PRACTICAL

ELECTRONICS

SEPTEMBER 1968

PRICE 2/6

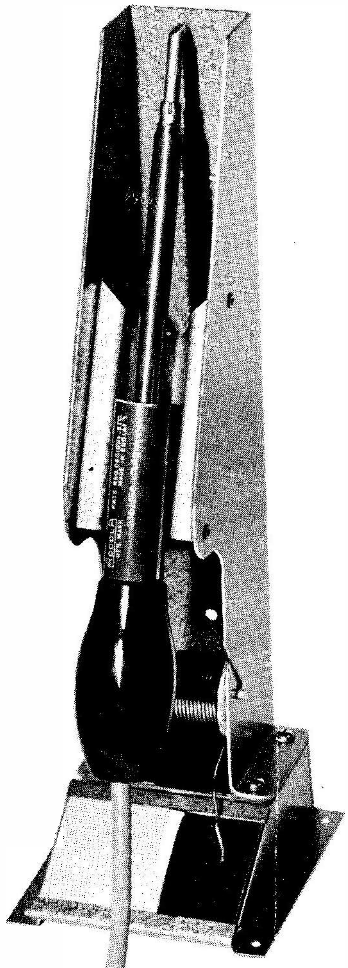
ADCOLA

PRODUCTS LIMITED
(Regd Trade Mark)

SOLDERING EQUIPMENT

for the

DISCRIMINATING ENTHUSIAST



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

APPLY DIRECT TO:

SALES & SERVICE DEPT.
ADCOLA PRODUCTS LTD.
ADCOLA HOUSE
GAUDEN ROAD
LONDON, S.W.4
TELEPHONE 01-622 0291

ORGAN BUILDERS! SILICON N.P.N. TRANSISTORS, ALL INDIVIDUALLY TESTED IN PUBLISHED DIVIDER CIRCUIT! GOLD-PLATED LEADS FOR EASY SOLDERING! Unbeatable value at **1/6** each or **£5/-/-** per 100.

TRANSISTORISED FLUORESCENT LIGHT. 8 WATT 12in TUBE. Current drain only 700mA! Complete and tested **£2/19/6** only! Or in kit form:

Case		**7/6**
Transistor		**10/-**
Lamp holders—	pair	**4/-**
Condensers, etc.		**3/-**
Transformer (on printed circuit)		**13/6**
Tube		**8/-**

TRANSISTORS
OC200, OC203, OC204, all at **2/-** each.
ASY22, 2N753, BSY28, BSY65, 2G344A, 2G345A, 2G345B, 2G371A, 2G378A, all at **1/6** each.
Transistors similar to OC44, OC71 and OC72, all **1/-** each.
Unmarked, untested transistors, **7/6** for 50.

LIGHT SENSITIVE TRANSISTORS (similar OCP 71), **2/-** each.
30 watt transistors (ASZ17), **10/-** each.

DIODES. Very low leakage. Make excellent detectors, also suitable for keying electronic organs, **1/-** each, 20 for **10/-**.

RECTIFIERS
BY100, 800 p.i.v., **2/6** each, **24/-** per doz., **£7/10/-** per 100, **£50** per 1,000.
BYZ13, 6-amp, 400 p.i.v., available on same terms.

MULLARD POLYESTER CAPACITORS
FAR BELOW COST PRICE!

0·001µF	400 volts	**3d**	0·02µF	200 volts	**3d**
0·0015µF	400 volts	**3d**	0·15µF	160 volts	**6d**
0·0018µF	400 volts	**3d**	0·22µF	160 volts	**6d**
0·0022µF	400 volts	**3d**	0·27µF	160 volts	**6d**
0·01µF	400 volts	**3d**	1µF	125 volts	**1/-**

VERY SPECIAL VALUE! Small Silver-mica, Ceramic, Polystyrene Condensers. Well assorted. Mixed types and values. **10/-** per 100.
PAPER CONDENSERS, MIXED BAGS, 0·0001 to 0·5µF. **12/6** per 100.

RESISTORS! Give-away offer! Mixed types and values, ¼ to ½ watt. **6/6** per 100, **55/-** per 1,000. Individual resistors **3d** each. Also ½ to 3 watt close tolerance. Mixed values. **7/6** 100, **55/-** 1,000.
WIRE-WOUND RESISTORS. 1 watt to 10 watts. Mixed bags only. 16 for **10/-**.

RECORD PLAYER CARTRIDGES
ACOS

GP	67/2	Mono.	**15/-** complete with needles.
GP	91/3	Stereo Compatible	**£1/-/-** ,,
GP	93/1	Stereo Ceramic	**£1/5/-** ,,
GP	94/1	Stereo Ceramic	**£1/5/-** ,,

Small pick-up arms complete with cartridge and needle, **10/-** only.

TRANSISTORISED SIGNAL INJECTOR KIT R.F./I.F./A.F. **10/-** only
TRANSISTORISED SIGNAL TRACER KIT **10/-** only

VEROBOARD

2½in × 1in	0·15in matrix	**1/1**	17in × 2½in	0·15in matrix	**11/-**
3¾in × 2½in	0·15in matrix	**3/3**	17in × 3¾in	0·15in matrix	**14/8**
3¾in × 3¾in	0·15in matrix	**3/11**	3¾in × 2½in	0·1in matrix	**3/9**
5in × 2½in	0·15in matrix	**3/11**	3¾in × 3¾in	0·1in matrix	**3/11**
5in × 3¾in	0·15in matrix	**5/6**	5in × 2½in	0·1in matrix	**3/11**
			5in × 3¾in	0·1in matrix	**5/6**

Spot Face Cutter **7/6**. Pin Insert Tool **9/6**. Terminal Pins **3/6—36**.

MULTIMETERS. 20,000 ohms per volt.
Ranges: a.c. 1,000V, 500V, 100V, 50V, 10V.
d.c. 250mA, 2·5mA, 50µA
d.c. 2,500V, 500V, 250V, 50V, 25V, 5V.
Resistance: 0/60kΩ and 0/6MΩ.
Special price **£4/-/-** only.

ELECTROLYTIC CONDENSERS

0·25µF	3 volt	4µF	4 volt	25µF	12 volt	100µF	16 volt
1µF	6 volt	4µF	12 volt	25µF	25 volt	125µF	25 volt
1µF	20 volt	4µF	25 volt	30µF	6 volt	320µF	4 volt
1·25µF	16 volt	6µF	6 volt	30µF	10 volt	320µF	10 volt
2µF	3 volt	8µF	3 volt	50µF	6 volt	400µF	6·4 volt
2µF	350 volt	8µF	12 volt	64µF	2·5 volt		
2·5µF	16 volt	10µF	6 volt	64µF	·9 volt	All at **1/-** each.	
3µF	25 volt	10µF	25 volt	100µF	9 volt		
3·2µF	64 volt	25µF	6 volt	100µF	16 volt	20 assorted (our selection) **10/-**.	

Orders by post to:
G. F. MILWARD, DRAYTON BASSETT, NEAR TAMWORTH, STAFFS.

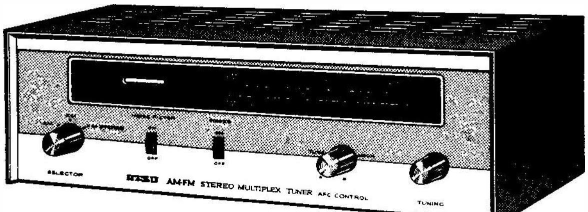
Please include suitable amount to cover post and packing. Minimum 2/-. Stamped addressed envelope must accompany any enquiries.

For customers in Birmingham area goods may be obtained from Rock Exchanges, 231 Alum Rock Road, Birmingham 8.

Lasky's Radio

SPECIAL INTEREST ITEMS!

OUTSTANDING HI-FI BARGAIN



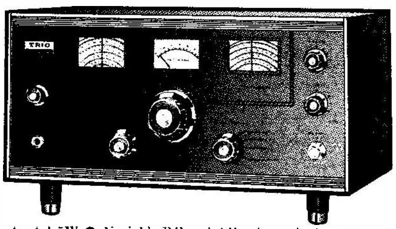
AFX-3U AM/FM STEREO TUNER

Superbly engineered by world famous manufacturer, the Model AFX-3U is an ultra sensitive AM/FM stereo multiplex tuner using 14 valves and 9 diodes. The extra wide bandwidth of the tuner and unique multiplex circuitry ensures the finest possible FM reception with optimum stereo separation of over 38dB. Stereo signal beacon with special circuitry unaffected by external noise, simplifies FM stereo broadcast selection. 3 gang variable condenser provides highly sensitive reception on both bands. The multiplex circuit is completely free from subcarrier leakage and permits direct tape recording without any beat noise interference. An MPX noise filter is also fitted. **Brief specification:** 14 valves, 2 Germanium diodes and 2 Silicon diodes. Frequency range: FM—80–108Mc/s, AM—535–1,605kc/s. Sensitivity: FM—1·9μV/98Mc/s, AM—2μV/100kc/s. Output FM/FM Stereo 2V, AM—3V. Frequency response: FM—20–20,000c/s. Distortion less than 1%. Special Circuits: FM Stereo indicator, AFC, Noise filter. Output for direct tape recording. Hammer enamel and brushed alloy finish. Cabinet size 14½ × 5 × 9½in. For 220/240V a.c. Mains (50 or 60c/s) operation. Complete with operating manual. **List Price 55 Gns.**

Lasky's Price 26 Gns. Carriage and Packing 7/6

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 115/250V 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.

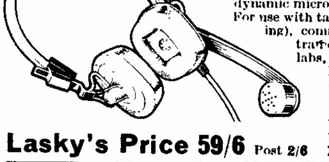
Lasky's Price £39.15.0 Carriage and Packing 12/6

MODEL JR-500SE

Brief spec.: Covers all the amateur bands in 7 separate ranges between 3·5 and 29·7Mc/s. Circuit uses 7 valves, 2 transistors and 5 diodes plus 8 crystals: output 8 and 500 ohm and 500 ohm phone jack. **Special features:** Crystal controlled oscillator ● Variable BFO ● VFO ● AVC ● ANL ● S meter ● SSB-CW ● Stand-by switch ● Special double gear dial drive with direct reading down to 1kHz ● Remote control socket for connection to a transmitter. Audio output 1 watt. For use on 115/250V a.c. Mains. Superb modern styling and control layout—finished in dark grey. Cabinet size 7 × 13 × 10in. Weight 18lb. Fully guaranteed, complete with instruction manual and service data.

Lasky's Price £68.0.0 Carriage and Packing 12/6

FOSTER HF-204 COMBINED MICROPHONE/HEADSET



High quality moving coil healphones and sensitive dynamic microphone combined in one lightweight unit. For use with tape recorders (provides constant monitoring), communications equipment, PA (crowd or traffic control), stage direction, language labs, etc. Extremely comfortable to wear for long periods—adjustable foam padded cushions, vinyl covered headband. Headphone imp. 8Ω, max. input 100mW. Microphone imp. 25Ω. Weight 8·8oz. • Single cable contains both headphone and microphone leads. **List Price 7 Gns.**

Lasky's Price 59/6 Post 2/6

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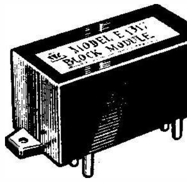
CONSTRUCTORS BARGAINS



NEW LASKY'S SOLID STATE INCAPSULATED MODULES

7 completely new special function circuit modules. Size of each module only 2¼ × 1½ × ⅞in. Ready for immediate use—just connect to power source (usually 9V batt.), input and output. Incapsulated modules are shock proof and almost indestructable. Complete with full instructions. **Post 1/6 each.**

E-1311 Phono Pre-amp Module—max. output 3V, RMS, input 50mV, input imp. 100Ω, 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/-**

TEST EQUIPMENT

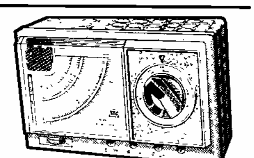
MINIMETER BARGAIN

TTC Model C-1000

A really tiny 1,000 O.P.V. pocket multi-tester with "big" meter performance. Precision 2 jewel meter movement. Hand calibrated to ±3% accuracy on full scale of d.c. ranges, 4% on a.c. ranges. 2¼in square meter. SPECIFICATIONS a.c./V ranges: 0–10, 50, 250, 1,000V at 1K/O.P.V. a.c./V ranges: 0–10, 50, 250, 100V at 1K/O.P.V. D.c.current: 0–1–100mA. Resistance: 0–150K/ohms (3,000 ohms centre scale). Decibels: −10 to +22dB. Operated on one penlight cell. Two colour buff/green case—size only 3½ × 2½ × 1in. Click stop range selection switch. Ohms zero adjustment. Complete with test leads, battery and instructions with circuit data.

Lasky's Price 39/6 Post 2/6

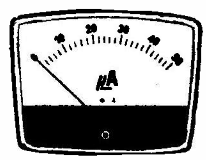
TTC Model C-1051



A completely new design 20,000 O.P.V. pocket multimeter with built-in thermal protection circuit and mirror scale. Exceptionally large easy to read meter with D'Arsonval movement. Colour coded scales. Single positive click-in, recessed selection switch for all ranges. Ohms zero adjustment. Range spec. a.c. volts: 0–6–30–300–1,200V at 10K/ohms/V. D.c. volts: 0–3–15–150–300–1·2KV at 20K/ohms/V. Resistance: 0–60K–6megs. D.c. current: 0–60μA - 300mA. Decibels: −20dB to +17dB. Hand calibration gives extremely high standard of accuracy on all ranges. Uses one 1½V penlight battery. Strong impact resistant plastic cabinet—size only 4½ × 3½ × 1½in. Two colour buff/green finish. Complete with test leads and battery. **Orig. list price £5.5.0.**

LASKY'S PRICE 75/- Post 2/6

LASKY'S CLEAR PLASTIC PANEL METERS



Precision made in Japan by HIOKI. Each meter boxed and fully guaranteed with all fixing nuts and washers. Sizes are of front panel. Add 1/6 P. on each. (Quotes for quantities.)

Type KR-52 3 × 2½in (illustrated).

1mA	38/6	50μA	56/-
5mA	38/6	1mA S Meter	39/6
100mA	38/6	100μA	52/6
300V	35/-	500μA	45/-

Type MK-38A 1⅝in square

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 MK-45A 2in square

1mA	29/6
5mA	28/6
100mA	28/6
300V	28/6
50μA	49/6
1mA S meter	32/6
100μA	42/6
500μA	35/-

Type KR-65 3½ × 3in

1mA	38/6
5mA	37/6
100mA	38/6
300V	36/-
50μA	59/6
1mA S meter	42/-
100μA	56/-
500μA	46/-

Type MK-65A 3in square

1mA	38/6
5mA	36/-
100mA	32/6
300V	36/-
50μA	59/6
1mA S meter	38/6
100μA	52/6
500μA	42/-

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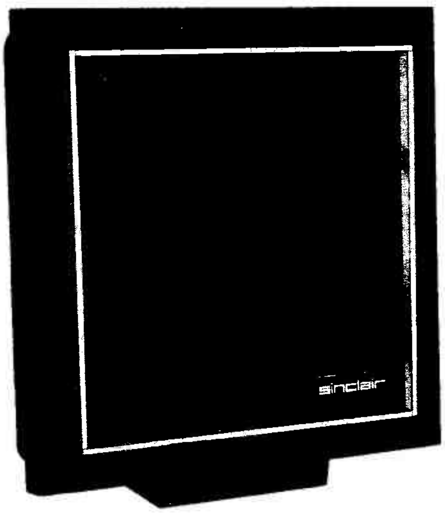
Buying Sinclair is an excellent investment. Performance and quality are of standards found in far costlier equipment. You save with Sinclair—and everything is guaranteed.

SINCLAIR DESIGNS ARE ALL-BRITISH

SINCLAIR Q.14

low priced hi-fi speaker

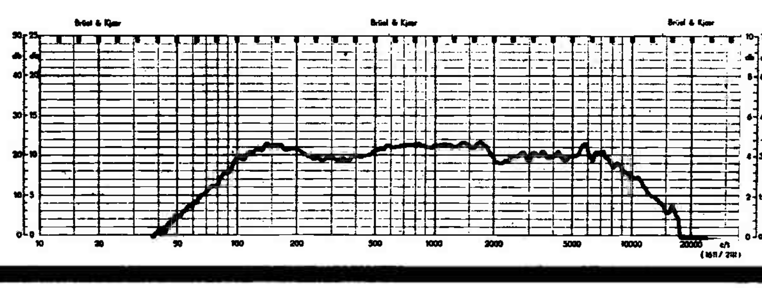


60–16,000Hz: 8 ohms impedance: loading up to 14 watts; acoustically contoured pressure chamber; brilliant transient response; polarised connections; detachable base.

£7.19.6

It costs about a quarter of what you would expect to pay for a good stereo speaker system when you choose Q.14s. This is because of the considerable research and experimentation into the acoustic properties of special materials carried out into the design of this excellent speaker. It resulted in an instrument so outstandingly good that experts, reviewers and the public alike were unanimous in their praise for the Q.14 at this year's Audio Fair. The Q.14 is very compact, measuring only 9¾in square on its face by 4¾in deep. Its unusual contours permit it to be positioned where no ordinary speaker could be used to advantage. The neat black matt finish with aluminium bar trim keep this speaker pleasantly in conformity with modern design trends.

Hear the Q.14 in your own home. If you are not delighted with it, send it back, and your money, including cost of return postage to this office will be refunded in full.



A fantastic performance curve

This independently made B & K curve shows results to compare favourably with much dearer speakers. It shows why the Q.14 performs so well. We cannot show transient response here —this is something you must hear for yourself. The quality is startlingly good. Impedance—8 ohms; loading up to 14 watts R.M.S.

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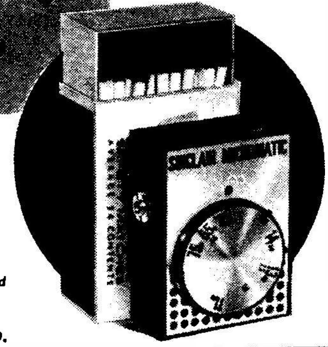
The world's smallest radio
IN A NEW PACK

For those other constructors who enjoy building their own equipment, the Sinclair Micromatic Kit now comes in a good-looking new presentation pack. It is complete down to a free, generous supply of solder. The moulded polystyrene interior shaped to fit each component enables you to check the contents in an instant, and helps to make building even easier and surer. Today, the Micromatic is better than ever—more powerful, better sounding, for the hi-fi quality magnetic ear-piece assures superb listening. But whether you prefer to build it, or buy your Micromatic ready built—don't be without one. It is the best and the smallest personal radio in the world—and it's British.



SINCLAIR MICROMATIC

The Sinclair Micromatic measures only $1\frac{4}{5} \times 1\frac{3}{10} \times \frac{1}{2}$in and is completely self-contained except for the special magnetic earpiece which switches the set on when plugged in. Slow motion tuning over the medium waveband brings in a choice of stations loudly and with superb selectivity. Available in kit form or ready built. The two Mercury cells, type RM675 give months of life with normal use.

- PLAYS ANYWHERE
- FANTASTIC POWER
- TUNES OVER MEDIUM WAVES

Complete kit, inc. earpiece, free solder and instructions in new pack **49/6**

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

Mallory Mercury Cell RM.675 (2 needed) each 2/9.

IDEAL FOR USE WITH CAR BATTERIES

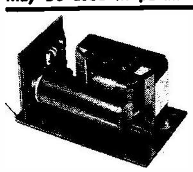
SINCLAIR Z.12 COMBINED 12 WATT HI-FI AMPLIFIER & PRE-AMP.

The most powerful amplifier for its size you can buy

No constructor's amplifier has ever achieved such success as the Sinclair Z.12. It has fantastic power-to-size ratio, and is easily adaptable to a wide range of applications. The Z.12 will operate from batteries or mains supply unit PZ.4, and give superb stereo reproduction. Thousands are in use throughout the world—in hi-fi, electronic music instruments, P.A., intercom systems, etc. This true 12 watt amplifier comes to you ready built, tested and guaranteed together with the Z.12 manual which details control circuits enabling you to match the Z.12 to your precise requirements. For complete listening satisfaction, use your Z.12 system with Q.14 loudspeakers.

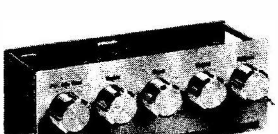
3in × $1\frac{3}{4}$in × $1\frac{1}{4}$in ● Class B Ultralinear output. ● 8 Special Transistors. ● 15–50,000Hz ± 1dB. ● Suitable for 3, 5, 8 or 15Ω speakers. Two 3-ohm speakers may be used in parallel. ● Input—2mV into 2kΩ. ● Output—12 watts R.M.S. continuous sine wave (24W peak). 15 watts music power (30W peak). ● Ready Built. Tested and Guaranteed. ● Complete with Z12. manual.

Built, tested and guaranteed with Z.12 manual **89/6**



SINCLAIR PZ.4

HEAVY DUTY STABILISED POWER PACK designed to supply power requirements of up to two Z.12 amplifiers and Stereo 25 control unit. For operation from A.C. mains 200–250V/50Hz. Delivers 18V d.c. at 1·5A. Supplied ready built, tested and guaranteed. **99/6**



SINCLAIR STEREO 25

De-luxe Control/Pre-amp Unit for Z.12 stereo system. Sensitivity Mic. 2mV into 50kΩ: P.U. —3mV into 50kΩ: Radio —20mV into 4·7Ω. Equalisation correct to within ±1dB on RIAA curve from 50 to 20,000Hz. Supplied ready built with attractive brushed and polished aluminium front panel and knobs to match. Selector/Bass/Treble/Vol./Balance controls.
BUILT, TESTED and GUARANTEED **£9.19.6**

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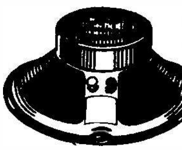
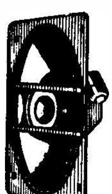


FANE 122/17. 12in 25 WATT HEAVY DUTY HI-FI LOUD SPEAKERS. With high efficiency Anti stropic Ferrite magnet. 17,000 gauss. Imp. 3-5 ohms. Brand new and guaranteed. List Price £12. **LIND-AIR PRICE £8.19.6.** P. & P. 7/6.

E.M.I. COMBINATION LOUD SPEAKERS. 13¼ x 8¼in. Elliptical with two 3¼in dia. Tweeters. Imp. 15 ohms. Power handling 10 watts. Brand new and guaranteed. List price £8.5.0.. **LIND-AIR PRICE 99/6.** P. & P. 7/6. (Also available without tweeters **59/6.** P. & P. 7/6.)



FANE 301 3in TWEETERS Imp. 3-5 ohms. 17,000 gauss. 12 watt. Brand new and guaranteed. List price £3.15 0. **LIND-AIR PRICE 59/6.** P. & P. 3/6.

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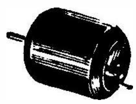
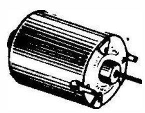
MOTOR BARGAINS

Ideal for mode makers, record players, tape decks, etc

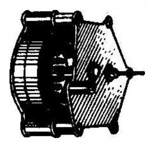


6.3 d.c. Motor. 10,900 r.p.m. at 230mA. 1¼in × 1in dia. Shaft ¼in long × 3/64in dia. **9/6.** P. & P. 2/6.



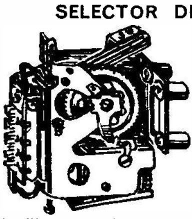
9V d.c. Gram deck replacement motor. 2in × 1¼in dia. Shaft ½in long × 3/32in. **17/6.** P. & P. 2/-. Two for **30/-** P. & P. 2/-.

SYNCHRONOUS CLOCK MOTORS



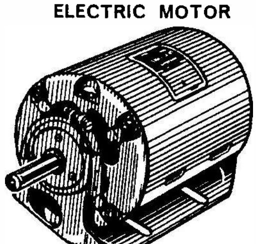
Geared for 40 revolutions per hour. 230v 50 cycle, with mounting flanges. Size approximately 1¼in deep x 2¼in diameter. **ONLY 22/6.** P. & P. 2/6.

SELECTOR DRIVE



Numerous applications Electro-magnet and brass tooth wheel. A switch wafer and contacts are coupled to this and arranged to be on for 10 pulses and off for 15. An Auxiliary contact is normally on but off 1 in every 25. Complete with suppressor, resistors, plus series contact for continuous operation. Ideal window displays, switching lamps, models, etc. 12V or 24V d.c. Brand new and boxed, **12/6.** P. & P. 2/6.

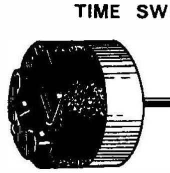
ELECTRIC MOTOR



FEW ONLY LEFT

Made by Crompton Parkinson. Single phase ¼ h.p. Motor. 230/250V, 50 cycles. 1·3 amps. 1,425 r.p.m. Continuous rating. Spindle 1¾ x ½in dia. Overall size less spindle approx. 8 x 6in. Perfect condition. A bargain for the work bench. **ONLY 69/6.** Carr. 20/-.

DELAY ACTION TIME SWITCH



Made by Smiths. A.c. operation 200 / 250V Double pole. Will give time delays from 0–10 minutes. Size 2¼in dia. x 2¾in long inc. ¾in x 3/16in dia. spindle. **BARGAIN PRICE 17/6.** P. & P. 2/6.

ERSIN Multicore 5 CORE SOLDER

for quick, easy, reliable soldering

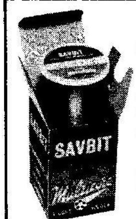
Contains 5 cores of non-corrosive flux, instantly cleaning heavily oxidised surfaces. No extra flux required. Ersin Multicore Savbit Alloy also reduces wear of copper soldering iron bits.

SIZE 5 HANDY SOLDER DISPENSER

Contains 10 ft. coil of 18 s.w.g. Ersin Multicore Savbit Alloy. 2/6 each.

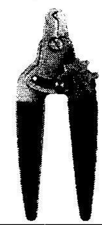
SIZE 15 SOLDER DISPENSER

Contains 21 ft. coil of 60/40 Alloy, 22 s.w.g. Ideal for small components, transistors, diodes. etc. 3/- each.



SIZE 12

Ideal for home constructors. Contains 90 ft. of 18 s.w.g. Ersin Multicore Savbit Alloy on a plastic reel. 15/- each.



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Strips insulation cleanly and quickly, fitted with unique 8 gauge wire selector. Plastic handles. 9/6 each.

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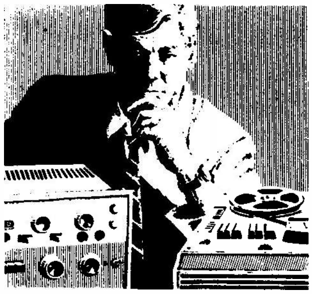

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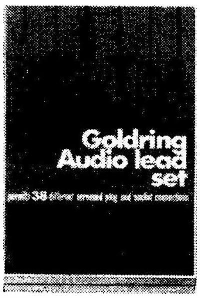
With a 3-pin DIN plug on one end and 3.5mm jack on the other? With the Goldring Screened Audio Lead Set, you've got it—instantly—at your finger tips. *And 37 other different* equipment-to-equipment connections as well. With cable lengths of 20", 40", or 60" according to the combinations you use. All tidily and instantly to hand in a small neat storage box. There's no longer any need to have an unwieldy collection of dozens of different leads . . . and still be short of the right one! This new Goldring set will give you most of the connections you're ever likely to want—without searching for cables and plugs, without soldering, without waiting, without further expense. The Goldring Audio Lead Set, from your Hi-Fi dealer, is a real investment at **£3.6.0**



*Goldring are now marketing an extremely useful range of individually packed leads, plugs, sockets and connections for audio enthusiasts.

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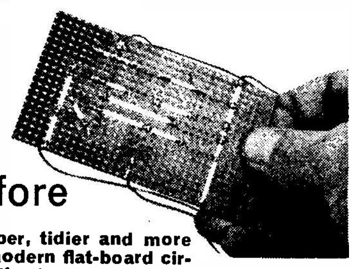
PEAK SOUND **Cir-kit**

INSTANT CIRCUIT SYSTEM

Better than anything you have ever used before



This is the quicker, cheaper, tidier and more efficient way to make a modern flat-board circuit. Unique "Cir-kit" adhesive copper strip and special matrix board enable you to work to professional standards with ease. Soldering is easier too, so are modifications. That is why "Cir-kit" is also widely used in labs., industry and by experimenters. A 5ft. spool, ⅛in. or 1/16in. wide. Costs only 2/-

"Cir-kit" 0·1in. Matrix Board is available in 3 sizes: **5 x 3¾in., 4/-; 2¾ x 3¾in., 2/6; 2 x 3¾in., 1/9.**

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In case of difficulty, please send direct, adding 4d. to value of order to cover cost of postage. **TRADE ENQUIRIES INVITED.**

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SEW PANEL METERS

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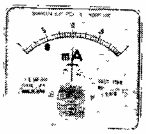
CLEAR PLASTIC METERS



5mA	37/6	300V d.c.	37/6
10mA	37/6	15V a.c.	37/6
50mA	37/6	300V a.c.	37/6
100mA	37/6	S Meter 1mA	39/6
500mA	37/6	VU Meter	59/6
1 amp.	37/6	1 amp. a.c.*	37/6
5 amp.	37/6	5 amp. a.c.*	37/6
10V d.c.	37/6	10 amp. a.c.*	37/6
20V d.c.	37/6	20 amp. a.c.*	37/6
50V d.c.	37/6	30 amp. 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	37/6	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.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.52P. 2½in square fronts

50μA	59/6	100-0-100μA	45/-
50-0-50μA	49/6	500μA	42/6
100μA	49/6	1mA	37/6

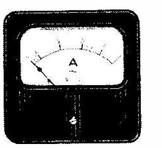
Type MR.85P. 4¼in × 4¼in fronts

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.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		

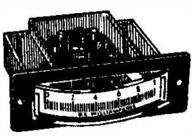
BAKELITE PANEL METERS



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 other moving coil.**



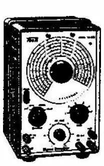
NEW RANGE OF "SEW" EDGEWISE METERS

MODEL PE70. Dimensions 3 17/32 × 1 11/32 × 2¾ 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		

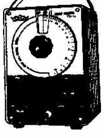
Post extra

TE-20D RF SIGNAL GENERATOR

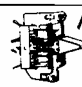


Accurate wide range signal generator covering 120kc/s to 500Mc/s on 6 bands. Directly calibrated. Variable RF attenuator, audio output. Xtal socket for calibration. 220/240V a.c. Size 140 × 215 × 170mm. Brand new with instructions. **£15.** Carr. 7/6.

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. **£16.** Carr. 7/6.



T.M.C. 1000 SERIES KEY SWITCHES

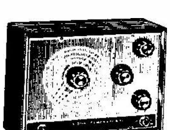
Brand New with knobs as follows.

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**; 2 way, 2 c/o., 4 c/o. **10/-**.

Post extra. Quantities available.

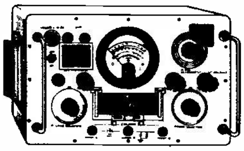
NOMBREX TRANSISTORISED TEST EQUIPMENT

All Post Paid with Battery



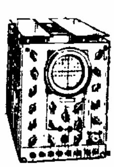
Model 22. Power Supply 0–15V d.c.	**£14.10.0**
Model 30. Audio Generator.	**£19.10.0**
Model 31. R.F. Signal Generator.	**£12.10.0**
Model 32. C.R. Bridge.	**£10.10.0**
Model 33. Inductance Bridge.	**£20.0.0**
Model 66. Inductance Bridge.	**£18.0.0**
Model 61. Power Supply.	**£6.10.0**

AVO CT.38 ELECTRONIC MULTIMETERS



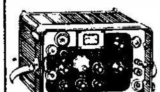
High quality 97 range instrument which measures a.c. and d.c. Voltage, Current, Resistance and Power output. Ranges d.c. volts 250mV–10,000V. (10megΩ–110megΩ input). D.c. current 10μA 25 amps. Ohms: 0–1,000mgΩ. A.c. volt 100mV–250V (with RF measuring head up to 250Mc/s). A.c. current 10μA–25 amps. Power 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



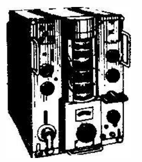
An excellent general purpose D/B oscilloscope. T.B. 2c/s–750 kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33mV/CM. Operating voltage 0/110/200/250V a.c. Supplied in excellent working condition. **£22.10.0.** Or complete with all accessories, probe, leads, lid, etc. **£25.** Carriage 30/-.

AM/FM SIGNAL GENERATORS



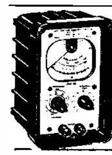
Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20–80Mc/s. AM/C.W./FM. Incorporates precision dial, level meter, precision attenuator 1μV-100mV. Operation from 12V d.c. or 0/110/200/250V a.c. Size 12 × 8½ × 9in. Supplied in brand new condition 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/-. With circuit diagrams. Also available **B.41** L.F. version of above 15kc/s–700kc/s. **£17.10.0** Carr. 30/-.

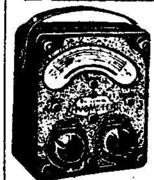
MARCONI CT44/ TF956 AF ABSORPTION WATTMETER



1 μ/watt to 6 watts

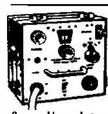
£20. Carr. 20/-.

AVOMETERS



Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions.
Model 47A **£9.19.6.**
Model 8 **£18.**
P. & P. 7/6 each.

CLASS D WAVEMETERS



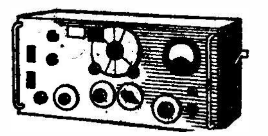
A crystal controlled hetrodyne frequency meter covering 1·7–8Mc/s. Operation on 6 volts d.c. Ideal for amateur use. Available in good used condition **£5.19.6.** Carr. 7/6. Or brand new with accessories **£7.19.6.** Carr. 7/6.

AUTO TRANSFORMERS

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

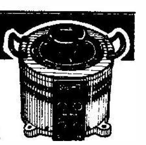
150 W.	**£1.12.6,**	P. & P. 3/–
300 W.	**£2.7.6,**	P. & P. 3/6
500 W.	**£3.10.0,**	P. & P. 6/6
1,000 W.	**£5.10.0,**	P. & P. 7/6
1,500 W.	**£6.10.0,**	P. & P. 8/6
3,000 W.	**£7.10.0,**	P. & P. 12/6
7,500 W.	**£15.10.0,**	P. & P. 20/–

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/–.
All aobve offered in excellent condition fully tested and checked.
TF. 1100 VALVE VOLTMETER, Brand New, **£50.** T.F. 1267 TRANSMISSION TEST SET, Brand New, **£75.**

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
3¼in 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. **12/6.** C90-90 mins. **17/6.** 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/–.

SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

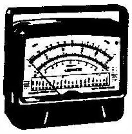
An extremely high quality oscilloscope with time base of 10Ω/sec. to 20m/sec. Internal Y amplifier. Separate mains power supply 200/250V. Supplied in excellent condition with cables, probe, etc., as received from Ministry. **£8.19.6.** Carriage 30/-.

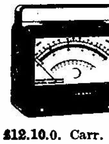
LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

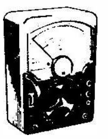
0–20kc/s. Output 5kΩ or 500 ohms. 200/250V a.c. offered in excellent condition. **£12.10.0.** Carriage 10/–.

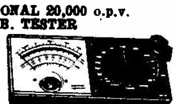
G. W. SMITH
& Co. (Radio) Ltd.
3-34 Lisle St., W.C.2
ALSO SEE OPPOSITE PAGE

MULTIMETERS *for EVERY purpose!*

LAFAYETTE DE-LUXE 100 KΩ/VOLT "LAB TESTER"

Giant 6½in. scale. Built-in meter protection. 0/·5/2·5/10/50/250/500/1,000V d.c. 0/3/10/50/250/500/1,000V a.c. 0/10/100μA/10/100/500 MA/2·5/10A. 0/1K/10K/100K/10M/10MΩ. −10 to 49·4dB **£18.18.0.** P. & P. 5/-.

LAFAYETTE

57 Range Super 50,000 O.P.V. Multimeter. D.c. Volts 125V-1000V. A.c. Volts 1.5V-1000V. D.c. Current 25μA-10 Amp. Ohms. 0-15 MegΩ. dB. −20 to +81dB. Overload Protection. **£12.10.0.** Carr. 3/6.

NEW MODEL 500.30,000 O.P.V.

with overload protection. Mirror scale. 0/0·5/2·5/10/25/100/250/500/1,000V. d.c. 0/2·5/10/25/100/250/500/1,000V. a.c. 0/50μA/5/50/500mA. 12 amp. d.c. 0/60/K6. Meg./60megohm **£8.17.6.** Post paid.

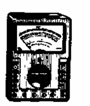
PROFESSIONAL 20,000 o.p.v. LAB. TESTER

Automatic overload protection, mirror scale. Ranges: 1/10/50/250/500/1,000 volts, d.c. and a.c. 0-500μA, 10mA, 250mA. Current: 0/20K, 200K, 2 megohm. Decibels: −20 to +22dB. **£5.19.6.** P. & P. 2/6.

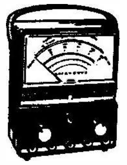
MODEL TE-70.

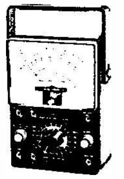
30,000 O.P.V. 0/3/15/60/300/600/1,200V. d.c. 0/6/30/120/600/1,200V. a.c. 0/30μA/3/30/300mA. 0/16K/160K/1·6M/16megohm. **£5.10.0.** P. & P. 3/-.

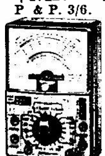
TE-51. NEW 20,000Ω/VOLT MULTIMETER.

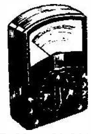
Overload protection mirror scale 0/6/60/120, 1,200V. a.c. 0/3/30/60/300/600/3,000V. d.c. 0/60μA/12/300 mA. d.c. 0/60K/6megohm. **85/-.** P. & P. 2/6.

MODEL 250J. 2,000 O.P.V.

0/10/50/500/2,500V. d.c. 0/10/50/500/2,000V. a.c. 0/2megohm. 0/250 mA. −20 to +36dB. **49/6.** P. & P. 2/6.

TE-900 20,000Ω VOLT GIANT MULTIMETER

6in. full view meter. 2 colour scale, overload protection. 0/2·5/10/250/1,000/5,000V d.c. 0/25/12·5/10/50/250/1,000/5,000V a.c. 0/50μA/110/100/500mA 10A d.c. 20K/200K/20 MΩ. **£15.** P. & P. 5/-.

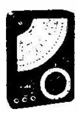
MODEL AS-100D. 100KΩ/VOLT

5in., mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1,200V. d.c. 0/6/30/120/300/600V. a.c. 0/10μA/6/60/300MA/12 Amp. 0/2K/200K/2M/200MΩ. −20 to +17dB. **£12.10.0.** P & P. 3/6.

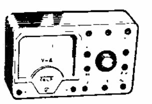
MODEL AF-105. 50KΩ/Volt.

Mirror scale, built-in meter protection. 0/.3/3/12/60/120/300/600/1,200v. d.c. 0/6/30/120/300/600/1,200 v. a.c. 0/30μA/6/60/300MA/12 Amp. 0/10K/1M/10M/100 MΩ −20 to +17 dB. **£8.10.0.** P. & P. 3/6.

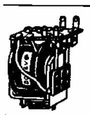
MODEL TE-12.

20,000 O.P.V. 0/0·6/30/120/600/1,200/3,000/6,000V. d.c. 1/6/30/120/600/1,200V. a.c. 0/60μA/6/60/600MA. 0/6K/600K/6meg./60. Megohm 50PF. 2 MFD **£5.19.6.** P. & P. 3/6.

MODEL TE 80. 20,000 O.P.V.

0/10/50/100/500/1,000V. a.c. 0/5/25/50/250/500/1,000V. d.c. 0-50μA. 5/50/500mA. 0/6K/60/K/600K/6 Meg. **£4.17.6.** P. & P. 3/-.

MODEL TE-10A.

200kΩ/Volt, 5/25/50/250/500/2,500 V. d.c. 10/50/100/500/1,000V. a.c. 0/50μA/2·5 mA./250 mA. d.c. 0/6K/6 megohm. −20 to +22dB. 10-0, 100 mfd. 0-100-0·1 mfd. **69/6.** P. & P. 2/6.

MODEL PT-34.

1,000 O.P.V.0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 KΩ **39/6.** P. & P. 1/6.

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.

MAGNAVOX 363 3-SPEED TAPE DECKS
4-track **£13.10.0.** Carriage Extra.

R.C.A. AR88 SPEAKERS
8in 3 ohm speakers in metal case. Black crackle finish to match our 88 Receivers. Available brand new and boxed with leads. **59/6.** Carr. 7/6.

DUBILIER NITROGEL CONDENSERS. Brand new. 8mF 800V, **8/6.** P. & P. 2/-; 2mF, 5,000V, **42/6.** P. & P. 5/-.

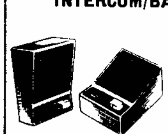
CT.53 SIGNAL GENERATORS. 8·9-15·5 and 20-300Mc/s. Output 1μV-100mV. Mains operated. Perfect condition less charts. **£12.10.0.** Carr. 15/-.

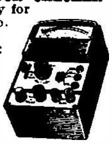
WS.88 TRANS/RECEIVERS. A and B sets available. Complete with valves. **39/6** each. P. & P. 4/6. Accessories available.

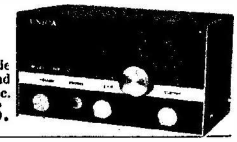
No. 10 MICROPHONE AND HEADSET. Moving coil Accessory for 19 set. Unused. **15/-.** P. & P. 4/-.

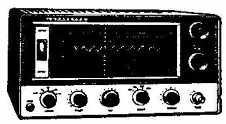
HOSIDEN DH04S 2-WAY STEREO HEADSETS

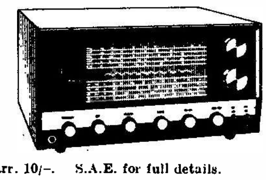
Each headphone contains a 2½in woofer and a ⅞in tweeter. Built in individual level controls. 25–18,000c/s. 8Ω imp. with cable and stereo plug. **£5.19.6.** P. & P. 2/6.

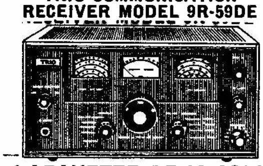
INTERCOM/BABY SITTER

Transistorised Intercoms, ideal for home/office/workshop etc. 2-way buzzer call system. For desk or wall mounting. Supplied complete with connecting wire, batteries, instructions, 2 station **59/6.** P. & P. 2/6. 4 station **£6.12.6.** P. & P. 5/-.

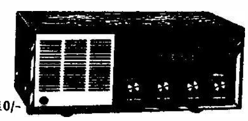
MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec: A: 0·7-0·9967. B: 5-200. Ico: 0-50 microamps 0-5mA. Resistance for diode 200Ω-1MΩ. Supplied complete with instructions, battery and leads. **£5.19.6.** P.&P. 2/6.

UNR-30. 4-BAND COMMUNICATION RECEIVER

Covering 550Kc/s—30Mc/s. Incorporates variable BFO for CW/SSB reception. Built in speaker and phone jack. Metal cabinet. Operation 220/240V. a.c. Supplied brand new guaranteed with instructions. **13 GNS.** Carr. 7/6.

LAFAYETTE MODEL HA700 AM/CWSSB AMATEUR COMMUNICATION RECEIVER

8 valves, 5 bands incorporating 2 MECHANICAL FILTERS for exceptional selectivity and sensitivity. Frequency coverage on 5 bands 150-400Kc/s, 550-1,600Kc/s, 1·6-4·0Mc/s, 4·8-14·5Mc/s, 10-5-30Mc/s. Circuit incorporates R.F. stage, aerial trimmer, noise limiter, B.F.O. product detector, electrical bandspread, S meter, slide rule dial. Output for phones, low to 2KΩ or speaker 4 or 8ohms. Operation 220/240V. a.c. Size 7¾ × 15 × 10in. Supplied brand new and guaranteed with handbook. **36 GNS.** Carr. 10/-. S.A.E. for leaflet.

NEW LAFAYETTE SOLID STATE HA600 RECEIVER

5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150KC/S TO 400KC/S AND 550KC/S TO 30MC/S.
F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Crystal calibrator ● Variable BFO ● Noise limiter ● S Meter ● 24½in. Brandspread ● 230V a.c./12V d.c. neg. earth operation ● RF gain control. Size 15in × 9¼in × 8¼in. Wt.18 lb. **EXCEPTIONAL VALUE £45.** Carr. 10/-. S.A.E. for full details.

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

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 SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF 445Kc/s ● Audio output 1·5W. ● Variable RF and AF gain controls. 115/250V. a.c. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. **£37.10.0.** Carriage 12/6.

LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152–174Mc/s. Fully tunable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75Ω aerial input. Headphone jack. Operation 230V a.c./12V d.c. Neg. earth. **£37.10.0.** Carr. 10/-

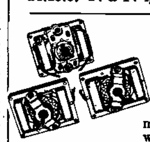
LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes, IHF music power, 30W at 8Ω. Response 30–20,000 ±2dB at 1W. Distortion 1% or less. Inputs 3mV and 250mV. Output 3–16Ω. Separate L. and R. volume controls. Treble and bass control. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with complimentary metal case. Size 10½ × 3⅞ × 7⅞in. Operation 115/230V. A.V. **£28.** Carr. 7/6.

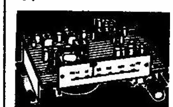
GARRARD DECKS
Brand new and guaranteed.

1025 mono	£7.10.0.
1025 stereo	£7.19.6.
2025 TC less cart.	£7.19.6.
SP25 Mk.II less cart.	£12.10.0.
A70 Mk.II less cart.	£12.12.0.
AT60 Mk.II less cart.	£13.19.6.
LAB80 Mk.II less cart., with base	£27.10.0.

Carr. 7/6 each
Wooden Plinths for Garrard Series 1,000, 2,000, 3,000, etc., with perspex cover. **£4.10.0.** P. & P. 4/6.

GARRARD TAPE MOTORS

Brand new stock as used by famous manufacturer. 200/250V a.c. Capstan motor **15/-.** Fast Forward **10/6.** Fast Rewind **10/6.** P & P. 3/-. Set of three motors **32/6.** P. & P. 5/-.

RECORDING HEADS
Reuter ¼-track. As fitted to Callaro Mk. IV and Studio Decks. High imp. record play back, low imp. erase. Brand new. **19/6** pair. **MINIFLUX** ¼-track record **12/6. COSMOCORD** 4-track with mounting plate. TR1-500/P/W record/replay **65/-;** TRI-120/P/W record/replay **65/-;** TEL 1-6 P/W Erase **20/-. MARRIOTT** 4-track heads. Record/playback. High imp. **65/-;** Erase low imp. **20/-.** Post extra.

★TRANSISTORISED FM TUNER★

6 TRANSISTOR HIGHQUALITY TUNER, SIZE ONLY 6 × 4 × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V. battery. Coverage 88–108Mc/s. Ready built ready for use. Fantastic value for money. **£6.7.6.** P. & P. 2/6. Stereo multiflex adaptors **5 gns.**

E.M.I. SINGLE PLAYERS
4 speed with separate arm and cartridge **52/6** Carr. 3/6.

B.S.R. UA50
Mini auto-changer with stereo cartridge, **£6.10.0.** Carr. 5/-

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

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

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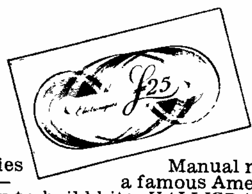

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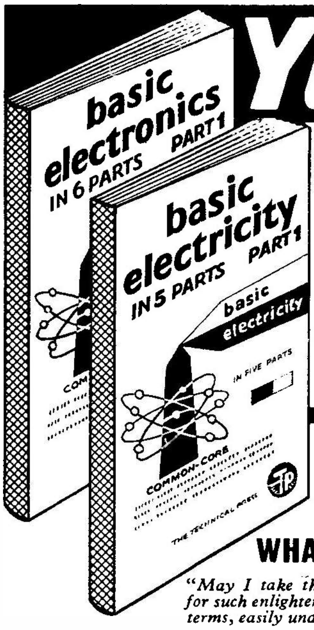

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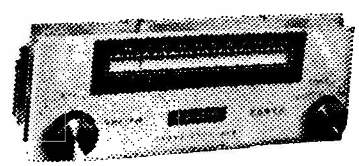

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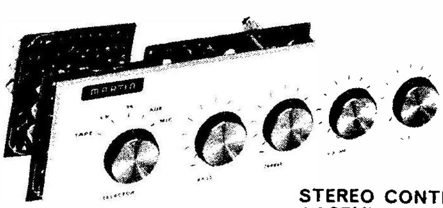

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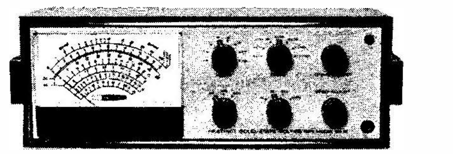

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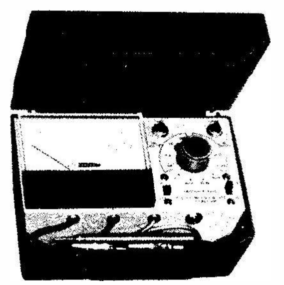

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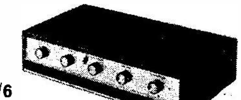

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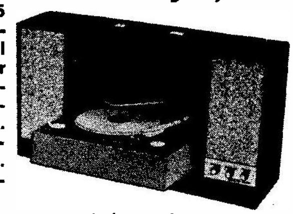

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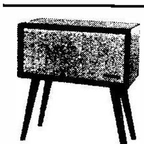

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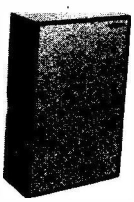

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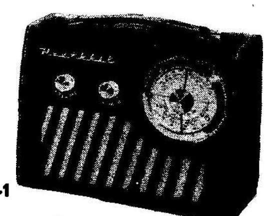

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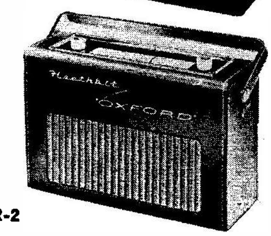

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VOL. 4 No. 9
September 1968

PRACTICAL ELECTRONICS

DESIGNING FOR THE FUTURE

THE future pattern of electronics is assuredly tied up in the word "microelectronics".

No enterprising constructor will wish to stand aside from the mainstream of emerging techniques. Even on the home constructor scale definite economic advantages will soon materialise from the outpourings of the micro-electronic plants. The cost of a "one-off" integrated circuit will become less than the equivalent discrete components. Nor is it fanciful to envisage IC's at "give away prices" in due time. (Just recall the dramatic fall in the cost of transistors over the last few years.)

Yet there is a very real problem facing the home constructor: how to select and use IC's to the best advantage. PRACTICAL ELECTRONICS has been investigating this subject for some little while, and the outcome of this work is now presented to our readers in the series of constructional designs commencing in this issue. It was realised that something more than the mere fitting of a "black box" into a circuit was required if the problem was to be properly tackled. Therefore an operational amplifier has been selected as our standard building block for this series; this device is highly versatile and gives the constructor the opportunity to try out several different modes of operation by building up external circuitry using ordinary discrete components.

These five projects can be rightly considered as educational aids, since they provide an introduction to system designing and to building ultimately on a larger scale—and this is how we are likely to make the most profitable use of IC's in the future. This is not the sole purpose of the projects however. Each has been carefully designed to serve a useful function, as a permanent unit.

These articles will demonstrate some of the potentialities of IC's in home constructional work; they will also bring out the fact that circuit design will not become a redundant art even when microelectronic devices take over the major role in electronic equipment. F. E. Bennett—*Editor*

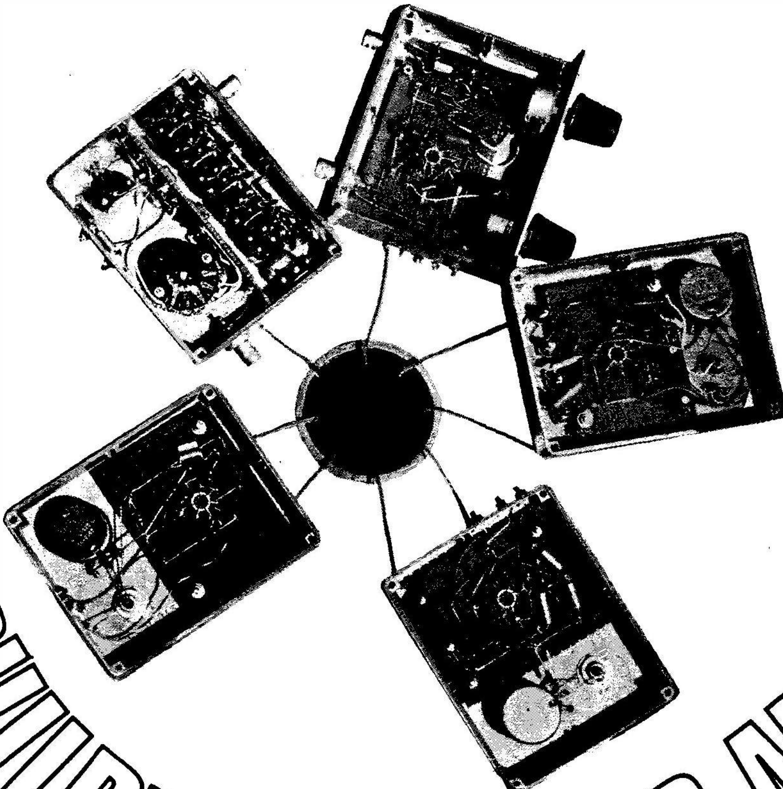
IMPORTANT ANNOUNCEMENT

Next month the price of PRACTICAL ELECTRONICS will be increased to three shillings. This is the first increase in price since the magazine was founded.
During recent years we have ourselves borne many increases in production costs that have occurred, but the position has now been reached when we must ask our readers to make some contribution towards these costs if the standard and authority that has been associated with PRACTICAL ELECTRONICS from its foundation is to be maintained.
We have made this increase with considerable reluctance but we feel sure our readers will understand the reasons which have made this necessary.

THIS MONTH

Our October issue will be published on Friday, September 13

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., 15/17 Long Acre, London, W.C.2. Phone: 01-836 4363. Telegrams: Newnes London. Subscription Rates including postage for one year, to any part of the world, 42s. © George Newnes Ltd., 1968. Copyright in all drawings, photographs and articles published in PRACTICAL ELECTRONICS is specially reserved throughout the countries signatory to the Berne Convention and the U.S.A. Reproductions or imitations of any of these are therefore expressly forbidden.



BUILDING AROUND AN INTEGRATED

★ **This is an introduction to a series of five constructional projects . . . the first appears in this issue and another will appear in each of the four subsequent issues.**

★ **The whole series has been planned as a practical introduction to integrated circuits for the constructor.**

★ **These projects will demonstrate how an IC operational amplifier can be used for a.c. and d.c. amplification, for signal generation, and for filtering purposes.**

★ **All designs are based on the Plessey SL701C Operational Amplifier.**

MANUFACTURERS of integrated circuits aimed initially at satisfying the requirements of the computer industry for digital circuits, because of the high volume market. Their efforts lead to revolutionary changes in electronics. Since the processing techniques and equipment developed for digital circuits will also serve for linear circuit production, IC manufacturers are now aiming at the rest of the electronic equipment industry. The initial cost of developing a linear integrated circuit is rather high—but the potential market is vast.

LINEAR CIRCUITS

Linear circuits can amplify, detect, limit, invert, modulate, or phase shift analogue signals in everything from radar systems to television sets or audio equipment. They usually perform a specific function, for example, the Plessey SL500 series, which are wideband amplifiers with 26dB of current gain and a bandwidth of 100MHz. These amplifiers are primarily in demand for use in radar i.f. strips at centre frequencies between 10MHz and 60MHz. At the moment their price prohibits their use in the obvious domestic application, a 10·7MHz i.f. amplifier for an f.m. receiver.

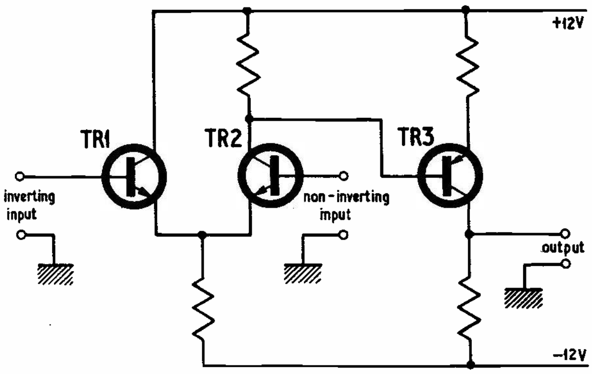


Fig. 1 (a). The basic circuit diagram for an operational amplifier using a pnp transistor for level shifting

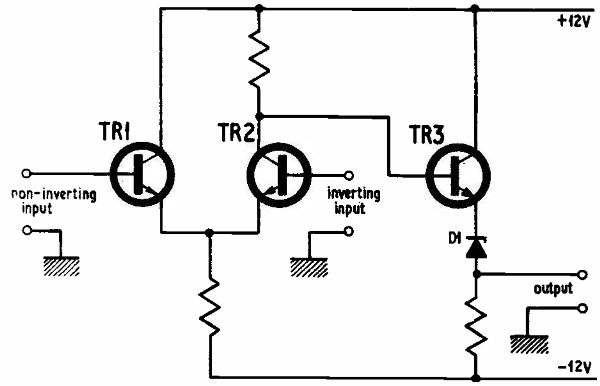


Fig. 1 (b). The basic circuit diagram for an operational amplifier using a Zener diode for level shifting

However, the average price of a linear integrated circuit is steadily dropping. When the circuit can be sold for less than the cost of the discrete components it replaces, no designer (professional or home constructor) can afford to ignore it! (quite apart from size and weight considerations).

CIRCUIT

OPERATIONAL AMPLIFIER

The most useful linear circuit (and hence from our point of view the one most likely to become readily available at a reasonable price) is the *operational amplifier*. Amplifiers in this category are general purpose high gain d.c amplifier units, intended for use with external components to define operating conditions and to set gain and frequency response.

Specifications we would like for an operational amplifier include high gain (60dB), high input impedance (100 kilohms), several volts output swing, a differential input, and a single ended output.

A simplified basic diagram of such an amplifier is given in Fig. 1a. Transistors TR1 and TR2 form a long tailed pair differential input stage, transistor TR3 provides extra gain and acts as a level shifting device so that inputs and outputs can both be at a nominal 0V.

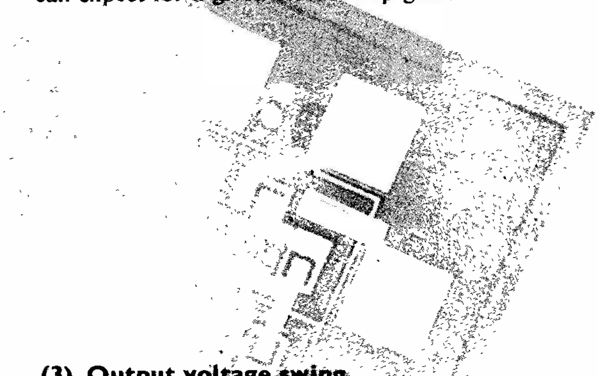
Level shifting may be accomplished in other ways, the Plessey SL700 series (for example) using an emitter follower output with a Zener diode, the basic arrangement of Fig. 1b. Both inverting and non-inverting inputs are always available, so that a wide variety of applications are possible. But before we can consider typical applications we must review the basic specifications associated with such an amplifier. These are:

(1) Voltage gain

This is the voltage gain of the amplifier itself, before we add external components. Because of production tolerances manufacturers normally specify minimum, typical, and maximum values for important parameters.

(2) Upper cut off frequency

This is the upper 3dB down point of the amplifier (at the other end it goes down to d.c.) and is important because we obviously like to know what bandwidth we can expect for a given closed loop gain.



(3) Output voltage swing

This is the minimum and typical peak to peak swing we can expect at our output, and may not be equal either side of earth potential.

(4) Input offset voltage

Since both halves of the differential amplifier at the input are made simultaneously, we would expect to have a reasonably close match between them, and with both the inverting and non-inverting inputs earthed, the output should be at earth potential. However, there must obviously be *some* unbalance in the amplifier, and the offset voltage is the difference in input voltage required to maintain the amplifier output at earth potential. It is typically 1 to 2mV for a single differential input and 5mV for a Darlington pair.

(5) Input resistance

This is, as we might expect, the input resistance of each input, and is typically 100 kilohms (Plessey SL700 series or Fairchild μA 709).

(6) Input offset base current

Just as we had a slight unbalance in input voltages, we also have an unbalance in input current requirements. While the actual input currents to each side may be approximately 1μA, there will be a small difference in requirements, so that one side may draw 1μA and the other $1{\cdot}3\mu$A. This $0{\cdot}3\mu$A is the input offset base current.

(7) Common mode rejection ratio

The long tailed pair input transistors should respond only to a differential signal applied between them, and should reject signals (such as hum or noise) which appear in phase to both inputs and hence tend to "push up" both inputs simultaneously. This ratio is a measure of the rejection achieved, and may be typically 60dB. This means that a 100mV signal applied simultaneously to both inputs only produces an effective differential input of 0·1mV.

TYPICAL APPLICATIONS

It is impossible to give here more than an outline of some applications, to demonstrate the versatility of the operational amplifier. This article is intended as an introduction to several practical articles, and so we must at least cover the principle configurations, even though we may not apply them immediately.

Both gain and d.c. conditions are set by negative feedback from the output to the inverting input, and we can apply our signal to either or both inputs to obtain an inverting, non-inverting, or differential amplifier, as required.

The bandwidth is extended (in the case of the SL701) and output impedance reduced as before, but the input impedance is *increased* and depends on the ratio between the open and closed loop gains and on the original input impedance of the amplifier. In practice this high input impedance may be shunted by the bias resistor required for the base of the input transistor.

Differential Amplifier

The differential mode is shown in Fig. 4. This arrangement can be used where there is hum or noise common to both input lines, and the common mode rejection property of the differential amplifier can be used to advantage to select only the required signal which is balanced about earth.

$$\text{Gain } G = \frac{R_f}{R_s} \quad \text{Input impedance} = 2R_s$$

OTHER APPLICATIONS

The applications we have so far shown are directly coupled, and we would have to be careful about offset voltage and drift of operating point with temperature for high gain applications.

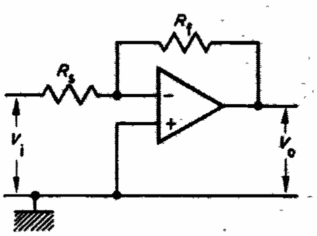


Fig. 2. The basic arrangement for an inverting amplifier

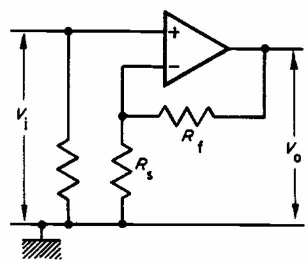


Fig. 3. The non-inverting high input impedance arrangement

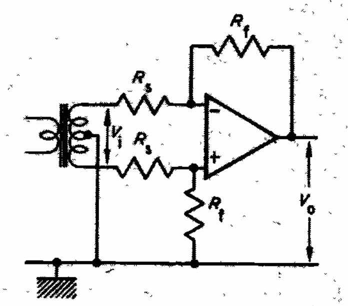


Fig. 4. The differential input amplifier configuration

The use of negative feedback to give a predictable mid-band gain, and to modify input or output impedances is well known, and we will content ourselves with presenting the formula suited to the application, without proof. These formulae assume that the closed loop gain with feedback is much less than the open loop amplifier gain. If the amplifier open loop gain is 20dB more than the required closed loop gain, then the error in our approximate formulae is about 1dB.

Inverting or Operational Amplifier

Fig. 2 shows the amplifier used in the inverting configuration.

$$\text{Gain } G = \frac{V_o}{V_i} = -\frac{R_f}{R_s} \quad \text{Input impedance} = R_s$$

The amplifier output impedance is reduced by the feedback, and bandwidth may be extended. This arrangement can be used for mixing purposes by connecting additional inputs to the junction of R_f and R_s.

Non-inverting Amplifier

For a non-inverting arrangement the feedback voltage is applied in series with the input, Fig. 3. In this case:

$$\text{Gain } G = \frac{V_o}{V_i} = 1 + \frac{R_f}{R_s}$$

For a.c. use the input or output can be capacitively coupled (or R_s can be a.c. coupled to earth in the non-inverting configuration) to avoid giving the amplifier a high d.c. gain, so that the risk of the output level being altered by amplifier drift is greatly reduced.

We can, if we wish, use frequency selective negative feedback, so that the operational amplifier can be used for active filters or tone control, as well as for trigger circuits, integration, oscillation, and so on.

THE "CHOICE" OF AN AMPLIFIER

The majority of integrated circuit manufacturers have always included one or more operational amplifiers in their professional range, but on the whole the need for an inexpensive device suitable for the retail market has been ignored. About twelve months ago, however, Plessey introduced a number of inexpensive amplifiers one of them being an operational amplifier, the SL701C. This device is readily available, in small or large quantities, directly from the manufacturer.

The Plessey SL700 series are intended for use as operational amplifiers or instrumentation amplifiers, and are available in 8 lead TO5 cans or in flat packs. Some versions do not have a level shifting Zener diode, and so their output is not about earth, but is about a point 5·5V above earth. In order to obtain a symmetrical output voltage swing about earth with these versions (desirable from the biasing point of view) we would have to add an external Zener diode. The versions available are:

Table 1: ELECTRICAL CHARACTERISTICS OF SL701C INTEGRATED CIRCUIT

Supply voltage ±12V

Characteristic	Minimum	Typical	Maximum	Units
Voltage gain	66	70	78	dB
Upper cut-off frequency (−3dB)	250	500	—	kHz
Output resistance	—	100	—	Ω
180° phase shift frequency	20	35	—	MHz
Input resistance	—	100	—	kΩ
Positive supply current	—	12	—	mA
Negative supply current	—	9	—	mA
Output voltage swing before clipping	7·0	8·6	—	V
Input offset voltage (untrimmed)	—	—	20	mV
Input base current	—	—	3	μA
Input offset base current	—	—	1·8	μA
Common mode rejection ratio	—	80	—	dB
Supply line rejection	—	70	—	dB

Type No.	*Encapsulation*	*Remarks*
SL701B, C	TO5 8 pin	Output about earth
SL702B, C	TO5 8 pin	Output about +5·5V
SL751B, C	Flat pack	Both outputs available

The "C" version is the industrial version with slightly relaxed specifications on some parameters, even though *typical* parameters remain unchanged. For our application the B or C versions would suffice, and we have chosen the SL701C. **This device is used throughout in the five practical designs we are publishing.**

DETAILS OF THE SL701C

The specifications given in Table 1 were taken from manufacturer's data for the SL701C. The pin connections and equivalent piece-part circuit is also shown in Fig. 5.

This amplifier uses a Darlington compound pair in a long tailed pair configuration at the input (TR1–TR4). The transistors are inherently well matched since they are made simultaneously in a single chip of silicon. An auxiliary balancing circuit is included in the h.t.+ supply to the 3·8 kilohm resistors R1, R2 to help make the balanced input less sensitive to supply voltage changes, and to enhance the inherent excellent common mode rejection of the long tailed pair.

Output is taken via an emitter follower TR8 and Zener diode D1 (in our case, for the SL701). Pins 4 and 6 are used for frequency stabilisation, though pin 4 can also be used as an output in some special applications.

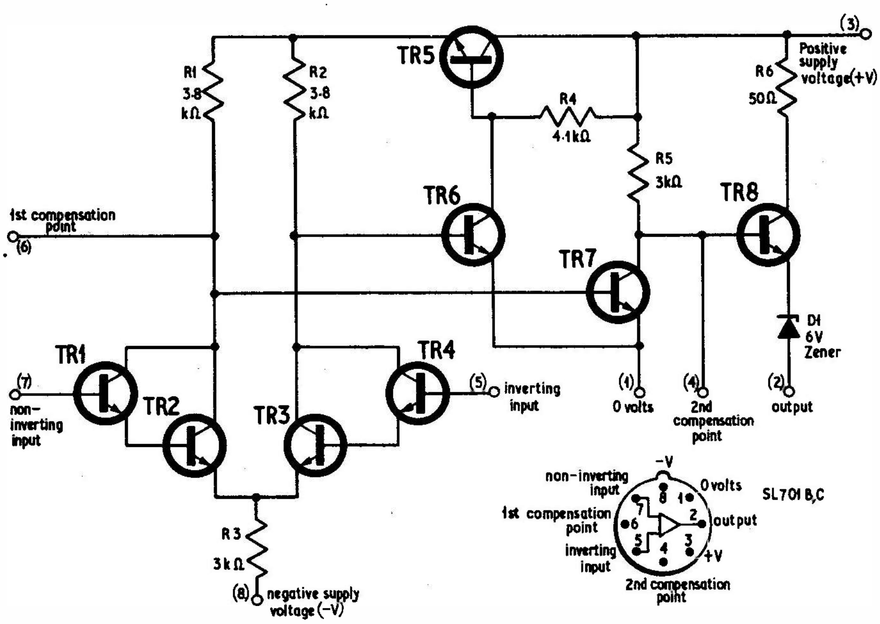


Fig. 5. The piece-part circuit diagram for the SL701 B or C

Now to our first project in this series

THERE are often times when the constructor or experimenter needs an amplifier which can just be plugged in for extra gain; to increase the sensitivity of a 'scope, to check a power amplifier in the absence of a suitable preamplifier, or to boost the output of a radio tuner, for example. The amplifier to be described is intended for such temporary test purposes, and gives switched fixed gains of 20, 30, 40 or 50dB.

