PRACTICAL ELECTRONICS

FEBRUARY 1968

PRICE 2/6

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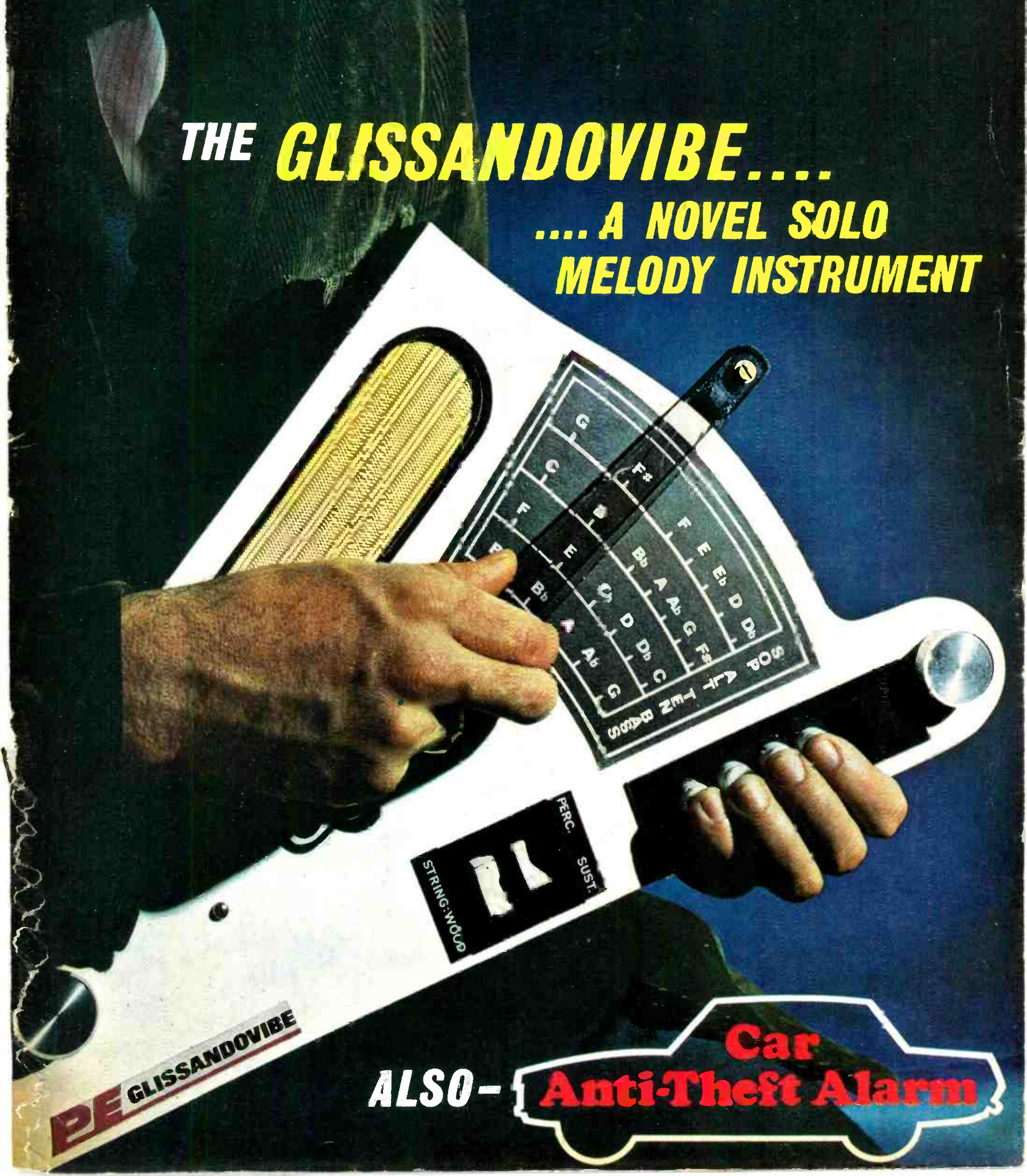

ALSO– Car Anti-Theft Alarm

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GREAT NEWS!

THIS YEAR LASKY'S CELEBRATE THEIR 35th ANNIVERSARY

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To celebrate our success and your satisfaction we have published a 12-page, fully illustrated colour "35th Birthday Pictorial" Catalogue

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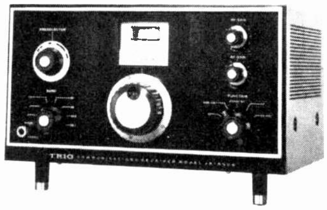
A MUST FOR EVERY ELECTRONICS HOBBYIST AND HI-FI ENTHUSIAST!

COMMUNICATION RECEIVERS

NOW AVAILABLE FOR THE FIRST TIME IN GREAT BRITAIN—TWO NEW TRIO RECEIVERS

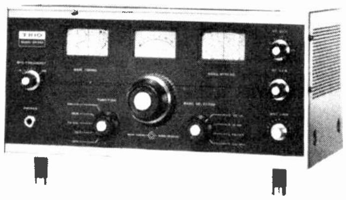


MODEL JR-500SE

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

LASKY'S PRICE £61.19.0 Carriage and Packing 12/6.

MODEL 9R-59DE



Brief spec: 4 band receiver covering 550 Kc/s to 30 Mc/s continuous and electrical band spread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. **Special features:** SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF frequency 455 Kc/s ● Audio output 1·5W ● Variable RF and AF gain controls. For use on 115/250V a.c. Mains. Beautifully designed control layout finished in light grey with dark grey case, size: 7 × 15 × 10in. Weight 19 lb. Fully guaranteed, complete with instruction manual and service data.

LASKY'S PRICE £36.15.0 Carriage and Packing 12/6.

SPECIAL INTEREST ITEMS!

NEW VOICE ACTUATED MICROPHONE

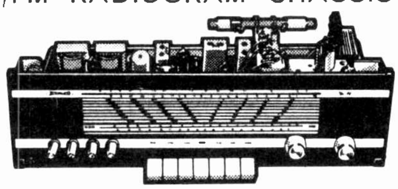
MODEL B 5001

This new voice actuated microphone is designed for use with tape recorders with facilities for remote control. The microphone is fitted with a three position switch allowing normal hand remote control, voice sensitivity action and off. The degree of voice or sound level required to operate the recorder can be adjusted. The microphone is self powered by one 9V (PP3 type) battery giving 6 to 10 hrs. operating time. Super sensitive 6 transistor circuit. Strong black plastic case. Length 7½in. Designed for hand held use or laying flat. Fitted with 2·5 and 3·5 mm. plugs for fitting polarised sockets.

LASKY'S PRICE £6.19.6 Post 3/6.

BULK PURCHASE SCOOP!

STEREO AM/FM RADIOGRAM CHASSIS BY FAMOUS GERMAN MAKER



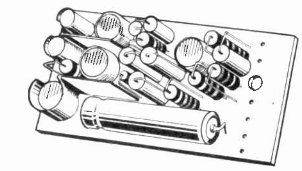
Long, medium and short wave bands coverage, plus VHF/FM multiplex. Piano key wave change, separate fly wheel tuning on AM and FM, bass, treble and balance controls, and magic eye tuning indicator. Ferrite rod aerial. The very latest printed circuitry. Output 5 watts per channel. Complete with multiplex decoder. 5 valves, line-up: ECC85, ECH801, ECC83, ELL80, EAF801. Full vision tuning scale, size: 21 × 6in. Overall dimensions: 21 × 6½ × 8in. Made to very highest standards.

LASKY'S PRICE £38.6.6 Carriage and Packing 10/-

ALSO AVAILABLE WITHOUT MULTIPLEX £33.12.0 C. & P. 8/6

CONSTRUCTORS BARGAINS

LASKY'S MINIATURE TRANSISTOR AMPLIFIER MODULES



Incorporating the very latest circuitry to provide high sensitivity and good quality in conjunction with extreme small size and compactness. High quality Newmarket transistors used throughout. All designed to operate on 9V miniature battery. **Add 1/-on each for post & packing**

TYPE LRPC 1. 3 transistor. Input sens. 50 mV., output 150 mW, output imp. 40 Ω, size 2×1×⅜in....... PRICE 27/6

TYPE LRPC 4. 5 transistor. Input sens. 150 mV, output 330 mV, output imp. 15 Ω, size 2½ × 1¼ × ⅜in. .... PRICE 18/6

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

TYPE LRPC 9. High to low impedance matching pre-amp.—input imp. 1 megohm, output imp. 2 k/ohms. Size 1¼×1¼×⅜in. .... PRICE 10/6

TYPE LRPC 10. Magnetic tape replay pre-amp. designed so that a 450 mH head can be matched into any of the audio amplifier modules listed above. Size 2¼×1¼×⅜in. .... PRICE 10/6

TYPES LRPC 9 and 10 are ideal for use with LRPC 1, 4 and 5 and are available at the reduced price of 7/6 each if bought with the LRPC 4.

FULLY INCAPSULATED MODULES

Special function modules — all one size 1½ × 1 × 1¼in. Complete with detailed function and installation instructions. Send S.A.E. for data.

TYPE PA-1. Public address amp. for use with carbon, crystal or Dynamic microphones. 3 Ω output imp. .... PRICE 30/-

TYPE GR-1. Gramophone amplifier—provides sufficient power to fill average room. 3 Ω output imp. .... PRICE 30/-

TYPE CO-1. Morse code practice oscillator — for use with morse key and 3 Ω speaker. .... PRICE 20/-

TYPE MT-1. Metronome module—provides audible and visual beat from 30 to 240 beats per minute (for use with 3 Ω speaker or ind. lamp). .... PRICE 22/6

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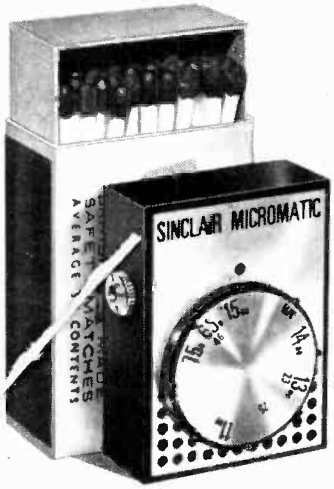
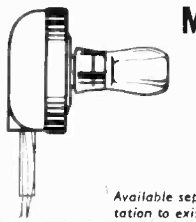


That's the SINCLAIR MICROMATIC. Robust, powerful, and as easy to take with you as the wristwatch you wear. Now that this British masterpiece of micro-electronic design is supplied with a hi-fi quality magnetic earpiece, reception is even more exciting. Hear how marvellously it brings in Radio I and other stations all over the medium waveband. Hear how well your Micromatic performs under even the most difficult listening conditions.

This is the set you will quickly learn to rely on as the best of all personal radios. With its elegant aluminium front panel and tuning control and neat smaller-than-matchbox-size black case, you will indeed delight in owning and using a MICROMATIC whether you build the kit or buy it ready built.

- PLAYS ANYWHERE
- FANTASTIC POWER & RANGE
- FULLY GUARANTEED
- $1\frac{4}{5} \times 1\frac{3}{10} \times \frac{1}{2}$ in.

NOW SUPPLIED WITH A DE-LUXE MAGNETIC EARPIECE



This new, finely engineered magnetic earpiece has great sensitivity and covers a very wide frequency range. It provides exceptional clarity and quality and is of robust construction. Each one is individually checked before despatch.

Available separately with instruction for adaptation to existing Micromatic Sets post free. **15/-**

NOW AT NEW PRICES

COMPLETE KIT OF PARTS INCLUDING MAGNETIC EARPIECE, CASE, INSTRUCTIONS, ETC. **49/6**

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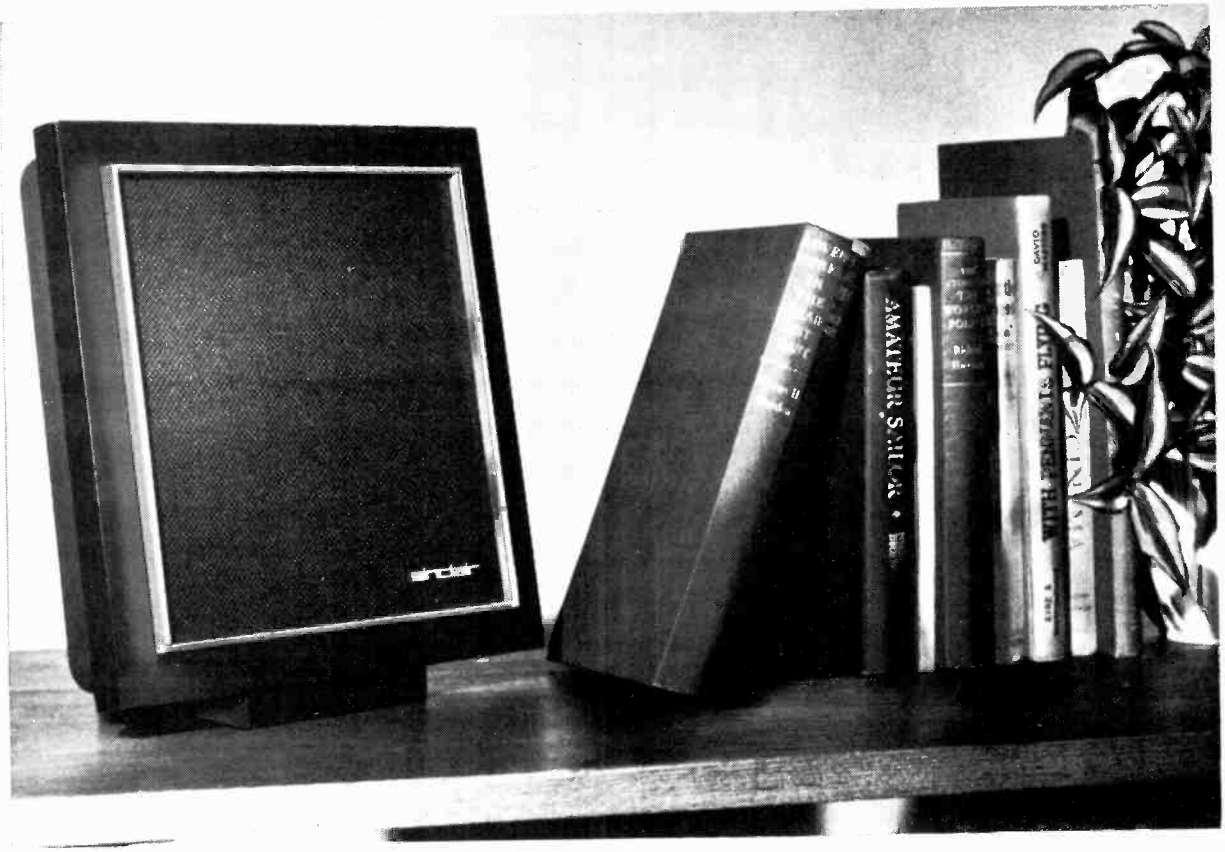

SINCLAIR Q.14

a truly superb loudspeaker

- **ACOUSTICALLY CONTOURED SOUND CHAMBER**
- **MAXIMUM LOADING IN EXCESS OF 14 WATTS**
- **BRILLIANT TRANSIENT RESPONSE**
- **15 OHMS IMPEDANCE**
- **AN ALL-BRITISH PRODUCT**

Price need no longer stop you enjoying the best possible high fidelity loudspeaker reproduction, nor is size any longer a problem. These are considerations of the utmost importance to the stereo enthusiast. In the Sinclair Q.14 you will find a loudspeaker of such superb standards and so compactly and cleverly designed that you will want to change over to Sinclair the moment you see and hear it. At a recent trade show, experts and technical reviewers were amazed at the performance of this Sinclair speaker and agreed that for its size and price, the Q.14 was extraordinarily efficient. Tests made on a stock model by an independent laboratory specialising in acoustic research show the Q.14 to have an exceptionally smooth response between 60 and 16,000Hz with well sustained output both below and above these readings. The remarkable transient response ensures clean cut separation between instruments, voices, etc; the unusual contours of the Q.14 allow it to be conveniently positioned on bookshelf, wall corner or flush-mounted singly or in assemblies of two or more units.

The Sinclair Q.14 comprises a seamless, sealed assembly of special ultra-low resonant materials with detachable base and embellishment of solid aluminium bars.

J.R.H. of Blackpool, Lancs. writes:

The Q.14 is superior to the speakers that I have been using . . . every note from the lowest to the highest comes through perfectly.

Try the Q.14 in your own home without delay. Your money plus cost of postage back to us will be refunded in full in the unlikely event of your not being fully satisfied with the Q.14.

£6.19.6

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SINCLAIR Z.12

COMBINED 12 WATT HI-FI AMP AND PRE-AMP

ONLY 3" x 1¾" x 1"

RESPONSE FROM 15-50,000Hz±1dB

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IDEAL FOR BATTERY OPERATION

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ULTRALINEAR CLASS B OUTPUT

Eight special H.F. transistors are used in the Z.12 to achieve results to compare favourably in every way with the costliest equipment you can buy. But the Z.12 is smaller, is more versatile and certainly saves you money. It is preferred not only for mono and stereo hi-fi, but it also enjoys enormous popularity fitted in electric guitars, used for P.A. and intercoms and many other instances where power and dependability are imperative. This superb amplifier with integrated pre-amp is supplied ready-built, tested and guaranteed together with the Z.12 manual which details matching, volume and tone control and selector switching circuits using one Z.12 in mono or two in stereo.

"I have installed your Stereo 25 with two Z.12 Amplifiers. I have not heard anything better on sets costing four times as much."

W. R. M., Newcastle-on-Tyne.

"I am surprised and delighted with the reproduction from Stereo Z.12's."

R. H., Ayrshire.

Built, tested and guaranteed. With manual.

89/6

A NEW MAINS POWER SUPPLY UNIT

PZ.4 Stabilised, heavy duty power pack for maximum operating standards from Z.12 assemblies. New circuitry, 18V d.c. at 1·5A from standard a.c. inputs.

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Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full at once and without question. **FULL SERVICE FACILITIES AVAILABLE TO ALL PURCHASERS.**

SINCLAIR STEREO 25

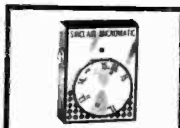
For use with two Z.12's or any good hi-fi stereo system. Frequency response 25Hz to 30KHz ± 1dB connected to two Z.12's. Sensitivity Mic. 2mV into 50kΩ: P.U.—3mV into 50kΩ: Radio—20mV into 4·7Ω. Equalisation correct to within ± 1dB on RIAA curve from 50 to 20,000c/s. Size 6¼in × 2¼in × 2¼in plus knobs.

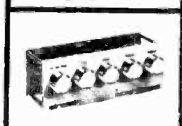
BUILT TESTED AND GUARANTEED £9.19.6

SINCLAIR MICRO FM

7 TRANSISTOR DUAL PURPOSE FM TUNER/RECEIVER

Low I.F. makes alignment unnecessary when built. Tunes 88-108 Mc/s. The telescopic aerial suffices for good reception in all but poorest areas. Signal to noise ratio—30dB at 30 microvolts. One outlet leads to amplifier or recorder the other allows set to be used as a pocket portable. *Complete kit with earpiece and instructions.* **£5.19.6**

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HI-FI AMPLIFIERS — TUNERS — RECORD PLAYERS

FM TUNERS FM-4U

TFM-IS

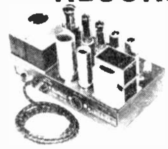
HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10·7 Mc/s and I.F. Amp. unit and valves (£13.13.0). Total Price Kit **£16.8.0**

HI-FI AM/FM TUNER. Model AFM-1. Available in two units which, for your convenience, are sold separately. Tuning heart (AFM-T1—£4.13.6 incl. P.T.) and I.F. amplifier (AFM-A1—£22.11.6). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total Price Kit **£27.5.0**

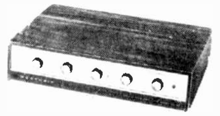
STEREO DECODER SD-1. Available as extra for above models. Self-powered. Kit **£8.10.0.** Assembled **£12.5.0**

Hear the BBC stereo FM programmes on the TRANSISTOR STEREO FM TUNER. Elegantly designed to match the stereo Amplifier, AA-22U. Available in two units, sold separately, can be built for a Total Price:
Kit TFM-IS (STEREO) **£24.18.0** incl. P.T.
Kit TFM-IM (MONO) **£20.19.0** incl. P.T.

10W POWER AMP. MA-12



20 + 20W STEREO AMP. AA-22U



20+20W TRANSISTOR STEREO AMPLIFIER. Model AA-22U. Outstanding performance and appearance. Kit **£39.10.0** (less cabinet). Attractive walnut veneered cabinet £2.5.0 extra. Assembled incl. cabinet, **£59.15.0.**

HI-FI MONO AMPLIFIER. Model MA-12. 10W output, wide freq. range, low distortion. Use with control unit.
Kit **£12.18.0** Assembled **£16.18.0**

HI-FI CABINETS. Full details available. MALVERN: Kit **£18.1.0.** GLOUCESTER: Kit **£18.10.0.**

DE LUXE STEREO AMPLIFIER. Model S-33H. De luxe version of the S-33 with two-tone grey perspex panel, and high sensitivity necessary to accept the Decca Deram pick-up. Kit **£15.17.6** Assembled **£21.7.6**

HI-FI STEREO AMPLIFIER. Model S-99. 9+9W output. Ganged controls. Stereo/Mono gram, radio and tape inputs. Push-button selection. Printed circuit construction. Kit **£28.9.6** Assembled **£38.9.6**

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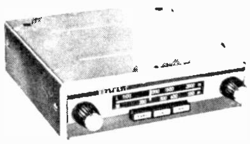
RADIOS

***Complete your motoring pleasure with this outstanding car radio,* Model CR-1**



Will give you superb LW and MW entertainment wherever you drive. Tastefully styled to harmonise with any car colour scheme. 8 latest semi-conductors (6 transistors, 2 diodes) for 12V positive or negative earth systems. Powerful output (4 watts) will drive two loudspeakers. Pre-assembled and aligned tuning unit. Available for your convenience in two units. Can be obtained for a Total Price: Kit (excl. L.S.) **£12.17.0** incl. P.T. 6" × 4" 3Ω loudspeaker £1.4.5.

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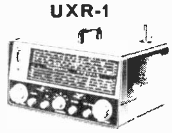
"OXFORD" LUXURY PORTABLE Model UXR-2. Specially designed for use as a domestic or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0** incl. P.T.

UXR-1

TRANSISTOR PORTABLE. Model UXR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" × 4" loudspeaker. Real hide case. Kit **£12.11.0** incl. P.T.

JUNIOR EXPERIMENTAL WORKSHOP. Model EW-1. More than a toy! Will make over 20 exciting electronic devices, incl.: Radios, Burglar Alarms, etc. 72 page Manual. The ideal present! Kit **£7.13.6** incl. P.T.



GC-1U

"MOHICAN" GENERAL COV. RECEIVER for Amateur or Short Wave listening. Send for leaflet. Model GC-1U. Kit **£37.17.6** Assembled **£45.17.6**

Prices quoted are Mail Order, retail prices slightly higher

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TEST INSTRUMENTS

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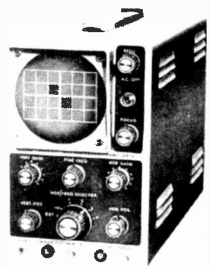
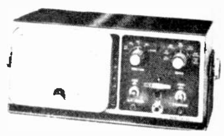


OS-2

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" × 7¾" × 12" deep. Wt. only 9¾lb. "Y" bandwidth 2 c/s–3 Mc/s ±3dB. Sensitivity 100mV/cm T/B 20 c/s–200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling.
Kit **£23.18.0** Assembled **£31.18.0**

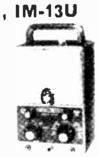
5" GEN.-PURPOSE OSCILLOSCOPE. Model 10-12U. An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s–4·5 Mc/s ± 3dB. T/B 10 c/s–500 kc/s. Kit **£35.17.6** Assembled **£45.15.0**



VVM, IM-13U

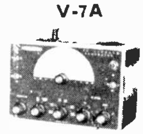
DE LUXE LARGE-SCALE VALVE VOLTMETER. Model IM-13U. Circuit and specification based on the well-known model V-7A but with many worth-while refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern styling.
Kit **£18.18.0** Assembled **£26.18.0**

AUDIO SIGNAL GENERATOR. Model AG-9U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0·1%, 10V sine wave output metered in volts and dB's.
Kit **£23.15.0** Assembled **£31.15.0**



V-7A

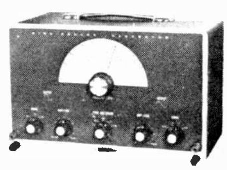
VALVE VOLTMETER. Model V-7A. 7 voltage ranges d.c. volts to 1,500. A.C. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0·1Ω to 1,000MΩ with internal battery. D.C. input resistance 11MΩ. dB measurement, has centre-zero scale. Complete with test prods, leads and standardising battery.
Kit **£13.18.6** Assembled **£19.18.6.**



RF-1U

MULTIMETER. Model MM-1U. Ranges 0–1·5V to 1,500V a.c. and d.c.; 150μA to 15A d.c.; 0·2Ω to 20MΩ 4½" 50μA meter. Kit **£12.18.0** Assembled **£18.11.6**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics. Up to 100mV output.
Kit **£13.18.0** Assembled **£20.8.0**



IG-82U

SINE/SQUARE GENERATOR. Model IG-82U. Freq. range 20 c/s–1 Mc/s in 5 bands less than 0·5% sine wave dist. less than 0·15μ sec. sq. wave rise time.
Kit **£25.15.0** Assembled **£37.15.0**

TRANSISTOR POWER SUPPLY. Model IP-20U. Up to 50V, 1·5A output. Ideal for Laboratory use. Compact size.
Kit **£35.8.0** Assembled **£47.8.0**

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BRING YOUR RECORD PLAYER UP TO DATE WITH

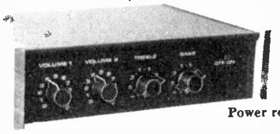
Sonotone TCL

HIGH FIDELITY STEREOPHONIC CERAMIC CARTRIDGES

Sonotone 9TA SERIES. Superior quality cartridges offering extremely high compliance for a cartridge with dual styli. Tracking weights as low as 1-3 gm. allow reproduction from heavy modulated records without distortion on most changers. Standard ½" fixing centres. Prices: Sapphire £2.18.10. Tax paid. Diamond £3.16.7. Tax paid. Other types available. Send for leaflet.

metrosound metrosound manufacturing co. ltd. bridge works, wallace road, london, n.1. tel. 01-226 8641/2/3

TRANSISTOR STEREO 8 + 8



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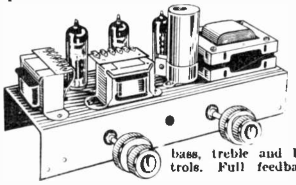

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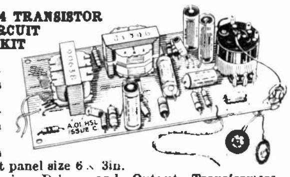

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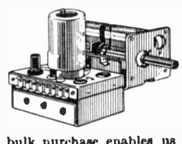

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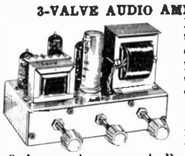

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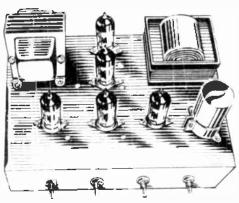

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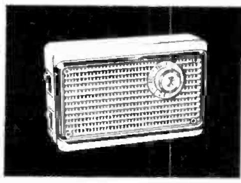

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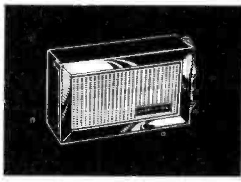
POCKET FIVE



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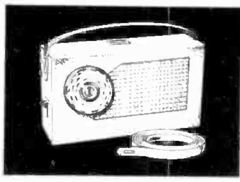

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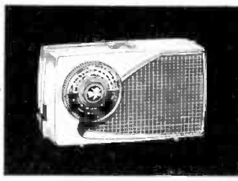

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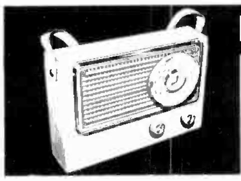

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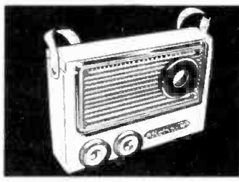

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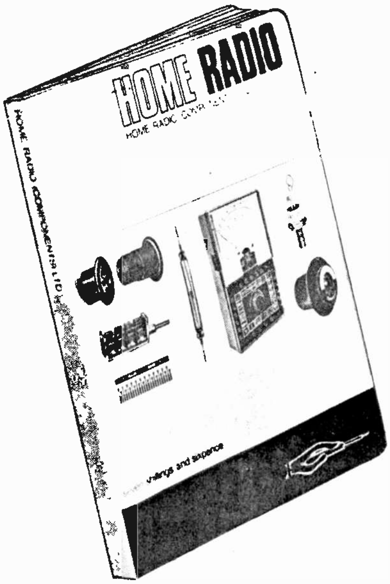

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VOL. 4 No. 2
February 1968

PRACTICAL ELECTRONICS

ART FROM COLOUR AND SOUND

ARE we on the threshold of a new revolutionary era of art? Will swirling colour patterns and surrealistic sound become the major elements of a new and dynamic form of art with limitless possibilities for expression of artistic ideas; and will this lead to a practical application where the production of an environmental atmosphere to suit the whim or mood of the occupier will be possible by the turn of a switch?

