FREE INSIDE
1 RESISTOR COLOUR CODE CALCULATOR
2 24-PAGE BOOKLET GUIDE TO VALVE CIRCUITS

THE 208 BANDSPREAD PORTABLE
For quick, easy faultless soldering

Ersin Multicore 5-core solder is easy to use and economical. It contains 5 cores of non-corrosive flux, cleaning instantly heavily oxidised surfaces. No extra flux is required. Ersin Multicore Savbit Alloy considerably reduces the wear of copper soldering iron bits.

- **Handy Solder Dispenser**
  - 12 ft. of 18 s.w.g. Savbit alloy in a continuous coil, used direct from free-standing dispenser.
  - 2/- each.

- **Low Temperature Solder**
  - Size 9 pack contains 24 ft. of 90/10 high tin quality 22 s.w.g.
  - 2/6 each.
  - Size 10 pack 212 ft. 2/- each.

- **Savbit**
  - Size 1 carton contains approximately 30 ft. of 18 s.w.g. Savbit alloy. Also available in 14 and 16 s.w.g.
  - 5/- each.

- **Bib Wire Stripper and Cutter**
  - Strips insulation, cuts wire cleanly.
  - Adjusts to any size.
  - 4/- each.

Available from all Electrical and Hardware shops. If unobtainable write to:

Ersin Soldering Solder Ltd.
Multicore Works, Hemel Hempstead, Herts. Hemel Hempstead 3636
TRANSMITED GUARANTEED TOP QUALITY

Bugs reduced. Red spot shifts now only 1/6.

White Spot R.E.

2/-.

Moulded Matched Output

96.

Barr & Stroud R.V. Elna OC44, OC45 (5)

3/10.

GERMANIUM DIODES

General Purpose miniature detector A.V.O. etc. 8d & 8s.

Gold Bonded highest quality individually tested 8d &

SILICON RECTIFIERS


150 ma. (2 for 5/6) 3/9 (3 for 1/6)

CERMAL, CERMAL Special bulk purchase prices available. All tubes at this low price (arr. 9/11).

25 WATT BASE SPEAKERS

No heat generated on 100% output chassis.

There is nothing to teach it for power handling and cost at the price. Plus 5/- p.p.

CONNECTING WIRE

Copper and bronze, Five sizes only.

$4.19/0.

HI-TACHI PORTABLE TAPE RECORDER

Latest Hitachi. Fabulous quality reproduction. "S-Track" type, 3-tracks, 4-speeds. Output 500 mV high gain speakers, Push forward record start and stop. Battery level and record level meters. Precise synchronous drive, 1/10000th inch. 16mm. Genuine normal sales of 50.

19 Gns.

HI-TACHI 4 TRACK MODEL TRA-5053

This superb 48 gns. recording machine is on limited very special offer. Two channel recording. Plays stereo tapes, 11m. and 21m. per sec. One track can be listened to on an earphone while recording on the second track, and during playback both tracks pace simultaneously through the loudspeaker. Excellent reproduction, single ended speaker connection. Stereo Dimension: 13in. x 131/2 in. x 41/4 in. Weight 101bs. Dynamic range from 44 to 180 db. Toolage included.

29 Gns.

MODEL TRA-722

Large 2-track semi-professional model with AC/DC response 40-15,000 c.p., 7m. reels with mike 'tape' large speaker, high level professional controls, Reliabale. Weight 50lbs.

29 Gns.

STEREO PORTABLE CABINETS

Latest black and silver metal finish. Consists of centre cabinet size 16inx. 13inx. in deep with lift top lid together with two 10 in. and 2 speaker cabinets which flip on each side cabinet size 48inx. 13inx. in size, making overall size of 35inx. 11inx. in height. Weight 210lbs. AllImportant fittings. Will take any administrative tape decks. Halid priced.

$3.19.

TRANSISTOR CAR RADIOS

Latest Atollux fully transistorised complete with speaker and fittings. Large purchase enables us to sell these superb sets normally approx. 9 Gns. 14/2 is the amazing price of

9 Gns.

GELOSO 100W AMPS.


42 Gns.

STEREO AMPLIFIERS

AC356 vs.6 watts per channel, excellent control panel, excellent quality finish. AC mains. Valve at

6 Gns.

SPEAKER CABINETS

Superior Gold/Brown Vynyle with small 42in. sq. or

12 sq. ft. (4 x 3)

$19.-
CAMBRIDGE RELAY STATION

The BBC's new television and v.h.f. sound relay station to serve Cambridge was brought into service on 7th March. It transmits BBC-1 television on Channel 2 with horizontal polarization, and the three sound programmes on v.h.f., also horizontally polarized, on the following frequencies: Midland Home Service 93·3 Mc/s, Light Programme 88·9 Mc/s, Third Network 91·1 Mc/s.

RECORDING EQUIPMENT DEMONSTRATED IN AMERICA

Sound recording equipment developed by EMI Electronics Ltd. aroused wide interest among leading sound engineers during recent demonstrations in the United States and Canada.

EMI senior sales engineer S. G. Griffiths held the demonstrations during a four-week sales and market evaluation tour of the two countries.

Mr. Griffiths visited major television companies in New York and the leading film studios in Hollywood. In Canada he met sound engineers in the major broadcast centres of Toronto and Montreal.

“Everywhere I went the interest shown in our equipment was tremendous,” said Mr. Griffiths. “Our new L4 professional portable tape recorder received particular attention and one Hollywood studio has taken an option on 40 of the machines.”

MARCONI COMPUTER FOR SAUDI ARABIA

This photograph shows one of the new Marconi Myriad computers of the type which will be used in the radar data handling systems for the Saudi Arabian defence system.

This computer which has been designed by Marconi for radar data processing and other on-line applications, features the latest techniques in microelectronics.

The complete machine is housed in this single desk unit which measures 6ft. x 3ft. x 2ft. 9in. high. All controls and indicator lights are mounted in the low superstructure of the desk top, which provides the operator with full facilities for machine operation and programme checking.

Good Old Henry

I am now what many people regard as an “oldster” and you and your colleagues are what Ibsen described as “Youngsters knocking at the door”.

So I feel that I must congratulate you on the wisdom, the balance and the up-to-dateness of the article by “Henry” entitled Oh, but it Hertz! This is what I call technical journalism at its best.

So, as a westerning planet, I salute the dawn of a new dispensation.

Percy Wilson.

Headington, Oxford.

We are grateful for this tribute from veteran technical journalist Percy Wilson who, as many readers will know, was for many years Technical Editor of “The Gramophone”. He has now established a Consortium of Audio Consultants, in which endeavour we wish him every success.—Editor.

Tapespondent Wanted

I would like to tapespond with anyone, anywhere of my own age (15) who is interested in amateur radio, short wave listening and radio construction generally. My tape recorder is a National 2 track 1½ and 3½ i.p.s. All tapes will be answered.

John Adams.

74 Spring Street, Sandringham, Victoria, Australia.

Ham or Sham

What type of person is worried about the “Radio Amateur”—why the concern? If a person is sufficiently interested in radio communications then he would not ask the “Ham or Sham” question. He would know that in amateur radio “Sham” cannot exist, because the operator is fully qualified to operate any equipment he may own, whether it be home constructed or commercial. This “amateur” tag may have been all very well in the far distant past when capacitors and all other equipment had to be hand-made, but of course even when an operator builds his own home-made gear, the components are all commercial.

I say to the Citizens band agitators and the like; put in some hard work and try for the R.A.E. and long before you pass, the “Ham or Sham?” will have disappeared from your minds.—You will know better!

E. W. Phillipson, G3NVE.

Yorkshire.

More News and Comment on Page 44.
FULLY GUARANTEED

INDIVIDUALLY PACKED

WELL PROVEN RELIABLE COMMUNICATION RECEIVER P.C.R.3

THERMAL PLUS MECHANICAL CIRCUIT BREAKER FOR A.C. & D.C. Current 1 amp. Protects against shorts (instantaneous cut out at approximately 8 amp.) and against overloads: 1.8 amp. 30 seconds, 2.1 amp. 15 seconds, 2.5 amp. 8 seconds. Delayed cut off may be adjusted to different currents and times. Separate pair of contacts to indicate device. Dimensions 3 x 1 x 3/4 in. Price £21. £1. 10/-.

CONNECT AND FORGET, CANNOT OVERCHARGE "ESTRON" MARK 1 AUTOMATIC BATTERY CHARGER. Initial charging rate 6-7 amp. The charger automatically adjusts itself to the charge in the battery. Automatic current and voltage control. Prewired and ready for connection to battery charging. Indicator lights show battery fully charged. Fully guaranteed both as new and at approximately "as new" condition. Weight 1 lb. Price £7.19.6.

MARCONI SIGNAL GENERATOR TYPE TF 103B3. S. Frequency range 12-45 Mc/s. in five stages. Provides accurately calibrated frequency, 10 Hz. Output: a. continuously variable directly calibrated from 0.1 µ-0.5 v. b. high: up to 1 v. modulated or 2 v., low: 2 v. amplitude sine waves, max. output 400 m.v. Fine frequency tuning control, carrier on/off switch, built-in crystal calibration for 2 Mc/s. and exceeds all others in quality and value. Excellent "as new" condition. Fully checked and guaranteed. £115. CARR. £50.

P. G. RADIO LTD.
170 GOLDFAWK RD., W.12
SHEpherd's Bush 4946
Open 9-5.30 p.m. except Thursday 9-1 p.m.

PERSONAL CALLERS WELCOME
**FIRST FOR QUALITY, PERFORMANCE AND PRICE!**

**NEW ROAMER SEVEN Mk IV**

7 WAVEBAND PORTABLE OR CAR RADIO

**FABULOUS PERFORMANCE SPECIFICATION**

Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS
- 9 stages—7 transistors and 2 diodes

Covers Medium and Long Waves, Trawler Band and three Short Waves to approx. 15 metres. Push-pull output for room filling volume from rich toned 7 x 4in. speaker. Air spaced ganged tuning condenser. Ferrite rod aerial for M & L waves and telescopic aerial for S waves. Real leather look case with gilt trim and shoulder and hand straps.

**MELODY SIX**

...amazed at volume and performance... has really come up to my expectations... S.G. Stockton-on-Tees.

- 8 stages—6 transistors and 2 diodes

Push-pull output. Wonderful reception. Ferrite Rod Aerial. Size 5½ x 7½ x 3in. approx.

**POCKET FIVE**

- 7 stages—5 transistors and 2 diodes

Covers Medium and Long Waves and Trawler Band. A feature usually found in only the most expensive receivers. On test Home, Light, Luxembourg and many Continental stations. Case with red speaker grille. Size 4½ x 3½ x 2⅓in. approx. UK. (Uses 1209 battery available anywhere.)

**NEW ROAMER SIX**

Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS
- 6 WAVEBAND!!!

- 8 stages—6 transistors and 2 diodes

Listens to stations half a world away with this 6 waveband portable. Tunable on Medium and Long waves, Trawler band and two Short Waves. Sensitive ferrite rod aerial and telescopic aerial for short waves. Top grade transistors. 3-inch speaker, handsomely case with gilt fittings. Size 7¼ x 5½ x 1½in. Carrying strap 1/- extra.

**NEW TRANSONA FIVE**

"Home, Light, A.F.N., Lux., all at good volume."

- 7 stages—5 transistors and 2 diodes

Fully tunable over Medium and Long Waves and Trawler Band, incorporates ferrite rod aerial, tuning condenser, volume control, new type fine tone super dynamic 2½in. speaker etc. Attractive case. Size 6¾ x 4½ x 2⅓in. (Uses PP4 battery available anywhere.)

**TRANSONA SIX**

- 8 stages—6 transistors and 2 diodes

This is a top performance receiver covering full Medium and Long Waves and Trawler Band. High-grade approx. 3½in. speaker makes listening a pleasure. Push-pull output ferrite rod aerial. Many stations listed in one evening including Luxembourg loud and clear. Attractive case in grey with red grille. Size 6½ x 4½ x 2½in. (Uses PP4 battery available anywhere.)

**SUPER SEVEN**

- 9 stages—7 transistors and 2 diodes

Covers Medium and Long Waves and Trawler Band. The ideal radio for home, car or can be fitted with carrying strap for outdoor use. Completely portable—has built-in ferrite rod aerial for wonderful reception. Special circuit incorporating 2 R.F. Stages, push-pull output. 3½in. speaker (will drive large speaker). Size 7¼ x 5½ x 1½in. (Uses 9V battery, available anywhere.)

**RADIO EXCHANGE CO.**

61 HIGH STREET, BEDFORD

Telephone: Bedford 52367

Callers side entrance Bartratt’s Shoe Shop open 9-5 p.m. Sats. 10-12.30 p.m.
QUALITY RECORD PLAYER AMPLIFIER

A unique design. The amplifier (which is used in a 29 cm. record player) employs heavy duty double wound transformers, ECCOS, and E50 valves. Separate Bass, Treble, and Volume Controls. Complete with all necessary parts for 20 cm. speaker. Sizes 72 mm. x 35 mm., & 72 mm. x 45 mm. Ready built and tested for efficient operation. Will be shipped complete with instructions and circuit diagram 1/6 (Free with Kit). All parts sold separately.

SPECIAL PRICE 6/-, & P. 6/- each. Also ready built and tested for 15 cm. speaker. P. 3/-.

QUALITY PORTABLE R/P CABINET

User's motor board. Will take above amplifier and B.S.R. or GARRETTON Ambioger or Single Record Player Unit. Complete with knobs and instruction. Price 14/-.

Order 8/-.

4-SPREAD UNIT PLAYER BARGAINS

All brand new in original packaging.

SINGLE PLAYERS

B.S.R. TU110. Carr. 6/-

GARRARD SP3-21 De Luxe 12/10.6.


AUTO CHARGERS

Latest B.S.R. UAG superb slim. £6.6.

GARRETTON Autogenic (4 pole motor) plug-in. £10.10.6.

B.S.R. AP6... Carr. 7/-.


BRAND NEW CARTRIDGE BARGAINS!

BONNIE'S STEREO 100 CARTRIDGE. Stereo L.P./F. complete with brushes. Original list price 67/-.

Our price £5/- 6/- P. & P. 1/-

BARGAINS GARRARD ŠP25.

Complete. List price £6.13. Our price £4.13/-

BRAND NEW 3 OHM LOUDSPEAKERS

GU76. (16 ohm) 12/-

RU2X. (16 ohm) 6/-

DC9. (16 ohm) 4/-

RU2XIF. 3/-

GU76I. 2/-

31XOM. 1/-

1216. 4/-

GU76F. 3/-

3/6 each.

BRAND NEW HEAVY DUTY 20X SPEAKERS

Kapton 48 ohm 12/- each. Best voice coil. Available in 3 to 15 cm. Guaranteed heavy duty. Fast cast aluminium frame. These are current production components. Each speaker is made and tested to very high standards. Will be sold at a price we are not permitted to disclose the name.


BRAND NEW TUNER TRANSFORMER, GRID AND OUTPUT TRANSFORMERS.

Station size 14 x 11 x 34 in. Overall transformat size 28 cm. x 12 cm. x 12 cm. output 4000 w. at 8000 volt. £15.6/-

AUXILIARY SPEAKER AND CABINET FABRIC.

Approx. 54 in. wide. Usually 85/- our price £11/6 per yard. P. & P. 1/6 (min. one yard) B.A.E. for samples.

MAINS TRANSFORMER

For transistor power supplies. Tapaged to 250/400 v. Sec. 40/40 at 1 amp. with Electrostatic screen and 6.5 at 5 amp for d.t.c. converter. Drop down mounting. Station size 14 x 11 x 34 in. £15.6/-

BRAND NEW TUNER TRANSFORMER BAR.

GU75F MATCHED PAIR 20X TRANSMITTER TRANSFORMER.

Station size 14 x 11 x 34 in. Overall transformer size 28 cm. x 12 cm. x 12 cm. output 4000 w. at 8000 volt. £15.6/-

AUXILIARY SPEAKER AND CABINET FABRIC.

Approx. 54 in. wide. Usually 85/- our price £11/6 per yard. P. & P. 1/6 (min. one yard) B.A.E. for samples.

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Approx. 54 in. wide. Usually 85/- our price £11/6 per yard. P. & P. 1/6 (min. one yard) B.A.E. for samples.
**EXCLUSIVE TO PRACTICAL WIRELESS READERS**

MORE TERRIFIC OFFERS FROM CONCORD!

