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GARRARD MODEL A70

Three-speed record changer complete with attractive metal plinth and including Sonotone 9TA Stereo pick-up head. Ready wired for connection to existing Hi-Fi Amplifier. Brand new in original packing. Listed over £28.

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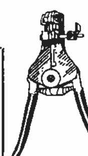


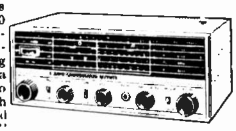
STEREO HI-FI HEAD SET Model ST 3R

Provides perfect stereo. Freq. res. 25-17,000 c.p.s. 8 ohms per channel. Feather soft ear cushions and headband, 8ft. lead with stereo jack plug and remote control but with separate volume control for each earphone.

92/6

P. & P. 2/6

FANTAVOX COMMUNICATIONS RECEIVER HE.50



4 wavebands 540kc/s to 30 Mc/s. Exceptionally sensitive tuning circuit. Extra large easy to read dial with Bandspread tuning. "S" meter for fine tuning. Built-in speaker and telescopic aerial. BFO. Phone output socket. Standby switch, etc. A.C. 200/250V.

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Ranges: D.C. volts: 100 mV., 0·5 v., 5 v., 250 v., 1,000 v. A.C. volts: 2·5 v., 10 v., 50 v., 250 v., 1,000 v. D.C. current: 5 μA., 0·5 mA., 5 mA., 50 mA., 250 mA. Size: 5¼ × 3¼ × 1⅜in. Complete with batteries and test prods.

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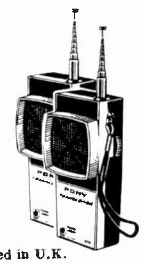

Complete 2-way communication for Business, Home, Farms, Boating, etc. Brilliant design, beautifully finished. Built-in speaker microphone, 10 section telescopic aerial. Battery strength indicator. Size 5⅞in. × 1⅞in. × 2⅞in. Complete with batteries, earphones, wrist straps. Cannot be operated in U.K.

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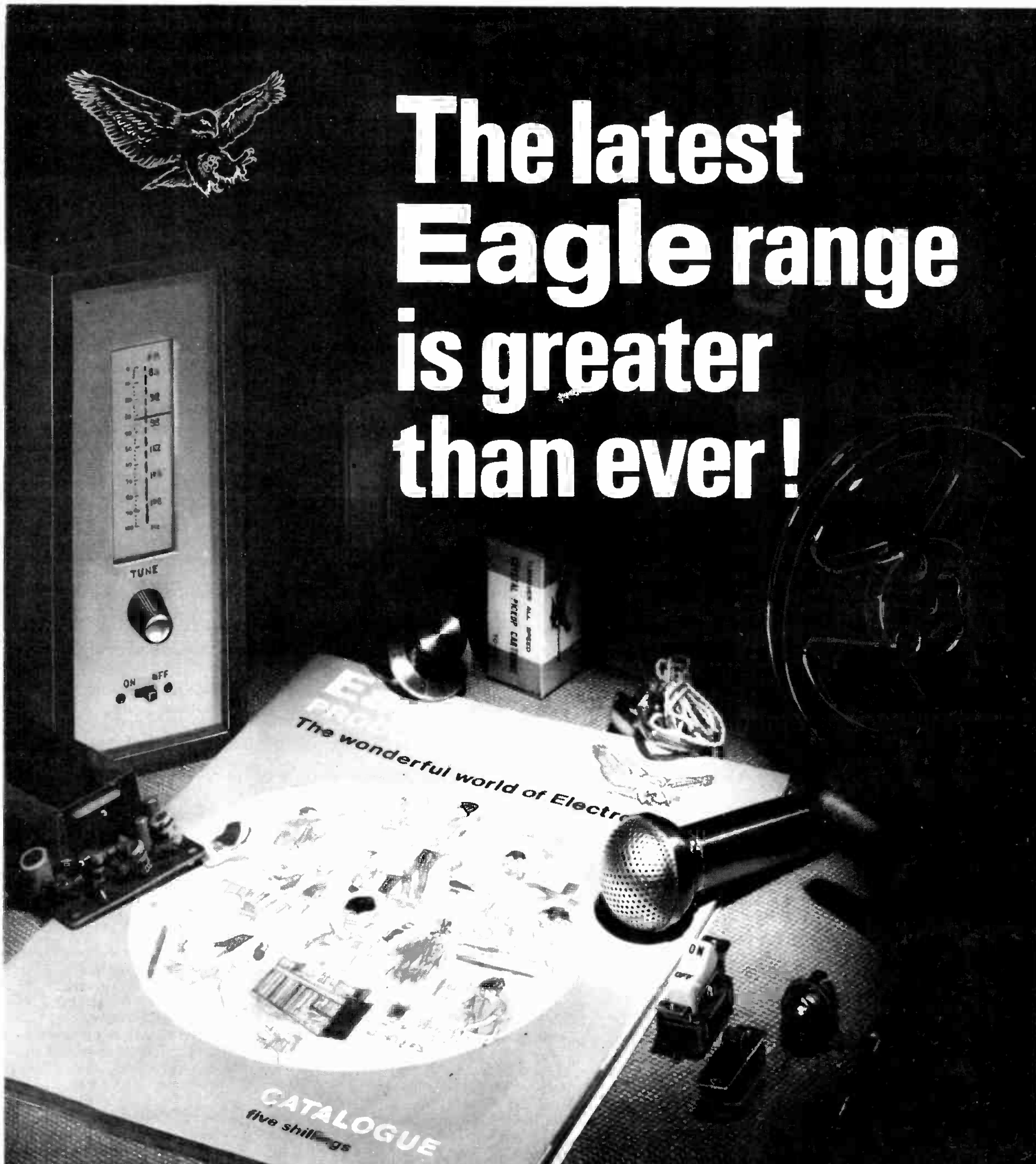

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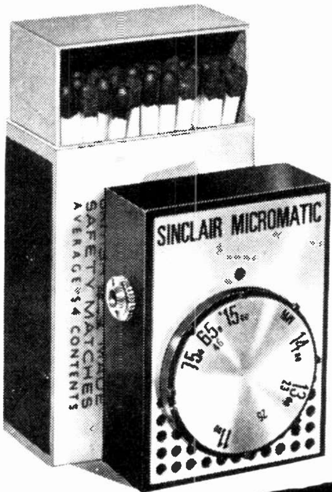

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Originally 59/6 complete with earpiece, solder and instructions in pack, the Micromatic Kit now costs **49/6**

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Originally 79/6, the Micromatic ready built, tested and guaranteed complete now costs **59/6**

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With sales and export orders for the Sinclair Micromatic breaking all records, we have changed over to new production methods to meet the ever-increasing demand for the world's smallest radio set. This has enabled us to effect dramatic economies because of the large quantities of materials involved. At the same time, we have appreciably improved the set's quality. We now supply a magnetic earpiece which matches perfectly to the powerful output of the Micromatic, and what was superb performance before, now sounds better than ever. Now that your Micromatic costs you less (49/6 kit; 59/6 built), you can afford not only to have one for yourself, but give them as gifts. But be quick. At the new prices, everyone is going to want the Micromatic. Order yours now.

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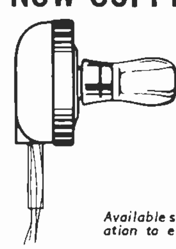
- $1\frac{4}{5}$ x $1\frac{3}{10}$ x $\frac{1}{2}$in.

NOW SUPPLIED WITH A DE-LUXE MAGNETIC EARPIECE



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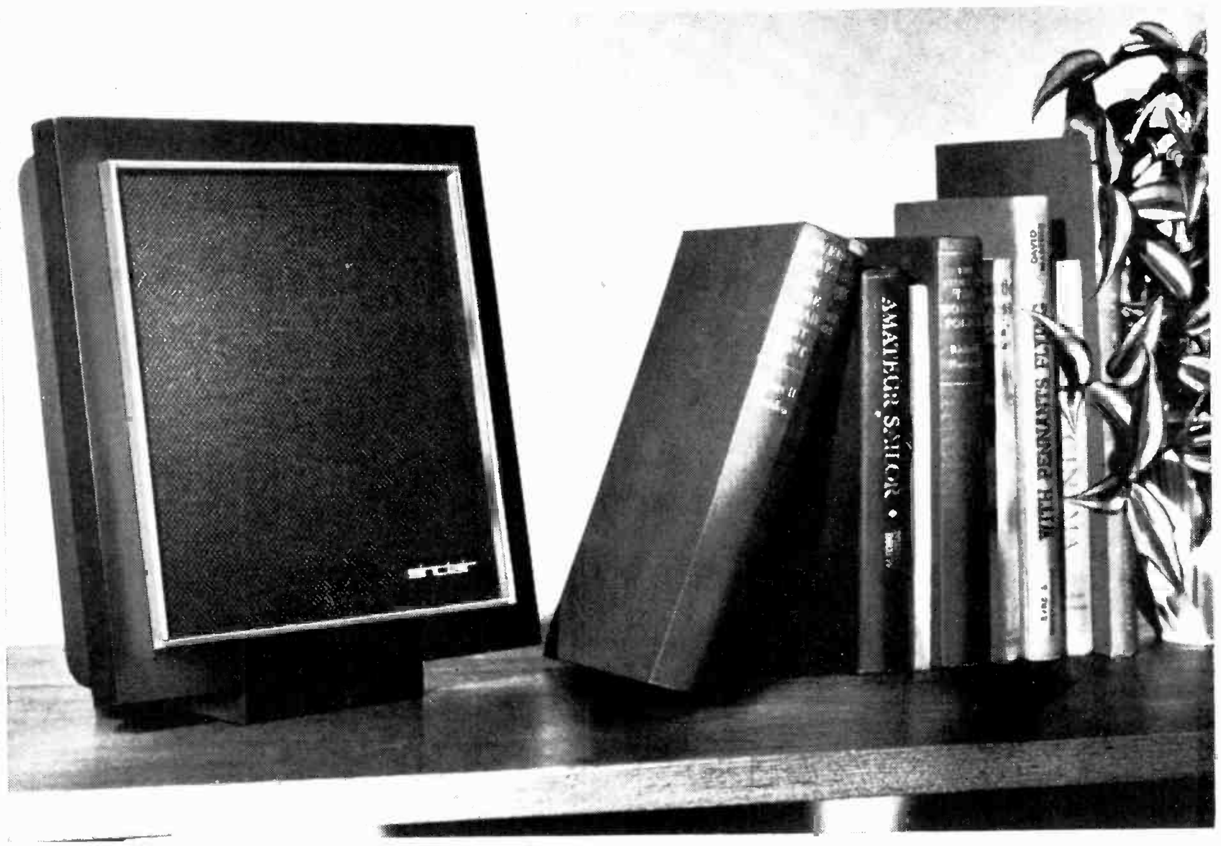
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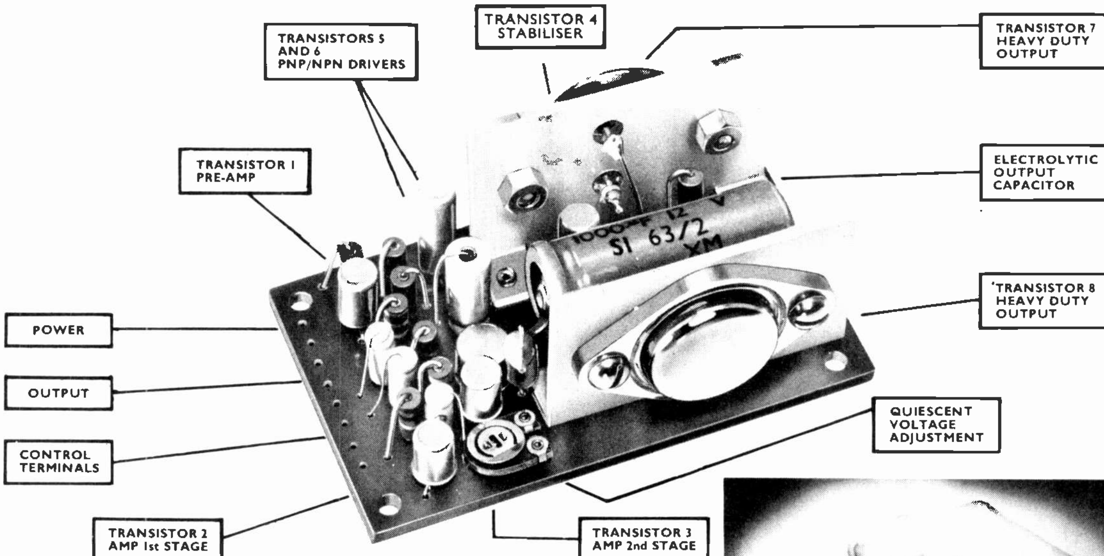
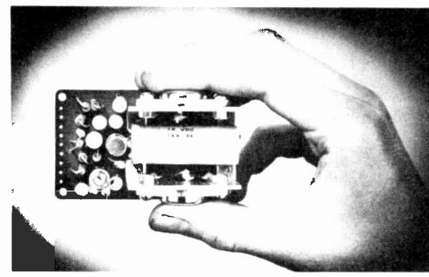
SINCLAIR Z.12

12 WATT INTEGRATED HIGH FIDELITY AMPLIFIER AND PRE-AMP





12 WATTS R.M.S. OUTPUT CONTINUOUS SINE WAVE (24W PEAK) 15 WATTS MUSIC POWER (30W PEAK)

- 3 x 1¾ x 1¼in.
- IDEAL FOR BATTERY OPERATION
- 15-50,000c/s ± 1dB

PZ.3 Mains Supply Unit for Z.12 and Stereo 25 users. **79/6**

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TECHNICAL DETAILS

- Class "B" ultra-linear output.
- RESPONSE 15-50,000 c/s ± 1dB.
- Suitable for 3, 7·5 or 15Ω speakers. Two 3Ω speakers may be used in parallel.
- INPUT—2mV into 2kΩ.
- Signal to noise ratio better than 60dB.
- Use two for stereo.

BUILT, TESTED AND GUARANTEED. **89/6**

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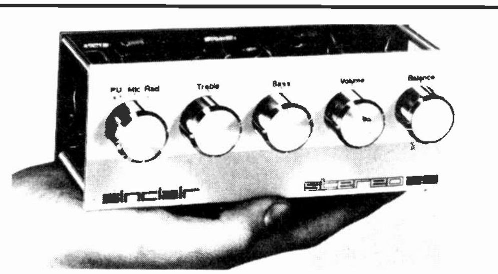

SINCLAIR STEREO 25

For use with two Z.12s or any hi-fi stereo system. Frequency response 25c/s to 30kc/s ±1dB. Switched inputs for P.U. Radio, Microphone, etc. Equalisation correct to within ±1dB on RIAA curve from 50 to 20,000c/s. 6½in. × 2½in. × 2½in. plus knobs. *Built, tested and guaranteed* **£9.19.6**

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LM 3000 Record Player with 9T.A. Stereo Cartridge. Brand new as from factory .. 8 gns

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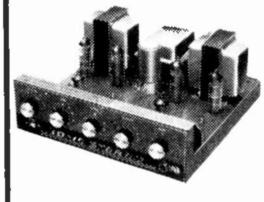

STEREO 10-10

Valve amplifier to exact Mullard spec. With pre-amp, tapped o/p transformer 3 and 15Ω all controls, H.T. and L.T. outlet, mono, stereo and speaker phase switching. Complete with escutcheon, knobs, plugs, etc. Ready built (p. & p. 12/6) **£20.0.0**

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With each reel of this tape we give you a strongly made library wallet in simulated leather with space for a reel each side. This is professional quality full frequency tape with metallised leader/stop foils.

5in reel, 900ft with wallet **12/6**

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PEAK SOUND SA.88 SUPER STEREO AMP.

14 Transistor Kit builds into superb hi-fi amp. 8W per channel (16W mono) with integrated pre-amp to take high quality ceramic p.u. Unusually easy to build by following the instructions (1/6d. purchased separately and refunded when kit is bought). This makes one of the best and most economical stereo transistor amps. we have ever offered. All purchases backed by T.R.S. service facilities. When built and fitted in its special cabinet, the SA.88 equals the best in modern styling.

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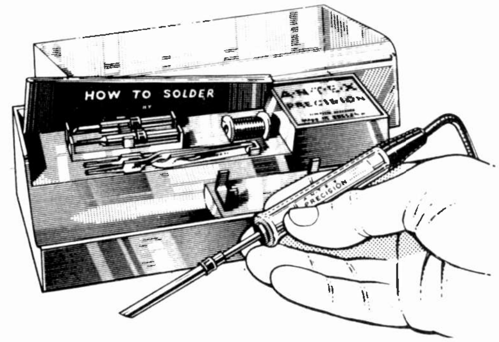

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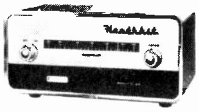
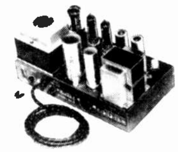
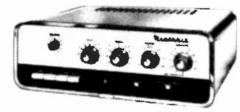


FM TUNERS FM-4U

TFM-IS



10W POWER AMP. MA-12



9 + 9W STEREO AMP. S-99

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 (STEREO) **£24.18.0** incl. P.T.
Kit (MONO) **£20.19.0** incl. P.T.

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Kit **£12.18.0** Assembled **£16.18.0**

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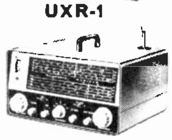
"OXFORD" LUXURY PORTABLE Model UXR-2. Specially designed for use as a domestic or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0** incl. P.T.

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**

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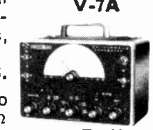

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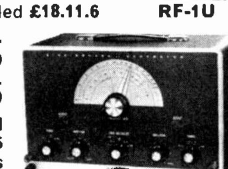

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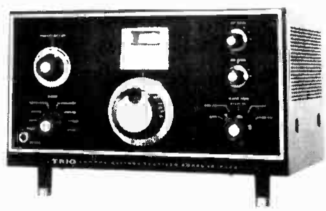

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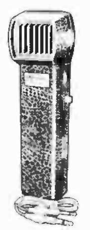

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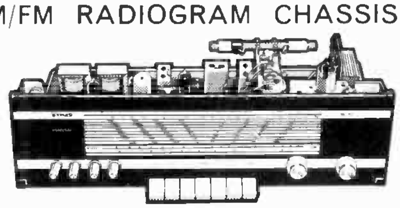

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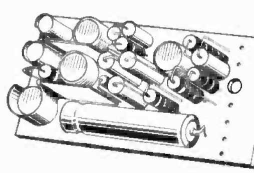

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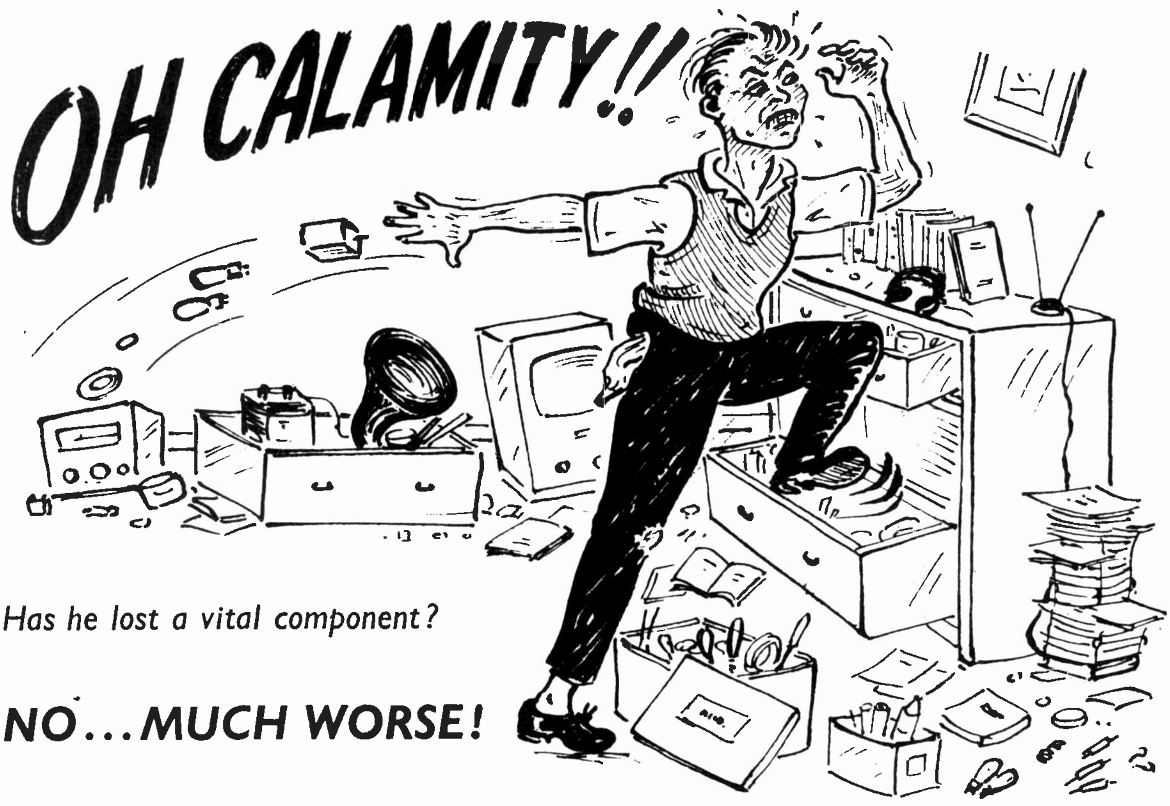

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VOL. 3 No. 12
DECEMBER 1967

PRACTICAL ELECTRONICS

BEGINNERS, OLD AND NEW

Today's beginner in electronics has a decided advantage over the beginner of, say, five to ten years ago. Today the position of the semiconductor is clarified. No longer any doubt concerning its future prospects. The emergence of new forms of semiconductor continually increase the versatility of electronics in general. From a practical point of view, the newcomer to the hobby is destined to be 80 per cent or more a transistor man. So he can concentrate on solid state right from the start.

Looking back to before the transistor era, the beginner received his initiation into electronics through valve theory and practice. When the transistor first appeared on the scene it received a somewhat cool welcome. It seemed to some an intruder bent on bringing undue complications into a nicely ordered field. Attempts to describe the unfamiliar transistor action in terms analogous to valves proved helpful to some extent, but the artificial parallels and somewhat contrived comparisons with a device which is fundamentally so different also produced some added confusion.

The old adage concerning the difficulty of teaching an old dog new tricks applies here: and not only in the amateur field, for this very same problem has caused more than a little consternation amongst many of the older generation of professional engineers and technicians.

In contrast to all this, the youngster of today is well acclimatised to semiconductors. As soon as he takes an intelligent interest in technical affairs he is very quickly made aware of the solid state family whose members appear in many gadgets and equipment now commonplace in everyday life. He can approach this subject without any trepidation; it is natural to him, and there is no initial barrier to overcome because of long familiarity with valve operated equipment.

This month we launch a series entitled Semiconductor Basics. These articles will explain in a clear and non-mathematical manner the essential facts the beginner to electronics requires to know in order to make sensible use of semiconductor devices of various types. This series will also provide an excellent introduction to the subject for those who wish to pursue academic studies in this direction.

We conclude with a word to some of the "old dogs"—pardon the phrase. Perhaps they will forgive us for suggesting it, but careful reading of Semiconductor Basics should enable them to overcome any persisting aversion to the transistor and its associates. With confidence restored, they will then be able to get up to some "new tricks" just like the rest!

THIS MONTH

CONSTRUCTIONAL PROJECTS

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PROPORTIONAL SERVO SYSTEM 893
ANTI-DAZZLE DRIVING MIRROR 903
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Our January issue will be published on Friday, December 15

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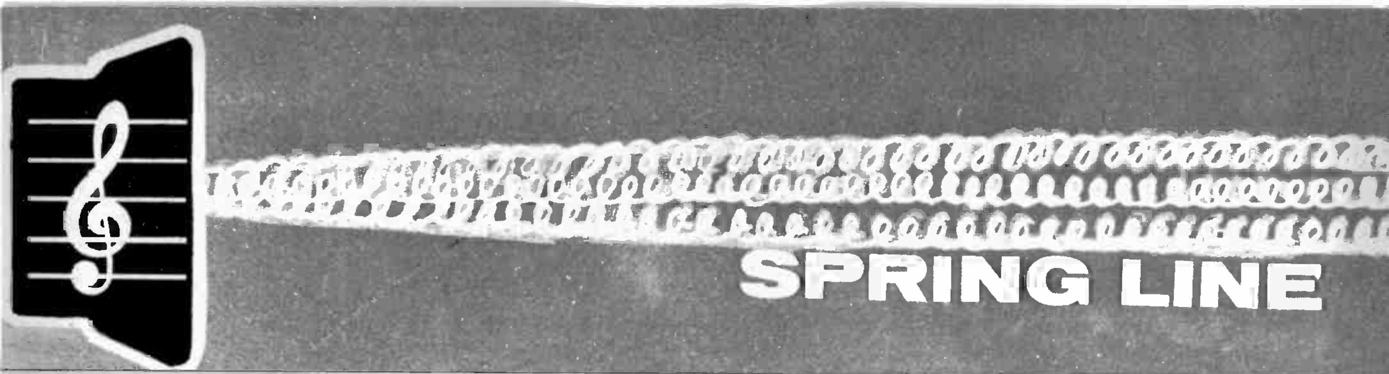


SPRING LINE

FOLLOWING the concluding article last month on *Electronic Sounds and Music*, we present here the first of a number of constructional projects designed to give special effects to existing musical instruments or recorded electronic sounds. Full theoretical and practical information is given to enable the constructor to build up his own effects equipment.

This reverberation unit is inexpensive to build and, in addition to its applications in electronic music, can be used to add "dimension" to an electric guitar, organ and other musical instruments. It is also effective when used with a microphone, magnetic tape recorder, or record player. The sound impression given is of a large hall, but even if only used in a small room the instrumentalist may give the impression that he is playing in a huge cavern.

STRETCHED SPRING

The complete circuit of the unit is shown in Fig. 1, and consists of a 4-transistor audio power amplifier (TR5, 6, 7, 8) with which are associated two pre-amplifiers TR3, TR4. A mains power supply unit with electronic smoothing (TR1, 2) is used and two electromagnetic transducers operate in conjunction with a stretched spring to achieve the echo effect. These transducers (X1 and X2) are, in fact, a pair of spaced headphones.

The input signal is fed from the input socket (SK1) to the amplifier by way of VR1, TR4, and VR2. The audio output from the amplifier drives the "transmit" transducer X1, which sets up vibrations in a helical steel spring. This then acts as an acoustic delay line.

The mechanical vibrations in the spring are picked up by X2 causing its diaphragm to vibrate in sympathy at the other end of the spring line. The induced electrical signal is fed into transistor TR3 which amplifies it before being passed on to the output socket SK2 by way of potentiometer VR5, the "dimension" control.

Some of the output from the power amplifier bypasses the spring line, and is taken to the output socket by way of the volume control VR4. Here, it is mixed with the signal from the dimension control. The output will thus contain a variable degree of reverberation.

Some of the amplified reverberation signal from TR3 is fed back via VR3 (the "sustain" control) to the input of the power amplifier. This signal goes once again through the spring delay-line, producing further echoes and resulting in further prolongation of the decay period of the sound. The echoes are thus "sustained" over a longer period.

If VR3 is turned too high, the loop gain of the sustain feedback circuit will exceed unity, resulting in oscillation and a whistle appearing at the output. This may be counteracted by substituting a larger value for resistor R26, or by connecting an appropriate audio filter in the input lead of the power amplifier (at point marked *) in series with C11.

The amplifier circuit is fairly conventional and will operate from a power source in the region of 18 to 24 volts. Although it can be run from batteries, a mains power supply is incorporated in the unit to provide voltage consistency in operation.

The amplifier output is taken from a pair of medium power transistors, TR7, TR8 connected as a complementary push-pull output stage. The output point (junction of R17, R23, R24) is held at about half the supply voltage by heavy d.c. negative feedback applied through R15 and R17 to the emitter of TR5.

This voltage is set to the required value by selection of resistor R13, which supplies positive bias to the base of TR5. Negative feedback at audio frequencies passes through the same feedback loop. The amount of this feedback is determined by the value of resistor R16.

The pre-amplifiers TR3 and TR4 serve to raise the signal levels to a value suitable for the input of this main amplifier.

POWER SUPPLY

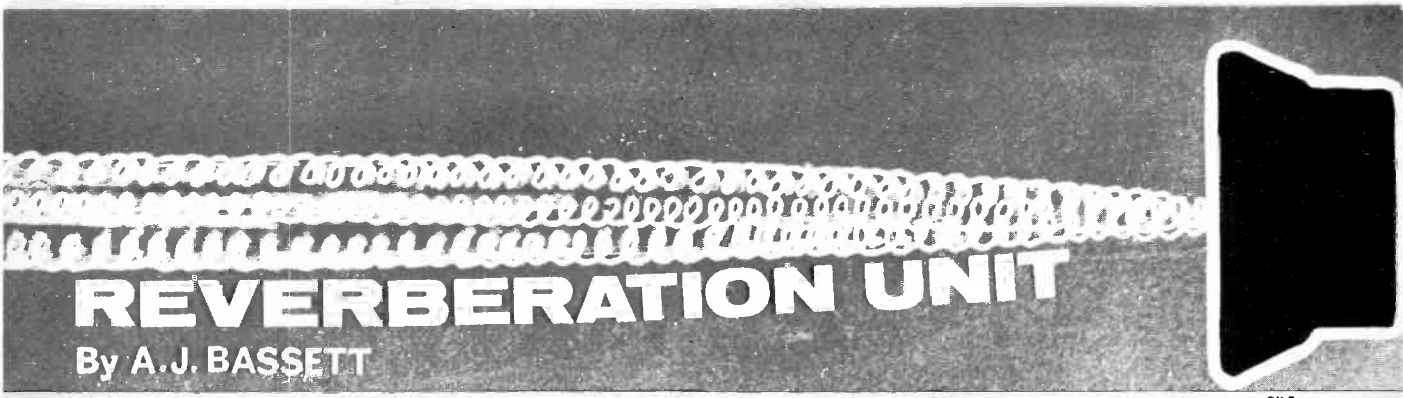
Mains transformer T1 supplies a secondary voltage of 17 volts which, when rectified by a full wave bridge rectifier (diodes D1, D2, D3, D4) supplies a d.c. output which charges C1 up to almost 24 volts. The current then passes to the output through an electronic filter circuit, comprising R1, R2, C2 and C3 in conjunction with transistors TR1 and TR2. This is a very effective smoothing circuit, necessary here because of the need to supply smooth d.c. to the power amplifier without introduction of mains hum, which could leak into subsequent amplifying circuits. The filter derives its effect from a capacitance multiplying action, in which the effective capacitance of C3 is multiplied by the very high gain provided by the transistors.

SURGE LIMITING

Also incorporated in the power supply circuit is a surge limiting feature, which limits the output current to a maximum of about 500mA. Diode D5 clamps the voltage on the base of TR2 to about 0·5V above the voltage on the positive output terminal.

The current through R3 causes a potential difference to appear across this resistor. When this current approaches the desired limiting value, the voltage across R3 will approach the same value as the voltage across D5. This would tend to cut off the current through TR2, and hence through TR1, as these are directly coupled, so limiting the total current output to the sum of the currents flowing in R3 and D5.

It will be seen, on examination of the circuit, that the value of resistor R3 is critical in determining the maximum current which may be drawn from the power supply. By alteration of the value of this resistor, the current can be limited to the desired maximum value for various applications of the power supply circuit.