Current activities suggest that these are no idle dreams. The merging of art and technology is one of the exciting happenings of today.

Interest in the æsthetic possibilities arising from the imaginative use of colour and sound in combination is not itself novel. Experimental work in this field has been going on ever since artificial light became a readily available and easily controllable media. The colour organ and Son et Lumiere presentations represent some early achievements in this art of blending colour and sound.

It is clear to see that greater sophistication, which really means depending more heavily upon electronic methods and devices, will increase the scope for creative effort. By way of example, there is the possibility of forming exciting patterns by means of the cathode ray tube. Fluorescent lighting tubes (and, one day, whole panels of electroluminous material) may provide alternative light sources. On the audio side, the potentialities are equally great and exciting: techniques for synthesising music and producing fascinating effects have already reached an advanced state. Somewhat surprisingly it is the human voice, natural and unadorned, that offers some further interesting possibilities. The effectiveness of the slow, deliberate annunciation of just words as an atmosphere creating background has been demonstrated at exhibitions.

It would be a mistake to attribute this present interest in colour and sound wholly or chiefly to the trendy pop set. Colour and sound have certainly been used with startling effect by the contemporary with-it movement. But the radiance of their psychedelic set-ups should not be allowed to obscure our view of work being undertaken on a more serious plane by various individuals and groups—like, for example, the Light/Sound Workshop of Hornsey College of Art.

As with all new forms of artistic expression, the results are rarely immediately acceptable to the general public. But we should welcome this attempt to exploit modern technology for purposes other than the more obvious and strictly functional. And, indeed, why should the hippies have all the best colour and sound!

F. E. Bennett—*Editor*

THIS MONTH

Our March issue will be published on Friday, February 16

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., 15/17 Long Acre, London, W.C.2. Phone: 01-836 4363. Telegrams: Newnes London. Subscription Rates including postage for one year, to any part of the world, 36s.

PE GLISSANDOVIBE

By R. Bebbington

HAWAIIAN guitars, trombones, violins, musical-saws all have one common characteristic—glissando! This is the term used to describe the gliding effect of musical instruments capable of a smooth variation in pitch. Most *electronic* musical devices that provide glissando make use of a potentiometer.

The "Glissandovibe" is novel in that it employs a permeability-tuned variable oscillator to produce glissando, vibrato, and percussive effects, either separately or in combination.

THE Glissandovibe is extremely portable, being powered by a 9V layer type battery. A larger amplifier may be employed if desired, but the 500mW push-pull amplifier described is adequate for most locations; in large halls a microphone can be conveniently sited to boost the sound.

Whilst the Glissandovibe is primarily a solo melody instrument, the smooth legato tone it produces suggests that several in harmony could give some pleasing effects. The frequency range is approximately two octaves.

HARTLEY OSCILLATOR

This simple electronic melody instrument uses a variable audio oscillator with a moving arm and press button switches to alter the pitch of the sound. The block diagram of the Glissandovibe indicates the refinements added to an audio oscillator to give the desired effect (Fig. 1).

A modified version of the Hartley oscillator is used for the note generator (Fig. 2). The tuned circuit comprises the tapped coil L1 shunted by the four "voice" capacitors. These capacitors are short-circuited by the "voice" switches S1–S4 which are normally closed until a particular range is selected. When a range is selected, the voice switch can be pressed to remove the short-circuit from the appropriate capacitor, which is then effectively connected in parallel with the coil. The capacitor values are chosen to produce four notes at intervals of about half an octave to cover the two-octave range desired. Operation of a voice switch not only selects the appropriate half-octave range, but also initiates the note. This simplifies the playing technique.

Continuously variable tuning of the half-octave selected is achieved by moving transformer laminations inside an air-cored coil. The moving laminated core is attached to a control lever which moves over a

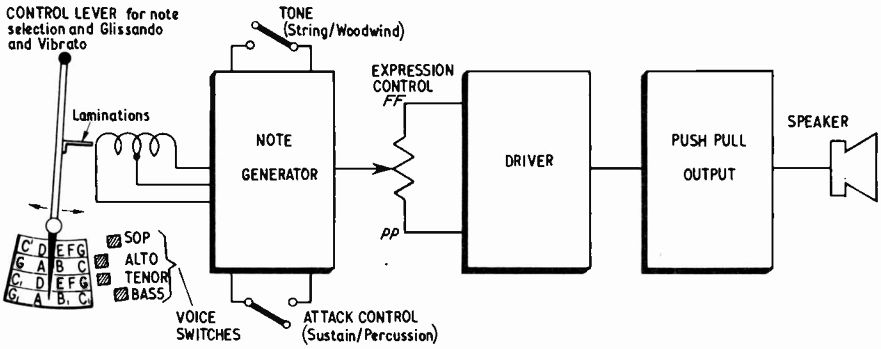


Fig. 1. Block diagram showing the main functions of the Glissandovibe

graduated scale. As the core enters the coil the frequency decreases due to the increase in inductance. Similarly, the withdrawal of the core increases the frequency. The control lever thus provides a convenient method of applying both glissando and vibrato. The latter effect is often produced electronically by means of an oscillator running at about 5 to 10Hz, but the side-to-side motion of the arm used with this instrument sounds more natural when the action is perfected.

ATTACK AND DECAY

A sustain/percussion switch S5 controls the attack and decay of each note. In the sustain position the attack and release of a note is governed by the length of time a voice switch is held down. In the percussion position a note has a chime-like attack and will die away even though a voice switch may be held down. The decay time depends upon the size of electrolytic capacitor C6 and some experiment may be necessary to suit individual tastes. Although this capacitor is within the tuned circuit its effect on tuning is almost negligible because of its large capacitance compared with that of the tuning capacitors in series with it. The voice switches perform an additional function in that they also effectively short-circuit this capacitor between notes. The prototype circuit had a complex switching arrangement to accommodate the sustain/percussion facility but the author's dislike of mechanical complications finally led to this simple if unorthodox circuit.

Two basic tone colours are provided by simply taking one output from the oscillator base circuit and one from the collector circuit. The output from the base approximates to a sine wave and in the upper register has a flute-like quality; this output is appropriately labelled "woodwind". The other position of the tone switch, "strings", is additionally connected to the collector output which provides a square-wave and gives a greater degree of bite to the notes.

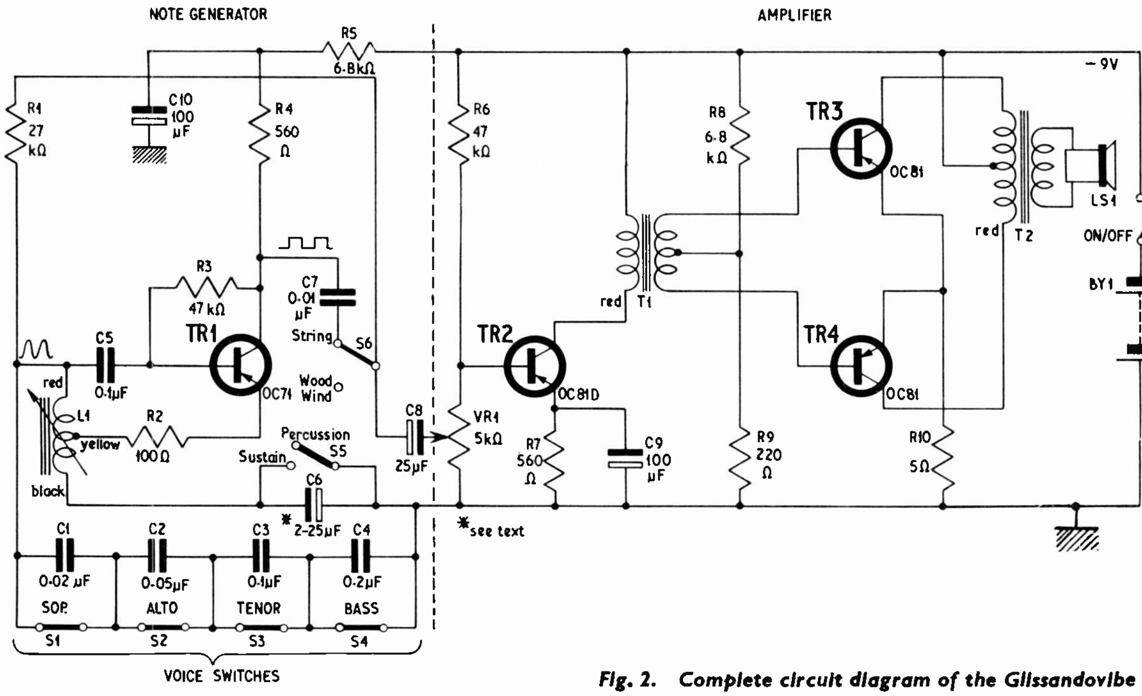


Fig. 2. Complete circuit diagram of the Glissandovibe

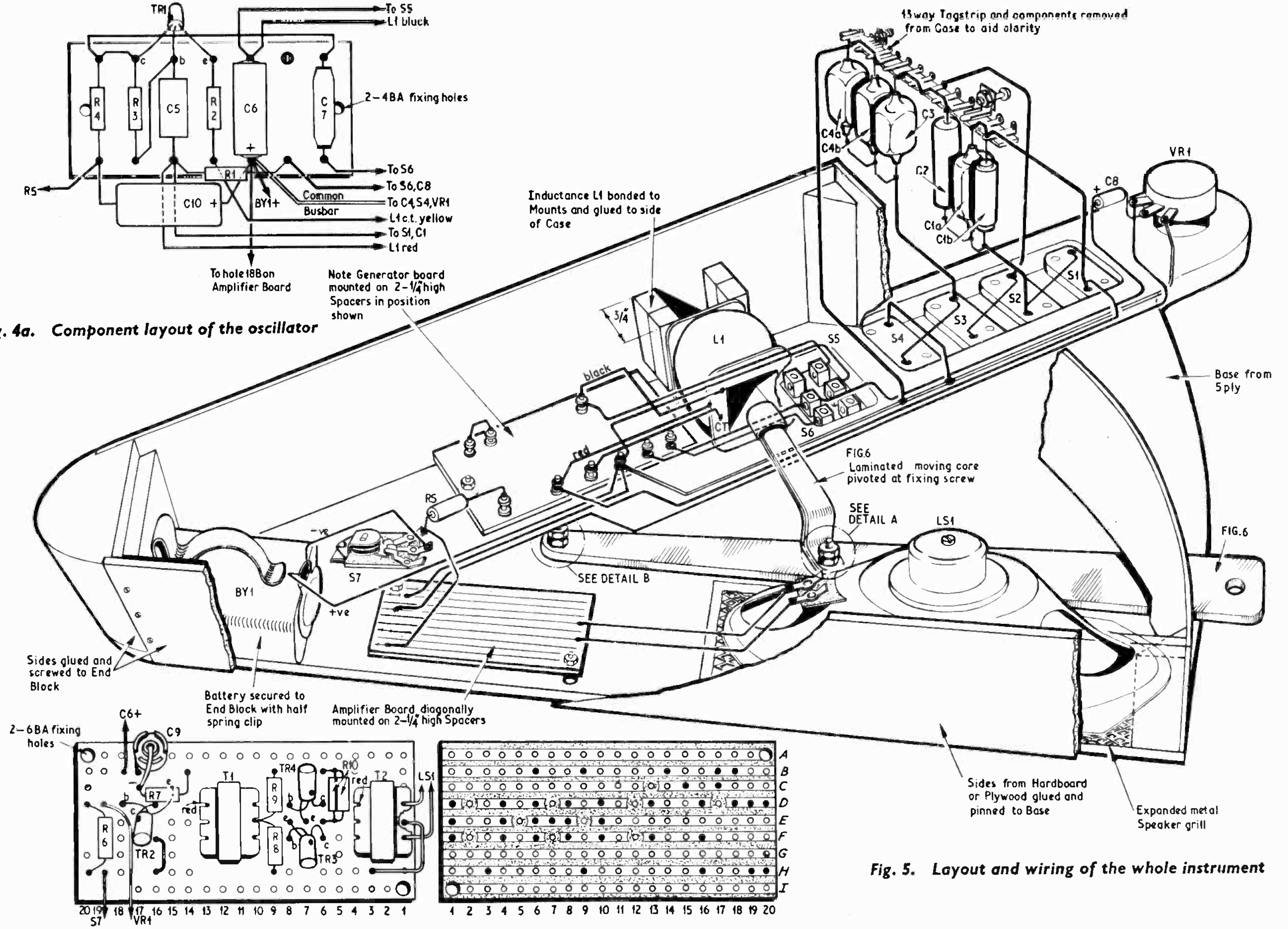


Fig. 4a. Component layout of the oscillator

Fig. 5. Layout and wiring of the whole instrument

Fig. 3a. Component layout of the main amplifier

Fig. 3b. Underside view of the main amplifier

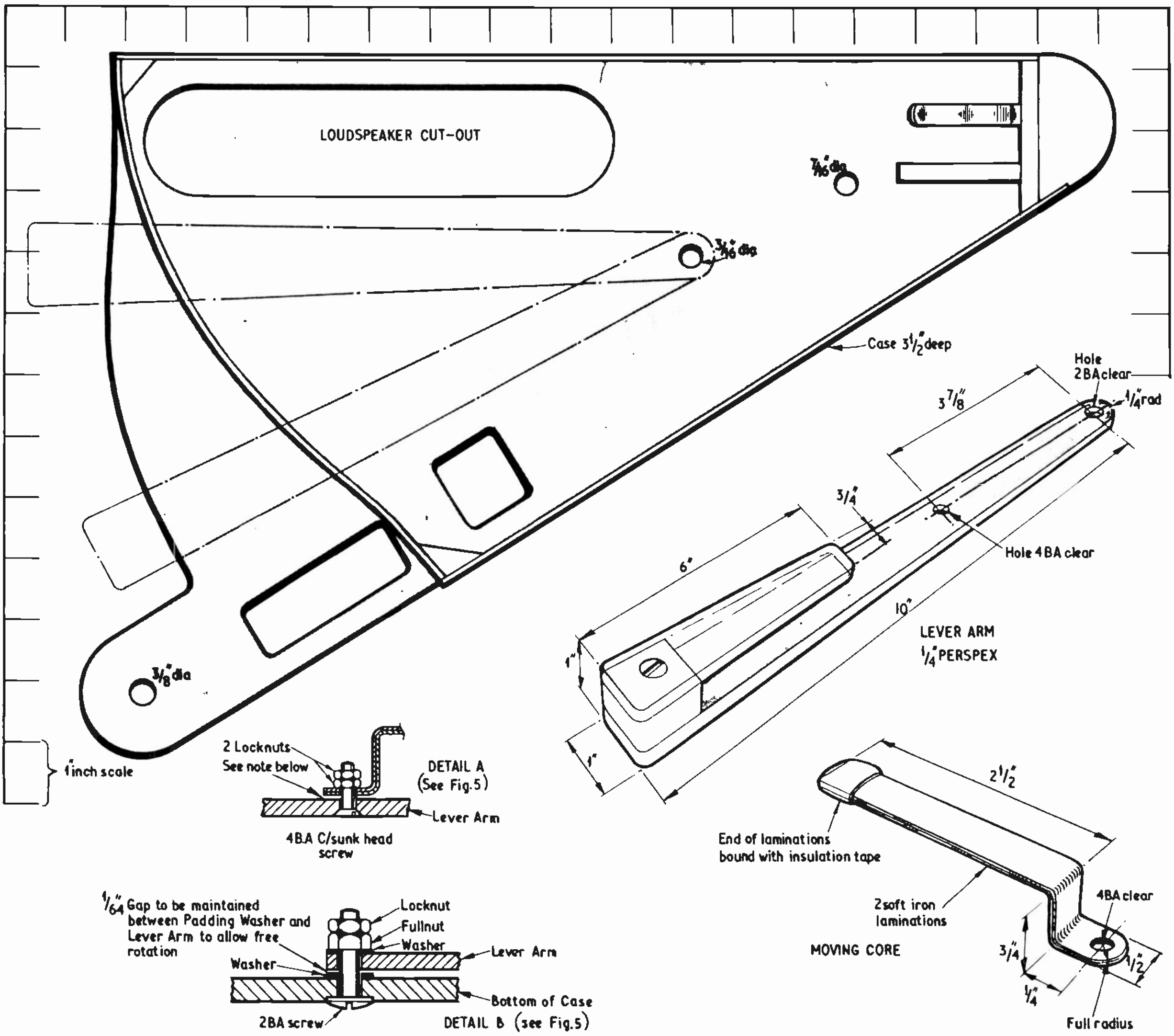


Fig. 6. Constructional details of the case, moving arm, and laminated core

COMPONENTS

Almost any audio transistor may be used for the note generator TR1. Despite the change in supply volts when the sustain/percussion switch is in the percussion position the notes are surprisingly stable throughout the decay period.

The air-cored coil used consists of 4,000 turns of 39 s.w.g. enamelled wire, with a centre tap, on a ½in diameter former. Alternatively, the primary winding of a valve output transformer, the laminations being removed first, may be pressed into service. The tapping point is not critical. If a centre tap is not provided, one end cheek can be bent back to reveal the primary turns; a point is easily found approximately half-way through to which a flying lead can be soldered.

The values given for the voicing capacitors C1–C4 are only approximate since they are dependent on the inductance of the coil used and the type of the laminated core attached to the control level. Some experiment may be necessary. Fortunately it is easy to calibrate the scale to whatever components are chosen once a reference note has been established; some readers may wish to increase the number of voice switches and capacitors to cover a greater number of notes. The wide tuning range of the control lever may then be reduced as required by removing laminations. Even one lamination inserted in the coil is sufficient to lower the pitch by one or two tones.

A conventional push-pull amplifier is used to boost the oscillator output to the required level. The driver stage TR2 has the expression or volume control as part of the d.c. stabilising chain; this is located on the front panel so that it is handy for crescendos, diminuendos and forte-piano (fp) effects. A return spring can be attached to the control to enable rapid dynamic changes to be made from a pre-determined volume level. The driver transformer T1 couples the signal to the push-pull output transistors TR3 and TR4. Transformer T2 matches the output stage to a 3 ohm elliptical loudspeaker. The amplifier transistors should be matched and can be obtained as a set package type LFH3.

COMPONENTS . . .

Resistors
R1 27kΩ
R2 100Ω
R3 47kΩ
R4 560Ω
R5 6·8kΩ
R6 47kΩ
R7 560Ω
R8 6·8kΩ
R9 220Ω
*R10 5Ω 1W

All 10%, ½W carbon except R10
*R10 can be two 10Ω ½W resistors in parallel

Potentiometer
VR1 5kΩ linear carbon or wirewound

Capacitors
*C1 0·02μF polyester 150V
*C2 0·05μF polyester 150V
*C3 0·1μF polyester 150V
*C4 0·2μF polyester 150V
C5 0·1μF polyester 150V
C6 2–25μF elect. 15V
C7 0·01μF polyester 150V
C8 25μF elect. 15V
C9 100μF elect. 6V
C10 100μF elect. 15V
*C1–4 are selected to tune with L1 and may need slight alteration. *C4 can be two 0·1μF capacitors in parallel (see text)

Inductor
L1 Tapped coil using 39 s.w.g. enamelled wire or valve output transformer (see text)

Transformers
T1 Driver transformer type TT45 (Repanco)
T2 Push-pull output transformer type TT46 (Repanco)

Transistors
TR1 OC71
TR2 OC81D } Matched set type LFH3
TR3, 4 OC81 (2 off) }

Loudspeaker
LS1 3Ω, 7in × 4in elliptical

Switches
S1–4 Miniature microswitches or light duty push button switches, normally closed (4 off)
S5, 6 Single-pole, on/off, rocker or toggle switches (2 off)
S7 Rotary on/off switch

Battery
BY1 9 volts layer type

Miscellaneous
Veroboard, tag boards (see text)
Plywood and hardboard for case
Perspex sheet for moving arm

MECHANICAL CONSTRUCTION

Readers will no doubt have their own ideas regarding the mechanical layout of the instrument. The disposition of the connecting leads and components is not at all critical and the layout given can be changed to suit individual requirements without any ill-effects. The voice switches in the prototype were low pressure push button switches. Rocker switches of the type used for cupboard lighting were used for the tone and attack switches. These are extremely easy to operate with only a light touch of the finger. They can be obtained as a dual unit.

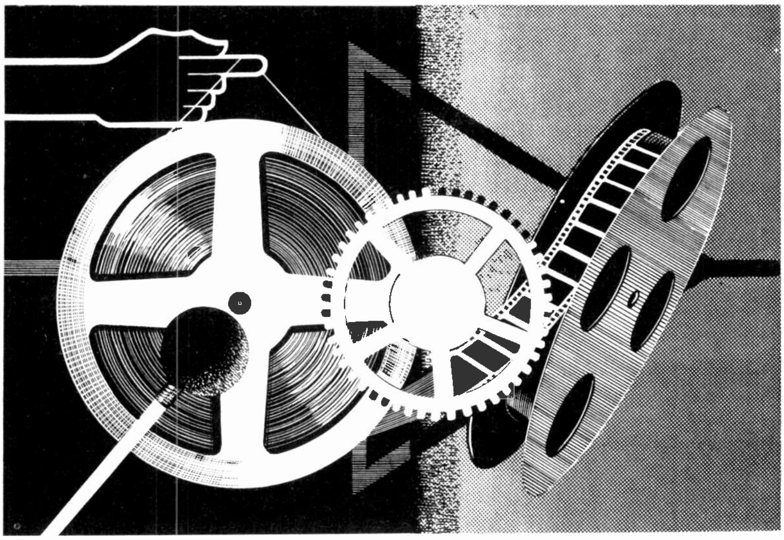
The amplifier circuit is built on a piece of Veroboard; the oscillator on a group tag board (Figs. 3 and 4). Care should be taken when soldering transistors as they can be damaged by the application of excessive heat. Solder quickly or grip the leads with pliers or a clip to dissipate excess heat.

The remaining items, the speaker, the coil, the controls and the battery are all mounted on the inside of the front panel (Fig. 5). This panel may be of aluminium or plywood or hardboard as desired. A guide to constructing the case is given in Fig. 6. The sides are curved by first thoroughly soaking the hardboard pieces then moulding to the required shape and fixing in position with wooden blocks and pins. Thick water-based glue such as Cascamite may also be used. The moving arm is made from ¼in perspex sheet and pivoted to the front panel by a bolt with locked nuts.

PLAYING TECHNIQUE

Even those with limited musical knowledge can quickly attain a reasonable degree of dexterity with this instrument. A little time spent in experimenting with the resources available will be well worthwhile.

Set the control lever to the note required and press the appropriate voice switch. If the attack switch is in the sustain position the note will sound out until the voice switch is released. If it is in the percussion position the note will decay as C6 charges through the oscillator circuit. This produces a chime effect because of the percussive attack and gradual decay. A slow side-to-side motion of the control lever at about 5 vibrations per second will produce a natural vibrato that will enhance the sound. Some practice is essential to perfect the movement from one note to another and to co-ordinate the action of the voice buttons and the control lever. ★



The idea of synchronising a cine projector with a tape recorder seems delightfully simple. The problem unfortunately is inherently complicated not only in obtaining exact synchronism between picture and sound, but also in preparing the sound track.

This article describes an entirely practical and reliable synchronising system which not only enables silent pictures to be shown in synchronism with the tape, but also enables lip synchronised films to be taken and projected.

cine and tape sync

By C. F. WEIR B.Sc. C.Eng.

THE equipment described in this article is the result of several years of development work. Before describing it, however, it would be as well to set down the basic requirements of a synchronising system and the various manners in which this may be accomplished.

TWO MAIN METHODS

Two main methods of sound film projection are available, one in which the sound and picture are combined on the one film, and the other where separate units are employed for sound and vision. These may be listed as follows:

(1) Sound on film where either an optical or magnetic sound track is used

(2) A double-headed arrangement whereby film and sprocketed magnetic tape are run through together in mechanical synchronism on a suitably designed projector.

These two methods are entirely convenient and satisfactory but of necessity they are expensive, and unless the most high grade equipment is used, the quality of the sound will not approach that obtainable from a first class tape recorder.

It should be noted also that where such arrangements are used, auxiliary tape recorders are still required for both recording original materials, and for mixing processes for preparing the final sound track.

METHODS EMPLOYING SEPARATE PROJECTORS AND TAPE RECORDERS

Methods for synchronising separate projectors and tape recorders are as follows:

(3) An arrangement whereby sprocketed tape is used, and both the projector and the sprocketed capstan on the tape recorder are driven by synchronous motors.

(4) An arrangement whereby tape from the recorder is fed through a capstan driven by the projector after the tape leaves the tape recorder capstan.

Any variation between the tape recorder capstan speed and the capstan driven by the projector will result in a greater or lesser length of tape at any instant being present between the two capstans. Tension on this length of tape is maintained by a spring loaded swinging arm. As the tension on the tape varies as a result of difference in projector and tape recorder speed, the arm moves, cutting in or out projector motor resistance in order to adjust the speed.

(5) A variation of (4) is the commercially available synchrodeck where tape and cine speeds are compared using a differential gear box. The measured difference in speed is used to control the speed of the projector.

(6) Electronic pulse system. In this system a series of pulses recorded on tape (usually one per cine frame) are used either to keep the cine projector in step direct, or in commercial applications the two speeds are compared visually on an oscilloscope and minor adjustments made manually to obtain synchronism, whilst a master sound track is prepared for the making of sound on film track.

(7) A servo system where tape controls the projector speed.

DISADVANTAGE OF MECHANICAL COUPLING

Systems (4), (5), and (6) are available commercially for the amateur.

The swinging arm or the synchro-deck methods give extremely satisfactory results without very great cost.

However, they have the disadvantage of mechanical coupling between the projector and the tape recorder which may make the arrangement a bit cumbersome.

Hundred per cent satisfactory lipsync is not really practicable with such arrangements. They do have the considerable advantage, however, of using a tape recorder for the purpose for which it was intended, namely the recording and play back of sound. This means that true high fidelity results may be obtained.

THE AUTHOR'S SYSTEM

The basic arrangement of the author's system is the use of a differential gear box to measure and correct difference in speeds between the tape recorder and the projector.

Consider the diagram in Fig. 1. If the wheels *A* and *B* are driven in opposite directions but at the same speed, the spider (*C*) will remain stationary. Any difference of speeds between wheels *A* and *B* will result in the spider rotating either clockwise or anticlockwise.

If a drive is taken from the spider to operate some form of speed control device (a simple rheostat is entirely satisfactory), then the basis of a synchroniser is built up.

If now, wheel *A* is driven from the cine projector and wheel *B* is driven from a synchronous electric motor, the projector will be made a slave to the speed at which the synchronous motor runs. The synchronous motor could obtain its supply from the mains, in which case the projector would run at an exact function of the mains frequency, or it could be supplied from 50Hz recorded on tape.

If the recorded output of 50Hz is taken from the recorder and suitably amplified and fed into the motor, it means that the cine projector will now follow precisely the tape speed. This means that tape stretch, slip at the capstan, etc. will all be of no consequence and perfect synchronism will be obtained.

The arrangement may be developed further by fitting a small generator on to the cine camera. The gearing is so arranged that when the camera operates at its normal speed (16, 18, or 24 frames a second), the generator will give an output of 50Hz. If this is recorded on tape at the same time as the audio information is recorded, this, during play back will make the projector keep in complete synchronism with the speed at which the camera was running during the original filming and recording.

It is thus possible with this equipment to take and to project lip synchronised films. A perfectly standard tape recorder is used except that it must be of the stereo type which will enable the two tracks, namely the audio and 50Hz track to be recorded simultaneously when lipsync is being undertaken. To assist in editing, the tapeheads should be of the in-line type.

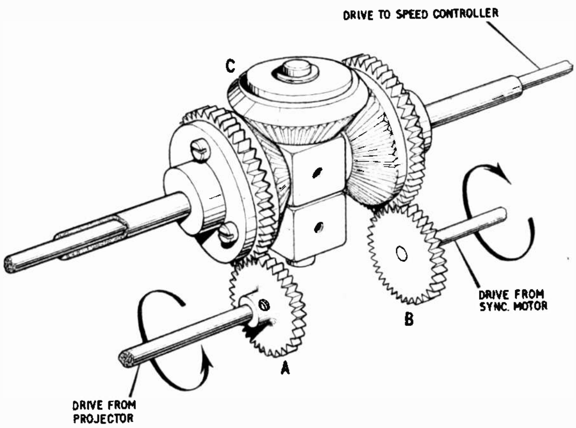


Fig. 1. The differential gear box

ENTIRELY AUTOMATIC

The equipment is entirely automatic in starting and running, although provision is made for fine adjustment should this be needed.

