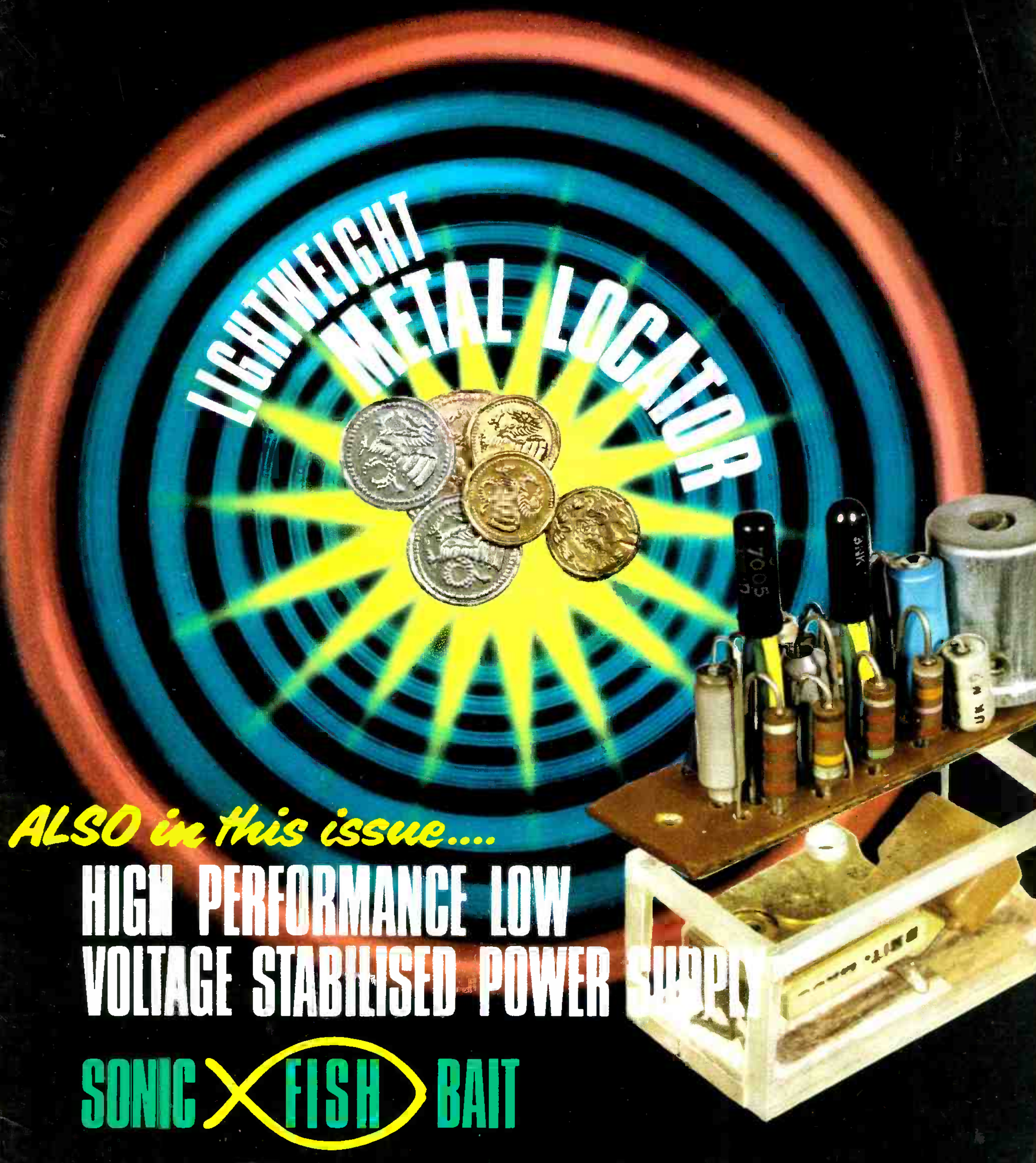
PRACTICAL

ELECTRONICS

JANUARY 1969

THREE SHILLINGS



LIGHTWEIGHT METAL LOCATOR

ALSO in this issue....

HIGH PERFORMANCE LOW VOLTAGE STABILISED POWER SUPPLY

SONIC FISH BAIT

Lasky's Radio

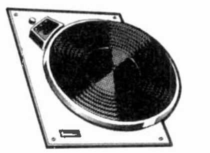
SPECIAL INTEREST ITEMS!

MIDLAND Model 10-502 VHF AIRCRAFT BAND CONVERTER

An entirely new item for the radio enthusiast bringing instant reception of the ground-to-air, air-to-ground waveband. For use with any standard AM or FM radio covering 535 to 1,605kc/s, 88 to 108Mc/s respectively—with no electrical conversion or connection required. The Model 10–502 (self powered by one 9V (PP3 type) battery) is merely placed close to the receiving set and then tuned over 110 to 135Mc/s which covers the whole aircraft communications band. Volume and reception effectiveness is adjusted by moving both sets to the most favourable position and balancing the volume controls of each accordingly. The Model 10–502 has a smartly designed black plastic cabinet with brushed metal front panel and 18in chrome telescopic antenna, size only 4 × 2⅞ × 2⅜in (inc. knobs). Complete with battery and full instructions.

Lasky's Price 79/6 Post 3/6

SPECIAL TRANSCRIPTION MOTOR OFFER — FAMOUS Connoisseur Classic



2 speed transcription deck. One synchronous motor for each speed—45 and 33 r.p.m. **List Price £15.15.7.**

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ALSO AVAILABLE Connoisseur SCU.1 pickup arm and cartridge. **List Price £8.13.4.**

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CLEARVIEW PERSPEX COVERS

SPC1 £3/3/10 SPC2 £4/4/4 SPC4 £4/4/11

Postage on all above 5/- extra.

HITACHI CAR RADIO SHORT WAVE ADAPTOR

Model WM20

New from Hitachi—world famous for high quality transistor radios—a push button Short Wave adaptor enabling you to receive all foreign broadcasts in the 3-22Mc/s waveband. The WM-20 adaptor is suitable for use with any make or model of AM car radio (covering the usual 535-1,605kc/s) in any make or model of car (6 or 12V, positive or negative ground). The WM-20 as will be seen has 10 push buttons which cover metre bands: 13, 16, 19, 25, 31, 41, 49, 60 and 90 plus Off button. Having selected the required band by pushing the appropriate button—fine station tuning is effected by use of the parent radio's tuning system—details with the adaptor show corresponding centres for each short wave band on the radio dial. Double superhet IFM circuit and the use of a Zenor diode and compensating condenser, provides great stability. Switched adjustment for 6 or 12V and pos. or neg. ground: external aerial trimmer provided. Connection to the parent radio is via the aerial jack, power is taken direct from the car AUX. supply with sep. line fuse. All necessary mounting brackets, leads and jacks are provided with instruction manual. The WM-20 is very smartly styled with brushed and bright chrome front panel and black push buttons. Size 8 5/16" wide × 1⅝" high × 3½" deep.

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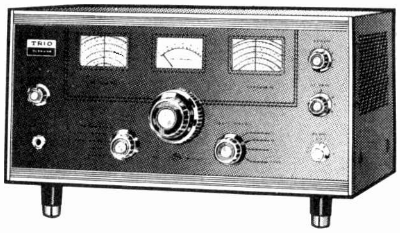
COMMUNICATION RECEIVERS

TRIO MODEL 9R-59DE

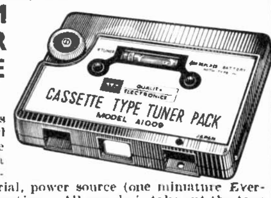


Brief spec.: 4 band receiver covering 550kc/s to 30Mc/s continuous and electrical band spread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. **Special features:** SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF frequency 455kc/s ● Audio output 1·5W ● Variable RF and AF gain controls. For use on 115/230V a.c. Mains. Beautifully designed control layout finished in light grey with dark grey case, size 7 × 15 × 10in. Weight 19lb. Fully guaranteed, complete with instruction manual and service data.

Lasky's Price £39.15.0 Carriage and Packing **12/6**

SPECIAL INTEREST ITEM JUST ARRIVED

TTC Model A.1009 AM TUNER ADAPTOR PACK FOR CASSETTE RECORDERS

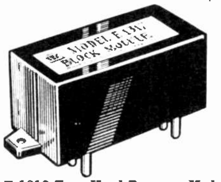


An amazingly ingenious AM Tuner that looks like and is exactly the same size as a standard tape cassette—which converts your tape cassette recorder/player instantly into a radio! The tuner pack is a completely self-contained unit with built-in ferrite rod aerial, power source (one miniature Ever-Ready type D23) giving approx. 150 hrs operation. All you do is take out the tape cassette and slip in the tuner. Tunable over 535-1,605kc/s (full Medium waveband). Suitable for use with all standard tape cassette recorders and players. Complete with battery.

Lasky's Price 89/6. P. & P. 2/6.

CONSTRUCTORS BARGAINS

LASKY'S ENCAPSULATED SOLID STATE MODULES



8 completely new special function circuit modules. Size of each module only 2¼ × 1¼ × ¾in. Ready for immediate use—just connect to power source (usually 9V batt.), input and output. Encapsulated modules are shockproof and almost indestructible. Comp. with full ins. **Post 1/6 each.**

- **E-1311 Phono Pre-amp Module**—max. output 3V. RMS, input 50mV, input imp. 100kΩ, gain 28dB, RIAA compensation. **29/6**
- **E-1312 Tape Head Pre-amp Module**—max. output 3V, RMS, input 50mV, input imp. 100kΩ, gain 25dB, NARTB compensation. **29/6**
- **E-1313 Microphone Pre-amp Module**—max. output 4V, RMS, input 50mV, input imp. 100kΩ, gain 28dB, response 10-50kc/s. **29/6**
- **E-1314 Power Amplifier Module**—max. output 300mW, input imp. 1kΩ, gain 20dB, response 50-10k/cs, distortion 3% at 20mW. **29/6**
- **E-1315 Electronic Organ** (tone oscillator) **Module**—frequency 200–1,000c/s. output 80mW. For use with keyboard, variable resistors and 8Ω speaker. **25/-**
- **E-1316 Morse Code Practice Oscillator Module**—frequency 400c/s, output 80mW. For use with morse key and speaker. **25/-**
- **E-1317 Modulated Wireless Signal Transmitter** for use in test bench fault finding—frequency 400c/s–30Mc/s, tone freq. 400c/s. For use with any AM receiver. **25/-**
- **E-1318 Lamp Flasher Module**—flashes two miniature lamps alternately. For use with 6V, 100/200mA bulbs and 6V power supply. **25/-**

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1mA	29/6
5mA	27/6
100mA	27/6
300V	27/6
50μA	37/6
1mA S meter	29/6
100μA	37/6
500μA	29/6

Type KR-65 3½ 3in

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100mA	38/6
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1mA S meter	42/-
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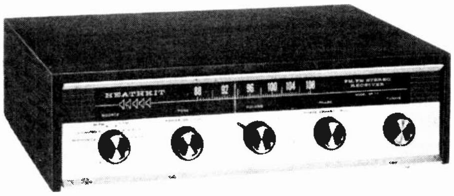
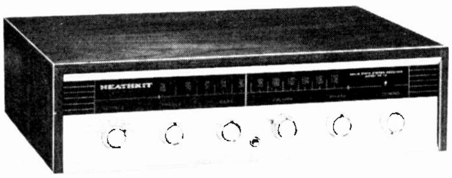


Low-cost FM Stereo Receiver, AR-17

Kit K/AR-17
£39.0.0
P.P. 10/6

28 transistor, 7 diode circuit, 14 watts music power, 10 watts r.m.s. from 25–35,000Hz @ ±1dB. Automatic stereo indicator light. Adjustable phase control. Complete front panel controls. Flywheel tuning. Factory assembled and aligned FM front-end. Circuit board assembly. Compact 10⅜" deep × 3" high × 12" wide. Use free standing with Heathkit cabinet optional extra.

Cabinet walnut or teak finish **£3.10.0** extra

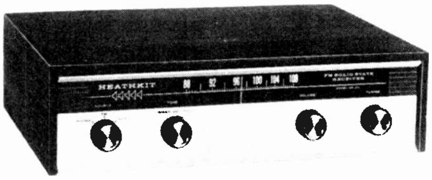


Quality FM Stereo Receiver, AR-14

Kit K/AR-14
£54.0.0
P.P. 13/6

31 transistor, 10 diode circuit can deliver ±1dB, 15 to 50,000Hz at 10 watts per channel (20 watts total) 15 watts per channel 1HF music power (30 watts total). Wide-band FM/FM stereo tuner plus two preamps, two power amplifiers. Compact only 3⅞" high × 15¼" wide × 12" deep. Install in a wall, free standing or in Heathkit cabinet optional extra. 210–240V 50Hz a.c.

Cabinet walnut or teak finish **£4.10.0** extra

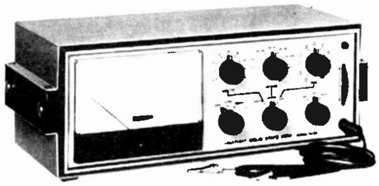


Low-cost FM Mono Receiver, AR-27

Kit K/AR-27
£22.10.0
P.P. 10/6

13 transistor, 6 diode circuit. 7 watts music power. ±1db, 25 to 60,000Hz at 6 watts. Input connectors for phono and aux. Complete front panel controls. Flywheel tuning, factory pre-aligned FM tuner. Circuit board assembly. Compact bookshelf size. Install in a wall, free standing or in cabinet optional extra. 210–240V 50Hz a.c. operation.

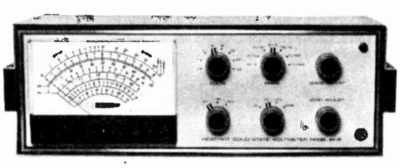
Cabinet walnut veneered **£3.10.0**



Solid-State Volt-ohm-Milliammeter, IM-25

Kit K/IM-25
£48.10.0
P.P. 10/6

9 a.c. and 9 d.c. ranges 150mV up to 1,500V f.s. 7 resistance ranges, 10 ohms centre scale with multipliers ×1, ×10, ×100, ×1k, ×10k, ×100k and ×1Meg. . . . measures from 1 ohm to 1,000Mohms. 11 current ranges from 15μA full scale to 1·5A full scale. 11Mohm input impedance d.c. 10Mohm input impedance a.c. 6" 200μA meter. Internal battery power or 120/240V a.c. 50Hz supply. PCB construction.



Solid-State Volt-ohm Meter, IM-16

Kit K/IM-16
£28.8.0
P.P. 10/6

8 a.c. and 8 d.c. ranges 0–5V to 1,500V f.s. 7 ohm-meter ranges with 10 ohms centre scale with multipliers ×1, ×10, ×100, ×1k, ×10k, ×100k and ×1Meg. . . . 11Mohm input on d.c., 1Mohm on a.c. Internal battery power or 120/240V a.c. 50Hz supply.

Solid-State Low Voltage Power Supply, IP-27

Kit K/IP-27
£46.12.0
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0·5 to 50V d.c. with better than ±15 Millivolts regulation. Four current ranges 50mA; 150mA, 500mA, and 1·5 amperes. Adjustable current limiter: 30 to 100% all ranges. Panel meter for output voltage or current.

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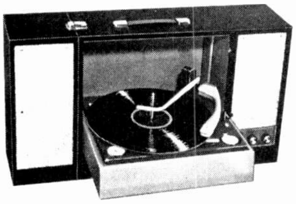

STEREO RECORD PLAYER, SRP-1

Two built-in speakers
Suitcase portability

Kit **£28.6.0** P.P. 10/6

CAR RADIO, CR-1

High performance at low cost. 12 v pos. or 12 v neg. operation. 4 watts output

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STEREO TAPE RECORDER, STR-1

Built-in speakers. Many features unobtainable elsewhere at this price

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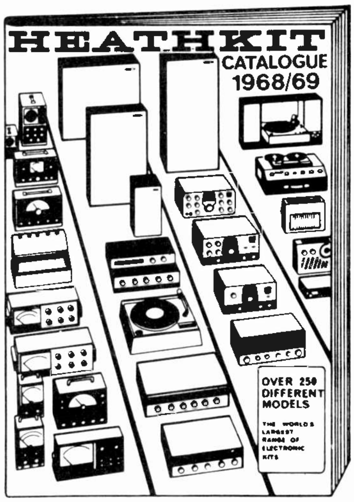
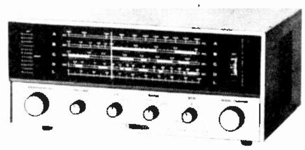


MANY SHORTWAVE RECEIVERS including:



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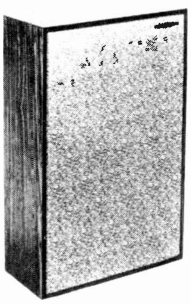
Cover 1 MH/z to 30 MH/z plus 550 kH/z to 1620 kH/z AM broadcast band. Built-in speaker. Handsome low-boy styling. Kit **£22.8.0** P.P. 9/-



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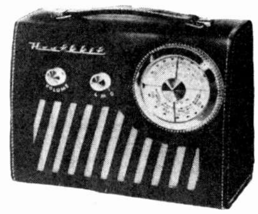
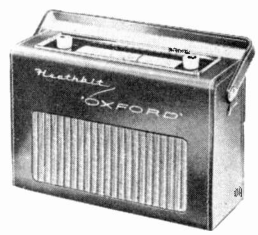


PORTABLE RADIO UXR-2

In black or natural leather

Kit **£15.10.0**
P.P. 6/-



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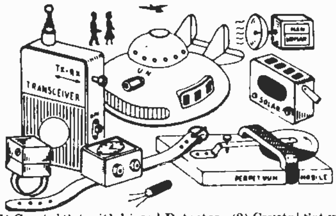

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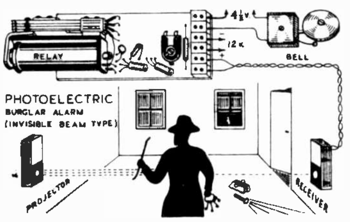

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Versatile Invisible-beam, Relay-less, Steady-light Photo-Switch, Burglar Alarm, Door Opener, Counter, etc., for the Experimenter.
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AF115	3/6	2N711	10/–
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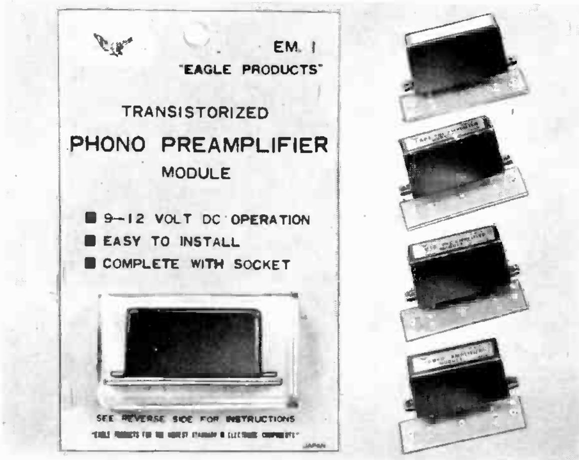

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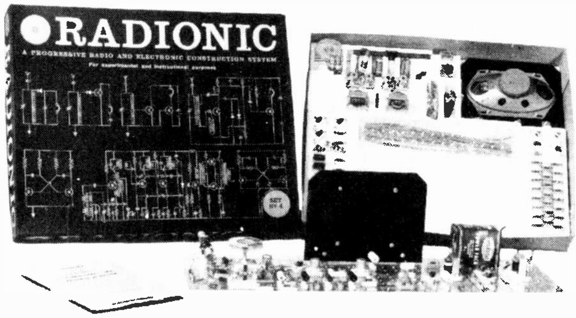

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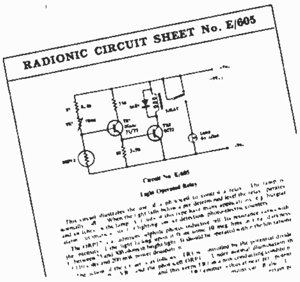

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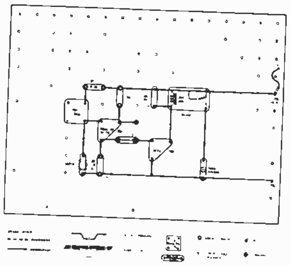

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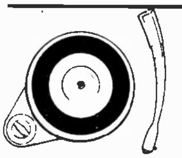

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FEW ONLY! ACOS GP69/1. For EP and LP 10/-. P. & P. 2/-.

QUALITY RECORD PLAYER AMPLIFIER

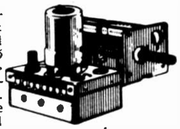
A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, EZ80 valves. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3 d. × 6 h. Ready built and tested. PRICE **75/-.** P. & P. 6/-.

ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. PRICE **97/6.** P. & P. 7/6.

DE LUXE QUALITY PORTABLE R/P CABINET

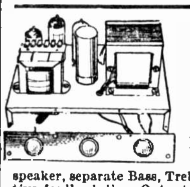
Uncut motor board size 14½ × 12in., clearance 2in. below, 5½in. above. Will take above amplifier and any B.S.R. or GARRARD changer or Single Player (except AT60 and SP25). Size 18 × 15 × 8in. PRICE **£3.9.6.** P. & P. 9/6.

FM/AM TUNER HEAD



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

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



3-VALVE AUDIO AMPLIFIER MODEL HA34

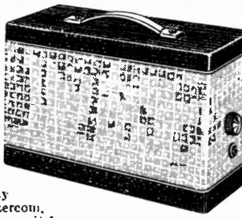
Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble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

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

BRAND NEW TRANSISTOR BARGAINS. GET 15 (Matched Pair) **15/-;** V15/10p, **10/-;** OC71 **5/-;** OC76 **6/-;** AF117 **7/6.**

Set of Mullard 6 transistors OC44, 2—OC45, AC128D, matched pair AC128 **25/-;** Mullard LFH3 Audio Transistor Pack AC128D and matched pair AC128 **12/6;** ORP12 Cadmium Sulphide Cell **10/6.** All post free.

SPECIAL OFFER!

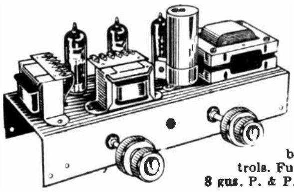


A great opportunity to purchase a first class GENERAL PURPOSE, HIGH GAIN, HIGH SENSITIVITY, PORTABLE AMPLIFIER. Completely self contained and can be used for a variety of purposes, i.e. Intercom, Baby Alarm, Booster unit for transistor radios etc., also ideal for classroom unit etc. Works perfectly with our special offer High Impedance Dynamic Microphone (30/-). Output 1000mW. Uses standard 9 volt battery. Smart two tone carrying case size 12 × 4 × 9in. fitted standard input jack socket, volume controls, 7 × 4in. speaker. Completely built and tested, brand new with full maker's guarantee.

Only 79/6 P. & P. 5/6

STEREO AMPLIFIER

Incorporating 2 ECL86's and 1 EZ80, heavy duty, double wound mains transformer. Output 4 watts per channel. Full tone and volume controls. Absolutely complete.

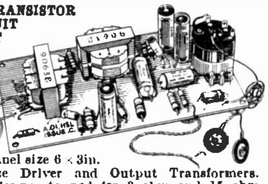


ONLY **£5.9.6** P. & P. 8/-.

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

HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT

Type TA1



● Peak output in excess of 1½ watts.
● All standard British components.
● Built on printed circuit panel size 6 × 3in.
● Generous size Driver and Output Transformers.
● Output transformer tapped for 3 ohm and 15 ohm speakers.
● Transistors (GET114 or 81 Mullard AC128D and matched pair of AC128 o/p).
● 9 volt operation.
● Everything supplied, wire, battery clips, solder, etc.
● Comprehensive easy to follow instructions and circuit diagram 2/6 (Free with Kit). All parts sold separately.

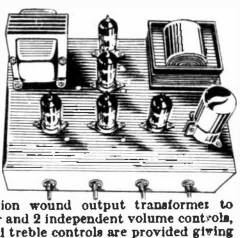
SPECIAL PRICE 45/-. P. & P. 3/-. Also ready built and tested, **52/6.** P. & P. 3/-.

HARVERSON'S SUPER MONO AMPLIFIER

A super quality gram amplifier using a double wound mains transformer, EZ80 rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. high overall. AC mains 200/240V. Supplied absolutely Brand New completely wired and tested with valves and good quality output transformer. LIMITED NUMBER.

OUR ROCK BOTTOM BARGAIN PRICE 49/6 P. & P. 6/-

10/14 WATT HI-FI AMPLIFIER KIT



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

Open all day Saturday
Early closing Wed. 1 p.m.

A few minutes from South Wimbledon Tube Station

HARVERSON SURPLUS CO. LTD.

170 HIGH ST., MERTON, S.W.19 Tel. 01-540 3985

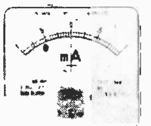
SEND STAMPED ADDRESSED ENVELOPE WITH ALL ENQUIRIES

(Please write clearly)

PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY. P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

SEW PANEL METERS

Send S.A.E. for full lists. Other ranges available. Please include postage. Special quotations for quantities.



CLEAR PLASTIC METERS

Type MR.52P. 2½in square fronts

50µA	59/6	100mA	37/6	300V a.c.	37/6
50-0-50µA	49/6	500mA	37/6	S Meter 1mA	39/6
100µA	49/6	1 amp.	37/6	VU Meter	59/6
100-0-100µA	45/-	5 amp.	37/6	1 amp. a.c.*	37/6
500µA	42/6	10V d.c.	37/6	5 amp. a.c.*	37/6
1mA	37/6	20V d.c.	37/6	10 amp. a.c.*	37/6
5mA	37/6	50V d.c.	37/6	20 amp. a.c.*	37/6
10mA	37/6	300V d.c.	37/6	30 amp. a.c.*	37/6
50mA	37/6	15V a.c.	37/6		

Type MR.38P. 1 21/32in square fronts

50µA	37/6	750mA	25/-
50-0-50µA	35/-	1 amp	25/-
100µA	35/-	2 amp	25/-
100-0-100µA	32/6	5 amp	25/-
200µA	32/6	3V d.c.	25/-
500µA	27/6	10V d.c.	25/-
500-0-500µA	25/-	20V d.c.	25/-
1mA	25/-	50V d.c.	25/-
1-0-1mA	25/-	100V d.c.	25/-
2mA	25/-	150V d.c.	25/-
5mA	25/-	300V d.c.	25/-
10mA	25/-	500V d.c.	25/-
20mA	25/-	750V d.c.	25/-
50mA	25/-	15V a.c.	25/-
100mA	25/-	50V a.c.	25/-
150mA	25/-	150V a.c.	25/-
200mA	25/-	300V a.c.	25/-
300mA	25/-	500V a.c.	25/-
500mA	25/-	S meter 1mA	29/6
		VU meter	39/6

Type MR.85P. 4¼in × 4¼in fronts

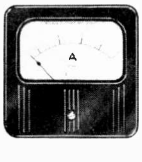
50µA	69/6	15 amp.	49/6
50-0-50µA	59/6	30 amp.	49/6
100µA	59/6	20V d.c.	49/6
100-0-100µA	59/6	50V d.c.	49/6
200µA	55/-	150V d.c.	49/6
500µA	52/6	300V d.c.	49/6
500-0-500µA	49/6	150V a.c.	49/6
1mA	49/6	300V a.c.	49/6
1-0-1mA	49/6	S Meter 1mA	55/-
5mA	49/6	VU meter	69/6
10mA	49/6	1 amp. a.c.*	49/6
50mA	49/6	5 amp. a.c.*	49/6
100mA	49/6	10 amp. a.c.*	49/6
500mA	49/6	20 amp. a.c.*	49/6
1 amp.	49/6	30 amp. a.c.*	49/6
5 amp.	49/6		

Type MR.45P. 2in square fronts

50µA	42/6	10V d.c.	27/6
50-0-50µA	39/6	20V d.c.	27/6
100µA	39/6	50V d.c.	27/6
100-0-100µA	35/-	300V d.c.	27/6
500µA	29/6	15V a.c.	27/6
1mA	27/6	300V a.c.	27/6
5mA	27/6	S meter 1mA	35/-
10mA	27/6	VU meter	42/6
50mA	27/6	1 amp a.c.*	27/6
10mA	27/6	5 amp. a.c.*	27/6
500mA	27/6	10 amp. a.c.*	27/6
1 amp.	27/6	20 amp. a.c.*	27/6
5 amp.	27/6	30 amp. a.c.*	27/6

Type MR.65P. 3½in × 3½in fronts

50µA	65/-	50V d.c.	39/6
50-0-50µA	52/6	150V d.c.	39/6
100µA	52/6	300V d.c.	39/6
100-0-100µA	49/6	15V a.c.	39/6
500µA	45/-	50V a.c.	39/6
1mA	39/6	150V a.c.	39/6
5mA	39/6	300V a.c.	39/6
10mA	39/6	500V a.c.	39/6
50mA	39/6	S meter 1mA	45/-
100mA	39/6	VU meter	65/-
500mA	39/6	50mA a.c.*	39/6
1 amp.	39/6	100mA a.c.*	39/6
5 amp.	39/6	200mA a.c.*	39/6
10 amp.	39/6	500mA a.c.*	39/6
15 amp.	39/6	1 amp. a.c.*	39/6
20 amp.	39/6	5 amp. a.c.*	39/6
30 amp.	39/6	10 amp. a.c.*	39/6
50 amp.	39/6	20 amp. a.c.*	39/6
10V d.c.	39/6	30 amp. a.c.*	39/6
20V d.c.	39/6		

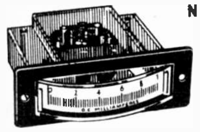


BAKELITE PANEL METERS

Type MR.65. 3½in square fronts

25µA	67/6	500mA	32/6	30V a.c.*	32/6
50µA	45/-	1 amp.	32/6	50V a.c.*	32/6
50-0-50µA	42/6	5 amp.	32/6	150V a.c.*	32/6
100µA	42/6	15 amp.	32/6	300V a.c.*	32/6
100-0-100µA	42/6	30 amp.	32/6	1 amp. a.c.*	32/6
500µA	39/6	50 amp.	32/6	5 amp. a.c.*	32/6
1mA	32/6	5V d.c.	32/6	10 amp. a.c.*	32/6
1-0-1mA	32/6	10V d.c.	32/6	20 amp. a.c.*	32/6
5mA	32/6	20V d.c.	32/6	30 amp. a.c.*	32/6
10mA	32/6	50V d.c.	32/6	50 amp. a.c.*	32/6
50mA	32/6	150V d.c.	32/6	VU meter	59/6
100mA	32/6	300V d.c.	32/6		

***Moving iron, all others moving coil.**



NEW RANGE OF "SEW" EDGEWISE METERS

MODEL PE70. Dimensions 3 17/32 × 1 11/32 × 2½ deep overall. Available as follows:

50 microamp	57/6	500 microamp	49/6
50-0-50 microamp	55/-	1 milliamp	45/-
100 microamp	55/-	300V a.c.	45/-
100-0-100 microamp	52/6	VU meter	62/6
200 microamp	52/6		

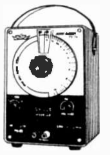
Post extra

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120kc/s to 500Mc/s on 6 bands. Directly calibrated. Variable RF attenuator, audio output. Xtal socket for calibration. 220/240V a.c. Size 140 × 215 × 170mm. Brand new with instructions. **£15.** Carr. 7/6.

TY 75 AUDIO SIGNAL GENERATOR

Sine Wave 20c/s to 200kc/s. Square Wave 20c/s to 30kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts a.c. Size 210 × 150 × 120mm. Brand new with instructions. £15. Carr. 7/6.



T.M.C. 1000 SERIES KEY SWITCHES

Brand New with knobs as follows.

1 way, 2 c/o 7/6; 1 way, 2 c/o 2b, 7/6; 1 way, 4 c/o. 8/-; 2 way, 3m., 3m. 8/6; 2 way, 2 c/o., 2 c/o. 8/6.

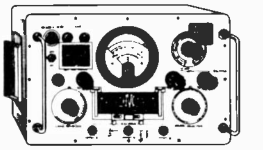
Post extra. Quantities available.

