PRACTICAL

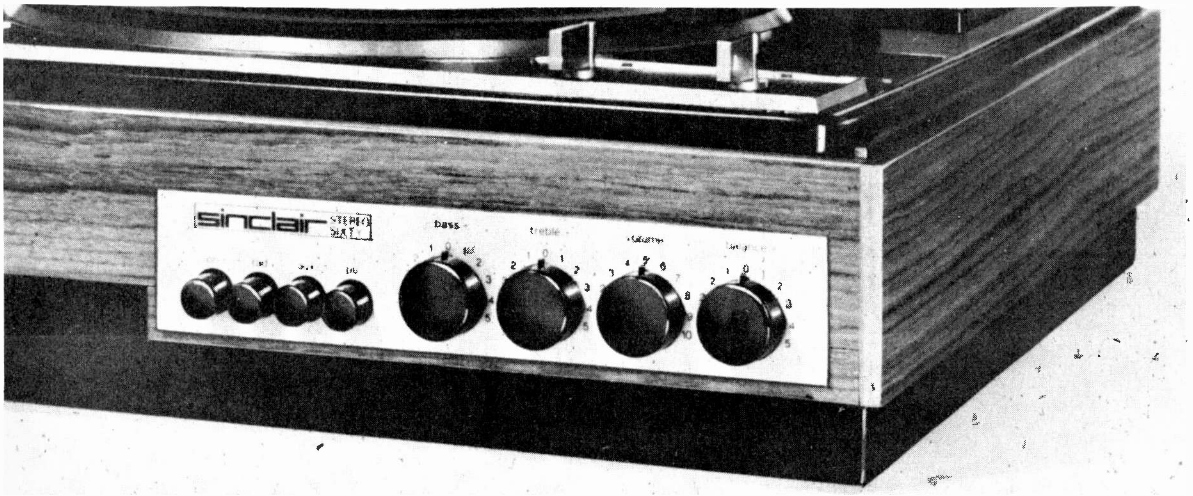
ELECTRONICS

NOVEMBER 1970 3/6 [17½ NEW PENCE]

DUAL PURPOSE STEREO AMPLIFIER

SPECIAL SUPPLEMENT:
....INSTALLING AUDIO EQUIPMENT

Project 60



Laboratory standard modular high fidelity

Sinclair Project 60 comprises a range of modules which connect together simply to form a compact stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance and now the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

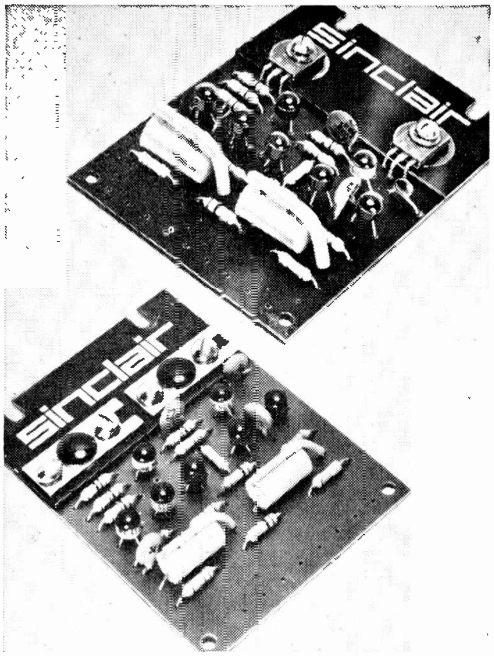
The modules are: **1.** The Z.30 and Z.50 high gain power amplifiers. **2.** The Stereo 60 preamplifier and control unit. **3.** The Active Filter Unit. **4.** 4 supply units–PZ.5; PZ.6; PZ.7 and PZ.8. In a normal domestic application, there will be no significant difference between PZ.5 or PZ.6 unless loudspeakers of very low efficiency are being used, in which case the PZ.6 will be required. For assemblies using two Z.50's there is the PZ.8 supply unit to ensure maximum performance from these amplifiers. No skill or experience are needed to build your system and the Project 60 manual gives all the instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as new additions are made to the range. A stereo F.M. tuner is next to come. These and all other modules introduced will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

	System	The Units to use	In conjunction with	Your Project 60 Units will cost
A	Car Radio	Z.30	Existing car radio, Sinclair Micromatic	89/6
B	Simple battery powered record player	Z.30	Crystal pick-up, 12 V or more battery supply and volume control	89/6
C	Mains powered record player	Z.30 and PZ.5	Crystal or ceramic P.U. Vol. control etc.	£9.9.0
D	20+20 watts RMS stereo amplifier for most needs	Two Z.30s, Stereo 60 and PZ.5	Crystal, ceramic or magnetic P.U., most dynamic speakers, FM tuner, etc.	£23.18.0
E	20+20 watts RMS stereo amplifier for use with low efficiency (high performance) speakers	Two Z.30s, Stereo 60 and PZ.6	High quality ceramic or mag. P.U., F.M. Tuner, Tape Deck, etc. All dynamic spkrs.	£26.18.0
F	40+40 watts RMS de-luxe stereo amplifier	Two Z.50s, Stereo 60 PZ.8 and mains transformer	As for E	£32.17.6
G	Outdoor public address system	Z.50	Microphone, up to 4 P.A. speakers, 12V car battery with converter or 45V d.c. controls	£5.9.6
H	Indoor P.A	One Z.50, PZ.8 and mains transformer	Mic., guitar, heavy duty speakers etc., controls	£17.8.6
J	High pass and low pass filters	AFU	D, E or F as above	£5.19.6
K	Stereo F.M. tuner	To be released shortly		£25

How to assemble and use Project 60 modules to best advantage in the above and other applications will be found in the fully descriptive Project 60 manual included with Project 60 systems. This 48 page manual is available separately, price 2/6d including postage.

sinclair SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

Telephone 0223 52731



Z.30 & Z.50 POWER AMPLIFIERS

The Z.30 together with the Z.50 are both of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0·02% at full output and all lower outputs. Whether you use the Z.30 or Z.50 power amplifiers in your Project 60 system will depend on personal preference, but they are the same physical size and may be used with other units in the Project 60 range equally well. For operating from mains, for the Z.30 use PZ.5 for most domestic requirements, or PZ.6 if you have very low efficiency loudspeakers. For Z.50, use the PZ.8 described below.

SPECIFICATIONS ***(Z.50 units are interchangeable with Z.30s in all applications.***

Power Outputs

Z.30 15 watts R.M.S. into 8 ohms, using 35V: 20 watts R.M.S. into 3 ohms, using 30 volts.

Z.50 40 watts R.M.S. into 3 ohms from 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.

Frequency response 30 to 300,000 Hz 1dB

Distortion 0·02% into 8 ohms

Signal to noise ratio better than 70dB unweighted

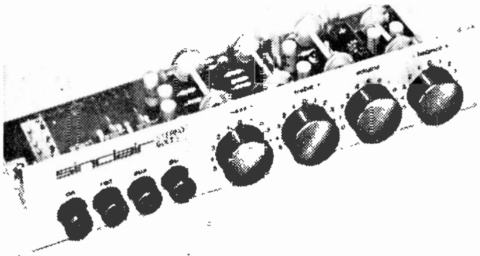
Input sensitivity 250mV into 100 Kohms.

For speakers from 3 to 15 ohms impedance

Size 3½ 2¼ ½ins.

Z.30 *Built, tested and guaranteed with circuits and instruction manual* **89/6**

Z.50 *Built, tested and guaranteed with circuits and instruction manual* **109/6**



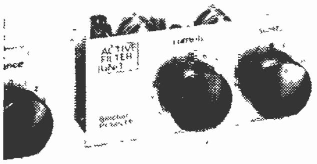
STEREO 60 Preamp/Control Unit

Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

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—25mV.
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB
- Tone controls—TREBLE +15 to 15dB at 10kHz: BASS 15dB to 15dB at 100Hz.
- Front panel—brushed aluminium with black knobs and controls.
- Size 8¼ 1½ 4ins.

Built, tested and guaranteed **£9.19.6**

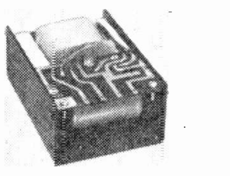


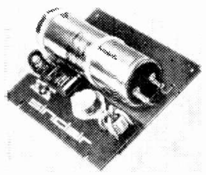
ACTIVE FILTER UNIT

For use between Stereo 60 unit and two Z.30s or Z.50s, the Active Filter Unit matches the Stereo 60 in styling and is as easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The Sinclair A.F.U. is suitable also for use with any other amplifier system.

Two stages of filtering are incorporated —rumble (high pass) and scratch (low pass). Supply voltage—15 to 35V. Current—3mA. H.F. cut-off (3dB) variable from 28kHz to 5kHz. L.F. cut-off (3dB) variable from 25Hz to 100Hz. Filter slope, both sections 12dB per octave. Distortion at 1kHz (35V supply) 0·02% at rated output.

Built, tested and guaranteed **£5.19.6**





POWER SUPPLY UNITS

The units below are designed specially for use with the Project 60 system of your choice. Illustration shows PZ.5 power supply unit to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

PZ-5 *30 volts unstabilised* **£4.19.6**

PZ-6 *35 volts stabilised* **£7.19.6**

PZ-8 *45 volts stabilised (less mains transformers)* **£5.19.6**

PZ-8 *mains transformer* **£5.19.6**

GUARANTEE. *If within 3 months of purchasing Project 60 modules directly from us you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.*

At the International Audio & Music Fair, Olympia. Stand **44**

sinclair

To: SINCLAIR RADIONICS LTD., 22 NEWMARKET RD., CAMBRIDGE

Please send ....

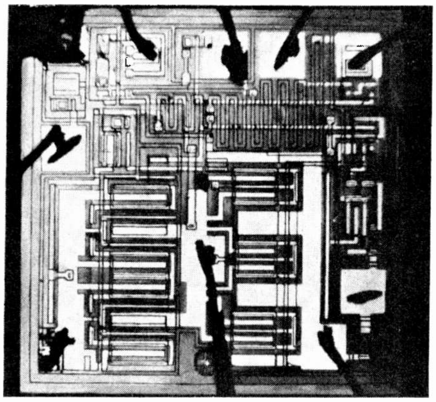
for which I enclose cash/cheque money order

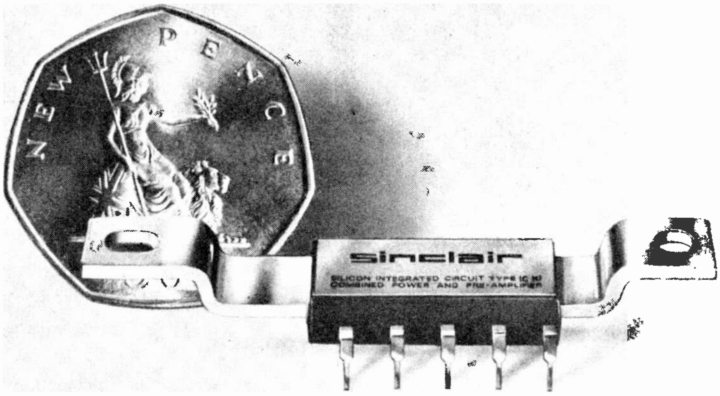
NAME ....

ADDRESS ....

PE 11A

Sinclair IC-10





the world's most advanced high fidelity amplifier

Specifications

Output: 10 Watts peak, 5 Watts R.M.S. continuous
Frequency response: 5 Hz to 100 KHz$\pm$1dB
Total harmonic distortion: Less than 1% at full output.
Load impedance: 3 to 15 ohms.
Power gain 110dB (100,000,000,000 times) total.
Supply voltage: 8 to 18 volts.
Size: 1 x 0.4 x 0.2 inches.
Sensitivity: 5mV.
Input impedance: Adjustable externally up to 2.5 M ohms.

Circuit Description

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

Applications

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a full guarantee on every IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

SINCLAIR
IC-10 *with IC-10 manual Post free.* **59/6**

To: SINCLAIR RADIONICS LTD., 22 NEWMARKET RD., CAMBRIDGE

Please send ....

for which I enclose cash/cheque money order

NAME ....
ADDRESS ....

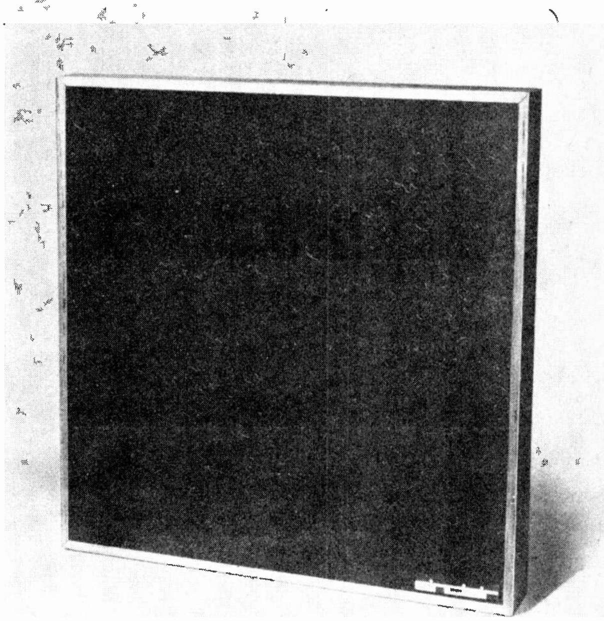
PE 11B

sinclair

At the International Audio and Music Fair, Olympia, Stand 44

Q.16 High fidelity loudspeaker

Developed out of the revolutionary and much praised design of the original Sinclair Q.14 comes this more advanced version to meet the requirements of even greater numbers of high fidelity enthusiasts. The Q.16 employs the same well proven acoustic principles in which a special driver assembly is meticulously matched to the physical characteristics of the uniquely designed housing. In reviewing this exclusive Sinclair design, technical journals have been loud in their praise for it and it comfortably stands comparison with very much more expensive loudspeakers. The shape of the Q.16 enables it to be positioned and matched to its environment to much better effect than is the case with conventionally styled enclosures, and with its improved styling, the Q.16 presents an entirely new and attractive appearance. A solid teak surround is used with a special all-over cellular black foam front chosen as much for its appearance as for its ability to pass all audio frequencies unimpaired.
The Q.16 is compact and slim and is the ideal shelf-mounted speaker, and brings genuine high fidelity within reach of every music lover.



Specifications

Construction:	A sealed seamless sound or pressure chamber is used with internal baffle, all of materials carefully chosen to ensure freedom from spurious tone coloration.
Loading:	Up to 14 watts R.M.S.
Input impedance:	8 ohms.
Frequency response:	From 60 to 16,000Hz, as confirmed. by independently plotted B & K curve.
Driver unit:	Specially designed high compliance unit having massive ceramic magnet of 11,000 gauss, aluminium speech coil and special cone suspension. Excellent transient response is achieved.
Size and styling:	$9\frac{3}{4}''$ square on face × $4\frac{3}{4}''$ deep with neat pedestal base. Black all-over cellular foam front with natural solid teak surround.
Price:	£8 19 6.

Micromatic Britain's smallest radio

Considerably smaller than an ordinary box of matches, this is a multi-stage A.M. receiver meticulously designed to provide remarkable standards of selectivity, power and quality. Powerful A.G.C. is incorporated to counteract fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy at all times. Vernier type tuning plus the directional properties of the self-contained special ferrite rod aerial makes station separation very much easier than with many larger sets. The plug-in high fidelity type magnetic earpiece which matches exactly with the output of the Micromatic provides wonderful standards of reproduction both for speech and for music. Everything including the batteries is contained within the attractively designed case. Whether you build your Micromatic or buy it ready built and tested, you will find it as easy to take with you as your wristwatch, and dependable under the severest listening conditions.

Specifications

Size:	$1\frac{13}{16}'' \times 1\frac{7}{16}'' \times \frac{1}{2}''$ (46 × 33 × 13mm).
Weight including batteries:	1 oz. (28.35gm) approx.
Tuning:	Medium wave band with bandspread at higher frequency end.
Earpiece:	High-fidelity magnetic type.
Battery requirements:	Two Mallory Mercury Cells, type R.M. 675, for long working life.
Case:	Black plastic with anodised aluminium front panel, spun aluminium dial.
Controls.	Tuning dial, and on/off switching by means of earpiece plug.
Price:	Available in kit form complete with earpiece, case, instructions and supply of solder in fitted pack. 49/6. Ready built, tested and guaranteed. 59/6.

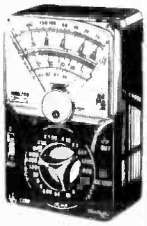
Sinclair Radionics Ltd, 22 Newmarket Road, Cambridge Telephone 0223 52731

sinclair

Laskys

TMK METER KITS

These two meter kits by TMK offer the unique opportunity of building a really first-class precision multimeter at a worthwhile saving in cost. The cabinets are supplied with the meter scale and movement mounted in position. The highest quality components and 1% tolerance resistors are used throughout. Supplied complete with full constructional, circuit and operating instructions.



MODEL 200 20,000 O.P.V. Multimeter. Features 24 measurement ranges with mirror scale. Large 3 × 2in meter. Full scale accuracy: DCV and current: ±2%, ACV: ±3%, resistance ±3%. Special 0·6V DC range for transistor circuit measurements.

SPECIFICATION
● DCV: 0–0·6–6–30–120–600–1,200V at 20K/OPV. ● ACV: 0–6–30–120–600–1,200V at 10K/OPV. ● DC Current: 0–0·6–6–600mA. ● Resistance: 0–10K 100K–1M–10M/ohms (58–580–5·8K–58K at mid-scale). ● Capacitance: 0·002–0·2μF (AC 6V range). ● Decibels −20 to +63dB. ● Output: 0·05μF blocking capacitor. Uses two 1·5V (U7 type) batteries. Black bakelite cabinet—Size 5¼ × 3⅞ × 1⅞in. Complete with test leads.

KIT PRICE **ONLY 92/-** Post 3/6

MODEL 5025 *50,000 O.P.V. FEATURING 57 MEASUREMENT RANGES*

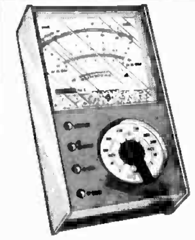
Uses an entirely new range selection mechanism which permits the use of a really large meter in a more compact cabinet. The range selected is indicated on the meter face. High speed rotary range selection knob; polarity reversal switch, shielded meter movement with overload protection circuit; Special μA and mA measurement ranges.

SPECIFICATION DCV: 0–0·25–2·5–10–50–250–1,000V at 25K/OPV. 0–0·125–1·25–5·0–25–125–500V at 50K/OPV. ACV: 0–3–10–50–250–1,000V at 2·5K/OPV. 0–1·5–5–25–125–500V at 5K/OPV. DCμA: 0–25μA at 125mA; 0–50μA at 250mA. DCmA: 0–2·5–25–250mA at 125mV; 0–5–50–500mA at 250mV. DC Amps: 0–5A at 125mV; 0–10A at 250mV. Resistance: 0–10M/ohms. Output: Capacitor (0·1μF, 400Vw) in series with ACV ranges. Decibels: −20 to +81·5dB. Operates on two 1·5V batts. Black bakelite cabinet, size 5¼ × 6⅞ × 2⅞in. Complete with test leads.

KIT **£10.10.0** Post 5/

MODEL 5025 *ALSO AVAILABLE READY BUILT AND TESTED £12.10.0* POST 5/-

EXCLUSIVE



TM-5

5 K ohms/V POCKET MULTIMETER

Another new look pocket multi-meter from Lasky's providing top quality and value. The "slimline" impact resistant case—size 4⅞in × 2⅞in × 1⅛in, fitted with extra large 2⅞in square meter. Readability is superior on all low ranges; making this an excellent instrument for servicing transistorised equipment. Recessed click stop selection switch. Ohms zero adjustment. Buff finish with crystal clear meter cover.

- DC/V: 3–15–150–300–1,200 at 5K/OPV.
- AC/V: 6–30–300–600 at 2·5K/OPV.
- DC Current 0–300μA, 0–300mA.
- Resistance: 0–10kΩ, 0–1MΩ.
- Decibels: −10dB to + 16dB.
- Complete with test leads, battery and instructions.

LASKY'S PRICE **49/6** POST 2/6

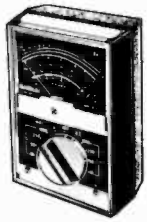
TM-1 MINI-TESTER

1 K ohms/volt

The first of Lasky's new-look top value meters, the TM-1 is a really tiny pocket multimeter providing "big" meter accuracy and performance. Precision movement calibrated to ±3% of full scale. Click stop range selection switch. Beautifully designed and made impact resistant black case—with white and metallic red/green figuring. Ohms zero adjustment.

Size Only 3⅛in. × 2⅛in. × 1⅛in

- DC/V: 0–10–50–250–1,000 at 1K/OPV.
- AC/V: 0–10–50–250–1,000 at 1K/OPV.
- DC CURRENT: 0–1mA, 100mA.
- Resistance: 0–150kΩ.
- Decibels: −10dB to +22dB.
- Complete with test leads, battery and instructions.



LASKY'S PRICE **39/6** POST 2/6

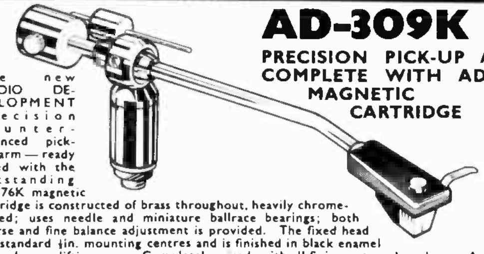
TMK 100,000 OPV

"LAB MODEL"

A highly accurate yet rugged Multitester using a 10μA meter hand calibrated to a D.C. accuracy of ±3% of full scale. Special features—ultra large meter scale 6¼ × 3⅛in incorporating an entirely new type of range selection panel which gives instant range identification without taking your eyes from the meter. An audible buzzer is provided for easy short testing. SPEC: D.C./V ranges: 0·5, 2·5, 10, 50, 250, 500, 1,000V at 100K/O.P.V. A.C./V. ranges: 3, 10, 50, 250, 500, 1,000V at 5K/O.P.V. D.C. current: 0–10, 100μA, 0–10, 100mA, 0–2·5, 10A. Resistance: 0–1K, 10K, 100K, 10M, 100M/ohms. Decibels: −10 to 49.4dB. Continuity test: Audible buzzer. Operates on 11·5V U2 and 1 15V B. 154 type batteries. Cabinet size 7⅞ × 6⅞ × 3⅛in. Weight 4lb.

LASKY'S PRICE **£19.0.0** POST 5/-

AUDIO DEVELOPMENT



AD-309K

PRECISION PICK-UP ARM COMPLETE WITH AD-76K MAGNETIC CARTRIDGE

The new AUDIO DEVELOPMENT precision counter-balanced pick-up arm — ready fitted with the outstanding AD-76K magnetic cartridge is constructed of brass throughout, heavily chrome-plated; uses needle and miniature ballrace bearings; both coarse and fine balance adjustment is provided. The fixed head has standard ½in. mounting centres and is finished in black enamel with chrome lifting spur. Completely wired, with all fixing nuts and washers. Arm rest also supplied. Tech. details: Overall length 285mm; needle to pivot length 223mm; offset angle 24°; overhang 10mm. Requires single 7/16in. dia. mounting hole.

LASKY'S PRICE **£8.10.0** Post Free

SONICS AS-57

ELEGANT BUDGET PRICED BOOKSHELF SPEAKER SYSTEMS

The AS-57 is a real space saver. This fine miniature high-fidelity speaker system will provide good quality sound anywhere in your home at remarkably low cost. Designed for use where space is at a premium, the AS-57 system is ideal for the small apartment or isolated listening area. The special high efficiency 5 × 7in full range speaker has a frequency range of 70–18,000Hz with a peak handling capacity of 10 watts. Imp. 8 ohms. Finish: oiled walnut. Size 5¾ × 15¾ × 8½in.

LASKY'S PRICE **£15** per PAIR POST 10/-

AUDIO DEVELOPMENT AD-76K

Stereo Magnetic Cartridge. Frequency response: 20–20,000Hz. Output: 5mV. Stylus: Diamond LP. Tracking force: 2 gms ±0·5 gm. Replacement stylus type JS.P1 41/- post free.

90/- Post Free

AUDIO DEVELOPMENT AD-96K

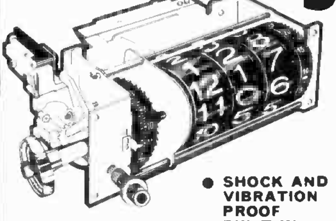
Stereo Magnetic Cartridge. Frequency response: 20–20,000Hz. Output: 5mV. Stylus: Diamond LP. Tracking force: 2 gms. Replacement stylus type Y.960S 51/6, post free.

£5.18.6 Post Free

Audio Tronics 71

Send your name and address now to receive immediately the new 1971 edition of LASKY'S famous Audio-Tronics pictorial catalogue, larger and more comprehensive than ever before, packed with 1000's of items for the Radio and Hi-Fi enthusiast, electronics hobbyist, serviceman and communications ham. Covers every aspect of Hi-Fi (including Lasky's budget Stereo Systems and Package Deals) **plus Lasky's amazing saving vouchers worth over £32.**
Send your name, address and 2/6 for post and inclusion on our regular mailing list.

EXCLUSIVE DIGITAL CLOCK SCOOP!



- MADE ESPECIALLY FOR LASKY'S BY FAMOUS MAKER
- MAINS OPERATION
- 12 HOUR ALARM
- AUTO "SLEEP" SWITCH
- HOURS, MINUTES AND SECONDS READ-OFF
- FORWARD AND BACKWARD TIME ADJUSTMENT
- SILENT OPERATION SYNCHRONOUS MOTOR
- SHOCK AND VIBRATION PROOF
- BUILT IN ALARM BUZZER

SPECIAL QUOTATIONS FOR QUANTITIES

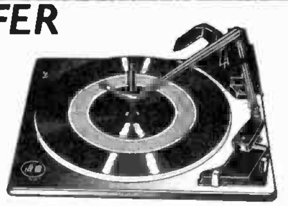
This unique DIGITAL CLOCK is now available **EXCLUSIVELY FROM LASKY'S** in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF-AUTO and AUTO ALARM, "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.
The sleep switch will automatically turn off any appliance—radio, TV, light, etc., at any pre-set time up to 60 min. and in conjunction with the AUTO setting will switch on the appliance again next morning.
The clock measures 4¾W × 1¾H × 3¾D (overall from front of drum to back of switch). SPEC: 210/240V AC, 50Hz operation; switch rating 250V, 3A. Complete with instructions. **HUNDREDS OF APPLICATIONS.**

COMPLETE WITH KNOBS.

LASKY'S PRICE **£6.19.6** Post 3/6

KNOBS AVAILABLE SEPARATELY—12/6 per set. Post 1/6

Garrard
SPECIAL OFFER
SL-55



One of the famous Garrard Synchro-Lab Series. Takes 8 Lps. 4-speed auto-changer; incorporating a tubular pickup arm and adjustable stylus force.
Wired for Mono and Stereo.
Size 14 in wide, 11¾in front to rear. 4¾in above and 3in below lower edge of unit plate. **NOW AT LASKY'S SUPER SPECIAL OFFER PRICE. Complete with SONOTONE 9TA STEREO CARTRIDGE**

SPECIAL OFFER PRICE £10.19.6

OTHER GARRARD UNITS FROM STOCK

AUTOCHANGERS

SL72B	£25 0 0	SL65B	£15 10 0
2025TC with stereo cartridge	£8 17 6	SL95B	£35 0 0
3000 complete with 9TAHC stereo cartridge	£9 19 6	SL75B	£28 0 0

SINGLE PLAYERS
SP-25 MK II **£11.19.6**, AP 75, **£18.10.0**, AP75 with AD76K mag. cart., **£21.10.0.**
401 Transcription Unit **£20.0.0.**
BASES AND COVERS FOR GARRARD UNITS
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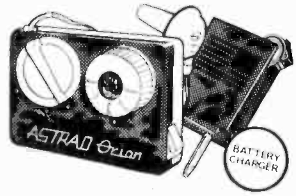

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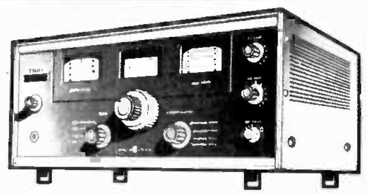

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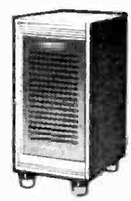

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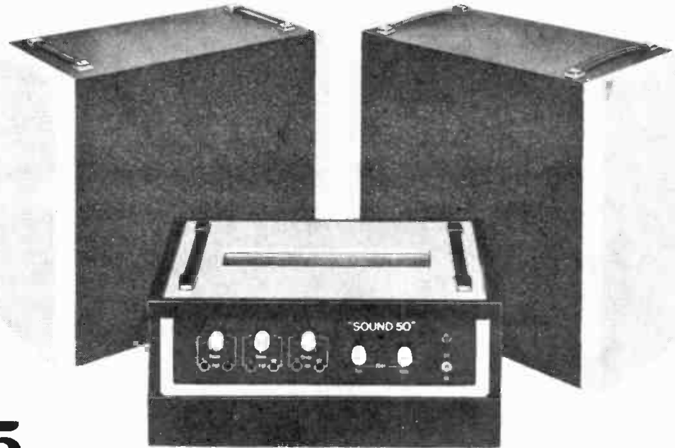

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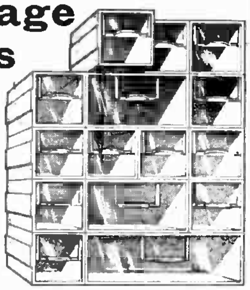

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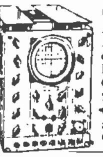

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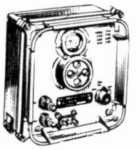

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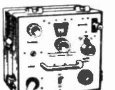

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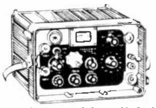

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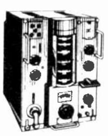

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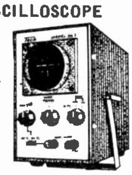

A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS-1 MHZ. Input imp. 2 megΩ 25 P.F. Illuminated scale. 2in. tube. 115 × 180 × 230mm. Weight 8lb. 220/240 V a.c. Supplied brand new with handbook. **£22.10.0.** Carr. 10/-.

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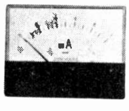
CLEAR PLASTIC METERS — TYPE SW. 100 — 100 x 80 mm



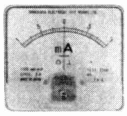
50μA	69/6	1mA	59/6
100μA	67/6	20V d.c.	59/6
500μA	62/6	50V d.c.	59/6
		1A d.c.	59/6
		5A d.c.	59/6
		300V a.c.	59/6
		VU Meter	75/-

BAKELITE PANEL METERS — TYPE S-80 — 80 mm square fronts

50μA	62/6	5A d.c.	49/6
100μA	59/6	300V a.c.	52/6
500μA	52/6	VU Meter	67/6
1mA	49/6		
20V d.c.	49/6		
50V d.c.	49/6		
1A d.c.	49/6		

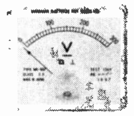
"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in × 4⅞in fronts.



50μA	72/-	10mA	52/-
50-0-50μA	62/-	50mA	52/-
100μA	62/-	100mA	52/-
100-0-100μA	62/-	500mA	52/-
200μA	57/6	1A	52/-
500μA	55/-	5A	52/-
500-0-500μA	52/-	15A	52/-
1mA	52/-	30A	52/-
1-0-1mA	52/-	20V d.c.	52/-
5mA	52/-	50V d.c.	52/-
		150V d.c.	52/-
		300V d.c.	52/-
		15V a.c.	52/-
		300V a.c.	52/-
		S Meter 1mA	57/6
		VU meter	72/-
		1A a.c.*	52/-
		5A a.c.*	52/-
		10A a.c.*	52/-
		20A a.c.*	52/-
		30A a.c.*	52/-

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



50μA	40/-	150mA	27/6
50-0-50μA	37/6	200mA	27/6
100μA	37/6	300mA	27/6
100-0-100μA	35/-	500mA	27/6
200μA	35/-	750mA	27/6
500μA	30/-	1A	27/6
500-0-500μA	27/6	2A	27/6
1mA	27/6	5A	27/6
1-0-1mA	27/6	10A	27/6
2mA	27/6	3V d.c.	27/6
5mA	27/6	10V d.c.	27/6
10mA	27/6	15V d.c.	27/6
20mA	27/6	20V d.c.	27/6
50mA	27/6	100V d.c.	27/6
100mA	27/6	150V d.c.	27/6
		300V d.c.	27/6
		500V d.c.	27/6
		750V d.c.	27/6
		15V a.c.	27/6
		50V a.c.	27/6
		150V a.c.	27/6
		300V a.c.	27/6
		500V a.c.	27/6
		S meter 1mA	32/-
		VU meter	42/-

Type MR.52P. 2½in square fronts.

50μA	62/-	10V d.c.	40/-
50-0-50μA	52/-	20V d.c.	40/-
100μA	52/-	50V d.c.	40/-
100-0-100μA	47/6	300V d.c.	40/-
500μA	45/-	15V a.c.	40/-
1mA	40/-	300V a.c.	40/-
5mA	40/-	S Meter 1mA	42/-
10mA	40/-	VU Meter	62/-
50mA	40/-	1A a.c.*	40/-
100mA	40/-	5A a.c.*	40/-
500mA	40/-	10A a.c.*	40/-
1A	40/-	20A a.c.*	40/-
5A	40/-	30A a.c.*	40/-

Type MR.45P. 2in square fronts.

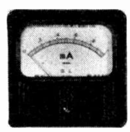
50μA	45/-	5A	30/-
50-0-50μA	42/-	10V d.c.	30/-
100μA	42/-	20V d.c.	30/-
100-0-100μA	37/6	50V d.c.	30/-
200μA	37/6	300V d.c.	30/-
500μA	32/-	15V a.c.	30/-
500-0-500μA	30/-	300V a.c.	30/-
1mA	30/-	S meter 1mA	37/6
5mA	30/-	VU meter	45/-
10mA	30/-	1A a.c.*	30/-
50mA	30/-	5A a.c.*	30/-
100mA	30/-	10A a.c.*	30/-
500mA	30/-	20A a.c.*	30/-
1A	30/-	30A a.c.*	30/-

Type MR.65P. 3½in × 3¼in fronts.

50μA	67/6	20V d.c.	42/-
50-0-50μA	55/-	50V d.c.	42/-
100μA	55/-	150V d.c.	42/-
100-0-100μA	52/-	300V d.c.	42/-
500μA	47/6	15V a.c.	42/-
500-0-500μA	42/-	50V a.c.	42/-
1mA	42/-	150V a.c.	42/-
5mA	42/-	300V a.c.	42/-
10mA	42/-	500V a.c.	42/-
50mA	42/-	S meter 1mA	47/6
100mA	42/-	VU meter	67/6
500mA	42/-	50mA a.c.*	42/-
1A	42/-	100mA a.c.*	42/-
5A	42/-	200mA a.c.*	42/-
10A	42/-	500mA a.c.*	42/-
15A	42/-	1A a.c.*	42/-
20A	42/-	5A a.c.*	42/-
30A	42/-	10A a.c.*	42/-
50A	47/6	20A a.c.*	42/-
10V d.c.	42/-	30A a.c.*	42/-

"SEW" BAKELITE PANEL METERS

Type MR 65. 3½in square fronts.



25μA	70/-	500mA	35/-
50μA	47/6	1A	35/-
50-0-50μA	45/-	5A	35/-
100μA	45/-	15A	35/-
100-0-100μA	45/-	30A	35/-
500μA	42/-	50A	35/-
1mA	35/-	5V d.c.	35/-
1-0-1mA	35/-	10V d.c.	35/-
5mA	35/-	20V d.c.	35/-
10mA	35/-	50V d.c.	35/-
50mA	35/-	150V d.c.	35/-
100mA	35/-	300V d.c.	35/-
		30V a.c.*	35/-
		50V a.c.*	35/-
		150V a.c.*	35/-
		300V a.c.*	35/-
		500mA a.c.*	35/-
		1A a.c.*	35/-
		5A a.c.*	35/-
		10A a.c.*	35/-
		20A a.c.*	35/-
		30A a.c.*	35/-
		50A a.c.*	35/-
		VU meter	62/-

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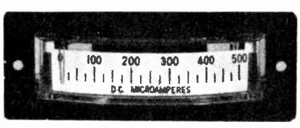

EDGWISE METERS

Type PE.70. 3 17/32in × 1 15/32in × 2⅞in deep.

50μA	60/-	500μA	52/-
50-0-50μA	57/6	1mA	47/6
100μA	57/6	300V a.c.	47/6
100-0-100μA	55/-	VU meter	65/-
200μA	55/-		

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25 WATT. 10/25/50/100/250/500/1,000/1,500/2,500 or 5,000 ohms, **14/6.** P. & P. 1/6.
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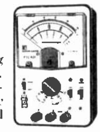
100 WATT. 1/5/10/25/50/100/250/500/1,000 or 2,500 ohms, **27/6.** P. & P. 1/6.

FTC-401 TRANSISTOR TESTER



Full capabilities for measuring A, B and ICO, *npn* or *pnp*. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. **£6.19.6.** P. & P. 3/-.

MARCONI TF142E DISTORTION FACTOR METERS. Excellent condition. Fully tested. **£20.** Carr. 15/-.

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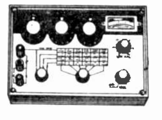


A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω-11·1 megΩ 6 Ranges ±1%. L.1 μH - 111 HENRYS 6 Ranges -2%. C. 10pF - 1110mFd. 6 Ranges ± 2%. TURNS RATIO 1:1/1000-1:11100. 6 Ranges ±1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¼ × 5 × 2in. **£20.** P. & P. 5/-.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

D.c. coupled. Band width 1kc/s. Perfect order. **£25.** Carr. 30/-.

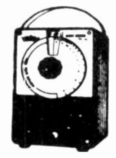
TE-20D RF SIGNAL GENERATOR

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

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0-20 Kc/s on 2 ranges. Output 500Ω or 5kΩ. Operation 200/250V. A.C. Supplied in perfect order. **£12.10.0.** Carr. 10/-.

TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20c/s to 200kc/s. Square Wave 20c/s to 30kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts a.c. Size 210 × 150 × 120mm. Brand new with instructions. **£16.** Carr. 7/6.

MARCONI TF885 VIDEO OSCILLATORS

0-5MHz. Sine Square Wave. **£45.** Carr. 20/-.

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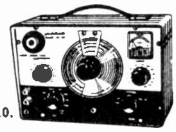

2pF-2,000 mfd 2 ohms-200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c. **Brand New £17.10.** Carr. 7/6.

MARCONI TF195M BEAT FREQUENCY OSCILLATORS

0-40KHz. **£20.** Carr. 30/-.

ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.
J1B. AUDIO SIGNAL GENERATOR. 15 c/s to 50 Kc/s. Sine wave. Output 600 ohms or 5 ohms. **£30.0.0.**
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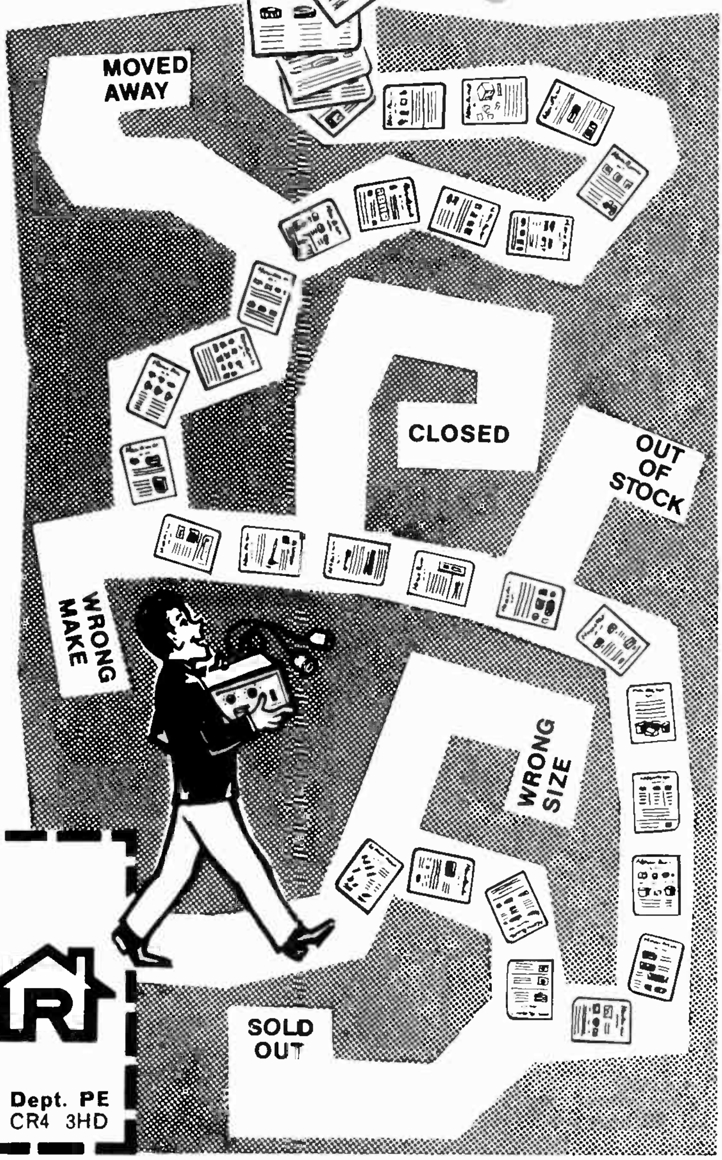

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VOL. 6 No. 11
November 1970

PRACTICAL ELECTRONICS

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THE PROFESSIONAL (AND PERSONAL) TOUCH

It is a fact that a piece of home built equipment can be indistinguishable, both internally and externally, from a factory produced equipment. The amateur constructor has access to much of the general range of circuit components and materials currently used by the professional manufacturers; and he can use one of the well established methods of assembly. For housing purposes, there are stylish commercially made cases. These can be neatly embellished on the outside as befits the particular equipment, since modern lettering aids make this operation quite simple even for those lacking artistic skill. (An article entitled "The Professional Finish" in this issue deals with the subject of housing and external appearance.)

