Published in Great Britain by the Proprietors and Publishers
Data Publications Ltd 57 Maida Vale London W9
Printed by A Quick & Co Ltd Oxford House Clacton on Sea England
Obtainable abroad through the following Collets Subscription Service Continental Publishers & Distributors Ltd William Dawson & Sons Ltd *Australia and New Zealand* Gordon & Gotch Ltd *South Africa* Central News Agency *Holland* "Radio Electronica"
Registered for transmission by Magazine Post to Canada (including Newfoundland)

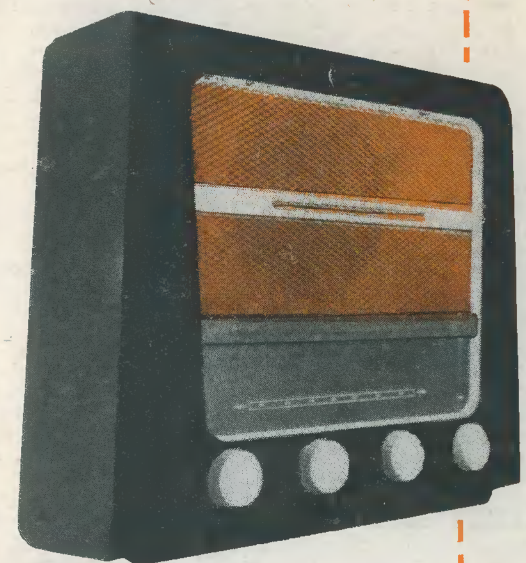
TRANSISTOR SETS FOR BEGINNERS

VOLUME 10
NUMBER 7
FEBRUARY
1957

The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS

A HIGH QUALITY BROADCAST RECEIVER



by R. HINDLE

Included in this issue
DESIGN OF TAPE RECORDERS, Part 4
DESIGN CHARTS FOR CONSTRUCTORS
MORSE PRACTICE OSCILLATOR
RADIO & TV SAFETY PRECAUTIONS
CONVERTING AMPLIFIERS FOR RECORDING

DATA Publications 1/9

THE MODERN BOOK CO

Transistor Techniques. Gernsback Library. **12s. 0d.** *Postage 9d.*

Improve Your Reception. By J. Cura and L. Stanley. **5s. 0d.** *Postage 4d.*

Frequency Modulation Tuner Units for Fringe and Local Area Reception. Data Publication. **2s. 0d.** *Postage 3d.*

Electronics Made Easy. A Build-It-Yourself Book. By L. Stern. **6s. 0d.** *Postage 9d.*

Radio Valve Data. Wireless World. **4s. 6d.** *Postage 6d.*

World Radio Handbook. For Listeners Broadcasting-Television. 1957. **12s. 6d.** *Postage 9d.*

T.V. Fault Finding. Data Publication No. 5. **5s. 0d.** *Postage 4d.*

Sound Reproduction. By G. A. Briggs. **17s. 6d.** *Postage 1s.*

Mullard Maintenance Manual. **10s. 6d.** *Postage 9d.*

Questions and Answers on Radio and Television. By E. Molloy. **6s. 0d.** *Postage 6d.*

Basic Radio Course. By J. T. Frye. **18s. 0d.** *Postage 9d.*

High Fidelity: The Why and How for Amateurs. By G. A. Briggs. **12s. 6d.** *Postage 9d.*

Mk Buizen Handbook. **10s. 6d.** *Postage 9d.*

High Quality Sound Reproduction. By Mullard Engineers. **3s. 6d.** *Postage 4d.*

We have the Finest Selection of British and American Radio Books in the country

Complete list on application

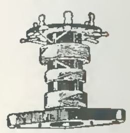
19-23 PRAED STREET (Dept RC) LONDON W2

Telephone PADdington 4185

TRANSISTOR IF TRANSFORMERS

Designed for 315 kc/s operation. High-Q "potted" construction, in screening cans 1" x $\frac{3}{4}$" diam., 6/6 each. Oscillator coils, transistor type ferrite rod aerials for MW band, and circuit data, also available.

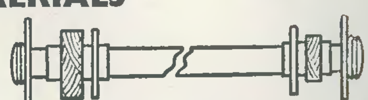
SUPER INDUCTOR COILS · MINIATURE DUST CORE TYPES



Selective crystal diode coil type HAX, 3/– (MW); HAX L, 3/6 (LW). Dual wave TRF coils, with adjustable iron dust cores, type A/HF, 7/– matched pair. Type S.S.O. supersonic oscillator coil for tape recorders (*Radio Constructor*, April, 1956). Provides 6.3V 0.3A for pre-amp. heater plus record/erase bias, price 15/– each.

TELETRON FERRITE ROD AERIALS

Wound on high permeability Ferroxcube rod. No external aerial required. Full sensitivity. Reduces static and whistles. Extremely selective. Simply fitted as replacement for Ae coil or frame aerial. Ideal for battery portable receivers.



Medium wave type FRM, 4" x $\frac{5}{16}$" 8/9
Dual wave type FRD, 8" x $\frac{5}{16}$" 12/9

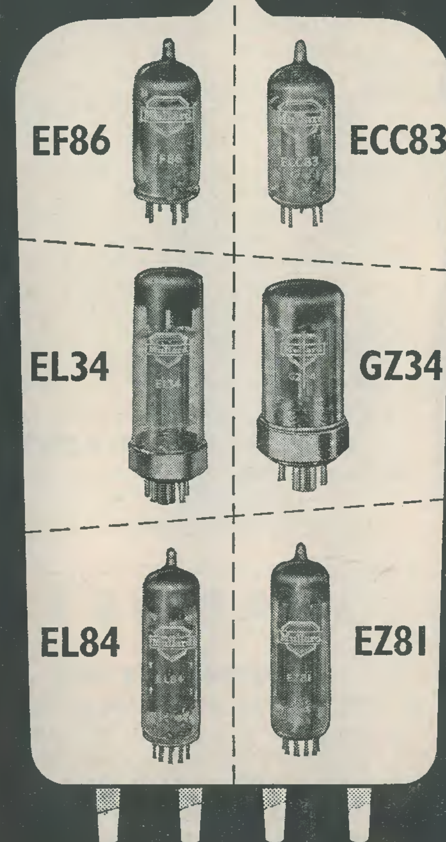
THE TELETRON COMPANY LIMITED

266 Nightingale Road · London N9

HOW 2527

Trade enquiries to sole distributor **S. Mozer 95 Kendal Ave N18** *Telephone* EDMonton 7707

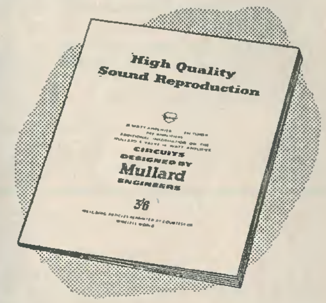
data for AUDIOPHILES*



Audiophiles all over the world are demanding Mullard audio valves for their high quality sound equipment. And who can blame them when they know that the Mullard World Series of Audio Valves is the finest in the world.

Fill in the coupon below for free data on Mullard World Series Audio Valves.

* *Audiophile—Enthusiast for high quality sound reproduction who is satisfied with nothing but the best.*



This popular book is available now from most dealers, price 3/6d. It contains designs and full constructional details of the new Mullard EL34 High Quality 20 Watt Amplifier, a Mullard Band II F.M. Tuner, pre-amplifiers for the Mullard EL34 Amplifier and for the popular Mullard 5 Valve 10 Watt Amplifier, together with other useful technical information.

COUPON

TO: MULLARD LTD., PUBLICITY DIVN.

Please send me, free of charge, leaflets on the Mullard World Series of Audio Valves, and details of "High Quality Sound Reproduction".

NAME..

ADDRESS..

....

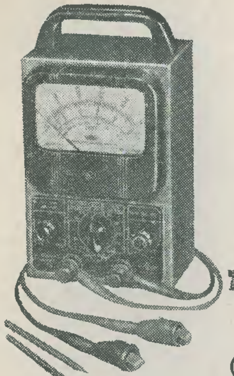
Mullard

WORLD SERIES

AUDIO VALVES

Mullard Ltd · Publicity Division
Mullard House Torrington Place
London WC1

MVM 349A



Yours by return for only £2·10·0 deposit

(CASH PRICE £12.7.6)

PULLIN SERIES 100 MULTI-RANGE TEST SET

21 ranges AC/DC from 100 microamps to 1,000 volts, sensitivity 10,000 ohms/volt. This is the famous Pullin Series 100, now available brand new on the easiest of terms. Fill in and post the coupon today.

To **HOME RADIO (Mitcham) LTD**
187 London Road, Mitcham, Surrey

Please send descriptive literature.
Please despatch one Pullin Series 100 Test Set. I enclose 50/- and promise to pay nine further monthly instalments of 24/6.

NAME — OCCUPATION
ADDRESS — IF OVER 21

QUALITY F.M. TUNER UNIT

SPECIAL PRICE **£5.12.6** *(Post and packing 2/6) (c.o.d. 1/6)*

Circuit similar to that described in Data Publications Ltd. Radio Reprint No. 2. Price includes all components with valves and everything needed. *Write for details (S.A.E. please).*
Power Pack components, **30/–** extra.
Booklet **2/2** *(free with orders)*

Band III Kit Set with **Power Pack** with valves EF91 and ECC81 — **62/6**
Complete Converter £5 in Rexine (Lizard) or walnut cabinet, 2 valves ECC81
Ditto metal cabinet, **90/–**

Send 4d. for list of components. Examples:

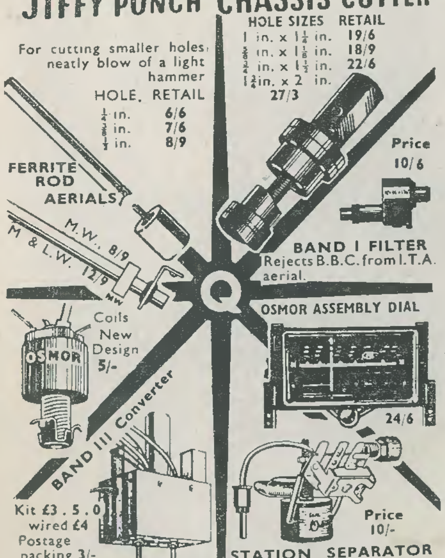
0.1µF 4kV wkg Tubular	3/6
2-gang Variable 500pF	4/6

Ceramic Air-spaced Variables 25pF **2/6**; 40pF **2/6**; 40+40pF split stator **4/–**; 100pF **4/–**

GLADSTONE RADIO

82B HIGH STREET CAMBERLEY SURREY
Open Saturdays to 5 p.m.

JIFFY PUNCH CHASSIS CUTTER



OSMOR RADIO PRODUCTS LTD
418 BRIGHTON ROAD SOUTH CROYDON SURREY (Dept. RC7) Telephone CROydon 5148-9

HANNEY

offers

COMPONENTS FOR

OSRAM 912 PLUS AMPLIFIER
OSRAM 912 PASSIVE UNIT
OSRAM 912 PRE-AMPLIFIER
OSRAM FM PLUS TUNER
OSRAM JUNIOR AMPLIFIER
MULLARD 510 AMPLIFIER
MULLARD 510 'A' & 'B' PRE-AMPS
MULLARD FM TUNER
MULLARD 3/3 AMPLIFIER
WIRELESS WORLD FM Tuner
DENCO Maxi-Q FM Tuner

MANUALS AVAILABLE
Mullard High Quality Amplifier Manual (contains FM details), 3/6
Osram 912 Plus Manual, 4/–
Denco FM Tuner Manual, 1/6
Send 2½d. postage for lists required. General Components List also available

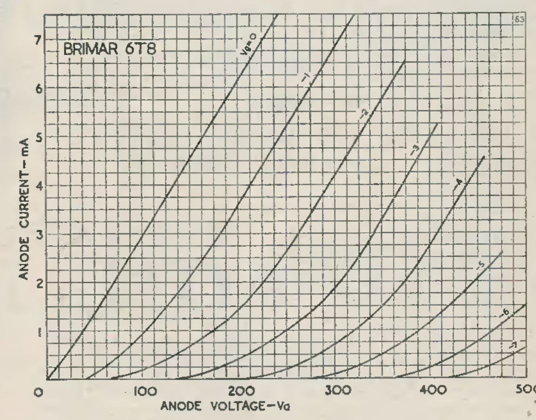
L. F. HANNEY
77 Lower Bristol Road BATH

BRIMAR

TRIPLE DIODE TRIODE

The Brimar 6T8 is a triple-diode-triode in which one diode has a separate cathode. The triode section has a high amplification factor making the valve suitable for use in AM/FM receivers in the demodulation and first stage audio circuits. The diodes may be used in series shunt limiter circuits, for example in the audio sections of television and communications receivers, followed again by the triode section for A.F. amplification.

Near Equivalents
EABC80
DH719
6AK8

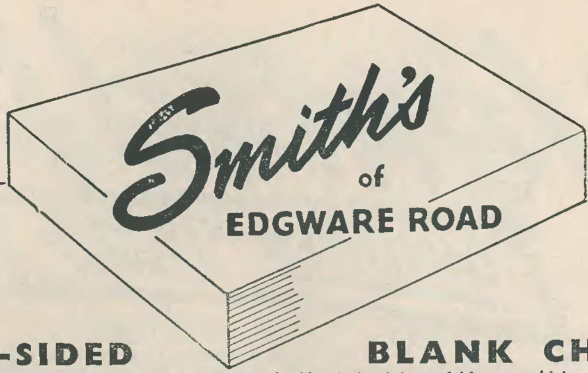


Typical Triode Operating Characteristics as an R.C. coupled amplifier

Anode Supply Voltage	250	250 volts
Anode Load Resistor	0.25	0.25 megohms
Grid Resistor	1.0	10 megohms
Cathode Bias Resistor	3	0 kilohms
Peak Output Voltage	43	40 volts
Stage Gain (for 24V peak to peak output)	42	42
Distortion (for 24V peak to peak output)	1	5%

Cut this out for further reference or write to the Publicity Department at Footscray for a data sheet

Standard Telephones and Cables Limited
(Reg. Office: 63 Aldwych, London, WC2)
FOOTSCRAY SIDCUP KENT *Telephone 3333*



FOUR-SIDED BLANK CHASSIS

Made in our own works from commercial quality half-hard aluminium of 16 s.w.g. thickness, these chassis will carry components of considerable weight and normally require no corner strengthening.

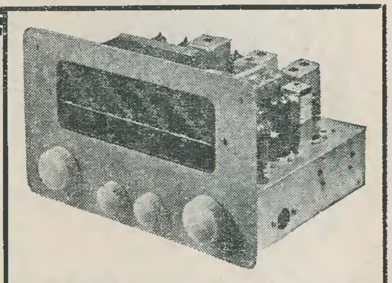
Standard stock sizes (in inches) are as follows:—

						14 × 10 × 2½	10/–
6 × 4 × 2	5/–	9 × 8 × 2½	7/6	10 × 8 × 3	8/6	12 × 10 × 3	10/3
7 × 5 × 2	5/6	10 × 8 × 2½	7/10	13 × 8 × 2½	8/10	15 × 10 × 2½	10/6
10 × 4 × 2½	6/4	12 × 5 × 3	7/11	12 × 9 × 2½	8/11	17 × 10 × 2½	11/3
9 × 7 × 2	6/6	12 × 7 × 2½	8/–	14 × 7 × 3	9/6	17 × 9 × 3	11/6
12 × 4 × 2½	6/10	11 × 8 × 2½	8/3	13 × 10 × 2½	9/9	17 × 10 × 3	12/3

The above are sizes for which we have most demand, but we can also make other sizes to order (at a small extra charge) within the following limits: Depths 1in., 1½in., 2in., 2½in. and 3in. only. Maximum length 17in. Minimum width for 3in. depth is 5in. Minimum width for 2½in. depth is 4in. Minimum width for 2in. depth is 3½in. Minimum width for 1½in. depth is 3in. Minimum width for 1in. depth is 2in. We cannot undertake to make odd shapes, extra bends, lips, etc. To arrive at the approximate cost of a special size of chassis take the nearest standard size above and add 2/6. **PANELS. We can also supply the aluminium for use as panels, screens, etc., cut to any size up to 3ft. by 3ft. at 4/– per square foot.** *NOTE.—A panel cannot be sent through the post if the length plus twice the width exceeds 6ft. Keep this list for reference.*

H. L. SMITH & CO. LTD 287/9 Edgware Road London W2 *Telephone* Paddington 5891

Build for Quality



WITH THE FAMOUS JASON ARGONAUT KIT

(AM—FM TUNER OR RECEIVER)

The "Argonaut" is a super-sensitive unit to receive medium-wave A.M. and F.M. transmission. It can be built either as a tuner for feeding to amplifier, or a complete receiver. Switching and wiring are reduced to complete simplicity without sacrificing performance and efficiency, and since its introduction the "Argonaut" is creating more and more enthusiasts for its all-round excellence.

Full building instructions are available as a Data Publications reprint, **price 2/–**

- **DIAL ASSEMBLY**
  With chassis, flywheel tuning, Jackson Bros. 4-gang condenser, 500pF+500pF, and 15pF+15pF, glass scale. Station-name calibrated on both bands. Hammer finish front panel **£4.4.0**
- **SET OF COILS**
  All coils, including ratio detector, M.W. coils and 2 twin-i.f.t's (472 kc/s and 10.7 Mc/s) **£2.17.9**

Approximate cost to build, as a self-powered receiver **£16 . 0 . 0**

Send S.A.E. for complete list of components and prices

JASON MOTOR AND ELECTRONIC CO **328 CRICKLEWOOD LANE LONDON NW2** *Telephone* SPEedwell 7050

HOME RADIO OF MITCHAM

FOR ALL YOUR PARTS FOR THE

"EAVESDROPPER"

TRANSISTOR POCKET PORTABLE

Red Spot transistors	each	10/–
Mullard 0A71 diodes		6/–
Teletron FRM ferrite rod aerial		8/9
5:1 intervalve transformers		10/6
Crystal microphone insert		5/–
JB .0005mfd tuning condenser		3/9
100pF compression trimmers		10d.
40pF compression trimmers		9d.
T.C.C. 20mfd 12V Picopack	each	2/6
Resistors ¼ watt	each	4d.
Paxolin panel 6½" x 3½"		1/–
Ever Ready B121 battery		2/–
6BA ¼" brass nuts and bolts	doz.	6d.
6BA solder tags, single or double	doz.	3d.
Bulgin S.591 Switc es		3/–

Detailed price lists of any of these kits available on request

ALSO ALL PARTS IN STOCK FOR THE **G.E.C. JUNIOR AMPLIFIER, G.E.C. 912 AMPLIFIER, MULLARD 3-3 and 510 AMPLIFIERS, JASON F.M. AND ARGONAUT RECEIVERS, HIGHWAYMAN PORTABLE**

HOME RADIO (MITCHAM) LTD
187 LONDON ROAD MITCHAM SURREY *Telephone* MIT 3282

POPULAR MECHANICS A **NEW** BUILD-IT-YOURSELF BOOK

ELECTRONICS MADE EASY

A valuable radio handbook

Amateurs, Radio Engineers, Hi-Fi enthusiasts and Electronics Engineers cannot afford to be without a copy of "Electronics Made Easy." With 192 packed pages, over 500 illustrations, drawings and photographs, this unique book is essential to everyone engaged in fascinating radio and electronics.

Radio, electrical and television repairs really run up the bills, this book will save you money

GET A COPY TODAY!

MONEY-BACK GUARANTEE if book does not meet with your approval and is returned to us within 5 days.

192 PAGES ONLY 6/6 POST PAID

PUBLISHED BY POPULAR MECHANICS PRESS, CHICAGO, U.S.A.

MAIL THIS HANDY ORDER FORM TO-DAY

Please send me ELECTRONICS MADE EASY.

I enclose 6/6.

Name..............................

Address..............................

POPULAR MECHANICS
109 JERMYN STREET · LONDON · SW1

The Radio Constructor

incorporating THE RADIO AMATEUR

CONTENTS FOR FEBRUARY

VOL. 10, NO. 7

FEBRUARY 1957

ANNUAL SUBSCRIPTION 21/–

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9

Telephone
CUNNINGHAM 6141 (2 lines)

Telegrams
DATABUX, LONDON

Editor
C. W. C. OVERLAND, G2ATV

Advertising Manager
F. A. BALDWIN, AMIPRE

NOTICES

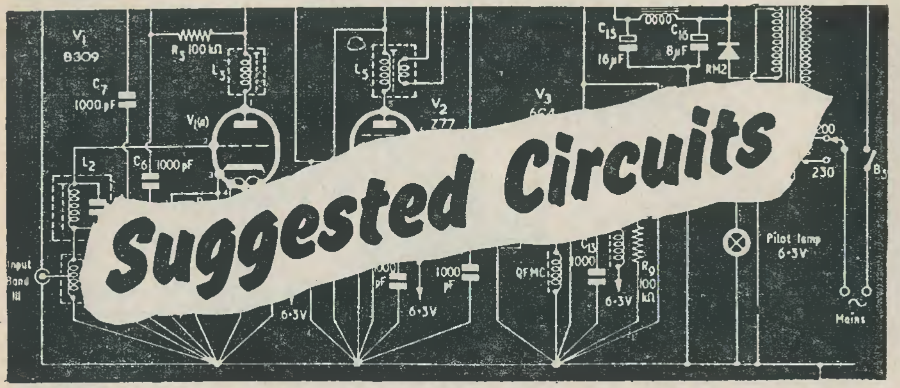
THE EDITOR invites original contributions on construction of radio subjects. All material used will be paid for. Articles should preferably be typewritten, and photographs should be clear and sharp. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included.

All MSS must be accompanied by a stamped addressed envelope for reply or return. Each item must bear the sender's name and address.

TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

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 the equipment described in these articles.

ALL CORRESPONDENCE should be addressed to THE RADIO CONSTRUCTOR 57 Maida Vale London W9



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

No. 75. THE ACCURATE MEASUREMENT OF INDUCTOR SELF-CAPACITY

IT OFTEN HAPPENS THAT, DURING EXPERIMENTAL work, it becomes necessary to measure the self-capacity of a coil with a high degree of accuracy. Unfortunately, this is not always a simple process to carry out when conventional methods are employed, since a certain amount of calculation is required before the self-capacity can be finally evaluated. There is, also, the fact that several sets of readings are usually required, whereupon calibration and reading errors are liable to become high. A typical example of the conventional methods used for finding the self-capacity of a coil or inductor consists of checking the resonant frequencies of the inductor when shunted by two known capacitors of dissimilar value, one after the other. The self-capacity is then calculated from the two sets of figures thus obtained. This approach relies, amongst other things, upon being able to accurately determine the two resonant frequencies given by the condensers. When self-capacities are low, small errors in frequency calibration may introduce large errors in the final, calculated, result.

This month's circuit introduces a rather novel technique for measuring the self-capacity of an inductor, and it has the advantage of obviating the necessity for accurate frequency calibration altogether. This is due to the fact that the frequencies at which the inductor is made to resonate consist of a fundamental and its second harmonic. The numerical values of the fundamental or the second harmonic in terms of cycles per second are unimportant, as they cancel out in the calculations. Another advantage given by the method to be described is that the self-capacity figure finally obtained bears a simple mathematical relationship to an external variable condenser. If the external variable condenser employed is not already calibrated its value may be determined, after setting up, by conventional bridging methods. There is, finally, the fact that there is no necessity to know the exact inductance of the coil whilst carrying out the check.

following relationship holds true:

$$2f = \frac{1}{2\pi\sqrt{L(C_s + C_L)}} \quad \ldots(1)$$

L being equal to the inductance of the coil.

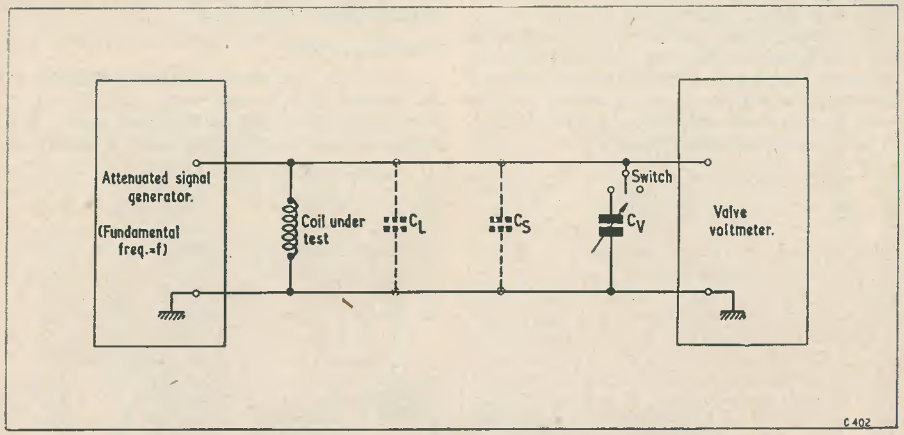


Fig. 1. Basic arrangement for measuring self-capacity of coil.

The Basic Technique

Fig. 1 illustrates the basic circuit arrangement involved in carrying out the self-capacity measurement. The output of a signal generator is coupled to the coil under test, across which a valve voltmeter is connected. The stray capacity caused by the signal generator and valve voltmeter connections is shown in the diagram as C_s. (In practice, C_s can be kept to a very low value.) The self-capacity of the coil is also illustrated in Fig. 1, this being represented by the condenser C_L. A variable condenser C_v is capable of being connected across the coil when desired by means of a switch. The valve voltmeter is required as a peak reading device only, it serving to indicate a state of resonance in the coil.

The first step in measuring the self-capacity of the coil is taken with C_v switched out of circuit. Under this condition, the capacities tuning the coil are C_s and C_L in parallel. The signal generator is then adjusted until resonance occurs at the *second harmonic* of its output, this being indicated by a peak reading in the valve voltmeter. (The process of using the second harmonic is discussed in more detail later.) The actual frequency at which the coil is resonating is unimportant, and we can refer to it as 2f, f being the fundamental frequency.

With the coil resonating at the second harmonic of the signal generator output, the following relationship holds true: [see above]

Without touching the frequency setting of the signal generator we then switch the variable condenser, C_v, across the coil. We next adjust C_v until the coil resonates at the *fundamental* of the signal generator frequency, this being indicated once more by a peak reading in the valve voltmeter. The resonant frequency now becomes f, and the capacity tuning the coil C_s, C_L and C_v in parallel. It may then be stated that

$$f = \frac{1}{2\pi\sqrt{L(C_s + C_L + C_v)}} \quad \ldots(2)$$

Combining equations (1) and (2) we obtain

$$\frac{1}{2\pi\sqrt{L(C_s+C_L)}} = \frac{2}{2\pi\sqrt{L(C_s+C_L+C_v)}}$$

$$\therefore \frac{1}{\sqrt{L(C_s+C_L)}} = \frac{2}{\sqrt{L(C_s+C_L+C_v)}}$$

$$\therefore \sqrt{L(C_s+C_L+C_v)} = 2\sqrt{L(C_s+C_L)}$$

$$\therefore L(C_s+C_L+C_v) = 4L(C_s+C_L)$$

$$\therefore C_s+C_L+C_v = 4C_s+4C_L$$

$$\therefore C_v = 3C_s+3C_L$$

$$= 3(C_s+C_L)$$

$$\therefore C_s+C_L = \frac{1}{3}C_v \quad \ldots(3)$$

As may be seen, the parallel combination of the self-capacity of the coil and the stray capacity introduced by the signal generator and valve voltmeter is equal to a third of C_v after it has been adjusted to resonance. The frequency setting of the signal generator and the inductance of the coil do not enter into the calculations whatsoever.

It is interesting to note that the technique just described enables the *inductance* of the coil to be found with a similarly high degree of accuracy; although it is necessary, in this case, to know the frequency of resonance, f, in addition to the capacity C_v.

$$=\frac{3}{4\omega^2 C_v}$$

where $\omega=2\pi f$.

As will be realised, by using this technique the stray and self-capacities are completely cancelled out, and only one frequency measurement is required.

Practical Points

Although the above method may appear to require a little care when carried out in practice, this is not actually the case. The only operation at which any difficulty is

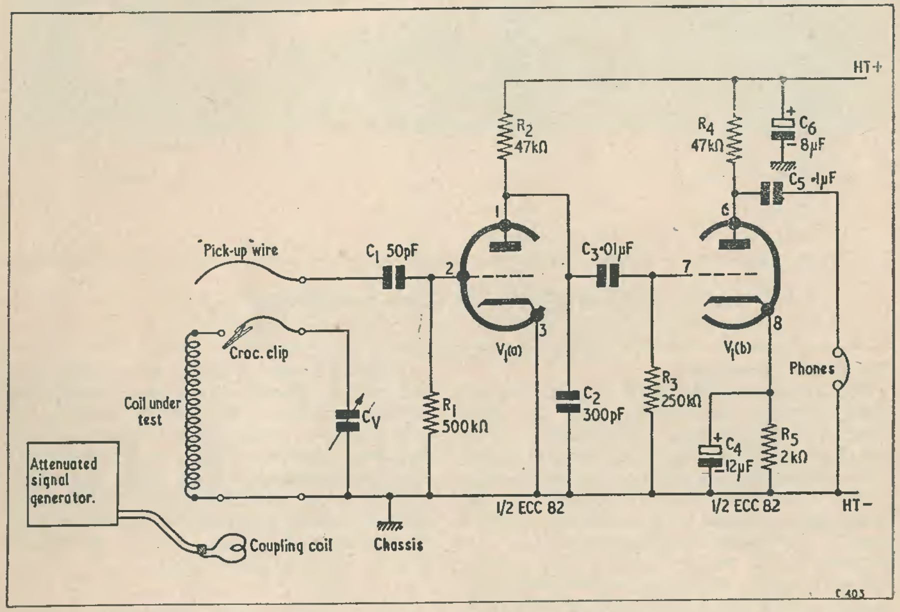


Fig. 2. A suggested practical circuit

From equation (2), we find

$$f=\frac{1}{2\pi\sqrt{L(C_s+C_L+C_v)}}$$

$$\therefore \quad f^2=\frac{1}{4\pi^2 L(C_s+C_L+C_v)}$$

$$\therefore \quad L=\frac{1}{4\pi^2 f^2(C_s+C_L+C_v)}$$

But $C_s+C_L=\frac{1}{3}C_v$ (from eq. 3)

$$\therefore \quad L=\frac{1}{4\pi^2 f^2 \frac{4}{3} C_v}$$

liable to be encountered is during the initial step wherein the coil is desired to resonate at the second harmonic of the signal generator output. One approach to ensuring that the correct harmonic is chosen consists of initially making the coil resonate (with C_v out of circuit) at the signal generator fundamental. The fact that the fundamental only is causing resonance can be confirmed by attenuating the signal generator such that a very small indication is given by the valve voltmeter. If the coil is then resonating at the fundamental, no other signal generator frequency setting will cause an indication in the valve voltmeter. The frequency of the signal generator should next be noted, roughly, whereupon it can be set to approximately half the frequency, its output being increased such that an adequate second harmonic amplitude is obtained. After being set for peak reading in the valve voltmeter, the signal generator needs no further frequency adjustment at all. When C_v is connected across the coil, the only frequency at which it can cause resonance is at the fundamental. After the initial step, therefore, the process automatically eliminates errors.

