

THE **Radio Constructor**

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 18 NUMBER 1
A DATA PUBLICATION
TWO SHILLINGS & THREEPENCE

August 1964

Transistor Operated Anemometer



Cascade T.R.F.
Feeder Unit ★

High Frequency Converter
15 to 7.5 Metres

★ Aerial Preselector
for S.W. Receivers

★ Percussion/Sustain Circuits
for Electronic Organs

THE EDDYSTONE HIGH STABILITY AMATEUR BANDS COMMUNICATIONS RECEIVER



-the
**EA
12**

The Eddystone "EA12" receiver is specially designed and built to give the extremely high performance, allied with ease of control, necessary for communications on the amateur bands under present-day conditions. With the many refinements included, this model will produce first-class results with all modes of signal.

The first oscillator is crystal controlled. The oscillator, which is tuned simultaneously with the first intermediate frequency section, has very high stability, as is so essential with reception of s.s.b. and c.w. signals. The correct degrees of selectivity for optimum performance are obtained in the second intermediate frequency (100 kc/s) stages.

A more than adequate degree of bandspread is provided by the superb slow-motion drive (140/1 reduction ratio) in conjunction with the wide linear scales, each of which covers 600 kc/s. A crystal calibrator and cursor adjuster permit accurate frequency resolution.

Other features to note—full coverage on six amateur bands; switched sideband selection; fine tuning control (s.s.b.); crystal filter; deep slot filter; noise limiter effective all modes; large "S" meter; two AGC time-constants; independent gain controls; stand-by sensitivity control; bright scale illumination; robust construction; modern styling and fine finish.

£185

Comprehensive information obtainable from any Eddystone Distributor or from the Manufacturers:

STRATTON & CO. LTD. EDDYSTONE WORKS. BIRMINGHAM 31.

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LASKY'S RADIO

FOR THE FINEST RANGE OF TRANSISTOR RECEIVERS

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

THE SKYROVER AND THE SKYROVER DE LUXE

★ LONG WAVEBAND COVERAGE IS NOW AVAILABLE FOR THESE WELL-KNOWN SETS



THE SKYROVER

Controls: Waveband Selector, Volume Control with On/Off Switch, Tuning Control. In plastic cabinet, size 10" x 6 1/2" x 3 1/2", with metal trim and carrying handle.

Can now be built for **£8.19.6**
P. and P. 5/- extra

A simple additional circuit provides coverage of the 1100/1950 M. band (including 1500 M. Light programme). This is in addition to all existing Medium and Short wavebands. All necessary components with construction data. **Only 10/- extra Post Free**. This conversion is suitable for both models that have already been constructed.

GENERAL SPECIFICATION. 7 transistor plus 2 diode superhet, 6 waveband portable receiver. Operating from four 1.5V torch batteries. The SKYROVER and SKYROVER DE LUXE cover the full medium waveband and short waveband 31-94 M, and also 4 separate switched band-spread ranges, 13 M, 16 M, 19 M and 25 M, with band-spread tuning for accurate station selection. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our easy to follow, stage by stage instructions.

SPECIFICATION: Superhet, 470 kc/s. All Mullard transistors and diode. Uses 4 U2 batteries. 5" Ceramic Magnet P.M. Speaker. Easy to read Dial Scale. Band-Spread Tuning. 500mW Output. Telescopic Aerial and Ferrite Rod Aerial.

WAVEBAND COVERAGE: 180-576 M, 31-94 M, and band-spread on 13, 16, 19 and 25 metre bands. All components available separately. Four U2 batteries 3/4 extra. Data for each receiver, 2/6 extra, refunded if you purchase the parcel.

THE SKYROVER DE LUXE

Tone Control circuit is incorporated, with separate Tone Control in addition to Volume Control, Tuning Control and Waveband Selector. In a wood cabinet, size 11 1/2" x 6 1/2" x 3", covered with a washable material, with plastic trim and carrying handle. Also car aerial socket fitted.

Can now be built for **£10.19.6**
P. and P. 5/- extra



REALISTIC SEVEN

★ 7-transistor Superhet. ★ 350 milliwatt output into 4" high flux speaker. ★ All components mounted on a single printed circuit board, size 5 1/2" x 5 1/2" in one complete assembly.

★ Plastic cabinet with carrying handle, size 7" x 10" x 3 1/2", available in Blue/Grey or all Grey. ★ Easy to read Dial. ★ External socket for car aerial. ★ I.F. frequency 470 kc/s. ★ Ferrite rod internal aerial. Operates from PP9 or similar battery. ★ Full comprehensive data supplied with each receiver. ★ All coils and I.F.s, etc., fully wound ready for immediate assembly.

An Outstanding Receiver. **LASKY'S PRICE** for the complete parcel including Transistors, Cabinet, Speaker, etc., and Full Construction Data. Can be built for: **£5.19.6**

P. and P. 4/6
PP9 Battery, 3/9. Data and instructions separately, 2/6. Refunded if you purchase the parcel.



REALISTIC 'Seven' De Luxe

With the same specification as standard model —PLUS a superior wood cabinet in contemporary styling. ALSO a full vision circular dial

FOR ONLY **£1** EXTRA
P. & P. as std. model

LAFAYETTE TAPE

Famous American Brand—Fully Guaranteed at record low prices. In sealed cartons.

5in double play, 1,200ft. Mylar base ...	15/-
5in long play, 900ft. Acetate base ...	10/-
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3in message tape, 225ft. ...	4/11
3in message tape, 300ft. ...	7/6
3in triple play, 450ft. Mylar base ...	12/6
4in triple play, 900ft. Mylar base ...	22/6
5 1/2in triple play, 1,800ft. Mylar base ...	42/6
5 1/2in triple play, 2,400ft. Mylar base ...	55/-
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P. & P. 1/- extra per reel; 4 reels and over Post Free

HI-FI TAPE RECORDER HEADS

High Impedance Record Play. Low impedance erase. Upper or lower track.

LASKY'S PRICE 29/6 Post free per pair. State track required when ordering.

MARRIOTT "X" Type 1/2 track heads. Record/Play and Erase.

LASKY'S PRICE 4 GNS. PAIR
1/2-Track heads Record/Play and Erase 59/6 pair.

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All New and Guaranteed
GET.51, GET.55, GET.56—2/6; 837A, 874P—3/6; OC.45, OC.71, OC.81D—4/6; OC.44, OC.40, OC.76, OC.81 (matched pair 10/6)—5/6; AF.117, OC.75, OC.171, OC.200—6/6; OC.42, OC.43, OC.73, OC.82D—7/6; OCP.71—9/6; OC.28, OC.201, OC.204—13/-; OC.205, OC.206—19/6; OC.28—24/6.

READY BUILT BARGAINS

BOY'S TRANSISTOR RADIO



Ready built, 2-transistor pocket radio. In attractive plastic case. Size only 4" x 2 1/2" x 1". Fitted with 2 1/2" loudspeaker. Socket for personal earpiece and telescopic aerial. Works from single PP3-type battery. Fully tunable over full Medium waveband. Supplied complete with earpiece, telescopic aerial, carrying purse and 9 volt battery. Ideal Birthday Present.

LASKY'S PRICE 39/6

with all accessories. Post Free.

6-TRANSISTOR POCKET RADIO
Fully built, 4" x 2 1/2" x 1", with 2 1/2" speaker. Uses single PP3-type battery. Supplied complete with personal earpiece and leather case. Tunable over full Medium waveband.

LASKY'S PRICE 69/6

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TRANSISTERS by BRUSH CRYSTAL CO.

TO-01B 465 kc/s ± 2 kc/s
TO-01D 470 kc/s ± 2 kc/s
TO-02B 465 kc/s ± 1 kc/s
TO-02D 470 kc/s ± 1 kc/s
TF-01B 465 kc/s ± 2 kc/s
TF-01D 470 kc/s ± 2 kc/s

6/6 each
P. & P. 6d.

GUITAR PICK-UP

Crystal—high imp. Size only 1 1/2" x 3/4" x 1/4". Clips to fingerboard—no screws. Complete with cable.

LASKY'S PRICE 15/11 P. & P. 1/-

TAPE POSITION INDICATOR

Open type—as used by most makers. With reset knob:
3 DIGIT 7/6; 4 DIGIT 10/6. P. & P. 9d. on each.

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A portable battery operated fully transistorised Record Player—for the music of your choice—any time, any place!
Made by a leading British manufacturer, fully guaranteed.
Size only 6 1/2" x 12" x 10 1/2". Weight 10lb.
Operates on 6 U2 torch batteries. 4 speeds—16 2/3, 33 1/3, 45 and 78 r.p.m. Goldring Sygnet record player unit with lightweight pick-up fitted with CM-60 turn over ceramic cartridge. Output 500mW to 5" ceramic magnet loudspeaker fitted into lid for maximum sound distribution. Cabinet constructed of wood, covered in two-tone (pale blue/grey) leather cloth, fitted carrying handle and strong lid catches. High quality amplifier with tone and vol. controls gives excellent reproduction at all speeds. Plays 7", 10" and 12" records. Today's value 12 Gns.



LASKY'S PRICE £6.19.6 Carr. & Ins. 7/6

New, boxed and guaranteed—Exc. batts.

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Motors for the Collaro Studio Deck—new and unused, 200-150V A.C. Take-up and rewind. Listed at £2.5s. each. **LASKY'S PRICE 14/11** each. P. & P. 2/6.



State motor required when ordering.

High quality tape deck capstan motor made by E.M.J. Holland. Bi-directional. Size: 4" dia., x 2" high. 1" x 1/2" spindle. **LASKY'S PRICE 19/11**. P. & P. 3/6.

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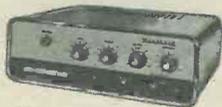
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HI-FI AMPLIFIERS — TUNERS — RECORD PLAYERS

S-33



S-99



AT-6



MA-12



HI-FI 6W STEREO AMPLIFIER. Model S-33. 3 watts per channel 0.3% distortion at 2.5W/chnl., 20dB N.F.B. Inputs for Radio (or Tape) and Gram, Stereo or Monaural, ganged controls. Kit **£13.76** Assembled **£18.18.0**

DE LUXE STEREO AMPLIFIER. Model S-33H. De luxe version of the S-33 with two-tone grey perspex panel, and higher sensitivity necessary to accept the Decca Deram pick-up. Kit **£15.17.6** Assembled **£21.7.6**

HI-FI STEREO AMPLIFIER. Model S-99. 18W output. Ganged controls. Stereo/Mono gram., radio and tape inputs. Push-button selection. Printed circuit construction. Kit **£27.19.6** Assembled **£37.19.6**

POWER SUPPLY UNIT. Model MGP-1. Input 100/120V, 200/250V. 40-60 c/s. Output 6.3V, 2.5A A.C. 200, 250, 270V, 120mA max. D.C. Kit **£5.2.6** Assembled **£6.12.6**

A wide range of American equipment available under direct mail order scheme. Full details and catalogue 1/- post paid.

GOLDRING Lenco TRANSCRIPTION PLAYER. Model GL-58. With G-60 pick-up arm and Ronette 105 cartridge. **£20.1.3**

GARRARD AUTO/RECORD PLAYER. Model AT-6. With R 105 cartridge. **£13.12.1** With Decca Deram pick-up **£14.6.1**

SUGDEN MOTOR UNIT "CONNOISSEUR CRAFTSMAN". Heavy duty motor operating at 33½ and 45 r.p.m. Very heavy 12" turntable. Virtually no rumble. **£17.2.11**

HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Presentation similar to S-33. Kit **£10.19.6** Assembled **£15.10.0**

HI-FI MONO AMPLIFIER. Model MA-12. 12W output, wide freq. range, low distortion. Kit **£11.18.0** Assembled **£15.18.0**



Enjoy Yourself and Save Money

FOR THE INSTRUMENTALIST



PA-1

PA AMPLIFIER PA-1. The ideal compact unit for VOCALISTS, INSTRUMENTALISTS, RECORDS, with 50 Watt output, 2 Heavy Duty Speakers. Variable TREMOLO. Elegant modern cabinet. Kit **£54.15.0** Assembled **£74.0.0**

Legs optional extra 17/6 set of 4

POWER AMPLIFIER MA-50. 50W output. Kit **£19.18.0** Assembled **£27.18.0**

ELECTRONIC ORGAN

(fully transistorised). Ideal for Soloists, Home use, Groups. FULL 20 WATTS VOLUME. **£187.10.0** Matching bench **£14.10.0** extra.

TRANSISTOR RADIOS

"OXFORD" LUXURY PORTABLE.

Model UKR-2. Specially designed for use as a domestic, car or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0**

TRANSISTOR PORTABLE. Model UKR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" x 4" loudspeaker. Real hide case. Kit **£12.11.0**

TRANSISTOR PORTABLE RECEIVER. Model RSW-1. In a handsome leather case, it has retractable whip aerial and socket for car radio use. Covers Med., Trawler and two S wave bands. Kit **£19.17.6**

JUNIOR TRANSISTOR RADIO. Model UJR-1. Single transistor set. Excellent introduction to radio. Kit **£2.7.6**



UKR-2



UKR-1



UJR-1

Money-back Guarantee

Daystrom Limited unconditionally guarantees that each Heathkit product assembled in accordance with our easy-to-understand instruction manual must meet our published specifications for performance or the purchase price will be cheerfully refunded.

TEST INSTRUMENTS



IO-12U



S-3U



C-3U

5" GENERAL-PURPOSE LABORATORY OSCILLOSCOPE. Model IO-12U. This outstanding oscilloscope, with its professional specification and styling, fulfills most laboratory and service requirements. Vertical frequency response 3 c/s to over 4.5Mc/s, sensitivity 10mV r.m.s. per cm. at 1 kc/s. T/B covers 10 c/s-500 kc/s. Kit **£32.12.6** Assembled **£41.10.0**

2½" PORTABLE SERVICE SCOPE. Model OS-1. This is a light, compact oscilloscope, ideal for servicing, etc. Dimensions 5"x8"x14½" long. Wt. 10½lb. Kit **£21.18.0** Assembled **£29.8.0**

ELECTRONIC SWITCH. Model S-3U (Oscilloscope Trace Doubler). Enables a single beam oscilloscope to give simultaneous traces of two separate and independent signals. Switching rates approx. 150, 500, 1,500, 5,000 and 15,000 c/s. Sig. freq. response 0-100 kc/s. ±1dB. Separate gain controls and sync. output. Sig. input range 0.1-1.8V r.m.s. Kit **£12.18.0** Assembled **£18.10.0**

AUDIO SIGNAL GENERATOR. Model AG-9U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0.1%, 10V sine wave output metered in volts and dB's. Kit **£22.10.0** Assembled **£30.10.0**

RESISTANCE/CAPACITANCE BRIDGE. Model C-3U. Measures capacity 10pF to 1,000µF, resistance 100Ω to 5MΩ and power factor. 5-450V test voltages. With safety switch. Kit **£10.10.0** Assembled **£16.0.0**

DE LUXE LARGE-SCALE VALVE VOLT-METER. Model IM-13U. Circuit and specification based on the well known model V-7A but with many worth-while refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern styling. Kit **£18.18.0** Assembled **£26.18.0**

CAPACITANCE METER. Model CM-1U. Direct-reading 44" scale. Full-scale ranges 0-100µF, 0-1,000µF 0-0.01µF and 0-0.1µF. Kit **£15.15.0** Assembled **£21.14.0**

VALVE VOLT-METER. Model V-7A. 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1Ω to 1,000MΩ with internal battery. D.c. input impedance 11MΩ. dB measurement, has centre-zero scale. Complete with test prods; lead and standardising battery. Kit **£13.18.6** Assembled **£19.18.6**

MULTIMETER. Model MM-1U. Ranges 0-1.5V to 1,500V a.c. and d.c.; 150µA to 15A d.c.; 0.2Ω to 20MΩ. 44" 50µA meter. Kit **£12.18.0** Assembled **£18.11.6**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics. Up to 100 mV output. Kit **£13.8.0** Assembled **£19.18.0**

A WIDE RANGE OF BOOKS ON ELECTRONICS AND RADIO AVAILABLE. SEND FOR LISTS OF PRICES



IM-13U



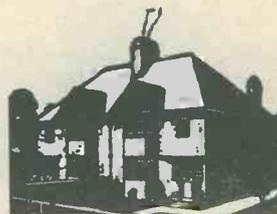
V-7A



RF-1U

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(If lady, please state Mrs. or Miss)

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Amateur Radio. By F. G. Rayer. 30s. Postage 1s.

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Wireless for Beginners. By G. L. Boltz. Revised by T. Roddam. 18s. Postage 9d.

Transistor Radios. Circuitry and Servicing by Mullard. 5s. Postage 6d.

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Guide to Broadcasting Stations. Compiled by "WW". 5s. Postage 6d.

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Dual-Standard and 625 Line Television Receivers. By G. J. King. 8s. 6d. Postage 6d.

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ABC's of Transistors. By G. B. Mann. 5s. Postage 8d.

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Read what constructors say about the Micro-6

PLAYS DOWN TUNNEL!

From Abbey Wood, London, S.E.2

"I think you may be interested to know that the Micro-6 will receive the Home Programme 20ft inside the north entrance to Blackwall Tunnel. Please find enclosed order and cheque for my 4th Micro-6." (Signed) D.B.P.

BUILT IN RECORD TIME!

From Coventry

"I am delighted with reception. Last night I was surprised to hear the Light Programme and Luxembourg. The volume of the Third Programme and Midland Home Service is such that the receiver must be turned on edge to ensure comfortable listening. Once more I must congratulate you on this excellent set which I put together with no trouble at all in less than an hour and a half." (Signed) J.L.P.

GOOD RECEPTION IN BRISTOL

"Was very pleased with the performance, the local stations coming in loud and clear with a fair sprinkling of foreign stations as well as including Luxembourg." (Signed) L.W.A.

"THE RADIO OF TOMORROW"

From London, S.W.16

"I have tried out the Micro-6 in trains, buses, taxis, cars, in offices and when walking in town. Its performance is incredible. After dark I have tuned in to Rome, Madrid, Lisbon, U.S.A. Forces, Warsaw and many others. Luxembourg is almost too strong. This really is a foretaste of the radio of tomorrow." (Signed) A.M.

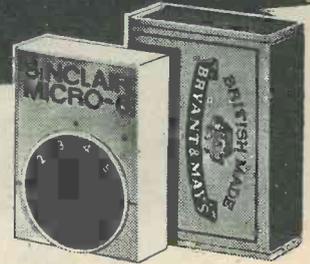
CHANGE OF ADDRESS

Demand for Sinclair products has grown so enormously that we have been obliged to move to bigger premises. With more space and staff, the delays experienced in the past by some customers will be no more. We offer them our apologies and assure them that Sinclair service is now back to its normal high level.

sinclair

PUT EUROPE IN YOUR POCKET WITH THE SMALLEST RADIO SET ON EARTH!

- ★ AN ALL-BRITISH DESIGN
- ★ WEIGHS LESS THAN 1 oz
- ★ ANYONE CAN BUILD IT IN A SINGLE EVENING
- ★ WITH BANDSPREAD TUNING FOR EASY RECEPTION OF LUXEMBOURG



When you have built your Micro-6, slip it into your pocket or on your wrist by means of the special "Transrista" strap available. No matter where you take your Micro-6 you will be staggered by its performance. In fact it will be so powerful and dependable, you will find yourself using and enjoying it more and more each day. After dark, as you tune by means of the unique vernier-type control, stations simply pour in from all over Europe, and with bandspread tuning at the high frequency end of the medium waveband, Luxembourg comes in like a local station. **THE SINCLAIR MICRO-6 IS A GREAT TRIUMPH OF BRITISH DESIGNING FAR AHEAD OF ANYTHING PRODUCED IN JAPAN, U.S.A., GERMANY OR ANYWHERE ELSE. IT MEASURES ONLY 1 4/5 x 1 3/10 x 1/2 in.**

"TRANSRISTA" nylon wrist strap with special fitting for holding Micro-6. Strongly made in black or grey nylon.

7/6 Mallory Mercury Cell Type ZM312 (2- required)

All parts including 8-page instructions manual and ear-piece come to

59/6

1/11



SINCLAIR RADIONICS LTD
COMBERTON, CAMBRIDGE

Telephone: COMBERTON 682

MICRO-6

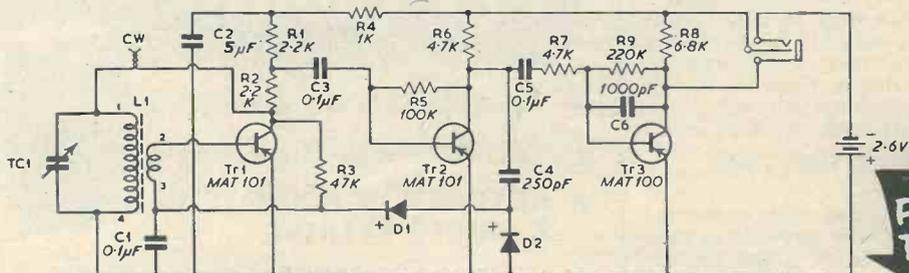
The Secret is in the Circuit See next pages

THE WORLD'S SMALLEST RADIO

6 STAGES FROM ONLY 3 TRANSISTORS

IN A CIRCUIT THAT ONLY UNIQUE M.A.Ts AND APPLIED RESEARCH MAKE POSSIBLE

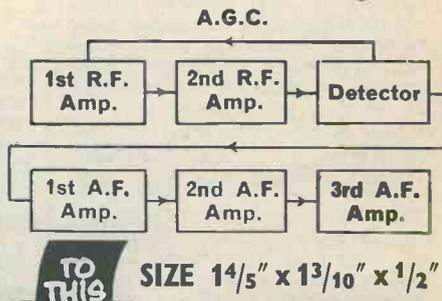
**MICRO-6
CIRCUIT AND
BLOCK
DIAGRAMS**



THE MOST ADVANCED RADIO CIRCUIT EVER MADE AVAILABLE TO CONSTRUCTORS

The Micro-6 uses three Micro-Alloy Transistors (MATs) in a unique double reflex circuit. The signal selected by L1 and TC1 is amplified at R.F. by Tr1 and Tr2. The output from Tr2 is rectified by the detector stage D1 and D2, and the resultant A.F. signal passed back to Tr1. Tr1 and Tr2 then amplify the signal again—this time at A.F. Thus both Tr1 and Tr2 have been used twice and give a gain normally only obtainable with four transistors. The output from Tr2 drives Tr3, the

output stage, which feeds into the featherweight ear piece (or the TR750 power amplifier). Tuning is over the medium waveband with bandspread for easy reception of Luxembourg and A.G.C. eliminates fading. It is important to realise that the Micro-Alloy Transistors which the Micro-6 uses not only give extremely high gains and low noise levels, but they consume only a fraction of a mA from the two minute batteries used to power the set. Battery working life is over 70 hours!



SIZE 1 4/5" x 1 3/10" x 1 1/2"

YOU CAN BUILD THIS SET IN AN EVENING!

No Special Tools or Skills Required

The Micro-6 is simplicity itself to build when you follow the meticulously detailed instructions. No special tools are required to build the set. All parts including transistors, diodes, elegant white and gold case, lightweight earpiece and 8-page manual come to

59 1/6

"Transista" strap for wearing your Micro-6 on the wrist. Black or grey nylon.

7 1/6

MALLORY MERCURY CELL — Type ZM312 (2 required) each
Pack of 6 10 1/6

1 1/11

SINCLAIR

MICRO-6

USE
THIS
ORDER
FORM

SINCLAIR RADIONICS LTD., COMBERTON, CAMBRIDGE

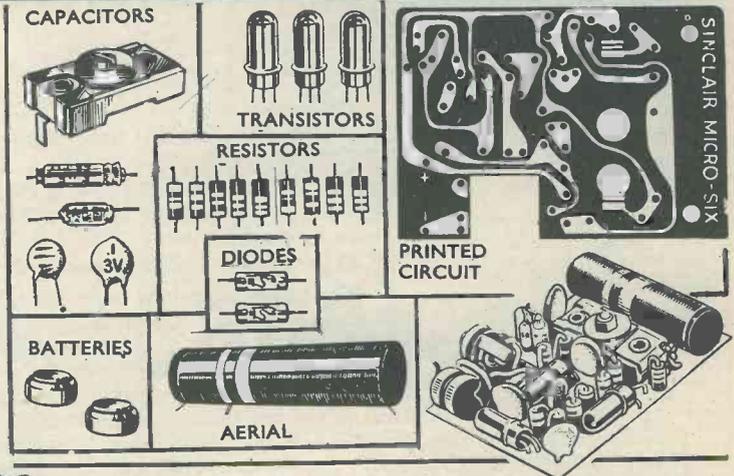
Telephone COMBERTON 682

..... AND IT'S BRITISH !

The MICRO-6 uses the smallest components ever

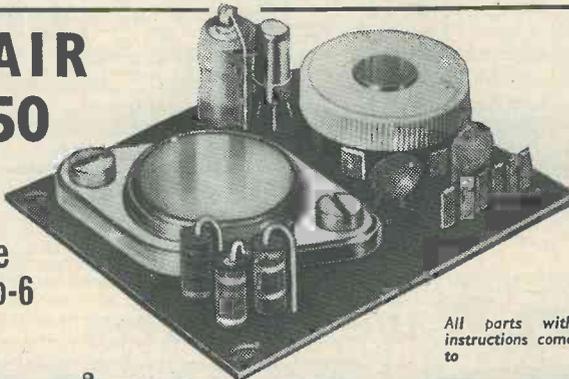
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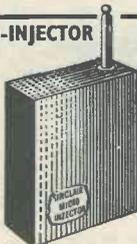
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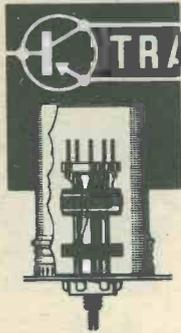
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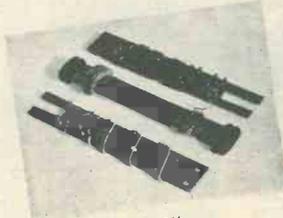
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TRC43	XT7	1/2 in. x 1/2 in. x 1 1/2 in.	455 kc. 3rd or detector IF, for use with above	6 0
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AUGUST 1964

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Combating Modulation Hum and Mains-borne Interference in FM Receivers

By J. BURGESS

THE EVER-INCREASING USE OF THE v.h.f. Band II for f.m. reception is making it possible for more and more people to receive radio programmes of a technical quality which compares favourably with, and in some cases better, the technical quality of the best sound available on disc. This in its turn means that it is now possible to record a programme from the radio using a tape recorder, which is within the financial reach of most enthusiasts, and obtain a final result which is comparable with good disc reproduction. The significance of this is that it is becoming ever more important to remove all forms of interference from the original signal. For example, a click from a switch, when recorded on a tape, has as much nuisance value as a scratch on a record. This article is written with the intention of providing readers with some ideas on how to remove the two major forms of annoyance inherent in the use of a v.h.f. set: modulation hum, and interference introduced through the mains power supply running the set.

Modulation Hum

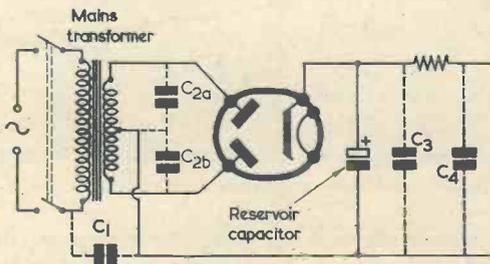
This is almost always introduced by the power pack of the tuner, a typical circuit for which is given in Fig. 1. Modulation hum can be easily recognised by the fact that it

only appears when a station is tuned in. In the regions between stations on the dial, there should be either no background at all or at most a rushing sound—certainly no hum. If there is hum between stations, this will be caused by a fault in the audio system, and it is necessary to check screening in the early stages of the amplifier and also the h.t. positive line for freedom from hum.

Having ascertained that the trouble is, indeed, modulation hum, a cure may be effected in the following manner. Referring to Fig. 1, capacitors of the tubular ceramic type should be wired in the positions shown, in the order given by the number of the component. C₁ should be tried first and so on. After each capacitor, in turn, has been wired into circuit, the set should be switched on and tried out. In many cases it will not be necessary to employ all the capacitors shown in Fig. 1, a cure being given by the first one or the first few fitted.*

*In a number of cases it may be possible to clear modulation hum by reversing the connections to the mains. A reliable earth connection to chassis can also be helpful. The capacitors in Fig. 1 should have a value of 0.01 μ F and a working voltage suitable for the application. To prevent the risk of shock, C₁ should have an a.c. rating of 250 working volts. Since C₁ will pass an appreciable alternating current which may be detectable if the chassis is touched, its inclusion makes it preferable to earth the chassis in any case.—EDITOR..

Fig. 1. Adding capacitors to the power supply circuit to remove modulation hum. If a half-wave secondary and metal rectifier are employed, C_{2b} is not required



The filter fitted in a tobacco tin

If when all the capacitors are wired in the hum persists, this means that it must be being introduced via the aerial circuit. The additional components required here are two more ceramic capacitors and a 6.8k Ω resistor. These are wired in as shown in Fig. 2. When connecting the capacitors into circuit, the lead-out wires should be kept as short and straight as possible in order to maintain the impedance of the wiring. The actual value of the capacitors is not critical, and may be between 1,000pF and 0.01 μ F.

If the hum persists after all these measures have been applied, then it is almost certainly being caused by something external to the set, appliances such as refrigerators, electric clocks, etc., are all capable of producing modulation hum, and fluorescent tubes are particularly prone to giving this trouble. If such an appliance is found to be the cause of the trouble, renewal of the suppressors (if fitted: if not, fit them!) should be sufficient to effect a complete cure.

Mains-borne Interference

Typical offenders giving rise to mains-borne interference include refrigerators, electric water-heating systems and indeed any equipment which incorporates some form of automatic switching. The first step to be taken, and one which in many cases will be sufficient, is to switch off all such appliances in the building and see if the interference stops. A process of elimination will then tell which appliance is causing the trouble, whereupon the simple cure is to replace the suppressors on this particular piece of equipment.

However, it quite often happens that the interference is not being generated in the building in which it is troublesome, and in this case it will be necessary to construct a mains filter unit to remove the high frequency transients from the mains supply before they reach the set. The circuit for the mains filters to be described here is given in Fig. 3. It will be seen that the circuit is closely similar to the type of smoothing circuit employed in power supplies; and indeed it is, apart from the values of the chokes and capacitors employed. In a power supply the undesired frequencies are of the order of hundreds of cycles per second, and so normally the value of the choke is something like 10 henries and the capacitors 10 to 50 μ F. In the case of the mains filter unit, the frequencies which it is desired to suppress are of the order of tens of megacycles per second and so the values of the choke and the capacitors can be much lower.

Construction of a filter unit will depend on individual tastes. Two possible methods will be described in detail, both of these having been found to be completely satisfactory and reliable.

When it is possible to incorporate a mains filter inside the power supply of the set, it can be built into an old i.f. transformer can of the larger type, and this may then be fixed to the chassis of the power supply in the usual manner, giving a safe and permanent mounting. The method of building the components into the case is shown in Fig. 4. The chokes are a single layer of 24 s.w.g. wire, closewound on a former which in the case of the prototype was an old 100k Ω 2 watt resistor. The number of turns is not critical, and it will be adequate to work to a minimum of 40 turns on a $\frac{1}{2}$ in former. The writer would put an upper limit of 120 on the number of turns required; above this figure the wire is being wasted. Two of the chokes are made and are mounted between the Paxolin sheets in the casing as shown. Often there are six holes in each sheet, and it is most convenient to have the chokes

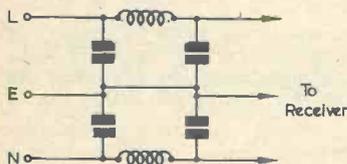


Fig. 3. The basic circuit of a filter which may be used to clear mains-borne interference

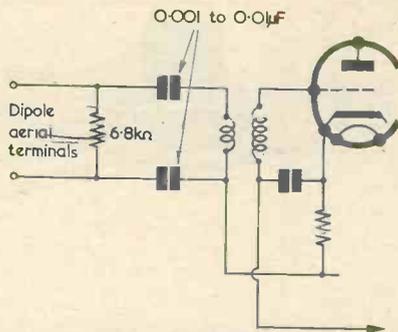


Fig. 2. Additional components in the aerial circuit

mounted at opposite corners. Thick wires (say 18 s.w.g.) are then taken from the ends of the chokes, through the holes at the other two corners of the insulating sheet, and back down to the base of the casing, see Fig. 4. These form the mains inlet leads. 18 s.w.g. wire is now run from the base of the casing, up through one of the remaining holes, across the

case, the chokes are wound on formers made from wooden dowelling, random winding with 24 s.w.g. double cotton covered wire being used in the original. The turns and former diameter required are the same as was specified for the chokes shown in Fig. 4. On one end of the former is fixed a small 4-way tag-board which serves to hold the cap-

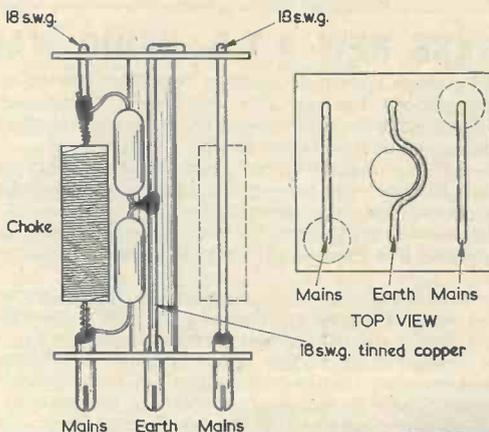


Fig. 4. The filter components may be conveniently fitted in an i.f. transformer can of the larger type

top of the sheet, and back to the base through the other hole. This forms the earth wire for the filter. The capacitors may now be mounted, remembering that it is more important that the wires be short than that the filter look neat and tidy. If the construction has been done carefully, it should be possible to fit the screening can on the assembly without causing any short circuits. The unit is now ready to be mounted on the chassis of the power supply. This is done in the usual way for i.f. transformers, taking care to keep the terminations well clear of the chassis.

