Practical Electronics

AUGUST 1966

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ADCOLA
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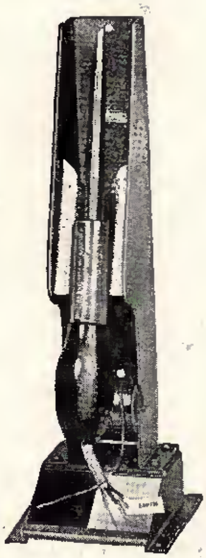

ILLUSTRATED:
L64 $\frac{3}{16}$" BIT INSTRUMENT IN
L700 PROTECTIVE SHIELD

APPLY DIRECT TO:
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LONDON, S.W.4
TELEPHONE: MACAULAY 0291/3

CONDENSER BARGAINS!

ELECTROLYTIC

32uf	...	1·5volt	2uf	...	6volt	64uf	...	9volt	3·2uf	...	64volt
·25uf	...	3volt	10uf	...	6volt	250uf	...	9volt	5uf	...	70volt
2uf	...	3volt	25uf	...	6volt	10uf	...	10volt	4uf	...	100volt
8uf	...	3volt	30uf	...	6volt	100uf	...	10volt	2uf	...	150volt
20uf	...	3volt	2uf	...	9volt	1uf	...	50volt	8uf	...	275volt
100uf	...	3volt	6uf	...	9volt	5uf	...	50volt			
200uf	...	3volt	20uf	...	9volt	8uf	...	50volt			

all at 1/- each or 9/- per doz.

3uf	...	12volt	200uf	...	12volt	100uf	...	15volt	32uf	...	25volt
4uf	...	12volt	6uf	...	15volt	750uf	...	15volt	64uf	...	25volt
6uf	...	12volt	8uf	...	15volt	2·5uf	...	25volt	150uf	...	25volt
10uf	...	12volt	10uf	...	15volt	3uf	...	25volt	16uf	...	30volt
25uf	...	12volt	30uf	...	15volt	4uf	...	25volt	6·4uf	...	40volt
100uf	...	12volt	50uf	...	15volt	25uf	...	25volt	12·5uf	...	40volt

all at 1/3 each or 11/3 per dozen

5,000uf ... 12volt 4/- each. 500uf ... 25volt 3/- each.

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·001uf	...	500volt	7d.	5/3	29/-	£7/5/-
·001uf	...	1,000volt	9d.	6/9	37/6	£9/7/6
·002uf	...	500volt	7d.	5/3	29/-	£7/5/-
·015uf	...	300 A.C.	9d.	6/9	37/6	£9/7/6
·005uf	...	750volt	7d.	5/3	29/-	£7/5/-
·02uf	...	350volt	6d.	4/6	25/-	£6/5/-
·02uf	...	600 A.C.	1/3	11/3	62/6	£15/12/6
·1uf	...	350volt	7½d.	5/8	31/3	£7/16/3
·1uf	...	750volt	9d.	6/9	37/6	£9/7/6
·25uf	...	350volt	10d.	7/6	41/8	£10/8/-
·5uf	...	150volt	1/-	9/-	50/-	£12/10/-
·5uf	...	350volt	1/3	11/3	62/6	£15/12/6
·5uf	...	500volt	1/6	13/6	75/-	£18/15/-

·0001uf	...	200volt
·001uf	...	200volt
·002uf	...	200volt
·005uf	...	200volt

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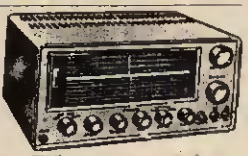
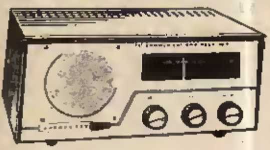
LAFAYETTE HA-63 COMMUNICATION RECEIVER

7 valves plus Rectifier. 4 Bands. 550 kc/s—31 Mc/s. "S" Meter—BFO—ANL—Bandspread Tuning. 200/250 v. A.C. Brand New **24 Gns.** Carr. Paid.

LAFAYETTE HA-230 AMATEUR COMMUNICATIONS RECEIVER



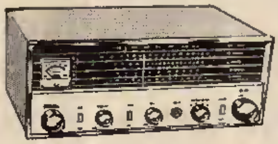
Supersedes model HE-30. 8 valves + rectifier. Continuous coverage on 4 bands. 550 Kc/s—30 Mc/s. Incorporates 1 RF & 2 IF stages, Q Multiplier, B.F.O., ANL, "S" meter, Electrical bandspread, Aerial trimmer, etc. Supplied brand new and guaranteed. **£33.** S.A.E. for full details. Also available in semi Kit Form. **25 gns.**



LAFAYETTE HA-55 A AIRCRAFT RECEIVER

108–136 Mc/s. High selectivity and sensitivity. Incorporates 2 RF stages including 6CW4 Nuvistor, 8 tubes for 11 tube performance, solid state power supply, adjustable squelch control, slide rule dial, built in 4in. speaker and front panel phone jack. 220/240V. A.C. Supplied brand new and guaranteed. **£19.7.6.** Carr. 10/-. 108-176 Mc/s Ground Plane Antenna 59/6.

HAM-1 COMMUNICATION RECEIVER



5 valve superhet receiver covering 550 Kc/s—30 Mc/s on 4 bands. Special features include slide rule dial. Bandspread tuning. 'S' meter. B.F.O. Built in 4" speaker. Operation 220/240 v. A.C. Brand New with instructions. **16 GNS.** Carr. 10/-. S.A.E. for details.

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8 Amp	£13.10.0
10 Amp	£17.0.0
12 Amp	£19.10.0
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5¾in. 2,400ft. T.P. mylar	45/-
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7in., 1,800ft. L.P. acetate	15/-
7in., 1,800ft. L.P. mylar	20/-
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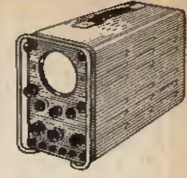
PORTABLE OSCILLOSCOPE CT.52



A compact (9"×8"×16½") general purpose 'scope. T/B 10 c/s-40 kc/s. Band width 1 Mc/s. Mullard DG 7/5 2½" CRT. For operation on 200/250 v. A.C. Supplied complete with metal transit case, strap, test leads, and visor hood. Brand new. **£22.10.0.** Carr. 10/-. Supplied complete with instructions.

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High quality Portable American Oscilloscope. 3" c.r.t. T/B 3 c/s-50 kc/s X Amp: 0-500 kc/s Y Amp: 0-2 Mc/s. Power requirements 105-125v. A.C. Supplied in brand new condition, fully tested. **£25.** Carr. 10/-. Suitable 230/115v. Transformer **15/6.**

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Accurate wide range signal generator covering 120 kc/s.-260 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions, **£12.10.0.** P. & P. 7/6.

S.A.E. for details.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYZER

2 PF—2,000 MFD. 2 ohms—200 Megohms. Also checks impedance, turns ratio, insulation 200/250v. A.C. Brand New **£15.** Carr. 7/6.

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Compact true one hand operation. Frequency range 1.7-150 Mc/s. 230v. AC operation. Supplied complete with all coils and instructions. **£12.10.0.** Carr. 5/-.

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Sine 20 cps to 200 kc/s. on 4 bands. Square: 20 cps to 20 kc/s. Output impedance 5,000 ohms. 200/240 v. A.C. operation. Supplied Brand New and Guaranteed with instruction manual and leads. **£15.** Carr. 7/6.

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Transistorised Audio Generator 10-100,000 c/s. Sine or square wave. **£16.15.0.**
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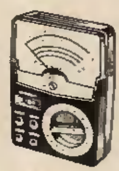
		500-0-500µA	22/6	300mA	22/6	150V D.C.	22/6
		1-0-1mA	22/6	500mA	22/6	300V D.C.	22/6
		1mA	22/6	750mA	22/6	500V D.C.	22/6
		2mA	22/6	1A D.C.	22/6	750V D.C.	22/6
		5mA	22/6	2A D.C.	22/6	15V A.C.	22/6
		10mA	22/6	5A D.C.	22/6	50V A.C.	22/6
50µA	32/6	20mA	22/6	3V D.C.	22/6	150V A.C.	22/6
100µA	29/6	50mA	22/6	10V D.C.	22/6	300V A.C.	22/6
200µA	27/6	100mA	22/6	20V D.C.	22/6	500V A.C.	22/6
500µA	25/-	150mA	22/6	50V D.C.	22/6	"S" Meter 1mA	29/6
50-0-50µA	29/6						

POST EXTRA. Larger sizes available—send for lists.

TE-51 NEW 20,000Ω/VOLT MULTIMETER



0 / 6 / 60 / 120 1,200V. A.C.
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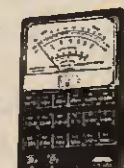
85/-. P. & P. 2/6.

TS-76 20,000 O.P.V. PUSH BUTTON MULTI-TESTER



Simple operation, D.C. volts up to 1,000 v. A.C. volts up to 1,000 v. Resistance up to 10 megohm. Current up to 250 mA. Decibels —20 to +36 db. **£5.5.0.** P. & P. 2/-.

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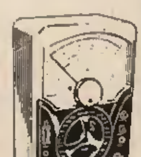
11 meg. input. 7 D.C. volt ranges. 1.5-1,500 v. 7 A.C. volt ranges 1.5-1,500 v. 4,000 Peak to Peak. Resistance .2 ohm to 1,000 megohm. Decibels —10db to +65db. Supplied brand new with instructions, leads and probe. **£12/10/-.** P. & P. 3/6.



MODEL 500. 30,000 o.p.v. 0/.5/1/2.5/10/25 / 100 / 250 / 500 / 1,000v. D.C.
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Chassis size 15 x 6½ x 5½in. high. New manufacture. Dial 14½ x 4in. in cream and red. 200-250v. A.C. only.
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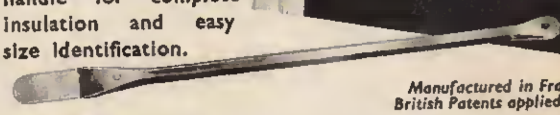
DIACROM SPATULA

The "Diacrom" is a metal spatula upon which diamond powder has been deposited by a special process. No deep scratches are possible because density is controlled and the polishing of the contacts is achieved by a gentle brushing motion. With coloured nylon handle for complete insulation and easy size identification.



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British Patents applied for

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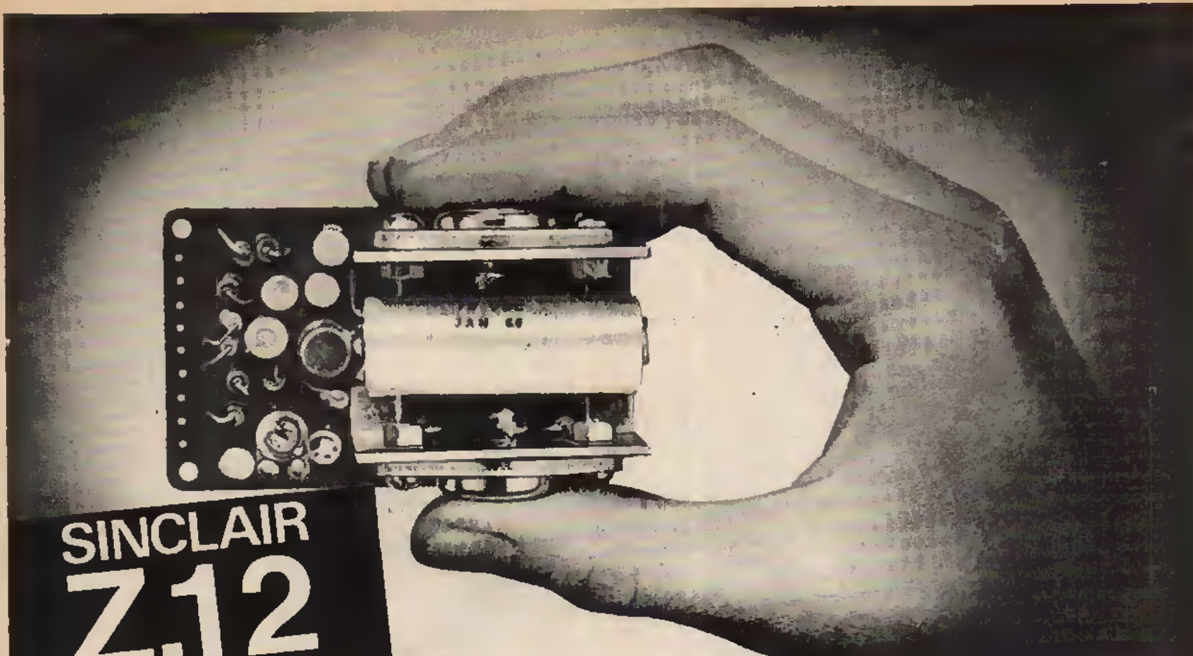

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INTEGRATED 12 WATT AMPLIFIER AND PRE-AMP

UNEQUALLED FOR QUALITY AND POWER

The Sinclair Z.12 has been developed to the highest possible standards for an amplifier of its size and power. At the same time its rugged construction and its amazing adaptability make it possible to use just *ONE* type of amplifier in an exceptionally wide variety of applications. Eight special H.F. transistors are used in a highly original circuit to achieve the characteristics demanded of any quality amplifier, irrespective of price, yet this Sinclair unit costs well under £5.0.0, including its own integrated pre-amplifier stage. It will function efficiently from anything between 6 and 20 volts, making it very convenient to run the Z.12 from a car battery, for example. Where it is required to run the Z.12 from mains supply, the PZ.3 is recommended. The Z.12 accepts radio, microphone and pick-up inputs, and detailed instructions for connecting these in mono and stereo are given in the manual supplied with every unit, together with a variety of matching control networks. Those wishing to have the very finest pre-amplifier and control system can connect inputs via the Stereo 25, a new unit designed specially for use with the Z.12 to produce the very finest stereophonic hi-fi you have ever heard—and the saving to you in cost is fantastic.

12 WATTS R.M.S. OUTPUT Continuous sine wave

(24 WATTS PEAK)

15 WATTS R.M.S. MUSIC POWER (30 W. PEAK)

SIZE—3″ × 1¾″ × 1¼″

IDEAL ALSO FOR CAR RADIO, GUITAR, P.A. AND INTERCOM SYSTEMS, ETC.

• TECHNICAL SPECIFICATION

The Sinclair Z.12 combined twelve watt amplifier and pre-amplifier uses eight H.F. transistors in an original design developed by Sinclair Radionics to ensure exceptional standards of reproduction. The pre-amp incorporated accepts all types of inputs. For the very best possible hi-fi stereo, two Z.12's should be used with the Sinclair Stereo 25 described opposite.

- **OUTPUT**—Class B, ultra-linear, with generous negative feed-back
- **FREQUENCY RESPONSE**—15 to 50,000 c/s ±1dB
- **INPUT SENSITIVITY**—2 mV into 2 K ohms
- **SIGNAL TO NOISE RATIO**—better than 60dB
- **OUTPUT IMPEDANCE**—suitable for 3, 7.5 and 15 ohm loudspeakers. Two 3 ohm speakers may be used in parallel
- **POWER REQUIREMENTS**—6 to 20 volts D.C.
- **QUIESCENT CURRENT CONSUMPTION**—15 mA

FULL SERVICE FACILITIES AVAILABLE TO ALL SINCLAIR CUSTOMERS

BUILT, TESTED AND GUARANTEED 89/6

Z.12 USERS WRITE

"I fitted it up for a guitar. It (Z.12) is a marvellous instrument and money well spent." *R.M.K., Lanark.*

"Members of our staff are ordering Z.12's for personal use they were so impressed by the one we have in use now. I now need a second Z.12 (by air mail please)." *A.J.V., O'seo Telecommunications Commission, New Guinea.*

"I am most pleased with its terrific performance." *H.R.L., Westor-super-Mare.*

"Fidelity is well up to the standards I require for a tuner and record player system." *A.C.R., Nottingham.*

SINCLAIR MICRO-6
SINCLAIR MICRO-FM

see preceding page

sinclair

sinclair radionics ltd.
22 newmarket road, cambridge

Telephone 52731

SINCLAIR STEREO 25
DE-LUXE PRE-AMPLIFIER AND CONTROL UNIT

DESIGNED TO THE FINEST HIGH FIDELITY STANDARDS

Sinclair's newest unit, the Stereo 25 has been designed specially to obtain the very finest results used in conjunction with the Sinclair Z.12 for stereo reproduction. The best quality components, individually tested before acceptance, are used in its construction, ganged controls are carefully checked for matching, whilst the overall appearance of this very compact de-luxe pre-amp control unit reflects the professional elegance which characterises all Sinclair designs. The front escutcheon panel is in solid brushed and polished aluminium with beautifully styled solid aluminium knobs. Mounting the unit is simple, and the generous output of the PZ.3 is more than enough to power the Stereo 25 together with two Z.12's for stereo. Hi-fi enthusiasts seeking the ultimate in equipment for domestic listening will find all they want from this combination of Sinclair units, and with a Micro FM to provide the radio, their installation will be just about as good as anything costing up to FIVE TIMES as much.

● TECHNICAL SPECIFICATION

Performance figures were obtained using the Sinclair Stereo 25 fed to two Z.12's and the entire assembly powered by a PZ.3 Power Supply Unit.

- **SENSITIVITY** for 10 watts into 1.5 ohms load per channel
  Mic.—2 mV into 50 K ohms
  Pick-up—3 mV into 50 K ohms
  Radio—20 mV into 4.7 K ohms
- **FREQUENCY RESPONSE** (Mic. and Radio)—25 c/s to 30 kc/s ± 1dB extending to 100 kc/s ± 3dB
- **EQUALISATION FOR P.U.**—Correct to within ± 1dB on RIAA curve from 50 c/s to 20 kc/s.
- **TONE CONTROLS**
  Treble +12dB to —10dB at 10 kc/s
  Bass +15dB to —12dB at 100 c/s

SIZE—$6\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$ ins. overall, plus knobs. FINISH—Front panel in brushed and polished solid aluminium with solid aluminium knobs. Black figuring on front panel.

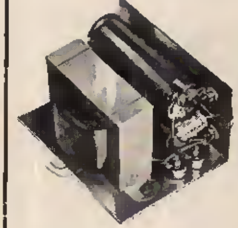
BUILT, TESTED AND GUARANTEED £9.19.6

Your Sinclair Guarantee
If you are not completely satisfied when you receive your purchase from us, your money will be refunded at once in full and without question.

A COMPLETE HIGH FIDELITY STEREO ASSEMBLY FOR £22.18.0

All you need is one **Stereo 25** Pre-amp Control Unit (£9.19.6), two **Z.12's** (£8.19.0) and one **PZ.3** Mains Power Supply Unit (£3.19.6) to possess the finest possible hi-fi stereo installation. As a very desirable optional extra, you could include the **Micro FM** (£5.19.6) described on page one of our advertising. The all-over saving to you in cash will be staggering, and you will have an installation second to none irrespective of price.

SINCLAIR PZ.3
POWER SUPPLY UNIT



Designed specially for the very high standards of the Z.12, this entirely NEW power supply unit uses advanced transistorised circuitry to achieve exceptionally good smoothing. Ripple is a barely measurable 0.05V. The PZ.3, which will power two Z.12's and the Stereo 25 with ease, costs—

79/6

If you prefer not to cut this page, please mention PE.8 when writing your order.

To SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

Please send ....
....
for which I enclose
....
CASH/CHEQUE/MONEY ORDER for
£ s. d.

NAME ....
ADDRESS ....
....
....P.E.8

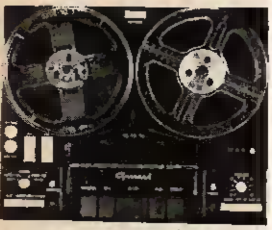
sinclair

LASKY'S RADIO

For the Finest Value and Service to HOME CONSTRUCTORS & ELECTRONICS ENTHUSIASTS

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

TAPE RECORDERS



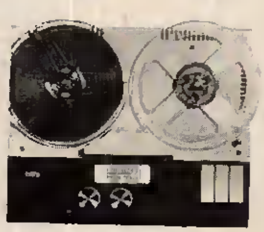
Carriage and Packing Free

JUST ARRIVED — THE NEW GARRARD STEREO DECK

Now available from stock — superb specification. Three ¼ track stereo/mono heads; 3 speeds—1⅞, 3¾, 7½ i.p.s.; takes 7in. spools; fast forward and rewind; tape position indicator; pause control; separate record, replay and erase heads— 4 tracks; piano key controls interlocked for all functions; stop/start can be remotely controlled; auto., tape-end stop. Heavy duty motor, capacitor start and run, large dynamically balanced flywheel. Deck finished in grey plastic, size: 14½ × 12 × 6 in., depth below plinth 4in. For 110 v. 50 c.p.s. Mains operation. Auto-transformer for 200/250 v. included free.

LASKY'S PRICE 29½ GNS.

MAGNAVOX-COLLARO 363 TAPE DECKS



The very latest 3 speed model—1⅞, 3¾, 7½ i.p.s. available with either ½ track or ¼ track head. Features include: pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate: 13½ × 11 × 5¼in. deep below unit plate. For 200/250 v. A.C. mains, 50 c.p.s. operation. New unused and fully guaranteed.

LASKY'S PRICE ½ track model £10.10.0

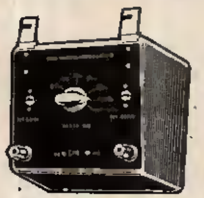
LASKY'S PRICE ¼ track model £13.9.6

Carriage and Packing 7/6 extra.

SPECIAL FOR OVERSEAS CUSTOMERS — the new Magnavox-Collaro 363 Deck for 110/125 v. 50 or 60 c.p.s. mains now available, prices as above. Post to any part of the world 35/-.

SPECIAL INTEREST ITEMS!

TEST METER ADAPTOR



Type P.E. 220—this is a fully transistorised device which enables any 50 microamp D.C. Multimeter to be used in place of a valve volt meter. On the 1V. range an impedance of 1 megohm is offered which increases on the 1000 V. range to 100 megohms. 7 ranges: 1 to 1000 volts. Designed for immediate connection to Avo 8 and similar size meters but quite suitable for use with any other 50 microamp meter. Size 6 × 6 × 5 in. New and boxed. List Price 7 Gns.

LASKY'S PRICE 39/6

Post 2/6. Set of batteries 7/5 extra.

SPECIAL PURCHASE—UHF/VHF TUNERS

Well known British makers' surplus stocks. Now available for the first time to the Home Constructor.

TRANSISTORISED UHF MINIATURE MODEL

Shielded metal case only 3½ × 1½ × 3in. Fully tunable—complete with two AF 139 transistors. LASKY'S PRICE 39/6

VALVE UHF MODEL *(Illustrated)*

In metal case size 4 × 6 × 1½in. Fully tunable—complete with PCC86 and PCC88 valves. LASKY'S PRICE 32/6. Without valves 19/6.

TRANSISTORISED VHF MODEL 1

Miniature turret type fitted with 12 sets of coils and 3 Mullard AF102 transistors. In metal case size 4 × 2 × 3½in. LASKY'S PRICE 29/6

TRANSISTORISED VHF MODEL 2

Sub-miniature turret type fitted with 12 sets of coils and 3 Mullard AF102 transistors. In metal case size 3 × 1½ × 2½in. LASKY'S PRICE 37/6

Add 2/6 Post and Packing on each.

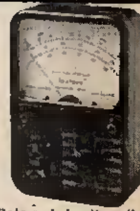
CONSTRUCTORS BARGAINS

The "Sixteen" Multirange METER KIT

This outstanding meter was featured by *Practical Wireless* in the Jan. '64 issue. Lasky's are able to offer the complete kit of parts as specified by the designer.

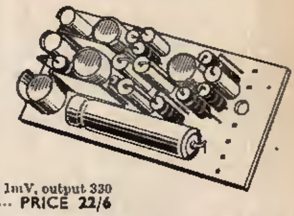
RANGE SPECIFICATION: D.C. volts: 0-2.5-25-50-250-500 at 20,000 Ω/V. A.C. volts: 0-25-50-250-500 at 1,000 Ω/V. D.C.current: 0-50μA, 0-2.5-50-250mA. Resistance: 0-2,000 Ω, 0-200kΩ, 0-20 MΩ. Basic movement: 40μA f.s.d. moving coil. With universal shunt full scale deflection current is 50μA. Black plastic case—3½ × 5½ × 1½in. Controls: 12 position range switch; separate slide switch for A.C. volts—D.C. ohms; ohms zero adjustment pot, meter, meter zero. Power requirements: One 15v. and one 1.5v. batts. Complete with all parts and full construction details. H.P. Terms available.

LASKY'S PRICE £5.19.6. P. & P. 5/-



Data and circuit available separately. 2/6; refunded if all parts bought. Pair of batteries 2/- extra.

NEW—LASKY'S MINIATURE TRANSISTOR AMPLIFIER MODULES



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**

TYPE PC 1. 3 transistor. Input sens. 50 mV., output 150 mW, output imp. 40 Ω, size 2 × 1 × ¾in....... PRICE 27/6

TYPE PC 2. 5 transistor. Input sens. 1mV, output 330 mW, output imp. 15 Ω, size 2½ × 1½ × ¾in.... PRICE 22/6

TYPE PC 3. 5 transistor. Input sens. 5 mV, output 400 mV, output imp. 15 Ω, size 2½ × 1½ × ¾in. .... PRICE 25/-

TYPE PC 4. 5 transistor. Input sens. 150 mV, output 330 mV, output imp. 15 Ω, size 2½ × 1½ × ¾in. .... PRICE 22/6

TYPE PC 5. 6 transistor. Input sens. 8mV, output 3W, output imp. 3 Ω, size 5½ × 1¾ × 1in. .... PRICE 59/6

TYPE PC 7. 6 transistor. Input sens. 8mV, output 1W, output imp. 8 Ω, size 3 × 1¾ × ¾in. .... PRICE 39/6

SINCLAIR SUPER MINIATURES

We stock the complete range. Write for details of package deals.

THE MICRO-6 miniature radio only 1⅞ × 1 5/16 × 1½in.	£2 19 6
THE SLIMLINE 2-transistor pocket radio	£2 9 6
THE MICRO-FM. (tuner/receiver)	£5 19 6
THE X-20 20 watt P.W.M. amplifier	£7 19 6
Available ready built, tested and guaranteed	£9 19 6
THE X-10 10 watt amplifier and pre-amp	£5 19 6
Available ready built, tested and guaranteed	£6 19 6
THE Z-12 12 watt amplifier and pre-amplifier. Fully built and tested	£4 9 6

VEROBOARD — High grade laminated board with copper strips bonded to it and pierced with holes.

Boards

42/1503	2½ × 5 in.	3/8
43/1504	2½ × 3¾ in.	3/-
45/1507	3¾ × 5 in.	5/2
46/1508	3¾ × 3¾ in.	3/8
44/1505	3¾ × 17 in.	12/6

Accessories

Terminal pins — pkt. of 50	3/-
Spot face cutter tool	8/6
Pin inserting tool	9/9

Post 6d. per item extra.
Orders of 10/- and over post free.

TRANSISTORS — ALL BRAND NEW AND GUARANTEED

GET 81, GET 85, GET 86 2/6; 873A, 874P 3/6; OC45, OC71, OC81D 4/6; OC 44, OC 70, OC 76, OC 81 5/6; pair (10/6); AF 117, OC 200 6/6; OC 42, OC 43, OC 73, OC 82D 7/6; OC 201, OC 204 15/-; OC 205, OC 206 19/6; OC28 24/6; OC 75 8/-.

TRANSFILTERS By BRUSH CRYSTAL CO. Available from stock.

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

7/6 EACH Post 6d.

GORLER UT 340 FM/VHF TUNING HEART

Permeability tuned — covering 87 to 108 Mc/s. For use with one ECC85 valve. In metal case, size 3 × 2½ × 1½in. Circuit supplied

LASKY'S PRICE 15/11 Post 2/-. ECC85 valve 9/- extra

207 EDGWARE ROAD, LONDON, W.2 Tel: PAD 3271
33 TOTTENHAM CT. RD., LONDON, W.1 Tel: MUS 2605
Both open all day Saturday. Early closing Thursday.

42 TOTTENHAM CT. RD., LONDON, W.1 Tel: LAN 2573
152/3 FLEET STREET, LONDON, E.C.4 Tel: FLE 2833
Both open all day Thursday. Early closing Saturday.

Please address all Mail Orders and Correspondence to 3-15 Cavell St., Tower Hamlets, London, E.1. Tel.: STE 4821/2

LASKY'S FOR SPEEDY MAIL ORDER SERVICE

SNIPERSCOPE

Famous war-time "cat's eye" used for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. A golden opportunity for some interesting experiments. 5/- each, post 2/-. Data will be supplied with cells, if requested.

MAINS POWER PACK

MAINS POWER PACK designed to operate transistor sets and amplifiers. Adjustable output 6v.-9 to 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries. PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer-rectifier, smoothing and load resistor, 5,000 and 500 mfd. condensers, zener diode and instructions. Real snip at only 14/6, plus 3/6 post.

SPEAKER BARGAIN

12 in. High fidelity loudspeaker. High flux permanent magnet type with either 3 or 15 ohm speech coil. Will handle up to 10 watts. Brand new, by famous maker. Price 29/6, plus 3/6 post and insurance.

ARDENTE HEARING AID

If not wanted as hearing aid these could be the basis of radio control units:—pocket transmitter, staff locators, etc. They are beautifully made little units and they contain many subminiature parts including crystal microphone on/off switch, volume control with on/off switch, interstage transformer, Mullard valves types DL 66 and DF 64 (2 of). All parts in good order in fact hearing aids believed to be in working order but not guaranteed so—complete in plastic case with pocket clip, only 29/6 (earphone not included).

SILICON CONTROLLED RECTIFIER. 500v 10A. 30/-.

THERMOSTATS

Type 'A' 15 amp for controlling room heaters, greenhouse, airing cupboard. Has spindle for pointed knob quickly adjustable from 30°—80°F. 9/6 plus 1/- post. Suitable box for wall mounting, 5/-. P. & P. 1/-.

Type 'B' 15 amp. This is a 17in. long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550°F. Internal screw alters the setting so this could be adjustable over 30° to 1,000°F. Suitable for controlling furnace, oven, kiln, immersion heater or to make flamestat or fire alarm, 8/6 plus 2/9 post and insurance.

Type 'D' We call this the Ice-stat as it cuts in and out at around freezing point 2/3 amps. Has many uses, one of which would be to keep the loft pipes from freezing if a length of our blanket wire (16 yds. 10/-) is wound round the pipes, 7/6. P. & P. 1/1.

Type 'E' This is a standard refrigerator thermostat. Spindle adjustments cover normal refrigerator temperature, 7/6 plus 1/- P.

Type 'F' Glass encased for controlling the temp. of liquids—particularly those in glass tanks, vats or sinks—thermostat is held (half submerged) by rubber sucker or wire clip—ideal for fish tanks, developers and chemical baths of all types. Adjustable over range 50° to 150°F—Price 18/- plus 2/- post and ins.

TWO WAY RADIOS

Give communication over ½ mile. FULLY transistorised—crystal controlled, built-in telescopic aerial—press button operation—PP3 batteries—pair instruments complete and ready to use £6.19.6, plus 5/- post and insurance. These cannot be operated in U.K.

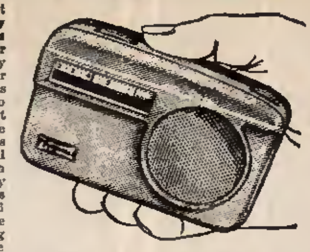
Three Unusual Items

OZONE OUTFIT—for removing smells and generally improving any oppressive atmosphere. Kit consists of Philips Ozone Lamp and mains unit, only needs box, 91/6 plus 3/6 post and insurance. **BLACK LIGHT UNIT.** 40 watt intensity, comprises lamp, lamp holder and 40 watt choke. Only 19/6 plus 6/6 carr. & ins.

TIMER KIT. Special offer of all components except metal box to make mains operated interval timer for photography, etc. 12/6 plus post 2/6.