REVERBERATION UNIT

By A.J. BASSETT

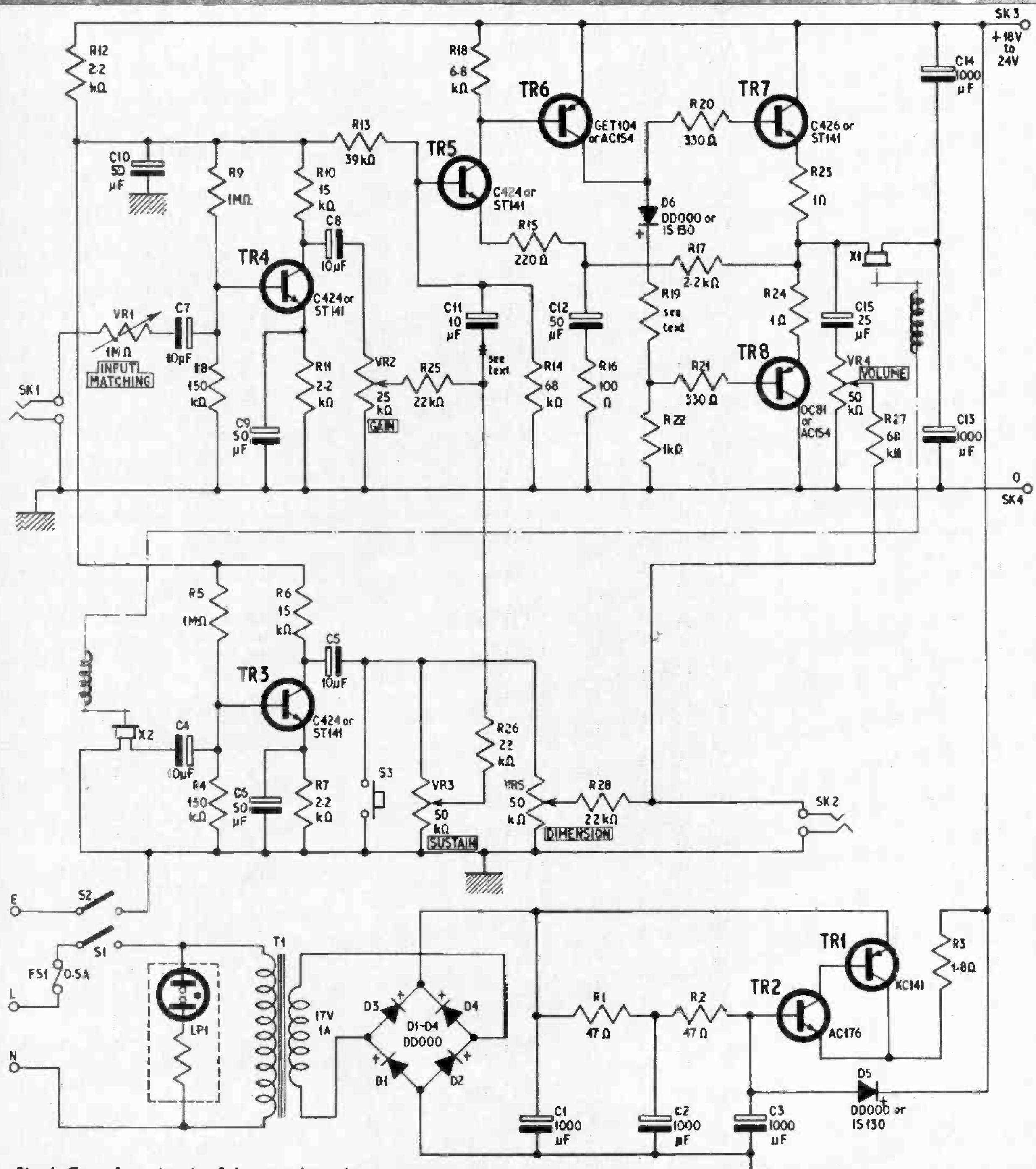


Fig. 1. Complete circuit of the reverberation unit and power supply. Transducers X1 and X2 are coupled by the spring line

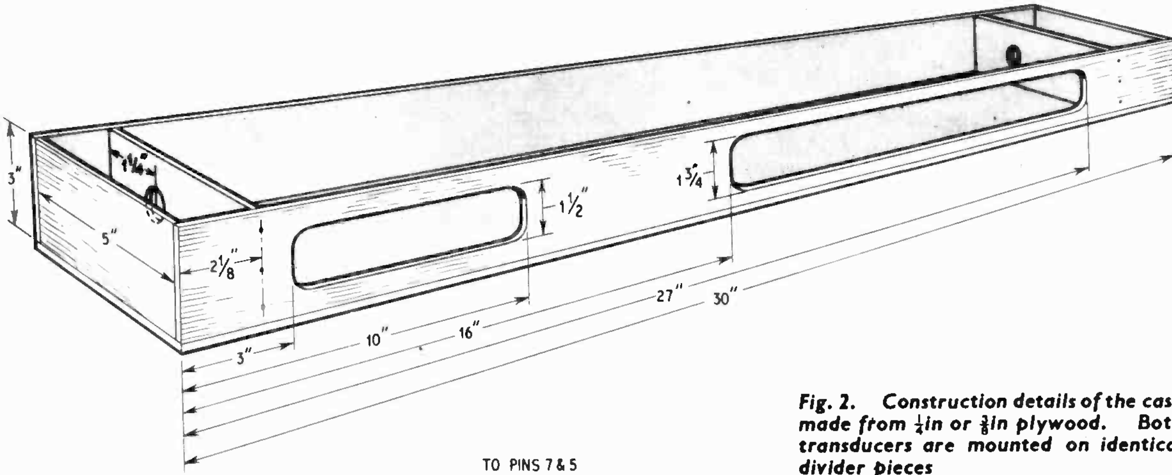


Fig. 2. Construction details of the case made from ¼in or ⅜in plywood. Both transducers are mounted on identical divider pieces

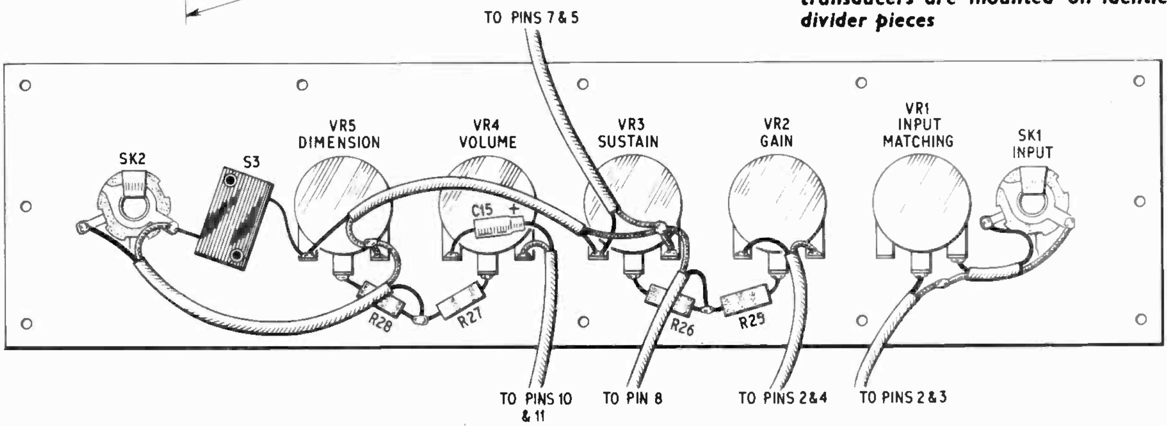
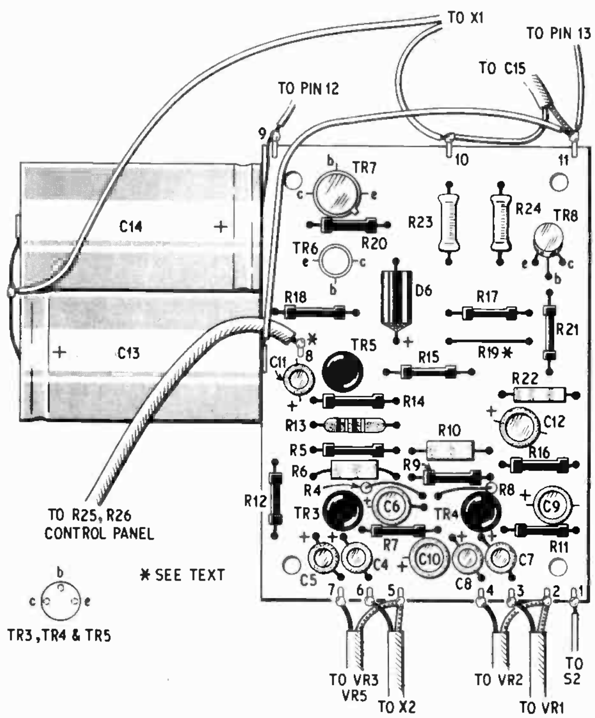


Fig. 3. Components and wiring on the amplifier control panel. Holes in the panel are drilled to size to suit components. Drawn here to half scale. Pin numbers refer to pin connections on the printed circuit layout below

Fig. 4a (left). Component layout and wiring on the amplifier board. Connecting leads to the control panel have pin numbers. Pins 12 and 13 are on the power supply panel



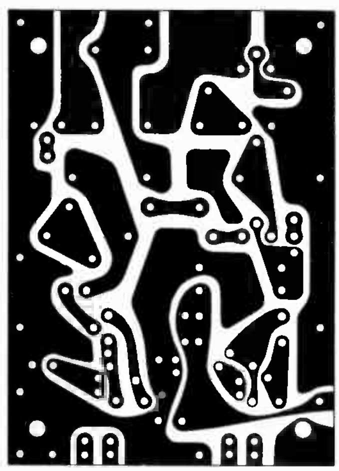


Fig. 4b (above). Printed circuit pattern for the amplifier panel drawn here half scale. The board can be etched by using a proprietary printed circuit kit

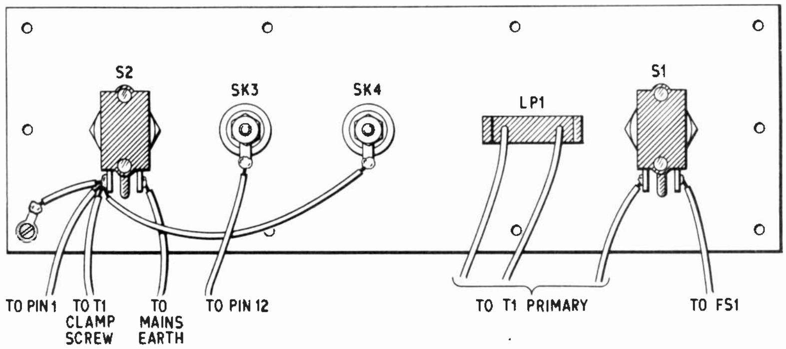


Fig. 5. Components and wiring on the power supply panel. Holes in the panel are drilled to size to suit components. Drawn here to half scale. The earthing connection from S2 to the soldering tag must also be connected to all pieces of foil lining the case. SK3 and SK4 are screw terminals for external supplies

Because of the very useful features of this power supply circuit it may be desirable for the experimenter to make use of it as an auxiliary supply, especially having regard to the fact that some future projects will operate from 18 to 24 volts. Therefore, the supply is connected to terminals on one of the control panels.

These terminals can be used as a low current source when the unit is plugged in to the mains, or as an alternative, they may be used for the purpose of running the reverberation unit from batteries, when connection to the mains would be inconvenient.

If it is required to use the power supply section by itself, without operating the reverberation section, a further switch cutting off the supply to the reverberation amplifier and pre-amplifiers can be inserted in the power output line.

POWER SUPPLY EARTHING SWITCH

The unit can be earthed either through its own mains supply connections, or through those of an external amplifier. If operating the unit with equipment which is not earthed, such as a battery powered amplifier, the earthing switch S2 earths the equipment via the mains earth wire, for safety and hum free operation.

If, on the other hand, the reverberation unit is connected to an amplifier which is already earthed, a severe hum level could be set up due to the formation of an "earth loop" via the two mains leads. In this case switch the earthing switch to its open-circuit position; the earth loop is broken, the hum level is much reduced, yet the equipment is safely earthed by the earth wire connection to the other apparatus.

WOODEN CASE

The wooden case is simple to make from ¼in or ⅜in plywood; each piece is cut to size and glued with strong adhesive (see Fig. 2).

The headphone panels have ¾in diameter holes and slots to accommodate connecting wire.

Cut the front panel as shown in Fig. 2 to accommodate the control panels. Cut out the control panels as Figs. 3 and 5 and screw to the wooden front panel.

All other wooden panels are cut to size and laid down in position on the bench ready for assembly. Before glueing the pieces together, apply a thin coat of impact adhesive to the inside surface of each piece and cover with aluminium cooking-foil. This foil should be in one complete piece for each piece of wood, with no joins. It will form an electrostatic screen on the inside of the cabinet and must be earthed via S2.

Assemble all the wood except the front panel and the lid using glue and panel pins, so producing the main structure of the cabinet. Whilst the glue is setting, proceed with other details of the construction.

PRINTED CIRCUIT BOARDS

Prepare and etch the printed-circuit panel designs shown in Figs. 4b and 6b. Glue the transistor heat sink on to the power supply printed board in the position shown (Fig. 6a), using Araldite epoxy resin. This may be set quickly by leaving in an oven at a low heat setting for 30 minutes, and allowing to cool in the oven with the door closed. It should not be cooled too rapidly or the adhesive may tend to crack.

Mount the components on to the amplifier board as shown in Fig. 4a. Resistor R19 in the author's amplifier was replaced by a link of copper wire, but a small value carbon resistor of a few ohms may be necessary in some instances to counteract crossover distortion.

When the printed board for the power supply circuit is cool, mount the components as shown in Fig. 6a. Bolt TR1 in place on the heat sink, using a little silicone grease to assist in heat conduction; make sure that the base and emitter leads do not touch the heat sink. A soldering tag may be fitted to

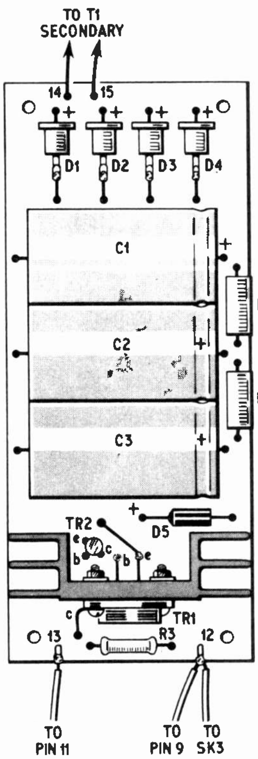


Fig. 6a (left). Layout of components on the power supply printed circuit board. Pins 9 and 11 are on the amplifier board

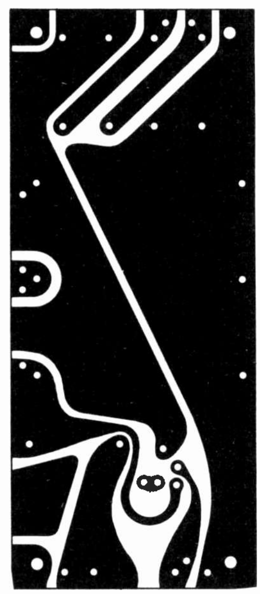
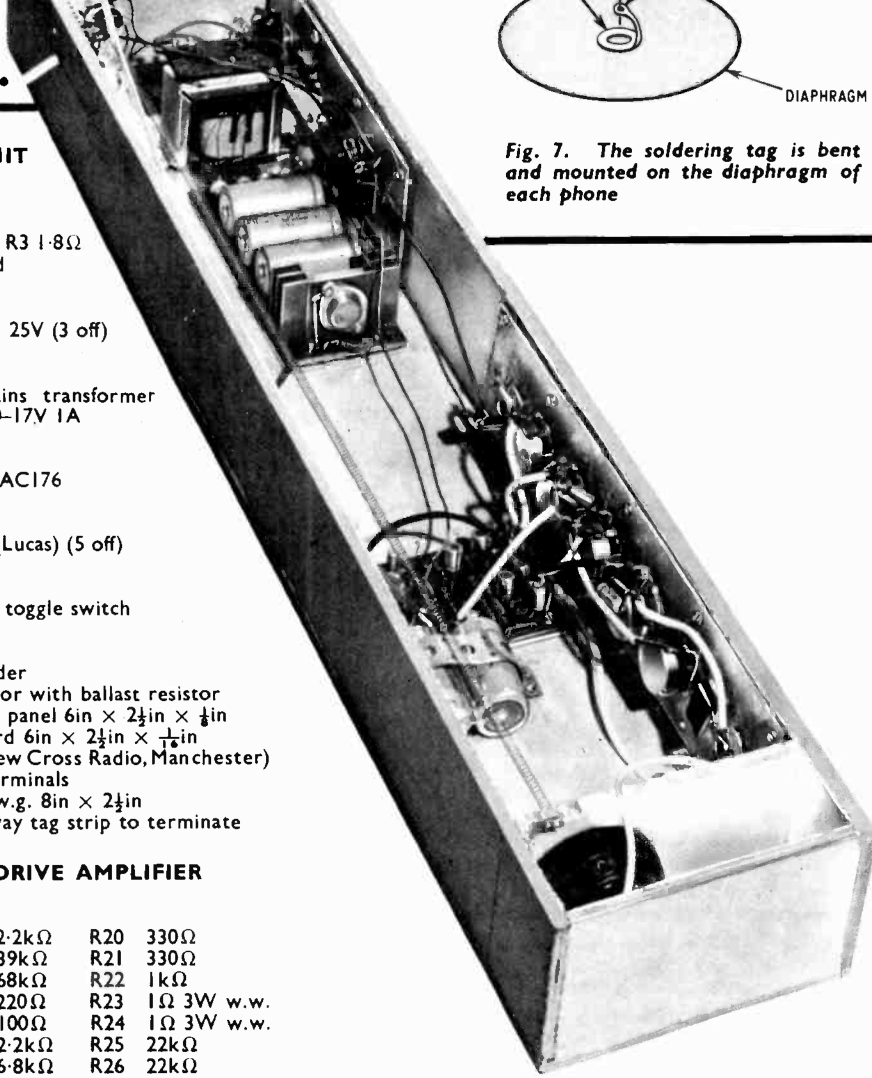


Fig. 6b (above). Printed circuit pattern drawn here half scale. Black areas are copper

COMPONENTS . . .



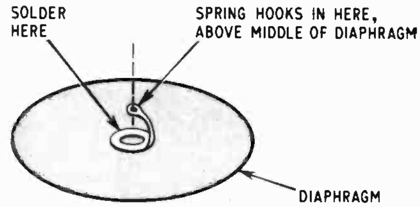


Fig. 7. The soldering tag is bent and mounted on the diaphragm of each phone

POWER SUPPLY UNIT

Resistors
R1 47Ω R2 47Ω R3 1·8Ω
All 5%, 3W wirewound

Capacitors
C1, 2, 3 1,000μF elect. 25V (3 off)

Transformer
T1 Charger type mains transformer
Pri. 240V mains; SEC. 0–17V 1A

Transistors
TR1 XC141 TR2 AC176

Diodes
D1, 2, 3, 4, 5 DD000 (Lucas) (5 off)

Switches
S1 Single pole, on/off, toggle switch

Miscellaneous
FS1 Fuse 0·5A with holder
LP1 Neon panel indicator with ballast resistor
Printed circuit kit with panel 6in × $2\frac{1}{2}$in × $\frac{1}{8}$in
S.R.B.P. insulating board 6in × $2\frac{1}{2}$in × $\frac{1}{16}$in
Heat sink for XC141 (New Cross Radio, Manchester)
Red and black screw terminals
Aluminium panel 18 s.w.g. 8in × $2\frac{1}{2}$in
Mains cable 3-core, 5-way tag strip to terminate

SPRING LINE DRIVE AMPLIFIER

Resistors

R4	150kΩ	R12	2·2kΩ	R20	330Ω
R5	1MΩ	R13	39kΩ	R21	330Ω
R6	15kΩ	R14	68kΩ	R22	1kΩ
R7	2·2kΩ	R15	220Ω	R23	1Ω 3W w.w.
R8	150kΩ	R16	100Ω	R24	1Ω 3W w.w.
R9	1MΩ	R17	2·2kΩ	R25	22kΩ
R10	15kΩ	R18	6·8kΩ	R26	22kΩ
R11	2·2kΩ	R19	see text	R27	68kΩ
				R28	22kΩ

All 10%, $\frac{1}{4}$W carbon except R19, R23, R24

Potentiometers
VR1 1MΩ log carbon
VR2 25kΩ log carbon
VR3, 4, 5 50kΩ log carbon (3 off)

Capacitors

C4	10μF	C10	50μF
C5	10μF	C11	10μF
C6	50μF	C12	50μF
C7	10μF	C13	1,000μF elect. 25V
C8	10μF	C14	1,000μF elect. 25V
C9	50μF	C15	25μF elect. 25V

All electrolytic 15V except C13, C14, C15

Transducers
X1, X2 Moving diaphragm magnetic earphones, high impedance, d.c.r. 40 ohms (e.g. ex-Gov't type 4035B)

Transistors and Diode
TR3, TR4, TR5 C424 (S.G.S.–Fairchild) *or* ST141 (Sinclair) (3 off)
TR6 GET104 *or* AC154 (Mullard)
TR7 C426 (S.G.S.–Fairchild) *or* ST141 (Sinclair)
TR8 OC81 *or* AC154 (Mullard)
D6 IS130 *or* DD000

Switch
SW3 Single pole, push on–push off press button switch

Miscellaneous
Printed circuit panel $3\frac{1}{2}$in × $2\frac{1}{2}$in × $\frac{1}{16}$in
S.R.B.P. insulating board $3\frac{1}{2}$in × $2\frac{1}{2}$in × $\frac{1}{16}$in
Aluminium panel 18 s.w.g. 12in × $2\frac{3}{4}$in
SK1, SK2 jacks
Helical steel tension spring $5\frac{1}{4}$in long, $\frac{3}{16}$in dia., 26 s.w.g.
Control knobs (Bulgin type K107) (5 off)
Single-core screened wire

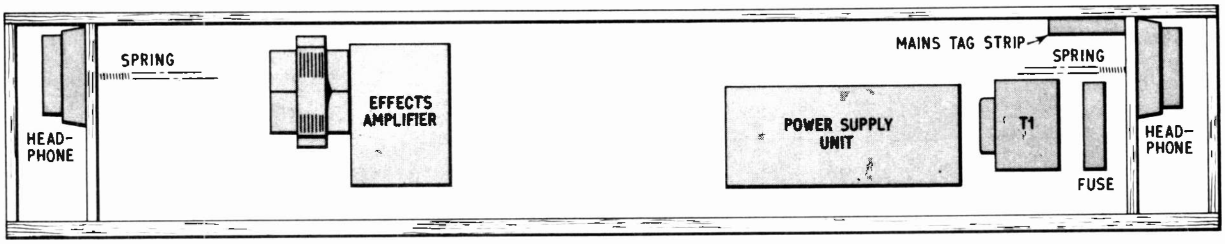


Fig. 8. Layout of units in the case

one of the brass screws at the same time, for subsequent connection of the collector of TR1 to the printed circuit board. After the collector, base, and emitter of TR1 have been wired to the printed circuit in this manner, fill the holes in the heat sink with polystyrene cement, or with Radiospares Sealing Compound, where the base and emitter leads come through. This will prevent lodging of dust in these spaces, which could lead to electrical unreliability if the dust contained metallic particles.

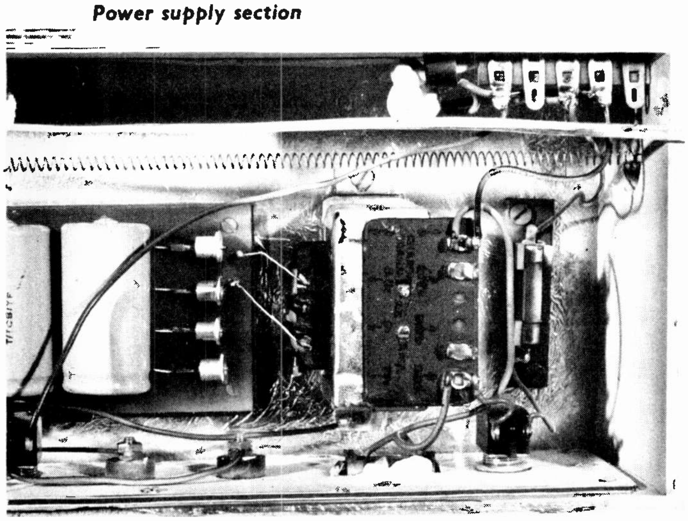
HEADPHONE TRANSDUCERS

Remove the front cover of each phone so as to gain access to the diaphragm. Find the exact centre of the diaphragm, and scrape away the varnish to expose a circle of clean metal about ¼in in diameter. As this metal does not accept solder very easily, it is necessary to apply a thin layer of non-corrosive flux, and solder with a very hot iron or a solder-gun, giving a shallow pool of solder ¼in diameter in the middle of the diaphragm.

A 4B.A. soldering tag which has been previously tinned and bent as shown in Fig. 6 is then soldered to the middle of each diaphragm so as to form an anchor-point for the spring. Cut a hole ½in diameter in the centre of the front cover of the phone, so that when it is re-assembled the soldering tag projects through this hole.

Each phone must now be mounted in its respective compartment at the ends of the cabinet. The headphones are mounted facing each other, with the tags projecting into the middle of the ¾in hole in the wood. Roughen the front of the outer rim of the headphones with a file, and apply a ring of "Evo-Stik" impact adhesive to each phone. Immediately press it into place on the wood, so that a ring of adhesive is deposited there. Remove the phone from the wood and set it aside for a few minutes in accordance with the instructions on the adhesive package, making sure first that the adhesive on both wood and phone is evenly spread.

Power supply section



When the adhesive has become partly set (about 5 to 15 minutes according to temperature and thickness of the layer) press the phone firmly into place, when it should stick firmly in position.

Follow the same procedure for both phones so that when in position they face each other.

Hook the loop at one end of the spring into the small hole in one of the soldering tags, and stretch it evenly to hook into the other tag. Be very careful not to let the spring fly back when it is stretched, as it may break the diaphragm in one of the phones.

Fix the printed circuit boards in position in the cabinet with wood screws, using the insulated boards to separate the copper sides from the aluminium foil on the wood. Mount in position also the mains transformer, fuseholder, and capacitors C13, C14. Mount the potentiometers, switches, sockets, terminals, and neon indicator on the control panels.

Wire the unit according to the layout diagram in Fig. 6. All connections to the "signal and effects" control panel components should use screened wire with the screen connected to the common line to S2. The connection to the "receive" transducer X2 should also use screened wire.

The aluminium panels, foil, and the frame of the mains transformer should be connected to the common line to S2 using thick copper wire. The mains cable passes through a small hole in the rear panel, to a cable-clamp fastened inside, then terminated on the tag strip mounted in the box. Check that wiring and components are correct, then test as follows.

TEST THE POWER SUPPLY UNIT

Disconnect the positive power supply wire from the amplifier. Connect a 470 ohm 1 watt wirewound resistor across the output terminals. Plug into the mains and switch on. The output voltage of the power supply, measured across the terminals on the control panel should be slightly over 20 volts. Switch off, remove the 470 ohm resistor, and reconnect the amplifier.

TEST THE AMPLIFIER

Turn all controls to their minimum setting, and switch on again. The voltage at the junction of R23 and R24 should rise to about half the supply voltage. If it is more than, say, a couple of volts away from this value, switch off and change the value of R13 to bring this voltage nearer to its correct value.

Connect the unit to an external amplifier and loudspeaker via the output socket SK2, and plug in a microphone or other signal source at the input socket SK1. When adjusting the "gain" (VR2) and "volume" (VR4) controls, the signal should be heard through the loudspeaker. If the signal source is of high impedance, or high output, adjust VR1 to give suitable matching, thus avoiding distortion at the input.

Check also the collector voltages of TR3, TR4, which should be in the region of 6 to 10 volts. It may be necessary to select transistors for these positions, or to alter the bias resistors R5 or R9 in order to achieve best results.

If crossover distortion is apparent from the amplifier, it may be necessary to use a higher value of resistor in place of R19, and in order to determine the best value, connect a 200 or 250 ohm potentiometer temporarily in this position, and gradually raise the value until the distortion is cleared. Be careful, as too high a value of resistor in this position will cause an excessive current to flow in the output transistors, causing them to overheat, and possibly to become damaged. The amount of current flowing through the entire amplifier (including pre-amplifiers) is about 15mA under quiescent conditions, rising to over twice this value for strong signals.

OBTAINING EFFECTS

Adjust the volume and gain controls so that the input signal is heard clearly through the loudspeaker. Carefully adjust "dimension control" VR5. If the reverberation switch S3 is in the open-circuit condition, varying degrees of reverberation should be obtained according to the setting of VR5. If, however, this control is set too high, acoustic feedback may occur as the unit is unavoidably somewhat microphonic.

The sustain control can be used to prolong the reverberation period, but, like the dimension control, should be used only moderately in order to avoid feedback problems.

REMOTE CONTROL

When the reverberation switch is operated, the reverberation effects should disappear and return according to the position of the switch. If it is desired to operate the unit from a remote switch, replace S3 by a standard audio jack socket into which a screened footswitch is plugged via a length of coaxial cable. If the "dimension" and "sustain" controls are deliberately set to obtain feedback, this may then be easily switched on and off for special effects.

ADVANTAGES AND DISADVANTAGES OF THIS TYPE OF UNIT

The use of headphones as transducers gives the advantage that the unit is much cheaper to construct than by other methods. Although the size of the unit is somewhat greater than that of some comparable commercial units, the author found that it is worthwhile to stretch the spring considerably in the interest of a better sounding effect.

The use of headphones gives the disadvantages of acoustic feedback, and colouration of the sound. This can be counteracted by replacing the entire spring assembly with a "Hammond Mk. IV" or similar mechanical system. The circuit given can be used with such a unit, and results are better, but a commercially built spring system must be obtained.

USE WITH OTHER EQUIPMENT

The reverberation unit can be used with most audio equipment, and with the *Fuzz Box* described in last month's issue gives a combined effect. It can also be used with the electronic sound sources to be described later for the production of electronic music and sound effects. ★

microelectronics

LINEAR ICs

PART FIVE

BY M.J. HUGHES M.A.

Last month some typical digital integrated circuits were described, and it was established that with most types of digital circuitry a certain amount of standardisation occurs between different manufacturers. This month we look at the linear types of circuit that are available, and describe in detail a few of the more general purpose devices.

Linear circuits can be broadly classified as all those which are not digital, and include such types as amplifiers, detectors, oscillators, mixers, comparators, and even resistor networks. As any constructor will know there are many different basic designs which can be called on to perform these functions, and the natural result of this is that there is much less standardisation between manufacturers, and although there may be many different types available no single unit is produced in anything like the same quantity as digital circuits. It follows immediately that linear integrated circuits, on the whole, are more expensive than their digital counterparts.

Cost, however, is purely relative, and in many instances the amateur will find that there is very little to choose between buying a ready made unit, and constructing his own at home—needless to say there is always an added risk in the latter that after building, the unit may or may not be satisfactory. At high frequencies, the integrated circuit really comes into its own, as it substantially reduces layout problems which directly leads to reductions in parasitic capacitance and inductance.

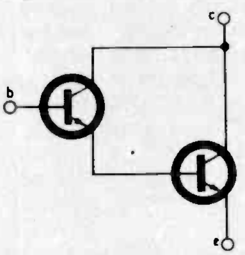


Fig. 21. Darlington pair

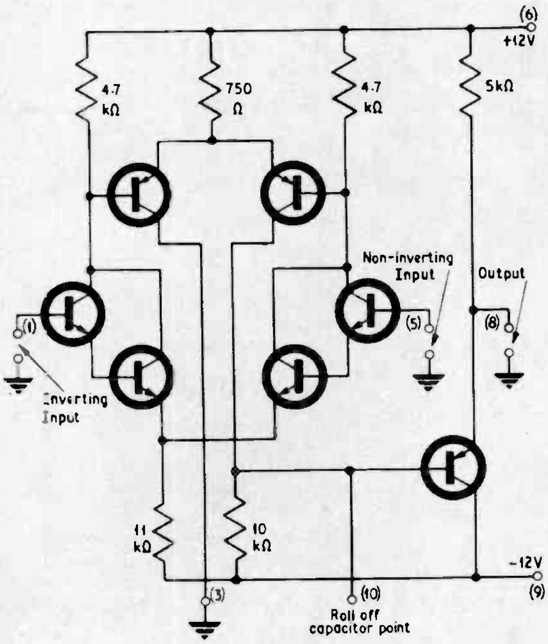


Fig. 22. Circuit of the SN524A differential amplifier

SUPER-ALPHA PAIR

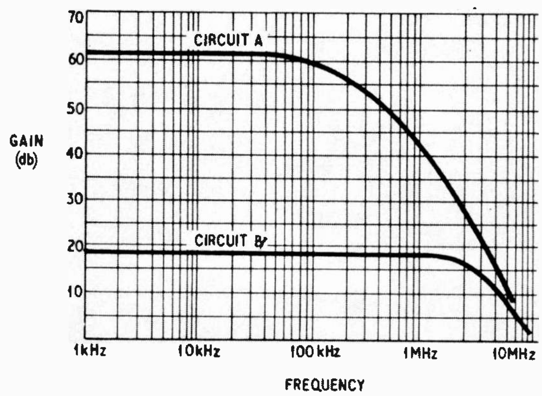
Perhaps the most simple linear circuit is the super-alpha transistor pair, or Darlington pair. This is shown in Fig. 21. This compound unit can be considered as a single transistor having a very high base input impedance and a very high current gain. The effective gain of the unit is the product of gains of the two individual transistors it comprises. Current gain can be typically in excess of 600.

Many manufacturers offer this circuit as a device in its own right, and also in matched pairs which are commonly used for the input of differential amplifiers. In this case variations of temperature will not seriously affect the stability of the final amplifier as the transistors are integrated into a single chip, and temperature effects are self-cancelling.

As temperature effects do not greatly influence well designed integrated circuits, and capacitors are usually to be avoided for the reasons given in previous parts of this series, most circuits to be encountered are direct coupled. This is advantageous as it allows a far wider application for any particular circuit.

A comparatively simple circuit of this type, which utilises two Darlington pairs as a differential input is the Texas SN524A shown in Fig. 22. Either input may be used provided the other is strapped to earth through a suitable resistor for normal single input applications, or both may be used for differential, or comparative purposes. A point to note is that if single input is used there is a choice to be made between an inverted, or non-inverted output signal.

Most integrated circuit amplifiers have a facility for frequency characteristic modifications. This can take the form of an output point for a capacitor to set the top frequency roll-off (in this circuit pin 10), or outputs to allow external feedback circuits. In the case of the SN524A, negative feedback is obtained by an external network between pins 8 and 1. Positive feedback would occur if the non-inverting input (pin 5) was used.



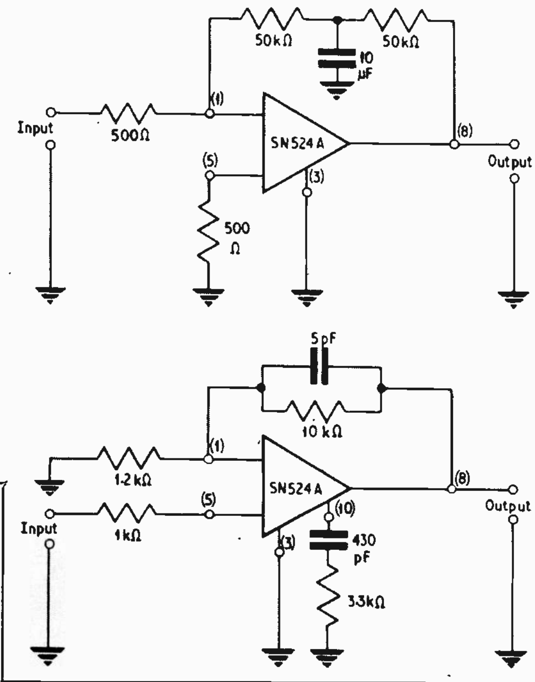


Fig. 23. Two possible circuit configurations using the SN524A with the frequency response of both

By careful selection of feedback it is possible to modify the overall characteristics of the amplifier quite considerably from one having very high gain at low frequencies to having medium gain at high frequencies. Two examples of this are shown for this circuit in Fig. 23.

Basic characteristics of this circuit are:

Voltage gain (no feedback)	63dB
Bandwidth (no feedback)	140kHz
Input impedance	1MΩ
Input offset voltage	12mV
Output impedance	200Ω
Output voltage swing (max)	15V
Power dissipation	120mW

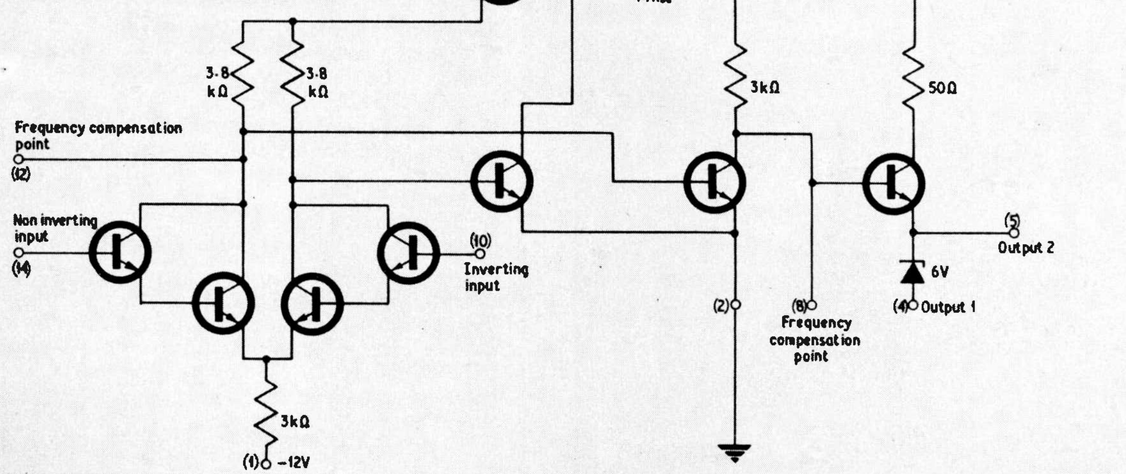
OPERATIONAL AMPLIFIER

Whilst the SN524A could be used (not necessarily to best advantage) without any external components, there is a family of circuits which rely solely on the addition of external components both to make a functional block, and also to modify parameters. These amplifiers are called "operational" or instrumentation amplifiers, and are designed to allow the widest possible use of a standard integrated device.

Basically these circuits can be regarded as being a means of obtaining gain and nothing else. By suitable external circuitry it is possible to make oscillators, differential amplifiers, and all other types of amplifiers from these basic units. A typical example of an operational amplifier is the Plessey SL 751B shown in Fig. 24.

Note the basic similarity between this, and the previous circuit, but also the number of available terminations. An example of external circuitry required to form an amplifier having a gain of 40dB up to 400kHz is shown in Fig. 25.

Fig. 24. Circuit of the SL 751B operational amplifier. Pin connections for the flat-pack version are shown



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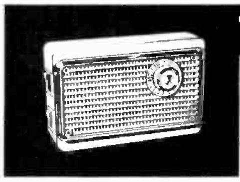

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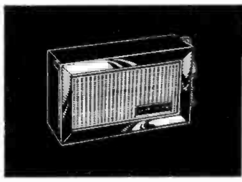

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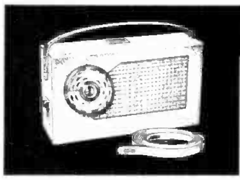

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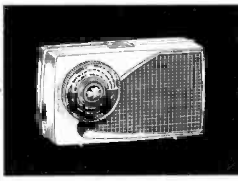
MELODY MAKER 6



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Total building costs 69/6 P. & P. 3/6

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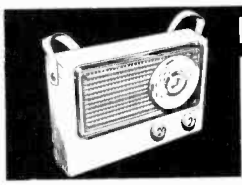

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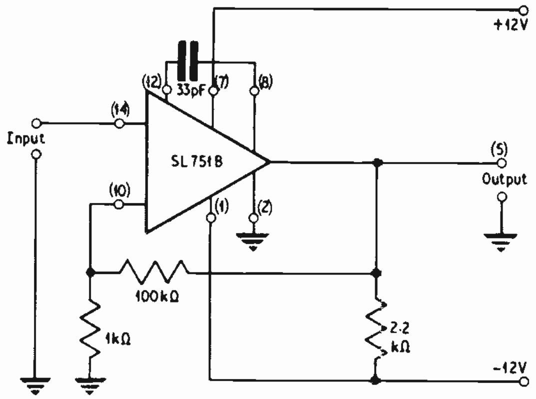
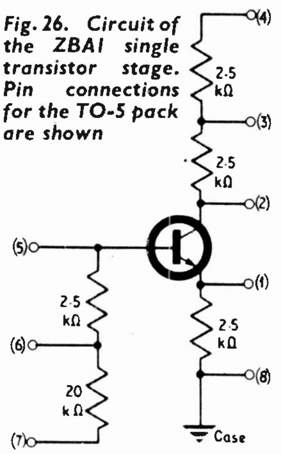


Fig. 25. The SL751B with added components to provide a 400kHz, 40dB amplifier

Fig. 26. Circuit of the ZBA1 single transistor stage. Pin connections for the TO-5 pack are shown



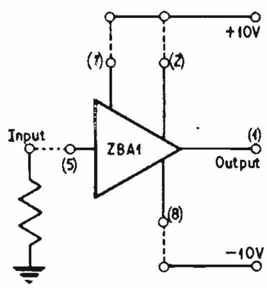


Fig. 27a. The ZBA1 wired as an emitter follower

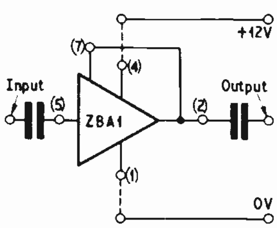


Fig. 27b. The ZBA1 wired as a common emitter audio amplifier

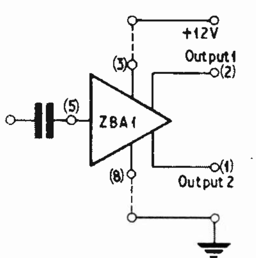
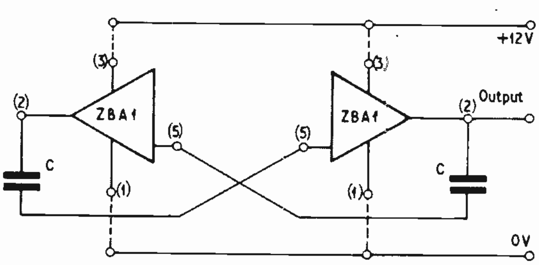


Fig. 27c. The ZBA1 wired as a phase splitter



C	Frequency
0·001μF	33kHz
0·0047μF	8kHz
0·01μF	2·5kHz
0·033μF	1·25kHz
3·3μF	10kHz

Fig. 27d. The ZBA1 wired as a free running multivibrator

Whilst in some cases it is possible to obtain amplifiers having facilities for inductance tuned collectors, e.g. for conventional i.f. work, these inductors always have to be included as external components. A more modern approach is to use a transfilter or similar device in a negative feedback loop associated with amplifiers of the above types. For very narrow pass bands, or oscillators, a simple bridged-T RC network can be used in negative, or positive feedback respectively.