Yes, in a sense it is all delightfully simple and straightforward. Perhaps *too* simple some veteran constructors may hint, mindful of the "old days". It provokes a natural reaction in some to recall with nostalgia early endeavours, especially if these occurred in a period when the private individual had access to but a few components and constructional materials, and when many items had to be entirely home made. The difficulties certainly spurred on the imagination; and successful innovation was cause for justifiable pride and satisfaction.

That kind of resourcefulness is not required in any great measure today, so far as normal circuit components and hardware are concerned. But it would be entirely wrong for the casual observer to conclude from what he may see or read that the present day private constructor is feather-bedded and spends his spare time merely assembling parts to stereotyped designs. On occasions he is just so employed, this is true. And indeed this is quite an important part of the hobby. But he can look further afield, as well. For there are actually more opportunities for personal innovation than ever, because of the wider applications of electronics now possible.

Consider, for example, the area of measurement and control. Here is boundless scope for individual enterprise. Electronic solid state devices already exist for translating many kinds of physical phenomenon into electrical signals. But mechanical and electro-mechanical contrivances are often indispensable parts of such electronic systems. It is not possible to obtain "off-the-shelf" devices or mechanisms suitable for every requirement, for these tend to be unique in every case. So more often than not such items have to be tailored for the job in mind. And here the imagination, resourcefulness, and skill of the constructor are all brought into play.

The knowledge that it is within his capabilities to produce a "professional looking" job so far as the electronics are concerned, will encourage the constructor to take great pains with any part of the equipment he must fabricate himself. The spur has not vanished.

F.E.B.

THIS MONTH

CONSTRUCTIONAL PROJECTS

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BEGINNERS

NEWS AND COMMENT

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Our December issue will be published on Monday, November 16

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SPECIFICATION...

PRE-AMPLIFIER

Inputs
Radio 100mV at 50kΩ
Tape 100mV at 50kΩ
Aux 100mV at 50kΩ
Disc 3mV (LO) and 60mV (HI) both at 47kΩ
Mic 1mV at 1MΩ and 10mV at 2MΩ
Microphone can be mixed with any other input with independent level control

Outputs
Tape output 400mV at 10kΩ unaffected by volume or tone controls
Auxiliary output 400mV at 10kΩ controlled by volume and tone controls

Tone control
Bass ± 12dB at 100Hz, ± 18dB at 30Hz
Treble ± 12dB at 10kHz, ± 15dB at 20kHz

Balance control
Full rotation cuts off either channel

Filter
15kHz, 10kHz, 7kHz, 5kHz or Out. Slope 18dB/octave

Signal to noise ratio
Unweighted figures referred to 30 watts into 8Ω
Weighted figures 20Hz–20kHz, 3-phon curve
All measured with inputs shorted

Aux, Radio, Tape	−77dB unweighted −83dB weighted
Disc. HI	−60dB unweighted −80dB weighted
Disc. LO	−62dB unweighted −82dB weighted
Mic. HI	−76dB unweighted −82dB weighted
Mic. LO	−70dB unweighted −74dB weighted

Interchannel crosstalk
−50dB at 1kHz, −35dB at 10kHz

Crosstalk betweeen inputs
−70dB at 1kHz, −60dB at 10kHz

Dynamic range
28dB before clipping

Distortion
0·01% at rated sensitivity, less than 0·1% at 10 times (20dB) overload

Supply
40V d.c. at 35mA (from main amplifier)

Dimensions
Width 13½in, height 3½in, depth 8in

MAIN AMPLIFIER

Output power
30 watts into 8Ω. 20 watts into 15Ω
15 watts into 4Ω. Continuous r.m.s. sinewave power into 8 and 15Ω. Intermittent sinewave or speech and music into 4Ω

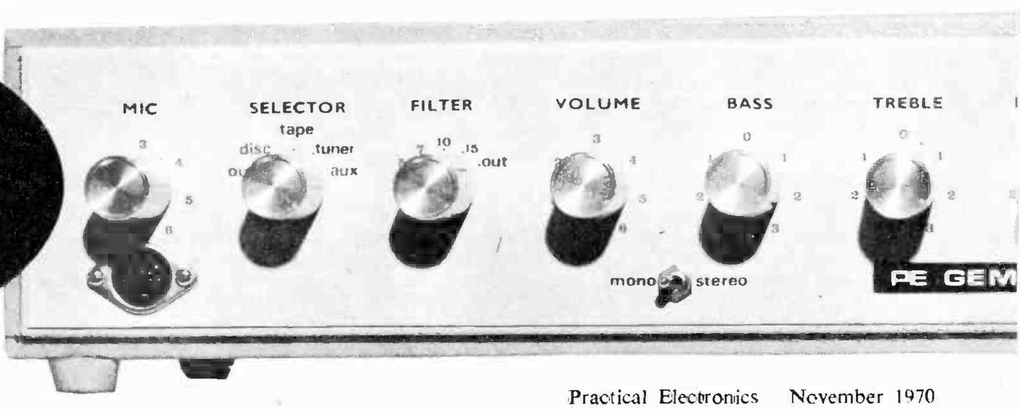
Harmonic distortion

At full power	Less than 0·01% with 8Ω or 15Ω load Less than 0·1% with 4Ω load

DUAL PURPOSE STEREO AMPLIFIER

By D. S. GIBBS and I. M. SHAW (FERRANTI LTD)

PE GEMINI



Maximum harmonic distortion
0·012% at 100mW into 15Ω load
0·02% at 35mW into 8Ω load
0·04% at 30mW into 4Ω load

Intermodulation distortion
Less than 0·05% at full power into 8Ω or 15Ω. S.M.P.T.E. method
100Hz + 10kHz ratio 4 : 1

Frequency response

8Ω or 15Ω load	−1dB 30Hz—50kHz −3dB 20Hz—100kHz
4Ω load	−1dB 50Hz—30kHz −3dB 25Hz—70kHz

Signal to noise ratio
−100dB unweighted 20Hz −20kHz
−110dB weighted—30 phon curve

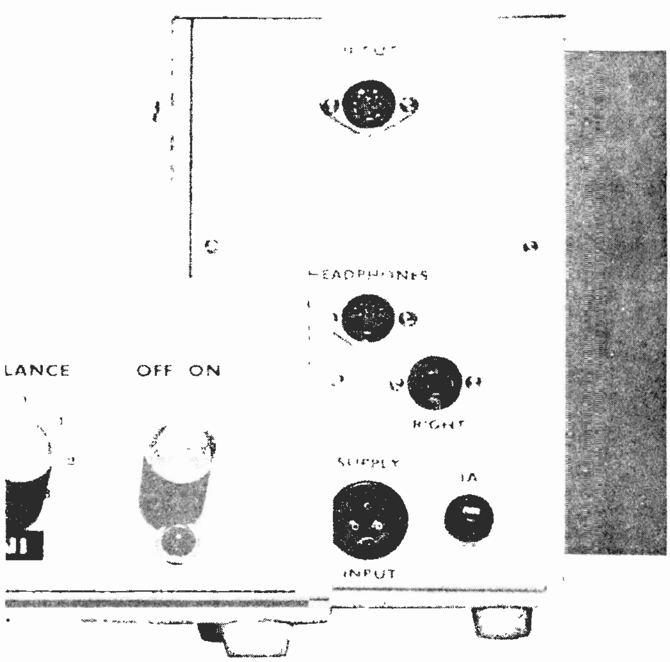
Output impedance
0·25Ω in series with 2,500μF plus 6μH

Stability
Unconditionally stable, suitable for electrostatic loudspeakers

Input sensitivity
400mV r.m.s. for 30 watts into 8Ω
430mV r.m.s. for 20 watts into 15Ω
200mV r.m.s. for 15 watts into 4Ω

Supply
220–250V a.c. at 50Hz

Dimensions
width 6in, height 7in, depth 13in



THIS short series of articles will describe the design and construction of a class B, 30 + 30 watt stereo amplifier and pre-amplifier of exceptionally high performance. The performance is certainly equal to anything one can buy no matter what the cost, but the construction of this amplifier is well within the capabilities of the ambitious amateur provided that the instructions are followed carefully, particularly with regard to layout and wiring.

The P.E. Gemini has been designed for both home hi fi applications and for use with discotheques and, for this reason, has a microphone input that can be mixed with any other input. The amplifier is designed to be capable of driving two Quad electrostatic speakers and is thus capable of driving any other speakers, provided they are of the correct impedance.

BASIC DESIGN

Over the past few years, countless audio amplifiers have appeared in the technical press, so that one might well be justified in thinking that there could not be anything new left to describe. It cannot be claimed that this amplifier contains any exceptionally original features but rather is aimed at achieving the highest possible performance.

Of course all engineering design is a compromise between conflicting requirements and in choosing a final circuit the designer has to weigh the relative importance of distortion, frequency response, signal to noise ratio, transient response, stability, ease of construction and cost, etc. As an example one can always achieve a lower distortion level, in the main amplifier, by increasing the negative feedback, but this usually makes the transient response worse. In describing this amplifier we shall explain the operation of each of the circuits and the reasons for choosing it. We shall also indicate some of the defects of the circuits rejected.

SEPARATE UNITS

A separate pre-amplifier and power amplifier is used instead of the normal commercial "integrated" units. There are certainly good reasons for integrated amplifiers, but they are mostly concerned with cost of manufacture or sales promotion. An "integrated" amplifier is cheaper to manufacture than a "separate unit" one because only one chassis and case are required and the whole amplifier can be assembled on one production line. Also it should be remembered that much hi fi equipment is purchased by people having more interest in music than electronics. Many non-technical purchasers would be put off by the additional complications introduced by separate units.

For the electronics enthusiast however, separate unit construction offers many advantages. Since the power supply and the pre-amplifier are completely isolated, the risk of hum induction from the mains transformer (which can often be very difficult to eradicate) is completely removed. Also the risk of h.f. oscillation from stray capacitive coupling between the output stages and the sensitive inputs is greatly reduced. Many people prefer to mount all their equipment in a console. Separate unit construction is ideal for this since the pre-amplifier is light and compact and can easily be mounted by its front panel, whilst the main amplifier and power supply containing all the heavy and bulky components can be hidden away in the cabinet.

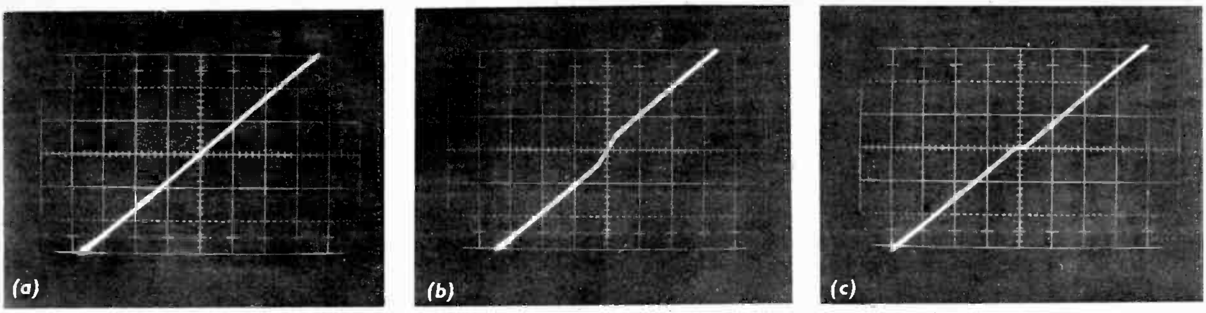


Fig. 1. Transfer characteristics (a) of class B output stage at 30mA bias; (b) of class AB output stage at 100mA bias; (c) at zero bias (threshold of conduction) showing the effect of too low a bias current on a class B output stage

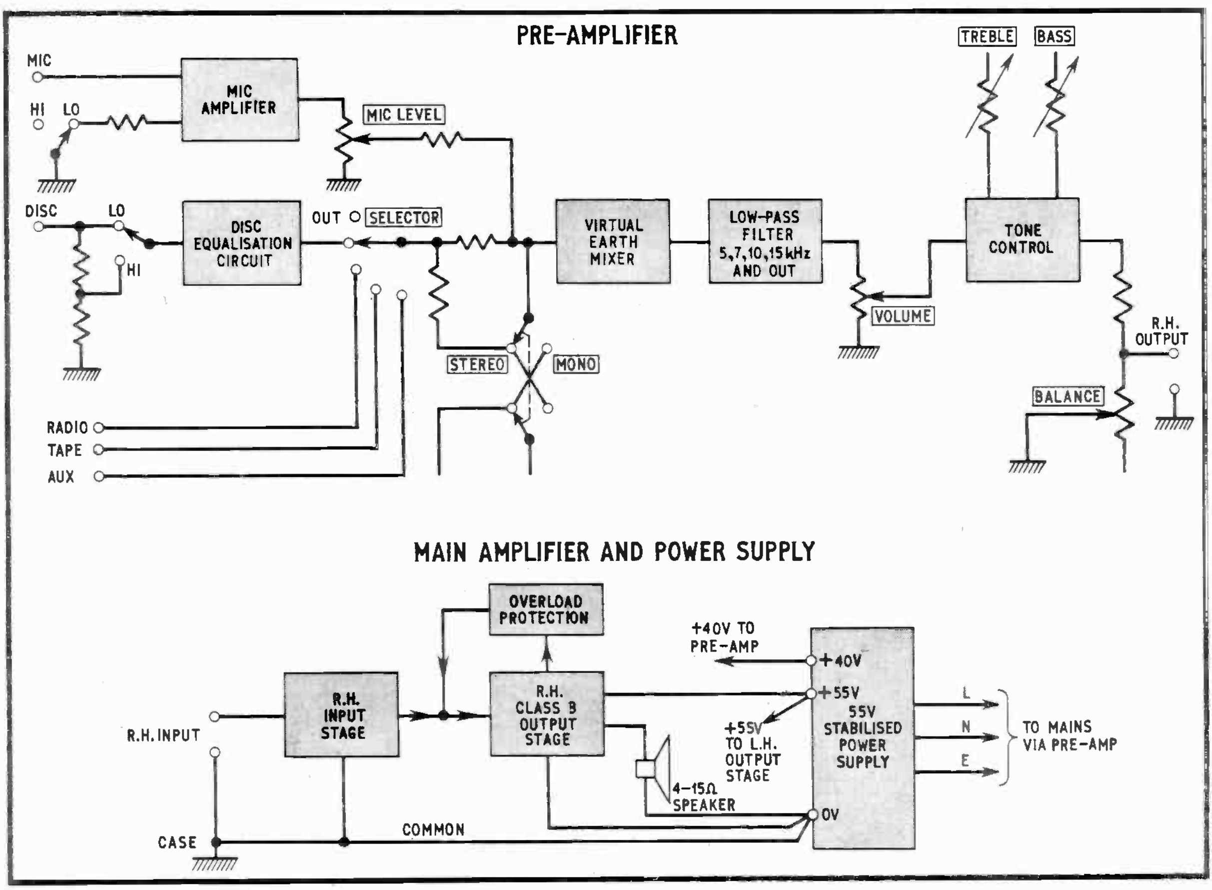
MAIN AMPLIFIER

The designer of a high quality audio amplifier can choose to operate in either class A, class B or class AB. Class A ùndoubtedly gives the lowest distortion, but at the expense of very high power dissipation and more costly components. The designers have chosen to operate this design in class B and although this produces a slight increase in distortion at low levels, the 0·02 per cent distortion so produced is subjectively inaudible.

One might think that class AB operation would combine the advantages of class A and class B, but in practice it tends to make things worse as Fig. 1 shows. On the central part of the transfer characteristic where both output transistors are conducting the mutual conductance (gm) doubles. When one of the output transistors cuts off as the circuit goes into the class B mode the abrupt change in the slope of the transfer characteristic produces a considerable rise in distortion.

The class B amplifier has been much maligned in recent years by the protagonists of class A. This is due probably to two factors, firstly that the transfer characteristic of the linear quasi-complementary output stage (used almost exclusively in early class B amplifiers) becomes markedly assymetrical at low

Fig. 2. Block diagram of one channel of the P.E. Gemini dual purpose stereo amplifier



signal levels and secondly, because of the difficulty of maintaining a stable bias current, many manufacturers took the easy way out and operated the output stage at or near zero bias. The overall effect was that, although the distortion may have been only 0·1 per cent at full output, it could easily rise to several per cent at low levels with disastrous effects on the reproduction.

However, now that fully complementary output transistors are available, these difficulties can be overcome. This design has a completely symmetrical transfer characteristic and a means of making the bias current exceptionally stable has been developed with the result that the standard of reproduction is subjectively equal to that of a class A amplifier, and with the added advantages of low dissipation and a wide choice of load impedances.

CIRCUIT DESCRIPTION

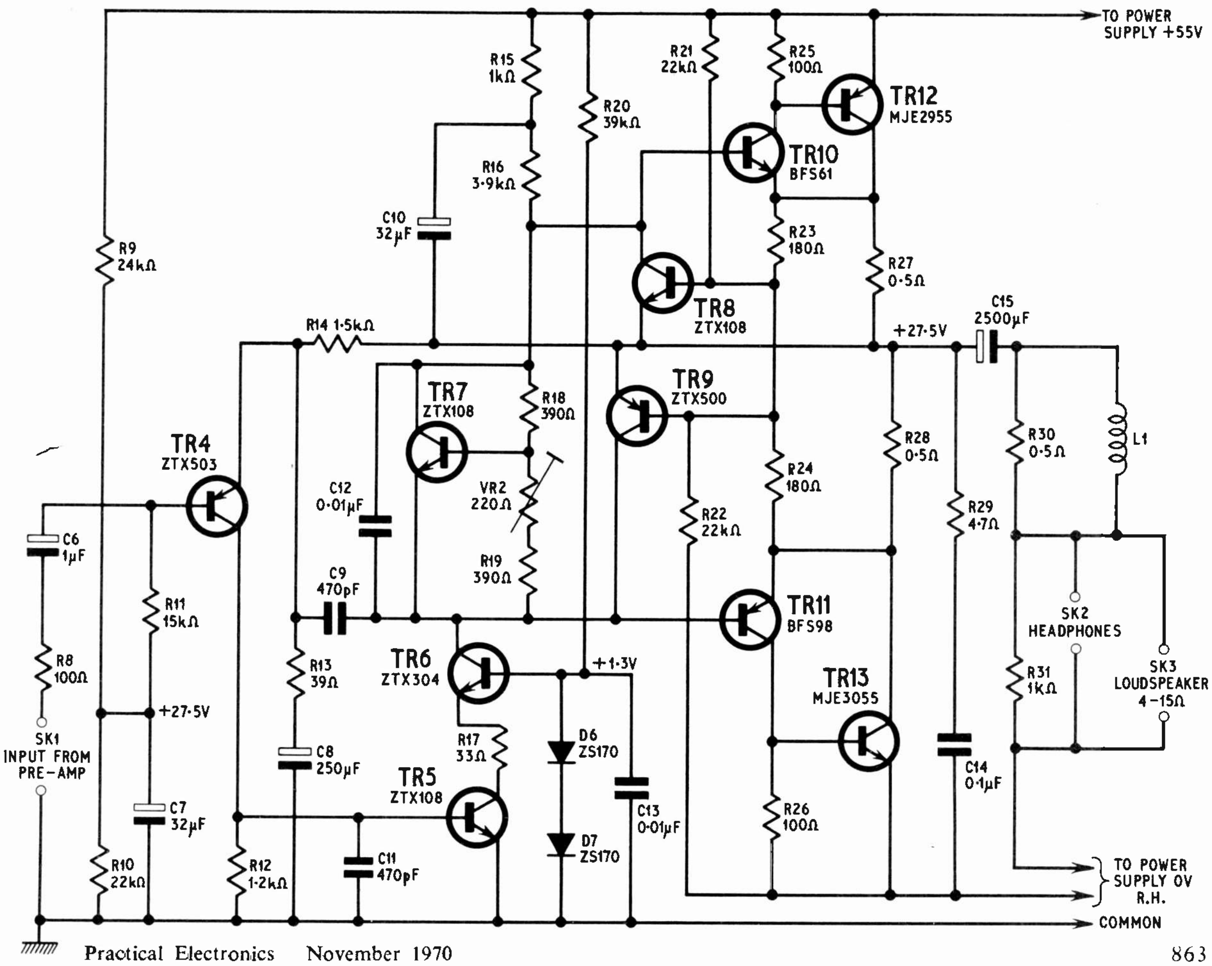
A schematic diagram of the P.E. Gemini is shown in Fig. 2 and the circuit diagram of the main amplifier itself is shown in Fig. 3. The main amplifier can be divided into three sections. The first section containing TR4, TR5 and TR6 provides all the voltage amplification but at low power level. The cascode arrangement of TR5 and TR6 eliminates "Early effect" distortion (Fig. 4) and R17 provides a means of limiting the current under short circuit conditions.

Transistors TR7, TR10, TR12 and TR13 form a fully complementary class B output stage giving a current gain of around 2,000 but a voltage gain of just below one. The high bias stability mentioned earlier is obtained by two means, firstly, compound *npn/pnp* and *pnp/npn* Darlington pairs are used instead of the more familiar configuration shown in Fig. 5, both of these compound pairs are effectively two stage feedback amplifiers by themselves and any change in bias current produced by a change in the junction temperature of the output transistors (TR12–TR13) is reduced by the loop gain stage; a factor of about 7.

Secondly, transistors TR7, TR10 and TR11 are thermally coupled so that any change in the base emitter voltage of TR10 or TR11 produced by power dissipation or variations in the ambient temperature is compensated by a similar variation in the base emitter voltage of TR7. The idea of thermal coupling is not new but it has been rarely put into practice because in the past it was necessary to mount the bias diodes or transistor on the same heatsink as the output transistors. This was often mechanically inconvenient so that more often than not no thermal coupling at all was used.

The present circuit overcomes the difficulty by using compound output stages and by thermally coupling the *driver* transistors to the bias transistors. As these three transistors are in close proximity on the printed circuit board, no mechanical problems arise. The improvement in bias stability is quite impressive. After sustained operation into a *short-circuit* with the output transistors running at 100 degrees Centigrade

Fig. 3. Circuit diagram of the right-hand channel of the main amplifier of the P.E. Gemini. The left-hand channel is identical—component numbers being the right-hand number plus 100



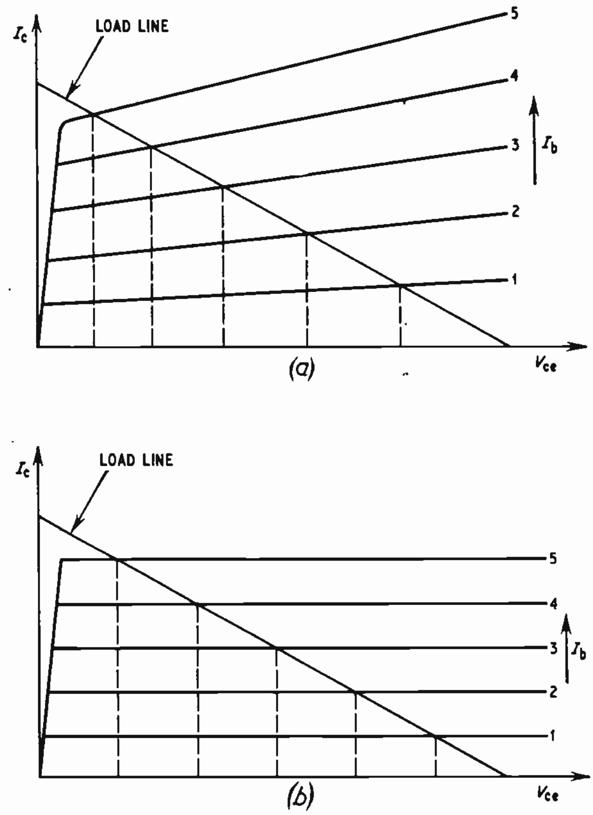


Fig. 4. Showing characteristics of single transistor and cascade output. (a) Single transistor—note that a change in V_{ce} between 1st and 2nd I_b step is much greater than between 4th and 5th step. This produces second harmonic distortion. (b) Cascade—in a cascade configuration the bottom transistor works at a fixed low voltage and the top transistor works in common base mode giving complete freedom from Early effect distortion

case temperature, the bias had changed by only 10 milliamps from the correct figure of 30 milliamps, and it returned to within 2 milliamps of the correct current in less than a minute.

Transistors TR8 and TR9 sense both the output current and the output voltage so that the output current under short circuit conditions is actually less than can be otained into a resistive load. When the base emitter voltage of either TR6 or TR9 exceeds about 0·6 volts, the transistors turn on and divert base current from TR10 and TR11. The circuit is thus protected against inadvertent short circuit but since the output transistors get very hot under short circuit conditions with full drive, it is unwise to operate the circuit for more than a few minutes into a short circuit.

PERFORMANCE—DISTORTION

Graphs of distortion versus output power are shown in Fig. 6. The rise in distortion at low levels may seem rather unusual but it is, in fact, far from unusual. Almost every audio amplifier exhibits this effect to some degree, many, especially those using quasi-complementary output stages, being very much worse. Only class A amplifiers are completely free from this effect.

It is interesting that one rarely sees curves such as these published either in manufacturers' brochures or in technical articles. One reason for this is that many designers measure distortion with an instrument called a distortion factor-meter; this works by completely eliminating the fundamental component of the waveform and measuring *everything* left, unfortunately including hum and white noise. When one is dealing with distortion levels as low as 0·01 per cent the harmonic components tend to disappear beneath the noise at power levels below 1 watt, so that low level measurements are, fortuitously perhaps, impossible.

A much more satisfactory and precise, although very expensive instrument is the wave analyser, which is in effect a very highly selective tuned amplifier. This

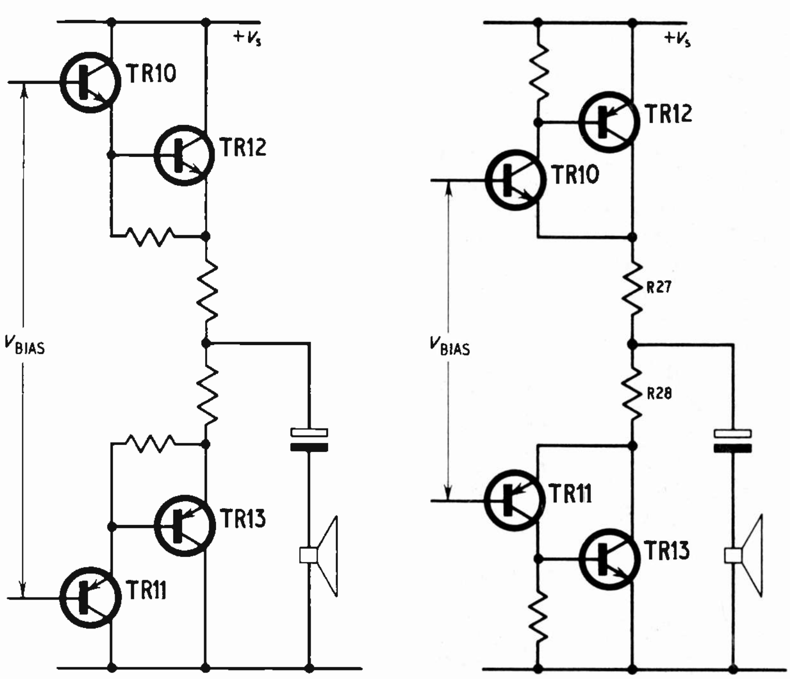


Fig. 5. Output stages (a) using conventional Darlington pairs. Power dissipation in TR12 and TR13 cause their V_{be} to drop, this causes the current in TR10 and TR11 to increase, providing more base current to the output transistors; net result is a large increase in bias current (b) using compound Darlington pairs. Power dissipation in TR12 and TR13 cause their V_{be} to drop but this does not affect the current in TR10 and TR11. Furthermore the small increase in bias current produced increases the voltage drop across R27 and R28 and reduces the collector current of TR10 and TR11 thus compensating for the original change

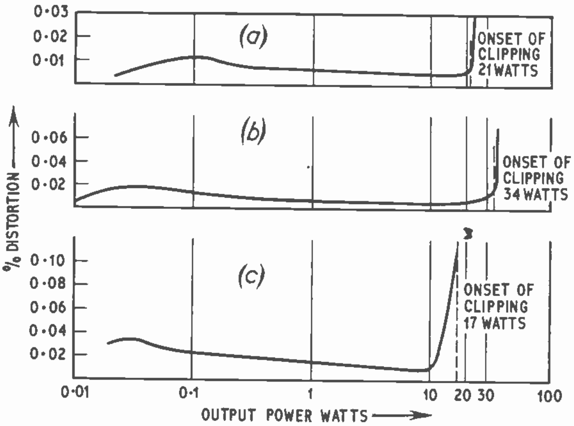


Fig. 6. Harmonic distortion plotted against output power for the P.E. Gemini main amplifier. (a) 15ohm load at 1kHz; (b) 8 ohm load at 1kHz; (c) 4 ohm load at 1kHz

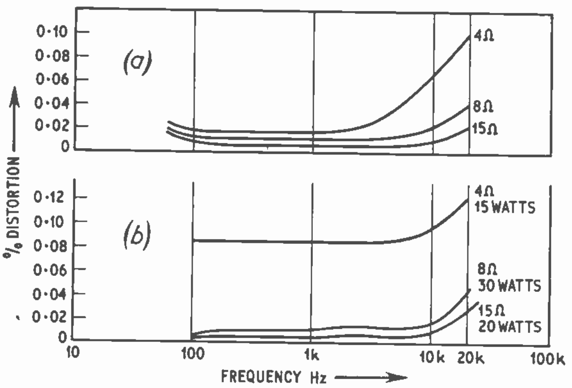


Fig. 7. Harmonic distortion plotted against frequency for the P.E. Gemini main amplifier. (a) 1 watt output into 4, 8 and 15 ohm loads; (b) maximum rated output into 4, 8 and 15 ohm loads

enables one to tune through the whole audio spectrum and measure the amplitude of each harmonic component separately. Because it is so highly selective the effect of noise is greatly reduced and one can make distortion measurements down to 10mW with ease. All our figures were measured with a wave analyser.

However, we suspect in many cases, when a designer has been able to make distortion measurements at low levels, he has preferred to forget the results.

Another popular trick that the enthusiast should watch out for is the practise of plotting distortion curves against a *linear* power scale. This expands the high power region to cover most of the graph and squashes everything below one watt to insignificance. As an example, if the curves shown in Fig. 6 were plotted on a linear scale, the region below 1W would occupy only the first one-fortieth of the scale.

The maximum distortion with a 15 ohm load is 0·012 per cent and this occurs at 100mW output; with an 8 ohm load this rises to 0·02 per cent at about 35mW. Both these levels are subjectively inaudible. Performance with a 4 ohm load is not quite up to the same standard but distortion still remains below 0·1 per cent for all levels up to 15 watts.

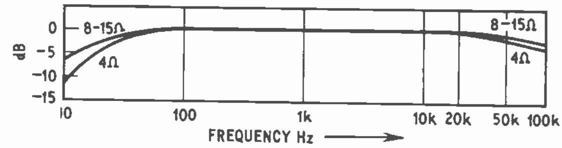


Fig. 8. Frequency response of main amplifier at 1 watt output

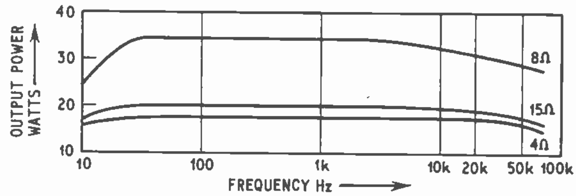


Fig. 9. Maximum output power—at onset of clipping—versus frequency for the main amplifier operating into 4, 8 and 15 ohm loads

Harmonic distortion versus frequency for 1 watt output is shown in Fig. 7a and for full rated output in Fig. 7b. The distortion with 8 ohm and 15 ohm loads remains reasonably constant between 100Hz and 10kHz, but starts to rise outside these limits because of various effects including falling loop gain and hole storage in the output transistors.

FREQUENCY RESPONSE

The frequency response of the amplifier is shown in Fig. 8 for an output of 1 watt at 1kHz, whilst Fig. 9 indicates the maximum output power that can be obtained at any frequency before visible waveform distortion becomes apparent. Fig. 10 shows the output waveform with a sinewave input slightly greater than maximum and shows that the amplifier limits cleanly without any tendency to latch-up.

Particular care has been taken to preserve a good transient response even with highly reactive loads such as Quad electrostatic loudspeakers. The transient response of the main amplifier under various load conditions is shown in Fig. 11. These photographs were taken with a 100kHz input filter to simulate the presence of the pre-amplifier.

Noise at the output of the amplifier is 100dB below full power into 8 ohms measured unweighted with a bandwidth of 20Hz to 20kHz.

However, because the human ear is most sensitive to noise components between 2 to 5kHz, an unweighted noise measurement does not correlate very well with the subjective noise level. Using a filter which approximates to the 30phon frequency response curve of the ear, the noise level is −110dB.

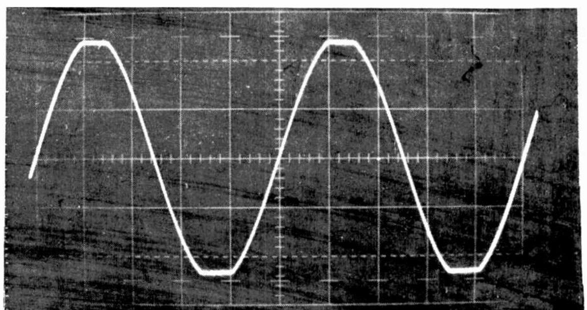


Fig. 10. Oscillogram showing clean limiting with freedom from latch-up with slight overload at 1kHz into an 8 ohm load

COMPONENTS . . .

MAIN AMPLIFIER

(both channels—components for L.H. channel are R.H. channel numbers plus 100)

Capacitors

C6, C106	1μF elect. 40V Mullard
C7, C107	32μF elect. 40V Mullard
C8, C108	250μF elect. 40V Mullard
C9, C109	470pF polystyrene 125V Radiospares
C10, C110	32μF elect. 64V Mullard
C11, C111	470pF polystyrene 125V Radiospares
C12, C112	0·01μF polyester 160V Mullard
C13, C113	0·01μF polyester 160V Mullard
C14, C114	0·1μF polyester 160V Mullard
C15, C115	2,500μF elect. 64V Mullard

2 off each

Resistors

R8, R108	100Ω	½W	± 10%	carbon
R9, R109	24kΩ	½W	± 2%	metal oxide
R10, R110	22kΩ	½W	± 2%	metal oxide
R11, R111	15kΩ	½W	± 10%	carbon
R12, R112	1kΩ	½W	± 10%	carbon
R13, R113	39Ω	½W	± 2%	metal oxide
R14, R114	1·5kΩ	½W	± 2%	metal oxide
R15, R115	1kΩ	½W	± 10%	carbon
R16, R116	3·9kΩ	½W	± 10%	carbon
R17, R117	33Ω	½W	± 10%	carbon
R18, R118	390Ω	½W	± 5%	carbon or metal oxide
R19, R119	390Ω	½W	± 5%	carbon or metal oxide
R20, R120	39kΩ	½W	± 10%	carbon
R21, R121	22kΩ	½W	± 5%	carbon or metal oxide
R22, R122	22kΩ	½W	± 5%	carbon or metal oxide
R23, R123	180Ω	½W	± 5%	carbon or metal oxide
R24, R124	180Ω	½W	± 5%	carbon or metal oxide
R25, R125	100Ω	½W	± 10%	carbon
R26, R126	100Ω	½W	± 10%	carbon
R27, R127	0·5Ω	3W	± 5%	wirewound
R28, R128	0·5Ω	3W	± 5%	wirewound
R29, R129	4·7Ω	1W	± 20%	carbon
R30, R130	0·5Ω	3W	± 5%	wirewound
R31, R131	1kΩ	½W	± 10%	carbon

VR2, VR102 220Ω preset pot (Radiospares "Mouldtrim")

2 off each.