Where postage is not definitely stated as an extra then orders over £3 are post free. Below £3 add 2/9.

STUPENDOUS OFFER—£11 for £2



The Princess superhet described below is a very fine little set that has carefully designed for high performance. Only recently (under another name of course) this was on offer in many radio shops, for £10.19.6, but we have been fortunate in obtaining the parts at a very low price and now pass this saving on to you. If you act quickly you can purchase this for only 39/6 plus 3/6 post and insurance. Note these features: ● Long and Medium Wave ● Long clear dial with travelling pointer and slow motion drive ● Push-pull output approximately 350 m.w. ● A.V.C. and feedback ● Dust cored H.Q. I.F. transformers ● High selectivity ferrite aerial ● Six tested transistors ● Printed circuit board for foolproof assembly ● Economy output circuit gives long life from PP3 battery ● Permanent magnet moving coil speaker ● Cabinet size 4⅝in. x 3in. x 1½in.

You get over 100 parts (list value over £10). In fact everything you need and easy to follow wiring and aligning instructions. Don't miss this wonderful offer. Make up several while you have the chance. Use them as presents and you'll be loved for ever. Made up chassis 10/- extra. Battery 1/9 extra. Data separately 2/6.

750 mW TRANSISTOR AMPLIFIER

4 transistors including two in push-pull input for crystal or magnetic microphone or pick-up—feed back loops—sensitivity 5 m/v.

Price 19/6

Post and insurance 2/6.

Speakers 3in. 12/6; 5in. 13/6; 6in. x 4in. 14/6.

THIS MONTH'S SNIP

A MOVING COIL METER BARGAIN. Panel meters are always being needed and they are jolly costly when you have to buy them in a hurry—so you should take advantage of this offer:—2in. moving coil flush mounting meters only 5/6 each or 48/- a dozen unused and in makers' boxes. These are actually R.F. meter and cost about £3 each but if you don't want them for R.F. then all you have to do is to remove the thermo-couple and you will have a 2-3 m.a. meter which you can make into almost anything by adding shunts or series resistor. These are ex-government of course.

NIM COMPUTER

All components and front panel to make the computer described in PRACTICAL ELECTRONICS (data supplied or available separately 2/6) are available as a kit price £4.17.6 plus 3/6 post and insurance.

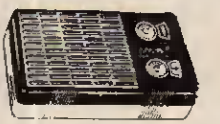
YAXLEY SWITCHES

Number of Ways or Positions

Poles	2 way	3 way	4 way	5 way	6 way	8 way	11 way	12 way
1	3/-	3/1	3/6	3/9	3/11	4/5	5/-	5/2
2	3/8	4/1	4/6	5/3	5/5	6/7	7/8	8/3
3	4/4	6/-	5/9	7/8		8/9	10/6	11/3
4	5/-	5/11	6/9	8/6	8/7	11/-	13/3	14/4
5	5/9	6/9		9/6	10/3	13/9	16/-	18/-
6	6/5	7/8	9/1	10/6	11/10	16/6	18/9	20/6
8	8/9	9/6	11/5	12/-	15/-	19/9	24/3	27/6
10	11/-	11/6	13/6	14/6	18/3	24/9	30/-	33/-
12	13/3	13/9	16/-	17/6	21/8	30/-	35/-	39/6
14	15/6	16/-	20/6	25/-				
16	17/9	18/-	21/-	23/6	28/6			

1 pole 24 way 15/- 2 pole 24 way 25/-.

CORONET PARCEL



Here's a bargain for you—parcel comprises: plastic case, printed circuit board, two dial knobs, volume control, earphone socket and plastic carrying case all for 8/6 plus 1/6 post.

AUTOCHANGER BARGAIN

GARRARD AUTO RECORD PLAYER Model 2000

This is one of the latest products of the World's most experienced maker of fine record reproducers—Its superior features include—automatic playing of up to 8 mixed size records—stopping and starting without rejecting—manual playing—pick-up pivots to give low stylus pressure—large diameter turn-table for max. stability—adjustments include pick-up height—pick-up dropping position and stylus pressure. Size is 13¼in. x 11¾in. clearances 4¾in. above 2¾in. below—fitted with latest hi-compliance cartridge for stereo—and mono., L.P. and 78. Supplied complete with mounting template and service sheet. Offered this month at the Special Snip price of £6.9.6 plus 7/6 carriage and insurance.

SUMMER SALE

Bargains Unlimited

TAPE DECK BARGAIN, 240v. Mains motor with capstan and heavy fly wheel to drive the tape at a very steady 3¾. Mounted on deck with high z tape head—the deck is shaped to take a Reditune cassette but its an easy matter to fit two spindles to take normal spools. The deck is enclosed in a metal box, with carrying handle, mains neon indicator, voltage adjustment panel and various input and output sockets. Size of the box is 11¼ x 10¼ x 7in. and there is plenty of room for an amplifier—this looks just the right unit for any one wanting to make a playback machine, telephone answerer, etc. A limited quantity only of these, price 37/6 plus 7/6 post and insurance.

MINIATURE RELAYS, with removable covers, very sensitive (will close on only 20 mA). Coil resistance 10,000 ohms—contacts are three sets:—triple set for changeover pair to open circuit and the third pair to close circuit—perfect order unused (removed from equipment) 7/6 each.

MAINS TRANSFORMER—upright mounting with primary tapped 200, 220, 240v. H.T. secondary is 250v.-0-250v. at 100 mA and it has two L.T. secondaries of 6.3v. 1½ amp—unused (removed from equipment) 15/- plus 3/6 post and insurance.

MULLARD SILICON RECTIFIER. 350v. 100 ma removed from unused equipment, perfect and guaranteed, ref. BY100, 4/6 each.

SOUND POWERED INSERTS. These are very delicately made units and work well either as microphones or loudspeakers—mount them on suitable boxes and you will be amazed how sensitive they are, they need no batteries or maintenance. Cost from makers over £1 each. Our price while stocks last is 5/6 each.

REED SWITCHES—a pair of contacts sealed into a glass tube. When a magnet comes close the contacts close immediately and the circuit is switched on—for burglar alarms on doors or windows—moving displays for advertising—rev. or batch counting-relay circuits, are new and perfect, price is 6/6 each.

½ MEG POTS. By ERIE, standard ¼in. spindle 1in. long, 7d. each in doz. lots, otherwise 10d.

½ MEG POTS WITH D.P. SWITCH. Again by ERIE, standard size spindle 1in. length, 10d. each in doz. lots, otherwise 1/3 each.

MINIATURE PICK UP. For pop records—this is made by Cosmocord—has a crystal cartridge and long play sapphire stylus—offered for less than the wholesale price of the stylus only—namely 3/9 each or 36/- per doz.

SYNCHRONOUS METER MOTOR. This is self starting and has a cog ended spindle—add a train of gears and you have a clock or hours elapsed meter, or it would drive a little fan to keep equipment cool or similar job, brand new and perfect 5/6 each, 54/- per doz.

RELAY SWITCHES. These enable micro switches, delicate thermostats or other low current devices to control up to 30 amps—ideal to switch thermal storage heaters, motors, etc., made by the famous A.E.I. group. These are listed at £25 each—you can buy if you hurry at a very keen price of 39/6 each and we will include diagrams and data. Mounted on panel size approximately 9×7×2in. deep.

UNBREAKABLE MAINS LEAD. Type of lead fitted to electric razors, makes fine lead for test meters and any other devices where subject to continuous bending. Twin figure eight construction, soft cream P.V.C. covered. Normally costs 2/- per yard. Three 6ft. leads for 2/-.

MAINS FROM CAR BATTERY. Rotary generators 12v. input, 240v. output, 110 mA, 40/-, 300 mA, £5 plus 5/- post.

H.R.O. POWER PACK, suitable 240 or 115 volt mains, gives 250v. H.T. and 6.3v. l.t., unused but soiled and less rectifier valve 19/6 plus 6/6 post.

A.C./D.C. AMMETER, 2½in. flush mounting, 0.8 amps. but external shunt easily removed, offered at silly price 8/6; £5 doz.

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VOL. 2 No. 8
AUGUST 1966

Practical Electronics

INVESTMENT FOR THE FUTURE

WHATEVER may have been the Government's real intention with regard to ELDO, the suspicion that withdrawal was seriously contemplated had quite a remarkable effect. Protagonists for Britain's continued participation in this European project for launching communications satellites must have been greatly heartened by the amount of publicity it received in the National press, and on radio and television.

Naturally enough the ensuing debate brought forth a flood of argument, both for and against this project. The aerospace and electronics industries certainly left no doubt as to their feelings on the subject. Perhaps the storm of protest aroused by the hint that we might abdicate our role in space really surprised the Minister of Aviation. Anyhow eventually he too became convinced of the vital importance of this programme to our future as a technological power.

The fountain-head of much of today's electronic development is the space programme of the U.S.A. This much is apparent to any keen observer: the evidence can be seen in exhibitions and also in published data relating to new circuit devices which are coming onto the commercial market in the States.

Chief grounds for opposition to ELDO seem as follows: firstly, the limited technical achievements possible when measured against the space activities of the U.S.A. and U.S.S.R.; secondly, the additional burden this will place on our already strained financial resources.

What is overlooked by these critics is the fact that this is an investment for the future—in minds as well as material things. Without large scale programmes of technical development it is impossible to provide stimulating and satisfying work for our brightest engineers and scientists, and for the even larger numbers of technicians who back up their efforts in research, development, and industry.

The "brain drain" is today already a matter for concern. One export trade we do *not* want to encourage is that in the output product of our new and expanded technical schools and colleges.

The wrong decision over ELDO could well have jeopardised the further expansion of electronics in this country. This, one might add without any exaggeration, would be calamitous for Britain.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our September issue will be published on Thursday, August 11

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. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 36s.

RADIO ASTRONOMY

by C. B. Sibley

IN 1932 a young American radio engineer, Karl Jansky, employed by the Bell Telephone Laboratories, was studying the effects of static charges upon short wave radio communication at 20Mc/s. After making a considerable number of measurements, Jansky made what was then a surprising announcement.

At certain times during the 24 hour day Jansky's receiver detected peaks in static noise which coincided with the apparent movement of the Milky Way star galaxy through the beam width of Jansky's receiving aerial system, see Fig. 1. He concluded that the static must have come from the Milky Way.

Karl Jansky's discovery was by and large accepted by his scientific colleagues, but strangely it did not stir further scientific investigation at the time. Jansky himself accepted his discovery and then turned his attentions and talent to other communication problems.

FIRST RADIO ASTRONOMER

A few years after Jansky's discovery another American, this time a radio amateur, Grote Reber, became interested in these strange extra-terrestrial signals. Reber worked for nearly 11 years (1936–1947), designing and building a radio telescope that, to say the least, was prophetic of radio telescopes of the future. He produced the first "radio" map of the sky during the year 1940.

In spite of this ambitious project it is interesting and very significant to note that he was looked upon as an amateur at this time. Reber scientifically exploited Jansky's discovery and in so doing he gave man a most valuable scientific tool with which to study the universe.

Although Karl Jansky must be remembered for his great discovery, Reber must surely be called the first radio astronomer.

During the war radar screens periodically became subjected to sudden bursts of intense interference, which appeared on the radar screen in a manner not unlike a "snow storm". At first it was suggested the enemy were attempting to "jam" the allied radar network. It soon became evident that this was not so; in fact the sun was found to be the culprit. This phenomenon was reported in 1942.

When eventually war ceased and scientists settled down to tasks of peaceful research and development, physicists and astronomers began to re-digest the findings of Jansky and Reber and the war reports of cosmic interference. War surplus radio and radar equipment was rebuilt to study these findings.

It soon became apparent that the infant which Reber had nurtured since 1936 was growing fast especially in England and Australia. This new science became officially known as "Radio Astronomy".

One of the greatest advantages radio astronomy has over optical astronomy is that it is independent of the time of day and normal meteorological effects. Consequently radio astronomers can set up their equipment virtually anywhere and at any time (only man made electrical interference is likely to upset operations).

RADIO WAVE EMMISSION

Cosmic radio noise emanating from within and without this galaxy is at present attributed to three classifiable phenomena occurring in the universe:

(1) Radio emission produced by thermal agitation of atomic particles;

(2) Radio emission produced by free electrons which travel through space under the influence of galactic magnetic fields;

(3) Radio spectrum line emission.

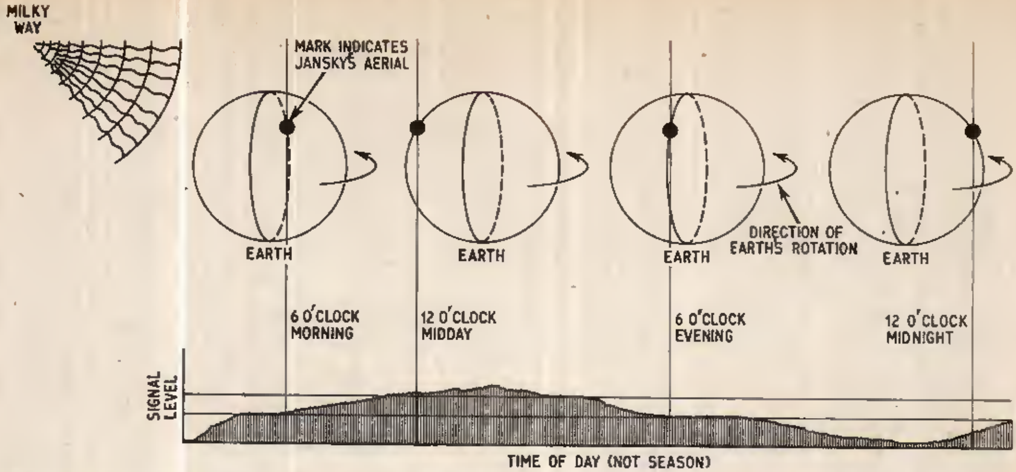


Fig. 1. Observations of static noise coinciding with the movement of the Milky Way as discovered with Jansky's aerial

Let us consider these three effects in a little more detail. Thermal agitation taking place in stars or in clouds of gas travelling through the universe causes their associated atoms and electrons to emit electromagnetic energy, some of which is radiated at radio frequencies. The intensity and bandwidth of the radiation varies in accordance with the temperature of the object radiating.

Most of the planets of our own solar system have temperatures which invite radio emission to take place; the frequency and intensity of such emissions once again are regulated by the temperature (and chemistry) of the planet. Radio emission under the above mentioned instances is called "thermal radio emission". A later section in this article describes radio noise from the sun.

Free electrons travelling through galactic space periodically fall under the influence of fluctuating magnetic fields, which cause the electrons to accelerate to speeds approaching that of light. This is called the "synchrotron" effect and is somewhat similar to the process used in nuclear accelerators for atom smashing.

In the case of galactic synchrotron effects the accelerating electrons are induced to spiral along these weak lines of magnetic force. It is this spiral action which causes the electron to emit electromagnetic energy.

The intensity of such radiation varies in accordance with the strength of the magnetic field and the number of electrons available per given dimension. Present evidence shows that synchrotron emission covers a wide band of radio frequencies. Synchrotron radiation can occur anywhere where there are electrons and magnetic fields. See Fig. 2.

Hydrogen gas is considered fundamental to the composition of the universe. Vast amounts of hydrogen exist inside stars and galaxies. In addition, large amounts of hydrogen also exist in small and exceedingly large clouds which drift from one galaxy to another usually at extremely high velocities.

Under certain conditions neutral hydrogen gas (non-ionised) becomes exposed to external forces and as a result the hydrogen gas atoms undergo a momentary change of energy state, this change manifests itself by a brief emission of radio energy at a spectral line frequency of 1420·4Mc/s (λ 21cm). Hydrogen clouds have sufficient mass to make this emission appear continuous.

QUASARS

Recently a fourth source of radio emission was detected. This emission comes from the deepest parts of space to be probed by instruments. The name "quasar" has been given to these new sources of cosmic

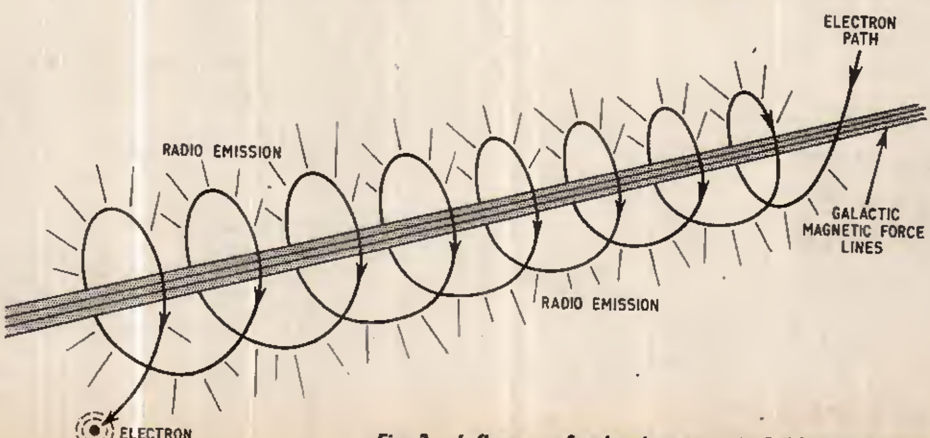


Fig. 2. Influence of galactic magnetic fields on electrons

radio noise. The intensity of the radio waves emitted by quasars must be immense at source because they are still relatively strong after travelling millions of light years across space to Earth.

The precise mechanism producing this huge amount of radio power is as yet beyond our understanding. The radio emissions coming from quasars appear to have both long and short duration fluctuations in intensity. Short term variations show changes of as much as 50 per cent over periods lasting only a few seconds, whilst long term variations extend over periods lasting several weeks. These intensity fluctuations could be the result of periodic blanketing of the transmission path by galactic phenomena such as clouds of hydrogen or dust, meteors, and other cosmic bodies.

MAPPING THE RADIO SKY

Unlike its optical brother, the radio telescope cannot be used to "photograph" the sky in order to make a map of what it sees. Instead a long series of recordings of radio noise is made of the sky. Readings taken from these recordings are then co-ordinated with existing optical maps of the sky which are divided up into the equivalents of latitude and longitude. Thus by carefully plotting the received signal onto these maps it becomes possible for man's eyes to "see" what the radio telescope "sees". See Fig. 3.

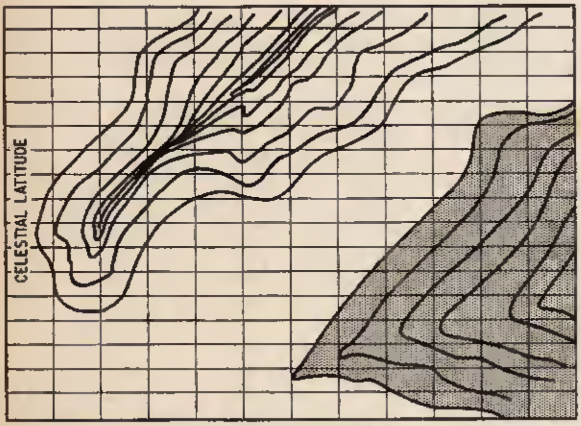


Fig. 3. Areas of radiation picked up by a radio telescope in the form of noise signals and translated into graphical form

Astronomers have several radio sources that do not correlate with visible observations of the area emitting radiation. In other words many sources of cosmic radio noise are detected only by the radio telescope.

RADIO NOISE FROM THE SUN

The nearest cosmic transmitter to Earth is the sun. Radio noise pours out from the sun over a wide range of electromagnetic frequencies, including radio frequencies. This noise can be classified into two types: thermal and non-thermal (synchrotronic).

Thermal Noise

Whilst there are no sun spots and the sun is relatively "quiet", normal thermal agitation of solar matter produces relatively steady emissions of radio noise

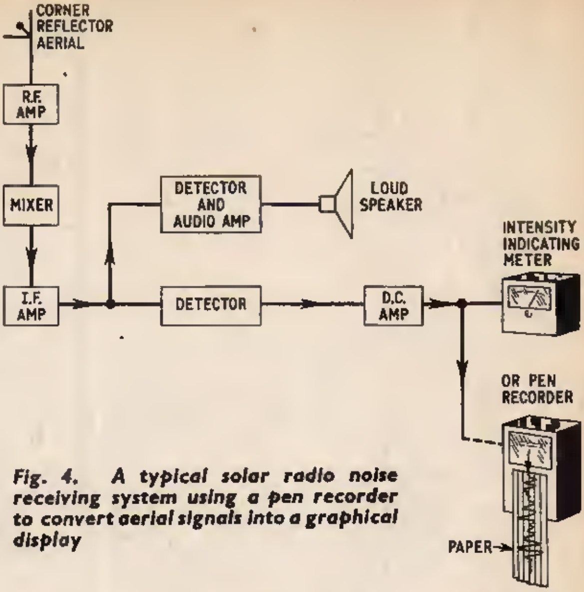


Fig. 4. A typical solar radio noise receiving system using a pen recorder to convert aerial signals into a graphical display

which is easily detectable by quite simple receiving equipment. An example of a simple solar radio noise receiving system is illustrated in Fig. 4.

Non-thermal Noise

At times of sun spot activity the sun becomes very active as a radiator of both electromagnetic waves and particles. Particle storms on the sun are thought to become involved with the high magnetic fields which exist around sun spots or near to them.

Thus once again we have an example of synchrotron action taking place, this time on the sun. The reception of solar synchrotron radio emission is quite impressive. The normal "quiet" signal level of thermionic noise is suddenly disturbed by "bursts," in signal intensity (see Fig. 5). These dramatic changes are a result of solar particle ejection from areas surrounding sun spots; at the same time solar magnetic fields spin or whirl the particles round and round. As the particles spiral so they radiate radio energy.

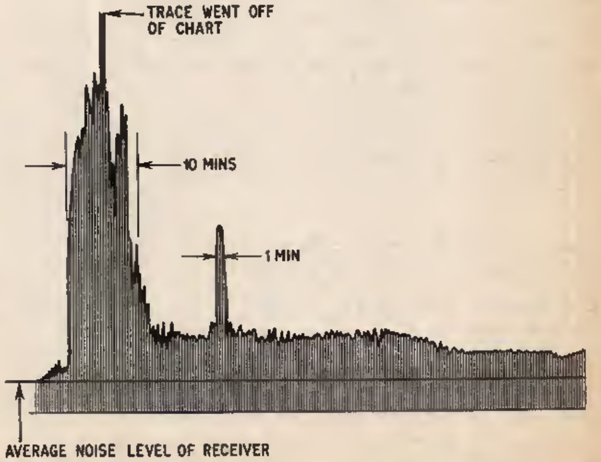


Fig. 5. Illustration of non-thermal noise interrupted by sun spot activity

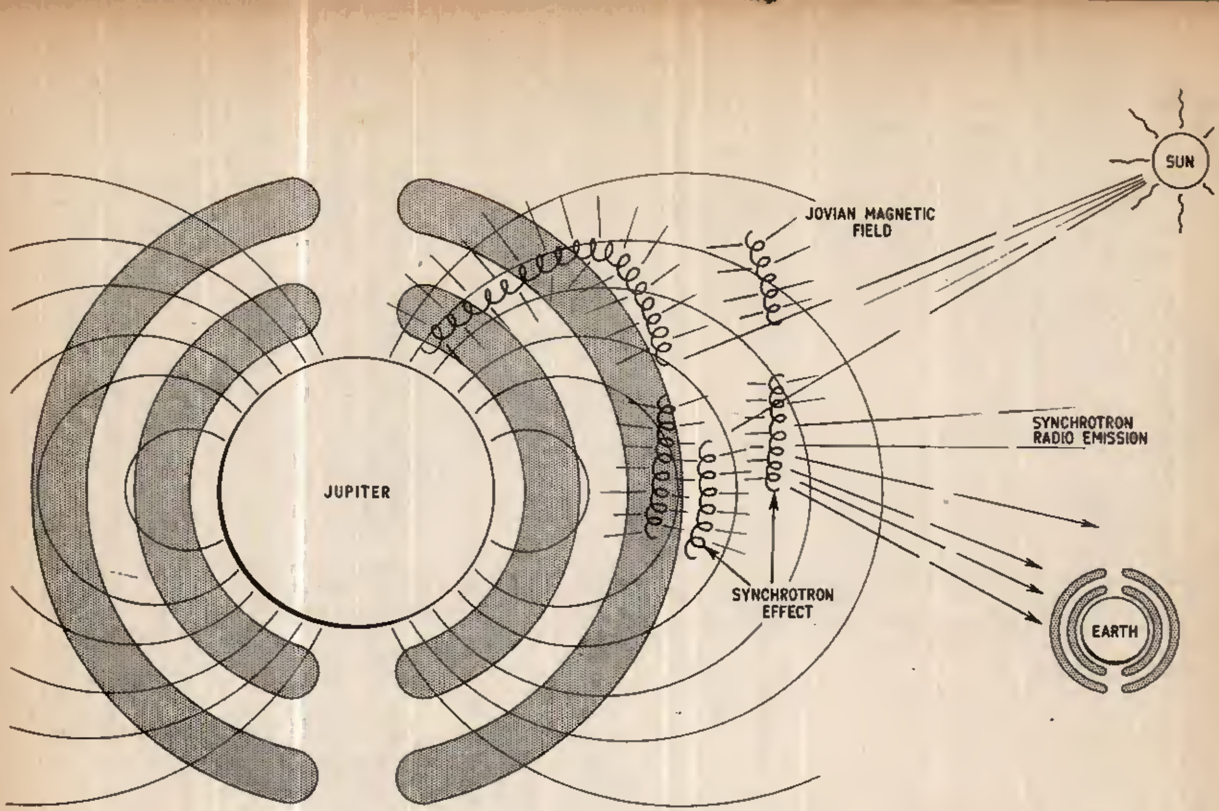


Fig. 6. Sychrotron radio emission from Jupiter. The "coil" pattern is intended to depict magnetic fields

Radio frequencies of 40, 60, 200, and 430 Mc/s have been found ideal for monitoring this form of solar emission. Because the sun is relatively close to Earth, quite small aerial systems are sufficient for receiving solar radio noise.

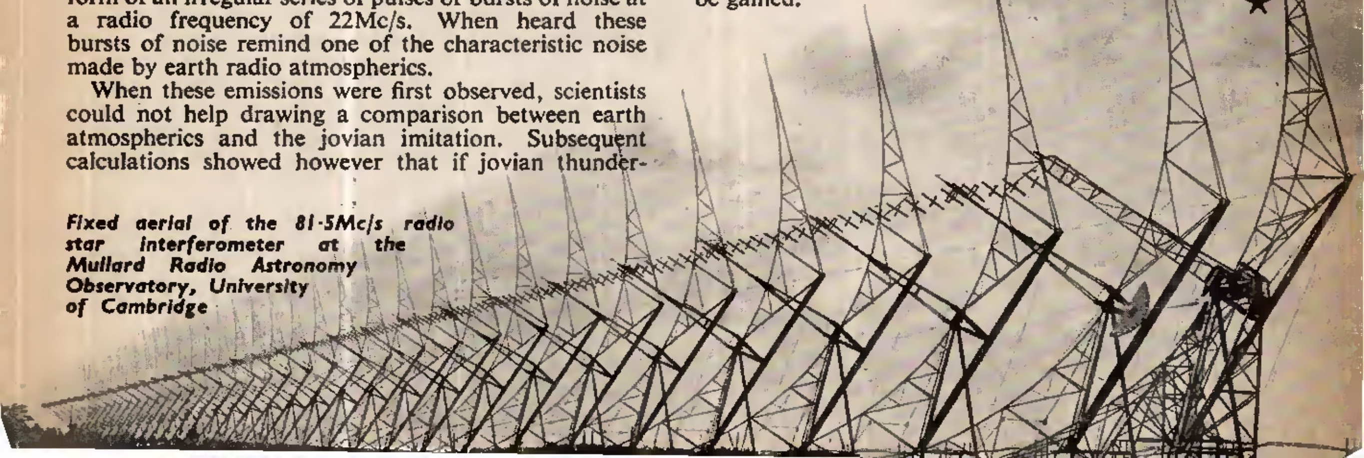
RADIO NOISE FROM THE PLANET JUPITER

So far radio measurements of the planets has revealed only radio noise of thermal origin, except in the case of Jupiter. Radio emissions from Jupiter are quite strong and with a suitable aerial system and sensitive communications receiver useful observation can be made. Non-thermal emission from Jupiter takes the form of an irregular series of pulses or bursts of noise at a radio frequency of 22Mc/s. When heard these bursts of noise remind one of the characteristic noise made by earth radio atmospherics.

When these emissions were first observed, scientists could not help drawing a comparison between earth atmospherics and the jovian imitation. Subsequent calculations showed however that if jovian thunderstorms did exist and were responsible for these radio emissions, their magnitude would have to be many times that of an earth thunderstorm.

Another theory, more recent, suggests that Jupiter has Van Allen belts of radiation similar to those of the earth. Within these belts are atomic particles trapped by the jovian magnetic field. Here then is a breeding ground for "synchrotron" radiation. The mechanics of synchrotron radio emission was explained in simple detail earlier in this article. Fig. 6 illustrates jovian synchrotron radio emission.

This is a necessarily brief introduction to the science of radio astronomy. It is a pure science essentially, that is to say, only knowledge for knowledge sake is to be gained. ★



Fixed aerial of the 81·5Mc/s radio star interferometer at the Mullard Radio Astronomy Observatory, University of Cambridge

ELECTRONIC FLASH GUN

by L. HICKINGBOTHAM

GAS FILLED discharge tubes are a common way these days of producing light. Various gases when subjected to an electric charge become ionised and emit light at a wavelength dependent on the type of gas. Sodium and mercury vapour lamps are two typical examples. Xenon is a gas which emits a particulary useful light in that it is analogous to daylight. This is useful in photography because it eliminates the need for a filter when using colour film. It is also much faster than the ordinary flash bulb.

Discharge tubes have the characteristic of presenting a high resistance to the passage of an electric current until ionisation of the gas takes place. Ionisation may be initiated by raising the voltage to a level prescribed by the manufacturer. When this occurs the resistance falls suddenly and a heavy current will flow which in the ordinary vapour discharge lamps is limited by a choke placed in series with the lamp.

Heat is also generated and the temperature of the glass envelope must be kept within limits. If the lamp is only to be used for a short duration flash then by suitable design a very much smaller size tube can be used. It is also desirable to have a more controllable method for initiating ionisation and so a trigger electrode is incorporated in the tube so that an easily controlled low power pulse can be used to fire the tube.

As only a flash is required then the power supply need only provide a small continuous current which may be stored in a capacitor until required. By choosing a suitable voltage and capacitance the total power dissipated by the tube can be controlled and the energy in joules stored in the capacitor is given by $J=\frac{1}{2}CV^2$ where C=capacitance in farads and V= the e.m.f. in volts.

Thus, when the tube is fired a high current flows momentarily through the tube, ionising the gas and discharging the capacitor. Under these conditions the frequency of flashing is limited to three per minute. By making the discharge tube small a compact light source can be made in which the energy is stored in a capacitor which is charged relatively slowly. The discharge occurs in about 1/1000 of a second producing an intense white light. The flash gun described here is rated at 27 joules.