A Suggested Circuit

Converting the basic arrangement of Fig. 1 into a practical circuit introduces one minor difficulty. This is due to the presence of the stray capacity, C_s, which has to be subtracted from the expression C_s+C_L to give the value of C_L. There are two approaches to the problem of C_s. One consists of deliberately introducing a known capacity for C_s into the circuit. The second consists of keeping C_s to a negligible value, whereupon it may be ignored, causing C_L, on its own, to become equal to one-third of C_v.

The first approach could be employed by connecting a valve voltmeter of known input capacity across the coil, and then subtracting this capacity from the figure for C_s+C_L finally obtained. Most good quality valve voltmeters quote a figure for input capacity which may be relied upon. The signal generator output can be very loosely coupled into the coil under test by means of a coupling coil mounted some distance away from it. When this method of coupling is employed, the capacity introduced by the signal generator may be ignored.

Fig. 2. shows a suggested circuit which uses the second method, that of keeping C_s to a negligible value. The device illustrated is extremely simple and should be suitable for most radio frequency coils having reasonable values of Q. The signal generator output is once more coupled into the coil under test very loosely by means of a coupling coil positioned some distance away from it. The detector circuit (which replaces the valve voltmeter of Fig. 1) is coupled to the coil under test by positioning a short pick-up wire sufficiently close to its "hot" end to enable a peak indication to be obtained. The coupling capacity thereby given should have a value of less than 1pF in most cases. The signal generator should be set to give a modulated output, whereupon resonance is indicated by maximum modulation in the phones. It will be noted that the sensitivity of the detector is increased by the use of a subsequent a.f. amplifier. The variable condenser C_v is connected to the coil under test by means of a crocodile clip, thereby obviating the self-capacities inherent in a switch.

Philips Release New Battery (Transistor) Record Player

Philips Electrical Limited announce that their AG9121 Battery (Transistor) Record Player/Amplifier is now available from stock at 30 gns. (List £22 14s. 10d. plus P.T. £8 15s. 2d.).

First shown at the 1956 National Radio Show as Type AG2130, this instrument, which has been somewhat improved, is one of the very few which operate at speeds of 33⅓ and 78 in addition to 45 r.p.m. It is believed to be the first of its kind to be generally released for immediate sale.

The AG9121 consists of a 3-stage transistor amplifier with a gramophone unit for playing 7, 10 and 12-inch records (standard or microgroove). It is mounted in a carrying case of modern design, covered with imitation leather cloth in two shades of brown.

It is completely portable, weighing only 10½lb, and the case fully protects the instrument against dust, dirt and moisture.

The specially designed, low consumption motor has a governor to maintain correct playing speeds throughout the life of the batteries. The motor and amplifier are automatically switched off when the pick-up arm reaches the end of a record.

The "Featherweight" pick-up arm has a detachable, lightweight, crystal pick-up head (type AG3010) suitable for standard and microgroove records.

The amplifier incorporates a push-pull output stage giving excellent tone and volume.

Power is supplied by four 1½V dry batteries of standard type. These provide approximately 100 hours playing time. Batteries must be purchased separately; they are not supplied with the instrument due to risk of deterioration in store.

SPECIFICATION

Description: Type AG9121 battery operated record player/transistor amplifier in portable case.
Batteries: Four 1½V cells in series. Approximately 100 hours life.
Consumption: 600mW approximately.
Pick-up: Philips Type AG3010 dual stylus.
Amplifier: Four transistors—One OC71 Input; one OC71 Driver; two OC72 Push-pull Output with negative feedback.
Controls: Volume Control and Tone Control combined (pull for minimum treble, push for maximum treble). Motor and amplifier are both switched by the pick-up arm. (Governor keeps motor speed constant over the whole of the useful life of the batteries.
Loudspeaker: Philips 4in high-sensitivity unit.
Dimensions: Height 6¾in; width 10¾in; depth 15¼in.
Weight: 10½lb.
Price: 30 gns. (tax paid).
Special Features: Complete portability. No spring motor to wind up. Long battery life.

Once more Smithy the Serviceman continues to run the Workshop aided by Dick, his able assistant.

THE PEACEFUL STILLNESS OF SMITHY'S Workshop one winter's morning was suddenly broken as a 400 c/s tone made itself audible from the bench at which the Serviceman's assistant, Dick, was working. The wailing note became louder as Dick progressed with the alignment of the sound receiver on which he was working. Smithy grumbled to himself as the tone increased in strength. When it was finally being reproduced at the full power of which Dick's receiver was capable he could stand it no more.

"For goodness sake, Dick," he called, "turn it down a bit! Can't you finish alignment with an unmodulated carrier or something?"

"Sorry, Smithy," returned Dick, raising his voice above the noise. "I'd got so interested in the job that I'd forgotten how annoying 400 c/s can be when it's going at full blast. Anyway, I've nearly finished now."

Whereupon he switched his signal generator to "C.W." and made a few last checks to the chassis he had been repairing. Smithy returned to his own job.

After a few seconds Dick gave a little exclamation. "Well, that's queer!"

A Scratchy Pot

"What's queer?" grunted Smithy.

"The results I'm getting from this set," explained Dick. "I've already checked everything in it, but now I've suddenly got an intermittent scratchy pot."

"Perhaps you should see a vet," suggested Smithy.

"No, let's be serious," said Dick. "The volume control potentiometer in the set was perfectly O.K. when I checked it earlier on, but now it's intermittently scratchy. I've got a knob on the spindle, incidentally," he added defensively, referring to an earlier demonstration by Smithy during which the Serviceman had shown him that turning an uninsulated spindle with the fingers can sometimes cause crackles.*

Smithy left the chassis on which he had been working and walked over to examine Dick's fault. He turned the volume control Dick had referred to and a noticeable "rushing" noise came from the speaker. He frowned a moment, then glanced at Dick's signal generator which, set to "C.W.", was still connected to the receiver. After a moment's thought he altered the frequency of the instrument. The receiver, which had previously been quiet, relapsed into a gentle hissing as the a.g.c. voltage diminished; and a faint station became audible in the background. Smithy turned the volume control once more. It worked perfectly, without a trace of noise.

"There you are," said Dick triumphantly, "it's intermittently noisy!"

"It's nothing of the sort," replied Smithy, "although, in a way, I'm glad you've bumped into this snag because it means you have learned another little practical point about radio. But," he added, sternly, "I do not agree with the use of such heavy input signals as you're putting into this set in order to line it up."

"I only turned the signal genny up to that level to check a.g.c. action," explained Dick. "I lined the set up on quite a low signal."

"In that case," said Smithy, mollified, "I must apologise for jumping to conclusions. Anyway, let's get down to examining the strange behaviour of this intermittently noisy volume control. Now, as you can see if you look at the circuit of this particular receiver, the volume control also doubles up as the a.g.c. diode load (Fig. 1). The slider of the volume control then connects, via a condenser, C_4, to the grid leak of the following a.f. valve.

"Because of this method of connection there are two important voltages appearing across the volume control whenever you tune in a signal. The first of these is a d.c. voltage which is proportional to the carrier level of the signal. This voltage we feed back as grid bias to the earlier stages of the receiver to give us our a.g.c. action. The second voltage is the detected a.f. of the signal and this is fed, via the coupling condenser, to the a.f. amplifier of the receiver.

Dick thought for a moment.

"Why, yes of course," he siad, his brow clearing. "In the first case we have a heavy signal input which means that we have a relatively high d.c. voltage across the volume control track. In the second case we have hardly any signal input at all and so there is very little d.c. voltage across the control. That means that the volume control functions correctly when a negligibly low d.c. voltage appears across it, and that it becomes noisy when a high d.c. voltage appears across it. When I noticed that the volume control was noisy it was because I had the signal generator adjusted to give a high output, with a consequently high d.c. voltage being built up across the control. Also the fact that the signal generator was set to C.W. meant that there was no a.f. present to mask the noise."

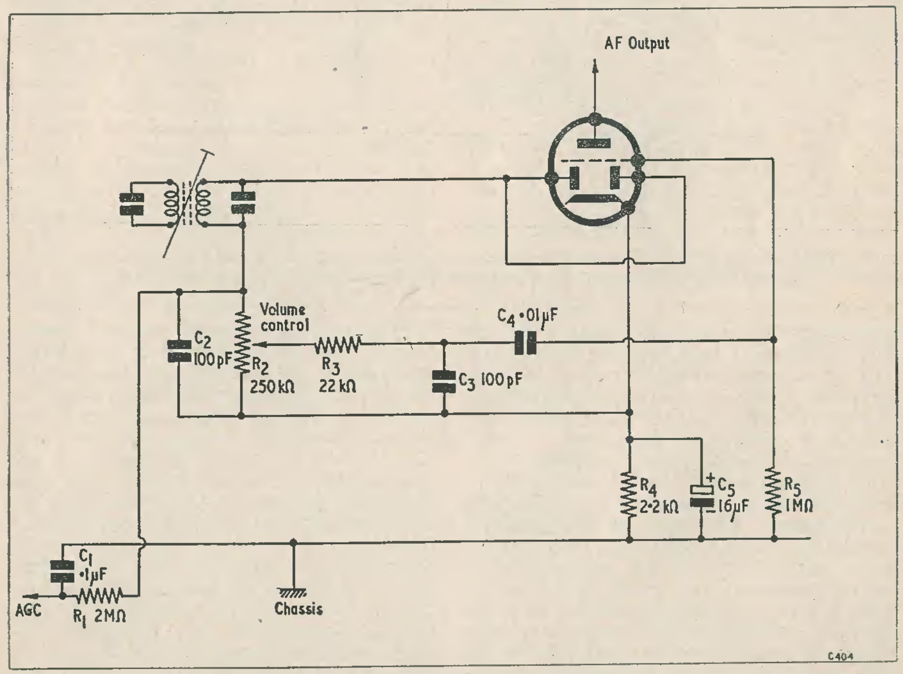


Fig. 1. The diode detector circuit referred to by Smithy. When a high d.c. voltage appeared across its track, the volume control became noisy.

"We know that the volume control is noisy under some conditions, and that it is not noisy under others. The noisy condition was given when the signal generator, with a large output, was fed into the set; and the quiet condition was given when no signal, apart from a faint station, was being handled by the receiver. Can you see a connection between these two sets of facts?"

"That's exactly right," remarked Smithy, "although I must point out that the d.c. voltage across the control was greater, with the particular setting of the sig. gen. attenuators you were using, than you would get from most local stations. However, the interesting point you have learnt is that volume controls may appear to be noisy whenever a d.c. voltage appears across them.

**In Your Workshop, October* 1956

This sort of thing is much more troublesome in a.f. amplifiers than it is in ordinary sound receivers because there is usually greater amplification after the control. If you have a circuit like this, for instance (Fig. 2), you may see that it only needs a slight amount of leakiness in C_1 to cause a d.c. voltage to appear across the volume control. In my own experience I have met the trouble not only in volume controls but also in tone controls. When tone control circuits are fitted in the early stages of an amplifier they sometimes employ arrangements wherein leakiness in one particular condenser may cause a proportion of the h.t. voltage to be developed across the track of a tone control potentiometer. The result, as with a volume control, is scratchy operation. Whenever I get a noisy control in an a.f. amplifier I normally make a quick check to ensure that there is no d.c. voltage across the track by checking it with a valve voltmeter or a high-resistance meter, like the Avo type 8. If such instruments aren't available a reasonably good check consists of temporarily shunting the track of the control with a resistor which has a value about ten times lower than that of the potentiometer. This resistor lowers the d.c. voltage across the track by a considerable amount and, if d.c. voltage is causing the trouble, lowers the scratchiness as well. Checks of this type, especially the voltage check, are much quicker to carry out than it takes to describe them."

"Well, that seems to be a useful hint," remarked Dick, "but there is one thing I can't quite understand. In your sketch (Fig. 2), you say that a d.c. voltage across the pot track can cause scratchy operation. How can this be when you have a condenser (C_2) between the slider and the following grid? Surely this condenser will block off d.c. voltages?"

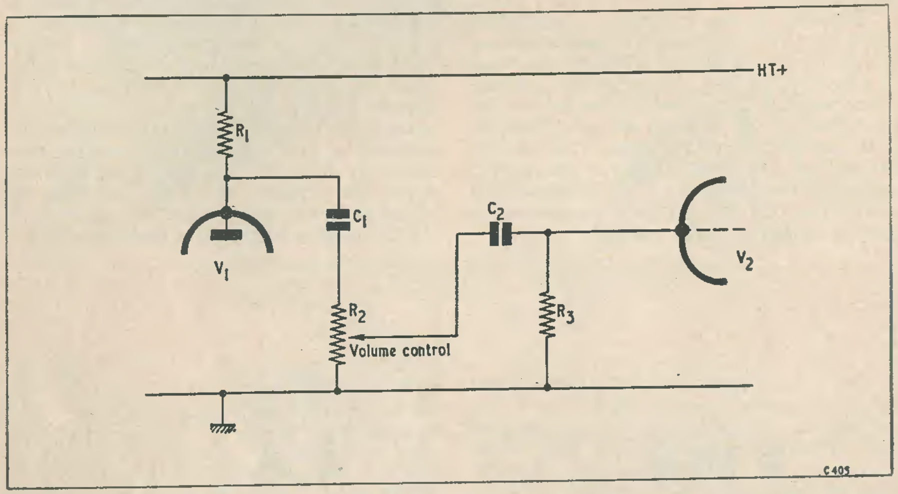


Fig. 2. A circuit arrangement found, with variations, in some a.f. amplifiers. In this case, leakiness in C_1 would cause a d.c. voltage to appear across R_2.

"That's quite a good point," replied Smithy, "and to understand the answer fully you have to try and consider the operation of the potentiometer in its basic form. As you know, the pot appears to give a very smooth control of voltage when you consider it in its entirety. However, if you examine its operation minutely, you must inevitably get down to the fact that the slider actually hops along over tiny, discrete*, little steps of resistance along the track. Something like this (Fig. 3). These steps may have very small amounts of resistance between them, and they may be very close together indeed, but they still exist. The result of these discrete steps is that, as the slider travels along the track, the signal level increases by very small amounts; these being so small that they cannot normally be detected by the ear. If there is a d.c. voltage across the track we will also get little increases in d.c. voltage from the slider as well. We will have something like this (Fig. 4). If the d.c. voltage across the pot is much higher than the signal voltage then these increases will be sufficiently high to cause noise in the amplifier. The increases 'get through' the coupling condenser, incidentally, because they represent a changing potential, and are in consequence a type of a.c. If we obtain a number of these increases in a short space of time their total effect is much worse than if they are 'spread out' over a long space of time. Look, I can demonstrate this to you now."

* *Discrete, a.* separate, individually distinct.

Smithy readjusted the frequency of the signal generator so that a heavy signal was, once more, injected into Dick's receiver; with the result that a relatively high d.c. potential appeared across the volume control.

"Now you can see," continued Smithy, "that if I turn the volume control very quickly—in order to obtain a large number of our little voltage steps in a short space of time—the resultant noise is quite heavy. But, if I turn it very slowly, the noise is almost inaudible."

Dick had been following Smithy's explanation very carefully.

"I think I understand it all, now," he remarked. "Summing it up, you can say that any potentiometer must really cause resistance changes in tiny little steps if you consider its action over a small enough amount of rotation. If you have a d.c. voltage across the pot then the little increases in d.c. potential on the slider, as you adjust it, may be reproduced as noise by the amplifier. For the noise to be loud compared with the signal, the d.c. voltage has to be considerably greater than the signal voltage."

"That's right," confirmed Smithy, "and, when you consider that many potentiometers in a.f. circuits handle signals in the millivolt class, you can understand that a d.c. potential of only a few volts could cause quite a lot of trouble."

"There is one other question," remarked Dick, "and that concerns the potentiometer itself. So far as I know, very high-grade volume controls, such as those used by the B.B.C., do not have tracks at all. Instead, the slider travels over a number of closely spaced studs with small values of fixed resistance connected between them. What happens with controls of this type so far as noise is concerned?"

"The answer there, of course," replied Smithy, "is that one has to be even more careful to keep d.c. voltages away from them. Volume controls of this type cause definite increases in signal voltage as they are turned, but these steps are still too small to be detected by the ear."

"There is one final point," continued Dick. "How do you define the difference between a volume control in which the discrete steps in resistance as the slider is turned are large, and one in which the steps are small?"

"You use the same term as you have in television," replied Smith, "the word being 'resolution.' A potentiometer with small discrete steps is defined as having good resolution, and one with large steps as having poor resolution. As an example, it would be safe to say that the average wire-wound pot has poorer resolution than the average carbon track pot."

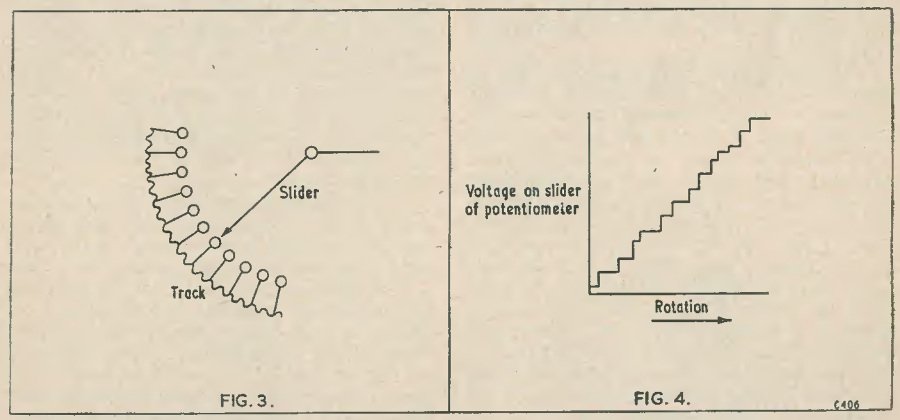


Fig. 3. If considered in very small detail, the movement of the slider of a potentiometer consists of hops along minute, discrete, steps of resistance. Fig. 4. The potential produced at the slider of a potentiometer when considered in very small detail. The irregular spacing and height of the steps correspond to random discrepancies in the discrete sections of resistance.

Oscilloscope Hum

Dick seemed satisfied with the explanations that Smithy had given him, and the workshop returned to its normal peaceful state once more.

After a while Dick decided that it was approaching "elevenses" time and he set about the morning ritual of preparing tea. Smithy liked to visualise his workshop as an efficient and "technical-looking" place, wherein things were kept reasonably well in their place and the general impression was not far short of that given by an electronic laboratory. However, when it came to the provision of tea even Smithy's enthusiasm waned, and a homely brown tea-pot occupied its own particular space on the corner of a bench, alongside a kettle and an electric ring.

Dick soon had the kettle boiling, and Smithy relaxed from his work as Dick poured out the tea.

"Do you remember," remarked Dick, putting his cup on the bench, "that some time ago we were discussing the waveshapes you got on an oscilloscope from the mains? You showed me that if you connected a 50 c/s voltage direct to the Y amplifier of an oscilloscope you got a reasonably pure sine wave; but that if you touched the Y terminal with your finger the waveshape was very distorted."

Smithy chuckled.

"I do remember, indeed," he replied, "and I have received quite a lot of letters concerning this particular point."

Smithy took some letters from a drawer.

"Here, for instance, is part of a very interesting note from one reader who prefers to be anonymous.

" 'My workshop,' says the letter, 'lies in one of 60-odd flats in a block which is largely occupied by a departmental store, i.e. in a veritable maze of mains and power wiring.

" 'Placing a finger on the 'scope input terminals gives always at least 30-50 volts peak-to-peak input (across approx. 1MΩ at approx. 7pF). The waveshape is double-peaked and can (by eye) be constructed quite frequently by adding a 25% 4th harmonic leading approx. 45° in phase; quite often the shape is more complicated, only rarely is it simpler. Quite often the hum amplitude is larger; several years ago approx. 180 volts peak-to-peak occurred which made me check on the voltage calibration of my 'scope, which was, however, O.K.

" 'Both voltage and waveshape usually drift, i.e. are different, say, an hour later; on one or two occasions I observed them to change suddenly consequent upon a surge. Minor changes can be produced by sitting down or getting up (while the finger remains on the input terminal), by stepping sideways, or by asking other persons to do it instead.

" 'Thus there is a multiplicity of complex impedance paths between mains potential and true earth, with the 'scope amplifier as a common branch, and the 'scope power pack is "on," too! The task of constructing a fully explanatory equivalent network would truly be one of those fearsome things fitting into Dante's Inferno!'

"Another interesting letter comes from Thomas P. Greig of Ebford in Devon, who has carried out some experiments into the condition.

" 'The set-up,' he says, 'was as shown here (Fig. 5), a Cossor model 1052 double beam oscilloscope being used. Using the Y_2 terminal, connection is made direct to the plates of the oscilloscope via a short length of wire.

" 'After some experimenting, it was finally clear that the waveform appearing on the tube of the oscilloscope depended on four factors:

(1) the nature of the magnetic field near the oscilloscope,
(2) the length and shape of the wire, and its disposition with respect to the oscilloscope,
(3) the resistance of the operator from hand to earth,
(4) the capacity of the operator to earth and to the frame of the oscilloscope.

" 'The effect of the third factor can be demonstrated by raising one leg, by touching the frame of the oscilloscope with the free hand, or by getting two people to hold the wire. In each of these cases the effective resistance to earth and, according to the theory embodied in Fig. 5, the voltage across this resistance produced by the current generator, will be decreased. This is verified in practice, as carrying out any operation resulting in a decrease in resistance results in a reduction of the size of the waveform on the oscilloscope.

" 'The fourth factor seems to be of least importance. Increasing the hand capacity by moving the hand nearer the frame produces only a shift of phase and a loss of "sync."

" 'A further experiment was carried out to remove the personal element from consideration. A high value tubular variable resistor was connected as shown between the Y_2 terminal of the oscilloscope and the frame. Being tubular this resistor has greater pickup than the single piece of wire and can also be used as a "direction finder" (see Fig. 6).

" 'Decreasing the value of the resistor produced a smaller waveform. Maximum pickup was produced with the tubular resistor parallel to the side of the oscilloscope, and moving it nearer the frame increased the size of the waveform. The culprit, then, appears to be the mains transformer of the oscilloscope, but whether it is the magnetising or the power current which produces the main distortion is a matter for further investigation. In the second experiment there was a pronounced third harmonic which seems to confirm the transformer theory.

" 'I am putting this forward as a possible explanation. I will be very interested to hear what others have to say about this problem'."

"That's most interesting," remarked Dick, "you know, it's nice to hear from people in this manner."

"It most definitely is," replied Smithy, "and I would like to thank everyone else who wrote in on this subject as well. The great thing about the radio game is that everybody is prepared to discuss points of interest closely and amicably."

Warming Up Time

Dick and Smithy finished their tea and resumed their work.

"You know, Smithy," remarked Dick, after some time had elapsed, "I was asked quite a few technical questions myself the other night! I was at a neighbour's house and they wanted to know why television sets take so long to warm up. I told them that the delay was caused by the line timebase, which took a long time to reach full working conditions. This was the reason why the sound always appeared before the picture. I don't think they had a clue as to what a 'line timebase' was, but they seemed very impressed."

"Young man," laughed Smithy, "you are already well on the way to becoming an

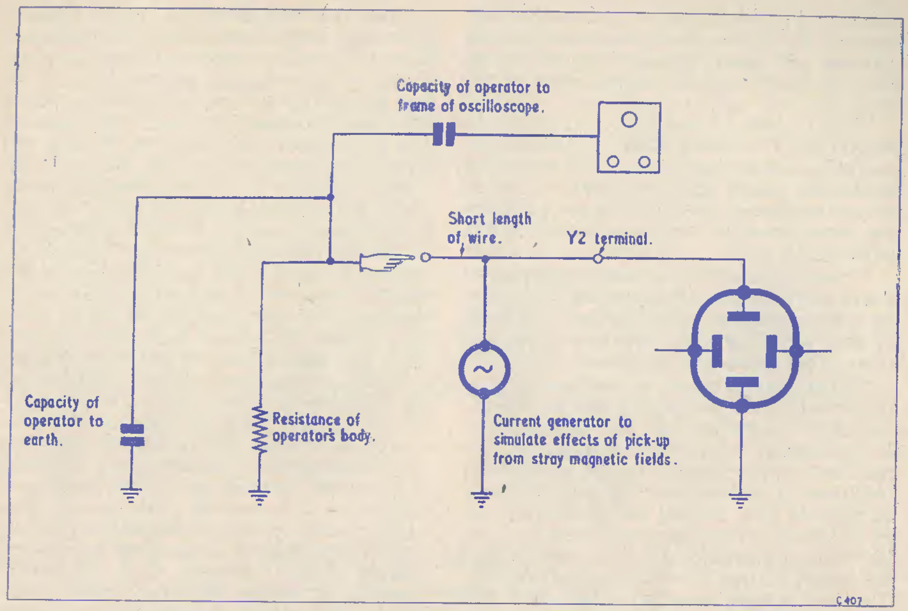


Fig. 5. A reader's explanation of the effects occurring when a finger is placed on the input terminal of an oscilloscope.

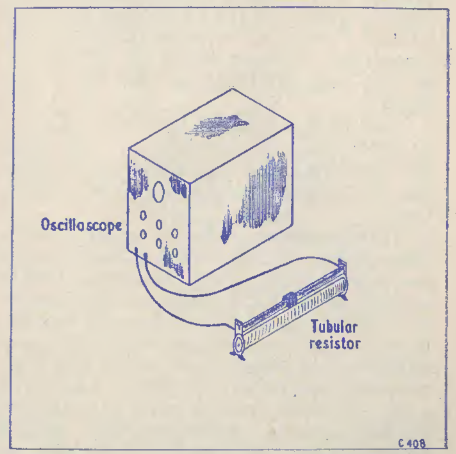


Fig. 6. An experimental means of determining the source of hum pick-up around an oscilloscope. This diagram, and Fig. 5, are discussed in the text.

'expert.' Only don't take too much advantage of it. In this case you have covered yourself with glory, because it is, of course, the line timebase which causes most of the delay."

"I don't quite understand *why* that should be, though," returned Dick. "I appreciate that there are some fairly powerful valves in the line output stage, but I see no reason why they should take any longer to warm up than does an ordinary audio output valve."

"I think you will understand things better if I describe all that happens after you switch on a television set," said Smithy. "In point of fact there are three separate steps, and these occur one after the other.

"When you switch on a television receiver the first thing that happens is that you supply current to the picture tube and valve heaters. If the receiver has a mains transformer, the tube and valves supplied by the transformer (with one exception) warm up just as quickly as they do in a normal sound receiver. If, as is almost always the case nowadays, the heaters are connected up in a series string, the heater current is limited by a thermistor. This has a high resistance when cold, and prevents a heavy surge current flowing through the heaters which have a *low* resistance until they reach operating temperature. As the thermistor warms up its resistance drops and the current through the valve and tube heaters increases. After a time, longer than that required for a transformer-driven set, all the valves in the string, except one, reach full operating temperature. At this time h.t. will be available because the rectifier, if a valve, will now have become warmed up also. If the h.t. rectifier had been a metal component we would have had h.t. immediately after switching on, of course. At this stage we begin to hear the sound signal."

"You have referred to one valve which is an exception," interjected Dick, "this valve not reaching operating temperature when the others have warmed up. Which one is that?"

"It is the efficiency diode," replied Smithy. "The efficiency diode takes a long time to warm up because there is a considerable amount of electrical insulation between its cathode and its heater. When the receiver is operating, the cathode of the efficiency diode receives pulses which have a very high potential with respect to chassis; a figure of 3 to 4kV being quite typical. As you can imagine, careful insulation and spacing between the heater and the cathode is essential at these potentials in order to prevent a breakdown between the two electrodes. Because of the high degree of insulation and the greater spacing the cathode of the efficiency diode takes a noticeably longer time to reach full emission than do any of the other cathodes in the set.

"In the conventional line output stage the h.t. supply to the line output valve flows through the efficiency diode. As soon as this commences to operate, the normal h.t. voltage is applied to the line output anode. After a number of cycles of oscillation of the line timebase, sufficient charge is held by the boost condenser or condensers to enable the full potential of the boosted h.t. supply to appear. This is rather an important point to observe, incidentally, if you intend running your line timebase oscillator from the boosted h.t. line. Such an oscillator must be capable of *starting* at the normal h.t. voltage which first appears, or you won't get any boost voltage at all! Another important fact is that, until the efficiency diode has started to conduct, the line output valve has an h.t. potential on its screen-grid but none at its anode. Because of this the screen-grid dissipation can rise to a dangerous level before anode current commences to flow. The normal way of limiting the screen-grid current during warm-up time consists of inserting a resistor in series with its h.t. supply. By the way, the value of this resistor should never be reduced below that specified by the manufacturer of the set during servicing, or damage to the line output valve may occur.

"We have now reached the second step in what occurs after switching on the receiver. The first step is that the h.t. supply and all cathodes, except that of the efficiency diode, become operative. We then wait for the efficiency diode to warm up, thereby enabling the line timebase to run. However, we still do not get a picture because it is only after the line timebase has started that a voltage is applied to the e.h.t. rectifier heater. As almost all e.h.t. rectifiers these days are indirectly heated, we now have to wait once more until its cathode warms up. After that, we get our picture."

"I see," remarked Dick. "It certainly seems logical enough. What would you say would be the average time of warm-up for a television receiver?"