CIRCUIT DESCRIPTION

The circuit of our complete switched gain general purpose amplifier is shown in Fig. 1. It consists of a non-inverting a.c. amplifier.

Both input and output are direct coupled, but the feedback resistor to earth has been a.c. coupled, so that the l.f. cut off is about 10Hz. In our case the d.c. offset at the output varied between about +0·5V for the 50dB gain position and −0·3V for the 20dB gain position.

In a fixed gain amplifier this offset could have been minimised by using equal source resistors for each input, and then "trimming" the values slightly, but it was anticipated that the external circuits used with the amplifier will have coupling capacitors so connected that they are correctly polarised. It is worth noting in this connection that tantalum capacitors can safely withstand up to 10 per cent of their normal rating as a reverse voltage. Where the nominal voltage across the capacitor is zero, we can ignore the possibility of a slight reverse bias. An alternative is to use a non-polarised electrolytic or use two ordinary electrolytics connected "back to back" (which comes to the same thing).

The input comes into the integrated circuit IC1 on pin 7 (the non-inverting input) and the input impedance can be switch selected (S1) as 100 kilohms or approximately 600 ohms, as required. When used at maximum gain the input impedance is slightly less than 100 kilohm (about 80 kilohm) due to the reduced amount of negative feedback (which increases the 100 kilohm input impedance of the integrated circuit so that it does not load the external 100 kilohm bias resistor).

FEEDBACK RESISTOR

The feedback resistor (R4–R7) from pin 2 to pin 5 sets the gain and d.c. conditions, and sections are shorted out by the switch S2 to provide the different gains required. It is important to use the form of connection shown rather than to switch individual resistors, since with our configuration even if the switch goes open circuit there still remains a d.c. path to set up the proper bias.

OUTPUT ARRANGEMENTS

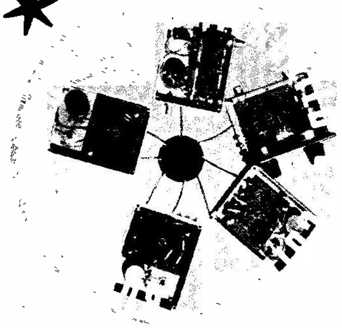
The 2·2 kilohm resistor (R9) in series with the output has been included for two reasons. Firstly, to prevent damage to the amplifier should the output be short circuited; secondly, to prevent possible instability should the amplifier be fed into a large capacitive load. We must remember that if the amplifier is used with a long screened lead on the output, the bandwidth may be reduced. A 100pF load (in conjunction with the 2·2 kilohm resistor) would produce an extra roll-off at 6dB/octave from 700kHz, and could reduce our overall bandwidth on the low gain settings.

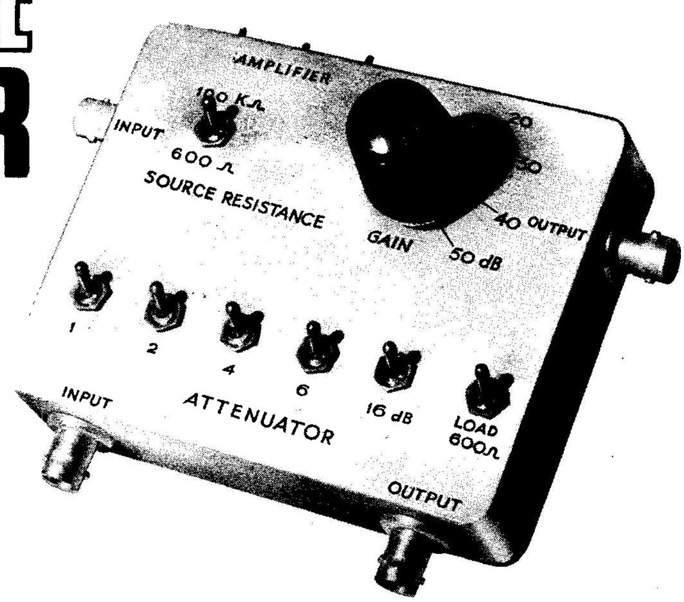
The current output capacity can be increased if required by *decreasing* the 5·6 kilohm resistor R8 to the negative rail and removing the 2·2 kilohm resistor R9 and feeding directly into the load. The manufacturer's data gives the maximum negative swing as a function of load resistance and the resistor from output to the negative rail; the maximum output current from the amplifier must not exceed 20mA.

FREQUENCY RESPONSE AND FEEDBACK STABILISATION

We have assumed that the amplifier has the constant 180 degree phase shift from input to output that we

SWITCHED GAIN GENERAL PURPOSE AMPLIFIER





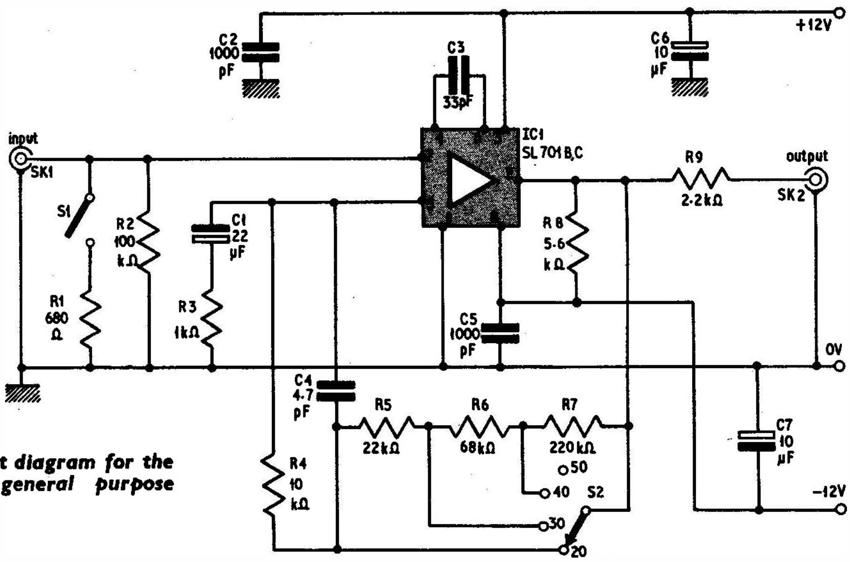


Fig. 1. The circuit diagram for the switched gain general purpose amplifier

Table 1. PERFORMANCE OF THE SWITCHED GAIN GENERAL PURPOSE AMPLIFIER

Nominal gains of	20 30 40 50dB (10) (32) (100) (320) times
Input impedance	100kΩ 600Ω switch selected
Output impedance	2·2kΩ
Maximum output	7V p.p. (open circuit load)
Bandwidth	20dB gain 1MHz 40dB gain 0·5MHz typically 50dB gain 0·1MHz
Noise referred to input	100kΩ source 200mV peak to peak 600Ω source 24mV peak to peak

require for negative feedback. Unfortunately any practical amplifier will have additional reactive elements which reduce gain and increase phase shift above a certain frequency (250kHz in our case for the SL700 series).

At 20MHz or so we have an extra 180 degree phase shift and an open loop gain for the amplifier of 20dB. If we now add our resistive potential divider from output back to input to set the *mid band* gain we may get positive feedback at 20MHz (180 degree normal phase shift plus an extra 180 degree to make 360 degree) which will cause oscillation. Obviously the amount of feedback will decide if the circuit oscillates.

For the case quoted, if the feedback network had an attenuation of less than 20dB, the loop gain (amplifier forward gain minus feedback path attenuation) will be greater than unity when the total loop phase shift is 360 degrees, and the circuit will oscillate. If the feedback network has an attenuation greater than 20dB the loop gain will be less than unity (when the total loop phase shift is 360 degrees) and the circuit cannot oscillate.

The greater the loop gain the more possibility there is of the circuit oscillating. If we take our two extreme cases:

(1) Closed loop gain 50dB.
 Open loop gain typically 70dB.
 Loop gain 70–50 = 20dB.

We have to ensure that this 20dB of loop gain is less than unity when the extra loop phase shift is 180 degrees.

(2) Closed loop gain 20dB.
 Open loop gain 70dB.
 Loop gain 70 – 20 = 50dB.

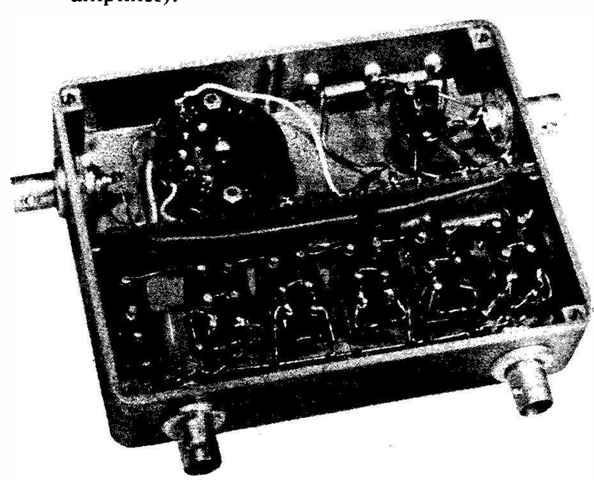
In this case we again have to ensure that the loop gain is less than unity when the extra loop phase shift is 180 degrees, but this is a much more difficult case since we have to control the loop characteristics from 50dB to 0dB rather than 20dB to 0dB as in the previous case.

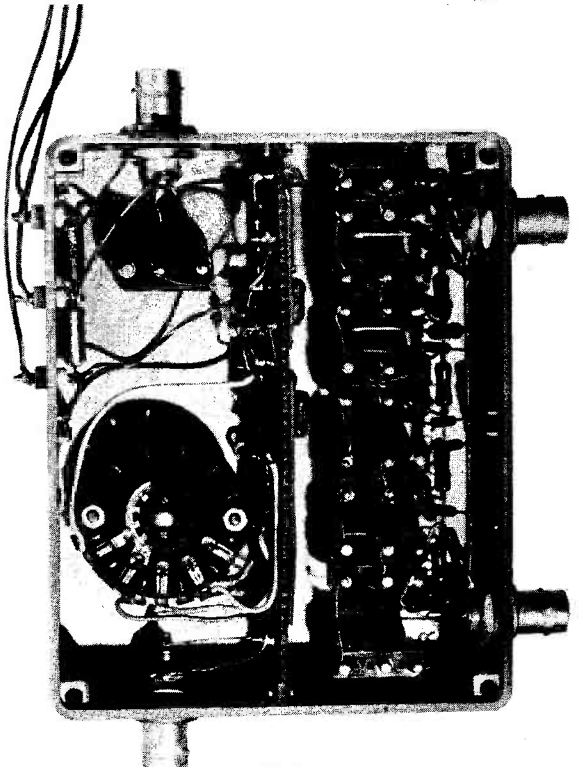
There are several ways in which stability can be determined, and the circuit modified if necessary, but these are really beyond our introduction here, the theory rapidly becomes formidable! Fortunately, manufacturers normally give gain and phase characteristics and make suggestions as regards stabilisation for various closed loop gains.

PRACTICAL POINTERS

The complete amplifier can be checked for stability by observing the response to a square wave input for ringing or overshoots. Since the amplifier has an open loop unity gain point of well over 10MHz, there are several points to be considered. These are:

1. Use the stabilising components recommended by manufacturer or designer (physically close to the amplifier).





NOTE

IC1 is available direct from the makers: The Plessey Co. Ltd., Components Group, Cheney Manor, Swindon, Wiltshire. Price: 18s.

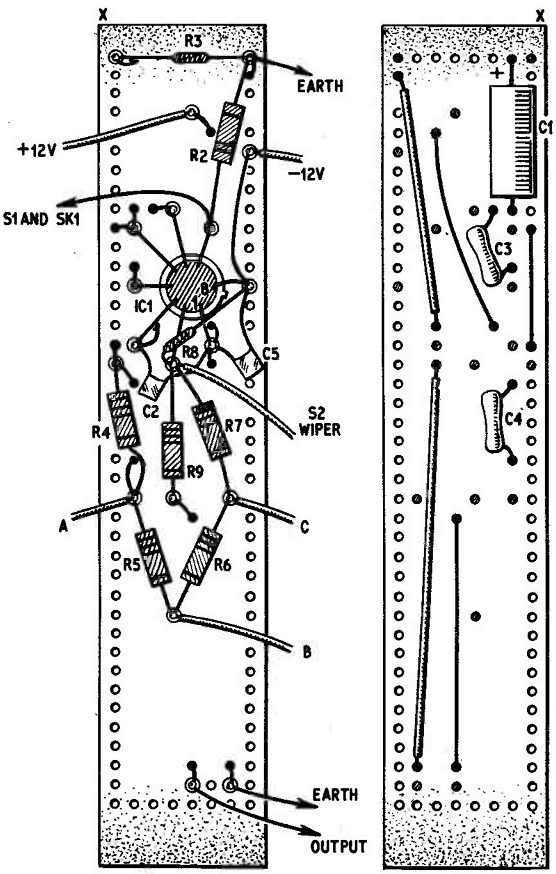


Fig. 3. Layout of the amplifier board

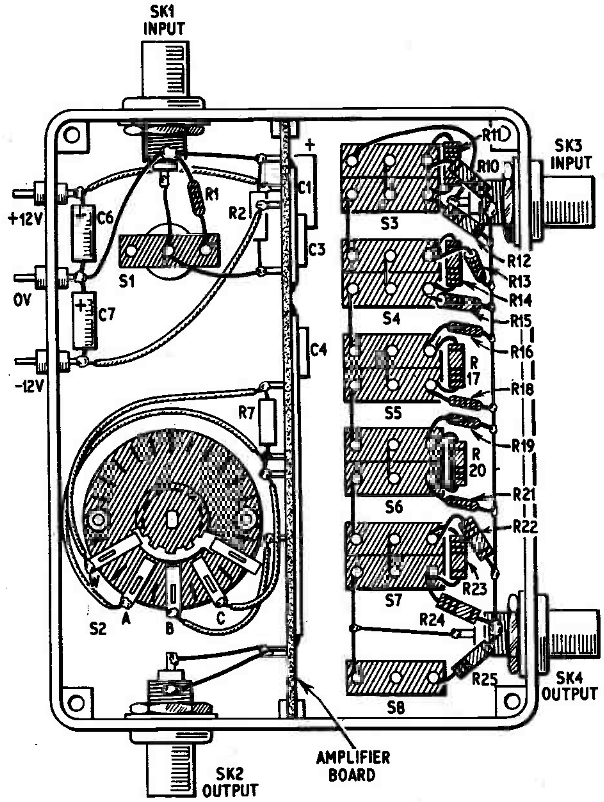


Fig. 2. General view of the completed unit. Note that the switched attenuator, which occupies the r.h. half of the box, is a separate and optional circuit that can be fitted

COMPONENTS . . .

AMPLIFIER

Resistors

R1 680Ω	R4 10kΩ	R7 220kΩ
R2 100kΩ	R5 22kΩ	R8 5·6kΩ
R3 1kΩ	R6 68kΩ	R9 2·2kΩ

All ±10%, ¼W carbon

Capacitors

*C1 22μF tantalum 20V	C5 1,000pF ceramic
C2 1,000pF ceramic	C6 10μF elect. 20V
C3 33pF ceramic 10%	C7 10μF elect. 20V
C4 4·7pF	* See text

Miscellaneous

IC1 Linear integrated circuit (d.c. coupled amplifier—Plessey SL701C) *see note*
S1 Single pole, on/off toggle switch
S2 Single pole, 4-way rotary switch
SK1, 2 Coaxial socket (2 off)
Die-cast box 4¾in × 3⅜in × 1in (Electroniques 46R.043A, but see text)
Perforated s.r.b.p. 4½in × ⅞in approx.
Three insulated feed-through terminals
22 s.w.g. plastic covered wire

ATTENUATOR

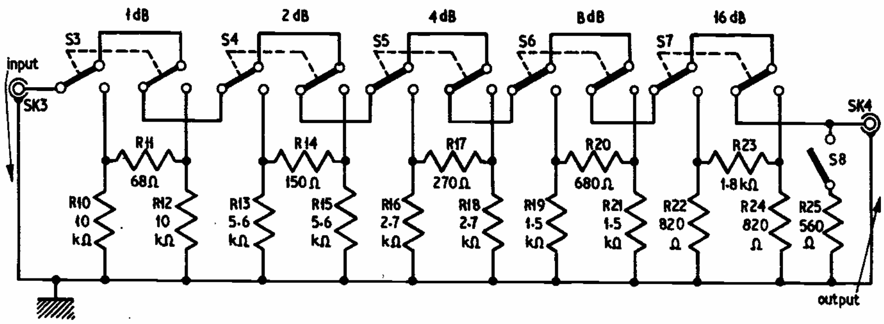
Resistors

R10 10kΩ	R16 2·7kΩ	R22 820Ω
R11 68Ω	R17 270Ω	R23 1·8kΩ
R12 10kΩ	R18 2·7kΩ	R24 820Ω
R13 5·6kΩ	R19 1·5kΩ	R25 560Ω
R14 150Ω	R20 680Ω	All ±10%, ¼W
R15 5·6kΩ	R21 1·5kΩ	

Miscellaneous

S3–7 2 pole, 2 way slide switch (5 off)
S8 Single pole, on/off toggle switch
SK3, 4 Coaxial socket (2 off)

Fig. 4. Circuit diagram for the switched attenuator



2. Use at least 1,000pF ceramic decoupling capacitors from each supply rail to earth *right at the amplifier terminals.*
3. Avoid capacitive or inductive loads if possible (no wirewound resistors!)
4. Ensure that d.c. or l.f. amplifiers have a properly restricted bandwidth, add a capacitor from the compensation point to ground or use another similar procedure if the design does not require the full bandwidth of the amplifier.
5. Use a reasonable layout with short leads.
6. Return the input and output to ground with separate leads. This is particularly important in high current amplifiers where the integrated circuit may be feeding an output stage to increase power handling capacity.
7. In cases of desperation a 56 ohm resistor can be added inside the feedback loop directly at the amplifier terminals in series with the output load and feedback network.

In fairness, the precautions of 1–6 are reasonable for a high gain wide band amplifier, and precaution 7 is sometimes used to prevent an emitter follower oscillating at a high frequency when feeding a capacitive load. We have never had any difficulties in using integrated circuits, provided loop stability requirements are met. Our 2·2 kilohm resistor in series with the output was added as a precaution against a short circuited output, rather than for stability reasons.

CONSTRUCTION

The form of construction is shown by the photographs and diagrams Figs. 2 and 3. Some difficulty may be experienced in finding a 4-pole switch shallow enough to fit in the specified box. If necessary, the next larger size of Electroniques box could be used as this is deeper. The amplifier can then be spread over a wider piece of Lectroboard while retaining the same basic layout. Three feed-through terminals are fitted to the top side of the box. These terminals are used for h.t. supply connections.

After inserting the pins in the board (spacing them out to accommodate the size of resistors used) we would suggest the following assembly order:

1. Add h.t. and earth wires on the back of the board.
2. Add the 1,000pF ceramic capacitors.
3. Add resistors and the electrolytic capacitor.
4. Add integrated circuit.
5. Add leads off board to switch, h.t., earth, input and output.
6. Place amplifier board in slot in box and solder remaining leads.

Since the circuit has a high rejection of hum on the h.t. lines, there is no point in providing excessive smoothing on these lines, especially if the unit is run off batteries or a supply already well smoothed. Nominal capacitors of 10μF or so may be used, unless feedback along the h.t. lines from other units is suspected.

The amplifier board could have been spread out slightly and mounted flat in the bottom half of the box, but we proposed to use this half for a 600 ohm calibrated attenuator, suitable for gain or frequency response measurements.

The calibrated attenuator (to be described next) is entirely separate from the amplifier and its inclusion is optional. It does of course enhance the value of the unit as an item of test gear.

CALIBRATED ATTENUATOR

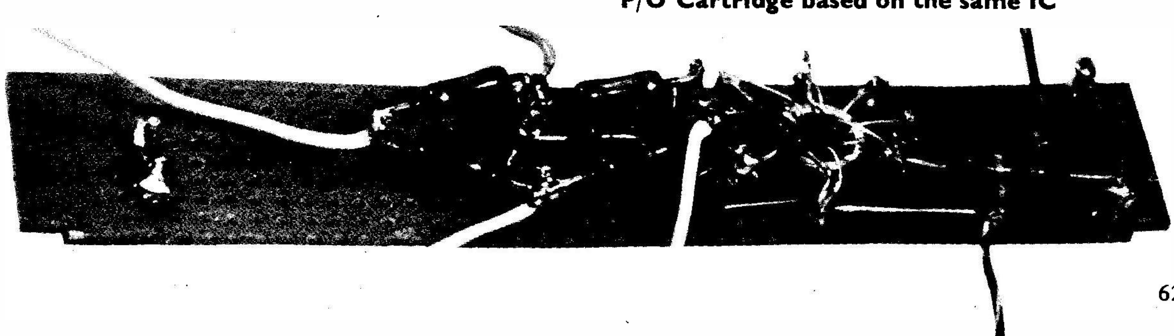
An unbalanced π arrangement, shown in Fig. 4 is employed as a switched attenuator. This gives 0 to 31dB in 1dB steps.

To provide the correct attenuation the last stage has to feed into 600 ohms. For the case where the following stage has a high input impedance, the attenuator can be terminated by a switched-in load. Preferred resistor values are used, since the resulting error is small. The attenuator has been tested against a commercial one at 1kHz and found to be accurate.

Assembly of the components is straightforward as can be seen from the photograph and diagram Fig. 2. A busbar of 18 s.w.g. tinned copper wire runs between sockets SK3 and SK4 and provides anchorage for the resistors.

Miniature toggle switches were used in the original model. However, two-pole, two-way slide switches are less expensive and more readily obtainable.

Next month: A Pre-amplifier for a Ceramic P/U Cartridge based on the same IC



U.S. SOUNDS and MUSIC

By L. Huggard, B.Sc.

IMPRESSIONS OF THE NATIONAL ASSOCIATION OF MUSIC MANUFACTURERS' CONVENTION IN THE UNITED STATES

ALTHOUGH Chicago is over six hundred miles from the nearest sea coast, it is one of the biggest cities and sea ports in the U.S.A. Yet each year the city "turns on" with the National Association of Music Manufacturers Convention. A town, once torn apart by booming equalisers, is rended anew by the distorted exuberance of today's music making equipment.

Over three hundred manufacturers of musical instruments of all kinds, from huge all-solid state church organs, to junior's recorder, display their products for nationwide dealer appreciation. This is the hard-sell of the manufacturers' year, when dealer and buyer assess the money making potential of next year's equipment.

Sales of guitars, classical and electrical, are down from their all time high of two years ago, but still exceed one million a year. New technical innovations may keep them there. Nylon stringed classical guitars are now fitted with pick-ups so that their amplified sound can compete in volume with other power dependent instruments. At least one manufacturer claims that special plastic bodies, coupled with the traditional Sitka spruce sound-board, improve the performance.

PAINFUL POWER

The latest electric guitar amplifiers are brutal—designed to put out sound until it HURTS. Equipment names include "The Bass Exterminator", "The Killer", and "Big Henry". The Killer is claimed to be "the only amplifier in the world with the thrilling effect of stereo vibrato at 300 watts peak music power. Stereo vibrato is said to be the result of two alternating vibratos heard from two precisely balanced speakers driven by two sound systems. Each pitch change is identified in opposing channels, one going sharp, one going flat, creating magnificent panoramic diffusion of swinging sound all-round".

Some can addle the mind with over six hundred watts peak music power output from their all silicon semiconductor circuitry.

Significantly the handouts only quote peak power and loudspeaker diameters. It is left to the shell-shocked hearing of audience and performer to judge the quality.

The amplifier and effects circuitry on most equipment is packaged in a unit separate from the speaker cabinet, on which it rides piggyback. Finish varies from "laboratory instrument" to "space-age contemporary", splashed with gaudy colours, like Martian camouflage.

Psychedelic lights provide visual reinforcement to the sound, the different coloured lights being flashed on and off by frequency discriminating circuitry operating from the music.

TEACH YOURSELF

New methods of instruction and equipment are available for those actually wishing to teach themselves to read and play music. The most sophisticated and costly of these is a teaching machine with programmed audio and optical instruction, which the student works out on piano or organ. The student has full control over the machine, and in fact would also have access to an instructor. It is claimed that the system will develop a standard of performance in 39 weeks, which would otherwise take five years to attain.

Another system, designed for home use and for the individual who wants to see if he *can* learn before purchasing an instrument, is designed around a very basic two-manual electronic organ. The upper manual covers two octaves and the lower, one and a half, with a special system of lights to indicate chords. If an organ is already in the home, then it can be fitted with a simple adaptor.

Tuition is by text and diagrams, using a book, and instruction and demonstration on a tape, which can be used with any domestic tape recorder. The student compares his own playing with the taped material, through headphones. Instruction and exercises are programmed so successfully that it is possible to play a simple tune and accompaniment after one lesson.

A new instrument, the "electro-piano", has made possible the music laboratory on the same lines as the already familiar language laboratory. This instrument has a key and hammer system similar to that on the conventional piano, but the sound is derived from shorter strings by amplifying signals from an electro-mechanical pick-up.

The piano has no sounding board, and is almost silent. Thus, while several pianos can be played in one room, each player can hear his performance on a headset without interfering with the others. For group instruction a number of electro-pianos are connected to a control consol on the teacher's instrument. This enables the teacher to listen in to any student's playing and to communicate with any one or group of students, or to demonstrate on his own instrument to them.

Such instruction systems may well further increase the popularity of keyboard instruments. It may be that the latest version of one of the oldest of these will make the next generation's music.

One of the oldest musical instrument manufacturers in America, the D. H. Baldwin Co., demonstrated a harpsichord fitted with pick-ups so that its sounds could be amplified and processed in the way previously used for guitars. The sounds are wild, and may well echo to the end of the seventies. ★

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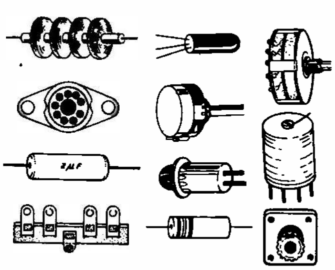

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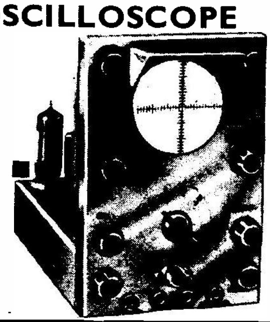

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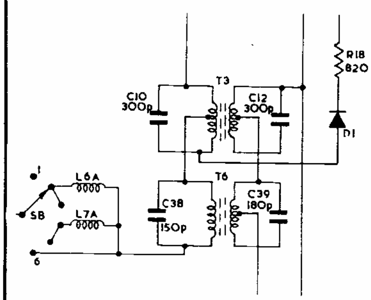

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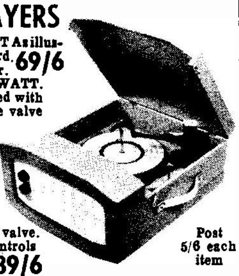

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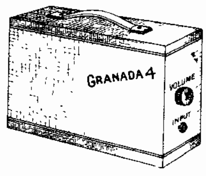

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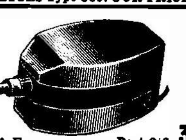

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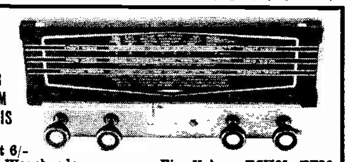

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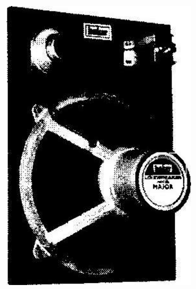

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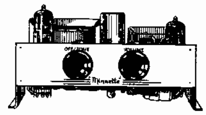

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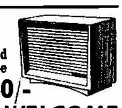

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WHISTLER RECEIVER

By S. T. ANDREWS

THIS equipment was designed to allow reception and investigation of very low frequency (v.l.f.) radio emissions. Since the radio waves concerned are in the audio frequency range a "receiver" for them will need no detector and will consist simply of a high-gain audio amplifier connected to a conventional aerial.

Due to the high gain involved, this equipment is highly susceptible to mains hum pick-up and to internal parasitic oscillations. To avoid the former difficulty the apparatus will generally have to be battery-operated and used in open country far from houses with mains wiring; the second difficulty can only be overcome by building the various sections as complete self-contained units connected only by the signal leads. Obviously, transistorised equipment is very well suited to this role.

OUTLINE OF THE RECEIVER

The block diagram of this equipment for v.l.f. reception is shown in Fig. 1. In the equipment to be described three separate "boxes" are used: (a) pre-amplifier, (b) intermediate amplifier (two, in fact, one as a standby), (c) audio monitor and S-meter, also a separate board to hold the test oscillator.

This represents a fairly comprehensive system and the S-meter and/or test oscillator can be omitted if not required. Each box is a watertight steel unit with clip-on lid, giving a reasonably weather-proof set-up. The total weight, excluding meter and headphones, is 4–5lb, most of which is due to the boxes. Thus the whole system is easily portable and, due to the use of the different boxes for different stages, quite stable. Although several batteries are required, the consumption from each is very small.

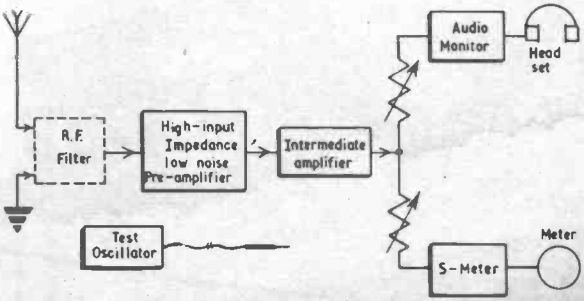


Fig. 1. Block diagram of the whistler receiver

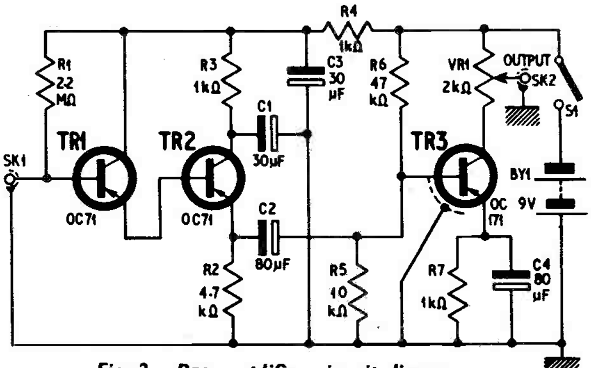


Fig. 2. Pre-amplifier circuit diagram

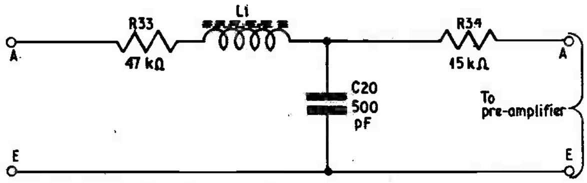
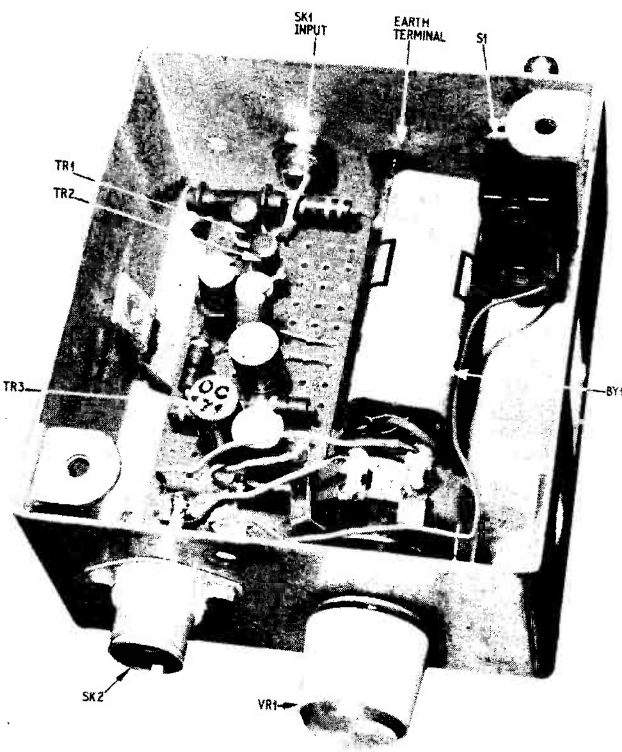


Fig. 4. R.F. filter circuit diagram



COMPONENTS . . .

PRE-AMPLIFIER

Resistors

R1	2·2MΩ	R4	1kΩ	R6	47kΩ
R2	4·7kΩ	R5	10kΩ	R7	1kΩ
R3	1kΩ				

All ±10%, ½W carbon

Potentiometer
VR1 2kΩ linear

Capacitors

C1	30μF	C3	30μF
C2	80μF	C4	80μF

All elect. 15V

Transistors
TR1 OC71 TR2 OC71 TR3 OC171

Miscellaneous
SK1–SK2 Chassis mounting coaxial socket (2 off)
S1 Single pole, on/off toggle switch
BY1 9V layer type battery, PP4 or similar

FILTER

Resistors
R33 47kΩ } 10%, ½W carbon
R34 15kΩ }

Capacitor
C20 500pF silvered mica

Inductor
L1 10 millihenry r.f. choke (Repanco CH4)

MISCELLANEOUS FOR ALL UNITS

Coaxial plugs and screened lead for interconnections. Battery connectors. Veroboard. Metal cases.

