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OCTOBER 1967

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		10mA	22/6	5A D.C.	22/6	50V A.C.	22/6
		20mA	22/6	3V D.C.	22/6	150V A.C.	22/6
		50mA	22/6	10V D.C.	22/6	300V A.C.	22/6
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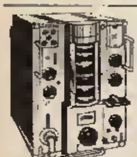
GARRARD RECORD PLAYERS

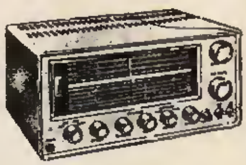
SRP12 Player mono £4.4.0; 1000 changer mono or stereo £5.15.6; 2000 changer mono or stereo £6.19.6; 3000 Changer mono or stereo £7.19.6; SP25 Player mono or stereo £9.19.6; SP25 with cast turntable £10.19.6; AT60 Changer mono or stereo £10.10.0; AT60 Mk II Mono or Stereo £11.11.0; A70 less cartridge £19.19.0; LAB80 Mk II Stereo £25.0.0; 401 Transcription 26 gns. Brand new and guaranteed. All plus post and packing 5/-.

ADMIRALTY B.40 RECEIVERS



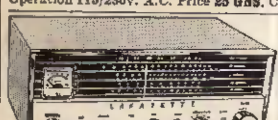
Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s.-30 Mc/s. I/F 500 Kc/s. Incorporates 2 R.F. and 3 I.F. stages, crystal bandpass filter, noise limiter, controlled B.F.O. calibrator, I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½in. × 13½in. × 16in. Wght. 114 lbs. Offered in good working condition, £22/10/0. Carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/0. Carr. 30/-.

LAFAYETTE KT-340 COMMUNICATION RECEIVER SEMI-KIT



Build this wonderful receiver and save Pounds! Supplied semi-completed, main components ready mounted, R.F. Section already wired and aligned. Full and precise instructions supplied. Specification: 8 valves + rectifier, 4 bands covering 550 Kc/s—30 Mc/s. Incorporates 1 R.F. and 2 I.F. stages, "Q" multiplier, B.F.O., A.N.L. "S" meter, bandspread, aerial trimmer, etc. Operation 115/230v. A.C. Price 25 GNS. Carr. 10/-

HAM-I. 4 BAND COMMUNICATION RECEIVER



4 wavebands covering 535 kc/s-30 Mc/s 5-valve superhet circuit. Incorporates S meter, B.F.O., BANDSPREAD TUNING, BUILT-IN 4in. SPEAKER, FERRITE AERIAL AND EXTERNAL TELESCOPIC AERIAL. Operation 220/240v. A.C. Supplied brand new with handbook. £15/15/0. Carr. 10/-.

NEW LAFAYETTE MODEL HA-700 AM/CW/SSB AMATEUR COMMUNICATION RECEIVER

8 valves, 5 bands incorporating 2 MECHANICAL-FILTERS for exceptional selectivity and sensitivity. Frequency coverage on 5 bands 150-400 kc/s, 550-1,600 kc/s, 1.6-4.0 Mc/s, 48.-14.5 Mc/s, 10-5-30 Mc/s. Circuit incorporates R.F. stage, aerial trimmer, noise limiter, B.F.O product detector, electrical bandspread, S meter, slide rule dial. Output for phones, low to 2K Ω or speaker 4 or 8 ohms. Operation 220/240 volt A.C. Size 7½in. × 15in. × 10in. Supplied brand new and guaranteed with handbook 36 GNS. carr. 10/-. S.A.E. for leaflet.

ALL ITEMS AVAILABLE AS PREVIOUSLY ADVERTISED

R.107 RECEIVERS

1·7-17·5 Mc/s. Mains or 12 volt D.C. operation. Perfect condition. £15. Carr. 30/-.

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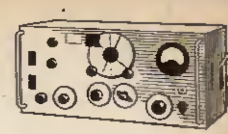

TF.144G STANDARD SIGNAL GENERATOR. 85 Kc/s.-25 Mc/s. 200/250 v. A.C. £25. Carr. 30/-. TF.329G. 'Q' METER. Brand new with access. £75. T.F. 195 M. BEAT FREQUENCY OSCILLATOR. 0-40 Kc/s. 200/250 v. A.C., £20. Carr. 30/-. All above offered in excellent condition fully tested and checked and offered at a fraction of original cost.

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Super quality. Brand new and guaranteed.

3 transistor	£6.15.0 pr.
4 transistor	£7.19.6 pr.
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6 transistor De Luxe	£17.10.0 pr.
10 transistor	£22.10.0 pr.
13 transistor 500 MW	£31.10.0 pr.
13 Trans. 1W	£35.0.0 pr. Post extra.

These cannot be operated in U.K.

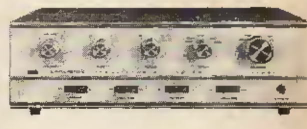
SINCLAIR TRANSISTOR AMPLIFIERS

Z12 Amplifier 89/6; Z12 Power Pack 79/6; Stereo 25 Pre-Amplifier £9.19.6; Micro FM Radio Kits £5.19.6; Micro 6 Radio Kit 59/6; Micromatic Radio Kit 59/6; Ready built 79/6. Post paid.

COSSOR 1035 Mk III DOUBLE BEAM OSCILLOSCOPES

Latest model using miniature valves. Perfect condition. £45. Carr. 30/-

LAFAYETTE HI-FIDELITY SOLID STATE STEREO AMPLIFIERS



Latest 1967 models now available. Outstanding performance from modern semi conductors. Provision for all types of inputs and outputs and comprehensive tone controls. Attractive metal cased free standing units.

Model LA-224T, 30 watt £25. Carr. 7/6. Model LA-60T, 60 watt £37.10.0. Carr. 7/6

DETAILS ON REQUEST

LAFAYETTE MODEL HA-500 SSB/AM/CW 80 THROUGH 6 METRE RECEIVER

New outstanding Ham Bands only receiver covering the 80/40/20/15/10/6 metre bands. Incorporates 10 valves, product detector, two mechanical filters, "S" Meter, dual conversion on all bands, crystal calibrator, B.F.O., noise limiter, aerial trimmer, I.F.'s 2,608 Mc/s and 455 Kc/s. Output 8 ohms and 500 ohms. Operations 220/240 volt A.C. Supplied brand new and guaranteed with handbook. 42 gns. Carr. 10/-. 100 Kc/s crystal 35/-.

★ TRANSISTORISED ★ FM TUNER

6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. £6.17.6. P.&P. 2/6.

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM.

Operative over amazingly long distances. Separate call and press to talk buttons, 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £5.19.6. P. & P. 3/6.

TYPE 13 DOUBLE BEAM OSCILLOSCOPES

5·5 Mc/s Bandwidth. Perfect condition. £22.10.0. Carr. 30/-.

VARIABLE VOLTAGE TRANSFORMERS

Brand New—fully Shrouded. Input 230v. 50/60 c/s. Output 0-260 Volts.

1 Amp	£4.10.0
2·5 Amp	£5.17.6
5 Amp	£9.0.0
8 Amp	£13.10.0
10 Amp	£17.0.0
12 Amp	£19.10.0
20 Amp	£32.10.0

Post extra.

AMERICAN TAPE

First grade quality American tapes Brand new. Discounts for quantities.

3in., 225ft. L.P. acetate	4/-
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5in., 600ft. std. plastic	8/6
5in., 900ft. L.P. acetate	10/-
5in., 1,200ft. D.P. mylar	15/-
5in., 1,800ft. T.P. mylar	35/-
5¾in., 1,200ft. L.P. acetate	12/6
5¾in., 1,800ft. D.P. mylar	22/6
5¾in., 2,400ft. T.P. mylar	45/-
7in., 1,200ft. std. acetate	12/6
7in., 1,800ft. L.P. acetate	15/-
7in., 1,800ft. L.P. mylar	20/-
7in., 2,400ft. D.P mylar	25/-
7in., 3,600ft. T.P. mylar	58/6

Postage 2/-. Over £3 post paid.

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.

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 200 Ω — 1 Meg. Supplied complete with instructions, battery and leads. £5/19/6. P. & P. 2/6.

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Cables: SMITHEX LESQUARE
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BUILD YOURSELF A QUALITY TRANSISTOR RADIO—FULL AFTER SALES SERVICE!

THE MAGNIFICENT ROAMER 7 MK IV

SEVEN WAVEBAND PORTABLE AND CAR RADIO WITH A SUPER SPECIFICATION

- 7 FULLY TUNABLE WAVE BANDS—MW1, MW2, LW, SW1, SW2, SW3 and Trawler Band.
- Extra Medium waveband provides easier tuning of Radio Luxembourg, etc.
- Built in ferrite rod aerial for Medium and Long Waves.
- 5 Section 22 in. chrome plated telescopic aerial for Short Waves—can be angled and rotated for peak S.W. listening.
- Socket for Car Aerial.
- Powerful push-pull output.
- 7 transistors and two diodes including Philco Micro-Alloy R.F. Transistors.
- Famous make 6×4 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 × 4¼ × 1¾in. 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

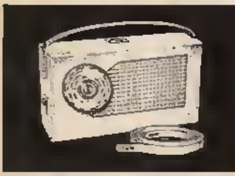
TWO WAVEBAND PORTABLE WITH 3in. SPEAKER

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

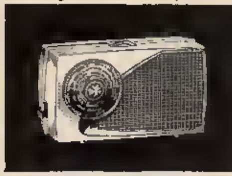


TWO WAVEBAND PORTABLE WITH 3in. SPEAKER

Handsome leather-look case, size 6¾ × 3¼ × 1⅜in. 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

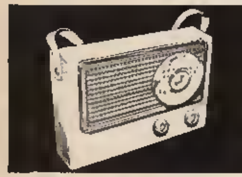


THREE WAVEBAND PORTABLE WITH 3in. SPEAKER

Smart pocket size case, 6½ × 3¾ × 1⅝in. 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

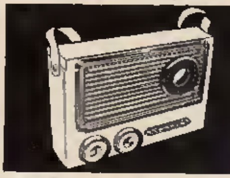


SIX WAVEBAND PORTABLE WITH 3in. SPEAKER

Attractive case with gilt fittings, size 7½ × 5½ × 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 × 1½in. 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

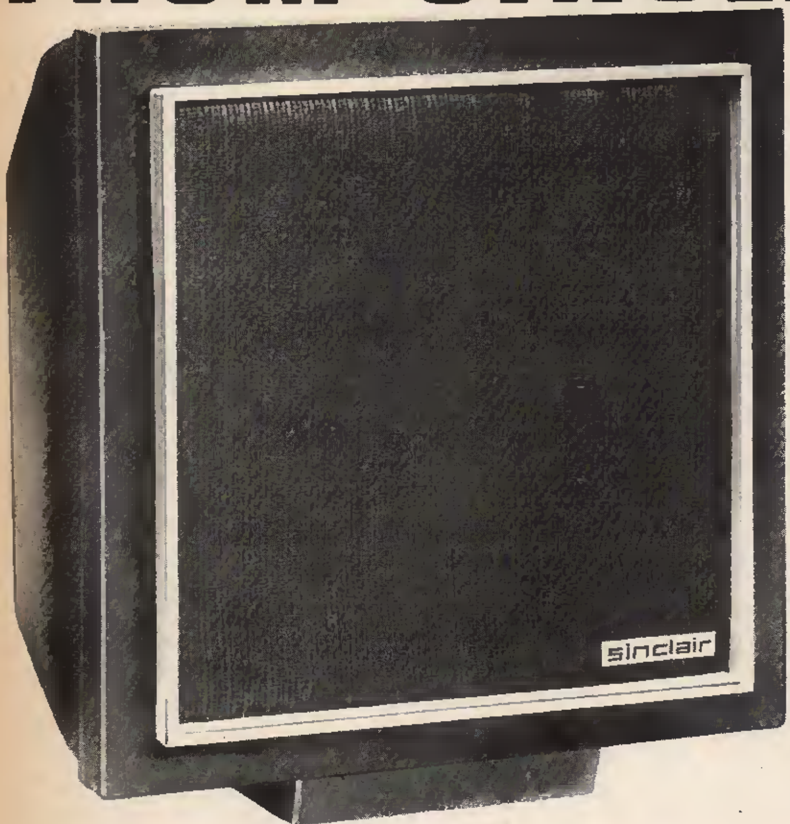
RADIO EXCHANGE Ltd

61a HIGH STREET, BEDFORD

Telephone: Bedford 52367

Callers side entrance Barratt's Shoe Shop. Open 9-5 p.m. Saturday 9-12.30 p.m.

FROM SINCLAIR - A



SINCLAIR Q.14

A HIGH FIDELITY LOUDSPEAKER FOR ONLY £6.19.6

- ACOUSTICALLY CONTOURED SOUND CHAMBER
- WIDE ANGLE OF SOUND DISPERSION
- BRILLIANT TRANSIENT RESPONSE
- MAXIMUM LOADING IN EXCESS OF 14 WATTS
- 15 OHMS INPUT IMPEDANCE
- ALL-BRITISH DESIGN AND MANUFACTURE

The Sinclair Q.14 is an entirely new sound reproducer designed and developed in Sinclair Radionics' Cambridge laboratories. The application of fundamentally proven acoustic principles and the use of new materials has resulted in exceptionally good standards of performance. The uniquely formed pressure chamber of the Sinclair Q.14 allows the instrument to be positioned in a variety of ways to take full advantage of the surroundings in which it will be used. Its shape and size will be found more adaptable in use than conventionally styled cabinets. At the same time, it presents a functionally elegant appearance used singly, paired for stereo or in multiple unit assemblies. In performance, the Sinclair Q.14 compares to advantage with loudspeakers costing over four times its price.

IDEAL FOR THE SINCLAIR Z.12

AND OTHER GOOD AMPLIFIER SYSTEMS

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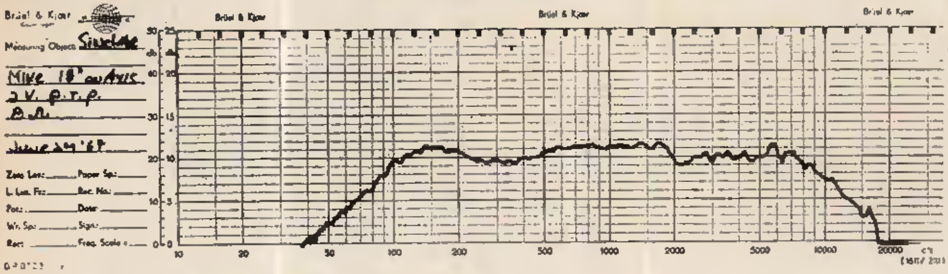
SINCLAIR RADIONICS LIMITED

22 NEWMARKET ROAD, CAMBRIDGE OCA3-52996

NEW LOUDSPEAKER



Unretouched reproduction of performance curve taken from a Sinclair Q.14 from stock. Scale reference 0-25.

INDEPENDENT TEST REPORT

The above curve, which is better than that obtainable from many speakers under £25, was taken by an independent testing laboratory and shows clearly why the Q.14 achieves such remarkable standards of reproduction. Superb response is maintained between 60 and 15,000c/s, completely covering listening requirements and assuring the user of getting the best from the equipment to which the speaker is coupled.

WHY THE SINCLAIR Q.14 IS FAR AHEAD IN EVERY WAY

CONSTRUCTION

The sound, or pressure chamber and mounting baffle are of special high-density ultra-low resonant materials made possible by modern bonding and processing techniques. The sound chamber is of seamless construction and the loudspeaker mounted to ensure complete freedom from spurious "coloration".

LOADING

The Sinclair Q.14 has an input impedance of 15 ohms and will comfortably accept loadings in excess of 28 watts music power. This rating is far greater than that required for average listening requirements. However, using the Q.14 in module formation (a unique Sinclair facility) enables a very powerful system to be built up efficiently and economically. This makes an ideal quality P.A. system.

FREQUENCY RESPONSE

As the independently made curve shows, a remarkably smooth response is maintained between 60 and 15,000c/s. This is why quality is so good from any sound source the Q.14 reproduces.

REPRODUCING UNIT

A specially designed driver unit is used. It has an exceptionally high compliance in the cone suspension, a massive 11,000 gauss ceramic magnet and an aluminium speech coil. The cone is treated to ensure brilliant transient response.

CONTOURED PRESSURE CHAMBER

The shape and proportions of the sealed sound or pressure chamber have been determined mathematically thereby ensuring maximum energy to sound conversion ratio with forward sound "presence" and freedom from any directional effect. This is why the Sinclair Q.14 is ideal for stereo. Connections at the rear are marked for correct phasing when using two or more Q.14's.

SIZE

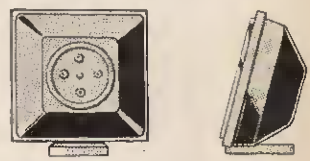
$9\frac{3}{4}$in $\times$ $9\frac{3}{4}$in $\times$ $4\frac{3}{4}$in deep. A separate base for free standing position is provided as well as a template for wall or flush mounting. A neat solid aluminium bar inset is used to embellish the front of the speaker.

SEND FOR YOURS TODAY

Try the Q.14 in your own home. Your money will be refunded in full (inc. postage) if not satisfied.

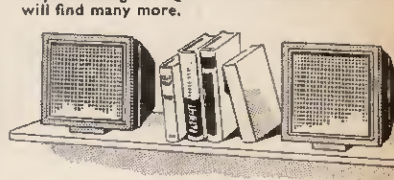
£6.19.6

AN ALL-BRITISH SINCLAIR GUARANTEED PRODUCT

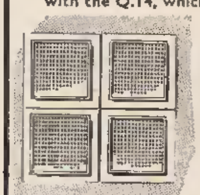


USING A SINCLAIR Q.14 SYSTEM

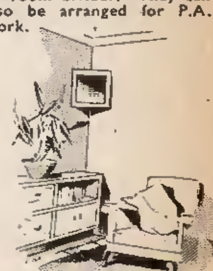
The size and form of the Sinclair Q.14 permit it to be used in a far wider variety of applications than with conventionally designed loudspeakers. This makes it possible to match the speaker to its environment much more easily and to achieve performance standards far better than anything in its size or price group. Here are some typical ways of using the Q.14. The enthusiast for hi-fi will find many more.



FREE STANDING BOOK SHELF ASSEMBLY
Ideal for stereo. A detachable base is supplied with the Q.14, which screws on for convenience.



MULTI UNIT ASSEMBLY
Any number of Q.14's can be flush mounted on to a flat surface, such as a false wall or room divider. They can also be arranged for P.A. work.



CORNER SPEAKER AT ANY HEIGHT
The Q.14 will fit comfortably into a wall corner, taking up a minimum of space. The wall surfaces then contribute to the sound radiation.

sinclair

Order form and more Sinclair products on next pages

ACTUAL SIZE

SINCLAIR MICROMATIC

To the fantastically small size of the Sinclair Micromatic must be added its brilliant performance. This British-made set assures you at all times of choice of BBC and many other stations in the medium waveband. After dusk, even more stations come in all round the dial with amazing power and excellent quality. Vernier type tuning takes full advantage of the set's selectivity. This remarkable set provides good listening no matter where you are—indoors, in car, bus, train—everywhere. The Sinclair Micromatic brings a refreshingly new approach to personal listening and for its size, appearance, price and performance, there is nothing to equal it anywhere in the world.

SINCLAIR MICRO FM

7 TRANSISTOR COMBINED FM TUNER AND RECEIVER

Less than 3in × $1\frac{3}{4}$in × $\frac{3}{4}$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

Technical description

The Sinclair Micromatic is housed in a neat plastic case, size $1\frac{4}{5}$in. × $1\frac{3}{10}$in. × $\frac{1}{2}$in. with attractive aluminium front panel and spun aluminium calibrated tuning dial.
Special Sinclair transistors are used in a six-stage circuit of exceptional power and sensitivity—two R.F. amplification; double diode detector; and a high gain three stage audio amplifier which feeds to a specially matched high quality lightweight earpiece. A.G.C. counteracts fading from distant stations. Bandspread brings in "pop" stations extra easily. The set is powered by two Mallory ZM.312 Cells obtainable anywhere for 1/7 each.

Complete kit in new "see-for-yourself" pack with earpiece instructions and solder

59/6

Built, tested and guaranteed with earpiece and batts. **79/6**

It (Micro FM) works very well and gives a quality very close to my hi-fi records. W.J.A., Natal, S.A.

Without doubt the Z-12 is the best value of the present day. A.W., Lanark

I am absolutely lost for words, it (Micromatic) is one of the most amazing inventions I have ever known. L.L., Norwich

I am very impressed with the quality of reproduction (Stereo 25). S.M.W., London, N.W.10

sinclair

SINCLAIR RADIONICS LTD., 22 Newmarket Rd., CAMBRIDGE

Telephone OCA3-52996

TRANSISTOR STEREO 8 + 8

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors giving 8 watts push-pull output per channel. (16 W mono). Integrated pre-amp with Bass, Treble and Volume controls. Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work, Cir-Kit board, attractive front panel, knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of.

Brief Specification: Freq. response ±3 db 20-20,000 c/s. Bass boost approx. to +12 db. Treble cut approx. to −16 db. Negative feedback 18 db over main amp. Power requirements 25 V at 0·6 amp.

PRICES

Amplifier Kit	£9.10.0	P. & P. 4/6
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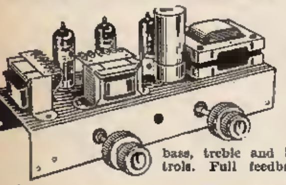
(Special offer—£14.10.0. Post Free if all above ordered at same time.)

Circuit diagram, construction details and parts list (free with kit) 1/6 (S.A.E.)

STEREO AMPLIFIER

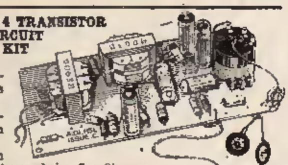
Incorporating 2 ECL86s and 1 EZ80, heavy duty, double wound mains transformer. Output 4 watts per channel. Full tone and volume controls. Absolutely complete.



ONLY **£4.19.6** P. & P. 8/-

Super De-luxe version with ECL86 valves, sep. bass, treble and balance controls. Full feedback. 8 gns. P. & P. 8/-.

HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT Type TA1



- Peak output in excess of 1½ watts.
- All standard British components.
- Built on printed circuit panel size 6 × 3in.
- Generous size Driver and Output Transformers.
- Output transformer tapped for 3 ohm and 15 ohm speakers.
- Transistors (GET 114 or 81 Mullard OC81D and matched pair of OC81 o/p).
- 9 volt operation.
- Everything supplied, wire, battery clips, solder, etc.
- Comprehensive easy to follow instructions and circuit diagram 2/6 (Free with Kit). All parts sold separately. **SPECIAL PRICE** 45/-. P. & P. 3/-. Also ready built and tested, 52/6. P. & P. 3/-.

BRAND NEW T.V. U.H.F. TUNER AND SOUND AND VISION I.F. PANEL

By world famous maker. Suitable for use in conversion of T.V. sets to B.B.C.2 (625 line reception). OFFERED (less valves) AT THE BARGAIN PRICE OF ONLY 27/6. Post Paid. (The components are worth far more than our price for the complete unit and due to the very high value we regret that no correspondence can be entered into regarding this item.)

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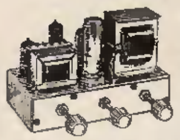
Beautifully designed and precision engineered by Dormer and Wadsworth Ltd. Supplied ready fitted with twin ·0005 tuning condenser for AM connection. Prealigned FM section covers 86–102 Mc/s. I.F. output 10·7 Mc/s. Complete with ECC85 (6L12) valve and full circuit diagram of tuner head. Another special bulk purchase enables us to offer these at 27/6 each. P. & P. 3/-. Order quickly! Limited number also available with precision geared 3 : 1 reduction drive. 30/-. P. & P. 3/-.

MATCHED PAIR AM/FM I.F.'s. Comprising 1st I.F. and 2nd I.F. discriminator. (465 Kc/s/10·7 Mc/s). Size 1in. × 1⅛in. × 2½in. H. Will match above tuner head. 11/- pair. P. & P. 2/-.

TURRET TUNERS by famous maker. Brand new and unused. Complete with PCC84 and PCF80 valves 34-38 Mc/s IF. Biscuits for Channel 1 to 5 and 8 and 9. Circuit diagram supplied. ONLY 25/- each. P. & P. 3/9.

GORLER F.M. TUNER HEAD. 88-100 Mc/s 10·7 Mc/s. I.F., 15/-, Plus 2/- P. & P. (ECC85 valves, 8/6 extra.)

3-VALVE AUDIO AMPLIFIER MODEL HA34



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £4.5.0. P. & P. 6/-.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc, 79/6. P. & P. 6/-.

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A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 2/6. (Free with parts.) **All parts sold separately.** ONLY £7.9.6. P. & P. 8/6. Also available ready built and tested complete with std. input sockets, £9.5.0. P. & P. 8/6.

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B.S.R. GU7 9 volt Battery Operated Record Player Units. 4-speeds, Automatic stop. Plays any size record. Complete with mono t/o head and sapphire styli.

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BRAND NEW CARTRIDGE BARGAINS! ACOS GP69-1 MONO CARTRIDGE. For E.P. and L.P. Complete with stylus. **ONLY 12/6.** P. & P. 1/-.

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A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, EZ80 valves. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3in. d. × 6in. h. Ready built and tested. **PRICE** 69/6. P. & P. 6/-. ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. **PRICE** 89/6. P. & P. 7/6.

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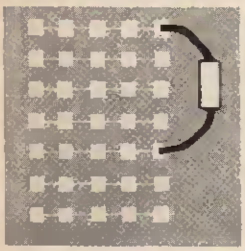

The contacts are arranged in rows of five (numbered) which are joined together electrically as shown in the diagram. This arrangement is similar to that used in the popular printed wiring board so that the same methods of laying out circuits may be used. An S-DeC contains two of these 5 x 7 panels enabling most electronic building blocks to be accommodated. For very large circuits the decking can easily be enlarged by keying the units together forming a firm continuous area of decking of any desired size.

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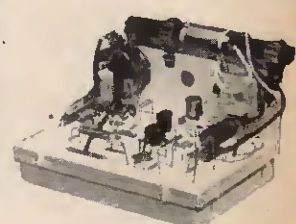
The photograph shows a three transistor plus diode reflex receiver mounted on a SINGLE S-DeC. FREE construction details for this radio are given with each S-DeC purchased NOW!



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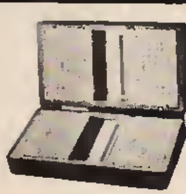

ACCESSORY KIT. This kit extends the usefulness of your S-DeC.
Contains:

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Please send me............S-DeCs each containing a free accessory kit and............4-DeC kits for which I enclose PO/Cheque/Money Order value £....../....../......

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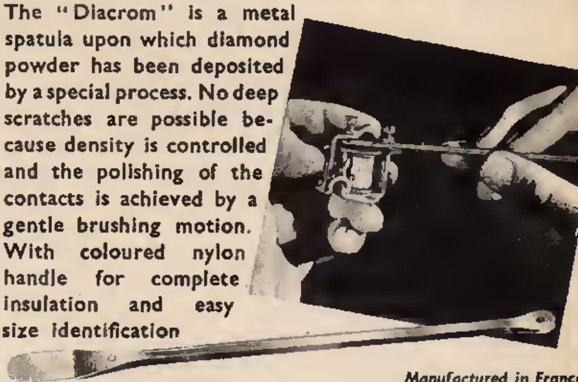

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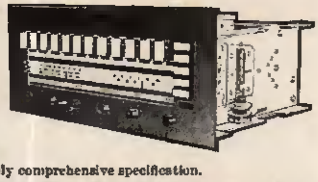

Model T10E—made for U.K. use by famous North American manufacturer and originally installed in De Luxe Hi-Fi consoles costing several hundred pounds. The chassis is of outstanding appearance and quality and offers many unique features plus an extremely comprehensive specification.

Features ● Separate transistorised AM and FM tuners ● 3 AM wavebands—LW, MW and Continental T.R. band ● full FM cover with 5 push button preselected stations (sep. tuning controls for AM and FM ranges) ● built in multiplex decoder with unique FMX feature which provides automatic switching from mono to stereo when stereo signal is received and vice versa ● unique split amplifier facility for simultaneous play of radio plus any other source ● channel reverse ● switched inputs for tape and auxiliaries (sep. sockets for tape in and out) ● switched extension speaker outlet ● thermal safety trip ● socket for stereo headphones.

Tech. spec.: Output 10 watts RMS per channel; output imp. 8 Ω p.c.; sensitivity 50mV for 8W output at 1 Kc.; input imp. 100 K Ω p.c.; 12 unique tumbler type function controls, 8 push button wavechange and station selection controls, vol., bass, treble and balance controls, push button contour (loudness) control; illuminated tuning scale; AM ranges: MW 520-1640 Kc/s, LW 140-290 Kc/s, Continental TR 170-345 Kc/s; FM range 88-108 Mc/s with switched AFC. Operates on 200/250V A.C., 50 or 60 c/s. Size 17½ × 8 × 12in.

LASKY'S PRICE 59 Gns. Post & Packing 20/-

A range of high quality Hi-Fi Console Cabinets by the same famous manufacturer is also available at almost ½ list price and may be seen at our Hi-Fi Audio Centres.

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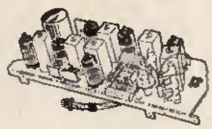
VALVE UHF MODEL

In metal case size 4 × 6 × 1½in. Fully tunable—complete with PCC86 and PCC88 valves.
LASKY'S PRICE 29/6. Without valves **7/6**

TELEVISION IF AMPLIFIERS



38 Mc/s. Contains a large number of components, IF transformers, resistors, capacitors, etc., and the following valves: 2xPCF80, 1xEB91, EF80, EF183 and EF184. Overall size 11½" × 3½" × 4" deep. Ideal for servicemen and experimenters. This IF amp. when used with the Valve model UHF Tuner (above) provides a suitable conversion for B.B.C.2. Circuit supplied.

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SPECIAL PACKAGE OFFER

Free standing table cabinet, size 17½ × 9 × 5½in., finished in medium Mahogany. Scale marked 21 to 68 (UHF band). Designed to accept the above IF Amplifier with space for a Valve UHF Tuner Cabinet only 27/6. Post 3/6.

Special Package Offer IF Amplifier, UHF Tuner with valves and Table Cabinet.

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Highly sensitive — suitable for either static or mobile use. Signal can be picked up by any FM radio or tuner which receives frequencies between 96-104 Mc/s. over several hundred yards. Size only 3 × 2½ × 1in. (in leather case). Operates on one PP3 type battery. Complete with neck cord, clip-on dynamic extension mike (¾ × ¾ × $\frac{5}{16}$in.) and battery.

LASKY'S EXPORT PRICE 10 Gns. Post Free. Anywhere in the World.

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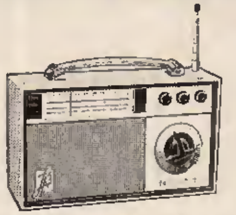
THE SKYROVER De Luxe



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LASKY'S PRICE £12.19.6 Post FREE.
POWER SUPPLY KIT for the SA-88 £3.10.0 Post FREE.

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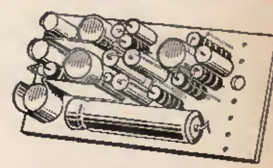

Incorporating the very latest circuitry to provide high sensitivity and good quality in conjunction with extreme small size and compactness. High quality Newmarket transistors used throughout. All designed to operate on 9v. miniature battery. **Add 1/- on each for post & packing**

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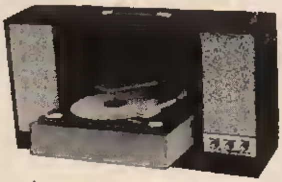

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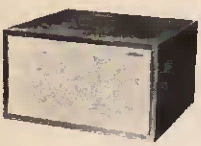

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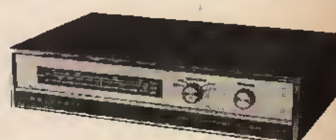

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VOL. 3 No. 10
OCTOBER 1967

PRACTICAL ELECTRONICS

RESEARCH AND DEVELOPMENT

THE Ministry of Technology was created just three years ago. One of the first tasks this new body undertook was a close examination of the electronics industry. In a report just released, the ministry states that although technically strong, the electronics industry is facing sharp international competition, and exports are not keeping pace with the growth of world markets. The remedy suggested is heavy expenditure on research and development, which can only be supported by large scale operations. Clearly some drastic reorganisation of the industry is in mind.

Research and development are the life-blood of the industry. Progress depends upon a constant flow of new ideas. An interesting point arising from this is whether the best results are obtained from large, highly organised laboratories or whether scientists and research workers produce their best in semi-isolation in small organisations.