NOMBREX TRANSISTORISED TEST EQUIPMENT

All Post Paid with Battery

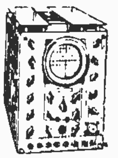
Model 22. Power Supply 0–15V d.c.	£14.10.0
Model 30. Audio Generator.	£19.10.0
Model 31. R.F. Signal Generator.	£12.10.0
Model 32. C.R. Bridge.	£10.10.0
Model 33. Inductance Bridge.	£20.0.0
Model 66. Inductance Bridge.	£18.0.0
Model 61. Power Supply.	£6.10.0

AVO CT.38 ELECTRONIC MULTIMETERS



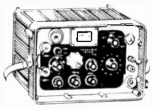
High quality 97 range instrument which measures a.c. and d.c. Voltage, Current, Resistance and Power output. Ranges d.c. volts 250mV–10,000V. (10megΩ–110megΩ input). D.c. current 10µA 25 amps. Ohms: 0–1,000mgΩ. A.c. volt 100mV–250V (with RF measuring head up to 250Mc/s). A.c. current 10µA–25 amps. Power output 50 micro-watts–5 watts. Operation 0/110/200/250V. C. Supplied in perfect condition complete with circuit lead and RF probe **£25.** Carr. 15/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES



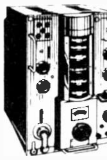
An excellent general purpose D/B oscilloscope. T.B. 2c/s–750 kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33mV/CM. Operating voltage 0/110/200/250V a.c. Supplied in excellent working condition. **£22.10.0.** Or complete with all accessories, probe, leads, lid, etc. **£25.** Carriage 30/-.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20–80Mc/s. AM/C.W./FM. Incorporates precision dial, level meter, precision attenuator 1µV-100mV. Operation from 12V d.c. or 0/110/200/250V a.c. Size 12 × 8½ × 9in. Supplied in brand new condition complete with all connectors fully tested. **£45.** Carr. 20/-.

ADMIRALTY B.40 RECEIVERS



Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650kc/s – 30Mc/s, I/F 500 kc/s. Incorporates 2 R.F. and 3 I.F. stages, band-pass filter, noise limiter, crystal controlled B.F.O., calibrator I/F, output, etc. Built-in speaker, output for phones. Operation 150/230V a.c. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition, **£22.10.0.** Carr. 30/-. A few available Brand New **£35.** Carr. 30/-. With circuit diagrams. Also available B.41 L.F. version of above 15kc/s–700kc/s. **£17.10.0** Carr. 30/-.

MARCONI CT44/ TF956 AF ABSORPTION WATTMETER

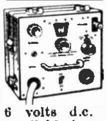
1 µ/watt to 6 watts.

£20. Carr. 20/-.

AVOMETERS

Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions. Model 47A **£9.19.6.** P. & P. 7/6 each.

CLASS D WAVEMETERS



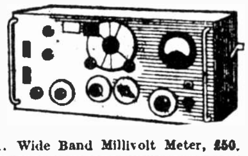
A crystal controlled hetrodyne frequency meter covering 1·7–8Mc/s. Operation on 6 volts d.c. Ideal for amateur use. Available in good used condition **£5.19.6.** Carr. 7/6. Or brand new with accessories **£7.19.6.** Carr. 7/6.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.

150 W.	£1.12.6,	P. & P. 3/-
300 W.	£2.7.6,	P. & P. 3/6
500 W.	£3.10.0,	P. & P. 6/6
1,000 W.	£5.10.0,	P. & P. 7/6
1,500 W.	£6.10.0,	P. & P. 8/6
3,000 W.	£7.10.0,	P. & P. 12/6
7,500 W.	£15.10.0,	P. & P. 20/-

MARCONI TEST EQUIPMENT



EX-MILITARY RECONDITIONED.
TF 144G STANDARD SIGNAL GENERATORS, 85kc/s–25 Mc/s, **£25,** carr. 30/-. TF.885. VIDEO OSCILLATOR. 0·5Mc/s, **£45.** Carr. 30/-. T.F. 195M. BEAT FREQUENCY OSCILLATOR 0–40kc/s, 200/250V a.c. **£20,** carr. 30/-. TF.142E. Distortion Factor Meter, **£20,** carr. 20/-. All above offered in excellent condition fully tested and checked. TF. 1100 VALVE VOLTMETER, Brand New, **£50.** T.F. 1267 TRANSMISSION TEST SET, Brand New, **£75.** TF.1371. Wide Band Millivolt Meter, **£50.**

Variable Voltage TRANSFORMERS

Brand new, guaranteed and carriage paid.
High quality construction. Input 230V 50-60 cycles.
Output full variable from 0-260V. Bulk quantities available.
1 amp.—**£5.10.0**; 2.5amp.—**£6.15.0**; 5 amp.—**£9.15.0**;
8 amp.—**£14.10.0**; 10 amp.—**£18.10.0**; 12 amp.—**£21**; 20 amp.—**£37.**

COSSOR DOUBLE BEAM OSCILLOSCOPES

Type 1035 general purpose a.c. coupled. **Type 1049** L. F. d.c coupled **£35** each. Carr. 30/-.

AMERICAN TAPE

First grade quality American tapes. Brand new. Discount on quantities.

3in., 225ft. L.P. acetate	3/6
3¾in 600ft. T.P. mylar	10/-
5in. 600ft. std. plastic	8/6
5in. 900ft. L.P. acetate	10/-
5in. 1,200ft. D.P. mylar	15/-
5in. 1,800ft. T.P. mylar	32/6
5¾in. 1,200ft. L.P. acetate	12/6
5¾in. 1,200ft. L. P. mylar	16/-
5¾in. 1,800ft. D.P. mylar	22/6
5¾in. 2,400ft. T.P. mylar	39/6
7in. 1,200ft. std. acetate	12/6
7in. 1,800ft. L.P. acetate	15/-
7in. 1,800ft. L.P. mylar	20/-
7in. 2,400ft. D.P. mylar	25/-
7in. 3,600ft. T.P. mylar	45/-

Postage 2/-, Over £3 post paid.

TAPE CASSETTES

C60-60 mins. **10/3.** C90-90 mins. **14/3.** Over £2 post paid.

EVERSHED VIGNOLES SERIES II 500 VOLT MEGGERS. Perfect condition **£21.** P. & P. 10/-.

LUCAS 20/0/20 AMMETERS. Brand new boxed. Suitable car/motorcycle. **12/6.** P. & P. 2/-.

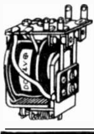
NO. 76 TRANSMITTER

2-12 Mc/s. Crystal Controlled (not supplied). 807PA, Operation 12V. D.C. (Rotary transformer). 9 watts output. C.W. only. New condition. **72/6.** Carr. 12/6.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0–20kc/s. Output 5kΩ or 500 ohms. 200/250V a.c. offered in excellent condition. **£12.10.0.** Carriage 10/-.

OMRON Mk. 2 RELAYS



Brand New and Boxed. 24 volt d.c. coils. 2 Pole changeover. 5 amp contacts. 7/6 each. P. & P. 1/6.

G. W. SMITH & Co. (Radio) Ltd.
3-34 Lisle St., W.C.2

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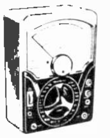

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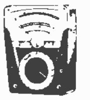

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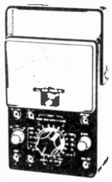

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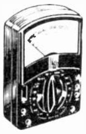

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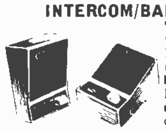

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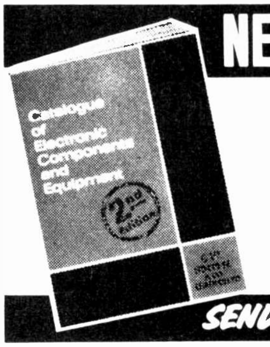

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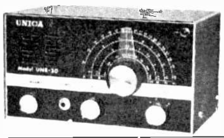

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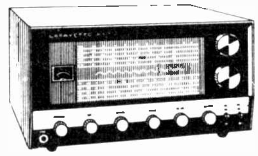

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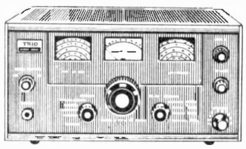

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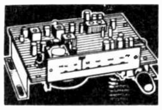

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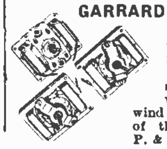

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VOL. 5 No. 1
January 1969

PRACTICAL ELECTRONICS

THE TRANSISTOR THREATENED?

In the two decades since the Americans Bardeen, Brattain, and Shockley invented the transistor, countless new and dramatic developments have occurred in the field of semiconductors. The material originally used, the rare element germanium, has given way to the more common material silicon, with drastic reduction in costs. Manufacturing techniques have advanced, so bringing about further economies, and also making possible a variety of active circuit devices closely related to the transistor, but endowed with certain features which allow each of them to make a marked individual contribution to progress in electronics technology.

Dissimilar in certain respects, such as construction, mode of operation and circuit function, all present day semiconductor devices do share a common physics background: all exploit the property of conduction through solid crystalline material by means of positive and negative current carriers.

But now a further discovery has been made that may revolutionise solid state technology. Another American, S. Ovskinsky, has discovered that non-crystalline substances possess the property of changing from high to low resistivity under certain conditions, and he has invented a microminiature two-way switching device based on this effect. The material used is an inexpensive amorphous glass substance and it is claimed that this device will have considerable advantages over the transistor, especially for computer and communications applications. Apart from cheapness of production, this new device is claimed to be more reliable than existing devices.

Professor Mott, director of the Cavendish Laboratory at Cambridge has described this as the newest, and most exciting discovery in solid state physics at the moment. Prof. Mott was speaking as a scientist of course, and it rests with the technologists to develop and prove this as a practical circuit element. There may be certain yet unseen snags in transferring this invention from the research laboratory to the production floor. There may also be a lack of enthusiasm from the semiconductor manufacturers if this newcomer seems likely to become a serious rival to the established transistor and diode. But the expansion of the computer industry and the widespread adoption of pulse techniques for control and communication purposes suggest there will be an ever growing demand for electronic switching devices in the future. Such commercial doubts are likely therefore to be quickly dispelled.

For the layman, it is difficult to contemplate a component that will outshine the transistor in efficiency, cost, and size. We can only wait and see.

F. E. Bennett—*Editor*

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our February issue will be published on Monday, January 13

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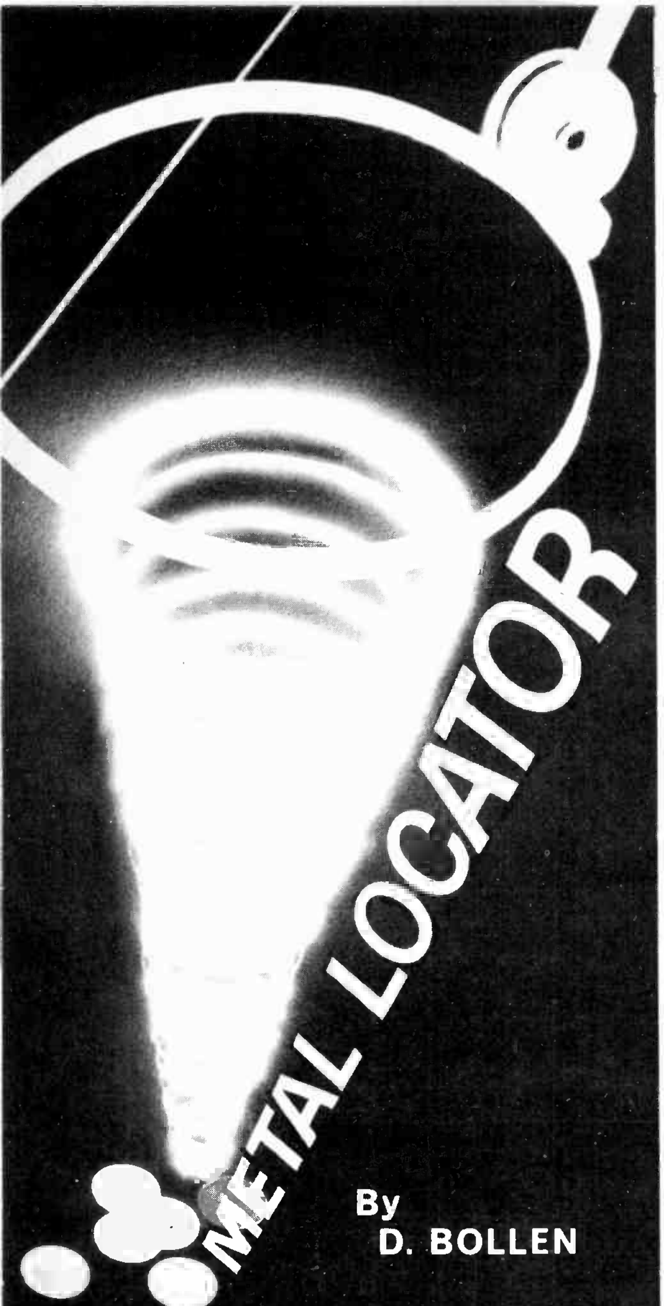


METAL LOCATOR

By
D. BOLLEN

WITH the aid of a mine detector, or its civilian counterpart the metal locator, valuable antiquities are sometimes unearthed. Veterinary surgeons can find indigestible objects in the stomachs of animals; policemen discover offensive weapons or loot; plumbers and electricians track pipes and cables.

The metal locator described here is designed primarily for ease of operation, and only weighs 1½ pounds, but nevertheless has a large diameter search coil, which provides good sensitivity. In the hands of a practiced operator, something the size and weight of a penny can be located under three inches of soil, while larger objects are traceable at greater depths.

MODE OF OPERATION

When certain materials are placed in close proximity to a coil of wire they will influence the inductance value of the coil. Readers will already be familiar with ferrite and brass tuning slugs, and will know that a ferrite slug increases the effective inductance of a coil, while a brass slug acts like a shorted turn and reduces inductance. Less well known is that some "lossy" insulators, such as wood or p.v.c., can also promote a slight increase in inductance.

If a large diameter unscreened coil is employed as an inductor in the tuned circuit of an r.f. oscillator, quite small amounts of metal introduced into the field surrounding the coil will produce detectable shifts in frequency.

However, the tuned circuit of such an oscillator must also contain capacitance, some of which will be distributed between adjacent turns of the coil, making the circuit susceptible to frequency shifts when the coil is brought close to large non-metallic bodies, such as earth, water, and masonry. Yet another unwanted effect is mechanical modulation of the oscillator frequency caused by poor construction and general lack of rigidity. Obviously, any change of frequency which is not due to the presence of metal will act as interference, and reduce sensitivity.

Moving on to the block diagram (Fig. 1) of the metal locator, the output from the metal sensitive search oscillator (frequency f_1) is compared with a fixed reference frequency f_2, by mixing both frequencies to produce a difference signal or beat note f_3. Assume that f_2 is at 300,000Hz, while f_1 is temporarily at 300,100Hz, the resulting beat note f_3 will be f_1–f_2 or 100Hz.

If f_1 is increased, by metal introduced into the field surrounding the search coil, to 300,101Hz, the beat note will become 101Hz. Although f_3 has experienced a one per cent change of frequency, which is about the limit of discrimination of the human ear, this corresponds to a much smaller percentage change in search oscillator frequency, some 0·0003 per cent, and an approximate coil inductance change of 0·0012 per cent.

Hence, this simple method of comparing two frequencies by audible beating magnifies minute alterations in search coil inductance without the need for delicate measuring instruments.

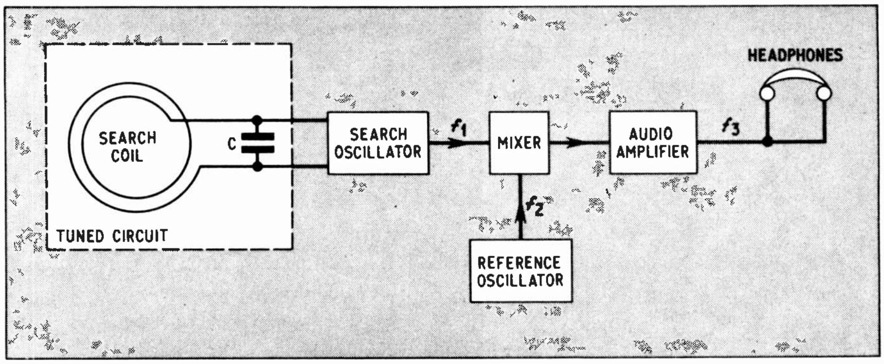


Fig. 1. Block diagram of the metal locator

OSCILLATOR CIRCUIT

The complete metal locator circuit appears in Fig. 2. Looking first at the search coil, this consists of two windings, L1 and L2, which are inductively coupled. L1, tuned by fixed capacitor C1 and trimmer VC1, is intentionally left "floating" to reduce capacitive effects when the coil is brought close to non-metallic bodies. Also, 4-turn coil L1 has a low intrinsic value of inductance, so that any unavoidable stray capacitance changes will be swamped by the large values of C1 and VC1 needed to bring L1 to resonance at the working frequency of 300kHz.

Coupling coil L2 forms the collector load of common base oscillator TR1, while collector-emitter capacitor C4 introduces positive feedback, and trimmer VC2 acts as a fine frequency control for adjustment of the audio note when the metal locator is in use. A small proportion of the available output from TR1 emitter is tapped off by VR1, and this particular arrangement largely eliminates the tendency of one oscillator to "pull" and lock with the other when their frequencies are almost the same.

The combined mixer and reference oscillator TR2 is similar to that used in a superhet receiver, and in fact employs a standard transistor medium-wave oscillator coil (L3, L4, L5), tuned by C8 to a fixed frequency of about 300kHz. Inductive coupling between L3 and L4 provides self-oscillation, and the reference frequency, while the signal derived from the search oscillator is fed to the base of TR2 and is amplified. Both frequencies are combined at the collector of TR2, but instead of the usual i.f. transformer, a simpler arrangement of a fixed resistor and a capacitor (R7 and C7) suffices to filter out the two high frequencies and leave the resulting difference or beat frequency.

The two remaining stages, consisting of components associated with TR3 and TR4, merely serve to amplify the audio beat note to a level adequate for headphone listening in a noisy environment.

CONSTRUCTION

A 6ft length of nylon curtain rail is bent round to form a 23in diameter circular search coil former. Although not particularly rigid when unbraced, the coil former is tough and light, and can be prevented from vibrating by a string stay. The stay also serves as a shoulder strap when transporting the folded metal locator to and from a site.

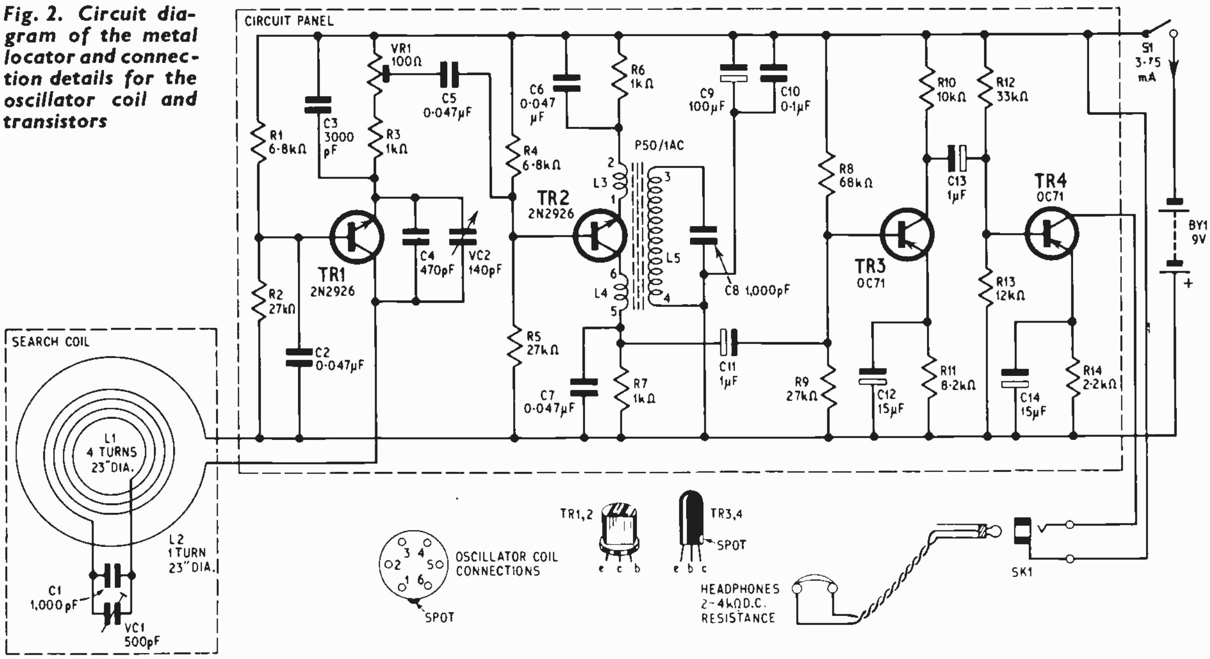


Fig. 2. Circuit diagram of the metal locator and connection details for the oscillator coil and transistors

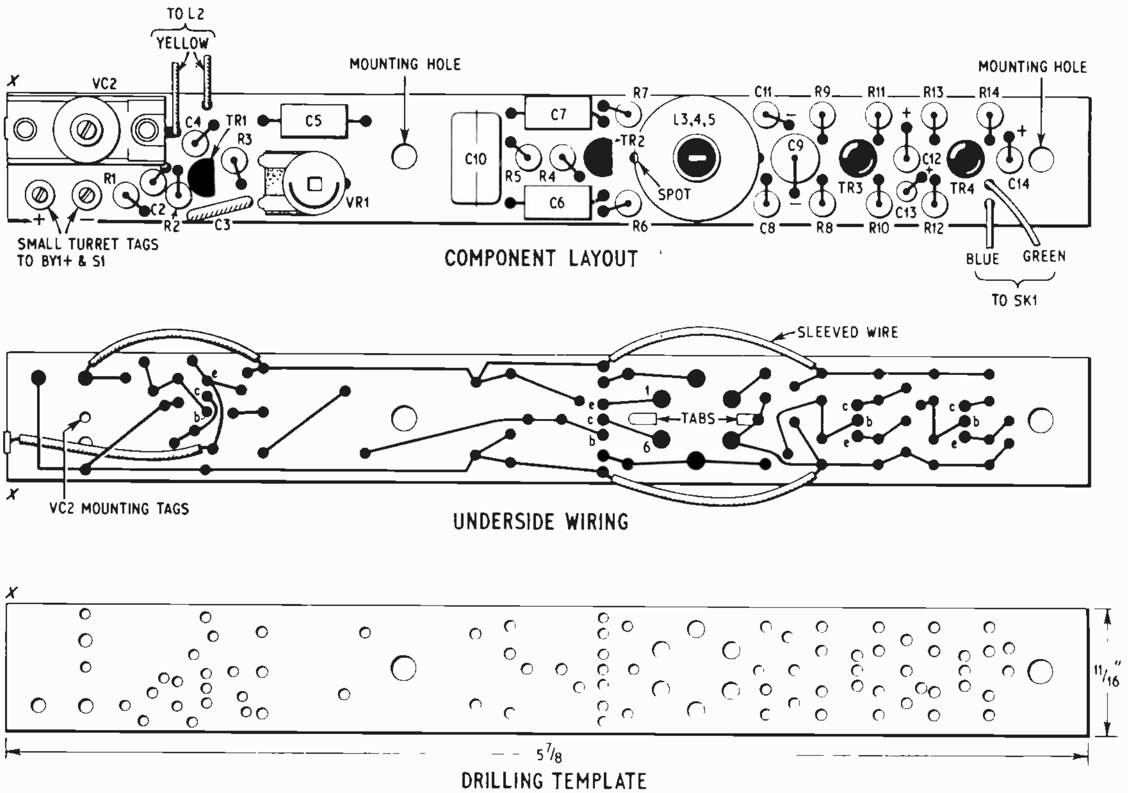


Fig. 6. Component layout and wiring details and drilling template for the circuit panel contained in the handle of the metal locator

COMPONENTS . . .

Resistors

R1	6·8kΩ	R8	68kΩ
R2	27kΩ	R9	27kΩ
R3	1kΩ	R10	10kΩ
R4	6·8kΩ	R11	8·2kΩ
R5	27kΩ	R12	33kΩ
R6	1kΩ	R13	12kΩ
R7	1kΩ	R14	2·2kΩ

All 10%, ½W carbon

Potentiometer

VR1 100Ω miniature horizontal skeleton preset (Body size 0·5in × 0·37in × 0·12in)

Capacitors

*C1	1,000pF polystyrene	125V	0·6in × 0·25in dia
C2	0·047μF polyester	250V	0·45in × 0·17in dia
C3	3,000pF disc ceramic		0·1in × 0·5in dia
*C4	470pF polystyrene	125V	0·4in × 0·2in dia
C5	0·047μF polyester	250V	0·45in × 0·17in dia
C6	0·047μF polyester	250V	0·45in × 0·17in dia
C7	0·047μF polyester	250V	0·45in × 0·17in dia
*C8	1,000pF polystyrene	125V	0·6in × 0·25in dia
C9	100μF elect.	15V	0·75in × 0·3in dia
C10	0·1μF polyester	250V	0·53in × 0·41in × 0·26in dia
C11	1μF elect.	15V	0·5in × 0·12in dia
C12	16μF elect.	15V	0·6in × 0·22in dia
C13	1μF elect.	15V	0·5in × 0·12in dia
C14	16μF elect.	15V	0·6in × 0·22in dia

* C1, C4, C8 are ± 2·5% tolerance types

Trimmer Capacitors

VC1	500pF	0·94in × 0·62in × 0·18in
VC2	140pF	0·81in × 0·38in × 0·25in

Both VC1 and VC2 are "postage stamp" type

Inductors

L1 Wound with 14/·0076 p.v.c. covered wire (see text)

L2 Wound with 7/·0048 p.v.c. covered wire (see text)

L3, L4, L5 M.W. oscillator coil type P50/1AC (Weyrad)

Transistors

TR1, TR2 2N2926 (orange grade) (2 off)

TR3, TR4 OC71 (2 off)

Switch

S1 Single-pole changeover miniature toggle switch

Plug and Socket

PL1 and SK1 Jack plug and socket open circuit jack type J2 and plug ¼in dia, 2 contacts (Bulgin)

Miscellaneous

Headphones 2 to 4kΩ d.c. resistance
Nylon curtain rail 7ft (Swish) (see text)
Plywood ¼in thick, 1 sq ft
Plywood ¾in thick, 8in × 4in
Dowel rod ¾in dia. 31in long
S.R.B.P. sheet 6in × ¾in × $\frac{1}{16}$in
Battery connectors, plastics wheel, nuts and bolts (see text)

will help to hold the dowel in place. Take care to keep the slot in the dowel free from glue, and facing towards the interior of the handle.

The 3/8in diameter plastics screw used to clamp the dowel and discs on the prototype was taken from a broken toilet seat; it is important to avoid the use of metal attachments (bolts) at the search coil end of the metal locator. Drill the discs and flat end of dowel to suit the size of clamping screw employed.

Drill holes in the handle to take S1 and SK1, in the positions shown in Fig. 4, and make up a battery box from three pieces of s.r.b.p. sheet or plywood. All wooden parts should be finally sandpapered and given one or two coats of protective varnish.

WINDING THE SEARCH COIL

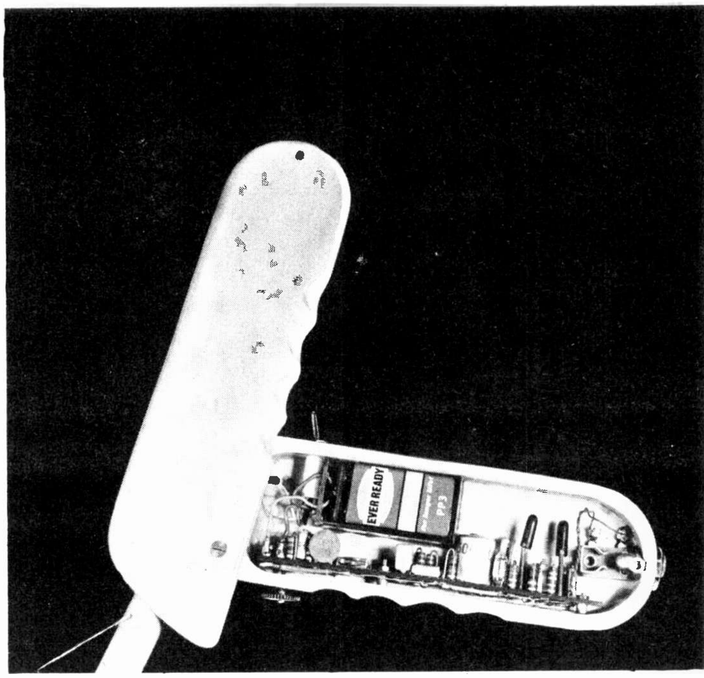
Small holes can be drilled through the nylon coil former to take start and finish leads of L1 and L2. L1 consists of four close wound turns of 14/·0076 p.v.c. covered wire, while L2 is a single turn of 7/·0048 insulated wire, the latter with ends left long enough to go up the slot in the dowel and into the handle (shown colour coded yellow in Fig. 2). Note that the single turn L2 is wound in the upper channel of the curtain rail, away from L1. It is advisable to fit protective sleeving to all coil lead-outs; L1 turns should be covered with a layer of plastics insulating tape to prevent movement.

Obtain a small plastics box, or make one up from wood, s.r.b.p. or polystyrene sheet glued at the edges, to take C1 and VC1. Two holes are drilled at one end of the box to admit L1 leads. There are holes also to take VC1 mounting screw, and a trimming tool. To mount the completed box assembly on the search coil former, carefully make a hole to clear VC1 mounting nut, in the top of the two short rail sections and glue the box to the rails in the position shown in Fig. 2.

If it is intended to use the search coil submerged in several inches of water, when exploring river bed or pond, for example, then the box, VC1 mounting screw and nut, and L1 lead entry holes must be thoroughly waterproofed with a generous layer of epoxy resin glue, before fixing to the search coil former. The trimming tool hole can be rendered waterproof with a small rubber bung.

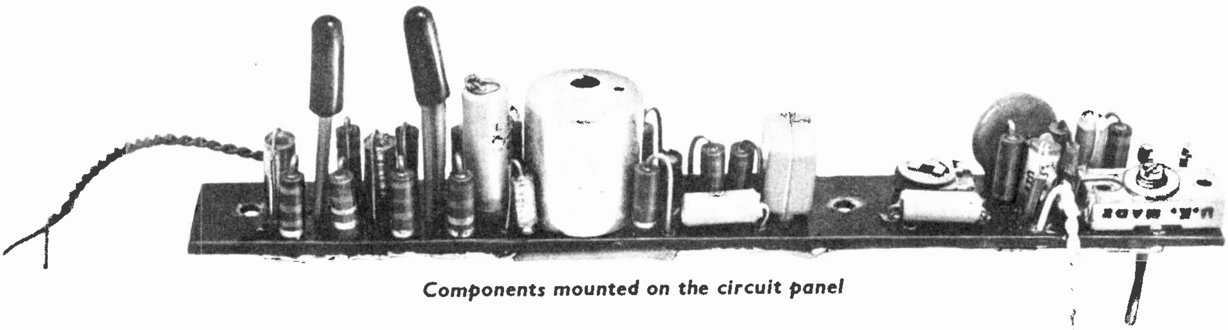
CIRCUIT PANEL

In order to accommodate the complete circuit panel in the space provided by the hollow handle, components used must not be much larger than those employed in the prototype. It is often the case, especially with capacitors, that components of near identical electrical specification will differ in size, and for this reason certain dimensions are included in the component list, to assist the reader.



Layout of components mounted inside the handle

Drill a 5⅞in × 11/16in piece of s.r.b.p., from the full size plan given in Fig. 5. Prior to mounting components, fit a 1in long 8B.A. screw to trimmer VC2, in place of the existing adjuster screw, and bend up one of the trimmer solder tags. Also, at this stage, use the circuit panel as a template to mark out and drill holes in the handle for VC2 screw, and the two 6B.A. countersunk mounting screws.