**TRANSPORTABLE POCKET RADIOS WITH LOUDSPEAKER**

**BULK PURCHASE ENABLES US TO MAKE THIS FANTASTIC OFFER**

ONLY 28/6

NO MORE TO PAY

_PAY 6/- ONLY_ into your pocket or handbag. Works for months on 12/- battery. Should last a lifetime, anyone can assemble it in a home, or two with our complete plan. Miniature speaker—everything, only 28/6. With 6/- it can be boxed and sent, so rush your order before it's too late.

**SAVE YOUR LEGS!**

**INTERCOM OUTFIT & BABY ALARM** Ready Built

LIMITED QUANTITY

ONLY 49/6

Robustly made, brand new current models. You get 2 separate fully transistorised intercommunicating sets—each can speak or listen to the other with absolutely no connecting wire. Fixed in a flush. Ends talking worry. Ideal for Workshop and Home. Sickness room, hundreds of uses. Hangs on wall or stands up. As new. 49/6 (4/6 and 1/- extra). Post, etc, 3/-6. Money refunded if not 6 guineas value!

**MAKE 5 DIFFERENT TRANSISTOR RADIOS for 35/-**

**NO EXPERIENCE NECESSARY.** No Soldering. Only 8 connections for first radio to work. Just look, you get Easy, A.C. Plan, Cabinet, Loudspeaker, Plans 1760, Barneys, S.G. 4. Semi-conductors, Coils, Condensers, Resistors, Turret, Switch, Screws, etc. **YES—EVERYTHING!** Loud clear English and Foreign reception. All supplied to the latest standard with British specifications. H.M. Forces, etc. TESTIMONIALS GALORE. Mr. R. O'D. Londonderry, writes: "I received your complete and it is already set up—COMPLETE HOME RADIO COURSE. Originally £6 SEND ONLY 35/- plus 6/- post, etc.

**UNIQUE NEW FULLY TRANSISTORISED PORTABLE RADIO**

NOW A FRACTION OF THE NORMAL PRICE ONLY 35/-

**WHY PAY MORE?** All the latest refinements are packed into this brilliant new MULTI-STATION ALL transistor radio. The internal design picks up all the transmissions and the powerful built-in speaker gives room filling volume. Ideal for the home, first-class reception. Purchase with confidence—packed in original manufacturer’s cardboard carton, and battery 4/-9. Send 35/- plus 4/- P. & P.

**NEW RADIO NO SOLDERING VOLTS radio can build in 54 HOURS**

19/6

**EVEN THE OLDER CHILDREN BUILD THEM!**...no soldering—only 19 connections...then build it reach our brkening in station after station, loud and clear. Palm-of-hand size 4 x 2 1/2 x 1 3/8. Many Testimonials M. H. of Bradford, writes: "...I have just completed one of your sets successfully, it is the first time I have ever tackled anything like a radio, and I must state here and now, I am amazed every day it is as a dream like me. Your instructions and plan have obviously been very carefully thought out and you can be proud of them. Direct from Manufacturers to You send 19/- plus 1/- P.

**PARTS AVAILABLE SEPARATELY**

**NO SOLDERING AMAZING CIGARETTE LIGHTER—DISPENSER**

18/6

**AUTOMATIC POCKET CIGARETTE LIGHTER—DISPENSER**

Adding and Subtracting up to 999,999 at your finger tips for

ONLY 8/- plus 6/- P. & P.

This superb, lightweight calculator is simple to operate and fascinating to use. Precision engineered by craftsmen and battery tested for reliability. Ideal for use in offices, shops, stores, playing games, etc. Complete with case. Slip easily into the jacket pocket or purse. Decimal tables, included for engineers—A terrific bargain that you're sure to love.

**MAKE A FANTASTIC OFFER**

Read what just a few of our satisfied customers say—

R.C. of Harringay writes Received with thanks Skyscans...very pleased. Working well...B.M. of Harrogate writes...I would like to thank you...it was a real bargain...L.S. to London W.8 writes even it a good try out and I am very pleased with the results...S.B. of Somerset writes...delighted with this radio...T.F. of Stevenage writes...I would just like to say how pleased I am with this radio...

**CONCORD ELECTRONICS LTD**

(Mail Order Only)

(Dept. P.W.30) 77 New Bond St., London, W.1

**PRACTICAL WIRELESS READERS**

35/-

**MORE OFFERS FROM CONCORD!**

(Note: The text contains many promotional offers and descriptions of various electronic devices.)
FOR THE FINEST VALUE TO HOME CONSTRUCTORS

We consider our construction parcels to be the finest value on the home constructor market. If on receipt you feel not completely built to the standards you may return it as received within 7 days when the sum paid will be refunded less postage.

TAPE RECORDERS

MAGNAVOX-COLLARO
363 TAPE DECKS

The very latest 3-speed model—11, 31, 71 in. b.p.c.a., available with either 3-speed or 4-speed truck head. Features include: pace control, digital clock, fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys; size of top plate 13x x 21/2 x 27/2, shelf below only plate.

For 500.00 s. & £2.00 stamp. For full details, applications, and parts list, please write.

Lasky's Price £10.10.6

Lasky's Price £13.9.6

Console and Packing 7/6 extra.

CONSTRUCTORS BARGAINS
TRANSMITTER RADIO CHASSIS

JUST ARRIVED—THE NEW GARRARD TAPE DECK

Fitted with 3 heads—1 track Stereomono; three speeds; takes 1/2, 3 and 4 speed, and 3 and 4 speed tape control etc., 6d.

For further details, please contact us.

Lasky's Price £9.6.6

TRANSMITTERS

ALL BRAND NEW AND GUARANTEED


TRANSMIT FILTERS

By BRUSH CRYSTAL CO. Available from stock.

SINCLAIR SUPER MINIATURES

THE MARK ONE S.T.P.A. F.M./V.H.F. TUNING

INTERNATIONAL TAPES

FUSS.Parcel Post

GOLPER UT 340 FM/VHF TUNING HEART

U.H.F. TUNERS

Brand new at lowest ever prices

GARRARD AUTOCHANGERS

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LASKY'S PRICE £9.6.6

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POCKET MULTI-METER

Size 2½ x 2½ x 1½ in. Meter size 2½ x 1½ in. Sensitivity 1,000 O.F.V. on both A.C. and D.C. volts. 0-10, 0-100, 0-1,000. D.C. current 0-100m.A., 0-10mA. Resistance 0-100,000Ω. Complete with test prods, battery and full instructions, 5/6d, P. & P. 3d. FREE GIFT for limited period only, 30 watt Electric Soldering Iron value £1-5/- to every purchaser of the Pocket Multi-Meter.

“MAYFAIR” 5-Transistor TAPE RECORDER


40W FLUORESCENT LIGHT KIT

Incorporating GEC choke size 6½in. x 1½in. x 1in. 2 pin-holden, starter and starter holder. Similar to above: 30W. Fluorescent Light Kit incorporating GEC choke size 5½in. x 1½in. x 1½in. Weighs only 7½lb. Takes 1½in. spools plus 7½d. P. & P.

CYLDON A.M./F.M. PERMEABILITY TUNER FOR ALL TRANSISTOR OPERATION


MAGNAVox COLLARO

Set of three Tape Deck Motors. These are made for 1½ in. but adaptable to 1 in. or more, by actual makers of certain brands. They are supplied with three motors. 3½d, P. & P.

Fixed Frequency SIGNAL GENERATOR

Crystal control in metal case, size 10in. x 5in. x 3½in. Incorporating 2 ECL7 valves, tuned transformer, out put transformer, volume and tone controls, rectifier, condensers, etc. $50, EXC plus and metal rectifier. Circuit lines free with kit. 7½d plus 3½d. P. & P.
MUSETTE 6 TRANSISTOR SUPERHET PORTABLE RADIO

PRICE

39'6
P. & P. 3/6
Circuit diagram 2/6.
Free with parts.

INCLUDING CARRYING STRAP.

NEW TRANSISTORISED SIGNAL GENERATOR

Elegant Seven
Mk II

The Radio with the STAR features

★ 4½" Speaker.
★ 6 Transistors Superhet Output 200mw.
★ Plastic Cabinet in red, size 4½" x 3" x 1½" and gold speaker louvre.
★ Horizontal Tuning Scale.
★ Ferrite Rod Internal Aerial.
★ IF 470 Kc.
★ All components, Ferrite Rod and Tuning Assembly mounted on printed board.
★ Operated from PP3 Battery.
★ Full comprehensive instructions and point-to-point wiring diagram.
★ Printed Circuit Board.
★ Tunable over medium and long wave band.
Car aerial and ear piece socket.

SIZE 5½" x 3½" x 1½". For IF and RF alignment and AF output 700 c/s frequency coverage 460 Kc/s to 2 Mc/s in switched frequencies. Ideal for alignment to our Elegant Seven and 39/6" & P Musette. Built and tested.

COMBINED PORTABLE AND CAR RADIO

POWER SUPPLY KIT
To purchasers of "Elegant Seven" parts, incorporating mains transformer, etc. A.C. mains 200-250v. Output 9v. 50mA. 7½ extra.

ALL ENQUIRIES STAMPED ADDRESSED ENVELOPE

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The new magazine for the experienced amateur and the beginner

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FREE ! 16-PAGE BOOKLET
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All you want to know to select the right wood from timber yard ranges for any woodworking project. Sections on Machined Mouldings — Hardboards — Wallboards — Flooring — Door Styles — Fencing — Rough-Sawn Wood.

Fold-out Sheet to build
★ Saw Sharpening Clamps
★ Hop-up Steps and Decorators’ Trestles

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Output 68 1/2 WATTS R.M.S. into 15 ohms.
15 WATTS R.M.S. into 8 ohms.
Maximum instantaneous peak power output 38 watts.
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BASS CONTROL: +40 dB to -50 dB at 50 c.p.s.
RATED INPUT: 600 ohms.
Input impedance 1000 ohms.
D.C. LEVEL: -75/-.
NEGATIVE DEPENDENCY: 556.

R.S.C. SUPER 15 S.I.F. Hi-Fi Amplifier.

COMPLETELY NEW UNITS WITH TECHNICAL SPECIFICATIONS COMPLYING WITHOUT FAIL TO PERFORMANCE STANDARDS OF SIMILAR AMPLIFIERS AT 34 TIMES THE COST.

IMPORTANT NOTE:
Rated output figures are given in B.M.S. and not speech, and material for current, and may be obviously quite much higher outputs.

R.S.C. SUPER 30 S.T.R. AMPLIFIER.

CROSS-TALK: -58db at 1,000 c.p.s.
CONTROL regain Position Input Selector, Bass Control.
Two Mic. Inputs, Volume level, R.F. Stabiliser.
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COMPLETELY NEW UNITS WITH TECHNICAL SPECIFICATIONS COMPLYING WITHOUT FAIL TO PERFORMANCE STANDARDS OF SIMILAR AMPLIFIERS AT 34 TIMES THE COST.

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R.S.C. STEREO 20/HIGH FIDELITY AMPLIFIER

Providing 10/6 WATT ULTRA LINEAR PUSH-PULL OUTPUT ON EACH CHANNEL SUITABLE FOR "HI-FI" GRAM, RADIO OR TAPE

1. Full Muirall design, and uses the latest valves ECC83, ECC88, EL84, EL15, ECC81, ECL81. Send 2.a.e. for leaflet.
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6 inch. 50 watt EXTRA HEAVY DUTY LOUDSPEAKERS

Famous name. Normal price over £25. Very limited number to draw on, with full guarantee. Terms available. Carr. 20/-

30 WATT HI-FI AMPLIFIER FOR Lead, Rhythm, Bass, Guitar, Vocal or Instrumental Groups

A Four input, two volume control Hi-Fi unit with 'phase in- phase-out' and 'cut and boost' controls. Latest type valves. Suitable for small 'on stage' type cabinets with twin carrying handles. Attractively finished in metal or wood cabinet. Mains operation. Suitable for $-300-500. A.C. mains. Output for $5 for 15 cm, £192 for 15 cm, 8 in. Each, 15-40 watts, Fitted. £12 5 Gns.

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For addresses see page 11
**R.S.C. BASS-REGENCY 50 WATT AMPLIFIER**

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  - Type A4, 4 x 1.65 x 3 6v. 2a

- **MIDGRT 100 Amplifier**
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  - Type A3, 4 x 1.65 x 3 6v. 2a
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Intended for use with high compliance cartridges and featuring a low mass arm that minimizes record wear. Four speeds included with dark green vinyl record changer. Complete with cartridge, arm and Stylus. For 120/240v AC. Complete with OTI/BO cartridge.

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  - 25 in. - 20.00/20.00
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- Austel
  - 15 in. - 12.00/12.00
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  - 30 in. - 25.00/25.00


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New, highly developed communications receiver outstanding immunity from unwanted hum at all broadcast bands, shipping, world-wide short wave and amateur bands. Built in super features include extra large dial, 90 watts, variable pitch EQ, Noise Limiter, extra loud receiver to suit all but most distant stations. Extras include phone output, Standby switch, etc. Uses all metal multi valve stages. Available in the output in 30 watt rating. Only 15% x 6 in. deep. Ideal for all serious listeners yet cheaper than many commercial sets. For 200/200 volt mains operation.

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New Hi-Fi and Tape to be launched at prices lower than American branded tape with guaranteed quality. Available in 1% in. and 56 in. lengths. Size 5 x 12 in. dia. Complete with stand. Screened cable. Complete with stand and adapter. Size overall 57/6 in. x 11 in. x 20 in. 500 x 250 x 500mm. Complete with stand and clamp. Finished in black, satin black and satin silver finish. Complete with stand and clamp. Size 57/6 in. x 11 in. x 20 in. 500 x 250 x 500mm. Complete with stand and clamp. Finished in black, satin black and satin silver finish. Complete with stand and clamp. Size overall 57/6 in. x 11 in. x 20 in. 500 x 250 x 500mm.
Superb new six valve unit covering long and medium waves on AM/FM and all Hi-Fi VHF transmitter on FM. High-sensitivity AM circuit provides most sensitive reception. Integral aerial, separate FM input employs famous 'Gingerbread' tuner heart. Uncluttered face covers whole front panel and simplifies adaptability to existing cabinets or building into contemporary bookshelf units. Extra large components allow massive free-air convection for volume, tone selection, and tuning sensitivity area. Offers precise limits that permit recording and tape playback to the highest standards set by the music industry. Single sub-miniature tube employs a single high-duty motor with heavy flywheel. Features include fast wind on and rapid rewind, pause control, 'taped-in selection with inter-tune, built-in revolution indicator, peak key controls. Sockets 12, 24 and 74 I.P.S. Wow and flutter 0.1%. On 74 I.P.S. Max. spool speed 7m. Playing time up to 120 minutes per track from 1m. Taped units. Size 8 x 11in. plus 41in. below mounting hole. Delivered in case. £11.10.0. With 4 track leads. £13.10.6. Add 10/- carriage and insurance.

Exceptional offer of AM/FM Radiogram Chassis

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Superb professional style, compact trans- mitter intercom for executive desk and office or home. Compact master unit and Melodical sub-stations, magnificently finished in pear wood and black gloss plastic case with black and gold anodised trim. Powerful two-transistor amplifier has 250W output, and 250W output at 75 to 90 volts. Power pack and mixer amplifiers have 90W output, and operate 4 months on 22 V.F. master battery. Station has Volumes, Mute, and 'Transmission on' and 'Transmission Off' control. 500ft. cord with phone plugs each end for immediate installation, stapler, cable hook-up and instructions, and attractive gift carton. £45.0. Post & Packing 5/-.

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- Square Wave Generator
- Morse Code Oscillator
- Simple Transmitter
- Electronic Switch
- Photo-electric Circuit
- Basic Computer Circuit
- Basic Radio Receiver
- A.C. Experiments
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PW 5.66
TOPIC OF THE MONTH

Face Lift

WELL, here it is! A newly styled and, we hope, improved Practical Wireless. The larger page size will not only allow a more attractive layout of articles but will also make for easier reading. The better quality paper will permit far better reproduction of photographs, which will be of great benefit in constructional articles. In order to carry out these improvements it has been necessary to slightly increase the cost of the magazine, but this is, we trust, a small price to pay for the considerable advantages reaped.

Regular readers need not feel anxious that this face lift will reflect on the general structure of the magazine. All the popular regular features will be retained and we will continue to balance the magazine with a good selection of material contrived to appeal to all the various interests in our hobby. The basic policy will remain as before and there will be no shifting of emphasis except where considered necessary from time to time in the light of our own experiences and the wishes of readers as expressed in correspondence.

Since 1932, Practical Wireless has held a unique position in the realm of amateur radio and through the years has served faithfully the interests of those who are interested in this absorbing hobby. At times, during these eventful 33 years, Practical Wireless has had, for some reason or other, to take stock of the existing situation and, where desirable, to initiate changes.