Is the large "ideas factory" type of research establishment conducive to the independent line of enquiry which is the essence of new discovery?. Or is there a danger of a computer-like complex being created by such establishments? Technological developments may proceed apace within a well-defined and systematically organised programme. Fundamental research on the hand other needs a freer and less inhibited atmosphere in which to thrive. Any suggestion of programming (which implies the unquestioning acceptance of traditional or conventional ideas) will retard or stifle original thought.

How far can we go in mass producing ideas? History records the achievements of brilliant men of invention whose individual genius was not damped by lack of material resources. Whether these personalities would have achieved earlier (or greater) success had they been supported by the resources of a large governmental or industrial organisation we can only speculate.

It is of note that some American scientists have in recent times questioned the great importance commonly attached to the large industrial research laboratories which are a prominent feature of the technological scene in the U.S.A. A doubt exists whether the "output" is commensurate with the huge expenditure involved. It has been pointed out that the most significant discoveries that emerge from these scientific "hatcheries" are the work of either an exceptional individual, or a small team headed by a brilliant leader. Would such individuals or small teams work just as efficiently in smaller establishments—or would they then be denied some vital cross-fertilisation of ideas which only a large community can provide?

One thing at least is sure: for our future prosperity we will continue to rely heavily on the detached and creative mind of the brilliant individualist—be he practical experimenter, inspired innovator, or scientific intellectual. No matter where he works.

THIS MONTH

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NEWS AND COMMENT

Our November issue will be published on Friday, October 13

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.

ELECTRONIC MUSIC TECHNIQUES

What is electronic music? Why not just "music"?— Or at least music produced by means of electronics. But this immediately suggests music produced by electronic musical instruments such as organs or guitars

THE term "electronic music" was probably used in the first instance by musicians who weren't perhaps quite so well informed about electronics, but it really has nothing to do with music produced by electronic or electrical musical instruments. And yet, as you will soon discover, the modern conception of electronic music is in fact music produced by hybrid electronic musical instruments. It is fairly essential therefore to deal first with some of the earlier techniques for producing electronic music.

Some years ago, even before the Second World War, musicians began to investigate the possibilities of electronics in music. Much of this stemmed from the development of audio amplifiers, loudspeakers, audio frequency tone generators and electronic circuits and devices for controlling production and reproduction. With a variable frequency audio oscillator one could quite literally "play tunes".

This soon led to the provision of a keying system so that a number of such oscillators could be used as the basis of a playable musical instrument—the electronic organ. This particular development is of course well known and the electronic organ is now one of the most popular of electronic musical instruments.

Serious music composers, however, saw other musical potentialities in the audio tone generator and in many other devices that could electrically or electronically generate or process sound within the audible frequency spectrum. Noise generators, for example, and electrical filters. They also realised that the frequency, amplitude, and dynamic ranges that could be obtained electronically were far greater than those of conventional musical instruments. The only real problem was in being able to reproduce the sounds exactly as and when required in a composition.

Then magnetic tape recording became popular, an almost perfect medium for storing sounds and editing a composition. At this point it would be as well to summarise with a quotation from Herbert Eimert one of the original team of the Cologne Studio of Electronic Music, one of the first studios ever set up for the exclusive production of electronic music.

In a technical paper, Eimert wrote: "Electronic music opens the door to acoustical phenomena of a kind still unknown in contemporary music. It demands new principles of artistic production which cannot be derived from playing an electronic musical instrument but only from the sound itself which is its raw material".

TERMINOLOGY OF ELECTRONIC MUSIC

This comment by Eimert clearly indicates that electronic music is something quite different from natural music, which it is. It involves creation, composition, and production using a terminology of its own.

Until recently such music was produced only from electronic tone sources, for example, tone generators and noise generators, whereby all the required sounds were recorded on magnetic tape and afterwards assembled in the order required by the composer. This "assembly" was done by actually cutting the required pieces from the tape, these being laboriously joined together again in accordance with the score.

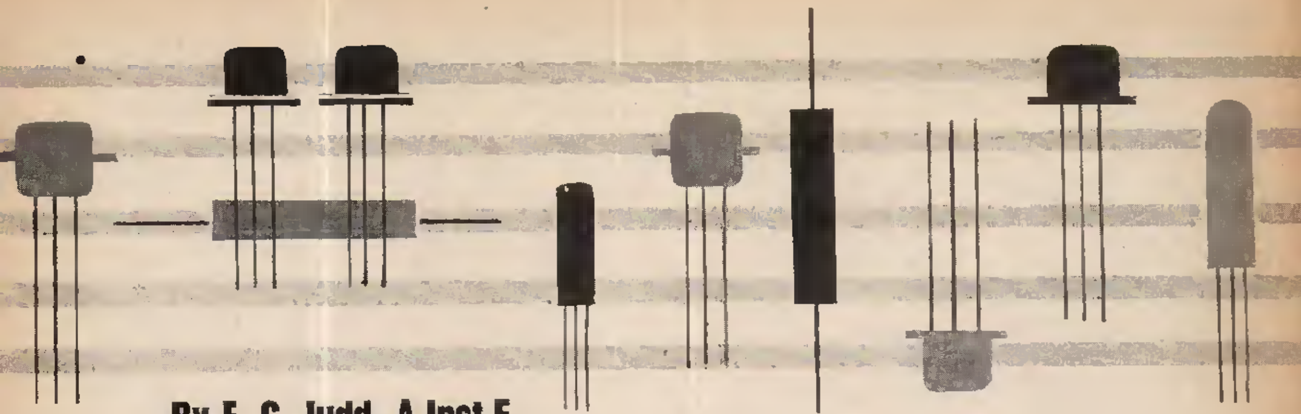
There are existing scores for electronic music using a special notation; an example is given in Fig. 1. The trend in many studios now is to use the keyboard which does away with the arduous job of splicing hundreds of pieces of recording tape. Magnetic tape is, however, still the only practicable medium for reproducing the composition. Electronic music is never played directly from a keyboard system over a loudspeaker as one might play an electronic organ.

COMPOSING PROCESSES

The classification of electronic music composing processes embraces all instruments, apparatus, and processes not used for concert or solo performance, but only for the production of a composition with the aid of sound storage devices, such as tape recording, disc, or film recording.

Such apparatus also includes the use of distorting or sound shaping devices connected between the sound sources and the sound storage or recording system. There are linear and non-linear distorting systems, convertors, modulators, phase delay systems, filters, attack and decay control systems, amplitude control methods, and so on.

The results of some of these processes can be heard on the record given free with this issue of PRACTICAL



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

ELECTRONICS. Notes on the sounds recorded are given in the display panel on the next page.

When sound recording techniques are added, the processes become even more complex because apart from storage of the sounds other modifications can be carried out, such as time and frequency compression and expansion, reversal, rhythmic repetition, reverberation and so on.

It is not possible on one record to provide an example of every one of the hundreds of different ways in which sounds can be treated or modified. Those that have been included are those most used and which can be produced with fairly simple equipment. The recording also includes an example of rhythmic electronic music employing some of the more simple techniques outlined in this article. Details of the music on the record are given elsewhere in this article.

SOUND SOURCES AND TREATMENT

The basic sound sources used in electronic music composition are pure tone (sine wave) audio frequency generators, the noise generator which produces "white noise" (a sound having random fundamental frequency, amplitude, and phase and which can cover the entire audio spectrum), pulse generators which include square and other shaped waves other than sine wave within the audio frequency spectrum.

The first recording on the demonstration record contains examples of the following sounds: 400Hz pure tone, 100Hz square wave, 10Hz pulse, and unfiltered white noise. Any of these basic sounds can now be treated in various ways, mixed together, given artificial reverberation, filtered, modulated, given specific attack (beginning of sound) and decay (end of sound) and so on.

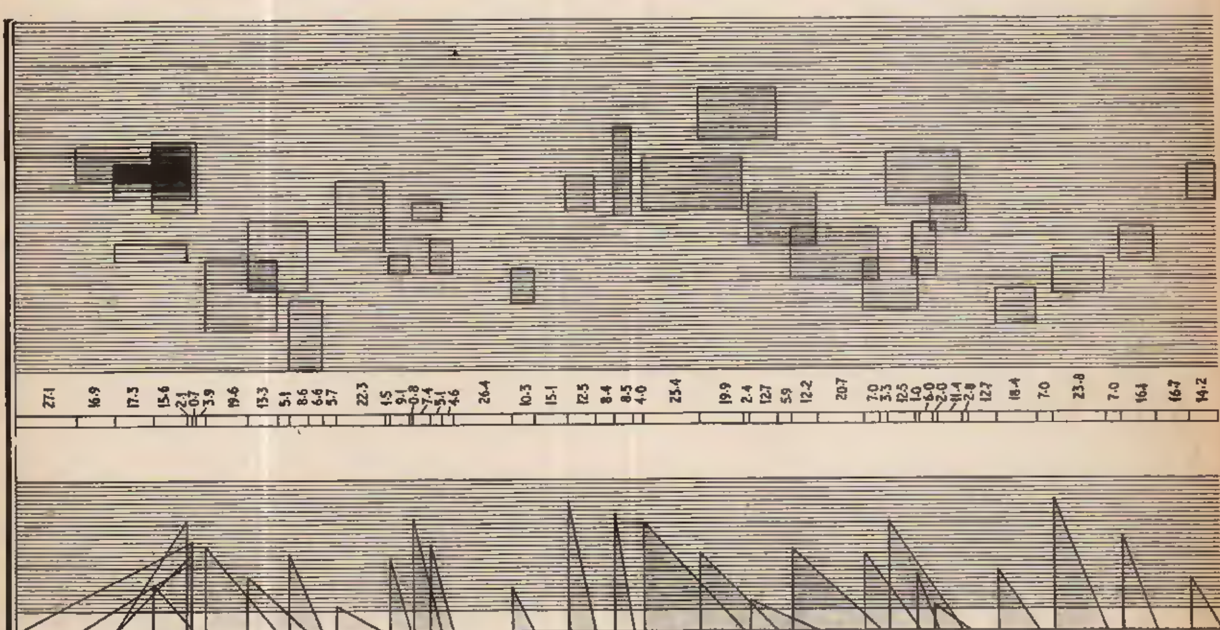


Fig. 1. Part of a score for electronic music (Universal Editions). This is one page taken from the 30-odd page score of STUDIE 2 by KARLHEINZ STOCKHAUSEN (DEUTCHE GRAMMOPHON LP 16133A), a classic piece of electronic music. The upper half of the score which contains 80 lines is used to indicate the frequencies contained within the "blocks" and according to the composer's instructions at the beginning of the score book. The duration of each frequency block is indicated by the middle scale which gives the respective length of tape in centimetres for recording at a tape speed of 30in/sec. The lower half contains the instructions for the amplitude of the frequency blocks rising or falling according to the duration of the recording. The 30 lines represent the level in decibels, the top line being 0dB or maximum record level

One of the most used treatments is the modulation of one sound by another by means of a ring modulator. When two pure (sine) tones of different frequency are fed into the modulator they are reproduced at the output together with two more tones at the sum and difference frequencies of the originals. The sound produced is a kind of chord with unusual timbre and an example is included on the record.

Audio frequency filters are also used extensively in the studios, but can be costly devices and difficult to make if sharp response is required. Simple forms of RC filter will cater for many amateur experiments; these and other electronic circuits for sound treatment will be given in the second part of this article. Examples of filtered white noise are given on the demonstration record.

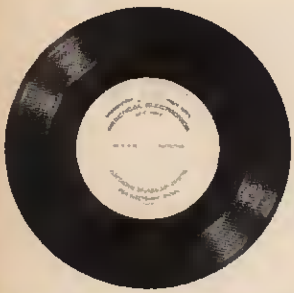
Treatment and mixtures can go on almost *ad infinitum*. For example ring modulated tones can be pulsed or further modulated with noise. Pure tones can be mixed or modulated with square waves or other wave shapes and any of these combinations, can be given controlled degrees of attack, decay and reverberation. Practically all of the various "electronic" treatments and mixtures can be carried out before recording.

REVERBERATION

Reverberation is a very popular effect. It can be produced by a tape recorder with two heads, or a plate or spring line reverberation unit. The "spring line" reverberation unit is the most effective and could be built by a knowledgable amateur. The reverberation produced by such a device is quite different from that produced by a feedback system employing magnetic tape. Spring line and plate reverberators produce an echo which closely approximates natural room echo but which can be extended to provide a "sound-in-a-large-empty-hall" effect.

Echo produced by the magnetic tape feedback method is hard and abrupt, but it is a very distinctive form of echo. Both kinds of reverberation (echo) are demonstrated on the record. The tape feedback system can

P.E. SOUNDS AND EFFECTS RECORD



THE examples contained on the record are typical of the sounds and treatments employed in a studio for producing electronic music. Most of them can, however, be produced with amateur equipment such as a sine wave generator, an ordinary multivibrator (square wave generator), a ring modulator, and various simple electronic circuits that will be described in Part 2 of this article.

Voice announcements precede each recorded example. Some notes on the equipment and treatment employed are included. Details of the individual recordings are given below.

BASIC SOUND SOURCES

1. Pure sine wave from an ordinary audio signal generator (400Hz).
2. Square wave from an audio signal generator (square wave output).
3. Pulse wave from a multivibrator.
4. Unfiltered white noise from a white noise generator.

ELECTRONIC TREATMENT

1. *Ring Modulated Tones.* Simple ring modulator and two pure tone sources (audio signal generators).
2. *Filtered White Noise.* Noise generator and one-third octave filters.
3. *Pulsed Tones.* Previously recorded ring modulated tones fed into a ring modulator (one input) with impulse generator (multivibrator) fed to the other input.
4. *Attack and Decay.* Use of volume control and/or electronic circuit.

REVERBERATION EFFECTS

1. *Mechanical Reverberation.* Obtained with a spring line reverberator.
2. *Tape Echo.* By feedback from a tape recorder replay head immediately following the record head. Signals returned via recording amplifier.
3. *Excessive Echo.* By allowing tape head feedback to build up followed by cut-off with volume control. Noise sound from noise generator.
4. *Pre-echo.* Sound echoed during reverse recording and then replayed in the original direction.

TAPE RECORDING TECHNIQUES

1. *Replay Speed.* Sound recorded and replayed at same speed.
2. *Replay Speed Doubled.* Sound replayed at twice recording speed.
3. *Reversed Recording.* First part as recorded; second part in reverse.
4. *Tape Loops.* Used for effective repetitive rhythms. Recorded basic sound cut from length of tape. Joined into a continuous loop.

Note: Reverse replay of a tape recording may only normally be carried out with a full track recorder or a twin track stereo recorder, in which case the recording is first made on the lower track and replayed, in reverse, on the upper track, or vice versa. If the recorder is made to play in either direction, this does not apply; the reverse play effect then becomes straightforward.

RHYTHMIC ELECTRONIC MUSIC EXAMPLE

The final track on this record is a piece of electronic music using the loop rhythm example described above, except that the tempo is slower. The melody is the theme of a complete electronic music composition for which the author was awarded first prize in the 1965 British Recording Contest (professional section).

The rhythm was first recorded on a continuous loop of tape. This tape was then cut to exactly 44 bars (in 2/4 time) thus providing a four bar introduction followed by 40 bars for the melody.

be produced quite easily with any tape recorder having an extra tape head, i.e. a replay head after the normal record head.

During recording, signals on the tape are picked up by the replay head and returned to the tape via the recording amplifier so that the sounds are re-recorded a fraction of a second later. The returned signals must be under control (via a volume control) otherwise the feedback will build up to a vicious roar. This effect is, however, sometimes used deliberately to produce dynamic sounds as illustrated on the record.

One other reverberation technique should be included and this is called pre-echo. Here the sounds are recorded in the normal way on tape. The tape is then played in reverse on one machine and re-recorded and simultaneously echoed on another. When this recording is replayed in the reverse direction the echoes of the sounds will precede the sound itself.

TAPE RECORDING TECHNIQUES

Any two or more of the sounds so far described can be combined to form a complex composite sound. The possibilities begin to become almost unlimited and we have not yet dealt with keyboard sound systems, rhythm machines, and the endless variety of pure recording techniques such as reversed playing, speed changing, frequency compression, tape loops, multi-track recording, superimposing, tape cutting and the re-assembly of recorded items.

With the help of the record included in this issue it is now possible to give actual examples of some of the effects that can be produced. Also at the end of this article will be found a list of recorded works containing examples of all kinds of electronic music and sounds.

However, before going on to describe some of the recording techniques used on the record, the following is a brief resumé of the author's equipment used to make the various sounds, although a more modest range can be used.

Sound sources include sine and square wave generators, a pulse generator (1·5 to 6,000Hz), white noise generators, electrical filters, double beam oscilloscope, stereophonic amplifiers and loudspeakers, spring line reverberation unit, sound mixers for up to six channels, ring modulator, microphones for non-electronic sounds, an electronic organ as a keyboard system (melody in tempered scale) and finally three tape recorders, two of which are half-track stereo machines, one full-track tape recorder (mono) and a replay deck with full-track and half-track heads.

THE BRITISH AMATEUR TAPE RECORDING CONTEST 1967

The above contest, held annually, is open to amateurs only. There are seven different categories for entry. Readers inspired by this article on Electronic Music Techniques may like to know that their own original work can be entered in Class 5 TECHNICAL EXPERIMENT, which embraces sound compositions, electronic music, musique concrête, multi-track music and trick recording. The maximum playing time for a tape is 4 minutes.

Closing date for receipt of tapes is December 30, 1967.

Rules of the Contest and entry forms can be obtained from The British Amateur Tape Recording Contest, c/o The Secretary, 33 Fairlawnes, Maldon Road, Wallington, Surrey.

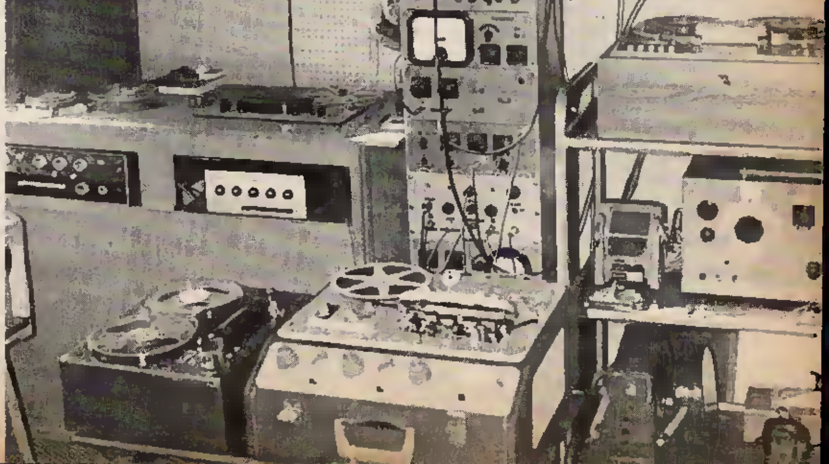
Despite this fairly comprehensive range of equipment, it is all set up in a very small studio and does not begin to compare with studios such as the BBC Radiophonic Workshop which occupies two large recording studios and features an enormous range of electronic and recording equipment.

Returning to recording techniques, magnetic tape is now the accepted recording medium and in itself provides various possibilities in the treatment of sounds. Of these, the change of speed is very frequently used; sounds are recorded at one speed and replayed or re-recorded at another.

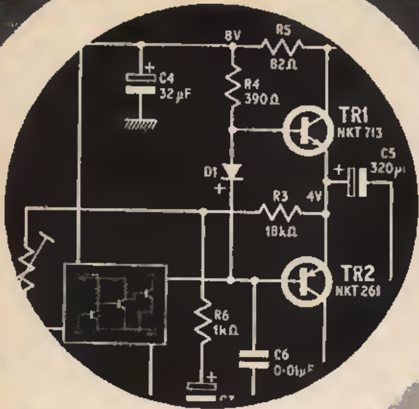
In electronic music the speed change is used to raise or lower the pitch of recorded sounds. Most tape recorders operate on two or three speeds which are normally related by one octave difference in pitch derived from doubling or halving the tape speed, using $3\frac{3}{4}$, $7\frac{1}{2}$ and 15 inches per second.

In the studio, recorders with small differences in pitch are frequently used and as a rule the speeds are pitch related so that a recording made in, say, the key

continued on page 748



Some of the sound generating and recording equipment used to produce the demonstration record



IC GRAM AMPLIFIER

By R. HIRST

LINEAR microcircuit elements have been available in this country for a relatively short period of time. At present, the output power of these devices is strictly limited. It would seem that for some little time hence, *hybrid* configurations will dominate system design, where microcircuitry will perform pre-amplifier functions and power output will be obtained by the addition of discrete transistors.

In the circuit of Fig. 1 a practical half watt gramophone amplifier follows this line where the *Mullard Integrated Linear A.F. Amplifier Type 263TAA*, functioning as a pre-amplifier, is followed by a complementary pair of germanium transistors.

CIRCUIT DESCRIPTION

If reference is made to Fig. 2 it may be seen that the circuitry contained within the 263TAA comprises three d.c. coupled transistor stages. Any feedback, a.c. or d.c., taken from pin 3 and fed to pin 1, will be of the negative variety unless any phase shift is introduced externally. Due to the fact that the output at the emitters of TR1 and TR2 are in the same phase as that at pin 3, occasioned by emitter follower action, it is possible to introduce negative feedback over the entire amplifier thus linearising the frequency response, reducing distortion, and from a d.c. point of view, stabilising the d.c. operating points.

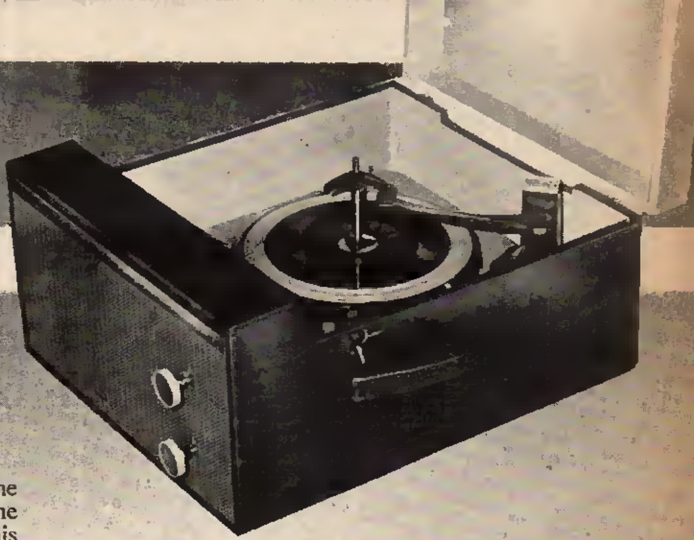
A.C. CONDITIONS

Considering now the complete circuit of the gramophone amplifier (Fig. 1): the signal from the pick-up cartridge is fed via the volume control VR1, R1, and C1 to the input of the integrated package where it is amplified sufficiently to drive the output transistors TR1 and TR2 to the full rated output. A.C. feedback is applied over the configuration via the d.c. path of

SPECIFICATION . . .

MAXIMUM OUTPUT	500mW
DISTORTION	Less than 0·8% total r.m.s. for output of 300mW
SIGNAL-TO-NOISE RATIO	72dB below full rated output
OUTPUT IMPEDANCE	8 ohms
FREQUENCY RESPONSE	80Hz to 15kHz
TONE CONTROL	3dB down at 1·5kHz; 18dB down at 12kHz
SENSITIVITY	200mW input at 400 kilohms for full rated output
CARTRIDGE CAPACITANCE	Not less than 2,000pF
POWER SUPPLY	Mains 9V power supply unit, or 9V battery

A hybrid design incorporating an integrated three-stage pre-amplifier and a discrete class-B complementary pair output stage. Mono or stereo applications.



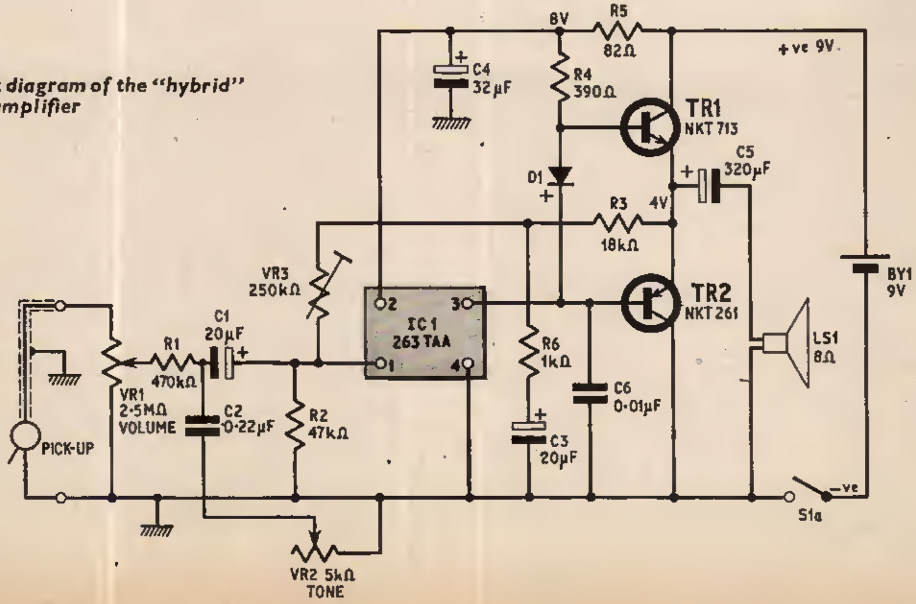
R3 and VR1. R3 has been introduced so that some of this feedback may be decoupled to promote the required input sensitivity; R6 and C3 perform this task and the values have been chosen so that for an input signal of 200mV the amplifier will produce the full rated output within the frequency range, 80Hz to 15kHz.

The integrated circuit is terminated by TR1 and TR2 which provide a considerable amount of power gain, driving up to half an amp peak into 8 ohms. The drive current through D1 and R4 is consequently in the order of 10mA as this is a function of the required output current and the current gain of the output transistors. To keep distortion within reasonable limits the two output transistors are matched to within 10 per cent for current gain at the operating current. The value of R4 is such as to determine that a voltage of approximately 4V is presented at pin 3 of the integrated circuit.

TONE CONTROL NETWORK

The lower frequency response rests entirely with the capacitance of the transducer, which is in the form of a crystal or ceramic pick-up cartridge. As the capacity of the pick-up increases so the lower frequency response extends further into the lower frequency range, and it was with this in mind that the Acos Type GP94/5 was selected. Although this cartridge is basically a stereo unit it performs equally well monaurally, and the high capacity lends itself to the lower impedances associated with the more normal semiconductor circuitry. With an output capacitance in the order of 4,000pF the lower frequency response will be 3dB down at 80Hz considering the worst condition of total input resistance to be 500 kilohms.

Fig. 1. Circuit diagram of the "hybrid" gramophone amplifier



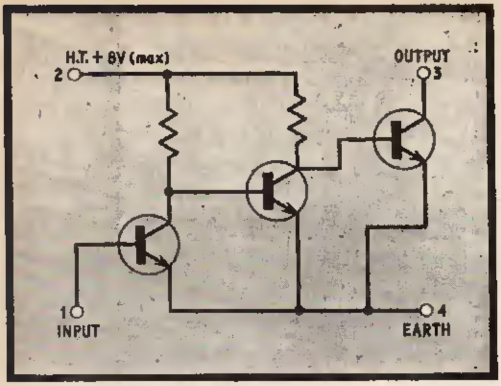


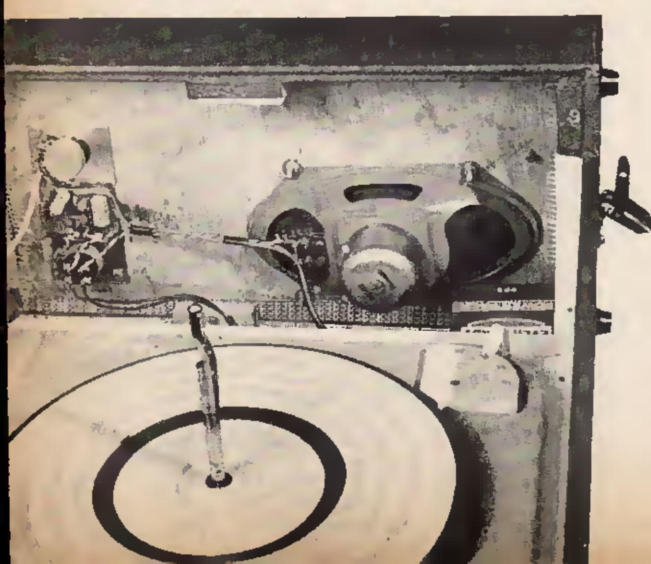
Fig. 2. Circuit diagram of the integrated linear amplifier Type 263TAA

The input resistance of the circuit, excluding all the components prior to C1, is in the order of 500 ohms and the external biasing resistor R2 has little effect upon this value. The turnover point of the tone control network with VR2 in the minimum resistive condition requires to be at approximately 1·5kHz, that is to say that when the tone control is operative the frequency will be down by 3dB at 1·5kHz. In order to establish this condition the reactance of C2 will have to equal the input resistance of the package at 1·5kHz and in this instance a value of 0·22μF promotes this effect.

With the tone control fully operative the response will be approximately 18dB down at 12kHz and to maintain a smooth operation with regard to the tone control and yet, at the same time achieve a condition at where the maximum resistive setting of VR2 has little effect upon the flat response, the value of VR2 was established at 5 kilohms.

D.C. CONDITIONS

In order to provide an output voltage that takes advantage of the full available supply voltage, the junction of the emitters of TR1 and TR2 is set at the half rail condition of 4 volts. This is established by ensuring that the base voltage of TR2 is approximately 3·9V and the base voltage of TR1 at about 4·1V. The voltage then dropped across D1 will be 0·2V requiring 3·9V to be dropped across R4 at at current of 10mA, hence the value of 390 ohms for R4.



A potential divider between the emitter of TR2 and the negative rail establishes the correct operating point for the microcircuit and may be adjusted by VR2 to cater for the spreads of the components.

As the 263TAA is a three stage device and any voltage presented at the emitters of TR1 and TR2 is in phase with the voltage at pin 3 of the unit, the whole circuit proves to be a very temperature stable configuration. This is because as any increase in the input d.c. current that can be attributed to temperature rise, is presented at the emitters of TR1 and TR2 as a *decrease*, and a portion of this decrease is fed back to the input via R3 and VR2 thus restoring the circuit to its original condition.

The diode D1 plays a considerable part in the stability of the ouput pair by decreasing in resistance when the temperature increases, thus reducing the quiescent current of the output transistors and maintaining the Class B operating condition of the output stage. (This diode is matched to the output transistors and comes as part of a matched output kit supplied by the transistor manufacturers.)

As the maximum supply voltage to the integrated package is 8·0V, R5 has been introduced to reduce the 9V supply to this figure. Should a sagging type of mains supply unit be used to provide the supply power, then it is essential that an 8V 100mW Zener diode be placed in parallel with C4, the positive side of the Zener to the positive supply rail.

A double pole switch is included on VR2. One section, S1a, is used to switch the amplifier battery BY1; the other section S1b is available for switching the supply to the gramophone motor—whether this be a.c. mains or battery.

PERFORMANCE SUMMARY

The amplifier performs extremely well, providing an output of 0·5W into 8 ohms. At an output of 300mW the distortion is less than 0·8 per cent total r.m.s. The signal to noise ratio is better than 72dB below the full rated output—making it difficult to establish audibly whether the amplifier is switched on when no signal is being applied to the input.

IMPORTANT

It is essential that the output terminals are not shorted out, nor should the output load be reduced below the stipulated 8 ohms, otherwise the excessive dissipation will ruin the output transistors. The circuit will operate at any load in excess of 8 ohms, but the output will be reduced accordingly and may be calculated from the equation that

$$P_{\text{out}} \approx \frac{(V_{\text{supply}-2})^2}{10R_{\text{load}}}$$

CONSTRUCTION

The circuit board is etched by one of the normal techniques from 2oz copper clad laminate board. A full size pattern of the printed circuitry is given in Fig. 4.

The integrated circuit unit and most of the discrete components are mounted on this board. R6 is mounted on the underside of the board. Arrangement of the components is given in Fig. 3.

The completed circuit board is mounted on a small aluminium plate. This plate also carries the potentiometers VR1, VR2. Dimensions and drilling details are given in Fig. 7. The completed amplifier unit can thus be readily secured inside almost any kind of cabinet by two screws.