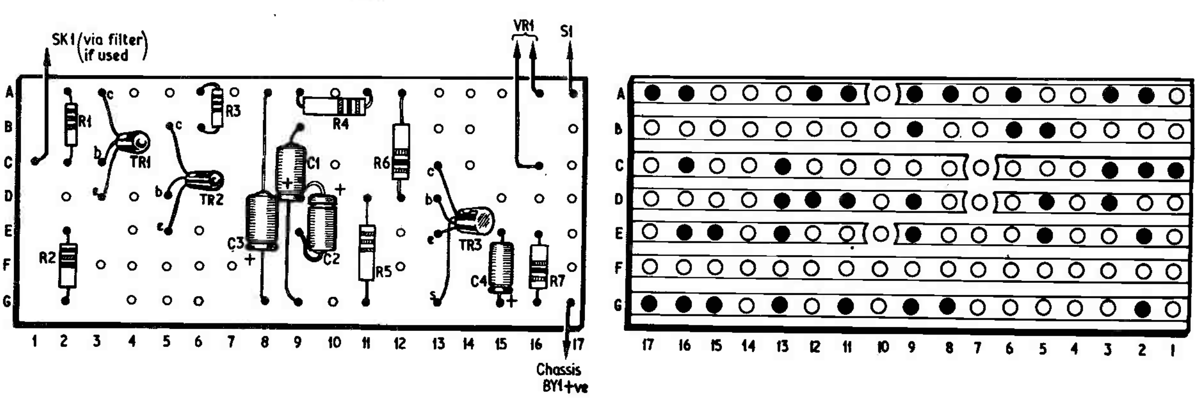


Fig. 3. Pre-amplifier circuit board layout

PRE-AMPLIFIER

The pre-amplifier is the input stage and is fed directly from the aerial. A high input impedance is required here; this could be obtained by using an f.e.t., but in this particular unit a super-alpha pair is used instead.

The circuit diagram of the pre-amplifier is given in Fig. 2 and the Veroboard layout in Fig. 3. This circuit has an input impedance, measured at 400Hz, of 3·2 megohm and a voltage gain slightly over 1,000.

Although this and the subsequent stages have a very good linearity response, the gain is so high that some radio break-through may occur due to the very slight non-linearity. A filter, which will remove much of the unwanted r.f. signal, is shown in Fig. 4. This, if desired, would be inserted between the aerial and the pre-amplifier input.

The performance of the transistors in this stage is the limiting factor in the whole system, since low-noise operation is essential. In the prototype pre-amplifier two OC71's were used, this particular pair having a rather lower noise level than average Other types of transistor may be used in this position, the main criterion being quiet operation.

INTERMEDIATE AMPLIFIER

The pre-amplifier will usually provide enough signal to feed the headphone monitor direct, but if an S-meter is to be used then some intermediate stage of amplification is needed. The intermediate amplifier used here is a conventional two-stage R–C coupled unit. The circuit is given in Fig. 5 and a suitable layout in Fig. 6. The voltage gain is around 150 and the amplifier takes 7mA from a 9V battery.

INTERMEDIATE AMPLIFIER

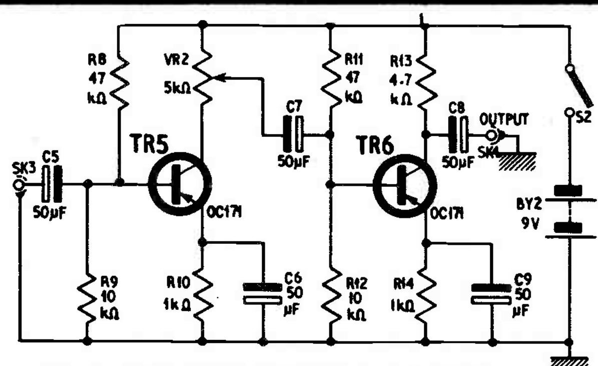
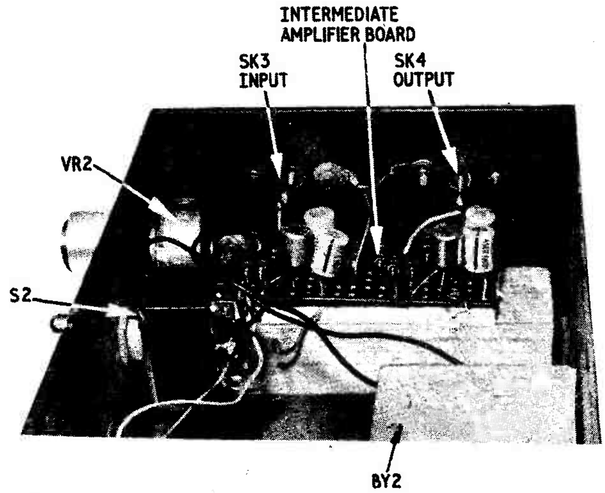


Fig. 5. Intermediate amplifier circuit diagram



COMPONENTS . . .

INTERMEDIATE AMPLIFIER

Resistors

R8	47kΩ	R11	47kΩ	R13	4·7kΩ
R9	10kΩ	R12	10kΩ	R14	1kΩ
R10	1kΩ				

All ±10%, ½W carbon

Potentiometer

VR2 5kΩ log carbon

Capacitors

C5	50μF	C8	50μF
C6	50μF	C9	50μF
C7	50μF		

All elect. 15V

Transistors

TR5 OC171 TR6 OC171

Miscellaneous

SK3-SK4 Chassis mounting coaxial socket (2 off)
S2 Single pole, on/off toggle switch
BY2 9V layer type battery, PP4 or similar

ADDENDA: Screens have been omitted from TR5 and TR6; these should be connected to +ve line (G3 and G12)

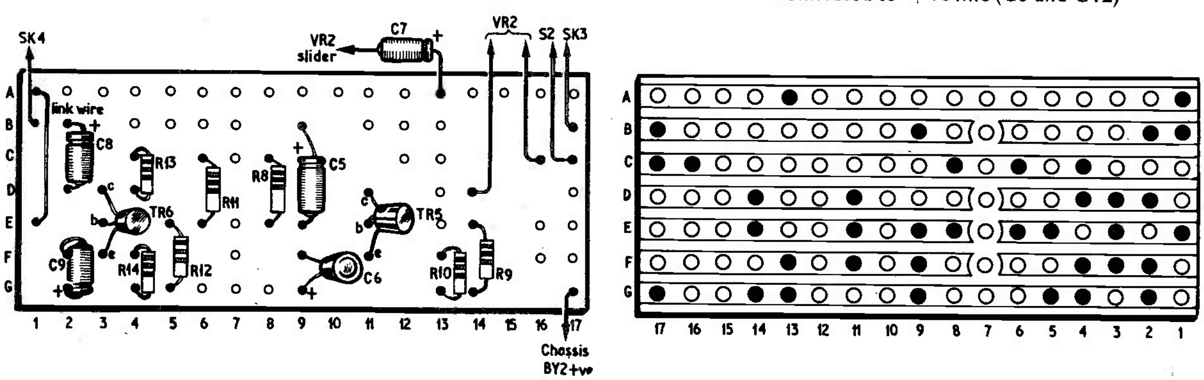


Fig. 6. Intermediate amplifier circuit board layout

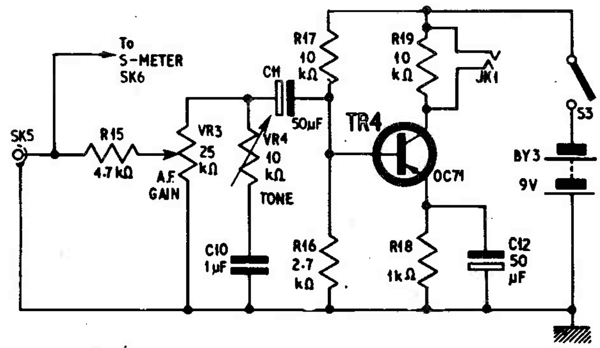


Fig. 7. Audio monitor circuit diagram

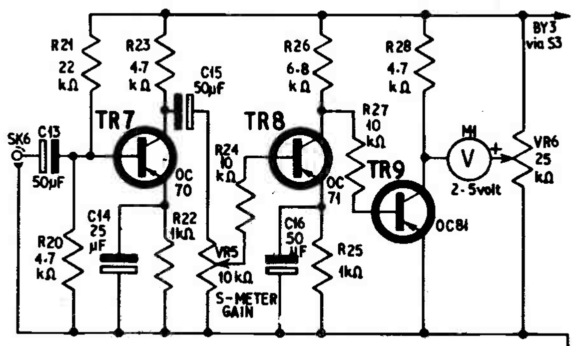


Fig. 8. S-meter circuit diagram

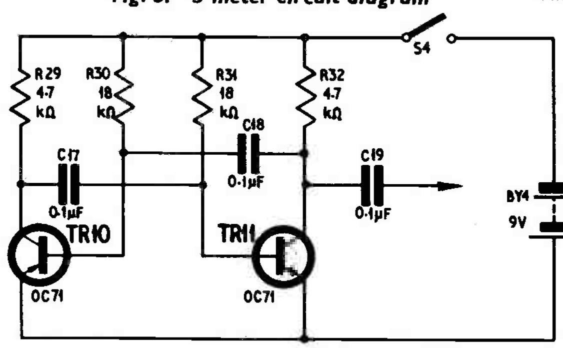


Fig. 10. Test oscillator circuit diagram

COMPONENTS . . .

AUDIO MONITOR

Resistors

R15 4·7kΩ R17 10kΩ R19 10kΩ
R16 2·7kΩ R18 1kΩ
All ±10%, ½W carbon

Potentiometers

VR3 25kΩ linear VR4 10kΩ linear

Capacitors

C10 1μF C11 50μF elect. 15V C12 50μF elect. 15V

Transistor

TR4 OC71

Miscellaneous

SK5 Chassis mounting coaxial socket
JK1 Standard jack socket (fully insulated)
S3 Single pole, on/off toggle switch
BY3 9V layer type battery, PP4 or similar
High impedance headphones

S-METER

Resistors

R20 4·7kΩ R23 4·7kΩ R26 6·8kΩ
R21 22kΩ R24 10kΩ R27 10kΩ
R22 1kΩ R25 1kΩ R28 4·7kΩ
All ±10%, ½W carbon

Potentiometers

VR5 10kΩ log VR6 25kΩ linear

Capacitors

C13 50μF C14 25μF C15 50μF C16 50μF
All elect. 15V

Transistors

TR7 OC70 TR8 OC71 TR9 OC81

Miscellaneous

SK6 Chassis mounting coaxial socket
M1 Volt meter, 2·5V f.s.d.

TEST OSCILLATOR

Resistors

R29 4·7kΩ R31 18kΩ
R30 18kΩ R32 4·7kΩ
All ±10%, ½W carbon

Capacitors

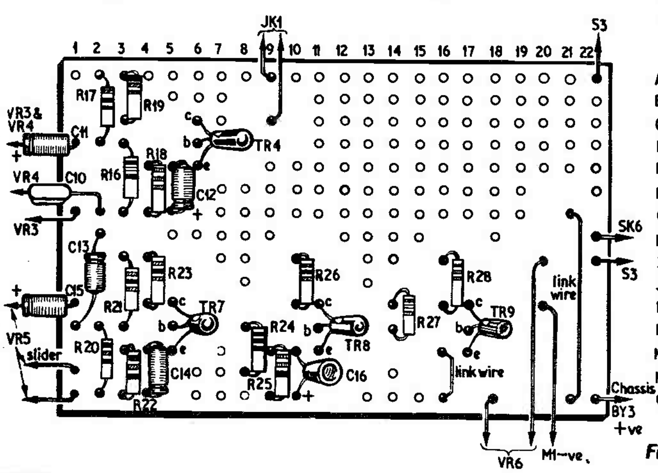
C17 0·1μF plastic C18 0·1μF plastic
C19 0·1μF plastic

Transistors

TR10 OC71 TR11 OC71

Miscellaneous

S4 Single pole, on/off toggle switch
BY4 9V layer type battery, PP4 or similar



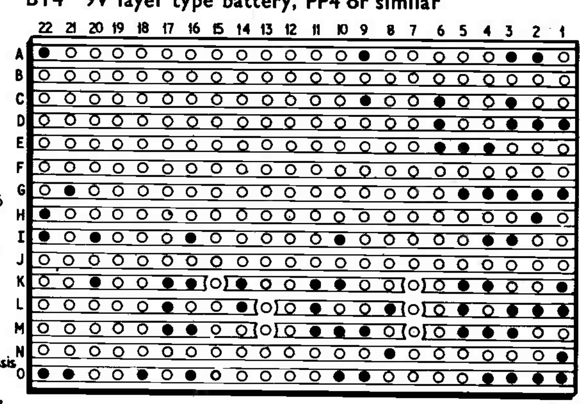


Fig. 9. Audio monitor and S-meter circuit board

AUDIO MONITOR

The audio monitor consists of a single-transistor stage designed to drive a set of high-impedance headphones. The circuit is given in Fig. 7. The monitor is built on the same piece of Veroboard as the S-meter and it will be seen included in the layout diagram Fig. 9. The tone control, comprising C10 and VR4, is an optional extra and provides a degree of treble cut.

There is no reason why a larger a.f. amplifier should not be fitted, for example one to drive a loudspeaker, and this would be connected to the monitor input instead of the headphone monitor.

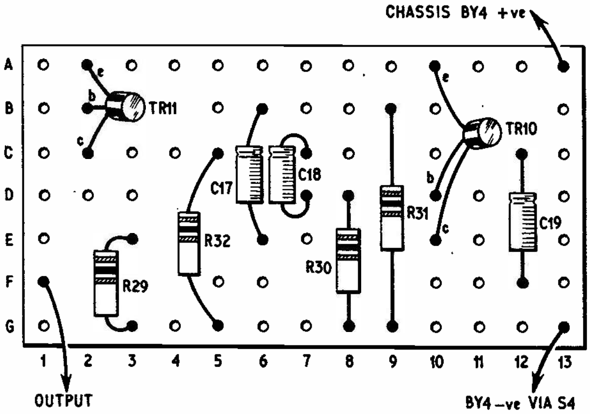


Fig. 11. Test oscillator circuit board layout. Note: no breaks in the copper strips required

S-METER

The function of the S-meter is to measure the strength of the incoming signal. The circuit is given in Fig. 8 and the components are numbered sequentially to those of the monitor. TR7 is a voltage amplifier which feeds a "detector", TR8. The output at TR8 collector consists of the input signal approximately integrated with respect to time, and this signal is applied to TR9. This last transistor forms one arm of a d.c. bridge which is initially balanced by the set-zero control VR6.

A meter was not actually built into the prototype, but sockets were provided so that an external meter could be plugged in when required. A meter with an f.s.d. of 2·5 volts is needed for this circuit.

The overall layout of the monitor and the S-meter is given in Fig. 9.

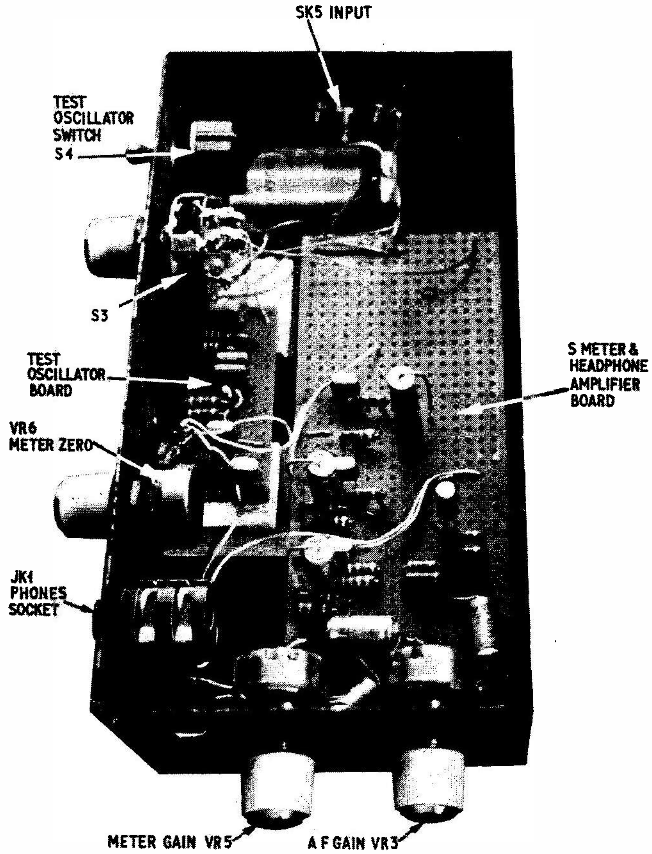
TEST OSCILLATOR

The requirement here is for a simple a.f. oscillator which can provide a signal for testing the various stages. A standard multivibrator is most easily used and a simple version, together with a layout, is given in Fig. 10 and Fig. 11.

This oscillator runs at about 300Hz and was originally incorporated in the same box as the monitor and S-meter. Stray pick-up, however, would make it preferable to use a separate box and power supply for this item.

OVERALL CONSTRUCTION

This equipment is most likely to be used out of doors and so a weather-proof construction is required. In the prototype the various circuit boards were screwed to short strips of wood which were then fixed inside steel boxes with lids which clipped shut. (The actual boxes used were ex-W.D. ones which once contained sets of spares for the "No. 19" set.) All controls and input/output sockets are mounted on the sides of the boxes and each unit has its own power supply. Details of these components and the wiring arrangements are shown in the various photographs.

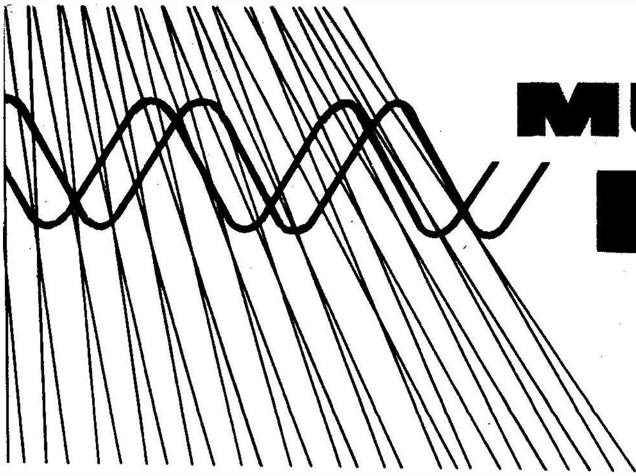


Prototype layout of audio monitor, S-meter and test oscillator in the same case. Note: in practice it was found necessary to mount the test oscillator in a separate box to avoid stray pick-up

SETTING UP

The method of use for this apparatus is self-explanatory. The units are connected as in Fig. 1 to form a complete receiver and, assuming that each individual stage is working correctly, little trouble should be encountered. A good earth connection is essential, this being applied to the pre-amplifier only. Due to the very high gain involved a certain amount of instability may occur, but this can be reduced by careful positioning of the units with respect to each other.

Some general notes concerning v.l.f. reception including details of suitable aerials were included in last month's article *V.L.F. Phenomena.* ★



MUSICAL PHASE

BY J.R. GREEN

LATEST addition to the pop-record producer's acoustic box of tricks is a "psychedelic" effect that was once regarded as a major nuisance in long-distance medium frequency broadcasting.

Phase, skying, or selective fading—according to context—occurs when a programme travels over two paths having slightly different delay times. The result is a weird quality of reproduction caused by the addition and cancellation of certain audio frequencies and the production of new ones.

This article investigates the theory of the phase effect and describes one professionally used means of achieving it. Suggestions are given for all-electronic phasing devices.

THE essence of the musical phase effect is to play two recordings of the same piece of music almost, but not quite, in step. The method formerly used by commercial radio disc jockeys—and now by record companies—is to play two copies of the soundtrack out of step and to mix the outputs at equal level. The characteristic "whoosh", accompanied by cancellation of some audio frequencies and re-inforcement of others, rises to an infinite frequency as the two recordings move exactly in step, and falls down in pitch as the recordings move apart—finally degenerating into a simple echo.

WHY DOES PHASE OCCUR?

The cause of the "whoosh" and frequency cancellation effect can be illustrated by a pulse waveform *A* (Fig. 1a).

The waveform is produced by (for example) differentiation of a square wave of frequency f (time period t). Suppose that another pulse waveform *B*, is available at a frequency of $f + f_2$, very slightly different in frequency from *A* (Fig. 1b).

If *A* and *B* are observed on a double beam oscilloscope (refer to left-hand column of Fig. 2) and the common timebase of the 'scope is synchronised to lock *A* in a stationary trace, then *B* will move very slowly relative to *A*. The speed of movement will depend on f_2, the frequency difference, which should be about one quarter of a hertz for f of about 100 to 200Hz.

Now suppose we mix *A* and *B* and display their resultant waveforms on a further, single-trace, oscilloscope (right-hand column of Fig. 2) and listen to the mixed waveforms with an amplifier and loudspeaker.

As the pulses close up, the time period t_w (t whoosh) reduces—and this will be heard in the loudspeaker as a rising "white noise" or "whoosh" effect. (It is possible to observe this effect without special equipment: the Loran navigation network audible on the amateur 160m band after dark can be heard to "phase" in this manner as the multiple radiating stations vary their pulse rates.)

APPLICATION TO MUSIC

Any "harsh" music—with particular apologies to the pop world!—is rich in peaky waveforms and lends itself to the production of phase on the same theoretical basis as the pulse trains *A* and *B*. What is needed is some

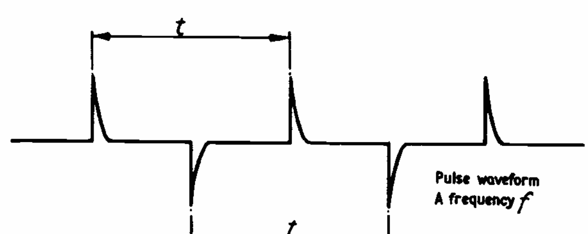


Fig. 1a. Illustrating the "whoosh" effect—waveform A

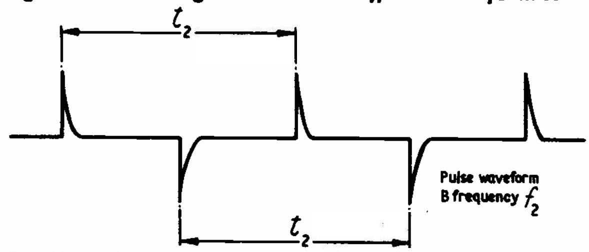


Fig. 1b. Waveform B, slightly different in frequency

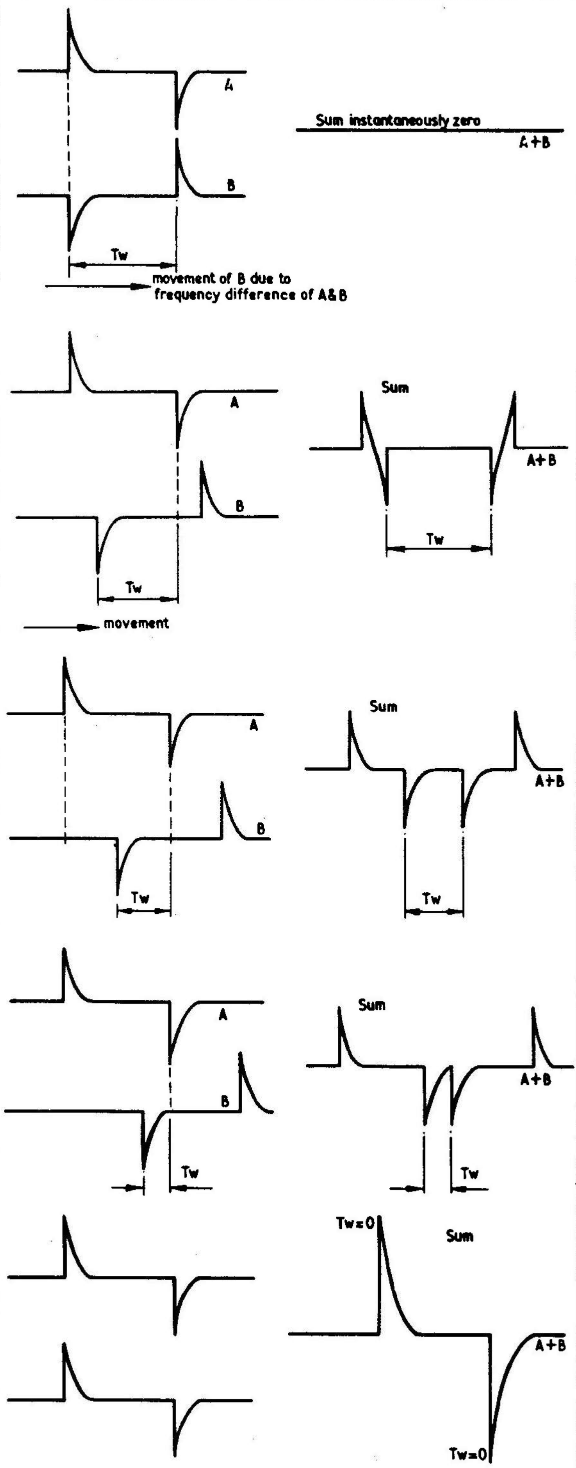


Fig. 2. Waveforms A and B observed with oscilloscopes. The interval t_w diminishes as the phase difference decreases, and the ear interprets this as a rising "whoosh" frequency

means of splitting the original signal into two versions, one of which can be electronically delayed, or (by recording) made to advance and retard relative to the other.

"PURE" PHASE PRODUCTION

Two record players or tape decks mixed through a common amplifier, and of course playing the same recording, can be used to produce phase. A further recorder can be used to make a permanent "phased" recording—or alternatively the following method can be applied using one four-track recorder, a record player and a mixer/amplifier.

Step 1: Record the disc on to track one of the recorder (Fig. 3).

Step 2: Record disc again on track three (Fig. 4) and monitor the taped disc on track one (assuming the recorder will allow this) and at the same time monitor the record player output through the same amplifier, with equally mixed levels. Achieve phase by keeping recordings closely in step and cause "overtaking" by carefully slowing the machine which is ahead.

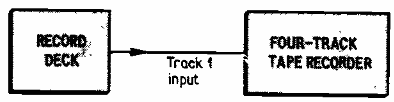


Fig. 3. Step one in creating pure phase

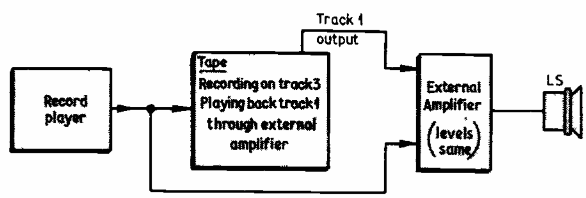


Fig. 4. Pure phase—step two. The direct output of the record player is mixed with the pre-recorded track one version and monitored while recording again on track three. Tracks are subsequently replayed together

Starting the recordings in coincidence requires some practice. It is easier to stop the tape (track one monitor) just after the beginning of the recording and then start the disc and keep the tape stationary until it is possible to start running the two in sync.

If you aim at producing an echo and then slow the faster of the two sources (finger on centre of disc or tape spool!), the echo time will decrease and you will achieve phase.

If both track one and track two final recordings are at approximately the same speed, the permanent phase recording can be reproduced at any time by parallel track playback. Fig. 5 shows an alternative method of playback which gives an impression of movement between two loudspeakers.

Another tape recorder approach is possible. Consider the two tape loop mechanisms with erase, record and playback heads arranged as shown in Fig. 6. If the distance in tape transport between record and playback heads is the same in each case, and the tape speeds are exactly the same, then whatever is recorded on the tape loops 1 and 2 at the record heads will appear at some time later at the playback heads exactly in step. However, if one tape loop speed is fixed and the other is slightly variable (but with its speed centred

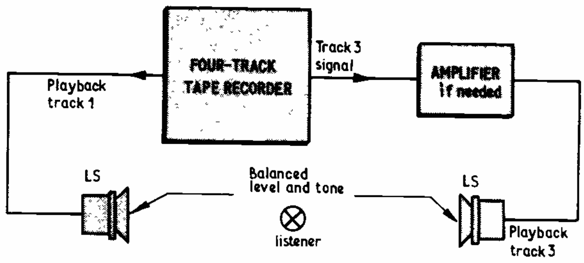


Fig. 5. Another way of replaying the phased recording derived from the method given in Fig. 4, which gives an impression of movement between the loudspeakers

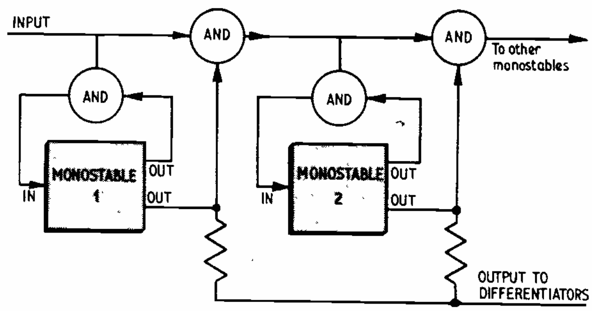


Fig. 9. Compound "Pradge". A number of monostables, similarly connected, are necessary

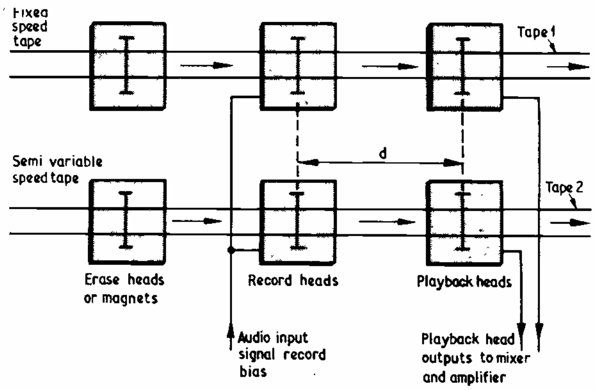


Fig. 6. Phase production with separate recorders held slightly out of sync.

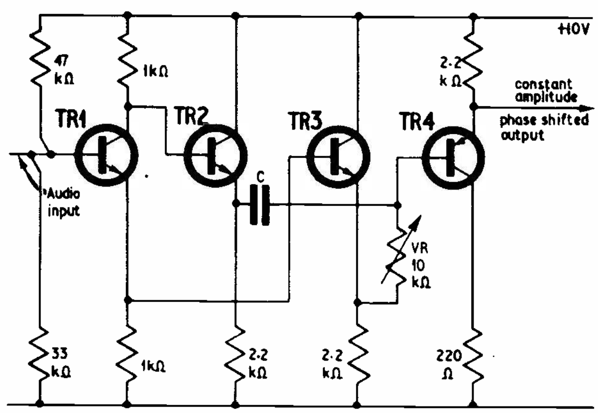


Fig. 10. A simple CR phase shift circuit. TR1 is a phase splitter, TR2 and TR3 are isolating emitter followers, C and VR provide the phase shift and TR4 provides a high impedance match for the CR network. TR1 to TR3 may be almost any small-signal npn transistors (of the same type) and TR4 is a pnp.

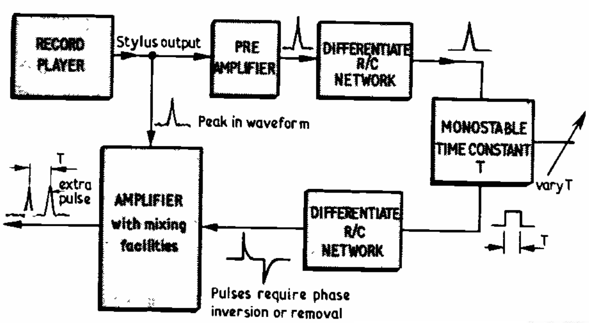
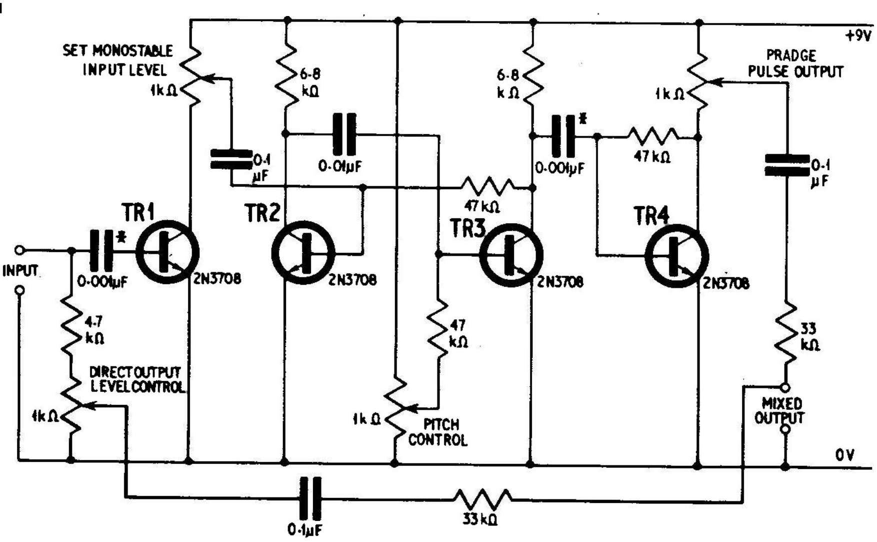


Fig. 7. Basic "Pradge" uses a variable monostable to create delayed pulses

Fig. 8 (right). Circuit diagram of the basic "Pradge"



upon that of the fixed speed loop) then whatever is recorded at the record heads can be made to reappear in step (tape speeds the same); with echo (tape 2 slower than tape 1); or a head (tape 2 faster than tape 1).

Clearly if the speed of tape 2 is continuously variable, then the recording will phase as one loop draws ahead of the other. Phasing will of course occur only while the speed is being changed—which to avoid wow must not be too rapid—and will cease when the second loop has stabilised at its new speed.

ALL ELECTRONIC PHASE

The most marked feature of phase, the high frequency "whoosh", can be simulated electronically. The great advantage of a successful electronic system is that it can be used in a live performance without any need for recording. One possible system will now be described. This has been called Pradge—from the pulse re-insertive audio distortion generating equipment employed.

The musical waveform applied to "Pradge" is differentiated to extract a pulse train which is then amplified sufficiently to trigger a monostable of variable time constant. The output from the monostable is differentiated and mixed with the direct music fed to the loudspeaker (see Fig. 7).

Hence for every pulse on the musical waveform large enough to trigger the monostable, a second pulse is produced after a time determined by the setting of the monostable time constant t. The time interval between the pulses gives rise to a whoosh frequency f_W, which can be made to vary with the alteration of a single control on the monostable. Thus the system generates whoosh by pulse re-insertion, the frequency being variable. With continuous waveform inputs, the circuit given in Fig. 8 provides a good "swish" as the pitch control is varied, but on music it lacks the pleasing effect of pure phase (dual disc or tape) methods. Although extra pulses can be produced they are insufficient in number, chiefly because the circuit contains only one storage element—the monostable—and thus only one pulse may be stored at any moment. It is nevertheless felt that the circuit is worthy of further attention.

