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MAY 1967

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L700 PROTECTIVE SHIELD

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0·25uf.	..3V.	4uf.	..4V.	16uf.	..150V.	64uf.	..40V.
1uf.	..10V.	4uf.	..12V.	20uf.	..3V.	100uf.	..3V.
1uf.	..15V.	4uf.	..25V.	20uf.	..6V.	100uf.	..6V.
1uf.	..40V.	4uf.	..100V.	20uf.	..9V.	100uf.	..10V.
1uf.	..50V.	5uf.	..6V.	20uf.	..15V.	100uf.	..12V.
1uf.	..350V.	5uf.	..25V.	25uf.	..6V.	100uf.	..15V.
1·25uf.	..16V.	5uf.	..50V.	25uf.	..12V.	150uf.	..12V.
2uf.	..3V.	5uf.	..70V.	25uf.	..25V.	150uf.	..25V.
2uf.	..9V.	6uf.	..12V.	25uf.	..30V.	200uf.	..3V.
2uf.	..10V.	6uf.	..15V.	30uf.	..6V.	200uf.	..4V.
2uf.	..15V.	6·4uf.	..40V.	30uf.	..10V.	200uf.	..16V.
2uf.	..70V.	8uf.	..3V.	30uf.	..15V.	250uf.	..2·5V.
2uf.	..150V.	8uf.	..6V.	32uf.	..1·5V.	250uf.	..9V.
2·5uf.	..16V.	8uf.	..50V.	32uf.	..25V.	250uf.	..15V.
2·5uf.	..25V.	10uf.	..6V	40uf.	..3V.	320uf.	..2·5V.
3uf.	..3V.	10uf.	..10V.	40uf.	..6·4V.	500uf.	..4V.
3uf.	..12V.	10uf.	..12V.	50uf.	..6V.	500uf.	..25V.
3uf.	..25V.	10uf.	..25V.	50uf.	..9V.	640uf.	..2·5V.
3·2uf.	..6V.	12·5uf.	..4V.	64uf.	..2·5V.	750uf.	..18V.
3·2uf.	..6·4V.	12·5uf.	..40V.	64uf.	..9V.	1000uf.	..6V.
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All at 1/- each, 9/- per dozen. Mixed packet (our selection) 20 for 10/-. 200/100uf., 275V.; 200/200uf., 275V.; 125/300/50uf., 275V.; 5/- each or 3 for 10/-.

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VERY SPECIAL VALUE! SILVER MICA, POLYSTYRENE, CERAMIC CONDENSERS
Very well assorted. Mixed types and values. 10/- per 100.

RESISTORS
Very small $\frac{1}{4}$ watt, 5% long leads, ideal for transistor work, 10/- for 50.
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PCF80, 7/6; PL81, 7/6; PCL82, 7/6; PCL85, 7/6; PCL84, 7/6; PCC84, 6/6; PY81, 6/-; ECC82, 6/6; PL36, 9/-; EY86, 6/-; PCL83, 9/-; PY33, 9/-; ECL80, 6/6; PCC89, 9/-.

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BY100 TYPE TELEVISION H.T. RECTIFIERS, SPECIAL PRICE 5/- each, 30/- dozen.
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NUTS, SCREWS and WASHERS, very useful assorted packs, 6/- each.
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Standard Play, 3in., 150ft., 3/6; 5in., 600ft., 10/6; 5$\frac{3}{4}$in., 900ft., 13/6; 7in., 1,200ft., 16/3.
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Double Play: 3in., 400ft., 6/6; 5in., 1,200 ft., 20/-; 5$\frac{3}{4}$in. 1,800ft., 28/-; 7in., 2,400 ft., 34/- 2$\frac{1}{2}$in., 300ft., 6/9.
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SIGNAL INJECTOR, parts and circuit to make, 10/- only.
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TRANSISTORS, COMPONENTS AND CIRCUIT to convert 1mA meter to 0 to 10 Meg. ohm meter, 10/-.
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NEEDLES FOR RECORD PLAYERS. HALF PRICE!
All types below at 3/6 each!
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SONOTONE MONO, 10/-. ACOS, 15/-. ACOS STEREO SAPPHIRE 12/6; DIAMOND, 17/6. All complete with needles!

LAPEL MICROPHONES, Magnetic or Crystal, 10/- each.
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2$\frac{1}{2}$in. × 5in., 3/11; 2$\frac{1}{2}$in. × 3$\frac{3}{4}$in., 3/3; 3$\frac{3}{4}$in. × 5in., 5/6; 3$\frac{3}{4}$in × 3$\frac{3}{4}$in., 3/11. Terminal Pins, 50 for 3/-; Spot Face Cutter, 7/3; Pin Insert Tool, 9/6. Special Offer—Cutter and 5 boards, 2$\frac{1}{2}$in. × 1in., 9/9.

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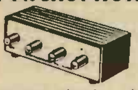
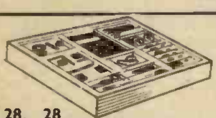
10 TRANSISTOR TWO-WAY RADIOS

Ultra sensitive superhet receiver with RF amplifier, 100mW output. Complete with telescopic aerials, leather carrying cases and batteries. A bargain at **£21.19.6** (These cannot be operated in U.K.).

4 CHANNEL MICROPHONE MIXER



Fully transistorised. Enables mixing of four separate signals—mike, radio, records, etc. Complete with battery at the amazing low price of **42/6**



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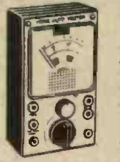
This advanced educational kit is excellent for beginners as well as the more advanced experimenter. Not even a soldering iron is needed. Complete with 60 page booklet giving full details of suggested circuits. **£6.10.0**

10 WATT HORN TWEETER

Brings true hi-fi reproduction to your system. Frequency response 1,500 to 18,000 cps. Crossover 3,000 cps. Sensitivity 104 db/W. Impedance 16 ohm. Buy now while stocks last. **22/6**

Crossover Networks. CN.23—3 ohm, 2-way, 14/6; CN.216—16 ohm, 2-way, 14/6.

FOR THE MOTORIST AND HOME HANDYMAN



Versatile home/auto tester for all electrical circuits in home and car. Measures A.C. Voltage 0–150, 0–300 v. Resistance 0–1000 ohm. High resistance and leakage 1000 ohm, 2 megohm. Current and power 0–15 amps, 0–3 kW. Car battery 0–75, 0–15 v. A must for only **£5.2.6**

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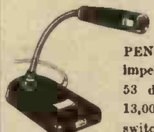
Gooseneck Dynamic Microphone. Dual impedance 600 ohm low/50 K high. Output—58 db. Response: 50–11,000 cps. With dual impedance on / off switch. Offered at well below regular price. **80/-**



PENCIL TYPE. 50 K impedance. Output—53 db. Response: 40–13,000 cps. On/off switch. Only **59/6**

SEVEN IN ONE TESTER

Ideal for quick checks in the home or service dept. Supplied with batteries, test leads and instructions. Featuring Resistance substitution in 5 ranges, Capacitance substitution in 5 ranges. R.F. Signal Generator 455 Kc/s, A. F. Signal Generator 400 c/s. D.C. and A.C. Voltmeter. 4 ranges; R.F. Field Indicator; 1-140 Mc/s. Unrepeatable at only **£5.10.0**

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Tests in-circuit or out of circuit. Identifies PNP and NPN types. Indicates electrode open circuits, short circuits and current drain. Complete with instructions. **£4.10.0**

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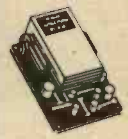
Fitted variety of plugs, sockets, etc. for a variety of uses.

CA.1—Right Angle Jack plug/phone plug, 5/-. CA.2—Right Angle Jack plug/alligator clips, 5/-. CA.3—Right Angle Jack plug/Right Angle Jack plug, 7/6. CA.4—Right Angle Jack plug/Spade Terminals, 5/-. CA.5—Chrome phone plug/chrome phone socket, 5/-. CA.6—Phonoplug/Alligator clips, 5/-.

SUB-MINIATURE TRANSISTORISED PUSH PULL AUDIO AMPLIFIERS



Ready built on printed circuit with full instructions. Ideal for building your own tuner, intercom, baby alarm, etc. 250 mW output, 32/6; 1 watt output, 42/6; 3 watt output, 49/6.

MCK.2. MORSE CODE KIT

Two station morse code kit supplied with instructions, 50ft. of connection wire and morse code charts. Only **27/6**

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FOR FULL DETAILS OF THESE AND MANY OTHER ITEMS SEND FOR FREE COMPREHENSIVE CATALOGUE, EAGLE NEWS AND ORDER FORM. ALL ITEMS AVAILABLE POST FREE AND COVERED BY 12 MONTHS' GUARANTEE.

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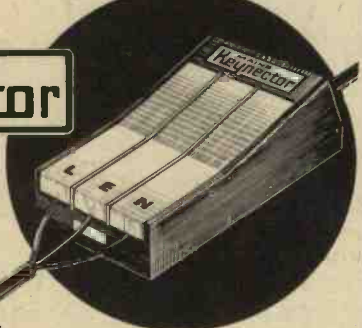
The safest, quick and handy connector for electrical appliances

MAINS Keynector

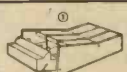


Measuring only 5in. × 3in. × 1¾in. the MAINS KEYNECTOR is made of non-combustible urea-formaldehyde. Designed in modern style and manufactured in attractive two-tone colour. The unit eliminates the need of terminating the mains input lead of any electrical instrument or appliance with a plug. It also enables more than one instrument or appliance to be connected in parallel and used simultaneously. In the workshop, the MAINS KEYNECTOR will prove invaluable to the experimenter and handyman.

Colour: Duo-Green
Rating: 13 amp.

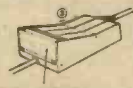
32/6 inc. p. & p.

British and Foreign Patents applied for



① Clamp bared lead from appliance under key.

② Opening fuse housing cuts off power to keys.



③ Neon safety lamp glows when power is applied.

④ Close fuse housing to supply power to keys.

CYBERNAUT CONTROLS LTD. (Ref. P.E.3)
28-30 Rivington St., London, E.C.2. Tel.: 01-739 2763

GOODMANS HIGH FIDELITY MANUAL

A Guide to full listening enjoyment

The Manual is much more than a catalogue of Goodmans High Fidelity Loudspeakers—it contains informative articles, including advice on stereo, special beginners page, and full cabinet drawings. You'll find it interesting as well as informative.

NEW MAXAMP 30 HIGH FIDELITY AMPLIFIER

MAXAMP 30 is a fully transistorised stereophonic High Fidelity Amplifier using Silicon Transistors throughout. It is precision engineered and fullest use is made of printed circuits. It will deliver continuously up to 15 watts of power on each channel and it looks as good as it is. 10½" x 5½" x 7¼" **£49.10s.0d.**

Full specification of the Maxamp 30 is given in the High Fidelity Manual - send the coupon for your FREE copy - or pay an early visit to your Goodmans dealer.

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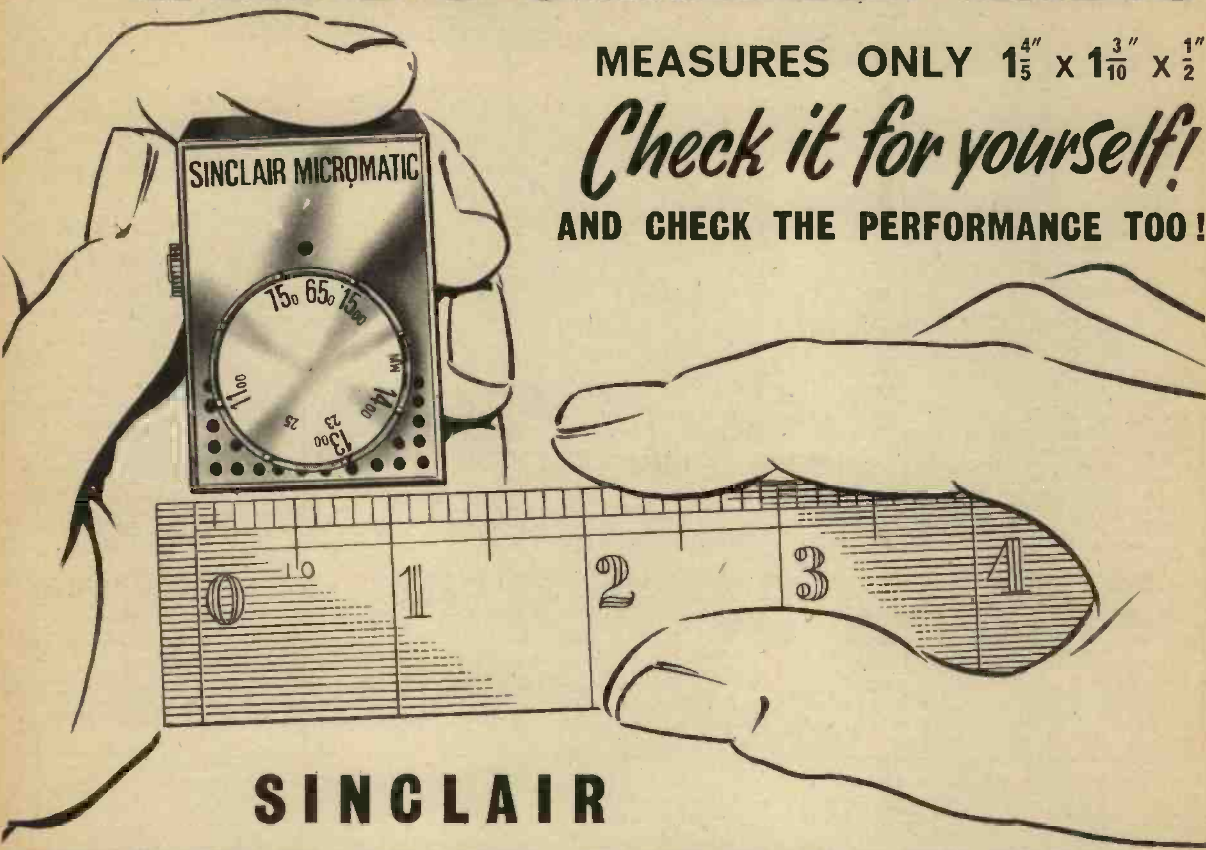
THE WORLD'S SMALLEST RADIO

MEASURES ONLY $1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$

Check it for yourself!

AND CHECK THE PERFORMANCE TOO!



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MICROMATIC

SIX STAGE TRANSISTOR RECEIVER

- ★ $1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$
- ★ CALIBRATED DIAL
- ★ NEW CIRCUITRY
- ★ BANDSPREAD
- ★ AMAZING POWER AND RANGE
- ★ GUARANTEED 5 YEARS

These are the facts — the Sinclair Micromatic is so small that its design brings it into the realm of real micro-electronics. Its performance and reliability are so good that it assures superb reception virtually anywhere. Its elegant styling inside and out make this a truly professional receiver, yet building the Micromatic is so simple that anyone can tackle it with complete confidence. Check these facts for yourself, and when you use your Micromatic, you will find it giving you the radio thrill of a lifetime.

TECHNICAL DESCRIPTION

The Sinclair Micromatic is housed in an elegant plastic case with attractive aluminium front panel and aluminium tuning dial to match, calibrated in Kc/s and metres. It has a six stage circuit of exceptional power and sensitivity. Two R.F. stages are followed by a double diode detector from which the signal passes to a high gain three stage audio amplifier. A.G.C. counteracts fading from distant stations. The set is powered by two Mallory Mercury cells Type ZM.312 which are readily obtainable from radio shops, Boots Chemists, Stores, etc. for 1/7 each.

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IN THE UNIQUE "SEE FOR YOURSELF" KIT PACK

Complete kit in pack including ear piece and instructions **59/6**

Ready built and tested **79/6**

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SINCLAIR RADIONICS LTD., 22 Newmarket Rd., CAMBRIDGE

Telephone 52996 (STD Code OCA3)

SINCLAIR STEREO 25 DE-LUXE PRE-AMP CONTROL UNIT

THE SINCLAIR STEREO 25 has been designed specially to ensure the highest possible standards of reproduction when used with two Z.12s or any other first class stereo power amplifier. Best possible components are used in the construction of this superb unit, whilst its appearance reflects the professional elegance characteristic of all Sinclair designs in hi-fi, radio and TV. The front panel of the Stereo 25 is in solid brushed and polished aluminium with beautifully styled solid aluminium control knobs. Mounting the unit is simple, and power is conveniently obtainable from the Sinclair PZ.3 which can also be used to supply two Z.12s to make a complete stereo assembly. Hi-fi enthusiasts seeking the ultimate in domestic listening will find all they want from this combination of Sinclair units. With a Micro FM for tuner, they will have an installation to compare favourably with anything costing from four to five times as much.

FOR USE WITH ANY GOOD STEREO SYSTEM

TECHNICAL SPECIFICATIONS

Performance figures obtained using Stereo 25, two Z.12s and a PZ.3.

- **SENSITIVITY** for 10 watts into 1.5 ohms load per channel. Mic.—2 mV into 50K ohms. Pick-up—3 mV into 50K ohms. Radio—20 mV into 4.7K ohms.
- **FREQUENCY RESPONSE** (Mic. and Radio)—25 c/s to 30 kc/s ± 1dB extending to 100 kc/s ± 3dB.
- **EQUALISATION** — Correct to within ± 1dB on RIAA curve from 50 c/s to 20 kc/s.
- **TONE CONTROLS** Treble +12dB to —10dB at 10 kc/s. Bass +15dB to —12dB at 100 c/s.
- **SIZE**—$6\frac{1}{2}$in.x$2\frac{1}{2}$in.x$2\frac{1}{2}$in. overall, plus knobs.
- **FINISH** — Front panel sectioned in brushed and polished solid aluminium with solid aluminium knobs. Black figuring on front panel.

BUILT, TESTED AND GUARANTEED **£9.19.6**

"Although a complete novice to radio I was able to assemble it (Micro-FM) without undue difficulty thanks to your clear and lucid instructions. I receive all B.B.C. programmes, etc. very strongly."
H.T., Warrington, Lancs.

"Far more sensitive (Micro-FM) than many commercial models."
M.M., New Romney, Kent

GUARANTEE

If you are not completely satisfied when you receive your purchase from us, your money will be refunded at once in full and without question.

SINCLAIR MICROMATIC
See previous page

SINCLAIR MICRO-FM

COMBINED FM TUNER AND POCKET FM RECEIVER

7 TRANSISTORS
●
NO ALIGNING
●
PULSE COUNTING DISCRIMINATOR
●
A.F.C.
●
TUNES 88-108 Mc/s
●
SIZE—less than $3'' \times 1\frac{3}{4}'' \times \frac{3}{4}''$

This unique, superbly engineered FM superhet is the only set in the world which can be used both as an FM tuner and an independent FM pocket receiver just whenever you wish. Problems of alignment have been completely eliminated making the Micro-FM ready for use the moment you have built it. The pulse counting discriminator ensures best possible audio quality; sensitivity is such that the telescopic aerial included with the kit assures good reception in all but the very poorest reception areas. The Sinclair Micro-FM will give you all you want in FM reception and the satisfaction of building a unique design that will save you pounds.

ANYONE CAN BUILD IT

FM superhet using 7 transistors and 2 diodes. The R.F. amplifier is followed by a self-oscillating mixer and three stages of I.F. amplification which dispense with I.F. transformers and all problems of alignment. The final I.F. amplifier produces a square wave which is converted to produce the original modulation exactly. A pulse-counting discriminator ensures better audio quality. One output is for feeding to amplifier or recorder and the other enables the Micro-FM to be used as an independent self-contained pocket portable. A.F.C. "locks" programme tuned in. Signal to noise ratio 30dB at 30 microseconds.

Complete kit, including transistors, case, aerial, earpiece, etc.

£5.19.6

FULL SERVICE FACILITIES AVAILABLE TO ALL SINCLAIR CUSTOMERS

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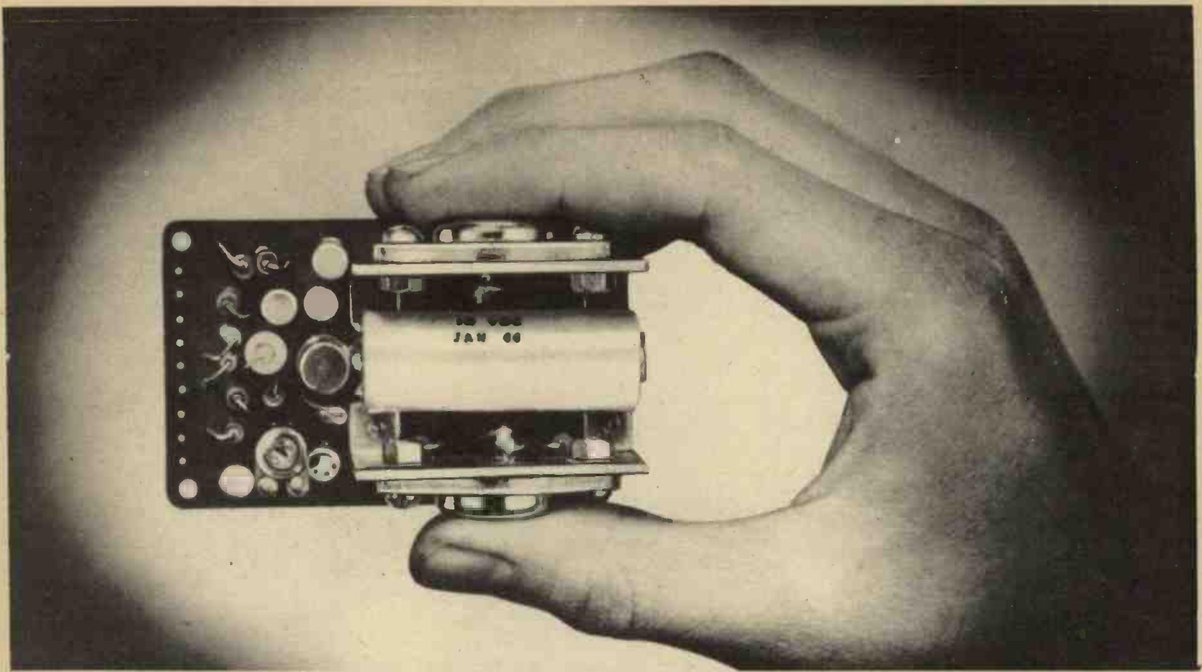

SINCLAIR Z.12

COMBINED 12 WATT HIGH-FIDELITY AMPLIFIER AND PRE-AMP

12 WATTS R.M.S. OUTPUT
CONTINUOUS SINE WAVE (24W. PEAK)

8 TRANSISTOR CIRCUIT WITH CLASS B ULTRALINEAR OUTPUT

IDEAL FOR HI-FI (STEREO OR MONO) CAR RADIO, ELECTRIC GUITAR, P.A., INTERCOM, ETC.