Semiconductors

TR4, TR104	ZTX503	Ferranti
TR5, TR105	ZTX108	Ferranti
TR6, TR106	ZTX304	Ferranti
TR7, TR107	ZTX108	Ferranti
TR8, TR108	ZTX108	Ferranti
TR9, TR109	ZTX500	Ferranti
TR10, TR110	BFS61	Ferranti
TR11, TR111	BFS98	Ferranti
TR12, TR112	MJE2955	Motorola
TR13, TR113	MJE3055	Motorola
D6, D106	ZS170	Ferranti
D7, D107	ZS170	Ferranti

2 off each

Miscellaneous

L1, L101 25 turns of 24 s.w.g. enamelled, copper wire on Mullard bobbin DT2178 (2 off)
SK2 5 pin 180 degree DIN socket
SK1 5 pin 300 degree DIN socket
SK3, SK103 DIN speaker sockets (2 off)
Capacitor clamps
Turret tags
Heat sinks, Redpoint type 6W (2 off, obtainable from Electroniques)
Grommets
Tag strip
¼in spacers, 6B.A. (8 off)
Case Contil type N style MOD—2 (West Hyde Developments)

Ready drilled fibreglass printed circuit boards and semiconductors are available from the authors at No. 4, Eleanor Road, Royton, Oldham, Lancs., by mail order only at the following prices:

Pre-amplifier p.c.b.	39s
Main amplifier p.c.b.	29s
Power supply p.c.b.	12s
Pre-amplifier semiconductors (stereo)	35s
Main amplifier semiconductors (stereo)	145s
Power supply semiconductors	50s
Postage and packing	3s

POWER SUPPLY

Capacitors

C1	250μF elect. 64V Mullard
C2	250μF elect. 16V Mullard
C3	2800μF elect. 100V Mullard
C4	0·1μF mixed dielectric 1000V Radiospares
C5	0·1μF elect. 250V Mullard

Resistors

R1	4·7kΩ	1W	± 2%	Radio spares metal oxide
R2	820Ω	½W	± 2%	Radio spares metal oxide
R3	3·9kΩ	1W	± 10%	carbon
R4	47Ω	½W	± 10%	carbon
R5	1·5kΩ	½W	± 10%	carbon
R6	2·2kΩ	1W	± 10%	carbon
R7	470Ω	1W	± 10%	carbon

VR1 470Ω preset pot (Radiospares "Mouldtrim")

Semiconductors

TR1	BFS98	Ferranti
TR2, TR3	MJE3055	Motorola (2 off)
DR1	KS100A	Ferranti
D2, D3, D4, D5	ZS271	Ferranti (4 off)

Transformer

Parmeko mains type P3175 (secondary 48V, 2A d.c.) obtainable from Electroniques. (Other transformers of 48–50V rms rated 2A d.c. or 3A a.c. may be used if they are of similar physical size)

Miscellaneous

FS1 1A slow-blow fuse and holder (Bulgin F55)
FS2 2A slow-blow fuse and holder (Bulgin F55)
SK4 3 pin mains plug and socket (Bulgin P429 and P430)
Capacitor clamps
Earth tags, 4B.A. and 2B.A. fixings, grommets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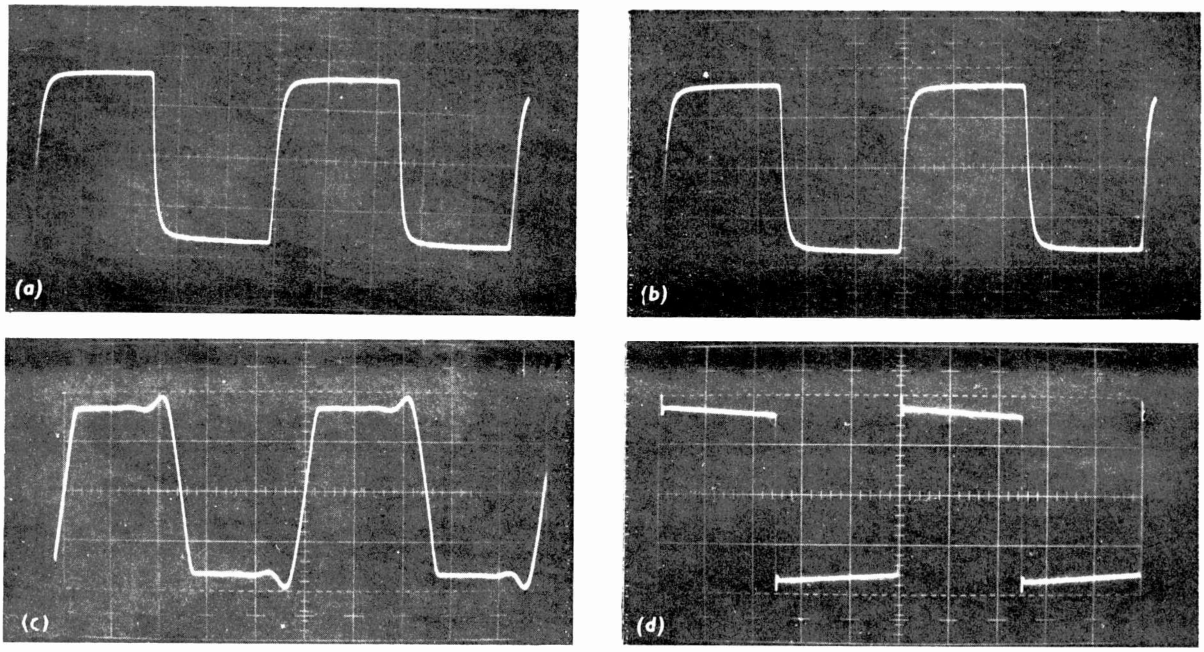


Fig. 11. Oscillograms showing the transient response of the main amplifier (a) into 8 ohm load at 1kHz; (b) into 8 ohm + 0·1μF load at 10kHz; (c) into 8 ohm + 2μF load (electrostatic loudspeaker) at 10kHz; (d) into 8 ohm + 2μF load (electrostatic loudspeaker) at 1kHz

POWER SUPPLY CIRCUIT

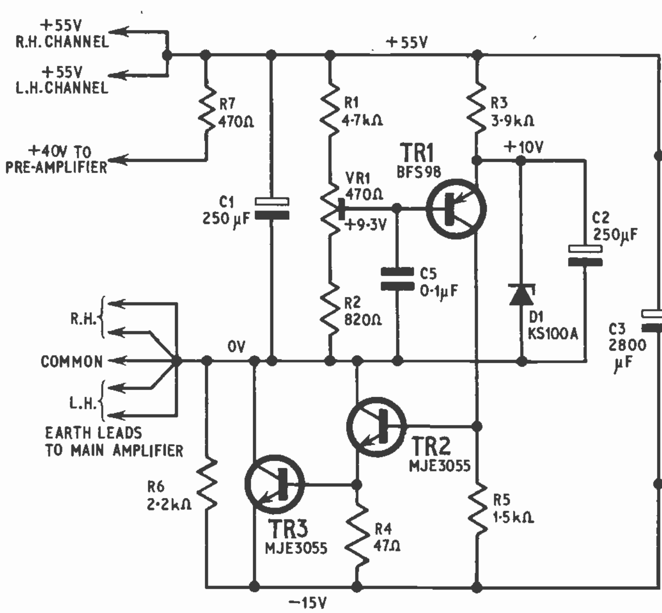
The circuit diagram of the stabilised power supply is shown in Fig. 12. This provides an output of 55 volts at up to 2 amps d.c., 6 amps peak (both channels driven at full sine wave power into an 8 ohm load).

Many constructors may tend to think of a stabilised power supply as an unnecessary luxury but it is strongly recommended that the stabilised power supply is used as its cost is a relatively small proportion of the total cost of the amplifier and it provides many advantages. The amplifier will deliver 30 watts per channel *continuously*; not just music power. Switch-on "plops" are eliminated by the slow switch-on characteristic of the power supply, the main amplifier is protected against mains surges and the low output impedance of the power supply greatly reduces the risk of low frequency instability.

The circuit of the power supply is somewhat unconventional and it has the valuable characteristic that if a short circuit is present at the output, it will not turn on. Transistor TR1 is the error amplifier which compares the voltage present at its base with the Zener regulated voltage at its emitter. If the base voltage is too low the collector current of TR1 increases and vice versa.

The collector current of TR1 is amplified by the Darlington pair TR2 and TR3, which provide an output current of up to 2 amps d.c. Capacitor C2 provides the slow turn-on characteristic by allowing the reference voltage to build up slowly as C2 charges through R3 until the Zener diode turns on. Capacitor C1 reduces the output impedance of the power supply at high frequencies.

Next month: main amplifier construction details



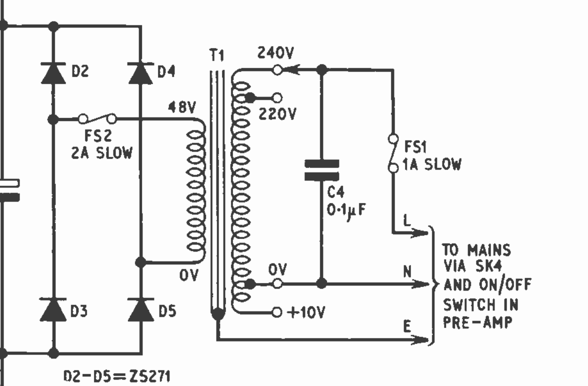


Fig. 12. Circuit diagram of the stabilised power supply of the P.E. Gemini

RADIO CONTROL SEQUENCE SWITCH

By A.D. BONE

THE unit to be described was designed to replace a mechanical sequence switch, in controlling a servo-motor, which in turn controlled the speed of a model boat. A unit which would respond rapidly and reliably to the pulses from the transmitter was therefore required.

This stipulation ruled out mechanical servos which, apart from being difficult to make, tend to be rather slow and unreliable in operation. An electronic switch was therefore the obvious answer, being easy to construct and install, and fast in operation.

CIRCUIT DESCRIPTION

The basic circuit is a bistable switch shown in Fig. 1. This effectively divides the number of pulses at the input by two. If, for instance, TR2 is conducting and TR1 is cut off, then nearly all the supply voltage will be developed across relay RLA, and so this relay will be operated. The collector of TR2 must therefore be just above earth.

As TR1 is cut off, then its collector will be at a point just below the supply voltage. This means then that D2 has only a small negative reverse bias across it, but D1 has nearly all the supply voltage across it in the reverse direction.

If a positive pulse now appears across the resistor R5, it will not overcome the 12 volts across D1, but will easily overcome the small voltage across D2, and hence D2 will conduct. As the pulse is positive though, it will reduce the base current of TR2 making the collector more negative. This, in turn, increases the base current of TR1, and hence reduces the collector voltage. This decreases the base current of TR2 until it is cut off and TR1 fully conducting.

At first TR2 was conducting and relay RLA operated. On the reception of a positive input pulse TR2 switched off, and TR1 switched on so that relay RLA released. As another positive pulse is applied TR1 switches off and TR2 switches on, operating relay RLA once again. Therefore the total effect on relay RLA is to operate and release to each respective input pulse.

MOTOR SWITCHING

In Fig. 1 the contacts of relay RLA are in the servo-motor supply, wired such that when the relay is operated the motor will drive in one direction, and when released,

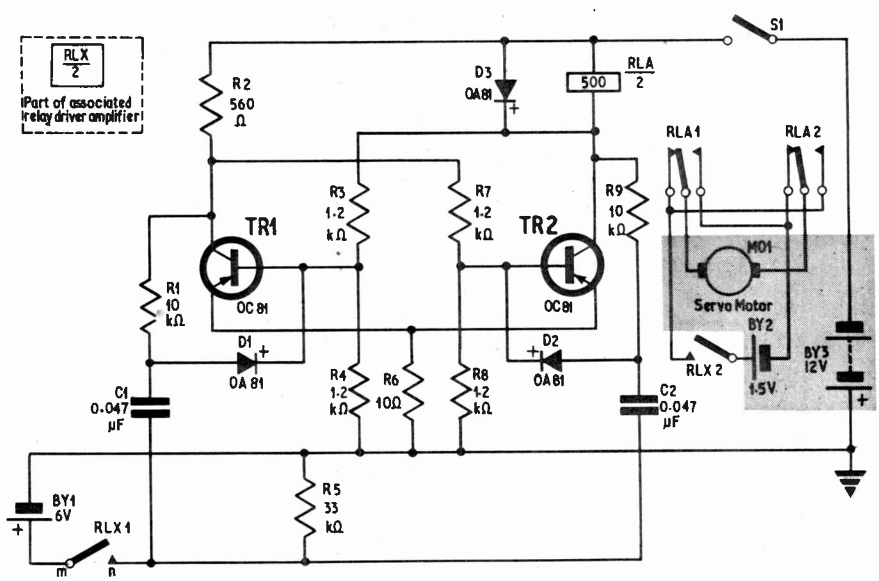


Fig. 1. Circuit diagram of sequence switch

the motor will drive in the opposite direction. Therefore the effect of the input pulses to the bistable will be to change its direction of drive at each input pulse.

If, as in Fig. 1, input pulses are supplied from relay RLX1 then the inclusion of another pair of make contacts RLX2 in the motor circuit makes the motor operate only on the reception of an input pulse. As long as this pulse is maintained the motor will drive, say anticlockwise.

On the release of this pulse, the bistable and relay RLA change their state, preparing the motor drive circuit for clockwise drive on the reception of the next pulse.

JUMPING POSITIONS

This circuit then, makes the motor very quick to respond to input pulses, and hence makes "jumping a position" very easy. This is an essential requirement in the precise control of a model in a sequential system, whether it be speed or steering that is being controlled.

In other words say, for complex manoeuvres of a model, two consecutive "left moves" may be required. It may not be required, though, to use the unavoidable "right move" sequentially placed between the two required left moves. It is therefore necessary to "jump" the intermediate right move, such that the model does not respond to this position of the servo.

With this system this is overcome by the fast acting bistable circuit. If two left moves are required, one fast blip on the transmitter button will be sufficient to operate the bistable and therefore change the direction of drive of the servo motor. This completely eliminates unwanted movements of the model.

CONSTRUCTION

The components of the sequence switch are assembled on Veroboard. This results in a neat compact unit, measuring $1\frac{3}{4}$in by $1\frac{1}{4}$in, which is small compared with similar mechanical units.

Firstly the Veroboard is cut to size, and the copper strips broken as shown in Fig. 2. The components are then mounted as shown in Fig. 2, the wires being pushed through and soldered on the underside of the Veroboard.

TESTING

Once the unit has been assembled, the relay RLA should be wired to the board. The 12V supply should now be connected.

To check transistor switching and consequent relay operation, a 6V battery should be loosely connected between the junction of C1, C2, R5 and the 0V line.

As this battery is connected and disconnected, relay RLA should operate and release in sequence. If it does not, disconnect immediately and check wiring connections.

INSTALLATION

The prototype sequence switch, plus relays and relay driver amplifier for relay RLX were mounted on a wooden base. However, the constructor is free to install these units into his model as required as placement is not critical.

Main motor batteries can be used to power the unit, in which case a common on/off switch would be used. Alternatively, a separate 12V battery (BY3) could be used.

In the author's boat a tone receiver drove an "amplifier B" as described in the January 1967 issue of PRACTICAL ELECTRONICS. This amplifier in turn operated relay RLX to supply input pulses. Of course, any relay with two pairs of contacts will suffice for RLX, if driven by a suitable relay amplifier.

This unit could also be used for direct control of the main motor, but would be rather wasteful of transmitter power, as the transmitter would have to be on all the while one wished to maintain a certain move of the model.

(Note: the January 1967 issue is now out of print)

★

COMPONENTS . . .

Resistors
R1 10kΩ
R2 560Ω
R3 1·2kΩ
R4 1·2kΩ
R5 33kΩ
R6 10Ω
R7 1·2kΩ
R8 1·2kΩ
R9 10kΩ
All 10%, ¼ watt, unless otherwise stated

Capacitors
C1 0·047μF polyester
C2 0·047μF polyester

Transistors
TR1 OC81 Mullard
TR2 OC81 Mullard

Diodes
D1 OA81
D2 OA81
D3 OA81

Relays
RLX (see text)
RLA 500Ω, 600 type P.O. relay, 6V 4-pole changeover

Miscellaneous
BY1 6V Ever Ready (Type 996)
Veroboard, solder, wire.

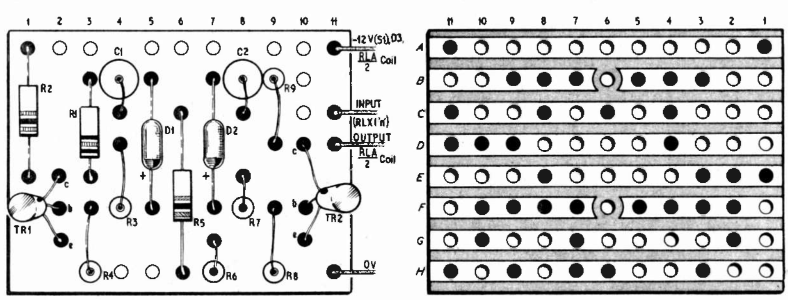
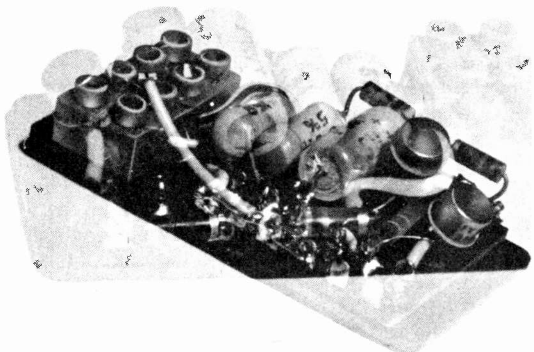


Fig. 2. Component and wiring layout of module

BRAKE LIGHT REPEATER

By S.C.HAYNES



THE circuit described in this article is a simple transistor switch to indicate to a car driver the correct operation of both brake-lights. It is most reassuring to have a continuous check on brake light function and to know that the vehicle is complying with the law, quite besides the safety considerations.

CIRCUIT

The circuit uses the principle that a silicon transistor needs about 0·7 volts across base and emitter to make it conduct fully. A low value resistor is placed in the brake light circuit (R1 in Fig. 1.), and the voltage developed across it when the brake lights are working is used to switch transistor TR1.

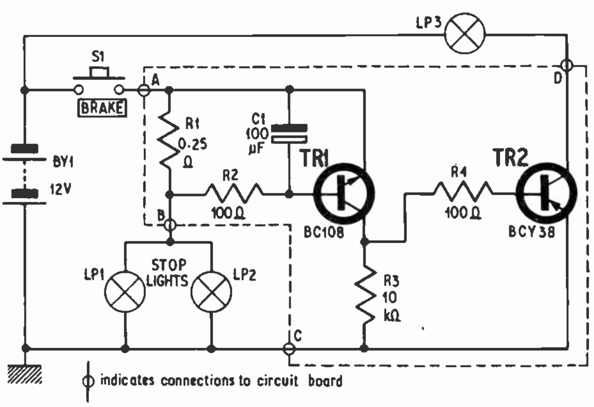


Fig. 1. Circuit diagram of the brake light repeater. Circuitry within the broken line is housed on the tag panel, all other circuitry—except LP3—is part of the car wiring

A resistor of 0·25 ohm is used and the fact that each 21 watt brake-light bulb takes about 2 amp means that with two bulbs working the transistor will be switched, but with only one bulb working the transistor will not switch, hence the panel-light will indicate correct operation. The presence of a resistor in the brake-light lead reduces the brake-light voltage by about a volt. This does not appear to dim the bulbs noticeably and has the advantage that the brake-lights are running nearer to 12 volts and so last longer. Remember that a motor vehicle electrical system runs at about 15 volts in daylight running conditions.

The two transistor circuit shown at Fig. 1 is self protecting, since in the event of a short circuit failure of TR2 the panel-light LP3 will be on whenever the ignition is on, any other transistor failure will prevent LP3 from illuminating, indicating that something is amiss. The circuit also includes a resistor and capacitor in the base circuit of TR1 to help alleviate the effect of the initial surge current that occurs with cold bulbs, so removing a possible cause of transistor failure.

The circuit shown is for positive earth; negative earth systems require the swopping of the transistor types, *pnp* for *npn* and vice versa. The wiring into the vehicle is complicated by the fact that an isolated panel-light is required with its other side connected to an ignition controlled supply.

CONSTRUCTION AND INSTALLATION

A piece of s.r.b.p. of suitable size is drilled and the tag-board and connector mounted with bolts. The wires and other components are soldered in place as shown in Fig. 2; the layout is not critical. The

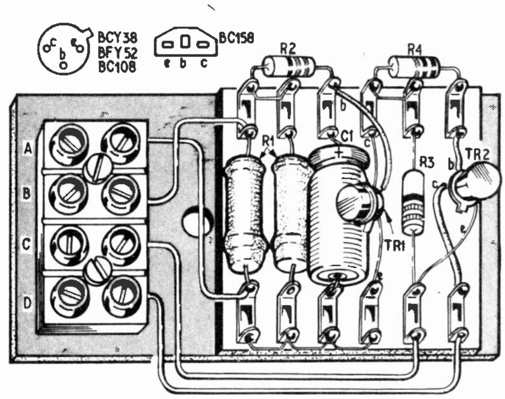
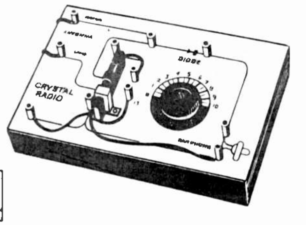


Fig. 2. Layout and wiring diagram of the tag panel for the brake light repeater, connections A to D correspond to those shown on the circuit diagram

ROC ELECTRONICS

CRYSTAL RADIO KIT
Model R.125

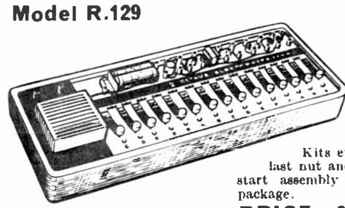


This easy to build Radio is based on the same circuit developed by Marconi for the very first radio transmission but uses a modern ferrite aerial for maximum efficiency.
A perfect introduction to Radio Theory.

PRICE £1.10.0.

EXCLUSIVE

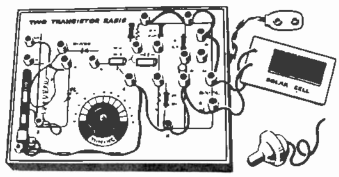
2 OCTAVE ELECTRONIC ORGAN KIT
Model R.129



Complete with a music book containing 10 easy to play songs the R.129 solid state organ kit covers 2 full octaves.
Slotting into a fitted hardwood case the top panel carries the key assemblies and all the components including the loudspeaker. Like all Roc Electronic Kits every item is included down to the last nut and bolt so that the constructor can start assembly within minutes of opening the package.

PRICE £4.10.0.

2 TRANSISTOR SOLAR RADIO KIT Model R.126



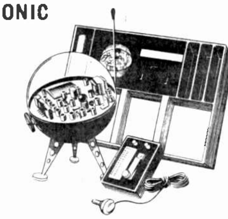
Like all Roc Electronic Kits the R.126 uses reliable no-solder connections to produce a complete 2 transistor radio in under 2 hours. As well as battery operation the kit is supplied complete with a solar cell to provide power from the Sun or any strong light source.

PRICE £2.10.0.

EXCLUSIVE

20 PROJECT SOLAR ELECTRONIC KIT Model R.128

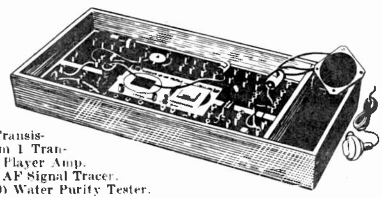
This ultra modern Project Kit is shaped for the space age. Carried inside a transparent domed 4½in capsule the R.128 comes complete with a self-contained solar cell to power any one of 20 projects ranging from a one transistor radio to a morse set complete with key and morse training code. Supplied complete with easy to follow instructions and even the cement to assemble this unique electronic space capsule.



PRICE £4.10.0.

EXCLUSIVE

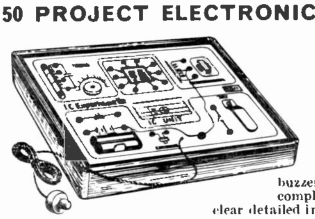
10 PROJECT INTEGRATED CIRCUIT KIT
Model R.127



Using a robust Solid State Integrated circuit the R.127 kits will build any one of these projects: (1) Germanium Radio. (2) Test Oscillator. (3) Morse Telegraph Training Set. (4) I.C.I. Transistor Radio. (5) Germanium 1 Transistor Radio. (6) Record Player Amp. (7) Continuity Tester. (8) AF Signal Tracer. (9) Radio Transmitter. (10) Water Purity Tester.

PRICE £3.10.0.

50 PROJECT ELECTRONIC KIT
Model R.130

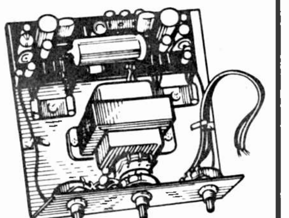


King of the Roc Electronic Kits is the Giant R.130 which makes up into no less than 50 separate projects including Radio Receivers, Transmitters, Tachometer, Rain Alarm, Testers, Electronic Switches, Amplifiers and even an Electronic Target Game. As well as earphone, speaker, meter, relay, transformer, solar cell, buzzer, etc., etc., the R.130 is supplied complete with a fitted hardwood case and clear detailed instructions for all 50 projects.

PRICE £7.19.0.

5 WATT STEREO INTEGRATED AMPLIFIER CHASSIS Model R.123

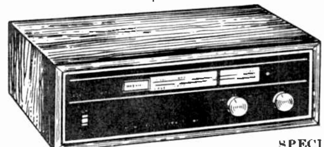
Mounted on a heavy gauge chassis the fully transistorised R.123 stereo amplifier is completely self-contained even down to ganged volume and separate tone controls. For a simple stereo amplifier of excellent quality all you have to provide is the cabinet and control knobs.
SPECIFICATION:
Output: 5W total. 2·5W per channel.
Input sensitivity: 600mV at 2·2Mohms.



PRICE £4.19.0.

EXCLUSIVE

AM/FM/MPX STEREO TUNER Model R.132

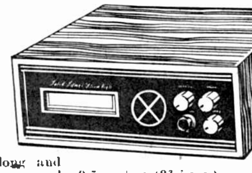


Matching the R.131 amplifier in both styling and performance the R.132 tuner covers AM and FM including stereo multiplex channels. A separate meter indicates signal strength and tuning on both AM and FM Bands. A usable FM sensitivity of 3μV means that the R.132 can be used anywhere, even in different stereo reception areas.
SPECIFICATION:
FM: frequency range: 87–108MHz.
Usable sensitivity: 3μV for 20dB quieting.
Stereo separation: 30dB at 1KHz.
Image rejection: 60dB.
AM: frequency range: 525–1605KHz.
Usable sensitivity: 250μV.

EXCLUSIVE

PRICE £36.0.0.

5 WATT 8 TRACK CARTRIDGE STEREO AMPLIFIER Model R.133



Just slot in one of the many 8 track cartridge tapes available for a continuous programme of your favourite music. A manual programme override switch enables you to switch from one track to the next at the push of a button at the same time a numbered indicator lights up to show which track is playing. Beautifully finished in an oiled walnut cabinet the R.133 is mechanically engineered to provide long and reliable service. SPECIFICATION—Tape speed: 9·5 cm/sec (3¾ i.p.s.). Wow & flutter: better than 0·3%. Frequency range: 40–12,000Hz. Cross talk: better than 45dB at 1,000Hz. Output: 5W total. 2·5W per channel. Amplifier outputs: 200mV.

EXCLUSIVE

PRICE £36.0.0.

40 WATTS STEREO AMPLIFIER Model R.131

Looking as good as it sounds the R.131 stereo amplifier offers excellent quality and value for money. Housed in a handsome wooden cabinet this new Roc Amplifier uses the latest solid state circuit techniques to give a specification second to none at the price.
SPECIFICATION—Output: 40W total 20W per channel. Frequency Range: 20–35000Hz. Inputs: Phone: Mag. 3·6mV R.I.A.A.: Xtal, 100mV; tape, 200mV; tuner, 200mV. Control: Bass, treble, volume left, volume right, selector main/remote speakers, power on/off, loudness and stereo/mono.

EXCLUSIVE

PRICE £25.0.0.

STEREO HEADPHONES
Model R.328

Built up to a standard not down to a price, the R.328 stereo headphones represent a breakthrough in value for money.
A valuable addition to any stereo installation they will provide many hours of listening pleasure.
SPECIFICATION:
Matching impedance: 8–16 ohms.
Frequency range: 30–15,000Hz.

PRICE £2.8.0.

EXCLUSIVE

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Orders under £10 please add 5/- post and packing. Orders over £10 sent post free.

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193 EDGWARE ROAD LONDON W2 1ET
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MICRO SWITCH

5 amp. changeover contacts, 1/9 each, 18/- doz. 15 amp. model 2/- each or 21/- doz.

TOGGLE SWITCH

3 amp. 250V with fixing ring. 1/6 each. 15/- doz.

CONSTRUCTORS' PARCEL
1. Plessey miniature 2 gang tuning condenser with built-in trimmers and wave gang switch. 2. Ferrite slab aerial with coils to suit the above tuning condenser. 3. Circuit diagram giving all component values for 6 transistor circuit covering full medium wave and the long wave band around radio 2. The three items for only 7/6 which is half of the price of the tuning condenser alone.

SLOW MOTION DRIVES
For coupling to tuning condensers, etc. One end ¼in shaft, the other end fits to a ¼in shaft with grub screws. Price 4/6 each, 48/- dozen.

LARGE PANEL MOUNTING MOVING COIL METERS
Size 5in 4in Centre zero 200-0-200 micro amp. made by Sangamo Weston. Regular price probably £8. Our price 59/6. Ditto but 100-0-100 79/6.

A.C. AMMETER
0-5 amps. flush mounting—moving iron. Ex equipment but guaranteed perfect 29/6.

CIRCUIT BOARDS
Heavy copper on 3/32 paxolin sheet ideal for making power packs, etc., as sheet is very strong and thick enough to allow copper to be cut away with hacksaw blade. 5in 5in 1/6 each. 15in · 5in, 4/6 each.

6KVA AUTO-TRANSFORMER
in ventilated sheet steel case—tapped. 110v-140v-170v-200v-230v. Ex equipment but guaranteed perfect £19.10.0, carriage at cost.

PP3 BATTERY ELIMINATOR

Run your small transistor radio from the mains -full wave circuit. Made up ready to wire into your set and adjustable high or low current. 8/6 each.

REED SWITCHES
Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:
Miniature. 1in long approximately ⅛in diameter. Will make and break up to ½A up to 300 volts. Price 2/6 each, 24/- dozen.
Standard. 2in long $\frac{3}{16}$in diameter. This will break currents of up to 1A, voltages up to 250 volts. Price 2/- each, 18/- per dozen.
Flat. Flat type, 2in long, just over $\frac{1}{16}$in thick, flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price 6/- each. £3 per dozen.
Small ceramic magnets to operate these reed switches 1/9 each. 18/ dozen.

0·005mFd TUNING CONDENSER

Proved design, ideal for straight or reflex circuits 2/6 each. 24/- dozen.

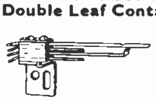
SUB-MINIATURE MOVING COIL MICROPHONE
as used in behind the ear deaf-aids
Acts also as earphone size only ½in ⅜in ¼in. Regular price probably £3 or more. Our price 19/6. Note these are ex equipment but if not in perfect working order they will be exchanged.

CHART RECORDER MOTOR
Small (2in diameter approx.) instrument motor with fixing flange and spindle (¼in long, ⅛in diameter) integral gear box gives 1 rev. per 24 hours. 19/6.

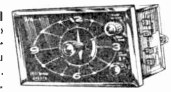
IGNITION (E.H.T.) TRANSFORMER
Made by Parmeko Ltd., Primary 240V 50Hz. Secondary 5kV at 23mA. Size approx. 4½in 3½in × 2¼in thick. 29/6 plus 4/6 P. & P.

12 VOLT EXTRACTOR FAN BY DELCO

Ideal for ventilation in Caravan, Car or Boat. 6 Bladed 5in diameter fan inside heavy duty cylinder with 3 point fixing flange. 5½in diameter fixing hole. Length approx. 8½in. Exceptional bargain 27/6 plus 5/6 post and insurance.

NEED A SPECIAL SWITCH?
Double Leaf Contact

Very slight pressure closes both contacts, 1/3 each, 12/- doz. Plastic push-rod suitable for operating, 1/- each, 9/- doz.

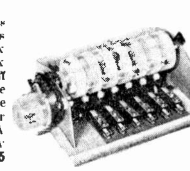
COMPUTER MULTI-CORE CABLES
12, 14/0076 copper cores, each one insulated by coloured P.V.C. then separately screened, the 12 metal braided cores laid together and P.V.C. covered overall making a cable just under ½ in. dia. but quite pliable. Price 7/6 per ft. Any length cut. Other sizes available 7 core 5/- ft., 6 core 4/- ft., 4 core 3/6 ft.

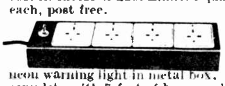
25 AMP ELECTRICAL PROGRAMMER

Learn in your sleep: Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5¼ · 3½ · 2½in. deep. Metal encased, glass fronted with chrome surround. Offered at 47/6 plus 4/6 postage and insurance.

15, 30, 40 & 100 WATT HI-FI SPEAKERS

FULL FI 12 INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi lead and Rhythm Guitar and public address. Flux Density 11,000 gauss- Total Flux 44,000 Maxwells- Power Handling 15 watts R.M.S. Cone Moulded fibre Freq. response 30-10,000 c.p.s.- Specify 3 or 15 ohms Mains resonance 60 c.p.s.—Chassis Diam. 12in.—12⅜in. over mounting lugs—Baffle hole 11in. Diam.- Mounting holes 4, holes ¼in. diam. on pitch circle 11⅝in. diam.- Overall height 5½in. A £6 speaker offered for only £3.19.6 plus 7/6 p. & p. 12in. 40 watt £8.19.6 plus 8/6 p. & p. 15in 25 watt £7.19.6 plus 10/6 p. & p. 18in. 100 watt £19.10.0 plus 30/- p. & p.

INTEGRATED CIRCUIT BARGAIN
A parcel of integrated circuits made by the famous Plessey Company. A once-in-a-lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first-grade device, definitely not sub-standard or seconds. 4 of the ICs are single silicon chip GP amplifiers. The 5th is a monolithic NPN matched pair. Regular price of parcel well over £5. Full circuit details of the ICs are included and in addition you will receive a list of many different ICs available at bargain prices 5/- upwards with circuits and technical data of each. Complete parcel only £1 post paid. *DON'T MISS THIS TERRIFIC BARGAIN.*

MOTORISED SWITCH
For Animated Signs, etc.

This is a motorised programmer switch, mains operated, with six 15 amp changeover contacts operated by triggers on a rotating drum. Six triggers will put switches up and another six triggers will put switches down. Also simple on/off operation or changeovers are possible. The triggers are exactly set to any position around the drum which is rotated by a one rev. per hour motor. (Motors with other speeds available.) A beautifully made precision switch which probably cost in excess of £20. Limited quantity only £9.15 each, post free.

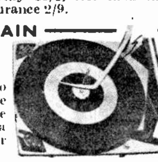
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 13 amp sockets and on/off switch with neon warning light in metal box. Takes standard 13 amp fused plugs. Supplied complete with 7 feet of heavy cable. 39/6 wired up, ready to work plus 4/6 post and insurance. 5 amp 3 pin model 35/-. 15 amp 3 pin model 45/-.

BARGAIN OF THE YEAR
MICROSONIC KEYCHAIN RADIO

7 transistor Key chain Radio in very pretty case, size 2⅜ · 2⅛ · 1⅛in—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne. Frequency range: 530 to 1,600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency: 465Kc/s or 455Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East these sets suffered slight corrosion as the batteries were left in them but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. Price only 24/6 plus 2/6 post and insurance, less batteries. 6 for £7, post free. Rechargeable Nicad batteries 8/6 pair.

ELECTRIC CLOCK WITH 25 AMP SWITCH

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

MOST AMAZING BARGAIN
PRINCESS AUTO CHANGER

The most amazing bargain ever! A brand new Auto change record player for less than the price of a single player . . . due to a frustrated export order we are able to offer the Balfour Princess 4 Speed Autochanger- a really fine machine at about one-third of its regular price.
The Balfour has two unique features (1) A patented brush system which automatically cleans stylus after each record playing and (2) at shut off the pick-up locks itself into its recess—other features include pick-up height and stylus pressure adjustments, and motor suitable for our 230/240 or for 115V. continental mains.
Beautifully styled—this is a high class expensive instrument but you can purchase one this month for only 59/6 plus 10/6 post and packing. One point, these changers have been to France and back and the vibrations of the journey, etc., may have loosened screws or otherwise put them out of adjustment. However, with each we supply a 16 page service manual and fault finding chart which is so detailed that if necessary you could completely re-build the changer. So this is truly a bargain that you will not want to miss so order today.

MAINS TRANSFORMERS
Note all these are first grade Transformers and all have normal 200/240 volt 50 cycle primary.
Mains Transformer Type No. 56786
Upright mounting, size 3 × 2½ · 2in. approximately. 2 secondaries one 28 volt 1 amp and the other 5·5 volt 1·5 amp. Earth screen between primary and secondaries—this transformer will power a 5·5 watt stereo amplifier (circuit diagram available, price 2/6). Suitable output transformer is type 56787 described below. Our price 17/6 plus 4/6 post.
Mains Transformer Type No. 56733
Chassis mounting type, size approximately 3 · 2½ 3in., 2 secondaries one 230 volt at 60 mA and other 6·3 volts 1·5 amp. Earth screen between primary and secondaries. This will power a 5 watt amplifier (circuit available 2/6). Matching OPT. is 56734 described below. Price 16/6 plus 4/6 post.
Mains Transformer Type No. 56695
Upright mounting, size approximately 4 · 3 ·2½in. 2 secondaries 275-0-275 at 90 mA and 6·4 volts at 3·1 mA. There is a screen between primary and secondaries. This is a partner to output transformer 56694 described below. Price 19/6 plus 4/6 post.

OUTPUT TRANSFORMERS
OPT. ref. 56694
Chassis mounting—size 2 · 2 · 2in. approximately 7 watts. A push pull transformer for matching 2/EL84 or similar valves to 15 ohm loudspeaker. 14/6 no extra for post if ordered with Transformer 56695. Circuit diagram of amplifier available, price 2/6.
OPT. ref. 56787
Upright mounting, size approximately 2⅜ · 2 · 2in. Matching impedance 60 ohms to 15 ohms. 5 watts output using transistor type AD140 (Circuit diagram available price 2/6). Price 8/6 each, no extra for postage if ordered with mains transformer type 56786.
OPT. ref. 525004
Upright mounting, size approximately 2 · 2⅜ · 2in. Primary impedance 60 ohm, secondary impedance 3 ohm, otherwise this is as 56787. Price 8/6.
OPT. ref. 56734
Chassis mounting, size approximately 2½ · 2 · 1½in. Primary 500 ohm centre tapped. Ratio 27/1. 5 watts output using twin ELL80 or similar. Price 12/6. No extra for postage if ordered with 56733.

HEAVY DUTY MAINS TRANSFORMER
30V. 37A. Primary tapped 200/240 in 10v. steps. A really beautiful "C" core transformer. Made by Parmeko, impregnated and varnished. Weight approx. 50 lb., size approx. 8in. wide 6½in. deep and 8½in. high. Metal framed for free standing and fitted with E.S. screen. Probably priced £40-£50 from Parmeko. Ex equipment, but perfect, £17.10 each, plus carriage at cost.

50 CYCLE TO 60 CYCLE INVERTERS
For operating American instruments and other equipment made for 60 cycles 115 v. from 230/240 50 cycle mains. These units have an output of 115 volts A.C. and will handle a load of up to 100 watts. These are precision made and have a reed type frequency meter which vibrates when the frequency is exactly 60 c.p.s. Adjustment of the frequency is by a knob on control panel. Input by 3 core output from 3 pin socket. Original cost of this in excess of £60. A limited quantity available £17.10. each.

SEED AND PLANT RAISING

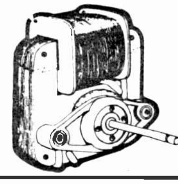
Soil heating wire and transformer. Suitable for standard size garden frame. Post and ins. 3/6. **19/6**

MAINS OPERATED CONTACTOR

220/240v, 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2¼ · 2 · 2in. 19/6 each.

AUTO-ELECTRIC CAR AERIAL

with dashboard control switch—fully extendable to 40in. or fully retractable. Suitable for 12v positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. £5.18.6 plus 5/- post and ins.

MAINS MOTOR

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

Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. Semiconductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD
Dept. PE, 266 London Road, Croydon CR0 2TH
Also 102/3 Tamworth Road, Croydon

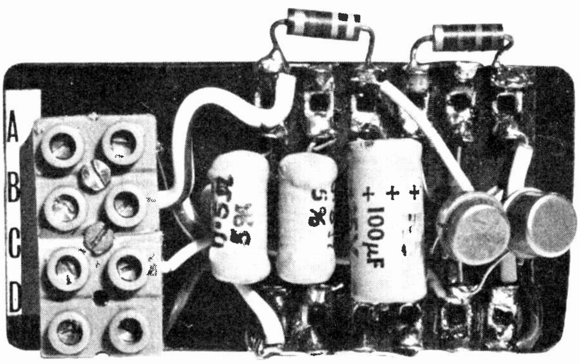
prototype unit was mounted, with a self-tapping screw, directly to the vehicle bulkhead near a convenient snap connector in the brake-light circuit. For this a packing piece of s.r.b.p. is required under the board to clear the bolt heads on the back.

It might be desirable to mount the unit in a box to avoid shorting and to provide protection to the unit, since the tag-board is live when the brakes are used. This will depend on the position of the unit. The wires connected to the terminals A and B on the unit can be fitted with snap connectors to facilitate wiring into the brake-light circuit on the vehicle. Do not forget that these wires carry approximately 4 amp and should be of heavy gauge.

The panel light is a 12 volt 2·2 watt bulb and any convenient form of panel mounting unit can be used, placed where it may be seen at a glance, remembering that a bright light in the direct line of sight may be distracting.

SETTING UP

Once the unit is installed in the vehicle its operation should be checked. A vehicle electrical system voltage varies from approximately 12 volts to 15 volts according to conditions. The unit is required to show



both brake-lights working at the minimum voltage and not to give a false indication with one bulb working at the maixmum voltage.

First, without the engine running, turn on everything that draws appreciable current like the headlights, heater blower, indicators, etc. including the ignition. Apply the brakes and the repeater panel-light should come on. This will simulate the minimum voltage condition. Now disconnect one of the brake-lights by taking out the bulb or undoing the appropriate connector. Start the engine and run it at about 2,000 r.p.m. for a few moments with all electrical systems, except the ignition, turned off to allow the battery to become reasonably charged and the system voltage to attain its highest level. With the engine still running fairly fast, apply the brakes, the repeater panel-light should not come on. If the panel lamp gives a short initial flash but turns off, this is quite in order since a cold bulb takes much more than its rated current for a few milliseconds after switching on.

COMPONENTS . . .

Resistors
R1 2 × 0·5Ω 5W wire wound in parallel
R2 100Ω
R3 10kΩ
R4 100Ω
All ¼W, ± 10% carbon except R1

Capacitor
C1 100μF elect. 25V

Transistors
TR1 BC108, TR2 BCY38 — for positive earth
TR1 BC158, TR2 BFY52 — for negative earth

Miscellaneous
LP3 12V 2·2W bulb and isolated holder
Tag board, four way connector, wire, s.r.b.p.

TRANSISTORS

The transistor types are not critical as long as TR2 can handle the panel-light current—about 200 milliamp for a 2·2 watt bulb. Some different transistor types may require a slightly different value for the sensing resistor, R1, and it might be necessary to wind a special resistor. This was done for the original development model using a piece of old electric fire element since the resistor has to carry about 4 amp. Measurement proved the homemade resistor to be 0·25 ohms hence the use of two 0·5 ohm resistors in parallel. ★

NEWS BRIEFS

New Goonhilly Aerial

THE Post Office has placed an order worth about £2¼m with Marconi to build a third aerial for the satellite earth station at Goonhilly Downs, Cornwall.