Components mounted on the circuit panel

After riveting the two turret tags to the panel, progressively mount all components and complete underside wiring. VC2 only needs to be initially secured to the circuit panel by blobs of solder on its push-through tags. Ensure that one of the oscillator coil can tags is wired to the positive circuit rail for screening purposes, and that the polarity of electrolytic capacitors is correct.

FINAL ASSEMBLY

Mount S1 and SK1 in the handle, and solder a 4B.A. nut to the lug on SK1, to take the lid fixing screw (see Fig. 3). Wire the battery connector to S1 and leave short red and blue leads for later connection to the circuit panel turret tags.

Slide the plywood discs on to the search coil former and clamp the dowel between the discs. Take the L2 leads and thread them into the handle, then retain the leads in the dowel slot with a thin smear of glue.

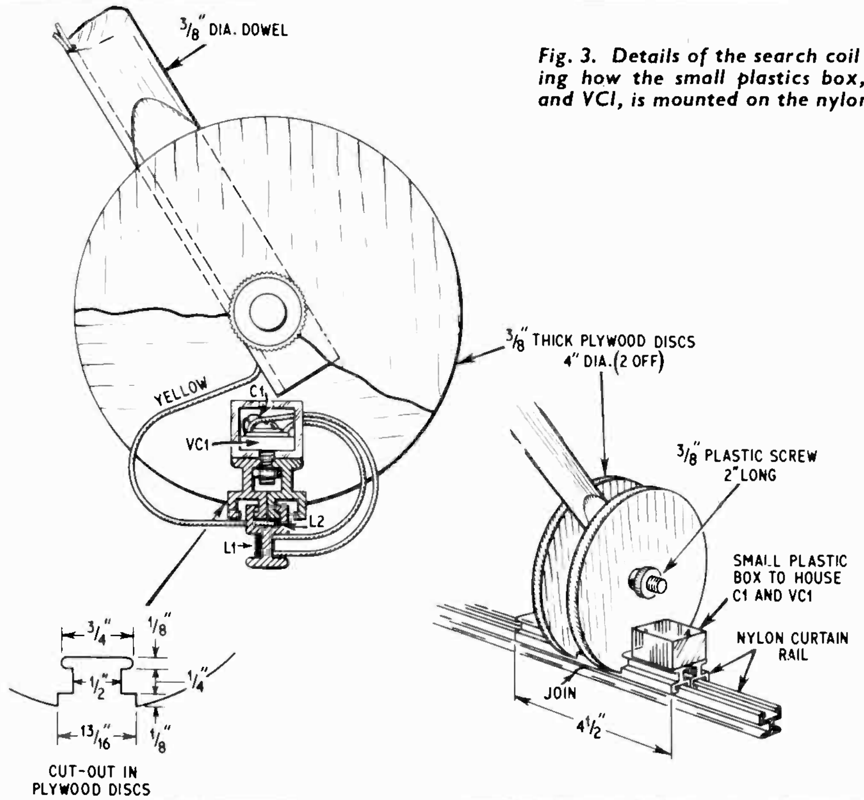


Fig. 3. Details of the search coil fixing showing how the small plastics box, housing C1 and VC1, is mounted on the nylon curtain rail

Referring to Fig. 3, two plywood discs are slotted on to the search coil former, and a wooden dowel stick is clamped between the discs by a large plastics screw and nut. Leads from L2 are taken up the stick, inside a groove, to the handle, which houses the circuit panel, battery, on/off switch, fine frequency control, and a headphone socket (Fig. 4). The handle is made from a hollowed out sandwich of plywood, with internal layout arranged so that the on/off switch S1 can be operated by the thumb, and the fine frequency control VC2 by the forefinger of one hand, leaving the other hand free to carry a digging implement.

Close-up view of the search coil fixing

Commence construction by making up the nylon search coil former. Cut a 6ft length, plus two $4\frac{1}{2}$in lengths of curtain rail, and smooth off the ends with sandpaper and a file. With the aid of an assistant, bend the curtain rail into a circle and butt the ends into the two short pieces of rail, as shown in Fig. 2. The resulting assembly should hold together quite firmly, without gluing.

Cut out two 4in diameter $\frac{3}{8}$in thick plywood discs and five $\frac{1}{4}$in thick plywood handle laminations from the templates shown in Fig. 5, using either a fretsaw or a suitable power tool. The cut-outs at the edges of the discs, shown in Fig. 3, should be a good fit on the curtain rail sections, but if they are sloppy, a thin wooden wedge can later be driven between the short lengths of rail to grip the discs.

Glue four of the handle laminations together under the pressure of a heavy weight or clamps (Fig. 5), and when dry temporarily clamp the lid to the rest of the laminations without gluing and sandpaper to the finished shape, not forgetting to chamfer the edges of the fingerholds.

Next take a 31in × $\frac{3}{4}$in diameter dowel and make a straight groove $\frac{1}{8}$in deep along the entire length with a tenon saw or plough plane, then cut and sandpaper flats at one end of the dowel to allow for clamping between the plywood discs. The other end of the dowel should be glued into the rectangular hole provided by the handle laminations; a small woodscrew

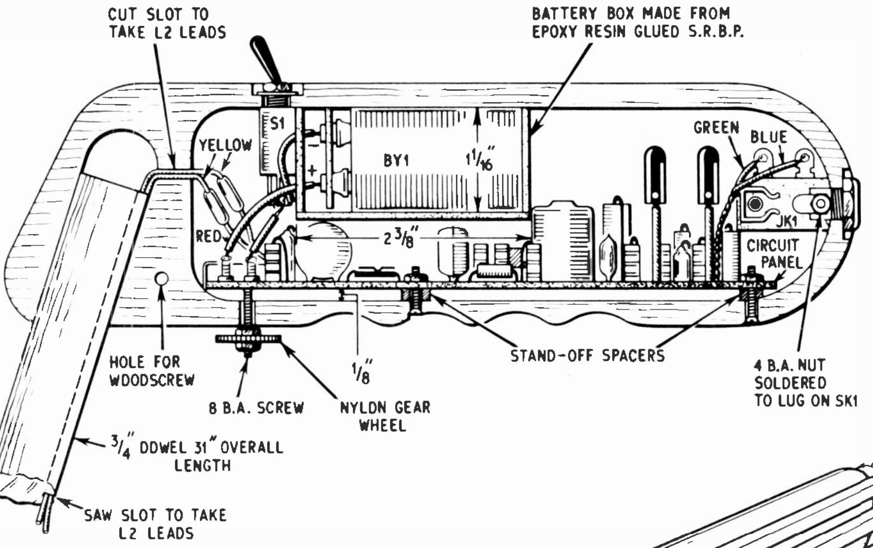
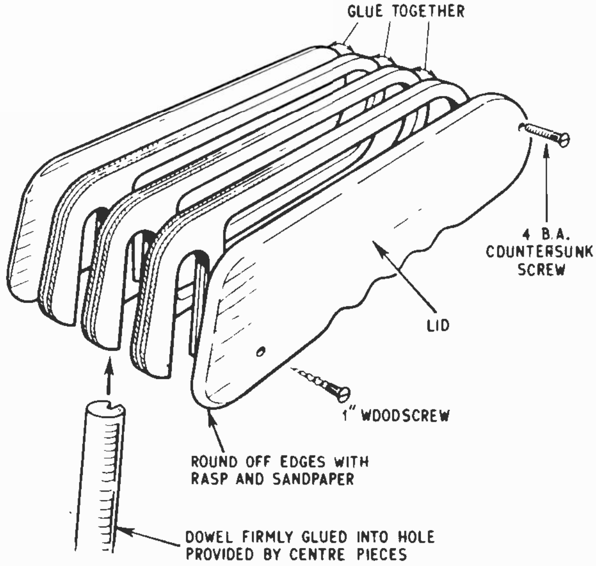
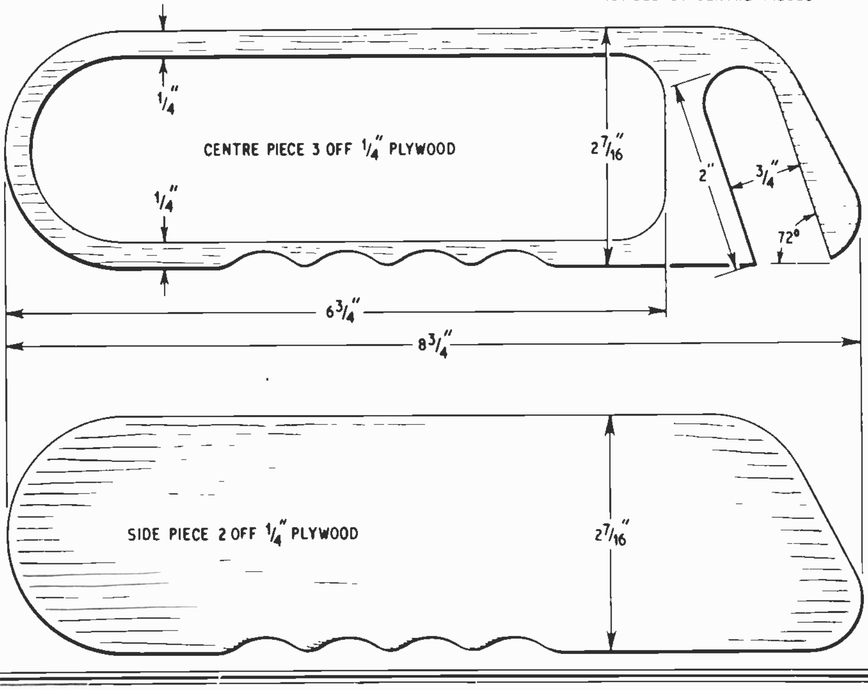


Fig. 4 (above). Layout and mounting details for all components contained in the handle of the metal locator. Note the 4B.A. nut soldered to lug on SK1 for securing the lid

Fig. 5. Method of constructing the handle from pieces of ¼in plywood





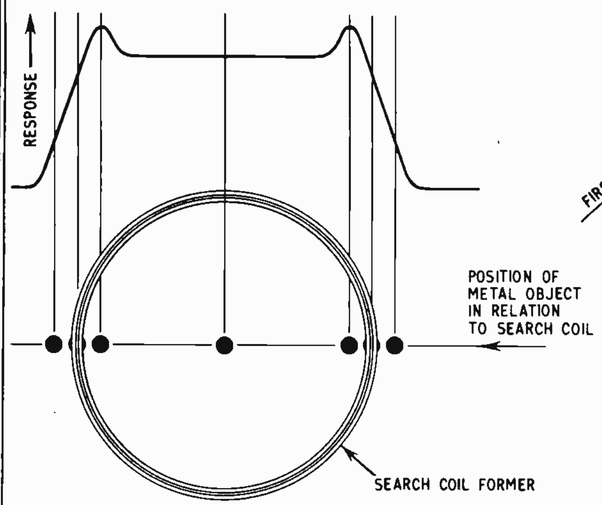


Fig. 7. Sensitivity response across the search coil

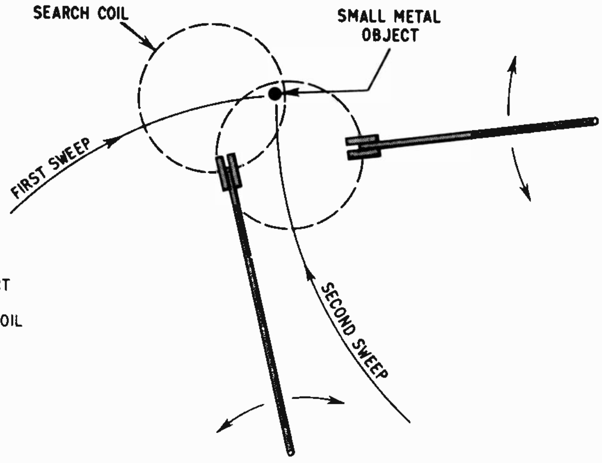


Fig. 8. Method of pinpointing location of small metal object

Next, install the circuit panel on stand-off spacers inside the handle, and connect up yellow panel wires to L2 leads, green and blue wires to JK1, and the red battery wire to its turret tag. A small plastic disc or gear wheel should be fixed between two 8B.A. nuts on the VC2 screw.

TESTING OPERATION

To test for correct circuit action, connect a milliameter between the blue battery wire and its turret tag, fit a battery, and switch on S1. A meter reading of about 3·75mA will show that there are no serious faults. Set VR1 to half track and insert the headphone plug in SK1. A hiss should be heard with perhaps a low level whistle. Rotate VC2 knob fully clockwise (maximum capacitance), then turn back half a turn. With a trimming tool, screw down VC1 slowly, and listen for a succession of whistles produced by oscillator harmonics. Near the maximum capacitance position of VC1 a much louder whistle should occur, indicating that L1 is tuned close to the reference oscillator frequency.

Now with the search coil laid flat on the ground, away from metal objects, it will be found that a null point—where the audible note drops in pitch to zero frequency and then begins to rise again—can be obtained by adjusting VC1 and trimming VC2. Without moving the search coil, bring a metal object into the field of the coil and listen for a note of rising pitch.

It only remains to attach the handle lid by its screws and fit the search coil string stay. Drill a small hole in the top of the search coil former at a point opposite the plywood discs, also drill a hole in the dowel just below the handle. Set the dowel at an angle to the search coil which suits the height and arm length of the user, then tie plastics sleeved string between the search coil and the dowel.

HINTS ON METAL LOCATION

Best sensitivity results from having a steady low frequency note in the headphones, which is caused to increase in pitch as the search coil is brought near metal. As a given beat frequency occurs twice, on each side of the zero frequency null point, it is important to select the right one. First obtain zero frequency with VC1, then unscrew VC2 towards minimum capacitance, so that the frequency of the search oscillator is slightly above that of the reference oscillator.

A sudden decrease of beat frequency will be observed when the search coil is lowered through the last ½in before touching the ground. It can be easily verified that this phenomenon is not wholly due to capacitive effects, but that the ground is acting as a "lossy" insulator. Suspend a large sheet of p.v.c. from the ceiling, positioned well away from all metal objects, and then bring the search coil towards the plastic, whereupon a similar decrease of frequency will be experienced. The "lossy" insulator effect is not too troublesome, and will only reduce sensitivity when searching over rough ground or in long grass.

It is possible to locate metal objects when they are submerged in fresh water, but sea water—being a good conductor—will affect the inductance value of the search coil. Nevertheless, it is still feasible to search for metal on a dry beach, or above the high water mark.

Despite the large diameter of the search coil, small buried objects can be located precisely by making use of the peak of maximum response which is situated near the inside edge of the search coil, see Fig. 5. The method given in Fig. 6, of first sweeping the edge of the coil across the object, then making a second sweep at 90 degrees to the first, will reveal the exact point of intersection.

As a rough guide to sensitivity, a 5in diameter 9 ounce brass ashtray should be detected under some 15in of soil, and something the size and weight of a motor car body will give a clear response at a distance of more than 9ft when submerged in fresh water. ★

MARKET PLACE

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

BATTERY CHARGER

The demand for small battery chargers for the more common alkaline cells now being used more frequently in transistor radios, cameras, tape recorders, etc. has long been needed to offset the relatively high cost as well as the superior performance obtainable with these types of batteries.

The Pencel battery charger from **DCB Instrument and Lighting Co.,** Austin House, Croft Road, Crowborough, Sussex, is one of many now appearing on the market designed specially for the more standard type of alkaline battery. Designed to cover the type of battery used in domestic equipment, it is claimed that 1·5V cells can be recharged between ten and thirty times, depending on operational conditions.

The Pencel charger is very neatly finished and as our photograph shows the cells are simply pressed into a holder mounted on the top of the unit. The charger costs 79s 6d, including four alkaline batteries which should soon pay for itself in increased battery life/hours.

TEST METERS

A neat and versatile pocket test meter has just been introduced by **West Hyde Developments Ltd.,** 30, High Street, Northwood, Middlesex.

Called the Tech Test Meter it costs only 45s including test leads, has 15 ranges for measuring 0 to 1kV a.c./d.c. and 0 to 100 kilohms. The meter movement has jewelled bearings and has a sensitivity of 1,000 ohms per volt.

The low cost of this meter means that it is possible to leave a number of multi-meters in circuit on the bench instead of using a more expensive, single range meter.

A more expensive, sensitive and professional multimeter is the Kelvo 6E Electronic Multimeter. This meter incorporates a self contained battery-operated d.c./a.c. amplifier enabling measurements to be made with an accuracy of ± 1 per cent.

The instrument has 26 voltage ranges, permitting measurements from 1mV f.s.d. to 1kV d.c. and a.c. The sensitivity of the meter is 1 megohm per volt at 1mV to 10V and 10 megohm per volt at 30V to 1kV. There are 28 current ranges from 1μA to 3A d.c. and a.c. Also, there are six resistance ranges for measurements between 0·2 ohm and 50 megohms, and six capacity ranges from 50pF to $5{,}000\mu$F.

The meter is fitted with a sensitive and effective automatic electrical cutout which operates independently of the condition of the batteries, protecting the instrument from damage if subjected to overload.

It is claimed that under continuous 24 hour usage the batteries will enable the instrument to operate satisfactorily for approximately two months.

The Kelvo 6E multimeter is marketed by **Smiths Industries Ltd.,** Kelvin House, Wembley, Middlesex, and cost £72.

RESEARCH INSTRUMENT

Designed for Industrial Laboratories and University Research Departments is the Universal Digital Instrument type EU-805 from **Daystrom Ltd.,** Bristol Road, Gloucester.

The Heath 805 Universal Digital Instrument is a multi-purpose instrument capable of many high accuracy standard measurements and has the adaptability and versatility required of modern research instrumentation. Some of the functions include events counter; frequency meter; integrating digital voltmeter; ratio meter; time interval meter and voltage integrator.

The unit incorporates a modular design based on 16 plug-in cards using TTL Integrated Circuit. This design enables card additions for new functions to be added, protecting it against obsolescence.

In both academic and industrial use it is intended as a companion to the Heath Analogue Digital Designer EU-801-A, a device for teaching digital logic and instrumentation.

FILMS FOR CLUBS AND SCHOOLS

Of interest to schools and clubs are two films from the **Central Office of Information** and **Mullard Ltd.**

The Mullard film is entitled *Mullardability*, is in colour, runs for 9 minutes and is of 16mm gauge.

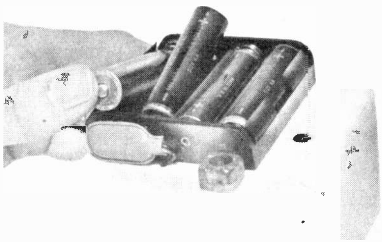
The film begins with illustrations of Mullard's capability to mass-produce vast ranges of electronic components, from television picture tubes to micro-electronic circuits. Finally the film deals with the Mullard Research Laboratories and its study and development of new materials, systems and techniques of the future.

Copies of the film are available on free loan from Mullard Film Library, Kingston Road, Merton Park London, S.E.19.

The COI film is entitled *Movies from Computers*, runs for 20 minutes and is of 16mm gauge. The film contains extracts from existing computer-generated industrial and research films. The use of computers in mathematics, physics and engineering, and also the use in flight training techniques are shown.

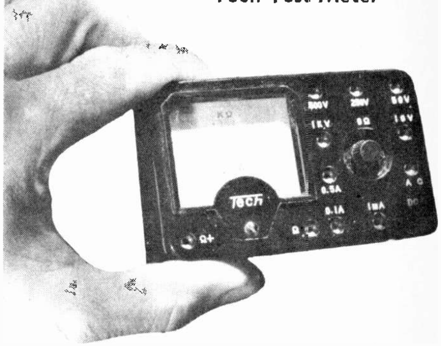
The film is available from the Central Film Library, Government Building, Bromyard Avenue, Acton, London, W.3. The hire charge is £1 for one day only (reduced charges for additional days). In addition to the hire charge there is a surcharge of 1s 6d per 16mm reel to cover despatch and certain other handling costs for the first day of hire only.

The current edition of the Films in Industry catalogue is also available from the Central Film Library, price 4s 6d post free.

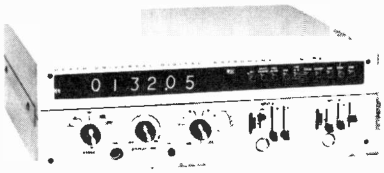


Pencel battery charger from DCB Instrument and Lighting

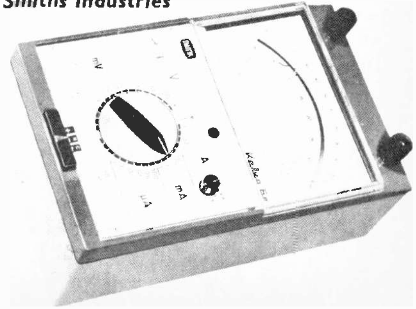
West Hyde Developments Tech Test Meter



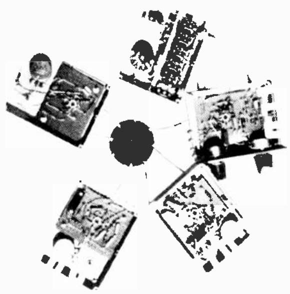
Heath EU-805 Universal Digital Instrument from Daystrom

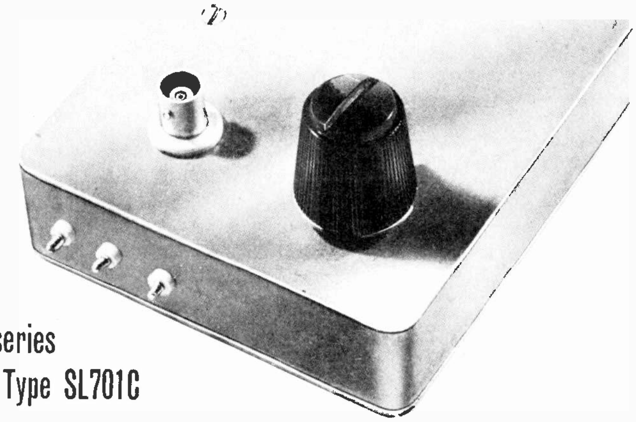


Kelvo 6E meter marketed by Smiths Industries



SQUARE WAVE TEST OSCILLATOR





This is the concluding project in our five-part series featuring the integrated circuit linear amplifier Type SL701C

THE use of a square wave in audio testing to detect overshoot, instability, or ringing of an amplifier is well known, and a straightforward single test with a square wave can be much more informative than even a complete frequency response curve. From the tilt on the top of the square wave we can obtain the l.f. bandwidth, from the rise time we have the h.f. bandwidth, and from the overshoot or ringing (if any) we can determine the approximate magnitude and frequency of any peak at the h.f. end of the frequency response.

This article is the last of this series on the practical uses of the Plessey SL701 integrated circuit, and deals with a simple square wave generator at 1kHz; Fig. 1 shows the basic diagram of the arrangement.

CIRCUIT OPERATION

Positive feedback is applied round the amplifier through the divider chain R1 and R3, while negative feedback is applied through R2 in conjunction with C1, and the circuit changes state regeneratively each time the two inputs are at the same potential. For our purposes we can make all three resistors equal in value, and for our explanation of how the circuit works we can assume that the output level is limited to $\pm$ 2V.

The expected waveforms are drawn in Fig. 2. If we assume that immediately we switch on, the output *c* goes to + 2V, then the input *b* will go to + 1V, and C1 will charge up (through R2) from zero towards + 2V. When the input *a* just exceeds the + 1V of input *b*, the circuit will rapidly switch to the other state of *c* at − 2V and *b* at − 1V. C1 then discharges from + 1V towards − 2V and the circuit reverts to its previous state when *a* now reaches − 1V; and so on. The *a* waveform is therefore of an exponential form. The mark to space ratio of the waveform should be one to one, and the frequency is given by:

$$f = \frac{1}{2{\cdot}2\, C_1\, R_2}\ \text{Hz}$$

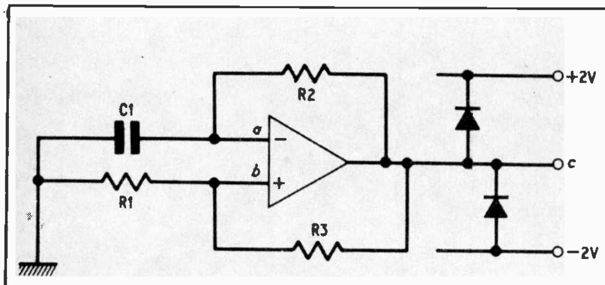


Fig. 1. Basic diagram for the square wave oscillator

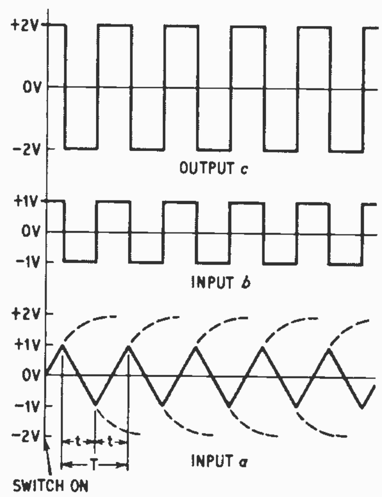


Fig. 2. Waveforms associated with Fig. 1 arrangement

SQUARE WAVE OSCILLATOR CIRCUIT

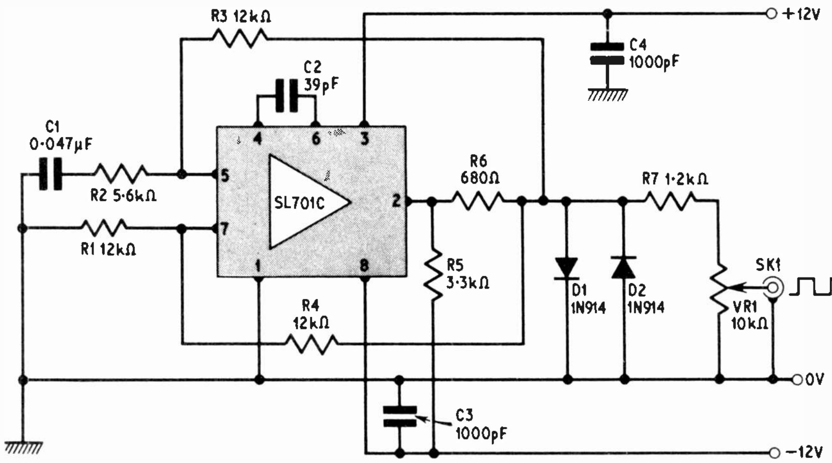
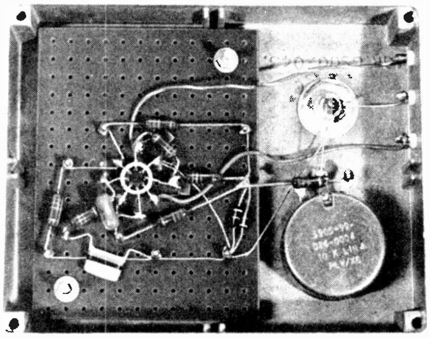


Fig. 3. Complete circuit diagram for the square wave test oscillator

CONSTRUCTIONAL DETAILS



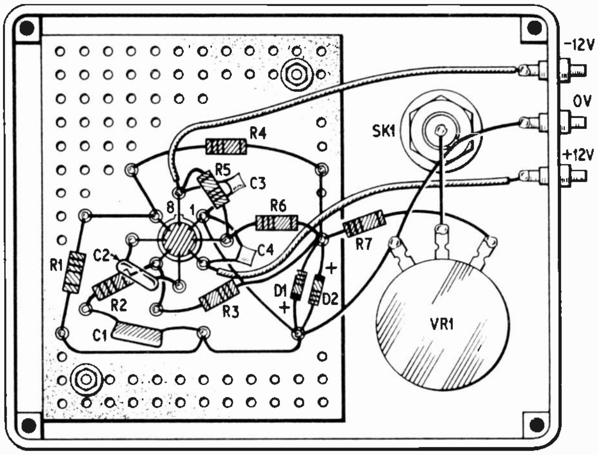


Fig. 4. Layout and wiring for the oscillator

COMPONENTS . . .

Resistors

R1	12kΩ
R2	5·6kΩ
R3	12kΩ
R4	12kΩ
R5	3·3kΩ
R6	680Ω
R7	1·2kΩ

All ± 10%, ¼ W carbon

Capacitors

C1	0·047μF ceramic or polyester
C2	39pF ceramic
C3	1,000pF ceramic
C4	1,000pF ceramic

Miscellaneous

IC1	Linear integrated circuit (d.c. coupled amplifier — SL701C) (available direct from the makers: The Plessey Co. Ltd., Components Group, Cheney Manor, Swindon, Wiltshire. Price: 18s)
VR1	10kΩ carbon potentiometer
D1, D2	1N914, 1N916 (2 off)
SK1	4mm socket and matching plug or coaxial socket and plug (Radiospares)

Die-cast box 4¾in × 3¾in × 1in (Electroniques 46R.043A)
Perforated s.r.b.p. 3in × 2⅜in
Three insulated feed-through terminals
Control knob
6BA screws and nuts

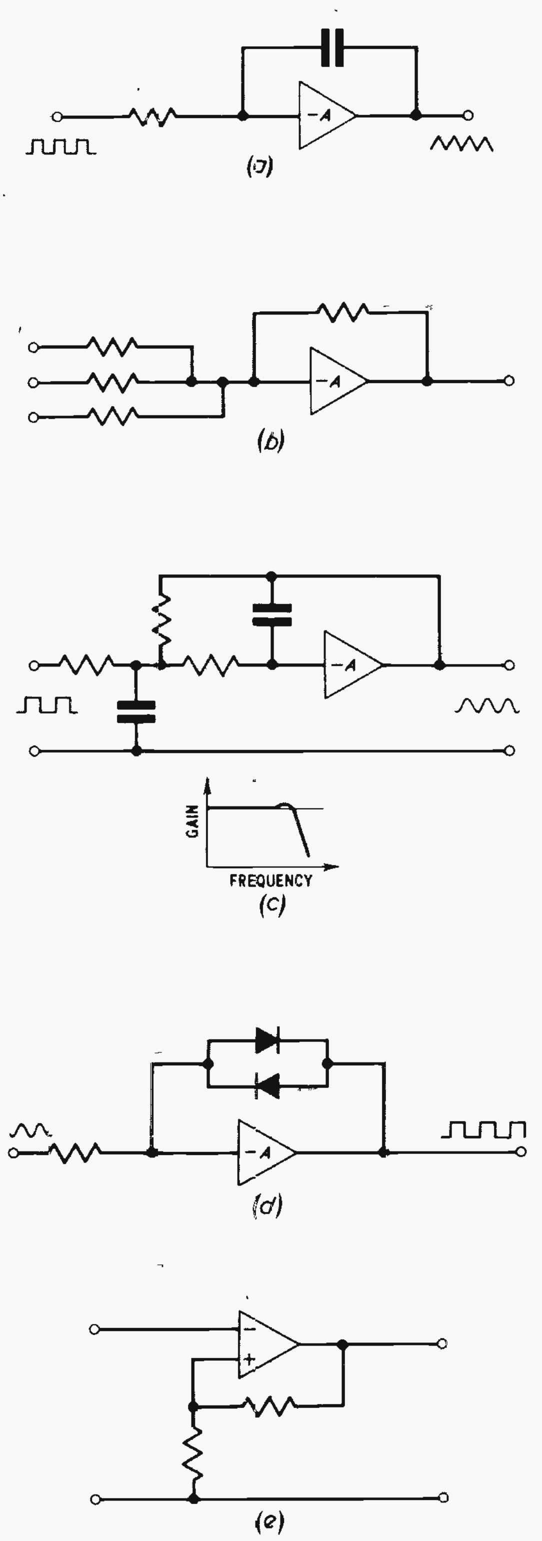


Fig. 5. Some other possible applications of the operational amplifier: (a) integration; (b) summation; (c) low pass filter; (d) limiting; (e) backlash circuit

THE PRACTICAL CIRCUIT

The practical circuit is shown in Fig. 3, and there are several additional points worthy of explanation.

The output is limited by the diodes D1, D2 to $\pm$ 0·6V, which keeps *b* within the permitted value of + 0·5V for correct common mode working of the differential input stage. The peak output current from the amplifier through the diodes is limited in a positive direction by the 680 ohm resistor R6.