TECHNICAL SPECIFICATIONS

- Size 3 in. × 1¾ in. × 1¼ in.
- Class "B" ultralinear output
- **RESPONSE** 15-50,000 c/s ± 1 dB.
- Suitable for 3, 7·5 or 15Ω speakers. Two 3Ω speakers may be used in parallel
- **INPUT**—2mV into 2kΩ
- **OUTPUT**—12 watts R.M.S. continuous sine wave (24 w. peak); 15 watts music power (30 w. peak)
- Signal to noise ratio better than 60dB.
- Quiescent current consumption—15mA.

89/6 *Built, tested and guaranteed. Ready for immediate use. With Z.12 manual.*

The amazing adaptability and rugged construction of this very powerful and exceptionally compact amplifier make it possible to use just one type of unit with outstanding success in an unusually wide variety of applications. The Z.12 accepts radio, microphone and pick-up inputs. Detailed instructions for connecting these in mono and stereo are given in the manual supplied with every unit. The Z.12 will operate efficiently from any supply between 6 and 20 V. d.c. The PZ.3 is recommended as a main power supply source. Those wishing to have a ready made pre-amp control unit can feed inputs via the Stereo 25, which, with two Z.12s will provide the finest stereophonic hi-fi possible.

WHAT USERS SAY OF THIS VERSATILE UNIT

"I have recently bought a Z.12 and have been amazed at the power output from such a small unit. I use it for an electric guitar system aed find that for small halls it is quite powerful enough."
J.R.F., Londonderry

"I have for some time been running my Z.12 with a PZ.3 power supply and may I say that I am thoroughly delighted with the performance which in my opinion is better than that given out by . . . costing many times as much as my unit."
R.S.C., London, N.20

"The whole assembly (two Z.12s, tone control circuits) works like a charm and is the envy of all who have listened to it."
P.C., Durban, S.A.

"I am the proud owner of a pair of those remarkable amplifiers, Z.12. I was more than surprised to hear the splendid tone and volume. The thing that staggered me most of all is the small size of the Z.12. May I express my thanks."
C.R.R., St. Vincent, West Indies

"It is wonderful to be able so hear my records properly (with the Z.12)."
J.S.H.S, London, W.2

"I have now had an opportunity of trying out the tuner with the Z.12 amplifier and my Quad speaker and am very pleased with the results."
H.A., London, N.6

PZ.3 MAINS POWER SUPPLY UNIT

This special power supply unit uses advanced transistorised circuitry to achieve exceptionally good smoothing. Ripple is a barely measurable 0.05 v. The PZ.3 will power two Z.12s and a Stereo 25 with ease.

79/6

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SINCLAIR RADIONICS LTD.
22 Newmarket Road, Cambridge 52996

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HI-FI AMPLIFIERS —— TUNERS —— RECORD PLAYERS

FM TUNERS FM-4U

TFM-IS

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10·7 Mc/s and I.F. amplifier unit, with power supply 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 available, please see below.

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.

10W POWER AMP. MA-12

9 + 9W STEREO AMP. S-99

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

3 + 3W STEREO AMPLIFIER. Model S-33. An easy-to-build, low cost unit. **While stocks last.** Kit £13.7.6 Assembled £18.18.0

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

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

TRANSISTOR MIXER. Model TM-1. A must for the tape enthusiast. Four channels. Battery operated. Similar styling to Model AA-22U Amplifier. Kit £11.16.6 Assembled £16.17.6

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Add Stereo RADIO to your listening pleasure at low cost. **FM DECODER SD-1.** This model will convert Heathkit valve (Mono) FM and AM/FM tuners to stereo. It can also be used with most other makes of FM tuner having facilities for multiplex output. Own built-in power supply. Compact, 3¼" x 3¼" x 9" deep. **Kit £8.10.0. Assembled £12.5.0.** Send for full specification details.

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Oxford

"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.

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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.
Kit £37.17.6 Assembled £45.17.6

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OS-2

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" × 7⅞" × 12" deep. Wt. only 9¾lb. "Y" bandwidth 2 c/s–3 Mc/s ±3dB. Sensitivity 100mV/cm T/B 20 c/s–200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling.
Kit £23.18.0 Assembled £31.18.0

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

VVM, IM-13U

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

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

V-7A

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

RF-1U

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

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

IG-82U

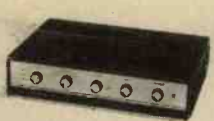
SINE/SQUARE GENERATOR. Model IG-82U. Freq. range 20 c/s–1 Mc/s in 5 bands less than 0·5% sine wave dist. less than 0·15μ sec. sq. wave rise time.
Kit £25.15.0 Assembled £37.15.0

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

Prices and specifications subject to change without notice

TAPE AMPLIFIERS — TAPE DECKS — CONTROL UNITS

20 + 20W STEREO AMP. AA-22U



GARRARD PLAYER AT-60

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

GARRARD AUTO/RECORD PLAYER. Model AT-60, less cartridge **£14.12.10.** With Decca Deram pick-up **£19.7.4** incl. P.T.

Many other Garrard models available, ask for Lists.

HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Modern functional appearance. Kit **£11.9.6** Assembled **£15.15.0**

WIDE RANGE OF HI-FI CABINETS, send for details. For example:
MALVERN Kit £18.1.0 incl. P.T.

TRUVOX DECK

AM/FM TUNER

TRUVOX D-106 and 108 TAPE DECKS. High quality stereo/mono tape decks. **D106,** ¼ track, **£39.15.0** **D108,** ½ track, **£39.15.0**

TRANSISTOR INTERCOM. Models XI-1U and XIR-1U. A time-saving device for office, shop or for the home. Master unit XI-1U will operate up to 5 remote stations. Master, XI-1U Kit **£11.9.6** Assembled **£17.9.6.** Remote, XIR-1U Kit **£4.9.6** Assembled **£5.18.0.** Send for full specification leaflet.

MONO CONTROL UNIT. Model UMC-1. Designed to work with the MA-12 or similar amplifier requiring 0·25V or less for full output. 5 inputs. Baxandall type controls. Kit **£9.2.6** Assembled **£14.2.6**

STEREO CONTROL UNIT. Model USC-1. Push-button selection, accurately matched ganged controls to ±1dB. Rumble and variable low pass filters. Printed circuit boards. Kit **£19.19.0** Assembled **£27.5.0**

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SPEAKER SYSTEMS

SSU-1

Berkeley

HI-FI SPEAKER SYSTEM. Model SSU-1. Ducted-port bass reflex cabinet "in the white". Two speakers. Vertical horizontal models with legs, Kit **£12.12.0,** without legs, Kit **£11.17.6** incl. P.T.

The **BERKELEY SLIM-LINE SPEAKER SYSTEM,** fully finished walnut veneered cabinet for faster construction. Special 12" bass unit and 4" mid/high frequency unit. Range 30-17,000 c/s. Size 26" × 17" only 7¾" deep. Modern attractive styling. Excellent value.
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COTSWOLD SPEAKER SYSTEMS. Outstanding performance for price.
MFS: Size 36" × 16½" × 14" deep.
Kit **£25.12.0** Assembled **£33.17.0**

STANDARD: Size 26" × 23" × 14½" deep.
Kit **£25.12.0** Assembled **£33.17.0**

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. Available for your convenience in two parts. Can be built for a total price Kit (excl. L.S.) **£12.17.0** incl. P.T. Hi-Fi Loudspeaker **£1.16.1** extra. Send for full details.

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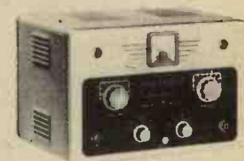
80-10m TRANSMITTER, DX-40U. Power inputs 75W. C.W., 60W peak CC phone. Output 40W to aerial. Provision for VFO.
Kit **£29.19.0** Assembled **£41.8.0**



DX-40U

AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160-10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage.
Kit **£39.6.6** Assembled **£52.10.0**

RA-1

160-10M TRANSMITTER. Model DX-100U. Careful design has achieved high performance and stability. Completely self-contained.
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AVON HI-FI PERFORMANCE 'MINI' SPEAKER KIT. A compact, bookshelf size, 7¾" wide × 19¼" high × 8¾" deep speaker with beautiful walnut veneered fully-finished cabinet, wide frequency response, special 6" bass, 3" HF units and crossover network. Cabinet Kit **£8.18.0.** Speaker Kit **£4.18.0.** Total Price **£13.16.0** incl. P.T.

LOW-COST TRANSISTOR STEREO AMPLIFIER KIT TS-23.

A really low priced unit yet incorporotes all essential features for good reproduction from gramophone, radio and other sources, 3 watts for channel output (15 ohms). Kit **£17.15.0.** Beautiful walnut veneered cabinet **£2.0.0** extra.

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STEREO AMPS.

FROM TRS — MULLARD 10-10

- 10 + 10 watts output
- For 3 and 15 ohm speakers
- Complete with valves

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(Carr. & pkg. 10/-)

This newest design from Mullard comprises integrated stereo pre-amp and amplifier with 10 watts output per channel. This is a very fine circuit, kitted by TRS to exact specification with top quality components. Features include ultralinear class B output on each channel with transformers tapped for 3 and 15 ohm speakers; bass, treble, volume and balance controls; switching for mono/stereo and speaker phasing; input switching; input sensitivity—210mV per section; H.T. and L.T. outlet for tuner. Pre-amp section metal shrouded. With escutcheon panel, pilot light indicator, knobs, plugs, etc. Size 11in. x 10½in x 4½in. Ideal for use with Garrard Units offered below.

Ready wired and tested, 50/- extra. (Ready built version only available at present)

SINCLAIR Z.12

Very good stereo is obtainable by using two of these famous integrated transistor amplifiers which can be used for 3, 5, 8 or 15 ohms speakers. Instructions included with the Z.12 enable you to use matched control circuits with all types of inputs for which we supply the necessary parts. Z.12 Amplifier as advertised in this journal.

89/6 each

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De-luxe pre-amp readily built and ideal for two Z.12s **£9.19.6**

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Mains Power Unit **79/6**

PEAK SOUND SA.8-8

14 transistor integrated stereo pre-amp and amplifier giving 17 watts output into two 5 ohm speakers. A fascinating kit to build, crammed with original features including "Shadow Template" and supply of Cir-kit. Complete down to wire and solder. With front panel, transistors and instructions. **£12.19.6**

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TRS FM STEREO DECODER

This outstanding kit is based on the highly successful Mullard design and uses 6 Transistors on a printed circuit size 5½in. x 2½in. A 2-stage transistor Stereo Beacon indicator is incorporated. Requires a 12v. supply.

Basic Kit is suitable for use with Transistor equipment. With simple mods (data supplied with Kit) easily adapted for use with Valve Tuners and Amplifiers.

Kit and assembly instructions complete with Mullard specified inductors Type WF2949 and WF2951.

£4.19.6 with coils pre-aligned **£5.0.0**

Packing and postage either model 2/6.

MULLARD FM DECODER COILS

Designed and made by Mullard, these inductors are as used in T.R.S. Decoder above. TYPE WF2949 and WF2951, each 25/-. Per pair 49/6. Post free.

GARRARD UNITS & PLINTHS

LM.3000 Record Player with 9 T.P. Stereo Cartridge. Limited number available. Brand new as from factory .... 8 gns.

AT.60 De-luxe Auto-changer. 12in. turntable. Superbly engineered. Less cartridge 9½ gns.

SP.25 De-luxe single record player, less cartridge .... 9½ gns.

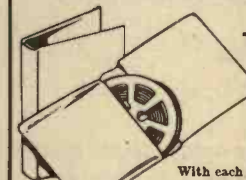
Packing and carriage on any one of above, 7/6 extra.

Garrard Plinth. The ideal modern mounting for the Garrard Units offered here. Will readily suit any hi-fi set-up. Beautifully finished in Teak. Complete with contemporary drop-on plastic cover. Packing and carriage 5/- 75/-

Garrard Mono Cartridges from 15/-; Stereo from 25/-.

Sinclair Micro-F.M. Kit £5.19.6
Sinclair Micromatic Kit 59/6
Micromatic

UNIQUE TAPE OFFER



Professional Tape in Unique Library Wallets only from TRS

With each 7in. reel of tape by an internationally famous manufacturer we give you a beautifully made wallet strongly made in simulated leather with stiff spring and space for a reel of tape each side. This is professional quality mylar tape with foil start and stop leads. These library wallets solve once and for all the problems of storing tapes efficiently and tidily.

7in. reel, **15/-** 1,200 ft. with wallet

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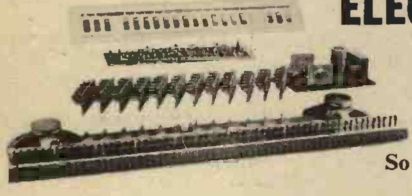

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The Solette. Precision made, pre-tuned units come to you ready to assemble in only 20 hours. Self-contained amplifier and speakers; perfect tone and generous volume, full 5-octave organ keyboard. Five pitches plus solo and melodic bass. Transistorised, portable. Price £118 complete (terms if needed).

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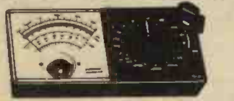
NEW MODEL 500. 30,000 o.p.v. With overload protection, mirror scale. 0/.5/1/2.5/10/25/100/250/500/1,000v. D.C. 0/2.5/10/25/100/250/500/1,000v. A.C. 0/50µA/5/50/500mA. 12 amp. D.C. 0/60K/6 Meg./60. Meg Ω. £8/17/6 Post Paid.

PROFESSIONAL 20,000 o.p.v. LAB. TYPE MULTITESTER



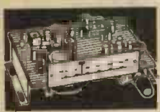
With automatic overload protection, mirror scale. Ranges: 1/10/50/250/500/1,000 volts, D.C. and A.C. 0-500 µA, 10 mA, 250 mA. Current: 0/20 K, 200 K, 2 megohm. Decibels — 20 to + 22db. £5/10/. P. & P. 2/6.

TE-900 20,000Ω/VOLT GIANT MULTIMETER 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 V. A.C. 0/25/12.5/10/50/250/1,000/5,000 V. D.C. 0/50µA/110/100/500 mA/10 amp. D.C. 02K/200K/20 Megohm. £12/19/6. P. & P. 5/-.

MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0·7-0·9967, B: 5-200, Ico: 0-50 microamps, 0-5 mA. Resistance for diode 200Ω — 1 Meg. Supplied complete with instructions, battery and leads. £6/19/6. P. & P. 2/6.

★TRANSISTORISED FM TUNER★



6 TRANSISTOR HIGH QUALITY TUNER, SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. £6/19/6. P. & P. 2/6.

NOMBREX TRANSISTORISED EQUIPMENT

ALL Post Paid With Battery

Transistorised Audio Generator 10-100,000 c/s. Sine or square wave. £16/15/-. Transistorised Signal Generator 150 kc/s. 230 Mc/s. £10/10/-. Transistorised resistance capacity bridge 1Ω. 100 Meg. Ω 1 pf-100µF. £9. Transistorised Induction bridge 1µH-100H. £18. Mains operated Transistor power supply unit, output 1-15 v. up to 100 mA. £6/10/-.

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400 v. P.I.V. 3 amp.	7/6
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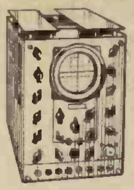
800 v. P.I.V. 5 amp.	7/6
400 v. P.I.V. 500mA.	3/6
70 v. P.I.V. 1 amp.	3/6
150 v. P.I.V. 165mA.	1/-
150 v. P.I.V. 25 amp.	19/6
700 v. P.I.V. 100 amp.	49/6
400 v. P.I.V. 3 amp. (S.C.R.)	10/-
100 v. P.I.V. 5 amp. (S.C.R.)	13/6
200 v. P.I.V. 5 amp. (S.C.R.)	15/6
400 v. P.I.V. 5 amp. (S.C.R.)	17/6

Discounts for quantities. Post extra.

TYPE 13A DOUBLE BEAM OSCILLOSCOPE BARGAIN!



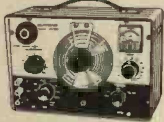
A high quality instrument, offered at a fraction of original cost. Timebase 2 c/s-750 kc/s. Separate Y1 and Y2 amplifiers up to 5.5 Mc/s. Built-in calibrators at 100 kc/s. and 1 Mc. Operation for 115/250 v. A.C. Available in excellent condition, fully tested and checked. £22/10/-. Carr. 30/-.

TE-20RF SIGNAL GENERATOR

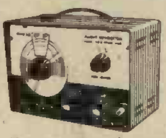
Accurate wide range signal generator covering 120 kc/s-260 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions £12/10/-. P. & P. 7/6. S.A.E. for details.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

2 P.F. - 2,000 MFD. 2 ohms - 200 megohms. Also checks impedance turns ratio, insulation, 200/250 v. A.C. Brand New £15. Carr. 7/6.



TE22 SINE SQUARE WAVE AUDIO GERERATORS

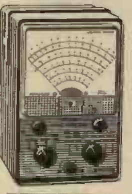


Sine: 20 cps to 200 kc/s on 4 bands. Square: 20 cps to 30 kc/s. Output impedance 5,000 ohms, 200/250 v. A.C. Supplied brand new and guaranteed with instruction manual and leads, £15. Carr. 7/6.

ARF-100 COMBINED AF-RF SIGNAL GENERATOR

AF. SINE WAVE 20 - 200,000 cps. Square wave 20-30,000 cps. O/P. HIGH IMP. 21 v. P/P 600Ω 3·8 v. P/P. TF. 100 kc/s-300 Mc/s. Variable R.F. attenuation Int/Ext. Modulation Incorporates dual purpose meter to monitor AF output and % mod. on R.F. 220/240 v. A C. £27/10/-. Carr. 7/6.

TE-65 VALVE VOLTMETER



High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/249 v. A.C. operation. Complete with probe and instructions, £15. P.P. 6/-. Additional Probes available: R.F. 35/-; H.V. 42/6.

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94-104 Mc/s. Transistorised. Operates from 9 v. battery. Complete with additional secret tie-clip microphone. List £12.10.0. ONLY £7.10.0. P. & P. 2/6.

These cannot be operated in U.K.

R.107 RECEIVERS

1·7-7·5 Mc/s. Mains or 12 volt D.C. operation. Perfect condition. £15. Carr. 30/-.

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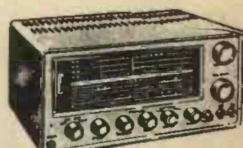

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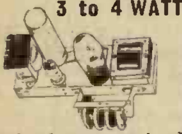

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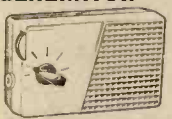

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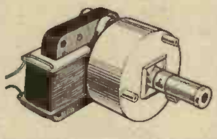

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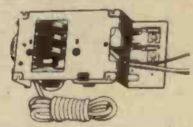

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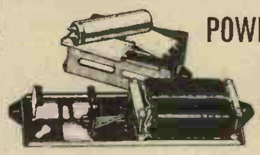

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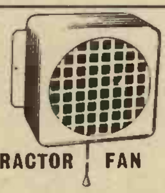

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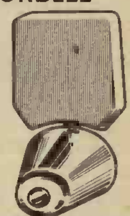

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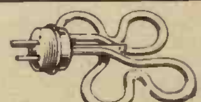

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VOL. 3 No. 5
MAY 1967

PRACTICAL ELECTRONICS

THREE SCORE AND TEN

SEVENTY years ago there occurred a momentous scientific discovery that was destined to set in motion the greatest technological revolution yet known. The ultimate extent of this revolution and its full consequences no one even today can envisage. Imagination cannot keep pace with events as developments in the field of electronics continue at a phenomenal rate.

Yet a mere three score years and ten separate us from the "pre-electron" era.

In May 1897 there appeared in the magazine the *Electrician* the first account to be published by J. J. Thomson of his epoch making investigations into cathode rays. These experiments definitely established that cathode rays are composed of discrete particles of matter, and that each of these particles has a negative electrical charge.

J. J. Thomson called these particles "corpuscles" and believed them to be a universal constituent of all matter. This was subsequently found to be true. The name electron was shortly afterwards given to these corpuscles.

It is of interest to note that the electrical industry played a significant part (if unwittingly) in this experimental work. Improved vacuum techniques developed for the manufacture of electric lamps greatly aided Thomson's investigations into the nature of the mysterious cathode rays.

Thus technology of the electrical industry contributed in this way to the outstanding scientific discovery of modern times: and from this discovery was to grow the most exciting and prolific technology of all. Once the electron had been identified many of the perplexing problems of atomic physics were soon resolved. Knowledge of the nature of the cathode rays lead to their utilisation under controlled conditions in vacuum tubes specially designed for particular applications. The production of X-rays, and of visible images on fluorescent screens; the control and amplification of electric currents; the use of the electron beam for microscopy—these were some of the major developments.

Born in the physicist's laboratory, subsequently developed and matured in industry, electronic technology has already completed the full circle by returning to the place of its birth in the form of elegant and powerful tools to aid the research workers probing at today's frontiers of science.

Three score years and ten may be the "normal" life span of man, but no worries of longevity need bother that spritely fellow the electron, for *his* active life as an agent of man has hardly yet begun!

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our June issue will be published on Friday, May 12

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

Replica of Pascal's Calculating Machine , (Crown Copyright. Science Museum, London)

1632 + COMPUTER

PART ONE

HISTORY OF CALCULATION

To the man in the street the subject of computers conjures up mysterious misconceptions of complex "robots" with minds of their own, or perhaps a threat to the working man's livelihood.