As second largest partner in INTELSAT, the International Telecommunications Satellite Consortium, Britain is already in the major league of satellite users. With three large aerials, Goonhilly will be one of the largest and busiest commercial earth stations in the world. The third aerial system—Goonhilly 3—is expected to go into service early in 1972, working with the next generation of satellites—Intelsat IV, first of which is to be launched into position over the Atlantic next year.

The new aerial is to be built to the standard Marconi design but incorporating special features for the Post Office application. Reliability of the earth station is most important and the aim of 99·8 per cent has now been achieved with Goonhilly 2. The new aerial will be made of aluminium, and will be capable of withstanding 210 m.p.h. winds.

Goonhilly 3 will operate at higher power and use a narrower bandwidth than previously possible and hence have greater capacity. The aerial is expected to pay for itself within 2 to 3 years and should enable the Post Office to reduce overseas telephone charges.

THE PROFESSIONAL FINISH

BY M. K. TITMAN B.Sc. (ENG.)

AMATEUR constructed equipment sometimes looks unprofessional largely due to the lack of external finish. The circuit specifications and components are often equal to that of commercial units and therefore it is unfortunate that this lack of finish attracts derisory thoughts, if not comments. The high standard of finish achieved by manufacturers is testimony to the poor technical discrimination of the public at large, who judge performance by price and finish alone. Consequently, if we are to have pride in our amateur achievements, we must at least approach the standard of finish attained by commercial firms.

Wooden record deck cabinet

Finish may be defined as the artistic effort involved in the construction of equipment, and in industry this field is the province of the industrial designer. Because finish contributes little, except perhaps reliability and simplicity of operation, it is the cinderella of amateur effort. Let us therefore consider the ways and means of improving finish, for which purpose it will be convenient to group the discussion into the following considerations: style and type of instrument housing; front panel layout and finish; internal layout and finish.

FINISH—STANDARD

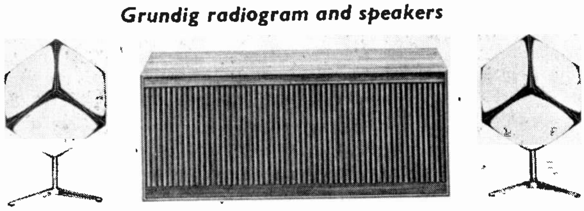
To assess the standard of finish required, most equipment can be divided into three groupings as follows: domestic equipment such as record players, and radios; electronic units such as transmitters and receivers; and test or breadboard equipment. A further sub-grouping is now popular and is used for domestic equipment of furniture standard but undisguised electronically; this group can be loosely termed electronic furniture.

Domestic equipment must have a high standard of finish and is usually required to blend with the room furniture. Electronic furniture is not disguised although the finish is to furniture standards and a combination of wood and metal is often used. Pure electronic units commonly utilise instrument cases, whilst test and breadboard circuits, which are only occasionally used, do not require more than the simplest casing.

DOMESTIC EQUIPMENT

Generally, domestic equipment is required to conform with commercial domestic units, and a glance at the local radio shops will demonstrate the style and finish required. Typical mass produced record player and radiogram cabinet are shown on this page. These are finished to a very high standard, manufactured from veneered wood or chipboard with jointing and polishing to furniture standards. Units of this type are available commercially at prices ranging from 5 gns. to 150 gns., but for the handman they can be constructed from readily obtainable veneered chipboard. A typical construction is shown in exploded form in Fig. 1 and costs from £2 to £25.

Grundig radiogram and speakers



MATERIALS...

Contiboard, 6ft × 9in (cut to 12in × 9in—2 off and 18in × 9in 2 off)
Contistrip, 6in—veneer to match Contiboard
Battens, wood or aluminium angle, 9in × 1in × 1in—4 off
Aluminium sheet, 18in × 7in × 18 s.w.g.—2 off
Perspex sheet, 18in × 7in × $\frac{1}{8}$in—1 off
Woodscrews, 6B.A. fixings, stain and matching grain filler, polyurethane varnish

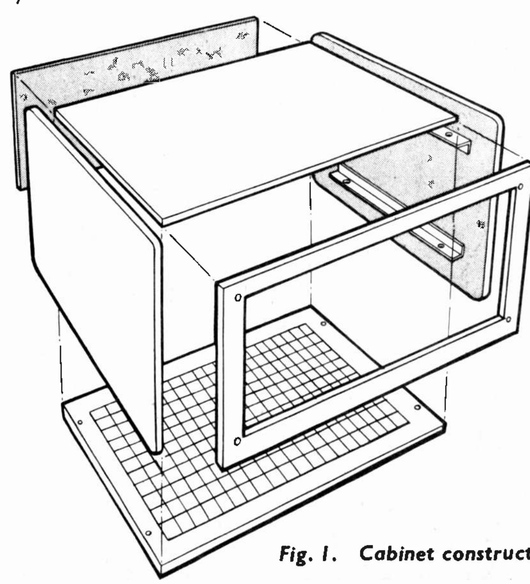


Fig. 1. Cabinet construction

This simple wood cabinet is constructed from veneered chipboard accurately cut to the dimensions required such that the side cheeks protrude from the centre section which contains the electronic equipment. Wooden battens or angled metal strips are screwed to the side cheeks and the wooden top section screwed directly to these battens, whilst the bottom plate, which can be ventilated wood or metal, is also screwed directly to the lower battens. The rigidity of this structure depends upon the accurate forming and jointing of all these panels which must be measured, cut and fitted to give a minimum of movement.

The front panel is screwed direct to the top and bottom sections and the back plate, which can be made of ventilated hardboard or metal, completes the structure and gives complete rigidity. It is convenient when using this type of construction to fix all the components to the front panel by means of a chassis arrangement and then to cover the fixing holes by means of an escutcheon, as discussed later under the heading "Front Panels". The cabinet illustrated can be constructed using the materials shown in the accompanying list, which is for an 18 inch by 9 inch by 12 inch deep cabinet.

Since these units are essentially furniture, care must be taken during the design and construction to choose a style, colouring and polish to blend with the surrounding furniture. Alternatively, the constructor with artistic leanings can choose a bold, striking, or even psychedelic design, providing it has artistic merit and a professional finish.

ELECTRONIC FURNITURE

This form of construction, which is becoming increasingly popular, is used for the domestic equipment

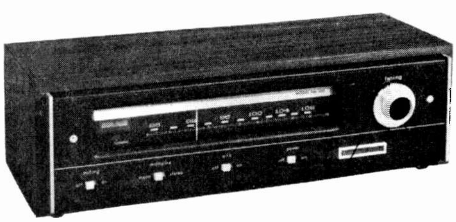
INSTRUMENT CASES

The general range of electronic equipment is not disguised as furniture, but is housed in utility casings of metal construction, although, even in this range, which includes oscilloscopes, receivers, transmitters and test equipment, manufacturers recognise the need for smart modern finishes. It is in this range also that the greatest improvements in finish are necessary amongst home constructors. Very often high quality circuitry is disguised by poorly labelled and finished housings resulting from a lack of time and effort devoted to their manufacture.

Two forms of enclosure commonly used for modern instruments are the visor fronted case, which is very popular due to its low cost, and cases with a recessed front panel formed from aluminium extrusion and trim; both are popular with manufacturers.

Each of these constructional forms illustrate the modern artistic trend of sharp straight edges, recessed front panels and slim shapes which is reflected in modern buildings. Naturally the prices of these units are higher than some conventional cases or die-cast boxes, and this can be an overriding consideration for the home constructor. However, the visor fronted construction is relatively cheap at prices from £2 to £5, whilst the extrusion forms are more expensive. Visor covers can always be added to conventional cases and a typical modification to a die-cast box is illustrated in Fig. 2.

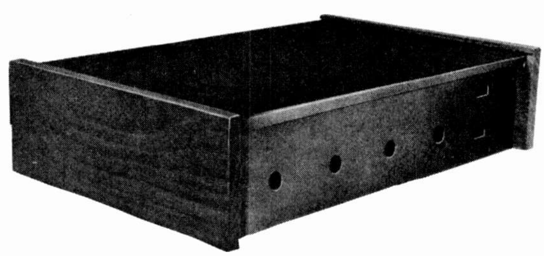
These forms of instrument housing are suitable mainly for the larger electronic units, such as receivers, transmitters and controls of a reasonably large complex nature. The boxes themselves are completely assembled and finished and only require the circuitry to be mounted, usually by a chassis to the front panel,



described above, but generally does not attempt to disguise the electronic nature of its function. Very often the construction consists of wooden side cheeks of teak or similar wooden facing which are polished to furniture standards. The central instrument housing, however, is of metal or plastics.

A large selection of equipment falls into this category of furniture/electronics and the plastics encased television sets and undisguised wood, metal and plastics record players with spun aluminium knobs, etc. are all illustrations of this form of design. For the home constructor these designs can be readily imitated, but the essential condition for success is that the surface and construction shall give a polished, professional finish.

It is worth noting that very few general instrument casings are suitable for this electronic furniture effect, with the exception, of course, of the units housed between wooden cheeks. It must be remembered that a fine finish in plastics is easily obtained when mass produced mouldings are used, whereas the amateur can only mould plastics by the craft of his hands using perhaps fibreglass as a base, and this is both difficult and time consuming.



Two examples of the "electronic furniture" effect—above and left

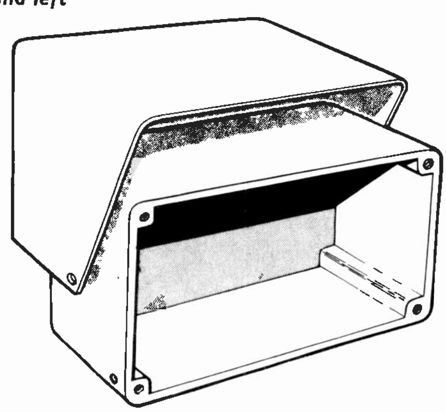


Fig. 2. Visor fitted to die-cast case

and this to be labelled or covered by an escutcheon, for the units to be an effective finished housing. Generally both the front and rear panels are removable and are retained by plated screws.

SIZE

Another problem associated with these casings arises from their rigid adherence to specific sizes, particularly since the vast majority are designed to fit rack systems of one sort or another and many are 19 inches wide and very deep. Relatively few are suitable for free standing applications and of these, even fewer cater for the small sizes generally required by the home constructor. The smaller die-cast boxes or tobacco tins, etc. are hardly finished or dimensioned to give aesthetic appeal. Consequently either an unsatisfactory finish results or considerable further effort is necessitated, such as the attachment of a visor cover. However, compared with the finish and trim of a professional instrument case, these modifications are generally considerably inferior. Hence, for the enclosure of small units such as burglar alarms, intercoms and signalling apparatus, the recessed construction as described under "Small Units" below is to be preferred.

MODULAR CONSTRUCTIONS

In order to allow the amateur to construct his own instrument casings, many forms of do-it-yourself casing are available for the amateur and professional instrument manufacturer. The construction is generally based upon aluminium extrusions preformed and supplied in lengths, which can be used for the edges of casing with smart trims and shapes for the front panel surround. The extrusion is cut to shape and both bevel and butt joints are used, whilst the side, top and rear panels can be directly fitted into recesses in the extrusion to give a very neat finish. This is particularly acceptable as a form of construction when a plastics coated metal sheet is used for the side and rear panels. Such a material is known as Bondene and consists of stippled p.v.c. bonded to aluminium sheets.

Another simpler and therefore cheaper constructional form consists of corner pillars of shaped material to which the front, side and rear panels are screwed. The construction allows for a modular build up of these units by bolting the corner pillars together, and thus extending the system to include large control units. This system has the advantage of cheapness but is not as flexible as the system using aluminium extrusion.

Both systems are illustrated by the sketches of Fig. 3 in which Fig. 3a shows the aluminium extrusion system using captive nuts and special corner connectors, all of which slide in channels in the extrusion. Fig. 3b illustrates the simpler drilled and tapped corner post system to which all the panels are screwed. The shape of the unit illustrated in Fig. 3a also illustrates the flexibility which can be achieved using this system, and thus explains why the cost is high compared with the corner post system.

A modification of this construction which is widely used by manufacturers is the wrap around casing. In this form the structure is formed from pillars and tie bars but the top and side casing is formed from a single moulded sheet screwed to the tie bars. Removal of this wrap around case enables easy access to the internal circuitry for maintenance and repair. This form of construction is used by many manufacturers of bench instruments such as oscilloscopes, power supplies, etc. and is particularly effective when the cover is of stippled p.v.c. covered metal sheet.

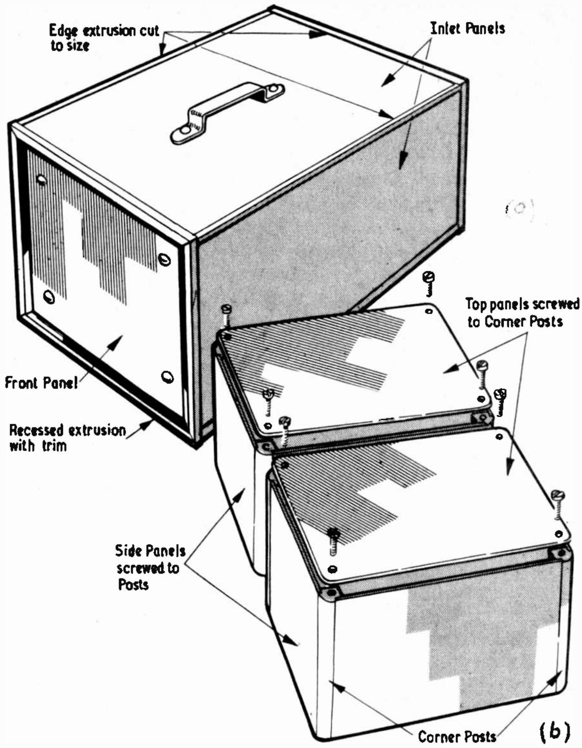


Fig. 3. Modular construction: (a) aluminium extrusion system; (b) corner post system

SMALL UNITS

Many items of equipment such as domestic sensing, alarm, and control circuits, etc. are of very small physical size and therefore only small equipment enclosures are necessary to contain all the circuitry. Very often the most useful form of construction for this type of equipment is the use of small die-cast or other metal boxes. Plastics boxes are also useful, especially for small portable equipment, but whereas the manufacturers of commercial equipment can afford to have these made, the amateur can only use what is available. It is surprising the number of suitable plastics boxes which can be freely purchased and which are also obtained as packing for other items, and often these can be used successfully for equipment.

Plastics boxes of this form are not very professional in terms of overall finish since to give a proper finish the controls, inputs and outputs should all be moulded to fit the particular box, particularly with regards to the obtrusion of controls. In most cases the surface finish of these small housings can be achieved with paint which gives a satisfactory finish, but care must be taken with the lettering used. In particular, the overall look is very much harmed by the use of numerous screws and holes in the outer casing, however necessary, for mounting internal components.

RECESSED UNITS

Most of these small boxes functioning as "house" alarms or controls can be recessed into walls and other fittings by making a large overlapping plate as the front panel to which the box is attached. This form of installation is also suitable for use with chassis systems of the valve type which are bolted directly to the front panel. The whole unit can be screwed to a recess in the wall or cabinet door and only the front panel is visible.

Fixings can be either by bolts to captive nuts or else by wood screws to Rawlplugs or similar fixings in walls. Two such small units are illustrated in Fig. 4a and b. Both of these units are designed to be wall mounted in precisely the same manner as recessed light switch boxes and similar commercial equipment. Often it is useful to use the metal switch boxes available for domestic electric fittings, especially since these have the mains inlet and outlet holes available as well as screw holes for wall fixing in addition to the tapped holes for screwing the front panel and attached circuitry to the box.

The advantage of front panel fixings to domestic switch boxes is that the boxes are cheap and very simple to install. In addition, as only the front panel is visible, this is the only item which must be professionally finished. In fact the only construction necessary when using such a box is to mount all the components on a metal panel to which a covering front panel escutcheon is fitted and the drilling of two holes for the fixing screws. The result is a very neat, professionally finished unit which is robustly, permanently, and professionally installed in the home.

WORKMANSHIP

To work with metal, plastics and wood and still retain a polished professional finish is difficult unless this is a desired objective. In particular, polished aluminium sheets used for side panels should be covered by cardboard and sticky tape to protect the finish, especially when a gloss paint finish is required. In addition, thin metal sheet should preferably be cut by shears rather than sawing and filing since unless great care is taken, sawing results in warped, twisted and misshapen panels which always give a poor appearance. For this reason it is simpler for the home constructor to work in aluminium since the forming and cutting of this material is considerably easier, without machine tools, than is steel.

To be continued

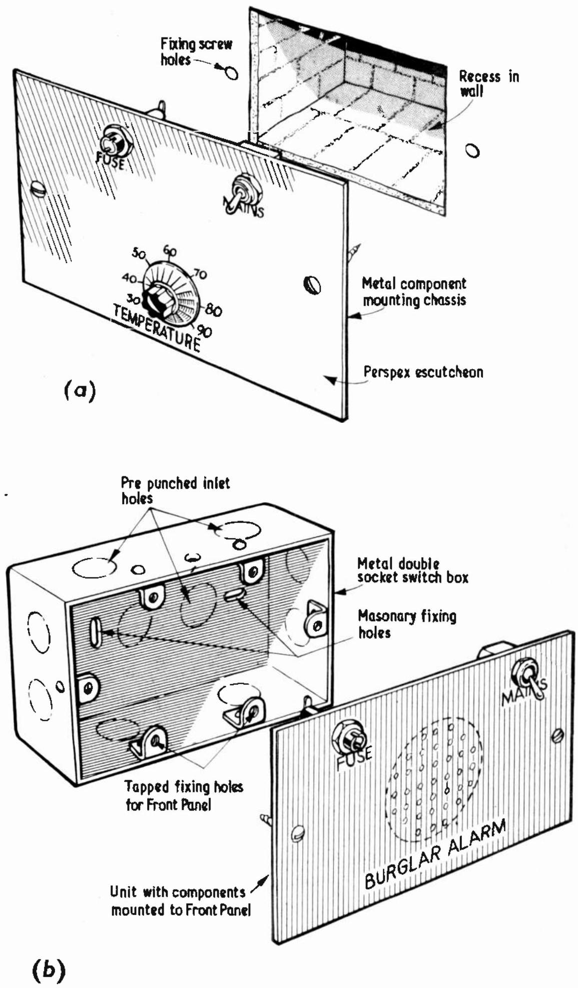
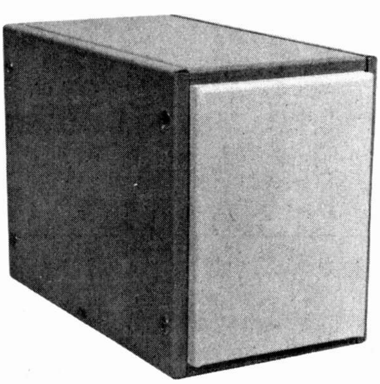
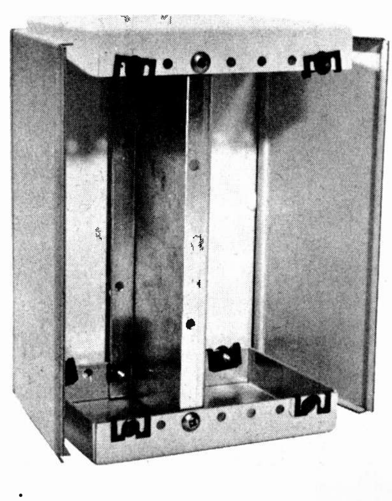
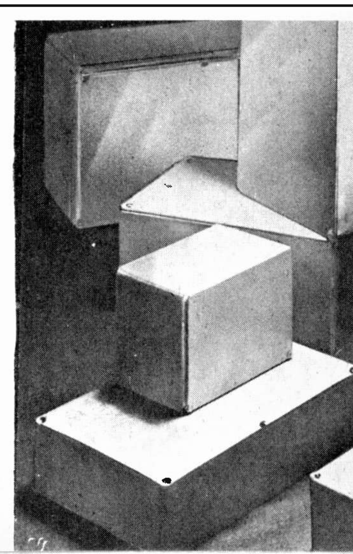


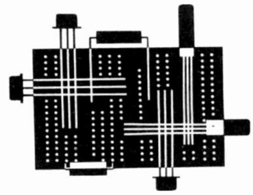
Fig. 4. Recessed units: (a) all components mounted directly to the front panel and recessed into a wall; (b) use of a metal switch box to house the electronics of a burglar alarm







Signal Injector & Code Practice Oscillator



A SPECIAL PROJECT FOR BEGINNERS

NEXT to the multimeter probably the most useful servicing tool is the signal injector or generator. With this instrument the technician can test audio or r.f. equipment, such as an amplifier or radio receiver, by simply tracing the signal injected through all the stages from the output to the input, any faulty stage being immediately revealed by the loss of signal at the loudspeaker.

The simple generator to be described provides not only these facilities but can be readily converted to a code practice oscillator which will provide sufficient output for it to be used in group practice.

UNIJUNCTION TRANSISTOR

The signal injector circuit is shown in Fig. 1a. Essentially this is made up of a relaxation oscillator comprising the unijunction transistor TR1; and TR2 which acts as a pulse amplifier.

With switch S1 closed C1 charges by way of R1 until it reaches the peak point voltage. This voltage (see Fig. 2,) is a unique fraction of the inter base voltage for a particular unijunction transistor and when it is achieved the normally reverse biased emitter junction is made to conduct, so discharging C1 through R3.

It can be seen from the graph that when the peak voltage is reached the emitter voltage falls, and the current increases. This means, in effect, that C1 discharges into a reducing resistance. At the "valley point" conduction ceases and the next charging cycle commences.

The choice of timing components give this oscillator a pulse rate of about 800Hz. In Fig. 1a the charge and discharge curves are shown as are the pulses produced at R3.

PULSE AMPLIFIER

To amplify the pulses TR2 is used as a switch. When the input pulses exceed about 650mV this transistor is turned on so that most of the line volts appears across R4.

The output is taken via C2 which serves to isolate the circuit from d.c. This should be rated for at least 350V if signal tracing in both valve and transistor equipment is contemplated.

HARMONICS

Any periodic wave or pulse can be shown by mathematics to be composed of a sine wave fundamental frequency and sine wave harmonics. The extent of these harmonics or higher multiple frequencies depends on the steepness of the leading edge of the wave or pulse.

Fig. 3a shows a pure sine wave. This consists only of the fundamental frequency as there are no harmonics.

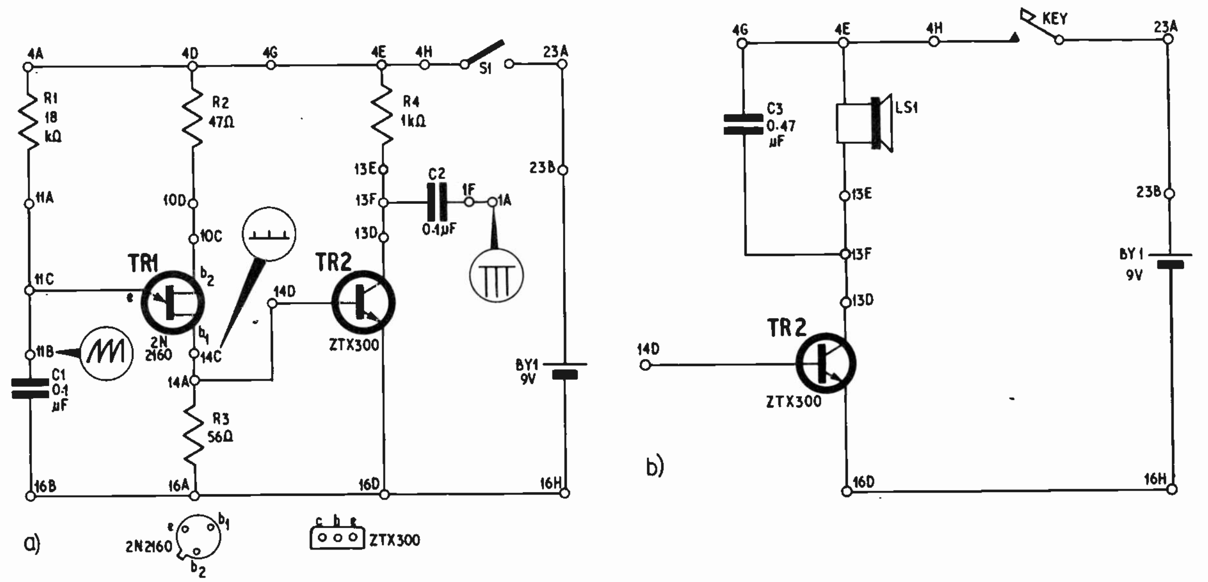


Fig. 1(a). Circuit diagram of signal injector; (b) modifications necessary at TR2 to convert to code practice oscillator

Fig. 3b shows, in expanded detail, the 800Hz pulses produced by the signal injector. Here the leading edges are extremely steep, the time taken for each pulse to reach its maximum being approximately 0·5μS. This means that there are a great many harmonics present.

MODULATION

The amplitude, or height, of the fundamental frequency of this pulse train is very much greater than the harmonics, so it influences all of them inasmuch as that they carry the fundamental; this process is known as modulation.

TESTING

Since the many harmonics produced all carry the modulation frequency, it is possible to troubleshoot all the stages in a radio receiver; r.f., i.f. and a.f.

The order of testing is a.f. stage first; then work back through the i.f. amplifiers and finally the r.f. stages.

This, of course, is a logical procedure since we must make use of the receiver's loudspeaker in revealing the presence or absence of a signal. Any defunct stage will be made apparent by the absence of sound from the loudspeaker.

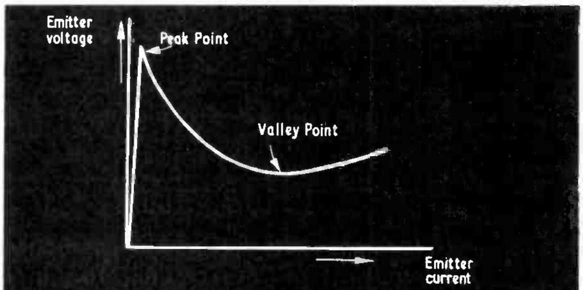


Fig. 2. Graph of the emitter voltage and current for a unijunction transistor

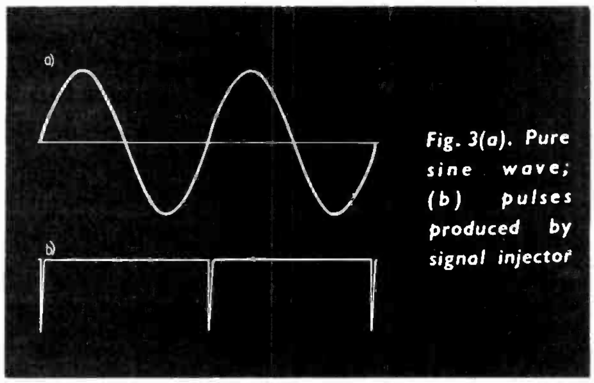


Fig. 3(a). Pure sine wave; (b) pulses produced by signal injector

The 400mW amplifier described in the September 1970 issue will prove an excellent alternative signal tracer.

CODE PRACTICE OSCILLATOR CONVERSION

Conversion of the injector to a code practice oscillator involves replacing R4 with an 80 ohm loudspeaker, and substituting a morse key for S1 as shown in Fig. 1b. To increase the pulse width and therefore the power available, C3 is connected across the loudspeaker LS1.

Whilst the loudspeaker is small the output is adequate for group practice, but if greater volume is required the signal injector output can be directly coupled to a radio receiver aerial input. It is sufficient to lay the output probe near the aerial coil where ferrite rods are used. The receiver dial is tuned to a quiet spot before signal injection. Adjustment in output level can be made with the volume control. ★

COMPONENTS . . .

Resistors

R1 18kΩ R3 56Ω
R2 47Ω R4 1kΩ
All ½ watt, 10% carbon

Capacitors

C2 0·1μF 350V polyester
C3* 0·47μF polyester

Transistors

TR1 2N2160
TR2 ZTX300

Battery

BY1 9V PP9

Loudspeaker

LS1* 80Ω 2¼in

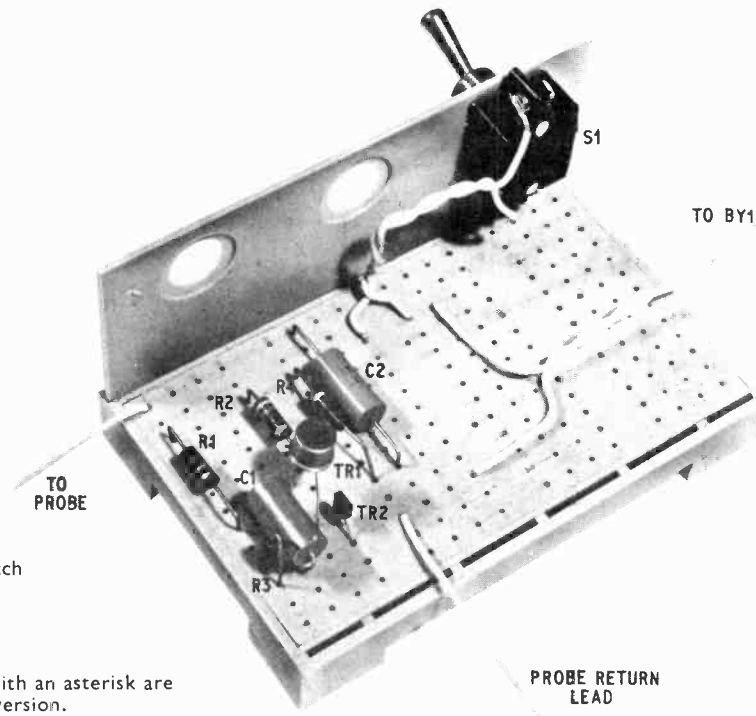
Switch

S1 Single pole on/off toggle switch

Miscellaneous

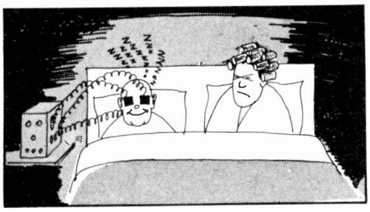
T-Dec, Morse key*

All components shown marked with an asterisk are for the code practice oscillator conversion.



Gerry Brown . . .

ON THE FRINGE



ELECTROSLEEP

These days it is difficult to imagine something to which electronics cannot be applied. In this respect even insomniacs appear not to have been forgotten, since for the last few years the Russians and several other countries have performed experiments which positively indicate that sleep might be induced electronically.

The U.S.A., on the other hand, although actively engaged in theoretical research in this subject are openly sceptical and cautious to admit of its clinical validity.

In essence the electrosleep technique is a fairly simple affair and amounts to the application of low voltage, low frequency pulses between the subject's eyelids and nape of the neck. Electrical connections are made via electrodes contained within saline pads made of foam plastics material.

Although very little design data is currently available in relation to the equipment, sufficient information about the waveforms generally utilised shows that one only needs a source of square waves to "be in business". Take a look at Fig. 1. This indicates the basic circuit details of a device I designed for the job.

The important point to remember about electrosleep apparatus is that it never actually puts anyone to sleep. All it is capable of achieving is the promotion of conditions for which sleep would be favourable.

Nevertheless, it does seem to work. At about 15Hz and a waveform amplitude of approximately 6V a slight "tickling", relaxed sensation is experienced which is often accompanied by the most intricate patterns of (apparent) light. Voltages much higher than this, apart from being of doubtful value, could prove to cause discomfort. Since the pulses employed are of such small amplitude (typically only $30\mu A$ at about 15Hz) complete safety from side effects is assured.

Clinically, the technique has been used with success in such diverse complaints as rheumatism and Parkinson's disease; and to date more than 450 papers on the work have been published.

Evolution of electrosleep and electroanaesthetic devices is well advanced in most of the contintental countries and Western Germany is no exception. Two German companies are already mass producing equipment for home and overseas markets!

HAPPY MACHINE?

It's all a matter of what you mean by happy I guess! Certainly several computer programmes have already been written that profess to simulate the more basic requirements of emotion, but then this isn't a machine *with* emotion.

Before we can even think of a machine being happy it must surely be necessary to define, in the first place, just what happiness is! And defining it is probably where the greatest difficulty lies.

We all know what pain is for example, but what is an accurate definition of it? The Oxford dictionary says ". . . bodily or mental suffering" and leaves it at that! For happiness it gets a little nearer with ". . . lucky, fortunate, content, . . .". Ah! "Content". Isn't that the word we're after?

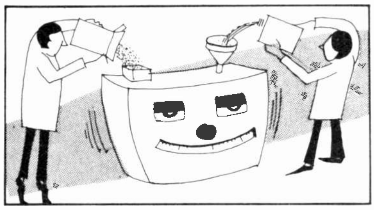
Happiness is an equilibrium state is it not, so perhaps "content" is a reasonable definition. But we still need to find the conditions that, when met, fulfil contentment and result in happiness. Could we not say that we always have a number of needs in our minds, some which may have been met and others which remain to be satisfied.

We now are in possession of the facts we require, surely? Perhaps the formula is something like this:

$$\text{Happiness } (H) = \frac{\text{Number of needs fulfilled } (F)}{\text{Number of needs } (N)}$$

Thus, complete equilibrium equals "1" (or unity) since F is either less than or equal to N.

Coming back to our machine, if we depict it as a box and let it have a number of needs to fulfil (say food, warmth, etc.) then couple it to another box called environment and permit the two to react with one another ultimately, and with luck, equilibrium should be reached. Could this be a happy machine?



TOPPED-UP?

How frequently do you check the level of hydraulic fluid in the brake master cylinder of your car? A glance, just occasionally, could very well save your life one day. I must confess that up to a while ago I rarely looked at mine, so imagine my shock, upon checking, when virtually no fluid showed in the cylinder!

Manufacturers, you might complain, ought to provide less bothersome ways of letting one know the fluid level. Indeed, this is not as unreasonable as it might at first appear since most contemporary fluids are slightly conductive.

A small metal probe situated in the cylinders filler cap, but insulated from the cap, can be arranged to just come in contact with the fluid when at the full mark. Any drop in level would break the connection with the probe.

The circuit in Fig. 2 shows a suitable level sensing amplifier which, as you can see, is quite "mean" in the use of components. As a result of this simple set-up one only needs to top-up on occasions when a lamp glows on the dash! What a treat!

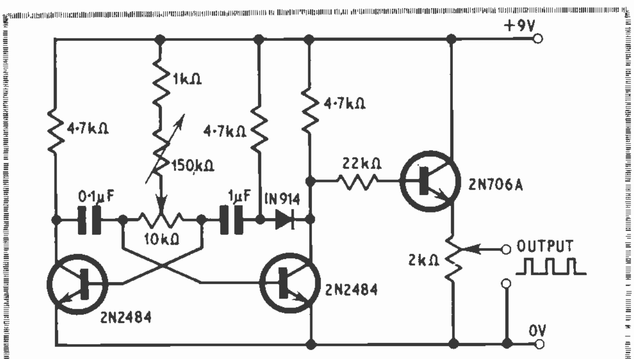


Fig. 1.

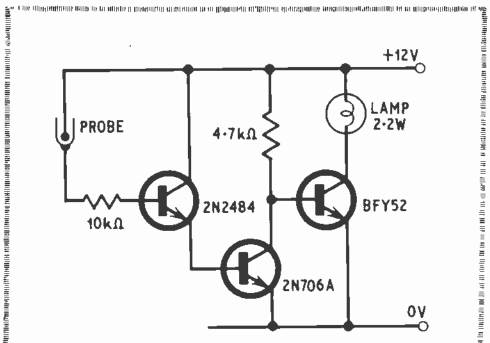


Fig. 2.

INSTALLING AUDIO

ALTHOUGH the primary problem for the hi fi enthusiast is the actual choice of equipment, some of the more practical problems associated with the interconnection and use of the different units call for some guidance too. These include impedance matching and signal level requirements, loudspeaker phasing for correct stereo reproduction, and pick-up tracking and alignment.

If incorrectly set-up, these aspects can completely spoil the performance of even the very best of equipment in one way or another.

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November 1970

IMPEDANCE AND SIGNAL LEVEL MATCHING

Correct matching between the loudspeaker and a transistor power output stage is very important if the full power of the amplifier is to be made available. Some tape record/replay units have what are nominally 600 ohm outputs with an attendant high output signal, usually around 1 volt r.m.s.

Although it may sound contrary to the laws of impedance matching, a 600 ohm output of this nature will operate quite satisfactorily with an amplifier input of much higher impedance. The real problem may be the high signal level, especially if the amplifier requires a maximum input signal of only 300 or 400mV. The signal level from the recorder would have to be attenuated of course to prevent overloading the amplifier input resulting in severe distortion.

Although a reasonably close match between an output and an input impedance is desirable, there are instances, like the one mentioned in the previous paragraph, where providing the signal level requirements are observed, outputs and inputs with seemingly large differences in impedance can be connected together without loss of efficiency.

If an amplifier has an outlet for tape-recording with an impedance of 10,000 ohms and a signal level of 500mV, while the tape recorder input is 100,000 ohms and requires a signal of only 50mV, the difference in impedance, although apparently large, is of little importance here. The large signal from the amplifier (500mV) could, however, grossly overload the tape-recorder input.

All that is required here is a simple attenuator which, in this case, could be a small pre-set potentiometer of around 50,000 ohms connected between the amplifier and recorder as in Fig. 1. Such an arrangement could be used to attenuate large signals from outputs ranging in impedance from 600 ohms up to at least 50,000 ohms. For higher output impedances the potentiometer should be about 100,000 ohms.

On the other hand the problem may arise when the output impedance is fairly high and the input impedance is fairly low. For example, if a radio tuner has an output impedance of, say, 100,000 ohms, and the appropriate input of an amplifier has an impedance of only 50,000 ohms or even 10,000 ohms, the mismatching of impedances is not critical, as long as the signal requirements match fairly well.

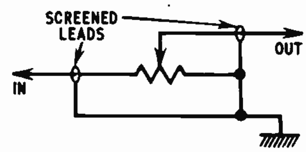

Fig. 1. Potentiometer attenuation

It is quite easy to reduce output signals to an appropriate level by means of a simple attenuator but a somewhat difficult problem arises when the output signal is too low. It is no good just turning the amplifier or tape recorder volume control up in order to amplify the low signal. This will also bring up the hum and noise level of the amplifier (or tape recorder) input stage.

PRE-AMPLIFIER SENSITIVITY

The only answer is a pre-amplifier for the signal source. A typical example is when a modern low sensitivity magnetic pick-up cartridge is to be used with an amplifier having no provision for such low signal levels (usually around 5mV) and no appropriate frequency response correction network (such as an R.I.A.A. response for playing disc records).

A similar case would be the direct connection of a tape head where the average signal output level may be only 3 to 4mV and for which frequency correction (C.C.I.R. tape replay response) is also necessary. In both cases a pre-amplifier with the appropriate frequency response

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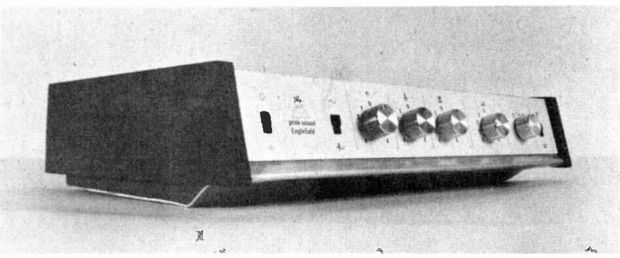

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and input sensitivity would be required and with sufficient gain to provide the requisite output signal level to drive the main amplifier.

It is unlikely, however, that this problem would arise with any modern hi fi amplifier, the majority of which cater for the direct connection of a tape head and which now have inputs for low sensitivity magnetic pick-up cartridges. This is a point worth checking on by those who contemplate buying an amplifier to be used with signal sources of this nature.

Most hi fi signal sources (radio tuner, tape recorders and/or tape record/replay units and pick-up cartridges of different makes and types) will match quite well with the majority of present day amplifiers.

It is worth noting that the average output signal from low sensitivity magnetic pick-up cartridges has until recently been around 5mV and certainly not more than 10mV. Now, however, the sensitivity of magnetic cartridges has been improved resulting in signal outputs of as high as 80mV or more. This could cause severe overloading of an amplifier pick-up input designed for only 5 to 10mV.

However, as the amplifier input impedance for magnetic cartridges is usually around 56 kilohms, it is not difficult to introduce the required attenuation as shown in Fig. 1. But a word of warning here! With such low signal and therefore high gain input stages, there is a great risk of introducing hum from any unscreened components connected in or across the input. Any form of attenuator used in such cases must be completely screened, with the screen connected to chassis. This brings us to one problem which often causes headaches—hum.

HUM LOOPS

When several different items of mains powered audio equipment are connected together, there is always the possibility of creating "hum loops". This is where small a.c. currents can be induced in the earthing wires if more than one earth wire is joined in a complete circuit close to mains wires. These currents may then flow through chassis or common signal wires and be picked up in live signal leads.