The Plessey SL701 integrated circuit is intended primarily for linear applications, rather than as a switching comparator, and therefore exhibits some hysteresis in its switching characteristics (like a Schmitt trigger) so that the output waveform from a circuit like Fig. 1 would be a rectangular waveform of about three to one mark to space ratio (rather than a square waveform as we would expect). This could be adjusted by returning R1 to a voltage rail slightly offset from earth, but this would mean a potential chain of two resistors. For our application we have chosen to include a resistor in series with the timing capacitor as an alternative approach. This ensures that the mark to space ratio is almost one to one, and for our particular circuit values, this measure increases the frequency from the 800Hz calculated from the formula to about 1kHz.

PERFORMANCE

The maximum output is about 1V peak to peak, spaced equally about earth potential, and has a rise time of 0·2μ seconds which is much faster than that required for audio applications. An amplifier with a bandwidth of 1·5MHz would degrade this edge to 0·3μ seconds.

Since the output impedance of the circuit depends on the setting of the output potentiometer VR1 and is in any case 1 kilohm at best, any capacitive load will degrade the edge. For video testing the output lead should be kept as short as practicable, while for audio use the rise time will be adequate in all positions of the potentiometer, provided the capacitive loading does not exceed 50pF.

CONSTRUCTION

Construction is detailed in the diagram of Fig. 4 and should present no difficulty provided a similar layout is followed.

All components except R7, SK1 and VR1 can be mounted on a piece of perforated s.r.b.p. 3in $\times$ $2\frac{3}{8}$in. Holes are drilled in the base to accommodate VR1, SK1, the three feed through supply terminals and the mounting screws for the board. Spacers are used under the board to prevent shorting between it and the base.

It is essential to use reasonably fast diodes in order to maintain the fast rise time inherent in the circuit, but the type specified is available from a number of suppliers.

OTHER APPLICATIONS: USING THE I.C. IN TRUE OPERATIONAL MODE

In this series of five articles based upon the SL701C integrated circuit we have considered some of the many possible ways of using this high gain amplifier, but ironically we have not in fact considered any of the analogue computing techniques which would use the amplifier in a true operational mode. An operational amplifier is one which takes the input signal and operates on it in a known mathematical way. Some of the analogue computing circuits which can be realised with a high gain amplifier are given in Fig. 5.

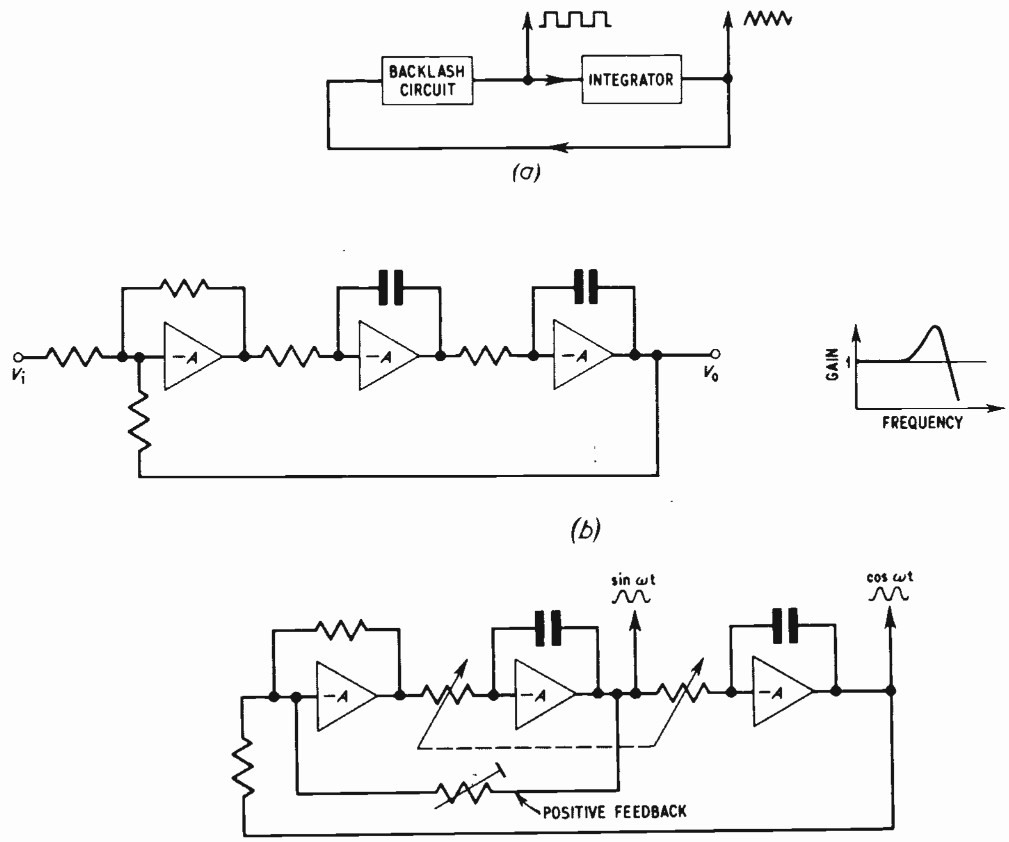


Fig. 6. Further applications using more than one operational amplifier: (a) square and triangular generator; (b) selective amplifier; (c) low frequency oscillator

Integration

We can, for example, integrate a square wave to obtain a triangular waveform.

Summation

We can add or mix a number of inputs to provide a combined output.

Low pass filter

This circuit could be used as a scratch filter for an audio amplifier.

Limiting

This circuit uses diodes to provide heavy negative feedback to limit an input signal to ± 0·6V.

Backlash circuit

This can be used in a similar fashion to a Schmitt trigger.

If we are more ambitious we can use several integrated circuits, and projects such as Fig. 6 become possible.

Square and triangular waveform generator

By combining an integrator and a backlash circuit we can produce a square and triangular waveform generator relatively simply. We could even shape the triangular waveform with yet a third circuit, to produce a sinewave.

Selective amplifier

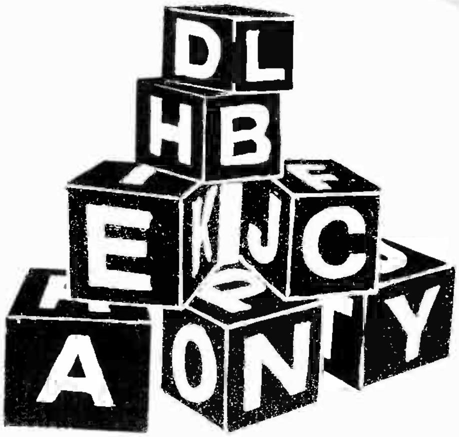
Two integrators and an inverter can be used to form a frequency selective amplifier.

Low frequency oscillator

By adding positive feedback to the selective amplifier, this can be made into an oscillator which will work over a frequency range from seconds per cycle (heavy negative feedback sets the d.c. conditions and outputs can be directly coupled) up to about 20kHz for the Plessey amplifiers.

By using a fourth integrated circuit in a peak amplitude detector (not shown) the distortion of the arrangement can be kept down to 0·1 per cent. Using variable resistors and switched capacitors this circuit can give us a two phase oscillator from 2Hz to 20kHz, and, with appropriate switching, a selective amplifier covering the same range with a variable, known Q. This shows the range and versatility of the analogue approach.

But an instrument such as this must wait until we can afford to use four integrated circuits in one constructional project, and for the moment we must be content to incorporate the odd single integrated circuit. We hope that these five articles have been of some help in this respect. ★



BIONICS

3

SIMPLE LEARNING

BY G.C.BROWN
M.S.H.A.A., A.M.R.S.H.

LAST month we examined the basic conditional reflex response as exhibited by some animals, and considered the possibilities for its synthesis. We shall discuss now the form which the hardware will take for the demonstration of this simple learning, also how it may be interconnected with the existing circuitry mentioned in the last article. There are in fact numerous circuit arrangements which will "fit the bill", but we shall deal with just one relatively simple example, this however will work quite successfully in our model.

LEARNING CIRCUIT

It will be remembered from our earlier "black box" hypothesis of a learning circuit that only a very few building bricks were utilised; i.e. a short term memory to extend S_n for a period of time to allow for coincidences with S_s, a differentiator for S_s, a means for summing the coincidences, and a few gates to route pulses at the correct times. A look at Fig. 3.1 will disclose just how simple the circuit really is. There are a few additional items of course such as the bistable flip-flop and the Schmitt; these however provide certain improvements and will be explained later on. Fundamentally, the results from a circuit without these extras would be very similar, in that it would exhibit the characteristics we are looking for.

The present circuit configurations of the model demand that the learning section be rather more digital than analogue, and so the basic schematic diagram has been tailored a little to meet this need. The reader will notice at once that our use of the term "differentiator" has been stretched considerably, so far in fact as to include in this instance a monostable! However, there is a reason for this.

LONG OVERLAP PERIOD

Look at Fig. 3.1 again. Imagine that the neutral stimulus has just occurred, and suppose now that the specific stimulus appears. Now if we are going to achieve any useful summing action during the overlap period of the specific and neutral stimuli, a differentiator using a capacitor of massive proportions would be required. It needs a while for us to appreciate this situation—in electronics we are used to things happening at enormous speeds: in this particular case though, everything has slowed right down and we are dealing with quantities which occur at rates we could comfortably count on our fingers.

The requirement then for our differentiator seems to be not that it chops off a very thin "slice" from the beginning of each S_s event, but that it takes a good sized chunk. If we make it behave in this way we are now the possessors of a very sloppy differentiator indeed, however this is of no concern.

The output waveform from this version naturally has none of the slender proportions of that seen from the normal type, and so it was decided that it might be as well to dispense with it altogether and use a monostable instead. This we have done. And where the "chastity" of the nice neat spikes from a normal differentiating circuit would have meant summing several hundred repetitions of the specific stimulus during the extension of S_n, we now need only a few.

CIRCUIT INTERCONNECTIONS

So that the reader can appreciate how the learning circuit is interconnected with the existing hardware, the relevant sections of the reflex circuitry are reproduced again in Figs. 3.2 and 3.3.

The design and construction of electronic "animals" or machines with artificial intelligence

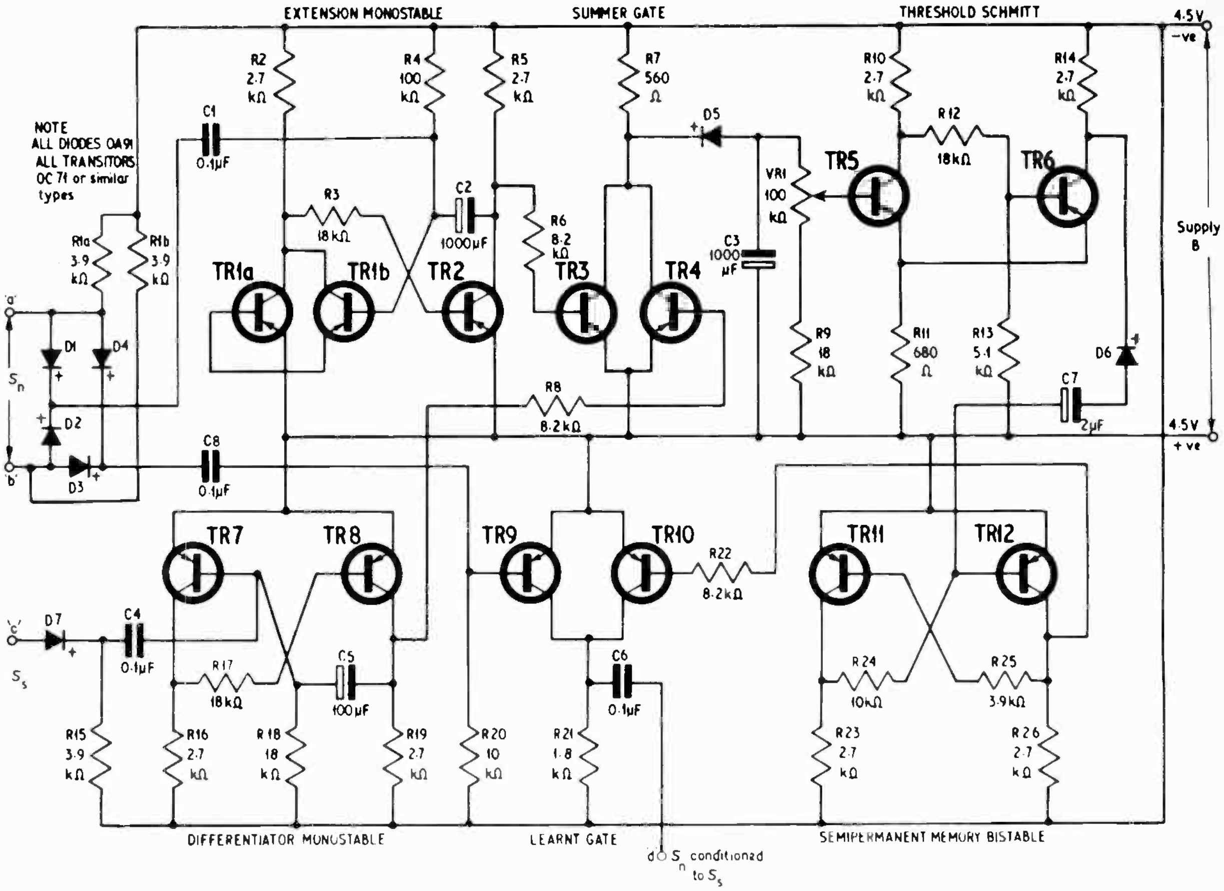


Fig. 3.1. The simple learning circuit. This is interconnected with the sensor and reflex sections of Fig. 2.4

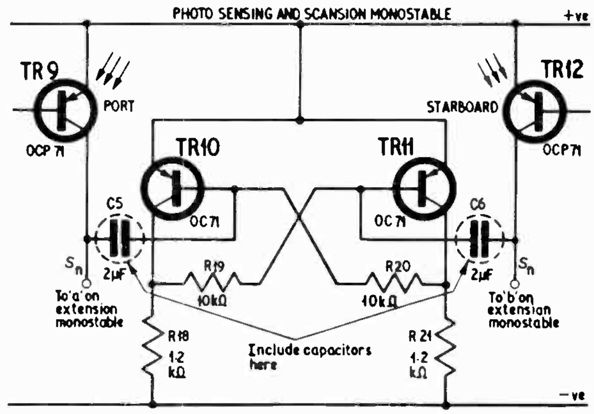


Fig. 3.2 Part of Fig. 2.4 with additions to permit extraction of the neutral stimulus

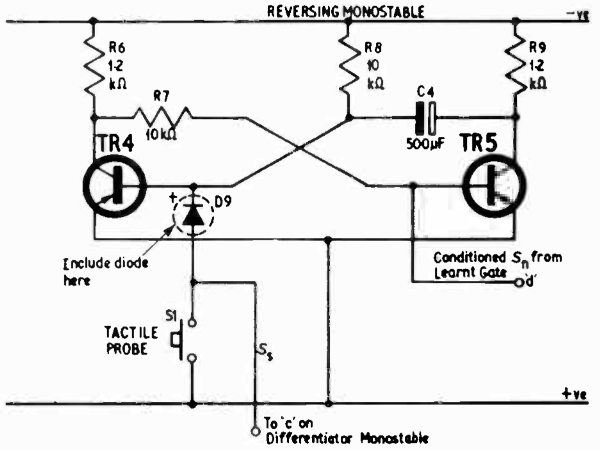


Fig. 3.3 Part of Fig. 2.4 with modifications to permit extraction of the specific stimulus and application of the "learnt" signal

Fig. 3.2 shows the method for extracting the neutral stimulus S_n.

The specific stimulus S_s is picked-off direct at the tactile probe in the reversing monostable indicated in Fig. 3.3; a diode D9 has been included here, the purpose of which will be seen shortly. A further connection is also made to the other side of the reversing monostable for use when the model has "learnt" a particular combination of stimuli—this will be discussed later.

OPERATION

Assuming now that all the necessary connections have been made between the reflex and "learning" sections of the model, we are now in a position to see how the circuits operate and interact with each other.

If a neutral stimulus (light) is applied by way of the photo-transistors in the reflex section, then a positive pulse will pass via either diode D1 or D2 to turn off transistors TR1a and TR1b of the extension monostable. This monostable will now turn over and hence TR2 collector will become positive, resulting in one side of the summer gate being opened. The extension monostable will remain in the quasi-stable state for approximately 60 seconds. If the tactile sense is stimulated by way of the probe in the reflex section, then a positive pulse will be fed via diode D7 resulting in transistor TR7 of the differentiator monostable being switched off. Hence this monostable turns over and produces our so-called "differentiated" pulse which in fact lasts about 1 second.

The collector of TR8 being connected via R8 to the other side of the summer gate hence causes the base of TR4 to go positive, opening this side of the gate. Now if the stimulus S_n occurs any time up to 60 seconds before S_s, then the result of their coincidence, or overlap, will cause the common collector point of the summer gate to go negative (i.e. both sides of the gate opened).

Diode D5 will now be forward biased and capacitor C3 will commence charging towards the negative rail potential. This capacitor thus serves as a sort of short-term memory for coincidences of S_s and S_n, and at this stage could be connected almost directly to the learnt gate were it not for the fact that in practice we require a more permanent memory.

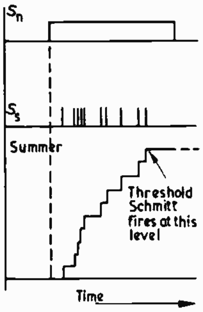


Fig. 3.4 Case where a conditioned reflex is evoked during one application of the neutral stimulus

THRESHOLD SCHMITT

In order to improve the learning circuit a little, the threshold Schmitt and the semi-permanent memory bistables have been added. Once potentiometer VR1 has been set to some value, the Schmitt will act as a threshold device and fire when the voltage due to the charging of C3 reaches a certain level (see Fig. 3.4). This will be equivalent to a given number of repetitions of S_s during extension of S_n, and in practice should be between 10 and 20 separate stimulations.

When the threshold Schmitt fires a negative going pulse will be passed via the diode D6 and capacitor C7 to the semi-permanent memory bistable.

MEMORY BISTABLE

It will be noticed that the base bias for transistor TR11 of the bistable is derived via a resistor (R25) whose value is relatively small compared with that in the opposite side (R24). This has been done deliberately to ensure that upon switching the circuit on an irrelevant memory is not produced.

Once the bistable has switched, one side of the learnt gate will be opened and hence any further S_n stimuli will open the other side also. The common collector point of the gate will thus go negative for all future applications of S_n and switch the reversing monostable via capacitor C6 (this could be replaced by a diode for analogue functions). Hence instead of S_n causing the usual homing response, this is now inhibited; the model now "cowers" and backs away with "its tail between its legs".

This will always be the result from now on, unless the permanent memory is disturbed by, say, the power supplies being switched off, or unless we make special arrangements for inhibiting the response. Suitable circuitry can be designed for this, modelled upon the black box systems shown earlier: however it is not at this stage intended to go into the actual design for the electronics.

CASE OF INSUFFICIENT STIMULI

Hitherto for the convenience of describing the operation of the learning circuit, we have assumed that a sufficient number of repetitions of S_s always occur during the extension period. But suppose S_s appears only a few times, insufficient to fire the threshold Schmitt: what will be the effect? The capacitor C3 will have received some charge, but if no further S_s arrives its voltage level will gradually diminish. However, this is the way we want it to be. This after all is the situation where an insufficient number of coincidences have occurred for the model to "see" any significant connection between S_s and S_n.

If on the other hand further combinations of the two stimuli occur during the slowly decaying voltage across C3, their result will be added to whatever level the capacitor has discharged to. This may, or may not, cause the threshold Schmitt to fire for it will depend solely upon the threshold voltage being reached.

In practice, if the coincidences are sufficiently infrequent, conditioning could take hours, and in fact may never take place at all. During conditioning experiments with real live animals exactly the same effect takes place if the neutral and specific stimuli are not allowed to overlap often enough.

FUNCTION OF D9

Earlier we mentioned the inclusion of diode D9 in the reversing monostable, its purpose will become clear upon examination: without the diode, after conditioning has taken place the neutral stimulus could thereafter trigger the differentiator monostable via the "avoidance system". This would result in capacitor C3 being charged due to S_n alone—not that this would matter, you might say, because the model has been conditioned.

However, if we decided to build in an inhibit circuit (which the constructor might choose to do) an irrelevant "short term" memory would already be stored in C3, and although this might not affect the inhibition it could none-the-less cause some problems. D9 thus overcomes this difficulty.

MORE FACTS ABOUT ANIMAL BEHAVIOUR

Having satisfied ourselves that we can indeed simulate the simple conditional reflex (albeit by quite different and less sophisticated means than those used by a biological example), we must now "press on" and discover some more facts about animal behaviour.

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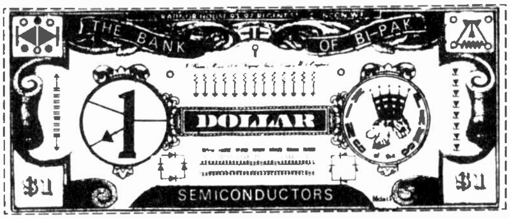

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Also whether or not we can arrange these facts to fit within our framework of black box analogies.

When we began discussing the conditional reflex, the reader will remember how we stressed the importance of the neutral stimulus being presented just before the specific stimulus if conditioning were to occur. As in all things there is the inevitable exception to the rule; this particular exception is, however, an important one as we shall see.

Let us assume we have conditioned an animal (it might be one of Pavlov's dogs) to, say, salivate when a bell is rung—the bell (neutral stimulus S_n) having been previously "paired" with food (specific stimulus S_s). We might now require the dog to salivate upon our touching its left ear. This presents no problem, we can simply combine this stimulus with S_s when the dog is fed, as we did with the bell. Suppose though that in this particular experiment we are forbidden to make this conditioning direct, is there any other method that can be adopted? This is where we meet the exception to the rule.

SECOND ORDER CONDITIONED REFLEX

Bearing in mind that the dog is conditioned to "bell-means-food", if we now wish to introduce a further stimulus (in this case tactile), to mean food, all that is necessary is to couple the new stimulus with S_n. After several repetitions of the new stimulus (call it S_{n_2}) just prior to the original neutral stimulus (let us now call this S_{n_1}) we will find that the condition "touch on left ear-means-bell-means-food" has been established. There will hence be an indirect connection between S_{n_2} and S_s via S_{n_1}, with the result that the dog will salivate upon application of S_{n_2} alone.

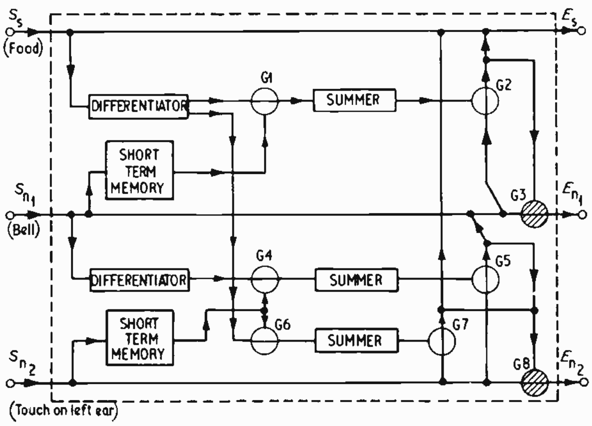


Fig. 3.5 Basic arrangement for synthesising higher or second order conditioning

This type of conditioning is called a second order conditioned reflex, and has been taken experimentally to third, fourth, and even higher orders. There does in fact seem to be almost no limit to how far this effect can be extended.

This carries us on to another interesting phenomenon, that of stimulus generalisation. Now that touching the dog's left ear elicits the salivation response, what if we touch the right ear, or the nose, or the right paw, or the tip of his tail—will there still be a response? Certainly there will: however if we measure the amount of saliva produced there will be a noticeable decrease as we move away from the site of initial conditioning. The important fact that remains is that the animal was never conditioned to anything other than the tactile stimulation to the left ear. The dog seemingly generalises about all the other stimuli.

TRACE REFLEX

Yet another effect emerges in many ways similar to the phenomena just described, which is worthy of some explanation. Generally speaking if a conditional reflex is to be produced, the neutral stimulus must come *just* before S_s, certainly within a minute or so. There is though a method whereby even this rule may be broken.

If during the time we are establishing the conditioned reflex we gradually make S_s come later and later, it is possible to increase the S_n/S_s interval to quite considerable lengths and yet still produce the conditioning effect. This is known as a trace reflex and extends the period of time between stimuli whilst still allowing conditioning to take place.

Following our brief examination of higher order conditioned reflexes, stimulus generalisation, and the trace reflex we should now be able to see if the black box technique can help us establish what mechanisms might produce these effects.

THE BLACK BOX APPROACH

The black box in Fig. 3.5 shows one way in which second order conditioning might occur. The real picture must of course be very much more complex than in the example—in our case we are only manipulating just a few elements, whereas in a live animal millions of nerve cells could be involved.

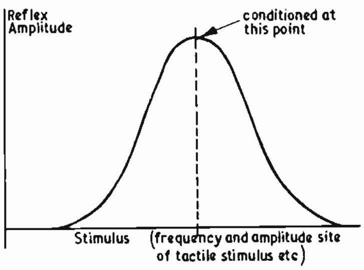


Fig. 3.6 Stimulus generalisation effect

As the reader will see, this hypothetical arrangement amounts to a compounded ensemble of our original learning units. S_{n_1} as before has the ability to pair itself with S_s (there is no reason why it should not have equal facilities for its possible combination with S_{n_2} either, except that the schematics become more complicated!). However, S_{n_2} can be conditioned to either S_s direct, or indirectly via S_{n_1} if S_{n_1} has been previously conditioned to S_s.

Looking even closer into the black box we notice that S_{n_2} could even become conditioned to S_s in another way. Suppose for a moment that the animal is in the unconditioned state, then we condition S_{n_2} to S_{n_1} so that "touch on left ear" means "bell". If later we then condition S_{n_1} to S_s (the food) we have also involved S_{n_2}. There are thus several possible ways here in which conditioning could take place.

STIMULUS GENERALISATION EFFECT

The stimulus generalisation effect probably does not need black box treatment here. One could liken the effect to the response of some filters, say a low Q tuned circuit. Fig. 3.6 gives the general idea.

If the peak in the graph indicates the maximum amplitude of the animal's response to a given stimulus, then for stimuli even some distance away from it there would still be some response. The generalisation about the stimuli would thus seem to depend on the "pass-band" of the filter. As a general term this type of device might be called a "property filter", for it could be involved with the separation of pitches, amplitudes, pulse widths, spatial positions, etc.

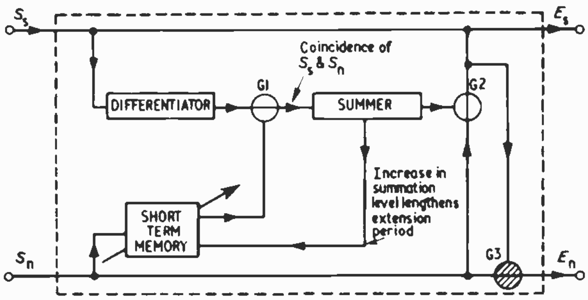


Fig. 3.7 The arrangement of Fig. 3.5 now modified to incorporate trace reflex conditioning

Trace reflex conditioning could be shown quite conveniently with a slight modification to our basic "learning" circuit Fig. 3.7. The "short-term" memory which provides for the extension of S_n has a fixed period, therefore any attempt to combine S_s with S_n after this time would be futile. However, if we arranged to feed part of the summation output back to control the short-term memory—so that increases in the summer level caused increases in the extension period—then the model would now by itself be capable of eliciting a trace reflex.

ABILITY TO ADAPT

Hitherto, our inquiries into learning led us to believe that the conditioned reflex depended upon it being bound quite rigidly to the exclusive characteristics of the stimuli that had been paired. Assuming this were the case, no further learning could occur—the animal would be in no position to vary or modify its responses and update them for current purposes. It therefore seems, that amongst other things, we have discovered in "generalisation", "higher order responses", and "trace reflexes", a quality which would allow the animal to adapt.

Animals *do* adapt, they are doing it constantly. Take, as an example, a television service engineer. At some early time in his career he undoubtedly received many electric shocks. However, the shocks weren't all the same, or from the same places. As time went by he adapted himself to avoid the characteristics that resulted in getting a shock: such things as seeing line output transformers, e.h.t. capacitors, large ceramic insulators, and so on. If it were not for "generalisation" in particular, he would probably now be the proverbial dead duck!

DEGREE OF REINFORCEMENT

It seems that we can therefore come to a very positive conclusion about this "generalisation", in that without it a difference in stimulus would have no effect in eliciting a response. Conversely, of course, it is equally important that the animal can produce differing responses despite similarities in the stimuli that may be presented.

What a paradox all these requirements seem to cause—nonetheless they are necessary. The inevitable balance that occurs between the generalisation of stimuli on the one hand, and differentiation on the other, is seemingly dependent upon the degree of reinforcement, and indeed which stimuli are reinforced.

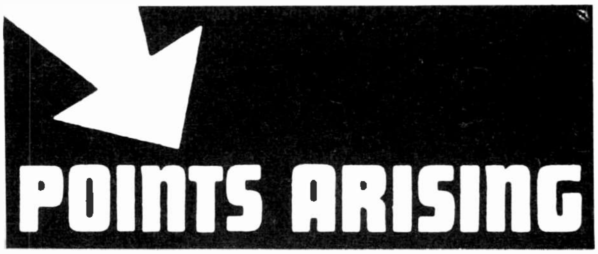
Throughout the article we have made considerable use of such indefinites as "seemingly" and "perhaps"—there will be no apologies though, for the subject of animal behaviour is fraught with so many variants that to be too specific about any particular aspect could be dangerous.

TRIAL AND ERROR

Because an animal exhibits what appear to be specific responses for certain stimuli there is no reason to believe that without these stimuli these characteristics will not still occur. There is a general theory that during the process of learning, animals may very well hypothesise (or make an assumption) about a situation. This would pre-suppose that the animal "sits tight", makes a number of guesses, and then proceeds to reach a goal (if one exists) by trial and error, eliminating all un-rewarded responses.

We can only conjecture about all these multifarious possibilities at present, though in later articles we may be considering how they could be implemented in a synthetic device. Next month we shall be adding to our breadboard device a rather crude "self and mutual recognition" circuit. We will also see whether it might be feasible to conceive of a machine which could display a type of anxiety neurosis. Imagine an "electronic animal" with ulcers! This is perhaps being a little too anthropomorphic!

To be continued



LIGHT OPERATED SWITCH *(October 1968)*

The transistor type NKT127 can be replaced by type NKT128 which is readily obtainable from transistor stockists.

VARI WINDSCREEN WIPER *(October 1968)*

Some readers have experienced difficulty in correct operation of this circuit due to the device not switching off. The author emphasises that the earth return wire from the control circuit board to car chassis should be as short and thick as possible. All connections between this wire and the battery earth connection must be clean and sound. Cable resistance and contact resistances can provide sufficient voltage drop across the thyristor to maintain conduction, i.e. not fall below the holding current. The holding current of the thyristor is about 10mA while the anode-cathode potential at this current is 0·8V which can result from long cables or faulty connections. A resistance as low at 0·1 ohm could cause this trouble.

BBC EXPERIMENTAL SOUND-IN-VISION SYSTEM

On November 7 at Broadcasting House was given the first public demonstration of the transmission and reception of composite sound and vision signals. This unique system of "Sound-in-Vision" has been developed by the BBC Research Department for use with 625 line television signals.

Ordinarily, the two components of a television programme, both picture and sound, are separately distributed from studio to transmitting station. With the sound-in-vision system these two studio derived components are combined and the combination is sent over a single vision circuit to the transmitting station where the sound is extracted, converted into its usual form and sound and picture are transmitted in the usual way.

Besides offering an improved audio bandwidth of 14kHz and excellent noise immunity this system simplifies the operational requirements as the separate circuits and often different routes used in transmitting the two components of the conventional television signal are reduced to one circuit and one route in this composite system.