A computer cannot think for itself; it relies on operators to feed it with information. The process of converting this information (software) to arrive at a mathematical solution or to control the functions of some other machine is the task of the computer.

This series of articles sets out to show how the computer is, in fact, a slave of man and not the converse. The first part looks back over centuries of crude developments, of mechanical devices, the forerunners of modern electronic computers.

Later parts will be divided into two broad sections—analogue and digital.

By S. A. HODSON B.Sc.

335

1967

EVOLUTION

NCR-Elliott 4100 electronic computer

WHEN man first began to recognise discrete quantities, it is easy to guess that he turned first of all to his fingers as a measure of what he was counting. In fact the whole decimal system has been built up from these first gropings. The fact that we work to a base of 10 is due, no more no less, to the fact that man has eight fingers and two thumbs. As we shall see later in the series, any basic block of numbers can be used as a counting system; and we use this fact to great advantage in the field of digital computers.

Coming back now to man and his fingers, he has a very easy way of remembering any number up to and including 10. Simply by raising the appropriate digits he can represent any one of 11 numbers (remembering that zero is a number). The important thing to note is that he can only count in jumps of one; nothing smaller. Fractions have not entered the story as yet.

Having got to 10, what does he do next? Let us say he picks up a stone when he reaches his count of 10, and puts it on one side to remind him that he has reached 10 once. Then when he reaches 10 again he picks up another stone and puts it with the first. That takes him up to 20 with unlimited possibilities for further counting. Our man has invented the first computing system.

This system of counting spread until about 5,000 years ago in the Tigress–Euphrates valley when someone thought of cutting grooves in a block of stone or wood, and letting the pebbles run in these grooves.

When this reached the ears of the Chinese, who were at that time highly civilised, they had to go one better. They drilled holes in the pebbles and threaded them on to rods; this machine they called an Abacus. (The Japanese reached the same answer at about the same time but they called theirs a Soroban.) Both these peoples became, and still are highly proficient in the use of these machines. Even now a Japanese who is practised in the use of an abacus can perform calculations on it faster than a Westerner with a mechanical calculating machine.

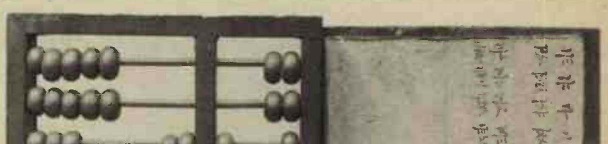
17th CENTURY MATHS

Having reached this stage of development, counting machines progressed little more until the early part of the 17th century.

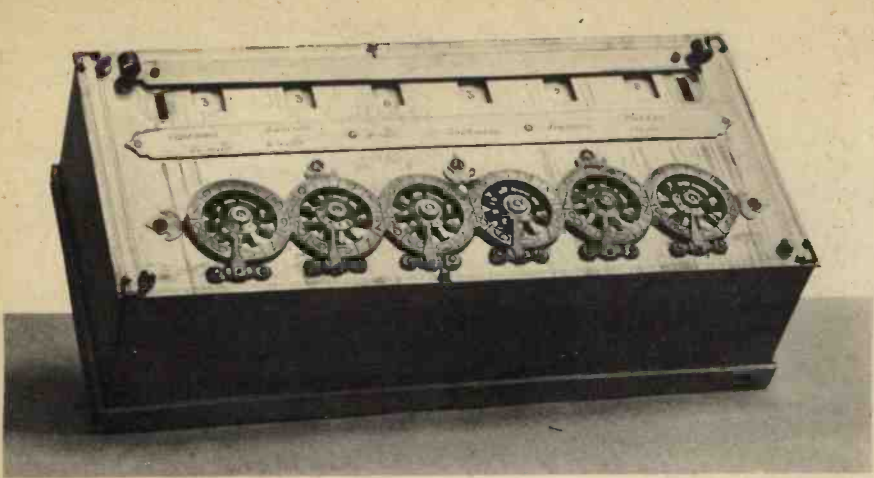
Before going on to describe the development of calculating machines in the renaissance period, it should be pointed out that the machines discussed so far have been able only to add up discrete numbers. They cannot count anything smaller than one stone, pebble or bead; whichever is being used. This point will be of significance later in this article.

At the beginning of the 17th century the great mathematicians and philosophers like Leibniz, Descartes, Napier, Pascal, and others were pushing the frontiers of knowledge outwards at a great pace; not least in the field of mathematics. It is from their advances in this subject that the modern computing machine was developed.

These men worked in the realm of the mathematical equation or "function", and by means of these functions they explained many observable phenomena. What is



Chinese Abacus (Crown Copyright. Science Museum, London.)



Replica of Pascal's calculating machine

(Crown Copyright. Science Museum, London)

perhaps more important is that they showed that any physical occurrence, be it observable or not, could be represented by some mathematical function. This is another of the axioms that is used to great effect in modern computers.

The first step in this period that was taken to make calculating easier was not a machine at all but a table of figures. In 1614 John Napier invented his Naperian Logarithms. In the following year Henry Briggs converted them to what mathematicians call "base 10", and gave us the familiar "log table" that we use today.

Directly derived from the log table is the slide rule, which is the most common form of analogue computing device in use today.

INTEGRATION

Mathematical development went on for 200 years after Napier without the aid of any new calculating machines until, in 1814, J. A. Hermann invented a device for measuring the area under a curve. This was the first true "integrator", and was the ancestor of the modern planimeter. The planimeter, which measures the area under any part of a curve, may be said to perform the function of integration; and as such is an analogue computing device.

The meaning of the term analogue should be explained at this point. It has been stated that the abacus and its contemporary machines have only been able to count in discrete jumps. Now history has reached a point where a device for integrating has been invented. Integration is essentially a smooth process, and this is sufficient to define it as an analogue process. The question "is the process smooth or jerky?" is a good guide to the classification of a device. If the answer is smooth then the device falls under the heading "analogue". If the answer is jerky then the device can be classified as "digital".

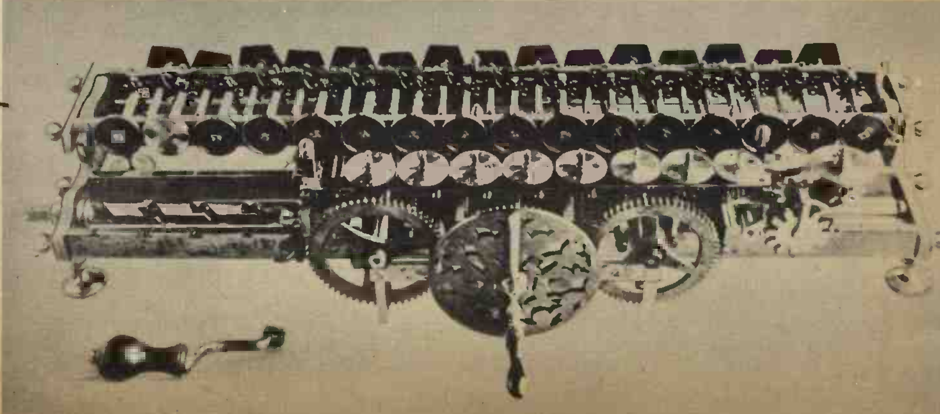
Broadly speaking, the term analogue can be interpreted as "model". An analogue device is a model of the system upon which it is performing calculations. For instance, the slide rule uses distance as a model of any unit that is being used in a calculation, be it feet per second, tons, or just a plain number.

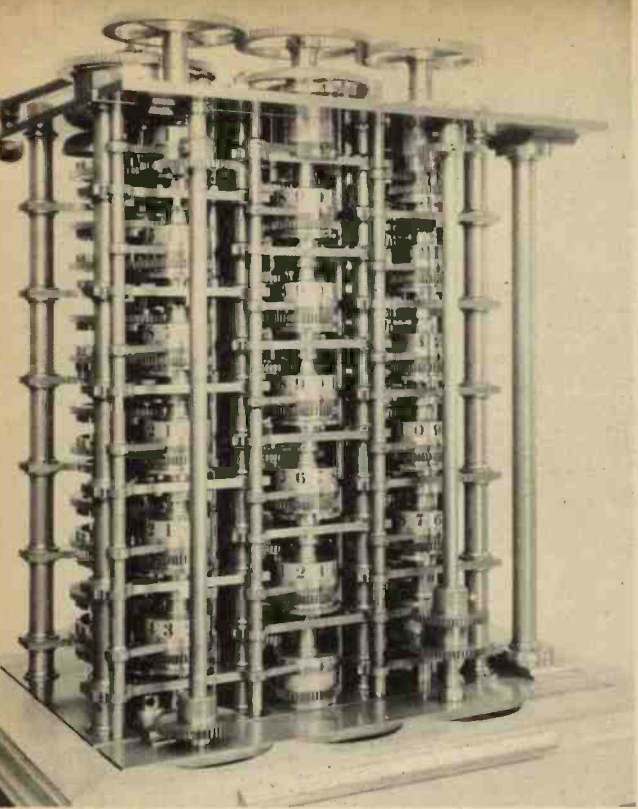
Soon after Hermann's invention of the integrator, James Thompson (the brother of Lord Kelvin) invented the ball-and-disc integrator which is still in use today. However, in this case credit must go to Lord Kelvin himself for connecting a series of his brother's integrators together in order to solve differential equations.

This spotlights one of the most important concepts to emerge from the renaissance period: a physical occurrence of any sort can be described in terms of a differential equation. This discovery is so general that it is sufficient, when designing an analogue computer, to make it able to solve differential equations. Once it can do this it can solve any physical problem whatsoever.

Thus Lord Kelvin's chain of integrators can claim to be the first step on the road to a modern analogue computer.

Leibnitz calculating machine. The outer case has been removed





Babbage's difference engine (Crown Copyright. Science Museum, London)

This has brought the development of analogue devices up to a point where they bear a recognisable relationship to modern machines, and it is convenient to leave their further progress until later in the series, and turn to that of the digital counting machine, which, at the present stage in this discussion has reached the stage of the abacus.

The nineteenth century was not devoted entirely to the development of the analogue computing device. Contemporary to the events described above were a whole string of counting machines that used digital principles. The use of the term "counting machines" rather than "computing machines" is deliberate in that they had not progressed beyond the stage of being merely an aid to the memory.

Just after Napier had invented logarithms, Blaise Pascal introduced, in 1632, what must be one of the most significant developments in the history of digital machines. He designed a calculator using toothed wheels instead of beads. Pascal's machine could perform additions and subtractions, and, to a limited extent, multiplications and divisions.

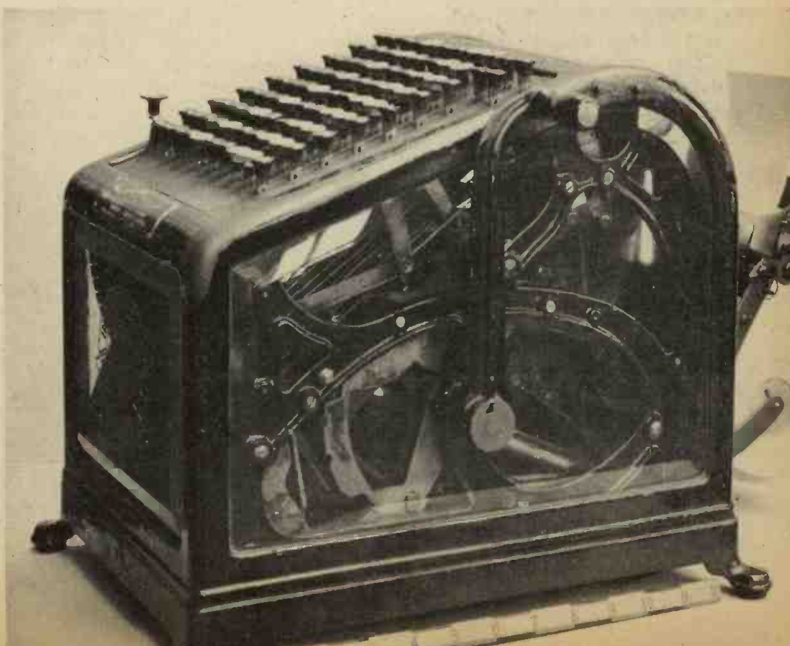
Another advantage of this machine, and this marks a new and very important difference between analogue and digital machines, was that its range, and hence its accuracy, could be increased simply by adding further identical toothed wheels. For instance, with three wheels, numbers of up to 999 can be represented. This range can be increased by a factor of 10 simply by adding one more wheel. The addition of this wheel represents an increase in the actual hardware of the machine of one third.

Compare this now with a similar situation on an analogue machine. Suppose that one linear foot of a scale represents 1ft/sec in a calculation. If 10ft/sec should need to be represented, the scale will have to increase in length to 10ft, an increase in hardware of ten times for the same increase in range. This kind of example shows that physical limitations of a representative scale for large values become obvious. However, as will be seen later in the series, they also have advantages that, in certain fields, make them superior to digital machines.

CALCULATORS

Returning now to Pascal's calculator, the manner in which it performs additions and subtractions need hardly be described; but the way in which it can be made to perform multiplications and divisions is both instructive and useful, since it is still in use in some machines today.

Suppose that, on a digital machine, it is desired to multiply 8 by 8. This can be done in eight steps by starting with 8, and adding 8 to it seven times, thus giving "eight eights".



An early Burroughs adding machine

(Lent to Science Museum, London, by the Burroughs Adding Machine Company)

In a similar manner, to divide 64 by 8, it is necessary only to keep subtracting 8 from 64, keeping a running total of both the result and the number of times the process has been repeated. This last figure then gives the answer when a zero running total is obtained. Should the answer not be exact, then the remainder is left in the running total.

These methods are known as: "multiplication by repeated addition" and "division by repeated subtraction". The important thing to note is that the results obtained by these methods are exact. The multiplication will always give the exact answer, and the division will give an exact answer with an exact remainder. If the same calculations are performed on a slide rule, it will be seen that the answers are only as accurate as the scale, and can only be given, at best, to four figures and sometimes only to three.

The next machine of any importance to be built after Pascal's, was designed by Baron von Leibniz, a very famous mathematician, who, unfortunately, was not as good at engineering as he was at mathematics. His first machine, finished in 1694, while being correct theoretically, was mechanically temperamental.

The important design feature of this machine was that it could perform multiplication and division by repeated addition and subtraction automatically. This set up a precedent, and from then on man has aimed for more and more automation in his calculating machines.

AUTOMATIC COMPUTER

Development of digital machines followed the path that Leibniz had started, and made no further major advance until 1812 when Charles Babbage, an English mathematician, set out to make an automatic computer. This was no small task that Babbage was setting himself, since there was at that time no successful calculating machine available, let alone a computer.

Unfortunately for Babbage, the technology of the time was not sufficiently advanced, and he had to abandon his project in 1842. However, before he abandoned it, he had laid down a basic layout for his machine that has survived into present day computer engineering in very much its original form.

Babbage envisaged a machine that could perform one addition every second. This was very fast for his day, and was certainly much faster than any human operator could enter figures into the machine. He decided to divide his machine into three parts, which he called the "store", the "mill", and the "control".

The store was filled with all the data necessary for the calculation; this information was held in the shape of holes punched in pieces of card—another of Babbage's innovations that has survived into the present time. The mill was the unit full of toothed wheels that actually performed the operations of addition, multiplication, and so on, and the control unit told the mill what and when to do, and where to find the means to do it.

Babbage's machine was over a century ahead of its time and it suffered the fate of many other machines whose only faults were that they were ahead of their time.

It should be possible to see now that the field of digital machines is subdividing itself naturally into calculators or counting machines, and the true computers. Leibniz's machine was the ancestor of the modern comptometer or desk calculator, and Babbage's idea was developed to become the modern digital computer. It is the operation and construction of this last mentioned device that is of interest in this series.

Next month: The analogue computer, its components and layouts, and the uses to which it can be put.

Motor scooters are vulnerable to theft both in their entirety and in their accessories. This article is the result of some experience in combating would-be thieves. Even the steering lock is only a modest deterrent and is no match to violence.

What is really needed is a system that would detect pilfering or tampering with accessories, tool box, or even the battery. One system tried by the author failed to prevent excessive battery drain and required manual resetting to switch off the alarm circuit.

A later model was successful in that it automatically reset itself after a pre-determined time interval had lapsed. Its current drain in a quiescent condition was negligible and the detector control circuit was small enough to be hidden out of sight.

D.C. AMPLIFIER

The circuit consists of a d.c. amplifier using two high gain transistors (about 70 to 110). In the configuration shown both transistors must be conducting before the alarm relay RLA can operate (see Fig. 1).

If the connection between the base of TR1 and chassis is broken (for example, if one of the microswitches is operated) the base voltage rises to about -350mV and a current of 9μA flows through the base, but TR1, and hence TR2, do not switch on until capacitor C2 has charged up, although this is only a very short time.

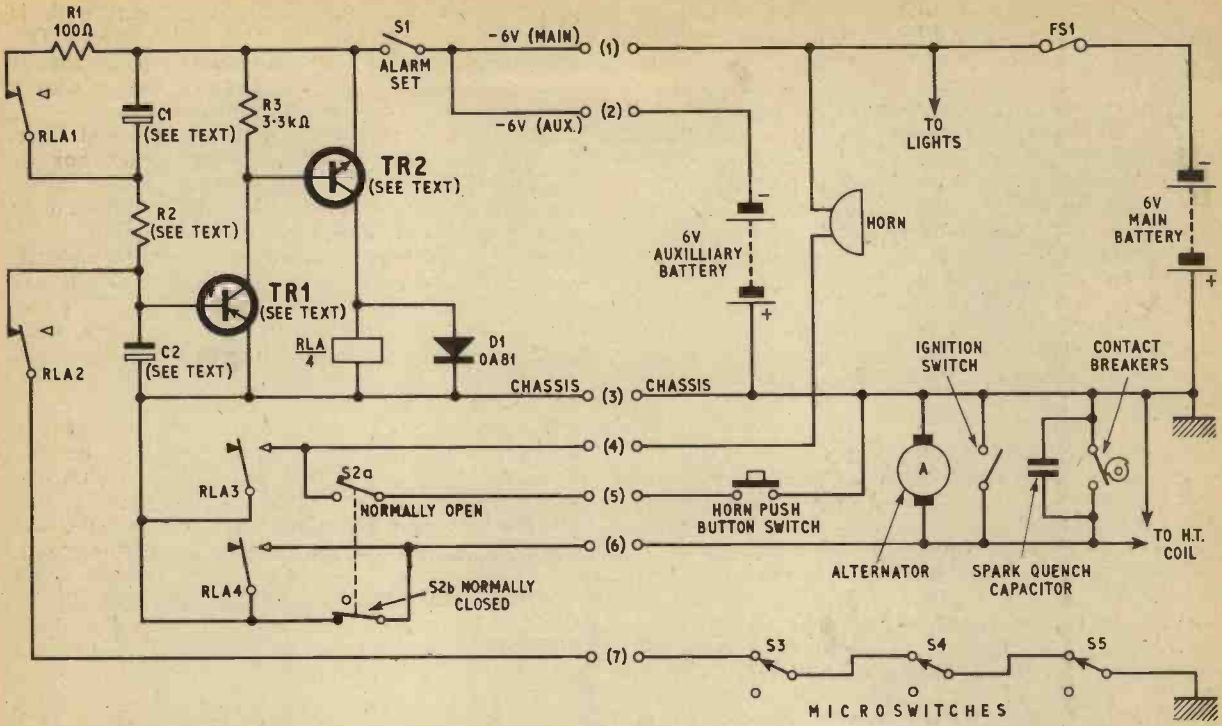


Fig. 1. Circuit diagram of the alarm system with associated scooter components and connections shown on the right. This diagram is for positive earth 6V systems

The four sets of contacts change over: RLA1 brings C1 into circuit to prepare for the time delay cut-off of the alarm; RLA2 maintains the break between TR1 base and chassis so that the microswitches are then made ineffective; RLA3 connects the horn direct to chassis, by-passing the horn push button and sounding the horn; RLA4 shorts the contact breaker points and prevents the sparking plug firing.

As the capacitor C1 charges up, the base current in TR1 falls until TR2 cannot supply enough current to operate the relay. When the relay switches off, capacitor C1 discharges via RLA1. The base connection of TR1 to earth via RLA2 is completed if none of the microswitches are open circuit. If any of the microswitches are open circuit then the alarm will be actuated again until the open circuit is closed. The horn and contact breaker circuits are broken by RLA3 and RLA4 changing back to their original state.

The value of R1 is found by placing a 1 megohm potentiometer in the base circuit of TR1 and adjusting until the current in the relay is 60mA. Capacitor C1 is removed for this operation; the working value may be adjusted and found by experiment. The base current of 9μA fell to 4·5μA when the relay switched off.

The diode D1 connected across the relay coil protects TR2 from the transient back e.m.f. generated when the magnetic field collapses.

The microswitches are the key components in this system in that they allow C2 to become effective if any one of them is operated by the would-be thief. Any number of microswitches can be installed and wired in series between RLA2 and chassis. Fig. 1 shows, as an example, three microswitches in circuit. The installation of these microswitches is given later.

As can be seen from the circuit, two batteries are used; one was fused to prevent a short circuit from neutralising the alarm. The second (auxiliary) battery was mounted in the tool compartment. If the thief breaks into the rear tool box and disconnects the main battery, the alarm would continue to sound as the auxiliary battery is still in circuit. If he then shorted

ALARM SYSTEM

By A. P. KEOGH

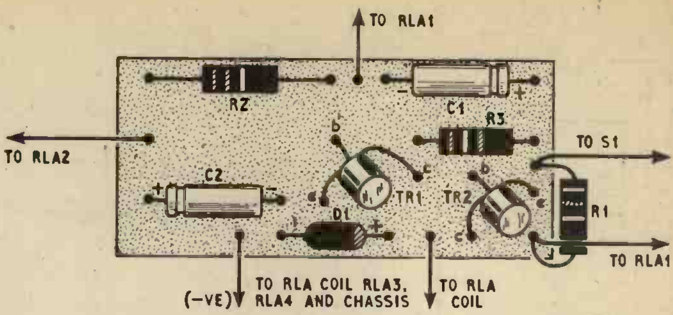


Fig. 2a. Component board layout for 6V positive earth systems

the negative line to chassis the fuse would blow, leaving the alarm and horn still being powered by the auxiliary battery.

