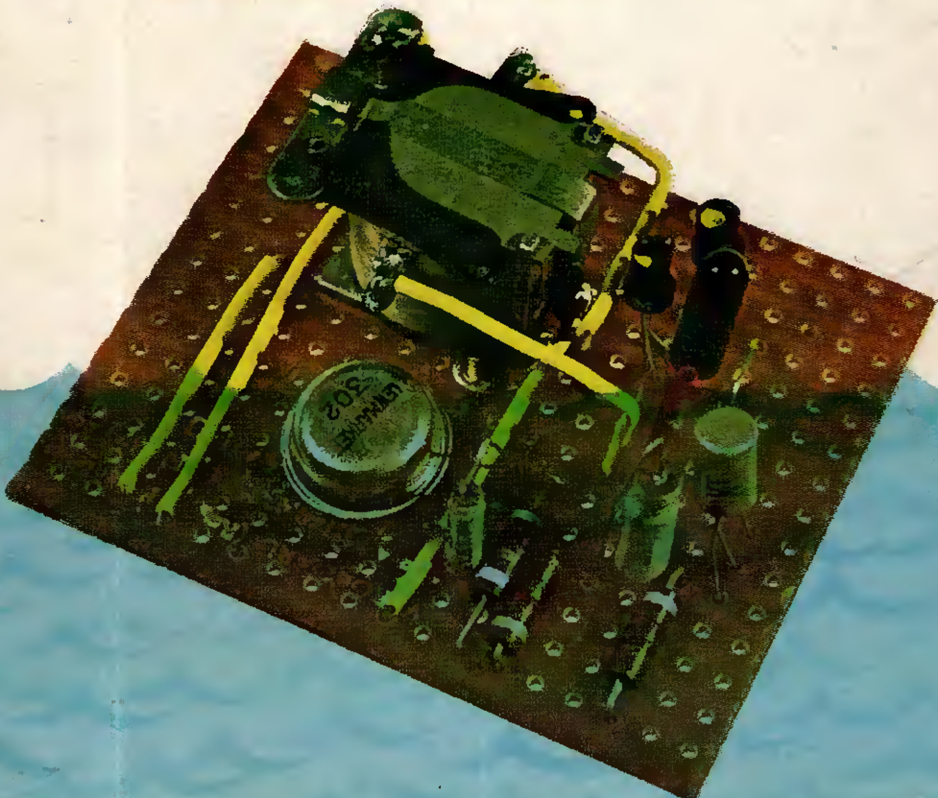
PRACTICAL ELECTRONICS

NOVEMBER 1967

PRICE 2/6

IN THIS ISSUE

WATER LEVEL ALARM



a useful device having many applications where level or presence of water needs to be indicated

Also: Full Details For Building:

"YODELLER" DOOR MONITOR

FUZZ BOX – EFFECTS UNIT FOR POP GROUPS

POCKET MULTI-METER

Size 3⅞ × 2⅛ × 1⅝in. Meter size 2⅛ × 1⅝in. Sensitivity 1000 O.P.V. on both A.C. and D.C. volts. 0-15, 0-150, 0-1000. D.C. current 0-150mA. Resistance 0-100k Ω. Complete with test prods, battery and full instructions, **42/6.** P. & P. 3/6., **FREE GIFT** for limited period only. 30 watt Electric Soldering Iron value 15/- to every purchaser of the Pocket Multi-Meter

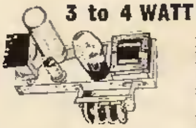
ANTI-THIEF CAR BURGLAR ALARM

The Melguard Safermatic consists of an electrical device housed in small metal box 4″ × 2″ × 1½″, which has been designed and developed to provide protection required by the average motorist at an economic cost. Using this system, an alarm and the immobilised condition is set automatically as soon as you park the car. Should you leave the key in the ignition, no one but you can drive the car away. Upon entering the vehicle the method of starting the car is by switching on the ignition, depressing two hidden switches and simultaneously operating the starter. Location of the switches is known only to you. Should the alarm be set off it can be stopped by following the normal starting procedure. For 12V operation. List price 79/6 our price 29/6 plus 2/6 P. & P. Full easy-to-follow instructions supplied.

EXTRACTOR FAN

AC Mains 230/250v complete with pull switch. Size 6″ × 6″ × 4″. Price 27/6 plus 5/- P. & P.

3 to 4 WATT AMPLIFIER



3-4 watt Amplifier built and tested. Chassis size 7 × 3½ × 1 in. Separate bass, treble and volume control. Double wound mains transformer, metal rectifier and output transformer for 3 ohms speaker. Valves ECC81 and 6v6. £2.5.0 plus 5/6 P. & P. The above in Kit Form, £1.14.6 plus 5/6 P. & P.

40W FLUORESCENT LIGHT KIT

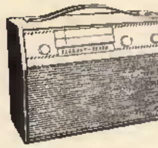
Incorporating GEC Choke size 8½″ × 1½″ × 1½″, 2 bi-pin holders, starter and starter-holder. 11/6. P. & P. 5/6.
Similar to above: 80 W. Fluorescent Light Kit incorporating GEC Choke size 11½″ × 1½″ × 1½″, 2 bi-pin holders, starter and starter holder 17/6. P. & P. 6/6.
Twin 40 W Choke instant start for 2 × 2 ft. tubes 17/6. P. & P. 5/6.

Special offer

ELEGANT SEVEN mk IIa

SPECIAL OFFER. Power supply kit to purchasers of 'Elegant Seven' parts, incorporating mains transformer, rectifier and smoothing condenser, A.C. mains 200/250 volts. Output 9v. 100 mA. 9/6 extra.

Buy yourself an easy to build 7 transistor radio and save at least £10.0.0. Now you can build this superb 7 transistor superhet radio for under £4.10.0. No one else can offer such a fantastic radio with so many de luxe star features.



ONLY £4.4.0
Plus 7/6 Post & Packing

★ De luxe wooden cabinet size 12½″ × 8½″ × 3½″. ★ Horizontal easy to read tuning scale printed grey with black letters, size 11½″ × 2″. ★ High 'Q' ferrite rod aerial. ★ I.F. neutralisation on each separate stage. ★ D.C. coupled push pull output stage with separate A.C. negative feedback. ★ Room filling output 350mW. ★ Ready etched and drilled printed circuit board back printed for foolproof construction. ★ Fully comprehensive instructions and point to point wiring diagrams. ★ Car aerial socket. ★ Fully tunable over medium and long wave, 168-535 metres and 1250-2000 metres. ★ All components, ferrite rod and tuning assembly mount on printed board. ★ 5″ P.M. Speaker. ★ Parts list and circuit diagram 2/6, free with parts.

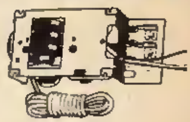
BSR TAPE DECKS

200/250 v. A.C. mains
Type TD2 Tape speed 3¾ twin track—£5.19.6.
Type TD10 2-track, 3 speed, plus rev. counter—£7.19.6.
Type TD10 4-track, 3 speed, plus rev. counter—£9.5.0.
P. & P. on each 7/6.

STAR SR 150 COMMUNICATION RECEIVER

Frequency range: 535 kc/s-30 Mc/s. 4 wavebands. 5 valve superhet. Incorporates BFO, bandspread tuning, "S" meter, external telescopic aerial and ferrite aerial. Built-in 4in. speaker. Easy-to-read dial. For 240v. A.C. operation. Complete, brand new, with full instruction manual. 15 gns. P. & P. 10/-.

TRANSISTORISED 1½ WATT AMPLIFIER



Incorporating Mullard transistors type: 2, AC128's, 2, OC75's and 2, AA129's. Separate bass and treble volume controls. Complete with Power Supply AC mains 240 v. Size 7½″ × 3½″ × 2″. Price 50/- plus 2/6 P. & P.

BSR MONARCH UA16 With FULL-FI HEAD

4-speed, plays 10 records, 12in., 10in. or 7in. at 16, 33, 45 or 78 r.p.m. Intermixes 7in., 10in. and 12in. records of the same speed. Has manual play position; colour, brown. Dimensions: 12½ × 10½in. Space required above baseboard 4¾in., below baseboard 2¾in. Fitted with Full-Fi-turn-over crystal head. £4.19.6. P. & P. 9/-.

FIRST QUALITY P.V.C. TAPE

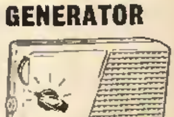
5¾″	Std.	850ft. ..	9/-	5″	L.P.	850ft. ..	10/6
7″	Std.	1200ft. ..	11/6	3″	T.P.	600ft. ..	10/6
3″	L.P.	240ft. ..	4/-	5″	T.P.	1800ft. ..	25/6
5¾″	L.P.	1200ft. ..	11/6	5¾″	T.P.	2400ft. ..	32/6
7″	L.P.	1800ft. ..	18/6	7″	T.P.	3600ft. ..	42/6
5¾″	D.P.	1800ft. ..	18/6	4″	T.P.	900ft. ..	15/-

P. & P. on each 1/6, 4 or more post free

600mW SOLID STATE 4-TRANSISTOR AMPLIFIER

Features NPN and PNP Complementary Symmetrical Output Stage. The elimination of transformers ensures maximum efficiency and frequency response. Automatic heat compensation. Combined AC/DC feed back. Class B output stage, i.e. output power is proportional to total current consumption, this ensures long battery life. Under no signal condition (IQ) current drain is approx. 12mA at 9 volts (4mA in the output pair). Printed circuit construction, size: 2¼″ × ⅞″ × ⅞″. Speaker output impedence 12 ohms. Output power 600mW at 5% distortion, 400mW at 2·5% distortion, 750mW at 10% distortion. Supply 9 volts. Total current consumption at a reasonable listening level approx. 35–40mA at full power (speech and music), average 65mA. Sensitivity for 50mW output is 10mW. Frequency response –3db points 90 c/s and 12 Kc/s. Price 15/- plus 1/- P. & P. 7″ × 4″ speaker to suit. 13/6 plus 2/- P. & P.

NEW Transistorised SIGNAL GENERATOR



Size 5¼″ × 3½″ × 1½″. For IF and RF alignment and AF output, 700 c/s frequency coverage 460 Kc/s to 2 Mc/s in switched frequencies. Ideal for alignment to our Elegant Seven and Musette. Built and tested. 39/6. P. & P. 3/6.

8-WATT 4-VALVE PUSH-PULL AMPLIFIER & Metal RECTIFIER

Size 9″ × 6″ × 1½″. A.C. Mains, 200-250 v. 4 valves. For use with Std. or L.P. records, musical instruments. All makes of pick-ups and mikes. Output 8 watts at 5 per cent of total distortion. Separate bass and treble lift control. Two inputs, with controls for gram. and mike. Output transformer tapped for 3 and 15 ohm speech coils. Built and tested. £4.4.0. P. & P. 11/-. 8″ × 5″ Speaker to suit. Price 14/6 plus 1/6 P. & P. Crystal Mike to suit 12/6 plus 1/6 P. & P.

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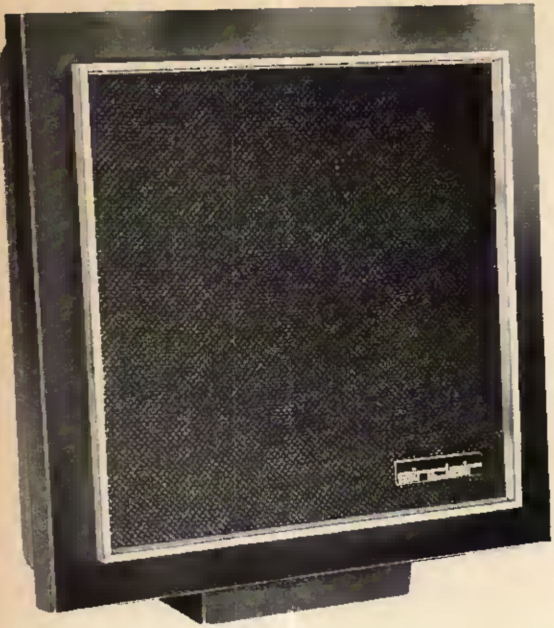
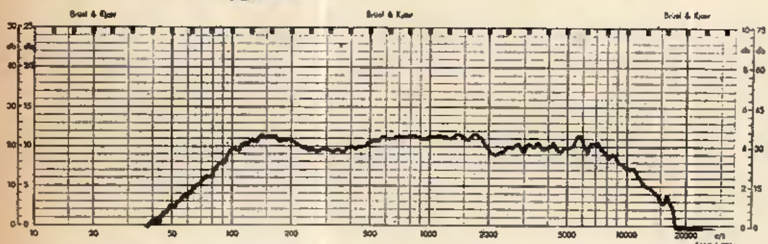
SINCLAIR Q.14



a no-compromise high-fidelity loudspeaker

- **ACOUSTICALLY CONTOURED SOUND CHAMBER**
- **BRILLIANT TRANSIENT RESPONSE**
- **15 OHMS IMPEDANCE**
- **MAXIMUM LOADING IN EXCESS OF 14 WATTS**
- **AN ALL-BRITISH PRODUCT**



The above curve was taken by an independent testing laboratory and shows clearly why the Sinclair Q.14 achieves such remarkable standards of reproduction. Level response is maintained to assure the user of the finest possible results from the equipment to which the speaker is coupled.

Note—curve taken against vertical 0-25 dB range and plotted on a log. scale.

THE MOST CHALLENGING DEVELOPMENT IN YEARS

CONSTRUCTION

The seamless sound, or pressure chamber and mounting baffle are of special high-density ultra-low resonance materials made possible by modern bonding and processing techniques to ensure freedom from spurious coloration.

LOADING

The Sinclair Q.14 has an input impedance of 15 ohms and will comfortably accept loading in excess of 28 watts music power, far greater than that required for average listening requirements.

FREQUENCY RESPONSE

As the independently made test curve shows, remarkably smooth response is maintained between 60 and 15,000 c/s.

DRIVER UNIT

This is a specially designed unit having exceptionally high compliance due to the method of cone suspension employed. It has a massive ceramic magnet of 11,000 gauss and aluminium speech coil, with the cone treated to ensure brilliant transient response.

CONTOURED PRESSURE CHAMBER

The shape of the sealed sound chamber has been determined mathematically to ensure forward sounding presence and freedom from directional effect. Connections at rear are marked for correct phasing.

SIZE AND STYLING

The Sinclair Q.14 measures 9¾in. square on its front face by 4¾in. deep from front to back. A separate base for free standing position is provided as well as a template for wall or flush mounting. A neat solid aluminium bar inset is used to embellish the front.

Listen to a Q.14. Hear it in your own home. Then marvel at its performance. The Q.14 is the result of long and thorough investigation into speaker design and behaviour in order to produce one which would outperform anything within pounds of its price and provide genuine high fidelity standards. How far we have succeeded can be seen from the independently taken test report. It compares excellently with loudspeakers over four times the price. The Sinclair Q.14 is uncommonly versatile, too. It can serve as a free standing unit for bookshelf, etc. as a corner radiator or flush mounted in a multi-unit assembly for P.A. or other heavy duty requirements. In stereo you could ask for nothing better and its design is such that the Q.14 is in keeping with every kind of domestic decor.

Ready to use and guaranteed. Money refunded if not satisfied. POST FREE

£6.19.6

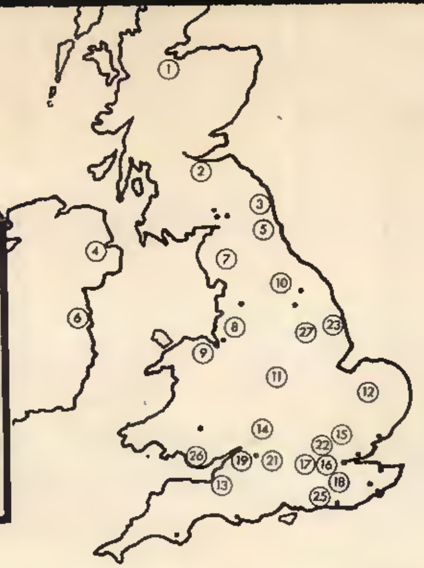
A GUARANTEED SINCLAIR PRODUCT

sinclair

Order form and more Sinclair designs—see next pages

SINCLAIR MICROMATIC

ACTUAL SIZE



The world's smallest radio

- $1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$
- SIX STAGE CIRCUITRY
- TUNES OVER M.W. WAVEBAND
- BANDSPREAD AND A.G.C. END OF TUNING
- AMAZING POWER AND RANGE

59/6 MICROMATIC KIT IN FITTED PACK with earpiece, instructions, solder, etc.

Ready built, tested and guaranteed. **79/6**

THE SET THAT PLAYS ANYWHERE

Until you use a Micromatic for yourself, you will never know how fantastically efficient the world's smallest radio is. We have received thousands of letters testifying to the staggering performance of this set, be it for quality, range, selectivity, sensitivity, long battery life or just playing in difficult places. We have letters galore to prove the excellency of this Sinclair design. That is why it is so fully guaranteed. You can build the Micromatic—an evening is sufficient—or buy it complete ready for use. The thing is to have one and prove for yourself too, how good this British product is.

USERS ALL OVER THE COUNTRY WRITE

From North, South, East and West enthusiasts for the world's smallest radio tell us of the wonderful results they get.

1 I was pleasantly surprised to find I was able to have it working in a few hours. W. J., Inverness

2 I would like to express my delight in the splendid sensitivity and quality. D.G.S., Edinburgh

3 I find it excellent in every way. W.A.S., Sunderland

4 We are very pleased with it. J.D.W., Belfast

5 Satisfactory results ... good compared to any other transistor of any size. L.W.S., Stockton-on-Tees

6 I have found reception is quite satisfactory. S.C., Dublin

7 I am very pleased with its performance. B.M.H., Cumberland

8 I am very satisfied with the kit. J.H., St. Helens

9 A fabulous little performer in every respect. D.C.M., Mold, Flint

10 A thoroughly reliable receiver. Performance is wonderful. H.S.M., Ripon, Yorks

11 Very pleased with the results. D.T., Kenilworth

12 Lost for words ... one of the most amazing inventions I have ever known. L.L., Norwich

13 Very pleased. J.M.H., Burnham on Sea

14 Amazed at such reception in these parts. K.T.R., Gloucester

15 The finish and quality is very good. N.P.C., Bishop's Stortford

16 Completed, and working extremely well. C.W., Harrow

17 Very pleased indeed with the Micromatic. D.M., Slough

18 Took only 5 hours to build and worked immediately. P.D., Reigate

19 The light programme came in better than a set costing £15. D.A.C., Bristol

21 Worked a treat. F.W., Banbury

22 Thank you for such a brilliantly designed little set. E.B.D., Epping

23 Fantastic reception from the Continent. T.G.S., Grimsby

25 Stations come in marvellously for such a difficult area. P.G.H., Brighton

26 A marvellous set to build and listen with. E.K.J., Swansea

27 Better than anything I could ever have imagined. W.T., Sheffield

SINCLAIR MICRO FM

7 TRANSISTOR COMBINED FM TUNER AND RECEIVER

Less than $3in \times 1\frac{3}{4}in \times \frac{3}{4}in$. F.M. Superhet using pulse counting discriminator for superb audio quality. Low I.F. makes alignment unnecessary. Tunes 88-108Mc/s. The telescopic aerial suffices for good reception in all but poorest areas. Signal to noise ratio—30dB at 30 microvolts. Takes standard 9V battery. One outlet serves for feeding to amplifier or recorder, the other allows set to be used as a pocket portable. Brushed and polished aluminium front, spun aluminium dial. A fascinating set to build which gives excellent reception by any standards. *Complete kit inc. aerial, case, earpiece and instructions.*

£5.19.6

NEEDS NO ALIGNING FASCINATING TO BUILD

FULL SERVICE FACILITIES AVAILABLE

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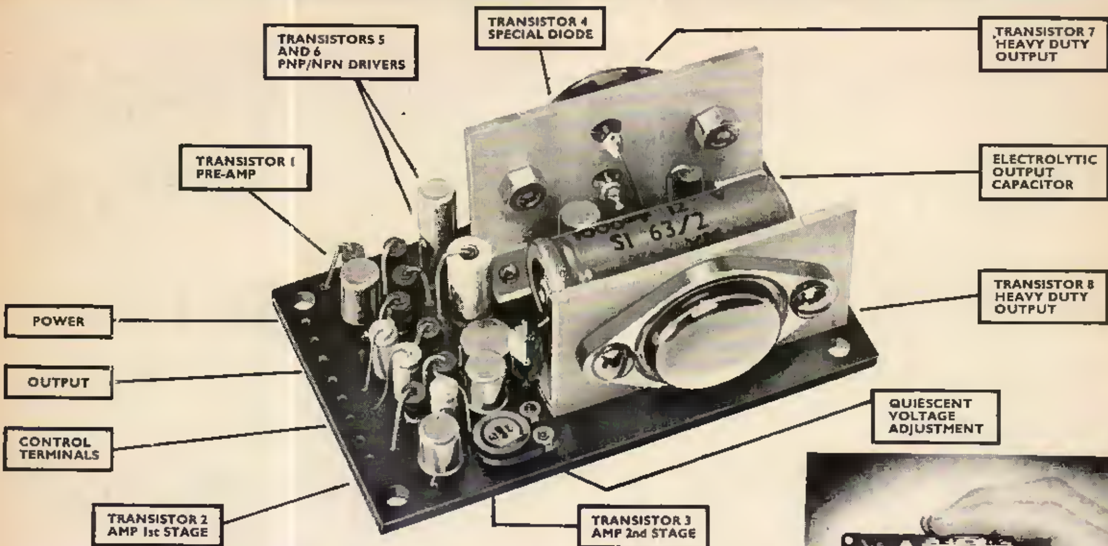
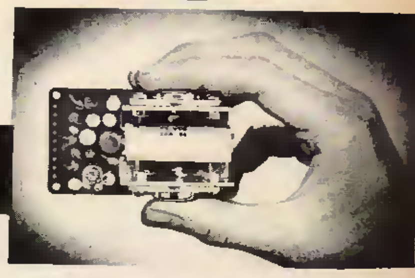
SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD, CAMBRIDGE OCA3-52996

THIS 12 WATT HI-FI AMP & PRE-AMP MEASURES ONLY 3" x 1¾" x 1¼"





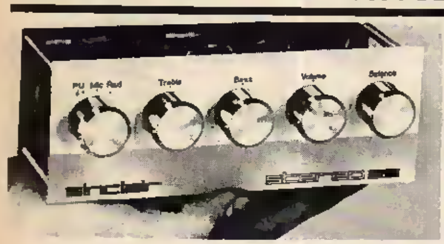
SINCLAIR Z.12

Because of its performance and very small size, the Z.12 has completely revolutionised the whole approach to transistor amplifiers. It proves beyond all question that high fidelity standards can be combined with very low price. No other amplifier in its field so successfully meets such a wide range of requirements. The Z.12 operates from any power supply between 6 and 20V d.c. Its output is suitable for any impedance between 1·5 and 15 ohms, making it suitable for any loudspeaker, including, of course, the Sinclair Q.14. It has facilities for matching to any type of conventional input, details of which are given in the Z.12 manual supplied. The most popular applications for the Z.12 are in mono or stereo hi-fi systems (two are needed for stereo), guitars, electric organs, car radios and P.A and intercom systems. Its characteristics make the Z.12 useful also in many kinds of experimental work.

- 12 WATTS R.M.S. CONTINUOUS SINE WAVE OUTPUT (24 W. PEAK)
- 15 WATTS MUSIC POWER
- 15-50,000 c/s ±1dB
- IDEAL FOR BATTERY OPERATION

READY BUILT, TESTED AND GUARANTEED **89/6**

USE IT WITH A SINCLAIR Q.14 SPEAKER



SINCLAIR STEREO 25

For use with two Z.12's or any good hi-fi stereo system. Frequency response 25c/s to 30 kc/s ±1dB connected to two Z.12's. Sensitivity Mic. 2mV into 50kΩ: P.U.—3mV into 50kΩ: Radio—20mV into 4·7Ω. Equalisation correct to within ±1dB on RIAA curve from 50 to 20,000c/s. Size 6¼in × 2¼in × 2¼in plus knobs.

Built, Tested and Guaranteed **£9.19.6**

GUARANTEE

Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full and at once without question.

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To remind you—

Sinclair Q.14 **£6.19.6**
Sinclair Z.12 **89/6**
Sinclair PZ.3 Mains Power Unit **79/6**
Sinclair Micromatic **£5.19.6**
Sinclair Stereo 25 **£9.19.6**
Sinclair Micromatic Kit **59/6**
Micromatic Built **79/6**

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INSTRUMENTS — HI-FI — RADIO — ELECTRONIC KITS

Treat yourself to superb LW, MW entertainment with the

High-Performance Car Radio Kit, CR-1

Complete your motoring pleasure with this small, compact, high-performance car radio. It can be fitted to any make of car, having a 12 volt positive or negative earth system. Tastefully styled in neutral grey with black knobs and chrome trim to harmonise with any car colour scheme.
Features include: Six-transistor, 2-diode circuit. Completely pre-assembled and aligned tuning unit. High sensitivity, combined with wide range automatic gain control (AGC), minimises fading under weak reception conditions. Easy-tune dial. Push button Long, Medium and Tone selection.

The car radio is available for your convenience, in two separate units; RF Amplifier Kit CR-1T **£1 . 13 . 6** incl. P.T., IF/AF Amplifier Kit CR-1A **£11 . 3 . 6.**

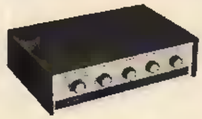
TOTAL PRICE KIT (excluding Loudspeaker) **£12 . 17 . 0** incl. P.T.
8″×5″ Loudspeaker Pt. No. 401-505 **£1 . 16 . 1** incl. P.T.

NEW! Portable Stereo Record Player, SRP-1

Automatic playing of 16, 33, 45 and 78 rpm records. All transistor—cool instant operation. Dual LP/78 stylus. Plays mono or stereo records. Suitcase portability. Detachable speaker enclosure for best stereo effect. Two 8″ × 5″ special loudspeakers. For 220-250v A.C. mains operation.
Compact, economical stereo and mono record playing for the whole family—plays anything from the Beatles to Bartok. All solid state circuitry gives room filling volume.

Kit **£27.15.0** incl. P.T. Assembled price on request.

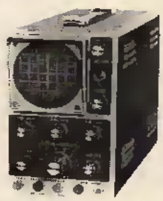
Low-cost Stereo Amplifier, TS-23



Breaks the price barrier in quality Transistor Amplifier cost. Incorporates all the essential features for good quality reproduction from gramophone records, radio and other sources.
Its many features include: 3 watts rms (15Ω) each channel. Good frequency response for outstanding fidelity. Compact slim-line styling. Ganged BASS, TREBLE and VOL. controls, 6-position SELECTOR switch for programme sources. Attractive perspex two-tone front panel. 16 transistor, 4 diode circuit. Handsome fully-finished walnut veneered cabinet. Outputs for 8 or 15 ohm loudspeakers. Printed circuit boards. For free-standing or cabinet mounting. Size 3¼″ × 13″ × 8″ deep.

Kit **£17.15.0.** Walnut veneered cabinet £2.0.0 extra.

A 3″ Service Oscilloscope Kit with outstanding features. Model OS-2



The attractively styled OS-2 is a compact, lightweight, portable oscilloscope that fulfills many of the general requirements in Laboratories, Service Departments and Educational Training. It is ideal for use in production line testing where otherwise expensive equipment would be tied up on ordinary routine tests. The bandwidth of the OS-2 is from 2 c/s-3 Mc/s ± 3dB, this 'scope can therefore be used in applications ranging through audio, ultrasonic and radio frequencies. The time base operates from 20 c/s to 200 kc/s in four ranges. Size 5″×7¼″×12″ deep. Weight 9¾ lb.

Kit **£23 . 18 . 0.** Assembled **£31 . 18 . 0**
Optional extra L/Cap Probe Kit, PK-1 Kit **£3 . 12 . 6**

NEW! Transistorised AM-FM Stereo Tuner

In the same attractive styling as our well-known AA-22U Stereo Amplifier. Features 18 transistor, 3 diode circuit. AM-LW/MW, FM Stereo and Mono tuning. Stereo indicator light. AFC, AGC. Pre-assembled and aligned FM unit. Separate AM and FM circuit boards. Self-powered. Handsome, finished walnut veneered cabinet. (Optional extra).
Comprising: Model AFM-2T RF Tuning Unit. Kit £7.17.6 including P.T. AFM-2A IF Amp. and power supply kit £24.9.6. **TOTAL PRICE KIT £32.7.0** incl. P.T.
Cabinet £2.5.0 extra.

Many other models in wide range.
Prices quoted are Mail Order, Retail Prices slightly higher.
Full specification sheets of any model available upon request.

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Over 150 models: Hi-Fi, Audio Speaker systems, Intercom, PA Guitar amplifiers, Amateur Radio, Educational, Transistor radios, Test and service instruments. Many shown in full colour.

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NEW MODEL 500. 30,000 o.p.v. With overload protection, mirror scale. 0/.5/1/2.5/10/25/100/250/500/1,000v. D.C. 0/2.5/10/25/100/250/500/1,000v. A.C. 0/50μA/5/50/500mA. 12 amp. D.C. 0/60K/6 Meg./60. Meg Ω. £8/17/6 Post Paid.

PROFESSIONAL 20,000 o.p.v. LAB. TYPE MULTITESTER

With automatic overload protection, mirror scale. Ranges: 1/10/50/250/500/1,000 volts, D.C. and A.C. 0-500 μA, 10 mA, 250 mA. Current: 0/20 K, 200 K, 2 megohm. Decibels — 20 to + 22db. £5/10/. P. & P. 2/6.

TE-900 20,000Ω/VOLT GIANT MULTIMETER 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 V. A.C. 0/25/12.5/10/50/250/1,000/5,000 V. D.C. 0/50μA/110/100/500 mA/10 amp. D.C. 02K/200K/20 Megohm. £12/19/6. P. & P. 5/-.

MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0·7-0·9967, B: 5-200, Ico: 0-50 microamps, 0-5 mA. Resistance for diode 200Ω — 1 Meg. Supplied complete with instructions, battery and leads. £5/19/6. P. & P. 2/6.

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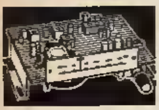

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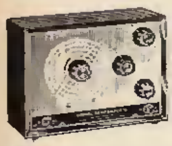

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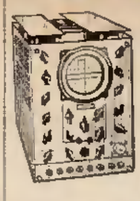

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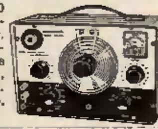

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500μA	25/-	1mA	22/6	750mA.	22/6	500V D.C.	22/6
50-0-50μA	29/6	2mA	22/6	1A D.C.	22/6	750V D.C.	22/6
		5mA	22/6	2A D.C.	22/6	15V A.C.	22/6
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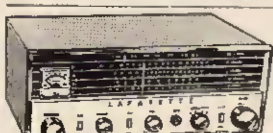

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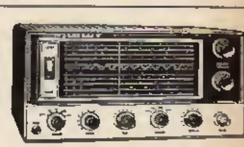

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VOL. 3 No. 11
NOVEMBER 1967

PRACTICAL ELECTRONICS

JUST A SIMPLE DEVICE

SIMPLE and relatively inexpensive electronic devices tend often to be overshadowed by more complex and elegant examples of the designer's art. Consequently some of the most rewarding and easiest ways for exploiting electronic techniques can be overlooked or neglected by the amateur. Let us consider one case which well illustrates this point.