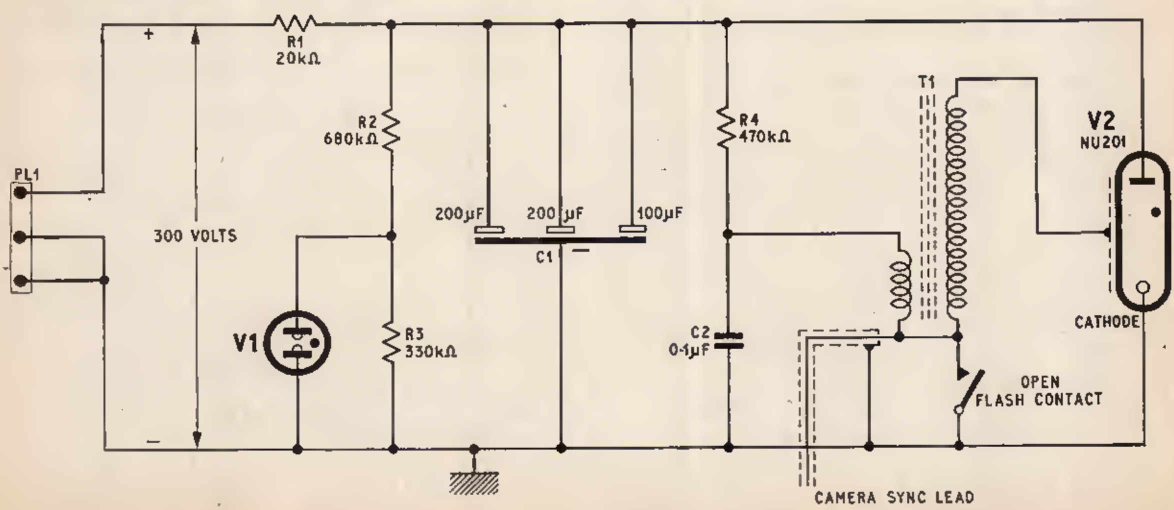


Fig. 1. Flash gun trigger circuit

SYNCHRONISATION

Thus a camera with a relatively slow shutter can be used for high speed photography, provided the ambient lighting is suitable.

In a practical circuit a means must be provided for synchronising the flash with the camera shutter. The synchronising circuit must be of low power to avoid damage to the camera synchronising contacts; this is achieved by discharging a small capacitor across a coil, the resulting pulse being converted by a pulse transformer and applied to the trigger electrode of the flash tube.

Fig. 1 shows the basic circuit, C1 being the flash capacitor which is permanently connected to the flash tube. With the power supply connected C1 will be charged up slowly to the required voltage, but the flash tube will not fire until a pulse is applied to the trigger electrode. R4 provides a high resistance path through which a smaller capacitor C2 is also charged.

When the camera contacts close C2 is discharged through the primary of the pulse transformer and a high voltage pulse appears across the secondary which fires the flash tube.

CONSTRUCTION

The circuit is made up on s.r.b.p., a small panel of which is drilled to suit the components and then soldered directly to the capacitor terminals. Fig. 2 shows the layout of the components. The connection to the flash tube should be insulated 16 s.w.g. wire to carry the high discharge current.

The pulse transformer T1 is made from an old i.f. transformer or long wave coil which is carefully dismantled to avoid breaking any of the leads to the coil. The type used had a wave wound coil on a piece of s.r.b.p. tube of $\frac{1}{16}$in internal diameter.

It was estimated that there were 950 turns of 41 s.w.g. wire on the coil. This forms the secondary of the flash gun transformer. The primary has 80 turns of 30 s.w.g. silk covered wire wound in two layers on a suitable piece of ferrite rod $\frac{3}{8}$in long. This may then be slipped inside the secondary and held in place with wax as shown in Fig. 3. The whole assembly is mounted on the component board by means of a rubber grommet and the leads soldered to the appropriate connections.

A piece of white faced laminated plastics is used to mount the tube and provide the bottom section of the reflector. When mounting the tube take care not to bend the leads close to the glass. The holes must be drilled accurately to suit the tube so that there is no strain on the glass otherwise it will crack. It should be mounted so that the cathode is connected to the negative side of the supply. This is seen as the larger of the two electrodes inside the tube, the trigger electrode being a metallised strip on the outside which is connected to a much finer wire.

It is important that the whole of the high voltage circuit be completely enclosed and insulated because the power stored in the capacitor may prove to be fatal to anybody touching this part of the circuit. Care must be taken to ensure that the capacitor cannot be inadvertantly shorted by any of the components or wires. Insulate all wires thoroughly. The power stored in the capacitor is sufficient to produce an effective weld if brought into contact with bare wire.

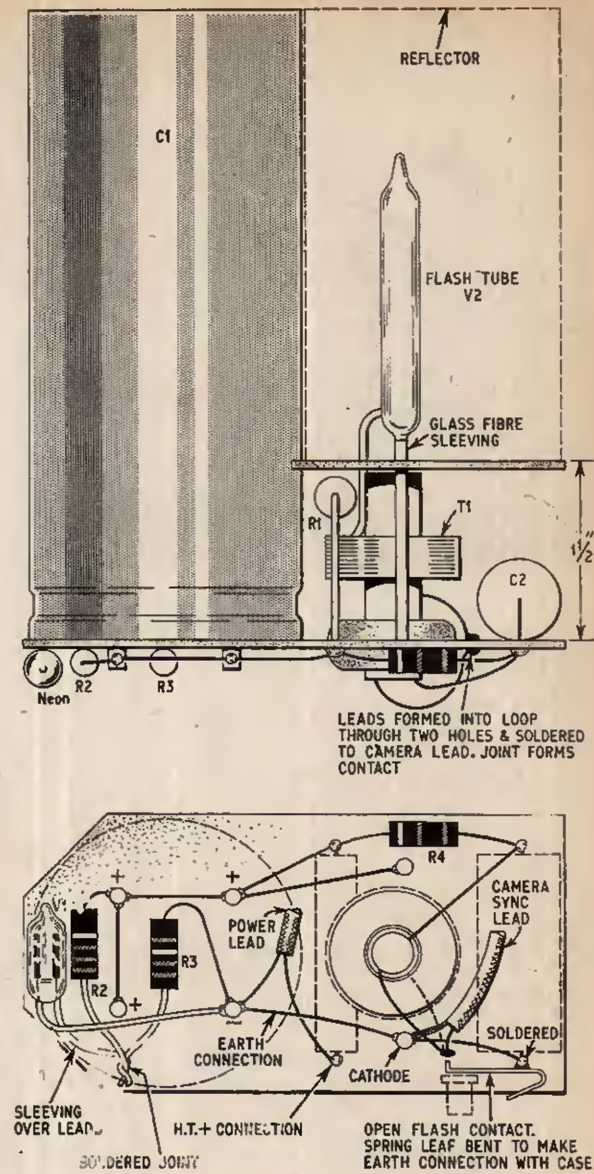


Fig. 2. Side and underneath views of the flash unit

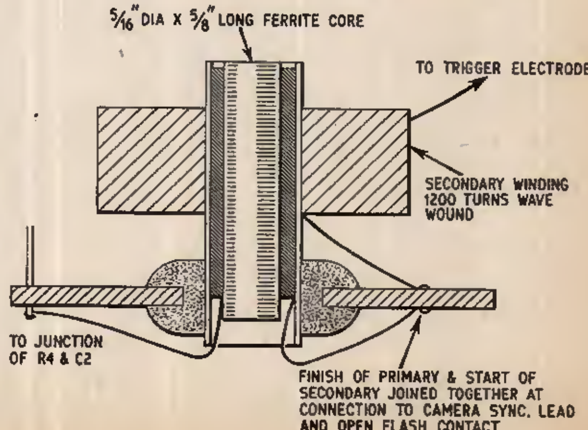
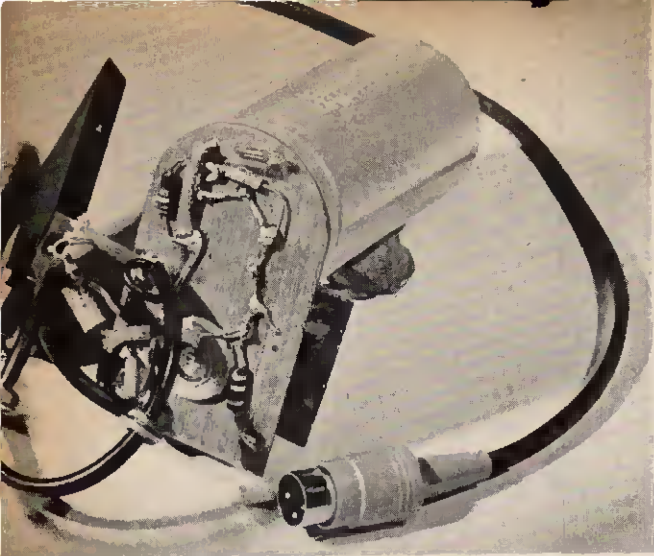


Fig. 3 (right). Construction details of the pulse transformer T1



THE CASE

The case is made from 27 s.w.g. tinplate, the top being soldered to form a rigid box (Fig. 4). The reflector is a piece of bright tinplate bent to half an ellipse as shown in the diagram. The base which carries the shoe for mounting on the camera is held in place by four self-tapping screws.

It was found that there was a variation in the size of the accessory shoe in different makes of cameras and it is suggested that this be filed to suit the particular camera the constructor is using. In addition, some cameras have the synchronising contacts built into the accessory shoe. In this case the method of construction shown in Fig. 5 is suggested. If the constructor wishes to use the open flash technique then a small phosphor bronze spring contact may be fitted in parallel with the camera synchronising lead and operated by a small push button as shown. The case can then be painted or covered with leathercloth to match the camera. A piece of $\frac{1}{8}$in reeded Perspex $4\frac{1}{2}$in × $1\frac{13}{16}$in is used for the front to protect the flash tube and give a diffused light when the tube is fired.

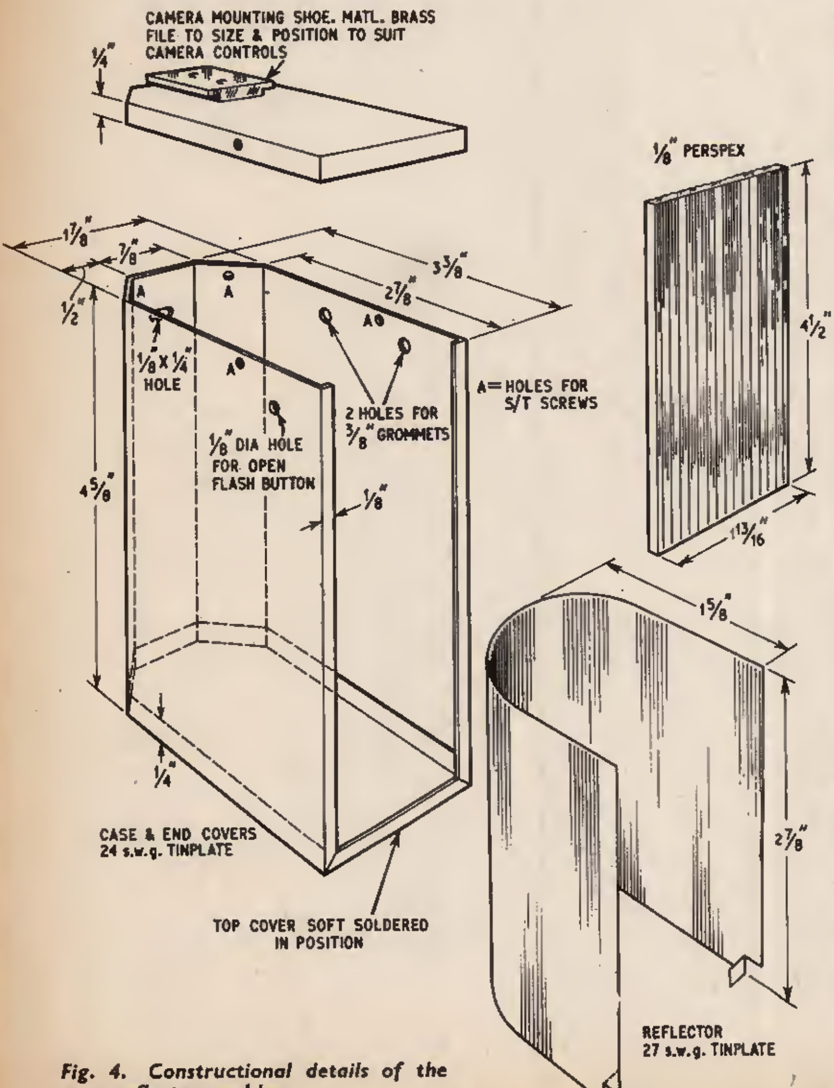


Fig. 4. Constructional details of the case, reflector, and lens

COMPONENTS . . .

Resistors
R1 20kΩ 6W wirewound
R2 680kΩ ¼W carbon
R3 330kΩ ¼W carbon
R4 470kΩ ¼W carbon

Capacitors
C1 200 + 200 + 100μF elect. 350V (Radiospares) All sections wired in parallel
C2 0·1μF paper 350V

Tubes
V1 Miniature neon indicators
V2 Flash tube type NU201 (Welmec)

Diodes
D1–4 Silicon rectifiers type 1S113 400 p.i.v. 400 mA (Texas)

Transformers
T1 Pulse transformer (see text)
T2 Midget mains transformer 125–0–125V 50mA (Radiospares)

Plugs and socket
PL1 & SK1 3-pin D.I.N. pattern (Radiospares)
PLM Mains plug 3-pin 13A with FS1 1A fuse

Miscellaneous
Camera sync. lead to suit camera
3-core mains cable
2-core mains cable (for power connection)
Sheet metal for boxes and reflector (see text)
Reeded Perspex (see text)

All the components are readily available through electronic components specialists. The flash tube is available from either Ferranti Ltd., Gem Mill, Chadderton, Oldham, Lancashire, or Welmec Corporation Limited, 27 Chancery Lane, London, W.C.2. If the constructor prefers to use a proprietary pulse transformer, a rather bulky item can be obtained from Ferranti.

POWER SUPPLIES

The flash gun requires a power supply of 300 volts d.c. and a peak charging current of 15 mA. It is essential that the correct polarity is observed otherwise the electrolytic storage capacitor will be permanently damaged.

Many commercial outfits use miniature components built into the body of the flash gun. Whilst these may be satisfactory for the average user it is felt that it is probably cheaper to buy the normal flash bulbs rather than batteries for the electronic flash. The larger rated units use a separate power unit, many of which can be used as portable equipment and recharged from the mains.

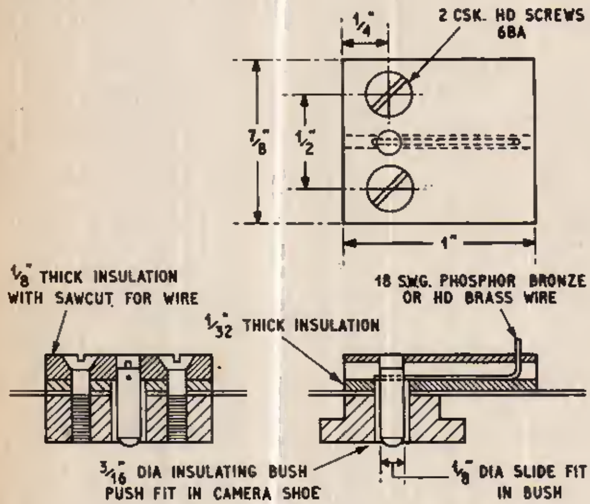


Fig. 5. Synchronising contact mounted in the camera shoe

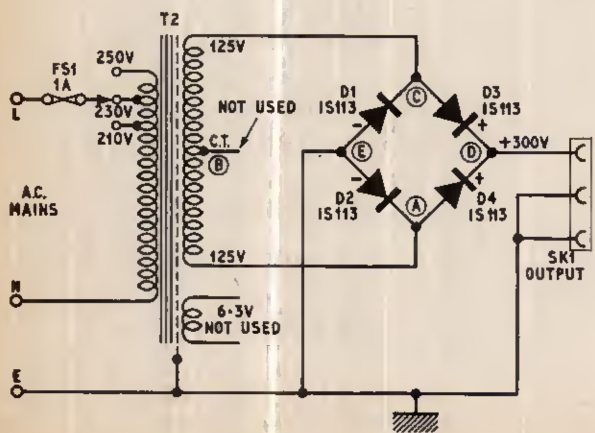


Fig. 6. Suggested circuit for a mains power supply unit

It was considered that the constructor may have his own special requirements and it should be possible to meet these from the following by using whichever method or combination of methods is most suitable..

MAINS POWER UNIT

Where the flash gun is only going to be used indoors a mains unit eliminates the need for batteries and gives consistant results. A double wound transformer is used to isolate the unit from the mains. This can be either a 250V secondary winding type or an h.t. supply transformer 125–0–125V. In addition to the 125–0–125V h.t. secondary there may be a 6·3V secondary winding but this is not necessary. The 6·3V connecting leads between the coil and tag panel can be cut off close to the coil so that there is no danger of short circuits.

The tags may then be used for mounting the silicon rectifiers and making the d.c. connection to the flash gun through a non-reversible socket. The centre-tap on the h.t. secondary is not used. The bridge rectifier connected across the whole of the secondary gives an output of 350V when the flash gun capacitor is fully charged. The circuit diagram is shown in Fig. 6, the mains lead being permanently connected to the unit and terminated with a 13A flat pin plug fused at 1A.

The unit is fully enclosed for safety in a metal box which is earthed through the mains plug. The box is made from two pieces of 22 s.w.g. mild steel bent and drilled as shown in Fig. 8.

For those who constructed the *DC/AC Inverter* described in the February 1965 issue of Practical Electronics this flash gun is useable outdoors by connecting this mains transformer unit to the inverter. The primary current of the inverter is about 1A so a self-contained unit could be built using a small chargeable 12V accumulator. This arrangement, however, is likely to be rather bulky and if a completely portable unit is required it is recommended that the following battery powered unit is constructed.

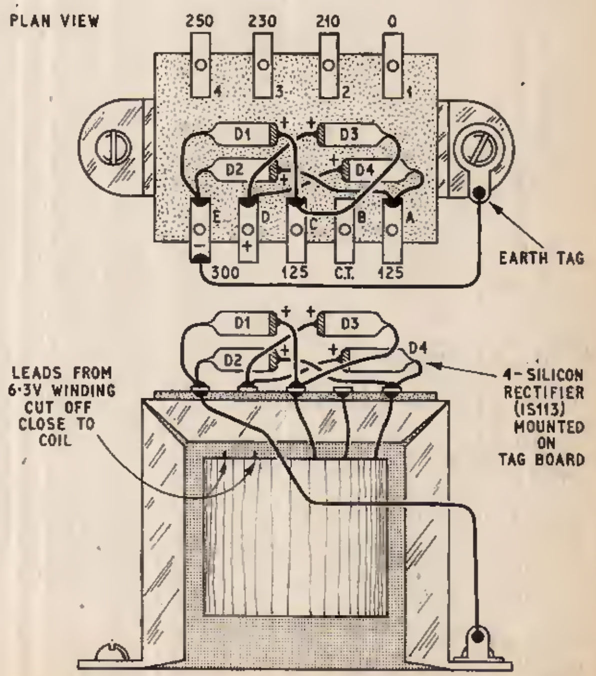


Fig. 7. Assembly of components on the mains transformer

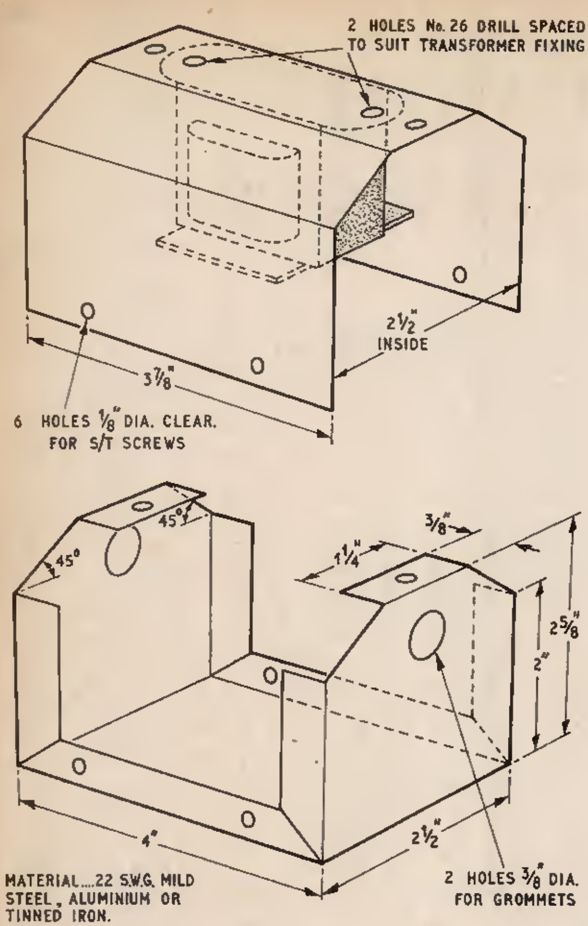
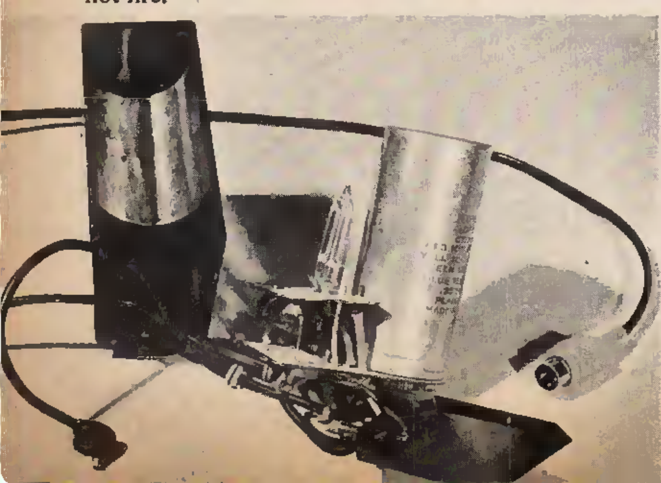


Fig. 8. Constructional details of the power unit case

PORTABLE POWER SUPPLY UNITS

The simplest form of portable power supply is the h.t. dry battery. Modern layer type of construction has produced efficient batteries which do not disintegrate and corrode away as easily as the older type of dry leclanché cells.

Small layer type batteries are available which should give something like 1,000 flashes before the end point voltage falls below that required. The neon V1 indicates this; if it does not light up the flash tube may not fire.



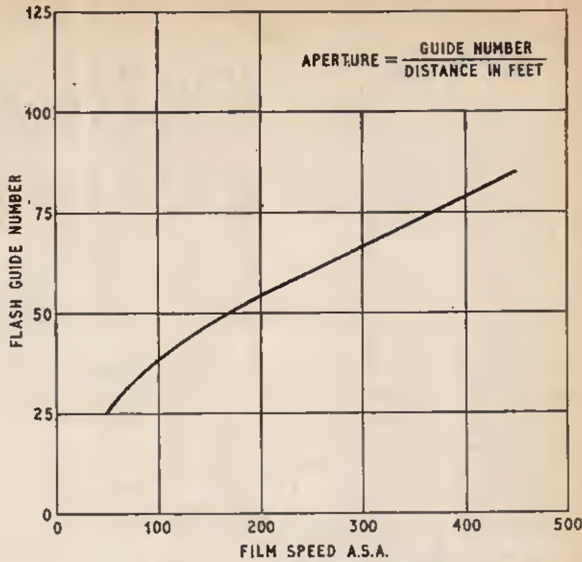


Fig. 9. Graph of flash guide number against film speed for the flash gun

Three Ever Ready 90V B126 batteries connected in series will give adequate voltage for a considerable period. For those who require a more compact unit the 300V B1489 can be used, but this will have a shorter life.

A carrying case for these is easily constructed from wood; plastics or sheet metal. The case should be fitted with a non-reversible socket similar to the one used for the mains supply unit.

USING THE FLASH GUN

The flash gun will provide an intensity of light which is approximately equivalent to a PF1 photoflash bulb at 1/500 second. The graph (Fig. 9) gives an indication of the guide number as obtained with the author's model. It is suggested that a few trial exposures be made as a test because of the variations that can occur due to the reflecting surfaces both in the unit and from the walls of the room in which it is used.

The shutter should be set to a 1/50 second and if the camera is fitted with a choice of synchronisation the "X" position should be selected. If the camera does not have this type of synchronisation then it may not be suitable for electronic flash because the contacts close before the shutter is fully open. As the electronic flash is much faster than the ordinary flash bulb it is over before the shutter is fully open. Your photographic dealer can advise you on this.

As the speed of the flash and the intensity of illumination is fixed the only variable control is the aperture. This is set depending on the distance between subject and flash and increasing the distance requires a large aperture (lower f number). The product of the distance times the f number is known as the guide number and once this has been found for a particular set of conditions the aperture may easily be calculated for other distances for the same film speed.

The flash tube should give about 10,000 flashes which will more than pay for the cost of the tube if ordinary flash bulbs are used. The maximum rate of operation is three per minute and with a 300V supply the charge limiting resistor is chosen so that 20 seconds is required before the capacitor is fully charged ready for the next flash. ★

3 EXPERIMENTS in LOGIC DESIGN

by S. T. ANDREWS

THE end-product of Parts 1 and 2 of this series was a binary adding unit—there were two input registers into which the operands were written, after which a single pulse was applied to the appropriate section of the circuit (the STARTADD generator) causing the operands to be added and their sum to be stored in a third, output, register. The sequence of events for an addition can thus be summarised as follows:

(1.) Write y to A
(2.) Write x to B
(3.) Add
(4.) Read result in R

In this, and all future references, x and y are the operands, A and B are the names of the input registers, and R is the register holding the result. This is all quite simple and we can now go on to consider other mathematical operations, in fact one was briefly mentioned last month, the "non-equivalence" function. For this the sequence was:

(1.) Write y to A
(2.) Write x to B
(3.) Inhibit CARRY's and add
(4.) Read (non-equivalence) result in R

The result in R having a 0 in any digit position where the digits in A and B were the same, and a 1 in the positions where they were not the same. The non-equivalence function can be represented by the symbol:

$$\not\equiv$$

LOGICAL NEGATIVE

The logical negative of an operand (distinguished from the number by a horizontal stroke over it thus: $\bar{x}$) is a number which has 1's in all the positions where the operand had a 0, and 0's in all the positions where it had a 1. For example if x = 1011010 then the logical negative, $\bar{x}$, = 0100101, and if y = 0011101 then $\bar{y}$ = 1100010.

The logical negative can be formed in the adder quite easily as follows: the number to be negated is written into one input register and the other register has 1's written throughout it. It is only then necessary to inhibit CARRY's and add and the logical negative appears in R. The explanation of this is: suppose that B contains all 1's and that the number to be negated is in A, then there are only two possible things that can happen. If in any given digit position A contains a 0 then the addition with the 1 in B will give a 1 in R, i.e. anywhere in x where there is a 0, in $\bar{x}$ (being formed in R) there will be a 1. If A contains a 1 this will be added to the 1 in B to give a 0 in R (and also a carry digit but this will be lost since the CARRY's are suppressed), thus any 1 digits in A will give a 0 in R. These are the only two possibilities since A must consist of only 1's and 0's, and the result in R will always be a number with the 0's and 1's the inverse of those in A.

THREE FUNCTION SYSTEM

Fig. 3.1 shows one example of a logical system capable of performing the *add, non-equivalence,* and *logical negative* functions. The adder shown in heavy outline is identical with the one described last month (see Fig. 2.4). It is assumed that the operands are held in storage somewhere and can be written into A and B whenever a pulse is sent along the "write y to A" and "write x to B" wires. Also provision has to be made for transferring the numerical result, formed in R, to its destination after the calculation is complete. This would be done by a suitable set of gates, opened by the "read R" output, which would transfer the contents of R to the required destination. This output, after a short delay, also causes R to be cleared after being read, and at the same time A and B are cleared so the adder is ready to receive the next set of operands. These circuits are not shown in Fig. 3.1 but it is not difficult to imagine where they would go.

Addition. A pulse sent along the "add" input causes the operands to be written into A and B and also initiates a delay circuit which triggers the STARTADD generator after a time interval to allow the operands to be written. The addition proceeds normally and after the last pair of digits has been added a pulse leaves the top end of the adder timing chain signifying "addition complete". This causes the content of R to be sent to its destination and, after a further delay, A, B and R are all cleared to zero, the adder is then re-set and ready to begin the next instruction.

Non-equivalence. The non-equivalence input also causes the two operands to be written into A and B and again initiates the STARTADD generator after a short delay. In this case, however, the input pulse also sets a bistable which turns on the "carry inhibit" circuits, these remain on during the addition which then takes place. After it is finished the content of R, which is the non-equivalence function between the two operands, is read in the usual way after which all the registers are cleared. While R is being read a pulse is sent to the "carry inhibit" bistable unsetting it so that when A, B, and R are cleared the adder is again completely reset and ready for the next instruction.

Logical negative. The logical negative input is very similar to the non-equivalence but instead of writing x to B it causes 1's to be written throughout B. Apart from this the action is identical with the previous case and the result is read from R.

SUBTRACTION

The adder cannot, as it stands, do a subtraction sum directly. Fortunately there is a very neat mathematical dodge which enables subtraction to be done quite easily, and this involves the use of a new type of function called the *complement* and it can now be discussed in some detail.

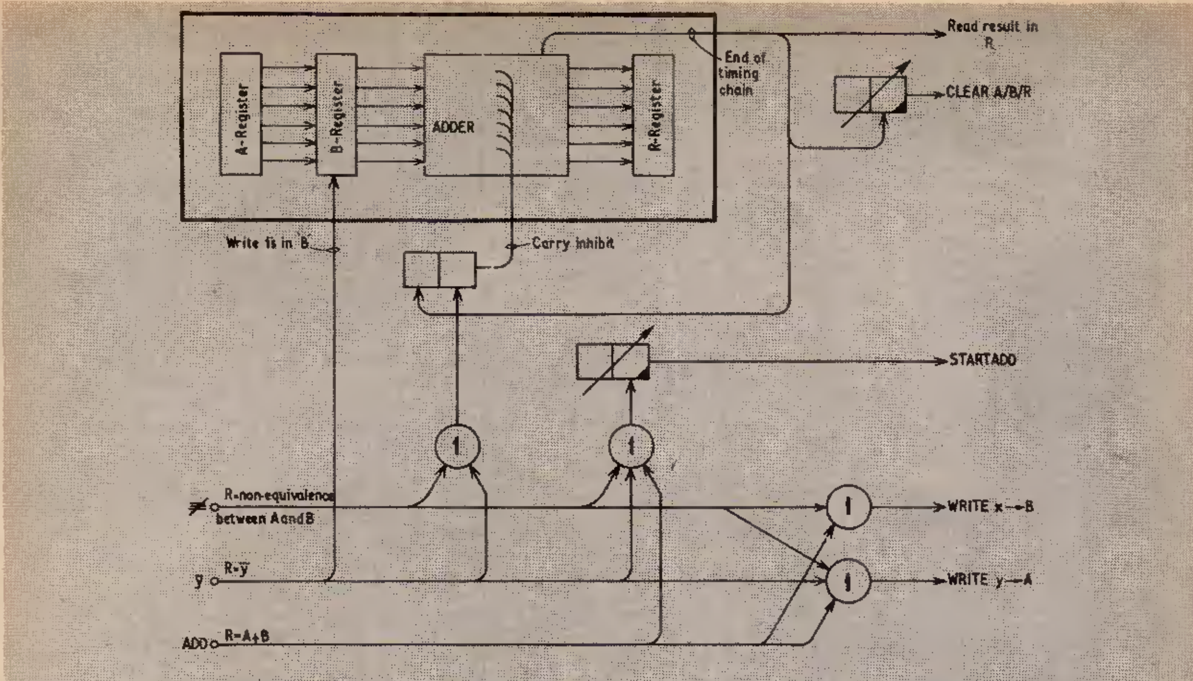


Fig. 3.1. Basic logical system for addition, non-equivalence, and logical negative

Any number can be complemented with any other number and the complement of a number p with respect to a number q is defined as (q − p). The methods of choosing a value for q in any particular case will be explained shortly. The value of a complement is this: in the subtraction (x − y) the correct result may be obtained by taking the complement of y and adding it to x. The subtraction, performed in this way, is actually done by an addition.

As an example consider the sum 33 − 14 which in binary is 100001 − 1110 or, restricting ourselves to six-digit numbers only, 100001 − 001110. Now suppose that q = 64, then the complement of 14 is 50 which in binary is 110010. Using the subtraction rule we add the complement of y to x: 110010 + 100001 and get (1)010011. The left-hand 1 is bracketed since we are only dealing with six-bit numbers, the remainder, 010011, is 19 in decimal which is the correct answer to the original sum. Ignoring the left-hand 1 may seem like cheating but the reason for doing this will become apparent soon.