When this method of construction is not practicable, either because of lack of space or lack of materials, the filter may be constructed as an independent unit inside a small box such as a 2oz tobacco tin. In this



A filter assembly ready for fitting in an i.f. transformer can

acitors. The formers are then mounted on to the sides of the tin by screwing through a hole in the metal. Alternatively, a long bolt may be used, serving the dual purpose of holding the tagboard to the former, and holding the former to the tin. The next stage in construction is to drill five holes in one of the short sides of the tin for the mains and earth wires. These are led out to a five-way terminal block, mounted on the side of the tin as shown in Fig. 5. The final stage is the wiring up. Again, short straight wires are more important than a clean appearance. The capacitors are mounted on the tagboards, two to each board. To finish the whole thing off, the tin may be painted matt black, which helps to disguise the identity of the case.

Conclusion

In conclusion, it must be said that while these measures will help the user to get the best from his f.m.

tuner, no amount of filtering of power supplies, decoupling of aeri- als and so on will help to remove what are quite often the basic sources of trouble, namely poor design or bad alignment. If modulation hum, and

more particularly interference, are still experienced even after all the measures described above have been taken, the only remedy is to have the set checked and accurately re-aligned.

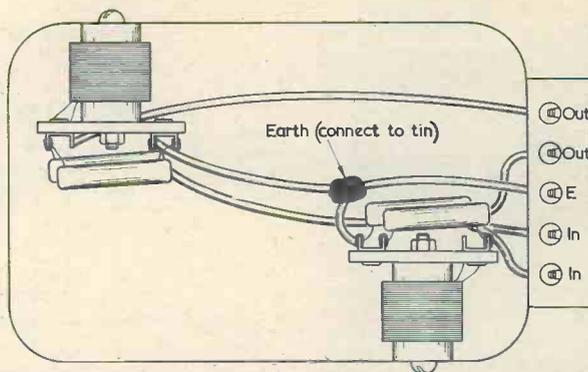


Fig. 5. An alternative method of mounting the filter components

SUN POWERS NEW A.T.E. RADIO WARNING SYSTEM

A solar-powered v.h.f. radio alarm system designed to broadcast instant warnings of power network failures, high water levels or other danger conditions, has been developed by British engineers for off-the-shelf delivery.

The warning system—believed to be the first commercial application in this country to make use of the sun's energy—is being manufactured by companies in the Plessey Group.

Even on the dull- est days, sufficient radiation penetrates the atmosphere to activate the highly-sensitive solar cells which keep the nickel-cadmium battery—the only power supply needed—fully charged. If a normal mains supply is available a battery charger can replace the solar converters.

The compact, fully-transistorised radio transmitter with its bank of solar converters can be easily mounted on top of remote high voltage transmission line towers or in similar exposed locations where normal power supplies are not available.

The instant a pre-determined danger point is reached, an alarm contact in the watch-dog system brings the transmitter into operation and warning signals are flashed to a central control point. In this way, life-saving seconds can often be saved where flood danger and other hazards strike unexpectedly.

The equipment has been developed by British Telecommunications Research Limited, a subsidiary of Automatic Telephone & Electric Company Limited, in collaboration with the Central Electricity Research Laboratories, Leatherhead.

Production of the equipment, likely to find ready markets in this country and overseas, has already begun at the Shropshire factory of A.T. & E. (Bridgnorth) Limited, another Plessey Group company.

In addition to electricity, gas and water undertakings, the warning system has widespread applications for the police, ambulance and fire services. Street corner push-button installations would eliminate the need for extensive cable laying and could send radio alarm signals direct to control centres or patrolling vehicles. Other possible applications include the signalling of river water levels, tide levels, and flood conditions for river boards and harbour authorities. It could also provide alarms on aircraft collision warning lights on high buildings, radio masts and high voltage line towers.

Known as the Type 68 system, the equipment has been designed to operate in conjunction with the v.h.f. radio control networks now operated by many public utilities. Use is normally made of the frequency allocated to the mobile-to-base channel of these networks, so that alarm facilities can be provided without the need for additional radio channels.

Particular attention has been given to developing a self-contained weatherproof equipment for use in all situations, over a wide temperature range especially those where remote unattended operation is required, so that maintenance visits are virtually eliminated.

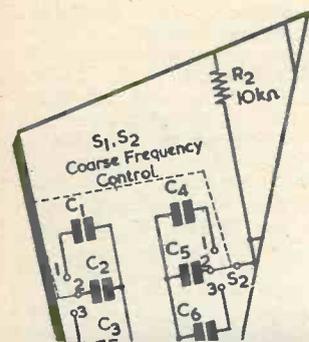
The Transmitter

The fully transistorised crystal-controlled transmitter is P.O. approved and operates in the 68–88 Mc/s band. It provides an output of approximately 200mW into a 75Ω load. It is expected that versions for high band (170 Mc/s) operation will be available later. Power supplies are obtained from a battery of sealed nickel cadmium cells within the transmitter case. A regulator circuit limits the potential to which this battery can rise, and by this means loss of electrolyte due to gassing is minimised.

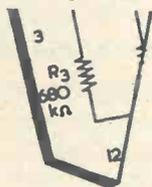
Operation

Closure of an external alarm contact or switch energises the transmitter, which radiates a signal to the base station in the form of "bursts" of audio tone modulated carrier. Alterations of the audio tone and the time interval between bursts allows for identification of one of a number of stations within a group, while the use of a modulated keyed carrier reduces interference with the normal speech from the mobiles.

The circuits presented in this series have been designed by G. A. French, specially for the enthusiast who needs only the circuit and essential data



suggested circuits



No. 165 Mains Transformer Memory Unit

IT HAS BECOME FASHIONABLE, OVER recent years, to refer to electronic devices as "black boxes" which present a number of terminals for external connection. The writer feels that it would be helpful to use the black box approach in introducing this month's Suggested Circuit also, since it emphasises more forcibly the functioning of the circuit. The object of the article is to demonstrate an attribute of a very common radio component which is, normally, completely ignored. Indeed, so far as the writer is aware, the manner in which the radio component is employed here represents rather a new technique; but it should be added that the principles involved are very well established.

The black box in which this month's circuit may be installed is fitted with two terminals and a continually illuminated pilot lamp. See Fig. 1. The lamp may only be extinguished by connecting an 18 volt battery to the terminals, but it is essential that the battery polarity be opposite to that given at its previous application.

Let us commence by connecting the battery to the black box such that its positive terminal connects to terminal A. According to the condition of the box (dependent, in its turn, upon battery polarity at the last application) the lamp will either remain illuminated or will extinguish. However, as soon as the battery is disconnected, a "memory unit" inside the box

"remembers" that this last application consisted of battery positive to terminal A. Any number of further applications of the battery with this polarity will not cause the lamp to extinguish because they do not meet the stipulation that polarity must be reversed from the previous application. If the battery is now reversed and re-applied so that battery negative connects to terminal A, the stipulation is satisfied and the lamp will go out, remaining extinguished until the battery is disconnected again. The black box "memory unit" now "remembers" this new state, and no amount of further applications with battery negative to terminal A will cause the lamp to extinguish. The lamp will only extinguish if the battery is again reversed and battery positive re-applied to terminal A. After which, the lamp will only extinguish if the battery polarity is reversed once more, and so on.

It will be seen that the black box contains a bistable circuit, which could, typically, be a bistable multivibrator. However, as shown in Fig. 2, the components actually installed consist only of two relays, the pilot lamp and a battery to light it, and an iron-cored inductor. This iron-cored inductor, which functions as the "memory unit", is the primary of a standard mains transformer!

Circuit Operation

To understand the operation of the circuit of Fig. 2 it is necessary

to consider the fact that, under certain conditions, it is possible for the laminations of a mains transformer to acquire a remanent magnetic field. This point may be demonstrated by the set-up shown in Fig. 3. In Fig. 3, the primary of a mains transformer is connected in series with a fixed resistor and a centre-zero milliammeter having an f.s.d. of 25mA. The resistor has a value which, in combination with the internal resistance of the transformer primary, limits the total possible current through the meter to some 10 to 25mA when a 1.5 volt cell is applied to the terminals. For most transformers likely to be encountered, the limiting resistor may have a value of 20Ω.

A 1.5 volt cell is initially connected to the terminals to set up the circuit and is then disconnected. It is next re-applied with the same polarity and the time taken for the meter needle to reach its final setting visually noted. The battery is then reversed and is connected to the terminals with opposite polarity. If the mains transformer exhibits the desired remanent magnetism property (a point which is discussed below) it will now be found that the movement of the milliammeter needle is slower, and that it takes a noticeably longer time to reach its final setting. If the cell is disconnected and re-applied with the same polarity the meter needle will, this time, rise with the previous rapidity. It will only exhibit the slower move-

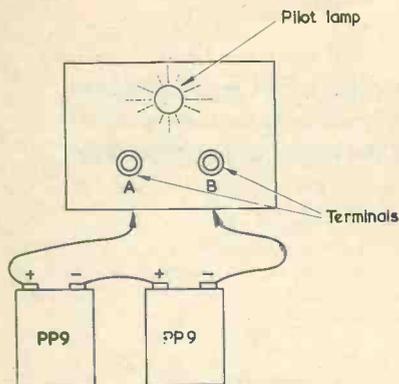


Fig. 1. A "black box" has two terminals and a continually illuminated pilot lamp. The lamp may only be extinguished by connecting an 18 volt battery to the terminals, the polarity of the battery being opposite to that of its previous application

ment if the polarity of the 1.5 volt is, once more, reversed.

When the 1.5 volt cell is initially applied the current flowing through the transformer primary causes the laminations to be magnetised. Part of this magnetic field then remains after the 1.5 volt cell is removed. If the cell is reconnected with reversed polarity, the current flowing through the primary has to overcome the remanent field in the laminations given by the previous application, and has also to set up a fresh field in the opposite direction. In consequence, the current takes a longer time to reach its maximum value.

The writer checked a number of mains transformers in the set-up of Fig. 3 and found that, with some, the difference between the slow and rapid movements of the ammeter needle (according to battery polarity, as just explained) was very noticeable. The effect appeared to be most evident for primary currents of the order of 10 to 25mA, and with primaries having resistances below 70Ω or so. Transformers with primary resistances around 50Ω or less and large lamination stacks caused the meter needle, when moving slowly, to take about twice as

long to reach its final setting as occurred when it moved rapidly. Such transformers had a lamination stack height of 1.5 to 2in and had h.t. secondary outputs of the order of 250-0-250 volts at 70mA. Smaller mains transformers did not show the effect as obviously as did the larger types.

Checks with iron-cored inductors having butt-joined laminations (e.g. all the E's on one side and all the I's on the other side) showed that these did not exhibit any noticeable remanent magnetism effect. As is rather to be expected, an interleaved construction (e.g. alternate E's and I's on one side) appears to show up.

It should be mentioned that, with these checks, all transformer secondaries were, of course, left open-circuit.

The "Black Box" Circuit

The arrangement of Fig. 2 was then devised to give a more striking demonstration of the ability of the laminations of a mains transformer to exhibit a magnetic memory. The writer aimed here at producing a simple circuit which incorporated the minimum number of components rather than on obtaining optimum

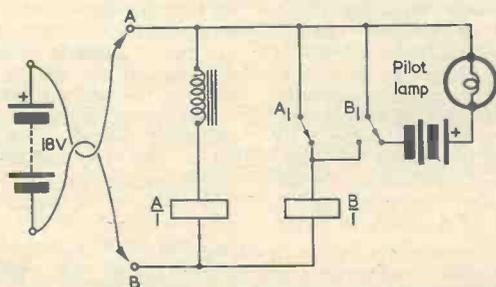


Fig. 2. The internal circuit of the "black box". The iron-cored inductor is the primary of a mains transformer

circuit efficiency. The prototype circuit functioned reliably in practice, although one of the relays required critical adjustment.

Fig. 2 shows the relays and their contacts with the "detached" method of presentation, wherein relay coils and contacts appear in separate parts of the diagram. Relay coils are depicted as rectangles, and contacts are shown in the de-energised position.

If an 18 volt battery is connected to terminals A and B of Fig. 2 with the same polarity as occurred at a previous application, the current in the primary of the mains transformer rises quickly, allowing relay $\frac{A}{1}$ to energise quickly also. As a result, contacts A1 open, and the supply to relay coil $\frac{B}{1}$ is broken before the latter can energise. Relay $\frac{B}{1}$ therefore remains de-energised, and its contacts B1 maintain the pilot lamp in the illuminated condition.

If the battery is now removed and re-applied to terminals A and B with reversed polarity, the current in the primary of the mains transformer rises slowly. In consequence, relay $\frac{A}{1}$ energises slowly as well, and its contacts A1 do not break as quickly as occurred in the last instance. This gives relay $\frac{B}{1}$ sufficient time to energise, and it then remains "held on" by its own contacts B1. These contacts also break the supply to the pilot lamp, which becomes extinguished. The pilot lamp remains extinguished until the battery is removed.

The mains transformer employed for the prototype circuit had a primary resistance of approximately 40Ω. This was then replaced by the primary of another transformer having a resistance of approximately 70Ω. The circuit functioned satisfactorily with the second winding, but the setting up required in relay $\frac{B}{1}$ was a little more critical. Connections were made, in both cases, to the zero and 240 volt taps of the primary.

It was found that the mains transformer retained its "memory" over long periods between one application of the battery and another. On several occasions these were half-an-hour in length. There seems little doubt that the "memory" would be retained over considerably longer times.

Relay $\frac{A}{1}$ was a P.O. type 3000 relay having a coil resistance of 500Ω . The type employed in the prototype had two sets of changeover contacts, although it is depicted as having a single set only in the diagram. The second contact was

left disconnected. Relay $\frac{B}{1}$ was a Rip Max type A30 relay with a $5k\Omega$ coil and a single set of changeover contacts. The setting of these contacts is adjustable. (A suitable alternative relay, having the same construction but a coil resistance of $3,800\Omega$, is currently available from Home Radio (Mitcham) Ltd. under Cat. No. Z70D).

As will be realised, it is necessary for the energising time in relay $\frac{B}{1}$ to be slightly slower than that of

relay $\frac{A}{1}$ for the condition where the current in the transformer primary rises rapidly. With the prototype it was found possible to achieve this by careful adjustment of the spring tension and contact screws of relay $\frac{B}{1}$, relay $\frac{A}{1}$ functioning in normal

manner without any adjustment. The contact screws of relay $\frac{B}{1}$ were set up to give a wide armature travel, with the result that, under the rapid current rise condition, the armature momentarily left its de-energised contact (thereby causing the pilot lamp to momentarily flicker) but could not reach its "hold on" contact before contacts A1 opened.

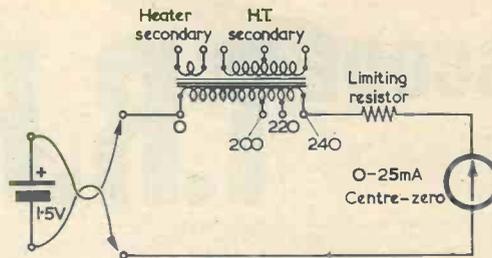


Fig. 3. A test set-up for checking the remanent magnetism effect in a mains transformer

This is not entirely a desirable approach because the time delay offered in relay $\frac{B}{1}$ is made to depend upon the time taken for the armature to travel over to its energised contact. It would probably be better to use closer contact screw spacing, and to "slug" $\frac{B}{1}$ electrically by inserting resistance in series with the coil and adding capacitance across it. However, the approach just described gave adequate results in practice and resulted in a very simple circuit.

Initially, the coil of relay $\frac{A}{1}$ had a resistor in series to limit final current to the 10 to 25mA range which had, in the previous checks, seemed to offer best results with typical mains transformers. It was found, however, that the circuit could function effectively without such resistance and so, once more in the interests of simplicity, it was deleted.

Provided that the principle of operation is understood and followed, it should be possible to employ alternative relays in the circuit of Fig. 2. The current drawn by relay $\frac{A}{1}$ should be sufficiently high to enable the mains transformer to exhibit the remanent magnetism effect. The current drawn by relay $\frac{B}{1}$ is unimportant.

Applications

Apart from its interesting and unusual mode of operation, the circuit of Fig. 2 can be of value in demonstration equipment since it offers an impressive illustration of a basic precept of electromagnetism. The fact that an iron-cored inductor offers a slow rise in current when the direction of the latter is reversed may have other applications also, such as with servo-mechanisms where reversing currents fed to an actuating motor could be automatically delayed.

THE B.B.C. REITH LECTURES, 1964

The B.B.C. announces that this year's Reith Lectures will be given by Sir Leon Bagrit, Chairman of Elliott-Automation Ltd.

His subject will be "The Age of Automation"—the nature and possibilities of systems of computerised automation and the implications he foresees in industrial, economic, political, educational and social aspects of our society.

Sir Leon will develop his ideas in the course of six lectures beginning on Sunday, 8th November, in the Home Service. Each lecture will be repeated in the Third Programme later in the week.

He believes that the influence of the intelligent, able, and appropriately educated will increase in our developing society; that there is a built-in resistance to automation which will inevitably be overcome; but that automation—or cybernation—should be the servant and not the master of mankind. In short, Sir Leon believes that full humanism can come into its own by the reduction of drudgery and unnecessary toil.

Sir Leon Bagrit, married with two daughters, is a man of wide interests. He is a member of the Council of the Department of Scientific and Industrial Research, a Director of the Royal Opera House, Covent Garden, and a past member of the Council of the Royal College of Art. His favourite relaxations are music and the visual arts—especially sculpture.

CASCADE T.R.F. FEEDER UNIT

By G. E. LEWIS, G3NFS

It is only rarely that circuits using cascode r.f. amplifiers for operation on Top Band or medium wave frequencies are encountered. The results given by the cascode feeder unit described here are stated by the author to be most satisfying, especially when it is considered that power consumption is low and that valves which are unserviceable for television applications may be given a new lease of life in the present circuit. The feeder unit is incorporated in a Top Band transceiver; however, only the r.f. and detector circuits are described, as the remainder of the transceiver is conventional.

THE FEEDER UNIT TO BE DESCRIBED IS USED IN A portable mains transceiver covering 160 metres, and is the outcome of much "cutting and trying" in an attempt to obtain economy of power and components.

After trying the more conventional superhet and t.r.f. circuits, it was decided to find how a cascode r.f. stage would perform at the low frequencies involved. The only suitable valve to hand was a PCC84 and, in spite of the fact that the heater is rated at 7 volts, 0.3 amp., no losses were apparent when using a 6.3 volt supply. *The valve employed can be one that has been discarded from a Band I and III television receiver due to impaired noise

factor on Band III. In fact the writer has tried six valves in this position, five "noisy" and one brand-new. No noticeable difference in gain or noise factor was apparent.

Frequency Coverage

During alignment of the complete feeder unit, it was found to cover the high frequency end of the medium waveband and the quality of reproduction was very good. To cover the whole of the medium waveband, it is only necessary to change C_1 , C_2 , the main tuning capacitor, for a component with a value of 500pF, and having built-in trimmers. The coils are then aligned accordingly.

Components List

Resistors

- R₁ 120Ω ¼ watt
- R₂ 120Ω ¼ watt
- R₃ 10kΩ ¼ watt
- R₄ 47kΩ ¼ watt
- R₅ 220kΩ ¼ watt
- VR₁ 5kΩ pot

Coils

- L₁, L₂ (see text)

Capacitors

- C₁ C₂ 100pF variable, two-gang, with 100pF trimmers for 160 metres or 500pF with 30pF trimmers for medium wave band
- C₃, 4, 5, 6, 7 0.005μF, disc ceramic
- C₈, 9 100pF tubular ceramic
- C₁₀ 0.01μF paper
- C₁₁, 12 80pF tubular ceramic (see text)

Valve

- V₁ PCC84

Diode

- D₁ GEX54 or equivalent

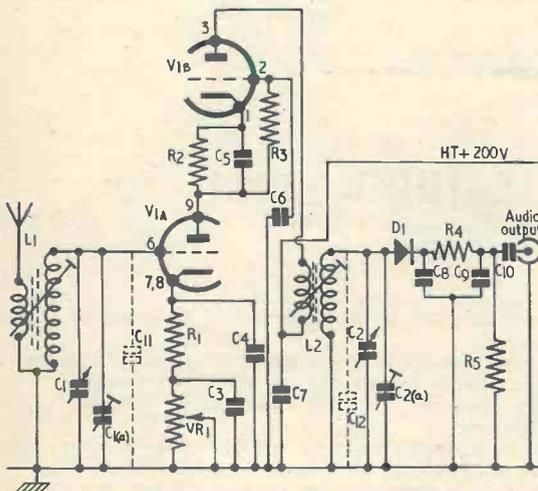


Fig. 1. The circuit of the cascode feeder unit. The audio output should preferably feed into an impedance of 1MΩ or more. The trimmers C_{1(a)} and C_{2(a)} are fitted to the tuning capacitors C₁ and C₂ respectively

Although constructed by the writer on a chassis measuring 7 x 4in (this also accommodates the receiver audio stages—12AX7 and 6BW6—which double as modulator on "Transmit") it is felt that for any other purpose the feeder unit could be constructed on the top of a 2 oz. tobacco tin (rectangular version) provided that a miniature twin gang tuning capacitor is available.

The Circuit

In the circuit diagram of Fig. 1, the first triode of the PCC84 acts as a grounded-cathode low noise amplifier, the only unconventional point here being in the r.f. gain control decoupling given by C₃ and C₄. The cathode resistor, R₁, and gain control, VR₁, are both decoupled to prevent any tendency for the tuning point to alter due to a variation of gain. This had been an objectionable point with some of the earlier feeder units constructed for the transceiver. No neutralising of the cascode stage was found to be necessary.

The second triode, V_{1(b)}, operates as a grounded-grid high gain r.f. amplifier.

The detector stage uses a GEX54 in the D₁ position, but any general purpose diode seems to perform satisfactorily here. By using a germanium diode detector the power requirements were kept to a minimum, and consisted of 200 volts h.t. at approximately 10mA and 6.3 volts a.c. at 0.3 amp. for the heater.

No audio gain control was included in this section of the transceiver, as control over the audio stages was required on "Transmit".

The twin gang capacitor used was removed from an RF26 unit, the associated trimmers being taken from capacitance-tuned i.f. transformers and sol-

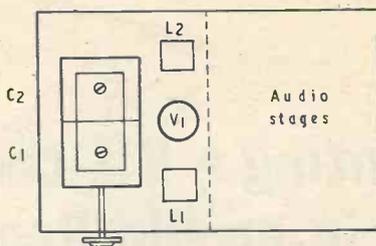


Fig. 2. Above-chassis layout of the prototype

dered on stiff wires above the tuning capacitor.

The above-chassis layout employed by the writer is shown in Fig. 2. So far as under-chassis wiring is concerned, the only precaution needed is to ensure the use of short leads, the minor components being arranged around the valveholder to meet this requirement.

The Coils

The coils employed in the prototype for L₁ and L₂ were constructed from television i.f. transformers having cans measuring 1½ x ¾ x ¾in, and ¾in formers. The original windings were removed, and the new coils wound with 38 s.w.g. enamelled copper wire in the following manner. Tuned windings: 65 turns close-wound, single layer, covered with p.v.c. tape. Coupling windings: 10 turns close-wound, single layer, over centre of tuned windings.

The original iron dust cores used in the i.f. transformers were retained for L₁ and L₂.

With the prototype it was necessary to add C₁₁ and C₁₂ (shown dotted in Fig. 1) to cause the coils and tuning capacitor to cover 160 metres.

CAN ANYONE HELP?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time.

Grundig TK1 Tape Recorder.—A. D. Lacey, 7 Alfred Street, Reading, requires service sheet or circuit, loan, hire or purchase.

* * *

PCR2 Communications Receiver.—M. Brown, "Mayside", High Road, Layer-De-La-Haye, Colchester, Essex, wants the loan or purchase of circuit or manual.

* * *

Wanted.—E. J. Wright, 30 Bosworth Drive, Burton-on-Trent, Staffs, has made and installed automatic opening garage doors but these can only be opened from the inside. Could any reader supply a circuit of a car-installed transmitter and receiver (transistorised) to operate a relay making the doors fully automatic in both directions.

R1155B Receiver.—M. T. Nutter, 1 Swinburne Avenue, Droylsden, Manchester, wishes to obtain loan or purchase of circuit and any information on converting output stage to include 6V6.

* * *

Type 3 Mk. II Transceiver.—L. O. Tully, 120 Victoria Street, Fairfield S3, Brisbane, Queensland, Australia, requires circuits for this unit, consisting of receiver model 3/II, power supply type 3 Mk. II and transmitter. Transmitter coverage is 3 to 8 Mc/s; receiver coverage 3 to 15.5 Mc/s; power supply 90 to 260V a.c. and 6V. Any information on this unit, however small, would be greatly appreciated.

Mounting a Kit-constructed Unit in an Old Receiver

By KENNETH HARKER

How one constructor tackled the problem of fitting an additional unit without spoiling cabinet finish

THE HOME-CONSTRUCTOR IS OFTEN content with his rat's nest of wires on the kitchen table. But in renovating old receivers the problem sometimes arises of fitting an extra unit into a set, while preserving the original appearance of the cabinet.

This happened with an old Ekco PB515, which covers short, medium and long wavebands. To get B.B.C. reception on Home, Light, and Third, free from the 10 kc/s "TV whistle", a kit-constructed Jason switched f.m. tuner was fitted. The mounting method employed allows easy removal of the Jason tuner, and the only outward signs on the Ekco polished wood cabinet are two extra switch knobs.

Switching

The aim was to either have the old set fully operative, or to use its power supply and output stage together with the Jason unit. This entailed re-routing h.t., filament, chassis, and output connections through a multi-pole 2-way selector switch.

The switch was fitted to the front of the Ekco cabinet alongside the original controls. Connections from it were then taken to a socket mounted on top of the Ekco chassis. Into this could be plugged a cable carrying supplies to and from the Jason unit.

The second visible knob is of course on the tuning switch of the Jason tuner. Fortunately, as often

happens with old cabinets, the available space was adequate enough to accommodate the new unit without too much squeezing. The dimensions of the Jason were approximately 8 x 4 x 4½ in, and its chassis was already drilled for front-mounting by four 4BA corner screws to a vertical surface.

Positioning

Bearing in mind the accessibility of tuning slugs, the best position was about an inch above the power pack and output valves of the old chassis. From the viewpoint of overheating, this was perhaps not too wise a choice; but running experience has shown no ill effects. The location places the tuning-switch knob at the side of the cabinet. Here, then, it was desired to prevent extra mounting screws from showing externally.

To achieve this, the arrangement shown in Fig. 1 was employed. The tuner was mounted on to a ¼ in thick plywood board. This was then fastened by ⅜ in Whitworth wing-nuts to a built-in false side, whose corners were off-set from the side of the cabinet by means of small blocks. Both the false side and the blocks were of ¼ in thick plywood, and glued in. It need hardly be stressed that the ⅜ in Whitworth screws and retaining nuts were fitted to the false side before it became a permanent fixture.

The only hole drilled through the side of the cabinet was that needed to accommodate the tuning switch. The various ply-thicknesses just allowed sufficient shaft to penetrate for a knob to be fitted.

The dimensions of the boards are not given since, for anyone adopting this mounting method, these will depend on the size of the added unit and the space available. A noteworthy point is the positioning of the Whitworth screws. These should be reasonably clear of the new unit to allow easy finger-access to the wing-nuts.

With the Jason tuner, three wing-nuts, two above and one below the tuner, gave adequate support. Two of these are shown in Fig. 1.

Make sure too that the weight of the mounted unit will not pull away the glued joints. This was safeguarded against in the writer's case by gluing an extra wooden block, as a wedge, between the false side and the speaker-mount.

It could be argued that the unit can be fixed straight on to the false side without the use of a separate mounting board, whilst still avoiding

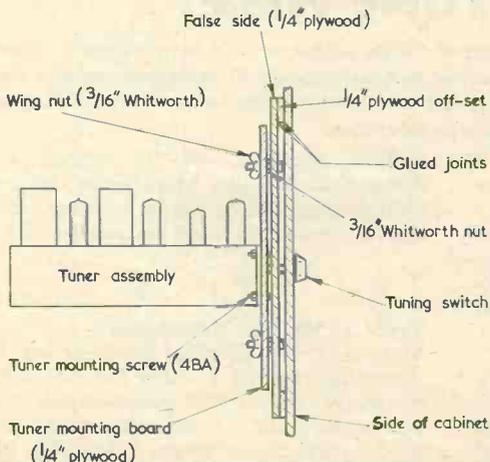


Fig. 1. The mounted tuner in position. The mounting board is secured to the false side of the cabinet by easily removable wing-nuts. No screws appear outside the cabinet

screws showing externally. But this would not allow for easy removal due to the screws being behind the unit.

Further Advantages

A further advantage of the mounting board is its use, if sufficiently high, as a support when the mounted unit is removed. This is shown for the Jason unit in Fig. 2, where it will be seen that the underside is available for inspection or tuning slug adjustment without weight resting on the valves. A sufficiently long cable enables the removed tuner to remain electrically connected to the set.

Despite the early fears of overheating, the Jason tuner has worked satisfactorily in this position for about 5 years. The wing-nut mounting method is recommended to anyone anxious to preserve the

polished appearance of an old cabinet, and to obtain an easily removable unit.

One last point is concerned with

nuts that spin off at a flick of the finger. Try to position them where, if you do drop them, they are not in the chassis—

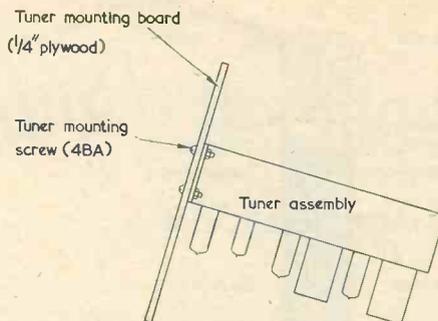


Fig. 2. The tuner removed. The mounting board acts as a support when the unit is inverted

EXPERIMENTAL BATTERY RECEIVER

By C. MORGAN

PERHAPS ONE OF THE MOST ABSORBING HOBBIES and probably the most interesting is the construction of miniature radio receivers for broadcast band reception. Many younger (and not-so-young) members of the fraternity spend countless hours constructing and discussing the various merits of performance of their handywork.

Another interesting field of experiment lies in the construction of the power supply that operates the receiver. Construction of a battery or cell is simplicity itself, and when one can boast that Radio Luxembourg was received with a home-made cell offering 1 volt at a current of $30\mu\text{A}$ (although the cell is capable of a far greater current) then prestige rises.

The Receiver

Reference to Fig. 1 shows the very simplest of crystal-transistor receivers. In the writer's home this is capable of reception of the Home and Light frequencies, together with shipping broadcasts and several Continental radio stations.

The aerial was slung round the picture rail, and consisted of about 35ft of 30 s.w.g. copper wire. An earth connection was found to be very essential, and was taken from a 3-way mains socket.