SYNC INTERVAL

How this is done without interaction between the composite video and sound components is by making use of the line synchronising interval. Reference to the sound-in-vision oscillogram (Fig. 1) shows that the sound signal occupies a period of 3·8μs within each 4·7μs line synchronising interval, its placement being equally disposed compared to the leading and trailing edges of the synchronising pulse. Apart from this interval the vision signal occupies the transmission circuit for the rest of the time. As can be seen the system constitutes in essence a form of time division multiplex.

SAMPLING

By sampling the sound signal at twice the 625 line frequency an audio bandwidth of 14kHz is possible for transmission. The two samples produced during each line period are converted to pulse code modulation signals then delayed and compressed in time then inserted into the television waveform during the next line synchronising interval.

In the 625 video oscillogram shown the p.c.m. signal precedes the colour burst. It consists of a marker pulse which identifies the start of the sound pulse group containing two 10 digit binary code groups so that 21 pulses in all are accommodated within each line synchronising period.

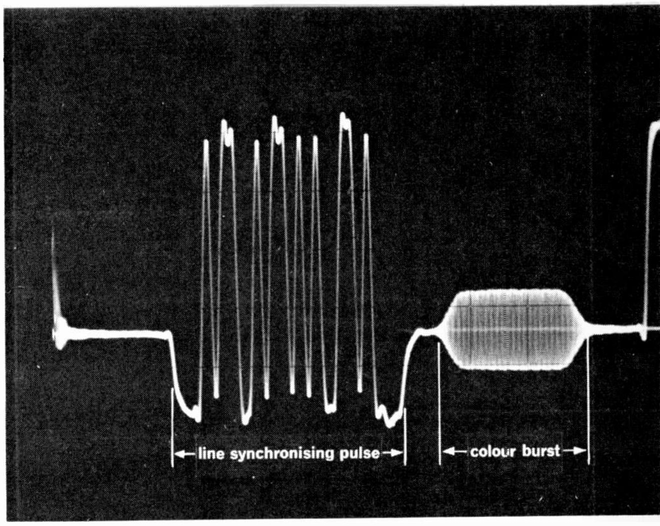


Fig. 1. 625 line video waveform during line blanking interval showing p.c.m. signal consisting of a marker digit plus two 10 digit groups inserted in line synchronising pulse

After transmission via the distribution link the sound pulses are extracted and reconverted to normal signals at the receiving terminal. The video waveform is also restored to standard form.

The use of p.c.m. and high amplitude pulses ensure that the sound signal is immune from all but the most severe interference and distortion.

TERMINAL EQUIPMENT

The sending and receiving terminal equipment are shown in block form, Fig. 2. The compressor and expander form a syllabic companding system which ensures that the mean signal level into the analogue to digital converter is as high as possible. This converter samples the audio frequency signal presented to it at twice line rate and provides an output in p.c.m. form to the combiner unit. This unit accepts the vision signal clamps it during the back porch and inserts the sound pulses.

At the receiving terminal this process is reversed with the combined sound-in-vision signal being fed to the separator unit from which a clamped and restored vision signal is produced. Separated sound pulses are decoded in the digital to analogue convertor which delivers an audio frequency signal.

Extensive use is made of integrated circuitry for the digital operations together with discrete transistor circuits for the analogue operations.

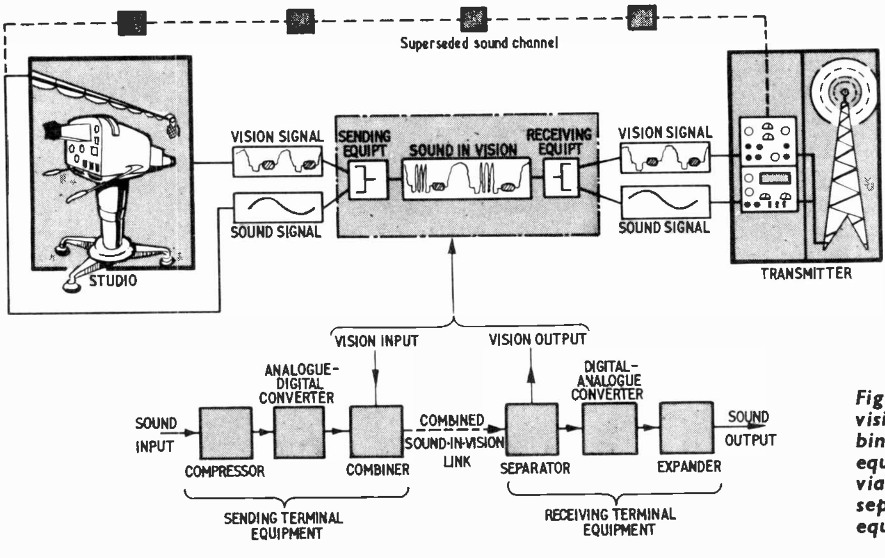


Fig. 2. Block diagram showing how vision and sound signals are combined at the sending terminal equipment, prior to transmission via the distribution link, and separated at the receiving terminal equipment

Any seaman who has worked with sonar equipment knows that fish are attracted by certain man-made noises. Perhaps the fish believe that the sound must be coming from some source of food such as a trapped insect—or perhaps their motivation is simply curiosity.

The device described here produces a repeating high pitched bleep under water which will help lure some species of fish to the fly. In a practical test on a quiet stretch of the North Tyne, the author consistently landed a better average than nearby anglers.

CIRCUIT DESCRIPTION

The circuit consists of a single transistor Hartley oscillator with feedback via the tapped inductance (Fig. 1). With the component values shown the output frequency is about 1kHz with a bleep-rate of 60 to 150 times a minute depending on the setting of VR1. With VR1 at maximum resistance the unit produces a continuous tone.

The bleeps are emitted from a high impedance earphone or microphone insert (detailed later), connected in parallel with the inductor.

CONSTRUCTION

The original model was built on a small 12-way tagboard, as shown in Fig. 3; layout is in no way critical. To augment the output in one direction a cone cut from the top of a plastics detergent bottle is glued to the face of the transducer, which is then glued to the underside of the tagboard. The battery is held by a Terry clip screwed to the tagboard on the same side as the transducer.

The unit must be fairly robust to withstand "casting" and retrieving when in use; it should also be kept as small as possible. All sharp projections must be rounded off or covered to protect the bag in which the unit is placed.

OPERATION OF "BAIT"

The completed bleeper can then be sprayed with a waterproofing compound as used on car electrical systems and enclosed in a polythene bag—carefully tested beforehand for leaks! Enough air should be left inside so that it will just float and the top sealed with an

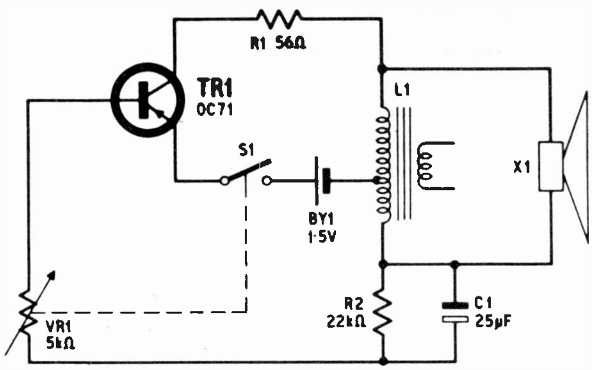


Fig. 1. Circuit diagram of fish bait

elastic band. A line and sinker are attached, as shown in Fig. 2, but the float is not required. To use the device adjust the distance between the unit and the sinker, so that the unit is held at hook depth, and cast the "bait" to the required position.

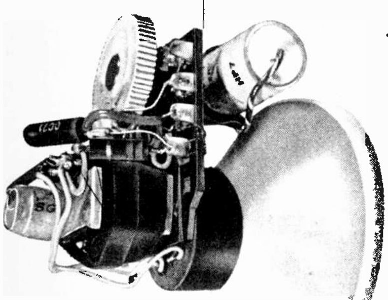
An alternative method is to squeeze the excess air out of the polythene bag and support the unit by using a float (Fig. 2). The float can be made from a small plastic detergent bottle or similar item and the depth of the unit is then set by adjusting the length of line between the float and the unit. If this method is adopted a weight may be required in order to keep the unit vertically below the float.

Note: if practicable the polythene bag can be heat sealed to ensure an airtight unit. This method of sealing can be carried out by some bait shops selling live bait in polythene bags.

Repetition rate is adjusted by trial and error to give the best results—VR1 can be manipulated through the polythene bag.

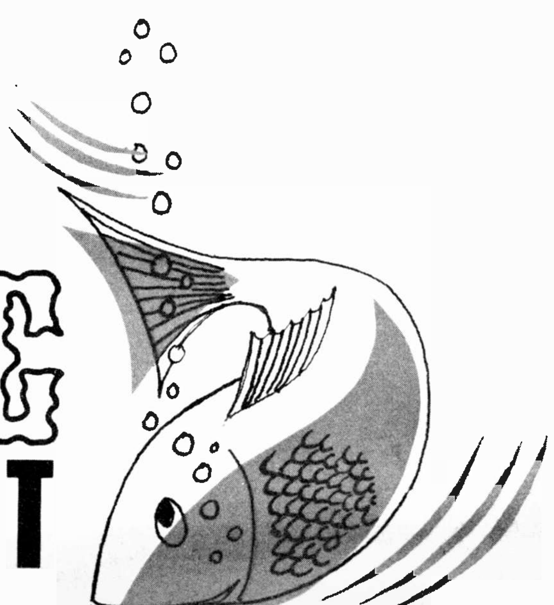
DIRECTION VANE

Where there are currents it will be possible to direct the sound by adding a vane (Fig. 2), as is done on hydrophones. The vane should be made as shown and the



SONIC FISH BAIT

By J. HING



COMPONENTS . . .

Resistors
R1 56Ω
R2 22kΩ
All ±10%, ¼W carbon

Potentiometer
VR1 5kΩ min. with switch (Radiospares)

Capacitor
C1 25μF elect. 25V

Transistor
TR1 OC71

Miscellaneous
L1 Repanco TT4 using secondary with centre tap
X1 Crystal earpiece type MC1 (Olrus Electronics, 748 High Road, London, E.11)
BY1 1·5V penlight cell
Tagboard: 12 way
Terry clip for battery
Float, small plastic detergent bottle (see text)
Fishing line and weight
Polythene bag

Complete unit sealed in polythene bag

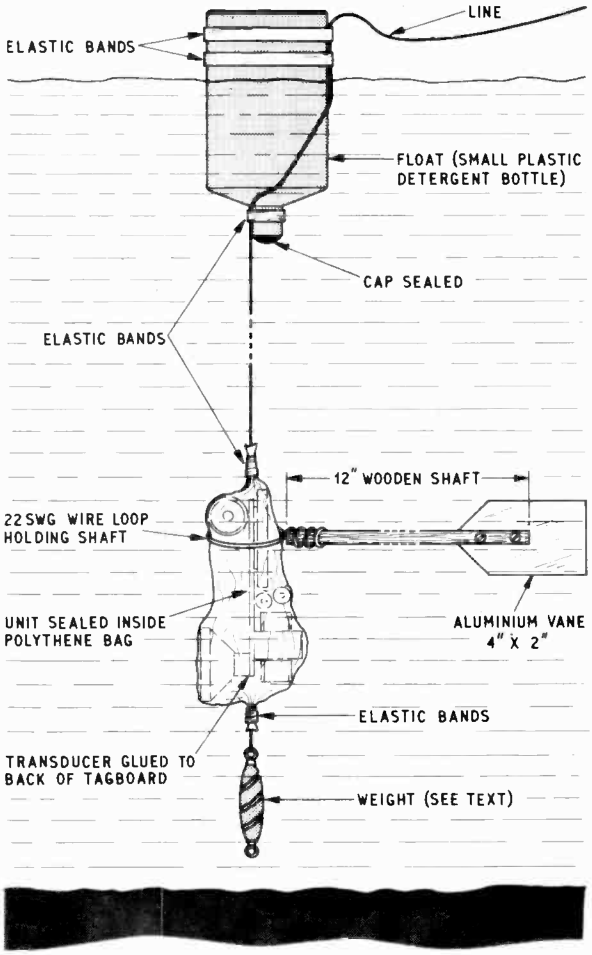


Fig. 2. Bait set up for use with float, vane and weight

length of the wooden shaft set to balance the weight of the vane when in the water. The vane can be attached to the unit by a shaped wire drawn around the polythene bag. Ideally, sound should be transmitted across currents.

COMPONENTS NOTE

Any crystal earpiece or microphone insert can be used—but the one specified in the components list gives more output than most. Use of the specified transformer for L1 is strongly recommended—although other types having a centre tapped winding with a total d.c. resistance of between 100 and 300 ohms may be tried. ★

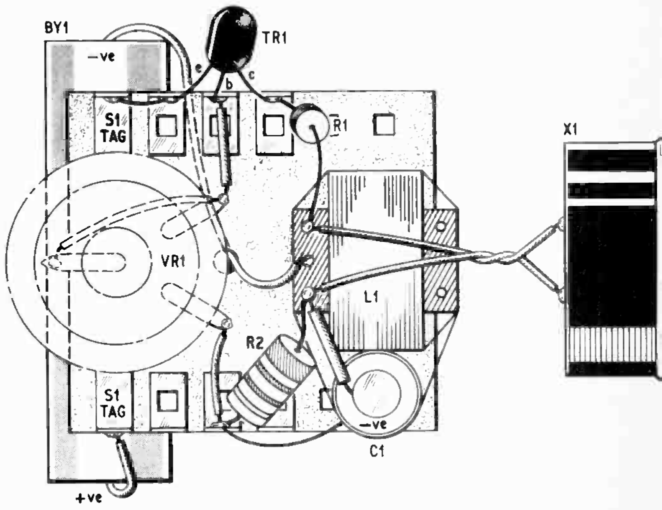
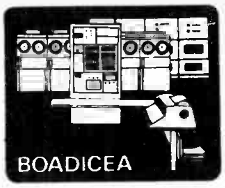
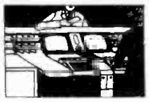


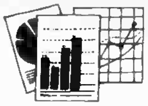
Fig. 3. Layout and wiring diagram showing position of components and tags removed from board



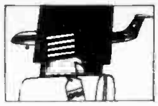


Passenger check-in

World-wide seat reservations



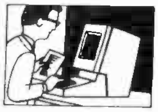
Statistics



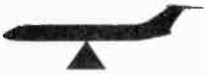
Crew schedules

ELECTRONORAMA

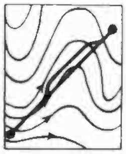
Accounting



Management information

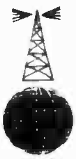


Weight and balance



Flight planning

Cargo



Message switching

BRITISH Overseas Airways Digital Information Computer for Electronic Automation is one of the world's largest computer complexes linked to one of the most comprehensive communications networks surrounding the globe.

The complete computer, power supplies, air conditioning units and all other ancillary equipments are housed in Boadicea House at London's Heathrow Airport. The complex is protected by one of the most sophisticated security systems in the country and is completely screened by aluminium foil from radar interference.

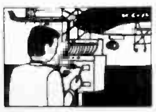
BOADICEA is designed to meet the needs of all BOAC's requirements well into the future and will cover all operations shown. The main "brain" consists of three IBM 360 model 65 computers, interlinked to form a comprehensive back up system. These computers work in conjunction with three other computers also at Boadicea House. All information passing through the computer is taped and microfilmed to provide three information storage systems, enabling BOAC to continue operations in the event of the complex being destroyed.

The main advantage of BOADICEA to the travelling public is the reservations system which uses cathode ray tube readout and solid state keyboards for operator's use. Reservation staff in the UK, Europe and North America have, at their fingertips, instant reservation information on all flights of BOAC and its associated companies. Seat availability on any flight can be established within seconds and four flights are displayed on request to aid passengers selection. Seat reservations, hotel bookings, car hire and any special requirements can be made through the computer system, up to 11 months in advance.

BOADICEA network is comprised of over 50 computers and handles 350,000 messages a day.

Magnetic data storage machines and information input and access points, in use inside the computer room, are shown above, whilst below an engineer is shown setting up one of the three IBM computers which form the main brain of BOADICEA

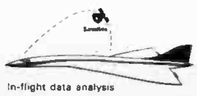
Timetables and Tariffs



Maintenance schedules

Personnel records

Stock control



In-flight data analysis

VISITS
BOADICEA

Ferranti readout tube and Honeywell solid state keyboard are shown in use at one of BOAC's booking halls below. The keyboards are quiet in operation thus allowing many units to be used in a small area without undue clatter

ULTRASONICS

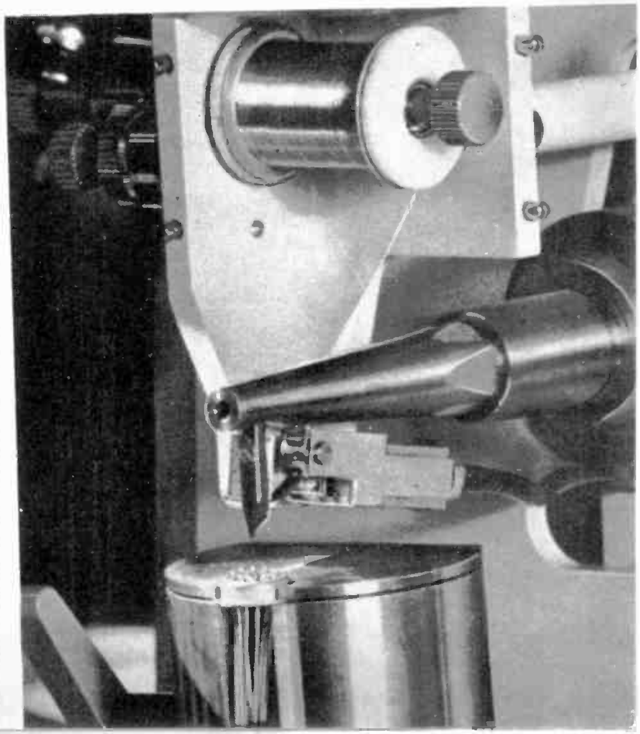
ULTRASONIC equipment has been in use for some ten years, it is only recently however that many of its industrial uses have been fully realised and exploited. Some of the latest solid state equipment, incorporating many of the recent advances, was shown at the Ultrasonics for Industry Exhibition in London on October 15 and 16. A wide range of subjects from data collection to holographic displays were discussed in a series of lectures on Ultrasonics.

More and more ultrasonics are being employed in hospitals, both for cleaning and diagnostic work. Most of the cleaning equipment now operates at 40kHz and above as it has been found that lower frequencies are more liable to damage solid state electronic devices if they are to be cleaned. Units used for diagnostic work that are now in use include: solid state blood flow detectors, capable of detecting foetal blood flow after 10 to 12 weeks of pregnancy, and medicine sprayers which disperse aqueous solutions into a fine mist for inhaling by patients.

Equipment for use in the electronic industry is being manufactured by some firms; of particular interest is the Kerry wire bonding machine. The photograph below shows the solid state unit being used to bond wires to an integrated circuit. The unit has a variable output power of up to 10 watts and can be pre-set for varying "weld" times. An insertion and staking machine, capable of inserting metal tags or bushes in plastics, is produced by the same manufacturer and has a range of applications in electronics.

Another field where ultrasonics is increasing in popularity is in detection systems where one unit can be used to detect leaks in gas pressure or vacuum systems, internal defects in running machinery and electrical faults. Units such as this are being made fully portable with a variety of probes and "displays".

The uses of ultrasonics are forever growing and as more is learned about the subject the more sophisticated the equipment becomes.



HIGH PERFORMANCE STABILISED POWER SUPPLY

By J.T. Tiernan

SPECIFICATION

Input: 240V 50Hz.
Output: 0 to 22V d.c. continuously variable.
Maximum load current: 1A continuous.
Current overload protection range: 25mA to 2·5A.
Output ripple at 1A load: 500μV.

THE power supply design described in this article is a general purpose unit covering the range 0 to 22V at load currents up to 1A r.m.s. Silicon transistors are used throughout and the unit includes an extremely reliable overload protection circuit. Standard components have been used where possible, and little difficulty should be experienced as regards component availability.

The design is presented with the reasonably experienced constructor in mind, and though practical details are accordingly brief, a comprehensive testing and setting-up procedure is included.

Fig. 1 shows a general block diagram of the unit, and should be studied in conjunction with Fig. 2.

D.C. SUPPLY AND OVERLOAD CIRCUIT

The circuit diagram of the unit is shown in Fig. 2. The "main" a.c. secondary voltage is full wave rectified by D1, D2, D3 and D4, and smoothed by C1, before being routed to the overload protection circuit and series stabiliser elements (TR3, TR4 and TR5).

In series with the common line is a resistor, selected by S2, across which is developed a voltage proportional to the load current being supplied. S3a is normally closed and, if the load current increases such that 2·5V is developed across the selected series resistor, the thyristor will be triggered into its conducting state. The anode of the thyristor will fall from around 30V, to practically 0V, the thyristor current being limited to

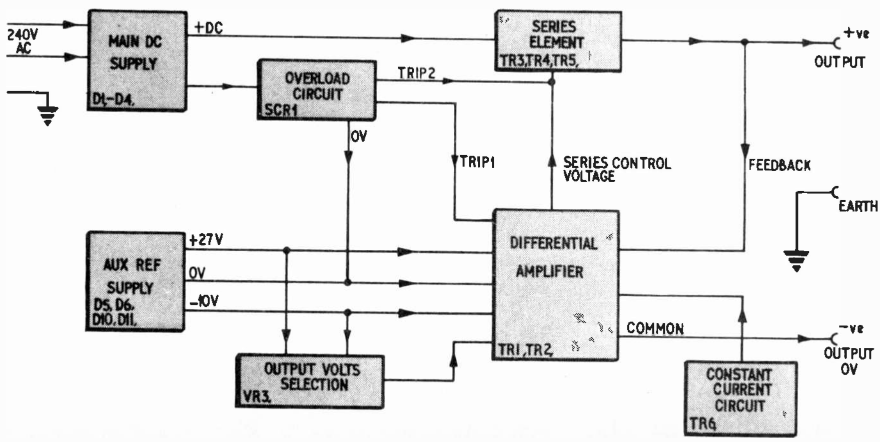


Fig. 1. Block diagram of power supply

between 30 and 40mA by R7 and LP2. Thus, 0V is reflected in the stabiliser section, via D8 and D9, causing the output voltage to fall to zero.

Momentarily opening S3a to the reset position will stop current flow in the thyristor, and on returning S3a to the normal position the output voltage will return to its original value, provided the excess load has been removed.

When the thyristor is not conducting, D8 and D9 are reverse biased and have no effect on the operation of the stabiliser section.

Reliable triggering of the thyristor is ensured by D7 and R8, and VR1 acts as a trip sensitivity control. D14 ensures tripping if LP2 is open circuit and C10 slows up the action of the trip circuit to prevent tripping when the output is increased (due to charging of C8).

REFERENCE SUPPLY

The auxiliary a.c. supply is rectified via the voltage doubler D5, D6, C2, C3 and fed to the reference supply diodes D10 and D11. The current through the Zener diodes is limited by R9 to approximately 25mA and C4 ensures minimum ripple on the reference supply lines.

The junction of D10 and D11 is connected to the common line, and the voltages at the cathode of D10 and the anode of D11 become the +27V and −10V lines respectively.

DIFFERENTIAL AMPLIFIER

The differential amplifier consists of TR1 and TR2, with a variable reference voltage applied to TR1 base, via VR3. The collector load for TR2 is R10, and feedback to TR2 base, via TR3, TR4, TR5 and D12, sets the voltage at TR2 base equal to that applied to TR1 base. Thus, by varying the reference voltage via VR3, the output voltage at the emitter of TR5 may also be varied.

A reasonable and steady collector-base voltage for TR2 is ensured by D12, a 3·3V Zener diode, which also allows any variations of the output line voltage to be passed in full to TR2 base. This results in maximum compensating action by TR2, keeping the output voltage constant over a wide range of load currents.

It is essential that the current through D12 is held as constant as possible, and to achieve this end D12 is fed from the constant current circuit formed by TR6. The values of R12, R13 and R14 are such that the current through D12 is approximately 2mA, and this changes by less than 2 per cent for an output voltage variation from 0 to 22V.

Since the voltage at the bases of TR1 and TR2 is 3·3V less than the output voltage, due to D12, the variation of voltage required from VR3 is −3·3V to +18·7V for an output range of 0 to 22V; VR2 and VR4 are adjusted to provide this variation across VR3.

The "trip 1" and "trip 2" lines are connected from D8 and D9 in the overload section to the bases of TR1 and TR3.

S3b ensures the load is removed when the overload circuit is being reset, and may be used to isolate the load from the unit. Whether a normal on-off switch or a spring loaded switch is used for S3 is a matter of individual preference.

It is important to note that C8 must be connected at the supply side of the switch, otherwise it will often not be possible to reset the overload circuit. The diode D13 is included to ensure tripping of all units if power supplies are used in series.

COMPONENTS AND CONSTRUCTION

A suggested layout and case size have been given (Fig. 8), but both depend on the size and shape of the transformer(s) and smoothing capacitors used. Most of the smaller components can be mounted

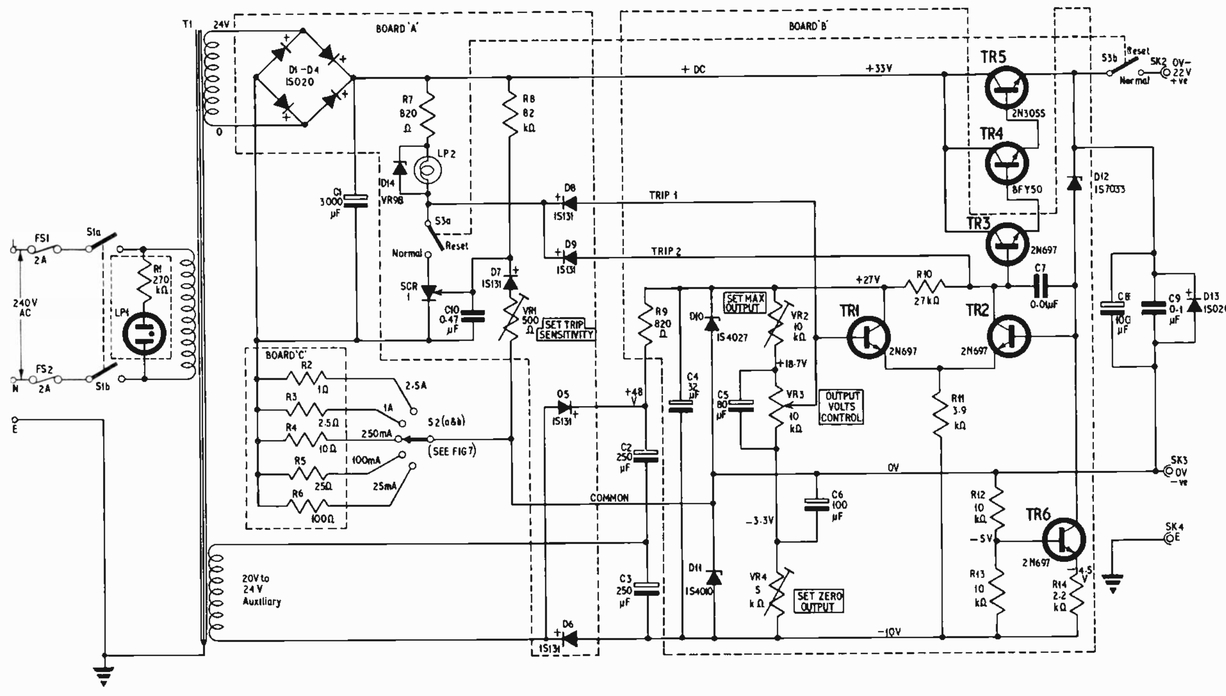


Fig. 2. Complete circuit diagram of the high performance stabilised power supply

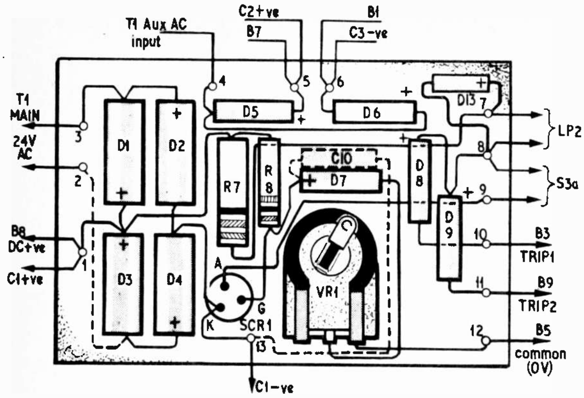


Fig. 3. Layout and wiring of overload and rectifier board "A"

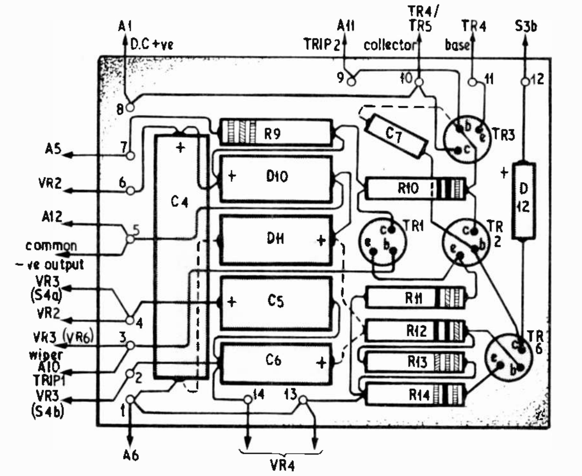


Fig. 4. Layout and wiring of differential amplifier and constant current board "B"

on pre-wired boards; layout and wiring diagrams for these are given in Figs. 3, 4 and 5. Plain Veroboard can be used with pins for component mounting. Solid wiring lines are on the non-component side of board and dotted lines indicate wiring on component side.

Layout of components within the unit is not critical and connections may, in general, be made with light-weight wire. It is recommended, though, that wiring carrying the main load current be 20 s.w.g. copper, or reasonably substantial multistrand wire.

TRANSFORMER DETAILS

The mains transformer is probably the only component which may prove at all difficult to obtain. Among firms which are able to supply transformers with a standard primary, and secondaries of 24V at 1A and 50mA are—T.R.S., Thornton Heath, Surrey, and Osmabet Ltd., Edgware, Middlesex. The cost being about 35s each.

However, in case of difficulty, the secondary voltages required may be conveniently obtained by using two separate transformers. The main secondary winding is required to deliver 1A, but the auxiliary supply may be obtained from quite a small transformer, since 24V at only 50 to 100mA rating is required. A suitable item is the Belclere type MS3169, however the one-off price for this item is a little high and cheaper alternatives can no doubt be found.

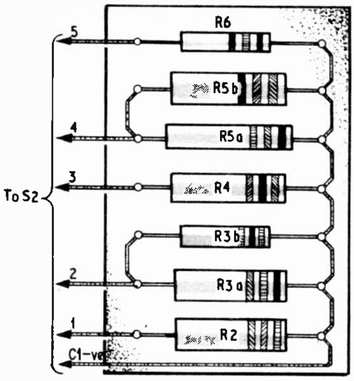


Fig. 5. Layout and wiring of overload resistor board "C"

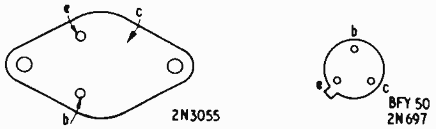


Fig. 6. Transistor connection outlines

Secondary voltage requirements are not critical; for the main supply this may be within the range 18 to 24 volts. The maximum output available from the unit, maintaining the 1A load capability, is about 2V below the a.c. voltage available. The auxiliary a.c. supply should be within the range 20 to 25 volts.

SEMICONDUCTORS

The thyristor specified is rated 1A at 50 p.i.v. and any similar component will be suitable provided trigger sensitivity is good. Poor trigger sensitivity will perhaps mean increasing the values of R2 to R6 if the overload current ranges are to be set as specified.

For example, a T140A4, 3A 400 p.i.v. thyristor, requires a 3 ohm series resistor for R3 before the unit will trip at 1A load current. The other series resistors would have to be increased by a factor of 1.2.

Transistor types used are also non-critical, apart from TR4 and TR5, and three suitable types have been specified in each case.