The projector is laced up on to a suitable cue mark on the film and the tape recorder started. The 50Hz recording on the tape starts the projector at the right moment and then holds it in complete synchronism throughout the film.

On a long film, it is desirable where there are lipsync inserts to check accuracy from time to time as variations in the supply voltage could cause a slight phase displacement between tape and film. This may be corrected on the fine adjustment control. Such correction is not normally necessary where music, commentary, and effects are being used.

PRACTICAL DETAILS

Standard and commercially available equipment has been used for the prototype. Synchronous electric clock motors serve quite well. A differential gear box may be salvaged from an old prepayment electricity meter, or, alternatively, purchased from one of the gear manufacturing firms.

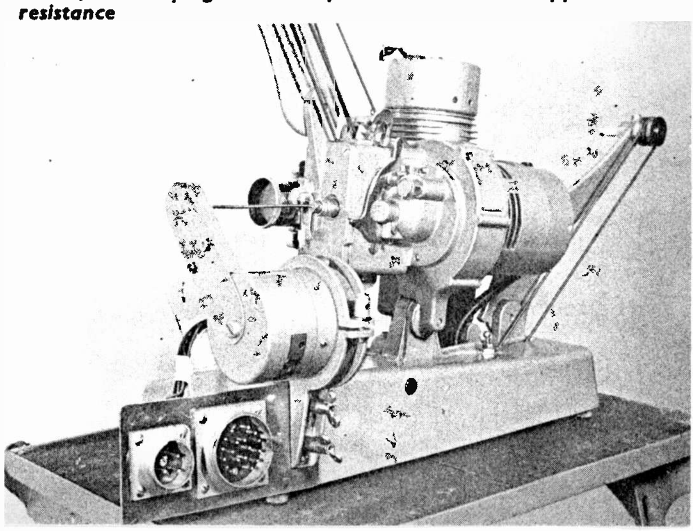
As shown in the simplified general arrangement diagram Fig. 2, the 50Hz recording from tape is fed into an amplifier—the one at present used is a modestly priced transistor unit. The amplifier 50Hz output is fed into a step-up transformer to supply a 240V synchronous clock motor. This clock motor drives one side of the differential gear box. The motor is shunted with a 0·2μF capacitor in order to improve the power factor. This considerably cuts down the current demand on the amplifier.

The 50Hz signal is also fed through the coil of relay RLA, the "start" and "run" relay. This relay closes up the main motor circuit at the correct instant.

TIME DELAY RELAY

Relay RLB is a time delay relay which, dependent on the sensitivity of the equipment, may, or may not be necessary. It is arranged to short out the motor speed controller for half a second or so when the equipment is

16mm Bell Howell Projector fitted with synchronising unit. This unit contains the differential gear box, synchronous motor, and wiping contacts for connection to tapped resistance



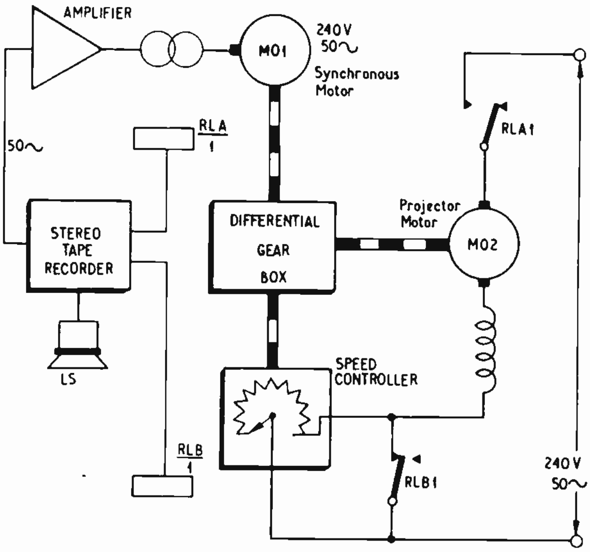


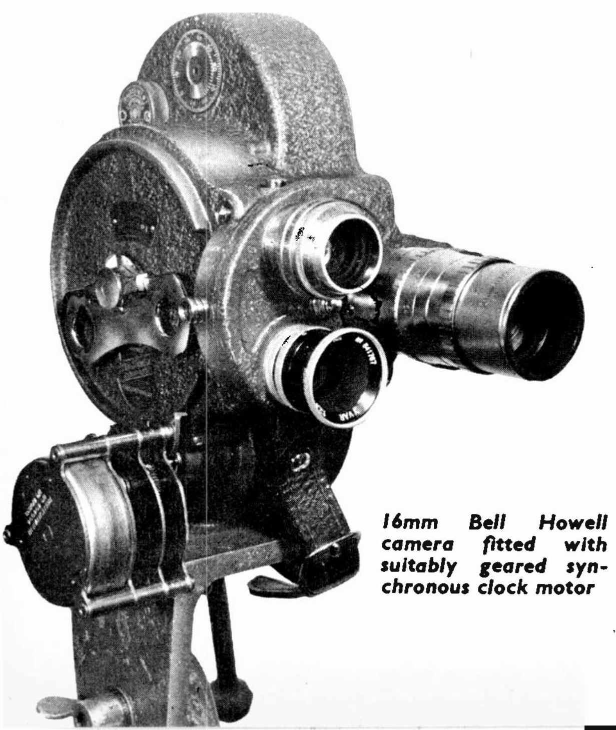
Fig. 2. Block diagram of the cine/tape sync system

first switched on, in order to give the most rapid acceleration to the projection motor.

Unless the motor is rapidly brought up to speed, it is possible that the spider on the differential gear box may make an excursion larger than the control range of the equipment. If this happens, it means that the synchroniser has permanently "lost time".

The length of the excursion time of the spider is a design consideration dependent on the gear ratio, i.e. the speed at which the differential gears run, the number of resistance steps on the speed controller, and the value of the resistance between each step. The higher the sensitivity of the equipment then the less will be the excursion time of the spider. A phase accuracy of ±half a frame is very readily obtainable.

The spider will hunt on either side of its normal position during operations. It is one of the advantages of this equipment that it can have an in-built tolerance of half a second or so during which to recover its lost or overshot time without losing synchronism.



16mm Bell Howell camera fitted with suitably geared synchronous clock motor

CORRECT STARTING

It is also of interest, although a fortuitous point in the design, that when the equipment is switched on the synchronous motor must always start in the right direction (the mechanical drive from the projector ensures this).

The equipment is not sensitive to momentary tap "drop out", or indeed to loss of half a cycle at a tape splice, since the inherent friction of the equipment will let the motor coast through.

If no servo gear was used and the amplified signal from the tape recorder was fed direct to a synchronous drive motor on the projector, the projector might suffer very considerable shock treatment at change of speed at the points of tape splicing.

SPEED CONTROLLER

On the prototype the speed controller was in the form of a tapped resistance carrying the main motor current. Despite the fact that the projector is a 16mm one and takes a fair load, no contact trouble was experienced on the speed controller.

A more modern approach would be to use a thyristor motor control circuit. This would certainly be more elegant, but it means that there is more to go wrong and it may result in noise pick-up from the thyristor.

EDITING

When a sound track is to be added to a film, much careful and accurate editing has to be done. Lip synchronised inserts must be correctly placed, commentary, music, and sound effects must also hit the picture at the right instant.

The equipment described lends itself ideally to editing. The cine film may, of course, be measured by a frame counter. Having, however, recorded 50Hz on the tape, we have virtually placed a ruler all the way along its length. By using a high speed magnetic counter capable of counting up to 3,000c/m the tape length can be measured to an accuracy of within one-third of a frame (at 16 f/m).

LONG TERM ACCURACY

In terms of speed control, the equipment's long term accuracy is 100 per cent. However, since the equipment of necessity must be hunting all the time during operation, its short term phase accuracy under settled running conditions will be according to the design in the order of ±half a frame.

This stability however, is naturally entirely dependent upon stable mains supply voltage. If this varies during the projection of a film, the spider on the differential gear box, in order to maintain correct speed, will compensate for this voltage variation, but at the expense of a change in phase relationship between picture and film.

ALL-ELECTRONIC VERSION?

Although this equipment operates with complete success, aesthetically it would be attractive to have completely electronic equipment. The need is for an electronic "gear box" which could measure the difference in the two speeds and store the information up to say, half or threequarters of a second to ensure that synchronism was never lost where there may be a sudden change in recorded tape speed.

Such an arrangement would no doubt be possible but perhaps would be more bulky and expensive than the mechanically geared box at present used. ★

UNLIMITED!

IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

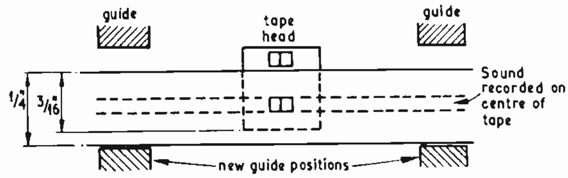
REVERSE SOUND ON A 4-TRACK RECORDER

FOR some time I have been using a method for reversing sounds with a tape recorder which I believe may be of interest to readers of the article *Electronic Sounds and Music* (November 1967).

The two centre tracks of a four-track tape are normally recorded in opposite directions. If the second track (which normally runs past one of the "clear" sections of the head) could be lowered by the width of one track, the information on that track could be reversed.

This could be achieved by removing the tape, including track 4. I have prepared 150 feet continuously by pulling the tape over a piece of wood, with two guides set in it, and a blade fixed at $\frac{3}{4}$ of the tape width. Thus, with $\frac{1}{4}$in tape, the necessary $\frac{3}{16}$in width of tape was produced along with an apparently unused length of $\frac{1}{16}$in wide.

By guiding the tape past the head as low as possible (see diagram) the information is recorded, using the track $\frac{2}{3}$ head) down the centre of the tape. Obviously,



to play this back in reverse, all one has to do is send the tape through on the opposite direction.

Unfortunately, due to slight irregularities in cutting, splicing, and in the tape guides of the recorder, I have found that to erase the centre track the tape usually has to be passed through two or three times. This may not be necessary with high quality recorders.

M. Horner,
Lincoln.

THYRISTOR SCREENWIPER DELAY

I WAS very interested in the *Screenwiper Delay Unit* (September 1967). However, the suggestion was made that it might be possible to use a thyristor instead of a relay in such a unit. Suitable low peak inverse voltage rated thyristors are now available at very reasonable cost and should be more reliable than a relay.

I have evolved a circuit that may be of interest. The only connection required to the existing car wiring is to the terminals of the dashboard wiper switch. The stud (anode) of the thyristor is at chassis potential; use can be made of this asset in mounting the unit behind the dashboard. Any convenient metal part will then form a heat sink.

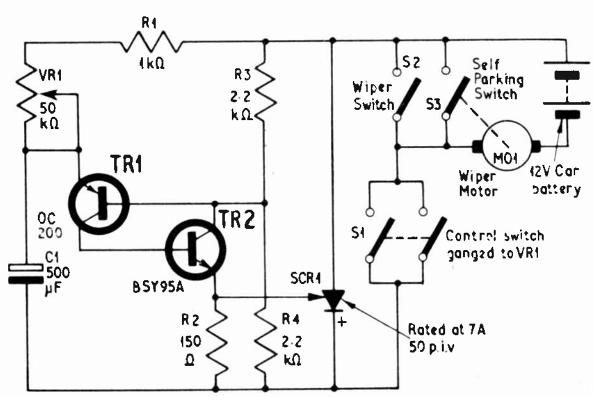
The components, except the thyristor and the potentiometer are mounted on a piece of Veroboard 1in × 1½in and tucked away in a small recess behind the dashboard ashtray. The thyristor and potentiometer can be bolted to the underside of the metal dashboard with the control knob readily accessible.

When the main wiper switch S2 is in the off position, a variable delay from 2 to 25 seconds was obtained between strokes of the wiper blades, while continuous operation was obtained on closing the main wiper switch.

The control switch S1 is double-pole on/off and ganged to VR1. Both poles are wired in parallel to increase the current carrying capacity of it.

It is emphasised that this circuit can only be used in a car having a wiper motor with a self-parking switch for the blades and a positive earth wiring system.

A. Edge,
Gloucester.



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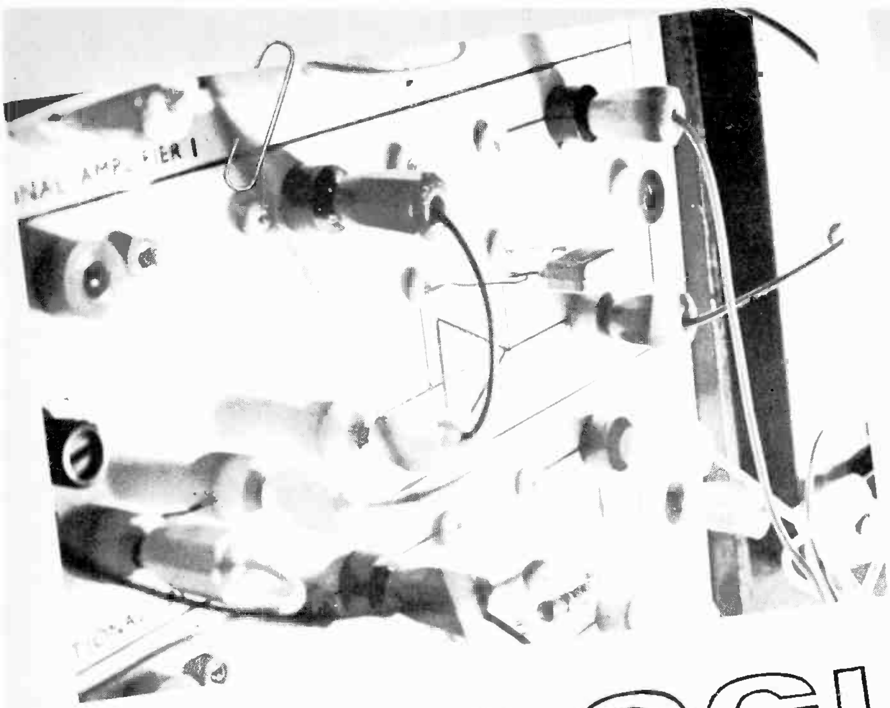


ANALOGUE COMPUTER

By D. BOLLEN

BEFORE embarking on constructional details, a few words must be said concerning measuring and test equipment required.

VOLTAGE STANDARD

It is necessary, at an early stage of computer construction, to establish a voltage standard for setting up the PEAC circuits.

Since *relative* voltage levels are more important than *absolute* levels, one particular voltmeter of proven reliability can serve as a voltage standard, and this might well be a reputable testmeter which has a large scale conveniently calibrated in terms of 0–10 volts, with a d.c. sensitivity of not less than 20,000 ohms per volt. Even if the testmeter has an error of 2 per cent of the indicated reading on d.c. ranges, it should be capable of reproducing a given reading, from day to day under similar room temperature conditions, with much greater accuracy.

In addition to use as a voltage standard, the testmeter can, of course, be employed for setting up problems, answer readout, comparative resistance checks, and for general testing of all circuits. There is nothing to prevent re-calibration of the computer to laboratory voltage standards at a later date, and this has been allowed for in the overall design of PEAC.

COMPUTER INSTRUMENTATION

Analogue computer instrumentation has much in common with electronic workshop equipment. Among those instruments likely to be of use to the computer operator are: an oscilloscope, a small collection of d.c. voltmeters, an audio oscillator, an a.c. voltmeter, and a component measuring bridge.

The oscilloscope need not conform to a modern specification, and could be a government surplus item. However, it is often an advantage to have a large screen area, and redundant television sets can be converted for computer readout purposes with excellent results. The limited bandwidth of magnetic deflection is no disadvantage at normal computer operating speeds.

D.C. voltmeters with centre zero scales are very useful for rough checks on the terms of a computer equation, where, for example, the wish is to see how y varies in relation to x when manipulating a simultaneous equation.

A sine wave oscillator, with attendant a.c. voltmeter, will often be employed for work on transfer functions, and for general electronic circuit simulation.

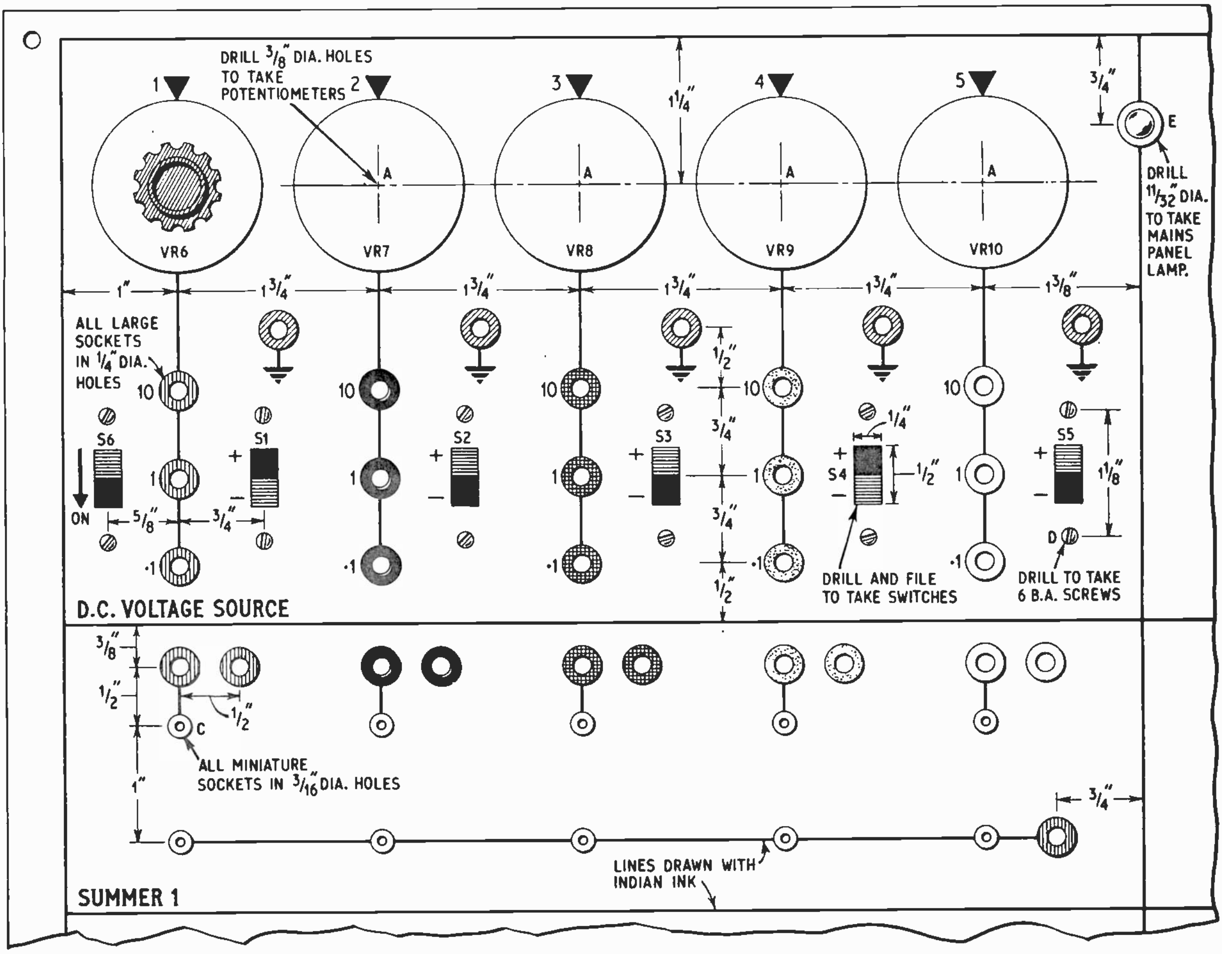
Finally, the component bridge is a help when making-up plug-in computing components, and for locating possible sources of error.

It is assumed that special classes of equipment, such as the XY plotter, will not be available to the amateur, and they are therefore excluded from further mention.

UNIT "A" CONSTRUCTION

The general form of construction adopted for PEAC is based on a series of boxes made with laminates of white Armaboard or Formica and hardboard. The resulting box is rigid and durable, with a surface which easily takes panel transfers and lines drawn in Indian ink. With such a construction, it is possible to achieve a professional appearance using only simple woodworking tools.

It is advisable to start with the UNIT "A" front panel and case. This slightly unusual procedure, of building the box before starting on internal circuits,



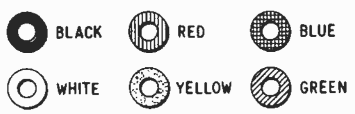


Fig. 2.2. Left-hand portion of front panel. Drilling details, layout of components, and panel engraving. (Below the broken line, there are two further sections, each a replica of "Summer 1")

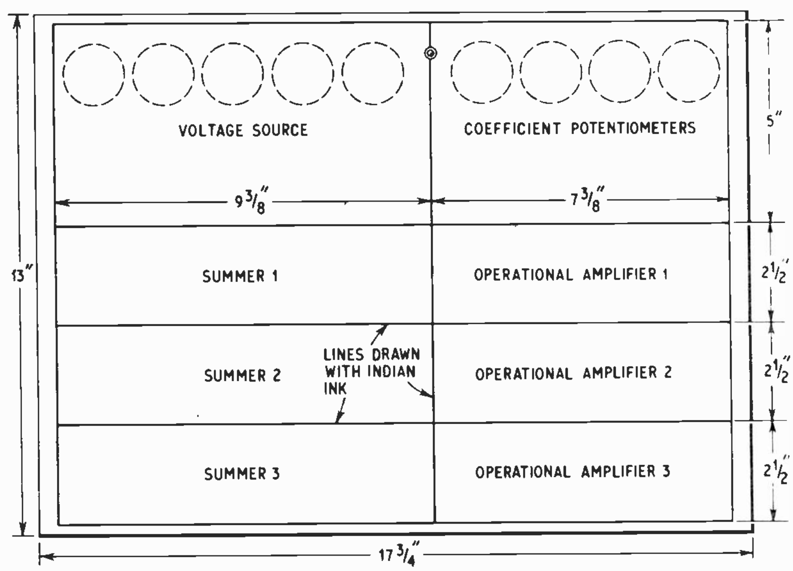


Fig. 2.1. UNIT "A" front panel. Overall dimensions and sectional dividing lines

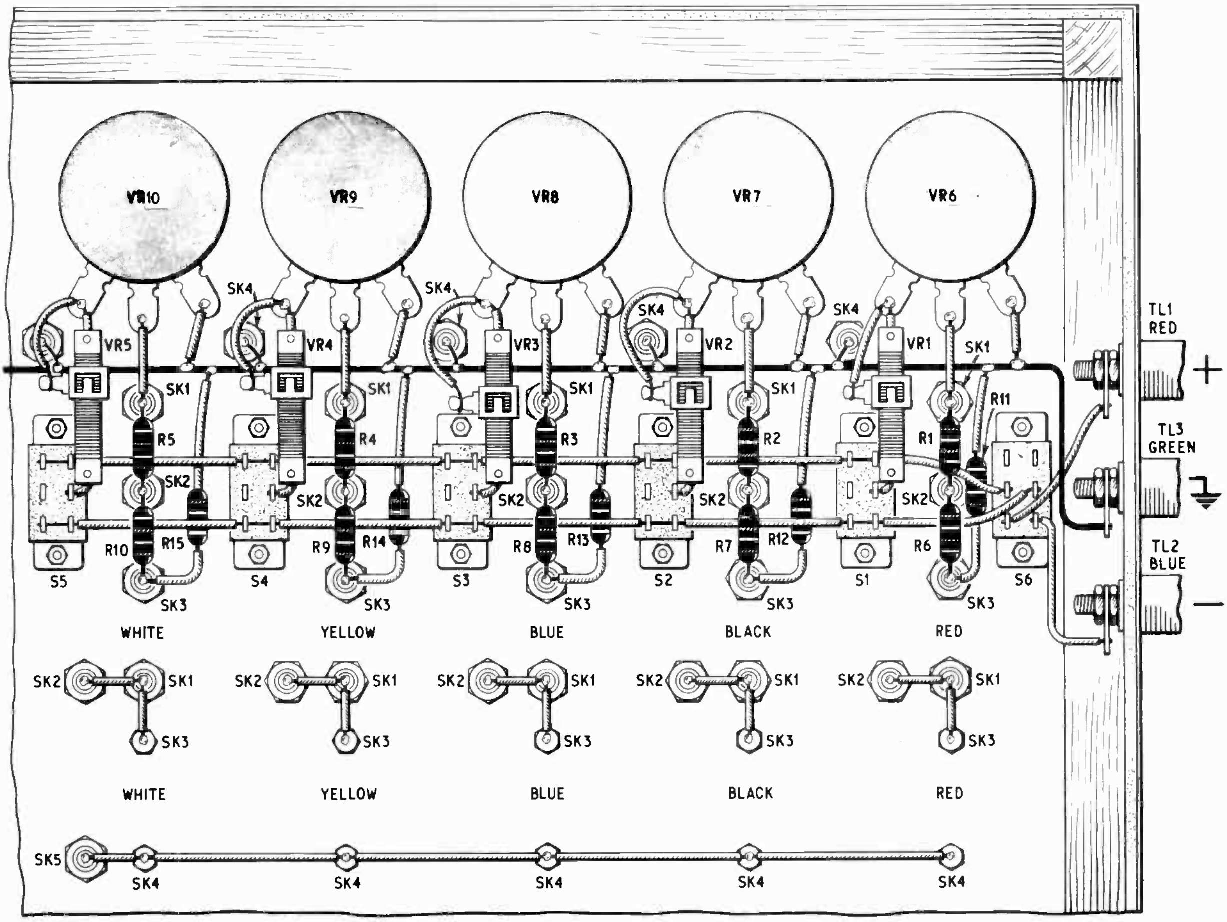
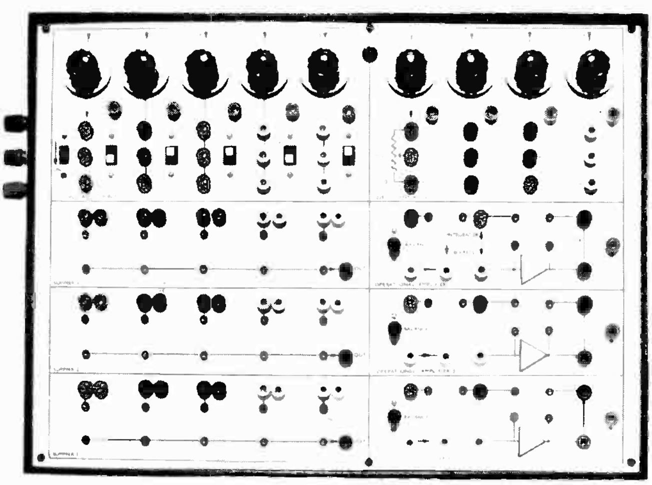


Fig. 2.3. Reverse side of front panel, left-hand portion (Fig. 2.2), showing components and wiring. Summer 2 and 3 are wired exactly as Summer 1 shown here. The three terminals TL1, 2 and 3 are mounted on the side of the box



UNIT "A" front panel

may be justified on two counts: firstly, the front panel really forms a circuit which is designed to be accessible, and is an important part of the unit; secondly, the method of construction chosen brings economy by dispensing with a self-supporting internal chassis assembly, and much of the internal gear is actually mounted on the front panel, or to the box itself.

UNIT "A" FRONT PANEL

To prepare the front panel, a sheet of white plastic laminate, slightly larger than its finished size of 13in × 17¾in, is glued to a sheet of hardboard of the same measurements with Evostick or a similar adhesive. When firm, the panel edges can be planed, rasped, or sandpapered down to size, while making sure that all is square. Next, taking Fig. 2.1 and the photograph of the front panel as a guide, mark out the main dividing lines with a pencil.

The positions of all holes and slots may be found by referring to panel drawings Fig. 2.2 and Fig. 2.5. Establish hole centres by first marking with a pencil, then indenting with a sharp spike. Note that all drilling should be carried out from the plastic laminate side of the panel, to avoid chipping the white surface. It is important to handle tools carefully, and prevent them skidding across the plastic surface and scoring it. When all holes have been drilled, deburr them on the reverse side of the panel with sandpaper, and check that components will fit correctly before applying a coat of clear varnish to the hardboard backing.