No layout diagram is given, and it is possible that the experimenter will want to try various other circuits. The transistor in the circuit of Fig. 1 was interchanged with other types, but little difference was noticed.

The Cell

Cell construction should present no problems, and the one in use at the time of writing has been in constant operation, day and night, for several months without any sign of deterioration or loss of voltage.

It was constructed with the following items.
(1) A medium sized glass test tube, (the flat bottom type is ideal), together with a tight-fitting cork.
(2) A small piece of thin (0.01in) copper foil. (3)

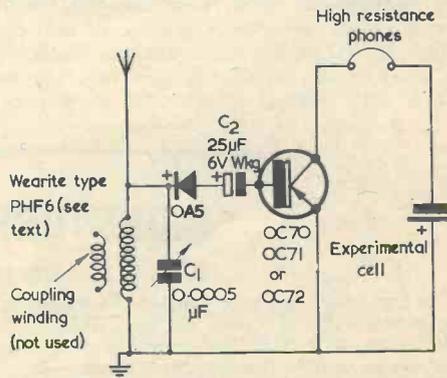


Fig. 1. The circuit of the experimental receiver and cell. Most germanium diodes should function satisfactorily in place of the OA5 shown. Several further points concerning the circuit are discussed in the text

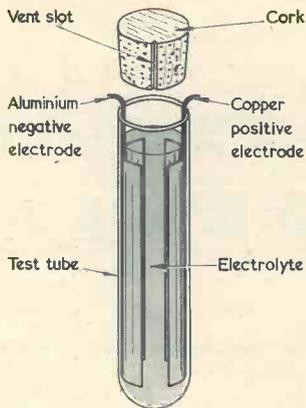


Fig. 2. The assembly of the cell

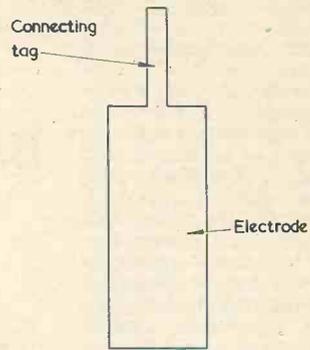


Fig. 3. The shape of each electrode. The lower section is bent round to fit the inside of the test tube employed

A similar piece of aluminium of the same thickness. (4) A quantity of vinegar, sufficient to three-quarters fill the test tube.

The cork should have a "V" slot cut in one side of it to allow the gas which the cell gives off to escape. However, the amount of gas is so small that it will never be evident. The test tube can be of any size, and no increase of voltage will result from having a larger volume, although there will be an increase of available current directly proportional to area if the electrodes are increased in size also.

Reference to Fig. 2 and 3, which show the shape of the electrodes, will assist in the construction of the cell. No dimensions are given as this is left to individual experiment. It is important to make sure that the two electrodes do not come into contact with each other, or this will cause a short-circuit.

If after several weeks of continual use the electrodes show signs of corrosion, all that is required is to remove the cork, take out the plates, give them a gentle clean with a piece of soft rag, and replace them in the tube again. If the vinegar has evaporated slightly it can be "topped up" with a little water, whereupon it will be once

again ready for several more months' use. The battery will also operate if a mixture of water and salt is used instead of vinegar, and the results are almost as good.

It might be thought that several of these cells could be linked in series to form a battery of higher voltage. A small amount of advantage will result from two cells so joined, but the internal resistance becomes so high that there is no great improvement when used with the circuit of Fig. 1.

If the resistance of the circuit driven by the cell is kept high, the cell will continue to function indefinitely.

It should be noted that the copper electrode is the POSITIVE, and that the aluminium is the NEGATIVE connection of the cell.

EDITOR'S NOTE.—The writer's original prototype employed a Wearite PHF6 coil, which covers 91 to 261 metres. He has since checked reception with a PHF2 coil, which covers the medium wave range of 200 to 557 metres, with satisfactory results. There would be less damping and capacitive loading of the tuned circuit if the aerial and earth were applied to the coupling coil instead of the tuned coil.

No bias is applied to the base of the transistor (apart from any small bias current which may flow, due to leakage in C₂, if a strong signal is received) and the writer states that he has found no improvement in performance if C₂ is short-circuited, or if a bias resistor is connected between the base and the negative supply line.

"INDUCTORFONE" FOR CRANES

A. T. & E. AND MARCONI MARINE AGREEMENT

An agreement has been concluded between A.T. & E. (Bridgnorth) Ltd.—a member of the Plessey Group—and The Marconi International Marine Co. Ltd., under which the latter will acquire exclusive marketing rights throughout the world for the A.T. & E. "Inductorfone" frequency-modulated radio transceiver so far as the use of this equipment in crane communication installations is concerned.

The "Inductorfone", developed primarily for use in mines, particularly for communication with drivers of locomotives, will be incorporated by Marconi Marine in their installations where there is a requirement for a means of communication with crane drivers which will not impose any restriction on the mobility or manoeuvrability of the cranes. In such cases it will be part of inductive loop intercommunication and remote handling installations, similar to one specially developed by Marconi Marine's sound systems department for new steel mills where cranes travel over quite considerable distances and their drivers must have individual remote control of soaking pit doors.

Versatile

Portable

Oscilloscope

PART 2

by P. Cairns, A.M.I.P.R.E., G3ISP

Construction

The construction of the instrument offers no special problems, the layout not being particularly critical and while it would be advisable to follow the layout shown in Figs. 4 to 7, a certain amount of tolerance in component positioning to suit particular items which may already be to hand is admissible. The front panel measurements, potentiometer and switch positions are shown in Fig. 6. The necessary marking or engraving for the front panel is shown in Fig. 7, and this can be carried out by hand using marking ink or transfers. The

above-chassis layout and measurements are shown in Fig. 5 whilst the layout and measurements of the under-chassis are shown in Fig. 4. Throughout, only the positions of either the large or critical components are shown, the remainder of the components being wired to suitable tagstrips or tagboards as indicated.

The following constructional points should be noted. The transformer T_1 should be so positioned that the stray magnetic field around its core causes minimum interference with the c.r.t. deflection plates. If the transformer field lies at the wrong angle to the c.r.t., trace distortion can occur due

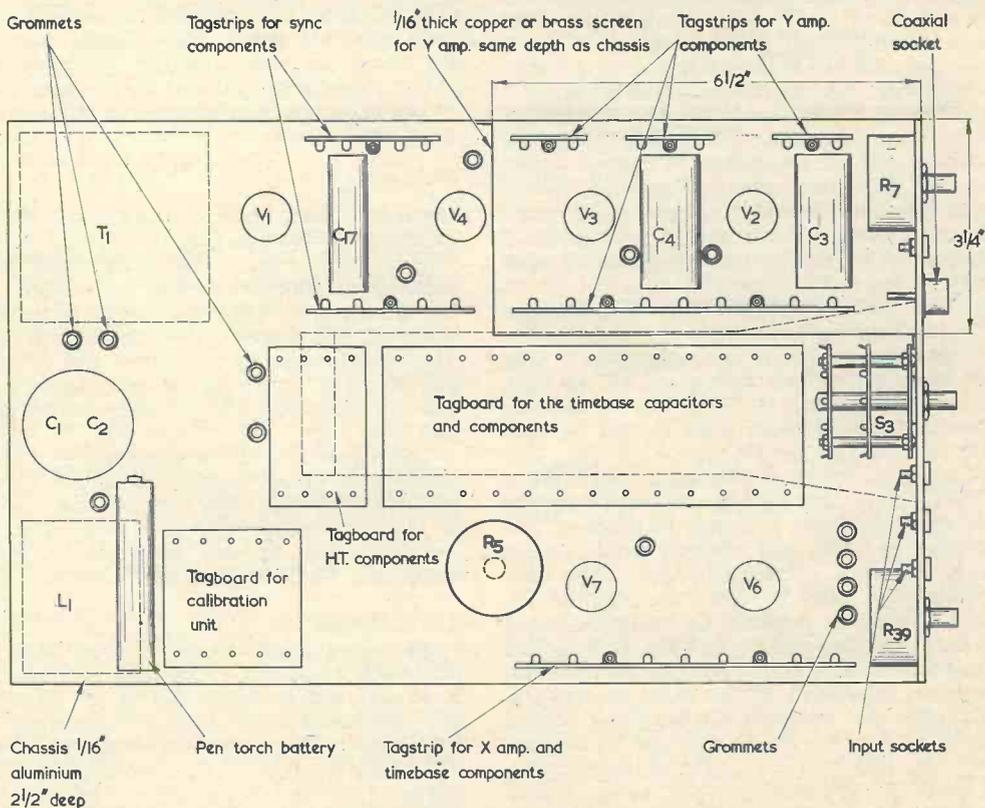


Fig. 4. The below-chassis layout

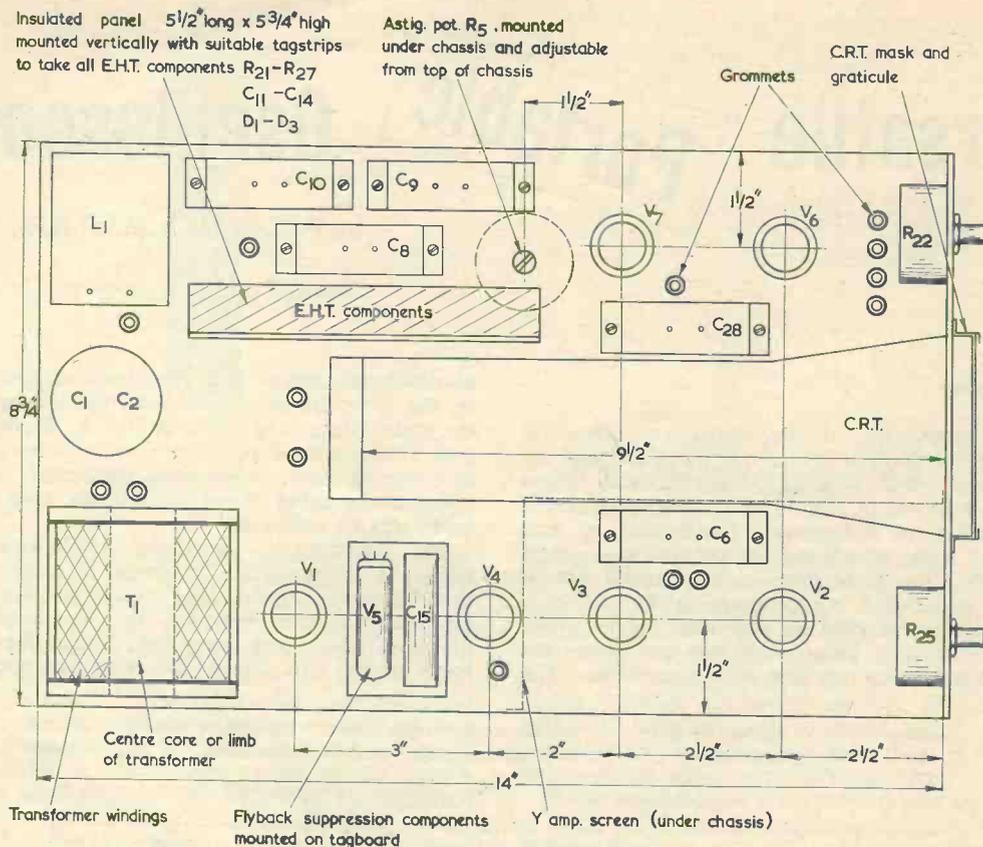


Fig. 5. Top view of the chassis

to interference with the electron beam in the tube. The correct position is shown in Fig. 5. A screened transformer is an added advantage but is not essential. A mu-metal screen for the c.r.t. is essential. The choke L_1 should also be positioned correctly in a similar manner to the transformer, but its position is much less important. The screened leads to the deflection plates of the c.r.t. should be positioned as far from the transformer as is practicable. Screened leads should be used wherever indicated in the circuit.²

The Y amplifier has its own screened compartment under the chassis, this keeping pick-up from the timebase to a minimum. It should be made of $\frac{1}{16}$ in thick copper or brass and screwed firmly to the chassis to ensure a good connection. The connections between the Y input sockets and V_2 should be as short as possible, C_3 being connected directly between these sockets and R_7 . All earthed components and screened leads associated with V_2 should be connected to the same chassis tag. Similarly only one common chassis point should be used for each of the V_3 , V_4 , V_6 , and V_7 circuits.

All wiring, with the exception of the heaters, should employ well-insulated 20 s.w.g. tinned copper wire. The heaters should be wired with a pair of flexible p.v.c. covered wires twisted tightly

together. The heater wiring run, XX, should be from the transformer to V_5 , V_4 , V_3 , V_2 , V_6 , V_7 , in that order. The heater and secondary winding centre-taps should be earthed close to the transformer, the input earth from the input three pin mains plug also connecting to this point. The mains leads to and from the mains switch on the front panel are twisted together in pairs and clipped along the chassis directly under the c.r.t.

The diode V_5 is wired directly into circuit. Grid leads to all valves should be as short as possible, R_{12} and R_{38} being wired directly on to their respective valve base pins. The timebase ext/int. switch, S_4 , can be a change-over toggle switch if a Yaxley type is not available.

The Graticule

The graticule is made of $\frac{1}{16}$ in thick Perspex cut to size so as to be a close fit in the c.r.t. mask. It is engraved as shown in Fig. 8. The lines are one centimetre apart, the two centre lines, one horizontal and one vertical, being engraved first. The engraving is done with a sharp, finely pointed scriber, the fine grooves being filled in with black wax or crayon. Providing the scriber is not allowed to slip during the engraving process, a finely lined

graticule is obtained when the surplus crayon is rubbed off.

The final piece of construction will be the case. This can be made of 1/4 in thick plywood, sheet aluminium, or mild steel, though the latter is rather more difficult to work with if the necessary tools are not available. A suitable ready made case is obtainable on the surplus market in the form of the BC929A radar unit. The chassis and front panel measurements are identical with those of the oscilloscope, no further work being necessary. The writer in fact used this unit as the basis for the prototype since it contains a 3BP1 tube complete with mask, screen and base, as well as many other usable components. The chassis, front panel and power unit are of no use. The BC929A unit is by no means essential, however, a straightforward plywood case being equally adequate. An attache-case handle bolted to the top of the case completes the job, these being obtainable in most large stores.

The correct positioning of the c.r.t. to ensure that the timebase line lies in the horizontal axis is shown in Fig. 9. In this position the timebase line should appear almost exactly horizontal. Any slight further adjustments can be made with the timebase line on, this being set to lie parallel with the horizontal lines on the graticule. With the c.r.t. so positioned and the X and Y deflection circuits connected as shown in the circuit diagram, the timebase scan will be from left to right across the tube face. In the Y direction, positive pulses or signals will give a deflection in an upwards direction.³

In all cases the zero setting on the potentiometers corresponds to the moving arm being at the earth or earthy end of the track.

Setting Up

The setting up procedure for the oscilloscope is a relatively simple matter. First, double check that the wiring is correct, particularly the h.t., e.h.t., and c.r.t. circuits. Now set the Y gain to zero, the timebase coarse control to Range 2, the sync control to zero and all other controls to approximately mid-position. The int./ext. switch, S₄, is set to the internal time base position, the calibration switch being off. The oscilloscope can then be switched on and allowed to warm up.

The horizontal timebase line should appear across the tube face, the Y shift control being used to centre it across the centre horizontal line on the graticule. Now adjust the brightness and focus controls to a suitable level of brightness

² The screened cable employed should have a low self-capacitance. This applies particularly to the grid circuit of V₂.—EDITOR.

³ In some references to the 3BP1 tube, pins 7 and 8 are quoted as Y1 and Y2 respectively, and pins 10 and 11 as X1 and X2. These differ from the connections shown in Fig. 9, as the X and Y plates are then transposed. If a particular tube should exhibit this apparent transposition of pin connections, the latter may be changed over, or the tube re-orientated.—EDITOR.

⁴ To set R₅ correctly the actual voltages on the X and Y deflection plates would have to be measured (after the shift controls had been centred). Due to the extremely high impedance of the deflection plate circuits, this is not a practical proposition using normal type voltmeters whose impedance would have a very marked shunting effect on the circuit. To overcome this difficulty the method described here was checked and found to be quite practical.

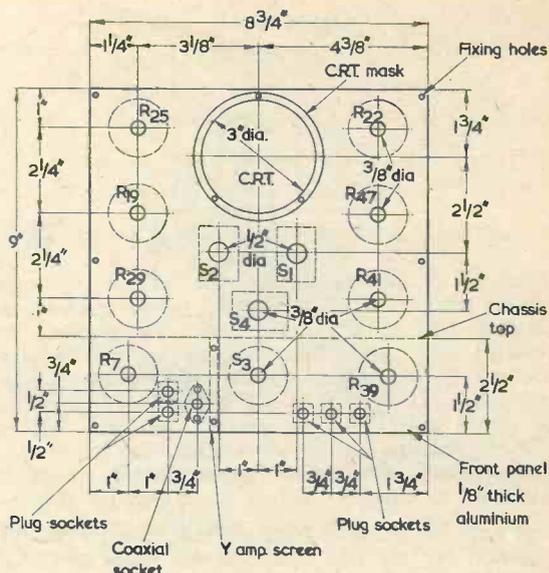


Fig. 6. Dimensions of the front panel

with optimum focus. Next turn the X gain to zero, this will cause the timebase line to contract into a spot which can then be centred on the graticule by means of the X shift. Turn the X gain up once more until the timebase line lengthens and both ends are just off the ends of the tube face.

Using a high impedance d.c. voltmeter check the voltage on the anodes of V₃ and V₇, this should be in the region of 220 volts with respect to chassis. Now connect the voltmeter to the centre of the pre-set control R₅, this controlling the A3, X2, Y2 voltage. Adjust this control until the voltage at the centre is 220 (or the same value as was read on the V₃, V₇ anodes).⁴ The timebase line

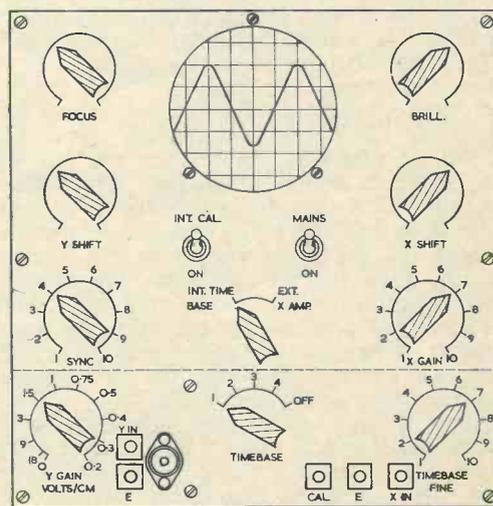


Fig. 7. Layout and marking of the front panel

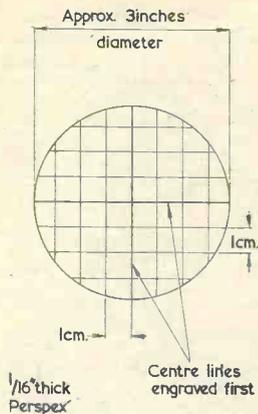


Fig. 8. Details of the Perspex graticule

will now be found to have shifted from its central position on the tube face, and the focus will also probably be changed. The timebase line should now be re-centred in both X and Y directions as just described and the focus control adjusted for optimum focus across the whole of the timebase line.

All the timebase coarse control ranges should now be tried, together with the fine control to ensure it is working throughout its entire range. On the very slowest timebase sweeps (about 175mS/cm.) a slight non-linearity may be noticed towards the end of the sweep. In practice this is offset by slightly increasing the X gain until the non-linear portion of the sweep occurs "off" the tube face, only the linear part of the sweep being viewed.

Next check the ext./int. switch, S₄, by selecting the ext. position. The timebase line will then disappear leaving a spot in the centre of the tube face. Connect a link between the calibration output socket and the X input socket. When the calibration is switched on, a small horizontal line will appear on the screen, this line increasing in length as the X gain is increased. The X shift will still function under these conditions. The calibration can now be switched off and all the controls restored to their former positions. In practice the timebase coarse switch is always set to the "off" position when using the X amplifier in the external position. This prevents any interaction between the timebase generator and the signal applied to the X input. It is not good practice to switch the timebase off and leave only a spot on the tube face for any great length of time as this can burn the screen phosphor. When all the above tests have been satisfactorily completed only the Y amplifier remains for testing and calibration.

With all the controls set back to normal, switch the timebase coarse to range 2 and connect a link between the Y input and the calibration output socket, the calibration then being switched on. The Y gain is now increased until the signal deflection occupies about 2cm of screen height. The fine

timebase control is then adjusted until two or three complete cycles of the square wave appear stationary on the tube face. Any tendency towards trace slip can be overcome by increasing the sync control setting to lock the trace in position. In practice the timebase fine control and the sync control are used in conjunction to ensure optimum synchronising. With the trace locked, the square waves should appear as in Fig. 3, with a slight slope on top and bottom edges, this being due to the l.f. response of the a.c. coupling (d.c. coupling is necessary to ensure an exact square wave). The Y gain should be increased until the trace disappears off both top and bottom edges of the tube. No distortion should be visible even with maximum deflection. When the signal is reduced to less than half a centimetre the trace may begin to slip due to the very small sync output which will occur under such conditions. By further increasing the sync control together with, perhaps, a slight adjustment on the fine timebase control, the trace can be locked again if required.

Calibration

Having proven that the Y amplifier is functioning correctly the Y gain control can now be calibrated, calibration being in peak-to-peak volts per cm. Set the Y gain until the top and bottom edges of the square wave just occupy 1cm on the graticule. This point is then marked as 3 on the Y gain scale. Now turn the control anti-clockwise until the square wave occupies only $\frac{1}{3}$ of a cm, this is now marked as 9 on the scale. By setting the amplitude of the signal to exactly 2cm a calibration point 1.5V/cm is obtained. An amplitude of 4cm gives a calibration point of 0.75V/cm. Any other points between the examples given can readily be marked by dividing the peak to peak deflection measured on

the graticule into 3, i.e. $\frac{3}{\text{peak/peak defl.}} = \text{Volts/cm.}$

Calibration points should not be made for deflections of greater than 4cm as the curvature at the edges of the tube could make the results inaccurate. For the lower values, therefore, a 10:1 divider is used, this being connected up as shown in Fig. 10. If possible, close tolerance

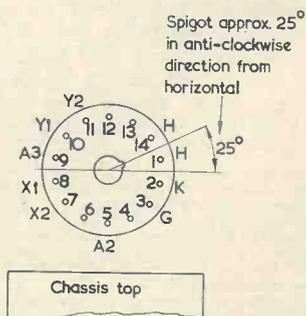


Fig. 9. Pin connections and orientation for the cathode ray tube

resistors should be used here. The output of this network is 0.3V or 300mV. By setting the Y gain control to give exactly 1cm deflection a 300mV calibration point is obtained. Higher and lower calibration points are obtained in the same manner as described above. Maximum sensitivity will be in the region of 175–200mV/cm. The following calibration points for the complete scale are suggested; 18, 9, 3, 1.5, 1, 0.75, 0.5, 0.4, 0.3, 0.2, volts/cm. Further points can be added however, if required.

If a certain amount of care is taken, and a pair of fine dividers used for measuring points between the graticule lines, a reasonably accurate scale can be made. When measuring waveform amplitudes during calibrating and subsequent use of the oscilloscope, the screen should always be viewed squarely from the front and not at an angle. This avoids parallax errors. The time and trouble taken to calibrate the Y amplifier is more than repaid in practice, as the approximate peak-to-peak value of any unknown waveform can then be measured directly. To measure the amplitude of signals at frequencies higher than the flat part of the response curve (Fig. 2), the necessary correction can be applied from this curve. This correction will, of course, be approximate since the response curve will vary somewhat between amplifiers. For example, if a 250 kc/s signal is measured as 2.5V peak-to-peak, its actual peak-to-peak voltage will be about 10, the gain of the amplifier being 75% down at this frequency (see Fig. 2). In the case of sine waves the peak-to-peak value can easily be converted to r.m.s. value, if required, by dividing the peak-to-peak value by $2\sqrt{2}$ or 2.83. The ability to carry out this type of measurement makes the oscilloscope invaluable for checking amplifier response curves, audio equipment, oscillators, pulse generators, etc. The calibration accuracy can be checked at any time by simply connecting the calibration output to the Y input and checking two or three points on the scale.

An instant timebase calibration can also be made using the calibration source. With the calibration source connected to the Y input and the Y gain set to give a reasonable deflection, the fine timebase control is adjusted so that one half period of the 50 c/s square wave occupies 1cm in the horizontal direction. The timebase scan speed at this point is 10mS/cm. For one half period or cycle per half cm the sweep speed is 20mS/cm. By altering the timebase speed to a half cycle over 4cm a sweep speed of 2.5mS/cm is obtained. If a permanent time calibration is wanted and a low frequency signal generator (up to say 50 kc/s) is available, a complete calibration of all four timebase ranges can be made for the fine timebase control by using the signal generator in the same way as the internal calibration signal; e.g. one cycle of 1 kc/s per cm is 1mS/cm, one cycle of 5 kc/s per cm is 200 μ S/cm, one cycle of 25 kc/s per cm is 40 μ S/cm, and so on. Such calibrations can be useful for finding the frequency or repetition rate of unknown signals or pulses.

A point to be noted with such calibrations,

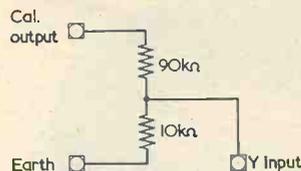


Fig. 10. A divider which may be employed for calibration

however, is that the X gain should be set and its position noted for any such calibration points or scales made. Any alteration of this control will, of course, alter the calibration. One further advantage of the internal calibration is that it automatically checks the h.f. and l.f. response of the amplifier. When the calibration signal is viewed on the oscilloscope all the corners should be sharp and clean cut. Any tendency to rounded corners or overshoot spikes indicates a wrongly compensated amplifier, the trouble normally being poor wiring layout, long input and grid leads, etc.

Using the Instrument

Finally, a few points may be mentioned in the use of the instrument. In practice only the centre 16 square cms of the graticule are used for measurements as the curvature at the edges of the tube tends to give some inaccuracy. Also, slight defocusing normally occurs at these points. The brightness should not be turned beyond the intensity required as not only is a better focus obtained at lower brightness levels but the working life of the c.r.t. is increased. When using the oscilloscope for Lissajous figures, whichever of the two input signals had the higher amplitude should be connected to the X input, as the X amplifier has the lower gain of the two.

The sync control should never be increased further than is necessary to keep the trace just locked, and it should be used in conjunction with the fine timebase control. Too much sync will produce a distorted waveform, causing sine waves to appear to have a "hook" or "blip" on the bottom of the negative half cycle. This is unavoidable and occurs in most oscilloscopes, since the sync control must be able to function with a wide variety of waveforms and a wide range of amplitudes.

The input capacitor of the Y amplifier, C_3 , is rated at 750 volt working and this should be adequate for all normal purposes. If, however, it is required to apply inputs higher than this, say for example to measure the ripple on a 1kV h.t. line, a capacitor of suitable voltage working should be used in place of C_3 .

While it is impossible in the confines of this article to describe the literally hundreds of uses and types of work to which an oscilloscope can be applied, it may be said in conclusion that the instrument described here should be of considerable value to the user in the servicing, constructional, and experimental fields of radio and electronics.

(Conclusion)

The thirty-fifth in a series of articles which, starting from first principles, describes the basic theory and practice of radio

part 35

understanding radio

By W. G. MORLEY

IN LAST MONTH'S ISSUE WE DEALT WITH SOME OF the loudspeaker enclosures which are employed for high quality or high fidelity reproduction, these including the completely enclosed housing ("infinite baffle"), the reflex enclosure and the labyrinth enclosure. We then dealt with the basic design of the horn.

We shall now carry on to methods employed for diffusing the higher audio frequencies, after which we will return to the basic moving-coil unit.

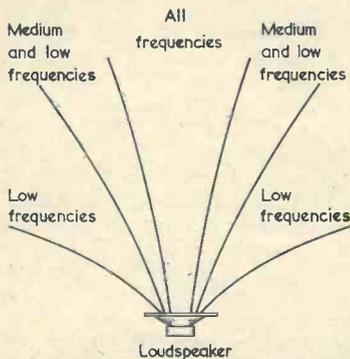


Fig. 228. Unless special design techniques have been employed, the higher audio frequencies produced by the moving-coil loudspeaker tend to travel forwards in a beam having a relatively small angle. This simplified diagram shows the resultant effect. An observer directly in front of the loudspeaker hears all frequencies at full strength. If the observer moves to one side, he hears only the medium and low frequencies at full strength. Further movement away from the centre results in a loss of the medium frequencies also

High Frequency Diffusion

A difficulty which arises with loudspeakers intended for high fidelity or high quality reproduction is that, whereas the lower audio frequencies from a moving-coil loudspeaker spread out into the air in front of the cone, the higher audio frequencies tend to travel forwards in a beam. As the frequency increases, the angle of this beam becomes smaller. The result is that a listener whose head is directly in front of a loudspeaker may hear all the reproduced higher frequencies, whereas another listener positioned to one side may hear the lower frequencies only. An approximate idea of the conditions which exist is given in Fig. 228.

This effect can, incidentally, usually be checked quite convincingly with the aid of a table radio receiver offering a reasonable quality of reproduction. If such a receiver is tuned to a strong signal (to ensure that background noise is at a minimum) it will normally be found that the sound reproduced by the loudspeaker is accompanied by a quiet hiss. This hiss, which corresponds to a very high audio frequency, may then only be heard at full strength when the ear is directly in front of the loudspeaker. For best results with this experiment the listener should be some 4ft to 6ft away from the loudspeaker, and any "tone controls" fitted to the radio should be adjusted to the position which allows the higher audio frequencies to be reproduced at maximum level.

To increase the angle of the high frequency beam from a moving-coil loudspeaker it is occasional practice to fit thin flat pieces of wood in front of the cone, as shown in Fig. 229 (a). These act as reflectors, whereupon some of the higher frequency sounds from the cone become spread out over a

wider angle of coverage, as illustrated in Fig. 229 (b). The reflectors are mounted vertically, with the result that the increased angle of high frequency sound coverage occurs in the horizontal plane. It is only necessary to increase the angle in the horizontal plane, of course, if the loudspeaker is fitted in the home or in a small hall.

This method of high frequency diffusion may employ two reflectors, as shown in Fig. 229 (a), or more. In some cases the reflectors may have a curved shape to ensure that the high frequency sound is more evenly dispersed.

In some tape recorders and television receivers where the cabinet design and internal component layout necessitate mounting the loudspeaker at the top or side of the cabinet, it is occasional practice to fit a hinged external flat reflector, an example being shown in Fig. 230 (a). The main function of this reflector is to project the higher frequency sounds forward towards the listener. The reflector does not offer any significant increase in diffusion because, so far as higher frequency sound is concerned, the cone of the loudspeaker tends to appear as an "image" behind the reflector, as illustrated in

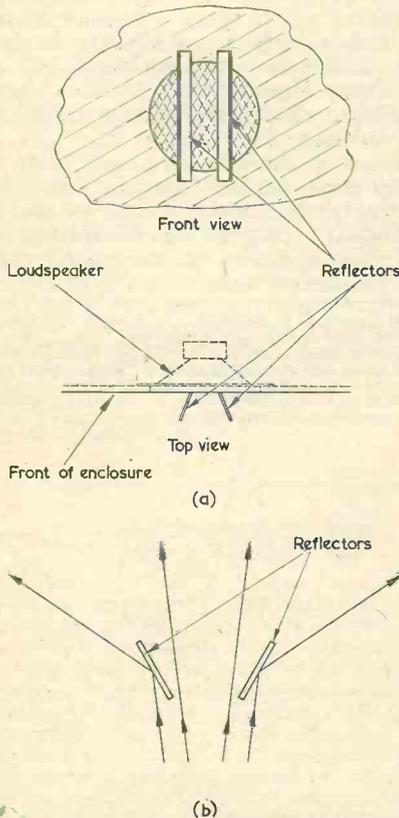


Fig. 229 (a). A front and top view of a loudspeaker enclosure employing reflectors for high frequency diffusion

(b). How the reflectors cause increased dispersion of the higher frequencies

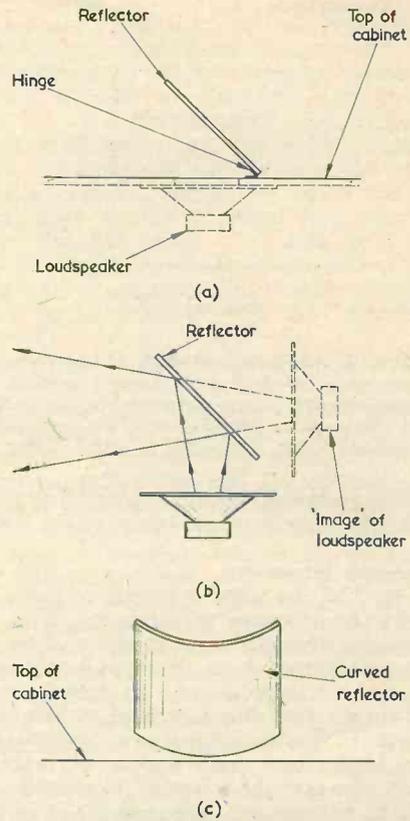


Fig. 230 (a). A flat reflector helps to cause the higher frequencies to be projected forward when the loudspeaker is mounted on the side or top of a cabinet

(b). So far as the higher frequencies are concerned, an "image" of the loudspeaker is formed behind the reflector

(c). When the loudspeaker is fitted at the top of the cabinet, high frequency diffusion may be achieved with a curved reflector

Nevertheless, the reflector can offer high frequency diffusion if it is mounted above the loudspeaker and its surface is curved, as in Fig. 230 (c).