COMPOUND PRADGE

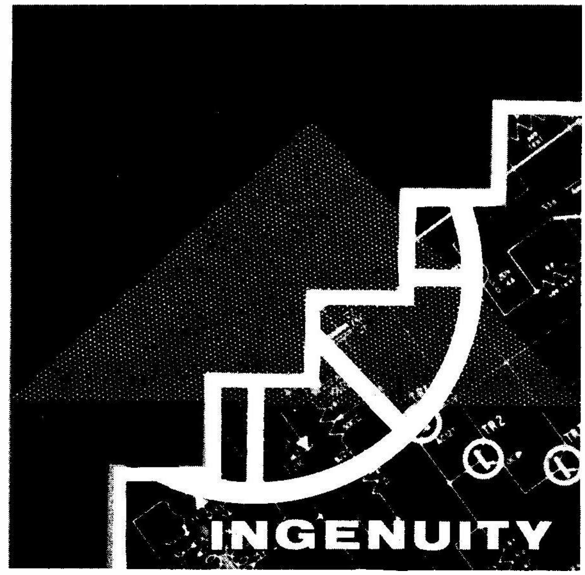
To overcome the problem of storing many pulses at the same instant, a compound Pradge system is proposed. Several monostables are used, with AND gates directing incoming pulses to the sections which are not storing signals, and are thus able to accept them at any instant.

The diagram (Fig. 9) shows the general arrangement, where the monostable outputs are taken from both collectors to obtain both direct and indirect outputs for the AND gates, which may be passive (diode) or active (transistor) elements.

The monostable outputs are added and differentiated to obtain a rapid sequence of pulses, each bearing a definite phase relationship to the original audio waveform peak that triggered a device, the time delay being dependent on the time constant of the storing device.

For the sake of completeness, a simple CR phase shift circuit is shown in Fig. 10. It consists of an antiphase-fed circuit which provides variable delay using the time constant of C and VR. It will provide a delay of 0·25Hz at 10kHz with C=1,500pF and R=10 kilohms. In practice several stages would probably be necessary to achieve audible phasing.

It is hoped to publish a more simple method of achieving the phase effect in the near future. ★



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.

AN ELECTRONIC STORM

A recent series of articles on electronic sound effects has given me the idea of constructing an electronic storm, which, once switched on rages indefinitely without any further help from the operator.

The equipment operates from the familiar *White Noise Generator* (January 1968). The output from the generator is passed to two electronic active filters. The output of one of the filters is fed to a diode demodulator and a two stage v.l.f. amplifier. The signal from this amplifier is fed to a transistor which modifies the transfer characteristic of the second filter. The output is taken from this second filter.

The output consists of two random signals. The wind itself is pink noise (i.e. a narrow band of white noise) whose bandwidth and amplitude are varied by the v.l.f. to produce a sound like a natural storm. Switches are provided to change from moaning gales to a violent storm with slashing rain. The sound of a steady downpour is available as an additional bonus from the v.l.f. side of the apparatus.

The circuit is given in Fig. 1 and a block diagram in Fig. 2.

The apparatus was built on a tagboard; layout should not be critical. However, unless a very low impedance power supply is used, it may be necessary to decouple the v.l.f. amplifier to prevent oscillation at these low frequencies which would ruin the whole effect.

The choke used in the first filter was included to give the filter higher gain and to make it more stable at high Q factors. It was a surplus item removed from a R1155B receiver filter.

It is considered best to test the equipment as it is being built. First construct the noise generator and its emitter follower. Connect the output, via a suitable capacitor, to an audio amplifier and ensure that there is a noise output.

Next build the first electronic filter, and connect its output, via the capacitor, to the amplifier. It should be

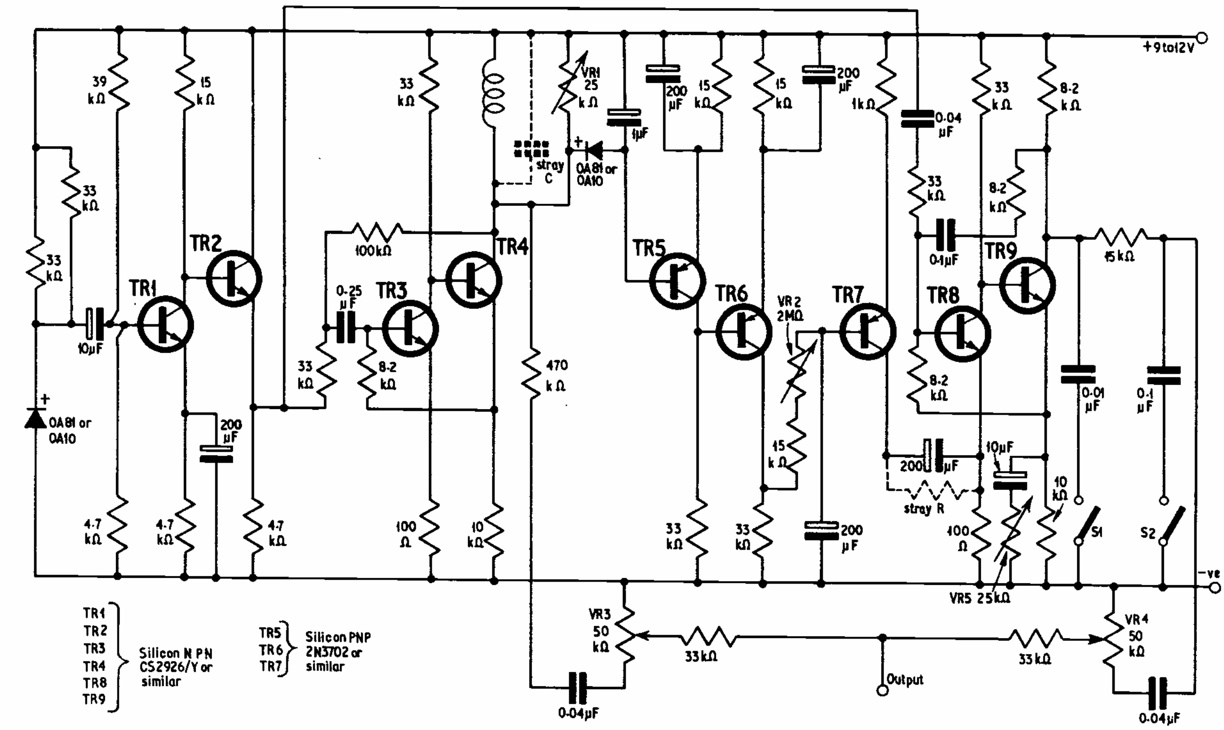


Fig. 1. Circuit diagram of the storm generator. The first OA81 (left) is selected for high noise output. Alternatively a cheap general purpose diode would do if it is noisy

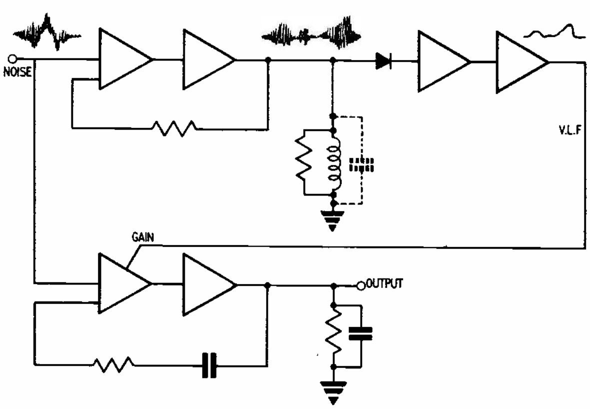


Fig. 2. Block diagram showing how the demodulated v.l.f. component of filtered white noise is used to vary the characteristic of an electronic filter

possible to adjust the VR1 to give an oscillation. If not, try disconnecting it. If oscillation then takes place use a high value resistor. If oscillation still does not occur, try an emitter bypass arrangement as in the second filter. If that won't do it the 100 kilohm resistor may be changed to 33kΩ. If none of these changes succeed, check the circuit and remedy the faulty wiring or component! The circuit should be oscillating at a high audio frequency, about that of the television line whistle on 405 line transmissions. Now reduce the gain of the circuit with VR1 and hear the sound of falling rain as oscillation just ceases. Some coils may require capacitors across them to achieve the desired effect, others may have too large an inductance, and the only cure is to rewind or replace them!

Next the demodulator and the v.l.f. amplifier may be built, as far as VR2. These are difficult to check without a high impedance voltmeter or oscilloscope, but if they are working, these instruments are not required for this experiment. If a high impedance voltmeter or d.c. oscilloscope is connected to the collector of the output transistor, a random varying voltage should be observed. It might be possible to hear a rumbling sound in the amplifier, if it is connected to the output.

Next, construct the rest of the circuit, but leave the 200µF capacitor connected to the first emitter of the filter with one end disconnected. When the filter is completed, it may be tested as before. With the switches on, deeper pink noise should be obtained.

The operation will be completed by the connection of the 200µF capacitor to TR5 emitter. With the 2 megohm resistor set at 1 megohm, the output of the filter should represent a violent storm. If not, it may be that a large resistance should be connected across the 200µF. I would suggest 330 kilohms for a start.

It should be noted that the setting of VR1 is critical for correct operation.

VR3 and VR4 are a mixing network for the final output. VR4 controls the wind, and VR3 the steady downpour outputs respectively.

J. C. de Rivaz, B.Sc.
Barnet.

For Future Reference

● An index for volume three (January 1967 to December 1967) is now available price 1s 6d inclusive of postage.

Orders for copies of the Index *only* should be addressed to the Post Sales Department, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

EXPERIMENTS WITH...

SOUND LIGHT AND COLOUR

PART 2—A CATHODE RAY TUBE COLOUR PATTERN DISPLAY

By F. C. JUDD A.Inst.E

THE first article of this series gave brief details of the employment of a cathode ray tube display with a colour scanner capable of producing moving patterns in colour from audio frequency signals, such signals being derived from music or sine/square-wave generators. A display of this kind can be produced from an old television receiver, providing that the cathode ray tube and the e.h.t. supply circuits are both in working order. Some familiarity with TV receiver circuitry is, of course, essential. *This experimental project should certainly not be undertaken by the novice.*

FIRST STAGE—POWER SUPPLIES

Having acquired a redundant TV receiver (suitable models are frequently available for £10 or less), modification is then carried out on the following lines.

The first stage is to strip out all unrequired valves and components, i.e. the r.f., i.f., video and frame oscillator circuitry. The line scan oscillator and its amplifier, which will most likely be part of the e.h.t. circuit, must be left in and supplied with the necessary h.t. from an external power supply so that the e.h.t. supply can be made to operate again.

Most TV sets employ the a.c./d.c. system of heater and h.t. supply derived directly from the mains. This must be done away with, particularly in view of the experimental nature of this project. *On no account should the new heater and h.t. supplies be taken direct from the mains. Such practice would not only be dangerous but could also prove to be lethal.*

The heater voltage for the remaining line scan oscillator, its amplifier, and the e.h.t. valves may well prove to be different for each valve left in circuit—although the common heater current will most likely be 0·3A. A low voltage a.c. supply from a transformer must therefore be provided. The voltage required will depend upon whether the heaters can be left in series at 0·3A, or parallel wired if each valve has the same heater voltage. The new h.t. supply must be capable of supplying 300–350V at 120mA since it will be providing power for the tube e.h.t. circuit as well as the new circuits. It must of course employ a mains transformer, rectifier, and smoothing circuit in the usual way.

BRILLIANCE CONTROL

The second stage is to get the e.h.t. supply and the tube working. The tube brilliance control circuit will probably have to be modified accordingly, and here it may be easier to rewire the brilliance control circuitry and employ variable cathode bias. Other tube potentials should be adjusted according to the make and type of tube.

The TV set shown in the photographs was originally a Ferguson type 306T with a Mullard MW43/64 flat faced tube designed to operate with a maximum of 14kV e.h.t. It required a grid bias of approximately −60V to produce cut off, i.e. brilliance reduced to zero.

On completion of this second stage the tube should now display a bright spot at the centre when the brilliance control is turned up. Do not run in this condition for more than is necessary as the beam intensity may be sufficient to burn a hole in the tube fluorescent coating. If an ion trap is fitted to the tube it must be properly positioned before brilliance can be obtained.

By using variable cathode bias for brilliance control the grid can be directly returned to earth via a 470 kilohm resistor. The pulsing voltage can then be applied directly to the grid via series resistances as will be shown later.

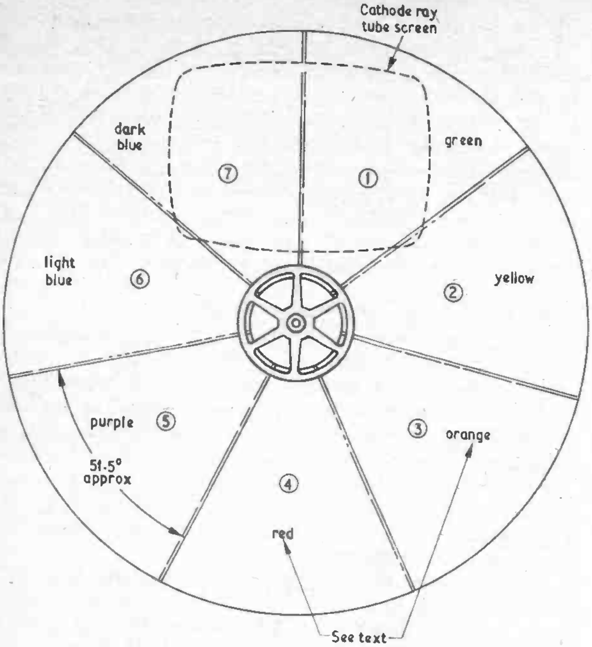


Fig. 2.1. The colour scanner assembly (see text and also Fig. 2.2)

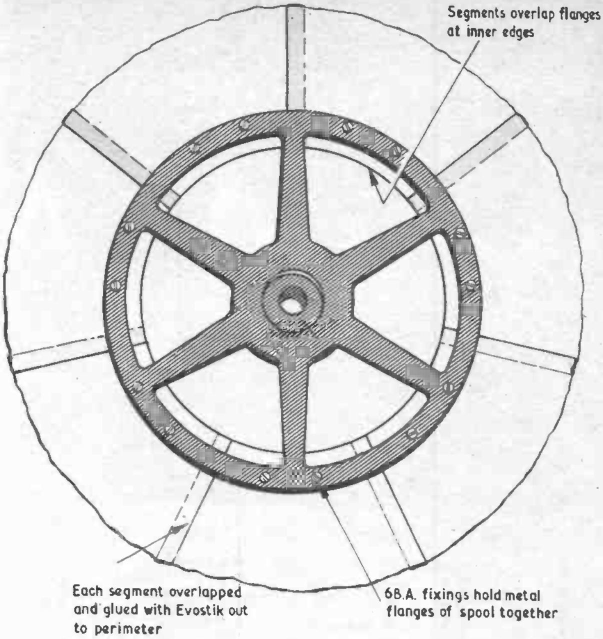


Fig. 2.2. Details of the colour scanner hub and method of securing the inner edges of the colour segments

DEFLECTOR COILS

The deflector coils may be found connected in parallel to preserve symmetrical deflection. They should be left wired this way ready for connection to the output transformers of the new deflection amplifiers. However, as a check on proper deflection of the tube trace, a low a.c. voltage, say 2V to 3V, could be connected to each coil in turn.

The display is now ready for the assembly, wiring, and connecting up of the new circuits which comprise two pulse generators, two deflector coil amplifiers, and input and phase shift circuitry.

The existing focusing arrangement is not altered or disturbed in any way.

THE COLOUR SCANNER

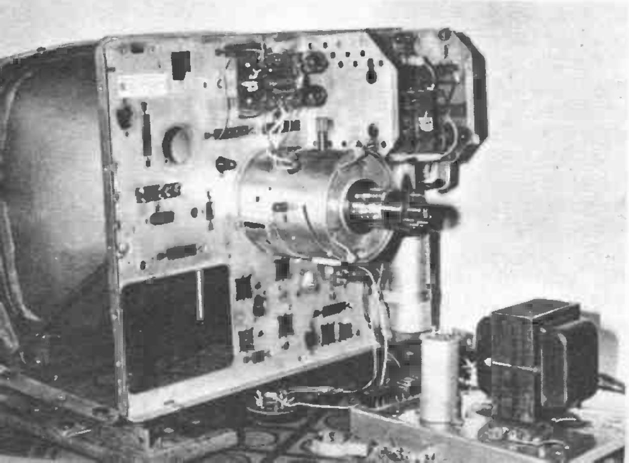
First, however, the colour scanner must be assembled and a suitable d.c. motor mounted under the tube.

The arrangement used in the writer's experimental display is shown in the photograph. The motor is a 12V d.c. type taking a current of 0·5A and runs at approximately 10 revolutions per second. This motor was mounted as shown beneath the tube with the shaft extended via a flexible coupler to the scanner hub.

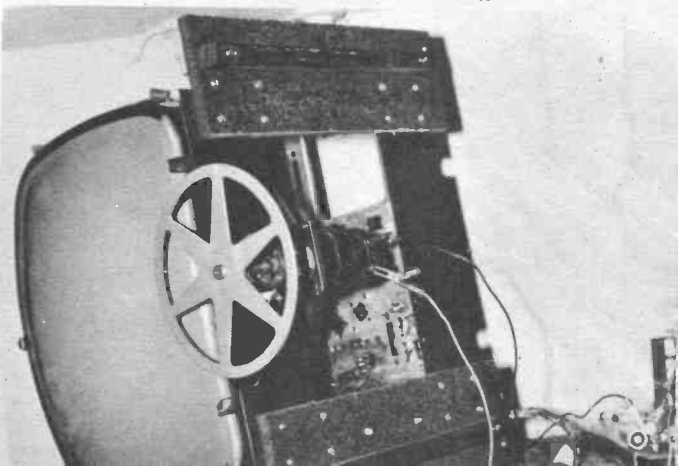
This hub was made from a metal tape spool (Ferrograph type). The centre section of the spool was removed leaving the two spoked faces which were bolted together and provided with a boss and spindle to couple up to the drive motor. Fig. 2.1 shows the general assembly of the scanner which has an overall diameter of 28in. The diameter will be larger if the c.r.t. is greater than 12in vertically across the face.

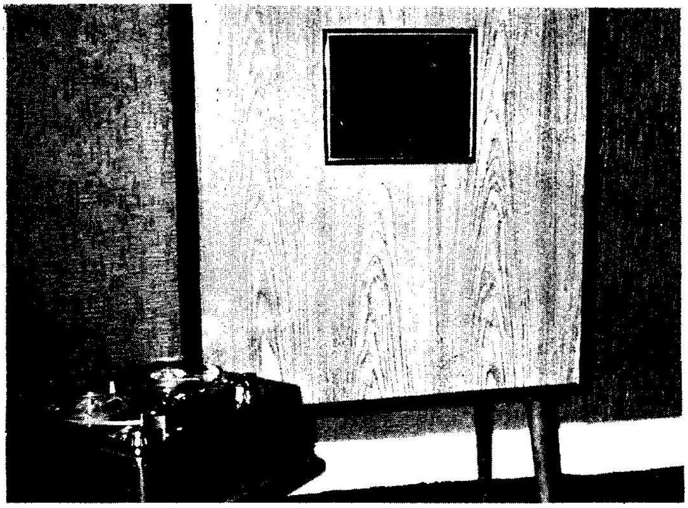
The colour material for the scanner is *Cinemoid* which is available from Strand Electric and Engineering Limited, 250 Kennington Lane, London, S.E.11. Pieces 12in × 12in cost 2s 9d each and are available in a great variety of colours. A piece of 12in × 12in will just allow for one segment of the scanner shown in

The stripped down TV set ready for the assembly and wiring of the new circuits. The partly assembled new heater and h.t. supply can be seen on the right



This shows the d.c. motor mounted beneath the c.r.t. This motor should be controlled by a variable series resistor if necessary so that the scanner will turn at 6 to 10 revolutions per second. Any 12 to 24 volt motor with sufficient power and a nominal speed of 600 r.p.m. will suffice





The completed cathode ray tube colour pattern display

Fig. 2.1. The Strand Electric reference for these pieces is No. 61 which ensures getting the 12in × 12in sheets.

ARRANGEMENT OF COLOURS

For optimum colour effect the segments should be coloured as shown in Fig. 2.1. The two segments marked light blue and dark blue (6 and 7) were found to give a contrast of blues but one or the other could be replaced with a deep red or green to obtain a similar effect.

The colour segments are cut to cover an arc of just over 51 degrees *plus half an inch for overlapping* as shown in Fig. 2.2. The inner edges also overlap the inside of the hub faces as in Fig. 2.2 and 6B.A. nuts and screws secure the two hub faces and the inner edges of the colour segments as shown in the same diagram. The long overlaps, i.e. from inner to outer diameter are glued with Evostick—the only adhesive found to glue *Cinemoid* successfully.

When rotating at between six and ten times per second the scanner, which may appear too flexible whilst stationary, remains quite stable and flat. Care should be taken, however, to see that the motor drive and scanner hub run true and that the scanner is perfectly round at the outer edge.

CIRCUIT DIAGRAMS

Details and circuits for the pulse generators and deflection amplifiers, etc. will be dealt with in next month's article.

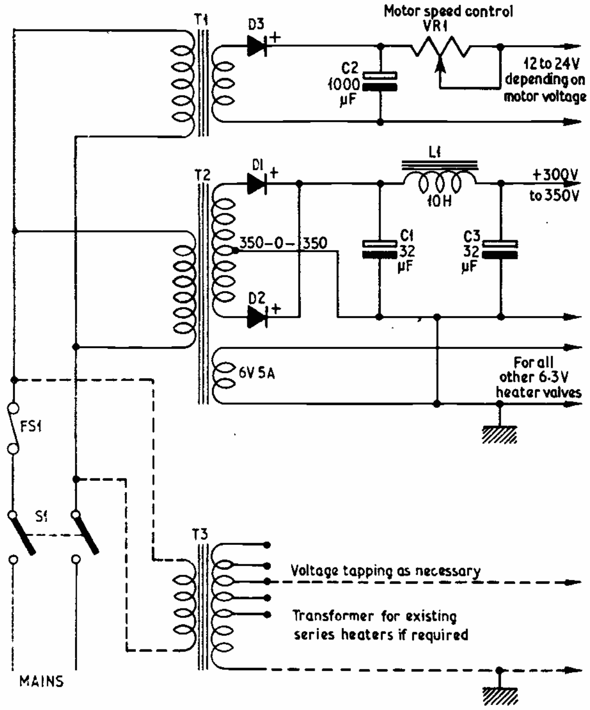


Fig. 2.3. Circuit of the power supply used by the writer which may serve as a guide to a general arrangement for obtaining the scanner motor voltage, h.t. and heater voltage for new circuitry and any necessary series heater voltage

The power supply circuit used for the display built by the writer may be of interest and is given in Fig. 2.3. The voltage for any series heater circuits remaining in use, i.e. line oscillator and e.h.t., circuit will of course depend on the number of valves and their respective heater voltages. The motor voltage and current will also depend on that required, but a d.c. motor capable of turning the colour scanner will most likely take around 0·5 amp at 12 volts or so.

The block diagram Fig. 2.4 shows the different circuits associated with the c.r. colour pattern display. These are fairly simple circuit arrangements and can be assembled on small chassis bolted to the existing TV chassis as will be shown next month.

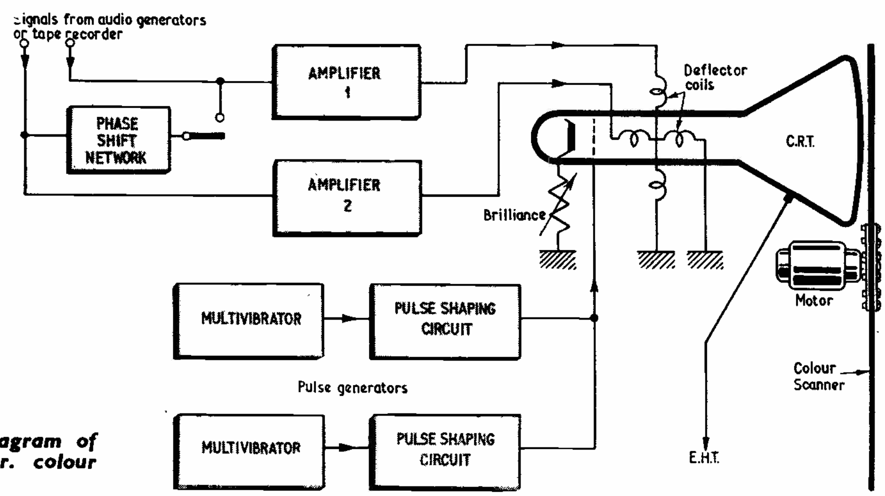


Fig. 2.4. Block diagram of the completed c.r. colour pattern display

ELECTRONORAMA

...MAMMOTH MICRO PLANT

NEW COMPANY ... NEW FACTORY

CLAIMED to be the largest European manufacturer of integrated circuits, Marconi-Elliott Microelectronics Ltd. has recently been formed by English Electric. This new company has a modern production plant with a production capacity of over five million microcircuits per year.

The new factory at Witham, Essex, total area 96,000 sq ft, was officially opened by the Minister of Technology, Rt Hon Anthony Wedgwood Benn MP on July 5. This significant development puts Britain in a strong position to combat international competition in European markets.

The gleaming white external appearance of the new factory is indicative of the clinical atmosphere within. Scrupulously clean working areas are essential in semiconductor production. At Witham the air cleanliness is controlled to very precise limits and temperature never varies more than 1½°C and humidity is kept within ±10 per cent of 45 per cent. Nylon coats or overalls are compulsory throughout this carefully regulated environment.

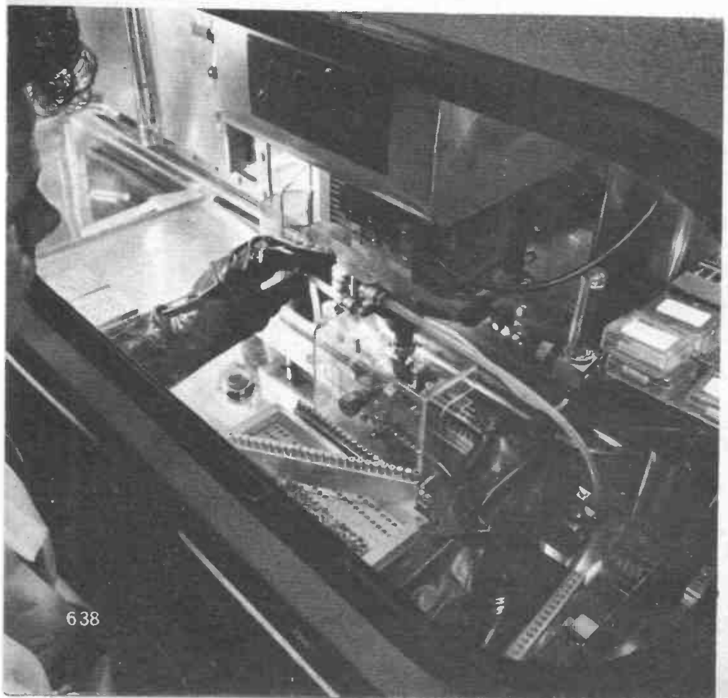
Certain processes require even higher standards of clean air than provided in the main areas: operators in, for example, the mask making sections operate equipment in

An operator controlling a semi-automatic encapsulation machine at the new Marconi-Elliott Microelectronics plant at Witham, Essex.

The process, in which semiconductors are put into cans and sealed in an atmosphere of dry nitrogen, is carried out in a cabinet into which nitrogen gas is fed at above atmospheric pressure and continuously monitored in humidity and temperature. The operator works through two portholes with rubber glove extensions attached.

A major feature of the service offered to customers is a comprehensive applications engineering facility, able to design integrated circuits for specific purposes.

The photograph shows an applications engineer working on a "breadboard" layout for a customer application.



A steam generator, connected to a quartz tube, used in the oxidisation process carried out on silicon slices when they are in a diffusion furnace

A general view of the main 6,000 sq ft assembly area. The front row of girls in the photograph are testing circuits before they are assembled into their final packages

laminar flow "boxes" providing Class 100 clean air conditions.

The factory is like a giant three layer sandwich, with production and development areas occupying a central floor. This floor is serviced by gas, water, electricity, etc., from below through a complex network of pipes, and from above by a giant rabbit warren of air conditioning ducts. Other services installed include an effluent treatment plant, a demineralised water treatment plant, vacuum cleaning plant and an auxiliary electrical supply to protect the banks of diffusion furnaces. Production and development staff gain access through changing rooms.

Production at present is concentrated on bipolar microcircuits, with MOST production being carried out in a smaller area. This relationship is expected to change radically by the 1970s with metal oxide silicon transistor (MOST) circuits accounting for a much higher percentage. Of major importance for the future is the research work being undertaken, especially in connection with large scale integration for linear and digital circuits; automated production techniques for interconnecting these circuits are being explored.

GOOD (COMPUTERISED) HOUSEKEEPING AT THE B.B.C.........

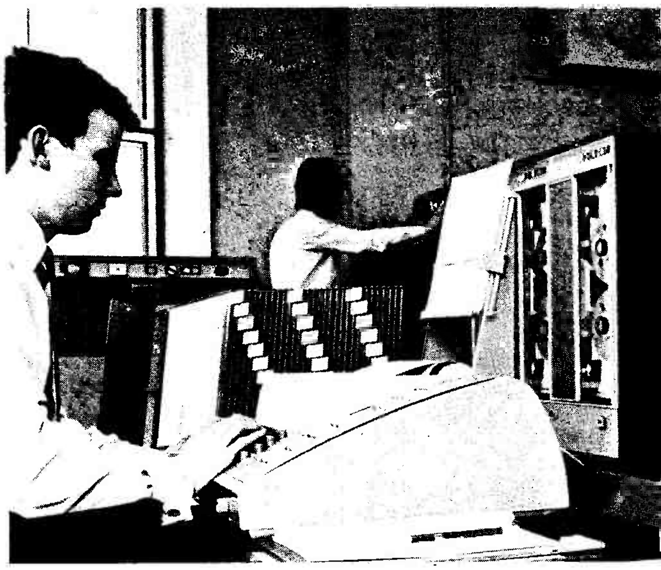
or how to stretch that licence revenue to the limit

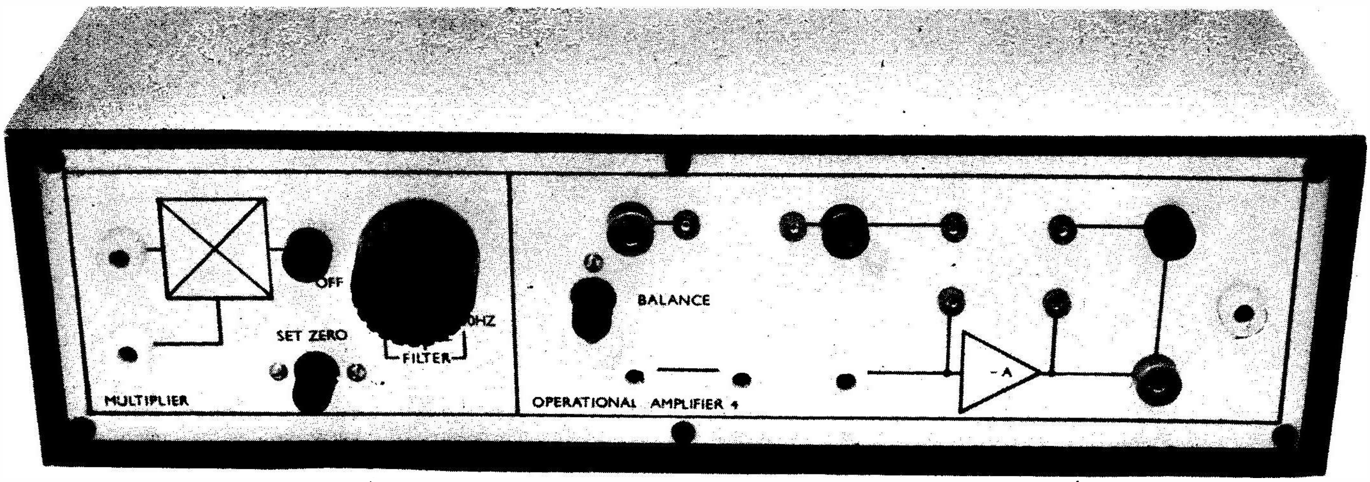
HOUSEKEEPING can be a great problem especially if you are responsible for supplying all the BBC's transmitting stations with essential parts. This is the problem of the BBC's Central Valve Store. Some transmitting valves can cost £3,000 each. No prudent "housewife" would want to hold too many of these items in stock.

Expansion of BBC television in monochrome and colour, the duplication of BBC-1 on u.h.f. and the modernisation of the shortwave stations, have greatly increased the range of valves, semiconductors, cathode ray tubes, camera tubes, and similar devices now in use. Some 4,000 different types are now held in store.

So now an ICT 1909 general purpose computer (see photo) has been called in to compile inventories of valve stocks, and to indicate when new supplies should be ordered from manufacturers. Factors taken in account in the computer programme are stock in hand, stock on order, shortages, requests for special schemes, forecasted demand, minimum order quantity.

The advantage of computerised housekeeping is that no capital is tied up in excess stocks, and that so far as possible no interruption of services will occur due to shortages of replacement parts. Store space is also reduced to the minimum—effecting further economies.





ANALOGUE COMPUTER

PEAC

By D. BOLLEN

THIS month's article deals with UNIT "D"—the multiplier, which is the final piece of PEAC equipment. After a technical description, details of the construction and setting up are given.

The servo driven potentiometer has been widely employed in the past for multiplication of one variable voltage by another, but its frequency response, in most cases, is seldom better than 0–5Hz. Modern analogue computers now tend to use all solid-state multiplier circuits, which have a frequency response extending into the kHz region, but they are both complex and expensive. Taking the quarter-square multiplier as an example, it needs five operational amplifiers and two diode function generators to produce an accurate product voltage from two inputs. It follows, therefore, that analogue multiplier circuit design can be expected to present considerable difficulties when cost is an important consideration.

UNIT "D"—THE MULTIPLIER

Working on the premise that even a multiplier of restricted performance can make a worthwhile contribution to an analogue computer which lacks such a facility, an accuracy of $\pm 2{\cdot}5$ per cent and a frequency response of 50Hz under the most favourable conditions was considered to be an acceptable specification for the UNIT "D" multiplier. Although 0–50Hz seems rather limited by ordinary electronic standards, in the context of "parallel" computer circuit operation it represents a useful compute time which compares favourably with the servo multiplier.

UNIT "D" contains three distinct circuits, two operational amplifiers and a bistable reed relay driver. One of the amplifiers is identical to those used with UNIT "A", and is available as a multi-purpose operational amplifier when the multiplier is not in service.