Such a time has recently passed. And as we start off on Volume 42 we are safely launched on another stage of the development of the magazine. And yet, in essence there is no division, for the fundamental objectives of the present staff are the same as those of the pioneers in the early 1930's—to present each month in the best possible way a magazine dedicated to the interests of all who derive enjoyment from one or more of the facets of amateur radio.

W. N. STEVENS, Editor

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The JUNE ISSUE WILL BE PUBLISHED ON MAY 5th
Were Pre-War Sets Better?

MR. L. WELCH complains of poor quality sound from sets he has made and also from high priced commercial sets he has heard (P.W. March, 1966).

Most modern sets use inadequate speakers and the cases are undersized and flimsy. Pre-War sets with larger speakers and heavier cases were much better, although they were generally "boomy".

For high quality reproduction, our friend must forget about a "set" and keep the radio equipment separate from the speaker enclosure. The speaker should be of good quality and mounted in a properly designed enclosure placed where it gives the best possible results. The output, as Mr. Welch realises, must be large enough to deal with peaks without distortion.

He writes that no commercial set offers the kind of specification he asks for. Although I would not wish to put him off building such equipment, I must point out that several makers produce tuner-amplifiers which give all he asks for and more. Connected to good speakers, they give results that are really something.

R. E. Barker.
Stockton-on-Tees, Co. Durham.

R220 MODS

There are a lot of R220 crystal-controlled v.h.f. receivers about and radio friends and myself have spent many hours trying to modify this set to make it tunable in the range 120-140Mc/s.

If any readers have managed to do this, we would be most grateful to learn the secrets of their success.

S. M. Giblions.
77 Windlehurst Road, High Lane, Stockport, Cheshire.

How About a Swop?

I REQUIRE the March 1962, December 1963 and January 1964 issues of PRACTICAL WIRELESS, and in order to obtain them, I am willing to exchange some 42 old copies of PRACTICAL WIRELESS, PRACTICAL TELEVISION and WIRELESS WORLD, all between 1949 and 1951.

If any readers are interested, would they please write to me first before sending copies, enclosing a stamped addressed envelope.

J. Currie.
156 Hillhead Road, Kirkintilloch, Near Glasgow, Scotland.
This is a six-transistor receiver with high frequency end bandspread, car aerial, tape output and personal phone facilities. A ferrite rod aerial is fitted, tuning long and medium wavebands. With ordinary 2-waveband circuits, many popular and well-received stations are heard over a small section of the high frequency end of the medium waveband. To simplify tuning these stations, a bandspread range is provided (covering about 185-215 metres), this being extended over almost the whole rotation of the tuning capacitor. As a result, it is easy to select Radio Luxembourg and other transmissions in this range.

Bandspread

The bandspread is achieved, without any particular ganging difficulties, by switch section S4, which places the 1 per-cent capacitor C4 in series with the oscillator section VC2 of the ganged tuning capacitor. S1 introduces the trimmer TC2 in series with VC1 for bandspread aerial tuning. Because of the low capacitance present, the bandspread range extends to a somewhat higher frequency limit than the medium wave range.

S2 selects separate base coupling windings, provided on the medium and long wave coils. S3 shorts the l.w. section for m.w. reception, and brings in C3 for l.w. reception, to obtain suitable oscillator coil coverage. The switch thus has three positions, "Long", "Medium" and "Bandspread".

Normal reception is by means of the internal ferrite rod aerial, but an external aerial can be connected to the "car aerial" socket, which has a coupling winding on the aerial rod. An external aerial is often used with a portable in a vehicle, to overcome screening and directive effects of the ferrite aerial.

AF117 transistors are used in mixer and i.f. stages, and need no neutralising. (It should be noted that the oscillator coil and i.f. transformers must be of the type intended for AF117's.) The audio signal obtained from the diode D1 may be taken to a tape recorder through the "tape output" sockets. This gives high quality, and an audio level suitable for the usual recorder. The usual automatic gain control bias reaches Tr2 through R5.

VR1 is the 5kΩ volume control, with on/off switch. The OC81D drives two OC81's, having base bias and feedback resistors R15 and R16. This gives excellent volume and quality from a large number of stations.

For personal listening, earphones or a personal phone can be plugged in, thereby automatically disconnecting the speaker. A low impedance type of phone should be used.

Construction is on a circuit board, with VR1, tuning and switch controls on a small panel, so that the finished receiver can be inserted in a cabinet from behind. With this arrangement, the actual positions of VR1, VC1/VC2, and the switch can be modified without any alteration to the circuit board, so that in some cases an existing cabinet can be used. It also gives plenty of latitude for positioning of the speaker.

Unless very small size is important, a 3½in. diameter (or equivalent oval) speaker unit is recommended, as these usually give slightly better results than midget speakers. Some notes on possible alternative transistors, etc., are given later.

The Circuit Board

This is 8 x 2½in. of 1/16in. thick paxolin, and is drilled as in Figs. 2 and 3 first. All wire ends can pass through 1/16in. holes. The oscillator coil and i.f.t.'s require clearance holes for the pins and can tags, and six holes are needed for T1. T2 is held with two 6BA bolts. Three small right-angle brackets hold the panel, but this is not fitted until the circuit board is wired. Complete as much drilling as possible, before inserting any components.

The i.f.t.'s will only fit one way, and are held by spreading the can tags. The oscillator coil P50/1AC has a coloured spot between pins 1 and 6 and this must face the i.f.t. P51/1 so that pins 1 to 6 fall in the positions in Fig. 3.

The driver transformer T1 has a green spot, placed as in Fig. 2, so that its tags emerge correctly (Fig. 3). T2 has three tags on its primary side, and two on the speaker side.

All the resistors may be placed either way round, but check the values because an error in reading them will probably completely upset results. Small capacitors may also be connected either way. But the electrolytic capacitors C6, C8, C13 and C14 must be placed with positive and negative ends as shown. This also applies to C12, running from R10.
Fig. 1: The Circuit

Fig. 2: Wiring of Circuit Board
The circuit layout has been arranged so that no wires cross under the board (Fig. 3). The identification of connections and components is much easier if 1mm, red sleeveing is placed on the “earth” or positive line, with black on the negative line, and capacitors having markings upwards. The can tags are earthed. Solder all joints rapidly but well, and snip off excess wires.

Transistors

These are added when the circuit board is otherwise finished. Identification of the leads is greatly eased by placing lengths of coloured 1mm. sleeveing on them. With the AF117’s, yellow is suggested for emitter, black for base, and red for collector, the screen wire being left bare. With the OC81D and OC81’s, use yellow for emitter, and red for collector. All the pieces of sleeveing can be 1/2 in. long.

There is then no difficulty identifying the leads, as they are threaded through in the positions shown in Fig. 2. Small pieces of sleeveing of the appropriate colour can also be slipped on the leads as they emerge as in Fig. 3. The transistor leads should be soldered rapidly, the iron being removed as soon as the joint is made. This also applies to the diode D1.

Panel

This is drilled for the switch, VR1, and ganged tuning capacitor. The latter is fixed with three 4BA bolts. These must be very short, or have washers, so that they do not protrude behind the capacitor plate, as this will short circuit or damage this component. Small brackets hold the circuit board and panel together.

VR1 is connected as in Fig. 2. Lead X from the positive line runs to the upper tag metal casing, and switch. Lead Y is from diode positive. R10 and C12 are closely in series, negative on C12 going to R11 and R12.

VC1 is the front section of the capacitor, and has more plates than VC2, the rear section. The frame (moving plates) is connected to the positive line of the circuit board.

Switching

This is quite straightforward, but it is also easy to test the receiver temporarily without the switching, to guard against errors. To do this, take green on the aerial to Tr1 base, white to R1 and R2, blue to VC1, and yellow to positive line. Normal medium wave reception should then be obtained, after rough trimming as described later. If all is well, the switch wiring can then be undertaken.

Connections to the ferrite rod aerial and switch will be greatly eased if leads are of the appropriate colours. These coloured wires are then soldered to the same coloured tags of the aerial. Suitably coloured wire is easily obtained, or leads can be marked with paint, sleeveing or any other means.

Switch positions are L, M and B, for Long, Medium, and Bandspread. The switch has four poles, S1, S2, S3 and S4. Connections are shown in Fig. 2, and can be checked as follows:

VC1 to S1, M and L tags to blue; TC1 and TC2.
B tag to TC2.
TR1 base to S2. M and B tags to green. L tag to red.

Earth line to S3. M and B tags to C1 and yellow.
L tag to C3.

The three trimmers have their tags and adjusting screws through holes in a small piece of paxolin, which is secured to the tuning capacitor by a short bolt. Use a soldering tag for frame leads. C3 and CP are soldered together, and sleeving placed on the lead passing near R3, through a hole, to pin 3 of the oscillator coil. The specified padder is 215pF, but this value may be difficult to obtain. A 1 per cent 220pF capacitor is suitable, and can be readily obtained.

Connections to the switch should be reasonably short and direct, with oscillator circuit leads clear of aerial wiring. The trimmers can be reached from behind when the receiver is in a cabinet.

Aerial

The specified aerial has coloured tags, connected as in Fig. 2. A 1½ in. bracket, cut from aluminium, is bolted vertically near R7, Fig. 2. A 6BA bolt secures the aerial rod to this, using the fitting provided.

The tags should face the rod centre, as in Fig. 2. The white tags of I.w. and m.w. sections are joined together. Yellow on the I.w. coil also goes to yellow on the m.w. coil.

Testing

A test and approximate alignment should be made before fitting the receiver in its case. Note that if the mixer and i.f. sections are working, good ‘phone reception of many stations should be possible from the tape output sockets. This test can be made before the audio section is wired, if necessary. Again, if an audio signal is fed in at the tape output sockets, good speaker results will be obtained, if the audio section is working.

The i.f. transformers should be adjusted first. If no signal generator is available, tune in any stable signal, and carefully turn the cores for best volume. Use a properly shaped insulated trimming tool. For final adjustment, use a very weak signal, with VR1 near maximum.

If a signal generator is to hand, apply a modulated signal for all alignment adjustments, and include a meter in one battery lead. Correct alignment then corresponds to an increase in current, though continuous running with a high current should not be allowed. With an unmodulated signal or programme, correct alignment corresponds to minimum current shown on a meter in series with R13. Once the IF’s are touched up for maximum sensitivity, they can be left.

Initially place the aerial coils so that their card tubes are about level with the ends of the rod. Fully unscrew the trimmers. If the tuning capacitor has trimmers, also unscrew these.

TC3 governs the frequency at the h.f. end of the m.w. band, so is adjusted until readings correspond with the tuning dial. Then adjust TC1 for best volume.

Afterwards, tune to the low frequency end of the m.w. band (gang capacitor nearly closed) and, if necessary adjust the oscillator coil core to obtain agreement with the dial. Then slip the m.w. coil along the ferrite rod for maximum sensitivity.
Switch to long waves, tune in a station with the capacitor nearly closed, and move the l.w. coil on the rod, for best results.

After repeating these adjustments, alignment should be roughly correct. Final trimming is then carried out in this order:

1. Switch at B. Adjust TC3 for correct position of Luxembourg.
2. Switch at M. Adjust TC1 for best volume.
3. Switch at B. Adjust TC2 for best volume.

When the receiver is finally in its cabinet, repeat the above until there is no improvement.

**Maximum Efficiency**

With values as specified, satisfactory results should be obtained at once. But transistors vary somewhat, and in commercially-manufactured receivers it is not unusual for certain resistors of best value to be fitted individually. It is not suggested this be done until the receiver is working correctly, and it may be quite unnecessary.

Should battery drain be under 8mA or so with no signal, and results sound a little distorted, R17 can be increased slightly. This will increase the OC81's collector current, and battery drain should be about 10—12mA with no signal, peaking up to about 20—30mA with good volume. R17 may be about 47, 56 or 68Ω, to achieve this. The receiver must not be switched on with R17 disconnected, or of such a high value that a heavy collector current flows.

R4 is occasionally modified slightly, to obtain best sensitivity to weak signals, with low background noise. No confusion about the source of any fault in the tuned circuits should arise if the set is first tested with the m.w. coil only, as explained, VC2 then being wired directly to the padder, which goes to pin 3 of the oscillator coil.

If to hand, popular transistors such as OC71 driver and OC72's for output may be used (maximum power handling capacity is somewhat lower than with OC81's). If so, resistor values in these stages must be those usual for the transistors fitted.

**Car Aerial**

A coaxial socket is most suitable, so that a screened coaxial lead can be used from an external aerial. No extra licence is needed for a portable used temporarily in a vehicle. Telescopic aerials may be obtained to clip on a window. Such an aerial increases signal strength, which is reduced by the

---

**Fig. 3: Layout of components on circuit board and wiring to wavechange switch, ferrite rod aerial and trimmer bank**
vehicle screening, and is not directive in the same manner as the ferrite rod.

If a telescopic or other short extended aerial is used merely to boost strength of weak transmissions (e.g., not in a vehicle) then it is better not to screen the connection to it.

**Tape Output**

These sockets supply an audio signal directly from the diode, at about 5kΩ impedance. Most tape recorders have an input circuit suitable for this, and permit direct recording at high quality. The best method of connecting here is to make up a short screened lead, fitted at one end with a plug to suit the recorder, and at the other with a small audio-type coaxial plug, to fit the receiver; or with separate plugs, if a 2-pin socket strip is provided. The screened lead outer braiding forms the earth circuit return.

The receiver should not be connected to a midget a.c./d.c. type amplifier or any apparatus live to the mains.

**Earphone**

The actual impedance is not very important, but is best not higher than about 50Ω. The jack and plug may be ordinary size, or miniature. The circuit from the secondary of T2 to the loudspeaker is completed through the jack contacts. These are closed when the plug is out. When the plug is inserted, it opens the contacts, disconnecting the speaker to silence it. Signals then reach the earphone from the sleeve and tip contacts of the plug.

**H.T. Whistles**

After dark, some inter-channel whistles or interference may occasionally arise, particularly around 200 metres. If necessary, it may be possible to orient the receiver so that directive effects of the aerial reduce this.

Should actual oscillation arise around 200m, it is in order to place a 100-—390Ω resistor between pin 6 of the oscillator coil and pin 3 of the i.f. transformer, or to connect a capacitor of about 0.01μF across R1.

---

**Components List**

**Resistors:**

<table>
<thead>
<tr>
<th>R1</th>
<th>56kΩ</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2</td>
<td>6.8kΩ</td>
</tr>
<tr>
<td>R3</td>
<td>2.2kΩ</td>
</tr>
<tr>
<td>R4</td>
<td>56kΩ</td>
</tr>
<tr>
<td>R5</td>
<td>6.8kΩ</td>
</tr>
<tr>
<td>R6</td>
<td>1kΩ</td>
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<tr>
<td>R7</td>
<td>22kΩ</td>
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<tr>
<td>R8</td>
<td>4.7kΩ</td>
</tr>
<tr>
<td>R9</td>
<td>1kΩ</td>
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<tr>
<td>R10</td>
<td>2.7kΩ</td>
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<tr>
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<tr>
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<tr>
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<td>8-2kΩ 5%</td>
</tr>
<tr>
<td>R16</td>
<td>8-2kΩ 5%</td>
</tr>
<tr>
<td>R17</td>
<td>37Ω 5%</td>
</tr>
<tr>
<td>R18</td>
<td>4-7Ω</td>
</tr>
</tbody>
</table>

**Capacitors:**

<table>
<thead>
<tr>
<th>C1</th>
<th>150μF 1% or 3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>0.02μF</td>
</tr>
<tr>
<td>C3</td>
<td>175μF 1% or 3%</td>
</tr>
<tr>
<td>C4</td>
<td>22pF 1%</td>
</tr>
<tr>
<td>CP</td>
<td>215μF 3% or 220pF 1%</td>
</tr>
<tr>
<td>C5</td>
<td>0.02μF</td>
</tr>
<tr>
<td>C6</td>
<td>10μF</td>
</tr>
<tr>
<td>C7</td>
<td>0.04μF</td>
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<tr>
<td>C8</td>
<td>100μF</td>
</tr>
<tr>
<td>C9</td>
<td>0.1μF</td>
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<tr>
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<tr>
<td>C13</td>
<td>100μF</td>
</tr>
<tr>
<td>C14</td>
<td>100μF</td>
</tr>
</tbody>
</table>

**Variable Capacitors:**

<table>
<thead>
<tr>
<th>VC1/2</th>
<th>208/176μF, Jackson type 00 slow motion, with screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCI, 2, 3</td>
<td>50μF trimmer</td>
</tr>
</tbody>
</table>

**Transistors and Diodes**

| Tr1  | AF117 |
| Tr2  | AF117 |
| Tr3  | AF117 |
| Tr4  | OC81D |
| Tr5  | OC81  |
| Tr6  | OC81  |
| D1   | GD9, OA70 or OA81 |

**Inductors:**

| Tr7  | LFDT4 |
| Tr8  | DFTI  |
| Tr9  | Weyrad P50/IAC |
| D10  | Ferrite rod aerial—Weyrad RA2W |

**Other Components:**

3Ω p.m. loudspeaker. 4-pole 3-way rotary switch. Paxolin (1/4 in.). 8 x 2½ in. (two pieces). Coaxial aerial socket. Output socket. Closed-contact jack socket and plug. Knobs, sleeving, etc.

