PRACTICAL

ELECTRONICS

OCTOBER 1973

20p

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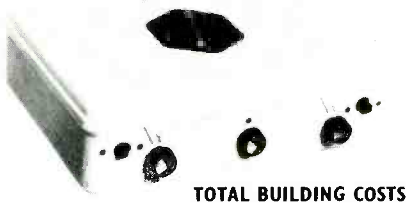
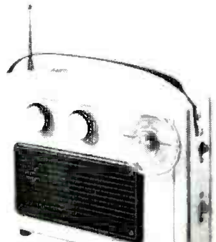


- 4 Transistor Earpiece Radio
- Signal Tracer
- Signal Injector
- Transistor Tester NPN —PNP
- 4 Transistor Push Pull Amplifier
- 5 Transistor Push Pull Amplifier
- 7 Transistor Loudspeaker Radio MW/LW.
- 5 Transistor Short Wave Radio
- Electronic Metronome
- Electronic Noise Generator
- Batteryless Crystal Radio.
- One Transistor Radio
- 2 Transistor Regenerative Radio
- 3 Transistor Regenerative Radio
- Audible Continuity Tester
- Sensitive Pre-Amplifier
- Complete with parts price list and plans.

TOTAL BUILDING COSTS
£7·23 P.P. & INS. 44p (Overseas P.P. £1·05p)

NEW ROAMER NINE



WITH V.H.F. INCLUDING AIRCRAFT

Nine Transistors, 9 Tunable wavebands as Roamer Ten. Built in ferrite rod aerial for MW/LW. Retractable chrome plated telescopic aerial for VHF and SW. Push Pull output using 600 mW transistors. 9 Transistors and 3 diodes, tuning condenser with VHF section, separate coil for aircraft, moving coil loudspeaker, volume ON/OFF and wavechange. Attractive all white case with red grille and carrying strap. Size 9½in × 7in × 2½in approx. Parts price list and plans 30p (FREE with parts).

TOTAL BUILDING COSTS **£6·95** P.P. & INS. 44p (OVERSEAS P. & P. £1·05)

NEW EVERYDAY SERIES

Build this exciting New series of designs

EV5 5 Transistors and 2 diodes. MW/LW. Powered by 4½ volt Battery. Ferrite rod aerial, tuning condenser, volume control, and loudspeaker. Attractive case with red speaker grille. Size 9in × 5½in × 2½in approx. Parts price list and plans 15p (FREE with parts).

TOTAL BUILDING COSTS **£2·73** P.P. & INS. 30p (OVERSEAS P. & P. 70p)

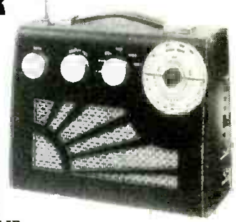
EV6 Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt Battery. Ferrite rod aerial, loudspeaker, etc., MW/LW coverage. Push Pull Output. Parts price list and plans 15p (FREE with parts.)

TOTAL BUILDING COSTS **£3·60** P.P. & INS. 30p (OVERSEAS P. & P. 85p)

EV7 Case and looks as above. 7 transistors and 3 diodes. Six wavebands, MW/LW, Trawler Band, SW1, SW2, SW3, powered by 9 volt Battery Push Pull Output. Telescopic Aerial for Short Waves. Parts price list and easy build plans 20p. Free with parts.

TOTAL BUILDING COSTS **£4·08** P.P. & INS. 31p (OVERSEAS P. & P. £1·05p)

ROAMER TEN



WITH VHF INCLUDING AIRCRAFT

10 TRANSISTORS. 9 TUNABLE WAVEBANDS. MW1, MW2, LW, SW1, SW2, SW3, TRAWLER BAND, VHF AND LOCAL STATIONS. ALSO AIRCRAFT BAND

Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated 7 section telescopic aerial, can be angled and rotated for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. 10 transistors plus 3 diodes. Fine tone moving coil speaker. Ganged tuning condenser with VHF section. Separate coil for Aircraft Band. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9in × 7in × 4in. Easy to follow instructions and diagrams. Parts price list and plans 30p (FREE with parts).

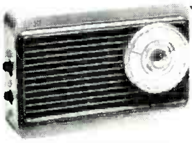
TOTAL BUILDING COSTS **£8·50** P.P. & INS. 52p (OVERSEAS P. & P. £1·05)

POCKET FIVE

3 Tunable wavebands. MW/LW and Trawler Band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, moving coil loudspeaker, attractive Black and Gold Case. Size 5½in × 1¼in × 3½in approx. Plans and parts price list 15p (FREE with parts).

Total Building Costs **£2·28** P.P. & Ins. 24p (Overseas P.P. 65p)

TRANSONA FIVE



Wavebands, transistors and speaker as Pocket Five. Larger Case with Red Speaker Grille and Tuning Dial. Plans and parts price list 15p (FREE with parts).

Total Building Costs **£2·50** P.P. & Ins. 25p (Overseas P. & P. 65p)

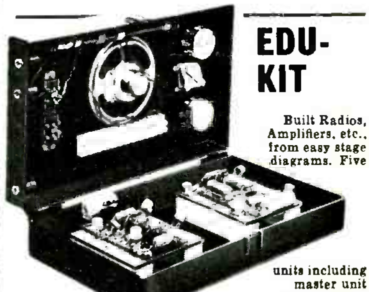
ROAMER EIGHT Mk. I

NOW WITH VARIABLE TONE CONTROL

7 TUNABLE WAVEBANDS: MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND. Built-in ferrite rod aerial for MW and LW. Retractable chrome plated telescopic aerial for short waves. Push-pull output using 600mW transistors. Car aerial and tape record sockets. Selectivity switch. 8 transistors plus 3 diodes. Fine tone moving coil speaker. Air spaced ganged tuning condenser. Volume/on/off, tuning, wave change and tone controls. Attractive case in rich chestnut shade with gold blocking. Size 9in × 7in × 4in approx. Easy to follow instructions and diagrams. Parts price list and plans 25p (FREE with parts).

TOTAL BUILDING COSTS **£6·98** P.P. & INS. 47p (OVERSEAS P. & P. £1·05)

EDU-KIT

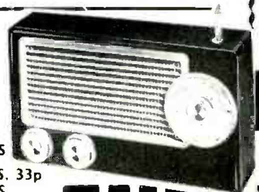


Built Radios, Amplifiers, etc., from easy stage diagrams. Five units including master unit to construct.

Components include: Tuning Condenser: 2 Volume Controls: 2 Slider Switches: Fine tone moving coil Speaker: Terminal Strip: Ferrite Rod Aerial: 2 Plugs and Sockets: Battery Clips: 4 Tag Boards: 10 Transistors: 4 Diodes: Resistors: Capacitors: Three ¼in Knobs. Units once constructed are detachable from Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction. Parts price list and plans 25p (FREE with parts).

TOTAL BUILDING COSTS **£5·50** P.P. & INS. 33p (OVERSEAS P. & P. £1·05)

TRANS EIGHT 8 TRANSISTORS AND 3 DIODES



6 TUNABLE WAVEBANDS. MW, LW, SW1, SW2, SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW. and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and plans 25p (FREE with parts).

TOTAL BUILDING COSTS **£4·48** P.P. & INS. 33p (OVERSEAS P. & P. £1·05)

ROAMER SIX 6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, TRAWLER BAND PLUS AN EXTRA MW BAND

FOR EASIER TUNING OF LUXEMBOURG, ETC. Sensitive ferrite rod aerial and telescopic aerial for short waves. 3in speaker. 8 stages 6 transistors and 2 diodes, etc. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Plans and parts price list 25p (FREE with parts).

TOTAL BUILDING COSTS **£3·98** P.P. & IN. 31p (OVERSEAS P. & P. £1·05)

Please add 10% for VAT INC. P. & P.

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P.E.57

PRACTICAL ELECTRONICS

VOLUME 9 No. 10 OCTOBER 1973

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL DATA SHEET

Our November issue will be published on Friday, October 12, 1973

You'll hardly be able to believe your ears!

Can you really get sound quality like this for less than £18?

Yes you can! with the new STEREO 21

Until now, richly satisfying sound has always cost a richly satisfying price. *But not any more!* For an almost unbelievable £17·95, you can have Stereo 21—audio for the connoisseur.

Whatever your taste in music, you can hear it on STEREO 21 the way its composers heard it in their dreams! Beethoven or Mahler . . . Ellington or Jellyroll Morton . . . Das Nibelung or Jesus Christ Superstar . . . Carols from King's College Chapel or the return of a Beatle . . . everything from a prettily fluting baroque organ to the newest pop group at full throttle—STEREO 21 does them all justice!

And have you ever seen a handsomer audio installation? Compact enough to go in a university student's bedroom-study, elegant enough for the suavest penthouse pad in Town, STEREO 21 offers you all the pride of possession as well as a thrilling musical experience!

Top-quality amplifier, BSR 8 record automatic changer turntable, matching speakers. Deck and speaker cabinets you simply wrap round and glue to build. Screw in the amplifier and connect up (all push fit, no soldering whatsoever), so simple literally anyone can do it. Except for glue and panel pins, all parts supplied including full instructions—all for £17·95 (plus the cost of post and packing if you buy by mail), and—to round it all off—a money-back Guarantee if your pleasure in STEREO 21 is not complete!

Just think—in only a few days you could be giving your ears the treat of a lifetime—AND introducing your envious friends to STEREO 21!

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£17·95

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Diamond styli, if required, £1·37 extra

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4 Bands covering 550kHz-30MHz. BFO Built-in Speaker 220/240V a.c. Brand new with instructions.

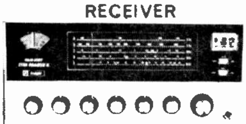
OUR PRICE **£15·75** Carr. 37p

UR-1A RECEIVER

4 Bands covering 550kHz-30MHz. FET. S Meter. Variable BFO for SSB. Built-in Speaker. Band-spread. Sensitivity Control. 220/240V a.c. or 12V d.c. 12½ × 4½in × 7in. Brand new with instructions.

OUR PRICE **£25·00** Carr. 37p

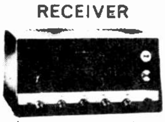
SKYWOOD CX203 RECEIVER



Solid state. 5 bands covering 200-420kHz and 0·55 to 30MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO. AVC, ANL, "S" meter. AM/CW/SS B. Integrated speaker and phone socket. 220/240V a.c. or 12V d.c. Size 325 × 266 × 150mm. Complete with instructions and circuit.

OUR PRICE **£32·50** Carr. 50p

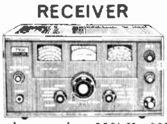
LAFAYETTE HA-600 RECEIVER



General coverage 150-400kHz, 550kHz-30MHz. FET front end. 2 mech. filters, product detector, variable BFO, noise limiter, S Meter Bandspread. RF Gain. 15in × 9½in × 8½in. 18 lb. 220/240V a.c. or 12V d.c. Brand new with Instructions.

OUR PRICE **£50·00** Carr. 50p

TRIO 9R59DS RECEIVER



4 bands covering 550kHz-30MHz 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. bandspread dial. IF frequency 445kHz audio output 1·5W. Variable RF and AF gain controls 115/250V a.c. Size: 7in × 13in × 10in with instruction manual.

OUR PRICE **£49·50** Carr. Paid

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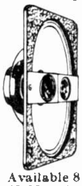
EMI LOUDSPEAKERS



Model 350. 13in × 8in with single tweeter /crossover. 20-20,000 Hz. 15W RMS. Available 8 or 15 ohms. **£7·25** each. P. & P. 37p.
Model 450. 13in × 8in with twin tweeters/crossover. 55-13,000 Hz. 8W RMS.
Available 8 or 15 ohms. **£3·62** each. P. & P. 25p.

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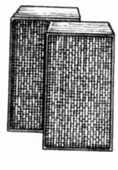
STEREO SPEAKERS



Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14½ in × 9in × 7½ in. 8 ohms. 8W RMS 16W peak. Complete with DIN lead.

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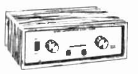
HA-10 STEREO HEAD-PHONE AMPLIFIER



All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. Inputs 5MU/100MU. Output 50MW.

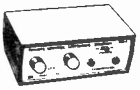
OUR PRICE **£6·97** P. & P. 20p

MP7 MIXER PREAMPLIFIER

5 microphone inputs each with individualgain controls enabling complete mixing facilities. Battery operated. 9¼in × 5in × 3in. Inputs Mics: 3 × 3mV 50K; 2 × 3mV 600 ohm. Phono meg. 4mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

OUR PRICE **£8·97** P. & P. 20p

1021 STEREO LISTENING STATION



For balancing and gain selection of loudspks. with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets 6in × 4in × 2¼in.

OUR PRICE **£2·25** P. & P. 20p

EA.41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar, etc., and output into your amplifier. Volume control, depth of reverberation control. Beautiful walnut cabinet 7¼in × 3in × 4¼in.

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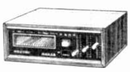
ACD660 STEREO CASSETTE DECK

A beautifully styled 4 track stereo deck with an outstanding specification offered at a remarkably low price. Incorporates a host of features including switchable noise filter, normal/chrome tape selector, twin VU meter, slider record/playback level controls, front panel headphone socket, recording indicator lamp, phono/Din line input sockets, 3·5mm mike input sockets, etc., etc. Frequency response 100-8kHz (100-12kHz CrO2). S/N —45dB. Crosstalk —45dB. Separation —35dB. Noise limiter —6dB at 10kHz. Complete with phone connecting leads.

OUR PRICE **£39·50** Carr. & Ins. 50p

AHP8A 8 TRACK STEREO TAPE PLAYER



Incorporates built in amplifiers giving 2¼ + 2¼W r.m.s. output. Push-button track selector, illuminated track indicators, slider controls for volume, balance and tone. Attractive cabinet with black and silver trim. Output impedance 8 ohms. 220/240V a.c.

OUR PRICE **£17·25** P. & P. 50p, plus V.A.T.

AHP8D 8 TRACK STEREO TAPE DECK

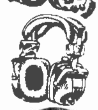
Can be used with most hi-fi amplifiers. Push button track selector andilluminated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. 220/240V a.c.

OUR PRICE **£11·95** P. & P. 50p, plus V.A.T.

STEREO HEADPHONES

LSH20. Individual volume controls. Stereo mono switch. 8 ohms. 40-19,000Hz.
£3·50 P. & P. 30p

LSH30. Open back type. Individual tone and volume controls. 8 ohms. 30-20,000Hz.
£5·50 P. & P. 30p



LSH40. Two way speaker system. Individual volume controls. 8 ohms. 20-20,000Hz.
£6·95 P. & P. 30p

LSH60. 3in speaker units. 8 ohms. 20-20,000Hz. Complete with zipped carrying case.
£8·50 P. & P. 30p

LQH400. 4-channel dynamic headphones. Each earpiece has 4 drive units. 4-32 ohms. 20-20,000Hz.
£9·95 P. & P. 30p

LSH50. Electrostatic with self powered energiser and control unit with headphone/speaker selector. 4-32 ohms. 20-24,000 Hz.
£15·95 P. &P. 30p

DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16⅞in × 8in × 3¼in. a.c. 00/250V2.

PROCESS TWO

For use with cassette and tape recorders. Freq. res. 30Hz—20kHz—2dB. Off tape monitoring. Switchable multiplex filter. Two Dolby calibration meters. S/N better than 70dB. Supplied with test cassette or tape as required.

OUR PRICE **£34·50** P.&P. 50p

PROCESS FOUR

For use with semi professional tape recorders. Freq. res. 30Hz—20kHz ±2dB. S/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

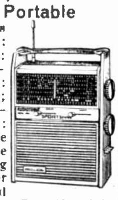
OUR PRICE **£50·00** P.&P. 50p

ACR14 BATTERY MAINS CASSETTE RECORDER

Portable twin track mono recorder with automatic recording level control. Built in speaker. Earpiece socket. Input for radio or record player. Fast forward and rewind. Output 500mW: 220/240V a.c. or 6V d.c. operation. Complete with remote control microphone, mains lead, earpiece and batteries.

OUR PRICE **£10·50** P. & P. 50p

AR1000 Sportsman AM/FM Portable



5 wavebands covering A.M.: 535 – 1065kHz: F.M. 88-108MHz; A.I.R: 108 – 135MHz; P.B. 147-174MHz; W.B.: 162·5MHz Large horizontal slide dial with logging scale. Slider volume and squelch controls. 7 section telescopic aerial for F.M. and built in ferrite bar for A.M. A.F.C. 3in speaker. Earpiece socket. Green leatherette covered cabinet with metal side panels. Size 152 × 79 × 219mm. Battery/mains operation.

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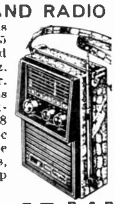
AMB500 MULTI BAND RADIO



5 wavebands covering MW 535—1605KHz and F.M. 88-175MHz. All transistor. Battery or mains operation. Built-in aerial and 8 section telescopic aerial. Complete with batteries, shoulder strap and earpiece.

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10 wavebands covering A.M.: 535-1605kHz; L.W.: 150-380kHz; M.B. 1·6-4·0MHz; S.W.1.: 4·0-8·0MHz; S.W.2: 8·0-16MHz; S.W.3: 16-24MHz; P.S.B.1: 30-50MHz; P.S.B.2: 148-174MHz; F.M. 88-108MHz; A.I.R.: 108-136MHz. Features time zone map and timing dial. Large clear scale. Telescopic aerial and built-in aerial. A.F.C. on F.M. 6in × 4in speaker and personal earpiece. Battery/mains operation. Size 345 × 133 × 305mm.

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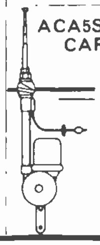

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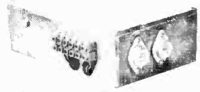
PRACTICAL ELECTRONICS "SCORPIO" ELECTRONIC IGNITION SYSTEM



This Capacitor-Discharge Electronic Ignition system was described in the November and December issues of Practical Electronics. It is suitable for incorporating in any 12V ignition system in cars, boats, go-karts, etc., of either pos. or neg. earth and up to six cylinders. The original coil, plugs, points and contact-breaker capacitor fitted in the vehicle are used. No extra or special components are required.

Helps to promote easier starting (even under sub-zero conditions), improved acceleration, better high-speed performance, quicker engine warm-up and improved fuel economy. Eliminates excessive contact-breaker point burning and the need to adjust point and spark-plug gaps with precision.

Construction of the unit can easily be completed in an evening and installation should take no longer than half an hour. A complete complement of components is supplied with each kit together with ready-drilled roller-tinned professional quality fibre-glass printed-circuit board, custom-wound transformer and fully-machined die-cast case. All components are available separately. Case size 7½in × 4½in × 2in. approx.

Complete assembly and wiring manual **25p**, refundable on purchase of kit. Price: **£12·10**.

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This unit represents a natural progression from our phenomenally successful Mk. I and 2 Units. As before the drive voltage is derived directly from the amplifier output or across the speakers. The unit converts the audio frequency signals into a three-coloured light display; the colour depending on the frequency of the signal and the intensity on the loudness of the audio source.

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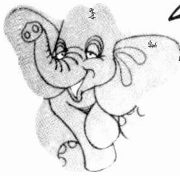

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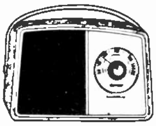
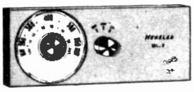
BUILD THIS RADIO



PORTABLE MW/LW RADIO KIT using Mullard RF/IF module. Features MW—bandspread for extra selectivity. Slow motion tuning. Fibre glass PVC cabinet. 600MW output. All parts **£7·98** (battery 22p). Carr. etc. 32p.



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605	Power supply for 115	3·88
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485	0–12V 300mA STAB. supply	9·68
570	LF generator 10Hz—1mHz	12·60
575	Sq. wave generator 20Hz–20kHz	12·87
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620	Ni-CAD Charger 1·2–12V	7·47
630	STAB. Power supply 6–12V 0·25–0–1A	7·65
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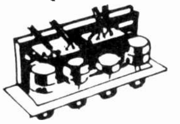

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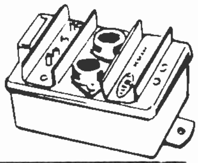

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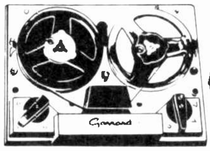

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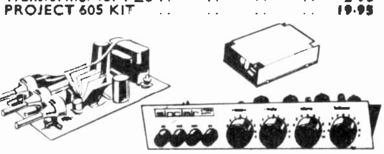

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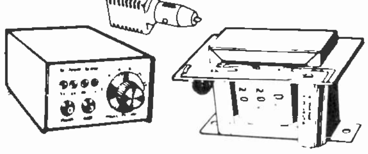

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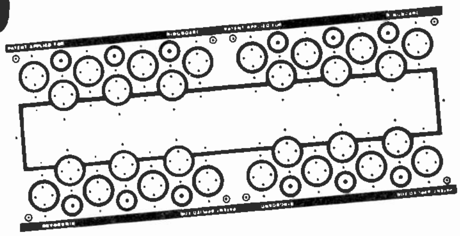

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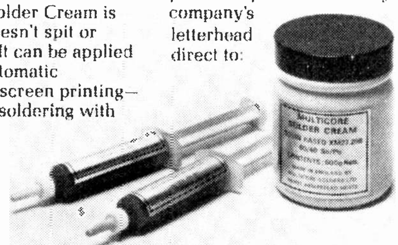

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AMATEUR RADIO JUBILEE

RADIO provided the original sturdy stock from which a host of branches have since proliferated, giving a variegated countenance to the lusty and profusely spreading technology now known as electronics. Digging back to the roots, one finds the amateur enthusiast playing his part right from the earliest times of wireless communication. This then new field offered exciting possibilities and attracted the interest of thousands of individuals possessed of a scientific bent and an urge to experiment with home-made equipment.

No doubt the community spirit engendered through contacts established by wireless between individuals and groups was responsible for the rapid formation of wireless clubs throughout the country. On September 23, 1913 the London Wireless Club held its first general meeting in London. This was a momentous event, because this body was later to be reconstituted as the Radio Society of Great Britain.

At this time when the RSGB is celebrating its Diamond Jubilee, it is well to record the event and acknowledge the vital part this body has played in furthering the interests of the radio amateur, not only within the U.K., but on an international level as well.

It has to be admitted that, in the popular eye, the radio amateur has become typified as a somewhat odd character living for much of his time in a peculiar world of his own, peopled only by other kindred spirits identified by call signs rather than names. That he *can* become so totally engrossed in his hobby as to be oblivious of all other affairs is a fact that many wives and acquaintances will affirm! It is also a fact that in recent times he has succumbed more and more to the sophisticated products offered by the communications equipment manufacturers, and his chief role now is likely to be that of an operator of a radio station equipped largely with commercial apparatus.

Nowadays the opportunities for making significant contributions to radio science are limited. Commercial interests have always quickly and eagerly followed up past pioneering achievements by amateurs (often to the latters ultimate cost). Exploitation of all kinds of radio communication with the very latest electronic techniques has for long been a prime concern of professionals working for industry and government agencies.

But the radio amateur still has his own fascinating hobby. No one who has experienced the thrill of that first over-the-air contact will dispute the attractive force of electromagnetic waves. When the bug bites, it usually bites deep. And, of course, not all amateurs are as single-minded as we might have suggested. Not for all the time, at any rate! Most are likely to be avid followers of electronics in its widest sense, and no doubt become involved from time to time in the building of equipment entirely foreign to a radio shack.

Today's amateur constructor and experimenter, whatever his field of specialisation within electronics, is continuing a fine tradition of individual enterprise where financial gain is not the goal; a tradition established by that pioneering band in the early days of wireless. We offer best wishes to the Radio Society of Great Britain and to their members, a fraternity which through usage over the last 60 odd years has acquired its own special kind of proprietary right to that honourable term "amateur."

F.E.B.

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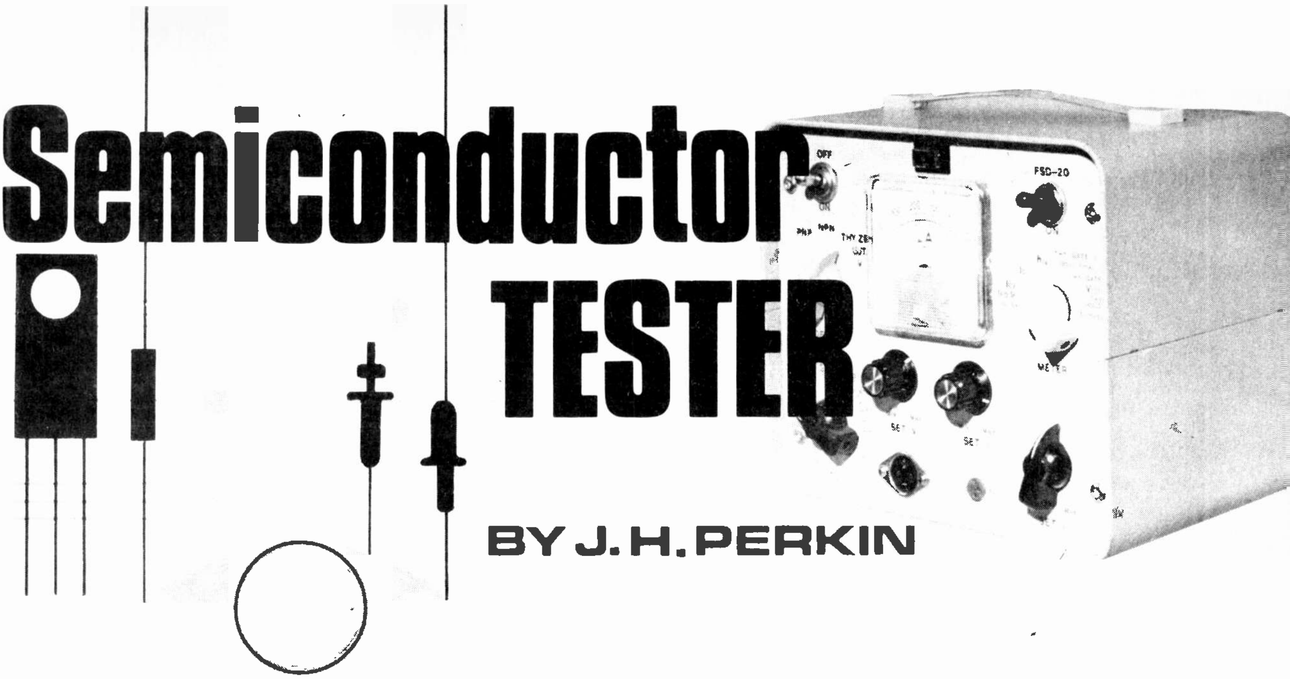
Semiconductor TESTER



BY J. H. PERKIN

THE semiconductor tester is an invaluable aid to the experimenter since it allows him to not only detect faulty components in both building and servicing but to select or match components for specific circuit requirements and, bearing in mind the availability of untested components, purchase and sort such devices.

However, to effect all these usually requires a number of different instruments because of the inherent differences between the devices to be tested.

The present tester removes this objection to a great extent by being able to cope with a wide range of discrete components and identify their main parameters.

It was designed so as to be of low cost and reasonable ease of construction, to be portable and easy to operate, and of course to be as versatile as possible.

SEMICONDUCTOR THEORY

Transistors

These have the ability to provide current gain, i.e. the application of a small change in base current of a transistor gives a larger change in collector current, giving current amplification. This may be converted to voltage amplification by use of external components.

The magnitude of this amplification is referred to as h_{fe} where:—

$$h_{fe} = \frac{\text{The change in collector current}}{\text{The change in base current}}$$

Ideally, when no base current flows no collector current should flow but in fact this is not so in practice. Even when the base is completely disconnected a small amount of current flows in the collector/emitter circuit. This current is known as I_{ceo} or leakage current.

Diodes

Basically a diode is a device which allows current to flow in one direction only. Again, as with the transistor, such devices are not perfect and, under some conditions of applied voltage, current can indeed flow in either direction through a diode.

Fig. 1 shows the curve of current to voltage for a diode, identifying the two conditions of forward and reverse bias.

When the diode is forward-biased very little current flows until voltage V_1 is reached. In practice the value of V_1 depends very largely on the nature of the semiconductor. If it is germanium V_1 will be 0·2 volts and if silicon it will be 0·6 volts.

Incidentally, this holds true of the base/emitter junction of a transistor.

When V_1 is exceeded the current rises rapidly for small increases in voltage and the slope of the graph (a tangent to the line at any given point) is the forward a.c. resistance of the diode which is approximated by using the formula:—

$$R_{fac} = \frac{26}{I_e}$$ where I_e is the diode current in mA.

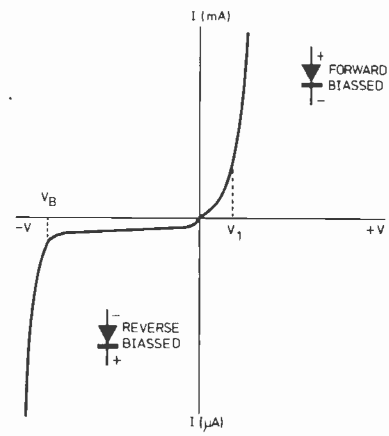


Fig. 1 Graph showing a typical voltage/current relationship for a diode

When the diode is reverse-biased little current flows and it is called the leakage current. This increases as the breakdown voltage V_B is reached and exceeded. Above V_B the current increases rapidly for small increases in voltage.

This region of the curve is known as the Zener region and the slope of the curve in the Zener region is known as the a.c. resistance or R_{ac}.

Thyristors

Basically a thyristor is an electrically controlled switch in which a small gate current can trigger a very much larger anode/cathode current. One drawback of this device is that once anode current is flowing it can be turned off only by either removing the voltage or breaking the circuit externally to the thyristor.

The current through the thyristor in its untriggered state is known as the leakage current, I_{fo} when the thyristor is forward-biased and I_{ro} when it is reverse biased.

The magnitude of the current required to "trigger" the thyristor *via* the gate is known as the "gate trigger current" and the magnitude of the current required to switch the thyristor "on" is known as the "gate trigger voltage," measured with respect to the cathode.

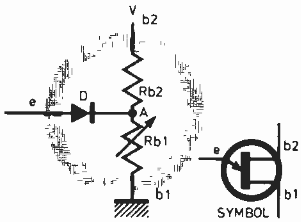


Fig. 2. Diagram of the equivalent circuit of a unijunction transistor with its usual symbol

As the current through a thyristor is reduced it reaches a state where further reduction would switch the thyristor "off." This level of current is known as the "holding" current.

Unijunction Transistors

The diagram of Fig. 2 shows the pictorial representation of a unijunction transistor.

The voltage at point A with the emitter disconnected is given by the formula:—

$$\frac{V \times R_{b1}}{R_{b1} + R_{b2}}$$

where the ratio $\frac{R_{b1}}{R_{b1}+R_{b2}}$ is known as π, the intrinsic standoff ratio (considering R_{b1} and R_{b2} in series).

The emitter connection is isolated from b2 and bl unless the potential at the emitter (e) is greater than A + 0·6V, when the diode will be forward-biased and thus conduct. In this condition the resistance R_{b1} decreases and the voltage at A drops as the current increases, thus producing a negative resistance region.

A point is reached where the emitter current ceases, R_{b1} returns to its initial value and the diode is reverse-biased until it attains a sufficiently high potential for the process to repeat.

CIRCUIT OPERATION

Transistor Testing

The block diagram of the system used to test transistors is as shown in Fig 3. To measure I_{ceo} only a meter and a meter switch S2 (see Fig. 4 which is the complete circuit diagram) are used, and the meter monitors the current through the transistor with the base disconnected. R12 is a meter shunt which is switched out by the f.s.d. ÷ 20 switch S4. (See Fig. 4.)

h_{fe} is measured as follows. The output of a multivibrator consisting of components R1, R2, R3, R4, C1, C2, TR1, TR2, oscillating at approximately 400Hz is fed *via* R5 to a calibrated attenuator VR1 and also to the comparator circuit. VR1 is calibrated to read h_{fe} directly and R15 is included to expand the h_{fe} scale.

The attenuated oscillation from the slider of VR1 is fed *via* R19 which compensates for differing input impedances of the transistors to be checked. The signal is then fed via C5, a d.c. blocking capacitor through S1e and S2d to the base of the transistor under test.