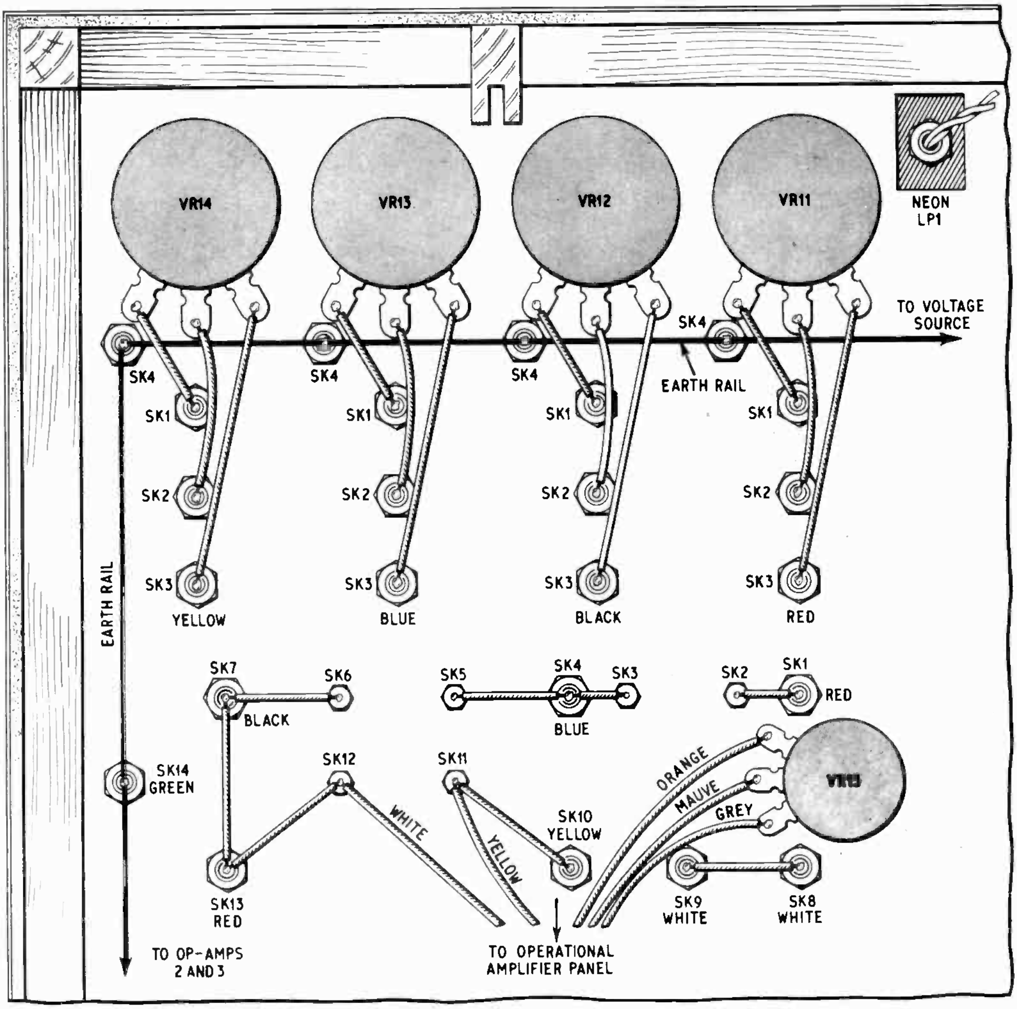
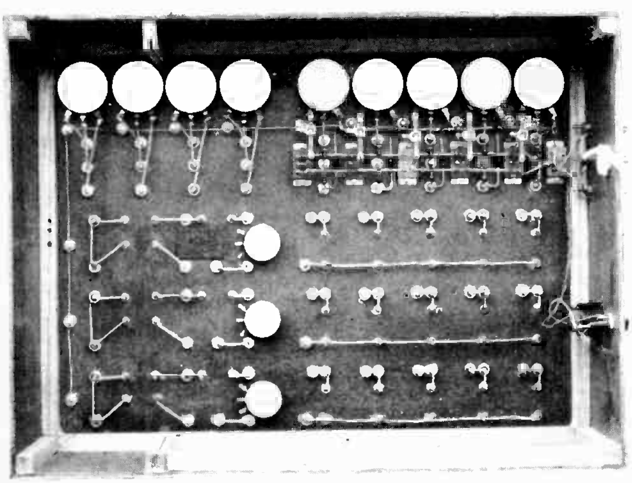


Fig. 2.4. Right-hand portion of front panel viewed from rear, showing components and wiring. Operational Amplifiers 2 and 3 are wired exactly as "Operational Amplifier 1" shown here



Rear view of UNIT "A" front panel

To finish the panel, draw in all lines and symbols with a nib pen and Indian ink. If any mistakes are made, the ink can be removed—when dry—with a typewriter eraser, and surface shine restored with metal polish. Lettering can be applied by the "rub-on" or "stick-on" transfer methods, and should be protected by a thin layer of clear varnish.

When the panel decor has dried, mount all sockets, potentiometers, knobs with dials, switches, and the neon mains lamp. Dials may be lined up on potentiometer spindles later.

UNIT "A" BOX

This time, the box is first constructed of hardboard on a wooden frame, and is later covered with plastic laminate. See Fig. 2.12.

Cut and finish the four hardboard panels to size, and cut the various lengths of softwood. The manner of assembly could be as follows: attach wood lengths *A* and *C* to top and bottom panels with panel pins or countersunk woodscrews, gluing all joints. Attach lengths *B* to side panels, bring panels together and secure. Next, position *D*, *E*, and *F*. Note that there is no length *D* at the back portion of the top panel so the slotted amplifier mount *F* should be lined up vertically with its companion *E*. All drilling must be left until the plastic laminate is in place.

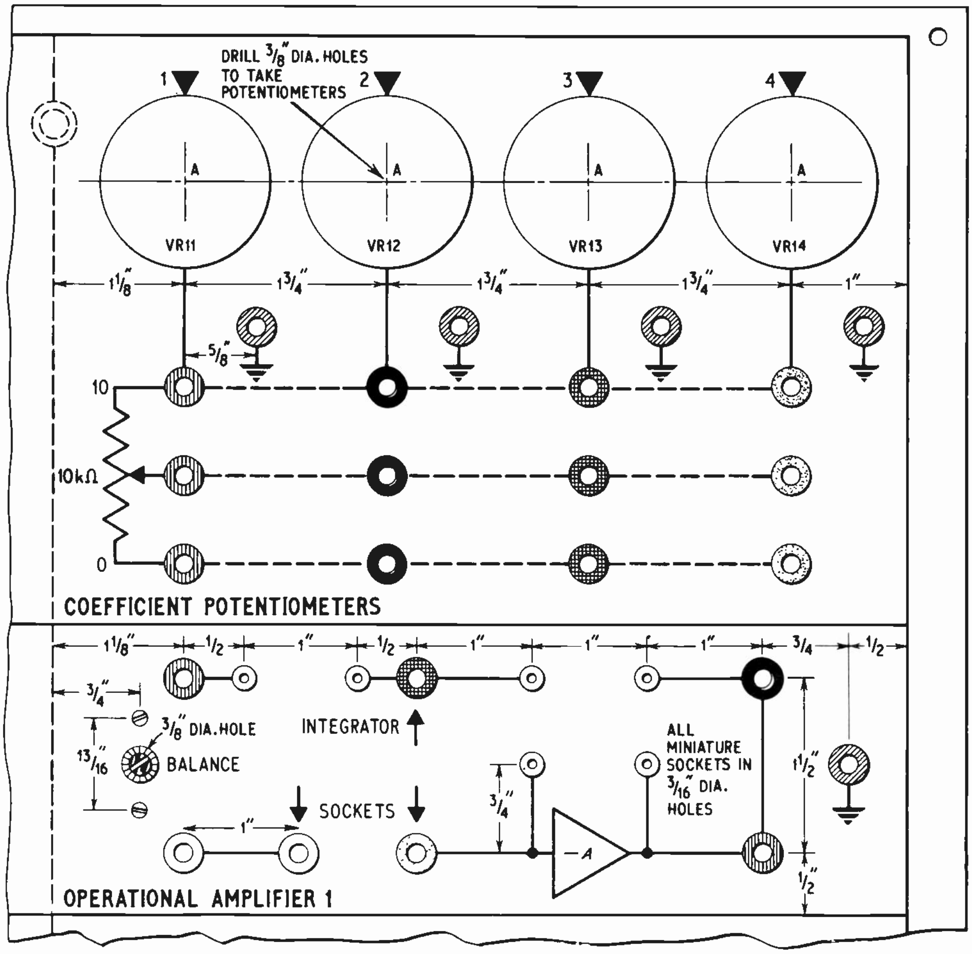


Fig. 2.5. Right-hand portion of front panel. Drilling details, layout of components, and panel engraving. Below the broken line there are two further sections, each a replica of "Operational Amplifier 1"

COMPONENTS . . .

UNIT "A" FRONT PANEL AND BOX

Resistors
R1–R5 9·1kΩ (5 off)
R6–R10 910Ω (5 off)
R11–R15 100Ω (5 off)
All 5%, ¼W carbon film

Pre-set Potentiometers
VR1–VR5 250Ω miniature wirewound slider type (5 off)
VR15–VR17 50Ω wirewound panel mounting type (3 off)

Potentiometers
VR6–VR10 1kΩ 3W linear wirewound, ±20% or better, 270° effective rotation (5 off)
VR11–VR14 10kΩ 3W linear wirewound, ±20% or better, 270° effective rotation (4 off)

Switches
S1–S6 Double-pole, on/off slide switch (Radiospares) (6 off)

Plug
PL1 3 way panel mounting mains plug and cable connector

Fuse
FS1 1·5A cartridge fuse and 20mm fuseholder

Lamp
LP1 Neon indicator lamp (Radiospares "miniature 200–250V panel neon" with self-contained resistor)

Sockets
21 Red, 15 Black, 15 Blue, 15 Yellow, 15 White, 12 Green (painted green, see text)
48 miniature sockets, black or red to choice

Terminals
Insulated screw, to take 4mm stackable plugs (Radiospares). 1 Red, 1 Green, 1 Blue

Miscellaneous
Material for panel and box: Hardboard: 2 off 13in × 5in, 2 off 18in × 5in, 1 off 13in × 17¾in. White plastic laminate: 2 off 13in × 5in, 2 off 18in × 5in, 1 off 13in × 17¾in. Softwood: 52in × ½in square, 4in × ⅞in × ⅜in.
20 s.w.g. tinned copper wire. Insulated sleeving

Dials and knobs
Nine 0–10 270° dial knobs (Bulgin type K400), black or grey

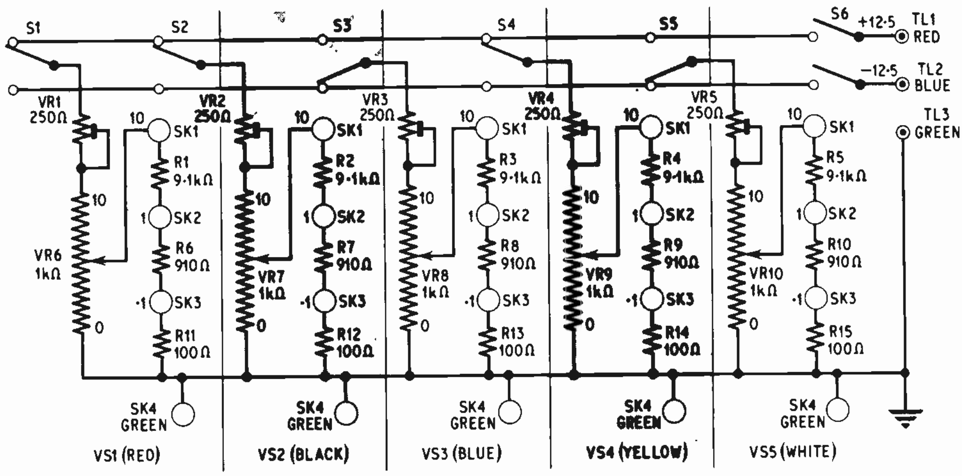


Fig. 2.6. Circuit diagram of Voltage Source section

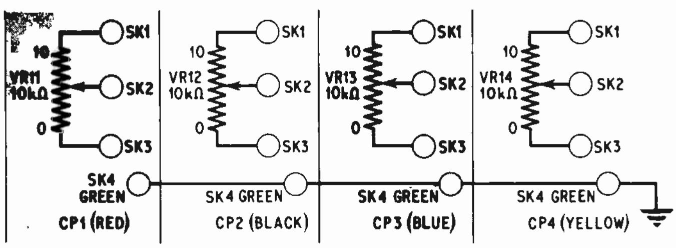


Fig. 2.7. Circuit diagram of Coefficient Potentiometers section

SOCKET IDENTIFICATION

The following abbreviations will be used in the programming instructions for PEAC. Applied as prefixes to socket (SK) numbers, they clearly establish the identity of the particular socket referred to. For example, "VS2/SK1"; "CP1/SK3" etc.

VS	Voltage source
CP	Coefficient potentiometers
S	Summer
I	Input (Summer)
OA	Operational Amplifier

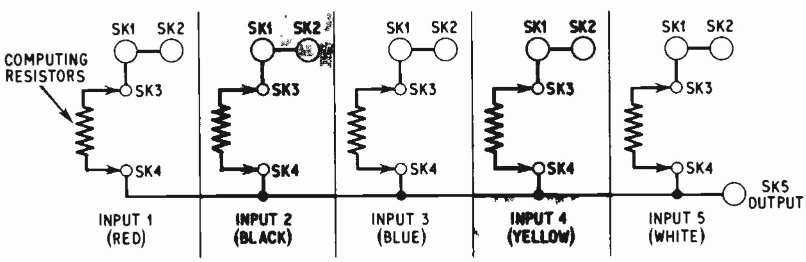


Fig. 2.8. Circuit diagram of Summer 1, 2, and 3

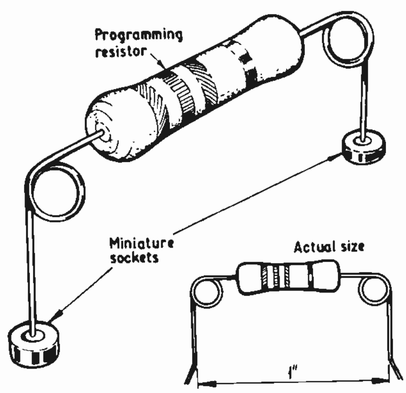


Fig. 2.11. Method of bending leads to make plug-in programming resistors

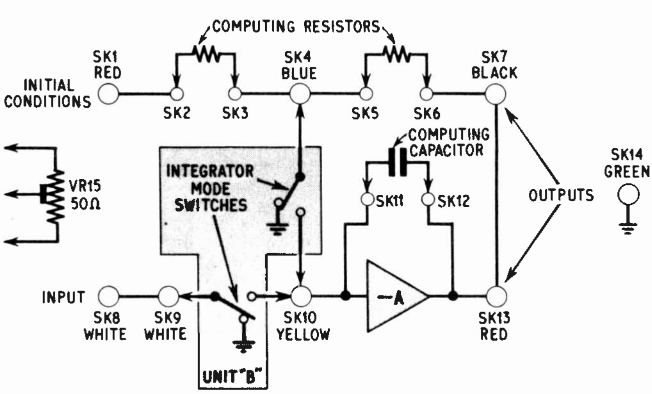


Fig. 2.9. Circuit diagram of Operational Amplifier 1, 2, and 3

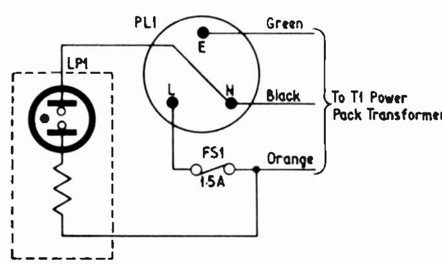


Fig. 2.10. Circuit diagram of mains supply

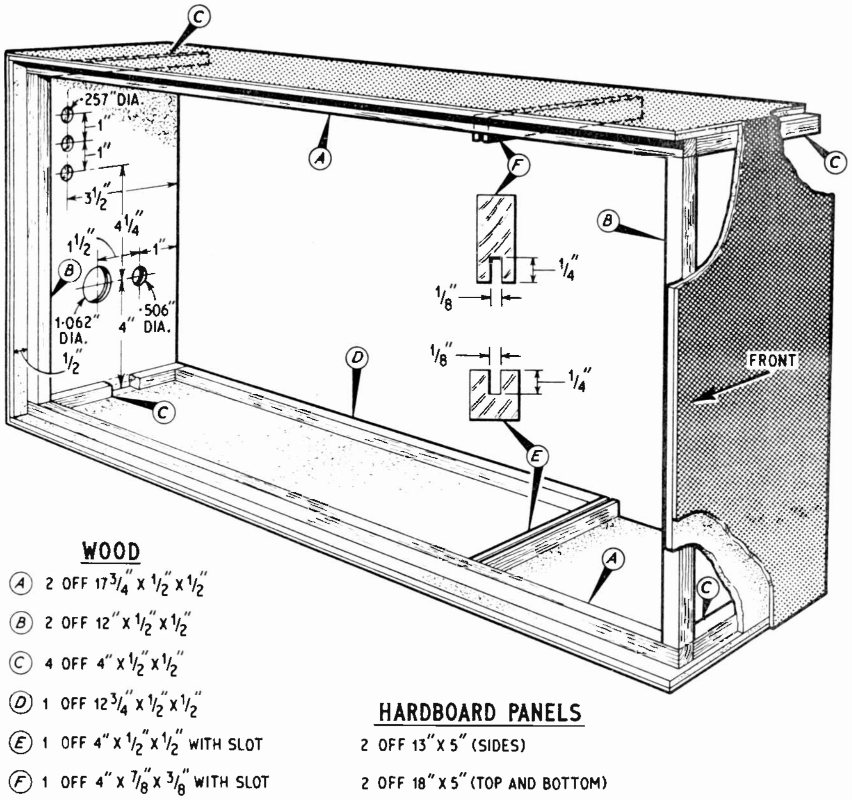


Fig. 2.12. Constructional details of UNIT "A" Box

Cut plastic laminate to fit hardboard panels with $\frac{1}{16}$in overlap, and glue to the box sides first. Reduce the overlap to size when the laminates are firm, before fitting the top and bottom surfaces. When trimming the top and bottom panels down to size, take care not to scratch and score the side pieces. For economy, the bottom plastic laminate layer can be omitted.

When satisfied with the laminated exterior, the 1·062in dia. hole can be made by a series of small drillings and finished with a half-round file. The box interior and wood may be varnished, but the raised lip at the front of the box is best painted black, or some dark colour, to contrast with the front panel.

The finished box is quite strong, and will support the full weight of a normal adult when the front panel is in place. However, it is recommended that this test should not be applied too often!

FRONT PANEL WIRING

Attach the front panel to its box, which will act as a convenient mount when wiring the back of the panel.

The bare earth wire linking all green sockets runs along the top half of the front panel and down its left-hand side, looking from the back; this should be soldered in place before embarking on the sleeved wiring. (No matching green sockets were available for the prototype, so odd coloured sockets were painted green with cellulose model aeroplane dope.)

The 4mm red, green, and blue terminal sockets on the side of UNIT "A" are designed to take stackable plugs, and will make available the power supply outputs to external sub-units. Wiring can proceed from the terminal sockets along the voltage source (see Fig. 2.3) and then to the rest of the front panel.

Circuit diagrams for all the various "sections" incorporated in the front panel are given in Figs. 2.6 to 2.10 inclusive. Wiring details are given in Fig. 2.3 and Fig. 2.4.

The summer and operational amplifier sections are triplicated—although only one of each of these sections has been shown in the diagrams Fig. 2.2 to Fig. 2.5 inclusive.

The purpose of the miniature sockets, which appear in the above mentioned diagrams, is to take the plug-in programming components; explained by Fig. 2.11. Resistor leads are preformed in the manner shown. The distance between miniature sockets is standardised at 1in, to allow the use of a special made-up two pin plug to support the bulkier components, such as large polyester capacitors.

When wiring up the operational amplifier sockets, ignore for the time being the coloured flexible wires shown in Fig. 2.4 as these are the flying leads from the operational amplifier panel, and will be referred back to when the time comes to mount the amplifiers.

Fit the mains connector PL1 and fuseholder for FS1 to the side of the box. Wire up the neon lamp LP1 and the fuse FS1 to PL1 as shown in Fig. 2.10.

CORRECTION.

In Part 1, Page 40, last line of the equation in the example at top of right-hand column should read:

$$E_0 = -\left(5\frac{10}{10} - 3{\cdot}5\frac{10}{2} + 2\frac{10}{100}\right) = -(5 - (3{\cdot}5 \times 5) + 0{\cdot}2),$$

therefore $E_0 = 12{\cdot}3$.

Next month: Power supply and operational amplifiers

MARKET PLACE

AUDIO TRENDS

A portable stereo record player for the home is the latest addition from **Daystrom Ltd.** to the Heathkit range of construction kits.

Called the SRP-1 it is housed in a factory preassembled cabinet covered with two-tone blue and grey rexine with vynair covered speaker grilles, and has a handle for ease of transportation.

One speaker enclosure can be detached from the main cabinet to obtain best stereo separation. A B.S.R. four speed automatic record changer is mounted on a swing-down platform.

When it is necessary to move the stereo record player from one place to another, the speaker enclosure clips on to one end of the cabinet and the record changer folds up in to the cabinet to form a "suitcase".

The only soldering required is when wiring the amplifier printed circuit board and interconnecting wires. The wiring procedure is set out in a fully illustrated step-by-step instruction manual.

The SRP-1 is mains operated and the transistor (four each channel) amplifiers give a total power output of 3 watts r.m.s. The frequency response is 50Hz to 12kHz $\pm$3dB. There are three controls: volume, balance and tone. The speakers are 15 ohm 8in $\times$ 5in permanent magnet types. Price £27 15s 0d incl. P.T.

The Pilot III a.m./f.m. battery operated receiver from **H. O. Thomas Electronics Ltd.,** Vernon Place, London, W.C.1, is claimed to be able to receive pilot to control tower messages on the special v.h.f. band of 108–130MHz, as well as all normal broadcasts on the a.m./f.m. wavebands.

The superhet circuit design of the receiver contains 10 transistors and 5 diodes with telescopic aerial for v.h.f./f.m. reception.

The recommended retail price of the Pilot III is £13 13s including leather case, battery and earpiece for personal listening.

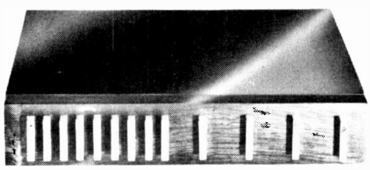
The Cosmocord GP80 is a miniature monophonic ceramic pick-up cartridge specially designed to withstand robust treatment.

One typical application for the GP80 is its use in car record players where the record is inserted in a slot, and the cartridge has to withstand the added vibrations from the roads while the car is in motion.

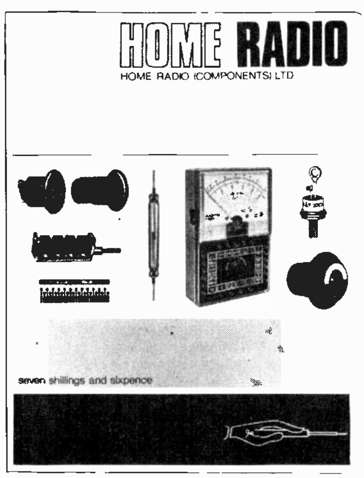
Further details and performance data can be obtained from **Cosmocord Ltd.,** Eleanor Cross Road, Waltham Cross, Hertfordshire.

Sinclair Radionics Ltd., make their appearance in the hi fi amplifier field with the Sinclair Neoteric 60 Integrated Stereo Amplifier priced at 55gns. As with previous products small size and latest technical techniques are used to obtain maximum performance. Housed in a steel case with a solid Rosewood front it measures $2\frac{1}{8}$in high, $8\frac{1}{2}$in wide and $9\frac{1}{4}$in deep.

Pilot III Receiver from Thomas Electronics


Sinclair Radionics Neoteric 60 Stereo-Amplifier


Heathkit SRP-1 Stereo Player



Home Radio Catalogue

The Neoteric 60 employs modular construction. All external connections are located at the rear, facing downwards to permit flush mounting to wall surfaces.

The maximum output of the amplifier is 60 watts, 30 watts each channel into an 8 ohm loudspeaker load. The frequency response is 20Hz to 100kHz $\pm$1dB. The total harmonic distortion at 1kHz with both channels working is 0·08 per cent maximum at 10 watts into 15 ohms and 0·1 per cent at 15 watts into 8 ohms.

There are five input facilities: magnetic pick-up, ceramic pick-up, radio tuner, tape head and auxiliary. Outputs for tape recorder providing 100mV r.m.s, stereo headphones, speaker terminals and switched mains outlet are provided.

The front panel controls are in the form of selector bars with international identification symbols printed on each bar, and are as follows: on/off, incorporating indicator light; two controls providing three h.f. cut-off frequencies; l.f. rumble filter; mono/stereo switch; three input selection switches providing equalisation for five inputs; tape monitor switch; balance control; volume control; bass and treble controls.

The Neoteric 60 is fully guaranteed and is available from Sinclair Radionics Ltd., 22 Newmarket Road, Cambridge.

LITERATURE

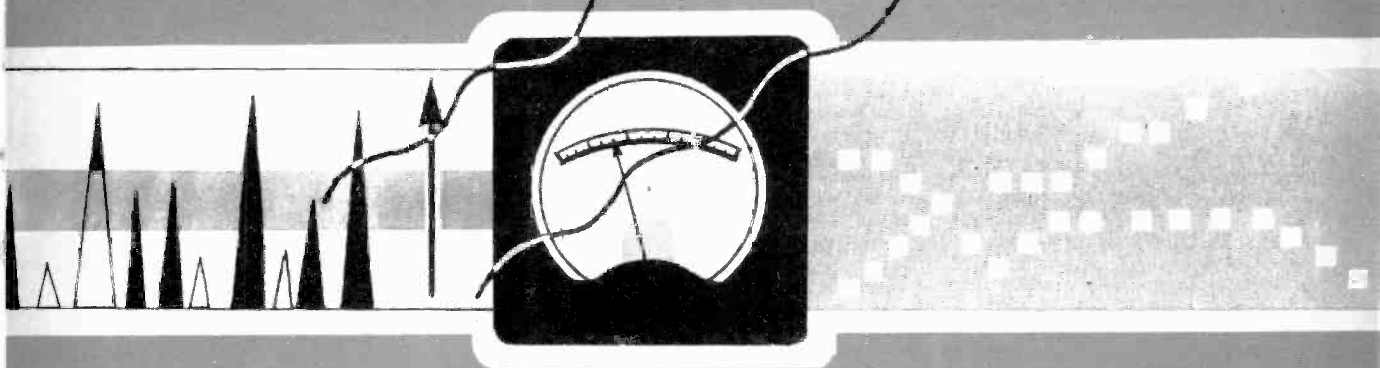
A new 90 page catalogue has been published by **Sound and Science Ltd.** It contains more than 20 separate sections listing over 500 items of hobby and do-it-yourself equipment, much of which is available in varying degrees of sophistication to satisfy all age-groups. Microscopes, for example, are priced from 42s for a small but effective hand-held model to £98 for an advanced, industrial standard instrument.

The section on optics is the largest, offering comprehensive selections of optical instruments from powerful refractor telescopes to pocket magnifiers.

Other sections cover sound reproduction; natural science; motoring and boating; and electronics and engineering kits. Copies of the catalogue are available from Sound and Science Ltd., 3–5 Eden Grove, London, N.7, price 3s 6d.

Many new items have been added to the new 4th Edition of the excellent **Home Radio (Components) Ltd.** catalogue. The new edition has over 250 pages and contains a new component prices catalogue supplement. Like the previous issue the catalogue costs 7s 6d plus 2s postage but there are five gift coupons valued at one shilling each. One shilling is deducted from each order of one pound if accompanied by a coupon.

nucleonics



for the EXPERIMENTER

By M. L. Michaelis M.A.

4—RADIATION DETECTORS (Continued); DETAILS OF G.M. HEAD UNITS FOR STRACE

FOLLOWING the discussion on gas ionisation type radiation detectors we now consider various other types, including solid state and scintillation detectors.

SOLID STATE RADIATION DETECTORS

The range of nuclear radiations before complete absorption is much shorter in solid substances than in a gas. Thus alpha particles of some 5MeV energy will travel about 8cm in air, but only about 0·1mm in solid substances.

In principle, the barrier layer of any semiconductor device forms a radiation detector in this sense, because the ions released by a particle stopped in the barrier layer will affect the diode or collector current of the device. The resulting pulse amplitudes are very small, again requiring critical amplifier equipment. But the amplitudes are essentially proportional to the energy of the incident particles deposited in the barrier layer.

The resolution, i.e. the minimised spread of actual pulse amplitudes obtained for a given strictly constant incident particle energy, is very favourable indeed with modern barrier-layer radiation detectors. The technological problems are here twofold. Firstly, the need to produce sufficiently wide barrier layers for complete absorption of the incident particles. Secondly, the need to locate the barrier layer right at the surface of the device so that the radiation has to pass as little insensitive material as possible before reaching the active layer.

However, present-day research is mastering these problems, and barrier-layer radiation detectors are widely used, especially in the instrumentation of space research satellites.

Ordinary semiconductors and transistors are certainly sensitive to nuclear radiation of sufficient intensity, as may be encountered ambient in outer space. This has led to certain problems in the design and selection of diodes and transistors for the electronic circuits in space vehicles, to make their performance reliable in the face of intense nuclear radiation. But it is quite pointless for the amateur to attempt using ordinary diodes and transistors as nuclear radiation detectors, since response is absent or negligible at the intensities which are safe to handle.

SCINTILLATION DETECTORS

A different form of solid state ionisation radiation detector makes use of the scintillation effect.