When working in binary q must always be a multiple of 2 and in general where the calculation is done on numbers of up to n bits q will be 2^n, i.e. in the above example n = 6 and q = 64 which is 2^6.

At first sight it might appear that there is a flaw in this argument since the complement of a number is itself formed by a subtraction, (q − p). This is quite true but it does not invalidate the argument because there is another way of forming complements. By a fortunate chance the complement of a number can also be formed by taking the logical negative and adding 1. For example with q still 64, take the two numbers in the example, the complement of 14 is 50 and that of 33 is 31. 14 in binary is 001110 and 33 is 100001, their logical negatives are 110001 and 011110 respectively, adding 1 to each gives 110010 and 011111 which turn out to be 50 and 31.

The subtraction process for (x − y) therefore breaks down into three separate stages, each using the adder once, *(A)* take y and form its logical negative. *(B)* add 1 to this to give the complement, *(C)* add this figure to x to give the required answer for (x − y). Each step can be broken down further and the complete sequence for a subtraction is:

(1) Write y to A
(2) Write 1's in B
(3) Inhibit CARRY's and add
(4) Clear A and B
(5) Transfer R to A
(6) Clear R
(7) Write 1 in least-significant position of B
(8) Add
(9) Clear A and B
(10) Transfer R to A
(11) Clear R
(12) Write x to B
(13) Add
(14) Read result in R, then clear all registers.

Of these 14 stages 1–3 form the logical negative, 4–6 transfer it back to the input and clear all other registers, 7 and 8 add one to give the true complement of y, 9–11 transfer this back to the input and clear all other registers, 12–14 add the other operand giving the result. Stages 4, 5 and 6 are identical with 9, 10 and 11; 12, 13 and 14 are the last stages of a normal addition.

SUBTRACTION—LOGICAL SYSTEM

It is possible to work out a logical system, of the type shown in Fig. 3.1, to perform all these functions. This system requires about a dozen more logic elements and is shown in Fig. 3.2. Also shown is the "add" input but not the non-equivalence, this is connected as in Fig. 3.1.

When an input pulse is recorded on the "subtract" input this does several things. It causes y to be written

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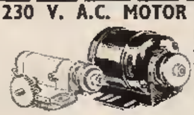

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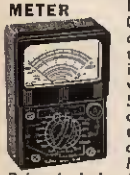

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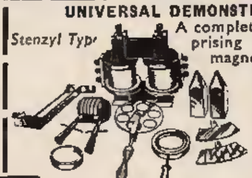

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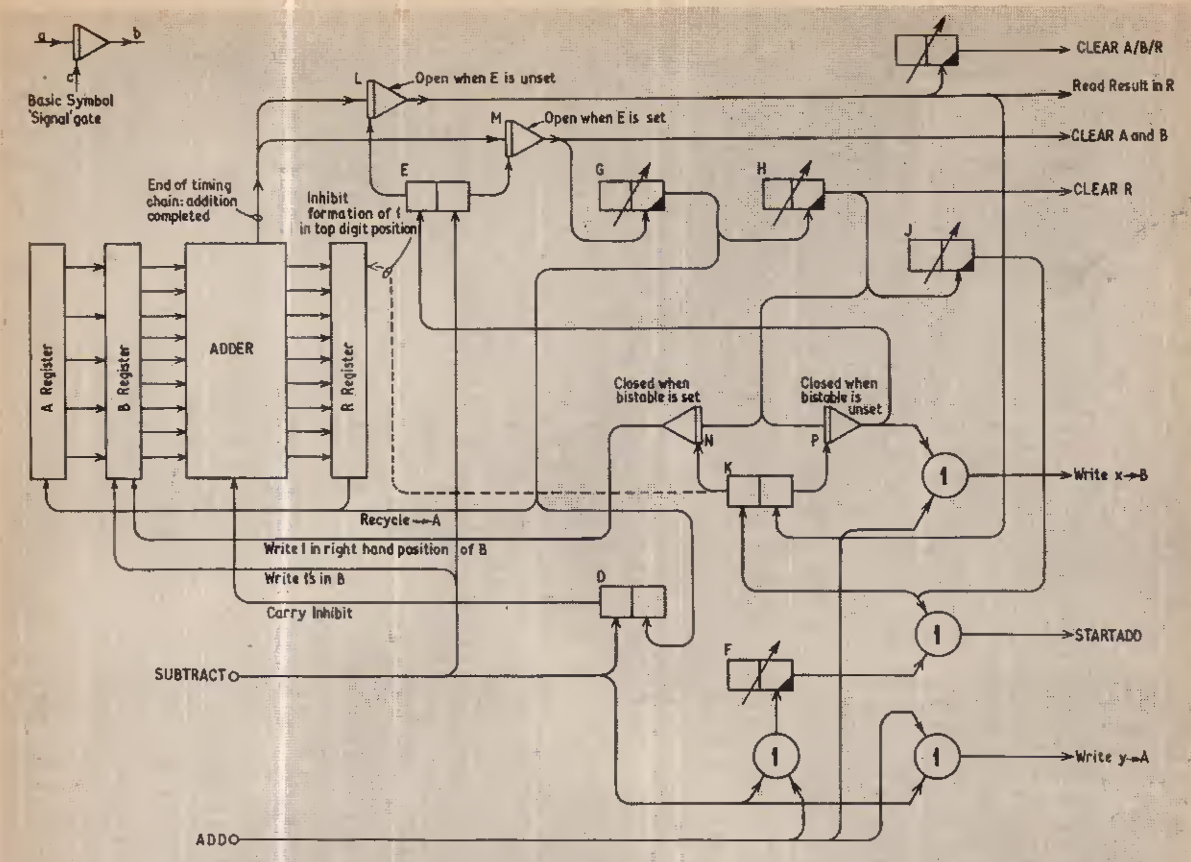

Fig. 3.2. Add and subtract logical diagrams

into A and 1's to be written into B register, in addition bistables D and E are set. D is the carry inhibit trigger and will prevent any CARRY's from being propagated in the adder until it is unset. E closes "signal" gate L and opens "signal" gate M, these gates decide what happens to the "addition complete" pulse from the timing chain.

These signal gates L, M, N, etc., are represented by a special symbol as indicated on Fig. 3.2. Operation is as follows. The input wire *a* is connected to the output wire *b* only if a suitable gating voltage is applied to a third input, *c*. For example, a signal applied to *a* will go through the gate to *b* only if the bistable connected to *c* provides a steady voltage representing a 1. In a sense the signal gate is similar to an AND gate.

Finally, the input pulse initiates the STARTADD generator after a delay given by F. This causes the addition, without CARRY's, of the content of A (y) to the 1's written in B, so the logical negative y is formed and written into R.

When the addition is finished the "addition completed" pulse is produced and applied to gates L and M, but it will only pass through M as bistable E is set. Leaving M it clears A and B and sets G, a short-term delay unit. When G finishes its delay period a set of gates is opened allowing the number in R to re-cycle back to A, simultaneously it initiates another delay unit, H, and finally unsets bistable D thereby ensuring that in any future operations CARRY's will be permitted in the adder. This corresponds to stages 4 and 5 of the process. After H has held up proceedings long enough for all this to happen it produces an output pulse clearing R, step number 6. It also triggers another delay unit, J, and applies a pulse to two further gates, N and P. These are driven off bistable K which is unset, therefore only N is open and the pulse from H passes through and writes a 1 in the least significant place of B. Finally, after J has delayed the pulse for a time, it produces a pulse which starts the addition by triggering the STARTADD circuits, and also it sets bistable K.

The addition, stage 8 of the whole process, produces the true complement of y in R. When it is finished the "addition completed" pulse again passes through gate M and, as before, passes progressively down G and H, clearing A and B, re-cycling R, containing the complement, back to A, and clearing R. This is steps 9 to 11 and the action is identical with the previous stages 4 to 6, but beyond this point there is a change. During stage 8 bistable K was set and as a result the pulse from H passes not through N gate but through P, causing the other operand x to be written into B. At the same time E is unset so gate M closes and L opens. When J produces its output pulse and starts the final addition (stage 13) it is adding x and the complement of y. When the addition ends the output pulse passes through gate L causing the result of the calculation in R to be read, and then clearing A, B and R. It also unsets K so that everything is now unset and returned to zero.

This all sounds very involved and complex—a real computer would probably do it in a few millseconds.

We have already seen that the complement is formed with respect to a number called q and that for maximum numerical efficiency $q = 2^n$ where n is the maximum number of bits in the operand. This is automatically the case in the logical system shown and ensures the maximum efficiency of the circuits.

When discussing the theory of subtraction by the complement method we saw that an apparently erroneous 1 would appear in the left-hand digit position of the answer. It is obvious that this digit cannot be a part of the answer—when subtracting a 6-bit number from another 6-bit number a 7-bit number cannot be the result. It is quite legitimate to ignore the most significant digit in the answer of a subtraction, in fact it is necessary to suppress it to prevent an incorrect answer. Methods of suppression are similar to those for inhibiting CARRY's, unset pulses could be applied to the most significant bistable in R, alternatively the 1 could be lost when the answer was transfered from R to its destination. Bistable K is set during the final addition and this could be used to provide some kind of signal to prevent a 1 from being formed in this position. This is shown dotted in Fig. 3.2.

LOGICAL SHIFTS

The formation of the complement is an essential part of the subtraction process. In a similar way the logical shift facility is inherent in the multiplication and division techniques so it will now be discussed in some detail.

When a number is shifted logically all the individual digits are moved a given number of places to the right or left. Considering, for the moment, only shifts to the left, 00011011 shifted one place left is 00110110 and, shifted two places it is 01101100. In order to keep the same number of bits in the number, a 0 is written into each of the digit positions left vacant on the right-hand end of the shifted number. If the number in the example is shifted five places to the left it loses two 1's and becomes 01100000. A logical shift of a number is equivalent to multiplying it by 2^n where n is the number of places shifted. Referring again to the example, the original number, 00011011 is 27 in decimal, shifted one place left it becomes 00110110 which is 54, while a second shift makes it 01101100 which is 108. Shifting a number to the left is also called "shifting it up", while a shift to the right is called a "shift down".

One easy way of shifting a number up is to add that number to itself, this can be done by writing the same number into both the adder input registers and simply adding. However it is not always convenient to use the adder for this purpose and an alternative method has to be found. One method of doing this is given in Fig. 3.3.

The shift logic elements are connected directly to the bistables which form the adder input register and the principle of operation is: clear each bistable and then copy into it the contents of the one immediately below it in the register. In Fig. 3.3 the shift is initiated by a STARTSHIFT pulse which sets A, a delay element. After a short delay the output pulse from A is applied to the top bistable of the input register and if this was set, i.e. if it was holding a 1, it is cleared, if it was unset to begin with then the pulse will have no effect. This pulse also sets another delay element, B, and the delayed output from this is AND-gated with the output from the next lower bistable of the register; if this contained a 1 then the top bistable will be set, if it held a 0 the top bistable will be unaffected. The output from B is also used to set yet another delay unit, C. This subsequently clears the bistable which has just been read, C being analogous to A in the position above.

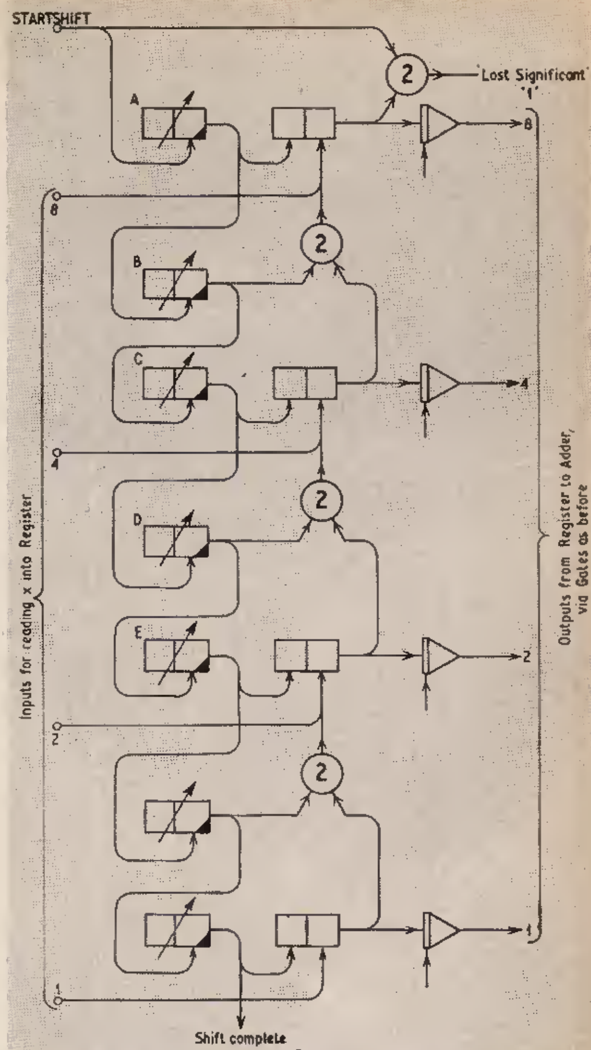

Fig. 3.3. The logical shift (up) facility logical diagram

Thus the top bistable is initially cleared and then has written into it the digit held in the next one down. This is turn cleared and has, copied into it, the digit in the next lower position again, this is done by D and E which are identical with B and C. This repeating unit can be duplicated as many times as required, it will cause each bistable to be first unset, and then have put into it the digit held by the next one down. The bottom position is simply cleared, i.e. has a 0 written into it. After the last position has been cleared a "shift complete" pulse is produced.

As already stated, it is quite possible for a significant 1 to be lost during a logical shift and this may, or may not, indicate an error, depending on how the shift is being used at the time. In order to test for a 1 in the top position before the shift is started the input STARTSHIFT pulse is AND-gated with the output of the top bistable. If this top bit is a 0 there will be no output from the AND but if it is a 1 a pulse will be produced. This pulse can be used in several ways, and one particular application will be mentioned next month when we will be dealing with multiplication.

BASS BOOSTER

BONANZA BOARD

By A. J. BASSETT

FOLLOWING the recent series of *Bonanza Board* projects (March and April 1966) we are presenting here an additional project, based on BB1, to provide bass boost to an existing audio amplifier. Two methods may be employed and suggestions are made to suit low impedance and high impedance inputs.

Whichever method is selected, the unit should be housed in a metal box with the box connected to the "earth" of the main amplifier. This is conveniently arranged by using a coaxial output socket, whereby the screen is used as the earthing connection.

Reference is made to the article, "Simple Pre-amplifier", on page 182 of the March 1966 issue, since this is the basic unit used. The printed circuit board used is the same; the components are mounted on it according to the layout diagram given on page 183 with additional components as reproduced in this article.

SIMPLE BASS BOOST

Fig. 1 below shows the circuit of the pre-amplifier with two feedback capacitors C6 and C7 added. Different values of capacitor may be used for different degrees of bass boost; if only a small amount of boost is required C6 could be 0·005 μF and C7 should be omitted. A larger degree of boost is achieved when C6 is 0·01μF and C7 (also 0·01μF) is inserted. The bass can be boosted further by doubling these values so that C6 and C7 are 0·02μF each.

STEPPED CONTROL

It may be preferable to fit switched variable bass boost control. Here the circuit is basically the same, but C6 and C7 are replaced by the network shown in Fig. 2. This is easily made up on a two-pole, six-way rotary wafer switch S1 and connected to the pre-amplifier at points (X), (Y), and (Z). Figs. 1 and 5 show the appropriate positions.

Provision can be made for the unit to be switched in and out of use at the flick of a switch. Fig. 3 shows how this is done; S2 provides this function and also acts as an on/off switch for the pre-amplifier battery.

To reduce noise generation, TR1 (and TR2 if necessary) can be replaced by low noise transistors such as AC107. This modification may be desired by hi fi users but for most purposes the OC71 is quite satisfactory. Resistors R1, R2, and R3 may be replaced if desired by low noise or high stability types.

Component values in Fig. 3 are selected according to the type of input and output to which the unit is to be matched. High impedance signal sources such as crystal microphones or ceramic pick-ups would require a high impedance input network on the booster. Conversely, low impedance signal sources such as dynamic microphone or pick-up would require a low impedance network.

The values of the output components are similarly important. For feeding another transistor amplifier of

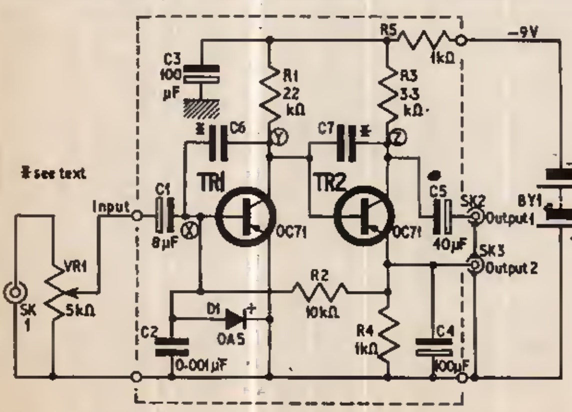

Fig. 1. Circuit diagram of the pre-amplifier modified to form a bass booster

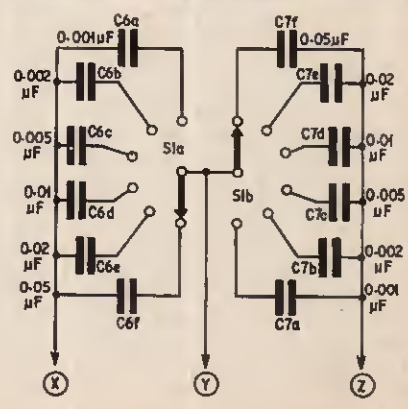

Fig. 2. Capacitors C6 and C7 can be replaced by a stepped control connected to (X), (Y), (Z) on the pre-amplifier

COMPONENTS . . .

Resistors
R1 22kΩ R5 1kΩ
R2 10kΩ R6 }
R3 3·3kΩ R7 } see text
R4 1kΩ R8 }
All 10% ¼ watt carbon

Potentiometers
VR1, VR2 see text

Transistors
TR1, TR2 OC71 (2 off)

Diode
D1 OA5

Capacitors
C1 8μF elect. 15V
C2 0·001μF polyester
C3 100μF elect. 15V
C4 100μF elect. 15V
C5 40μF elect. 12V
C6, C7 (see text)
In the stepped "bass booster" circuit, C6 and C7 is replaced by:
C6a, C7a 0·001μF }
C6b, C7b 0·002μF }
C6c, C7c 0·005μF } Ceramic or
C6d, C7d 0·01 μF } mica, 2
C6e, C7e 0·02 μF } off each value
C6f, C7f 0·05 μF }

Battery
BY1 9 volt light duty

Switches
S1 2-pole 6 way wafer
S2 2-pole changeover toggle switch

Plugs and sockets
PL1 and SK1 coaxial for the input
PL2 and SK2 coaxial for the output

Miscellaneous
Printed circuit board 2in × 2in
Battery connectors and p.v.c. wire

low impedance input low values are required. For feeding into a high impedance valve amplifier high values would be used. Table 1 shows suggested values. Some experimenting might be necessary to achieve a more perfect match.

Table 1: COMPONENT VALUES FOR HIGH AND LOW IMPEDANCE

Component reference	Input impedance		Output impedance	
	High	Low	High	Low
R6	270kΩ	10kΩ	—	—
R8	—	—	270kΩ	4·7kΩ
VR1	250kΩ	5kΩ	—	—
VR2	—	—	100kΩ	5kΩ

PRINTED CIRCUIT

Fig. 4 shows the basic pattern of the printed circuit board full size. The link wires at positions B, C and D only are used. Components for the circuit in Fig. 1 are mounted on the board as shown in Fig. 5.

If C6 and C7 are replaced by the stepped control (Fig. 2) lead out wires should be connected at points (X), (Y), and (Z) for linking the control. ★

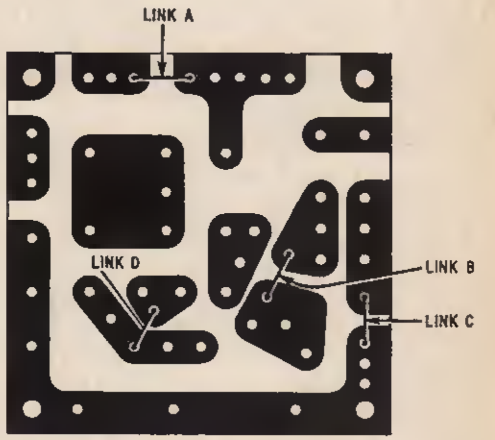

Fig. 4. Basic pattern of the printed circuit board. In this circuit links B, C, and D only are used. Link A is replaced by resistor R5

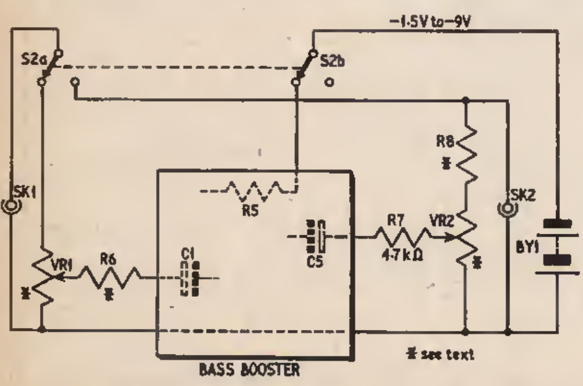

Fig. 3. The bass booster can be switched in by using this circuit. Components marked with an asterisk are given in Table 1 above

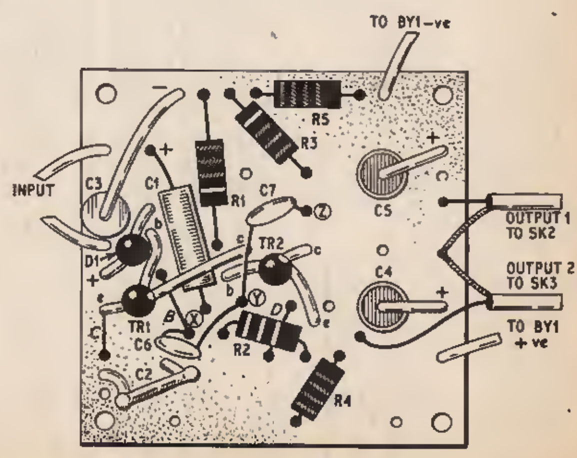

Fig. 5. Layout of components on the printed circuit board

the 73 page

by Jack Hum G5UM

Lobes and Beams

Last time we had something to say about the metre wavebands which are allocated to the Amateur Service—the "very highs" and the "ultra highs" in terms of frequency.

For the moment let us continue to focus our attention on this part of the spectrum, which we may very profitably do in the knowledge that it is here that the future of the Amateur Radio movement very largely resides; and let us concentrate on a particular and fascinating aspect of it—aerials.

Now there is nothing mysterious about aerials even though the mathematics of their design and behaviour may be beyond the experience of many practical electronicians. What is well *within* the experience not only of readers of this journal but of the non-technical world outside is that for the homely and everyday business of receiving television you need "a special aerial".

Electronic man does not need telling that the requirement that aerials shall conform to certain shapes and dimensions arises because such aerials have to be resonant at the frequency of the appropriate TV channel—long rods for BBC1, short rods for ITV, and midget rods for BBC2. He does not need telling, either, that if he wishes to listen on one or other of the amateur v.h.f. bands he will need to use an aerial of appropriate resonant frequency.

Certainly, results of a sort can be obtained by the time-honoured process of using "any old length of wire" by way of an aerial, and on the lower frequencies the enthusiast is all too often compelled to do just this for the practical reason that his garden will not accommodate the immense length of wire required for resonance at, say, the popular 80 metre band: 134ft would be needed.

At v.h.f. the situation is very different. Short rods replace the "any old lengths", and because they are—or should be—*resonant* rods they develop maximum voltage across their ends from the incoming signal.

Simple Dipole

One of the simplest aerials in the world is the two-metre dipole consisting of nothing more than a couple of 19in rods of aluminium or Woolworth's curtain rail, each extending outwards from a central insulator and with a coaxial cable downlead soldered to their separate ends.

Mounted horizontally, high and clear, such a dipole will give passable results on the two-metre amateur band. To add to it a reflector and a series of directors is to convert "passable" results to "amazing" results, and is an operation well worth performing. The resultant structure is what is known as a Yagi aerial. They exist by the million atop the homes of Britain: every ITV and BBC2 array is a Yagi!

Here we come to the great dividing line between the requirements of television reception and of the reception of amateur signals on the v.h.f. bands. Because the location of the desired television transmitter remains fixed and constant the household aerials that pick up its broadcasts remain permanently directed towards it.

Not so in the case of amateur transmissions. These may come from any point of the compass. Consequently, the receiving aerial must be capable of rotation so that it may be aligned precisely on the wanted signal. Even the simple dipole already described possesses inherent directivity. The more elaborate Yagi array has it to the nth degree—which is not just a figure of speech: it happens to be the case that the "goodness" or gain of a v.h.f. aerial is expressed by comparing it with a dipole as the basic reference source. A Yagi has a gain of ndB over a dipole determined by the number of elements it possesses.

To examine the polar diagram of a Yagi aerial is to be able to see for yourself how this gain looks on paper. In the line of fire a huge forward lobe is present. Tiny subsidiary lobes exist at the rear and sides. As the Yagi is rotated the user may imagine this invisible lobe traversing the terrain before it—a radio searchlight to detect sources of signal many miles away.

Rotating

But how to rotate it? Here we are faced with problems of practical mechanics rather than practical electronics.

Ready made electric rotators may be purchased if the budget permits. A variety of these of American origin is available in this country (there is wide use of them in the States for rotating domestic television aerials in circumstances where receivers have not one or two but dozens of TV services within range, and the ability to focus the "antenna" upon the desired station proves important).

War-surplus electric motors may be adapted for aerial rotation service. Even the humble bicycle-wheel-and-sprocket arrangement has been pressed into service, as have endless cords running over cotton reels.

How John Hazell has overcome the problem of aerial rotation at his station G8ACE at Hatfield, Hertfordshire. Drive is applied from a war-surplus electric motor to the base of a dural mast carrying aerials for 23 cm, 70 cm, two metres and four metres. A ladder type bottom section concreted into the ground secures the mast when it is upright and its guide cables when it is lowered

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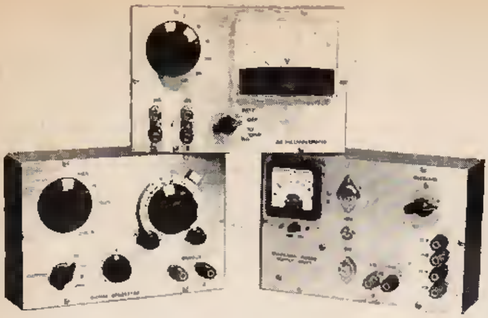
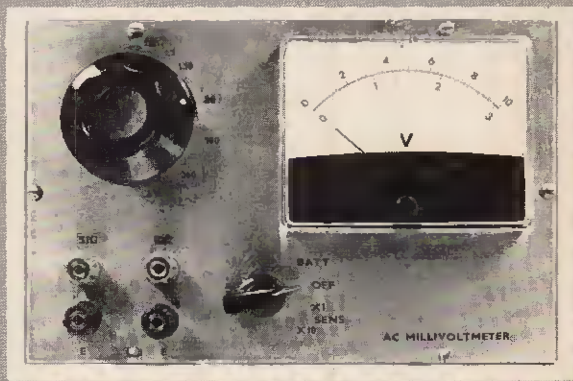


1. A.C. MILLIVOLTMETER

2. SIGNAL GENERATOR

3. STABILISED TRANSISTOR POWER UNIT

TEST 1 GEAR TRIO



SPECIFICATION

A.C. RANGES
Sensitivity switch ×10:
0–300μV, 0–1mV, 0–3mV,
0–10mV, 0–30mV, 0–100mV
Sensitivity switch ×1:
0–3mV, 0–10mV, 0–30mV,
0–100mV, 0–300mV, 0–1V*
*External probe circuit extending highest range to 100V.

ACCURACY Better than ±2% full scale deflection
INPUT IMPEDANCE Better than 5 megohms at 25°C
(External probe) better than 2·5 MΩ at 25°C
NOISE Better than 1μV on the 1mV range from 100 kilohm source
FREQUENCY RESPONSE
20c/s—250kc/s ±0·5dB

THE term "a.c. millivoltmeter" is possibly one of the most contrary phrases in the sphere of electronic test equipment. In itself, a millivolt is one thousandth part of a volt, so an instrument measuring from 1 millivolt to 1 volt is indeed a true millivoltmeter and from 1 volt upwards, a voltmeter.

The majority of instruments however, classified in the original term, have a range in the order of 1 millivolt to 300 volts, and more often than not, the higher voltage ranges are included as an integral part of the equipment. This usually leads to a compromise with respect to the frequency response and noise characteristics due to the high impedance, large signal attenuators that are, by necessity, introduced into the front-end circuitry. This poses the further problem of accurately and consistently, setting up and maintaining the effective control of stray capacity.

This constructional article sets out an instrument that is bereft of these major drawbacks, on the higher ranges mentioned above. The basic instrument

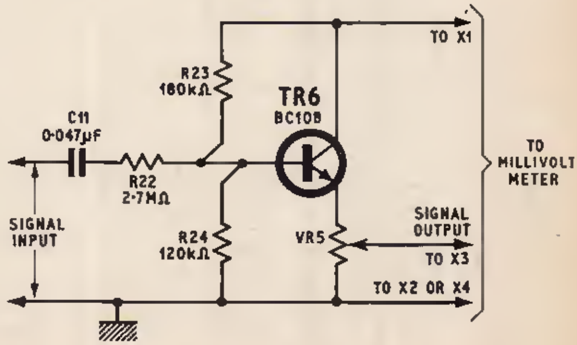


Fig. 1a. Circuit diagram of the probe unit which is connected to the terminals on the main instrument. VR5 is 10 kilohms

For experimental work, especially where audio frequency equipment is being built, the amateur often lacks facilities for testing and measuring its characteristics. At a relatively modest outlay he can set up a test bench with three basic items of test gear that will prove useful for a wide variety of applications.

measure . . .
FREQUENCY RESPONSE
DYNAMIC RANGE
SIGNAL/NOISE RATIO
OVERALL GAIN
SENSITIVITY

R. HIRST

A.C. MILLIVOLTMETER

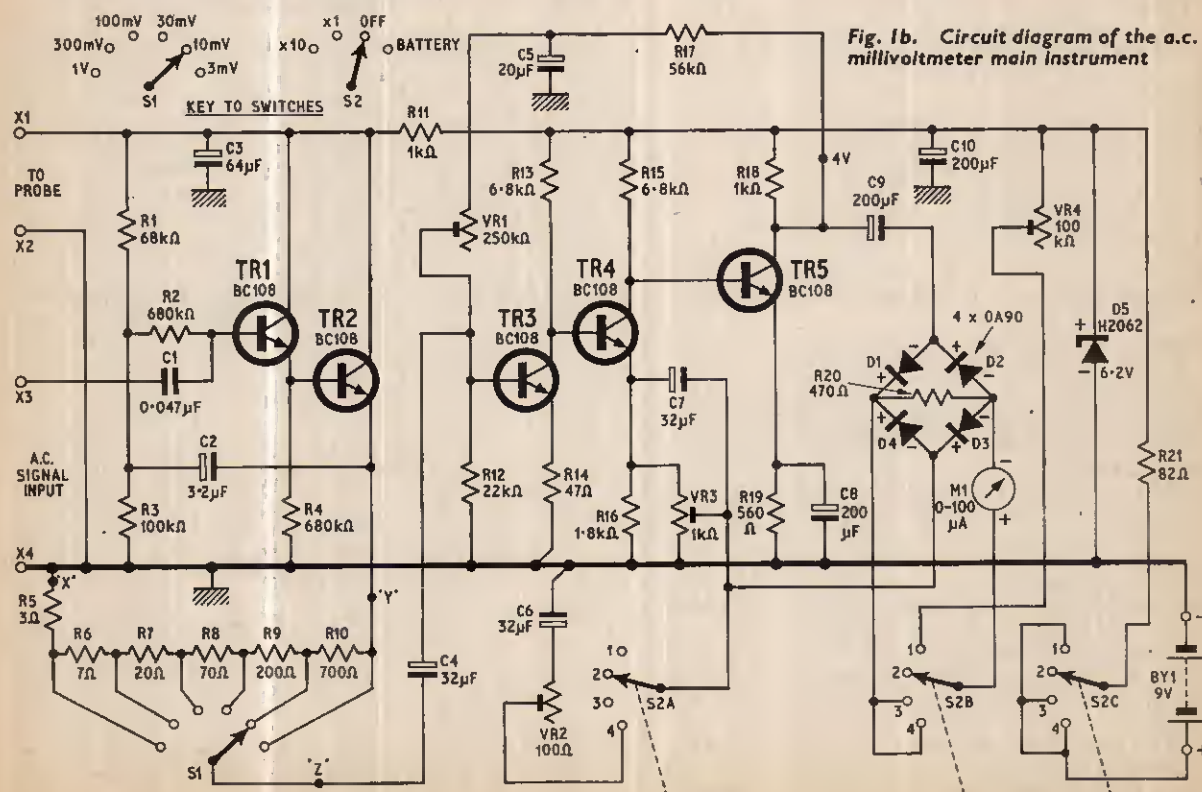


Fig. 1b. Circuit diagram of the a.c. millivoltmeter main instrument

measures from 1 millivolt to 1 volt in eight ranges with a 0·3 millivolt range introduced to facilitate noise measurements.