The transistor connected in the common emitter mode amplifies and inverts the signal at its base. The amplified signal is fed *via* R7 and C4 to the base of TR3 where it combines with the non-inverted

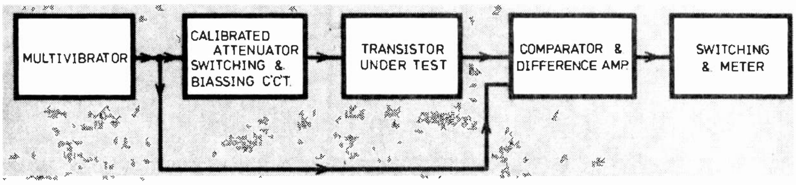


Fig. 3. Block diagram of the Semiconductor Tester as used to measure transistor characteristics

oscillation from the multivibrator which has been fed *via* R16 and C3; VR2a and R17 compensate for attenuation made by the network R19, VR2b and R10. If VR1 is correctly adjusted the two signals cancel at the base of TR3. Any uncancelled oscillation is amplified by TR3, TR4 and R6, R18 biasing TR3. The amplified signal is passed by C6 and R21, rectified by D7 and D3 and causes a deflection on the meter when the meter switch is set to h_{fe}. VR2 is set to the required no signal current in the transistor which is being checked. D4 and D5 provide a path for collector current when I_c is not being monitored.

Diode and Zener Testing

Diode testing is accomplished by connecting the diode to the power supply through an internal resistor R11. The current through the diode is monitored by the meter both when the diode is forward and reverse biased. Reverse biasing is accomplished by reversing the polarity of the supply voltage.

The voltage across the diode can be measured by utilising a meter as a voltmeter, this is accomplished using the meter switch and a multiplier resistor R23, which converts the meter to read 25V f.s.d. The breakdown voltage (Zener voltage) of a Zener diode can be measured using the meter as a voltmeter. A

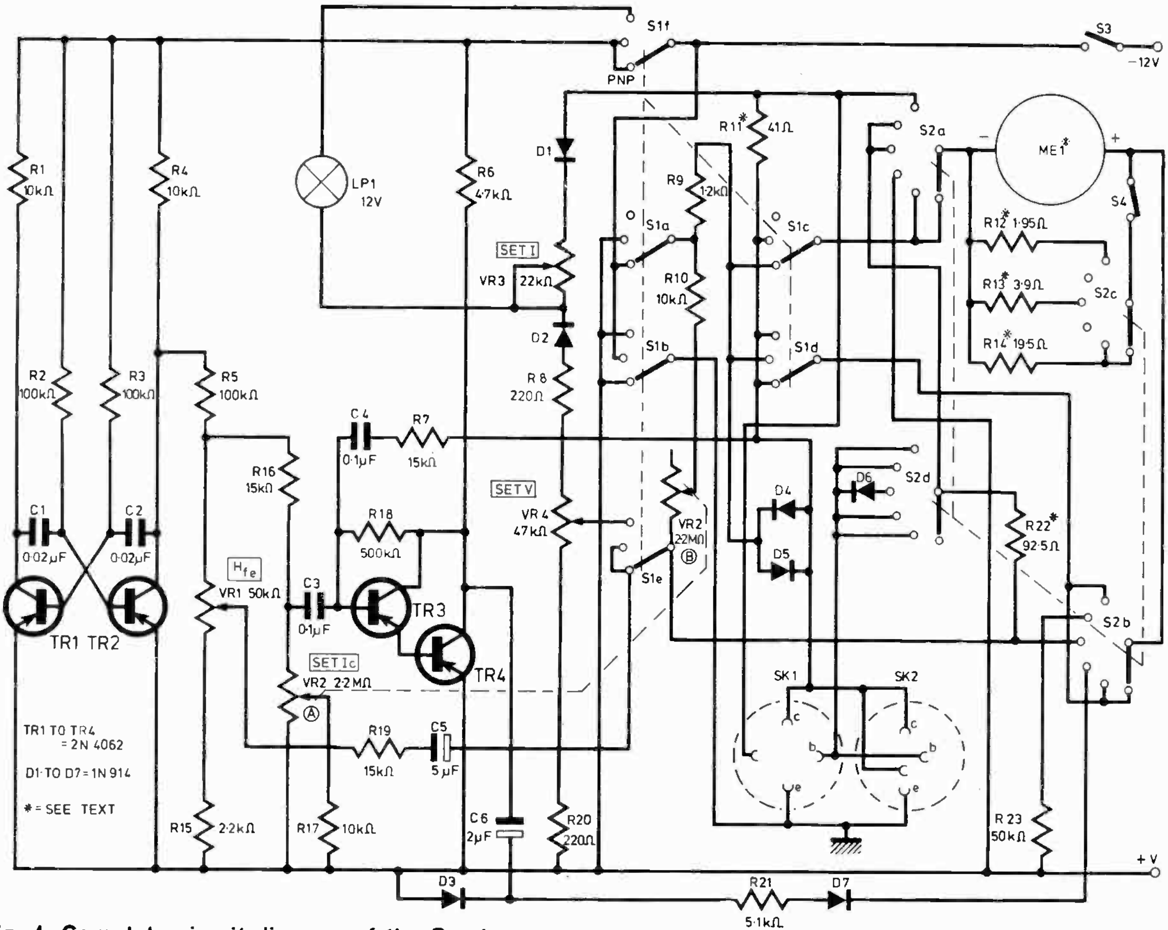
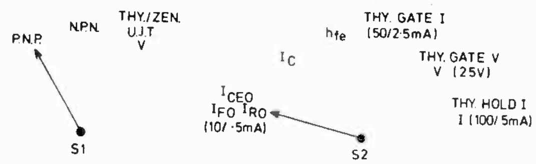


Fig. 4. Complete circuit diagram of the Semiconductor Tester. The resistors marked with an asterisk are made from two or more in parallel. Switch S1 is shown in the PNP position and S2 in the I_{FO}, I_{RO} position, other switch positions being shown right



COMPONENTS . . .

Resistors

R1 10kΩ
R2 100kΩ
R3 100kΩ
R4 10kΩ
R5 100kΩ
R6 4·7kΩ
R7 15kΩ 2%
R8 220Ω
R9 1·2kΩ
R10 10kΩ
R11 41Ω (43Ω 2% in parallel with 910Ω 2%)
R12 1·95Ω (5·4Ω in parallel with 5·1Ω and 8·2Ω all 2%)
R13 3·9Ω 2%
R14 19·5Ω (22Ω 2% in parallel with 180Ω 2%)
R15 2·2kΩ
R16 15kΩ 2%
R17 15kΩ 2%
R18 500kΩ
R19 15kΩ 2%
R20 220Ω
R21 5·1kΩ
R22 92·5Ω (100Ω 2% in parallel with 1·2kΩ 2%)
R23 50kΩ 2%
All $\frac{1}{2}$W 5% carbon unless otherwise stated

Potentiometers

VR1 50kΩ log moulded track
VR2 2·2MΩ + 2·2MΩ linear double ganged
VR3 22kΩ linear
VR4 47kΩ linear

Capacitors

C1, C2 0·02μF (2 off)
C3, C4 0·1μF (2 off)
C5 5μF 25V elect
C6 2μF 35V elect

Diodes

D1 to D7 1N914 *or* similar (7 off)

Transistors

TR1 to TR4 2N4062 *or* similar high gain *pnp* silicon (4 off)

Switches

S1 6-pole 3-way (R.S. Components Miniature Maka-switch. Shaft assembly plus 2 × 4-pole 3-way wafers)
S2 4-pole 6-way (Maka-switch shaft assembly plus 2 × 2-pole 6-way wafers)
S3 Single pole on/off
S4 Single pole on/off biased on

Plugs and sockets

SK1 4 pin transistor socket
SK2 3 pin DIN socket
PL1–3 3 pin DIN plugs (3 off)

Miscellaneous

ME1 500μA f.s.d. (SEW type MR45P)
LP1 12V 0·1A (with holder)
B1, B2 6V PP1 or equivalent with battery connectors
West Hyde MOD303 case with rubber feet
Veroboard $3\frac{3}{8}$in × $1\frac{1}{4}$in 0·15in matrix
4BA $\frac{1}{2}$in bolts, nuts and washers (4 off)
6BA $\frac{1}{4}$in bolts, nuts and washers (4 off)
Crocodile clips (7 off)
Screened double cored cable (6ft)

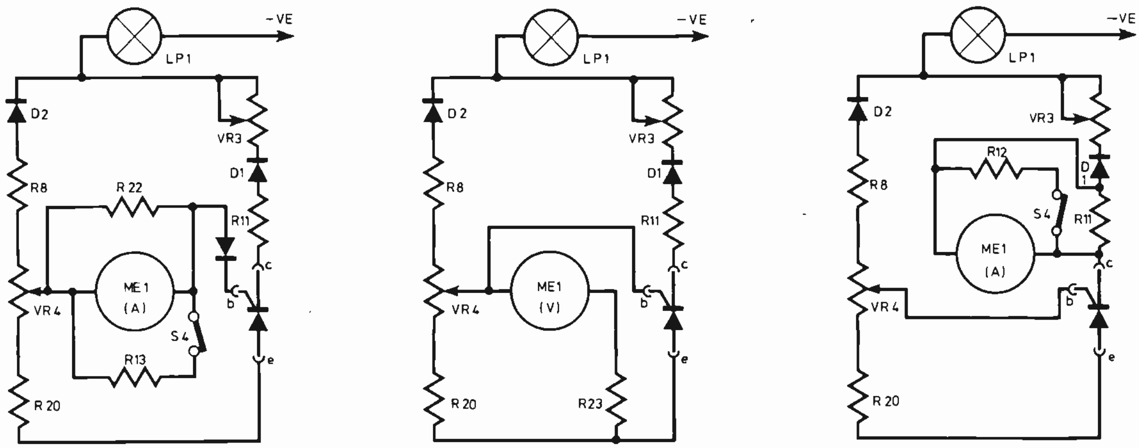


Fig. 5 (a) (left). The equivalent circuit when the switch is set to measure gate trigger current, (b) (centre) shows the switch in the gate trigger voltage position and (c) (right) in the holding current position

measure of R_{ac} and R_{fac} can be found by varying the current through the diode by adjusting VR3 and monitoring the change in voltage across the diode.

Thyristor testing

The circuits used in thyristor testing are as shown in Fig. 5a, b and c. The "gate trigger current" is found by increasing the voltage applied to the gate with respect to the cathode by adjusting VR4 until the thyristor switches on. The thyristor "ON" condition is indicated by the meter reading falling to zero and the lamp LP1, lighting (if VR3 is set to minimum resistance). R13 and R22 act as meter shunts and S4 is the f.s.d. ÷ 20 switch. Diode D6 protects the meter from reverse currents which would flow through the meter when the thyristor is in the "ON" condition. The gate trigger voltage is found by setting the meter switch S2 so that the meter plus the multiplier resistor are connected across the gate and the positive supply line.

The leakage currents I_{fo} and I_{ro} through the thyristor can be found in the same way as the leakage currents for *npn* and *pnp* transistors.

Thyristor holding current is found by setting the meter switch to THY HOLD I which places the meter in the cathode circuit of the thyristor. Increasing VR4 (SET I) towards maximum decreases the current through the thyristor until a point is reached where the thyristor switches off. The diodes D1 and D2 isolate the resistor line VR3, R8, VR4, R20 to 0V when the semiconductor tester is operating in the *pnp* on *npn* mode. Resistors R11 and R12 act as meter shunts giving two holding current ranges of 5mA and 100mA.

Unijunction Testing

The basic circuit used to test unijunction transistors is shown in Fig. 6. The voltage with respect to base of the emitter can be increased by VR4 (SET V) by adjusting it from maximum to minimum until at a certain point the unijunction and the semiconductor components behave as an oscillator; this point is indicated by a rise in the meter voltage.

Voltmeter and Ammeter

The above semiconductor tester components are used in this mode of operation. Resistor R23 acts as a meter multiplier.

When the meter switch is set to THY HOLD I the meter can be used as a two range ammeter when the ammeter plug is used, R11 and R12 acting as meter shunts.

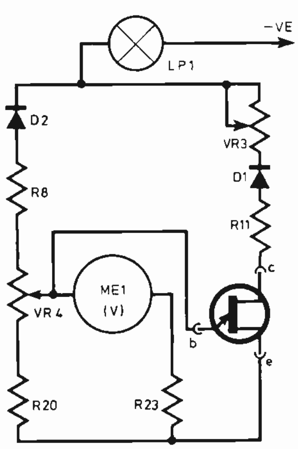
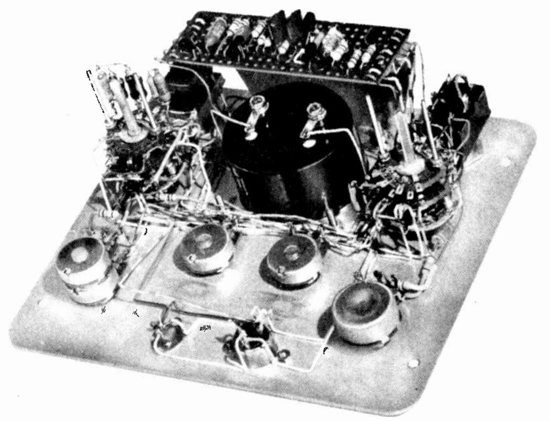


Fig. 6. The circuit used when the switches are set to measure unijunction intrinsic standoff ratio



Next month: Constructional details and operating instructions.

NEW DEVICES ...APPLICATIONS

Automobile Integrated Circuit

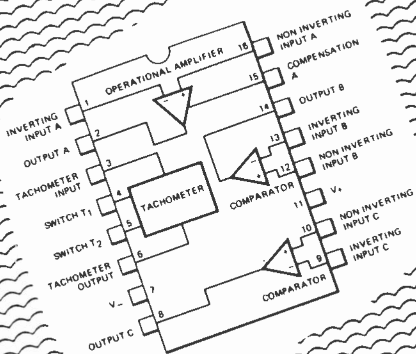


Fig.1.

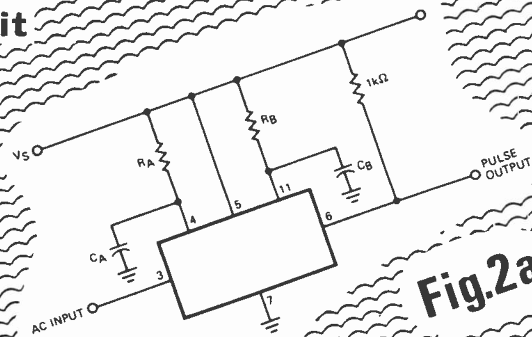


Fig.2a.

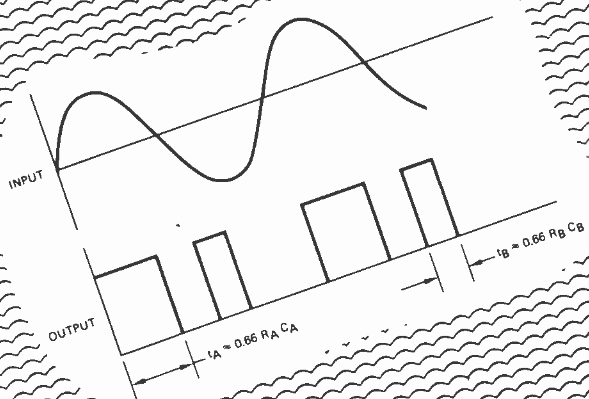


Fig.2b.

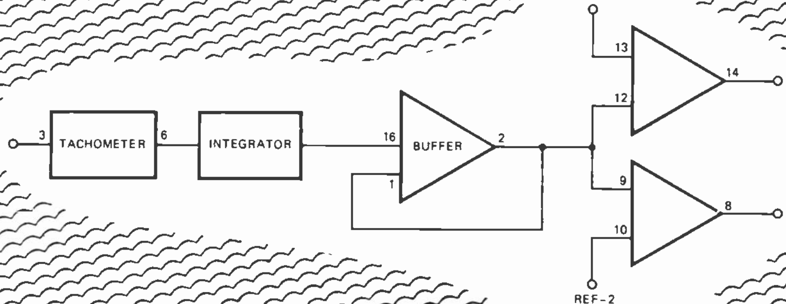


Fig.3.

In this section we present a selection of both new devices and applications, with news of applications developed for existing devices.

Generally only basic circuit details will be given sufficient for the experimenter to create his own equipment.

JUST coming on to the market are two integrated circuits from Fairchild, both designed with the Automobile market in mind. The first is the μA7350 a complete tachometer subsystem, and the second is a triple operational amplifier, the μA7351.

The μA7350 is a monolithic i.c. which includes a tachometer, an operational amplifier and two comparators. The tachometer produces fixed width pulses at the zero crossings of a ground reference a.c. input signal.

Each pulse width is individually determined by the choice of an external resistor and capacitor. The output stage of the tachometer section is a common emitter *npn* transistor with an uncommitted collector.

The operational amplifier and comparators are of identical design except that the comparators have no provision for external compensation. Their output stages consist of class A *pnp* amplifiers with uncommitted collectors which allow a variety of loads for general purpose applications.

In addition, the outputs of the comparators may be wired-OR for use as a dual level sense device.

Typical applications of this chip include over- and under-speed and frequency sensing, servo control, tone detection and a variety of timing functions.

Power requirements can be met by a single or a dual supply with an absolute supply voltage maximum of 24V. The chip is short-circuit protected.

Figure 1 shows the block schematic of the 7350 whilst Fig. 2 is a circuit of the tachometer section in application. R_A and R_B are 27kΩ and C_A and C_B are 5,670pF (all at 1%) for an output pulse width of between 900μs and 110μs. Fig. 2b shows the output in graphic form.

Figure 3 shows the block diagram of a complete system.

TRIPLE OPERATIONAL AMPLIFIER

The second i.c. the μA7351 shown in block form in Fig. 4, is again a monolithic device carrying three identical operational amplifiers. Each two-stage amplifier uses a class A *pnp* common emitter output stage with an uncommitted collector, providing a variety of loads for general-purpose applications.

The chip is designed specifically to operate from a single supply and is thus ideal for automotive applications or any portable battery-type environment. In fact, the power requirements run from +4V to +16V single supply or ±2V to ±8V double.

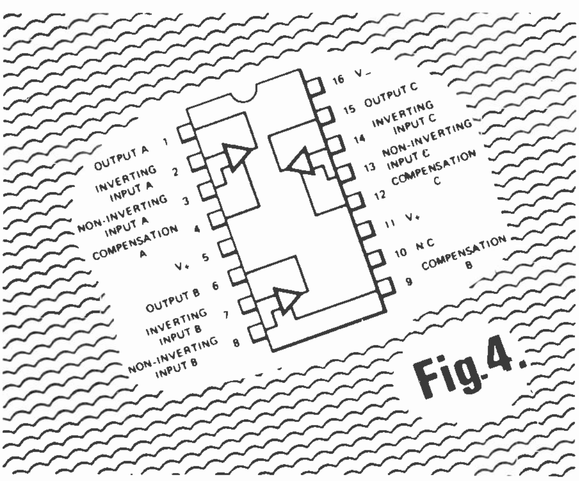


Fig.4.

INGENUITY 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 merits.

SERIES REGULATOR

IN Fig. 1, the operational amplifier acts as a differential amplifier controlling the base current of the Darlington pair arrangement in series with V_{in}. The Darlington pair used came in one package (TIP140). This has a high gain and a current capability of 10A.

TR2 across R2 acts as a current limit. When the voltage across R2 is greater than V_{BE} of TR2, it will conduct and cause TR1 to turn off until the voltage across R2 is equal to V_{BE}.

The present circuit is capable of withstanding a continuous short circuit across its output. The line voltage used was 12V and was adjusted for 5V output. The circuit will regulate the output to 5V from anything from the maximum operating voltage of the op-amp down to 7V.

A very simple input can be used consisting of just a transformer, bridge rectifier and smoothing capacitor.

A. Belka,
Bletchley.

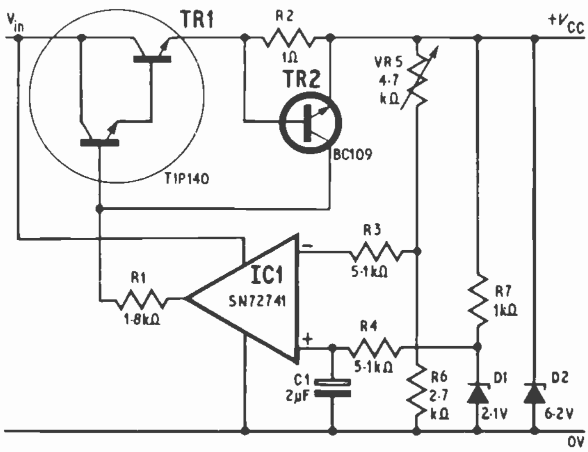


Fig. 1. Circuit diagram of Series Regulator using a Darlington pair transistor

EVENTS TIMER WITH READOUT

THE TIMER in Fig. 1 uses an electromechanical readout device which is not capable of actuating faster than 10 times per second. Thus the speed of operation is similarly limited.

In basis, an oscillator section, TR1 and TR2 form a multivibrator which can run at 1 or 10Hz dependent on the selection of C1 and C3 or C2 and C4. Thus C1 and C3 are made 10μF for 10Hz and R2, R3 about 7kΩ each. The exact value is adjusted by VR1. A lower value of C1, C3 may be necessary as the voltage change produced at the base of TR3 may be insufficient to turn the counter off.

For the second range S1 is switched to bring in C2, C4, 100μF to give a frequency of 1Hz and again VR1 may need to be adjusted.

In practice capacitance adjustment was found to be much better than varying R2, R3 as too high a value for these resistors when lowering the frequency can reduce the voltage at the base of TR3 too far.

The output via TR3 is straightforward; a positive pulse at the base causes a large change in voltage at the emitter to activate the counter.

The diode D1 deals with back e.m.f. induced in the counter coil.

Basically the current drawn depends on the counter coil resistance as very little is drawn by TR1 and TR2. Indeed this can be further reduced by increasing R1, 4.

Several counters are available but if the resistance falls below 500Ω, R5 should be reduced, increasing current drain.

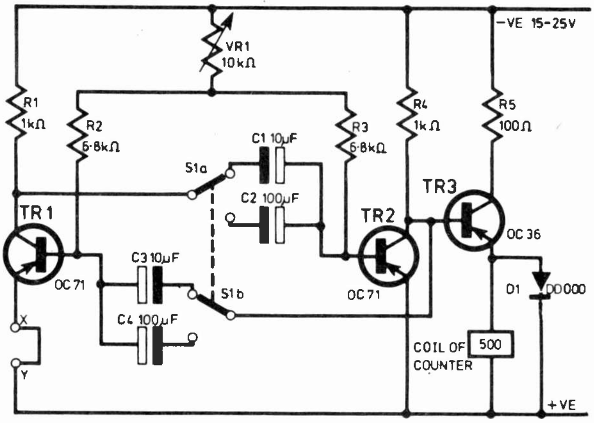


Fig. 1. Events Timer with Readout

For accuracy of timing the supply should be stabilised. Calibration could be by comparison with the Greenwich "pips" and resetting is not needed if a note is made of the reading each time it is used.

If it is required to synchronise the timer to some event such as a photocell switch then the trigger should be connected between *X* and *Y* in the emitter lead of TR1. This holds one capacitor discharged when the circuit is not oscillating so as to ensure fast and short-lived events can be handled.

Accuracy is not up to crystal-controlled standards and probably most applications will require only, say, about 5 per cent accuracy. However, the original exhibited a loss of only 3 seconds during one hour, an accuracy of better than 1 per cent.

G. Bachelor,
Coventry.

TWO-TONE AUDIO ALARM OSCILLATOR

FIGURE 1 shows the circuit diagram for a two-tone audio alarm oscillator, using two TTL i.c. packages.

IC1 is an SN7404N, its inverters wired in pairs to form three astable multivibrators, two oscillating at different audio frequencies, the other switching at a slow rate.

The output of one audio oscillator is gated with an output of the switching oscillator, the complementary output of the latter being separately gated with the second audio frequency. The two resultant outputs pass through a third gate, which drives a single transistor amplifier. The three NAND gates are contained in the SN7410 package.

If the two unused inputs to the first two gates are linked, a logical 1 at point *X* will cause the alarm to sound; a logical 0 turning it off. If these inputs are left open, the alarm sounds on connection of the power supply. The latter should be between 4·5 and 6V.

To alter the frequencies of the audio oscillators, change the values of C1 and C2; C5 and C6. Their associated resistors must NOT be altered.

This circuit was intended for use as an alarm in a digital clock, but for other purposes where a greater output is required a more powerful amplifier is needed.

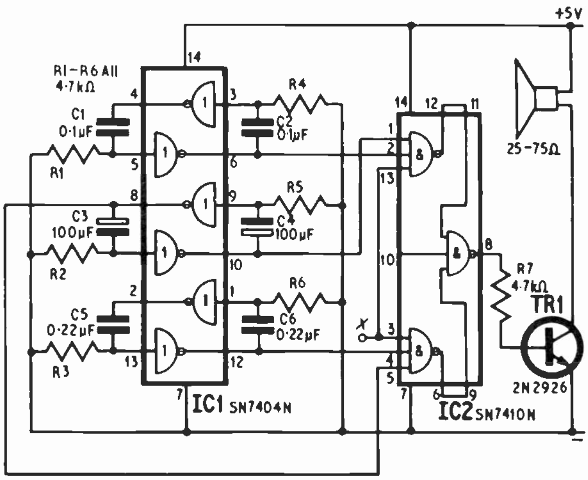
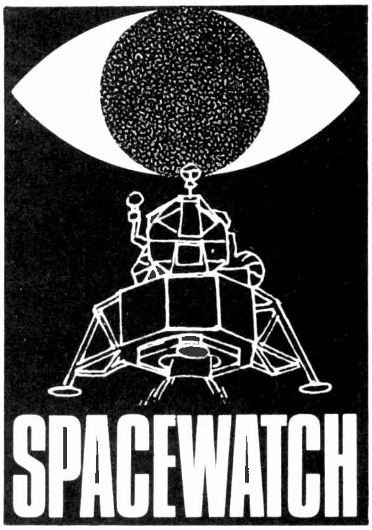


Fig. 1. Circuit diagram of the Two-tone Audio Alarm

If a transformer is to be used to power the alarm, then its output must be Zener stabilised.

B. Woodland,
London, S.W.6.



BY FRANK W. HYDE

RED PLANET PROBES

MARS is again coming to the forefront of space exploration. With the two new probes from Russia now well on their way, the plans for the fly-by by the USA in 1976, and the final *Viking* missions of landing craft as a prelude to the manned missions in the next decade, there is much to be done in preparation. A number of problems will need to be resolved for distant direct control of landed vehicles. If it is the case that the Russians intend to land a similar vehicle on Mars as they did on the moon, then the control from a distance will be somewhat difficult. Even at a close approach between the earth and Mars the controllers will be *seeing* their vehicle on the surface as it was four minutes earlier. Any guidance or correction will take a similar time to reach operation points.

There will be some areas which, though of great scientific interest, are too hazardous for landings. It therefore follows that the majority of the experiments will be automatic. Already a number of ingenious instruments have been designed for the *Viking* landing craft. These will sample the soil for biological activity.

The very ambitious search for life on Mars can only begin with instrumental techniques. Even so the instruments devised will only work if the basic chemistry of any Martian life that there may be, is similar to the basic chemistry of earth life. Should it be of a different chemistry then it may well be that any realistic search for life will have to wait until the 1980's for manned exploration. No one has succeeded in establishing a model of life chemistry that is entirely different from the carbon based system of earth life.

The final goal must of course be by manned exploration. The *Apollo* missions to the moon have more than made this point. It is only by this means that it will be possible to determine the other puzzles that need to be resolved. For example whether life on Mars may have developed from non living chemicals and whether the apparently lifeless planet may once have enjoyed a rich variety of life that has disappeared. Any relics of this could only be determined by live exploration.

SPECULATIONS

There are a number of people who believe that there was once an abundance of water on the planet, though it is dry today. It is therefore possible that any form of life that developed, when the conditions were warm and the climate resembled that of the earth, would have had millions of years in which to grow hardy. Sufficiently so, in fact, that as the vital gases in the atmosphere escaped from the surface including water vapour, the life adapted to the severe conditions. As on earth the successive generations would exhibit the survival of the fittest and it could well be that there does exist a hardy plant life or something similar.

Some who have been thinking on these lines feel that with the possible colonisation of Mars the first platform will have been reached in space travel. Meanwhile Professor Carl Sagan has speculated that Mars is not dead but sleeping, and suggests that the climatic variations might well be extreme enough for there to be running water at times and the means for life, as we know it on earth, a possibility. These ideas are based on the presence of huge amounts of carbon dioxide frozen into the polar caps. Released as gas the density of the atmosphere would increase. The result could be a greenhouse effect which, with the prevailing meteorological conditions, could well support life.

THE LUSTROUS PLANET

Venus will be having a visit from a USA probe in early 1978. This will be some 840 pounds in weight. When it arrives at Venus the four smaller vehicles will be ejected to penetrate the Venusian atmosphere. These four probes will consist of one large one with a 60 pound payload and three smaller ones of about 3 pounds. The big one will take about an hour and a half to reach the surface of the planet and the smaller ones about 75 minutes. The carrying vehicle will enter the atmosphere of the planet sending back data until it burns up. While all this is going on a sister probe will have been launched to arrive and orbit the planet at about the same time as the multiple probe. Thus the benefits of two observation vehicles will be available.

The discovery that there are vast vertical movements of the atmosphere of Venus presents another problem for astronomers. This pulsing of the clouds was detected by infra red telescopes. The indications are that the distance over which this pulsing takes place is about one kilometre.

At the present time there is no clue to the mechanism of this activity. Certainly enormous energy is indicated but where it originates is not known. Some further information may well be gathered by the spacecraft which will fly-by on its way to Mercury sometime next year.

SOVIET AND FRENCH CO-OPERATION

The co-operation between France and Russia in some of the lunar activities is having a special orientation to geodosy. The laser reflectors, placed on the moon and on the earth in an attempt to measure accurate distances and changes, have provided important data. In consequence the techniques of this system has been developed to a stage where the satellites are to be brought into the picture.

Next year a launch is planned for a special satellite which will carry 60 corner reflectors for use with laser beams. It will have a purely passive role to play being in fact an orbiting reflector with a known position. The satellite will be known as *Starlette* with reflectors that will be grouped in threes on the outer surface on twenty plates making a total of sixty. It will have a very high density of 18·7 to ensure good dynamic stability. It will be some 26cm in diameter and be made largely of uranium. The orbit will be 50 degrees at a height of between 800 and 1,000km. It is hoped that the accuracy of the measurements will be of the order of 20cm over a period of 12 hours.

SKYLAB RESULTS

One of the principal activities designed for *Skylab* was the detailed photography of the Sun. The results obtained in the first mission have been rewarding. In fact it would seem that the same situation exists on this venture as on so many others in space exploration, namely that a whole new vista opens up. In the case of these preliminary solar results the films show detailed structure of the Sun's atmosphere and the special changes that have been brought about by the magnetic field and the plasma which streams out from the Sun. In the X-ray part of the spectrum many small flares that were observed, developed in a few seconds. None of this type of phenomenon is observed from the ground.

LOGIC TUTOR EXPERIMENTS..

WIRED OR

THE problem of last month was of rather a theoretical nature—to prove that the output of the four NAND gates (Fig. 5.4) was EXCLUSIVE OR. From the circuit layout and writing down the functions at each node we arrived at an output which was:

$$Q = \overline{\overline{A(\overline{A.B})}} + \overline{\overline{B(\overline{A.B})}}$$

The two double negates cancel and we are left with:

$$Q = A(\overline{A.B}) + B(\overline{A.B})$$

By applying De Morgan's Theorem to the A.B terms we get

$$Q = A(\bar{A} + \bar{B}) + B(\bar{A} + \bar{B})$$

There is a rule in Boolean Algebra known as the Distributive Rule which allows us to expand bracketted functions—rather like multiplying out brackets in conventional algebra:

$$Q = A.\bar{A} + A.\bar{B} + B.\bar{A} + B.\bar{B}$$

But $A.\bar{A}$ is always 0—if A is 1, NOT A must be 0; 1 AND 0 gives 0. We would get nought if A was nought and NOT A was one. Likewise $B.\bar{B}$ is always 0; so our expression becomes:

$$Q = (0 + 0) + (A.\bar{B} + B.\bar{A})$$

Note we have changed the sequence of the terms—this is permitted by the Boolean Commutative Rule—and grouped the functions (Associative Rule). Nought OR nought is always nought so the expression now becomes:

$Q = (0 + A.\bar{B}) + B.\bar{A}$ (again we have done a bit of re-grouping) 0 OR A.B is always $A.\bar{B}$—you can prove this with a little truth table so we are left with the final expression that:

$Q = A.\bar{B} + B.\bar{A}$—the EXCLUSIVE OR expression we arrived at last month.

WIRED OR

The WIRED OR function is extremely valuable for economising on the number of gates used in a piece of equipment. To use the function you are limited to a logic type that uses passive pull up resistors in the output stages (such as DTL); it is not possible to apply the principle to conventional TTL gates which use the two output transistors in totem pole configuration but there are a number of TTL modules now available with open collectors and passive pull up which can be used. If you have made the Logic Tutor exactly as specified you will have used DTL and so can carry out this month's experiment; if you have used standard TTL please do not attempt the experiments as you will damage your gates.