The above circuits are rather special as they are designed to make as much use as possible of integrated circuit techniques, but in some instances they may be over complicated. Although they are usually very well described with detailed circuitry in manufacturers' applications reports, they may present theoretical problems for the more inexperienced experimenter. There are, however, a number of conventional circuits available, and these range from simple single transistor stages to complete video amplifier stages.

SINGLE STAGE

An example of the single stage is the Ferranti ZBA1 shown in Fig. 26. A certain amount of redundancy is built into the chip because it is necessary to offer various choices of resistors for different loads and bias conditions, therefore more resistors are shown than one would normally encounter in a single stage. Fig. 27 shows the way in which this stage can be used to form

(a) an emitter follower,
(b) a common emitter audio stage,
(c) a phase splitter having two equal amplitude outputs 180 degrees out of phase, and
(d) a free running multivibrator oscillator which could be used as a test signal injector.

Typical characteristics of this circuit are as follows:

Supply voltage	6V
D.C. current gain	30 (min)
Current gain (at 10MHz)	5

A slightly more complex circuit is the ZLA10 wideband amplifier shown in Fig. 28. Basically a two-stage, direct coupled amplifier, the unit has an 880 ohm feedback resistor built in, which can be used if wider

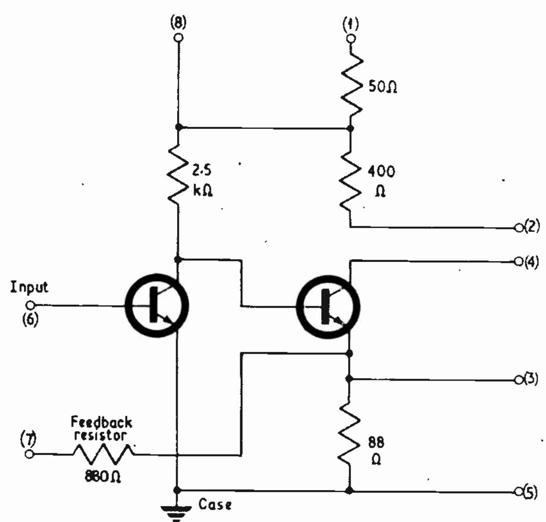


Fig. 28. Circuit of ZLA10 wide band amplifier. Pin connections for the TO-5 pack are shown

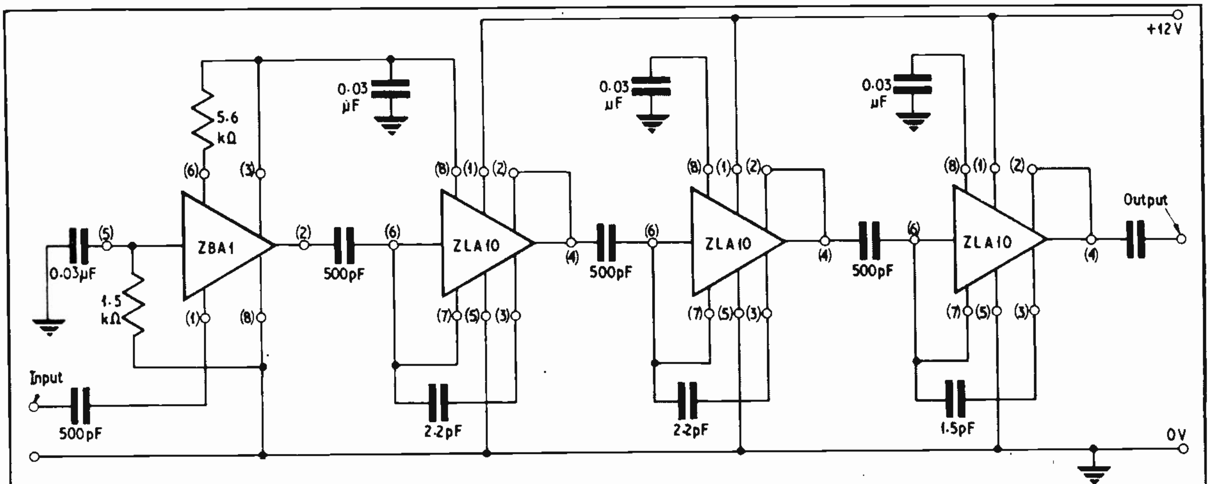


Fig. 29. Four integrated circuits with 12 capacitors and two resistors formed into a video amplifier

bandwidth at a lower gain is required. There is an optional open circuit collector which allows the use of external loads, e.g. an inductor, but under normal circumstances pin 4 would be short-circuited to pin 2 thus utilising the built-in load resistors.

Typical characteristics are:

Supply voltage	12V
Current gain	10
Upper frequency limit	120MHz
Output impedance	400Ω
Power dissipation	150mW

An example application utilising the ZLA10 and the ZBA1 is shown in Fig. 29. This circuit is a video amplifier having the input and output matched to 50 ohms thus making it ideal for use as a television video mixer panel amplifier. Suitable modifications could make it the basis of a home made television camera. In this application the ZBA1 is used as a grounded base stage having a low input impedance. Overall characteristics of the circuit are:

Input impedance	50Ω
Output impedance	50Ω
Voltage gain	52dB
Bandwidth	95MHz
Power consumption	430mW

In the space of this article it is impossible to describe all the various types of linear circuits that are available, but it is hoped that the outlines given will encourage experimentation. Most manufacturers are only too pleased to give help in the form of very detailed applications hints that deal explicitly with their own circuits.

To sum up the series it is obvious that the integrated circuit is well and truly here to stay, and is certainly well inside the price limit of the average experimenter. It only remains to make the best possible use of this new development, and as more use is made so the prices will fall.

DO's AND DON'Ts

Use the simplest possible circuit for a given application.

Try and use the most common circuits (these are the cheapest).

When using logic circuits stick to one type for a given application unless other types are stated as being directly compatible.

Avoid mixing package types (TO-5, flat-pack, and dual-in-line) unless it is unavoidable. Amateurs will find the dual-in-line, and TO-5 most easy to handle.

Make absolutely certain that the circuit board, or printed circuit is correctly wired before inserting the integrated circuits. It is extremely difficult to remove them without a special de-soldering tool.

Do not load more than the stipulated maximum fan outs on gate circuits.

Do not apply more than the specified supply voltage.

Ensure that polarity of supply voltage is correct.

Make sure that there are no solder runs between pins of packages.

Do not apply soldering heat for more time than is necessary to make the joint.

In complex systems ensure that the dissipated heat can be removed.

Remember that it may be necessary to decouple between stages particularly in TTL, and all linear circuits.

DEVELOPMENTS

Where are integrated circuits likely to go from here? Already there are highly specialised techniques for manufacturing special types of circuit (e.g. the metal oxide semiconductor device). This particular technique could bring about the introduction of large scale integration in the space of the next year or two. It is already possible to buy 21-bit shift registers on a single chip.

S.T.C. have recently announced a new concept which they call DOFICS (Domain orientated functional integrated circuits). These will allow amplifiers and oscillators to operate by the control of waves of electrons through geometrically shaped pieces of semi-conducting material (the Gunn effect). If notches are introduced to the geometrical structure, pulses can be obtained at each notch, the number of pulses generated being proportional to the distance and speed of the wavefront. Here then is a very simple analogue-to-digital converter. A further possibility using this concept is the development of solid state replacements of the conventional cathode ray tube.

What the future holds is still a little obscure, but certainly there are going to be even more changes in techniques and applications in this rapidly expanding field. ★

Proportional Servo System

for MODEL CONTROL

By J. Tennant

THE availability of high frequency transistors has markedly changed radio control techniques. A few years ago, it was usual to employ the "bang-bang" system of control whereby the presence of the transmitter carrier frequency caused the receiver to operate a simple relay. This in turn supplied power to the coils of actuators or simple escapements worked by rubber bands and connected in ingenious ways to operate the model's controls sequentially.

The rudder of a boat, for example, could be turned to the right on full lock, released to a self-centred position then, after an interval, turned to the left on full lock. Skilled operation was necessary to make the model perform simple functions. Today, multi-channel proportional equipment enables an enthusiast to set such a ship's rudder at any angle between locks for any length of time, vary it at will, and simultaneously operate other controls.

BASIC SYSTEM

The servo system described here is intended for use with radio control equipment but is also suitable for other applications such as two-wire rotational control of indicators, volume controls and light mechanisms.

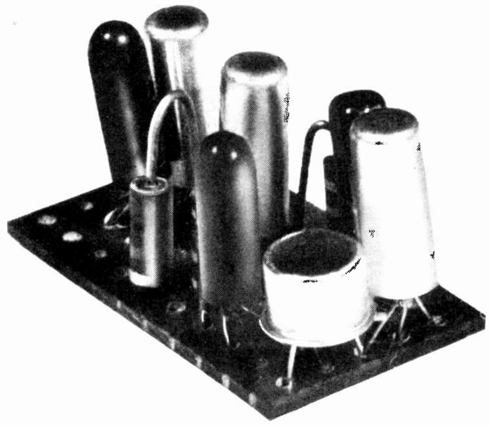
The carrier frequency of the transmitter 26·96 to 27·28MHz is modulated by an audio tone (or tones for multi-channel control) which is, in turn, proportionally controlled by one of several methods. The resulting output of the receiver is applied to a servo amplifier and motor.

It is arranged that a change of receiver output causes the motor to rotate turning a small potentiometer through a gear train until a voltage derived from the potentiometer equals and neutralises that from the receiver. A relatively large torque is obtained from the final gear which takes up a position "proportional" to that of a potentiometer control on the transmitter.

Although the price of a complete five- or six-channel servo proportional system is in the order of £100, some of the circuitry is identical to simple systems which could be converted subject to the addition of tone filters, discriminators, servo motors, and allied amplifiers.

The availability of small motors in the price range 2s to 5s suggested the thought that if such a motor were "doctored" to give reasonable reliability, and a gear train fitted, then all that would be necessary to produce a cheap servo would be the amplifier.

Equation must always be made between reliability and cost but if the motor is treated as having a distinct "life" a reasonable compromise is effected. The particular motor chosen for the first tests was rather large and suitable for boat work. It had a "start-to-run" load of 350mA on no load and an efficiency of approximately 30 per cent. Burrs on the armature were removed, the pole pieces centred by packing and the spring commutator contacts treated with switch cleaning fluid.



A simple Meccano type gear train was fitted with a ratio of 50 : 1, the final gear being a push fit on a 10 kilohm potentiometer spindle acting as a clutch.

AMPLIFIER

The basic amplifier circuit used (Fig. 1) is similar to many existing designs. Equivalent transistors may be used and the resistor values are not critical, subject to certain effects common to servo systems which depend on the type of motor and gear ratio used. As a guide, consider the action of TR1, TR2, and TR3.

TR3 has to pass the full "stalled" load current of the motor. This is limited by the battery's internal resistance and by the voltage across the transistor (V_{BE}) and may be further reduced if necessary, by R_x which should be as low a value as possible to give the maximum running torque. TR3 is a *pnp* OC84 with an $I_{C(max)}$ (maximum current) of 1A and a current gain of at least 60. OC72, OC76 and OC77 are similar transistors having a current gain of 45, but an $I_{C(max)}$ of only 250mA.

The current into the base of TR3 is $\frac{I_{C(max)}}{\text{gain}} = \frac{1000}{60}$ = 16mA. This is provided from TR2 which is an *npn* transistor with a gain of at least 80 (and an $I_{C(max)}$ of 400mA). TR2 and TR3 operate in the "bottomed" condition only, for short periods so "power" limitations may be ignored. TR1 is a *pnp* OC202 with a gain of at least 45. ($I_{C(max)} = 100$mA.)

Though high gain transistors have been chosen for best performance, less expensive ones may be used provided that $I_{C(max)}$ is not exceeded. It is possible to measure the gain of a transistor with a simple circuit, and it is often found that an individual cheap transistor has a higher gain than an expensive one that has a specified minimum gain.

Suppose point A (Fig. 1) is joined to 0V. If point B is made at least $-0{\cdot}7$V (V_{BE}) then TR1 conducts developing a voltage across R2 which turns on TR2 and TR3 causing the motor to run, the current passing from 0V (+ve) through the motor to −3V via TR3. The gear train turns VR1 in a direction so as to reduce the voltage between A and B, and so cut off TR1.

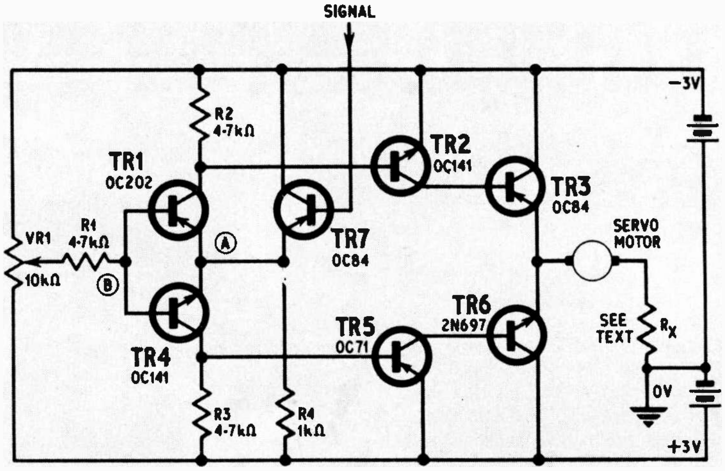


Fig. 1. Basic circuit of the servo amplifier on which the circuits in Figs. 2 and 3 are based

If the gear ratio was low and the motor large, "over-run" would be possible and the inertia would turn VR1 till TR4 conducted and the motor reversed.

The current now passes from +3V via TR6 through the motor to 0V (−ve).

The use of a small motor and a gear train prevents excessive over-run and the drive stops in a position with neither TR1 nor TR4 conducting. The "dead spot" corresponds to the sum of the turn-on V_{BE} voltages of TR1 and TR4. V_{BE} is dependent on collector current and by keeping this low (by means of R2 and R3) the nominal values of 0·3V and 0·7V are reduced to approximately 0·6V total.

The usual rotation of a potentiometer is 270 degrees. The "dead zone" is, therefore, $0{\cdot}6/6 = \frac{1}{10}$ of $270 =$ 27 degrees. This is satisfactory for most purposes but may be reduced by several means; boat modellers for example, may use a 12V battery across VR1 thus giving a dead zone of approximately 13 degrees.

AUXILIARY CIRCUIT

Fig. 2a indicates an auxiliary circuit in which the bases of TR1 and TR4 are only separated by the voltage across the diodes D1 and D2. This voltage varies with individual diodes and with current, but is approximately 0·3V for germanium types such as OA70, OA10 and OA5. If TR1 is just conducting with a V_{BE} of 0·5V then the voltage at C is −0·5V relative to A. Point D is approximately 0·6V positive to C, or 0·1V positive to A. Changing the voltage at C by less than 0·2V positive will, therefore, cut off TR1 and turn on TR4, the dead zone being less than 9 degrees as before.

Fig. 2b shows the bases of TR1 and TR4 taken to separate wipers of the same potentiometer, the annular separation determining the "dead zone". This method is of particular interest since it is easily adjusted, and one method of mounting a potentiometer is to extract the disc of a miniature type and mount it on a gear shaft with "pigtail" ends and the wipers secured to the frame.

The signal voltage is applied to point A (low impedance) by means of an emitter follower TR7, which has a standing current of approximately 6mA in the inactive condition of the amplifiers. In practice the base of TR7 is directly connected to the discriminator circuits but for test purposes may be connected to a potentiometer as shown in Fig. 2c.

A signal voltage applied to point E from a relatively low impedance (e.g. a battery) causes the servo to act; if the signal is removed VR1 is rotated to the original position set by VR2. Thus VR2 may be used as a neutralising trim control.

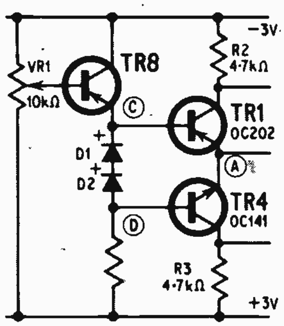


Fig. 2a. Modification to first stage with an extra transistor TR8

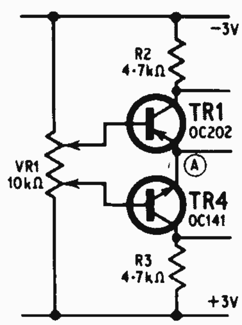


Fig. 2b. Two-wiper potentiometer to determine the dead zone

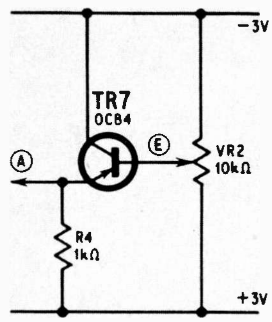


Fig. 2c. Test circuit around TR7 by connecting a d.c. source to the base

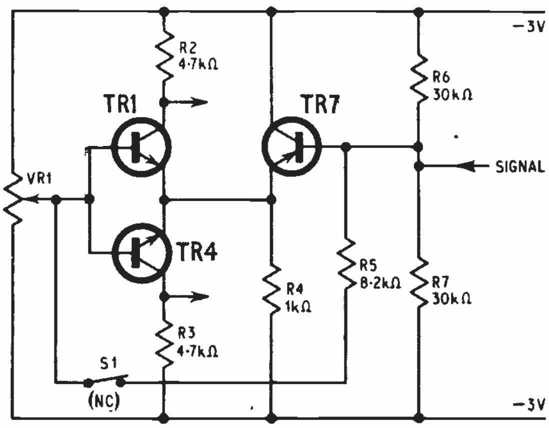


Fig. 3. Facility for injecting a d.c. signal to TR7 base and TR1 and 4 via R5

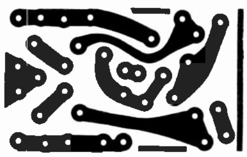


Fig. 4a. Printed circuit pattern (full size) for the amplifier in Fig. 1

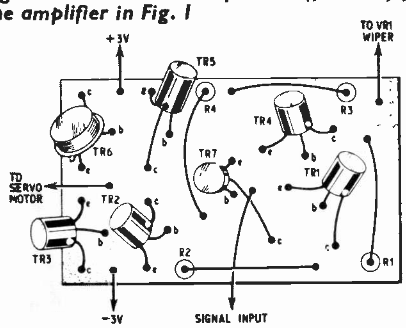


Fig. 4b. Component layout on the printed circuit board

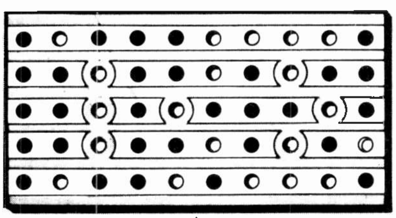


Fig. 5a. Veroboard is a simple method of making the amplifier unit

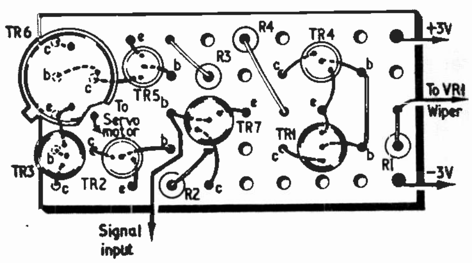


Fig 5b. Component layout on the Veroboard of the amplifier in Fig. 1

COMPONENTS . . .

Resistors

R1	4·7kΩ	R5	8·2kΩ
R2	4·7kΩ	R6	30kΩ
R3	4·7kΩ	R7	30kΩ
R4	1kΩ	Rx	(see text)

All 10%, $\frac{1}{8}$ or $\frac{1}{10}$ watt carbon
R6 and R7 selected from 33kΩ 10%

Potentiometers

VR1 10kΩ
VR2 10kΩ

Transistors and Diodes

TR1	OC202	TR4	OC141
TR2	OC141	TR5	OC71
TR3	OC84	TR6	2N697

D1 and D2 (see text)

Miscellaneous

Printed circuit board or Veroboard (see text)
Motor and gearing (see text)

Fig. 3 indicates the replacement of VR2 by R5 wired to VR1. In this case, on the removal of the signal voltage from point E, the servo stays in its last position, i.e. it does not neutralise at all. Provided there is little delay in the removal of the d.c. signal there is no reason why a number of servos (with corresponding tone filters, etc.) should not be operated in sequence as well as simultaneously. Not only does this give extreme versatility but it also allows for progressive development.

A system with, say, two simultaneous channels plus one non-neutralising (e.g. throttle) channel could be later developed to bi-simultaneous operation plus a number of non-neutralising channels.

Fig. 3 also shows R6 and R7 (approximately 20 kilohms) and switch S1. If S1 is opened with no signal present then the servo would rotate to the limit or to a given amount, depending upon the ratio of R6/R7. This could form part of any fail safe device.

CONSTRUCTION

For radio control work it is preferable to use a printed circuit board to keep the unit compact and lightweight (Fig. 4). The printed circuit board should be drilled with a No. 60 drill and resistors R1, R2, R3 ($\frac{1}{8}$ or $\frac{1}{10}$ watt) soldered in first.

Transistors TR1, 2, 4, 5, and 7 should be soldered in with a clean iron and with minimum lead length, using wiring pliers as wiring heat sinks, following the layout diagram. Transistors TR3 and TR6 do not normally require heat sinks. If prolonged use is contemplated or if substitutions are made heat sinks should be fitted and the "stalled" motor torque should not exceed the maker's maximum working rating.

If necessary a resistor R_x may be mounted on the motor to reduce the "stalled" current to within the rating of the transistors. This may take the form of two $\frac{1}{8}$ watt 5 ohm resistors in parallel.

For other users the amplifier may be built on Veroboard as illustrated in Fig. 5, layout not being critical, and two-wire control being obtained by using a remote variable resistance to shunt R6 or R7 in Fig. 3.

VR1 must be phased correctly by experiment and a simple friction clutch is recommended in the system to prevent the destruction of the driven potentiometer at its end stops. ★

the 73 page by Jack Hum G5UM

What of the Future ?

"SAY HEART, what will the future bring?" The question recurs over and over again in that noble paean by John Ireland, "These Things Shall Be". Appropriately at the year end, traditional time for looking back over what has been achieved and ahead to what might be, the radio amateur may well ask himself "What will the future bring?"

On the one hand he sees his kind proliferating in such numbers that today there are almost half a million licensed amateur transmitting stations the world over, more than the tally of all the professional stations put together.

Intruders

On the other hand he is aware of constant pressure on his frequency space—and indeed encroachment upon it—by services that have no right to use it (a situation, one might add parenthetically, which is by no means accepted passively. The Radio Society of Great Britain's intruder watch, constantly vigilant, collects evidence of poaching stations to pass on to higher authority. Less officially, many written protests are known to have gone to Radio Peking — especially — against intrusion into amateur territory).

As he ponders "What will the future bring?" the transmitting amateur finds himself confronted by what is a world problem—too little space for the clamorous claimants for living room. Not that this is anything new: he more than any other user of the radio frequency spectrum has adapted himself to the exigencies of living under crowded conditions.

And when it comes to outside demands on his frequency space, he is well represented by strong national and international societies to champion his interests.

At times, though, he is saddened by what appears to him to be failure to use valuable frequencies to full advantage; commercial stations idling for hours on end "to keep a channel warm", vast areas of v.h.f. completely blank, ostensibly required for "business radio" interests, and never show a signal.

Sideband

Of the many devices to which resourceful amateur radio has turned to make life more bearable, undoubtedly the most dramatic is the development of the single sideband suppressed carrier mode of transmission. At once this enormously increases a transmitter's talk-power (and therefore readability at great range), abolishes the heterodyne problem and permits greater occupancy of a given frequency space.

But these advantages are achieved at a price: in some countries less technologically based than our own the poor quality of single sideband transmissions needs to be heard to be believed, and in our own country there are many who, deploring what sounds to them to be the dehumanised "space noise" timbre of s.s.b., seek refuge in the v.h.f. regions where voices sound natural, and where "BBC quality" is still the standard.

Single sideband has a further disadvantage, say some: it cannot be readily resolved by the inquiring short wave listener whose graduation to transmitting status must come from what he hears through attending to the amateur bands. In the past, thousands have become transmitting amateurs through chance overhearing of conversations on the air.

A picture to typify the ascendancy of v.h.f. work in amateur radio today. Two enthusiasts brave wild weather to establish a portable meterwave station on a lonely highspot during one of the R.S.G.B. contests of 1967.

"Very Highs"

"More single sideband", then, is one of the anwers to the question "What will the future bring?" Another is: "More v.h.f.". And those who provide this particular answer are the enthusiasts who believe that the real future of amateur radio lies in developing the "very highs".

To examine what they are doing is to be convinced of the strength of their advocacy. For in no other area of amateur radio is so much forward-looking experimental work going on, both in the development of equipment and in its evaluation on the air.

Popularly, the metre-wavelengths extend from four metres and down. The band at 70·1 to 70·7MHz is the lowest of the v.h.f. allocations used by the British transmitting amateur. Then come the 144 to 146MHz and the 427 to 440MHz areas, customarily known as "Two" and "Seventy Cems" respectively, while centred upon 1,296MHz is the 23 centimetre band.

As might be expected, this order of frequency bands is also the order of difficulty presented to the individual in getting started on any of them.

Getting going on "Four" is easy, and "all-surplus" equipment may be pressed into service here. "Two" and "Seventy Cems", much more difficult, offer constant challenges to operators to develop their own equipment. As for 23 centimetres, approaching the microwaves, the problems are even more formidable, demanding for instance the construction of special parabolic aerial arrays.

Higher still in frequency, the true microwaves are already being essayed by the British experimentalist, and with encouraging results.

Although individually an amateur experimenter cannot be expected to match his results with those obtained in professional laboratories (most of them largely staffed with transmitting amateurs), what in fact is achieved by "loners" in the v.h.f. and u.h.f. field is truly astonishing.

Collectively, the mass of information yielded from the work of several thousand U.K. amateurs now equipped for metre-wave working adds much to the sum of knowledge of electronic communication, not the least in respect of how to "achieve the mostest with the leastest". Always the amateur is ready to show how impressive results can be achieved at economic cost.

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		5mA	22/6	2A D.C.	22/6	15V A.C.	22/6
		10mA	22/6	5A D.C.	22/6	50V A.C.	22/6
		20mA	22/6	3V D.C.	22/6	150V A.C.	22/6
		50mA	22/6	10V D.C.	22/6	300V A.C.	22/6
		100mA	22/6	20V D.C.	22/6	500V A.C.	22/6
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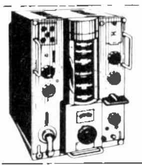

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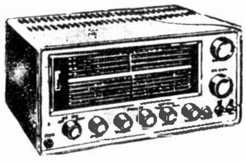

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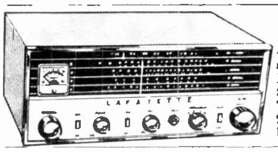

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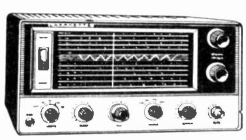

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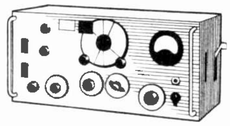

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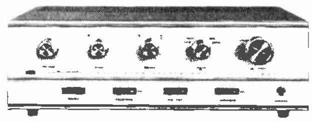

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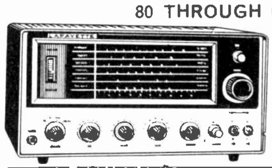

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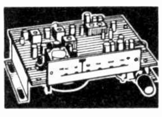

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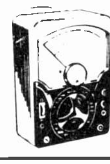

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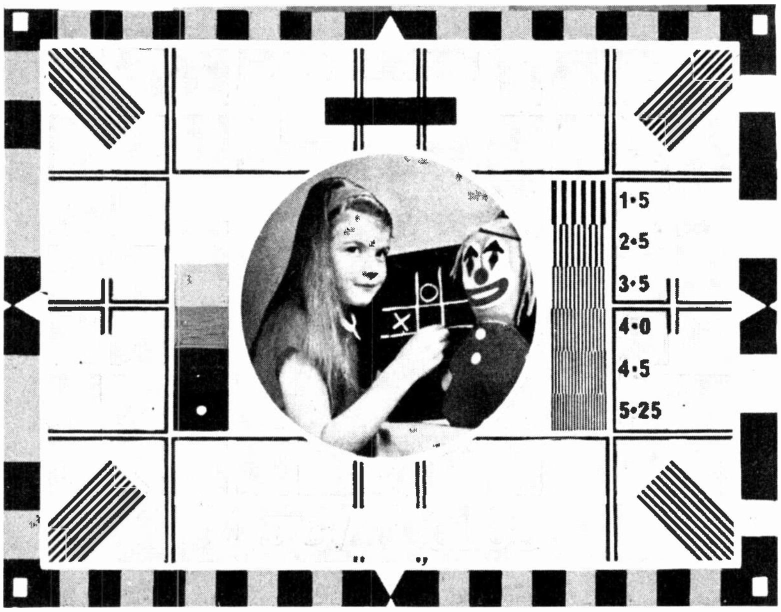


Colour test card F

THE COLOUR RECEIVER

By W. Mizon

Part Two
Setting-up Adjustments Procedure

COLOUR picture make-up in television receivers, described in Part 1 last month, is a delicate and precision operation. Naturally some care and special knowledge is necessary to achieve the best results when setting up. It is essential for engineers to be conversant with the setting-up procedure for the colour receiver, since these adjustments will be necessary for initial installations (to correct the effects of transporting the receiver itself) apart from routine service work once installed.

Experience gained from the practical application of these adjustments will be of great benefit for fault diagnosis apart from the satisfaction derived from a colour picture which has been correctly "set up".

Adjustments which are common to those normally encountered with monochrome receivers should be carried out first using a test card in the usual way. Picture height, width, linearity, centring, etc. are carried out on both 405 and 625-line operation, disregarding any colour which may be present on the monochrome picture obtained. During this initial setting-up procedure, two additional adjustments are required:

(a) *Set E.H.T. Volts*—adjusted to give 25kV at zero beam current.

(b) *Pincushion Correction*—adjusted for minimum bowing of the top and bottom horizontal lines.

This is followed by the "colour" picture adjustments.

PURITY

Purity is a term used to describe the individual primary colour raster or field displayed from the appropriate gun of the picture tube. A red field, for example, is "pure" when the red raster is uniform red, and not contaminated with blue or green. The three colour rasters or fields may be viewed individually by cutting off the output from the unwanted guns. A simple switch shunt circuit is shown in Fig. 9 and can be made up and used by the engineer to effect purity and convergence adjustments. However, colour receivers will incorporate a built-in switch for this purpose.

It will be remembered that the principal of the shadow mask within the tricolour tube is to ensure that the individual beams from each of the three guns will strike only those phosphor dots of the required colour.

The three beams are deflected from left to right and up and down as required for scanning by a deflection coil assembly, and the function of the purity adjustment is to ensure that the beams will enter the correct deflection centre. There are two adjustments which effect the purity.

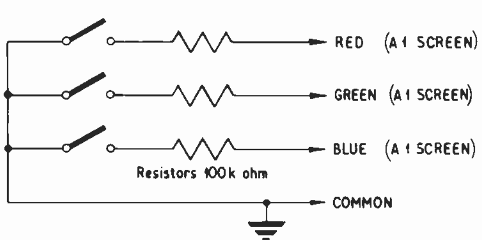


Fig. 9. Screen shunt to cut off selected guns in the picture c.r.t.

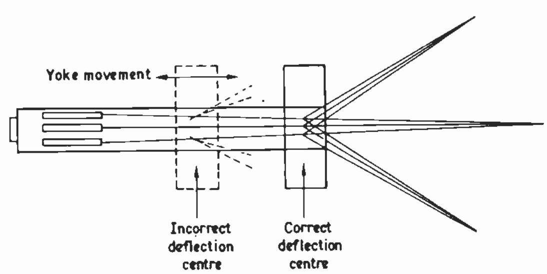


Fig. 10. Effects of deflection yoke position for purity adjustment

Firstly, the purity magnet which is similar in construction to the permanent magnet centring device normally encountered on conventional monochrome receivers. This is located on the neck of the tube behind the deflection coils and adjustment will affect purity in the centre of the picture.

Secondly, overall purity adjustment is achieved by the position of the deflection yoke along the neck of the tube (Fig. 10) and in conjunction with the magnetic field from the purity magnet, will ensure that the beams approach the correct centre.

However, these purity adjustments can be severely affected by stray magnetic fields which may result in magnetism of the steel parts of the chassis or even the steel shadow mask itself. These unwanted fields can be induced by heavy electric currents in nearby conductors, or the earth's magnetic field, and must be completely eliminated before purity adjustment is attempted.

Magnetic fields are neutralised or demagnetised by the use of a degaussing coil, a large coil of wire which is energised from the mains supply and, when placed near to and moved around the receiver, it eliminates the effects of nearly all the static magnetic fields including the earth's magnetic fields. Most colour receivers will incorporate an automatic degaussing coil within the receiver itself, but on the initial setting-up procedure a stronger degaussing source may have to be used externally.

PURITY ADJUSTMENT PROCEDURE

Place the receiver in the final viewing position and carry out the degaussing operation previously described.

Effect preliminary static convergence adjustments. (See under "Static Convergence".) This is a preliminary adjustment to be made before the purity adjustment, as there is some interaction between the purity and the static convergence magnets.

Switch off the blue gun and the green gun leaving a red raster on the cathode ray tube.

Loosen the clamp that secures the deflection yoke and slide back towards the tube base. This will upset the purity severely at the edges of the picture, but will have little effect at the centre of the screen. Adjust the purity magnet to obtain a pure red "blob" in the centre of the screen, and slide the yoke forward to obtain the optimum overall clear red raster. Compromise between these two adjustments for the best final result, then tighten the clamp.

Check the green purity in the same way by switching off the red and blue guns. Re-adjust if necessary.

Repeat this operation for blue purity by switching off the red and green guns.

GREY SCALE

The next step is to ensure that the output from the individual guns will give a uniform level of brightness for the red, blue and green content respectively. This adjustment is referred to as the grey scale, since these primaries in the correct proportion will yield white light, and subsequently gives the shades of grey normally encountered in a monochrome picture.

In most receivers the facilities for this adjustment will consist of three potentiometers which control the voltage applied to each A1 electrode (screen) of the individual guns, and will facilitate the brightness "cut off". As this adjustment is easier with the frame time base collapsed, receivers will incorporate a switch for this purpose. A further two "drive" controls will facilitate the proportion of white light. These will adjust the grid potential on the "green" and "blue" grids, against the red which will be "fixed".

Finally a "background" control is used to effect bias on the chrominance output amplifiers and together with the controls previously mentioned will give the overall grey scale setting.

GREY SCALE ADJUSTMENT PROCEDURE

(1) Switch to 625 lines (input black raster).
(2) Set blue and green drive controls to mid-position, the background control down to minimum and the red, green, and blue screen controls to maximum.
(3) Set the brightness control to mid-position and collapse the frame time base with the switch provided.
(4) Turn the background control up until the red, green, and blue lines are just visible, then turn down the relevant screen control(s) to just extinguish the visible line(s). This procedure will ensure that at least one screen control will be at maximum.
(5) Restore the frame scan (switch provided) and adjust the brightness control for a visible raster. Check neutral tint and adjust appropriate screen control if required.
(6) Set the blue and green drive control to determine the proportions for the white content of the picture. Adjustment of these controls will effect the overall brightness which must be reset before the final result can be assessed.