The electronic relay type of device is certainly one of the simplest of projects to construct, yet its value as a practical aid of everyday utility cannot be overestimated. The possible applications for such a device are limitless. With the appropriate sensing element, for example, a phototransistor, thermistor, or some electromechanical probe or transducer, circuits can be devised to produce an electrical response from a specific physical effect occurring in a chosen locality.

Such an arrangement of course forms the basis of the great range of detecting and measuring instruments which are usually quite elaborate in design and offer many facilities. But here we are considering only the elementary form of circuit which reacts to a particular change in the atmosphere by operating an electromagnetic relay. The relay contacts can be applied to whatever purpose is required: to operate a lamp or bell, or (via suitable ancillary circuits) electrical power machinery.

It should be apparent that this modest kind of electronic device employing perhaps three or four transistors, a similar number of resistors, and a miniature relay, and operating usually from a small low voltage battery, offers countless possibilities to the imaginative amateur. Plenty of scope here for experimenting with transducers, while the "output end" presents further opportunity for exercising personal ingenuity in the manner in which the resultant relay operation is put to good effect.

This month we are describing an electronic relay device designed to respond immediately water or other liquid contacts a simple twin-wire probe. Essentially uncomplicated in design and economical in components, this Water Level Alarm will perform reliably many useful and important functions. A few applications are suggested in the article, and doubtless further ideas will spring to the minds of our readers—now that we have supplied a trigger pulse.

THIS MONTH

CONSTRUCTIONAL PROJECTS

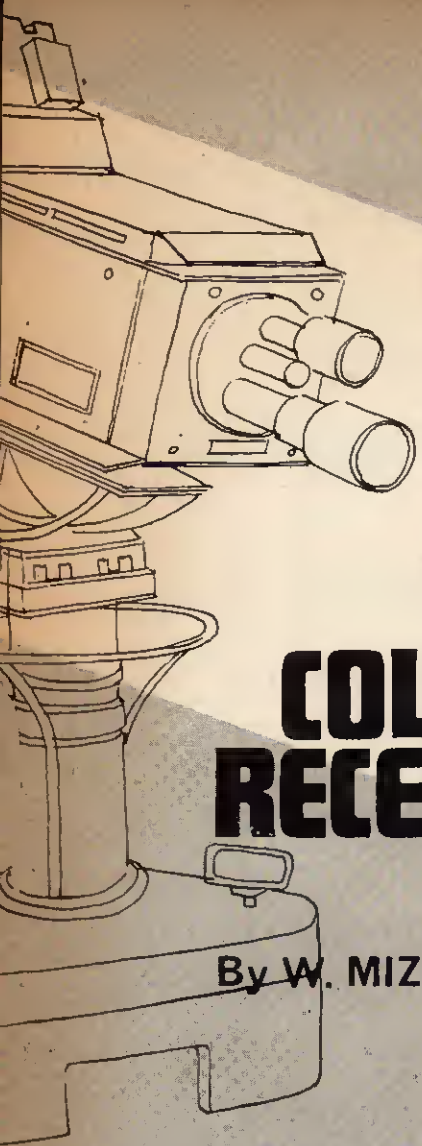
SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our December issue will be published on Friday, November 17

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., 15/17 Long Acre, London, W.C.2. Phone: 01-836 4363. Telegrams: Newnes London. Subscription Rates including postage for one year, to any part of the world, 36s.



This article is presented as an introduction to the basic principles involved in the PAL colour television system which is now being used in this country.

It is not intended to cover the more scientific aspect of the subject, but it is levelled as an introduction to the practical television engineer.

THE COLOUR RECEIVER

By W. MIZON

COLOUR as perceived by the human eye can be measured in frequency and wavelength within the visible light spectrum (see Fig. 1a).

The frequency of colour is extremely high by comparison with that used for conventional television and radio broadcasting, so much so that it becomes too cumbersome for general use. To give an example, a green colour can be said to have a frequency of something in the order of 520×10^6 MHz. It is easier, therefore, to speak of colour in terms of wavelength.

These wavelengths are, of course, too small to be measured in meters, centimeters, or even millimeters, and so for colour the millimicron (mμ) has come into use as a regular unit in the metric system and equals one billionth of a meter. Thus, when we speak of a wavelength of blue light it would be in the order of 400 millimicrons (1/62,500 inch) (see Fig. 1b).

The limits of the visible spectrum used for colour television are between 400 millimicrons (blue) and 700 millimicrons (red) (see Fig. 1c).

By means of a complicated process related to the construction of the retina in the eye, these colour wavelengths stimulate the optical nerve and are transmitted to the visual centres of the brain which senses the colour. It is not yet possible to explain this phenomenon but it is thought that the "cones" of the retina are of three different kinds, being mainly sensitive to green, red, and blue light respectively.

Experiments and studies carried out over the years have established that white light can be created by combining the three primary colours in the correct proportion. Hence, these colours are known as *additive* primary colours.

It is also known that by combining these three colours in other proportions, or any two of them, the greatest variety of other colours can be seen by the human eye. This condition more than anything else accounts for the selection of these primaries for colour television. As a matter of interest, there are said to be as many as 35,000 different variations of colour which can be "matched" with the basic colours of the visible spectrum.

Fig. 1a. Complete electromagnetic frequency spectrum

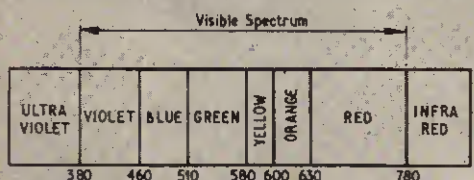


Fig. 1b. Visible light spectrum in millimicrons

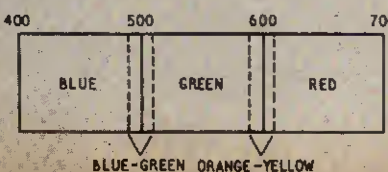


Fig. 1c. Practical colour range for television

COMPATIBILITY

Before commencing on the techniques employed, our first consideration should be that of compatibility meaning that colour transmissions are receivable in black and white on monochrome receivers, and that the colour receiver is capable of reproducing standard transmissions in black and white.

In colour receivers, the r.f. and i.f. circuits are basically similar to those employed in a monochrome receiver, but the requirements for the greatest fidelity in colour reception will dictate that the high frequency channels (video, r.f., and i.f.) will have to be responsive to their maximum specified bandwidth.

As the function of the tuner unit employed for monochrome reception will serve for colour reception, it is evident that a u.h.f. aerial system, at present employed to receive programmes on 625-line transmission in monochrome, will be suitable for colour reception. The same will apply should it ever be decided to transmit colour programmes on 625 lines, in the v.h.f. spectrum.

Colour transmission techniques are necessarily far more complex than those required for monochrome transmission. The colour television camera is made up of three basic units (see Fig. 2a). Each unit lens is fitted with a colour filter, so that it will only detect one of the red, green, or blue colours of the scene. The output of these units is combined to give the brightness or luminance signal level, known as Y.

To receive colour pictures it is essential that additional information is transmitted to give references to the colour content of the picture. This information is governed by the three basic proportions of coloured light: brightness, hue, and saturation.

BRIGHTNESS

Brightness, or luminance, is an indication of the quantity of light reflected or projected to the eye. In monochrome pictures degrees of brightness may range from zero (black) up through all shades of grey to pure white. A pure white object radiates or reflects all white light striking it while a black object reflects none.

The sensitivity of the human eye varies between different colours. In other words, some colours would appear to be "brighter" than others when projected with equal power. A large number of measurements of subjective human response have been made and the result averaged to produce a standard characteristic.

The sensitivity factor has been determined as follows: Red 30% (0·3r); Green 59% (0·6g); Blue 11% (0·1b).

Each camera unit is, therefore, attenuated to give the correct illusion (see Fig. 2b). If the separate units are given an equal output of say, 1V, the luminance (or brightness) signal will be $Y = 0{\cdot}3r + 0{\cdot}6g + 0{\cdot}1b$.

It is also established that these colours in this proportion will yield white light and subsequently this arrangement will serve for transmission in monochrome.

HUE

The hue or chrominance of an object is the actual colour—red, green, or blue. Such distinctions as light or dark when applied to a given colour do not change the hue. Colours which belong to the same family have the same hue. For example, light pink and dark red are the same hue, and fall into the same category relative to hue, namely, red. Light blue, dark blue, deep blue, all have the same hue, namely blue. Yellow is a hue; greenish yellow, light yellow, chrome yellow, all fall into the same category, namely, yellow.

SATURATION

The saturation of a colour is a measure of its dilution with white light and the degree of saturation will determine the shade or the tint of the colour. A fully saturated colour contains no white light and degrees of saturation applied to a colour will, therefore, determine the redness, blueness, and greenness.

Thus, these three factors, brightness, hue, and saturation, enable the eye to distinguish between colours and to receive colour pictures it will follow that information must be transmitted with reference to these three factors.

In the PAL system the luminance signal (Y) occupies the whole bandwidth of the video channel and provides

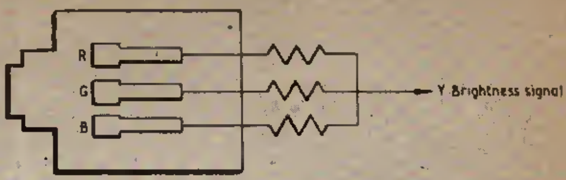


Fig. 2a. Three basic colour units in the camera

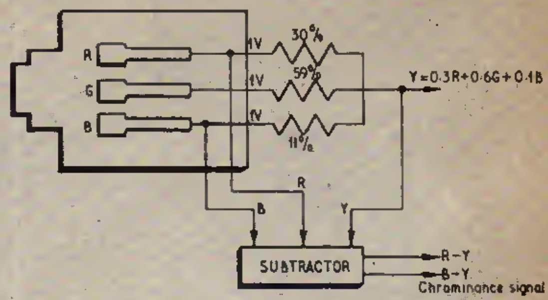


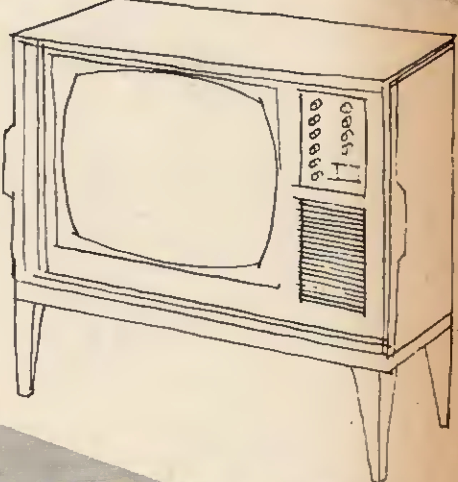
Fig. 2b. Attentuation to each colour to provide chrominance signals

information on the brightness of the transmitted picture.

The colour information that refers to hue and saturation is transmitted in the form of two chrominance signals (see Fig. 2b) and modulate a subcarrier in both amplitude and phase so that at any instance information is transmitted on the hue and saturation of the picture being scanned.

These chrominance signals are referred to as (R − Y) and (B − Y) and by mathematical formula will give reference to the colour information required.

The formula shown in Table 1 applies to all of the colours that can be "matched" from the three basic primaries; the collective information is transmitted on the two chrominance signals.



The total of (R − Y) and (B − Y) in every instance is used to determine the vectors of the subcarrier.

The hue is determined by the phase of the subcarrier and the saturation by the amplitude. This, together with the luminance signal (Y), completes the information required for colour pictures.

It will be noted that in the case of white, which we have already established as being made up of

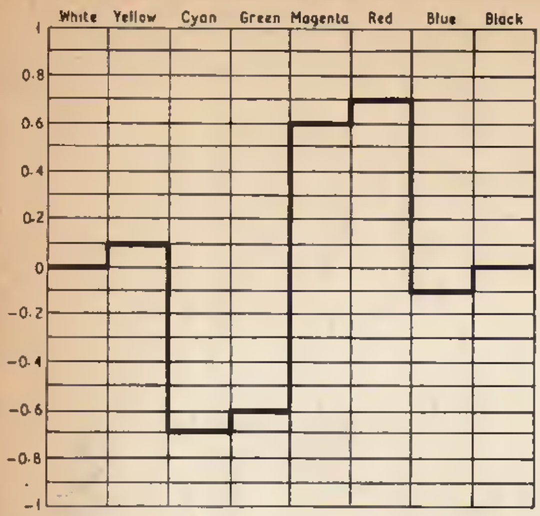


Fig. 3. (R — Y) waveform through the light spectrum

Table 1: FORMULA FOR R — Y AND B — Y VALUES

Red = 1 Blue = 1 Y = 0·3r + 0·6g + 0·1b

Colour		Y	R — Y	B — Y
White	(R + G + B)	1	0	0
Yellow	(R + G)	0·9	0·1	−0·9
Cyan	(G + B)	0·7	−0·7	0·3
Green		0·6	−0·6	−0·6
Magenta	(B + R)	0·4	0·6	0·6
Red		0·3	0·7	−0·3
Blue		0·1	−0·1	0·9
Black		0	0	0

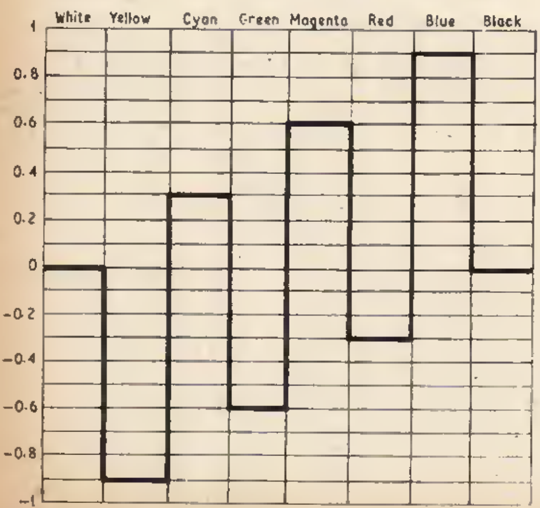


Fig. 4. (B — Y) waveform through the light spectrum

0·3r + 0·6g + 0·1b, the (R — Y) and (B — Y) is at zero level. Therefore, in the absence of the chrominance signals it is evident that the picture will be received in monochrome.

Reference to Figs. 3 and 4 will give a typical waveform reproduced by the (R — Y) and (B — Y) signals respectively for a picture composed of the colour bars in general use for test purposes.

These waveforms can be related to the formula shown for the appropriate colours in Table 1.

THREE-GUN TUBE

Since experiments with colour television have been carried out, many different systems employing various techniques have been tried to reproduce an acceptable colour picture. One type of picture tube using a single gun has been the subject of considerable experiment in America, but as yet, cannot be produced in commercial quantities. It is identified as the Lawrence "Chromotron", and may at some future date become a commercial possibility.

However, only one basic design has been produced so far which offers a practical solution to the many problems involved, and this is generally referred to as the "Shadowmask" tube. The ingenious method of actually producing this tube together with a fully simultaneous system which has been developed to almost perfection, will meet all possible requirements for many years to come.

The Shadowmask tube employs three guns which provide the three primary colour light sources (see Fig. 5a).

Each gun is identical in construction and consists of three parallel electron beam assemblies built into a single unit. In each gun, grid no. 1 is the control electrode which controls the intensity of the beam as in a monochrome tube; grid 2 is an accelerator electrode; grid 3 is the main focusing element. Actually, the electric field between grids 3 and 4 provides a focusing effect. Grid no. 4 is called the "convergence electrode".

The convergence electrode for each gun is a small diameter cylinder externally connected to the ultor (an aquadag coating on the inside of the tube) and is operated at about 25,000 volts from a regulated power supply. In addition to these electrodes there are beam-converging pole pieces fitted just in advance of the exit aperture of each gun.

When an additive colour system is in use only three primary colours (red, blue, green) are needed for good colour reproduction of large area segments of the picture. The eye is not particularly colour sensitive to fine detail, and this aspect may be reproduced in monochrome with no apparent loss in the colour value of the overall picture.

Thus, a tri-colour picture tube requires good three colour primary reproduction for large areas, but needs only good black and white response to satisfy the requirement for fine detail. The three luminophors or phosphors which emit light in the primary colours are applied to the face plate of the tube in the form of small dots, in such a way as to constitute a regular system of small triangles or "triads".

These phosphors are caused to glow in the primary colours when excited by a high velocity electron beam. With the recent application of rare earth phosphors, the range of colours produced has been found superior to everyday commercial (printing) colour reproduction.

The diameter of each dot is about 0·42mm and the dots are 0·72mm apart. At normal viewing distance these dimensions are so small that the resolving power

SHADOWMASK TUBE

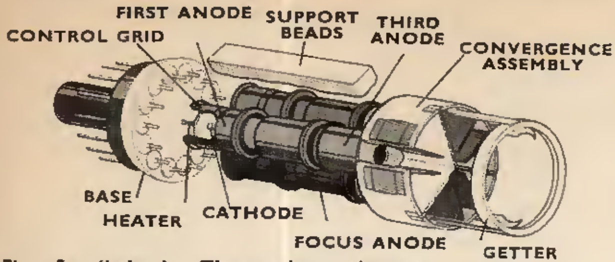


Fig. 5a (below). Three-colour electron gun assembly

Fig. 5b (above). Sectional view of a Mazda colour receiving tube with enlargements inset of a section of the Shadowmask and screen

ELECTRON GUN ASSEMBLY

HEATER—High resistance tungsten coated with alumina to insulate it from cathode.

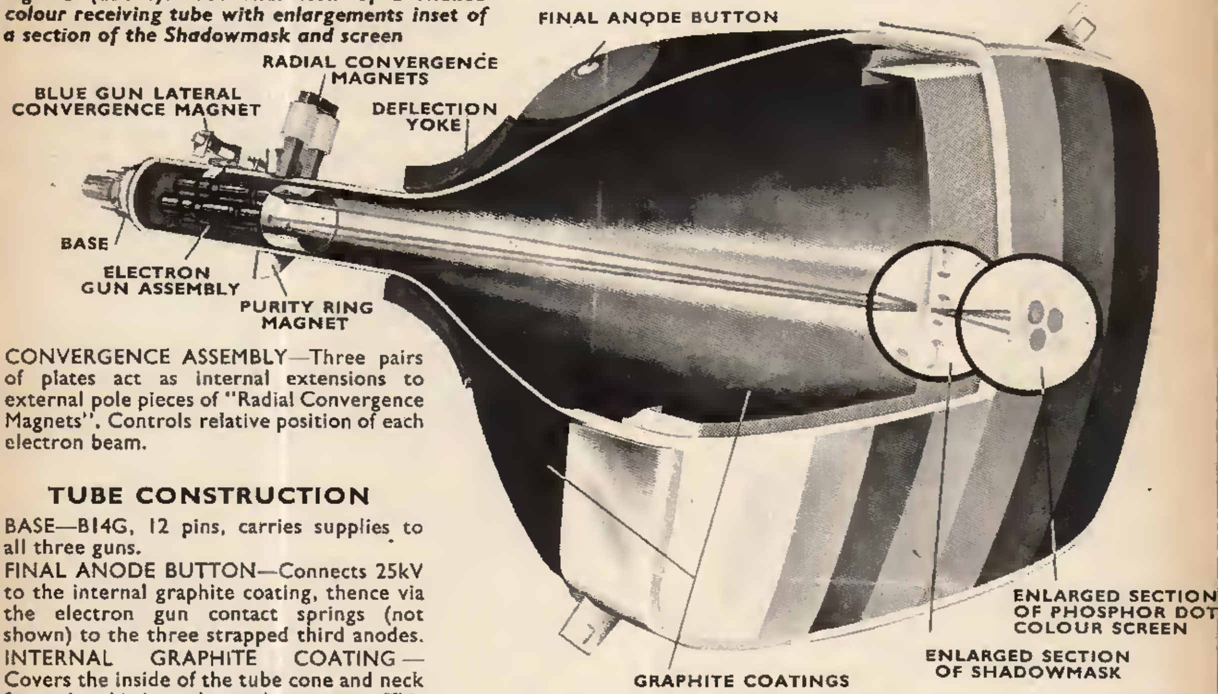
CATHODE—Nickel alloy cylinder protrudes through a ceramic insulating disc. End of the cylinder coated with oxides of barium, strontium, and calcium to aid emission.

CONTROL GRID—Closed-end metal cylinder with small hole in the end plate. Beam current controlled by p.d. between cathode and grid to give correct instantaneous mixture of colours at the screen. (0 to − 150V).

FIRST ANODE—Attracts the electron beam forward from the cathode. (200 to 500V).

FOCUS ANODE—In conjunction with first and third anodes, creates two electrostatic lenses. Operating voltage (5kV) controls and focuses the electron beam.

THIRD ANODE—Accelerates electrons to a very high velocity (200 million miles per hour). (25kV).



CONVERGENCE ASSEMBLY—Three pairs of plates act as internal extensions to external pole pieces of "Radial Convergence Magnets". Controls relative position of each electron beam.

TUBE CONSTRUCTION

BASE—B14G, 12 pins, carries supplies to all three guns.

FINAL ANODE BUTTON—Connects 25kV to the internal graphite coating, thence via the electron gun contact springs (not shown) to the three strapped third anodes.

INTERNAL GRAPHITE COATING—Covers the inside of the tube cone and neck from the third anode to the screen. This coating (sometimes called the Fourth Anode) encloses the post-deflection electron paths by one potential. Avoids electrostatic fields set up by nearby current carriers, hence illiminates spurious unwanted beam deflection.

EXTERNAL GRAPHITE COATING—Coating on outside of tube cone connected to chassis; isolated from final anode button. Acts with the internal coating as a high voltage smoothing capacitor.

SHADOWMASK—Steel sheet 0·006in thick, perforated with more than ½ million etched holes 0·012in diameter, one hole for each triad of phosphors. Positioned ½in from the screen. Aids convergence and alignment of colour beams on the correct colour phosphors.

COLOUR SCREEN—Phosphor dots deposited by photographic techniques. Three different phosphors emit three different colours when bombarded by electrons. Screen is backed by aluminising to maintain the screen at one potential and reflect light towards the viewer; protects the phosphors from ion burn.

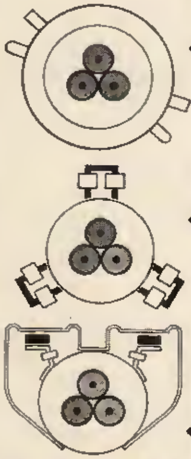


Fig. 5c. External neck components shown looking at the end of the tube neck

EXTERNAL DEFLECTION MAGNETS

PURITY RING MAGNET—Double ring magnet adjusted by contra-rotation of the tabs. Bends all three beams to permit small variations in the angles at which the beams arrive at the Shadowmask, so that only the right colours strike the right phosphor dots. Only suitable for colour purity in centre area of the screen. Purity over outer areas achieved by moving the deflection yoke along the tube neck.

RADIAL CONVERGENCE MAGNETS—Align the three beams so that they all coincide exactly on passing through the Shadowmask.

Static convergence, by adjusting the three radial convergence permanent magnets, applied to the centre area of the screen.

Dynamic convergence, by adjusting the three separate pairs of electromagnets, applied to the outer area of the screen. Waveforms are fed by the line and field scanning circuits.

BLUE GUN LATERAL CONVERGENCE MAGNET—Deflects the blue beam in a lateral direction. Final adjustment to blue convergence is made with the "blue lateral" permanent magnet.

DEFLECTION YOKE—Contains line and field scanning coils to scan all three beams simultaneously in a 625-line raster.

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or visual acuity of the eye is insufficient to distinguish either the individual dots or the triads. For different luminous intensities of the three phosphor dots in the triads, the eye cannot distinguish the different colours of light, but (and this is the essence of the system) only the result of additive mixing of the colours.

It will now follow that the three electron beams modulated respectively with the R, G and B signals, and passing over the triads in their normal scanning motion across the screen, must be made to pick out one of the required colour dots from each group of triads.

This is the function of the Shadowmask, a metal screen which is mounted a short distance behind the face plate of the tube and has an array of closely spaced holes equal in number to each triad of dots on the screen. Each hole is accurately aligned with respect to each triad of dots (Fig. 5b) and the function of the Shadowmask is to guide the electron beams to a selected group of phosphor dots during the scanning process.

CONVERGENCE

There now remains the need to control the electron beams so that in scanning the screen, only the beam from the appropriate gun reaches the proper individual colour dot of a triad. This is achieved by "convergence", a rather complicated arrangement of weak magnetic fields which is described later.

The precision and accuracy required in the manufacture of the Shadowmask tube is extremely critical as the holes in the mask must line up with the colour triads over the entire face of the tube. To understand fully the magnitude of this feat of engineering it should be appreciated that there are as many as 300,000 holes in the Shadowmask of a 25in colour picture tube, corresponding to something like a million individual colour dots in groups of three.

The method used in production ensures accuracy by using as a basis the Shadowmask itself, complete with perforations, to group the phosphor dots on to the tube face. This mask is manufactured from a photographic reproduction, many times reduced, of a carefully prepared large scale drawing, this being followed by an etching process, initially flat. The mask is then pressed to its ultimate slightly spherical form.

Precision equipment is used to position it accurately with respect to the tube face, which is the actual position it will occupy in the finished tube. One of the phosphors, for example the red one, will have been applied in emulsion form to the face of the tube in a uniform layer.

The assembly apparatus incorporates a point-source of illuminant mounted exactly in the position at which the theoretical deflection will later occur, i.e. when the tube is finally assembled. Thus, the mask fulfills its function for the first time by causing the light passing through its perforations to fall exactly on those points on the emulsion which will be struck by the red beam.

As a result of this irradiation, the emulsion is converted photo-chemically and, by a subsequent process that can be compared with the development of photographic material, the emulsion at those places which received no light is dissolved and washed away, leaving only the red dots as a regular pattern on the tube face plate.

This process is repeated for the green and the blue dots, the beam being directed each time at the point where the respective deflection will finally take place.

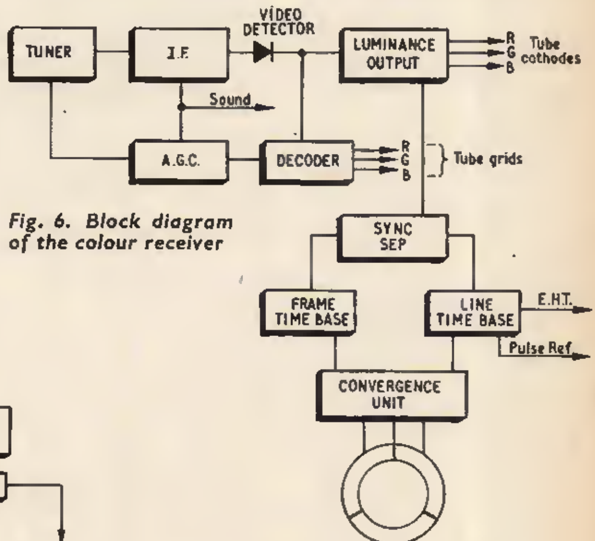


Fig. 6. Block diagram of the colour receiver

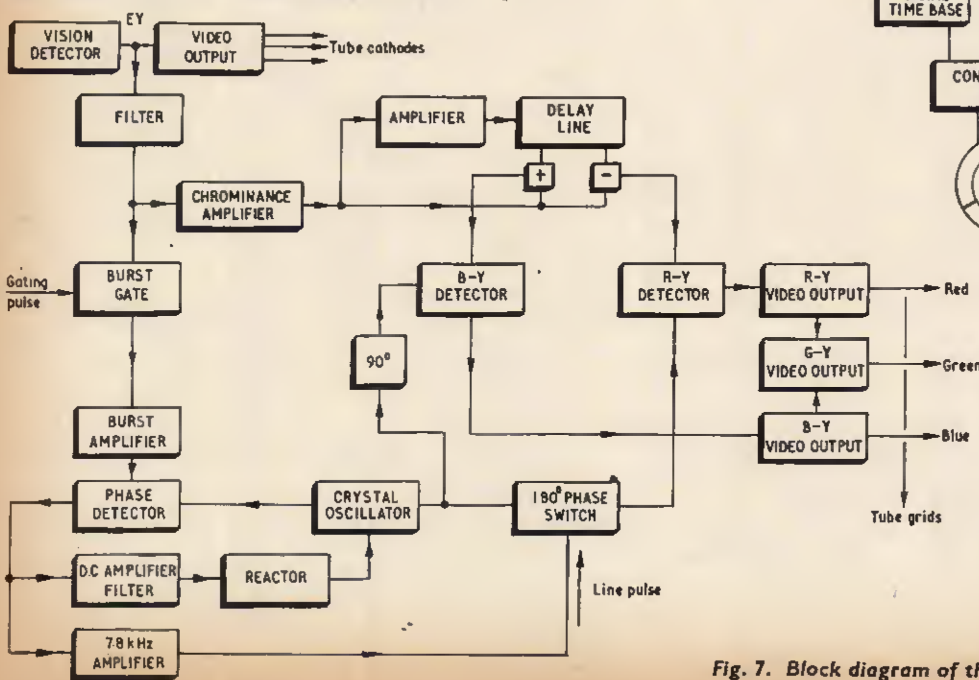


Fig. 7. Block diagram of the PAL decoder circuit

In this way, the perforations in the mask are made to correspond infallibly to the phosphor triads on the screen.

The simple block diagram shown in Fig. 6 will indicate considerable similarity to the techniques employed in the conventional monochrome receiver. Most of the complicated circuitry involved with colour will be found in the decoder section of the receiver and the convergence fields applied to the Shadowmask tube.

Assuming the reader to be familiar with the techniques employed for monochrome reception, detailed reference will be made to the circuitry which is exclusive to the colour receiver.

DECODER

Fig. 7 shows a block diagram of a decoder circuit for a PAL receiver (the name PAL is derived from Phase Alternation Line) and is a development of the American N.T.S.C. system intended to overcome problems of colour distortion due to phase changes in transmission from the studio to the picture cathode ray tube. Any change of phase relationship, caused for example by errors in phase characteristics of long distant links, or by reflections from obstacles, could appear as hue distortion in the received colour picture.

To prevent this distortion becoming objectionable, the phase of one of the chrominance signals contributing to the sub-carrier is reversed on alternate lines. The phase of the other chrominance signal remains constant throughout the transmission. This phase alternation enables hue errors between lines to be corrected in the receiver before the colour signals are fed to the picture tube, thus making the system far less sensitive to phase displacement errors.

The two chrominance signals are impressed upon the sub-carrier at the transmitter and are incorporated as sideband energy within the composite vision signal. This sub-carrier is phase-modulated for colour hue, and amplitude modulated for colour saturation. Fig. 8a shows the phase of the chrominance signals (R — Y) and (B — Y) plotting a vector to give a colour reference for cyan. Diagrammatically, the vector line would lengthen with increased amplitude modulation, and saturation for this particular colour would adjust itself accordingly.

The combined chrominance information (R — Y) and (B — Y) in composite form is extracted from the overall video signal by a high pass filter, which eliminates the low frequency brightness or luminance component, leaving only the chrominance information, which is then amplified and fed into the delay line circuit.

At this stage, the (R — Y) and (B — Y) information is separated, by a delay line of 64μs, the period of one line scan.