"Well, most sets take about two minutes or so," replied Smithy, "although I have met perfectly serviceable sets which take a little longer than three minutes. A time longer than that appears to me to be excessive, and it might be worth while checking if a particular valve or component is not on the point of expiring. You can obtain a fair idea of which step in the warm-up cycle is causing the trouble by checking the performance of the set after switching on from cold. If, with the correct mains tapping and voltage, a long time elapses before the sound comes up, the fault will probably be due to trouble in the heater chain—possibly the thermistor or the dropper—or to an ageing h.t. rectifier, if this is a valve. You can usually tell when the line timebase commences running by the whistle from the line output transformer or the commencement of glow in the e.h.t. rectifier heater. If the starting of the line timebase seems excessively delayed the efficiency diode may be at fault. Don't forget, however, that if the line output stage is self-running it may not start until full h.t. current is available to it through the efficiency diode, and this may cause a slight additional delay. Too long a wait for the e.h.t. to appear after the line timebase has started points to a faulty e.h.t. rectifier, or to a low rectifier heater voltage caused by incorrect operation of the line output stage. The latter would be confirmed by low scan and/or low e.h.t. on load with a new rectifier. Some manufacturers fit small-value resistors in series with the heaters of their e.h.t. rectifiers, and these should not be overlooked."

"Thanks," grinned Dick. "I got rather more than I bargained for with that question! Anyway, I know a lot more about the switching-on cycle of a t.v. set now than I did before. Just wait till I go round to my neighbour's place again. I shan't half baffle them with science this time!"

"I shouldn't say *too* much if I were you," chuckled Smithy. "Don't forget that one question successfully answered often leads to another that is much more difficult."

RIGHT—*From the Start*

PART 12

WAVES

by A. P. BLACKBURN

An important use of the valve is as an oscillator. Understanding the operation of oscillators (and many other circuits) depends upon one's knowledge of alternating current. Before you hastily turn the page, I hasten to say that a.c. can be a complicated business, but for our purposes it can be pretty simple.

A knowledge of the meaning of such terms as phase, sine wave, etc., helps to make the operation of oscillators and their ilk far easier.

Sine Waves

Here is a term that is always cropping up. A sine wave is a very special kind of wave which occurs in many branches of mechanics, electricity, light, sound and so on. Imagine an engine crank rotating as shown in Fig. 1. If the vertical distance from the base line to the end of the crank is plotted against the angle through which the crank has turned, a graph is produced as shown. Another example is a swinging pendulum, with a pen attached to its end. If a piece of paper is drawn past the pendulum in a direction at right angles to the direction of swing, the pen will draw a shape the same as in Fig. 1. This is illustrated in Fig. 2.

So much for mechanical examples of the sine wave, now for the electrical. Fig. 3A shows a voltage sine wave and 3B a current wave. There is a difference between Fig. 3 and Fig. 1. The horizontal axis in Fig. 1 is marked off in angles of rotation, but Fig. 3 as time in seconds. These are really the same thing, because if the crank makes one revolution (an angle of 360°) in 1/50th second, a complete wave is produced in 1/50th second just as in Fig. 3. In one second, then, 50 waves are produced or, to put it in more familiar terms, 50 cycles/second.

Probably the simplest way of producing a wave like that of Fig. 3 is to rotate a coil of wire in a magnetic field, as shown in Fig. 4. As before, one complete rotation will produce 1 cycle and the number of revolutions per second gives the number of cycles per second.

If we connected the output of the simple generator of Fig. 4 to a loudspeaker we would hear, say, a 50 c/s note. Now the sine wave is

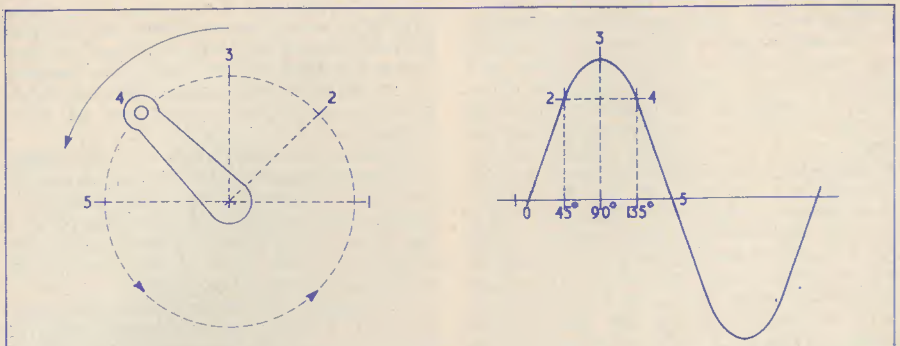


FIG. 1

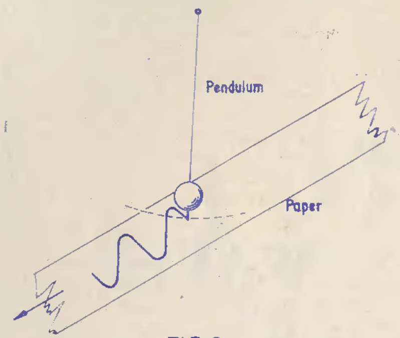


FIG. 2

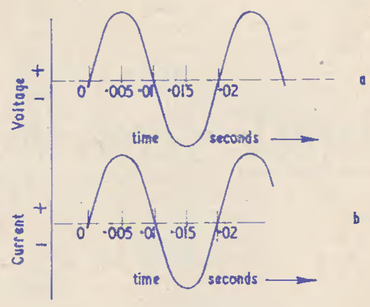


FIG. 3

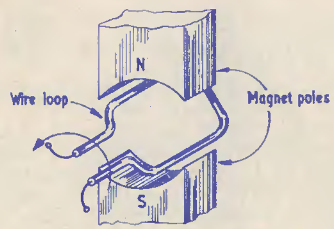


FIG. 4

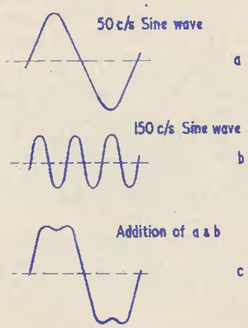


FIG. 5

G 410

unique in that it contains no harmonics; that is, the note we should hear would be a pure tone. If the sine wave should become slightly distorted, harmonics would be introduced. For example, Fig. 5A shows a 50 c/s sine wave; and Fig. 5B a 150 c/s wave. Now 150 c/s is the third harmonic of 50 c/s, and adding a and b together gives Fig. 5C, which is far from sinusoidal. This shows that a waveform which is not a sine wave contains some harmonic frequencies, or in other words, any waveform may be broken down into sine waves, consisting of the fundamental and harmonics.

In passing, it is interesting to note that it is the presence of varying properties of these harmonics which gives musical instruments their particular tonal quality.

Phase

Another frequently used term is "phase." This is relevant to the sine wave and is important particularly in oscillation. The meaning of the word is that the maximum values of the sine waves occurring at different points in the circuit are displaced in time. Fig. 6 illustrates this. Wave b is said to be 180° out of phase with respect to wave a. A shifted (i.e. how many degrees) depends upon the values of C_1R_1 and the frequency. Any phase shift up to 90° can occur in a circuit of this kind.

Although phase is a subject not particularly fascinating in itself, its effect upon many circuits is so important that some knowledge of it is essential in order to understand the operation of the circuit.

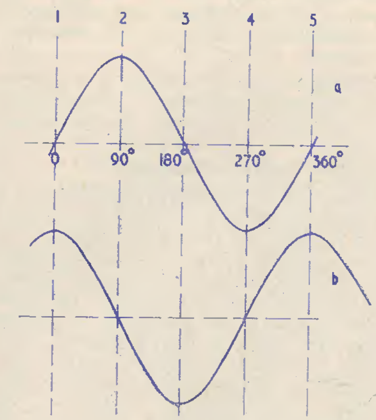


FIG. 6

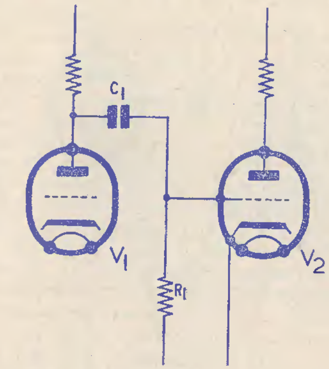


FIG. 7

simple valve amplifier, for example, shifts the phase of the input signal by 180°. We can easily see how this comes about. If the waveform of Fig. 6A were applied to the grid of a valve at the point marked 1, the voltage is zero; but at point 2 it has reached its maximum positive value. Over the period, the current in the valve would be increasing under the control of the grid voltage. As more current flows in the valve the voltage drop across the anode load would increase and the anode voltage would decrease, until the grid were at point 2, when the anode would be at its lowest value. As the grid voltage increases, then, the anode voltage decreases and the anode waveform would look like Fig. 6B, i.e. 180° out of phase with the grid.

Another cause of "phase shift" in amplifiers is in coupling circuits. The voltage at the anode of V_1 in Fig. 7 is fed to an R/C coupling circuit, C_1R_1. A phase shift will occur between the anode of V_1 and the grid of V_2. The amount by which the phase is

Oscillators

The most commonly used types of oscillators in radio circuits depend upon some kind of "feedback"; that is, the feeding back of some of the output to the input. We have already seen that the output voltage of a valve is 180° out of phase with the grid voltage. If the output were merely connected back to the input, nothing would happen because the two voltages would cancel. If, however, the phase of the output voltage could be changed by 180°, and then fed back to the input, both voltages would add. Under these conditions, a small voltage at the grid would be amplified by the valve and fed back to the grid where further amplification would occur, resulting in more feedback, and so on. The valve would be in a condition of oscillation, therefore.

The circuit of a commonly used oscillator is shown in Fig. 8. As there is no "input" signal, oscillation must start itself when the circuit is first switched on. When the switch is closed, some small disturbance in the grid, however small, will be amplified by the valve, and fed back to the grid via the coupling between L_1 and L_2. This form of feedback coupling is used because the phase of the output voltage is changed appropriately by it. The fed-back voltage will, therefore, be in phase with the originating disturbance at the grid and they will add together. This larger voltage will now be amplified and fed back, making yet a larger grid voltage. It seems that this process could go on *ad infinitum*.

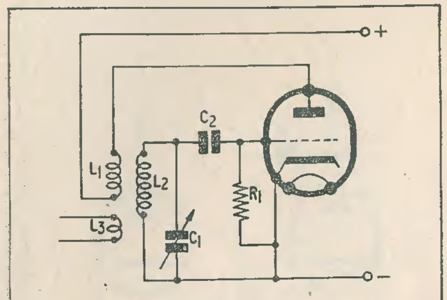


FIG.8

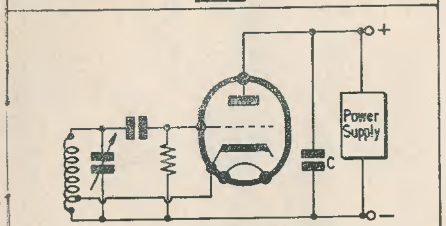


FIG.9

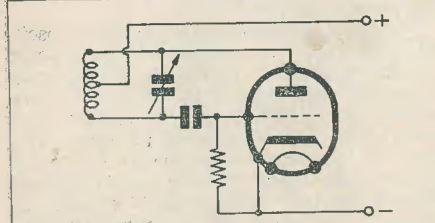


FIG.10

However, C_2R_1 are introduced to help this expanding process to settle down. As the grid voltage gets larger and larger, the positive excursions will cause grid current to flow. This current flowing through R_1 will produce a voltage drop across R_1 which will cause C_2 to accumulate a negative charge. This negative charge will bias the valve and reduce the gain. The larger the signal becomes, the larger this negative bias becomes, the more the gain is reduced. A stable condition is thus achieved and the output will stay constant. The frequency of the oscillation is, of course, decided by the tuned circuit L_2C_1.

The output of the oscillator may be taken from a separate coil such as L_3. This circuit, like all other sinusoidal oscillators, is a sort of valve equivalent of the simple generator of Fig. 4. The valve is especially useful, of course, because the generator would have to be rotated at 60,000 r.p.m. to produce a voltage of 1,000 c/s frequency. To produce a frequency of 1 Mc/s per second would obviously be impossible with a mechanical device. In some of the more advanced types of oscillator, frequencies of 20,000 Mc/s are produced.

There are literally dozens of other circuits for oscillators, too many to describe here, so one of the more important will be mentioned.

Electron Coupled Oscillators

This type looks remarkably different, when drawn as a circuit, from Fig. 8. The operation is, however, remarkably similar. A circuit is shown in Fig. 9. Here the cathode is tapped into the coil and one end is earthed. It is difficult at first to see where the feedback from anode to grid comes in. The secret is where the anode is really connected. Admittedly, the power supply (marked + and –) appears to be connected between earth and anode. But consider where the anode current flows. Starting at the anode, it flows through the power supply or the capacitor, C, through the lower section of the coil, into the cathode, and from there through the valve and back to the anode. If the impedance offered by C and the power supply in parallel is very small, at that frequency of operation, the lower section of the coil represents the anode load. There is a considerable amount of coupling between the lower and upper sections of the coil, and the anode current flowing in the lower section will, therefore, induce a voltage in the upper section of the coil.

This voltage is applied to the grid and feedback has occurred in a very similar way to the circuit of Fig. 8. The advantage of Fig. 9 is that only one coil is used instead of two in Fig. 8.

Another circuit of the same type is shown in Fig. 10. The feedback is easier to see in this case. The anode current flowing through the upper section of the coil induces a voltage in the lower section which feeds the grid. The phase is always correct in these circuits to produce oscillation at the resonant frequency of the tuned circuit.

There is another group of oscillators called "relaxation oscillators," but these must be held over until another time.

MAGNETIC TAPE RECORDERS

Some design considerations for the Home Constructor

PART 4

by A. BARTLETT STILL

HAVING DEALT SEPARATELY WITH THE record and replay amplifiers, let us now consider their amalgamation into a complete equipment. If a really ambitious job is being considered, utilising a tape deck that has separate record and playback heads, these amplifiers may be built as individual units to be used in parallel and the switching necessary is relatively simple. In most cases, however, one head and one amplifier will be required to record or to replay at any one time, and it is for this reason that the changeover switching becomes a little involved.

The circuit shown in Fig. 11 is a combination of the circuits previously given, and has been used successfully in practice. The recorder built from this circuit admittedly did not fulfil our requirements in respect of hum level on playback (the measured figure is actually 42 db), but it has been proved that this is partly due to insufficient magnetic shielding of the head on the deck in use, and partly to lack of foresight in the positioning of the mains transformer. Be warned by this! In every other respect, however, the equipment will bear comparison with quite expensive commercial models. No power unit or power amplifier stages are given since the former will depend on the choice of the latter, itself a matter of individual preference and purse. A single output valve may be added, or, were one of the currently popular amplifiers used, neither piece of apparatus would be disgraced.

For changing from "Record" to "Replay" a seven-pole three-way switch S_1 is used, and this should be made up on three wafers, with screens between, and enclosed in a screening can. With care, the switch may then be mounted in almost any position, i.e. convenient to the tape deck controls. The first wafer would contain contacts "a" and "b," the second contacts "d" and "f," and the third the remaining contacts "c," "e" and "g."

A three-way switch is used specifically in order that a "demagnetise" position may be interposed, during which the bias oscillator dies slowly due to the reservoir capacitor. In this middle position the frequency selective feedback chains have been replaced by a single resistor, in order that the recorder may be used as a "straight-through" amplifier with a level response.

The amplifier described is for two-speed working, $3\frac{3}{4}$in/sec and $7\frac{1}{2}$in/sec, and the changeover switch S_2 is a simple two-pole on-off. If three-speed working is being considered, the principle will remain the same. If the third speed, however, were 15in/sec, the attainable frequency at the upper end would not be doubled. Due to a number of factors, one of which is head self-capacity, do not expect more than 15 or 16 kc/s, and *do* expect a harder job to maintain the lower end at 50 or 60 c/s. Quite frankly, the writer considers that 15in/sec is not a practical tape speed for domestic purposes; it results in little advantage, and has the tremendous disadvantage of being very uneconomical with tape.

One further point in respect of the amplifier. A single input is shown, and from our specification this has a sensitivity of 2mV. For higher signal inputs it is permissible to insert a "break-circuit" jack socket between the capacitor coupling from the anode of the first valve and the top of the volume control; alternatively, a second input may be connected in parallel with the existing socket, fitted with an attenuator of about 50 or 100 to 1.

We must now consider the problem of testing and aligning the complete recorder. This cannot be undertaken with any degree of confidence without certain test apparatus. That specified here must be considered to be a minimum, and, as will be seen, will not enable us to place an exact figure against all the items on our specification. These blanks, therefore, will have to be filled in by "intelligent guesswork." Those constructors in possession of other items of the test gear outlined in the previous instalment will soon appreciate just where they can be put to good use.

It has earlier been stated that a valve voltmeter is essential, and the writer has in mind one similar to that described in this magazine a year or so ago. The most sensitive a.c. voltage range will be of the order of 5 volts f.s.d., and will be adequate for most of our

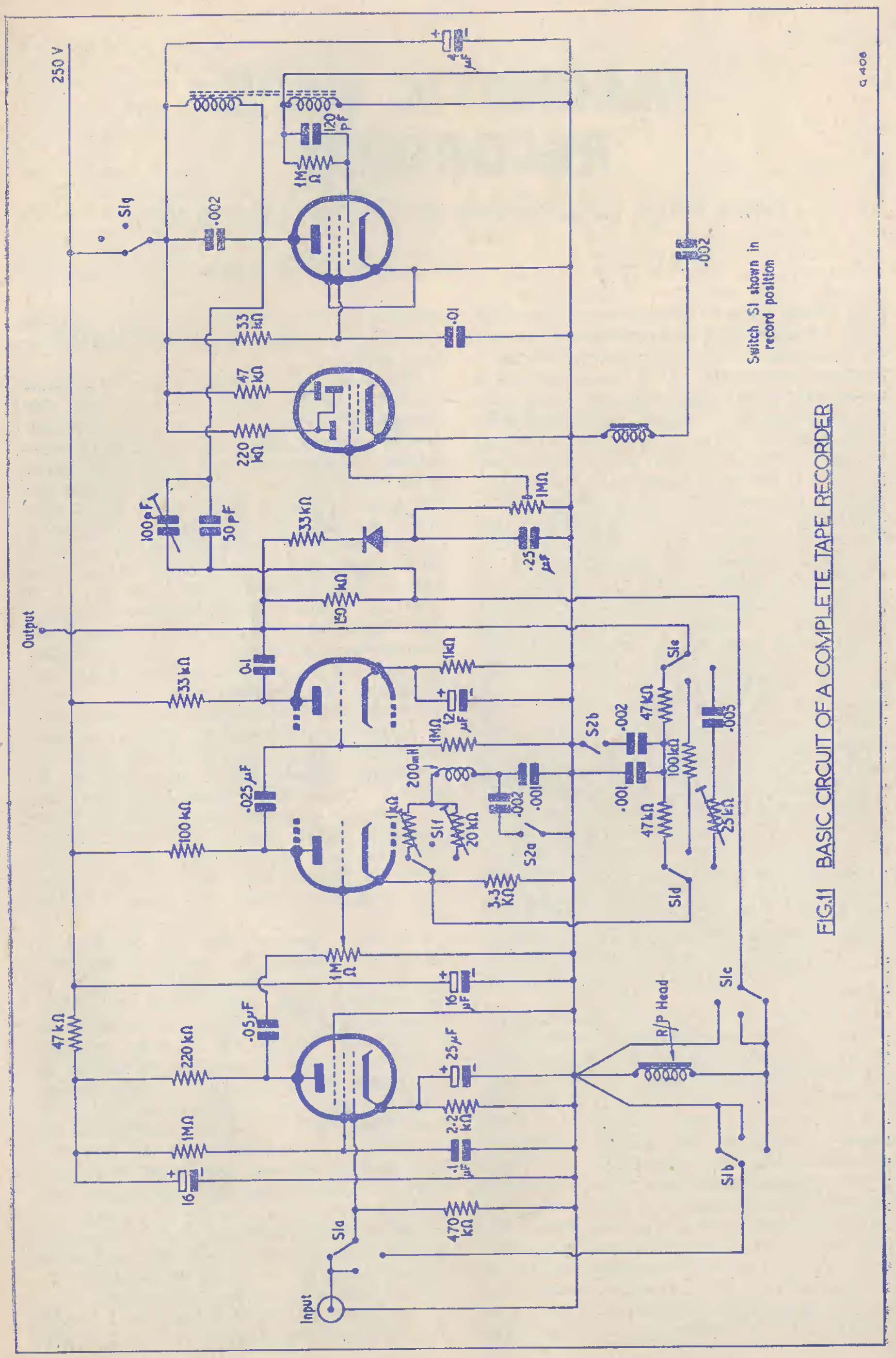


FIG.11 BASIC CIRCUIT OF A COMPLETE TAPE RECORDER

tests. For those who do not possess an audio signal generator it is suggested that one of the frequency test records available should be used. The writer knows of Decca K1804 at 78 r.p.m. or LXT2695 on L.P. If used with a pick-up only, it will not be possible to meter the output directly, but, remembering that the first stage of our recording amplifier should have a linear characteristic, we may consider it justifiable to monitor the signal level at the top of the volume control. When a pre-amplifier is available with the record player, the output at the various frequencies can be measured at the source, which should then be coupled to the tape recorder by a suitable resistive attenuator. The recorded frequencies available will range from 40 c/s to some 14 kc/s, and the first step should be to calibrate the "signal generator" at each spot frequency, carefully noting the respective levels for correction of the curves obtained later on. A table of voltage ratios against decibels will prove of trememdous help here.

The next step is to set approximately the full modulation (i.e. magic eye closed) signal level to the head. The makers of the tape deck will most likely have given an average figure for the audio head current, which will probably be of the order of 0.2mA. Note that if the makers' figure is vastly different, the series resistor feeding the head will need to be altered from the value shown, in inverse proportion. Taking the example given, 200 microamps must be fed through 150kΩ (the head impedance may be neglected). Connect the voltmeter to measure the output from the second anode of the double triode, feed in 1 kc/s with the recorder set to "record" (the bias oscillator valve should be removed) and adjust the gain control until the output is 30V r.m.s. Set the record level indicator to show maximum signal.

The signal level should now be reduced, either externally, or by means of the gain control of the recorder, by 20db (i.e. 10x) so that the meter shows 3V. With the speed switch (if fitted) set to 7½in/sec, the series tuned circuit should be set to resonate at the correct frequency, 12 kc/s. Our record has bands at 11, 12 and 13 kc/s, so it will be a fairly simple matter to adjust the core of the coil until the correct tuning point is found. We can at the same time check the slow speed resonant

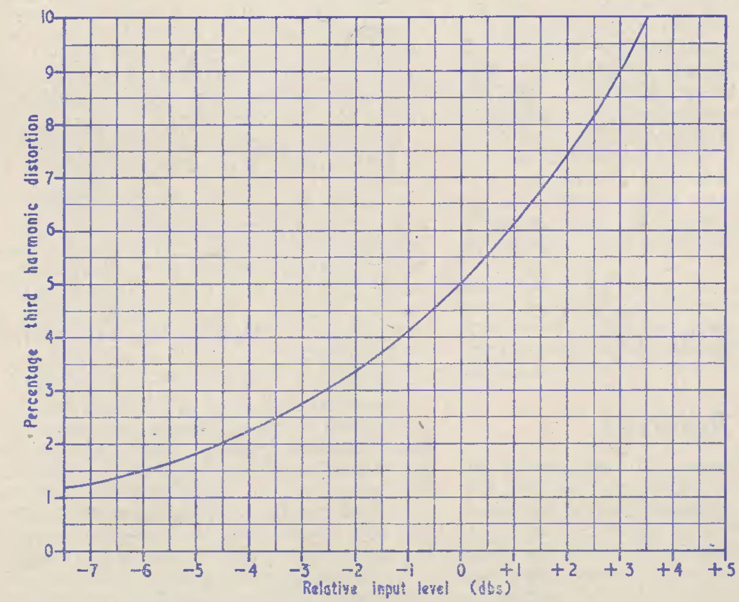


FIG.12 Curve showing increase of tape distortion with increase of signal at 1,000 c/s

frequency, which should be about 6.5–7 kc/s. If the latter requires alteration, however, this must be done by variation of the value of the "add-on" capacitor. It will be noted that, due to the effect of our pre-emphasis, at the peak frequency the record level indicator shows nearly full modulation, hence all frequency tests should be carried out at the −20 db level.

Now run through the whole frequency range, noting the meter reading at each point, and plot the record characteristic, not forgetting to make the corrections referred to earlier. The 1kΩ pre-set resistor should be adjusted to give the correct amount of boost at the peak, when the rest of the curve should be as in Fig. 3. Any undue variations between 3 kc/s and about 9 kc/s will require alteration of the frequency selective components in the negative feedback chain. The slow speed characteristic will have the same general form, peaking at the lower frequency, and should have some 4 or 5 db greater maximum lift.

The recording bias can now be considered. Bearing in mind that the frequency should be 4 or 5 times 12 kc/s, 50 kc/s suggests itself, but 55 kc/s is better due to the proximity of the harmonics of the lower figure to the L.W. Light programme. If you bring the oscillator close to the back of a radio, the 3rd harmonic should give a.v.c. "quieting" at about 165 kc/s (1,820m.). Setting the amount of bias is admittedly a tedious business. With a signal of 1 kc/s, the level of which must remain unaltered, a number of test recordings should be made to arrive at the bias current that gives maximum output on playback. This output signal voltage should be carefully measured and the bias current then increased until the signal, on playback, has dropped by 2 db. Since the bias required by different heads varies, it may be found necessary to alter the value of the fixed capacitor feeding the head. Care should be taken to use a sample of tape similar to that intended for normal use.

The next step is to record a complete frequency run on tape, and watch the meter reading on playback to check the overall response. The figures will still need correcting for our calibration, by the way. Provided the record characteristic was reasonable, the 25kΩ variable in the replay feedback line should enable a flat response to be obtained, except, possibly, for the very highest frequencies. Here the 20kΩ resistor in series with the tuned circuit should be adjusted in order to squeeze the highest possible frequency out of the head. Do not forget that you only need to make the one recording, since we are adjusting the replay amplifier only. Difficulty in obtaining a flat response from 7 or 8 kc/s onwards will indicate the need for bias adjustment, while a sharp fall off at 10 or 11 kc/s will show that too much is being expected from that particular head. In the latter case it will be necessary to re-tune the peaking coil to a slightly lower frequency. Either of these changes will mean that a new recording will have to be made.

Assuming that the frequency response is satisfactory, the next item on our original specification to be considered is distortion. For a good signal-to-noise ratio we must record at as high a level as possible provided the distortion is not unreasonable. This can only be measured with a suitable meter, but a lot can be done by ear. In this connection Fig. 12 will be found useful, showing the sharp rise in tape distortion once a certain level of signal is reached. By experiment, the magic eye, or other indicator, should be set to just below that level. At that full modulation level, record 1 kc/s and measure the replay voltage at full gain (10V specified). Our meter won't be sensitive enough (we hope!) to measure the hum level when the tape is taken off, but an output stage, or further amplifier, should be of assistance there.

The foregoing test procedure will certainly take time, but should produce worthwhile results.

In conclusion, while the circuit given in Fig. 11 produced the desired practical results, remember that some of the component values may need slight alteration to suit your particular choice of tape deck, so solder in the various frequency determining components with an eye to changing them later, during your test runs.

Literature Received

Catalogue.—Messrs. R. Fagelston, 46 Hardwicke Road, London, N.13. The 1957 edition of this catalogue, comprising some 24 pages plus cover, is literally packed with bargains and interesting items for the home constructor. Components and complete kits for receivers, amplifiers, band 3 converters and test gear are all listed. The kits are set out as complete component lists, each part being priced separately.

Apart from the usual order form, there is an enquiry form on which the intending purchaser may, without obligation, obtain further information about any particular component or kit. Together with this, a Radio Savings Club membership card is also enclosed. With this, one is able to forward any amount, in excess of a shilling, towards a credit account. Thus, one is able to save towards purchasing that kit or component —no extras being charged for this service. A 5d. stamp to the above address will bring the catalogue by return.

TRANSISTOR SETS FOR THE BEGINNER

PART 1

by JAMES S. KENT

MANY BEGINNERS IN RADIO, AND THE old-timer looking for a new line of experiment, have heard a lot about transistors in recent times. *The Radio Constructor* has, for some time past, published an almost unbroken series of constructional articles using the transistor in a varied assortment of circuits from the "straight" receiver to the superhet, and even including some test gear. As these transistors will come to be used more and more as time passes, some introductory paragraphs about them will not come amiss—especially as this article is intended for the beginner interested in the possibilities of transistors.

Transistors were first announced in 1948, and they were then of the point contact type, i.e. a layer of semi-conductor material against which was pressed two springy wire whiskers. It was discovered that when the two whiskers, being separated by a few thousandths of an inch, were placed in contact with a small piece of germanium, the current flowing in one whisker influenced the current flowing in the other wire and amplification could, therefore, be achieved. The property of amplification was that which allowed the thermonic valve to oust the old-time crystal and catswhisker from its position of eminence in the very early days of radio. This property has now been discovered to be shared by the crystal, and this was occasioned by war-time use of silicon mixers in centimetric radar equipment, which functioned far more efficiently than could the thermionic valve. Experiments with various crystals showed that germanium, while an insulator in its pure form, becomes a conductor once an impurity has been added.

Germanium in its pure crystal form has its atoms arranged in an orderly manner, sometimes referred to as a lattice network, in which there are a large number of diamond shapes, complete with an atom at each corner; each atom having four electrons in its outer orbit. Now each atom has four neighbouring atoms, and every one of the four electrons in each atom orbit shares an orbit with an electron from one of these nearby atoms. It will be seen that all the electrons have partners and are not, therefore, free to move from their orbits with the other electrons. As no electrons are available to carry any current, pure germanium is, therefore, an insulator.

If we introduce into the lattice of germanium an atom having five electrons (the impurity referred to above), such as arsenic or antimony, it will fit in with the "mechanics" insofar that four of the electrons will pair with those of four of germanium, but the one remaining electron of the impurity will have no partner and will, therefore, be available for conduction. It follows that if only a very limited amount of impurity is added the remaining current carriers will be few, and the result will be a limited conductivity and a material known as a semi-conductor or an n type. In an n type material the current is carried by the negative electrons—hence negative (n).