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![Fig. 4 (left): Details of a suggested cabinet](image1.png)

![Fig. 5 (below): Calibration of dial](image2.png)
Albania: Radiodiffusion et Televison Albanaise (Rue Ismail Qemal, Tirana) has new English transmissions at 1200—1230 on 7,265 and 1630—1700 on 9,520. The 0630—0700 transmission is now on 7,265/9,390.

Czechoslovakia: Ceskoslovensky Rozhlas (Prague 2, Vinohradská 12) using 5,930/7,345 for English 1900—1930 to Europe. To Africa 1730—1830 on 5,930/7,285/7,345/9,795/11,990. English to North America is carried at 0100—0200 and 0330—0430 on 5,930/7,115/7,345/9,795/11,990. Also on Sundays 1400—1500 on 15,285/15,448/17,825.


Luxembourg: Radio Luxembourg (Villa Louvigny, Luxembourg) may be heard very faintly around 2200 on 15,350 carrying a relay of the 233 kc/s long wave French programme.

Monaco: Radio Monte Carlo (16 Boulevard Princesse Charlotte, Monte Carlo) now has a long wave transmitter. Frequency is 215 and power 1,250 kW. On air from 0500—0100 with same programme as 1,466/6,035/7,135.

Portugal: Emissora National de Radiodifusao (Rua Sao Marcal, 1-A Lisboa) now uses 7,130/9,645 for the 0730—0900 English transmission.

Spain: Radio Nacional de Espana (General Yague 1, Madrid) has English 2020—2050 on 9,360.

U.S.S.R.: Radio Dushanbe may be heard around 1900 on 4,640 carrying the programme of Moscow I. Radio Frunze heard around 1600 on 4,008. Relays Moscow I at 1700. Radio Kiev (Ukrainske Radio, Radio Centre, ul Khreshchatitk 24, Kiev, Ukrkian S.S.R.) has formed a Dx club. To qualify for membership listeners must send in three reception reports. Transmits in English Mondays and Thursdays, 1900—1930 on 6020/9,640 and 2230—2300 on 1,241. Also Tuesdays, Wednesdays, and Fridays at 0030—0100 on 7,120/7,140/7,280/7,310/7,330/9,680 and 0430—0500 on 7,180/7,290/7,310/7,330. The 1900 transmission on 6,900 seriously interferes with transmissions from Radio Nederland. Radio Moscow (Moscow) now has a 75 m.b. home service transmitter on 3,990. The 2300 English transmission can be heard surprisingly on 4,860 as this programme is intended for North America. The transmission does not appear to be a harmonic of 9,720. Radio Petropavlovsk may be heard with relay of Moscow I on 4,055 around 1930. Radio Vilnius (Lietuvas T.S.R. Radijas, ul Kanarskio 49, Vilnius) has English, Sundays and Fridays, 2230—2300 on 7,113. Also believed to use transmitters in 51, 50, 41 and 40 m.b.s. Radio Yerevan (Armenian Radio, Marvian Street 5, Yerevan 25) has Arabic 1900—1930 on 4,040.

Algeria: La Voz de la Libertad (F.P.L.N., 3 Rue Aubier, Algiers) on air Sundays and Thursdays in Portuguese, 0015—0100 on 6,080.

Angola: Radio Comercial de Angola (Casilla Postal 269, Sa de Bandeira) has replaced 3,995 by 4,795. The station is on the air 1700—2400.

Ascension Island: B.B.C. relay station is expected to begin operations in June. Four 250kW transmitters are being installed.

Bechuanaland: B.B.C. relay station beams programmes to Rhodesia 0400—0730 and 1015—1145 on 7,295 and 1545—2015 on 4,842. Power is 10 kW.


Morocco: Radiodiffusion Television Marocaine (I Rue Pierre Parent, Rabat) has English 2130—2230 on 11,735/15,410.

Nigeria: Nigerian Broadcasting Corporation (Broadcasting House, Lagos) has replaced 11,900 by 11,915. Other frequencies used for English 1700—1900 and 2100—2200 are 7,275/9,690/15,255.

Zambia: Radio Zambia (Broadcasting House, P.O. Box RW15, Ridgeway, Lusaka) can sometimes be heard between 1730—2000 on 3,270 in English.

China (People’s Republic): Radio Peking (Peking) has English 2030—2130 in 58-51-48-42 m.b. and 2130—2230 in 51-48-42 m.b.

China (Republican): Broadcasting Corporation of China (Voice of Free China) (New Park, Taipeh, Formosa) has English 0250—0350 7,130/11,825/11,860/15,345; 1000—1045 7,130/9,655/9,685/11,825/11,860; 1530—1610 7,130/9,685/9,720/11,725/11,825/15,125/17,890.

Indonesia: Radio Republik Indonesia (P.O. Box 157, Djakarta) has news in English on 9,555 from 1000—1010.

Japan: N.H.K. (Tokyo). Results of a poll held among its listeners by N.H.K. to find the station they listened to most apart from N.H.K., were 1: Radio Australia, 2: B.B.C., 3: Voice of America, 4: Radio Peking, 5: Radio Nederland, 6: Radio Canada, 7: Radio Moskow, 8: Swiss Broadcasting Corporation, 9: La Voz de los Andes, 10: Deutsche Welle.

THE good openings on the Lf. bands continue as some of the logs received show. Top band has been particularly good and has produced many W's for those who “listened with intent”. Eighty has been noisy with a bit of the long distance “stuff” creeping through the chinks now and again. Forty—even noisier with fewer chinks! Twenty, wide open at times and staying open until quite late. Europeans still audible at 2200 hrs!

Fifteen metres, described by one SWL as the Yo-Yo band. One minute half the world and the next minute—
the proverbial Miss Adams.

Ten metres getting better but still a bit patchy, though those do come through usually do it loud and clear and nearly always on a.m. too. W's are reported at 5 and 9 plus on one or two occasions. All in all and with a bit of luck the summer looks like being a “good ‘un” from the amateur bands point of view. If conditions hold it should be a very lively NFD this year.

Low Frequencies

Steve Wilson went on safari into the wilds of 160. Armed only with an HRO/MX, a BC348R and a dipole cut for 1830 kc/s he captured DJ6TK, DL1FF, DL8AM, DL9KRA, E19J, G, GI, GM, GW, HB9CM, IS1FR, OH0NI (Aaland Is.), OLI1AE, OL8ACC, PA0DC, VE1ZZ, W1BB/1, W2IU, W2GGl, W8RRH, K8MGW, ZB2AM, ZB2AJ, 4U1ITU, 9HI1AE, 9LI1HX, 9M4LP (Malaya).

R. Ball (Worksop), SX28+PR30, 80ft. l.w., K10YB/1, K2DGT, K8HKB, OE5CR, VE2ATU, VO1FB, W1BB/1, W1HTG, W2FYT, W2GGL, W3ELS, W8FGK, W9HGW, W9WEC, W6VXO, 4U1ITU, all c.w. On 80 metre phone Alan Lattimore (Darfield), CR100, 20ft. whip raised many G’s plus CT1MS, KP4AST, K9JWV, YU2NZ, James Brown (Cardiff), 19 set and a dipole logged EA4GZ, 10FGM, K4AP, K4X3L, OY7ML, many VE's including VE6ALQ, VP5AB, VP9DW, many W’s, YV5AFH, ZB2AJ. James would like to know the location of V53EA (so would I). No reports for Forty this month—sacrilege, so a new heading and on to the h.f. bands.

High Frequencies

K. Evans (Shetpperton), HE3O, 132ft. l.w., 20 metres s.s.b., KR6UL, VK2JZ, VK3ALB, VK4SB, VK6SA, VK7SM, VP5GU, YV5AF, ZL1AS. Congratulations on passing the RAE Keith.

Colin Morris (Tenbury Wells), Electronique front end into homebrew 9 valve s/het. 330 l.w., BV1USA, CN8BB, CP1FOF, CR6AC, EP3AM, FR7ZB, H8XMT, HK2QQ, HP9FC/MM, JA6NG, KG6APS, KL7EBK, KP4AXC, KR6UL, KV4AB, KZ4PW (no connection with the magazine!), LUSDBS, OX3LP, PY2BFO, PZ1BW, TF2WJK, UA9HA, VE1, 2, 3, 4, 5, 6, 8, Ø, many VK's, VS9HQ, VS1JRD, ZD8JPL, ZS1VT, ZS6IK, ZL2BE, 7Q7PS, 7X2BG, 9J2AB, all s.s.b. D. Howell, 7 valve receiver, 66ft. l.w., KR6QL (Okinawa), KL7EBK (Alaska), MP4BB (Bahrain Is.), VK2NN, VK5NJ, W0NNI, W7ADS, ZS2NV, ZD8ARF, ZL3U, ZL4BX, 4X4JU. A rare one from Frank Viedean (St. Albans) who reports hearing WA3BYG/AM on twenty, the /AM meaning aueronautical mobile and giving his location as 35N, 78W.

On Fifteen, A4378 (Cardiff), 9v. s/het, 95ft. l.w., heard CN8AD, K2EYG, K9WEZ, W1DUJ, W1BYA, WA2FQG, W3GTL, YO3TL, 9HI1. A. Trickey (Bristol), 9R-59+PR30, 100ft. l.w., KP4CNF, W1JRY, W2BLQ, W3TDY, YV4BG, 5A1T5, XG1FL, YH1IAL, Louis Baker (Pantyagaseg), HE3O, 61ft. l.w., CN8’s, CR4AB, CR6CZ, CR7FM, CR8AT, FW8BJ (Wallis Is.), KP4AXC, KZ5AM, MP4BBA, O4A4Y1, PY1, 2, 3, 5, 9, PZ1BE, SV0WB (Rhodes), SV0WO (Crete), VE1S, VO1, VP9, W1-Y, YV1D, ZB2AG, ZC4AK, ZE2KL, ZE6JL, ZS1BV, ZS6IN, 4X4HB, 5A1TK, 5N2FEL, 5X5FR, 6W8BG, 7X2WW, 9HI1, 9J2DL, 9K2AD, 9Q5GG, 9US8, 9X5MW. Paul queries a 9Y4RS claiming his QTH as Trinidad.

Ten metres, Chris Clarke (Farnham), sends in a colossial list which includes K1, 3, W1, 2, 3, 4, 8, WA4, plus 52 G’s. A4378 again reports GW’s, and ZE3JU, ZS9G.

What and Where

Reports from readers and over the air say the following are to be had for the listening. 4S7W (Ceylon), around 14200, ZL4CH (Campbell Is.), VK0 (Macquarie Is.) still at it, also around 14200. VK9PL (Papua) on 14 Mc/s, CEØAC (Easter Is.), c.w. end of 20, FUS8G (New Hebrides) ditto, TT8BS (Chad) on 15 c.w. and a TY3 ditto (Dahomey). Contests include May 8th, 144 Mc/s Portable contest, 22nd, D/F qualifying event, 28-29th, 420 Mc/s open contest, 29th 1296 Mc/s contest. June 4th and 5th National Field Day.

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It is a strange fact that a very great percentage of people tend to spoil the ship for a "ha'porth of tar". This, unhappily, is all too true in amateur radio. The ham with nice new shiny transmitter, home-built or commercial, will usually have a pi-tank output circuit.

The pi-tank offers many advantages. For instance, it gives good harmonic discrimination against TVI and it will match a variety of impedances. This is another way of saying that it will often tune or load up anything from a dipole to any random length of wire which happens to be to hand. Although this is true, there are drawbacks.

Component values in a pi-network are calculated very carefully and the capacitors and inductor cannot merely be selected to resonate at the desired frequency. As will be appreciated, there are a great number of combinations of L and C which will tune to a given wavelength. How then do we decide which is the correct combination?

Pi Configuration

The pi configuration is often used in low pass filters and again exactly the same problem is present—which combination of inductance and capacitance to use. Fig. 1 shows the circuit in question, and you will notice that, in addition to the two capacitors and inductor, two resistances are shown \( R_\text{in} \) and \( R_\text{out} \).

These are the flies in the proverbial ointment. \( R_\text{in} \) is calculated from the valve anode voltage and current in the case of transmission, and \( R_\text{out} \) is the impedance of the antenna. A dipole, and indeed most beams and quads etc., are commonly fed with 75\( \Omega \) coaxial so that pretty well all pi-networks are designed to feed into 75\( \Omega \).

If we now stick the odd length of wire in the output terminal it is highly probable that we can still load it, but it is almost certain that it will not present an impedance of 75\( \Omega \). Any transmitting amateur will tell you that a low pass filter will only work efficiently if it is set up correctly and is terminated in the correct impedance.

Although perhaps not generally realised, this is also true of the pi-tank. If you use it to load odds and ends it does not follow that it is working efficiently, or that it will give the same harmonic discrimination, the very thing for which it is often used.

In the case of a parallel tuned circuit Fig. 2, it will be seen that \( R_\text{in} \) is shown as a link coupling. Unfortunately optimum coupling will vary from band to band, so that if any degree of constant efficiency is to be maintained this link will need to be variable not only in the degree of coupling, but also its inductance.

The Solution

In the case of matching an aerial to a receiver or transmitter it is found that no one circuit will suit every single need. Some aerials are very high impedance and might require a parallel tuned circuit while others are low impedance and would require a series tuned circuit.

Some time ago the writer wrote an article on a S.W.R. bridge (PRACTICAL WIRELESS, Feb., 1965), and contained in the same case was a coil and a capacitor. If high impedance was desired, then the circuit was wired in parallel, if low impedance then it was altered to series tuned with the aid of a soldering iron.

After a short time it became obvious that some form of switching would be a great saving of opening and closing the case at each change of antenna not to mention the "frigging" about with the link coil at each change of band. Accordingly back copies of various magazines were scanned but the same problem came up again and again.

One a.t.u. was fine for tuned feeders but not long wires. Another tuned only three bands or else no
 provision was made for varying the link winding. Others had link winding with no alternative input. In short each design, although doing its intended job very well had limitations and the most serious one was lack of flexibility. After writing down all the different desirable properties of the perfect a.t.u. (for the writer) the following was arrived at.

It should be switchable to almost any configuration, and it must match anything from low to high impedance from the longest long wire to the shortest and everything in between. (Yes, even end fed coat hangers and base loaded cufflinks too!) It must have an optional and variable link which should be controllable from the front panel, and be usable with the three main antenna inputs single wire (any length), coaxial feed and tuned feeders. It should also be usable in any of the popular configurations, parallel tuned, series tuned, pi-network, L network, transmatch, balanced transmatch etc.

This unit will do just these things from 1.8Mc/s to 30Mc/s continuous, and it even peaks some of the medium wave band as well. It will also give added discrimination against unwanted harmonics on transmission, and give an extra stage of quite sharp selectivity on reception. NOTE: It will not give any gain. However it will match impedances and the difference for the prototype between tuned and untuned peaks up to something like three to four S points.

A six foot length of lighting flex draped across the bench was loaded up on all bands while OK’s have been heard on topband. The same set up raised East Coast American stations, plus W6 and W7 and PY.

It will, of course, peak signals on all frequencies between 1.8 and 30Mc/s and is therefore entirely suitable for listening to the commercial bands as well as the amateur bands.

SWL’s or those intending to use the unit for reception only can use small Yaxley switches and receiving type capacitors, this will also result in a smaller and more compact unit. The coil too is not critical and some may like to use an inductance which is to hand or wind one themselves. As a guide the inductance of the coil specified is 41µH.

The Circuit

The complete circuit in Fig. 3 shows two coils, three capacitors, eight switches and ten terminals, together with a coaxial socket. The link coil L2 has a variable capacitor VC3 which gives variable loading. Also the link coil itself can be switched to vary its inductance by turning S5.

---

Fig. 4: Mounting details of L1 and L2.

Fig. 3: Complete circuit diagram of the unit.
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<th>Component</th>
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30
With S5 acting as a sort of coarse loading and VC3 a fine adjustment a great range of control is available over the link winding and the amount of coupling can be varied between wide limits. R.F. currents circulating in the unused portion of both the link and the main coil were found to have negligible effect on performance.