To understand the function of the delay line circuit, one should consider a given instant of time (see Fig. 8b). Taking a phase reference of the chrominance signal, and feeding into the delay line will give the reverse (R — Y) values for that reference simultaneously.

It will be remembered that in the PAL system, the phase of (R — Y) is reversed on alternate line scans. A line scan period is 65μs, the exact time constant of the delay line. Therefore, the output from the delay line will give the phase reference of the previous line scan at the same instant of the present line scan. These simultaneous references are added and subtracted to give the separate (B — Y) and (R — Y) values respectively.

As the chrominance signal is really sideband energy,

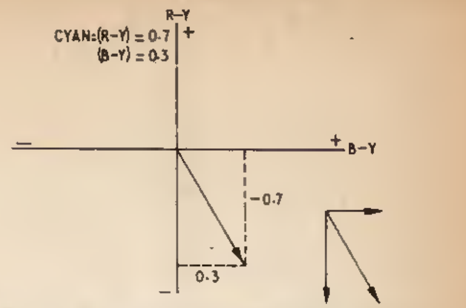


Fig. 8a. Vector of chrominance sub-carrier for cyan colour reference

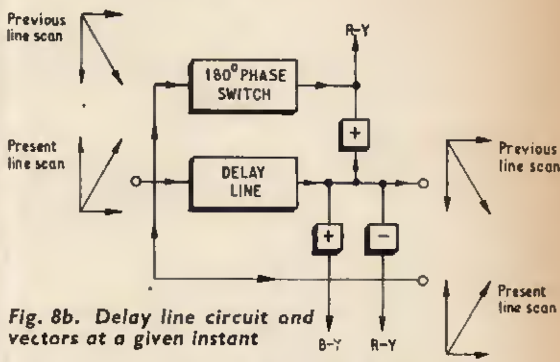


Fig. 8b. Delay line circuit and vectors at a given instant

it is necessary to reintroduce the carrier component for demodulation, and this is the function of a crystal oscillator circuit, operating at 4·43MHz, and called the colour reference oscillator. Having reinserted the carrier the separated colour information is then demodulated and amplified as a video output signal. The (G — Y) content is determined from a proportion of the sum of (R — Y) and (B — Y), resulting in three colour difference video references which are fed to the c.r.t. grids.

It is essential that the colour reference oscillator must be accurately synchronised with the original suppressed sub-carrier at the transmitter, and therefore the circuit requires a reference to determine the phase of the oscillator.

Incorporated in the composite transmitted signal is a colour burst reference, a sample of the transmitter sub-carrier frequency, which remains constant, and is used as a measure to synchronise the oscillator with the original sub-carrier suppressed at the transmitter. This colour burst reference is made to produce correcting voltages that bring the phase and frequency of the oscillator exactly into line with that of the original sub-carrier.

The burst signal is "gated" by means of a pulse from the line output stage, so that only this reference is passed to the burst amplifier. In the absence of the chrominance signal, i.e. a monochrome transmission, there is no burst reference to the phase detector. This condition is utilised to cut off the function of the chrominance amplifier, and can be termed the "automatic killer" or "turn-off" of the decoder circuitry.

The (R — Y) reference signal is switched 180 degrees line-by-line by means of a switch triggered by a pulse from the line output stage, producing a switching waveform to reinsert the reference carrier to the correct phase.

Next month: Setting-up a receiver for colour

WATER LEVEL ALARM

By G.M. HARVEY

THIS article describes how a simple high gain, sensitive electronic relay can be employed as a bath water level indicator or flood alarm. Some additional applications are included to extend its usefulness.

The action of the alarm depends on the contact through water between two wire probes, which constitute the input circuit. The probes can be adjusted to any required water level and can be hung over the side of the bath. Connection from the probes is made to a portable alarm unit, which provides an audio note or visual winking indication when the water short-circuits the two probe wires. Since the whole device is battery powered there is no danger in its operation and no risks of electric shock.

"SUPER" TRANSISTOR

One of the most versatile and simple of direct coupled multi-stage circuits is the Darlington or super-alpha pair. The latter name describes what is in essence a "super" transistor, for in practice the pair, TR1 and TR2, can be considered as a single transistor with a combined gain approximating to the product of the two individual transistor gains. In theory then, the overall gain of this circuit would be 225^2 since the h_{fe} of each 2N2926 used is 225.

One shortcoming of this kind of circuit is the effect of leakage currents, since by transistor action the total leakage current of this compound stage would be a function of the product of the gains. If similar high gain germanium transistors were used, saturation would occur with no applied input, unless the first transistor of the pair is biased. In this particular circuit low leakage silicon types were used to reduce this trouble to negligible proportions.

The active terminals of this compound transistor are indicated by the reference C, B, and E (collector, base, and emitter). The input short from the water probe is applied to the base by current limiting resistor R1. A 330 ohm 6 volt relay provides the load, with its coil shunted by a diode for transient suppression.

The relay contacts RLA1 operate to supply power from the battery to an oscillating circuit TR3 and TR4, the time constants of which providing a pulse repetition frequency of about 50Hz with a 3:1 mark/space ratio. This gives to the speaker output an imperative boat horn quality that would alert anyone to stop it by turning the taps off and removing the probe.

WINKING LAMP

The construction of the main alarm unit is straightforward, most of the components being mounted on a piece of Veroboard (Fig. 2). A miniature jack socket, 3in loudspeaker, and battery switch are all fitted to a small box, which is easily made from plywood or hardboard and suitably decorated.

An alternative to the audible alarm is a winking lamp—especially useful for deaf persons. This does not require any rearrangement of component assembly. The coupling capacitors C1 and C2 should be changed to $100\mu F$; the loudspeaker should be replaced by a 6 volt 60mA bulb, preferably housed in a red-lensed panel lampholder. This type of indicator would provide a considerable saving in battery power, the total consumption of the unit being about 80mA.

RAIN SENSOR

Some applications with suggested modifications will now be pursued. For use as a rain sensor the probes can be substituted by a piece of Veroboard or Lektrokit chassis plate No. 5 or 6. The copper strips can be wired so that the whole area of the board is used as a series of parallel copper sensors, alternate strips being connected together.

LATCHING

A simple latching arrangement is shown in Fig. 3. This could be employed where a wave action is set up on the water surface. One such application might be a swimming pool, or a private or public lido, where any unauthorised intrusion would provide the requisite wave action to complete the probe circuit. Although this water switch action is of short duration the relay will latch and the alarm will sound until the supply is disconnected.

When the probe circuit is made by the wave action, RLA1 closes, activating the 8 volt bell alarm. Diode D2, which normally blocks any collector current through the bell alarm, is now forward biased with the relay contacts closed, and will keep the relay latched

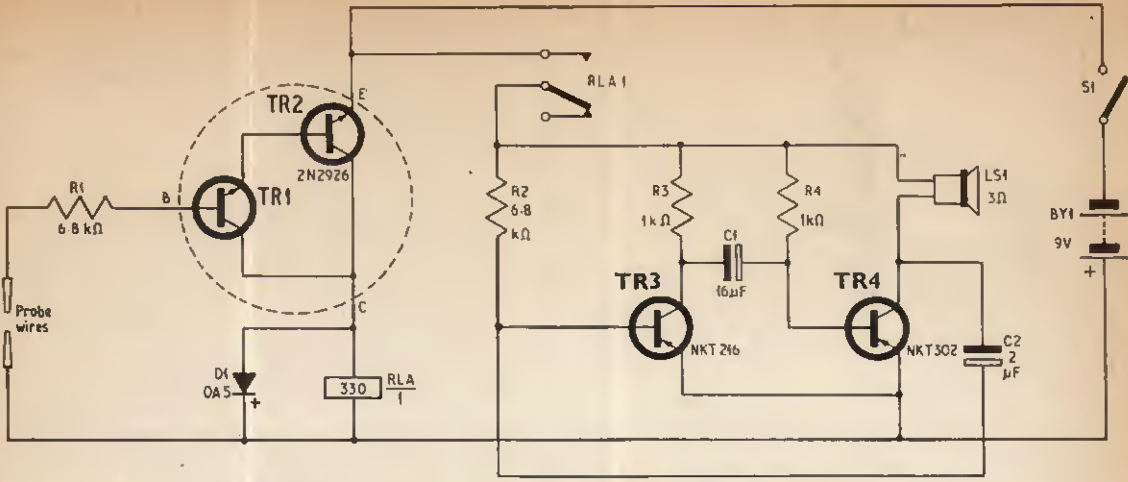
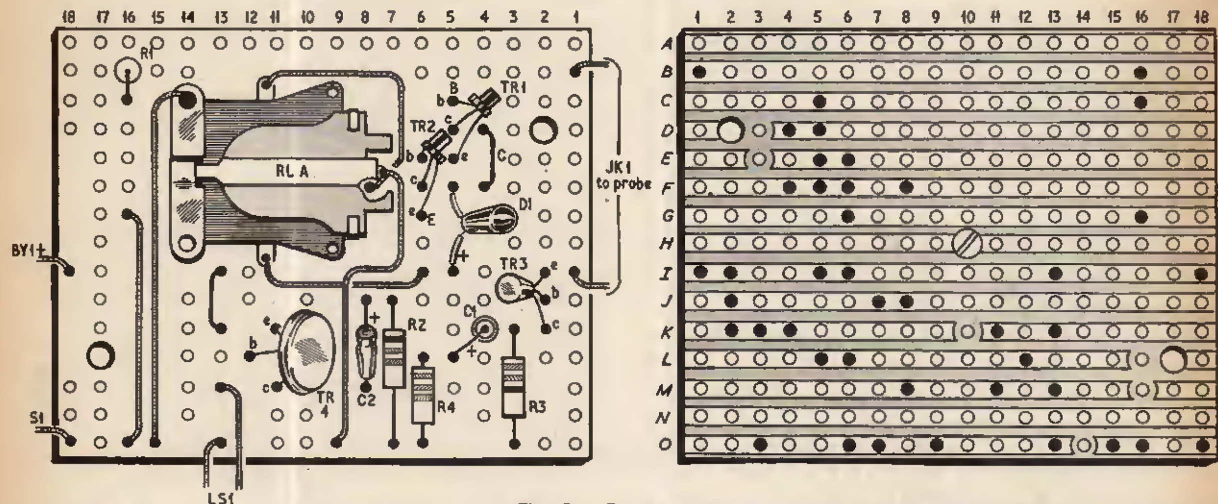
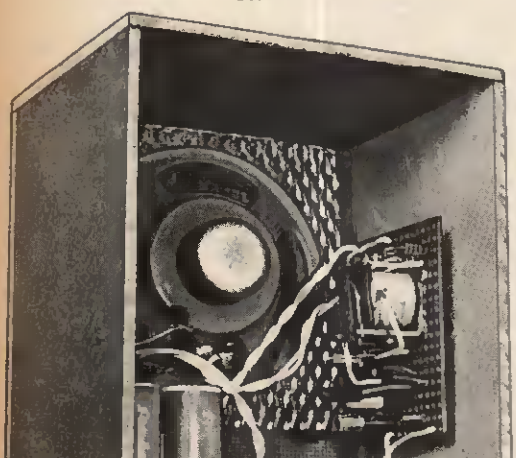
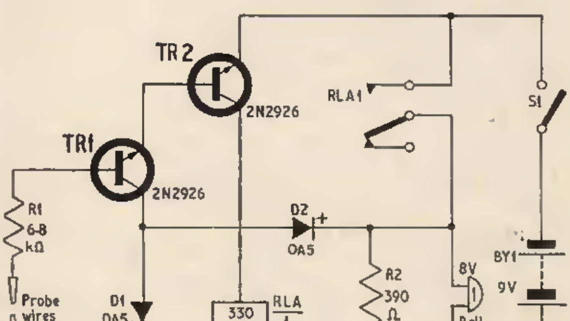


Fig. 1. Complete circuit of the water alarm. The dotted circle encloses the super-alpha pair







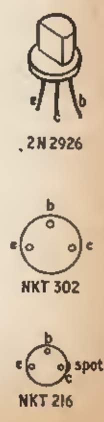


Fig. 2. Component layout on the Veroboard and the underside view. The transistor connections are shown below right. The lower two TR3 and TR4 are shown looking at the wire ends

Fig. 3. Simple latching to overcome wave action

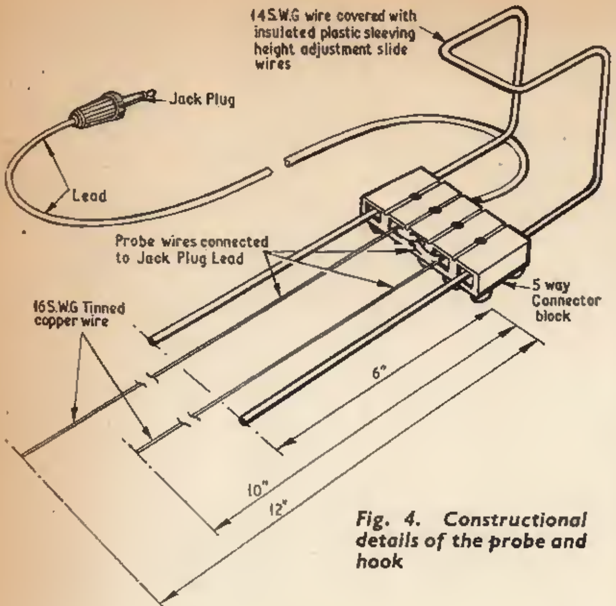


Fig. 4. Constructional details of the probe and hook

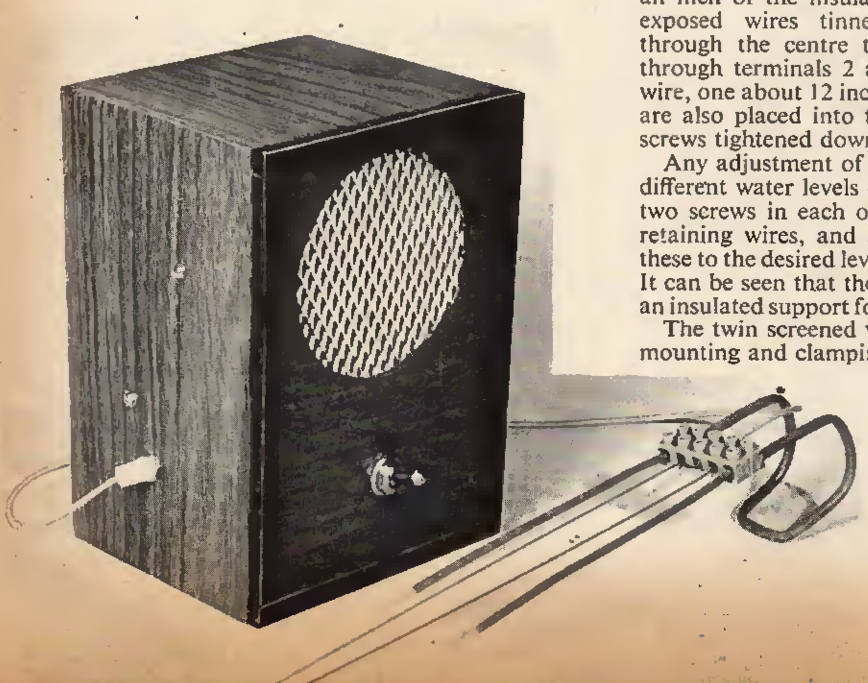
on with the passing of the wave. To de-energise the relay it will be necessary to flick the supply switch momentarily to return the relay contacts to standby.

The contacts on the relay will not carry sufficient current to switch a water pump but a supplementary relay of adequate rating can be placed in series with the contacts RLA1.

The maximum rating of the miniature open type relay used in this circuit is 115V a.c. 2A.

WATER SWITCH FOR BOATS

Another application that could usefully be explored is the use of the unit as an automatic water switch for electric motors in model boats. Here any mechanical switch could be dispensed with as the total leakage of the compound pair TR1 and TR2 is only about 20μA.



COMPONENTS . . .

Resistors
R1 6·8kΩ   R3 1kΩ
R2 6·8kΩ   R4 1kΩ
All 10%, ¼W carbon

Capacitors
C1 16μF elect. 15V
C2 2μF elect. 15V

Semiconductors
TR1 2N2926 } high beta gain (see text)
TR2 2N2926 }
TR3 NKT216
TR4 NKT302
D1 OA5

Relay
RLA Miniature open type 6V 330Ω (Radiospares)

Switch
S1 Single pole on/off toggle

Miscellaneous
LS1 3 ohm, 3⅜in dia. (Radiospares)
BY1 4·5V flat pack batteries (2 off)
16 s.w.g. and 14 s.w.g. tinned copper wire
Miniature jack plug and socket
Veroboard 2in × 2¾in, 0·15in matrix
Five-way terminal block
Miniature twin screened cable

With the model placed on the water surface the motor would immediately start and stop on its removal.

PROBE

The probe was made up from a 5-way terminal block. The probe suspension hook is made from 14 s.w.g. wire shaped to hook on to the side of the bath and then sleeved. This is then pushed home into the two outer terminals and clamped by the retaining screws.

The centre terminal was used to hold the miniature twin screened cable but, before insertion of this, about an inch of the insulation should be stripped and the exposed wires tinned. When these wires appear through the centre terminal they are doubled back through terminals 2 and 4. Two lengths of 16 s.w.g. wire, one about 12 inches and the other about 10 inches are also placed into these terminals and the retaining screws tightened down.

Any adjustment of probe height for the detection of different water levels can be achieved by loosening the two screws in each outer terminal, holding the probe retaining wires, and sliding the terminal block along these to the desired level. The screws are then tightened. It can be seen that the moulded polythene block forms an insulated support for the probes at any desired height.

The twin screened wire was used for convenience of mounting and clamping in the terminal block. ★

DIGITAL INTEGRATED CIRCUITS — PART FOUR — microelectronics

By M. J. HUGHES M.A.

ONE apparent drawback of using semiconductor integrated circuits is that the user cannot have any control over the actual circuitry of the device he intends to use. Therefore, he must think in terms of building blocks; instead of designing circuits around components, he must now design systems around the circuits. In many cases this makes life a lot simpler, but nevertheless the long term implications are tremendous.

Those users already converted usually look upon integrated circuits as a method of removing the tedium of wiring routine repetitive circuits, thus allowing more sophisticated thought to the overall design of the equipment being built.

As the prices of integrated circuits are rapidly approaching the prices of individual transistors, the experimenter can get more "electronic function" for his money, and can therefore involve himself in systems much more complex than those he has previously been used to.

As it was felt early on that integrated circuits would have to be manufactured on a really large scale to obtain cost benefits, the original manufacturers decided to make circuits which could be standardised most easily, and would be in most demand. Undoubtedly the most commonly used electronic circuits are switching circuits, flip-flops, and logic gates, therefore most low cost circuits fall into this category.

The fact that there are only a few possible combinations of components to make these circuits has resulted in a natural standardisation between manufacturers, and although there are many manufacturers, the types of logic circuits they make usually fall into any of four or five main groups. A point worth mentioning here is that although the same types of circuit may be offered by different manufacturers, it does not necessarily imply that the terminal connections are the same.

Linear (or non-digital) circuits are not nearly so easily standardised as any constructor will know. For example there are innumerable ways in which one can wire up an audio amplifier stage to give either similar, or subtly modified performances. For this reason the numbers of amplifiers available are not nearly so great; the prices are usually higher than for digital circuits.

FOUR COMMON FAMILIES

The four most common families of circuit to be encountered at present are RTL (resistor transistor logic), DTL (diode transistor logic), TTL (transistor transistor logic), and ECCSL (emitter coupled current steered logic). In nearly all these families the unit block is either a NAND or a NOR gate with anything from one to six inputs. Most circuits are available as multiple gates, the controlling factor being the number of inputs and gates per package. For example, one package might contain four independent gates each with two inputs, or two gates each with four inputs, and so on. The other standard circuits common to all families are bistable, and monostable multivibrators of various types.

It is the basic gate which determines the family, and examples of each of the four main types are shown in Figs. 15 to 18. Generally speaking the user need not worry too much about the actual circuitry of the package, but he should know the overall characteristics of each type in relationship to each other, as this could affect the choice of family for a given application.

RESISTOR TRANSISTOR LOGIC

RTL was one of the very first families of circuits to be made, largely due to its comparative simplicity and ease of manufacture. Because of this it is now one of the cheapest types of circuit available on the market.

Operation of the gate is very easy to understand (see Fig. 15a). If any input is in a "high" state, i.e. has a logical "1" or a positive potential applied to it, the output will fall to level "0". Only when all inputs are at level "0" will the output rise to level "1". The operating function of the gate is therefore NOT OR or NOR.

This description of the function of the gate is usually written on data sheets in the form of a "truth table", which shows the condition of the output for all possible combinations of logic levels at the input.

This is sometimes expressed on data sheets in Boolean algebraic form. For example, $D = \overline{(A + B + C)}$, which simply means D is not equal to A or B or C. Both these expressions are common to any three-input NOR gate irrespective of the circuitry, and therefore it is possible to write a symbol which can be used in logic diagrams of systems to show that the gate required is of the NOR type (see Fig. 15b).

Although it is doubtful if the amateur would be worried by limitations in speed, it is worth noting that with RTL a compromise has to be drawn between the propagation delay of a gate, and its power dissipation. It is always desirable to keep power dissipation low as in large computer systems, which may involve thousands of such gates, the overall power consumption can be

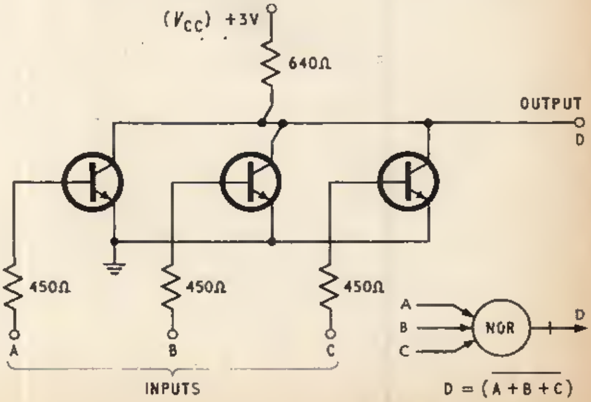


Fig. 15a. A typical RTL NOR gate

Fig. 15b. Logic symbol for NOR gate

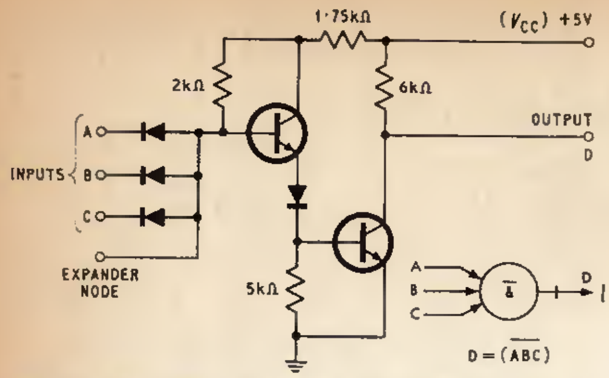


Fig. 16a. Basic DTL NAND gate *Fig. 16b. Logic symbol for NAND gate*

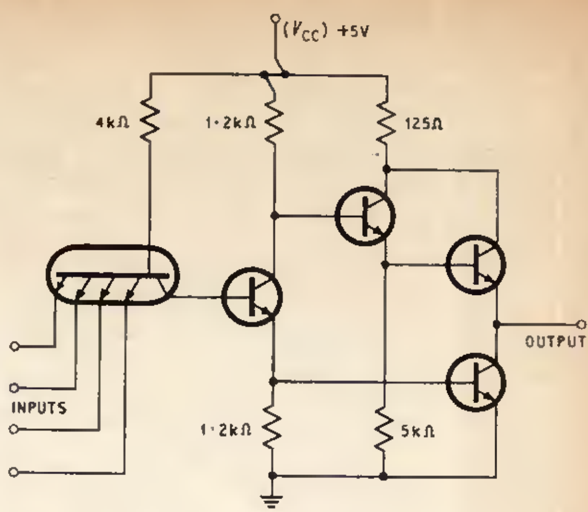


Fig. 17. Basic TTL NAND gate

enormous. Unfortunately, to reduce the power dissipation of RTL, it is necessary to increase all the resistance values proportionally. This immediately reduces the switching speed of the gate as the capacitance of the output has a larger resistive load through which to discharge.

This problem can be overcome by bypassing the input resistors with capacitors which act as a low impedance path to the pulse without upsetting the transistor bias conditions. It is undesirable to include capacitors in integrated circuits, and to achieve this faster switching speed involves greater costs.

A further point worth mentioning is that the driving current for any gates connected to the output of a particular stage has to be supplied via the collector load resistor of the driving stage. There is thus a maximum number of gates which can be driven successfully by a single stage, and this is again proportional to the value of the resistive load, and indirectly proportional to the switching speed.

Typical parameters of RTL gates are as follows:

Power requirements (V_{cc})	+3 to +5V
Power dissipation (per gate)	12mW
Propagation delay (per stage)	15ns
Fan-out (per gate)	5
Fan-in	2 to 4
Flip-flop frequencies	20MHz

An important feature of all types of gate is "noise margin". This is the difference in voltage between the state of an input, and the voltage necessary to make the gate change its logical state. There are many arguments as to what "noise margin" actually is, but it can be considered as a "safety margin" between the triggering levels of a gate. In general, the larger this margin the better.

With all types of gate this safety margin is reduced as the fan-out load is increased and consequently if systems involving large numbers of fan-outs are required, the noise margin of the gate must be as large as possible to prevent accidental triggering from spurious signals. RTL unfortunately does not have a good noise margin compared with other systems; therefore, fan-outs should be kept down to five or less. The typical value of noise margin for RTL is 300mV.

DIODE TRANSISTOR LOGIC

A more sophisticated gate is the diode transistor logic (DTL) gate shown in Fig. 16. Again this is a very popular circuit, and consequently is relatively low priced, but it has certain advantages over RTL.

The most immediate difference is that the input resistors of RTL are dropped in favour of multiple diodes. This is a much more satisfactory circuit to make in integrated circuit form for the reasons stated previously. A secondary advantage of this form of input is the ease with which fan-in can be expanded merely by paralleling further diodes to the direct entry point, or common node.

The effect of the first transistor, and the coupling diode, is to improve the noise margin of the gate, and the second transistor gives signal inversion (NOT function) as well as acting as a driver for subsequent stages. The overall function of such a gate is NAND.

An important feature of this NAND gate is the way in which it is possible to parallel the outputs of several gates to carry out the OR function between gates with no extra components. This operation is called "wired OR", and can save a considerable number of components in some types of system.

The power dissipation per gate is relatively low, and fan-outs are high, thus making it an ideal all round gate for universal applications.

Typical parameters are:

Power requirements (V_{cc})	+5V
Dissipation (per gate)	16mW
Propagation delay (per stage)	25ns
Fan-out (per gate)	8
Fan-in (using expander diodes)	Up to 20
Flip-flop frequencies	8 or 20MHz
Noise margin (typically)	1V

TRANSISTOR TRANSISTOR LOGIC

A neck and neck runner with DTL in the popularity race is transistor transistor logic (TTL). This is sometimes called T^2L.

Referring to Fig. 17 it can be seen that the diode inputs are replaced with a multiple emitter transistor. Each emitter acts as a diode but, as they are coupled to form the active part of a transistor, gain is injected which helps towards enhancing the noise margin. This stage is followed by a phase splitter, which drives two output transistors operating in push pull.

As with DTL the overall function of the gate is NOT AND (NAND), but the advantage it holds over DTL is its

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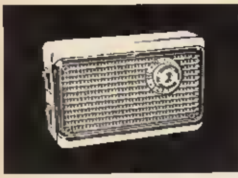
- Socket for Car Aerial.
- Powerful push-pull output.
- 7 transistors and two diodes including Philco Micro-Alloy R.F. Transistors.
- Famous make 7×4 in. P.M. speaker.
- Air spaced ganged tuning condenser.
- Separate on/off switch, volume control, wave change switches and tuning control.
- Attractive case with hand and shoulder straps. Size 9×7×4 in. approx.
- First grade components.
- Easy to follow instructions and diagrams make the Roamer 7 a pleasure to build with guaranteed results.

Total building costs £5.19.6 P. & P. 5/6

Parts price list and easy build plans 3/– (FREE with kit).

TRANSONA FIVE

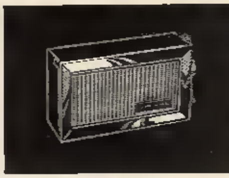


MEDIUM WAVE, LONG WAVE AND TRAWLER BAND PORTABLE

Attractive case with red speaker grille. Size 6¼ × 4½ × 1½in. Fully tunable. 7 stages—5 transistors and 2 diodes—ferrite rod aerial, tuning condenser, volume control, fine tone super dynamic speaker, all first grade components. Easy build plans and parts price list 1/6 (FREE with kit).

Total building costs 42/6 P. & P. 3/6

POCKET FIVE



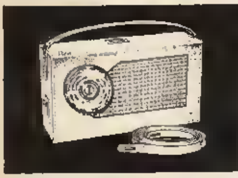
TWO WAVEBAND PORTABLE WITH 3in. SPEAKER

Attractive black and gold case. Size 5¼ × 1¼ × 3½in. Fully tunable over both Medium and Long Waves with extended M.W. band for easier tuning of Luxembourg, etc. All first grade components, 7 stages—5 transistors and 2 diodes—super-sensitive ferrite rod aerial, fine tone 3in. moving coil speaker, etc. Easy build plans and parts price list. 1/6 (FREE with kit).

POCKET FIVE Medium and Long Wave version with miniature speaker ONLY 29/6. P. & P. 3/6.

Total building costs 42/6 P. & P. 3/6

MELODY SIX

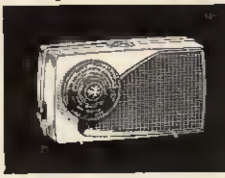


TWO WAVEBAND PORTABLE WITH 3in. SPEAKER

Handsome leather-look case, size 6¾ × 3¾ × 1½in. with gilt trim and hand and shoulder straps. Fully tunable over both Medium and Long Waves. Incorporates pre-tagged circuit board, 8 stages—6 transistors and 2 diodes—ferrite rod aerial, push-pull output, wave change slide switch, tuning condenser, volume control, 3in. moving coil speaker, etc. Easy build plans and parts price list 2/– (FREE with kit).

Total building costs 59/6 P. & P. 3/6

MELODY MAKER 6

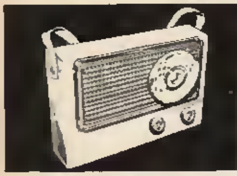


THREE WAVEBAND PORTABLE WITH 3in. SPEAKER

Smart pocket size case, 6½ × 3¼ × 1¼in. with gilt fittings. Fully tunable over both Medium and Long Waves with extra M.W. band for easier tuning of Luxembourg, etc. 8 stages—6 transistors and 2 diodes—top grade 3in. speaker, 2 R.F. stages for extra boost, high "Q" ferrite rod aerial. Easy build plans and parts price list 2/– (FREE with kit).