The electrons dislodged in the crystal structure by incident, absorbed nuclear radiation, will ultimately drop back to their correct positions if no voltage is applied. In doing so, they release their excitation energy as electromagnetic radiation. If suitable crystals are chosen, notably *sodium iodide*, *anthracene* or certain proprietary plastics, the emitted electromagnetic radiations are visible or ultra-violet light, which can be picked up and converted to electrical pulses by conventional photoelectric devices. The combination of a scintillator and a photoelectric device is called a *scintillation detector*, see Fig. 4.1a.

Scintillator crystals must be highly purified and grown as single crystals over their entire volume. Impurities and irregularities would permit energy dissipation by means other than light emission, so that such inferior crystals would be useless as radiation detectors. However, the inherent advantages of a properly grown and purified scintillator crystal are considerable. Above all, it is very readily possible to grow crystals with large volumes, whereas it is difficult to obtain large barrier-layer volumes in a semiconductor. It is thus easier to ensure total absorption of incident radiation in the scintillator crystal.

On the other hand, it is more difficult to get all the light out of the crystal and into the photoelectric device without severe losses, so that the energy resolution of a scintillation detector is inherently poorer than that of a barrier-layer detector. Various fractions of the emitted light get lost, according to the positions of emission within the crystal, so that incident nuclear radiation of strictly constant energy produces output pulses from the photoelectric device spreading over a range of amplitudes. This problem hardly arises with a semiconductor barrier-layer detector, because it is a simple matter to draw off essentially all liberated ions with suitable applied voltages.

ENERGY RESOLUTION

The scintillation detector specified for our STRACE equipment possesses an energy resolution of about 10 per cent This has the following meaning.

If a very large number of incident particles of energy E are imagined, and the resulting output pulses from the photoelectric device are sorted according to amplitude, we find a maximum counting rate for the amplitude corresponding to E (see Fig. 4.1b). In the ideal case, there should be no counts at all for other amplitude levels, but in practice there will be progressively fewer counts as we move away from E on either side.

We now look for the amplitudes at which the counting rate is half that for the position E, i.e. half the maximum observed rate. The distance between these two half-value points, expressed as a proportional percentage of E, is the resolution mentioned above.

In practice, a resolution of 10 per cent means that two nuclear radiation streams must differ in energy by at least 10 per cent if they are to be resolved clearly by the scintillation detector, to produce separate counting rate peaks at the corresponding pulse amplitude levels. Barrier-layer radiation detectors have been produced with resolutions of 1 per cent or better under optimum professional conditions. A resolution of 5 per cent is already extremely good for a professional scintillation detector, and our value of 10 per cent is by no means poor for this type of detector, even in professional circles.

LIQUID STATE RADIATION DETECTORS

Certain liquids and solutions can be excited by absorbing nuclear radiation, with subsequent de-excitation and emission of light. Thus scintillation detectors may well use liquid scintillators in place of solid crystals. There are no other important kinds of liquid radiation detectors.

CHOICE OF DETECTOR TYPE

The choice between a liquid scintillator or a scintillator crystal for a scintillation detector is governed by the type of nuclear radiation and the type of radioactive sample to be measured.

As a general rule, the physical dimensions of the scintillator should be of the same order as the range of the radiation in the scintillator substance, so that there is a good chance that light will be emitted anywhere within the volume of the scintillator.

Secondly, the radiation must be able to "get into" the scintillator, i.e. the range of the radiation must be very much greater than the thickness of any container used for the scintillator. Gamma rays in the energy range from 0·1 to 3·6MeV are most commonly met with from radio-active substances, and these have ranges of many centimetres in solid matter. A sodium iodide crystal 1·5 inches in diameter, 2 inches long, contained in a thin aluminium capsule, is thus very suitable for this kind of radiation and has been specified for our STRACE equipment.

Beta rays in the same energy range will penetrate at most a few millimetres, and small anthracene crystals are often used here in professional equipment. Nevertheless, reliable work is difficult in this manner, so that we

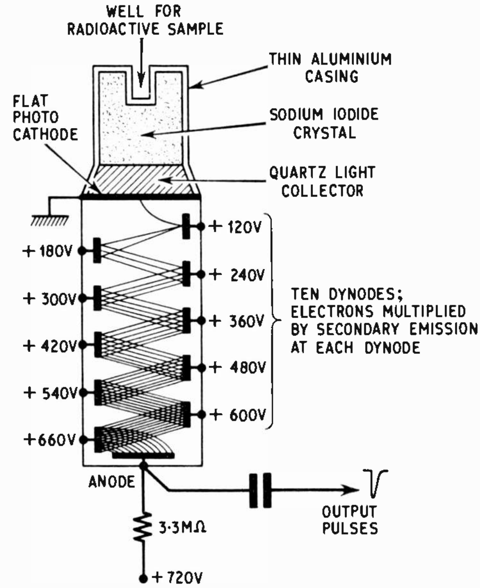


Fig. 4.1a. Construction of a scintillation detector

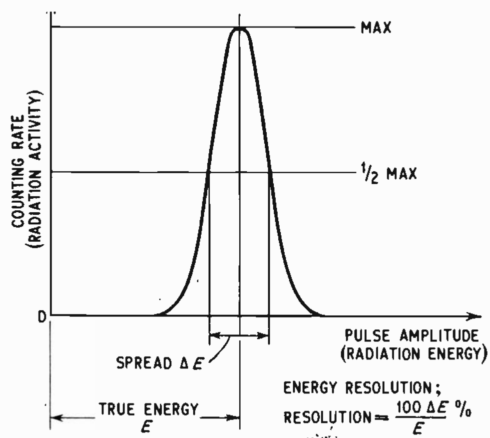


Fig. 4.1b. Definition of energy resolution of a spectrometer

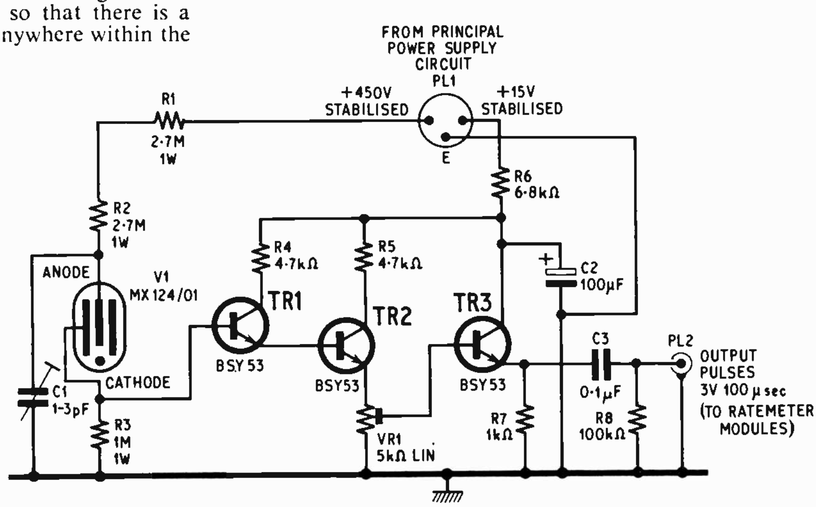


Fig. 4.2. Circuit diagram of the STRACE G.M. head unit

have taken a different approach in our amateur equipment. G.M. tubes with the electrodes in a thin-walled glass tube sealed coaxially inside an outer glass tube into which radioactive samples are introduced (see Fig. 3.4a), are eminently sensitive to beta rays, since these can easily penetrate the thin glass walls of the inner tube and the thin layer of sample material surrounding it. We have thus specified Mullard MX124/01 G.M. tubes for the STRACE. These tubes are in fact also sensitive to gamma rays, so that they have excellent response for fission products, such as are found in rain, snow, foodstuffs, vegetation, soil samples, etc. from the fallout of nuclear explosive tests.

Alpha radiation has a range of only a fraction of a millimetre in sold matter, so that it is extremely difficult to get it into a radiation detector from an outside source. For this reason, accurate measurements of alpha radiation are very difficult and thus hardly recommendable—or necessary for that matter—for amateur studies. The most effective method is to introduce the alpha-radioative sample into the detector itself. If a liquid scintillator is used, the alpha-radioactive substance may be dissolved in it. Alternatively, it may be deposited on the electrodes or mixed-in with the filling gas of a G.M. tube. Such methods are largely confined to professional circles, and destroy the detector for each measurement.

If the amateur wishes to detect and measure alpha radiation, a good silicon surface-barrier diode detector is probably the best device for his purposes. (We have already published an article in this journal on this type of barrier-layer radiation detector and its basic circuitry.) After suitable preamplification, the pulses from this detector can be handled by the STRACE radiation meter unit.

Alpha particles give by far the largest pulses with a barrier-layer detector, because they are absorbed essentially completely in the barrier layer. Other types of nuclear radiation usually have a greater range and thus deposit only a fraction of their energy in the barrier layer. Simple amplitude threshold discrimination following a barrier-layer detector can thus distinguish alpha rays from any other types of radiation which may also be present.

THE CLOUD CHAMBER

To complete our survey of radiation detectors, we must mention a few other kinds which have attained some technical importance.

The *cloud chamber* is of great historical importance, and derivatives thereof are vital tools in present-day research. The principle is to reduce suddenly the pressure of a volume of gas above a layer of water so that the gas is supersaturated with water vapour. The ionisation of the gas along the track of a particle of nuclear radiation then induces condensation of fine water droplets along that track, so that the track can be photographed in full detail. The type and energy of the particle can be determined by applying magnetic and/or electric fields and noting the resulting curvature of the track.

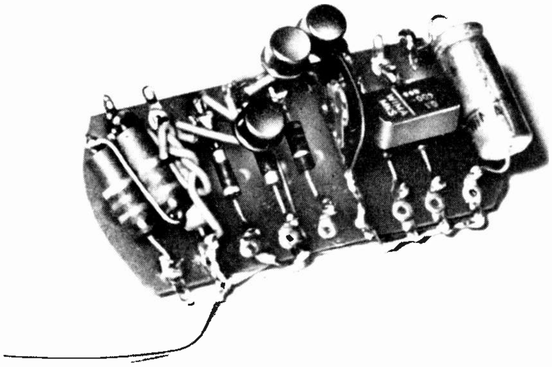
Similar track recordings can be made with *nuclear emulsions*. These are special photographic films, either stacked or with appropriate thickness on a single film. The ionisation produced by the nuclear radiation is equivalent to exposure, so that the track image appears during conventional development of the films.

Ordinary amateur photographic films are quite sensitive to nuclear radiation. If such films wrapped in black paper are sprinkled with radioactive substance and kept for some hours or days in this state before developing, the

continued on page 119

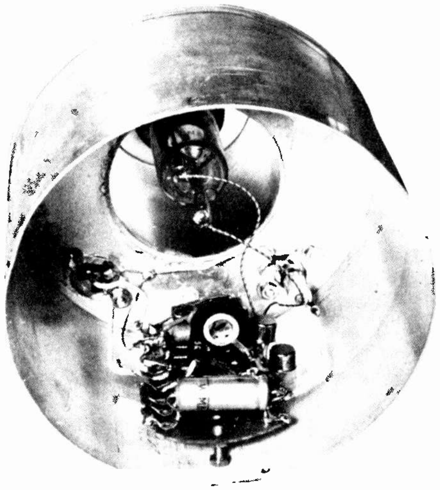
STRACE G.M. HEAD UNIT

General view of the G.M. head unit. The cover cap has been removed and the top of the sample tube can be seen

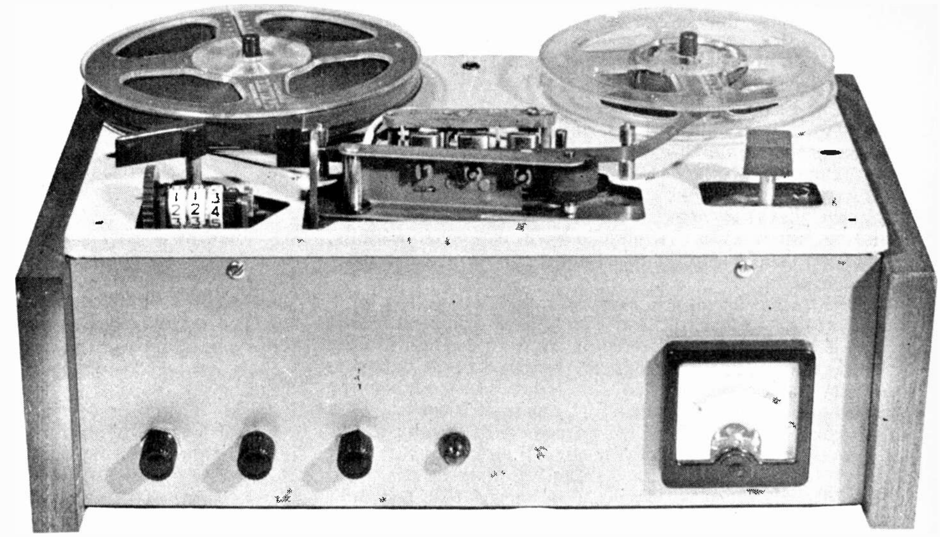


The pulse pre-amplifier assembly. All circuit components (see Fig. 4.2.) are wired onto a 9-way tag board

(Below). An interior view of the G.M. head unit. This shows the pre-amplifier assembly mounted inside the casing, also the underside connections to PL1, PL2 and V1



PART 2



INTEGRATED CIRCUIT TAPE RECORDER

By R. HIRST

THE integrated circuit tape recorder, using separate record/replay amplifiers, was described last month. Details of the oscillator coil and panels were given. Now the electronics construction is shown followed by setting-up procedure.

CONSTRUCTIONAL POINTS

The amplifier section was constructed on a piece of perforated board with a 0·1in matrix (Fig. 4a). The interconnecting wires between components are formed from 24 s.w.g. tinned copper wire as indicated in Fig. 4b. The potentiometer terminals are fed through the board offering a simple method of mechanical construction coincident with ease of examination. The indicator light is wired directly on the board in such a position as to shine through the panel at the appropriate point. The front panel, which houses the amplifier in its entirety, is made from 18 s.w.g. aluminium and is finished with an aerosol spray of a suitable colour.

A $\frac{1}{2}$in tapped pillar is glued to the front panel with Araldite (as shown in Fig. 3b last month) to secure the perforated board to it.

The meter can be of almost any type as long as the rating at full scale deflection is 1mA with an appropriate marking indicating the maximum record level at three quarters of full scale. If necessary this part of the scale above 8 can be coloured with a red pencil while the 0–8 section can be coloured green (see setting-up procedure).

When holes are being drilled into the deck plate it is essential that no swarf falls into the mechanism and this may be obviated by smearing the drill liberally with grease which will tend to hold the fine swarf which would otherwise cause damage. The holes to take the power supply are pre-drilled by the manufacturer. It is advisable to remove the head cover and top plate of the deck while work is being carried out to ensure that the finish is not damaged, but do not allow swarf to enter the head cases otherwise damage can ensue.

When ordering the extra replay head make sure that the azimuth spring and screw is ordered as well. (This will be described later.) The fitting of this is self explanatory by observing the record head which is already fitted. The replay head must be aligned for azimuth as indicated in the section on setting-up, otherwise the upper frequency response of the tape recorder will be severely limited.

Capacitors C15 and C18 have been placed on the back of the board so that any constructor, who wishes to equalise the recording amplifier more precisely for operation at $3\frac{3}{4}$ and $1\frac{7}{8}$in/second, may do so while making a mechanical link to the speed change spindle that will operate a set of contacts to switch the capacitors. The wires to this switch should be screened to avoid instability. For $3\frac{3}{4}$in/second C15 is 0·022μF; C18 is 680pF. For $1\frac{7}{8}$in/second C15 should be 0·033μF and C18 680pF.

SETTING-UP PROCEDURE

Once the tape recorder has been built and checked for wiring errors, a shorting link should be placed temporarily across D1 to minimise the risk of damaging the output transistors should there be some fault condition in this area. The unit may now be switched on in the replay condition and the indicator light should come on.

Connect a d.c. voltmeter from the emitters of TR2 and TR3 to the negative rail. VR2 should be adjusted for 6·2 volts at this point. No further setting-up is required for the replay amplifier. Now remove the shorting link from D1. An indication that this chain is working may be obtained by turning up the replay volume control and the tone control. A hiss should now be heard in the speaker.

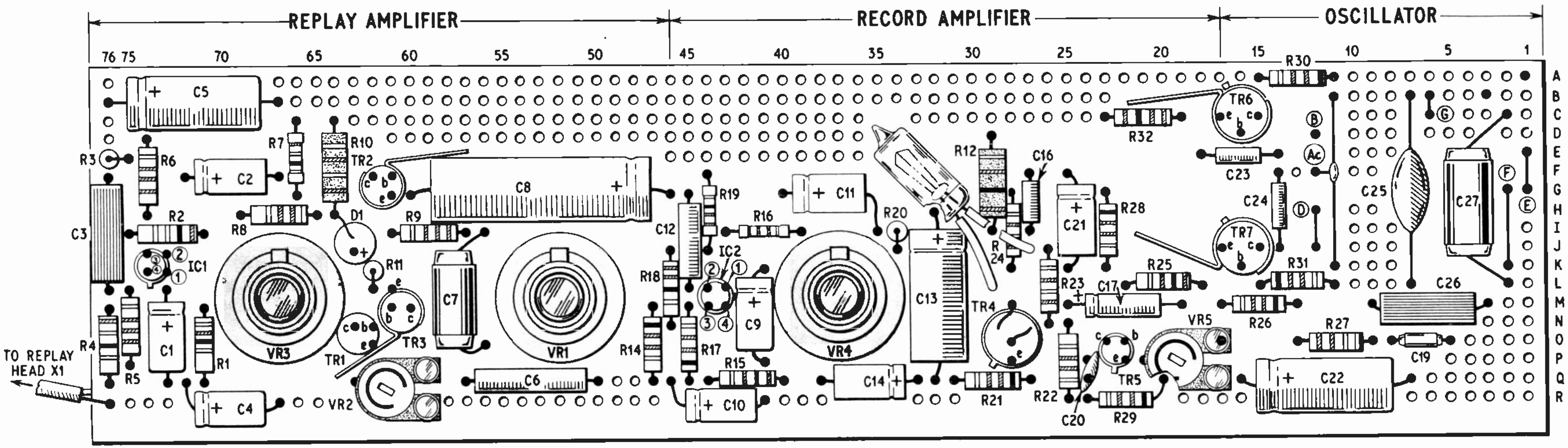


Fig. 4a. Component layout on the perforated board

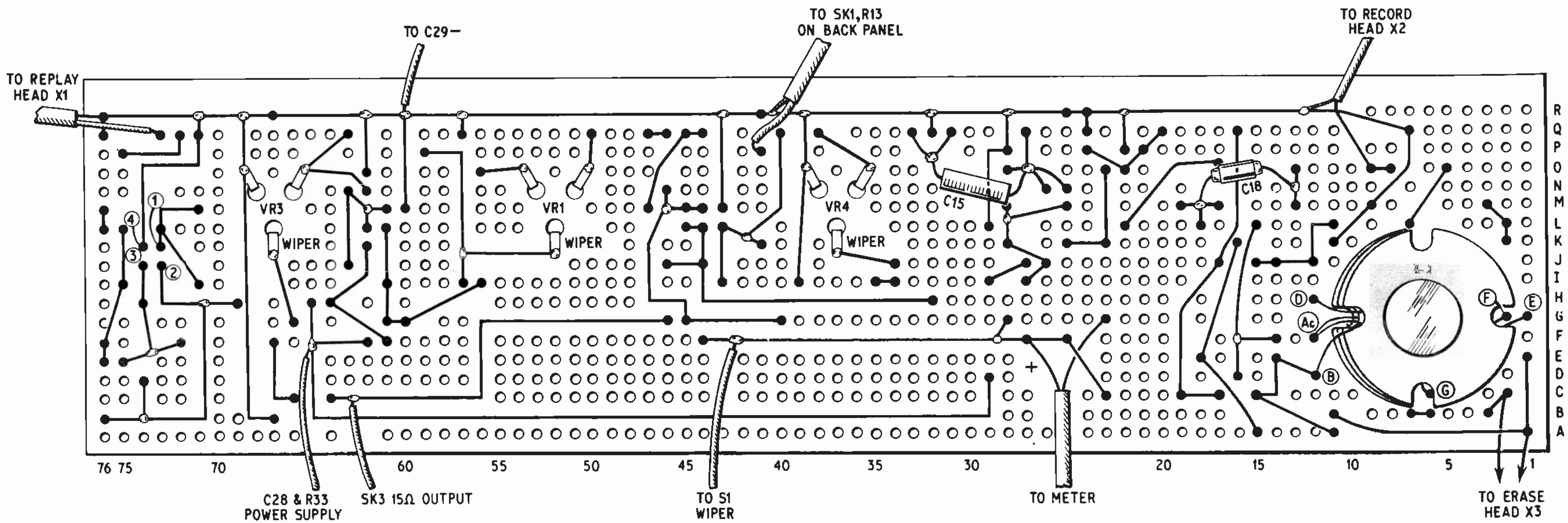


Fig. 4b. Wiring underneath the perforated board

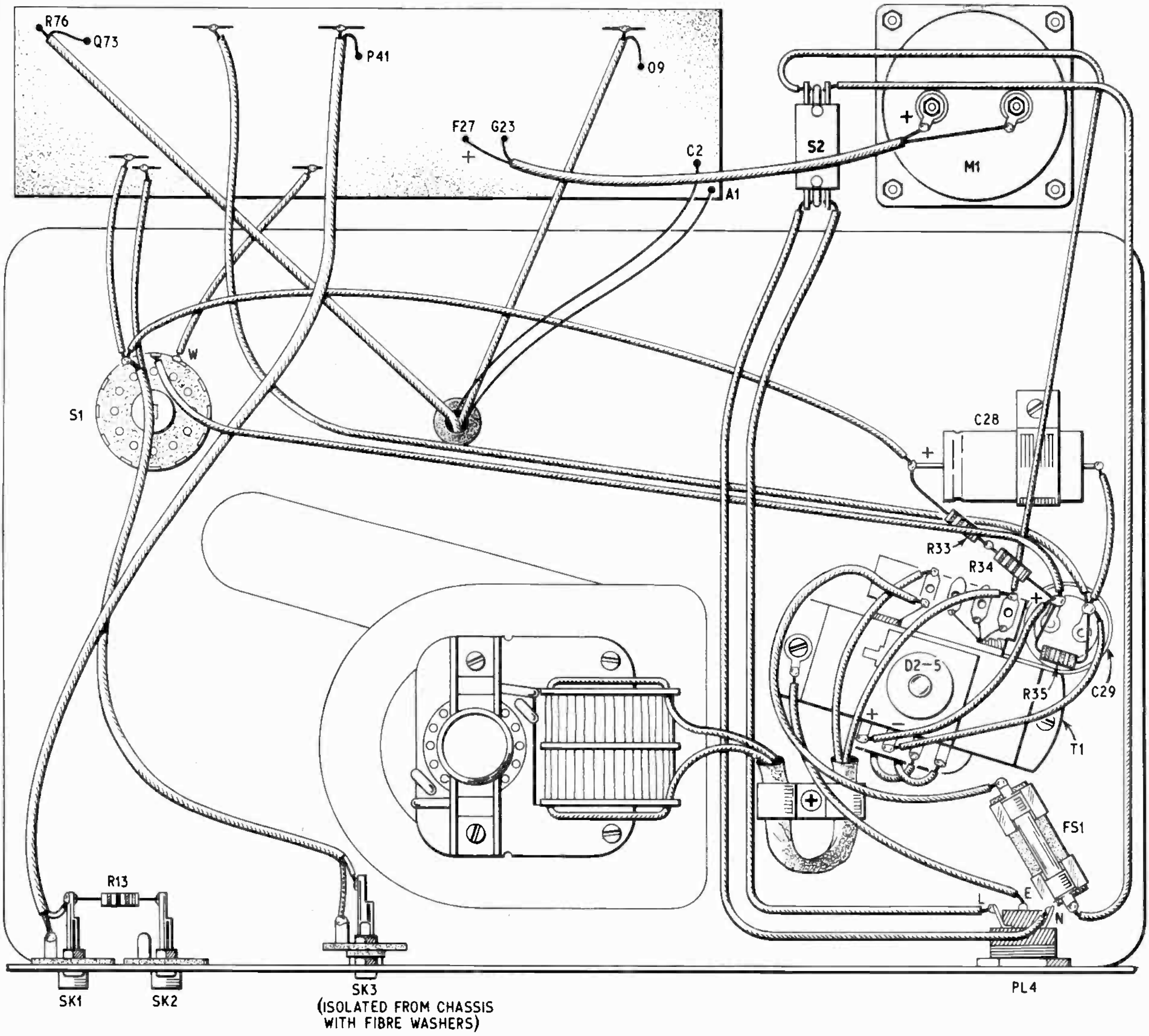
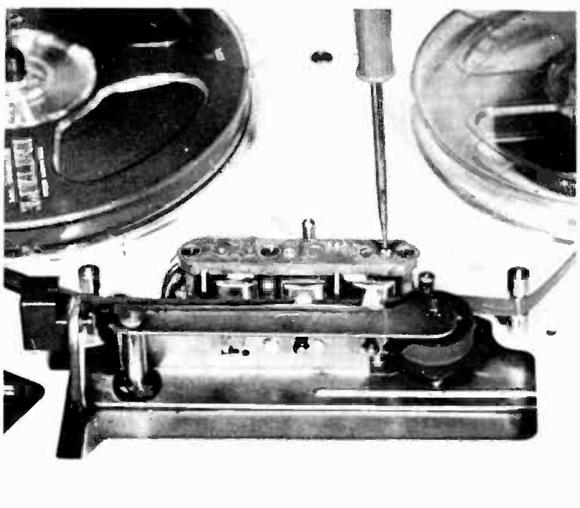


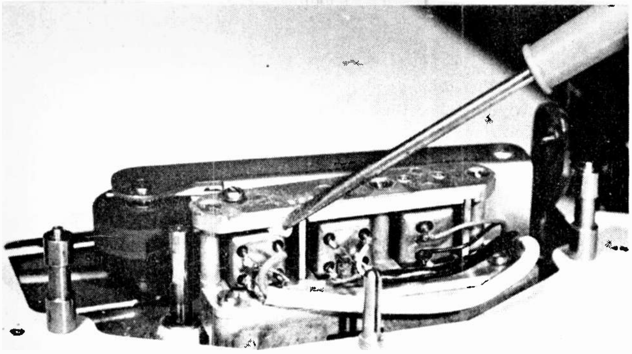
Fig. 5. The tape recorder assembled and wired. The main component board (top) indicates the wiring connection hole numbers (see Fig. 4b)

Under no circumstances should the replay amplifier be terminated by a speaker or other load of less than 15 ohms otherwise the output transistors will be destroyed. Also it is inadvisable to run the amplifier with a sinusoidal input signal in excess of 4kHz unless the output voltage developed across the load is less than 1 volt peak-to-peak.

The recording head lead which is connected to the negative rail may be disconnected and a 100 ohm resistor inserted in series with this lead and the negative rail so that the audio current and bias current may be checked. This operation is only required to calibrate the level meter, or if a fault in the recording chain is observed, as the current levels are pre-determined by the associated values of components. To measure the correct voltages present across the extra 100 ohm resistor an a.c. millivoltmeter capable of measuring down to 10mV full scale deflection, and also capable of measuring 50kHz, should be used.



Adjusting the azimuth screw of the extra replay head



Rear view of the head block and wiring. The screwdriver is pointing to the extra replay head

To measure the record current, switch to the record position, disconnect C19 and increase the record volume control to the maximum output condition. A pure sine wave signal at 1kHz should be applied to the MIC input socket at a level in the region of 1mV, this level should now be increased until the a.c. millivoltmeter reads 4·2mV. With this level held steady VR5 should be adjusted until the meter reads 8 which indicates the maximum level that may be recorded without the introduction of distortion.

Now reduce the input signal so that the measured output signal falls to 1mV; alter the input signal frequency to 10kHz. The output should now be in the order of 4mV. If this level is recorded for some little time the replay gain may be advanced and the azimuth adjustment for the replay head may be adjusted for maximum output at this frequency whilst the unit is in the replay condition.

The replay head is secured to the sub-plate by two screws; one of these screws has a spring washer. This screw is adjusted for azimuth alignment, i.e. the gap in the head core should be exactly at right angles to the direction of tape movement.

This is done by recording a high frequency signal (about 4 to 10kHz) and replay this signal while monitoring the output on an a.c. millivoltmeter. Adjust the azimuth screw (described above) for maximum output at this frequency. The adjustment is fairly critical and should be very carefully done. It is advisable to keep the replay volume as low as is convenient for this operation to avoid large output dissipation in the output transistors at this high frequency.

After azimith alignment, go through the record amplifier calibration procedure again, just to make sure that previous adjustments are still correct.

If the signal is now removed with the record volume control reduced to zero, C19 may be reconnected and the voltage measured across the 100 ohm resistor should be 22mV. If this is reading low C19 may be increased in value and vice versa.