L2 is wound on a 2in. dia. former and mounted inside L1. This avoids the awkward method of winding it around the outside of L1, a rather difficult task because of the tapping points and numerous lead-off wires coming from L1. Details of the mounting and positioning of L1 and L2 are shown in Fig. 4. VC3a, shown in dotted lines in Fig 3, is an unused gang of a 500pF twin gang and is only included for completeness.

Coil L1

This is the main tuning coil and takes time and patience to wire up. The tapping wires are all lengths of 18s.w.g. tinned copper wire threaded with sleeving. Great care should be exercised as a dry joint or a poorly soldered connection here can prove disastrous later on, especially when the coil is mounted in position and all the taps are soldered on. Fig. 5 gives all relevant information on L1.

One word of warning before passing on. Ensure that none of the taps, i.e. the lead off wires from L1 touch. Failure to observe this will result not in an a.t.u. but a first-class arc welding unit.

Other Components

VC1 and VC2 must be insulated from the chassis and front panel. In the prototype they are large transmitting types and are mounted off the chassis with small Eddystone stand-off ceramic insulators. The holes in the front panel for their spindles were cut with a B7G chassis cutter to allow ample clearance.

The switches are as shown and are straightforward switches obtained from the "surplus" market. If the unit is to be used for transmission then these should be ceramic. If, however, it is only to be used for receiving then ceramic or ordinary Yaxley type switches will suffice.

The coloured terminals at the top are arranged in groups of five, the centre one of each bank H and J being earthed. There is also a coaxial socket mounted centrally or if preferred terminal I together with one of the earth terminals may be used. The terminals may be used as either input or output and by this factor alone a large number of permutations are possible without recourse to any switching at all.

S8 allows the coil to be shorted out equally from either end thus the link coil is always at the centre of the main coil. This would not be so if the inductance were varied by shorting out from one end only. As the switch tapped up the coil the link would, in effect, move down towards the tapping point automatically and once the tap had gone above the link there would be very little coupling at all.

Also, of course, in the case of certain aerials it is desirable to tap in equidistant from the ends of the coil. In this instance with S7 in position 1 and the aerial input on terminals F and G, S8 will perform this function.

S6 is provided to short out L1 from one end only. This is useful when the unit is switched for a pinetwork or L network or wherever the inductance is to be tapped or varied. It is also possible to use the tap as an input or output point by using terminal A and switching S3 to position 1.

Configuration

The different configurations possible appear to be almost limitless so no claim is made as to the maximum possible number. However some of the circuitry available is shown in Table 1, together with the position of the switches, the terminals to use, and which capacitors are in or out of circuit. With most
Above—Table 1 shows some of the configurations possible.

Below—Switching and I/P-O/P connections for configurations shown in Table 1.

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of the arrangements shown the input side is optional. For instance in 3 the input may be either the link or at terminal D. This is so in a number of other instances.

Conclusion

A number of antenna have been successfully loaded up. These include dipoles and odd lengths of wire, also some very unlikely ones have been used with marked success. American stations have been worked using the garden fence, and the house guttering also loads up very well on all bands.

There is a strange fascination and also a great satisfaction in plugging in all sorts of things into the unit and watching the s.w.r. go down to 1:1 indicating a near perfect match. Originally the unit was designed to present 75Ω to the transmitter and receiver regardless of the type of antenna used.
Pickup output is given in terms of root-mean-square (rms) volts for a certain stylus velocity. A typical specification is 1mV/cm/sec. This means that for each cm/sec of stylus velocity the output is 1mV. As the velocity imparted from the groove to the stylus is continuously changing, so also is the output voltage—to the pattern of the audio signal.

Broadly speaking, the amplifier's sensitivity voltage should be about five times the V/cm/sec output of the pickup. Thus, to cater properly for a pickup of the above specification, the amplifier should have a sensitivity of 5mV. It rarely happens, of course, that the amplifier's sensitivity exactly matches the signal voltage in this way. Often the signal voltage is above the input sensitivity of the amplifier.

This is fair enough, for a preamplifier can usually cater for a signal a number of times above its sensitivity voltage before overloading starts to cause significant trouble. This has to be so to handle the dynamic range of music.

When the signal voltage is far above the amplifier's sensitivity voltage, there is not a great deal of trouble involved in attenuating the signal prior to its application to the input. All that is generally required here is a simple resistive attenuator to match the source and amplifier impedances.

The biggest problem is when the signal voltage is considerably below the sensitivity voltage of the amplifier input. Say, for example, that we have a magnetic pickup with an output of 5mV/cm/sec, and that the sensitivity of the amplifier is 100mV. For full drive conditions the amplifier sensitivity should be around 25mV so the effect of connecting this pickup to the 100mV input would be a serious lack of drive.

Actually, some sort of reproduction would be possible by turning the amplifier's gain (volume) control full on, but even then full power would not be delivered by the amplifier, and the signal/noise ratio would be bad.

The problem would be resolved either by using a pickup with an output of about 20mV/cm/sec, or by using a booster between the pickup and the amplifier. This article describes such a booster, which can have one or two channels for mono or stereo pickups.

**Equalisation**

The majority of amplifiers that will be used in conjunction with this booster will possess an equalised pickup input circuit. It will be understood, of course, that all magnetic pickups require an equalising circuit because the output voltage from this kind of pickup rises approximately at the rate of 6dB per octave, as shown in Fig. 1(a). Actually here is shown the relative velocity of the cutter stylus over the frequency spectrum. On playing back with a magnetic pickup, therefore, the signal output follows a similar curve.

If nothing is done about this at the amplifier the reproduction sadly lacks bass, and treble has predominance. Pickup equalisation simply means that the pickup channel of the playback amplifier should have a gain/frequency response which is the reciprocal of that of the pickup output. This is shown in Fig. 1(b). The curves in Fig. 1 are in reality associated with the recording characteristics of the disc. These differ from the basic 6dB/octave characteristic.
in that at about 1,000 c/s the output rise is checked and controlled treble lift is applied (a) as a means of improving the signal/noise performance of the reproducing system.

Crystal Pickups

Now, how about piezo or crystal pickups? Well, the output from these is not specifically affected by frequency. That is, when they are loaded to a high impedance of about 2MΩ. The output then is proportional to the level of the recording.

In practice, this means that the output from the pickup is substantially "flat" over the normally recorded frequency spectrum. Such a pickup, then, can be connected direct to an unequalised input, and this, indeed, is necessary to preserve correct balance over the spectrum. If, for instance, a crystal pickup were connected to a high impedance equalised input, there would be far too much bass and too little treble.

However, an output very similar to that from a magnetic pickup is produced by a crystal pickup when it is connected across a relatively low impedance input circuit. This output, incidentally, is often referred to as "velocity", as the output rises with rise in velocity of the stylus.

Now, on some amplifiers the crystal pickup input is of an impedance below that required for true "piezo" pickup action, meaning that the amplifier incorporates some kind of equalisation on the piezo input as well as on the magnetic. Other amplifiers, on the other hand, utilise an "unequalised" crystal input, loaded to a high value of impedance or resistance.

Moreover, the voltage from a "high-loaded" crystal pickup is considerably above that from the same pickup loaded to a relatively low value for velocity operation. To reconcile all these factors in terms of a pickup booster is not impossible without a great deal of complexity, which is what the author set out to avoid.

To provide all facilities would be little different from designing an entirely new preamplifier or control unit to cater for a pickup with an output below that of the sensitivity voltage of the existing preamplifier or control unit.

Compromise

Nevertheless, a reasonable compromise has been created in the booster unit now to be described. The circuit of one channel of this is given in Fig. 2. For stereo operation, of course, a pair of identical amplifiers are necessary. The circuit board and unit design are such that two channels can easily be accommodated, as we shall see.

There is nothing particularly new about the circuit which employs a pair of OC75 transistors in common emitter mode and which is used in all kinds of audio applications. The two transistors are directly coupled. This means that the collector of Tr2 is in d.c. connection with the base of Tr2. The avoidance of a coupling capacitor here improves the low-frequency response and the phase characteristics.

The pickup signal is applied direct to the base of the first transistor, via the electrolytic capacitor C1. Appearing across the collector load R4 is thus the amplified signal which is fed to the base of Tr2. Again, further amplification takes place and the processed signal appears across Tr2 collector load R6. The signal is then passed out of the unit, via C4, and applied to the input of the amplifier which is insufficiently sensitive for direct connection of the pickup in use.

Now, there are several interesting aspects of the booster. Firstly, it arranges the signal from either a magnetic or piezo pickup so that at the output it appears as of "velocity" characteristics. This means that the booster must normally be connected to an equalised pickup input of the parent amplifier.

Secondly, the overall gain is adjustable by the negative feedback applied from the collector back to the base of Tr1, via R2. The small value of this resistor, the greater the feedback and the smaller the overall gain.

Thirdly, the first transistor is arranged for a current input from either a magnetic or a crystal pickup. Transistors, of course, are current-operated devices, so the more current that can be injected efficiently into their emitter/base junction the better the noise performance.

Pickup Coupling

Fig. 2 shows a resistor R1 connected in series with the pickup signal. Actually, this resistor is used only with a magnetic pickup. Its value is arranged in conjunction with the inductance of the pickup to provide high-frequency roll-off. In effect, the resistor tends to endow the input towards constant-current operation. The greater the inductance of the pickup, the greater should be the value of R1. For the best results it may be necessary to experiment a little here with resistors from about 2-7k to 10kΩ.

When a piezo pickup is used (either a crystal or ceramic) the input is coupled direct to C1, and R1 is deleted. The source impedance of a piezo pickup is capacitive, and because of this the signal current into the emitter/base junction of the first transistor increases with increase in frequency. It is this effect that provides the basic "velocity" characteristics. Moreover, it ensures that all the available signal current from the pickup passes into the emitter/base junction.

The signal passing into the first transistor does not match perfectly the requirements of equalisation, but it is fairly close and slight modifications to the settings of the amplifier's tone controls should provide the final tailoring to the response.
The frequency response is also affected to some extent by the value of R2, for since this applies the feedback via C1 there is a tendency towards a rising bass response due to the reducing feedback at the lower frequencies. This is countered, however, by the rising degenerative feedback across the emitter resistor R4, for here C2 progressively has less signal bypassing effect towards the lower frequencies. A further, smaller amount of correction in this respect is given by C3 in Tr2 emitter circuit.

A degree of feedback is purposely introduced into Tr2 by the unbypassed emitter resistor R7. Apart from reducing the stage gain, the action of this increases the impedance at the bases of Tr2 and thus provides improved signal transference from Tr1 to Tr2 due to the resulting improvement in matching.

With the booster and pickup connected to the parent amplifier, the value of R2 should be adjusted to produce the correct output with the amplifier’s volume control about half on. Of course, any required gain conditions can be achieved by altering the value of R2. There is rarely any possibility of the booster being overloaded by a too strong pickup signal, for if the pickup signal is that strong then a booster would not be needed anyway!

**Booster Coupling**

It is possible, however, to overload a low-level input on the parent amplifier by the booster delivering too strong a signal, but—as already mentioned—this can be corrected by decreasing the value of R2. This can be set initially at 10kΩ.

Fig. 2 shows a resistor R10 in series with the output signal. This may not be required, depending on the characteristics of the parent amplifier’s equalised pickup circuit. Sometimes the equalisation is sensitive to load impedance (or load inductance). This may then make it necessary to put a resistor in R10 position. This usually requires to be about 47kΩ when the equalised magnetic pickup of the amplifier is used.

The booster runs on a 9-volt PP4 or similar type of battery, and the current consumption is approximately 2mA per channel (4mA when a pair of stereo channels are adopted).

The idea has been to produce a booster that is completely self-contained with its own internal battery. A piece of Veroboard was prepared to take both channels and to fit snugly into a 2-oz. tobacco tin, which makes an excellent housing for transistor devices of this nature.
Veroboard Circuit

Veroboard Circuits Limited make available through the retail trade four standard sizes of Veroboard, and the piece chosen was 16-way board of approximately 3½in. long. About half an inch was cut from the length of the board, giving 21 holes along each metal strip. Thus, the total number of holes in the board is 16 times 21, or 336.

Each amplifier section is accommodated along the length of ten holes over the 16 strips. Thus, the length is divided by 16 holes not employed for either section.

The layout of one amplifier section of the board is given in Fig. 3. The 16 strips are marked "A" to "P" inclusive, while the lines of holes on the other axis are numbered 1 to 10 inclusive. By this means each hole in the board can be identified. The line of holes separating the two sections is marked "O" and then, of course, the numbering starts again to 10 to cater for the other amplifier section, both sections being identical.

The circuit on Veroboard is created by using the metallised strips as the conductors. Thus it is necessary to break some of the strips and interconnect others with external wire links to form the required circuit. A special tool is available for cutting the strips cleanly and without tearing the metallic foil from the insulated laminate.

The reverse of the Veroboard with the holes and strips identified as in Fig. 3 is shown in Fig. 4. This reveals exactly how one section of the board must be processed. Here is shown the foil cut-outs and the external links. The Veroboard should be processed exactly in this way for one section of 10 holes by 16 strips for a single-channel mono amplifier or for two sections of 10 holes by 16 strips for a two-channel stereo amplifier.

It will be seen that there are three strips common to both sections, they are two strips for battery plus and one strip for battery negative. These strips are not severed at the line of holes corresponding to "O" in Figs. 3 and 4. The "X" marks on the component layout plan in Fig. 3 indicate the foil cut-outs on the reverse side of the board, and these, of course, correspond with the cut-outs indicated on the strip side of the board in Fig. 4.

* components list

<table>
<thead>
<tr>
<th>Resistors:</th>
<th>Capacitors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2 see text</td>
<td>C1 4µF electrolytic 6V</td>
</tr>
<tr>
<td>R3 10kΩ</td>
<td>C2 4µF electrolytic 6V</td>
</tr>
<tr>
<td>R4 27kΩ</td>
<td>C3 50µF electrolytic 6V</td>
</tr>
<tr>
<td>R5 33kΩ</td>
<td>C4 0.1µF, 160B or less.</td>
</tr>
<tr>
<td>R6 33kΩ</td>
<td></td>
</tr>
<tr>
<td>R7 150Ω</td>
<td></td>
</tr>
<tr>
<td>R8 220Ω</td>
<td>Transistors</td>
</tr>
<tr>
<td>R9 680Ω</td>
<td>Tr1 OC75</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>All ½W or ½W high stability type.</td>
<td></td>
</tr>
</tbody>
</table>

Other Parts:
S1—SPST toggle on-off switch.* Veroboard—see text.*
One phone socket. One 2-oz. tobacco tin.* One rubber grommet. One 9V battery (PP4 or equivalent).* Length of screened signal output cable. Wire, cork, etc.

Note: The above list is for the mono version; for the stereo version, two of each part mentioned will be required, except for those marked.*

Fig. 5: The arrangement of the Veroboard and other components in the 2-oz. tobacco tin.

The full lines (dotted underneath the components) in Fig. 3 show how the circuit is formed from component to component, and a little study will reveal that this physical circuit follows exactly the theoretical circuit in Fig. 2.

Assembling in Box

Fig. 5 shows how the Veroboard and the remaining components are mounted in the 2-oz. tobacco tin. Phono sockets are adopted for channel A and channel B signal inputs, while screened leads—taken out of the tin through rubber grommets—transfer the boosted signals to the equalised pickup sockets of the parent amplifier.

The positive battery clip wire is soldered direct to the inside of the tin, beneath the Veroboard. The tin box is made common with the supply positive line, this being accomplished by the connection of short lengths of wire from strip "P" on the board to the side of the tin box. Two connections are made here, one to hole P2 and the other to hole P9 on channel B section of the board.

These wires also serve to suspend the Veroboard in the tin box, and balancing suspension wires are soldered on the other side of the board, to the opposite side of the tin box at holes C2 (channel A section) and C9 (channel B section). The strips associated with these two holes are not concerned with the circuit and are thus isolated.

To avoid the circuit side of the Veroboard and the channel A edge from shorting to the tin box, a thin piece of cork is glued to the inside base of the tin, of a size equal to that of the Veroboard, and to the left-hand edge of the tin and corner.

Note also that the outer conductor (braiding) of the signal output leads is soldered to the side of the tin box, the inner conductor being terminated at holes B10. If R10 is not required a wire link is connected between holes B5 and B9.

The "earthy" side of the phono sockets is automatically connected to the tin box and the "live" side of each channel is connected to the strip corresponding to hole O1.
I have been building radios and electronic equipment for a good number of years now and I find, as I am sure a lot of readers do, that the most difficult stage of construction is the cabinet.