Total building costs 69/6 P. & P. 3/6

ROAMER SIX

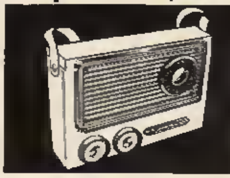


SIX WAVEBAND PORTABLE WITH 3in. SPEAKER

Attractive case with gilt fittings, size 7¼ × 5¼ × 1¾in. World wide reception. Tunable on Medium and Long Waves, two Short Waves, Trawler Band plus an extra M.W. band for easier tuning of Luxembourg, etc. Sensitive ferrite rod aerial and telescopic aerial for Short Waves. All top grade components, 8 stages—6 transistors and 2 diodes including Philco Micro-Alloy R.F. Transistors, etc. (carrying strap 1/6 extra). Easy build plans and parts price list 2/– (FREE with kit).

Total building costs 79/6 P. & P. 3/6

SUPER SEVEN



THREE WAVEBAND PORTABLE WITH 3in. SPEAKER

Attractive case size 7¼ × 5¼ × 1¾in. with gilt fittings and carrying strap. The ideal radio for home, car or outdoors. Covers Medium and Long Waves and Trawler Band. Special circuit incorporating 2 R.F. stages, push-pull output, ferrite rod aerial, 7 transistors and 2 diodes, 3in. speaker (will drive larger speaker) and all first grade components. Price list 2/– (FREE with kit).

Total building costs 79/6 P. & P. 3/6

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very low output impedance both in the "1" and "0" condition. This means that the gate can be used to drive relatively high capacitance loads without seriously affecting the switching speed, or alternatively the fan-out can be considerably greater.

Unfortunately this advantage has to be paid for at the expense of power dissipation which is relatively high, and rises as the pulse repetition frequency increases. This increase in dissipation is caused by the fact that on one portion of the switching cycle both output transistors are conducting simultaneously for a short period, thus giving a short circuit path to earth. As the mark/space ratio between consecutive pulses decreases, the effect of the short circuit condition becomes more marked.

A secondary effect caused by the same action is that of current "spikes" being fed back down the power lines, which in the worst case could trigger other gates if the spikes exceeded the noise margin. This problem is only likely to occur in complex systems, and can be avoided by carefully decoupling power lines between stages.

Typical parameters of TTL gates are:

Power requirements (V_{cc})	+5V
Dissipation (per gate)	22mW
Propagation delay	25ns
Fan-out (per gate)	15
Fan-in	4
Flip-flop frequency	20MHz
Noise margin	1V

It is not possible to expand the fan-in by coupling extra diodes, neither is it possible to carry out wired OR due to the very low output impedance in both states.

CURRENT MODE LOGIC

So far we have dealt with one group of logic circuits which are all "saturating" circuits. This means that the two states are defined by a transistor being either switched hard on or off. When this happens voltage swings tend to be in the same order as supply voltages (3 to 4 volts). This causes a substantial reduction in switching speeds as any stray capacitance in the circuit has to charge to this voltage before switching can occur.

For most amateur applications the switching speeds mentioned so far for RTL, DTL, and TTL would be more than adequate. The requirement for increased switching speed brought about the development of non-saturating logic, which has very low voltage swings giving overall propagation delays for gates as small as 1·5ns. Fig. 18a shows such a circuit. This circuit configuration is called emitter-coupled current-steered logic (ECCSL) or sometimes current mode logic (CML).

The circuit (Fig. 18a) is similar to a differential amplifier, the transition between the "1" and the "0" state being defined by the reference voltage V_b. When the gate input transistor bases are below this reference the current from the common emitter resistor flows through the reference transistor. When any of the inputs rise above the reference voltage the current will be steered through the resistive collector load of the input transistors. This causes the output $\overline{D}$ to go negative, and D to go positive.

The overall function of such a gate is OR or NOT OR (NOR) depending on which output point is used. As the logic levels are relative to the reference voltage it is very important that this reference voltage is stable. In practice this voltage is obtained from a simple regulator circuit which resembles a Zener diode stabiliser built into the chip.

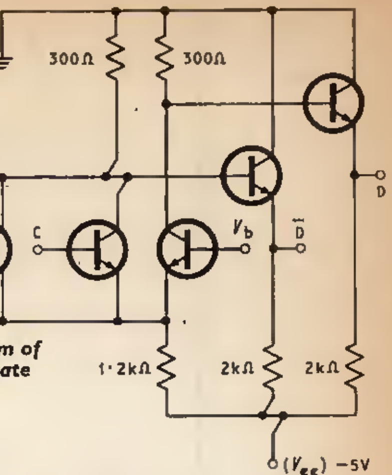
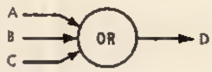


Fig. 18a. One form of ECCSL NOR/OR gate



D = A + B + C *Fig. 18b. Logic symbol for OR gate*

Two conventional diodes are used to generate this reference voltage from the forward voltage drop across them which is approximately 1·1V. This forward voltage drop is temperature dependent, which is why the stabilising circuit is built into the chip. Any changes in temperature will affect the circuit as a whole, and to a certain extent the effect will be neutralised. Nevertheless this circuit cannot withstand wide variations of temperature.

Noise margin is very low, and power dissipation is high as current is always flowing through one collector load or the other.

The circuit has been mentioned here for general interest, but it is not to be recommended for general amateur use unless ultra high speed is absolutely essential.

BISTABLE ELEMENT

A very important circuit to the logic user is the flip-flop, or binary element. Every range of gates whether it be RTL, DTL, or TTL has associated with it one or two types of flip-flop. At first sight these are most formidable looking circuits compared with the straightforward Eccles Jordan types of circuit with which we are more familiar.

The simplest form of bistable element is the RS (reset/set) type. This can be made by cross-coupling two 2-input NOR gates as shown in Fig. 19. If a pulse is applied to one of the inputs, the element will take on a condition where one output will be high, and the other low. This condition will be held indefinitely until a pulse is applied to the other input, when the circuit condition will be reversed. These conditions can be shown in the truth table below:

Table 1. TRUTH TABLE FOR TWO NOR GATES

Input R	Input S	Output Q	Output $\overline{Q}$
0	0	Dependent on switch-on condition	
1	0	1	0
0	1	0	1
1	1	Indeterminate	

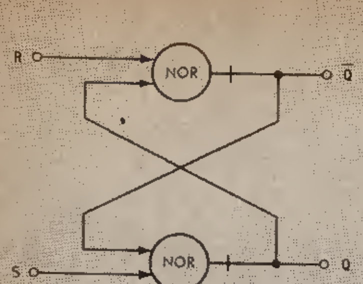


Fig. 19a. Logic diagram of an RS flip-flop using two cross-coupled NAND gates

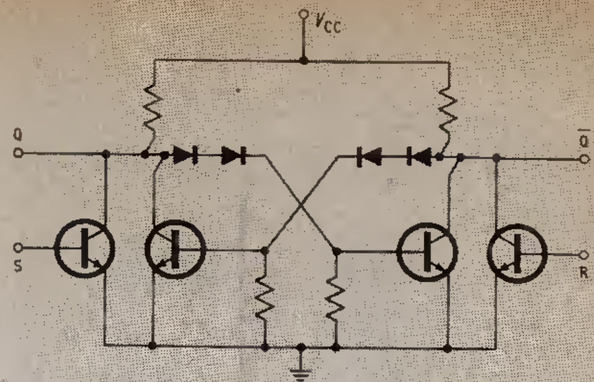


Fig. 19b. Typical circuit of an RS flip-flop

When both inputs are simultaneously at condition "1" there is no set rule for the output, as this will be dependent on the internal parameters of the components giving rise to an ambiguous condition. This is an undesirable state of affairs; therefore, the circuit has to be modified to prevent ambiguity and to ensure that when "1" appears simultaneously on both inputs the bistable will change state irrespective of its previous condition. This type is called a "J K flip-flop".

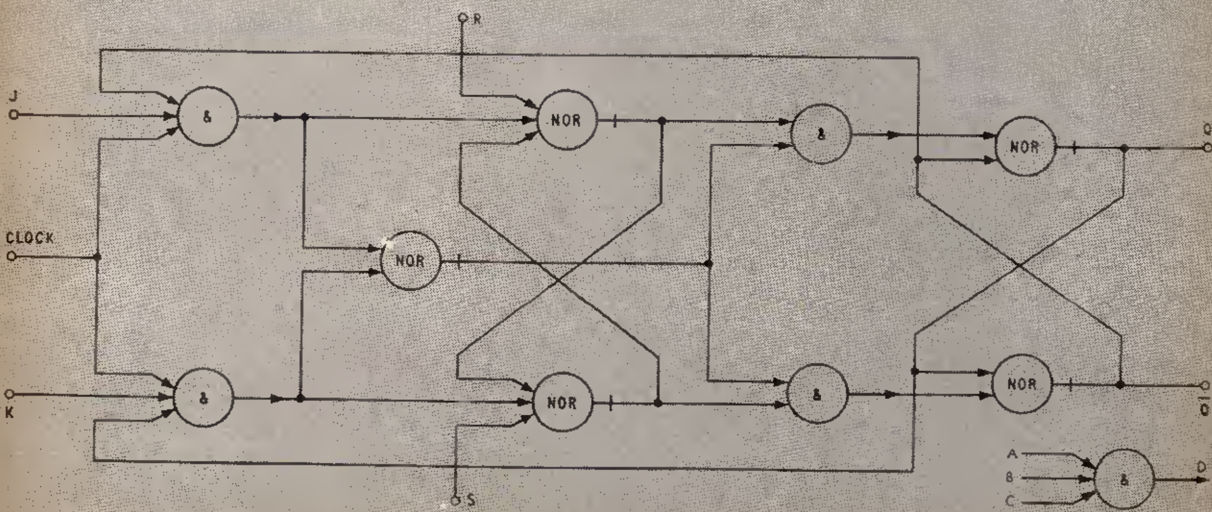
It is usual in a system to command the flip-flop to change state with a "clock" or command pulse. To do this the J K inputs are each gated through an AND gate with the clock pulse.

Fig. 20 shows the block logic diagram of such a circuit. There are J, K, R, and S inputs, and a clock input. With such a unit it is possible to make binary divider chains, shift registers, ripple counters and ring counters by arranging the input and output connections accordingly.

By cascading four binaries with suitable feedback it is possible to make a scale of ten counter. Some manufacturers actually offer complete counting chains and shift registers in a single chip of silicon, which would be housed in the same size package as a single binary. While these steps to large scale integration are at present comparatively expensive, it is easily foreseeable that in the next year or so a complete scale of ten counter will cost very little more than a single binary element using discrete components.

There are many special types of logic circuits available within each family: inverters, buffers, power gates, monostables, and gate expanders. In the main these are self-explanatory, but it is worth mentioning that some of the power gates and buffers are quite capable of driving low power indicator lamps or relays. These should, however, be used with care and limiting currents should not be exceeded. One must remember that while it is a comparatively cheap matter to replace a single transistor in a conventional circuit when it has been overloaded, the whole of the integrated circuit is scrap even if the only fault is a damaged output transistor. On the whole, however, integrated circuits are very tolerant, and manufacturers go to great lengths to make them immune to such effects as short circuits between terminals.

Next month: Linear amplifying circuits



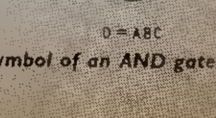


Fig. 20a. Logic diagram of the JK binary

Fig. 20b. Logic symbol of an AND gate

FUZZ BOX

By A. J. Bassett

THE fuzz effect produces a marked change in the tone of a guitar or other sound source, and may be used to add more interest to appropriate musical passages.

Various mechanical means of producing these effects are supplemented by purely electronic methods. Some of the electronic circuits are capable of introducing considerable signal gain or "volume boost" whilst others consist of diode limiters or similar devices, and do not result in an increase in volume.

Examination of the circuit diagram (Fig. 1) and other constructional diagrams, shows that the "fuzz module", which is the basis of the electronic fuzz effects described in this article, is both cheap and easy to construct. The printed circuit board is the standard P.E. "Bonanza Board" design without any link wires.

A number of effects are introduced, sometimes separately, sometimes simultaneously, according to the operating conditions. They are:

(1) Severe amplitude distortion and harmonic generation;
(2) Treble boost;
(3) Frequency division by various discrete factors;
(4) Intermodulation when fed with two or more frequencies;
(5) Tremolo (when one or both diodes are omitted).

BASIC PRINCIPLE

The main function of the first stage TR1 is as an impedance-matching device, as many guitars are designed for high impedance operation. Although a certain amount of distortion, and clipping of the waveform peaks, may occur here, the main effects are brought about by the circuitry of the remaining two stages.

The second stage TR2 functions as a non-linear amplifier, and although it can be biased into a linear amplifying state when quiescent or at low signal level, even here it is not used linearly, as it usually becomes overdriven in normal use.

The third transistor TR3 is the output stage, and is usually overdriven, giving even more distortion. As its output voltage is quite high, and is likely to have a peak-to-peak value equal to almost the full supply voltage of about 9 volts, this stage is usually followed by an attenuator as described elsewhere in this article.

AMPLITUDE DISTORTION

The fuzz module produces amplitude distortion in several ways; this originates principally in TR2. If this transistor is biased to an extent where "bottoming" occurs, it will amplify on signal peaks of one polarity only, producing a "spiked" or pulsed collector voltage waveform. Signal peaks of this same polarity may be clipped by diode D1, if of sufficient amplitude.

Peaks of the opposite polarity are clipped by the transistor itself. If the transistor is biased into a slightly less conductive region, signal peaks of one polarity will be much amplified, giving a spiky waveform, whereas the remainder of the waveform will not be amplified very much.

Further alteration of the bias is likely to result in high sensitivity, and this can be used to produce acoustic feedback. This is due to a change of the operating point of TR2 to a point of high gain. Increase of the bias to the point of "bottoming" or just beyond, results in low sensitivity, tending to suppress feedback effects. Where waveform peaks can overcome this bias, the resultant volume of the distorted sound output from the loudspeaker can be great.

COMPONENTS . . .

FUZZ MODULE

Resistors

R1	4·7MΩ	R4	3·3kΩ
R2	10kΩ	R5	470kΩ
R3	10kΩ	R6	22kΩ

All 10%, ¼ watt carbon

Capacitors

C1 0·01μF disc ceramic 20V
C2 100μF elect. 15V
C3 10μF elect. 15V
C4 0·01μF disc ceramic 20V
C5 0·01μF disc ceramic 20V
C6 0·01μF disc ceramic 20V

Transistors

TR1 MAT101
TR2 MAT101
TR3 MAT120

Diodes

D1, D2 OA5 (2 off)

Miscellaneous

Printed circuit board kit

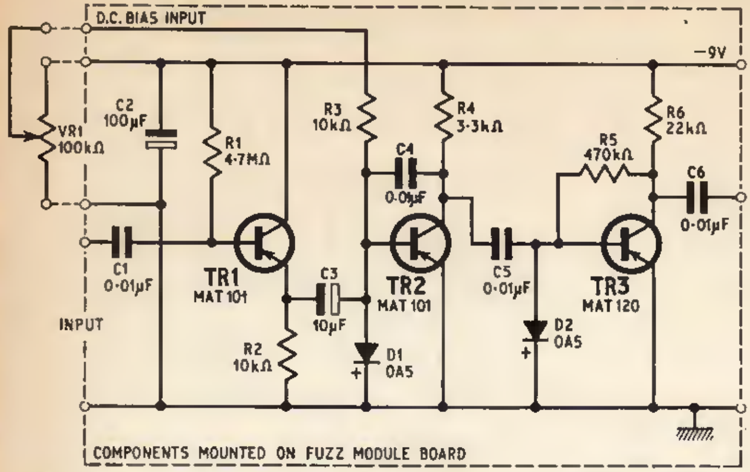


Fig. 1. Circuit diagram of the basic fuzz module

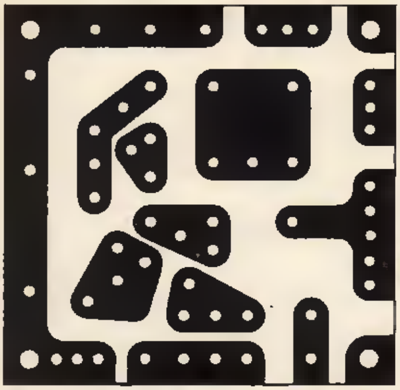


Fig. 2. Printed circuit pattern for the fuzz module reproduced here full size

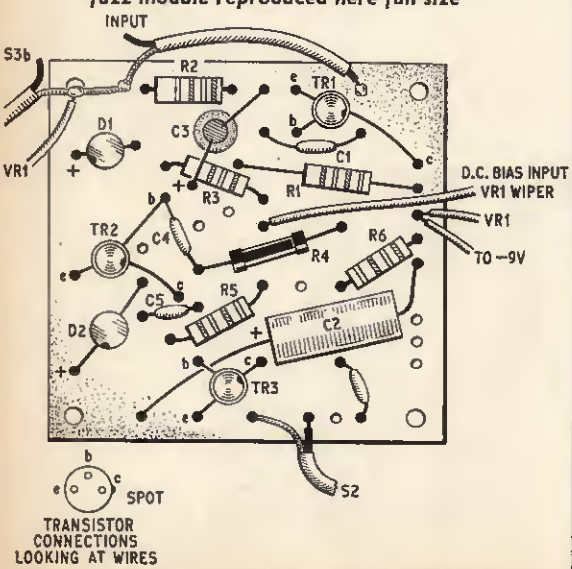


Fig. 3. Layout of components on the printed circuit board

Amplitude distortion and waveform clipping generate plenty of harmonics, which gives the fuzz sounds such a rasping quality.

TREBLE BOOST

The coupling capacitors are of low value to give some treble boost. The effect may be boosted further by the removal, or reduction in values, of the negative feedback capacitor C4, at a slight risk that stray capacitances may cause the circuit to produce unwanted high frequency oscillation. The treble boost is also more evident when TR2 is biased to give a high gain.

FREQUENCY DIVISION

Frequency division occurs mostly when TR2 is "bottomed", or nearly so. Not all the peaks of the incoming waveform will then transfer the transistor over to an amplifying state. This happens only at intervals, but must bear a definite relation to the inupt frequency. The output is then at a frequency lower than that of the input, and known as a "sub-harmonic".

Since the division may be by a ratio of two or some higher number, the "sub-harmonic" frequency is often quite low. Hence the fuzz module is capable of introducing more bass as well as more treble frequencies into the output, thus reproducing the guitar sound over a wider portion of the audio spectrum. (Might not the popularity of this "frequency range expansion" be related to what is known in some circles as "consciousness expansion"?)

INTERMODULATION

When two or more strings are played simultaneously, intermodulation is almost certain to occur. This is a well known phenomenon which results in the production of additional tones, which are not harmonically related to the notes played. The result is often not musical, though with skill in use, the effect can be made musically useful.

TREMOLO

If one or both diodes are omitted from the circuit, a tremolo effect may be produced, dependent upon periodic (but not always regular) blocking of TR3. If this effect is required, a switch may be included in

series with D2, and mounted on the chassis. If an increase in the duration of the blocking action is required, a larger value of capacitor may be placed in parallel with C5, which couples the signal from TR2 to the base of TR3. Values tried may be up to several microfarads and these higher values may be either paper or electrolytic as convenient.

WAVEFORM JITTER

Waveform jitter is an effect deliberately produced in mechanical fuzz units. A small amount of "jitter" is produced in this electronic fuzz module and originates in slight irregularities in the incoming signal. Some of these irregularities are amplified and intensified to a certain degree, giving rise to random effects. The result is a slight waveform "jitter" which can be observed with an oscilloscope and, if intensified, gives rise to some interesting effects.

BUILD THE MODULE

Using components in the parts list (see Fig. 1), construct the fuzz module on the basic printed circuit pattern shown in Fig. 2. This particular pattern is, in fact, the P.E. Bonanza Board design, but a new one can be made by using one of several printed circuit kits now on the amateur market. The pattern in Fig. 2 is printed full size so that it can be used as a template.

There should be no difficulty in mounting the components on the other side of the board, provided the usual precautions are taken when soldering. Fig. 3 should be followed to help obtain a neat finished result.

Before testing the module, check that your construction is correct, and agrees with the circuit diagram. C4 may be omitted unless there are signs of h.f. instability.

Before incorporating the module in the chassis, read the following notes on applications, then decide what effects are required and construct the chassis accordingly. Placement of components in the chassis for both versions A and B is given as a rough guide, but there is plenty of room to alter the layout if required.

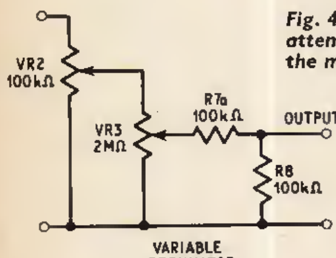


Fig. 4 (left). Simple variable attenuator used when testing the module

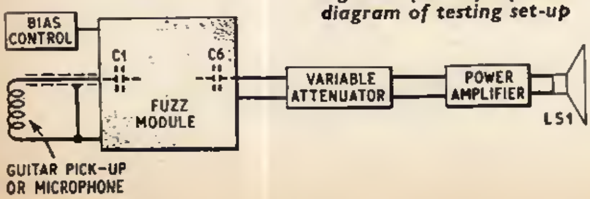


Fig. 5 (below). Block diagram of testing set-up

Simple version—Fuzz Box A

TEST THE MODULE

To test the fuzz module the following will be required: an audio amplifier with loudspeaker, an electric guitar or a microphone (most microphones are suitable, but one of medium impedance between 500 ohms and 100 kilohms is advised), a 9 volt battery, a 100 kilohm potentiometer, and an attenuator to prevent overloading of the amplifier input.

A simple variable attenuator circuit (shown in Fig. 4) is connected to the output of the module, with the attenuator output wired to the input of the power amplifier. The circuit for testing the module is shown in Fig. 5, and may be temporarily set up for this purpose before the module is used in a more advanced project such as a fuzz box or other effects unit.

All volume controls should be set to a low level, and a sound signal injected into the system from the guitar or microphone. Adjust the controls so that the sound comes through at a reasonable level, and carefully vary VR1 to give different levels of distortion and gain. This may result in acoustic feedback at certain points, with lower volume at both top and bottom settings. Set VR1, in conjunction with the volume controls, for best results, giving a rasping tone to the signal.

NOISE LEVEL

At some settings of the controls, the circuit can be quite noisy, but careful adjustment can reduce this to a lower level. Signal-to-noise ratio is also better with some instruments than with others, and may depend upon the settings of the controls on the guitar itself.

USING THE MODULE

For those with economy in mind, the module may be simply installed in a screened metal box along with standard audio input and output sockets, battery, and on/off switch. A small carbon resistor may be connected from the "bias input" to the negative supply, the value chosen to give the degree of distortion required. A suggested value is 1 megohm.

If the attenuator network is omitted, it is best to connect a 4·7 megohm resistor in series with the output, to cut down the output signal and avoid overload to the main amplifier. The complete chassis using this simple arrangement is shown in Fig. 6. The fixed resistor R7b can be switched in by S2.

An arrangement which is in general more satisfactory as a "fuzz box" is shown in the circuit diagram of Fig. 7, and the layout is shown in Fig. 8. This circuit uses the variable attenuator with two boost switches S1 and S2. In both designs the battery is switched into circuit by the insertion of a "tip-sleeve" jack plug into JK2. The connection is made between the jack

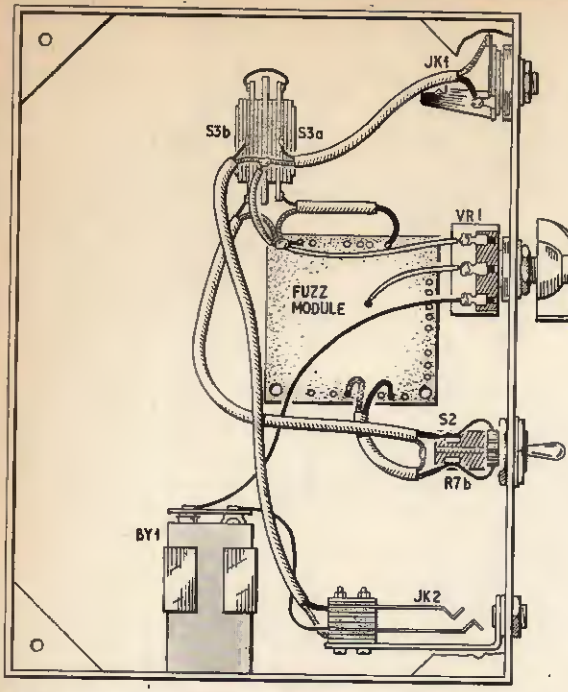


Fig. 6. Layout of components in the chassis for the simple version of the fuzz box

The photograph (right) shows the interior of the simple Fuzz Box A

COMPONENTS . . .

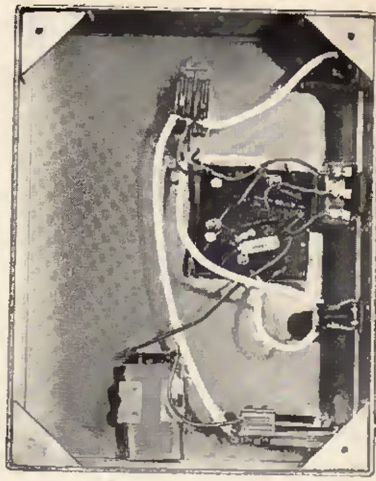
FUZZ BOX 'A' COMPLETE

(Simple version Fig. 6)

In addition to the Fuzz Module:

VR1 100kΩ linear carbon potentiometer
R7b 4·7MΩ 10%, $\frac{1}{4}$W carbon resistor
S2 Single pole, on/off, toggle switch
JK1 Jack socket, tip and sleeve, with plug
JK2 Jack socket, tip and sleeve insulated from mounting (Bulgin type J16 with plug)
S2 Push-to-make, push-to-break, double-pole, double-throw switch (Bulgin type SR 270)
BY1 Battery 9V

Chassis, aluminium 8in × 6in × 2$\frac{1}{2}$in
Single core screened wire
Battery connector and knob



COMPONENTS . . .

FUZZ BOX 'B' COMPLETE

(Advanced version Fig. 8)

In addition to the Fuzz Module and all components for the simple version:

VR2 100kΩ log. carbon potentiometer
S1 Single pole, on/off, toggle switch

Note: When testing the module the following are also required for the attenuator (see Fig. 4):

VR3 2MΩ log. carbon potentiometer
R7a 100kΩ } 10%, $\frac{1}{4}$W carbon resistors
R8 100kΩ }

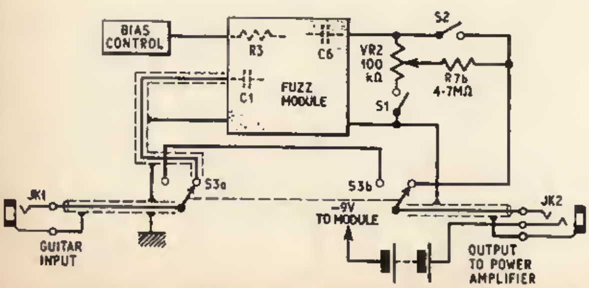


Fig. 7. Circuit diagram of the advanced fuzz box

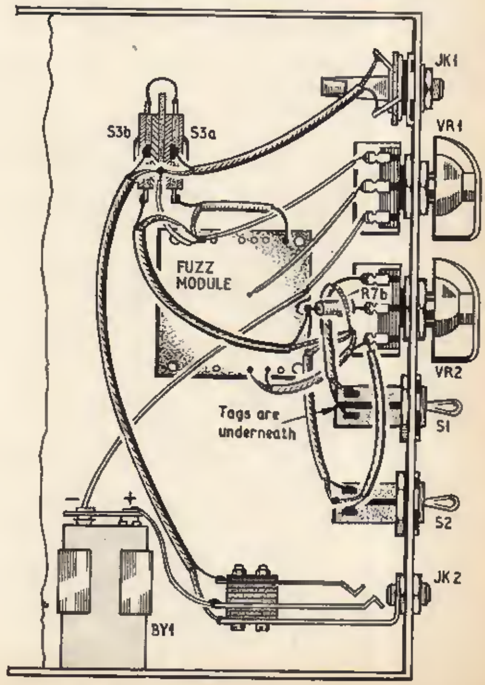


Fig. 8. Component layout for the advanced fuzz box

mounting nut (chassis) and the plug sleeve connected to battery positive.

Although the circuit can be built in a much smaller box than that shown, and will fit with ease in a box only 6in × 3in × 2½in, the larger size is more convenient for use on stage, particularly when operated by a foot on the push button "action" switch S3.

One advantage of this arrangement is that, in the straight-through or "non-fuzz" position of the "action switch" S3, the guitar signal passes straight through the unit absolutely unchanged. In some commercial and amateur designs, this is not the case; the signal may be attenuated or interfered with in some other way.

MAKING YOUR GUITAR HOWL

The boost switches S1 and S2, which are used in the better design (Figs. 7 and 8), can be used singly or in combination to produce a very strong fuzz signal, which usually results in acoustic feedback or howl.

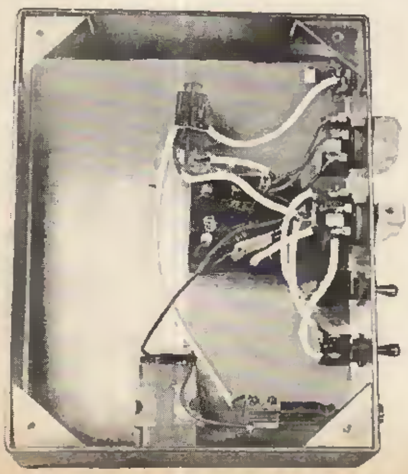
Your loudspeakers and amplifier should be able to handle the extra volume without damage. (Some manufacturers guarantee that certain of their amplifier and loudspeaker equipment is built to withstand operation under continuous overload conditions. Others do not, and in some cases the equipment might fail. It is a wise precaution to check on this point first.) Here is an opportunity to make simultaneous use of the vibrato arm, or a "bottleneck".

OTHER USES

The fuzz module may be used in theatrical production to disguise the voice. In this connection, and also for guitar use, simultaneous introduction of other effects such as echo, reverberation, tremolo, treble or bass boost, or filters as used in electronic organs can add greatly to the tonal interest. These other effects should be added between the fuzz module and the power amplifier in order to modify the output waveform of the fuzz module.

ANTI-HOWLROUND

For some purposes it may be desirable to use high volume without acoustic feedback. This can be done by turning VR1 carefully clockwise—towards the negative supply. At first, feedback will be intense, but a point can be found where the feedback will subside, yet ample volume will be available from the unit, often considerably higher than can be obtained with the instrument connected straight to the amplifier.



Interior view of advanced Fuzz Box B

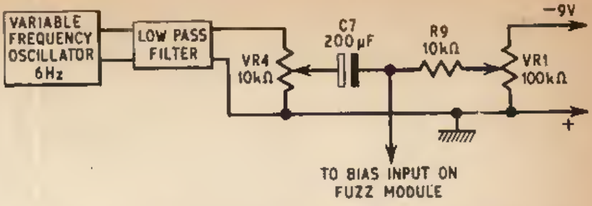


Fig. 9. Using an l.f. oscillator and low pass filter, add VR4, C7, and R9 to the bias control VR1 for rhythmic fuzz

RHYTHMIC FUZZ

The behaviour of the module is greatly influenced by the amount of negative bias fed to the bias input. Also a small amount of positive bias will switch off TR2, and effectively block the signal path altogether. The experimenter may take advantage of these features for various purposes including remote or automatic control over the module.