An alternative approach to high frequency diffusion is given by mounting the loudspeaker behind a vertical slot in the front surface of the enclosure, instead of behind a circular aperture. See Fig. 231. This has the effect of increasing the angle of coverage of high frequency sound over a wider horizontal angle. Enclosures with slot apertures have been employed for public address work in small halls, but they need to be designed with some care due to the risk of undesirable resonance effects in the volume of air between the front of the loudspeaker cone and the inside front surface of the enclosure.

Apart from the devices and techniques just described, it is also possible to obtain increased high frequency diffusion by using special cone

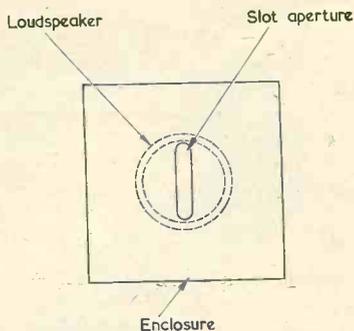


Fig. 231. A wide horizontal angle of high frequency diffusion may be obtained by using a vertical slot aperture instead of the usual circular aperture in front of the loudspeaker. The position of the loudspeaker, behind the slot, is indicated in dotted outline

shapes and materials, or by fitting diffusing deflectors immediately in front of the centre of the cone.

Loudspeaker Impedance

In Fig. 224¹ we showed several response curves in which loudspeaker performance, with regard to resonance, was evaluated in terms of frequency. The loudspeaker attribute employed for the response curves was the impedance of its speech coil, and it was shown that this increased at the resonant frequency or frequencies of the loudspeaker, or of the loudspeaker and enclosure combination. We shall now examine this point in greater detail.

As is to be expected, the speech coil of a loudspeaker offers both resistance and inductance. These two simple factors are, however, modified by the fact that the speech coil is capable of moving in a magnetic field. The result is that the simple combination of resistance and inductance which is given when the coil is not capable of movement changes to a considerably more complex quantity.

In Part 32 of this series² we saw that, by passing a current through a wire which is positioned in a magnetic field, the wire is caused to move at right angles to the lines of magnetic force, the direction of movement depending upon the direction of the current through the wire. It is this effect which causes the speech coil of a loudspeaker to move in the magnet gap when an alternating voltage is applied to it. However, the coil, in moving, is itself cutting lines of magnetic force, and we know from our initial examination of inductance³ that this causes an induced voltage to appear in it. The induced voltage, which can be described as the back e.m.f. in the speech coil when it is in motion, opposes the applied voltage, and therefore reduces the current which would otherwise flow.

The back e.m.f. due to the coil in motion should not be confused with the back e.m.f. of an ordinary inductor. The latter opposes change of current due to the property of inductance, whilst the

former opposes change of current due to the mechanical movement of a conductor in a magnetic field. Since, with the speech coil in motion, mechanical movement appears in the chain of events between the application of an initial voltage and the formation of the back e.m.f., and since such movement may not *exactly* follow the phase and amplitude variations in the initial voltage, the back e.m.f. appearing in a coil in motion may not be *exactly* 180° out of phase with the applied voltage, as occurs with an ordinary inductor.

It can now be seen that the overall impedance offered by the speech coil of a moving-coil loudspeaker is a combination of the resistance of the coil, the inductive reactance of the coil, and the impedance offered due to the formation of a back e.m.f. when the coil is in motion. All of these offer opposition to the flow of current when an alternating voltage is applied. The impedance offered by the coil in motion is referred to as the *motional impedance*.⁴

Loudspeaker Response Curve

Let us now examine the impedance of a loudspeaker mounted on a flat baffle at different frequencies in the audible range. We shall select a loudspeaker which has a resonance at around 40 c/s. This is fairly typical of what is given by a large loudspeaker intended for high quality or high fidelity reproduction. A curve illustrating the impedance of this loudspeaker from zero to 10 kc/s is given in Fig. 232.

If we start at the zero frequency point at the left of the curve we have the case where we are actually applying a direct voltage to the speech coil. The total impedance then offered will be that given by the resistance of the speech coil.⁵ If we move to the right, away from the zero frequency

⁴ *Motional impedance* is defined as the impedance which results when the "blocked impedance" (given when the speech coil is prevented from moving) is subtracted from the "loaded impedance" (given when the speech coil is free to move in the normal manner).

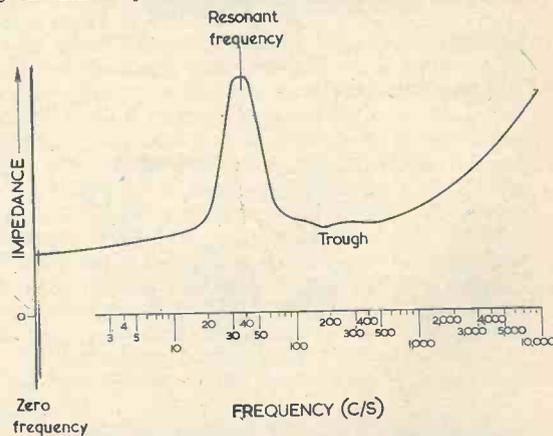


Fig. 232. How the impedance of a loudspeaker with a resonance at 40 c/s varies with frequency. For the purpose of explanation, the curve shown here is extended to zero frequency (d.c.). Usually, loudspeaker responses are not given below 10 c/s

¹ Published last month.

² Published in the May 1964 issue.

³ See "Understanding Radio" part 12, August 1962 issue.

point, we commence to apply an alternating voltage of continually increasing frequency to the speech coil. As soon as we apply this alternating voltage the speech coil begins to move in the magnet gap, and a back e.m.f. due to this movement appears. This back e.m.f. opposes the flow of current and the overall impedance of the speech coil commences to rise. At these low frequencies, the inductive reactance offered by the coil is very small, and it can be ignored. If we continue to increase the frequency we commence to approach the resonant frequency of the loudspeaker, and the movement of the cone and speech coil becomes increasingly more vigorous. This increasingly large movement of the speech coil results in the formation of an increasingly large motional back e.m.f., and the overall impedance offered by the speech coil continues to rise. The resonant frequency of the loudspeaker under discussion occurs at 40 c/s, and, at this frequency, the cone and speech coil are undergoing their most vigorous movement. The motional back e.m.f. is then at its maximum and so, in consequence, is the speech coil impedance. The high motional back e.m.f. at the resonant frequency offers the maximum opposition to flow of current.

As we increase the frequency beyond the resonant point, the movement of the cone and speech coil becomes increasingly less vigorous. When we reach 150 c/s or so, the speech coil impedance drops to a level which is only some 20 to 30% higher than the resistance which occurred at the zero frequency point. The response curve now remains fairly flat up to about 800 c/s, the overall impedance being almost entirely due to the combination of resistance and motional impedance. Because of the mechanical inertia of the cone, it is possible for speech coil movement to decrease as frequency rises, with the result that motional impedance

⁵ This assumes that the speech coil has come to rest after the application of the direct voltage. The speech coil will offer, for a short time, a motional impedance (plus a very small inductive reactance) whilst it is moving to the displaced position resulting from the applied direct voltage.

decreases also. The frequency at which the drop in motional impedance becomes significant depends upon the design of the individual loudspeaker.

Around 600 c/s to 1,000 c/s, the impedance due to the inductive reactance of the speech coil becomes sufficiently large to be of importance and, as frequency further increases, the inductive reactance becomes considerably larger than either the resistance or the motional impedance. The curve of Fig. 232 comes to an end at 10 kc/s, at which point the impedance, given almost entirely by inductive reactance, has become sufficiently high to be comparable with the impedance at resonance.

We can sum up our examination of the response curve of Fig. 232 in the following manner. At zero frequency the impedance offered is that due to the resistance of the speech coil. As soon as we introduce an alternating voltage the speech coil commences to move, and the overall impedance becomes a combination of the resistance and the motional impedance. As we advance towards the resonant frequency, motional impedance becomes increasingly high, reaching a maximum at the resonant frequency itself. After resonance, motional impedance falls and we reach a fairly flat trough in the response where the overall impedance is not a great deal larger than the resistance at zero frequency. Around 600 to 1,000 c/s, the inductive reactance of the speech coil becomes sufficiently high to be significant and, as we increase frequency, the overall impedance commences to rise again. This final rise is due to the increase in inductive reactance of the speech coil.

Next Month

In next month's article we shall conclude our examination of impedance and resonance. It had been hoped to discuss this month the reason for employing a logarithmic frequency scale for response curves such as that of Fig. 232, but space requirements necessitate that this be held over until next month also.

SUCCESS OF NEW MARGONI COMPUTER

The new, experimental, high-speed, on-line digital computer, recently announced by The Marconi Company, has already aroused a great deal of interest with customers in this country and overseas. As a result of this interest, the Company has now accelerated the development programme for this work, to produce a range of new machines, based on the design techniques pioneered in this first experimental device. Fully engineered equipment will now be available at least twelve months earlier than would have been possible.

In order to give this new programme full priority, all development work on the Marconi Mentor computer has now been cancelled. The new range of computers, which has been given the name Myriad, will include variants to fulfil all the functions of the Marconi TAC computer and the cancelled Mentor machine. The Myriad range will, however, have a greatly increased capability, due to the very much faster operating speed.

Myriad combines a number of advanced techniques in the fields of microelectronics and high-speed silicon logic, to produce a desk size unit operating at ten times the speed of earlier types. The silicon micrologic devices employed have a stage delay time of as little as 5 nanoseconds. Printed circuits are used wherever possible, and this, together with other new techniques, will offer a considerable reduction in assembly time. As a result, the cost of the new machine will be about the same as for existing Marconi computers, and Myriad will be available well before Mentor was scheduled to appear. Steps are being taken by the Company to incorporate machines from the Myriad range into all schemes which are currently under consideration.

IN YOUR WORKSHOP



As always occurs at August, Smithy the Serviceman, accompanied by his able assistant, Dick, leaves the familiar surroundings of the Workshop to sample life in the Great Outside World. Even the interruptions inevitable in this extramural scene do not, however, prevent the pair from discussing 50 c/s hum and public address line voltage working techniques

I BEG YOUR PARDON?"

"I asked," repeated Dick, idly rolling over to present his back to the hot August sun, "what would happen if I were to touch the input grid of an a.f. amplifier down here on the beach?"

Smithy propped himself up on one elbow and stared incredulously at his supine assistant.

"Am I really to understand," he queried disbelievingly, "that you've dragged me all the way down to the seashore to talk about sticking your finger on an a.f. grid?"

Dick lazily rested his head on his arms in order to return Smithy's gaze.

"It was," he remarked casually, "just a thought."

Smithy turned away in disgust and, shading his eyes, scanned his surroundings. The yellow strand of sand was starting to fill up with its usual afternoon crowd of holiday-makers, each family arriving complete with a bag, its mysterious contents shrouded under a gaily coloured towel, a transistor radio, and assorted progeny. Already the surf was being kicked up by shrieking children, whilst their elders battled grimly with the waves farther out. Smithy and Dick had previously selected a stretch of sand which was relatively free of discharged oil, ice cream wrappers and orange peel, and had solemnly divested themselves of their outer garments to emerge in

what each considered to be the optimum in beach attire. Dick wore snappy fawn trunks, whilst Smithy was resplendent in a pair of vast and flappy blue bathing shorts which had occasioned considerable ribaldry on the part of his assistant. Such ribaldry had, of course, been sternly suppressed by the Serviceman who, carefully placing the bag he had been carrying down on the sand beside him, had proceeded to stretch himself out on the sand. Dick had followed suit and the pair had allowed almost half an hour to pass in relative silence, the latter being broken only by a session of pop records on the Light Programme from a nearby radio.

Audible and Inaudible Hum

After Dick's last statement the silence returned, but it was clear that something was troubling Smithy.

"Why on earth," he grumbled, after several minutes, "should you ask me a question like that?"

"It's obvious," replied Dick immediately. "There's no mains wiring down here."

Smithy sighed. It was manifest that this would have to be pursued right through to the bitter end.

"Well?"

"If I touch the input grid of an a.f. amplifier in the Workshop," said Dick brightly, "I get a hum from the loudspeaker. What would I get down here?"

Despite himself, Smithy was becoming interested.

"I would suggest," he remarked, "that you would hear a 'plop' when you put your finger on the grid and another 'plop' when you took it off again. I'm assuming, of course, that the a.f. amplifier is a battery-driven job."

"No hum?"

"No hum," confirmed Smithy. "When you touch an a.f. grid your whole body picks up any electrostatic fields which may exist in the vicinity. And there shouldn't be any 50 c/s fields down here. It's possible, by the way, that if the battery-driven amplifier we're talking about had its h.t. supply derived from a vibrator or a motor-generator, you might hear some 'hash' from these. I'm assuming, incidentally, that there's no serious non-linearity in the early stages of the amplifier."

"What," asked Dick, "would happen then?"

"You might hear the local medium or long wave station," replied Smithy, "if the signal were strong enough. It would be detected due to the non-linearity in the amplifier."

"I see," mused Dick thoughtfully. "Getting back to the hum business, I've always thought it a pity that the mains frequency in this country is 50 c/s."

"Why's that?" queried Smithy.

"Well," continued Dick, "if it were a lower frequency it would fall

outside the audible range and we wouldn't have to spend half as much time filtering it out as we do at present. Its frequency would be too low to be audible anyway!"

Smithy grinned.

"Apart from anything else," he chuckled, "a lower mains frequency would result in an increased national expenditure, if only because of the larger transformers that would be required whenever a change in voltage was needed. But you are, in any case, barking up the wrong tree. When it is reproduced over most of the radio and TV equipment which is in use today, a 50 c/s tone appears at quite a low level."

"Come off it, Smithy," said Dick indignantly. "I've heard enough 50 c/s hum from faulty radios and things like that to convince me that it's at a jolly high level. Dash it all, it's nearly deafening when you've got a serious fault."

"What you've been hearing," replied Smithy, "are, mainly, the harmonics of 50 c/s. For instance, you're pretty certain to hear a good loud hum if a smoothing capacitor in, say, a mains radio goes open-circuit. If the set has a full-wave or a bridge rectifier you then get a 100 c/s ripple on the h.t. line, which finds its way to the speaker via the a.f. stages. (Fig. 1 (a).) This ripple is far from being a sine wave and so it contains quite a few harmonics of 100 c/s as well as the basic 100 c/s note. The result is a good rich tone, which we refer to as a hum."

"What about half-wave rectifiers?" asked Dick. "The ripple from these is basically 50 c/s." (Fig. 1 (b).)

"True enough," agreed Smithy. "But it is so far removed from a true sine wave that it is, once again, full of harmonics. And so you hear 100 c/s plus a series of further harmonics of 50 c/s. Again, you get a full rich tone."

"Are you saying that I've never heard a 50 c/s tone?"

"Indeed I'm not," replied Smithy. "I was very careful not to be as dogmatic as that. The point I'm trying to make is that, with the usual small speaker and cabinet you encounter with radio and TV sets, a pure 50 c/s tone is not reproduced at by any means as high a level as the frequencies above it. This, combined with the falling-off in response of the ear at this frequency, can result in a 50 c/s tone being much less audible than higher frequency tones of similar amplitude. If you feed a pure 50 c/s tone from a good quality amplifier into a typical radio or TV speaker, you can often feel, by touching your fingers against the

cone, quite a large amount of cone displacement for what appears to be a very low level of sound."

"What happens," asked Dick, "if you feed the 50 c/s output of your amplifier into a hi-fi loudspeaker fitted in a proper enclosure?"

"In that case," said Smithy, "the speaker would pump out a strong sound at 50 c/s. The amount of 50 c/s sound you actually hear, however, depends on the response of your own particular ear at that frequency. You will almost certainly find that you need to feed a signal with significantly higher amplitude into the speaker to reproduce a 50 c/s sound having the same apparent loudness as one at 100 c/s."

"Well, I'm dashed," said Dick. "It seems that, over the years, I've been listening to what I thought was a 50 c/s sound when, in actual fact, it was a 100 c/s sound together with harmonics."

"It is a little surprising," agreed Smithy. "The first time I bumped into the effect myself was quite a few years ago, when I was working on some high quality public address amplifiers intended for 100 volt line working."

Line Matching

Dick's eyebrows shot up.

"100 volt line working?" he asked.

"What's that?"

But Smithy had lost interest in matters technical and was delving into the bag alongside him. Eventually he produced a large black cylinder fitted with a nickel-plated handle at the top.

"What," he remarked proudly, "about this, then?"

Dick tore his mind away from the mysteries of Smithy's previous statement and examined the object.

"What is it?"

"This," said Smithy, placing the

cylinder on the sand and unfastening two small clips at the top, "is nothing more nor less than a thermos flask."

He removed the flat lid of the flask and a spiral of steam ascended into the shimmering summer air.

"Ye gods," commented Dick, peering into the depths of the canister, "if this is tea, there's enough here to feed a regiment!"

"Not quite a regiment, laddy," replied Smithy, "but you're not all that far off. We used this type of flask in the army to supply a day's tea ration for about eight men."

"Blimey," commented Dick. "When you left the army you must have taken half the stores with you! It would be worth their while starting up another war just so they could call you back again with all your gear. It's the only way they could get their books straight!"

"Nonsense," replied Smithy. "I bought it surplus."

The Serviceman turned once more to his bag and produced a cracked china cup and a once-white enamelled mug. Dick regarded these objects with horrified recognition.

"Those," he gasped incredulously, "are out of the Workshop!"

"Of course they are," said Smithy shortly. "There's no point in leaving them there doing nothing if we can employ them usefully down here. I could just about do with a cup of tea right now, so I'll leave you to get on with the makings."

Grumblingly, Dick took a bottle of milk which Smithy also unearthed from the bag and proceeded to fill the disreputable utensils.

"Dash it all," he complained, "we might as well have brought down a few sets and a couple of testmeters whilst we were at it. I did at least think we'd be able to forget the Workshop for one afternoon."

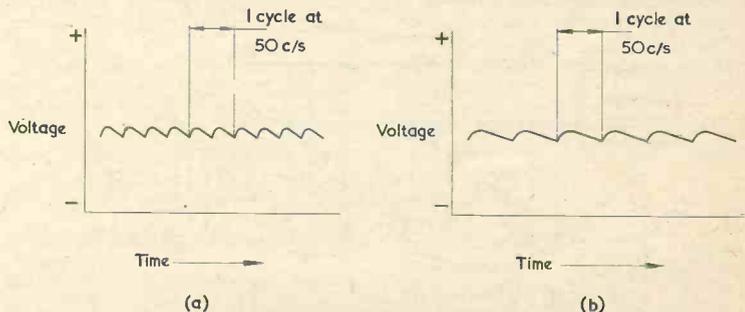


Fig. 1 (a). The ripple voltage from a full-wave or bridge rectifier has a basic frequency of 100 c/s

(b). With a half-wave rectifier, the ripple voltage has a basic frequency of 50 c/s. Due, however, to its non-sinusoidal form, the ripple contains a high percentage of harmonics of the basic frequency

"Stop chuntering," snorted Smithy, taking a deep draught from the mug which Dick had handed him. "In any case, it's *you* who's brought the Workshop with us. All your questions about hum and that!"

"At least," grumbled Dick, "I don't go around showing other people up like you do. I'm certain that everyone's watching us."

There were, indeed, plenty more people around them now who could, if they had a mind to, well enjoy the dubious pleasure of watching Smithy take his afternoon refreshment. The beach had continued to fill up and Dick and Smithy were now surrounded by other searchers after the sun. The ambient noise had risen to quite a high level and several more transistor radios were reproducing the pop record session from the Light Programme. One individualist had, however, tuned in to a play on the Home Service, turning the volume well up to ensure that no word of the action was lost.

"I must say," remarked Smithy, smacking his lips loudly and ignoring Dick's last remarks, "that all this makes a very pleasant change from work."

"Perhaps you're right," commented Dick moodily.

A thought recurred to him.

"You haven't yet," he remarked, "told me what you meant by 100 volt line working."

"Dear oh dear," sighed Smithy, "you never let go, do you?"

"You shouldn't have aroused my curiosity," replied Dick accusingly. "If you'd said nothing about 100 volt line working, I'd never have got curious about it. What does it mean?"

Wearily, Smithy gave way to the inevitable.

"Let's get back," he said resignedly, "to hum. I was saying that I first bumped into this business of

the audibility of hum when I was checking high quality public address amplifiers. These had an output of 50 watts or so, and when they were tested for hum their outputs were connected to a resistive load matching into the output transformer and capable of dissipating the full output power. A small bench speaker with a matching transformer was then coupled up in parallel with this load to give an audible indication of what the amplifier was pushing out. Most of the amplifier hum level was pure 50 c/s due to stray heater wiring couplings, and it was measured by connecting a testmeter switched to an a.c. volts range across the output. You could get quite a high reading on this meter without hearing any audible hum from the bench-speaker at all."

"What," persisted Dick, "about the 100 volt line business?"

"I'm just getting on to that," replied Smithy patiently. "As a matter of fact, it has nothing to do with hum, but I wanted to finally clear the hum question up first before getting on to it. Line voltage working is, in effect, a simple method of dealing with the matching of loudspeakers to public address amplifiers which are installed in fixed locations. Let's suppose you have a p.a. amplifier which offers an output of 50 watts at an impedance of 200Ω. This is a fairly typical impedance figure with fixed installations, such as in factories or office blocks where there may be long wiring runs to some of the speakers. Let's next say that we want to run 50 loudspeakers from this amplifier. How would you set about seeing that these matched up to the amplifier output?"

"Can each loudspeaker be fitted with its own transformer?"

"Oh yes," said Smithy. "Each loudspeaker and transformer combination is connected in parallel

across the output lines from the amplifier." (Fig. 2.)

"I see," said Dick thoughtfully. "Now, if we have 50 loudspeaker and transformer combinations in parallel, it means that the impedances they present to the amplifier output are in parallel also."

"That's right," agreed Smithy. "For convenience, you can assume that the fact that each speaker has its own matching transformer is understood. Just think in terms of the impedance offered at each speaker point."

"Fair enough," said Dick. "We need 50 impedances in parallel to give us 200Ω. Why, that's easy! Each speaker unit impedance would be 200Ω multiplied by 50, or 10,000Ω. Fifty impedances of 10,000Ω in parallel give 200Ω, which is just what is needed for matching to the amplifier."

"Exactly," confirmed Smithy. "And if the amplifier was pushing out its full 50 watts, how much power would be consumed by each speaker?"

"That's easy, too," replied Dick. "Each speaker would be handling one-fiftieth of the power. Which is 1 watt each."

Different Power Levels

"Fine," said Smithy. "The next step is to consider what happens if we want some speakers to handle more power than the others. Let's say, for instance, that we only want 10 loudspeakers to reproduce sound at 1 watt. This uses up 10 of the 50 watts output provided by the amplifier. Of the remaining 40 watts, let's assume that we want 4 speakers to work at 5 watts and 2 speakers to work at 10 watts. (Fig. 3.) How do you sort out the impedances at the speaker points then?"

"You're becoming," commented Dick, "a bit more complicated now. Why do you want all these different powers anyway?"

"It depends upon where the speakers are positioned," explained Smithy. "The speakers which consume 1 watt could, for instance, be installed in small offices where there's only a low noise level. The speakers working at 5 watts could be fitted in, say, a small hall; and the ones working at 10 watts in a larger hall or a more noisy location."

"I see the point," admitted Dick. "But it looks as though it's going to be a bit of a problem to work out."

"It is rather a fiddling calculation," admitted Smithy. "When you work from the point of view of impedances in parallel. A much easier method consists of using the idea of line

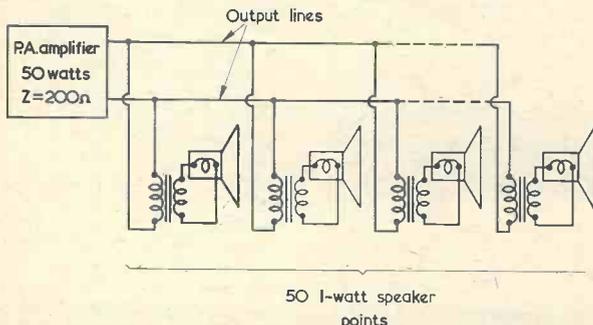


Fig. 2. Coupling 50 loudspeakers to a p.a. amplifier installed in a fixed location. Each speaker point presents an impedance of 10,000Ω to the amplifier lines

voltage working. If we connect our amplifier up to a 200Ω load resistor (Fig. 4), what voltage do we get across the resistor when the amplifier feeds its full 50 watts into it?"

"This bit's simple!" said Dick.

$$P = \frac{E^2}{R}$$

E is e.m.f. in volts and R is resistance

$$\text{in ohms. So in this case } 50 = \frac{E^2}{200}$$

Shift the 200 over to the left-hand side and you get $50 \times 200 = E^2$. Just a minute! 50×200 is 10,000, so $10,000 = E^2$. Now, what's the square root of 10,000? Why, it's 100 of course! So $100 = E$."

Smithy looked at Dick in grudging admiration.

"Your mental processes never cease to baffle me," he remarked. "Only you could have gone through that entire rigmarole with E on the wrong side of the equation!"

"I'm right, though, aren't I?" asked Dick belligerently.

"Of course you're right," replied Smithy soothingly. "We've now learnt that the amplifier offers 100 volts output when it's connected to its correct load. So we say that we have a 100 volt line. We could, by the way, get different line voltages by varying the output power or the output impedance. Our next job consists of finding the impedance which is required at each speaker point to provide the desired power output. We'll start off with the 1 watt speakers."

Smithy carefully brushed a few grains of sand from the rim of the enamelled tin mug, and drank deeply of its contents.

"Ah, that's better!" he remarked appreciatively. "Now, let's get on with these 1 watt speakers. Each speaker unit has to draw 1 watt of power from the 100 volt line and so we employ the same formula as before, except that we now use Z for impedance instead of R for resistance. It is assumed, incidentally, that the impedance is resistive. Now,

$$P = \frac{E^2}{Z} \text{ or } Z = \frac{E^2}{P}$$

This gives us, for 1 watt, $\frac{100^2}{1}$ or 10,000Ω. Thus, each 1 watt speaker point has to offer an impedance of 10,000Ω to the line if it is to consume 1 watt from it."

"Well, that's nice and easy, too," remarked Dick. "Let's have a bash at the 5 watt speakers next. $P = \frac{E^2}{Z}$

$$\text{so } 5 = \frac{100^2}{Z} \text{ Therefore } Z = \frac{100^2}{5} \text{ or}$$

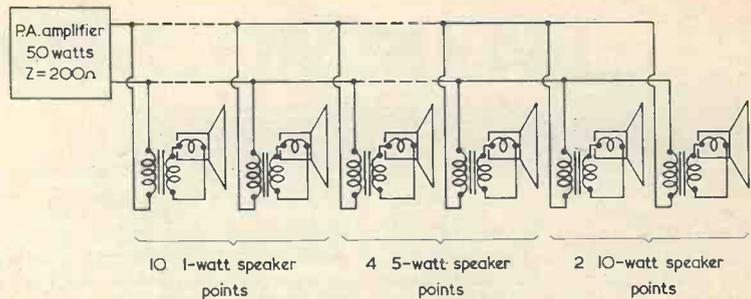


Fig. 3. An alternative p.a. speaker installation

2,000Ω. With the 10 watt speakers

$$\text{you have } 10 = \frac{100^2}{Z} \text{ with the result}$$

$$\text{that } Z = \frac{100^2}{10} \text{ So you have an impedance of } 1,000\Omega.$$

"That's the idea," confirmed Smithy. "And I'm glad to see that you eventually got Z over to the left hand side in both cases! You end up with 10 speaker points at 10,000Ω, 4 speaker points at 2,000Ω and 2 speaker points at 1,000Ω." (Fig. 5.)

"I suppose," said Dick a little doubtfully, "that you will get the correct impedance of 200Ω if you work out the total impedance given by all these speaker points."

"Definitely you will," confirmed Smithy. "To start off with, you've got 10 speaker points at 10,000Ω each, so their total parallel impedance is 1,000Ω."

Smithy traced out this figure in the sand.

"You next," he continued, "have 4 speaker points at 2,000Ω, so these give a total parallel impedance of 500Ω. Finally, you have 2 speaker points at 1,000Ω, which also give you 500Ω. The two sets of 500Ω impedances combine together to give you 250Ω, and so the total impedance is 1,000Ω in parallel with 250Ω."

"That shouldn't be too hard to work out," said Dick, rolling over and tracing out a calculation in the sand alongside Smithy's figures. "1,000Ω and 250Ω in parallel gives

$$\text{you } \frac{1,000 \times 250}{1,000 + 250} \text{ which is } \frac{250,000}{1,250}$$

Knock off the end noughts and you get $\frac{25,000}{125}$. Which is, of course,

200Ω. Piece of cake, isn't it?"

"Dead simple," replied Smithy. "And it proves that, by using the line voltage working idea, we not only present the correct impedance

to the amplifier, but we also tap off the required wattage ratings at each loudspeaker location as well. As I mentioned just now, we treat the impedances at the speaker points as though they were resistive, and this is quite acceptable for the application."

"What about the actual loudspeaker impedances themselves?" asked Dick. "Could these be, say, 3Ω or 15Ω, or something like that?"

"Oh yes," replied Smithy. "You have a matching transformer at each speaker, as I said earlier on. The turns ratio in this transformer is then equal to the square root of the impedance ratio. If you have a 3Ω speaker and want it to present 1,000Ω to the amplifier line, the turns ratio in the transformer is the

square root of $\frac{1,000}{3}$ or 333. Which

works out at something like 17:1 or 18:1 or so."

It was Dick's turn to gaze with admiration at his partner.

"Did you actually," he remarked, "work out that square root in your head?"

"Not really," admitted Smithy. "It was just a rough guess using squares which I've learned to remember off by heart. The square of 15 is 225 and the square of 20 is 400. Since 333 comes roughly in the middle of 225 and 400, its square root should, similarly, come roughly between 15 and 20."

Other Line Voltages

"I must say," said Dick enthu-



Fig. 4. Coupling the amplifier of Figs. 2 and 3 to a 200Ω load resistor

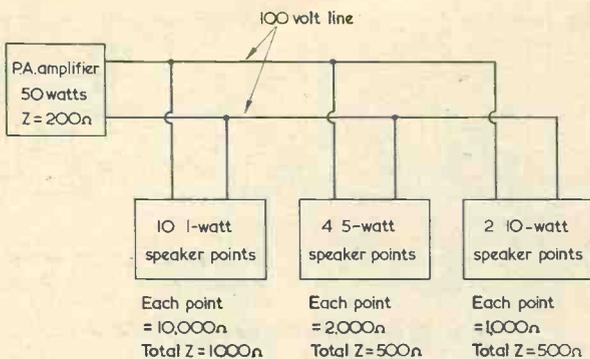


Fig. 5. Demonstrating the impedances offered by the speaker points illustrated in Fig. 3

siastically, "that we haven't half been delving into the old basic theory this afternoon, even if we are on the beach. This Pythagoras act is really something!"

"Pythagoras act?"

"Doing these sums in the sand. That's how Pythagoras worked out all that jazz about the square on the hypotenuse."

"Wasn't he the chap who invented resistance wire?"

"Hey?"

"That's right," continued Smithy. "He jumped up in his bath and called out 'Eureka!'"

"Blimey," said Dick. "Just how corny can you get? Anyway, that was Archimedes."