The MIC input socket is designed to take a moving coil microphone with an impedance in the order of 100 to 600 ohms; the tape may be fully modulated with an input signal as low as 500μV. The RAD/GRAM socket input presents an impedance of 220 kilohms and is suitable for most crystal pick-ups, modulating the tape fully with an input level of 400mV.

It is most important that the speaker output socket is isolated from the rear chassis as shown in Fig. 5 otherwise the supply voltage will be shorted to earth. It is recommended that small insulating washers are placed at either side of the phono socket.

Do not insert or remove the speaker plug while the tape recorder is switched on. ★

NUCLEONICS FOR THE EXPERIMENTER

continued from page 115

outlines of the radioactive crystals or heaps will be found to have "printed through". Such experiments are instructive and well worth trying on the part of amateurs. The method is known as *auto-radiography* when the aim is to produce blackening of the film in proportion to the activity, rather than photographing particle tracks.

COLORIMETRIC DETECTORS

Colorimetric detectors consist of special glass or plastic which suffers permanent discoloration in proportion to the dose of nuclear radiation it is exposed to. Persons working in nuclear research establishments or in industry where radioactive substances or radiation are employed, are bound by law to carry radiation detectors on their person, e.g. in a pocket, which permit subsequent evaluation of the total dosage of radiation received by the human body.

Two types of such "personal dosage monitors" (dosimeters) are prevalent. The first type is simply an autoradiographic sheet of film in a lightproof package. The second type takes the form of a fountain pen, containing a small reed electrometer and optical viewing system with scale.

The electrometer is charged on a power pack such that the reed is deflected onto the zero-mark of the backwards-reading scale. Incident nuclear radiation gradually discharges the self-capacitance of the reed with respect to the casing, so that the received dosage can be read-off at any time by looking through the barrel against a light. The insulation is so good that self-discharge due to leakage is negligible over 24 hours, making these units eminently suitable for daily monitoring of persons potentially exposed to nuclear radiation.

G.M. HEADS OF STRACE

We now give some practical details of the G.M. head units used in the STRACE equipment.

The G.M. heads contain the G.M. tube and a simple transistorised pre-amplifier, whose purpose is to reduce the impedance level to a low value suitable for feeding the pulses down the coaxial cable to the radiation meter unit.

The accompanying photographs show the construction of the G.M. heads, using a Mullard MX124/01 tube in each unit. This tube is of all-glass construction, with the sensitive section sealed coaxially inside a glass sample tube. About 10ml of liquid may be filled into this tube, or solid samples may be suspended on a small filter paper in the annular space, using a tag of Sellotape.

The casing should be made of brass or aluminium to provide good shielding, since the circuit is rather sensitive to mains-radiated interference pulses if used in a plastic or wooden case.

The pulse pre-amplifier is constructed on a small tag-board and incorporated inside the casing as shown in the photograph.

The opaque cap must be placed over the open end of the G.M. tube during measurements, since the tubes are slightly sensitive to light.

The theoretical circuit of the G.M. head is given in Fig. 4.2. The amplitude of the pulses developed at the cathode of the G.M. tube is about 10V in this circuit, so that voltage gain is not required. All three transistors provide current gain. The transistor types are not critical; almost any *npn* silicon transistor is suitable. The output pulses at PL3 are at low impedance and thus suitable for feeding over considerable lengths of coaxial cable. VR1 should be adjusted such that the pulses at PL3 have an amplitude of 3V.

The pulses are produced at the G.M. tube cathode by transfer of charge stored in C1 to the cathode circuit stray capacitance. C1 thus influences the pulse amplitude. C1 is adjusted so that the pulse amplitude across the entire track of VR1 is about 10V.

Next month: Spectroscopy—the measurement of different energy levels

NEW TELECINE SYSTEM

THE Marconi Company announces the introduction of an entirely new telecine system which, it claims, sets a new standard of reproduction of television pictures from all types of colour films, black and white films, and slides

At the heart of the colour unit is a version of the well-known Mark VII colour camera which receives images through a revolutionary optical switch, operating faster than the reaction of the human eye, and allowing "on-the-air" cuts between film and slide projectors.

This equipment is probably the first to have the optics, from the lamphouse through the optical switch to the camera itself, designed as one complete system. So little light is lost that a low intensity lamp is employed. A variable density filter adjusts the light output from the lamphouse, enabling increases in intensity to be achieved if an extremely dense film is encountered.

The optical switch attached to the camera enables it to scan images from various combinations of the 16mm and 35mm film projectors and the dual slide projector. Three units can be grouped around three sides of the switch, and on one of these sides there are two closely spaced inlets for a dual slide projector.

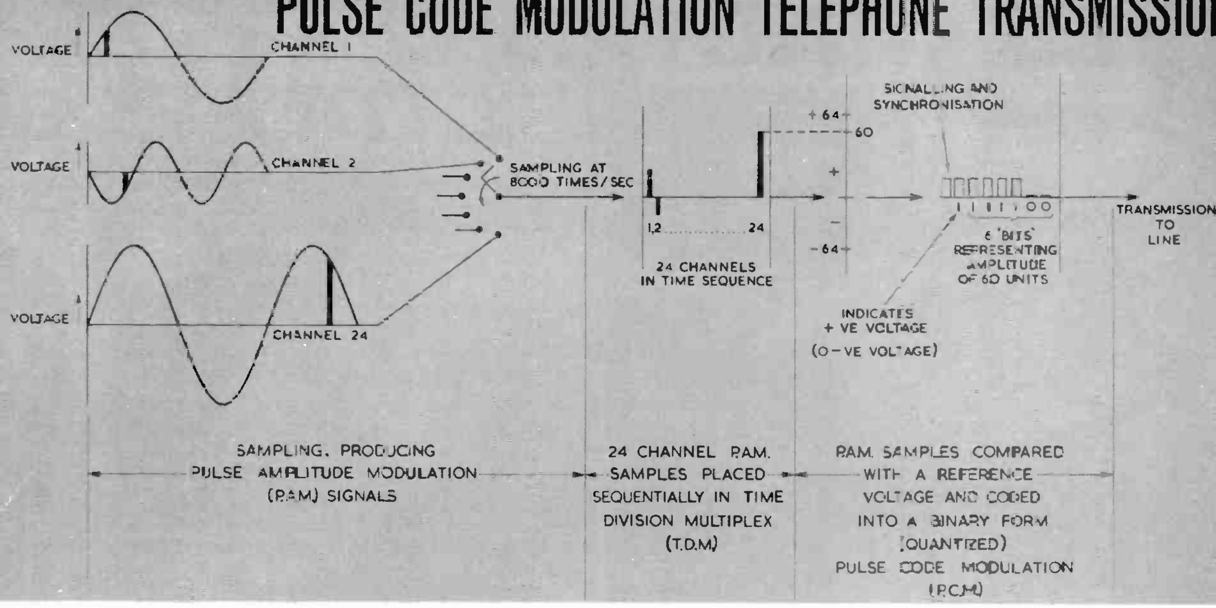
As a result, images are projected on to mirrors within the switch through four inlets. The mirrors move very rapidly in a vertical plane enabling "on-the-air" cuts between any of the film or slide inputs in 0·05 second. As the plane does not alter during the switchover process, the optical image remains stationary, and as fully silvered mirrors are employed there is little light loss through the system.

Two new slide projectors are used individually; slide changing "on-the-air" can be achieved by switching between projectors using the mirrors in the multiplexer.

Owing to the variation of colour fidelity of different films when used in television, it is desirable to correct for film dye inefficiencies, particularly when the film is inserted into a live camera production. This is achieved in the new telecine system electronically.

The photograph below shows the colour television telecine equipment. On the left is the 35mm projector, on the far side a 16mm projector, and on the right is a dual slide projection unit. The colour camera and optical switching system is in the centre.

PULSE CODE MODULATION TELEPHONE TRANSMISSION



FOLLOWING many years of development and field trials, the Post Office has now officially inaugurated the p.c.m. telephone transmission technique in London and will quickly follow up with similar systems in provincial areas.

Pulse code modulation was first conceived in principle by A. H. Reeves, Senior Scientist with Standard Telephones and Cables, in 1938, following experiments on digital transmission techniques. The idea was slow to become commercially viable because of the shortcomings of valve components at the time. The advanced development of high speed switching transistors and digital integrated circuits, which we have today, provides the ideal means to solving these early problems.

The principle of the system lies in breaking down the speech signal into several narrow band pulses with amplitudes varying in proportion to this signal. By transmitting a limited number of pulses it is possible to use the time between pulses to inject pulse codes from another channel on the same transmission wires. In fact, the new Post Office system uses four wires to transmit 24 speech channels simultaneously.


Test measurements on a p.c.m. encoder card at the S.T.C. Transmission Group factory, Basildon. The card is mounted on an extending outrigger

The pulse rate has to be very high to achieve good intelligible speech reproduction on all channels in this case 8,000 pulses per second. The diagram shows how the speech is processed through sampling, pulse amplitude modulation, time division multiplexing, and coding in binary form. The receiving terminal has to decode the transmission signal in reverse order before the message can be understood by the receiver.

Although the system can be used over any length of time, its initial importance is over long distance routes, where present demand for transmission time exceeds the supply of multichannel cables. Repeaters are used every 2,000 yds to maintain the quality of speech code. The long term cost of installing p.c.m. is said to be "competitive by comparison with the supply and installation of additional cables for the conventional system".

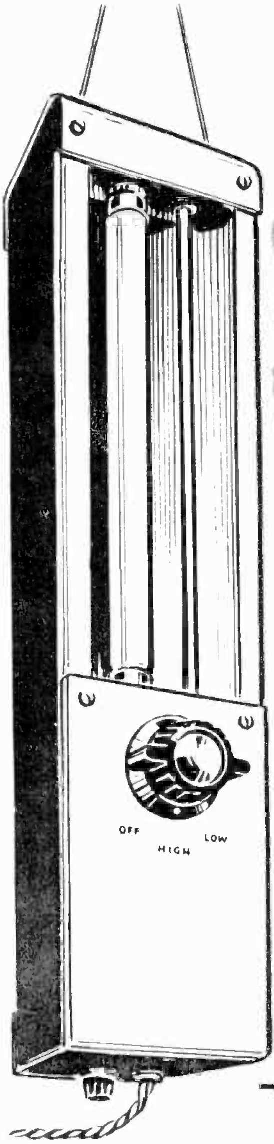
Floor space in exchanges is also at a premium; the new system would occupy a fraction of the space required for the older automatic electromechanical equipment.

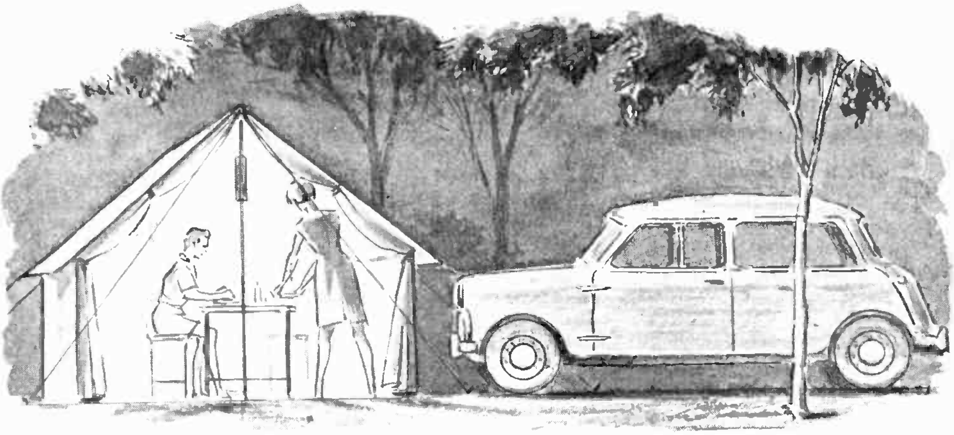
Initial contracts have been placed with S.T.C. and G.E.C. for 72 p.c.m. groups, with the possibility of a further 160 groups later this year. These will serve outlying country areas around suburbia, including Redhill, Caterham, Esher, Weybridge, Ashford, Walton-on-Thames, Staines, Uxbridge, Watford, Potters Bar, and Welwyn Garden City.

An underground repeater on the p.c.m. link between Reading, Maidenhead, and Slough

PRACTICAL ELECTRONICS

next month





Fluorescent Lighting for Campers

Next month, PRACTICAL ELECTRONICS includes full details of a specially designed lighting unit bringing all the convenience of home lighting to campers. All you need is a 12V battery to run this transistorised unit, which is incorporated in the casing of a 9in fluorescent tube. Simple to build, and costs little to run—a boon for all readers who enjoy camping holidays and weekends.

Other constructional features

IMPACT COUNTER Wide range of applications wherever small moving objects need to be recorded.

RHYTHMIC SOUND EFFECTS UNIT Coupled to a suitable audio source, enables a host of fascinating sounds to be created.

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SEMICONDUCTOR BASICS

3—TRANSISTORS

By G. J. KING

PROBABLY the best known semiconductor device is the transistor, which is now undertaking the many and varied jobs that valves have so far handled in most branches of electronics. The transistor can be used as an electronic switch, an amplifier, oscillator, detector, or modulator; it can, in fact, do almost anything that the thermionic valve can do—often more efficiently.

The very first transistors were made rather like the point contact diode (described last month), but with two cat's whiskers instead of one pressing upon a piece of *n*-type semiconductor crystal. In the early days of radio the author recalls experimenting with a crystal detector in an endeavour to get better results from a crystal set. Batteries were connected to the crystal while two cat's whiskers were arranged to make contact with the crystal of galena, which was popular with crystal set enthusiasts.

There was not much improvement in reception, but with one combination of connections the circuit could be persuaded to oscillate at critical settings of the two cat's whiskers. In retrospect, it seems that the transistor effect might unwittingly have been discovered, but little importance was attached by the author to the oscillating crystal set at that time.

Later, however, when point contact transistors were announced, further experiments were undertaken to simulate the early effect by some microscopic work on point contact diodes—fitting two cat's whiskers to these. The basic transistor effect was then demonstrated more scientifically.

CONSTRUCTION

Before going on to investigate this effect, let us see how transistors are made today.

The point contact technique is rarely employed now, and more sophisticated techniques have been evolved to obtain the two basic transistor junctions. One technique is a development of the junction diode, where three regions of suitably doped crystal are arranged to form a sandwich, as shown in Fig. 3.1a.

When the outer regions are *n*-type and the inner *p*-type, the transistor is called an *npn* type. Conversely, a *pnp* transistor has two *p*-type regions sandwiching an *n*-type region. The *pnp* and *npn* transistor symbols are given in Fig. 3.1b.

JUNCTION TRANSISTOR

This basic mode of construction forms the junction transistor and it is easier to understand the working of a transistor based on this construction. There are usually three external transistor connections, one joined to the inner region and one joined to each of the two outer regions. The inner region is called the "base" and the outer regions "emitter" and "collector". These are shown in Fig. 3.1a. Consequently, two junctions exist within the transistor's construction.

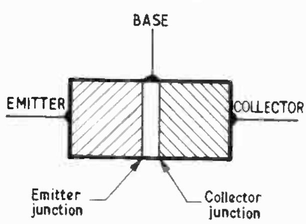
Fig. 3.1a also shows these two junctions, the one on the emitter side of the base being the emitter junction and that on the collector side—the collector junction. The base is thus common to both junctions. In effect, there are two junction diodes connected in series opposition, with the base being the common element of each one.

Fig. 3.1c shows the equivalent circuit symbol in diode form. The two junctions exhibit exactly the same effects as two separate junction diodes joined back to back. That is, they pass a high current in the forward direction and a low current in the reverse direction (see Part 2 last month).

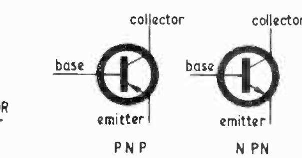
Fig. 3.2 represents a *pnp* transistor, with the collector junction biased for reverse (high resistance) conduction and the emitter junction for forward conduction. Thus, the collector is negative with respect to the base and the emitter positive with respect to the base.

The transistor effect is produced, however, because the base is common to both junctions and because it is a very thin layer of semiconductor material compared with the end layers.

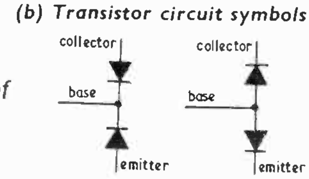
Due to the forward biasing of the emitter junction, (i.e. battery positive to emitter), holes flow from the *p*-type emitter into the base and the potential barrier is overcome. Some of the holes entering the base recombine with the electrons already present there, but many of the holes pass through the base region, because it is very thin, and then come under the influence of the negatively biased collector, thereby creating the collector current.



(a) Block representation of the construction



(b) Transistor circuit symbols



(c) Theoretical equivalents in diode form

Fig. 3.1. Basic junction transistor

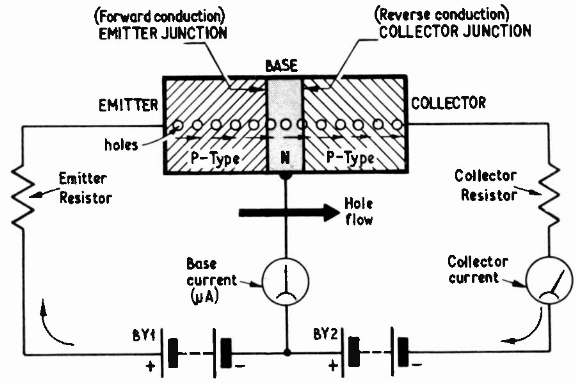


Fig. 3.2. Basic action of a correctly biased pnp transistor

Although the collector junction is biased for reverse conduction, from *n* (base) to *p* (collector) a high collector current flows due to the diffusion of holes through the base region from the emitter junction. Therefore, the collector current will rise as the current in the emitter junction is increased. It must be noted, however, that current from the emitter junction flows in the base circuit, so it is generally considered to be this current (base current or base bias) which controls the collector current.

An *npn* transistor works in exactly the same way, but electrons instead of holes constitute the current carriers. Electrons, for instance, flow from the *n*-type emitter into the *p*-type base due to forward biasing of the emitter junction. These are attracted into the collector circuit by this *n*-type region being connected to a positive source. Note, therefore, that the bias voltage polarities are reversed on *npn* transistors.

AMPLIFICATION

So far so good, but how does a transistor amplify? We know that a semiconductor junction biased for reverse conduction is equivalent to a high resistance element (low current for a given applied voltage) and that a junction biased for forward conduction is equivalent to a low resistance element (high current for a given applied voltage).

From Ohm's law the power yielded by a given current is greater in a high resistance circuit than in a low resistance one. For instance, the power in watts (*P*) is equal to the current in amperes (*I*) squared multiplied by the resistance in ohms (*R*). Thus, since the emitter-to-collector current is substantially the same through the transistor, while the emitter junction is of low resistance (forward biased) and the collector junction high resistance (reverse biased), the transistor yields a power gain.

However, the current gain in the basic configuration of Fig. 3.2 is less than unity, typically about 0·98. This is because some of the holes which represent the emitter current recombine with the electrons in the *n*-type base region. In other words, not all of the emitter current carriers end up as collector current. This remaining current represents the actual base current of the transistor.

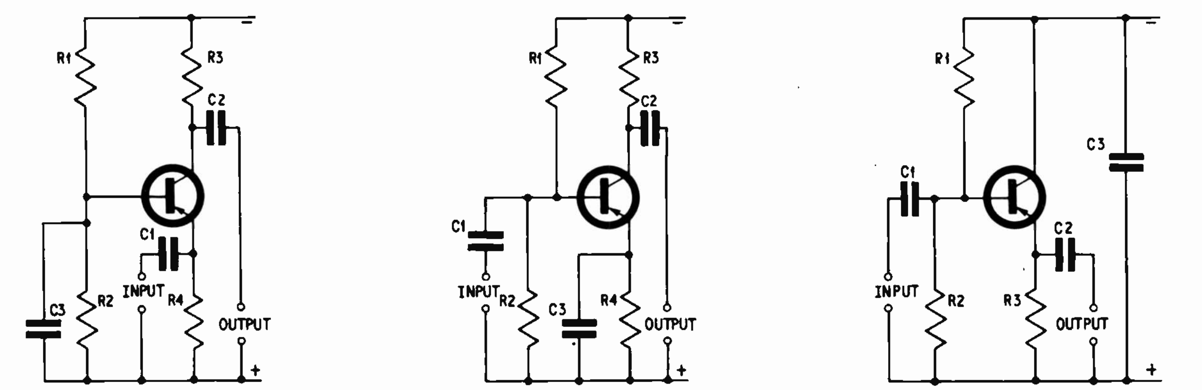
The emitter current is thus equal to the collector current *plus* the base current. If the emitter current is, say, 1mA, the collector current might well be about 0·98mA, leaving 20μA base current. The configuration shown in Fig. 3.2 is called "common-base" because the base circuit is common to both emitter and collector circuits. The figures given above illustrate how the currents combine but, in fact, a very much smaller portion of the emitter current is lost through leakage.

Typical values of emitter-to-base and collector-to-base resistance are 500 ohms and 1 megohm respectively, these representing a resistance gain of 2,000 times, producing power and voltage gains in the order of 1,900 and 1,960 times respectively.

PRACTICAL CIRCUITS

In practical circuits a single battery serves both junctions, as shown in Fig. 3.3. These circuits are all based on *pnp* transistors, but they would have the same configuration with *npn* devices except that the supply polarity would be reversed.

Resistors R1 and R2 in all circuits form a potential divider across the supply to bias the emitter junction for a small forward conduction, R3 is the load, C1 the input coupling capacitor, and C2 the output coupling capacitor. R4 in Fig. 3a is the emitter resistor across which the input signal is applied, while R4 in Fig. 3.3b is used essentially to combat any increases in collector current with temperature rise of the junction.



(a) Common base
Input impedance low
Output impedance high
Current gain less than unity
Voltage gain high
Phase shift zero

(b) Common emitter
Input impedance medium
Output impedance medium
Current gain high
Voltage gain high
Phase shift 180 degrees

(c) Common collector
Input impedance high
Output impedance low
Current gain high
Voltage gain less than unity
Phase shift zero

Fig. 3.3. Transistor circuit configurations

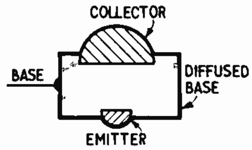


Fig. 3.4. One form of diffused alloy transistor construction

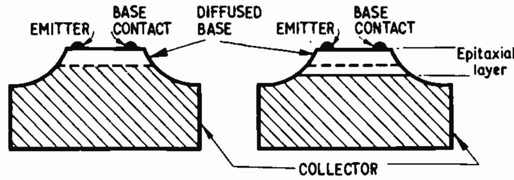


Fig. 3.6. Basic development of (a) mesa and (b) epitaxial transistors

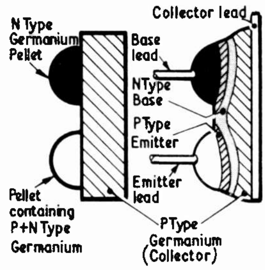


Fig. 3.5. Basic construction of alloy diffused transistor

To avoid the a.c. signal being partly lost through R4 (Fig. 3.3b), a capacitor C3 is connected across R4 to make R4 appear as a short circuit to the a.c. signal. C3 has no effect on the d.c. voltage. The action of C3 in the other two circuits is similar. In (b) and (c) the signal current is superimposed upon the standing base current, while in (a) it is superimposed upon the emitter current.

The basic d.c. conditions of the transistors are virtually the same for amplification in all three configurations, but the variations in input and output connections have some effect on the impedance (a.c. resistance) to the signal itself. The differing impedances, gains, and phase shift are shown in each case.

TEMPERATURE EFFECTS

Previous articles in this series revealed the falling resistivity of semiconductor materials with rise in temperature. This can prove disastrous in some transistor circuits, especially amplifiers, and some means must be used to combat the effect, otherwise the junction properties could be destroyed. Metal heat sinks are used on large diodes and power transistors to dissipate the junction heat, but with smaller devices the emitter resistor, in conjunction with the base potential divider is set to a value which would control the operating d.c. voltages of the transistor.

Since all the collector current flows in the emitter resistor, an increase in this current would cause an increasing voltage drop across the emitter resistor. Because this voltage is of a polarity which counters the base voltage (for instance, reduces the voltage across the base-emitter junction), the forward current in the base-emitter junction is automatically pulled down as the collector current rises. This, in turn, reduces the collector current giving d.c. stabilisation. Other methods are employed but they all work on the same principle of d.c. feedback over one, two or more direct-coupled stages.

ALLOY DIFFUSED TECHNIQUE

A major problem with the junction transistor is that the thickness of the base region limits its efficiency at very high frequencies; it is impractical to reduce the thickness to permit operation much above 15MHz. This shortcoming has led to the development of the alloy diffused technique; devices based on this principle can work up to at least 1,000MHz.

There have been various developments along these lines. One design uses a wafer of *p*-type material which eventually forms the collector of a *pnp* transistor. Two metal pellets forming the emitter and base are then placed side-by-side on the wafer, the former embodying both *n*- and *p*-type impurities and the latter *n*-type only. This set-up is heated to cause the pellets to diffuse into the collector wafer.

Because the *n*-type impurity diffuses slowly compared with the *p*-type, a very thin base layer (about 0·005mm) is developed between the *p*-type collector and the *p*-type emitter pellet. This in itself solves the problem of the relatively thick base region of the junction transistor but, in addition, the holes (in the *pnp* device) from the emitter are actually accelerated through the base region, owing to the non-uniform distribution of the *n*-type impurity in this region. This is brought about by the *p*-type impurity of the emitter diffusing into the start of the base region. This type of construction is often called a "drift field" transistor.

The technique is also used in some basic junction transistors, where the collector and emitter are in the form of pellets on either side of the diffused base crystal, as shown in Fig. 3.4. Fig. 3.5 shows the basic construction of an alloy diffused transistor.

MESA AND PLANAR TECHNIQUES

Different techniques are used in the construction of mesa and planar transistors. In these transistors the original semiconductor wafer serves as the collector, with the base region diffused into the wafer. In this case, the emitter region is diffused (or alloyed) into the base region. A mesa (flat-topped peak) is then etched to minimise the area at the collector junction. Mesa devices can work at high frequencies, they are capable of handling high powers and they are extremely rugged.

Mesa and planar transistors involve two primary constructional activities. The planar structure is created by the employment of diffusion masking materials in conjunction with photolithographic techniques, allowing the junctions to be protected by a non-active layer. A separate collector contact diffusion (often called epitaxial growth) is used to minimise the collector series resistance. The basic build-up of mesa and epitaxial transistors are shown in Fig. 6.

SWITCHING

Having shown how a transistor amplifies an a.c. signal, consider now how a transistor can serve as a switch, important in many electronic applications. It has been established that a transistor allows the control of a relatively large collector current from a very much smaller base current. Indeed, at zero base current the collector current will consist solely of collector leakage current; an increase of base current causes an increase in collector current.

The transistor is said to have "bottomed" when no further rise in collector current is possible with further increase in base current. Most of the supply voltage is then developed across the collector load. The transistor is said to be "cut off" when there is no "real" collector current due to zero base current. In this case, most of the supply voltage appears across the transistor.

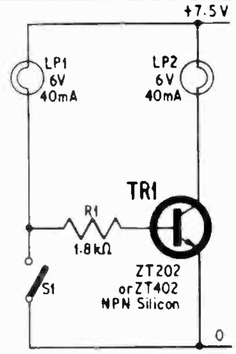


Fig. 3.7. Basic switching circuit

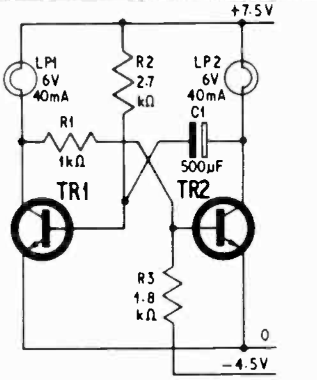


Fig. 3.8. Monostable switching circuit

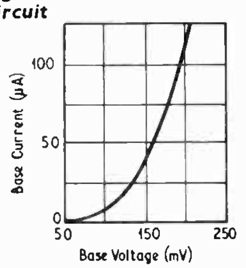


Fig. 3.9a. Input characteristic of a common emitter stage

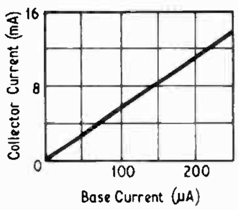


Fig. 3.9b. Transfer characteristic of a common emitter stage

These two actions constitute the switching effect.

The principle is well illustrated in Fig. 3.7. Here a small 6V 40mA bulb LP2 is connected as the collector load, while switch S1 controls the base current. When S1 is closed, the base is connected to the emitter; then there is no base current and the collector bulb is extinguished. Bulb LP1 in the base circuit then lights up due to the completed path to the battery via switch S1. When S1 is open, a small base current flows in R1 and LP1, via the positive line, but LP1 will not light because this current is too small. However, it switches the transistor on, thereby lighting LP2.