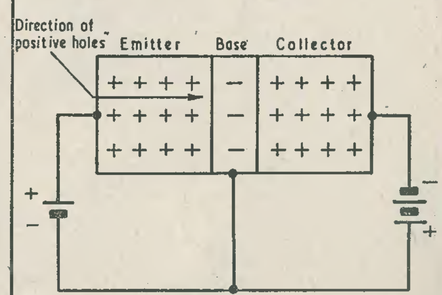
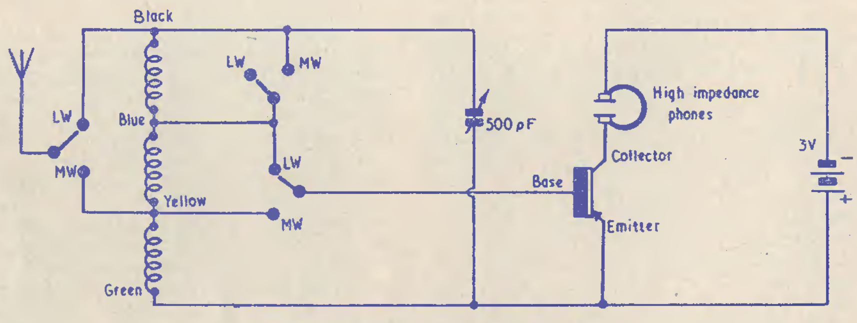


Fig. 1
P-N-P Type junction transistor

Suppose that we now, instead of introducing a five electron atom impurity, introduced a three electron atom, what would be the effect? Fitting them into the diamond lattice of germanium, the three electrons can only pair with three counterparts, leaving one of germanium; and, since this is not available for conduction, its orbit has a space for another electron, which it will readily accept —this being termed as a positive "hole." Now an electron coming from an orbit to fill a positive "hole" in another orbit leaves a vacancy in its original place, thus, the "hole" would appear to move in the opposite direction to that of the electron. To explain this more simply, imagine a long row of chairs all of which are occupied except the end one. If the person next to the empty chair moves into it, and all the others shift up likewise,

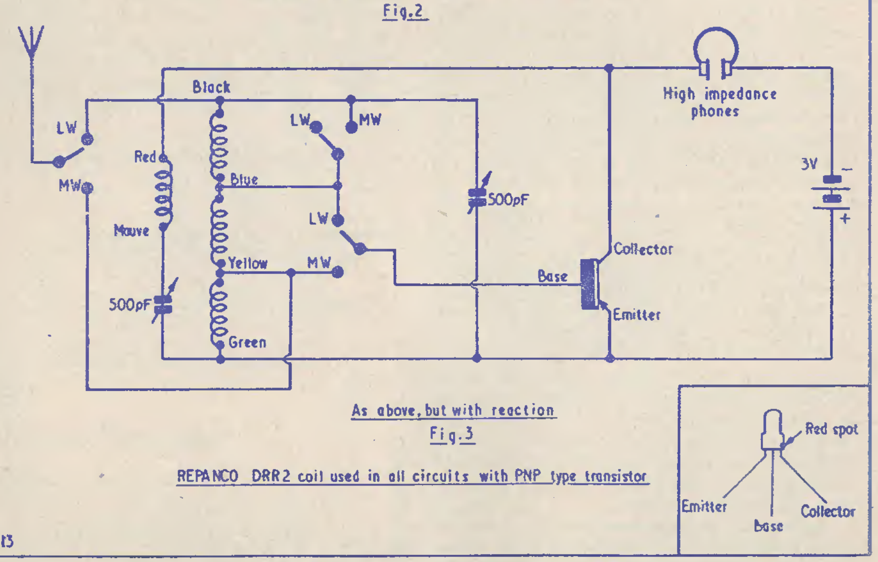
a movable positive charge, and this type of semi-conductor is known as a p type by virtue of the fact that the current is carried by the positive "holes."

It is hoped that, from the above, the beginner has grasped the fact that, just as there exist negative current carriers known as the electrons, there are also positive current carriers termed "holes." It follows that the flow of "holes" will carry just as much current from + to − as a flow of negative electrons going in the opposite direction.



Long & medium wave transistor headphone receiver

Fig.2



As above, but with reaction

Fig.3

REPANCO DRR2 coil used in all circuits with PNP type transistor

Note: The Chassis and earth line is that connected to the green tag of the coil

one after the other, then the persons moving up in one direction cause the gap to move in the opposite direction. To return to the "hole" for a moment, this acts in practice like

Junction Transistors

With the thermionic valve, the current is carried from cathode to anode, the electrons being emitted from the cathode and attracted

towards the anode. With the transistor, the current is carried by both the holes and the electrons, but one will be much more numerous than the other, depending on the type of transistor used. At the present time there are two main types of transistor, these being the *n-p-n* type, where the majority of current carriers are the electrons, and the *p-n-p* type, where the majority of carriers are the "holes" (see Fig. 1).

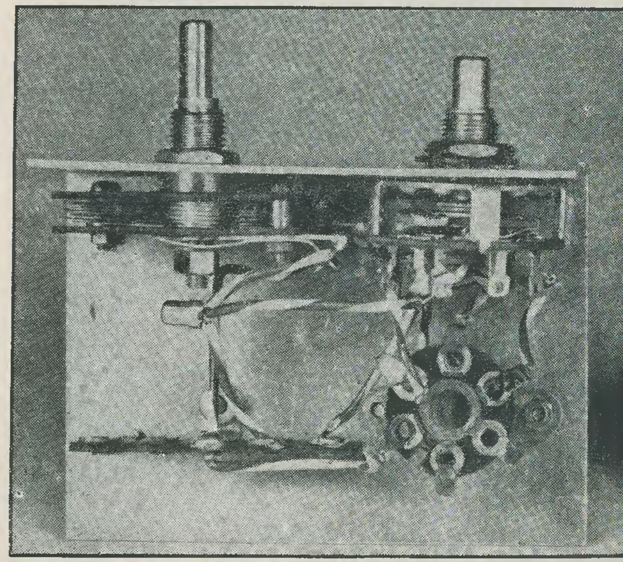
The most common transistor type on the market at the moment is the *p-n-p* type, and reference to Fig. 1 will show that this consists of three layers of semi-conductor material bonded together as a unit. From the designation *p-n-p* it will be noted that the two outer layers are of the *p* type semi-conductor and that sandwiched in between is of the *n* type semi-conductor. Of these two outer layers, one is the emitter and the other is termed the collector, whilst that layer in the centre is known as the base. The current carrying "holes" from the emitter (*p*) penetrate through the thin base (*n*) and arrive at the collector (*p*). In this manner it will be seen that the emitter corresponds to a cathode, the base to a grid, and the collector to an anode. The *p-n-p* type, therefore, is akin to a triode valve. To further explain this, one must again refer to Fig. 1. With the *p-n-p* type shown, the collector is negative to the base, and forgetting the emitter for the time being, the circuit becomes that of a junction diode connected in reverse, with its current being due to the negative electrons from the *p* type collector and positive "holes" from the *n* type base. However, the current will be relatively low, since the number of current-carrying electrons and "holes" will be small in number. These are known as the *minority* carriers. Now, by bringing in the emitter and making it positive to the base, this portion of the circuit now becomes a junction diode, being conductive in its forward direction by its negative electrons from the base and the positive "holes" from the emitter. These latter are known as the *majority* carriers. These positive "holes" diffusing through the thin base material, come under the control of the negatively biased collector and thereby increase the collector current. It follows, therefore, that any change in the emitter current will vary the collector current and amplification will occur by virtue of the different impedances in which both these currents flow, that of the emitter being an easy direction flow with that of the collector being a difficult direction flow, the resulting impedance being that of a megohm or so.

It is not possible in a short article of this type to fully explain all of the foregoing in detail, but only to give some broad outlines to those about to commence on the "transistor road." For those who wish to pursue the subject further, and in greater detail, a list of suitable books is given at the end of this instalment.

Practical Circuits

The first of these is shown in Fig. 2 and, as the beginner must commence somewhere with transistors, it will be seen that this is little more than the old crystal set, or germanium diode design, this time utilising the transistor. The circuit is that of a Long and Medium wave local station receiver.

The coil used is the Repanco type DRR2, this being clearly colour coded so that no possible error can occur with the wiring-up process. Band changing is by means of the Yaxley type switch, this being clearly visible in the photograph, where it is shown mounted alongside the 500pF solid dielectric variable condenser on the front panel. High impedance headphones are connected between the



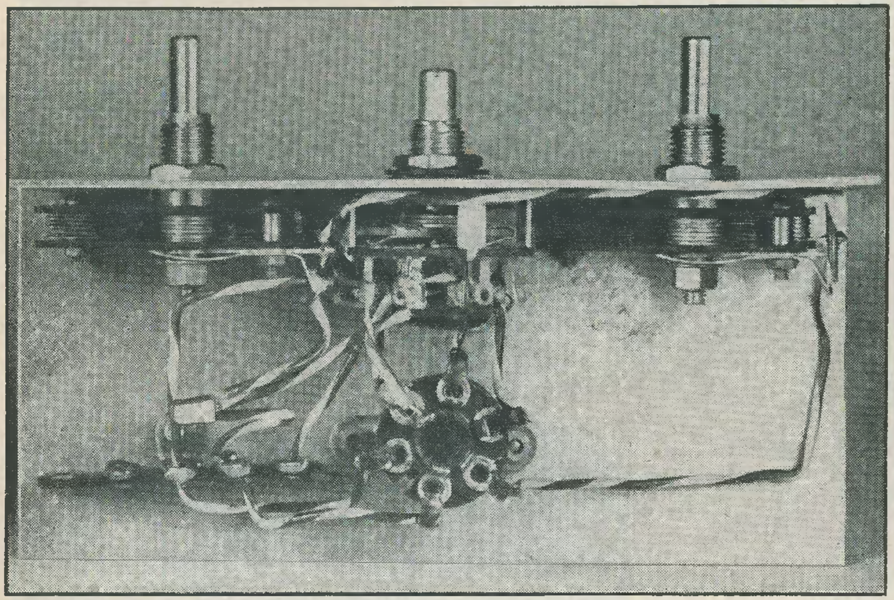
The dual wave receiver shown in Fig. 2

3-volt tapping of a grid bias battery and the collector. A glance at the photograph will show that these connections, and those of the aerial and earth, are made to the 5-way tag strip mounted on the chassis.

This neat little receiver, as a first step in transistor construction, takes only a few moments to build and is ideal as an introduction to the transistor field. All the components are available, including the modest "chassis," from current advertisers (see Component List).

voltage is applied—never reverse the plus or the minus.

Fig. 3 shows a circuit similar to that of Fig. 2, but this time with the addition of reaction. This is, logically, the next step after having completed the receiver shown in Fig. 2 and, having had some fun with it, conversion to that of Fig. 3 is a simple matter. All the identical components used in the first receiver are used with that of Fig. 3, the only additional component being that of the second 500pF solid dielectric variable condenser,



The regenerative transistor receiver shown in Fig. 3

Before commencing construction, however, the following few notes on the practical side may not come amiss to those about to embark on their first transistor receiver.

In operation, transistors are mechanically more robust than the valve, but they are easily destroyed by heat—therefore, the following precautions should be observed before attempting to solder them into position. All of the soldered connections must be made quickly and, when doing so, it is advisable to use a pair of thin nosed pliers to hold the connecting wires, between the transistor and the soldering iron, so that the pliers form a thermal shunt during the soldering process.

When experimenting with the completed receiver, always disconnect the collector supply before disconnecting the emitter. Always ensure that the correct polarity of the

this being used as the reaction control in the normal manner. Whereas in the first receiver the reaction winding was unused, in this one it is connected to the condenser as shown in the photograph. The inset to Fig. 3 shows the connections to the actual transistor.

Next month a further two units will be described, largely using the same components as shown here. These units will be a Long and Medium wave feeder unit and a bandpass feeder unit respectively.

(*To be continued*)

COMPONENT LIST

Simple Headphone Receiver

500pF variable condenser, Jackson Bros. Ltd.
3-pole, 2-way Yaxley switch
Coil, Repanco type DRR2
Chassis, Repanco Ltd.

Component List—*continued*

5-way tag strip
P.P.N. Junction Transistor, Red Spot or Blue Spot

Headphone Receiver with Reaction

Two 500pF variable condensers, Jackson Bros. Ltd.
3-pole, 2-way Yaxley switch
Coil, Repanco type DRR2
Chassis, Repanco Ltd.
5-way tag strip
P.N.P. Junction Transistor, Red Spot or Blue Spot

References

VACUUM-TUBE CIRCUITS AND TUBE TRANSISTORS. By L. B. Arguimbau. 82/–.
TRANSISTOR HANDBOOK. By W. D. Bevitt. 63/–.
TRANSISTORS. THEORY AND APPLICATIONS. By A. Coblenz & H. L. Owens. 45/–.
TRANSISTOR CIRCUIT HANDBOOK. By L. E. Garner Jnr. 40/–.
TRANSISTOR TECHNIQUES. Gernsback Lib. No. 61. 12/–.
TRANSISTORS IN RADIO AND TELEVISION. By M. S. Kiver. 37/6.
FUNDAMENTALS OF TRANSISTORS. By L. M. Krugman. 25/–.
TRANSISTORS ELECTRONICS. By Lo and Others. 81/–.
CRYSTAL RECTIFIERS AND TRANSISTORS. By M. G. Say. 21/–.
TRANSISTORS AND OTHER CRYSTAL VALVES. by T. R. Scott. 45/–.
PRINCIPLES OF TRANSISTOR CIRCUITS. By R. F. Shea. 102/–.
TRANSISTOR AUDIO AMPLIFIERS. By R. F. Shea. 52/–.
TRANSISTORS—THEORY AND PRACTICE. By R. P. Turner. 16/–.

All the above can be obtained from the Modern Book Co., 19–23 *Praed Street, London, W.*2.

BOOK REVIEWS

ELECTRONICS MADE EASY. By Lothar Stern. 192 pages, over 200 diagrams and illustrations. Published by Popular Mechanics Magazine, Eagle House, 109 Jermyn Street, London, S.W.1. Price 6s. 6d. paper-covered, 21s. 6d. cloth-bound.

Do-it-yourselfers or home hobbiests are thought to be no less prolific in this country than anywhere else, though it seems to be noticeable that the American variety of the species has a wider choice of books appealing to the anxious learner than we have here. If this book is a sample of what our cousins across the Atlantic have to help them, then they may well be envied.

The appearance of cartoons on some pages to illustrate a function or theory is certainly not to be deplored even if they do tend to shock our more conservative minds. After all, crowds of pygmies representing electrons jumping off a hot cathode and making away as fast as they can round the circuit is no more than one would expect them to do, and the fact that their long noses label them as negative beings does help in a way to convey the idea of their existence and actions to those who have yet to grasp the complexities of electronics.

This is not a "funny" book by any means, nor are all the illustrations comic pictures. There is a great deal of down-to-earth education in it, particularly for the younger folk to whom it will mainly appeal. It lives up to its aim and title of making the understanding of basic radio rather easy. There are several pieces of simple apparatus, such as radio sets and amplifiers, so well described and illustrated that the newest of newcomers could achieve almost instant success.

The chapter on servicing receivers is commendable for its detailed exposition. The basic circuit under consideration is reproduced on every page where reference to it is made, so that it is always in front of the reader.

In the chapter on transistors several experimental hook-ups are shown, a piece of peg-board being used as a "chassis" for fixing brackets on which components are mounted. The idea is a good one, and could perhaps have been introduced earlier in the book where wooden and aluminium chassis (sometimes with rather elaborate drilling plans) are advocated.

As the components are of American manufacture, most of the equipment described would have to be translated into British equivalents to reproduce it. This may not always be easy for the expert, much less for the tyro. On the whole, however, the book is purposeful, and not expensive.

IMPROVE YOUR TV RECEPTION. By John Cura and Leonard Stanley. 112 pages, 134 photographs and diagrams. Published by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 5s.

Most of the defects in picture reproduction which one sees on various television receivers can be attributed to mis-operation of the controls, while some other deformities can be recognised as being consequent upon extraneous circumstances. In the vast majority of cases where these conditions apply, the owners of the affected receivers are not familiar with the reasons why such defects arise, or have any idea of how to correct them.

If this exceptionally useful booklet could find its way into the hands of all those who could benefit from it, its sales could run into millions. The authors have produced some particularly good work in faithfully reproducing almost every form of picture defect that could be experienced, and written simple yet clear descriptions of the faults and how to rectify them.

Each control on the receiver is dealt with in turn. A glossary of control names enables one to decipher some of the curious legends with which they are labelled at times.

A useful chapter deals with aerials and feeders, while several pages devoted to facts and fallacies give concise answers to several popular beliefs or mis-conceptions held by many people. A particularly useful chapter shows how to recognise or detect failings in the cathode ray tube itself, which should prove invaluable to many viewers.

Even a cursory glance through the pages of this book will convince anyone that it is unusual value for the low price at which it is offered.

LEAD NEWS. Published and distributed by The Lead Development Association, Eagle House, 109 Jermyn Street, London, S.W.1.

This publication can be obtained free of charge by those interested, on application to the Association. Various techniques in which lead and its alloys play a part in industry are described, and the manufacturing processes discussed are most interesting.

continued on page 486

Technical Forum

A Method of Modifying a Standard Audio Amplifier for use with a Tape Deck—Part III

CONTINUING THIS SHORT SERIES ON methods of modifying standard amplifiers to function with tape equipment, we are this month considering the amplifier/equalizer stage. In suggesting the modifications and additions, it has been assumed that the simplest possible circuits consistent with good performance are employed. This has been extended to the equalizing stage where it has been possible to use a single high gain pentode in conjunction with a frequency selective negative feedback loop. Readers who have been following the last two articles in this series will thus see that the total modification involves the addition of only two valves plus a tuning indicator.

The Equaliser Stage

The need for including some form of frequency equalization has already been described in some detail in the November issue, and it will be recalled that during the recording process an appreciable degree of treble boost is employed, the exact amount depending upon the tape speed and characteristics of the head. During replay some degree of bass boost is often employed, but it is at the high frequency end of the audio range that the greatest correction is required. It is typical to employ a lift of 16 db at 10 kc/s for a tape speed of $7\frac{1}{2}$in a second, or more, and a lift of some 18 db at 5 kc/s for a tape speed of $3\frac{3}{4}$in per second. In both these cases the zero db level is taken at 1 kc/s. For the sake of clarity these two frequency response curves are shown in Fig. 1. To the newcomer to tape recording technique these degrees of top boost might seem excessive, until it is remembered that they are used to compensate for a lack of top response due to the following causes.

(*a*) The degree of magnetism retained by the tape after recording decreases as the frequency increases.

(*b*) There is a tendency for the a.c. bias voltage applied to the recording head to act as an erase signal at the higher audio frequencies.

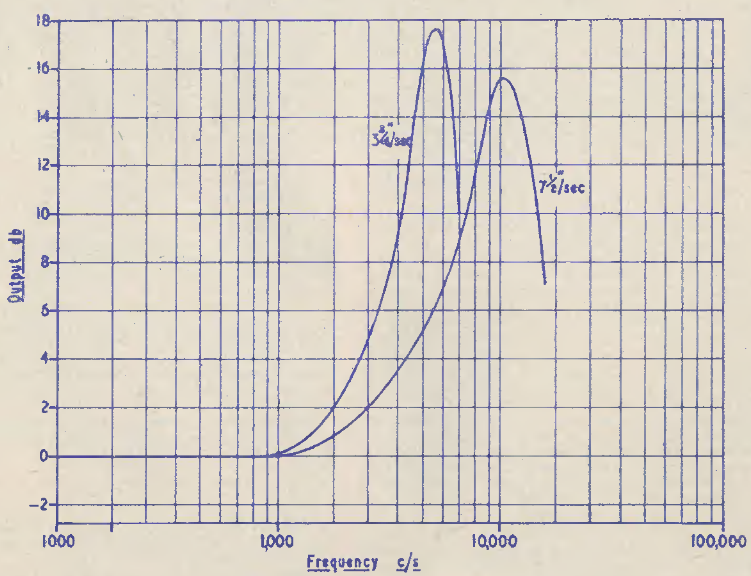


FIG.1 FREQUENCY RESPONSE OF EQUALISER STAGE ON 'RECORD'

Mullard EF86 or Osram Z729 is employed in a resistance/capacitance coupled arrangement to give a gain without feedback of some 120 times.

This gain is appreciably reduced at all other frequencies except that to which the circuit is tuned, by means of a feedback loop. This frequency selective feedback takes the form of a bridge T network connected between the anode and grid circuits of the valve. This type of network offers greatest impedance to a signal applied across its ends when the capacitative reactance equals the resistance in each limb; it will thus be apparent that the

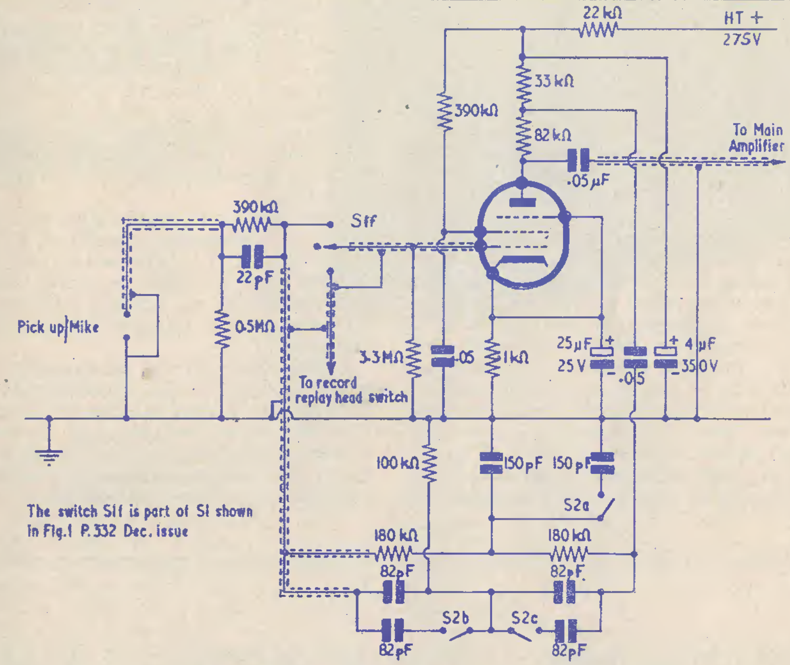


FIG.2 CIRCUIT OF SIMPLE EQUALISER / AMPLIFIER

The need for some bass boost during replay arises because the voltage induced into the playback head depends upon the rate of change of magnetic flux cutting the coils in the head. The rapidly changing flux induced by a tape carrying a high frequency will thus produce a greater voltage than a section carrying a low frequency, even though the level of magnetisation may be the same in both cases. It is typical to apply some 20 db of bass boost at 100 cycles a second, to compensate for this effect.

Turning now to the circuit of the complete pre-amplifier/equaliser stage, this is shown in Fig. 2. A low noise a.f. pentode such as the

feedback will be at its maximum and hence the gain at the minimum for the very low frequencies, and will decrease as the frequency rises, reaching a minimum at the tuned frequency of the bridge T network. At this point the gain will reach its maximum. In order that the maximum treble boost should be obtained at 5 kc/s for the low tape speeds and 10 kc/s for the higher speeds, arrangements are made for switching the capacitors in the feedback circuit. The lower frequency peak is obtained when the maximum value of capacitance is in circuit.

When the amplifier is switched to the replay position, the feedback loop is automatically taken out of circuit, thus permitting a substantially flat response to be obtained. During replay the tone controls in the main amplifier may be adjusted to give optimum reproduction, and for the reasons already given some degree of bass boost may be found desirable. When a recording is being made, the controls should be set in the position which provides a reasonably flat response. A little experimental work in this direction will soon indicate the settings which provide the best results. It will be noted that a 5% tolerance is specified for the components in the feedback loop. This is necessary because any appreciable deviation in value can cause the tuning point to shift by a considerable amount, thus upsetting the recording characteristic.

Turning now to the general switching which has been employed throughout the unit, there are two switch assemblies, a 6-pole 3-way switch and one of 3-pole 2-way. The first one, S_1, is in the nature of a master switch, and its three positions are Record, Erase and Replay. If desired, it is a simple matter to dispense with the Erase position and employ a 6-pole 2-way assembly. This, indeed, is essential when using the switch contacts operated by the buttons on many of the tape decks. A special erase position on the switch is by no means essential as, when the unit is set to the Record condition, erasure is automatic, and if the tape is run through with no input applied to the p.u. socket it will be completely cleaned. Rarely is it necessary to clean a tape in this manner, however, as previous recordings are obliterated by the erase head immediately before a fresh recording is made. The second switch S_2 in the unit sets the equalising circuit for the tape speed to be employed. With some tape decks it is possible to mechanically couple this switch with the tape speed selector knob in order that the setting should be automatically achieved.

The layout of the equaliser circuit requires very careful consideration, as the signal levels are low and the stage is very sensitive to hum. All leads associated with the control grid and anode circuits must be screened, together with the switch S_2 and components in the feedback loop. When the main amplifier is required to function in the normal way, the switch S_1 should be set to the replay position, then if the equaliser stage is disconnected from the input to the amplifier it will be returned to normal operation. A third switch may be employed to disconnect the equaliser output; but this is left to the discretion of the constructor, as much depends upon whether the main amplifier is to be used for other purposes once it has been set up for recording.

Next month will see the final part of this series on converting amplifiers for tape recording, and it is proposed to give details of the way in which the wafer switches incorporated in the Collaro tape deck are connected in the circuits which have been considered.

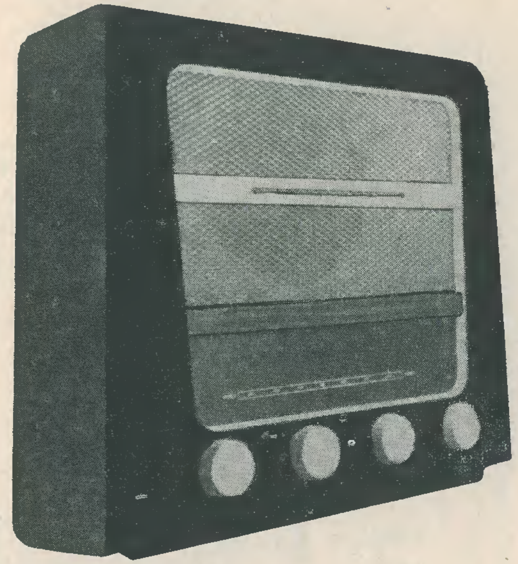
One final word about the sensitivity of the equaliser stage. It will handle inputs up to 0.5 volt and is thus suitable for direct feed from pick-ups and microphones. If, however, a radio unit having a greater output is to be used, a resistive attenuator should be employed to prevent overloading.

Radio Miscellany

continued from page 488

wiring is invariably earthed, the chassis of a universal set (to which one side of the mains is connected) will, whenever plugged-in a certain way round, be at the mains voltage above earth potential. When the lead to the receiver is connected so that the chassis is at earth potential, all is well, provided there is no fault in the wiring. There is, of course, no danger if connected the opposite way round, unless the receiver is touched. Contact can, of course, be made with a "live" chassis through an incompletely sunken grub-screw on one of the control knobs. With all universal apparatus a check should be made to make sure the chassis is on the earth side before making any adjustments. The receiver will, naturally, work equally well connected either way round, although sometimes a mains hum is audible when the chassis is "live." It is particularly important with t.v. sets, where the h.t. is often taken direct from the mains, to satisfy oneself on this point before any part of the chassis is handled. The neon indicator is a cheap and permanent warning device against this danger. It simply consists of a miniature neon lamp in series with a 500kΩ resistor. By a curious coincidence, I am informed that J.R.D. is dealing fully with this point elsewhere in this issue, so I will not labour it further, except to mention that Belling-Lee make a combined holder for a fuse and a miniature neon lamp. For some inexplicable reason they have never been widely used so, if you are interested in this very practical safety precaution, you may find it necessary to order one specially from your local dealer.

A High Quality Broadcast Receiver



by **R. HINDLE**

IN THE PREVIOUS ARTICLE (SEPT. 1956, p. 116) the considerations in mind when designing a receiver for general family use were, to give good quality at a reasonable price, and to make it simple to operate so that even the most inexperienced member of the family can get the best results from the receiver. It will be remembered that switch tuning of two channels, with manual tuning over the medium wave range, was to be provided; and that bottom-end coupling was indicated in the circuit diagrams. There is a peculiarity of that method of coupling, when used for this kind of receiver, that should be pointed out. The tuned aerial circuits not required for a given switch position are not actually isolated, but appear as series tuned circuits across the coupling capacitance. They have the effect of reducing the coupling reactance for the frequency to which they are tuned. This is hardly noticeable in practice, because generally the switch-tuned stations are not required on the manual range and are, in most districts, of good strength, so a slight diminution due to occasional accidental coincidence of the manually tuned frequency with the wanted switch-tuned frequency is not noticed. It might be thought that this feature would be of use as a kind of wavetrap to eliminate interference, and in fact it works as such—but only to a limited degree, because the impedance across which the series tuned circuit appears is of comparatively low impedance.