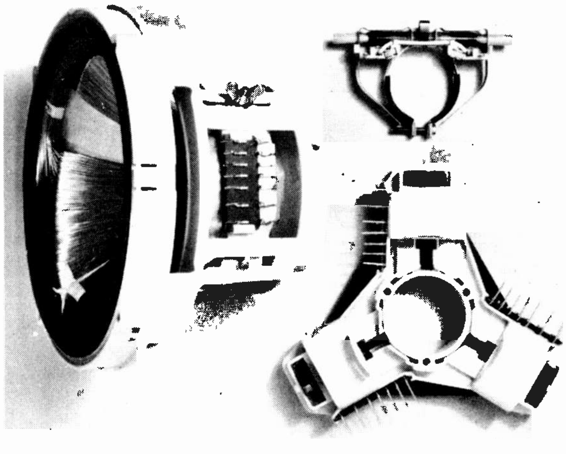
A picture now received should be a true monochrome with the normal grey levels between black and white. Any odd traces of colour on this picture will be due to mis-convergence.

STATIC CONVERGENCE

The three electron beams must be made to converge so as to pass through the same hole in the shadow mask and fall only on the appropriate colour dot of a particular triad.

The beams are deflected simultaneously by a common deflector system, but each beam is individually controlled in density (current) by its own electron gun.

Convergence of the beams is in the first instance achieved by the application of weak magnetic fields, applied externally adjacent to the gun assembly and aligned with the internal pole pieces (Fig. 11a).



Mullard deflection and convergence yoke assembly for a shadow mask tube. Left, deflection coils; above right, blue lateral assembly; below right, convergence coil assembly.

It will be noted from this diagram that the arrangement of the external magnets will adjust the beams radially (Fig. 11b).

Radial adjustment, however, is not enough to ensure that all three beams will converge to a common point at the centre of the mask, at least one of the beams must be controllable in a second direction as well. The blue beam was selected for this purpose and is accordingly made to pass a second pair of pole pieces which, when energised by an external "blue lateral shift" magnet, displaces the beam horizontally. With these four magnets the beams can be made to converge near enough at the centre of the mask. This is known as static convergence. The use of a white cross-hatch signal generator will be essential for all convergence adjustments.

STATIC CONVERGENCE ADJUSTMENT

Connect a cross-hatch pattern generator and adjust the tuner (fine tuner) and brightness to obtain a clear steady cross hatch pattern on the screen.

Concentrating on the squares in the immediate centre vicinity of the screen, adjust the three static magnets and the blue lateral shift magnet to achieve the best possible line convergence.

DYNAMIC CONVERGENCE

The need for further convergence application will be readily understood if the spherical shape of the tube face and shadow mask is taken into consideration (Fig. 12). By virtue of the fact that this curvature will not coincide with the scanning motion of the three beams, which undergo different geometrical deformation. Therefore, while convergence may occur at the centre of the screen (static convergence) it will not occur at any point away from the centre. The colour rendering itself, that is the purity of colours, is not affected because the shadow mask will ensure that the three beams will always strike phosphor dots of the right colour. They may not, however, actually occur in the same triad.

This error in convergence must, of course, be avoided and hence the need for dynamic convergence. To ensure that convergence will occur at all points on the screen, a dynamic convergence signal is applied in conjunction with the magnets provided for static convergence. Whereas a direct current of the required polarity and strength is sufficient for the static convergence, we now require correction currents for each gun which are available at line and field frequencies.

These currents are essentially parabolic in waveform and are superimposed with a "sawtooth" current. Therefore, four such extra currents, variable in amplitude, are required for each gun: parabolic and sawtooth waveforms at line frequency, and parabolic and sawtooth waveform at field frequency.

Together with the static convergence correction and the blue horizontal correction there are 16 controls to ensure optimum convergence over the whole area of the screen. As the colour receiver will be capable of receiving programmes on both 405 and 625-line transmissions, the field (dynamic control) will serve for both systems, but additional line controls at the 405-line frequency will be necessary.

DYNAMIC CONVERGENCE ADJUSTMENT

The procedure for this adjustment will vary according to the differences in manufacturing design. In all probability as many as 20 controls may be encountered and reference to a service manual will be essential to establish the exact function of each coil and potentiometer adjustment. Since the waveform at line frequency will differ between 405 and 625-line operation, adjustments must be carried out on both systems.

However, the ultimate requirement will be the same for all receivers, that is, to achieve convergence of the three beams in the overall area of the picture screen.

Apart from identifying the function of each control, the following procedure will apply:

Connect a cross-hatch pattern generator and adjust the tuner (fine tuner) and brightness to obtain a clear steady cross-hatch pattern on the screen.

Switch off the output from the blue gun. Dynamic convergence is in the first instance carried out with the red and green outputs only, thus producing a yellow hatch. Adjust the controls by reference to the service manual.

Switch on the blue gun, and adjust the controls by reference to the service manual. Final convergence will result in a white cross hatch.

During the procedure for dynamic convergence adjustments it will be necessary to revert back to the static adjustment to achieve ultimate overall convergence.

FINALLY

This two-part article is by no means exhaustive and is intended only to serve as a guide to the colour television engineer. It is not recommended that individual viewers attempt the setting-up unless they are fully conversant with colour techniques and also have the relevant receiver servicing manual. However, it is hoped that the reader will have gleaned some useful information to help in the general understanding of colour television receiving systems.

In Part 1 a millimicron was given as being a billionth of a meter. In American terminology this is correct, but in the U.K. it is a thousand-millionth (10^{-9}) meter. ★

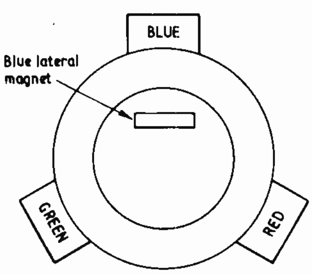


Fig. 11a. Convergence assembly mounted on the neck of the c.r.t. behind the deflection coils

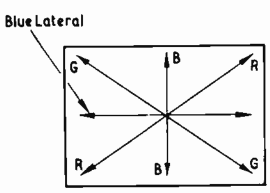


Fig. 11b. Direction of movement by adjustment of static magnets

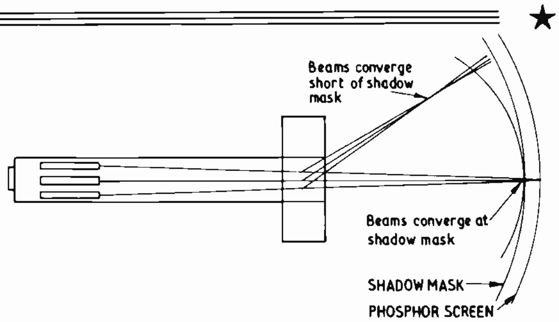


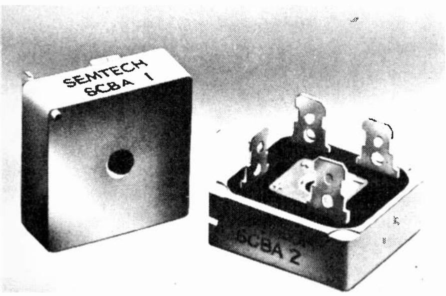
Fig. 12. Uncorrected beams showing the need for dynamic convergence

MARKET PLACE

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

SEMICONDUCTORS

Many companies have recently announced price reductions in their ranges of semiconductors, the latest being **Joseph Lucas (Electrical) Ltd.,** who announced a reduction of up to 30 per cent on one range and 25 per cent on their press-fit automotive rectifiers. Nearly all the large firms explain these reductions as being a result of better manufacturing processes and increased demand.



Semtech bridge rectifier

Another reason could be the gradual increase of Japanese transistors that are becoming more readily available at a competitive price. **Photain Controls Ltd.** have just been appointed U.K. distributors of Sanyo Electric Co. Ltd., of Japan, semiconductor components.

Further details of Sanyo Electric components can be obtained from Photain Controls Ltd., Randalls Road, Leatherhead, Surrey.

The Semtech "Alpac" is a high current power bridge rectifier enclosed in an aluminium case and available from most good retailers.

Ideal for use where space is limited they are marketed in this country by **Bourns (Trimpot) Ltd.,** and manufactured by the Semtech Corporation of California, U.S.A. They are available in ratings up to 25 amps, average rectified current from p.i.v. ratings of 50 to 600 volts.

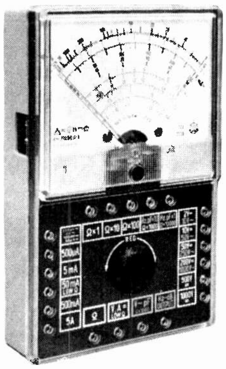
SERVICING AIDS

The Iskra S6A multimeter, imported from Yugoslavia, is a handy portable instrument with a claimed accuracy of ±2½ per cent of f.s.d. Measuring ranges include a.c. and d.c. voltage, direct current, resistance, capacitance, frequency, and decibels on a clear two-colour scale.

The meter is protected from overload by silicon diodes across the movement and by a glass fibre needle which is virtually unbreakable.

One of the advantages of the S6A is the use of multiple input terminals for range selection which produces a self-wiping action each time a different range is selected. This action reduces the contact resistance that is often evident in the more usual rotary switched range selectors.

Sensitivity is 20,000 ohms per volt d.c. and 4,000 ohms per volt a.c. Measuring ranges are 0·1, 2, 10, 50, 200, 500, 1,000 volts d.c. and 2, 10, 50, 250, 1,000 volts a.c. Direct current ranges are 50μA, 500μA, 5mA, 50mA, 500mA, and 5A. Resistance multipliers are ×1, ×10 ×100, ×1,000, ×10,000. For resistance measurement up to 10 megohms a 3 volt battery can be accommodated inside the instrument; with mains input the range can be extended to 100 megohms.



Iskra S6A multimeter

Capacitance measurements are also possible with an external a.c. supply with multipliers of pF ×1 and pF ×10 providing a range from 100pF to 0·5μF. By using the internal d.c. supply, and a simple conversion scale provided in the accompanying booklet, it is possible to extend the range to include electrolytic capacitors up to 150μF.

The 50Hz mains input also permits frequency measurements up to 50,500 Hz. This latter range may be further extended by a factor of 10 by the addition of an external capacitor.

The lowest scale provides decibel measurement for both power and voltage ratios.

The S6A multimeter is supplied in a plastics storage box complete with test probes and leads and can be obtained from **Guest Electronics Ltd.,** 78–86, Brigstock Road, Thornton Heath, Surrey, at a price of £10 5s 0d.

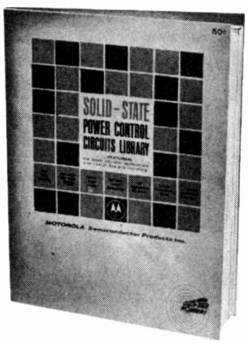
The Espi K651 is a new type of tweezer marketed by **Special Products Distributors Ltd.,** 81 Piccadilly, London, W.1.

The feature of this tweezer is the reverse action whereby the operator squeezes to pick up and squeezes to release objects. The points are precision ground, anti-magnetic, resistant to acid and many other chemicals and automatically exerts a uniform pressure on an object until released by the operator. The amount of tension exerted on an object is adjustable by a small fulcrum screw near the tip. The price of these tweezers is £1 3s 6d.

LITERATURE

Issued as part of the new 1968 Belling-Lee aerials catalogue, is a supplementary wall chart for aerials, masts, lashings and clamps. Measuring 23in × 16in, copies of the wall chart are available separately from **Belling-Lee Ltd.,** Heysham Road, Netherton, Bootle 10, Lancashire.

Also available free from the above firm is a leaflet giving basic information about aerials for u.h.f. colour reception. The leaflet is entitled "Aerials for Colour Television" and gives typical questions and answers that are most likely to arise once the colour service is fully operational.



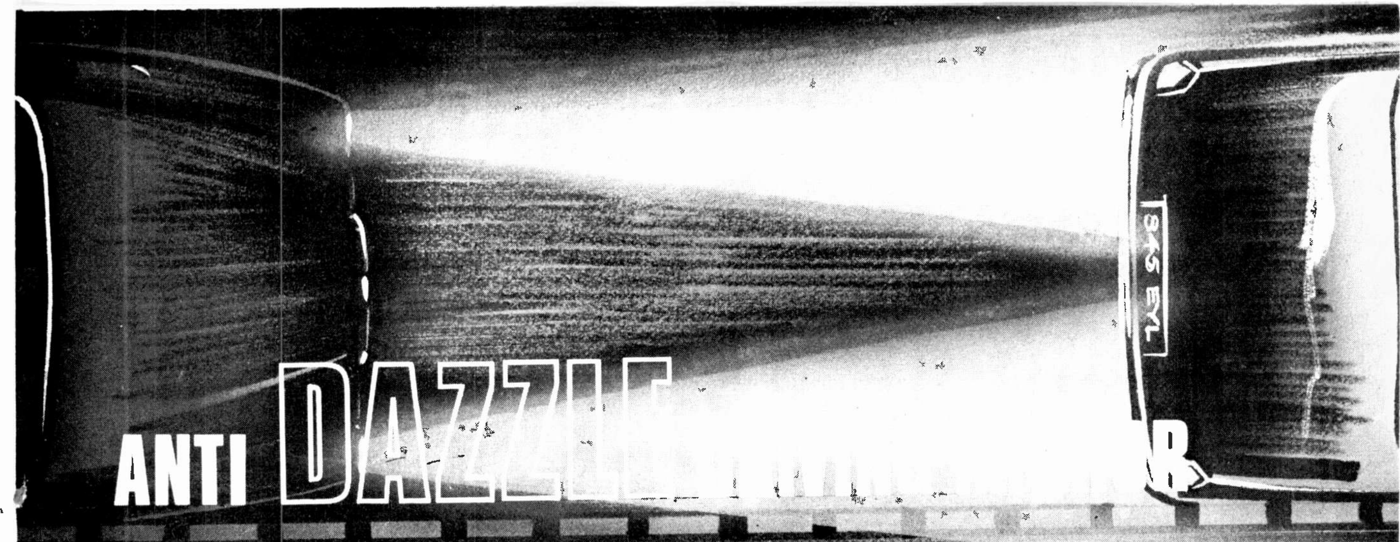
Motorola Solid State Circuits Guide

Motorola Semiconductor Products Division have compiled two new comprehensive guides entitled "R.F. Circuit Design Library" and "Solid State Power Control Circuits Library". Both guides contain actual circuit design and testing information from their own applications engineering staff.

The "R.F. Circuit Design Library" contains 150 pages and includes 10 application notes describing the use of basic r.f. design techniques, plus specific details for communications circuit designers.

Besides applications notes, there are sections on Whats and Whys about Y-Parameters, Systemising R.F. Power Design, R.F. Small Signal Design Using Admittance Parameters, and a 50-watt, 50MHz Solid State Transmitter.

The "Solid State Power Control Circuits Library" lists sections on S.C.R. Pulse Trigger, High Torque Motor Speed Control, Thyristor Trigger Circuits, and R.F.I. Suppression in S.C.R. Circuits.



By D. Burn Ph.D.

ONE of the more irritating features of night driving is the dazzle caused by the reflections in the driving mirror of the headlights of following cars. Most drivers no doubt have their own methods of dealing with this problem; here is one solution that has the advantage of dealing with it automatically. The gadget to be described tilts the driving mirror upwards whenever a bright light falls on to a light-dependent resistor mounted behind the mirror. The whole unit is neat and compact and can be made for as little as £3.

SOLENOID SWITCH

The light operated circuit is ideally suited to this task and is arranged so that the mirror is tilted by means of a solenoid.

Solenoid switching stages present some rather special problems and careful design is necessary to ensure that they operate correctly. First, a fairly high current (1A or more) must be supplied, which means that it is desirable to use a power transistor. At the same time, it is essential that this transistor is fully switched on in order to avoid excessive power dissipation, and hence overheating. This is achieved by the addition of a driver stage which applies plenty of current to the base of the output transistor.

Although a fairly high current is required to actuate the solenoid, a relatively small current may suffice to keep it actuated. It is therefore necessary to ensure that the transistor is fully switched off. This is achieved by applying a small negative potential to its emitter, so that in the off-state, the base-emitter junction is reverse biased.

When the solenoid is switched off, an inductive back e.m.f. of some several hundred volts appears across it, and hence across the output transistor. Since this pulse could cause the collector to become positive with respect to the emitter, with consequent damage to the transistor, it must be dissipated in a diode connected across the solenoid. The complete circuit is shown in Fig. 1.

The l.d.r. is arranged to form part of the bias network of an emitter follower circuit with a high input impedance. This is coupled by way of the sensitivity control VR2 to the Schmidt trigger TR2, 3. The potential divider formed by R9 and D2 applies the necessary potential to the emitter of the output transistor TR5. An increase in sensitivity can be obtained by connecting a 47 kilohm resistor between TR1 emitter and −12v line.

MIRROR BOX

The dimensions given in this article apply to the author's particular driving mirror, but they could be readily modified to suit a different size mirror. It should be mentioned however that several of the components are quite bulky and considerable care and ingenuity would be required to fit them all into a much smaller box. The general layout and construction will be evident from the photographs and drawings.

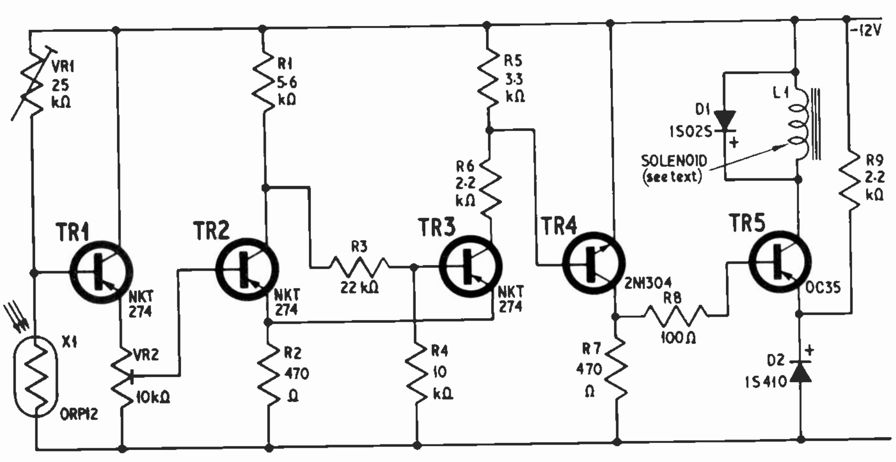


Fig. 1. Complete circuit of the solenoid tilting mirror powered by the 12V car battery or heavy duty dry battery

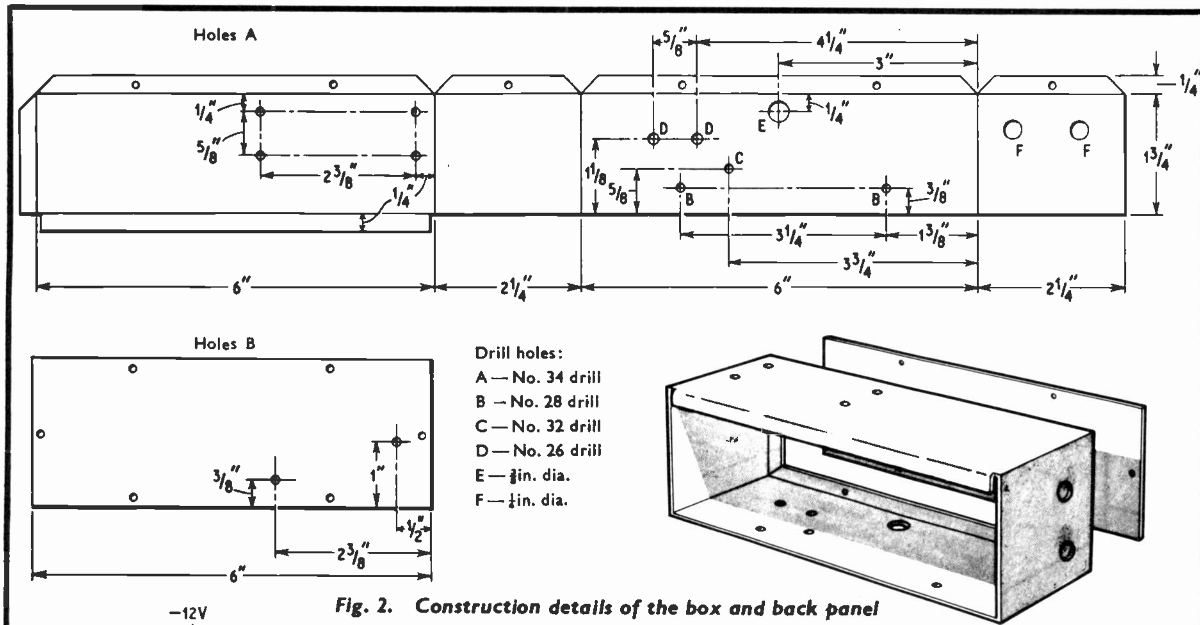


Fig. 2. Construction details of the box and back panel

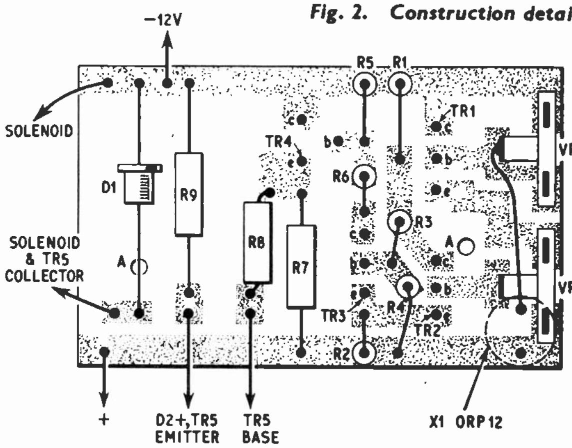


Fig. 3. Printed circuit pattern (dotted) and the components on the reverse side. Scale full size. Drill holes A with No. 32 drill

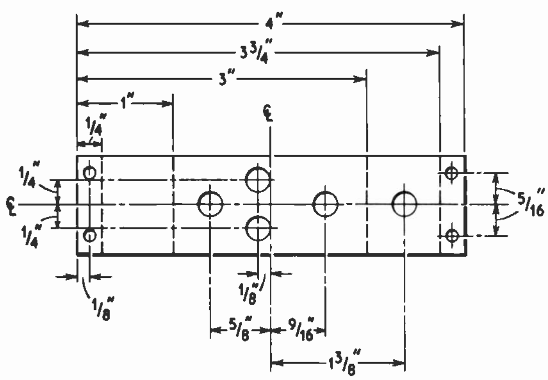


Fig. 4a. Cutting and drilling the bracket for TR5 and D2. Large holes $\frac{3}{16}$in. dia.

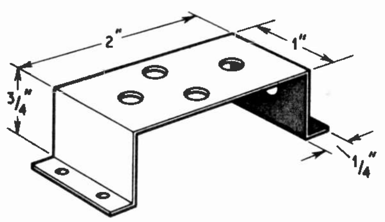


Fig. 4b (left). The transistor bracket after folding

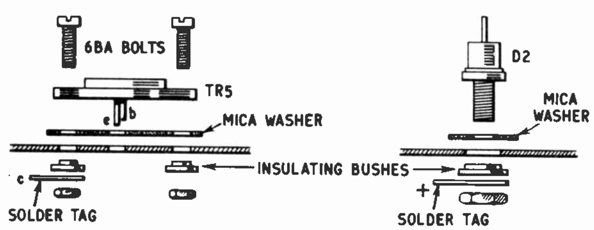
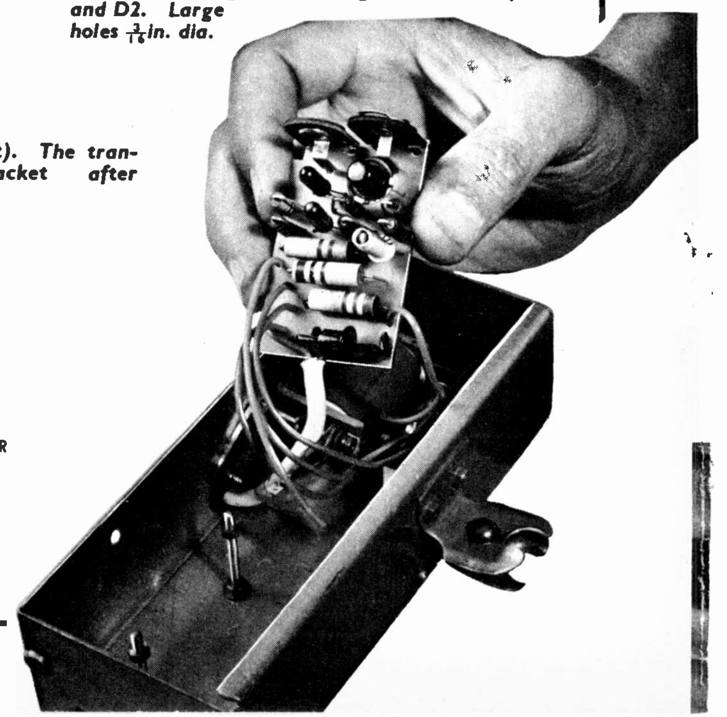


Fig. 4c. Assembly and connections of TR5 and D2



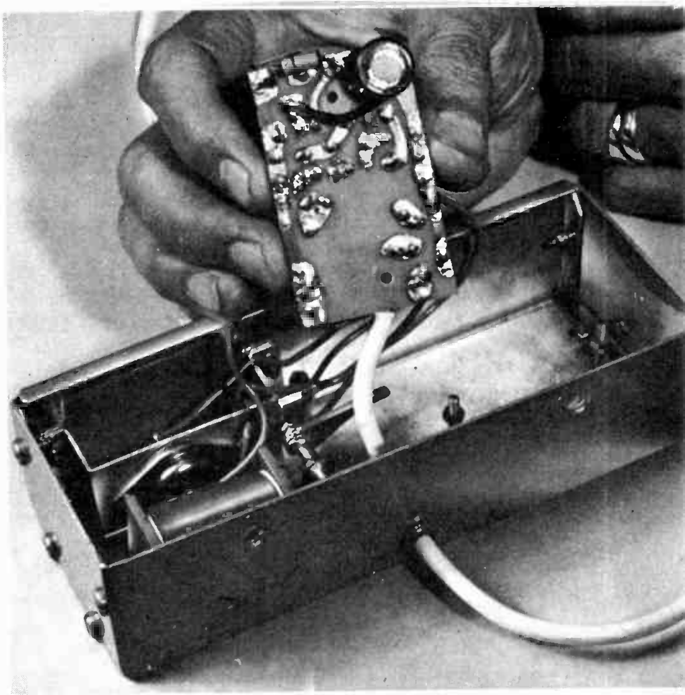
The case is constructed from 18 s.w.g. aluminium, cut and bent as shown in Fig. 2. The back-plate is secured to the case with self-tapping screws.

The bulk of the electronics is mounted on a small printed circuit board Fig. 3, with the two potentiometers mounted on one edge. The l.d.r. is mounted on the back of the board opposite a hole scraped in the silvering of the mirror. The power transistor and diode are mounted on a separate bracket, using the usual mounting kits to ensure that they are electrically isolated from the case.

Fig. 4a shows the bracket used to mount the power transistor and diode, together with exploded views of the mounting method (Fig. 4c). It is fixed to the case with 6 B.A. bolts and nuts. The solenoid, mounted beneath it, is also secured with countersunk bolts.

The mirror is fixed with "Evo-stik" to a piece of 18 s.w.g. aluminium, cut and bent as shown in Fig. 5a. The lugs bent over the end of the mirror (see photograph) are not really necessary as the mirror is firmly held by the adhesive. The hinge, also formed from 18 s.w.g. aluminium, is cut and bent as shown, and forms a complete unit with the mirror. Two small helical springs are formed from 26 s.w.g. piano wire and mounted as shown in detail (see Fig. 5d); they serve to hold the mirror firmly in the normal driving position. The complete mirror assembly is fixed to the case with self-tapping screws through the hinge strips.

Probably the trickiest part to make is the linkage between the solenoid and the mirror. Various simple arrangements involving pieces of nylon thread were tried but proved unreliable. The rigid linkage shown in the photograph and Fig. 5e was then tried and found to be perfectly satisfactory. This linkage is



made from two shaped pieces of $\frac{1}{16}$in brass sheet soldered to a short length of brass tubing, which is a loose fit on a 6 B.A. countersunk bolt; these levers are at approximately 90 degrees to one another. One of them is passed through a loop formed from 16 s.w.g. copper wire and fixed to the solenoid armature. The other is hooked behind a 6 B.A. bolt on the back of the mirror support.

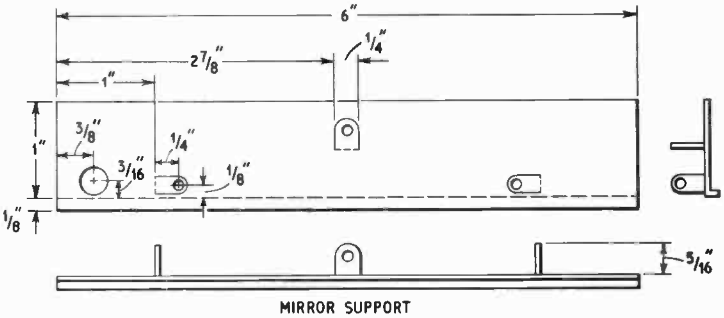


Fig. 5a. Construction of the mirror support. The three lugs are cut and bent at right angles to the plate

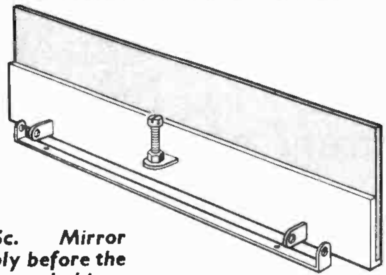


Fig. 5c. Mirror assembly before the springs and hinge screws are fitted

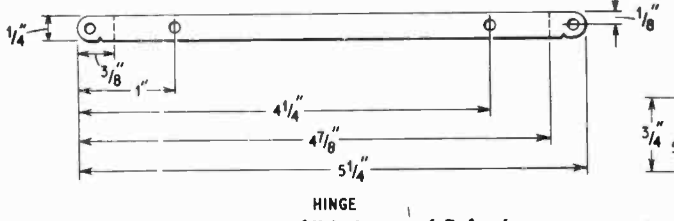


Fig. 5b. The hinge strip. All holes are 6 B.A. clear

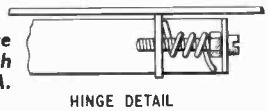


Fig. 5d. Hinge strips fitted with springs and 6 B.A. bolts

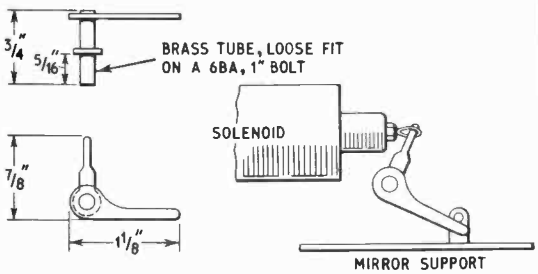
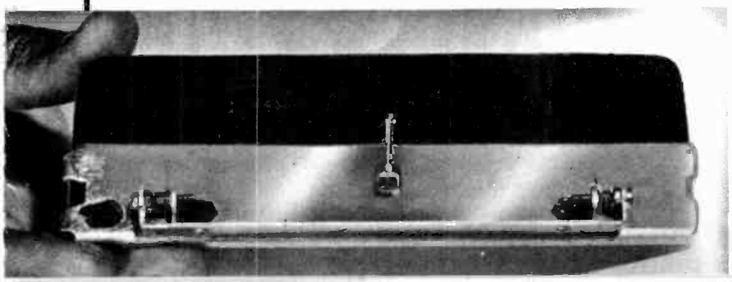


Fig. 5e. Cantilever linkage between the solenoid and mirror support



The printed circuit board is held in the case with two long 6 B.A. countersunk bolts as shown in Fig. 6. Fibre washers are used on the circuit side of the board to ensure that no part of the circuit is earthed to the case. The position of the nuts is adjusted so that the potentiometers just clear the case. Using the dimensions given, it will then be found that the l.d.r. is about ⅜in behind the mirror assembly, allowing enough room for the mirror to swing back into the "dipped" position.

FINISHING AND SETTING-UP

The unit is fixed in the car using the ball and socket assembly supplied with the mirror. Because of the considerable weight of the unit, the socket was placed on the top, as close to the point of balance as possible—this accounts for the rather lop-sided appearance. No dimensions are given here as the best way to find the correct position is by trial and error. Finally, the unit is given a coat of paint using an aerosol spray.

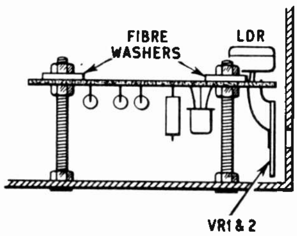


Fig. 6. Section view of the printed circuit board fitted on the bottom of the case so that the holes in the side line up with VR1 and VR2

COMPONENTS . . .

Resistors

R1	5·6kΩ	R4	10kΩ	R7	470Ω	1 watt
R2	470Ω	R5	3·3kΩ	R8	100Ω	1 watt
R3	22kΩ	R6	2·2kΩ	R9	2·2kΩ	1 watt

All 10%, ¼W carbon, except where stated

Potentiometers

VR1 25kΩ carbon skeleton preset
VR2 10kΩ carbon skeleton preset

Transistors

TR1, 2, 3 NKT274, NKT277 *or* OC71 (3 off)
TR4 XC701 *or* 2N1304
TR5 XA141 *or* OC35

Diodes

D1 1S025 *or* ZR11 D2 1S410 *or* TM41

Photocell

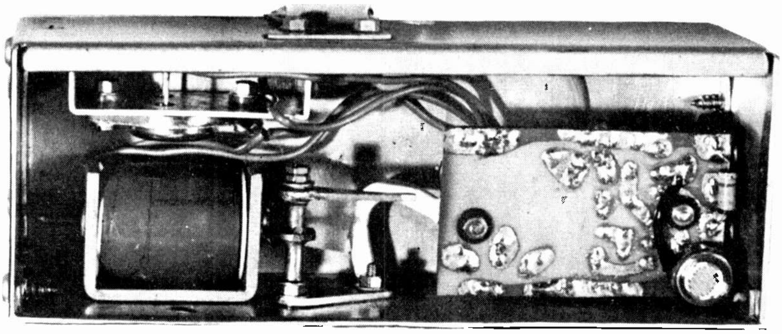
X1 ORP12

Solenoid

L1 Type 1, 12V d.c., pull action (Proop Brothers Ltd.)

Miscellaneous

Printed circuit etching kit
Aluminium 18 s.w.g. 2ft × 2¼in
Insulating kit for TR5
Brass tubing, springs, nuts and bolts (see text)



Electricity is supplied to the unit via a two-cored cable passed through a rubber grommet in the bottom of the case. Since no part of the circuit is earthed, it may be used with positive or negative earth cars, the only precaution necessary being to observe the correct polarity. The unit is wired to the "dead" side of the sidelight switch, so that it automatically comes into operation when the lights are switched on, and no other switch is required.

The last operation is to put the mirror into place and this can be a little tricky. The mirror unit is first inserted under the lip at the top of the case. The mirror is then positioned as near to the case as possible and the linkage lever is guided behind the bolt at the back of the mirror. Finally, the mirror is pushed right into the case and the self-tapping screws are inserted.

The sensitivity controls are best adjusted with the help of a friend with another car. This car should be positioned 20 to 40 yards behind your car and the headlights turned on full, pointing straight into the driving mirror. The potentiometers are then adjusted until the solenoid operates.

If the headlights are now flashed on and off, the mirror should dip and return in step. Because the l.d.r. is mounted a little way behind the mirror, a directional effect is produced, and the unit will not respond to even quite bright lights unless they shine straight on to the mirror. ★

POINTS ARISING

YODELLER DOOR MONITOR (*November, 1967*)

TR5 emitter and collector connections in Fig. 2 should be transposed to agree with the circuit diagram.

A scoop of lunar soil picked up by the mechanical digger on Surveyor III

SPACEWATCH

By Frank W. Hyde

DECADE OF PROGRESS

As this column goes to press a decade of progress is marked by the anniversary of the launching of the first artificial satellite. The memory of this occasion is an exciting one for those who were waiting for the momentous breakthrough that was to shatter the sceptics. For the writer it has a special significance, for the records made at the time confirmed predictions offered before the launch. There is, it must be confessed, a certain sense of satisfaction when the original tapes are replayed. Progress from that time has been very rapid and has resulted in a very wide field of discovery.

Apart from the manned spaceflights with the wealth of new knowledge accumulated (and it must be said the de-bunking of prophets of dire consequences) new techniques have evolved in the control of flights, the transmission of data, and the greatly increased understanding of the environs of the earth. The deep space probes have added to our knowledge of the moon and reached the stage of instrument landings with successful close up pictures of the surface. This alone has led to considerable rethinking and restudy from the earth of the rival theories of how craters came into being. The Soviet Union launched the first *Sputnik* which began the new age of astronautical discovery. The first orbiting probe to send back pictures of the hitherto unknown side of the moon was also a Russian success. It was shown that there was little difference in that hemisphere from the rest of the surface.