One suggestion here is to connect the bias input to a low frequency oscillator (as used in tremolo units) according to the circuit in Fig. 9, when the fuzz output quality and amplitude will be controlled by the oscillator to give a rhythmic fuzz effect. The oscillator may be run at around 6Hz for most purposes. ★

Meetings . . .

SOCIETY OF ELECTRONIC AND RADIO TECHNICIANS

COVENTRY

Date: October 19
Title: Thyristors
Time: 7.30 p.m.
Address: Herbert Art Gallery and Museum, Earl Street, Coventry.

NORTHAMPTON

Date: October 26
Title: Record Playing Units
E. Mortimer
Time: 7.0 p.m.
Address: Northampton College of Technology, St. George's Avenue, Northampton.

INSTITUTION OF ELECTRICAL ENGINEERS

LONDON

Date: October 20
Title: Testing and Specification of Integrated Circuits
Time: 5.30 p.m.
Address: Savoy Place, London, W.C.2.

INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS

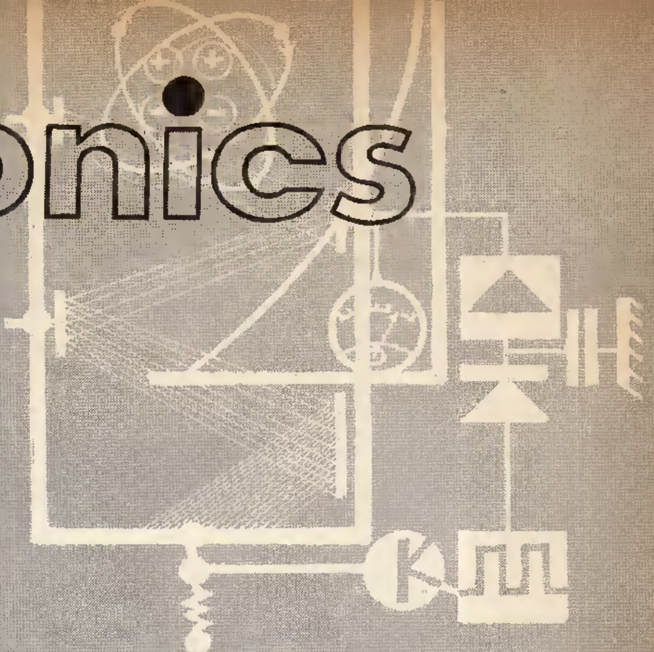
COLCHESTER

Date: October 24
Title: The Future of Electronic Telephone Exchanges
V. E. Mann
Time: 7.0 p.m.
Address: University of Essex, Wivenhoe Park, Colchester.

NOTTINGHAM

Date: October 18
Title: Microcircuitry, Dr. I. C. Walker
Time: 6.30 p.m.
Address: Nottingham University, University Park.

nucleonics for the EXPERIMENTER



By M.L. Michaelis M.A.

This series will discuss the nature of nuclear radiations and the design and use of electronic equipment for their detection and measurement.

Constructive experiments and observations which can be carried out by schools, amateur clubs, and individuals will be included.

These articles will also serve as a comprehensive introduction to pulse circuit techniques for students of atomic physics.

1—THE NATURE OF NUCLEAR RADIATIONS

It is important that we first of all understand what the word nucleonics stands for. Nuclear physics, or the study of the atomic nucleus, is sometimes referred to as nucleonics; but more usually this term is applied to the *electronic techniques* and *equipment* designed specifically for the generation, registration, detection, quantitative measurement, and general study of radiation emitted by the atomic nucleus.

ELECTROMAGNETIC RADIATIONS

There are two important classes of nuclear radiations. Firstly, there are the energy quanta emitted by displacements of the constituents of an atomic nucleus. These radiations are known as *gamma rays*.

Also generally included in this category are X-rays, although these do not originate from the nuclei of atoms, but from the energy quanta involved in the displacement of the innermost planetary electrons around the atomic nucleus. (Similar displacements of the *outermost* planetary electrons around the atomic nucleus involve much smaller energy quanta, so that the corresponding radiations are visible light, or wavelengths of electromagnetic radiation close thereto.)

It is thus evident that there is no essential difference between visible light, X-rays, and gamma rays—or ordinary wireless waves for that matter. All are electromagnetic waves with the same basic character, differing only in wavelength and frequency, whereby the product of wavelength and frequency is always the speed of light, *c*.

CORPUSCULAR RADIATIONS

The other important class of nuclear radiations is known as *corpuscular* radiation, and the simplest example is a beam of electrons. This is known as a *cathode ray* when emitted from a thermionic cathode of a cathode ray tube in the familiar manner, and such cathode rays are not generally classed among the true nuclear radiations. They consist of planetary electrons external to the nuclei of atoms in the cathode, drawn away by the applied high anode voltage, see Fig. 1.2.

Now numerous types of atomic nuclei are unstable, and ultimately eject various fragments as corpuscular radiation, in order to reach a more stable inner structure. The ejected particles may be electrons. In this case, the electron beam is known as a *beta ray*. The ejection of beta rays (electrons) out of the atomic nucleus takes place *spontaneously*, without any need for heating or an anode voltage analogous to the cathode ray tube.

Any fragment of the parent atomic nucleus may be emitted as a corpuscular ray, in principle, but only one type of fragment is encountered very commonly apart from the already mentioned beta ray electron. This is the so-called *alpha ray*, or alpha particle. Curiously, it is not the simplest brick in the structure of an atomic nucleus, but is composed of four such primary bricks.

In this series of articles, we are thus concerned with electronic equipment for the detection and quantitative measurement of alpha, beta, and gamma rays. The former two are corpuscular radiations, i.e. they are particles of matter, whilst the gamma rays are pure electromagnetic waves.

To be strictly accurate, modern theories of the duality of matter and radiation show that an electromagnetic wave also possesses mass and inertia, i.e. may be treated as matter in the same rights. However, the important distinction remains, that an electromagnetic wave is never at rest, but always travelling at the speed of light. Its mass and inertia are solely due to this motion. In contrast thereto, true corpuscular particles possess mass and inertia even when at rest. Furthermore, they may be hurled out of the parent atomic nucleus at any speed, according to the energy dissipated in the process. The speed of light is merely a maximum limit in this case.

ATOMIC STRUCTURE

An atom may be described by analogy to the solar system, see Fig. 1.1. Almost all the mass is concentrated in the nucleus, which occupies only a very small portion of the volume of the atom. The sun similarly contains almost all of the mass of the solar system, but only a negligible part of the volume encompassed by the tracks of the planets. The planets around the atomic nucleus are the so-called *planetary electrons*. Their binding energy, i.e. energy required to remove them out of the sphere of influence of the nucleus, is most conveniently expressed in terms of the voltage stress needed to draw them away. The energy unit for nucleonics is thus the *electron-volt* (eV).

The binding energy of the outermost planetary electrons lies in the region of one or two eV. This fact is familiar as the e.m.f.'s of simple primary cells and accumulator cells, which function by virtue of displacements of the outermost planetary electrons of atoms in the electrodes and electrolyte. The binding energies of the innermost planetary electrons of a complex atom, i.e. of those electrons closest to the nucleus, are very much greater. Values of several keV (kilo-electron-volt = 1,000eV) are common, and 100keV is reached in some cases. Energy quanta of these magnitudes are emitted as *X-rays* when the reverse process takes place, i.e. when an electron is captured by a deep vacancy close to the nucleus of the atom, which was produced by some earlier disturbance.

REPRESENTATIONS OF HYDROGEN AND HELIUM ATOMS

Fig. 1.1a and Fig. 1.1b are classical depictions of the hydrogen and helium atoms, respectively. These representations are in direct analogy to the solar system, with discrete electrons considered to be revolving in prescribed orbits around the nucleus. The major difficulty with this simple model is that a revolving particulate electron would have to emit electromagnetic radiation, just as the non-linear electron motions in transmitting antennas lead to the energy radiation there. If a planetary electron in an atom were to radiate energy, it would ultimately collapse into the nucleus, i.e. the simple orbital model is untenable, when we consider it more closely. The only way to avoid the difficulty is to realise that the electron loses its localised particle nature, once it is in the atom.

In place of the orbit, we must consider an extensive system of contours in the space around the nucleus of the atom, defining either the statistical chances of finding an electron at each point (for interactions with external influences releasing electrons from the atom), or defining the space charge distribution.

Mathematically, the electron is here treated as a wave field, whose intensity contours are calculated by a modern system of mathematical operations known as *wave mechanics*, based on the equations of Schrödinger. The contours for a particular electron may well turn out to be a system of disconnected lobes, as sketched in Fig. 1.1c. Note that all these lobes belong to a *single* electron, so that in a complicated atom with 92 or more planetary electrons, there will be an extraordinary complicated system of wave-mechanical lobes around the nucleus. Chemical processes of combination between two or more atoms involve modifications and sharings of the outermost lobes of the complex systems. Ionisation involves "drip off" of outermost lobes as electron particles.

Normal electric conduction and semiconduction involve processes of *hybridisation*. This is the merging of the lobe systems of two or more electrons of one or more atoms, to form a distinctly new, comprehensive lobe system. Where such a lobe system embraces all atoms in a macroscopic piece of metal, the particle electrons can "drip in" and "drip out" at any point and are able to move freely within the hybridised lobe system. The application of potential differences then causes the flow of electrons familiar as an electric current. In semiconduction, the hybridisation is only conditional: there remain certain energy barriers which must be jumped, in passing between successive atoms.

NUCLEAR PARTICLES

The nucleus of any atom is formally considered to be composed of two types of primary particles, *protons* and *neutrons*. Each of these particles possesses unit mass by definition. The proton also carries unit *positive* electric charge, whilst the neutron is electrically neutral.

The total number of protons in the nucleus characterises the chemical nature of the atom, i.e. whether it is oxygen,

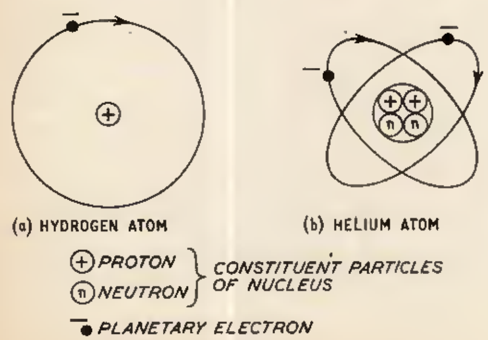


Fig. 1.1a, b. Classical depictions of atomic structure

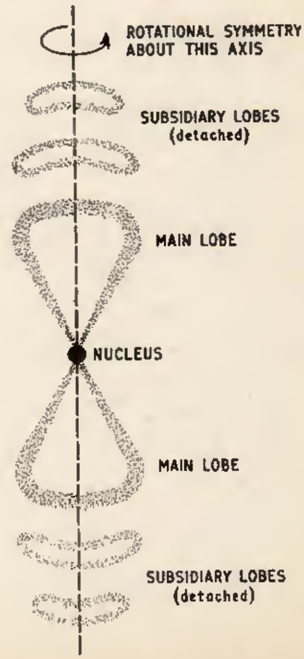


Fig. 1.1c. Pictorial attempt to sketch a typical electron orbit in a complicated atom such as uranium

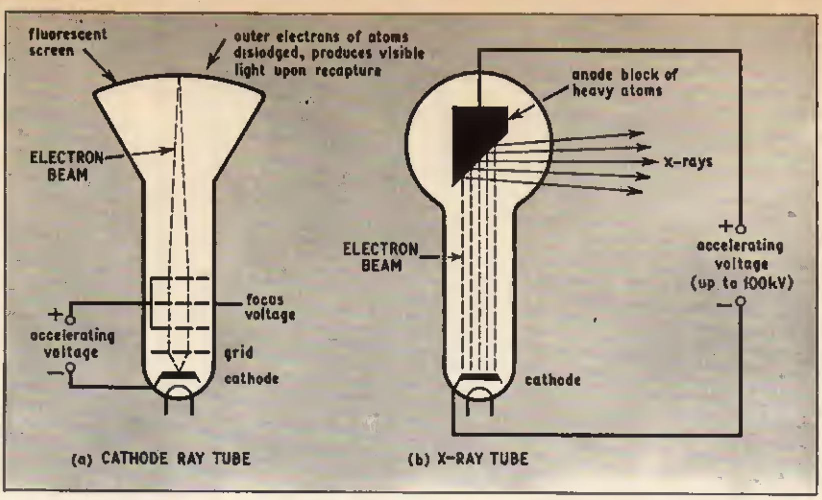


***Fig. 1.2. Comparison of a Cathode ray Tube and an X-Ray Tube.** In the cathode ray tube (a), electrons are accelerated with relatively low voltages and then impart a fraction of their energy (a few eV) to atoms in the fluorescent screen material, thereby dislodging only outermost electrons. When these are recaptured, the binding energy is released as electromagnetic radiation in the visible light spectrum.*

In the X-ray tube (b), very much higher accelerating voltages are employed, and a target of heavy atoms, with correspondingly greater binding energies of its electrons, is employed in place of the fluorescent screen. Inner planetary electrons (binding energies up to 100keV) are released in the target by the bombarding electrons, and when these inner electrons drop back, the binding energy is released as electromagnetic radiation of much shorter wavelength than visible light, known as X-rays.

Poorly designed cathode ray tubes can also emit X-rays, since acceleration voltages of one or two kV already suffice to produce soft X-rays if corresponding heavy atoms are present, e.g. in the glass of the tube face. Ordinary television picture tubes with final anode voltages up to 25kV normally produce negligible X-rays, but projection TV tubes with anode voltages up to 80kV and much higher beam currents usually emit considerable X-ray intensities and thus require efficient shielding.

sulphur, iron, uranium, or any other one of the chemical elements. This number of protons is known as the *atomic number* of the particular chemical element, and is quite specific for that element.

The total number of primary particles in the atomic nucleus, i.e. protons and neutrons taken together, is known as the *atomic weight* of that nucleus. It is not specific to a particular chemical element, because the same number of protons may be combined with various numbers of neutrons to produce different atomic nuclei all belonging to the same chemical element. Such groups of different nuclei are known as *isotopes* of the particular chemical element.

As far as elementary considerations are concerned, the atomic nucleus does not contain anything else apart from protons and neutrons. It does not contain any electrons as such. Electrons are present only external to the nucleus, as the already-mentioned planetary electrons. Just as the solar planets have only very small mass and size compared to the sun, so do the planetary electrons have negligible mass and size compared to the atom as a whole. The sole important attribute of the electrons is their unit negative electric charge.

The electrically neutral complete atom thus possesses the same number of planetary electrons as protons present in its nucleus, i.e. the atomic number is also the number of planetary electrons required to constitute a neutral atom with the given nucleus. If the number of actually present planetary electrons differs from the atomic number of the nucleus, then the resulting atom bears a net electric charge and is known as an *ion*. Ionisation is thus simply the process of removing planetary electrons from a neutral atom, or attaching surplus ones to it. In the former case we obtain a positive ion, in the latter case a negative ion.

BETA RAYS

Tne atomic nucleus does not contain electrons as such. Nevertheless, the emission of electrons as corpuscular rays is an extremely common nuclear radiation. In this process, a neutron changes into a proton and an electron, whereby the electron is hurled out as a beta ray, and the proton remains inside the nucleus. The atomic number has thus increased by one, so that a new chemical element has resulted, but the atomic weight has not changed.

The reverse process is also possible, but much rarer: a proton changes into a positive electron (known as a *positron*) and a neutron. The positron is hurled out of the nucleus and the neutron stays put. A third possibility, also much rarer than straightforward beta-ray emission, but commoner than positron emission, is the capture of an innermost planetary electron into the nucleus, whereby a proton combines with this electron to produce a neutron. Soon afterwards, an external electron is captured by the atom to fill the planetary electron vacancy left by the nuclear capture process. As already explained, this leads to the emission of a corresponding X-ray.

It is evident that beta ray emission and the described analogous processes are ones adjusting the *ratio of protons to neutrons* in the atomic nucleus. Optimum stability of an atomic nucleus results when about equal numbers of protons and neutrons are present, with somewhat greater numbers of neutrons being favoured, the greater the total number of particles.

ALPHA RAYS

An alpha particle consists of two protons and two neutrons. It is the nucleus of an ordinary helium atom, as shown in Fig. 1.1, and represents the most stable one of all atomic nuclei. For this reason, it is ejected in preference to simple protons, neutrons or other heavy particles, in the overwhelming majority of cases where a parent nucleus is unstable on account of pure excessive weight.

An alpha ray emission clearly reduces the atomic number by two, and reduces the atomic weight by four units, so that a new chemical element with a *different* atomic weight than the parent is produced.

RADIOACTIVE DECAY CHAINS

Any atomic nucleus which is unstable, i.e. which sooner or later sheds particles to reach a more stable state, is described as being *radioactive*. The process of shedding the particles is known as *radioactivity*.

Heavy radioactive nuclei are usually unstable for both reasons—excessive total number of primary particles and unfavourable proton/neutron ratio. The radioactive decay to the final stable residue thus takes place in a series of successive steps which are together known as a radioactive decay chain. In many cases, such decay chains show repetitive sequences of an alpha emission followed by two successive beta emissions. The final result of this set of three steps is to leave the atomic number unchanged, because the alpha emission decreased the atomic number by two, but each beta emission increased it again by one. However, four units of atomic weight have been irretrievably lost by the alpha emission. The new nucleus is thus another isotope of the original parent nucleus, with four less neutrons. This composite method of, in effect, shedding neutrons is very much more common than direct ejection of neutrons as such.

NUCLEAR STRUCTURE

The structure of an atomic nucleus is very complex, hardly conceivable in rational concepts, and not yet fully understood in terms of even the most advanced mathematics. However, certain important basic facts must be underlined here.

The diagram Fig. 1.3 should be taken as a formal depiction of the observed behaviour, rather than as the true structure of the nucleus. Thus it is probably incorrect to insist that the protons and neutrons in the nucleus are ready grouped as alpha particles and lone excess neutrons. This representation has been adopted in a formal manner, only because it stresses two important facts. Firstly, the emission of alpha particles, not protons or neutrons, when the aim is to lose weight. Secondly, the fact that the ratio of the number of neutrons to the number of protons is greater than two for all but the lightest atoms, and increases with increasing total number of nuclear particles. Thus lighter nuclei formed by splitting heavier ones (e.g. in nuclear explosive devices and reactors) contain an excess of neutrons. These stabilise by the transformation of successive neutrons each into a proton and an electron, the latter being ejected as a beta ray.

The over-simplification of the diagram is also evident when it is remembered that the total number of protons need not be even. Whether an alpha particle or a beta particle is emitted, the disturbance may be considered formally as leaving a hole. The energy released when this hypothetical hole closes is emitted as a gamma ray (electromagnetic radiation).

MESON FIELD

The cement holding the various nuclear particles together, is depicted as a "meson field". The only net charges in the nucleus are positive, i.e. all of one polarity. Thus there are enormous electrostatic repulsion forces. The meson field must not only bind the particles, but also overcome the electrostatic repulsions. The meson field may be considered as a force field resulting on account of resonances between various states of the nuclear particles.

Mesons are particles associated with this field and capable also of external independent existence, just as photons are now familiar particles associated with the electromagnetic field and indeed identical thereto. The gamma rays emitted in conjunction with many alpha and beta particle emissions, may also be treated as particles, as photons, because they are electromagnetic waves.

From the nature of beta ray emission and analogous processes described above, it is clear that even the primary

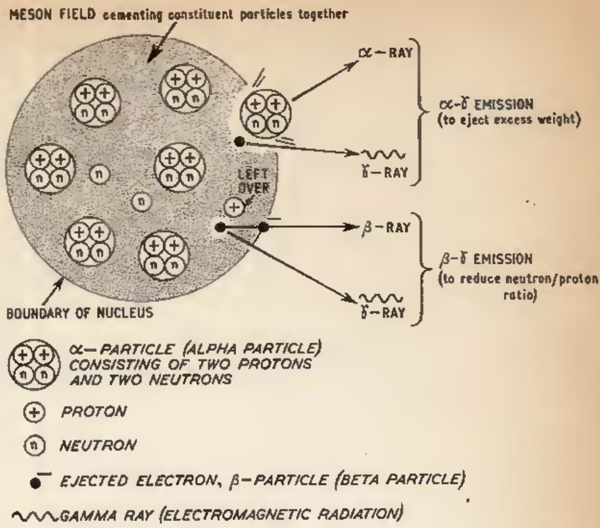


Fig. 1.3. An attempt to depict the structure of an atomic nucleus

particles can not be considered as indestructible or unchangeable entities, for they can clearly mutually change into each other.

Certain resonance effects between the various states of a common principle represented by these primary particles give rise to extremely powerful forces holding the neutrons and protons together, in spite of the powerful electrostatic repulsion of the numerous positively charged protons. These resonance forces may be formally described in terms of a whole host of other particles, which indeed have been observed to have a fleeting independent existence outside the atomic nucleus too.

BINDING ENERGIES

The important systematic principle underlying these effects may be expressed in terms of binding energies and energy groupings. We saw that the binding energies of planetary electrons range from a few eV for the outermost ones, to some 100keV for the innermost ones. The binding energies of nuclear particles are of even greater order of magnitude, mostly lying in the range from 0·1 to 10MeV (mega-electron-volt = 1 million eV). Certain groupings are particularly stable, notably the alpha particle. This does not necessarily imply that groups of two protons and two neutrons are present in a complex nucleus ready to be ejected as alpha particles in due course, any more than a radioactive nucleus ultimately ejecting a beta ray contains any electrons as such beforehand. The true nature of the particle and energy groupings and re-shufflings is certainly vastly more complex.

The emission of *gamma rays*, which in most but not all cases accompanies the corpuscular emissions, is intimately connected with these internal particle re-shuffles inside the nucleus. Before, during, or after a corpuscular particle emission, the particles in the nucleus may be left in an "excited" state, i.e. with internal groupings possessing more energy than the alternative grouping of lowest possible energy for the given set of particles. The nucleus will then in due course revert to the *ground state*, as the lowest-energy grouping is called. The surplus energy is thereby emitted as a gamma ray.

In most cases, the lifetime of the excited state is so extremely brief, that the gamma ray is to all intents and purposes emitted simultaneously to the beta or alpha ray, but in a few cases there may be a delay of minutes or hours. Only in such cases is the excited state of the nucleus, which later decays by a pure gamma ray emission, considered to be a separate step in the radioactive decay chain. Thus gamma ray emission alone is not one of the commoner classes of radioactive processes.

PENETRATING POWER

The penetrating power of a nuclear radiation depends upon three factors:

(1) The nature of the radiation.
(2) The incident or emission energy of the individual particles or quanta involved.
(3) The nature of the material which the radiation is called upon to penetrate.

Alpha particles are less penetrating than beta particles, which in turn are less penetrating than gamma rays.

Alpha particles have such low penetrating power, that they are stopped by the walls of most detectors, which are thus largely insensitive to external alpha-emitting samples. To a first approximation, it is solely the *mass per unit area* which determines whether a radiation can penetrate the obstacle or not. The detailed chemical and physical nature of the obstacle is only of secondary importance. It is thus customary to state the mass per unit area for the sensitive surface of radiation detectors intended for use in conjunction with external samples.

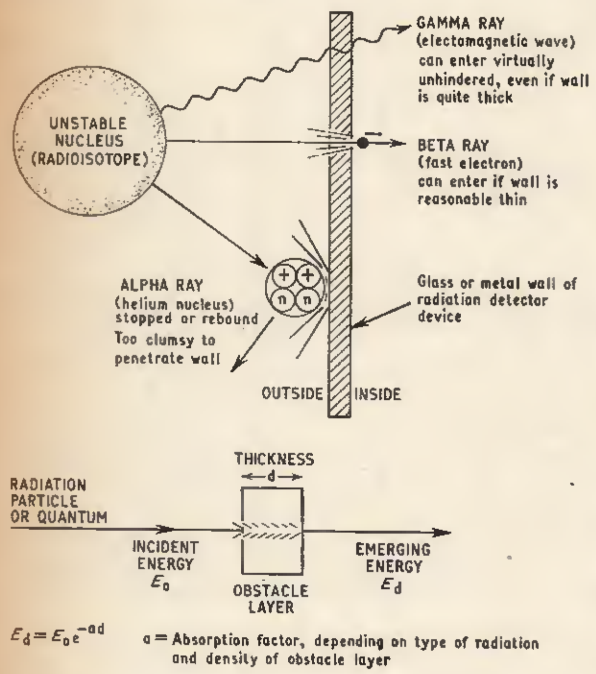


Fig. 1.4. The penetrating power of nuclear radiations

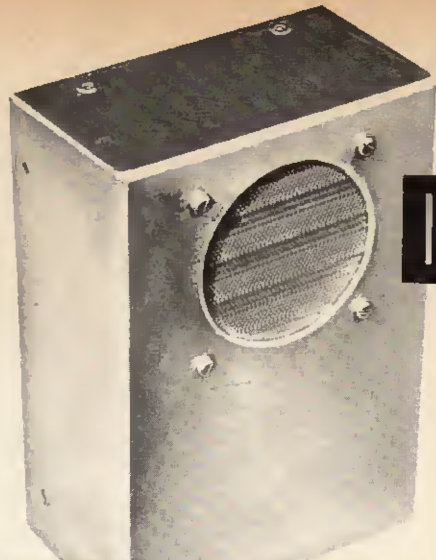
Gamma rays will penetrate many grams/cm^2, so that any normal glass or metal walls are satisfactory.

Beta rays will satisfactorily penetrate 20–60 milligrams/cm^2, calling for thin-walled glass tubing, thin metal windows, or cleaved mica windows in the sensitive region of Geiger-Müller counter tubes.

Good penetration of alpha rays calls for windows of less than about 15 milligrams/cm^2, i.e. extremely thin entrance windows on the side or face of the detector.

All three types of nuclear radiation are absorbed by successive small energy losses through collision with or ionisation of the encountered atoms of the obstacle layer. The charge density on the ionisation track is thus inversely proportional to the penetrating power. Alpha particles produce the densest, but shortest, ionisation tracks; gamma rays produce the least dense, but longest ionisation tracks.

Next month: Every day applications of nuclear radiations; a composite equipment for the amateur



DOOR

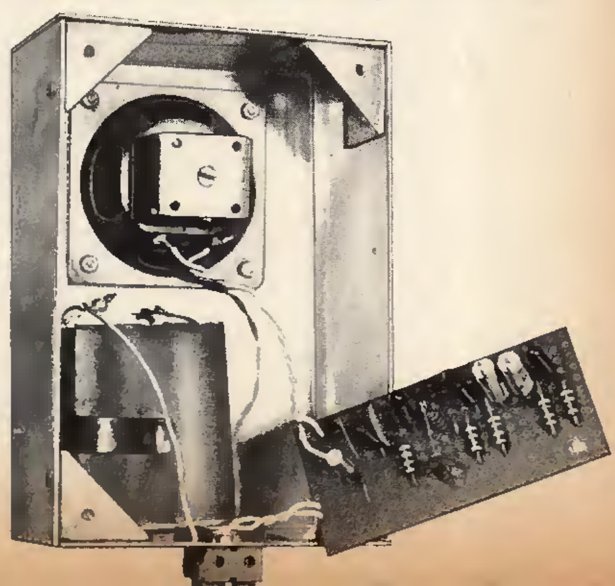
TWO-TONE door chimes are popular in many households, as long as the caller does not push the button too many times. Here is described an alternative two-tone calling signal generator using electronic techniques.

RELAXATION OSCILLATOR

In essence the two-tone generator is a relaxation oscillator TR4 and TR5, which is switched on and off by a multivibrator TR1 and TR2. The switching rate or "yodel" frequency is determined by the time constant networks R2C1 and R3C2 which provide a switching time of about 0·5 second.

The pulse output from TR2 collector is fed to a Schmitt trigger TR3 via R6. The value of R6 can be adjusted to change the rate of alternation, while R5 and R8 can be adjusted if a change of pitch is required.

To lengthen switching interval, capacitors C1 and C2 should be increased. When TR2 is switched off during the relaxation period, TR3 is hard on, providing bias current to TR4. The base of TR4 goes negative while the base-emitter junction of TR5 is biased positively. This step increase across the loudspeaker load is fed back through R9 and C3 to TR4 base to provide regeneration. The yodel pitch is determined by the charge and discharge rate of C3 through the low resistance path of the base-emitter junction of TR4.



YODELLER MONITOR

By G.E. DUNNING

COMPONENTS . . .

Resistors

R1	4·7kΩ	R4	4·7kΩ	R7	1kΩ
R2	47kΩ	R5	1kΩ	R8	47kΩ
R3	47kΩ	R6	330kΩ	R9	470Ω

All 10%, ¼W carbon

Capacitors

C1 32μF elect. 15V
C2 32μF elect. 15V
C3 0·1μF disc ceramic 10V

Transistors

TR1, 2, 3, 4 OC71 (4 off)
TR5 NKT713

Miscellaneous

LS1 3Ω loudspeaker, 2½in square
S1 Single-pole push button switch
BY1 4·5V flat pack battery
Veroboard 3½in × 1⅝in, 0·15in matrix
Chassis 6in × 4in × 2¼in, twin cable
Two-way terminal block

When TR3 is switched on the frequency goes up; when switched off the frequency falls. The volume of the output is not easily controlled, but a certain amount of judicious experiment with speaker and cabinet size, and the location of the unit in the house, will give satisfactory results.

WARNING

A word of advice: continuous operation can be rather trying on the ears, so remember the neighbours. It is unnecessary to keep the push button pressed for long.

If only a brief push is applied the yodel may not have had sufficient time to work on two tones, because there is a slight time delay before the yodeller changes pitch initially.

Secondly, for those readers looking for two-tone car horns, we stress that they are strictly reserved for the three emergency services and it is illegal to use similar two-tone car warning devices for private vehicles.