The bottom-end coupling circuit was suggested originally so as to leave a switch pole available for indicator lamps, and if these indicators are not required double-wound aerial coils can be used, completely isolating the unwanted ones at each switch position. A receiver has been made up using both versions of the circuit, and each is satisfactory. The complete circuit in Fig. 1 gives the double-wound aerial coil version and this will be the subject of the following description. Parallel-fed a.v.c. is retained for the first valve though it could, in this second version, be fed to the bottom end of the grid coil if preferred. On the manual tuning range VC_{1a} and VC_{1b} form the two-gang tuning capacitor. An orthodox i.f. amplifying stage is provided, followed by double-diode detection and a.v.c. rectification. R_{10}, C_{19}, C_{20} form the i.f. filter, and the audio signal is developed across

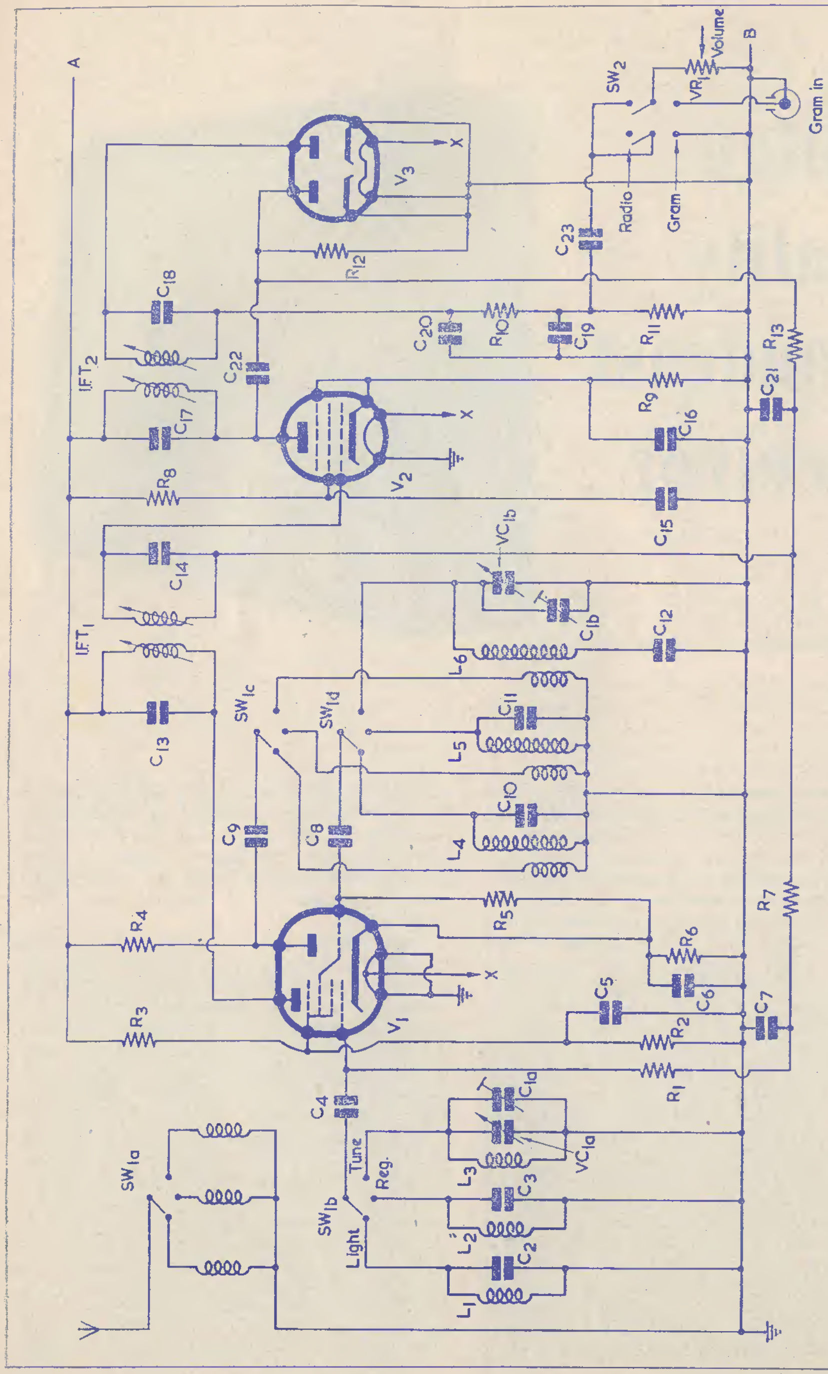


FIG. 1a. Theoretical Circuit of R.F. Stages.

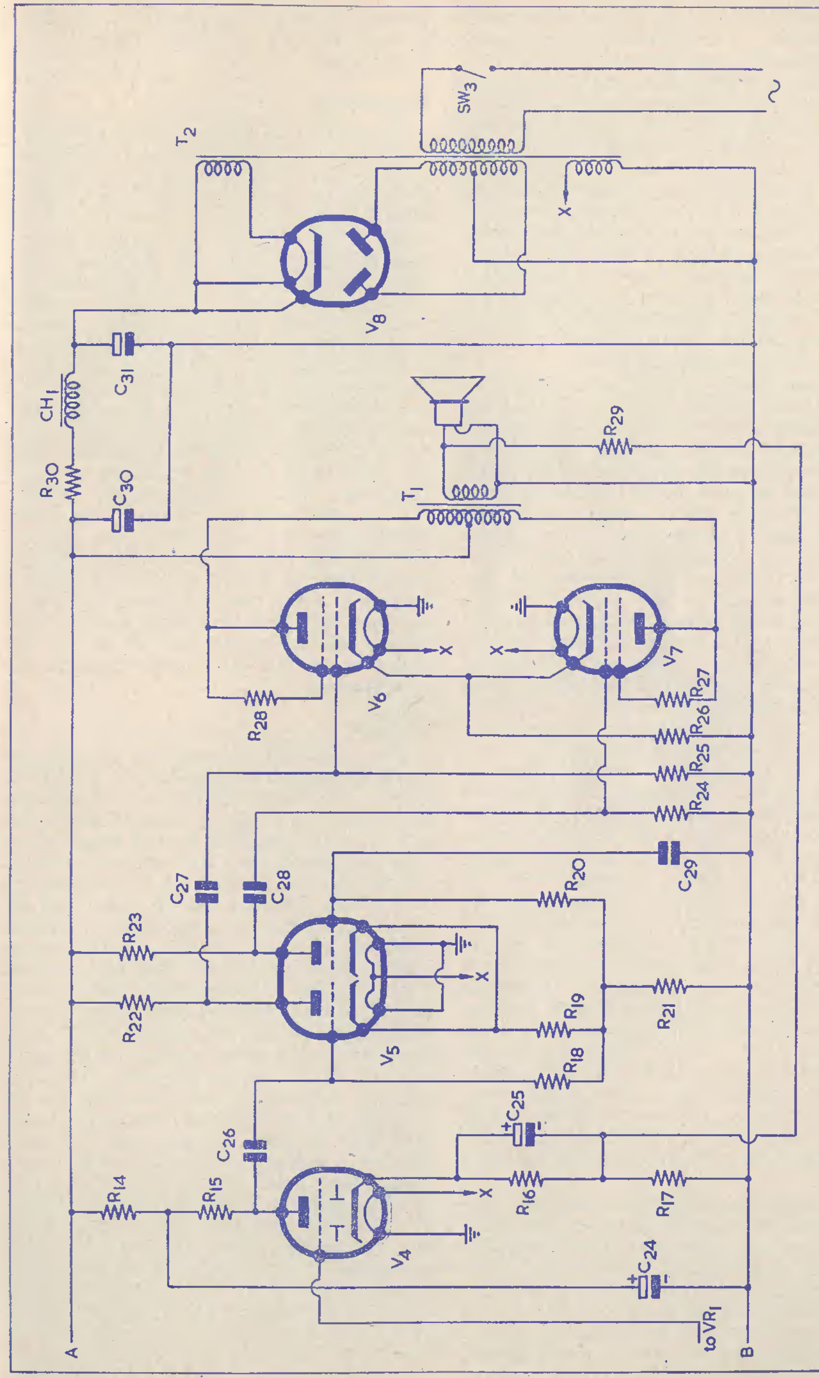


FIG. 1b. Theoretical Circuit of Audio Section and Power Supply.

the diode load R_{11}. The usual parallel diode circuit is used for a.v.c. fed from the primary of the second i.f. transformer.

This is the point where the gramophone input is provided, SW_2 muting the radio side when switched to gramophone by shorting out the diode load. Any number of alternative audio inputs could be provided here, if desired, by using a switch with more positions. For instance, a separate tuner could be made up for the frequency modulated transmissions, or the constructor may like to enter the television field by building a sound tuner which eventually could be incorporated in a complete t.v. receiver, using the audio section of the present design to make the best of the high-quality t.v. transmissions.

The first audio stage is a triode and a Brimar 6AT6 is used, the diodes being left without connection, The reader may wonder at first glance why a separate double-diode is used when these are available in the audio stage. The reason is that it is much better to have the separate cathodes so that bias can be correctly applied without complication. These problems can be overcome, of course, but results in a mass of circuitry around one valve socket, and it sets a more difficult problem in construction. A cathode coupled phase splitter follows; the advantage of this is that amplification is obtained from the circuit. There is necessarily a state of unbalance in the signal currents in the two halves or else the coupling would not work, but this is corrected so far as the voltage output is considered by using anode load resistors of different values. The degree of unbalance is determined by the size of the coupling resistor R_{21}; the larger this is the less the current unbalance, but it cannot be made too large or it would starve the valve of anode volts.

It will be noticed that the cathode circuit of V_4 has been complicated by the inclusion of R_{16}, C_{25} and it may be wondered why simply an unbypassed cathode bias resistor was not used here, increasing R_{29} to suit. The reason is that the bias resistor needed for V_4 is as high as 3,300 ohms and there is a tendency to introduce hum, which disappears if the resistance between cathode and earth (from an audio signal point of view) is decreased. In the circuit given, R_{16} can be ignored so far as hum is considered, and the only resistance to be considered in this connection is 100 ohms (R_{17}).

The need to take pains to reduce hum and distortion in an amplifier that is to have feedback anyway may also puzzle some readers. It should be remembered that feedback does not eliminate, but only reduces, these undesirable effects. Feedback is not a cure-all. When a feedback amplifier is built (and the present equipment is no exception) feedback should first be disconnected and the circuit made to work reasonably well without it. Feedback is then applied to finally clean up the reproduction.

Construction

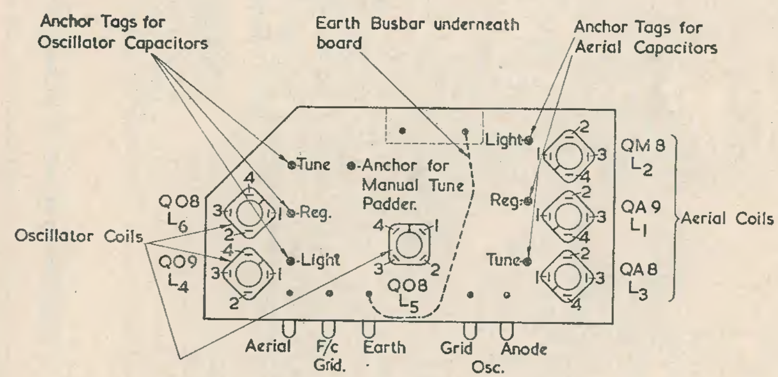
The theoretical design given is ideal for a radiogram, but the purpose in the designer's mind when embarking on this project, was to show how good quality could be obtained at low cost, and with this in mind a table model cabinet was decided upon. One of the cabinets sold by Electronic Precision Equipment Ltd. with the name "Windsor" was obtained and was found eminently suitable for the purpose. A chassis assembly and dial is supplied with this cabinet, but as the drilling is not suitable for this design a new chassis has to be made up of the same dimensions as the one supplied. The front assembly is suitable, of course: a special dial could be made up or can be engraved professionally. One has been made for the prototype by A. G. Engraving, 19A Windmill Road, London, S.W.18, who have the pattern, if any reader should wish for a similar one. The chassis is not very big for such an ambitious design, and it became a little exercise in fitting a quart into a pint pot; but a little thought led to a very suitable layout, using modern small valves, and the result was not in any way cramped—in fact it is very accessible for construction.

Coilpack

The easiest way to assemble the coils and associated switch is in the form of a coilpack. This is the most difficult part of the construction for the less experienced, but it does at least make the work as easy as possible if it is undertaken away from the main chassis. Those who are doubtful about tackling this part of the job may like to know that the Osmor company are marketing a complete pack of this type that will suit the present design. For those who wish to construct, that company will supply all the necessary parts including baseboard and switch bracket. The coils and switch are mounted on the baseplate so that the solder tags are on the opposite side of the plate to the coils. This is so that the solder tags are presented for the purpose of connecting the necessary capacitors after the pack has been mounted in the receiver. Before mounting the switch, connect a length (say 6in) of wire to each tag. A 16 gauge earth busbar is run on the side of the baseplate with the tags. The anchor tags used to connect the hot end of the tuned windings, the capacitors and the switch points, as well as the relative positions of the coils, are indicated in Fig. 2. Wire the pack now in accordance with the circuit diagram, leaving the necessary tuning capacitors, and the padding capacitor for the manual tuning

oscillator circuit, until later. Try the pack in place on the chassis, but then remove it until the rest of the chassis wiring is completed.

Fig. 3 gives the dimensions and the drilling of the chassis for the components used in the prototype. It is wise, however, to collect all the components before commencing construction to make sure that they are of suitable dimensions and to check that the same drilling is required. Note the cut-away required for the drive drum supplied with the chassis assembly. It will be noticed that the smoothing choke is mounted inside the chassis. Ample ventilation must be provided, and to this end holes are drilled through the chassis above the choke position and also in the bottom of the cabinet to allow the passage of air. Holes are also required through which to pass the connections from the mains transformer, the tuning capacitor and the output transformer, all mounted above chassis, and these are fitted with grommets to protect the wires.



Connect Variable Capacitor to tags indicated 'Tune'.
Connect Padder Capacitor between tag indicated and Earth Busbar.
Connect Fixed Capacitors between 'Regional' tags and Earth Busbar. } See table.
Connect Fixed Capacitors between 'Light' tags and Earth Busbar.
Note that anchor tags are not in same order as associated coils.

FIG.2. Assembly of Coil Pack.

M399

An aluminium chassis is used, and in this material the larger holes do not drill at all well. To get really good results tools such as the Osmor punches will be found invaluable. Holes are first drilled at ⅛in throughout in the first instance, and these are then enlarged to the necessary sizes with the Jiffypunches or, for the larger holes, a Jiffypunch makes the pilot hole for the larger punches. A set of these punches makes all the difference to the metalwork of construction.

Fitting the tuning capacitor presents something of a problem. This requires to be of such a height that when the drive drum is fitted to the spindle the top is level with the cord pulleys fitted as instructed in the drive kit supplied with the chassis. The JB capacitor specified is normally fitted with mounting feet that bring the spindle just above mid-way up the endplate, but it was found that if similar feet were screwed onto the endplates at the other end (holes are already provided) the spindle is practically the right height and can be finally levelled by introducing washers between the feet and the chassis. If an alternative component is used, the method of mounting will have to be left to the ingenuity of the constructor; there is no room for a larger component than that specified, but one of the miniatures now available could no doubt be used satisfactorily.

A pair of postage stamp trimmers are held on top of the tuning capacitor by means of short 16 gauge supports. Before mounting, the component wires should be soldered to the fixed plate solder tags to be nearest to the chassis. At this stage the cord drive should be assembled to ensure that everything is right mechanically before commencing to wire.

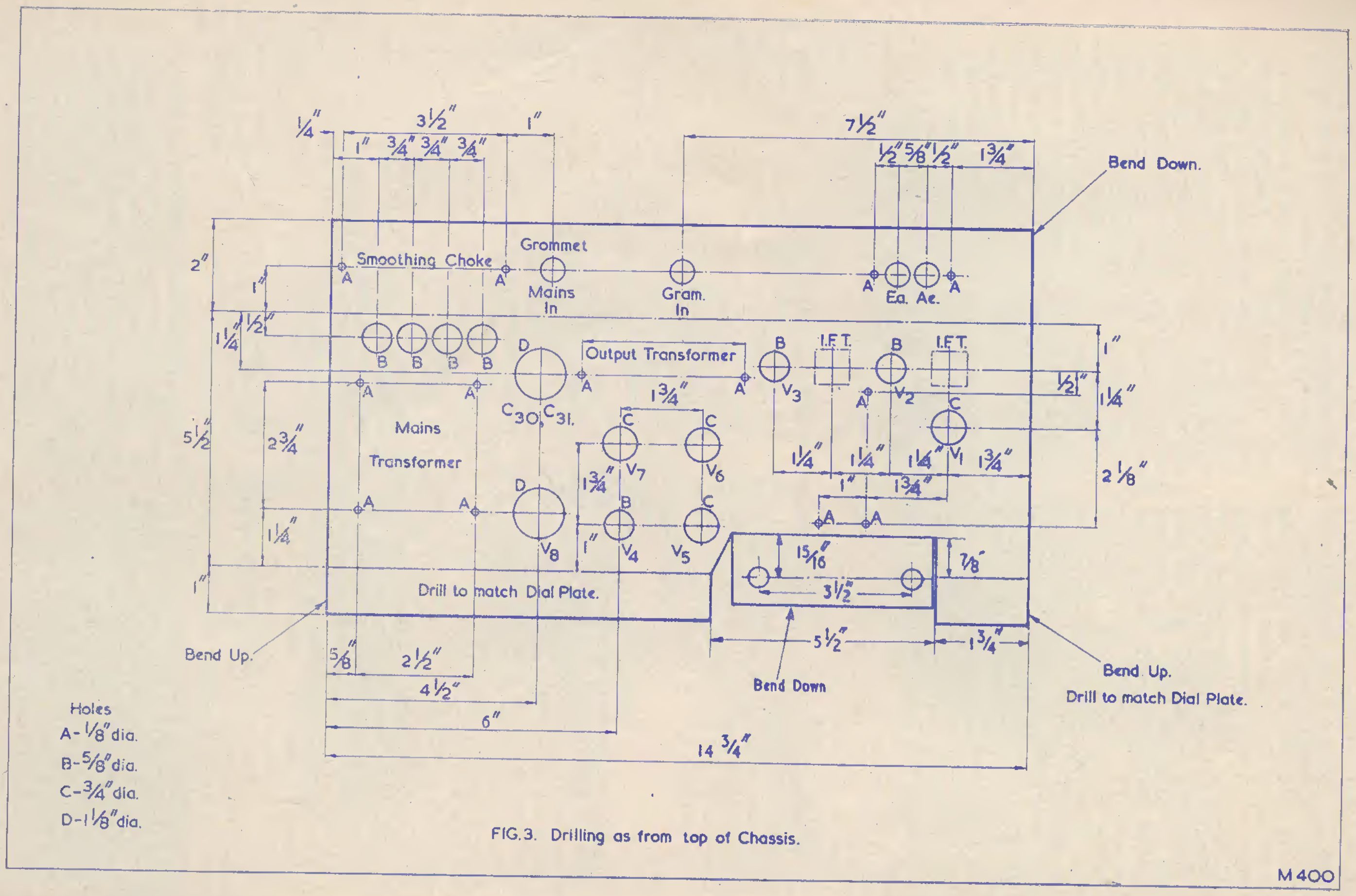


FIG.3. Drilling as from top of Chassis.

COMPONENTS USED IN PROTOTYPE—set out for easy reference to Figs. 1a and 1b, pages 472 - 473

Condensers	
C_2, C_3, C_{10}, C_{11}	according to stations to be tuned, Dubilier type 400
C_{13}, C_{14}, C_{17}, C_{18}	part of i.f. transformers
C_4, C_8, C_9, C_{19}, C_{20}	100pF Dubilier type 400
C_5, C_7, C_{15}, C_{21}	0.05µF 250 volt, Dubilier type 210
C_6, C_{16}, C_{23}, C_{26}, C_{27}, C_{28}, C_{29}	0.1µF 250 volt
C_{12}	500pF, Dubilier type 400
C_{22}	50pF, Dubilier type 400
C_{24}	16µF 350 volt, Dubilier type BR
C_{25}	25µF 25 volt, Dubilier type BR
C_{30}, C_{31}	8–16µF 450 volt, Dubilier type CT
C_{1a}, C_{1b}	60–60pF twin postage stamp trimmer
VC_{1a}, VC_{1b}	twin gang tuning capacitor type E, 487pF max, JB
Resistors	
R_{29}	4kΩ but see text, Dubilier
R_1, R_{12}	1mΩ ½ watt, Dubilier
R_4	27kΩ ½ watt, Dubilier
R_5, R_{10}, R_{14}, R_{23}	47kΩ ½ watt, Dubilier
R_6	220Ω ½ watt, Dubilier
R_7, R_{15}	220kΩ ½ watt, Dubilier
R_8, R_{22}	33kΩ ½ watt, Dubilier
R_9, R_{17}, R_{27}, R_{28}	100Ω ½ watt, Dubilier
R_{11}, R_{24}, R_{25}	100kΩ ½ watt, Dubilier
R_{13}, R_{18}, R_{20}	470kΩ ½ watt, Dubilier
R_{16}	3.3kΩ ½ watt, Dubilier
R_{19}	470Ω ½ watt, Dubilier
R_{21}	22kΩ ½ watt, Dubilier
R_2	47kΩ 1 watt, Dubilier
R_3	22kΩ 1 watt, Dubilier
R_{26}	250Ω 5 watt wirewound, Dubilier
R_{30}	500Ω 10 watt (not required if 300–0–300V transformer used)
VR_1	500kΩ volume control with switch, Morganite
Valves	
V_1	12AH8 Brimar
V_2	6BA6, Brimar
V_3	6AL5, Brimar
V_4	6AT6, Brimar
V_5	12AU7, Brimar
V_6, V_7	6BW6, Brimar
V_8	5Z4, Brimar
2 off	i.f. transformers, 465 kc/s, Osmor miniature
1 coilpack or the following components	
2 off	QA8 coils, Osmor
2 off	QO8 coils, Osmor
1 off	QA9 coils, Osmor
1 off	QO9 coils, Osmor
1 off	4-pole 3-way switch Osmor
1 off	Coilpack baseboard and switchplate, Osmor
1 off	QC1 h.f. choke, Osmor
1 off	2-pole 2-way wafer switch (SW2), Osmor
1 off	Coaxial socket, Aerialite
1 off	Aerial/Earth socket strip
1 off	tagboard 5-way plus earth
1 off	tagboard 3-way plus earth
1 off	tagboard 2-way plus earth
2 off	tagboard 1-way plus earth
1 off	Cabinet "Windsor de Luxe", Electronic Precision Equipment Ltd.
1 off	Chassis and dial assembly for above, Electronic Precision Equipment Ltd.
T_1	Mains transformer 350–0–350V, 150mA; 6.3V; 5V, Elstone MT/A150
T_2	Output transformer, Elstone MR/7
CH_1	Smoothing choke, 20H, 150mA, Elstone SC150
1 off	Valveholder internat. octal
3 off	Valveholder B7G
4 off	Valveholder B9A (Noval)

Values of Fixed Capacitors

	Aerial	*Oscillator*
Long wave Light Programme	200pF	150pF
Medium wave:		
Below 250 metres	50pF	50pF
250–300 metres	100pF	100pF
300–350 metres	150pF	100pF
350–400 metres	200pF	150pF
400–450 metres	300pF	150pF
450–500 metres	300pF	200pF
Over 500 metres	450pF	200pF

Wiring

Before commencing to wire, check that there is no short between the chassis and any connecting pins or tags projecting through the chassis. In wiring, tagboards are avoided so far as possible, small components being soldered directly to the valve sockets. Where otherwise the remote ends of these components would have no secure anchoring points, however, small tag strips are used.

V_1 base has to be wired before the coilpack is fitted, but it must be remembered that the work here must be kept flat to the chassis and resistors generating heat should be kept clear of the pack. Great care is needed also when fitting the pack, to see that the coils do not foul any of the components and consequently sustain damage.

The principle of earthing adopted is generally to earth to a solder tag under one of the valve holding-down screws, so far as r.f. and i.f. circuits are concerned, but at the audio end an earthing busbar is provided connected to the chassis at only one point. This is of 16 gauge wire and runs from one of the gram. input coaxial sockets holding-screws to the appropriate end of the volume control. The heater earthing for the audio valves goes to a tag at the valve base and not to the busbar.

First put in the connections that have to be kept near to the chassis. Connect one side of each valve heater to earth and the other side to the 6.3V tag on the mains transformer, the other side of the 6.3V winding going to a convenient tag on the chassis. Single P.V.C.-covered flex is good material for heater leads.

Layout difficulties were largely overcome by arranging the r.f. and i.f. circuits compactly on one part of the chassis, and the audio circuit also compactly at another part. Coaxial leads are then used to connect the detector output to the radiogram switch, the gram. input to the switch and the switch to the volume control. These go close to the chassis and are now wired in. Mains leads should also be near the chassis; a three-way tag strip is used at which to terminate the mains lead, the leads from the switch on the volume control and the leads to the mains transformer.

At the V_1 position two tag strips are used, each with one tag plus earth. One is used to anchor the junction of C_7, R_1, R_7 and the other to anchor the h.t. end of R_3. Heat is generated in R_3, R_1 and to keep these a reasonable distance away from the coils they are brought towards the front of the chassis. C_5, C_6 are first wired in, with shortened end leads, keeping them down to the chassis. The link from anode to the first i.f. transformer follows, and then the other components including R_4, C_8, C_9, the other ends of which cannot be fixed until the coilpack is in position. Proceed on similar lines with V_2, V_3 keeping the links from valve to i.f. transformer short in each case. A five-way tag at the back of the chassis serves to anchor the components.

On the audio side the earthing busbar is shaped from 16 gauge tinned copper wire and run from one gram. input socket holding bolt to the earthy side of the volume control. The 0.1μF capacitors coupling the valves are wired directly between the appropriate valve socket tags and are self-supporting; tag strips are used only for the ends of components remote from the signal-carrying pins. In the power circuits, tag 3 of the rectifier socket is used to support the voltage dropper R_{30} (if used) and to this point goes one side of the smoothing choke.

The Elstone output transformer is of the multi-ratio type and the leads from one of the unused tags were carefully removed, the tag being used to anchor the feedback resistor and the coaxial feedback lead; if preferred, a separate tag strip could be mounted for the purpose. The actual size of R_{29} used depends on the impedance of the speaker.

Speaker

The table cabinet obviously does not justify one of the expensive high-fidelity speakers now available, but a very satisfactory solution to the problem was found in the range of units marketed by W.B. The 8in model was found to fit the cabinet perfectly, and the resulting reproduction was startlingly good for a table receiver. The 15 ohm model was used.

The higher the speed coil impedance, the greater the speech voltage across it for a given wattage, and so the larger must be the feedback resistor R_{29} for a given degree of feedback. The exact size of R_{29} is best left to experiment, because if too much feedback is applied phase shifting may bring the amplifier near to instability, with ill-effects to quality. A preset wirewound resistor, say 10kΩ, could be fitted in the first instance; adjust this well clear of the instability point and then measure the value and substitute a fixed resistor. Using the same components as the prototype, however, 4kΩ should be found satisfactory. The size eventually decided upon should be such that the slight hum heard without feedback disappears when the feedback resistor is connected, and there should be a very appreciable reduction in gain.

Setting Up

If a signal generator is available, first set up the i.f. circuits to 465 kc/s. If not, the constructor will be wise to purchase Osmor i.f. transformers ready aligned, and in this case he should leave them untouched at this stage. To prove the point, the author used pre-aligned transformers and had no difficulty in setting up the receiver without his generator.

Switch first to the manual tune position, a padding capacitor of 500pF having been connected from the appropriate coilpack tag to the coilpack earth busbar. Now tune in a signal by means of the manual tune knob, preferably at the upper end of the waveband, and identify the transmitter. If setting up to a calibrated dial, this transmission should be brought to the proper position using the core of L_6. Short circuit C_{21} to stop a.v.c. whilst carrying out these adjustments, and also disconnect R_{29} meanwhile to remove feedback. The aerial circuit should then be brought into tune. Now the i.f. transformers can be adjusted slightly to maximum signal. A station towards the lower end of the waveband is now selected and brought to the proper point of the dial, using the trimmers. Revert to the upper end and readjust the cores, and alternate in this way until no further improvement can be made.

Adjustment of the switch-tuned circuits is simply a matter of putting in the appropriate capacitors on the coilpack and then adjusting the cores to the wanted signal. If the core is full out for best results, decrease the size of the capacitor, and vice versa. The approximate capacitance required is indicated in the table, though there may be some variation due to the different strays in the constructor's receiver. The Dubilier type 400 specified fit snugly onto the coilpack—anything larger will be difficult to accommodate.

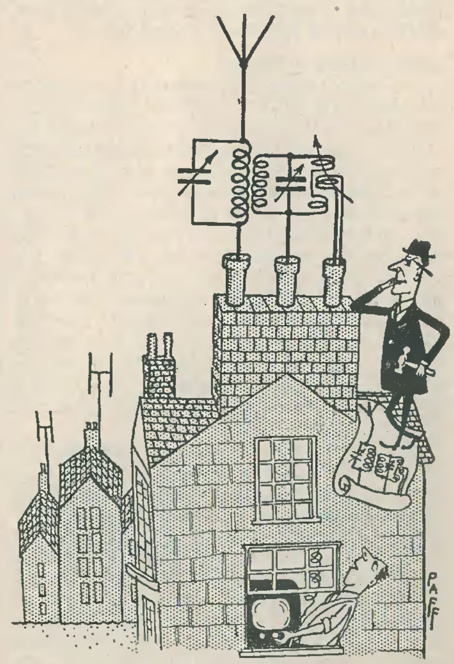
The tuning complete, remove the link shorting C_{21}. Quite good results should be obtained without feedback, and if this is not so the cause of distortion should be sought first. There may be some slight hum, and care should be taken to keep the volume control down or the amplifier will be overloaded. If, on connecting the feedback circuit, the receiver bursts into oscillation, it is likely that the output transformer has been connected the wrong way—reverse the secondary connections. The quality of reproduction should now be cleaned up and no hum should be audible; when the volume control is at minimum the receiver should be dead quiet. If a variable resistor is being tried in the feedback circuit, start with it at maximum and gradually reduce it until the required condition is obtained. Make sure that this is well clear of the instability point by further reducing it, and when satisfied a fixed resistor of similar size can be substituted.

C. H. Gardner Elected President of Inst. P.R.E. for 21st Anniversary Year

Some 25,000 service engineers and other technicians have listened to technical talks given by Colin Gardner on the occasions of Mullard film meetings held during the last year or two. Many of these film meetings were organised in co-operation with the Incorporated Institute of Practical Radio Engineers and Centres of the Radio and Television Retailers' Association.

It will therefore be of interest to service engineers to hear that Mr. Gardner has been elected President of the Institute for the year in which they celebrate their 21st anniversary.

Mr. Gardner, a Fellow of the Institute, and who has been associated with it since its inception, was elected President for the years 1950 and 1951 following which he was elected a Vice-President and operated as liaison officer for the Institute.



"It should work, old man. It's the same as the blueprint!"

TELEVISION for the HOME CONSTRUCTOR

PART 8 *by* **S. WELBURN**

This month S. Welburn, our popular contributor on television topics, has some remarks to make concerning safety whilst handling television receivers. He also deals with line linearity controls.

THE WRITER WOULD LIKE TO COMMENCE this month's contribution to the present series of articles by discussing a topic which is far too often ignored by professional and amateur engineers—that of personal safety whilst handling television receivers. The reason for this choice of subject is that, over the past year or so, the writer has seen work carried out on television sets with what is an almost unbelievable disregard for the common-sense rules of safety which apply when dealing with electrical equipment. If what is written here has some beneficial effect, insofar as the avoidance of shock hazard is concerned, then this article will at least have served part of the writer's purpose.

