc}$ and $V_{b2} = -V_{cc}$, i.e., a voltage negative to the earth rail. Diode D2 is thus in hard reverse bias and is non-conducting. The steering circuit viewed from the trigger input is thus a low impedance presented through to Tr1 base via the forward biased diode, and a very high impedance through to Tr2 base via the reverse-biased diode. If a negative pulse is applied at the trigger terminal, therefore, the steering circuit guides the pulse to the base of Tr1, the transistor in the ON state, and the pulse thus cuts off Tr1. The pulse has no effect on D2, the negative swing being insufficient to reduce the reverse bias significantly.

Tr1 collector goes to the positive rail, its base goes negative, and diode D1 goes into hard reverse bias. Meanwhile Tr2 has switched on as bias is provided when the base is taken to 0.7V, and with the collector at saturation voltage and base at its more positive voltage, D2 now comes into forward bias. Thus the gate is now open to Tr2 base for the next negative trigger pulse.

Figure 4.4 is a modified version of the bistable with its steering circuit, and here only one supply is used. This uses the sharing emitter resistor, as described in the case of the monostable, to lift the emitter of both transistors to a potential above earth, and thus allow potential dividers to take the base of the transistor in the OFF state slightly negative with respect to the emitter. The saturation current of both transistors should be the same, and with the same current—this saturation current—always provided for one or other of the transistors, the voltage at the top end of R9 should stay substantially constant.

There is another slight addition to this circuit over that of Fig. 4.3, and that is the diodes placed across the steering circuit resistors. The time constant set by the input capacitors and the steering circuit resistors is set such that the diode will always remain conducting until the end of the input pulse, ensuring that the gate to the other transistor does not open too early. The repetition rate of input pulses is limited by the time required for C3 or C4 to return to its initial potential, and for a good triggering action, the time constant should be about five times the trigger width. For faster switching rates, the diodes as added in Fig. 4.4 allow the input capacitors to recharge more rapidly through the conducting transistor and its associated conducting diode bypassing the appropriate resistor.

The next instalment, Part 5, will deal with the remaining digital circuits, the Schmitt Trigger and complementary switch, and also the ramp generator.
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