CONSTRUCTION

Construction is very simple, the whole circuit being built round a piece of Veroboard. Two wires go to the loudspeaker, two to the push button, and two to the battery. Wiring details are shown in Fig. 2 and the photograph, so little more need be said on the subject. ★

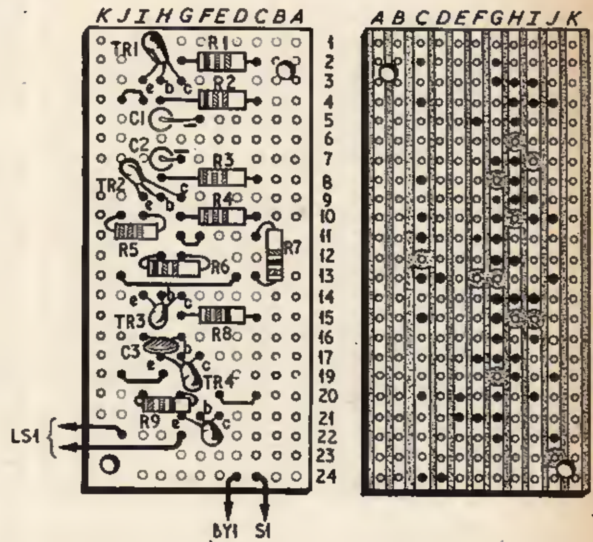


Fig. 2. Component layout and underside view of the Veroboard panel

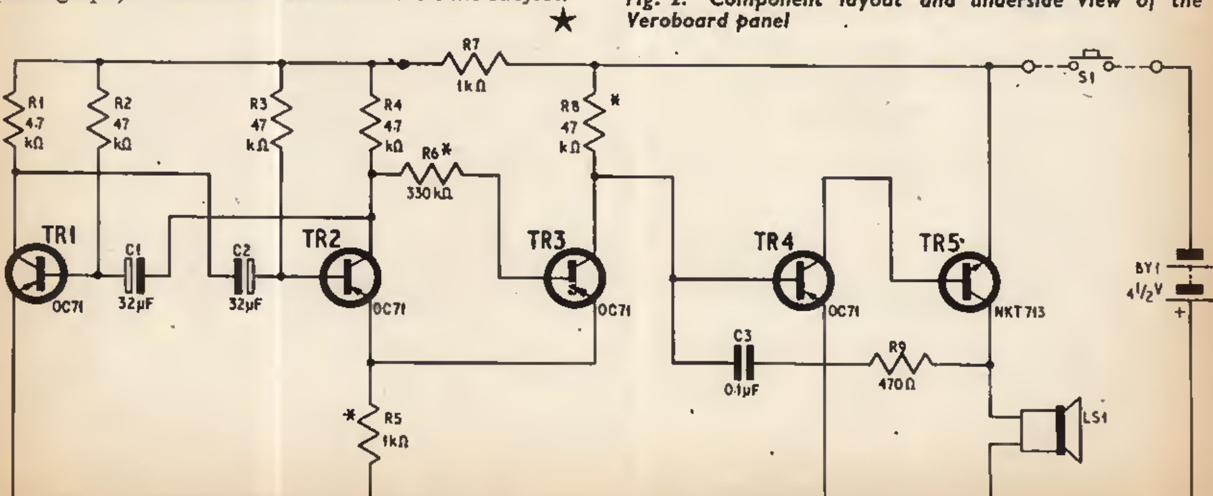


Fig. 1. Circuit diagram of the complete "Yodeller" Door Monitor

COMPUTER FOR "QUEEN ELIZABETH II"

THE NEW Cunard liner, *Queen Elizabeth II*, launched by Her Majesty the Queen on September 20 at John Brown's shipyard, Clydebank, is the first merchant ship to combine technical, operational and commercial functions at sea by using a Ferranti Argus 400 computer (right).

This ship-borne computer can undertake a wide range of functions which previously has only been carried out on a shore-based installation. The range of shipboard applications in the liner greatly exceed that of any other existing installation in a merchant ship.

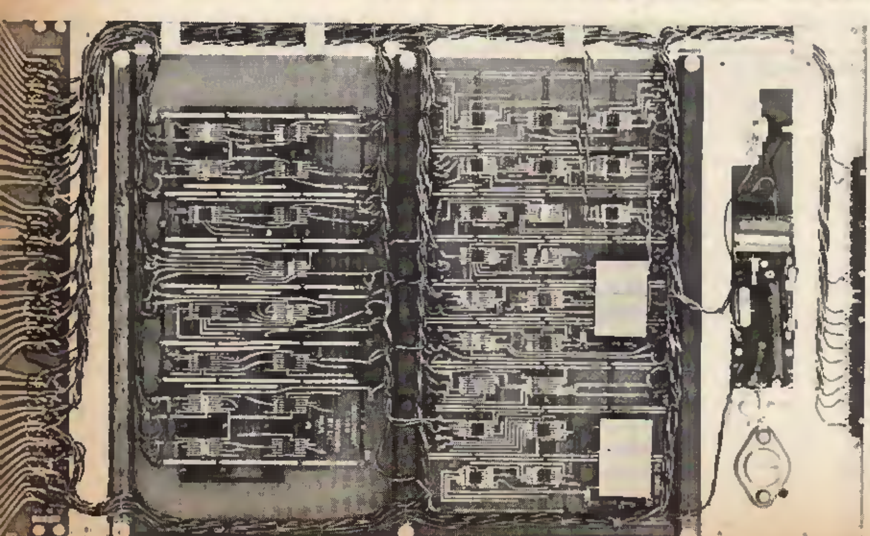
Initially the computer system will have six main functions:

1. Data logging—automatically recording the state of the main engines and other machinery, and printing the engine room log.
2. Alarm scanning—continuous automatic check on the main machinery. When any temperature or pressure departs from normal limits the computer warns the engineers immediately.
3. Machinery control—continuous control of certain machinery to give increased economy and thus lower fuel consumption.
4. Weather routing—computing almost instantaneously as weather reports are received, the best speed and course to minimise fuel consumption without delaying the ship.
5. Prediction of fresh water requirements—enabling maximum efficiency and economy in the use of the evaporating plant, which makes fresh water from sea water.
6. Stock control—recording of stocks of some 3,000 items of food, drink, and domestic supplies in six major stores in the ship, and reporting bonded goods unsold at the end of a voyage.

It is hoped to extend the computer's functions to other data-processing needs of the ship, such as the billing of passengers' personal bar accounts.

The computer installation is the outcome of research in which Cunard have co-operated with the British Ship Research Association, the N.R.D.C., Ferranti Ltd. and John Brown & Co. (Clydebank) Ltd.

ELECTRONORAMA

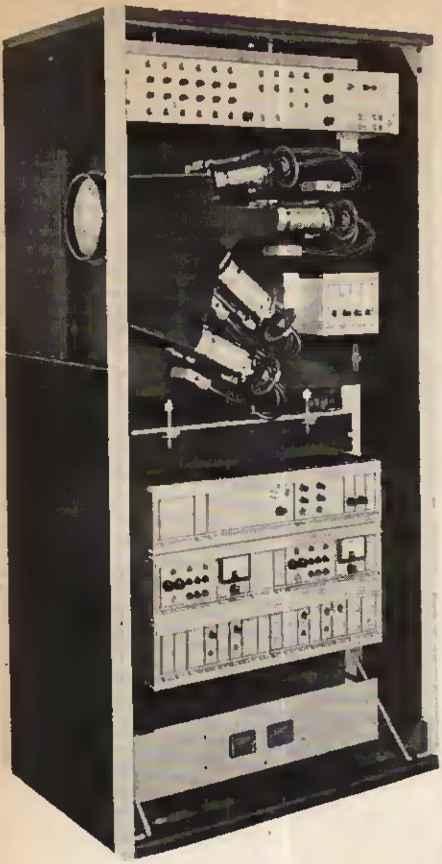


P.C.M. Tandem Uses Integrated Circuits

THE world's first pulse code modulation tandem telephone exchange, developed by the Telephone Switching Division of the Post Office Engineering Research Establishment, will be installed in the switched network at the London Empress exchange by the end of this year.

The unique part of this exchange system is the use of silicon integrated microcircuits supplied by SGS-Fairchild. It is being built to prove in public service, the practical feasibility of a Post Office theory, with the expectation that efficiency will be improved and running costs reduced.

(Photograph by courtesy of the Postmaster General)



Colour Telecine Camera and O.B. Vehicle

On exhibition at the Design Centre in London recently was a new range of matching units for television broadcasting studios.

Vision and sound equipment, in Range 70 by Pye TVT Ltd., is already being used by ATV at Elstree in outside broadcast vehicles. Our picture above shows the interior of such a set-up having an audio mixer with 50 inputs, vision monitors, and loudspeaker monitor.

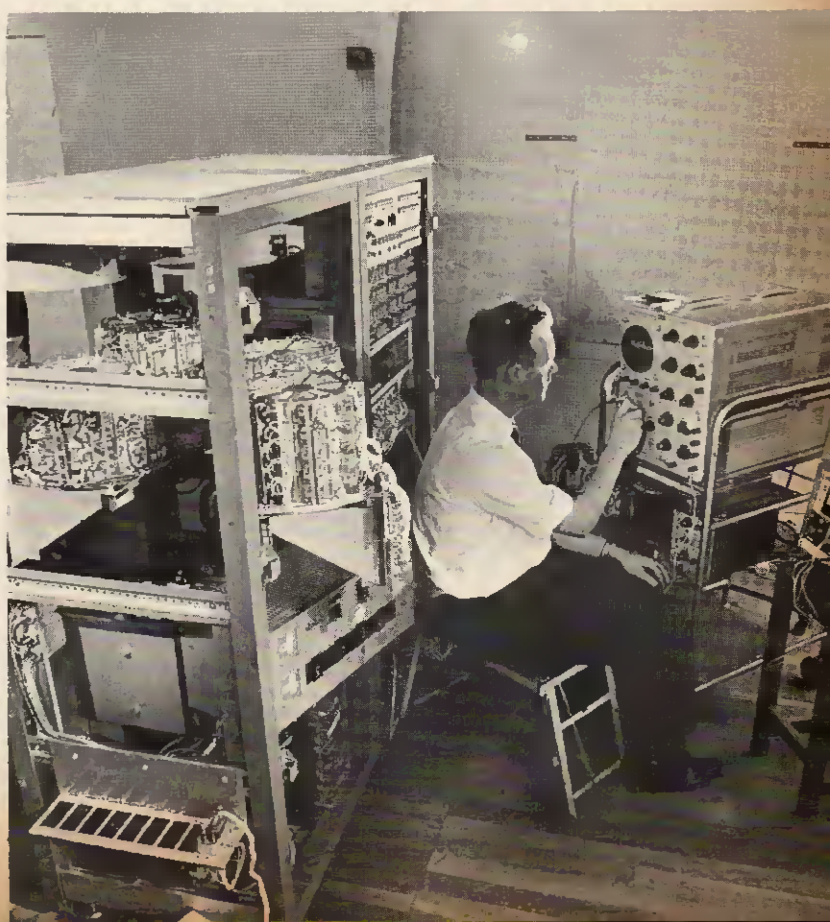
On the left is shown the new Pye 4 Plumbicon colour telecine camera which can be used in conjunction with up to three film projectors.

Power Regulators for Computer Stores

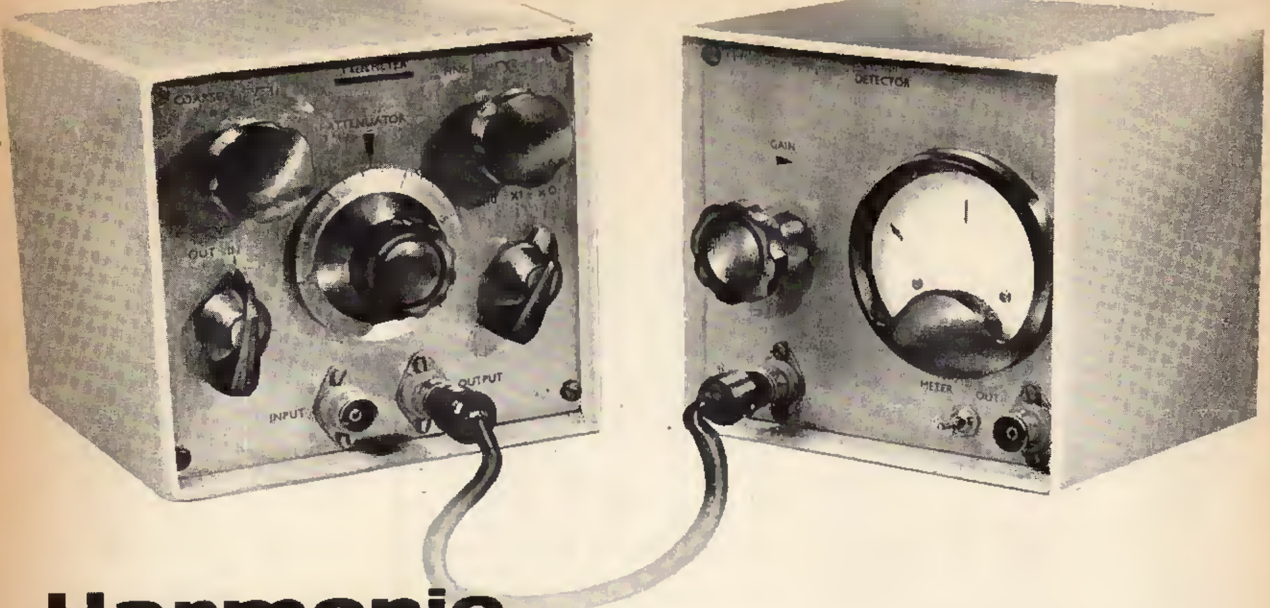
To ensure that power supplied to System 4 computer central processors and core stores is maintained at a constant voltage, English Electric Computers Limited have incorporated power supply units capable of compensating for wide variations in the mains supply.

In the photograph an engineer is using an oscilloscope to test the performance of a power supply unit for use with a System 4-50 central processor and core store. This unit is capable of compensating for a 20 per cent drop in mains voltage level and an increase of up to 10 per cent. It incorporates a monitor panel (visible behind and above the engineer's head) which monitors all circuits for abnormal conditions of faults and indicates any it discovers on a row of lamps.

The regulator circuits are located on four radially extending heat sinks (one of which is seen extended outwards from the body of the unit, left centre) and cooling is effected by fans which force air through each heat sink.



By D. BOLLEN



Harmonic DISTORTION Meter

EVEN well equipped workshops sometimes lack facilities for making distortion measurements. Many audio amplifier specifications include a figure for total harmonic distortion at 1kHz, and the need is primarily for a distortion check at a single frequency, and at a given power level, to ensure that an amplifier lives up to its original specification. A harmonic distortion meter designed for single frequency working can be simple, and the cost will be much lower than for an instrument covering the whole audio band.

A notch filter and attenuator unit is described in this article, which will enable total harmonic distortion at 1kHz to be measured down to 0·01 per cent, depending on input level and detector sensitivity, when an oscilloscope or audio amplifier is employed as an output monitor.

For those desiring a complete instrument, a simple add-on 500μV detector unit is also given. The aim has been to produce an instrument with as few components as possible without sacrificing sensitivity or accuracy.

DISTORTION MEASUREMENTS

Distortion can be described as the unwanted additions made by an imperfect amplifier in the process of amplifying a signal. Since valves and transistors are both non-linear devices, their use in an amplifier with a power gain greater than unity will inevitably result in some distortion of the signal. Small amounts of non-linearity are difficult to measure directly, but the side-effects resulting from non-linearity are easily detected.

When a sine wave of known purity is applied to the input of a non-linear amplifier, a series of harmonically related signals will be generated, and will appear at the output terminals, together with the original signal plus noise. A signal at frequency f will give rise to spurious output signals at $2f$, $3f$, $4f$, and so on. If a filter is arranged to remove the fundamental signal, the remaining output will consist of total harmonic distortion and noise.

NOTCH FILTER

The most convenient way of rejecting the fundamental is to employ an RC notch filter, with its skirt response improved by placing the filter in the negative feedback path of a local amplifier. The rejection notch must be sufficiently narrow not to cause attenuation of frequencies apart from the fundamental.

Two curves are compared in Fig. 1, and show the effect of negative feedback on a parallel-T network. The dotted line gives the response without negative feedback and, as there is considerable rejection of second and third harmonics, such a response would lead to an optimistic estimate of the amount of distortion present. With the solid curve, however, there is virtually no attenuation even of the second harmonic, and this is, in fact, the response given by the instrument described here. Note also that the pass band response is linear over a wide range of frequencies, due to the generous use of negative feedback.

MEASURING METHOD

A block diagram is given in Fig. 2 showing the method used for measuring distortion. The purpose of the attenuator, in the diagram, is to provide a reference level against which the distortion and noise content may be compared. An alternative method would be to employ a multi-range millivoltmeter to measure filtered and unfiltered outputs, but accuracy would be hampered by meter linearity and range switching discrepancies.

With the attenuator, accuracy will mainly depend on the ability of the constructor to graduate a potentiometer, which is not difficult. Moreover, the attenuator allows a simple output detector to be used in place of an expensive millivoltmeter, and this need be nothing more than a small transistor amplifier coupled to a testmeter or an oscilloscope, to give indications at levels of around 1mV.

Harmonic distortion is normally given as a percentage and it should not include noise. Another term, distortion factor, should be expressed as a decimal, with noise included. Often the two are confused. Percentage harmonic distortion can be found by measuring noise separately and subtracting it from the distortion plus noise figure. Returning to Fig. 2, V is the fundamental signal, D the total harmonic distortion, and N the noise. The notch filter will eliminate V in the upper branch when the switch is in the position shown in the diagram, leaving $D + N$. The attenuator is adjusted so that the output detector reads the same in both switch positions. $X(V + D + N)$ will therefore equal $D + N$, where X is the amount of attenuation.

It only remains to calibrate the attenuator dial 0–100, call $V + D + N$ 100 per cent and X will then be a direct percentage $D + N$ figure. The noise may be subtracted from the distortion by removing the signal when the filter is switched in, so that N alone is measured and compared with $V + D + N$, in the filter out switch position with signal on.

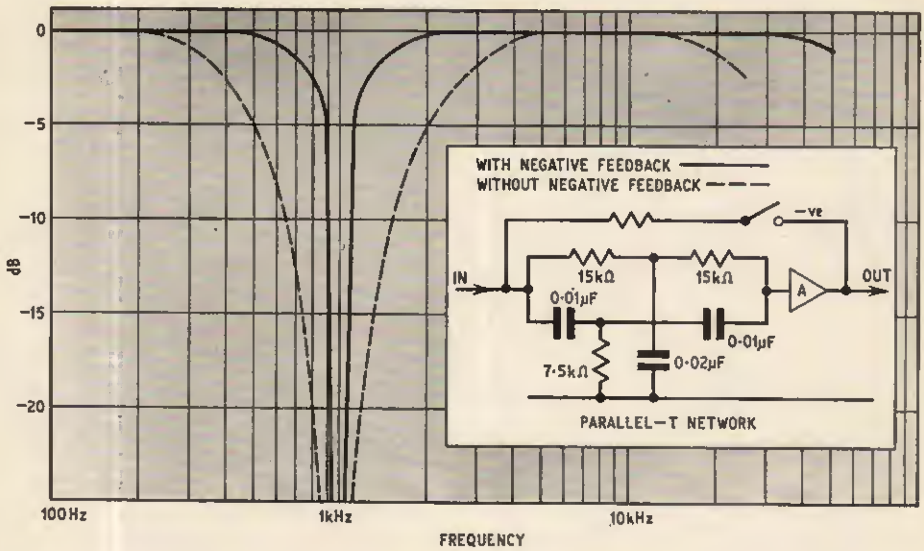


Fig. 1. Frequency response of parallel-T network

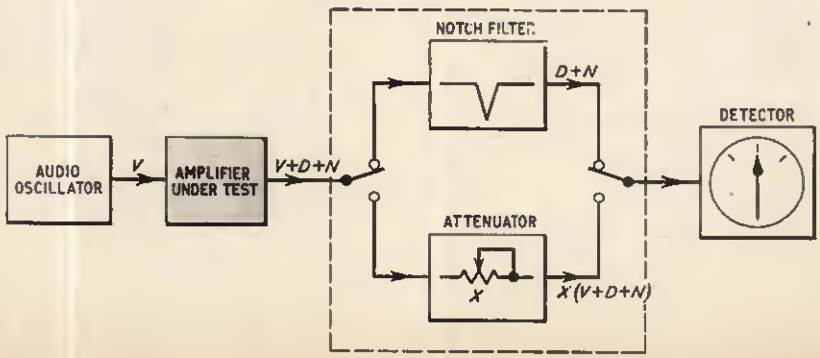


Fig. 2. Block diagram showing method of measuring distortion

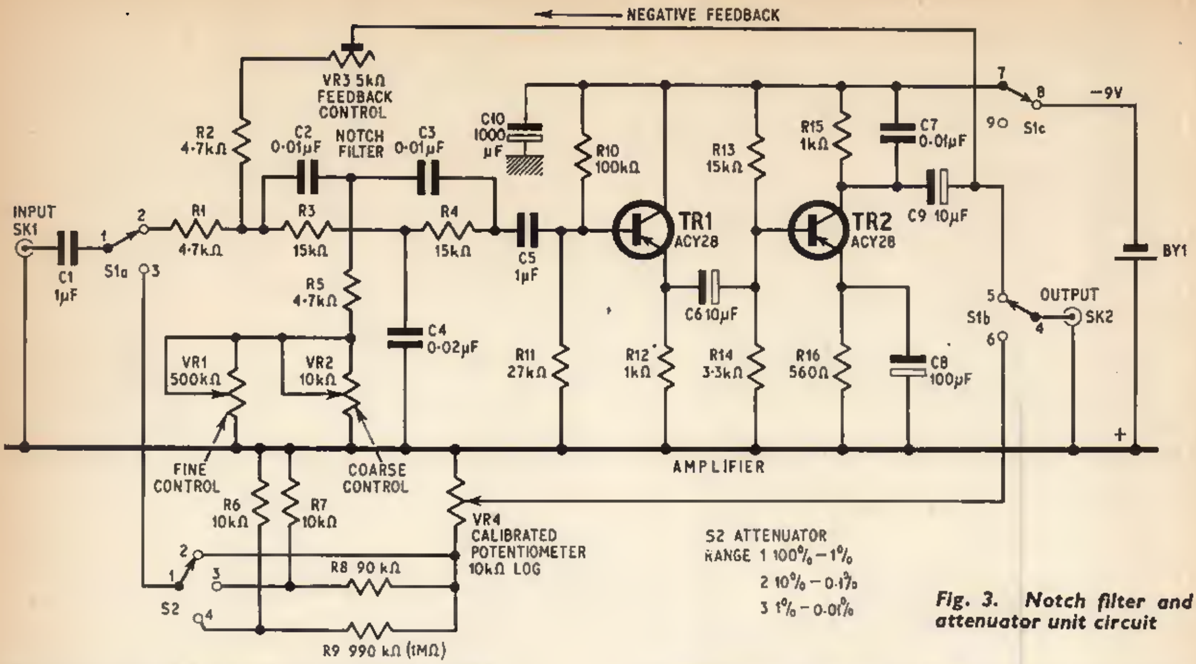


Fig. 3. Notch filter and attenuator unit circuit

NOTCH FILTER AND ATTENUATOR CIRCUIT

The circuit of Fig. 3 gives the 1kHz notch filter and feedback amplifier, combined with a calibrated attenuator. TR1 and TR2 form a phase reversing amplifier with a medium input impedance, which also cancels gain losses introduced by the passive filter network. VR3 is the negative feedback control, adjusted for an overall unity gain. R2 has been selected to ensure that there is always enough feedback present to keep the rejection notch narrow.

The parallel-T filter is composed of R3, R4, R5, coarse notch control VR2, fine notch control VR1, together with capacitors C2, C3, and C4. When a signal with a very low distortion content is to be assessed, null adjustment of the filter can be critical, hence the fine control VR1.

With the filter switched in by S1, the battery supply is activated and the signal passes via C1, R1 to the filter, where the fundamental is rejected. The remaining distortion and noise is picked up by the emitter follower TR1, which places a negligible load on the filter. TR2 is a common emitter amplifier, with C7 included in its collector load to prevent high frequency instability. The maximum available output from TR2 is more than 1V r.m.s.

R6 and R7 ensure that the input impedance of the attenuator is the same as that of the filter, i.e. close to 10 kilohms, to prevent load variations between the two functions when coupled to a high impedance source. Calibrated potentiometer VR4 has a logarithmic track to spread the lower calibration division on its dial and give an overlap between ranges.

Although precise values are assigned to R8 and R9 on the circuit diagram, they are based on the assumption that the total track resistance of VR4 is 10 kilohms exactly, and adjustment of their values might be called for if the track resistance is not as stated. R8 should be as close to 9 times the track resistance as possible, but a 1 per cent 1 megohm resistor for R9 will cause a negligible error with all but the widest tolerance potentiometers. The range switch S2 gives ×10, ×1, ×0·1 multiples with the VR4 dial calibrated 0·1–10 per cent.

OVERLOAD PROTECTION

The circuit will withstand an input of 50V r.m.s. at any frequency within the audio band. Tests were carried out with an input of 50V r.m.s. at 5kHz, this representing a gross overload. The maximum r.m.s. voltage appearing on the base of TR1 under such conditions was 5V r.m.s. Naturally, when a high voltage input at 1kHz is experienced the filter will absorb most of it. Typically, a 50V 1kHz input containing 1 per cent distortion and noise will place 50mV on the base of TR1. It is useful to have this margin of overload protection when taking high level outputs from equipment using valves, where the voltage swing can be considerable.

CONSTRUCTION OF NOTCH FILTER AND ATTENUATOR

The controls are mounted on an 18 s.w.g. aluminium front panel measuring 4½in × 5in, and drilling details are given in Fig. 4. A bracket is used to mount the circuit panel, and this is made up according to Fig. 5. The front panel can be given a pleasing appearance—and scratches removed—by drawing a damp suede brush repeatedly across its face. The "brushed" lines should be kept parallel and as straight as possible. After transfer lettering has been fixed on, the surface can be protected with a thin layer of varnish.

Assembly can proceed with the mounting of potentiometers, switches, and coaxial sockets. Layout and wiring of these components is shown in Fig. 6. Attenuator resistors are wired to S2 terminals as shown. The circuit panel mounting bracket slides under the bushes of VR1 and VR2, and is clamped securely when the potentiometer bush nuts are tightened. Flying leads should be left for later connection to the circuit panel, and are colour coded in the diagram to prevent errors. While calibrating VR4 dial, the leads should be taped to insulate them from chassis and from each other.

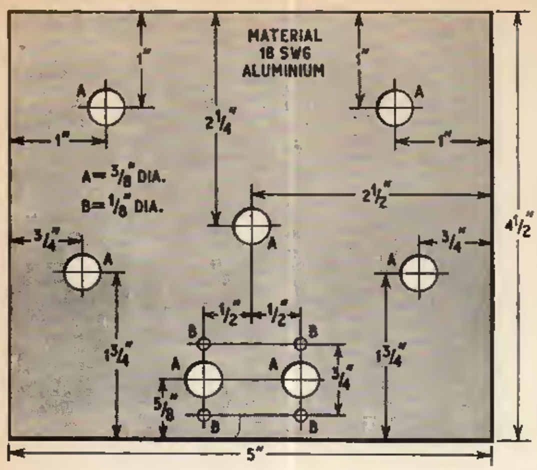


Fig. 4. Front panel drilling details

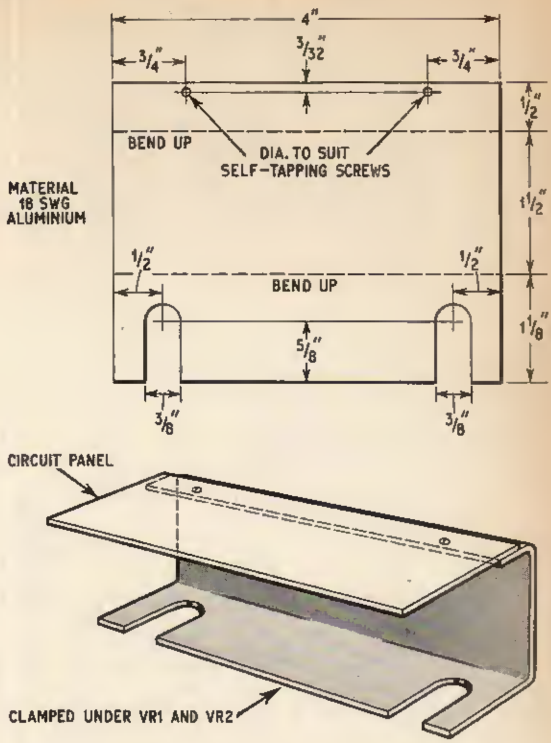
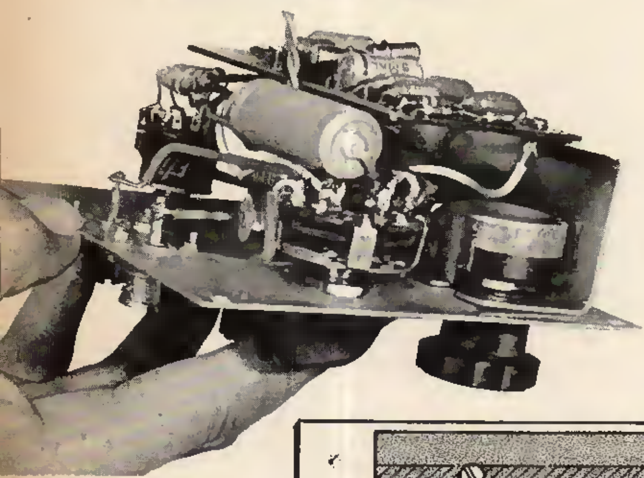


Fig. 5. Circuit panel mounting bracket dimensions and drilling details



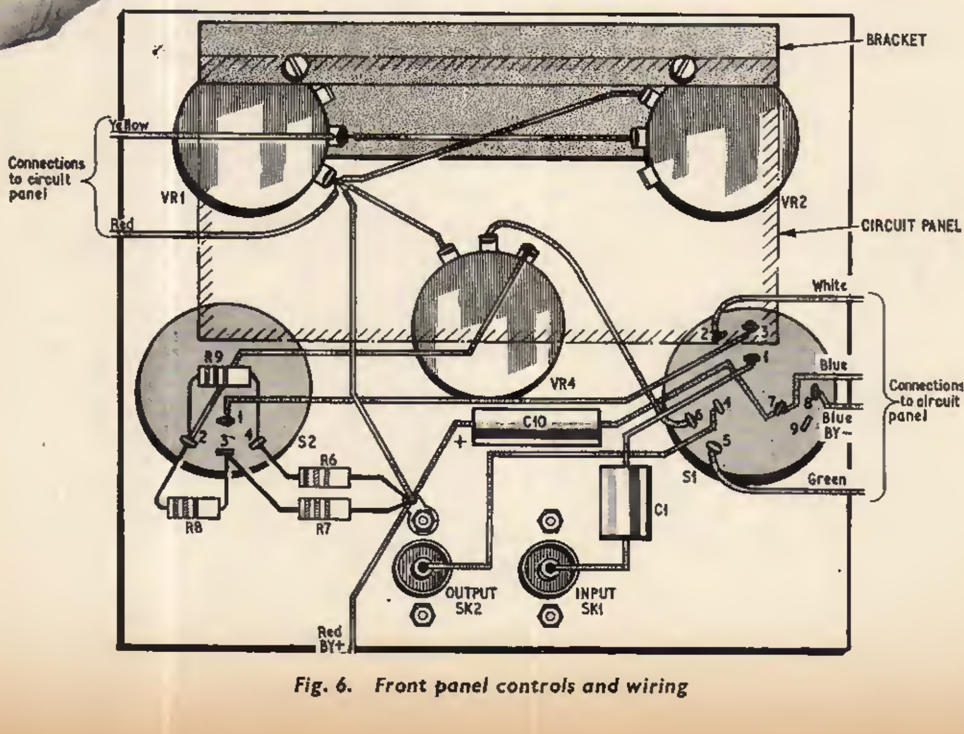
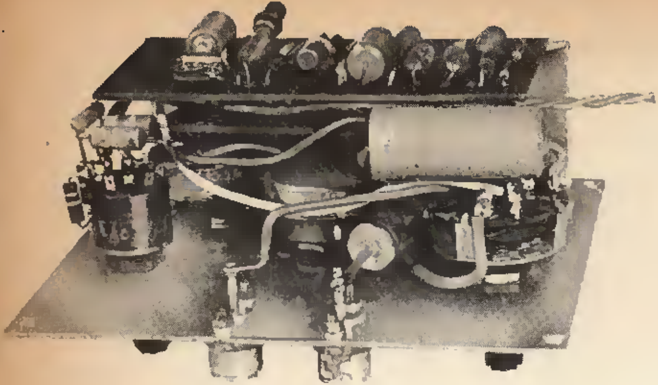


Fig. 6. Front panel controls and wiring



CIRCUIT PANEL CONSTRUCTION

The circuit panel drilling and underside wiring diagrams are given in Fig. 7, with component positions. An etched circuit can be used as there are no awkward cross-over points, but the prototype panel was wired underneath.