Lethal Mains Voltages

It does not seem to be generally appreciated that the normal 200 to 250 volt mains supply installed in the home can cause death by shock. How death may occur following contact to the mains supply depends on a number of factors, the most important of these being the state of health of the recipient of the shock, the contact area of the body to the electrodes carrying the mains potential, the route the current takes in travelling through the body, and the amount of resistance between the body and either of the mains electrodes. The last factor, that of resistance, arises particularly in such cases as when a live mains point is touched by the hand whilst the body makes contact to earth through, say, damp shoes and flooring.

The above factors are interconnected with each other, one qualifying the next. It is obvious that a person who, for medical reasons, has to lead a life which does not involve excessive exertion is more liable to suffer from an electric shock than one who is not so hindered. However, it is difficult and, indeed, unwise, to lay down any laws as to what is, or is not, a safe case so far as mains shock is concerned. *Any* shock from the mains is potentially lethal, and the only safe rule is to avoid touching all live points. If a television engineer has to approach live points in the course of his work, it is up to him to ensure that he does not complete any circuit to earth through his body.

The following are some instances, quoted without comment, of the results of shock caused by mains voltage. An engineer working on a corrugated iron roof was handling an electric drill, the lead of which was connected to a 3-pin socket inside the associated building without the use of the correct plug. Instead, the wires from the drill were wedged into the socket with the aid of matchsticks. The metal body of the electric drill became live, and the body of the engineer completed the circuit to earth via the metal roof. The engineer died.

Another engineer was unfortunate enough to catch hold of the two bare wire ends of a piece of flex carrying mains potential, one in each hand. He could not let go. He was, fortunately, able to bring the two ends together so that the mains supply was short-circuited and the fuses blew. He lived.

A little girl sitting in front of the fire happened to touch the metal speaker fabric of a television set whilst her other hand was resting on a metal fender. Due to a fault in the receiver, the metal fabric had short-circuited to a loudspeaker mounting screw and was at the same potential as the live chassis inside the cabinet. The metal fender was effectively connected to earth. The little girl died.

A group of young men decided to play a joke on one of their friends by connecting a metal door handle to the live side of the mains. When the victim caught hold of the knob, he died.

And so the stories go on. The first two instances just quoted are known personally to the writer. The last two cases made headline news in the newspapers at the time when they occurred. As readers know, there are instances of electrocution occurring all the time due to the domestic mains supply, but these are not usually "news-worthy" enough to be mentioned in the national papers, and they normally receive a few lines in local newspapers only.

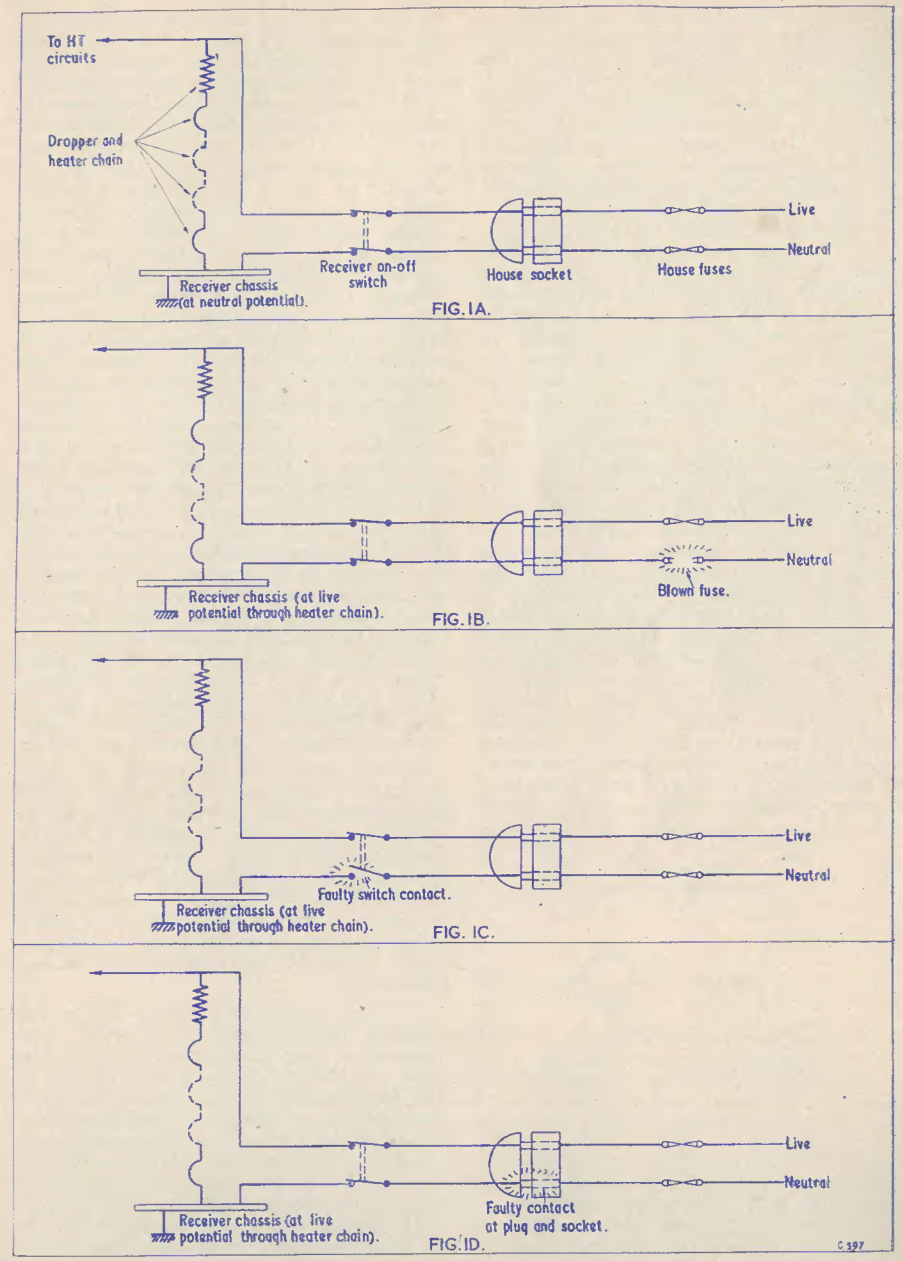


Fig. 1 (a). It is often erroneously believed that, when a chassis is connected to the neutral side of the mains, as shown here, it may be considered "safe." (b) This diagram illustrates what happens if the fuse in the neutral line blows. The chassis immediately becomes live. (c) Should the on-off switch of the receiver develop a faulty contact, the chassis once more becomes live. (d) Yet another very commonly-encountered factor which renders a chassis dangerous to work upon.

The above cases detail the risks which are known to be present when handling metal-work carrying mains potentials. So far as the television engineer, amateur or professional, is concerned, it is his responsibility to prevent others from receiving shocks and to avoid receiving shocks himself. If, after the servicing of a television receiver, its back is put on with just one or two screws, instead of the full complement, then the engineer is passing an unjustified risk on to his customer.

So far as risk to the engineer himself is concerned, the best approach consists of avoiding all contact with metal work at mains potential. Ideally, this can be achieved by carrying out servicing or similar work on live television chassis only when such chassis are connected to the mains via 1 : 1 isolation transformers. So far as the writer is aware, suitable transformers are available in the trade and are not excessively expensive. It is quite possible that it is *legally* necessary to fit isolation transformers in premises where servicing is carried out, but the writer is not in a position to comment fully on this point.

When work is done on a live television chassis without an isolation transformer, the associated television engineer should take especial care to ensure that, when he touches the chassis, no other part of his body makes contact to earth. Stone and concrete floors are especially dangerous in this respect, as their conductivity to earth is high. Linoleum or, preferably, rubber flooring provides reasonable protection, if dry. To reach out and pick up an earthed soldering iron whilst the other hand is resting on a live chassis is, of course, asking for trouble.

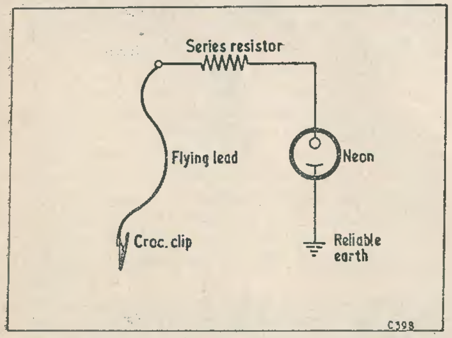


Fig. 2. A simple device suitable for indicating unsafe chassis and metalwork. If the point to which the crocodile clip is connected becomes live, the neon bulb glows.

It often seems to be imagined that, if a receiver is connected to the mains such that its chassis is at neutral potential, then the set is "safe" to work on. Such is far from being the case; and Fig. 1 illustrates the fallacy of this argument. In Fig. 1 (*a*) we have a receiver connected to the mains with its chassis at neutral potential. In this condition, no serious shock will be given if the chassis is touched by someone whose body is in contact with earth, However, a number of eventualities can occur which change this state of affairs. In Fig. 1 (*b*) we have a typical instance, wherein the fuse on the neutral side of the mains supply has blown. Such an occurrence is not at all untoward: there is no reason why a faulty chassis should not cause a fuse to blow, and as both live and neutral fuses have the same rating it is a matter of luck as to which fuse (assuming that both do not blow) breaks the circuit. Because of the blown fuse of Fig. 1 (*b*) we have the live side of the mains connected to the chassis via the resistance of the dropper and the valve and tube heaters. This resistance is quite low compared with that of the body, and the chassis can be considered, to all intents and purposes, as being live. Fig. 1 (*c*) shows what happens when one of the contacts of the double-pole on-off switch becomes faulty. In this case the faulty contact is in the neutral side and the chassis becomes live through the dropper and the valve and tube heaters as before. In Fig. 1 (*d*) we have the same state of affairs again, only in this case the trouble is caused by a faulty connection at the mains plug. This faulty connection could be caused by a strained flex at the plug, or by poor contact between the plug pin and the socket.

As the reader will be aware, the three possibilities just detailed are typical of the sort of thing that is met continually in experimental and servicing work. Any of them could occur at any time. It is because of these facts, and any similar events which may disconnect the receiver from the neutral but not from the live side of the mains, that a chassis at neutral potential presents almost as much danger as does one that is at live potential.

A rather useful and simple device for checking chassis for live potentials was described some years ago by J.R.D. in "In Your Workshop," and is shown in Fig. 2. The device consisted of a small neon bulb connected via a resistor to a reliable earth. The other side of the neon was connected to a flexible lead terminated in a crocodile clip (a suitable clip with rubber cover is manufactured by Bulgin). It was intended that this clip be fitted to any chassis being handled. If the chassis became live the neon bulb would glow and warn the engineer, who would then take the appropriate steps to clear the risk. It would be advisable to check the neon circuit from time to time to ensure that it was still operating, although this check would probably be done automatically when unfamiliar chassis on the bench were initially connected up to the mains. J.R.D. employed a miniature stabilising neon, the value of the series resistance being that which caused it to glow reliably when the flexible lead was connected to a live mains point.

Receiver Voltages

Up to now we have considered shock hazard only from the point of view of mains voltages. There are, of course, other voltages associated with the receiver itself, and these may offer similar risks.

The first of these is the h.t. voltage proper. In the normal television receiver the h.t. line has a potential of some 200–250 volts above chassis. The impedance of the h.t. supply is usually very low, and dangerous shocks can be caused in consequence. It should be remembered that, if a receiver has its chassis connected to the neutral side of the mains, its h.t. line provides a potential which is several hundred volts above earth, at a low source impedance. As a result the h.t. line should be treated with as much respect as are any live mains points. One factor reducing the risk of shock from the h.t. line is that the h.t. potential only appears at terminal points on the chassis, whereas the live mains potential may appear on large areas of the chassis metal-work itself.

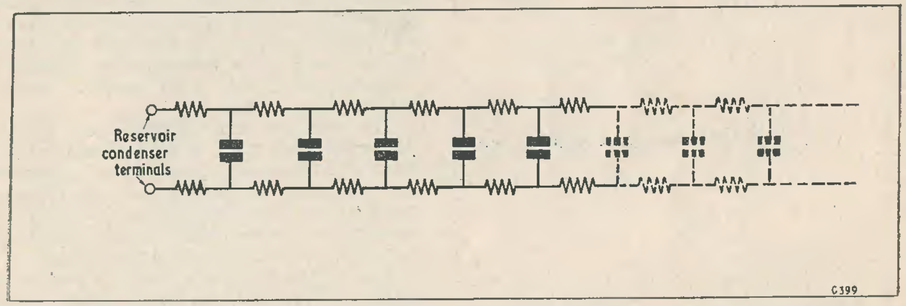


Fig. 3. The e.h.t. reservoir capacity provided by the inside and outside graphite coatings of a c.r.t. may be represented as a very large number of condensers connected together by resistors. This equivalent circuit is discussed in the text.

Flyback e.h.t. voltages are nowadays comfortingly described as "non-lethal." This is to differentiate them from earlier supplies which were obtained from an e.h.t. winding fitted to a 50 c/s mains transformer. The low impedance of the transformer winding, combined with the high value of reservoir capacity needed, earned e.h.t. supplies of this type the descriptive adjective "lethal." So far as present-day e.h.t. supplies are concerned, they can certainly cause unpleasant shocks, and care should be taken to avoid such occurrences. It should not be forgotten that the involuntary action following a shock may cause as much damage as the shock itself. It is possible, incidentally, to receive a shock from an e.h.t. point through a pencil, the graphite of its lead forming the conductor.

When many modern television receivers are switched off, the e.h.t. reservoir condenser still remains charged. Because of this, e.h.t. potentials can be found in receivers which have been switched off for periods as long as several days or more. When the e.h.t. reservoir condenser is formed by graphite coatings on the outside and inside of the cathode ray tube, the question of remanent charge assumes considerable importance. It is quite possible to remove a tube from a set and then receive a shock from its anode connector whilst it is held in the hands. Involuntary action may easily cause the tube to be dropped.

It is difficult to discharge the reservoir condenser given by graphite coatings on a cathode ray tube by an *instantaneous* short-circuit. There are two main reasons for this fact. The first of these is the well-known feature of any condenser insofar that a small charge re-appears some time after it has been short-circuited. The second reason has to do with the resistance inherent in the c.r.t. graphite coatings themselves. The reservoir condenser provided by a cathode ray tube can be depicted with reasonable accuracy by the equivalent circuit shown in Fig. 3. This diagram assumes that the reservoir capacity is made up of a very large number of individual condensers, all being joined together by resistors. The resistors in Fig. 3 represent the resistance of the graphite, and the "terminals" the points of contact to the internal and external coatings. When the e.h.t. supply of a receiver is short-circuited after switching off, the condensers nearest to the terminals are immediately discharged, but those furthest away may only be partially discharged. When the short-circuit is removed the charge on the condensers furthest away from the terminals

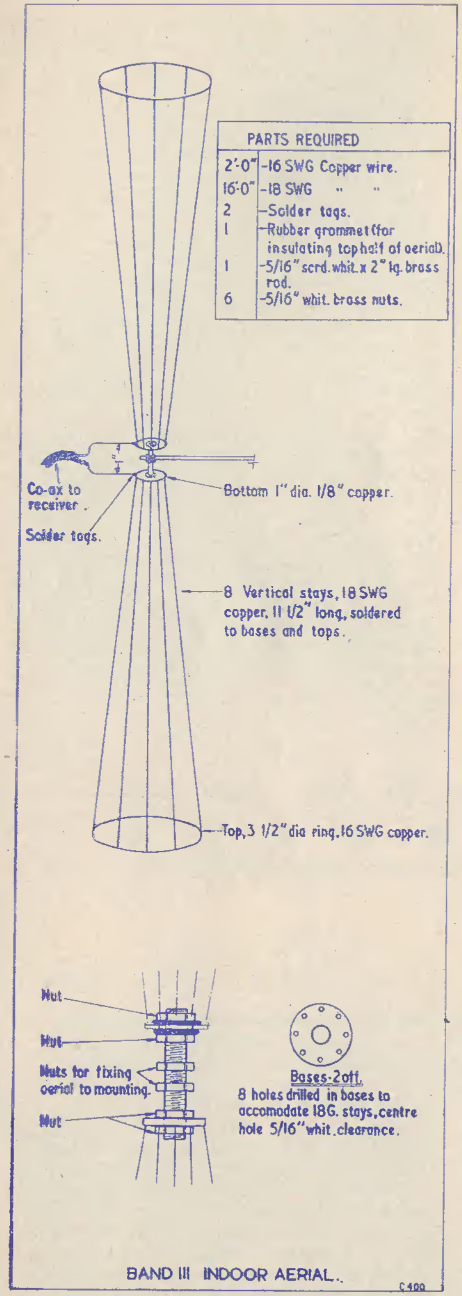


Fig. 4. An interesting and novel Band III indoor aerial. This design has been contributed by a reader.

becomes re-distributed through all the condensers in the network, whereupon a high potential appears across the terminals once more. Because of this re-appearance of the charge it is advisable to short-circuit the e.h.t. reservoir condenser for an appreciable time before handling the tube.

An Indoor Band III Aerial

A reader, Mr. G E. Bickley, of Sinfin Lane, Derby, has sent us an interesting and rather novel Band III indoor aerial which, he considers, gives better results than any commercial indoor aerial he has tried.

In the writer's view the aerial is definitely of interest, and he has pleasure in reproducing Mr. Bickley's design as Fig. 4 in this article.

Line Linearity

An interesting little point was encountered recently by the writer, and as he feels that the subject concerned may be of equal interest to readers he would like to pass it on in these columns.

An acquaintance had been servicing a television receiver when he noticed that the permanent bar magnet on the line linearity control was on the point of falling away from its mounting. He took off the magnet, repaired the mounting and re-affixed the magnet. After this had been done, he found that he could not get anything approaching linear horizontal scan at all. The writer advised him to refix the magnet to the control the other way round, as he might have fitted it incorrectly after repairing the mounting. This was done, and good linearity became evident once more.

The writer's acquaintance was a little puzzled at this state of affairs, and pointed out that, as the sole purpose of the magnet was to reduce the permeability of the linearity control core by applying a field of controlled strength to it, then surely it did not matter which way round the magnet was fitted.

This appears to be a fairly wide misconception. However, the writer would like to emphasise that it is incorrect, and that when a line linearity control employs a permanent magnet the polarity of that magnet relative to the linearity control core is of importance, and that the magnet should not be reversed during servicing.

Fig. 5 illustrates a typical line linearity control inserted in series with the line deflector coils of a television receiver. The control consists essentially of a coil wound on a thin ferrite core. A magnet is mounted such that it may be moved closer to or further away from the core as desired. The material employed for the ferrite core is such that its permeability drops considerably when a magnetising force is applied to it. When the magnetising force is sufficiently high, the core "saturates" and has minimum permeability.

A decrease in permeability of the core causes a corresponding decrease in inductance of its coil and this, in turn, gives a decrease in the impedance inserted in series between the line output transformer and the line deflector coils. Considering the effect as a whole, it may be stated that the greater the magnetising force in the linearity control core, the less the series impedance inserted, and the greater the current flowing in the deflector coils.

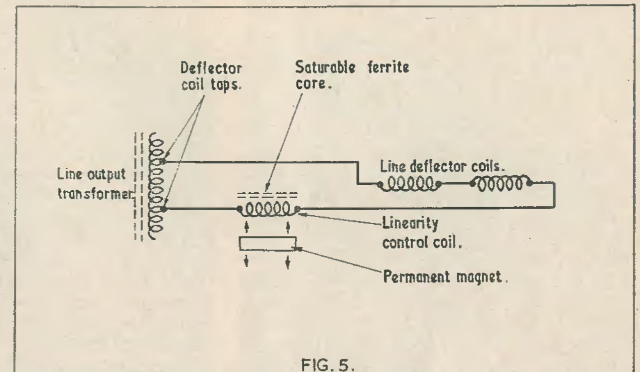


Fig. 5. A skeleton circuit illustrating the position taken up by a linearity control in the line deflector circuit.

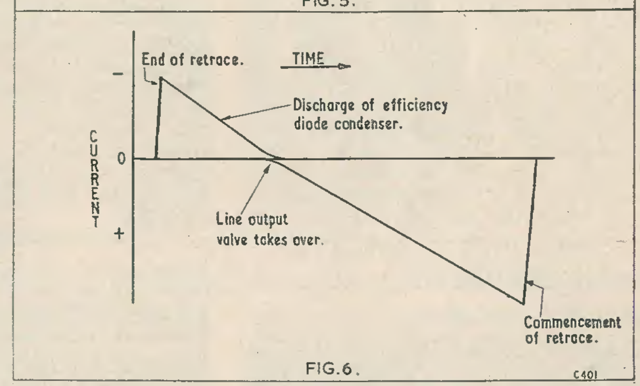


Fig. 6. Illustrating, in simplified form, the current flow through the line deflector coils and linearity control.

Although the linearity control magnet has a considerable effect on the core, this is not the only magnetising factor present. Also magnetising the core is the deflection current flowing through the linearity coil itself. If we examine this current we will find that it reverses direction about a third of the way along the line scan, as is shown in Fig. 6. At the left-hand edge of the current trace shown in this diagram, we have the commencement of the horizontal scan. At this point the deflection current (flowing through the linearity coil and the deflector coils) is supplied, not by the line output valve but by the discharge of the efficiency diode condenser.

About a third of the way along the scan the drive provided by the efficiency diode condenser ceases, and the line output valve takes over. At this stage the current flow in the deflection circuit is approximately zero, and the line output valve causes it to increase in the opposite direction to the initial flow. This continuingly increasing current then provides deflection until the end of the line, whereupon retrace occurs. Summing up, it may be said that the current flowing through the deflector coils is really a half-cycle of a.c., slightly displaced from its normal zero line.

The current flowing through the deflector coils also flows through the linearity coil of Fig. 5. As may now be appreciated, we have the case wherein the coil applies a magnetising force to the core whose polarity reverses during the scan period. If, at the beginning of the scan, the linearity coil magnetises the core such that its right-hand end becomes a north pole, at the end of the scan the current in the coil will cause the right-hand end to be a south pole.

In television line deflection circuits we usually find that we need to compress the left-hand side, and to open out the right hand side of the picture. The necessity for opening out the right-hand side is probably due to the fact that this corresponds to greatest current drawn by the line output valve, with possibly lowest permeability in the line output transformer core in consequence. The permanent magnet of the linearity control can help us to achieve the compression and expansion needed if we apply it to the core such that its field opposes the magnetising force provided by the coil at the beginning of the scan, and assists it at the end of the scan.

Under such circumstances we will obtain the following course of events. At the beginning of the scan the field of the magnet is opposed by the magnetising force of the linearity coil. As a result, the total magnetising force exerted on the core is low and it has a high permeability. This high permeability enables the linearity coil to offer a high impedance to the flow of deflection current in the deflector coils, and the left-hand side of the picture becomes compressed. At the right-hand side of the picture the current flowing through the linearity coil provides a magnetising force which adds to that given by the magnet. The permeability of the linearity core drops, a low impedance is offered to deflection current flow, and the right-hand side of the picture opens out. If the magnet were accidentally fitted the wrong way round we would have the reverse effect, i.e. the left-hand side of the picture opening out and the right-hand side being compressed.

As may be readily imagined, although arrangements of the type shown in Fig. 5 provide one of the best solutions that are at present available to the problem of line linearity control, they do not give perfect results. This is due to the fact that the changes in permeability in the linearity core do not exactly balance out the changes inherent in the line output stage over all sections of the scan. A fairly good answer to this problem consists of providing the linearity coil with a few more turns than is required and by shunting it with a resistor to reduce its total overall change in impedance. By judicially juggling with the number of turns on the coil, the position of the magnet, and the value of the shunt resistor, it then becomes possible to find a compromise solution which offers acceptable linearity over the whole scan. In commercial receivers such experimental work is, of course, undertaken by the manufacturer's design staff. So far as the home-constructor is concerned, the field for experiment here is very wide, provided that the normal prerequisites of patience and logical approach are employed. It should be pointed out that experiments on line linearity are sometimes a little difficult to carry out when Test Card "C" is being received. This is due to the fact that the squares of this test card are rather too large to show up non-linearity over small sections of the scan. A test pattern generator giving closely spaced vertical dimensions gives better results. Although of no great use during experimental work, it has to be pointed out that one of the best checks for non-linearity of the line scan, incidentally, is given by programme signals wherein the camera pans horizontally across a scene. Non-linearity in the line scan causes objects in the scene to change in width as they pass along the screen, the visual effect being very noticeable.

BOOK REVIEWS

continued from page 467

TRANSISTOR TECHNIQUES. The Gernsback Library, Inc., New York. 96 pages, 76 diagrams and illustrations. Obtainable from The Modern Book Co., 19–23 Praed Street, London, W.2. Price 12s., postage 9d.

This small American handbook sets out to introduce the reader to transistors in eight short chapters. As is to be expected the treatment is very brief, though inessentials have given place to factual information.

The first two chapters pay due regard to the delicacy of these devices by expounding the correct methods of testing them and the protective measures which should be taken in operating and handling them. The next two chapters discuss their operating conditions, including the newly-introduced tetrode transistor, and methods of measurement for ascertaining characteristics for various applications.

Some circuits for transistor applications are given in the remaining four chapters. Those who are seeking to make their fortune prospecting for Uranium ore will avidly devour chapter eight wherein a Geiger counter is described. It would seem, however, that in this country Geiger-Muller tubes are just about as scarce as the uranium itself.

Access to information showing the British equivalents for the American components specified for apparatus designs would be a useful accessory for reference purposes, so the reader is advised to avail himself of it to gain a full appreciation of data in the book. Despite its brevity the book contains much useful information.

THE MORSE CODE FOR RADIO AMATEURS. By Margaret Mills, G3ACC. 20 pages. Published by The Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1. Price 1s. 0d., postage 3d.

This latest addition to the R.S.G.B. publications has been prepared by an operator who has had a great deal of experience in teaching Morse Code. Her method not only makes learning easier; it trains the learner at the recognised speed of 12 words per minute which would enable him to pass the Post Office examination.

The nine lessons take series of letters in blocks of five designed to imprint the sounds of the morse characters on the learner's mind. Following these there are further groups of actual words which, if sent in the specified time, attain the required speed of 12 w.p.m.

Anyone setting out to learn code correctly would be well advised to spend a shilling on this book. He would certainly spend it wisely, and profitably.

One minor error is noticed. Twice the word OVEN is out of place in Lesson 2, since the letter N is not taken until the third lesson.

W. E. THOMPSON

Radio Miscellany

CENTRE TAP *talks about* *Items of General Interest*

A MONTH OR TWO AGO I WROTE OF THE Jason Frequency Modulation Tuner which was originally described in this magazine over a couple of years ago and proved so popular that the constructional details had to be reprinted in the form of one of our Data Book Series. Its neat and efficient appearance was intriguing, and for the first time in my long association with the hobby I made an exact replica of someone else's design and specification. What was of equal interest was what sort of results comparatively inexperienced constructors were getting with it? V.H.F. is very exacting in its requirements, and for many it would be their first f.m. venture.

Oddly enough I had a little trouble with mine, due to a faulty capacitor. It was a brand new one; and although it was a one in ten thousand chance, it might have taken an inexperienced trouble-shooter some time to find it.

The circuit, properly adjusted (which is by no means as tricky a business as it first appears in print) gives excellent results; and provided the specified components and the ready-drilled chassis are used, is well within the capabilities of a careful beginner. Indeed, it is a "front-end" to be strongly recommended for those who have built one of the many quality amplifiers described in the pages of *The Radio Constructor* during the past two or three years.

Wot—No Ends ?

To confirm (or confound) my theory regarding its suitability for the less experienced, I went to some trouble to find a few readers who might fairly be described as coming within this category, to learn of their experiences. Three of them achieved perfect results without trouble (although two of them had help in aligning), but the fourth had no joy. We quickly traced the trouble to a dry joint from C_4 to the oscillator coil, and I left him highly delighted after warning him to go over all the other connections to make sure they were electrically sound. I also recommended shortening all leads wherever possible. Dry joints can be avoided if one makes a practice of giving the connection a gentle "rubbing" with the iron before you take it away. Regarding the second point, shortening the leads, with v.h.f. it is all to the good if you can avoid having any leads at all and can manage to solder the components virtually direct to the pins, etc. Even if you can only shorten the leads by an eighth of an inch, it's often worth it. There is a marked reluctance on the part of beginners to snip back the length of the leads on capacitors and resistors. My view is that reminders on this point could well be included at the beginning and end of all v.h.f. constructional description. To a lesser extent there is a tendency for stylishness and good looks in wiring to rank higher with beginners than the saving of length, especially in all leads carrying r.f. Well may it be more pleasant to look at whilst working on it, but once the chassis is put into use (except perhaps when it is inspected occasionally for servicing) it is never seen again! The Jason is so thoughtfully planned that even when it is finished it can look as though there is scarcely any wiring to it.

All of a Kind

An unusual feature of this tuner, which rather surprisingly has not been noted in any published references to it, is the fact that the four valves employed are of the same type (Z77's or EF91's). I feel this to be a very admirable feature. I have always nursed a passion for uniformity which surges into action whenever I go to my spares shelf where over sixty different types (some becoming obsolete) are included in my collection. The idea of an all-purpose valve is as old as broadcasting itself. In the very early 'twenties Mullard called their valve ORA because it oscillated, rectified and amplified. In the 'thirties a successful all-purpose valve, the Hivac-Herries, proved efficient in operation although it did not achieve the popularity it deserved. I built a 6-valve superhet using them and they gave several years good service. Just after the beginning of the war one of them failed and I couldn't get a replacement. Eventually I made the other five the subject of a small ad. This brought quite a response, so evidently there were plenty of other satisfied users, and one keen type who called the first evening the ad. appeared, bought the lot!

Since writing this I have just had a check up on the valves in current use at Centre Tap Villa. They number no less than seventeen different types, five of which are not represented on the spares shelf!

Odds and Ends

For the past two Februarys I have commented on the reader who has sent me a Christmas card of ye olde snow-covered cottage on which he had drawn in an assortment of t.v. aerials, v.h.f. yagis and 130-ft long wires. This year he has let me down, and I missed it. By way of consolation, however, I received a nice card from L.H.B. of the Atomic Energy Research Establishment, Harwell, which has a real aerial *printed* on it. This is the first Christmas card I have ever seen with a pukka aerial! Perhaps next year some enterprising firm will print one depicting an aerial radiating seasonable greetings to all points of the compass.

While on the subject of oddities, I was recently asked how a 100-ft length of twin cable (with a break in one of the wires at some unknown point) could be used to the best advantage. Apparently it had seen service in hoisting an aerial mast into position.