SOFT LANDINGS

The first soft landing on the moon again went to the credit of the Soviet Union. In February 1966 the spacecraft *Luna 9* landed safely and some four minutes after touchdown pictures were being transmitted back to earth. The landscape was scanned and the signals were received by both British and Russian stations. The camera was arranged to give a panorama of 360 degrees. This was made at several different elevations of the sun above the lunar horizon and the results obtained enabled a mock-up of the landscape to be made.

Between two of the transmissions the craft slipped with the result that there was a change in inclination of several degrees of the camera. This was a fortunate event as it turned out. It meant that the stereo effect could be utilised to determine the distance of objects from the camera. In addition to the photographic results, radiation was detected on the surface amounting to 30 milliradions per day.

The second controlled soft landing was performed with *Surveyor I* which successfully touched down on the lunar surface on June 1, 1966, after a 63 hour 36 minute flight from Cape Kennedy. It landed at a velocity of 7·5 miles per hour at 2·45 degrees south of the lunar equator in the south-west portion of the Ocean of Storms (*Oceanus Procellarum*).

During the six weeks that followed the spacecraft's survey television camera took 11,150 high resolution pictures of the surface of the moon showing in some close-ups resolution of the order of about one fiftieth of an inch. The pictures showed that the surface at the landing was smooth and level. It was surrounded by a gently rolling surface studded with craters and littered with fragments. The tops of low mountains were visible beyond the horizon (about a mile at this point).

In contrast to this the next *Surveyor* crashed at about 6,000 miles per hour on the surface of the moon. *Surveyor III* was more successful though it bounced twice before coming to rest. It landed on the east wall of a crater 650 miles across in the Ocean of Storms. It was able to dig four trenches in the lunar surface and in the course of some 18 hours of work made bearing strength tests and penetration samplings. The operation of the television camera yielded some 6,315 pictures which included a solar eclipse as the earth passed in front of the sun, pictures of the lunar terrain, portions of the spacecraft, and the crescent earth.

The way is now paved by these experiments so that the astronauts who land will have preknowledge of the environment they will have to experience.

SPACE PROBES

All this was a quarter of a million miles from home but other probes went deeper. In 1962 the successful *Mariner* flight past Venus passed within 21,600 miles of the planet and measured cloud top temperature to be about 240 degrees F and the magnetic field to be negligible. The results of *Mariner V* will already be known when this article is in print.

The next significant event was the deep probe to Mars. The probe made its flight past Mars on July 14, 1965. The distance from the planet was between 7,000 and 10,000 miles. The pictures transmitted over distances that varied between 135 and 148 million miles were of excellent quality. The first conclusions were that there were not many craters visible though the fact that there were any at all was a major discovery not previously suspected. Subsequent analysis of the data showed that that there were in fact many more craters than originally supposed. There were some three hundred well defined craters varying between 110 miles in diameter and 1·75 miles in diameter. There still remain other features not yet resolved because the positive identification is limited to about one per cent of the surface. There was evidence of a number of straight features which might be identified as part of the so-called canals. It was not possible to detect vegetation though variations of texture was observed. There were ridges, and depressions ranging from 1·00 to 200 miles in length and from two to seven miles in width. There were also signs of fracture zones in the crust. However the Martian surface shows marked deterioration of the craters compared with the moon and this is probably due to the fact that there is an atmosphere on Mars while there is none on the Moon. The wide daily fluctuations of temperature may also be responsible for the production of rubble created by the rapid expansions and contractions.

Newspaper Transmitted Across the Atlantic

A COMPLETE page of a newspaper, including pictures and words, was transmitted across the Atlantic on October 17 via satellite from London to San Juan, Puerto Rico. This was the first time that a newspaper page has been sent by satellite.

A complete page of the *Daily Express* was wrapped around a drum on the Muirhead transmitter (above) and a beam of light traversed the drum, illuminating a small square of the page. The drum revolved and the whole page was scanned in the form of a spiral. Light from a minute area of this square was reflected through a precision optical system and used to control the electrical output of a photocell. The amplitude of the output signal depends upon whether the scanning beam falls on white paper or print, including the dots in the half-tone pictures.

The signals were transmitted via a cable and microwave system to Goonhilly where they were directed to the *Early Bird* satellite. The receiver in Puerto Rico converted the signals back to "light" information for processing into printing plates.

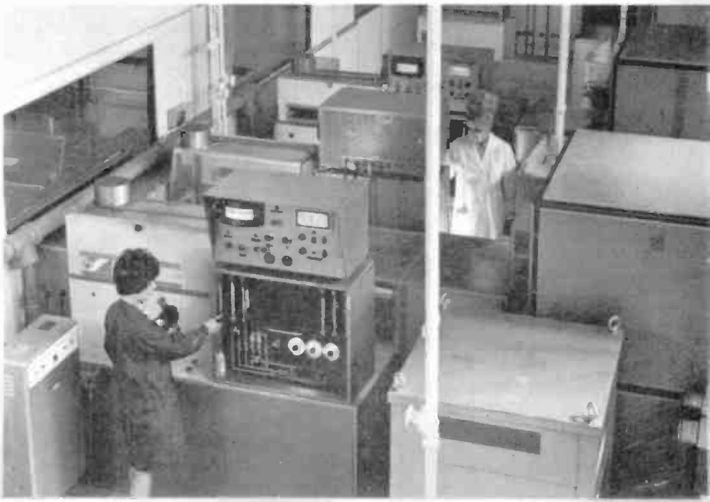
Ballot Paper Counter

CUBIC CORPORATION of the U.S.A. have designed a ballot paper counter using 1,500 Motorola digital integrated circuits. Known as the Votronics ballot paper counter, it takes hand-fed papers up to 18in wide containing up to 299 voting positions. Perhaps we may see instant election results in the near future with same-day results in all cases!

ICs for Future Applications

THE Southampton works of Mullard concentrates its activities mainly in the manufacture of integrated circuits and semiconductor devices. The bulk of present production is on digital circuits but new fast types of EECL device are being made for use in the next generation of computers.

Among the new linear circuits is one that has the functions of five transistors and a diode and is the heart of an a.m./f.m. receiver up to and including the first audio stage. Variations of this device are expected to be produced for the sound channel of colour and monochrome television receivers. Our photograph (right) shows a bank of epitaxial reactors used in making integrated circuit slices.

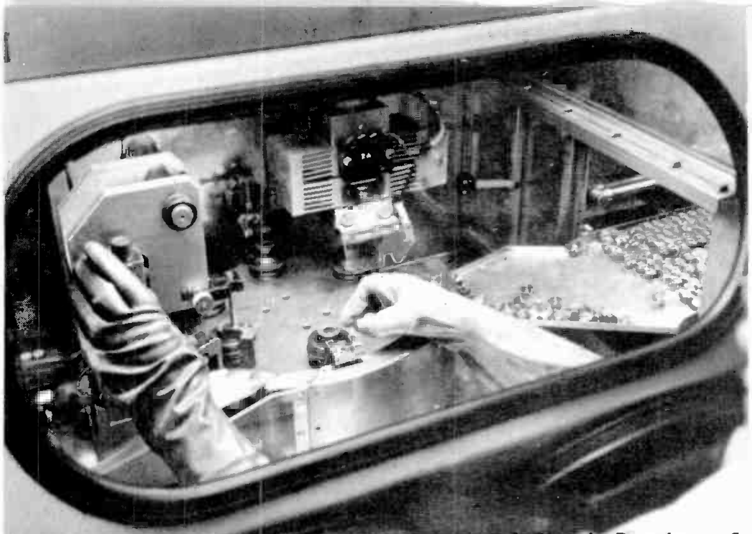


Electronics in Business

THIS new audio teaching aid by Philips, shown at the Business Efficiency Exhibition, comprises four "source" dictating machines and a master tape recorder.

The teacher's control panel gives full control of up to a maximum of 60 students. Clear, easily understood directions are indicated on the panel.

The student control panel (inset below) includes a four position channel selector, volume control, and a socket into which the Stenolab headphones can be plugged. There is also an additional socket provided for teacher monitoring.



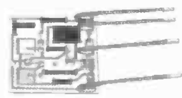
Integrated Circuit Regulator for Car Alternator

Lucas 15ACR alternator and regulator

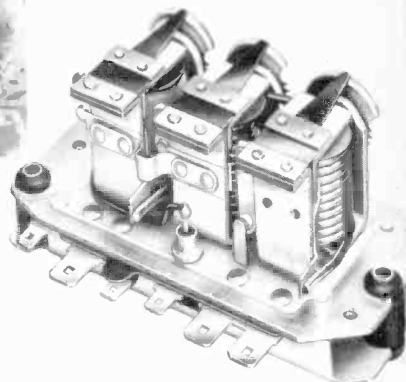
A NEWCOMER to motor car electrical systems is designed for increasing the life and reliability of the battery charging system. The Lucas alternator 15ACR and the 8TR regulator replaces the old dynamo and is claimed to provide the battery with a continuous regulated voltage—irrespective of the load on the battery and engine running conditions.

This system (shown top right) occupies less space under bonnet than the old system. Instead of being a separate unit, as was the old electromechanical regulator, the new 8TR regulator is fitted inside the end cover of the alternator.

The comparison of size (far right) between these two shows a significant achievement in size reduction coupled with improved performance, due to development of a thick film integrated circuit regulator. Semiconductor silicon diodes are built in to the "finned" heat sink (just visible on the right of the alternator photo) with arrangements incorporated for simple plug-in connection.



New 8TR integrated circuit regulator



Old electro-mechanical RB340 regulator

The other three photographs show the manufacturing processes of Lucas semiconductor rectifiers. The silicon slice is diced and fitted with lead-out wires for small diodes. High current rectifiers are made by fitting the silicon dice on a thick metallic disc so that the connections are made through the disc and a central pin insulated from it. The picture (top left) shows the "top hat" cover being cold-pressed on to the disc periphery.

Rigid testing and polarity identification is carried out on the equipment shown in the centre of this page and below right. These two pictures show low current Zener devices and DD000 diodes. Polarity is indicated by placing the unencapsulated diodes on small racks. Connection through the lead-out wires is made to neons situated under the wires. Reverse positioning is carried out as necessary by the operator before being placed on the roller conveyor to the encapsulation fitters.

HIGH INPUT Z (IMPEDANCE) TECHNIQUES

By K.T. WILSON

How can a crystal pick-up be coupled into a transistor amplifier? Can a capacitance bridge work with transistor circuits? The answers to such questions as these depend on the input impedances which can be achieved with transistors. The impedance of a circuit element is a measure of how much electrical power is lost in it.

If a high impedance circuit is connected to a low one as in Fig. 1, then, as an a.c. current is passed through the combination, most of the power will be lost in the high impedance and very little will appear at the output across the low impedance. Sometimes this may be deliberate, as when using a volume control where the ratio of high to low can be varied.

If turned up the other way, then there is very little loss across the low impedance and the output across the high impedance is almost as large as the input.

TRANSISTOR IMPEDANCE

When using a transistor as an amplifier, the input is usually applied to the base, with the emitter earthed either directly or through a large capacitor. The input impedance of a transistor used in this way is rather low; if the source of the signal has a high impedance, then there will be very little signal left to go into the transistor.

This situation is even worse when feeding the input to the transistor through a capacitor, for the impedance of a capacitor varies with the frequency of the signal, being high for a low frequency signal and low for a high frequency signal. The opposite case holds for a choke, but this will not be discussed further as chokes are not so frequently found in transistor circuits.

If, then, a signal is fed through a capacitor into the base of a transistor, the amount of amplification obtained will vary with the frequency of the signal, being very low at low frequencies and rising to the amount we expected to get when we designed the circuit at high frequencies.

Sometimes this can be offset quite simply by using very large capacitors, and this is what is often done to couple two stages in an amplifier. The fact that very low frequencies will be amplified so much less is not a disadvantage providing that the lower limit is not too low; it may be 100Hz in an ordinary amplifier, rather lower in a hi fi amplifier.

NO CONTROL

In some cases, there may be no control over the impedance through which the transistor amplifier is fed. This is particularly so in the case of a crystal pick-up. If a crystal pick-up is coupled to a resistance (which is an impedance without any complications of frequency variation) and the output measured across the resistor at various frequencies, the result is exactly the same as it would be in the circuit of Fig. 2.

This circuit is termed the equivalent circuit of the arrangement, and the part enclosed by the dotted line is the equivalent circuit of the crystal pick-up. The capacitor is of rather a low value, about 2,000pF, so that if the pick-up is fed directly into the input of a transistor, there would be very little amplification at low frequencies.

This is the case, and special precautions have to be taken when using crystal pick-ups with transistor amplifiers. The whole trouble is that the input to the transistor is of low impedance and the circuit requires a high impedance.

The same sort of thing happens in the case of a bridge circuit, and is very much worse in the case of a potential divider circuit for measuring capacitance, such as is shown in part in Fig. 3.

All these troubles could be overcome if transistor circuits had a high input impedance. It is true that there are several other ways round the problem, but they all have their disadvantages.

The new field effect transistors known as MOSFETs have a very high input impedance, so high that the static

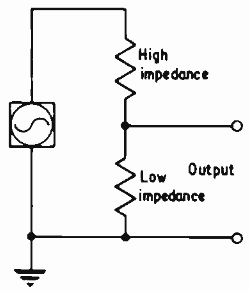


Fig. 1. A.C. potential divider or potentiometer

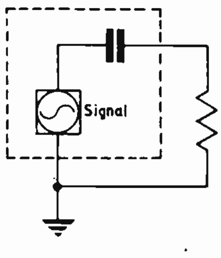


Fig. 2. A capacitive signal source connected to a resistive load

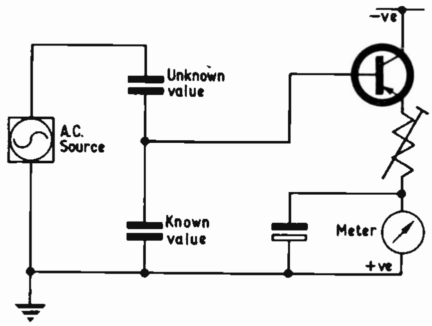


Fig. 3. An a.c. signal source with capacitive load

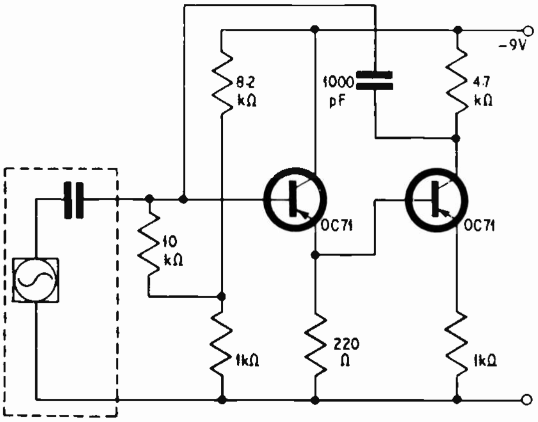


Fig. 4. Negative feedback applied over to stages to the input

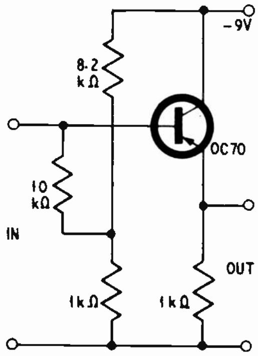


Fig. 5. Simple emitter follower with a high input impedance

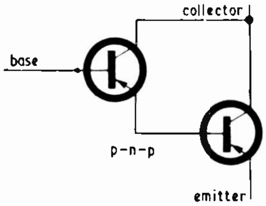


Fig. 6. Darlington pair using pnp transistors

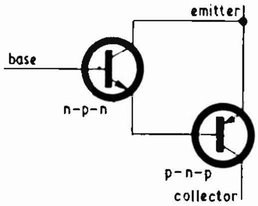


Fig. 7. Complementary Darlington pair

electricity generated by rubbing the leads against an insulator cannot leak away, but will damage the transistor. Mosfets are very expensive, however, around £2 to £20 each, and hardly likely to be used at the moment in quantity except where nothing else will do.

It is possible, of course, to place a high resistance in series with the input. This has the disadvantage that the amplifier must now do more work, since the input signal is now so small; the increase in amplification required means more noise so that the signal-to-noise ratio suffers greatly.

Another method is to apply negative feedback to the input through a capacitor as shown in Fig. 4. This works by making the input impedance of the transistor amplifier seem like a capacitor as the equivalent circuit shows.

This can be a useful dodge where the input is fixed, as in the case of an amplifier, but is less useful with a variety of inputs, as the amount of amplification obtained depends on the capacitance of the source, and the feedback must be changed to resistive if a resistive input is to be used.

BEST SOLUTION

On the whole, the best solution is to use a high impedance input circuit of which several are known.

Most of these circuits use at least two transistors, but a useful improvement in input impedance can be obtained by using a simple emitter follower, as shown in Fig. 5. This is not good enough to be used with a crystal pick-up, but is very useful for isolation when two transistor units are coupled together. This circuit can be found as the last stage in pre-amplifiers or tuners.

The genuine high impedance circuits are usually of one of two types, the bootstrap type or the Darlington type. Taking the Darlington pair first, the name is derived from the combination of two transistors first investigated by Darlington, and shown in Fig. 6.

Two transistors connected in this way have a very high gain, and since the input impedance of an emitter follower circuit depends on the gain of the transistor, many designers have assumed that an emitter follower using a Darlington pair as a single transistor would have a very high impedance. In actual fact the impedance is not particularly high, due to feedback in the transistors (internally); but many designs can be seen where it is confidently stated that the Darlington pair is used to increase the input impedance. The constructor building such a circuit can quite confidently replace the Darlington pair by a single emitter follower at some saving in cost.

A very different proposition is the circuit of Fig. 7, known as the complementary Darlington. It will be seen that one transistor of the Darlington pair is now an *npn* type. Such an arrangement avoids the difficulty of the internal feedback which makes the normal Darlington pair less useful.

This type of circuit can be used wherever a high impedance input is required, but it has two disadvantages: it requires one *npn* transistor, and any resistors used to bias the base of the first transistor will detract from the high input impedance, as they will be in parallel with the input.

BOOTSTRAP

These difficulties are avoided in the "bootstrap" circuit, at the expense of some extra circuit complications. The principle of the "bootstrap" circuit is shown in Fig. 8. If a signal is fed into a resistor of low value, and at the same time a signal of the same voltage is fed into the other end of the resistor, there will be no current through the resistor. This is another way of

continued on page 915

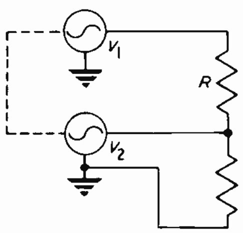


Fig. 8. Bootstrap principle. V_1 and V_2 produce the same waveform and the same voltage

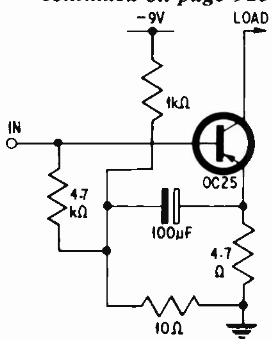
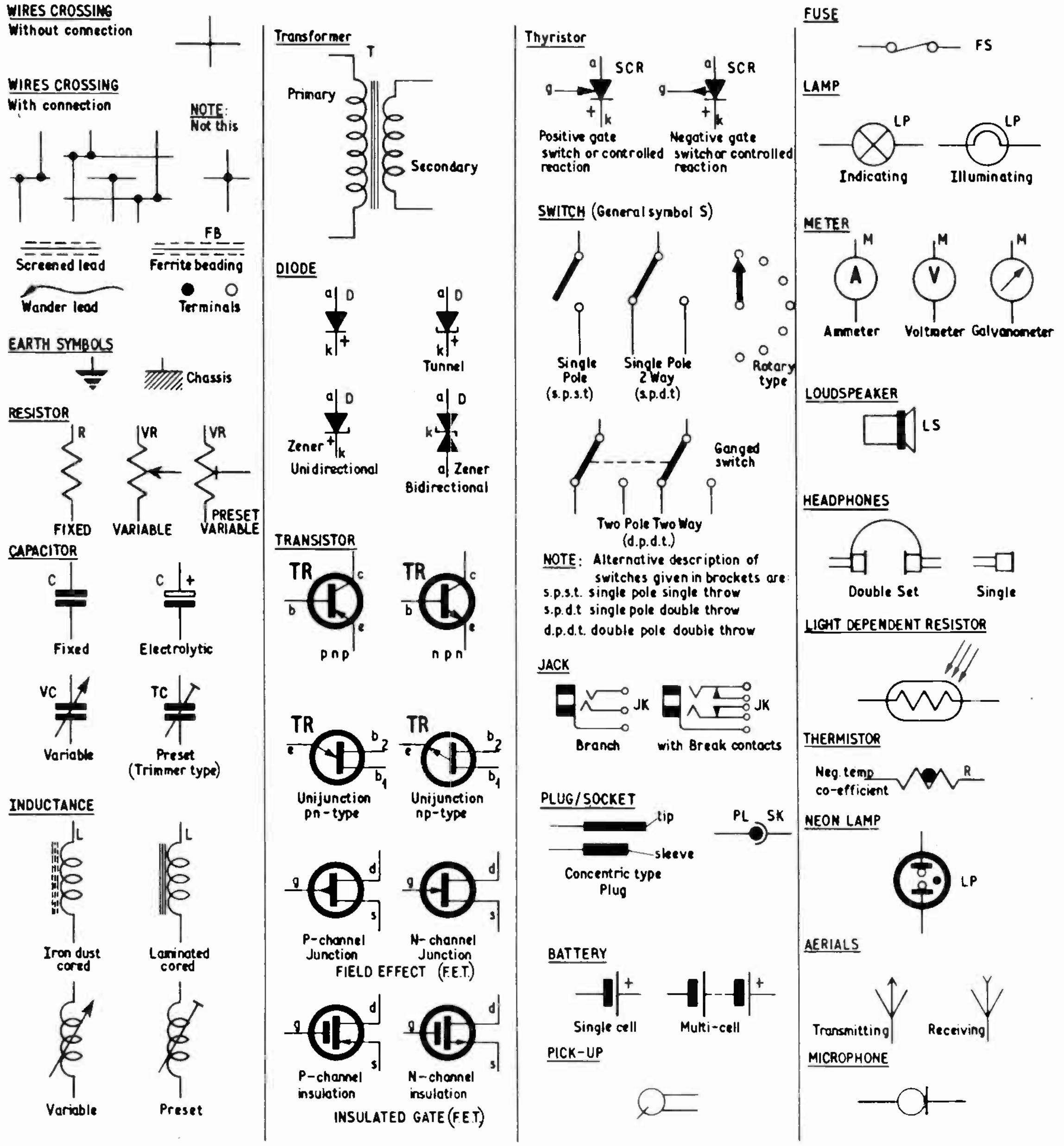


Fig. 9. Low bias resistance in a high impedance input

CIRCUIT SYMBOLS



COMMON SYMBOLS AND ABBREVIATIONS

Unit abbreviations

A	amperes
dB	decibels
F	farads
H	henries
Hz	hertz (formerly cycles per second)
J	joules
V	volts
W	watts
Ω	ohms

Quantity abbreviations

C	capacitance (farads)
E	e.m.f. (volts)
f	frequency (hertz)
I	current (amperes)
L	inductance (henries)
P	power (watts)
R	resistance (ohms)
X	reactance (ohms)
Z	impedance (ohms)
λ	wavelength (metres)
α, β, h_{FE}, μ	amplification factor

Other abbreviations

a.m.	amplitude modulation
f.m.	frequency modulation
l.w.	long wave
m.w.	medium wave
s.w.	short wave
l.f.	low frequency
m.f.	medium frequency
h.f.	high frequency
i.f.	intermediate frequency
v.h.f.	very high frequency
u.h.f.	ultra high frequency

Semiconductors

e	emitter
b	base
c	collector
s	source
g	gate
d	drain
k	cathode
a	anode
b_1	base one
b_2	base two
sh	shield

Sub-multiples and multiples

p	pico = $\times 10^{-12}$	μ	micro = $\times 10^{-6}$	k	kilo = $\times 10^{3}$		
n	nano = $\times 10^{-9}$	m	milli = $\times 10^{-3}$	M	mega = $\times 10^{6}$		

SEMICONDUCTOR BASICS

1—INTRODUCTION

By G. J. King

THIS is the first of a series of articles written specially for beginners to electronics. As the large proportion of electronic circuitry involves the use of semiconductor devices, a straightforward and easily understood account is given of what semiconductor materials are and how they are put to good use.

Part 2 and all subsequent articles in this series will be accompanied by a special constructional article aimed at providing a practical demonstration of the operation of the particular semiconductor device under discussion.

CONDUCTORS AND INSULATORS

As implied by its name, a semiconductor is neither an insulator nor a good conductor of electric current. One of the best *practical* conductors is copper—a better one silver. All metals conduct electric currents to a fairly high degree, but some conduct them better than others. An elementary definition of an insulator is a substance through which an electric current cannot be persuaded to flow.

Again, there are various degrees of "insulation". Substances like glass, ceramic, mica and various plastics afford a good insulation against electricity, since materials like these are used to house electric and electronic elements and appear between the terminals of the devices. Hosts of other materials have the same property of insulation.

In some applications, the materials have to retain their insulating properties up to very high temperatures, such as the bars and blocks upon which are wound the elements of electric fires. Although some materials are adequate insulators for relatively low electric pressures, these same materials might be totally unsuitable for working at much higher pressures as present, for instance, in X-ray plant, oscilloscopes, and television equipment.

The pressure of electricity is measured in volts (signified by the capital letter V) or fractions of a volt, while the flow of current through the conductor is measured in amperes (signified by the capital letter A). The resistance offered to a flow of electricity by the conductor is measured in ohms (often signified by the greek omega Ω).

Why can electricity flow through conductors and not through insulators? This brings in the electron theory, but this will only be pursued here as far as essential to acquire a basic understanding of semiconductors.

PROPERTIES OF ATOMS

The smallest unit of any of nature's elements is the *atom*. This means that an element can be divided, sub-divided and sub-divided again many times over right down to its basic atom and still retain element identity. Further sub-division would then destroy its identity and, indeed, possibly change it into two or more atoms of a different element!

It is not easy to appreciate just how small an atom really is, and various imaginary artifices are adopted in text books and by teachers to convey to the student some idea of its diminutiveness. It is rather like trying to assimilate the vastness of space. Anyway, as a rough measure, take a small blob of copper, about the size of a pin's head, and keep on dividing and subdividing this until you end up with 10^{18} bits; each bit would then be a copper atom! Happily, we do not have to be too subjective about dimensions.

Atoms have two main component parts, called the *proton* and *electron*. The former is about 2,000 times the mass of the latter. The number of protons and electrons determine the nature of the atom. The simplest case of an atom to take is hydrogen because this has just one proton and one electron. The proton is positively charged and the electron is negatively charged.

Now, there is a well known law about like charges repelling and unlike ones attracting, so one might expect the electron (of the hydrogen atom, for instance) to be stuck to its protonic partner. Actually, this is not so because the electron is revolving round the proton in exactly the same manner in which the Earth revolves round our Sun. In other words, the electron is in orbit round its proton, and the force that this motion creates on the mass of the electron balances out the electrically attractive force between them. A specific orbital path is thus established, as governed by the nature of the atom.

The centre of the atom, where the protons congregate in a cluster, is called the nucleus, and to maintain balance here, some atoms have inner-orbiting electrons. These are very closely associated with the nucleus and bonded in orbit very tightly to it. They are not easily moved and for this reason are called "fixed electrons".

Other atoms have electrons spinning round on outer orbits. These are called "free" electrons because they are not so tightly bound to the nucleus. They can dodge from the outer orbit path of one atom to that of another atom in the material. These so-called free electrons provide electric conductivity.

Some atoms are highly complex, but to illustrate the basic theme, Fig. 1.1a shows the simple hydrogen atom with one electron and one proton. In Fig. 1.1b the next complex atom, that of helium, with two free electrons orbiting its nucleus, is compounded of two protons. In Fig. 1.1c the carbon atom has six electrons in two orbits round its six-proton nucleus. A very complex atom is that of the metal uranium. This has a nucleus compounded of 184 protons with 92 fixed and 92 free electrons in complex orbits.

ELECTRON MOVEMENT

The essential difference, then, between conductors and insulators is that conductors have an abundance of free electrons while insulators' electrons are mostly tightly bonded to inner orbits. This implies, therefore, that an electric current is in some way related to a movement of electrons. This, indeed, is certainly the case; and electricity, in fact, is nothing more than a movement of electrons from point A to point B—that is, over a specific circuit.

Small random current "transients" are produced when free electrons dodge from atom to atom in a conductor. These random electron movements do not produce electricity in its known form, but the transients that they do create can be seen on the screen of an oscilloscope or, in fact, heard in a loudspeaker. In electronics they are known as the noise signal. Noise is the hiss heard when a receiver is tuned to a vacant channel.

Of course, the transient currents produced by these random electron movements have to be very considerably amplified before we can hear them in this way. On an oscilloscope screen they look like spiky pulses—the effect is known colloquially as "grass" by engineers.

Electricity in its more common form is due to an orderly movement of electrons. One can consider a conductor as a tube containing masses of electrons packed closely together, as shown in Fig. 1.2. Now, if one more electron is forced into one end, one will have to fall out at the other end. This is better visualised by assuming that the conductor has just one row of electrons with an extra one to spare. If this extra one is pushed in one end, the far one at the other end will fall out and this can be pushed in at the start again, thereby keeping up the flow—albeit, highly intermittent!

Actually, it is difficult to make electrons just fall into space from the end of a conductor (wire) and then get back into circuit again at the other end. We must have a complete circuit, and to keep the electrons moving we must have an electron pump of some sort (Fig. 1.3). The source of electricity is the "pump", so to speak. This might be a battery, generator or some other device to keep electrons in motion in a circuit.

In this context, electrons can be considered as current carriers. Actually, they constitute the current when they are in motion; but without them there would be no current carried, so it is perfectly proper to refer to them as current carriers. This term is used extensively in semiconductor parlance.

This brings up the question of how fast electricity travels. Some people tend to rate this with the velocity of light, which is wrong. True though it may be that the effect of electricity is felt immediately a switch is operated, this is only because electricity lies dormant, so to speak, in the conductors.

It is akin to the water supply to a house. Water falls from the tap immediately it is turned on: but this almost zero time is not that taken for the water from the reservoir to arrive at the tap. Water—like electricity—is displaced along the pipe (conductor) and the pump (battery or generator) at the reservoir and keeps it flowing. The actual speed is relatively low.

Good conductors represent material in which the atoms have plenty of free electrons. And good insulators are materials in which the atoms have closely bound orbiting electrons. In such materials, any flow of electricity is due to electron current carriers, which are negative.

CRYSTALLINE SEMICONDUCTORS

Some semiconductors are based on a crystalline material in which there are virtually no free electrons in its purest form. Typical crystals for this application are germanium and silicon, and they are purified to a

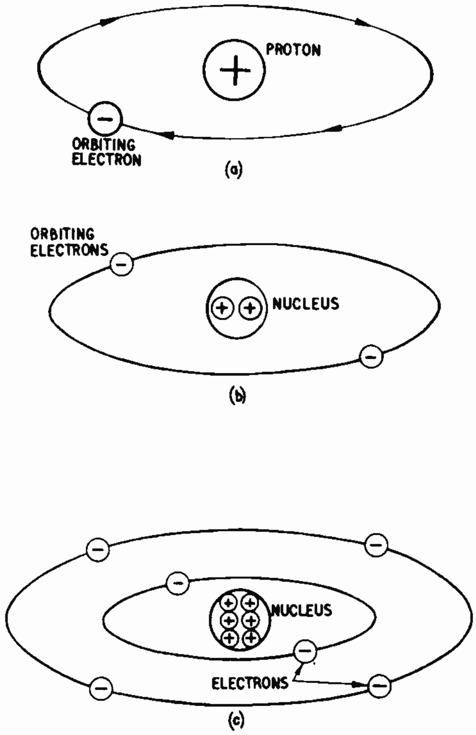
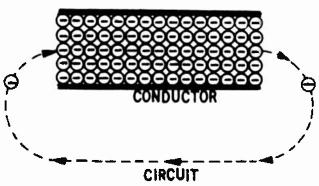


Fig. 1.1. Elementary representation of atoms (a) hydrogen, (b) helium, and (c) carbon



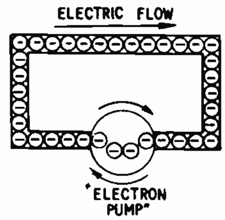


Fig. 1.2. A conductor can be considered as a tube full of electrons, a flow of electricity being a movement of the electrons which would occur by an electron entering at one end and leaving at the other

Fig. 1.3. An "electron pump" (battery or generator) keeps the electrons moving in a conductor, thus producing electric current

very high degree making them incredibly good insulators. They are then made into semiconductors with specific parameters by the controlled addition of impurities—from the electrical point of view.

If atoms of an impurity so added have more electrons than the atoms of the crystal, electrons are "let loose" in the material to serve essentially as current carriers. Since these are negative, this sort of semiconductor is called *n*-type (*n* for *n*egative).

Impurity agents to provide excess electrons include arsenic and antimony. It should be appreciated at this juncture that the negative charge of the electrons is balanced by an equivalent positive charge in the nucleus of the impurity atoms.

To provide a semiconductor of different characteristics, impurity atoms such as aluminium, gallium, or indium are added. When these atoms get into the basic crystal structure they set up conditions which give an apparent shortage of electrons. In other words, there are positions for electrons which are not, in fact, present in the material. These electron vacancies or "holes", as they are called, encourage electron flow through the material, for the electrons flowing through use the holes as "stepping stones" (Fig. 1.4).

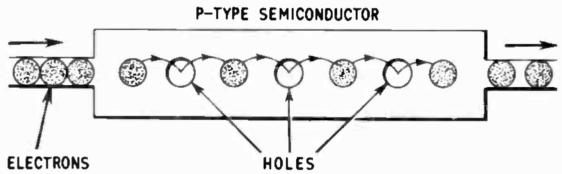


Fig. 1.4. Electrons can also move through material lacking in electrons but possessing spaces (holes) to accommodate electrons. In this case, electrons move through the material from hole to hole, as this diagram reveals. Since the electrons are moving from left to right in this drawing, the holes can be considered as moving from right to left in relation to the electrons

A hole in a crystal structure is considered to have a positive charge because it represents the absence of an electron, but as with *n*-type material, the net charge of the crystal as a whole is unchanged. Semiconductor materials which contain holes or positive charges are called *p*-type (*p* for *p*ositive). *p*- and *n*-type semiconductors are used extensively in diodes and transistors, as we shall see in later articles, but in addition to these there are many more kinds of semiconductor.

The resistivity of some materials is reduced or increased with temperature increase. These are called thermistors. Others drop substantially in resistance as the voltage across them increases. These are called voltage dependent resistors. Then there are others whose resistance falls as the intensity of light directed on to them increases. These are members of the phototransistor and photoconductive family and light dependent resistor.

In all cases, the resistivity is reduced (i.e. the conductivity is increased) by the stimulus causing a change in the amount of free electrons available for conduction. That is, the number of current carriers is increased, whether these are electrons or holes.

Next month we shall be investigating semiconductor diodes, looking more at the crystalline make-up of the materials and seeing how it is that a diode easily passes electric current in one direction but not in the other.

HIGH INPUT IMPEDANCE TECHNIQUES

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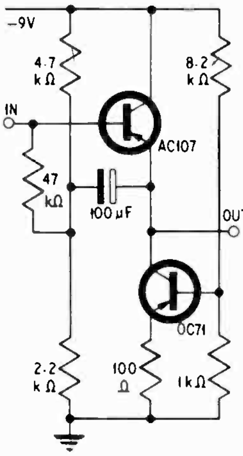


Fig. 10. Very high impedance circuit using two transistors

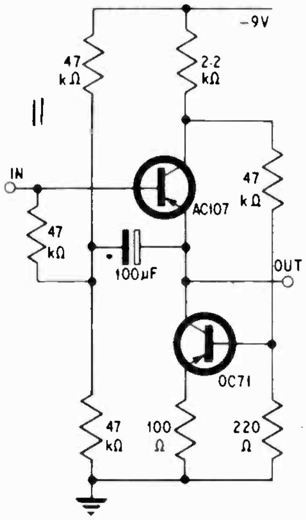


Fig. 11. Feedback applied to increase the apparent emitter load

saying that the resistor seems to have infinite impedance, although we know very well that the real impedance of the resistor is low.