AMPLIFIER WIRING

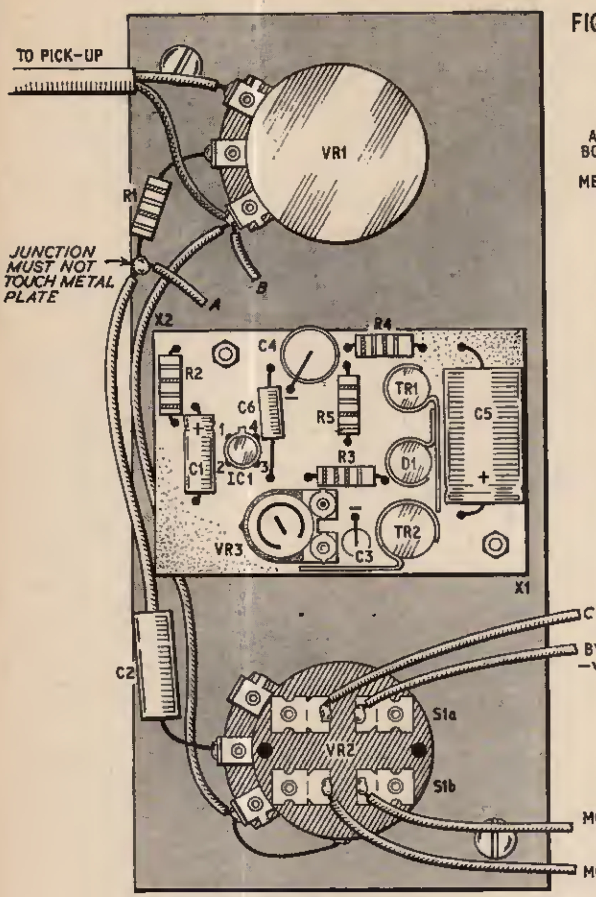


FIG.3

FIG. 6

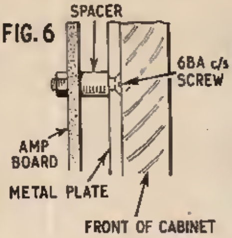


FIG. 4

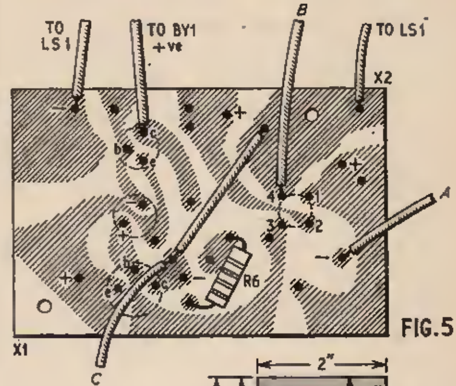


FIG.5

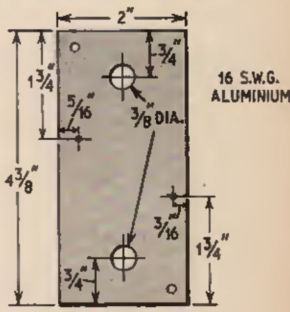


FIG.7

Fig. 3. The completed amplifier assembly, showing the circuit board mounted on the metal plate, together with the controls VR1 and VR2

Fig. 4. Printed circuit—full size
Fig. 5. Wiring details of printed circuit
Fig. 6. Detail showing method of fixing board to metal plate
Fig. 7. Dimensions and drilling details for metal plate

COMPONENTS . . .

Resistors

R1	470kΩ	R4	39Ω
R2	47kΩ	R5	82Ω
R3	18kΩ	R6	1kΩ

All ±10%, ¼W high stability carbon

Potentiometers*

VR1 2·5MΩ log. carbon
VR2 5kΩ log. carbon, with d.p. switch
VR3 250kΩ log. carbon, miniature preset

Semiconductors

TR1 NKT713 } Newmarket
TR2 NKT261 } (matched
D1 Diode } output kit)
IC1 263TAA Mullard

Capacitors

C1	20μF elect.	C4	32μF elect. 10V
C2	0·22μF paper	C5	320μF elect. 6·4V
C3	20μF elect. 25V	C6	0·01μF paper

Battery

BY1 9V type PP9 or equivalent

Loudspeaker

LS1 7in × 4in elliptical, 8Ω

Miscellaneous

Copper clad laminate. Aluminium, 18 s.w.g.
Battery connectors. Two knobs

***STEREO VERSION**

VR1 2·5MΩ carbon } log. tandem
VR1a 2·5MΩ carbon }
VR2 5kΩ carbon } log. tandem, with d.p. switch
VR2a 5kΩ carbon }

Before securing the circuit board to the plate, various flying leads must be soldered to the printed circuit (see Fig. 5); also the wiring to VR1 and VR2 should be completed. Note that R1 and C2 are wired directly to their respective potentiometers. Spacers must be fitted to the two 6B.A. screws, between the circuit board and metal plate.

MAINS SUPPLY UNIT

Fig. 8 indicates a suitable mains supply unit which is adequately smoothed to provide a relatively ripple free output voltage thus keeping the hum level to a minimum.

All parts are accommodated on a piece of aluminium measuring 3¼in × 2¾in. Details of construction are given in Fig. 9. The mains transformer T1 is secured in position by the lugs which are bent and clamped around the metal plate. The terminal block is fixed by means of two 6B.A. screws and nuts; however, since this entails removal of the transformer clamp an alternative method of glueing with Araldite may be preferred by some constructors.

INSTALLATION

The illustrations show a typical installation inside a portable gramophone case. The cabinet is a well known type, generally available as manufacturers' surplus, and accommodates an a.c. operated three-speed turntable deck. A seven inch elliptical loudspeaker is mounted on the front panel, and to the right of this is the amplifier unit. A 9V battery is situated in the corner, just behind the loudspeaker. A small fillet of wood glued to the cabinet bottom holds the battery in position.

If the main operated power unit is employed, this can be installed in a similar position; however it may be necessary to experiment with various positions in order to eliminate hum pick up from the mains transformer.

The pick-up input lead, although being screened, should be kept away from any source of mains to eliminate hum pick up. The screen of this lead should be earthed to the metal plate of the turntable where convenient. All earth return leads should be earthed directly to the correct place on the printed

POWER SUPPLY UNIT

COMPONENTS . .

Resistors
R1 6Ω 2W wirewound
R2 200Ω 1W wirewound

Capacitors
C1 2,000μF elect. 12V
C2 2,000μF elect. 12V

Transformer
T1 Primary 200–250V 50Hz; secondary 9V 400mA (Belclere)

Rectifier
D1 Bridge type rectifier, type P64 E/1B (S.T.C.)

Miscellaneous
Terminal block, 5 way. Aluminium, 18 s.w.g.

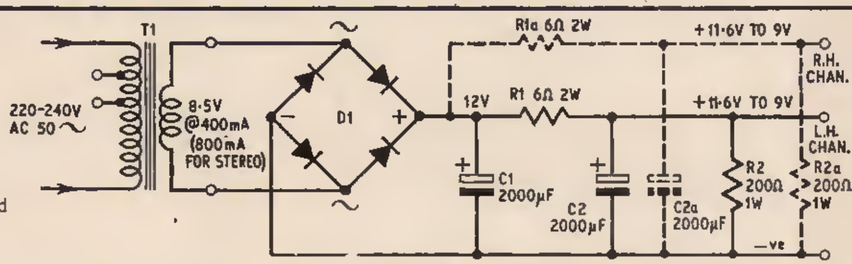


Fig. 8. Circuit diagram of mains operated power unit. The components shown dotted are only required if two amplifier units are being used, i.e. for stereo operation

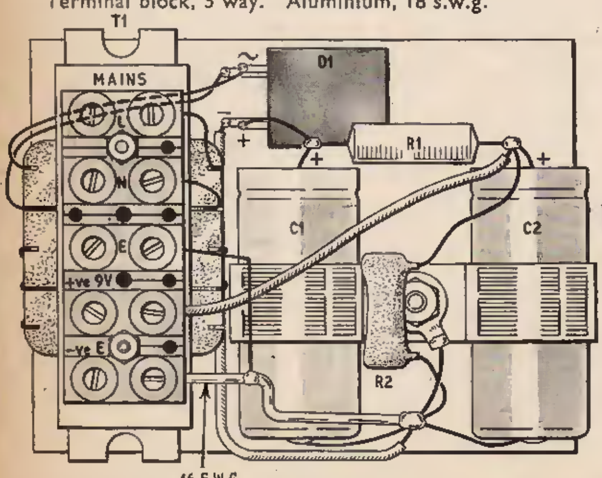
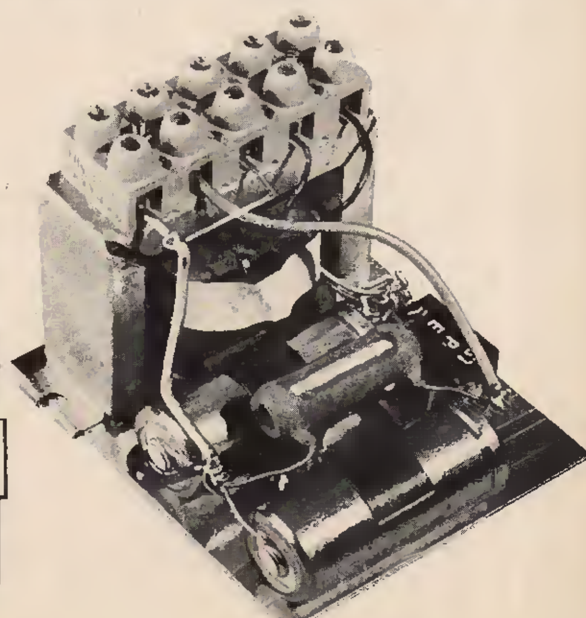
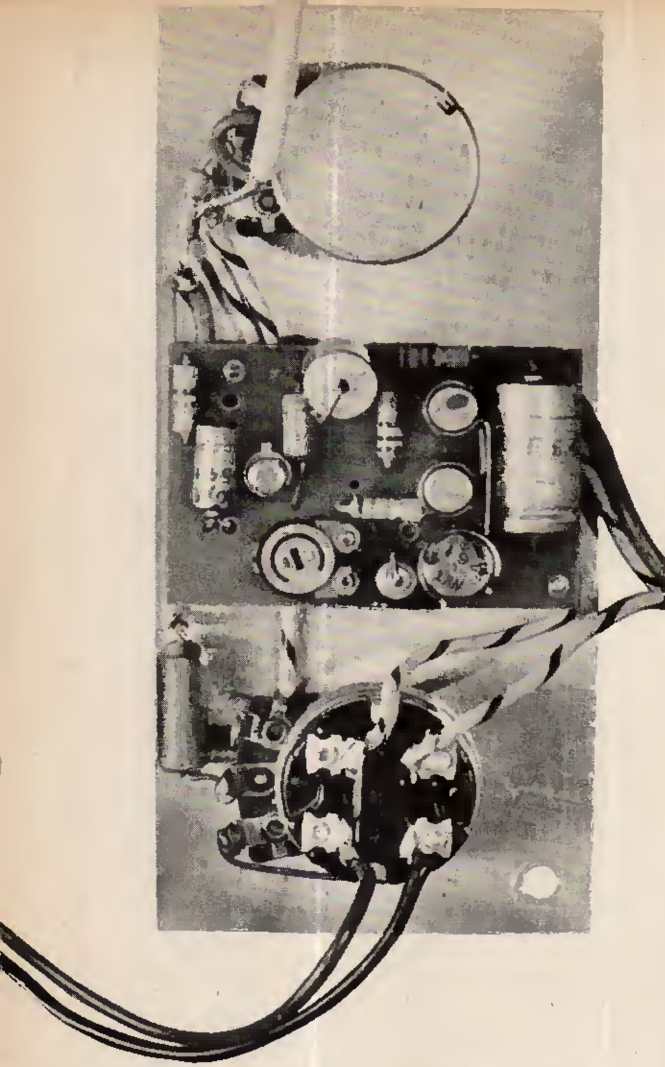


Fig. 9. Layout of components and wiring of power supply unit





circuit board and under no circumstance should any one lead carry two potentials.

The negative supply lead should be of relatively substantial proportions to avoid the introduction of any feedback over this path thus eliminating any deviation from the quoted amplifier figures.

There may be an instance when a pick-up has a very low output voltage and is insufficient to drive the amplifier to its full rated output. In these circumstances the value of R6 may be reduced to 470 ohms to effect the required increase in gain, but it must be noted that the signal to noise ratio will deteriorate by the amount that the gain has increased and the overall distortion will worsen by a small degree.

Should a battery be used as the source of supply voltage it is advisable to obtain one that has a relatively high current output capacity, such as the PP9. The life of this type of battery should be very good as the quiescent current of the amplifier in the "no signal" condition is less than 15mA and only increases proportionally with the output voltage.

SETTING UP PROCEDURE

Once the amplifier connections have been thoroughly checked over, the unit should be switched on—having first set VR3 in the mid-position. A d.c. voltmeter should be connected between the emitter of TR1 and the negative rail, and VR3 then adjusted so that 4V is measured at this point. This is all the setting up required and the amplifier should then be ready for use.

STEREO VERSION

A stereo installation can be easily built using two identical circuit boards. The metal plate can be enlarged in width to accomodate the second board. Twin ganged potentiometers replace the normal types for volume and tone control, see Components List.

Inter-channel wiring is shown in Fig. 10. Twin core screened cable should be used for the stereo pick-up to avoid duplicating the earth return.

The second loudspeaker may be mounted in the player cabinet, but a better arrangement is to house this loudspeaker in a separate cabinet. A pair of sockets can then be provided on the player cabinet for connecting to the external unit.

For battery operation, one battery will suffice for both amplifiers. For mains operation the power supply unit should be modified as indicated in Fig. 8.

ALL BATTERY PORTABLE

A completely self contained record reproducer (mono or stereo) can be built using a battery operated record player unit, such as the B.S.R. GU7. A separate 9V battery must of course be provided for the motor. ★

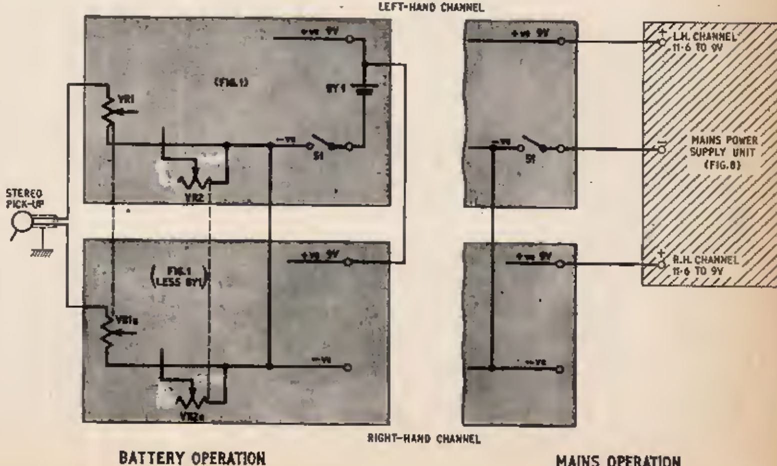


Fig. 10. Block diagram showing inter-unit wiring for stereo version

By S.A.HODSON B.Sc

COMPUTER EVOLUTION

PART FIVE HARDWARE & SOFTWARE

IN the previous article, the basic elements of Boolean algebra were discussed, and it was shown how Boolean logic could be made to perform algebraic functions on the binary code. It is now intended to delve more deeply into the binary code and show how it can be used for representing both negative numbers, and fractions. Then we will go on to describe how a computer is programmed.

NEGATIVE BINARY

It may seem obvious that the easy way to make a binary number negative, is to put a minus sign in front of it. This, unfortunately, does not help the computer which can only recognise "1"s and "0"s. The next step then is to add a bit on to the front of each number and let it represent the sign of that number. Thus a "1" for positive and a "0" for negative or vice-versa.

This means now that the computer has to decide whether the number being subtracted is bigger than the number it is being subtracted from, and hence decide on the sign of the answer. This method is awkward, and, since an alternative exists, is somewhat pointless.

The alternative method of subtraction is known as the "method of complements". This is a perfectly general method, and can be used in the decimal as well as the binary system.

The complement of a number is defined as the difference between that number and the next highest power of the root of its number system. For instance the complement of 27 (which will be called c27 for simplicity) is $100 - 27 = 73$.

Now suppose that 27 is to be subtracted from 42. Normally,

$$42 - 27 = 15$$

and everybody is happy. Not so the computer though. It says that

$$42 - 27 = 42 + c27 = 42 + 73 = 115.$$

The left hand digit that has been generated is a sign digit, and defines the number as positive. Thus $115 = +15$.

This calculation can equally well be done in reverse:

$$27 - 42 = 27 + c42 = 27 + 58 = 85.$$

Now in this case no sign bit has been generated, and so the result is known to be negative. The method of complements is extremely consistent in that it gives negative results in complement form. Thus 85 is really the complement of the true answer which is -15.

This method is just as applicable in the binary system. In this system, the complement of a number is found by subtracting it from the next highest power of two. For instance the complement of 1011 is $10000 - 1011 = 0101$.

There is an easier way than this to find a binary complement, and that is to reverse every bit in a number and then add a 1. Thus 1011 reversed is 0100, and when the 1 is added, this becomes 0101, which is the right answer.

This method of subtraction is extremely quick and cheap, since it does away with the necessity for both the ADD and the SUBTRACT instructions, leaving the ADD to do the work of both.

FRACTIONS

Another detail that is essential to the accurate working of a digital computer is the ability to work with fractions. Some computers work entirely in fractions and all numbers used in them have to be scaled down to less than one. This type of machine is known as a "fixed point" machine, in that the decimal point is fixed at the left hand end of the computer word.

A refinement that is added on larger machines is that of "floating point" working. In this type of machine, the decimal point is fixed somewhere in the computer word by the way in which the word is broken up. Of course, it is possible for a compiler programme to be written that will enable a fixed point machine to work in floating point manner, and this is quite common practice.

To return to the subject of fractions, the binary code, just as the decimal one, can have numbers to the right of the point. Here the "point" is no longer a decimal point, but a "binary" point. It still represents the change over from fractions to whole numbers though. As in the decimal system, numbers to the right of the point decrease in powers of ten, those to the right of the binary point in the binary system decrease in powers of two.

Thus $0{\cdot}1 = \frac{1}{2}$ (or 0·5 in decimal) and $0{\cdot}001 = \frac{1}{8}$ and so on.

Compound numbers can be formed just as easily as in the decimal system, for instance, 10110·001101 in binary is equivalent to $22\frac{13}{64}$ in decimal.

BUILDING UP A COMPUTING SYSTEM

The reader should now know how to handle basic arithmetic operations, simple routing exercises and Boolean operations within the computer. He also should know how to store the results of his endeavours. All that remains now is to bind the various parts of the machine together by describing its "software" or programming aspects.

A technique that pops up again and again in computing, both in the hardware and the software, is that of the "loop". A loop in software consists of a sequence of instructions performing an operation that starts itself again each time it finishes. In other words it goes round in circles, or loops.

The basic hardware loop is that from the store to the registers and back again (see Fig. 5.1).

The registers form a temporary store for data that is in current use by the computer. They may add numbers to them, subtract numbers from them, invert them, shift them up and down, multiply them, divide them, and perform a whole host of other functions.

To enable these operations to be carried out, a second loop with an arithmetic unit is added to the basic hardware loop (see Fig. 5.2).

The computer must have some means of communicating with the outside world. There are many ways of doing this, some of which will be described later; suffice it for the present to lump them under the heading of "input-output devices". In general, a computer will communicate with its input/output devices, or "peripherals", directly from the registers. It is perhaps less usual, but quite conceivable, for the peripherals to communicate directly with the store. This extends the diagram of Fig. 5.2 into that of Fig. 5.3.

There is one further unit to add to Fig. 5.3 before it is complete, and that is some form of control unit. Without this unit, no sequence of operations could be followed, and the computer would be helpless. This gives the final computer block diagram shown in Fig. 5.4.

PROGRAMMING

It may be remembered that in Babbage's original concept of the digital computer, he intended to store both the data required, and the sequence of operations to be followed, in the store. The reason for this was that a human operator would not be able to tell the computer what to do quickly enough. This technique is adopted in modern computers. The sequence of operations is known as the computer programme.

The store can only hold information in the form of numbers, so whether it is storing data or programme, the store contents are going to look much the same. For this reason, the standard computer word is split up into sections. One section may represent the function to be obeyed, another section might be the address of a piece of datum, and so on. The only difference between programme and data is that the computer is told by the control unit to obey the programme parts of the store, and the programme tells the control unit, and hence the computer, to make use of the data parts of the store.

This is an important point, and often causes confusion among newcomers to computers. A number in the store is not defined as data or programme until it comes to be used; it is then the programme that decides to use it in one way or the other.

For instance let a number such as 8192 be placed in the store. Now when this number is broken up into the operation and address, it may mean "Add the number in address x to the accumulator".

Suppose now that an instruction in the programme says "Read the number in address y (this is the 8192) and add it to the accumulator" then the number 8192 automatically becomes data. Now suppose that later in the same programme, an instruction occurs which says "Go and obey the contents of location y", then the 8192 becomes part of the programme, and means "Add the number in location x to the accumulator".

Any operation requires at least three addresses to be specified before it can be completed. These are the addresses of the two numbers to be operated upon, and the address in which the result is to be put.

In simple machines, the accumulator (the main register) is used as two of these addresses. In this manner, a number in the accumulator is operated on with a number from a specified address, and the result is left in the accumulator. This type of machine is known as a "single address" machine.

On very fast, process machines, the three address system is very useful, since the addresses of the two operands and the result can be specified. A short example will show how economical in instructions this can be:

(a) *Three address system*

"Add the contents of location x to the contents of location y, and put the result in location z". One instruction only is used.

(b) *Single address system*

"Read the contents of location x into the accumulator".

Fig. 5.1. Basic hardware loop

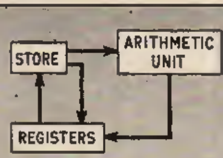


Fig. 5.2. Add an arithmetic unit

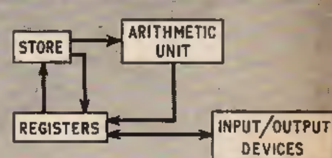


Fig. 5.3. Communication with the outside world

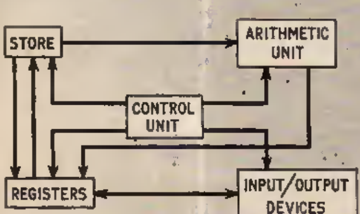


Fig. 5.4. Control of the computer is essential

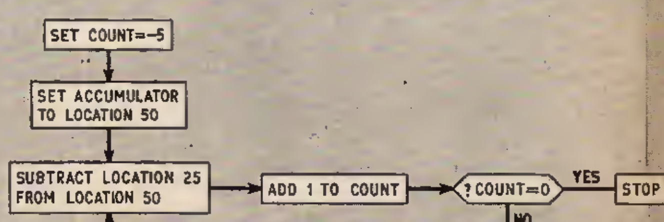
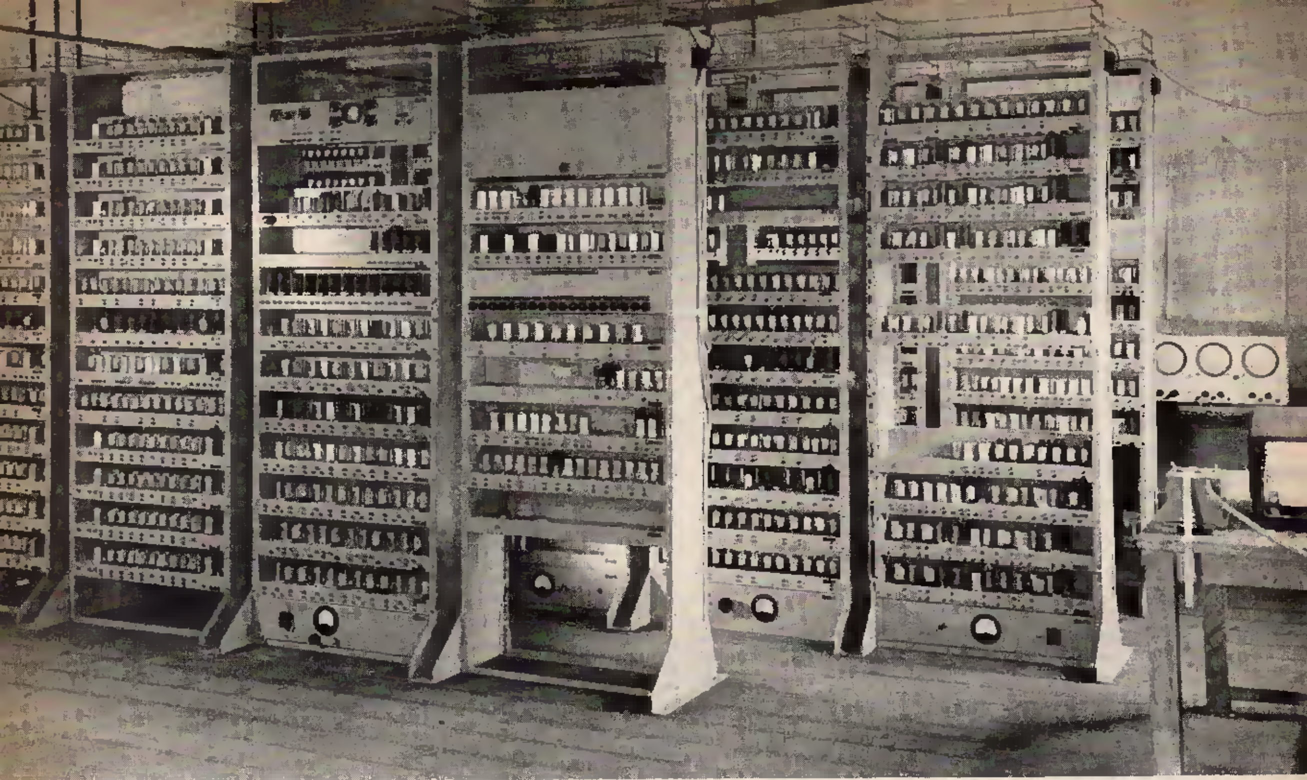


Fig. 5.5. Flow diagram used in the early stages of writing a programme



An early electronic digital computer EDSAC I at the University Mathematical Laboratory, Cambridge, in 1949

"Add the contents of location y to the accumulator, leaving the result there".

"Put the contents of the accumulator into location z".

Three instructions are used here.

The normal way in which a computer goes about its business, is to extract a word from the store, obey it, and then extract the word from the next store location, and obey that, and so on. The control unit tells the computer when, and at what address to start, and then the programme takes over, and carries on to the end of the programme.

Now programming would be an extremely tedious task if every operation had to be put in sequence like this. It would also be repetitive, since certain standard routines, like taking a square root may occur dozens of times in a programme. For this reason, the list of instructions that a computer can obey is not confined to arithmetic operations alone. There are a certain number of "control" instructions.

One of the most useful of these is the "Jump" instruction. This tells the computer to break away from the sequence of operations in one part of the store, and move to another part. For instance, in location 8, there may be the instruction "jump to 99". The computer will come along, obeying instructions 6, 7, etc., and when it gets to 8 it will obey the instruction by obeying the contents of location 99.

An even more useful extension of this instruction is the "conditional jump". This instruction makes its action depend on some condition, such as the accumulator being zero, or negative. In this way, count can be kept of the number of times a software loop has been performed. For instance, let the contents of a certain part of a computer store contain the following instructions:

Address	Instruction
1	Set location 7 to −5
2	Read location 50 into the accumulator
3	Subtract location 25 from the accumulator
4	Add 1 to location 7
5	If location 7 is negative, jump to 3
6	Stop

This last instruction is very important, since without it, the computer would go on extracting instructions from the store and obeying them right through the whole of its contents. This is not very desirable.

Looking at the programme example in more detail, it can be seen that it subtracts the contents of location 25 from the accumulator five times. Going through it step by step, the first step is to set up a "count" in a location known as a "workspace". In this case, location 7 is used as a workspace, and is set initially to −5.

The next step is to load the accumulator with the number from which to subtract. The subtraction is performed once, and then one is added to the count, making it −4. This is still negative, so the next instruction to be obeyed is in location 3. This performs the subtraction again, and then adds another 1 to the count. This "loop" continues until the count reaches 0, by which time, the subtraction will have been performed 5 times. When this occurs, the conditional jump instruction is not obeyed, and the computer goes on to the next instruction which tells it to stop.

It may be easier to follow a programme like this in the form of a block or flow diagram (see Fig. 5.5).

Programmers use the flow diagram in the early stages of writing a programme, before they have got to the stage of actual instructions.

A block drawing can be altered very much more easily than a sequence of orders, and by breaking it down in this manner, a large programme can be given to several programmers to do, each one writing one little block or "sub-routine".

SUB-ROUTINE

A sub-routine is a sequence of instructions that performs an operation needed several times in a programme, such as finding a square root. Having once written a sequence of instructions, or programme, to find the square root of a number, the programmer does not want to have to copy out this sequence every time he wants to take a square root.

To save him having to do this, he can write his "sub-routine" in such a way as to be able to find the square root of any number that is placed in a certain location within it. Then in his main programme, all he has to do is to place the number he wants the square root of in the right place, and the sub-routine takes over.

This is all very well until the sub-routine has finished, but the computer doesn't know where to go next. It was obeying a sequence of instructions when it jumped out of sequence to go to the sub-routine, once at the end of the sub-routine, it is helpless unless it has been told where to go next. This means that there are two things a programmer must remember to do before entering a sub-routine.

(a) Set up the parameters that the sub-routine is to operate on.

(b) Set up a "return" location so that the computer knows where to go when it has finished the routine.

There are no hard and fast rules as to how the programmer sets about arranging (a) and (b); it is up to him. The way in which the sub-routine works can perhaps be seen more clearly in Table 5.1.

Even using a sub-routine, or several sub-routines, a lot of the programmers time is spent arranging entries and exits and a whole lot of other things that are vital to his programme, but are no more than routine "book-keeping". This book-keeping doesn't really require the programmers skill, it just wastes his time. This is quite pointless, since this sort of book-keeping is just the sort of job that the computer is eminently suited for. This is where the programming language comes into its own.

Table 5.1. A TYPICAL SUB-ROUTINE (S/R)

	Address of Location	Contents of Location
S/R	$m-1$	$+0$ (used as a workspace)
	m	$+0$ (used as a workspace)
	$m+1$	Find the square root of the number in location $m-1$
	⋮	
	$m+n$	
	$m+n+1$	Jump to the address contained in location m
	⋮	⋮
	$p-1$	Put no. whose sq. rt. is to be found in loc'n $m-1$
	p	Put $(p+2)$ into loc'n m
	$p+1$	Jump to loc'n $m+1$
	$p+2$	Continue programme
	⋮	⋮
	$r-1$	Put no. whose sq. rt. is to be found in loc'n $m-1$
	r	Put $(r+2)$ into loc'n m
	$r+1$	Jump to loc'n $m+1$
	$r+2$	Continue programme

LANGUAGE

If a programme were to be written that would look at another programme, and recognise where sub-routines were needed, and then arrange the programme in such a way that the entries and exits to and from the sub-routines were taken care of, then the amount of pointless work done by the programmer would be cut to a minimum. Such a programme is known as a compiler.

When the programmer is writing his programme, if he should want to take a square root, he just writes SQRT x or some such expression. He is rigidly limited in what he uses to mean "take the square root of . . ." by the compiler. When the compiler programme comes to look at this part of the programme, it sees SQRT x, and knows that a sub-routine is called for, and it performs all the book-keeping operations necessary to put it into the programme.

Elliott ARCH on-line computer at the Spencer works of Richard Thomas & Baldwin where it is engaged on information handling for the steelworks

The sequence of operations involved is roughly as follows:

First the programmer writes his programme in the language that his compiler can understand. This programme is useless to the computer until it has been "compiled". Next he feeds into the computer his compiler programme, which will contain all the more common sub-routines that he is likely to need.

After this he feeds in his own programme, which the compiler first checks for errors in format. Then it outputs a programme, written in a form that the computer can understand, that the programmer can feed back into the computer and run.

The advantages of this sort of programming make themselves felt when one compiler run produces a programme that will be used many times over. If a programme is only going to be used once, as is often the case in scientific circles, then this method has little to recommend it, since a compiler run would have to be done every time a programme was needed, and that would be a waste of time.

There are several major programming languages each with its own merits and fortés. ALGOL and FORTRAN are two very widely used languages in scientific circles, and COBOL is one that is used in business. The reason for having the different languages in different fields, is that the range of sub-routines required is different. For instance, the business programme is quite likely to want to be able to work out the interest on a sum of money over a period of years, whereas it is hardly likely to want to take the sine of an angle.

The compiler is one way in which software can save programming time. There is a way in which software, in the form of a programme known as an "executive" programme, can also save on hardware.

When a computer is running a programme, it frequently has to make reference to peripheral devices, or external banks of storage. In general, these outside devices are slower than the computer. Whereas an instruction in a modern machine may take 20 microseconds, a typical peripheral may take 20 milliseconds to react to a demand from the computer.