HEAT SINK REQUIREMENTS

The heat sink requirements for TR5 will vary according to the anticipated conditions under which the unit will work. The following may be used as a guide:

1. For continuous operation at full load, with output voltage above 12V, mount TR5 on an aluminium panel with a mica washer and insulating bushes. Minimum panel area required is 36sq in.
2. For continuous operation at full load, with output voltage above 6V, insulate the panel from the unit and mount TR5 in direct contact. Panel area 36sq in.
3. For continuous full load operation below 6V output, it is advisable to use two transistors in parallel for TR5, with a 0·5 ohm 3W wirewound resistor in each emitter lead. Mounting as in para. 2 above, but with a panel area of 48sq in.

A separate heat sink assembly may be used to meet all requirements, and a suitable item, size approx. 5in × 4in × 2in, is given in the component list. A finned clip-on heat sink should be fitted to TR4.

COMPONENTS . . .

Resistors
- R1 270kΩ (may be incorporated in LP1)
- R2 1Ω 7W wirewound
- R3 2·5Ω 7W wirewound (may be made up from 2·7Ω 7W and 33Ω 1W in parallel)
- R4 10Ω 3W wirewound
- R5 25Ω 1W (may be made up from 27Ω 1W and 330Ω in parallel)
- R6 100Ω 1W
- R7 820Ω 1W
- R8 82kΩ
- R9 820Ω 1W (for aux. supply voltages less than 22V, R9 is 680Ω 1W)
- R10 27kΩ
- R11 3·9kΩ
- R12 10kΩ
- R13 10kΩ
- R14 2·2kΩ
- 18 × 1kΩ 1% resistors (only needed if S4 is fitted)
- (All $\frac{1}{2}$W, 10% carbon except where stated)

Potentiometers
- VR1 500Ω skeleton preset
- VR2 10kΩ wirewound preset
- VR3 10kΩ wirewound (not needed if S4 is fitted)
- VR4 5kΩ wirewound preset
- VR5 25kΩ wirewound preset } (only needed if S4 is fitted)
- VR6 2·5kΩ wirewound } (only needed if S4 is fitted)

Capacitors
- C1 3,000μF elect. 50V
- C2 250μF elect. 50V
- C3 250μF elect. 50V
- C4 32μF elect. 64V } (Mullard)
- C5 80μF elect. 25V } (Mullard)
- C6 100μF elect. 6·4V } (Mullard)
- C7 0·01μF polyester or metal foil 160V
- C8 100μF elect. 25V
- C9 0·1μF polyester or paper 160V
- C10 0·47μF polyester or paper 160V

Transistors
- TR1 2N697, 2S004, ZT82
- TR2 2N697, 2S004, ZT82
- TR3 2N697, 2S004, ZT82
- TR6 2N697, 2S004, ZT82
- TR4 BFY50, 2N3053, 2N1507
- TR5 2N3055, 2S024, ZT1702, 2S033

Diodes and Rectifiers
- D1 1·5A 100 p.i.v. (1S020)
- D2 1·5A 100 p.i.v. (1S020)
- D3 1·5A 100 p.i.v. (1S020)
- D4 1·5A 100 p.i.v. (1S020)
- D5 0·2A 100 p.i.v. (1S131)
- D6 0·2A 100 p.i.v. (1S131)
- D7 0·2A 100 p.i.v. (1S131)
- D8 0·2A 100 p.i.v. (1S131)
- D9 0·2A 100 p.i.v. (1S131)
- D10 27V 1·5W (Zener) (1S4027)
- D11 10V 1·5W (Zener) (1S4010)
- D12 3·3V 0·4W (Zener) (1S7033)
- D13 1·5A 100 p.i.v. (1S020)
- D14 9V 1·5W (Zener) (VR9B)

Thyristor
- SCR1 1S610, 2N1595

Sockets
- SK1 Mains (Bulgin type P360)
- SK2, 3 and 4 Output terminals (Bulgin type T103)

Miscellaneous
- T1 Mains transformer sec. 1, 24V at 1A sec. 2, 24V at 50mA (see text)
- LP1 Neon panel indicator (may include R1)
- LP2 6V, 0·04A lamp. (Electroniques SGF9/G/RD/6)
- FS1, FS2 2A fuse holder and fuse
- Plain Veroboard and Veropins (size depends on components used) (3 off)
- Heat sink—see text (Electroniques HSD5)
- 18 s.w.g. aluminium for case

Switches
- S1 Double pole single throw (see text)
- S2 Maka-switch shaft assembly and 2 Maka-switch 2-pole, 5 way, make-before-break wafers (Radiospares)
- S3 Double pole single throw toggle
- S4 Maka-switch shaft assembly and 2 Maka-switch single-pole, 11-way, make-before-break wafers (Radiospares) (if used)

CURRENT AND VOLTAGE CONTROLS

Switch S2 should be a make-before-break type and, unless a rotary stud switch is available, is made up from two 2-pole 5-way wafers. Each switch section should be connected in parallel as shown in Fig. 7.

The only other component worthy of special mention at this point is VR3, the output voltage control. This may be a normal 10 kilohm linear potentiometer as indicated in Fig. 2. S1 must then be a separate switch. The output will be varied linearly with rotation of VR3. However, with a power supply of this type it is somewhat pointless to use such a coarse control, and the following alternatives are suggested:

1. Use a 10-turn helical potentiometer for VR3, which will enable the output voltage to be set extremely accurately. These components occasionally appear on the "surplus" market at prices ranging from 10s to 30s, although they may need looking for. Again S1 will have to be a separate double-pole, single-throw switch.
2. Replace VR3 with the network as shown in Fig. 9 (S4). This arrangement gives switched increments of

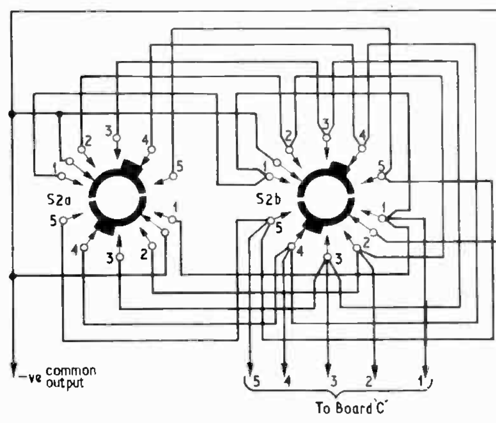


Fig. 7. Wiring of S2: 4 poles are wired in parallel to switch large currents

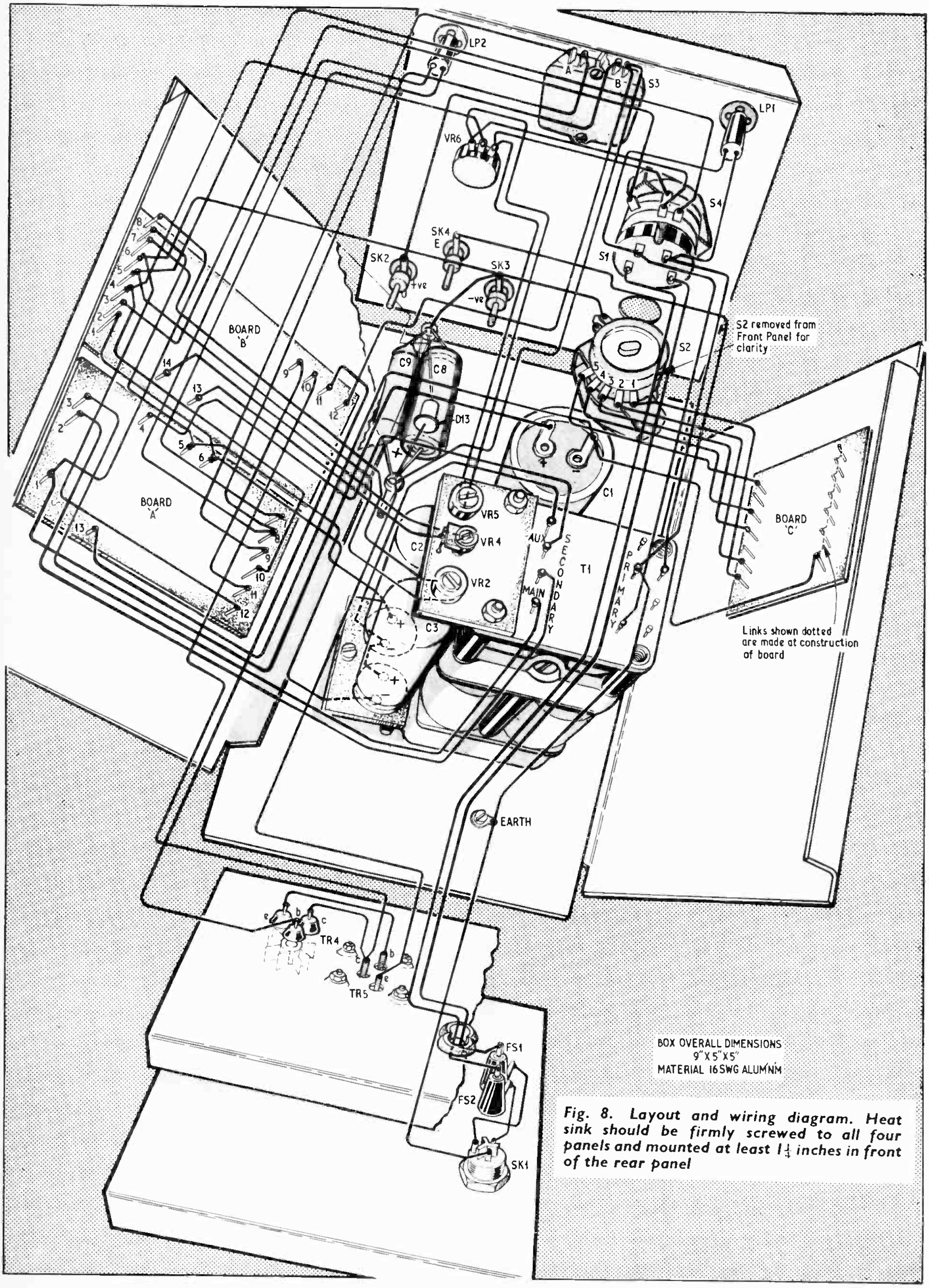


Fig. 8. Layout and wiring diagram. Heat sink should be firmly screwed to all four panels and mounted at least 1¼ inches in front of the rear panel

2V, and the 2·5 kilohm potentiometer (VR6) will vary the output ±2V on the selected value. It is probably also the most convenient arrangement to use; S1 can then be incorporated in S4, as shown in Fig. 8. This is done by using a Radiospares "Mains-switch" which is made to mount on "Maka-switch" assemblies.

TESTING AND SETTING UP PROCEDURE

Complete assembly and wiring of the unit, but omit the following connections:

(a) Positive d.c. line between component boards;
(b) Connection between C2+ and the stabiliser board (B).
(c) All connections between TR4, TR5, and stabiliser board.

When this stage has been reached, first check that all diodes and rectifiers have been wired in the correct polarity, then switch on a.c. mains, whereupon LP1 should light.

(1) Check d.c. voltage across C1, which should be about 1·4 times the a.c. voltage available from the "main" secondary winding of the transformer.
(2) Check the d.c. voltage between C2+ and C3−, which should be approximately three times the a.c. voltage available from auxiliary secondary.
(3) Set VR1 for minimum resistance and select 100mA overload current with S2. Touch a 100 ohm resistor between the d.c. positive and the common output pins on the rectifier-overload board. Check that the voltage across the thyristor is less than 1V and that LP2 lights.
(4) Reset overload with S3 and return S3 to normal. LP2 should extinguish and the voltage across the thyristor should rise to equal the voltage across C1. Repeat Test 3.
(5) Switch off a.c. mains and wire in the connection between C2+ and the stabiliser board.
(6) Wire temporary links on stabiliser board as follows

(a) Between pins 11 and 12 on board.
(b) Between d.c. positive pin and C4+ (+27V line).

Set VR2 and VR4 to maximum resistance.

Note: d.c. line between boards and TR4, TR5 still out of circuit.
(7) Recheck connections, switch on a.c. mains and check that the voltage between common (−ve output) line, and C3− equals −10V ±10 per cent.
(8) Check that the voltage between C4+ and common line equals +27V ±10 per cent.
(9) Check that the output voltage is available from the unit, and may be varied by VR3 (or S4 if fitted).
(10) Set output voltage control to maximum and adjust VR2 to give 20V output.
(11) Set output voltage control to minimum and adjust VR4 to give 0·5V output.
(12) Set output to about 10V, and check that the overload setting is 100mA.
(13) Repeat Test 3, and check that the output from the unit falls to less than 2·5V, with LP2 lit.
(14) Switch off a.c. mains and remove temporary links wired in Test 6.
(15) Connect TR4 and TR5 to the stabiliser board, and link the d.c. positive line by connecting 100 ohm resistor between the d.c. positive pins on the two boards (positions 1*A* and 8*B*).
(16) Recheck connections, select 25mA overload, turn VR1 to maximum and switch on a.c. mains. (Overload circuit will probably operate.)

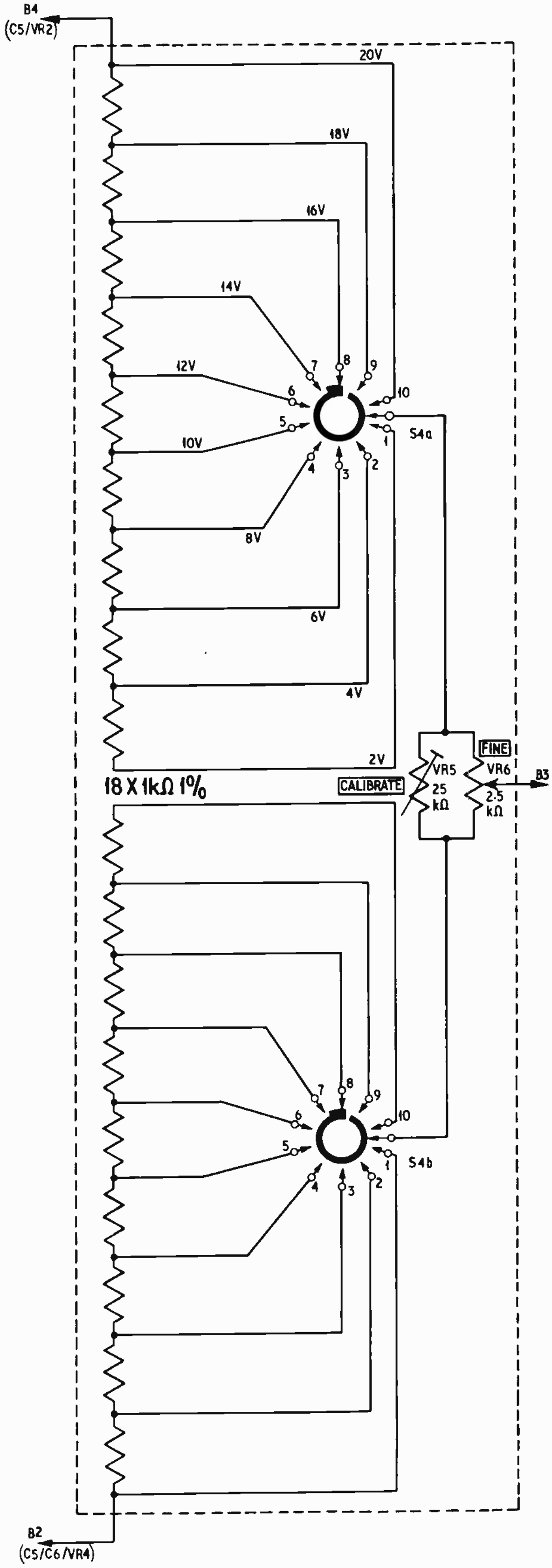
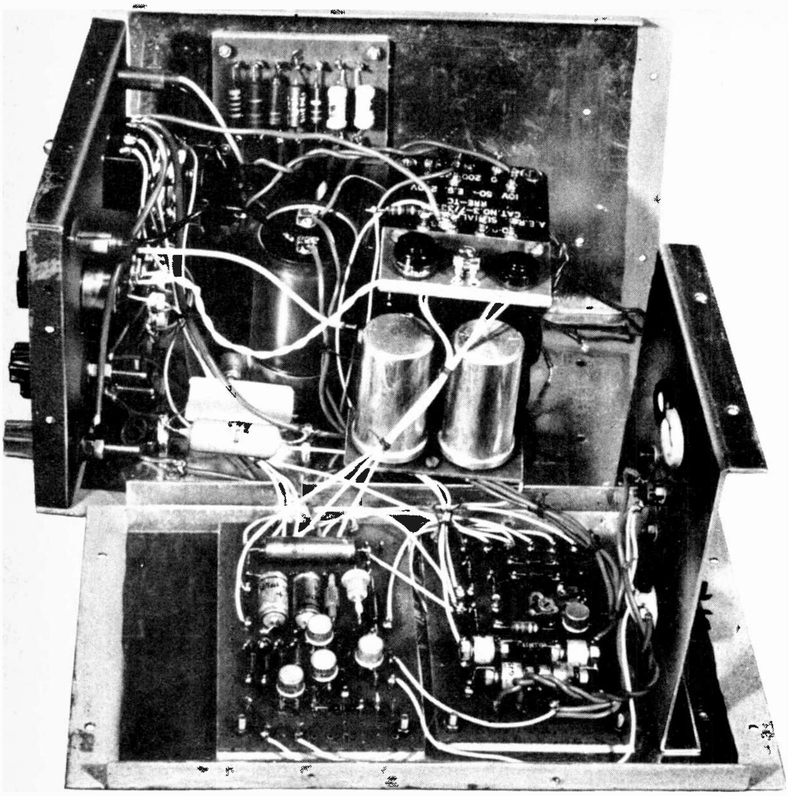


Fig. 9. Wiring of S4 output volts control. The 18 × 1 kilohm resistors are ¼W h.s. and are wired around the switch wafers



Leave power unit switched on for about 10 minutes to settle down, and then reset with S3 if necessary.

(17) If a variable resistor is used for VR3, repeat Tests 10 and 11, setting these voltages to 22V and 0V respectively, then go to Test 25 when completed.

Note: VR2 and VR4 interact, and Tests 10 and 11 should be carried out as many times as necessary to achieve an optimum result.

If S4 is fitted as in Fig. 8, proceed as follows:

(18) Replace VR6 and VR5 variable resistors with two 1 kilohm 1 per cent resistors connected in series; junction of the two resistors to be connected to TR1 base.

(19) Select 20V output position and adjust VR2 to give 20V output.

(20) Select 2V output position and adjust VR4 for 2V output. Repeat Tests 19 and 20 as necessary.

(21) Remove the two 1 kilohm resistors and connect VR5 and VR6 back in circuit.

(22) Select the 2V output position, turn VR6 for minimum output, and adjust VR5 to give 0V output.

(23) Check that VR6 can now vary the output from 0 to 4V.

(24) Select 20V output position and check that VR6 can vary the output between 18V and 22V.

(25) Select 100mA overload and set output to 10V.

(26) Load output with 100 ohm, 1W resistor and adjust VR1 slowly until overload circuit operates.

(27) Remove 100 ohm load resistor and reset.

(28) Check overload trips when 100 ohm load is reconnected.

(29) Remove 100 ohm resistor, in series with +d.c. line, between boards, and replace with permanent connection. (Switch off to do this.)

(30) Recheck for correct output voltage variation range, and recheck operation of overload circuit as in Tests 25 and 26 (VR1 should not need to be altered).

(31) Select 20V output and 1A overload, connect an 18 ohm resistor across output terminals and check that unit trips.

(32) Check short circuit output current is less than 10mA. It will probably be much less than this, but is dependent on leakage current through TR3, TR4 and TR5.

PERFORMANCE DETAILS

The unit built by the author used a transformer with secondaries of 22·3V, 0·9A (main) and 21V, 60mA (auxiliary). The voltage range was set for an output of 0 to 20V and the output control was as per Fig. 8.

Measured performance was as follows:

Voltage range—	0 to 20V
Max. r.m.s. load current—	1A
Output resistance at 20V, 1A—	30 milliohm (0·03 ohm)
Output resistance at 0·2V, 1A—	40 milliohm (0·04 ohm)
Output ripple at 1A load—	500μV r.m.s.
Voltage setting accuracy—	Better than 1·5 per cent
Output variation for $\pm$10 per cent mains variation—	Better than 0·1 per cent
Overload protection range—	25mA to 2·5A
Short circuit output current—	1mA

The only parameter not mentioned in the table is that of temperature stability.

When first switched on the output voltages will be, at worst, 6 per cent low, and this is due almost entirely to the temperature coefficients of D10 and D11. The output voltages settle very quickly and are within 1 per cent of their final value in about one minute of switching on.

If it is required to decrease the effects of temperature variation, then the following is suggested: make D10 from five Zener diodes, each rated at 5·6V, connected in series, and D11 from two Zener diodes each of 5·1V, connected in series.

However, unless the unit is to be used for applications where temperature stability better than 1 or 2 per cent is mandatory, then the extra cost of replacing D10 and D11 is not justifiable.

FINAL COMMENTS

There are two further points worth mentioning.

Although the unit is only intended to handle a maximum load current of 1A, a 2·5A overload position has been included. This allows the unit to be used where average currents are less than 1A but where high current peaks may be encountered. For example, class-B and class-C power amplifiers.

The −10V line may be made available on the front panel of the unit. Although currents of only 2 or 3mA may be drawn from this line without affecting the main supply, this can nevertheless be useful for small signal biasing applications. ★

BOOK REVIEWS

RCA HOBBY CIRCUITS MANUAL

**Published by RCA Great Britain Limited,
Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex
224 pages, $8\frac{3}{8}$in × $5\frac{3}{8}$in. Price 17s 6d.**

In this one reasonably priced volume are presented thirty five circuits which should have a broad appeal to electronics hobbyists.

Whilst including some games and novelty circuits, the majority fall into specific categories such as photography, motoring, ham radio, audio, etc., providing solid state aids or accessories in these pursuits.

The Manual opens with brief, but adequate, descriptions of the theory and operation of the semiconductor devices used in the various circuits and a general introduction to some commonly encountered circuit "bricks". A section on construction techniques provides all the information necessary both in the handling and assembly of the components used.

Sections on test circuits for component troubleshooting, and suggested circuit uses, preface the thirty five projects all of which are dealt with in detail both for circuit operation and construction.

Semiconductor types used can be obtained from RCA Great Britain at the address given above.

G.M.H.

COLOUR TELEVISION:

**A Background to Colour Tube Adjustment for the Service Engineer
Published by Distributor Sales Division, Mullard Limited
48 pages $8\frac{1}{2}$ × 6in. Price 17s 6d.**

With the advent of colour television has come more rigorous demands on the service technician both in the understanding of new circuit techniques and the application of new and necessarily more complex setting up procedures.

In two parts this book provides a liberally illustrated "teach-in" on colour tube control assemblies and their adjustment. Part 1 provides a brief description of the shadowmask picture tube with explanations of convergence and colour purity and associated assemblies necessary to achieve this. Part 2 gives a typical setting up sequence of adjustments, the emphasis being on a simple easy-to-follow procedure which should appeal to the service man.

Colour pictures and diagrams are used to show the operation of the various controls and to give examples of the displayed picture before and after adjustments are made.

G.M.H.

AUDIO DIARY 69

**Published by Link House Publications Ltd.
60 pages of information plus diary section,
$4\frac{1}{8}$in × $2\frac{7}{8}$in. Price 8s 6d.**

The information section of this diary will be a most useful and convenient work of reference for all who appreciate good music and the means for its reproduction in the home. The subject matter has been selected to embrace the musical art as well as acoustic science and audio engineering. Topics succinctly but objectively dealt with include: frequency and pitch, gramophone records and their reproduction, loudspeakers, and tape recording. There are also other data such as music terms, index of composers, audio terms, and circuit symbols. Illustrated with charts and diagrams.

TRANSISTOR SERVICING GUIDE

**Prepared and published by RCA Institutes Inc.
194 pages, 8in × 5in. Price 35s.**

Service engineers, who prefer to learn from straightforward factual reporting of technical information, might find this book helpful. For those hitherto unfamiliar with transistor techniques, the early chapters lay out clearly and concisely the necessary basic theory of circuit operation of amplifying and r.f. stages.

Typical circuits used in transistor radio receivers are given in Chapter 3, while the next chapter looks at transistor television circuitry. This is dealt with in some considerable length. One would have thought that by this stage in the book one might have read about typical fault diagnosis and practical work—according to the title—but this aspect is given only in the last 40 pages.

Although of American origin, this book has been Anglicized to a considerable degree making it more digestible to the British service man.

M.A.C.

NEWS BRIEFS

Safer Level Crossings

Television cameras are being mounted on Italian unmanned level crossings to provide an unobstructed view of the whole crossing area. The cameras, which use English Electric Vidicon picture tubes, feed monitors mounted in the signal box, these monitors provide the signalman with a continuous view of the crossing and, in the event of the track being obstructed when the barriers are lowered, allow him time to warn approaching trains.

Britain Contributed to Apollo 7!

Britain's contribution to the Apollo 7 space mission consisted of five Cable and Wireless stations in Antigua, Ascension, Bermuda, Suva (Fiji) and Tortola (B.V.I.). The "NASCOM" communications network, used to control and track the entire flight, consisted of teleprinter, voice and data circuits and covered a large part of the globe. Circuits had to be maintained in the highest state of efficiency throughout the mission; reliability requirements being as high as 99·8 per cent.

Computer-Aided Design Centre

The Ministry of Technology have been negotiating with ICL to operate the new computer-aided design centre at Cambridge under Mintech direction. The design centre, which is expected to be operational in mid 1969, will provide multi-access facilities working largely through the medium of teleprinters but using displays and other devices in some instances. Expected costs and running expenses for the first five years are about £$2\frac{1}{2}$ million.

Integrated Circuits Joined by Electrons

An electron beam cutting and welding unit, which is to be used for connecting together micro-integrated circuits, is being developed by the research division of ICL. The heart of the control system for the unit is to be an English Electric M2140 multi-processor computer.

Computing Past and Present

A small exhibition of mechanical, electro-mechanical, and electronic computing machines, past and present, is now being shown in the Science Museum, South Kensington, London. It is open every day (except Christmas Day) until January 12, 1969, admission free.

Zener Diodes

By J. S. LAMB

BEFORE using any unfamiliar electronic device it is wise to examine the characteristics carefully and if possible try to understand its physical properties. With Zener diodes both these points are relatively simple to master. The Zener diode is very similar to any silicon diode and if used in the forward biased condition will give similar results. The difference, due to impurities injected during manufacture, is found when the device is reverse biased as it breaks down at a given voltage and will conduct large currents (see Figs. 1a and 1b).

Before proceeding it is important to note that, like all semiconductors, Zener diodes are likely to be damaged if excessive currents are allowed to pass through them. To avoid this ensure that a series resistor is used to limit that current whenever the breakdown voltage is to be exceeded.

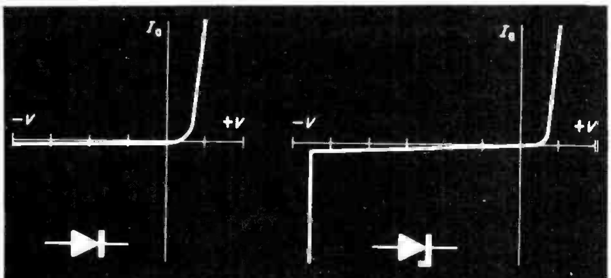


Fig. 1. Characteristic curves and circuit symbols of (a) silicon diode and (b) Zener diode

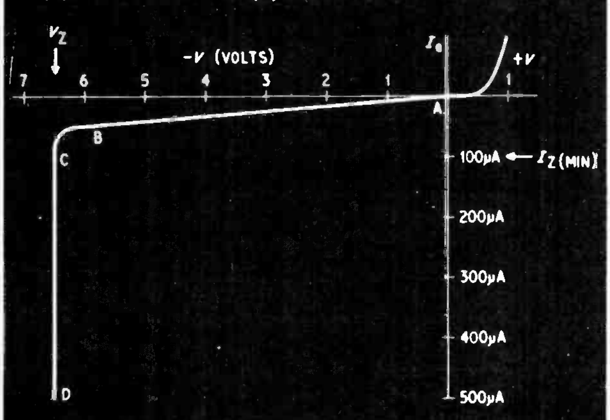


Fig. 2. Characteristic of Zener diode 1N753

ZENER BREAKDOWN

Looking at a typical characteristic curve (Fig. 2) of a Zener diode type 1N753, AB is a region in which very little current flows and the device presents a high impedance usually above 50 kilohms. Region BC is the breakdown voltage V_z and is usually a very sharp knee but it can be a steep curve especially at very low breakdown voltages, i.e. 3 to 4 volts. Finally in the region CD the breakdown voltage is exceeded and very large currents flow for small increases in voltage.

The manufacturers data for Zener diodes is presented with a definite value of Zener current $I_{z(min)}$ being quoted for the breakdown voltage. This is usually greater than required and lies well into the conducting portion of the curve, to ensure that the working point of the device never lies on the curved portion BC. It is important to note, however, that for large variations in Zener current the breakdown voltage increases slightly, i.e. this device still has a finite resistance R_z after breakdown. Two other parameters are also quoted $I_{z(max)}$ and maximum power dissipation $P_{c(max)}$. The maximum power dissipation depends on temperature, but for the purpose of this article it is assumed that an ambient temperature of 25 degrees C prevails and the devices are never subjected to maximum power dissipation. All Zener diodes are subject to a 5 or 10 per cent tolerance and it is not unreasonable for a nominal 6·2V Zener to have an actual breakdown voltage between 5·6 and 6.8V, although any one diode will always have a constant breakdown voltage within this range. Zener diodes also vary with temperature; those below 5V have a negative coefficient, those above 6V a positive coefficient, and those at 5 to 6V have a zero temperature coefficient. Thus by combining selected diodes (i.e. above 5V and below 5V) the total temperature coefficient of several devices can still be less than the temperature coefficient of one diode of corresponding voltage.

STABLE VOLTAGE SOURCE

The Zener diode is most commonly found in voltage reference and stabilising circuits. Fig. 3 shows the most common Zener diode circuit used to produce a constant voltage with a varying load current and supply voltage. As the latter varies, the voltage across R1 varies, allowing V_z to remain constant provided that $I_{z(min)}$ is allowed to flow continuously through the Zener diode. Under the conditions where no load current is taken, the maximum load current required in the external circuit plus $I_{z(min)}$ flows through the diode, while on full load the Zener diode conducts only $I_{z(min)}$.

DESIGN PROCEDURE

The design procedure for a stabiliser of 6·2V (as in Fig. 3) is as follows:

1. Stipulate maximum and minimum current I_L to be drawn in load (e.g. 10mA and 0mA).
2. Stipulate the maximum supply voltage V_i likely to occur (e.g. 12 volts) and ensure that the minimum supply voltage is at least 1V above the breakdown voltage of the Zener diode.
3. At any time $V_i = V_z + V_{R1}$, where V_z is the breakdown voltage V_{R1} is voltage across R1, and $I_z = I_{z(min)} + I_L$, where I_L is the maximum load current stipulated.

Using Zener diode 1N753 where $V_z = 6{\cdot}5$V, $I_{z(min)} = 100\mu$A (from Fig. 2).

$$\text{Maximum } I_z = 100\mu A + 10mA$$
$$= 10{\cdot}1mA$$

Therefore R1 must conduct 10·1mA at the minimum supply voltage.

Allowing 1·5 volts minimum across R1, i.e. $V_i - V_z$.

$$R_1 = \frac{1{\cdot}5}{10{\cdot}1 \times 10^{-3}}$$
$$= 148{\cdot}5 \text{ ohms}$$

The nearest preferred value resistor would be 150 ohms.

4. At maximum supply voltage 12V:

$$V_{R1} = I_z\, R_1$$
$$I_z = \frac{(12 - 6{\cdot}5)}{150}$$
$$= 36{\cdot}7mA$$

Under no load conditions this current flows through the Zener diode when the Zener dissipates most power.

5. The power dissipation for these open circuit conditions is given by

$$P_c = I_z\, V_z$$
$$P_c = 6{\cdot}5 \times 36mA$$
$$= 234mW$$

This is well within the 400 mW rating of the 1N753. The results of this circuit are shown graphically in Fig. 4.