My suggestion that it could be kept for erecting other aerials was coldly received. The enquirer eventually decided to cut it in half and thus be sure at least of one 50-ft length of good cable. He then intended to cut the faulty 50-ft in half and be sure of another 25-ft of sound wiring. This was to go on ad infinitum until the useless length was eliminated, leaving him with the maximum amount of good stuff. Any better ideas?

Too Soon Forgotten

My recent remarks on the need to keep alive component manufacturers' and wholesalers' interests in the amateur market have been warmly endorsed in a letter from J. D. McG. (30 Mitchell Crescent, Alloa). Despite his disappointment with some makes of components, he says he has found "Radiospares" replacement items give every satisfaction and would like to see this firm enter the amateur field with a wider range of items suited to home constructor needs. He would appreciate a full list of their products if anyone can oblige. Another subject upon which he makes some pointed remarks—the need for "follow-up" news and later developments on gear described for construction. He considers it most frustrating to build a set and then never to see any further mention of it at all. Other readers I have discussed this point with have expressed considerable sympathy with this viewpoint and for such a purpose the Editor would, no doubt, willingly throw open a column in which praise, criticism or suggestions for modification of *Radio Constructor* constructional items *while of topical interest* could be aired. I had some success on these lines with the "Basic Superhet" I described early after the war. The chief drawback is, of course, the trouble involved in writing. Many feel they would like to write and indeed have every intention of doing so. The snag seems to be that they keep putting it off—until finally it never gets written at all!

At Long Range

Another interesting letter, about which pressure on space has prevented earlier reference, comes from Mr. T. Farmer of Putney, S.W.15, who readers will remember wrote of his method of soldering aluminium some time ago. This time he writes on converting small meters to extended scale sizes. This delicate operation has often been satisfactorily performed by fastening a black bristle to lengthen the needle to traverse the larger scale. Such a modification should not be tackled unless one has great deftness and certainty of touch. Meter needles which often look rigid and sturdy affairs are frequently found to crumple up under the proverbial puff of wind! Although I pride myself on possessing some small skill in such affairs, on the rare occasions I have "done things" to meter pointers I always find myself with my heart in my mouth when doing it.

Mr. Farmer has successfully used a similar idea with a short length of black cotton impregnated with a cellulose glue to stiffen it. If necessary, as in his case, a small blob of the same cement can be used for counterbalancing.

Safety Precaution

He also asks about using neon indicators to show whether the chassis on an a.c./d.c. receiver is "live." As one side of the mains

continued on page 470

DESIGN CHARTS FOR CONSTRUCTORS

No. 12 POWER AND VOLTAGE RATIOS TO DECIBELS

by **HUGH GUY**

THE DECIBEL, AS A UNIT OF MEASURE OF voltage or power ratios, is more than just a mysterious word used by the "Hi-Fi" specialist. It plays a very useful role in the vocabulary of the radio engineer, being designed to obviate unwieldy units of gain or attenuation and complicated calculations.

In fact, the decibel was introduced as a convenient measure of sound intensity, to record sound levels in exactly the same manner as the human ear responds to them.

This form of response is logarithmic by nature. If, for example, the output power of a loudspeaker increases from ½ watt to 1 watt, and then from 1 watt to 2 watts, to the listener the power has increased in equal steps. In just the same way, if the frequency of a note from the loudspeaker rose from 100 cycles per second to 200 c/s and then from 200 c/s to 400 c/s, to a listener the frequency would appear to have increased in equal steps, or by 2 octaves.

To the ear, then, the effect is dependent upon the ratio of the change, be the latter in frequency or power; and if, as in the example, the ratio is constant as we increase the quantity involved, the effect increases uniformly to the ear. It is due to this fact that frequency scales on graphs of, say, amplifier responses are always drawn in logarithmic units. The reader will find, for example, in Fig. 1, where a typical response curve for a crystal pick-up is reproduced, that the frequency scale is logarithmic and that if a distance corresponding to a frequency change from 10 c/s to 20 c/s is measured by means of a rule, then this same length will correspond to a change from 20 c/s to 40 c/s and thence from 40 c/s to 80 c/s, and so on. Each time the length is equivalent to the steady step-by-step change that the ear would hear, and each time this change is due to a steady ratio of increase of frequencies of two to one.

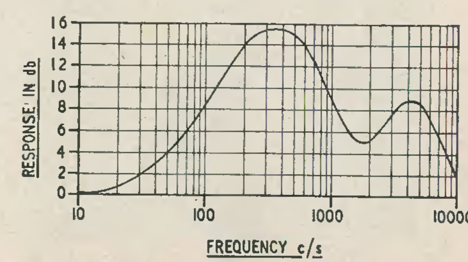


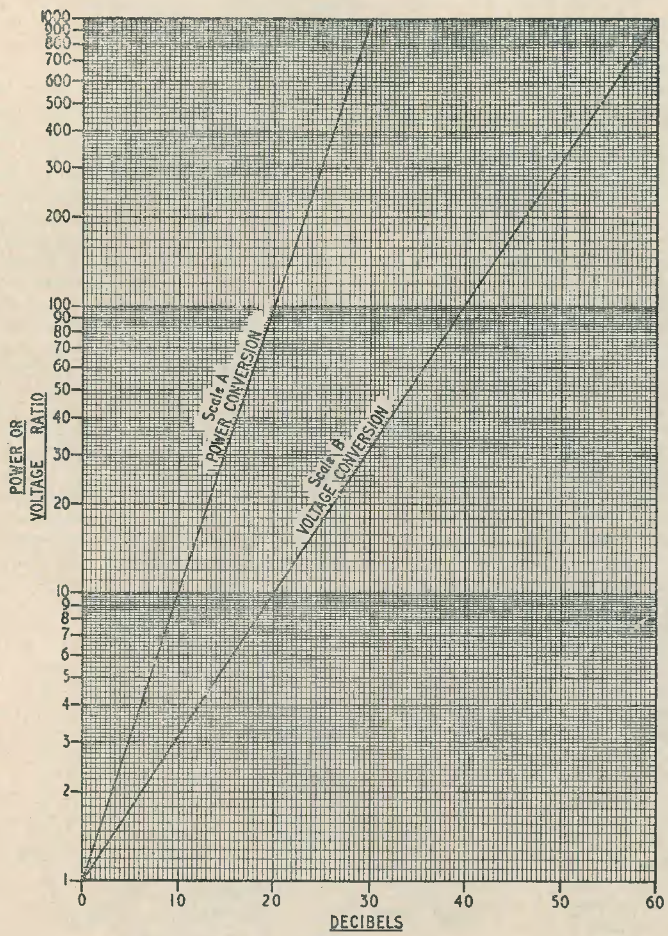
FIG.1 TYPICAL CRYSTAL PICK-UP RESPONSE CURVE ON LOGARITHMIC FREQUENCY SCALE

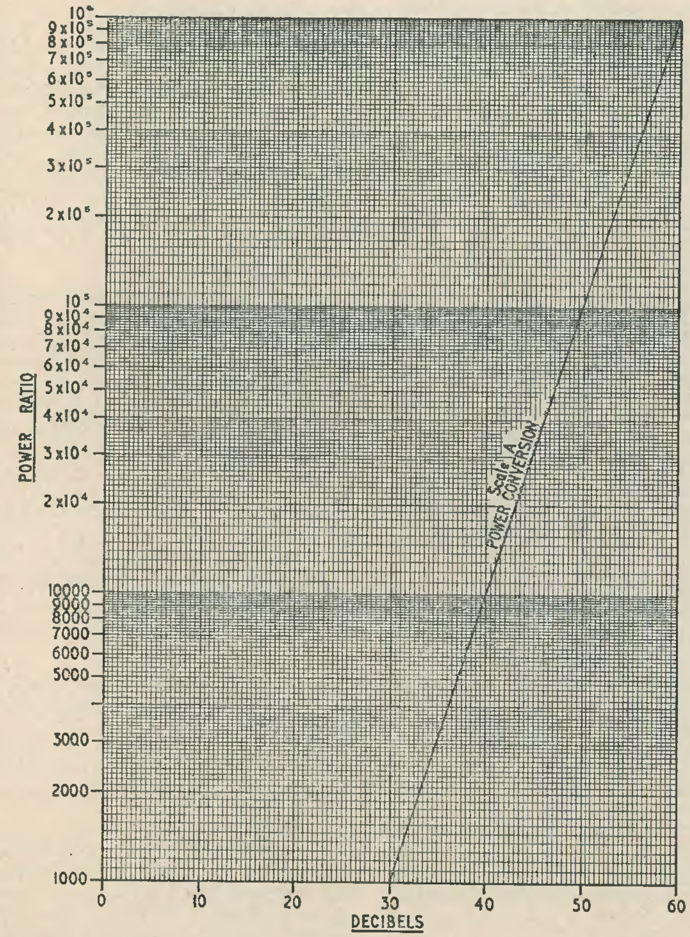
G 415

In musical parlance these ratios of increase in frequencies are called octaves, and the reader can verify that an increase of five octaves on 10 c/s gives a frequency of 320 c/s.

This can be explained in simple steps. Firstly, an octave increase means a ratio of increase of two to one. Secondly, five octaves must mean five such successive ratios of two to one, and this in turn gives a ratio of 2 multiplied by itself 5 times. In other words, the final ratio is 2^5 which is 32. The final frequency must, therefore, be 320 c/s. Working in terms of octaves, that is in ratios of two, simplifies frequency calculations to some extent.

For gain or attenuation calculations, however, since the ratios with which we have to deal can vary so widely, a far more versatile sort of measure is required. To demonstrate this need, consider a three-stage amplifier each stage of which has a gain of 15.6. The overall gain of the amplifier is found ordinarily by multiplying individual gains. In this case the overall gain will be 15.6 multiplied by itself three times. This is $(15.6)^3$ and is not a


POWER OR VOLTAGE RATIO
DECIBELS
Scale A POWER CONVERSION
Scale B VOLTAGE CONVERSION
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
0
10
20
30
40
50
60
G 416


POWER RATIO
DECIBELS
Scale A POWER CONVERSION
1000
2000
3000
5000
6000
7000
8000
9000
10000
2x10⁴
3x10⁴
4x10⁴
5x10⁴
6x10⁴
7x10⁴
8x10⁴
9x10⁴
10⁵
2x10⁵
3x10⁵
4x10⁵
5x10⁵
6x10⁵
7x10⁵
8x10⁵
9x10⁵
10⁶
0
10
20
30
40
50
60
G 417

straightforward type of calculation. One would normally use logarithms to solve it in the simplest case. In fact, the logarithm of 15.6 would be multiplied by 3 (the power of 15.6) to give the logarithm of the answer.

If all three stage gains had been different, say 14.8, 15.2, and 15.8 respectively, then one would have added the logarithms of these individual numbers, the antilogarithm of the total giving the overall gain as in the previous case.

Notice the advantage of using logarithms. In the first case the *power* of a number is found by *multiplying* the logarithm, and in the second case the *product* of numbers is found by *adding* their logarithms. In each case the only inconvenience apart from looking up logs is converting the logarithmic total back to numbers.

The decibel system of ratio measurement enables us to avoid this last step. In fact, the decibel is a unit of ratio measure left in logarithmic form. To find the overall gain in decibels (abbreviated db) each stage gain is converted to decibels and the quantities *added.* If each stage gain is the same, as in the first quoted example, then the decibel-equivalent of this gain is merely *multiplied* by the number of stages to obtain the overall gain.

The only restricting factor in using decibels involves distinguishing power measurements from voltage or other simple measurements.

The Power Decibel

Relative power levels were originally measured in bels, named after Graham Bell of telephone fame. Then if different output powers from an amplifier, say, were P_1 and P_2, the ratio in bels is given by N where

$$N = \log\left(\frac{P_1}{P_2}\right) \text{ bels.}$$

A more practical sort of unit is given by one-tenth of the bel, called the decibel, and thus the ratio of the powers P_1 and P_2 in decibels is given by n where

$$n = 10 \log\left(\frac{P_1}{P_2}\right) \text{ db}$$

All that remains to do is to convert the power ratios into their decibel equivalent, and this, of course, is the function of this issue's design chart. Simple examples will illustrate its use.

Example 1

The output power of a receiver is doubled. What is this increase in decibels?

To double the power means to have increased the ratio of power by two to one. The ratio of two is located on the vertical scale. This value intersects the "power" key line at 3db on the horizontal scale. Thus a power ratio of 2 equals 3 db.

What happens when a ratio is less than 1? In these instances a power loss has occurred and the reciprocal of the ratio is used in the calculation to give a negative decibel value. Consider the last problem in reverse. This time the output power of a receiver is halved. What is the loss in decibels?

The ratio of half to one, when inverted, becomes two to one. This ratio we know gives a decibel ratio of 3db. Thus halving the power is equivalent to −3db, more usually referred to as a loss of 3db.

Example 2

The power gain of a receiver is 30db from aerial to loudspeaker. Calculate the input power if the output power is 250 milliwatts.

This involves using the chart in the reverse direction. Converting the power of 30db to a power ratio via the power key line gives a gain of 1,000. Thus the loudspeaker power is 1,000 times as much as the received aerial power, which must, therefore, be 250 microwatts.

The Voltage Decibel

Ohm's Law may be applied to the power ratio used in the definition of the power decibel to extend its use to voltage and current ratios. If the power P_1 is developed in a resistance R_1, and that of P_2 in a resistance R_2, then to be 100% correct the ratio in voltage decibels (abbreviated dbV) is given by

$$e = 20 \log\left(\frac{V_1}{V_2}\right) + 10 \log\left(\frac{R_2}{R_1}\right)$$

where V_1 is the voltage due to P_1 and V_2 that due to P_2.

In practice the correcting ratio of R_2/R_1 is generally ignored and the voltage decibel is just considered to be

$$e = 20 \log\left(\frac{V_1}{V_2}\right) \text{dbV}$$

Once again ratios of less than one are inverted in the calculation and reckoned as losses in dbV.

On the chart the voltage key line is given by scale B, and it is used in exactly the same manner as the power key line, scale A.

Example 1

An audio amplifier has a gain of 40dbV. A microphone pre-amplifier associated with it has a gain of 200. What is the overall gain of the amplifier in dbV, and what input voltage will give an output of 10 volts?

The chart shows directly that a voltage gain of 200 corresponds to a dbV gain of 46dbV. The overall amplifier gain is the sum of the preamplifier gain and the audio section gain —viz. 86dbV. Now to answer the second part of the question, the gain of 86dbV must be converted to a gain ratio, and this is beyond the limit given by the chart. The conversion can be done in steps, however. The top limit of the chart is 60dbV, corresponding to a gain of a million—10^6. This still leaves 26dbV to be accounted for, and this converts to a gain of 20. The overall gain is, therefore, 20 times 10^6 or 20 million. The input voltage for an output of 10V will, therefore, be 0.5 microvolt.

Example 2

The output voltage from a tone control falls at the rate of 6dbV per octave as the frequency is raised above 10 c/s, at which frequency it is 1V. At what frequency will it have fallen to 1mV?

The ratio of voltage is 1,000 to one, which in decibels is 60dbV. At 6dbV per octave, then, the frequency must have risen 10 octaves. Earlier we noted that an octave is a ratio of 2. Ten octaves is, therefore, a ratio of 2^{10} which is 1,024. The final frequency is, therefore, 1,024 times the original frequency, namely 10.24 kc/s.

From these examples we note that, apart from distinguishing between power and voltage ratios, the only rule to remember is that gains are reckoned positive decibel values, and attenuations or losses as negative decibel values. In each case the ratio giving the decibel value is expressed as greater than one. Further, the chart limits may be extended by using the method in Example 1 in the voltage decibel paragraph.

The application of "decibel jargon" will be brought home more forcefully when tone control circuits and their design is considered in this series of charts for the constructor.

Can Anyone Help?

Requests for information are inserted in this section free of charge; subject to space being available

W. G. Metcalfe, 33 Caldy Road, Liverpool 9, is anxious to obtain a.v.c. circuits for transistor l.f. amplifiers and for valve l.f. amplifiers. His own attempts with the latter have so far only resulted in instability.

* * *

J. Credland, 24 Victoria Mount, Horsforth, Leeds, urgently requires information on the power pack for the Transmitter T1154N. He also requires information on the conversion of the ex-WD R1355 to an f.m. receiver, and on its power pack.

* * *

B. Morrell, 65 The Bungalows, New Kyo, Stanley, Durham, would like to borrow the circuit diagram of the Sobell receiver model No. 599.

* * *

K. J. A. Bland, 56 Evington Street, Leicester, needs the service manual and circuit of the Philips radio type 797A, No. M11238, or any details of it, and is willing to buy.

* * *

A. E. Franklin, 8 Redcliffe Road, Chelmsford, Essex, wishes to obtain the circuit and other data of the G.E.C. A.C. Overseas Ten receiver, cat No. BC.4010. He is willing to purchase.

* * *

A. Jackson, 92 Walden Road, Sheffield 2, wishes to buy, borrow or hire the manual, circuit or any data whatsoever on the Sobell 4-valve mains portable.

* * *

M. C. Law, 315a Finchley Road, London, N.W.3, wonders if any reader has the circuit, to sell or lend, of the Clifton Tape Recorder, model MQ1, or can give any information on the connections from the input transformer to switches, etc.

D. M. Baker, 22 South Drive, Harrogate, Yorks, wishes to borrow or buy all available information on the Unit TR.5043 (SCR.522) modified for Low Power input, ref. No. 10D/NIV 788, and Power Unit type 2A modified, ref. No. 10K/17S. All letters will be answered.

* * *

G. Whittle, 34 Hollylodge Road, Croesyceiliog, Cwmbran, Monmouth, requires any information and the circuit of the type 19 Transmitter/Receiver, and is willing to hire or purchase.

* * *

R. C. Wood, 2 Bank Chambers, 140 Herne Hill, London, S.E.24, wishes to obtain the circuit diagram, with values, of the H.M.V. television set model 1807, and also the base connections of the 10in Emiscope c.r.t. type 3/16.

* * *

C. T. Pearce, 89 Tyrone Road, Thorpe Bay, Essex, would like to buy or borrow the manual for the Receiver type R.109. He has the circuits of the 18 and 68 Sets, and the manual for the 48 Set.

* * *

A. E. Woods, 23 Delius Street, The Hill, Coventry, wishes to borrow or purchase the service sheet for the Ferguson 998T television receiver. He is mainly interested in details of conversion to Band 3.

* * *

G. S. Hilton, 5 Glenham Grove, Brookes Bar, Old Trafford, Manchester 16, would like to obtain circuit details of the Remote Display Unit "E," APW9250A, manufactured in 1945 by the Stanhope Engineering Co., London, N.W.2, with modifications for conversion to an oscilloscope. Expenses willingly defrayed.

A Morse Practice Oscillator

by J. BROWN

THE WRITER WAS RECENTLY APPROACHED with the request to build a morse practice oscillator which would be suitable both for class and for individual instruction.

Various prototypes were built up and tested, but the usual neon bulb and the battery operated types were all found to have their particular disadvantages. The model finally approved was rather out of the ordinary, and it was felt, therefore, that it might interest other readers of this journal.

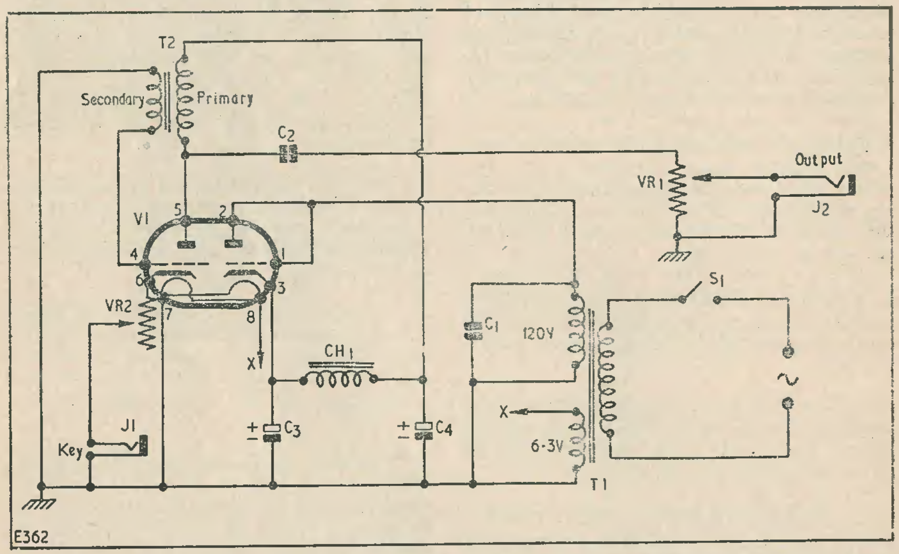
The only really unconventional part of the circuit is, perhaps, the method of tuning used to obtain the required frequency. The cathode has in series with it a variable resistor, which in turn is in series with the key. Variation of this cathode resistance will give variation of the pitch obtained.

The oscillator is of the "inductance feedback" type. Its operation will be well known to "old timers" of the early days of radio, as it was frequently—albeit undesirably—heard as "l.f. howl" in transformer coupled audio stages, a phenomenon usually corrected by reversing one of the windings of the interstage transformer. In the circuit used here we need the "howl," so the windings of the transformer have to be so connected that this "howl"—or feedback, as it is more technically described—is deliberately produced.

The refinement of frequency control has the advantage that after a period of practice, when the note begins to get monotonous, it can be changed, thus allowing the "labour of learning morse" to be endured for yet another period!

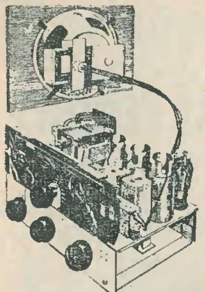
The Circuit

A 6SN7 double triode is used, one half section with the anode and grid strapped and fed from the transformer h.t. secondary becoming a half-wave rectifier. The d.c. thus produced is taken from the cathode and smoothed by two 32μF electrolytic condensers and a choke CH_1. The other section of the valve is used as the oscillator, with the anode fed via one winding of the a.f. transformer and the control grid fed via the other; the cathode is taken to chassis via the variable resistor and the key.



COMPONENT LIST

T_1	Primary 200–250V, Secondaries 120V at 25mA, 6.3V at 1.5A (R.C.S. Products type PU1)
T_2	Intervalve transformer (Radiospares 5 : 1)
J_1, J_2	Jack sockets
S_1	S.P. On-Off toggle
CH_1	10H smoothing choke
C_1	0.01μF 500V wkg. paper
C_2	0.1μF 250V wkg. paper
C_3, C_4	32μF 250V wkg.
VR_1	500kΩ pot
VR_2	25kΩ pot
V_1	6SN7



RADIOGRAM CHASSIS 29/9

5 valve s/het. Including 8″ speaker. 3 w/band. A.C. mains. Complete, less valves. Front drive. Chassis size, 12″ x 10″ x 8″. Free printed dial. Carr & Ins. 4/6

12 MONTHS ★ GUARANTEE

TV TUBES { 14″ £5 . 10 . 0 / 17″ £7 . 10 . 0 }

We are now able to offer this wonderful guarantee. 6 months full replacement and 6 months progressive. Made possible only by improved high quality of our tubes. Carr. and ins. 15/6.

CONVERT YOUR 9″-10″ and 12″ to 14″-15″ or 17″. Our pamphlet is FREE, and on many sets it costs only the tube to give you these giant pictures. SPECIAL OFFER 14″, 15″ and 16″ TV tubes £5. All Perfect. **12″ TV TUBES £5.** 15/6 carr. and ins. on all tubes.

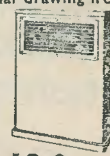
TV CHASSIS 97/6

Complete chassis by famous mnfr. Easily converted to I.T.A. R.F. e.h.t. unit included. A.C. s/het. 3 separate units (power-s/vision-t-base inter-connected). 8″ p.m. speaker free with each order, also drawings. I.F.s 16.5-19.5 Mc/s. Carr. and ins. 10/6

IDEAL RADIO or R/GRAM CHASSIS 39/9

3 w/band & gram, s/het. 5-valve international Octal. Ideal for table gram., but still giving high quality output. 4 knob control. 8″ p.m. speaker 7/9 with order. Set of knobs 2/-. Chassis 15″ x 6″ x 7½″. Less valves. Ins. carr. 4/6 **8″ P.M. Speakers, 8/9.** Stocks cannot last. Have you had all that you may require? Complete with o.p. trans. 10/-, p. & p. 1/9. **V.H.F. 1125 Set, 7/9.** This little set is a v.h.f. receiver. Requires some modification to put it into service. Complete with valves. P. & p. 2/3. **V.H.F. 1466 Receiver, 27/6.** Ex-W.D. New condition. 6-channel switching. Receives t.v. sound and amateurs 30.5–40 Mc/s. I.F. 7 Mc/s. FREE drawing. Carr & ins. 4/6. **Coil Packs, 3/9.** 3 band including pair 465 i.f.s., 2-gang condenser and printed dial (similar drawing free), p. & p. 2/3. **Coax. Cable, 6d.** yard. Any length. Allow 1d. yd post.

ELECTRIC CONVECTOR HEATER 99/6



Hotter and cheaper than oil. 1d. an hour. A.C./D.C. Switched for 1 or 2 kilowatt. Total purchase, third of normal price. Carr and ins., 10/6

14″ TV CHASSIS £13.19.6

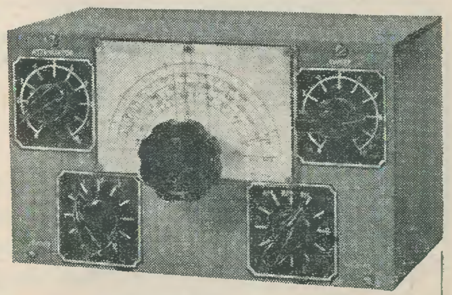
Complete with tube and speaker. Modified ready working. Fully guaranteed for 3 months. These are demonstrated to personal callers. LESS valves. As above with 5 of the valves, **£15 . 19 . 6.** Or with all the valves, **£19 . 19 . 6.** Some delay on the latter. Ins., carr. incl. tube 25/-. **17″ Tube Rectangular** on adapted chassis. LESS valves, **£19. 19 . 6.** With 5 valves, **£21 . 19 . 6** or complete with all the valves, **£25 . 19 . 6.** Plus 25/- ins. carr. FREE catalogue.

Liverpool Street to Manor Park—10 minutes
OPEN SATURDAY ALL DAY

DUKE & CO (RC) **621/3 ROMFORD ROAD MANOR PARK LONDON E12**
Telephone GRA 6677, 2791

For a really professional finish use . . .

PANEL-SIGNS TRANSFERS



Set No. 1: Receivers and Amplifiers
Five sheets 8½″ × 5½″ containing one Large scale, twelve control panels and wording. 3s. 6d. Postage 2d.

Set No. 2: Test Instruments
Five sheets 8½″ × 5½″ containing two Medium scales, twelve control panels and wording. 3s. 6d. Postage 2d.

Set No. 3: Wording
Wording for Receivers, Amplifiers, Transmitters, Test Equipment and other Radio Apparatus.
4 Sheets, Approx. 400 words, 2s. 6d. Postage 2d.

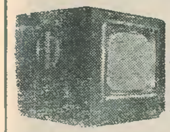
Panel-Signs Transfers Fixing Varnish 1s. per bottle Postage 4d.

Note—all wording is in white

Published by
DATA PUBLICATIONS LTD
57 MAIDA VALE . LONDON W9
Telephone CUNingham 6141 (*2 lines*) *Telegrams* Databux London

12″ T.V. CABINET, 15/-

We are offering these at not much more than the cost of the plywood they contain. If not wanted for T.V. many useful items can be made—record storage cabinets, H.F. loudspeaker case, book case, etc. Price 15/-, carr. 3/6



ELECTRIC BLANKET WIRE

Waterproof P.V.C. covered, so blanket washable, 16½ ohms per foot—1/6 per yard. 14 yards, ideal for average blanket, £1, post free.

MULLARD AMPLIFIER 510

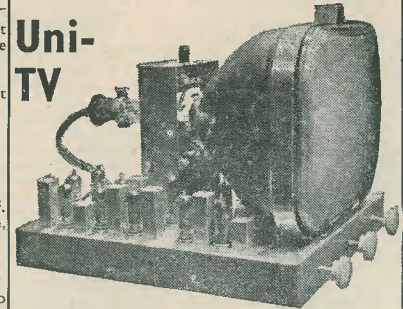
A quality Amplifier designed by Mullard. Power output exceeds 10 watts. Frequency response almost flat from 10 to 20,000 c.p.s. For use with the Acos "Hi-G" and other good pick-ups. Made up and ready to work is **£12 . 10 . 0** or **£1 . 10 . 0** down and 8 payments of **£1 . 10 . 0**, plus 10/- carriage and insurance

Miniature Components for Transistor Sets, Deaf Aids, etc.

Made by Fortiphone and other famous firms.

Intervalve transformer—N22, 10/-; N23, 10/-	
Push-pull input transformer—A203	15/6
Push-pull output transformer—A204	15/6
Earphone, 250 ohm, L	18/-
Plastic eartip	2/9
Tinsel plug and plug for earphone	5/-
Slide switch ref.SW5	4/-
Pots with switch, ½ meg.	2/-
Very small resistors, many values	6d.
Very small condensers, prices from	6d.
Tinsel leads without plugs	6d.
Deaf aid cases with clip for pocket	2/6
Plastic box with lid, 4½″ x 3″ x 1¼″	2/6

Uni-TV



Undoubtedly the most up-to-date televisor for the home constructor. You can build all or only part and the set when finished will be equal to a factory-made equivalent. What other constructor TV has all these features?

- Made up units if required
- All miniature valves
- Metal rectifier
- 13-channel circuitry
- Ferrox cube, E.H.T. and scan coils
- 34/37 Mc/s I.F.
- Suitable for any modern 12, 14 or 17″ tube

The building cost (less tube) is only **£31 . 10 . 0** plus 10/- carriage and insurance. All parts guaranteed twelve months. **Full information and data,** price 3/6

TV COMMERCIALISING OUTFIT

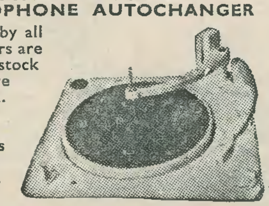
Do it yourself—it's really quite easy. You will manage it in an evening and we guarantee **Successful results or money back.**

Our parcel contains:
I.T.A. Aerial
36ft I.T.A. Down-lead
I.T.A. Converter

A special bargain price for all the above items if bought together is **£8.10.0.** Or **£1.10.0** down and 8 payments of **£1.** Post and insurance 4/6. Full details with illustrations, 1/6.