TIME DIVISION

With the time division multiplier, a square wave is modulated in such a way that the mark/space ratio is proportional to one input voltage, while the amplitude of the waveform is proportional to another input voltage. The mean value of the resulting waveform is then proportional to the product of the two input voltages.

Looking at Fig. 9.1, which sets out the simplified multiplier circuit with associated waveforms, a voltage E_2 is compared with a fixed voltage E_3 at the input of the integrating amplifier. A bistable relay is arranged to switch S1 and S2 when the integrator output reaches a pre-determined value, conveniently about two thirds of the maximum available amplifier output swing. If the sign of E_3 at the S1 contacts is correct, the feedback will be positive, and a self-sustained oscillation at a frequency determined mainly by E_2 and C_f will result. When $E_2 = 0$ the output from the integrator will consist of a sawtooth or symmetrical ramp waveform, with identical rising and falling slopes, which is generated by E_3.

Assume now that a voltage E_2 is applied; this will be added to, or subtracted from E_3, depending on the position of the S1 switch. The ramp waveform is therefore modified to an asymmetric form where the rising and falling slopes become dependent on the level and sign of E_2.

Waveform (a) in Fig. 9.1 depicts the asymmetric ramp for $+E_2$ and $-E_2$, while waveform (b) shows the square wave generated by the switch, of mark/space dependent on the magnitude of E_2. As S2 is synchronised with S1, so the input resistor R1 will be alternately switched to the inverting and non-inverting inputs of the product amplifier, and will remain at each contact for a time dependent on the frequency and mark/space of the switching waveform.

The amplitude of the product amplifier output is

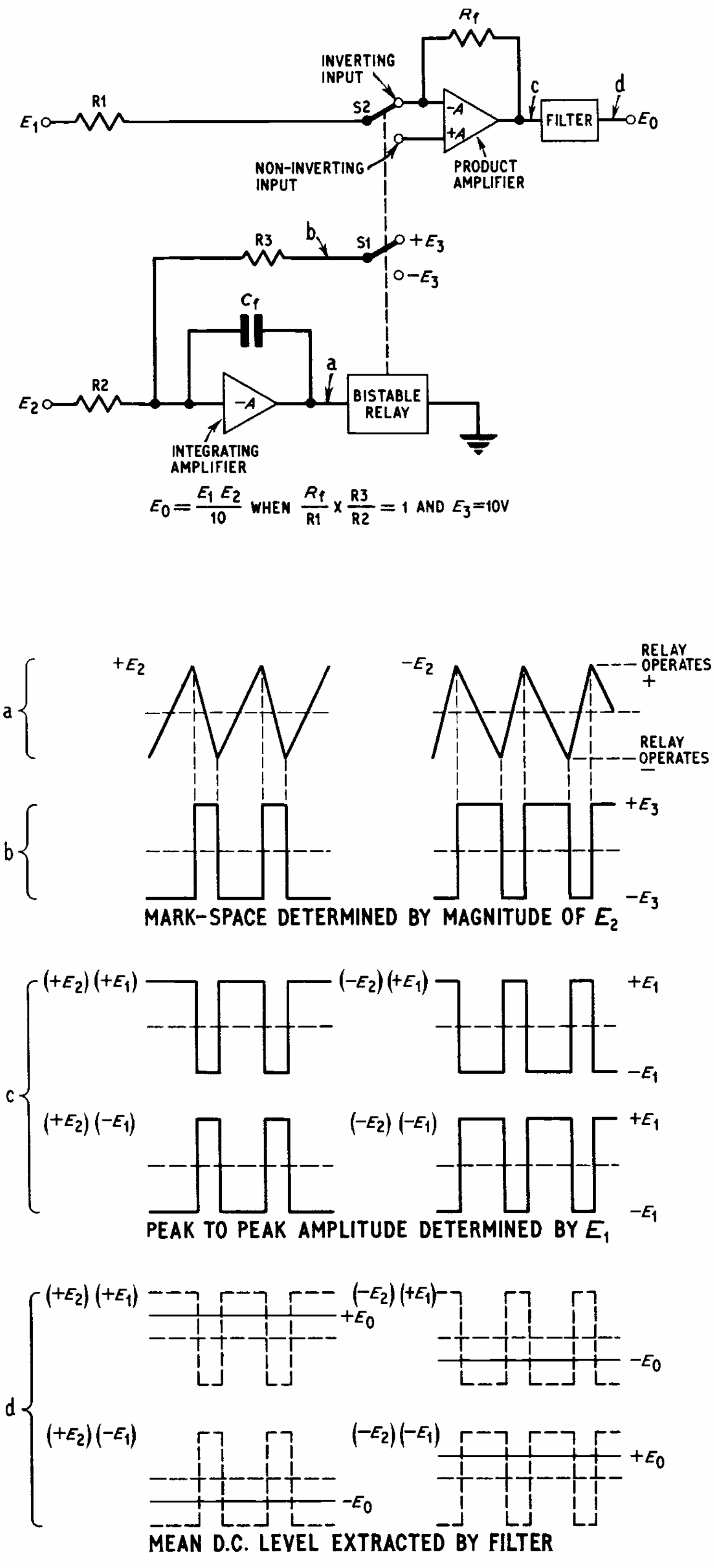


Fig. 9.1. Time division multiplier with associated waveforms

COMPONENTS . . .

UNIT "D" FRONT PANEL AND BOX

Potentiometers
VR25 100Ω wirewound
VR26 50Ω wirewound
(both panel mounting type)

Switches
S11 3 pole, 4 way rotary
S12 Double-pole slide switch (c/o contacts)

Sockets
2 red, 2 blue, 1 black, 2 yellow, 3 white, 1 green, and 6 miniature sockets

Miscellaneous
Material for front panel and box. Hardboard, 2 off 12⅜in × 4½in, 2 off 4½in × 3 3/16in. White plastic laminate, 2 off 12⅜in × 4½in, 2 off 3½in × 4½in, 1 off 12in × 3½in. Softwood, 25in × ½in × ½in. Knob, one Radiospares 1⅛in type PK with pointer.

UNIT "D" BISTABLE RELAY AND PRODUCT AMPLIFIER

Resistors

R1	1kΩ	*R14	10kΩ 1%
R2	4·3kΩ	R15	1kΩ
R3	4·3kΩ	R16	820Ω
R4	4·3kΩ	R17	820Ω
R5	1kΩ	R18	1kΩ
R6	100Ω	R19	8·2kΩ
*R7	11kΩ 1%	R20	22kΩ
R8	10kΩ	R21	22kΩ
R9	27kΩ	R22	8·2kΩ
R10	2·2kΩ	*R23	200Ω 2%
R11	100Ω	*R24	1kΩ 2%
*R12	10kΩ 1%	*R25	1·2kΩ 1%
*R13	9·1kΩ 1%	*R26	300Ω 1%

(All 10% ½ watt carbon composition except * = 1W metal oxide)

Potentiometers
VR1 100kΩ vertical skeleton pre-set
VR2 220Ω miniature horizontal pre-set

Capacitors
C1 1µF polyester 250V d.c.
C2 0·25µF polyester 250V d.c.
C3 1µF elect. 15V
C4 8µF elect. 15V
C5 100µF elect. 15V

Transistors
TR1, TR2 2N2926 (orange) or 2N3904 (2 off)
TR3 2N3906
TR4 2N3904
TR5, TR6 ACY28 or AC126 (2 off)

Diodes
D1–D4 OA202 (4 off)

Choke
L1 5H (Radiospares "Midget" type)

Reed coils
RLA, RLB Miniature triple 12V Osmor type MT12V (2 off)

Reed switches
RLA1, RLA2 Hamlin MRG2 20–40AT (4 off)
RLB1, RLB2

Miscellaneous
S.R.B.P., 1 off 3in × 3½in, 1 off 3in × 4½in. Small turret tags. Baseboard 12 in × 4in s.r.b.p. or plastic laminate

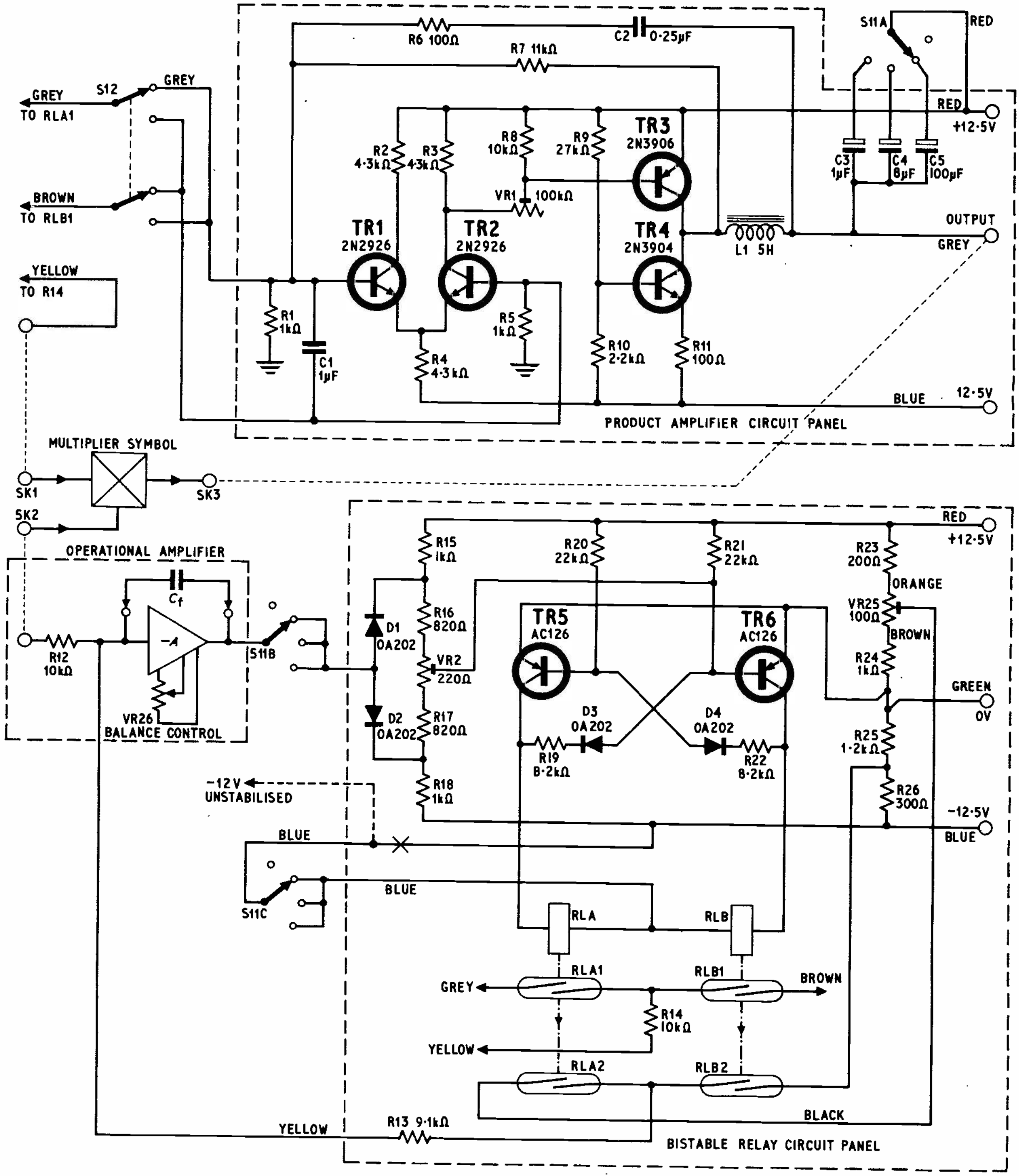


Fig. 9.2. Multiplier circuit, comprising product amplifier panel and bistable relay panel

wholly dependent on E_1, but whatever the value of E_1 it will be divided by $10/E_2$ (time division), which is the same thing as $(E_1 \times E_2)/10$, assuming of course that appropriate values for R1–R3, R_f and E_3 are chosen.

Waveforms (c) shows what happens to different signs of E_1 and E_2, in terms of the square wave. If now the mean voltage level of the output from the product amplifier is extracted by a suitable filter (see waveform (d)) it can be seen that four quadrant multiplication has been achieved. When E_1 and E_2 are both positive, or both negative, the product voltage will be positive, but when E_1 and E_2 are of opposite sign, the product becomes negative.

The multiplier circuit will now be described.

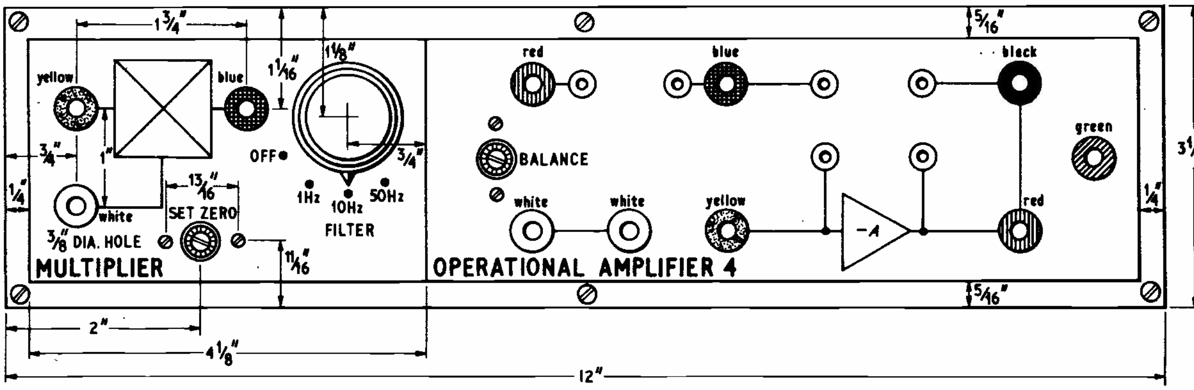


Fig. 9.3. Dimensions and engraving details for UNIT "D" front panel

UNIT "D" MULTIPLIER CIRCUIT

As the operational amplifier circuit has already been given in connection with UNIT "A", it appears in symbolised form only in the multiplier circuit of Fig. 9.2, with VR26 as the front panel balance control, and a fixed value of input resistor R12 provided internally for use with the multiplier. As the feedback capacitor C_f only affects the integrator waveform frequency, without altering other multiplier characteristics, it is useful to leave it as a plug-in component, so that the multiplier carrier frequency can be adjusted easily.

The output from the integrator, which it will be remembered from Fig. 9.1 carries information as to the magnitude and sign of input E_2, is fed via S11B to a diode resistor network composed of D1, D2, R15–R18, and VR2, the purpose of which is to allow the following bistable relay driver to be switched at precisely determined voltage levels. VR2 establishes the working point of the diode resistor network.

A conventional cross-coupled multivibrator is utilised as a relay driver, with reed coils RLA and RLB forming the respective collector loads of TR5 and TR6. D3 and D4 are used to ensure a "cleaner" switching action at high repetition rates, and the bistable circuit will function satisfactorily at frequencies in excess of 100Hz without undue relay contact bounce. The reference voltage, which was shown as $\pm E_3$ in Fig. 9.1, is extracted from a resistor network R23–R26 and VR25 in Fig. 9.2. VR25 allows positive and negative values of E_3 to be made equal. E_3 voltages are then fed, via RLA2 and RLB2 switches, and resistor R13, back to the summing junction of the integrator, thus completing the closed-loop to maintain oscillation.

SIGN CHANGE

The square wave switching cycle is presented to the input of the product amplifier by RLA1 and RLB1, with R14 acting as the input resistor. Changeover switch S12 is included to allow the sign of the multiplier output voltage to be changed to suit a particular problem set-up.

A product amplifier open-loop gain of about 1,000, which is the gain of the Fig. 9.2 circuit, is quite satisfactory for good accuracy when working with a fixed, closed-loop gain close to unity. Long-tailed pair TR1 and TR2 provide inverting and non-inverting inputs, while TR3 is the output transistor, and TR4 forms a constant current load for TR3, in place of a fixed resistor, thus enabling larger loads to be driven without excessive dissipation. VR1 serves to zero the amplifier output.

The ratio of resistors R7 and R14 gives a product amplifier gain (closed-loop) of 1·1, while R13/R12 yields an equivalent gain for the integrating amplifier of 0·91. The lower value of gain for the integrator enables E_2 to equal E_3 without stopping the integration cycle, and yet the overall gain of the multiplier is still unity because $1{\cdot}1 \times 0{\cdot}91 = 1$.

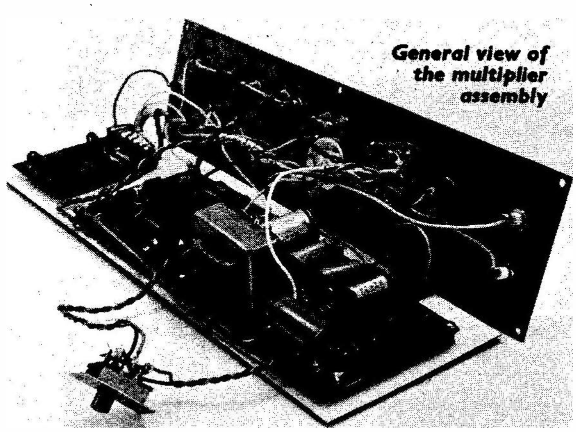
FILTER CIRCUIT

The purpose of the filter circuit L1, C2–C5, R6, and S11A, is to remove the square wave carrier without distorting the product waveform when input voltages are time varying. Bearing in mind that computer waveforms are extremely diverse, it is almost impossible to achieve near perfect results with one filter circuit, especially when the carrier frequency is not far removed from input frequencies. To allow compromise, therefore, the cut-off frequency of the Fig. 9.2 filter can be set by switch S11A to suit the circumstances of a particular problem set-up.

The three switch positions, 1Hz, 10Hz, and 50Hz, represent approximately the roll-off points given by the filter, and the bandwidth handled by the multiplier. In the 1Hz position the filter will virtually eliminate carrier ripple when input voltages are of very low frequency, but the 50Hz setting is used with fast integrator waveform inputs, where ripple may be less objectionable.

CONSTRUCTION OF UNIT "D" FRONT PANEL AND BOX

Details of the UNIT "D" front panel and box appear in Fig. 9.3 and Fig. 9.4. Note that the operational amplifier (OA4) socket positions and panel markings



General view of the multiplier assembly

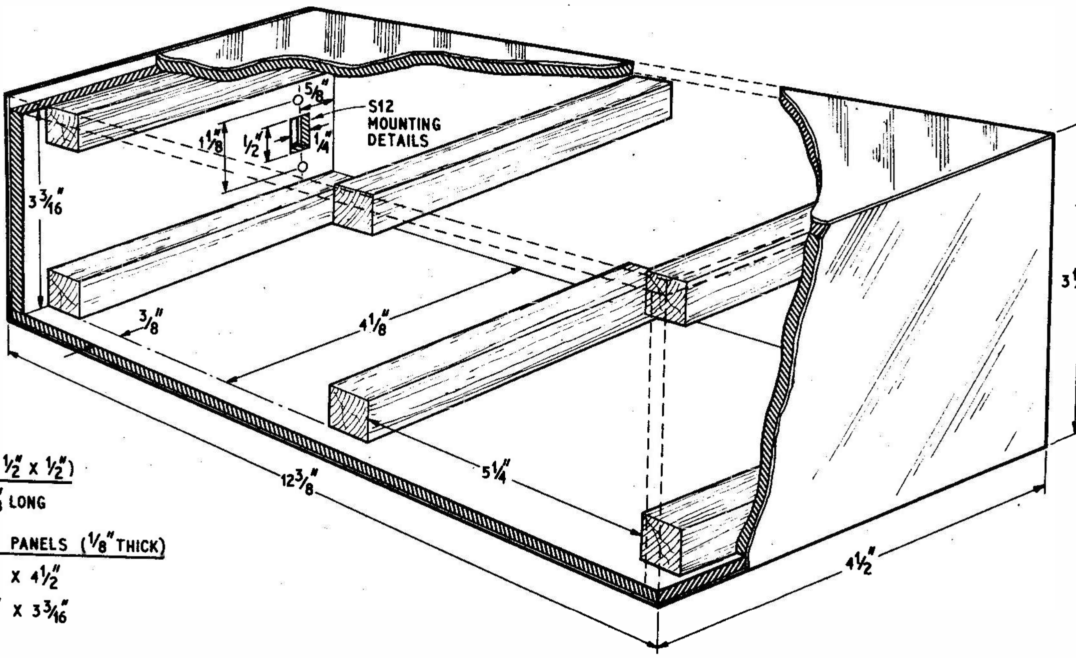


Fig. 9.4. Construction of the box for UNIT "D"

are the same as for UNIT "A" operational amplifiers. S11, VR25, VR26, and all sockets may be mounted after the front panel has been marked and drilled.

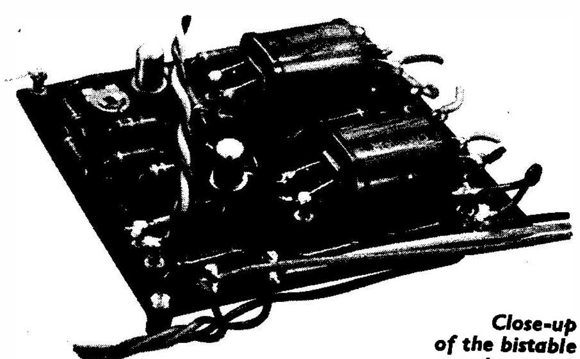
INTERNAL LAYOUT OF THE MULTIPLIER

The internal layout and interconnecting wiring of the multiplier are shown in Fig. 9.5. Operational amplifier, bistable relay driver, and product amplifier circuit panels are bolted with stand-off spacers to a 12in × 4in s.r.b.p. or plastics laminate baseboard, which rests on the wooden bearers at the base of the UNIT "D" box.

Component placement positions for the bistable relay circuit panel, and the product amplifier panel, also appear in Fig. 9.5, together with a rear view of the front panel assembly. The operational amplifier (OA4) is made up in accordance with instructions given in the May issue of PRACTICAL ELECTRONICS (pages 209–210).

BISTABLE RELAY CIRCUIT CONSTRUCTION

Drill the bistable relay circuit panel according to Fig. 9.6, and insert turret tags. Then mount all components and complete underside wiring, leaving the reed switches RLA1, RLA2, RLB1, and RLB2 until last. A triple reed coil is specified for the Fig. 9.2 circuit, to allow the addition of an extra pair of reed switches if the multiplier is to be enlarged to cater for three input voltages; this modification will, of course, also involve the construction of another product amplifier.



Close-up of the bistable relay panel

PRODUCT AMPLIFIER CIRCUIT CONSTRUCTION

Drilling details and underside wiring of the product amplifier panel appear in Fig. 9.7. Accurate matching of input transistors TR1 and TR2 may not be necessary with this low gain circuit. A 2N2926 transistor should not be employed in the TR4 position, in place of the 2N3904, as its maximum V_{ce} will be exceeded.

After inserting turret tags, mount resistors and transistors first, then follow with L1, and capacitors C2–C5. C1 is soldered into position last of all, across the amplifier input turret tags, as shown in Fig. 9.5.

FINAL ASSEMBLY AND SETTING UP OF UNIT "D"

Mount the three circuit panels on the baseboard and complete all interconnecting wiring between the circuit panels and the front panel, including S12 which can be left floating for the time being. The resulting assembly can be set-up and tested out of its box.

Connect red, green, and blue flexible wires from the bistable relay panel to the UNIT "A" power supply solder tags, or alternatively to TL1, TL2, and TL3 with stackable plugs.

Place S11 in the "off" position and zero-set the operational amplifier (OA4) following instructions given earlier for UNIT "A" amplifiers, after allowing the usual warm-up period. When adjusting the VR26 balance control connect M/SK2 to any earth socket with a patching lead. Next, attach a sensitive d.c. voltmeter (0–1V) to M/SK3 and zero-set the multiplier output by adjustment of VR1 on the product amplifier circuit panel.

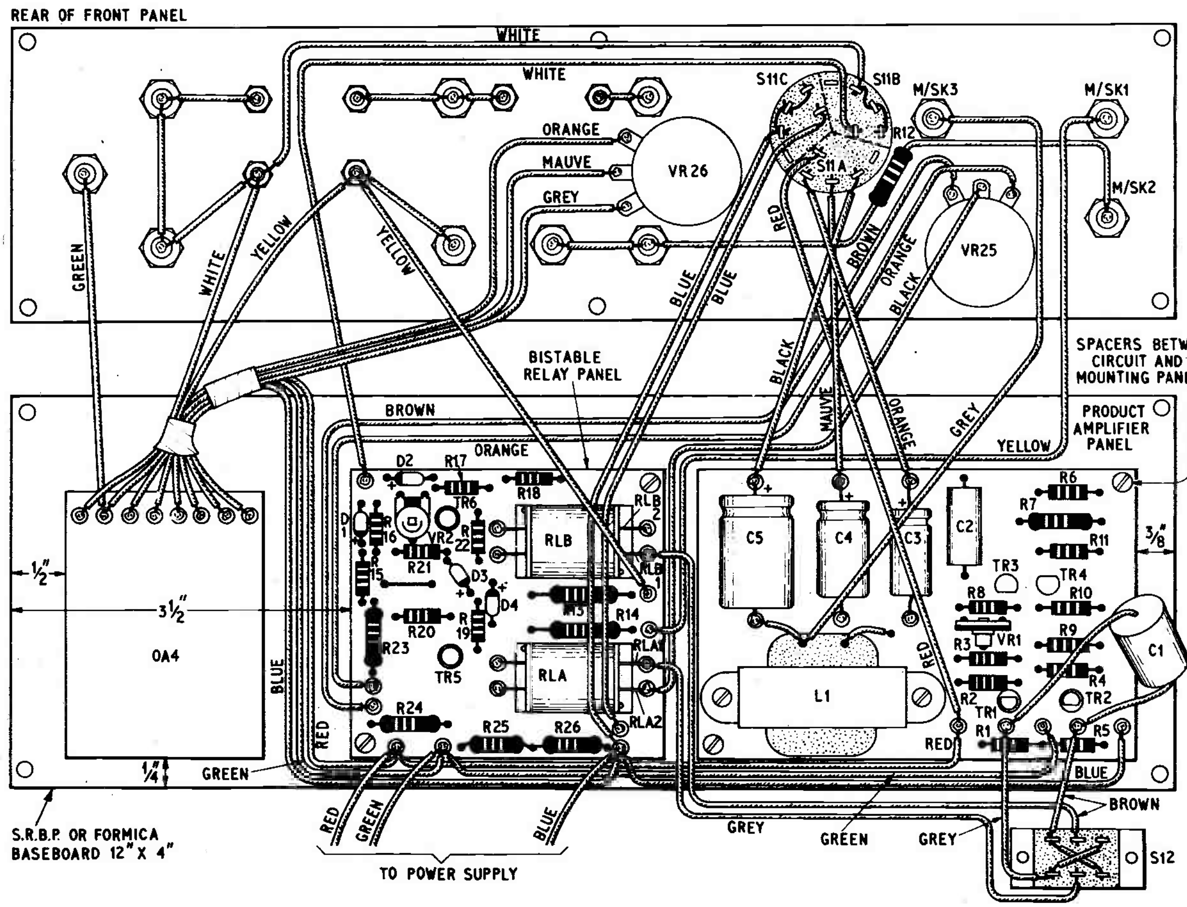


Fig. 9.5. Internal layout and wiring of UNIT "D" multiplier

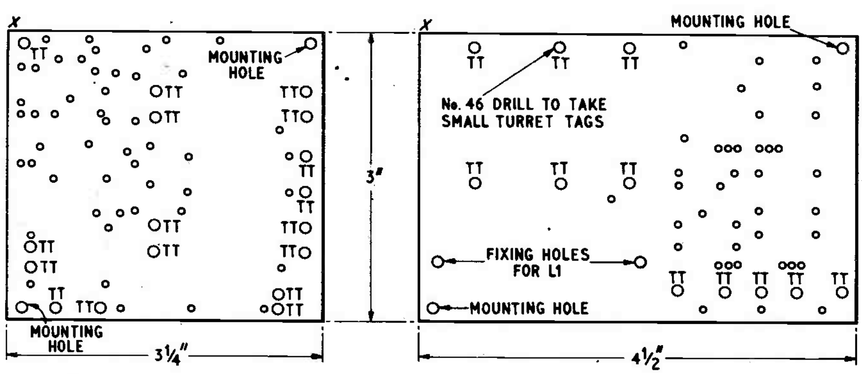


Fig. 9.6 (far left). Top and underside views of bistable relay panel

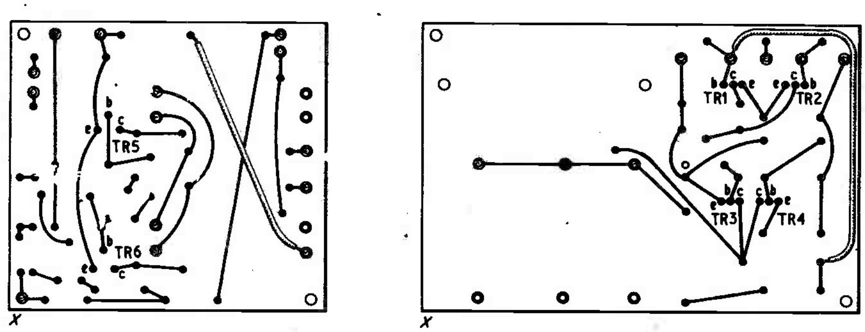


Fig. 9.7 (left). Top and underside views of product amplifier circuit panel

Insert a 0·25μF capacitor into OA4/SK11 and SK12, and switch S11 to 10Hz. A "buzz" from the relays should now be heard, which may or may not sound erratic. Transfer the d.c. voltmeter to OA4 output while the relays are still working and adjust VR2 on the bistable relay panel for zero volts; this should produce an even note from the relays. Return the voltmeter lead to the multiplier output M/SK3 and this time zero-set with VR25.

Apply an input of +5V to M/SK2; the relay "buzz" will drop in frequency, but no output should be observed at M/SK3. Transfer the +5V patching lead to M/SK1 and again no output should be seen. Finally, apply +5V to both inputs, M/SK1 and SK2, to produce a multiplier output of $5^2/10$ or 2·5V.

Throw switch S12 to change output polarity and experiment with inputs of differing sign. If all is well, the product voltage should retain its value of 2·5 for any sign combination of input voltages and S12.

For best accuracy it is advisable to go over all adjustments again to obtain optimum settings, and also verify that the multiplier will handle a full range of input voltages.

Due to the fact that the power supply may be working close to its maximum current limit, there could be some fall-off in multiplier accuracy because of switching transients, this can be checked by employing the extra current facility, S1 in Fig. 3.1. The optional −12V relay power supply should obviate the difficulty if it occurs.

To use the operational amplifier (OA4) on its own, merely switch S11 to the "off" position and patch the amplifier sockets in the normal way.

Next month: The final article in the PEAC series. This will complete the operational details of UNIT "D", and will give some examples of special circuits to represent mechanical phenomena, and some general notes.

BOOK REVIEWS

RADIOISOTOPE EXPERIMENTS FOR SCHOOLS AND COLLEGES

By J. B. Dance, M.Sc., B.Sc.
Published by Pergamon Press Ltd.
200 pages, 7½in × 5in. Price 27s 6d

This concisely written book fulfils a long-felt need for a synoptical guide to the properties of radioactive materials, simple experiments therewith, and an outline of their applications. This subject is now so topical that modern school teaching cannot ignore it. Mr Dance writes in a clear style which is delightful to read and easy to understand, assuming only elementary general knowledge of physics, chemistry and very simple mathematics. All further concepts are adequately explained within the text.

The first two chapters deal briefly with fundamentals of atomic structure and nuclear radiation, including units and measuring equipment. Further chapters are devoted to the problems of biological hazards from nuclear radiations and tolerance limits, as well as general methods of experimental procedure. Four chapters describe numerous safe experiments for practical teaching. Appendices present data tables, a list of suppliers and the legislation controlling the use of radioactive materials.

All experiments are described in sufficient detail to permit immediate practical implementation and copious suggestions are included for further work. The experiments are designed to make use of existing materials and facilities in any school chemistry laboratory, calling for only inexpensive auxiliaries and simple electronic equipment restricted to G.M. tube detectors (Geiger counters). Nevertheless, the range of experiments covers all important basic principles in a well rounded-off survey. No experiments with a gamma ray spectrometer are described, on account of the prohibitive price of this instrument in commercial forms. (This financial barrier has now been broken down by the STRACE spectrometer design published in this magazine.)

Natural rainfall is a most rewarding subject for radiochemical study by school groups and societies, as Mr Dance points out in some very brief notes, giving rather insufficient information to reveal the scope of such projects. This is no just criticism, because such information has nowhere yet been available and Mr Dance has not set out to tread new paths, but rather to present a fine collection of well-tried experimental recipes aimed to illustrate basic principles which he has described equally well.

M.L.M.

BEGINNERS GUIDE TO TRANSISTORS

By J. A. Reddihough
Published by the Hamlyn Publishing Group Ltd.
160 pages, 7½in × 5in. Price 15s

This addition to the Newnes' series of Beginners Guides packs a great deal of information into few pages.

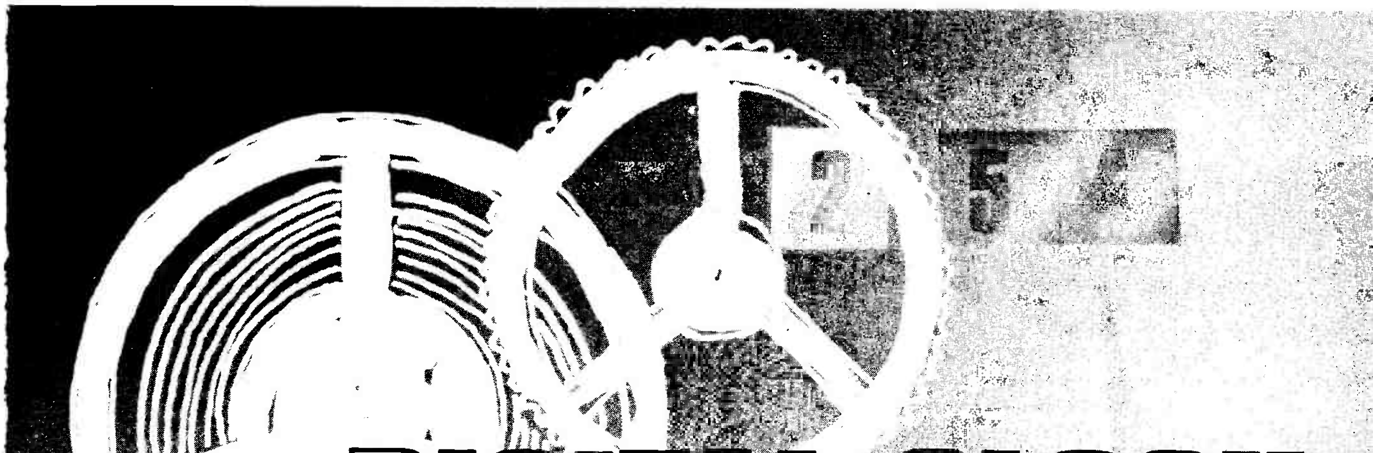
The tenor of the text is essentially practical with an absolute minimum of mathematics. Analyses of commonly encountered circuits, both domestic and pulse, is managed in concentrated and readily assimilable bites of a few paragraphs.