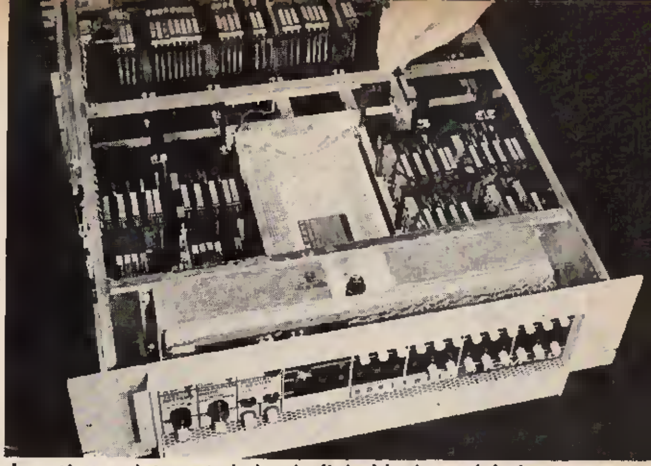
Hence, while the computer is waiting for a reply from a peripheral, it could perform 1,000 more instructions. This means that in normal conditions, the computer is only running at the speed of its slowest peripheral, which may be hopelessly inefficient, since the computer spends a large percentage of its time waiting.

By making use of an "executive" programme, time-sharing can be introduced. This enables several programmes to be run virtually at the same time. The executive programme senses when one programme is held up for any reason, and allows a different programme to run. This means that the computer is being run much more efficiently. More will be said on this subject later.

PERIPHERAL DEVICES

Turning now to the peripheral devices that have figured so prominently in the series, one is faced with a bewildering diversity of machines that perform almost any task under the sun. It is usually the peripherals in a system that make a computer do some of the more spectacular tasks. The computer can always be made to give the instructions, but it takes a good peripheral to carry them out.

Basically, the peripheral device converts the signals from the computer into the form in which they will be used in the outside world. If the computer is working "on line" (i.e. directly controlling some process or other) then the peripheral unit may have control over a steel mill, or a chemical refinery.



Inserting an integrated circuit digital logic module into a U-store core memory system, the heart of the Honeywell DDP-516 control computer

Data as to the quality of the steel, or the composition of the chemical, is fed to the peripheral, which converts it to the form accepted by the computer. The computer makes the necessary decisions, depending on its programme, and passes the instructions to the peripheral, which carries them out.

In a scientific system, the function of the peripheral is more likely to be that of converting the computers output to a form acceptable to human beings. This may be a paper tape punch, (the punched tape must then be fed into a special translator to get an understandable output). On a more sophisticated plane, the peripheral may be what is known as a "line printer". This prints information out directly, a line at a time.

Going even further into the realms of sophistication, the peripheral may control a television screen which can display directly the results of computation, or even pictures and diagrams.

Turning to a different kind of system altogether; in a business orientated system the peripheral might be an envelope addressing machine which could be addressing envelopes and then putting paperwork pertaining to that particular customer into the envelope.

The range of computer applications could be said to be the range of the peripheral devices that can be attached to the computer. Since most modern machines are fast and sophisticated enough to handle most jobs, they are only limited by what their peripherals can do.

THE FUTURE

One application to which peripherals are just beginning to be applied is that of direct communication. Peripherals are, at the present moment, learning to read and speak. The writing they can understand is very stylised at the moment, but it can only be a matter of time before virtually any writing can be read.

From there it is only a small step in the imagination, albeit a large one technologically, to a peripheral device that can understand speech directly, so that the programmer can read his programmes directly to the computer instead of having to go through various other media of communication.

One factor that should always be born in mind is that the computer can contribute nothing to its work for human beings that it has not been programmed to do. It can never make an original decision. Presented with a set of circumstances, it can only do what the programmer has already told it to. ★

microelectronics PART THREE

By M.J. HUGHES M.A.

HAVING covered, to some extent, the intricate detail of making thin film and semiconductor integrated circuits, this article now delves into monolithic circuits, these being the most recent of integrated circuits to be marketed. It will become apparent that monolithic circuits have great advantages over other types of IC, especially regarding the cost. Size is also reduced, although this is dependent largely on resistance values.

MONOLITHIC DIFFUSION

A monolithic circuit, as its name implies, is made from a single chip of silicon. If we look more closely at the same circuit there is no reason (apart from the isolation problem) why we should not combine the resistors on the same wafer as the transistors, the materials and processes used being identical. Let us consider just a small section of this circuit: a single transistor, its base input resistor, and its collector load (see Fig. 11).

Modern techniques allow an extension of the epitaxial isolation concept. This enables the designer to split an epitaxial layer into separately isolated "boxes". Basically the process used is one of diffusion, but is complicated by the fact that depths of diffusion are usually very small (rarely greater than 5 microns) and epitaxial layers are at least twice this thickness. The diffusion is therefore carried out in two parts (Fig. 12).

A very heavily doped region of *p*-type material, defining the walls of the isolation boxes, is diffused into the basic *p*-type substrate before epitaxial deposition is carried out. This process is called "sub-epitaxial diffusion". When the epitaxial layer is grown over the substrate, this sub-epitaxial diffused region diffuses back through the epitaxial layer as it grows, but unfortunately at a slower rate to the growth rate of the layer.

By very careful photographic alignment it is possible to carry out a second diffusion of *p*-type material from the surface of the epitaxial layer which will exactly join the diffused region that has tried its hardest to reach the surface. When the two *p*-type walls meet we end up with lots of identical boxes of *n*-type epitaxial material bounded on all sides, and underneath, by *p*-type which gives very adequate isolation between the boxes.

ADJACENT BOXES

We can now, to all intents and purposes, consider each box as an independent dice. A single wafer measuring $1\frac{1}{2}$in diameter could contain many thousands of these boxes. Let us consider three adjacent boxes for the purpose of explanation.

A photographic mask (negative) can be made which not only holds the image of the base of a transistor but also the images of two different value resistors. Therefore, in the localised region of the wafer we are looking at, we could diffuse a disc of *p*-type material to form the base of the transistor, and at the same time diffuse two stripes of the same material to form the resistors, one in each of the adjacent isolated boxes. When the emitter of the transistor is diffused in, the passivating oxide over the resistors is left undisturbed, so no diffusion takes place in them.

Interconnection of the individual components is now a comparatively simple businees; it is only necessary to open windows in the oxide over the points where contact is to be made, i.e. over either ends of each resistor, the emitter, base, and collector of the transistor. A thin film of aluminium can now be deposited over the whole surface by vacuum evaporation and, in the same way as

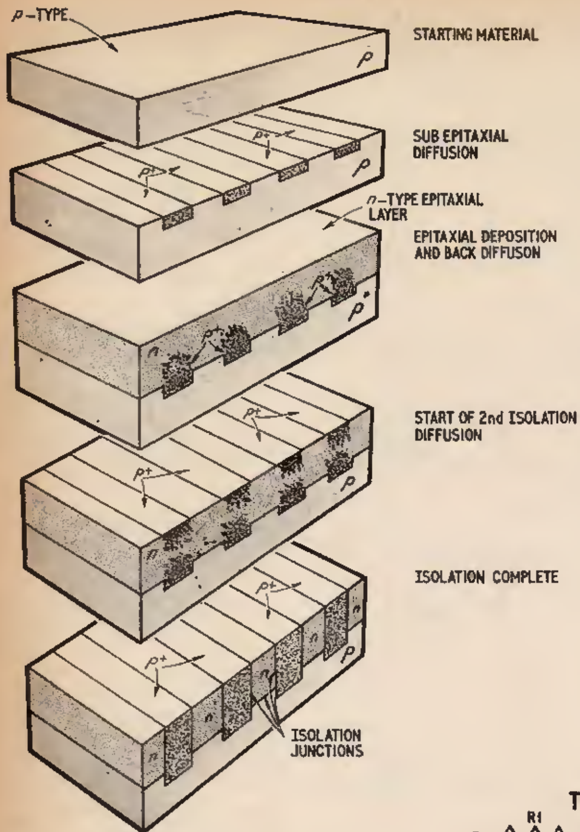


Fig. 12. Stages in forming isolated boxes

for thin film circuits (described last month) the excess material can be etched away by a photolithographic process leaving only the interconnection pattern.

Where the circuit ends in a lead-out point the interconnection pattern broadens out to form a pad of aluminium to which lead-out wires can be bonded. This latter operation is still necessary, but obviously a large number of the other interconnection operations are removed.

The advantages of this process are not only those of labour saving. As all but the final lead-out wire bonding operations are carried out by photolithographic processes it is possible to compress the circuit into a much smaller area, and therefore many more circuits can be made on a single wafer. This increases the speed of production, a factory's capacity, and cuts down on waste material therefore leading to price reductions. Halving linear dimensions increases the number of devices available per wafer by a factor of 4, and therefore this process is a very significant improvement over the multichip method.

To give some idea of the dimensions involved this simple circuit of a transistor and two resistors together with lead-out pads could be quite easily contained in an area measuring 0·5mm square, and most of this area would be taken up by the lead-out pads.

DIODE CAPACITANCE

Although we have so far confined ourselves to talking about transistors, and resistors, it is a simple matter to make diodes. As any experimenter will know a transistor can be used as a diode by making direct connections between either the emitter and the base, or the base and collector.

Exactly the same applies to the transistors described so far. If we had left out the emitter diffusion in the last example, the circuit would have simply become two resistors coupled through a diode formed by the base/collector junction. The diode so formed would have had quite a high breakdown voltage—in the region of 30 to 50V, but it would have been a "slow" diode. This means that it would have had quite a high parasitic capacitance due to its large areas (in comparison with the emitter/base junction). Although from a voltage working point of view it was a good diode, its applications would have been limited to audio frequencies.

Conversely, if we had ignored the collector region and had used the emitter/base junction as a diode, we would have had a diode with low breakdown voltage—typically 8 to 12 volts—but also a very low capacitance. The low capacitance is brought about by its comparatively small area, and also the level of doping of the two regions which are considerably higher. (A higher level of doping increases the chances of holes and electrons recombining, and therefore reduces any tendency to charge storage—or capacitance.) The emitter/base diode so formed could operate quite happily up to frequencies in the tens of megahertz.

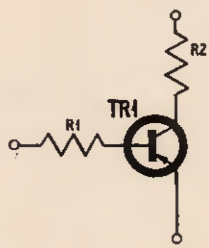


Fig. 11 (left). Very simple circuit ideal for monolithic integrated circuit manufacturing techniques

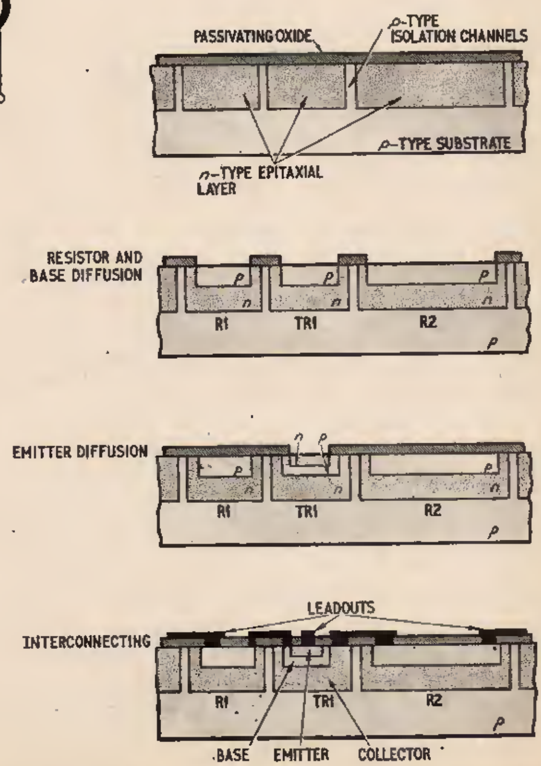
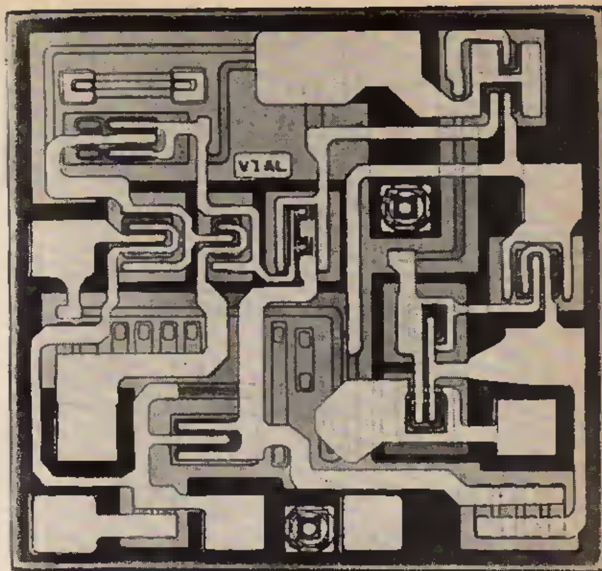


Fig. 13. Stages in making the circuit (Fig. 8) as a monolithic integrated circuit

Although not much use as a high frequency diode, the base/collector junction can be used as a capacitor in its own right although certain limitations have to be borne in mind. Firstly, the capacitance per unit area of a typical diode is fairly small, perhaps 200pF per square millimetre, and on our scale a square millimetre is very large. Secondly, to obtain this capacitance effect the diode must always work under conditions of reverse bias, and this is not always practicable. Thirdly, and perhaps most important, is the fact that the capacitance of a diode varies proportionally to the reverse bias potential. This is due to changes in width of the depletion layer formed by the junction. Capacitance decreases as the potential across the junction increases—up to the point of breakdown.

COUNTING THE COST

The capacitor is therefore a problem child as far as integrated circuits are concerned, and although they can be made, and indeed are to quite an extent, a good integrated circuit designer would try wherever possible to design without them. Likewise inductors are special cases. A satisfactory method of making small inductors with values greater then a few picohenries, that can be used economically in semiconductor integrated circuits, has not yet materialised.



A 3-stage common emitter cascade followed by an emitter follower provides the basis of this monolithic video amplifier by Motorola

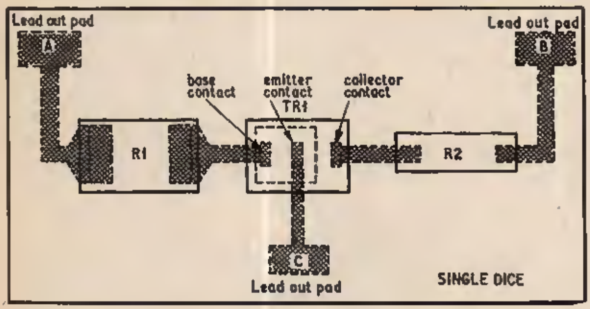


Fig. 14a. Plan view of the simple circuit (Fig. 11). As drawn here R1 would be a lower value resistor than R2. The transistor is shown here as a number of rectangular shaped diffusions. This is a more common shape for modern transistors than the pear shaped devices described so far

Although we have only dealt with a very simple circuit, and have discussed a few details about component types, a picture is building up to show that integrated circuits call for a highly specialised type of circuitry, employing transistors, diodes, and resistors, none of which have very serious problems associated with them. Of these three components however the resistor is the one which usually takes up most space on a dice, which can cost a lot of money from a production point of view.

From a manufacturing point of view there is very little to choose between all three, therefore the logical way one would design an integrated circuit would be to make as much use of transistors and diodes as possible and only use resistors where essential, capacitors being avoided except in exceptional circumstances.

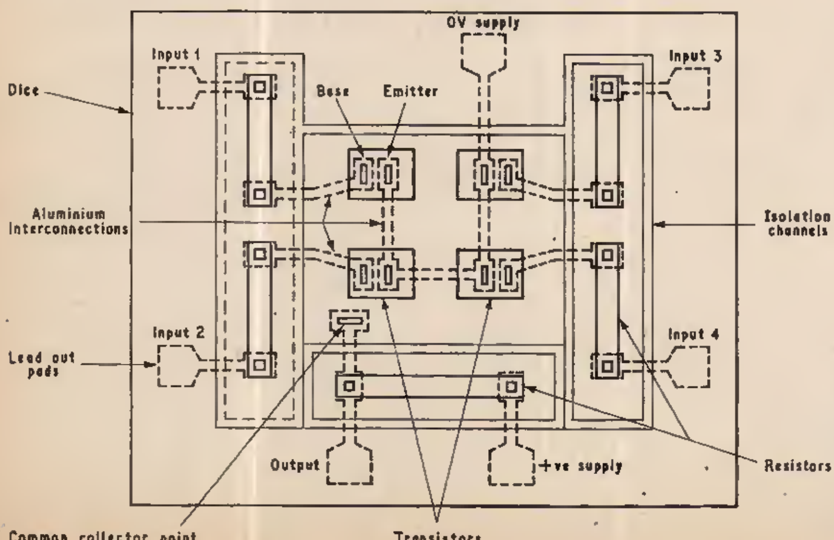


Fig. 14b. Plan view showing how the simple DCTL circuit (shown as a multichip circuit in Fig. 7) might be laid out as a monolithic circuit. Overall dimensions of the dice would be about 1·5 × 1·5 × 0·2mm

Note: The captions for Fig. 6 and Fig. 8 (last month) should be transposed. Also, the caption at the top of page 677 should read: "An enlarged view of the MOST dice".

Next month:
Digital integrated circuits.

the 73 page by Jack Hum G5UM

More About Field Day

LAST time, we had something to say about National Field Day, the supreme transmitting contest for the British radio amateur and the prototype for similar alfresco contests held in many other parts of the world. How, since its genesis three and a half decades ago, has "N.F.D." developed, and does it, in a phrase, keep up with the times?

Of the event's popularity there can be no doubt. More members of the British amateur radio movement are involved in it than in any other corporate activity throughout the year. This is not to say that all of them have a go at operating Field Day stations: that privilege is restricted to the top morse men experienced in high pressure contests. But it *is* to say that without a considerable support group of men to hoist aerials and tents, to provide transport, to undertake log-keeping, and indeed to see to the more mundane requirements attendant upon any outdoor transmitting contest—preparing the food, for instance—the mounting of a National Field Day station would be impossible.

Many a reader of "The 73 Page" has doubtless had his attention drawn to amateur radio by the sight somewhere out in the country of a large masted encampment which is the outward evidence that N.F.D. has arrived. This interest, more often than not the dawn of a lifelong attachment to amateur radio, derives great satisfaction from the opportunity to serve in some measure on The Day.

In the light of its widespread popularity, the temptation to leave National Field Day well alone is strong. What in fact happens is that the event seems to adapt itself to advancing techniques and the annually framed rules to be adjusted accordingly.

Whereas in earlier times crystal controlled transmitters and search receiving procedures were the rule, today the variable frequency drive oscillator and co-channel communication are universal. You drop your v.f.o. on to the frequency of the wanted station heard calling, give him a quick burst on the morse key, and back he comes (if he happens to select *your* signal from the 49 others all calling on the same channel!).

Power Points

Likewise, in respect of power sources, the use of ex-War Surplus motor generator sets, many of which gave the impression of having been designed to occupy as much as possible of the soldiery's time through being difficult to start and thirsty to run, is being steadily supplanted either by modern compact P/E sets or by semiconductor inverters.

Of these, the P/E unit—several examples of which, smaller than a biscuit box, are on the market today—confers the advantage of providing light for the operating tent as well as power for transmitter and receiver.

Wrestling with large power supply units such as this one is a thing of the past for many of the local radio groups which participate annually in the National Field Day transmitting contest. Semiconductor units are steadily taking over

The transistor inverter, though even smaller, calls for a few hefty car accumulators to keep it going for the twenty-four hours of N.F.D., these in turn needing a motor generator charging set to maintain their terminal voltages.

Semiconductor Role

Nevertheless, the role of the semiconductor is bound to enlarge if National Field Day is to conform with the wider world of practical electronics as it is today. Already, the use of such compact valveless receivers as the Eddystone EC10 eliminates the need for bulky high voltage power supplies; and these in turn, even for tent lighting, become less necessary as high power dry batteries of the type used to power portable television sets take over (we have seen an Ever Ready TV1 battery used with a 36 watt car bulb for tent lighting throughout the dark period of Field Day operations).

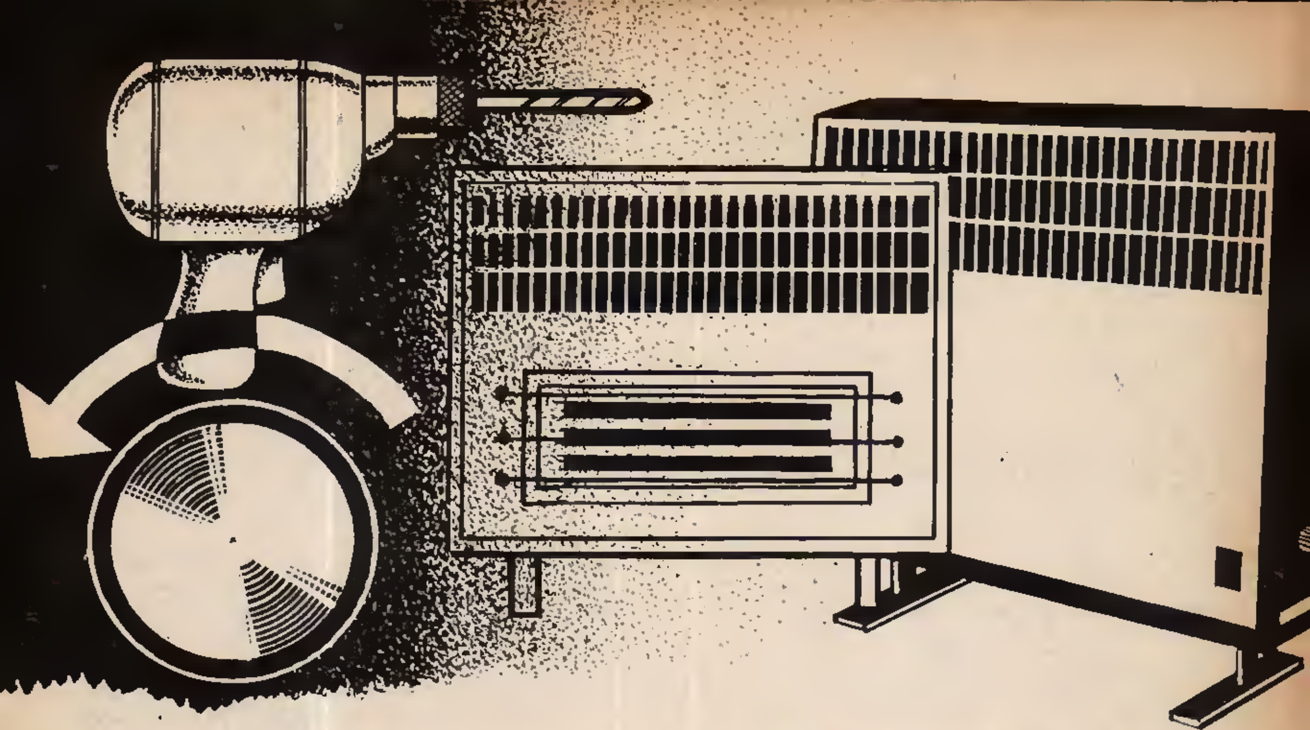
When eventually completely transistorised transmitters become the accepted thing, the total weight of electronic equipment to be humped on to field day sites will be drastically reduced.

At the present time National Field Day's power limit is an input of ten watts to the final valve, or a maximum rated dissipation of 13·5 watts—and for the 1967 event an inspection squad visited stations to make sure this rule was kept (even in a sporting event like National Field Day there will be a few "doped horses" whose presence needs to be identified).

But what was very significant in the 1967 rules was the recognition of the semiconductor as a possible final output stage for a high frequency transmitter, a positive instance of how the regulations keep up with the times. Powers up to 20 watts dissipation were permitted with semiconductor "finals".

Developments of this kind, bringing with them all-transistor receivers and transmitters and not a high voltage source in sight, will realise as never before the aspiration which many transmitting amateurs in Britain have held for a very long time: that National Field Day should be a demonstration of just how portable (not transportable!) a transmitting station can be made to be if the design problem is approached intelligently.

The day—the National Field Day—is steadily approaching when the heaviest part of the N.F.D. station will be its aerial equipment—and we don't count the trees from which it is suspended!



THYRISTOR POWER CONTROLLER

By T. M. NAPIER

THYRISTOR power controllers described so far in PRACTICAL ELECTRONICS have been designed primarily for low power devices such as electric light bulbs. The controller described in this article is capable of working in conjunction with a wide variety of appliances, including smoothing irons, heavy duty electric drills, and fires of up to 4 kilowatts rating. Particular attention has been given to safety during use and prevention of damage to the thyristor, which could be very costly to replace.

The function of the control module is to vary the power flowing into the load in an a.c. circuit. This is done by varying the "on-time" of a thyristor connected in series between the a.c. mains and the load. The load may be a lamp, an electric fire, or an electric motor having brushes such as an electric drill; it cannot be a transformer or a brushless motor. If an output voltage lower than 240 volts is required a transformer may be used between the mains and the thyristor provided that it is connected in the correct phase sense.

The maximum permissible load current depends only on the rating of the thyristor and the size of the heat sink used. This unit is designed to drive thyristors up to the 16 amp BTY91 series and hence can control loads of the order of 4 kilowatts. This should prove adequate for most purposes.

The power level is controlled either manually or by application of an external d.c. control voltage. This permits control of large powers by simple thermistor circuits to maintain, for example, a fish tank, or a room, at a constant temperature. A possible application would be to use a photocell input to turn room lights up gradually as darkness falls outside. An input of 5 volts into the 10 kilohm input resistance of the module is sufficient to turn on the full 4 kilowatt load, a power gain of two million.

TRIGGERED CONTROL

A thyristor behaves like a rectifier but it conducts in the forward direction only after a trigger pulse has been applied between its gate electrode and its cathode. Once "on" it continues to conduct until the voltage applied to the anode is removed.

If it is connected between the a.c. mains and a load, no current will pass, even when its anode is positive, until a trigger pulse is applied. Current then starts flowing through the thyristor and the load until the end of that half-cycle when the reversal of the mains polarity turns the thyristor off again. No current flows during the half-cycle that the anode is negative.

If the trigger pulse occurs near the end of the positive half-cycle, the thyristor conducts for a very short time and the load receives a train of short 50Hz pulses corresponding to a low mean current and low power. If we trigger the thyristor near the start of each positive half cycle it conducts for almost the complete half-cycle and the load receives a train of long 50Hz pulses corresponding to a high mean current and high power.

By varying the timing of the trigger pulse relative to the start of the positive half-cycle any power between these limits can be selected. The output at maximum power consists of a train of half-cycles and hence is a form of pulsing d.c. This is why a transformer cannot be used with this device. When driving a load, such as a motor, designed to operate from the mains this train of pulses corresponds to a half of the normal power. In fact a series silicon rectifier makes a useful dimmer for a table lamp or a means of running a soldering iron at a "standby" temperature without wasting heat through a resistive dimmer.

For many purposes, this zero to half-power range is sufficient since the load resistance can be chosen to give the desired maximum power with this waveform. For example, to get from zero to one kilowatt use two 1 kW fire bars in parallel.

In order to achieve the full range of control where this choice of load is not possible (as when varying the speed of an electric drill designed for mains operation), an additional control range is added by switching a rectifier in parallel with the thyristor so as to pass the previously blocked negative half-cycle. With this switched in, the range of the control knob lies between half and full power thus covering the complete power range in two switched control ranges.

If for any reason a single range is required to cover zero to full power a second thyristor must be used, connected to pass the negative half-cycle and controlled by a second control module. The two manual controls would then become preset balance controls and a potentiometer would be used to apply an equal control voltage to both modules.

The same power supply can be used for both units. The output would now be more or less symmetrical and could be applied to a transformer. For some purposes, the additional cost and complexity might be worthwhile but the "single ended" unit described should be adequate for most requirements.

If a higher power is required a larger, more expensive thyristor must be used. The present module is not intended to drive thyristors to control above 4 kilowatts and would have to be redesigned to supply more gate current.

GATING ACTION

The control module consists of a device to detect the start of the positive half-cycle, a variable delay and a pulse generator to trigger the thyristor. The complete system is shown in block diagram form in Fig. 1.

For safety, one side of the load is connected to the neutral side of the mains via the mains switch. The thyristor is in series with the live side of the mains via the ganged mains switch. Since the cathode and gate end of the thyristor spend much of the time at mains live potential it is necessary to use a transformer to isolate them from the control unit which is connected to earth.

Since a pulse transformer is necessary it is logical to use it to generate the gate pulse by making it part of a blocking oscillator circuit. A useful property of some types of blocking oscillator is their ability to generate an output pulse only when the applied bias voltage reaches a well defined level.

If we generate a voltage ramp which starts from zero volts at the beginning of the positive half-cycle and apply this to the bias input of the blocking oscillator then the gate pulse will occur when this ramp reaches the trigger voltage of the blocking oscillator. By changing the rate of increase of the ramp voltage we can vary the delay between the start of the half-cycle and the time when the thyristor is triggered. This is the condition required to vary the load power.

If instead of applying the ramp directly to the blocking oscillator we add to it an external d.c. input then

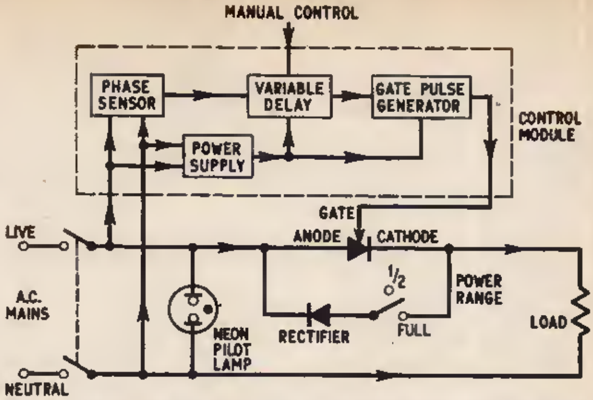


Fig. 1. Block diagram showing the basic functions in the Thyristor Power Controller

the gate pulse is generated at a time controlled by the sum of the ramp voltage and the external input. If the ramp slope is set correctly by means of the manual control the full power range can be controlled by the external d.c. voltage.

It only remains to generate a variable slope ramp commencing at the beginning of the positive half-cycle. This is done by switching a transistor on during the negative half-cycle and off during the positive half-cycle. Its collector voltage is thus clamped to zero during the negative half-cycle and returns slowly towards the supply voltage during the positive half-cycle.

The rate of return is controlled by a *CR* time constant circuit, which can be varied to change this rate of return and forms the manual power control. (The waveforms at various parts of the circuit are shown in Fig. 2.) This time constant is shown in the circuit diagram (Fig. 3) as C1 with R2 and VR1, the latter being the variable component.

PRACTICAL CIRCUIT

A small transformer T1 supplies d.c. power at −9V and also the phase reference signal via R1 for TR1, turning it on and off. D2 prevents a high

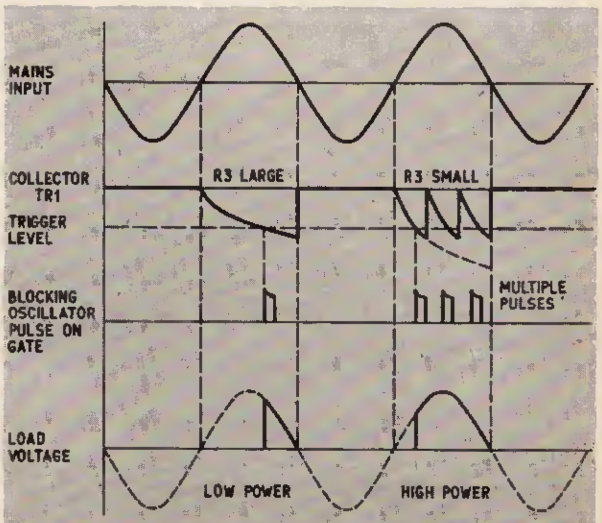


Fig. 2. Waveforms at given points in the circuit

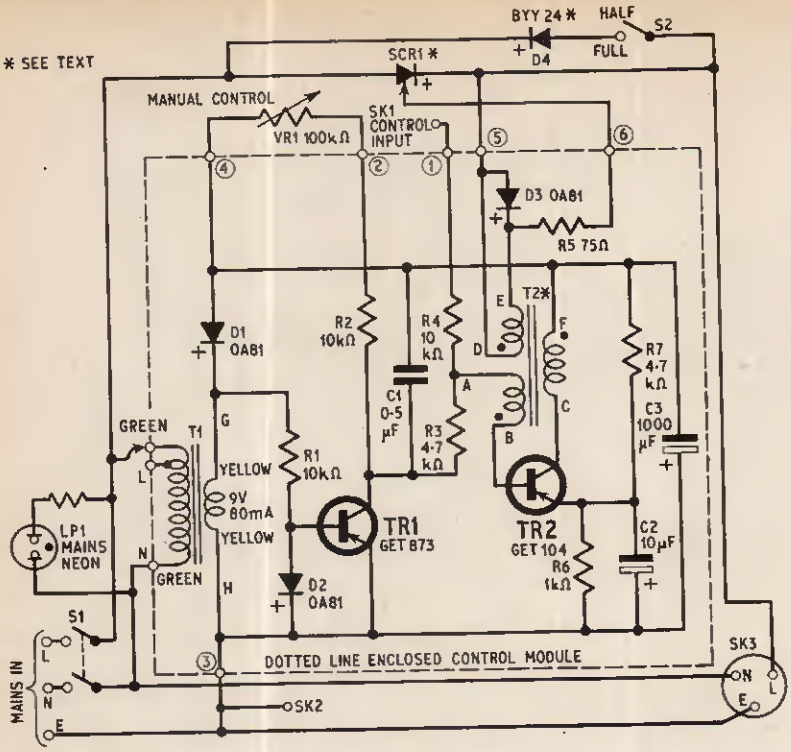


Fig. 3. Complete circuit diagram of the controller. The components inside the dotted line box are mounted on the printed circuit; pin connection numbers are shown

it has time to recharge before the next half-cycle.