Internally generated noise is held to a very low level, being in the order of 1μV on the 1mV range. As an optional feature the instrument may be used as an a.c. voltmeter by the connection of an external probe (Fig. 1a), bringing the full scale deflection, on the uppermost range, to 100 volts.

This external probe circuit has the conventional high input impedance and, what is possibly more essential, a relatively low capacitance loading upon the measured circuitry. We may now use a reasonable length of connecting lead to the instrument proper, without the attendant problem of hum pick-up or capacitive losses. This advantage is gained by the output impedance of the probe being comparatively low, i.e. in the order of 100 ohms.

We can best show this advantage, by stating that the high frequency loss in the input configuration with 3ft of coaxial cable, at 20pF per foot across a 200 kilohm load, will be 3dB down at approximately 13kc/s, thus rendering any measurements inaccurate when made at or around this frequency.

With the external probe, however, the loss would occur at approximately 26Mc/s—well outside the range of the instrument. It must be clearly pointed out that all leads have to be kept as short as possible when measuring high frequencies on the millivolt ranges, with care taken to avoid any extraneous hum pick-up, should unscreened leads be used.

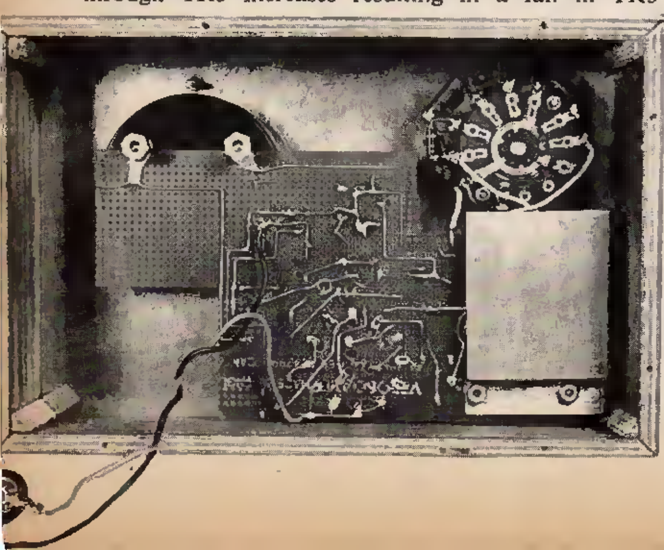
CIRCUIT DESCRIPTION

The input circuitry is of a well proven nature taking advantage of the "boot-strapped Darlington pair", the only relatively new feature being the employment of epitaxial silicon transistors (Fig. 1b). This configuration enables a reasonably high input impedance in the order of 5 megohms to be obtained. The input impedance is theoretically approximately equal to $\beta_{TR1} \times \beta_{TR2} \times R_e$.

The attenuator in the emitter of TR2 is possibly the greatest controlling feature in the accuracy of the instrument and care in selection of close tolerance resistors will be well rewarded in the final application.

TR3, TR4 and TR5 form a "d.c. coupled trio" which gives an excellent temperature stability factor, as any change in the working point of TR3 is immediately inverted and fed back to the input of TR3 in the following manner.

As the temperature increases, the collector current through TR3 increases resulting in a fall in TR3



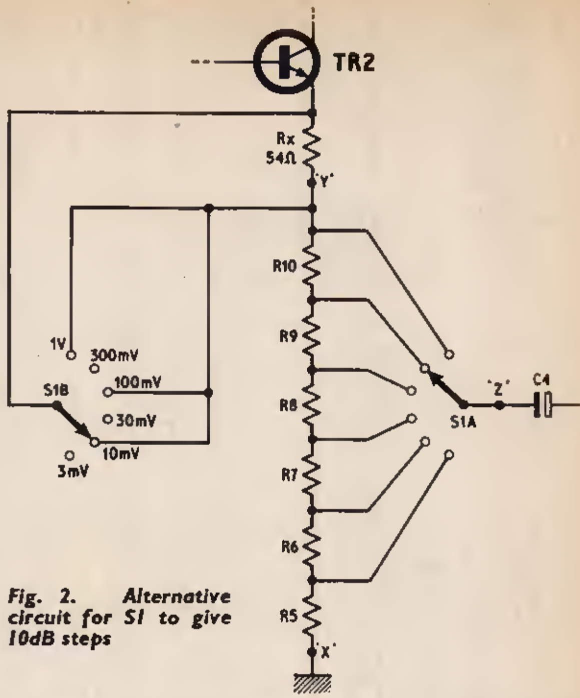


Fig. 2. Alternative circuit for S1 to give 10dB steps

collector voltage and consequently a fall in TR4 base voltage. As TR4 cuts off, the collector voltage of TR4 and the base voltage of TR5 rise, causing the collector voltage of TR5 to fall. This reduction in voltage at TR5 collector is fed back to TR3 base via R17, thus causing the collector current of TR3 to fall and restore the circuit to its original d.c. condition.

In order to clamp the d.c. conditions even further, a relatively high collector current is present in TR3, TR4 and TR5 with d.c. feedback over all the emitters, giving stability over the temperature range of −5 degrees C to 70 degrees C. A potentiometer VR1 is included for the final setting up operation.

As an a.c. amplifier, TR3 has an undecoupled emitter resistor giving a reasonably high input impedance in the order of 10 kilohms (approximately $\beta \times R_{14}$), to obviate any heavy loading of the attenuation network thus preserving accuracy. The output is directly coupled into TR4 which in turn is directly coupled to TR5. This lack of coupling capacitors helps to maintain a.c. stability at the very low frequencies.

The meter is heavily damped and fed from a bridge network of diodes connected to TR4 emitter and TR5 collector via C7 and C9. This ensures a very wide and consistent response, occasioned by the large degree of negative feedback via C7.

VR3 is adjusted in the final setting up procedure for the precise gain setting required. An increase in sensitivity of ten times is introduced by S2A in conjunction with C6 and VR2, in order to measure directly the low outputs from tape heads and other similar low signal transducers. This feature also facilitates the measurement of noise.

A stabilised line check has been incorporated, the meter reading full scale deflection for correct working conditions when S2 is switched to "BATTERY". The battery should be replaced when the reading has fallen below 0·95 of full scale. BY1 is a 9V battery giving an approximate life of 150 hours. The line voltage is stabilised at 6·2 volts by the Zener diode D5 in conjunction with R21. The inclusion of this arrangement ensures very consistent results for considerable changes in battery voltage.

For constructors wishing to use a meter calibrated in 10dB steps the range switch modifications required are shown in Fig. 2. S1 in the case has two banks and an additional resistor Rx inserted in the emitter circuit of TR2.

CONSTRUCTIONAL NOTES

The entire instrument is of a very simple constructional nature. The components can be mounted on a perforated board with an 0·15in hole matrix, or a printed circuit board may be made. It is essential that the small metal screen is included around the input circuit or hum pick-up could give inaccurate readings on the lower ranges.

The diagrams in Figs. 3, 4, and 5 show clearly all the necessary details for constructing this instrument. The external probe can be made up in any appropriate metal casing ensuring that the input leads are not more than 12in long. The three output leads are connected to the instrument as shown in Fig. 5c.

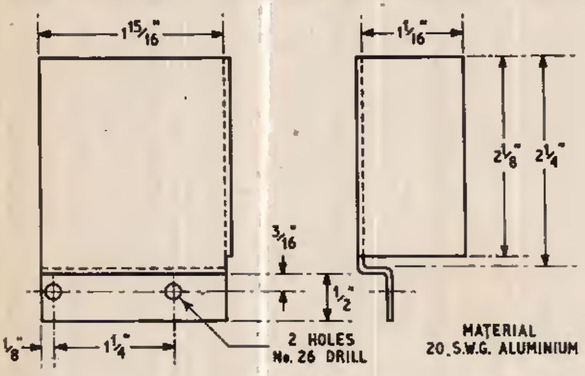


Fig. 3. Front and side elevations of the screen fitted over the first two stages

SETTING UP PROCEDURE

After very carefully checking the wiring a battery may be connected and the instrument switched to the 1 volt range with S2 in the ×1 position. VR1 should now be adjusted so that the voltage between the negative rail and TR5 collector is 4V d.c., measured with a 20,000 ohms per volt multi-range meter switched to the 10 volt range.

The next step is to apply an input signal of 1kc/s to the input terminals, X3 and X4, measuring exactly 100mV r.m.s. The switch S2 should be set to the ×1 range and S1 to the 100mV range. VR3 should be adjusted so that the meter reads full scale deflection. Finally, set the range switch S1 to 1V and S2 to ×10 and adjust VR2 for full scale deflection.

Some difficulty may be encountered in obtaining a 1kc/s signal source so a simple circuit that will give quite satisfactory results, providing one has an a.c. voltmeter,

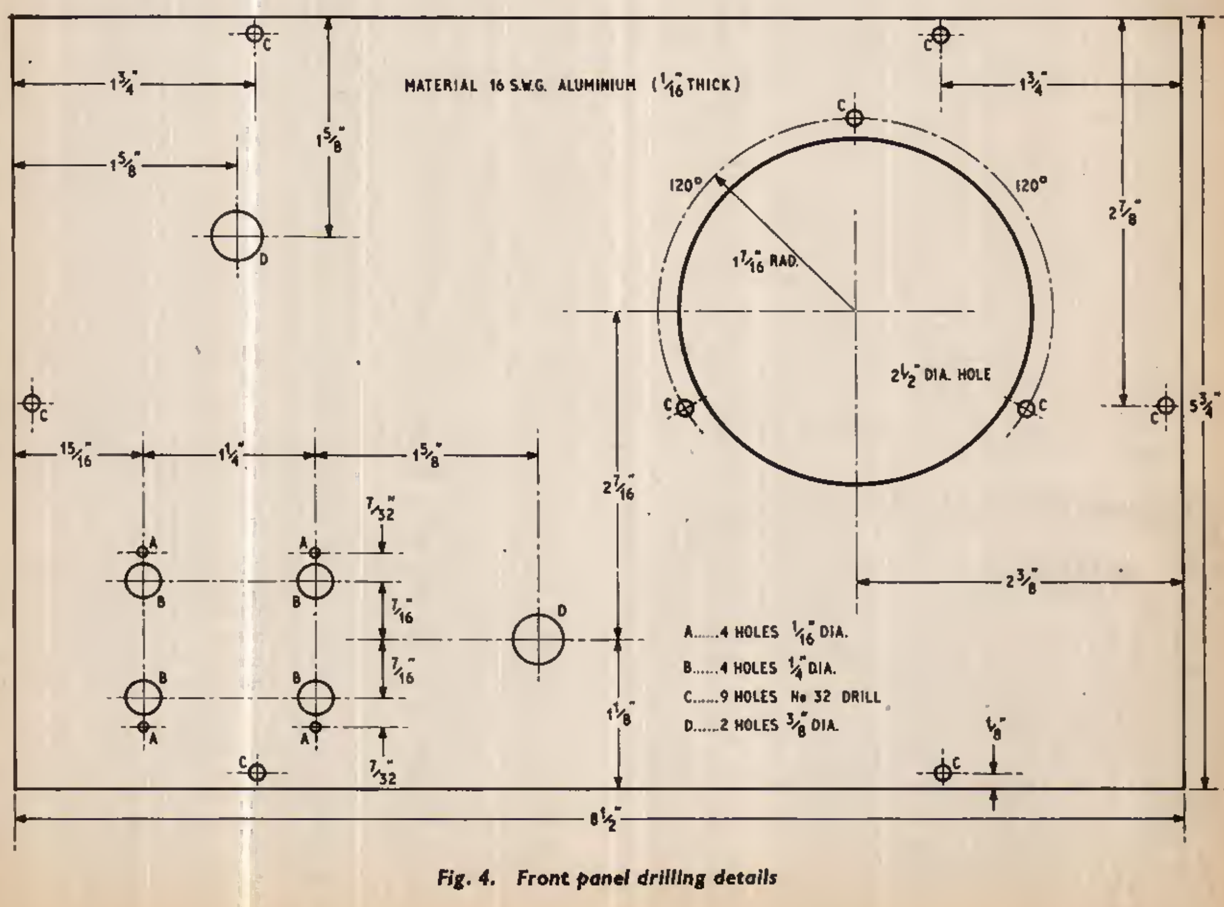
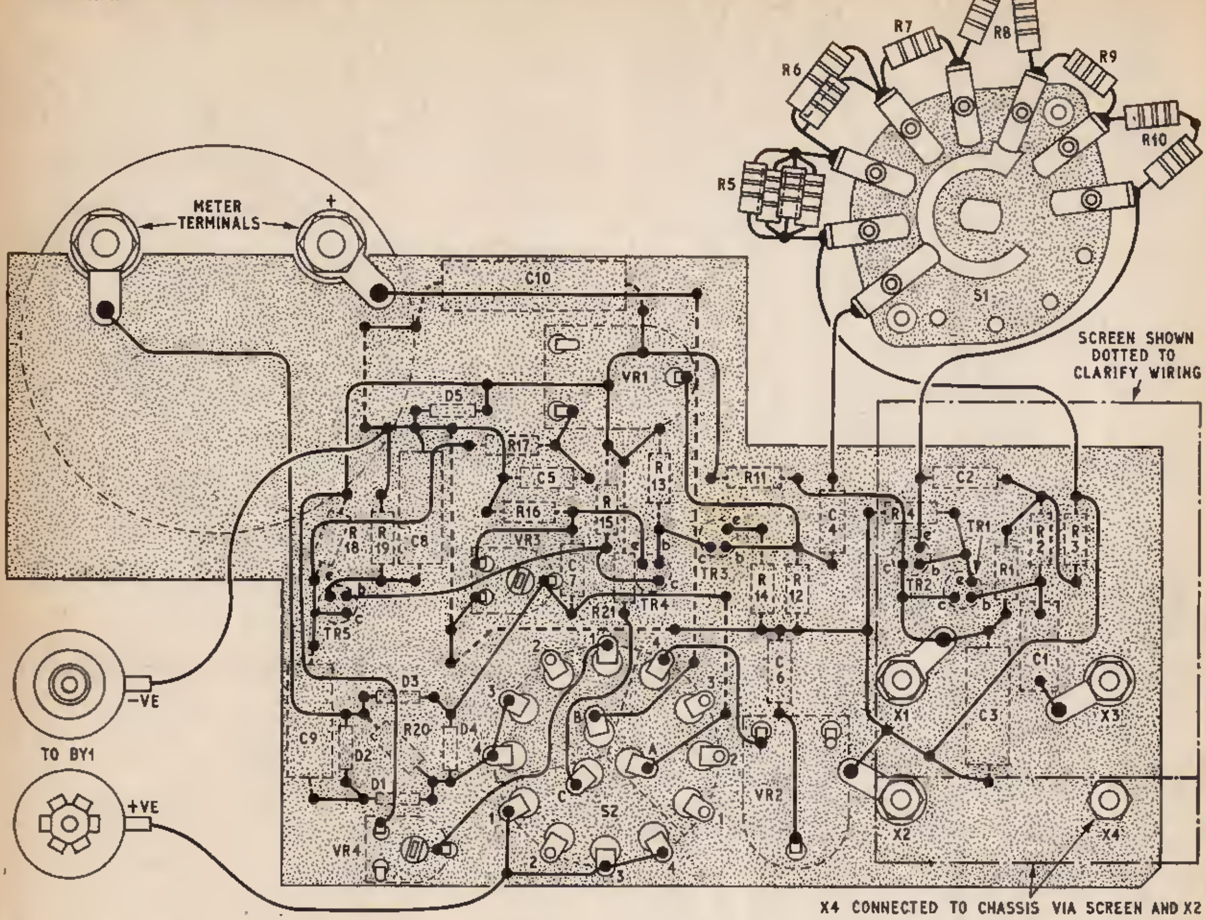


Fig. 4. Front panel drilling details

Fig. 5a. Layout and wiring looking at the back of the instrument



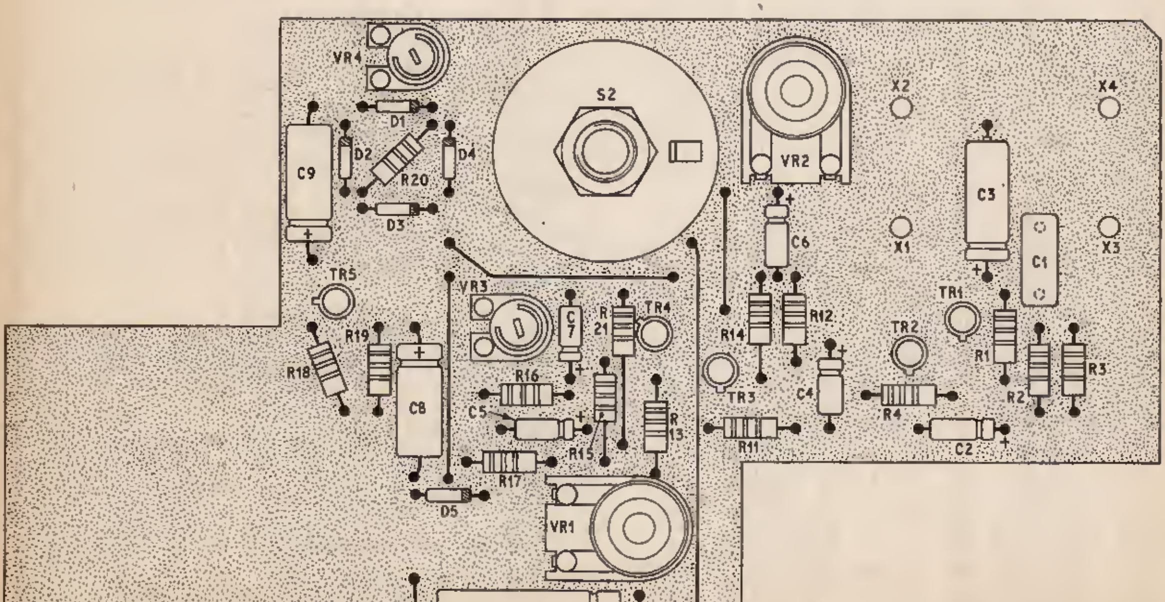


Fig. 5b. Component positions on the perforated board

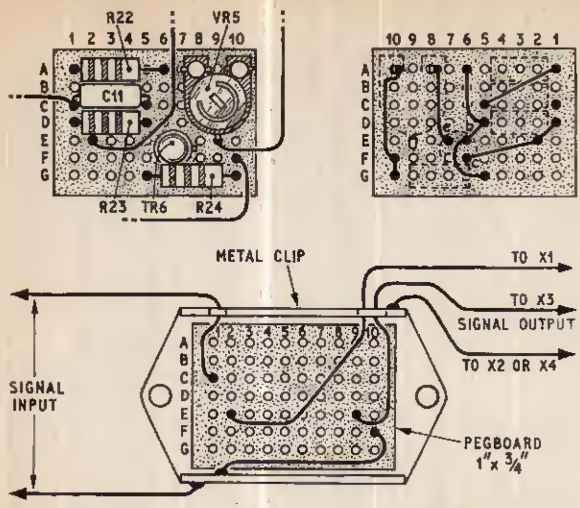
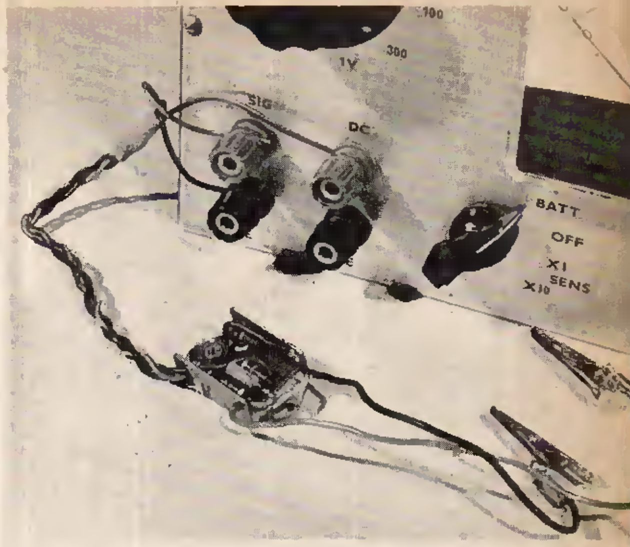


Fig. 5c. *The layout and wiring of the probe unit*



COMPONENTS . . .

Resistors
- *R1 68kΩ
- *R2 680kΩ
- *R3 100kΩ
- R4 680kΩ
- *R5 3Ω (four 12Ω resistors in parallel)
- *R6 7Ω (10Ω and 18Ω in parallel)
- *R7 20Ω
- *R8 70Ω (27Ω and 43Ω in series)
- *R9 200Ω
- *R10 700Ω (20Ω and 680Ω in series)
- R11 1kΩ
- R12 22kΩ
- R13 6·8kΩ
- R14 47Ω
- R15 6·8kΩ
- R16 1·8kΩ
- R17 56kΩ
- R18 1kΩ
- R19 560Ω
- R20 470Ω
- R21 82Ω
- *Rx 54Ω (two 27Ω resistors in series)

* Resistors marked with an asterisk are 5% high stab. ½ watt carbon; all other resistors are 10% ½ watt carbon. R5 and R6 may be wirewound (see text)

Potentiometers
- VR1 250kΩ carbon linear preset skeleton
- VR2 100Ω
- VR3 1kΩ
- VR4 100kΩ carbon linear preset skeleton

(Waycom)

Capacitors

C1	0·047μF polyester	C6	32μF elect. 2·5V
C2	3·2μF elect. 6·4V	C7	32μF elect. 2·5V
C3	64μF elect. 10V	C8	200μF elect. 6·4V
C4	32μF elect. 2·5V	C9	200μF elect. 6·4V
C5	20μF elect. 6·4V	C10	200μF elect. 6·4V

All capacitors except C1 are Mullard miniature electrolytics

Transistors
- TR1–5 BC108 (5 off) (Newmarket)

Diodes
- D1–4 OA90 (4 off) (Mullard)
- D5 6·2V Zener H2062 (Hughes) *or* OAZ243 (Mullard) *or* 1S7062 (Texas)

Meter
- M1 0–100μA f.s.d., 10kΩ/volt, moving coil type

Battery
- BY1 9 volts to fit in case

Switches
- S1 1 pole 6-way rotary wafer switch (see text)
- S2 3 poles 4-way rotary wafer switch (see Fig. 6 for style to fit component board)

Terminals
- X1–4 Screw type 4mm (4 off) (Radiospares)

Miscellaneous
- Wooden box made up 8·5in × 5·75in × 2·5in
- Aluminium panel 16 s.w.g. 8·5in × 5·75in
- Perforated s.r.b.p. 0·15in hole matrix 8in × 4·5in
- Battery connectors

PROBE UNIT

Resistors
- R22 2·7MΩ
- R23 180kΩ
- R24 120kΩ

All 10% ¼ watt carbon

Potentiometer
- VR5 10KΩ linear skeleton preset midget (Waycom)

Capacitor
- C11 0·047μF polyester 125V

Transistor
- TR6 BC108 (Newmarket)

Miscellaneous
- Perforated board (offcut from main panel)
- Suitable metal housing

is shown in Fig. 6. In order to arrange a signal source of 100mV a.c. any mains transformer capable of giving 6–9V at 30mA may be used.

Before switching on, the 500 ohm potentiometer should be turned to its maximum resistance. An a.c. voltmeter should be connected across the 3 ohm resistor and set to 1V a.c. range (after switching on). The 500Ω potentiometer should be very carefully adjusted so that 0·1V is indicated on the meter. Now inject this 50c/s signal across X3 and X4.

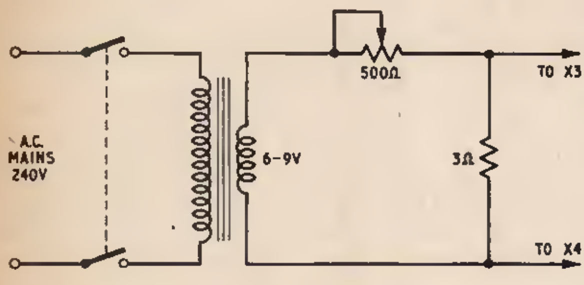


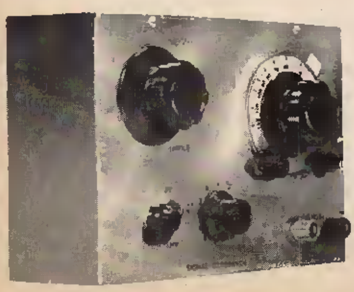
Fig. 6. Suggested circuit for providing a 50c/s calibration signal

In the prototype unit high stability 5 per cent resistors were used in the attenuator with great success but the 7 ohm and 3 ohm resistors were wound from eureka wire around a 1 megohm ½ watt resistor and then varnished over. Closer tolerance resistors will definitely ensure a high degree of accuracy.

To set up the probe, the 100mV test signal as previously used can be connected across the probe input and the a.c. millivoltmeter switched to the 10mV range, with the function switch to ×10 (i.e. to read up to 1mV) then VR5 is set for full scale deflection. This setting up should be done only after the instrument has been set up as in the earlier paragraphs. When setting up on the "battery check" position, the voltage of the battery should not be less than 8V. After ascertaining this, VR4 should be adjusted so that the meter reads full scale deflection. This is not a reading of battery voltage but a measurement of the stabilised rail voltage and any reduction in the full scale reading, once having been preset, should be regarded as detrimental to the performance. As previously mentioned, any fall indicates the necessity for battery replacement.

Note: Potentiometers quoted are made by Piher and are available from Waycom Limited, Wokingham Road, Bracknell, Berkshire.

NEXT MONTH SIGNAL GENERATOR



detached particles

JOHN VALENCE

ANALOGUE v DIGITAL

In the field of computing the digital system has long been recognised as the more refined and accurate. The analogue computer has limitations chiefly due to the difficulty of designing completely drift-free direct coupled amplifiers. Pulse circuitry on the other hand presents no such problems and the order of accuracy of computation can be increased by increasing the pulse rate.

Even in the field that was once the exclusive preserve of the analogue computer—machine control—the digital computer is taking over more and more as new techniques permit even higher operating frequencies.

DIGITAL PLOTTER

A graphic demonstration of the capabilities of the digital system in high speed positional control was given by the CalComp Digital Plotter during this year's Instruments, Electronics and Automation Exhibition.

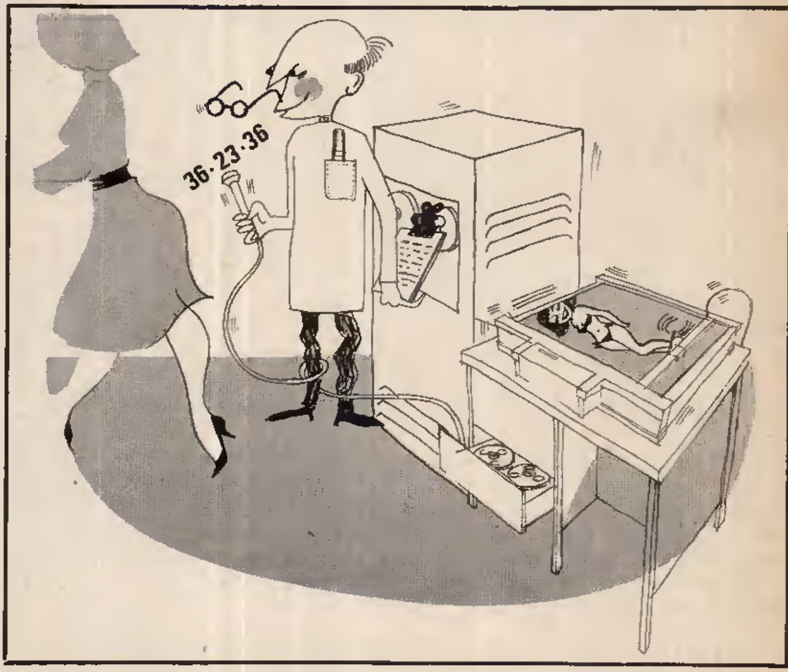
I don't know if any visions of impending redundancy were conjured up in the minds of visiting drawing office staff who stopped to look at this exhibit! Perhaps they will be somewhat reassured when they learn of the price of this machine, £40,000. Still the writing is on the wall; or rather more accurately in this case—on the flat bed.

Briefly this super draughtsman works something like this. A pen driven by two-directional motors in both the X and the Y axes traverses a large plotting surface. The motors respond to the digital output from a computer and move the pen in incremental vectors, of any 24 different combinations of length and direction, at a maximum speed of 450 steps per second.

Switch on and hey presto—a cross-sectional drawing of a mountain range with cross hatching and other details included, or maybe an isometric engineering diagram with all relevant dimensions, rapidly takes form before one's eyes as the mercurial pen dances a lively fandango to a tune played by a punched tape.

The invasion of the drawing office by computers has been under way for some time, although the forces so far deployed are generally far less formidable than the advanced type of plotter just referred to.

The Ford company, for instance, uses a computer for the preparation of new car designs. To date, I note, it is estimated that the computer has saved 2,000 hours of drawing time in a year.



ELECTRIC DRIVE

Forward looking as the motor car industry may be in this respect, I can't help feeling that in more fundamental matters it is very reactionary. Will we never see a replacement for the internal combustion engine? Seemingly, little effort is being made to develop electrically powered road vehicles. It is encouraging, however, to learn that other organisations are experimenting in this field and designs for electrically operated "town" cars have been drawn up.

NOT WITH IT

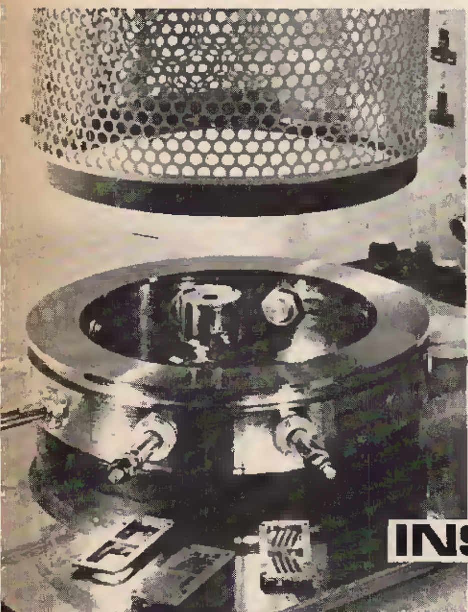
The Government's dithering about whether or not to continue participation in the European Space programme was not exactly an inspiring performance. The lack of resolution becomes a little more understandable when one reads the idiotic remark made by a well known MP that he would prefer free pills to a share in the space world. If there are many more of this mentality amongst our representatives, heaven help us.