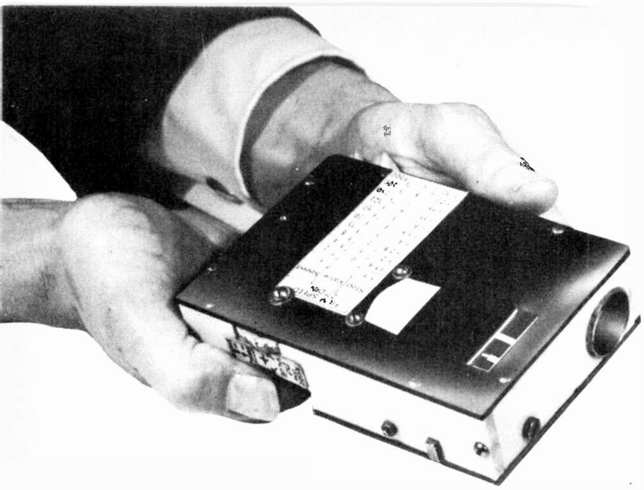
It is rather difficult to feed the other end of the resistor with *exactly* the same waveform as is being fed into the "business end", but for many purposes the voltage from the emitter of an emitter follower is good enough. Using this principle, a low value of resistance can be used to bias a power transistor for example, so that good thermal stability can be achieved, and yet the input appears as a high impedance to the signal, so that reasonably sized coupling capacitors may be used. Such a circuit is shown in Fig. 9.

To obtain the highest impedance, however, two transistors must be used, and two commonly used circuits are shown in Fig. 10. Their valve equivalents are well known to radar designers as improvements on the cathode follower principle. In each case the bias resistor has been "bootstrapped" to increase its apparent impedance, and the emitter load of the upper transistor which acts as an emitter follower, is formed by the lower transistor.

The lower transistor acts as if it were a high resistance as far as the signal is concerned (because the impedance at the collector of the transistor is high), but it does not restrict the current flowing in the same way that a "real" resistor would. This is one way of getting the best of both worlds.

The slightly modified version of this circuit, shown in Fig. 11, uses a feedback connection from the collector of the top transistor to the base of the bottom one to increase the apparent emitter load still further. Very high impedances can be obtained with this circuit.

Still higher impedances, of the order of 20 megohms upwards, can be obtained by elaborations of the circuits shown. It is to be hoped that this glimpse of the possibilities of high impedance circuits with transistors will encourage experimenters to try such circuits in such devices as potentiometer detectors, amplifiers for capacitance microphones and crystal pick-ups, proximity detectors and the like. ★



photographic EXPOSURE METER

By S. C. HOOSON

THE cadmium sulphide cell is of obvious interest to photographers since its resistance varies with the rate at which light energy falls on it. The cell recommended for use in this exposure meter (ORP12) varies in resistance from about 20 ohms to 10 megohms over the range of illumination which is of use in photography. Unfortunately the characteristics of individual cells differ, so that the meter must be calibrated for the particular cell it is using.

WHEATSTONE BRIDGE

The basic circuit is shown in Fig. 1. A Wheatstone bridge is used so that results do not depend on battery voltage. R_A and R_B are the ratio arms. By means of the switch S2 the ratio of resistances R_A and R_B may be set to either of two different values, so providing the instrument with two ranges.

R_C is a variable resistance which is used to balance the bridge—the condition for balance being, of course, that $R_A/R_B = R_X/R_C$. Since the resistance R_X depends on the illumination of the cell, then the value of the resistance R_C needed for balance will indicate the illumination.

The author tried using a variable resistance for R_C, but found this unsatisfactory. In order to obtain a linear scale, appropriate resistance values were selected by a multi-way switch. This article will show how the values of these resistors may be calculated.

Construction of the exposure meter is fairly straightforward as dictated by the simplicity of circuit. The main criterion is the range switch which is a single-pole, 18-way wafer with edge control. In the instrument described, only 11 ways are used. The overall size of this switch is $2\frac{7}{8}$in × $2\frac{3}{8}$in × $\frac{7}{16}$in, so a case (the author's was in Perspex) of internal dimensions 3in × $5\frac{1}{2}$in × 1in minimum should be able to house all the components comfortably (see Fig. 4).

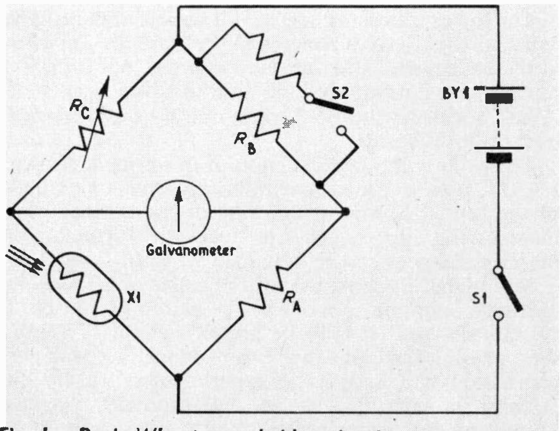
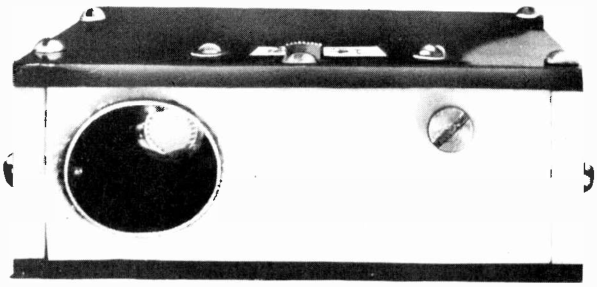


Fig. 1. Basic Wheatstone bridge circuit

All drilling and slot cutting should be done in the sides of the case before assembly, each side being fixed to the adjacent ones with glue or screws. The exact positions and sizes of holes will depend on the components used.

The range resistors are mounted directly on the selector switch, but space must be allowed to house the mercury cells in the corner by this switch. An insulating retainer is glued to adjacent sides of this corner to keep the cells in position and insulate from the switch components. Similarly, the photo-cell tube should be wrapped in thin plastics sheeting to insulate from the nearby resistors and meter movement.



Wiring is straightforward and the circuit in Fig. 3 is used in the actual model. Insulated wiring is used as much as possible.

Before finally closing the lid (the part with the meter mounted on it) on the case, check all wiring and make sure that there is no risk of shorts.

The case should be made dust proof to protect the meter movement. Thin rubber or plastics sheet inserted at all case joints will help to achieve this.

MOUNTING THE CELL

Before making any measurements on the cell, it is essential to mount this component in its final form, since its resistance will depend on the acceptance angle it presents to the light source. It is recommended that a fairly narrow acceptance angle be used, since the meter may be used to measure the brightness of a small part of the scene, instead of giving an overall average brightness.

A metal or cardboard tube, of about 2½in in length and ¾in diameter forms a suitable container for the cell. A disc of s.r.b.p is cut to fit one end of the tube, two suitable holes are made in the disc, and the wire ends of the ORP12 pushed through the holes. The wires are then carefully bent over to anchor the cell. The disc is cemented to the end of the tube, with the cell inside the tube. The inside of the tube should be blackened with matt black paint.

An alternative, which can be easily obtained and provides a neat finished appearance, is a large cigar tube, which can be painted matt black.

The length of the tube controls the acceptance angle, a shorter tube giving a larger acceptance angle, but this may be altered to suit individual preference. It should be noted that the larger the acceptance angle, the less is the need for a sensitive meter in the bridge circuit.

CALIBRATING THE CELL

It is now necessary to find the resistance of the cell at a few known values of illumination, and for this it will be necessary to borrow a calibrated exposure meter, or light meter.

Arrange a sheet of white paper vertically, with both the cadmium cell and the exposed meter pointing at it, at a distance of about a foot. Connect the cell to a reliable ohmmeter, or other accurate resistance measuring device.

Set the film speed dial of the exposure meter to, say, 22 Din (125 ASA), and leave it at this setting. Readings are taken of the resistance of the cell, and of the exposure value readings on the exposure meter. This should be repeated a few times over a wide range of illumination of the white paper using daylight only.

A graph is now made, plotting the logarithm of the cell resistance against the exposure values. This will be found to be a straight line, as in Fig. 2. The calculation of the resistances for R_C and R_B is made from this graph.

CALCULATION OF RESISTANCES

A decision must now be made on the exposure values to be covered by each of the two ranges. Suitable values would be: Range 1, 0 to 10; Range 2, 8 to 18, and it is on this basis the calculation will be made. This requires a multi-way switch with 11 ways. The ranges may, of course, be extended or reduced to suit a switch with a different number of ways.

Tables 1 and 2 are now prepared, the third line of each table being obtained from the graph (Fig. 2). If the values of the resistances in the third line of each table are compared, it is found that their ratio is about

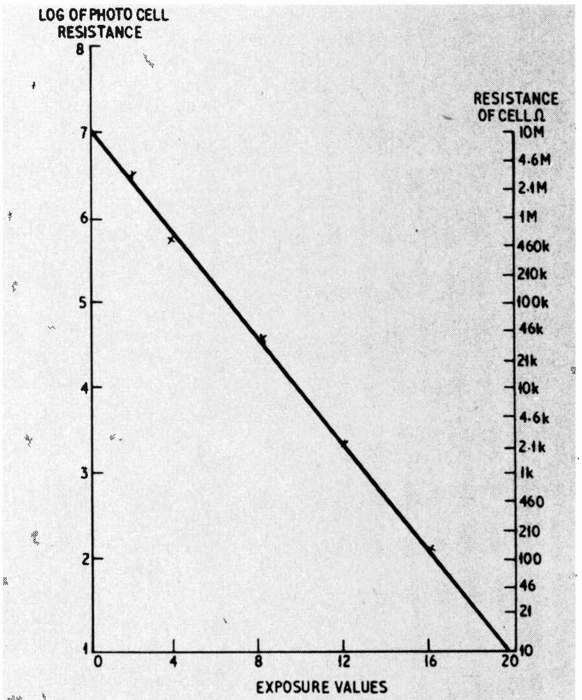


Fig. 2. Graph of photocell resistance against exposure values

300 : 1 (e.g. column 2 . . . 5 Megohms : 17 kilohms; and column 8 . . . 75 kilohms : 240 ohms, etc.).

Take the square root of this figure, 300, which is approximately 17. Line four of Table 1 is obtained by *dividing* line three by 17. Line four of Table 2 is obtained by *multiplying* line three by 17. Thus line four of each table should be the same, and this represents the value of the resistance needed for R_C for each switch position. The ratio of R_A/R_B must be either 17/1 or 1/17, depending on the position of S2.

Referring now to Fig. 4 which gives the complete circuit, it will be seen that the table of resistance values fulfils the above conditions (bearing in mind that line four of the tables gives the *total* resistance required for R_C at the various switch positions).

GENERAL CONSIDERATIONS

All the resistors should be 5 per cent tolerance or less and of high stability. It is worthwhile connecting R1 to R11 on the multi-way switch, and then checking with an ohmmeter that the resistance at each switch setting does in fact agree with line four of the tables.

Table 1: RANGE 1 VALUES

S3 switch position	1	2	3	4	5	6	7	8	9	10	11
Exposure value for range 1	0	1	2	3	4	5	6	7	8	9	10
Resistance of photocell (ohms)	10M	5M	2·5M	1·2M	600k	300k	150k	75k	36k	17k	9k
Resistance needed on selector S3 R_C (ohms)	600k	300k	150k	70k	34k	17k	8k	4k	2k	1k	500

Table 2: RANGE 2 VALUES

S3 switch position	1	2	3	4	5	6	7	8	9	10	11
Exposure value for range 2	8	9	10	11	12	13	14	15	16	17	18
Resistance of photo-cell (ohms)	36k	17k	9k	4k	2k	1k	460	240	120	60	30
Resistance needed on selector S3 R_C (ohms)	600k	300k	150k	70k	34k	17k	8k	4k	2k	1k	500

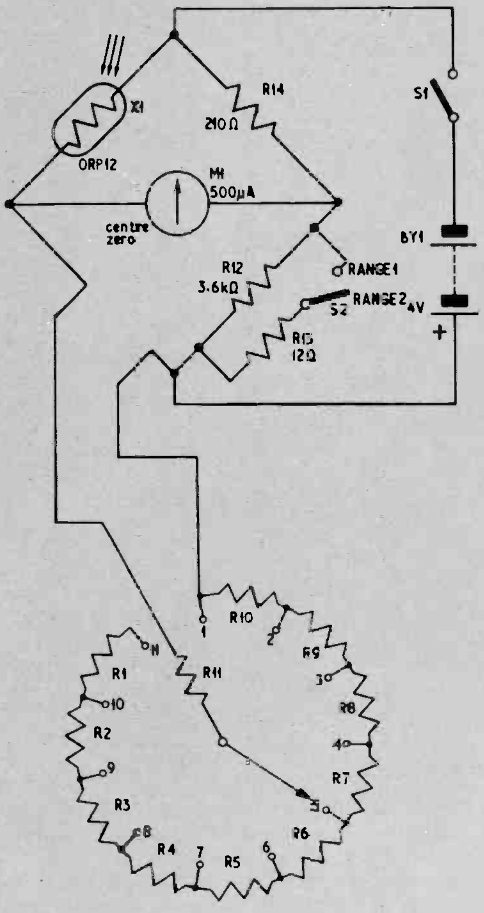


Fig. 3. Circuit diagram of the model described

COMPONENTS . . .

Resistors

R1	500Ω	R6	17kΩ	R11	500Ω
R2	1kΩ	R7	34kΩ	R12	3·6kΩ
R3	2kΩ	R8	85kΩ	R13	12Ω
R4	3·8kΩ	R9	150kΩ	R14	210Ω
R5	9·2kΩ	R10	300kΩ		

All 5%, ¼W high stability, selected from nearest preferred values (see text)

Switches

- S1 Single-pole push-to-make (see text)
- S2 Two-pole on/off miniature slide switch
- S3 Single-pole, 18-way (Henry's type A)

Miscellaneous

- M1 500µA centre-zero meter
- X1 ORP12 (Mullard)
- BY1 3 × 1·35V Mallory cells
- Metal or cardboard tube for mounting CdS cell (see text). Plastics case (see text)

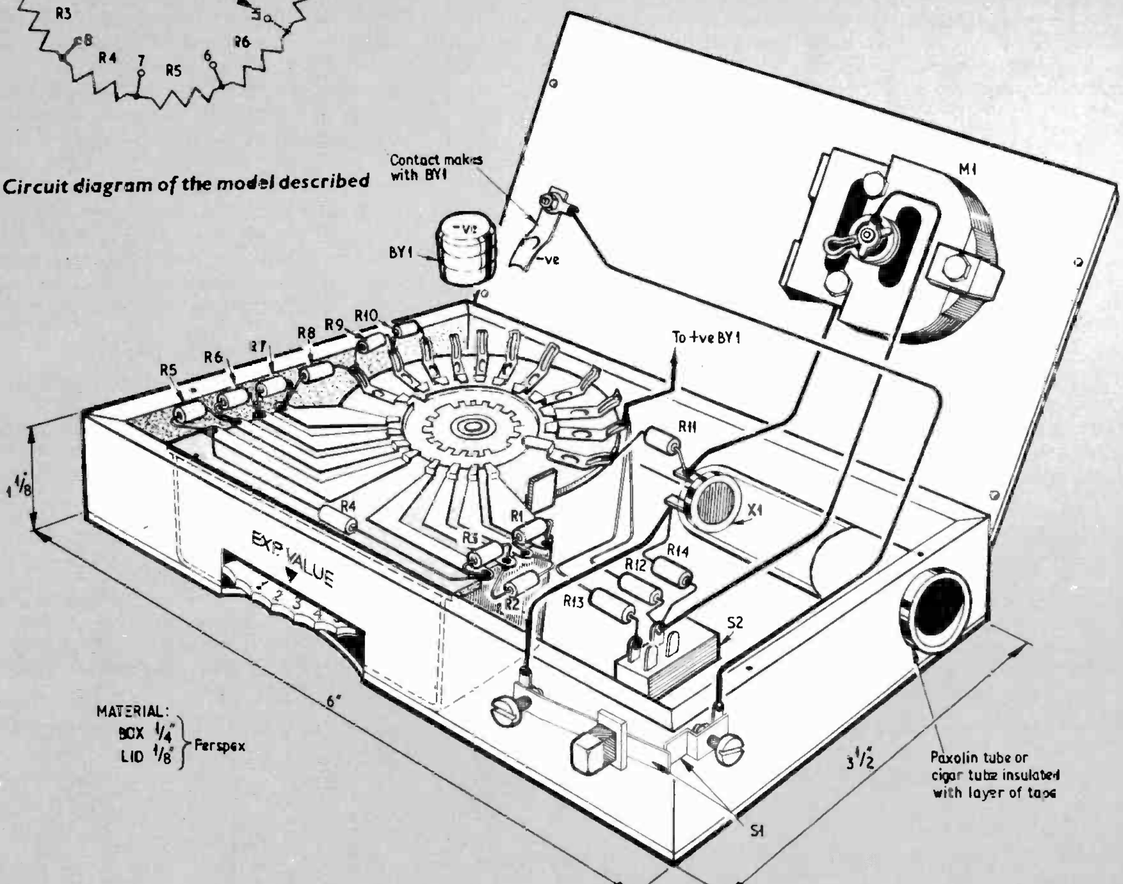
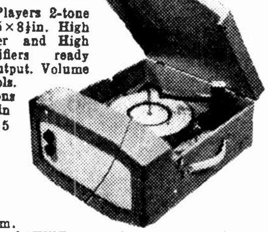


Fig. 4. Layout and wiring inside the case

DE LUXE PLAYERS



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PORTABLE CABINET As illustrated. To fit standard player or autochanger. **69/6**

RCS AMPLIFIER 3 WATT. Ready made and tested with UCL82 triode pentode valve and loudspeaker. **59/6**

SUPERIOR AMPLIFIER. Ready made and tested. Guaranteed better sound! Fully isolated AC Mains Transformer 4 watt output. ECL86 triode pentode valve. Volume and tone controls with knobs. Quality Loudspeaker. **89/6**

SINGLE PLAY MONO		AUTOCHANGE MONO	
BSR TU9376	£4.19.6	BSR Superslim	£5.19.6
Garrard SRP22	£4.19.6	Garrard 1000	£5.19.6
Garrard SP25	£10.19.6	Garrard 2000	£6.19.6
Philips AG1016	£12. 9.6	Garrard 3000	£8. 9.6
Garrard A70	£19.19.6	Garrard AT60	
Garrard LAB80	£24.19.6	diecast turntable	£12.19.6
Garrard 401	£29.19.6		

All with mono cartridge (Stereo 12/6 extra)

GARRARD TEAKWOOD BASE WB.1 Ready cut for mounting 1000, 2000, 3000, SP25, AT60. **75/-**
GARRARD PERSPEX COVER SPC1 for WB.1, 58/-.

A.18 TRANSCRIPTION TONE ARM with template and two plug-in shells. OUR PRICE **90/-**
Decca Deram Stereo Diamond Cartridge £4.10.0 extra, or Stereo Moving Coil Diamond 20-18,000 c.p.s. 5 gns. extra.

Q MAX CHASSIS CUTTER

Complete: a die, a punch, an Allen screw and key
½in. 14/6 ⅝in. 15/9 1⅛in. 18/- 1⅜in. 20/6 2$\frac{3}{32}$in. 37/9
⅝in. 14/9 1in. 18/- 1¼in. 18/6 1⅝in. 22/6 2¼in. 44/3
¾in. 15/6 1$\frac{1}{16}$in. 18/- 1½in. 20/- 2in. 34/3 1in. sq. 31/6

ACOS XTAL GP67, 15/-. PICK-UP ARM Complete with ACOS LP-78 Turnover Head and Stylii 20/-: Stereo 30/-.
SPEAKER FRET Tygan various colours, 52in. wide, from 10/- ft.; 26in. wide from 5/- ft. SAMPLES S.A.E.
EXPANDED METAL Gold or Silver 12 × 12 in. 6/-.

FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12 v. outputs, 1½ amp., 8/9; 2 a. 11/3; 4 a., 17/6.
CHARGER TRANSFORMERS. P. & P. 2/6. Input 200/250 v. for 6 or 12 v., 1½ amps., 17/6; 2 amps., 21/-; 4 amps., 25/-.

MOVING COIL MULTIMETER TK 25. 0-1,000v. A.C./D.C., ohms 0 to 100k. etc., **47/6**
MOVING COIL MULTIMETER EP10K. 0-1,000v. A.C./D.C., ohms 0 to 3 meg. etc., **79/6**
MOVING COIL MULTIMETER EP20K. 0-2,500v. D.C. 20,000 ohms per volt. 0-1,000v. A.C. Ohms 0 to 6 meg. 50 Microamps. **99/6** (Full list Meters S.A.E.)

NEW MULLARD TRANSISTORS

OC71 6/-; OC72 6/-; OC81D 6/-; OC81 6/-; AF115 8/-; AF114 8/6; OC44 6/-; OC45 6/-; OC171 6/-; OC170 6/-; AF117 6/-. OC26 12/6; AD140 15/-; OC35 15/- Holders 1/-.

REPANCO TRANSISTOR TRANSFORMERS
TT45, Push Pull Driver 9:1CT. OC71, OC81D 6/-
TT46, Push Pull Output CT 8:1. OC72, OC81. ..... 6/-
TT49, Interstage, etc. 4.5:1 ..... 5/-
TT52, Output 3 ohms 20:1 ..... 5/-

TRANSISTOR MAINS ELIMINATORS. FAMOUS "POWER MITE". 9 VOLT. SAME SIZE AS PP9 BATTERY. FULLY SMOOTHED. 150mA. FULL WAVE CIRCUIT. **45/-**
SPECIAL 9 VOLT. 500mA POWER PACK 49/6

WEYRAD P50 — Transistor Coils

RA2W 6 in. Ferrite Aerial with car aerial coil	12/6	Spare Cores	6d.
Osc. P50/1AC	5/4	Driver Trans. LFDT4	9/6
I.F.P50/2CC 470 kc/s	5/7	Printed Circuit, PCA1.	9/6
3rd I.F. P50/3CC	6/-	J.B. Tuning Gang	10/6
		Weyrad Booklet	2/-

Volume Controls

LONG SPINDLES. MIDGET SIZE 5K. ohms to 2 Meg. LOG or LIN. L/S 3/-. D.P. 5/-. STEREO L/S 10/6, D.P. 14/6.

80 Ohm Coax 6d yd.

Semi-air spaced Cable 100 yd. drum 50/- post free.
FRINGE LOW LOSS Ideal 625 lines **1/6** yd.

COAXIAL PLUG 1/-. PANEL SOCKETS 1/-. LINE SOCKETS 2/-. OUTLET BOXES, SURFACE OR FLUSH 4/6. BALANCED TWIN FEEDERS 1/- yd., 80 or 300 ohms. TELESCOPIC CHROME AERIALS. 6in. extends to 23in. 6/6 each. CAR AERIAL PLUGS 1/6. Sockets 1/3.

SPECIAL PURCHASE! STELLA BATTERY RECORD PLAYER

Amplifier and loudspeaker—all transistor — top performance of discs at 33⅓, 45 and 78 r.p.m. LP xtal cartridge. Smart red or blue plastic cabinet.
WORTH DOUBLE! OUR PRICE **£8.5.0.** P. & P. 5/-.

THE E.A.R. RECORD PLAYER CABINET

Strongly built wooden cabinet covered in Blue and Grey leathercloth size 15×17×8 in. Motorboard 14½×12½ in. ready cut out for B.S.R. Monarch UA 12/14/15/16/25 decks. Gilt fittings, strong carrying handle. Amplifier space size 14×7×3 in. is completely enclosed. The baffle board is cut out for a 6½ in. dia. speaker. P. & P. 5/6. PRICE **59/6**

NEW TUBULAR ELECTROLYTICS				CAN TYPES	
2/350 v.	2/3	100/25 v.	2/-	8/600 v.	9/6
4/350 v.	2/3	250/25 v.	2/6	16/600 v.	12/6
8/450 v.	2/3	500/25 v.	4/-	16+16/500 v.	7/6
16/450 v.	3/-	8+8/450 v.	3/6	32+32/450 v.	6/-
32/450 v.	3/9	8+16/450 v.	3/9	50+50/350 v.	7/-
25/25 v.	1/9	16+16/450 v.	4/3	60+100/350 v.	11/6
50/50 v.	2/-	32+32/350 v.	4/6	100+200/275 v.	12/6

SUB-MIN. ELECTROLYTICS. 1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 250 mfd. 15v. 2/6; 500, 1000 mfd. 12v. 3/6 2000 mfd. 25v. 9/6.
CERAMIC. 500 v. 1 pF. to 0.01 mfd., 9d. Discs 1/-.

PAPER TUBULARS
350v.-0.1 9d., 0.5 2/6; 1 mfd. 3/-; 2 mfd. 150v. 3/-.
500v.-0.001 to 0.05 9d; 0.1 1/-; 0.25 1/6; 0.5 3/-.
1,000v.-0.001, 0.0022, 0.0047, 0.01, 0.02, 1/6; 0.047, 0.1 2/6.
E.H.T. CONDENSERS. 0.001mfd., 7kV., 6/6; 20kV., 10/6

SILVER MICA. Close tolerance (plus or minus ½ pF.), 5 to 47 pF., 1/-; ditto 1% 50 to 800 pF., 1/-; 1,000 to 5,000 pF., 2/-.
TWIN GANG. "0-0" 208 pF.+176 pF., 10/6; 365 pF., miniature 10/-; 500 pF. standard with trimmers, 9/6; 500pF. midget less trimmers, 7/6; 500 pF. slow motion, standard 9/-; small 3-gang 500 pF. 18/9. Single "0" 365 pF. 7/6. Twin 10/-.
SHORT WAVE. Single 10 pF., 25 pF., 50 pF., 75 pF., 100 pF., 160 pF., 5/6 each. Can be ganged. Couplers 9d. each.
TUNING. Solid dielectric, 100 pF., 300 pF., 500 pF., 3/6 each.
TRIMMERS. Compression ceramic 30, 50, 70 pF., 9d.; 100 pF., 150 pF., 1/3; 250 pF., 1/6; 600 pF., 750 pF., 1/9.

250v. RECTIFIERS. Selenium ½ wave 100mA 5/-; BY100 10/-.
CONTACT COOLED ½ wave 60mA 7/6; 85mA 9/6.
Full wave 75mA 10/-; 150mA. 19/6; T.V. rects. from 10/-.

NEW B.A.S.F. LIBRARY BOXED TAPE

7 in. L.P. 1,800 ft. 45/-; 7 in. D.P. 2,400 ft. 70/-
60 min. Cassette C60 (For Philips, etc.) 17/6
Spare Spools 2/6. Tape Splicer 5/-. Leader Tape 4/6.
Tape Heads: Collaro 2 track 28/6 pair. B.S.R. 4 track 99/6

MAINS TRANSFORMERS

Post 2/6 each

250-0-250 80 mA. 6.3 v. 3.5 a. 6.3 v. 1 a. or 5 v. 2 a. 25/-
350-0-350 80 mA. 6.3 v. 3.5 a. 6.3 v. 1 a. or 5 v. 2 a. 29/6
MT. 510/300-0-300 v. 120 mA., 6.3 v. 4 a. 29/6
MINIATURE 200 v. 20 mA., 6.3 v. 1 a. 10/6
MIDGET 220 v. 45 mA., 6.3 v. 2 a. 15/6
SMALL 250-0-250 50 mA. 6.3 v. 2 a. 19/6
HEATER TRANS. 6.3 v. 1½ a., 8/6; 6.3 v. 4 a. 10/6
Ditto tapped sec. 1.4 v., 2, 3, 4, 5, 6.3 v. 1½ amp. 10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 25/-
1 amp., 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60, 29/6
AUTO TRANSFORMERS 0-115-230 v. Input/Output, 60w. 18 6; 150w. 25/-; 500w. 92/6; 1000w. 175/-.

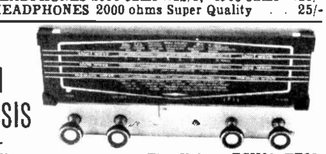
CRYSTAL MIKE INSERTS

1½ × ⅜in. 6/6; ACOS 1½ × ⅜in. 8/0
MOVING COIL MIKE with Remote Control Switch 19/6

ALL PURPOSE HEADPHONES

MOVING COIL HEADPHONES 100 ohms (ex. Govt.) 12/6
H.R. HEADPHONES 2000 ohms ..12/6, 4000 ohms 15/-
H.R. HEADPHONES 2000 ohms Super Quality 25/-

1968 GRAM CHASSIS



Post 5/-

Three Wavebands: Long., Med., Short. Gram. Five Valves: ECH81, EF89, EBC81, EL84, EZ80, 12-month guarantee. A.C. 200-250 v. Ferrite Aerial 5 watts 3 ohm. Chassis 13½in. × 7in. × 5in. dial size 13in × 4in. Two pilot Lamps. Four Knobs. Aligned calibrated. Chassis isolated from mains **£10.10**

DE LUXE STEREO GRAM CHASSIS V.H.F., MW, SW 19-50m, SW 60-180m. Magic eye, push buttons, 6 valve plus rect. Size 15" × 7½" × 6" high **£19.19**

TAPE DECK AMPLIFIER FOR B.S.R., T.D.2, etc.

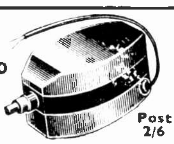
With Pre-Amplifier, Oscillator, all valves, "magic-eye" tuning indicator, 3 watt. 3 stage amplifier especially built for B.S.R. TD.2 Tape Deck. Bolts directly to tape deck chassis. Inputs for mike and radiogram. Output 3-5 ohms. A.C. 200/250v. Ready built. PRICE £7.19.6. Carriage 5/6.

BLANK ALUMINIUM CHASSIS. 18 s.w.g. 2½in. sides. 7×4in., 5/6; 9× 7in., 6/6; 11×3in. 6/6; 11×7in. 7/6; 13×9in. 9/6; 14×11in. 12/6; 15×14in., 15/-.
ALUMINIUM PANELS 18 s.w.g. 12×12in. 5/6; 14×9in. 4/6; 12×8in. 3/6; 10×7in. 2/9; 8×6in. 2/-; 6×4in. 1/6.

ALL PURPOSE TRANSISTOR PRE-AMPLIFIER

Gain 14: 1. 250v. or 9v. input. Ready built with Mu Metal input transformer for Mikes, Pick-Ups, Tuners. Instructions and circuit supplied. Post 2/6. **15/-**

THE INSTANT BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER



200/250 v. A.C.
Leaflet S.A.E.
Post 2/6 **35/-**

BAKER MAJOR 'MODULE'

Ideal mono or stereo conversion of existing cabinets, furniture, etc. 12 inch Baker Major Full range speaker on 19" × 12½" baffle board with 2½" tweeter and cross-over. Output 20 watts. Response 30-17,000 c.p.s. Impedance 15 ohms.

In kit form with instructions.
£10.19.6
or Fully assembled
£12.10.0
Post Free

'Group 25'	'Group 35'	'Group 50'
12in. 25w. 5gns.	12in. 35w. 8½gns.	15in. 50w. 18gns.

"BONDACOUST" Wadding for cabinet lining 15/- sq. yd.

Quality Horn Tweeters 3-16kc/s. 10w. 27/6. Crossover 14/6.
LOUDSPEAKERS P.M. 3 OHMS. 2½in., 3in., 4in., 5in., 7in. × 4in., 15/6 each; 8in. 22/6; 6½in. 18/6; 10in. 30/-; 12in. 30/-; (15 ohms 35/-); 10 × 6in. 30/-; 8 × 5in. 21/-; E.M.I. Double Cone 13¼×8in., 3 or 15 ohm models, 45/-.
SPECIAL OFFER! 8 ohm. 2½in., 5in.; 80 ohm. 2½in., 2¾in. **15/6** 25 ohm. 5in., 6×4in.; 35 ohm. 3in., 5in., 7×4in.; EACH—ANY TYPE. 15 ohm. 3in., 5in., 7×4in.
JACK SOCKETS Std. open-circuit 2/6, closed circuit 4/6; Chrome Lead Socket 7/6. DIN 3-pin 1/3, 5-pin 1/6; Lead 3/6, Phono Plugs 1/-. Socket 1/-. JACK PLUGS Std. Chrome 3/-; 2.5mm.; 3.5mm. 1/9; DIN 3-pin 3/6; 5-pin 5/-.
WAVE-CHANGE SWITCHES WITH LONG SPINDLES. 2 p. 2-way, or 2 p. 6-way, or 3 p. 4-way 3/6 each.
1 p. 12-way, or 4 p. 2-way, or 4 p. 3-way, 3/6 each.
Wavechange "MAKITS" 1 p. 12-way, 2 p. 6-way, 3 p. 4-way. 4 p. 3-way, 6 p. 2-way. Prices include click spindles, adjustable stops, spaces, etc., 1 wafer, 10/6; 2 wafer, 15/-; 3 wafer, 19/6.
TOGGLE SWITCHES, sp. 2/-; sp. dt. 3/6; dp. 3/6; dp. dt. 4/-.

DE LUXE TAPE SPLICER Cuts, trims, joins for editing and repairs. With 3 blades. **14/6**

4 CHANNEL TRANSISTOR MICROPHONE MIXER. Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. **52/6**

DYNAMIC MICROPHONE. Dual impedance 600 ohm/50K. Universal Mounting. 70-12,000 cps. **£6.6.0**

AM TUNER MEDIUM WAVE. Three Transistor Superhet. Ready built. Printed Circuit. Ferrite Aerial. Sizes 5½" × 3½" × 1½". Ideal for Tape Recorders. **79/6**

FM TUNER 88-108 Mc/s Six Transistor. Superhet. Ready built. Printed Circuit. Calibrated slide dial tuning. Size 6" × 4" × 2½". **£6.19.6**

3 WATT QUALITY AMPLIFIER. 4 Transistor Push-Pull Ready built, with volume control **65/-**

★ RADIO BOOKS ★ (Postage 9d.)

High Fidelity Speaker Enclosures and Plans	5/-
Transistor Superhet Commercial Receivers	7/6
Mullard Audio Amplifier Manual	8/6
Radio Valve Guide, Books 1, 2, 3, or 5	each 5/-
Practical Radio Inside Out	4/6
Transistor Audio Amplifier Manual Book 1, 3/6; Book 2,	6/-
Shortwave Transistor Receivers	5/-
Transistor Communication Sets	6/-
International Radio Stations List	2/6
Modern Transistor Circuits for Beginners	7/6
Sub-Miniature Transistor Receivers	5/-
Wireless World Radio Valve Data	9/6
At a glance valve equivalents	6/-
Valves, Transistors, Diodes equivalents manual	10/6

RESISTORS. Preferred values, 10 ohms to 10 meg. ¼ w., ½ w., 1 w., 20% 3d.; 1½ w. 8d.; 2 w. 1/-; ½ w. 10% 6d.
HIGH STABILITY. ½ w. 1% 10 ohms to 10 meg., 2/-. Ditto 5%. Preferred values 10 ohms to 22 meg., 9d.

5 watt	0.5 to 8.2 ohm 3 w.	1/6
10 watt	WIRE-WOUND RESISTORS	1/9
15 watt	10 ohms to 6,800 ohms	2/-

10K, 15K, 20K, 25K, 68K, 10W. 3/-
MAINS DROPPERS. Midget. With sliders. 0.3 a., 1 K., 0.2 a., 1.2 K., 0.15 a., 1.5 K., 6/- each.
LINE CORD 100 ohms ft. twin plus resistance. 1/- ft.

WIRE-WOUND 3-WATT POTS. T.V. Type. Values 10 ohms to 30 K., 3/3, Carbon 30 K. to 2 meg., 3/-.

WIRE-WOUND 4-WATT STANDARD SIZE POTS. LONG SPINDLE VALUES 50 OHMS to 100 K., 7/6.

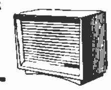
VALVE HOLDERS. Int. Oct. 6d. Mazda Oct. 6d.; B7G, B8A, B8G, B9A, Moulded 9d. Ceramic 1/-. B7G, B9A Cans 1/-. Valve base plugs B7G, B9A, Int. Oct., 2/3.

60 ONLY—SANGAMO 3 inch SCALE LABORATORY MOVING COIL METERS

Various calibrations and movements. 100 Microamp 55/-; 1 Milliamp 50/-, etc. Post 5/- extra. Send S.A.E. for list.

BRAND NEW QUALITY EXTENSION LOUDSPEAKER

Cream plastic cabinet, 20ft. lead and adaptors. For any radio, intercom, tape recorder, etc. 3 to 15 ohm
Size: 7½" x 5½" x 3"



Post 2/6 **30/-**

RETURN OF POST DESPATCH *Post and Packing 1/6 unless otherwise stated. C.O.D. 5/- extra. Full List 1/-.* *CALLERS WELCOME*

RADIO COMPONENT SPECIALISTS 337 WHITEHORSE ROAD, WEST CROYDON

Written guarantee with every purchase. *(Export: Send remittance and extra postage, no C.O.D.) Buses 133, 68 pass door. S.R. Stn. Selhurst.* **Tel. 01-684-1665**

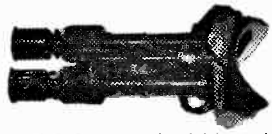
GEARED MOTOR

Half rev. per minute. Made by famous Smith Electric, mains operated and quite powerful. Size 3¼ × 2¼ × 1½in deep. Secondary use as process timer. Internal switch can be made to break circuit within a period up to 2 mins. **17/6.** P. & P. 2/6 unless ordered with other goods.