An effort should be made to avoid overheating resistors and capacitors, particularly those associated with the notch filter.

When the circuit panel is completed it should be temporarily wired to a battery to see that its current consumption is between 3 and 5mA. If not, check for a possible fault in the wiring or one of the transistors.

Finally, the circuit panel can be connected to the flying leads on the front panel and mounted on its bracket by means of two small self-tapping screws.

NOTCH FILTER AND ATTENUATOR UNIT

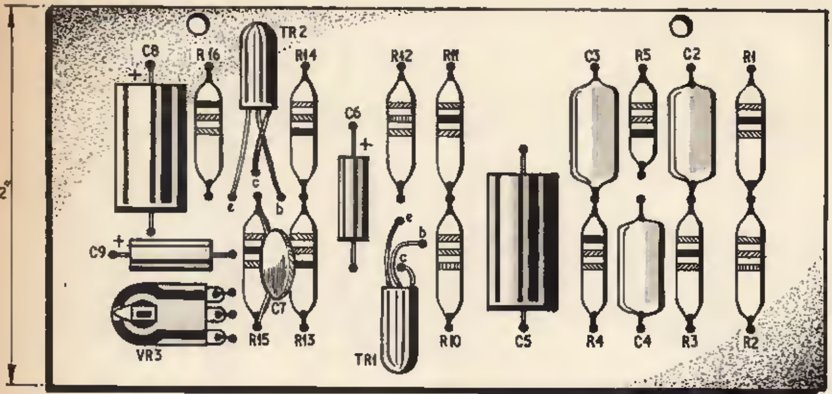


Fig. 7a. Circuit panel, component layout

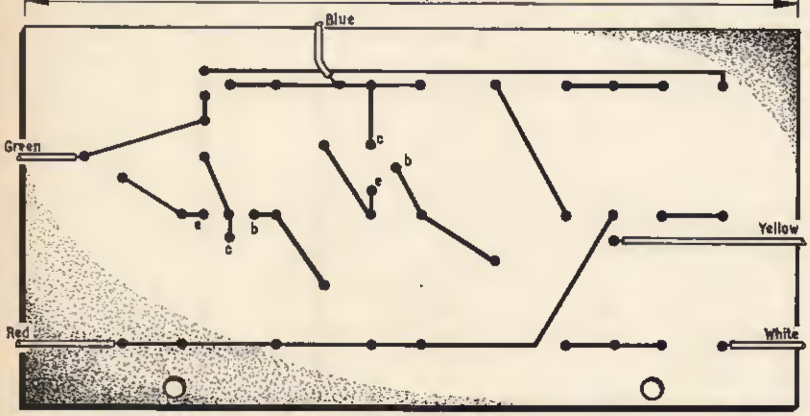


Fig. 7b. Circuit panel, drilling and underside wiring

COMPONENTS . . .

NOTCH FILTER AND ATTENUATOR UNIT

Resistors

R1 4·7kΩ
R2 4·7kΩ
R3 15kΩ 5%
R4 15kΩ 5%
R5 4·7kΩ
R6 10kΩ
R7 10kΩ
R8 90kΩ 1%
R9 1MΩ 1%
R10 100kΩ
R11 27kΩ
R12 1kΩ
R13 15kΩ
R14 3·3kΩ
R15 1kΩ
R16 560Ω

All ±10%, ¼W carbon, except where otherwise stated.

Potentiometers

VR1 500kΩ linear
VR2 10kΩ linear
VR3 5kΩ sub-miniature skeleton pre-set, linear
VR4 10kΩ log

Capacitors

C1 1μF 125V
C2 0·01μF 5%
C3 0·01μF 5%
C4 0·02μF 5%
C5 1μF 60V
C6 10μF elect. 12V
C7 0·01μF
C8 100μF, elect. 12V
C9 10μF elect. 12V
C10 1,000μF elect. 12V

Transistors

TR1, TR2 ACY28 *or* OC76 (2 off)

Switches

S1 Three pole two way rotary
S2 One pole three way rotary

Sockets

SK1, SK2 Coaxial panel mounting sockets (2 off)

Miscellaneous

Aluminium panels 4½in × 5in and 3½in × 4in
Laminated plastics panel 4in × 2in. Knobs

CALIBRATION OF ATTENUATOR

VR4 is best calibrated with an a.c. signal, but first roughly divide the dial into 1 kilohm divisions using an ohmmeter; this will serve as a guide later. The dial should show approximately equal divisions from 10 kilohm to 1 kilohm, see Fig. 8. The 1 kilohm mark will be at the centre of the dial, due to the logarithmic track of the potentiometer.

The remaining part of the dial is then marked in 100-ohm divisions. In Fig. 8, the division mark 10 coincides with the potentiometer slider at the end of the track remote from the positive rail, 5 is mid-way in terms of resistance, and 1 is the 1 kilohm point. It can be seen that the dial figures correspond to the actual track resistance measured from the positive rail. Dial markings 0·1–10 per cent were selected rather than 1–100, because this distortion range is most often used.

With S1 in the filter "out" position, apply 100V r.m.s. 50Hz across the potentiometer track and measure the voltage at the slider with an a.c. meter plugged into the output socket of the unit. The high voltage is specified to avoid loading errors and to ensure meter scale linearity.

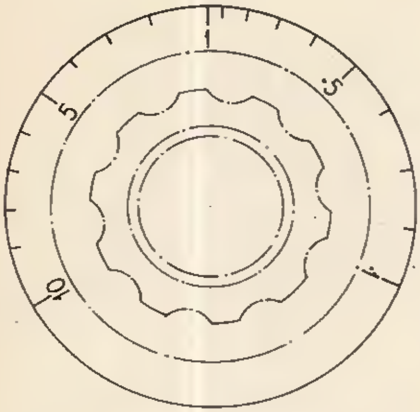


Fig. 8. Dial markings for VR4

Most multimeters will present a load of 100 kilohms when set to their 100V range, but on their lower ranges the impedance of the meter will be nearly the same as the potentiometer itself. With the a.c. meter reading 100 in the 10 position of the dial, it is a simple matter to mark off the divisions in terms of voltage and the rough ohmmeter markings will quickly indicate any serious error. The above operation should be tackled methodically as the ultimate accuracy of the instrument will depend on it.

It is permissible to switch the a.c. meter to one of its lower ranges when marking off the dial below division 1, where loading is less important.

When satisfied that calibration points are correct they can be scribed onto the aluminium dial disc. On range 2, still with an input of 100V, 10 on the dial should yield 10V and, on range 3, the output should be 1V if resistors R8 and R9 are of correct values.

ALIGNMENT

Connect an audio oscillator to the input socket of the notch filter and tune the oscillator to about 5kHz, which is far enough away from the rejection notch to cause no attenuation in the filter "in" position even with no negative feedback applied. The filter output can be taken to an oscilloscope, or else via a 50 kilohm resistor to an audio amplifier with an a.c. meter wired to its speaker terminals.

Adjust VR3 until the output level is the same in both positions of S1 with the attenuator dial set to 100 per cent. Next tune the oscillator to 2kHz and look for a reduction in output level when the filter is switched in. In the unlikely event of a dip at 2kHz, the negative feedback loop to the filter should be examined. If the local amplifier seems to be low in gain, TR2 should be replaced.

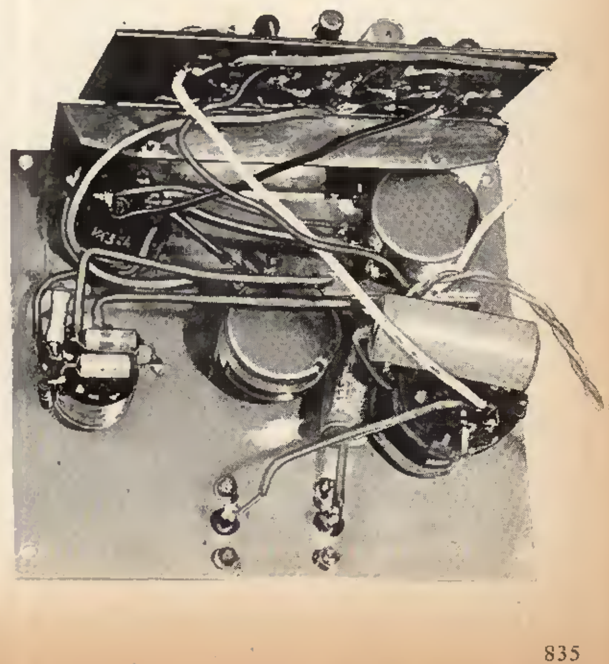
Having determined that the pass-band characteristic is satisfactory, and that the output level is the same for both S1 positions, it only remains to check response at 1kHz and, at the same time, measure the distortion of the oscillator itself.

Tune the oscillator to 1kHz and trim VR2 for maximum dip. As adjustment becomes critical, change over to VR1 and also re-trim the oscillator frequency until satisfied that no further reduction of output is possible. It might be found that the resonant frequency of the parallel-T network is slightly lower than 1kHz, as resistors of preferred value are used for R3 and R4; this will not affect distortion measurements but the filter can be brought up to 1kHz by shunting R3 and R4 with high value resistors, starting with 100 kilohms.

USING AN OSCILLOSCOPE

If an oscilloscope is being used as a detector, note the peak to peak voltage of the display, or else the reading given by the "amplifier with output meter" arrangement.

Switch S1 to the filter "out" position and adjust VR1 until the output is the same as when the filter was in. Oscillator distortion can then be read off the dial. Even if the sine wave does look "clean" on the scope, there is no cause for despair if oscillator distortion is higher than expected. Many general purpose oscillators will have a distortion of up to several per cent, in some cases.



A SIMPLE DETECTOR UNIT

For those wishing to build a complete instrument, incorporating a detector, a suitable circuit is given in Fig. 9. The detector unit can be constructed on a companion panel to fit alongside the notch filter unit.

Since scale linearity is of no importance in this application, a high gain can be achieved with few components, mainly due to the absence of overall negative feedback. (A surplus meter movement, scaled in Roentgens, was used for the prototype detector, and a piece of paper was pasted over the old scale with a mark at the central division only.)

The 100 kilohm input potentiometer is employed to position the pointer on the mark when taking measurements. An output is available from the collector of TR3 to allow the distortion plus noise signal to be displayed by an oscilloscope, so that the relative levels of different harmonics can be visually assessed, even at exceptionally low signal levels.

The solution to this problem is to filter the oscillator output to remove the unwanted harmonics, and two filter circuits are given in Fig. 12, as a guide.

LADDER FILTER

The ladder filter (*a*) will reduce oscillator distortion up to five times, at the expense of a sizeable reduction in output, thirty times approximately. Even so, if the oscillator has a fairly low distortion to begin with, the use of a ladder filter might be worthwhile. With the component values given, the ladder filter is suitable for feeding a high impedance amplifier input. To reduce impedance, for use with transistor amplifiers, divide *R* and multiply *C* by the same amount. For example, the impedance of the filter can be lowered by substituting 3·3 kilohm resistors for *R* and 0·1μF capacitors for *C*.

INDUCTIVE FILTER

With the filter of (*b*) the inductor is tuned to resonance by capacitors C1 and C2. The primary winding of a speaker transformer, taken from an old battery portable valve receiver, was found to be suitable as an inductor.

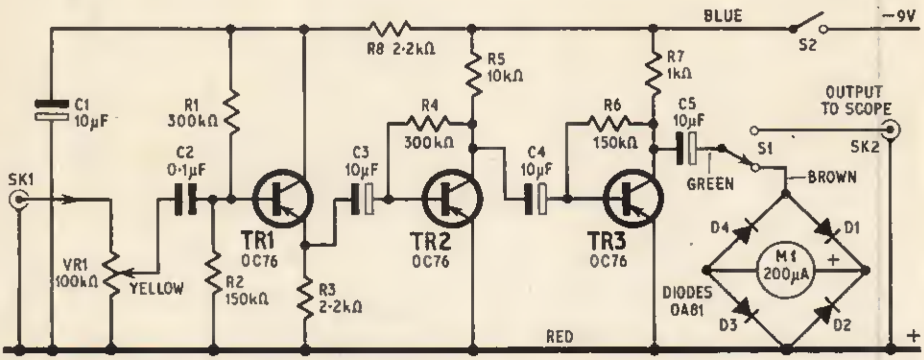


Fig. 9. Detector unit circuit

The Fig. 9 circuit is that of a straightforward medium input impedance amplifier coupled to a rectifier meter, giving a centre scale sensitivity of approximately 500μV. When coupled to the filter unit, the overall noise generated by the instrument is not sufficient to cause the meter pointer to leave the zero mark, even with VR1 advanced to maximum gain.

DETECTOR CONSTRUCTION

Construction follows closely the method given for the filter unit, and requires little further description. Front panel details are given in Fig. 10, and the circuit panel in Fig. 11.

Note that the circuit panel is mounted on the meter terminals and if a different type of meter movement is employed, some rearrangement of the terminal holes and meter position on the front panel will be called for. S2 can be mounted either on the front panel or on the side of the instrument case, serving both filter unit and detector as a master supply switch.

REDUCING OSCILLATOR DISTORTION

It is obviously a waste of time trying to measure amplifier distortion if the distortion present in the test signal exceeds that of the amplifier. A total harmonic distortion of about 0·25 per cent is the best one can expect from ordinary oscillators of the Wein Bridge type, often it is much worse than this. A good quality amplifier, on the other hand, is expected to produce not more than 0·1 per cent distortion.

The value for C1 is arrived at, starting with a fixed capacitor of 5,000pF, by adding 1,000pF capacitors until the voltage across the inductor starts to rise sharply, with an input to the filter of 1kHz. The large pre-set padder C2 will finally trim the circuit to exact resonance. With its high Q factor, distortion is reduced by ten with the circuit of (*b*), and voltage output is decreased by the same amount. Very low distortion levels can be attained by cascading such filters.

Once again, filtering is enormously simplified by single frequency working. 1kHz pre-set tuned filters can be assembled in a small box to fit in the output lead of an audio oscillator, the lead being brought into use only when making distortion measurements. If oscillator distortion is as high as 1 per cent, two cascaded inductive filters can reduce this to 0·01 per cent.

APPLICATION NOTES

If the oscillator is battery powered, or works from a low voltage mains unit, avoid using this same supply for the notch filter and detector amplifiers. Even with a 2,000μF capacitor across the supply rails, there is enough 1kHz ripple present to completely falsify distortion measurements.

Remember that 0·1 per cent distortion of a 1V r.m.s. sine wave represents a level of only 1mV, and there is

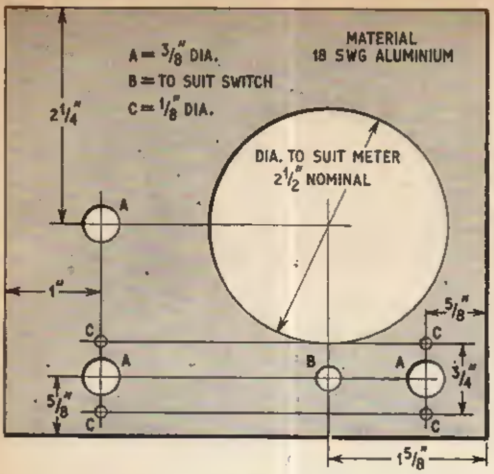


Fig. 10a. Front panel drilling details

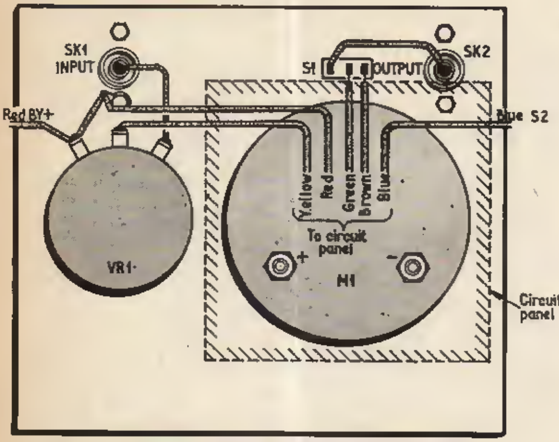


Fig. 10b. Front panel controls and wiring

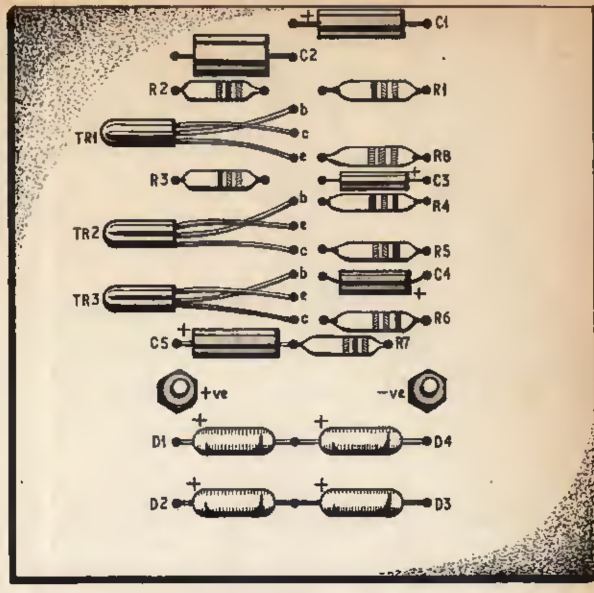


Fig. 11a. Circuit panel, component layout

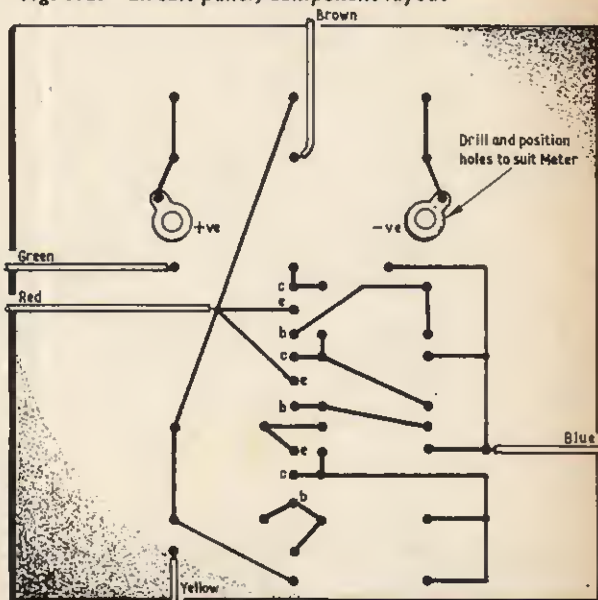
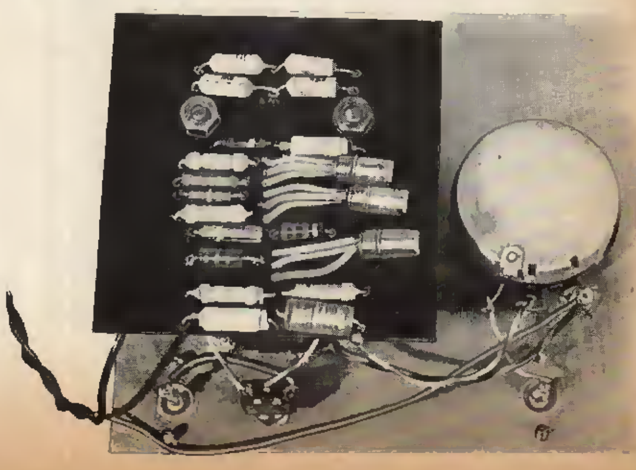


Fig. 11b. Circuit panel, drilling and underside wiring



COMPONENTS . . .

DETECTOR UNIT

Resistors

R1 300kΩ R4 300kΩ R7 1kΩ
R2 150kΩ R5 10kΩ R8 2·2kΩ
R3 2·2kΩ R6 150kΩ All ±10%, ¼W carbon

Potentiometer

VR1 100kΩ linear

Capacitors

C1 10μF elect. 12V C4 10μF elect. 12V
C2 0·1μF C5 10μF elect. 12V
C3 10μF elect. 12V

Transistors

TR1, TR2, TR3 ACY28 *or* OC76 (3 off)

Diodes

D1, D2, D3, D4 OA81 (4 off)

Meter

M1 200μA f.s.d. 100Ω moving coil

Switches

S1 Single pole two way miniature toggle
S2 Single pole on off

Sockets

SK1, SK2 Coaxial panel mounting sockets (2 off)

Miscellaneous

Aluminium panel 4½in × 5in
Laminated plastics panel 3in square. Knob

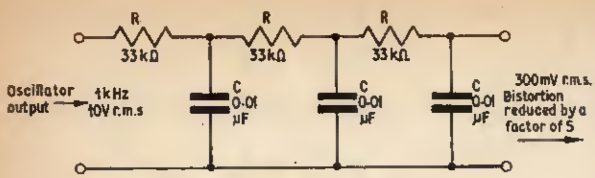


Fig. 12a. Ladder filter circuit

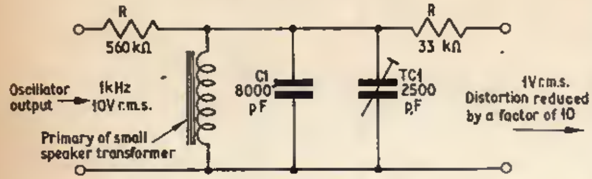


Fig. 12b. Inductive filter circuit

plenty of scope for hum and noise when measuring down to 0·01 per cent. It is as well to do a quick check for abnormal noise levels before taking a measurement, with the detector turned to maximum gain.

An oscilloscope photograph showing a sine wave and its 1 per cent distortion signal is given in Fig. 13. Most of the distortion is second and third harmonic, as might be expected. An oscilloscope makes an admirable detector as the signal is always under close inspection and the null point can be reached with almost as much ease as with a meter. Any trace of unlooked-for hum will be revealed when the timebase speed is reduced to 50Hz, or a low multiple.

To measure audio amplifier distortion, connect a load resistor of appropriate value and wattage rating in place of the loudspeaker. Monitor the voltage across the load with a multimeter and inject a low distortion 1kHz signal. The gain should be increased to the point where the amplifier is delivering its maximum quoted continuous r.m.s. output.

Connect Harmonic Distortion Meter and follow the procedure previously given for taking a distortion reading. If the result is poor, try reducing amplifier output and see if there is a marked improvement. If not, check for hum in the output or excessive amplifier noise.

★

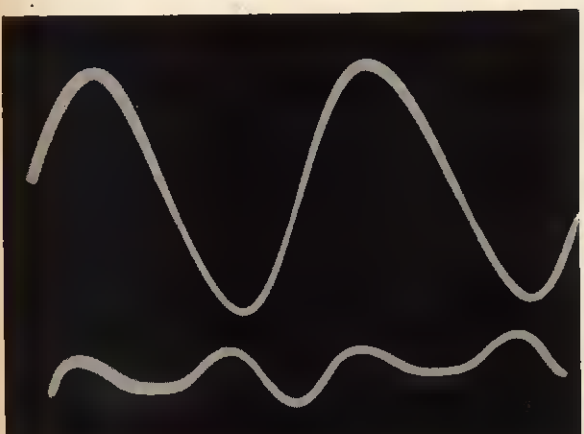


Fig. 13. Oscillograph of sine wave containing 1 per cent distortion. Lower trace shows distortion signal

NEW amplifiers and radio units claim special attention this month. For example, there is the Dulci model 220 which, although exhibited to the public some time ago, has only recently gone into production. Elizabethan are the makers and the price is 39gns.

This small, neat amplifier, housed in a teak case, is rated at 10 watts per channel into 15 ohms, the output being higher for lower impedances. Facilities include tape recording outlets, rumble and low-pass filters, and all the inputs normally required for radio, pick-up, and tape heads.

MATCHING UNIT RANGES

One of the most interesting trends is the emergence of matching ranges which can be formed into systems by either non-technical people or more knowledgeable audiophiles. Philips and Ferguson are among the best known names in this particular field.

Philips have added a "luxury" tuner-amplifier type RB771 which covers f.m., medium and long wave bands, and has a built-in stereo decoder.

The Philips range, known as "Audio Plan", includes a new speaker for shelf mounting and a two-speed turntable type GA217 complete with arm. The turntable is mounted on a black moulded base and has a removable translucent cover, while the arm is adjustable for playing weight and has provision for side-thrust compensation.

Matching ranges of this kind enable alternative systems to be arranged at various prices. This is also true of Ferguson Unit Audio, to which is added a stylish tuner-amplifier model 206STA, equipped for stereo radio and preselection of stations. Price is £48 6s.

MICROPHONES

Reslosound are well known British manufacturers of microphones, marketing a number of moderately priced models used by amateurs as well as professionals. They now add the EC1, a strongly made cardioid microphone which can be used outdoors with the wind shield supplied. The miniature insert is claimed to have very directional sensitivity, and the buyer has a choice of impedances. Weight is 6 ounces, stand fixing is possible, and 6 yards of cable are supplied.

The Audac Marketing Company offers solid state equipment in professional rather than specifically domestic presentations. The firm's literature, which makes interesting reading, can be obtained from Audac at Carey Road, Wareham, Dorset, One of their specialities is the "Hike-Mike", essentially a cordless microphone in which a Shure microphone inset shares the housing with a miniature transmitter.

Recently arrived from Germany are some additions to the MB range of microphones and accessories. The MB190 is said to be one of the smallest dynamic microphones made in pen form, with dimensions about 5in by ½in. Then there is the MB220 stereo set, consisting of a pair of microphones on a special adjustable stand, ready for stereo recording. Also new is the MBK600 stereo headset with an overall frequency range quoted as 16 to 20,000Hz. MB products are marketed by Denham and Morley Ltd., 173 Cleveland Street, London, W.1.

DISC EQUIPMENT

Special stereo-compatible cartridges were mentioned in *Audio Trends* in September. These are mono cartridges which can track stereo discs safely while producing a mono signal from them; they are intended as replacements for low cost crystal or ceramic mono only type cartridges often found in portable players and radiograms. Of this general type are recent additions to the Compat range made by Electronic Reproducers (Components) Ltd. of St. Albans. There are medium and high output models of the crystal type, plus a medium output ceramic. Prices are in the range 24s 8d to 44s 8d, depending on stylus fitted. This firm also markets conventional stereo and mono cartridges.

MB 190 pen type microphone

Philips GH 923 stereo amplifier in the "Audio Plan" range of equipment

MB 200 stereo microphone set

MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned.

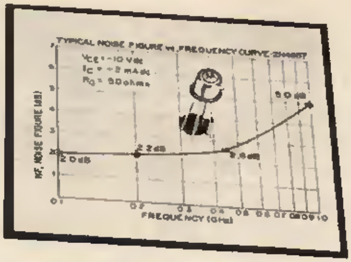
IN BRIEF

The latest addition to the **Painton** range of rotary switches is a 10-position miniature switch rated at 250mA at 28V d.c. and is housed in an aluminium case marked with switching positions 1 to 10. For further details and price list contact Painton & Co. Ltd., Kingsthorpe, Northampton.

Dubilier Condenser Co. (1925) Ltd., announce a new range of dipped silver mica capacitors types D10 and D20. The D10 capacitance range is 10pF to 1,000pF at 350V d.c. peak. The D20 capacitance range is 100pF to 4,700pF at 350V d.c. peak and 200pF to 2,200pF 750V d.c. peak. Both the D10 and the D20 are available in tolerances ranging from ± 10 per cent to $\pm 0{\cdot}5$ per cent.

The 2N4957–59 transistors from **Motorola Semiconductor Products Inc.**, York House, Empire Way, Wembley, Middlesex, are a new series of *npn*-types suitable for high gain, low noise amplifiers and mixers or other v.h.f./u.h.f. small signal applications.

This new range of transistors features maximum noise figures as low as 3dB and minimum power gains as high as 17dB at 450MHz in the common emitter configuration. It is claimed that the performance of this series makes them ideal for critical front end applications. Further information and complete specifications are available from Motorola.



Motorola 2N4957 transistor

The "Lerloy" is a new soldering stand available from **Henri Picard & Frère Ltd.**, 34/35 Furnival Street, London, E.C.4. It consists of a holding stand, suitable for most soldering irons, and a tip cleaning sponge.

The stand holds the iron at a convenient angle in an insulated socket and is further protected by a cylindrical metal guard. The tip cleaning sponge is kept moist by a water reservoir beneath it. No mention is made of any odours that we think may be caused by the hot soldering iron tip on the damp sponge. The Lerloy soldering stand is priced at 41s. The cleaner is available separately at 14s 6d.

Bradel cases from Nandel Electronics

Our photograph shows the new range of Bradel instrument cases now being marketed by **Nandel Electronics Ltd.**, 28 Middle Hillgate, Stockport, Cheshire. Designed to allow easy access for wiring, the cases are made in three sizes, 7in wide × 5in × 5in; 9in × 7in × 5in; 11in × 7in × 6in, and available in two styles. Type A has a detachable panel for either a front or back plate as required. Type B has detachable front and back panels. The price of the Bradel cases range from 35s to 45s each according to size ordered.

Transformer operated signal lamps from Arcoelectric Switches

Arcolectric Switches Ltd are now manufacturing transformer operated signal lamps which operate from mains voltage input and 6V output. There are a wide range of lens colours and there is no danger from mains voltage during bulb replacement. The actual bulb life is claimed to be longer and there is very little heat dissapation from the bulb and transformer.

Lerloy soldering stand imported by Henri Picard & Frère

It should not be long before printed circuit board assembly packs for posting and transit purposes by **R. & H. Whale (Joinery) Ltd.**, are available in electronic shops. At the moment they are only available to the trade, but once retailers realise that amateurs like to send friends completed circuits, and face the same problem of breakages as they themselves face, they will be available to the amateur.

The packs are made from 0·042in to 0·060in lined chipboard and fold up into neat robust containers.

LITERATURE

Technical data of 27 lead-acid batteries and 61 primary batteries for electronic applications are listed in the new edition of booklet number W.5039 issued by **Exide Batteries Division of Electric Power Storage Ltd.** There are many new types listed which have been designed to function under some of the extreme conditions that modern transistor circuits have to perform.

Entitled "Exide Batteries for Light Electrical and Electronic Applications", copies can be obtained free from Electric Power Storage Ltd., 50 Grosvenor Gardens, London, S.W.1.

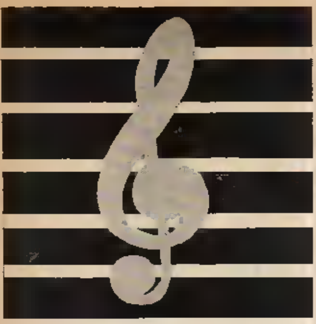
Over 70 new products are among the devices listed in the 1967/68 Semiconductor Summary published by **S.T.C. Semiconductors Ltd.** Copies of the summary (MK/106X Ed. 41), are available from S.T.C. Semiconductors Ltd., Footscray, Sidcup, Kent.