In practice it may recharge in time to generate a second or third gate pulse if the first gate pulse occurs near the start of the half-cycle. These extra pulses have no effect on the operation of the thyristor and no attempt has been made to suppress them.

From the nature of the circuit it is impossible, provided it has been wired correctly, for a gate pulse to be applied to the thyristor during the negative half-cycle thus obviating a possible source of damage to the thyristor.

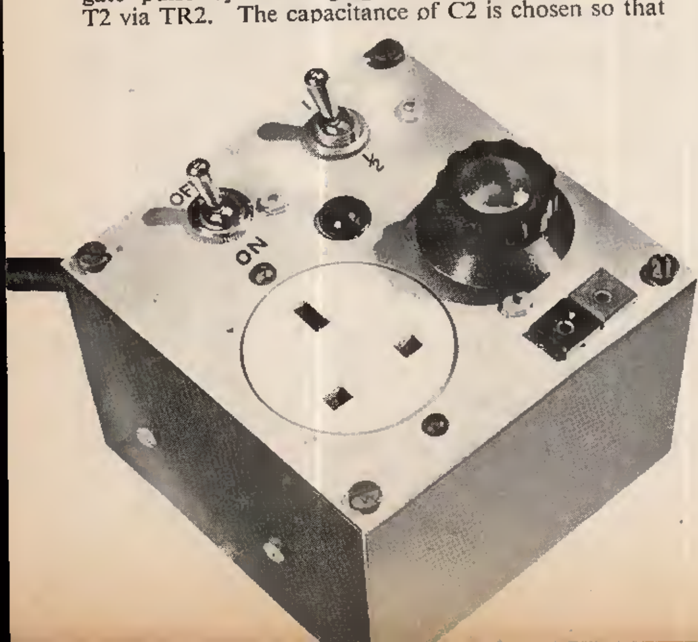
Turning the control knob past its "zeropower" point causes suppression of the gate pulse generator rather than triggering too late in the cycle. At the other end of the range, the delay is so short that less than 20 degrees phase difference and negligible power are lost.

CONSTRUCTION

This circuit is very tolerant of the components used. Almost any transistors can be used, except very low power types (such as microalloy transistors) and surplus types having either low beta or high leakage current. A list of possible types is given but many others can be used.

positive voltage being applied to the base of the transistor, a condition that would otherwise lead to breakdown of the base emitter junction in most transistors. During negative half-cycles C1 is charged via TR1 and during positive half-cycles it discharges towards −9V through R2 and VR1.

The voltage appearing at the junction of R3 and R4 is the sum of the ramp from C1 and the external voltage applied. When this reaches a value of about −2V, set by R6 and R7 TR2 conducts, generating a gate pulse by discharging C2 into the transformer T2 via TR2. The capacitance of C2 is chosen so that



The diodes D1, 2, and 3 similarly can be whatever is available provided they can carry a mean forward current greater than 10mA and withstand 25V reverse voltage. This includes almost all diodes available to the amateur constructor. Point contact signal diodes were used in the prototype.

It is recommended that the specified mains transformer is used to avoid the risk of connecting the phase reference to TR1 incorrectly. If any other transformer is used an oscilloscope is required to make certain the trigger pulse is not being applied to the thyristor during the wrong half-cycle. This could, of course, be found by trial and error but this way the thyristor could be damaged by wrong connection.

The choice of rectifier D4 is dictated by the load to be controlled. The BYY24 is rated at 10A; for lower currents the BYZ12 for up to 6A is suitable. Advertised components can be selected according to the load current and voltage.

The blocking oscillator transformer is not a standard component and must be wound by the constructor. The ferrite core used is a Ferroxcube type LA7 supplied with a bobbin. The windings are 38 or 39 s.w.g. enamelled copper wire with thin p.v.c. covered wire used to make lead-in and lead-out connections. The output winding of 150 turns is wound on the bobbin first and covered with two layers of thin plastics insulating tape. The other two windings of 250 turns each go on top with one layer of tape between them.

The start and finish of each winding must be clearly marked as it is essential that the windings are connected the correct way round when wiring up. Correct phasing is denoted in Fig. 3 by the dots on the windings; these are the lead-out wires.

COMPONENTS . . .

Resistors
R1 10kΩ R4 10kΩ R6 1kΩ
R2 10kΩ R5 75Ω R7 4·7kΩ
R3 4·7kΩ
All 10% ¼W carbon

Potentiometer
VR1 100kΩ linear wirewound 3 watts (see text)

Capacitors
C1 0·5μF paper 150V
C2 10μF elect. 12V
C3 1,000μF elect. 15V

Transformers
T1 Mains transformer 9V 80mA
(Radio Component Specialists, 337 Whitehorse Road, West Croydon, Surrey)
T2 Special transformer (see text) using Ferroxcube type LA7 and 38 s.w.g. enamelled copper wire

Transistors
TR1 OC44, OC45, or GET873
TR2 OC81 or GET104

Thyristor
SCR1 (see text and Table 1)

Diodes
D1, 2, 3 OA81 (3 off)
D4 BYY24 (10 amp) (Mullard) (see text)

Switches
S1 Double-pole on/off toggle switch (see text)
S2 Single-pole on/off toggle switch

Sockets
SK1 and SK2 Wander plug sockets for control input
SK3 Mains 13A panel mounting socket

Miscellaneous
Printed circuit kit or other assembly board
Aluminium or copper sheet for panel and heatsink (see text)
Conduit box 4¼in × 4¼in × 3½in or other suitable case
Neon mains indicator with ballast resistor

It is recommended that the control module is assembled on the printed circuit board shown in Fig. 4. Veroboard or tagboard can be used if great care is taken to connect both transformers exactly as shown for the printed circuit component layout. On the board T2 is bolted down and T1 glued in place with Araldite.

Components C1, C3, and D1 are mounted vertically on the board with the free ends of all three joined together. The positive ends of C3 and D1 are nearest the board. A short wire from pin 4 on the edge of the board, and one end of the collector winding of T2 (labelled F in Fig. 3), are both connected to the free ends of C1, C3, and D1 (see Fig. 4).

If the mains transformer is positioned as shown in Fig. 4b, with the two green mains leads next to the mains input tags, the yellow secondary leads should be conveniently placed to fit holes G and H in the board. The green lead nearest the board should be connected to the live mains lead to ensure correct phasing for firing the thyristor. The metal case of the unit must be earthed.

The thyristor cathode and gate tags (large and small respectively) are connected to the appropriate pins on the board. The anode connection to the live side of the mains is made to the stud of the thyristor or to a solder tag bolted to its heat sink.

The mains double-pole switch is specified in the components list as a toggle switch, but if desired this can be replaced by employing a carbon potentiometer VR1 with the switch ganged to it. The unit can then be switched on at low power (maximum resistance in VR1), then the control is gradually advanced to the required setting. *This switch must be capable of carrying the maximum load current.*

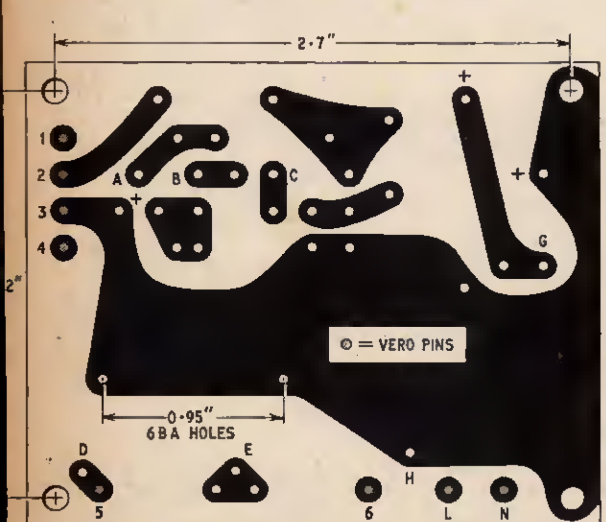


***Fig. 4a.** Full size pattern of the printed circuit board. Pin numbers correspond with those given in Fig. 3*

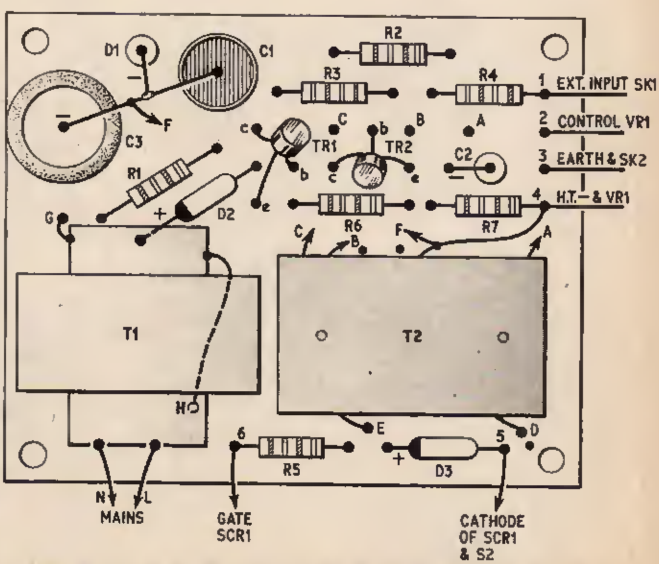


***Fig. 4b.** Component layout on the printed circuit board with leads to front panel components*

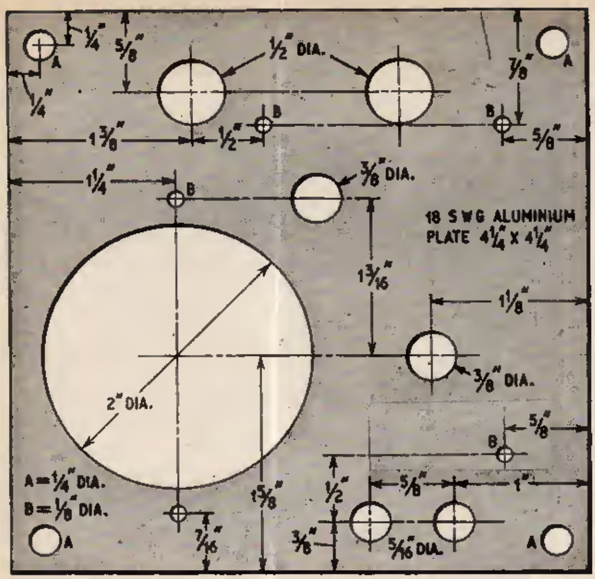
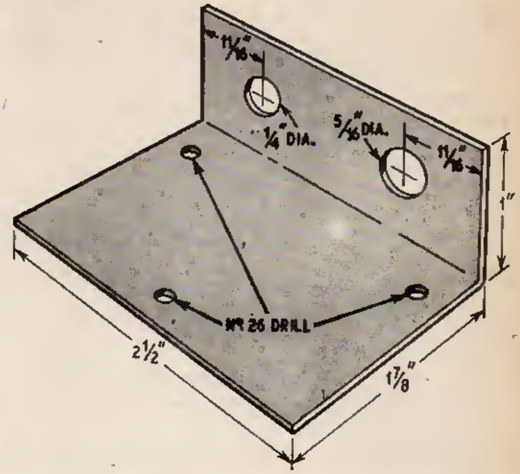


Fig. 5a (left). Drilling diagram of the front panel made to fit a conduit box 4in square. Three holes B are drilled to mount the printed circuit board on pillars

Fig. 5b (below). Heat sink for 5A load thyristor mounted on inside of box. For higher ratings see text



LARGER HEAT SINK

The final form of the unit depends on the use to which it is to be put. The prototype was built into a 4in × 4in × 3½in conduit box with the controls and a 13A socket mounted on the front panel. The thyristor and rectifier were mounted on an L-shaped bracket bolted to the side of the box by nylon nuts and bolts. These insulate the bracket, which is at mains line potential, from the earthed box.

The bracket is too small a heat sink to permit operation at the full rated power of the thyristor but the unit can handle a 5A load without complaint. A fused plug connects the unit to the mains.

Table I. THYRISTOR AND RECTIFIER RATINGS

Appliance Power Rating (Watts)	Load current at 65°C (Amperes)	Thyristor SCR1
750	3	CRS3/40AF
1,125	4·5	BTY79/400R
3,000	12	BTY87/400R
4,000	16	BTY91/400R

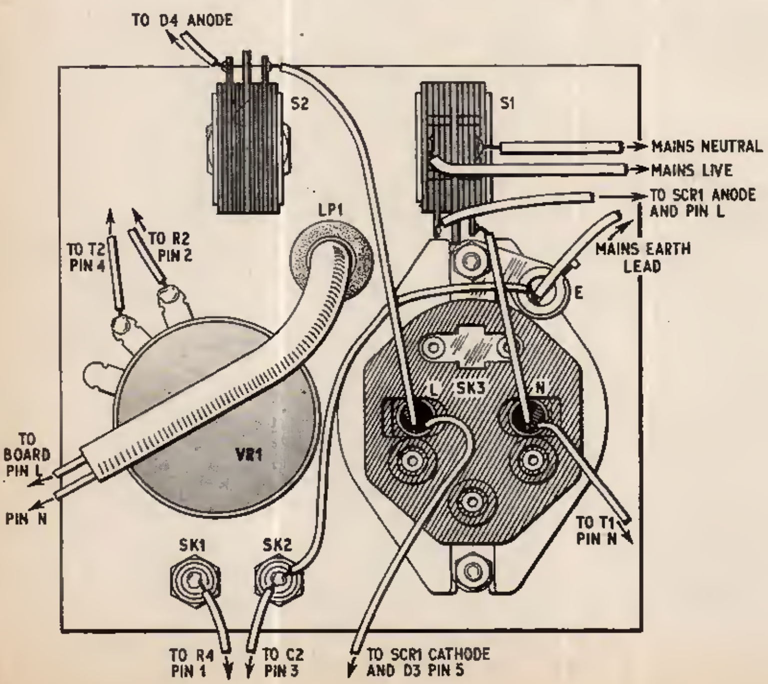
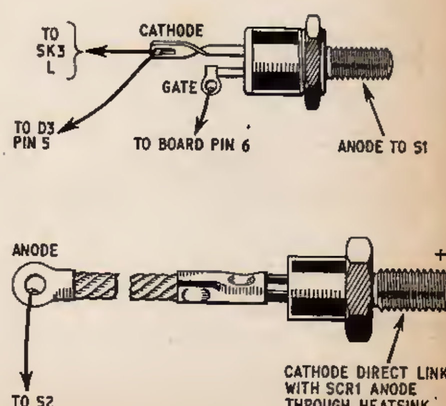


Fig. 6a (left). Component wiring on the front panel. Switch S2 is drawn inverted for clarity. The tags should be near VR1 so as not to foul on the box

Fig. 6b (below). Connections to the thyristor SCR1 and rectifier D4



For larger loads a larger heat sink is required; 100 square inches of 16 s.w.g. aluminium should be sufficient and can be bent to fit the space available bearing in mind the need for a clear air flow round it and adequately insulated supports. When switching off after a period at full power, the heat sink at the thyristor stud should not be hotter than just bearable, about 70 degrees C. If it is, a larger heat sink is required. Table 1 gives thyristor types for various loads.

One application for this control module is the temperature stabilisation of electronic equipment. In this case an existing a.c. supply between 6 and 15 volts could be used to power the module; the rectifier across the thyristor would not then be required. This would reduce the cost of the module itself by a few shillings. The manual control would then become a preset temperature control. It can be used to set the input control voltage level to any suitable value in the range; "normally off/negative signal switches on" to "normally on/positive signal switches off".

The external control signal is applied between pins 1 and 3 on the board, pin 3 being the common connection. To turn the unit on, a negative voltage should be applied to pin 1. The range of control voltage required is set by adjusting the manual control.

A 60 watt bulb makes a suitable load for testing the completed unit before attempting the control of larger loads. ★

Meetings . . .

ELECTRONIC ENGINEERING ASSOCIATION

LONDON

Date: September 20–22
Title: International Broadcasting Convention
Address: Royal Lancaster Hotel, London.

This is a joint conference sponsored by E.E.A. and The Royal Television Society. Details and registration forms can be obtained from the Convention Secretary, International Broadcasting Convention, Royal Television Society, 166 Shaftesbury Avenue, London, W.C.2.

EXHIBITIONS

SCOTLAND

Date: October 17–19
Title: Electronics in Action
Address: Napier College of Science and Technology, Edinburgh.

This exhibition is sponsored by the Scottish Section of the I.E.E. and I.E.R.E. Further details can be obtained from the Exhibition Secretary, 21 Craigmount Loan, Corstorphine, Edinburgh, 12.

MANCHESTER

Date: September 26–29
Title: Electronics, Instruments, Controls and Components
Address: Belle Vue Gardens, Manchester, 12.

COURSE

MANCHESTER

Date: September 25
Subject: City and Guilds Radio Amateurs Examination
Address: Monton Evening Centre, Park Road, Monton, Eccles, Manchester.

Applications should be addressed to Mr. Camp, Principal.

ELECTRONIC MUSIC TECHNIQUES

continued from page 723

of C can be replayed at a semi-tone or whole tone higher but still in "concert" pitch. This can be done with a tape deck or tape recorder with interchangeable capstans which are turned down to a pre-determined diameter, although these are not normal stock items and may have to be made specially.

With a full-track mono tape recorder, or a stereo tape recorder with two half-track heads, it is possible to replay recordings in reverse. When this technique is used the attack or beginning of a sound comes at the end. An example of this is included on the demonstration record.

TAPE EDITING

Tape editing is one of the primary techniques used in electronic music composition and was at one time used almost exclusively. The splicing of individual musical notes recorded on tape is, to say the least, laborious. This method is now being short-circuited by using keyboard systems so that the sounds or melodies can be actually "played" in the required order. The output from these keyboard systems can be connected directly to a tape recorder.

A simple keyed oscillator system can be extended to rhythm machines employing electronic and mechanical/electronic methods of producing percussion sounds in various rhythms and at different speeds. A device of this kind is, however, somewhat complex and here we may return to the technique of recording sounds individually, and re-assembling these into a loop.

Each required percussive sound is first recorded on magnetic tape. The sounds are then cut from the tape and assembled in the required order. The completed rhythm sequence is then looped and replayed at the desired speed.

It is, of course, essential to provide the correct time values to each sound in order to create a useable rhythm. The illustration included in the record gives a better idea of the possibilities than any form of diagram. The tape loop technique can also be used for the repetition of long rhythmic or musical sequences, for example, several bars of rhythm may be looped. Looped rhythms can also be recorded and these recordings joined together so as to form the complete rhythmic background to a melody and harmony.

Part 2 of this article will deal with simple electronic circuits for sound production and treatment and the use of a domestic class tape recorder in the creation of electronic music.

Records of Electronic Music available in the UK—

1. *The Fascinating World of Electronic Music.* Kid Baltan and Tom Dissavelt. Eight recordings on an l.p. disc containing some very fine examples of rhythmic electronic music. Philips P.08168L (Mono only).
2. *Fantasy in Orbit.* Tom Dissavelt. Fourteen recordings on an l.p. disc. Fine examples of etherial music. Philips 633.302.BL Mono (also available in stereo).
3. *Poeme Electronique.* Edgar Varese. A good example of the dynamic effect of electronic music. Philips ALB.3392.
4. *Music from Mathematics.* Electronic music (?) by an IBM7090 computer. Interesting for its technical achievement. Brunswick STA.8523.
5. *Electronic Sounds and Music.* Various examples of electronically derived sounds and one composition.
Electronic Music and Musique Concrête. Four compositions employing tape assembly techniques.
Rhythmic Electronic Music. Four compositions of electronics in rhythm. These three records are produced by the author of this article on Castle EFX1, 2, and 3.

SPACEWATCH

By Frank W. Hyde

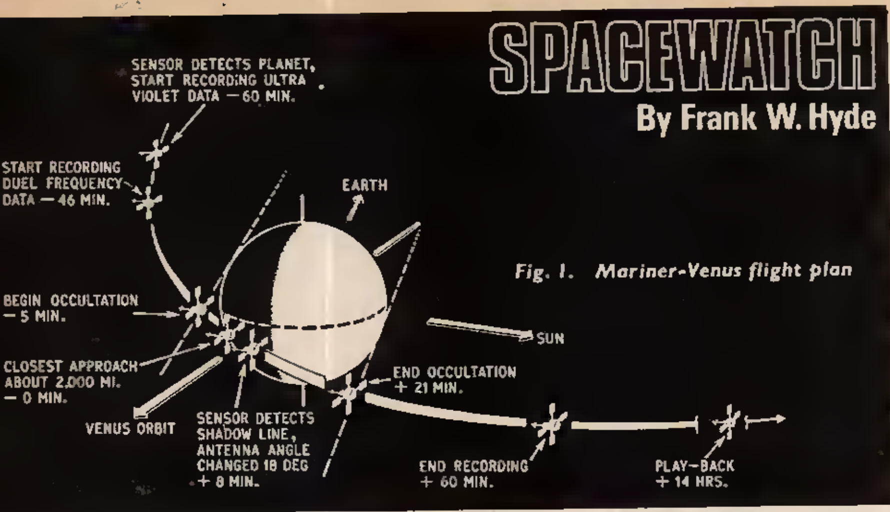


Fig. 1. Mariner-Venus flight plan

MARINER VENUS 1967

The four month long journey of *Mariner* to keep its rendezvous with the bright planet Venus on October 19 is expected to yield important information in relation to the environment and correct the previous information that was obtained by *Mariner 2* in 1962. *Mariner '67* will be ten times closer to the planet at the time of nearest approach (some 2,000 miles) than was *Mariner 2*.

Venus is somewhat of an unknown, its surface is not visible owing to the dense cloudy atmosphere, its rotation period has until recently been given as being from a few hours to 300 days. *Mariner 2* gave the period as 247 days which is longer than the planet's "year" of 244·75 days. Radar measurements have confirmed the longer period.

It was also observed that the motion was retrograde, i.e, the rotation was east to west, so that on Venus the sun would appear to rise in the west and set in the east. Using the 1,000ft dish aerial at Arecibo in the West Indies, Pettengill and Dyce have now reached the conclusion that the rotation period is 244·3 days plus or minus one day. Within the limits that they have quoted there is an important period of revolution of 243·16 days.

Now this is a periodicity which would appear from the earth to indicate that Venus was making four rotations between successive inferior conjunctions. The fact that this period is within the limits seems to suggest that the rotation period is controlled by the earth in some way. So far no one has been able to offer a completely satisfactory answer to this.

Another interesting point about the fly past on this occasion is the possibility of more information about the two areas or markings that have been detected by radar. Optical observers have long maintained that they existed though there was considerable disagreement as to the position. These areas have been named "Alpha" and "Beta" with a size for "Alpha" of 900×3,800 kilometres and "Beta" rather longer and more complex. With the much closer approach of *Mariner '67* there are hopes of more accurate and detailed data.

Among the other measurements to be made are those of the magnetic fields in the environment and the trapped radiation. Plasma probe equipment is installed and also an ultra-violet photometer.

The American probe will be able to correlate data obtained from the Russian probe and there may be very useful comparisons to be made as the successive passes occur. A diagram of the flight plan is shown in Fig. 1.

NEW LIGHT ON THE UNIVERSE

Supporters of the "big bang" theory have a further addition to their data in the discovery of a new kind of cosmic radiation which is supposed to be coming from the "Primeval Fireball".

This kind of radiation has been detected for some years but had not been recognised for what it was until two years ago. Some of this radiation does, in fact, appear on the television screen among the other "snow". These radiations of the original fireball enable cosmologists to study the very early universe conditions.

The radiation which probably started off as very energetic gamma rays have with the course of time, as the system "cooled" lost energy with the result that the radiation now appears in the radio and microwave bands. The earth is immersed in these radiations and this fact explains why they appear to come from all directions more or less uniformly.

There is a "window" through which the radiation can be observed. The range is from one centimetre to approximately 20cm. At the longer wavelengths the galactic radiation is strong enough to submerge the radiation but at less than one centimetre the radiation from the earth's atmosphere conceals it. Though the study of the universe by radio astronomers has been going on in this range of wavelengths the fireball radiation has been overlooked. The reason for this is that the methods used to separate signal from noise in ordinary observations are not suitable for the observation of this special radiation. It became necessary therefore to develop a new technique for this study.

DICKE RADIOMETER

In 1964, a group at Princeton University began to build a new type of radio telescope. The instrument was designed round the type of receiver known as the Dicke Radiometer, named after Professor Dicke of Princeton. He developed the original receiver in 1945; his system enabled the detection of radiations far below the noise level of the receiver.

The limiting factors of noise in the normal receiver would drown almost all the radiations coming from outside the earth and make its separation very difficult. The Dicke system used a noise source which was kept at a standard level and the receiver switched periodically from the aerial to the noise source.

When the switch frequency is set at say 100Hz, there will be an output from the receiver which contains a 100Hz signal which will depend for its power on the difference between the power from the aerial and that of the noise source. There is, therefore, a direct method of separation which can be used, for if a filter amplifier sharply tuned to the 100Hz is included in the measurement apparatus, the result will be a signal that is related to the variations of the original signal. The block diagram Fig. 2 illustrates this.

There is now, therefore, a picture which covers the range from 3·2cm to 20·7cm, all of which confirm the primeval radiations. There is no doubt that this is an important fundamental and quite revolutionary discovery in cosmology.

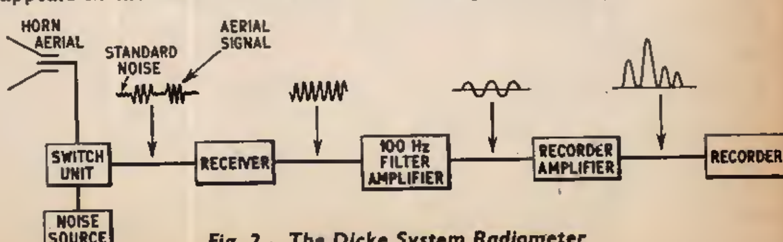


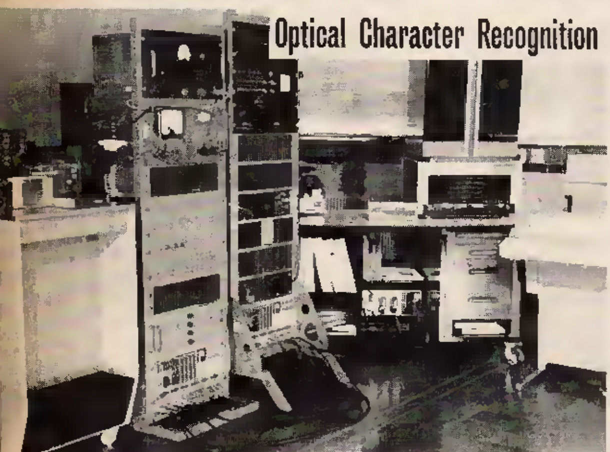
Fig. 2. The Dicke System Radiometer

ELECTRONORAMA VISITS THE MULLARD RESEARCH LABORATORIES

MULLARD first set up a small unit near Redhill, Surrey, in 1946 to study the applications of electronic devices and equipment in the domestic and industrial markets. This unit has now grown to the present size with a staff of 600, over a third of which are graduates or equivalents.

The work of the Laboratories is grouped within four research divisions: solid state physics; vacuum physics; circuit physics and applications; and systems. As well as liaison and team work between these Divisions there is extensive co-operation with Government and other laboratories in the U.K. and overseas. M.R.L. investigates materials, devices, and electronic systems likely to have application in industry, and exploits the results in practical form by producing laboratory models or prototypes together with the necessary technologies. Beyond this stage, product development takes place in the development departments at the manufacturing plants.

Optical Character Recognition



ALTHOUGH optical character recognition of stylised type founts specially designed for the purpose is now well established, much work remains to be done on the reading of characters from an uncontrolled source.

The problem involved is largely one of designing a system which is insensitive to the mutilations and distortions which can occur in hand-printed characters.

The M.R.L. approach has been to represent the input character as a matrix of points, each having a value determined by the "blackness" of the matrix at that point. Although it is possible to have a large number of blackness levels the simplest and least expensive system has been adopted in which a binary matrix is used with each point recognised as being black or white.

The basic elements of a character recognition system are the "receptor", the "preprocessor" and the "classifier". The receptor converts the input information (i.e. the printed or written information) into a suitable electrical analogue; the preprocessor selects only the information which is useful for classification and rejects the rest; the classifier accepts this information and categorises the processed pattern.

The equipment shown on the extreme left is a commercially available paper-handling equipment, which has been modified by the addition of a digital cathode ray tube scanner. This part of the equipment is the receptor.

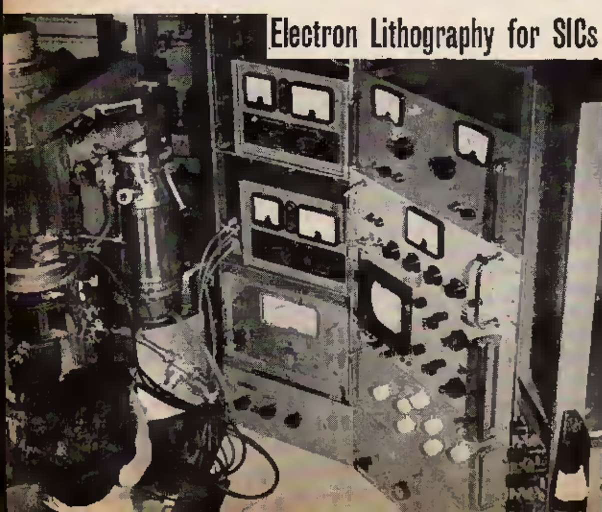
The preprocessor, which is the next stage, attempts to select only the information presented to it which is meaningful for recognition. Research at the Laboratory has been concentrated on obtaining a description of the character in terms of directions describing the character edge. When the complete character edge has been traced and a list of directions assembled, this information is passed to the classifier, shown at right of picture.

Two types of classifier have been investigated, one for numerals only using adaptive threshold logic units, and the other intended to recognise a full alpha-numeric set of characters and using the principle of feature extraction.

This equipment is a purely experimental real-time character reading machine which reads at a speed of one character per second. The target is to develop a machine reading up to 1,000 characters a second, with an error or reject rate better than 0·1 per cent for hand-produced characters.

The present work is one of the Ministry of Technology's advanced computer techniques projects.

Electron Lithography for SICs



ELECTRONS may be used to expose photo-resist, and electron lithography is now being considered as a method for replacing the conventional techniques which use light to expose the resist through masks. An electron beam may be focused to a small spot which can be rapidly scanned over the surface of a target. By using the output of a small computer to control the beam position and intensity it is possible to generate the complex patterns required for microcircuit technology.

The flexibility of the technique lends itself to the discretionary wiring of large scale integrated circuits and, in this case, the computer may itself work out the interconnection pattern required for the fault distribution data.

An electron beam machine, specifically designed for the electron beam deposition of thin films with sub-micron resolution is shown (left) being set up for the deposition of a fine line of silica film, to be used as the diffusion barrier separating the source and drain regions of an experimental m.o.s.t.