INFRA-RED HEATERS

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

See in the Dark INFRA-RED BINOCULARS



These infra-red binoculars when fed from a high voltage source will enable objects to be seen in the dark, providing the objects are in the rays of an infra-red beam. Each eye tube contains a complete optical lens system as well as the infra-red cell. These optical systems can be used as lenses for TV cameras—light cells, etc. (details supplied). The binoculars form part of the Army night driving (Tabby) equipment. They are unused and believed to be in good working order but sold without a guarantee. Price **£3/17/6,** plus 10/- carr. and ins. Handbook 2/6.

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.

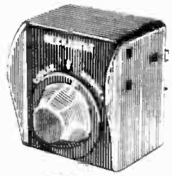
DRILL CONTROLLER

Electronically changes speed from approximately 10 revs. to max. 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.**

750mW TRANSISTOR AMPLIFIER

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.**

BECKERSTAT



An Instant Thermostat. Simply push it into 15A wall socket and plug your fire or other appliance into it. Knob setting. Will save its cost in a season. Normally 39/6. We offer at **19/6.** Plus 2/- post. 15A socket **4/6** extra.

ARMCHAIR CONTROL UNIT

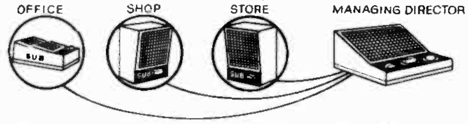
Remote Controller for Philips, Stella and Cossor TV sets but adaptable to most others, and to model control. Comprises 3 rock switches, two variable resistances and components including Mullard OA81—Knobs—10 way plug—11 ft. 7 way cable, etc., etc. List price £3/3/-, yours for only **12/6** plus 2/- post and insurance.

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 re-marking **2/6** each, **24/-** doz.

THIS MONTH'S SNIP

INTERCOM BARGAIN

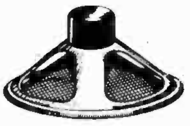


Will save time and improve efficiency. Ideal in home—office—shop—surgery, etc. Complete outfit comprises Master unit and three substations, each of which can call the master and have full two-way working. No wiring problems as subs fitted with 60ft twin flex and they plug into sockets. Also included is packet of staples—and battery. Nothing else to buy—**£4/19/6,** plus 4/6 post and insurance.

G.U.7 RECORD PLAYER

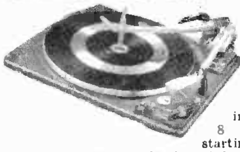
BSR Record Player for normal mains operation. This is the famous BSR Model G.U.7. Four speeds with automatic stop. Plays any size of record and is complete with stereo cartridge and sapphire stylus. Special snip price this month **67/6** plus postage and insurance 6/6.

HI-FI SPEAKER BARGAIN



12in High fidelity loudspeaker. High flux permanent magnet type with either 3 or 15 ohm speech coil. Will handle up to 10 watts. Brand new by famous maker. Price **29/6** With built-in tweeter **35/-,** plus 3/6 post and insurance.

GARRARD AUTO RECORD PLAYER Model 2000



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 turntable for max. stability adjustments include pick-up height—pick-up dropping position and stylus pressure. Size is 13¼ × 11¼in, clearance 4¾in above, 2¼in below—fitted with latest hi-compliance cartridge for stereo—and mon. 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.

PP3 Eliminator. Play your pocket radio from the mains! Save £s. Complete component kit comprises 4 rectifiers—mains dropper resistances, smoothing condenser and instructions. Only **6/6,** plus 1/- post.

WATERPROOF HEATING ELEMENT

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

HURSEAL AUTOMATIC TIME SWITCH

12 hour. 15A to control heating, lighting, radio, immersion heaters, etc. Regular price £4/4/- Limited quantity **39/6.** P. & P. 3/-.

TUBULAR HEATERS

New and unused made by G.E.C.—rated at 60 watts per ft—these are ideal in airing cupboards, bedrooms, offices, stores, greenhouses, etc., curtains or papers can touch them without fear of scorching or fire. Supplied complete with fixing brackets and available in the following sizes. Prices which are about quarter of list price includes carriage by B.R.S. 8ft **30/-.** 10ft **36/-,** 12ft **42/-.**

THE VECTRONOME CAPSTAN DRIVEN TAPE RECORDER

This is a truly portable, self-contained instrument with built-in microphone and loudspeaker using a 5-transistor amplifier with P.P. output and suitable for operation from mains or by chargeable batteries. Tape capacity is 25 minutes on easily changed spools. A tape position indicator gives quick reference to any part of dictation. Recording level is automatically preset during dictation and can be adjusted to suit operator. Interlock prevents unintentional erasures. Tape speed controlled by fly wheel driven capstan. Very portable in net case with carrying handle, overall size of which is approximately 6¾ × 7¼ × 2in. Price, with tape, nickle cadmium rechargeable batteries and mains battery charger **£9/19/6** (rather less than ½ original price). Postage and insurance 7/6. Unused and in perfect working order.

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Type "A" 15A for controlling room heaters, greenhouse, airing cupboards. Has spindle for pointer knob. Quickly adjustable from 30-80°F. **9/6,** plus 1/- post. Suitable box for wall mounting **5/-,** P. & P. 1/-.

Type "B" 15A. 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 1,000°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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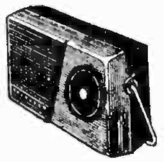
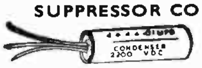
Type "F" Glass encased for controlling the temp. of liquid—particularly those in glass tanks, vats or sinks—thermostat is held (half submerged) by rubber sucker or wire clip—ideal for fish tanks—developers and chemical baths of all types. Adjustable over range 50° to 150°F. Price **18/-,** plus 2/- post and ins.

NO SOLDERING POCKET 3



Lots of fun to build and good results when finished—complete kit with detailed instructions and crystal earpiece (batteries 1/2 extra). £5 value only **19/6** plus 3/- post and insurance.

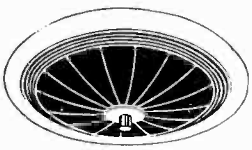
SUPPRESSOR CONDENSER



Stop your drill or other appliances interfering with you or your neighbours' radio or television. Simple instructions given. **1/6** each. **12/-** dozen.

CIRCULAR FLUORESCENT

Brings sunshine into your home. 150 watts of light but uses only 40W. Beautiful fittings with glass, non-plastic centre, fluorescent tube and choke control. Regular price **£4/15/-.** **Special budget price 65/-,** plus 10/- carr. and ins. Please state colour of glass centre, white, pink, blue, red, black, yellow or cream. Also whether plug into lamp holder or ceiling mounting model. 80 watt model **99/6.** 10/- carr. and insurance.



FLUORESCENT CONTROL KITS

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 & 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.

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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. 5,000 and 100mfd. condensers and instructions. Real snip at only **14/6,** plus 3/6 postage.

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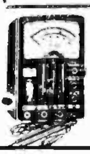
EASIEST WAY TO FAULT FIND—Traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece **29/6**—twin stetoset instead of earpiece **7/6** extra. Post and ins. 2/9.

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

11 RANGE TEST METER



For checking car electrics, radio, TV, ignition systems, household lighting, etc. Measures a.d./d.c. volts, d.c. current. Resistance. Will last a lifetime.

39/6 P. & P 3/6.

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Table 3: EXPOSURE TIMES FOR THREE FILM SPEEDS

FILM SPEED 15° DIN

Stop	Value	Speed
f1	1	1
f1·4	2	1/2
f2	3	1/4
f2·8	4	1/8
f4	5	1/15
f5·6	6	1/30
f8	7	1/60
f11	8	1/125
f16	9	1/250
f22	10	1/500
f32	11	1/1000

FILM SPEED 21° DIN

Stop	Value	Speed
f1	0	1
f1·4	1	1/2
f2	2	1/4
f2·8	3	1/8
f4	4	1/15
f5·6	5	1/30
f8	6	1/60
f11	7	1/120
f16	8	1/250
f22	9	1/500
f32	10	1/1000

FILM SPEED 27° DIN

Stop	Value	Speed
f1		1
f1·4	0	1/2
f2	1	1/4
f2·8	2	1/8
f4	3	1/15
f5·6	4	1/30
f8	5	1/60
f11	6	1/125
f16	7	1/250
f22	8	1/500
f32	9	1/1000

A 10 per cent error is admissible, but if this is exceeded the addition of one or two extra resistors of suitable value will correct it.

Since the finished instrument should be as small as possible a small centre-zero galvanometer should be used. The author removed a movement from its case in order to save space. A sensitivity of 0·5mA is sufficient. Power requirements are met by a battery of three small Mallory mercury cells. These take up little room, and should last for years.

The switch S1 should be of the press-to-make type, and is best constructed from springy brass (as found on some batteries).

USE OF THE INSTRUMENT

In order to avoid awkward calculations, it is suggested that the following method be adopted.

The exposure values, as in line two of Tables 1 and 2, should be marked at the corresponding switch positions, using different colours to identify the two different ranges. Cards can now be prepared, one for each film speed which is likely to be used, and provision made for attaching the appropriate card to the meter. Examples of the cards are given in Table 3.

On the table appropriate to the speed of the film in use, each aperture (*f*5·6 etc.) and each time ($\frac{1}{30}$ sec etc.) is allocated a number, this number being in the centre column. The sum of the number representing the aperture and the number representing the time should be equal to the exposure value as read from the instrument.

In use, the meter is directed at the scene; the resistance range switch is adjusted to zero the meter as closely as possible (half values may be estimated). The value is read direct from the switch dial. Looking at the card for the appropriate film speed, the figures in the centre column opposite the chosen *f* stop and shutter speed must total this value for correct exposure.

For example, suppose the film speed is 15 Din, and the value from the dial is 9. Then combinations such as $\frac{1}{15}$ second at *f*2·8; or $\frac{1}{2}$ second at *f*8 are correct. Again, suppose the film speed is 27 Din (400 ASA) and the value from the dial is 14, then one possible correct exposure is 1/125 second at *f*22.

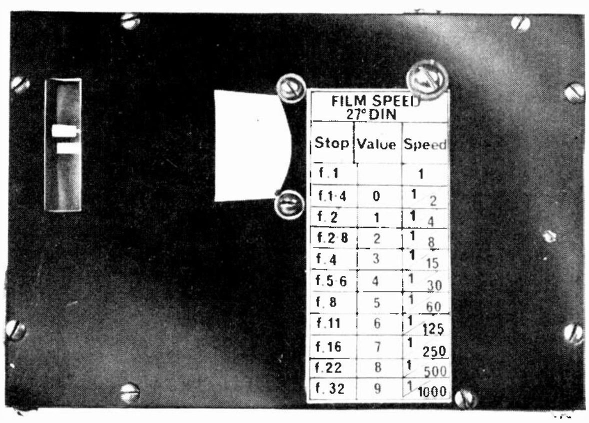
Because of the sensitivity of the CdS cell to red light, it is recommended that, when using the meter in tungsten light, the exposure value as given by the meter should be reduced by two before referring to the tables. If this is not done, there will be some under-exposure.

FURTHER REFINEMENTS

The instrument as described above will be found to be quite efficient. However, the reader may care to incorporate some of the following ideas.

If reversal colour film is regularly used, it is convenient to have a definite indication of half stops. This would require a switch with, say, 18 ways, and each range could then be arranged so that the exposure values increased in halves, i.e. 8, 8½, 9, 9½ and so on for successive switch positions.

On range 1, due to the large resistance of the cadmium cell, it may be found desirable to substitute a more sensitive meter, say a 100μA movement. If this is done, then S2 should be changed to a two-pole switch so that on switching S2 to range 2 a safeguarding resistance is switched in series with the meter. Alternatively it could be arranged that only one of the mercury cells is used on range 2. ★



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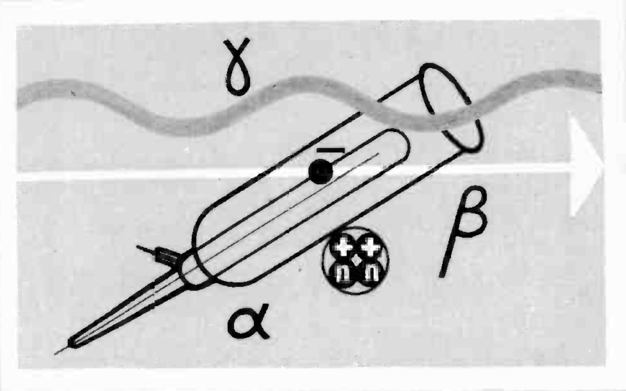

By M. L. Michaelis M.A.

2—EVERYDAY APPLICATIONS OF NUCLEAR RADIATION; A COMPOSITE EQUIPMENT FOR THE AMATEUR

Following the introductory discussion concerning the nature of nuclear radiations, it will be worthwhile now to look at some of the commonplace uses to which these radiations are applied in professional circles, before considering amateur activities in this field.

PRACTICAL APPLICATIONS

In certain respects, nucleonic equipment (electronic equipment for detecting and measuring nuclear radiation) represents a special branch of electronic computer techniques. However, the subject is by no means as specialised as one might suppose. Its topicality and extremely wide field is best borne out by the following summary of practical everyday applications of commercial nucleonic equipment.

INDUSTRIAL TECHNOLOGY

The range and relative absorption of nuclear radiations by matter are subject to well-established laws. Thus the thickness of sheet metal or plastic lamina in manufacturing processes may be monitored by using a radioactive substance on one side and a suitable radiation detector on the other side. The signals picked up by the detector can be used to derive automatic corrections for the settings of machine controls to maintain a constant desired thickness of the product.

A radioactive substance attached to a float in a liquid tank, in conjunction with a suitably mounted fixed detector, provides a reliable liquid level indicator. Again, such systems can be extended for automatic control of the liquid level or for the detection of leaks.

These are just two examples of countless technical applications of radioactive substances requiring nucleonic measuring equipment.

POWER ENGINEERING

We have seen that the binding energies of particles in the atomic nucleus are in the MeV-range, i.e. some millions of times greater than the binding energies of the outermost planetary electrons of an atom. The latter are involved in the chemical processes of conventional combustion fuels. The same weight of nuclear fuel can thus provide at least several millions of times as much energy as a combustion fuel. There is thus intense interest throughout the world in designing nuclear reactors (atomic piles) as a source of energy in competition to, and ultimately in place of, conventional fuels such as coal, oil, or water-power.

The special problems arising with nuclear reactors, whether intended for large scale power production or for experimental purposes being immaterial in this respect, are largely twofold. Firstly, the very high capital cost of a complete nuclear reactor station is an important economic factor. Secondly, the nuclear radiations which are produced as inevitable byproducts, and in particular the radioactive waste substances, are lethal to human beings and life in general if not properly shielded and confined. A very extensive system of nucleonic detection and measuring equipment is thus an essential part of any nuclear power station.

GEOLOGICAL APPLICATIONS

Geological prospecting often makes use of probes containing a radioactive substance and a radiation detector, with a shield between them to prevent direct entry of radiations from the radioactive substance into the detector. The latter then responds only to the radiations from the radioactive substance which are scattered from the rock forming the walls of a test drilling into which the probe is lowered. It is possible to draw conclusions regarding the nature of these rocks deep down in the ground, from the intensity and spectral composition of the scattered radiations. This method is of great value, for example, in oil prospecting.

Out of the numerous other geological applications, apart from searching for deposits of radioactive minerals, we may consider just one further, quite different example.

Cosmic radiation produces a small proportion of a radioactive isotope of carbon. by forced modification of the nuclei of some atmospheric nitrogen atoms. This radioactive isotope of carbon is chemically identical to the ordinary inactive isotope of carbon, and thus participates in constant proportion in the biological and geological carbon cycle. All living matter and other substances containing carbon thus possess a very small specific radioactivity with a constant radiation intensity per unit weight of contained carbon, as long as they are still actively engaged in the carbon cycle.

Once carbonaceous matter is cut off from the carbon cycle, e.g. as coal, oil deposits or fossils deep down in the ground, the radioactive carbon isotope decays with time and is not replenished any longer. As a result, the specific radioactivity is progressively smaller with increasing geological age of the deposits. Sensitive electronic equipment for such measurements has proved a valuable aid for dating geological and archæological discoveries.

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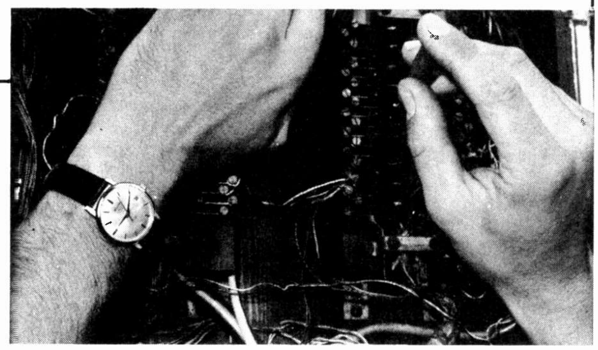

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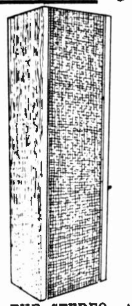
SPEAKER SYSTEMS



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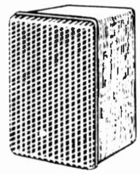
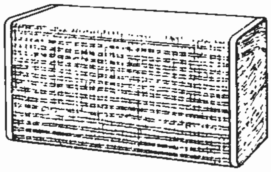
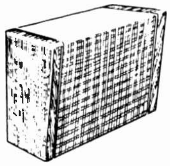


THE MILTON. A Hi-Fi Bookcase Cabinet. Size 9 × 5 × 6in. with 5in. speaker. Finished in Teak cloth with bold silk front. **30/-.** P. & P. 3/6.

THE STEREO. A superior extension cabinet fitted with two 7 × 4in. speakers. Size 16 × 9 × 8½in. Finished in fawn Vynair with natural teak ends. **£3.** P. & P. 5/-.





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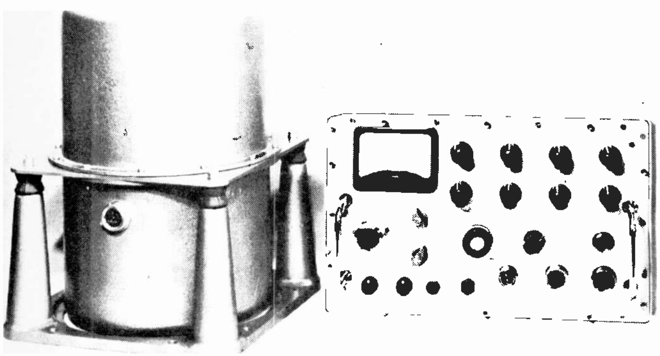
Nucleonic equipment is of course required for prospecting for radioactive ores forming the raw materials for atomic reactor fuel production. The amateur can here participate to a limited extent, although this application is so well covered by professional circles and so limited in scope, that we do not consider it among the more interesting amateur applications of nucleonics to be sketched in this series of articles.

MEDICAL AND BIOLOGICAL APPLICATIONS

Nuclear radiations have an inherently destructive effect on living tissues, and under suitable circumstances cancerous tissues and other malignant growths are more sensitive than healthy tissue. Substances such as radium, and more recently cobalt-60 and others, are thus used extensively for cancer therapy.

Particle accelerators are here very effective competitors. These are electronic devices producing nuclear radiation beams by controlled electronic means instead of by spontaneous decay of radioactive atomic nuclei. Their great advantage lies in the better ability to aim the resulting radiation beams exactly at the desired spots, and the much greater achievable beam intensity.

The second medical application of radioactive substances is concerned with diagnosis and basic research rather than with therapy.



Scintillometer NE 8420 (Nuclear Enterprises (G.B.) Ltd.)

A transistor transportable multi-channel scintillometer for gamma ray spectrometry. The detector unit (left) contains a NaI crystal and photomultiplier and pre-amplifier. The control unit houses a pulse amplifier, single channel analysers, ratemeters, radiation level alarm, and stabilised power circuits.

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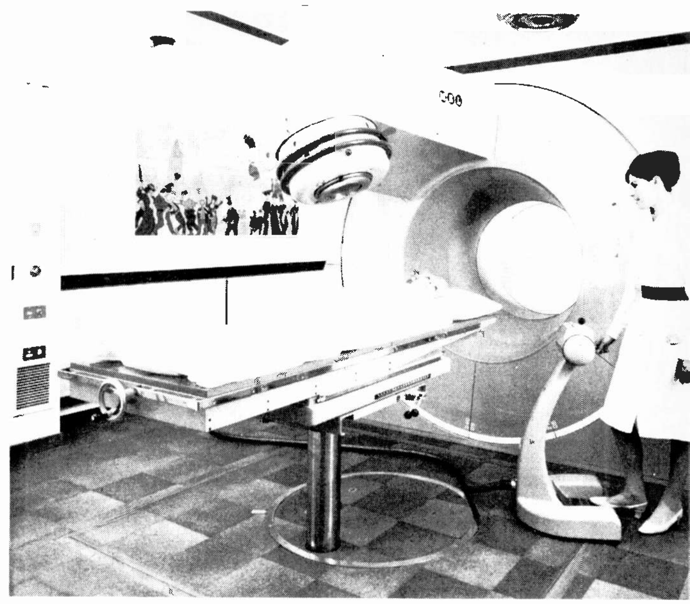
If we introduce small amounts of a radioactive isotope of a particular chemical element into a human body or any other living organism, we can very conveniently follow the path and the rate of movement of that chemical element, as well as any tendency for accumulation in certain organs. The radioactive isotope behaves in every way identical to the ordinary inactive isotopes of the chemical element concerned, as far as biological and chemical processes are concerned, so that we here have a unique and very elegant method of studying biological metabolism without disturbing the natural system.

Electronic detection equipment for nuclear radiation can readily be made enormously more sensitive than living tissues to nuclear radiation, so that very small doses of radioactive substances, which are quite harmless to the living organisms, can be used for these so-called radioactive tracer studies.

Although amateur experiments would be possible in principle here, readers are emphatically warned that these are prohibited by safety legislation and for ethical reasons. Experienced medical supervision is essential here, and all large as well as many small hospitals nowadays maintain extensive radiation departments for diagnostic purposes and for essential medical research in this line. In some cases, use is made of the tendency of certain chemical elements to concentrate in certain organs, e.g. iodine in the thyroid gland or phosphorus in the brain and nervous system, to apply selective radiation therapy to these organs through the injection or oral administration of suitable radioactive isotopes.



Medical Linear Accelerator SL75 (The M.E.L. Equipment Co. Ltd.)

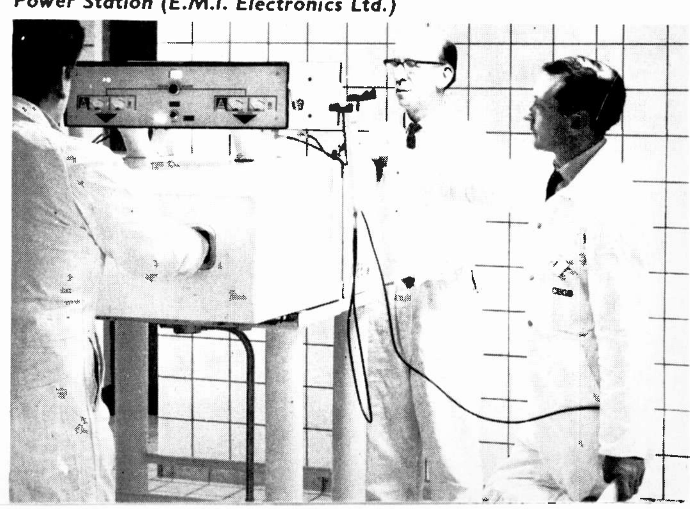
High energy X-rays are produced by this equipment. The radiographer adjusts the position of the gantry carrying the X-ray head and the couch by means of the controls on the pedestal unit

RADIO-CHEMISTRY

The use of radioactive isotopes in chemical research and industry is termed radio-chemistry. Professionally speaking, this field is of immense importance. It is also possible here to carry out a wide range of interesting, instructive and *quite safe* experiments under private amateur or school conditions. These will be introduced later in this series of articles.

The principle of most of these methods is analogous to the biological tracer studies. If a known amount of a radioactive isotope is mixed with a given quantity of inactive isotopes of the same chemical element, then the fate of that

Hand and clothing monitors in use at Oldbury Nuclear Power Station (E.M.I. Electronics Ltd.)



element in the course of complex chemical reactions can be followed with electronic radiation measuring equipment. This may prove quicker, more sensitive or more reliable than conventional methods of chemical analysis, but it also opens the way to some studies which are inherently impossible by other means. For example, the efficiency factors of standard separation processes in chemical analysis can be checked and determined directly, by comparing the radioactivity of the precipitated or otherwise separated material with the radioactivity of the residues of unseparated material.

Radiochemistry also overlaps the other fields already discussed, because chemical methods are employed to check and separate the complex radioactive products from a nuclear reactor to produce the individual radioactive isotopes for use as medical tracers, for radiation sources in prospecting and technology, etc. Many nuclear reactors are operated primarily for these radioactive products rather than for large-scale power generation. In this connection, it is appropriate to sketch the principle of a nuclear reactor. It is basically the same, regardless of whether the reactor is employed for power generation or for the production of radioactive isotopes.

We are here concerned with *nuclear fission*, which is a process of break-up of a heavy atomic nucleus (uranium, plutonium, etc.) into two roughly equal-size smaller nuclei, instead of by successive ejection of alpha and beta particles. Very few radioactive nuclei undergo spontaneous fission as a means of radioactive decay under normal circumstances. Large-scale nuclear fission is induced by exposing certain heavy nuclei to large ambient concentrations of neutrons. These bear no net electric charge and can thus easily penetrate the atomic nuclei. The chances for such encounters are made favourable simply by the large concentration of neutrons present.

As soon as a large atomic nucleus captures a roving neutron, it becomes violently unstable and splits into two almost equal fragments rather than mere alpha or beta emission decay. We already saw that the optimum ratio of neutrons to protons in an atomic nucleus is the greater, the more particles the nucleus contains. The result of fission of a heavy nucleus is thus to produce lighter nuclei with an enormous excess of neutrons. Some of these surplus neutrons are already liberated during the fission process, and maintain the ambient neutron concentration so that the fission process is self-sustaining. But many remain inside the fission products for the time being, adjustment taking place at some later moment through beta ray emission converting successive neutrons into protons. Radioactive isotopes produced as fission products in a nuclear reactor are thus essentially beta ray emitters. In the majority of cases, a gamma ray accompanies the beta ray emission, because the latter at first leaves the product nucleus in an excited state.

The only essential difference between a nuclear explosive device and a nuclear reactor is that the fission process is uncontrolled and almost instantaneous for all nuclei present in the first case, whereas in the latter case, the fission process is moderated to proceed at a steady controlled rate. The fission products and liberated radiations are the same in both cases.

The study of fission products, whether from reactors or from nuclear explosions, thus calls for electronic equipment sensitive to beta and gamma rays. Alpha ray detection is here of little importance, because essentially only the residues of initial fissionable heavy nuclei which have escaped unchanged manifest alpha-radioactivity. It is readily possible to construct electronic equipment which is exclusively sensitive to alpha radiation in one case, or to beta and gamma radiation in the other case, so that studies of the fission efficiency of nuclear fuels and explosives are possible in this manner.

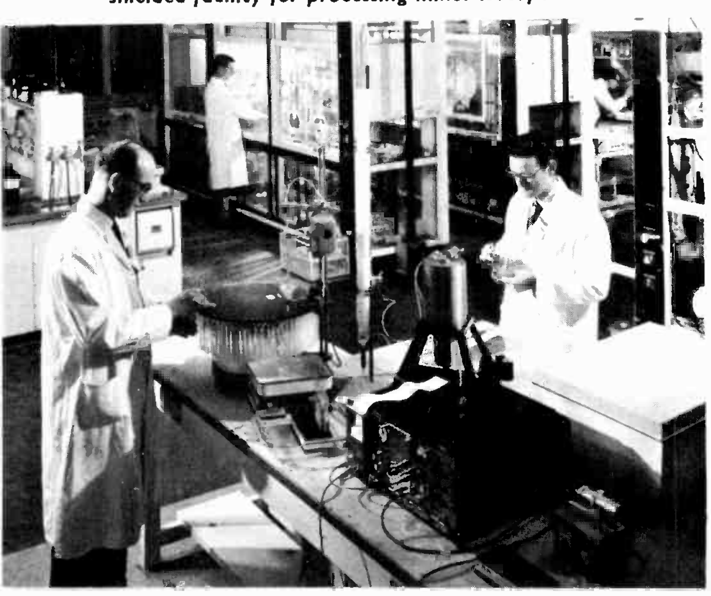
GAMMA RAY SPECTROSCOPY

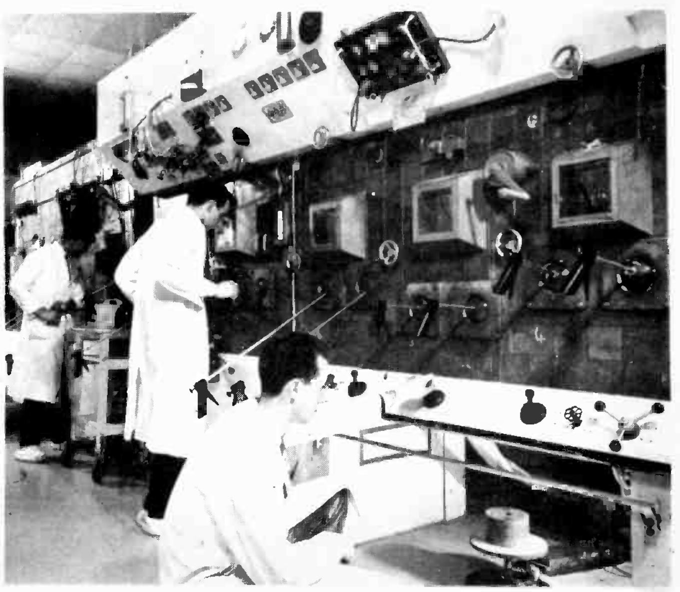
Corpuscular radiations, i.e. beta and alpha rays, are emitted with a range of energies from any particular radioactive nucleus, so that specific correlation between emission energies and the type of nucleus concerned, e.g. for empirical analysis of radioactive mixtures, is somewhat difficult. The emission energies of gamma rays, on the other hand, are in most cases quite constant and specific characteristics of each particular radioactive nucleus.

As far as their corpuscular radiations are concerned, the radioactive nuclei may thus be likened to a broadband jamming transmitter, e.g. a former-day spark transmitter or a super-regenerative oscillator. The gamma radiations, on the other hand, may be likened to accurate crystal-controlled carrier frequencies, and this is more than an analogy because a gamma ray of clearly defined constant emission energy is indeed an electromagnetic wave of fixed (exceedingly high) frequency.

A gamma ray spectrometer is an electronic equipment capable of selective detection and intensity measurement of gamma radiation according to emission energy. Although it looks nothing like a radio receiver, it is one in principle, with a tuning range covering the frequencies equivalent to the emission energy range of interest. The range from 0·1MeV to 3·6MeV covers most important gamma ray

The U.K. Atomic Energy Authority's Radiochemical Centre at Amersham, Bucks, has since 1940, produced and distributed throughout the world, a comprehensive range of radioisotopes, radioactive sources and labelled compounds. (left) Laboratory for the development of new carbon-14 labelled compounds in the Organic Department. (right) View of shielded facility for processing minor isotopes





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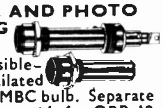

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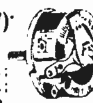

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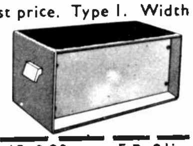

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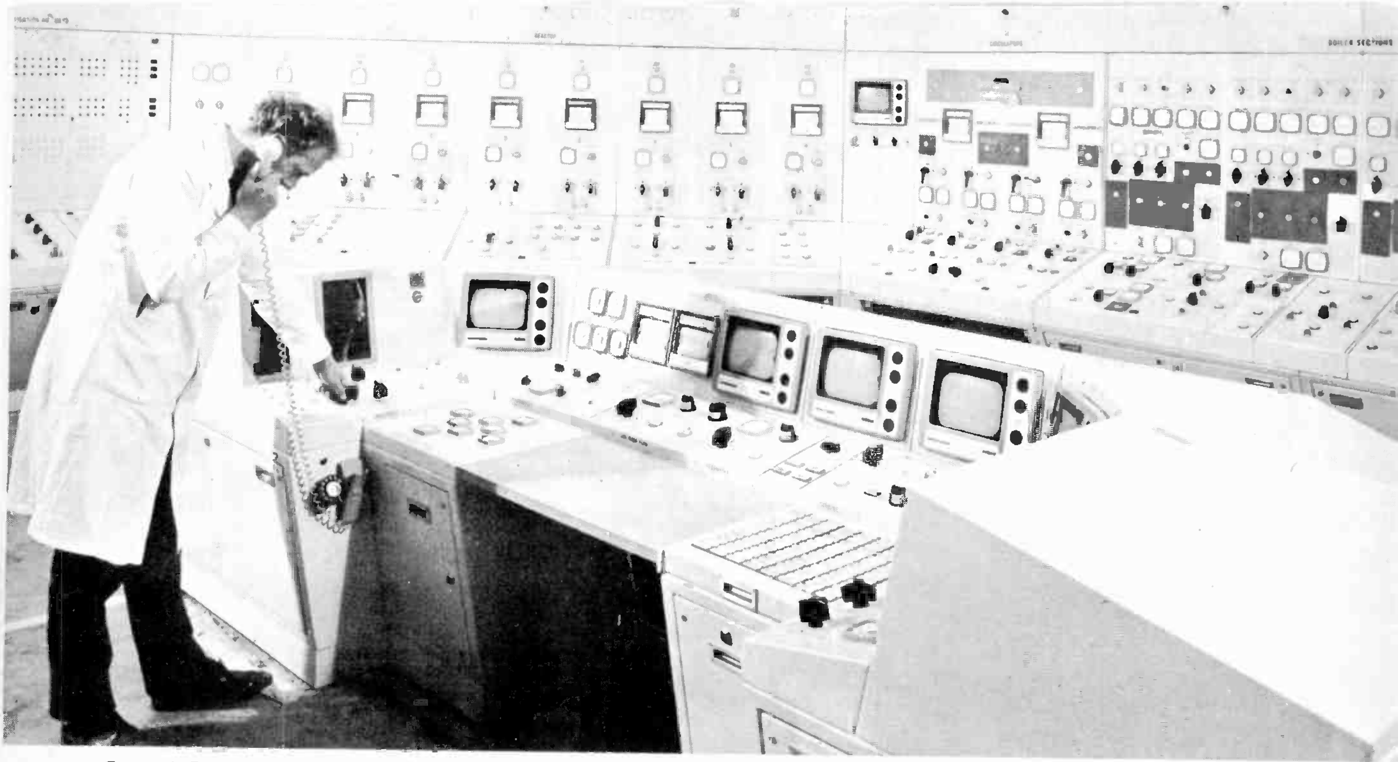


Central Control Room at Wylfa nuclear power station. This is the ninth and most powerful of Britain's first series of nuclear power stations.

A comprehensive computer controlled monitoring system is employed. This system includes English Electric Datapac digital and analogue scanners and Marconi TAC computers and tabular displays linked to cathode ray tubes

emissions accompanying radioactive decay processes, at least for amateur purposes, so that the practical gamma spectrometer design sketched in this series of articles covers this range.

We saw that gamma rays are produced as the means of dissipating the energy difference when an excited state of an atomic nucleus reverts to the ground state or to some interim state of lower energy.

Considered alone, these are processes of internal re-shuffle without gain or loss of particles. The clearly defined emission energies of gamma radiation imply that the nuclear structure involves well-defined energy states. Gamma ray spectroscopy is thus an important research tool for investigating nuclear structure, although this is beyond amateur practical work. However, the characteristic gamma ray energies for each radioactive nucleus which emits gamma rays at all, makes it possible to detect certain types of nuclei to the exclusion of others in a radioactive mixture.

Many interesting amateur experiments discussed later in this series make use of this elegant possibility. It must be pointed out that the gamma ray spectra, i.e. the energies at which gamma rays appear, are complex for very many radioactive nuclei. This is because the various energy levels through which an excited nucleus can finally reach the ground state often form an intricate and intermeshed system. In most cases the various paths are alternatives or a sequence of successive steps, so that each decaying individual nucleus produces only one gamma ray, with a certain one of the many possible energies determined by pure chance. Only the contributions of numerous decaying nuclei produce the complete spectrum of all characteristic energies for that type of nucleus.