"Archimedes invented the Archimedean screw," stated Smithy. "It was frequently used in Greece in the old days."

"I always thought", said Dick, "that he was the immersed body geyser. You know, a body immersed in a fluid loses weight according to the weight of the fluid it displaces. Talking of that, incidentally, when are you going to immerse that body of yours in some fluid—namely the sea—and similarly lose a bit of weight?"

Smithy looked down at his middle regions.

"I can see no reason why I should lose weight," he remarked. "A certain portliness is, I feel, becoming to a person of my age and stature."

"You certainly keep it well covered anyway," commented Dick, critically surveying the Serviceman's abdomen. "Where on earth did you get those enormous drawers?"

"My swimming costume," replied Smithy with dignity, "offers complete comfort combined with a decent and discreet covering of the limbs. A large costume has the further advantage, in my case, of

hiding my appendicitis scar."

"Do you mean to say," asked Dick incredulously, "that they found your appendix in *that* lot. They must have charged a search fee!"

"Whuff," said Smithy.

This extraordinary utterance was not intended as a reply to Dick but was occasioned by the forceful descent of a heavy beach ball on the exact centre of Smithy's stomach. The sudden appearance of the ball awoke Dick to a realisation of the world about him. By now the bay was fully crowded, and he was surprised to find how closely hemmed in they were on all sides. The radios about them continued with their various renderings of the Light Programme and the Home Service. Even as Dick watched, a young man sat down to produce a further transistor radio, which he tuned in to a cricket commentary on the Third Network. Things were settling down to the usual British version of an afternoon at the seaside.

"Oh," said a youthful female voice. "I'm so sorry."

The owner of the voice stepped daintily over the recumbent bodies about them and extended two sun-honeyed arms to pick up the beach ball at Smithy's side. Dick looked up to see a slender feminine figure hovering gracefully above him clad in the dinkiest of bikinis. An exquisite smile appeared on the face of this vision, and he became lost in the depths of two clear blue eyes.

"That's all right," he stammered eventually.

"Oh, I'm so glad."

The voice reminded Dick of the murmuring of bees in a sun-drenched garden.

"In any case," continued Dick, indicating the rhythmically puffing Serviceman, "he doesn't mind."

"I'm so glad," repeated the girl.

Slowly she turned away to make her way delicately through the crowds and their paraphernalia. She turned round to give a long glance at Dick, then finally disappeared.

Smithy returned to normality.

"Phew," he rumbled. "That gave me quite a turn."

He turned to his outsize flask, refilled his outrageous mug, quaffed deeply of the restoring liquid it contained, and returned to a supine position on his back.

"Now where were we?" he remarked, collecting his thoughts. "Oh, yes, we were talking about 100 volt line working. I think I should add that there are other standard line voltages as well, these being at 60, 80 and 120 volts. However, the 100 volt line is that which appears to be most common. If the public address system has to reproduce music and there are long wiring runs to the speaker units, self-capacitance in the cable can sometimes be a nuisance because it causes attenuation of the higher audio frequencies. This effect can be reduced by going down to lower line voltage working.

"Another point," he continued, "is that the wattage figures I talked about just now were meant mainly to illustrate the method of working out speaker impedances. In practice, an office usually requires about 2 watts, whilst a fairly noisy factory shop may require anything from 20 to 100 watts or more overall, according to its size and general noise level. Yet another factor . . ."

The Final Scene

Suddenly aware of an absence of comment, Smithy broke off and turned over to look at his companion.

But Dick was gone.

Smithy sat up and surveyed the area around him. There was no sign of Dick anywhere at all. He had become completely swallowed in the teeming mass which now thronged the beach.

"Oh well," commented Smithy philosophically to himself. He pouroed himself yet another draught of tea, then lay back and allowed the various sounds of the beach to flow over him. Idly his ears responded to the triad combination of Light Programme, Home Service and Third Network which pervaded the air.

A thought struck him, and he started to rummage in his bag, eventually producing a large and powerful-looking transistor radio. He switched this on and selected the medium wave band.

Carefully, he searched for Radio Caroline . . .

NEWS AND COMMENT . .

Commercial SSB

At the 1959 conference in Los Angeles, the International Radio Communication Consultative Committee (C.C.I.R.) recommended that a single-sideband system of communication should be introduced to combat the increasing congestion in the frequency bands allotted to the marine mobile services, and the recommendation was passed by last year's C.C.I.R. Plenary at Geneva.

In anticipation of the stringent standards which will be required under the recommendations of the committee, Marconi Marine have introduced a new single-sideband high power transmitter and associated single-sideband receiver for use in deep sea vessels where radio communication equipment is a compulsory fitting.

"Crusader", as the new transmitter is named, has been fully tested and type-approved by the British Ministry of Transport and General Post Office. With a power output of up to 1,000 watts on high frequency radiotelegraphy and up to 1,400 watts on single-sideband telephony, "Crusader" provides complete coverage of all bands allotted to the marine mobile service between 400 kc/s and 26 Mc/s on telegraphy and/or telephony (double-sideband or single-sideband) as appropriate to each band.

"Crusader", with ten times the punch of a conventional radiotelephone transmitter of similar peak power, has been made very compact and reliable by the use of transistors in all stages up to the power amplifier chain, while a minimum number of controls ensure simplicity of operation.

Designed as a complement to the "Crusader" transmitter, the "Penant" radiotelephone receiver provides an efficient and easily-operated radiotelephone system. Selection of an h.f. radiotelephone channel in the transmitter automatically sets the receiver to the appropriate receiving channel. The only receiving controls which normally require adjustment by the operator are the gain controls. The automatic filter system protects the receiver against interference from the ship's own transmissions, thus full duplex operation is automatically provided without the need for additional units.

Women Engineers

In the June issue of *Rotor*, the magazine of the Apprentice Association of A.E.I. (Manchester), there appears an article entitled "Women Engineers"; in view of our comments on "Lady Servicemen" we read the article with some interest.

The idea that women wish to be engineers merely to invade a male stronghold is dismissed. In the opinion of the author the fact that modern life is so highly mechanised makes it natural for women to become interested in engineering of one sort or another.

According to the writer one-third of the engineers in Russia are women whereas the proportion in England is only a fraction of 1%. We wonder what the comparative proportions are in electronic engineering?

One of our readers commenting on "Lady Servicemen" queried some of the language which might be used by fellow servicemen; the lady engineer said that bad language disappeared when she was around!

Another one of our correspondents on the same subject gave a glowing tribute to his wife instancing many occasions when she had helped him in electrical matters despite no previous training. We will conclude by quoting from his letter. "I do think wives can be very helpful in this radio-tele business and after all, who knows, if you fall on bad times you have a lady serviceman ready to go. Good luck and more of them I say."

BBC Use of Records

The BBC and the Musicians' Union have reached agreement on the question of increased use of gramophone records for the extension of the Light Programme and for the Serious Music Network without reference to the Performing Right Tribunal.

By this agreement the Union, whilst maintaining opposition to use of gramophone records where musicians in their view should be employed, have withdrawn their objection to the use of the 47 extra hours per week of needle time that the BBC required.

In our remarks last month on "pirate" radio stations we hazarded the guess that mainland stations would in due course come into existence to meet the demand for continuous "pop" music. We did not necessarily mean BBC stations as there is a powerful group of M.P.s in favour of commercial and local land-based stations for this country. However, the foregoing increase in use of gramophone records by the BBC will in fact, if not in intention, give competition to the "pirates".

The increase in popular music in the Light Programme will have repercussions affecting broadcasts on the other wavelengths. For example, the magazine programme "Sound" on Network 3 is to cease. This is a great pity from our point of view as it is the one programme which is likely to have general appeal to all our readers: Regular readers of these notes will recall that in this programme talks are given by leading personalities in the radio, hi-fi and tape recording fields and discussions held on matters of interest to amateurs.

The last programme planned is to be broadcast on Sunday, 2nd August, the day after this issue is published. There will be talks on the foregoing subjects including one on radio as a hobby by our well-known contributor, F. C. Judd.

Conversation Pieces

From the *Daily Telegraph*:

"Computers which can already talk to each other on the telephone will soon be able to dial their own calls and try again if the line is busy.

An engineer said: 'It will soon be possible for a computer that needs data from another to dial the second computer and ask for information.'"

From an R.A.F. Newsletter issued in Borneo for circulation within the R.A.F. Marine Branch:

"Local Boatman: Your ship—is Navy?"

R.A.F. coxswain: No—R.A.F.

Local: Ah. Last week, those helicopters—they R.A.F.?"

Coxswain: No—Navy!

Local: You came from England?"

Coxswain: No—Scotland!

... Local departs, shaking his head."

Cover Feature

Transistor-Operated ANEMOMETER

By H. S. KING, G3ASE

The rotating cups of anemometers (instruments which measure the velocity of the wind) are familiar sights on airfields and weather stations. In this article our contributor describes an anemometer which may be completely home-constructed. It has the considerable advantages of displaying wind velocity directly on a meter, and of employing a completely frictionless system for translating cup rotation into electrical impulses

IT IS REMARKABLY DIFFICULT TO FIND AN INEXPENSIVE anemometer displaying wind speed on a meter dial. Moderately priced impulse systems and "run-of-wind" indicators are available, but these are simple instruments and give no directly available measurement of wind speed.

Several methods have been considered and tried by the author over the last few years, but all suffered from certain disadvantages. The usual troubles with systems which generate an e.m.f. are high friction, inertia, undue complexity and uncertainty at low speeds.

Interrupted Light Beam

To solve these problems, the instrument described in this article uses the principle of an interrupted light beam. An aluminium disc measuring 3in in diameter has 16 rectangular holes evenly spaced near the periphery. A 6 volt bulb is focused through the holes on to a phototransistor, and the output is differentiated and then amplified before being applied to a bridge rectifier and display meter.

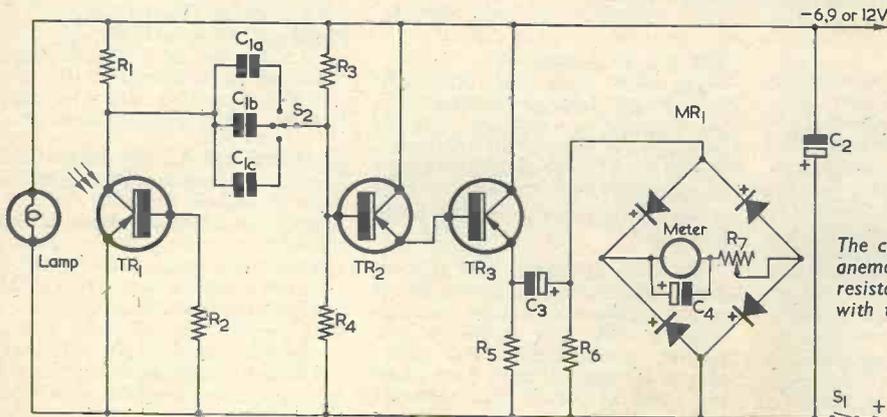
The disc was mounted for convenience on a Meccano rod by first bolting the disc to a Meccano

wheel. Similar wheels or collars may be used for bearings. The cups may be plastic funnels attached to Meccano or light wooden strips.

A 6 volt 0.3 amp bulb is mounted above the disc and a small lens (diameter $\frac{1}{2}$ in, focal length 1in) converges the light through the disc on to an OC71 with its paint removed. The OC71 is about $\frac{1}{4}$ in below the disc, but experiment will determine the best position. This may conveniently be done by connecting a d.c. voltmeter across the transistor load resistor to determine the optimum light/dark ratio of collector current. With a 6 volt supply a 2 volt change should easily be obtained. If the bulb is placed very close to the disc the lens may be dispensed with, although there will be some loss in output which may be compensated for by using a higher gain amplifier and more sensitive meter.*

As the international height for reading wind speed is 10 metres above ground level, the bulb, disc and phototransistor assembly may be mounted imme-

* It should be noted that it is impossible to remove the opaque covering from some versions of the OC71. An alternative to the OC71 is the OCP71, which is expressly intended for use as a phototransistor. An OCP71 may be connected into the present circuit in the same way as the OC71.—EDITOR.



The circuit of the transistorised anemometer. If necessary, a resistor may be inserted in series with the lamp for 9 or 12 volt operation

diately beneath the cups, the remaining amplifier, meter and battery being positioned more conveniently indoors. However, as the writer required a portable, self-contained instrument, all the components were fitted into an ex-Civil Defence radiation detector case which fortunately already contained a $50\mu\text{A}$ meter. (The ex-C.D. unit is a Portable Dose-Rate Meter Type 1038A.) As will be seen later a 1mA meter may be used.

Circuit Operation

In the accompanying circuit diagram, the voltage fluctuations across R_1 are applied to TR_2 via the differentiating circuit $C_1R_3R_4$. The resulting voltage on the base of TR_2 is thus dependent on frequency and, in consequence, the speed of rotation of the cups. By suitable choice of C_1 various ranges may be obtained and, in conjunction with meter sensitivity and supply voltage, the linearity of the scale reading can be determined. The input impedance to TR_2 is made high by virtue of its emitter connecting to the base of TR_3 and is sufficient to prevent reduction of the voltage changes across R_1 . The low impedance output from TR_3 is full-wave recti-

Components List

Resistors (all fixed resistors $\frac{1}{4}$ watt 10%)

R_1	47k Ω
R_2	22k Ω
R_3	220k Ω
R_4	220k Ω
R_5	2k Ω
R_6	10k Ω
R_7	10k Ω potentiometer

Capacitors

$C_{1(a)}$	0.01 μF
$C_{1(b)}$	0.05 μF
$C_{1(c)}$	0.001 μF
C_2	500 μF electrolytic (working voltage to suit supply)
C_3	100 μF 6V wkg. electrolytic
C_4	100 μF 6V wkg. electrolytic (see text)

Transistors

TR_1	OC71 (or OCP71—see text)
TR_2	OC44
TR_3	OC44

Lamp

6 volt 0.3 amp lamp (or to suit supply)

Rectifier

MR_1 1mA instrument bridge rectifier

Switches

S_1	s.p.s.t. on-off switch
S_2	Single pole, 3-way, range switch

Meter

Moving coil meter, $50\mu\text{A}$ to 1mA (see text)

Battery

6, 9 or 12 volt battery (see text)



Close-up view, showing the lamp, lens and disc assembly

fied with a 1mA meter instrument rectifier. C_4 smoothes out vibration of the pointer at low wind speeds but, if it has too large a value, will give a long zero return time. The best value must be found to suit the meter and other circuit constants. R_7 must also be experimented with to give a linear scale, although some cramping may be found at the upper end of the scale. Increasing the supply potential to 9 or 12 volts will help linearity, but provision must be made for the bulb by either fitting a type of suitable voltage rating or using a series dropper resistor.

If R_6 is not fitted in the circuit, the meter may, if it is a sensitive one, swing over against the stop on switching off as C_3 discharges, with a risk of damage to the movement. If a 0.5mA or a 1mA meter is used with R_7 suitably reduced this effect may not be serious. However, the inclusion of R_6 , which carries the discharge from C_3 , prevents the meter overload from being serious even with a $50\mu\text{A}$ meter.

Calibration

This anemometer has a big advantage over systems which generate a current because the rotating mass may be kept to a minimum. Hence response to wind changes is rapid, and light winds can still cause the cups to revolve since friction is kept low. Wind speeds of 2 to 60 m.p.h. can be accommodated in 3 ranges with a good overlap if required. The values of $C_{1(a)}$, $C_{1(b)}$ and $C_{1(c)}$ must be found by experiment. A single range may, of course, be used if simplicity is desired at the cost of

accuracy in reading low wind speeds. Calibration may be roughly determined by using a signal generator feeding into C_1 , when 10 to 200 cycles may be considered a useful total coverage. To calibrate actual wind speeds it is necessary to pick a calm day and get a colleague to hold the anemometer through a car window and check speeds against the car speedometer. At the higher speeds slipstreaming may cause some inaccuracy. It may be found possible to extrapolate for speeds exceeding those of the particular car used.

In the writer's experience it is necessary to hold the instrument about 2ft from a side window for steady readings and to avoid slipstream turbulence.

It would no doubt be advantageous to use a car with a sliding roof and to stand up with the anemometer well above the car.

Typical calibration figures obtained by the writer with his own unit and using a 6 volt supply are given in the table.

TABLE
Meter indications with 6 volt supply

Range	Value of C_1	Half-scale reading	Full-scale reading
1	0.01 μ F	10 m.p.h.	25 m.p.h.
2	0.05 μ F	20 m.p.h.	50 m.p.h.
3	0.001 μ F	40 m.p.h.	100 m.p.h. (estimated)

HIGH FREQUENCY CONVERTER for 15 to 7.5 metres

By G. WADE

The converter described in this article is capable of extending the normal broadcast receiver short wave of 50 to 16 metres up to 7.5 metres. An ingenious feature is that it employs the unusual intermediate frequency of 10.7 Mc/s in order to minimise second channel interference

An aerial coupling winding was abandoned in favour of a tap, this providing an autotransformer in the signal grid circuit of V_1 together with the tightest possible coupling to the aerial.

If L_1 is tapped too near the grid loss of selectivity results, whereas a tapping near the chassis end improves selectivity, and the loss of signal voltage is partly compensated by the voltage step-up due to the turns ratio.

The incoming aerial signal is tuned by C_1 and C_2 . C_2 is the signal frequency trimmer, and should be set at about 25pF. The oscillator works 10.7 Mc/s higher than the signal, and thus tunes from 30.7 to 50.7 Mc/s. Tracking is very satisfactory. The oscillator frequency is

THE AUTHOR IS BY NO MEANS A "dab hand" at electronics, but he would nevertheless like to interest other beginners in something which is a little different from single valve receivers and straight sets. It was with this view in mind that he built the converter unit described in this article. The unit covers 20 to 40 Mc/s (15 to 7.5 metres), this being a band that few simple receivers cover, and which is therefore of interest to the experimenter.

The converter is intended for use in conjunction with a normal broadcast receiver having the usual 15 to 50 metre short wave band. No adaptation of the broadcast receiver is needed, and the unit is connected up by merely plugging its output into the aerial and earth sockets.

The Circuit

It will be noted that, in the circuit shown in Fig. 1, there is no r.f. stage. One reason for having such a stage is to provide another tuned circuit resonant at signal frequency, so increasing the image rejection ratio. However, the high i.f. of 10.7 Mc/s used in the present design takes care of image signals.

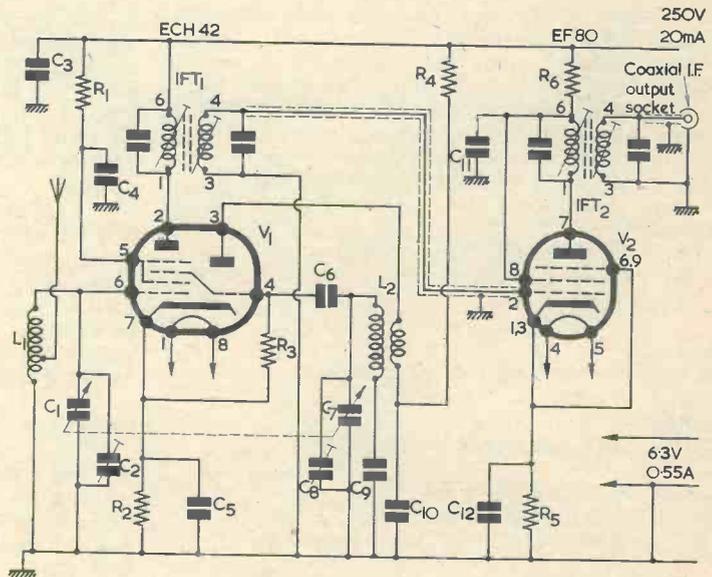


Fig. 1. The circuit of the converter. The layout should allow the screened lead connecting i.f.t.1 to the grid of V_2 to be short, otherwise its self-capacitance may prevent i.f.t.1 secondary from being adjusted to 10.7 Mc/s

Components List

Resistors

(All resistors 20%)

R ₁	56kΩ	½ watt
R ₂	220Ω	¼ watt
R ₃	33kΩ	¼ watt
R ₄	47kΩ	½ watt
R ₅	220Ω	¼ watt
R ₆	3.3kΩ	½ watt

Capacitors

C _{1, 7}	75+75pF	two-gang
C ₂	30pF	trimmer, air spaced
C ₃	0.1μF	
C _{4, 5}	0.01μF	(preferably ceramic)
C ₆	47pF	ceramic or silver mica
C ₈	30pF	trimmer, air spaced
C ₉	100pF	silver mica
C _{10, 11, 12}	0.01μF	(preferably ceramic)

Valves

V ₁	ECH42
V ₂	EF80

Inductors

L _{1, 2}	See text
I.F.T. _{1, 2}	10.7 Mc/s i.f. transformers, Jason (or equivalent)

Miscellaneous

- 1 B8A valveholder with screening can (for V₁)
- 1 B9A valveholder with screening can (for V₂)
- 2 coaxial sockets (one for aerial input)
- 1 chassis (6 x 4in for prototype)

applied to G₃ of the hexode section of V₁, and beats with the aerial signal to produce the intermediate frequency at the anode. The EF80, V₂, functions as a conventional i.f. amplifier.

The output from pins 3 and 4 of i.f.t.₂ is fed to the aerial and earth sockets of a receiver tuned to 10.7 Mc/s (28 metres), thereby forming a "double superhet". The tuning of the broadcast receiver to 28 metres

is not very critical, and it was found that, by slightly tuning off frequency (to within ±1 metre), there was a reduction in noise whilst signal reception remained good.

Construction

L₁ is air cored, and has an inductance of 0.63μH. It consists of 10 turns on a ½in diameter former, with a tap 3 to 4 turns from the grid end. Its length is ¾in. L₂ is similarly air cored, and it has an inductance of 0.54μH. The tuned grid coil consists of 9½ turns on a ½in diameter former. (See Fig. 2.) The anode winding has 3 turns, these being wound, as indicated, in the same direction as the tuned winding. The length of the tuned winding is ¾in. L₁ and the tuned winding of L₂ are wound with 22 or 24 s.w.g. tinned copper wire. The anode coupling coil of L₂ may be wound with a similar gauge of wire, this being enamelled and cotton or rayon covered.

The connection from pins 3 and 4 of i.f.t.₂ should be by way of coaxial cable to avoid signal pick-up on 28 metres. The i.f. circuit wiring must be well screened from the mixer section to avoid interaction. Poor wiring here can result in what appear to be strong, unmodulated carrier waves beating with each station received. Generally, short wave wiring techniques must be observed, with short stiff leads and components rigidly fixed. The EF80 should preferably be screened.

Power requirements are 250V at 20mA h.t., and 6.3V at 0.55A for heaters.

Results

One of the principal reasons for building the unit was sheer curiosity as to what results could be obtained at these frequencies. With 4ft of aerial wire, transmissions from Carolina (U.S.A.), Canada, Switzer-

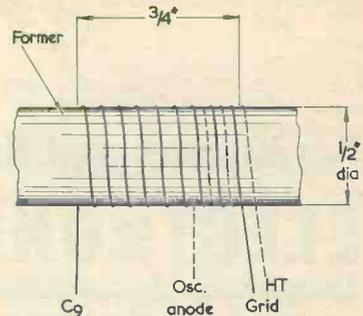


Fig. 2. Details of the oscillator coil

land and Italy were received on the 13 and 11 metre bands. The unit also tunes over the 10 metre amateur band. A rough dipole, consisting of two wires dangling over the bench was attached, and the trimmer C₈ was slightly reduced in value to enable the lower end of Channel 1 TV to be received. The B.B.C. sound transmissions on 41.5 Mc/s from Crystal Palace could then be heard without difficulty. (The author is resident at Birmingham.)

EDITOR'S NOTE.—The output of the unit is coupled to the receiver by way of coaxial cable, the outer conductor of which connects to the earth socket of the receiver. If the receiver has its chassis connected to one side of the mains, care should be taken to ensure that the isolating capacitors in both its aerial and earth circuits are reliable and satisfactory. In the event of modulation hum, reverse the mains input to the receiver. The converter unit may obtain its h.t. and heater supply from a separate power pack with a mains isolating transformer. If h.t. and heater power is taken from the power supply in the receiver (assuming that the additional current can be provided) it is essential that the receiver have an isolating mains transformer.

The high self-capacitance of the lead between the converter and the receiver will probably make it impossible to tune the secondary of i.f.t.₂ to 10.7 Mc/s, whereupon it may prove helpful to remove the secondary core altogether. The primary should still, however, tune satisfactorily.

BUILDING SAFETY INTO THE ARTIFICIAL HEART MACHINE

A paper in *The Lancet*, a leading British medical journal, recently acknowledged work by engineers of Standard Telephones and Cables Ltd. new safety devices for Hurt's cardiac bypass apparatus—an artificial heart machine that takes over the heart's pumping function during certain surgical operations.*

In his paper Dr. P. V. Cole, M.B., St. And., F.F.A., R.C.S., of St. Bartholomew's Hospital, London, describes work by the hospital team and prototype equipment built by engineers of S.T.C. Semiconductor Division (Rectifiers) at Harlow, Essex.

The problem was to find a reliable and instant method of stopping the bypass pumps in the event of their blood reservoirs falling below a safe level. Continued pumping, even for a few seconds in these circumstances would introduce fatal air into the patient.

A special solar-cell was devised to stop the pumps automatically. The design had to meet three essential requirements:

- The photo-cells which detect the fall in reservoir level had to be highly sensitive because the transparency of the plastic containers is not high; the material becomes yellowish after sterilisation and also carries a blood film on the inside surface during operation.
- The cells had to give a high output, sufficient to operate relays directly so that amplifiers and other potential causes of failure could be avoided.
- The cells themselves had to be of the highest quality and reliability available.

High output solar cells (S.T.C. type PV20) were chosen because no additional lighting or optical focusing was found necessary beyond the 30-watt lamp used to illuminate the machine itself.

The pump is restarted automatically when the rising blood level in the reservoir again obscures the light to the photo-cell. A separate switch also permits over-riding manual control of the pump when required.

*Hurt's bypass apparatus has been used in St. Bartholomew's Hospital for over 100 operations in Drew's technique. The Drew method for open cardiac surgery involves cooling the patient's body to 12° C at which temperature the circulation may be arrested for periods up to one hour without damage to the brain. Circulation must, however, be maintained during the cooling and warm-up period. This is done by means of two pumps bypassing the right and left sides of the heart. It is vital that the blood volume of the patient be kept constant and that no air be injected.

Percussion and Sustain Circuits for ELECTRONIC ORGANS

By ALAN DOUGLAS, Senior Member, I.E.E.E.

ORGANS FOR USE AT HOME HAVE undergone a steady revolution in the last ten years. From the traditional voices of few pitches have developed "new" voices with multiple pitches. This is possible because of the frequency divider system.

Such systems, if inexpensive, often produce poor imitative tones, so other adjuncts are required to enhance the effect. In addition, divider systems speak very rapidly so that, unless one's fingering is well controlled, the effect tends to be ragged. The complete lack of reverberation in normal rooms makes the organ sound thin.

Synthetic Reverberation

Synthetic reverberation is often used to delay the decay of the sound and thus cover up many playing deficiencies. In some circumstances it may really enhance the tonal effect, in many cases it does not.

A more agreeable and controllable effect is obtained from circuits which sustain the sound for a comparatively short period after the key is released. Sustaining circuits are available for both valve and transistor organs.

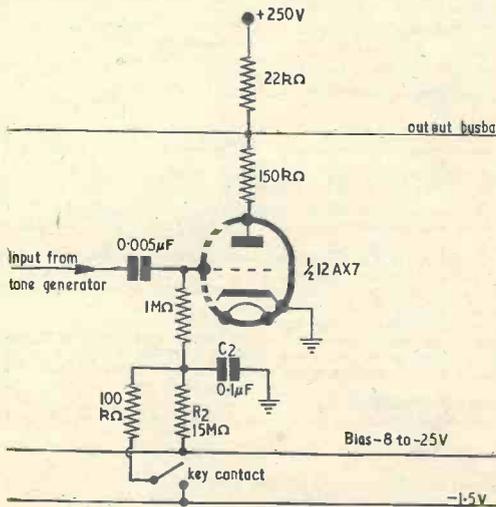


Fig. 1. A valve sustaining circuit

It will be noted that on commercial organs it is usual to find only flute-like sounds controlled by sustain or percussion circuits. This is because such circuits usually release stored energy exponentially, and if a tone quality rich in harmonics were applied, these harmonics would be dropped out one by one (at least, if a sawtooth wave were used) and this makes the decay most unreal; if percussion is used, it is not possible to fully develop a complex wave and, again, the effect is unreal and irritating. Therefore approximately sine waves only are fed to such circuits.

Valve Sustain Circuit

There are far more valve organs than transistor organs in existence,

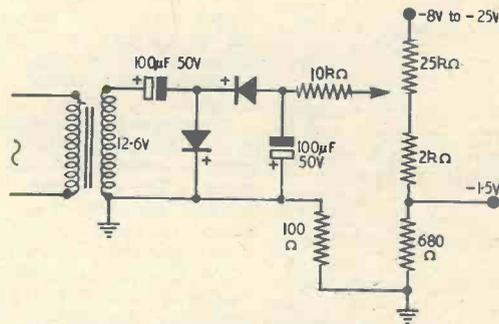


Fig. 2. Bias supply for Fig. 1

so let us look at a valve sustain circuit first. In Fig. 1 we see a valve connected to tone generator outlets and bias control contacts. Normally, the grid returns through the 15MΩ resistor to a bias sufficient to cut off the valve. This bias must exceed the normal cut-off voltage for the valve plus the peak value of the incoming signal voltage. There is then no output from the valve.

On pressing a key, the grid is connected through the 100kΩ resistor to an operating value of bias, in this case—1.5V. The valve then conducts the signal from the tone generators. Note that when the contact is closed, the voltage present at the lower end of the 15MΩ resistor has virtually no effect on the bias since 15MΩ is such a high resistance compared with 100kΩ.

Now when a key is released, the cut-off bias starts to return to the grid but is delayed by the time constant of C₂ and R₂. As the bias increases, the valve conducts on positive excursions but is cut off on negative swings. With each successive cycle, the valve conducts less and less until it is fully cut off again. The time taken to do so is controlled by the bias voltage; this is adjustable

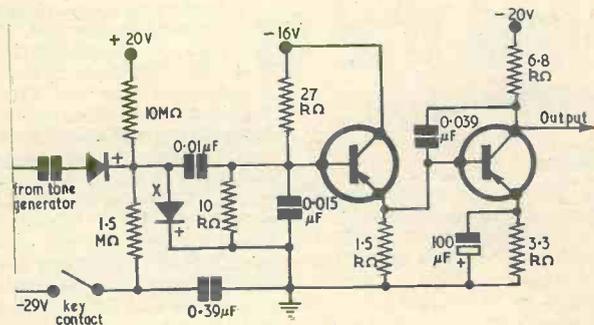


Fig. 3. A transistor sustain circuit

from $-8V$ to $-25V$. The output is common to all valves, one of which is required for each note sustained.

As the valve approaches cut-off, it operates in a very non-linear manner. This tends to cause harmonic distortion and so underlines what has just been said about confining the effect to simple waveforms. Of course, any attempt to use one valve for more than one note would lead to serious intermodulation and intolerable distortion.

A small power supply unit for providing the biasing voltage is shown in Fig. 2, which is self-explanatory.¹

Transistor Circuits

Those interested in transistors can look at Fig. 3. In this case the out-

¹ At first sight it would appear that variation in the potentiometer of Fig. 2 would seriously affect the $-1.5V$ output. However, the circuit is correct as shown and, in company with the other circuits discussed in this article, is in actual production and large-scale use in the U.S.A.—EDITOR.

put from each tone generator is brought through a diode, which is reverse biased to prevent the signal from being heard. The sustain contacts, when operated by the keys, connect $-29V$ to the diode cathode through the limiting $1.5M\Omega$ resistor;

at the same time this voltage charges the $0.39\mu F$ capacitor. The $-29V$ overcomes the cut-off bias of $+20V$ and the diode conducts. The sound continues until the $0.39\mu F$ capacitor has discharged and the diode is again cut off. As is usual with such circuits, an emitter follower couples the tone output to the sustain amplifier. A clamping diode is used at X and this is followed by a simple RC filter to stop any click due to the capacitor charging.