UNIT CONSTRUCTION

The printed circuit board is then made. The board measures 2·25in × 1in and is secured by two bolts as shown in Fig. 2. Normal etching processes can be used for this and it is suggested that the constructor refers to the special feature on printed circuits in the March 1966 issue of PRACTICAL ELECTRONICS.

When the printed circuit is ready to accept components, it is easier if they are mounted and soldered to the board in this order: C1, R2, C2, R3, TR1, D1, R1, and then TR2. Care should be taken to ensure that the transistors are not overheated when soldering in place, a pair of pliers should be used as a heat shunt by gripping each wire as it is being soldered. Both C1 and R2 should stand about ⅛in above the board, in order that they can be moved aside so that the bolts which secure the board to the chassis can be tightened. The board and the relay bases can now be secured to the chassis and a rubber mat is placed under the copper side of the board to prevent any short circuits.

The whole unit was mounted on a small chassis which was insulated from the main aluminium chassis by a rubber pad and insulated bolts.

The chassis and case are shown in Fig. 3; the chassis is insulated from the case because the base of TR2 is connected to its case and the heat sink on this transistor is connected to the chassis. All the holes are simple drillings except for the relay apertures. If a punch is not available, then the holes could be drilled and then filed to shape. The hank bushes are used to assist assembly of the case, as holding 6 B.A. nuts with a pair of long-nosed pliers is awkward.

The wires from the switches and the board are passed through the holes in the chassis and connected as shown in the circuit diagram (Fig. 1).

A 7-way plug could be used for connecting the board to other components but snap connectors (as frequently found in scooter wiring) can be used.

INSTALLATION

When the case is assembled, the alarm is mounted in the scooter. In the Vespa scooter the alarm can be fitted in the front tool compartment and secured to an aluminium bracket by three 6 B.A. nuts and bolts.

Switch S2 is incorporated for use in the event of a "flat" battery or when the ignition key is not available. S2a connects the horn to the horn push button and S2b removes the short across the contact breaker points. This can be fitted either in the box containing the alarm unit or anywhere convenient for wiring to the horn and ignition systems.

COMPONENTS . . .

6 VOLT POSITIVE EARTH SYSTEM

Resistors
R1 100Ω R3 3·9kΩ
R2 Selected by experiment using a 1MΩ potentiometer (see text)

Capacitors
C1 16μF tantalum foil elect. 25V (T.C.C. type TA14CZ)
C2 16μF tantalum foil elect. 25V

Transistors and Diode
TR1 2N1303 *or* GET882
TR2 2N1302
D1 OA81

Relay
RLA 90Ω 6V 4-pole changeover Omron type MH4 (Keyswitch Relays Ltd., 120-132 Cricklewood Lane, London, N.W.2)

Switches
S1 Single pole on/off toggle switch
S2 Double pole changeover toggle switch
S3–5 Microswitches with operating lever (3 off)

Miscellaneous
Small piece printed circuit board
Heavy duty motor-cycle cable
Box, nuts, bolts, rubber, etc. (see text)

6 VOLT NEGATIVE EARTH SYSTEM

Reverse Polarity of C1, C2, and D1
Reverse supply leads to control unit

Transistors
TR1 2N1302
TR2 2N1303

Resistor
R2 (see text)

12 VOLT SYSTEMS

Components as in relevant 6V systems except:

Relay
RLA 430Ω 12V 4-pole changeover, Omron type MH4

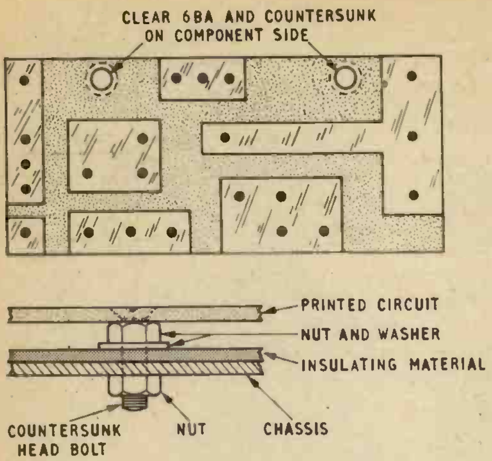


Fig. 2b. Printed circuit board (full size) and mounting detail

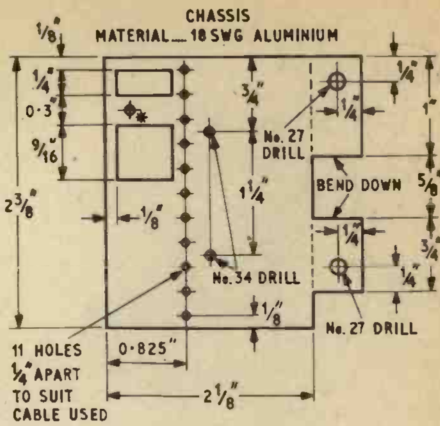
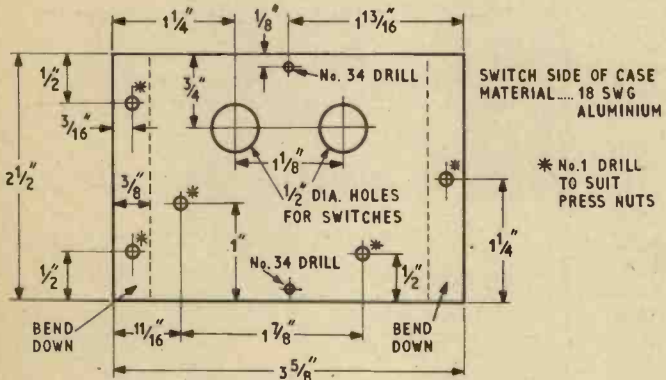


Fig. 3a. Chassis construction. The fixing hole for the relay base should be marked with the base in position



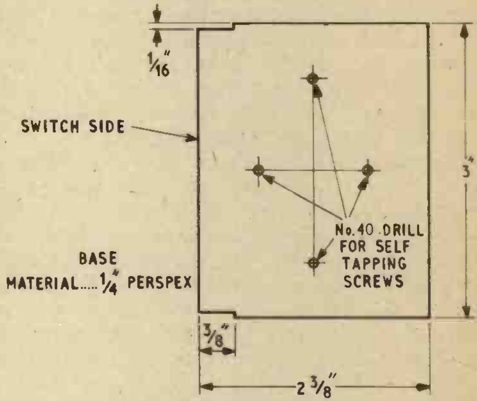
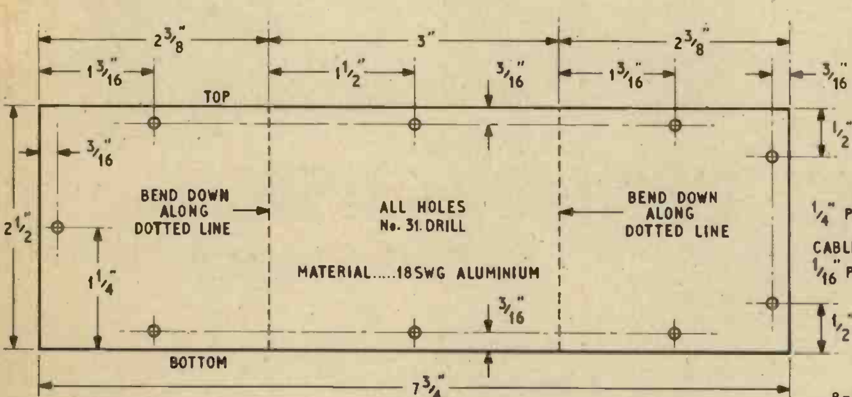
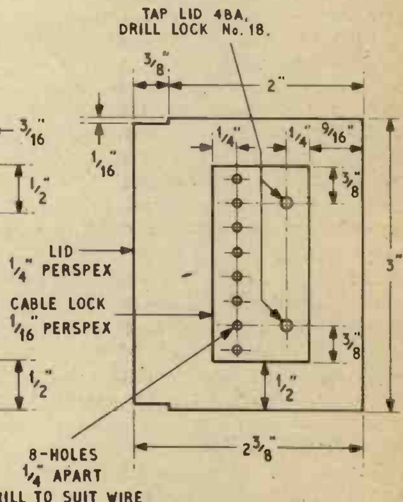
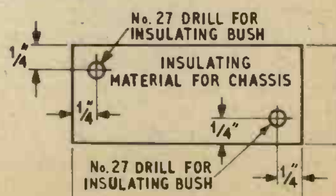


Fig. 3b. Case construction details







The unit is fitted in the front tool box

Unfortunately, the lids on tool compartments on most scooters are flexible and easily forced open when locked. To overcome this difficulty, fit braces (Fig. 5) to the lids making the lids more rigid to prevent forcing. The braces are tapped 4 B.A. and each bolt is held by two lock nuts to protect the bolts from removal from the outside. The braces were made from ½in Perspex sheet; those shown are for the Vespa Sportique and G.S. tool compartments.

ACCESSORY PROTECTION

Although seven points are protected by the alarm system, only one relay and three microswitches need be used. Accessories are protected by insulation from earth and connecting a wire to one side and taking a wire discreetly from the other side. If the accessory is removed, then TR1 base circuit to earth is broken.

The front carrier is secured to the scooter at four points, two of which are lugs which hook over the top of the legshield. Both these lugs have rubber sheaths which insulate them from the chassis (Fig. 6). Two bolts secure the bottom of the carrier to the chassis and hold it firmly. Both these bolts are insulated from the chassis and they are used as contacts for a "home-made" microswitch.

In Fig. 7 a sketch of the crashbar insulation is shown. The rear brackets are insulated by a piece of rubber and the wires connected to these brackets. The front bracket is insulated by rubber washers with nylon sleeves on the securing bolt.

The crashbars can be removed by unscrewing the nuts (shown hatched in Fig. 7) and can then be removed from the securing bracket by pulling. The wire will be broken near the securing bracket. If the wires from the tool box microswitch and the wire to the spare wheel are connected to the rear securing brackets, then immediately the nut securing the crashbar is loosened, the alarm will sound before the thief has a chance to pull it away from the securing bracket.

When either of the crashbars is removed, the circuit is broken. A similar method was used for the horn, front carrier, rear carrier, spare wheel and wheel disc. This insulation overcomes the problem of hiding microswitches, and hence avoided some expense.

The microswitch wire from the alarm unit is first connected to the microswitch in the front tool compartment (Fig. 8). From here it is attached to the front carrier.

If any of these bolts is disconnected from the front carrier (for example, by sawing the front carrier off) the connection between these two bolts is broken and the alarm sounds.

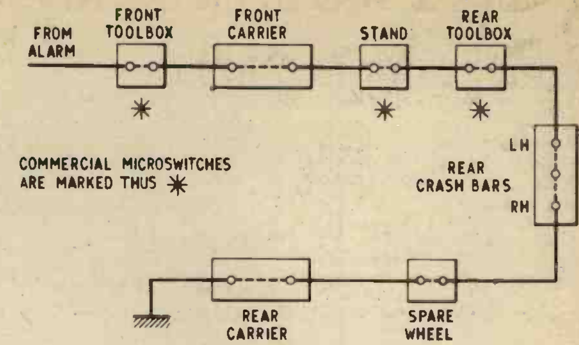


Fig. 4. Block diagram of accessory wiring

Front carrier

Fig. 6. (below). Front carrier insulation

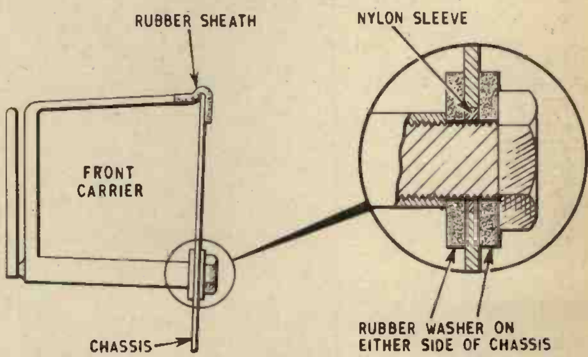
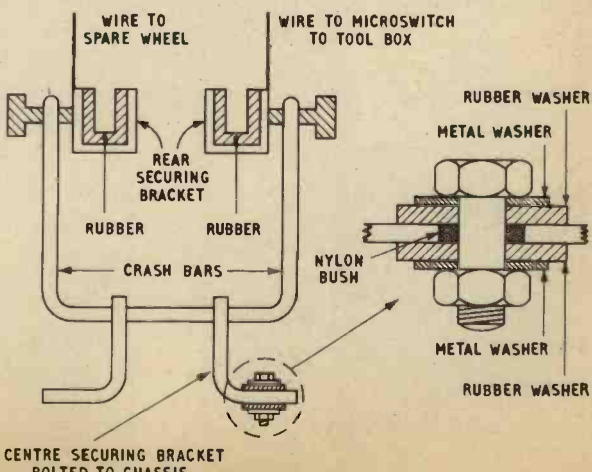


Fig. 7 (below). Crash bar insulation



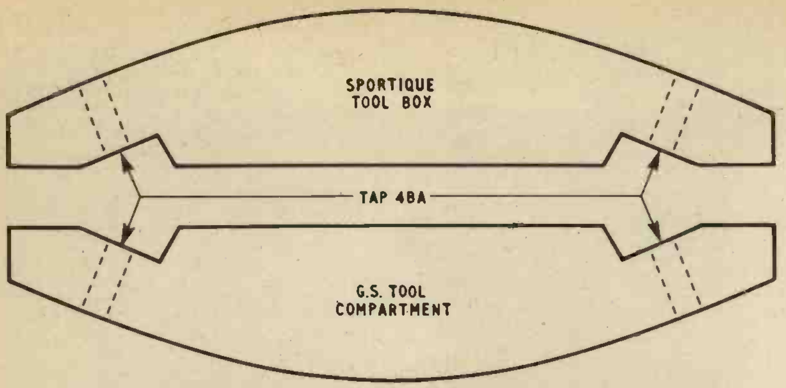


Fig. 5. Strengthening braces for Sportique and G. S. tool boxes

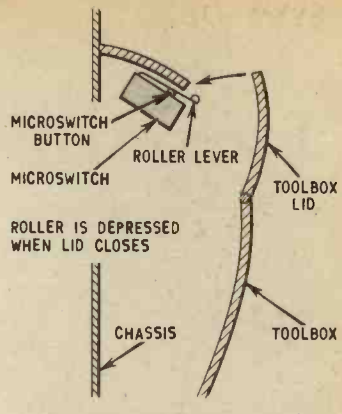


Fig. 8. Front toolbox with microswitch

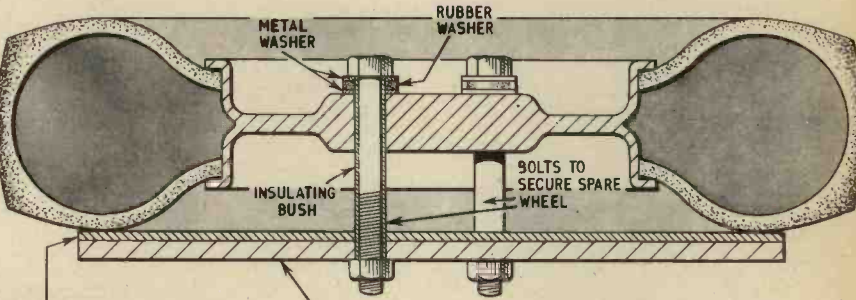
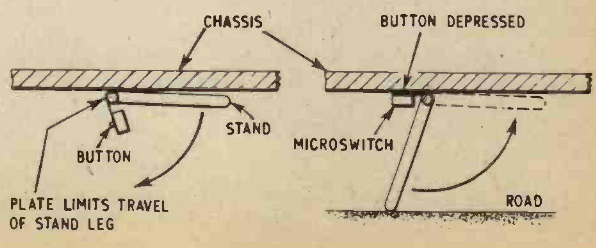
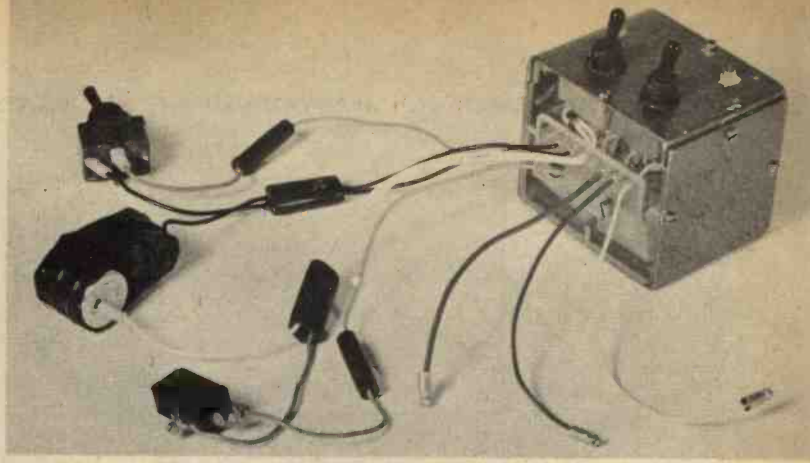


Fig. 9. Insulated spare wheel fitted to rear carrier

Spare wheel and battery compartment on the Sportique model

Fig. 10. Microswitch fitted to the stand





From the front carrier the microswitch wire now travels to the microswitch on the stand under the foot boards and then onto the microswitch on the rear tool box.

The footboards microswitch was bolted to the flat plate, on the stand, which limits the travel of the stand leg. When the stand is down, the microswitch button is depressed but there is no load on the microswitch itself (see Fig. 10).

The second spare wheel bolt has no insulation on it and gives an electrical contact between the spare wheel and the rear carrier. The carrier is then connected to earth. If either of the bolts securing the spare wheel

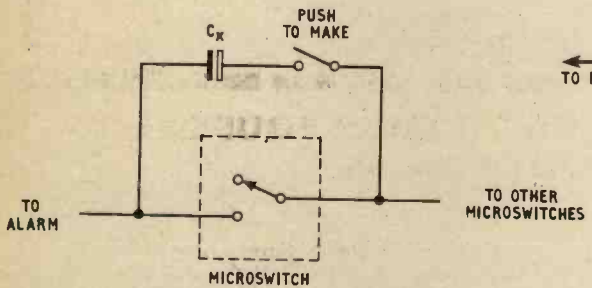


Fig 11. By-pass capacitor for each microswitch

is removed, then the circuit to earth is broken since the wheel is insulated from the carrier. If the rear carrier is removed the connection to earth will once again be broken (see Fig. 9).

The electrical contact in the front carrier is from one bolt, through the metal carrier to the second securing bolt. The electrical contact in the rear crashbars is from one rear securing bracket through the left-hand crashbar, centre securing bracket, right-hand crashbar and the other rear securing bracket. Contact in the spare wheel is from the washer on the insulated bolt through the centre of the spare wheel through the carrier, via the second securing bolt and from the carrier to earth.

ALTERNATIVE SYSTEMS

The component values for 6 or 12 volt operation with either positive or negative earth systems are shown in the components list. It should be pointed out to those who do not like the idea of an alarm which draws current, that the leakage from a metal rectifier is many times more than that of this alarm circuit. The battery drain in this system is a mere 18μA compared with the metal rectifier's leakage of about 760μA.

To determine the value of R2 for 12V systems, a 2 megohm potentiometer (or a 1 megohm potentiometer with 1 megohm resistor in series) should be used and adjusted until a current of 25mA flows through the relay.

The alarm is mounted in the front tool compartment and there is a push switch mounted on the tool box above the alarm. When the alarm is set, it may sound because the microswitch on the tool box may not be closed. To rectify this, a push-switch was

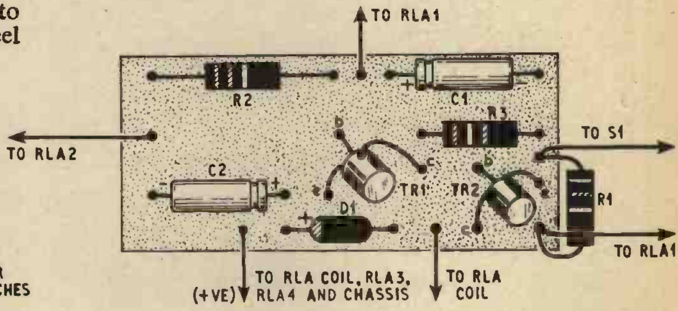
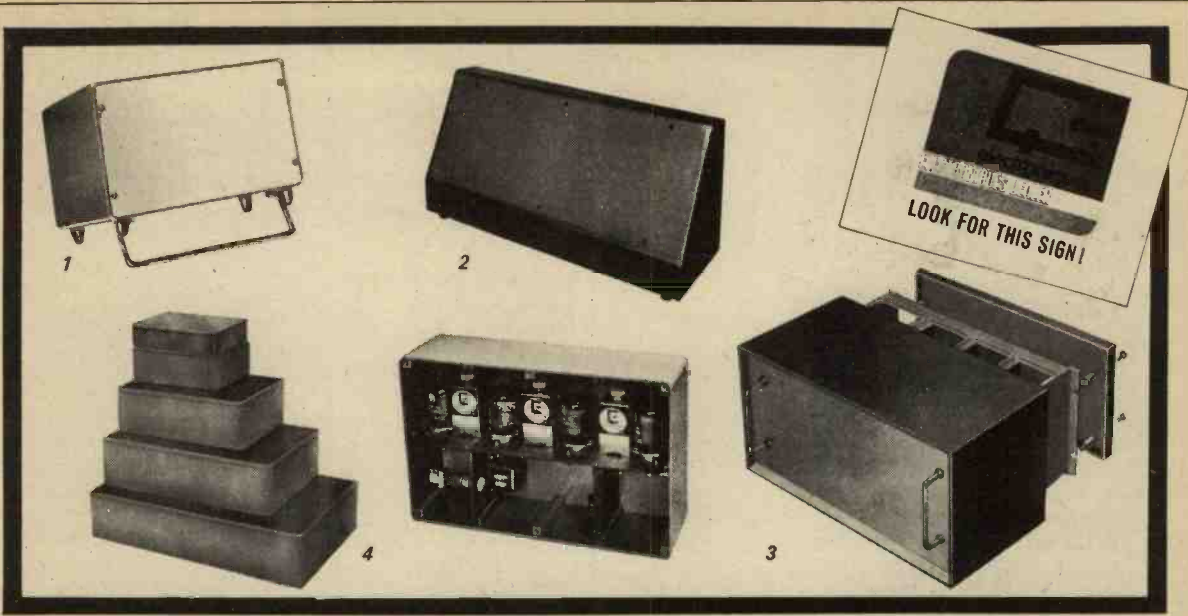
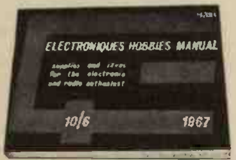


Fig. 12. Component layout for negative earth systems

fitted to bypass the microswitch. A 50μF capacitor was included in the line, so that it bypassed the microswitch for approximately 4 seconds. This is C_x in Fig. 11.