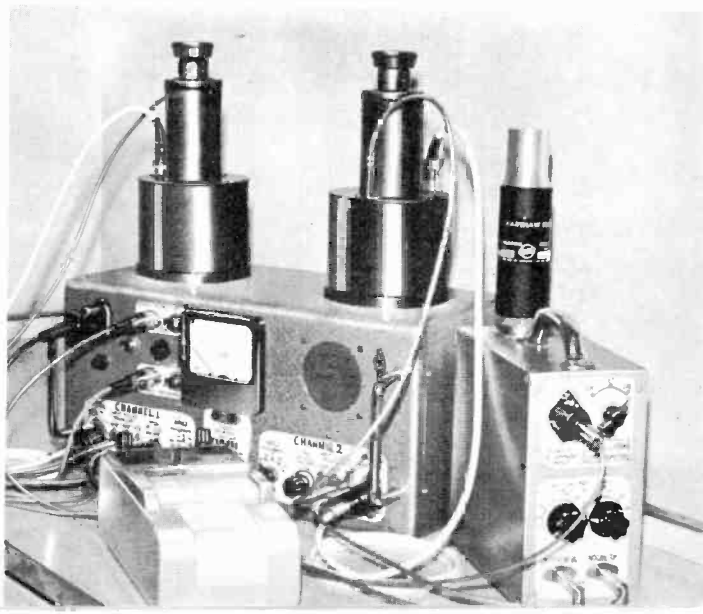
The relative intensities (number of rays emitted per unit time) of the various gamma ray energies are thus determined by statistical chance, but are again extremely constant if an adequately large number of radioactive atoms of the species concerned is considered.

Nevertheless, some cases are known where all, or a large proportion of all decaying nuclei of the species produce two gamma rays of different energies essentially simultaneously. Cobalt-60 is here a notable example, and it permits certain instructive experiments on account of its gamma-gamma emission. The necessary quantities of cobalt-60 for these experiments are very small and safe, thus readily available to schools and responsible amateurs (from the Radiochemical Centre, Amersham, Bucks.). We will describe these experiments too, in due course.

We will conclude this article with a brief presentation of the electronic equipment which will form the theme of this entire series.

This photograph shows the complete "STRACE" equipment, consisting of five units and connecting cables. Fig. 2.1 shows the block diagram of this equipment which has been specially designed for amateur experimental purposes.

The two Geiger counter heads are the round black units standing on top of the radiation meter unit. The gamma ray spectrometer unit is standing to the right and the "chimney" on the upper side is the scintillation detector. The chart recorder unit is in the foreground



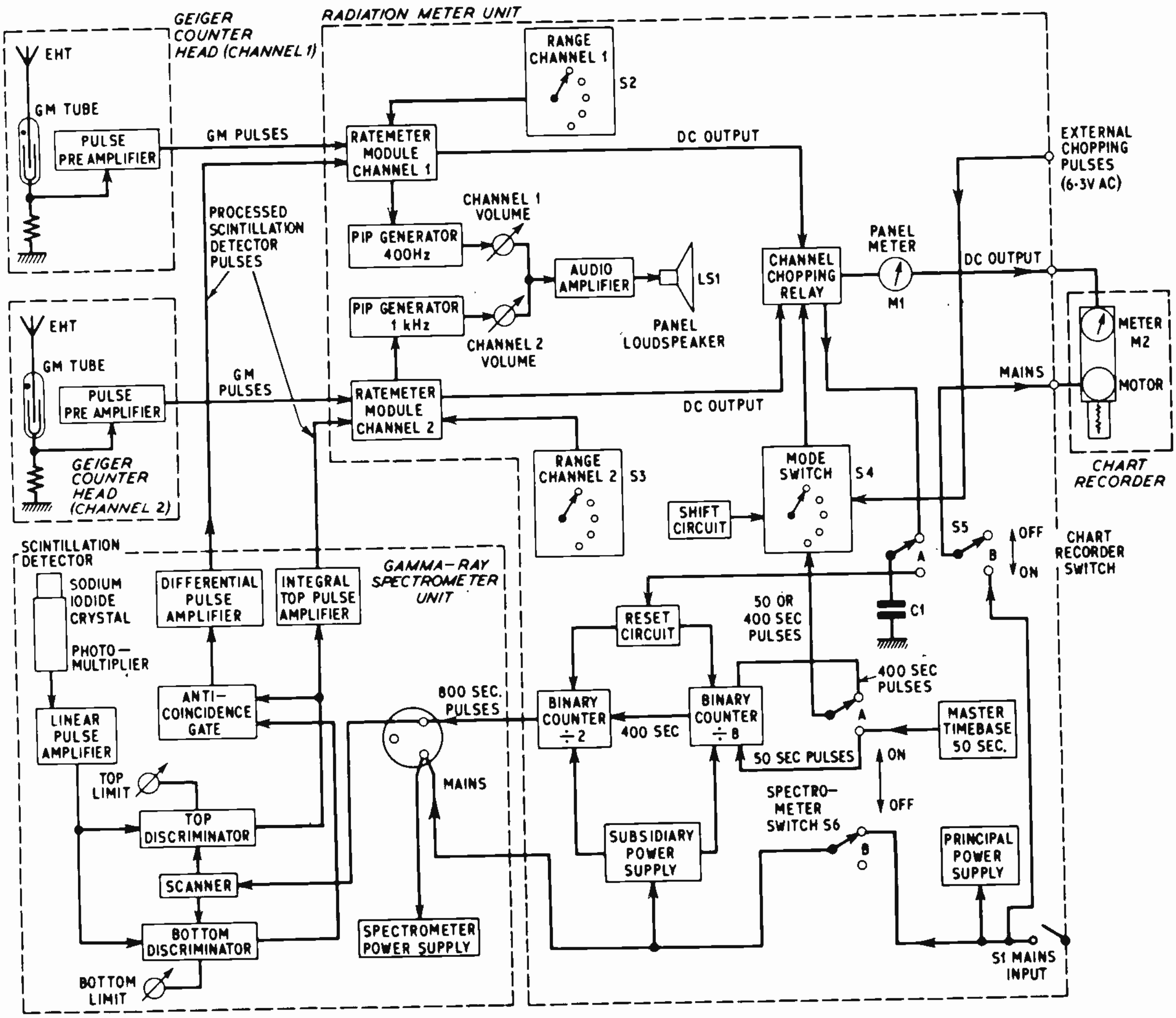


Fig. 2.1. Block diagram of STRACE

STRACE

The main aim of these articles is to acquaint the reader with the types of electronic circuitry required for nuclear radiation measurements involved in the applications discussed above, and to point out the scope of practical amateur constructional and experimental work in this fascinating field.

For this purpose, a composite equipment has been designed. See Fig. 2.1. This will enable all important types of nuclear radiation measurements, as far as the amateur is concerned, to be performed. Furthermore, this equipment embodies a very representative selection of all important types of nucleonic circuit bricks. Subsequent articles in this series will include theoretical circuits and photographs of the various sections of the equipment.

Most stages operate in Class C, i.e. they are normally resting cut off and are briefly keyed-on by each electric pulse produced in response to a nuclear radiation quantum sensed by the detector. The functions are thus less ones of amplification, but rather ones of pulse processing, shaping, and counting. The intensity of a nuclear radiation is expressed in terms of the number of quanta emitted per unit time, so that the essential computer functions of nucleonic equipment amount to plain counting and division by elapsed time. These functions, at least for amateur purposes, are not beset by the instability pitfalls associated with high-gain amplifiers, so that within reason, component layout is pleasantly uncritical.

The systematic discussion of the full theoretical circuit of a specific equipment with brief references to common refinements found in advanced professional equipment, provides an intelligible theme for the reader seeking only general information. At the same time, more experienced readers will be quite able to construct the equipment from the theoretical circuits and photographs alone, with excellent prospects that it will work correctly immediately with any reasonable layout, or substitute components.

Furthermore, the modular presentation is such that readers can build any self-sufficient group of sections instead of the entire equipment, according to purse. We are deliberately aiming to stimulate enlightened experimental initiative rather than presenting finished blueprints with these articles, which are essentially descriptive.

We have called the composite equipment forming the descriptive basis of this series "STRACE" (STatistical RAte Computing Equipment), to express its functions. The nuclear radiation quanta are emitted according to the *statistical* laws of chance. The sequence is quite irregular; but the mean *rate* over a sufficiently long period of observation is an accurate measure of the radiation intensity.

Next month: The fundamental sections of a nucleonic equipment

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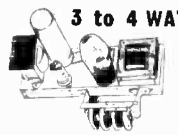
AC Mains 230/250v complete with pull switch. Size 6″ × 6″ × 4″. Price 27/6 plus 5/- P. & P.

3 to 4 WATT AMPLIFIER



3-4 watt Amplifier built and tested. Chassis size 7 × 3½ × 1 in. Separate bass, treble and volume control. Double wound mains transformer, metal rectifier and output transformer for 3 ohms speaker. Valves ECC81 and 6v6. £2.5.0 plus 5/6 P. & P.

BSR MONARCH UA16 With FULL-FI HEAD

4-speed, plays 10 records, 12in., 10in. or 7in. at 16, 33, 45 or 78 r.p.m. Intermixes 7in., 10in. and 12in. records of the same speed. Has manual play position; colour, brown. Dimensions: 12½ × 10¾in. Space required above baseboard 4¾in., below baseboard 2¾in. Fitted with Full-Fi-turn-over crystal head. £4.19.6. P. & P. 9/-.

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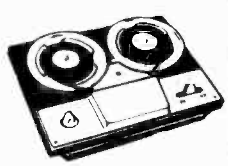
SPECIAL OFFER. Power supply kit to purchasers of 'Elegant Seven' parts, incorporating mains transformer, rectifier and smoothing condenser, A.C. mains 200/250 volts. Output 9v. 100 mA. 9/6 extra.

Buy yourself an easy to build 7 transistor radio and save at least £10.0.0. Now you can build this superb 7 transistor superhet radio for under £4.10.0. No one else can offer such a fantastic radio with so many de luxe star features.

ONLY £4.4.0
Plus 7/6 Post & Packing

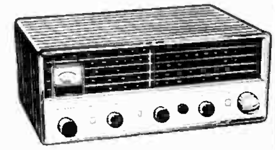
★ De luxe wooden cabinet size 12½″ × 8½″ × 3½″. ★ Horizontal easy to read tuning scale printed grey with black letters, size 11½″ × 2″. ★ High 'Q' ferrite rod aerial. ★ I.F. neutralisation on each separate stage. ★ D.C. coupled push pull output stage with separate A.C. negative feedback. ★ Room filling output 350mW. ★ Ready etched and drilled printed circuit board back printed for foolproof construction. ★ Fully comprehensive instructions and point to point wiring diagrams. ★ Car aerial socket. ★ Fully tunable over medium and long wave, 168-535 metres and 1250-2000 metres. ★ All components, ferrite rod and tuning assembly mount on printed board. ★ 5″ P.M. Speaker. ★ Parts list and circuit diagram 2/6, free with parts.

BSR TAPE DECKS



200/250 v. A.C. mains
Type TD2 Tape speed 3¾ twin track—**£6.19.6.**
Type TD10 2-track, 3 speed, plus rev. counter—£7.19.6.
Type TD10 4-track, 3 speed, plus rev. counter—£9.5.0.
P. & P. on each 7/6.

STAR SR 150 COMMUNICATION RECEIVER



Frequency range: 535 kc/s-30 Mc/s. 4 wavebands. 5 valve superhet. Incorporates BFO, bandspread tuning, "S" meter, external telescopic aerial and ferrite aerial. Built-in 4in. speaker. Easy-to-read dial. For 240v. A.C. operation. Complete, brand new, with full instruction manual. 15 gns. P. & P. 10/-.

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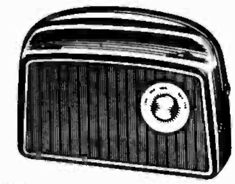
Transistor Portable Radio

plus Baby Alarm Facilities



Completely modulised high quality portable radio featuring complementary N.P.N. and P.N.P. output stage.

The comprehensive easy-to-follow drawings supplied make this the easiest-ever transistor radio set of parts, with the following features:

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- Only 4 connections on the A.F. module to complete the 4 transistor 600 milli-watt solid state amplifier.
- Pre-aligned R.F./I.F. module built and tested.
- A.F. module built and tested.
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- Intermediate Frequency 470 Kc/s.
- Sensitivity: M.W. at 1 Mc/s 10 microvolts plus or minus 3db. L.W. at 200 Kc/s 40 microvolts plus or minus 4db.
- High Q internal ferrite rod aerial on both wavebands.
- Finger tip controls.
- Class "B" modulised output stage with thermistor controlled heat stabilization. Class "B" output stage ensures long battery life. Current drain is proportional to the output level. Total current drain of the receiver under no signal conditions is 10-12mA. At reasonable listening level 20-30mA.
- Extension sockets for car aerial input, tape recorder output (independent of vol. control) and Ext. Speaker.
- All components (except speaker) mount on the printed circuit board. Easy to follow instructions. Size of cabinet 12″ long, 8″ high and 3″ deep.

Circuit and parts list 2/6, free with parts.

PRICE: £5.5.0 *plus 7/6 P. & P.*

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3″ L.P. 240ft.	4/-	5″	T.P. 1800ft.	25/6	
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7″ L.P. 1800ft.	18/6	7″	T.P. 3600ft.	42/6	
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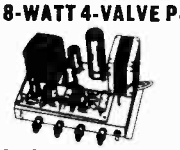

Size 9″ × 6″ × 1½″. A.C. Mains, 200-250 v. 4 valves. For use with Std. or L.P. records, musical instruments. All makes of pick-ups and mikes. Output 8 watts at 5 per cent of total distortion. Separate bass and treble lift control. Two inputs, with controls for gram. and mike. Output transformer tapped for 3 and 15 ohm speech coils. Built and tested. £4.4.0. P. & P. 11/-. 8″ × 5″ Speaker to suit. Price 14/6 plus 1/6 P. & P. Crystal Mike to suit 12/6 plus 1/6 P. & P.

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JOHN VALENCE

CURRENT EXPENDITURE

The increased electricity charges will be making all domestic consumers economy conscious. Some of the pleasure derived from the red glowing element is going to be dampened for, at any rate, that member of the household who actually foots the bill. The cleanliness and convenience of electricity has always been bought at a cost—compared with other fuels—but the additional 15 per cent or so is a real blow, no mistake. Let us hope for a moderate winter!

Leaving aside the harsh economic facts of today, it is appropriate to give a little thought to the man initially responsible for the practical means for generating electrical power.

MICHAEL FARADAY

It is indeed particularly fitting around this time to recall Michael Faraday and his unparalleled contributions to technical and scientific progress: the centenary of his death was last September. Michael Faraday was in a sense the founder of the electrical industry—since his great experiments into the nature of electricity lead to his discovery of electro-induction. Of the many debts modern society owes to this largely self-taught genius of the 19th century, that in respect of the discovery which gave us the dynamo is probably the greatest.

FUEL CELLS

The fact that Faraday's discovery could be put to practical use almost at once was due to the general availability of steam engines capable of providing the necessary rotary action. The state of contemporary technology assisted Faraday in this respect.

How different though in the case of one of his contemporaries. Just eight years following Faraday's discovery of electromagnetic induction, the principle of the fuel cell was discovered by W. G. Grove. Unfortunately for the latter, the technical problems of applying this discovery in an economical manner were insurmountable. Thus a device which is potentially very much more efficient than the mechanically driven generator never materialised as a commercial proposition.

But if Grove was denied success and the attendant popular fame this would have aroused during his life time, it does seem that the latter part of the 20th century may make amends. Space exploration and military requirements have created an urgent need for a portable and highly efficient producer of electrical power. Research work into the possibilities of the fuel cell have been going on for several years now and there can be little doubt but that this will become a reality before long.

FOR THE HOME?

It has even been suggested that domestic supplies could be obtained from fuel cells and so eliminate the costly process of current distribution through the grid system.

In this event, since the output from a fuel cell is direct current, an electronic static invertor would be required in every home to convert this to the conventional 240 volt a.c. How shrewd therefore of the giant Associated Electrical Industries to enter the field of static invertors. A.E.I. are, of course, one of the largest makers of power station electrical generating plant!

"Turn down the gas, dear—the picture's gone!"

GAS MAINS

I can't leave this current topic without registering surprise at the lack of initiative by the Gas Board. This organisation often shows great enterprise, but we have heard no news of the exploitation of the thermoelectric effect. With all these developments in the field of semiconductor materials, isn't it about time Seebeck's discovery was put to good purpose? What better way of using all that North Sea gas than to heat up solid state thermo-electric generators by the gas ring? And what a crafty way in which to infiltrate the opposition's territory. Instant d.c. from high speed gas. Note the "d.c." again: so either way the *electronic* industry will be laughing.

Sober last thought on the subject. Will any of these technically exciting schemes result in a smaller bill for the householder? Your turn to laugh now.

SIR JOHN COCKCROFT

Some of my readers will be able to recall hearing the news of that epoch-making event when the atom was split for the first time. This was at Cambridge and the year, 1932. John Cockcroft and E. T. S. Walton in association carried out these wonderful experiments. The "gun" they devised for firing charged particles at the atom was the forerunner of the modern high energy particle accelerators.

Outside its atomic, or nucleonic, setting the "Cockcroft-Walton voltage multiplying circuit" has since become a classic electronic circuit and is widely used.

Sir John Cockcroft, master of Churchill College, Cambridge, who died last September, will be mainly remembered for his monumental work in atomic and nuclear physics. How closely these subjects are allied to electronics, and how frequently "pure" research leads to practical technological inventions, is well demonstrated in the example I have quoted above.

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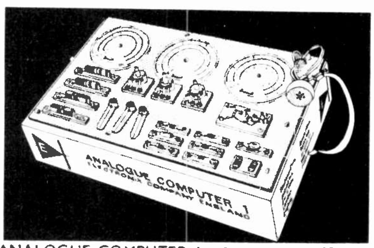

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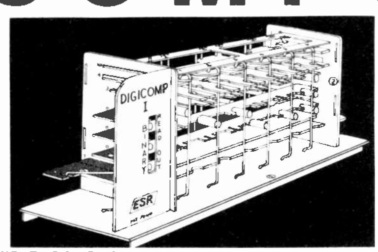

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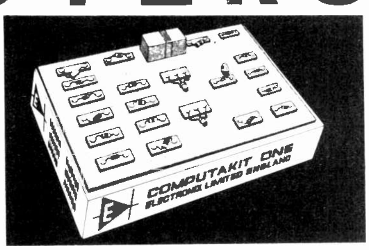

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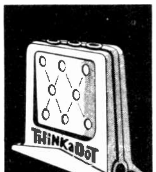

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VALVES WANTED, brand new popular types boxed. DURHAM SUPPLIES (E), 175 Durham Road, Bradford 8, Yorkshire.

HIGHEST prices paid for certain G.E.C. and other relays in any condition. Also wanted notched relay contacts. S.A.E. details ELEY ELECTRONICS, 112 Groby Road, Glenfield, Leicester.

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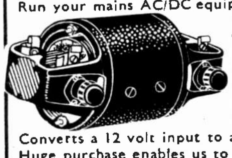
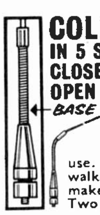
240 VOLT ELECTRIC POWER FROM YOUR 12 volt or 6 volt CAR BATTERY

Run your mains AC/DC equipment direct from



your car battery with this compact low battery consumption dynamotor. Size only 5in. × 3in. Sturdy construction. Converts a 12 volt input to a 240 volt output. Huge purchase enables us to offer them at only 39/6 each, post and packing 6/-. 6 volt input model only 35/-, post and packing 6/-. Thousands already sold.



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A fully adjustable highly efficient whip aerial. Made to exacting specifications. Copper plated sections. Brass Base. An ideal aerial for TX/RX use. Easily adaptable for cars, scooters, walkie talkies, etc. Brand new in makers' boxes. Only 17/6 each, p.p. 2/6. Two aerials for 30/-, post & packing 2/6.

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Boxed Valves — **Fully Guaranteed**

EF80	4/-	PCC84	5/-	PY33	7/6
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ECL80	6/-	PL81	5/-	30P4	7/6
EB91	2/-	PY81	5/-	U191	7/6
EF85	5/-	PY800	5/-	U301	7/6
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Postage: One valve 9d. extra, Two valves 6d. each extra, Three to Six valves 2d. each extra, over Six post paid. Speakers ex T.V. 5 inch round 3/6, 6 × 4 3/6, post 2/6, 8 inch round 6/6, post 4/6 for one or two.

Transistors
OC45 3/-, ACY27 4/-, ACY28 4/-, ACY30 10/-, 2N697 10/-, 2N706 3/-, AC128 2/6, G.E.C. Rect. 60 volt P.I.V. 1/-. Postage 6d. per order.

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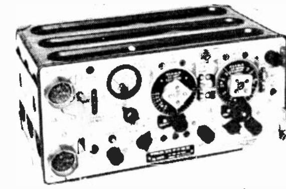
FAMOUS ARMY SHORT-WAVE TRANSRECEIVER MK. III



This set is made up of 3 separate units: (1) a two valve amplifier using a 6V6 output valve; (2) (some only, not built in the very latest models) a V.H.F. transreceiver covering 229–241 Mc/s using 4 valves; (3) the main short wave transmitter/receiver covering, in two switched bands, just below 2–4½ Mc/s, and 4½–8 Mc/s (approx. 160–37·5 metres) using 9 valves. For R.T., C.W. and M.C.W. The receiver is superheterodyne having 1 R.F. stage, frequency changer, two I.F. (465 kc/s) signal detector, A.V.C. and output stage. A B.F.O. included for C.W. or single side-band reception. T.X. output valve 807, other valves octal bases. Many extras, e.g. netting switch, quick flick dial settings, squelch, etc. Power requirements L.T. 12 volts, H.T. receiver 275 volts d.c., H.T. transmitter 500 volts d.c., size approx. 17½ × 7½ × 11ins. Every set supplied in new or as new condition in carton with book including circuits, only £4.10.0, or Grade 2 slightly used 50/- carriage both 15/-.

A FULL KIT of brand new attachments for this set including all connectors, control box, headphones and mike, aerial tuning unit, co-axial lead, etc. at only 45/- carriage 5/-. WE MAKE A MAINS 200/250 VOLT POWER UNIT in louvred metal case to plug direct into set power socket to run (1) receiver, 70/- post 5/-. (2) TX and RX, £6.10.0 post 7/6. (3) 12 VOLT D.C. P.U. for receiver, 50/- carriage 5/-. A charge of 10/- to unpack and test the receiver of these sets is made only if requested.

V.H.F. TRANSRECEIVER MK. 1/1

This is a modern self-contained tunable V.H.F. low powered frequency modulated transreceiver for R.T. communication up to 8–10 miles. Made for the Ministry of Supply at an extremely high cost by well known British makers, using 15 midget B.G. 7 valves, receiver incorporating R.F. amplifier. Double superhet and A.F.C. Slow-motion tuning with the dial calibrated in 41 channels each 200 kc/s apart. The frequency covered is 39–48 Mc/s. Also has built-in Crystal calibrator which gives pips to coincide with marks on the tuning dial. Power required L.T. 4½ volts, H.T. 150 volts, tapped at 90 volts for receiver. Every set supplied complete with valves and crystals. New in carton, complete with adjustable whip aerial and circuit. Price £4.10.0, carriage 10/-. Headset or hand telephone 30/-. Internal power unit stabilised for 200/250 A.C. input, £6.10.0 extra.

CONTINUED OVERLEAF

RADIO CONTROL RECEIVERS. New fabulous low priced units. Sensitive four transistor design. For escapements, relays, lights, motors, etc. Requires only 4·5V. Size 2¼ × 1½ × ¾in, weight 1½oz. Fully guaranteed. **£3 19s. 6d.** RADIO CONTROL PRODUCTS, 38 Franche Rd., Kidderminster.

DUXFORD ELECTRONICS
DUXFORD, CAMBS.

C.W.O. P. & P. 1/-. Minimum order value 5/-.

CAPACITORS (Tubular, Axial Leads)
Polyester: ± 10%. 160V: 10,000 pF, 15,000pF, **6d.** 22,000pF, **7d.** 33,000pF, **8d.** 47,000pF, 68,000 pF, 0·1μF, **9d.** 0·15μF, 1/-. 0·22μF, 1/1. 0·33μF, 1/3. 0·47μF, 1/6. 0·68μF, 1/10. 1μF, 2/6.
400V: 1,000pF, 1,500pF, **5d.** 2,200pF, 3,300pF, 4,700pF, 6,800pF, 10,000pF, **6d.** 15,000pF, **7d.** 22,000pF, **8d.** 33,000pF, **9d.** 47,000pF, 68,000 pF, **10d.** 0·1μF, 1/-. 0·15μF, 1/3. 0·22μF, 1/6. 0·33μF, **2/3.** 0·47μF, **2/9.** 0·68μF, 3/9. 1μF, 4/6.

Polystyrene: ± 5%. 160V: 33pF, 39pF, 47pF, 56pF, 68pF, 82pF, 100pF, 120pF, 150pF, 180pF, 220pF, 270pF, 330pF, 390pF, 470pF, 560pF, 680pF, 820pF, **4d.** 1,000pF, 1,500pF, 2,200pF, 2,700pF, 3,300pF, 3,900pF, 4,700pF, 5,600pF, **6d.** 6,800pF, 8,200pF, 10,000pF, 15,000pF, 22,000pF, **8d.**

JACK PLUGS (Screened): Heavily chromed, ¼in. Standard: **2/9** each. Side-entry: 3/3 each. Standard (Unscreened): With black, grey, white, red blue, green or yellow covers, **2/3** each.

JACK SOCKETS (¼in Plug): With black or white bezel and chrome nut, **2/9** each. Available with: Break/Break, Make/Break, Break/Make, Make/Make contacts.

POTENTIOMETERS (Carbon): Long life, low noise. ¼W at 70°C. ± 20% ≦ ¼M, ± 30% > ¼M. Body dia., ⅞in. Spindle, 1in × ¼in. **1/9** each. Linear: 1k, 2·5k, 5k, etc., per decade to 10M. Logarithmic: 5k, 10k, 25k, etc., per decade to 5M.

SKELETON PRE-SET POTENTIOMETERS (Carbon): Linear: 1k, 2·5k, 5k, etc., per decade to 5M.

Miniature: 0·3W at 70°C. ± 20% ≦ ¼M, ± 30% > ¼M. Horizontal (0·7in × 0·4in P.C.M.) or Vertical (0·4in × 0·2in P.C.M.) mounting, 1/- each. **Submin.** 0·1W at 70°C. ± 20% ≦ 1M, ± 30% > 1M. Horizontal (0·4in × 0·2in P.C.M.) or Vertical (0·2in × 0·1in P.C.M.) mounting, **9d.** each.

RESISTORS (Carbon film): High stability, very low noise. ¼W at 70 C. Body ⅓in × ⅛in. Values in each decade: 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91 from 4·7Ω to 1M. ± 5%, **2d** each. 1·2M, 1·5M, 1·8M, 2·2M, 2·7M, 3·3M, 3·9M, 4·7M, 5·6M, 6·8M, 8·2M, 10M. 10%. **2d** each.

SILICON RECTIFIERS: 0·5A at 70 C (no heat sink required). 400 P.I.V., **2/9.** 800 P.I.V., 3/-. 1,250 P.I.V., 3/6. 1,500 P.I.V., **3/9.** 1·2A at 50°C (no heat sink required). 400 P.I.V., **5/6.** 800 P.I.V., 7/-. 1,250 P.I.V., **7/6.** 1,500 P.I.V., 8/3. 2·5A at 50 C (no heat sink required). 400 P.I.V., **6/-.** 800 P.I.V., 7/6. 1,250 P.I.V., 8/3. 1,500 P.I.V., 11/3.

SWITCHES (Chrome finish, Silver contacts): 3A 250V, 6A 125V. Push Buttons: Push-on or Push-off (with white, black, green or red buttons) **5/-.** Toggle Switches: SP/ST, 3/3d. SP/DT. **3/6d.** SP/DT (with centre position) **3/9d.** DP/ST, **4/3d.** DP/DT, **5/-.**

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Lord Alexander House
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OC28	4/6	2N697	5/-	NKT211	4/9	NKT227	8/3
OC35	10/-	2N706	4/3	NKT212	4/4	NKT228	4/1
OC36	8/6	2N2646	12/3	NKT213	4/6	NKT601	5/9
OC41	2/3	2N2926	2/6	NKT214	3/6	NKT612	4/8
OC44	1/6	2N3053	10/-	NKT215	3/6	NKT613	4/9
OC45	1/9	2N3055	19/-	NKT216	8/3	NKT674	5/-
OC70	2/3	NKT124	3/6	NKT217	7/9	NKT675	4/-
OC71	2/-	NKT125	5/-	NKT218	4/1	NKT676	4/1
OC72	2/-	NKT126	5/-	NKT219	4/7	NKT677	4/1
OC81	2/3	NKT127	8/6	NKT221	4/8	TK20C	2/-
OC139	2/6	NKT128	5/9	NKT222	4/-	TK40C	2/6
OC140	4/6	NKT129	5/-	NKT223	4/1	OA81	1/-
OC170	2/3	NKT141	5/9	NKT224	3/6		
OC171	2/6	NKT142	5/-	NKT225	3/6		
2N696	4/6	NKT143	4/9	NKT226	8/9		

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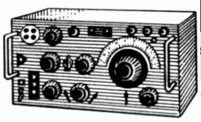
PRODUCTS PREVIOUSLY SHOWN ARE STILL AVAILABLE

Send 9d. stamps for complete lists Transistors, Rectifiers, Integrated Circuits, Etc.

Cash with order please. Postage 9d. Airmail extra

FAMOUS BRITISH R.107 RECEIVERS BY COSSOR



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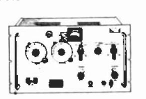
TELESCOPIC AERIAL MASTS. Tubular steel copperised, spray finish, ring cam locking on each section provides for full or any height required. Suitable all fixings and base locations. Bottom section 1¾in. diameter. 20ft. (4 section) Closed 5ft. 9in., Weight 16lbs., 60/-. Carr. 10/-. 34ft. (6 section) Closed 6ft. 6in., Weight 20lbs., 80/-. Carr. 10/-.

VHF COMMUNICATION RECEIVER 1392



15 valve Superhet, Covering 95-155 Mc/s (2-3 metres Police, Aircraft and Amateur Broadcasts.) Power required 240-250 v. at 80mA, 6.3v at 4 amps. Size 19×10×10in. **£7.10.0.** Carr. 15/-.

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Phone: Codicote 242

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7"	1,200' 7/9	1,800' 12/-	2,400' 19/6	2/3
5¾"	900' 6/9	1,200' 8/9	1,800' 14/6	2/-
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3"	185' 2/-	225' 2/9	300' 3/9	9

Post and packing, 2/9 per order

SEMICONDUCTOR BARGAINS

OC22	8/-	OC83	4/-	AFZ12	8/-
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OC36	6/-	OA202	2/-	BFY52	5/6
OC38	10/-	AC107	8/-	BY100	4/6
OC44	3/-	AC126	4/-	BYZ12	8/-
OC45	2/6	AC127	4/-	BYZ13	6/6
OC46	3/-	ACY17	4/-	GET103	4/-
OC70	3/-	ACY18	4/-	GET113	4/-
OC71	2/6	ACY19	4/-	GET116	10/-
OC72	2/6	ACY20	5/6	GET118	4/6
OC75	3/-	ACY21	5/6	GET119	4/6
OC76	3/-	ACY22	4/-	BYZ10	10/6
OC77	4/-	AD140	8/-	BYZ11	9/6
OC78	3/-	AD149	8/-	GET102	4/-
OC78D	3/-	AF114	4/-	OC202	6/6
OC81	3/-	AF115	4/-	OC205	6/6
OC81D	3/-	AF116	4/-	OA200	2/-
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All mixtures are to your specified values. Large quantities stocked.
Quality carbon Skeleton Pre-sets: 100Ω, 250Ω, 500Ω, 1kΩ, 2·5kΩ, 5kΩ, 10kΩ, 25kΩ, 50kΩ, 100kΩ, 250kΩ, 500kΩ, 1MΩ, 2·5MΩ, 5MΩ, 10MΩ.
All values available in horizontal or vertical mounting, 1/- each.
Volume controls: 100, 250, 500Ω etc. to 10MΩ linear, 2/6 each
5k, 10k, 25kΩ etc. to 5MΩ log, 2/6 each
5k, 10k, 25kΩ etc. to 2MΩ log, DP switch, 5/3 each

10% DISCOUNT OVER £3

Peak Sound Products
CIR-KIT No. 3 Pack, contains 12in × 6in board, 15ft × ⅛in strip, 6in × 4in copper sheet, 12/6.
Strip: 5ft × ⅛in or 1/16in 2/-; 100ft × ⅛in or 1/16in 30/-.
Perforated board, 0·1in matrix, 5in × 3¾in 4/-; 2½in × 3¾in 2/6; 2in × 3¾in 1/9.
Transistorised Stereo Amplifier type SA8–8. Amplifier kit, £10/10/-. Descriptive leaflet only (refunded on purchase of amplifier) 1/6. Power supply kit £3/0/0.

10% DISCOUNT OVER £3

Mains neons, square, red, single hole fixing, 3/9 each.

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Ceramic, low noise, small signal amplifiers ..	CS2926 Red	55–110 3/6
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Low noise, high gain NPN: BC109 4/3; 2N3707 5/-. PNP: 2N4058 5/6.
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PNP: 2N3702 4/-; 2N3703 4/-; 40319 13/3; 40362 14/9.
High Power output: 2N3054 (planar) 26/-; 2N3055 £1; 40465 16/3.
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Field effect transistor: MPF105 10/- (equivalent to 2N3819).

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Germanium
Low noise AF PNP: NKT265 3/6; 2G308 6/9; 2G309 7/9.
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High Power Complementary matched pair: AD161/AD162 23/- pair.
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Fast Service **10% DISCOUNT OVER £3** **Post Free Over 10/-**
ELECTROVALUE, 6 Mansfield Place, Ascot, Berkshire

RECEIVERS AND COMPONENTS

(continued)

REPANCO Transistor Coils and Transformer, for the Constructor. Send stamp for lists RADIO EXPERIMENTAL PRODUCTS LTD., 33 Much Park Street, Coventry.

2N1302	NPN	Ger.	25V	150mW	3MHz		4/6
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2N1305	PNP	Ger.	20V	150mW	5MHz		4/3
2N2926	NPN	Si.	18V	200mW	120MHz		3/-
2N3702	PNP	Si.	25V	300mW	100MHz		4/3
2N3704	NPN	Si.	30V	300mW	100MHZ		4/3
2N3055	NPN	Si.	100V	65W	Power		19/6
2N3819	N-Channel FET (Plastic)						19/6

P. R. COCKRAM
28 Royston Av., Byfleet, Surrey
C.W.O. P. & P. 6d. MAIL ORDER ONLY

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1/- each
BAY31, BAY50, DK10, OA70, OA81, OA200, OA10, OA90, OA91, OA259, IN914, IN916, JL102

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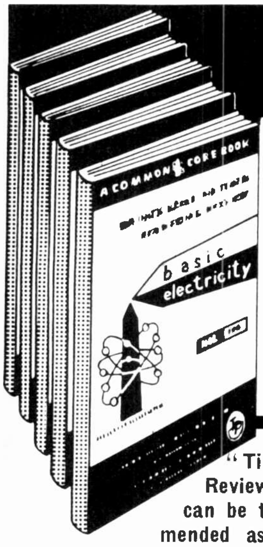

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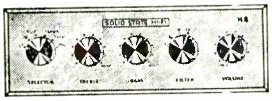

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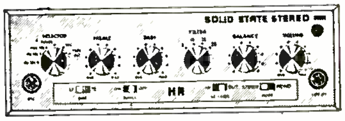

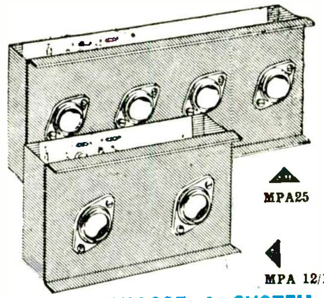

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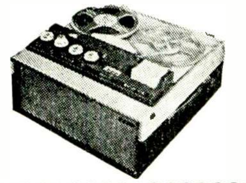

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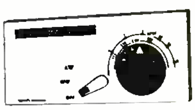

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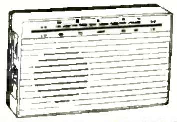

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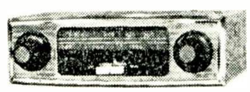

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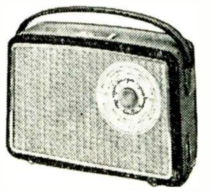

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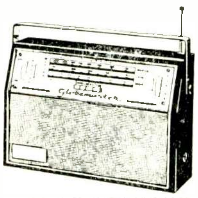

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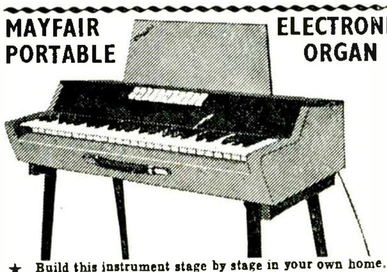

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