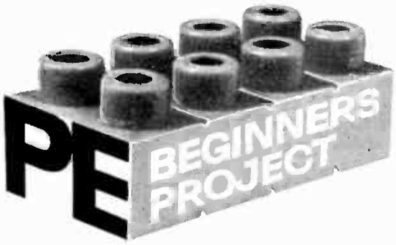
By using two transistors, as in Fig. 3.8, a "monostable" switching circuit is created. This has one state whereby TR1 is switched on while TR2 is off, and one state with TR1 off and TR1 on. In the stable state, TR1 is switched on (and held on) by its base current flowing through R2. This causes C1 to charge almost to full supply potential. TR2 is off because its base is held negative, via R3 (note the use of *npn* transistors).

When TR2 collector is shorted momentarily to its emitter, TR1 base goes negative, which switches this transistor off, resulting in a rise of TR1 collector voltage. This is communicated to TR2 base, thereby switching this transistor on, a condition which remains until C1 discharges through R2. The action of the circuit is clearly indicated by the switching on and off of the bulbs in the collector leads.

To conclude this article Fig. 3.9 gives two curves of basic transistor action. Fig. 3.9a shows how the base current rises with increase in base voltage (which is the input characteristic in the common-emitter configuration); Fig. 3.9b shows the transfer characteristic in the same configuration, and reveals clearly how the collector current rises as the base current is increased.

Next month's article will deal with the thermistor, an entirely different kind of semiconductor.

A Simple AUDIO



ALL the energy for working the headphones of last month's crystal set comes from the radio signal rectified by the diode, and as it is the aerial that abstracts this signal from the passing radio wave, the better the aerial, the louder the signal heard in the 'phones. The earth, too, is very important with crystal sets because the aerial signal is relative to earth, and there must be a return path. On mains sets the earth does not count so much since the set is earthed (albeit, inefficiently) by the connected mains supply. Portables with ferrite rod aerials work in a different way, again. If the crystal set is not giving very good reception, therefore, make sure that the earth is efficient, as well as the aerial.

However, if the aerial is too long it tends to damp the tuned circuit, giving flat tuning, known as poor selectivity. Some improvement is possible under this condition by adding a 100pF capacitor between the aerial and terminal 3. At best, though, the selectivity of any crystal set is rather poor, and the local station can generally be heard over, at least, a quarter of the rotation of the tuning capacitor; but since a crystal set is for local station reception this does not matter unduly.

IMPROVING SELECTIVITY

Selectivity can only be improved by increasing the number of complete tuned circuits and arranging these in so-called "bandpass" mode with ganged tuning

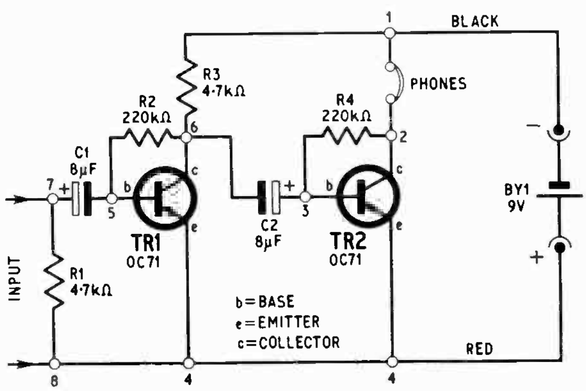
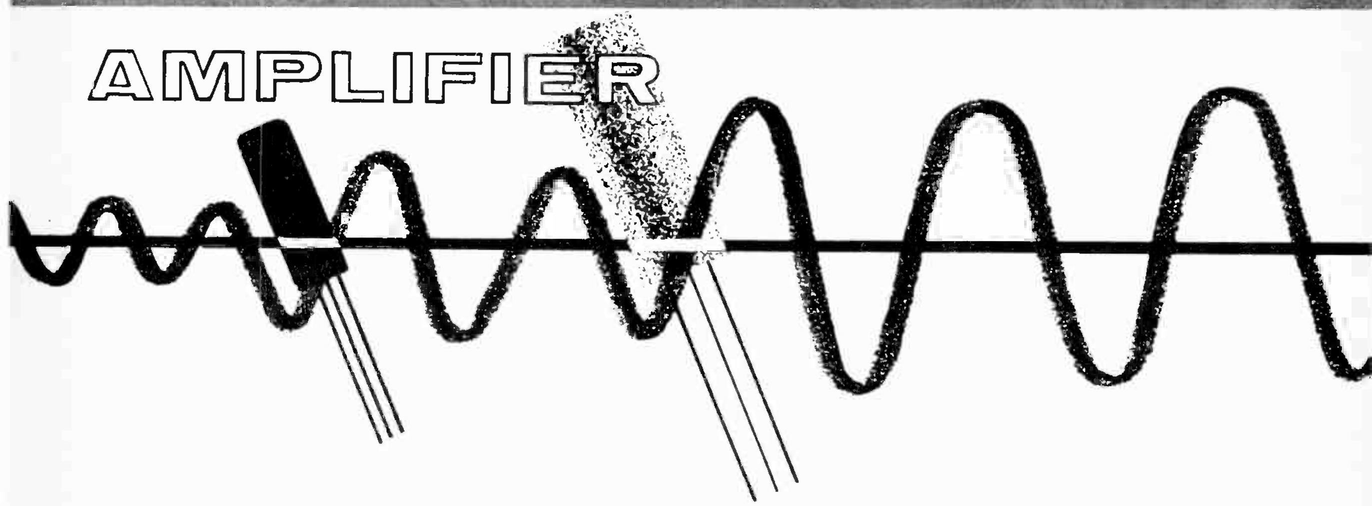


Fig. 1. Circuit diagram of the simple audio amplifier. The numbered circles represent the terminal strip connections

AMPLIFIER



capacitors. A transistor (or valve) amplifier *in front* of the diode and its tuned circuit makes it possible easily to multiply on the tuned circuits with a consequent improvement both in sensitivity and selectivity. This is called a radio-frequency (r.f.) amplifier because it amplifies the signal delivered by the aerial before it is passed on to the detector diode.

For this month's constructional item it was in the balance whether to illustrate the amplifying capabilities of a transistor in terms of r.f. or a.f. (audio-frequency) signal. The a.f. signal, as present across the load of the diode detector, was eventually decided upon because it was felt that the majority of simple crystal set builders would prefer a more comfortable volume of sound from the headphones of the local station, rather than more sharply-tuned programmes from several stations. The simple a.f. amplifier which forms this month's constructional feature was thus developed.

TWO STAGE A.F. AMPLIFIER

This is very basic and easy to build and the extra volume given to the diode signal is significant. Indeed, if a fair aerial and a good earth are used, and a series capacitor connected to the aerial, it will be possible to listen to a few Continental stations which fail to produce an output from the diode alone. This a.f. amplifier also has other useful applications—reference to these will be made in due course as this series progresses.

The circuit diagram of this amplifier appears in Fig. 1. Two germanium *pnp* transistors are set-up in common-emitter mode, and the output from the collector of the first transistor TR1 is capacitively coupled to the base of the second one, TR2. Base bias is provided separately to each transistor by the 220 kilohm resistors R2, R4. The base current flowing is almost equal to the collector voltage divided by the base resistance (220 kilohm). A small degree of d.c. stabilisation is given by this kind of circuit, since should the collector current tend to rise due to thermal effects, the collector voltage will fall and thus reduce the base current.

The 4·7 kilohm resistor R1 across the input lead provides the load for the diode detector when the headphones are removed. The circuit as a whole takes only about 1mA, so a small 9 volt battery will give many months of service provided it is always disconnected after use.

CONSTRUCTION

The construction is quite simple and follows the same general procedure as described last month (see *Crystal Receiver*, page 51).

Careful reading of the text and close study of the illustrations should be undertaken at each stage of construction, and all connections should be carefully rechecked before connecting the battery.

The circuit diagram, Fig. 1, has numbered circles which represent the terminal strip connections, which are also indicated on the wiring diagram, Fig. 2.

An 8-way plastics terminal block is required and this can be cut from a 12-way strip or can be the remaining portion from the block used last month.

The first stage is to mount all components on the terminal block before screwing it down on the baseboard. The components should be mounted in the order of the terminal numbering, e.g. R3 between terminal 1 and 6,

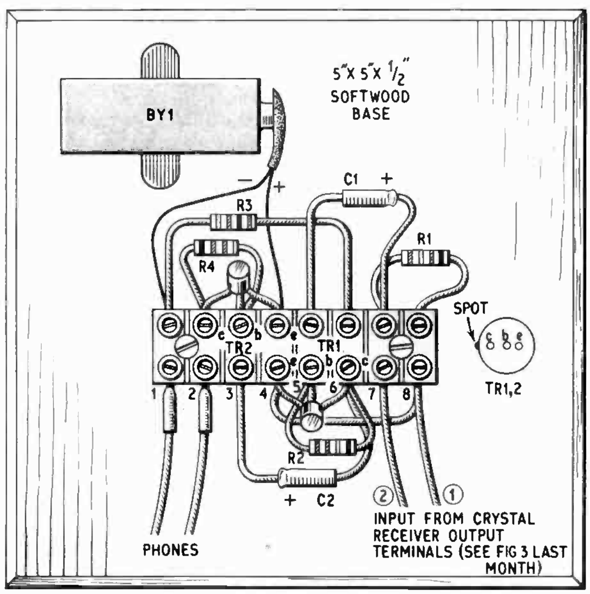
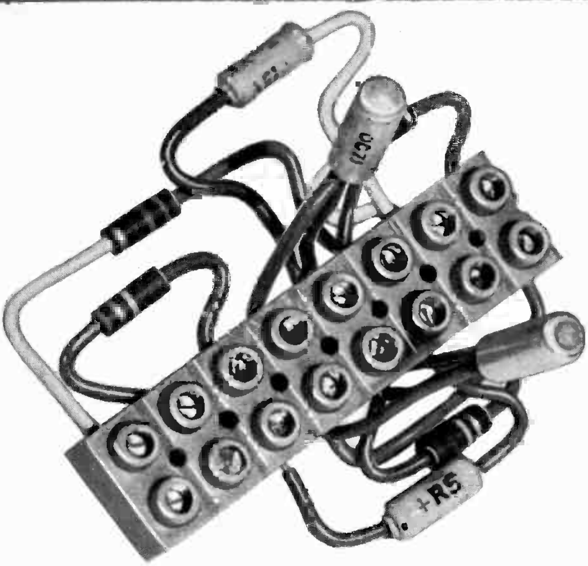
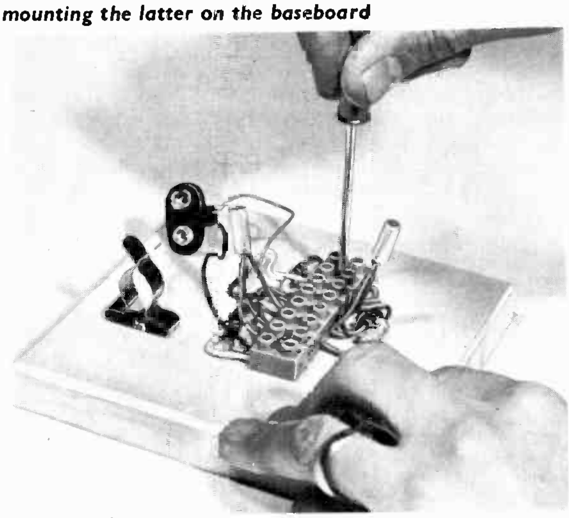


Fig. 2. Constructional and wiring details. Note particularly the transistor connections—refer to key diagrams given above



Showing all components wired to the terminal strip prior to mounting the latter on the baseboard



Mounting plastics terminal strip on baseboard

The completed audio amplifier. The input and phones are not shown connected

COMPONENTS . . .

Resistors
R1 4·7kΩ
R2 220kΩ
R3 4·7kΩ
R4 220kΩ

Capacitors
C1 8μF elect. 12V
C2 8μF elect. 12V

Transistors
TR1 OC71 (Mullard)
TR2 OC71 (Mullard)

Miscellaneous
BY1 9 volt PP3 battery (Every Ready)
One 8-way plastics terminal strip (see text)
Wooden baseboard 5in × 5in × $\frac{1}{2}$in
One spring clip for holding battery
Woodscrews for mounting terminal strip and spring clip
One moulded battery clip with leads (Henry's Radio)
Plastic covered, single core copper wire (Woolworths)
Plastic sleeving

TOTAL COST £1 0s 0d including battery

R4 between 2 and 3, C2 between 3 and 6, etc. Note that a link wire is needed between terminals 4 and 8.

Particular care should be taken to ensure that the transistor leads are wired to the correct terminals, as they can be damaged if wired incorrectly.

Once all the components have been mounted the battery leads should be inserted between terminal 1 (black) and 4 (red). The next step is to mount the terminal strip on a 5in × 5in × $\frac{1}{2}$in softwood baseboard. It is a good idea to check the terminal strip wiring before mounting on the baseboard with two $\frac{3}{4}$in No. 4 countersunk wood screws.

Finally, the spring clip for the battery should be screwed to the baseboard as indicated in Fig. 2 by a $\frac{3}{4}$in No. 4 countersunk wood screw.

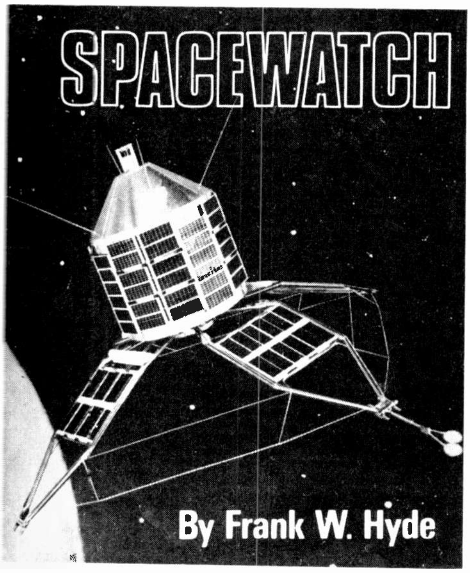
All that remains is to insert the battery BY1 in the clip and connect the battery to the connectors. No switch is shown in the circuit but the battery connectors act as a suitable on/off switch.

To connect the Crystal Receiver to the Amplifier, the phones are removed from the receiver and inserted in terminals 1 and 2 (see Fig. 2). Two wires are taken from the receiver output terminals 1 and 2 and inserted in terminals 7 and 8 of the amplifier. It is important that the wire from terminal 1 of the receiver goes to terminal 8 of the amplifier and that the wire from terminal 2 of the receiver goes to terminal 7 of the amplifier.

OTHER USES FOR THE AMPLIFIER

This two stage audio amplifier has many other applications. Some of these will be described in future articles.

Next month: An electronic thermometer



SOFT LANDING

Venus IV and *Mariner V* launched respectively by the Soviet Union and the U.S.A. both achieved their objectives. *Venus IV* however proved to be the more ambitious and spectacular. Whilst the United States were content to repeat the previous *Mariner II* programme with a much closer approach to the planet, the Soviet Union repeated their previous programme but this time accomplished a soft landing.

The information so far released relates to *Venus IV*. During the 129 day journey the spacecraft was regularly interrogated as to its own condition and the monitoring of the space environment. Details of this are not yet released. The soft-landing capsule was ejected from the main body at the fringe of the planet's atmosphere. The capsule was a sphere equipped with a heat shield designed to protect the unit from the heat of entry to the point where a parachute could be opened. The time of free fall was some 90 minutes and during this period regular signals were picked up. The long time of descent is said to have been due partly to the fact that during the fall there were times when the braking effects were such that part of the time the unit was suspended in the Venusian atmosphere.

The parachute was jettisoned upon landing and to ensure that the aerials were correctly orientated towards the earth, the payload was so distributed that the capsule would regain its correct aspect however it might fall. It was designed also not to sink in water or benzene and as an additional safeguard should there be an even lighter liquid there was a "sugar lock". This would have dissolved and released a spring aerial to the surface.

There were a number of points of difference between the new data and that of *Mariner II* when it passed in 1962. The results then given as to the temperature was some 600 degrees K. The Soviet results show that the variations are between 320 degrees K and 520 degrees K. The atmospheric pressures varied between 1 and 15 atmospheres whereas *Mariner II* gave figures varying between 5 to 50 atmospheres.

When the American results are released there may be other points of comparison.

RESCUE IN SPACE

Spacecraft *Surveyor V* will have a special place in space history as the vehicle that was rescued in space. The launch was perfect and some 16 hours later the staff at the operations unit were making ready for the mid-course manoeuvre. At the correct time the vernier engines were fired. Shorly after this the telemetry reported that the helium gas was leaking. The gas is used to force the propellant into the vernier engines. The mid-course manoeuvre had been completed successfully but the pressure of the helium was falling rapidly. The spacecraft was then more than 100,000 miles on its way to the moon.

Groups of engineers covering all the techniques went into action and by the following day set up special tests using the next *Surveyor* which was being prepared for launch.

It was established that if certain changes were made in the order of firing the vernier rockets, there could be a rescue. The vernier rockets have a special duty in the last stages of the flight to enable the soft landing to take place. A command tape was prepared and when the altitude of the craft was indicated at 60 miles above the surface the command commenced. The retro rockets were delayed by 12 seconds at a height of 150,000ft—a little more than half the normal point for this action. The danger existed that if the retro burn-out and jettison did not take place in time for the attitude to be stabilised the craft could land and take-off again. However the technique adopted enabled burn-out to occur at some 4,500ft. The speed of descent was about 60 miles per hour at this point. The verniers now continued to burn to a point 14ft above the surface and touchdown was accomplished safely.

It is significant that prediction of the results of certain courses of action are possible during a crisis period, and must be looked upon as an important part of the knowhow of extra terrestrial travel.

The rewards that have been reaped from the landing of *Surveyor V* have not been completely assessed and only a certain amount of information is available, nevertheless certain important conclusions have been aired.

MOON RESEMBLES EARTH

It has been shown that the surface of the moon is similar in chemical composition to that of the earth. The elements which are most abundant on earth are the most abundant on the moon and the rocks mostly resemble volcanic rocks such as are seen in the Deccan Plateau of India and the Giant's Causeway in Ireland.

Though this does not bring us any nearer to knowledge of the moon's origin it does dispose of any ideas that there were chemicals not known on earth. It is safe to say that the astronauts will tread safely on the surface and that there will be no lunar radiation of a lethal nature to deal with.

LUNAR WORK PLAN

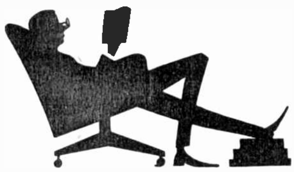
The work plan for the men who do land has been disclosed in outline. The first task will be the deployment of instruments which will transmit rudimentary data about the structure of the surface, about the atmosphere, and the temperature gradients. This would represent the first stage after which more sophisticated instruments would be landed by unmanned craft to be followed later by equipment and a shelter to sustain two astronauts for about a fortnight.

During the brief stay that is made there will be great activity, for the astronauts will have to set up a central relay station linked with several satellite stations. More than 30 different sites will be needed for instruments including an optical telescope and the cables linking the sites. The system will have to be tested before the astronauts leave. Power supplies will come from thermoelectric generators.

The central station will be on command from the earth and will transmit to and receive from the satellite stations data which is passed back to earth. This data will be extensive and will concern optical observations, examination of the exterior and interior structure of the moon. Volcanic eruptions and moonquakes will be recorded and also the tidal fluctuations due to the pull of the earth. Electrical and magnetic fields will be measured as well as resisitivity of the surface and the temperature gradient of the crust. It should be possible for such a work unit to function for up to two years without attention.

NEW X-RAY STAR

Termed the CRUX XR-I by the joint directors of the project Prof. K. G. McCracken and Dr. A. G. Fenton, this object was the brightest of about 25 discovered which emit X-rays. The equipment used on this project was a group of proportional counters installed behind portholes in the walls of *Skylark* rockets fired from Woomera.



BOOK REVIEWS

PRINCIPLES OF TELEVISION RECEPTION

By W. Wharton and D. Howarth
Published by Sir Isaac Pitman & Sons Ltd.
296 pages, 8¾in × 5½in.

THIS is an eminently readable and excellently produced book which will satisfy a real need by practising engineers or aspiring technicians to have in one book concise accounts of circuits and techniques associated with 625 line u.h.f. transmissions and of colour television systems.

With the advent of transistorised television receivers, the authors, both members of the BBC Engineering Division, have thoughtfully provided parallel descriptions of both solid state and the equivalent valve circuit when analysing sections of the receiver.

From the brief introductory chapter on picture origination equipment and general information on transmission, the book goes on to describe the basic principles of monochrome and colour television together with an informative survey of receiver design techniques. Apart from a chapter on circuit and modulation theory the book is broadly non-mathematical, but for those who would wish to look for more than this succinct but informative survey has to offer an exhaustive 18 page bibliography is provided.

Two appendices, one on colorimetry and the other on aerials and feeders provide useful references.

G.M.H.

ELECTRIC-WIRING DIAGRAMS

By R. H. Ladley, C.Eng.M.I.E.E., M.I.Nuc.E.
Published by Sir Isaac Pitman & Sons Ltd.
313 pages, 7¼in × 5in. Price 25s.

EVERY handy man has a nodding acquaintance, at least, with electrical wiring systems. The electronically minded will certainly have a natural affinity to the closely allied subject of lighting and power supply.

Despite any such familiarity it is well to stress at this juncture that the installation of wiring for connection to electricity mains should only be carried out by competent electricians or electrical engineers.

Apart from technical knowledge and practical expertise, it is essential to be well aware of the relevant regulations. Fortunately the essential information is available for student, professional, and keen amateur alike in one pocket sized volume. The latest edition of Electric-Wiring Diagrams is fully up to date with the 14th edition of the I.E.E. Wiring Regulations. The pertinent regulations are set out at the commencement of sections dealing with Mains Fuses, Switchgear and Meters; Distribution Circuits; and Motor Circuits. In all there are 12 sections covering all kinds of domestic, industrial, and amenity requirements for lighting and power. Wiring diagrams total 351. Every conceivable requirement seems to have been catered for.

Ten complete diagrams for cookers are included. Also wiring diagrams for alarm indicating systems and telephone systems. Ex-mains, there is a section devoted to motor vehicle circuits; this contains complete wiring diagrams for 20 different cars.

J.V.

ELECTRONICS POCKET BOOK

Edited by J. P. Hawker and J. A. Reddihough
Published by George Newnes Ltd.
306 pages, 7½in × 5in. Price 21s.

THIS is the 2nd edition of a book written for newcomers to electronics and for those who may have a certain knowledge of electronics—but limited to the traditional fields of radio and television.

Such a purpose seems fully justified. There have long been many popular works of reference dealing with communications; on the other hand the widespread use of electronics in industrial control systems, computers, and other less orthodox applications has created more recently a real demand for a relatively simple book to suit the reader of limited technical experience.

The subject range is immense and there are obvious limitations in a "pocket" book. The editors and contributors have faced a difficult task in selecting and condensing much information into such a space; however, the kind of reader they have in mind is likely to agree that they have been very successful. The text is direct and to the point, as indeed a reference book should be. Concise but satisfactory basic explanations are well supported by circuit diagrams, waveshape patterns, and schematic diagrams which well illustrate the function of various classic electronic circuits and a variety of active devices, including many different transducers.

In the chapters dealing with fundamental circuit elements and amplifier circuits, thermionic and semiconductor devices receive about equal treatment. As we reach pulse, switching, and logic circuits, the semiconductor assumes the larger role in these pages as in real life.

Subjects covered by other chapters include: an outline of electronic systems as used in industry for controlling machinery, welding apparatus, and process counting and timing; computers; and microelectronics. Some useful advice is given relating to the installation and maintenance of electronic equipment in general. The final chapter contains formulae and data.

J.V.

SOLUTION TO LAST MONTH'S CROSSWORD

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I	M	P	E	D	A	N	C	E	A	R	M	
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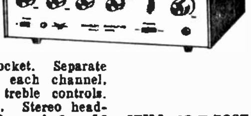

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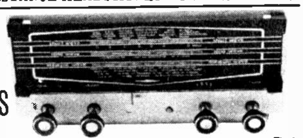

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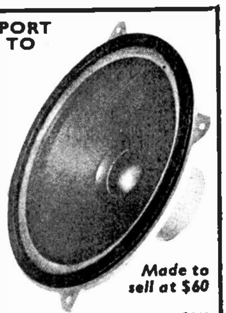

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Transistor Amplifier DESIGN

1 BIASING ARRANGEMENTS

By A. Foord

AUDIO AMPLIFIER circuits can be simple or complex depending on what sort of performance is required. The purpose of this short series of articles is to show how to go about designing transistor amplifier circuits. Although it may not be exhaustive, it deals with many of the problems that frequently confront the designer. The physics of transistor operation are not included since this aspect is not always of prime importance in designing circuits. The intention is to concentrate on the application of transistors to audio amplification. Most of the examples given use *pnp* types, more for convenience of explanation rather than any other reason. But this does not mean that the principles described apply *only* to *pnp* types. Indeed, some examples require the use of both *pnp* and *npn* types.

Part 1 this month outlines the principles of various biasing arrangements for small signal stages, while later parts will look into power amplifier stages, special circuits, and negative feedback applied to several kinds of amplifier configuration.

IN biasing simple transistor amplifier stages it is often difficult to decide on the method of biasing to use—a simple resistor from base to supply, the self bias method, or the conventional potential divider method. The advantages and disadvantages of these commonly used methods are discussed here, with practical examples shown in the circuit diagrams.

BASE RESISTOR

The simplest arrangement is shown in Fig. 1.1 where the base is connected by a single resistor to the supply line.

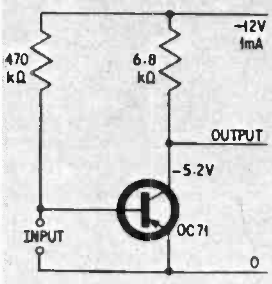

Fig. 1.1. The simplest bias arrangement possible

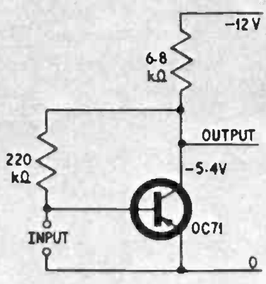

Fig. 1.2. An improved arrangement to compensate for gain variations

For the values shown the collector voltage will be −5·2V for a transistor gain of 40. However the current gain of a particular transistor type is by no means fixed, and can vary over a wide range from specimen to specimen.

For example, for a gain of 20 the collector voltage is −8·6V, and for a gain of 50 the collector voltage is −3·3V. This shows that the collector voltage is very dependent on current gain, and spreads in this gain can alter the collector voltage considerably, even before considering a possible shift in the working point, due to leakage current in the transistor. This means that for this arrangement the bias resistor would have to be varied to obtain the required collector voltage. There would be no hope of just soldering the circuit together and expecting the collector voltage to be around the required value.

This dependence of collector voltage on gain can to some extent be avoided by taking the bias resistor to the collector instead of the supply, since there is a phase reversal in the common-emitter amplifier. If the circuit is designed for a given current gain, and a transistor of higher gain is placed in the circuit, the transistor would conduct harder than normal. This would reduce the collector voltage, and so reduce the bias current, to compensate partly for this. So the circuit shown in Fig. 1.2 is more tolerant to gain variations.

If the gain of a given transistor is 40, the collector voltage would be −5·4V; this voltage varies between −7·2V for a gain of 20 and −4·7V for a gain of 50.

For the collector voltage to be as low as −3·3V, which was our worst case, the gain would have to be as high as 85. So this method of biasing can tolerate wide variations in gain, provided we are using low signal levels and do not require a specific collector voltage. This arrangement is often used in the first stage of tape replay pre-amplifiers or similar positions; obviously silicon transistors are better than germanium with this bias method, as the leakage current can be ignored.

Apart from the uncertainty of the bias point, there is also the disadvantage that the bias resistor provides a.c. as well as d.c. feedback, hence signal gain is reduced. Decoupling this path is sometimes necessary to maintain audio gain, Fig. 1.3.

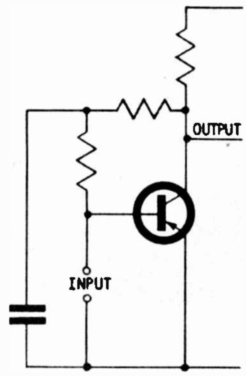

Fig. 1.3. Decoupling the bias chain to prevent reduced audio gain

POTENTIAL DIVIDER

The two simple methods of biasing already discussed, use a bias current injected into the base without being sure of the exact magnitude of current required for a particular collector voltage. To overcome this limitation the potential divider chain bias method is frequently used, as shown in Fig. 1.4.

The bias chain sets the base at −1·3V, since the current into the base is small compared with the current in the divider chain, and the transistor conducts until it has 0·3V between base and emitter. The emitter current (and hence collector current) is well established at about 1mA, and variations in gain or leakage current do not appreciably alter bias conditions. The emitter capacitor decouples the emitter from audio signals and prevents negative feedback which would reduce the gain.

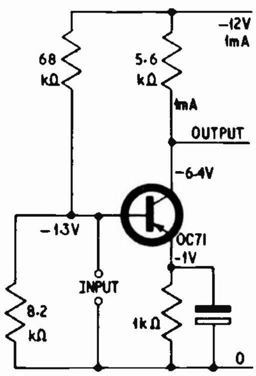

Fig. 1.4. The potential divider chain bias method

DIRECT COUPLING

For two common emitter stages in series an extension of this arrangement is to take the top of the potential divider chain to the emitter of the second transistor as in Fig. 1.5.