M.O.S.T. Stores

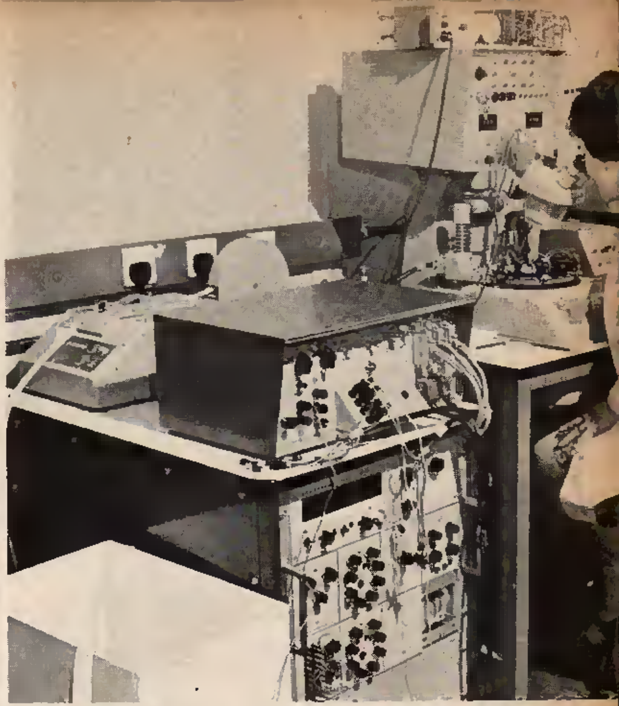
WITH the technologies of magnetic stores and thin film becoming more difficult, research is continuing on alternative techniques to achieve comparable or better performance in computer stores at reduced cost.

The M.R.L. is investigating the possibilities of the metal-oxide-semiconductor transistor store. With cost as a major factor the m.o.s.t. is a clear favourite as the active element in an integrated circuit store. Although the m.o.s.t. has a larger area than a conventional transistor of equivalent gain, it has better isolation.

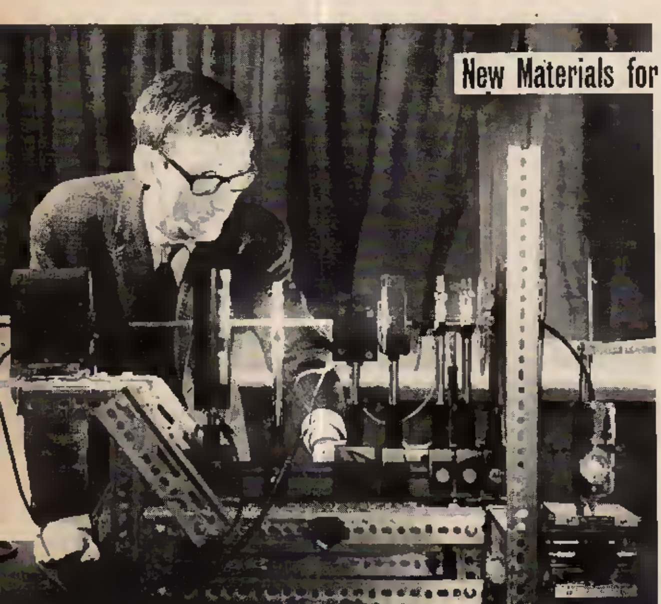
Present work conducted in co-operation with the R.R.E. Malvern is aimed at producing a storage capacity of 32 words each of 32 bits on a single slice. With seven devices needed in each storage element, some 7,000 good devices are required on the slice.

The projected production method involves automatic testing of every device on the slice (six tests on each device) and the automatic production of a tape showing the distribution of faulty devices. The tape will then be analysed by computer which will produce the interconnection pattern required to produce a working store. The discretionary wiring will then be achieved either by opto-mechanical or electron beam methods.

The picture (right) shows the set-up for automatic measurement of electrical characteristics of m.o.s.t. circuits with the output on punched tape ready for computer processing.



New Materials for Solid State Devices



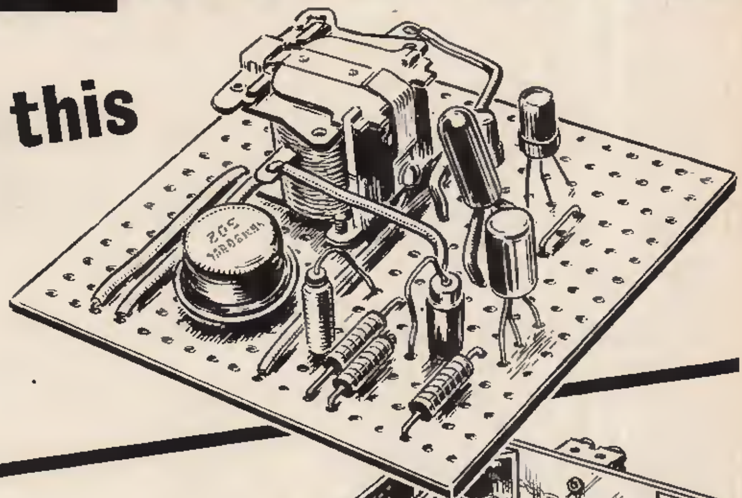
INTENSIVE research is being carried out in the quest for improved materials for semiconductor devices. The picture above shows apparatus for measuring the fluorescence of the 111-V semiconductor gallium arsenide doped with varying amounts of impurities, such as zinc and tin. The fluorescence is excited by visible and ultra-violet light.

Experimental apparatus for measuring the performance of a transluxor is shown right centre. A transluxor is a light operated solid state device with a power gain and properties similar to a transistor. A separated emitter and heterojunction transmits an audio modulated h.f. signal (1MHz) which can be interrupted by a shutter.

On the right, the fluorescence efficiency of rare earth ions in an yttrium gallium garnet host lattice is being measured at 77 degrees Kelvin. A monochromator, integrating sphere, and photomultiplier detector are the main units used in this set-up.

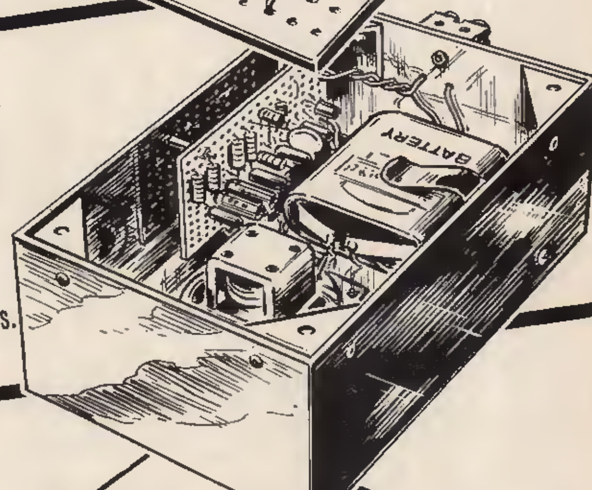
PRACTICAL ELECTRONICS

next month



You can make this WATER LEVEL ALARM

A useful switching device having many applications where the level or presence of water has to be watched.



. . . and this 'YODELLER' DOOR MONITOR

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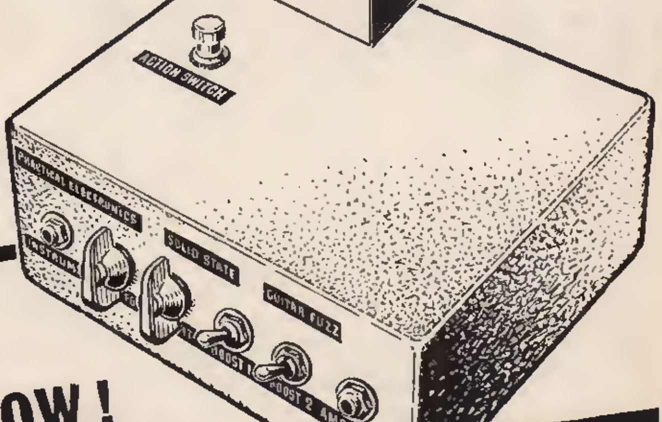

. . . and this FUZZ BOX

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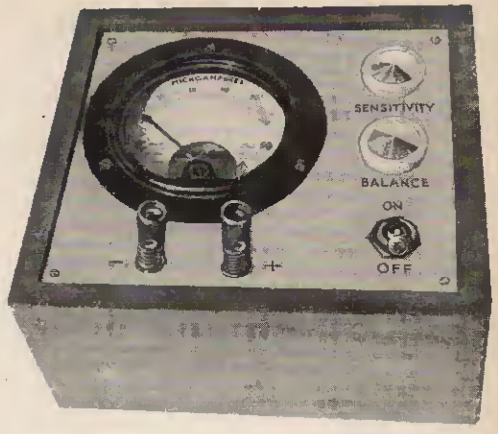
TRANSISTOR MILLIVOLTMETER



By F. G. RAYER

THIS instrument is of quite small size, and operates from a 4·5V battery, the current drawn being a little under 10mA. It has two main uses: measuring very small d.c. voltages; and measuring low, medium, or high voltages with extremely small current drain from the point tested.

METER RANGES

Readings are obtained on a 1mA moving coil meter, and sensitivity is adjustable. On the author's model, maximum sensitivity is 6mV (0·006V) for a full-scale reading of 1mA on the meter.

To allow easy reading on a 0–1mA scale, it is best to use ranges such as 0–100mV, 0–1V and 0–10V, then the original milliammeter scale need not be altered. A 1mA meter will usually be calibrated from 0 to 1mA at 0·1mA and smaller intervals. It is only necessary to ignore the decimal point, or mentally add one or more noughts, according to the range in use.

If a more sensitive meter movement is to hand, it can be shunted to obtain a full-scale range of 1mA. So a 0·5mA (500μA), 250μA, or 100μA meter can be utilised. The shunt may be calculated from:

$$\text{Shunt (ohms)} = \frac{\text{meter coil resistance (ohms)}}{(n-1)}$$

where n is the number of times the full-scale reading is to be multiplied.

Alternatively, a shunt can be made by trial and error, checking the full-scale reading against a testmeter as follows. Place the two meters in series, with a variable resistor (or potentiometer) and battery in circuit. Take care to have sufficient series resistance to avoid damage—a 50 kilohm potentiometer is suitable with a 100μA meter and 4·5V battery. With this voltage, a 20 kilohm or 25 kilohm potentiometer will do for a 250μA meter, while a 10 kilohm potentiometer is sufficient for a 0·5mA meter. Find a suitable length of resistance wire for the shunt by trials, wind it on insulating material, and solder it to tags on the meter terminals.

To avoid opening the meter, the ranges are best chosen to suit the existing scale. For a 100μA meter, they can be as for the 1mA instrument. For a 250μA meter, ranges such as 0–25mV, 0–250mV, 0–2·5V, etc., can be read at once. With a 0·5mA or 500μA meter, ranges of 0–50mV, 0–500mV, 0–5V and so on will suit the scale.

MULTIPLIER PRODS

Low, medium, and high voltages can be read using suitable voltage prods with series multiplier resistors.

The transistorised instrument has no particular advantage for testing batteries, power supplies, or other circuit voltages where the current drawn by an ordinary moving coil voltmeter is insignificant and causes no appreciable change in potential. But when the potential to be measured is obtained through a high series resistance, or will drop severely if an ordinary voltmeter is connected, then the transistorised meter gives a reading of much higher accuracy.

A conventional voltmeter or multirange testmeter incorporating a 1mA movement is said to be a "1,000 ohms per volt" (1kΩ/V) instrument. This means that on a 0–1V range its series resistance would be 1 kilohm, and it draws 1mA from a point having a potential of 1V. In the same way, a 10kΩ/V instrument has a series resistance of 10 kilohm for a 0–1V range, and draws 0·1mA when reading 1V on this range.

The transistorised meter can be used with an input resistance of 100kΩ/V, or even 1 megohm per volt, if wanted. Circuit point potentials can then be checked with negligible loading by the meter.

Ranges are obtained as described later. For transistorised equipment using supplies up to 9V, the 0–100mV, 0–1V, and 0–10V ranges are convenient.

CIRCUIT DESCRIPTION

Fig. 1 shows the circuit of the complete instrument.

With no voltage applied to the input terminals, the circuit is balanced, and no reading is obtained on the 1mA meter M1. Now assume a positive potential is applied to the blue input lead; the base of TR1 becomes more positive, so collector current falls. The voltage drop across R3 is thus reduced, making, in turn, TR3 base negative. The collector current of TR3 through R6 rises, and an increased voltage drop occurs across R6, so that TR5 base moves positive. The collector and emitter current of TR5 falls, reducing the voltage drop in R9, so that the junction point of R9 and VR2 is now more positive. At the same time transistors TR2, TR4, and TR6 have operated in the reverse manner, so that TR6 is passing a larger collector and emitter current, thus increasing the voltage drop in R10. Consequently a potential difference appears across the 1mA meter and VR2, and a reading appears on M1.

VR1 is a balancing control, to compensate for variations in the tolerances of resistors and transistors. This control is set so that the M1 reads zero with no input voltage.

VR2 allows sensitivity to be adjusted to suit the meter scale, or in some cases the range wanted. Increasing the value of VR2 reduces sensitivity.

CIRCUIT BOARD

Most of the circuit components are mounted on a piece of laminated plastics board, $\frac{1}{16}$in thick. Dimensions and drilling positions are indicated in Fig. 3. The corner fixing holes can be $\frac{1}{8}$in, and other holes $\frac{1}{16}$in.

The components are placed as in Fig. 2.

Assembly of components commences with the resistors.

(Note: To avoid unnecessary unbalance, R3, R4, R6, R7, R9 and R10 are 5 per cent tolerance, or 10 per cent resistors selected with a meter. Pairs of matching values are more important than the actual value.)

The resistor wire leads are bent a little clear of the body and passed through the holes. The board is then turned over and connections made as in Fig. 3.

The transistors are then fitted. Cut $\frac{1}{2}$in lengths of red sleeving for the collector wires, and similar lengths of yellow sleeving for the emitter leads. Base wires are bare, except for TR2. Connections are then easily identified. In Fig. 2 and Fig. 3, e, b, and c indicate emitter, base and collector respectively. Solder the transistors with usual care, removing the iron immediately the joint is made.

Snip off surplus wires. External connections should be made with thin coloured flex for easy identification. Blue is positive input, and grey negative. White leads from TR1 and TR2 emitters go to the outer tags of VR1, Fig. 2. A red lead runs from VR1 slider to R5. Black and red run from R10 and VR2, for the milliammeter. Take a further pair of black and red leads from C and R11 in Fig. 2, for the battery BY1. A 4·5V lamp battery will provide long service, and leads can be soldered directly to it. The on/off switch S1 is in the negative lead.

HOUSING THE INSTRUMENT

A wooden box was used for the prototype. The milliammeter M1 and other items are fixed to an insulated panel which is secured to the front of the box.

Of course, it is not essential to make the case, since various square and sloping front instrument cases of similar dimensions can be bought. A cheap plastic box is also satisfactory. Clear boxes can be painted inside.

The general assembly and covering is shown in Fig. 4. After testing, secure the circuit board with wood screws. A bracket cut from scrap metal helps keep the battery in place.

INITIAL TEST

An initial test should be made immediately after wiring. Proceed as follows. Connect a 1 kilohm resistor from blue to grey (across input) and adjust VR2 so that the whole element is in circuit (knob anticlockwise). Temporarily place a meter in one battery lead and switch on. Current should be around 7mA to 10mA. If much lower or higher, switch off at once and look for a wrong connection, short circuit, or wrong resistor value.

When VR2 is rotated towards minimum resistance, the 1mA meter will probably show some current. Adjust VR1 to restore the reading to zero.

If VR1 reaches its limit in one direction, without zero being obtained, the pairs of resistors R3 and R4, R6 and R7, or R9 and R10 may be unbalanced. If there is no obvious mistake such as an error in reading

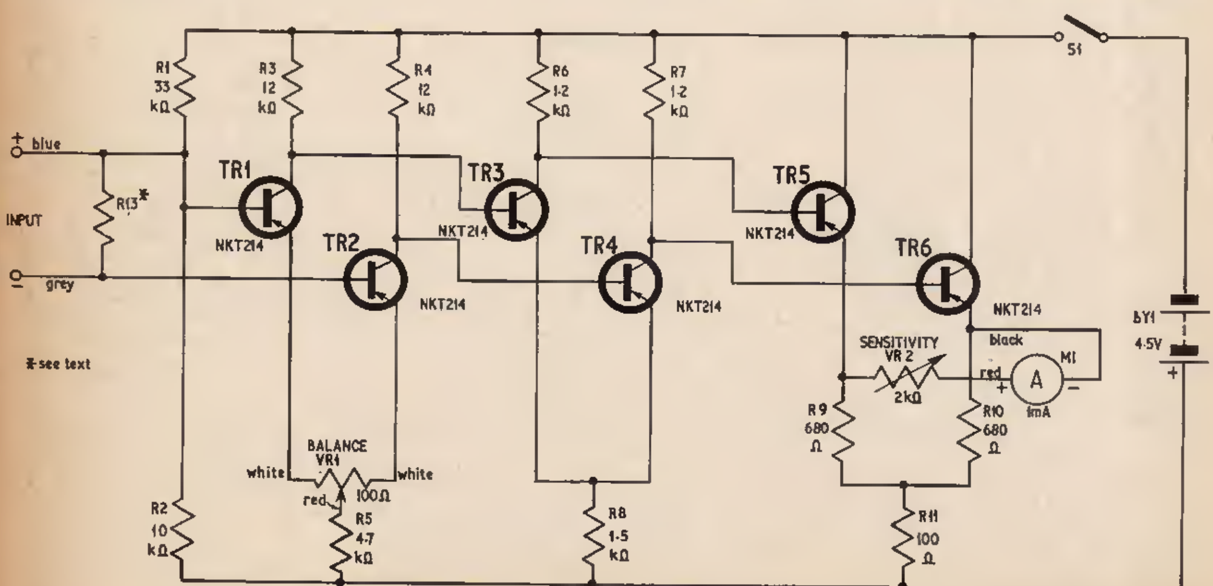


Fig. 1. Circuit diagram of the transistor millivoltmeter

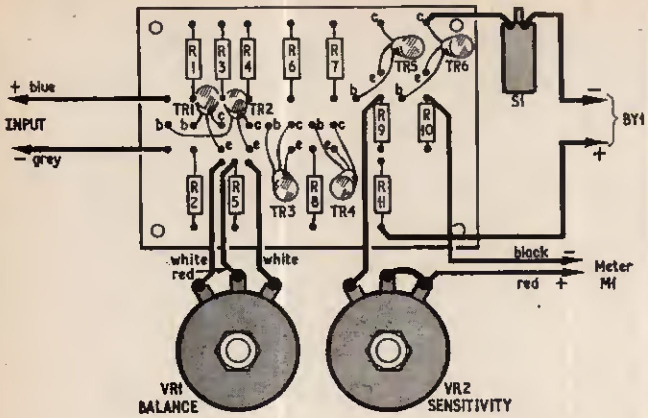


Fig. 2. Circuit board showing arrangement of components

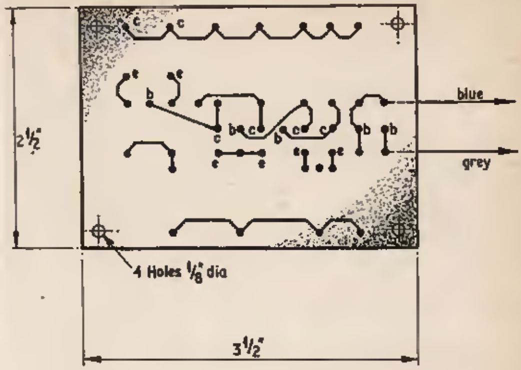


Fig. 3. Underside wiring of circuit board

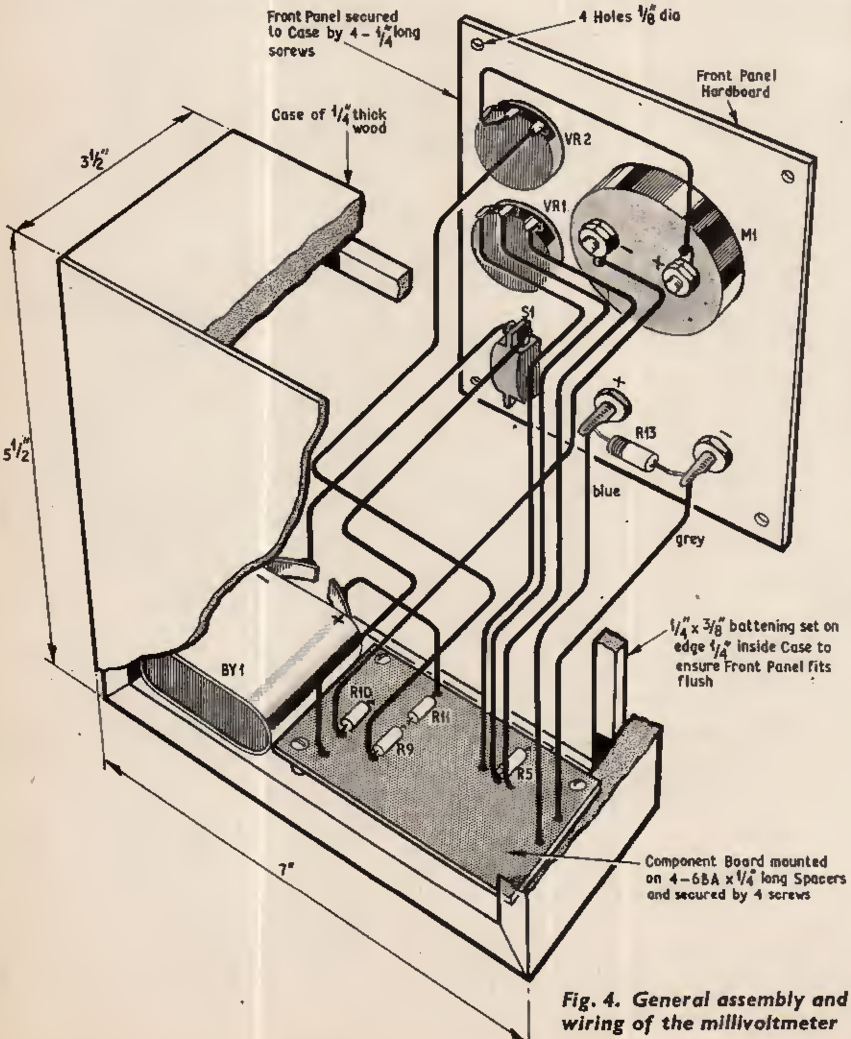


Fig. 4. General assembly and wiring of the millivoltmeter

COMPONENTS...

Resistors

R1 33kΩ
R2 10kΩ
R3 12kΩ 5%
R4 12kΩ 5%
R5 4·7kΩ
R6 1·2kΩ 5%
R7 1·2kΩ 5%
R8 1·5kΩ
R9 680Ω 5%
R10 680Ω 5%
R11 100Ω
R12, R13 See text

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

Potentiometers

VR1 100Ω linear
VR2 2kΩ linear

Transistors

TR1–6 NKT214 (Newmarket) (6 off)

Miscellaneous

BY1 4·5V flat torch battery
M1 Moving coil meter, 1mA f.s.d.
S1 Single pole on/off toggle switch
Two terminals. Two knobs
Piece $\frac{1}{16}$in plastics laminate
Material for case (see Fig. 4)
Material for prod (see Fig. 6)

colour coding, it should only be necessary to change R3 or R4. Temporarily place a 100 kilohm, 68 kilohm or 47 kilohm resistor across R3 or R4. If this sufficiently corrects the error, it can be left. Alternatively, slightly reduce the value of the original resistor (or increase the value of the second of the pair).

If a high-resistance voltmeter is to hand (preferably one of 2kΩ/V to 10kΩ/V) it can be used to check the operation. When a small input voltage is applied as described later, there should be a small drop in the potential across R3, and a similar rise across R4. The voltage changes across R6 and R7 should also be similar, though opposite in direction. This also applies to R9 and R10.

CALIBRATION

The required range is obtained by means of two resistors. One is placed across the input points, see Fig. 1. For the ranges described, it can be 1 kilohm, permanently wired across the terminals on the panel. It is R13 in Fig. 5.

The second resistor is R12 (Fig. 5) and is in series with one test prod. This resistor could be included within the instrument for purely d.c. measurements. But with it included in the prod, the loading on points where audio or radio frequencies are present is negligible, so this arrangement is to be preferred.

Calibration of the 1mA meter is initially obtained with the aid of a d.c. voltmeter, service meter, or multirange meter. Nearly all such instruments can read 1V or 0·5V accurately. Some are suitable for much smaller voltages.

Connect a voltmeter or the service meter M2, a 1·5V battery BY2, and a 1 kilohm potentiometer (VR3) as in Fig. 5. Adjust VR3 until M2 indicates 1V.

Now the voltage across R13 depends on the ratio of the resistors R12 and R13. If R12 is 99 kilohm and R13 is 1 kilohm, then 1V across points 1 and 3 will provide 0·01V, or 10mV across points 2 and 3. Rotate VR2 (Fig. 1) until the milliammeter M1 shows full-scale. The instrument range is now 0–1V across points 1 and 3.

If R12 is reduced to 9 kilohm, then 100mV across 1 and 3 provide 10mV across 2 and 3. So the instrument now has a 0–100mV range.

When R12 is 99 kilohm and R2 is 1 kilohm, the input resistance from 1 to 3 is 100 kilohm (ignoring the transistors) and 1V applied across points 1 and 3 gives a full-scale reading. So the instrument is working with a 100kΩ/V input resistance.

MAKING THE PRODS

A prod is readily made as in Fig. 6, using the body of an old ball point pen, or any suitable insulated tube. One wire end of the resistor R12 projects about ¼in and acts as the "probe". A thin flexible lead is soldered to the other resistor wire. The resistor is pushed in the tube, and sealing wax used to close the ends.

Mark each prod with its resistance value or voltage range. For a very high value, two or more resistors are employed in series.

When R13 is 1 kilohm, the prod resistors (R12) for various ranges are as follows:

0–10mV	zero
0–100mV	9kΩ
0–1V	99kΩ
0–10V	1MΩ

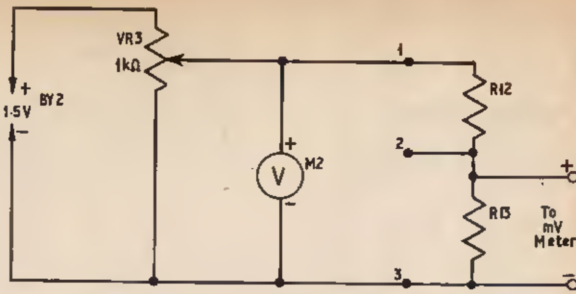


Fig. 5. Calibration circuit. BY2, VR3 and M2 are external components for setting up purposes only; R12 and R13 are incorporated in the prod and the millivoltmeter respectively

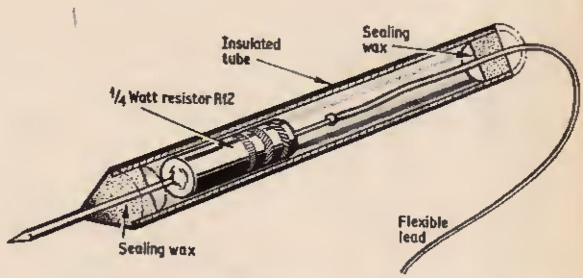


Fig. 6. Construction details of the voltage multiplier prod

GENERAL POINTS

To secure maximum versatility, the following points are worth noting.

When resistors R12 and R13 (Fig. 5) provide a voltage range across points 1 and 3, and this voltage can be checked with a service meter (M2), these resistors need not be close-tolerance. Compensation for the actual values is obtained by adjusting VR2 until the M1 meter reading agrees with the service voltmeter reading at some convenient point.

When resistors R12 and R13 form a potential divider in which the voltage from 2 to 3 needs to be known, then both resistors should be close-tolerance components.

Because sensitivity is adjustable, calibration must be made in advance from a multirange or other voltmeter.

When one test point is "earthed" at radio or audio frequency, the negative test prod is taken to this, if d.c. voltages to be found are positive relative to the earth line. If voltages to be checked are negative relative to "earth", then include the prod in the negative lead.

If a d.c. voltage test is required between two points both of which have r.f. or a.f. present, then a prod made as in Fig. 6 can be placed in each test lead. The *total* value is as for a single prod for the same range; for example, two 0·5 megohm prods are required for 0–10V.

For a higher input resistance, R13 can be 10 kilohm. Sensitivity is then 1 megohm per volt. R1 can then be 90 kilohm for 0–100mV, 1 megohm for 0–1V, and 10 megohm for 0–10V.

Extremely high value resistors between points 2 and 3 are not recommended, as drift upsets calibration. ★

PART TWO

ELECTRONIC stopclock

By M. L. Birch

THE stopclock unit is built up from a number of ready made logic blocks, which are assembled together on Veroboard. A point to be noted early on is that the Veroboard is not that which is normally used by amateurs, but the industrial grade material which has a hole spacing of 0·1in. This choice was necessary becuse of the pin configuration of the logic blocks.

Certain problems can be encountered if the constructor is not used to this narrower spaced strip laminate, not least that of possible short circuits due to solder runs between adjacent strips. It is essential that a sub-miniature soldering iron, and a good quality cored solder be used.

Reference to the circuits given last month will be helpful.

LOGIC SANDWICH

The logic section is built up on two sheets of Veroboard type VC 659-44. One piece holds the register, and digital-to-analogue converter network, and the second the multivibrator, and inhibit NOR gate. Fig. 7b shows the underside of the main register board, and it can be seen that there are a large number of connections to each of the logic blocks. Great care must be taken to ensure that the logic units are inserted into the correct holes before any attempt is made to solder, as it is extremely difficult to remove them after soldering unless a special desoldering tool is used.

After making the breaks in the strip at the points indicated in Fig. 7b insert the logic elements with careful reference to Fig. 7a, which shows a top view of the board. It is important that the maker's name panel appears in the position indicated. Make sure that the units are fully inserted, and that none of the thinner pins have been "crumpled"; then carefully turn the board over and solder up. When this has been done use some 22 s.w.g. tinned copper wire to connect the jumpers, with the same precautions in mind.

The resistors for the digital-to-analogue converter must now be prepared. For these select five carbon resistors with values below, but as near as possible to, those specified for R1, R2, R3, R4, and R5. Connect each in turn to a good quality ohmmeter or bridge and carefully file away the material of the resistor until its value is exactly that specified.

The same operation can be carried out for R6, but the author found that this resistor was so critical to adjust that it was better to use a preset potentiometer, which was set up in use. When this has been done, position and solder these components into place.

Next cut eight 9in lengths of insulated connecting wire; bare one end of each, and solder them into the positions marked for flying leads A′ to H′ of Fig. 7.

Carefully check the connections to make sure that the components are all correctly positioned, and that no joints have been overlooked. When this has been done, put the unit to one side, and then proceed to wire up the multivibrator board.

The multivibrator board is shown in Figs. 8a and 8b. The same rules apply to this as for the register. Before starting to assemble this board, however, drill two holes ⅛in diameter in the positions shown. These are for mounting into the cabinet at a later stage. Use a sharp drill at preferably a high speed. With a very light pressure, make the holes starting from the copper side of the board.