I pride myself that I am "mechanically minded" but when it comes to working with wood my skill is very limited indeed. Evening classes on the various arts of woodwork were out of the question (I work shifts). "D.I.Y." books are very good but I found very little of value even in the excellent shelves of the local library. Space in my "den" is very limited, as also is cash for the purchase of expensive carpentry tools. My friends were envious of my first transistor radio because it worked so well but were amused at the cabinet which almost housed it. The stabilised power pack which has worked so perfectly right from the initial first "plug in", remains unmoved on the bench: the cabinet will not stand the strain of being lifted. Without "plastic wood" and modern adhesives some of my earlier attempts would, I fear, not even be dustproof.

However, all that is now in the dark past, I am pleased to say. I have reorganised my thinking and my methods to produce some examples of cabinet building which has astounded me no less than my friends.

There is, of course, no magic formula, just an application of common sense and the judicial use of a few of the products of the wonderful age in which we live.

I began by reorganising my thinking thus:
1. Keep design strictly simple, this is the modern trend anyway.
2. Be meticulous with your measurements at all stages of construction.
3. Use only new timber. (I found that by careful buying, the extra expense was not large and the results were very much easier to obtain.)

My altered methods consisted of:
1. Using no conventional joints, i.e. dovetail, tenon, butt or mitres. (This was of course my main point.)
2. Keep tools to an absolute minimum, but choose them with care. My basic tool kit consists of: One good quality rip saw, not too coarse and regularly sharpened; one hammer; one fretsaw and good supply of blades; one wheel brace or electric drill with a few twist drills say from \(\frac{1}{4}\)in. down to \(\frac{1}{8}\)in. and a "rosebud" type countersink; screwdriver and a good selection of screws. Sandpaper or sanding discs; sharp knife; good ruler and metal set square; panel pins and nails.

The main material used in all my cabinets is "blockboard". This is a material consisting of blocks of softwood sandwiched between two layers of plywood and can be obtained usually in three thicknesses, \(\frac{1}{8}\)in., \(\frac{3}{8}\)in. and 1in. It is easy to saw, never splits when nailed or screwed, extremely strong and has a very smooth finish. If, when buying timber, the...
sizes of the pieces required are accurately known, then you may find, as I did, that the shopkeeper will saw them for you and save a lot of effort and sawdust on your part.

Let us consider the construction of a radio cabinet of average size to house a 3 plus 1 set with a 5in. speaker and covering long and medium wave, in fact a typical constructor’s piece often discussed in the pages of this magazine. The cabinet would need to be about 18in. by 12in. by 8in.

Saw four pieces accurately of blockboard, two 18in. by 8in. and two 12in. by 8in. and nail them together with long nails (Fig. 1). Countersink all nails slightly and fill the holes with plastic wood or putty. Sandpaper the edges to make them level (a high finish is not necessary) and check that all angles are true with the set square.

From a length of ½in. by ½in. softwood now saw four pieces 16in. long and four pieces 10in. long. These are panel pinned into the cabinet after carefully drawing a line 1in. on both front and rear of the four sides of the inside of the insides of the rectangle formed.

Two pieces of softwood 6in. by 2in. by 1in. are now cut and screwed, after countersinking, on to the bottom of the cabinet about 1in. This raises the cabinet up and a piece of felt glued on to these two pieces make them virtually scratchproof to furniture.

The two sides and top of the cabinet are now covered with “Con-tact” self adhesive plastic finish to your own colour requirements. This very attractive form of finish can be bought in a variety of colours and either in gloss or matt finish.

The back and front are of hardboard and should fit easily in to rest against the four wooden strips inside the cabinet. The back is “vented” to allow for heat dissipation and suitably drilled for aerial, earth, mains lead, etc. The front will of course be cut to suit the position of dial, knobs, speaker and so on and for this the fret saw is used. The front is finally to be covered with “Con-tact” adhesive but before this is done, a word about how the front and back are held in place. I decided against screwing or nailing for two reasons, as I wished to be able to dismantle any piece of equipment easily and quickly for the purpose of repairs or modifications and, for the fact that hardboard does not take easily to being drilled near the edges, I decided to use springs. The type of springs used can be obtained very easily and cheaply from most hardware shops or even from car accessory shops. In the case of our example, a fairly “soft” spring, 4in. long (when closed) will do nicely. Two are usually sufficient, and placed near to the edges of the cabinet can, as a rule, be kept well clear of the radio chassis. Make two small holes in the front piece and thread a loop of stiff tinned copper wire through as shown in Fig. 1. A groove cut with the knife between the two holes allows the wire to lie flat under its final covering of plastic. The wire is now twisted tightly and soldered, it will now be self supporting in a horizontal position which is ideal for our purpose. The fixing for the spring on the back can be one of the holes which were cut for ventilation.

The front panel can now be covered with the plastic adhesive (preferably in a contrasting colour) and with the knife cut out the shapes already in the hardboard. If two diagonal cuts are made in each of
the shapes it will be found that the edges can be turned back very neatly.

Attention can now be turned to the front edge of the cabinet which, up to now, has been left unfinished. This edge I cover very carefully with glossy black or black and gold plastic strip. This can be obtained in quarter inch, half inch or three quarter inch widths and is flat on the back and rounded on the front. It is usually fastened with a good quality contact adhesive and if desired can be mitred at each corner. To complete the job, a suitable handle can now be screwed on top for the purpose of making the set “portable”. All that remains now is for the radio to be housed in its new and shiny cabinet, the springs to be fastened and the knobs pushed home.

It needs very little imagination to see that almost any type of cabinet can be made in this manner and as there is no paint or varnish involved, no awkward “waiting period” between stages. Blockboard is obtainable in all sizes and I have seen sheets 10ft. square. It has little or no grain to worry about and therefore can be safely sawn and used in any direction. Radio chassis can be screwed directly to it and it does not appear to warp with heat.

After a few trial runs on cabinets of this sort I attempted my most ambitious piece a stereogram. Here as in the other designs, the shape was kept as simple as possible and I carefully measured each piece to be purchased. The pieces were cut for me by the shopkeeper and this ensured a right angle cut on each edge (he used a circular saw). It is essential that the edges are accurately sawn if only nails and screws are to be used. (See heading, page 40.)

The main construction proceeded very quickly and was remarkably easy, long screws were used and each screw hole was drilled and countersunk to give maximum strength to the whole assembly. Screw and nail heads were hidden by plastic wood and sanded flat as were any imperfection in the sawn edges of the blockboard.

The door for the record cabinet (right hand side) was hung on two brass hinges and is held closed by a magnetic catch. The door itself is blockboard and is slightly larger than the opening, when closed it is “proud” of the door jamb and gives a very attractive appearance as well as being easy to make.

The front and back are held in by springs in exactly the same way as previously described.

The two speaker cabinets are in blockboard of two thicknesses, three quarter inch for the baffles and half inch for the sides. Again, screws and nails were used throughout. The inside of each is lined with thick felt (carpet underlay) and the back is quarter inch hardboard panel pinned and stuck with contact adhesive. Connection to each speaker is by standard jack plug. The finished product is covered, as explained, in glossy “Con-tact”.

The equipment was bought on a strict budget and was selected for a maximum outlay of under £40. This I just managed to do by being fortunate enough to purchase the speakers second hand. Here is a brief description of the rest of the equipment used. Amplifier, “Heathkit” S33 Stereo/Mono. Turntable, Collaro type RP594 but the original arm has been replaced by one built to my own design by an engineer friend. It has jewelled bearings and a tracking weight of 2 to 8 grammes. Tracking error is negligible and adjustment is possible in all directions to correct stylus error. The speaker “line up” consists of one 10in. and one 5in. in each column capacitor connected. A jack is fitted to allow for headphone listening and the speakers are switched out when this is used.

Results are much better than most commercial models of the £80 to £100 range that I have heard and compares favourably with a few very expensive models.

Fig. 2: Some suggested cabinet designs.
To allow the use of manageable figures in radio and electronics, the basic units are often subdivided or multiplied, providing such terms as megacycle (one million cycles) and millivolt (one thousandth part of a volt).

While the terminology may be quickly recognised, complications may result when the beginner is faced with calculations involving values other than the basic or quoted units, and errors can quite easily be made by dropping or adding the odd nought.

The use of mathematical indices provides a simple and, once properly understood, infallible solution to this problem. It also allows any particular calculation to be carried out from one basic formula, irrespective of what pre-fixed values are employed.

Indices

Consider the expression \( a^x \); \( a \) may be any number and \( x \), the index, may be any number. Basically, it means that \( a \) is multiplied by itself \( x \) times. For example, \( 4^3 \) (four cubed) is \( 4 \times 4 \times 4 = 64 \).

The index \( x \) need not be a whole number. If it is a simple fraction a root is indicated, e.g. \( 4^{\frac{1}{2}} \) is \( \sqrt[2]{4} \) (the square root of four) = 2. Extending this a little, \( 4^{\frac{1}{4}} \) (or \( 4^{\frac{1}{64}} \)) is \( \sqrt[4]{4 \times 4 \times 4 = 8} \).

Reciprocals are expressed by a negative index; thus—

\[
\frac{1}{a^x} = a^{-x} \quad \text{or} \quad \frac{1}{a^{-x}} = a^x.
\]

Calculations involving indices could not be simpler.

In multiplying, the indices are added:

\[a^x \times a^y = a^{x+y} \quad \text{and} \quad a^x \times a^z = a^{x+z} \ldots\]

Note that when dividing or dealing with reciprocals, the signs of the indices must be observed: e.g.—

\[
\frac{a^x}{a^y} = a^{x-y} \quad \text{and} \quad a^{-x} = a^x
\]

The expression \((a^x)^y = a^{xy}\), i.e. the indices in this case are multiplied. For example \((a^2)^3 = a^{6}\).

Note that \( a = a^1 \) and not \( a^0 \).\( \text{(a}^0 = 1, \text{whatever the value of } a) \). Generally the index is omitted in the expression \( a^1 \), but the 1 must be included when adding the indices.

Multipliers

In applying multipliers to basic units, multiples of 10 are invariably used; these may be applied directly (as in megacycle) or inversely, by dividing (as in millivolt).

We therefore have the case where \( a = 10 \) and \( a^x = 10^x \). Now \( 10^2 \) is 100, \( 10^3 = 1,000 \), \( 10^4 = 10,000 \) and so on. It will be seen that the number of noughts in the resulting number corresponds to the index value.

Similarly \( 10^{-1} = \frac{1}{10}, \quad 10^{-2} = \frac{1}{100} \) etc.

It is now apparent that any of the prefixes or multipliers used in electronics can be simply represented by the figure 10 with an index, or \( 10^x \) where \( x \) is a whole number. The following table gives prefixes commonly used with their corresponding numerical values:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>TERA-</td>
<td>T-</td>
<td>( 1,000,000,000,000 ) ( (10^{12}) )</td>
</tr>
<tr>
<td>GIGA-</td>
<td>G-</td>
<td>( 1,000,000,000 ) ( (10^9) )</td>
</tr>
<tr>
<td>MEGA-</td>
<td>M-</td>
<td>( 1,000,000 ) ( (10^6) )</td>
</tr>
<tr>
<td>KILO-</td>
<td>K-</td>
<td>( 1,000 ) ( (10^3) )</td>
</tr>
<tr>
<td>HECTO-</td>
<td>H-</td>
<td>( 100 ) ( (10^2) )</td>
</tr>
<tr>
<td>DECA-</td>
<td>DECA-</td>
<td>( 10 ) ( (10^1) )</td>
</tr>
<tr>
<td>deci-</td>
<td>d-</td>
<td>( \frac{1}{10} ) ( (10^{-1}) )</td>
</tr>
<tr>
<td>centi-</td>
<td>c-</td>
<td>( \frac{1}{100} ) ( (10^{-2}) )</td>
</tr>
<tr>
<td>milli-</td>
<td>m-</td>
<td>( \frac{1}{1,000} ) ( (10^{-3}) )</td>
</tr>
<tr>
<td>micro-</td>
<td>( \mu )-</td>
<td>( \frac{1}{1,000,000} ) ( (10^{-6}) )</td>
</tr>
<tr>
<td>nano-</td>
<td>n-</td>
<td>( \frac{1}{1,000,000,000} ) ( (10^{-9}) )</td>
</tr>
<tr>
<td>micro-micro-</td>
<td>( \mu \mu )-</td>
<td>( \frac{1}{1,000,000,000,000} ) ( (10^{-12}) )</td>
</tr>
</tbody>
</table>

Applying this to actual values, 13Mc/s may be written \( 13 \times 10^6 \) c/s, 2mA as \( 2 \times 10^{-3} \) A and 8mgF as \( 8 \times 10^{-6} \) F. Going a little further, 300pF may be written as \( 300 \times 10^{-12} \) F, but 300 is \( 3 \times 10^2 \) and by adding the indices we obtain the value \( 3 \times 10^{-10} \) F.

To resolve the result of a calculation in terms of a prefixed unit, just subtract from the index in the answer. Any remainder will normally be incorporated in the value figure. For example

\[
4 \times 10^6 \Omega = 400k\Omega \\
3 \times 10^{-11} \text{F} = 30\text{pF}
\]

A decimal may be eliminated or modified by means of a multiplier. Moving the point to the left introduces a positive index corresponding to the number of digits the point is moved. Conversely, moving the point to

---continued on page 49---

An explanation of Indices, Multipliers and Roots

by B. L. BURROUGH
Mods for Modulated Light

After reading your article on the Modulated Light Telephone link (Feb., 1966, issue of P.W.) I would like to put forward an idea.

There are certain times when one person in a household may need a bit of peace and quiet and another may want to watch the television. Surely this can be overcome without the use of bothersome wires and equipment by connecting a modulated light transmitter to the sound, together with a switch for normal listening. The receiving unit could be completely transistorised and compact enough to stay unobtrusively on a coffee table. Actual listening would, of course, be by means of an earpiece.

J. Douglas.
Newcastle upon Tyne

⭐⭐⭐⭐

Just over two years ago, I carried out similar experiments to those described in the February issue of Practical Wireless.

Although I was only able to obtain a range of up to about 20 yards I would like to offer the following hints to anyone thinking of experimenting in this field.

An ordinary household torch with the minimum of alteration (i.e., breaking the circuit and connecting in the output of the transmitter amplifier), makes an almost ideal transmitter, especially if it is of the type that can be focused. Instead of mirrors (which may be difficult or expensive to obtain) the reflectors from car headlamps, obtainable for a nominal fee from scrap merchants, can be used with great success. For short range experiments, both amplifiers can be simple battery-operated transistor types having an output of about 1W.

B. M. R. Green.
Ripon,
Yorkshire.

U.H.F. and V.H.F. Designs

I enthusiastically echo the request by S. Peat (P.W. March 1966) for designs on u.h.f. and v.h.f. receivers, though not for the same reasons.

Having built the t.r.f. version he mentions, I feel that the next step is a portable switched band a.m. superhet covering 70-160Mc/s, this covering the amateurs, broadcast and a host of other interesting stations.

How much longer must we put up with the superregenerative hiss?

P. M. Thacker.
Morley,
Yorkshire.

NEWS AND...

IEEETE LONDON MEETING


The outline of the lecture was that the digital computer is the tool that provides the Auto in automation. The whole technology of computers, not only their electronics, but even more their application, is new.

The power of the computer comes from its quite unique method of operation - the stored programme techniques. The profession of programming is new and offers a completely new career line.

As a control tool, the computer’s flexibility holds out a new dimension of “power” in control systems. The ever decreasing size and increasing capability made possible by transistor and microelectronic development opens up new fields of application in every walk of life.

1966 PHYSICS EXHIBITION

Mullard Ltd. Educational Service was on stand E5 at the 1966 Physics Exhibition held at Alexandra Palace, London, from March 28th-31st.

Several experiments designed by the Mullard Educational Service for use in schools, technical colleges and other training establishments were shown. They included a computer demonstration unit, an electronic very high voltage generator, a 1c/s sinewave oscillator, an oscilloscope, a simple timer and a binary adder/subtractor.

NEW LABORATORY PREMISES FOR MULLARD

Many of the 3,000 employees at Mullard Southampton Works—the principal establishment of Associated Semiconductor Manufacturers Ltd., the joint Mullard/GEC manufacturing and development company for Mullard transistors—work in the plant’s extensive laboratories.

Two important sections of these laboratories are now moving to new premises on the N.E. outskirts of Southampton. These sections are the reliability and quality laboratories. Both of which form part of the 200-strong team under the technical direction of Mr. L. B. Johnson.

When the move is completed, well over £1 million worth of technical equipment will occupy the 25,000 square feet of space in the new premises.