There are few domestic organs having a completely separate oscillator for each note, but sustain is easily applied in such cases by the simple circuit of Fig. 4, in which the voltage applied to the base through

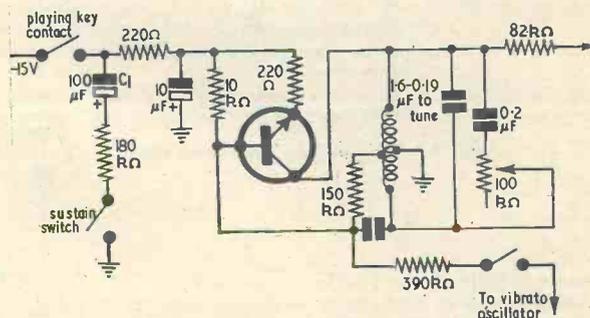


Fig. 4. Sustain circuit for directly keyed oscillator

the playing key also charges the $100\mu F$ capacitor. On release of the key, the oscillator continues to function until C_1 loses its charge. Naturally, this calls for an oscillator in which the frequency is not dependent on the applied voltage.

Percussion Circuits

It will readily be appreciated that percussion circuits are essentially the same as sustain circuits, but with different envelope controls. An example of a valve circuit is shown in Fig. 5. The difference of potential between grid and cathode of the control valve is $5V$. Normally, a $+35V$ is connected to the cathode. On pressing a key, $+35V$ is connected to the grid through a $1M\Omega$ resistor. The bias voltage is then zero and the valve conducts. The $0.47\mu F$ capacitor is also charged by the $35V$ contact at the same time. On releasing the key, the signal is maintained until this capacitor discharges to $30V$, which again cuts the valve off due to the $5V$ grid-cathode biasing condition. The rate of decay can be increased by the switch shown, which connects the $0.47\mu F$ capacitor

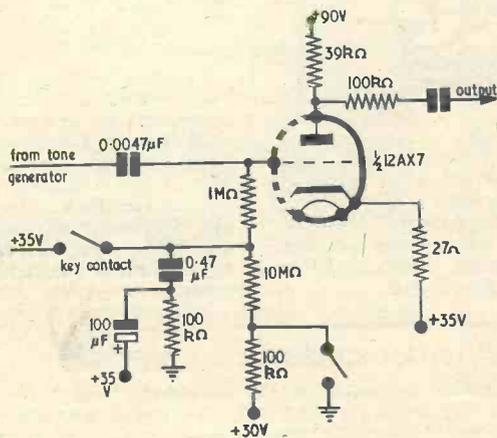


Fig. 5. A valve percussion circuit

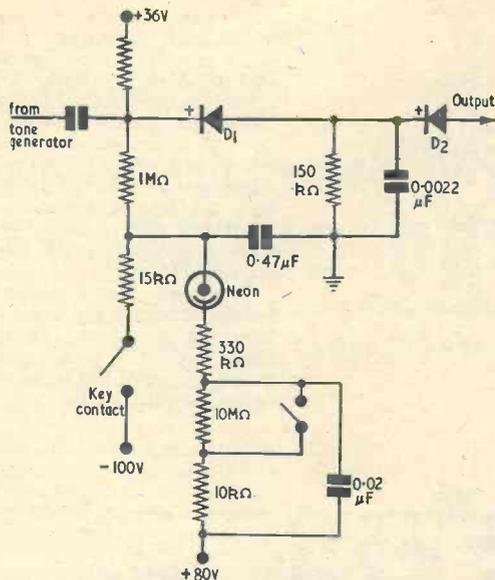


Fig. 6. A percussion circuit using diodes

directly to earth through the 10MΩ resistor. The sound is then more percussive.

Turning again to transistors, one of the best circuits is that of Fig. 6. Once again we find a reverse-biased diode. On connecting the -100V busbar by a key contact, the diodes conduct and the 0.47μF capacitor charges to 100V. Opening the key contacts enables the capacitor to maintain the forward bias on the diodes until it discharges through the 1MΩ resistor. Note that D₂ isolates each circuit from the remainder, as all outputs are in parallel.

To increase the percussive effect, a neon lamp may be connected to +80V. The 10MΩ resistor has no effect on the rest of the circuit but prevents the lamp from striking. When it is short-circuited, the lamp fires and the capacitor discharges through it much more quickly than through the 1MΩ resistor. It can easily be seen that with a little experiment, this circuit can be used for both sustain and percussion by suitable switching of values.

Common Circuit

Naturally, a circuit which could be common to all notes would be very desirable, and a number of these exist; most are, however, too complicated for the average amateur. One arrangement which could be tried is shown in Fig. 7.

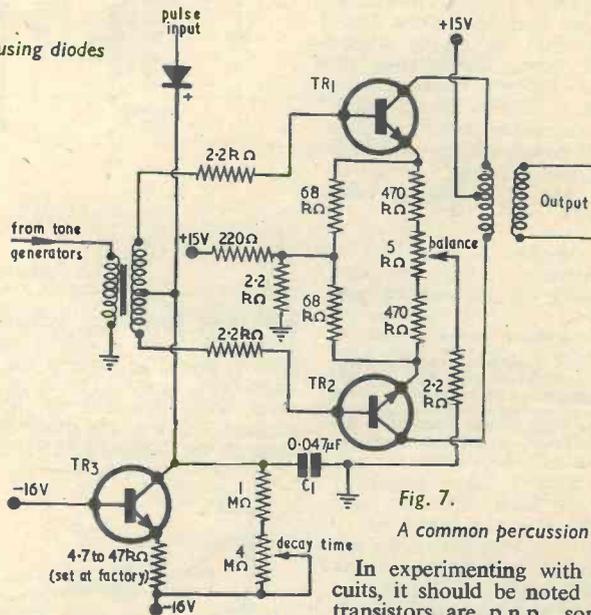


Fig. 7.

A common percussion circuit

The push-pull modulator is normally cut off by the bias from TR₃. Tone is fed to the input transformer from the generators. If, now, a pulse is applied to TR₁ and TR₂ through the transformer, these can be momentarily driven into conduction and the signal will pass. The push-pull drive eliminates thumps. The best way to provide the pulse is by rectifying the output from a one-shot multivibrator; such a circuit can be triggered off by discharging a capacitor on depressing a playing key, the capacitor being always charged when the key is "up" by way of a change-over contact on the key. The rate of decay can be increased by altering the value of C₁.²

² In Fig. 7 the bias on TR₁ and TR₂ is controlled almost entirely by adjustment of the -16V and the emitter resistor of TR₃. It needs to be just sufficient to cut off TR₁ and TR₂. Apparently, the pulse from the one-shot multivibrator is of large amplitude. —EDITOR.

In experimenting with these circuits, it should be noted that some transistors are p.n.p., some n.p.n., so polarity of supplies must be carefully observed. The diodes used in Figs. 3 and 6 should be single disc selenium rectifiers as made by S.T.C. and Westinghouse, and could consist, for example, of the discs used in e.h.t. rectifiers stacked in insulating tubes.

BRITISH AMATEUR TELEVISION CLUB CONVENTION

The Convention will be held this year on Saturday, 12th September, at the Conference Suite of the Independent Television Authority at 70 Brompton Road, London, S.W.3, from 10 a.m. to 6 p.m. The programme of the Convention will include an exhibition of members' equipment, the Annual General Meeting of the club and a short symposium when papers on television topics of general interest will be presented by members. Further information can be obtained from M. H. Cox at 135 Lower Mortlake Road, Richmond, Surrey.

Experiences of an Early Amateur

C. H. GARDNER

In an eventful career, Mr. Gardner has always been closely associated with the radio amateur movement and with the hobby of radio construction. He commenced amateur activities in 1911 and transmitted under the call signs 2WQ and 5XH in the post-1914-18 war period. He made the first transmissions ever from a racing car engaged in record breaking in 1922 and, in the same year, provided transmissions to the first Radio Exhibition, held at the Horticultural Hall, Westminster, to enable receivers to be demonstrated.

In the period 1925-29 Mr. Gardner was engaged on work connected with the design and development of broadcast receivers, during which time he made a number of broadcasts from the B.B.C. on radio reception and operated as the Midlands organiser for the Radio Association. In 1929 he joined the Mullard Company.

Called up for duties as Station Signals Officer at R.A.F. Warmwell in August 1939, he was attached to the Air Ministry for a short period to undertake the siting of v.h.f. stations for Fighter Command and subsequently took over duties as a radar instructor at Yatesbury. This was followed by appointments as Officer Commanding Chain Radar Station, R.A.F. West Beckham, and technical officer at a Wing Headquarters. The termination of the war found him serving on the Inter-Services Components Committee, and on demobilisation, he rejoined the Mullard Company in 1945, being appointed Manager of their Films and Lectures Organisation in 1953.

He took an active part in the I.P.R.E. and became their President in the two consecutive years 1950 and 1951, being made an Honorary Life Fellow in 1960.

On retirement from Mullard in 1961 he was appointed as consultant to their Films and Lectures Organisation and undertook a number of lecturing appointments for them in the North of England, to where he has now gone to live and pursue his other hobby of game fishing.

IT IS WELL OVER HALF A CENTURY SINCE THE work of Hertz, Oliver Lodge and Marconi inspired youngsters with a leaning towards electrical matters to endeavour to repeat experiments in which signals were transmitted through space. The basic equipment for these experiments was a sparking coil, some form of high voltage capacitor and a small glass tube filled with silver or nickel filings known as a coherer. The operation of this latter piece of equipment depended upon the fact that a loose heap of filings scarcely conducts at all but, when subjected to electro magnetic waves, exhibits a greatly reduced resistance. A gentle tap on the container of the filings was sufficient to render the filings non-conductive again.

The sparking coil was used to set up oscillations in a tuned circuit consisting of a couple of brass rods and a capacitor, and the electro magnetic waves thus produced could be "received" by means of a suitably tuned circuit including the coherer as a detector. When the coherer became conductive it allowed a current from a dry cell to pass through it and operate an electric bell which, by an ingenious arrangement, could be made to tap the coherer and thus render the filings non-conductive again.

Construction In The Early Days

At this point it may be as well to compare the lot of the young amateur of those days with the enthusiast of today. The era of the flat had not really started, and many of us lived in houses spacious enough to allow a room to be allocated

for our use as a workshop, den, or shack. But, whilst space was fairly readily available hard cash was not, our parents having somewhat different ideas on the subject of pocket money to those of today. Even if we had reached the age of starting a job our earnings were still usually confined to a few shillings a week.

So far as electrical components were concerned, the amateur was fairly well catered for by at least two concerns which specialised in looking after his interests. Their catalogues were masterpieces of psychology as, also, were their technical advice departments. The small boy enquiring about the correct size of lamp to use with a 4 volt dynamo constructed from one of their "sets of parts" received a detailed technical letter of advice which made him feel at least the chief engineer of a generating station. Later in life I came to know the owner of one of these mail order businesses and spent many hours helping him with descriptions of bits and pieces to be included in his latest catalogue. No false claims were ever made and the technical reasons given for the desirability of employing certain parts for given purposes caused these catalogues to be used and kept as manuals of information, and the customer was never let down.

At the time of which I am writing, these concerns had not entered into the "wireless" market and in fact it was impossible to purchase ready-made parts for our new hobby. "Sparking coils" could be purchased, at a price, and that well beyond the extent of our pocket money; so we had to be

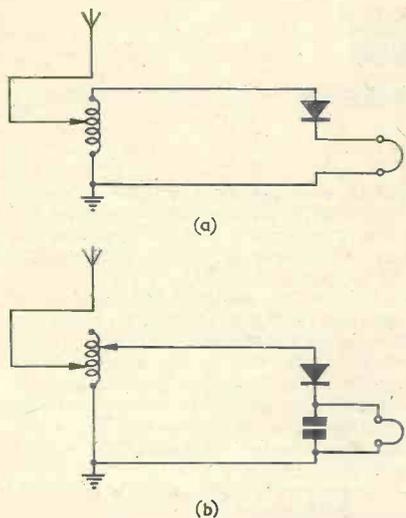


Fig. 1 (a). The "single slide" crystal receiver
(b). The "two slide" receiver, which appeared later

content with buying the necessary make and break contacts and constructing the remainder of the coil ourselves. This was a major project involving the winding of several pounds of 36 s.w.g. wire on home made waxed paper formers. (The family candle supply was apt to run low at these times). The primary winding was fairly easy and the core was soon made up from lengths of soft iron wire. On the other hand, the capacitor across the make-and-break was more difficult and required more waxed paper again, together with a large supply of tin foil sheets. Altogether, we were lucky if we managed to complete the construction of the coil and obtain a half-inch spark after several weeks of somewhat tiresome work.

The high voltage capacitor was fairly easy to construct from cleaned half plate glass negatives on to which tin foil sheets had been stuck with shellac. The physical size of these pieces of equipment had to be seen to be believed.

Saturday Sixpences

Several weeks' Saturday sixpences had to be sacrificed in order to provide the silver filings for a coherer. The electric bell was apt to be "borrowed" from the maid's room after an urgent request that she should not forget to wind up her alarm clock, and there only then remained the matter of the power supply for the transmitter. Those of you who think of power supplies in terms of a.c. mains and transformers may well ponder on the fact that most of our houses were still lit by gas. A favoured few might have a d.c. supply but our far-seeing parents showed no great enthusiasm for 250 volt mains sockets in our dens. So we had to fall back on accumulators and these, in due course, required recharging. This necessitated the construction of a small dynamo from a "set

of parts" and a source of power supply to drive it. The "water wheel" was a great favourite for this purpose and this was usually directly coupled to the dynamo shaft. The whole lot was installed, when required, in the kitchen sink, and was connected to the tap with a piece of hose. The latter burst at frequent intervals and not only flooded the immediate surroundings but, unless attended to without delay, also caused the dynamo to motor and use up the small bit of charge that we had managed to get into the accumulator.

It was something in the nature of a major achievement to get the entire equipment operating and to finally transmit and receive a signal from one end of the room to the other. This accomplishment can only be put on a par with the achievement today of putting a man into space!

But whilst all this was going on we read of ships and commercial stations sending out transmissions, and of types of detectors which enabled such transmissions to be received with reliability. We heard of magnetic detectors, far too complicated for amateur construction and very insensitive, of electrolytic detectors, which we tried to make and which never seemed to work, and of crystal detectors, which seemed to be full of promise. The apparatus required to receive transmitted signals seemed to be much less expensive and more easily constructed than the equipment with which we had been battling. Also, the possible results seemed to offer much greater interest. So our coils and coherers were put on one side whilst we explored every possible source of information to find what was needed for the reception of transmitted signals.

The first requirement was an efficient aerial. In these days of pocket transistor receivers it is perhaps a little difficult to realise that the only signal energy available to operate our headphones was that which was "collected" in the aerial system itself. As most of the stations we might be able to receive were working on wavelengths of 600 metres or more, this meant that we needed the highest and longest aerial that we could conveniently erect. Stranded enamelled copper wire was needed to keep down the resistance, and the insulation had to be as near perfect as possible. You might think that aerials provided little opportunity for experimental work, but we noted many variations

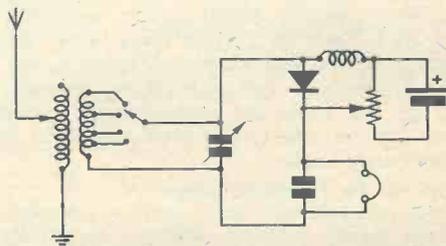


Fig. 2. A crystal receiver with a "loose coupler" and potentiometer. The inductor between the cell and the crystal functioned as an r.f. choke

in use by Service and Government stations. We tried, in turn, single wires, twin wires and "cage" aerials of the T or inverted L types. Although we were apt to imagine an improvement by using some "new" form, the plain single-wire inverted L gave as good results as any even though a twin wire with spreaders looked more impressive and professional.

For an "earth" the household water pipes seemed to do the job satisfactorily, although an elder and more wealthy friend went to the extent of digging up his lawn and burying under the grass a 50 yard length of solid copper strip one inch wide and a quarter-inch thick.

The next essential was a device for tuning the circuit and this we made from a roll of old lino, usually about two feet long and wound end to end with 20 s.w.g. enamelled copper wire. In order to obtain the necessary tuning adjustment we scraped the enamel insulation from a strip about an inch wide from end to end of the coil. The coil on its roll of lino was now mounted between two wooden end-pieces, a brass rod screwed to these carrying a springy copper contact which made a sliding contact on the bared strip on the coil. This device was known as a single slide tuning inductance. There were variations known as two or three slide inductances, and these had either one or two brass rods and sliders added to provide further circuit facilities. In a misguided attempt to obtain still greater efficiency from this piece of equipment I built, on one occasion, an inductance using 12 s.w.g. copper wire wound on a former two feet in diameter. This certainly added to the impressiveness of the receiver but not appreciably to the signal strength.

The telephone earpiece needed to hear the signals was a vital piece of equipment and in this case efficiency bore a direct relationship to cost. Although many of us had to be satisfied at the start with an ordinary G.P.O. earpiece having far too low a "resistance" for the job, our sights were set on a headset manufactured by S. G. Brown. So far as I can remember this headset had a total resistance of some 6,000Ω and the price was such that we could only obtain it as a rather special Christmas or birthday present. The S. G. Brown headphones used a reed in place of the usual diaphragm assembly and seemed to be way ahead of any other form of earphone available at the time.

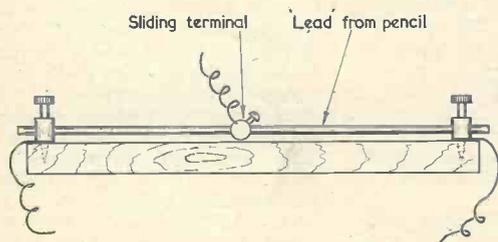


Fig. 3. A "lead pencil" potentiometer

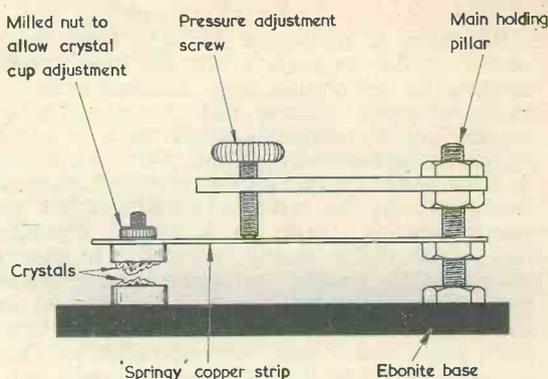


Fig. 4. An early detector employing two crystals

The Detector

The remaining equipment necessary to complete our receiving installation consisted only of the crystal detector. In these days of crystal diodes of wide variety and with published data it is difficult to realise the difficulties which had to be overcome in obtaining both efficiency and stability from the crystal detector. Its operation depended upon three main factors: finding a minute sensitive spot on the crystal, obtaining just the right pressure between the crystal and its contact, and finally making sure that no one moved, breathed or spoke in its vicinity. The tiniest of vibrations would throw the detector out of adjustment, and divorces, gastric ulcers and nervous breakdowns amongst the early radio amateurs can all be traced to the behaviour, or rather misbehaviour, of the crystal detector. However, even if it left some human wreckage in its train, we must at least give the crystal credit for the real commencement of growth of the amateur movement. As such, it deserves quite a little space of its own.

The crystal in general use at commercial stations at that time was carborundum but, although this was fairly reliable in operation, it lacked sensitivity. The amateur, for whom sensitivity was a major consideration, was apt to experiment with combinations of many other materials, a fact which was not lost on a few commercial concerns, who soon realised the possible extent of a new market for them. The claims put forward for some of the crystals of those days were of such a nature that the enthusiast was unable to resist trying them for himself. They would generally arrive carefully packed in an attractive box, the crystal being laid, like a precious jewel, in cotton wool. Galena, a common lead ore, was a favourite and the contact to this generally consisted of a fine copper wire cat's whisker. A trouble with this type of cat's whisker was the gradual oxidation of the contact point and, at a much later period, an attempt to commercialise this matter was made by the sale of "platinum tipped cat's whiskers" at a price made possible only by the reason of the magic word "platinum"

Returning to the earlier period, I think that it would be fair to suggest that the most popular combination of crystals were zincite/Bornite and zincite/tellurium. Zincite was a most attractive-looking crystal containing small spots of a ruby red colour and it always seemed that it was contact to these particular spots which provided maximum sensitivity. As the text books informed me that zincite was zinc oxide in a natural crystalline form, I felt that it should be possible to improve on nature by making "all ruby" zincite crystals by heating zinc oxide to a high temperature and allowing the molten form to crystallise. Unfortunately, many hours spent with charcoal and blow-lamps failed to produce any such crystals, but it was fun trying.

It came to my notice that the sensitivity of this type of detector could be greatly improved by the addition of a small potential to the crystal. The potential required was a small fraction of a volt and this necessitated the use of a potentiometer across a dry cell. Suitable potentiometers were not available but it was found that the "lead" out of a "lead" pencil offered about the correct resistance. This was obtained by boiling a new pencil until the two wooden halves fell apart. The "lead" was then mounted between two end terminals, a third terminal with a lightly adjusted screw sliding along the "lead" to provide the moving contact. This fragile piece of equipment required a frequent boiling of pencils to keep it in service.

The crystals themselves were mounted in brass cups and held in position by an alloy with a very low melting point known as Wood's metal. Whilst the application of the heat from a match was sufficient to melt the alloy this temperature was insufficient to damage the crystal. With "two cup"

detectors, some form of accurate adjustment of the pressure between the crystals was necessary as, also, was the ability to rotate the crystal cups to enable a sensitive point of contact to be found. Many ingenious designs provided a basis for experimental work and, strange as it may seem to those acquainted with the modern crystal set, this apparently simple form of receiver provided sufficient scope for experimental work to keep us busy over a period of quite a few years.

Signals Available

The younger reader may wonder just what signals we were able to receive on this type of equipment. These naturally varied according to the district in which one happened to be living. In the West Riding of Yorkshire our reliable regulars were the signals from the Eiffel Tower in Paris, the Admiralty station at Cleethorpes in Lincolnshire and the German station at Nordeich. Each had a distinctive note due to the use of spark or arc and, as their powers did not vary, they provided reliable standards for our experimental work. But we were constantly searching for more distant and lower powered stations, and the reception of Morse from a ship was always a notable event. The reception of signals from Glace Bay in Nova Scotia was an achievement considered almost impossible, nevertheless I did accomplish this on one occasion and one occasion only. On some pretext or another I had obtained permission to sleep on a camp bed in my den and at 4.0 a.m., for the space of a few minutes, I was able to hold these signals. Such was our enthusiasm; contributed to, I should add, by competition between ourselves in the design and operation of our receivers.

(To be continued)

Aerial Preselector Unit for Short Wave Receivers

By JAMES S. KENT

When operating on the short wave bands, any length of aerial wire cannot possibly match into a receiver at the correct impedance over all frequencies within its range. With the aid of three alternative external preselector units, either of which will produce the required results, the writer shows how a considerable improvement may be effected

QUITE A NUMBER OF COMMUNICATION receivers currently in use have an input impedance, at the aerial terminals or sockets, of approximately 300Ω or 400Ω and, when such a receiver is used in conjunction with an aerial feeder

having the same impedance, a good match (i.e. optimum transference of energy) results.

In the writer's experience, however, it has been found that most short wave listeners tend to erect either an arbitrary length of wire

simply cut to the length of the garden or, conversely, one which is cut for effective operation over a small range of frequencies; the latter usually being for the 20 or 40 metre amateur bands.

When an end-on long wire type of aerial is used, or a feeder cable exhibiting a different characteristic impedance to that of the receiver input, then a mismatch will be the result.

With a receiver having an input impedance of the order of 300Ω to 400Ω, the use of a low impedance feeder cable of some 75Ω to 80Ω between the aerial and the receiver results in a serious mismatch. Moreover, with an end-on long wire aerial, the degree of mismatch will vary quite considerably according to the frequency to which the receiver is tuned. Should the receiver be tuned to a frequency such that the length of the aerial represents an exact quarter wave, then the end of

Components List (Fig. 1)

Capacitors

- C₁ 25 + 25pF differential, Eddystone. (Cat. No. 719, Home Radio Ltd.)
- C₂, C₄ 27.5pF variable, Eddystone. (Cat. No. 588, Home Radio Ltd.)
- C₃ 365pF variable, single-gang (Jackson Bros. Ltd., type 01)
- C₅ 25 + 25pF differential, Eddystone. (Cat. No. 719, Home Radio Ltd.)

Coils

- Ranges 3 to 5 (or as required—see text) Denco (Clacton) Ltd., Miniature dual-purpose Yellow

Valveholder (for coils)

B9A

Miscellaneous

Panel, Chassis, etc.

the aerial will exhibit a low impedance, this being usually around 40Ω or so. If, on the other hand, the aerial happens to be an exact half-wave then the impedance at the receiver end will be high—some 2,000Ω or even greater! It follows therefore that, at any intermediate frequency, the end impedance of the aerial will vary between 40 and 2,000Ω. The aerial cannot, of course, possibly match into an input impedance of 300Ω or 400Ω although apparently many short wave listeners expect it to do so! The results

Components List (Fig. 2)

Resistors

- (All ½ watt types)
- R₁ 10kΩ ±20%
- R₂ 1kΩ ±20%
- R₃ 820Ω ±5%

Valve

EF92 (Mullard)

Valveholder

B7G

Capacitors

- C₁ 25 + 25pF differential Eddystone. (Cat. No. 719, Home Radio Ltd.)
- C₂ 365pF variable, single-gang (type 01, Jackson Bros. Ltd.)
- C₃ 0.01μF mica
- C₄ 0.01μF mica
- C₅ 4μF, electrolytic, 350V wkg.

Coils and Holder

As for Fig. 1

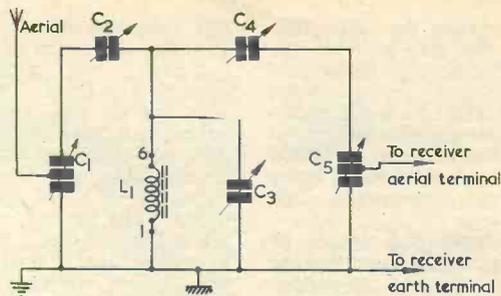


Fig. 1. Simple aerial preselector unit

obtained from such a mismatch will not greatly affect reception of the more powerful stations, especially when operating over the broadcast band frequencies. At amateur frequencies, however, and especially with the weaker transmissions, such a mismatch will greatly affect the results obtained.

In the case of the usual long wire aerial, another complication will be given by multiples of quarter and half wavelengths. It will be apparent from the above that only over certain small bands of frequencies will the degree of impedance match from the aerial to the receiver be at optimum; this being achieved when the aerial is slightly longer or shorter than a quarter wavelength when the receiver has an input impedance of 300Ω or 400Ω.

Simple Preselector Unit

The simple preselector unit shown in Fig. 1 tends, in practice, to overcome the results of mismatching and it provides a high input sensitivity over a wide range of frequencies. When used with a communication receiver, the added tuned circuit will produce a small amount of additional selectivity and will reduce image interference.*

Construction

The construction of the unit is simple but it should be noted that the spindles of the differential capacitors C₁ and C₅ must not be earthed and that the standard variable capacitors C₂ and C₄ must similarly be isolated from earth, or chassis. The best method of mounting capacitors C₂ and C₄ to a metal panel is to cut a small square portion of the panel away and to mount over this aperture a small piece of Bakelite or similar material through the centre of which the capacitor is mounted and secured into place. The differential capacitors C₁ and C₅ mount direct to the metal panel by means of two small bolts and, provided a large enough hole is made for the spindles to protrude without touching the metal, no part of the capacitors will then be earthed to chassis. The variable capacitor C₃ is, of course, mounted to the panel in the usual manner.

Only a small metal chassis will be

* The preselector circuits shown here are based on an aerial matching design originally introduced by J. N. Walker (G5JU) in *Short Wave Listener* for April 1949. The writer has successfully employed these circuits for a considerable number of years and feels that the advantages they offer should be much more widely known.

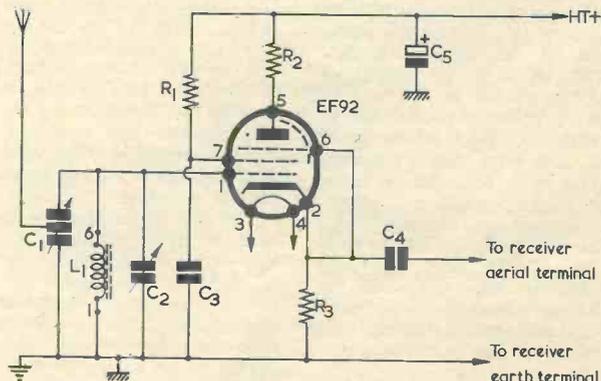


Fig. 2. Aerial preselector using a valve

20–60 metres (15–5 Mc/s); and range 5, 9.5–28 metres (31–10.5 Mc/s). These ranges assume a 300pF tuning capacitor.

An Improved Version

An improved version of the pre-selector unit, and that used by the writer at the present time, is shown in Fig. 3. The circuit is basically similar to that of Fig. 2, but in this case the unit may be switched in or out of circuit at will by means of the double-pole three-way yaxley switch $S_{1(a)}$, (b) . At position 1 the aerial signal is fed into the unit via the differential capacitor C_1 whilst, at $S_{1(b)}$, the receiver input is connected to the preselector output via C_4 . At position 2, the aerial is disconnected from the unit and fed directly into the receiver input terminals. At position 3 the receiver is disconnected

both from the unit and the aerial, and the writer has found this to be an ideal arrangement when using a 100 kc/s crystal marker. With the aerial disconnected, it has been found that the marker points are clearly heard and simply found, no extraneous signals confusing the issue.

The coils L_1 , 2 , 3 are the same types mentioned previously and have been made up into a small coil pack simply by mounting all three coils on the chassis deck and incorporating a single-pole three-way yaxley switch. The Denco coils are fitted at one end with an 0B.A. thread and an insulated nut for chassis fixing, and they are supplied in a metal can which may be used as individual screens for the coils. In the writer's unit, however, the coils are not screened.

The wavechange switch S_2 should,

of course, be mounted on the front panel and this obviates the somewhat tedious process of coil changing. Moreover, the unit may now be contained within a small metal cabinet.

The switches S_1 and S_2 should be mounted under the chassis deck whilst C_1 and C_2 should be fixed to the front panel above the chassis deck. The coils should also be mounted under the chassis.

Some communication receivers have an aerial input impedance of around 75Ω . In this case, the cathode resistor R_3 will require to be 180Ω in value, and the valve should be a type having a high mutual conductance such as the Mullard EF80. The connection to the receiver may then be made via 75Ω coaxial cable.

THE NEW DUAL-STANDARD TV SETS

By Gordon J. King, Assoc. Brit. I.R.E., M.T.S., M.I.P.R.E.

PART 4

This article, the fourth in our series on 405–625 line receivers, describes the switching circuits and filters employed in dual standard vision i.f. amplifiers

The I.F. Stages

LAST MONTH, U.H.F. AND V.H.F. TUNERS WERE dealt with and it was shown that the u.h.f. i.f. signals are fed to the i.f. channel via the mixer section (pentode) of the v.h.f. frequency changer so as to step up the usually weaker u.h.f. signals to the same level as the v.h.f. signals.

This method of feeding greatly facilitates the coupling to the i.f. channel and avoids basic signal switching arrangements.

This is brought out in Fig. 13. Here is shown a dual standard i.f. stage (EF183 and EF184, V_3 and V_4 respectively) and the vision detector (OA70 germanium diode). The triode V_{8B} is wired as a diode and serves as a "clamp" on 405 and a "blocking eliminator" diode on 625, as we shall learn later.

Response Switching

The i.f. channel proper is switched from one standard to the other by two switch sections— SW_{2-2} and SW_{2-4} . Switches SW_{2-7} and SW_{2-6} are concerned with the detector switching. All switches are shown in the "405" position and the various sections are located along the length of a slider type switch so that they are as close as possible to the circuits being switched.

The exercise, then, is to get these switches to change the i.f. response from that shown in Fig. 8 for 405 lines to that shown in Fig. 9 for 625 lines.*

These two response characteristics are drawn again in Fig. 14 for convenience, but this time they are superimposed, with the 405 response shown in broken line.

Fig. 14 shows clearly what needs to happen to the 625 response when changing to 405 lines, for it will be recalled that the i.f. channel is designed initially to provide the wider 625 response and that filters are switched in (or modified) to narrow the response to suit the 405 signal.

Looking at the superimposed responses in Fig. 14 with the above in mind, it can be seen that in the "405" position a substantial slice of the top frequency end of the 625 response needs to be cut and that a deep trough has to be applied at the sound i.f. The sound rejector does, in fact, cut off quite a bit of the high-frequency end of the 625 curve, but other filters are also required to avoid the response from suddenly rising again after the influence of the sound rejector has tailed off.