Perhaps this MP with his self advertised "social conscience" and deep concern for the ailing would like to ponder over this: arising out of problems concerning communication with astronauts the Americans have produced experimental devices which may help the blind to "see" by using the sense of touch. And this is only one of the countless fruits that may be plucked from "space" for all mankind to share.

To put it into the current vernacular, some people are *not with it!*

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE



Magnetic Tape Typewriter

AN I.B.M. magnetic tape typewriter can record matter as it is typed. When played back the tape operates the typewriter automatically at 15·5 characters per second whenever required.

INSTRUMENTS ELECTRONICS

HIGHLIGHTS FROM THIS BIENNIAL EXHIBITION HELD AT OLYMPIA, LONDON

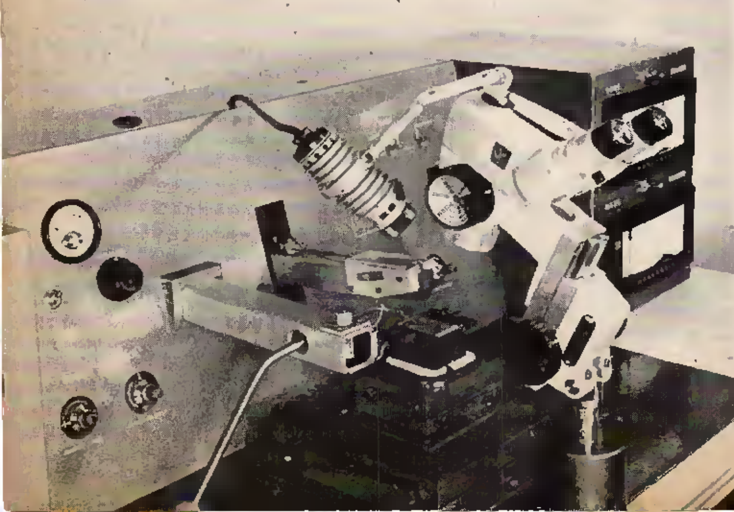
Thin Film Tools

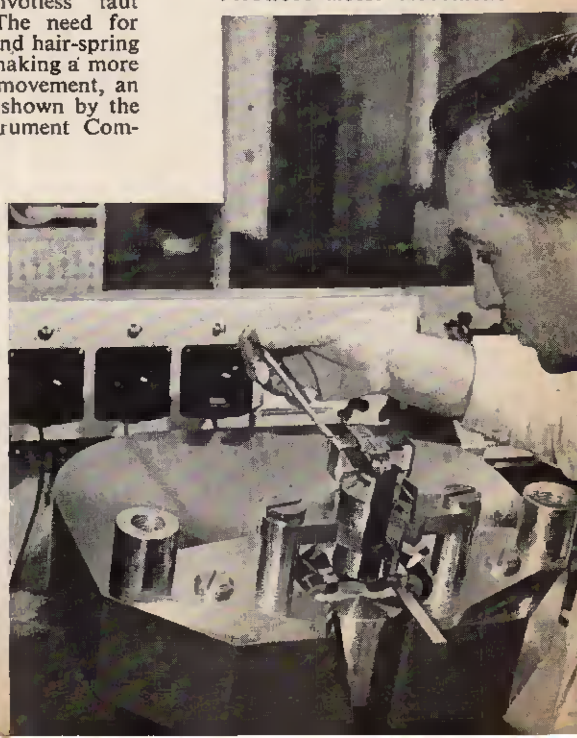
A NEW complete kit for adapting existing vacuum evaporators to the electron beam method. The picture above shows a horizontal water cooled evaporation source around the electron beam gun.

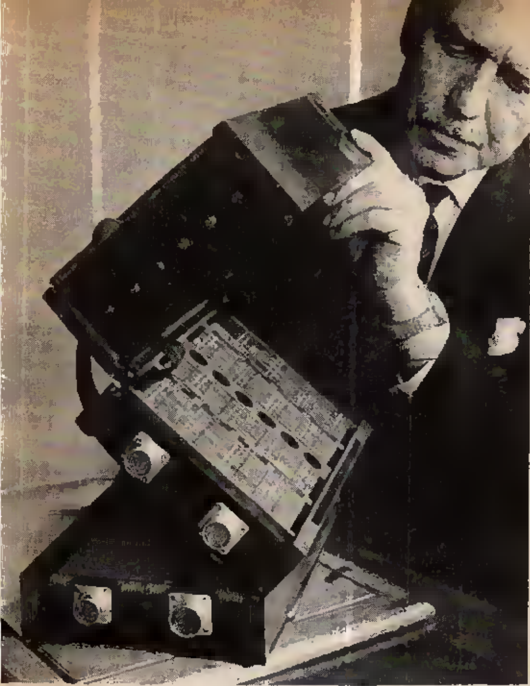
A thermocompression bonder (below) is used for high speed volume production of thin film microcircuits and semiconductor devices.

THE latest in meter movements (right) uses a pivotless "taut band" principle. The need for pivot jewel bearings and hair-spring is eliminated, hence making a more robust meter. The movement, an enlarged model, was shown by the Sifam Electrical Instrument Company.

Pivotless Meter Movement







Atomic Clock on Tour ▶

THREE caesium standard atomic clocks have been touring the world; one was on show at the I.E.A. exhibition. The object of the exercise is to check international time standards against each other to achieve an accuracy of within one microsecond. The clock shown here, built by Hewlett-Packard, is seen in operation at Royal Observatory, Herstmonceux, Sussex. The lower panel is the power supply unit; the centre panel is the caesium beat frequency standard oscillator; the top panel contains the frequency divider and digital display.

Computers are Getting Smaller!

THE concept of folding computers is not new, but this model MCS 92OM microminiature computer, produced by Elliott-Automation, weighs only 30 pounds.

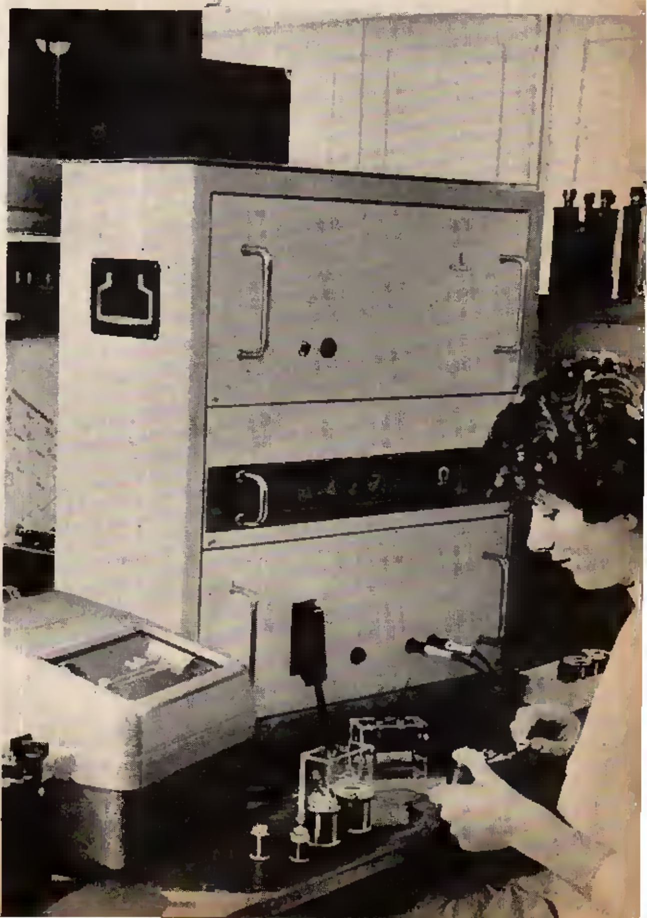
AUTOMATION 1966

Automatic Resistance Measurement

RESISTORS are measured on the instrument below and gives a digital display of the value at the touch of a button. It will measure up to 999 megohms and indicate visually the decimal point position and "K" or "M" factors. The instrument has been developed by Siemens and Halske and imported by R. H. Cole Electronics Limited.

"Nim" on Maxalog

THIS model of the Post Office Tower was specially built for demonstrating Maxalog computing equipment. Built by Maxam Power Limited it was programmed to play the game of "Nim". The machine will lose if its human opponent at the control panel below makes no mistake, but a single slip allows fluid logic to take over so that the machine wins. The game is played with ball bearings.



BEGINNERS start here... 22

An Instructional Series for the Newcomer to Electronics

IN recent articles we have referred to the production of simple signals by electronic means. First the production of a very low frequency square wave was explained, then circuits were described illustrating the production of sine wave signals of high and low frequency, respectively. As a part of our progress, we covered the requirements and actions of the various components used, and we have managed to mention some of the basic laws governing circuit operation—the "rules of the game" as it were.

Now we are ready to ask the question, "To what uses can these various types of signals be put?"

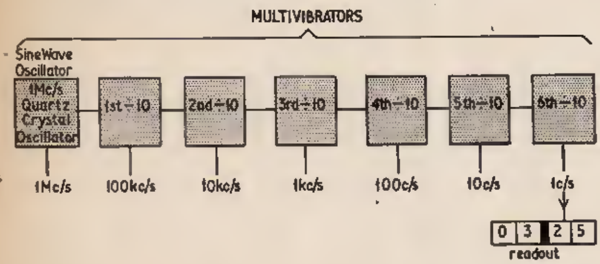


Fig. 22.1. The principle of the quartz crystal clock. Multivibrators are used to divide down the highly accurate frequency generated by the oscillator

CONTINUOUS OSCILLATIONS

It has already been seen that a sine wave purely and simply cannot convey very much in the way of information, but that which it does carry is very important. This information concerns *time;* or strictly, what amounts to the same thing, frequency.

If we have a continuous oscillation of very accurate and stable frequency we have (the analogy of the "pendulum" again!) a very good time keeper. This is the principle of the quartz clock (see Fig. 22.1), which uses the constant signal from a quartz crystal oscillator to time the readout device, in this case a digital hours/minutes/seconds/tenths/hundredths/thousandths, etc. seconds indicator. Also, all the wavemeter or frequency meter test equipment (and some of these devices are very expensive) rely essentially on an oscillator to produce a very stable and accurately known oscillation, for calibration purposes.

RADIO TELEGRAPHY AND TELEPHONY

Perhaps the earliest method of transmitting intelligence by means of electronics, was the chopping up of the continuous sine wave oscillation into the long and short bursts corresponding to the Morse Code as illustrated in Fig. 22.2a. This type of signal became known as "c.w." (continuous wave) and is still used a great deal.

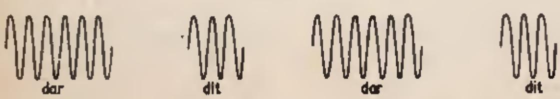


Fig. 22.2a. A continuous wave of oscillations is broken up into long and short bursts by a morse key

It was soon found that the electrical signals produced as a result of sound waves striking the diaphragm of a microphone could be superimposed or "carried" by the high frequency c.w. radiated by a radio transmitter. This is performed by varying the amplitude of the radiated wave in sympathy with the microphone signal, see Fig. 22.2b. The resultant "amplitude modulated" signal is then processed by circuits in the receiver to give back a replica of the original microphone signal, which can then be used to operate an earphone, producing a sound similar to the original. The "carrier" wave, as it is known, is discarded in the receiver.

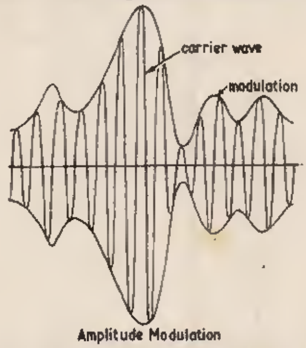


Fig. 22.2b. Here the steady continuous wave is "modulated" by a low frequency signal such as that produced by a microphone. This is known as amplitude modulation

Thus Wireless Telephony became possible .... and it was only a matter of time before visual signal information was "carried" in the same way, to give radio photograph transmitting systems, and then television.

Another development took place, in which the *frequency* of the radiated wave is varied in sympathy with the *audio frequency* signals, as microphone and other low frequency (hearable) signals are called. This is illustrated in Fig. 22.2c. Frequency modulation (f.m.) has certain advantages over a.m. systems, in that less interference is caused by noise "signals" from such sources as thunder storms, motor-car ignition systems, and so on.

RADAR TECHNIQUES

With the advent of Radar, electronic techniques really began to develop. Radio Detection and Ranging uses a large signal pulse radiated by a transmitter and a

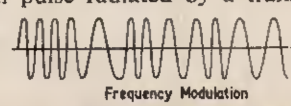


Fig. 22.2c. An alternative method of transmitting audible intelligence is to vary the frequency of the carrier in sympathy with the audio signal. The amplitude remains constant

receiver which detects returning "echo" signals produced by objects in the field of the transmitted pulse. Obviously, a great deal of development had to take place in order to arrange for circuits to switch on the transmitter, switch it off again, turn on the receiver, connect over the aerial to it, start the time measuring device and get the readout device ready—all within *millionths* of a second, and repeat this some thousand times a second anyway.

Radar signals contain a large amount of information. The distance of the "target", the bearing, and the altitude perhaps, are all recoverable from the received pulses, by appropriate processing. The transmitter is switched on, and some one microsecond later switched off again, by using a square pulse. A multivibrator is often used in these devices, just like the one you built to switch the lamps (see No. 13 of this series). This is probably where the term *switching waveform* was first used. The same multivibrator starts the timing circuit, and operates the receiver, also the readout device, usually a cathode ray tube. In fact, the whole circuit works in synchronism controlled by one *master multivibrator* which generates the switching signal. A block diagram of a radar installation is given in Fig. 22.3.

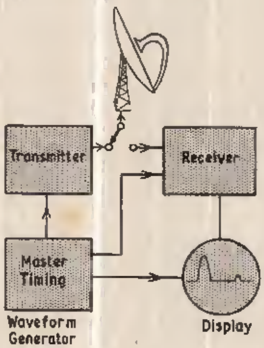


Fig. 22.3. The basic arrangement of a radar installation

It is possible to use pulses of *sound* waves and a microphone to pick up the echoes, and this sound version of a radar set is termed AUDAR, and the writer knows of two successful sets built by amateurs. A similar system for detection of objects under water is known as SONAR. (No example of a radio wave radar set built by an amateur is known to the writer, but it would form a very interesting and challenging project for an enthusiast to attempt.)

TRANSDUCERS

Of course, *all* the methods of producing electronic signals from the variety of sources that exist, both electrical and non-electrical, are important and the student of electronics would be very wise to attempt an early understanding of the methods and techniques commonly used. This part of the subject involves devices called *transducers*, and these are so important (and interesting) that a separate article will be devoted to them. However, once the electrical signal is produced, from whatever source or kind of transducer, it is "handled" by circuits which are all very similar. All said and done, electronic signals are virtually the same from any source—it is the information they carry which differ.

We mentioned before that it is the purpose of the electronic circuits and components behind the front panels to either *amplify* the signals without changing their form, or to process them in some way. The transducers are the "go betweens" between the sources and the electronics, and then from the electronics to the ultimate destination—whether it is a "readout" device to stimulate one of our senses, or the operation of some machine or control device. This is illustrated diagrammatically in Fig. 22.4.

TO SUM UP

To sum up our survey of signals and the handling of them, we should first mention the oscillators we have already described in this series; these are, of course,

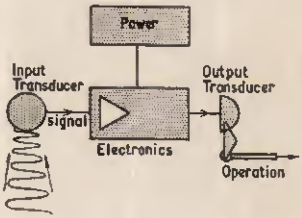


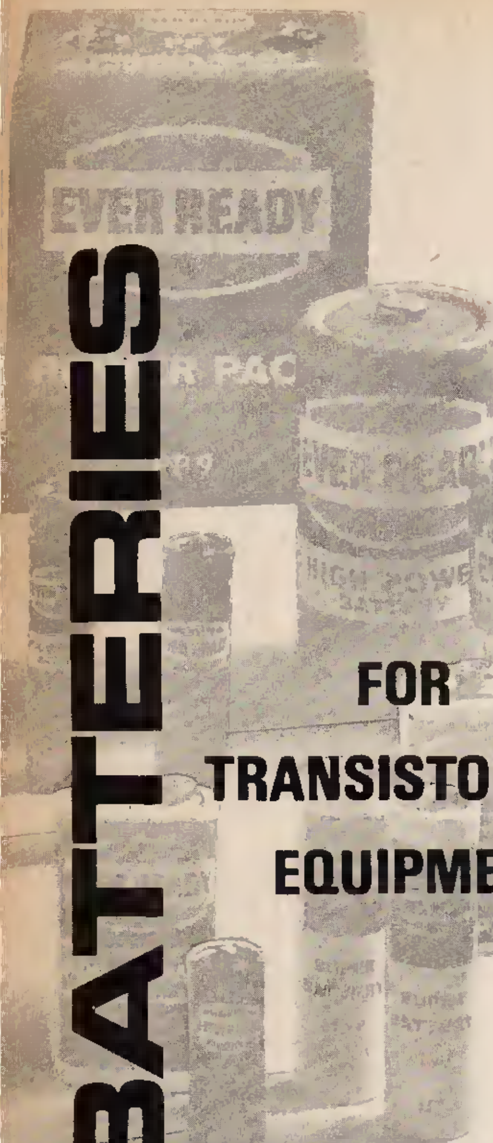
Fig. 22.4. Industrial control systems are built up on the lines depicted in this basic diagram

electronic generators of signals. The main job of much electronic circuitry is to amplify such signals, and we will describe a practical amplifier for home construction next month. You will then have an idea of all the basic operations carried out in simple electronic apparatus; all except transducers, that is, but another article in this series will cover these devices.

You could gain plenty of experience now, by studying all the devices and circuits described in PRACTICAL ELECTRONICS, and analysing them by using your now increasing knowledge. The *Radio Control of Models* articles are a good example. Study how the signal is generated at the transmitter, the nature of this signal and the kind of information it carries; how the receiver "processes" this signal, the operation of the *servo* (electro-mechanical transducer) and the final result obtained.

The mysteries behind the front panels should be unfolding now!

BATTERIES FOR TRANSISTORISED EQUIPMENT



Information presented by the Technical Department of Ever Ready Co. Limited

MODERN techniques in electronics, in particular the increasing use of transistor circuitry and portable equipment, call for a discriminating choice of power supplies to satisfy the electrical and physical demands of such equipment. For convenience of size and weight per unit capacity the primary cell has largely superseded the secondary (or wet) cell where low wattages and currents are required.

Widespread use is made of "dry batteries" for transistor circuits, particularly where portability is an essential requirement. The most commonly used type of dry cell is a development of the Leclanché cell, two or more of which constitute a "battery" when suitably connected together and jacketed or boxed.

Since there is a variety of sizes and shapes of dry battery on the market, this article is aimed at providing a guide for constructors and users so that the most appropriate cell or battery can be selected for a particular purpose.

BASIC CONSTRUCTION

Let us first look at the basic construction of a dry Leclanché cell. Fig. 1 shows a cut away section of a "leak-proof" cell. The electrolyte is normally a paste made up from ammonium chloride with moisture retaining agents added. In a completely dry state the solution cannot function properly. The depolariser is a mixture of manganese dioxide and carbon which is held between the electrolyte and the carbon rod or the positive electrode (anode). The negative electrode is normally a zinc cup which contains all the necessary ingredients outlined above.

In the case of a "leak-proof" cell (Fig. 1) a leak-resistant tube is wrapped round the outside of the zinc cup and fixed to a steel plate at the bottom and plastic cover at the top.

The term "leak-proof" is used advisedly since it is possible for the electrolyte to seep out under severe abnormal conditions, but in a normal working environment little or no leakage should be experienced.

Cells of the type described above can be classified under a general term "round" cells for obvious reasons.

HIGH PERFORMANCE BATTERIES

High performance batteries are relatively new and have extended the range of equipment which can be economically operated from low cost primary batteries. They derive their improved performance from both constructional modifications and changes in the materials used. The construction is similar to that of conventional round cells, using a zinc can, separator, electrolyte, depolarising mix (manganese dioxide and carbon) and a carbon rod collector.

The thick paste separator of the conventional cell has been replaced in h.p. cells with a specially developed low resistance paper. This allows for a much greater weight of active materials to be included.

The effect of these changes are very obvious at the higher rates of discharge as is seen in the various curves and tables illustrating the typical performances. Voltages are maintained at higher levels and the voltage fall is far less rapid than with standard cells.

LAYER CELLS

Layer cells have certain unique advantages over round cells:

(1) They have greater potential capacity per unit volume;
(2) They are conveniently assembled into high voltage stacks where intercell connections are made automatically.

They are unable however to deliver heavy currents as will be shown in the examples to follow. The basic construction of a layer type cell is illustrated in Fig. 2.

CORRECT CHOICE

There are characteristics which are common to all varieties of Leclanché dry cells which must be fully understood if full use is to be made of the potential energy available.

These characteristics are:

(a) Nominal voltage per cell is 1·5 volts;
(b) Voltage falls on discharge;
(c) If the discharge is intermittent the battery will "recharge" itself during the rest period.

There are other life parameters which can be neglected for the majority of amateur work; these are:

(d) Ambient temperature during discharge;
(e) Storage conditions before use.

To choose the correct battery for a particular application the following must be known:

(1) Space available and life required;
(2) Working voltage range of the equipment;
(3) Current consumption and period of use per day.

The tables given later in this article show the common batteries available and their life-current performance. This is a convenient method of showing battery capacity because for power supplies of 6–9 volts or above, where the current drawn will give a life of 20 hours or more,'a layer type cell battery would be used.

For voltages below 6–9 round cells may be more conveniently used. For life values of less than 20 hours high performance round cells should be used for all voltages as they are specially formulated for high rates of discharge.

Whilst it is appreciated that mercury cells are also available, for the purposes of this article examples to illustrate how selection should be made are based on high-performance round, standard round, and layer types of conventional zinc-carbon cell.

The figures quoted for equipment operating conditions are not necessarily applicable to a particular item but are only assumptions for finding the most suitable battery.

TRANSISTOR MEASURING EQUIPMENT

There are a host of these devices which, with the advent of transistors, have enabled equipment to be powered very readily from dry cells. To name just a few: signal generators, transistor voltmeters, pre-amplifiers, transistor testers, noise analysers. In general these operate well from voltages between 6 and 24, are used intermittently, and the current drawn during operation is relatively low, about 5 to 50mA. Many commercial devices available use one or two PP9s to give 9 or 18 volts as required. Smaller layer "Power Pack" batteries may be used if space is limited.

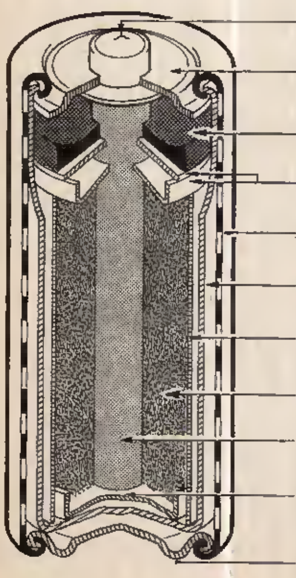


Fig. 1. Section through a typical "leak-proof" dry cell

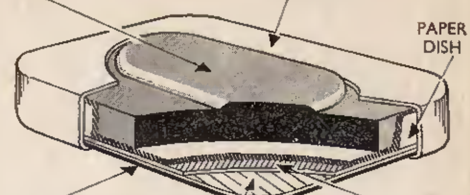


Fig. 2. Section through a layer type cell

Estimates of the life to be expected from the various batteries listed can be made from column (a) in the current guide tables on the next page.

The current values listed represent the currents at which the battery will give 350 hours life. Approximate estimates of life at other currents may be made by *pro rata* calculations. They will, however, become inaccurate as the life falls below the 100 hours. Examples are given here for three batteries to illustrate these points and to further illustrate the difference in characteristics of the layer, round and h.p. batteries.

Layer type PP9 *350 hours at 17mA*

At 34mA we would expect $\frac{350}{2}$ = 175 hours.
Actual life = 150 hours

At 68mA we would expect $\frac{350}{4}$ = 87·5 hours.
Actual life = 57 hours

At 102mA we would expect $\frac{350}{6}$ = 58 hours.
Actual life = 29 hours

High performance type HP2 *350 hours at 21mA*

At 42mA we would expect 175 hours.
Actual life = 175 hours
At 105mA we would expect 70 hours.
Actual life = 65 hours
At 210mA we would expect 35 hours.
Actual life = 30 hours
At 420mA we would expect 17 hours.
Actual life = 9 hours

Conventional round type LPU2 *350 hours at 20mA*

At 40mA we would expect 175 hours.
Actual life = 170 hours
At 80mA we would expect 87·5 hours.
Actual life = 56 hours
At 160mA we would expect 43·8 hours.
Actual life = 15 hours

These figures illustrate the versatility of the h.p. range and the limitations of the other types and will guide you into the use which can be made of the figures in columns (a) and (b) of the current guide tables. It should still be borne in mind that the figures in the table are for voltages down to 0·9V per cell and that corresponding reductions in life can be expected if higher end points are used.

CURRENT GUIDE TABLES

Battery type	Current Guide Milliamps (a)	(b)	(c)	Weight lb.	oz.	Dimension Inches Length	Width	Height	Price s	d
1·5 VOLT BATTERIES										
U16	2	16	200	—	0·3	0·406 dia		1·75	0	5
HP16	2	20	250	—	0·4	0·406 dia		1·75	1	0
HP7	4·5	40	500	—	0·5	0·563 dia		1·984	0	7
LPU11	9	70	500	—	1·4	1·031 dia		1·969	0	8
HP11	10	140	1000	—	1·4	1·031 dia		1·969	1	3
LPU2	20	150	750	—	3	1·344 dia		2·406	0	10
HP2	21	275	2500	—	3·5	1·344 dia		2·406	1	6
4·5 VOLT BATTERIES										
1289	7	55		—	4	2·438	0·875	2·625	1	3
126	24	180		—	13	4·063	1·375	3·438	3	0
PP11	34	260		1	—	2·563	2·063	3·594	5	6
AD28	35	200		1	—	4·0	1·375	4·188	3	6
6 VOLT BATTERIES										
PP1	17	130		—	10	2·563	2·188	2·188	3	0
996	35	200		1	4·5	2·656	2·656	4·0	4	0
9 VOLT BATTERIES										
PP3	1·2	14		—	1·3	1·047	0·688	1·906	2	6
PP4	1·5	16		—	1·8	1·0	1·0	1·969	2	3
PP6	4	40		—	5	1·422	1·359	2·75	2	9
PP7	8	55		—	7	1·813	1·813	2·438	3	3
PP9	17	130		—	15	2·594	2·047	3·188	3	9
12 VOLT BATTERIES										
TV1	42	550		3	8	5·25	2·688	5·375	14	0
15 VOLT BATTERIES										
B154	0·25	2		—	0·6	0·625	0·594	1·375	2	0
B121	0·4	5		—	0·75	1·031	0·625	1·469	2	0
22·5 VOLT BATTERIES										
B122	0·4	5		—	1·13	1·031	0·625	2·0	2	6
60 VOLT BATTERIES (Tappings at 45–30–15 volts)										
* B1702	17	130		6	—	7·688	2·625	5·75	38	9
67·5 VOLT BATTERIES										
B101	2·1	15		—	12	2·813	1·375	3·719	11	0
90 VOLT BATTERIES										
B126	2·1	15		1	—	2·781	1·969	3·844	9	0
300 VOLT BATTERIES										
B1489	0·4	5·0		—	15	2·688	2·219	3·906	42	6

CURRENT GUIDE VALUES

Discharge.	Fixed resistance
Current.	Milliamps at 1·5 volts
Temperature.	20 degrees C
Storage.	Fresh batteries
End-point voltage.	0·9V per cell. The lower the voltage end point the more energy will be available from the Battery. In addition to this, as the load increases the initial working voltage will drop. At the highest currents quoted end point voltages above 1·2V per cell will not be practicable. In these cases much lower end points such as 0·8V should be used if possible.
Column (a)	350 hour rate—4 hours per day. Currents shown in this column will exhaust the battery after approximately 350 hours. At this rate the apparent ampere hour product (350 × current) may be used to obtain an approximate indication of service life on discharges of different periods per day including 24 hours per day. Calculation can also be made at higher rates as in the examples shown. Capacities on much lower drains or shorter periods per day will be reduced by shelf deterioration.
Column (b)	20 hour rate—4 hours per day. Current shown in this column will exhaust the Battery in approximately 20 hours. At this rate changes in period per day will materially effect the service life.
Column (c)	1 to 2 hour rate. 5 minutes per day. Shown for 1·5V batteries only. Figures show the order of magnitude of maximum current which the Battery can deliver. These figures apply as previously stated to fixed resistance load discharges. Half the currents shown in this column could be the transmitter current in a TxRx that is 1,250mA for an HP2. This battery would deliver the 2·5 amp peaks which could well be required in the application.

Table 1: BATTERY COMPARISON FOR TAPE RECORDER EXAMPLE

Battery type	Calculated life to 0·9V per cell (hours)	Actual life (hours) at 100mA 4 hours per day to		Weight (ounces)	Cost	Cost per hour for actual life down to 1V per cell
		1·0V per cell	0·9V per cell			
6 × LPU2	$\frac{20 \times 150}{100} = 30$	30	35	18	5s	2d
6 × HP2	$\frac{20 \times 275}{100} = 55$	60	65	21	9s	1·8d
6 × LPU11	$\frac{20 \times 70}{100} = 14$	8	11	9	4s	6d
6 × HP11	$\frac{20 \times 140}{100} = 28$	24	27	9	7s 6d	3·75d
1 × PP9	$\frac{20 \times 130}{100} = 26$	25	30	15	3s 9d	1·8d
2 × PP9 (in parallel)	$\frac{20 \times 130}{50} = 52$	80	95	30	7s 6d	1·13d

SMALL PORTABLE TAPE RECORDERS

Assume the following operating conditions of the recorder:

Nominal operating voltage	8V
Maximum acceptable voltage	10V
Minimum acceptable voltage	6V
Average current on "playback"	75mA
Average current on "record"	100mA
Average current on "rewind"	300mA
Minimum life approximately	20 hours.

Let us assume a mean current of 100mA for calculation purposes but bear in mind that for rapid rewinding there should be ample reserve of power to supply up to 300mA.

To start with one simple characteristic requirement can be ascertained, i.e. the nominal battery voltage, which would be 9 volts. Since all dry cells are nominally 1·5 volts when new, the battery would have six cells. This can be one self-contained battery or six individual cells connected in series.

The tables on the previous page show the characteristics of a variety of dry batteries (other types are given in manufacturers' literature). It will be seen that the current range column is divided into three categories:

(a) 350 hrs at 4 hours per day;
(b) 20 hrs at 4 hours per day;
(c) 1 to 2 hour rate, 5 minutes per day (1·5V cells only).

Explanations of these characteristics are shown below the tables.

Referring again to the example in hand, Table 1 above summarises the characteristics of six combinations. The current drain time in the second column is calculated on the basis of the 20 hour rate, after which time the voltage of *each cell* has dropped to 0·9V.

The third column indicates the actual life assuming a consumption of 100mA at 4 hours per day until the battery "end-point" voltage is (a) 1·0V per cell; (b) 0·9V per cell. The figure of 100mA is taken as the average maximum current during normal running.

Although the "rewind" current is higher it is unlikely to be a strain since this operation is on for only about a minute or two.

It can be concluded from Table 1 that if a small tape deck is used the HP11 battery is most suitable particularly if weight is of prime importance. The HP11 will cater easily for the extra current required on rewind.

CURRENT GUIDE VALUES continued

Columns (a) & (b) *Pro rata* estimations on intermittent drains. Estimations of life of LPU2 and HP2 batteries when discharged at 60mA 4 hours per day to 0·9V

LPU2 From 20 hour figure $\frac{20 \times 150}{60} = 50$ hours

From 350 hour figure $\frac{350 \times 20}{60} = 117$ hours

Actual figure is 90 hours

HP2 From 20 hour figure $\frac{20 \times 275}{60} = 92$ hours

From 350 hour figure $\frac{350 \times 21}{60} = 122$ hours

Actual figure is 117 hours

ACCOMMODATING THE FALLING VOLTAGE

The higher the discharge rate the more important is "end-point" voltage. Comparing capacities of the LPU2 down to 1·1 and 0·8 volts we have a difference of 25 per cent at 20mA 4 hours per day but at 150mA 4 hours per day there is an extra 180 per cent available as follows:

Life down to	1·1	1·0	0·9	0·8	volts
LPU2 150mA	9	12	18	25	hours
20mA	315	350	370	395	hours

At high rates if the end point seems high the circuit voltage limitations should be reconsidered.