Fig. 6.1. shows that WIRED OR is obtained by shorting together the outputs of two gates. If points X and Y were both at level 1 the output at node Q will obviously be 1.

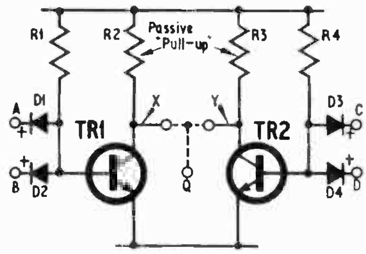


Fig. 6.1. The WIRED OR function is obtained by shorting the outputs of two NAND gates together

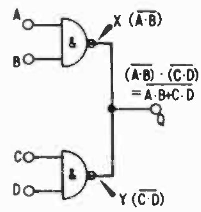


Fig. 6.2. The NAND gates showing the Boolean expressions at each node

If, however, the inputs A with B were such that TR1 was non conducting (i.e. the output from the left hand gate wanted to go to 1) but the inputs C with D forced an output of 0 from the right hand gate the combined output Q will have to be 0 because TR2 will act as a sink for current flowing through R2.

If you think about it you should see that the output Q has a level that can be specified by ANDing the levels the individual gates would have given had they not been connected together. If X wanted to be 1 but Y was 0 Q is nought and vice versa. Q will be 1 only when both X and Y want to be 1. Thus shorting the outputs of two DTL gates together effectively gives an AND function between the two outputs—a logic function obtained with no extra gates.

It might seem strange to call this WIRED OR but the name is derived from the overall function from inputs A with B and C with D to the output Q. Fig. 6.2 shows the functions that X and Y would like to go to and then shows these functions ANDed for the combined output. The final expression is an INVERTED OR of the ANDed forms of the two pairs of inputs.

This function could be obtained by using the basic logic gates shown in Fig. 6.3—AND followed by OR followed by INVERT. The effect produced by wiring together two outputs of two NANDS to give WIRED OR is sometimes called

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AD162 *pnp* germanium medium power	**40p**
AF139 *pnp* germanium UHF	**49p**

NPN: BC107 **13p**, BC108 **12p**, BC109 **13p**, BC167 **11p**, BC168 **10p**, BC169 **11p**.

PNP: BC177 **21p**, BC178 **19p**, BC179 **21p**, BC257 **12p**, BC258 **11p**, BC259 **13p**.
Standard groupings available.

BD135 *npn* medium power	**37p**
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DIODES

OA90, OA91, OA95, 6p each; OA200, **9p**; OA202, **10p**.

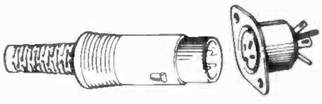
Other semiconductors: AC128, **17p**; AF117, **32p**; BFY51, **19p**. Full lists and technical data will be found in Catalogue No. 6. See also amendments list.

Send S.A.E. for latest supplement of additional lines and price amendments to our No. 6 Catalogue

ZENER DIODES full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **48p** each. Clip to increase 1·5W rating to 3 watts (type 266F) 4p.

DIN PLUGS AND SOCKETS

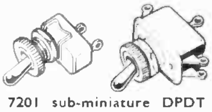
by Hirshmann, 4A rating



2 way LS —socket **10p**, plug **12p**
3 way scr.—socket **10p**, plug **12p**
5 way scr.—socket **11p**, plug **15p**

TRANSISTOR ACCESSORIES
TO3 cover, **7p**; Heat sinks 1°C/W, type 6W1, undrilled, **60p**.

SWITCHES

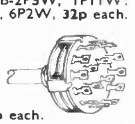


1011 SP5T toggle, **20p**; 409 DPDT toggle, **29p** (these are chrome plated, 2·5A rating); 7201 sub-miniature DPDT 250V a.c./2A, **48p**.

ROTARY SWITCHES

Radiospares Miniature Maka-switch (in assembly kit form). Shaft, **48p**, Wafers, MBB-2P5W, 1P11W; BBM1P12W, 2P6W, 3P4W, 4P3W, 6P2W, **32p** each.

WAVECHANGE SWITCHES



1P12W, 2P6W, 3P4W, 413W, **24p** each.

ELECTROLYTIC CAPACITORS AXIAL LEAD

Rated voltage: Capacity µF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	**10p**	**7p**
1·0	—	—	—	—	—	**10p**	—	**7p**
2·2	—	—	—	—	**10p**	—	**7p**	**8p**
4·7	—	—	—	**10p**	—	**7p**	**8p**	**7p**
10	—	—	—	—	**7p**	**8p**	**7p**	**8p**
22	—	—	**7p**	**7p**	—	**7p**	**7p**	**9p**
47	**7p**	—	**8p**	**8p**	**8p**	**7p**	**9p**	**12p**
100	**8p**	**7p**	**7p**	**7p**	**7p**	**9p**	**11p**	**19p**
220	**7p**	**8p**	**8p**	**8p**	**9p**	**10p**	**17p**	**27p**
470	**8p**	**9p**	**9p**	**10p**	**12p**	**17p**	**24p**	**43p**
1,000	**10p**	**12p**	**12p**	**17p**	**20p**	**24p**	**40p**	—
2,200	**14p**	**17p**	**22p**	**25p**	**36p**	**40p**	—	—
4,700	**25p**	**28p**	**37p**	**41p**	**54p**	—	—	—
10,000	**40p**	**43p**	—	—	—	—	—	—

Prices subject to amendment by the manufacturer.

POLYCARBONATE—5% TOLERANCE
250V up to 0·1µF: 100V, 0·1µF and above.
0·01; 0·012; 0·015; 0·018; 0·022; 0·027; 0·033; 0·047; 0·056; **4p** each. 0·068; 0·082; 0·1; 0·12; 0·15; **4p** each. 0·18; 0·22; **5p** each. 0·27; 0·33; **6p**. 0·39 **7p**. 0·47 **8p**. 0·56 **10p**. 0·68 **11p**. 1µF **13p**. *Prices subject to amendment by the manufacturer.*

Minitron Digital Counter
Type 3015F. Seven Filament segment indicators to make 0-9 + decimal point. Compatible with standard logic modules, nett **£2.** Decoder driver type FLL 121T nett **£1·36.** DIL socket, nett **£2.**

RESISTORS – 10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
C	1/20W	5%	82 Ω–220K Ω	E12	**9**	**8**	**7·5**
C	1/8W	5%	4·7 Ω–470K Ω	E24	**1**	**0·9**	**0,75 nett**
C	1/4W	5%	4·7 Ω–10M Ω	E12	**1**	**0·9**	**0·75 nett**
C	1/2W	5%	4·7 Ω–10M Ω	E24	**1·2**	**1**	**0·95 nett**
C	1W	5%	4·7 Ω–10M Ω	E12	**2·5**	**2**	**1·6 nett**
MO	1/2W	2%	10 Ω–1M Ω	E24	**4**	**3**	**2 nett**
WW	1W	10% ± 1/20 Ω	0·22 Ω–3·9 Ω	E12	**7**	**7**	**6**
WW	3W	5%	1 Ω–10K Ω	E12	**7**	**7**	**6**
WW	7W	5%	1 Ω–10K Ω	E12	**9**	**9**	**8**

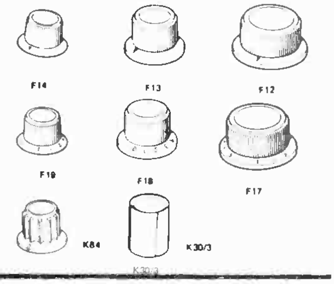
Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.)

KNOBS

All grub screw fitting for ¼in shafts. Black. For other types—see Catalogue No. 6, p. 54.

F.14 (20mm) pack of 2, **32p**; F.13 (26mm) pack of 2, **38p**; F.12 (33mm) pack of 2, **40p**; F.19 (20mm) pack of 2, **32p**; F.18 (26mm) pack of 2, **38p**; F.17 (33mm) pack of 2, **40p**; KB.4 (20mm) pack of 4, **40p**; K30/3 (17mm) aluminium, **24p** each.



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MT104 50V/2A plus 4 taps	**£3·50**
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13TO5 13V/½A, CT	**£1·25**
28TO5 12+12V, 2–0–2V	**£1·65**

BAXANDALL SPEAKER KIT

As designed by P. J. Baxandall and described originally in "Wireless World." Simple to assemble, fantastically good results and a greater money saver. Carries 10 watts RMS. 15 ohms impedance. Size 18in × 12in × 10in. Complete kit, including pack-flat cabinet, **£14·90** Plus 60p part cost of carr.

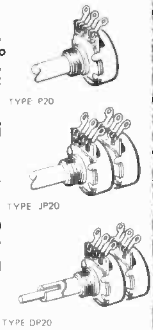
Equaliser Assembly, **£2.**

Loudspeaker Unit 59RM109, **£2·45.**

Cabinet Kit (to Baxandall design), **£10·45.**

POTENTIOMETERS

Rotary, carbon track, double wipe
SINGLE P20 lin. 100 Ω to 2·2M Ω, **12p**; P20 log. 4·7K Ω to 2·2 Meg. **12p**; JP20 log. 4·7K Ω, to 2·2M Ω, **12p**; **Dual gang** lin. 4·7K Ω to 2·2M Ω, **42p**; Dual log. 4·7K Ω to 2·2M Ω, **42p**; Log/antilog, 10K, 22K, 47K, 1M Ω only, **42p**; Dual antilog. 10K only, **42p**. Any type with 2A D.P. mains switch, **12p** extra.
Only decades of 10, 22 and 47 available in ranges quoted.
DUAL CONCENTRIC DP20 in any combination of P20 values, **60p**; with switch, **72p.**
SLIDER
Lin. or log. 10K to 1 meg. in all popular values, each **26p.**
Control knobs blk./white/red yel./gr./blue/dk. grey/lt. grey, **5p** each.



CARBON SKELETON PRE-SETS
Small high quality, PR lin. 100 Ω, 220 Ω, 470 Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10M Ω. Vertical or horizontal mounting, **5p** each.

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All items offered for sale in accordance with our stated terms of business, copy of which available on request.
Not allowed on nett price items. 10% on orders for **£5** or more. 15% on orders of **£15** or more.
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Eng. Reg. No. 1047769 **Registered Office: 28 St. Jude's Rd., Englefield Green, Egham, Surrey TW20 0HB**

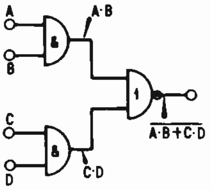


Fig. 6.3. Basic AND-OR-NOT configuration of circuit in Fig. 6.2 showing the economy effected by WIRED OR

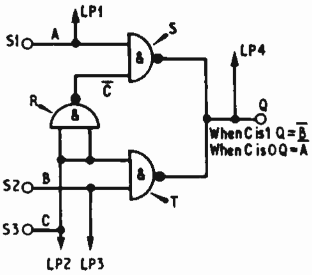


Fig. 6.4. Practical application of the AND-OR-NOT function for steering signals

an AND-OR-NOT gate—a frequently used function to enable two sources of digital waveforms to be selected alternately and fed (in an inverted form) into a common line.

Fig. 6.4 shows how you can demonstrate this on the Logic Tutor. The signal lines are A and B and digital waveforms can be simulated with switches S1 and S2; input C is the control line that selects the line we want to appear at the output Q. When C is 1 the output of gate S always wants to stay at 1 but the output of gate T wants to give an inverted form of input $\overline{B}$. AND the output of S with that of T and you get B. Waggle S2 and you will see the inverted signal appear at the output but signals from S1 (line A) will be inhibited. Make C go to 0 and the signal from A will pass while that from B will be inhibited.

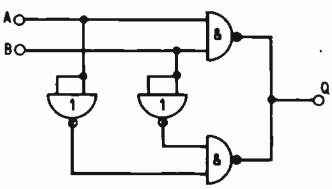


Fig. 6.5. The four gates plus the WIRED OR function in this circuit provide a well-known logic function. What is it?

Could you do this as economically without using the WIRED OR function? As an exercise try and sort out the logic of Fig. 6.5. The output of the gate configuration is quite well known; what is it?

by M. J. Hughes

Next month: The Half Adder.

PE RONDO PART 2

AUDIO AMPLIFIERS

BY R. A. COLE

PRE-AMPLIFIERS

POWER AMPLIFIERS

TONE AND BALANCE CONTROLS

IN the first part of the RONDO series we described the subject of quadraphonics in general, its abilities, and the various systems available. In addition the construction of a CBS SQ quadraphonic decoder was explained in detail. Now we come to the power and pre-amplifiers and tone controls.

The Rondo system shown in block diagram Fig. 1.15 in Part 1 of the series uses integrated circuits extensively throughout. There are a total of 13 in the basic system, of which eight are in the power amplifier, tone control and pre-amplifier stages. The balance are two in the f.m. tuner, one in the a.m. tuner, one in the stereo multiplex decoder and one in the CBS SQ matrix decoder. An additional four are required for the full logic enhancement board.

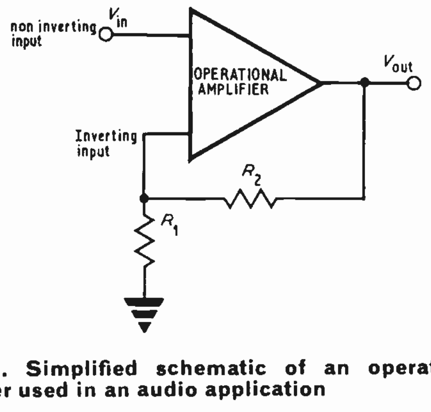


Fig. 2.1. Simplified schematic of an operational amplifier used in an audio application

Some of these integrated circuits perform specific complex functions, whilst others are used as "gain blocks". The eight used in the amplification stages fall in this latter category and are, in fact, operational amplifiers.

The Rondo power and pre-amplifiers use operational amplifiers of the 748 series which are available from many device manufacturers in a number of DIL and TO packages. The Rondo PC boards are drawn so as to accept either the 14 pin dual-in-line package or the 8 pin dual-in-line package.

Operational amplifiers have a number of points in their favour in amplifier design. For example, they replace quite complex discrete voltage gain circuits and require only a few external components and they can operate from a balanced supply which permits d.c. connection of some stages, thus reducing the use of electrolytic capacitors.

As they have a very high mid-band gain they can be very accurately equalised and yet have a good loop gain margin for reducing distortion. An inherently high ripple rejection allows them to work well on unregulated power supplies and reduces the chances of l.f. instability so often found in stereo systems due to large circulating earth currents.

High input and low output impedances simplify the design of feedback networks and a good common mode rejection, the ability to ignore spurious voltages which appear at both inputs rather than the differential signal inputs, is advantageous.

Fig. 2.1 is a simplified schematic of a typical operational amplifier, showing the two inputs and its application to audio amplification. The closed loop gain is determined as follows

$$\frac{V_{OUT}}{V_{IN}} = \frac{R_1 + R_2}{R_1}$$

THE DISCERNING CONSTRUCTORS CHOICE:

★ *A Total Quadraphonic System*

★ *An advanced design AM/FM radio*

★ *Complete loudspeaker enclosure design*

★ *Flexible modular design allows individual to be incorporated in existing equipment*

★ *Switching facilities and modules for SQ, QS(RM) and CD4 systems*

THE PRE-AMPLIFIERS

Two 748 operational amplifiers are used, one for each channel of the basic stereo system, one channel of which is shown in Fig. 2.3. The 748 (IC1) amplifies the incoming signal to around 100mV, whilst providing equalisations for the appropriate input signal.

There are four inputs selected by the selector switch bank.

The "Gram" input is compensated for RIAA disc characteristic, see Fig. 2.2, and requires an input of 3mV for full output. The compensation is carried out by the network R7, R9, C6, C7.

The other three inputs have a linear response, the gain of which is set by R8.

It will be noted that R7, which is in fact part of the RIAA network, is permanently in circuit. This is to reduce the switching transient caused by open-circuiting the feedback loop when using push-button switches. These switches are break-before-make types and if this precaution is not observed a momentary, but startling, screech will ensue. R7 and R8 are in parallel for all linear response inputs but as R7 is very large in comparison with R8 the resultant value is virtually the same as R8.

An output from the i.c. is taken via a 0·22μF capacitor from each channel to provide an isolated signal (prior to volume and tone controls) for tape recording.

TONE CONTROL, VOLUME AND BALANCING

The tone controls, also shown in Fig. 2.3, are of the standard Baxandall type. The 748 integrated circuit IC2 provides the necessary loop gain requirements. There is only small interaction between the bass and treble controls and R12, R15 and R11, R14 provide the end stops for bass and treble controls respectively and limit their range (see Fig. 2.4).

A 10μF tantalum capacitor C11 is used at the output of the tone control stage before the master volume control. As the output voltage of the i.c. depends upon the input offset voltage, it can be of

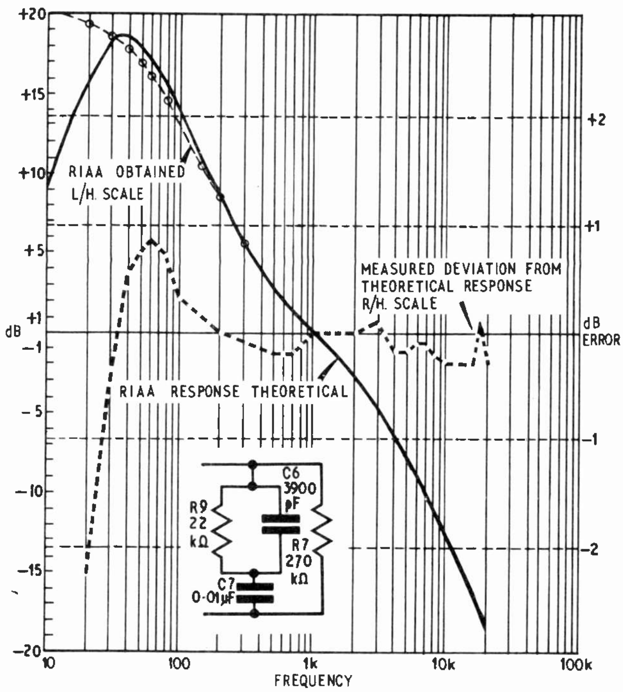


Fig. 2.2. Graphic representation of the playback response obtained for RIAA correction in disc playback and the filter network used

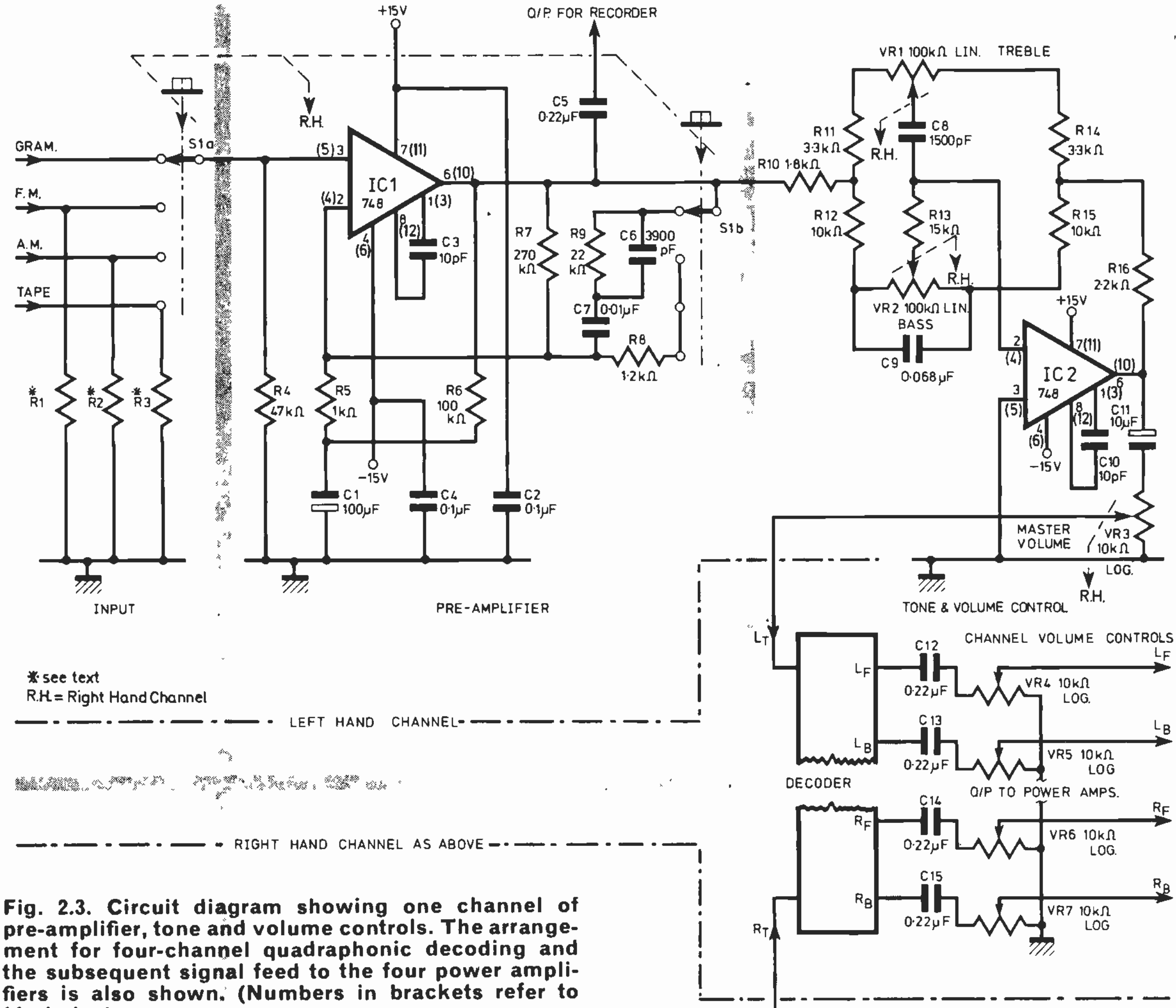


Fig. 2.3. Circuit diagram showing one channel of pre-amplifier, tone and volume controls. The arrangement for four-channel quadraphonic decoding and the subsequent signal feed to the four power amplifiers is also shown. (Numbers in brackets refer to 14-pin i.c.)

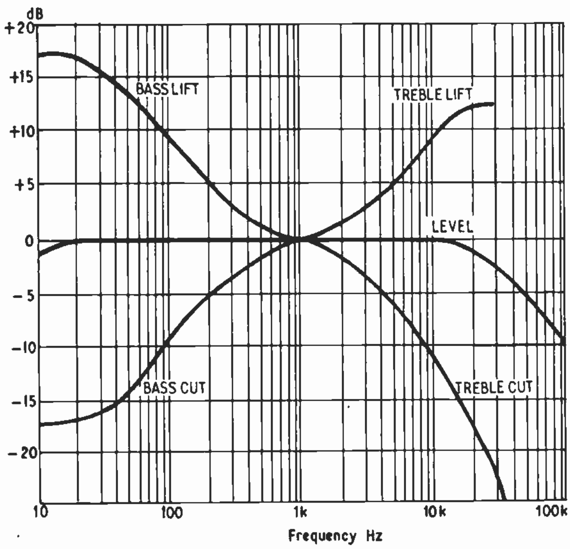


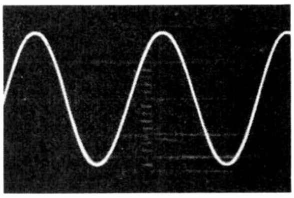
Fig. 2.4. Overall response of each tone control circuit

either polarity. The tantalum capacitor can withstand the maximum reverse polarity likely to be reached at any setting of the controls.

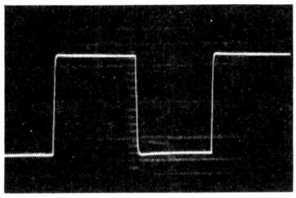
Fig. 2.5d shows a 1kHz square wave response of the pre-amplifier combined with the tone control stage with controls set level.

Signals have been processed as stereo signals up to the output from the master volume control. The signals are now passed through the quadraphonic decoder and are henceforth four channel signals; these pass, *via* 0·22µF capacitors C12 to C15, through the four balance controls VR4–VR7 to the power amplifiers.

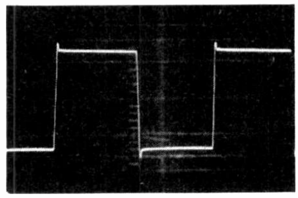
The balance controls provide total control over the level of each of the four channels and each can be faded to zero independently. This is considered to be superior to the normal left-right and front-back balance controls as fully independent control of each channel is far more flexible and fine control of low level listening can be obtained using the full swing of the master volume control VR3.



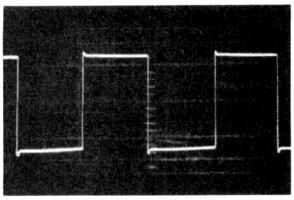
(a) 1kHz sine wave output at 21W, illustrating the onset of clipping



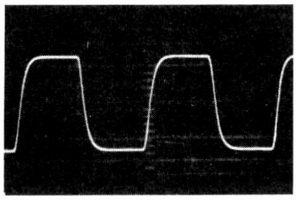
(b) A 1kHz square wave at 12W into an 8 ohm load



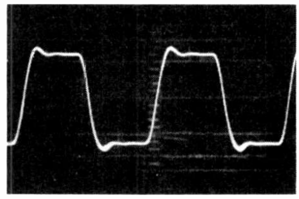
(c) As (b) but with 2μF in parallel with load



(d) 1kHz square wave at output of pre-amplifier and tone controls at 100mV with tone controls in mechanically "level" position



(e) A 10kHz square wave at 12W into an 8 ohm load



(f) As (d) but with 2μF in parallel with load

Fig. 2.5. Oscilloscope photographs showing a variety of output responses for different operating conditions

POWER AMPLIFIER

The overall voltage gain of the power amplifier, the circuit of which is shown in Fig. 2.6, is defined by the ratio of $\frac{R17 + R20}{R17}$ and is about 40dB. The reactance of C16 reduces the gain to unity at d.c. giving a final d.c. offset at the output of a few millivolts.

Normal loudspeakers, and those with inductive loads, e.g. crossover networks, can be coupled direct to the output stages without the use of output capacitors. Electrostatic loudspeakers can also be coupled direct.

Fig. 2.5b, c, e, and f show square wave responses at 1kHz and 10kHz with and without capacitive loads.

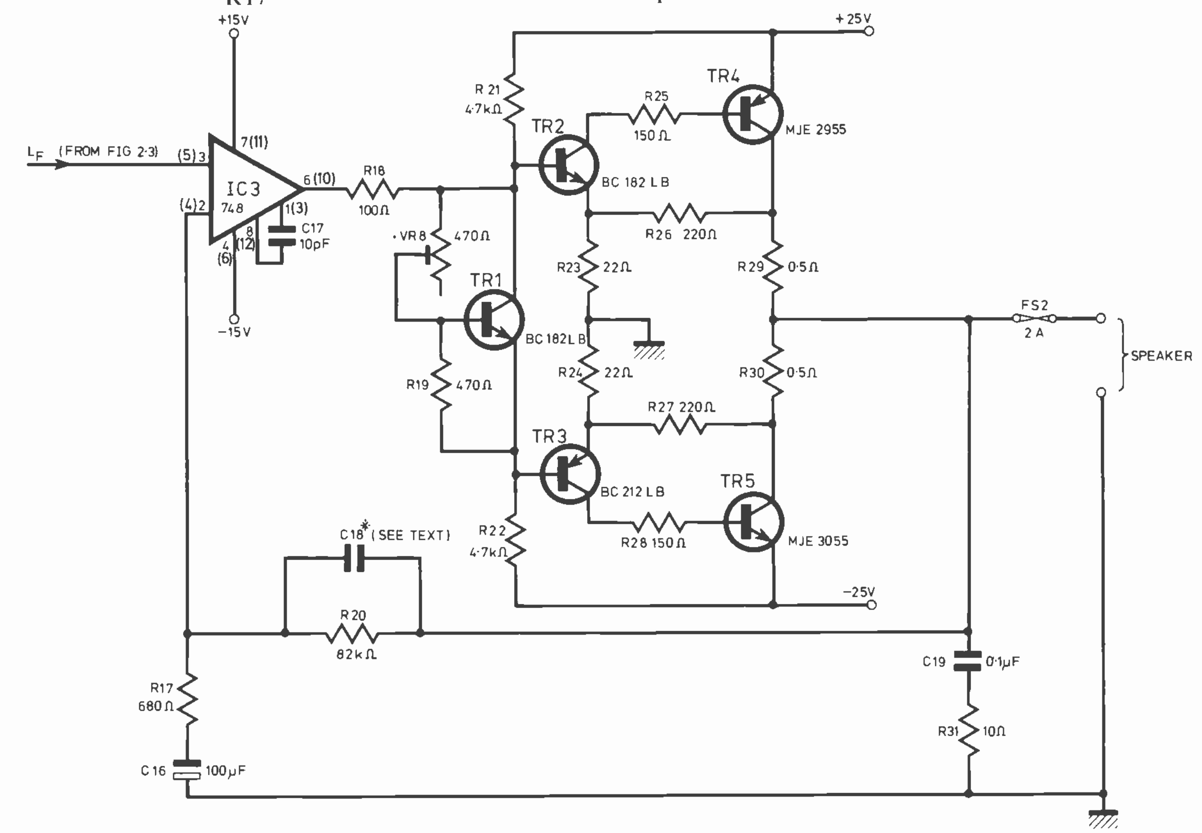


Fig. 2.6. Circuit diagram of the power amplifier (numbers in brackets refer to 14-pin device). Note that only one channel of a stereo pair is shown. There are four of these circuits mounted two to a board

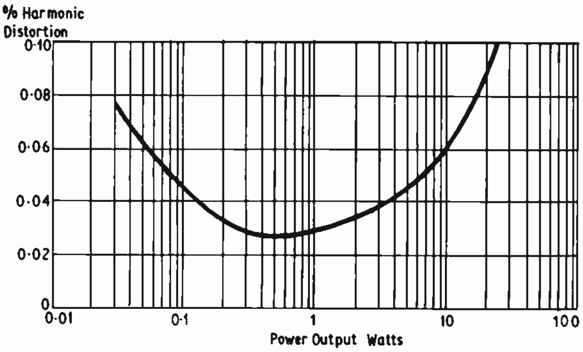


Fig. 2.7. Total harmonic distortion of power, tone, and pre-amplifier combination against power (log scale)

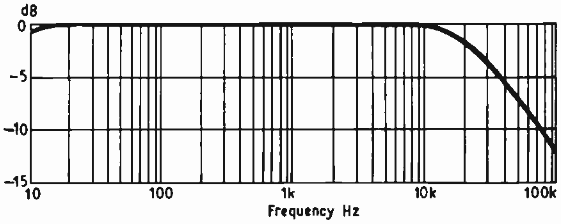


Fig. 2.8. Frequency response of the system at 1W into 8 ohms

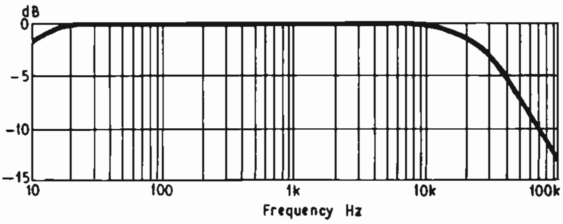


Fig. 2.9. The rated power bandwidth at 20W into 8 ohms

Although the open loop gain of the 748 i.c. op-amp is typically around 95dB, a stable closed-loop gain of some 20dB is utilised to give low harmonic distortion, see Fig. 2.7, and intermodulation products. It is therefore necessary to provide additional gain elsewhere.

This is achieved by use of a modified Darlington output stage in which resistors R26, R23 and R27, R24 apply attenuation of the feedback path in the Darlington pairs TR2, TR4 and TR3, TR5, giving a voltage gain of 20dB. The drivers TR2 and TR3 are fed by a phase splitter TR1 which also controls the bias conditions.

QUIESCENT CURRENT

The quiescent current in the output stage, around 20mA, is controlled by the network R19 and VR8. VR8 is in the base-collector half and is preset for the correct quiescent current. Placing the preset in this half of the network ensures that if the preset goes open circuit (the most common fault) the quiescent current in the output stages drops to a minimum and not, as so often happens, to a damaging maximum.

TR1 and TR2 are placed in contact with each other to provide a thermal path which enables the biasing to "track" easily so that, after prolonged full output, the quiescent current falls back to near normal in a much shorter time.

Two power amplifier channels are provided on each circuit board with a common heat sink. As much lower power is transmitted to the back channels from many quadraphonic recordings, one front and one back channel are routed to each board to balance the heat dissipation.

Fig. 2.8 shows the overall frequency response of the power amplifiers at 1W output into 8 ohms.

Fig. 2.9. The rated power bandwidth graph shows that, at full output, the frequency response is virtually the same as at lower outputs.