ZENER DIODES IN SERIES

As stated earlier in this article it is possible to add two or more diodes in series (Fig. 5). The calculation is similar but in this circuit $I_{z(min)}$ must be a minimum value, so that the current passing through any diode is never less than the value at which the breakdown voltage of that diode occurs. If this condition is fulfilled then six different stable supplies can be obtained from three diodes as shown in Fig. 5.

ZENER DIODES IN PARALLEL

For very good stability at low voltages, especially for supplies containing a.c. ripple, two Zeners can be added in parallel, Fig. 6. The calculation is the same for both diodes, each being treated as a single stage. If a potentiometer is substituted for R2 then a variable stabilised supply can be obtained although stabilisation is not as good as in the fixed voltage circuit.

If large load circuits are required or the supply varies by more than 2 to 3V the Zener diodes can easily be over loaded; to overcome this a transistor is usually added.

VOLTAGE STABILISE WITH TRANSISTOR

In this type of circuit the Zener diode is used as a constant voltage source on the base of a transistor. The transistor is operated in the emitter follower configuration, with the load acting as the emitter resistor (see Fig. 7).

The voltage at the emitter follows the voltage at the base. In this circuit, the latter is constant so the output across the load is also constant and the maximum current through the load is the maximum emitter current of the transistor. The gain of the transistor h_{fe} should be high (e.g. 50) to ensure that under maximum load conditions the base current is not large enough to load the Zener diode circuit.

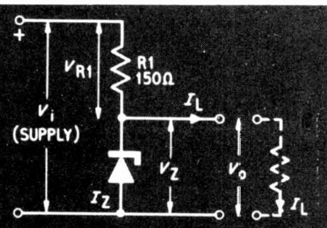


Fig. 3. Circuit diagram of a simple Zener diode stabiliser

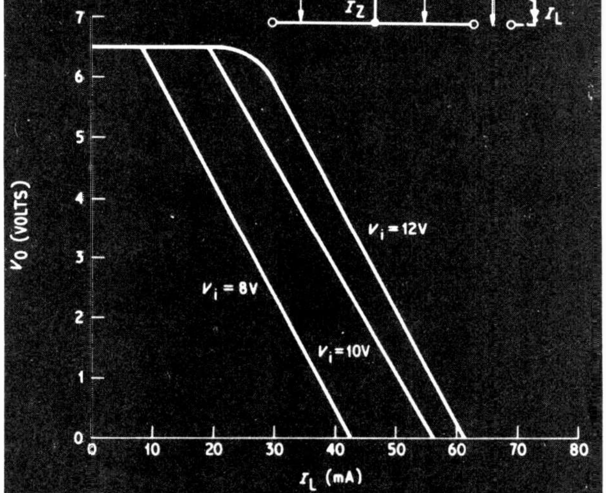


Fig. 4. Load characteristics for given inputs of Zener diode stabiliser

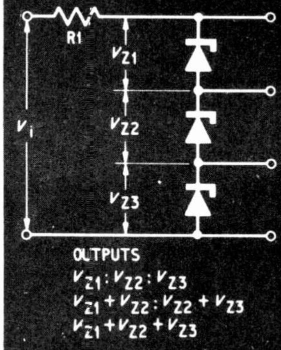


Fig. 5 Three Zener diodes connected in series provide six stabilised outputs.

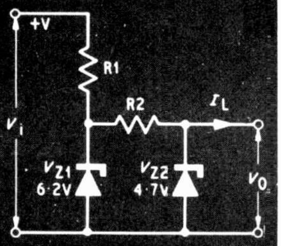
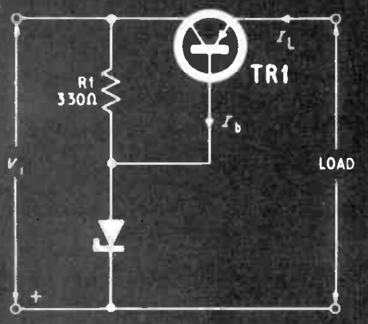


Fig. 6. Zener diodes connected in parallel



V_i = 7 VOLTS	
V_O (VOLTS)	I_O (mA)
6·25	10
6·20	50
6·15	100
6·15	200

V_i = 13·0 VOLTS	
V_O (VOLTS)	I_O (mA)
6·10	10
6·05	30
6·05	50
6·05	60

Fig. 7 (left). Circuit diagram and table of results of voltage stabiliser using a transistor connected in series.

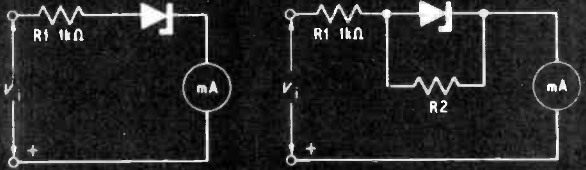


Fig. 8. Use of Zener diodes in meter circuits

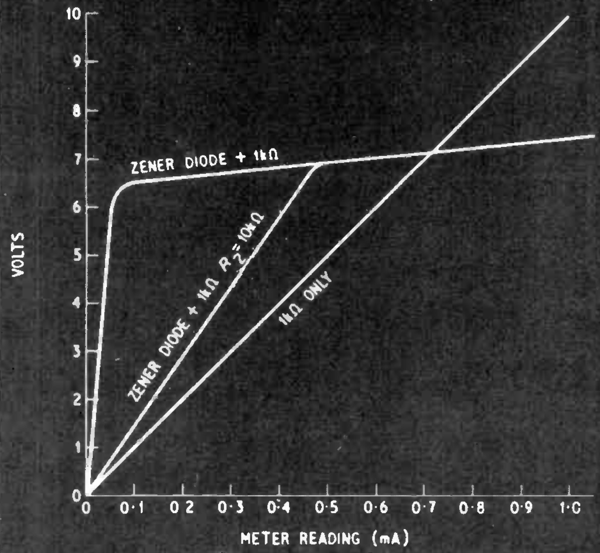


Fig. 9. The results of adding a Zener diode and parallel resistor to a 1mA meter

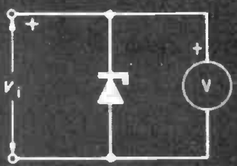


Fig. 10a. Zener diode used to protect a voltmeter against overload

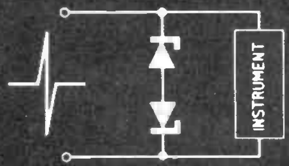


Fig. 10b. Two Zener diodes used "back to back" to give protection against positive and negative transients

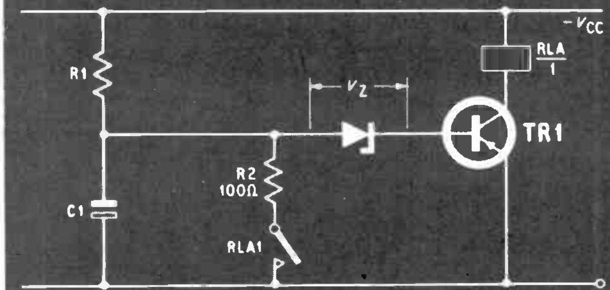


Fig. 11. A free running square wave generator using a Zener diode

STABILISER DESIGN

The procedure for designing a circuit using 1N753 to give 6·5 volts output, as in Fig. 7, is as follows:

1. Stipulate maximum and minimum load current, (e.g. 50mA and 0mA respectively).
2. Stipulate maximum and minimum supply voltage; again the minimum supply should be 1 to 2V above V_z (e.g. $V_{i(max)} = 12V$, $V_{i(min)} = 8V$), i.e. $V_{R1} = 1{\cdot}5V$.
3. Select transistor for power dissipation P_{tot}

$$P_{tot} = (V_{i(max)} - V_o) \times I_{L(max)}$$
$$= (12 - 6{\cdot}5)\ 50 \times 10^{-3}$$
$$= 275\text{mW}$$

It is also required that $h_{fe} = 50$ (use transistor type OC84)

$$\text{Therefore } I_b = \frac{I_{L(max)}}{1 + h_{fe}} \simeq \frac{I_{L(max)}}{h_{fe}}$$
$$I_b = 1\text{mA}$$

4. For good regulation the current through the Zener diode should be much larger than the required base current, i.e. by a factor of 5.
The value of R_L is then calculated as in the simple stabiliser.

$$\text{i.e. } R_L = \frac{V_{i(min)} - V_z}{I_z}$$
$$= \frac{8 - 6{\cdot}5}{5 \times 10^{-3}}$$
$$= 300 \text{ ohms}$$

The nearest preferred value resistor is 300 or 330 ohms.

5. The power dissipation is given by

$$P_c = \left(\frac{(V_{i(max)} - V_z)}{R_1} - I_{b(min)}\right) V_z$$

If the minimum load current is zero, $I_b = 0$

$$P_c = \left(\frac{12 - 6{\cdot}5}{330}\right) 6{\cdot}5$$
$$= 112\text{mW}.$$

For the results of this circuit, see tables in Fig. 7.

It is interesting to note that as this circuit behaves as an emitter follower the output voltage is smaller by the V_{be} of the transistor. It is also worth noting that V_{be} increases slightly as the emitter current increases.

ZENER DIODES FOR METER CIRCUITS

One of the most useful applications of Zener diodes to the amateur constructor is its addition to voltmeter circuits (Fig. 8a).

For this application a 1mA meter was used, with a series resistor R1, as a voltmeter. Sensitive meters should be shunted to measure at least 1mA f.s.d. to ensure that f.s.d. is not reached by Zener diode leakage current (Fig. 2).

The Zener diode presents a very high impedance (about 50 kilohms) until the voltage across it reaches the breakdown voltage, so from zero volts to the Zener breakdown voltage the meter reads only the Zener leakage current, i.e. Fig. 2 (A − B). After breakdown the Zener resistance is very small (e.g. in the region 10 to 100 ohms) so the meter now behaves as a normal voltmeter. The scale is compressed up to the Zener breakdown voltage, whereafter it is linear. If it is required to measure a voltage of 7V accurately then using a Zener diode of 6·5V and a 1mA meter, the meter will read 7·5V full scale with a deflection range of 1V if R1 = 1kilohm.

If a resistor is placed in parallel with the Zener diode (Fig. 8b) to form a potential divider then the lower part of the scale can be increased, while still being compressed, to give a reasonable reading outside the required range. Fig. 9 shows the results of adding a Zener and parallel resistor to a 1mA meter.

CIRCUIT PROTECTION

A Zener diode can be used very effectively to protect a voltmeter against overload or a reversed polarity signal (Fig. 10a). When the input reaches the breakdown voltage the diode conducts and short circuits the meter. In practice the diode used has a breakdown voltage 2 to 3 times that which would overload the meter. Also, if a voltage is applied which is of reversed polarity the Zener diode behaves like a normal diode, forward biased, thus again short-circuiting the meter. This method of protection can also be used to protect instruments from transients through supplies. In this case it is usual to place two Zener diodes back to back as in Fig. 10b, thus protection is gained against positive and negative transients.

SIMPLE TIMING CIRCUIT

In the circuit of Fig. 11 the capacitor C1 is charged through the resistor R1 until the voltage across it reaches the Zener breakdown voltage plus the V_{be} of the transistor.

The Zener diode then conducts allowing a base current to flow which switches the transistor hard on. The time taken for this to occur is given by

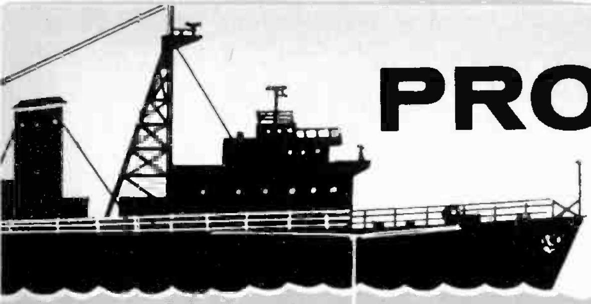
$$t \simeq \frac{0{\cdot}7C_1R_1V_z}{V_{cc}}$$

Unfortunately the value of R1 has a practical maximum. This resistor must be able to conduct the $I_{z(min)}$ of the Zener diode and a base current large enough to switch on the transistor. This means that large values of capacitance must be used for long time delays.

The repeatability of the time delay depends on the capacitance and the shape of the knee of the Zener diode. Thus this circuit can never be used in applications which require a high degree of accuracy.

If a relay is used in the collector circuit with one set of contacts used to discharge the capacitor then the circuit becomes a free running square wave generator.

★



PROBING THE OCEAN

By P. R. HINCHCLIFFE B.Sc.

A STUDY of the ocean involves the accurate determination of such parameters as pressure, temperature, salt content and current flow in regions of the earth's surface where man could never live, without the aid of bulky and expensive protective vessels. The following article describes how the oceanographer enlists the aid of electronics to penetrate depths otherwise forbidden to him, and to study them both in situ and in the laboratory.

MEASUREMENT OF DEPTH

The earliest measurements of depth were, of course, taken by the technique of throwing a weighted rope over the side of a ship. In later years, a blob of candle grease on the weight also provided early marine geochemists with a convenient sample of the sediment from the sea floor.

However this procedure was inaccurate, and especially in deep waters, very lengthy. Paying out and winding in 3,000 fathoms of wire is a very tedious procedure, and a survey of a small area could take months using this procedure.

A modern day technique is to use sonar. A high frequency acoustic pulse (about 10–15kHz) is released from a transducer below the ship, at the same time that a pen recorder begins to sweep across a paper. The reflected echo is received and causes the pen to mark the paper.

The time pulse and echo gives the depth accurately, assuming that the velocity of sound in water is known. This value is taken to be 800 fathoms per second, but tables are available to correct for different parts of the ocean.

Accurate measurement of sound velocity is also useful for determining current flow or water densities under certain circumstances. The method usually used to measure velocity is based on the "sing-around" system (Fig. 1). A pulse emitted from the transmitting transducer travels an accurately known path and is received by a second transducer, which feeds the signal back to the transmitter via shaping and amplifying circuits, causing electrical oscillations to occur. The frequency of oscillation is dependent on the velocity of sound in the water between the transmitter and receiver.

This transmission of data as a frequency modulation is very convenient, requiring only one probe-to-ship cable to carry many different channels of information. Considerable modification is often incorporated into a sensor system so that a modulated frequency signal can be obtained, as we will see later.

DEPTH RECORDER

Knowing the velocity of sound enables accurate depth measurements to be made using the system mentioned above. Fig. 2 shows in block diagram form a typical depth recorder based on this principle.

Use of the "sing-around" principle would cause loss of definition of the structure of the sea bed as the interval between pulses may be several minutes in deep waters, and in this time the boat may have travelled quite a distance. To overcome this a string of pulses is given out and this is gated in a particular code to determine which echo came from which pulse.

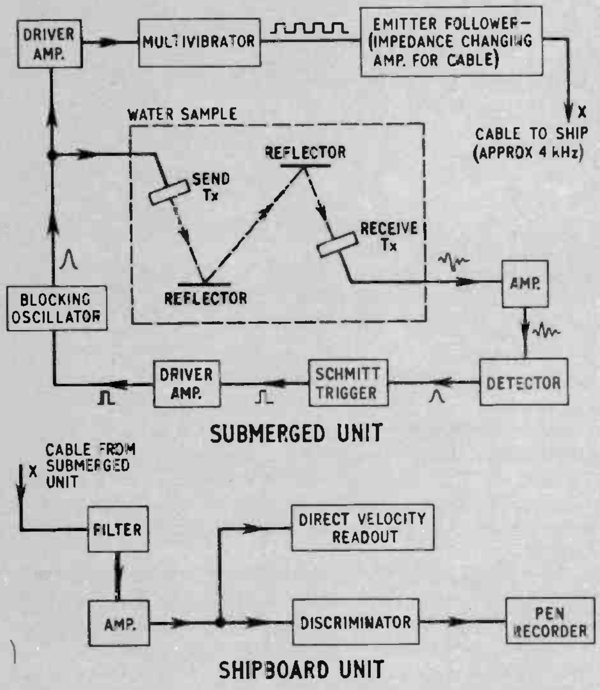


Fig. 1. Sound velocity meter using "sing-around" principle

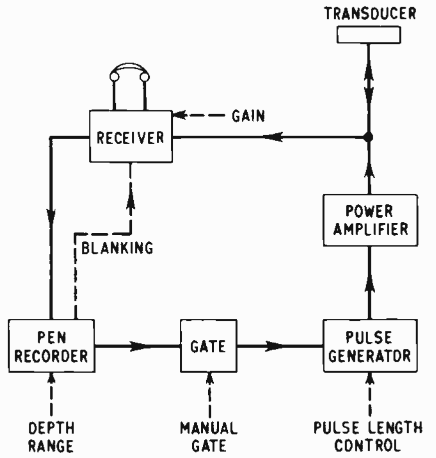


Fig. 2. Block diagram of typical depth recorder

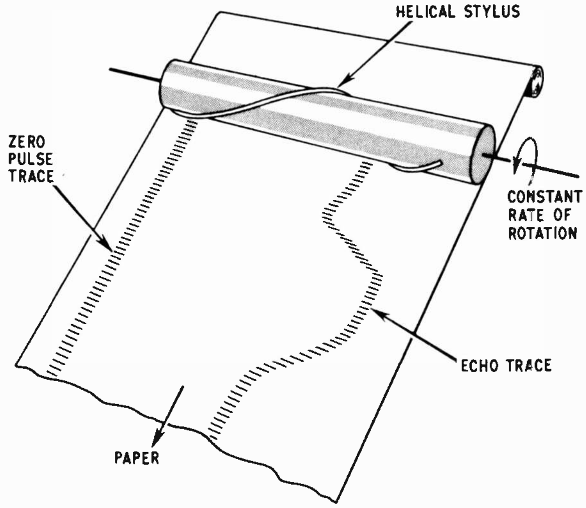


Fig. 3. Helical stylus used on depth recorders

Sing-around type depth recorders, however, have the advantage that loss in signal strength by absorption in water can be compensated for automatically by using a time-variable gain on the receiver.

The recorder uses a pen which sweeps across the paper at a constant rate—often a helical stylus is used to achieve this effect (Fig. 3). A pulse is emitted as the stylus is at zero and the pen marks the paper again on receipt of the echo. Different rotating speeds of the stylus give different depth ranges.

The transducers used are usually multiple ceramic devices, but for some cases nickel/iron magnetostrictive rings or quartz crystal devices may be used.

Sonar systems are also used for giving the depth of probes or sampling devices below the sea surface. A "pinger" is fitted on to the probe, which gives out a string of sonar pulses. Two main pulses are received onboard the ship, one direct and one reflected from the sea bed. When the two traces on the recorder coincide, the probe or sampler will be on the sea bed.

VIBROTRON

Depth is closely related to pressure, to such an extent that a pressure recorder is often used to indicate the depth of an instrument. A useful sensor, which directly gives a signal whose frequency is dependent on pressure, is the vibrotron, in which the pressure is used to tighten or slacken a vibrating wire, hence varying the frequency of vibration of the wire. Devices in which pressure varies the capacitance of the capacitor in an LC oscillator are also useful.

The vibration and the sonar device described may be used in wave measurement, which may become important in the future for predicting storms. However, these have to be resting on the sea bed and cables must run from the instrument to shore or ship, so they are only really useful as near-shore, shallow water devices.

For shipborne wave analysis a very elegant system is used. An arbitrary reference depth is fixed below the ship. Shipborne transducers measure the pressure (and hence the height of the wave) and compare this to the reference level to allow for the motion of this ship in both vertical and rolling motion. The reference level is fixed by measuring the vertical acceleration due to the wave motion at each side of the ship. Distance is found from acceleration by double integration.

The transducers used are variable inductance transformers (Figs. 4a and 4b). A voltage of 10V at 10kHz is fed to the fixed coil, and 10V ± 10 per cent is induced into the other, dependent on its height relative to the

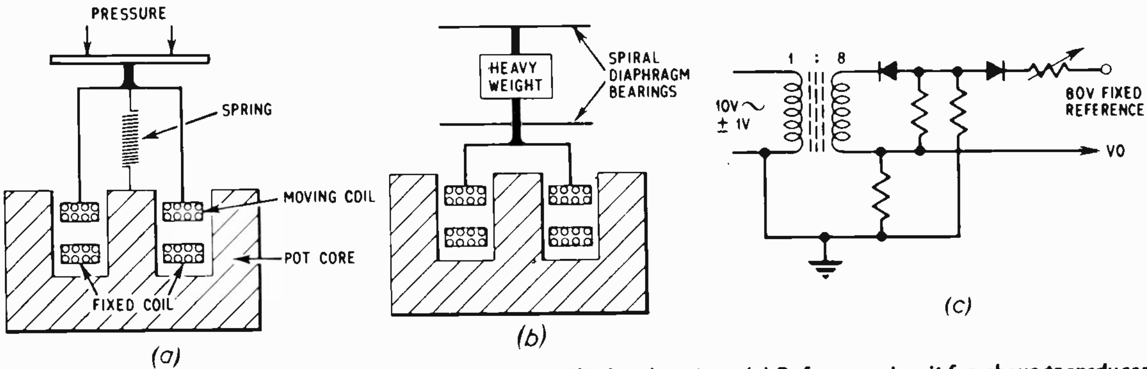


Fig. 4. Pressure, acceleration transducers: (a) Pressure; (b) Acceleration; (c) Reference circuit for above transducers

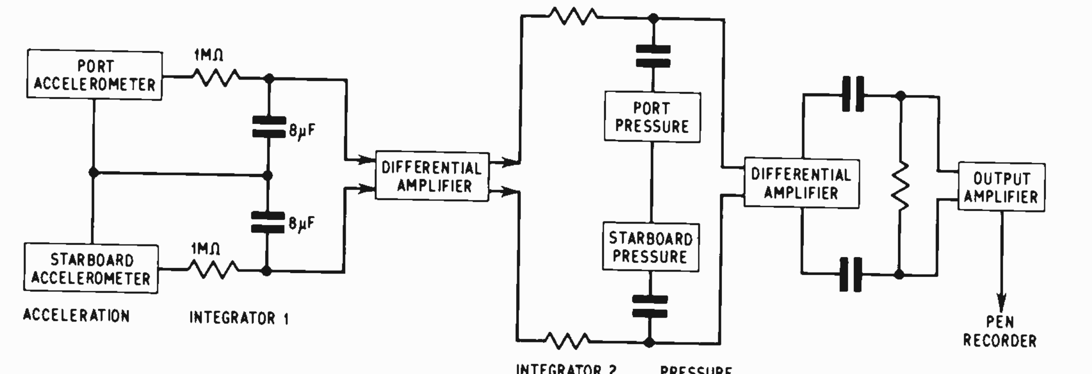


Fig. 5. Shipboard wave recorder

core. This is compared to the standard 80V reference to give an output V_0 (Fig. 4c) dependent on either acceleration or pressure.

The acceleration signal is integrated twice (Fig. 5) and mixed with the pressure signal. The resultant is fed via a filter to eliminate long term drifting in the previous network into a pen recorder. The trace may then be analysed at leisure on land.

MEASUREMENT OF TEMPERATURE

There are two quite separate problems involved in temperature measurement of the ocean—the thin skin of the surface is often at a quite different temperature to that of the mixer layer immediately below. Measurements of the surface skin are usually carried out using an airborne radiation thermometer (a.r.t., see Fig. 6) which, as the name suggests, is usually carried in an aeroplane.

This device compares the infra-red radiation of the surface layer of the sea with the radiation reflected from a shutter in front of the thermostatically controlled container. The shutter rotates to give a chopped 20Hz signal in the thermistor; the signal is then filtered, analysed and recorded. This method was used to plot the Gulf Stream very accurately, as it can measure surface temperatures of large areas rapidly to within $\pm 0{\cdot}2$ degree C.

For sub-surface measurements, reversing thermometers and isothermal sampling bottles are often used, but for the fast temperature/depth contouring a device known as a bathythermograph (b.t.) is used. This is in the form of a fish which is towed behind the ship.

On paying out the hawser the weight at the end of the b.t. causes it to sink, and on stopping the winch and then winding in the hawser the b.t. rises to the surface by means of its fins. Pressure drives a smoked glass plate in one direction, whilst the expansion of a liquid in a copper tube drives a stylus over the plate to indicate temperature against depth.

However, a more modern procedure is to use the expendable bathythermograph (e.b.t.) which is in the form of a streamlined plumb carrying a thermistor. An extremely fine 3-core cable connects the thermistor to a compensated bridge circuit on board the ship. As the cable is reeled out from both the e.b.t. and the shipboard unit simultaneously, it will float along the sea surface allowing the plumb to fall freely at a known speed whilst the ship steams away from the spot where it dropped the e.b.t.

The temperature is recorded against time, and hence against depth. These e.b.t.'s cannot be recovered, as the cable is far too fine to stand the strain of rewinding the instrument. It is possible to record the temperature to within $\pm 0{\cdot}1$ degree C.

Contouring temperature recorders (strings of 20 or more thermistors on a single hawser) are often used to plot the variation of the depth of an individual isotherm. The thermistors are wired individually into circuits such as that shown in Fig. 7.

MEASUREMENT OF SALINITY

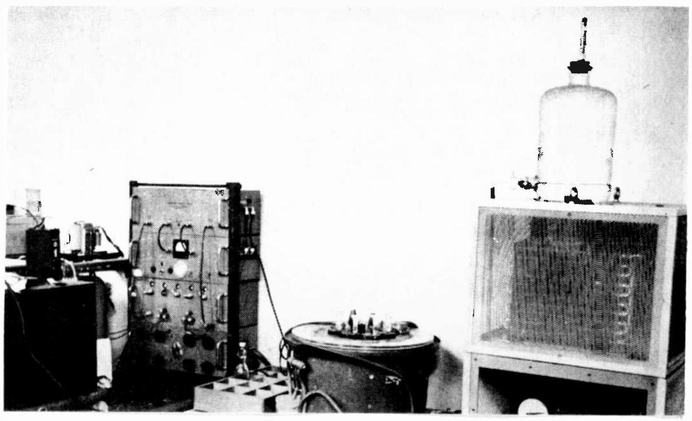
Water masses in the ocean can be accurately defined and their movements plotted by measurement of their depth, temperature and salt content. However, variations of salinity in the major oceans are fairly small, and measurements to within $\pm 0{\cdot}01$ per cent would be required.

The most reliable and accurate method of salinity measurement is by the chemical procedure of titration, but this requires isolated samples of sea water, and a good deal of time and care. Rapid laboratory techniques usually measure the resistance of a standard vessel of sea water. The resistance is inversely proportional to the salinity, but also varies with temperature and pressure of the water.

In the laboratory pressure presents no problems—if the sample has been taken from a great depth, the pressure may be allowed for by use of tables. However, temperature must be controlled to a very fine degree, and this is done by immersing the conduction "cells" in an accurate thermostat.

Fig. 8 shows the circuit of a simple conduction bridge. The circuit is a Wheatstone bridge compensating

Conductivity salinometer



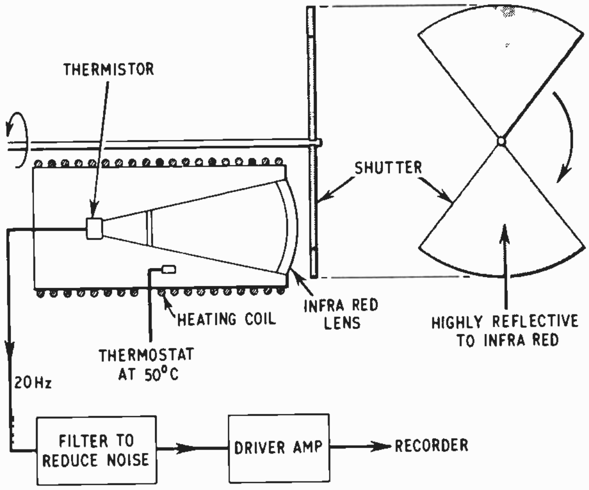


Fig. 6. Airborne radiation thermometer

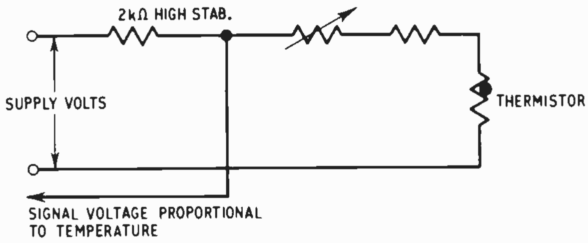


Fig. 7. Thermistor circuit, as used in temperature contourer

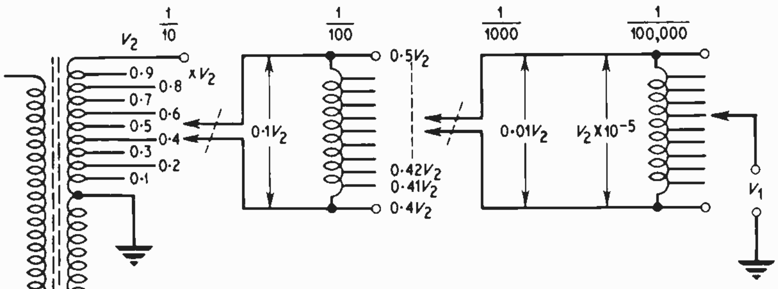


Fig. 9a. Details of transformer tapping system to give variations of 1 part in 100,000

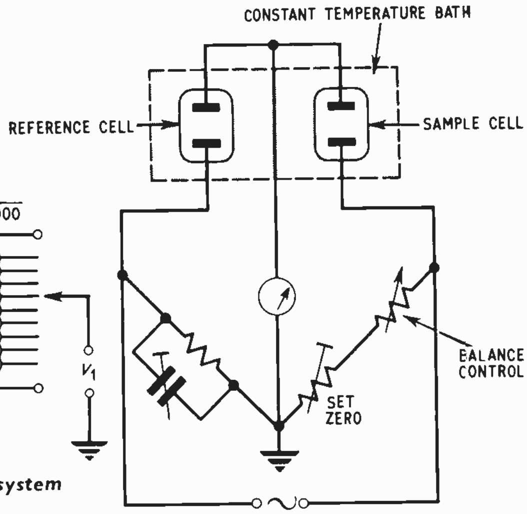


Fig. 8. Simple conduction bridge circuit

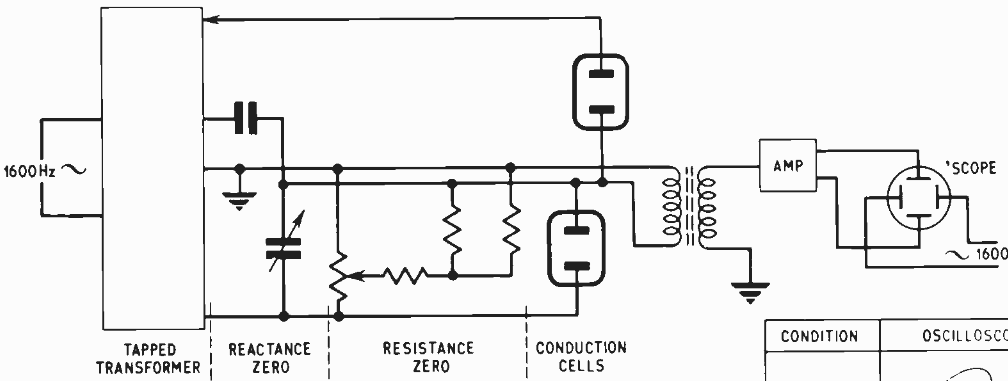


Fig. 9b (above). Typical conductance salinometer circuit

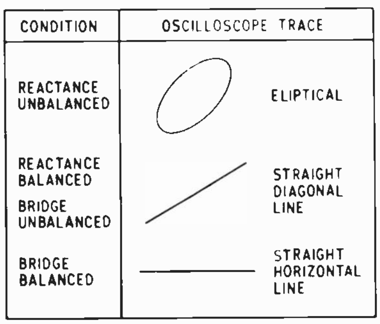
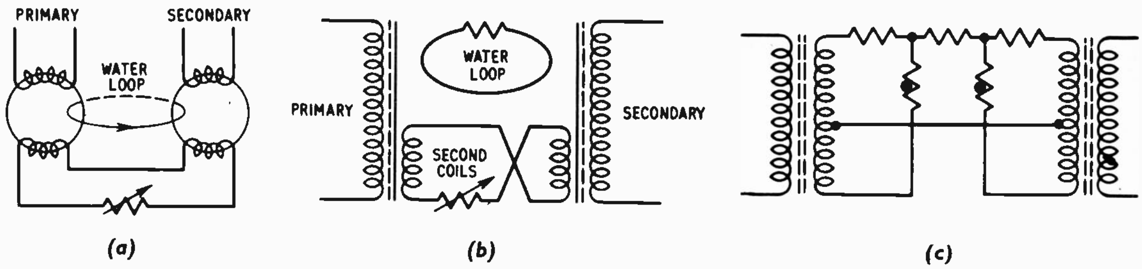