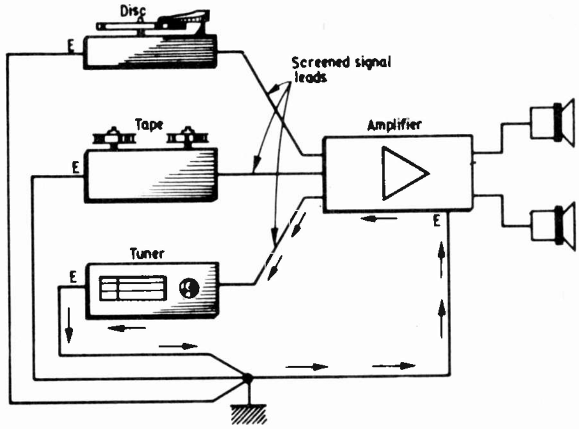


Fig. 2. Hum loops could be caused by too many common earth connections

All a.c. mains operated equipment should, of course, be properly earthed for safety reasons; where possible this should be done at one central point, such as the earthing pin of the power socket. If more than one mains plug is used, only one should have an earth connection. This does not always prevent the formation of hum loops which can be set up around interconnecting screened cables as well as earth lines (Fig. 2).

The only way to determine that hum is due to a loop circuit is by trial and

error. The usual procedure is to disconnect earth leads one by one and uncouple the various screened signal cables.

The cure may simply amount to leaving the direct earth connection off one item of equipment altogether, especially if it is earthed by another route, such as via a screened and therefore earthed signal cable. Only one item of equipment should bear the direct connection to the earth pin of the mains plug. Reversal of the mains connection to one piece of equipment may also get rid of the hum, or at least reduce it.

On the subject of 50Hz mains hum, don't forget that it can be introduced into tape heads and magnetic pick-up cartridges from nearby mains transformers. This is an often unsuspected cause of hum, but one which is quite common especially when equipment of this kind is close together, in a hi fi cabinet for instance. Keep all signal carrying leads well away from mains supply leads and components and make sure that all high impedance leads are screened, with the screen connected to chassis.

LOUDSPEAKER CONNECTION

Now let us turn to loudspeakers and their connection; first to transistor power output stages and secondly for stereo. The importance of accurate matching between loudspeakers and transistor output stages has already been mentioned.

Do not connect or disconnect loudspeakers to or from a transistor amplifier whilst the power is switched on. A chance short circuit across a transistor output line running at more or less full power could, in many cases, destroy the output transistors. Not all transistor amplifiers have protective fuses or other protective devices.

If the lines to the loudspeaker(s) are to be very long then fairly heavy cable should be used because the signal current via the loudspeaker can be quite high on peaks. Ordinary 5A "lighting" cable is quite satisfactory.

CROSSOVER NETWORKS

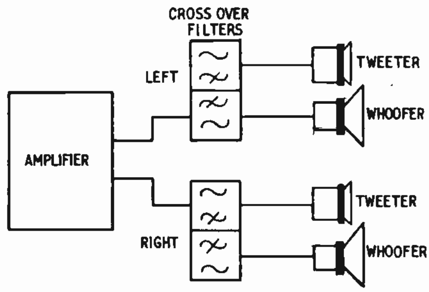


Fig. 3. Crossover networks for stereo

When planning a speaker system made up from two or more units in the same enclosure, they should not be connected directly in parallel to the amplifier output unless due consideration to matching is given. Most ready-built speaker systems are designed to present a combined matched load impedance to the amplifier, using crossover units and/or matching networks (Fig. 3).

The larger speaker (10in or more) is called a "woofer". It is coupled to the amplifier via the crossover filter, so that it will handle powerful bass frequencies without interference from the treble range. The crossover filter is also designed to pick out the treble range to drive a smaller speaker (tweeter) of less than 6in diameter. Sometimes electrostatic types are used for the

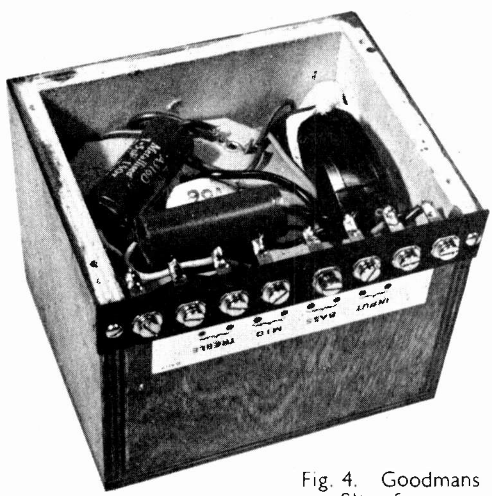
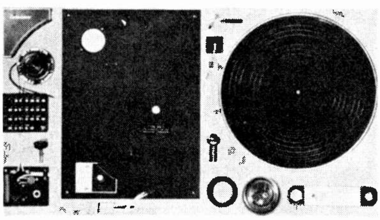


Fig. 4. Goodmans crossover filter for mono



treble range and it is important that this is matched correctly to the crossover unit.

Some small bookshelf speakers, while giving pleasing results, can give rise to irritating vibration if driven with a strong low frequency sound; damage can result to the speaker if sustained. The bass control should be judiciously adjusted to prevent this occurring, since a small speaker is not capable of handling such low frequencies adequately.

CHANNEL IDENTIFICATION

As to which will be the left- and right-hand channel connections can of course be determined if each piece of equipment has its outputs (or inputs) appropriately marked. Some hi fi manufacturers label the channels A and B, in which case A is the left-hand channel and B the right-hand channel. Otherwise one must resort to checking right through each channel from each source.

For disc, and tape this can be done with the aid of test discs or tapes. The left and right channels from radio tuners with stereo decoders can, if they are not marked, be determined by the special BBC stereo test transmissions on Radio 3 v.h.f. (more about this later).

STEREO SPEAKER POSITION

Stereo enthusiasts have different ideas as to the most effective loudspeaker positioning and spacing. Some like to think that speakers placed one in each corner of the room, at least 12 feet apart and each turned slightly inward, produce the best effect. Some prefer the speakers to be flat against a wall, a little way in from each corner and therefore parallel to the listener line of sight.

It is all rather a matter of personal choice and how much space one has in the room in which the speakers are to be installed. A speaker in each corner and pointing slightly inwards does provide a better directivity of the higher frequencies toward the listener; assuming the listener to be at a point equidistant from the speakers (a_2, a_3) as in Fig. 5.

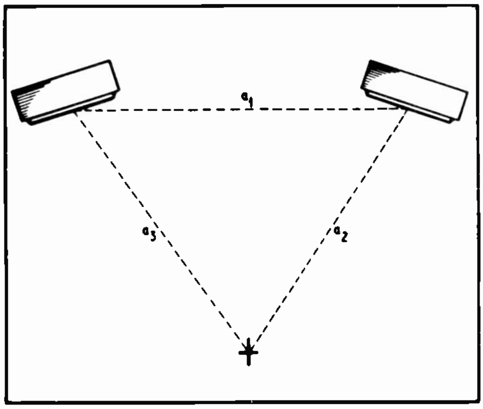


Fig. 5. Stereo speaker positions

Much depends of course on the spacing between speakers, which should if possible be not less than about 8 feet (a_1), and also on the type of loudspeaker available, for example, corner reflex or closed baffle type. Perhaps the best advice here is, experiment a little and settle for what sounds best.

PHASING

When two loudspeakers are used for stereo they must be operated in phase to ensure the correct stereo effect and avoid output sound loss at low frequencies. Most manufacturers of stereo amplifiers mark the twin connections for loudspeakers with regard to "phase". The earthed side may be marked "negative" and the live side "positive", but the majority of loudspeaker manufacturers also mark their speaker connections with positive and negative signs or with a red mark on one terminal.

For mono operation from a single channel amplifier, it would not matter which way round the speaker is connected. For stereo, the polarity of the connections should be observed, but no damage will result from incorrect connection. If in doubt, or if there are no polarity markings on either the speakers or the amplifier output terminals, the most simple way of determining "in-phase" operation is as follows.

Connect both speakers and play a record with a fairly strong bass content. First note the strength of the bass response from the loudspeakers. Now reverse the connections to *one* of the loudspeakers and note whether this produces an increase or decrease in bass response. If the bass response increases then leave the connections to that speaker as you have now made them. If the bass decreases then reconnect the speaker as it was.

Some amplifiers have a switch for phase reversal and all that is necessary is to set the switch for the strongest bass response. Another check is to switch the amplifier to mono, in which case all the sound should appear to come from a point midway between the two speakers, when listening from a position equidistant from both speakers as in Fig. 5.

STEREO RADIO

Radio broadcasts in stereo via the BBC v.h.f./f.m. services present no reception problems provided an efficient aerial is used with the correct type tuner and decoder. The noise level on f.m. stereo broadcasting is about 3dB higher than for f.m. mono and a poor aerial can make this even worse. Those particularly interested in stereo broadcasts from the BBC can obtain various BBC Information Sheets 1102(4): *V.H.F. Radio Receiving Aerials*; 1605(2): *Stereo Broadcasting—Test Tone Transmissions.* These tests are transmitted on Wednesdays and Saturdays every week at

11.30 p.m. (23.30hrs), using the standard Zenith-GE Pilot Tone System. Information sheet 1603(6) and a leaflet called "Stereo Q and A" both deal with the more general aspects of stereo.

These are all available free of charge from The Engineering Information Department, BBC, P.O. Box 1AA, London, W.1, and contain very useful information regarding reception.

Never use a.c./d.c. television or radio receivers with your amplifier unless an isolating transformer is inserted between the two.

TRANSCRIPTION UNITS

Good quality disc transcription units rarely call for special attention other than an occasional spot of oil according to the manufacturers' instructions and should only be placed where they are free from vibration, especially through the floor. A heavy footstep on loose flooring can cause a lightweight pick-up to jump right across the record with disastrous results. Be careful when dusting or cleaning around transcription units and in handling the pick-up arm. Its quite easy to catch a duster on the stylus of a cartridge and break it clean off. A good stylus is expensive! A very soft camel hair brush is useful for removing dust from the pick-up head and is less likely to cause damage. Never touch the stylus with the fingers.

Some transcription units have an "off" position on the speed selector. The machine should be left in the "off" position when not in use to prevent continuous pressure of the rubber idler on the turntable and/or capstan spindle. Any "flats" on the idler that may result from not doing so will cause "flutter" in the turntable speed, giving an apparent gurgling effect to the sound reproduced.

It is a good plan to arrange a transparent Perspex cover over the transcription unit with adhesive foam draught excluder strips round the edges. This will keep ingress of dust to an absolute minimum. This cover can be lowered during playback, while still giving a view of playing position of the pick-up.

Correct tracking and balance of the pick-up arm and cartridge are most important for good quality and minimum record wear. Instructions about this are always given with the transcription unit and/or the pick-up arm and should be closely followed.

Records are made of plastics material which attracts dust by means of the static charge built up.

If you value your records keep them clean and free of dust, using one of the proprietary record cleaning devices specially made for the purpose. Alternatively, a barely damp sponge *(not cloth)* will help.

TAPE RECORDERS

Tape recorders and/or tape record/replay units present few problems except that some record/replay units have very large signal outputs (as explained earlier) which may be too high for the appropriate amplifier input and may therefore have to be attenuated.

The more common causes of loss in treble response are usually due to the accumulation of dust on the tape head or wear of tape guides, causing the tape to wander off track. Here again a camel hair brush is useful for cleaning.

Keep the tape heads and guides clean and if, after a time, there should be a noticeable loss in treble response, it may be necessary to check the azimuth alignment of the heads. This can be done on tape recorders with a common record/replay head simply by using a white noise azimuth alignment tape made by B.A.S.F., 9A Gillespie Road, London, N.5 (instructions for use are included). Alignment of the heads on machines with separate record and playback heads calls for the use of an audio

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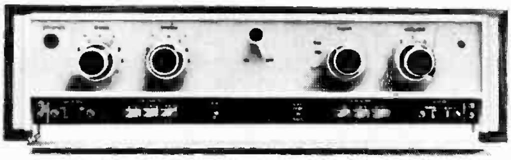

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Sometimes the heat generated by the recorder may be enough to do the trick.

CONNECTING DIN PLUGS

If you are able to make up your own connecting leads, using a soldering iron, the following may be helpful to sort out the profusion of plug and socket types and their uses. The illustration in Fig. 6 shows the more common types.

A high proportion of equipment now uses the versatile German DIN pattern three or five way connectors and are usually wired to the same pattern. However, it is best not to assume this but check first with the manufacturers' literature.

These plugs are usually used for input and output connections from and to other equipment. They may also be used for microphone inputs.

The range of DIN plugs available is shown in Fig. 6a. The pins are numbered, but not in the expected order in the case of the 5- and 6-pin types. They are in the order 1, 4, 2, 5, 3 reading clockwise from the keyway. The positions of 1, 2, and 3 coincide with those on the 3-pin plug.

In all cases the pin at position 2 is the common or earthy connection. This is important because there is often a connection from pin 2 to the case of the plug, maintaining the screen.

Microphones are connected for mono use to pins 1 and 2 for high or medium impedance unbalanced types; pins 1 and 3 with screen to 2 for low impedance balanced types; pin 3 and 2 for unbalanced low impedance types. These are shown in Fig. 6, together with connections for stereo microphone, pick-up, tape recorder, and f.m. radio.

DIN plugs and sockets may also be used for loudspeaker connections, particularly for stereo where non-reversible plugs are required. These have two

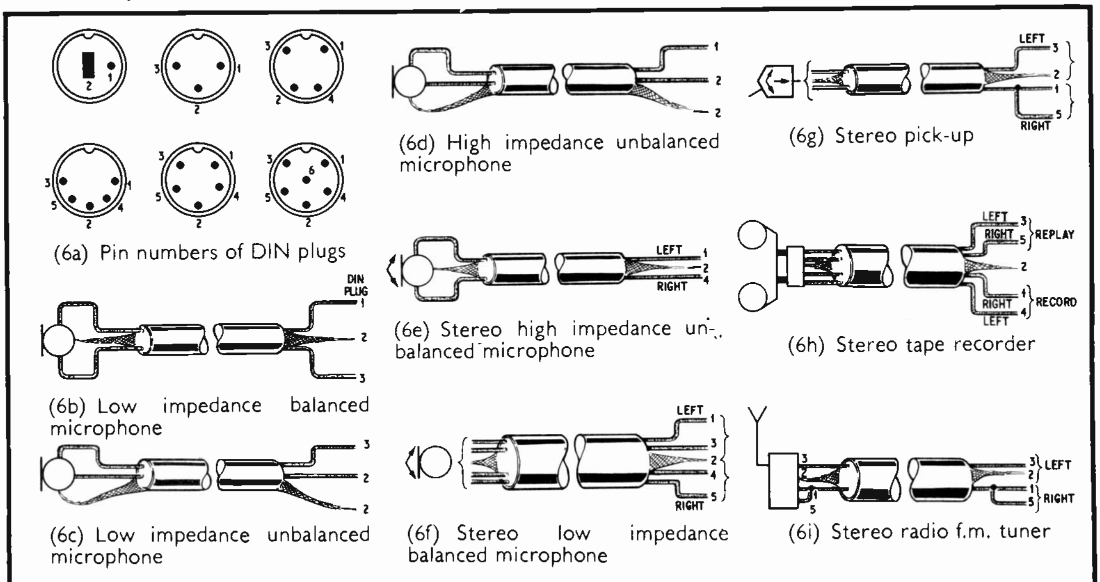
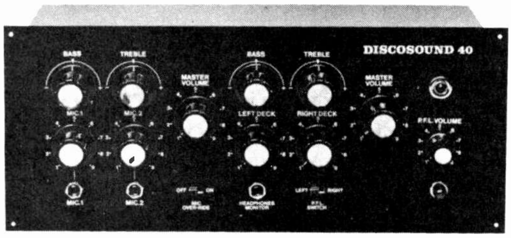


Fig. 6. Pin connections for DIN plugs

DISCOSOUND



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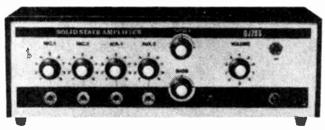

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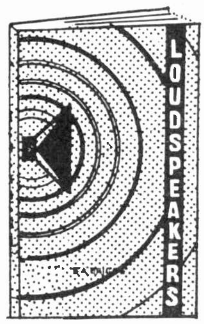

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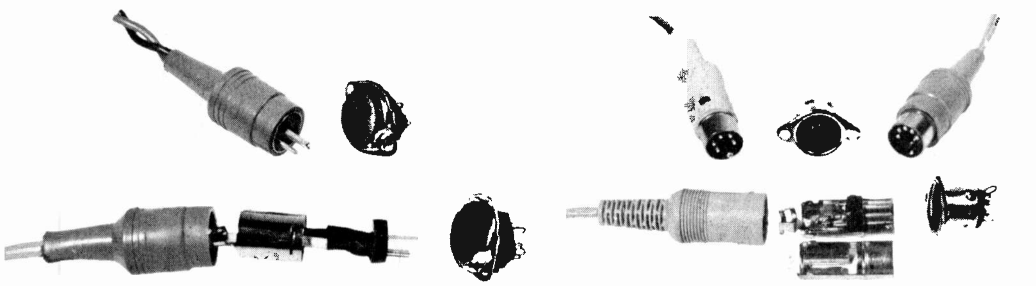


Fig. 7. Complete and opened views of 2-pin (left) and 5-pin (right) DIN plugs and sockets

pins, one flat and one round. The flat pin is usually the common line but is not always earthy, so be careful with connections and do not earth or connect to the chassis of other equipment.

OTHER PLUGS

Phono plugs are commonly found on mono or individual channel connections into the amplifier. These and similar alternatives use one pin for the line and the case for the "earthy" connection. The centre wire has to be soldered inside the pin.

Jack plugs come in various shapes and sizes, with either metal or plastics covers. Where high impedance lines apply, metal covers are recommended to maintain the screen effect. It is worthwhile inserting a rolled card sleeve inside this cover to prevent short circuits with the terminations inside (Fig. 8a).

Connection is usually straightforward if you have a soldering iron. Soldered joints are much preferred to screw terminals, which can work loose and cause crackling and even short circuits. A cord grip is also recommended.

Cable screen wires should be insulated with sleeving to prevent short circuits, and connected to the sheath, sleeve, or body tag of the plug. The tip is the line connection.

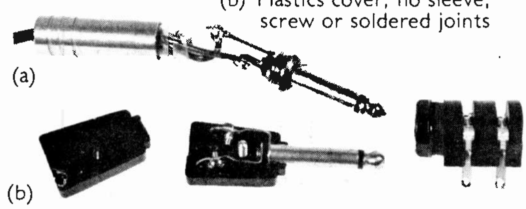
Stereo jack plugs have a tip and a ring connection; the tip to one channel, the ring to the other.

Break jacks may be used where the lines may be shorted when not connected to external equipment. They may also be used to mute the internal speaker when an extension is connected.

CAREFUL HANDLING

Finally, the life and performance of any hi fi equipment is dependent on careful handling and maintenance. Many of the equipment manufacturers issue maintenance advice for straightforward servicing; serious faults or breakdowns should be dealt with by the manufacturers' service departments, or by a trained qualified engineer who specialises in this kind of equipment. ★

Fig. 8. Jack plugs and sockets
(a) Metal cover, plastics sleeve, soldered joints
(b) Plastics cover, no sleeve, screw or soldered joints



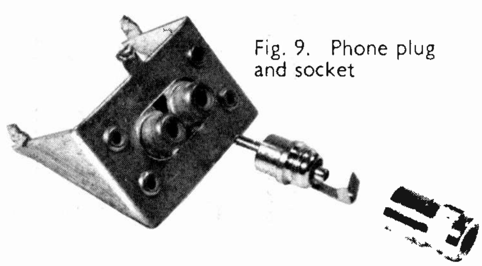
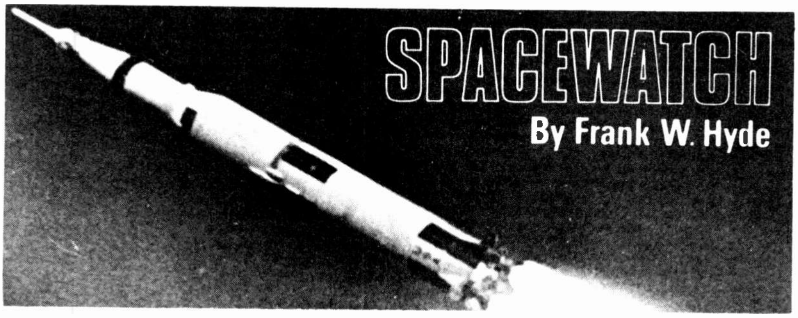


Fig. 9. Phone plug and socket



CRATER STUDY

Geologists have been able to identify a number of craters on the earth which have been formed by the impact and explosion of meteorites. The 1 kilometre diameter crater in Arizona is one example where there is meteoric material in substantial quantities. There is another in Germany known as the Nordlingen Ries crater. This crater also contains a substantial amount of meteoric material.

The Upper Rhine Geological Society held a conference in Nordlingen and an informal Research Group was set up to explore the possibilities of this crater. It was decided to sink a borehole two or three kilometres deep into the crater to study its structure.

It is hoped that the extensive attack on the problem by a number of disciplines will provide data as to the method of formation of lunar craters. There is abundant evidence from the samples collected by the *Apollo* missions to suggest that multiple impact shock is an important factor.

The lunar samples have shown that minerals have been formed in a plastic state, phase changes which could only be the result of very high pressures and temperatures; and some show evidence of the vaporisation of minerals as fracturing and melting effects.

Certain of the rocks from the Ries crater are almost identical with those from the Moon. They resemble them in that they contain some 20 per cent of shock metamorphosed minerals. The age of the Ries crater is of the order of 20 million years and may retain most of its original structure beneath the enormous amount of debris which was blown outwards and then fell back during the impact of the large meteorite.

INFRA-RED SPECTROSCOPY

In the wavelength range from 23 to 900 microns, water vapour in the atmosphere has in the past prevented useful astronomical observations being made at sea level stations. There is now a solution to this problem other than by orbiting observatories.

At the Meudon Observatory for Infra-red Space Studies, J. Gay has shown that above a height of 28km the water vapour content is much less than was expected. It is therefore possible to use balloon borne detectors for observations in this region.

The same group have also carried out the first direct measurements of the temperature of the photosphere of the Sun in the wavelength range from 100 to 200 microns.

In the past a great deal of information has been gathered about extra-terrestrial infra-red radiation by using high flying balloons, jet aircraft and rocket flights. With the new technique of using comparatively low flying balloons, weak sources can be studied. This will include the larger planets as well as instellar regions of ionized hydrogen.

There are new avenues in X-ray and Gamma ray astronomy which no doubt will encourage observers in these fields to take full advantage of the facilities offered by balloon techniques for an exhaustive study of the whole of the infra-red spectrum.

VENUS-MERCURY MARINER

The 113lb package aboard the Venus–Mercury *Mariner* spacecraft noted in October *Spacewatch* consists of seven experiments. The study of the solar particle bombardment of the surface of Mercury will be by a charged-particle detector for electrons in the energy range in excess of 200keV and protons in the energy range 6f 600keV.

An ultraviolet spectrometer will determine whether Mercury has an atmosphere and to measure airglow. This will enable the constituents of the atmosphere of both planets to be determined. An infra-red radiometer will measure emission temperatures over the range −185°C to 370°C. It is hoped that it will be possible to measure both cloud top temperatures as well as limb darkening temperatures.

On Mercury the experiment will measure surface temperature distribution and determine whether the surface features show temperature anomalies.

MAGNETIC FIELDS

A scanning electron analyser will measure ions whose energies lie 80eV and 80keV and electrons between 40 and 400eV. It is hoped that this data will give information as to the effects of the solar wind and how it interacts with Venus and Mercury. This will provide, in turn, information about the electromagnetic properties of the planets.

A magnetometer which is made up of two triaxial fluxgate instruments will be in operation. Venus has no measureable magnetic field though there are indications of a magnetic shock front close to the surface.

It is not known what may be the situation on Mercury in this respect. As Mercury has a diameter of less than half that of the earth it could be too small to possess a liquid or molten core which is conducting and therefore preclude the possibility of a magnetic field.

TELEVISION CAMERAS

There will be two television cameras with a resolution equivalent to pictures of the moon taken from earth based cameras. In the case of Mercury the surface features will be resolved well enough to enable a check to be made of its rotation period and its attitude on its axis.

The radio transmitters will function in an occultation mode for both planets, single for Venus but double for Mercury. Radio signals past the limb of each planet will yield information about the atmospheres, mass, radii, surface features and ionospheres if they exist.

GETTING UNDER THE SKIN

W. Koppl of Martin Marietta Corporation, of Denver, Colorado, recently described an ultra high frequency radiometer that could examine the u.h.f. radiation below the surface and measure the dielectric constant of the soil. At u.h.f. frequencies the dielectric constant is between 2 and 10 for dry soil and rises to around 20 for wet soil.

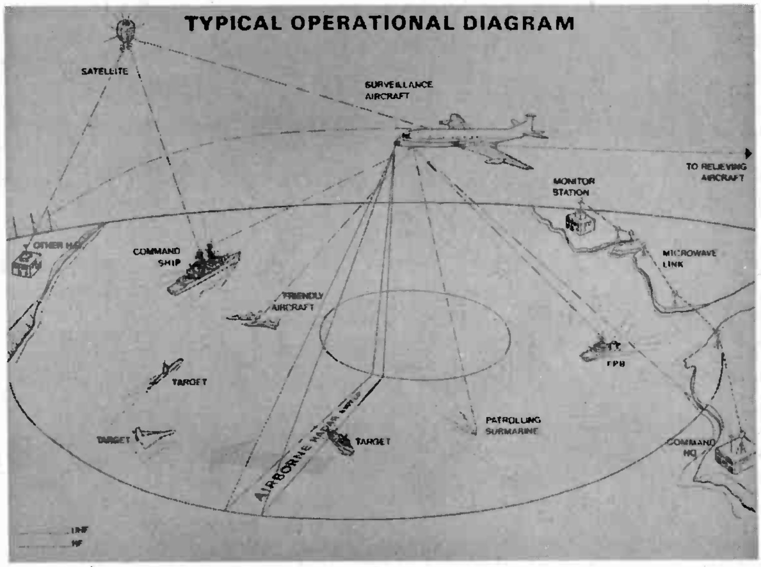
A satellite or orbiting spacecraft could measure a particular zone or area and determine from the degree of penetration the dampness of the soil. A radiometer to tune over a range from 500 to 1,500MHz would be able to penetrate even permafrost zones. Koppl considers that a microminiaturised unit could be developed weighing not more than a pound plus the weight of the aerial. More detailed measurements could be made if the frequency range was extended to 200MHz.

ELECTRONORAMA

AT FARNBOROUGH 1970

UK-4 Satellite

SUCCESSOR to the *Aerial III* scientific satellite, the *UK*-4 will be launched by the N.A.S.A. Scout vehicle in June 1971. This satellite is being tested out at Space Systems Group of the British Aircraft Corporation and is expected to provide additional information about ionosphere. The photograph shows the solar cells used to power the electronic systems.



Surveillance Data Transmission

THE use of data link in an Offset Target Indicator System is based on the requirement for obtaining real time information on targets in a surveillance area. OTIS uses the Decca variable bit rate data link which supersedes voice communication. The diagram above shows how a *Nimrod* aircraft picks up information on the area and sends it to Command H.Q. The radar operator uses a "rolling ball" to position a symbol over a target on his p.p.i. display. This gives the exact target position which is fed in digital form to a similar p.p.i. at H.Q.

Television Aids Firing Control System

A RANGE of compact television equipment by the Marconi Electro-Optical Systems Division is based on a number of units which can be built up as required to cater for a wide range of military applications, with sensor tubes available to cover light levels from the brightest sunlight to the darkest night.

The Vidicon Camera from the 323 Series is shown in the photograph (left) in a weatherproof housing, installed on a warship as part of the ship's fire control system.

Anglo-French Strike/Trainer

THE *Jaguar* (below), designed and built by B.A.C. and Breguet Aviation, is undergoing test flights using Plessey electronic weapon control. The aircraft is also equipped with the latest microminiaturised PTR 377 u.h.f./v.h.f. airborne transmitter/receiver.

The electronic navigation/attack system used in the *Jaguar* is the first of its type in Europe. It includes a 920M Elliott central digital computer; inertial platform; Smith's head-up display; projected map; navigation control unit and horizontal situation indicator.

The system is completely independent of ground aids and is immune to jamming and radar. Provision is also available for laser ranging.

Laser Assisted Long Range Missile

ATLAS is a joint project of the British Aircraft Corporation Guided Weapons Division and the Fabrique Nationale D'Armes de Guerre SA of Belgium, aimed at an advanced low-cost infantry anti-tank weapon system which can be used at short ranges in a direct fire mode, or with the assistance of a laser which gives terminal guidance to the missile at longer ranges.

CONCORDE 002 made its debut at Farnborough, the second public display of this superb aircraft, after carrying out sonic boom tests down the west coast of Scotland, Wales, and Cornwall.

Aviation of the Future

THERE was plenty of talk at Farnborough about the next generation of airliners, the airbus, particularly from Hawker Siddeley and B.A.C. The A300B is a high capacity (260 to 300 passengers) wide body jet built by Hawker Siddeley with other companies in France, Germany and the Netherlands.

B.A.C. is now developing the *Three-Eleven* of similar size. The photograph (right) shows the increasing complexity of instrumentation, coupled with electronic control systems for automatic landing and navigation, that is going into the *Three-Eleven*.

Hawker Siddeley has submitted design details to the Ministry of Technology of a vertical take-off 600 mph aircraft for commercial airline use in the 1980s, based on experience from the *Harrier*. Details of electronic systems to be used are not yet available, but it is expected to carry similar equipment to that used in the *Harrier* for navigation at high speed, and the automatic landing system as used in the new *Trident 3B*.

Concorde uses data processing from 3,000 test point systems greatly reducing the time scale of the flight test programme and giving instant indication of abnormal functions

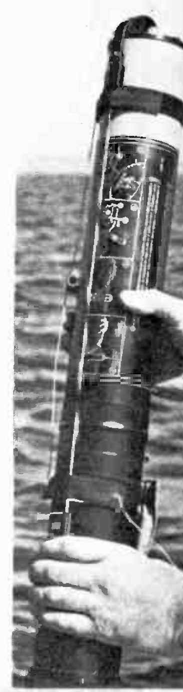
Tyre Anti-skid System and Dynamometer

CALIBRATION and skid response tests are being carried out on a Dunlop electronic adaptive anti-skid system. Signals depicting the actual skid characteristics are fed to this measuring instrument (left) to detect the system's response.

A new dynamometer testing facility for aircraft tyres, wheels and brakes is being installed at Birmingham, and is scheduled to be in operation by 1972 for new generation jet aircraft. Any cycle of tests can be carried out with the tyre assembly running at varying angles of steer, camber, or both. Resultant forces in the tyre in three planes are read off in real time via a computer.

Flotation Beacon Buoy

RADIO survival beacon (right) BE369 is a flotation beacon buoy, designed by Burndept Electronics. It operates on aviation frequencies and is being supplied to Norway, the only country to require beacons by law.



MARKET PLACE

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

SOLDERING

The average constructor of electronic components probably has an average constructor's soldering iron. That is, one which has been attacked frequently with a coarse file until none of the bit remains visible. It has then been mangled in a vice and assaulted with an electric drill in an effort to remove the remains of the bit.

The new "Invader" iron from the **Adcola** certainly seems to have been designed by an avid user of soldering irons who has ironed out (sorry about that!) all the problems of maintaining irons in a working condition.

The collett holding the bit has been designed so that the bit can be easily pulled out when the iron is cold and any accumulated scale removed, and yet is held tight when the iron is hot.

In the past, replacing an element has always been good for a laugh with tiny insulating beads falling down and around like the gentle rain from heaven. Adcola have again spoilt all the fun by arranging for the element to be rapidly exchanged using just a screwdriver. No tiny nuts and washer to fiddle around with any more, the connections being made via three pins and a socket.

The iron normally has a bit temperature of 360°C but other irons are available on request, working at other temperatures and voltages from 6V to 240V, at no extra cost. The handle is styled so that it can be put down without the hot bit burning the work surface or rolling off at the slightest provocation.

The two-yard lead was found to be quite adequate for most purposes and the model L646 uses $\frac{3}{16}$in diameter bits and costs 37s. The model L1076 is for $\frac{1}{4}$in bits and costs 38s. The iron is normally supplied with a straight bit but a wide range of interchange bits of many shapes and angles is available.

An electronics manufacturer, probably using several hundred or more soldering irons, would find the cost of servicing these irons much reduced.

Also from Adcola is the L267 desoldering iron. This desoldering instrument draws the molten solder through the hot bit when a rubber bulb, mounted on the handle, is squeezed and slowly released.

Like their irons, many different interchangeable bits of varying shapes and sizes are available on request.

Full details of local stockists of the irons and desoldering instrument can be obtained from Adcola Products Ltd., Adcola House, Gauden Road, London, S.W.4.

New Invader soldering iron from Adcola Products

AUDIO TRENDS

Two items received too late for our *Audio Trends* pages last month, but of significant importance that they will surely make their own impact on the audio scene are announced by **Rank Aldis-Audio Products** and **Hammond Organs Ltd.**

By acquiring the U.K. marketing rights of the complete range of elliptical stylus magnetic cartridges manufactured by the **Empire Scientific Corporation** of New York, they have certainly acquired a first-class product. From the non-critical to the hyper-critical there should be a suitable cartridge amongst their large range to meet the need of most people who like to appreciate good reproduction.

For the non-critical user the 80EE should give completely satisfactory results for an outlay of £9 18s. Indeed, at a recent demonstration the performance of the 80EE compared very favourably against the 999VE at £44 10s., and to the human ear hardly any difference could be detected, although laboratory tests would prove otherwise.

The frequency response of the 80EE is claimed to be 12Hz to 25kHz. The output voltage is 8mV per channel and channel separation is claimed at more than 30dB. The tracking force is approximately 1 to 4 grams. The load impedance is 47 kilohms.

For the average user the price against performance of the 80EE will certainly take some beating.

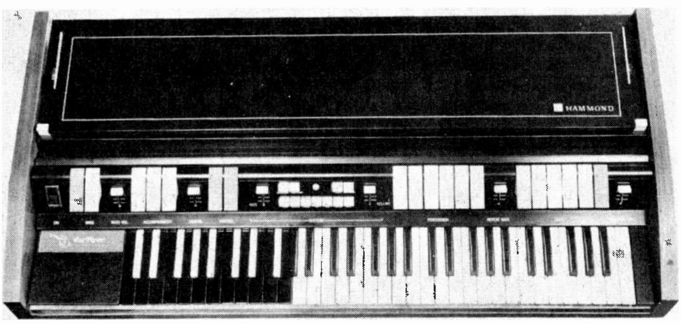
All the cartridges will be available through the usual audio shops.

Recently introduced by the Hammond Organ Company, Edgeware, Middlesex, is the unusual Piper organ, an entertainment instrument which assures the one fingered musician a creditable performance by the simple expedient of providing switch selected automatic rhythmic accompaniment in a multiplicity of tempos such as rock, waltz, country and western, march, ballad, latin american, or combination of any of them.

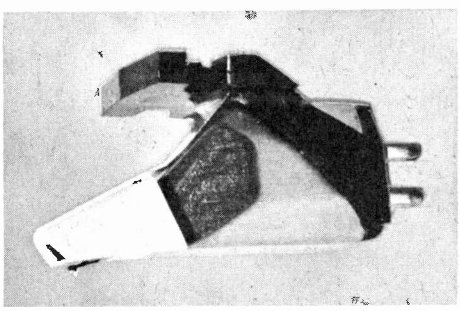
The keyboard is divided to provide an octave of rhythm keys and a three octave solo. The stops available for melody colouration are trumpet, accordion, mellow flute, violin or deep trombone. These again can be mixed in any combination. Vibrato and reverberation are available for this department.

The most unusual feature of this instrument is that percussion stops, titled sitar, harpsichord, banjo or piano can be switched singly or in combination in a selected rhythm. In fact, if the rhythm rate was sufficiently slowed down it is possible to transpose the melody line onto the rhythm key with some very exciting effects.

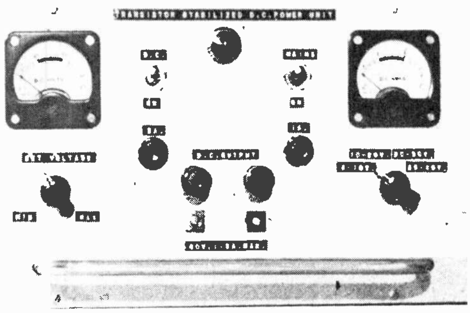
Retailing for £595 the Piper is an exhilarating novelty instrument which should provide an avid appeal for the pop orientated performer.



Layout of the Piper organ marketed by Hammond Organs



The 80EE magnetic cartridge from Rank Aldis-Audio Products



TRANSTAB POWER SUPPLY UNIT

BY P. CAIRNS

As transistors are now commonplace in circuits used by both professional and amateur constructors and experimenters, one automatically considers the best form of low voltage d.c. supply for the circuit in question. While many radio and amplifier circuits only require supplies in the 6–15 volt region with a small current drain, dry batteries are often sufficient for the purpose.

In the case of many electronic devices and power amplifiers, voltage requirements of between 15 and 50 volts are often specified, and in many cases a relatively heavy current drain is called for.

The stabilised power unit described in this article should prove to be an extremely useful piece of equipment, catering for almost all types of low voltage semiconductor circuit. While the initial cost may seem rather high compared with the cost of batteries or a simple unstabilised power supply, it could turn out in the long term to be more economic and more reliable.

FLOATING SUPPLY

The power supply unit was designed to combine simplicity with reliability, provide a wide range of voltage and current output while at the same time maintaining good regulation. The full specification is shown in the display panel, which shows the versatility of the unit to provide controlled supplies up to 1A at the low regulation figure of 0·3 per cent.

One very necessary and useful facility is that the d.c. output is completely isolated from earth and chassis. This allows the unit to be used in a number of modes. Either positive or negative side may be earthed at the output terminals or in the external circuitry supplied, or they can remain isolated leaving the supply floating.

Looking at the circuit diagram in Fig. 1, the only form of overload protection provided is the fuse. The "short-circuit" detection and correction principle is not always necessary and one must decide whether the extra complexity and cost is justified in view of the application of the unit in practice.

The author has found by experience that unless such circuits are rather complex so as to ensure a very fast electronic cut-out, the protection circuit can be "too late" to prevent damage to the rest of the circuit. The simpler types of protection circuit are generally only effective in preventing overload damage when a reasonable impedance is present between the circuit under test and the power supply source.

D.C. SUPPLY

The action of the circuit is quite straightforward and follows the usual feedback loop sequence of the majority of stabilising circuits. The secondary output from transformer T1 is tapped to the required voltage range through S2a and applied to the full wave bridge rectifier D1–D4. A suppression circuit consisting of

SPECIFICATION

D.C. Output Voltage	6 to 40V at 0 to 1A or 1·5A at slightly reduced regulation
Regulation at 0 to 1A	Less than 0·3% voltage change over range 6 to 40V (see Fig. 6)
Ranges	Switched ranges 6 to 12V; 12–20V; 20 to 30V; 30 to 40V. All variable.
Ripple over 6 to 40V range	75mV peak-to-peak (<0·05%) at full load 30mV peak-to-peak (<0·02%) at half load
Stability	Less than 0·3% change in output for mains voltage variation between − 3% and + 5%.
Dimensions	Width 12in, height 7in, depth 7in.

R1 and C1 prevent mains transients and short duration "spikes" being fed via the transformer into the stabiliser circuit. The diodes operate well within their maximum ratings of 200V p.i.v. at 6A, thus coping easily with filter surge current.

The filter circuit C2, C3, L1, is quite orthodox, a choke being used in preference to a resistor as, despite its seemingly low inductance, it is still much more effective, particularly at higher load currents. Its low d.c. resistance also allows a much smaller source impedance to be achieved, giving an improved stabilisation factor. A constant current bleed across this circuit is obtained through R2.

The output from the smoothing circuit is fed into the series stabiliser TR1. As this transistor has to be capable of handling the maximum load current at relatively wide range of voltage levels, it was chosen with a certain amount of care.

Under the worst conditions with S2 on the 30–40V output range, VR1 set to give 30 volts output at full load current of 1·5A, the transistor will be required to dissipate approximately 26 watts. On the same range with 40V output the maximum dissipation is about 15 watts. The transistor should never, therefore, exceed its 30W maximum dissipation rating. See the dissipation curves in Fig. 2.

Under these conditions a reasonably high gain is still required to maintain good stability. The OC29 was found to be the most suitable of the easily available power transistors, having a maximum dissipation of 30 watts at a case temperature of 45°C, a maximum collector voltage of 60V and a minimum gain of 45 a 1A. A large extruded aluminium finned heat sink is used to dissipate heat.