The circuit which has been described here is for positive earth machines and must not be fitted to machines with negative earths. The printed circuit shown in Fig. 12 can be used for negative earth systems; the component arrangement is amended as shown. The other connections are as before. ★





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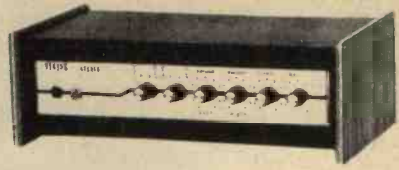

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THE ELECTRONIC ORGAN

By ALAN DOUGLAS, Sen. Mem. I.E.E.E.

PART SIX
SOUND PROPOGATION AND SPECIAL EFFECTS

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Then again, in normal programme music it is rare to find sustained notes of any power; harmonics convey the sense of power and these are the main content of orchestral music. When we come to an organ, however, we have a power/frequency spectrum which is quite different from that of an orchestra, see Fig. 6.1. Further, we encounter an appreciable amount of sine wave drive, which is very tough on amplifiers and loudspeakers.

LOUDSPEAKERS FOR ORGANS

Much is written about intermodulation distortion in reproducing systems, but this problem becomes so acute with organ sound that it is essential to separate the bass out into its own speaker. Then we have another problem peculiar to the organ: if we enter a building where a pipe organ is being played, it will be

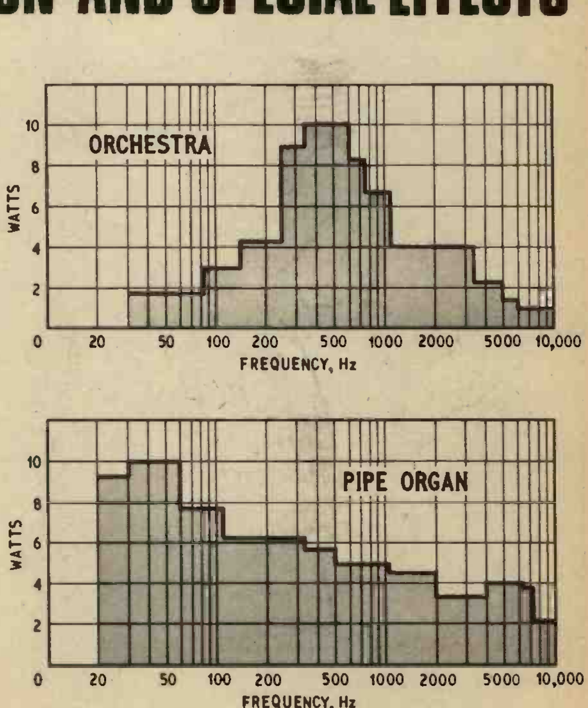

Fig. 6.1. Distribution of average power from an orchestra and an organ

quite easy to follow the sounds from the manual pipes; but one cannot pin-point the bass; it seems to come from everywhere. This is because of the distance needed to reflect long wavelengths

$$\left(\text{wavelength in feet} = \frac{\text{speed of sound in air, in feet per second}}{\text{frequency, cycles per second (or hertz)}}\right)$$

which may reach 80ft, and also, because the vibrating sides of the pipe contact a large volume of air, thus imparting a great amount of energy.

This does not necessarily mean that the sound is loud, indeed it is most noticeable on soft, breathing tones. For example, taking a small scale pedal bourdon pipe of CCC = 16ft = 32Hz approximately, then as it is stopped it will be 8ft in length and the two vibrating sides (two do not vibrate in a rectangular wood pipe) might be 9in wide. Thus we have 8ft × 9in twice, which is 12 square feet. Consider how many 18in cones would be required to produce the same effect!

Obviously this is quite impossible, but the largest available radiating area should be chosen. An economical way of doing this is to use 9 or 10 quite cheap 10in units mounted close together on a baffle, as in the Hammond H40 cabinet. This is much cheaper than one 18in unit. In passing, 27in units have been made by Altec-Lancing in the U.S.A., but the author has played organs with these pedal loudspeakers and was not greatly impressed.

Of course, we know that space is at a premium with domestic applications, but to obtain a free, natural, and unforced bass we will have to allow about 12 cubic feet for the bass cabinet. The dimensions of the H40 cabinet are given in Fig. 6.2.

Turning now to the manual range of frequencies, that is, from 65–8,000Hz, for most purposes this range can be handled by one unit. Small traces of hum,

Fig. 6.2. The Hammond H40 loudspeaker enclosure. Dimensions: 33in wide, 48in high and 17in deep

Fig. 6.3. The Wharfedale Super 8/RS/DD speaker unit. This may be mounted in a 1 cubic foot enclosure, on a 3 feet square baffle, or in a concrete column

transients, mains interference, etc. are greatly reduced if the loudspeaker cone faces upwards. An excellent unit is the Wharfedale (Fig. 6.3), but owing to its exceptional high-frequency response, some top cut will have to be introduced into the amplifiers.

It is a mistake to think that great powers are called for in the home: 12–20 watts for the bass speaker, 7–10 watts for the treble will be more than ample in an average room. This does depend on the efficiency of the loudspeaker enclosures, which if properly designed can approach 10 per cent. Many small commercial organs have quite powerful amplifiers built in since their ultimate use is not known by the makers and this sometimes leads to a certain amount of dissatisfaction in the home as the balance may be difficult. No greater mistake could be made than to imagine that a large amplifier makes a large organ; one might as well amplify up a string quartet and expect it to sound like the complete string section of an orchestra. There is an optimum loudness for every kind of musical sound.

RHYTHMIC EFFECTS

Many experimenters are interested in effects such as rhythmic aids which are not really part of an organ though they may be found on theatre organs. These are quite entertaining devices and of course are also useful in their own right, for they do not have to be associated with an organ or built into one.

The classic example of a rhythm generator is the Wurlitzer "Side Man", but this uses valves. It is probably best to give as an illustration a semiconductor circuit which, if not quite so comprehensive, does enable a performer to have additional effects under his control.

The rhythm sound most in demand is the cymbal. Accordingly we show a circuit (Fig. 6.4) which permits both a single stroke and a wire brush effect. Analysis of a conventional brass cymbal shows that all the energy resides in the band 8–12Hz. The obvious way to obtain this is to use a noise generator and filter off what is not required. At one time gas tubes were much in demand as white noise generators and are still used in Germany; but one can also generate noise from a semiconductor.

It is a good idea to make the lighter "brush" effect available on the manuals, since it fits in better with most rhythm patterns and can be sustained at will. The single stroke is then put on the pedals, but it could go on a toe piston so as to be quite independent of any other sound.

CYMBAL EFFECT CIRCUIT

Fig. 6.4 shows a simple arrangement for this scheme.

Taking the pedal circuit first, when a key is depressed a voltage is applied through VR3 to one plate of C11. This voltage passes through D4 so charging C12 and applying the keying voltage to the base of TR5, thus making it conduct and amplify the white noise from TR3. This noise is transferred to the base of TR5 through C6. The output level of this effect is set by VR3, which varies the amount of keying voltage.

In the collector circuit of TR5 is a broadly tuned circuit L2, C13 which is resonant at about 8Hz; from this shaping network the signal is amplified by TR4 and is then ready to be applied to the main amplifying system. The comparatively low frequency of 8Hz imparts a more solid sound to the cymbal, the pedal effect being in any case usually set to be much louder than the manual "brush". Note that the rate of decay of the tone is fixed by C12 and R15, whilst C11 and R13 control the shaping and keying. One cymbal stroke occurs every time a pedal key is operated.

The brush effect can be routed to either manual, but we only show one in the circuit. Of course, 61 of the 200 kilohm keying resistors are required. The circuitry is very similar to that just described. On actuating the cymbal stop switch, a small change in d.c. voltage appears at the base of TR1 when a key is used. This change is amplified by TR1 and appears in magnified form at one plate of C3. This voltage now passes through D2 and charges C4, reaching the base of TR2, which conducts and amplifies the noise from TR3. In the collector of TR2 is a circuit L1, C7 resonating at 11Hz. The pitch is thus higher than that of the pedal cymbal. The output of TR2 joins the common pre-amplifier TR4 and so meets the common line out. VR1 adjusts the "brush" output level whilst the decay time is set by C4 and R8.

There are in fact many circuits in use today to provide a cymbal-like sound; this one has been chosen because it is extremely simple.

REVERBERATION

Everyone knows that the effect of any music is greatly enhanced if it is performed in a large hall or building. This is because of reverberation, which broadly speaking means that some of the sound waves which do not travel directly to the listener are reflected from the walls, floor, and roof, and reach the ears of the listener at varying times all slightly later than the original sound.

In an ordinary living room, the carpets, curtains,

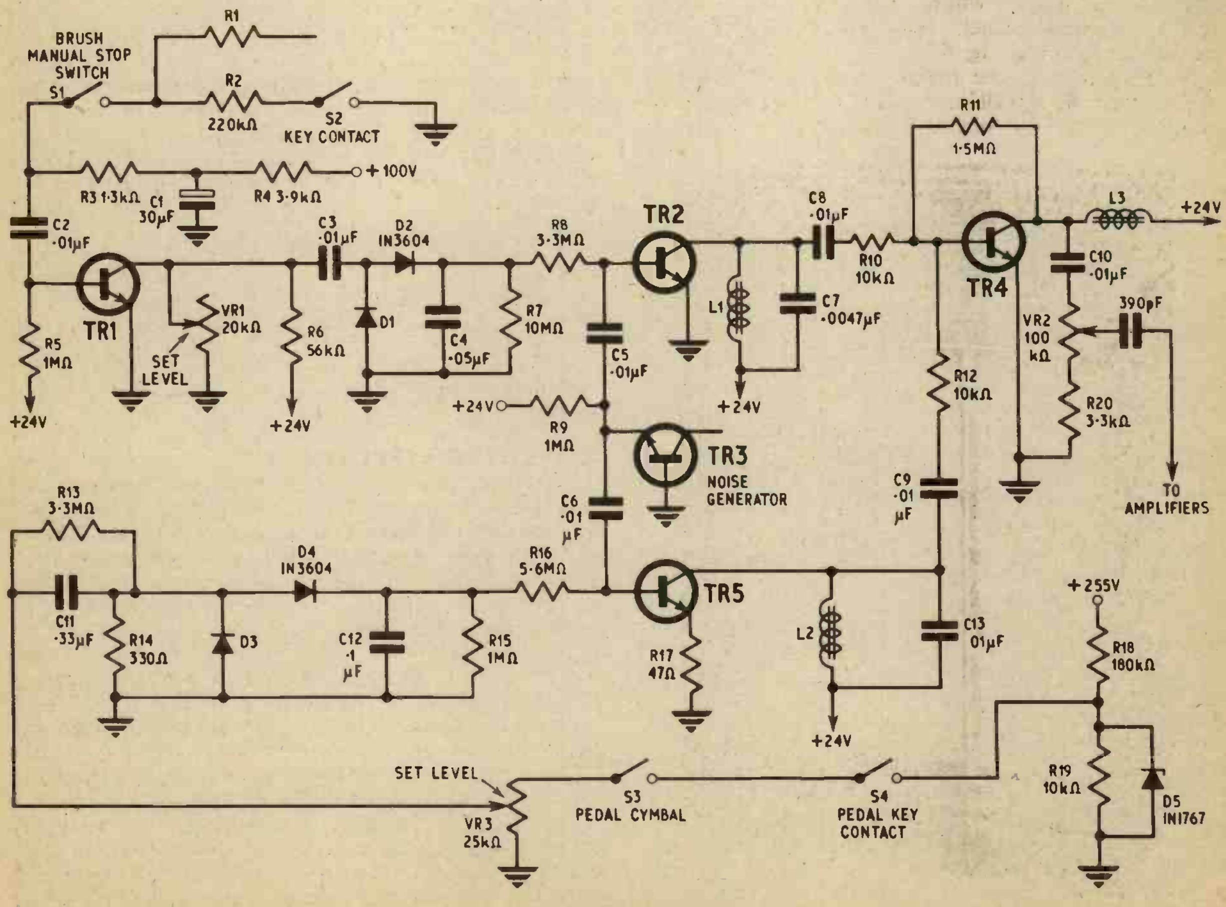

Fig. 6.4. Cymbal effect circuit

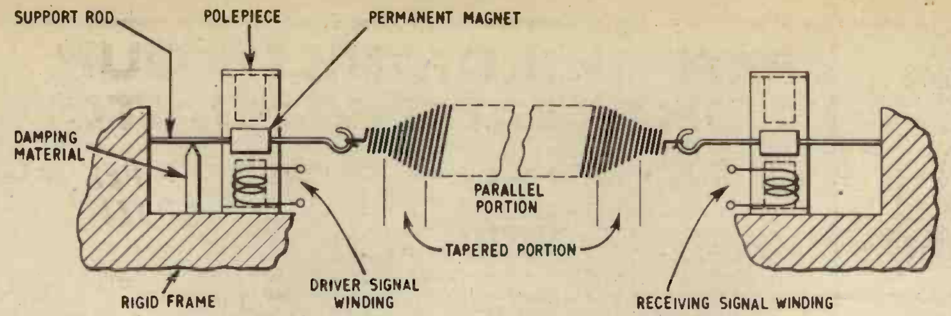

Fig. 6.5. Tapered spring reverberation delay line

and upholstery absorb all of the sound not coming directly to one's ears, and in any case the room is generally too small to contribute to reverberation. None would be evident in a room less than 30ft long or of about 4,000 cubic feet capacity.

Unfortunately the one instrument which benefits above all others from reverberation up to about 5 seconds is the organ. The sound tends to be clipped and lifeless without it, except at very low levels. However, we can produce some simulation of reverberation by causing part of the signal to traverse a delay line. It is then mixed with the instantaneous signal.

The most common method is to change the electrical signal energy into mechanical vibrations and then apply these to one end of a helical spring, in which (if properly proportioned) the rate of travel will be slowed down. The vibrations are then converted back at the end of the spring into an electrical signal by a transducer and coupled into the main amplifier circuit.

It has been customary to use one or more helical springs with adjacent coils not touching each other (or anything else); such springs, either horizontal or vertical, being driven at one end by a crystal or magnetic motor, translation of the mechanical vibrations at the other end being by the same means.

Now in a helix of constant diameter, no matter what this is, *the rate of propagation is the same for all frequencies*. Moreover, the signal must be held to a very low level to avoid over-driving the spring with consequent distortion and "flutter", and the lowest frequency transmitted must be well above the resonant frequency of the spring. Accordingly, some systems have used a plurality of springs, each favouring some particular frequency band. This is an attempt to imitate the actual time characteristics of the hall, where the unequal reflection lengths of the many pencils of sound cause the reverberant sound to arrive at different times at the ear of the listener.

With an organ the effect is further broadened by the fact that the treble pipes speak instantly, the bass pipes not so; this adds to the reverberant nature of the sound, but we will not notice this feature with an electronic instrument where the rate of speech is the same for all notes (in this kind of organ, at any rate; some instruments do have delays corresponding to the pitch).

TAPERED SPRING DELAY LINE

An ingenious way to overcome the frequency-insensitive properties of a helical spring is shown in Fig. 6.5. Here we have a spring which is partly tapered, partly of uniform diameter. Neglecting the narrow neck, which is common to many springs because of the means of attachment to the transducers, the spring is then gradually increased in radius for a distance. Since the mean turn length now alters, the rate of propagation for different frequencies will also vary; in other words, this part of the spring is frequency-sensitive, the helix radius differing for each component of the complex wave.

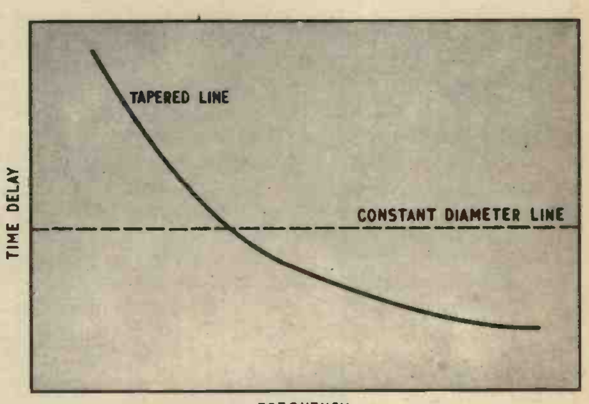

Fig. 6.6. Comparison of tapered and constant diameter delay lines

The energy is now transmitted along the constant diameter section of the helix until it reaches the far end taper, where the vibrations undergo a transition to the torsional mode and are converted back to an electrical signal by the receiving motor. These transducers may be crystals or electromagnetic, the latter being preferred as imposing less restraint on the delay line. Apart from the initial transport of the vibrations, as there is an impedance mismatch at the receiving end of the spring, some of the energy is reflected back again to the input end and in fact there may be a number of such reflections to and fro, the impulses gradually losing energy; in this way, the effect is like that of the concert hall.

A plot of the frequency response versus time for this delay unit is given in Fig. 6.6 with the response from a constant diameter spring shown dotted for comparison.

If used horizontally, it is permissible to support the spring in the centre by a thin nylon cord. Perhaps "spring" is not a very happy term in this application, since the coils will not touch if unloaded. The wire, 8 to 15 thou diameter, is wound like a spring but pulled apart so that adjacent turns cannot touch each other. Hard wire such as beryllium copper or music wire is preferred for the helix.

The next article will deal with the different methods of introducing vibrato into electronic organ circuits.

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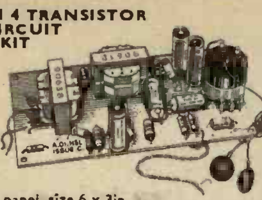

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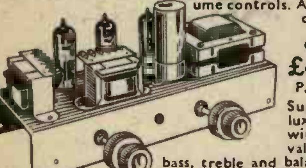

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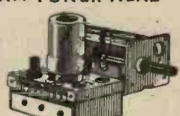

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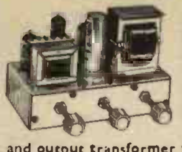

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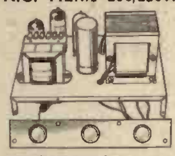

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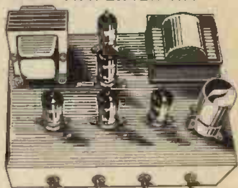

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DOOR SLAVE

PART TWO

By S.T. ANDREWS

LAST month's article described the Door Slave in theory. This concluding article deals with the practical aspect. Complete wiring diagrams for all units are included here, and also instructions for setting up the completed system.

Finally, a suggested method for obtaining "coded knocking" is outlined.

CONSTRUCTIONAL DETAILS

The basic unit, which contains nearly all the electronics, is best kept near the door so that the lead from it to the microphone can be as short as possible. It can be built into any convenient box and a suitable component layout is given in Fig. 6.

The components are mounted on a wooden baseboard measuring 6in × 7in.

Two 20-way group boards are used for the smaller components. The sockets SK1 and SK2 are actually B9A valveholders and these are fitted to a small bracket secured to one corner of the base board.

A metal box 4in deep fits over the base board, thus providing complete enclosure for the basic unit. The rear side of this box, or cover, carries the two jack sockets JK1, JK2 and the battery BY2; the latter is held against the side of the box with a simple metal clip. Two holes are cut in the box for SK1 and SK2, and two smaller holes (in the right-hand side) for the preset controls VR1 and VR2.

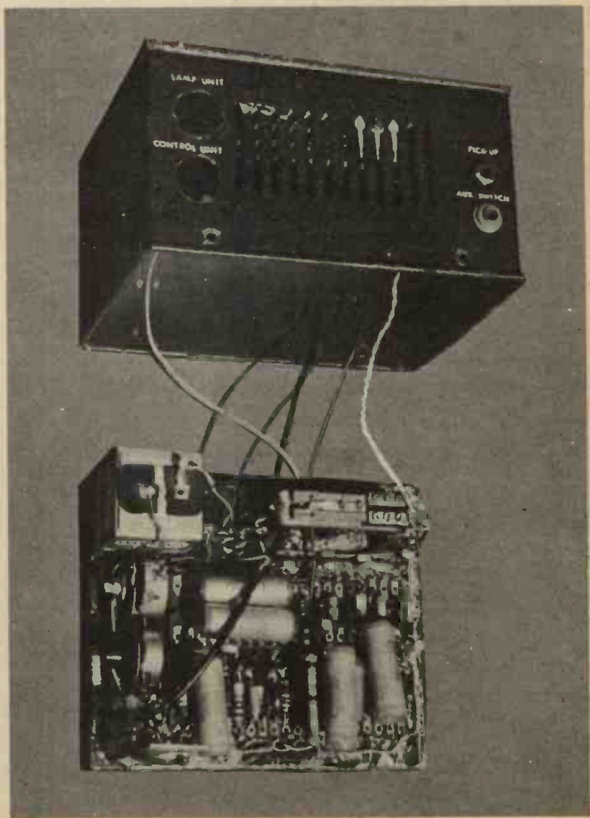
The cable running to the control unit can be several yards long, so the control unit can be some distance away if required.