DISTORTION

Reference back to Fig. 2.7 shows the small increase in harmonic distortion at low outputs. When drawn on a linear power scale (a very common way) this rise is masked and power outputs of 50mW or so are conveniently ignored.

Fig. 2.5a shows the sine waveform at 1kHz just at the onset of clipping (21W into 8 ohms), the condition being indicated by the bright-up at the crest of the waveform.

CONSTRUCTION DETAILS

Pre-amplifiers

Figs. 2.10a and b show the layout of the pre-amplifier board copper and components. Assembly follows normal practice. A space of $\frac{1}{16}$in is left between the plastic switch bodies and the board to prevent capillary action drawing the solder up into the switch mechanism.

Tone, Volume and Balance Controls

Figs. 2.11a and b show the layout of this board. The slider controls should be soldered into the board after all other components have been assembled and soldered.

When the slider controls are mounted care should be taken to ensure that they are well seated onto the board surface so that the wiper levers are all parallel.

Power Amplifiers

Figs. 2.12a and b show the layout of one of the stereo power amplifier boards. As mentioned earlier there is a common heat sink for the two amplifiers on each board.

The Motorola devices are supplied with a compression washer which should be tightened by the screw until the washer just deforms.

The Texas devices are supplied with a stepped insulating bush which should be inserted between the head of the screw and the fixing hole in the metal tab. The smaller mica insulating washer should have a thin smear of silicone grease applied to both sides to improve thermal conductivity between transistor and heat sink.

COMPONENTS . . .

PRE-AMPLIFIER

Resistors

R1, R101	Input matching	(2 off)
R2, R102	resistors, to be	(2 off)
R3, R103	discussed in future article	(2 off)
R4, R104	47kΩ	(2 off)
R5, R105	1kΩ	(2 off)
R6, R106	100kΩ	(2 off)
R7, R107	270kΩ	(2 off)
R8, R108	1·2kΩ	(2 off)
R9, R109	22kΩ	(2 off)

All ± 5% ¼W Hi-Stab carbon film

Capacitors

C1, C101	100μF 3V tantalum	(2 off)
C2	0·1μF polyester	(1 off)
C3, C103	10pF 30V polystyrene	(2 off)
C4	0·1μF polyester	(1 off)
C5, C105	0·22μF polyester	(2 off)
C6, C106	3900pF 30V polystyrene	(2 off)
C7, C107	0·01μF polyester	(2 off)

Integrated Circuits

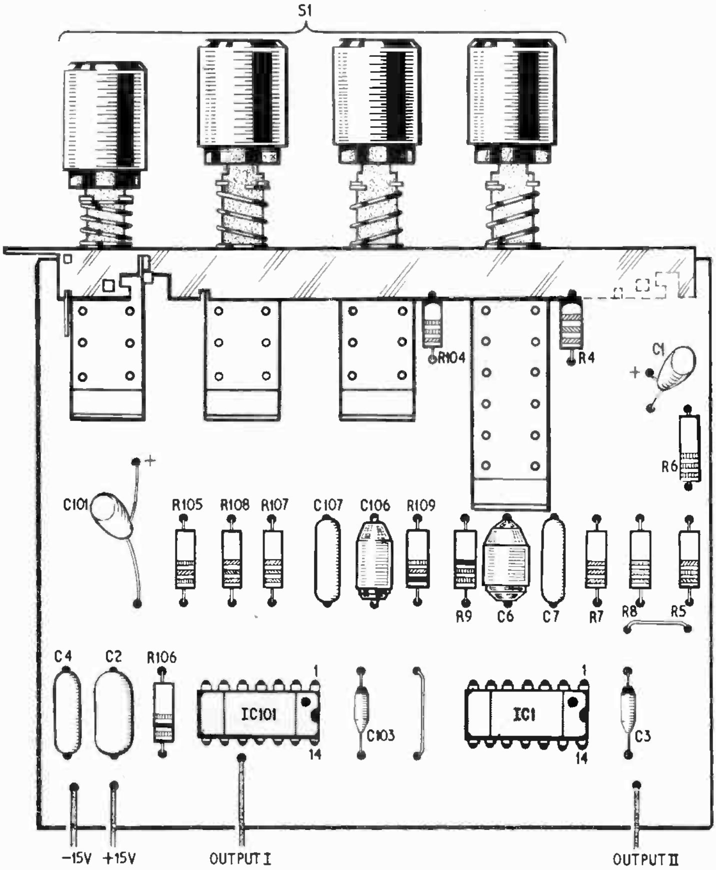
IC1, IC101 ML748, μ748 or SN72748P (2 off)

Switch

S1 4-pole 4-way Special (Lipar Isostat) selector switch—Sonax Electronics

Miscellaneous

Printed circuit board, link wire and connecting wires



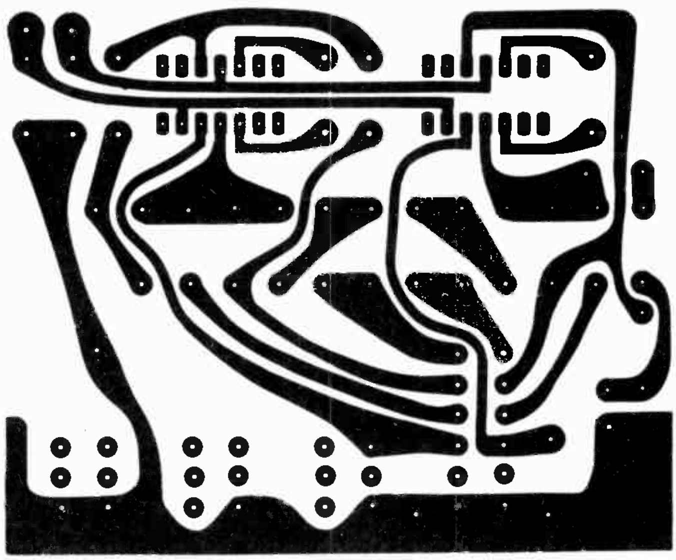
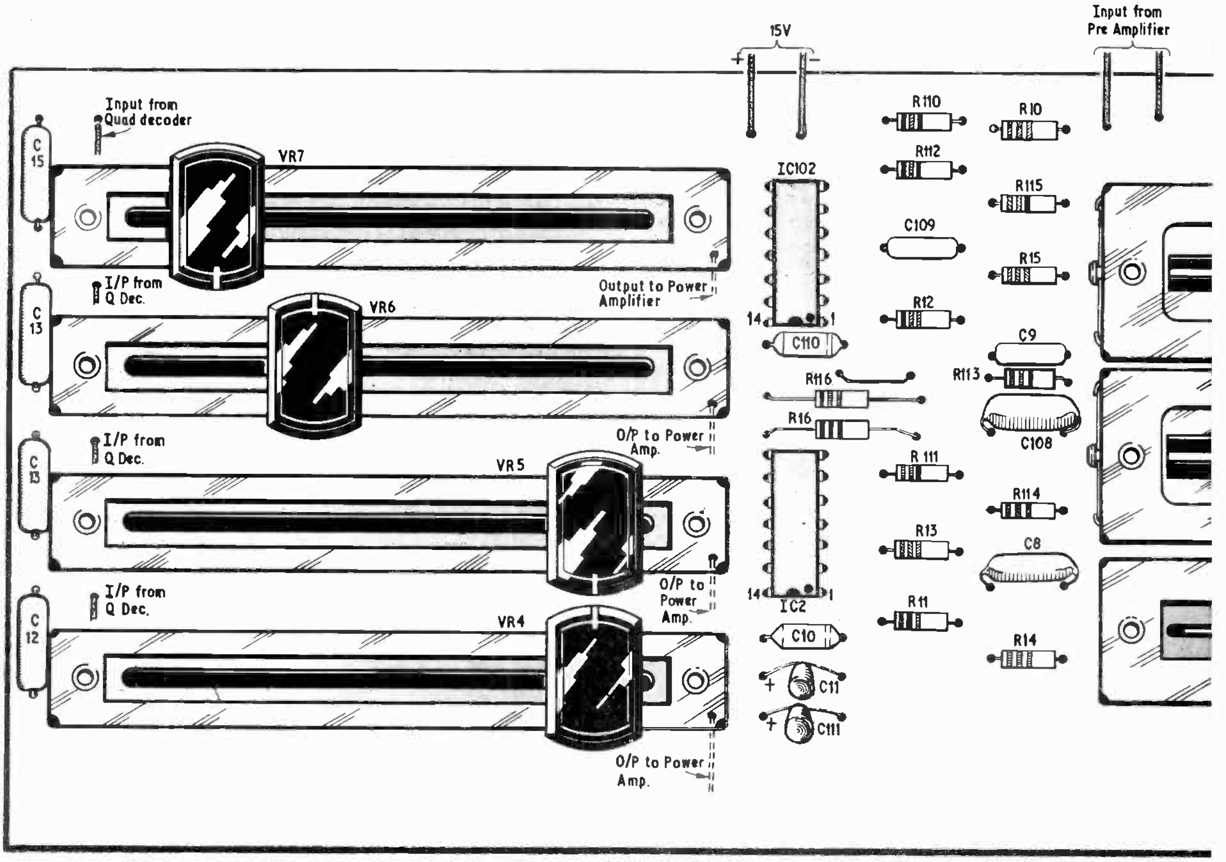
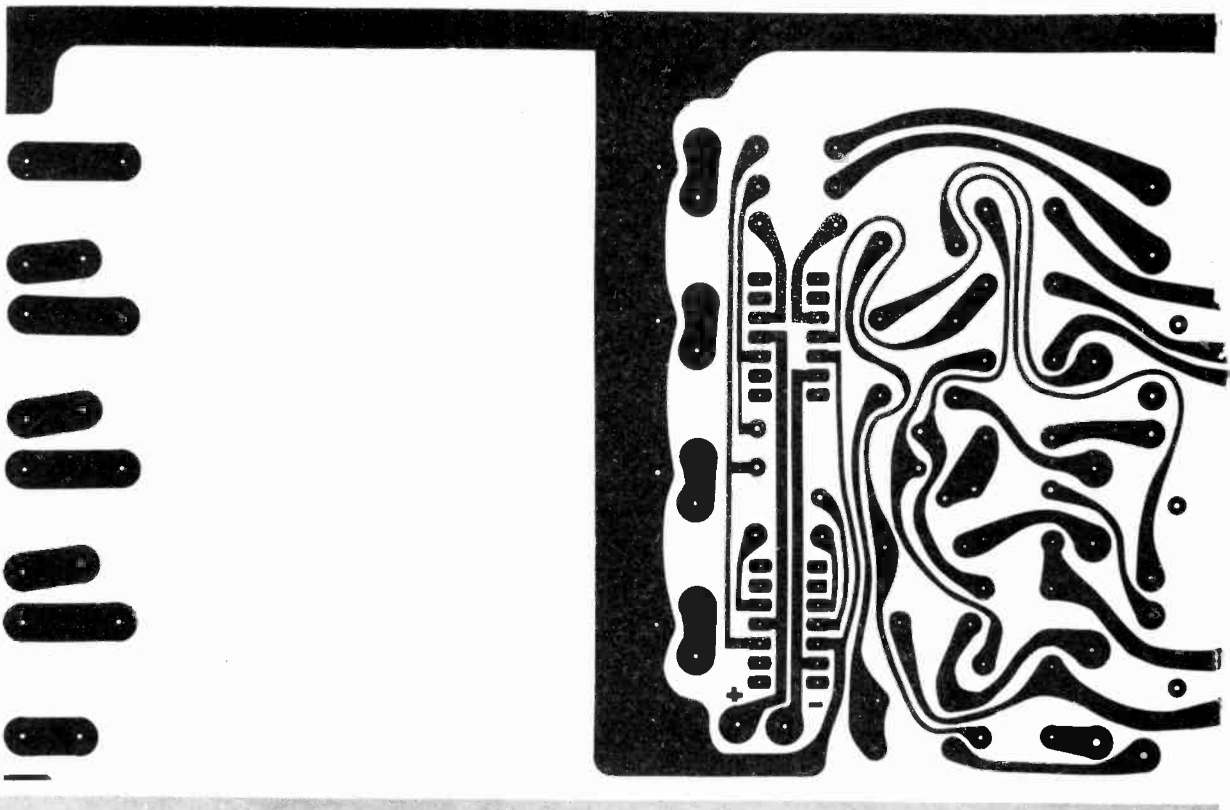
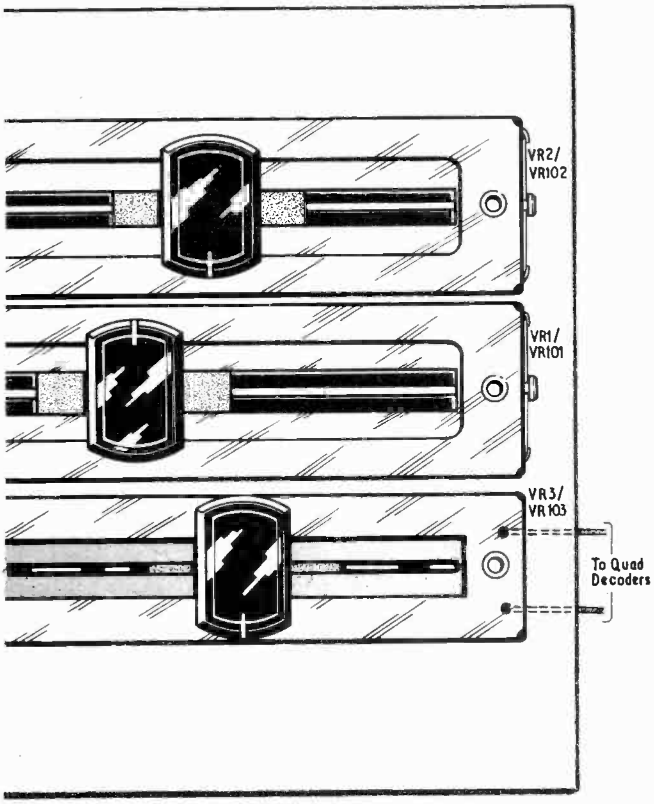


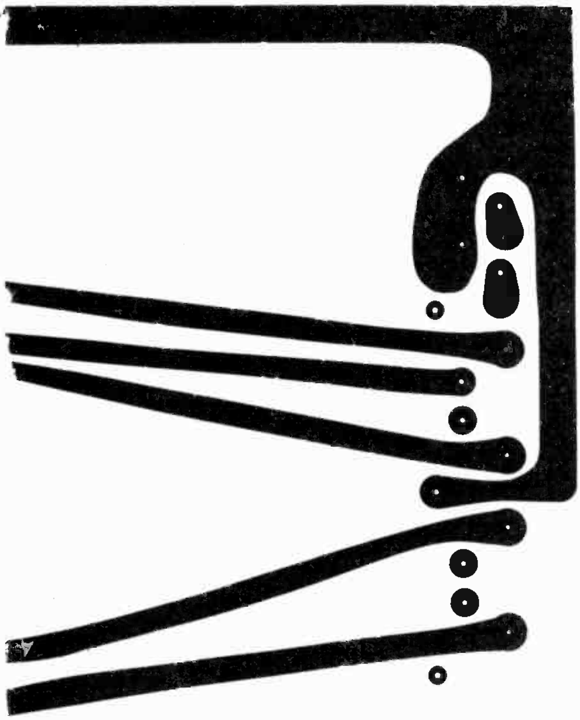
Fig. 2.10. Component layout and printed circuit master (full size) for the pre-amplifier board

TONE, BALANCE AND VOLUME CONTROL MODULE









COMPONENTS . . .

TONE AND VOLUME CONTROLS

Resistors

R10, R110	1·8kΩ	R14, R114	3·3kΩ
R11, R111	3·3kΩ	R15, R115	10kΩ
R12, R112	10kΩ	R16, R116	2·2kΩ
R13, R113	15kΩ		

All 5% ¼W Hi-Stab carbon film (2 off each required)

Capacitors

C8, C108	1500pF 30V polystyrene	(2 off)
C9, C109	0·068μF polyester	(2 off)
C10, C110	10pF 30V polystyrene	(2 off)
C11, C111	10μF 16V bead tantalum	(2 off)
C12–C15	0·22μF polyester	(4 off)

Potentiometers

VR1/101	100kΩ lin.	2-gang (Alps) Sonax Electronics	(1 off)
VR2/102	100kΩ lin.	2-gang (Alps) Sonax Electronics	(1 off)
VR3/103	10kΩ log.	2-gang (Alps) Sonax Electronics	(1 off)
VR4–VR7	10kΩ log. (Alps)		(4 off)

Integrated Circuits

IC2, IC102 ML748, μ748 or SN2748P (2 off)

Miscellaneous

Printed circuit board, connecting wires

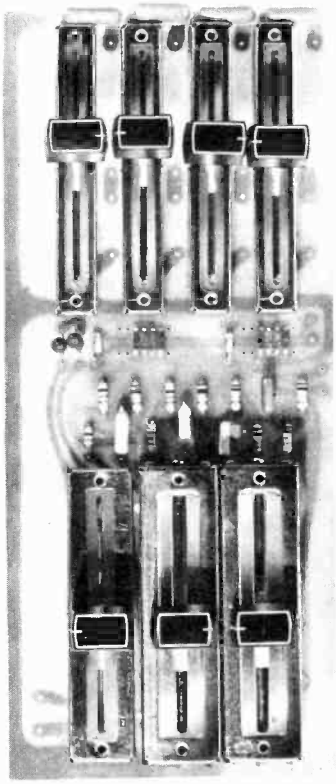
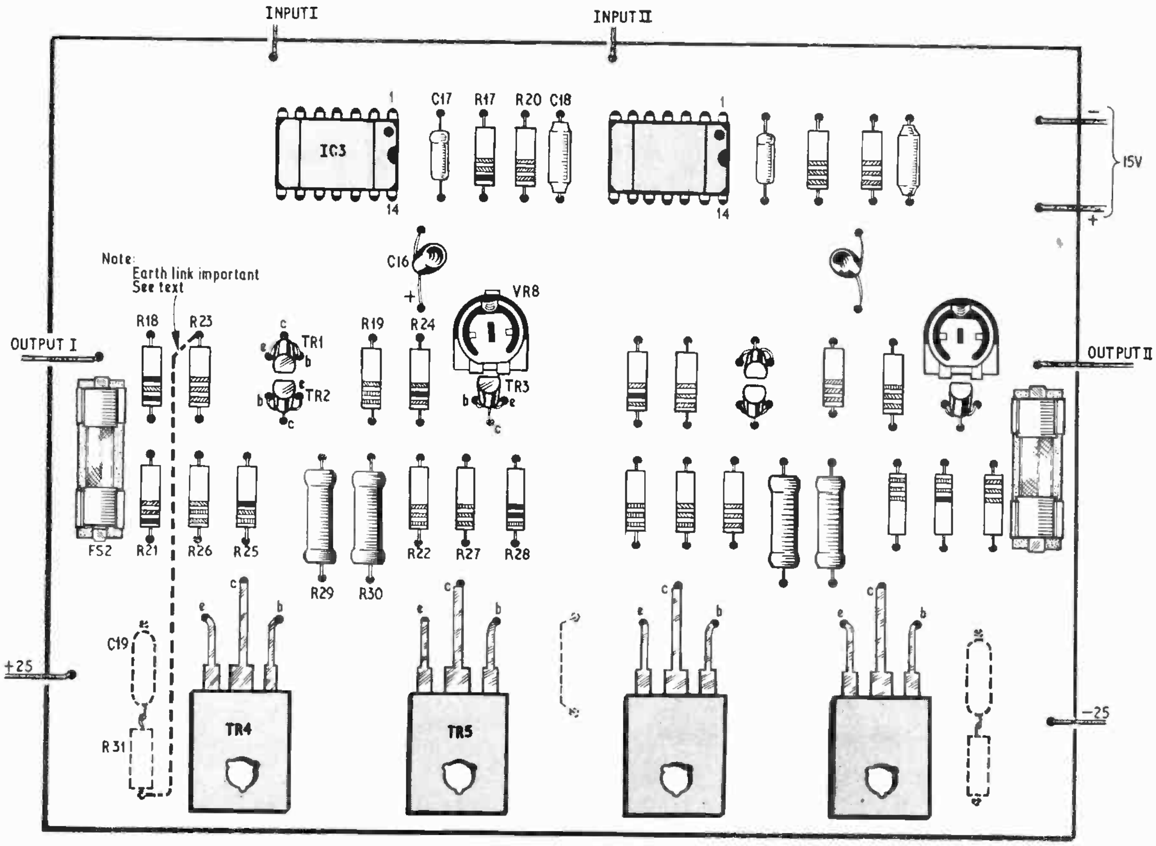


Fig. 2.11. Component layout and printed circuit master (full size) for the tone control and balance board. A photograph of a prototype board is also shown



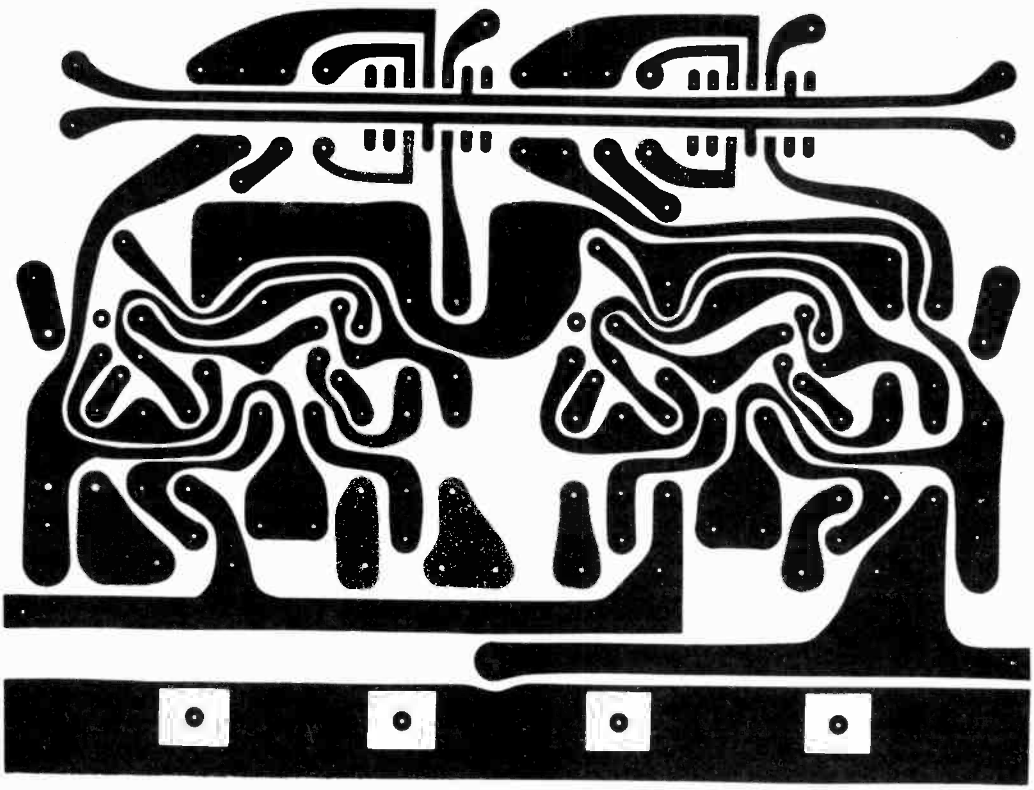
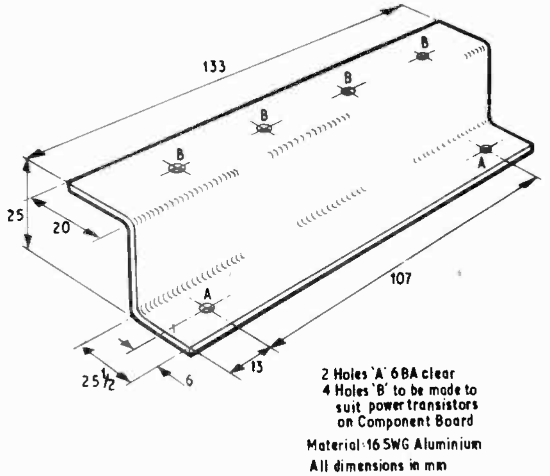


Fig. 2.12. Component layout and printed circuit master (full size) of one of the two power amplifier boards. Components on the right are similar to the left channel



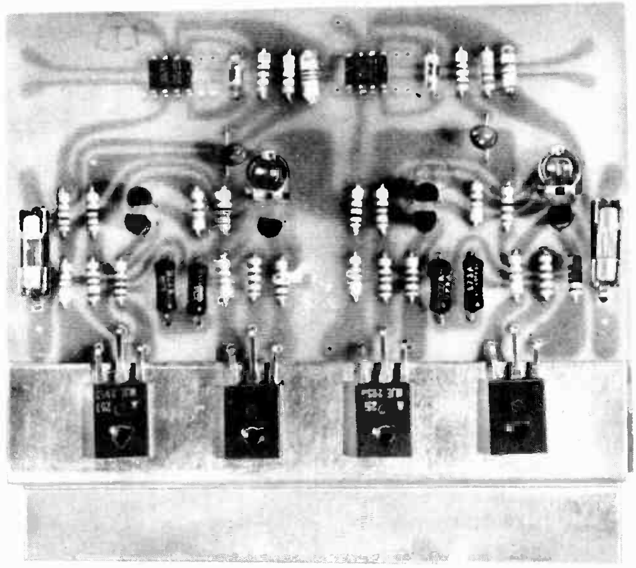


Fig. 2.13. Details of one of the heat sinks for the power amplifiers. A photograph of the amplifier board is shown opposite with a heat sink in position ready for marking for drilling

Fig. 2.13 shows the dimensions and form of the heat sink. Reference to the layout drawing Fig. 2.12 shows two links (dotted lines) on the copper side. R31 (10 ohm) and C19 (0·01µF) are also fitted on the copper side. These last components are high frequency compensation networks provided to ensure stable performance into difficult loads.

COMPONENTS . . .

POWER AMPLIFIERS
(two boards required, two amps per board)

Resistors

R17	680Ω	R25	150Ω
R18	100Ω	R26	220Ω
R19	470Ω	R27	220Ω
R20	82kΩ	R28	150Ω
R21	4·7kΩ	R29	0·5Ω } 2 W wirewound or metal film
R22	4·7kΩ	R30	0·5Ω }
R23	22Ω	R31	10Ω
R24	22Ω		

All 5% ¼W Hi-Stab carbon film (4 off each required)

Poteniometer
VR8 470Ω Skeleton preset (Piher) Sonax (4 off)

Capacitors
C16 100µF 3V bead tantalum
C17 10pF 30V polystyrene
C18 see text
C19 0·1µF polyester
Four of each capacitor required

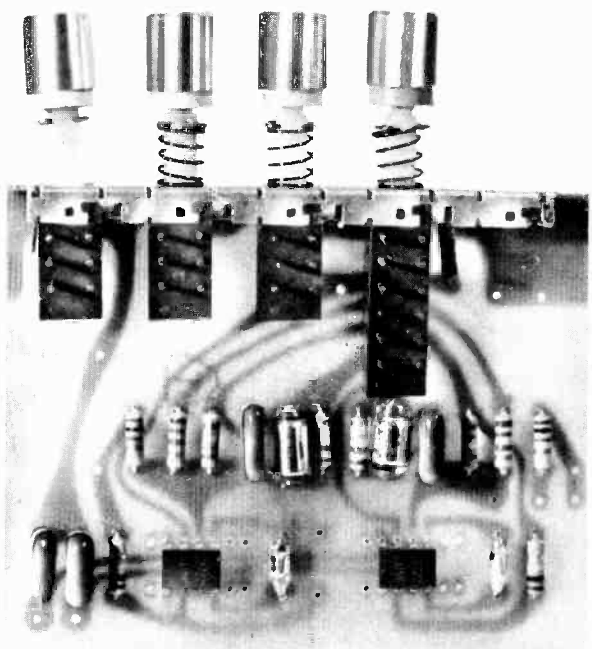
Integrated Circuits
IC3 ML748, µ748 or SN72748P (4 off)

Transistors
TR1, TR2, BC182LB (8 off) TR3 BC212LB (4 off)
TR4 MJE 2955 (4 off) TR5 MJE 3055 (4 off)

Miscellaneous
FS2 2A Fuseholder and fuse (4 off)
Printed circuit boards (2 off), connecting and link wires, set of mica washers for power transistors

C18 can be either 37pF or 68pF. A greater rate of roll off in frequency response is obtained by use of the 69pF, which in some circumstances can help reduce r.f. breakthrough. This is rather rare, but some constructors close to transmitters, or sources of r.f. interference, may experience this trouble.

Next month: Power supply and mechanical details and wiring



An almost completed pre-amplifier board

PART 1:
PHASE LOCKED
LOOP PRINCIPLES
AND DEFINITIONS

PHASE LOCKED LOOPS

BY J. B. DANCE M.Sc.

DURING the past two or three years a type of circuit known as the phase locked loop has aroused enormous interest in a number of fields, especially in that of radio receiver design. These articles will provide readers with a simple explanation of the operation of phase locked loops, their advantages and limitations, together with some of their practical applications.

The phase locked loop offers certain advantages over the other types of detector used in radio receivers. It can also be employed in a wide variety of other applications such as in frequency synthesisers, in frequency shift keying demodulators, in f.m. generators, in tape recorder flutter meters, for electric motor speed control, etc.

SINGLE INTEGRATED CIRCUITS

The principles of the phase locked loop have been known for many years (an account of the synchronous reception of radio signals was published as long ago as 1932). However, the circuits are so complex that it has not been very economical to construct them with discrete components. In the past three years, however, complete phase locked loops have become available as single integrated circuits. Their potential possibilities have stimulated great interest especially in radio receiver circuitry.

Currently available phase locked loops can replace nearly all of a receiver intermediate frequency strip (including the detector) with a single integrated circuit. The frequency of operation is set by a single component connected to the integrated circuit, whilst another component can be used to control the selectivity.

THE PHASE LOCKED LOOP

The phase locked loop contains an electronically controlled oscillator which can be synchronised with an incoming signal.

The basic operation of the phase locked loop may be illustrated by the block diagram of Fig. 1.1.

In subsequent parts we shall see that this basic system can be employed as a demodulator for f.m. signals, and with some additional stages, it can be employed to demodulate a.m. signals.

FREE-RUNNING FREQUENCY

If no input signal is fed to the phase locked loop of Fig. 1.1, the voltage controlled oscillator operates at a frequency known as the "free-running" or "centre" frequency. This frequency can be controlled by changing the value of certain components external to the integrated circuit phase locked loop.

In the free-running condition, the phase detector provides no output signal (or error signal). There is therefore no control voltage fed to the voltage controlled oscillator.

If an input signal is now applied to the system of Fig. 1.1, the phase detector will compare the phase of the input signal with that of the signal generated by the voltage controlled oscillator. The error voltage at the output of the phase detector is dependent on the phase difference between the two signals. It may be either positive or negative, according to which of the signals is leading or lagging the other in phase.

The error signal is passed through a low-pass filter, after which it is amplified to produce the signal which is used to control the frequency of the oscillator. The control voltage alters the frequency of the voltage controlled oscillator and can make it approach the frequency of the input signal. If the input frequency is close enough to the free-running frequency of the voltage controlled oscillator, the latter will become locked to the input frequency.

PHASE DIFFERENCE

When the phase locked loop is "in lock", the voltage controlled oscillator frequency is identical with that of the input signal, but in general there is a

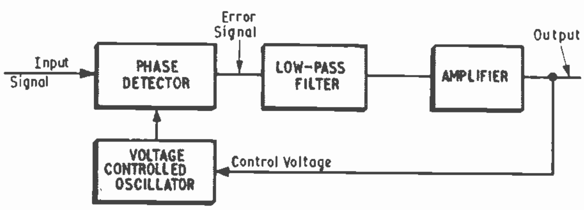


Fig. 1.1. Basic block diagram of a phase locked loop

certain finite phase difference between the signals. This phase difference must be present in order to generate the error voltage which is required to change the voltage controlled oscillator frequency from its free-running value to the input signal frequency.

FEEDBACK SYSTEM

The feedback system employed in a phase locked loop enables the frequency of the voltage controlled oscillator to change automatically as the input frequency changes. A slight change in the input frequency will result in a phase change between the input signal and the signal from the voltage controlled oscillator. The error signal produced by the phase detector will automatically adjust itself so that the voltage controlled oscillator frequency is kept the same as the input frequency.

PHASE COMPARATOR

It is instructive to note that the phase comparator is essentially a multiplier circuit which acts like a frequency changer. It operates on the input and voltage controlled oscillator signals so as to generate the sum and difference of these frequencies.

The sum frequency is unable to pass through the low-pass filter of Fig. 1.1. However, when the loop is locked the difference frequency is zero (since the two frequencies being fed to the phase comparator are the same) and a d.c. voltage is produced which can pass through the low-pass filter and keeps the loop locked.