The life figures in the current guide tables are all down to 0·9 volts per cell, this is of course 5·4V for a 9V battery. If the circuit is designed round 8V as in the case of the small tape recorder exemplified here, and this was assumed to be the maximum, the nearest battery voltage to this would be 7·5 volts. A 6V battery would represent 6/5V per cell (1·2V). Probably less than $\frac{1}{6}$ of the pptential energy of the cell would be realised.

If high voltage end-points are necessitated by circuit limitations, h.p. batteries are essential as they give a considerable proportion of their energy output above 1·1V. It is possible that in this particular tape recorder seven cells could be used in series to give a nominal voltage of 10·5V. The circuit should be analysed and the maximum on-load voltage determined for playback, record, and rewind. For example, these might be (a) Rewind 12V; (b) Playback 12V; (c) Record 10V.

If the 100mA record current will lower the voltage to 10 volts, seven cells may be used in series and extra life will be obtained. There is however not much useful energy left in the cell below 0·8V. Extra cells in series to give end voltages below this will therefore not necessarily give extra life.

MORE SEVERE TAPE RECORDER DISCHARGES

The discharge curves in Fig. 3 show the results of the HP2 and LPU2 battery when discharged on a fixed

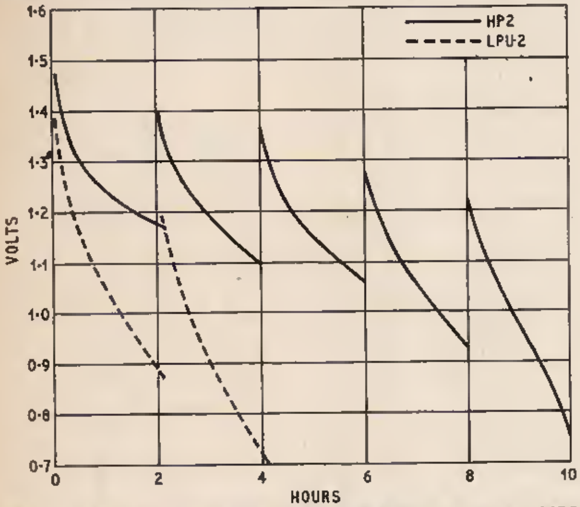


Fig. 3. Graph showing the fall of voltage across an HP2 and LPU2. Discharge rate 3 ohms per battery, 2 hours per day

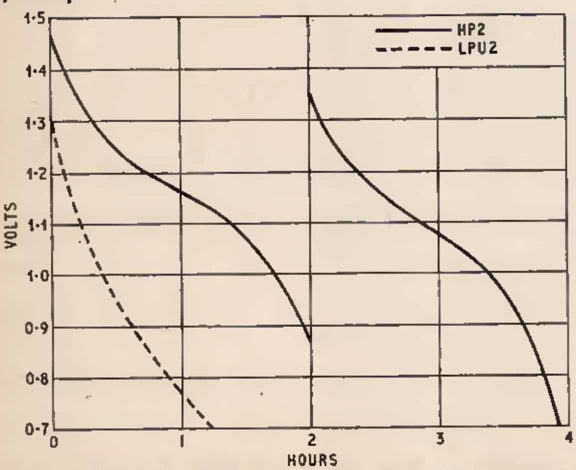


Fig. 4. Graph showing the fall of voltage across an HP2 and LPU2. Discharge rate 500mA constant current, 2 hours per day

resistance of 3 ohms for 2 hours per day. The current at 1·5V will be 500mA.

The other graph (Fig. 4) shows the same batteries when discharged at a fixed current of 500mA. The latter discharge is of course more severe and the batteries last a correspondingly shorter time. It should be borne in mind that an equivalent discharge for many transistor devices and electric motors would be somewhere in between fixed resistance and constant current.

PORTABLE TRANSMITTER-RECEIVER

Transmitter-receivers are rather different from the preceding examples because normally the power required by the transmitter is considerably in excess of that required by the receiver. However, h.p. batteries accommodate these variations reasonably well.

As a guide, some current values are given here which correspond to about 12 hours life from the selected batteries. Assume conditions of discharge as follows:

Transmit current is 10 times receive current. End point voltage is 0·9V per battery. Battery is discharged continuously alternating from transmit to receive with one minute on transmit and nine minutes on receive.

Battery	Tx	Rx	
HP2	1,250mA	125mA	All life 12 hours
HP11	500mA	50mA	
HP7	250mA	25mA	

Very approximate estimates of life at other rates can be made from the average of the transmit and receive current. Taking, for example, the HP2

$$\text{Average current} = \frac{1{,}250 + (9 \times 125)}{10} = 237{\cdot}5\text{mA}$$

At this average current drain until each cell is 0·9V, the life is 9 hours.

This calculation could of course have been made much more accurately if the life was 20 hours or more. However, it is obvious that reasonably worthwhile estimates may be made with h.p. cells at even these high rates of discharge.

INTERMITTENT DISCHARGE

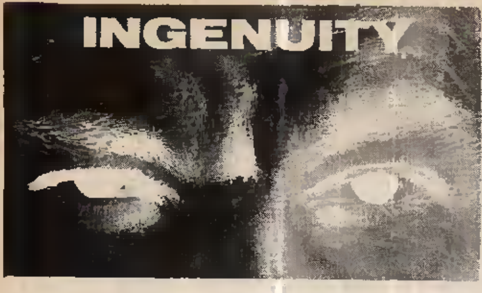
These figures are for continuous discharge of 12 hours. If discharged 4 hours per day as in the tables (more likely for amateur use) the life would be increased to the order of 20 hours and calculations could be made more accurately from the tables. The period of use per day materially affects the life when the discharge rate is fairly high. The effect is more noticeable with layer cells and least noticeable with h.p. cells as one would expect. Table 2 below shows three examples at the higher rates of discharge.

All figures are for voltages down to 0·9V per cell. ★

Table 2: COMPARISON AT HIGH DISCHARGE RATE

	HP2 at 400mA	LPU2 at 20mA	LPU2 at 150mA	PP9 at 50mA
1 hr/day	14	295*	40	100 hours
4 hr/day	10	370	18	95 hours
12 hr/day	4·5	320	12	65 hours

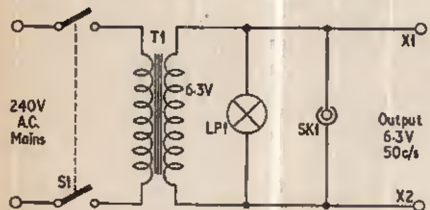
* LPU2 begins to show a slight loss of life due to the extended period of use.



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 individule requirements. The views expressed by readers are not necessarily those of the Editor.

6·3 VOLT PROBE



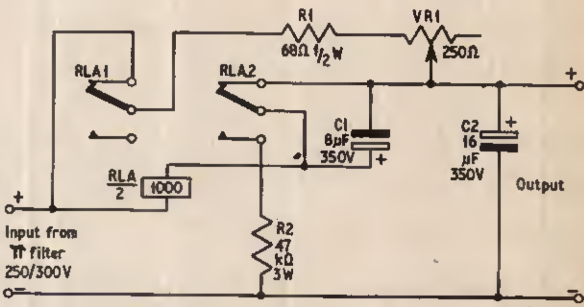
WHERE the experimenter or television service technician requires a torch, 6·3V heater tester, or a low voltage 50c/s supply for feeding the external timebase terminals of an oscilloscope, this unit will provide these facilities at low cost. The torch consists of a jack socket, a 6·3V bulb in a suitable holder, coupled to a 6·3V heater transformer. The unit was designed as a 50c/s supply for connection to the external timebase terminals of an oscilloscope to enable it to display Lissajous figures. This a.c. supply, of 6·3 volt amplitude, is available at the terminals. An on/off switch and a pilot light are also included.

A. R. Brown,
Ayr,
Scotland.

VARIABLE HIGH TENSION CUT-OUT

MOST power supply units built for experimental purposes are protected only by a mains fuse although a high tension fuse is sometimes incorporated. Often these power units are used to test partly assembled equipment and in other circumstances where overloads and even short circuits may occur. Any of these conditions put an excessive strain on the power supply components which will shorten their lives. This can be overcome by the use of a simple cut-out relay system which may be easily fitted to an existing power supply. The device may be reset by switching the high tension off and then on again, the current at which it operates being variable.

The circuit employed operates in the following manner. Whilst insufficient current flows to close the relay the contacts are set to supply current to the output connections through the relay coil and the shunt resistance R1 and VR1. If enough current flows to close the relay then the shunt resistance is taken out of circuit and the high tension current flows to negative via R2, thus keeping the relay closed. Providing that the overload has been removed, switching the high tension off and then on again will return the contacts to their original positions and will restore the supply to the output. The 8μF capacitor C1 is included to maintain the current through the relay coil during the transition period whilst the contacts are changing. By adding C2 a π filter is formed, thus improving the smoothing. The actual overload which causes the cut-out to operate is set by VR1. In the



prototype a 1,000Ω G.P.O. type relay with two sets of change-over contacts was used which closed at 5mA and with the given resistance values gave a range of cut-out currents from 20mA to 75mA. Other relays, however, of the same resistance and design may not close at exactly the same current and the values of the resistors in this case may need to be changed. The values of R1, VR1, and R2 may be calculated as shown below.

In the case of R2 this is only an approximate value and the exact value should be found by trial and error to give a resistance which effectively holds the relay closed.

G. A. Dimelow,
Ashton-u-Lyne,
Lancashire.

Relay coil voltage = current to close relay × resistance of relay

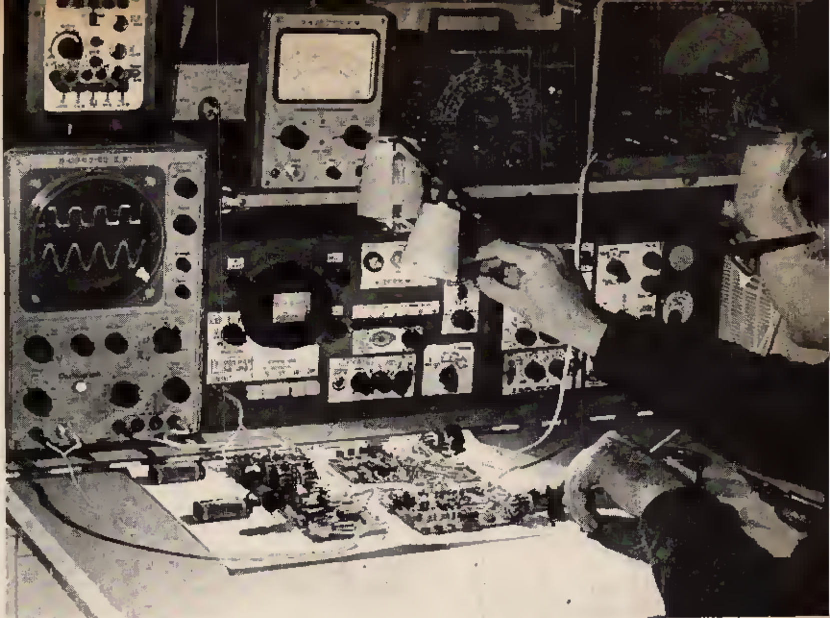
$$R1 = \frac{\text{Relay coil voltage}}{\text{(Max. setting, i.e. 75mA)} - \text{(current to close relay)}}$$

$$R2 = \frac{\text{Supply voltage}}{\text{Current to close relay}}$$

$$VR1 = \left[\frac{\text{Relay Coil voltage}}{\text{(Min. setting, i.e. 20mA)} - \text{(current to close relay)}}\right] - R1$$

PART ONE

THE AUTHOR
M. L. MICHAELIS M.A.
MAKES FINAL
ADJUSTMENTS TO HIS



...beam switching unit

THE conventional oscilloscope allows us to examine *one signal waveform at a time.* If we wish to compare various signal waveforms, then we must feed them one at a time successively into the oscilloscope and remember, draw on paper or photograph each one off the screen for subsequent mutual comparisons. For simple radio and audio equipment, this is neither difficult nor time-consuming and numerous simplifications of procedure are possible. For example, if we are interested in observing the degree of distortion in an audio amplifier, we can feed a good sinewave test signal from a signal generator into the amplifier input. We know what an undistorted sinewave looks like, so that any departures therefrom as the oscilloscope is connected to the outputs of the successive stages of the amplifier chain immediately reveal the faulty section of the equipment. It can speed-up work if we had some means of displaying two signals *simultaneously* on the oscilloscope screen, but this facility remains largely a luxury for simple radio and amplifier servicing and design.

TIMING AND PHASING

Matters are quite different when we turn to more general electronic equipment. We are here not only interested in the correct waveform shapes as a whole in such equipment, but also in the precise timing of each part of any waveform, i.e. in their relative phases and time-leads or time-lags with respect to each other. If the various pulse flanks from different stages are used, say, to set-off responses in electronically controlled machinery, it is immediately obvious that the behaviour of that machinery would be quite erratic if the control flanks in the electronic control circuit waveforms are mixed up or otherwise incorrectly phased. Here we see the first *essential* need to have a means for *simultaneously* displaying *two signal waveforms* on an oscilloscope when designing and servicing machinery control electronics and a host of other logical electronics.

It is clearly not possible to gather information regarding the *phasing* of two waveforms by applying them separately and successively to a normal oscilloscope, since the "synchronisation" circuitry of the oscilloscope timebase deflection always forces the horizontal timebase run to commence at the moment of a predominant flank in the waveform. In other words, the synchronisation arrangement, essential to make the repetitive traces coincide and yield a stationary display, cancels all phase-shifts as far as relative positions on the screen are concerned.

We are obviously no better off when using two oscilloscopes to display one waveform each of a pair of waveforms whose phases we wish to compare. The synchronisation circuit will cause each oscilloscope to display its signal as if there were no phase difference! If we "turn off" the synchronisation action, then the trace will drift about arbitrarily and matters are worse still—we can then not even observe the waveform shape any more, since the successive traces no longer coincide.

TWIN-BEAM CATHODE RAY TUBES

An obvious—but very expensive—way round the problem is to use a special type of cathode ray tube in our oscilloscope, which produces two electron beams, either from two separate electron guns or by some electrostatic means of beam splitting. This double beam can be deflected in the horizontal direction by a common timebase which is synchronised from *one* of the two signals we wish to compare.

This signal, which we will call the *leader*, is applied as vertical deflection to only one of the electron beams, usually the one moving in the upper part of the fluorescent screen. The other signal waveform is simultaneously applied alone to the lower beam. Now it is immediately evident that the two waveforms will appear simultaneously on the screen, in the *correct phase/time relationship*. For example, if the leader is derived from the input to a certain stage in the electronic equipment on test, and the second signal (the *dependant*) from the output of that or a later stage, then the time-delay of signal transfer between the stages in question is accurately portrayed by the horizontal displacement between the salient flanks in the two respective waveforms on the double-beam oscilloscope screen.

Genuine double-beam oscilloscopes of the type described above are manufactured commercially and widely used in professional circles. However, they are very expensive compared to normal single-beam oscilloscopes and seldom found among the offers of oscilloscopes for amateur purchase. This is because there is a cheaper and in many respects more elegant method of achieving virtually the same function with any ordinary single-beam oscilloscope, which need fulfil only a bare minimum of essential prerequisites for the purpose.

BEAM SWITCHING

It is the purpose of this article to present a design for a beam switching unit which may be used in conjunction with most ordinary oscilloscopes to give accurate simultaneous two-signal display, conserving full phase information as well as waveform shapes. This unit may be connected between the signal probes taking the signals off from the test points in the equipment under examination, and the vertical deflection amplifier (Y-deflection amplifier) input of the conventional oscilloscope.

A block diagram of the beam switching unit is given in Fig. 1. It will be seen that the unit has two separate inputs, each with its respective signal pick-up probe and separate pre-amplifier and attenuator (*modules 1 and 2*). The display amplitudes of any two signals of widely different input amplitudes may thus first of all be matched. We remember, one signal is the *leader* (we will call its input channel "Y1" on the beam switching unit) and the other is the dependant ("Y2" channel).

Associated with the Y1 pre-amplifier is a *sync amplifier*. This develops a synchronisation signal from the salient flanks of only the Y1 signal, i.e. from the leader. This signal must be fed to the "external sync" input of the oscilloscope, since the internal synchronisation circuit of the oscilloscope can not work under these conditions.

The output from the beam switching unit to the normal Y-amplifier of the oscilloscope is a controlled mixture of the leader and dependant signals together with a switching waveform. The oscilloscope is unable to discriminate from this mixture which is the leader, which the dependant and which the switching waveform. As far as it is concerned, all three signals are equivalent and internal synchronisation would try to lock onto any one or all, giving an unsteady and unintelligible display. Thus the oscilloscope must be set to "external sync" and fed with a clear synchronisation signal derived in the beam switching unit from the flanks of the leader signal. Any signal may be taken as leader signal simply by connecting it to the Y1-

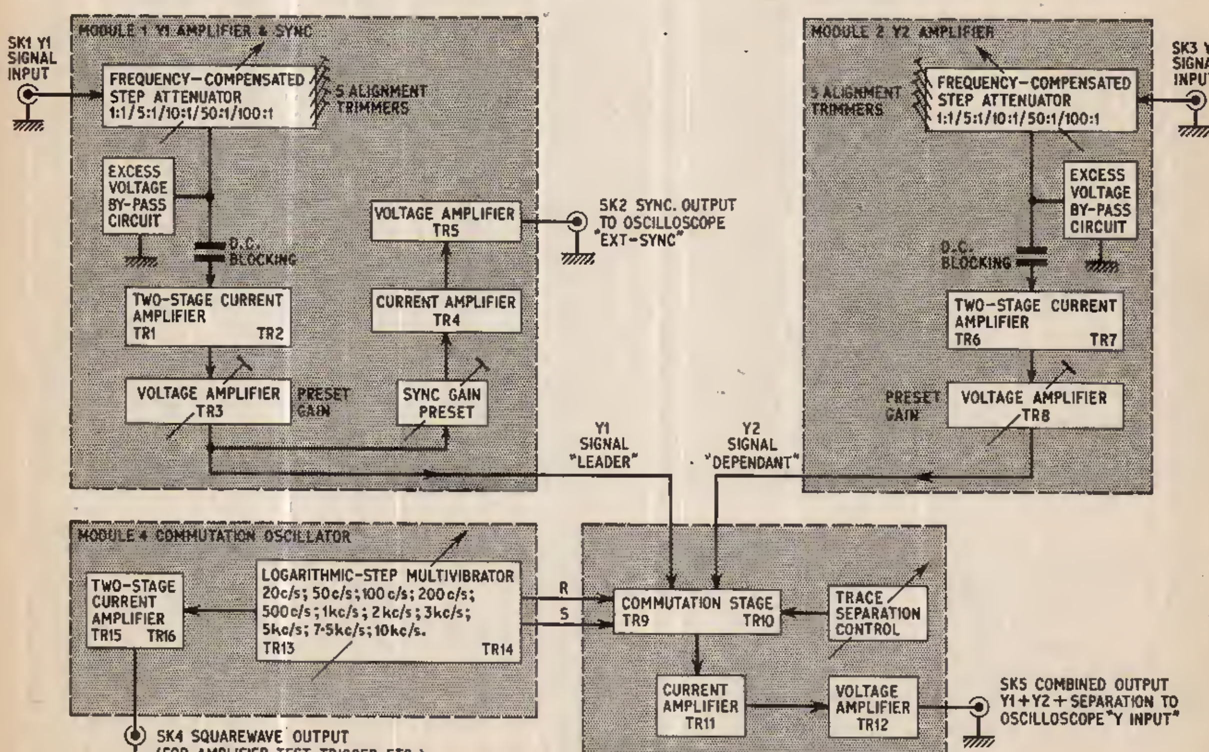


Fig. 1. Oscilloscope beam switching unit. Block diagram

channel input of the switching unit. The signal connected to the Y2-channel input is the dependant.

COMMUTATION

The function of the beam switching unit is to *commutate* the Y1 and Y2 signals alternately through to the output amplifier (*module 3*). For this purpose the unit contains a commutation oscillator (*module 4*), which is a conventional multivibrator generating an accurate symmetrical square wave. The antiphase outputs of the oscillator are fed to gating stages between the outputs of the Y1 and Y2 pre-amplifiers and the common output amplifier (*module 3*). Thus Y1 is connected through to the output amplifier during one half-period of the commutation square wave and Y2 is disconnected because its gate is closed by the antiphase square wave. At the moment the commutation square wave changes over to its other half-period, Y1 gate closes and Y2 gate opens and remains open for the duration of this half-period. Thereafter, Y1 is open and Y2 closed, and so on. As a result, Y1 and Y2 are each chopped through to the output for an average of half the time. Whenever Y1 gate is open, a third signal in the form of a controlled "beam separation voltage" is operative to throw the single electron beam higher up on the screen as a whole.

SWITCHING TRANSIENTS

It is now easy to grasp the resulting overall action. During each interval that Y1 gate is open, the electron beam is higher up on the oscilloscope screen and tracing a segment of the leader signal up there in the correct horizontal (time phase) position. During each interval that Y2 gate is open, the single electron beam is tracing a correctly positioned segment of the dependant signal. In between times, when neither Y1 nor Y2 gates are open, the commutation oscillator is switching over.

These switching transient intervals are very brief and normally negligible compared to the Y1 and Y2 intervals. However, the electron beam is travelling the greatest distances just at these moments, since it is shooting up to the Y1 region, or back down to the Y2 region then. The corresponding switching transient will therefore leave only a very faint trace intensity compared to the chain of Y1 and Y2 segments, since the electron beam is only very briefly at any selected point within the switching flank. Appropriate adjustment of the main brilliance control on the oscilloscope will thus make the switching flanks invisible, leaving only the assembly of Y1 and Y2 segments.

THE COMMUTATION OSCILLATOR

The commutation oscillator in this unit is provided with an eleven-position wafer switch on the front panel, providing eleven spot frequencies for the commutation square wave. These frequencies are staggered logarithmically from 20c/s to 10kc/s. This wide range has been included primarily in the interests of a separate output amplifier for this square wave signal alone, which has been included as a useful extra in our design. This square wave output is available at SK4 (*module 4*).

Having explained the general principle of operation, the individual circuits that together make up the beam switching unit will now be described in detail.

Y1 ATTENUATOR

Refer to Fig. 2. The entire circuitry around S1a and S1b, to the left of the vertical line through D2, constitutes a frequency compensated attenuator network to enable the amplifier to accept high amplitude input signals without overloading.

The signal attenuation is primarily established in the normal manner with a pair of voltage dividing resistors. For example, let us consider the "100" setting of the attenuation ratio selector switch S1. Here the input signal is fed via S1a to R4 and R10 in series, while the output signal is taken off across the small resistor R10 alone, via S1b. Since the value of R10 is a hundred times smaller than that of R4, the signal amplitude passed on to TR1 via S1b is only one hundredth of the input amplitude via S1a. The other steps for ratios of 50, 10 and 5 attenuation ratio function correspondingly, while the final step "1" is in effect a straight-through connection without attenuation.

FREQUENCY COMPENSATION

Such a simple resistive step attenuator will not function above about 5kc/s, because the division ratio due to the parallel stray capacitances, which have then dropped to comparable impedance levels, may be different and arbitrary. This may lead to low or high peaking, whereby a square wave would be distorted to a rounded sawtooth or receive transient noses and a drooping roof, respectively. In either case, this implies phase and amplitude distortion with respect to the signal frequency, and while such an amplifier may be suitable for audio work, it is useless for general oscilloscopy.

The trick to overcome this trouble is to swamp the stray capacitances with comparable or larger intentional capacitors which can be suitably adjusted to make the capacitive division ratio identical to the resistive one. In other words, the product of capacitance (time constant) of every section of the entire network must be the same. The frequency and phase response is then linear, theoretically right up to infinitely high frequencies.

The actual value of the section time constant is not of primary importance, being determined by secondary matters. The greater its value, the easier the adjustment but the greater the damping loading imposed on the circuit from which the input signals are derived. A compromise thus has to be struck, and 100 microseconds is a commonly accepted value. In a 1megohm resistive impedance circuit, this allows 100pF total parallel capacitance, about 60pF of which will be taken up by the self-capacitance of the coaxial cable to the signal probe. The balancing or trimmer capacitors (TC1–TC5) for the attenuator network must thus be adjusted so as to present about 30 to 40pF between S2a slider and chassis in all settings.

THE SIGNAL PROBE

Fig. 8 shows that the probe is simply another "top-section" of a capacitively balanced resistive divider. In the attenuation setting "1", which is a straight-through connection on the module itself, the 10 megohms/10pF of the probe constitute the top section and R14, R15, C12, TC5 and connecting cable represent the bottom section. The probe thus gives a 10:1 attenuation factor in the "1" setting, and correspondingly ten times the attenuation factors of the other settings. It is seen that C12 and TC5 are required only in conjunction with the probe, in order to be able to establish frequency balance therewith in the "1" setting too. They do not interfere when using the input without a probe.

The inputs should under all normal circumstances be used with their probes, since only then is the damping loading and signal falsification of high impedance

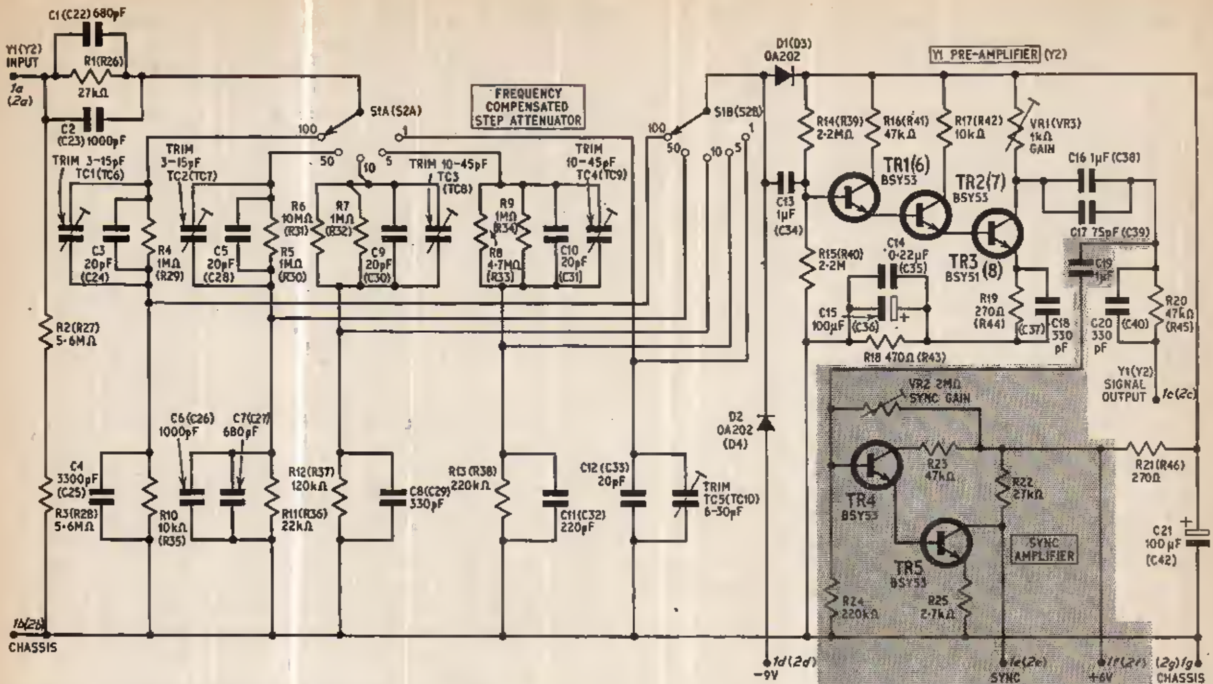


Fig. 2. Circuit of module 1 — Y1 attenuator, pre-amplifier, and sync amplifier. Module 2 is identical to this circuit except for the area shown shaded. Module 2 circuit references are in brackets

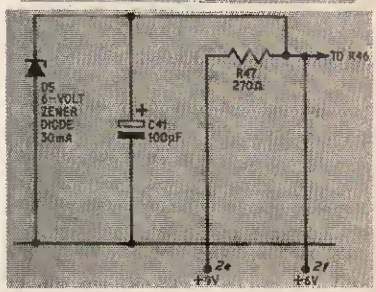


Fig. 3. This section of circuitry applies to module 2 only —Y2 attenuator and pre-amplifier

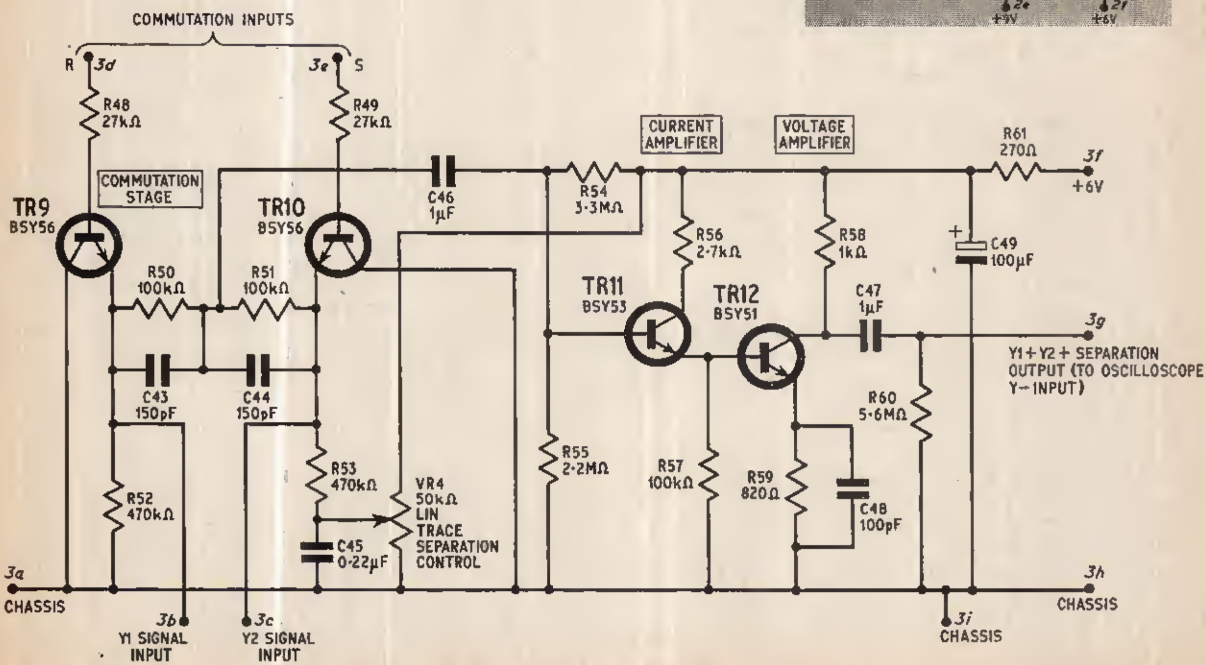


Fig. 4. Circuit of module 3 — combination amplifier

sources sufficiently small. The direct input may be used only at low frequencies and/or on very low impedance sources, when the benefits of the ten fold greater sensitivity are available. However, if the signals are of high amplitude, needing attenuation, the probe should first of all be inserted even for low frequency low impedance sources instead of switching the attenuator to a higher ratio.

With careful adjustment, the entire step attenuator network around S1 (or around S2 in the Y2 module) has level phase and frequency response from d.c. to many Mc/s and the actual cut-off frequencies are determined by the limitations of other parts of the entire circuitry.

SAFETY FUNCTIONS

The remaining components in the Y1 input circuit fulfil safety functions.