This method combines the advantages of a potential divider and the self-biasing arrangement shown in Fig. 1.2. The current through the 39 kilohm and 18 kilohm resistor chain is arranged so that it is much larger than the bias required by TR1.

For the circuit shown,

Input impedance	= 1 kilohm	
Output impedance	= 6·8 kilohm	
Gain	= 200	for a 1kΩ load
Maximum output	= 150mV r.m.s.	
Frequency response	= +0 to −3dB in the range 20Hz to 10kHz	

Since the two transistors are directly coupled, the voltage measured at one point will show that the d.c. conditions are correct. If TR2 collector is around −10·5V then the entire circuit must be correctly biased. It will be difficult to measure voltages around TR1 since currents are low here, but TR2 emitter and collector voltages can be measured with a meter of 20kΩ/V sensitivity.

This article has described the limitations and advantages of the commonly used bias methods, so that the home constructor can choose the most suitable arrangements for his needs. While this description is based on *pnp* types of transistor, the same principles will apply equally to *npn* types. The only differences lie in the polarities of supply voltages and electrolytic decoupling capacitors.

The next article will deal with power amplifiers. The different output stage configurations will be shown with the relative merits of each type discussed.

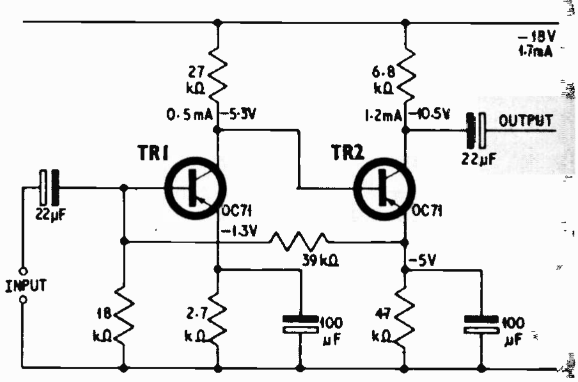

Fig. 1.5. The potential divider chain principle extended over two stages of a directly coupled amplifier

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Tweeter unit
4" dia. 10,000 lines, $\frac{3}{16}$" pole
Size
11" × 6½" × 2½" deep
(28 × 16·5 × 6·4 cm).
Weight
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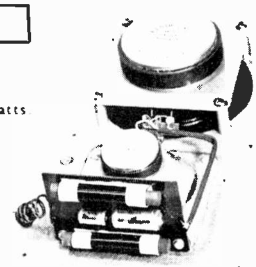

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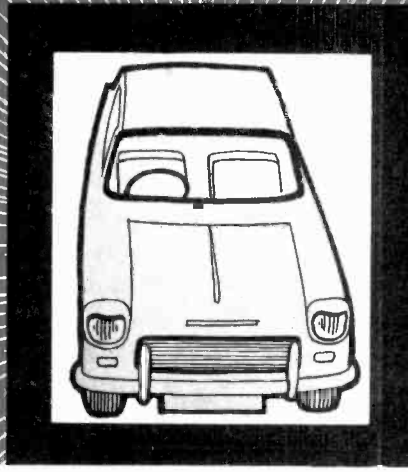
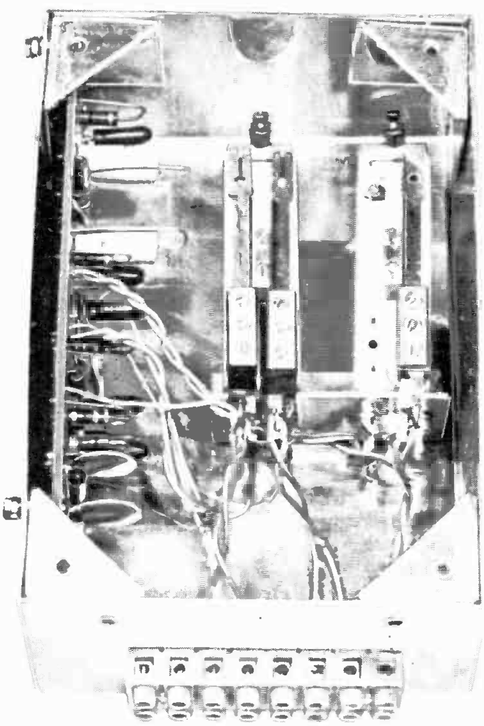
CAR ANTI-THEFT ALARM



By S.T. ANDREWS

THE UNIT to be described here is an anti-theft unit intended primarily for cars but equally suited to use in motor-bikes, scooters and any other similar vehicles with a 12-volt battery supply.

Anti-theft units in general fall into two types: those intended to prevent entry to the protected vehicle, and those intended to immobilise the vehicle and give an external indication that the vehicle is being tampered with. It was considered that the second type is preferable, particularly in the case of convertible cars where it is often possible to "break in" through the soft top without setting off any alarm connected to the doors. The device described in this article is thus of the second type and it has provision for a number of possible alarm types, the horn or lights being made to operate or the fuel pump to be disconnected when it is set off.



Interior of burglar alarm showing layout of component board and relays

THE CIRCUIT

The unit is built around two common circuits, a low-speed multivibrator and a bistable switch. The bistable, however, is of a slightly unusual design and is not the usual symmetrical version. This asymmetrical design was developed so that the two stable conditions were not equally stable and on initial switch-on the circuit always adopted the same state.

It is necessary to tap only one existing lead in the vehicle's wiring, that from the ignition switch to the ignition coil; this wire can be found from the wiring diagram of the vehicle. It is not necessary to break this wire, the anti-theft unit lead can simply be clipped on at a suitable point. It is also necessary to provide leads from either side of the battery and, of course, leads to the horn or lights which are to be used as the alarm indicator.

A block diagram of the anti-theft system appears in Fig. 1. The circuit diagram is given in Fig. 2 where it can be seen that TR1 and TR2 form the asymmetrical bistable switch with TR3 as a relay driver for RLA. TR4 and TR5 form a conventional multivibrator with a mark-to-space ratio of 1:1·5. This is due to TR5 having a slightly lower collector load than TR4, the actual cycle times are 3 seconds "on" and 2 seconds "off".

With S1, the on/off switch, set "off" no battery power can reach any part of the circuit. With S1 turned on the bistable takes up its initial state with TR1 cut off and TR2 conducting; TR3 base is thus maintained at nearly the positive rail potential and RLA remains de-energised. As long as no attempt is made to start the vehicle no power will be supplied to the multivibrator, so RLB will also be de-energised.

If any attempt is now made to start the engine, power will be supplied to point "X" of Fig. 2. This is true not only if the ignition is turned on, but also if a more ingenious person tries to connect the battery direct to the ignition coil, by-passing the ignition switch. A fair degree of protection is thus attained.

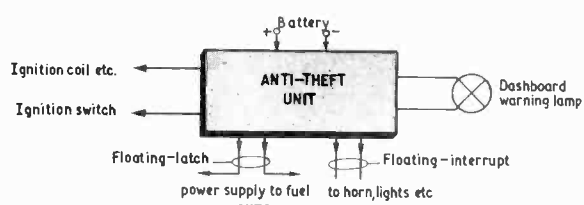


Fig. 1. Block diagram of the Anti-Theft Alarm

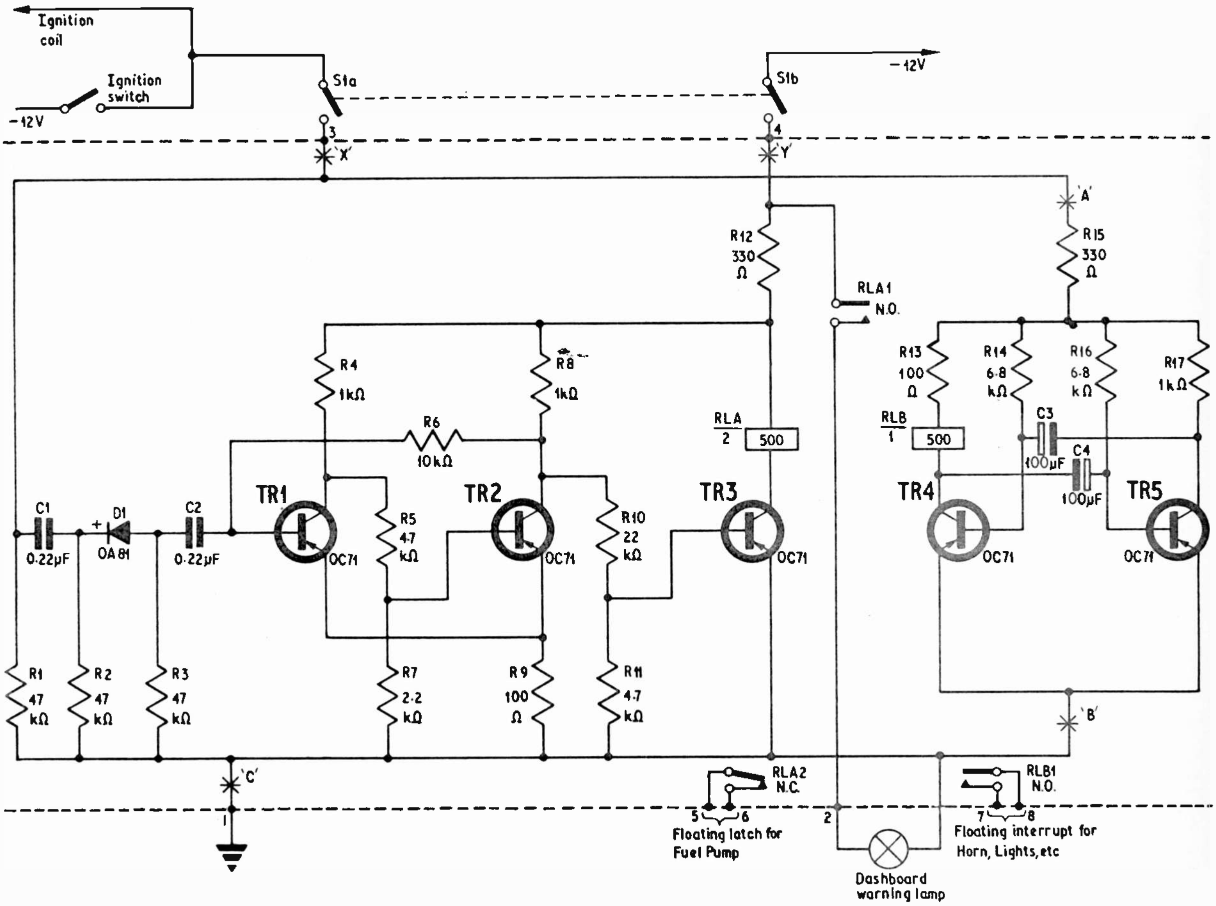


Fig. 2. Circuit diagram. All external connections to the unit are made at the dotted line enclosure

When power is supplied to point "X" two things happen. First, the multivibrator operates and the "floating interrupt" contacts open and close repeatedly. These contacts (floating in the sense of being unconnected to the battery) may be used to operate the horn and, possibly, the headlights; an intermittently sounding horn is a fairly effective deterrent. This action will continue until power is removed from point "X" by abandoning the attempt to start the engine.

Second, the pulse provided by the change in potential of point "X" is shaped by C1, D1 and their associated components and applied to TR1 base. This causes the bistable to change over, so RLA operates. The warning lamp on the dashboard lights and any units connected to "floating latch" are triggered. If the vehicle petrol pump is supplied with power via RLA2 contacts as in Fig. 1 it follows that the fuel supply is removed and the engine will be unable to run for more than a minute or two. Switching off the ignition will not cause the bistable to revert to its original state, it will remain set until the anti-theft unit is turned off.

SUMMARY OF EFFECTS

This unit provides a fairly comprehensive protection system. When it is turned on any attempt to start the vehicle, either by using an ignition key or by shorting the battery direct to the coil, will set off the alarm. This will cause the horn and/or the lights to operate intermittently and to go on doing so until the attempt at starting is abandoned. At the same time, a warning lamp on the dashboard will light and the petrol pump will be disconnected, effectively immobilising the vehicle.

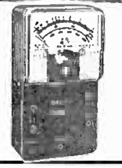
EXTRA PROTECTION

If desired, extra protection can be added by having microswitches on the vehicle doors. These would be arranged to make contact when the doors were opened, and all such microswitches should be wired in parallel across points "X" and "Y" in Fig. 2. Opening any door which is so protected will have the same effect as turning on the ignition.

CONSTRUCTION

The components are mounted on a piece or Veroboard 5in × 2in as shown in Fig. 3. The wiring layout corresponds exactly with the circuit thus enabling a rapid check out of assembly when the project is completed. Since there is nothing critical in component disposition with these types of switching circuits, higher density board mounting can be undertaken by the more experienced constructor thus reducing the Veroboard area employed.

With the board assembly completed, the relays should be connected up to enable a functional check of the bistable and multivibrator sections of the circuit to be carried out before chassis mounting. With the



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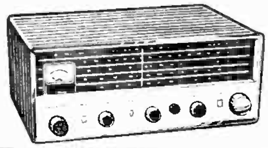

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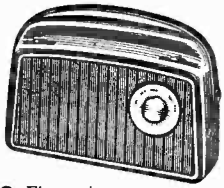

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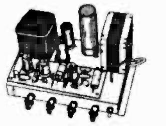

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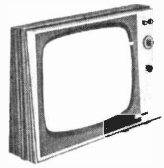

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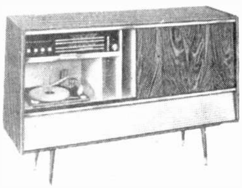

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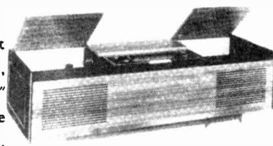

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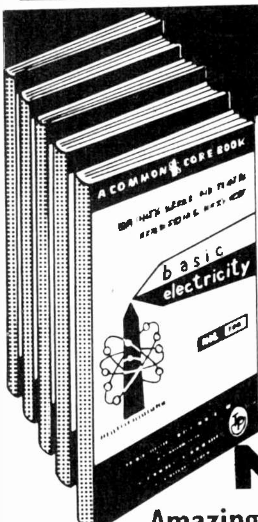

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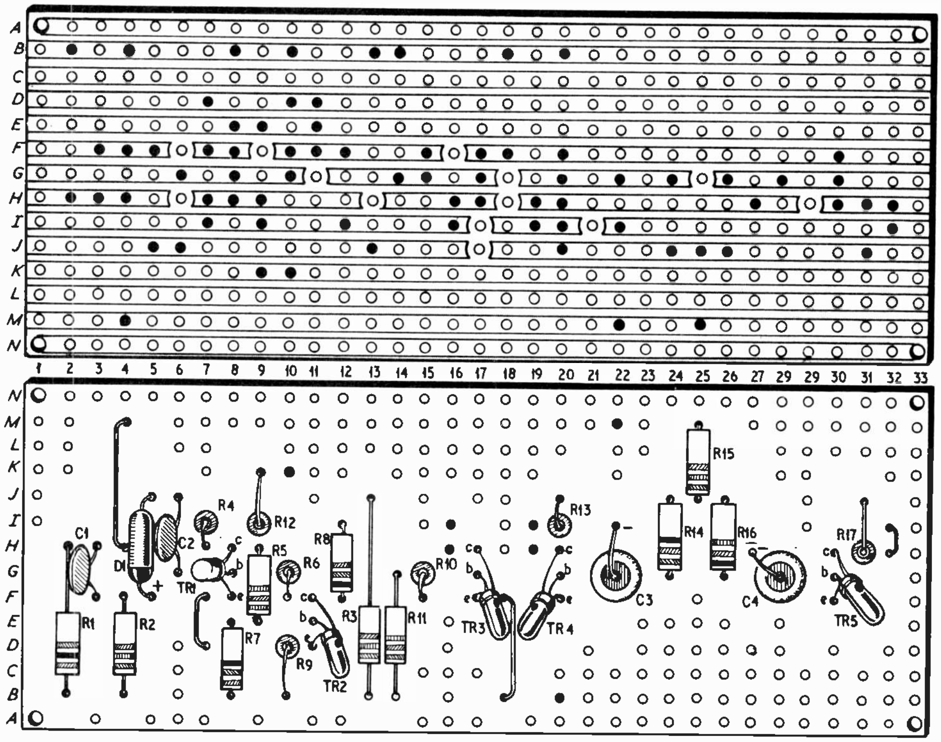

Fig. 3. Component layout and Veroboard showing breaks and connections at the copper strips

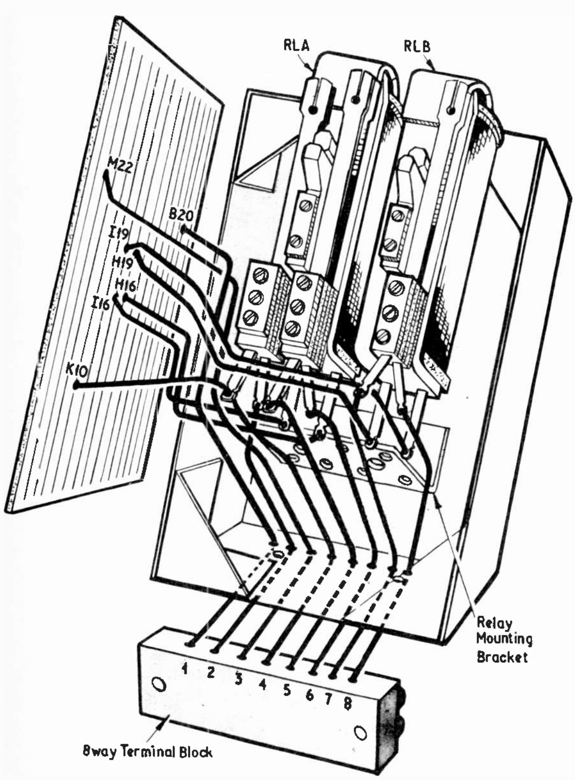

Fig. 4. Wiring of relays showing connections to terminal block and component board

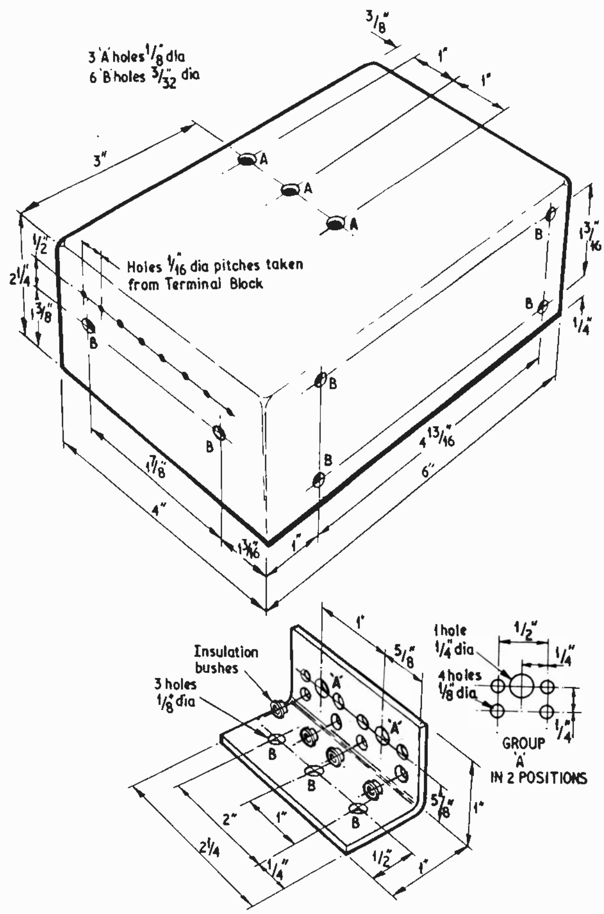

Fig. 5. Chassis and relay mounting bracket showing details of drilling

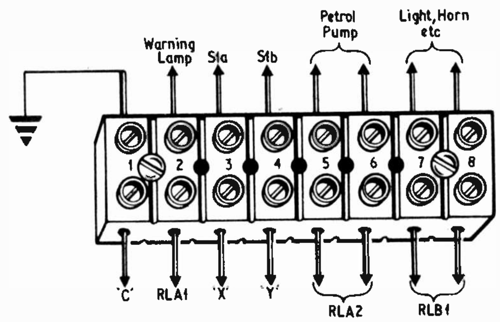

Fig. 6. Terminal strip wiring layout. Note that other side of warning lamp will go to car chassis

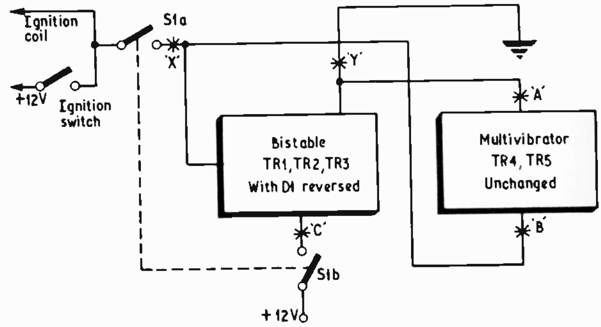

Fig. 7. Wiring diagram for negative earth systems

supply connected and S1a switched on, correct operation will be evidenced by the relays performing in the manner previously described.

A 6in × 4in chassis is used to house the board and relays. A similarly dimensioned aluminium sheet should be used to form the bottom plate of the box when all internal wiring is completed.

A piece of aluminium 2¼in × 1½in serves as a bracket for relay mounting (Fig. 5). This should be bent at right angles at ½in of its width and drilled along this smaller edge for the screws that will retain it to the chassis. The longer edge should be drilled using the template provided with the relays as a guide. Also included in the relay purchase are bushes for the coil tags. It is important that all burrs should be cleared prior to inserting these. The relays can now be mounted on the piece of aluminium angle and this bolted to chassis using shakeproof washers.

As all flying leads should have been connected to the component board in the test set up, this can be mounted to the chassis side panel using stand-off bushes and shakeproof washers in the assembly.

The final component for mounting is the eight way section of plastics screw terminal strip which connects all external wiring to the unit. When this has been fixed to the chassis panel, holes should be drilled adjacent to the strip connections. Burr clearing at these points is important to remove any chance of insulation puncture when feeding through wires.

All wiring should now be completed as shown in Fig. 4, making sure that heavy duty automobile wire is used between the terminal strip and relay contacts.

NEGATIVE EARTH

The unit as shown in Fig. 2 is intended for a 12 volt supply with a positive earth system, however it can be adapted for a negative earth supply. In this case some alterations to the circuit are required. Diode D1 should be reversed so that its cathode is connected to TR1 base via C2; the multivibrator should be re-wired so that points "A" and "Y" in Fig. 2a are connected together; the connection from the ignition circuit to the multivibrator, via S1a should be applied to point "B". S1b should now be inserted between the battery positive input and point "C", and point "Y" taken direct to battery negative. If the extra protection microswitches are used these should be wired between points "X" and "C". These changes are shown in Fig. 7.

INSTALLATION

The completed unit should be hidden in any convenient place in the vehicle. The connecting leads to the horn, and also the direct feeds to the ignition coil and switch, should be of heavy duty cable. The on/off switch, S1, may either be a conventional toggle switch in a concealed position, or a more prominent control with a mis-leading name, e.g. FOG-LAMP.

The prototype has been in use for just under a year and is left on for about eight hours a day. During this time it has never given a false alarm. Admittedly, it has not caught any would-be thieves but this is mainly because no-one has tried to steal the car. It has, however, caught its designer a number of times and may be considered quite efficient. ★

COMPONENTS . . .

Resistors

R1	47kΩ	R10	22kΩ
R2	47kΩ	R11	4·7kΩ
R3	47kΩ	R12	330Ω
R4	1kΩ	R13	100Ω
R5	4·7kΩ	R14	6·8kΩ
R6	10kΩ	R15	330Ω
R7	2·2kΩ	R16	6·8kΩ
R8	1kΩ	R17	1kΩ
R9	100Ω		

All 10% ½ watt carbon

Capacitors

C1 0·22μF } 20V Disc ceramic
C2 0·22μF }
C3 100μF } 15V Electrolytic
C4 100μF }

Transistors

TR1–TR5 OC71 or NKT214 (5 off)

Diode

D1 OA81 Mullard

Relays

RLA 9V 500Ω coil. 1 make 1 break light duty contacts. 600 Type
RLB 9V 500Ω coil. 1 make heavy duty contacts. 600 Type (Keyswitch Relays Ltd., 120–132 Cricklewood Lane, London, N.W.2.)

Switch

S1 Double pole on/off toggle

Miscellaneous

Chassis 6in × 4in. Aluminium sheet. Veroboard. 5A 8-way terminal strip. Heavy duty wire, nuts, bolts and shakeproof washers, etc.

3-PUSH SWITCH

For test meter, hi-fi amp., etc. 1st button operates mains on/off switch, the other two operate change-over switches. Knobs engraved On/Off, Bass, Treble but engraving easily removed leaving clean surface for remarking. **2/9** each **24/-** doz.

SATCHWELL OVEN THERMOSTATS

Type TO. With capillary tube and sensor. 20 amp. A.C. type and as fitted to many cookers. Adjustable by control knob (not supplied). 12/6 each.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12V for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6**, plus 3/6 postage.

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Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly resin filled. Kit A.—15-20W. **19/6**. Kit B—30-40W., **17/6**. Kit C—80W., **17/6**. Kit D—125W., **22/-**. Kit E—65W., **19/6**. Kit MF1 is for 6in., 9in. and 12in. miniature tubes **19/6**. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

MINIATURE WAFER SWITCHES

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

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Type "B" 15 amp. This is a 17in long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550°F. Internal screw alters the setting so this could be adjustable over 30° to 1000°F. Suitable for controlling furnace, oven kiln, immersion heater or to make flame-start or fire alarm. **8/6** plus 2/6 post and insurance.

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

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This is one of the latest products of the World's most experienced maker of fine record reproducers. Its superior features include—automatic playing of up to 8 mixed size records—stopping and starting without rejecting manual playing—pick-up pivots to give low stylus pressure—large diameter turn-table for max. stability adjustments include pick-up height—pick-up dropping position and stylus pressure. Size is 13¾ × 11¾in. clearance 4¾in. above, 2½in. below—fitted with latest hi-compliance cartridge for stereo and mono. L.P. and 78. Supplied complete with mounting template and service sheet. Offered this month at the Special Snip price of **£6.19.6** plus 7/6 carriage and insurance.

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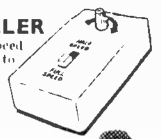
CONTROL DRILL SPEEDS

DRILL CONTROLLER



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

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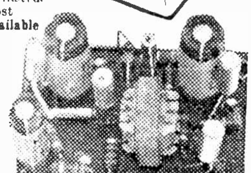
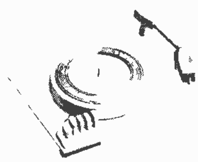


4 transistors including two in push-pull input for crystal or magnetic microphone or pick-up—feed-back loops sensitivity 5mV. Price **19 6**. Post and insurance 2/6. Speakers 3in. **12 6**, 5in. **13/6**, 6 × 4in. **14/6**.

THIS MONTH'S SNIP

THE 'TECHNICAL' GRAM MOTOR



4 speed, gram. motor with lightweight pick up, motor electronically balanced and free from wow and flutter. Speed change by push button—16, 33, 45, 78 r.p.m. Price **39/6**. Cartridge extra mono 10/6, stereo 15/- plus 4/6 post and insurance. DON'T MISS THIS TERRIFIC BARGAIN

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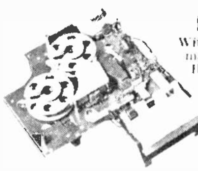
BATTERY OPERATED TAPE DECK



With Capstan control. This unit is extremely well made and measures approx. 6 × 5 × 2in. deep. Has three piano key type controls for Record, Playback and Rewind. Motor is a special heavy duty type intended for operation off 4/5 volts. Supplied complete with 2 spools ready to install. Record, Replay head is the sensitive M4 type intended for use with transistor amplifier. Price **£4.15.0.** Post and ins. 4/6.

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Capstan Driven, 4 Transistors
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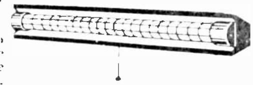

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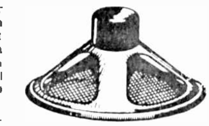

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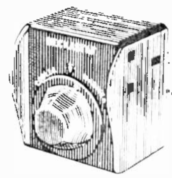

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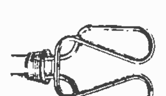

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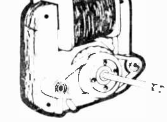

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RECEIVERS AND COMPONENTS *(continued)*

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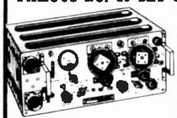

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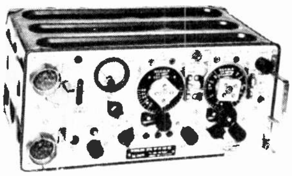

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