If the input frequency is changing with time (as in an f.m. signal), the error signal will contain some frequencies which are much lower than the input frequency. The low-pass filter may transmit these frequencies almost unattenuated, in which case the voltage controlled oscillator will track the input frequency and the loop will remain locked.

Most phase detectors are also sensitive to the amplitude of the signals.

LOCK RANGE

The lock range of a phase locked loop is the range of input frequencies over which the loop remains locked to the input signal. The lock range is also known as the tracking range.

The term "hold-in" range is sometimes used to denote the maximum allowable difference between the centre frequency and the signal frequency at which the loop just remains locked. It is one half of the lock range, since the latter extends on each side of the centre frequency.

In a loop which is locked to the input frequency, the error voltage is of zero frequency and will therefore always be transmitted by the low-pass filter. The lock range is therefore not affected by the characteristics of this filter.

The lock range is limited by the maximum value of the control voltage which can be generated in the loop and thus the corresponding frequency of the voltage controlled oscillator.

The lock range can be many times the bandwidth of the signals accepted by the loop. This means that if the frequency of the input signal varies somewhat, the voltage controlled oscillator frequency will follow it, but at all times the bandwidth will be narrow so that the amount of noise is small. Effectively this means that the tuning of the receiver is automatically corrected as the input frequency changes.

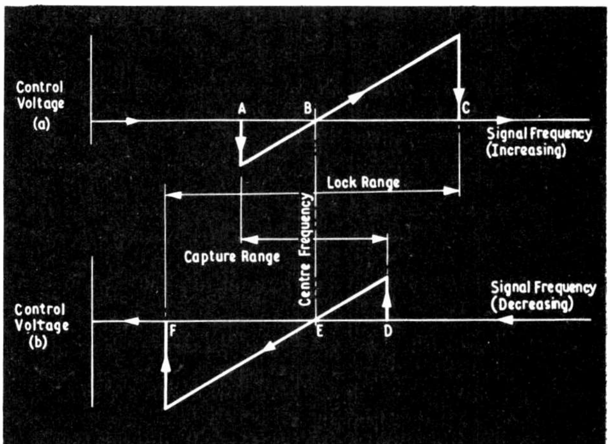


Fig. 1.2(a). As frequency is increased the loop locks at point A, passes through the centre frequency at B, and goes out of lock at C

Fig. 1.2(b). With decreasing frequency the loop locks at D, and unlocks at F

CAPTURE RANGE

The capture range is the range of input signal frequencies which can cause the loop to become locked. The capture range is generally smaller than the lock range. In other words, if a signal near to one of the ends of the lock range is applied to an unlocked loop, it will not bring the loop into lock. However, a loop to which this signal is being fed will remain in lock.

The capture range never exceeds the lock range. It is a measure of how close the input signal frequency must be to the centre frequency of the loop for locking to take place.

If the signal frequency in Fig. 1.2(a) is slowly increased, the loop will suddenly become locked at point A which is the edge of the capture range. As the frequency is increased further, the control voltage applied to the voltage controlled oscillator decreases linearly with frequency and passes through a value of zero at the free-running frequency, B. The loop remains in lock until the frequency reaches point C, the edge of the lock range. The control voltage returns to zero when the system comes out of lock.

If the frequency is now reduced, one obtains the characteristic illustrated by Fig. 2(b). The loop does not come into lock until point D is reached, the edge of the capture range. The centre frequency, point E, is reached when the control voltage is zero and the loop finally comes out of lock at point F.

THE CAPTURE PROCESS

The mechanism of the capture process may be examined by first considering a loop which is not yet locked to the input frequency. The phase detector produces sum and difference frequencies of the two signals being fed to it, but both of these frequencies are so high that they cannot pass through the low-pass filter. The voltage controlled oscillator therefore continues to operate at its free-running frequency.

If the signal frequency now approaches the free-running frequency, the difference frequency decreases until it falls within the pass band of the low-pass filter. The part of the difference frequency voltage which passes through the low-pass filter causes the voltage controlled oscillator frequency to move towards the input signal frequency. This reduces the difference frequency further so that it is transmitted more easily through the low-pass filter and exercises a greater effect on the oscillator.

The mechanism is essentially one of positive feedback. It has the effect of causing the voltage controlled oscillator frequency to suddenly become the same as that of the input signal.

Capture occurs when the difference frequency between the input and the voltage controlled oscillator signals can pass through the low-pass filter without being attenuated so much that it cannot produce an adequate control voltage. The capture range is therefore determined mainly by the maximum frequency which can pass through the low-pass filter.

The capture effect determines the selectivity of the phase locked loop circuit. Thus selectivity is determined by the characteristic of the low-pass filter.

PULL-IN TIME

The pull-in time of a phase locked loop is the time taken for the loop to become locked to the input frequency. In some systems the pull-in time can be very short—even less than the time for one oscillation of the difference frequency; in this case lock can be established without any oscillations in the frequency of the voltage controlled oscillator occurring.

The pull-in time depends on the difference between the initial free-running frequency and the signal frequency, the bandwidth of the low-pass filter and the overall gain around the loop. In general locking will take place more rapidly when the frequency of operation is relatively high, since a given number of cycles of the waveforms occur in a shorter time.

One might expect that locking would be instantaneous when the input frequency is exactly equal to the free-running frequency. This is not necessarily true, however, since although the frequencies are the same, the phases of the waveforms may be different and it is the phase differences which are detected.

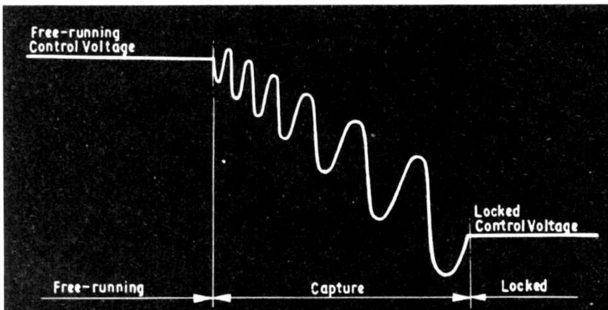


Fig. 1.3. Diagram showing transient locking characteristic

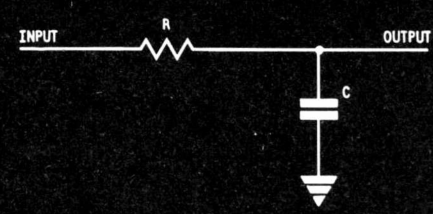


Fig. 1.4. The simplest low-pass filter circuit

THE LOCKING TRANSIENT

When the voltage controlled oscillator is free-running and as the loop approaches lock, the output from the phase detector contains a sinusoidal frequency equal to the difference frequency between the two signals. When the input frequency moves to a point within the capture range of the loop, the difference frequency is fed through the low-pass filter to the voltage controlled oscillator.

This oscillator frequency is modulated for a moment by the difference frequency and the latter will therefore vary with time. Once locking has occurred, the output from the phase comparator is of zero frequency.

The control voltage thus changes from the constant zero voltage in the unlocked state through an oscillating signal containing the difference frequency to a non-zero constant voltage when the loop is locked to the input frequency.

In the intermediate state during the capture process, the control voltages consists of a non-sinusoidal asymmetrical waveform containing a steady (or d.c.) component, as shown in Fig. 1.3.

The steady component causes the voltage controlled oscillator frequency to move towards the signal frequency. The difference frequency component in the control voltage gradually increases during the capture transient, as shown by the increasing width of the peaks in Fig. 1.3.

THE LOW-PASS FILTER

The low-pass filter is often extremely simple — merely a resistor and capacitor, as shown in Fig. 1.4, however, it has a very profound effect on the performance of the phase locked loop.

We have already seen how the characteristics of the low-pass filter can control the capture range. This filter also increases the pull-in time, since a rapid change of the output voltage from the phase comparator will produce a slower change in the output from the filter.

The use of the low-pass filter improves the noise rejection characteristics of the phase locked loop. If an interfering noise signal reaches the input of the phase comparator, the output will change almost instantaneously. However, the low-pass filter will delay any change in the oscillator frequency. The filter therefore acts as a short term memory which keeps the voltage controlled oscillator locked to the input frequency during a short noise pulse. Similarly, the loop remains locked during a short period when fading of the signal occurs.

SELECTIVITY

The selectivity of the whole phase locked loop is controlled by the characteristics of the low-pass filter. Although the low-pass filter operates at a relatively low frequency, its characteristics are effectively imposed on the high frequency response of the phase locked loop. A simple low-pass filter can provide selectivity which is equivalent to that of a conventional superheterodyne receiver containing six tuned circuits at the intermediate frequency.

Phase locked loops are especially useful for receiving radio signals which are "buried" in noise. Their pass band can be made almost ideal for this purpose.

If the bandwidth of the low-pass filter is sufficiently narrow, the signal-to-noise ratio at the output of the voltage controlled oscillator can be considerably better than that at the input. The use of a low-pass filter with a large time constant will provide greater noise rejection and immunity to a momentary loss of the input signal, but it does result in a lower tracking rate, a reduced capture range and a longer pull-in time.

The low-pass filter limits the rate at which the voltage controlled oscillator can track the input signal. If the frequency of the latter changes at a greater rate than the maximum rate for the loop used, the loop will not remain locked. Capture will not occur at the new input frequency if this is outside the capture range. A low-pass filter with a relatively high cut off frequency will produce a higher tracking rate, but the ability of the loop to reject short term noise will be reduced.

THE INPUT LEVEL

If the input signal is relatively large, its amplitude will be limited either in the phase locked loop or in the preceding circuits. The capture range and the lock range are then independent of the signal amplitude.

Although a phase locked loop can act as its own limiter, greater freedom from noise and from spurious signals can be obtained when the input level is below the threshold at which limiting occurs. When the amplitude is high enough to drive the system outside the limit for linear operation, there are more cross modulation signals formed. However, higher input levels do result on a reduced pull-in time.

Next month: f.m. and a.m. demodulation techniques will be described.

POINTS ARISING

WIDE RANGE PULSE GENERATOR (*June 1973*)

Capacitor C1 should be positioned in the circuit adjacent the contact of S1 and not, as shown in Fig. 2, in the direct connection from pins 2 and 3 to C2. It is shown correctly in the wiring diagram of Fig. 3.

THE 555 TIMER IC (*June 1973*)

It has been pointed out by a reader that any constructor attempting to use this chip to construct a 1:1 mark-space ratio monostable as described on pages 486 and 515 may run the risk of damaging TR1 because of a reduction of RA below a suggested value of 1 kilohm. The manufacturers have, in fact, not considered taking the resistance value below 1 kilohm.

AUDIO COMPRESSOR (*August 1973*)

In the base diagram of the 2N3708 transistor in Fig. 2 the base and emitter leads are shown transposed. Copper strip should be broken at F12. Resistor R13 should go to K29 not J29.

LIGHTING CONTROL UNIT (*July 1973*)

Page 612, the end of the fourth paragraph under the side heading "THE THYRISTOR" should read ", so that the voltage applied to the load looks like Fig. 2 (c) not 3 (c)." Also, at the end of the section headed "TESTING" Fig. 4 should read Fig. 3.

PHASING UNIT (*September 1973*)

Changing the 10kΩ linear dual-gang potentiometer VR2 for a logarithmic type will enhance the performance of the unit.

P.E. SOUND SYNTHESISER (*March 1973*)

POWER SUPPLY REGULATORS

It should be noted that the maximum input voltage for the voltage regulator μA7815 should not exceed 36V. Thus if the 30V Rec. Transformer by R. S. Components is being used in the power supply it is necessary to connect the 25V windings instead of the 30V windings given in March P.E.

Constructors using alternative 30V transformers should protect the regulator by means of an 8·2V 10W Zener diode connected between the bridge and C1 positive (cathode to the diode bridge). The Zener should be mounted on a heatsink, (2in × 2in 14 s.w.g. aluminium would suffice), which can be bolted to the power supply subframe lip above the transformer.

It will be necessary to insulate the heatsink from the subframe and separate heatsinks should be used for each Zener. The Z3B series of Zeners by Semitron would be suitable for use in the suggested circuit.

550 VOLT MEGOHMMETER (*August 1973*)

The function of VR2 was omitted. It should be adjusted so that the meter reads full scale with the leads shorted.

SOUND SYNTHESISER LECTURE

Our author Mr. G. D. Shaw will present a lecture-demonstration at the coming International Audio Festival and Fair, Olympia, London.
The lecture will be given at 2 p.m. on Tuesday, October 23, 1973.

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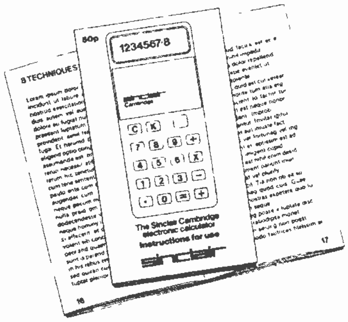

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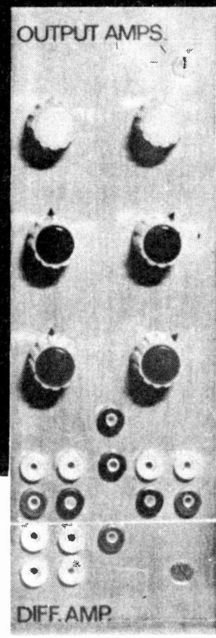
PLEASE PRINT

PE Sound Synthesiser 9

VOLTAGE CONTROLLED & DIFFERENTIAL AMPLIFIERS

By G.D.SHAW



THIS part describes the construction and operation of the Voltage Controlled Amplifiers, the Differential Amplifier and finalises the interconnection details outlined in Part 1 of the series.

OUTPUT AMPLIFIERS

The heart of each of the Voltage Controlled Amplifiers is the Motorola MFC6040 electronic attenuator which was described in Part 7 of the series and which, by means of an externally derived voltage, enables the input signal to be attenuated by 77dB or amplified by 13dB.

Two Output Amplifiers are employed, each having two stages, and arranged to be operated in parallel with cross-coupling between the final stages by means of panning controls. The general arrangement is shown in block form in Fig. 9.1. The first stage consists of a two input resistive mixer at the front end of the MFC6040 which has, for each channel, a separate control amplifier. Output from the first stage is led to a pan-pot which can route the signal to either of the output stages direct or to both channels at a range of intermediate levels.

Fig. 9.2 shows the theoretical circuit of the left channel Output Amplifier in which IC1 provides the variable gain input mixer, IC2/TR1 the control amplifier and IC3 the final output stage. The right channel is identical in design except that the 'a' side of the pan-pot is coupled to IC3 of the left channel instead of direct to the right channel output stage. This is so that clockwise rotation of the pan-pots will route signals to the right channel and anticlockwise rotation to the left.

PAN-POTS

The pan-pots themselves are designed to allow the smoothest possible transition when swinging the signal from one channel to the other and in such a way that equal increments of rotation of the pot give approximately equal incremental changes in the level of the signal.

The pots consist of two tracks ganged together and wired back-to-back so that as the output of one track increases the output of the other decreases by a similar amount. The ideal arrangement is when one of the tracks follows a logarithmic law with the other being anti-logarithmic. Unfortunately the manufacture of accurately matched tracks of this type is difficult and purpose built pots having the desired characteristics are not easily available and generally expensive.

The pan-pots in the Synthesiser represent a compromise in that they utilise linear tracks which, for most practical purposes, are made logarithmic in action by the addition of a relatively low value load resistor (R11 and R12 in Fig. 9.2).

PRACTICAL PROBLEMS

On completion of the module and having checked that each channel's performance characteristics are similar for a given input signal the following procedure should be adopted for determining the electrical centre of rotation of the pan-pots. Set both pots to approximately the mid-point of rotation and apply a signal of about 250mV to the input of one channel only. The remaining inputs should be grounded.

With the gain on the appropriate channel turned full up monitor the output stages of both amplifiers and adjust the appropriate pan-pot until the output signals are exactly equal. With a well matched pot the electrical centre should be quite close to the

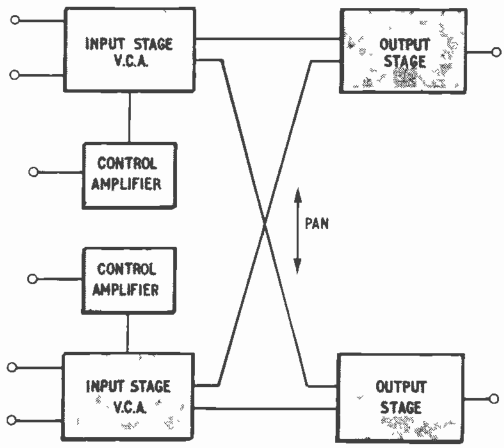


Fig. 9.1. General arrangement of voltage controlled Output Amplifiers

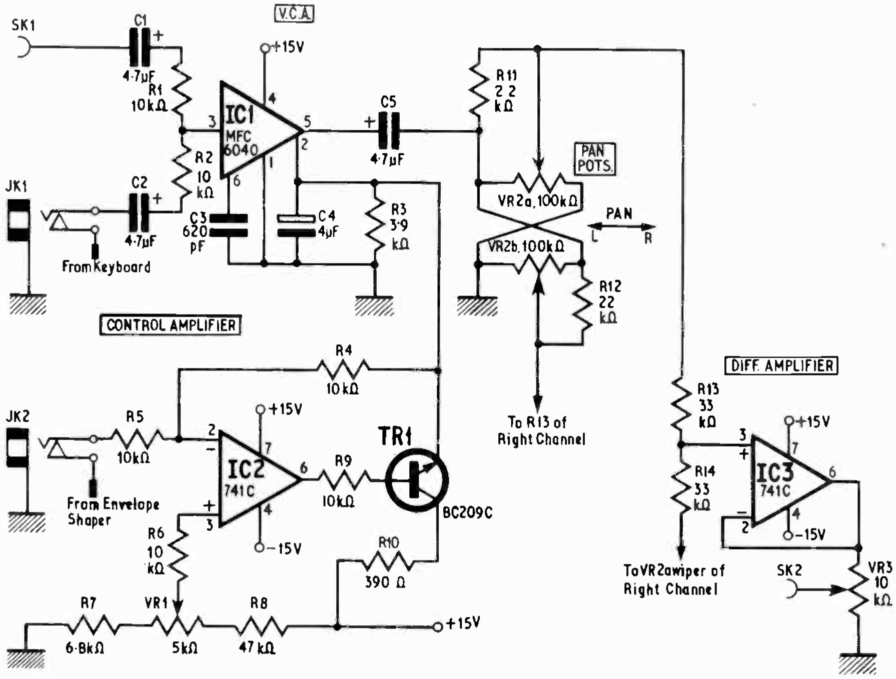


Fig. 9.2. Output Amplifier for left channel, right channel is identical. Note that if the Envelope Shaper is not connected by prewired link or if auto-programming of gain is not required JK2 must carry a grounded jack plug in order that full range of attenuation gain is achieved

COMPONENTS . . .

OUTPUT AMPLIFIERS (Left and right channels)

Resistors

R1–R2	10k Ω (4 off)
R3	3·9k Ω (2 off)
R4–R6	10k Ω (6 off)
R7	6·8k Ω (2 off)
R8	47k Ω (2 off)
R9	10k Ω (2 off)
R10	390 Ω (2 off)
R11–R12	22k Ω (4 off)
R13–R14	33k Ω (4 off)

All 5% ½ watt carbon

Capacitors

C1–C2	4·7uF tantalum 35V (4 off)
C3	620pF (2 off)
C4	4uF elect. 18V (2 off)
C5	4·7uF tantalum 35V (2 off)

Potentiometers

VR1	5k Ω midget linear carbon (2 off)
VR2	100k Ω ganged midget linear carbon (2 off)
VR3	10k Ω midget linear carbon (2 off)

Integrated Circuits

IC1	MFC 6040 (2 off)
IC2–IC3	741C (4 off)

Transistors

TR1 BC209C (2 off)

Sockets

SK1–SK2	2mm miniature sockets (4 off)
JK1, JK2	3·5mm jack sockets (4 off)

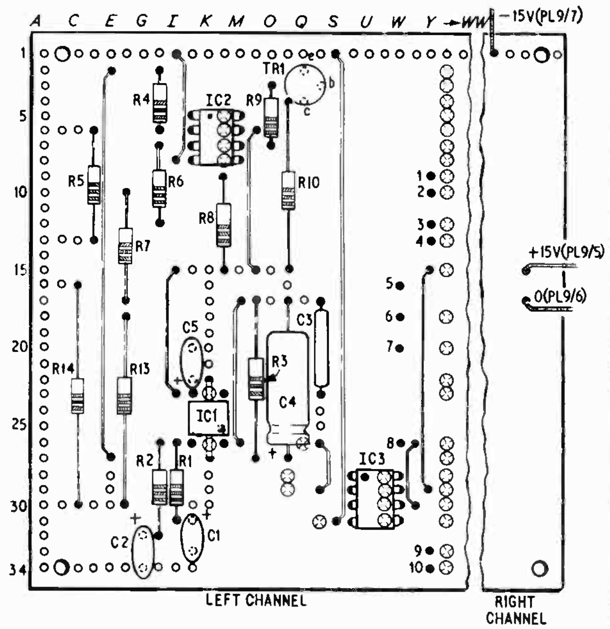


Fig. 9.3. Component layout for Output Amplifiers. As both channels are identical only the left hand is shown

mechanical centre. If there is more than say 10 to 15 per cent rotation between the two points it may be worth considering the empirical adjustment of one of the loading resistors in order to obtain a better balance or, alternatively, replacing the pot.

Both channels should be checked out in a similar manner and the electrical centres, when satisfactorily determined, marked on the front panel for reference.

CONTROL AMPLIFIER

In Part 7 of this series the action of the MFC6040 was described and it was shown that the full range of attenuation/gain could be obtained by varying the control voltage applied to pin 2 of the device. Maximum attenuation is associated with a control of +6V whilst maximum gain is obtained when the control falls to +3·5V.

As in the Reverberation Amplifier the control voltages are supplied by a separate amplifier, IC2 in this case, which is operating in the differential mode. Signals normally arrive at the control amplifier, via R5, from the envelope shaper to which it is permanently linked by means of a pre-wired interconnection. This means that R5 is effectively grounded since it is looking into a low impedance whatever the setting of the envelope shaper level control.

The non-inverting input of IC2 is provided with a reference voltage supplied via the divider R8, VR1, R7, which is variable between +1·75V and +3V and which, since the feedback around IC2 is halved due to the coupling on R5, results in the amplifier having an output swing ranging between +3·5V and +6V.

TR1 acts as a follower/current amplifier to ensure that the current sink at the MFC6040 control input has no effect on the output voltage of IC2.

Fig. 9.3 shows the recommended board layout of the output amplifiers.

If the output amplifiers are tested out before making the necessary pre-wired interconnections it is essential to insert a grounded jack plug into the control socket, or otherwise ground the input end of R5, in order to ensure the correct functioning of the circuit.

ENVELOPE COMPARISON

The rapidity with which the MFC6040 responds to changes in control voltage depends very largely on the value of C4 which has been chosen to present a time constant as close as possible to the fastest rate of attack/decay set by the envelope shaper. However it is prudent to compare the signal envelope at the output of the v.c.a. with the control envelope produced by the envelope shaper.

Fig. 9.4 gives a typical example of such a comparison. The slight rounding off at the corners of the signal envelope is due to the buffering action of C4 and is perfectly acceptable. If the rounding off is too pronounced there is a case for reducing the value of C4 to the next lowest preferred value but it is not recommended that the capacitor be removed entirely.

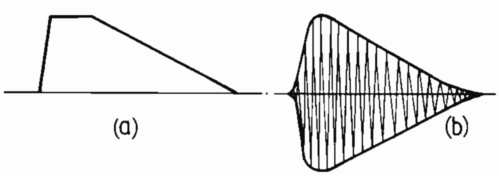


Fig. 9.4. (a) Control envelope—positive going (b) audio signal envelope with rounded edges

DIFFERENTIAL AMPLIFIER

In common with the voltage inverter appearing in Part 3 there is little which need be said concerning the Differential Amplifier which is of the simplest kind. Despite its simplicity however the Differential Amplifier can be made to perform many useful functions in the Synthesiser particularly in connection with the mixing of complex programming waveforms.

Fig. 9.5 gives the circuit diagram of the differential amplifier, while Fig. 9.6 shows the recommended board layout. The front panel component layout and wiring is shown in Fig. 9.7.

MODULE CONSTRUCTION

Construction of the module should generally follow the pattern already established in the series, that is, with the assembly and wiring of the components to the front panel before the panel itself is mounted to the circuit board support plate.

Wiring from the front panel components should be formed into two harnesses, one containing all leads to the output amplifiers passing out at the top of the front panel to the circuit board which is mounted in the position adjacent to the McMurdo plug. Leads to the differential amplifier should pass direct to the circuit board which is mounted in the lower postion adjacent to the front panel.

The board size for this latter circuit should not exceed 17 ways in depth otherwise there may be some difficulty in clearing the ganged pan-pots.

USING THE MODULE

As was explained last month the Voltage Controlled Amplifiers are principally intended for use with the Envelope Shaper in order that signals passing through them can be amplitude modulated in a variety of ways. However, only the left channel v.c.a. is permanently linked to the Envelope Shaper while the right channel control input is open circuit, that is, it requires a grounded jack plug inserted if control over signal amplitude is to be exercised.

With a jack plug in position the input level control may be operated in a similar fashion to a normal volume control, the characteristics of which were illustrated in graphical form in Part 7.

It is worth bearing in mind that the input level potentiometer is linear and thus the greatest degree of change in volume of the audio signal will occur within the last 30 degrees or so of rotation of the control. Alternatively, the control socket of the right channel may be linked by means of a patch-cord with the positive going envelope socket in order that both channels may be programmed by the envelope shaper. This latter procedure in no way compromises the audio signal and, in fact, with the pan-pots in the full left and right positions respectively the separation between channels is almost perfect.

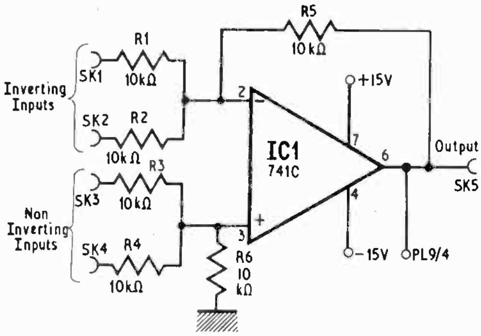


Fig. 9.5. Differential Amplifier circuit

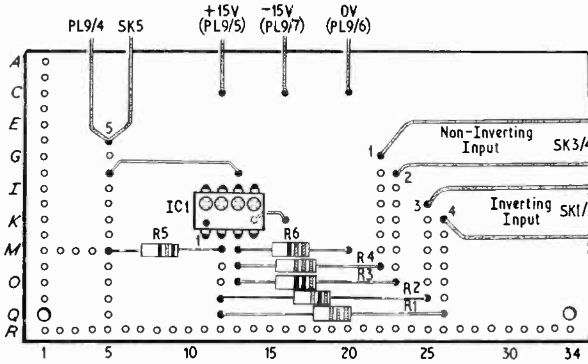


Fig. 9.6. Board layout for Differential Amplifier components

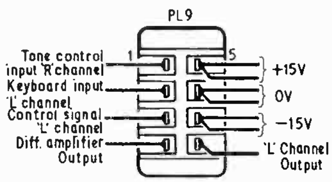
COMPONENTS . . .

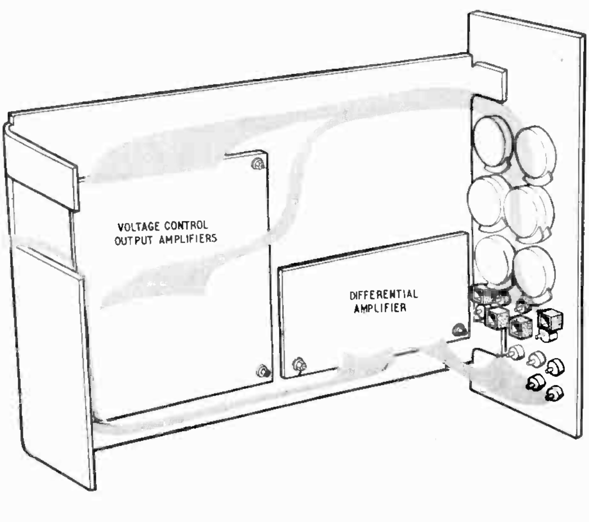
DIFFERENTIAL AMPLIFIER

Resistors
R1–R6 10k Ω (6 off)

Integrated Circuit
IC1 741C

Sockets
SK1–SK5 2mm miniature sockets (5 off)





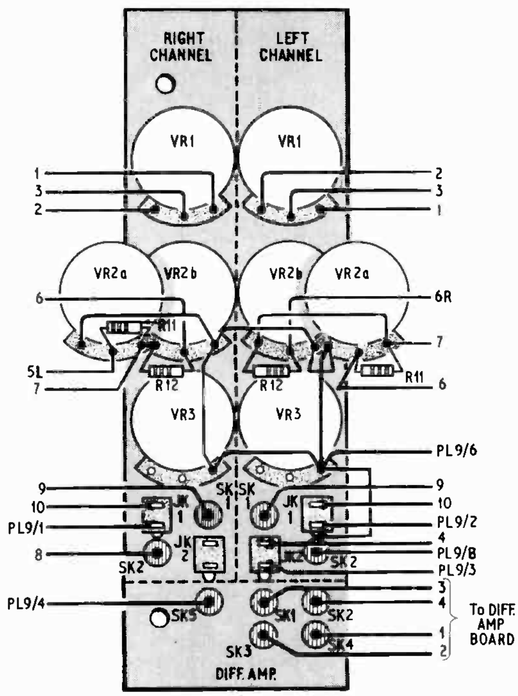


Fig. 9.7. Front panel wiring and inter-board connections. Note: Leads from VR3 as follows: wipers to SK2, unconnected tags to pin 8 on output amplifier board. Board positioning on the module is shown on the left with the McMurdo plug connections above

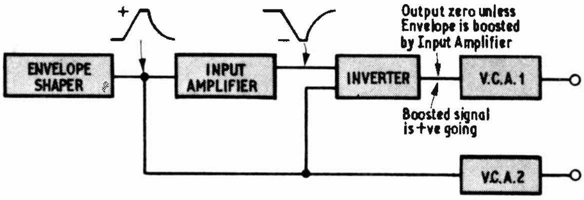


Fig. 9.8. Showing a method of obtaining a differential in envelope level

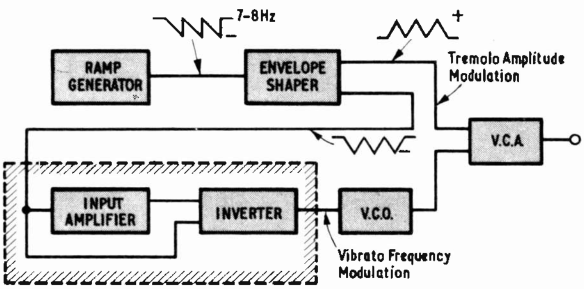


Fig. 9.9. Arrangement for combining tremolo and vibrato modulation

INPUT LEVEL

The total audio input signal level to the MFC6040 should not exceed 500mV and it is worthwhile ensuring that, if two signals are to be mixed in the v.c.a., each signal does not exceed 250mV peak. The penalty for neglecting this precaution lies in the possibility of damage to the device. The mean output level of the final stages will depend very much on the settings of the pan-pots. However, with 500mV input to the v.c.a. and with the pan-pots in mid-position, the maximum output is unlikely to exceed 2·2V. Output level controls are provided so that the output may be tailored to suit a range of input levels required by external apparatus such as tape recorders, power amplifiers and so on.

When the Envelope Shaper is programming the amplitude of the audio signal it is normal to set the input level control to zero if the full 90dB range of the v.c.a. is to be used. An alternative method is to adjust the input level so that, with a zero level envelope, the signal is just audible. The provision of an envelope under these conditions will serve to emphasise parts of the continuing signal. This technique is useful when one channel is carrying a repetitive rhythm which is to be mixed with another signal derived from, say, the keyboard. In these circumstances it is sometimes possible for the rhythm to be swamped by the keyboard signal unless the former signal is boosted.