Take particular care on this board that the polarities of C4, C5, D1, and D2 are as shown. It is not necessary to cut more connecting wire for this board as the

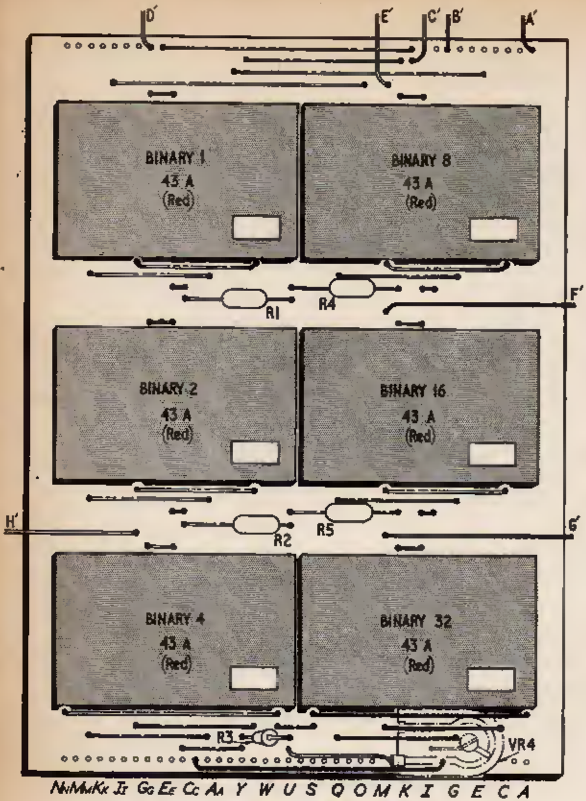


Fig. 7a. Layout of the register

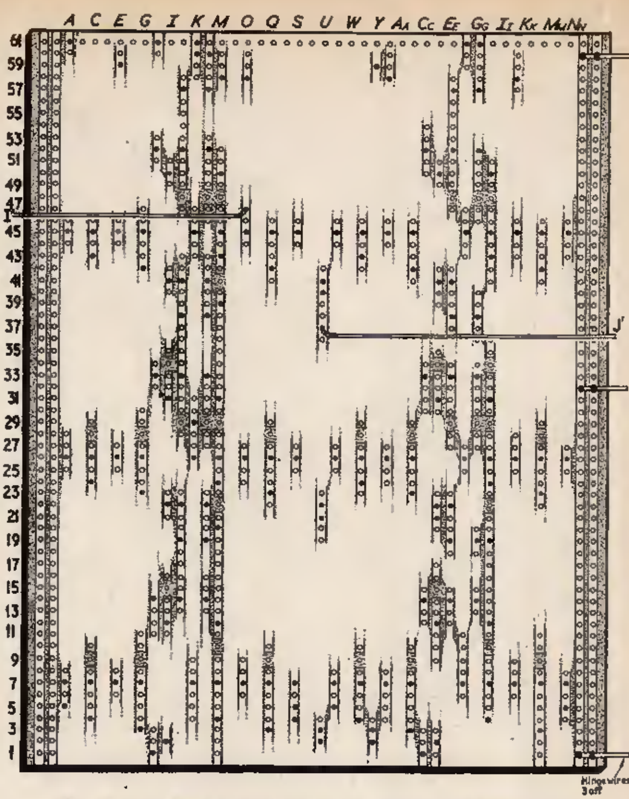


Fig. 7b. Connections and breaks in the copper strips

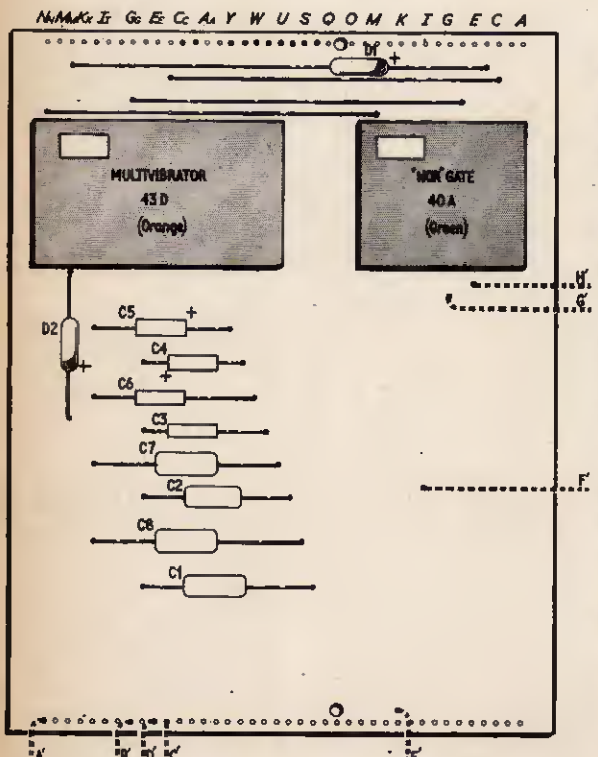


Fig. 8a. Layout of the multivibrator board

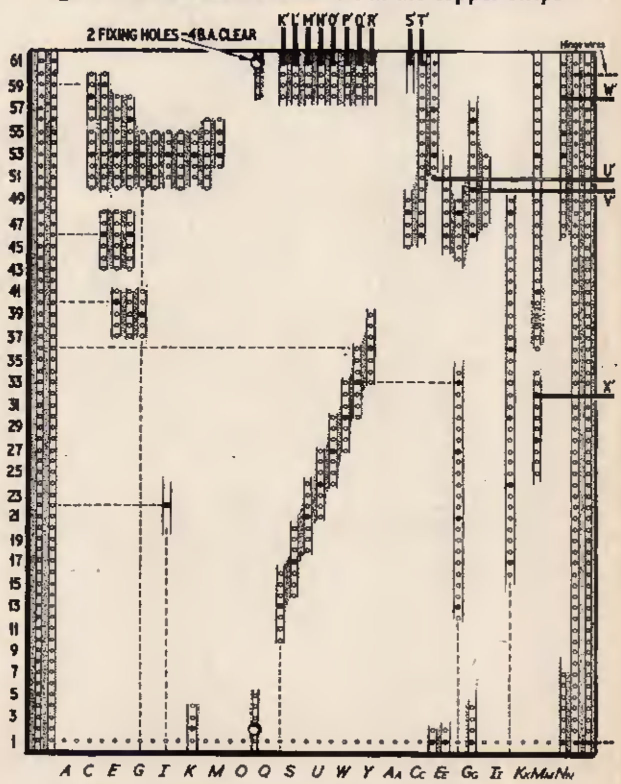


Fig. 8b. Connections and breaks in the copper strips

Note: Although both boards are shown with holes in the four outer strips, these have been drawn to help identification of the hole numbers. In the model these strips are, in fact, undrilled and are only used to fix the hinge wires. Many unused holes and strips are omitted for clarity, but where necessary, thin dotted key lines are shown to aid identification and location flying leads shown are the other ends of those shown on the register board. Do not, at this stage, connect any flying leads to positions shown on the copper sides of either board, as this will only lead to confusion.

The two boards must now be joined together to produce the sandwich like structure shown in the photograph. This novel method of construction is better shown in Fig. 9. First, place the two boards face to face, the orientation being that shown in Fig. 9. Using 18 s.w.g. tinned copper wire make three simple hinges by bending the wire round the back edges of the boards, and solder these into position on each board, making use of the non-perforated copper strips as anchor points.

When this has been done, the two boards can be opened up like a book, and the interconnecting wires A′ to H′ are cut to length, and routed as shown in Fig. 9. Solder the free ends of these wires to their respective positions (Fig. 8). Finally, close the board structure, and with another wire, clip and solder across the open end to make a rigid close structure.

This unit which measures approximately 7in × 4·5in × 1in is the completed logic section of the instrument.

FRONT PANEL

Proceed to assemble the front panel unit. Dimensions have not been given here, as these will depend to some extent on the type of components used. First mark up the panel, and mark cut-outs for the meter, range, and on/off switches, the push-button, and the input socket. These components should be fixed in position and connected as shown in Fig. 10.

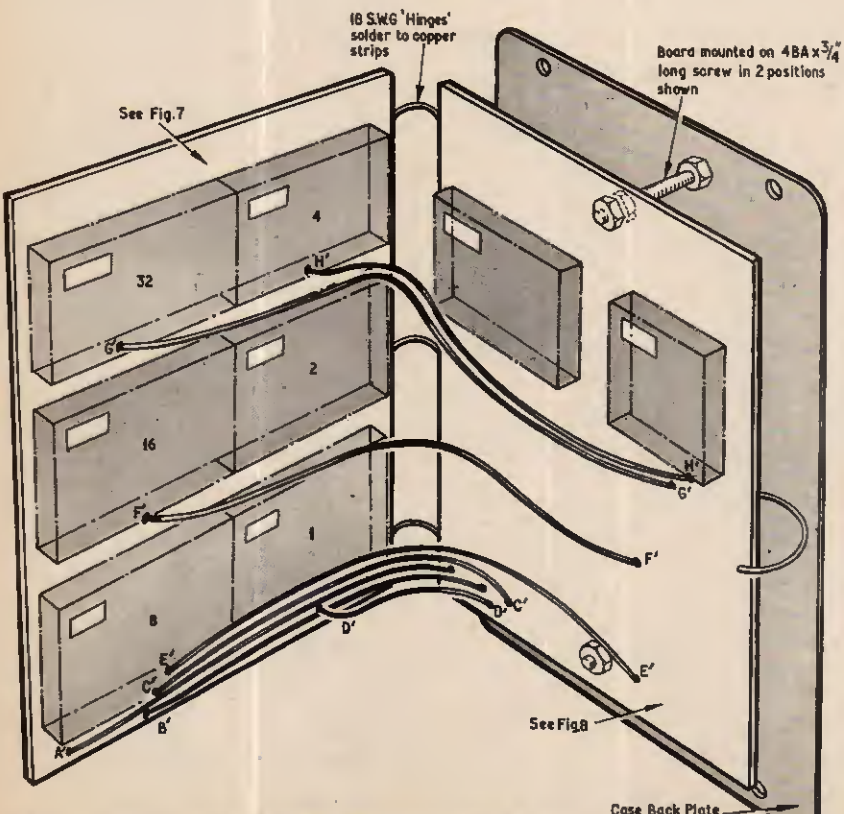
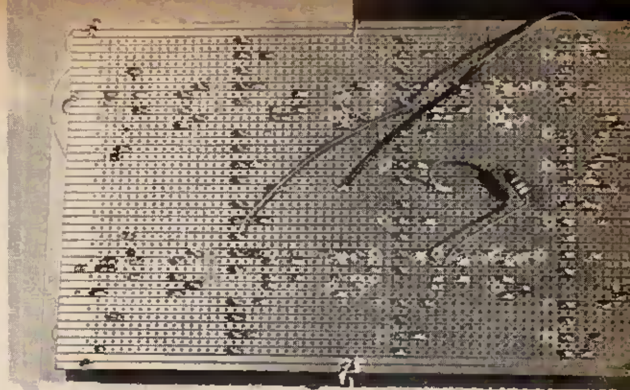


Fig. 9. View of the Veroboard sandwich opened out with the back of the case fitted



Underside view of the register board. Note the four plain copper strips on the long sides. The extra resistor shown here was used to adjust the value of R5 but this should not be needed (see text)

The preset potentiometers VR2 and VR3 are supported by the wiring which is sufficient as there will be no strain on these components. VR1 is held off the panel by a short length of heavy copper wire looped round one of the meter fixing nuts, and is positioned so that a screwdriver can be inserted into its slot through the calibration hole in the front panel.

The flying leads should be cut to approximately 12in each, the free ends being connected to the copper clad sides of the logic unit boards as shown in Figs. 7 and 8. The three power line leads should be taken to suitable battery clips. Finally, bind as many of the flying leads as possible to make a more robust structure.

The cabinet used for this instrument is a Datum Box Dinkicase type DD585. Before assembling the unit in the case first drill two holes in the back panel to coincide with the holes drilled in the multivibrator board. Using two long bolts with stand-off nuts, mount the logic unit on to the back panel of the box, and then fix the back and front panels into the box. The batteries can be conveniently fixed into the box between the front panel, and the logic unit.

TESTING AND SETTING-UP

To test the instrument, switch to the fastest multivibrator range, and with nothing connected to the input socket, switch on. If all is well, the meter will register a reading, or go off the top of the scale. Adjust VR1 (the calibration control) until the reading is exactly full scale. Press the reset button S2, and keep it held down; the meter should now read exactly zero. If there is a slight error here, adjust the mechanical zeroing of the meter, and then re-adjust the top scale reading.

Next switch to the slowest range of multivibrator, and depress the reset button momentarily. On releasing the push-button, the meter should begin to move up

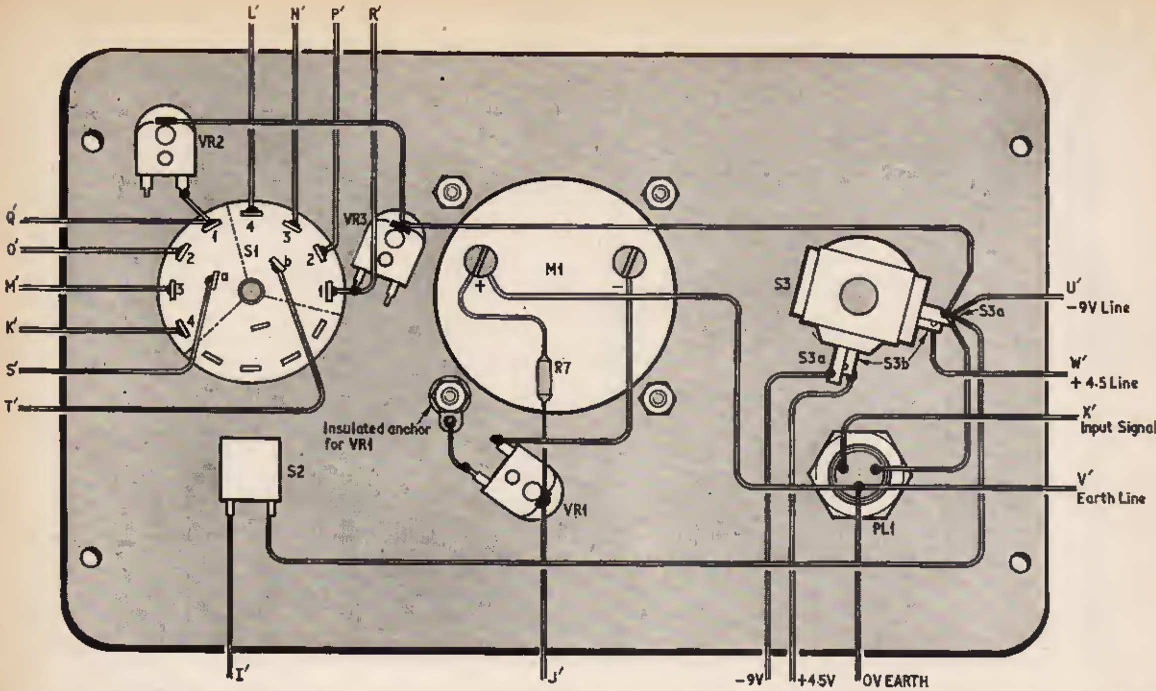


Fig. 10. Layout and wiring of components on the laminated plastics front panel. If a metal panel is used, VR1 anchor wire must be insulated from the panel

the scale very slowly, and after about twelve seconds should read full scale. There will be some error on this range due to the nature of the electrolytic capacitors used, and controls VR2 and VR3 should be adjusted in value until the time taken to reach full scale is exactly 12 seconds.

If the needle moves up the scale in a jumpy manner it means that the digital-to-analogue network is out of ratio, and these values should be checked, or alternatively VR4 should be adjusted (if this was used instead of a fixed resistor).

To check that the input is working satisfactorily, short the top two pins on the input socket together; this effectively applies a level "1" to the input. After resetting, the meter should now stay at zero, but as soon as the short circuit is removed, the instrument will start to count up the scale. On re-applying the level "1" the meter can be stopped at any part of the scale.

When all these points have been established the instrument is working correctly, and it is only left to re-scale the meter to show seconds. The full scale should be calibrated 12, and in between values scaled in linearly. The range switch should be marked ×1, ×0·1, ×0·01, and ×0·001 thus giving effective full scale values from 12 seconds to 12 milliseconds.

APPLICATIONS

The last section of this article describes a simple photo-trigger circuit which can be used in conjunction with the electronic stopclock and also suggests various other input trigger circuits for applications covering velocity measurement, and reaction time measurement.

The reader can devise many other types of input circuitry provided the basic input requirements of the unit are satisfied. These are simply that to make the clock start timing, a logic level "0", that is to say a potential of the order of −0·5 to +1·0 volts, must be applied to the input. To stop the clock the level must change to logic level "1" (−4 to −8 volts). The response time for the instrument is directly related to the rate of change of these logic levels and, therefore, for the best accuracy this rate of change should be reasonably fast, and be positive in action.

To produce fast changing logic levels from various types of input, it is usual to have a circuit such as a Schmitt trigger as a buffer stage where the trigger, or threshold, voltage can be adjusted to give any sensitivity. A Schmitt trigger generally acts as a "sharpener" of waveforms, and if care is taken in the design and selection of components in the preceeding stages this buffer can be omitted. However, if the reader so desires, he may include a trigger as a buffer to any of the following proposed circuits.

PHOTO TRIGGER

The instrument was designed, in the first instance, as a tool to measure the speed of camera shutters, and after experiments with various types of photosensitive circuits of conventional form the one chosen for its simplicity, and reliability of operation was that shown in Fig. 11.

The number of components involved are an absolute minimum, but it should be noted that the transistor used should be a silicon *npn* type such as the BSY95A. The photocell used is a type not usually specified in amateur projects, but nevertheless is readily available, and although it tends to be a little more expensive than conventional phototransistors this is more than offset by the economy of components resulting from its use.

A second, and most important feature of the cell (PV10AF—photovoltaic diode) is its frequency response. A normal germanium phototransistor will only operate up to approximately 10kHz, but this particular device will respond up to 200kHz. As the basic time unit measured on the clock could be 0·2ms it is essential that, to make full use of the range of measurement with any degree of accuracy, the response of the input transducer should be faster than this.

SPECIAL BARGAINS

White Circular Flex. Ideal for lighting drops, twin made by BICC. Usually 8d yd, 100yd coil for 30/- plus 5/- postage.
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1 MEG MINIATURE. Pot-meter Morganite standard. ¼in spindle. 1/- each, 9/- per dozen.
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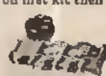

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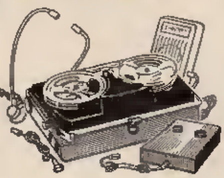

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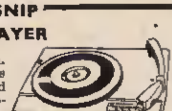

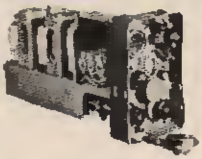

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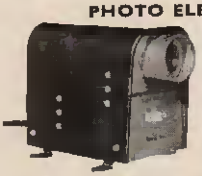
Half rev. per minute
Made by famous Smiths Electric, mains operated and quite powerful. Size 3½"×2½"×1½" deep. Secondary use as process timer. Internal switch can be made to break circuit within a period up to 2 mins. 17/6, P. & P. 2/6 unless ordered with other goods.

PHOTO ELECTRIC CONTROL SYSTEM



Comprises a light source unit with optional Infra Red filter and lens system to focus the light. Also a photo-electric Relay control unit. Both are housed in metal cases for bench or wall mounting and there is a sensitivity control as well as mains on-off switch. The outfit works from 230/240V, a.c. Mains. Can be used as a simple on-off switch by breaking the beam of light (invisible if Infra Red filter is used) and as such it will operate as a burglar alarm, or will open doors, etc. Also in conjunction with a counter or other equipment it will perform many functions in the factory or warehouse. Price £9.19.6 plus postage and insurance 8/-.

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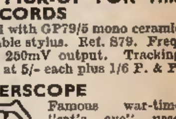

COSMOCORD PICK-UP FOR 7in. RECORDS
Grey plastic arm fitted with GP79/5 mono ceramic cartridge and replaceable stylus. Ref. S79. Freq. response 50–8,000cs., 250mV output. Tracking weight 9 gms. Offered at 5/- each plus 1/6 P. & P.

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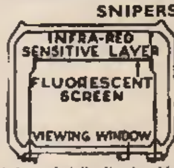

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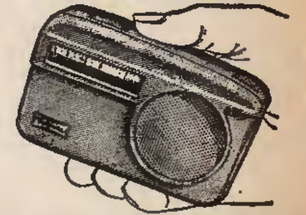

Only recently sold for £10.9.6. Note these features: ● Long and Medium Wave ● Long dial ● Push pull output ● A.V.C. and feed back ● Ferrite aerial ● Six transistors ● Cabinet size 4½in × 3in × 1½in with carrying strap. You get everything you need and instructions. 39/6 plus 3/6 p. & p. or **supplied with made up chassis 10/- extra.** Battery 1/9 extra. Data separately 2/6.

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As it stands, the sensitivity of the circuit is fixed so that the output condition in normal ambient light is level "1". A reasonably bright source of light, such as a torch bulb held 3ft away, and beamed on to the active surface of the cell will positively change the output level to "0". If variable sensitivity is required R8 should be made a preset potentiometer, of 1 megohm.

It should be noted that this circuit is not, strictly speaking, a trigger, as it does not have two completely independent states. For example if the light source is controlled carefully in intensity any output voltage between the 0 and 1 condition could be obtained at the output. In practice, however, the gain of TR1 is so great that it is extremely difficult to hold this indeterminate state, and this does not represent a problem in use.

The layout of the trigger circuit is not at all critical, and it is suggested that it be made up on a strip of Veroboard for mounting in a diecast box (see components list last month). Fig. 12 shows a suggested layout. It is essential that the unit be encased in a reasonably light-proof box with a hole cut to expose the active surface of the cell.

The output cable from the phototrigger comprises three cores, two of which are the power lines, and the third the signal line. Normal mains cable is suitable provided the length does not exceed 6ft. The free end of the cable is taken to a plug which mates with the input socket on the clock. The power requirement is thus provided from the battery within the clock itself.

CAMERA SHUTTER SPEED

To use the unit for measuring camera shutter speed remove the back from the camera, and position the phototrigger so that it is central and in line with the aperture axis. Hold the shutter open on "brief" and position a lit torch bulb in front of the camera lens so that the clock starts to count on its slowest range. The system is then ready to make measurements.

Close the shutter, and ensure that the lens is at full aperture, reset the clock, and switch to the required time range. Set the camera shutter to the speed to be measured, and fire the shutter. The clock will indicate the length of time the shutter was open.

There is a point which should be noted here; some shutters operate with "between lens" blades, and others with a focal plane "blind". It is difficult to define any instant of time when the former type is open or shut, as it behaves more like a fast moving aperture. A focal plane shutter does not present this problem to the same extent, but nevertheless the same reasoning applies.

It is outside the scope of this article to give theories of relative speeds of different types of shutters, and the point is made merely to show that this problem exists, and that apparent erroneous speeds do not always imply that the camera is at fault.

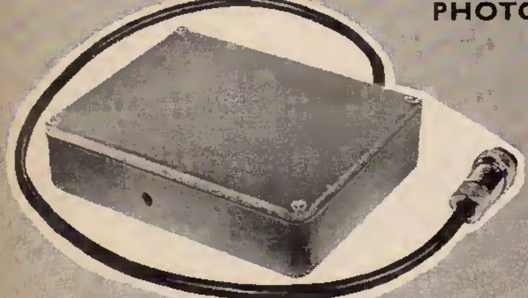
VELOCITY MEASUREMENT

If we take the basic phototrigger circuit of Fig. 11 and couple it with an identical unit (shown in Fig. 13) it is possible to obtain a simple velocity measuring input.

If the two trigger circuits are positioned a fixed distance apart in such a way that a moving object has to cut beams of light illuminating both cells, the action of cutting each beam will produce two negative pulses at the collector of TR2. These pulses occur at the exact moments of obscuring each cell, and are fed to a bistable which is normally reset by a push button S4 to a condition so that the output is normally at level "1".

On receiving the first impulse the bistable will offer a level "0" output, which, if coupled to the clock, will cause it to start timing. On receiving the second impulse it will revert to level "1", and the clock will stop. As the distance between the two cells is known, and the time taken to cover this distance is measured,

PHOTO TRIGGER



COMPONENTS . . .

Resistor
R8 470kΩ } 10% ¼ watt carbon
R9 56kΩ }
Photovoltaic cell
X1 PV10AF (Electroniques)

Transistor
TR1 BSY95A

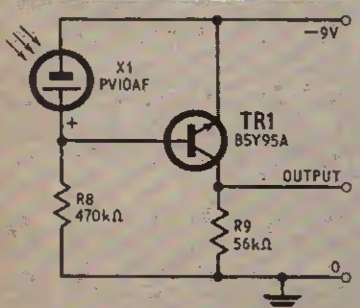


Fig. 11. Circuit of the photo trigger

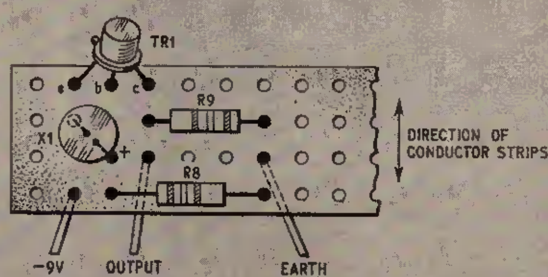


Fig. 12. Suggested layout of the photo trigger on Veroboard

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4-Speed Mono Players 2-tone Cabinets 17×15×8½in. High flux loudspeaker and High Quality Amplifiers ready built. Quality output. Volume and Bass controls. Special instructions enable assembly in 30 minutes, only 5 wires to join. 12 months' guarantee.

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Garrard SP25	£10.19.6	Garrard 2000	£6.19.6
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Garrard A70	£19.19.6	Garrard AT60 Mk. II diecast turntable	£12.19.6
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SPEAKER FRET Tygan various colours, 52in. wide, from 10/- ft.; 26in. wide from 5/- ft. SAMPLES S.A.E.
EXPANDED METAL Gold or Silver 12 × 12 in. 6/-.
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D3034, 1.75 : 1 CT. Push Pull Driver for OC72, OC81 .. 11/-
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TRANSISTOR MAINS ELIMINATORS. FAMOUS "POWER MITE". 9 VOLT. SAME SIZE AS PP9 BATTERY. FULLY SMOOTHED. 150mA. FULL WAVE CIRCUIT. **45/-**
SPECIAL 9 VOLT. 500mA POWER PACK..........49/6

WEYRAD P50 — Transistor Coils

RA2W 6 in. Ferrite Aerial with car aerial coil	12/6	Spare Cores	6d.
Osc. P50/1AC	5/4	Driver Trans. LFDT4	9/6
I.F.P50/2CC 470 kc/s	5/7	Printed Circuit, PCA1.	9/6
3rd I.F. P50/3CC	6/-	J.B. Tuning Gang	10/6
		Weyrad Booklet	2/-

Volume Controls

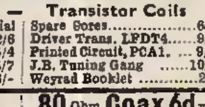
LONG SPINDLES. MIDGET SIZE 5 K. ohms to 2 Meg. LOG or LIN. L/S 3/-. D.P. 5/- STEREO L/S 10/6, D.P. 14/6.

80 Ohm Coax 6d yd.

Semi-air spaced Cable 100 yd. drum 50/- post free.
FRINGE LOW LOSS Ideal 625 lines **1/6 yd.**

COAXIAL PLUG 1/-. PANEL SOCKETS 1/-. LINE SOCKETS 2/-. OUTLET BOXES, SURFACE OR FLUSH 4/6. BALANCED TWIN FEEDERS 1/- yd., 80 or 300 ohms. TELESCOPIC CHROME AERIALS. 6in. extends to 23in. 6/6 each. CAR AERIAL PLUGS 1/6. Sockets 1/3.

SPECIAL PURCHASE! B.S.R. GU7 9 volt Battery Operated Record Player Decks



4 speeds, automatic stop. Plays any size record. Complete with mono LP/78 xtal and sapphire stylus. (With stereo cartridge 12/6 extra). ONLY **69/6** P. & P. 5/6

STELLA RECORD PLAYER AMPLIFIER

4 watt. 2 stage. 3 to 7 ohm. Neg. feed back. UCL82. UY85. 200-250v. A.C. tapped input. Chassis size 9 x 2½ x 4in. high. Gold/Walnut knobs. Volume and Tone controls on separate Polished Wood Panel 6 x 2in. Brand new with makers' guarantee. BARGAIN PRICE P. & P. 2/6. **78/6**

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8/450 v.	2/8	500/15 v.	3/-	16+16/500 v.	7/6
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25/25 v.	1/9	16+16/450 v.	4/3	60+100/350 v.	11/6
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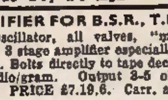

200/250 v. A.C.
Leaflet S.A.E.
Post 2/6 **35/-**

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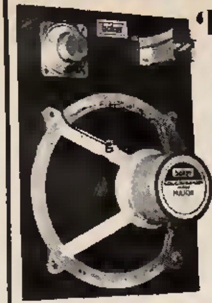

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In kit form with instructions.

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Quality Horn Tweeters 3-16kc/s. 10w. 27/6. Crossover 14/6.
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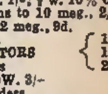
Various calibrations and movements. 100 Microamp 55/-; 1 Milliamp 50/-, etc. Post 5/- extra. Send S.A.E. for list.

BRAND NEW QUALITY EXTENSION LOUDSPEAKER



Cream plastic cabinet, 20ft. lead and adaptors. For any radio, intercom, tape recorder, etc. 3to 15 ohm Size: 7½" x 5½" x 3"
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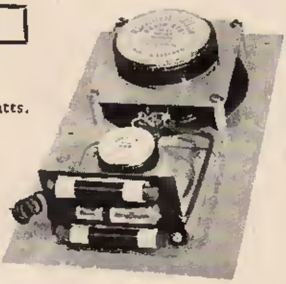
The Mid-range and Tweeter Module is a further development of the well established High Fidelity Module, and is similar to it in that it consists of 5" and 4" units mounted on a rectangular aluminium plate. However, different cone and magnet assemblies are utilised to suit the specialised purpose for which it is intended.

Ideal for adding to existing systems for extra sparkle, filling in the "hole in the middle," or including in new designs, the Mid-range Module is complete with crossover network and is fitted with a sensitivity control for ease of matching to various loudspeakers.

SPECIFICATION

Frequency Range
500-17,000 Hz.
Power Handling
For use with systems up to 20 watts.
Impedance
8 or 15 ohms.
Mid-range unit
5" dia. 12,000 lines, 1" pole.
Tweeter unit
4" dia. 10,000 lines, 5/16" pole.
Size
11" × 6½" × 2¼" deep
(28 × 16·5 × 6·4 cm.).
Weight
3½ lbs. (1·6 Kg.).



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DAWE AUDIO SWEEP OSCILLATOR AND CONTROLLER TYPE 443B
20c/s to 20Kc/s in a Single Sweep Logarithmic Scale Calibration. Accuracy ±1% ±1c/s. Power supply 110V and 200-250V. Dimensions: 19 × 12 × 13in. Supplied Brand New with Instruction Manual. Less than half Maker's Price. £125. Send 6d. Stamp for Data Sheet.

DAWE AUTOMATIC L.F. SWEEP OSCILLATOR
Type 444C. 5c/s to 5,000c/s in a Single Range. 6-in. dia. dial with Logarithmic Calibration over 216° of Arc. Fre. Accuracy ±5%. Output continuously variable up to 10V. R.M.S. into a minimum Load Resistance of 10kΩ. Monitored on a Panel Voltmeter Power Supply. 110V and 200-240V. 50c/s. Dimensions: 19 × 18 × 9in. Supplied Brand New with Instruction Manual. Less than half Maker's Price. £100. Send 6d. Stamp for Data Sheet.

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0–48V 10A, continuous from 240V a.c. Silicon full wave bridge rectification, isolated transformer with Variac controlled primary. 3in. scale voltmeter and ammeter. Neon indicator. Housed in strong metal case. Size 17 × 7 × 6½in. £29/10/0. Carr. 15/-.

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A.c. input tapped 250-250V d.c. output. Tapped 24-26V. Very conservatively rated at 8A. Also a separate tapped a.c. output of 6-10·6V 18A. Completely enclosed in metal wall mounting case. Size: 15½ × 9 × 6½in. Brand new, £9/10/0. Carr. 15/-.

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SPECIAL OFFER OF WODEN TRANSFORMERS BRAND NEW
No. 1. PRI tapped 200-250V E.S. Sec. Tapped 8-15-25-28-30-33-35V 15A. Tropically finished table top connects. £5/17/6. Carr. 10/-. No. 2. PRI 240V E.S. Sec. No. 1. 50V 4A. Sec. No. 2. 18-0-18V 1A. 55/-. P.P. 7/6. No. 3. PRI tapped 200-250V E.S. Sec. 1. 315-0-315V 110mA. Sec. 2. 175-0-175 25mA. Sec. 3. 5V 1·9A. Sec. 4. 6·3V 3·1A. Sec. 5. 6·3V CT4A. Sec. 6·3V CT2A. Sec. 6·3V 1A. "C" Core table top connections. 50/-. P.P. 7/6.

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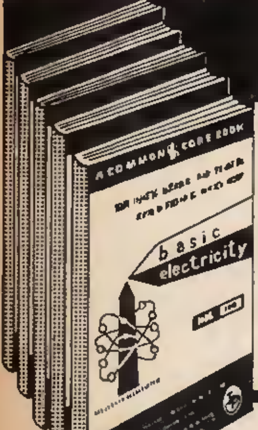

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VELOCITY MEASURING CIRCUIT

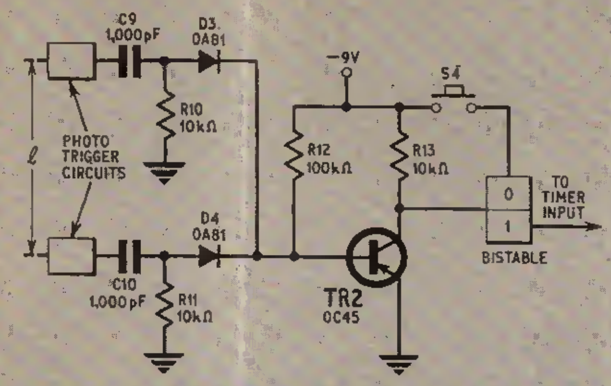

Fig. 13. Circuit diagram of the velocity measuring device using two photo triggers and a bistable module

COMPONENTS . . .

Resistors
R10 10kΩ R12 100kΩ
R11 10kΩ R13 10kΩ
All 10% ¼W carbon

Capacitors
C9 1,000pF polyester
C10 1,000pF polyester

Transistor and Diodes
TR2 OC45
D3 OA81
D4 OA81

Switch
S4 Push button on/off switch

Logic Module
Bistable type 43A (Electroniques)

it is a simple calculation to determine the velocity of the object.