From an opening chapter outlining the physics of conduction in semiconductor materials, the reader is instructed briefly in manufacturing techniques and types of transistor. A chapter on basic transistor circuits and characteristics leads on to a whole host of representative circuits found in a.f., r.f., and pulse equipment. These include amplifiers, both single and compound, and a.m. and f.m. radio receivers. A u.h.f. tuner is examined in a section on television transistor circuitry and intergrated circuits have a short chapter to themselves.

The pulse circuit family is well represented in a general chapter on electronic circuits. This also embraces operational amplifiers and sinewave generators.

The final chapter outlines general fault finding procedures and there are some useful guidelines provided both for diagnoses of faulty stages and transistor check outs with an ohmmeter.

G.M.H.



DIGITAL CLOCK

By G. HOLLOWAY

This article describes the construction of a crystal clock with simple digital display. It was first designed to operate in a car with a 12 volt system. Although it may be thought to be fairly expensive for the duty required, the circuitry is given for the guidance of readers who are interested in frequency division principles.

As a pure exercise, it is probably worth considering the relative merits of a.c. and d.c. powered systems and readout briefly before going into the clock circuitry more closely.

DESIGN CONSIDERATIONS

Let us suppose a pure electronic readout is required using numerical display tubes. A 200 to 350 volt supply at 10mA would be required. If this method is run from the nominal 12V d.c. supply, the output must remain reasonably steady for supply fluctuations between 9 and 16V at a consumption of about 7 watts. To this must be added the consumption (and cost) of four ring counters using high voltage transistors or thyristors. The net result would be a display unit taking much more power than the basic clock.

It could be argued that, since we would require 250V d.c., why not run the equipment from an a.c. 250V mains supply, using the 50Hz mains frequency as a fairly constant frequency supply source instead of the crystal. Some of the divider stages could therefore be eliminated. As the power consumption is not now a critical factor, two more number tubes may be driven to display seconds, but two more ring counters would be required.

It can be inferred that if a number tube display is required, complete with long-term count-down, then considerably more current would be required.

The system described in this article overcomes power consumption problems by using a pulsed Ledex switching unit with direct dial readout. Consequently, a mains supply is not necessary and the circuitry is simplified. It is not restricted to being a "one only" clock; the basic electronic frequency dividing unit can be used as a master to operate any number of slave display units, provided sufficient power is available.

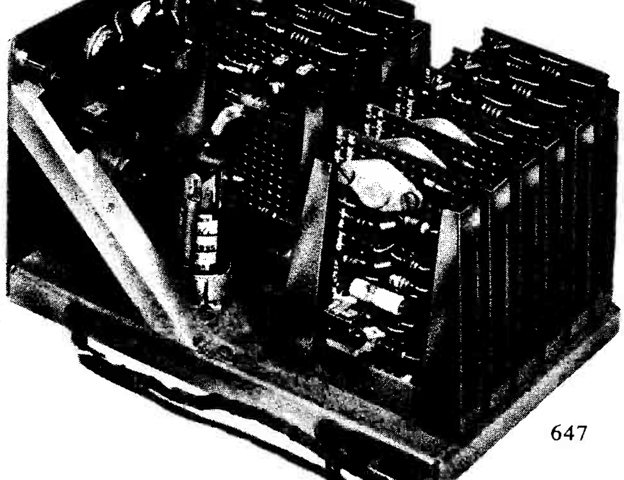
In the case of a car, the tube h.t. supply could be switched on only when the ignition switch is operated. In the home, slave units could be strategically placed and driven from the central timing unit.

This could be powered by a small motor cycle battery which is on constant charge via a mains power unit. In the event of mains failure the clock would be able to keep running for up to four days solely from the charged battery.

The prototype described here was designed for operation in a car, but it had to withstand variations in supply voltage and temperature. Divider stability depends on the quality of its capacitors; these values sometimes depend on temperature, which may govern the accuracy of the clock.

In practice the prototype clock has maintained excellent operations with variation from 9 volts to approximately 16 volts, and temperatures from −10°C to +50°C. The current consumption is 40mA continuous with short pulses of up to 1·3A when the Ledex switches on the display sub-assembly are pulsed into rotation. Averaged out over a long period, the consumption of the clock is far less than that of a parking light.

Control chassis



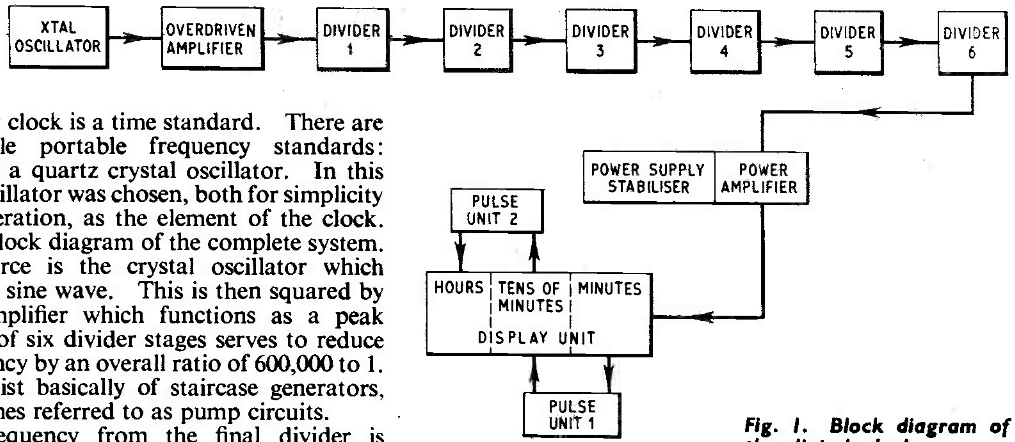


Fig. 1. Block diagram of the digital clock

OPERATION

The basis of any clock is a time standard. There are two highly stable portable frequency standards: a tuning fork and a quartz crystal oscillator. In this unit the crystal oscillator was chosen, both for simplicity of tuning and operation, as the element of the clock. Fig. 1 shows the block diagram of the complete system.

The signal source is the crystal oscillator which produces a 10kHz sine wave. This is then squared by an overdriven amplifier which functions as a peak clipper. A train of six divider stages serves to reduce this output frequency by an overall ratio of 600,000 to 1. These stages consist basically of staircase generators, which are sometimes referred to as pump circuits.

The output frequency from the final divider is routed through a power amplifier circuit, then on to the "minutes" display Ledex solenoid. By specific wiring of the contact arrangement on the wafers of this switch, every tenth "minute" pulse is passed through "pulse unit 1" to provide a tens of minutes display on Ledex 2. Every sixth one of these is passed through "pulse unit 2" to provide the hours display.

CRYSTAL OSCILLATOR

If a crystal is used as the basic element of a clock, one of the simplest circuits to employ to provide a frequency standard is the transistor version of the Pierce circuit. This has one unique advantage in that it contains no tuned element except for the crystal which is contained in the feedback path, from collector to base, of TR1, see Fig. 2.

The trimmer VC1 provides frequency adjustment in the final setting up of the unit. Decoupling and additional line volt stabilisation is achieved with the capacitor C3 and Zener diode D1, the latter maintaining approximately 3 volts to keep the crystal drive voltage down to a suitable level.

CRYSTAL OSCILLATOR

COMPONENTS . . .

CRYSTAL OSCILLATOR

One of each of the following required

Resistors
R1 820kΩ
R2 3·9kΩ
R3 4·7kΩ
R4 18kΩ
R5 4·7kΩ
All 10%, ¼ watt

Potentiometer
VR1 1MΩ carbon skeleton preset

Capacitors
C1 22pF mica
C2 0·01μF polyester
C3 8μF elect. 15V
VC1 300pF mica compression preset trimmer

Crystal
X1 10kHz type DJC/195 (see text)

Transistors
TR1 2N3707
TR2 2N3704

Diode
D1 ZF3·3 (400mW Zener)

Miscellaneous
Veroboard 23 holes × 12 holes, 3·5in × 1·875in (copper strips run lengthways)
Plug-in card holder and socket (12 way) for above

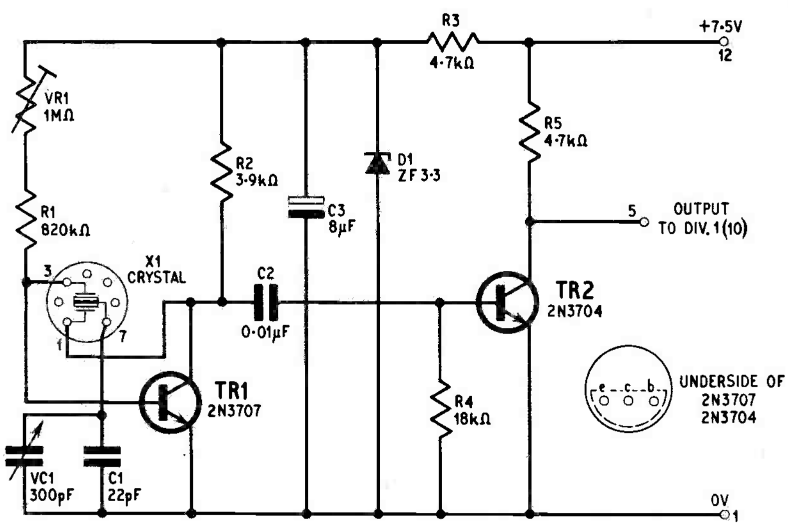
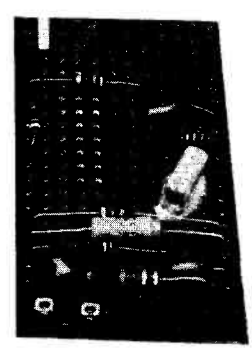


Fig. 2. Circuit diagram of the crystal oscillator



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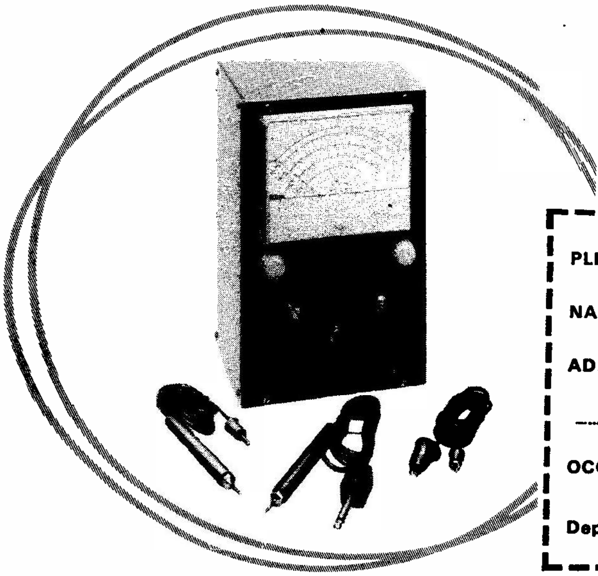

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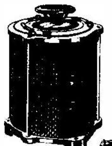

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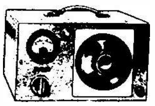

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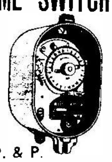

2 on/off every 24 hours at any pre-set time. Fitted in metal case. 36 hr. spring reserve. Used but fully tested. Fraction of makers' price. **£3.19.6** plus 4/6 P. & P.

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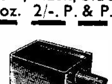

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Approx. 8 oz. push. Price **8/6** plus 1/6 P. & P.

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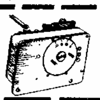

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3	10, 17, 18 v. at 10 amps.	**£4/10/0**	4/6
4	6, 12 v. at 20 amps.	**£5/17/6**	6/6
5	17, 18, 20 v. at 20 amps.	**£6/12/6**	6/6
6	6, 12, 20 v. at 20 amps.	**£6/5/0**	7/6
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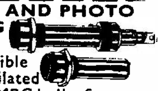

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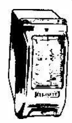

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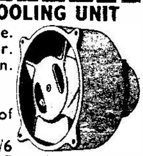

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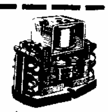

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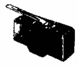

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FREQUENCY DIVIDERS

There are six frequency dividers: five giving divide by ten and one divide by six. Fig. 3 shows the basic circuit used in all these stages.

The input from the overdriven amplifier is fed to the base of TR1 which is a buffer emitter follower. This provides the necessary low source impedance to drive the transistor pump circuit, which provides an intrinsically linear staircase output across C2. With a positive going pulse appearing across R1, C2 commences to charge through diode D1 at a time constant equal to the product of the sum of the emitter follower output impedance and diode resistance, and C1 plus C2.

C2 is larger in value than C1 so that the voltage change across C2 on the pulse is small in comparison with the input voltage. In the interval of the pulse, C2 charges. After the first pulse, D1 becomes reverse biased and the voltage on C2 remains stored. On the leading edge of the next square wave the operation occurs again. Thus a staircase waveform, as shown in Fig. 3, appears at C2, the height of each step being equal to the initial charge voltage.

To linearise the waveform TR2 acts as a bootstrap

FREQUENCY DIVIDER

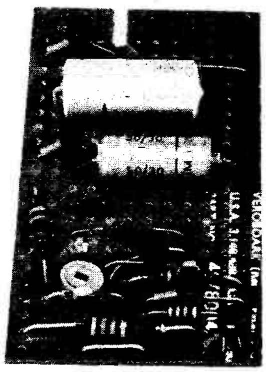


Table 1: FREQUENCY DIVIDER COMPONENTS

Divider stage	R2*	C1	C2
1	S.C.	1,000pF	0·01μF
2	S.C.	0·005μF	0·05μF
3	S.C.	0·05μF	0·5μF
4	S.C.	0·5μF	5μF
5	S.C.	5μF	50μF
6	47Ω	80μF	500μF

* S.C. means that R2 is short-circuited. Capacitors are polyester or electrolytic 15V types as appropriate to the values.

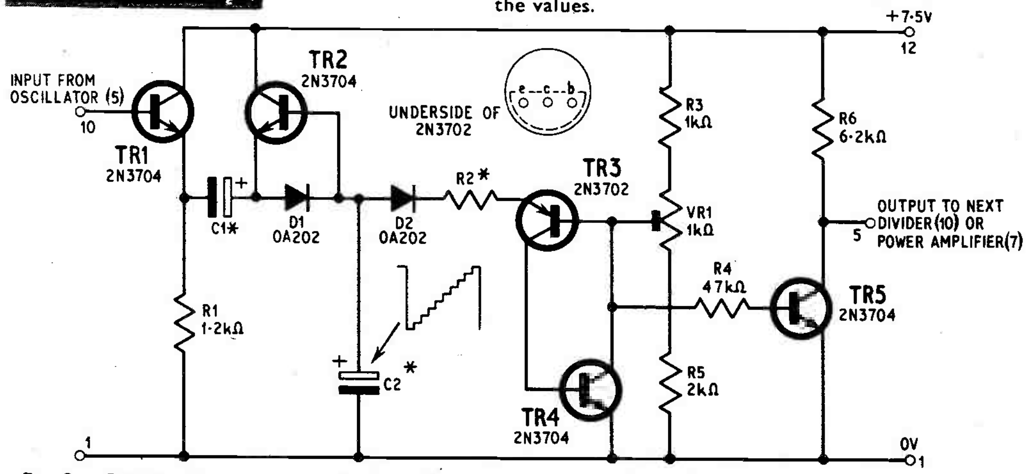


Fig. 3. Circuit diagram of one divider. See Table 1 for details of C1, C2, and R2 for all dividers

COMPONENTS . . .

FREQUENCY DIVIDERS

There are six of these each with the following:

Resistors
R1 1·2kΩ 10%
R2 See Table 1
R3 1kΩ 5%
R4 47kΩ 10%
R5 2kΩ 5% (or 2 × 1kΩ in series)
R6 6·2kΩ 5%
All ¼ watt carbon

Potentiometer
VR1 1kΩ carbon skeleton preset

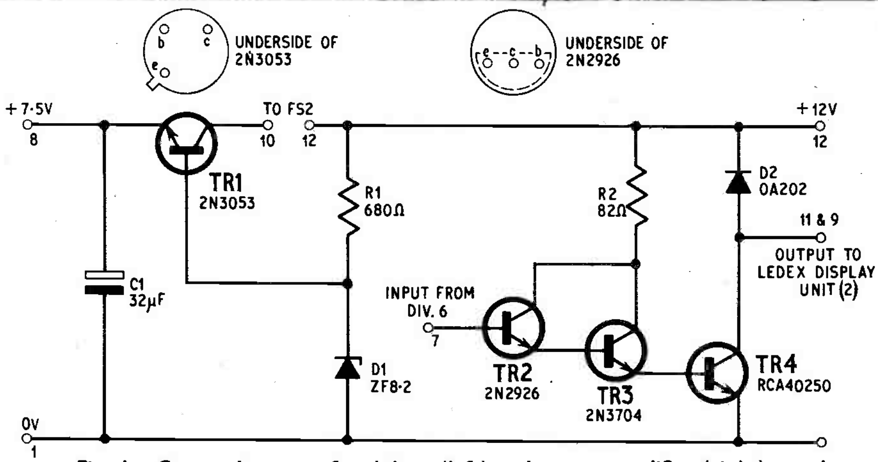
Capacitors
C1 and C2 See Table 1

Transistors
TR1–5 2N3704 (5 off)

Diodes
D1 and D2 OA202 (2 off)

Miscellaneous
Veroboard 23 holes × 12 holes, 3·5in × 1·875in (copper strips run lengthways)
Plug-in card holder and socket (12 ways) for above

STABILISER AND POWER AMPLIFIER



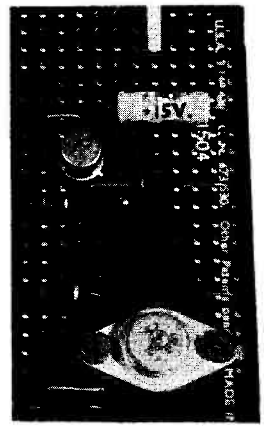


Fig. 4. Circuit diagram of stabiliser (left) and power amplifier (right) panel

COMPONENTS . . .

POWER AMPLIFIER AND STABILISER

One of each of the following required

Resistors
R1 680Ω 10%, ¼W
R2 82Ω 10%, ½W

Capacitor
C1 32μF elect. 25V

Transistors
TR1 2N3053
TR1 2N2926 (any colour grade)
TR2 2N3704
TR4 RCA 40250

Diodes
D1 ZF8·2 *or* IS7082 (400mW Zener)
D2 OA202

Miscellaneous
Veroboard 23 holes × 12 holes, 3·5in × 1·875in (copper strips run lenghtways)
Plug-in card holder and socket (12 ways) for above

amplifier holding the positive end of C1 at a voltage slightly below that on C2 so that each input pulse adds an equal amount to the voltage already on C2.

Staircase frequency dividers have been found unsuitable for many circuits requiring stable division, because the division ratio is inversely proportional to the input voltage. In this circuit the effect of input voltage variation is greatly reduced.

The height of the input pulse is proportional to the d.c. supply and so is the trigger level, as they are both derived from the same supply. If the supply voltage varies, so will the height of each individual step, also the trigger level. These changes tend to balance out. Just to make sure of stability, the supply is fixed at 7·5 volts.

VOLTAGE COMPARATOR

When the staircase voltage reaches a certain level, TR3 will be forward biased when the voltage at the emitter just exceeds the base voltage set by VR1. VR1 sets the trigger level and the number of steps that build up before TR3 is switched on. Conduction in this transistor forward biases TR4 which in turn biases TR3 even further. This cumulative action discharges C2 and reduces the voltage on the wiper of VR1 to zero. This turns TR5 off producing a positive output pulse at the collector. With C2 discharged, the trigger reverts to its normal stage and the staircase sequence starts again.

Reference to Table 1 shows the capacitors to be used in the pump circuit of the six dividers. It will be seen also that R2 is only included in the final divider stage, otherwise D2 is connected directly to TR3 emitter.

Poor divider stability can be put down to a leaky capacitor; it is particularly important to use the best possible capacitors for the C1 and C2 positions.

POWER AMPLIFIER

"Minute" pulses from the sixth divider are fed to the cascaded triple transistor switch (Fig. 4) which is in effect a buffer and current amplifier to boost the low level output of the final divider. Sufficient current is then available to drive the "minutes" display switch solenoid.

On the same panel the supply voltage (12V) is fed to the power amplifier and to the voltage stabiliser TR1 (via fuse FS2) to provide 7·5V for the dividers, oscillator, and pulse unit multivibrator.

DISPLAY OPERATION

The Ledex switches have twelve positions, but the first "minutes" Ledex has only to indicate up to ten digits; that is 0 to 9 inclusive as shown in Fig. 5. It is arranged that when the 9 is displayed, and the next pulse occurs, the motoring contacts of the commutating switch, integral to the "minutes" Ledex, are placed in series with its coil for the next two positions. This carries S1a over these positions to 0.

Whilst this is happening, S1b switch wiper, which is mechanically coupled to S1a, passes a pulse back to "pulse unit 1" by way of R1, which in turn feeds a longer pulse to the tens of minutes Ledex. It is necessary for the tens of minute stage to display 6 digits (0 to 5 inclusive). This can be accommodated twice in one revolution.

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AC128	2/4	OC201	7/-
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AF115	3/6	2N711	10/-
AF116	3/6	2N1302-3	4/-
AF117	4/6	2N1304-5	5/-
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AF119	3/6	2N1308-9	8/-
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BSY25	7/6	OC23	10/-
BSY26	3/-	OC25	8/-
BSY27	3/-	OC26	5/-
BSY28	3/-	OC28	7/6
BSY29	3/-	OC35	5/-
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OC41	2/6	GP826	40/-
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OC71	2/6	AAY42	2/-
OC72	2/6	OA10	2/-
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B54	40 ,, ,, NPN To5	10/-
B55	40 ,, ,, NPN To18	10/-
B56	40 ,, ,, NPN/PNP	10/-
B68	10 Top Hat Recs. 750 M/A 100-800 PIV	10/-
B69	20 Diodes. Gld-Bnd. Germ Sil. Planer	10/-
B74	5 Gld-Bnd. Diodes. 2 OA.9 3OA5	10/-
B75	3 Comp. Set. 2G371, 2G381, 2G339A	10/-
C2	1 Unijunction Transistor 2N2160	15/-
C26	3 TEXAS Power Transistors 2S012A	15/-
C32	6 Top Hat Recs. 1S100 Type	15/-
A1	7 Silicon Rectifiers BY100 Type	20/-
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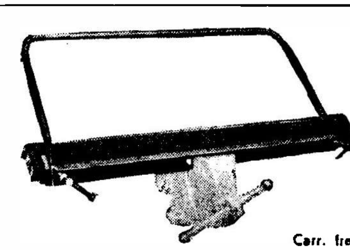

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COMPONENTS . . .

CONTROL CHASSIS

Plug-in card circuit components and crystal are listed separately. Refer also to chassis drawings next month for metalwork details.

Chassis
$7\frac{1}{8}$in × $5\frac{1}{8}$in × $\frac{1}{2}$in 18 s.w.g. aluminium

Front Panel
5in × 4in 18 s.w.g. aluminium

Panel Supports
$\frac{1}{2}$in angle aluminium 5in long (2 off)

Switches
S3, 4, 5 Sub-miniature push-to-make, release to break panel mounting
S6 Single pole, on-off toggle switch

Fuses
FS1 5A
FS2 250mA
} Miniature cartridge and fuseholder

Miscellaneous
B7G valve holder for crystal
Spring retainer for crystal
Flexible one way p.v.c. wire
6B.A. nuts and bolts
$\frac{1}{4}$in grommets

DISPLAY UNIT

COMPONENTS . . .

NUMERICAL DISPLAY CHASSIS

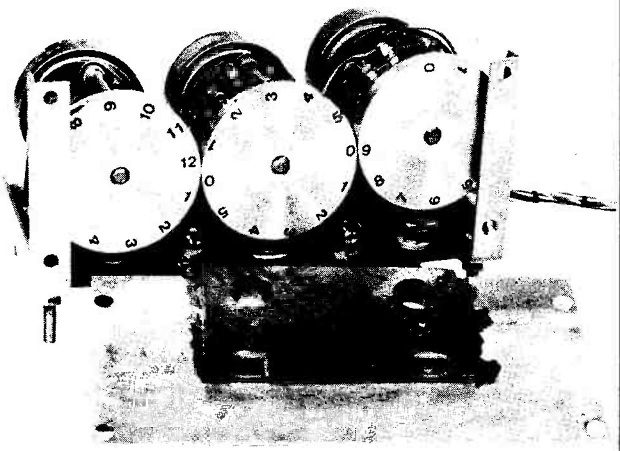
Resistors
R1, R2 8·2kΩ 10%, $\frac{1}{4}$W carbon

Switches
S1 2-bank, single-pole, 12-way wafers
S2 1-bank, double-pole, 6-way wafers; both are mounted on Ledex mechanisms; three solenoid mechanisms required. S1 must have motoring contacts attached to mechanism (see text)

Lamps
LP1, LP2

Chassis
S.R.B.P. or similar $\frac{1}{8}$in thick $6\frac{1}{2}$in × $3\frac{3}{4}$in
Angle aluminium $\frac{1}{2}$in × $6\frac{3}{4}$in long (2 off)
Sheet aluminium $6\frac{1}{2}$in × 3in × 18 s.w.g. (front panel)

Miscellaneous
2B.A. and 6B.A. nuts and bolts
Indicator dials $2\frac{1}{4}$in dia. $\frac{1}{4}$in thick aluminium or any strong material capable of being tapped 6B.A.
Terminal screw block, 8-ways
8-way Jones plug and socket for cable fixing
Perspex sheet for windows $3\frac{1}{2}$in × 2in × $\frac{3}{16}$in



Front view of the display unit. The front panel has been removed to show the Perspex panel and lights

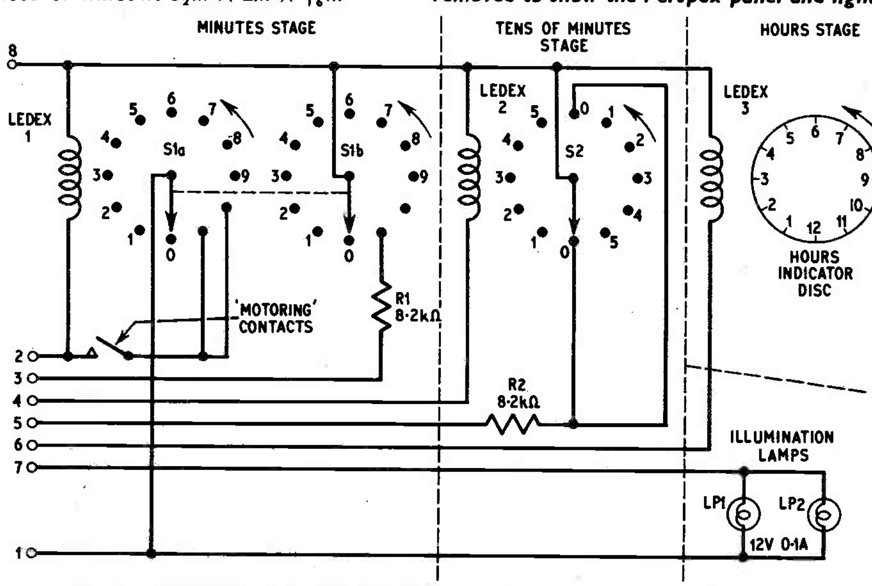


Fig. 5. Circuit diagram of Ledex display switches looking at front panel end

PULSE UNIT

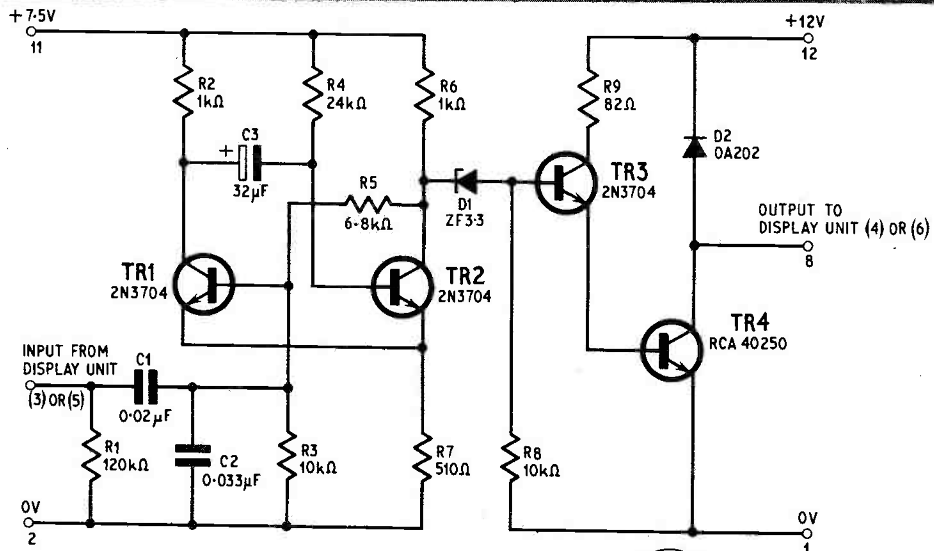
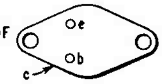
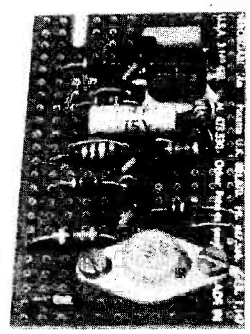


Fig. 6. Circuit diagram of pulse unit. Two are required

UNDERSIDE OF RCA 40250





COMPONENTS . . .

PULSE UNIT

There are two of these each with the following:

Resistors
- R1 120kΩ
- R2 1kΩ
- R3 10kΩ
- R4 24kΩ 5% (or 2 × 47kΩ in parallel)
- R5 6·8kΩ
- R6 1kΩ
- R7 510Ω 5% (or 2 × 1kΩ in parallel)
- R8 10kΩ
- R9 82Ω ½W
- All 10%, ¼ watt except where otherwise stated

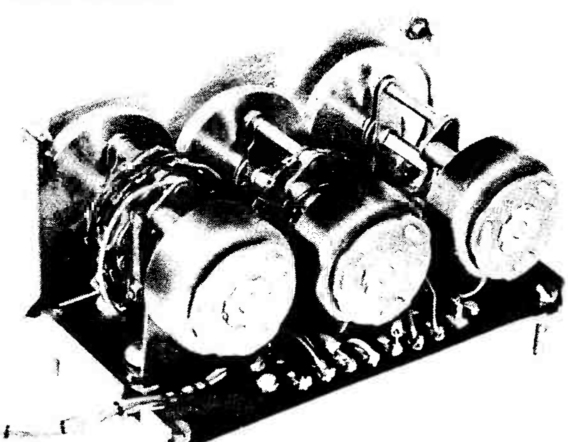
Capacitors
- C1 0·02μF polyester 150V
- C2 0·033μF polyester 150V
- C3 32μF elect. 25V

Diodes
- D1 ZF3·3 (400mW Zener)
- D2 OA202

Transistors
- TR1, 2, 3 2N3704 (3 off)
- TR4 RCA 40250

Miscellaneous
- Veroboard 23 holes × 12 holes, 3·5in × 1·875in (copper strips run lengthways)
- Plug-in card holder and socket (12 ways) for above

Rear view of the display unit showing the Ledex switch solenoids.



A switch wafer on this Ledex is arranged so that when 5 is displayed and the next pulse arrives, two contacts close sending a pulse via R2 to "pulse unit 2", driving the hours Ledex. It is arranged such that these contacts close twice per revolution of the tens of minutes Ledex.

Illumination of the perspex windows is arranged by continuous edge lighting which is described later.

LEDEX PULSE UNITS

The first two transistors of each pulse unit functions as an emitter-coupled monostable multivibrator (Fig. 6), the pulse width output of which is given by the period $0{\cdot}7C_3R_4$ seconds, which is approximately half a second. TR3 and TR4 are similar to the power amplifier both in design and function since the compound pair acts as a switch to supply power to both the solenoids of Ledex 2 and Ledex 3 at the display unit.

One of the main problems encountered during the development of this clock was the triggering of the pulse

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STEREO AMPLIFIER. **13½ gns. only.** Retail value 27 gns. A Fully Transistorized High Fidelity Stereo Amplifier complete in free standing case. Switched input facilities. Socket (1) tape or crystal P.V. (2) radio tuner. (3) ceramic P.U.-mike. Controls: Volume, Bass, Treble, Balance, Input Selector Switch, Stereo/Mono Switch. Facia plate rigid perspex with black/silver background and matching knobs.

Output 6 watts per channel (R.M.S.) 12 watts Mono. Free response to 3dB, 20–20,000c/s bass boost approx. 10–12dB. Treble out 2–16dB approx. Negative feedback—18dB over main amp.

12 months' unconditional guarantee. P./P. 6/-.

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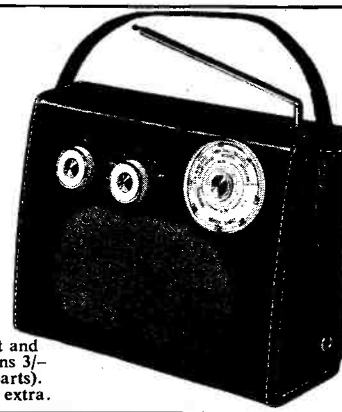

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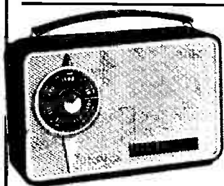

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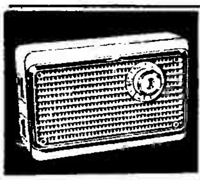

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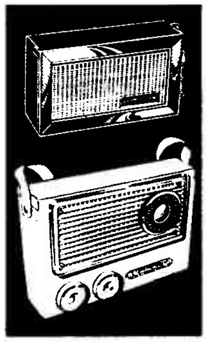
MED. AND LONG AND TRAWLER BAND to approx 50 metres. ***WITH SPEAKER AND EARPIECE.*** 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, moving coil speaker. 6¼ × 4½ × 1½in. **Total Building Costs 47/6.** P. & P. 3/9. Plans and Parts list 1/6 (free with parts).