If it is required to provide a differential level of positive going envelope for the latter purpose a suitable method is illustrated in Fig. 9.8. Set the envelope shaper signal level to provide the lowest amplitude response required between the two channels. Route the positive-going envelope to an input amplifier set to unity gain and also to the inverter. The output of the input amplifier should similarly be routed to the inverter. Since the inputs to the inverter are now of equal level and opposite polarity, the net output will be zero. Advancing the

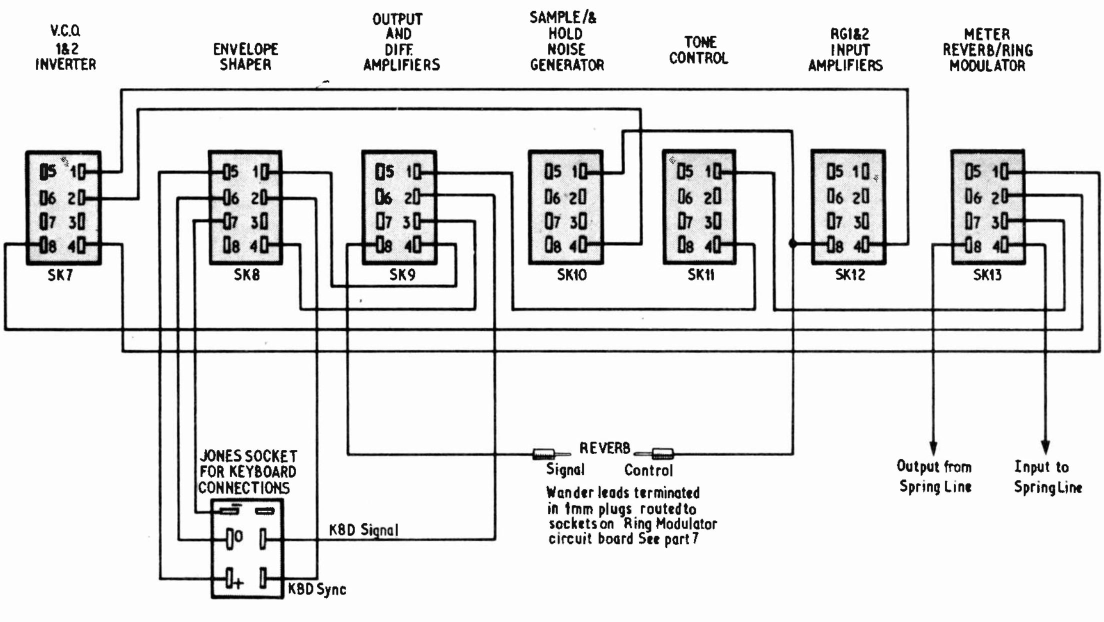


Fig. 9.10. Socket arrangement and wiring on connector mounting rails. Prewired interconnections are shown only

Table 1: Prewired Connections

Terminal Number	SK7 V.C.O. 1 & 2 Inverter	SK8 Envelope Shaper	SK9 Output Amplifiers Diff. Amp.	SK10 Sample/ Hold Noise Gen.	SK11 Tone Control	SK12 Ramp Gens. 1 & 2 Input Amps.	SK13 Meter Reverb. Ring Mod.
	Connect to	Connect to	Connect to	Connect to	Connect to	Connect to	Connect to
1	SK12 (4)	SK9 (4)	SK11 (4)	SK12 (8)	SK13 (3)	NC	SK7 (4)
2	SK10 (4)	Jones Skt. kbd. conn. sync.	Jones Skt. kbd. conn. signal	NC	NC	NC	SK7 (8)
3	NC	NC	SK8 (4)	NC	NC	NC	SK11 (1)
4	SK13 (1)	SK9 (3)	SK8 (1)	SK7 (2)	SK 9 (1)	SK7 (1)	Input to Spring Line
5	V+	V+	V+	V+	V+	V+	V+
6	O	O	O	O	O	O	O
7	V−	V−	V−	V−	V−	V−	V−
8	SK13 (2)	NC	Wandering lead	NC	NC	SK10 (1) Wandering lead	Output from Spring Line

gain control of the input amplifier will have the effect of providing a positive going envelope which may be adjusted to suit the requirements of the so-far unprogrammed output channel.

TREMOLO EFFECTS

An interesting experiment lies in the investigation of tremolo effects. Set a ramp generator to about 7–8Hz programming the envelope shaper direct. Adjust the attack and decay controls so that the resultant envelope is triangular in form and adjust the envelope level so that it provides peak modulation to a v.c.a. Couple a v.c.o. running at about 300Hz to the audio signal input of the same v.c.a. and adjust the input level control so that the sound does not die away completely at zero envelope level. The resultant pulsating sound is known as tremelo modulation.

The next stage is to take the negative going envelope and couple it to the same series of modules described in the previous example. The output of the inverter should be led to the v.c.o. providing the 300Hz signal. If the input level control to the v.c.a. is now turned to maximum and the input amplifier gain carefully increased the resultant sound is known as vibrato or, perhaps more suitably, frequency modulation. Variation of input amplifier gain, in conjunction with v.c.a. input level, can provide an interesting range of sounds in which tremelo and vibrato modulations are mixed. The schematic arrangement of modules for the above experiment is shown in Fig. 9.9.

Further interest may be provided by variation in the triggering rate of the envelope shaper and variation in the mark-space ratio of the envelope by careful adjustment of the ratio control.

PRE-WIRED INTERCONNECTIONS

This article concludes with some notes on interconnections which was outlined in Part 1.

Permanently connected interwiring is advocated to reduce the problems associated with external patch cords which, besides being possible sources of hum-pick-up, can often render the front panel controls difficult to operate particularly if a complicated patch is in use.

Table 1 gives the scheme of interconnection, whilst Fig. 9.10 gives a wiring layout based on the original illustration shown in Part 2 of the series. The socket numbers shown correspond to the socket numbers on that illustration which is a view from behind, as it were, of the front panel also depicted in that issue. Those constructors who have changed the arrangement of modules from that shown in Part 2 should note that the wiring on the McMurdo sockets will have been re-routed accordingly and would, perhaps, be well advised to use the table of connections as a guide.

There are two minor changes in the interwiring differing from the block diagram depicted in Part 1. These are:

(a) V.c.o. 1 is no longer programmed direct from the envelope shaper since the range of sounds which could be produced was not considered wide enough to merit a permanent connection.

(b) The Envelope Shaper programming of reverberation depth has been replaced by R.G.2 to gain the benefit of the wholly opposite type of effect resulting from the use of negative-going programming signals. At the same time the R.G.2 connection to the envelope shaper has been replaced by a connection from the differential amplifier since it has been found, in practice, to be the more useful of the two.

Note: See Points Arising this month.

Next Month: Commencement of the Keyboard Unit. This is an independent instrument that can be used for live performance apart from the main Synthesiser.

WIND and RAIN EFFECTS

By P. J. TYRRELL

THIS project describes the construction of a simple unit whose output when fed into an audio amplifier produces a sound resembling howling wind or falling rain. The circuit uses an operational amplifier in a dual-in-line package, which simplifies construction and aids stability in the high gain arrangement used. This also means that the circuit layout is less critical than if discrete components were used.

PRINCIPLE OF OPERATION

The circuit consists basically of an active tuned filter fed from a white noise source. The sound of howling wind is produced by varying the resonant frequency of the filter. By removing one of the capacitors in the filter, the circuit behaves as a broad band amplifier, producing the sound of rain.

Fig. 1 shows the basic filter circuit used. The resonant frequency is determined by the values of C_1, C_2 and R_1, R_f determining the gain of the system. Removing C_2 widens the bandwidth of the filter. In the final circuit this function is performed by placing a variable resistor in series with C_2, permitting the rain to be gradually introduced.

FINAL CIRCUIT

The complete circuit of the unit is shown in Fig. 2. The white noise is generated in TR1 by giving it a reverse bias, then passed via R2 and C3 to the input of the filter. VR1 controls the resonant frequency of the filter, and is therefore, the wind control. VR2, in series with C2, is the rain control.

The output from the filter passes through R4 to VR3, the output level control and then to the output socket SK1 via C4. VR3 was wired as shown, not with the wiper connected to the output as it was envisaged that other equipment may be connected to the same input of the main amplifier.

The operational amplifier chosen for this circuit is the 741. It was chosen in preference to the 709 as the former requires no external frequency compensation and the greater bandwidth offered by the latter is not necessary in this application. The 741 will work satisfactorily from supply voltages of ±4 to ±15 volts, making it most suitable for operation from a pair of 9 volt batteries, as is done here. At this supply voltage the open loop voltage gain is over 90dB.

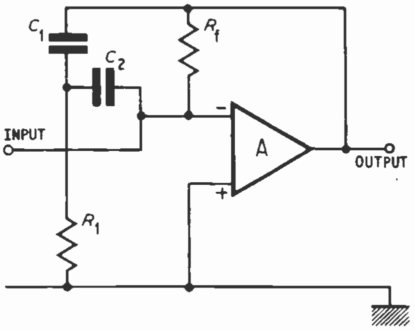


Fig. 1. Basic filter circuit. C_1 and C_2 determine the resonant frequency and R_1 and R_2 determine the gain

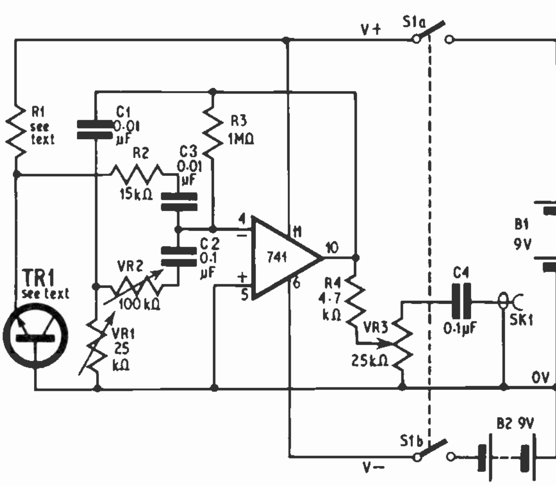


Fig. 2. Complete circuit diagram of the Wind and Rain Effects Unit

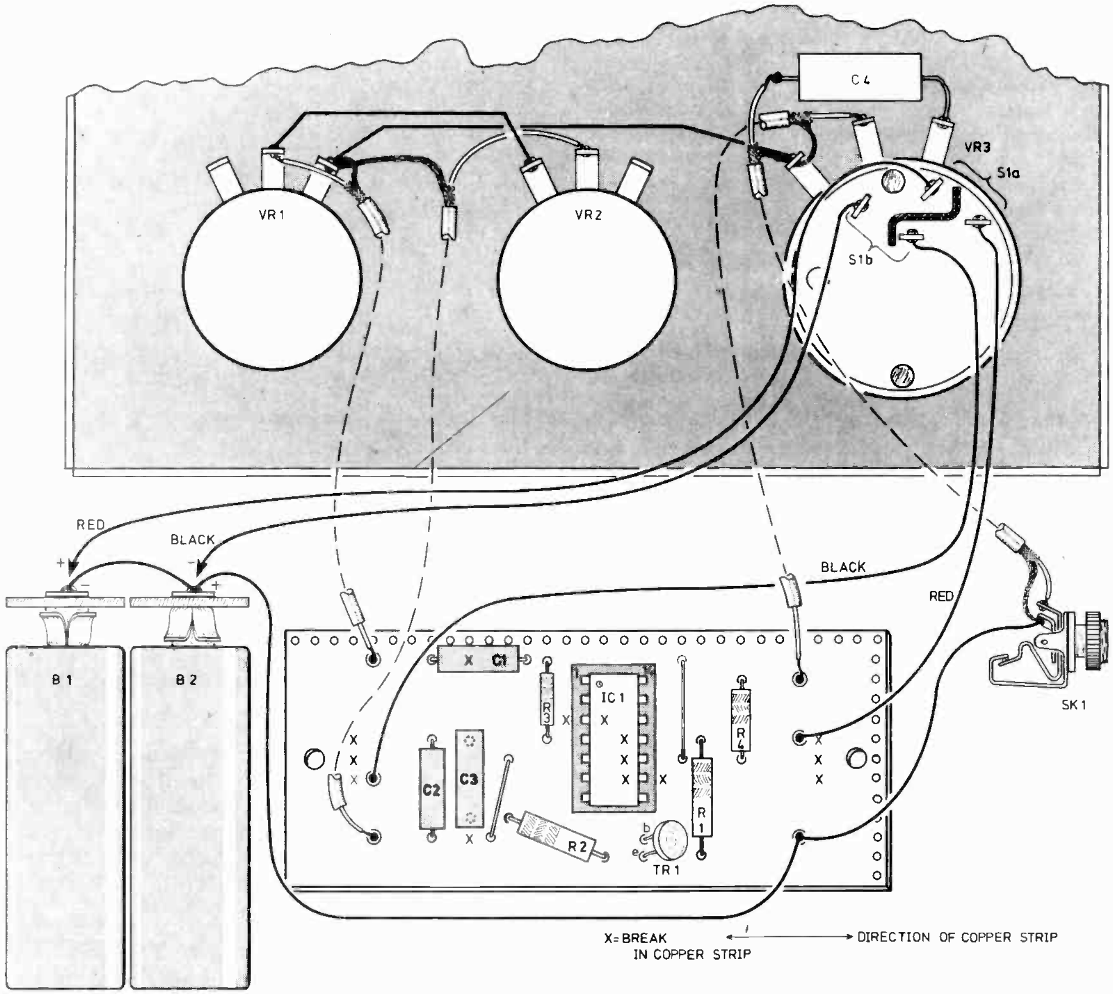


Fig. 3. Construction and interwiring details. All but battery leads should be screened leads

COMPONENTS . . .

Resistors
R1 100kΩ nominal (see text)
R2 15kΩ
R3 1MΩ
R4 4·7kΩ
All $\frac{1}{4}$ or $\frac{1}{8}$W ±10% carbon

Potentiometers
VR1 25kΩ linear
VR2 100kΩ linear
VR3 25kΩ linear with double pole switch

Capacitors
C1 0·01μF   C3 0·01μF
C2 0·1μF   C4 0·1μF
All 160V polyester or polycarbonate

Semiconductors
TR1 Any *npn* transistor (see text)
IC1 SN72741 *or* equivalent

Miscellaneous
Aluminium box 5$\frac{1}{4}$in x 4in x 1$\frac{1}{2}$in
B1, B2 9V PP3 batteries (2 off)
SK1 3·5mm jack socket
Veroboard 0·1in matrix, 31 holes x 13 strips
Veropins (6 off)
Knobs, nuts, bolts, screened wire, aluminium for battery holder

CONSTRUCTION

The circuit was constructed on a piece of 0·1 inch matrix Veroboard, using a socket for the 741.

Start by cutting the Veroboard to size (31 holes long by 13 strips wide). Next cut the copper strips according to Fig. 3, and then fix the Veropins for attachment of flying leads. All the components except TR1 and R1 should then be soldered in. The integrated circuit socket should be soldered before inserting the i.c. C4 is mounted directly onto VR3 to simplify wiring.

SELECTING TR1 AND R1

In order to select suitable components for TR1 and R1, flying leads should be temporarily connected to V+, 0V and R2. The 9 volt batteries should be connected up and the output from R4 fed into an audio amplifier. VR2 can be left out of circuit, but VR1 should be temporarily wired in. It facilitates the selection process if a number of leads with insulated crocodile clips on both ends are available.

It is best to have a number of transistors at hand and select a suitably noisy specimen for TR1. Varying R1 alters the noise output from the transistor, but it should not be reduced below about two kilohms. In the prototype R1 was 100kΩ and TR1 was a silicon *npn* device obtained from a computer board.

A *pnp* transistor can be used instead, by reversing the base and emitter connections. Alternatively, a noisy Zener diode, reverse biased, may be used. A number of advertisers in this magazine offer untested transistors for sale, cheaply in bulk, and it is worth investing in some of these.

Having chosen R1 and TR1, these should be soldered in place on the Veroboard.

CASE CONSTRUCTION

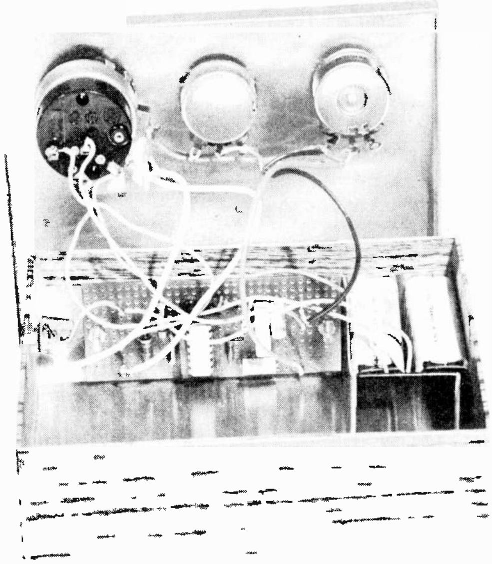
The prototype was constructed in a ready-made aluminium box. Construction and interwiring details for the box and its lid are shown in Fig. 3. A battery retaining clip can be made from a piece of aluminium. The end of this should be wrapped with insulating tape to prevent the battery clips from shorting out.

If it is thought that the batteries may be inadvertently inserted the wrong way round then the inside of the box, next to the Veroboard, can be insulated as well. The Veroboard is mounted with two 6BA bolts and ⅜in spacers. One of the bolts serves to hold the battery retaining clip in position as well.

The prototype box was covered with woodgrain pattern, plastic self-adhesive, and the lid brushed with steel wool. A piece of foam plastic was glued to the inside of the lid, to prevent the batteries from rattling, and Letraset legends applied above the three controls. The front panel was then given a coat of polyurethane varnish, to protect the surface and the lettering. Cellulose varnish should not be used as this dissolves Letraset.

FINAL WIRING UP

The circuit should be wired up using screened wire, apart from the battery leads, due to the possibility of instability in the high gain arrangement. Do not forget to connect C4, which is mounted on VR3.

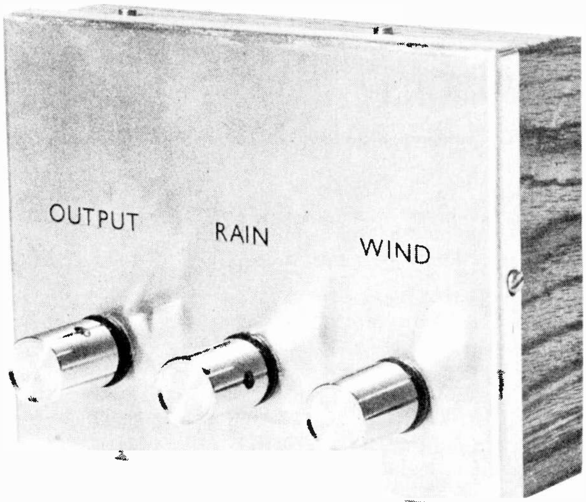


Photograph of the internal layout

TESTING AND OPERATION

With the circuit fully assembled, the current drawn from each battery should be about 1·6mA. With the unit connected to an audio amplifier, VR3 fully clockwise, VR2 and VR1 fully anticlockwise, a low moan should be audible. By advancing VR1 the frequency of the wind should rise up to a scream. With VR1 again fully anticlockwise, as VR2 is advanced, the sound of falling rain is heard, increasing in intensity with rotation of VR1 and VR2.

No detailed description of application is included here, as this is best left to the constructor's imagination. ★



Photograph of the completed Wind and Rain Effects unit

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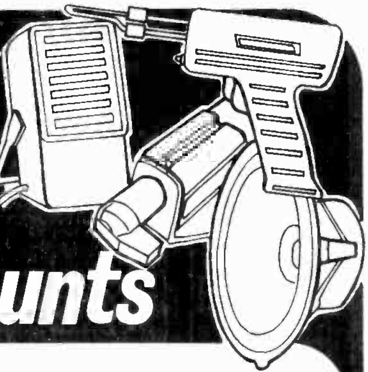

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ZTX107	9p	ZTX330	15p	2N3055	72p	ZS270	11p
ZTX108	8p	ZTX331	16p	* DIODES *		ZS271	16p
ZTX109	11p	ZTX382	13p			ZS272	18p
ZTX212	14p	ZTX383	15p	ZS120	8p	ZS274	19p
ZTX213	14p	ZTX384	18p	ZS121	10p	ZS276	26p
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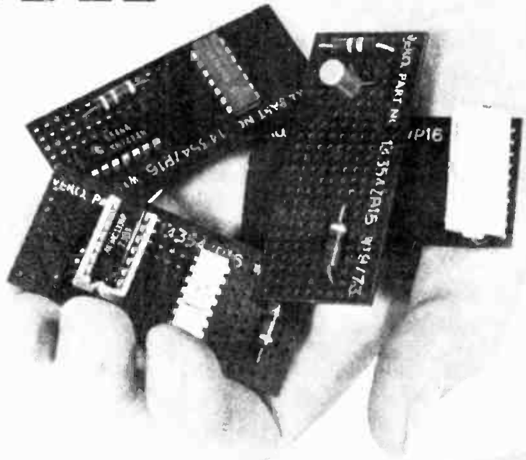

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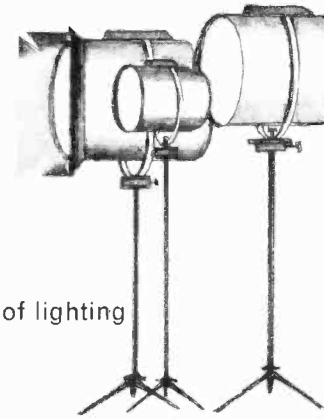

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PATENTS REVIEW...

FOUR CHANNEL VOLUME AND BALANCING CONTROL

In BP1 317 530 Motorola Inc. of Illinois, USA, describe a simple but useful system for balancing 4-channel sound. The patent is concerned mostly with cartridge players for cars.

The basic system diagram is shown in Fig. 1. Four channels drive four speakers i.e., left rear, left front, right rear, right front.

Each of the four speaker driver amplifiers uses a transistor to act as a variable impedance device to control the gain of the audio signal, see Fig. 1. Usually the transistors used are of the *npn* type with the collector connected to the drive for the speakers and the emitter connected to earth. For *pnp* types the emitter and collector connections are reversed.

Potentiometer VR2 acts as a side balance (left to right) control and has one end connected to the left channels and the other end connected to the right channels. As VR2 slider is moved it thus provides a variable voltage divider network between the respective pairs of channels.

Adjustment of VR2 varies the amount of d.c. voltage delivered to the respective pairs of channels at the bases of their associated transistors. But the total sum of the d.c. applied remains the same; so it follows that although the respective pairs of channels are balanced, a constant volume is maintained with respect to the total output of the pairs of channels. This is because there is no shunting or limiting effect.

Potentiometer VR3 acts as a control for balancing the front and rear sets of speakers. One end is connected to the rear channels and the other to the front channels. VR3 functions in exactly the same manner as VR2 dividing a fixed amount of d.c. voltage between the front and rear channel pairs.

In the circuit shown fixed value resistors are connected in series with the base of each transistor to serve as a bias current limiting device.

The overall gain or volume of the system is controlled by VR1, the slider being connected directly to the sliders of VR2 and VR3 respectively. Once control VR1 has been set to achieve the required overall volume level, this will be maintained whatever balancing positions are set on the other controls. Also, the set balance will remain the same as the overall volume level is raised or lowered.

BP1 317 530

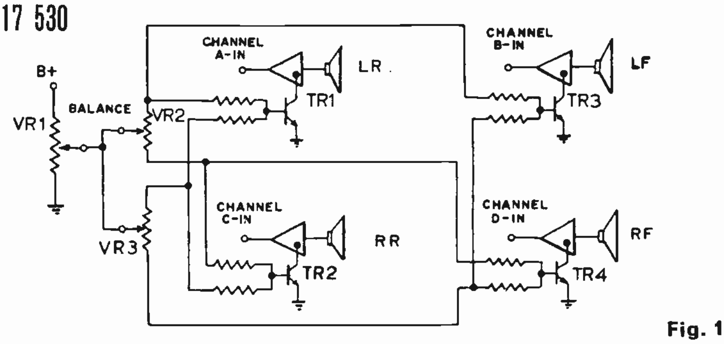

Fig. 1

STEREO AMPLIFIER AVC

Blaupunkt-Werke of Germany in BP 1 307 074 describe an automatic volume control for a stereo amplifier. The idea is to provide a.v.c. with no cross-talk between channels, but without buffer amplifiers.

The output of the first channel amplifier is fed to one end of a potential divider network, the other end of the divider is connected to the positive line. Capacitor C3 connects the junction of resistors R3, R4 to one side of a bridge. The anodes of D2 and D4 connect via VR1 to the base of amplifier transistor TR1 and the cathodes of D3 and D4 are connected to the emitter of TR1. The second channel is connected in exact mirror fashion.

The collector of TR1 is connected through D5 and filter network C7, R12 to the base of TR2. Its emitter is connected through VR2 to a pair of voltage dividers and transistors TR3 and TR4.

When one of the two channels produces a signal which is too large, the negative going half wave passes through the respective capacitors C3, C4, charged by the positive half wave and action of diodes D1, D3, via either D2 or D4 and VR1 to the base of TR1. The resultant control signal from the collector of TR1 is fed to the base of TR2 and is applied to the variable control VR2 which allows compensation for tolerances of TR3 and TR4.

With correct adjustment of VR2, the voltages on the bases of both TR3 and TR4 will be altered by equal amounts so that the collector/emitter junctions of the transistors are more or less conductive. This will achieve ganged automatic volume control because there will be an alteration in the ratio of the potentiometer in each channel formed by the input resistors R1, R2 and its respective transistors TR3 and TR4, with a resultant change in the fraction of the signal applied to the channel amplifiers.

BP1 307 074

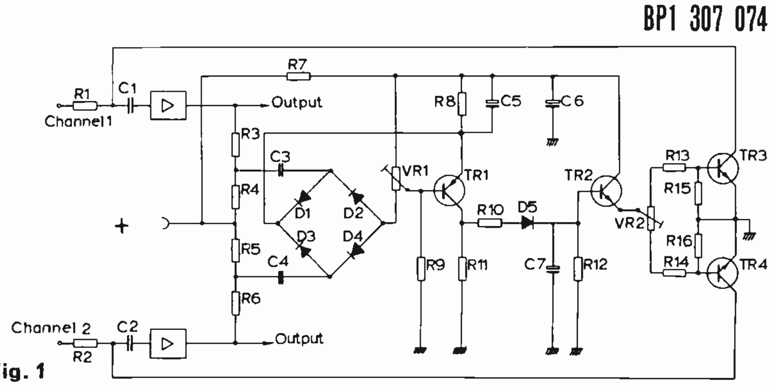

Fig. 1

INDUSTRY NOTEBOOK

By Nexus

CMOS CATCHES ON

Last year European manufacturers bought £1 million worth of CMOS devices. This year the figure will be £3 million and 1974 will see European sales topping £7 million. If these figures are correct, and top Motorola marketing men believe they are, then the faith of the pioneers led by RCA will be fully justified.

Watch out for Motorola grabbing a big share of the CMOS market. Their UK marketing manager is talking of "dedication" to the technique and is backing his words with a costly promotional campaign centred on a big applications seminar to be staged in London in early October. The seminar will also be going on tour to other European capitals.

Motorola latched on to the CMOS bandwagon by second-sourcing established RCA devices. But the pattern is now changing. Of 48 device types brought to the market last year by Motorola, 23 types were second-sourced RCA but 25 were Motorola originals. This year's developments bring the score up to 30 types second-sourcing RCA plus 50 Motorola originals.

While Motorola's newest European plant was in construction at East Kilbride there was indecision on its final function. But now the CMOS market is firming up I can reveal that East Kilbride is to be the major European centre for CMOS production.

At present, wafer diffusion is based on Phoenix, Arizona, assembly and packaging in plants in Mexico, Korea and Malaysia and with European testing in Scotland. But East Kilbride is scheduled to start diffusion of 3-inch wafers in October and will thus have complete capability to serve Europe and will be totally committed to this task.

Manufacturers of CMOS see a world market worth more than £80 million annually in two years time. CMOS, they say, will bite savagely into the present TTL and DTL dominated markets at frequencies up to 25MHz. But more important is the opening up of completely new markets for which other forms of logic are not suitable. Cited are watches and clocks, car electronics, domestic appliances, and even toys.

DRIVE-IN

The car market is not only opening up for electronic component manufacturers. The automatic test equipment (ATE) brigade are also moving in.

Historically, ATE found its feet in testing complex avionic systems and has slowly found its way down to more mundane tasks such as checking out PCB boards and other assemblies in manufacturing plants where it is used to speed up production and cut costs because automatic diagnosis of faults dispenses with skilled labour.

Car manufacturers are being invited to attend Automatic Testing '73 Exhibition and Conference in Brighton in November where the programme includes papers on automated engine test beds. More than 30 ATE equipment manufacturers will be showing their skills in hardware and novel applications in the exhibition halls. But potential users of ATE still need a lot of education on the subject. I note from the provisional list of papers to be presented that D. B. Gemmell of Membrain Ltd. has submitted one with the intriguing title "Some Fancies and Fantasies in ATE Architecture" that could be amusing as well as instructional.

TECHNICIAN TRAINING

A discussion document on technician training has been produced by a working party of the Institution of Electrical and Electronics Technician Engineers under the chairmanship of Robert Winton of Mullard Ltd. Entitled "The Future Development of Further Education Courses for Technician Engineers and Technicians" it proposes a modular course structure which will bring students forward to the educational standards stipulated by the Engineers' Registration Board.

An "open house" meeting will take place at 2.30 p.m., October 16, at the IEE H.Q., Savoy Place, for those interested in discussing the document with the working party. The document can be obtained free on request from the IEETE, 2 Savoy Hill, London, WC2R 0BS.

CUT-PRICE COMPUTERS

While world meat prices soar, the cost of computing comes tumbling down. Computer Automation is now offering the latest Naked Mini/LSI for less than £500 in quantities of 200 or more. This is a computer-on-a-card, a single PCB of 15 × 17 × 1in dimensions weighing only 4lbs and designed for OEM use.

If you want the same thing boxed as a stand-alone unit with control console, data input keyboard and power supply the cost is £995 for one-off but still, say Computer Automation, less than half the listed price of the PDP-11-05 or Nova 1210 of comparable specification. Secret of the new low price is a central processor that uses only seven MOS LSI chips custom-built for the company.

AUTUMN BOOM

After the August holiday season expect plenty of product and business announcements in September. FR Electronics is concluding marketing deals with more overseas companies. Dymar Electronics will be launching a complete new range of land mobile communications equipment in London on September 12 which could well be countered by a surprise announcement from market leader Pye. But Dymar, one of the liveliest companies in mobile radio, has a fine reputation and should continue to prosper in this highly competitive but fast-expanding field.

Expect, too, some new products from Racal Group whose 5th biennial Racalex exhibition and conference opens on September 25

RAIDING PARTY

While British TV manufacturers are worried about the invasion of Japanese sets in the UK market, a group of British components and equipment manufacturers will be probing the Japanese market at the great Japan Electronics Show in Osaka in October.

Fifteen companies are taking the long trip East with the backing of the Department of Trade and Industry and the Electronic Engineering Association. Trade prospects in Japan, say the DTI, are good for companies that have the right products.

Readout—

A SELECTION FROM OUR POSTBAG

Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.

PLUGGING THE LEAK

Sir—With regard to your present series of articles "P.E. Sound Synthesiser". First, may I point out, that my comments are in no way intended to "have a go" at Mr Shaw's circuits, which show considerable technical ability and have no doubt required considerable effort on his behalf.

I have found, however, during evaluation of the Ramp Generator circuit a possible snag and therefore supply my findings as other readers may find my conclusions useful.

In Mr Shaw's circuit, an OC140 transistor is employed to switch the direction of integration. It would appear that the two main factors governing the choice of transistor type are; low leakage—since the transistor is in a high current amplifying loop—and high base/emitter reverse bias capability—since the emitter is fixed at −3·5V during main ramp, with the base held at approximately −14V by the comparator output.

On testing my constructed generator, it was found that upon switching on the integrator output ramped positive to its positive saturation level, although zero volts was applied to the input and the 10 megohm shunt in circuit. Adjustment of the offset null pot proved useless.

The problem, it was found, was due to leakage in TR1, being sufficient to drive the integrator, which once started, naturally continued to ramp until hitting the rail; the leakage being too large to be offset by the null control.

I believe Mr Shaw's choice of transistor was due to the OC140's base/emitter reverse bias capability, which is in the order of 20V; however, the leakage current of the device, being of germanium junction construction, can be as high as 3 microamps, more than adequate to cause IC1 to integrate. Further, since the direction of integration produced is positive, the comparator cannot switch and a steady state is produced with IC1 output "stuck" at the positive rail.

My suggested solution to the problem, should it arise, is as follows:

The OC140 may be replaced by a silicon transistor such as a BC109; this will reduce the maximum possible leakage current to nA. However, since the BC109 cannot withstand the high reverse bias, the base/emitter junction will Zener. This will not affect the circuit operation, but if it is considered "not nice" to Zener the junction, a small signal diode—such as an 1N914—can be inserted in series with the base to protect the transistor.

Finally, since a silicon transistor has a higher "on" resistance than a germanium device the 82 ohm resistor should be reduced in value until the ramp starts at zero volts. Without modification of this value the ramp will be approximately 200mV negative of earth.

Alan A. Thomas,
Engineering Dept.,
Dolby Laboratories Inc.