D.C. AMPLIFIER

The action of TR1 is controlled by the d.c. amplifier TR3 and TR4. The base of TR3 is biased from the potential divider chain R5–R8, VR1, R9–R12, the level of operation being capable of variation over the specified range by means of the range switch 52b and 52c with VR1. The four ranges selected by S2 are matched to the amplifier circuit via the switched resistors R5–R12, these ensure that VR1 only covers the approximate range selected by S2. Close tolerance resistors are used in these divider circuits to ensure reasonably accurate tracking between ranges.

The high gain amplifier transistors are connected as a Darlington pair, this circuit giving an extremely high d.c. gain. The load resistor for this amplifier is R3, the output developed across R3 being d.c. coupled from the collector of TR4 into the base of the emitter follower driver transistor TR2. This in turn is d.c. coupled to the series transistor TR1 and so completing the feedback loop.

The constant voltage reference point for the d.c. changes, which tend to occur across the divider chain, and thus the base of TR3, is given by the Zener diode D5. This holds the emitter of TR4 at a constant level, the current feed for this diode being taken from the stabilised side of the supply via R4.

The emitter of TR4 is effectively decoupled by C4 which also helps to prevent self oscillation in the amplifier. The base of TR3 is decoupled by C5, this serving a similar function. A large value smoothing capacitor C6 reduces the ripple on the output voltage to its final low value and is shunted by a smaller paper capacitor C7 to keep the source impedance at higher frequencies at a low value.

STABILISATION

The stabilising action is quite simple to follow. Assume that with S2 and VR1 set to give a particular voltage level, an increase in load current occurs. The voltage across the divider network will fall, thus the base of TR3 (and so TR4) will go more positive with respect to the emitter of TR4 which is held constant. This will reduce the collector current through R3, allowing the collector of TR4 to go more negative with respect to the emitter.

The base of TR1, which is d.c. coupled to TR4 collector via driver transistor TR2, is driven more negative also, so turning TR1 harder on and allowing more emitter current to flow. The initial increase in load current is pulled down by this increase in emitter current. Small changes in output voltage are thus detected, amplified, fed back to the regulator circuit and so make up a complete amplified negative feedback sequence.

Transistor TR2 is simply an emitter follower driver

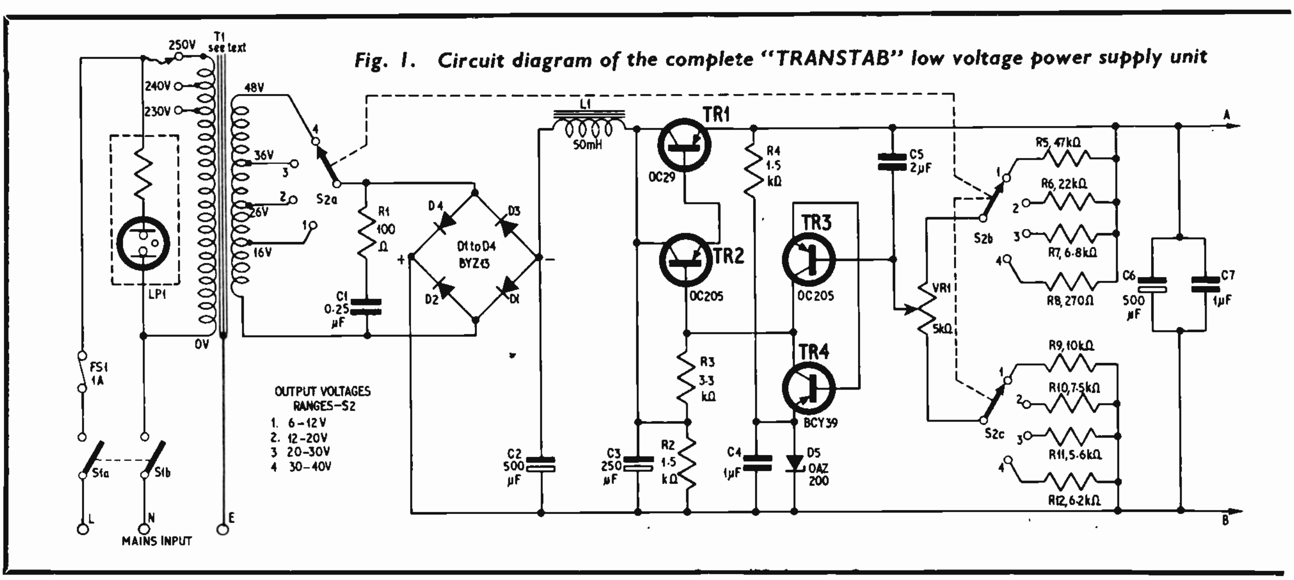


Fig. 1. Circuit diagram of the complete "TRANSTAB" low voltage power supply unit

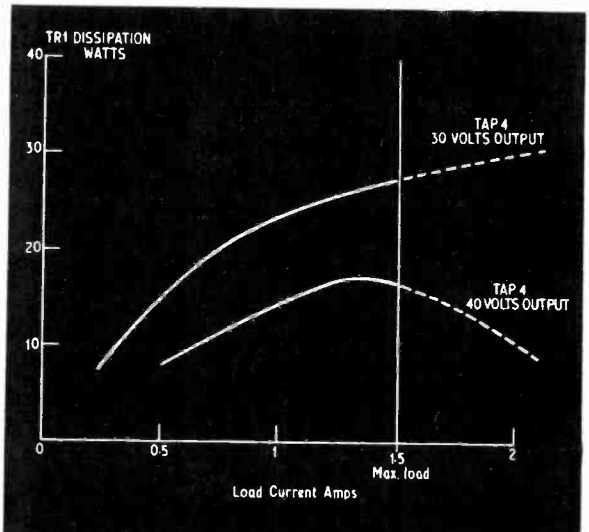
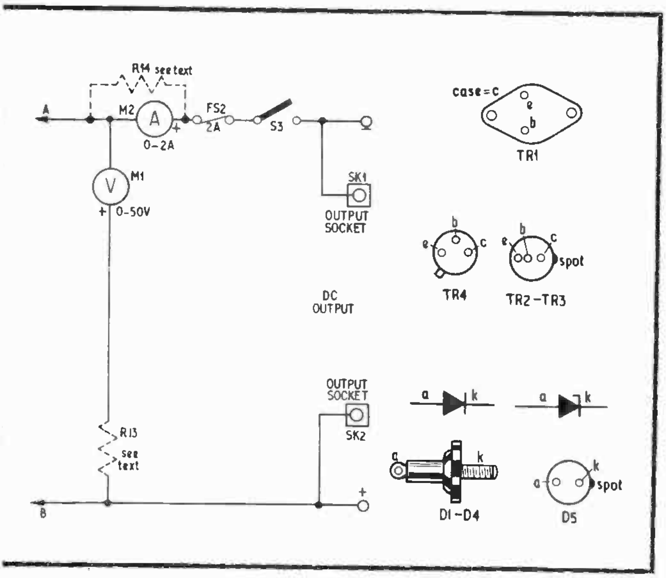


Fig. 2. Power dissipation in TR1 for varying loads

stage giving a low impedance drive into the base of TR1. No phase reversal occurs between TR4 and TR1. When considering the overall action of the circuit TR1 is also regarded as an emitter follower having a very low output impedance, the external load between the positive and negative terminals being the emitter load. The action described above is of course almost instantaneous, a decrease in load current having the reverse effect to that described.

The stabilised output is taken to the output terminals via the ammeter M2, fuse FS2 and switch S3. This toggle switch must be rated to carry at least 1·5A d.c. Many toggle switches only have a 1A rating for d.c. supplies, in which case a double-pole switch with the two poles connected in parallel allows the full load current to be switched if necessary.

The voltmeter M1, is connected to the supply side of the switch, this allowing the correct voltage to be set before being switched to the load. All controls and outputs are accessible from the front panel.



COMPONENTS . . .

Resistors

R1	100Ω ½W 10%	R7	6·8kΩ
R2	1·5kΩ 5W wirewound	R8	270Ω
R3	3·3kΩ 2W	R9	10kΩ
R4	1·5kΩ 2W	R10	7·5kΩ
R5	47kΩ	R11	5·6kΩ
R6	22kΩ	R12	6·2kΩ

All 5%, ½W carbon except where stated.

Potentiometer
VR1 5kΩ linear wirewound

Capacitors
C1 0·25μF or 0·22μF paper 500V
C2 500μF elect. 50V
C3 250μF elect. 64V
C4 1μF paper 150V
C5 2μF paper 150V
C6 500μF elect. 50V
C7 1μF paper 150V

Transformer
T1 Any mains transformer with the following *minimum* ratings:
Primary: 0–200, 220, 240, 250V
Seconding: 48V 2A tapped at 16V, 26V, 36V.
This transformer is part rewound—see text.

Inductor
L1 50mH 2A 0·6Ω choke (Gardners) see text

Transistors
TR1 OC29
TR2, TR3 OC205 (2 off)
TR4 BCY39

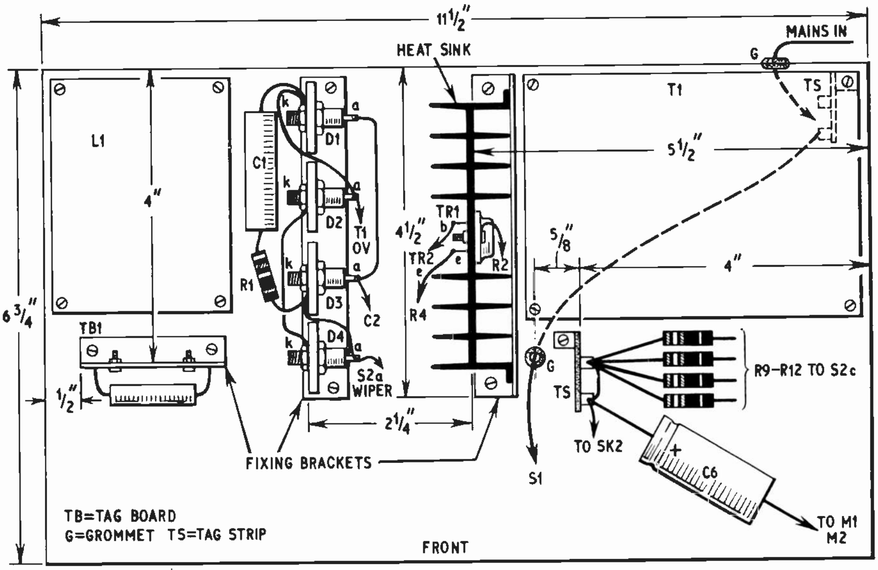
Diodes
D1–4 BYZ13 (4 off)
D5 OAZ200 (Zener diode 4·7V 100mA)

Meters
M1 0–50V f.s.d. (see text)
M2 0–2A f.s.d. (see text)

Switches
S1 Double pole, on-off toggle switch
S2 3-pole, 4-way wafer switch
S3 Single pole, on-off toggle switch (see text)

Fuse and fuseholders
FS1 1A
FS2 2A

Miscellaneous
LP1 Mains neon indicator with current limit resistor
Cabinet 12in × 7in × 7in aluminium case type W, fully louvred (H. L. Smith & Co. Ltd., 287–289 Edgware Road, London, W.2.)
Front panel 12in × 7in to fit case
Heat sink 4·875in × 1·05in extruded aluminium 4in long with eight pairs of fins
Mica washers, bushes, nylon screws for OC29
Plugs, wander, and sockets (2 off)
Screw terminals (2 off)
Pointer knobs (2 off)
Component tag board, tag strips, grommets, tinned copper wire and sleeving
Chrome handle 9in. Lettering or transfers



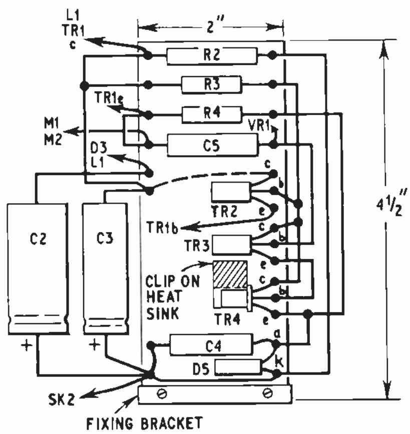
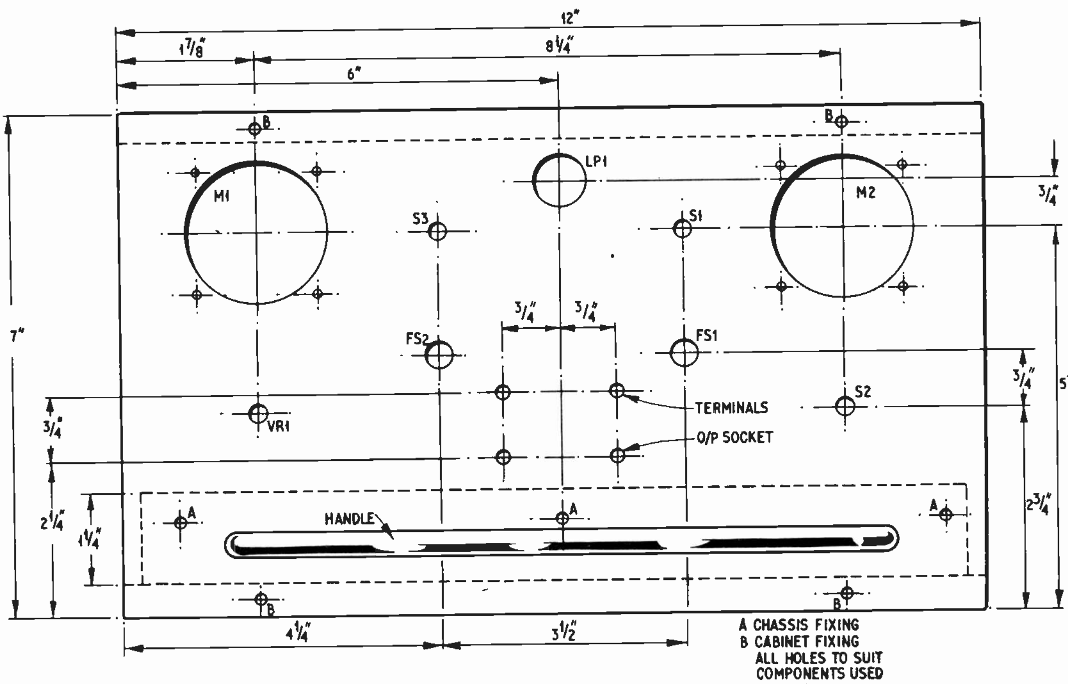


Fig. 3 (above). Layout of components on top of the chassis. Drilling details are made to suit the components used. More detail is shown in the photographs and in Fig. 4

Fig. 4 (left). Layout and wiring of the component tag board TB1

Fig. 5 (below). Drilling details of the front panel with the chassis position shown dotted. Fixing holes for the meters may differ according to the meters used



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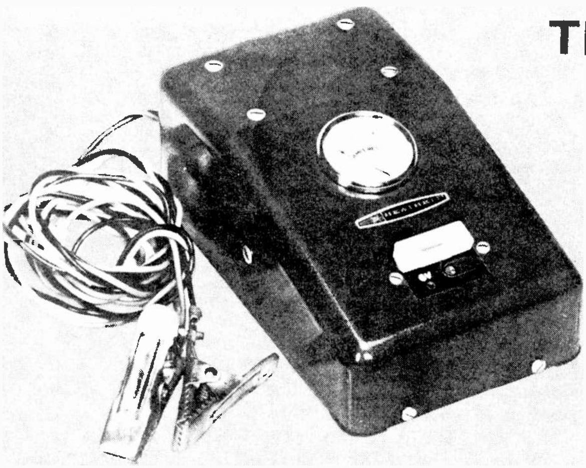

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25/11A

CONSTRUCTION

The construction of the unit is relatively straightforward, there being nothing at all critical about the layout.

The above chassis layout is shown in Fig. 3, together with relevant dimensions. The photographs also show the method of construction.

All components are mounted on top of the chassis, thus allowing a shallow chassis to be used. Only the mains lead is brought under the chassis from the rear grommet and three-way tag strip. This lead is brought up to the mains switch and fuse. The earth wire on the three-core mains input lead is taken to the earth tag on the chassis. No other connections are taken to earth or chassis.

As the transformer and choke (described later) can vary in size, the fixing holes for these components should be marked off from the components themselves.

HEAT SINKS

The OC29 (TR1) is fitted to the heat sink specified, the standard mica washer being placed between the bottom of the transistor and the heat sink. The two screws holding the transistor should be passed through the insulated bushes, a solder tag being fastened under the head of the top screw so as to make contact with the case (collector). This case should not touch the heat sink or chassis.

Ensure that the base and emitter pins are clear of the heat sink and no rough metal burrs are left around these or the fixing holes, as the transistor must lie perfectly flat on the heat sink for maximum efficiency. Before clamping the heat sink to the chassis by means of a small right angle bracket along the bottom, check that there is no d.c. continuity between the transistor elements and the heat sink.

If a short circuit is present, check that the mica insulating washer has not cracked or been pierced by a small spike of metal, or that the fixing screw insulating bushes have not cracked. The heat sink should be mounted with the cooling fins vertical.

DIODE MOUNTING

The diodes D1 to D4 are each mounted on a strip of aluminium 1in wide and 4in high, the four strips of aluminium being mounted together on an insulated angle bracket. The strips of aluminium not only make a convenient form of mounting but also act as heat sinks. The four strips should not touch one another and they should be isolated from the chassis by the bracket, this being of s.r.b.p., wood or similar material. Solder tags should be put on the diode studs and the nuts tightened.

Resistors R9 to R12 are connected between the three-way terminal strip beside T1 and S2c. Resistors R5 to R8 are connected between S2b and the negative terminal of the ammeter M2.

A clip-on heat sink should be placed over the can of TR4 as under certain conditions this can approach its maximum dissipation figure of 410mW at 25°C. Such small heat sinks, to fit a TO5 can, may be bought very cheaply or simply made from a strip of $\frac{1}{32}$in copper $\frac{1}{4}$in × $1\frac{1}{4}$in. This is bent and clipped tightly round the transistor can. Ensure the heat sink does not make contact with any other components as with this type of transistor the base is common to the can.

The stabiliser circuit components are mounted on a tag board which is mounted vertically on the chassis. The layout of the tag board, with dimensions, is shown in Fig. 4. This board should be wired up before being fitted to the chassis, flyleads being left for external connections.

FRONT PANEL

The front panel layout together with necessary dimensions is shown in Fig. 5.

As the type and size of meters used may vary, the meter holes should be cut to suit the particular meters which are going to be used (see later). The remainder of the front panel components should be mounted as shown, much of the front panel wiring being done before the panel is fitted to the chassis.

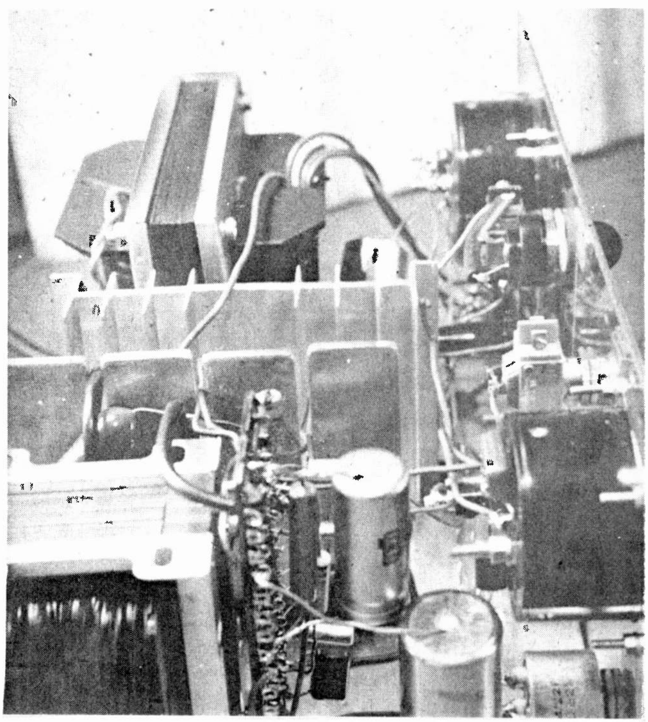
With the particular type of cabinet specified, a lip of approximately $\frac{3}{8}$in will be found all round the inside when the front panel is removed. The front panel is fitted into the upper and lower lips by means of self tapping screws.

To allow the chassis to fit into the cabinet, both of the vertical or side lips should be cut off, these serving no particular purpose. As the cabinet is made from aluminium, they can be simply removed using a small hacksaw blade or Abrafile.

When mounting the front panel to the chassis, allow the bottom edge of the front panel to protrude approximately $\frac{3}{8}$in below the bottom edge of the chassis. This compensates for the bottom lip of the cabinet as mentioned above.

If the fixing holes are drilled in the front panel first, they can be marked off on the chassis front with the chassis inside the cabinet, the front panel being loosely held in place by two of its four fixing screws. A hole must also be cut in the rear of the cabinet to line up with the grommet for the mains supply lead outlet.

With all the construction completed, final extras in the form of rubber feet and a carrying handle may be fitted if required. Four $\frac{3}{4}$in rubber feet mounted on the bottom of the cabinet prevent benches or tables being scratched, while a 9in chrome handle mounted on the bottom of the front panel (as illustrated) or on top of the cabinet, not only improves the appearance of the unit, but also makes the unit portable.



METER CALIBRATION

Before going on to the testing of the unit, mention may be made on the types of meters used and their calibration. The meters may be any 1½in to 2¼in moving coil type instruments, having either round or square faces.

While new meters may be obtained to cover the ranges quoted, these can be rather expensive. However, any moving coil instruments having a basic movement of 1–5mA may be used, these being suitably calibrated using an external shunt for the ammeter and an external series resistor for the voltmeter.

The ammeter will have to read amperes and not milliamps, therefore the shunt will not only be of a very low resistance but will have to be of heavy gauge resistance wire (22 s.w.g.) to carry the current. As the accurate measurement of such a small shunt is somewhat impracticable for the average constructor, the shunt may be altered in length a small amount at a time, the calibration being checked each time by connecting a multirange testmeter in series with the meter under test.

The meters are calibrated using a scale to suit the particular scale divisions marked on the meter face, new numerals being marked by hand on the scale if necessary.

While calibrating one's own meters can involve extra work, a great saving in cost is made as such instruments can generally be picked up on the surplus market at a very modest price. The accuracy of the calibrated meters can be checked against a normal multirange meter, this being sufficiently accurate for this type of calibration.

SHUNT AND SERIES RESISTORS

Two examples for calculating shunt (R14) and series resistors (R13) are shown below, the equations holding good for all types of moving coil meter. These resistors will only be needed if low rating meters are used.

Assume a 1mA movement, scaled 0–1 f.s.d. in 10 divisions, having a resistance of 50 ohms (meter resistance is normally marked or can be measured), is to be used for the voltmeter.

Rescale the dial 0–50 volts f.s.d., each division now representing 5 volts.

$$\text{Series Resistance } R_{13} = \left(\frac{V}{I\text{M}_1}\right) - R\text{M}_1$$

Where

V = full scale voltage required (50)

$R\text{M}_1$ = meter resistance (50)

$I\text{M}_1$ = Basic meter movement in amperes (0·001)

$$R_{13} = \left(\frac{50}{0{\cdot}001}\right) - 50 = 49{,}950 \text{ Ohms,}$$

say 50 kilohms.

Assume a 2mA movement, scaled 0–2 f.s.d. in 10 divisions, having a resistance of 30 ohms, is to be used for the ammeter.

Rescale the dial 0–1·5A f.s.d., each division now representing 150mA.

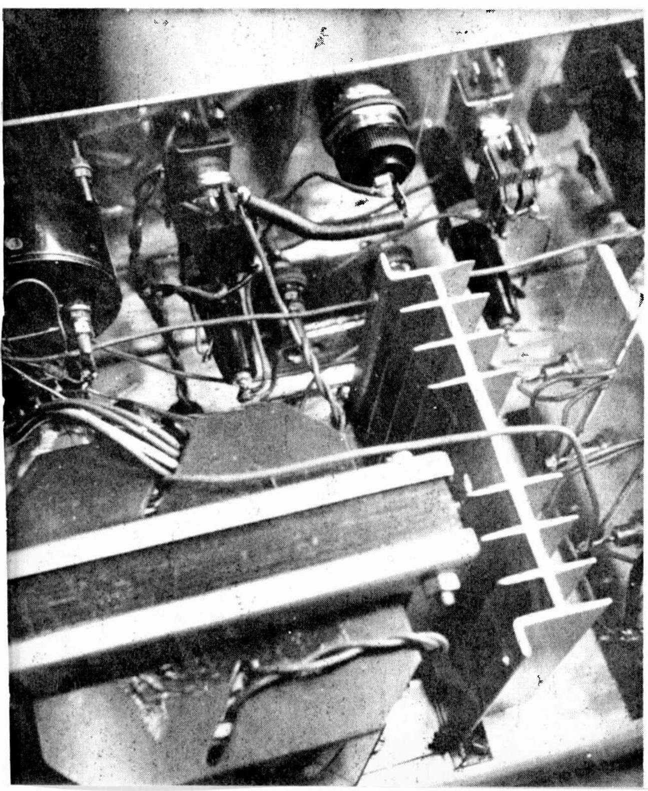
$$\text{Shunt Resistance } R_{14} = \frac{R\text{M}_2}{n-1}$$

where

$R\text{M}_2$ = meter resistance (30)

n = ratio by which meter range is to be extended (1,500 to 2 = 750 to 1).

$$R_{14} = \frac{30}{750-1} = \frac{30}{749} = 0{\cdot}04 \text{ ohms}$$



CHOKE

While the choke L1, may be bought commercially, a suitable alternative can be made very simply and much more cheaply. Any unwanted radio transformer or old l.f. choke having a core cross-sectional area of about one square inch is required. The existing winding is stripped off and the former rewound with 250 turns of 18 s.w.g. enamelled wire.

When restacking the core use a butt stack with $\frac{1}{64}$in air gaps in outer and centre limbs (equivalent to five thicknesses of writing paper). Using a 1in × 1in stalloy core with the winding quoted the inductance is approximately 50mH; the d.c. resistance is 0·6 ohm. These figures allow a good degree of smoothing to be achieved while at the same time maintaining a very low impedance.

TRANSFORMER

The transformer requires a little more attention. As suitable transformers may not be readily available on the market, a practical "do-it-yourself" method is therefore necessary.

An old mains transformer having a normal tapped primary winding for a.c. mains is used. As a total VI (volts × amps) rating of at least 75 is necessary, a stalloy core having a cross-sectional area of at least 1·6 square inches is required. Thus any core having

TEST AND SERVICING PROCEDURE

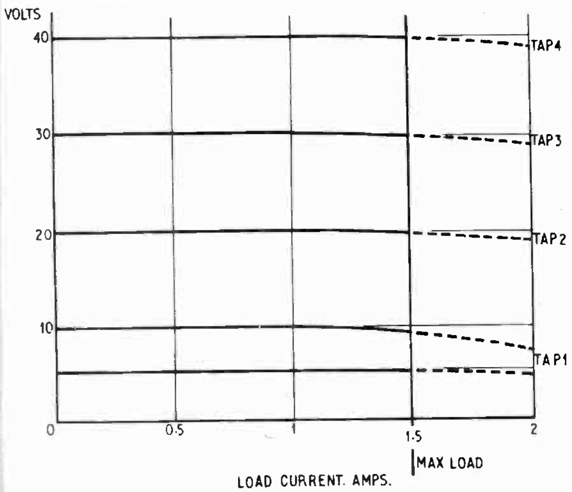


Fig. 6. ***Regulation curves of output voltage against load current***

Table 1: VOLTAGE CHECK

All d.c. voltages shown are NEGATIVE *and were measured with respect to the common* POSITIVE *line on a* 20kΩ *per volt multi-meter under no load conditions. Mains input 244V on 250V tapping.*

Secondary winding of T1	A.C.	D.C. OUTPUT TERMINALS
Tap 1	15·5V	6·4 to 11·6V
Tap 2	25·3V	11 to 21V
Tap 3	35·4V	18·7 to 31V
Tap 4	46·5V	28·8 to 42V

The following d.c. voltages were measured with voltage selector on tap 3 and VR1 set to give 25V d.c. output.

Junction of D2, D4, L1, C2	48V
Emitter of TR1 (output)	25V
Base of TR2	26V
Emitter of TR4	5·3V
Base of TR4	6·1V
Base of TR3	6·6V
Junction of R6, VR1	9V
Junction of R10, VR1	5·4V

TEST 1. OUTPUT NOT STABILISING OR INCORRECT

Check voltage across C3 is correct. If stabilising is correct on only two ranges check R5 to R12 and S1 on appropriate ranges. If incorrect proceed to Test 2a. If voltage O.K. proceed to Test 2b.

TEST 2. NO OUTPUT AT ALL

Check voltage across C3 is correct. If incorrect proceed as in (a) below. If correct proceed as in (b) below.

(a) Incorrect voltage across C3

Check voltage across C2
Check voltage on T1 secondary
Check FS1, S1, and mains supply
Check for short circuit across R2, R3, C1, C2, C3, C4, C5, C6, C7
Check for open circuit across D1, D2, D3, D4, L1
Check voltage across D5 (4·7V)

(b) Correct voltage across C3

Check TR1, TR2, R3, FS2, M2 are O.K.
Check for short circuit across M1, C6, C7, C5, C4
Check for open circuit across R3, R4, R5 to R12
Check TR3, TR4, VR1 are O.K.

a centre limb core dimension of 1¼in × 1¼in or greater will be suitable. A larger core will require fewer turns per volt.

By using an old mains transformer with a normal primary winding, only the secondary need be rewound. Only about 300 turns are required; this can be done quite simply by hand. Having acquired a transformer with a suitable core size and primary winding, the outer secondary windings are stripped off, care being taken not to damage the inner primary winding or insulation.

The turns per volt could be calculated from the core area, but due to variations in magnetic properties between one core and another, a more accurate method is to wind on a test winding of 20 turns of 18 s.w.g. enamelled wire, restack the core, connect the mains supply to the appropriate primary winding and measure the secondary voltage.

Handle the core laminations very carefully; they must not be scratched, bent, dented, or kinked, otherwise the electrical results will not be correct.

One side of each lamination should have an insulated coating which must not be scratched. This insulation reduces eddy current losses through the core. It is important to interleave each layer of laminations with the insulated surface facing one way only.

The clamp plates must be fitted carefully when all laminations are firmly fitted, and closed up by tapping the edge with a piece of wood.

This test winding will give an a.c. voltage which is best measured with a multimeter. From this the turns per volt figure can be calculated from the formula $n = \frac{20}{V_t}$, where n is the turns per volt and V_t is the test winding voltage.

Now calculate the number of turns for each voltage tapping required fron $n \cdot V$, where V is the secondary voltage. For example, if $n = 5{\cdot}6$, the number of turns for each tapping will be $16 \times 5{\cdot}6$, $10 \times 5{\cdot}6$, $10 \times 5{\cdot}6$, and $12 \times 5{\cdot}6$.

An allowance for voltage drop on load should be added, so 5 per cent should be added to these figures giving for $n = 5{\cdot}6$:

(a) 0 to 16V,	$16 \times 5{\cdot}88 \simeq 94$ turns
(b) 16 to 26V,	$10 \times 5{\cdot}88 \simeq 59$ turns
(c) 26 to 36V,	$10 \times 5{\cdot}88 \simeq 59$ turns
(d) 36 to 48V,	$12 \times 5{\cdot}88 \simeq 71$ turns

The total secondary winding in this case would have 283 turns.

The tapping points should have very thin flexible p.v.c. covered wire soldered to the winding after a small part of the enamel is removed with very fine emery paper. This joint must be insulated with plain non-adhesive tape. Some types of adhesive tape are not suitable as the enamel tends to be removed after a period of time.

When the secondary winding is completed a layer of insulating material, such as "Empire Tape" or thin p.v.c. sheet is wrapped round the winding, covered the full width of the winding.

Mains transformers have a tendency to produce "buzzing" unless the windings are impregnated with wax. Ideally the whole bobbin with windings should be immersed in a bath of hot beeswax or paraffin wax for ten minutes. Alternatively the wax can be melted and allowed to flow into the winding through crevices in the side cheeks of bobbin.

The laminated core and clamp can then be re-assembled as outlined earlier. The whole transformer is tested before fitting to the power unit chassis; make sure that there are no short circuits between the windings and the laminations.

TESTING AND SETTING UP

Before connecting the completed unit to the mains supply, the wiring should be carefully checked, particularly diode, transistor and capacitor polarity. Before switching on, set S2 to position 1 and VR1 to about mid-position.

Immediately the unit is switched on the voltmeter should indicate an output about midway between 6 and 12 volts. Vary VR1 from minimum to maximum and ensure that the range covered is approximately 6 to 12 volts

Next set S2 to positions 2, 3 and 4 in turn and check that VR1 gives the correct spread of voltage in each case. A complete list of the voltage ranges covered, together with a list of various voltage levels throughout the circuit is given in the display Table 1.

Should it be found that one or more ranges do not quite track (though about one volt overlap at each end was allowed for) the particular range or ranges in question can be simply brought into line by a slight adjustment of the appropriate resistor in the R5–R12 network. Reducing resistors R5–R8 lowers the voltage range while reducing resistors R9–R12 increases the voltage range.

Connect a dummy load of about 20 ohms across the output terminals with S2 set to position 1 and VR1 set to give mid-range output close S3 and check that the voltage shows no perceptible difference. A suitable load would be a 10 watt resistor.

To prevent overheating the dummy load, leave S3 closed just long enough to check the output levels. Using suitable load resistors of different value, the other three ranges can be checked if required. In each case there should be negligible change in output voltage for loads up to 1A. See regulation curves in Fig. 6. The load current should be shown on meter M2.

As may be seen from the regulation curves figures are given for loads up to 2A. The author has found in practice that overloads of up to 4A resulted in no more damage than a blown fuse and that an overload of almost 2A for a short period resulted in no damage.

If the unit is to be run for long periods at near full load ratings it is advisable to ensure that the louvres on the sides of the cabinet are not blocked by closely situated apparatus or walls.

CHANGING RANGES

It is advisable if changing ranges at near full load current to switch S3 off while S2 is altered. This prevents heavy surge currents being made through S2 contacts when switching transformer taps. While the switch contacts will carry the normal steady current, repeated changes of range, with heavy currents flowing, could burn S2 contacts.

Having satisfactorily completed the above tests the unit can be mounted in its cabinet and is ready for use.

The complete power unit with good stabilisation factor, low ripple value, wide range of outputs and portable size, make an extremely useful addition to any test bench or workshop where it should give long trouble free service.

Although the initial outlay is somewhat higher than for a straightforward power supply, versatility and reliability always cost a little extra, though over a period of time generally repay that extra cost may times over. ★

NEWS BRIEFS

Radiocom 70

NEW dates for this year's International Radio Engineering and Communications Exhibition meant few school parties attended and hence less attention to the stands of the various exhibitors, taking part primarily to attract recruits, resulted. Interest among amateurs was as high as ever and faces were put to many call signs in the bar.

Although this exhibition is popular we were very surprised to find so few home constructed equipments on display, particularly as there is now more interest in home construction than ever before; surely the R.S.G.B. members can do better than a handful of units, even if the standard is high. In this we echo the feelings of the R.S.G.B. who must have felt a little red faced at the response.

PRACTICAL ELECTRONICS shared a modern design stand with PRACTICAL WIRELESS and PRACTICAL TELEVISION; equipment described in past, present and future issues were displayed. The P.E. Marksman attracted much attention from young and old alike. Other equipment on display on our stand included a process timer, a boat speed indicator and a multi-function logic circuit using integrated circuits all these items will be described in future issues.

Last year this magazine suggested that the R.S.G.B. exhibition "needs progressive thought in its design" this is still apparent and we are sure that much can still be done to promote communications in general by the R.S.G.B. through this exhibition. Both the R.S.G.B. and its members have a right to feel proud of their exhibition but we feel that they are capable of even greater things—why not more demonstrations and lectures such as those arranged for the VHF–UHF Convention.

MAKING THE MOST OF LOGIC IC's

PART FIVE—By R. W. COLES

TRANSISTOR TRANSISTOR LOGIC

This article deals with the third of the major logic families mentioned at the beginning of the series, although the explosive growth of this section of integrated circuit technology has promoted two other families to the status of "major".

Transistor Transistor Logic, usually written TTL or T²L, is undoubtedly the most important, and certainly the most popular of all the i.c. logic families available. It combines a number of advantages, including high speed, high fan-out, and the flexibility afforded by the large variety of logic "building-bricks "of which the family is made up.

Flexibility is in fact the key word describing this versatile logic form, as it is also available in the form of medium scale integration (MSI). Instead of having a single package containing, for instance, one bistable, it is possible to obtain a complete four bit counter, or eight-bit shift register, in the same space. This last section of the TTL family is expanding very rapidly; some of the circuits available will be described later.

As we have considered the other two families in depth, in this section the performance details of TTL will only be dealt with briefly, as by now the interested reader will no doubt be familiar with the meaning of terms such as fan-out and noise immunity, and the space gained in this way will be used to discuss the design of counters, shift registers and other circuits, using TTL.

BASIC TTL GATES

The basic gate used in this family can take one of the two forms shown in Fig. 5.1; the principle of operation is the same in both cases, the difference being in speed of operation and power dissipation.

The most obvious characteristics of these gates are the unusual multi-emitter input transistor, and the "totem-pole" or "quasi-complementary" output stage, both of which would be most unusual in a discrete component logic gate, where the number of components employed would be prohibitive on cost grounds.

Fig. 5.1a shows the original type of TTL circuit to be developed and is often referred to as the "Phoenix gate".

This is the fastest gate of the two types, propagation delay being in the region of only 7ns. It has a slightly higher power dissipation than the circuit in Fig. 5.1b, which is a developed version, produced by Texas Instruments, usually described as series 54 or 74. This second type is probably the most popular, in spite of its propagation delay of around 13ns.

As far as this article is concerned, these two circuits may be considered identical in use and, although it is seldom acknowledged by the irrespective manufacturers, they are compatible with one another, and may be mixed in a system.

The fan-out recommended for both is a maximum of ten loads, or gate inputs, which is a significant increase over the drive capability of RTL or DTL. Logic implementation is, therefore, made easier when the paper design is turned into hardware.

The noise immunity of both types is also good, and is quoted as being typically 1V, with an absolute minimum of 400mV guaranteed under the worst conditions likely to be encountered. The logic levels encountered in a system using either of these gates are identical, the maximum low level output being 400mV, and the minimum high level output being 2·4V.

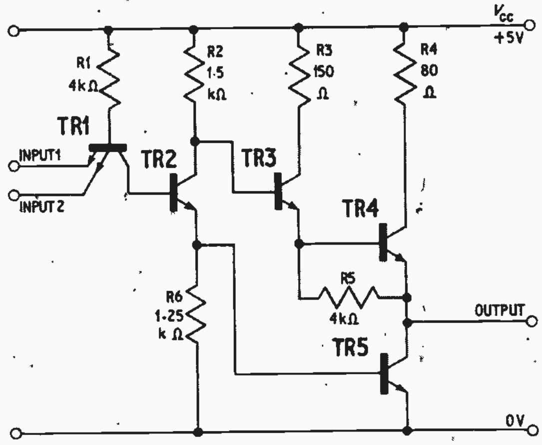


Fig. 5.1a. "Pheonix" TTL gate circuit. Note the two emitters on the input transistor

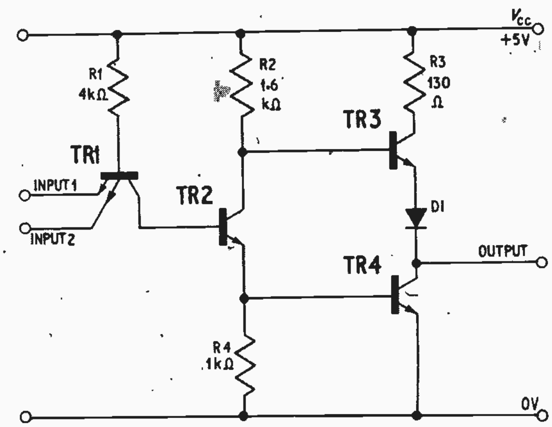


Fig. 5.1b. Series 54/74 gate by Texas Instruments

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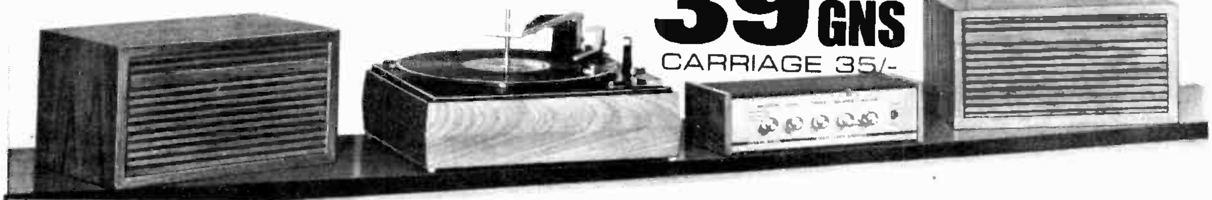

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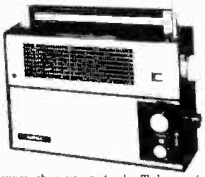

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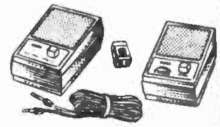

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Saves time and simplifies soldering in the home and service dept. Two position trigger gives instant dual heat 100/140 watt. 240 volt A.C

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Lightweight, 3/16" pencil bit. 25 watt. 240 volt A.C. **31/6.** P. & P. 2/-.