A useful reference booklet entitled "Osram Bulbs for Electronic Applications" is now available from **Osram (G.E.C.) Ltd.**, East Lane, Wembley, Middlesex.

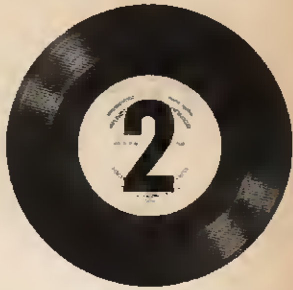
The publication lists the extensive range of bulbs available, and each section gives a brief description of suitable applications. In addition, the booklet includes a Nomogram, which enables changes in performance of tungsten filament lamps under different operating conditions to be calculated.

Available from **Gardners Transformers Ltd.**, Somerford, Christchurch, Hampshire, is a brochure, GT.17, containing details of their complete range of low voltage and isolating transformers. Also available are separate brochures for audio and pulse transformers.

For the designer there is a new Catalogue of Industrial Electronic Components available from **The DTV Group**, 126 Hamilton Road, London, S.E.27. Containing 248 pages this catalogue lists items from complete integrated circuit modules to instant lettering sheets.



ELECTRONIC MUSIC TECHNIQUES



By F. C. Judd, A.Inst.E.

ELECTRONIC musical instruments provide some interesting possibilities in the creation of multi-track recording which will be described later. In the meantime let us take a look at the techniques used in the production of some of the sounds illustrated on the record (in last month's issue) all of which necessitate the use of electronics.

It would be as well to remember that although the few circuits and techniques described in this article are of a fairly simple nature, they are basic to the rather more complex devices found in professional studios. For instance, the well-known multivibrator (square wave oscillator) is the basic component in a complicated waveform generator designed, built and used by engineers and musicians in the University of Utrecht, Holland. It will produce a waveform of almost any shape at any frequency within the audio spectrum.

GENERATOR CIRCUITS

The pure tone generator (phase shift oscillator) is widely used in studio keyboard systems in which a large number of oscillators, covering the audio spectrum, are keyed as in an electronic organ, except that the intervals may be as little as a quarter of a tone.

The first sound illustrated on the PRACTICAL ELECTRONICS record was in fact a sine wave tone from a phase shift oscillator. As a pure tone source any standard audio signal generator will serve very well, but supposing a controlled degree of decay (dying away of the sound) is required. The output from the generator can be fed into a simple circuit like that shown in Fig. 2a.

This is simply an audio amplifier with control over the biasing network. When the key (S1) is open the valve is cut off. When the key is closed the circuit conducts. If the key is quickly depressed and then released the capacitance in the biasing network will slowly charge up until the valve is cut off again, thereby allowing the sound to die away gradually.

The rate at which the sound decays is largely determined by Cd which is usually about 25µF. The circuit is quite noiseless in operation but must be treated as any normal audio amplifier with regard to screening against hum pick-up. A transistor version of the circuit is prone to producing clicks when the key is operated, but is, however, shown in Fig. 2b.

A similar arrangement can be used to control an a.f. phase-shift oscillator directly as shown in Fig. 3

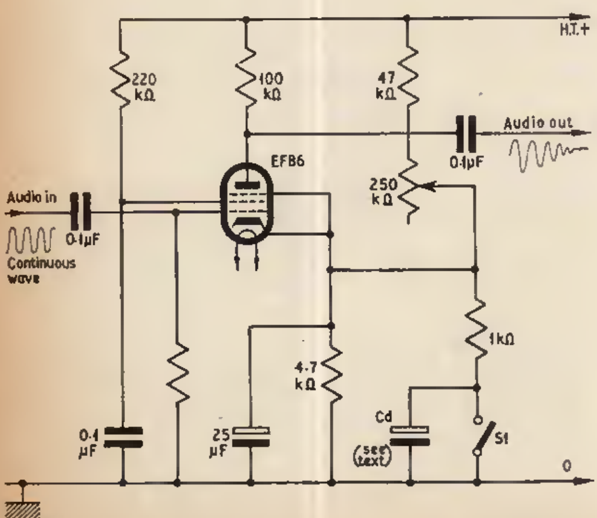


Fig. 2a. Sound decay circuit using a single valve

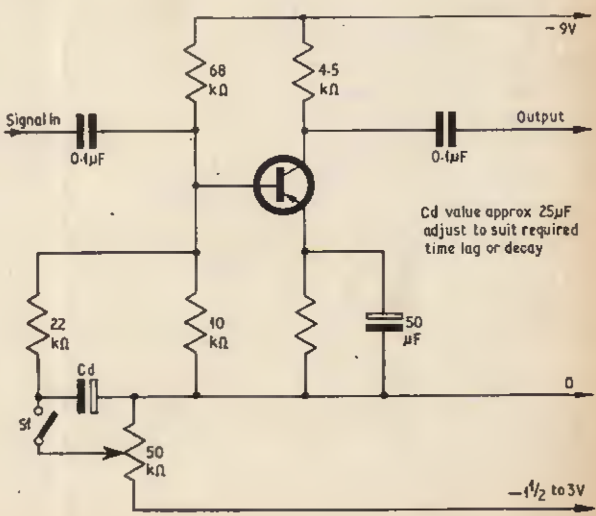


Fig. 2b. A suggested transistor decay circuit; prone to generating clicks when key S1 is closed

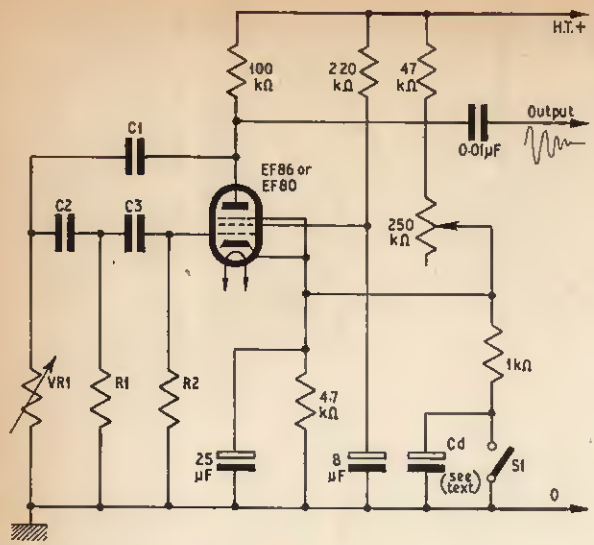


Fig. 3. Decay applied directly to a phase shift oscillator. The values of C1, C2, C3, VR1, R1, and R2 will depend on the frequency required. VR1 gives a fine adjustment of the nominal frequency

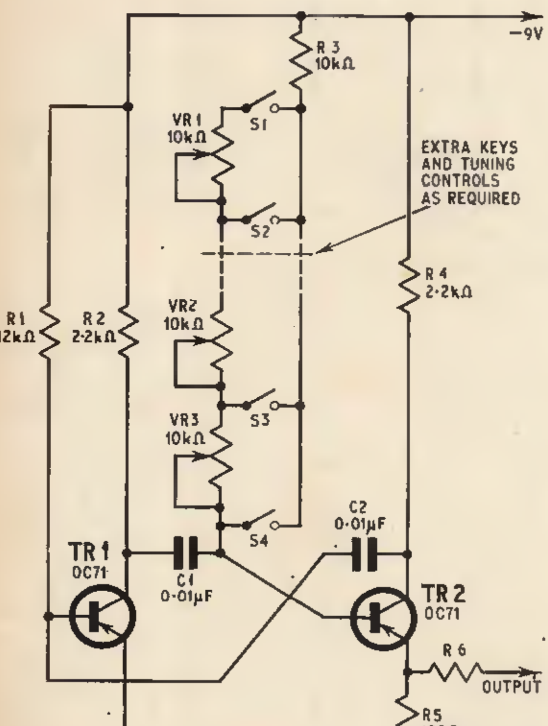
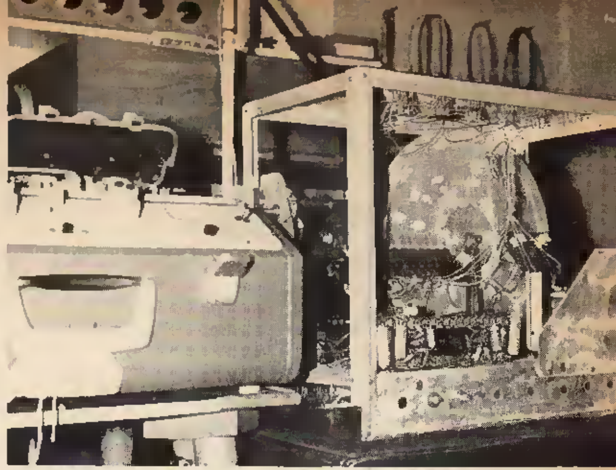


Fig. 4. A suggested transistor square wave generator tuned by adjustment of VR1, 2, and 3. Pitch can be selected by S1, 2, 3, 4



An experimental electro-mechanical rhythm machine

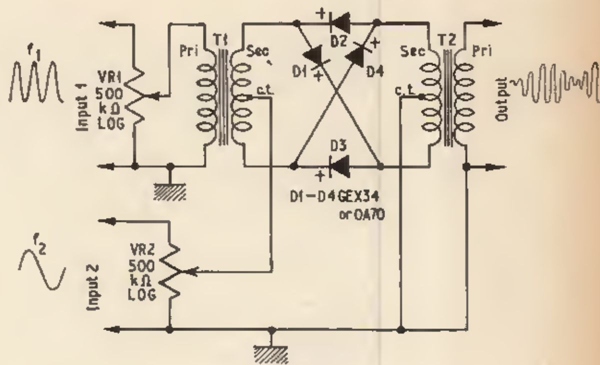


Fig. 5. Ring modulator. The output signal consists of f_1 and f_2 plus their sum and difference frequencies. The resulting sound is an unusual chord

Part of the sound studio used in producing the P.E. sounds and effects record. The electronic organ is used for multi-track recording

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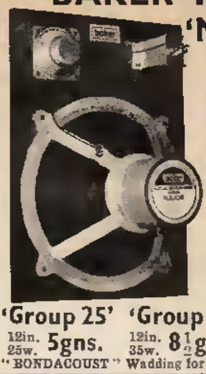

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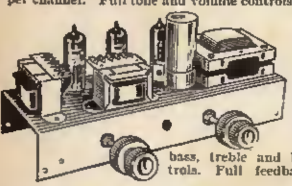

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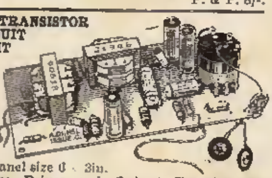

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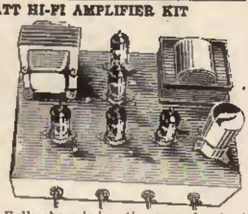

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and is, in fact, actually used in the rhythm machine shown in the photograph (more of this later). In Fig. 3 the valve is normally cut off by the positive voltage applied to the cathode. The keying circuit (Cd and S1) is exactly the same as in Fig. 2.

Phase shift oscillators have a very large voltage output which may require considerable attenuation before being applied to a tape recorder.

The second sound illustrated on the P.E. record was a square wave tone from a multivibrator. An example of such a circuit using transistors is shown in Fig. 4. The mark/space ratio of the waveform depends largely on the values of the coupling components.

The multivibrator can be made to oscillate at very low frequencies which makes it useful as a pulse generator with a pulse rate from 1 to 10Hz.

The pulsed tone sound on the P.E. record was produced by connecting a low frequency multivibrator to one input of a ring modulator and sine wave tones to the other. Some form of attenuation may be needed at the output of a multivibrator because of the large output voltage.

The multivibrator can also be used as a keyed tempered scale tone source by employing suitable different values of potentiometer (see Fig. 4). Each potentiometer is set to tune the oscillator to the required pitch.

SOUND CONTROL

Fig. 5 shows an example of a ring modulator using germanium diodes with two centre-tapped transformers. However, it has been found that small transistor coupling transformers will suffice providing the primary and secondary impedances are fairly high (greater than 600 ohms). One could, for example, use two transformers each with a primary of, say, 600 ohms and secondary (centre-tapped) of 1,000 ohms. They are wired into circuit back to back. Ideally, however, the transformers could have a ratio of 1 : 1 and high impedance windings.

Another useful circuit much favoured by guitarists and which provides an amplitude vibrato is often used in electronic music.

The system simply makes use of the low frequency sinusoidal voltage from the oscillator to raise and lower the gain of the amplifier. The sinusoidal voltage is applied as bias to the control grid or cathode of an a.f. amplifying valve. However, in low audio signal applications (such as an electric guitar pre-amplifier) there is always the problem of audible "thump" from the 10Hz or so vibrato oscillator, particularly when the remainder of the amplifier system has a good low frequency response.

NO THUMP

An alternative arrangement can be used to do away completely with the problem of "thump" and can be used at almost any stage in an amplifier chain. It is basically an electronic volume control that varies the amplitude of the signal at the required speed—usually around 8 to 10Hz. Electronically it is simple but it does call for some mechanical construction.

The general arrangement is shown in Fig. 6 and the basis of the system is a light sensitive resistor. Light is interrupted sinusoidally by means of rotating polaroid material which, in turn, produces a sinusoidal variation in the resistance of the l.d.r. The l.d.r. forms part of a simple attenuator that can be connected between two amplifier stages. It is completely noiseless in operation but does have an overall insertion loss

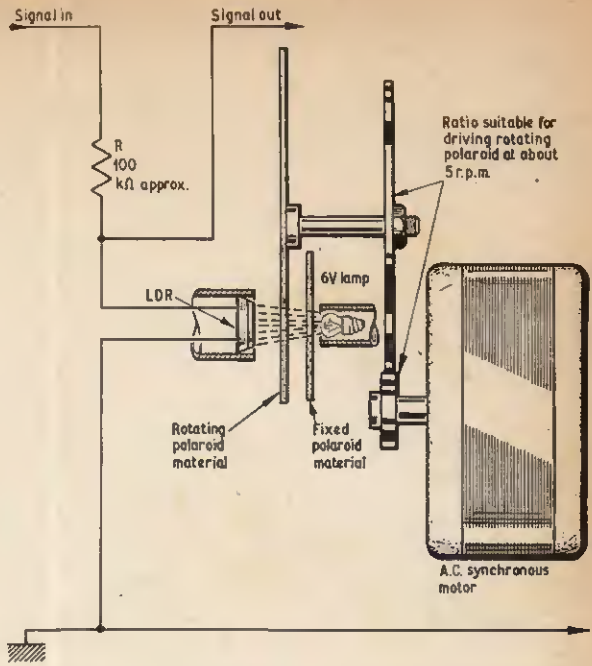

Fig. 6. No-thump vibrato using a photo-sensitive cell with polarised light filters

of approximately 6dB. It may well be of interest to electric guitar players because of its virtually noiseless operation.

The machine can be driven by an ordinary 50Hz synchronous or induction motor via a suitable speed reduction system, so that the rotating polaroid material turns at approximately 5rev/min (vibrato frequency 10Hz). The variation of the attenuator network (the l.d.r. and resistor R) is quite sinusoidal.

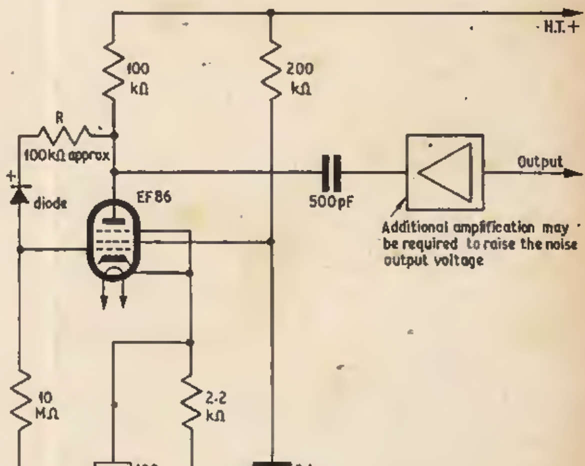

Fig. 7. White noise generator. Resistor R may need adjustment to produce maximum noise output, which may have to be further amplified. This circuit is unsuitable for adaptation using a transistor

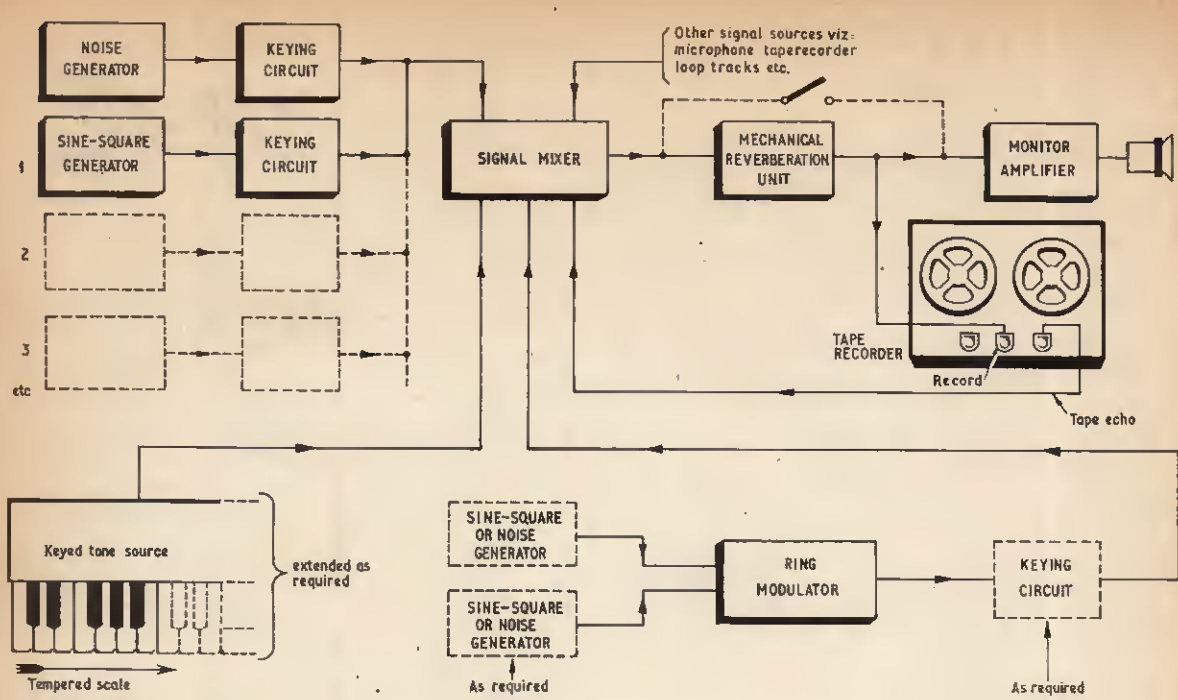

Fig. 8. Typical set-up for recording various tones and sound effects

WHITE NOISE GENERATOR

In audio work random noise is often kept to an absolute minimum by employing special low-noise amplifier valves and other components, and yet random noise is present to some degree even in the sounds produced by musical instruments.

To produce random, or white noise as it is called, at fairly high amplitude is not difficult and one common way of doing this is by means of a super-regenerative oscillator, i.e. an h.f. oscillator in the squegging condition. A high degree of random noise can be extracted from the output but, unless the whole oscillator is completely screened, it can pick up unwanted h.f. radio signals.

A more simple and quite satisfactory method is to amplify the thermal noise produced by passing current through a diode. The circuit shown in Fig. 7 employs a general purpose germanium diode and a high gain audio amplifier. The random noise output is only a few millivolts so further amplification may be required before the signal is large enough for recording purposes.

Noise of this kind has random frequency, amplitude and phase components, and sounds like escaping steam. It can, however, be filtered so as to produce a sound with a definite pitch (examples are given on the P.E. record). Audio filters for this purpose are complex and difficult to construct although simple forms of RC filtering could be employed. A twin-T RC network in a negative feedback path could be employed to produce a narrow band amplifier. The arrangement is commonly used for pre-emphasis in recording amplifiers.

HYBRID GENERATORS

Part one of this article mentioned that the process of tape cutting and splicing is a somewhat laborious method of assembling sounds, and does not lend itself to the production of music in tempered scale or indeed any form of rhythmic music. Many studios have therefore resorted to the use of keyboard tone systems and even rhythm machines and it is not unusual to find a standard electronic organ as part of the studio equipment.

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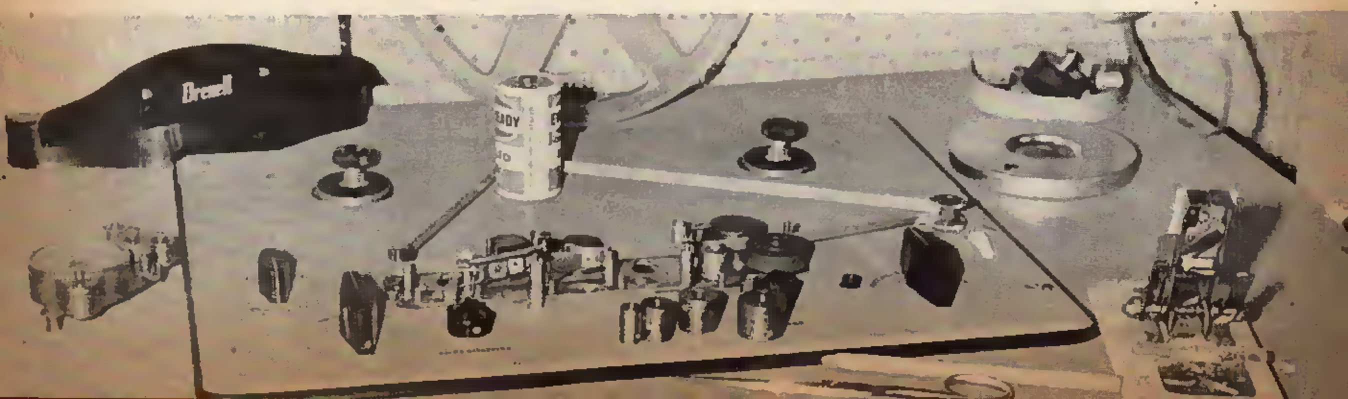

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The use of a keyboard instrument in conjunction with a tape recorder is fairly obvious. What may be of greater interest is the electronic rhythm machine which has some quite interesting possibilities. The rhythm sounds on the P.E. record, including the rhythm backing of the final example, were originally derived from the experimental rhythm machine shown in the photograph. A rhythm sequence from the machine was recorded and then looped, although the machine itself is capable of running continuously.

The basis of the machine is a constant speed drive but with provision for variable speed in order to obtain variable tempo. The drive, therefore, consists of a 50Hz synchronous motor which is coupled via a suitable reduction idler wheel into a rotating disc 12in diameter. The motor and idler wheel are made to move between the outer edge of the disc to a point about three inches from the centre, thus the disc can be rotated at constant yet variable speed.

The various sound generators are triggered off by means of gold plated organ type contacts which in turn are actuated by raised "pips" on a perspex disc attached to the main drive disc. The complexity and nature of the rhythms that can be produced with a machine of this kind are limited only by the number of contacts and inter-switching of these and of course the number of sound generators.

MULTI-TRACK RECORDING

This article would not be complete without some reference to multi-track recording techniques especially as many studios employ recorders capable of recording on up to eight separate tracks simultaneously.

Domestic tape recorders are quite capable of producing good quality multi-track material by the simple means of re-recording from track to track on a single machine or from recorder to recorder where two are available.

The ideal method is to use two recorders and work from one to the other as new material is added. Care must be taken with noise build-up through successive re-recording, but with good quality recorders up to four or five "dubbings" are possible before quality suffers and the noise build-up consequently becomes unacceptable.

The making of multi-track music recordings with the best results are usually those employing electronic musical instruments such as the electronic organ and electric guitar, which can be coupled directly to the tape recorder. This obviates the use of a microphone and the consequent loss of quality as well as unwanted acoustic effects. If acoustic effects are required they are best introduced artificially by means of a reverberation unit or by tape echo.

The author's own method of multi-track recording with an electronic organ may serve better to describe the process which by and large is the same whether one is using professional equipment in a studio or domestic class recorders. Normally two twin half-track stereo machines are employed, these being coupled to each other via a twin channel mixing circuit.

First, the music to be recorded is "arranged", i.e. a full score drafted out on paper. This is not done by ear since it becomes almost impossible to memorise all the parts, i.e. key changes, bridging passages and so on.

The rhythm track, if any, is then recorded to exactly the right number of bars required. This is set up on one recorder, the output of this being coupled to one channel on the second recorder. The electronic organ output is coupled to the other channel (second machine). The rhythm and first music part can now be recorded together.

These two parts are then mixed together and fed to one channel of the first recorder. The organ output is connected to the remaining channel and the next part is completed and so on until the recording is finished.

By using twin tracks each recording can be carefully balanced with respect to the other. With a simple tape recorder having track-to-track re-recording facilities, the problem of balance becomes a little more difficult but can, with a little practice, be accomplished with a fair degree of success.

IN CONCLUSION

Whether you are a musician wishing to explore electronics in music or an electronics enthusiast with a mind to investigate the technical possibilities of electronics in music, you may well find a great deal of interest in the purely creative prospects when the two subjects are combined. There is almost unlimited scope for experiment.

Electronics has much to offer the world of music in terms of new sounds, rhythms otherwise unplayable on or with conventional percussion instruments, and even acoustic effects otherwise quite impossible to produce in the drawing room or the concert hall.

The circuits given in this article are only intended to provide a general indication of how effects can be produced. They provide a starting point for the keen experimenter and full details of components are not included since these will vary with circumstances.

Many of the electronic devices outlined in this article will be featured as constructional projects in due course. The first of these detailed designs, a "Spring-Line Reverberation Unit", will appear next month. ★

detached particles

JOHN VALENCE

FLIGHTS OF FANCY

Everyone seems to love an argument, whether one be participant or mere onlooker. Television producers are well aware of the attraction of the verbal battle. How often do we sit enthralled by the aplomb and expertise with which distinguished contestants defend their point of view. Frequently no obvious winner emerges from these contests and we are left just as confused as before concerning the great issues of the day—no matter, it has all been jolly good fun.

Visitors to the British Association meeting at Leeds this summer were presented with a rare entertainment before which the nightly confrontations on the goggle box must pale. In a gladiatorial contest between eminent men of science, Lord Bowden was first into the arena with a fierce attack on the whole purpose of space flight. The U.S. space programme was condemned as being an extravagant form of outdoor relief, with real science having but a very small part in these activities.

But the "get a man onto the moon" plans found an able and enthusiastic champion in the astronomer Patrick Moore. His retort that Lord Bowden was the kind of man who would have opposed the invention of the wheel must have wounded deeply; a trifle unjust for the erstwhile Minister of Education and Science and pioneer in the field of electronic computers.

A somewhat middle of the road view was voiced by Professor Dennis Gabor, inventor of holography (and destined to become fairy godmother to the next generation of housewives with his other brain child the domestic automaton). The Professor was not convinced of the practical purpose of space flight, but queried whether the money so spent would otherwise be put to worthwhile humanitarian causes.

When experts like these cannot agree amongst themselves what chance have we poor onlookers of forming an objective opinion on such matters? We just pay the piper without the privilege of calling the tune.

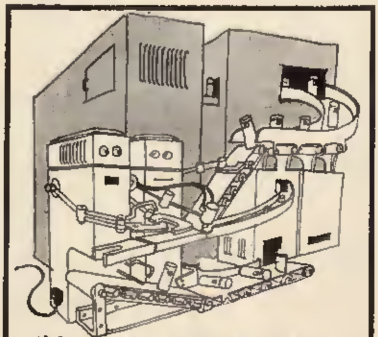
Perhaps we should stop deluding ourselves about the scientific aspect of manned space flight. If scientific exploration is really the aim, instrument carrying space vehicles are all that is necessary. Telemetering systems and remotely controlled automated devices will do all the "field" work for us.

TERRA FIRMA

The mention of automation brings me back to earth again. All of us in this little old island should be worrying more about automation in land based factories than in outer space! Do you know that in a typical industry it takes 42 of us to produce the same output as 10 men in the United States; or 38 in Germany, 26 in France, or 23 in Italy?

Why? Because our rivals in other countries have more power tools and automated plant backing them up. So please no snide remarks concerning the British worker. The accusing finger should be pointed at the boardroom, not the shop floor.

If one seeks a single justification for the establishment of a Ministry of Technology, it is surely here. In furtherance of their campaign to encourage industry (and this includes small firms as well as the larger) to invest in automated systems, the Ministry is setting up Automation Centres in co-operation with leading colleges of technology. A recent example was the opening of the Automation Centre at Leicester Regional College of Technology. Here, the permanent laboratory devoted to this subject was backed up by an exhibition of commercial equipment. The whole gamut of technology, more or less, was represented here. It was clearly demonstrated how electronics, nucleonics, pneumatics, fluidics, electrics, and mechanics can be harnessed two or more together, in various combinations—and so provide more power to the human elbow. Industrial proprietors of Leicester ("Town of a thousand crafts") and other regions please note.



"It's no good. What with the increase in electricity charges, I really will have to get a second job."

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The makers of integrated circuits are now themselves about to be integrated. Wholesale use of microelectronics means room for only three or four manufacturing companies in this field.

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THE BELLS

A strange quiet has descended on certain portions of the medium wave band. No longer are we regaled by a great variety of mini sounds from transistor receivers being taken for a stroll by their young (and not so young) owners. But wait . . . already a new sound has taken the place of the ethereal offerings of pop groups.

The tintinnabulation provided by wandering flower people evoke memories of eventide in some enchanting alpine village—that is until the harsh honking of a taxi sends us scampering across the road.

I do hope however that the followers of this current cult will not adopt any electronic amplification of their tiny bells in some misguided attempt to emphasise the effectiveness of flower power. I shudder at the mere thought!

Let them stick to gentle persuasion —and never mind the decibels.

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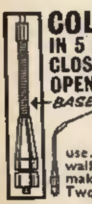

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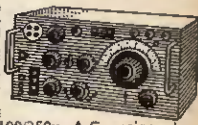

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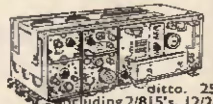

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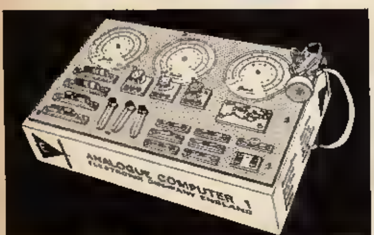

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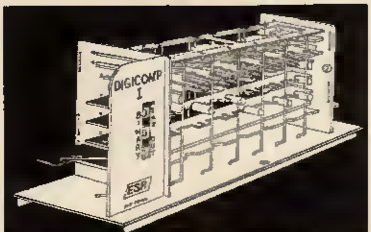

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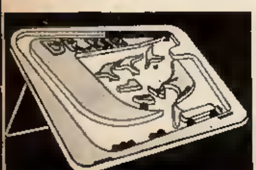

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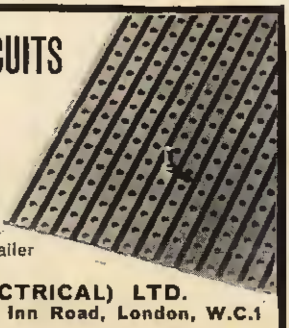

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