I am indebted to Mr Thomas who, with his lucid explanation of an apparent fault in the Ramp Generator, has highlighted an omission in the setting-up procedure for which I humbly apologise.

In order to avoid the problems associated with current leakage through TR1 it is necessary to temporarily disconnect R6 from the summing junction of IC1 during the balancing of the offset. With the setting-up procedure as outlined in the original text IC1 can be prevented from going into positive saturation by adjustment of VR1 to counteract the leakage through TR1 but this is a rather unsatisfactory method since it is not possible to be absolutely sure of the input conditions at IC1 and thus there is little point in nulling the offset.

Mr Thomas's suggestion of replacing the OC140 with a diode protected BC109 is particularly valid since it has been learned that, although the OC140 is still available from a number of sources, it is now considered to be an obsolete device.

G. D. Shaw

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Anyone who can supply the undermentioned are asked to communicate directly with the reader.

We regret that back numbers of Practical Electronics can no longer be supplied. We will try to publish announcements of readers' requirements (without a guaranteed date) free of charge.

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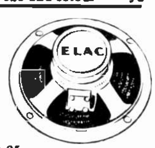

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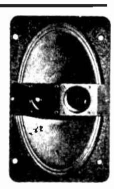

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MIDGET 220V 45mA, 6·3V 2A, 2¾ × 2¼ × 2in	90p
HEATER TRANS. 6·3V 3A	60p
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2A, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30V	£2·80
1A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V	£2·80
2A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V	£3·80
5A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V	£8·75
3A, 5, 8, 13V £1·00, Ditto 5A	£1·20
3A, 5, 8, 10, 13V, 5-0-5V £1·30, Ditto 5A	£1·50
6–0–6 500 mA	90p
9V 1 amp	95p
12V 300 mA	75p
12V 500 mA	85p
12V 750 mA	95p

AUTO TRANSFORMERS. 115V to 230V or 230V to 115V. 150W £2·80; 500W £6·25; 750W £10; 1000W £15.
CHARGER TRANSFORMERS. Input 200/250V. for 6 or 12V, 1½A, £1·50; 2A, £1·80; 4A, £2·50.
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Primary 0-110-240V. Secondary 0-240V. 3A. 720W. Insulated terminals. Varnish impregnated. Fully enclosed in steel case with fixing feet. Famous make. (Value £19) OUR PRICE **£10** Carr. 50p
Can be used as 800W auto transformers 240-110V.
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4/350V	14p	500/25V	20p	60+100/350V	85p
8/450V	18p	1000/25V	35p	32+32/250V	20p
16/450V	22p	1000/50V	47p	32+32/450V	45p
32/450V	35p	8+8/450V	22p	350+50/325V	55p
25/25V	10p	8+16/450V	25p	32+32+32/350V	55p
50/50V	10p	16+16/450V	40p	100+50+50/350V	55p
100/25V	10p	32+32/350V	40p		

LOW VOLTAGE ELECTROLYTICS.
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p.
500mF 12V 15p; 25V 20p; 50V 30p.
1000mF 12V 17p; 25V 35p; 50V 47p; 100V 70p.
2000mF 6V 25p; 25V 42p; 50V 57p.
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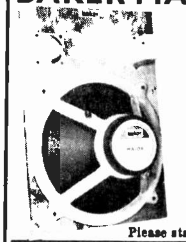

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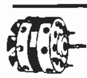

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Type	Price p
AC107	22
AC113	20
AC115	22
AC117K	32
AC122	13
AC125	19
AC126	19
AC127	20
AC128	20
AC132	16
AC134	16
AC137	16
AC141	20
AC141K	32
AC142	20
AC142K	28
AC151	17
AC154	22
AC155	22
AC156	22
AC157	27
AC165	22
AC166	22
AC167	22
AC168	27
AC169	16
AC176	22
AC177	27
AC178	31
AC178	31
AC179	31
AC180	22
AC180K	32
AC181	22
AC181K	32
AC187	24
AC187K	25
AC188	24
AC188K	25
ACY17	28
ACY18	22
ACY19	22
ACY20	22
ACY21	22
ACY22	18
ACY27	20
ACY28	21
ACY29	39
ACY30	31
ACY31	31
ACY34	23
ACY35	23
ACY36	31
ACY40	19
ACY41	20
ACY44	39
AD130	42
AD140	53
AD142	53
AD143	42
AD149	55

Type	Price p
AD161	37
AD162	37
AD161 & AD162 (MP)	61
ADT140	55
AF114	27
AF115	27
AF116	27
AF117	27
AF118	39
AF124	33
AF125	33
AF126	31
AF127	31
AF139	33
AF178	55
AF179	55
AF180	55
AF181	55
AF186	55
AF239	41
AL102	72
AL103	72
ASY26	28
ASY27	33
ASY28	28
ASY29	28
ASY50	28
ASY51	28
ASY52	28
ASY54	28
ASY55	28
ASY56	28
ASY57	28
ASY58	28
ASY73	28
ASZ21	44
BC107	10
BC108	10
BC109	11
BC113	11
BC114	17
BC115	17
BC116	17
BC117	20
BC118	11
BC119	33
BC120	88
BC125	13
BC126	20
BC132	13
BC134	20
BC135	13
BC136	17
BC137	17
BC139	44
BC140	33
BC141	33
BC142	33
BC143	33

Type	Price p
BC145	50
BC147	11
BC148	11
BC149	13
BC150	20
BC151	22
BC152	19
BC153	31
BC154	33
BC157	20
BC158	13
BC159	13
BC160	50
BC161	55
BC167	13
BC168	13
BC169	13
BC170	13
BC171	16
BC172	16
BC173	16
BC174	16
BC175	24
BC177	21
BC178	21
BC179	21
BC180	27
BC181	27
BC182	11
BC182L	11
BC183	11
BC183L	11
BC184	13
BC184L	13
BC186	31
BC187	31
BC207	12
BC208	12
BC209	13
BC212L	12
BC213L	12
BC214L	16
BC225	28
BC226	39
BC301	30
BC302	27
BC303	35
BC304	40
BC440	34
BC460	40
BCY30	27
BCY31	29
BCY32	33
BCY33	24
BCY34	28
BCY70	16
BCY71	22
BCY72	16
BCZ10	22
BCZ11	28
BCZ12	28

Type	Price p
BD115	68
BD116	88
BD121	66
BD123	72
BD124	76
BD131	55
BD132	66
BD133	72
BD135	44
BD136	44
BD137	50
BD138	55
BD139	61
BD140	66
BD155	88
BD175	66
BD176	66
BD177	72
BD178	72
BD179	77
BD180	77
BD185	72
BD186	72
BD187	77
BD188	77
BD189	83
BD190	88
BD195	94
BD196	94
BD197	99
BD198	99
BD199	£1·05
BD200	£1·05
BD205	88
BD206	88
BD207	£1·05
BD208	£1·05
BDY20	£1·10
BF115	27
BF117	50
BF118	77
BF119	77
BF121	50
BF123	55
BF125	50
BF127	55
BF152	61
BF153	50
BF154	50
BF155	77
BF156	53
BF157	61
BF158	61
BF159	66
BF160	44
BF162	44
BF163	44
BF164	44
BF165	44
BF167	24
BF173	24

Type	Price p
BF176	39
BF177	39
BF178	33
BF179	33
BF180	33
BF181	33
BF182	44
BF183	44
BF184	28
BF185	33
BF187	30
BF188	44
BF194	13
BF195	13
BF196	16
BF197	16
BF200	50
BF222	£1·05
BF257	50
BF258	66
BF259	94
BF262	61
BF263	61
BF270	39
BF271	33
BF272	88
BF273	39
BF274	39
BFW10	66
BFX29	30
BFX84	24
BFX85	33
BFX86	24
BFX87	27
BFX88	24
BFY50	22
BFY51	22
BFY52	22
BFY53	19
BPX25	94
BSX19	17
BSX20	17
BSY25	17
BSY26	17
BSY27	17
BSY28	17
BSY29	17
BSY38	20
BSY39	20
BSY40	31
BSY41	31
BSY95	14
BSY95A	14
Bu105	£2·20
C111E	55
C400	33
C407	28
C424	28
C425	55
C426	39
C428	22

Type	Price p
C441	33
C442	33
C444	39
C450	24
MAT100	21
MAT101	22
MAT120	21
MAT121	22
MJE2955	95
MJE3055	62
MJE3440	55
MPF102	46
MPF104	41
MPF105	41
OC19	39
OC20	70
OC22	52
OC23	54
OC24	62
OC25	42
OC26	32
OC28	55
OC29	55
OC35	46
OC36	55
OC41	22
OC42	27
OC44	17
OC45	14
OC70	11
OC71	11
OC72	16
OC74	16
OC75	17
OC76	17
OC77	28
OC81	17
OC81D	17
OC82	17
OC82D	17
OC83	22
OC139	22
OC140	22
OC169	28
OC170	28
OC171	28
OC200	28
OC201	31
OC202	31
OC203	28
OC204	28
OC205	39
OC309	44
OCP71	48
ORP12	48
ORP60	44
ORP61	44
P20	55
P21	50
P346A	22
P397	46

Type	Price p
ST140	14
ST141	19
TIS43	33
UT46	30
ZN414	£1·20
2G301	21
2G302	21
2G303	21
2G304	27
2G306	44
2G308	39
2G309	39
2G339	22
2G339A	18
2G344	20
2G345	18
2G371	18
2G371B	13
2G373	19
2G374	19
2G377	33
2G378	18
2G381	18
2G382	18
2G401	33
2G414	33
2G417	28
2N388	89
2N388A	61
2N404	22
2N404A	31
2N524	46
2N527	54
2N598	46
2N599	50
2N696	14
2N697	15
2N698	27
2N699	39
2N706	9
2N706A	10
2N708	13
2N711	33
2N717	39
2N718	27
2N718A	55
2N726	31
2N727	31
2N743	22
2N744	22
2N914	16
2N918	33
2N929	23
2N930	23
2N1131	22
2N1132	24
2N1302	16
2N1303	16
2N1304	19
2N1305	19
2N1306	23

Type	Price p
2N1307	23
2N1308	26
2N1309	26
2N1613	22
2N1711	22
2N1889	35
2N1890	50
2N1893	41
2N2147	79
2N2148	63
2N2160	66
2N2192	39
2N2193	39
2N2194	39
2N2217	24
2N2218	22
2N2219	22
2N2220	24
2N2221	22
2N2222	22
2N2368	19
2N22369	16
2N2369A	16
2N2411	27
2N2412	27
2N2646	52
2N2711	23
2N2712	23
2N2714	23
2N2904	19
2N2904A	23
2N2905	23
2N2905A	23
2N2906	17
2N2906A	20
2N2907	22
2N2907A	24
2N2923	16
2N2924	16
2N2925	16
2N2926(G)	14
2N2926(Y)	12
2N2926(O)	11

Type	Price p
2N2926(R)	11
2N2926(B)	11
2N3010	77
2N3011	16
2N3053	19
2N3054	51
2N3055	55
2N3391	16
2N3391A	18
2N3392	16
2N3393	16
2N3394	16
2N3395	19
2N3402	23
2N3403	23
2N3404	31
2N3405	46
2N3414	17
2N3415	17
2N3416	31
2N3417	31
2N3525	83
2N3614	74
2N3615	82
2N3616	82
2N3646	10
2N3702	13
2N3703	13
2N3704	14
2N3705	13
2N3706	13
2N3707	14
2N3708	9
2N3709	10
2N3710	10
2N3711	10
2N3819	31
2N3820	55
2N3821	39
2N3823	31
2N3903	31
2N3904	33
2N3905	31

Type	Price p
2N3906	30
2N4058	13
2N4059	11
2N4060	13
2N4061	13
2N4062	13
2N4284	19
2N4285	19
2N4286	19
2N4287	19
2N4288	19
2N4289	19
2N4290	19
2N4291	19
2N4292	19
2N4293	19
2N5172	13
2N5294	60
2N5457	35
2N5458	35
2N5459	44
2N6211	75
2S301	55
2S302A	46
2S302	46
2S303	61
2S304	77
2S305	86
2S306	86
2S307	86
2S321	62
2S322	46
2S322A	46
2S323	62
2S324	77
2S325	77
2S326	77
2S327	77
2S701	46
40361	44
40362	50

DIODES AND RECTIFIERS

AA119	0·09	BY114	0·13	BYZ18	0·39
AA120	0·09	BY126	0·16	BYZ19	0·31
AA129	0·09	BY127	0·17	CG62	
AAY30	0·10	BY128	0·17	(OA91 Eq.)	
AAZ13	0·11	BY130	0·18		0·06
BA100	0·11	BY133	0·23	CG651—	
BA116	0·23	BY164	0·55	(OA70–OA79)	
BA126	0·24	BYX38/30			0·07
BA148	0·16		0·46	OA5	0·39
BA154	0·13	BYZ10	0·39	OA5SL	0·23
BA155	0·16	BYZ11	0·33	OA10	0·39
BA156	0·15	BYZ12	0·33	OA47	0·08
BY100	0·17	BYZ13	0·28	OA70	0·08
BY101	0·13	BYZ16	0·44	OA79	0·08
BY105	0·19	BYZ17	0·39	OA81	0·08

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Type No.	Price 1-24	25-99	100 up
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BP701C-SL701C	50p	45p	40p
BP702C-SL702C	50p	45p	40p
BP702-72702	50p	48p	45p
BP709-72709	35p	33p	30p
BP709P-μA709C	35p	33p	30p
BP710-72710	45p	43p	40p
BP711-μA711	45p	43p	40p
BP741-72741	40p	38p	35p
μA703C	28p	26p	24p
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TAA350	£1·85	£1·80	£1·70

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CD66	£1·87
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3015F Minitron	£1·50

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	Price each 1-24	25-99	100 up
UL900	38p	36p	29p
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Type	Price 1	25	100+
BP930	15p	14p	13p
BP932	16p	15p	14p
BP933	16p	15p	14p
BP935	16p	15p	14p
BP936	16p	15p	14p
BP944	16p	15p	14p
BP945	30p	28p	25p
BP946	15p	14p	13p
BP948	30p	28p	25p
BP951	70p	65p	60p
BP962	15p	14p	13p
BP9093	45p	43p	40p
BP9094	45p	43p	40p
BP9097	45p	43p	40p
BP9099	45p	43p	40p

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TO3 Plastic 1·5 Amps

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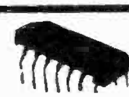

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SN7404	0·17	0·16	0·15
SN7405	0·17	0·16	0·15
SN7406	0·39	0·34	0·31
SN7407	0·39	0·34	0·31
SN7408	0·20	0·19	0·18
SN7409	0·20	0·19	0·18
SN7410	0·17	0·16	0·18
SN7411	0·28	0·27	0·26
SN7412	0·39	0·34	0·31
SN7413	0·32	0·29	0·27
SN7416	0·48	0·44	0·42
SN7417	0·48	0·44	0·42
SN7420	0·17	0·16	0·15
SN7422	0·55	0·53	0·50
SN7423	0·55	0·53	0·50
SN7425	0·55	0·53	0·50
SN7426	0·50	0·46	0·44
SN7427	0·50	0·46	0·44
SN7428	0·77	0·72	0·66
SN7430	0·17	0·16	0·15
SN7432	0·50	0·46	0·44
SN7433	0·88	0·83	0·77
SN7437	0·71	0·68	0·66
SN7438	0·71	0·68	0·66
SN7440	0·17	0·16	0·15
SN7441	0·74	0·71	0·64
SN7442	0·74	0·71	0·64
SN7443	1·43	1·38	1·32
SN7444	1·43	1·38	1·32
SN7445	1·98	1·95	1·93
SN7446	1·07	1·04	0·97
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SN7451	0·17	0·16	0·15
SN7453	0·17	0·16	0·15
SN7454	0·17	0·16	0·15
SN7460	0·17	0·16	0·15
SN7470	0·32	0·29	0·27
SN7472	0·32	0·29	0·27
SN7473	0·41	0·39	0·35
SN7474	0·41	0·39	0·35
SN7475	0·50	0·48	0·46
SN7476	0·44	0·43	0·42
SN7480	0·74	0·71	0·64
SN7481	1·32	1·27	1·21
SN7482	0·96	0·95	0·94
SN7483	1·21	1·16	1·05
SN7484	1·10	1·05	0·99
SN7485	3·96	3·85	3·74
SN7486	0·35	0·34	0·33
SN7489	6·05	5·78	5·50
SN7490	0·74	0·71	0·64
SN7491	1·10	1·05	0·99
SN7492	0·74	0·71	0·64
SN7493	0·74	0·71	0·64
SN7494	0·85	0·82	0·75
SN7495	0·85	0·82	0·75
SN7496	0·96	0·93	0·86
SN74100	1·82	1·76	1·71
SN74104	1·07	1·04	0·97
SN74105	1·07	1·04	0·97
SN74107	0·44	0·42	0·40
SN74110	0·61	0·59	0·55
SN74111	1·38	1·27	1·21
SN74118	1·10	1·05	0·99
SN74119	1·49	1·38	1·21
SN74121	0·44	0·41	0·38
SN74122	1·54	1·43	1·21
SN74123	3·08	2·97	2·86

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SN74153	1·32	1·21	1·05
SN74154	1·98	1·87	1·76
SN74155	1·54	1·43	1·32
SN74156	1·54	1·43	1·32
SN74157	2·09	1·98	1·87
SN74160	1·98	1·87	1·76
SN74161	1·98	1·87	1·76
SN74162	4·40	4·13	3·85
SN74163	4·40	4·13	3·85
SN74164	2·43	2·37	2·31
SN74165	2·48	2·42	2·37
SN74166	3·85	3·58	3·30
SN74174	2·53	2·42	2·31
SN74175	1·76	1·65	1·54
SN74176	2·75	2·64	2·53
SN74177	2·75	2·64	2·53
SN74180	2·20	1·76	1·54
SN74181	6·05	5·50	5·23
SN74182	2·20	1·98	1·76
SN74184	3·85	3·58	3·30
SN74190	2·15	2·09	2·04
SN74191	2·09	2·04	1·98
SN74192	2·15	2·09	2·04
SN74193	2·20	1·98	1·93
SN74194	2·97	2·86	2·75
SN74195	2·20	2·09	1·98
SN74196	1·98	1·87	1·76
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Coded and Guaranteed

Pak No.			EQVT
T1	8	2G3713	OC71
T2	8	D1374	OC75
T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

All 55p each pak

ND120 NIXIE DRIVER TRANSISTOR. Suitable replacement for BSX21, C407, 2N1893 120veb

1	25	100+
0·19	0·17	0·16

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 6p each. Any Quantity.

GP100 TO3 METAL CASE GERMANIUM
Vebo=80V. Vceo=50V. I.C.=10 amps. Ptot=30W. hfe=30–170. Replaces the majority of Germanium power transistors in the OC, AD and NKT range.

1	25	100+
0·48	0·44	0·40

GP300 TO3 METAL CASE SILICON
Vebo=100V. Veco=60V I.C.=15 amps. Ptot=115W. hfe=20. 100fT.=1MHz. Suitable replacement for 2N3055, BDY11 or BDY20.

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Q 7	4	AC128 transistors *pnp* high gain	0·55
Q 8	4	AC126 transistors *pnp*	0·55
Q 9	7	OC81 type transistors	0·55
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Q11	2	AC127/128 Complementary pairs *pnp/npn*	0·55
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Q13	3	AF117 type transistors	0·55
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Q17	5	*npn* 2 × ST.141 & 3 × ST.140	0·55
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120	0·55
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Q21	4	AC127 *npn* Germanium transistors	0·55
Q22	20	NKT transistors A.F. R.F. coded	0·55
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Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·55
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Q32	3	*pnp* Silicon transistors 2 × 2N1131, 1 × 2N1132	0·55
Q33	3	Silicon *npn* transistors 2N1711	0·55
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Q35	3	Silicon *pnp* TO-5. 2 × 2N2904 & 1 × 2N2905	0·55
Q36	7	2N3646 TO-18 plastic 300MHz *npn*	0·55
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Q38	7	*pnp* transistors 4 × 2N3703, 3 × 2N3702	0·55

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U 4	40	Germanium Transistors like OC81, AC128	0·55
U 5	60	200mA Sub-Min. Silicon Diodes	0·55
U 6	30	Sil. Planar Trans. NPN like BSY95A, 2N706	0·55
U 7	16	Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·55
U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·55
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·55
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Code Nos. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-33V. 400mW (DO-7 Case) 15p ea. 1½W (Top-Hat) 20p ea. 10W (SO-10 Stud) 33p ea.

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	PIV	50 £p	100 £p	200 £p	400 £p	600 £p	800 £p
1A	TO5	0·22	0·27	0·27	0·32	0·42	0·63
3A	TO66	0·27	0·27	0·32	0·42	0·52	0·70
5A	TO66	0·39	0·52	0·54	0·59	0·75	0·88
5A	TO64	0·39	0·52	0·54	0·62	0·75	0·88
7A	TO48	0·52	0·55	0·62	0·67	0·84	0·99
10A	TO48	0·55	0·63	0·67	0·83	1·07	1·32
16A	TO48	0·58	0·62	0·67	0·77	0·97	1·50
30A	TO48	1·27	1·54	1·76	1·93	—	4·40

SIL. RECTS. TESTED

PIV	300mA DO7	750mA SO16	1A Plastic	1·5A SO16	3A SO10	10A SO10	30A TO48
50	0·05	0·06	0·05	0·08	0·15	0·21	0·60
100	0·05	0·07	0·06	0·10	0·17	0·23	0·75
200	0·06	0·10	0·07	0·12	0·22	0·25	1·00
400	0·08	0·15	0·08	0·15	0·30	0·38	1·35
600	0·09	0·17	0·10	0·18	0·36	0·45	1·90
800	0·12	0·19	0·11	0·20	0·38	0·55	2·10
1000	0·14	0·30	0·12	0·25	0·48	0·65	2·50
1200	—	0·35	—	0·30	0·58	0·75	3·00

INTEGRATED CIRCUIT PAKS

Manufacturers' "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

Pak No.	Contents	Price	Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	=12×7400	0·55	UIC46	=5×7446	0·55	UIC86	=5×7486	0·55
UIC01	=12×7401	0·55	UIC48	=5×7448	0·55	UIC90	=5×7490	0·55
UIC02	=12×7402	0·55	UIC50	=12×7450	0·55	UIC91	=5×7491	0·55
UIC03	=12×7403	0·55	UIC51	=12×7451	0·55	UIC92	=5×7492	0·55
UIC04	=12×7404	0·55	UIC53	=12×7453	0·55	UIC93	=5×7493	0·55
UIC05	=12×7405	0·55	UIC54	=12×7454	0·55	UIC94	=5×7494	0·55
UIC06	=8×7406	0·55	UIC60	=12×7460	0·55	UIC95	=5×7495	0·55
UIC07	=8×7407	0·55	UIC70	=8×7470	0·55	UIC96	=5×7496	0·55
UIC10	=12×7410	0·55	UIC72	=8×7472	0·55	UIC100	=5×74100	0·55
UIC20	=12×7420	0·55	UIC73	=8×7473	0·55	UIC121	=5×74121	0·55
UIC30	=12×7430	0·55	UIC74	=8×7474	0·55	UIC141	=5×74141	0·55
UIC40	=12×7440	0·55	UIC76	=8×7476	0·55	UIC151	=5×74151	0·55
UIC41	=5×7441	0·55	UIC80	=5×7480	0·55	UIC154	=5×74154	0·55
UIC42	=5×7442	0·55	UIC81	=5×7481	0·55	UIC193	=5×74193	0·55
UIC43	=5×7443	0·55	UIC82	=5×7482	0·55	UIC199	=5×74199	0·55
UIC44	=5×7444	0·55	UIC83	=5×7483	0·55	UICXI	=25 Assorted 74's	1·65
UIC45	=5×7445	0·55						

Paks cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

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F.E.T.'S

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100 v RMS	40p ,,
400 v RMS	50p ,,

Size 16 mm × 16 mm.

D1699 NPN SILICON DUAL TRANSISTOR (Similar to 2N2060)

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0·28	0·26	0·23

BIP 19/20 TO3 NPN PLASTIC SILICON
Vebo=100V. Vceo=50V. I.C.=10 amps. Ptot 50W hfe=typ. 100 fT=3MHz.

1	25	100+
0·38	0·35	0·32

BIP 19/20 Matched Pair.

1	25	100+
0·66	0·61	0·55

RECORD PLAYBACK HEADS (TRUVOX)
Individual prices of these are:—
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Erase heads are also available separately—2 track **33p**—4 track **55p**.
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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. **£1·95.** 13p post and p. Made up model also available. **£2·95.**

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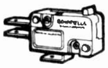
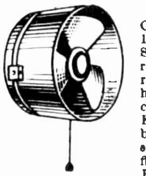
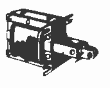
13 amp self-fixing into an oblong hole. Size approximately 1" × ⅝" **9p** each, 10 for **82p.**

SLIDE SWITCHES
Slide Switch. 2-pole changeover panel mounting by two 6B.A. screws. Size approx. 1in × ½in rated 250V lamp. **8p** each. 10 for **73p.** Ditto as above but for printed circuit **6p** each 10 for **63p.** **Sub Miniature Slide Switch.** DPDT 19mm (¾in approx.) between fixing centres. **20p** each or 10 for **£1·90.** SP Change over spring return 250V 1 amp. **11p.**

MICRO SWITCH

5 amp changeover contacts, **11p** each. 10 for **99p.** 15 amp on/off. Model **15p** each. Changeover **19p** each.



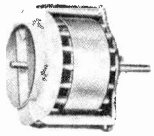
EXTRACTOR FAN
Cleans the air at the rate of 10,000 cubic ft. per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5½in casing with 5½in fan blades. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. **£2·75** + 20p P. & P.

MAINS OPERATED SOLENOIDS

Model 772 — small but powerful 1in pull—approx. size 1½ × 1¼ × 1¼in **68p.**
Model 4001/—½in. pull. Size 2¾ × 2 × 1⅝in. **83p.**
Model TT1—1¼in pull. Size 3 × 2½ × 2in **£1·98**
plus 20p post and insurance.

MAINS TRANSISTOR POWER PACK
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1·10.** Plus 20p postage.

DESK TELEPHONES

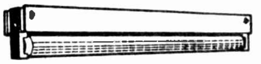
Ex G.P.O. Black standard model with dialing dial but no internal bell. Supplied with connection diagram **£1** each. Ditto, with bell but without dialing dial **£1·25.** Model as illustrated with bell and dial **£1·50** each plus 50p post for single then 65p per pair.

PAPST MOTORS

Est. 1/40th h.p. Made for 110–120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·65** each. Postage one 23p, two 33p. 23V model **£3·30.**

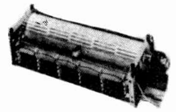
10 AMP DIMMER CONTROL
For the control of lighting on stage or in a studio or for control of portable equipment in workships, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in, width 3½in and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price **£8·25.**

STANDARD WAFER SWITCHES
Standard size 1½in wafer—silver-plated 5 amp contact, standard ¾in spindle 2in long—with locking washer and nut.

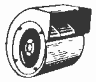
No. of Poles	2way	3way	4way	5way	6way	8way	9way	10way	12way
1 pole	44p	44p	44p	44p	44p	44p	44p	44p	44p
2 poles	44p	44p	44p	44p	44p	44p	44p	77p	77p
3 poles	44p	44p	44p	44p	77p	77p	77p	£1·04	£1·04
4 poles	44p	44p	44p	77p	77p	77p	77p	£1·32	£1·32
5 poles	44p	44p	77p	77p	£1·04	£1·04	£1·04	£1·60	£1·60
6 poles	44p	77p	77p	77p	£1·04	£1·04	£1·04	£1·87	£1·87
7 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·15	£2·15
8 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·42	£2·42
9 poles	77p	77p	£1·04	£1·04	£1·60	£1·60	£1·60	£2·70	£2·70
10 poles	77p	77p	£1·04	£1·32	£1·60	£1·60	£1·60	£3·00	£3·00
11 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·25	£3·25
12 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·52	£3·52

THE TWENTYLITE

Fluorescent lighting units with polyester choke and finished white enamel. 2ft. model, ideal kitchen, bedroom, hallway, porch, lift, etc., with tube. Assembled ready to install. Price **£2·20** + 40p P. & P.

MULLARD UNILEX
This D.I.Y. Stereo Amplifier is still available complete at **£7·00** for the four Mullard Modules, or Modules can be bought separately as follows:—
4 watt amplifier module (2 required) Mullard Ref. No. E.P.9000—**£1·60.**
Pre amp module Mullard Ref. No. E.P.9001—**£1·98** each.
Power Module—Mullard Ref. No. E.P.9002—**£2·53** each.
In addition and made to Mullard specification we offer:—
Standard Control Unit with escutcheon and knobs—**£3·30.**
Knobs—Set of 4—**50p.**
Special offer the complete Unilex with control panel at Pre VAT price **£10·00** post paid.

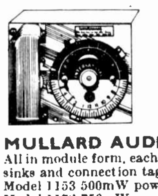
TANGENTIAL HEATER UNIT

This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. **£3·85.** 2kW Model as above except 2kW **£2·75.** Don't miss this. Control Switch **35p.** P. & P. 40p.

THIS MONTH'S SNIP
Room Thermostat made by the famous Smiths Company. 15 amp at 250V. Elegant white and beige case, size 4½in long by 1¾ square approx. Adjustment is by slider (lockable), adjusts through range 30°–90°F.
Special Snip price **£1·65.**

CENTRIFUGAL FAN

Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1/10th h.p. giving considerable air flows but virtually no noise. Approx. dimensions 10½in wide × 12in dia. outlet into trunking 10¼ × 4½in. **£6·55** plus £1 post and insurance.

TAPE PLAYBACK UNITS

Mains operated. Made by Rediltune the famous "music in background people". These are complete units ready to work and we understand that they are in good going order. We have not tested them but would exchange any that do not work properly. These have a superior motor driven fly wheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle. Two models offered, good as new **£6·50** and somewhat used at **£3·50.** 75p carriage up to 200 miles then 50p per 100 miles extra.



24-HOUR TIME SWITCH
Made by Smiths, these are A.C. mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. Two completely adjustable time periods per 24 hours, 5A changeover contacts will switch circuit on or off during these periods. **£2·75** post and ins. 25p. Additional time contacts **55p** pair.

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output **72p.**
Model 1172 750mW power output **94p.**
Model EP9000 4 watt power output **£1·60.**
EP9001 twin channel or stereo pre amp. **£1·99.**
10% discount if 10 or more ordered.

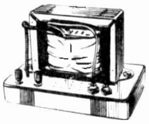
NEW ITEMS THIS MONTH

MINIATURE SEALED RELAY
American made. Our Ref.: REL A1. Measures only ¾in wide × ¾in thick and ½in high and it's a double change over, we don't know the contact rating but estimate this at 3/5 amps. The coil resistance is 600 ohms and 9–12 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price **28p** including base.

SUB-MINIATURE MICROSWITCH
Made by Burgess, their ref. V4T6 our ref. MS. A1. These measure only ¾in × ⅜in × ¼in thick—have change over contracts and tag connection. Price **16p** each or 10 for **£1·44.**

3 CORE MAINS FLEX
Metric size 0·5mm which is approx. equivalent to the old 14/36 rating. Suitable therefore for mower or similar portable tools. Cores are colour coded to the new European standard. Brown—live; Blue—neutral; Yellow/Green—earth. Grey P.V.C. covered overall. 100m coils **£5.** 50m coils **£3** and 25m coils **£1·75.** Post 40p on 100m. **25p** for 50m coils and **20p** for 25m coils.

PANIC SWITCHES
Tough enough to be foot switches and elegant enough to be panel switches. Bakelite construction with white push rod. Price **40p** less quantity discounts. Switch is rated 250v–2 amp.

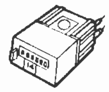


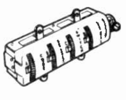
12 VOLT 1½ AMP POWER PACK
This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 mF smoothing. Price **£2·20,** plus 20p post and packing.

6 MAINS TRANSFORMERS
Our Ref.: MTM1 27 volt at 8 amp. Upright mounting fully shrouded—flying leads—fully tapped primary. Price **£3·30.**
Our Ref.: MTM2 12v at 1 amp. Upright mounting with fixing lugs, tag connection. 240v primary—12v 1 amp secondary. Price **82p.**
Our Ref.: MTM3 6·3v 2 amp upright mounting with fixing lugs, tag connections, 240v primary 6·3v 2 amp secondary. Price **77p.**
Our Ref. MTM4 18v–½ amp with thermal cut-out, upright mounting with fixing lugs-tag connections. Primary 240v—secondary 18v at ½ amp. Price **88p.**
Mains Isolation MTM5 350 watts earth shielded—flex leads—upright mounting lugs for fixing. Price **£4·40** each.