At the low-frequency end of the response the alterations are less severe. There is a little compression here, but far less than at the high-frequency end.

One feature of the responses which will be noted is the relative ease at which the two standards can be accommodated by virtue of the 405 sound and vision carrier relationship being the reverse of that of the 625 standard. For instance, if the 625 vision carrier occurred at the same side of the response as the 405 vision carrier it would be nowhere as easy a matter to accommodate the 405 standard simply

* Figs. 8 and 9 appeared in Part 2 of this series.

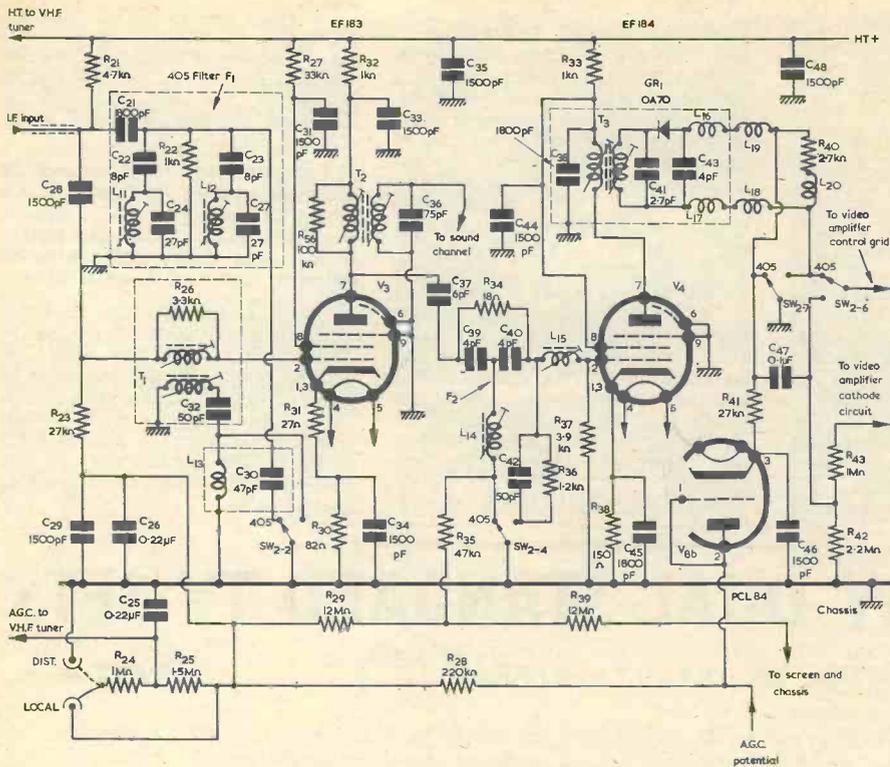


Fig. 13. Dual standard i.f. amplifier. This shows the vision detector and the a.g.c. clamp diode

by the introduction of filter circuits to compress and reshape the 625 response.

Switched Filters

Let us look again at the circuit in Fig. 13. On 405 lines, the i.f. signal is applied to the control grid of the first vision i.f. amplifier valve via C_{28} and the primary of T_1 . Note, however, that SW_{2-2} connects the 405 filter F_1 across the signal input circuit, via C_{30} . This filter, it will be seen, comprises two inductors (L_{11} and L_{12}), five capacitors (C_{21} , C_{22} , C_{23} , C_{24} and C_{27}) and a resistor (R_{22}).

Filter 2 (between V_3 and V_4) is switched in on 405 lines to provide the trough at the sound i.f. This takes the form of the well-known bridged-T rejector which is noted for its great selectivity and high rejection ratio characteristics. It comprises L_{14} , C_{39} , C_{40} and R_{34} .

Further shaping of the 405 response is accomplished by T_3 and the primary of T_2 . These give the flat top while the low-frequency sloping side of the response and the defining of the channel limits are provided by filter F_1 .

The sound on the 405 standard is extracted from the anode of V_3 at T_2 secondary. This is conventional so far as the 405 line system is concerned, and the tuning of T_2 secondary to the sound i.f. further assists with the sound rejection.

On 625 lines, SW_{2-2} and SW_{2-4} change over and the filters described above are removed. The

response curve is then allowed to open out so as to approximate to that shown by the full line in Fig. 14.

It is interesting to observe the dual functions of some of the standard-change switch sections. SW_{2-2} , for instance, disconnects F_1 from the input circuit while also short-circuiting L_{13} when switched from 405 to 625 lines. On 625 lines the secondary of T_1 in conjunction with C_{32} provides an absorption type rejector, it dissipating some of the signal energy passing by way of T_1 primary at the frequency to which it is tuned.

This circuit is adjusted to the 625 sound carrier and is thus responsible for the "ledge" on the low-frequency side of the response curve. We have already seen that the sound carrier, at about 30dB below the level of the vision carrier, is allowed to pass through the i.f. channel on 625 lines to provide the intercarrier signal at the detector.

Note that when SW_{2-2} is in the "405" position L_{13} is in series with T_1 absorption winding. This alters the rejection frequency and puts the trough elsewhere in the response curve, for reasons that will be clear later.

When SW_{2-4} changes to the "625" position filter F_2 is removed and the response opens out at the high-frequency end of the channel. Response correction is provided, however, by the filter effect of L_{15} and C_{42} (with R_{36} giving the required degree of "roll-off").

The dual action of SW_{2-4} should also be observed. This changes the a.g.c. line conditions by switching R_{35} between a feed from the a.g.c. line and chassis in the "405" position only.

It is the aim of dual standard sets to have each switch section perform as many tasks as possible, thereby reducing the number of switch sections required.

Filter Frequencies

Although the circuit in Fig. 13 cannot be considered as "typical" of all dual standard models (much of the individuality of the designer is reflected into dual standard i.f. strips), it does, nevertheless, serve to illustrate the basic principles adopted in most dual standard strips.

A slightly different version is shown in Fig. 15. Here the switching is undertaken between the i.f. input and the first i.f. valve. With switches S_1 and S_2 in the "405" position, as drawn, the i.f. signals are directed to the control grid of V_1 via three rejector circuits resonated at 38.15 Mc/s, 33.15 Mc/s and 39.65 Mc/s respectively (indicated on the circuit).

A further rejector is located between the first and second i.f. amplifier valves and, like the 38.15 Mc/s rejector, takes the form of our friend the bridged-T circuit. This intercoupling rejector is resonated at 41.5 Mc/s and is in circuit on both 405 and 625 lines.

When the switches are in the "625" position the 38.15, 33.15 and 39.65 Mc/s rejectors are switched out and a 33.5 Mc/s rejector is switched in.

The action allows the response to expand, to suit the 625 signal while, at the same time, applying a depression at the 625 sound i.f. to provide the

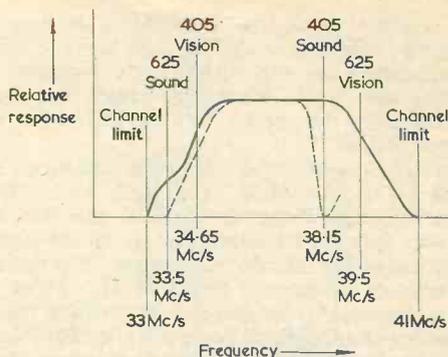


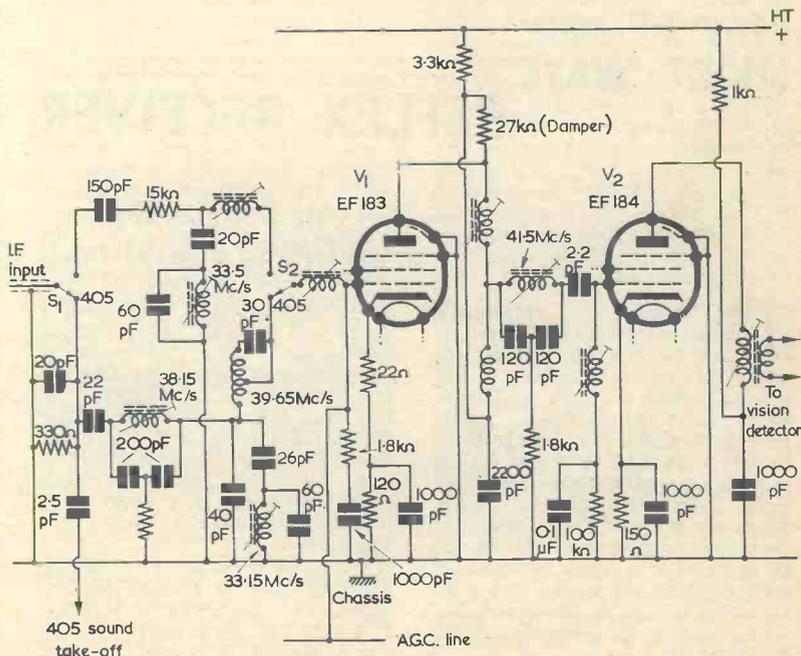
Fig. 14. Dual standard i.f. response curves superimposed, showing the main frequencies

requisite degree of sound i.f. signal attenuation, relative to the vision i.f. signal.

The remaining tuned circuits serve to couple the signal through the amplifier strip and their alignment, in conjunction, of course, with the rejector circuits, shapes the response characteristics on both standards.

At this stage a summary of the main rejector frequencies involved would not be amiss. On 405 lines, a fundamental circuit is the sound rejector. This is tuned to the sound i.f. of 38.15 Mc/s and, along with the 405 sound take-off coupling, is responsible for putting the deep trough in the vision response curve. To prevent the sound of an adjacent channel breaking into the vision of the tuned channel (this can cause 1.5 Mc/s patterns on the picture and sound-on-vision effect in bad cases)

Fig. 15. Dual standard i.f. amplifier circuit, illustrating the rejectors and their frequencies



the rejector tuned to 33.15 Mc/s is employed. Similarly, rejection of the adjacent vision channel is accomplished by the 39.65 Mc/s rejector. This rejector also holds down any peaks that may be introduced by the operation of the 38.15 Mc/s sound rejector itself:

On 625 lines the chief rejector is that tuned to the sound i.f. of 33.5 Mc/s. This does not completely delete the sound signal, as does the 405 sound rejector, but it attenuates it so as to facilitate operation of the intercarrier system. The remaining 625 rejector or filter is tuned to 41.5 Mc/s. This has a threefold application. It defines the high frequency channel limit and pulls the response right down at that point; it acts as an adjacent channel sound rejector; and it also prevents breakthrough of the sound due to a high signal field in a Channel 1 v.h.f. reception area (41.5 Mc/s is, of course, the frequency of the Channel 1 sound signal).

Vision Detector

Thus we have seen how the response of the i.f. channel is shaped to suit the type of signal passing through it. Now let us look back at Fig. 13 again.

It will be seen that i.f. transformer T_3 feeds the OA70 germanium diode vision detector and that, in the "405" position, switch SW_{2-7} connects the "anode" side of the load R_{40} to chassis. The demodulated vision signal is thus developed across this load in the usual manner and it is fed through SW_{2-6} to the video amplifier control grid.

Now in the "625" position the "earth" is changed to the opposite side of the load (that is to the diode

"cathode" side) by SW_{2-7} while the connection to the video amplifier is also altered by SW_{2-6} changing over. The video on 625 lines is, therefore, extracted from the opposite side of the load via a coupling capacitor C_{47} .

Switches SW_{2-7} and SW_{2-6} in the main simply reverse the phasing of the detector from one standard to the other. This is necessary because of the positive modulation of the 405 standard and the negative modulation of the 625 standard. (See Figs. 1 and 2 of Part 1.) On 405 lines, the demodulated video is taken from the "cathode" side of the diode (that is the side indicated by the thick line on the symbol and by red paint or a plus sign on the component). The video output thus goes positive with increase in modulation level (i.e. towards peak white).

On 625 lines, the demodulated video is taken from the "anode" side of the diode (the side indicated by the arrowhead on the symbol and by black paint or a minus sign on the component). The video output here, then, goes negative with increase in modulation level (i.e. towards the tips of the sync pulses).

These aspects of the detector switching should be remembered, as also should the fact that the video is coupled capacitively on 625 lines to the video amplifier.

Note in Fig. 13 that the cathode of V_{8B} is taken to chassis by SW_{2-7} on 405 lines while on 625 lines the cathode is connected to the active side of the detector load. The reason for this switching function will be considered next month.

(To be continued)

6-Stage 3-Transistor SHORT WAVE REFLEX RECEIVER

Sir Douglas Hall,
K.C.M.G., B.A. (Oxon.)

THE AUTHOR HAS PREVIOUSLY described circuits employing, as their heart, a new arrangement using the reflex principle.¹ The present article discusses a 3 transistor short wave design which provides 6 stages and tunes from 17 to 3.85 Mc/s (17.6 to 78 metres). It is built round the same reflex principle. As there are two radio frequency stages there is plenty of sensitivity. Loudspeaker results can be expected from some hundreds of stations, both on speech and c.w.,

even when using a short indoor aerial and a small metal plate as capacitance earth. There is no trimming involved and the design is quite suitable for a beginner. The fact that there is a buffer stage between the aerial and the tuned circuit assists in providing freedom from the hand-capacitance effects which so often spoil short wave listening with simple receivers.

The Circuit

If Fig. 1 is examined it will be seen that the aerial is coupled to TR_1 acting as a radio frequency common base amplifier. R_1 is the aerial load, and R_2 isolates the base of TR_3 from

radio frequency currents. The base of TR_1 is at chassis potential through C_3 and C_5 . The amplified signal appears across L_2 and is transferred to the base of TR_2 by means of the tuned circuit, L_1, VC_1 . TR_2 is wired as a duo-reflex amplifier. That is to say, it amplifies first at radio frequencies as a common collector amplifier, and then, after rectification by D_1 , provides further amplification at audio frequencies as a common base amplifier.

L_3 , with R_3, R_4 and C_5 effectively in parallel, forms a high impedance load for the output of TR_2 , and the audio frequency signal is fed back to TR_1 through C_3 . It then receives further amplification by TR_1 as a common collector audio frequency amplifier. TR_1 is directly coupled to TR_3 which is a common emitter Class A output transistor.

Reaction is obtained by coupling back a portion of the radio frequency signal from the emitter to the base of TR_2 . Control is effected by VR_1 which, at its lowest setting, short-circuits L_2 and deprives TR_1 of a radio frequency load. It acts, in

¹ See article by the present writer in the June 1964 issue

Components List

Resistors

(All fixed resistors $\frac{1}{2}$ watt 10%)

R ₁	2.2k Ω
R ₂	470 Ω
R ₃	470k Ω
R ₄	100k Ω *
R ₅	47k Ω
R ₆	3.3k Ω
R ₇	100 Ω
VR ₁	5k Ω potentiometer linear track

Capacitors

C ₁	30pF*
C ₂	0.01 μ F
C ₃	0.04 μ F
C ₄	50 μ F electrolytic 6V wkg.
C ₅	1,000pF
C ₆	0.1 μ F
C ₇	50 μ F electrolytic 6V wkg.
VC ₁	500pF air spaced variable*

Inductors

L ₁ , L ₂	See text
L ₃	Primary of Radiospares "Midget" 5:1 intervalve transformer
T ₁	Output transformer type TT5 (Repanco) or LT700 (Henry's Radio Ltd.)

Semiconductors

TR ₁	MAT121 or MAT101
TR ₂	MAT101
TR ₃	OC72
D ₁	OA81

Miscellaneous

S ₁	s.p.s.t. battery switch (may be ganged with VR ₁)
Loudspeaker	3 Ω impedance
Battery	9V
	*See text.

consequence, as a true volume control as well as providing reaction.

In the previous duo-reflex circuits which have been described the current flowing through the collector-emitter circuit of the transistor has been limited to from about 80 to 150 μ A. In order to obtain good amplification at frequencies of the order of 17 Mc/s a larger current is desirable, and the optimum value proved to be between 600 and 700 μ A. This ruled out the possibility of a resistor as the collector load, since the voltage drop would have been too great. It also ruled out the use of a sub-miniature inductor as, with the very high impedance necessary, the core would have become saturated. L₃ is therefore the secondary of an intervalve transformer, which is, of course, the winding with the larger inductance and d.c. resistance. A Radiospares "Midget" 5:1 transformer is used, on which the windings are clearly marked.

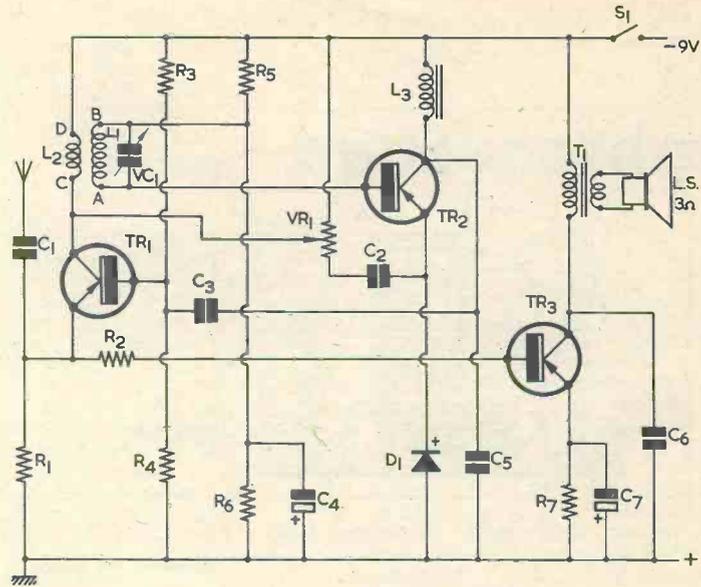


Fig. 1. The circuit of the 3 transistor reflex receiver

The Current

The following facts determine the optimum current for TR₂. If the current is too large, not only may the core of L₃ become saturated, but any increase in the amplification factor of TR₂ is offset by a reduced input impedance in that transistor. A common collector amplifier has a relatively very high input impedance provided the output load is not too low. The current passing through TR₂ also passes through D₁ and, since this is a crystal diode, its impedance decreases as the current passing through it increases. D₁ is the output load of TR₂ and, as its impedance decreases, the input impedance of TR₂ decreases and consequently the tuned circuit becomes damped. This damping will eventually cancel out the increased amplification factor of TR₂ so much that it can no longer be conveniently overcome by reaction. When oscillation is impossible or difficult to obtain, particularly at the high frequency end of the range, the current passing through TR₂ can be assumed to be too large. As already stated, the optimum value for an MAT101 (TR₂) used in conjunction with an OA81 (D₁) proved to be of the order of 600 to 700 μ A. The values of R₅ and R₆ are chosen to allow this current to be passed.

TR₁ will pass about 500 μ A, causing a voltage drop of a little over 1 volt through R₁. About 7 to 9 μ A will be taken by TR₃. The total consumption of the receiver is there-

fore about 10mA from a 9 volt battery.

The Coil

The coil L₁, L₂ must be home-wound. L₁ consists of 12 turns of 24 s.w.g. enamelled wire close-wound on a former $\frac{3}{16}$ in diameter. This winding is covered with a turn of Sellotape and L₂ is over-wound on the bottom part of L₁ (i.e. the R₅ end). It consists of 5 turns of 32 s.w.g. enamelled wire close-wound in the same direction as L₁. Sellotape holds L₂ in position. This very close coupling is necessary, and side-by-side windings will not be satisfactory. The top end of L₁ connects to the base of TR₂, and the top end of L₂ to the collector of TR₁. There will be no reaction if one of the coils is connected the wrong way round.

VC₁ should be a good air spaced tuning capacitor, and a slow motion drive must be fitted. VC₁ may be reduced in value to 160pF if desired, in which case the top limit of the tuning range will be about 49 metres. Provided a good slow motion drive is used the larger value of 500pF is worth while.

Layout

As with almost all short-wave receivers it is important to arrange the layout so as to achieve short wiring, and the exact arrangement used in the prototype is shown in Fig. 2. A tagboard is employed for most of the small components, and an earth busbar of tinned copper

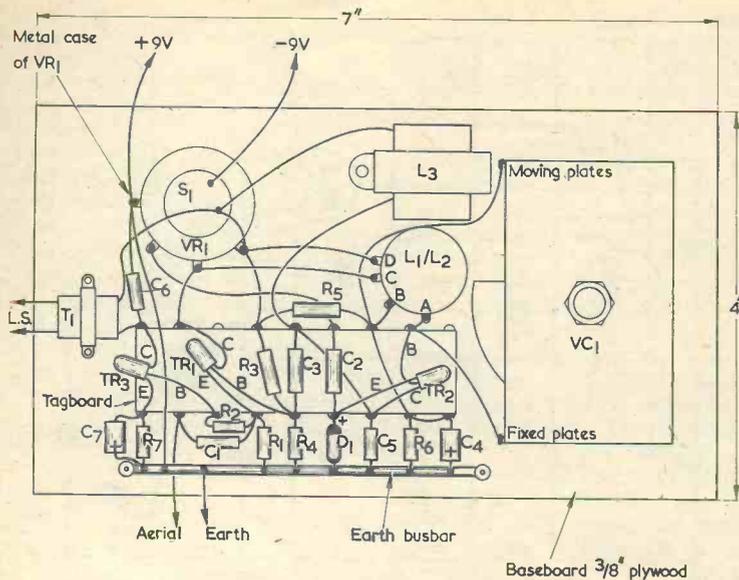


Fig. 2. The layout employed in the prototype

wire. If an LT700 output transformer is used it can have tags soldered to the feet of its clamp for fixing to the base board. The Repanco TT5 has drilled feet for this purpose.

The prototype uses a 6 by 4in loudspeaker at the T₁ end of the base board, and two 4.5 volt flash lamp batteries behind VC₁ and VR₁ respectively. The receiver is housed in a box measuring 13½in long by 4½in high by 3½in deep. The loudspeaker is thus well separated from VC₁, which removes any risk of howling due to microphony.

If an amplifier is already available with an input consisting of a volume control of about 5kΩ, the output stage of the receiver can be omitted and the input of the amplifier connected to the end of R₂ which is remote from R₁, and chassis. The prototype has been tried with the "economical amplifier" described in an earlier issue,² with which it gives

excellent results. Volume had to be reduced on many stations and even on the weaker ones the best results were obtained with the amplifier volume control backed down a few degrees.

If a milliammeter is available, it is helpful to check the current passing through TR₃ by connecting the instrument between the emitter and the top of R₇, since the exact characteristics of TR₁ determine the current passing through TR₃. If TR₁ is an exceptionally efficient specimen it is possible for TR₃ to pass a current which is unnecessarily though almost certainly not dangerously, high. In this event R₄ can be reduced in value until a reading of from 7 to 9mA is obtained. However, with the great majority of MAT transistors the value of 100kΩ specified will prove a satisfactory figure

² Sir Douglas Hall, "An Economical Amplifier And Variable Inductance Tuner", *The Radio Constructor*, January 1964.

for R₄, and the procedure suggested is more of a refinement than an obligation.

Increased Sensitivity

Constructors who are used to receiving short wave stations on a regenerative receiver without radio frequency amplification will be surprised at the greatly increased sensitivity given by the two h.f. stages of this receiver. With the older type of circuit it is necessary to keep the detector on the threshold of oscillation to receive any but the strongest of short wave signals. With this circuit the operator feels more as though he were searching for stations on the medium wave band, except for the large number that come through! Many signals will be heard with the reaction control well back. The one selected can then be brought up to full strength, and selectivity established, by advancing VR₁. Weak stations can receive the full benefit of critical reaction, which can be held very close to the oscillation point for the whole of a wave-band without the need for re-setting.

As already stated, a short indoor aerial will give excellent results. If a long outside aerial is used it will probably be necessary to reduce the value of C₁ in order to obtain adequate selectivity. Although the receiver is very free from hand capacitance effects, these can be introduced by using too long an aerial which is too tightly coupled to the receiver. An earth connection of some sort is very desirable. Not only is this necessary to avoid hand capacitance trouble, but it will also be found to give a marked increase in sensitivity. An earthed socket of the mains supply will very likely prove satisfactory if an outdoor earth is difficult. Alternatively, if the receiver is used on the ground floor it may well be found that a sheet of metal on the floor, some 4 sq. ft. in area, will prove better than the best of outside earths, though its effectiveness may begin to fall off at about 4 Mc/s. Such an "earth" can be very efficient at the other end of the scale.

"AUTOFLEX" TRANSISTOR CIRCUIT

Messrs. S.G.E. Signals Ltd., East Lane, Wembley, have told us that the word "Autoflex" is a trade name employed in connection with their Vehicle Actuated Road Signalling equipment. We wish to point out that the circuitry described in "Autoflex Transistor circuit", by Sir Douglas Hall, in our June issue has, of course, no connection with that employed in the S.G.E. Signals equipment.

The reflex circuit discussed by Sir Douglas Hall in the June article will be featured in several further articles in future issues, and it will be referred to under a new name, "Spontaflex".

RADIO TOPICS . . .

by Recorder

IN THE MAY ISSUE I PRESENTED a short and somewhat facetious list of the descriptions which TV-owners tend to apply to faults in their receivers, together with the actual snags you may encounter if you volunteer to fix them. The complaints and faults were listed under separate headings, and it has since occurred to me that the same approach could be used, in more serious vein, with regard to shortcomings in transistor radios. In this instance there is, however, no need to examine the receiver. It is merely necessary to make a spoken diagnosis after having been told the symptoms. Since there is a very good chance of being right in most cases, one can soon acquire a local reputation as an "expert" without ever having moved a finger towards earning it.

Transistor Diagnosis

Complaint. The receiver sounds weak.

Fault. The battery has run down. Apart from any other effects this may have, it results in the output transistors working with reduced power and giving, in consequence, a weak output.

Complaint. The receiver seems quite loud, but it sounds distorted.

Fault. The battery has run down. Because of this the output transistors have shifted from their proper bias point, and there is crossover distortion.

Complaint. The only way the set will work is to tune to one end of the dial and bring the pointer back again.

Fault. The battery has run down. The result is that there is insufficient voltage for the oscillator to function. The only way to get the oscillator started is to tune to one end of the band (sometimes, surprisingly, the low frequency end), whereupon oscillator tuned circuit Q and feedback conditions are sufficiently good to allow oscillation to commence. Once the oscillator has started, it continues running over all parts of the band until the set is switched off again.

Complaint. The set gets the Light Programme and Home Service at good strength, but Radio Luxembourg is very weak.

Fault. The battery has run down. With full battery voltage, the radio reproduces local and distant stations at approximately the same level because a.g.c. action reduces the receiver's sensitivity on local signals. When battery voltage is low, the resulting loss of sensitivity may cause even the local stations to be received with very little a.g.c. action. Distant stations become correspondingly weaker.

Complaint. We can't get a peep out of the darned thing.

Fault. Need we say it?

Human Nature

The instances I've just mentioned represent actual cases which I've encountered myself over the last year. It is obvious, of course, that falling battery voltage produces different results with different sets. With some it produces distortion, with others it causes erratic oscillator operation, and so on. The reactions of the set-owners are rather interesting here, too. Many of them seem to feel that they aren't getting their full money's worth out of a battery if they have to discard it whilst the set is still producing noises of a sort. In an ideal world, the receiver volume would gradually die down to a whisper as the battery finally expired.

Nevertheless, to suggest that the battery may have run down is not at all a bad idea if anyone approaches you with a query concerning a faulty transistor radio. It has the advantages that the set-owner is not involved in any expenditure which would not eventually be incurred anyway, that he carries out the "repair" himself by fitting a new battery, and that you don't have to even see or hear the set yourself. Also, you'll be surprised to find how often your diagnosis is correct!

Empire Made?

Talking of transistor radios, I was a little disturbed recently to learn that many of the miniature transistor radios sold in this country under the well-known British brand marks are not made here at all.

One British manufacturer, apparently the last to give up home production of these receivers, recently

announced a new model which was to be made in Hong Kong for subsequent sale in this country under the manufacturer's name. In this instance the set was designed by the manufacturer, and it undergoes final inspection at the manufacturer's premises. But it is produced in Hong Kong.

Business is business, and if companies find it cheaper to shed their production on to overseas factories then they are obviously entitled to do so. I get the impression, though, that some firms ceased home production of miniature transistor radios quite a long time ago, and that this is a fact which is not generally known.

Perhaps it *should* be generally known.

The New Test Cards

Since Test Cards "D" and "E" were introduced on B.B.C. and I.T.V. transmissions a few months ago, we have received several queries and comments from readers. These have almost all been concerned with the frequency gratings.

The new Test Cards are similar in many respects to the familiar Test Card "C" and so I'll just pass on, for the record, the points raised by our correspondents.

Apart from the frequency gratings, Test Cards "D" and "E" are identical. Test Card "D" is for 405 line transmissions and Test Card "E" is for 625 line transmissions. Within the circle there are two sets of frequency gratings, these differing in frequency in the two Cards. The frequencies of the gratings (according to their positions) are as follows:

Test Card "D"	
1.00 Mc/s	1.50 Mc/s
2.00 Mc/s	2.50 Mc/s
2.75 Mc/s	3.00 Mc/s

Test Card "E"	
1.50 Mc/s	2.50 Mc/s
3.50 Mc/s	4.00 Mc/s
4.50 Mc/s	5.25 Mc/s

An important point is that the gratings produce a signal of approximately sine wave form, with the result that the stripes have a gradual transition from black to

white, and from white to black. The sine wave corresponds to 50% modulation only. The gratings on the earlier Test Card "C" produced a square wave signal, giving a sudden change from black to white, and from white to black. Because of their sine wave form, the gratings on the new Test Cards do not produce sharply defined stripes, and may give an impression of poorer resolution to those who have become used to the previous Card. One reader reports that he has already been "caught" on this!

As with Test Card "C" there is a 5-step contrast wedge in the centre of the circle. An innovation is that, within the top and bottom squares of the wedge are small circular areas of slightly brighter tone. If these appear to merge into the surrounding area, white or black crushing, as the case may be, is indicated.

How Superb Is Your Reverb?

That rather euphonious rhyming term "hi-fi" tends to raise difficulties when attempts are made to define it precisely. Thus, in a footnote on page 746 of the June issue, I note that W. G. Morley states: "Unfortunately, the indiscriminate

use of the term (high fidelity) by some manufacturers has caused it to lose some of its potency." American lay usage, as exemplified by the dialogue in the American films we see on television, certainly implies a degradation in meaning. It seems that almost any sound-reproducing equipment which offers reasonable quality and is good and loud is described as a "hi-fi set". Horrors!

I note also, in the June issue of our American contemporary *Radio-Electronics*, that the Institute Of High Fidelity, Inc. has decided "regretfully" that it is impossible at the moment to define "hi-fi". The consensus of opinion amongst manufacturer members of the Institute is that it is impractical to arrive at a meaningful definition. According to Victor Pomper, a director of the Institute, the task is similar to that of finding capsule definitions of "metaphysical" terms like "beauty" or "truth". Mr. Pomper stated also that a definition of "high fidelity" would do more harm than good for the industry and the public, and would set boundaries for hi-fi production.

So far as I can see, the time is ripe to discard "hi-fi" altogether and to introduce some new rhyming

terms for audio work which are much more precise. May I suggest the following?

Champ Amp. The better of two amplifiers.

Tower Power. A domestic amplifier offering 20 watts output.

Cover Power. A domestic amplifier offering in excess of 20 watts output.

Beyond Bond. An amplifier giving less than 0.007% distortion.

Danger Changer. A record-player which chews bits out of your discs.

Risk Disc. Any record placed on a danger changer.

Jive Drive. The output from a pick-up playing a pop record.

Ace Bass. Excellent low frequency reproduction.

Chronic Harmonic. An overloaded Class-B transistor output stage.

Top Drop. A de-emphasis filter.

Scraper Taper. A dirty playback head.

Squeaker Speaker. A tweeter.

Pumper Thumper. A woofer.

Superb Reverb. An echo-box with outstanding performance.

Natch Match. A 3Ω output feeding a 3Ω speaker.

Sorry about all that. See you next month!

WAVEMETER----- -----W1191A

By S. CHISHOLM

By modern standards, the Wavemeter W1191A may appear a little old-fashioned due to the fact that it employs 2 volt battery valves. Despite this, it incorporates a number of precision frequency-determining components and is capable of carrying out its functions with a very high degree of accuracy. In this article our contributor gives a full description of circuit functioning and operation

TWO TYPES OF WAVEMETER ARE NOW IN COMMON use, the absorption and the heterodyne type.