The control unit made by the author utilises a small ex-G.P.O. telephone switchboard, as can be seen from Fig. 5 and Fig. 8. Such switchboards are often available on the "surplus market". It is not essential to use this particular unit, of course, and any "discrete" switches, either of the rotary or toggle kind, would serve equally well. The warning lamps, which form part of the telephone switchboard unit, could be dispensed with or, alternatively, individual lamp holders could be installed and wired up, one in association with each switch.

The size of the front panel is 12in × 4in. A view of this panel was given in Fig. 5 last month. Layout of components and wiring of the control unit is given in Fig. 8.

The 16-way group board shown to the right of the control unit in this figure contains the components of the "memory latch"—an optional extra which was described last month.

The power supplies for the memory latch can be separate batteries as indicated in Fig. 3 and Fig. 8, or those used for the main unit could also serve this additional unit. The memory latch was built into the control unit, as shown in the illustrations. It could, however, be incorporated in the basic unit if preferred.



The basic unit

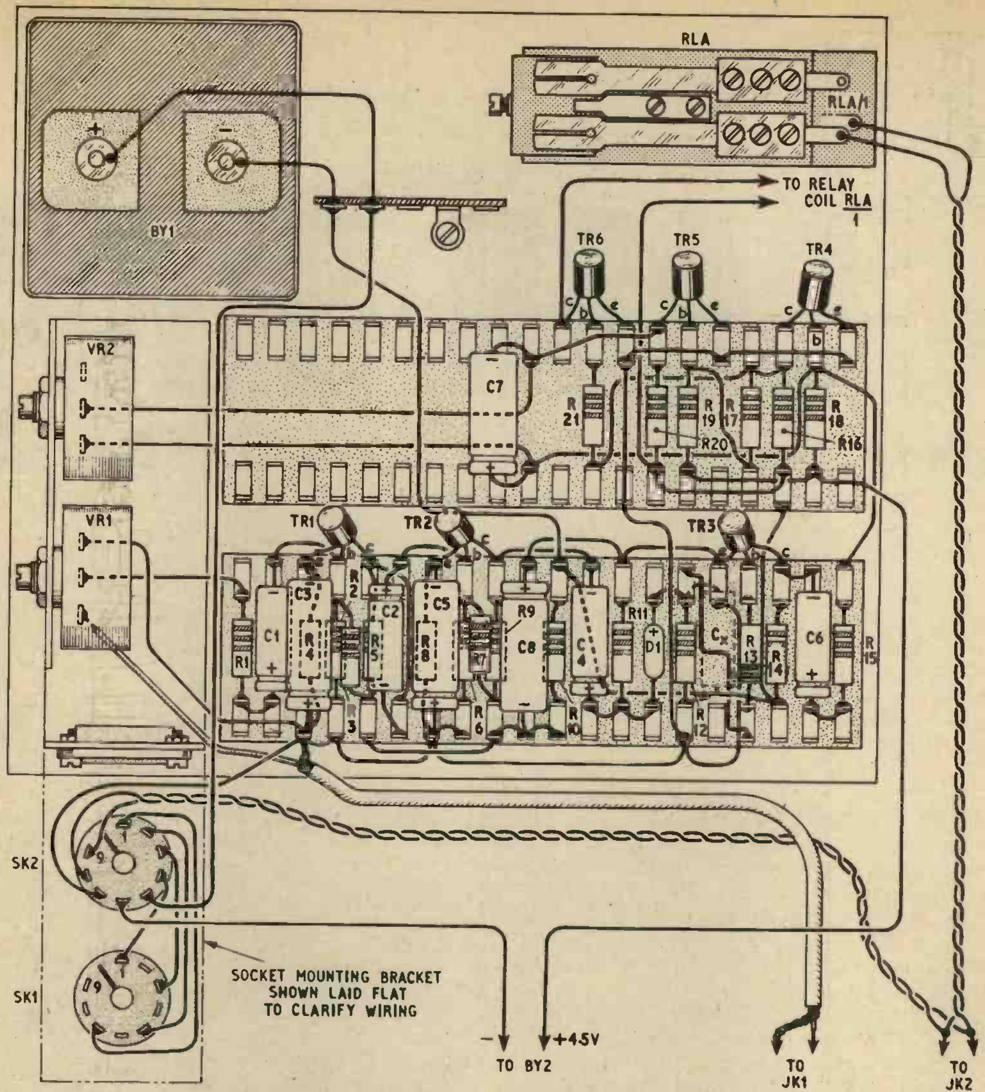


Fig. 6. Component layout and wiring for the basic unit

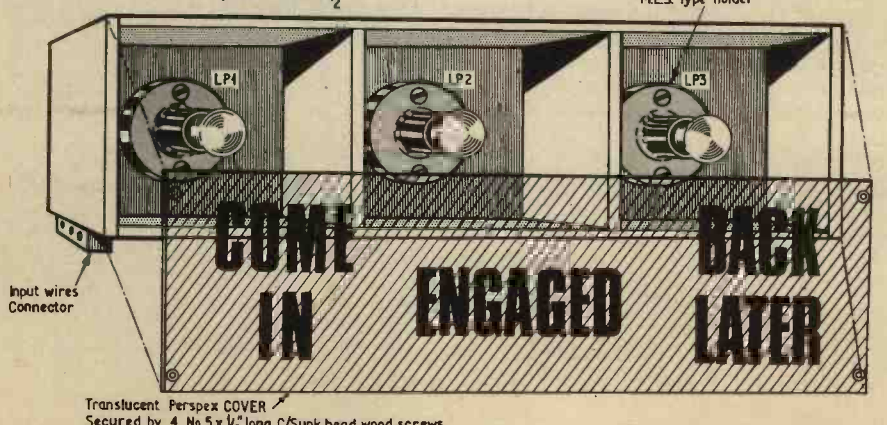


Fig. 7. The lamp unit

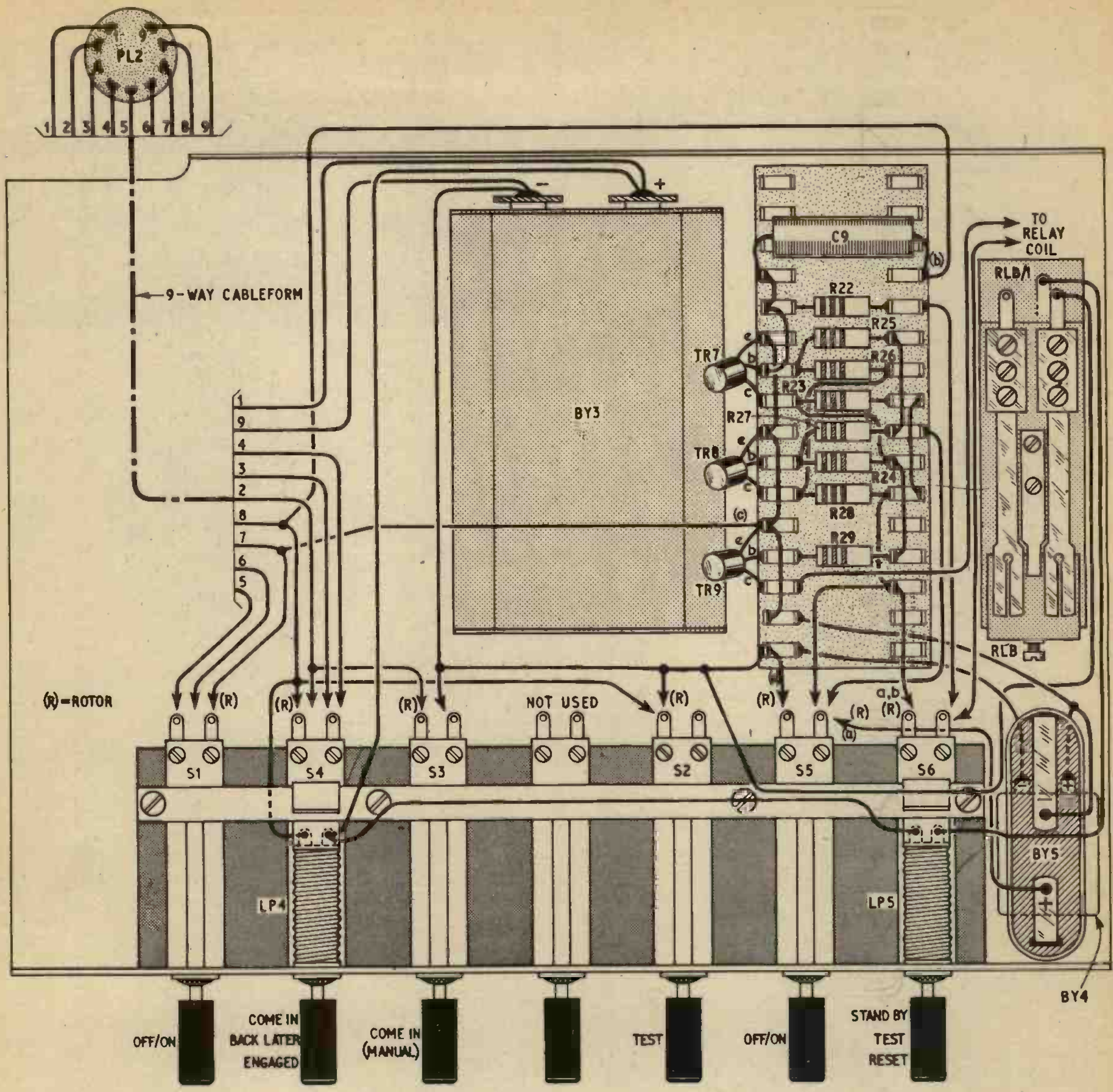


Fig. 8. Component layout and wiring for the control unit

Components . . .

MEMORY UNIT

Resistors

R22	2·2kΩ	R27	6·8kΩ
R23	1kΩ	R28	1kΩ
R24	4·7kΩ	R29	3·3kΩ
R25	6·8kΩ		
R26	4·7kΩ		

All ± 10%, ¼W carbon

Capacitors
C9 0·01μF paper

Transistors
TR7–9 OC71 (3 off)

Relay
RLB 500Ω coil. One make-break contact

Switches
S5 Double pole on/off
S6 Double pole 3-way

Lamp
LP5 6V 0·3A

Batteries
BY4 9V
BY5 4·5V

One 16-way group board

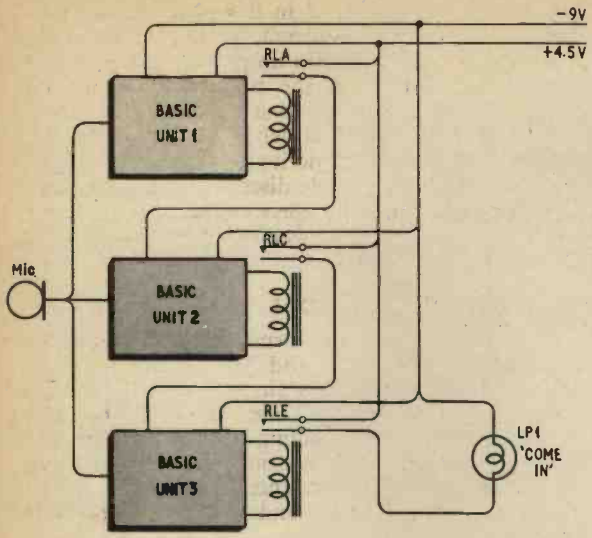


Fig. 9. A possible system for "coded knocking"

The lamp unit can also take any convenient form, one suggested pattern is given in Fig. 7. This is a three compartment box made of plywood and measures 3in by 1½in by 8in. The front panel consists of a piece of opaque plastic with the appropriate legends printed on the inside.

SETTING-UP PROCEDURE

When setting the pre-set controls it is best to adjust first the flip-flop bias control VR2. This has an effect on the length of time that the flip-flop remains in the triggered state. With VR2 turned to maximum resistance TR4 will be unable to conduct any of the time and the circuit will remain permanently in the triggered state. If VR2 is set to minimum then TR4 will conduct heavily all the time and applying a trigger pulse will have no effect on it. Between these two extremes there is a point where triggering the circuit causes TR5 to begin conducting and continue to do so for 3–5 seconds. The most convenient way of triggering the circuit at this stage is to short briefly the emitter and base leads of TR4 with the metal blade of a screwdriver.

The sensitivity control VR1 is adjusted so that the appropriate loudness of knock causes the circuit to operate. If the sensitivity is too high then other sounds can trigger the circuit at the wrong time.

CODED KNOCKING

A more elaborate version of the Door Slave uses several basic units and illuminates the "Come In" lamp only if a certain sequence of knocks is heard. One version of this is given, in block diagram form only, in Fig. 9. Three basic units are used and the output relay of each of the first two units supply power to the next one; only the third one lights a lamp. With this arrangement the lamp will light only if three knocks are heard in quick succession. Other systems of connection will make the arrangement respond to other types of coded knocks. There is obvious scope here for further development of the system so that even more complicated "knocking" procedures are needed to operate the device. ★

BASS GUITAR

By

S. Simpson

The bass guitar described in this article is not particularly difficult to construct, but the author would point out here that the strain on parts of a bass guitar is very great and, while the prototype has proved highly satisfactory both for tone and keeping in tune, the success is attributed largely to the method and materials used in its construction.

And now, having probably discouraged a few would-be bass guitarists and doubtless whetted the eagerness of many others more venturesome, we will see how the guitar is made.

GENERAL DESCRIPTION

The body of the guitar is formed from two sheets of $\frac{5}{8}$in blockboard, the neck and head is one piece of solid oak, the fingerboard is $\frac{1}{8}$in mahogany-faced plywood, and the "trimmings" are $\frac{1}{16}$in white Perspex. The metalwork is mainly aluminium and duralamin; the bridge adjusting screws are mild steel. The pick-up is a "bought-in", high impedance component.

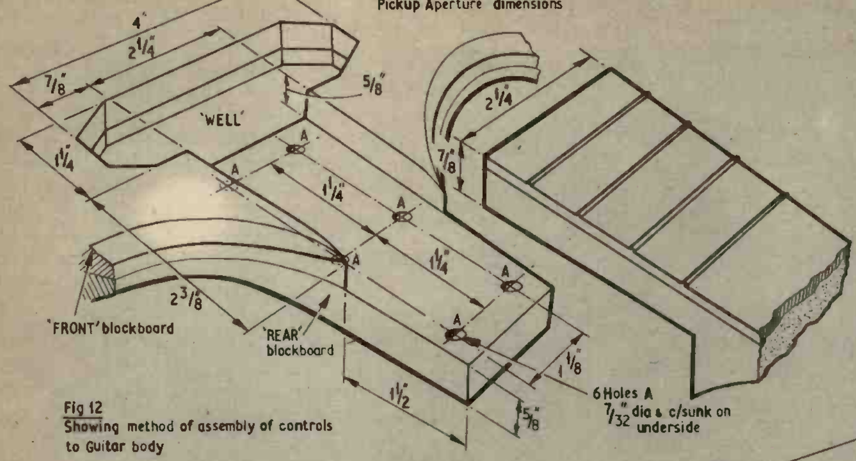
Other components are standard items, obtainable anywhere.

The strings are a standard set and the maximum string length from bridge to nut or string spacer (where the neck becomes the head) has been set at $30\frac{1}{2}$in. A longer span gives a tighter E string with less likelihood of "rattle", but, unless the neck is reinforced by a steel truss, the neck will yield and become permanently distorted. The present model will rattle if it is played violently, but the output from this guitar, *played normally*, has proved ample in quite "noisy" conditions.

All materials and items required are specified in the Parts List.

No attempt will be made to estimate costs, as prices for these materials may vary quite widely throughout the country. The most costly item, of course, is the pick-up and will probably run to 6gn approximately. As stated earlier, intending constructors may have their own ideas, enabling them to use materials at hand; the following instructions, in such cases, should serve as a reliable guide to what is necessary.

FIG 2
Showing Finger Board Neck Cutout and Pickup Aperture dimensions



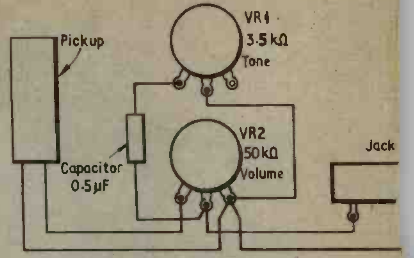
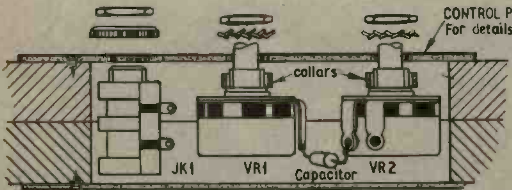


FIG 11

Fig 12
Showing method of assembly of controls to Guitar body



Additional collars to be used if threaded bush projects to far above Control Plate

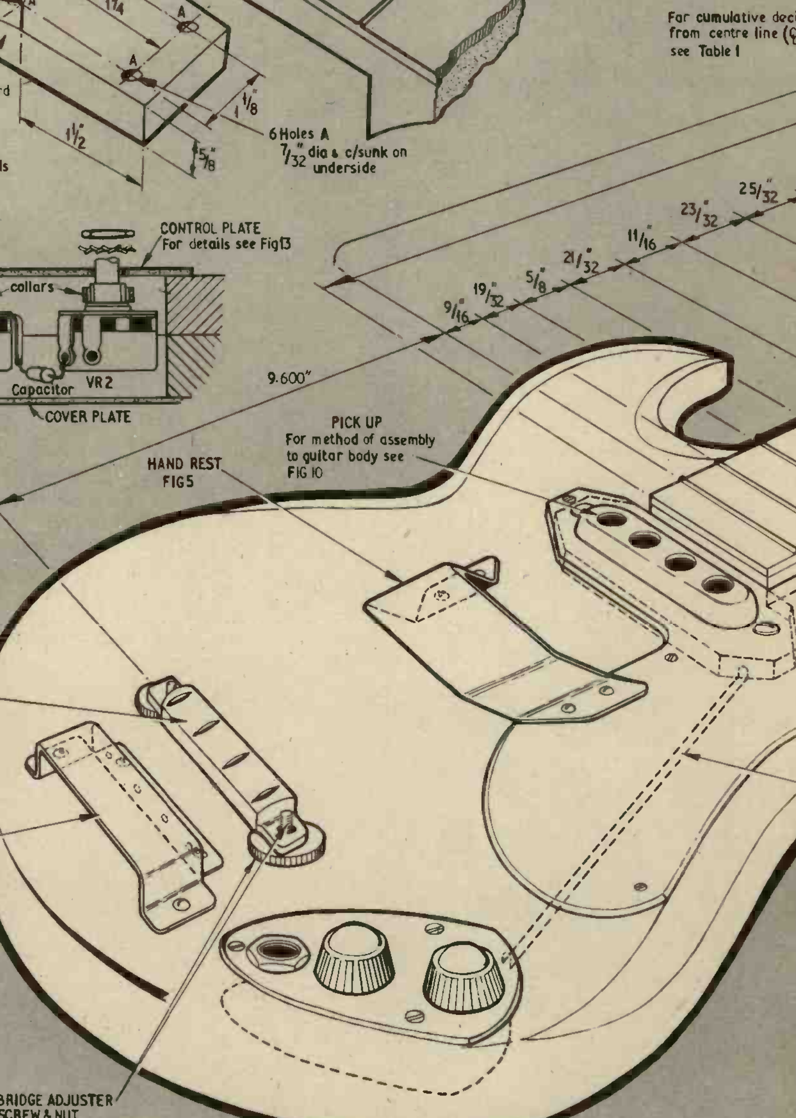
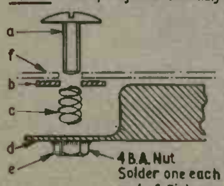


FIG 10 Pick up adjuster assembly



a) Height adjustment screw
b) Perspex washer
c) Compression spring
d) Pick up fixing lug
e) 4 B.A. Nut
f) Guard Plate

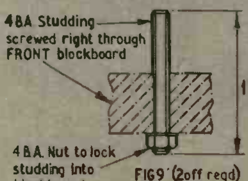


FIG9 (2off reqd)
Scale: 1:2

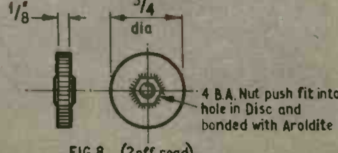
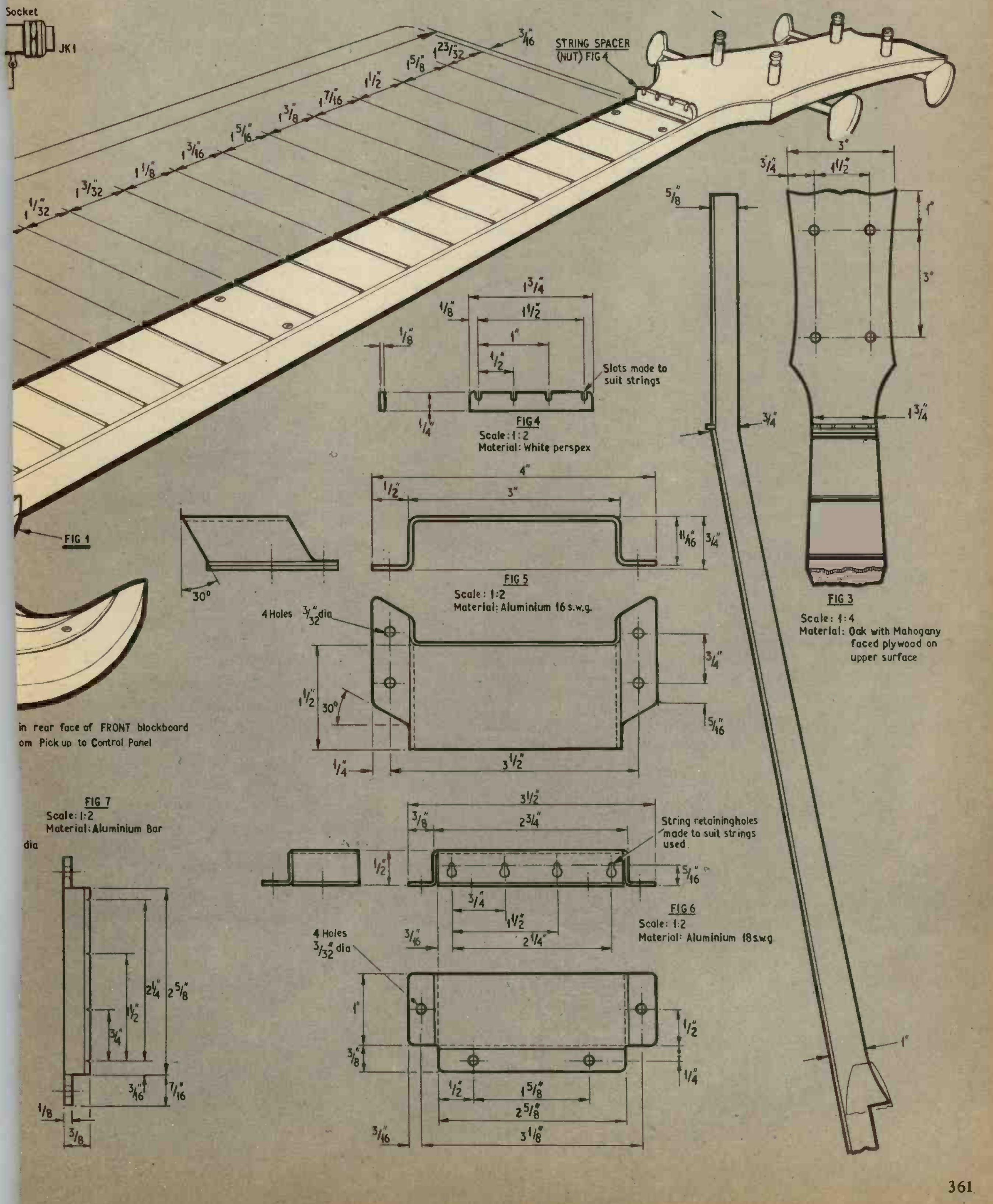


FIG 8 (2off reqd)
Scale: 1:2
Material: White Perspex

BASS GUITAR CONSTRUCTIONAL DETAILS



MAKING THE BODY

Begin by marking out one piece of blockboard to the pattern shown in Fig. 13, which is a half-scale drawing of the body. Using a coping saw, cut out the shape; again using the coping saw, cut the bevel shown down to $\frac{1}{4}$in from the underside of the workpiece. Finish off, using a rasp to begin with and progressing through fine, to very fine, glasspaper.