4-SPEED & 3-SPEED GRAMOPHONE AUTOCHANGER

Latest types by all famous makers are invariably in stock at competitive prices. B.S.R. Monarch, Garrard, etc. Latest models from **£7.15.0** plus 5/- carr. and ins.



FREE THIS MONTH
To all *Radio Constructor* readers who send s.a.e. we will present free a copy of our booklet "*Making an Electric Blanket.*"

19/6 AMPLIFIER

Construct a powerful 3-valve mains amplifier. Ideal for dances, parties, etc. Complete less chassis, cabinet and speaker (available if required). Data 1/6 (free with parts)

TRANSISTORS
Red-spot replaces Mullard OC71, etc., 10/-
Blue-spot suitable r.f. up to 1.6 Mc/s 15/- each

Wrap our heater cable around the pipes in your loft to prevent a freeze up. Minor pack 14 yds £1; major pack 21 yds **£1.10.0**

Don't Be Caught Like This

CAR STARTER CHARGER KIT

All parts to build 6-and 12volt charger which can be connected to a "flat" battery and will enable the car to be started instantly. Kit comprising the following:

Mains transformer	22/6
5 amp rectifier	17/6
Regulator stud switch	3/6
Resistance wire	2/-
Resistance Former	2/6
Mains on/off switch	2/6
0-5 amp Moving coil meter	12/6
Constructional data	1/6

or if bought all together price is 62/6 plus 2/6 post and packing

ELECTRONIC PRECISION EQUIPMENT LTD
Post Orders should be addressed to Dept. 34 Sutton Road Eastbourne

Personal shoppers, however, can call at—
266 London Road Croydon *Telephone* CROydon 6558 Half-day Wednesday
42-46 Windmill Hill Ruislip Middx. *Telephone* RUIslip 5780 Half-day Wednesday
152-3 Fleet Street EC4 *Telephone* FLEet 2833 Half-day Saturday
29 Stroud Green Road Finsbury Park N4 *Telephone* ARChway 1049 Half-day Thursday
249 High Road Kilburn *Telephone* MAIda Vale 4921 Half-day Thursday

HENRY'S
(RADIO) LTD

5 Harrow Road Edgware Road
Paddington London W2

PADdington 1008/9 and 0401

OPEN MON. to SAT. 9-6, THURS. 1 p.m.

Send Stamps for New 1957 28-page Catalogue

EAVESDROPPER
THREE TRANSISTOR POCKET RADIO
(No Aerial or Earth Required)

Pre-selected to receive the Ligh and Home Stations. Total cost, as specified, including Transistors, Transformers, Coils, Condensers and Battery, etc., with circuit and baseboard.

77/6
(LESS INSERT)

Acos Insert 15/6. Single Headphone 3/6 or Miniature Hearing Aid 24/-

QUARTZ CRYSTALS
FT241A 200 kc/s 10/- each, 500 kc/s 10/-. Crystal Holders for both types 1/3 each

F.M. CONVERTER UNIT
88/100 Mc/s

Containing 6 valves—2 6BA6, EB91, VR137, 2 EF54. Two I.F. stages and separate local oscillator, graduated vernier tuning. Just plug in to your radio and obtain good listening on F.M. Voltage required 250V 50m/A and 6.3V 2A. £7 . 19 . 6

TRANSMITTER/RECEIVER
Army Type 17 Mk. II

This well-known R/T Transceiver is offered complete with valves, high resistance headphones, No. 3 hand mike and instruction book giving complete details and circuit, contained in strong cabinet. Variable tuning Frequency range 44.0 to 61 Mc/s. Range approximately 3 to 8 miles. Power requirements standard 120V h.t. and 2V l.t. Ideal for Civil Defence and communications.

BRAND NEW 59/6

Calibrated Wavemeter for same, 10/- extra

TRANSISTORS
JUNCTION TYPE (Red-Spot) (P.N.P.)

10/- each

(Tested and complete with data and circuits)

N.B.—These transistors may be used in place of Mullard OC71 or similar transistors

Please note that these Red-Spot Transistors are ideal for most circuits including "W.W." Pocket Transistor Receiver and Transistor Amplifier. All transistors are British manufactured and guaranteed. Send for circuits and data.

PRE-SELECTED SEVEN TRANSISTOR PUSH-PULL PORTABLE SUPERHET
Just switch to your favourite station. No tuning, no aerial or earth. Pre-select 3 stations. Complete with all components and seven transistors. 7" x 4" elliptical speaker. Teletron superhet coils and I.F.T.s. Powered by 7½V dry battery which lasts for months. 150 milliwatts output. All the above with circuits, etc.
£9 . 17 . 6 carr. paid
Or with matched Mullard OC72's (200mW output) and 7" x 4" elliptical high resistance speaker, 30/- extra
Suitable plastic Cabinet easy to assemble, 18/6
CALL AND HEAR DEMONSTRATION MODEL WORKING.

TRANSISTOR SIGNAL TRACER
Complete kit with 2 transistors, components, 'phones with circuit, 42/6

TRANSISTOR SQUARE WAVE GENERATOR
Ideal for signal tracing. Complete kit with 2 transistors, components and Circuit, 25/-

TRANSISTOR PUSH-PULL AUDIO AMPLIFIER
(150 milli-watts output)

Build this push-pull amplifier which is ideal for crystal or magnetic pick-up amplification, baby alarm, microphone amplifier, etc. Powered by 6V dry battery lasting for months. Complete kit of parts including 4 transistors and all components with circuit (less speaker), £4 . 10 . 0

SPECIAL OFFER
Set of four Transistors, including one R.F. Transistor, 42/6
Set of six Transistors including one R.F. Transistor, 60/-

CRYSTAL MICROPHONE INSERTS
Ideal for tape recording, gramophone amplifier, etc. Very sensitive. Guaranteed and tested, 5/-

Complete stocks of Teletron Coil and Ferrite Rods
We have over 50,000 Valves in stock. Send for Lists.

SPECIAL REDUCTION FOR SETS OF VALVES

	Per set
1A7GT, 1N5GT, 1H5GT, 1A5GT (or 1Q5GT or 3Q5GT) ...	37/6
10 EF50 (Ex-brand new units), 5/- each ...	45/-
10 EF50 (Red Sylvania, ex-new units) 6/- each ...	55/-
6K8G, 6K7G, 6Q7G, 5Z4G, 6V6G...	35/-
1R5, 1S5, 1T4, 1S4 (or 384 or 3V4) ...	27/6
TP25, VP23, HL23/DD, PEN25 (or QP25) ...	25/-
DK96, DF96, DAF96, DL96...	32/6
6K8G, 6K7G, 6Q7G, 25A6G, 25Z5 (or 25Z3G) ...	37/6
12K8GT, 12K7GT, 12Q7GT, 35Z4GT, 35L6GT (or 50L6GT) ...	37/6
12SA7GT, 12SK7GT, 12SQ7GT, 35Z4GT, 35L6GT (or 50L6GT) ...	35/-

SMALL ADVERTISEMENTS

Readers' small advertisements will be accepted at 3d. per word, including address, mimimum charge 2/-. Trade advertisements will be accepted at 9d. per word, minimum charge 6/-. If a Box Number is required, an additional charge of 2/- will be made. Terms: Cash with order. All copy must be in hand by the 8th of the month for insertion in the following month's issue.

PRIVATE

FOR SALE V.C.R. 97 T.V. in oak console cabinet, magnifier, spare tube, £10. 17in table cabinet, £3. 61 Barn Rise, Wembley, Middlesex. Telephone Arnold 9405.

EXCHANGE Triumph motorcycle, 350 s.v., for a communications receiver or television; or will sell £30. Send S.A.E.: Suban, 80 Dalyell Road, Stockwell, London.

FOR SALE Eddystone 670 Marine Receiver 100/110–200/250, AC/DC. Also Mains Filter Unit, £25. Collister, 199 Winchester Road, Chandlers Ford, Hants.

FOR SALE Taylor Valve Tester Model 40, Walkie Talkie 38, AC 455A with Dynamotor, one each 6 and 12V VIB Packs, 10 Oak Single Wafer Switches (boxed), Wearite Coil Pack 705 new boxed, various trans., chokes, valves, etc. Offers? S.A.E. Gasson, 60 Park Road Witney, Oxon.

ANYONE WANT A BARGAIN? Osram 912 Amplifier, separate tone control unit, £6 10s. 0d. carriage paid. Mullard EF36 (new) 10/-; two KT61 10/- for both. 54 Muston Road, Filey.

FOR SALE Wearite Tape Deck £20. Collaro RC54 Auto-Changer £6. R1155 new unused £7. R103 Receiver Mk. 11 works but needs attention £2 10s. Lane Tape Deck £8. Amp. for Lane Deck £5. Cabinet for Lane Deck and Amp. £2. Mullard Amp Commercial job £8 15s. VHF Trans. Rec. built-in power pack for mobile work ex-Admiralty 9 AB (two) at £5 each. Germanium Diodes suitable crystal set HF probe, etc., 4/- doz. Taylor valve tester 46A with B9A B7G bases £10. Avo All-Wave Bat. Sig. Gen. 95kcs. to 80 mcs £5. Mikes Acos Mic 35–1 crystal 10/-. Mic. 33–1 crystal £1 15s. Acos Mic. 30 £1 5s. Two valves 813 17/6 each. Rexine-covered cabinet suitable Port. Gram., etc., £1. Eddystone Rec. 90 kcs–30megs plug-in coils. Perfect. £12 10s. Reasonable offers considered. Blackburn, 67 Pembroke Road, Ruislip, Middx. Ruislip 8719

FOR SALE 2 Dynamotors each 28V 1.6A input 230V 0.1A output 12/6 each plus 2/6 post. Box E133.

FOR SALE Caxton's "Modern Practical Radio and Television." Four volumes. Mint. £3 10s. 3 Hill Crescent, Chelmsford, Essex.

TRADE

TELEVISION INTERFERENCE. Receiver filters High-Pass E.5037, 30/-; Low-Pass E.5031, 30/-; Composite Band I/III, 49/6. Transmitter filter: E.5034 80dB 1kW, £6; Labgear (Cambridge) Ltd., Willow Place, Cambridge.

MORSE CODE TRAINING. Special course for Beginners. Full details from (Dept. RC) Candler System Company, 52b Abingdon Road, London, W.8.

continued on page 503

E.M.I. TEST EQUIPMENT FOR AMATEURS

Spot Frequency Marker Type AD/U405. Operating on a frequency of 1 Mc/s and generating harmonics at 1 Mc/s intervals up into the V.H.F. range.

V.H.F. Grid Dip Oscillator Type AD/U406. Frequency may be varied over the range 65-150 Mc/s and accuracy is within ±2% at all frequencies within this range. Consumption 0.3A at 6.3V and 3mA at 150-250V. Stabilised power supply is not essential.

Absorption Wavemeter Type AD/U408. Consists of a variable tuned circuit, across which is connected a germanium crystal in series with a 500 microammeter. Frequency range continuous from 1.6-50 Mc/s. Accuracy within ±2%.

V.H.F. Absorption Wavemeter and Field Strength Meter Type AD/U409. Similar design to the Absorption Wavemeter but for operation in frequency range 65-150 Mc/s, accuracy being within ±2% over specified range. Case measures 8½" x 4¾" x 2¾"

General Purposes Power Supply Unit Type AD/U410. L.T. supply isolated from earth. Separate h.t. On/off switch provided. Input: 200-250V 50 cycles a.c. only. Output: 6.3V at 2A approx. and 250V at 60mA (unstabilised). Dimensions 8½" x 4¾" x 5½"

All Above Units New and Boxed

AD/U 405–406–408–409 ... **£3. 10. 0** each
AD/U 410 Power Unit ... **£4. 0. 0** each
Postage and Packing 3/-

PROOPS BROS. LTD *Open all day Saturday*
Dept. R, 52 Tottenham Court Rd. W1
Hours 9-6 p.m. *Thursday to 1 p.m.* *LANgham 0141*

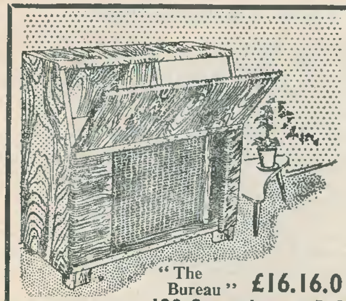
★ Specified Components for

THE BEGINNER'S TRANSISTOR RECEIVERS

J.B. .0005µF Variable Condensers	each 3/11
3-pole 2-way Switch	3/9
Chassis, ready drilled—	No. 1 1/6 No. 2 1/9
5-way Tag Strip	3d.
Junction Transistor	10/-
Repanco Coil Type DRR2	4/-
High Impedance Headphones	17/6

S.A.E. for free point-to-point wiring diagrams

RADIO EXPERIMENTAL PRODUCTS LTD
33 MUCH PARK STREET · COVENTRY



CABINETS & HI-FI EQUIPMENT

We can supply any Cabinet to your own specification

This ever-popular walnut bureau cabinet is veneered with the finest selected walnut and beautifully polished in a medium shade. Designed to accommodate any type of Automatic Record Changer, Tape Deck, Amplifier, chassis, etc., and to give generous storage compartments.
We can also supply and fit this or any cabinet with the latest Hi-Fi amplifiers, tuners, transcription units, record changers, speakers, etc.

Send for comprehensive illustrated catalogue of cabinets, auto-changers, speakers, etc., all available on easy H.P. terms.

LEWIS RADIO COMPANY
120 Green Lanes Palmers Green London N13 *Telephone* BOWes Park 1155/6

BOUND VOLUMES

A limited number of bound volumes (Vol. 9 only) are available,
price **£1.5.0.** *post free.*

DATA PUBLICATIONS LTD
57 MAIDA VALE LONDON W9
Telephone CUN 6141 (2 lines)

QUALITY COMPONENTS

in stock for the

MULLARD 3 VALVE AMPLIFIER
and

510 AMPLIFIERS, FM TUNER	circuits 3/6
912 AMPLIFIER, FM TUNER	" 4/-
RADIO CONSTRUCTOR FM	" 2/-
DENCO FM TUNER	" 1/6
G.E.C. "FM PLUS" TUNER	" 2/6

Price Lists available on request

J. T. FILMER MAYPOLE ESTATE BEXLEY . KENT
Telephone BEXLEYHEATH 7267

★ VALVES NEW TESTED AND GUARANTEED

1R5	7/6	6L6G	9/6	DL92	7/6	EK32	8/6
1S5	7/6	6Q7GT	8/6	DL94	7/6	EL32	7/6
1T4	7/6	6SA7	8/-	DL96	9/-	EL41	10/-
3S4	7/6	6SN7GT	8/6	EA50	1/6	EL84	10/6
3V4	7/6	6SS7	6/6	EB91	6/6	EY51	11/6
5U4G	8/6	6V6G	7/6	EBC41	9/6	EZ35	8/-
5Y4G	7/-	6V6GT	7/6	EBC33	8/6	EZ40	8/-
5Z4G	8/6	6X4	7/6	EBF80	10/-	GSL7GT	8/-
6AG5	6/9	6X5GT	7/6	ECC81	10/6	KT33C	7/6
6AM6	7/6	12AT7	9/-	ECC84	11/6	KT66	11/6
6AL5	6/6	12AU7	9/-	ECF82	11/-	PCF82	11/-
6AT6	8/-	12AX7	8/6	ECH35	9/-	PL81	10/6
6B8	7/6	35L6GT	9/-	ECH81	10/6	PL82	10/6
6B8G	7/6	807	6/9	ECH42	10/-	PY81	10/6
6BA6	8/6	5763	8/6	ECL80	10/6	PCC84	11/6
6BE6	7/6	DAF91	7/6	EF36	7/6	U76	8/6
6BR7	8/6	DAF96	9/-	EF37A	14/6	UBC41	10/-
6BW6	7/6	DF91	7/6	EF39	5/6	UCH42	10/-
6G6G	4/9	DF96	9/-	EF41	10/-	UF41	10/-
6J5G	5/6	DH76	8/6	EF80	9/6	UL41	10/-
6J5GT	6/6	DK91	7/6	EF85	10/6	UY41	8/-
6K7G	6/-	DK92	7/6	EF91	7/6	W76	8/6
6K8G	9/6	DK96	9/-	EF92	4/9	X65	10/6

Matched Pairs. EL84, **23/-**; 6V6G & GT, **17/-**; 6BW6, **18/-**; KT33C, **19/6**; KT66, **27/6**; 807, **14/6** per pair
P.P. OP. Transformers. 3 ohm for EL84, 6V6, 6BW6, **14/6**
Volume Controls. All values, long spindle. L/S **3/-**, SP **4/-**, DP **4/6**, ext. spkr. control, **3/-**
W.W. Pots. Pre-set **3/-**; 3W, long spindle **5/6**, SP **6/6**
P.M. Speakers, 3 ohm. 5" **16/6**, 6½" **17/6**, 8" **21/-**, 10" **25/-**, 12" **27/6**

★ **C.R.T. Isolation Transformers** with 25% boost. Low capacity, a.c. mains 200-240V. For 2V, 4V, 6.3V and 13V tubes. All **10/6** each; 1-1 for H.C. shorts **8/6**
Coaxial Cable. 75 ohm ¼" stranded, **8d.** yd; semi-air spaced, **9d.** yd; screened cable single and twin, **9d.** yd.
Coaxial Plugs 1/- each; **Sockets** 1/- each
Valveholders. 4, 5, 7 pin English and U.S.A. B7G, B9A, 1.0 Mc. B8G, **9d.** each; B7G, B9A with screening can, **1/6**. Aladdin formers ¼" with core, **8d.** each
2-Gang Condensers, .0005 small size, **6/6**
I.F. Transformers, 465 kc/s, small size, **7/6** pair
Capacitors, small mica, 5% 1pF to 100pF, **8d.**; 120pF to 1,000pF, **9d.**
Ceramic Capacitors, close tol. 500V for V.H.F., **9d.**
Paper Capacitors, tubular, .01, 1,000V, **1/-**; 0.1 to 0.5 500V, **10d.**
Paper Blocks, 4 mfd, 1,000V wkg, **2/3**; 2 mfd, 350V, **2/-**; 4 mfd, 350V, **2/6.** P. & p. 6d. each
Heater Trans. 200/240V, 6.3V, 1.5A, **7/6**
Resistors, ¼ and ½W, insulated, **4d.** and **6d.**; 1W, **8d.** 6W W.W., **1/-**; 10W, **2/-**
Electrolytics. Wire ends. 25/25V, **1/6**; 50/50V, **2/-**; 12/50V, **9d.**; 8/450V, **2/-**; 16/450V, **2/9**; 32/450V, **4/-**; 8+16/450V, **4/6**; can types: 16/450V, **3/6**; 32/500V, **6/6**; 32/450V, **6/6**; 20+20/450V, **4/6**; 64+120/275V, **7/6**
Wavechange Switches, midget: 1P 12W, 2P 6W, 3P 4W, 4P 3W, 4P 2W, long spindles, **4/6**
Toggle Swtiches. QMB, s.p.s.t., **2/-**; s.p.d.t., **3/3**; d.p.s.t., **3/6**; d.p.d.t., **4/-**
Chokes, 80mA 15H, **5/6**; 100mA 10H, **8/6**; 150mA 10H, **14/6**
Solder, Multicore, 4d. yd; Sleeving 2mm, **3d.** yd

Band III Converter Kits for all I.T.A. Transmitters. Complete kit of parts, including ready-wound coils, two EF80 valves, drilled chassis and wiring diagram. For a.c. mains 200-250V. **£3 10s. 0d.,** p. and p. 1/6
As above less power pack components. Power required, 200V 20mA, 6.3V 0.6A. **£2 5s. 0d.,** p. and p. 1/-
Teletron Band III Coil Set. Mk I **17/6**; Mk II **17/6**; Osmor Coil Set **17/6**
Aerials. Band I from **13/6**; Band II **17/6**; Band III **6/6**

Spares for Philips Radio and TV Receivers and most other makes supplied

P. and P. 6d. Over £1 post paid except where stated
R. COOPER G8BX 32 SOUTH END CROYDON SURREY CROYDON 9186

SMALL ADVERTISEMENTS

continued from page 501

TRADE

PANL, the air-drying black crackle paint. 3/6 per 1/8th pint can. G. A. Miller, 8 Kenton Park Crescent, Kenton, Mddx.

INCORPORATED Practical Radio Engineers home study courses of radio and TV engineering are recognised by the trade as outstanding and authoritative. Moderate fee to a limited number of students only. Syllabus of Instructional Text is free. *The Practical Radio Engineer*, journal, sample copy 2/-. 6,000 Alignment Peaks for Superhets, 5/-. Membership and Entry Conditions booklet, 1/-, all post free from the Secretary. I.P.R.E., 20 Fairfield Road, London, N.8.

BLUEPRINTS. High Gain 10 metre converter, with a de Luxe circuit comprising EF91 r.f. stage, ECC91 double triode mixer and oscillator, EF92 i.f. amplifier, with stabilised voltage supply via 7475, 1/8 post free with full instructions. Data Publications, Ltd., 57 Maida Vale, London, W.9.

MULLARD 3 valve, 3 watt, high fidelity audio amplifier, featured in April 1956 issue, full sized blue print, 2/8 post paid. Data Publications, Ltd., 57 Maida Vale, London, W.9.

ILLUSTRATED CATALOGUE No. 13 containing over 450 items of Government Surplus and Model Radio Control Equipment, 2/- post free. Refunded on purchase of goods, 2/6 overseas seamail. Arthur Sallis Radio Control Ltd., 93 North Road, Brighton. Telephone 25806.

LIMITED QUANTITY Superb Continental VHF/AM Radiogram Chassis, complete with 3 Speakers, Magic Eye, Internal Aerials, etc., £25. Details: Buttle, 177 Tentelow Lane, Southall, Mddx.

FREE: Brochure giving details in Home Study Training in Radio, Television, and all branches of Electronics. Courses for the hobby enthusiast or for those aiming at the A.M.Brit.I.R.E., City and Guilds, R.T.E.B., and other Professional examinations. Train with the college operated by Britain's largest Electronics organisation. Moderate fees. Write to E.M.I. Institutes, Dept. RC28, London, W.4.

JOIN THE INTERNATIONAL S.W. LEAGUE Free Services to members including Q.S.L. Bureau, Translation, Technical and Identification Depts.—both Broadcast and Fixed Stations, DX Certificates, contests and activities for the SWL and Transmitting members. Monthly magazine, "MONITOR," containing articles of general interest to Broadcast and Amateur SWL's. Transmitter page and League affairs, etc. League supplies such as badges, headed notepaper and envelopes. QSL cards, etc., are available at reasonable cost. Send for League particulars. Membership, including monthly magazine, etc., 15/- per annum. Secretary, ISWL, 86 Barrenger Road, London, N.10.

COILS, COILS, COILS. We can supply coils for all frequencies, r.f. chokes, etc. Send SAE for circuits and data. The Teletron Co., 266 Nightingale Road, London, N.9.

LEARN as you do it—we provide practical equipment combined with instruction in Radio, Television, Electricity, Mechanics, Chemistry, Photography, etc. Write for full details to E.M.I. Institutes, Dept. RC47, London, W.4.

Situations Vacant—see page 504

NEW SURPLUS...

1A3	4/6	6K7M	6/6	801A	10/6	EF91	7/-
1G6	5/6	6K8G	9/6	803	20/-	EF92	5/-
1A5	5/6	6K8M	10/6	805	30/-	EL32	4/-
1LN5	4/-	6H6M	3/6	807	6/6	EL41	10/-
1R5	9/-	6L6G	9/6	808	25/-	EL84	10/6
1S5	7/6	6L6M	11/6	813	60/-	EM80	10/-
1T4	7/6	6L7	7/6	830B	15/-	EY51	11/6
2A3	8/6	6Q7GT	8/6	866A	12/6	EZ40	8/-
2D21	8/6	6SA7M	7/6	955	5/-	EZ80	8/-
2X2	3/6	6SG7M	7/6	956	5/-	GZ32	10/6
3A5	9/6	6SJ7M	7/6	1625	5/6	HK24G	25/-
3D6	5/-	6SK7M	6/6	1626	5/6	KT33C	9/6
3A4	7/-	6SL7GT	7/6	1629	5/6	PCC84	10/6
3Q5GT	9/6	6SN7GT	6/6	DAF96	9/6	PCF80	12/6
3S4	8/6	6SQ7M	7/6	DF96	9/-	PCF82	11/-
3V4	8/6	6V6GT	7/6	DK96	9/6	PL81	11/6
5R4GY	10/6	6X4	6/6	DL33	9/6	PL82	9/6
5U4G	8/-	6X5GT	7/6	DL35	9/6	PL83	11/6
5Y4G	6/6	7B7	9/-	DL96	9/6	PCL83	12/6
5Z4G	9/6	7C5	9/-	EA50	1/6	PY80	9/6
6AC7M	5/-	7C6	9/-	EABC80	10/-	PY81	10/-
6AG5	3/6	7S7	9/6	EAF42	10/6	PY82	9/6
6AG7M	10/-	7Y4	8/6	EB91	7/-	R19	12/6
6AK5	5/-	12A6M	7/6	EBC41	10/6	SP61	3/-
6AL5	7/-	12AT6	8/-	EBF80	10/-	TT11	4/-
6AM6	7/-	12AT7	9/-	ECC82	9/6	U25	12/6
6AQ5	8/6	12AU6	9/-	ECC83	9/6	UAF42	10/6
6AT6	8/-	12AH8	12/6	ECC84	11/-	UBC41	10/6
6AU6	8/6	12BE6	8/6	ECC85	10/-	UCH42	10/-
6B8G	4/6	12C8M	7/6	ECF80	14/6	UF41	10/6
6BA6	8/6	12J7GT	9/6	ECH35	9/6	UY41	7/6
6BE6	7/6	12K7GT	9/-	ECH42	10/-	UL41	10/6
6BS7	7/6	12Q7GT	9/-	ECH81	10/-	VR105/30	
6BR7	11/6	12SC7M	2/6	ECL80	10/-		8/6
6BW6	8/6	12SK7M	7/6	EF36	4/-	VR150/30	
6C4	5/-	12SQ7M	8/6	EF37A	8/6		7/6
6C5M	5/6	12SR7M	7/6	EF39	5/-	VS70	3/-
6F6M	6/6	20L1	10/6	EF41	10/6	VS110A	4/6
6F8G	4/6	35L6GT	9/6	EF50	4/-	W77	5/-
6F13	12/6	35Z4GT	8/6	EF50(S)	5/6	XP1.5	3/-
6G6G	3/6	35Z5GT	8/6	EF55	7/6	Z77	7/-
6J5GT	5/-	42	7/6	EF80	9/-	9006	4/6
6J5M	6/-	50L6GT	8/6	EF85	10/-	EY86	13/6
6J6	4/-	80	9/-	EF86	12/6		
6K7G	5/6	446A	17/6	EF89	10/-		

Special prices quoted for following types in minimum quantities of 100 of a type: 6B8G, 6AK5, 6J6, 6AG5, TT11, EL32, 6K7G, 12SC7, 6AC7M, 6SN7, EF50(S), EF39.
Transistors (Red Spot) P.N.P. type, **10/-** each
Transmitter/Receiver Type 17, Mk. II. Complete with valves, high res. 'phones, hand mike and instruction book in strong cabinet. Brand new **55/-** carriage paid
Command Receivers BC454B. Range 3-6 Mc/s. Brand new with 6 valves, **45/-** carriage paid. **RF24 Units,** 20-30 Mc/s, new, **12/6** each, post paid
Resistance Unit Type 231 with 12 heavy duty (10" long) 80 ohm carbon non-inductive resistors. Just right for the antenna match. **27/6** each plus 5/- carr.
M.C. Meters 3¼" rd, fl. mtg. (2½" dial), 0-1 mA, **26/-**; 0-30 mA, 0-200 mA, 0-500 mA, 0-2A, **13/-** each; 0-150V a.c. (1 mA basic with rect.), **28/6**
Midget Mains Transformers (same size as std. spkr. o/p), input 230/250V, output 175V 25mA, 6.3V 0.6A. Ditto but 220V 20mA. Both types **11/9** each, post paid
Moulded Valveholders. B7G, B8A, B9A, int. octal, **9d.**; B9G cer., **1/-**; B7G, B9A with cans, **1/6**; B9A cer. with cans, **2/-**; B9A pax., **6d.**

Jason FM Feeder Unit (Fringe). All components, chassis, dial, etc., **£6**, or with 5 valves, **£7 . 15 . 0**

"PANL" Crackle Paint, 3/6 tin post paid

Post 6d. *Free over £1 except where stated*

JOHN ANGLIN
385 CLEETHORPE ROAD GRIMSBY LINCS
Telephone 56315

Errata—Technical Forum, Dec. 1956 issue. In Fig. 1, in the Record/Replay Head filter, two series-connected 47 pF condensers were shown connected in parallel with two series-connected resistors, one of which was given no value. Both resistors are 56 KΩ.

SITUATIONS VACANT

ENGLISH ELECTRIC VALVE CO. LTD.
CHELMSFORD

have opening for Electrical Engineer, Physicist or Chemist able to speak and to write fluently in Spanish; a similar knowledge of Portuguese is also desirable.

There is a non-contributory superannuation scheme and the Company will assist successful candidates to obtain suitable accommodation.

Please write to Dept. C.P.S., 336/7 Strand, W.C.2., quoting Ref. RC 1516A.

AERONAUTICAL INSPECTION SERVICE. Aircraft, Aero Engines, Radar, Wireless, Electrical and Instruments Divisions. Vacancies for examiners (unestablished) in the provinces, mainly in the West and West Midlands of England and at Henlow, Bedfordshire (Radar and Wireless only). Ordinary National Certificate in Mechanical or Electrical Engineering required for Aircraft, Aero-Engines and Electrical and Instruments Divisions; City and Guilds Intermediate Group Certificate in telecommunications engineering required for Radar and Wireless Divisions. Equivalent technical knowledge acceptable. Experience in industry or Service essential. Salary range £595–£742 (men). Prospects of promotion and establishment. No age limits. Application forms from Air Ministry S2 (g), Cornwall House (F.7), Stamford Street, London, S.E.1, or any Ministry of Labour and National Service Office (quoting Borough Order No. 3010/066.41).