Fig. 9c (right). Traces obtained on oscilloscope



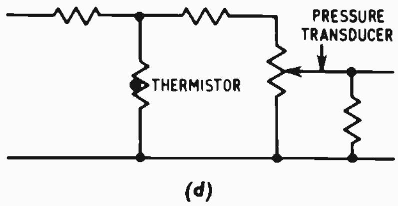


Fig. 10. Details of induction salinometer

Fig. 10a. Coil system of inductive conductivity sensor

Fig. 10b. Theoretical circuit of sensor

Fig. 10c. Circuit that will give approximately the correct compensation for a temperature change over a limited range

Fig. 10d. Pressure compensator

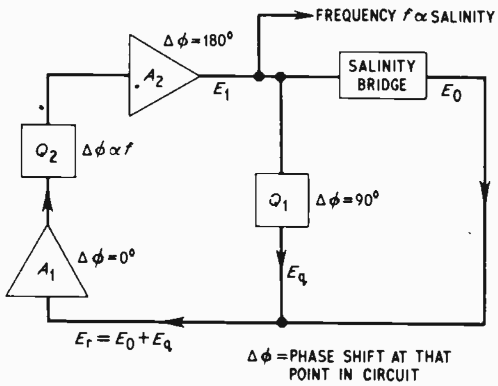


Fig. 11a. Paralog system

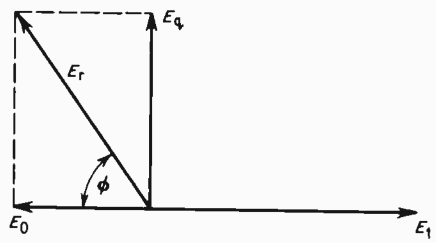


Fig. 11b. Vector diagram showing that phase ϕ varies with magnitude of E_0

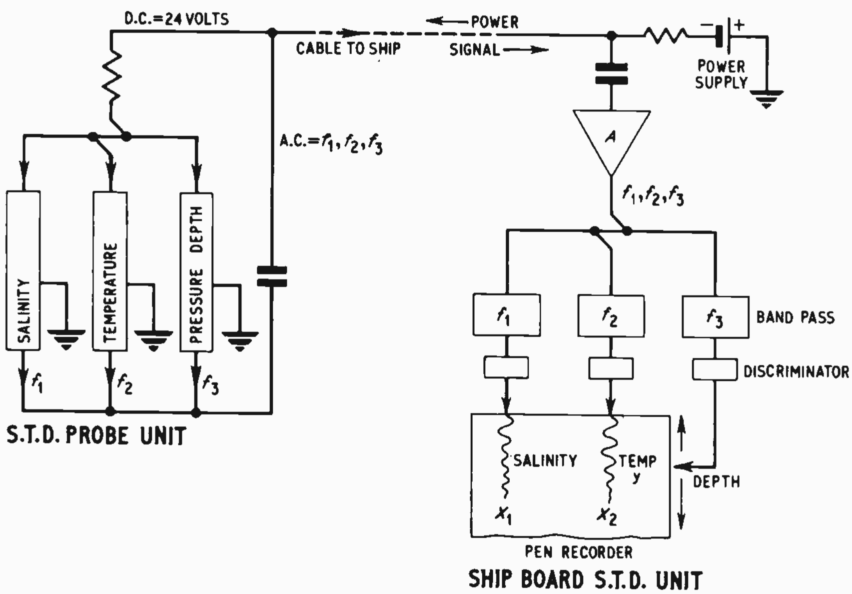


Fig. 11c. Salinity, temperature, depth probe

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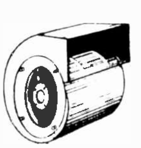

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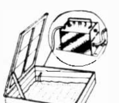

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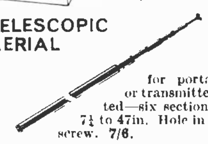

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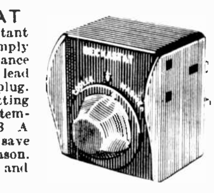

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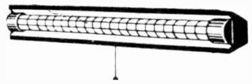


Make up one of these latest type heaters. Ideal for bathroom, etc. They are simple to make from our easy-to-follow instructions—uses silica enclosed elements designed for the correct infra-red wavelength (3 microns). Price for 750 watts element, all parts, metal casing as illustrated, **19/6**, plus 4/6 post and insurance. **Pull switch 3/- extra.**

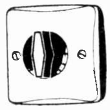
BREAST MICROPHONE

Fine American made dynamic type, adjustable on breast plate with neck straps, **7/6**, post 4/6.

12V BLOWER

Heavy duty motor with centrifugal blower coupled to one end. Ideal for car heater. **12/6**, plus 4/6 post.

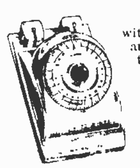
VARYLITE



Will dim incandescent lighting up to 600 watts from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob **£3.19.6**.

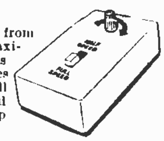
THIS MONTH'S SNIP

Electric Clock



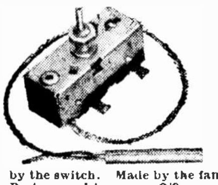
with 3 amp switch made by Smiths for Dreamland. These are mains driven and frequency controlled so are extremely accurate. The dial enables "switch-on" time to be accurately set. Switch off is 3 hours later or by manual control. Intended for switching electric blankets this needs only one setting for the season. Suitable also to control tape recorder, radio and lamp etc. In neat plastic case with mains lead and two outlet plugs. New and unused, **39/6**, post and insurance 3/6.

DRILL CONTROLLER



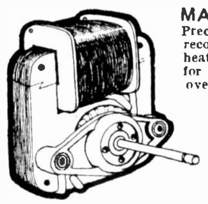
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **19/6** plus 2/6 post and insurance. Or available made up **25/-**, plus 2/6 post.

THERMOSTAT WITH PROBE



This has a sensor attached to a 15A switch by a 14in. length of flexible capillary tubing—control range is 20°F to 150°F so it is suitable to control soil heating and liquid heating especially when in buckets or portable vessels as the sensor can be raised out and lowered into the vessel. This thermostat could also be used to sound a bell or other alarm when critical temp. is reached in stack or heap subject to spontaneous combustion or if liquid is being heated by gas or other means not controllable by the switch. Made by the famous Teddington Co., we offer these at **12/6** each. Postage and insurance 2/9.

MAINS MOTOR

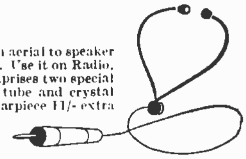


Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. **Snip at 9/6.** Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

WORKSHOP or REFRIGERATOR?

Many readers will have found to their dismay that the loft, garage or shed, which they so carefully converted into a workshop, is just a refrigerator in the winter—it can't be used, because it never gets warm until it is time to finish. The answer is "RADIANT ZONE HEATING". Benefit from this type of heating is immediate and low in cost. Our Radiant Zone Heaters (made by the famous Philips Company) are internally mirrored glass tubes with built in 500 watt heat and light elements. Four of these over the average size bench is all you need and will cost only about 4d. an hour to run. Ideal also under typists' desks. Keeps legs and knees warm, no matter how mini the "mini". Price is **27/6**, post and insurance 4/6 on one or any quantity.

RADIO STETHOSCOPE

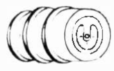


Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. **29/6**—twin stethoset instead of earpiece 11/- extra—post and ins., 2/9.

ELECTRIC CLOCK WITH 25 AMP. SWITCH

Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **39/6**, less than the value of the clock alone—post and insurance 2/9.

DEAC RECHARGEABLE BATTERY



3·6V-500mA hr.—size 1½×1⅞in. dia. really powerful will deliver 1 amp for ½ hour. Regular price **32/6** each—our price **12/6** each unused but ex-equipment.

Multi Purpose Neon Test Unit. Robust, useful and instructive, tests insulation, capacity, continuity, resistor, volume controls, also acts as signal injector, and L.T. fault finder, kit comprises neon indicator, 4-way wafer switch, ebonite tubes, resistors-condensers, terminals, etc., with diagram, only **9/6**, plus 2/- post and insurance.

5 Push Switch. One push operates mains on/off switch, the other four operate various on/off and change-over switches, **2/6**.

A.E.I. Fractional H.P. Motor. 200/250V 50/60c/s enclosed, continuous rating 1/40 h.p., ex. equip. Perfect order, **19/6**, plus 4/6.

Experimenting with ultra violet? Philips U.V. lamp, **16/6**; holder and control gear **19/6**.

G.E.C. Black Light Tube for experiments and special lighting effects—40 watt 2ft. tubes only, **14/6** each; holders and control gear, **19/6**, plus 4/6 post.

Clock Motor. 230V 50c/s synchronous—self-starting, **6/6**.

Pentode Output Transformer. Standard size, 40–1, ex-equipment but OK, **4/3** each, **48/-** doz. Post paid.

E.H.T. Condenser. 0–1 mfd. 5kV, **8/6** each.

Neon Mains Tester, 1/3 each, **12/-** doz.

Flood Lamp Control. Our dim and full switch is ideal for controlling photo flood lamps; it gives two lamps in series, two lamps full brilliance and lamps off. Similar control of other appliances can be arranged where used in pairs or where circuit can be split exactly in half. Technically the switch is known as a double-pole change over with off. Our price **4/6**.

Sub-Miniature Silicon Diodes. General purpose type with gold-plated leads, **1/-** each or 7/6 per dozen.

Message Tapes. 225ft. Tape on 3in. spools, normally 4/6 each, we offer 4 tapes for **12/6**.

White Circular Flex. Ideal for lighting drops, twin made by BICC. Usually 8d. yd. 100yd coil for **30/-**, plus 6/- postage.

Edgewise Control. Morganite, as fitted many transistor radios, 2K or 5K with switch, **2/6** each or 24/- per dozen.

12V Inverter. Full transistorised for operating a 20-watt fluorescent tube, size 6in. long × 1¾ × 1⅞. **£3.10.0.** Post and insurance 3/-.

Silicon Rectifier. Equiv. BY100 750mA 400V. 10 for **20/-**.

Miniature Pickup for 7in. records made by Cosmocode, crystal cartridge with sapphire stylus only **3/9** or 36/- dozen.

Telescopic Aerial for radio or transmitter, chrome plated, 6 section extends from 7¼in. to 47in., **7/6** each, £4 per dozen.

Midget Neons for mains indicators, etc., **1/3** each or 12/- dozen.

Compression Trimmers. Twin 100pF. **1/-** each; 9/- per dozen.

3in. PM Loudspeaker. 3 ohm, **12/6**; 80 ohm, **13/6**

Rotary Cam Operated Switch. 12 positions each of which close a separate pair of contacts except the last which leaves them all open. Contacts rated at 250V 16 amps, **15/-** each.

Rotary Cam Operated Switch. 4 positions: 1st position all contacts open; 2nd contact 1 closed; 3rd contacts 1 and 2 closed; 4th contacts 1, 2 and 3 closed. Contact rated 250V 16 amps, **8/6 each.**

Under Carpet Heating Element. Waterproof plastic covered element 12 yds. long, 900 watt, **12/6** each.

Breast Microphone. Fine American made dynamic type, adjustable or breast plate with neck straps, **7/6**, post 4/6.

Circular Fluorescent. 22 watt, 9in. diam. tube complete with choke, starter, holders and chrome clips, **29/6**, post, etc., 4/6.

Midget Relay twin 250 ohm coils, size approx. 1¼in. × 1in. × 1in. 4 pairs changeover contacts, **7/6** each.

P.O. Type Relay. Twin 200 ohm coils, size approx. 3in. × 2in. ¾in. 4 pairs changeover contacts, **8/6** each.

Printed Circuit Board, Edge Connector, solder terminations. 32 contacts, standard spacing for veroboard, etc. 6in. long but easily cut, **7/6** each, 80/- doz.

1,000W Fire Spiral, replacement for most fires, **1/3** each, 12/- doz.

50 ohm 50 watt Wire Wound Pot-meters, 8/6 each.

1 Meg Minature. Pot-meter Morganite standard ¼in. spindle 1/- each; 9/- per dozen.

1 Meg Miniature. Pot-meter Morganite preset screwdriver control. **9d.** each; 8/- per dozen.

Pre-Set 100K by Welwyn with integral bakelite knob, 1/- each; 9/- per dozen.

100K Pot-Meter. Miniature type with double pole switch and standard ¼in. spindle, by Morganite, **2/-** each; 18/- per dozen.

Blanketstat. Glass enclosed. Normally closed. Circuit will open should blanket overheat, **4/6** each.

Thermal Relay. Can be used to delay the supply of HT while heaters warm up, or will enable 15A loads to be controlled by miniature switches or relays. Regular list price over **£2**, price **7/6** each.

Siemens High Speed Relay. Twin 1,000 ohm coils. Platinum points changeover contacts—Ex equipment, **8/6** each.

Toggle Switch Bargain. 10A 250V normal one hole fitting **2/9** each; or 30/- doz.

Electric Lock. 24V coil, but rewindable to other voltages, **4/6** each.

When postage is not stated then orders over £3 are post free. Below £3 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD.

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circuit, two arms being the cells containing the sample and a reference standard, the third the balance control and zero setting trimmer, and the fourth having a capacitance zero trimmer to allow for the capacitance in the cells, across the reference resistor. To avoid electrolytic dissociation of the sea water damaging the electrodes, an a.c. source is used, between 500 and 5,000Hz. The cells must be of high resistance to avoid electrical heating.

The main difficulty of this circuit is the problem of measuring the variable resistor to 1 part in 50,000 as would be necessary to obtain the required accuracy. This may be overcome by using a transformer bridge. Other advantages of this form of circuit are that it has a negligible temperature coefficient and very little capacitance to earth. The number of turns must be controllable to 1 part in 100,000, and this is overcome by using a system of tapped coils shown in Fig. 9a.

Fig. 9b shows the complete bridge which will give an output as an oscilloscope trace indicating both resistive and reactive null-points.

INDUCTION CELLS

For *in situ* measurements of salinity the conductance bridge is quite unsuitable. The electrodes would be fouled very quickly with insoluble matter and the temperature would be difficult to control accurately or compensate for. These problems are not inherent, however, in the induction or electrodeless salinometer.

Figs. 10a and 10b show the principle of the induction cell. Two magnetically shielded toroids are wound on a non-inductive former with the water sample coupling them. On to each former a second coil is wound, one of which is in opposition to its primary, so that it may be used to give a null-reading at the balance point of the bridge, i.e. when the voltage induced in the secondary by the water link is balanced out by the voltage induced by the second coil system.

However, the salinity of a given sample is dependent on temperature and pressure in a rather complex way, and whilst some induction cells record pressure and temperature along with conductance for subsequent compensation, a more convenient way is to compensate within the instrument. Typical temperature and pressure compensating circuits are shown in Figs. 10c and 10d.

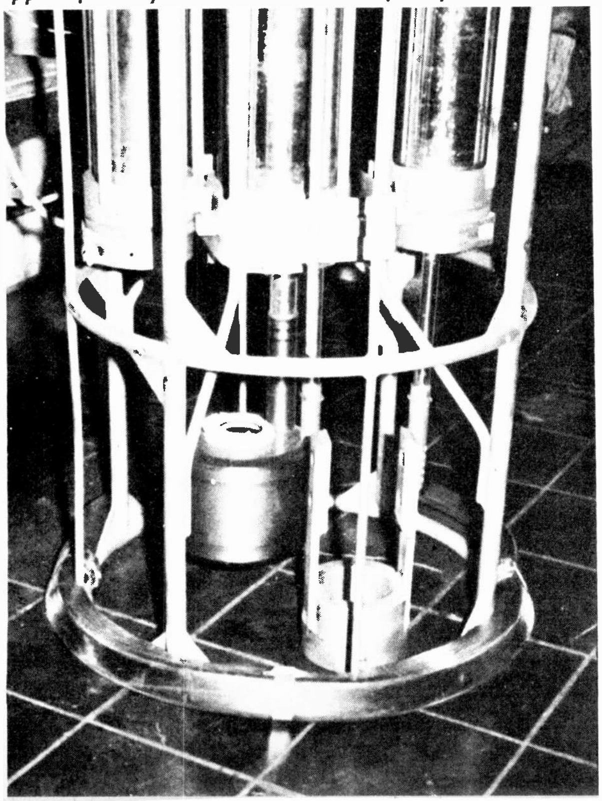
As mentioned earlier, the most efficient way of transmitting analogue data from a probe to a ship is in the form of a modulated frequency. This salinity system can be made to vary a frequency by use of positive feedback through a variable phase amplifier (Figs. 11a, 11b). In the paralog system positive feedback occurs through amplifiers A1 and A2. For this to occur the total phase shift around the circuit must be zero or 360 degrees, and the frequency of oscillation will change until the variable phase amplifier (Q2) can create this condition. The phase shift due to E_r, the combination of E_0 and E_1 shifted through 90 degrees, depends on the magnitude of E_0, which in turn, is dependent on the state of the sensor.

In a typical survey probe three such systems may be incorporated using respectively an induction cell, a thermistor and a vibrotron unit, giving out three different main frequencies modulated to give the variation in salinity, temperature and pressure of the water surrounding the probe.

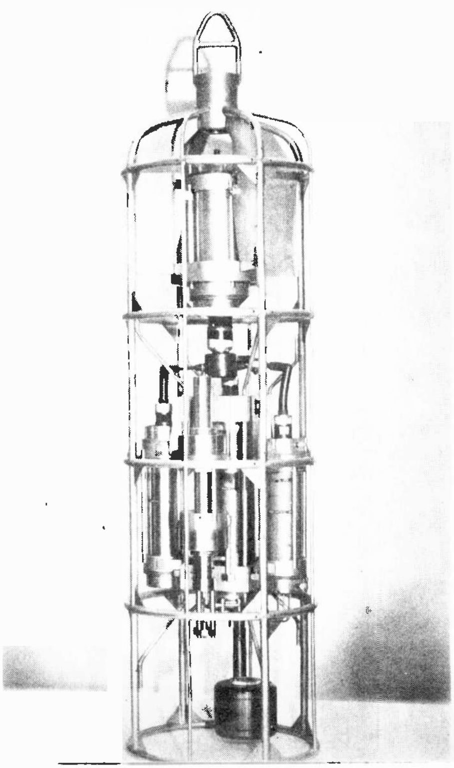
Fig. 11c shows how this information can be received on board the ship and analysed by use of narrow bandpass amplifiers and frequency modulation detectors to give a voltage dependent on frequency, and subsequently recorded as a plot of temperature and salinity against depth (equivalent to pressure) on an X1, X2, Y pen recorder.

To be continued

Close-up of the probe, showing inductive salinity sensor—upper of two cylinders near the base of the probe



Salinity, temperature, depth probe
(Plessey)



UNLIMITED!

A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merit.

SUPPRESSED ZERO CAR VOLTMETER

THE voltage appearing across the terminals of a car battery is a useful indication of the state of the battery and charging circuit. If a conventional voltmeter (say 0 to 15 volts) is connected across the battery it will be found that only a small portion of the scale is used, centred on the nominal battery voltage of 12 volts and extending a maximum of about 3 volts on either side, as the battery charges and discharges (see Fig. 1).

A Zener diode has the property of not conducting until a certain voltage, the Zener voltage, appears across it. The voltage drop across the diode then remains constant provided its wattage rating is not exceeded.

Consider now the circuit of the improved battery voltmeter (Fig. 2). A 9 volt Zener diode is connected in series with a conventional voltmeter circuit (moving coil meter plus multiplier resistance) which measures 6 volts full scale. If the voltage across the terminals of the instrument is less than 9 volts then the diode will not conduct and the meter will read zero. Suppose the voltage now rises to 12 volts. The diode will conduct and a voltage drop of 9 volts will appear across it, 3 volts will then appear across the voltmeter circuit which will then indicate half full scale deflection. If the voltage now increases to 15 volts, 9 volts will again appear across the diode and 6 across the meter, which will indicate full scale deflection. The meter will, therefore, only indicate voltages between 9 and 15 volts, thus spreading the useful part of the readings on a conventional voltmeter along the full scale length of the meter used.

In the prototype a 9 volt, ¼ watt Zener diode was used and the 0 to 6 volt voltmeter, M1, consisted of an ex-Government 5mA moving coil meter in series with a 3 kilohm potentiometer, VR1.

CONSTRUCTION

Construction consisted of mounting the two components on a small piece of Veroboard which was bolted to the back of the meter by the nuts on the meter terminal bolts. Connection to the meter terminals was by solder tags which were soldered to the board. A red lead and a black lead from the board formed the input connections to the instrument. Care was taken to observe the correct polarity and one lead was taken to the car chassis and the other to the ignition switch so that the voltmeter continuously monitored the battery voltage when the ignition was turned on.

CALIBRATION

Calibration was carried out by setting the potentiometer VR1 to its maximum resistance and connecting an accurate 12 volt supply to the instrument. The potentiometer was adjusted for half full scale deflection on the meter. The potentiometer was then sealed with a blob of wax. The original scale on the meter which read 0 to 5mA was covered with white paper, leaving the scale itself uncovered. The figures 9 to 15 were substituted for 0 to 5. The figure 12 appeared at the centre of the scale in place of the original 3.

A very neat and professional looking job was obtained with the aid of "Letraset" dry transfer letters. The legend VOLTS was also added.

This type of instrument is known as a suppressed zero voltmeter and this technique could be adapted for uses other than the one described. Care must be taken not to exceed the manufacturer's published wattage ratings of the diode. The prototype has been in use in the author's car for some months and has proved very useful.

P. A. Graves,
Westcliff-on-Sea,
Essex.

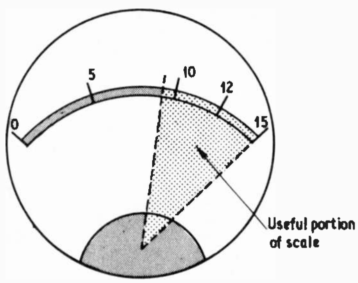


Fig. 1. The small segment of the scale that is used in conventional car voltmeters

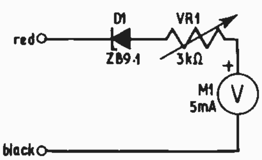
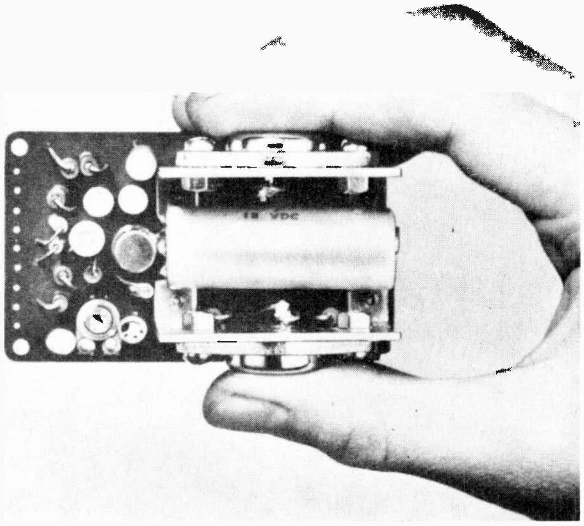


Fig. 2. Circuit diagram of the improved car battery voltmeter

SINCLAIR Z.12 12 WATT INTEGRATED HI-FI AMPLIFIER & PRE AMP

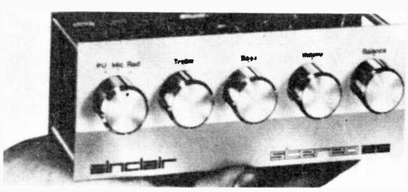


12 watts R.M.S. continuous sine wave output.

This is the recommended amplifier for those requiring greater power than that provided by the IC.10. This eight transistor amplifier is the most successful of its kind ever designed. It has an excellent power to size ratio and is easily adapted to a wide variety of applications. The Z.12 performs satisfactorily from a wide range of voltages and it can easily be run from car batteries. This true 12 watt amplifier comes to you ready built, tested and guaranteed together with useful manual of circuits and instructions for matching the Z.12 to your precise requirements. Two may be used for stereo, when the Sinclair Stereo 25 will be found the ideal control unit for use with it.

Size—3in x $1\frac{3}{4}$in x $1\frac{1}{4}$in. Class B Ultralinear Output: Frequency response from 15 to 15,000Hz ±1dB: Output suitable for loudspeakers from 3 to 15 ohms impedance. Two 3 ohm speakers may be used in parallel: Input 2 mV into 2K ohms: Output 12 watts R.M.S. continuous sine wave (24 watts peak); 15 watts music power (30 watts peak) Power requirements 6—20V d.c. from battery or PZ.4 Mains Supply Unit. Ready built, tested and guaranteed.

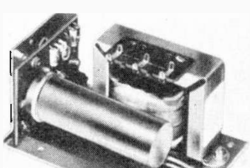
89/6



SINCLAIR STEREO 25

De Luxe Pre-amp and Control Unit for IC.10 or Z.12 Stereo assemblies. Switched inputs for P.U (equalised to R.I.A.A. curve from 50 to 20,000 Hz ±1dB), Radio and auxilliary. Supplied ready built with very attractive solid brushed and polished aluminium front panel. Control knobs for Bass/Treble/Volume/Balance/Input are solid aluminium. Size—$6\frac{1}{2}$ x $2\frac{1}{2}$ x $2\frac{1}{2}$in plus knobs. Built, tested and guaranteed.

£9.19.6



SINCLAIR PZ4

STABILISED MAINS POWER SUPPLY UNIT

Heavy duty transistorised power supply unit to deliver 18V d.c. at 1.5A. Designed specially for use with two Z.12 or IC.10 Amplifiers together with Stereo 25. Built, tested and guaranteed.

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SINCLAIR MICROMATIC

The world's smallest radio

This fantastic little British pocket receiver is available in kit form to build for yourself or ready built, tested and guaranteed. Its range and selectivity must be experienced to be believed; its power and quality everything you could want. The Micromatic tunes over the medium waveband and has A.G.C. to counteract fading from distant stations. Bandpass tuning makes reception of Radio 1 easier; in fact, you will find your Micromatic performing where other sets cannot be heard at all. The neat black case with aluminium front panel and tuning control give the Micromatic elegantly modern appearance.

- High quality magnetic earpiece
- Choice of many stations
- Plays anywhere

Kit in fitted pack with earpiece, solder and instructions. **49/6**

Built, tested and guaranteed. **59/6**

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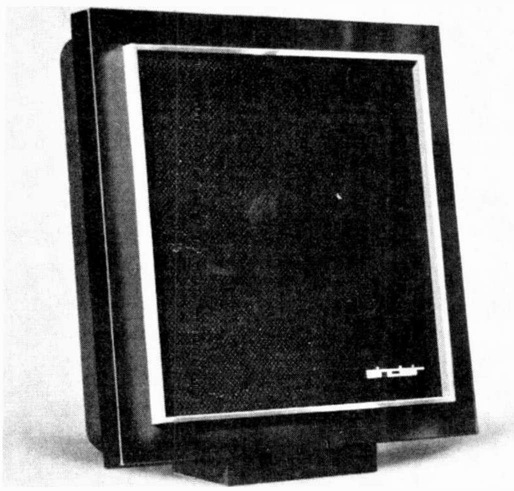
SINCLAIR Q.14



the most challenging loudspeaker design in years

It is more than a matter of saving money when you choose the Q.14. This is the loudspeaker that delights experts and critics alike for its find forward quality, its clarity and exceptional adaptability. Designed on original lines and from unusual materials, the Q 14 will easily carry up to 14 watts and has very smooth response from 60 to 16,000 Hz. Size—9¾in square x 4¾in deep, with matt black finish and solid aluminium bar embellishment. Input impedance—8 ohms.

The Q.14 costs about a quarter of what you might expect to pay for a good stereo speaker system. A pair used with IC.10s or Z.12s and the Stereo 25 will give you superb high fidelity to stand comparison with far costlier equipment.

Try the Q.14 in your own home without delay. If it does not delight you, send it back and your money including cost of postage will be refunded in full.

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GUARANTEE Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full at once and without question. *Full service facilities available to all purchasers.*

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Bargain—Car Radios. Our Price **9 gns.** Retail value 16 gns. Negative or positive earth (switched) fully transistorised (12v) medium and long waves. Speaker and fitting kit supplied at no extra cost. P/p. 5/-

Intercom/Baby Alarm System. Fully transistorised ideal for home, office or workshop. Robust construction, offered at a fraction of retail price **47/6** + 2/6 p/p.

Sonotone 9TA and 9TA/HC. Diamond Cartridge brand new, boxed in manufacturers' carton **49/6** + 2/6 p/p. **Acos** GP 91-1 and GP 91-3 stereo compatible cartridges, new in sealed manufacturers' cartons **22/6** + 2/6 p/p

TR10 Stereo Moving Magnet Cartridge Model AD76K. Diamond Stereo LP Stylus. Frequency response 20-20,000 c/s output 7mv tracking pressure 2 grammes ± 0.5 grm. Fully guaranteed. Price **85/-** p/p free.

BASF TAPE	LONG PLAY	
5in.	900ft.	**17/-**
5¾in.	1200ft.	**21/6**
7in.	1800ft.	**33/-**

Bargain—Changer Decks at Lowest Prices Ever

Plinth WB1 **£2.15.0**	Garrard 1025	p/p. 7/6	**£8. 0.0**
	Garrard 2025	p/p. 7/6	**£8.10.0**
Cover SPCI **£2.15.0**	AT60 Mk. II	p/p. 8/6	**£12.19.6**
	SP25 Mk. II	p/p. 8/6	**£12. 0.0**
	3500 with Son 9TA Cart		**£10.10.0**

The greatest HI-FI Budget system to-day—Can't be beaten—price or quality anywhere—look at these great features—then compare.

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Teleton F2000 tuner amp. AM-FM with multiplex decoder and A.F.C.—2 x 5w channels R.M.S. Bass Volume Treble Balance controls, a truly outstanding unit	35 8 11
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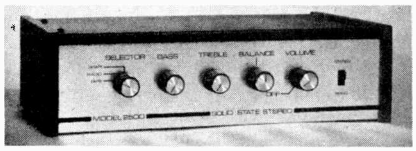
Plinth and perspex cover	7 0 0
	£70 16 10

Exclusively offered by SBE at the remarkably low price of £59 gns.

4 Watt Transistorised Amplifier with integral stabilised power unit. Complete ready built and tested, with volume and tone control on flying lead. Retail price £6.15.0. Now offered at **79/6** p/p 2/6.

Beautiful oiled teak enclosure to suit EMI 13 x 8in. speakers. Retail value £8.15.0. Our low-low price Only **99/6** plus 8/- p/p.

This month's SBE offer 5 x 5W transistorised stereo amplifier. Undoubtedly a most remarkable offer—outstanding performance, comparable with amplifiers in the £25-£30 price range. Brief specification includes volume, bass, treble, balance control, stereo, mono, switch, inputs, sockets, tape tuner pick up AUX. Being Manufacturers' distributors of this fine stereo amplifier, as an initial promotion we are prepared to offer this unit at fractionally above cost for a limited period only. **15 gns.** p/p free.



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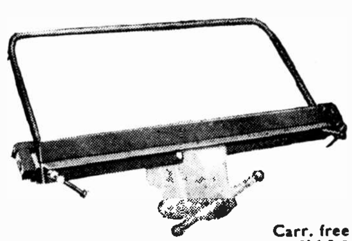

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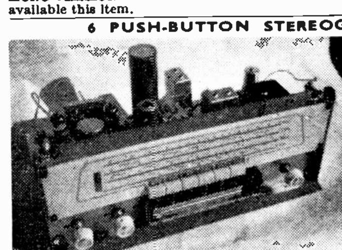

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