Treat the second piece of blockboard in the same way, then, first protecting the surfaces of the two pieces, clamp them in a vice, ensuring that the edges match as nearly as possible. Finish off the shaping with the pair thus matched. These two body pieces will be subsequently referred to as the "front" and the "back", respectively.

CUTTING THE APERTURES

Separate the two body pieces; lay the "back" piece aside meantime.

Study Fig. 2 in relation to Fig. 1 and note how the aperture for the pick-up and the slot for the neck are cut in one process. The entire thickness of the "front" is removed and a "well" will be cut from the "back" later on to accommodate the depth of the pick-up. The neck will fit on to the upper surface of the "back", and be snugged between the walls of the cutaway in the "front", as described in detail under "The neck and head".

The dimensions given in Fig. 2 suit the Burns "Tri-sonic" pick-up; if a different pick-up is to be used, these dimensions will change, of course, and probably the well in the "back" also. All cutting must be accurate, especially where the neck is to fit.

No dimensions are given here for the aperture to accommodate the volume control, tone control, and output socket, as these depend upon the items obtained. Approximate positions for them are shown in Fig. 1. The piece is removed from "front" and "back"; the controls will be concealed by a Perspex plate providing access to the controls for maintenance. The controls should not be crushed needlessly; in any case, room for rotation of knobs and clearance for the output cable will partly determine the spacing of the controls and socket.

A groove, shown as a dotted line in Fig. 1, accommodates the twin lead from the pick-up to the volume control. This should be cut into the underside of the "front" and extend from the pick-up aperture to the volume control aperture.

The "back" must be recessed where the pick-up will lie; only enough material should be removed to provide the necessary depth.

This completes the preliminary work on the body, which can now be enamelled and left to dry.

THE NECK AND HEAD

The shape of the neck is shown in Figs. 1 and 3. In the prototype, the angle at the head was obtained by using a milling machine; if this is not possible, it must be cut by a coping saw, shaped by a rasp, and smoothed off, using various grades of glasspaper. Dimensions of the stub fitting into the channel already cut in the body are given in Fig. 2. The stub should be a tight fit.

The head can be drilled to take the pegs of the machine heads at the points indicated in Fig. 3, but the heads themselves should not be fitted until the neck and head have been enamelled (or finished in some other way).

TABLE 1
Distance from Datum (centre line of bridge) 9·6in

Fret No.		Fret No.		Fret No.	
1	10·17in	8	15·25in	15	22·84in
2	10·77in	9	16·15in	16	24·20in
3	11.42in	10	17·11in	17	25.64in
4	12·38in	11	18·13in	18	27·17in
5	13·11in	12	19·21in	19	28.78in
6	13·58in	13	20·35in	20	30·50in
7	14·39in	14	21.56in		

THE FINGERBOARD

The fingerboard can now be attended to. Cut the plywood to the dimensions shown in Figs. 1, 2 and 3. Note that the top fret is set $\frac{3}{16}$in from the end of the board, then mark off for fret positions at the distances quoted in Fig. 1 and Table 1. Cut to the depth of the tongue on the fret-wire, using a fine saw-blade such as the "Junior" hacksaw, or a fret-saw. If the cutting is very carefully done, so that the frets are a tight push-fit, no adhesive will be necessary as the strings themselves will hold the frets quite firm. Cut and fit the frets, then attach the fingerboard to the neck, using "Evostik".

THE NUT OR STRING SPACER

The nut or string spacer is cut from white Perspex to dimensions given in Fig. 4. The channels to hold the strings are of various widths and should be a fairly close fit. When prepared, put the nut aside for assembly later.

THE HAND REST

The hand rest is cut from 16 s.w.g. sheet aluminium to the shape shown in Fig. 5, then drilled and bent to the shape shown. It will be secured to the body by four $\frac{1}{2}$in No. 2 round head plated woodscrews.

THE BRIDGE

The bridge can be fashioned from either $\frac{3}{4}$in diameter duralumin, if milling is available, or from $\frac{1}{2}$in square stock if to be filed to shape. (If the reader cannot operate a milling machine, but knows someone who

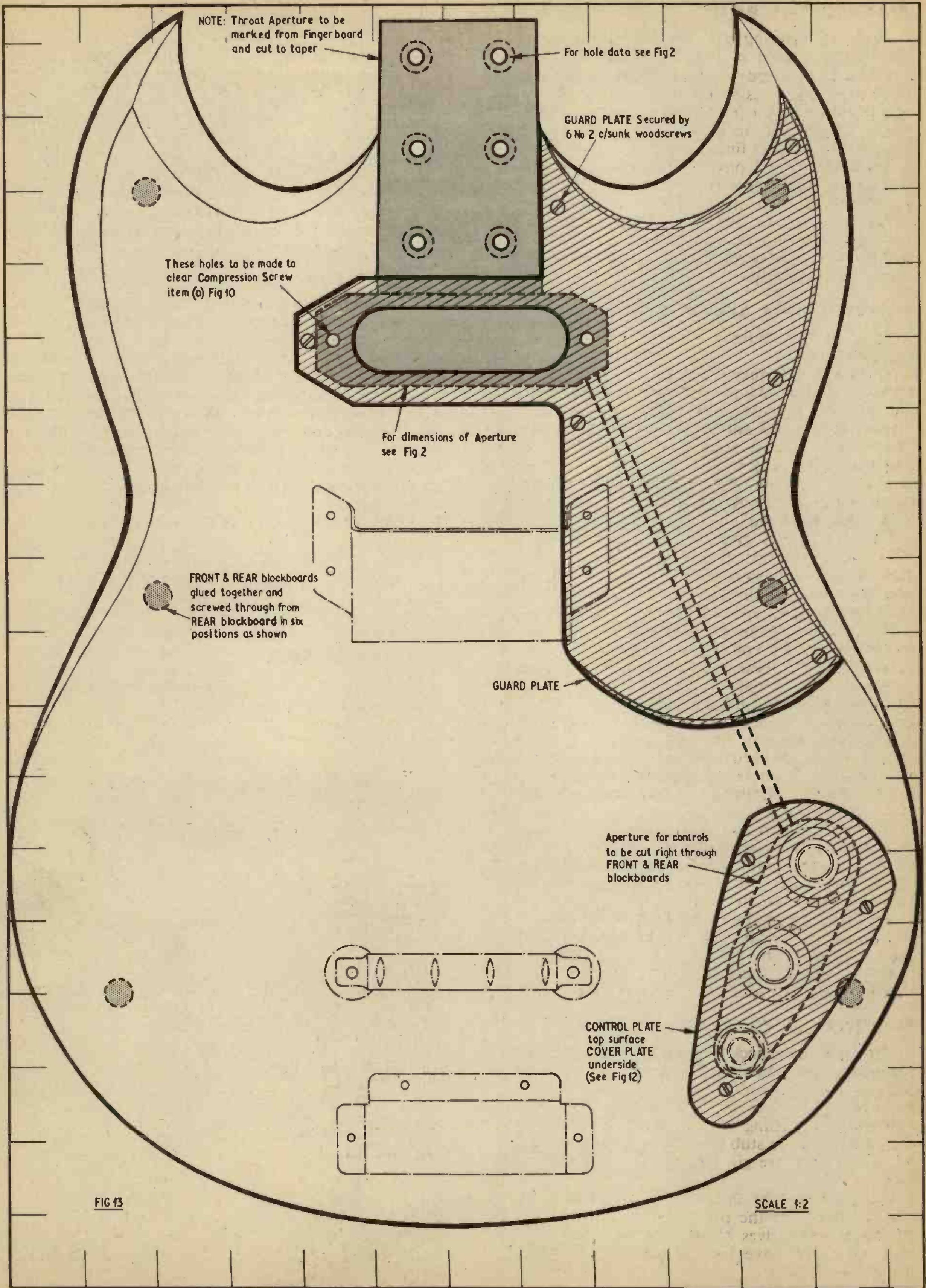

NOTE: Throat Aperture to be marked from Fingerboard and cut to taper
For hole data see Fig2
GUARD PLATE Secured by 6 No 2 c/sunk woodscrews
These holes to be made to clear Compression Screw item (a) Fig10
For dimensions of Aperture see Fig 2
FRONT & REAR blockboards glued together and screwed through from REAR blockboard in six positions as shown
GUARD PLATE
Aperture for controls to be cut right through FRONT & REAR blockboards
CONTROL PLATE top surface COVER PLATE underside (See Fig12)
SCALE 1:2

FIG 13

can, he should show the person the drawing given in Fig. 7, which is adequate for an experienced machinist.)

Dimensions must be strictly adhered to, otherwise the string spacing may make fingering difficult. The bridge will be secured to the body by two specially-made screws described in the next section.

BRIDGE ADJUSTER SCREWS AND NUTS

The bridge adjuster screws are fashioned from two lengths of 4B.A. studding screwed right through the "front" blockboard, Araldited, and locked on the rear face with a 4B.A. nut (Fig. 9).

The adjuster nuts are made from white Perspex discs, ¾in diameter and ⅛in thick. The rims of the discs are serrated with a fine saw. A hexagonal hole is made in the centre and a 4B.A. nut is firmly Araldited in place, see Fig. 8. (First drill a ¼in hole in the disc and then file out the hexagonal shape.)

THE STRING ANCHORAGE

The string anchorage is also manufactured from 18 s.w.g. aluminium as shown in Fig. 6. The string anchorage will be secured to the body by four ½in No. 2 plated screws, *provided the material used for the body is hard*; if soft, a longer screw must be used.

GUARD PLATE, CONTROL PLATE AND COVER PLATE

The guard plate, control plate, and cover plate are cut from white Perspex to the shapes shown in Fig. 13, or to the reader's own liking.

The only particular part is that surrounding the pick-up aperture and, here again, the pick-up obtained will determine the shape of the guard plate. The control plate shape will be determined by the type of components used, as also the cover plate to be fitted at the back of the instrument directly above the controls. Those shown in Figs. 1, 12 and 13 are typical readily available items.

ASSEMBLING THE GUITAR

Have at hand the two parts of the body, the guard plate, the pick-up, the tone control and volume control, the output socket and the pick-up height adjuster screws and compression-springs shown in Fig. 10. It is assumed that the pick-up already has threaded holes in the lugs; if not, a 4B.A. nut should be soldered to the underside of each lug, as shown in Fig. 10, first removing any plating on the surface to be soldered. As most metals transmit heat rapidly, the nuts should be fitted by a person experienced in *quick* soldering; damage to the pick-up might ensue if the application of heat is prolonged.

Fit the pick-up to the guard plate as shown in Fig. 1, gently compressing the springs meantime. Lay the pick-up into the aperture in the body "front", then screw down the guard plate, using small plated countersunk woodscrews.

Fit the tone control, volume control and socket to the controls assembly plate. Connect the wiring as shown in the circuit, Fig. 11, and the "back" and "front" may then be assembled by glueing and screwing, using six 1in No. 6 c.s.k. woodscrews in the positions indicated in Fig. 13. Check that the wiring is still intact, then fit the cover plate over the aperture at the controls (looking at the "back" of the instrument).

The neck should now be fitted and attached by six 1¼in No. 6 woodscrews (no glue is used, thus allowing for packing pieces to be inserted if necessary to clear the pick-up polepieces; the screw adjustment at the bridge should, however, take care of clearance if all cutting and shaping has been done accurately).

Summing up; so far we now have the head and neck (complete with fingerboard and frets) assembled to the body (complete with pick-up, controls and socket). At this stage the neck and head can be enamelled, or polished as the reader desires, then the final assembly items can be fitted.

MACHINE HEADS

The machine heads must be strongly built. The author found that right-hand heads appear to be sturdier than "lefts" (for no known reason) and he eventually converted two "rights" to form two "lefts". The method was quite simple and obvious. Advice should be obtained from the dealer regarding heads.

Having converted two of the machine heads, all four should now be fitted.

STRINGS AND POSITION OF ANCHORAGE

Have the nut or string spacer (Fig. 4) close at hand. Pass the No. 1 string and No. 4 string through the anchorage and attach each to its respective machine head. Tighten both until the strings are just taut when the anchorage is held at its allotted position (Fig. 1). Set the nut under the string at the head, then laterally adjust the anchorage so that each string lies approximately central about its polepiece on the pick-up. (Do not bother about clearance just yet: *lateral* position is the matter in hand.) Having set the anchorage, mark through the fixing holes. Slack off the strings and screw down the anchorage.

THE BRIDGE

Tighten the strings just taut, then insert the bridge under the strings at a point 9·60in from the nearest fret. If cutting and slotting have been accurate, the strings should accept the bridge without movement across the polepieces. Mark through the bridge fixing holes, then slack off the strings and remove the bridge. Drill for the bridge screws (remember that these *must* be a tight drive-fit) and fit the screws quite vertically. A block of hardwood will protect the screws when fitting them.

Fit the adjusters and run them down to the bottom of the threaded screws. Fit the bridge, then pass the remaining strings through the anchorage, and the bridge, over the nut and on to the machine heads. Set the strings just taut and check clearance at the pick-up when each string is pressed against the fret nearest the pick-up. Adjust for minimum clearance by screwing the adjusters upward on the bridge screws. Note that the bridge can be set at a small angle from horizontal to allow for the considerable difference and thickness between No. 1 and No. 4 strings. The nut should remain quite firm without any fixative and is, in fact, better free as this allows the strings to take up a "natural" position.

The hand rest can now be fitted over the strings as shown in Fig. 1 and this completes the assembly of the guitar.

TRYING OUT THE GUITAR

Tune the strings against another guitar, or by piano or other instrument. Insert the output cable and connect it to a suitable amplifier either known to the reader, or in the care of someone who does know the control functions. Switch on the amplifier at low volume, and normal tone. Set the tone control at half-traverse and the volume control likewise. Pluck the No. 4 string and check that the loudspeaker responds.

Continue plucking, meanwhile turning the volume control clockwise; check that the loudspeaker output increases. If it *diminishes*, the volume control *outer* connections at the guitar must be changed over, but before doing so, check that the tone becomes less deep as the tone control is turned anticlockwise. If it becomes *deeper*, the *outer* connection on the tone control must be changed over to the (at present) unused outer connection. Return the tone control to mid-position.

If all is well, try out the No. 1 string, increasing volume carefully. When at maximum setting on the guitar, gently increase volume at the amplifier. At some point, the loudspeaker may "break" from a clear string note to a rattle. This is just beyond the maximum setting the amplifier can take; reduce the control slightly.

Now check the effect of tone controls by adjusting anticlockwise to increase depth, still striking No. 4 string. At some point, rattle may again be encountered and two remedies are possible—(a) reduce volume at the amplifier or (b) reduce depth at the tone control on the guitar. (This is the "getting to know" process.) Volume and depth should be very much more than ample before these limiting conditions are reached.

Now strike the string with the No. 4 string pressed to the bottom fret (nearest pick-up). Check that, when strongly struck, it does not vibrate against the pick-up. If it does, the bridge adjusters must be raised slightly (this will probably entail a small increase of volume control setting to obtain maximum permissible volume).

A little practice along these lines should quickly enable the guitarist to set his instrument against any other high impedance amplifier he may encounter in travelling from one group to another. ★

MATERIAL REQUIRED

2 pieces blockboard, 18in × 18in × $\frac{5}{8}$in
1 piece oak, 30in × 3in × 2in
1 piece high-quality $\frac{1}{8}$in plywood, 30in × 2$\frac{1}{2}$in (mahogany finish)
1 piece 4B.A. studding, 3in long
1 piece duralumin, 4in long × $\frac{3}{4}$in diameter. (This may be 4in long × $\frac{1}{2}$in square; see text under heading "The Bridge")
1 piece 16 s.w.g. sheet aluminium, 5$\frac{1}{2}$in × 2in
1 piece 18 s.w.g. aluminium, 4$\frac{1}{2}$in × 2in
1 piece white Perspex, 1$\frac{3}{4}$in × $\frac{1}{4}$in × $\frac{1}{16}$in thick
1 piece white Perspex, 8in × 8in × $\frac{1}{16}$in
1 piece white Perspex, 1in × 2in × $\frac{1}{8}$in
1 set (four) heavy duty machine heads ("string winders"), all metal
1 set bass guitar strings for *electronic* guitar
4ft length of T-section fret-wire for bass guitar
8 $\frac{1}{2}$in No. 2 round head woodscrews, preferably plated
12 $\frac{1}{2}$in No. 2 csk woodscrews, preferably plated
6 $\frac{3}{8}$in No. 10 csk woodscrews
6 1$\frac{1}{4}$in No. 6 csk woodscrews
6 1in No. 6 csk woodscrews
4 4B.A. full nuts and 2 washers
Quantity "Evostik"
White undercoat paint
White brushing Belco (or a similar self-spray enamel)

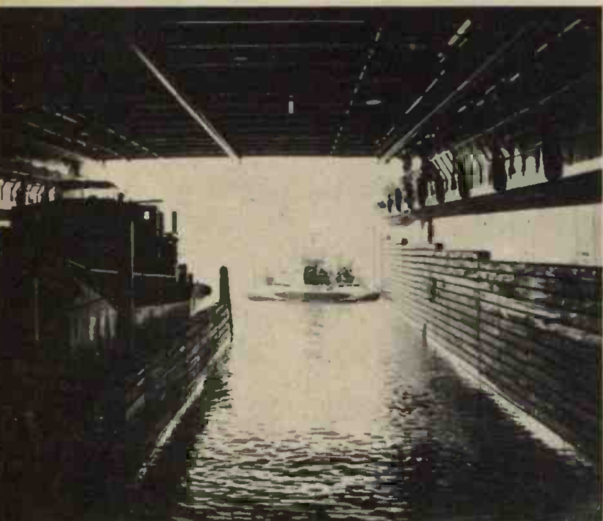
CIRCUIT COMPONENTS

VR1 3,500Ω potentiometer (tone control)
VR2 50,000Ω potentiometer (volume control) both preferably semi-miniature, 1in dia.
C1 0·5μF 150V working. (The working voltage is not important; small physical size matters)
X1 Four-pole pick-up. (Prototype incorporates a Burns "Tri-sonic" which is very satisfactory for operation with a high-impedance, high-power amplifier)
JK1 single-pole jack socket (Belling)
PL1 single-pole jack plug to suit JK1 (Belling)
Two control knobs, to fit volume control and tone control

ELECTRONORAMA

New Assault Ship has Docking Eyes

THE latest Royal Navy assault ship, due to serve East of Suez in September, has massive docking facilities for landing barges, hovercraft, helicopters, tanks, and armoured vehicles. This ship, H.M.S. *Intrepid* (above), carries a comprehensive communications network which is necessary for co-ordinating the activities of about 590 officers and men of the Royal Navy, Royal Marines, and the Army. Up to 700 troops can be carried in addition.



One essential feature of interest is the use of closed circuit television cameras in the docking area and decks to ensure maximum packing of the various vehicles. H.M.S. *Intrepid* is to relieve H.M.S. *Fearless*, a similar ship whose docking area is shown on the left with a landing barge and hovercraft.

Four *Seacat* guided missiles and two 40mm guns are fitted armaments on *Intrepid*, which was built and commissioned at John Brown's shipyard, Glasgow.