To save having to make the calculation it is possible to scale the meter of the clock to read feet per second, or miles per hour direct. This scale would not, however, be linear, and would get very cramped at the lower end.

Of course, the input trigger for this application need not necessarily be via photo cells, and the conditions could be produced by pneumatics, ultrasonic beams, or for slower movements, by microswitches.

ACCELERATION

Under certain circumstances a twin light cell unit may be used to measure acceleration.

An experiment often encountered in a school laboratory is that of determining the acceleration of a body moving from rest. Fig. 14 shows such an experiment.

As soon as it is released, the truck accelerates under the force of gravity acting on the weight, and after travelling a certain distance will have a velocity imparted by the accelerating force. By using the photo electric trigger it is possible to measure this velocity and thence the acceleration. Assuming that the acceleration is linear, and that the truck started from rest the acceleration is $\frac{v^2}{2s}$ where v is the velocity after having travelled a given distance s.

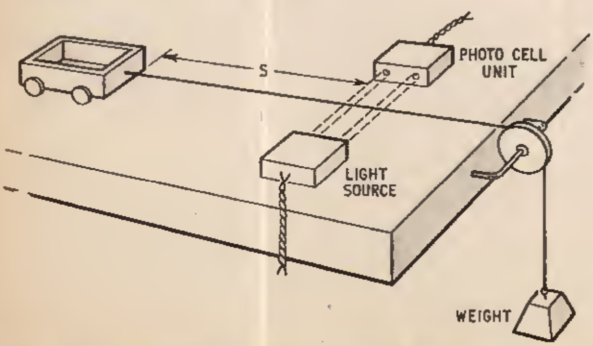

Fig. 14. Experimental set-up for acceleration measurement using the photo trigger and light beam

To determine v at the distance s it is essential that the distance between the photocells is small compared with s. This reduces errors due to the increase in velocity during measurement. This measurement is repeated several times for different values of s, and the result can be plotted on a graph.

Another interesting experiment would be to measure the acceleration of a free falling weight. This is done in exactly the same way, but in a vertical plane (see Fig. 15).

REACTION TIMING

The clock can equally well be used for measuring the time interval between two signals from different sources, an example of this would be in the case of a reaction timer. Here the person under test would receive a signal at the exact moment the clock started timing and would generate his own signal to stop the clock. The start signal could either be originated electronically, or by a second person who would be acting as the controller.

To make a reaction test realistic, it is important that the signal should appear at some random point of

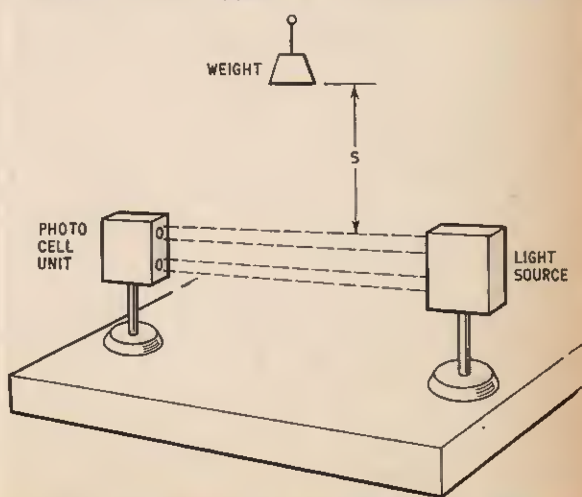

Fig. 15. An alternative arrangement for measuring acceleration

REACTION TIMING

COMPONENTS . . .

Resistors
R14, R15 3·3MΩ (2 off)
R16 2·2kΩ
All 10% ¼W carbon

Capacitors
C11, C12 5,000pF polyester (2 off)

Transistor
TR3 OC82

Logic Module
Bistable type 43A (Electroniques)

Switches
S5, S6 Push button on/off switches (2 off)

Lamp
LP1 6·3V 0·115A (with lampholder)

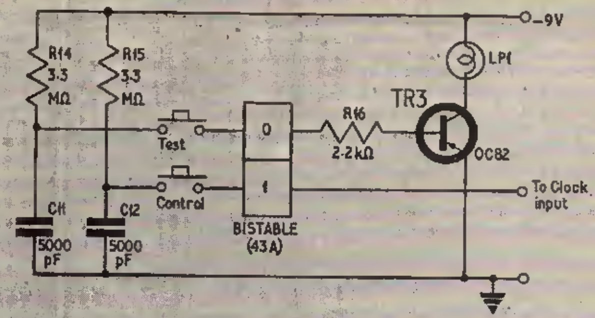

Fig. 16. Circuit for reaction timing using a bistable module with two setting switches

Miscellaneous for any of the above circuits
Diecast box type 46R, 043A (Electroniques)
Veroboard

time, but obviously there must be practical limits to this, and naturally the subject of the test is fully aware of the fact that he, or she, will have to react within the space of, at the most, one or two minutes. This awareness detracts to a certain extent from the value of such a test from the absolute point of view, but nevertheless comparative figures are quite meaningful.

If one were to say that the signal must occur within one minute of switching the instrument on it would be possible to design a random timing circuit to generate this signal, but the design of a circuit such as this is not quite so straightforward as it may seem at first sight.

The alternative method, which works out much cheaper, and certainly easier is to have a person controlling the test. This person, by pressing a button (obscured behind his back) could initiate the signal and start the clock at any moment of time. The subject under test could be armed with a similar button which would generate a signal to stop the clock.

Reaction time is closely coupled to the sense used to detect the stimulus. The stimulus could be sound, touch, sight, or even smell. All but the latter are practical propositions, but it is generally accepted that most reactions (particularly those of drivers) are instigated by sight. For the purpose of experiments a light source is used to generate the signal; when the light goes on, the subject has to press his button with the minimum of delay.

A suitable circuit which can be used with the electronic stop clock is shown in Fig. 16. The direct set and reset entry points of a modular bistable are used to set the conditions. When the controller presses his button, C11 discharges into the "set" side of the bistable, and the output feeding the base of TR3 rises to level 1. This drives TR3 hard into conduction, and the lamp in the collector load circuit lights up. Simultaneously the other output which feeds the clock drops to level "0", and thus allows the clock to start timing. If the controller were to depress his button a second time no change in state would occur as direct entry to the bistable is being used. The only way to turn off the light, and to stop the clock, is for the subject under test to depress his button. Any time difference is immediately displayed on the meter of the clock.

It should be noted that R14 and R15 are very high value resistors, and C11 and C12 comparatively low value capacitors. These have been selected to provide a "cheat-proof" circuit.

The person under test might think that if he holds his button down while the controller starts the clock the clock will not start. He would, however, be wrong for the input circuit of the bistable, while being of medium input resistance, is extremely low in comparison with the 3·3 megohm charge resistor associated with the capacitor. Therefore any charge stored by the capacitor is bled away, rendering the input inoperative as long as the button is depressed.

If the clock was started while the subject had the button depressed, the subject would be at a disadvantage as he would have to remove his finger from the button first before depressing it a second time. The reaction time would therefore be greater.

The whole of the reaction timer circuit can be enclosed in a small diecast box, with the light source built in. It should be noted that the internal battery of the clock supplies the power to drive the reaction circuit, and also the lamp, therefore to avoid unnecessary load on the supply a very low current bulb should be used. If other forms of stimulus were required, it would be easy to substitute a relay coil for the bulb.

Reaction times can vary enormously from person to person, but experience has shown that the average time taken to respond to a light stimulous is between 300 and 450 milliseconds.

These examples of applications are given as suggestions of possible uses of the equipment, and there are of course many other possible functions which could be covered. ★

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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.

LOOKING AROUND

Two new thyristor power controllers have recently been announced by **Electrothermal Engineering Ltd.**, 270 Neville Road, London, E.7, and **Headquarters & General Supplies Ltd.**

The Electrothermal "Electrogate" controller, price £9 15s 0d, is rated at 1kW a.c. and is suitable for controlling lights, heaters, power drills, motors, dryers, etc. It can also vary the heat of soldering irons and electric fires.

The "Tragonic", price £2 14s 6d, by Headquarters & General Supplies is also claimed to be capable of doing the same jobs listed above, although no power rating was quoted.

Designers may be interested in a new microswitch marketed by **M.L. Industrial Products,** 238 Leigh Road, Slough, Bucks. These microswitches type M.P.100 are completely waterproof and dustproof. This is achieved by moulding synthetic rubber diaphragms into the actuating plunger and welding this to the fibreglass case by ultrasonic welding. These switches are fairly expensive but no doubt they will meet particular problems encountered by designers.

ACCESSORIES

The new type 49A handle from **Alfred Imofs Ltd.**, Cowley Mill Road, Uxbridge, Middlesex, is attractively designed for fitting behind cut-outs in instrument cases and would certainly enhance the appearance of test gear (such as the **P.E. Investigator Oscilloscope**). They add that touch of professionalism that we all like to try and achieve in our finished equipment. The lift-up handle is finished in satin chrome and recessed into a matt black shell that acts as a 90 degree stop for the handle. The price of the handle is 17s 0d.

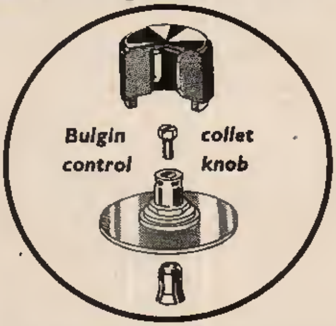
Multicorder imported by Denham & Morley

A new set of collet fixing knobs is the latest addition to the **Bulgin** range of control knobs. The knobs consist of three basic parts: knob bodies, collet assembly and skirts. In use, the collet is first fixed to the spindle, then a suitable size skirt, with any predetermined legend embossed on it, is screwed to the collet and finally the knob body is held in position by a strong spring clip in the body.

The main advantage of this type of control knob is that any number of different knob bodies and skirt sizes are interchangeable.

We all like to admire commercial equipment and its very smart and attractive finish. Probably the most enviable finish is that of stainless steel, which to the amateur is a costly luxury.

With the introduction of a stainless steel aerosol spray from **DCMC Industrial Aerosols Ltd.,** of 291 Edgware Road, London, W.2. the problem of high cost does not arise.



Bulgin control collet knob

The price of the 16oz can is 13s 6d each, and the makers claim that metals, wood, and plastics can be sprayed with it.

The range of aerosol spray paints from **Yukan Ltd.,** 307a, Edgware Road, London, W.2, is another company which produces various types of finishes, such as hammer and matt, that help to improve home constructed equipment.

RADIO AND TAPE

Electroniques of Edinburgh Way, Harlow, have been appointed sole U.K. agent for Hallicrafters radio communications equipment.

Denham & Morley Ltd., have had such considerable success with the imported Norwegian Radionette Radios that they have enlarged their stocks of Radionette equipment. Of particular interest is the Multicorder four track tape recorder with a total playing time of 12 hours from one spool of tape.

Operated from the mains or battery supply the Multicorder has two speeds, $1\frac{7}{8}$in/sec and $3\frac{3}{4}$in/sec and wow is approximately 0·2 per cent at $3\frac{3}{4}$in/sec $\pm$ 3dB at 10kHz. It is possible to obtain 12 hours' playing time by using the track selector switch; the recording head covers only quarter of the width of the tape, so that the tape is divided into four tracks. The selector switch can be used whilst the recorder is running.

M.P.100 microswitch from M.L. Products Ltd.

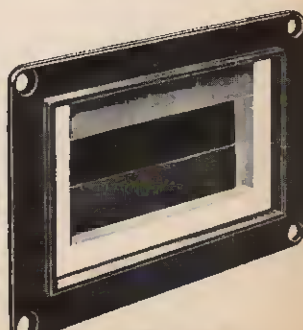
LITERATURE

A new catalogue from **Lind-Air (Electronics) Ltd.,** 53, Tottenham Court Road, London, W.1, contains probably the largest selection of plugs and sockets listed by a retailer. Over 100,000 different British and American types are listed as off the shelf items in the 69 page catalogue entitled "Plugs, Sockets and Connectors".

Although it is Lind-Air's policy to deal with orders from the trade, research institutes, universities and colleges, they are prepared to handle any orders from individual readers on a "cash with order" basis. Besides the catalogue mentioned, a short-form components catalogue, which includes complete alphabetical listings of valves, semiconductors and relays, etc., is also available.

Available from **Hird-Brown Ltd.,** Bolton, Lancashire, is a brochure containing details of their complete range of photo-electric equipment. Over 40 types of photo-electric projectors and receivers are included, these vary in physical size from 1in $\times$ $\frac{1}{2}$in $\times$ $\frac{3}{8}$in to $9\frac{3}{8}$in $\times$ $6\frac{3}{8}$in $\times$ $4\frac{1}{8}$in. Beam projection lengths vary from $\frac{1}{8}$in to 65ft.

The brochure contains general information on photo-electric equipment for automation, possible arrangements of photocells and relays and complete price list.



Imofs 49A handle

INGENUITY UNLIMITED!

IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

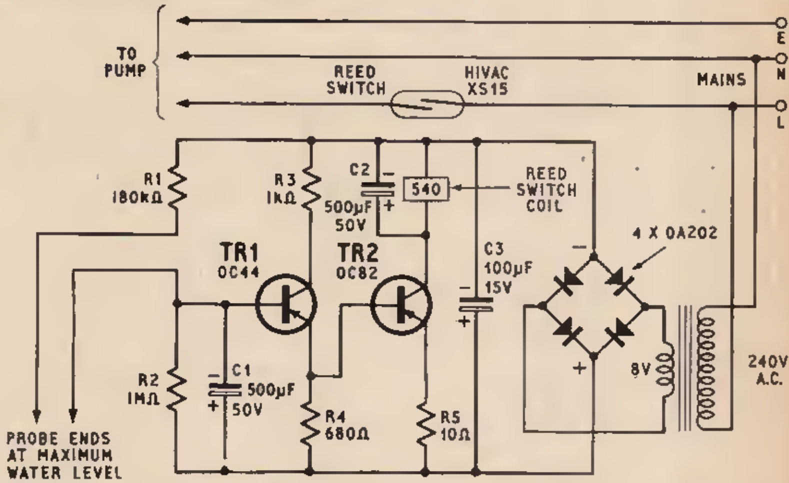
AUTOMATIC WATER PUMP

THE following describes the adaptation of the P.E. *Parking Light* circuit to automatic operation of a water pump.

The circuit, adapted as shown in the diagram, includes a heavy duty reed switch which operates a mains water pump. No arc suppression is shown for the reed switch contacts as this would vary with the type of pump in use.

The capacitors C2 and C3 serve to form a time delay which keeps the pump running for 15 to 20 seconds after the probe has become dry. As a result of this, the cut-in and cut-out level can be kept very close; an advantage in this particular case.

The probes were simply the bared ends of a piece of twin plastic covered lighting flex. As little as ¼in bared is quite sufficient with the two ends about 1in apart suspended at the required height to start the pump. The unit is extremely sensitive and has in practice been found to be very reliable.



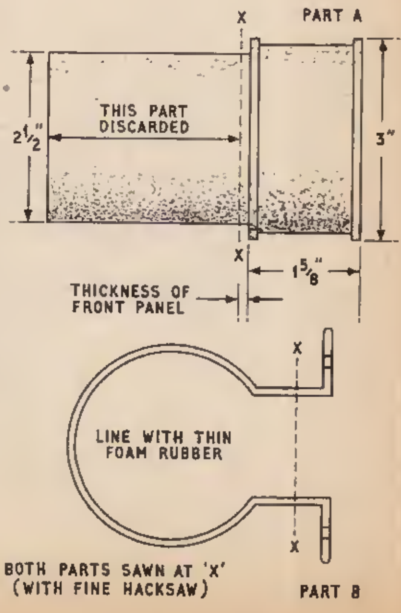
D. R. Walker,
Winchester.

OSCILLOSCOPE VISOR

I AM in the process of constructing the *Investigator Oscilloscope* described in your July and August issues. I have stumbled on the following adaption which produces pleasing results.

I was unable to find the aluminium tubing specified for the visor and tube support so I looked for a substitute. I was fortunate enough to find something which could have been specially made for the job. It consists of a part supplied with the new p.v.c. drainpipes and gutterings (see drawing). The first coincidence was that the narrow dimension of the tube was 2½in as specified for the hole in front panel; the larger dimension was 3in and has an attractive lip each end (this also assists glueing to the panel). The clip supplied with the tube is sawn at "X" as is the tube and the parts are then Araldited to back and front of the panel respectively.

M. Francis,
Cheltenham,
Glos.



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Twin 40 W Choke instant start for 2×2 ft. tubes 17/6. P. & P. 5/6.

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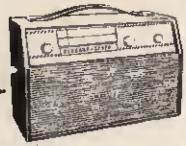

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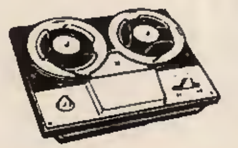
BSR TAPE DECKS



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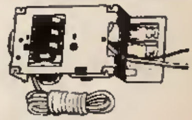

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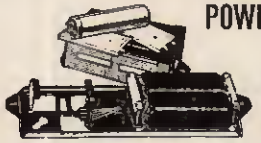

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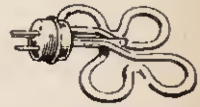

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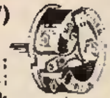

AVAILABLE IN THE FOLLOWING VALUES

1 ohm, 10 a.; 5 ohm, 4.7 a.; 10 ohm, 3 a.; 25 ohm, 2 a.; 50 ohm, 1.4 a.; 100 ohm, 1 a.; 250 ohm, .7 a.; 500 ohm, .45 a.; 1,000 ohm, 280 mA; 1,500 ohm, 230 mA; 2,500 ohm, .2 a. Diameter 3½in. Shaft length ⅝in., dia. 5/16in. All at 27/6 each. P. & P. 1/6.

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10 ohm, 1.5a.; 25 ohm, 1 a.; 50 ohm, .75a.; 100 ohm, .5a.; 250 ohm, .3a; 500 ohm, .2a; 1,000 ohm, .15a; 1,500 ohm, .12a.; 2,500 ohm, .1 a; all at 14/6. P. & P. 1/6.

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75 ohm coil 24 v. D.C.

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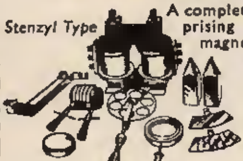
Stenzyl Type



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0-36 Volt at 5 Amp. £8.10.0. P. & P. 8/6.
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Input 185-250 v. A.C. Output 230 v. A.C. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17 lbs. Price £11.10.0. P. & P. 15/-.

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BBC (Band 1). Telescopic loft, 21/-. External S/D, 30/-. "H", £2.10.0.

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Combined BBC/ITV. Loft 1+3, 41/3; 1+5, 48/9; 1+7, 58/9; Wall mounting 1+3, 56/3; 1+5, 63/9; Chimney 1+3, 63/9; 1+5, 71/3.

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F.M. (Band 2). Loft S/D, 12/6, "H", 30/-, 3 element, 52/6. External units available. Co-ax. cable, 8d. yd. Co-ax. plugs, 1/3. Outlet boxes, 4/6. Diplexer Crossover Boxes, 12/6. C.W.O. or C.O.D. P. & P. 5/-. Send 6d. stamps for illustrated lists.

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27 Central Parade, New Addington
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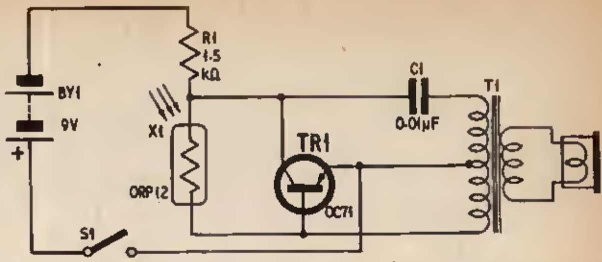
LODGE HILL 2266

INFRA-RED DETECTOR

In the November 1965 issue of PRACTICAL ELECTRONICS there is an article by J. H. du Bois about constructing a Code Practice Oscillator. On experimenting with this oscillatory circuit I produced a unit which may be used as an infra-red ray detector.

To operate the unit the photoelectric cell is allowed to move into the presence of infra-red rays.

The rays and the strength of the rays are determined by the pitch of oscillation the oscillator produces. A low pitch note for weak rays and a high pitch note for strong rays. The unit can also be used to determine the strongest point of infra-red rays from an appliance corresponding to the highest pitch of note produced by the detector unit.



The detector unit is portable and the infra-red sensor is housed in a pen and covered by an infra-red filter such as Everine black tile. The sensor is then attached to the detector unit by microphohe cable.

J. Walker, Dunfermline, Fife.

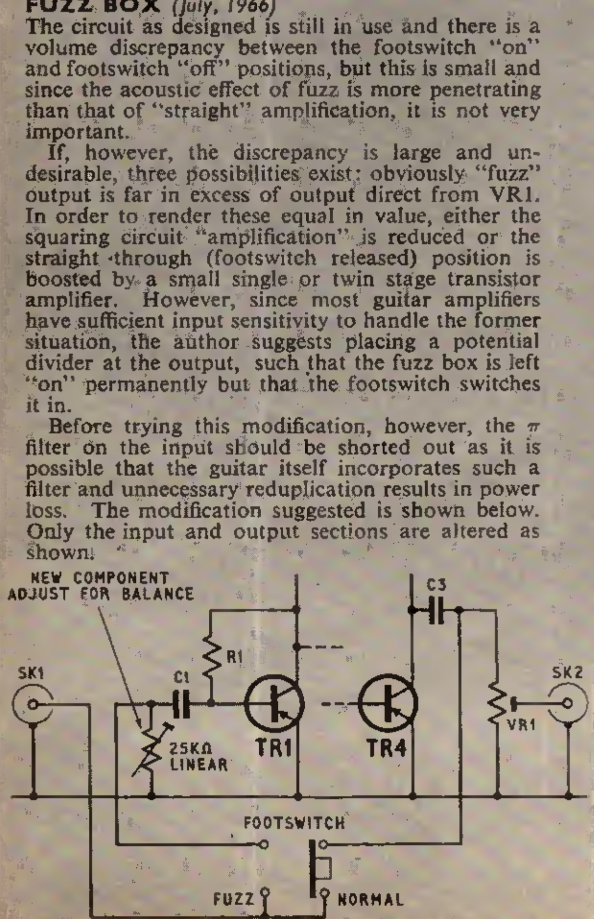
POINTS ARISING

FUZZ BOX *(July, 1966)*

The circuit as designed is still in use and there is a volume discrepancy between the footswitch "on" and footswitch "off" positions, but this is small and since the acoustic effect of fuzz is more penetrating than that of "straight" amplification, it is not very important.

If, however, the discrepancy is large and undesirable, three possibilities exist; obviously "fuzz" output is far in excess of output direct from VR1. In order to render these equal in value, either the squaring circuit "amplification" is reduced or the straight through (footswitch released) position is boosted by a small single or twin stage transistor amplifier. However, since most guitar amplifiers have sufficient input sensitivity to handle the former situation, the author suggests placing a potential divider at the output, such that the fuzz box is left "on" permanently but that the footswitch switches it in.

Before trying this modification, however, the π filter on the input should be shorted out as it is possible that the guitar itself incorporates such a filter and unnecessary reduplication results in power loss. The modification suggested is shown below. Only the input and output sections are altered as shown.



COMPUTER EVOLUTION *(July, 1967)*

The electronic analogue equation for Fig. 3.1 did not take into account the fact that an operational amplifier, as well as performing its task of integrating or differentiating, also reverses the sign of the function. This being the case, the intermediate points of Fig. 3.1 should be

$$-2x, \; -\frac{dx}{dt}, \text{ and } -\frac{d^3x}{dt^3}.$$

This gives the final equation (8) as

$$\frac{d^3x}{dt^3} + \frac{4d^2x}{dt^2} - \frac{3dx}{dt} + 2x = 0$$

INVESTIGATOR OSCILLOSCOPE *(July-August, 1967)*

The value of VR1 is 20kΩ and *not* 10kΩ as indicated in the components list.

On the wiring diagrams, Fig. 7 and Fig. 8, VR3 and C3 have been wired in reverse order to that shown on the circuit diagram, Fig. 1. However, this does not make any difference to the functioning of the oscilloscope.

The 700A tube is a commercially available tube; the VCR139A is a similar device coded for Ministry use.

A mu-metal shield is not required in the oscilloscope as the reflected field is very little.

To save any further confusion it should be noted that although a 12 pin c.r.t. base is specified there are only 10 pins on the tube, pin positions 6 and 12 being omitted by the manufacturers.

If wirewound pots are not readily available, pots of *solid* carbon variety are quite suitable.

It should be noted that S1 is a three-bank Radiospares "Maka-Switch", each bank having 1 pole 12 ways. Two banks are used electrically, the third being used as a termination point for ease of wiring.

SERVICING AID FOR TRANSISTOR RADIOS *(July, 1967)*

For a square wave output the capacitor C3 should be connected to TR1 collector, *not* to the base.

detached particles

JOHN VALENCE

REQUIEM FOR A COMPUTER

Playing the Dead March from *Saul*, before a specially invited audience, was the final task undertaken by the English Electric DEUCE computer at the company's Kidsgrove Bureau Division.

Victim of accelerating electronic progress, DEUCE at the young age of 13 summers has been outdated by second generation models using transistors. When the first DEUCE computer was brought into use in 1954 it was then the very latest design. But now its valves, mercury delay lines, and magnetic drum storage devices are already relics of the past. Power and glory is so often but a fleeting possession. Like their human masters, these machines are caught up in a ceaseless rat race. Today's successors of DEUCE are more powerful and speedier due to transistorised circuits, but soon *these* machines must start composing their own requiems. The day of the microelectronic computer is dawning. Meanwhile . . . down in the research laboratories they are plotting the downfall of the ferrite core memory device; thin magnetic film storage elements are promising contenders for this field, because they are *faster*. And so it goes on.... As someone said, "stop the world, I want to get off!"

ON RECORD

The craze for speed is not peculiar to electronic computers, it pervades all human affairs. This we know often to our regret. The series of sonic booms kindly presented by Mintech and featuring R.A.F. Lightning jets, provided novel and stimulating sound effects for the Londoner a few weeks ago.

One blast (which incidentally shook my office windows) provided an unwelcome background effect to Joan Sutherland who was at that time recording with the Covent Garden Orchestra in the nearby Kingsway Hall. I believe the Decca Record Company had thoughts of seeking compensation from Mintech.

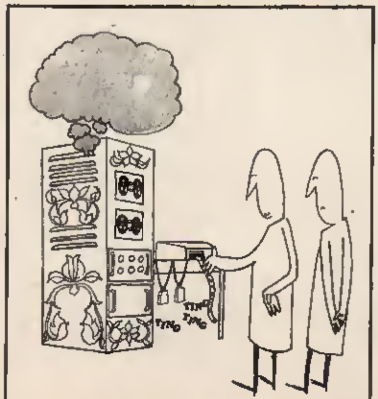
Still, there's a silver lining. Just think of the exciting and exhilarating performances of the 1812 Overture that will be possible (and at no extra expense to the recording company) when supersonic jets boom their way across southern England every ten minutes or so in 1970! In the meanwhile, gramophiles can put their auditive perception to a further test.

Not that I expect many of these "happenings" to escape detection by the makers. Modern recording techniques using tape are certainly very amenable to editing, and unwanted noises-off are not necessarily indelibly recorded for all time, as was the case in the earlier days when wax masters were cut. For example, the Great Western Railway (as it was then) provided some gratuitous accompaniment on certain recordings issued by a famous company way back before the supersonic jet age.

The "steam" accompaniment probably endowed these records with a special value as collectors' items. Present day music lovers are likely to be less tolerant of the percussive contributions from supersonic jets.

SHORT CIRCUIT

Electronics knows no bounds. We are accustomed to hearing, almost every day, of yet some other new and surprising application. Nevertheless, I was rather nonplussed when I saw a newspaper item referring to mini-circuits for High Court judges. It must have been the rather oppressive humid weather we had been experiencing at the time that caused me to think first (perhaps somewhat irreverently) that the newspaper had misprinted "circuits" for "skirts". What a sensible idea, I thought to myself, reflecting on those distinguished gentlemen, heavily garbed in the traditional manner, down the other end of the Strand.



"It says it's opted out"

Then it occurred to me that there had recently been a spot of bother concerning the use of tape recorders in place of the Court shorthand report writer. Ah, perhaps it was concerned with this. But no, for close examination of the newspaper story revealed that mini-circuits relate to proposed shorter tours around towns on Assizes.

Ah, well I suppose they really do have a prior claim on "circuit" having been in business a little longer than electronics. The adoption of the adjective "mini" is surprising—and confusing though.

RALLYING CALL

Warnings of the stiff fight facing the British electronics industry have issued forth from Millbank Tower.

Foreign competition is indeed becoming tougher and we must not treat such warnings lightly. However, there are frequently examples of the old native enterprise breaking through. Two current examples will allow me to bring this month's piece to a reasonably cheerful conclusion:

(1) The Soviet trade foreign organisation is to purchase an English Electric computer (costing £467,500). Confidence in the quality and effectiveness of British-made electronic equipment was mentioned by a U.S.S.R. spokesman as an important factor in selecting this machine.

(2) A major advance in transistor technology has won for Joseph Lucas Ltd. the Queen's Award to Industry for technical innovation. This company was the first to develop and put into volume production high voltage transistors. These Lucas designed components are now being manufactured under licence in the U.S.A. A very welcome reversal of what has (regrettably) become the conventional direction of current flow!

Want to get going in a career as a technician?

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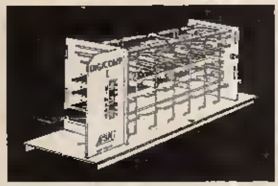

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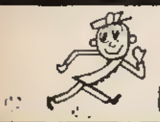

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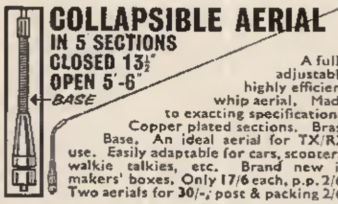

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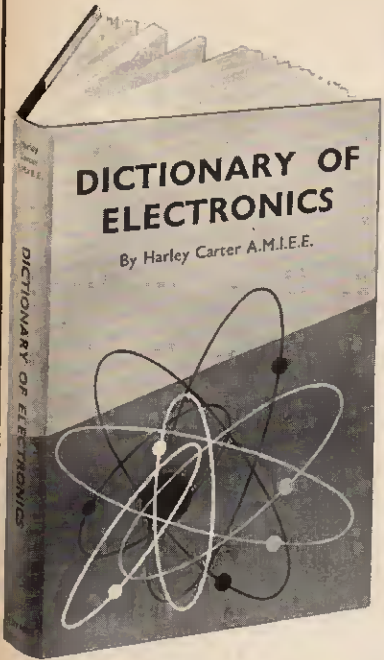

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by Harley Carter, A.M.I.E.E.

The field of electronics has widened to such an extent that, with the new terms introduced with specific branches of the subject, the student and even the scientist find it difficult to keep up with new developments. Many engineers trained in alternative fields of technology are nowadays having to apply their knowledge to electronic equipment. It is with these points in mind that this illustrated dictionary is presented. The concise but explanatory definitions from many branches of electronics, including radio, television, communications, radar, electronic instrumentation and industrial electronics, should prove of use to engineers, students, technicians, apprentices and to all those whose work or interest requires them to understand modern electronic terminology.

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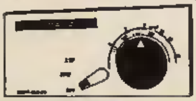

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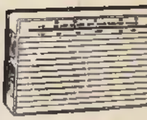

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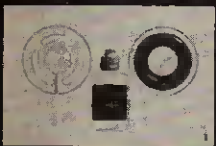

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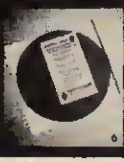

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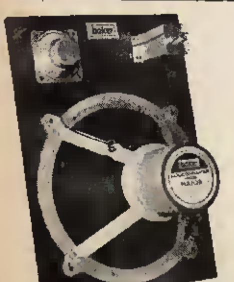

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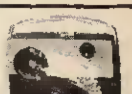

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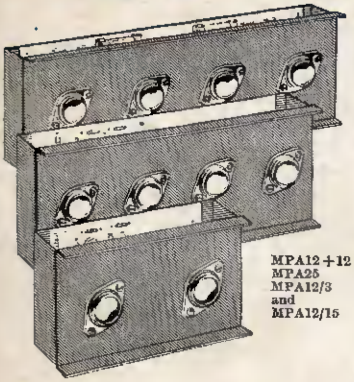

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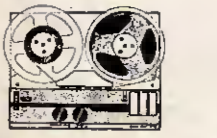

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