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With wide angle, jewelled meter movement, ceramic long-life, low-loss switching, tough impact resisting case. Sensitivity 20,000 ohms/volt D.C. 10,000 ohms/volt A.C.
19 Ranges: 0–5–25–50–250–500–2500 volts D.C. 0–10–50–100–500–1000 volts A.C. 0–50μA–2·5mA–250mA D.C. 0–6000 ohms–6 megohms, 10μ μf–0·001 mfd–1 mfd. −20 to +22dB. Complete battery, test lead and instructions.

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Garrard SP25 Mk. II Single Record Player. Fitted Goldring 850 Magnetic Stereo Cartridge. Complete in Teak Plinth with Rigid Perspex Cover. Total list Price over £24.

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Battery operated 4-channel audio mixer providing four separate inputs. Size 6 × 3 × 2in. suitable for crystal microphone, low impedance microphone with transformer, radio, tape, etc. Max. input 1·5V, max. output 2·5V, gain 6dB. Standard jack plug socket inputs, phonoplugs output. Attractive teak wood grain finish case.

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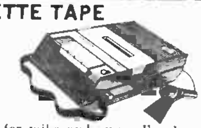
MIDLAND CASSETTE TAPE RECORDER 12-115



Solid state incorporating piano key controls for trouble-free 2-track recording. Inputs for mike and aux. Earphone socket. Complete with batteries and earpiece. Size 10½in × 5¾in × 2¼in.

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TT3	3"	450'	POLYESTER	7/6
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LP5	5"	900'	P.V.C.	10/-
DT5	5"	1200'	POLYESTER	15/-
LP6	5¾"	1200'	P.V.C.	12/6
DT6	5¾"	1800'	POLYESTER	22/6
TT6	5¾"	2400'	POLYESTER	37/6
SP7	7"	1200'	P.V.C.	12/6
LP7	7"	1800'	P.V.C.	15/-
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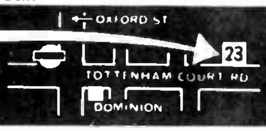


It follows, therefore, that there is no need to examine each gate and its uses separately. After a mention of the circuit operation of the Phoenix gate, the 54/74 gate will be used to illustrate systems design.

GATE OPERATION

The operation of both gate circuits is best understood by treating the logic performing input circuit and the output drive circuit separately.

The input circuit looks a little strange at first sight, but its operation is quite simple and is similar to that of the DTL gate, the two being compared in Fig. 5.2. By simplifying the gate input circuits into *p*-type and *n*-type semiconductor blocks, the TTL and DTL examples are shown to be identical.

However, it is important to note that the regions of semiconductor material in the TTL example are joined by semiconductor junctions, not by an interconnection. This *npn* block exhibits current gain, which is the important difference between the two, and the reason for the superiority of the TTL circuit.

When the current through R1 in Fig. 5.2b is sunk by either emitter e1 or e2, through the output stage of a further gate, the collector potential of TR1 drops rapidly to its saturated state, and effectively pulls the stored base charge out of TR2, causing it to switch off very quickly.

In the circuit in Fig. 5.2a, the diodes switch in a passive manner and so the gate operation is slower. When the inputs to either circuit are high, the operation of both is exactly the same; R1 and D3 provide a current path to the base of TR2 in Fig. 5.2a, and R1 and the base collector diode of TR1 provide a similar path in Fig. 5.2b.

The operation of the rest of the TTL gate circuit is quite straightforward and will be described by reference to Fig. 5.3. The totem-pole output stage behaves in a manner not unlike that of the push-pull amplifier circuit. Transistor TR2 in both gate circuits acts as a "phase-splitter", and ensures that when TR3 is turned on, TR4 will be turned off, and vice versa. The upper transistor TR3 behaves as an emitter follower and TR4 behaves as a common-emitter switch.

The difference between the two gates can now be readily seen, in the "Phoenix" type TR3 is made up from two transistors TR3a and TR3b connected as a Darlington pair, or compound emitter follower. In the 54/74 type, the upper transistor is a single emitter follower with a diode D1 in its emitter lead.

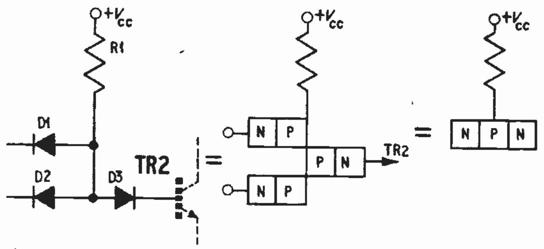


Fig. 5.2a. Input of a typical DTL gate with equivalent junction arrangements

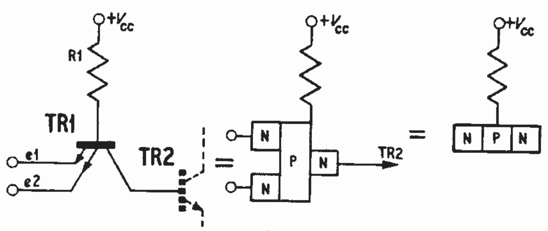


Fig. 5.2b. Input of a typical TTL gate with equivalent junction arrangements

OPERATION STATES

To understand why either a double emitter follower, or a single emitter follower plus diode, must be used and not just a single transistor, it is necessary to look at the circuits in one of the two operating states, and consider the effect of transistor saturation voltages and base emitter voltages when they add or subtract to define output levels.

The transistors are all silicon *npn* devices of course; their V_{be} and $V_{ce(sat)}$ will resemble the characteristics of discrete transistors of the same type, i.e. their V_{be} will be typically 600mV, and their $V_{ce(sat)}$ will be about 100mV. The diode in the 54/74 gate behaves as a base-emitter junction, and will have a forward voltage drop of 600mV.

For the output of the gates to be in the low level state, TR4 and TR2 (Fig. 5.3a and 5.3b) must be conducting, so the minimum voltage on the base of TR2 to achieve this will be twice V_{be} or 1·2V.

When TR2 is conducting, its collector voltage will be 100mV above its emitter potential, or 700mV. This would be sufficient to turn on a single emitter follower in the TR3 position, because its emitter potential would be taken to only 100mV when TR3/4 is on.

As it is essential that this should not occur, it is arranged that the voltage necessary to turn on TR3a and TR3b is much more than the V_{be} of a single transistor, hence the extra transistor in the Phoenix gate and the diode in the 54/74 gate. Both of these add 600mV to the voltage required to turn on TR3 in each circuit.

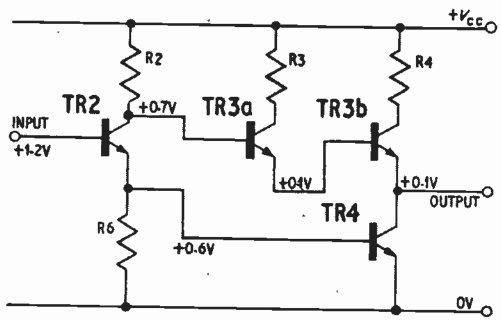


Fig. 5.3a. Simplified output stages of the "Phoenix" gate

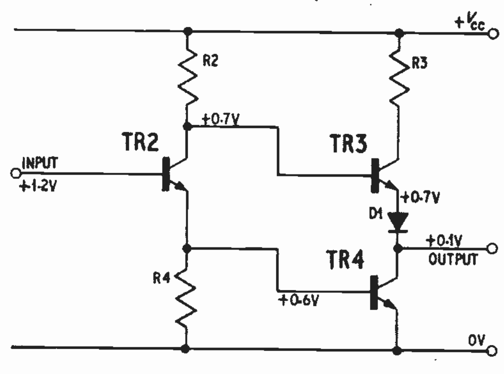


Fig. 5.3b. Simplified output stages of the 54/74 gate

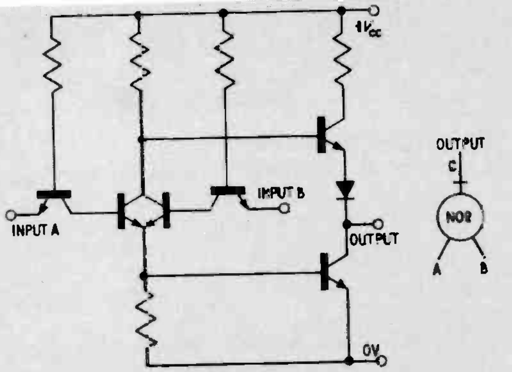


Fig. 5.4. Positive logic NOR gate circuit and symbol

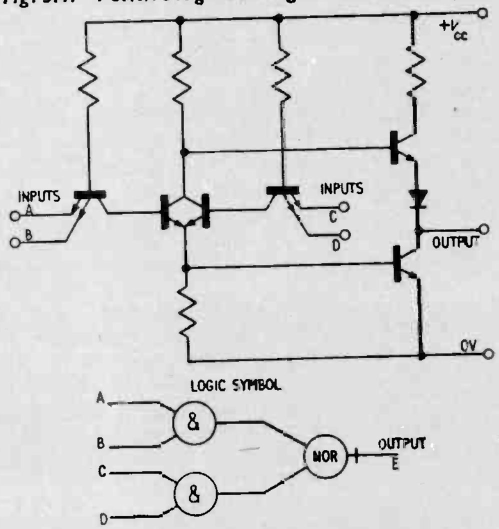


Fig. 5.5a. AND/OR INVERT gate circuit and symbol

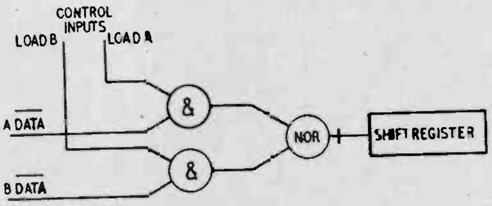
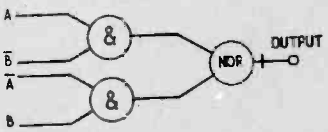


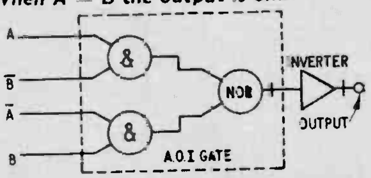
Fig. 5.5b. AND/OR INVERT gate used to load data from one of two sources into a shift register



TRUTH TABLE

A	B	O/P
0	0	1
1	0	0
0	1	0
1	1	1

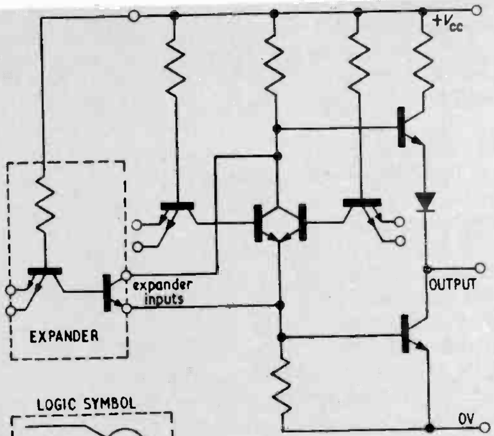
Fig. 5.5c. Equivalence gate and truth table. When A = B the output is one



TRUTH TABLE

A	B	SUM
0	0	0
1	0	1
0	1	1
1	1	0

Fig. 5.5d. Half adder; adds two binary numbers but does not produce a carry output



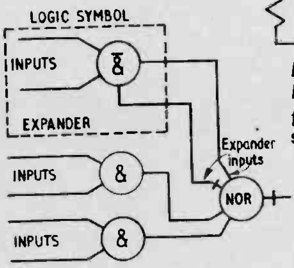


Fig. 5.6. AND/OR INVERT gate with expander input and circuit symbol

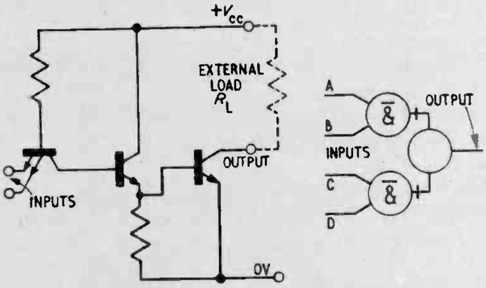


Fig. 5.7. Logic diagram of two gates connected in the wired-OR configuration with circuit symbol. The logic performed is the same as that of an AND/OR INVERT gate

FASTER OPERATION

The advantage of this form of gate output is its faster operation than in the DTL type when the output is rising; instead of a resistor setting the high level output impedance, an emitter follower is used. The resulting decrease of output impedance allows any capacitive load on the output (which must be charged before the output level can rise) to charge very rapidly.

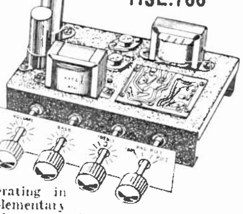
There are disadvantages as well: the maximum high level output voltage will be at least 1V less than the V_{CC} voltage due to the drop incurred in the emitter follower circuit, although this need not worry us.

Because transistors turn off more slowly than they turn on, there will be a very short period during the transition from one state to another, when both output transistors are conducting, and a current limited only by the load R_L will flow from V_{CC} to ground. This current spike, which only lasts for a few nanoseconds, can cause noise problems and affect other gates if the V_{CC} line is not properly decoupled; it also causes the power dissipation to rise with input frequency.

CIRCUIT FUNCTIONS

Armed with an understanding of the basic TTL gate circuitry, we can turn to the interesting subject of circuit elements available in the 54/74 range. As

MONO TRANSISTOR AMPLIFIER HSL.700



A really high fidelity monaural amplifier with performance characteristics to suit the most discriminating listener. 6 transistor circuit with integrated preamplifier assembled on special printed sub panel. AD161-AD162 operating in symmetrical complementary pair. Output transformer coupled to 3 ohm and 15 ohm speaker sockets. Standard phono input sockets. Full wave bridge rectifier power supply for a.c. mains 200-240v. Controls: bass, treble, volume/on/off. Function selector for PU1, PU2, tape, radio. The HSL.700 is strongly constructed on rigid steel chassis bronze hammer enamel finish, size 9½ × 5 × 4½in. high.

Sensitivity—PU1—50m/v, 56K input impedance.
PU2—110m/v, 1 meg input impedance.
Tape—110m/v, 1 meg input impedance.
Radio—110m/v, 1 meg input impedance.

Output power measured at 1Kc—6·2 watts RMS into 3 ohms. 5·8 watts RMS into 15 ohm. Overall frequency response 30c/s–18Kc/s: Continuously variable tone controls; Bass, +8db to −12db at 100c/s. Treble, +10db to −10db at 10Kc/s.

The HSL.700 has been designed for true high fidelity reproduction from radio tuner, gramophone deck and tape recorder preamp. Supplied ready built and tested, complete with knobs, attractive anodised aluminium front escutcheon panel, long spindles (can be cut to suit your housing requirements) full circuit diagram and operating instructions.

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3in 4 ohm **10/-**, P. & P. 1/6. 5in 3 ohm **16/-**, P. & P. 3/-. 7 × 4in 3 ohm **21/-**, P. & P. 4/-. 10 × 6in 3 or 15 ohm **35/-**, P. & P. 6/-. E.M.I. 8 × 5in 3 ohm with high flux magnet **26/-**, P. & P. 4/-. E.M.I. 13½ × 8in 3 ohm with high flux ceramic magnet **42/-**, (15 ohm **45/-**), P. & P. 6/-. E.M.I. 13 × 8in, 3 or 15 ohm with two inbuilt tweeters and crossover network **4 gns**, P. & P. 6/-.

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Also available in 8 ohm with EMI 13" × 8" bass speaker with parasitic tweeter £6.10.0 Carr. 10/-

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PRICES: AMPLIFIER KIT **£10.10.0;** POWER PACK KIT **£3.0.0;** CABINET **£3.0.0.** All Post Free.

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

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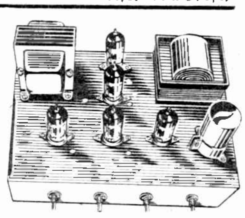

A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet **2/6** (Free with parts). **All parts sold separately.** ONLY **£7.19.6.** P. & P. 8/6. Also available ready built and tested complete with std. input sockets, **£9.19.6.** P. & P. 8/6.

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For 12v. D.C. operation. Off load consumption approx. 100mA. Totally enclosed. Quiet in operation with high starting torque. Overall size approx. 1⅞"L × 1½" dia. Free shaft $\frac{1}{16}$" dia. × ½"L. Ideal for Model Makers, etc. ONLY **7/6** each P. & P. 1/-. 3 or more post free (A few 6v. versions also available).

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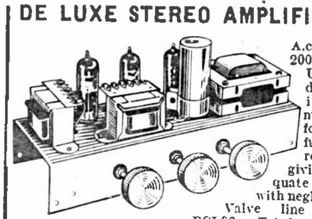

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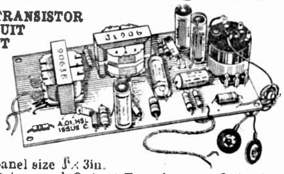

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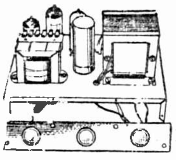

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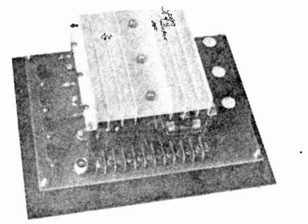

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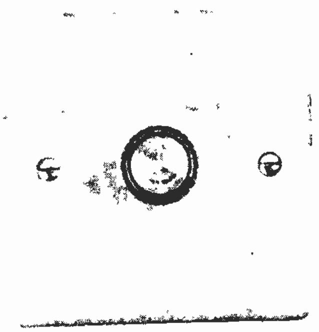

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mentioned earlier, TTL logic is complemented by a range of medium scale intergration packages, which contain quite complex elements such as shift registers, but for the moment we will concern ourselves with only the "standard range" and its uses.

As with DTL and RTL, the 54/74 series is available in all three of the package outlines commonly used, i.e. the reduced height TO-5 can, the dual-in-line plastic pack and the hermetically sealed flat-pack, although the TO-5 version is rather less common. The dual-in-line pack (which is the most popular) is sometimes found with 16 pins, instead of the more usual 14, to allow more freedom in the use of some of the more complex elements.

GATE TYPES

A wide range of different gate packages are available in this family, providing excellent flexibility when designing a logic system. There are three extra gate types in the range which are slightly different from the basic gate, so perhaps it is best if we have a look at the circuits of these first.

The basic logic convention used with TTL is positive logic NAND (otherwise useful as negative logic NOR). If the NOR function on positive "1" inputs is required, it is necessary to invert those inputs before using a standard gate to perform the NOR decision.

To overcome the possible waste of gates as inverters, a positive logic NOR gate has been added to the TTL range; the circuit of this is shown in Fig. 5.4. It is left to interested readers to work out how the circuit operates. The input and output arrangement is standard, therefore the gate is completely compatible with the rest of the range.

Another gate circuit available is the AND/OR INVERT gate, which is really three gates connected together inside the semiconductor chip, to form a versatile building block which may also be described as a half adder or exclusive-OR gate. The circuit of this and some of its many logic uses is shown in Fig. 5.5.

Expansion of the number of AND functions is allowed on some of these gates, and an expander is shown in Fig. 5.6, connected to a gate of this type.

PULL-UP RESISTOR

The article dealing with DTL investigated the very useful "wired-OR" function, which could be performed with that family. With TTL this is not possible because of the active pull-up emitter follower in the output stage, which must not be shorted to ground, as it would when using the wired-OR connection.

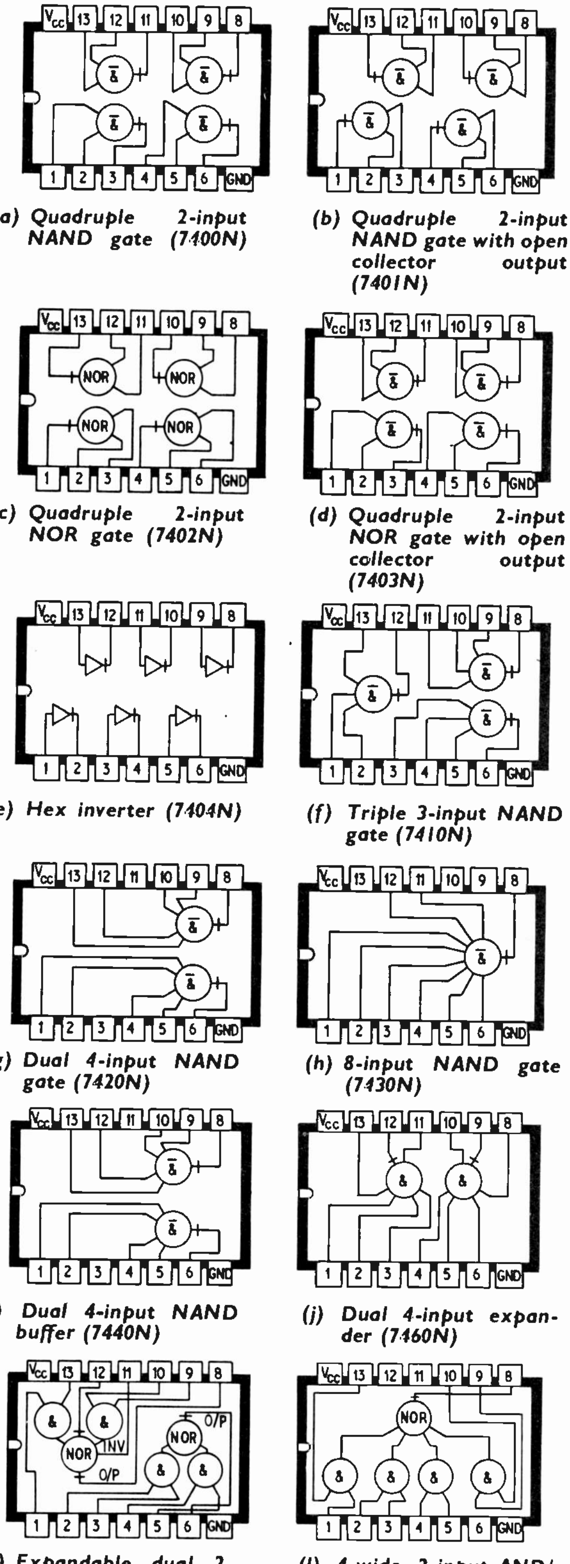
To overcome this limitation, a TTL gate is available without the usual "totem-pole" output stage, to enable gates to be connected together with a single external "pull-up" resistor, in the wired-OR configuration.

This circuit (Fig. 5.7) does slow the response of the gate, but this may be off-set by using a low value of resistance. The fan-out of this gate is reduced to a maximum of seven, but up to ten gate outputs may be connected together in the wired-OR function.

A list of gate packages is given in Fig. 5.8, which also shows the pin connections. Pin connections for i.c.s are always given as if you are looking down on the top of the package. This catalogue is not complete but it shows a useful cross section of the 74 range.

USING TTL GATES

As with all branches of electronic design, there is a certain amount of useful knowledge attached to the



(a) Quadruple 2-input NAND gate (7400N)

(b) Quadruple 2-input NAND gate with open collector output (7401N)

(c) Quadruple 2-input NOR gate (7402N)

(d) Quadruple 2-input NOR gate with open collector output (7403N)

(e) Hex inverter (7404N)

(f) Triple 3-input NAND gate (7410N)

(g) Dual 4-input NAND gate (7420N)

(h) 8-input NAND gate (7430N)

(i) Dual 4-input NAND buffer (7440N)

(j) Dual 4-input expander (7460N)

(k) Expandable dual 2-wide, 2-input AND/OR INVERT gate (7450N)

(l) 4-wide, 2-input AND/OR INVERT gate (7454N)

Fig. 5.8. Typical gate package outlines and their connections in the 54/64/74 range

use of TTL which is not normally given in manufacturers' data sheets, but is picked up by experience. To save constructors at least some of this expensive experience the following paragraphs are intended to help to get the best from TTL.

Gate inputs may not always be needed to perform the logic required, for instance, if one 4-input gate and one 3-input gate is needed in one section of a design, the cheapest package to use would be a dual 4-input gate (7420 for example), but this leaves one unwanted input. What should we do with it?

Anyone who has grasped the principle of TTL gate operation will quickly realise that a logical one (high level) voltage applied to the unused input will not affect the gate operation for the three used inputs, but there are several ways to achieve this. Connecting the input directly to the positive supply seems a possible solution, but this is permissible only if the supply never exceeds 5·5V. This condition includes the noise or transient spikes so often encountered.

If the supply does rise above 5·5V the emitter so connected will break down like a Zener, destroying the input transistor. For this reason, this solution is not to be recommended unless a resistor of about 1 kilohm is used in series to limit the current if breakdown occurs.

A better solution is to connect the unused input to one of the used inputs, so that the two are driven in parallel. This method does have the disadvantage that it increases the load on the driving gate output, but in about eight out of ten cases the driving gate will probably have some "fan out" in hand.

pulses while the gate passes through this transient state. This effect is shown graphically in Fig. 5.9.

To prevent this most undesirable state of affairs, it is necessary to keep rise and fall times to less than 1μs, which has the effect of making the duration of the indecisive state so small that the gate does not have a chance to start oscillating. If it is necessary to drive a gate from slow edges, such as those derived from 50Hz mains, or unijunction timebase circuits, then a Schmitt trigger should be used to provide the necessary steep edge by regenerative action. A Schmitt trigger is easily made from two TTL gates and one external diode and resistor as shown in Fig. 5.10.

SWITCH DRIVE

It is often necessary to drive gates from mechanical switches. Here again it is possible for the gate output to produce more than one pulse due to the reproduction of "switch-bounce" present at the switch contacts.

The classic solution to this problem is to use a monostable which produces an output pulse lasting longer than the period of "switch-bounce". Although TTL monostables are readily available, they are quite expensive, and there is a more simple method using only two gates connected as a bistable.

The circuit of this arrangement is given in Fig. 5.11. Two gates connected in this way form a "latch" bistable, which changes state when the switch is operated. The first momentary contact causes the change of state, and any subsequent bounce has no effect on the output. This method gives a high fan-out

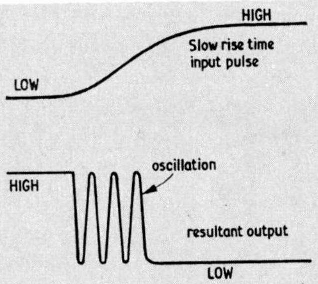


Fig. 5.9. Gate oscillation when driven from slow rise edges

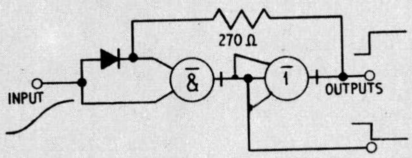


Fig. 5.10. Schmitt trigger using TTL gates

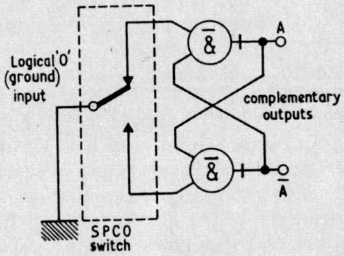


Fig. 5.11. Two 2-input NAND gates cross connected to form a latch

The best solution, although one which is likely to be practical only in large systems, is to use a complete spare gate as a driver for any unused inputs, by ensuring its output is always at a high level. This is simply achieved by tying all its inputs to ground.

Leaving a spare gate input open circuit will have the same effect as connecting it to a high level input, but this method, although apparently ideal, has an adverse affect on noise immunity and propagation delay.

PREVENTING OSCILLATION

From what we have seen of gate operation it might be thought that an input rise time of any length will successfully cause the output to change accordingly; this is true with one very important reservation. As the input voltage rises or falls, it must pass through an area of indecision, where the input is midway between the high and low level states.

Under these conditions it could be said that the gate is biased to operate as a linear amplifier of very high gain. Any stray capacitance round the gate connections could (and usually does) cause the gate to oscillate at a high frequency, giving rise to a string of narrow

of nine from each of the two complementary outputs, and may be used with several types of switch.

WIRING LENGTH

A consideration which is somtimes neglected when wiring up a TTL circuit, and which can cause unforeseen problems, is that of the maximum permissible lengths of interconnections. The very fast edges produced when gates switch have a large high frequency content, and so the interconnections between packages behave like transmission lines, giving rise to reflections from the remote end of the line.

The obvious way to prevent reflection occurring is to terminate the end of the line with a resistance equal to the characteristic impedance of the type of interconnection used. This impedance may be in the region of 50 to 150 ohms for printed circuit or twisted wire runs; it is not practical because of the load it would impose on the gate driving the line.

As we cannot terminate the line it is inevitable that reflections will occur. The only solution is to specify a maximum length of line which may be used before this problem can become troublesome. The period during

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2N2925	4/6	2N5192	25/-	ASY28	6/6	BF167	8/6	ZTX302	4/6
2N2926	2/3	2N5195	28/3	B5041	15/-	BF178	10/6	ZTX303	4/6
2N3053	5/6	2N5457	9/9	BA102	9/-	BF180	12/-	ZTX304	6/9
2N3054	14/3	2N5458	9/9	BA156	4/-	BF194	7/-	ZTX500	5/-
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2N3705	3/5	40430	37/-	BC126	12/-	BFY50	4/6		

RESISTORS

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	18d	16d	15d
C	⅛W	5%	4·7 Ω–330k Ω	E24	2·5d	2d	1·75d
C	¼W	10%	4·7 Ω–10M Ω	E12	2·5d	2d	1·75d
C	½W	5%	4·7 Ω–10M Ω	E24	3d	2·5d	2·25d
C	1W	10%	4·7 Ω–10M Ω	E12	6d	5d	4·5d
MO	½W	2%	10 Ω–1M Ω	E24	9d	8d	7d
WW	1W	10% ± 1/20 Ω	0·22 Ω–3·9 Ω	E12	15d all quantities		
WW	3W	5%	12 Ω–10k Ω	E12	15d all quantities		
WW	7W	5%	12 Ω–10k Ω	E12	18d all quantities		

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 same ohmic value and power rating, NOT mixed values. (Ignore fractions of ***1d*** *on total resistor order.)*

INTEGRATED CIRCUIT AMPLIFIERS

SINCLAIR IC.10 complete with instruction book giving amplifier circuit details and range of applications. **59/6** nett.

PLESSEY SL403A. Only **42/6** each. 3W into 7·5 Ω for 18V supply. Application data with two or more.

WAVECHANGE SWITCHES LONG SPINDLES

1P 12W; 2P 6W; 3P 4W; 4P 3W .. .. **4/9** each

SLIDER SWITCHES D.P.D.T. .. .. .. **3/-** each

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MULLARD POLYESTER C280 series

250V 20%: 0·01, 0·022, 0·033, 0·047, **8d** ea.; 0·068, 0·1, **9d** ea.; 0·15, **11d**; 0·22, **1/-**. 10%: 0·33, **1/5**: 0·47, **1/8**; 0·68, **2/3**; 1μF, **2/9**; 1·5μF, **4/2**; 2·2μF. **4/9**.

MULLARD SUB-MIN ELECTROLYTIC

C426 range axial lead **1/3** each

Values (μF/V): 0·64/64, 1/40, 1·6/25, 2·5/16, 2·5/64, 4/10, 4/40, 5/64, 6·4/6·4, 6·4/25, 8/4, 8/40, 10/2·5, 10/16, 10/64, 12·5/25, 16/40, 20/16, 20/16, 20/64, 25/6·4, 25/25, 32/4, 32/10, 32/40, 32/64, 40/16, 40/2·5, 50/6·4, 50/25, 50/40, 64/4, 64/10, 80/2·5, 80/16, 80/25, 100/6·4, 125/4, 125/10, 125/16, 160/2·5, 200/6·4, 200/10, 250/4, 320/2·5, 320/6·4, 400/4, 500/2·5.

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MEDIUM RANGE ELECTROLYTICS

Axial leads: 50/50 **2/-**; 100/25 **2/-**; 100/50 **2/6**; 250/25 **2/6**; 330/25 **2/6**; 250/50 **3/9**; 500/25 **3/9**; 500/50 **4/6**; 1000/25 **4/-**; 1000/50 **6/-**; 2000/25 **6/-**.

SMALL ELECTROLYTICS

Axial leads: 4·7/10, 4·7/25, 5/50, **1/-** ea. 10/10, 10/25, 10/50, 33/10, 50/10, **1/-** ea. 25/25, 25/50, 47/25, 100/10, 220/10, **1/3** ea.

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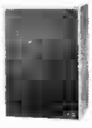
Build it 12 + 12 or 25 + 25

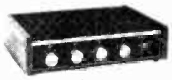
Stereo amplifier in modular kit form (including cabinet) 12 watts per channel **£38.9.0**; 25 watts **£58.15.0**. Cabinet kit only **£6**. These prices nett. As recently reviewed in Hi Fi Sound.

BAXANDALL SPEAKER SYSTEM



Designed by Peter Baxandall. Superb reproduction for its size. Handles 10 watts with ease. Uses ELAC 15 Ω 59RM109 speaker unit. Kit **£13.12.0** nett.; built **£19.8.6** nett.

STEREO AMPLIFIER SA.10-10



Developed from the very successful SA.8-8 amplifier giving first class stereo amplification featuring separate volume controls for each channel, bass and treble controls. 10 watts per channel into 5 to 8 Ω. Kit **£19.7.6** nett.; built **£24.16.8** nett. Suitable 8 Ω wide range speakers available **£13.15.0** each nett.

MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500–700mV for full output into 8 Ω.

Power	Kit price including components	Suitable unreg. power supply kit
12W	168/- nett	92/-
25W	195/- nett	N/A
40W	210/- nett	115/1
70W	252/- nett	138/10

30 WATT BAILEY AMPLIFIER KIT

Special summer reduction (to Sept. 30th, 1970, only). Sensitivity 1·2V for full output into 8 Ω. Transistors for one channel **£7.5.6** list, **£6** only nett. Transistors for two channels **£14.11.0** list **£11** only nett. Capacitors and resistors (metal oxide) **30/-** per channel nett. Complete unregulated power supply kit **87/6** nett.

ZENER DIODES

5% full range E24 values: 400mW: 2·7V to 30V **4/6** ea. 1W: 6·8V to 82V **9/-** ea. 1·5W: 4·7V to 75V **12/-** ea. Clip to increase 1·5W rating to 3 watts (type 266F) **9d.**

CARBON TRACK POTENTIOMETERS, long spindles.

Double wiper ensures minimum noise level.

Single gang linear	220 Ω to 2·2M Ω	2/6
Single gang log	4·7K Ω to 2·2M Ω	2/6
Dual gang linear	4·7K Ω to 2·2M Ω	8/6
Dual gang log	4·7K Ω to 2·2M Ω	8/6
Log/antilog	10K, 47K, 1M Ω only	8/6
Dual antilog	10K only	8/6

Any type with ½A D.P. mains switch, extra **2/6**. Please note: only decades of 10, 22 and 47 are available within ranges quoted.

CARBON SKELETON PRE-SETS

Small high quality, type PR, linear only 100 Ω, 220 Ω, 470 Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10M Ω. Vertical or horizontal mounting **1/-** each.

COMPONENT DISCOUNTS

10% on orders for components for £5 or more. 15% on orders for components for £15 or more (No discount on nett items).

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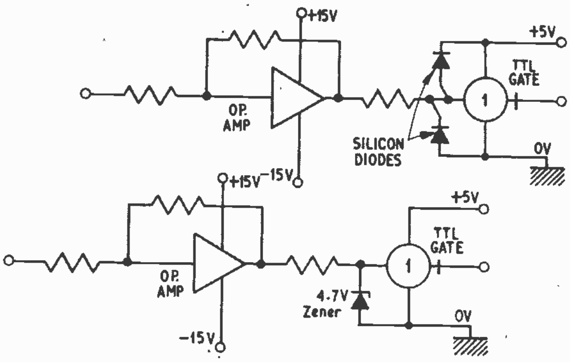


Fig. 5.12. TTL gate driven by an operational amplifier. (a) The two diodes clamp the input voltage to +5·6V and −0·6V. (b) The Zener diode limits the swing to +4·7V and −0·6V

which reflections will not affect gate operation is set by the propagation delay time, which is typically 13ns.

As the speed of an edge travelling down a typical interconnection is about 6in per nanosecond, the maximum allowable length is regrettably quite small. In fact, manufacturers recommend a maximum of 6 to 10 inches, but in the light of the facts laid out above it may be possible to extend this slightly.

Of course, in very large commercial systems, such as computers, it is often necessary to use interconnections many feet in length. To facilitate this there is a special series of TTL packages called "line drivers" and "line receivers" available.

OPERATIONAL AMPLIFIER DRIVE

It may be necessary to drive the input of a TTL gate from some other kind of circuit, such as an operational amplifier, which uses much higher supply voltages, and which consequently has a much higher voltage swing at its output.

TTL inputs must not rise higher than 6·5V or go negative with respect to the ground line, so when interfacing with this sort of circuit it is necessary to prevent these ratings from being exceeded. Two methods of achieving this are shown in Fig. 5.12, where a TTL gate is connected to the output of an operational amplifier.

In Fig. 5.12a, two silicon diodes are connected to the gate input so as to clamp the input voltage to between +5·6V and −0·6V; one or other of the diodes conducts when the amplifier output swing is outside these limits.

In Fig. 5.12b, a single Zener diode is used to limit the swing to +4·7V and −0·6V, the Zener conducting in the reverse direction on positive excursions, and in the forward direction on negative excursions.

INCREASING FAN-OUT

One last hint, should it be necessary to have a fan-out of greater than ten, it is quite permissible to parallel the outputs of several gates, provided that their inputs are also paralleled. A better solution if a much greater fan-out is required, is to use the special buffer gate, which will drive up to 30 loads, and, incidentally, can be used to drive longer transmission lines than a standard gate if a ground plane or twisted wire line is used.

The buffer gate was not treated separately in the circuits section, as its principle of operation is exactly the same as that of the basic gate, the main difference being the use of smaller resistor values to obtain more drive for the high current output stage.

Next month—practical TTL binary full adder.

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.

Information here

Sir—In PRACTICAL ELECTRONICS (June 1970) I notice one of your readers bemoaning the lack of information available on semiconductors.

For some time now we have been providing our mail order customers with a data sheet service, and the popularity of this service is evidenced by the fact that we have supplied 15,000 copies of data sheets since installing our new high speed electrostatic copier in January this year.

Due to the high cost of re-producing this data, and of maintaining an extensive library, it is not practicable to pack data sheets with every single transistor. The information on any one transistor can run into seven or eight pages.

I thoroughly agree with your reader's comments regarding somewhat ridiculous duplication of part numbers. I am sure all of us in the industry wish there was some way around this thorny problem. Meantime, we have to continue to stock a colossal number of types of transistor, many of which do the same job as each other.

P. F. Clarke G3LST,
Managing Director,
LST Electronic Components Ltd.,
Brentwood.

Progressing

Sir—I am writing in the hope that you may be able to help solve a problem that partially concerns your beginners series "This Way To Electronics".

I wish to take up practical electronics as a hobby, but knowing very little about the design of circuits with view to construction, I have gone somewhat aground. In the past I have had to rely on books, but up until now I have not come across any one book that seems to satisfy my needs.

In your wide experience have you come across a book that will explain, in layman's language initially, the design and practical construction of circuits with ample reference to the calculation of circuit component values. From this to progress to more complex circuit designs involving the derivement of pluses, bias's, etc. but still outlining the practical choice of components.

And finally to end up with the design of quite complex circuits, such that to any one who diligently follows the advice in the book, can, by the time of completion, be both confident and competent enough to design and construct his own equipment.

But does such a book exist? What I ask for is one that covers such a huge field that I find it not hard to appreciate the reasons why I have yet to see one.

W. K. Bennett,
Bradford,
Yorks.

Naturally, we are very sympathetic towards beginners and do understand many of their problems.

I should explain that the series "This Way" . . . deliberately excluded mathematical calculations, and was intended to present a descriptive treatment of the subject. As such I think it has served a very useful purpose.

This article should not be seen just on its own. We have published, on various occasions, other articles dealing with the theory of electronics circuitry. For example, I refer you to the "Demo Switching Circuits" series, in which the full mathematical treatment was given.