R2 and R3 complete a d.c. path for C74 (Fig. 6) in the "1" setting. R1 limits the charging surge current for C74 to about 20mA when the input is suddenly tapped onto a point at the maximum permissible d.c. level of $\pm$500V. C74 will charge up and block d.c. levels of either polarity up to this magnitude, even if the attenuator is set to a much greater sensitivity to scope small superimposed a.c. waveforms. This is permissible with or without the probe, in any setting of the attenuator. The transient charging surge for C74 appears almost entirely as a voltage pulse across R1, where it is harmless. According to the polarity of the blocked d.c. level, D1 or D2 conducts and limits the transient amplitudes actually reaching the transistors to a harmless level equal to the low supply voltages used to bias these bypass diodes. Both diodes D1 and D2 are normally cut off and thus without effect upon the circuit.

Note that it is NOT permissible in this circuit to obtain d.c. blocking transient bypass with the help of a pair of low voltage Zener diodes connected back-to-back between S1b slider and chassis, because all low voltage Zener diodes which the author was able to trace in makers' lists have self-capacitances of 100 to 1000pF, which are far too great for present purposes. It is thus necessary to use biased ordinary diodes in the positions shown. Make sure that low-capacitance r.f. types, e.g. television video detector diodes, are employed if adopting substitutes to the specified ones. The self capacitance at some 6V reverse bias should not exceed a few pF in the makers' ratings.

All capacitors to the left of D2 in Fig. 2 (and to the left of D4 in Fig. 3) must be 500V working rating, whereas all components to the right of these diodes including C12 (C34) may be low voltage types, since no high voltage transients pass to the right of the bypass diodes.

Note that the described bypass arrangement will also give full protection if excessive input signal amplitudes are applied, i.e. if the attenuator is set to the wrong step position in relation to the a.c. signal amplitude. The output signal reaching the oscilloscope will then approach a square wave for any input waveform, i.e. distortion will be tremendous, but no damage is suffered on a.c. input signals up to 500V peak-to-peak amplitude, whatever the attenuator setting. Nevertheless, do not prolong the application of excessive signal amplitudes in an incorrect attenuator setting, since R1 could otherwise gradually overheat if the frequency is high.

Also note that R1 is shunted with C1 and C2, since it represents another section of the attenuator network and must therefore be shunted capacitively to the same time constant.

Y1 SIGNAL PRE-AMPLIFIER

TR1 and TR2 constitute a two-stage current amplifier (emitter follower cascade) whose function is to step-down the impedance level. TR3 is a voltage amplifier stage with a gain of about 3–4 maximum, adjustable with VR1. This compensates the slight voltage loss in the chain TR1 to TR3 emitter, as well as the subsequent division via R20 and the chopper gate circuits on the combination amplifier module. The intention is to make the overall gain exactly unity from Y1 or Y2 input terminal to combination output terminal, in the respective "1" settings of the attenuators. The beam switching unit as a whole then involves zero insertion loss when connected to the oscilloscope.

As is already evident with C20 across R20, the output feed to the combination amplifier involves considerable capacitive loading. Two measures have been adopted to make this tolerable without undue restriction of bandwidth. Firstly, VR1 is of very low value, permissible thanks to the impedance step-down of TR1 and TR2. Secondly, emitter compensation has been applied by shunting R19 with C18 to yield an emitter circuit time constant roughly equal to the collector circuit time constant of VR1 with the feed capacitances. R19 at the same time provides a.c. negative feedback, and together with R18 heavy d.c. negative feedback over all three stages to stabilise the operating points.

Y1 SYNC AMPLIFIER

The sync amplifier consists of TR4 and TR5. The circuit configuration is similar to the final two stages TR2 and TR3 of the Y1 pre-amplifier, but without capacitive compensation since wide bandwidth is not necessary. R25 provides strong a.c. and d.c. negative feedback so stabilising the gain and operating point set with VR2. This preset control should be adjusted for maximum possible undistorted output swing, as will be described later.

"Y2 AMPLIFIER" MODULE

Module 2 (see Fig. 3) is in every way identical to the corresponding sections on *module 1*—but the sync amplifier section is absent.

The Y1 and Y2 step attenuator switches may of course be set to very different positions, for matching two signals of widely different amplitudes for simultaneous display. Assuming that this is tolerable on other considerations (see above), one channel may be operated without a probe and the other with a probe. In the extreme case, this permits matching of signals differing in amplitude by a factor of 1000:1 (60 dB) for approximately equal height display on the dual trace.

The graded steps of the attenuators are normally adequate, so that there is no need for a continuous fine control whose inclusion would have added complications of frequency balancing.

COMMUTATION GATES

The circuit diagram for the combination amplifier is given in Fig. 4.

R20 (*module 1*), R50, R51 (*module 3*), and R45 (*module 2*) constitute a balanced resistive bleeder strung between the output collector circuits of the channel pre-amplifiers. The combination signal to the actual combined signal amplifier TR11, TR12 is taken from the centre of this balanced bleeder, i.e. from the junction of R50, R51.

The two transistors TR9 and TR10 are the chopping gates which effect the required signal commutation by chopping the chassis connection on the balanced

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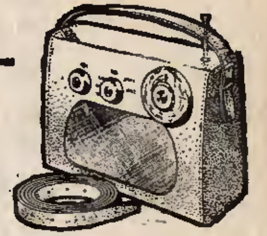

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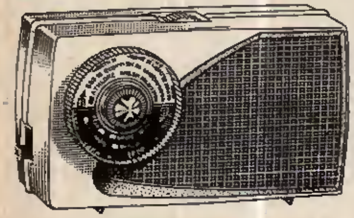

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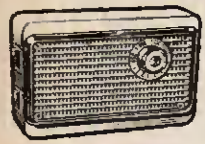

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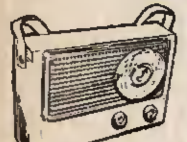

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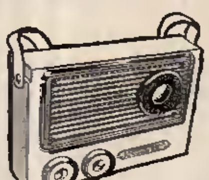

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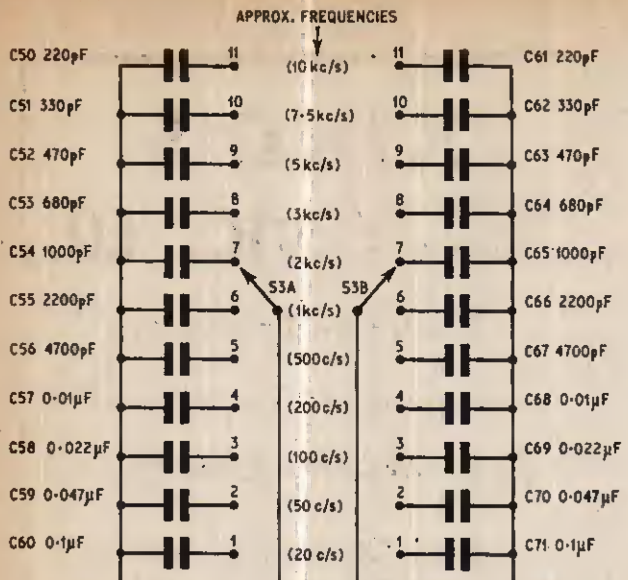

bleeder to alternating sides of the pick-off point for the combined signal amplifier. The bases of the gate transistors are fed via R48, R49 respectively with anti-phase square waves from a multivibrator as commutation oscillator. These square waves commutate between −3V and +6V at the input ends of R48 and R49 which go directly to the respective collectors of the commutation multivibrator.

Whichever gate transistor of the pair TR9, TR10 happens to be connected to the −3V level during any commutation half-period is cut off and may thus be considered as if it were not present. The other transistor is at the same time fed with +6V at the input end of its base resistor, so that it is cut on hard and presents an effective short circuit to chassis between emitter and collector. In other words, it places a chassis connection on to the balanced signal bleeder at the point of connection of its emitter thereto. For the other half period of the commutation square wave, the gate transistors change over their roles.

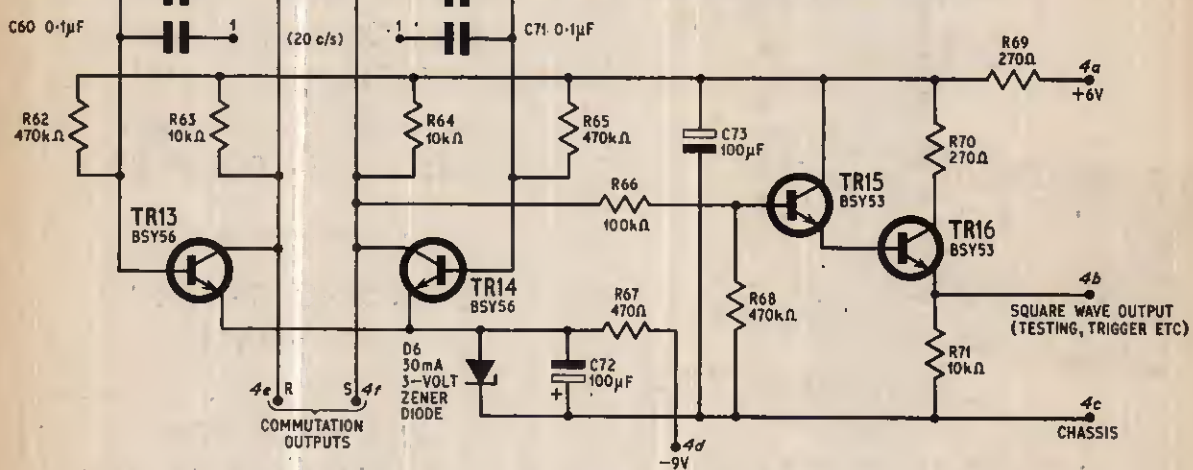

Fig. 5. Circuit of module 4—commutation oscillator

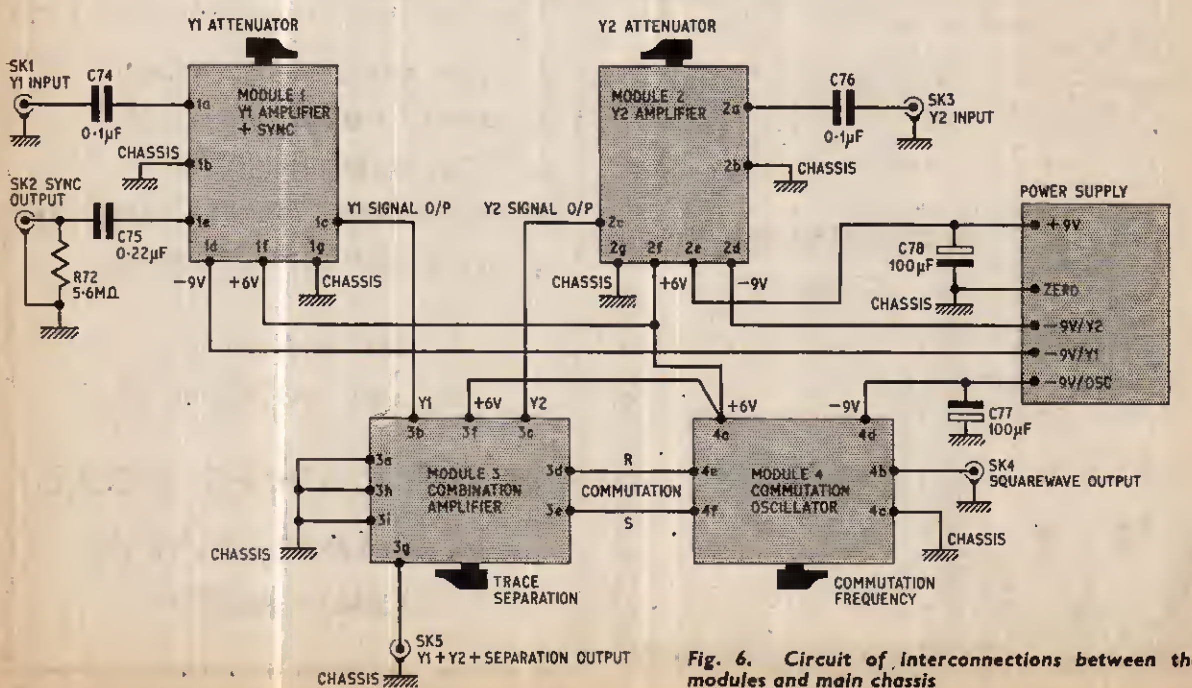

Fig. 6. Circuit of interconnections between the modules and main chassis

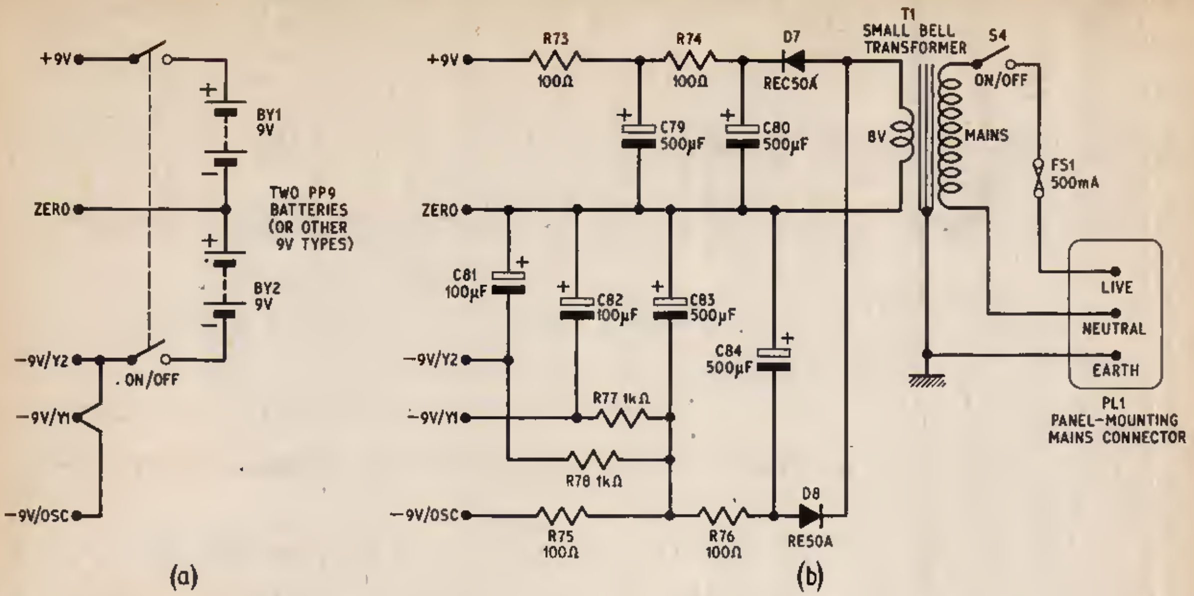

Fig. 7. Power supply circuits: (a) arrangement for battery operation;(b) mains operated power unit

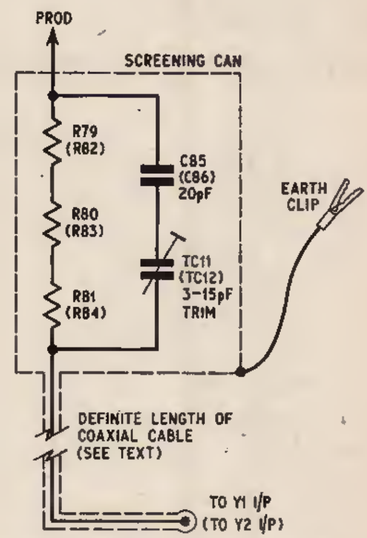

Fig. 8. Circuit of input signal probe

TRACE SEPARATION CONTROL

R53, R51, R50 and cut-on TR9 represent a d.c. voltage bleeder to chassis for the voltage at VR4 slider whenever TR10 is cut-off. When TR10 is cut-on, it shorts-out this d.c. voltage along with the Y2 signal. There is thus a positive square wave component (controlled by VR4) at the junction of R50, R51 whenever and only when the Y2 signal is being fed-through. In other words, Y2 is given a positive d.c. component and Y1 is left as pure a.c. After phase inversion in TR12, Y2 has a *negative* chopped d.c. component and Y1 is pure a.c. Both signals are also again "erect", i.e. of the same polarity as at the inputs to their respective modules, since TR3, TR8 had already caused one phase inversion.

A correctly designed oscilloscope gives upward beam deflection for positive and downward beam deflection for negative signal inputs. Thus the beam switching unit maintains this convention and always makes the Y2 (dependant) trace appear lower down on the screen than the Y1 (leader) trace when trace separation voltage is inserted.

COMBINED SIGNAL AMPLIFIER

TR11 and TR12 constitute the combined signal amplifier which handles the commutated mixture of Y1, Y2 and separation signals. Its output feeds the normal Y-amplifier input of the oscilloscope. The values of C46 and C47 determine the bass cut-off frequency and thus the lowest usable commutation frequency. The values of 1μF each as shown in Fig. 4 represent the highest convenient ones which are possible with modern subminiature printed circuit capacitors without resorting to electrolytics.

Due to the high impedance at TR11 base, leaky electrolytics would lead to trouble, but good ones may be tried. However, the values of 1μF shown for C46 and C47 already give a cut-off frequency around 1c/s which is better than most a.c. oscilloscopes.

TR11 is a current amplifier (emitter follower impedance step-down stage) and TR12 is a conventional voltage amplifier stage with a gain very slightly greater than unity, determined by the ratio of the emitter and collector resistors. This compensates the slight voltage loss in TR11. TR12 also provides the essential final phase reversal, to compensate the first phase reversal due to the voltage amplifier stages TR3 and TR8 in the respective pre-amplifier modules.

Almost any oscilloscope may be used immediately, without any special matching measures. However, the design basis was that a cable (coaxial) of about 60pF self capacitance is connected to feed an oscilloscope Y-amplifier with about 30pF input capacitance and any resistive input impedance component greater than 100 kilohm (usually 1 megohm).

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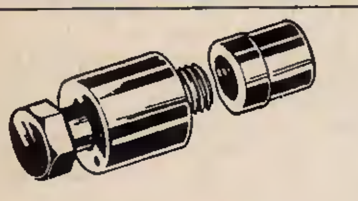

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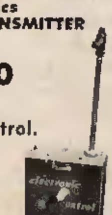

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without compensation. The cut-off time constant is about 90 microseconds and has been duplicated by placing C48 across R59 in the emitter circuit. This gives additional boost around the h.f. cut-off, so that the overall bandwidth of the entire circuit including all modules is at least 1Mc/s. Some experiments may be worthwhile using other values for C48 if the sum of the connecting cable and oscilloscope input capacitances differs from about 90pF.

AVAILABLE OUTPUT AMPLITUDE

TR12 circuit in the combination amplifier has been designed to give a maximum undistorted output amplitude (peak-to-peak) of at least half a volt. It is thus suitable for feeding the Y-amplifier of an oscilloscope set to a sensitivity of 0·5V for full-screen deflection. This corresponds to some 100mV/cm for the usable trace height of a scope using a 3in c.r.t. or 50mV/cm for one using a 5in c.r.t. These are normal and common figures for the maximum sensitivity settings of the majority of such oscilloscopes as used for amateur, servicing and educational purposes.

The beam switching unit should thus be used with the oscilloscope Y-amplifier set to maximum gain, and signal attenuation undertaken with the help of the input probes and respective step attenuators on the beam switching unit.

Note that Y1 and Y2 are not present simultaneously, but only alternately, so that the full 0·5V peak-to-peak swing is available for both signals. However, trace separation is in fact added to the Y2 signal, whose swing must be kept correspondingly smaller when trace separation is inserted. The Y1 signal is unaffected. The maximum available trace separation at the output from TR12 is about 0·3V, or about 60 per cent of the screen height under optimum conditions. The Y2 signal must then be kept down to 0·2V amplitude to avoid overloading. More space is not available on the screen anyway when the traces are separated that far.

COMMUTATION OSCILLATOR

Fig. 5 shows the circuit of the commutation oscillator (*module 4*).

TR13 and TR14 constitute a conventional symmetrical multivibrator operating between −3V and +6V stabilised supply lines. The switch-over is very rapid, so that the waveform at each collector is a good square wave commutating between −3V and +6V. The negative lower level, instead of the otherwise customary choice of chassis potential as lower level, is here necessary to make sure that the gate transistors in the combination amplifier are cut off hard under all circumstances when the oscillator collector feeding them is at the lower commutation level.

SWITCHED CAPACITORS

The use of constant resistors and switched capacitors assures the same rise and fall time ratios for the output square waves at all frequencies, so that direct comparisons of amplifier performance at all frequencies are possible. Were variable potentiometers to be used as the base resistors with fixed capacitors, the higher frequencies would yield very rounded and useless "square" waveforms.

BASE-TO-EMITTER VOLTAGE RATING

A final point of some importance in the multivibrator circuit concerns the moment just after a switch-over relaxation. The transistor which has thereby just been cut off is momentarily driven negative at the base to an extent such that the reverse voltage between base and emitter is equal to the full supply voltage (3 + 6 = 9V in our case). Very few transistors are rated for such high base-to-emitter reverse voltages, the common limiting ratings being 5 or 7V for silicon transistors, sometimes even lower. The author has tested the circuit with a large variety of silicon transistors in the 5 and 7V range, and even some with 3V limiting rating. All performed quite satisfactorily for long periods. Upon reporting these findings to a manufacturer, the author was told that all base to emitter limiting ratings are well below voltage breakdown, which normally does not take place until values two to three times as great are reached. They are more concerned with other characteristics of the particular transistor. Silicon transistors may be used in relaxation circuits with virtually perfect reliability under any conditions where the peak base to emitter transients do not exceed twice, better still 1·5 times the static limiting rating. Types with a V_{EBO} rating of 5V, preferably 7V, are therefore quite satisfactory for the present circuit.

GATE DRIVE

The commutation oscillator drives the gate transistors TR9, TR10 on the combination amplifier module, via the two 27 kilohm resistors R48, R49. These resistors are essential to prevent the waveform collapsing at the oscillator collectors when the gate transistors open.

The greater the values of R48, R49, the less the collapse of the positive part of the oscillator waveform at the oscillator collectors and the better the output of the square wave test amplifier. The maximum permissible value of R48 and R49 is dictated by the need to still turn on the gates hard enough. For this purpose, one may treat each gate transistor as an emitter follower which divides this base feed resistor by its current gain and presents the resulting low resistance value as bottom-end section of a resistive bleeder for the signal feed it is supposed to be shorting right out.

This leads to a finite cross-talk factor. With the value of 27 kilohm for the base feed resistors and a current gain of 120 for the specified transistors under the given conditions, this cross-talk resistance is about 200 ohms. This is forming a bleeder with the 47 kilohm resistor from the pre-amplifier output which it is supposed to be shorting out. The division ratio is thus about 100, multiplied by a further factor of 2 due to the resistors R50, R51. The cross-talk is thus about 0·5 per cent. This is of the same order of magnitude as the spot diameter on the c.r.t. and thus not seriously noticeable. It may be slightly greater near the h.f. cut-off frequency if unbalanced capacitive effects then arise. To minimise this, it is advisable to choose a matched pair for the gate transistors, though not essential. The use of gate transistors with lower current gain will lead to intolerable increase of cross-talk between Y1 and Y2 with the given circuit values.

POWER SUPPLIES

The circuit of the power supply section appears in Fig. 7b. A bell transformer T1 provides an output of approximately 8V from the mains. This output is applied to two separate rectifier and filter circuits; one of these providing a 9V positive output, the other a 9V negative output.

If preferred, the beam switching unit can be driven from a pair of 9V batteries as indicated in Fig. 7a.

Part Two next month will include the complete components list, detailed constructional drawings, and setting up and alignment instructions.

Readout—

A SELECTION FROM OUR POSTBAG

Why not resistors?

Sir—After reading your article on the *Transistor Tester* in the May 1966 issue, I think that it would be easier to use resistors, or resistor networks instead of the potentiometers VR1 and VR2 which have to be set.

Using this method, neither the multirange meter, nor the extra variable resistors would be necessary for setting VR1 and VR2.

Could you advise me as to whether or not this method is possible, and if so could you tell me the resistors or resistor-network values?

C. C. Milner,
Beaconsfield,
Bucks.

Because of the differences which exist in the resistance of different meters and variations in the forward characteristic of the diode across the meter, it is not possible to compute values of fixed resistors to replace the two potentiometers.—B.F.P.

Magnetic actuators

Sir—In his article on Single Channel Proportional Control, June issue, Mr. Warring refers to magnetic actuators and says, "They are attractive in principle, but not very satisfactory, or useful, in practice due to the very low mechanical output possible".

This may be true of commercial equipment (actuators and models) but my own design and home-made equipment is completely successful. The same basic design of actuator has been used for different sized models, the largest having been 5ft 6in wing span with a 3·5cc engine. The actuator took 200mA at 3 volts, for full rudder control, enough to spiral the model in either direction. My more usual model is 44in span with a 1·3cc Mills engine, and the actuator takes 40mA at 3 volts for full right turn. No current is used for full left turn, and sufficient force is given to spiral dive the model in either direction.

The models are based on the old Taylorcraft Auster light aeroplanes, and have properly hinged rudders. Control is such that on coming in to land the model can be steered to a few inches.

Howard Boys,
Weedon,
Northampton.

Howard Boys is one of the original pioneers of single channel radio control for model aircraft and noted for the ingenuity and originality of his ideas.

Simple proportional systems have been of particular interest to him and I am aware that he has produced workable results with magnetic actuators. This does not alter the fact that they are not to be recommended for general use; nor the fact that better control can be realised by alternative systems as described in my article.—R.H.W.

Microphone pick-up

Sir—I have just finished reading the June issue and am writing to tell you that there is an easier way of fitting pick-ups on a mandolin or any acoustic guitar or stringed instrument. To do this I intend to use a microphone, crystal type. This microphone clips on to the sound board and can be connected to one's own volume and tone controls or direct to an amplifier. It also has the advantage on guitars that nylon strings can be used.

Colin Greig,
Laurencekirk,
Kineardire.

Substitute thyristor

Sir—I have been having great difficulty in obtaining the thyristors BTY79/400R and CRS 3/40 and would be very grateful if you could also let me know where I could obtain one of these from.

R. C. Swan,
Gloucester.

We are sorry to hear of your difficulty in obtaining the BTY79/400R and CRS 3/40. However, a substitute for this is the SCR05 which may be obtained from the International Rectifier Co., Distributor Sales Division, Hurst Green, Oxted, Surrey.

Warning

Sir—I am interested in constructing the "Guitar Practice Adaptor" (BB4) from your March issue, but I'm not quite clear on three points.

First, what is an a.c./d.c. receiver; secondly, why should one of these not be used with the adaptor, and thirdly, what would be the rough cost of the components.

P. D. Clothier,
Liverpool.

The reason why the BB4 adaptor should not be connected to an a.c./d.c. receiver is that there is a distinct likelihood of severe electric shock from this type of radio if any other device is connected to it. This could be very dangerous not only to the experimenter but to other people also. However, it is quite safe to use a battery powered portable transistor radio, and some mains radios, provided they are not of the a.c./d.c. variety, but use a properly earthed chassis which is not connected directly to the mains.

An a.c./d.c. receiver is a radio or TV receiver which does not use a mains transformer, and with these sets it is very possible that the entire chassis of the set will become electrically "live" when connected to the mains. Hence the danger of shocks.

At current prices the adaptor components would cost about £3 10s 0d to £4.—A.J.B.

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Letters for inclusion under this heading should be as brief as possible. Replies should be made direct to the readers concerned.

Sir—I wish to obtain back copies of the whole of Volume 1 and also 1, 2 and 3 of Volume 2 complete with blueprints if possible.
J. V. Finch, 149, Gordon Road, Ilford, Essex.

Sir—Can any reader supply me with the August 1965 and January 1966 editions complete with blueprints if any?
J. Booth, 3, Kenwith Road, Raleigh, Bideford, N. Devon.

Sir—I require the following issues, complete with blueprints and data booklets, of Volume 1; November, December 1964, January, February and May 1965.
M. W. Hudson, 30, Merril Way, Allenton, Derby.

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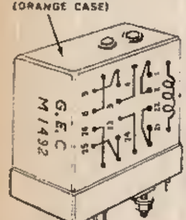

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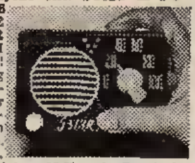

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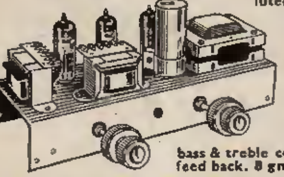

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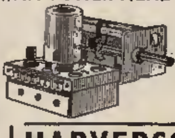

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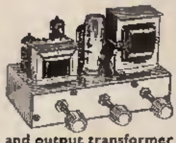

Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. x 4in. d. x 4¾in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls.

The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only **£4.5.0** P. & P. 6/-.

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A.C. Mains 200/250v., 4 watt, using ECC83, EL84, EZ80 valves.

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Comprehensive circuit diagram, practical layout and parts list 2/6 (free with kit).

This kit although similar in appearance to HA34 employs entirely different and advanced circuitry.

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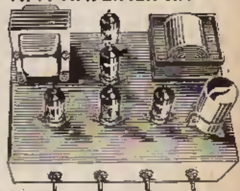

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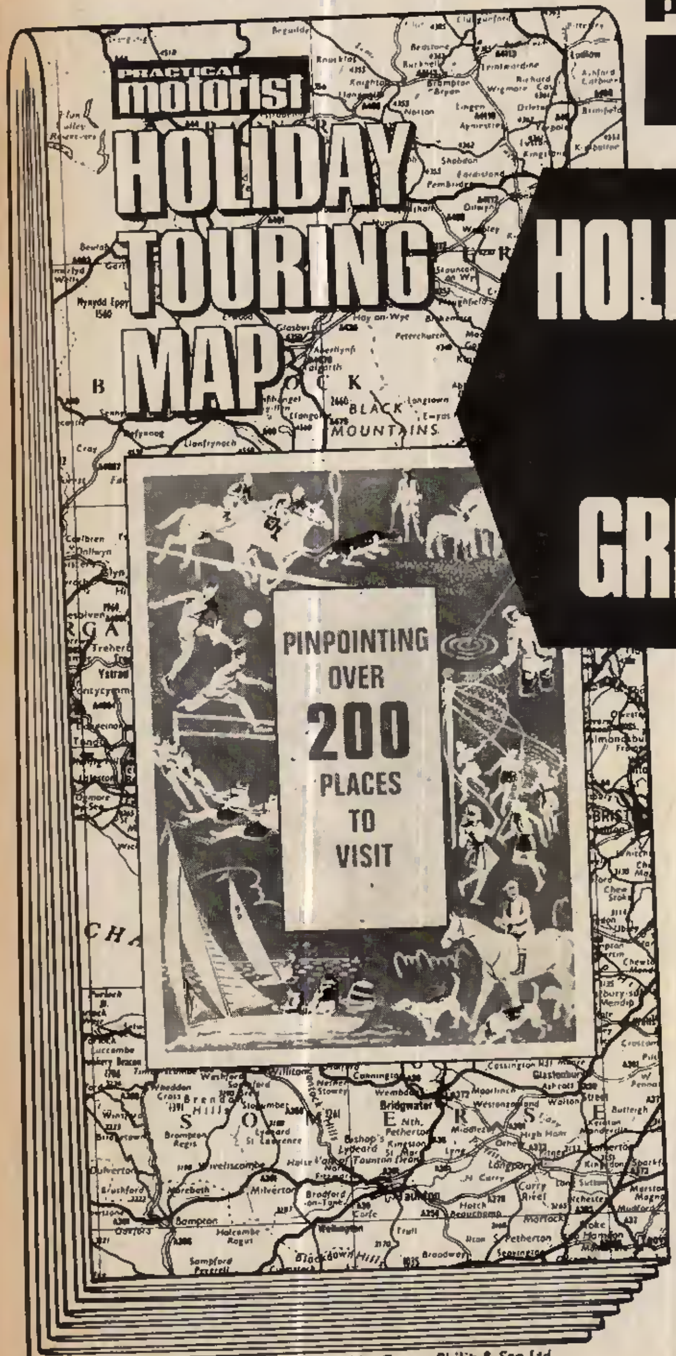

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