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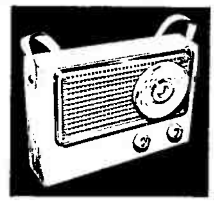

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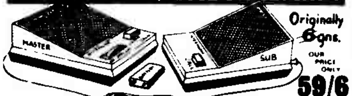

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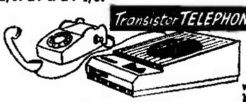

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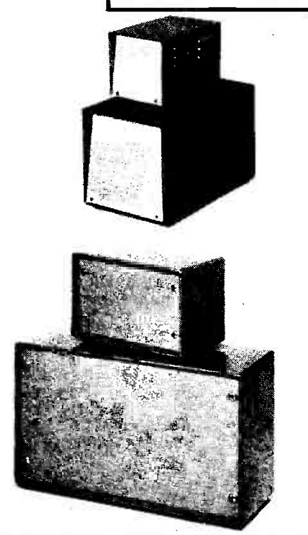

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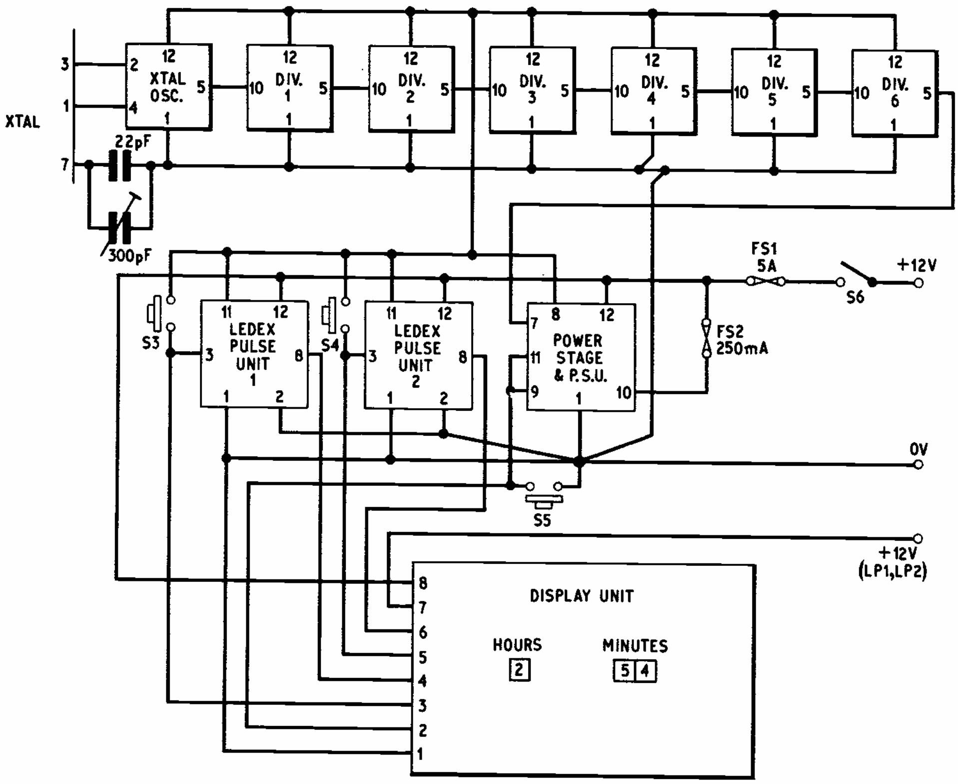


Fig. 7. Interconnection wiring of plug-in cards and display unit

units for no apparent reason. This was finally traced to voltage transients caused by the heavy pulses of current required by the Ledex solenoids. This was overcome by using two "earth" return lines, appearing at line 1 for heavy current and line 2 for light current (Fig. 6), both terminating at the power stabiliser common line. This is shown in Fig. 7 which also provides the interconnections of all sub-assemblies in the completed unit.

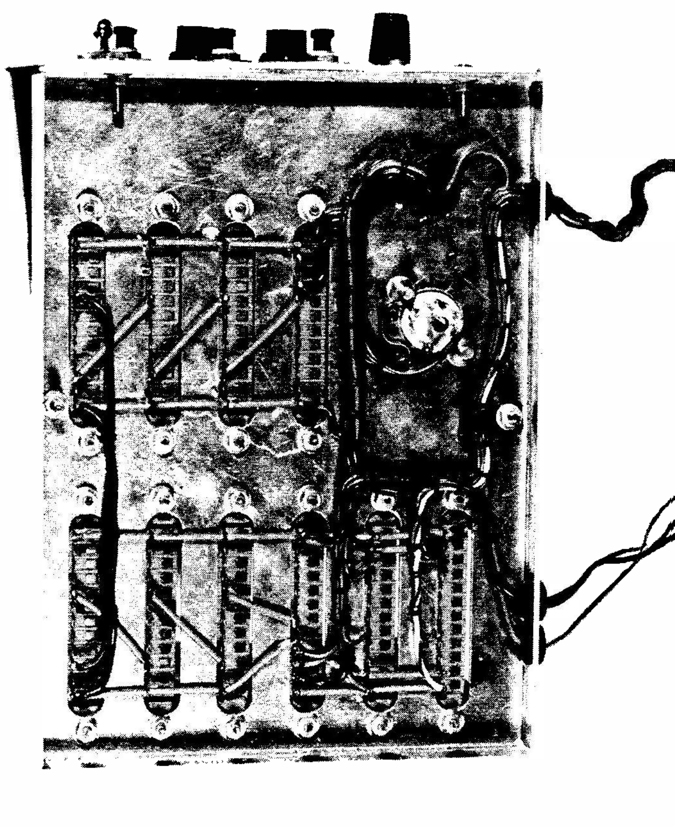
The switches S3 to S5 serve only in the setting up of the clock and these will be referred to in the second part next month which will deal with constructional details and testing.

COMPONENTS

Before contemplating building this clock as described, readers should consider all the implications outlined earlier, and additionally should bear in mind the likely outlay on components, as the job in hand may prove expensive when compared with a conventional clock.

A 10kHz crystal may cause some problems but they are made and the type suggested is DJC/195 manufactured by Salford Electrical Instruments Ltd., Times Mill, Heywood, Lancashire. The price quoted to us is £15 1s 6d each. S.T.C. make one at a slightly cheaper price, but it may require oven temperature control. The mounting is not the same.

Ledex rotary solenoid switches are supplied by NSF Limited, although these may have to be ordered from NSF through your retailer. This company is well known for its switch wafers which are supplied with the Ledex solenoids. Solenoid type 5S or 3E low voltage types are required with 25 deg. right rotary stroke, shaft extension on base end, and fitted with spring return ratchet. Switch wafers are as given in the components list.



Underside view of the control chassis

NEWS BRIEFS

International Mobile Meeting

On the last Sunday in June, East Anglia was invaded by a swarm of four wheeled vehicles with extended antennae. Not ordinary car radio aerials, but much longer and equipped with important and purposeful looking cylindrical pods. In the morning the roads approaching Mildenhall, Suffolk, fairly bristled with these vertical antennae, which seemed to become more agitated and excited as they sensed the "talk-you-in" signals radiated from the fixed station at their destination, the USAF base at Mildenhall. Their "delight" was equalled, if not surpassed, by the eager ham/'s behind the steering wheel, not to mention the exYL and small harmonics.

This was the annual rally of the Amateur Radio Mobile Society, and the emphasis on these occasions is on the family outing aspect. The U.S. airforce provided a spacious venue and an airborne telecommunications centre for inspection; plus one hanger for a trade show. Some well-known manufacturers were present, as well as retailers of components.

Once the cars had found their parking place, and the antennae ceased their waggling, the families piled out to enjoy a picnic in the hot sun. Any thoughts of afternoon dozing were dispelled by a great additional attraction—the RAF Red Arrows Acrobatic Team.

Russians Make Arctic Sparks

Russian physicists are investigating the effect of temperature on semiconductor materials. They have found that the electrical output of an illuminated photoelectric film only one thousandth of a millimetre thick rises to a high voltage under sub-zero conditions.

Triple Order for Decca

Decca Radar are equipping harbour authorities at Dover, Southampton and St. Georges, Bermuda, with additional radar facilities.

Computer Will Plan Phones

The Post Office is buying a £1 million computer from English Electric Computers to assist planning of the telephone network, currently growing at the rate of 17 per cent a year.

The computer, a System 4-70, will provide a centralised record of plant and equipment throughout the whole of the country's trunk telephone network. There are about 11,000 cable records containing details of 68,000 sections and some 3 million pairs of wires.

Following installation at the end of this year, the new system will be introduced gradually over three years. Eventually it will be able to forecast telephone circuit requirements which, say the GPO, will reduce the delays in connecting new subscribers.

Second Mullard Glass Plant

The Mullard television tube plant at Simonstone, near Burnley, is to have a second glassmaking unit costing about £1 million. It will double the company's glass-making capacity to 240 tons a day and provide jobs for an additional 100 to 150 people. The Simonstone plant (see special feature in the June issue of PE), has the capacity to produce 1½ million black and white tubes a year and is expected to be manufacturing tubes for colour receivers at the rate of 150,000 a year by the end of 1968.

Colour Set Uses IC

A new Rank Bush Murphy colour TV receiver to be launched this autumn will contain a silicon integrated circuit—said to be the first to appear in a British consumer product. The 20-lead SIC handles both the linear and switching circuit functions connected with colour matrixing and decoding, and has permitted the use of a more sophisticated "red-green-blue" drive to the picture tube.

Twin Thyristor Export

Two big export orders for thyristor systems to control printing presses have been won by English Electric's control gear division at Kidsgrove, Staffs. The first is for a 150 h.p. thyristor controller and d.c. motor to drive a web-offset printing press at Pasadena, California, and the second is for ten 65 h.p. controllers with d.c. motors which will power two web-offset machines printing a Danish national newspaper.

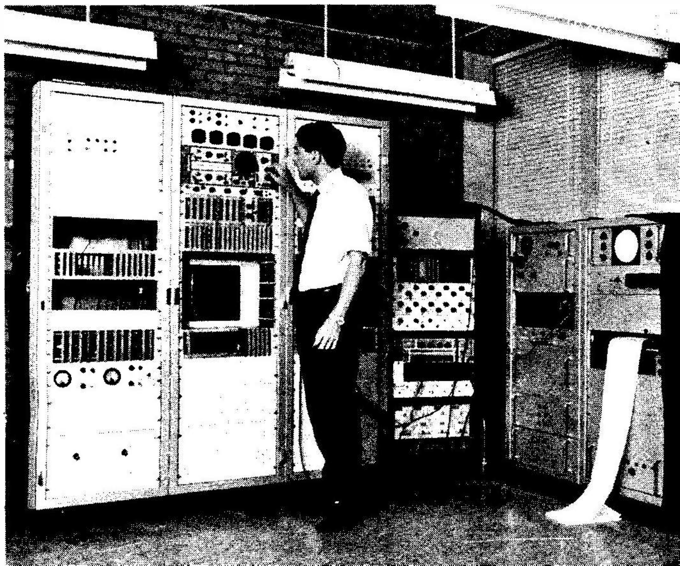
R.F. Transistor Breakthrough

Difficulties of producing high power at high frequencies using transistors seem to have been overcome by engineers of RCA Electronic Components. They have developed a solid-state amplifier capable of 1,000 watts continuous output at 400MHz. It uses 64 type 2N5016 transistors.

National Physical Laboratory Open Days 1968

One of the important activities of the National Physical Laboratory is researching into wider applications of computers. Improved methods of communication with computers are essential for future progress in this field. The Division of Computer Science of the NPL is concerned with such problems. Work currently being undertaken includes automatic pattern recognition machines. "Cyclops" (see photo) is a machine which reads poorly printed numerals with great speed and accuracy. Work is now proceeding with an improved version called "Ochre" using the latest electronic techniques. In this exercise NPL is collaborating with Plessey Automation Ltd.

Speech recognition devices are another important aspect of computer research. The equipment seen at the NPL Open Day last June gave a convincing demonstration of its capability to distinguish between vowel sounds. Not yet perfect by any means, but the design team seem confident that it will ultimately be able to cope even with regional dialects.



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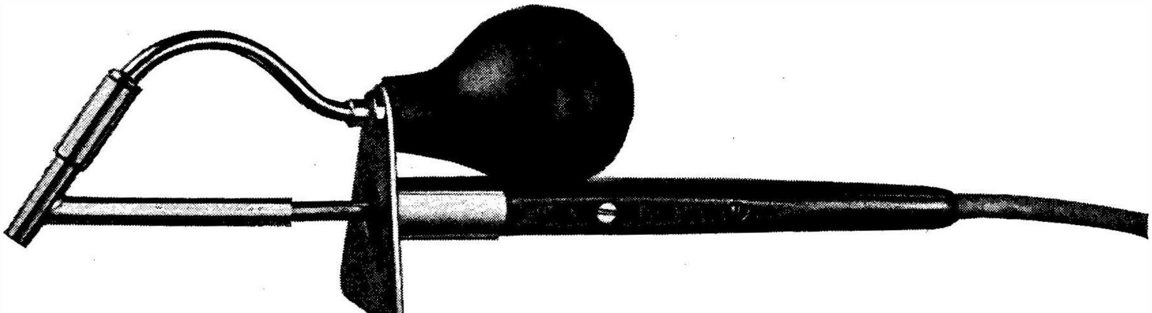

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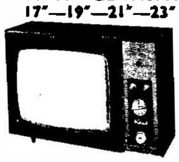

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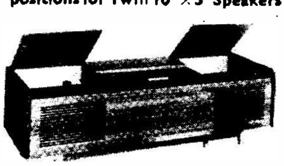

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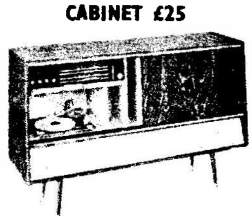

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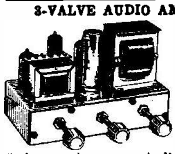

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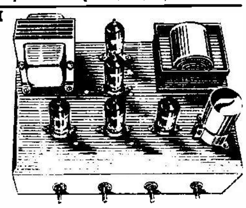

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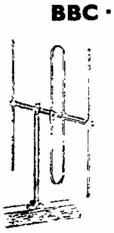

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Readout—
A SELECTION FROM OUR POSTBAG

It's not on!

Sir—The "Flip-Flop" circuit suggested by Mr Hodgson, Huthwaite (*Ingenuity Unlimited* July issue) will not operate satisfactorily as there is no method of holding "on" period of relay for a long enough period to keep the projector in sync. Also, should the tape and projector pulses occur close together the change-over state may not occur at all.

The answer is to drive the two sides of the flip-flop via "steering diodes". Further, the tape pulse should be sharpened up by a Schmitt trigger, as sharply defined and regular pulses are a necessity for steady operation.

One further point. The reed switch contacts should have a high wattage resistor across them, the value to be found by experiment. The correct value will be that which causes regular speed of projector and incidentally steady "ticking" from reed switch. A suitable starting point for this value is 5 kilohm (10W). The 0·1μF (C1) should also have a 10 ohm ($\frac{1}{4}$W) resistor in series with it or sparking will still occur.

I have myself constructed a sync unit of these lines, which has operated most satisfactorily for the past six months.

G. M. Farrer,
Slough, Bucks.

The end—or is it?

Sir—May I thank all the correspondents who have been kind enough to offer their thoughts on that cine/tape sync problem. All the points are well taken, particularly those of Mr Bridger and Mr Hodgson.

The l.d.r. pick-up for projector speed could work on spillage light rather than from the screen, but that asymmetrical wave form is rather discouraging. The idea was to avoid any extra parts at all fixed to the projector, but the general opinion seems to be that a more positive pick-up is necessary.

Thyristor control of the projector certainly is possible. I have a control box similar to that published by Mr J. N. Watt in the July issue, and this gives admirable speed adjustment, although the bulb output is affected also. Whilst a relay is better for controlling a camera motor consuming 250mA at 6V, I doubt if it would last long on mains voltage at about 3 amps.

Regarding the signal from the tape, I would still prefer to take an output from a parallel track rather than phototransistor and perforated tape. The general switching idea of "ON" from tape and "OFF" from projector implies, as Mr Chapman does, a distinct error over a relatively large number of frames before there is a suitable response. However, once the projector speed has caught up, manual override will then give the lip sync I am aiming for. The same performance may be possible with an s.c.r. circuit, although some opinions are against this. A phase sensitive detector is what I had in mind, so that the projector current could be controlled from zero to maximum with an error of about half a frame.

Consider two sinusoidal signals: when added in phase and rectified, we obtain large pulses, say to speed up the projector fed through an s.c.r. If the speed now takes the projector slightly faster, just half a circle out of sync, there will be cancellation, no pulses, and a slowing down into sync again. Unfortunately, any further slowing down of the projector will stop the pulses in a similar manner till the cycles are in phase again and we have slipped a frame!

Perhaps an expert on f.m. detection could help at this stage to fill that black box?

D. Watts,
Washingborough, Lincoln.

Harp on this

Sir—After being unable to purchase locally a 2N2926 transistor for the *WAA-WAA Pedal Unit* (described in July issue) I tried using a transistor of slightly different characteristics to those of the specified transistor and the result was quite amusing. Instead of the intended WAA-WAA effect, a sound similar to a Jew's harp was heard when tested with a guitar.

The circuit was adjusted slightly to give the effect mentioned the most "life". A BFY18 transistor was used in place of TR1, R7 was replaced with a 50 kilohm resistor (this was made up of two 10kΩ and two 15kΩ resistors). As the boosted band must be shifted up and down in frequency (in one operation of the pedal) from maximum to minimum, VR2 was replaced with a 1 megohm log-law potentiometer. The circuit was otherwise unaltered.

G. J. Sharp,
Sheerness, Kent.

Electronic music studio survey

Sir—I am conducting a survey of electronic music studios in Great Britain.

Perhaps some of your readers will know of studios either privately or collectively owned with which they could put me in touch. Some may even have their own equipment. In any case I would be grateful if they would contact me with any relevant information.

K. Winter,
The Arts Council of Great Britain,
105 Piccadilly, London, W.1.

EXHIBITION . . .

The twenty-third annual Electronics, Instruments, Controls and Components Exhibition and Convention will be held at Belle Vue, Manchester, from September 24 to 27 inclusive.

The Convention will incorporate a programme of Lectures and Film Shows on subjects allied to Electronics, Instruments and Components.

The Exhibition will include displays of electronic devices, instruments, controls and components, of British and Overseas Manufacture, that will be of interest to members of all branches of Science and Industry.

Exhibition admission tickets may be obtained from the Exhibitors or from the Exhibition Secretary, Institution of Electronics, 78 Shaw Road, Rochdale, Lancashire. Catalogues will be available (post free 5s 6d each on receipt of an addressed label) after September 9.

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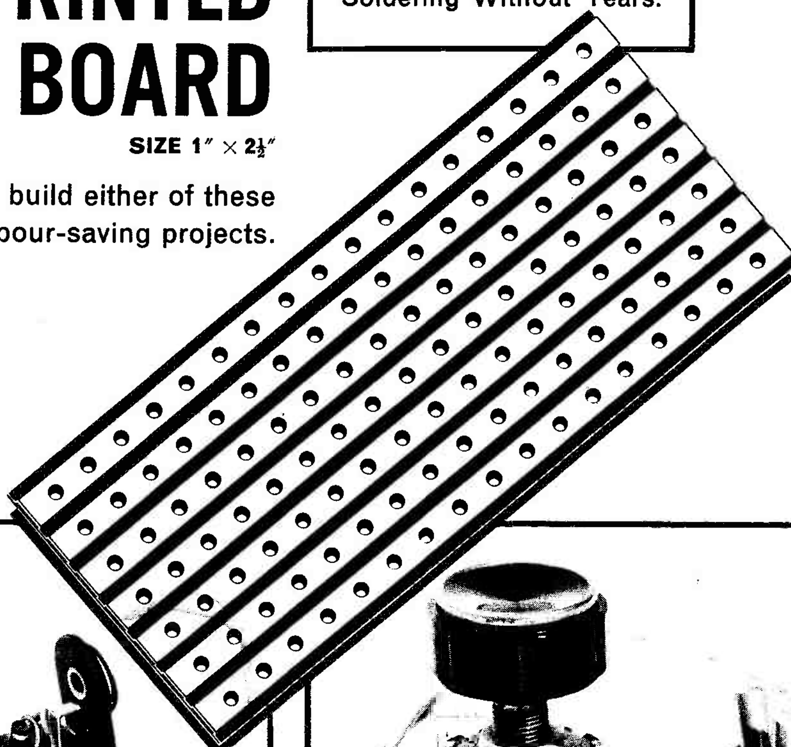

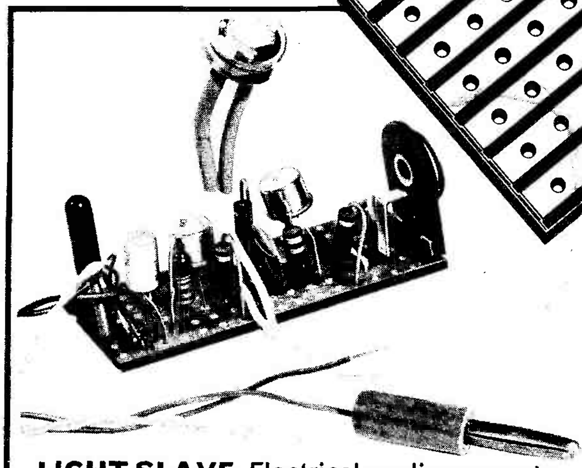

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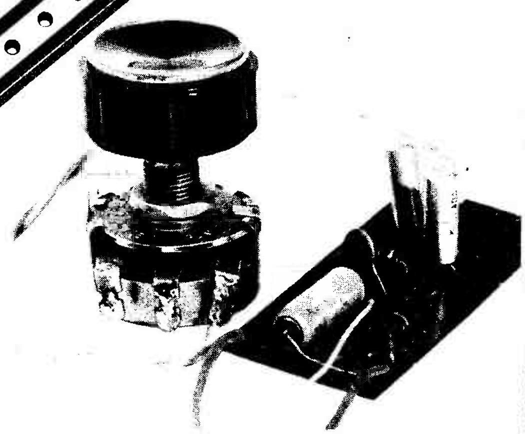


VARI-WIPE. In fog or gentle rain, this thyristor controlled device will give your windscreen a quick wipe automatically at pre-determined time intervals.

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.

POWER SUPPLY

One of the main essentials in any good workshop is a source of reliable power supply for running test equipment and prototype projects. With the now common use of semiconductor devices the main requirement is for regulated low voltage supplies with a minimum amount of fluctuation from selected setting.

The new improved **Heathkit** Model IP-27 regulated low voltage power supply varies from 0·5 to 50 volts in ten switched ranges. The voltage regulation is claimed to be better than $\pm 1{\cdot}5$ millivolts from zero to full load. There are four switched current ranges: 50mA, 150mA, 500mA and 1·5A, and there is an adjustable current limiter control for all ranges.

The IP-27 is housed in a new styled case which is fully portable and uses all solid-state devices, including Zener diodes. The unit operates from 120/240V a.c. mains supply and costs £46 12s in kit form plus 9s postage and packing.

A new electronically controlled entirely automatic car battery charger has been introduced by **JD Electronics Ltd.**, Leafield, Corsham, Wiltshire.

Known as the JD Autocharger it checks its own electronic circuit to ensure correct operating conditions and will cut out on locating any irregularities, extinguishing its red external electric-eye charging lamp. The fault located and corrected it will commence recharging once the reset button has been activated.

One of the features of the charger is the self-determination of whether it has been connected to a 6 or 12 volt battery, regulate itself and operate. It will allow only sufficient current to recharge. The recharging progress is determined by the modulated glow from the indicator lamp.

There is a temperature limiting device so that if the operator tries to charge a faulty battery it will cut itself off before overheating.

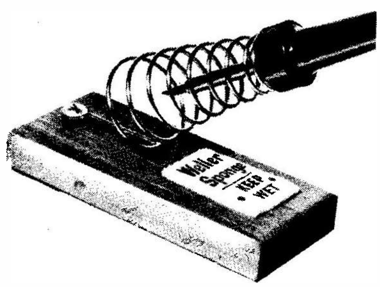
The body shell of the JD Autocharger is shatter-proof white plastics and can be hung on the garage wall while in operation or when not in use. The charger is double insulated to British Standard requirements against accidental shock and costs £5 12s 6d.

IRON STAND

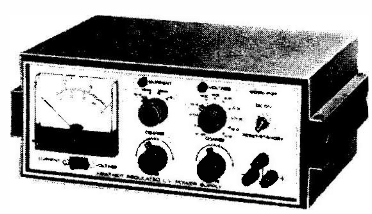
Soldering irons are frequently a source of danger in the home workshop and it is often a problem where to place it when working on equipment. Young Jimmy or any visitor to the workshop runs the risk of burns and damage to clothing.

Weller Electric Ltd. have now introduced a range of simple bench soldering iron stands to ease this risk. It consists of a teak base with a spring funnel mounted on the top to take the iron.

Prices range from 16s and, in addition to the holder and base, each stand includes a sponge for easy cleaning of the soldering iron tip.



Bench soldering iron stand from Weller Electric



Heathkit improved Model IP-27 regulated low voltage power supply

LITERATURE

The new **Mazda** booklet entitled *Electrons in Shadow-mask Colour Tubes* is biased towards the training of dealer's service technicians in the sphere of colour television. It is the latest addition to their series of *Electrons* instructional booklets.

The text has been specifically levelled at service technicians already familiar with the principles of black and white television.

Starting with the system requirements and evolution to the shadow-mask tube display device, the booklet gives, in logical easy stages, the basic principles of operation of tubes with their external neck components and also outlines the methods used in tube manufacture. While the principles of convergence are clearly explained, detailed convergence procedures are not given because they vary from receiver to receiver.

The booklet has been written by Bernard Eastwood B.Sc., M.I.E.E. who is Manager and Chief Engineer of the Thorn-AEI Applications Laboratory, and costs 3s 6d plus 6d postage from Mazda Publicity Department, Thorn-AEI Radio Valves and Tubes Ltd., 7 Soho Square, London, W.1.

Readers who have been following our series on *Nucleonics for the Experimenter* may be interested in two booklets now available from **Mullard Ltd.** which provide an introduction to nuclear radiation and radiation detectors.

The first booklet entitled *An Introduction to Nuclear Radiation and their Detection*, describes briefly the structure of the atom and explains the phenomenon of radiation. The three main types of radiation (alpha, beta, gamma) are described, radioactive decay is explained and the units of nuclear energy are defined. The last part of the booklet deals with the various types of detectors that are available.

The other booklet, entitled *Germanium and Silicon Radiation Detectors*, describes semiconductor nuclear radiation detectors and their associated equipment.

The first part of this booklet outlines the factors governing the choice of a lithium-drifted germanium detector and its resolution.

The last section deals with silicon surface barrier detectors and lithium-drifted silicon detectors. As with germanium detectors, tables and diagrams are given to enable the best possible device to be selected for any particular application.

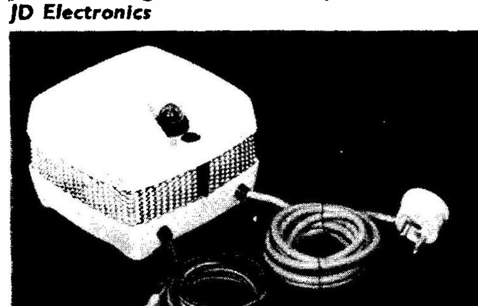
The two booklets are available on request, on company headed note paper, from the Industrial Electronics Division, Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

Also available from Mullard and particularly suitable for schools and clubs is a large wallchart (31in × 43in) entitled *The Shadowmask Picture Tube for Colour Television.*

The chart covers in detail the construction and operation of a colour tube and illustrates briefly the general principles of colour television.

Copies are available from the Mullard Educational Service, Mullard House, Torrington Place, London, W.C.1, price 5s including postage and packing.

JD Autocharger marketed by JD Electronics



Practical Electronics Classified Advertisements

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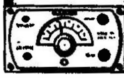

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RECEIVERS AND COMPONENTS
(continued)

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½ watt Resistors increased to E24 Series—from 910 ohm to 91k. ohm.

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SILICON PLANAR TRANSISTORS—EPOXY CASE NPN
Similar to 2N2926 (Brown to Orange gain spreads), 2N3707, etc. All tested and guaranteed. New Manufacturer's surplus.
ORDER AS: 2N3707E @ 15/- DOZEN

SILICON PLANAR TRANSISTORS—EPOXY CASE PNP
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Similar to BCY70/71/72. Not tested—approx. 50% yield of good devices. 10,000 pieces to clear.
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5 Page data/details 2/6d

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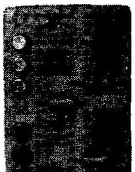

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ELECTROLYTIC CAPACITORS (Mullard).—10% to +50%.
Subminiature (all values in μF)

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6·4V	6·4	25	50	100	200	320
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25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/6	1/3	1/2	1/-	1/1	1/2

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Tubular 10%, 160V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047μF, **8d.** 0·068, 0·1μF, **9d.** 0·15μF, **11d.** 0·22μF, **1/-.** 0·33μF, **1/3.** 0·47μF, **1/6.** 0·68μF, **2/3.** 1uF, **2/8.** 400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, **6d.** 6,800pF, 0·01, 0·015, 0·022μF, **7d.** 0·033μF, **8d.** 0·047μF, **9d.** 0·068, 0·1μF, **11d.** 0·15μF, **1/2.** 0·22μF, **1/6.** 0·33μF, **2/3.** 0·47μF, **2/8.**
Modular, metallised, P.C. mounting, 20%, 250V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047μF, **8d.** 0·068, 0·1μF, **9d.** 0·15μF, **11d.** 0·22μF, **1/-.** 0·33μF, **1/5.** 0·47μF, **1/8.** 0·68μF, **2/3.** 1μF, **2/9.**
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POTENTIOMETERS (Carbon), miniature, 1in × ½in spindle. Lin. 100Ω to 10MΩ, Log. 5kΩ to 5MΩ, **2/3.**
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Spools: 8¼" 6/3, 7" 2/6, 5¾" 2/3, 5" 2/3, 3" 9d

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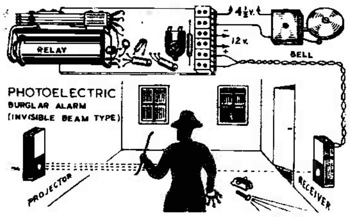

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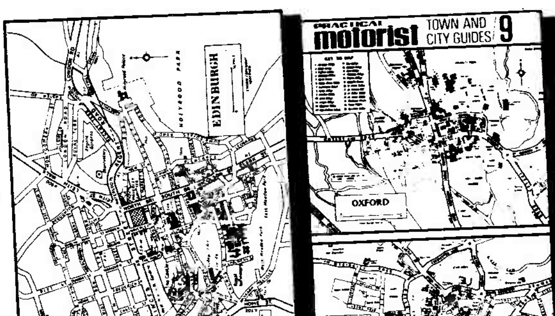

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Sub-min C426 range (μF/V): 10/2·5, 8/4, 6·4/6·4, 4/10, 2·5/16, 1·6/25, 1/40, 0·64/64 .. .. **1/8 each**
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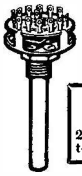

4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each, 36/- dozen, your assortment.

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26 yards length 70W. Self-regulating temperature control. 10/- post free.

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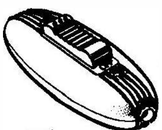
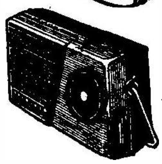


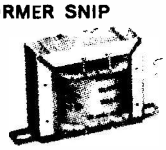
Double Pole with neon let into side so it is luminous in dark, ideal for dark room light or for use with waterproof element—blue plastic case. 7/6 each.

TRANSISTOR SET CASE



Very modern cream cabinet, size 5½ × 3 × 1¼in with chrome handle, tuning knob and scale. Price 4/6 plus 2/- postage. Printed circuit board for this case TRF circuit 2/6, superhet 3/6.

MAINS TRANSFORMER SNIP



Making a power pack for amplifier or other equipment? These transformers have normal mains primaries (230/40V) and isolated secondaries. Two types: (1) 12V 500mA at 9/6; (2) 15V 500mA at 10/6.

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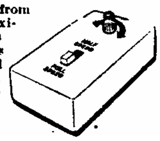
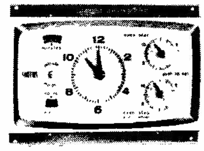


Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. 19/6 plus 2/6 post and insurance. Or available made up 32/6, plus 2/6 post.

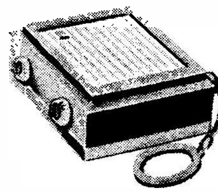
THIS MONTH'S SNIP



Electric Clock with 20 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—also on the left is another timer or alarm—this may be set in minutes up to 4 hours. At the end of the period a bell will sound. 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 ins. 2/9.

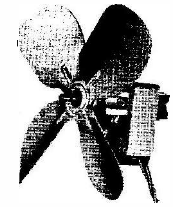
BARGAIN OF THE YEAR

MICRO-SONIC



7 transistor Key chain loudspeaker Radio in very pretty case, size 2¾ × 2¼ × 1¼in—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne. Frequency range: 530 to 1600kc/s. Sensitivity: 5mv/m. Intermediate frequency: 465kc/s, or 455kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: permanent magnet type. In transit from the East these sets suffered slight corrosion as the batteries were left in them but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. 19/6 plus 2/6 post and ins., less batteries. A pair of rechargeable everlasting batteries 3/6 each (2 required)

AC FAN



Small but very powerful mains motor with 6½in blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 17/6, post 4/6. Mounts from back or front with 4BA screws.

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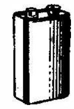

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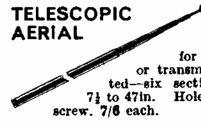

for portable, car radio or transmitter. Chrome plated—six sections, extends from 7¼ to 47in. Hole in bottom for 6BA screw. 7/6 each.

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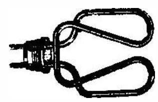

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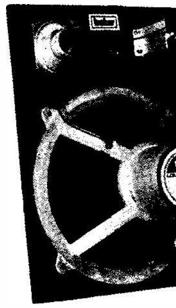

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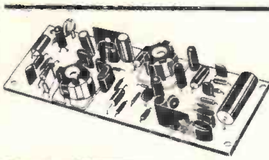

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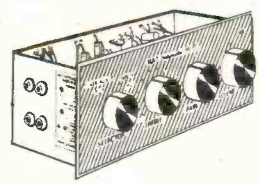

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