The West End unit is planned to have a direct link with the new ICT computer at the main factory, which is on Southampton’s Millbrook estate. This will enable scientists in the reliability and quality laboratories to feed their problems directly into the new computer.

SELF-ADHESIVE INITIALS

From Convex Ltd., 41 Brecknock Road, London, N.7, come the sets of Myrogram self-adhesive gold coloured plastic initials 6½ in. high. These are especially useful for putting that “finishing touch” to front panels of receivers, equipment, etc. The price is 5s. per sheet (26 letters and various ornamental shapes). Further details from the above address.

HEATHKIT CATALOGUES AND BROCHURES

In addition to the distribution of their normal catalogue, which is published quarterly, Daystrom Ltd., Gloucester, now send—to those people interested—special brochures covering the Electronic Instrument field, and the Amateur Radio market. Copies of the latest Heathkit Catalogue may be obtained by writing to Daystrom Ltd., Gloucester.
A Challenge

I refer to the letter published in the March 1966 issue of Practical Wireless. Perhaps few people have noticed one unfortunate fact. In 1935, fifteen pounds represented a fair sum to pay for a radio of sturdy build, excellent cabinet work and a good technical design. Unfortunately, fifteen pounds now is only equivalent of about three pounds ten then. No one, manufacturer or home constructor, can give you three bands, three watts, an 8in. speaker and a good solid wood cabinet for three pounds ten!

However, give the constructor his chance with sixty pounds, he might produce a valve receiver of comparable performance; with f.m., perhaps slightly better musical reproduction.

Why Mr. L. Welch should want this set to be a transistor type working from the mains, I cannot imagine. I have heard of built-in obsolescence, but please do save us from built-in inferiority. As the Homburg hat is an inferior substitute for a fine head of hair; so is the transistor an inferior substitute for a valve, as far as the matter of music reproduction is concerned.

My 1936 Aerodyne is not as good as it once was, but I could not replace it musically with a transistor set. Snakes are said to hiss, but transistors do hiss. If we were really music lovers, we would have hissed the transistor off the audio stage by now.

A. Biddlecombe.

Ickenham,
Middlesex.

To Build or Not to Build

I completely endorse a letter in one of your recent issues where the writer states that the cost of building one's own equipment works out more than buying the finished article.

Admittedly I, as a radio experimenter, obtain much pleasure from building my own gear. But let us face it, sooner or later finance must be the deciding factor. Although I consider myself at least average at making a decent job of construction, there is still a lot to be desired when surveying the end product, especially as to a neat and professional-looking front panel which is so often a let-down.

I think that the time is rapidly approaching when price and appearance will count for a great deal and radio construction as such, will be a rich man's hobby.

A. J. Simmonds.

Welling,
Kent.
JUST before the war considerable interest was aroused by volume expansion devices in radio receivers, the idea being an attempt to reproduce the loudspeaker the range of volume level produced in the studio. As is well known, both in the recording and broadcasting studio, the range of audio volume is compressed, low levels being boosted and high levels attenuated so that a fairly constant output is achieved.

**Simple System**

If this was not done low-volume levels would insufficiently modulate the carrier or impress the record groove, as the case may be, while loud signals would cause over-modulation or a break through from one record groove to its neighbour.

However, in the interests of good-quality reproduction, which aims to make the speaker output a copy of the original in volume range as well as freedom from distortion, there is much to be said for schemes for restoring, if only partly, the orchestra’s wide range of sound output.

Within the confines of the average living-room it would probably be impossible to reproduce, say, a solo artist at adequate strength for comfortable listening and, at the same time, reproduce in full proportion the sound output from the full accompanying orchestra composed of up to 100 players. But undoubtedly there is a case for some degree of volume expansion, adjustable at will.

The simplest device of all, used by Pye in many pre-war models, was the switching in of a small dial bulb across the speaker itself. On loud passages the bulb would light up and as its hot resistance is higher than its cold resistance it would impose a heavier load on low signals than peak signals and thus expand the volume range.

This simple system had great disadvantages, of course. The loading created by the bulb effected a mismatch between speaker and valve, it absorbed power, transient loud passages of duration shorter than the thermal delay of the bulb failed to create effect and the arrangement did not have a linear input/loading curve. But it was simple and it did work.

For experiment in this direction it is advisable to use a tapped speaker transformer so that various types of bulb can be tried. Ideally the bulb should fully light at peak volume and be completely extinguished at about quarter to one-third of this value. Obviously any bulbs should be of low current consumption and with a fine filament for rapid heating up.

**Negative Feedback**

By incorporating negative feedback with this simple arrangement its range of operation can be greatly increased. Instead of shunting the bulb directly across the transformer a resistor is placed in series with it of value about equal to the resistance of the bulb when half-lit, and a voltage will be then developed across the resistor which will not rise proportionately with increase of output but will tend to fall off at high volume.

With the bulb half-lit an equal voltage will be developed across bulb and resistor, but as the signal rises the greater fraction of the voltage will be fed across the bulb and less across the resistor. If the resistor voltage is then fed back as a negative feedback signal to the valve grid it will be apparent that the greater the volume the less the feedback.

This circuit lends itself well to adaptation and experiment to suit individual tastes and receiver characteristics. However, the use of a bulb imposes an undue load on the valve and does not provide anything like an ideal device to satisfy the requirements.

Much more satisfactory are voltage dependent
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2m. 500ft. T.P. mylar 7.0
7m. 1.000ft. std. plastic 12.0
2m. 500ft. D. paper 9.0
7m. 1.000ft. std. plastic 12.0
2m. 500ft. T.P. mylar 7.0
7m. 1.000ft. std. plastic 12.0
2m. 500ft. D. paper 9.0
7m. 1.000ft. std. plastic 12.0
2m. 500ft. T.P. mylar 7.0
7m. 1.000ft. std. plastic 12.0
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7m. 1.000ft. std. plastic 12.0
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7m. 1.000ft. std. plastic 12.0
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resistors, since these small components have an internal resistance which decreases rapidly as the applied voltage is increased, have a long working characteristic and do not impose a heavy load on low inputs.

To fully take advantage of the characteristics of VDRs it is best to apply them across a high impedance so that there is maximum variation in applied voltage. In practice this means feeding them from the anode of the output valve via a d.c. blocking capacitor and series resistors.

The blocking capacitor should be sufficiently large to have negligible reactance to the signal compared with the ohmage of the series resistors to avoid any phase change, so a value of at least 0.5µF is indicated.

As shown in the circuit of Fig. 3 the ratio R3/R1+R2+R3, without taking into account the effect of the VDR, would determine the percentage of negative feedback. If R3 was 5,000Ω and it was desired to have 5% feedback, then R1 and R2 should have a combined resistance of 5,000×19 or 95,000Ω.

If R1 and R2 are made equal at 47,500Ω each the shunting of the VDR across R2 and R3 will lower their effective value and thus reduce the degree of voltage feedback, and as output voltage rises on peak volume the VDR's internal resistance will drop still further and decrease feedback accordingly. Thus the louder the volume handled by the output valve the less is the percentage of negative feedback supplied to the grid.

This is probably an ideal way to approach the problem and by making R1 and R2 variable the characteristics of the feedback can be varied to suit individual receivers and choice.

**Matching**

There are, of course, very many different types of VDR but practically any type will suffice for this purpose and undoubtedly those used in TV for line or field stabilisation will do. However, it is always necessary to match the VDR to R1 and R2, that is if tests indicate that the particular VDR to hand has a high impedance, so should the resistors and vice versa. Obviously if it was thought desirable to treble the value of these components it would be necessary also to treble the value of R3 if the same percentage of feedback was required.

Altogether this circuit offers many opportunities for experiment and by including a switch in the lead to the VDR normal non-expanded results can be readily obtained and contrasted with the modified output.

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**Micro to Mega**

—continued from page 43

the right introduces a negative index. Thus 0.003 is 3×10⁻³ and 7.45 is 7.45×10⁻².

**More about Roots**

From the general expression (aⁿ)ᵇ = aⁿᵇ it will be seen that to find the square root of 10ⁿ, the x is divided by 2. Similarly to find the cube root, divide by 3.

One very important consideration in finding roots however. The result of dividing the index by the root divisor must be a whole number and any remainder must be considered separately as shown in the following examples:

\[ \sqrt{10^6} = 10^{6/2} = 10^3 \times \sqrt{10} \]

\[ a^{1/3} = 10^{6/3} = 10^2 \times \sqrt[3]{100} \]

**Examples**

The following examples show simple calculations involving Ohms Law for d.c.

1. \( R = 2k\Omega; E = 300V. \)
   \[ I = \frac{300}{2 \times 10^3} = 150 \times 10^{-3} = 150mA. \]

2. \( E = 9V; \ I = 300mA. \)
   \[ R = \frac{9}{300 \times 10^{-3}} = 3 \times 10^2 \times \frac{1}{10^{-3}} = 3 \times 10^1 = 30\Omega. \]

A typical example of a calculation involving a square root is that for determining the resonant frequency of a tuned circuit:

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

if \( L = 7.8\mu H \) and \( C = 100pF \)

\[ f = \frac{2\pi\sqrt{7.8 \times 10^{-4} \times 100 \times 10^{-12}}}{1} = \frac{2\pi \sqrt{7.8}}{1 \times 10^{-6}} \times \frac{1}{10^6} = \frac{2\pi \times 0.057 \times 10^6}{17.55} \approx 5.7 \times 10^6 = 5.7\text{Mc/s}. \]

**Further Uses of Indices**

Multiplying base numbers by adding the indices is similar to the multiplication of numbers by adding the logarithms. This parallel is not without justification, for the common logarithm of a number \( N = 10^x \) is \( x \), i.e. if \( 10^x = N \) then \( x = \log_{10} N \).

Therefore \( \log 10 = 1, \log 100 = 2, \log 1,000 = 3 \) etc.

This principle is extended further to produce the slide rule, which in fact is only an adding device whereby logarithms are added together, the scales being logarithmic.

**Footnote**

A world of warning about the nomenclature of numbers. The term "million" is readily understood as being 10⁶, but there is sometimes confusion about the word "billion". A billion is, strictly speaking, 10⁹ although it is sometimes erroneously attributed the value 10⁶.
An ELECTRONIC GATE or TRACE DOUBLER

(Continued from page 1081 April)

The power supply requirements are quite modest and many oscilloscopes should be able to provide them without undue strain. There is no reason, however, why an integral power supply should not be incorporated, though this will almost certainly necessitate an increase in the size of the equipment plus, of course, some provision for ventilation, which was not found necessary in the present equipment, which generates very little heat. Where an external power supply, from the oscilloscope or otherwise, is used, thorough decoupling by means of C18, C19, R16 is essential, otherwise there is a very real danger of the high-amplitude gating waveform interacting with the ancillary equipment or with the oscilloscope’s vertical amplifier. It will be noted that two decoupling capacitors, C18 and C19, are used. This is desirable because high value electrolytics have an appreciable self-inductance which renders them less effective at higher frequencies. C19, being a paper component, is less affected and so continues decoupling where C18 leaves off. Some paper capacitors are marked with a band at one end. This is the outer foil and should be connected to chassis.

The gate operated satisfactorily at varying h.t. voltages, these extending from 150V to 350V. At the lower voltages the output was necessarily restricted, whilst the higher voltages only increased the current consumption, so that an arbitrary value of 250V was selected. This was a convenient value because it allowed a measure of decoupling to be effected from the oscilloscope’s h.t. voltage of 270V. The extra 20V was dropped by a 1kΩ 2W resistor R16 which may require some adjustment for differing h.t. voltages.

The metal work is quite straightforward and calls for little comment. The sides are made of aluminium and are 3in. x 5in., whilst the bottom is a piece of aluminium 5in. x 8in. The cover, which is U-shaped, measures 5in. deep x 3in, high x 8in, wide and is best made up after the front and rear panels are made up and joined together by the side pieces. Any errors or alterations can then be allowed for. It must also be borne in mind that components other than those specified may not fit in the available space. The potentiometers and S2 must not exceed 1¼in. diameter and the chassis must be spaced sufficiently far from the front panel to allow the valves to be easily removed or replaced. In the prototype a spacing of 2¼in. was found to be adequate. The front and rear panels and the chassis are attached to the sides by ¼ in. c/s 6BA screws (and nuts), which then allows the cover to fit snugly all round. This and the bottom are attached to the front and rear panels by small self-tapping screws, producing a strong and rigid assembly. In the prototype the chassis and front and rear panels were screwed to the sides, the bottom was screwed on and then the remaining edges of the panel were masked off, after which they were sprayed glossy black enamel. The top cover was sprayed black crackle after the inside edges were masked off. All mating surfaces must be free from paint so that the electrical continuity necessary for preserving electrical screening can be maintained.

Small transfers on the front and rear panels complete the “finishing” of a very presentable little piece of equipment. Note that the “separation” control has been labelled “trace height”. This was resorted to after it was found that the transfers did not include “separation” and attempts to make the word up from individual letters proved a dismal failure—except possibly as an exercise in time wasting!

The operation known as “wiring up” should not provide any difficulty to the experienced constructor, though the novice would be well advised to enlist the aid of an experienced friend, particularly when trying the gate out for the first time. A few notes, however, would not come amiss. C11 and C12 must be of small physical size in order to fit into the available space; 200V components, as suggested, should prove suitable, though it is undesirable to reduce their capacity any further unless R5, R6 are increased in proportion to a maximum value of 10MΩ.

Gating Capacitors

The gating speed capacitors C1-C5 and C6-9 are wired in series from tag to tag of S2a/b, whilst C5 and C10 go from the second last tags of both sections to pins 1 and 6 of V1. The switch S1 is wired so that the slowest speeds are obtained with the switch anti-clockwise looking from the front and the highest speeds with the switch rotating clockwise. The last position is connected to earth and puts the multi out of action, though two 47pF capacitors could be substituted if higher gating speeds were desired. This is an experimental suggestion which has not been tried with the prototype. The outputs from both halves of V4 are connected directly to the output sockets without the usual coupling capacitors since these are already in the oscilloscope. C15 and C16 are wired directly from the input sockets to S2 and are spaced away from the chassis. C14 and C17 are wired from
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the input sockets to VR2 and VR3 and should be pushed into their respective corners to minimise cross-coupling both mutual and with V4. It is desirable for each stage to have its own earthing point. R1, R2 and the two cathodes of V1 are connected to an earth tag adjacent to V1, to which is also connected the wiper of VR1. R5, R6 are earthed to a tag adjacent to V2, whilst the earthy ends of VR2 and VR3 are connected to a tag adjacent to V3. The centre spigots of V1, V3 and V4 are earthed to their adjacent tags, that of V2 being used as an h.t. tie point. This is contrary to commonly accepted practice and was adopted as a convenient way of wiring the various resistors that connect to the h.t. line. R7 is a 1.5 or 2W component and is spaced away from the other components in order that it may safely dissipate its heat. R11, R12 and R13 are connected end-on to the valveholder so that they point towards the sig. o/p socket to which their junction is connected. On the rear panel wiring C18 is held by a clip and has C19 wired across it. The earthy ends of both should be connected to an earth tag on the main chassis. R16, which generates some heat, should be connected between the live end of C18, C19 and a stand-off tag and spaced away from other adjacent components.

The wiring when completed should be checked over for mistakes (we all make them sometimes!) and the gate can then be tried out. The static voltages should be measured with a 20k/V meter and should agree reasonably closely with those given on the circuit. The voltages on V1 anodes were measured with VR1 at its central position and with S1 at the 1,750c/s position. All other voltages were measured with S1 at “off”. At no time was an external signal fed into the Y1 and Y2 input sockets. The gating square wave should be checked on the oscilloscope and should appear to be reasonably square. Some sag at the 50c/s position and some rounding off at 5kc/s may be evident but is not worth worrying about unless it is really severe. If the square wave does sag or round off to an excessive extent the oscilloscope can also be suspect unless it is known to have a first-class transient response. Rotating VR1 should cause the positive and negative peaks to transpose, the output being at or near zero

Above—25kc/s square wave, rise time 2μS. Lower trace, ditto reproduced at 1W by a 1OW amplifier

Below—200kc/s sine wave fed into both inputs. Gating speed 17kc/s approx.

with VR1 at its mid position. The fact that VR1 is at its mid position for this check shows that the two halves of V2 and V3 are reasonably equal in respect of gain.