6 VOLT RELAYS
Our ref.: REL M1. Removable clear plastic enclosed two screw fixing. Have a 6 volt D.C. operated coil but two change-over contacts, each rated to make and break 240v A.C. at 15 amps. Price **66p** each.

P.O. TYPE 3000 RELAY
Our ref.: REL M2—100 ohms coil and 2 pair normally open heavy duty contacts. Price **75p** each.

6 DIGIT COUNTER

Resettable. 440 ohm coil up to 25 impulses per second. Ex-equipment but guaranteed perfect. **£2·20** each.

COMBINATION SWITCH

This comprises of 12 miniature change - over micro switches. Joined in banks of 3 and mounted on frame with four digital numbered thumb wheels and a removable lever for locking the thumb wheel—the thumb wheel operates 3 banks. Over 4,000 combinations are possible but by re-wiring the switch connections underneath then thousands more variations are possible. If you are making equipment which you don't want switched on accidentally or without authority then this is a switch to consider—this can also be used as a coding switch for many other operations. Very neat and compact and measuring approx. 4in × 1½in × 1½in deep. Priced at **£3·03.**

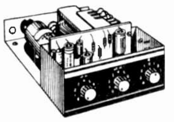
PUSH BUTTON SWITCH
Type 14 D.M.G. A very fine switch made by Honeywell. The switch is intended for mounting on panel through oblong hole. No screws required for fixing its sprung clips secure it quite firmly. The operating button is approx. 1in dia. round and dished for ease of operation. Has 2 sets of 10 amp change-over contacts. Spring loaded, returns to normal when pressure is released. Ideal for instrument or quality gear. Price **50p** each. 10 for **£4·50.** 100 for **£40.**

PHOTO-MULTIPLIER TUBE
American R.C.A. type No. 4555. These tubes have a gain of a million or more. Regular Price—over **£15.** We have a limited quantity and offer these at **£4·50.**

TERMS: 10% discount if ten of an item ordered, send postage where quoted—other items, post free if order for these items is £6·00, otherwise add 20p.

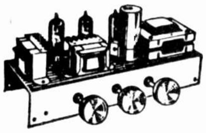
J. BULL (ELECTRICAL) LTD.
(Dept. P.E.), 7 Park Street, Croydon CRO 1YD
Callers to 102/3 Tamworth Road, Croydon

SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz-30KHz ± 3dB. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high × 6in wide × 7½in deep. AC 220/250V.
PRICE £11·60. P. & P. 25p.

DE LUXE STEREO AMPLIFIER



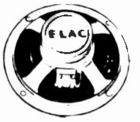
A.C. mains 200-240V. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up:—2 × ECL86 Triode Pentodes. 1 × EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate 'Balance' control fitted at the rear of the chassis. Input sensitivity is approximately 300mV for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11in w × 4in d. Overall height including valves 5in. Ready built and tested to a high standard. **PRICE £9·90** P. & P. 45p.

PRECISION ENGINEERED PLINTHS
Beautifully constructed in heavy gauge "Colorcoat" plastic coated steel. Resonance free. Designed to take Garrard 1025, 2000, 2025TC, 2500, 3000, 3500, 5100, SP25 II and III. SL65B. AT60 etc. or B.S.R. C109, C129, A21, etc. Black leatherette finish. Size 12¼in × 14¼in × 3¼in high (approx. 7¼in high, including rigid smoked acrylic cover).
NOW ONLY £4·95 P. & P. 35p.

SPECIAL OFFER!
HI-FI LOUDSPEAKER SYSTEMS

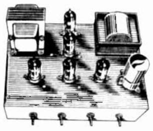
Beautifully made teak finish enclosure with most attractive Tygan-Vynair front. Size 16in high × 10½in wide × 6in deep. Fitted with E.M.I. Ceramic Magnet 13in × 8in bass unit, two H.F. tweeter units and crossover. Maximum power handling 10 watts. Available 3 or 8 or 15 ohms impedance.
OUR PRICE £9·25 Carr. 70p.
Cabinet Available Separately £4·95 Carr 65p.
Also available in 8 ohms with EMI 13 in × 8in bass speaker with parasitic tweeter £7·15 Carr. 70p.

HAVERSON'S SUPER MONO AMPLIFIER
A super quality gram amplifier using a double wound fully isolated mains transformer, rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. high overall. A.C. mains 200/240V. Supplied absolutely Brand New completely wired and tested with good quality output transformer.
BARGAIN PRICE **£3·30** P. & P. 35p.



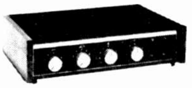
SPECIAL OFFER!
LIMITED NUMBER OF BRAND NEW ELAC 10in TWIN CONE LOUDSPEAKERS
With large ceramic magnet and plasticised cone surround.
8 ohm impedance. **£2·70.** P. & P. 25p.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 15p + SAE (Free with parts). **All parts sold separately. ONLY £8·80** P & P. 55p. Also available ready built and tested **£12·10** P. & P. 60p.

HARVERSONIC SUPER SOUND 10 + 10 STEREO AMPLIFIER KIT



NEW FURTHER IMPROVED MODEL WITH HIGHER OUTPUT AND INCORPORATING HIGH QUALITY READY DRILLED FIBRE GLASS PRINTED CIRCUIT BOARD WITH COMPONENT IDENTIFICATION CLEARLY MARKED FOR EVEN EASIER CONSTRUCTION.

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled fibreglass printed circuit board, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output: 14 watts r.m.s. per channel into 5 ohms. Frequency response ± 3dB 12-30,000Hz Sensitivity: better than 80mV into 1MΩ. Full power bandwidth: ± 3dB 12-15,000Hz. Bass boost approx. to ± 12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1·0 amp. Overall Size 12in w. × 8in d. × 2½in h. Fully detailed 7 page construction manual and parts list free with kit or send 18p plus large S.A.E.

AMPLIFIER KIT ..	**£11·55**	P. & P. 18p
(Magnetic input components 33p extra)		
POWER PACK KIT ..	**£3·30**	P. & P. 33p
CABINET	**£3·30**	P. & P. 33p

(Post Free if all units purchased at same time)
Full after sales service
Also available ready built and tested **£23·10.** Post Free.

QUALITY RECORD PLAYER AMPLIFIER MK. II
A top quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. wide × 3in. deep × 6in. high. Ready built and tested. PRICE **£4·40** P. & P. 40p.
ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE **£5·85** P. & P. 50p.

Open 9-5.30 Mon. to Fri. 9-5 Sat. Early closing Wed. 1 p.m.
A few minutes from South Wimbledon Tube Station.
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HARVERSON SURPLUS CO. LTD.
(Dept. P.E.) 170 HIGH ST., MERTON, LONDON, S.W.19 Tel. 01-540 3985
SEND STAMPED ADDRESSED ENVELOPE WITH ALL ENQUIRIES

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

NORTH AMERICAN SEMICONDUCTOR COMPANY LIMITED

TRANSISTORS

2N696	0·150	2N2219A	0·270	2N3108	0·540	2N3638	0·120	2N4135	1·500	2N5132	0·080
2N697	0·180	2N2221	0·190	2N3109	0·540	2N3638A	0·130	2N4140	0·270	2N5133	0·080
2N699	0·340	2N2221A	0·230	2N3110	0·540	2N3639	0·200	2N4141	0·290	2N5134	0·090
2N706	0·100	2N2222	0·190	2N3117	0·850	2N3640	0·200	2N4142	0·310	2N5135	0·090
2N708	0·145	2N2222A	0·245	2N3120	0·540	2N3641	0·150	2N4143	0·320	2N5137	0·100
2N718	0·230	2N2243	0·930	2N3121	0·580	2N3642	0·150	2N4208	1·670	2N5138	0·090
2N722	0·680	2N2243A	0·930	2N3133	0·280	2N3643	0·150	2N4209	2·000	2N5139	0·090
2N744	0·180	2N2270	0·390	2N3134	0·280	2N3644	0·160	2N4227	0·300	2N5140	0·170
2N753	0·180	2N2297	0·400	2N3135	0·280	2N3645	0·160	2N4228	0·370	2N5141	0·165
2N760	0·270	2N2303	1·330	2N3136	0·280	2N3646	0·130	2N4248	0·110	2N5142	0·105
2N760A	0·270	2N2368	0·150	2N3209	0·605	2N3665	0·800	2N4249	0·130	2N5143	0·105
2N834	0·255	2N2369	0·155	2N3248	1·690	2N3666	0·950	2N4250	0·150	2N5910	0·270
2N914	0·200	2N2369A	0·170	2N3249	2·020	2N3691	0·150	2N4257	0·175	BC107	0·130
2N915	0·380	2N2483	0·210	2N3250	0·300	2N3692	0·150	2N4257A	0·230	BC108	0·420
2N916	0·300	2N2484	0·245	2N3250A	0·440	2N3693	0·150	2N4258	0·245	BC109	0·140
2N917	0·330	2N2509	0·710	2N3251	0·580	2N3694	0·150	2N4258A	0·275	BC177	0·180
2N918	0·330	2N2510	0·710	2N3251A	0·620	2N3724	0·420	2N4274	0·135	BC178	0·180
2N929	0·165	2N2511	1·130	2N3252	0·680	2N3724A	1·100	2N4275	0·135	BC179	0·180
2N929A	0·740	2N2586	1·080	2N3253	0·740	2N3725	0·425	2N4313	0·250	BC261A	0·340
2N930	0·190	2N2604	1·300	2N3299	0·340	2N3725A	1·090	2N4354	0·210	BC261B	0·340
2N930A	0·680	2N2605	0·640	2N3300	0·405	2N3734	1·170	2N4355	0·240	BC262A	0·360
2N956	0·320	2N2657	3·070	2N3301	0·285	2N3735	2·700	2N4356	0·240	BC262B	0·360
2N980	2·210	2N2658	4·500	2N3302	0·420	2N3903	0·165	2N4400	0·190	BC263A	0·380
2N995	1·080	2N2890	3·600	2N3304	0·700	2N3904	0·160	2N4401	0·240	BC263B	0·380
2N1131	0·235	2N2891	3·500	2N3439	0·600	2N3905	0·175	2N4402	0·190	BCY70	0·155
2N1132	0·235	2N2894	0·320	2N3440	0·460	2N3906	0·165	2N4403	0·240	BCY71	0·220
2N1420	0·215	2N2894A	0·685	2N3444	0·830	2N3945	0·500	2N4916	0·110	BCY72	0·120
2N1613	0·180	2N2904	0·225	2N3502	0·790	2N3946	1·200	2N4917	0·160	BFS92	0·655
2N1711	0·220	2N2904A	0·255	2N3503	1·150	2N3947	1·370	2N4943	3·000	BFS93	0·740
2N1893	0·270	2N2905	0·270	2N3504	0·790	2N3962	0·380	2N4964	0·170	BFX29	0·280
2N1990	0·280	2N2905A	0·300	2N3505	0·790	2N3963	0·455	2N4965	0·170	BFX30	0·330
2N2017	0·870	2N2906	0·230	2N3545	4·500	2N3964	0·455	2N4966	0·170	BFX84	0·230
2N2102	0·375	2N2906A	0·245	2N3546	1·320	2N3965	0·760	2N4967	0·170	BFX85	0·280
2N2192	0·405	2N2907	0·210	2N3547	1·750	2N4030	0·465	2N4968	0·170	BFX86	0·230
2N2192A	0·405	2N2907A	0·220	2N3548	1·900	2N4031	0·510	2N4969	0·170	BFX87	0·230
2N2193	0·470	2N3011	0·180	2N3549	2·100	2N4032	0·530	2N4970	0·190	BFX88	0·210
2N2193A	0·570	2N3012	0·530	2N3550	2·500	2N4033	0·670	2N4971	0·340	BFY50	0·190
2N2194	0·485	2N3015	0·405	2N3563	0·130	2N4036	0·480	2N4972	0·360	BFY51	0·180
2N2194A	0·530	2N3019	0·540	2N3564	0·150	2N4037	0·400	2N5055	0·200	BFY52	0·190
2N2195	0·420	2N3020	0·500	2N3565	0·110	2N4121	0·135	2N5056	2·000	BSY38	0·170
2N2195A	0·470	2N3053	0·180	2N3566	0·130	2N4122	0·150	2N5057	2·270	BSY39	0·170
2N2217	0·275	2N3054	0·450	2N3567	0·120	2N4123	0·145	2N5127	0·110	BSY51	0·200
2N2218	0·215	2N3072	0·580	2N3568	0·170	2N4124	0·145	2N5128	0·140	BSY52	0·200
2N2218A	0·245	2N3073	0·455	2N3569	0·150	2N4125	0·160	2N5129	0·080	BSY53	0·200
2N2219	0·240	2N3107	0·540	2N3576	1·220	2N4134	1·500	2N5130	0·080	BSY54	0·260
								2N5131	0·100	BSY95A	0·130

THYRISTORS

Type No	Price	IT (RMS)	V DROM
NAS106F	0·250	4A	50
NAS106A	0·310	4A	100
NAS106B	0·360	4A	200
NAS106D	0·580	4A	400
NAS206F	0·283	6A	50
NAS206A	0·349	6A	100
NAS206B	0·405	6A	200
NAS206D	0·653	6A	400
NAS306F	0·313	8A	50
NAS306A	0·389	8A	100
NAS306B	0·450	8A	200
NAS306D	0·725	8A	400
NAS406F	0·350	10A	50
NAS406A	0·434	10A	100
NAS406B	0·504	10A	200
NAS406D	0·812	10A	400
NAS806F	0·438	16A	50
NAS806A	0·543	16A	100
NAS806B	0·630	16A	200
NAS806D	1·015	16A	400

TRIACS WITH INTERNAL TRIGGERS

Type No	Price	IT (RMS)	V DROM
NASQ1610	0·310	1 6A	100
NASQ1620	0·330	1 6A	200
NASQ1640	0·360	1 6A	400
NASQ4510	0·390	4 5A	100
NASQ4520	0·440	4 5A	200
NASQ4540	0·710	4 5A	400
NASQ6510	0·420	6 5A	100
NASQ6520	0·480	6 5A	200
NASQ6540	0·780	6 5A	400
NASQ8510	0·460	8 5A	100
NASQ8520	0·500	8 5A	200
NASQ8540	0·830	8 5A	400
NASQ10010	0·500	10A	100
NASQ10020	0·550	10A	200
NASQ10040	0·880	10A	400

TRIACS

Type No.	Price	IT (RMS)	V DROM
NAS1610	0·295	1 6A	100
NAS1620	0·314	1 6A	200
NAS1640	0·342	1 6A	400
NAS4510	0·350	4 5A	100
NAS4520	0·400	4 5A	200
NAS4540	0·640	4 5A	400
NAS6510	0·390	6 5A	100
NAS6520	0·440	6 5A	200
NAS6540	0·700	6 5A	400
NAS8510	0·430	8 5A	100
NAS8520	0·460	8 5A	200
NAS8540	0·770	8 5A	400
NAS10010	0·480	10A	100
NAS10020	0·520	10A	200
NAS10040	0·840	10A	400

EPOXY 4 AMP AND 6 AMP BRIDGE RECTIFIERS

Type No	IF	VRM	Price
N7001	4A	50PIV	0·320
N7012	4A	100PIV	0·360
N7013	4A	200PIV	0·430
N7014	4A	400PIV	0·580
N7015	4A	600PIV	0·755
N7021	6A	50PIV	0·360
N7022	6A	100PIV	0·430
N7023	6A	200PIV	0·540
N7024	6A	400PIV	0·650
N7025	6A	600PIV	0·810

2 AMP ENCAPSULATED PLASTIC BRIDGE RECTIFIERS

N6001	2A	50PIV	0·350
N6002	2A	100PIV	0·380
N6003	2A	200PIV	0·400
N6004	2A	400PIV	0·430
N6005	2A	600PIV	0·500

PLASTIC RECTIFIER

1N4001	0·080
1N4002	0·080
1N4003	0·090
1N4004	0·100
1N4005	0·110
1N4006	0·120
1N4007	0·130

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All Types
from ½ to 50 amp from stock.

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	20A £49
5A £11·75. Post 75p	**37·5A £82**
	50A £98

CARRIAGE AND PACKING EXTRA unless shown
(Panel Mounting)
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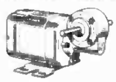
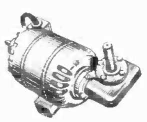
All primaries 220–240V

Type No.	Sec. Taps	Price Post
1	30, 32, 34, 36V at 5A	**£4·70+45p**
2	30, 40, 50V at 5A	**£6·90+60p**
3	10, 17, 18V at 10A	**£5·00+50p**
4	6, 12V at 20A	**£6·50+60p**
5	17, 18, 20V at 20A	**£7·30+60p**
6	6, 12, 20V at 20A	**£6·90+60p**
7	24A at 10A	**£5·30+50p**
8	4, 6, 24, 32V at 12A	**£7·20+60p**
9	6 and 12V at 10A	**£3·80+40p**

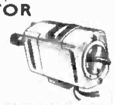
PARVALUX Type: SD1. S/86896/OJ
230/250V A.C. 50 r.p.m. 7 lb/in. Continuously rated. Less base. **£6.** Post 30p incl. base.



PARVALUX TYPE SD19 230/250 VOLT A.C. REVERSIBLE GEARED MOTORS
30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of makers' price. **£6·30.** Post 70p.

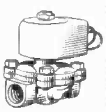


PARVALUX TYPE SD2. 200/250 VOLT A.C./D.C. HIGH SPEED MOTOR
Speed 9,000 r.p.m. approx. or 3,200 r.p.m. if used with built-in governor, or variable speed over a wide range if used in conjunction with our Dimmer Switch, illustrated below. PRICE **£1·75.** Post 35p.



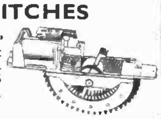
600 WATT DIMMER SWITCH
Easily fitted. Fully guaranteed by makers. Will control up to 600W of all lights except fluorescent at mains voltage. Complete with simple instructions. **£2·75.** Post 25p.

240V A.C. SOLENOID FLUID VALVE
Will handle liquids or gases up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½in b.s.p. inlet/outlet. Precision made, British mfg. PRICE: **£1·75.** Post 25p.
Special quotation for quantity.
(New in makers' carton)



UNISELECTOR SWITCHES

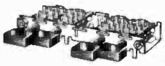
NEW **4 Bank 25 Way,** 24V d.c. operation. **£6·90.** Post 30p. **6 Bank 25 Way,** 24V d.c. **£7·90.** Post 30p. **8 Bank 25 Way,** 24V d.c. operation. **£9·50.** Post 40p.



GENERAL ELECTRIC POWER-GLAS TRIACS
10 amp. Glass passivated plastic triac. Latest device from U.S.A. Long term reliability. Type SC146D 10 amp, 400 PIV, **£1.** Post 5p. Type SC146E 10 amp, 500 PIV, **£1·30.** Post 5p. (Inclusive of data and application sheet.) Suitable Diac **18p.**

VOLTAGE CHANGING TRANSFORMER
M.f.g. to highest W.D. spec. Auto wound, and tapped 0–130–160–200–250 at least 2kVA. Can also be used as 230–240V input, 115V out for U.S.A. equipment, or reverse to obtain 240V from 115V. The ideal transformer for making up solid state constant voltage unit, by use of taps the following voltages may be obtained 30–40–50–70–90V at 10 amps. Weight 40lb, length, 260mm, height 190mm, width 230mm. In original maker's wooden case, **£8.** Carr. £1.

4 BANK 3c/o PUSH BUTTON ASSEMBLY
Black rectangular buttons. 5 units (min. order) **85p.** Post 15p.



FOOT SWITCH

Suitable for Motors, Drills, etc., etc. 5 amp. 250 volt. Price **75p.** Post 15p.

STROBE ! STROBE ! STROBE

Build a Strobe Unit, using the latest type Xenon white light flash tube. Solid state timing and triggering circuit. 230/250V a.c. operation.
EXPERIMENTERS' ECONOMY KIT
Speed adjustable 1 to 30 flash per sec. All electronic components including Xenon Tube and instructions **£6·30.** Post 30p.
NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories, etc. Speed adjustable 1-80 f.p.s.
Approx. ½ output of Hy-Lyght. Price **£10·50.** Post 50p.
HY-LYGHT STROBE MK III
For use in large rooms, halls and utilises a silica tube, printed circuit. Speed adjustable 0-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. **£12.** Post 50p.

THE 'SUPER' HY-LYGHT KIT

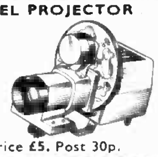
Approx. four times the light output of our well proven Hy-Lyght strobe.
- Variable speed from 1-3 flash per sec.
- Reactor control circuit producing an intense white light. ONLY **£20.** Post 75p.

ROBUST, FULLY VENTILATED METAL CASE. For Hy-Lyght Kit including reflector **£4·75.** Post 25p.
Super Hy-Lyght Kit including reflector **£7.** Post 60p.
7-inch POLISHED REFLECTOR
Ideally suited for above Strobe kits. Price **55p.** Post 15p.

1 R.P.M. MOTOR
220/240 volt a.c., 1 r.p.m. synchronous motor. 2 watt. A/clock. Spindle 10mm long, 3mm dia. Motor only 20mm deep. Fixing centres 44mm. Price **£1·10.** Post 5p.

RAINBOW STROBE FOUR LIGHT CONTROL MODULE
Will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2 + 2; or all together. Thoroughly tested and reliable. Complete with full connection instructions. Price: **£18.** Post 50p. Send S.A.E. for details.

COLOUR WHEEL PROJECTOR
Complete with oil-filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. **£18·50.** Post 50p.
6 INCH COLOUR WHEEL
As used for Disco lighting effects, etc. Price **£5.** Post 30p.



BIG BLACK LIGHT
400Watt. Mercury vapour ultra violet lamp. Powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos, etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb **£16.** Post £1.
Spare bulb **£7.** Post 40p.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft 40 watt. Price **£5·50.** Post 30p. 2ft 20 watt, **£4·25.** Post 25p. (For use in stan. bi-pin fittings.)
MINI. 12in 8 watt, **£1·60.** Post 15p. 9in 6 watt, **£1·30.** Post 15p. Complete ballast unit and holders for 9in and 12in tube, **£1·70.** Post 25p. (9in and 12in measures approx.)

ELECTRONIC ORGAN KIT
Easy to build. Solid State. Two full octaves (less sharps and flats). Fitted hardwood case. Powered by two penlite 1½V batteries. Complete set of parts including speaker, etc., together with full instructions and 10 tunes. Price **£3·25.** Post 35p.

All prices are subject to
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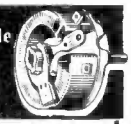
Superior Quality Precision Made NEW POWER RHEOSTATS



New ceramicconstruction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/250/300/500/1k/2·5k ohm **95p.** Post 10p.
50 WATT 1/5/10/25//50/100/250/500/1k/1·5k/2·5k/5k ohm **£1·35.** Post 10p.
100 WATT 1/5/10/25/50/100/250/500/1k/1.5k/2·5k/3·5k/5k ohm **£1·95.** Post 15p.
Black Silver, Skirted knob calibrated in Nos. 1-9. 1½in. dia. brass bush. Ideal for above Rheostats, **20p** each.

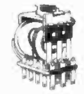
RELAYS SIEMENS, PLESSEY, Etc. MINIATURE RELAYS

Col.(1) Coil ohms
Col. (2) Working d.c. volts
Col. 3 Contracts
Col. (4) Price
HD = Heavy duty
*Incl. Base
All prices incl. P. & P.

1	2	3	4
52	4–6	6M	**60p***
150	6–12	4 c/o	**80p***
185	8–12	6M	**60p***
280	8–16	2 c/o	**60p***
410	10–18	4 c/o	**70p***
600	9–18	2 c/o	**60p***
700	16–24	4M 2B	**60p***
700	16–24	4 c/o	**80p***
700	15–35	2 c/o HD	**70p***
700	16–24	6M	**60p***
700	6–12	1 c/o HD	**50p***
700	20–30	6 c/o	**80p***
1,250	24–36	4 c/o	**60p***
2,500	36–45	6M	**60p***
2,400	30–48	4 c/o	**50p**
9,000	40–70	2 c/o	**50p***
15k	85–110	6M	**50p***

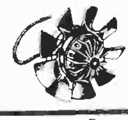
9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil. **75p.** Post 5p.
12 VOLT D.C. RELAY
3 c/o 5 amp contacts. 120 ohm coil. **75p.** Post 5p.

230 VOLT A.C. 'DIAMOND H' RELAYS (Unused)
Three sets c/o contacts rated at 5 amps. PRICE: **55p.** Post 5p. (100 lots) **£40.**
24 volt A.C. 3 c/o **55p.** Post 5p.



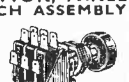
MINIATURE LATCHING RELAY
Manufactured by Clare-Elliott Ltd. Type F. 2 c/o permanent latching in either direction. Coil 1150 ohm, 15-30 Volt D.C. Size ⅞" high, ⅞" wide, ⅜" thick. Complete with 3in. leads. New **65p.** Post 5p.

BLOWER UNIT
200-240 Volt A.C. Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 120 mm. dia. × 60 mm. deep. Price **£3.** Post 30p.



230V FAN ASSEMBLY
Continuously rated, special sealed bearing, removable aluminium blades. Price **80p.** Post 20p.

"HONEYWELL" PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY
Each bank comprises a c/o rated at 10 amps 240V. A.C. Black knob 1 in. Fixing hole ⅜ in. ONE bank **30p;** TWO bank **40p;** THREE bank **50p.** Quote for quantity.



VERY SPECIAL OFFER
Micro Switch. 5 amp c/o contacts. M.f.g. bg. Honeywell. NEW. Twenty for **£1·50.** Post 10p (min. 20).

'HONEYWELL' LEVER OPERATED MICROSWITCH
15 amps 250 volt A.C. c/contacts. In maker's carton. PRICE: 10 for **£1·90.** Post 15p.

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Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L.8in, W.4in, H.6in, weight 6lb. **1,000V,** 1,000 megohms, **£34.** Post 60p. **500V,** 500 megohms, **£28.** Post 60p.

BALANCE/LEVEL METERS
100-0-100 Micro Amp. Size 1½in + 1½in + ⅜in. Price only **70p.** Post 5p.

AMMETERS NEW! 2½in. Flush round. Available in D.C. Amps 1, 5, 10, 15, 20 or A.C. Amps 5, 10, 15, 20, both types ***£1·85.** Post 15p. **0-300V** A.C. **£2.** Post 15p.

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£22·50 ELECTRONIC DIGITAL CLOCK
(For complete kit of parts including case.)

This 4 digit 24 hour clock is available to readers at this special price. Parts would normally cost over £25. Kit of parts includes twelve IC's, indicators, and a smart white plastic case. P.C. Board.

Integrated Circuits

74 series T.T.L. I.C.'s (Prices inclusive of VAT)

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SN7405	17p	16p	14p	SN7470	33p	29p	26p	SN74153	£1·32	£1·21	£1·15
SN7406	39p	35p	31p	SN7472	33p	29p	26p	SN74154	£2·05	£1·81	£1·62
SN7407	39p	35p	31p	SN7473	41p	40p	35p	SN74155	£1·54	£1·41	£1·31
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SN7410	17p	16p	14p	SN7476	44p	44p	39p	SN74160	£2·00	£1·81	£1·77
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SN7422	55p	53p	48p	SN7486	36p	34p	30p	SN74174	£2·52	£2·42	£2·32
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SN7425	55p	53p	48p	SN7490	64p	57p	48p	SN75176	£2·75	£2·64	£2·52
SN7427	51p	46p	42p	SN7491	£1·10	£1·05	£1·00	SN74177	£2·75	£2·64	£2·52
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SN7433	94p	83p	75p	SN7495	85p	82p	75p	SN74184	£3·85	£3·65	£3·45
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SN7441	73p	71p	65p	SN74105	£1·07	£1·04	94p	SN74193	£2·00	£1·98	£1·88
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SN7443	£1·33	£1·37	£1·27	SN74110	61p	58p	51p	SN74195	£2·20	£2·10	£1·96
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330μF	7p	15μF	7p	47μF	7p
1,000μF	13p	33μF	7p	100μF	7p
4,700μF	29p	68μF	7p	150μF	10p
6.3 VOLT		150μF	8p	200μF	11p
33μF	7p	220μF	9p	470μF	19p
68μF	7p	680μF	17p	680μF	26p
150μF	7p	1,000μF	19p	1,000μF	26p
470μF	11p	1,500μF	28p	2,200μF	44p
680μF	14p	2,200μF	36p	3,300μF	68p
1,000μF	18p	3,300μF	38p	**63 VOLT**	
1,500μF	20p	6,800μF	63p	1μF	7p
2,220μF	22p	**25 VOLT**		2·2μF	7p
3,300μF	27p	10μF	7p	4·7μF	7p
6,800μF	39p	22μF	7p	6·8μF	7p
15,000μF	63p	47μF	7p	10μF	7p
10,000μF	49p	100μF	8p	22μF	7p
10 VOLT		150μF	8p	68μF	10p
22μF	7p	220μF	10p	100μF	11p
47μF	7p	470μF	14p	150μF	14p
100μF	7p	680μF	20p	200μF	19p
220μF	8p	1,000μF	22p	330μF	22p
330μF	10p	2,200μF	40p	470μF	27p
470μF	10p	3,300μF	48p	1,000μF	44p
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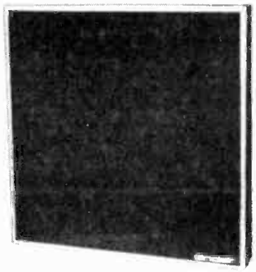

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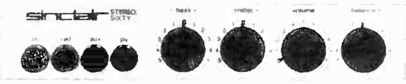

Stereo 60 pre-amp/control unit

Designed specifically for Project 60 systems, the Stereo 60 is equally suitable with any high quality power amplifier. Silicon epitaxial planar transistors used throughout ensure high signal-to-noise ratio and excellent tracking between channels. Input selection is by press buttons, with accurate equalisation on all input channels. The unit is easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV. correct to R.I.A.A. curve ±1dB: 20 to 25,000Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

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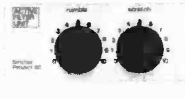

For use between Stereo 60 and two Z 30's or Z 50's in stereo formation. Cut off frequencies are continuously variable, with 12dB/octave cut in the rejection band. Two stages of filtering – rumble (high pass) and scratch (low pass). Amplitude and phase distortion are negligible. Supply voltage needed – 15–35V. H.F. cut-off (–3dB) 28KHz to 5KHz: L.F. (–3dB) 25Hz to 100Hz. For Project 60 or any good stereo system. Built, tested and guaranteed

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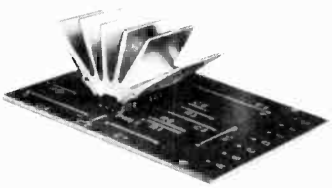

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SPECIFICATIONS
Output power: 6 watts RMS continuous (12 watts peak) into 6–8 Ω. **Frequency Response:** 5Hz to 100KHz ±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0.1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 x 45 x 28mm including pins and heat sink.

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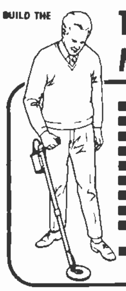

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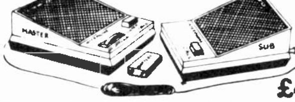

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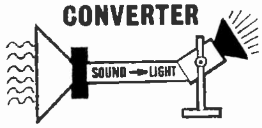

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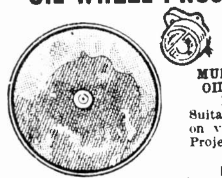

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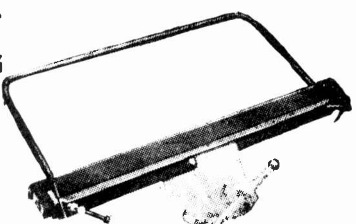

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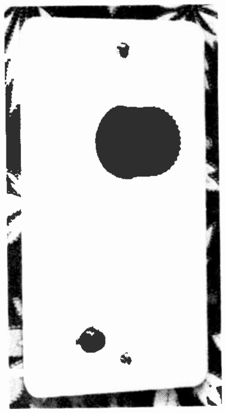

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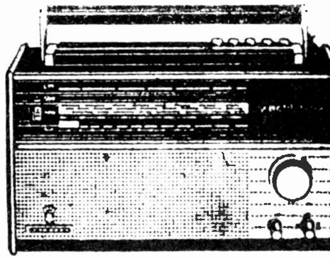

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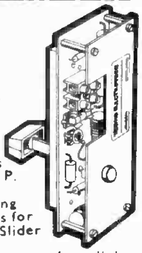

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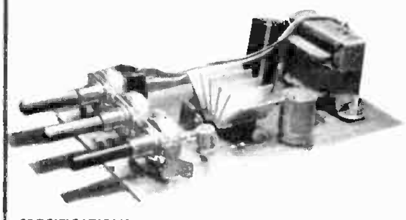

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