I am afraid it is impossible to recommend any one particular book which will give you all you ask for. There are so many publications available, yet no single volume appears to be the ideal one, covering all aspects. I think that if you continue to read our magazine, over a period of months, you will find that the articles we publish are covering your needs.—Ed.

Pick-up vibrations

Sir—Mr. L. F. Dickson's article (September 1970) describes the construction of a *Magnetic Guitar Pick-up*, but omits one important point, that is spurious note emission (also called second string vibration).

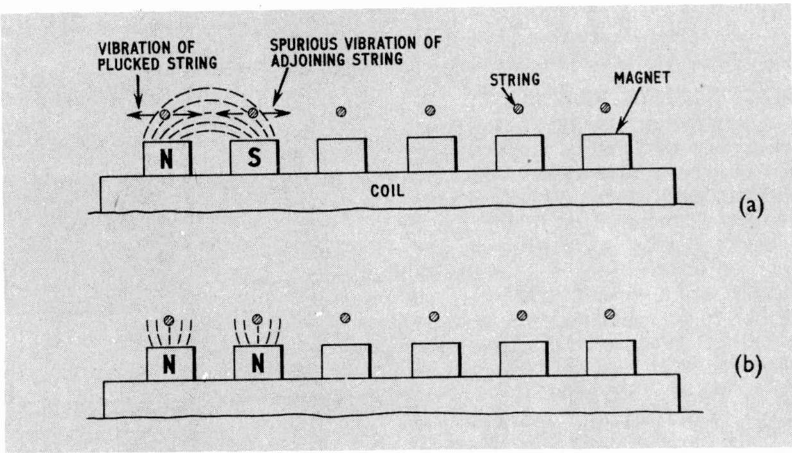
Before dealing with this point, a few words about the operation of such pick-ups. This is probably old hat to most P.E. readers, but is worth repeating. Magnetic pick-ups follow Fleming's law of electromagnetic induction. When a string is plucked it vibrates in the field of the magnet beneath it (see diagrams); this produces eddy currents in the string which in turn produce magnetic fields around the string. These fields in their turn produce an induced current in the pick-up coil which is fed to the amplifier.

If in the making of a pick-up, two of the magnets (or more) have unlike poles together, as in Fig. 1a, their fields will combine as shown. This means that the corresponding strings will vibrate in one combined field instead of two separate ones. So when one string is plucked, the other will start vibrating in sympathy due to the changes in the strong field caused by the two magnets, and so a spurious note will be produced.

This can be reduced, by ensuring on construction that all the magnets have like poles in the same direction. There will always be a tendency for second string vibration due to the magnetic field produced by a vibrating string, but this field is so small that it cannot have much effect on adjoining strings and can be ignored, see Fig. 1b.

Another source of unwanted notes is the common coil winding, but it is impractical to give each magnet its own individual coil, so this has to be put up with. In fact the same argument for ignoring it applies, as the field, due to the coil, is also very small.

A. D. Jones,
Maidstone,
Kent.



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BCY42	3/-
BCY43	3/-
BCY54	6/6
BCY58	4/6
BCY59	4/6
BCY60	19/6
BCY70	4/-
BCY71	8/6
BCY72	3/6
BCZ10	5/6
BCZ11	7/6
BD116	22/6
BD121	13/-
BD123	16/6
BD124	12/-
BD131	19/6
BD132	19/6
BDY10	27/6
BDY11	37/6
BDY17	37/6
BDY18	49/6
BDY19	62/6
BDY20	22/6
BDY38	19/6
BDY60	36/-
BDY61	36/-
BDY62	27/6
BF115	5/-
BF117	9/6
BF163	7/6
BF167	5/-
BF173	6/6
BF177	6/6
BF178	12/6
BF179	14/6
BF180	7/-
BF181	6/6
BF184	6/6
BF185	8/6
BF194	6/6
BF195	5/6
BF196	8/6
BF197	8/6
BF198	8/6
BF200	10/6
BF224	6/-
BF225	6/-
BF237	6/6
BF238	6/6
BF244	9/6
BFX12	4/6
BFW61	136
BFX12	4/6
BFX13	4/6
BFX29	7/-
BFX30	9/-
BFX43	7/6
BFX44	7/6
BFX68	13/6
BFX68A	13/6
BFX84	6/-
BFX85	7/-
BFX86	6/-
BFX87	10/-
BFX88	5/-
BFX89	12/6
BFX92A	12/6
BFY10	6/6
BFY11	8/6
BFY12	4/6
BFY13	4/6
BFY17	4/6
BFY18	6/6
BFY19	6/6
BFY20	12/6
BFY21	8/6
BFY24	9/-
BFY29	10/-
BFY30	10/-
BFY41	10/-
BFY43	12/6
BFY50	4/6
BFY51	4/6
BFY52	4/6

BFY53	5/6
BFY56A	11/-
BFY75	6/-
BFY76	8/-
BFY77	11/6
BFY85	9/-
BFY90	13/6
BFW58	5/6
BFW59	5/-
BFW60	5/-
BPX25	37/-
BPX29	36/-
BPY10	29/-
BRY39	9/6
BSX19	3/6
BSX20	3/6
BSX21	7/6
BSX26	9/-
BSX27	9/6
BSX28	6/6
BSX60	16/6
BSX61	12/6
BSX76	4/6
BSX77	5/6
BSX78	5/6
BSY24	3/-
BSY25	3/-
BSY26	3/6
BSY27	3/6
BSY28	3/6
BSY29	3/6
BSY32	5/6
BSY36	5/-
BSY37	5/-
BSY38	4/6
BSY39	4/6
BSY40	6/6
BSY51	6/6
BSY52	6/6
BSY53	7/6
BSY54	8/-
BSY56	18/-
BSY79	9/-
BSY82	10/6
BSY90	11/6
BSY95A	2/6
BSW41	8/6
BSW70	5/6
D16P1	7/6
D16P2	8/6
D16P3	7/6
D16P4	8/-
GET102	6/-
GET113	4/-
GET114	4/-
GET118	4/-
GET119	4/-
GET120	6/6
GET873	3/-
GET880	6/-
GET887	4/-
GET889	4/6
GET890	4/6
GET896	4/6
GET897	4/6
GET898	4/6
MAT100	6/-
MAT101	6/-
MAT120	6/-
MAT121	6/-
MC140	6/6
MJ400	21/6
MJ420	22/6
MJ421	22/6
MJ430	20/6
MJ440	19/6
MJ480	19/6
MJ481	25/-
MJ490	20/-
MJ491	27/6
MJ1800	43/6
MJE340	12/6
MJE520	17/6
MJE521	17/6
MPF102	8/6
MPF103	7/6
MPF104	7/6
MPF105	7/6
MPS3638	6/6
NKT0013	7/-
NKT124	6/6
NKT125	4/6
NKT126	4/-
NKT128	6/-
NKT135	6/6
NKT137	6/6
NKT210	4/6
NKT211	4/-
NKT212	4/-
NKT213	5/-
NKT214	4/-
NKT215	4/-
NKT216	7/6
NKT217	9/-
NKT219	5/-
NKT223	5/-
NKT224	4/-
NKT225	4/-
NKT229	4/-

NKT237	6/-
NKT238	5/-
NKT240	5/6
NKT241	5/6
NKT281	5/-
NKT713	4/-
NKT781	5/-
NKT10419	4/6
NKT10439	6/-
NKT10519	5/-
NKT20329	7/-
NKT20339	6/6
NKT80111	14/6
NKT80112	17/6
NKT80113	21/-
NKT80211	17/-
NKT80212	17/6
NKT80213	17/6
NKT80214	17/6
NKT80215	17/6
NKT80216	17/6
OC20	15/-
OC22	10/-
OC23	10/-
OC24	11/6
OC25	10/-
OC26	6/6
OC28	12/6
OC29	15/-
OC30	8/-
OC35	8/-
OC36	12/6
OC38	10/6
OC41	4/6
OC42	5/-
OC44	4/-
OC45	2/6
OC46	3/-
OC70	3/-
OC71	2/6
OC72	2/6
OC74	6/6
OC75	4/6
OC76	4/6
OC77	6/-
OC81	4/-
OC81D	4/6
OC83	5/-
OC84	5/-
OC139	6/6
OC140	6/6
OC170	6/-
OC171	6/-
OC200	6/6
OC201	9/6
OC202	12/6
OC203	8/6
OC204	8/6
OC205	8/6
OC207	7/6
OCP71	8/6
ORP12	12/6
ORP61	10/-
P346A	4/6
TIP31A	16/6
TIP32A	19/6
TIS34	12/6
TIS43	8/-
TIS44	2/6
TIS45	3/6
TIS46	3/6
TIS47	3/6
TIS48	3/6
TIS49	3/6
TIS50	4/6
TIS51	3/6
TIS52	3/6
TIS53	6/-
TIS60	6/-
TIS61	6/-
TIS62	6/-
ZTX107	3/6
ZTX108	3/6
ZTX109	3/6
ZTX300	3/6
ZTX301	3/6
ZTX302	4/6
ZTX303	4/6
ZTX304	6/6
ZTX500	4/6
ZTX501	5/-
ZTX502	5/-
ZTX503	5/-
ZTX504	12/6

Post & Packing 1/6d per order. Europe 5/-. Commonwealth (Air) 13/- Minimum.
Send 6d. stamp for price list.

PANEL METERS

38 Series—FACE SIZE 42 × 42mm. All prices for 1-9 pieces. 50μA, 37/6; 100μA, 35/-; 200μA, 32/6; 500μA, 27/6; 50-0-50μA, 35/-; 100-0-100μA, 32/6; 500-0-500μA, 25/-; 1MA, 25/-; 5MA, 25/-; 10MA, 25/-; 50MA, 25/-; 100MA, 25/-; 500MA, 25/-; 1A, 25/-; 5A, 25/-; 10V, 25/-; 20V, 25/-; 50V, 25/-; 300V, 25/-; 500V, 25/-. ALL METERS ARE D.C.

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200
1A	2/9	3/-	3/3	3/6	3/9	4/-	4/6	—
3A	3/-	—	—	4/6	—	6/-	—	—
6A	—	—	5/-	6/-	6/6	7/-	10/-*	—
10A	10/6	11/6	13/-	15/6	17/6	19/6	25/-	32/-
17A	11/6	12/6	15/6	18/-	19/6	24/-	31/6	37/6

*5A only 1A Types are plastic

DIODES & RECTIFIERS

1N461	4/6	1S131	2/6	BA144	2/6	BY164	11/6	OA73	1/9
1N914	1/6	1S132	3/-	BAX13	1/6	BYX10	4/6	OA79	1/6
1N916	1/6	1S940	1/6	BAX16	1/9	BYZ10	7/-	OA81	1/6
1N4007	4/6	AA119	2/6	BAY18	3/3	BYZ11	6/6	OA85	1/6
1S010	3/-	AA213	4/6	BAY31	1/6	BYZ12	6/-	OA90	1/6
1S021	4/-	AAZ13	4/-	BAY38	3/9	BYZ13	5/-	OA91	1/6
1S025	5/-	AAZ15	2/6	BY100	3/6	FST3/8	4/-	OA95	1/6
1S44	2/-	AAZ17	2/-	BY103	4/6	OA5	3/6	OA200	2/-
1S113	3/-	BA100	3/-	BY122	7/6	OA9	2/-	OA202	2/-
1S120	3/-	BA102	4/6	BY124	3/-	OA10	2/6		
1S121	3/6	BA110	7/-	BY126	3/6	OA47	1/6		
1S130	2/6	BA115	1/6	BY127	4/6	OA70	1/6		

MAINS TRANSFORMERS

1 amp Charger. Sec. 0–3·5–9–17V 19/6
2 amp Charger. Sec. 0–3·5–9–17V 25/6
1 amp (Douglas) MT103 Sec. tappings from 6V to 50V .. 32/6
2 amp (Douglas) MT104 Sec. tappings from 6V to 50V .. 42/6
Post and packing 4/6.
5 amp (Douglas) MT107 Sec. tappings from 6V to 50V .. 110/-
Post and packing 7/6.
Various other Douglas Transformers ranging from ½A to 5A in stock (details in catalogue).

TRIACS

SC41A 6 amp 100V 19/6
SC41B 6 amp 200V 22/-
SC41D 6 amp 400V 27/6
SC50D 15 amp 400V 60/-
40512 (RCA) TO-5 mod. 6 amp 400V 33/-
40430 (RCA) TO-66 6 amp 400V 27/6
40486 (RCA) TO-5 mod. 6 amp 400V 24/-
Economy Range Triacs
TC4/10 (Pressfit) 4 amp 100 PIV 15/-
TC4/20 (Pressfit) 4 amp 200PIV 17/-
TC4/40 (Pressfit) 4 amp 400 PIV 19/6
TC3/40 (TO-5) 3 amp 400 PIV 22/6
ST2 DIAC 9/6

INTEGRATED CIRCUITS
SEE OUR SEPARATE ADVERTISEMENT ON PAGE 920 SHOWING NEW I.C.s AT NEW LOW PRICES.

SCOTCH CASSETTES C-60
NORMAL PRICE 17/11. OUR PRICE 12/-
SCOTCH 3in TRIPLE PLAY 600ft
NORMAL PRICE 24/10. OUR PRICE 18/-

PLEASE NOTE: DUE TO BULK BUYING WE CAN NOW OFFER MOST TEXAS, RCA AND NEWMARKET SEMICONDUCTORS AT INDUSTRIAL DISTRIBUTOR PRICES. NEW QUANTITY PRICE LIST NOW AVAILABLE FOR INDUSTRIAL USERS UPON REQUEST.

THYRISTORS

PIV	50	100	200	300	400
1A	5/-	5/6	7/6	8/-	9/6
3A	6/-	7/6	8/-	9/-	10/6
5A	—	11/-	13/-	—	15/-
7A	—	11/-	13/-	—	19/6
25A	27/6	30/-	33/-	—	37/6

Also 12A, 100 PIV, 15/-; 600 PIV, 35/6; 25A, 400 PIV 37/6

VEROBOARD

	0·15 Matrix	0·1 Matrix
2½ × 3¾in	3/6	4/-
2½ × 5in	4/3	4/9
3¾ × 3¾in	4/3	4/9
3¾ × 5in	5/6	5/6
3¾ × 17in	16/-	21/6
3¾ × 17in (plain)	—	11/6
5 × 17in (plain)	15/6	—
Vero Pins (bags of 50)	5/-	5/-

Vero Cutter, 9/-

HEAT SINKS

4·8 × 4 × 1in Finned for Two TO-3 Trans., 9/6. 4·8 × 2 × 1in Finned, for One TO-3 Trans., 6/6. For SO-1, 6d. For TO-5, 1/- Finned. For TO-18, 1/- Finned. For TO-18, 1/- Finned.

RESISTORS

Carbon Film
⅛ watt 5%, 3d.
¼ watt 5%, 4d.
½ watt 5%, 5d.
1 watt 10%, 6d.
2 watt 10%, 1/3

CAPACITORS

A large and comprehensive range available: Electrolytic, Polyester, Ceramic, Polystyrene, Silver Mica, Tantalum, Trimmers, Tuners.
Examples:
2,000mF 25V, 8/6
2,500mF 50V, 13/6
3,000mF 25V, 10/6
5,000mF 50V, 19/6

WIRE-WOUND RESISTORS

2·5 watt 5% (up to 270 ohms only), 1/6
5 watt 5% (upto 8·2kΩ only), 2/-
10 watt 5% (up to 25kΩ only), 2/6

POTENTIOMETERS

Carbon:
Log. and Lin., less switch, 3/-.
Log. and Lin., with switch, 4/6.
Wire-wound Pots (3W), 5/6.
Twin Ganged Stereo Pots, Log. and Lin., 7/6.

PRESETS (CARBON)

0·1 Watt 1/-
0·2 Watt 1/3
0·3 Watt 1/6

THERMISTORS

R53 (STC) 25/6
K151 (1k) 2/6
VA3705 17/6
Mullard Thermistors also in stock. Please enquire.

Tel. 01-452 0161/2/3
Telex 21492
A. MARSHALL & SON
28 CRICKLEWOOD BROADWAY, LONDON, N.W.2

Send 2/6 for our New Comprehensive Catalogue containing Vouchers worth 6/-

CALLERS WELCOME
MON-FRI 9-5.30
SAT 9-5

STEPHENS ELECTRONICS

P.O. BOX 26
AYLESBURY, BUCKS.

SEND S.A.E. FOR LISTS
GUARANTEE
Satisfaction or money refunded

GUARANTEED VALVES BY THE LEADING MANUFACTURERS BY RETURN SERVICE
1 YEAR'S GUARANTEE ON OWN BRAND, 3 MONTHS' ON OTHERS

AZ31	10/-
AZ50	12/-
CBL1	16/-
CBL31	17/-
CY31	7/-
DAF91	8/3
DAF96	8/3
DF91	9/-
DF96	9/-
DK91	11/6
DK96	11/6
DL92	7/6
DL94	7/6
DL96	9/3
DM70	6/6
DY86/7	8/-
DY802	8/6
E55L	55/-
E88CC	8/-
E280F	42/-
E130L	90/-
E180F	19/-
EABC80	10/6
EAF42	10/-
EBC33	11/-
EBC41	9/6
EBC81	6/6
EBC90	9/6
EBF80	8/-
EBF83	8/-
EBF89	8/-
EB91	5/3
EC53	10/-
EC86	12/-
EC88	12/-
EC90	6/-
EC92	6/6
EC93	9/6
ECC81	8/-
ECC82/3	8/6
ECC84/5	8/6
ECC88	11/-
E88CC	12/6

ECF80/2	9/6
ECF86	11/-
ECH35	13/6
ECH42	13/3
ECH81	10/3
ECH83	8/-
ECH84	9/6
ECL80	8/-
ECL82	9/9
ECL83	11/6
ECL86	9/9
ECL L800	30/-
EF39	10/6
EF80	8/-
EF83	10/-
EF85	8/3
EF86	13/3
EF89	8/-
EF91	8/6
EF92	10/-
EF93	9/6
EF94	15/6
EF95	12/6
EF183	11/3
EF184	7/-
EF800	20/-
EF804	20/-
EF811	15/-
EL34	10/6
EL36	9/6
EL41	11/-
EL42	11/6
EL81	10/-
EL83	8/3
EL85	8/6
EL86	8/6
EL90	6/6
EL91	5/-
EL95	7/-
EL360	23/-

EL803	17/-
EL821	11/-
ELL80	15/-
EM34	16/-
EM71	12/6
EM80	8/-
EM81	8/6
EM84	7/6
EM87	11/-
EN91	6/6
EY51	8/-
EY80	9/-
EY81	8/-
EY83	11/-
EY86	8/-
EY87	8/6
EY88	8/6
EZ35	5/6
EZ40	9/-
EZ41	9/-
EZ80	5/6
EZ81	5/6
EZ90	5/-
GS10C	100/-
GY501	16/-
GZ30	7/6
GZ31	6/-
GZ32	9/6
GZ33	16/-
GZ34	11/-
HK90	6/6
HL92	7/-
HL94	8/-
KT66	27/6
KT88	33/-
N78	21/-
PABC80	8/-
PC86/8	10/3
PC95	7/3
PC97	8/3
PCC84	9/3

PCC85	8/6
PCC88	14/-
PCC89	12/3
PCC189	12/3
PCF80	10/3
PCF82	10/6
PCF84	9/6
PCF86	12/3
PCF200/1	16/3
PCF801	12/3
PCF802	12/3
PCF805	13/-
PCF806	12/3
PCF808	13/6
PCH200	14/-
PCL82	10/3
PCL83	12/3
PCL84	10/3
PCL85	10/6
PCL86	10/3
PD500	30/6
PFL200	14/9
PL36	12/9
PL38	18/-
PL81	10/3
PL81A	12/6
PL82	7/3
PL83	10/3
PL84	8/3
PL500	16/6
PL504	17/-
PL505	29/-
PL508	20/-
PL509	30/9
PL802	17/3
PL805	17/3
PY33	12/6
PY80	6/6
PY81	8/3
PY800	8/3
PY801	8/3
PY82	7/-

PY83	10/-
PY88	8/3
PY500	20/-
PZ30	16/-
QQVO2-6	42/-
QQV03-10	25/-
QVO3-12	13/-
R19	13/-
R20	15/-
8U2150A	15/-
TT21	48/-
TT22	50/-
U18/20	13/6
U20	13/6
U25	15/-
U26	15/-
U31	9/-
U37	30/-
U50	6/-
U52	6/-
U76	5/-
U78	5/-
U191	15/-
U193	8/3
U201	7/-
U281	8/-
U282	8/-
U301	11/6
U403	10/-
U404	7/6
U801	20/-
UABC80	10/6
UBF89	8/-
UBC41	9/9
UCC85	9/3
UCH42	13/9
UCH81	10/9
UCL82	10/3
UCL83	12/3
UF41/2	11/-
UF80/5	7/6
UF89	8/3

UL41	11/6
UL84	11/-
UM80/4	9/-
UY41	8/-
UY85	6/9
U25	15/-
U26	15/-
U191	14/6
U301	17/-
W729	11/-
Z759	24/6
OA2	6/6
OA3	9/-
OB2	6/6
OB3	10/-
OC3	7/-
OD3	6/6
3Q4	8/-
384	7/-
384	8/-
5R4GY	11/-
5U4G	6/-
5U4GB	7/6
5V4G	8/-
5Y3GT	6/-
5Z3	9/-
5Z4GT	8/-
6/30L2	15/-
6AB4	6/6
6AF4A	9/6
6AG7	7/6
6AH6	10/-
6AJ8	5/9
6AK5	6/-
6AK6	11/6
6AL8	8/6
6AL5	3/3
6AM5	5/-
6AM6	4/6
6AQ5	6/6
6AQ6	10/-

6AR5	6/6
6AR6	6/6
6AS5	7/-
6AS7G	16/-
6AT6	9/-
6AU6	5/9
6AV6	6/-
6BA6	9/6
6BE6	12/-
6BH6	8/6
6BJ6	8/6
6BK7A	10/-
6BL8	7/-
6BN5	8/6
6BN6	8/-
6BQ5	5/-
6BR7	15/-
6BR8	19/-
6BW6	16/6
6BW7	13/9
6BX6	5/-
6BZ6	6/6
6C4	6/-
6C5GT	7/-
6CD6G	28/-
6CA4	5/6
6CA7	10/6
6CBC	5/6
6CD6GA	23/-
6CG7	9/-
6CH6	11/-
6CL6	10/-
6CW4	12/6
6CY5	8/-
6CY7	12/-
6D3	8/-
6DC6	13/6
6DK6	8/6
6DQ6B	12/-
6DS4	15/-
6EA8	11/-

6EH7	6/6
6EJ7	7/-
6EW6	12/-
6F1	14/-
6F5	8/-
6F6G	5/-
6F11	6/6
6F12	4/6
6F13	7/-
6F14	12/-
6F15	11/-
6F18	8/-
6F22	6/6
6F23	15/6
6F24	13/6
6F25	15/-
6F26	7/-
6F28	14/-
6F29	6/6
6F30	7/-
6J4	9/6
6J5GT	6/-
6J7	8/6
6K6GT	10/-
6K7	6/6
6K8G	6/-
6K23	10/-
6K25	15/-
6L6GT	9/-
6L7	6/6
6L18	6/-
6LD20	6/6
6N7GT	7/-
6P1	12/-
6P25	21/-
6P28	12/6
6Q7	7/6
6R7G	7/-
682	8/-
684A	11/-
6SA7	7/6

6SG7	6/6
6SJ7	7/6
6SK7	6/6
6SL7GT	6/6
6SN7GT	6/-
6SQ7	8/-
6SR7	7/6
6T8	6/6
6U4GT	12/6
6U8	7/-
6V6GT	6/6
6X4	5/-
6X5GT	5/6
6X8	11/-
6Y6G	12/-
7Y4	12/-
9BW6	8/6
10C2	10/-
10D1	8/-
10D2	8/-
10F1	18/-
10F9	10/-
10F18	8/-
10L1	8/-
10LD11	11/-
10P13	11/-
10P14	20/-
12AB5	10/-
12AC6	7/6
12AD6	7/6
12A15	8/-
12AQ5	8/-
12AT6	5/-
12AU6	15/-
12AV6	6/-
12AV7	9/-
12AX7	6/-
12AY7	13/6
12B4A	10/-
12BA6	6/6
12BA7	6/6

12BE6	6/6
12BH7	6/6
12BY7	10/-
12K5	10/-
12K7GT	7/-
12Q7G	5/-
12SC7	5/-
12SG7	7/-
12SH7	5/-
12SJ7	5/-
12SK7	8/-
12SL7GT	8/-
12SN7GT	8/-
12SQ7	8/-
12SR7	6/6
1487	16/-
20D1	9/-
20L1	20/-
20P1	10/-
20P3	12/-
20P4	20/-
20P5	20/-
25C5	9/-
25L6GT	7/6
25Z4G	6/-
25Z6GT	10/-
30A5	8/-
30AE3	8/-
30C15	15/-
30C17	16/-
30C18	15/-
30F5	17/-
30FL1	15/-
30FL2	18/6
30FL13	10/-
30FL14	15/6
30L1	7/-
30L15	17/-
30L17	17/-
30P12	16/-

30P18	7/-
30P19	15/-
30PL1	15/6
30PL13	18/-
30PL14	17/-
35A3	10/-
35A5	11/-
35B5	13/-
35C5	7/-
35D5	13/-
35L6GT	9/6
35W4	5/-
35Z3	11/-
35Z4G	5/-
35Z5GT	7/6
50A5	13/-
50B5	7/-
50C5	7/-
50L6GT	8/-
83A1	18/-
85A2	7/6
90AV	48/-
90C1	12/-
90CV	25/-
807	9/6
811A	30/-
812A	65/-
813	75/-
866A	14/-
5642	12/-
6080	27/6
6146	30/-
6146B	47/6
6267	6/6
6360	25/-
6939	42/-
7199	15/-
7360	36/-
7586	25/-
9002	6/6
9003	10/-

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2N388A	12/6
2N404	4/6
2N696	4/-
2N697	4/-
2N698	5/-
2N699	12/6
2N706	2/6
2N706A	2/6
2N708	3/-
2N709	12/6
2N718	5/-
2N718A	6/-
2N726	6/-
2N727	6/-
2N914	3/6
2N916	3/6
2N918	6/-
2N929	4/6
2N930	5/6
2N987	10/6
2N1131	5/6
2N1132	6/6
2N1302	3/6
2N1303	3/6
2N1304	4/6
2N1305	4/6
2N1306	5/-
2N1307	5/-
2N1308	6/-
2N1309	6/-
2N1507	5/6
2N1613	5/-
2N1631	8/6
2N1632	8/6
2N1637	8/6
2N1638	7/6
2N1639	7/6
2N1701	32/6
2N1711	5/-
2N1889	6/6
2N1893	8/6
2N2147	14/6
2N2148	12/6
2N2160	11/6
2N2193	9/6
2N2193A	10/-
2N2194A	4/6
2N2217	5/6
2N2218	6/6
2N2219	6/6
2N2220	5/-
2N2221	5/-
2N2222	6/-
2N2287	21/6
2N2297	6/-
2N2368	3/6
2N2369	3/6
2N2369A	4/-
2N2410	8/6
2N2483	5/6
2N2484	6/6
2N2539	4/6
2N2540	4/6

2N2613	7/-
2N2614	6/-
2N2646	11/6
2N2696	6/6
2N2711	6/-
2N2712	6/-
2N2713	5/6
2N2714	6/-
2N2865	12/6
2N2904	7/-
2N2904A	8/-
2N2905	8/-
2N2905A	9/-
2N2906	6/-
2N2906A	6/6
2N2907	8/-
2N29023	3/6
2N2924	3/6
2N2925	3/6
2N2926	
Green	2/9
Yellow	2/6
Orange	2/6
2N3011	6/-
2N3014	6/6
2N2053	5/6
2N3054	11/-
2N3055	15/-
2N3133	6/-
2N3134	6/-
2N3135	5/-
2N3136	5/-
2N3340	19/6
2N3349	26/-
2N3390	7/6
2N3391	4/-
2N3391A	6/-
2N3392	4/-
2N3393	4/-
2N3394	4/-
2N3402	4/6
2N3403	4/6
2N3404	7/6
2N3405	9/-
2N3414	5/6
2N3415	5/6
2N3416	7/6
2N3417	7/6
2N3439	26/-
2N3440	19/6
2N3570	17/6
2N3572	17/6
2N3605	5/6
2N3606	5/6
2N3607	4/6
2N3662	7/6
2N3663	7/6
2N3702	3/6
2N3703	4/6
2N3704	4/6
2N3705	4/-
2N3706	4/6
2N3707	4/-

2N3708	3/6
2N3709	3/6
2N3710	4/-
2N3711	4/-
2N3713	30/-
2N3714	35/-
2N3819	7/-
2N3823	22/6
2N3826	6/-
2N3854	5/6
2N384A	5/6
2N3855	5/6
2N3855A	6/-
2N3856	6/-
2N3856A	7/-
2N3858	5/-
2N3858A	6/-
2N3859	5/6
2N3859A	6/6
2N3860	6/-
2N3866	30/-
2N3877	8/-
2N3877A	8/-
2N3900	7/6
2N3900A	8/-
2N3901	19/6
2N3903	7/-
2N3904	7/-
2N3905	7/6
2N3906	7/6
2N4058	5/6
2N4059	5/-
2N4060	5/-
2N4061	4/6
2N4062	4/6
2N4244	9/6
2N4245	8/6
2N4254	8/6
2N4255	8/6
2N4284	3/6
2N4285	3/6
2N4286	3/6
2N4287	3/6
2N4288	3/6
2N4289	3/6
2N4290	3/6
2N4291	3/6
2N4292	2/6
2N5027	10/6
2N5028	11/6
2N5029	9/6
2N5030	8/6
2N5172	3/-
2N5174	10/6
2N5175	10/6
2N5176	9/-
2N5232A	6/-
2N5245	12/6
2N5246	12/6
2N5249	13/6
2N5249A	13/6
2N5265	65/-
2N5266	55/-

2N5267	52/6
2N5305	7/6
2N5306	8/-
2N5307	7/6
2N5308	7/6
2N5309	12/6
2N5310	8/6
2N5354	5/6
2N5355	5/6
2N5356	6/6
2N5365	9/6
2N5366	6/6
2N5367	11/6
2N5457	7/6
28005	15/-
28020	37/6
28102	6/6
28103	6/6
28104	6/6
28501	5/6
28502	5/6
28503	5/6
3N83	37/6
3N128	18/6
3N140	19/6
3N141	19/6
3N142	19/6
3N143	17/6
3N152	22/6
R.C.A.	
40050	13/6
40250	10/-
40251	19/6
40309	8/-
40310	11/6
40311	9/6
40312	12/6
40314	9/6
40315	9/6
40316	12/6
40317	9/6
40319	13/6
40320	9/6
40323	8/6
40324	11/6
40326	19/6
40329	7/-
40344	7/-
40347	8/6
40348	12/6
40360	11/-
40361	12/6
40362	13/6
40370	7/6
40406	14/6
40408	12/6
40467	16/6
40467A	14/6
40468A	14/6
AC107	6/-
AC117	12/-
AC126	4/-
AC127	5/-

AC128	4/-
AC154	4/6
AC176	5/-
AC187	12/6
AC188	7/6
ACY17	5/6
ACY18	5/-
ACY19	5/-
ACY20	5/-
ACT21	5/-
ACY22	4/-
ACY28	4/-
ACY40	4/-
ACY41	5/-
ACY44	8/-
AD140	8/-
AD149	11/6
AD150	12/6
AD161	7/6
AD162	7/6
AF106	8/6
AF114	5/-
AF115	6/-
AF116	5/-
AF117	5/-
AF118	12/-
AF119	4/-
AF124	4/6
AF125	4/-
AF126	4/-
AF127	3/6
AF139	7/6
AF178	9/-
AF179	9/-
AF180	10/6
AF181	8/6
AF186	13/4
AF239	8/6
AF279	9/6
AF280	12/6
AFZ11	6/6
ASY26	5/-
ASY27	7/6
ASY28	5/6
ASY29	5/6
ASY36	5/-
ASY50	5/-
ASY51	6/6
ASY53	5/-
ASY54	5/-
ASY62	5/-
ASY63	3/6
ASY72	5/-
ASY83	5/-
ASY86	6/6
ASZ20	7/6
ASZ21	8/6
AUY10	30/-
BC107	3/-
BC108	3/-
BC109	3/-
BC113	5/6
BC114	7/6

BC115	6/6
BC116	12/6
BC116A	7/6
BC117	7/9
BC118	6/6
BC121	4/-
BC122	4/-
BC125	11/-
BC126	11/-
BC134	11/6
BC140	7/6
BC147	3/6
BC148	3/-
BC149	3/6
BC152	3/6
BC157	4/-
BC158	3/6
BC159	4/-
BC160	12/6
BC167	3/-
BC168B	2/9
BC168C	3/-
BC169B	2/9
BC169C	3/-
BC170	3/6
BC171	3/6
BC172	3/6
BC175	5/6
BC182	4/6
BC183	4/6
BC184	4/6
BC182L	4/-
BC183L	3/6
BC184L	4/-
BC187	5/3
BC212L	4/6
BC213L	5/4
BCY10	5/6
BCY12	5/6
BCY30	5/6
BCY31	5/6
BCY32	7/6
BCY33	4/-
BCY34	4/6
BCY38	4/6
BCY39	8/6
BCY40	7/6
BCY42	3/-
BCY43	3/-
BCY54	6/6
BCY58	4/6
BCY59	4/6
BCY60	19/6
BCY70	4/-
BCY71	8/6
BCY72	3/6
BYZ10	5/6
BCZ11	7/6
BD116	22/6
BD121	13/-
BD123	16/6
BD124	12/-
BD131	19/6

BD132	19/6
BDY10	27/6
BDY11	37/6
BDY17	37/6
BDY18	49/6
BDY19	62/6
BDY20	30/6
BDY38	19/6
BDY60	36/-
BDY61	36/-
BDY62	27/6
BF115	5/-
BF117	9/6
BF163	7/-
BF167	5/-
BF173	6/6
BF177	6/6
BF178	7/-
BF179	14/6
BF180	7/-
BF181	6/6
BF184	5/-
BF185	8/6
BF194	4/6
BF195	5/6
BF196	8/6
BF197	6/4
BF198	8/6
BF200	7/4
BF224	6/-
BF225	6/-
BF237	6/6
BF238	6/6
BF257	9/6
BF22A	9/6
BFX12	4/6
BFX13	4/6
BFX29	7/-
BFX43	7/6
BFX44	7/6
BFX68	13/6
BFX84	6/-
BFX85	7/-
BFX86	6/-
BFX87	6/-
BFX88	5/-
BFX89	12/6
BFY10	6/6
BFY11	8/6
BFY17	4/6
BFY18	6/6
BFY19	6/6
BFY20	12/6
BFY21	8/6
BFY24	9/-
BFY25	5/-
BFY26	4/-
BFY29	10/-

BFY30	10/-
BFY41	10/-
BFY43	12/6
BFY50	4/6
BFY51	4/6
BFY52	4/6
BFY53	4/6
BFY56A	11/6
BFY75	6/-
BFY76	8/6
BFY77	11/6
BFY90	13/6
BFW58	5/6
BFW59	5/-
BFW60	5/-
BPX25	37/-
BPX29	36/-
BPY10	29/-
BSX19	3/6
BSX20	3/6
BSX21	7/6
BSX26	9/-
BSX27	9/6
BSX28	6/6
BSX60	16/6
BSX61	12/6
BSX76	4/6
BSX77	5/6
BSX78	5/6
BSY10	5/6
BSY11	5/6
BSY24	3/-
BSY25	3/-
BSY26	3/6
BSY27	3/6
BSY28	3/6
BSY29	3/6
BSY32	5/-
BSY36	5/-
BSY37	5/-
BSY38	4/6
BSY39	4/6
BSY40	6/6
BSY51	6/6
BSY52	6/6
BSY53	7/6
BSY54	8/-
BSY56	18/-
BSY78	9/6
BSY79	9/-
BSY82	10/6
BSY90	11/6
BSY95A	2/6
BSW41	8/6
BSW70	5/6
D16P1	7/6
D16P2	8/-
D16P3	7/6

D16P4	8/-
GET102	6/-
GET113	4/-
GET114	4/-
GET118	4/-
GET119	4/-
GET120	10/6
GET873	2/6
GET880	6/-
GET887	4/-
GET889	4/6
GET890	4/6
GET896	4/6
GET897	4/6
GET898	4/6
MAT100	6/-
MAT101	6/-
MAT120	6/-
MAT121	6/-
MJ400	21/6
MJ420	22/6
MJ421	22/6
MJ430	20/6
MJ440	19/-
MJ480	19/6
MJ481	25/-
MJ490	20/-
MJ491	27/6
MJ1800	43/6
MJE340	12/6
MJE520	17/6
MJE521	17/6
MPF102	8/6
MPF103	7/6
MPF104	7/6
MPF105	7/6
MPS3638	6/6
NKT0013	9/6
NKT124	8/6
NKT125	5/6
NKT126	5/6
NKT128	5/6
NKT135	5/6
NKT137	6/6
NKT210	6/-
NKT211	6/-
NKT212	6/-
NKT213	6/-
NKT214	4/6
NKT215	4/6
NKT216	7/6
NKT217	8/6
NKT219	6/-
NKT223	5/6
NKT224	5/-
NKT225	4/6
NKT229	6/-
NKT237	7/-

NKT238	5/-
NKT240	5/6
NKT241	5/6
NKT242	4/-
NKT243	12/6
NKT244	3/6
NKT245	4/-
NKT261	4/-
NKT264	6/-
NKT271	4/-
NKT272	4/-
NKT274	4/-
NKT275	4/-
NKT281	4/-
NKT401	17/6
NKT402	18/-
NKT403	15/-
NKT404	12/6
NKT405	15/-
NKT406	12/6
NKT451	12/6
NKT452	12/6
NKT453	9/6
NKT603F	6/6
NKT613F	6/6
NKT674F	6/-
NKT677F	6/-
NKT713	5/-
NKT717	8/6
NKT734	5/6
NKT736	7/-
NKT773	5/-
NKT781	6/-
NKT10339	6/6
NKT10419	6/-
NKT10439	7/6
NKT10519	6/6
NKT20329	9/6
NKT80111	15/6
NKT80112	19/6
NKT80113	22/6
NKT80211	18/6
NKT80212	18/6
NKT80213	18/6
NKT80214	18/6
NKT80215	18/6
NKT80216	18/6
OC20	15/-

OC22	10/-
OC23	10/-
OC24	11/6
OC25	10/-
OC26	6/6
OC28	12/6
OC29	15/-
OC35	8/-
OC36	12/6
O341	4/6
OC42	5/-
OC44	4/-
OC45	2/6
OC46	3/-
OC70	3/-
OC71	2/6
OC72	2/6
OC74	6/6
OC75	4/6
OC76	4/6
OC77	5/6
OC78	5/-
OC81	4/-
OC81D	4/-
OC83	5/-
OC84	5/-
OC139	6/6
OC140	6/6
OC169	4/8
OC170	6/-
OC171	6/-
OC200	6/6
OC201	9/6
OC202	9/6
OC203	6/6
OC204	8/6
OC205	8/6
OC207	12/6
OCP71	8/6
P346A	4/6
T1834	12/6
T1843	8/-
T1844	2/6
T1845	3/6
T1846	3/6
T1847	3/6
T1848	3/6
T1849	3/6
T1850	4/6
T1851	3/6
T1852	3/6
T1853	6/-
T1860	6/-
T1861	6/-
T1P29A	13/6
T1P30A	15/-
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BSY27 1/9	OC202 1/9	2N3705 1/9
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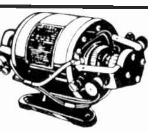

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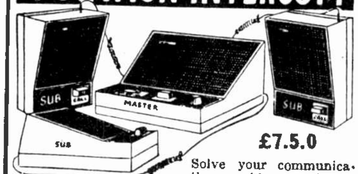

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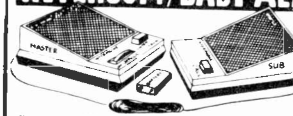

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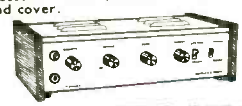

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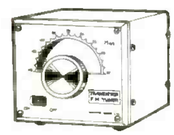

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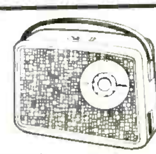

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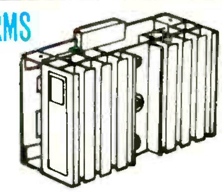

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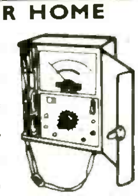

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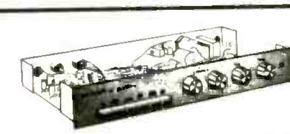

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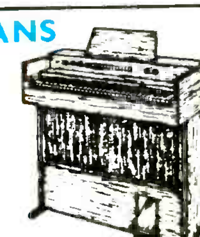

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