The absorption wavemeter, as its name implies, absorbs power from the signal source when resonant at the source frequency and uses that power to provide some form of indication of resonance. The heterodyne wavemeter, on the other hand, uses a local oscillator to drive a mixer into which the frequency to be measured is also fed. It is, therefore, inherently sensitive and may be operated at locations remote from the signal source. Its high degree of accuracy makes it a most useful acquisition to any amateur.

General Information

The Wavemeter W1191A, whose theoretical

operation and practical use are described in this article, is a very good example of the heterodyne instrument. As received, it is powered by a 60 volt h.t. battery and a 2 volt accumulator, but it may readily be modified for use with mains-generated h.t. supplies.

The unit operates in the spectrum 100 kc/s to 20 Mc/s, divided into eight ranges. Harmonics allow operation up to 40 Mc/s, but at the expense of accuracy.

Four valves are used, the stage line-up being as follows:

- (1) A triode-heptode (V₁) operating as a mixer for incoming frequencies. The triode section can also operate as a variable-frequency source when required.

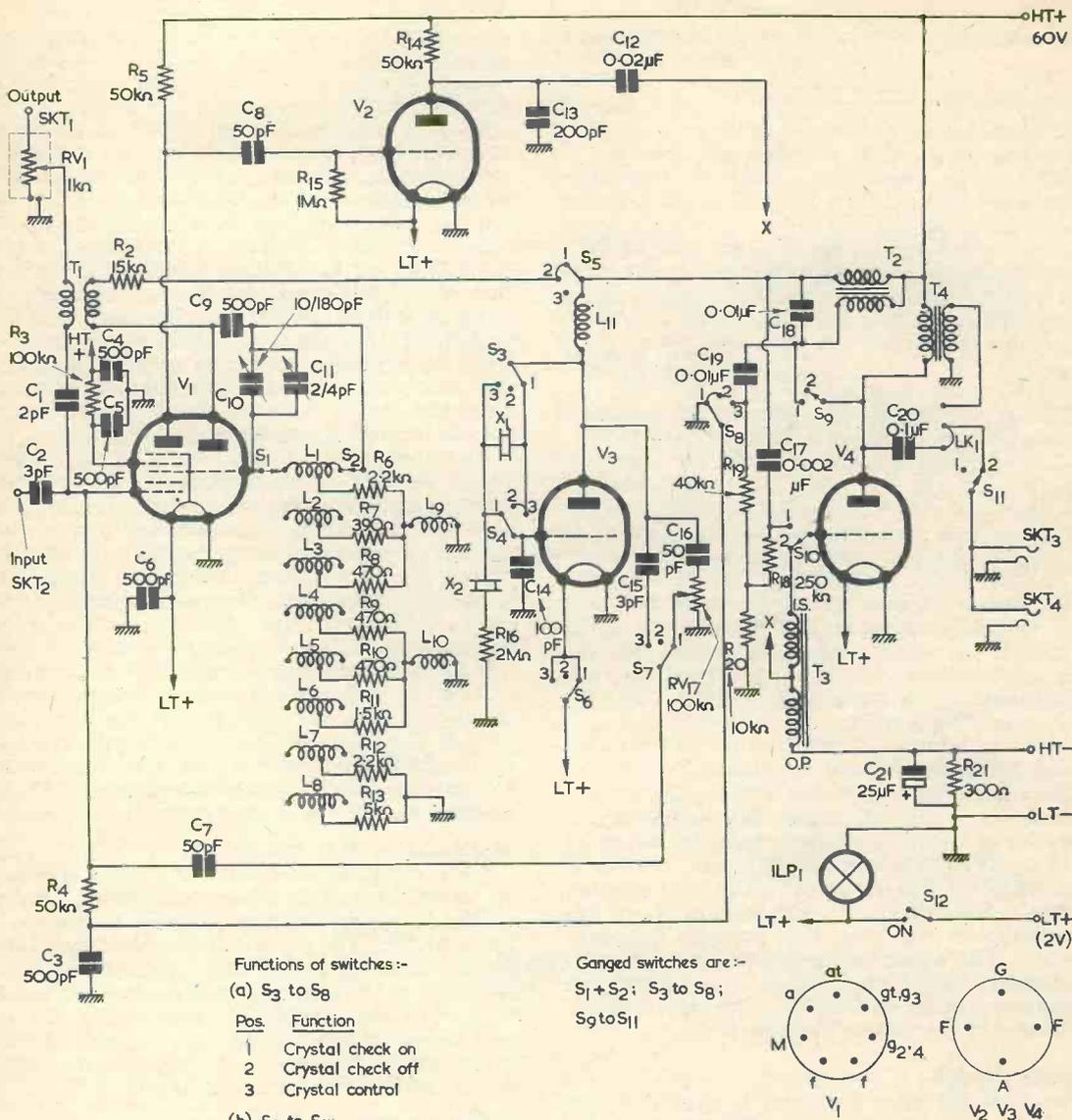


Fig. 1. The complete circuit of the Wavemeter W1191A

- (2) A triode beat-frequency detector (V_2).
- (3) A triode amplifying the output of the detector and feeding a headset (V_4). This valve can also operate as an a.f. oscillator to provide optional modulation (1 kc/s) of the r.f. source in item (1).
- (4) A triode, operating as a crystal-controlled frequency check oscillator (V_3). When required, this valve can be used to drive a crystal-controlled r.f. source via the heptode section of the triode-heptode. In this configuration, the LC oscillator is quiescent.

Mechanical Description

The unit, whose panel is shown in Fig. 3, measures approximately 11in high (panel vertical) by 12in back to front, by 13in wide. Its weight is 15lb, excluding batteries. A hinged lid protects the front panel, calibration charts being carried inside the lid. The unit may be operated in any position if an unspillable accumulator is fitted; a modification described later allows bench operation with an external accumulator. Two supports are supplied for use when operating with the panel in the horizontal position. Carrying handles are fitted, as well

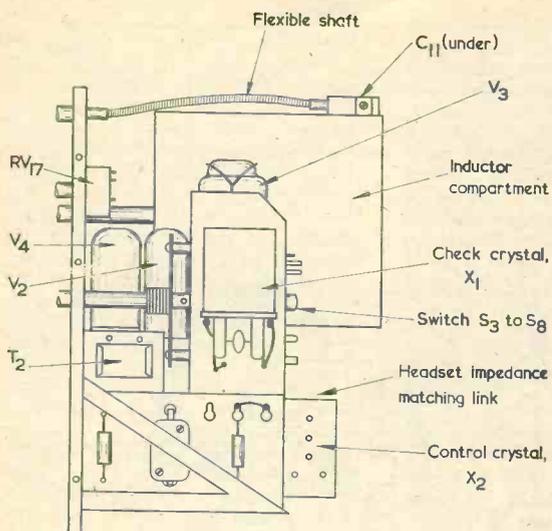


Fig. 2. A side view of the internal components

as a webbed carrying strap. A small rod aerial completes the accessories which, except for the strap, are stowed on the wavemeter case. The h.t. current required in full operation is 6mA and the l.t. consumption is 0.6A.

Circuit Description—Local Oscillator

The circuit diagram is shown in Fig. 1. Triode-heptode V_1 is the r.f. mixer, the triode section operating as a Hartley oscillator using the inductors L_1 to L_8 to cover the frequency ranges. Tuning is achieved by C_{10} and trimmer C_{11} , and band selection by Range Selector S_1, S_2 . The resistors R_6 to R_{13} and inductors L_9 and L_{10} provide frequency stability. The triode anode output passes through the primary of r.f. transformer T_1 to supply an output signal at the socket SKT₁; this signal may be attenuated by the Output Control, RV₁.

Heptode Section

The local oscillator frequency is applied to the signal grid of the heptode in the usual manner. Also applied to this grid are (a) a signal from the Input socket SKT₂, or (b) a signal from the crystal check oscillator V_3 , or (c) both simultaneously. The output of the heptode, developed across R_5 , is passed to the detector, V_2 .

Decoupling of the screen grid in the heptode is provided by C_4, R_3, C_5 , and this, together with the type of valve chosen for this stage, assists in stabilising the triode oscillator section. All the triode-heptode stage is adequately screened by housing it within a metal box, itself fitted inside the outer case of the wavemeter.

The Detector

At V_2 , the signal from V_1 heptode is detected and the a.f. output produced across R_{14} is passed

through C_{12} to autotransformer T_3 at V_4 . Remanent r.f. at V_2 anode is bypassed by C_{13} .

Amplifier Section

V_4 is a dual-purpose valve serving as an a.f. amplifier, or as an a.f. oscillator when required to modulate the r.f. source. As an amplifier, it obtains its input signal from the secondary of T_3 (via part of the Trans CW and Receive switch, S_{10} , at position 2) and it produces an amplified version at the primary of T_4 . A high-impedance headset can be used with the wavemeter, in which case the drive is taken from V_4 anode through C_{20} . If a low-impedance (150Ω) headset is available, it can be fed from the step-down secondary of T_4 . Selection of the required drive is made by a link inside the unit. Grid bias for V_4 is derived from the h.t. current passing through R_{21} and bypassed by C_{21} .

As shown in Fig. 1, the Trans CW and Receive switch, S_9 to S_{11} , is set to position 2 causing V_4 to act as an amplifier. Its alternative setting, position 1, Trans MCW, sets up the audio oscillator mode in which V_4 becomes a Hartley oscillator, using transformer T_2 . In this mode, switch S_{11} , ganged with S_9 and S_{10} , disconnects the headset from V_4 anode (or T_4 secondary). Transformer T_4 primary then becomes part of the anode circuit of the oscillator.

Stability of frequency is assisted by feeding back to V_4 grid a part of the a.f. output generated by the oscillator. This is done by passing the signal through C_{19}, R_{19} and R_{20} , and taking V_4 grid leak R_{18} to the junction of R_{19} and R_{20} . Transformer T_2 and capacitor C_{18} , in conjunction with T_4 , are designed to oscillate at approximately 1 kc/s.

Modulation of R.F. Source

When using the wavemeter as a signal source in the crystal-controlled mode, modulation can be applied by setting switches S_9 to S_{11} to position 1, Trans MCW. The a.f. signal generated by V_4 and passing through C_{19} is then applied via S_8 in position 3 to the control grid of the heptode section of V_1 . In the variable-frequency mode, the a.f. modulation passes across the Crystal Control switch, section S_5 in positions 1 or 2, and thus varies the h.t. potential at the triode section of V_1 .

Crystal Control

Valve V_3 serves two purposes, (a) as a frequency-check, and (b), as a crystal-controlled source of r.f. output. It is controlled by the ganged Crystal Control switches, S_3 to S_8 , as follows:

- (1) Switch S_6 provides On/Off control of l.t. to V_3 . The supply is disconnected when Crystal Check Off (position 2) is selected.
- (2) Switches S_3, S_4 permit selection of either the 1 Mc/s frequency-check crystal, X_1 (position 1, Crystal Check On) or a crystal of any required frequency within the operating range of the unit (position 3, Crystal Control). Sockets to permit use of one such crystal are located on the chassis, but are accessible from outside the unit.
- (3) Switch S_5 isolates the variable-frequency

oscillator in V_1 when Crystal Control is selected.

- (4) Switch S_7 in the Crystal Check On setting (position 1), provides an attenuated, crystal-controlled r.f. signal for application to the heptode control grid. The attenuation is provided by Crystal Check Coupling, RV_{17} , to prevent pulling the input signal frequency. In the Crystal Control setting (position 3), S_7 supplies an unattenuated r.f. output for the heptode.
- (5) Switch S_8 is the modulation on/off switch. In the Crystal Control setting, the a.f. generated by V_4 (if Trans MCW has been selected by switches S_9 to S_{11}) is inserted in the grid return circuit of the heptode. If S_9 to S_{11} are set to Trans CW and Receive, the switch S_8 is simply part of the heptode control-grid return circuit.

Grid Bias: On/Off Control

Grid bias for V_4 is produced by the h.t. current flow through R_{21} between h.t. negative and the chassis. The voltage developed across R_{21} is smoothed by the bypass capacitor C_{21} , and passed through autotransformer T_3 to V_4 grid when V_4 is operating as an amplifier.

On/off control is obtained by interrupting the i.t. negative supply at S_{12} . An indicator lamp (2.5V, 0.5W) is illuminated when S_{12} is closed.

Headset Connections

Two forms of headset jack are catered for, one being the commonly-used P.O. "tip-and-sleeve" type and the other the type supplied with headsets

worn by aircrews. Both sockets are wired in parallel and fed from the impedance-matching link mentioned earlier.

Internal Details

Fig. 2 shows the appearance of the right-hand side of the unit. The locations of the check crystal X_1 and control crystal X_2 are shown, as also is the matching link to suit the impedance of the headset in use.

Access to the inductor compartment (within which V_1 is fitted) is gained by undoing seven captive screws located in the compartment cover. The worm gear assembled on top of the compartment which drives trimmer C_{11} should be lubricated occasionally.

Modifying for External H.T. Supply

As received from the suppliers of ex-Government apparatus, the check crystal should be separately wrapped and stowed under the chassis. To gain access to the crystal, remove twelve screws which secure the panel to the outer case, then withdraw the case (which may be a very tight fit).

In this partially dismantled condition, it is opportune to modify for an externally-supplied h.t. source. To alter the unit, proceed as follows:

- (1) Note the existing leads at the on/off switch, disconnect them, and remove the switch.
- (2) Fit a 2-pole, 3-way rotary switch as the new on/off switch.
- (3) Connect the incoming i.t. positive lead to one pole of the switch. On the same sector, leave contact 1 free, but link contacts 2 and 3, counting clockwise.

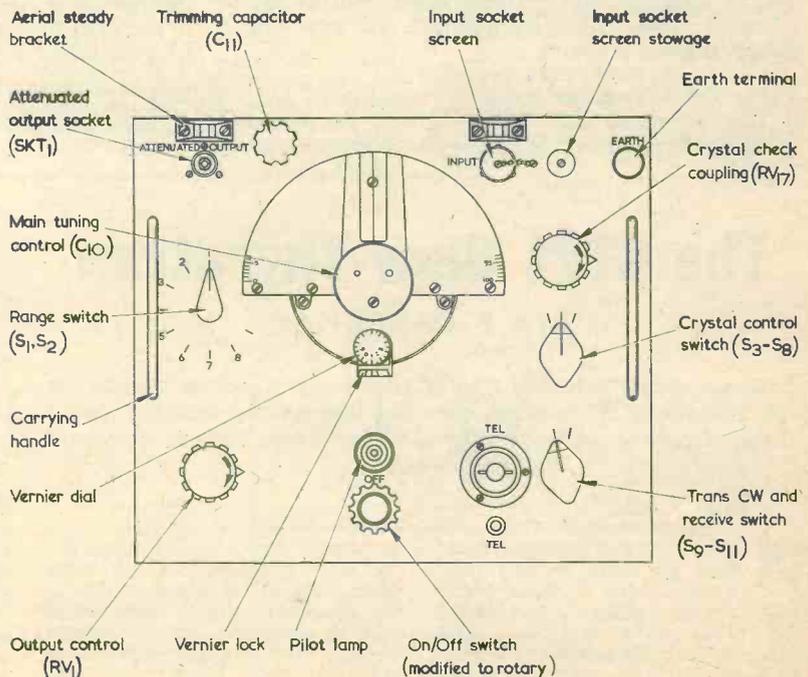


Fig. 3. The front panel, showing control functions

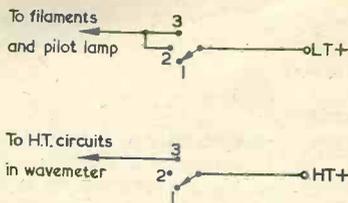


Fig. 4. A modified switching circuit

- (4) Connect the l.t. positive line feeding the valves and the pilot lamp to contact 3.
- (5) Connect the l.t. supply. Set the on/off switch fully counter-clockwise and check that the pilot lamp is extinguished. Set the switch to position 2, then 3, and in both positions check that the lamp is alight. Disconnect the l.t. supply.
- (6) Disconnect the h.t. positive lead from the terminal on the underside of the inductor compartment. Connect it to the remaining pole of the 2-pole switch.
- (7) Connect a new lead between the disconnected terminal and contact 3 of the switch sector. contacts 2 and 1 remain unconnected.
- (8) Extend, or renew as necessary, the h.t. and l.t. leads to reach the supplies. Set the on/off switch to off, then connect the supplies.
- (9) Plug in a headset. Switch to the first position clockwise and check that the pilot lamp lights, and that the wavemeter is still dead. Switch to the next position and note that the wavemeter is now fully operational.

This modification allows keeping the valves warm during intervals, and prevents slight drift of frequency as when starting from "cold". The switching circuit is given in Fig. 4.

Using The Wavemeter

The calibration charts supplied with the instrument give very numerous tuning points for frequen-

cies throughout the spectrum which the wavemeter covers. Other frequencies are obtained by interpolation, making possible a 1 kc/s discrimination at the 100 kc/s band and 5 kc/s at the 20 Mc/s band. The instructions given for such interpolation by the chart are quite adequate and need not be repeated here. Major check points, backed up by local check points, both crystal-controlled, ensure extremely high accuracy for such an instrument.

The following notes on using the vernier may prove helpful to a newcomer to this instrument. The vernier drive is a flat spiral whose convolutions engage the teeth of a large crown wheel fitted behind the main dial. The vernier thus gives a 1,000 : 1 reduction. When the user is moving the main dial from one end of its scale to the other, the vernier may be disengaged by pulling the vernier knob outward; a slide will then move upward to lock it. (Note that the vernier knob looks askew; this is a part of the design, and is concerned with re-engaging the spiral drive.) When setting the main dial to a calibration figure, set it to the whole-number part of the calibration reading. Now set the vernier to 0. Pull the knob outward, press the slide upward, and allow the knob to move inward to re-engage the vernier and the main drive. Thereafter, set the vernier to the fractional part of the calibration reading and proceed to tune for the zero beat which will be nearby.*

When searching for zeros, keep the crystal injection as small as possible by counter-clockwise adjustment of Crystal Check Coupling. This also applies when receiving incoming signals.

Use of the wavemeter as a "transmitter" is also described in the calibration charts. Although the description is perhaps scanty, one should be able to see what happens when it is read in conjunction with the information given in this article.

* It may be found that backlash exists in the drive to C₁₀. If this occurs, it will prove helpful to approach all settings from one direction.—EDITOR.

The GT21 Glow Thyatron

By J. B. DANCE M.Sc.

Details of a new switching tube developed on the Continent which has the advantages of thyatron operation without the necessity for a heater supply or warm-up time. The tube may, also, be transistor controlled.

A NOVEL TYPE OF COLD CATHODE tube has been recently produced by the Cerberus Company (of Switzerland), this being the GT21 glow thyatron. The GT21 is basically somewhat similar to a trigger tube, but it has the

advantage that it can be controlled by input potentials of the order of 5 volts. It is therefore one of the few cold cathode tubes which can be operated from transistor circuits. Like all other cold cathode tubes with pure molybdenum cath-

odes, glow thyatrons have a very long life expectancy (exceeding 25,000 hours), are extremely reliable, give a clear and visible glow when conducting and require no warming-up time. In addition they can operate over a wide temperature range (-30° C to +90° C) and can be manufactured with very close tolerances.

In a trigger tube the input pulse initiates a discharge between the control or trigger electrode and the cathode, and the resulting ionisation causes the main anode-to-cathode gap to conduct. In a glow thyatron, however, there is a permanently maintained auxiliary discharge and the main discharge is controlled by the potential on a grid. The quiescent power required when the main gap is not conducting is very small.

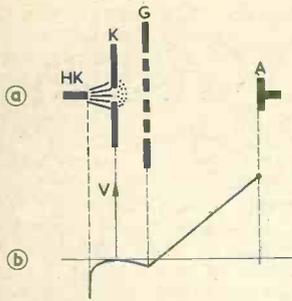


Fig. 1 (a). Electrode configuration of the glow thyatron. (HK=auxiliary cathode, K=cathode, G=control grid, A=anode)
(b). Potential distribution along the tube axis

In Fig. 1 (a) the auxiliary discharge is maintained between the auxiliary cathode HK (Hilfskathode) and the main cathode K; the latter acts as an anode for the auxiliary discharge. Electrons from the auxiliary discharge are attracted towards the main cathode (since it is more positive than the auxiliary cathode) and some of them will pass through the hole in the main cathode into the cathode-grid space. In this region the electric field is a function of both the grid and main anode potentials. If the grid is sufficiently negative with respect to the main cathode, the electrons will be decelerated and returned to the main cathode. In such a case the graph of potential against distance is as shown in Fig. 1 (b). If the grid potential is made less negative, a point will be reached at which the electrons pass through the grid towards the anode. After they have moved

a short distance under the accelerating field of the anode, they acquire enough energy to knock electrons out of the atoms of the gas with which they collide, and positive and negative ions are formed. In the electric field the light negative ions are accelerated and gain enough energy to form more and more ions by the avalanche effect. A relatively large anode current can then pass through the tube. Instead of the discharge terminating at K (as in Fig. 1, (a)) it now reaches the anode.

Characteristics

The firing characteristic of a GT21 tube is shown in Fig. 2. If the operating point is between the two lines of this graph the main gap will be non-conducting, whereas if it is above the upper line breakdown will have occurred. The graphs are for the average GT21. The point A is the minimum anode holding voltage for any tube at the maximum permissible negative grid potential. Point B shows the negative grid voltage which is required to ensure cut-off in all tubes at the minimum anode holding voltage. The critical grid voltage which will ensure firing at the minimum anode supply voltage is shown at point C, whilst D is the minimum inverse anode holding voltage at the maximum permissible positive grid voltage.

A magnified view of the most important section of the firing characteristic is shown in Fig. 3; this is usually called the control characteristic. At point B all tubes are cut off, whilst at point C all tubes will conduct. If all of the tubes were absolutely identical, B and C would, of course, lie on the curve.

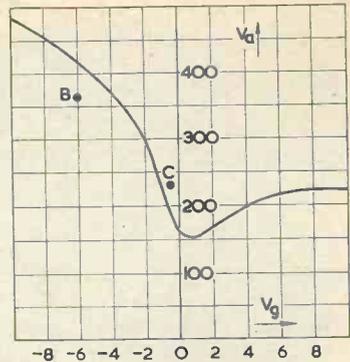


Fig. 3. The GT21 control characteristic

Once a glow thyatron has fired the grid loses its control in the same way that the grid of a thyatron or the trigger electrode of a trigger tube loses control once the tube has fired. In order to extinguish the tube, the anode voltage must be reduced below the maintaining voltage. If the tube is being operated from an alternating voltage supply, this will automatically occur towards the end of each alternate half-cycle.

The GT21 glow thyatron is a B9A based tube suitable for use with either a.c. or d.c. power supplies. It is especially suitable for the operation of relays and can itself be operated from various devices such as photocells or transistors, etc.

Typical GT21 Circuits

(1) Temperature Control with a Thermistor

Thermistors are semiconductor devices which have a resistance which decreases with increasing

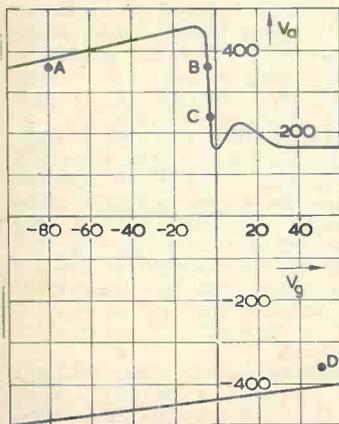


Fig. 2. The firing characteristic of the GT21

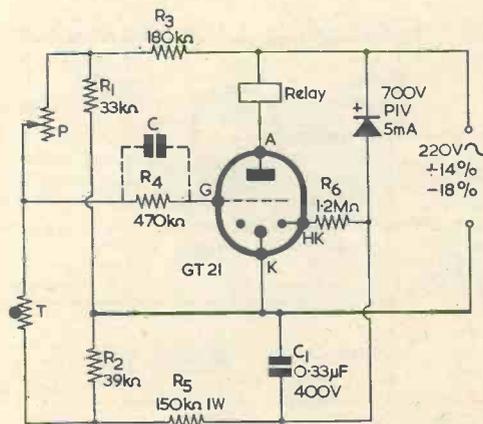


Fig. 4. A temperature control circuit

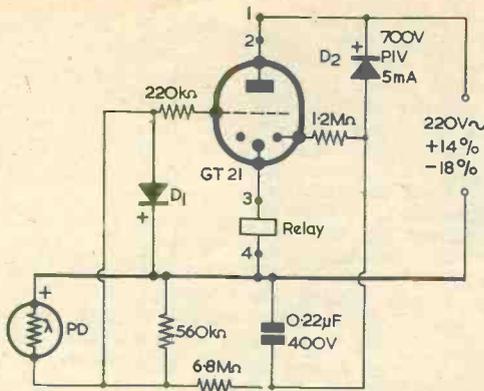


Fig. 5. Operation of a relay from a photodiode

temperature. They are very suitable components for temperature control, since they are small, have constant characteristics and can be obtained in a range of resistance values. The maximum temperature which can be controlled is, however, about 150° C.

A suitable circuit for temperature control using a thermistor and a glow thyratron is shown in Fig. 4. Potentiometer P selects the temperature at which an enclosure containing the thermistor T is to be stabilised. The heater which warms the enclosure is switched on and off by means of the relay in the anode circuit of the GT21.

Principle of Operation

An alternating potential is applied across the relay in series with the GT21 tube. The diode rectifies the a.c. supply in conjunction with the capacitor C₁. The negative potential thus obtained is used to supply the auxiliary cathode

via R₆ and a portion of it is tapped off from the potential divider R₅ and R₂ to provide the grid bias for the tube via the thermistor T.

The GT21 will not strike unless its anode is positive with respect to its cathode at a time when the grid potential is not too negative. If the temperature is low, the resistance of the thermistor will be fairly high. At the moment the anode is positive, a positive supply will be fed through R₃ to the potential divider formed by P and T. The potential at the grid tapped off this potential divider is not appreciably negative when the resistance of the thermistor is high and therefore the tube ignites. The relay thus switches on the power supply to the heater. As the temperature of the enclosure rises the resistance of T falls and, owing to the potential dividing action of P and T, a point will be reached at which the grid is so negative

(even during the time a positive pulse is applied to the anode) that the GT21 no longer strikes. The relay is then not energised and the power supply to the heater is cut off until the temperature has fallen to a point at which the glow thyratron can conduct again.

If the thermistor is interchanged with the potentiometer P, the relay will be energised when the temperature is high. This enables the circuit to be used with a relay whose contacts are normally closed. A capacitor C may be placed across R₄ to obtain a switching interval between the energising and de-energising point of the relay; it may have a value of about 6,800pF. A diode may be connected from the junction of P, T and R₄ to the cathode of the tube to bypass the positive voltage that is generated at the grid of the fired tube, and thus prevent additional loading (and consequent heating) of the thermistor.

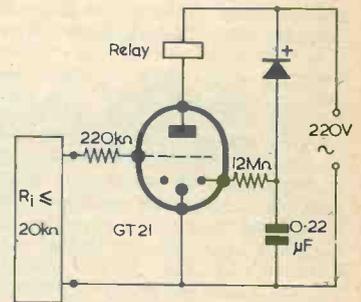


Fig. 7. Operating a GT21 from a transistor circuit

(2) Photoelectric Relay with Photodiode and GT21

The circuit of Fig. 5 is controlled by the light falling on the photodiode PD. When the amount of light falling on this diode is fairly large, the relay will be energised and will automatically be de-energised when the light intensity falls. The circuit of Fig. 6 is similar except that the relay is energised when the amount of light falling on the photodiode is small, and is de-energised when it is large.

If a high speed of response is required, the relay should be connected between points 1 and 2, and points 3 and 4 should be short-circuited.

The circuits of Figs. 5 and 6 are somewhat similar to the circuit of Fig. 4. When light falls on the photodiode of Fig. 5 it conducts and short-circuits the negative bias

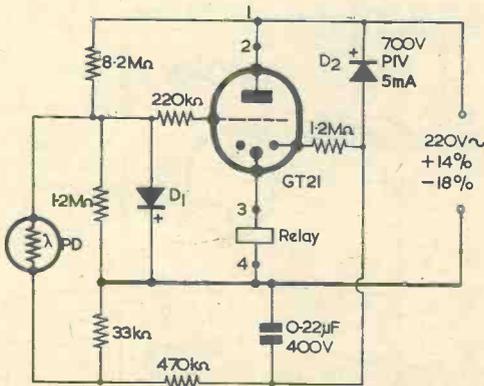


Fig. 6. In this circuit the relay is energised when little or no light falls on the photodiode

TABLE
The basic characteristics of the GT21 glow thyatron

Auxiliary cathode current	100 to 250 μ A
Maximum auxiliary discharge breakdown voltage	180V
Maximum mean cathode current	40mA
Minimum mean cathode current	10mA
Typical maintaining voltage at $I_a=20$ mA.	115V
Minimum anode supply voltage	180V alternating or 250V d.c.
Maximum anode supply voltage	250V alternating or 350V d.c.
Grid voltage for cut-off	-6V minimum -80V maximum
Grid voltage to ensure conduction	-0.5V minimum +50V maximum

Base Connections

1	2	3	4	5	6	7	8	9
A	IC	IC	G	K	HK	K	G	IC

applied to the grid, so that the glow thyatron conducts. In Fig. 6 a conducting photodiode will apply a negative bias to the grid of the glow thyatron and prevent the latter from conducting.

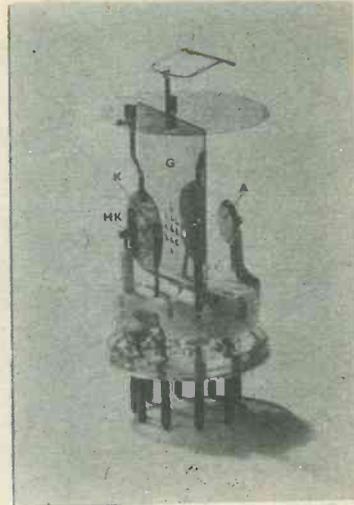
The photodiode used should have a minimum working voltage of 30 volts, a maximum dark current of 25 μ A and a minimum light current of about 50 μ A. Suitable photodiodes are the Siemens TP5111 and the Texas Instruments H11. If a photodiode with a higher dark current is used, or if the relay is required to respond only at a higher illumination level, the values of the 6.8M Ω and 560k Ω resistors of Fig. 5, or the values of the 8.2

and 1.2M Ω resistors in the grid circuit of Fig. 6, should be reduced in value.

(3) Operation from Transistors

The basic type of circuit for the operation of a GT21 from a transistor circuit is shown in Fig. 7. When the input to the GT21 grid is between -5 and -80 volts, the glow thyatron is cut-off, but it conducts if the grid potential is raised from -0.5 to +50 volts. If the grid potential of the GT21 is between -0.5 and -5 volts, some GT21 tubes will conduct, but others will not.

Further details of the GT21 tube have been published in *Cerberus*



The internal construction of the GT21

Elektronik, Nos. 17 and 18. These publications and others giving details of the GT21 and its circuitry are available from the tube manufacturers, Cerberus A.G., Werk für Elektronentechnik, Männedorf, Switzerland. Cerberus tubes are available from Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, London, W.C.2. The circuits described in this article have been designed by the manufacturers of the tube.

Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. Queries should be submitted in writing.

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continued from page 69

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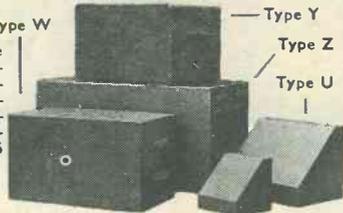
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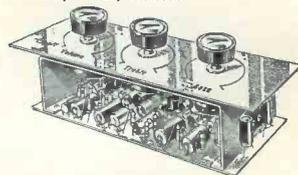
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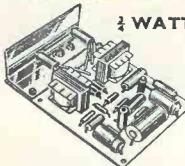
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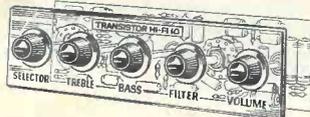
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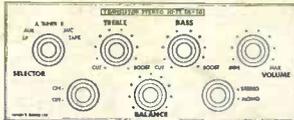
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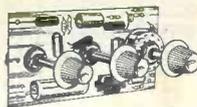
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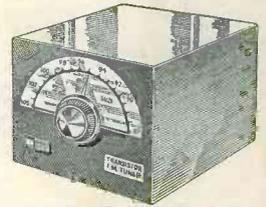
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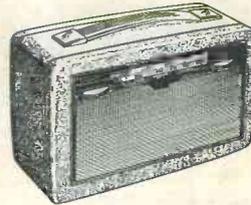
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