If all seems in order the gate can be checked for correct operation. In order to do so the gate’s output should be coupled to the oscilloscope input using a short length of coaxial and not ordinary screened wire which has an excessive shunt capacity. The sync o/p should be connected to the “ext sync” input of the oscilloscope. For preliminary tests it is convenient to temporarily connect the Y1 and Y2 inputs in parallel, thereby feeding the same signal to both. This signal should be of fixed frequency and amplitude since this type is the easiest to display. It is most undesirable to experiment with varying or different input signals until some familiarity with the gate’s modus operandi has been gained, for too many inputs, particularly those varying in frequency or amplitude or both, such as an audio signal, will only tend to confuse.

The oscilloscope’s Y amplifier should be set for maximum sensitivity and the timebase adjusted to display a few complete cycles of the input signal. The Y1 and Y2 gain controls can be adjusted as necessary. By setting the oscilloscope’s vertical amplifier at its most sensitive position the chances of overloading the gate’s amplifier stage is avoided and, also, the separation control need not be used at the ends of its travel, thereby avoiding any possibility of introducing any distortion into the signal due to excessive over or under biasing. Rotating the separation control should cause the two traces to separate, to merge and to transpose without any distortion being evident. If it is the gate should be bypassed and the signal examined directly on the oscilloscope. The effect of the different gating speeds should be noted and then different inputs can be tried, S2 being used to select the input that provides the best sync. If a steady image is difficult to obtain it may be due to it having a direct harmonic relationship to the gating speed and a different gating speed should be tried.

The amount of advice that can be put into print is of necessity limited, whereas careful experiments on the part of the user are not. The operation of the gate is by no means difficult, though it may appear so to the novice. Obviously familiarity with an ordinary oscilloscope is of inestimable value, for then the gate is but an extension of it.
THERE used to be a fellow down our street who could never put a finger wrong. He was always in demand. Replacing washers, knocking up pelmets, changing tyres or gaskets, putting in windows; from electric bells to herbaceous borders, it was all the same to Mr. B.

He called at the shack to borrow a file, just as I was in the middle of a ticklish piece of amplifier building. "Your fuses—cor!" said Mr. B expressively.

Now it isn't that Henry cannot tackle a blown house-fuse. My wife had called in Mr. B to help with the constructional aspect—replugging the wall. Somehow, when Henry gets hold of a hammer the theory of Relativity takes a twist. I am happier with a soldering iron.

In fact, I was wielding that familiar instrument as Mr. B leaned against the shack door, scraping at the blade of his grub screwdriver. He watched my clumsy efforts for a while.

"Why don't you use a clothes-peg to clamp those bits together?" he asked. "Easier than burning your fingers," he added, as I sucked.

Like all the exasperating Mr. B types, he was quite right. Henry just hadn't thought about the simple expedient. Another case of Shute's Mr Honey and the dishmop. Yet Mr. Honey, faced with the prospect of having to resign from aeronautical research at Farnborough, had been sure of a job at the National Physical Laboratory.

Makes one wonder how many of these industrial computerised assemblies, with their sophisticated servo devices, could be supplanted by a part-time Mr. B, with Ready Reckoner in the back pocket of his overalls, and pencil stub behind his ear. Perhaps the boffins had not thought of the obvious.

A little while ago, the Automonomics Division of the N.P.L. told us that pattern recognition machines were still a long way short of the ability of the human eye. To quote: "The outstanding performance of the human brain underlines the gap between nature and cybernatic artefacts."

Well, our Mr. B wouldn't know a cybernatic artefact from a wooden leg! But even he could tell at a glance that Auntie Maud's postcard was all the Mephisto crossword can take. And her arthritis really meant she would not be coming to babysit next Friday—which is more than any computer could do, despite all its epitaxical semi-planar micro-module flip-chips.

It all comes down to practical know-how in the end. Down to Mr. B with his odd bits of wire and a dash of ingenuity. Soft-landings on the moon are one thing, but without some equivalent Comrade B-ski to polish the old solar cells, Lunik IX would hardly have got so far as a lift-off.

What I am getting at—hold your seats, lads. Henry is approaching the point—is that there will always be room for the capable technician. No matter how complex the design conception, some cost-conscious manufacturer is going to build in a few faults with his flap-happy printed boards and haystack-wired components.

In a recent review of a very expensive tape recorder, the remark was made that had it not been for the outstanding performance the machine would have been returned to the maker on account of its atrocious construction. Performance, for how long, Henry would like to ask?

One of our esteemed contemporaries has bemoaned the shortage of "skilled labour" coming forward to answer the adverts of some electronics giants. May we suggest they are aiming too high. Instead of recruiting graduates to refine even more sophisticated hardware, flashing their sliderules for brief spasms, then sitting over the Mephisto crossword while they wait for Mr. B to mend the fuses, we suggest they advertise in these pages for a few "practical types" with enough working knowledge of electronics to take the mysteries within those magic black boxes in their stride!
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THE Verulam Amateur Radio Club came into being towards the end of 1961 when a short wave listener, Brian Cockell, conscientiously, worked through the R.S.G.B. call book, extracted the names of and addresses of some 100 local “Hams” and wrote to each one individually inviting them to a rendezvous at the “Red Lion”, St. Albans, with the object of forming an amateur radio club, and partaking of wine in the process.

His efforts were most successful and a committee was duly elected under the steadying hand of C. F. Thomas, G3EKU, whose connection with radio goes back to World War 1, while at one stage he held an Artificial Aerial licence and was connected with airships. The Club membership, which is steadily rising, includes some 36 licensed operators. Meetings are monthly at Hedley Road, St. Albans, where visitors are always welcome and a quick word with the Secretary G3PAO, 6, Leggatts Wood Avenue, Watford, Herts. (WATford 25526) will bring full details.

Club finances are under the watchful eye of our lady treasurer Miss P. Connelly who incidentally is also licensed. Her “stirling” efforts include creeping across a dark meadow last year at three in the morning to operate in V.H.F. Field Day.

The Club’s “newspaper” consists of a monthly news sheet sent to all members, edited by G3LXP and dispatched piping hot from the press by our “printer” Wilf Whitehouse G3SKB.

A regular feature is the Club “Owls Net” on 1980kc/s, Saturdays. This usually starts up about 10.30 p.m. with everybody “having to cut it short tonight”, and finishing with a final ragchew around 2.0 a.m.

Most contests are entered including N.F.D. V.H.F.N.F.D., M.C.C., etc. Last year a small group of keen types went on safari to nearby Salisbury Hall to rig up a station and take part in the Top

Two hours to go and the coax on the Cubical Quad comes adrift, one of the many incidents on NFD.

Affiliated Societies Contest last year. Logging G3LXP, on the key G3JDG. Gear, “LXP” 10 watt Tx, s.w.r. bridge, Z match, B88A.

Continued on page 66
Oscillator Circuitry

R. Leyland

3 - A.F. Oscillator Networks

The only kind of waves that can pass through phase-shifting networks without distortion are sine waves. However, changes do take place in their amplitude and phase. The output wave is usually smaller in amplitude and shifted out of synchronism by a fraction of a cycle, or so many degrees.

It is convenient to represent a sine wave by an arrow called a complexor. The length of the arrow (see Fig. 1) is the peak amplitude of the wave, and by turning the arrow through the corresponding angle, the level at any other point of the wave is obtained.

Fig. 1: Method of representing the attenuation and phase shift of a sine wave by means of a complexor diagram.

Fig. 2: The frequency responses of (a) high pass; (b) low pass networks.

A vertical complexor represents the input to the network, and another tilted complexor, shorter in length, represents the output. The angle between them is the amount of phase shift.

There is no phase shift in a network containing only resistance, but a capacitor stores and releases energy, and this causes its current to lead the voltage by 90°. When the current from a capacitor passes through a resistance, the voltage across the resistor will be 90° ahead of the voltage across the capacitor. If, as in Fig. 2(a), the output is from across the resistor, it will lead the input voltage, although by less than 90°. On the other hand, if the output is from across the capacitor, the output voltage will lag on the input.

Frequency Response

The actual amount by which the output voltage wave is shifted relative to the input depends upon the frequency and, in many types of network, phase shift is accompanied by attenuation; i.e. as the phase shift increases, the output becomes smaller. The vertical arrow or complexor representing the input remains the same, but as the frequency is varied, the other complexor representing the output swings to a new phase angle and also changes in length.

In so doing, it will trace out a path or locus depending upon the type of network. Quite often the locus is circular, although in the case of the simpler networks (Fig. 2), only a semi-circle.

In the diagrams, the locus curve, dotted, shows how the alternating voltage of the output terminal marked S changes as the frequency is varied. At the points on the locus corresponding to a series of frequencies, the complexor is drawn in, giving the magnitude and phase of the output at these frequencies.

It will be noticed that the frequencies are shown as half, twice, etc., of a special frequency, \( f_1 \), which can be calculated from the values chosen for \( R \) and \( C \). The value of \( f_1 \) can be altered without changing the impedance of the circuit at \( f_1 \) by multiplying only the capacitance values, since this leaves the reactances unchanged. In the formula \( C \) is in farads,
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Alternatively, the impedance of any of these circuits can be altered without changing \( f_i \) if the capacitances are multiplied by the same number used to divide the resistance values, e.g., to double the circuit impedance, leaving \( f_i \) unaltered, double the resistances and halve the capacitances.

Resistors are made in preferred values, and will not give a required frequency exactly. This accounts for the frequencies 1061 c/s, 1160 c/s, 1181 c/s in the diagrams, which are the nearest to 1000 c/s using fixed resistors.

Once component values have been chosen, a locus diagram for the network will show how the output varies with frequency above and below \( f_i \). What this special frequency is can be seen from the diagram, e.g. in Fig. 2, \( f_i \) is the frequency at which the output is 70% of the input, and the phase shift is 45°. Capacitive reactance decreases with frequency, so in (a) the phase shift and attenuation are greatest at low frequencies, while in (b) phase shift and attenuation are greatest at high frequencies.

Notice how as the phase shift increases to 90° the output decreases to zero. We thus have a complete picture of the response of the circuit for different frequencies.

**Constant Output**

It can be seen that although the circuits of Fig. 2 have a semi-circular locus, in both the output varies down to zero because the complexor radiates from the point Q. If the end of the complexor can be moved further up the diagram until the complexor becomes a radius as in Fig. 3, it will then be possible to vary the phase over a very wide range while keeping the output constant in amplitude.

All that is needed is a centre-tapped input voltage. For this we can use two equal resistors, or a centre-tapped transformer, but the most useful arrangement is probably a "phase splitter" using a valve or transistor. The circuit is shown in Fig. 3. The phase of course varies with frequency as before, and \( f_i \) is now the frequency of 90° phase shift. The output is constant and equal to the "input voltage" which is half the total applied voltage.

An important point is that the anode voltage of a valve is in antiphase to the grid voltage, while the cathode voltage is in phase with the grid. This reversal of phase means that for circuit (b) of Fig. 3, the locus diagram is turned through 180°, so that the output is lagging the input instead of leading as with circuit (a). Grid (or cathode) potential is in antiphase to anode potential (referred to point T as zero potential). Both are additive across the phase-shifting circuit.

In this arrangement the phase can be varied by changing the value of R and C, and the output will remain constant, providing the values of RL are low so that no appreciable change in loading occurs. Two such circuits in cascade can give an overall phase-shift of 180° and this can form the basis of a very satisfactory type of a.f. oscillator.

**Ladder Networks**

To produce this phase shift of 180° by means of a ladder network requires three sections. The locus diagrams (Fig. 4) of ladder networks consisting of equal resistances and equal capacitances are not quite
circular in shape. Because the network has three sections, the locus curves into the third quadrant, reaching zero at 270°.

The output at f₁, here the frequency of 180° phase shift, is almost too small to show on the diagrams since it is only 1/29th of the input voltage, but this does not prevent the network from being successfully used in an oscillator, providing there is a sufficient amplifier gain. Since a single valve or transistor gives a phase reversal in the usual arrangement, an oscillator using a single valve or transistor is possible with a ladder network.

The 180° phase shift of the network is cancelled out again by the phase reversal of the amplifying stage to give an overall phase shift of zero as is required for oscillation.

It should be noticed that with these ladder networks, the frequency is six times higher for shunt capacitances and series resistances than vice versa, assuming that the component values are the same in both circuits. This is why in Fig. 4 the series resistances in (b) for a frequency of roughly 1kc/s are six times as high as the shunt resistances in (a).

Used in a transistor oscillator, the frequency would be somewhat different owing to the loading effect of the transistor.

Zero Phase Shift
It only makes sense to employ a phase shifting network to produce zero phase shift when this is obtained at one particular frequency, which in an oscillator determines the frequency of oscillation.

A high-pass network produces a leading phase shift, while a low-pass network produces a phase lag. If we combine the two we might expect that at some frequency the two phase shifts would exactly cancel, making the effective phase shift zero.

This is in fact what happens in the three networks of Fig. 5, and the output also passes through a maximum at f₁, the frequency of zero phase shift, although this maximum is only one third of the input voltage. The output therefore is slightly peaked at f₁ which is at the top of the circular locus, this time a complete circle, but this peaking of the output is relatively unimportant.

What matters in a phase shift oscillator is the phase shift, which takes place with any variation of frequency about f₁, since oscillation can only be maintained at a frequency where the overall phase shift is zero.

The third of these circuits, Fig. 5 (c) is the most widely used. It is the Wien Network, but all three have the same frequency response, as shown in the locus diagram. At f₁ the phase shift is zero, so positive feedback applied through the network in an oscillator will produce oscillation at this frequency. Usually negative feedback is also applied, and this will alter the locus diagram, moving the end of the output complexor upwards from the point Q. This should increase the rate at which the phase angle changes with frequency variation, so making the circuit more effective.

The combination of positive and negative feedback forms a bridge circuit, and since there is zero phase shift at f₁ a balance or null at f₁ would be possible, as in a Wien Bridge for measuring purposes, but in

![Fig. 5: Three networks having the same "peaked" frequency response.](image)

![Fig. 6: Three networks with the same "valley" response.](image)
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an oscillator there must be an excess of positive feedback for oscillation, so the bridge must be unbalanced.

"Bridged-T" Networks

After mentioning the four-branch arrangements known as bridges, we now turn to circuits which are "bridged" in the more obvious sense of having one component connected like a bridge across two other components.

The output of the networks in Fig. 5 is from terminals SQ. If, instead, the output is taken from terminals SP, the three networks will re-arrange as shown in Fig. 6 where (a) and (b) are symmetrical "Bridged-T" arrangements. There is now a minimum at f1 instead of a maximum, because the original "peaked" output has been subtracted from the input to produce a "valley" response.

The re-arranged circuits also can be used in an oscillator, but are placed in a negative feedback path. As before, a surplus of positive feedback at f1 is needed to produce oscillation, and this has the effect of reversing the complexor in the locus diagram, so that conditions are virtually the same as when one of the original three networks of Fig. 5 is employed.

Many different types of a.f. oscillator are possible incorporating one or another of the phase-shifting networks described, as a substitute for an L-C tuned circuit. Tuned amplifiers and filters are also possible, and in these feedback is used to magnify the effect of the network, so that a more sharply peaked response to the signal input results than is depicted by the locus diagram.

Parallel-T Network

Another circuit of interest is the parallel-T network (Fig. 7). This can be described as a true null network because it is complete in itself and gives zero output at a particular frequency f1. In this circuit, unlike the previous ones, it is no longer possible to choose all the components alike in value, and certain ratios must be observed. The simplest arrangement makes the shunt impedances half of the series impedances.

The output follows a circular locus which has a diameter equal to the input. At the frequency f1 the output decreases right down to zero, so the arrangement is applicable as a filter. An output taken from terminals PQ instead, will be maximum at f1, and equal and in phase with the input.

Used in an oscillator the circuit requires less amplification than other arrangements, but is restricted to fixed frequency applications, because tuning would require a triple-ganged potentiometer with one section half the resistance of the others.

The full capabilities of all versions of this network are not obvious without a more complete analysis, and it appears that with different ratios one variation of the parallel-T network can produce oscillation from a single transistor.

All of the networks described have been voltage-transfer networks, but the corresponding current transfer networks are easily derived from them, and are often preferred for use in transistorised oscillators.

---continued from page 57---

CLUB SPOT

band Transatlantics. Armed with ten watts of s.s.b./c.w. and 300 feet of wire the net total for the night was some 50 cups of cocoa, 4lbs. of sausages and six contacts across the pond.

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A lecturer is in attendance most meetings either resident or visiting. A fortunate annual event is a visit from Mr. G. Turner of the GPO Engineering Dept., when TV1/BCI is the topic for the evening. Other lecturers in the past year have included Antennas (G3HRH), Working DX (G3AAZ), SSB (G3DZW), and Receiver alignment (J. Akim, Marconi Instruments).

Demonstrations have also proved very popular and have included some well-known names such as T. Withers (G3HGE), Vic Hartopp (J. Beams), and Green and Davis.

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