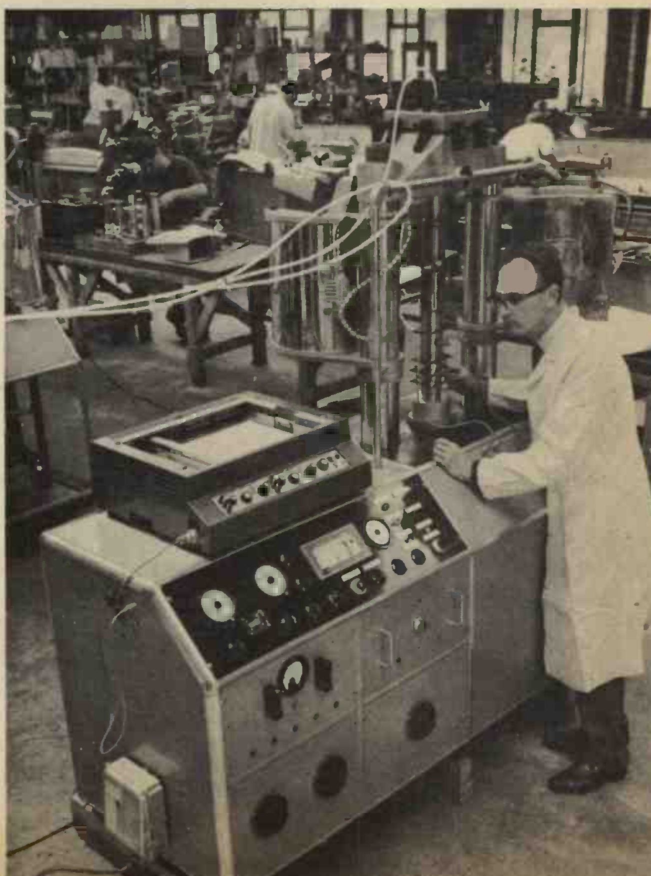
Plotting Strain in Tensile Testing

RECORDING and measuring strain in conjunction with tensile testing machinery is one of the many operations which was a problem until the introduction of compact, highly sensitive and extremely accurate XY Plotters. The problems arose out of the fact that materials are tested in both tension and compression, often at temperatures in excess of 700°C.

Measuring equipment which is capable of plotting a load/strain diagram and of detecting fractional movement of the test specimen with complete accuracy, thus has an indispensable role in tensile testing.

In this photograph (right) we show a combination of a Mand High Strain Fatigue Machine and a Bryans 20000 series XY Plotter.

The machine has a fully automatic push/pull testing facility, capable of applying cyclic modes of up to 25,000lb on either tension or compression and at temperatures of up to 750°C.



Driver Teaching System

A NEW system for teaching people to drive was introduced in March when the first "Drivotrainer" school was opened in Nottingham.

The method of teaching involves watching the actions of the driver on the screen, and then later the pupils looking straight through the windscreen and completing the actions themselves. In each film there is a test period, during which time an electronic machine records all the movements of each pupil. After the films have been shown the instructor can point out to the class everyone's mistakes.

Cables Down Under

BELOW the London underground railway, is a complex of tube tunnels probably unknown to many people. Built on similar principles to the railway tube, this system of tunnels holds the secret to telephone communications in London.

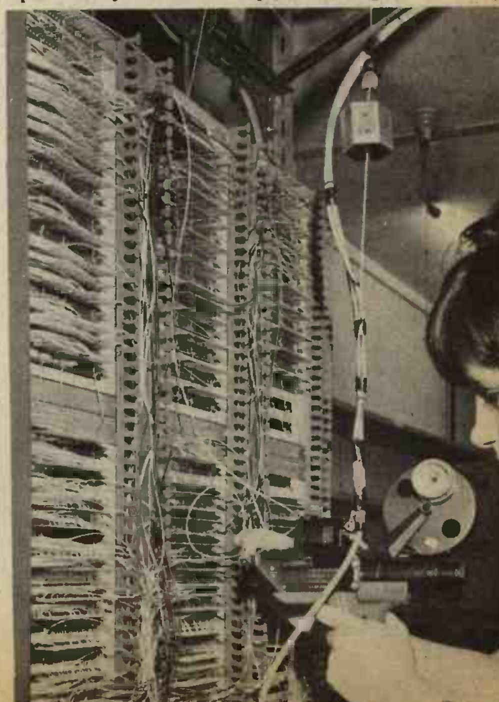
A lift shaft takes engineers 100ft below ground at the Post Office Tower to a surprisingly clean and odourless environment to instal cables between main exchange centres. Our picture below shows an electric tractor, 18in wide, pulling a long cable off a drum and through the tunnel, to be lifted on to the side carrier arms later.

Mechanical Wiring Gun

A QUICK and effortless method of making wire connections to tags is the "Termi-Point" system of solderless connections.

The picture (below) shows an operator using the A-MP Termi-Point gun to make a connection on a digital logic box that may require as many as 800 connections to the square foot.

Based on the standard Termi-Point gun, which is pneumatically powered and uses a magazine to contain a supply of connectors in continuous reel, LDEP Industrial Automation have developed a technique of presenting the wiring instructions to the operator by the use of tape recordings.



AUDIO FAIR SPECIAL

New products for the delectation of audio enthusiasts appear in above average variety at this time of the year. The reason, of course, is the Audio Festival and Fair, held from March 30 to April 2 in London. This annual event marks the unveiling of interesting developments to which manufacturers have been putting finishing touches during the late winter months. This article, largely devoted to components and systems prepared for introduction at the exhibition, is necessarily a *pre*view because this issue went to press before the doors opened.

In some instances full specifications were not available in advance of the exhibition; this is true of hi fi units by Armstrong, further details of which will follow as soon as possible. This firm has introduced a completely new range, the Series 400, comprising a transistor tuner and tuner-amplifier as well as a stereo amplifier. The whole series is designed for either shelf-mounting or easy cabinet fitting. Amplifier power outputs are about 15 watts per channel. A transistor decoder is available for stereo radio.

SILICON TRANSISTOR UNITS

Indeed, stereo radio and transistor applications are major talking points this year. Both these subjects are within the province of firms such as Ferranti who are concerned to promote the use of silicon transistors. This particular company has prepared a book of audio circuits for amateur and professional users; one design shown is an f.m. stereo tuner which uses low cost epoxy resin encapsulated transistors. Enquiries should be addressed to the company at Gem Mill, Oldham, Lancs.

Truvox now use silicon transistors in their Series 100 equipment, which includes several tape recorders as well as the TSA100 amplifier and FM100 tuner. Other firms going ahead with transistors include Radford and Goodmans. The latter now offer a stereo a.m./f.m. tuner, the "Stereomax," to match the Maxamp 30 amplifier.

Units bearing the "Arena" trademark are made in Denmark and imported by Highgate Acoustics of London. Several new arrivals include the T2500H stereo receiver with a pre-selection f.m. tuner coupled to 15 watt power amplifier channels. This model sells at £90 8s 7d plus 6 gns for a stereo decoder. Rather similar is the T2500F which, at £84 1s is presented as a tuner-amplifier without speakers.

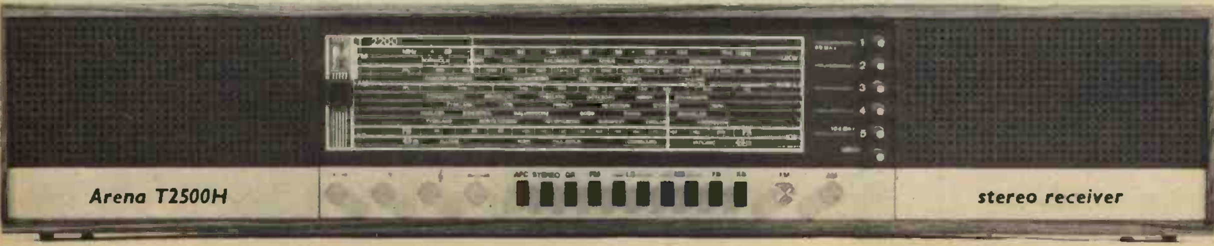
Armstrong 426 tuner-amplifier

Model F210 stereo amplifier by Arena, priced at 36 gns and rated at 10 watts per channel, is an encased unit finished in teak. It has input arrangements for magnetic pick-up (3mV sensitivity), radio tuner, tape recorder and crystal pick-up (the latter despite the preponderance of ceramic types now used for hi fi). As usual with Continental amplifiers, the output impedance is low (4 ohms in this instance) but Arena market a wide range of matching speaker systems.

Stereosound, who some time ago introduced a low cost stereo outfit with separate speakers, have now added a one-piece instrument which sells at 63 gns. Known as the SS16, this model has an output of 8 watts per channel and incorporates a speaker system comprising a bass unit in each end of the cabinet plus a pair of front-facing tweeters. These units are isolated within their own enclosures. This outfit, which employs the B.S.R. UA70 player, will also be available in a version with a.m./f.m. tuner, stereo facilities being provided if required.

SPEAKER SYSTEMS

A new medium-sized system, the Sarabande by Richard Allan Radio, houses three drive units. The aim of no-compromise bass reproduction down to 30Hz is realised, the firm claims, by using a 15in unit in a 4 cu ft enclosure. The rest of the range is covered by a mid-range and tweeter assembly of modular type complete with crossover filter. Enclosure dimensions



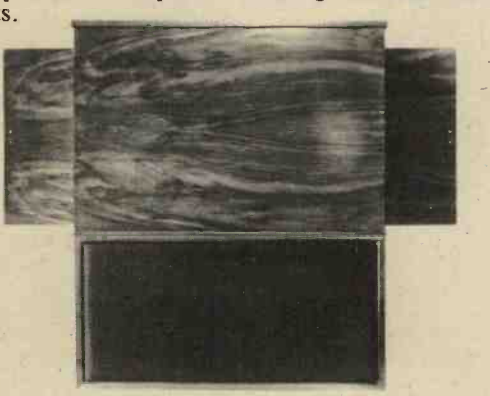
Arena T2500H stereo receiver

are 33in × 20in × 14in and the price is in the £40 region.

Celestion introduce the Ditton 15, a 1 cu ft model which they describe as something different in compact speakers. It is a three-unit system incorporating a new type of low frequency drive unit—the "auxiliary bass radiator." This is claimed to provide deeper, cleaner bass, in the important lowest octave from 30 to 60Hz, than is ordinarily obtained from sealed enclosures of comparable size. Other units in the enclosure are a new 8in mid-range speaker and the HF1300 Mk2 tweeter.

K.E.F. Electronics also add to their range a new miniature system called the "Cresta." The drive units are entirely new designs: the 5in bass unit has a synthetic rubber surround, nylon rear suspension and a cone of specially developed material; the h.f. unit employs a ¾in Melinex plastics diaphragm which gives smooth response and a broad polar radiation pattern. Thus directional output is avoided. Enclosure size is only 13in × 9in × 7in and speaker impedance is 4 to 8 ohms, chosen to suit transistor amplifiers.

The Jordan-Watts 6in square metal cone module is used as a building brick for a number of speaker systems which include reflex, sealed-box and folded horn types. The latest development is a compact one-piece stereo speaker called the Stereola. In adopting this approach, involving the use of two acoustic channels in one assembly, Jordan-Watts say their aim is to produce a superior blending of both stereo outputs.



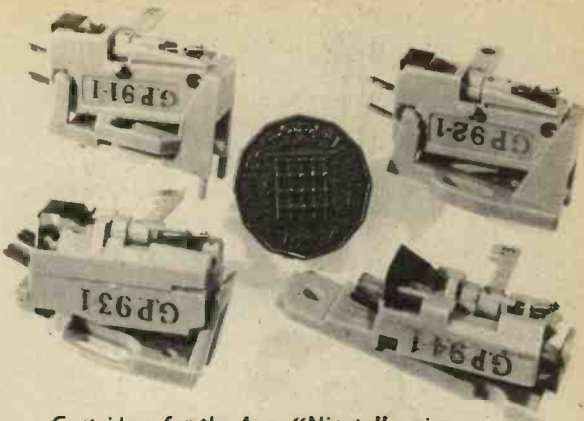
Jordan-Watts Stereola speaker system

TAPE EQUIPMENT

Equipment by Akai of Japan is marketed by Pullin Photographic, a company in the Rank Organisation. New arrivals include the X2000, a four-track stereo recorder with a most comprehensive specification and the correspondingly high price of 150 gns. This solid-state instrument has four speeds (15in/sec is the highest) and records and plays back in either tape direction. Features include 20 watts output on each channel, two V.U. meters, sound-on-sound facilities, bass and treble controls and built-in monitoring speakers.

The same company is introducing the AA7000 stereo tuner-amplifier which features silicon transistors in all circuits and an output of 40 watts per channel. Equipped for stereo, the a.m./f.m. tuner section has a tuning sensitivity indicator, muting switch and moveable a.m. ferrite aerial.

Said to be ideal for the hi fi enthusiast, the new "Scotch" C60 compact tape cassette is loaded with "Superlife" tape which is claimed to reduce oxide



Cartridges for the Acos "Ninety" series

rub-off and promote improved frequency response and tape life. Other recent items from this source are leatherette bound albums and self-threading spools in 5¾in and 7in sizes. The spool is designed to utilise centrifugal force to grip the end of the tape and ensure quick and smooth take-up.

P.A. and CARTRIDGES

Lustraphone now offer a portable P.A. system which enables a lecturer to take with him, in convenient form, his own sound-reinforcement equipment for use in small halls lacking such facilities. This ingenious solution to an old problem comprises a desk type housing containing a transistor amplifier, batteries and horn speaker, together with a ribbon microphone on a flexible tube stand. The housing is of "lectern" shape, surmounted by the microphone, and is simply placed on a desk or table so that the loudspeaker grille faces the audience.

The Acos "Ninety" series by Cosmocord includes pick-up cartridges which have been designed to suit all types of disc equipment. For example, the GP91–1 is a mono crystal cartridge giving 200mV average output and provided with a dual stylus assembly for l.p. and 78. The GP92–1 is in some respects similar to the GP91 cartridges but is a ceramic mono type. The GP93–1 and GP94–1 are stereo versions, and the GP96 is a ceramic stereo cartridge intended for 33 and 45rev/min discs only.

Stereosound SS16 stereo record reproducer

DESIGNED originally to eliminate the human element in timing car driving tests, this equipment is equally suitable for operating a stopwatch for many other sporting events.

The major design criteria were absolute reliability regardless of weather conditions during operation; positive operation for battery voltages down to 10·5V; total current consumption is not above 2A including the lamps; simple installation and operation on site.

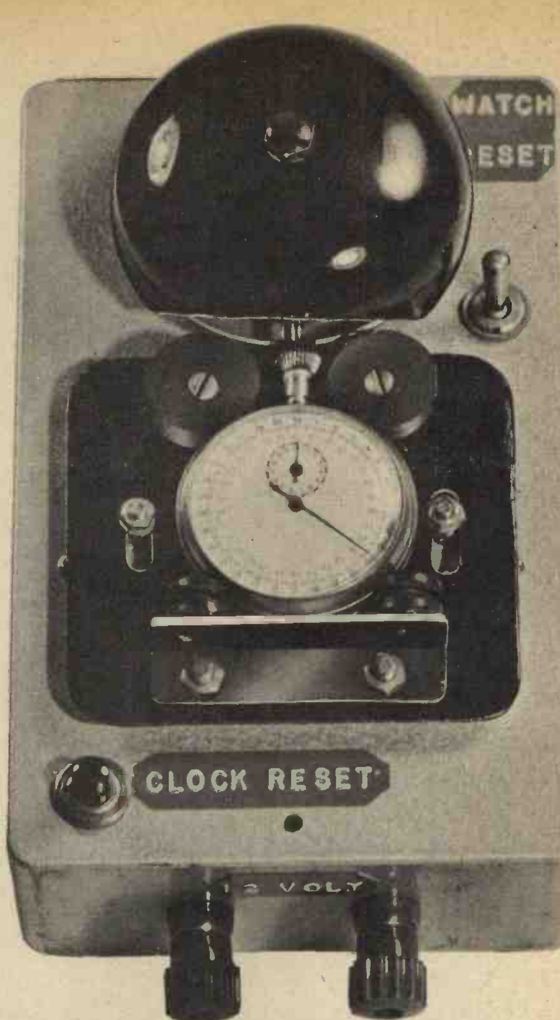
The final version described here met these conditions admirably. The essential operating element is a light dependent resistor (l.d.r.) controlling a transistor with a relay in its collector circuit. This relay in turn controls a solenoid in the master unit which starts and stops the stopwatch. There are, however, several novel ideas which have been devised in the light of experience and incorporated in the design.

In the block diagram (Fig. 1) it will be seen that a beam unit and a light are positioned so that the vehicle (or person) breaks the beam of light at the start. This immediately operates the stopwatch on the master control unit. A second beam unit and light are placed at the end of the course; when the beam is interrupted the master control unit stops the watch. The time can be read off by the operator who then presses a non-locking switch to reset the watch for the next operation.

A secondary feature of this equipment is that it is designed to be used on its own or in conjunction with a large electronic clock indicator such as the one described in the May 1965 issue of PRACTICAL ELECTRONICS. This provides considerable spectator interest at sporting events.

BEAM UNITS

The lights are 12 volt 6 watt car side lamp bulbs mounted in reflectors taken from cycle lamps. Originally



LIGHT OPERATED

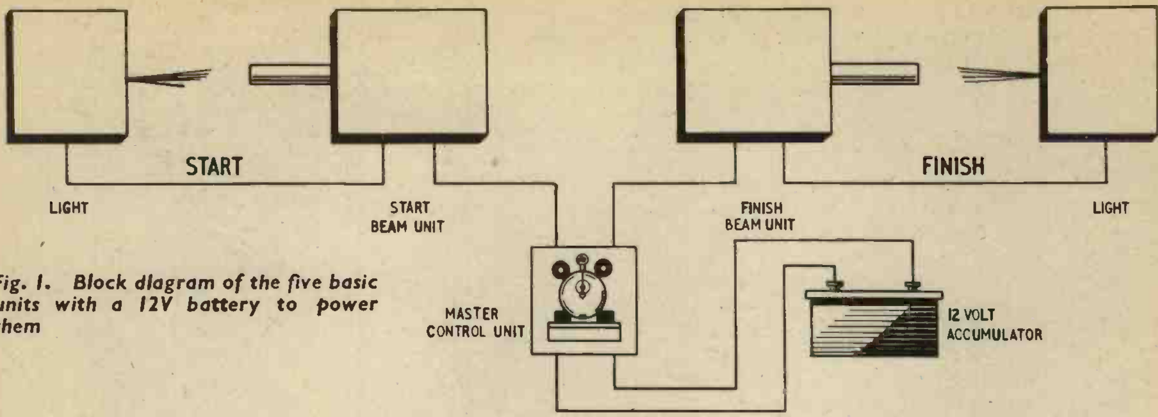


Fig. 1. Block diagram of the five basic units with a 12V battery to power them

2·2 watt screw-in bulbs were tried but were found to be of too low a power rating for reliable operation. With the 6 watt lamps and reflectors (no lenses) the units operate satisfactorily when spaced up to 30ft apart. It is possible to operate over several hundred feet using a 35 watt spot lamp, but this is rarely of any practical use and in any case is very heavy on battery consumption.

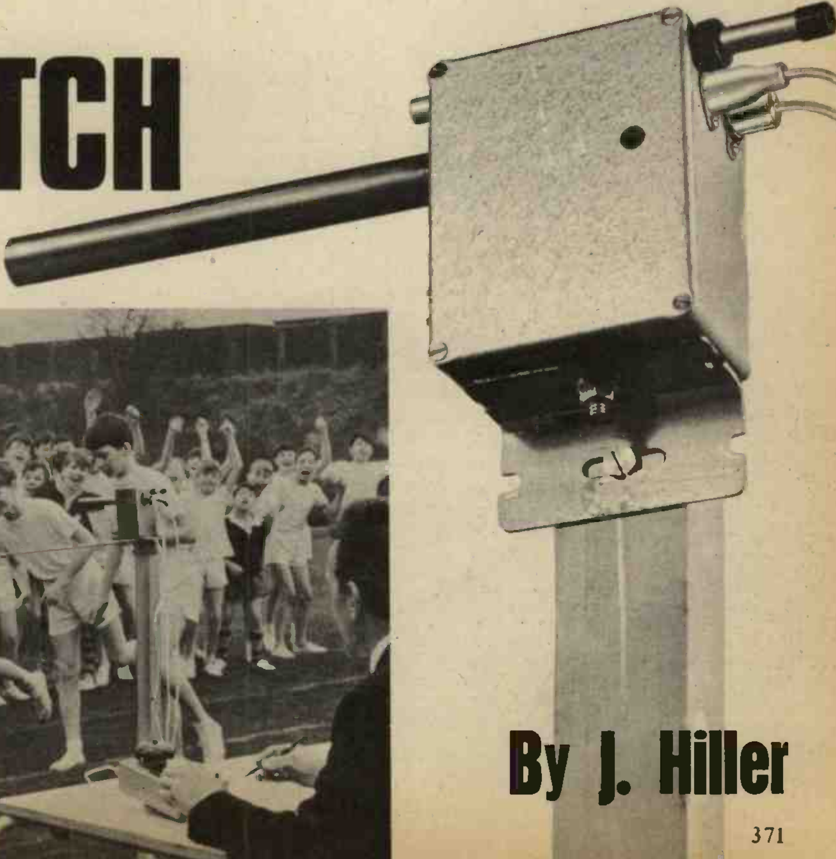
To reduce the cable runs—and so facilitate installation—each lamp takes its supply via its associated beam unit. For convenience all connections are plug-in. The lights are housed in small square metal boxes, but there is nothing critical in the design and any arrangement which will permit mounting in such a way to allow adjustment in any direction will do. For use on grass tracks, lengths of slotted angle iron provide the best support for the units; for hard ground small wooden stands can be made. All beam units and lamps should be rigidly mounted so that they do not move under the influence of strong winds.

Start and finish beam units are identical in construction and in circuitry except for the wiring to the relay contacts. In the start unit the relay contacts switch on when triggered, in the finish unit they switch off (see Fig. 2).

CONTROL OPERATION

Component values have been arrived at by a combination of calculation and practical experience. Originally a variable sensitivity control was incorporated in the top section of the base bias network of the transistor but experience proved this to be more a liability than an asset. Fixed resistors are more stable in operation and have operated satisfactorily.

STOPWATCH



By J. Hiller

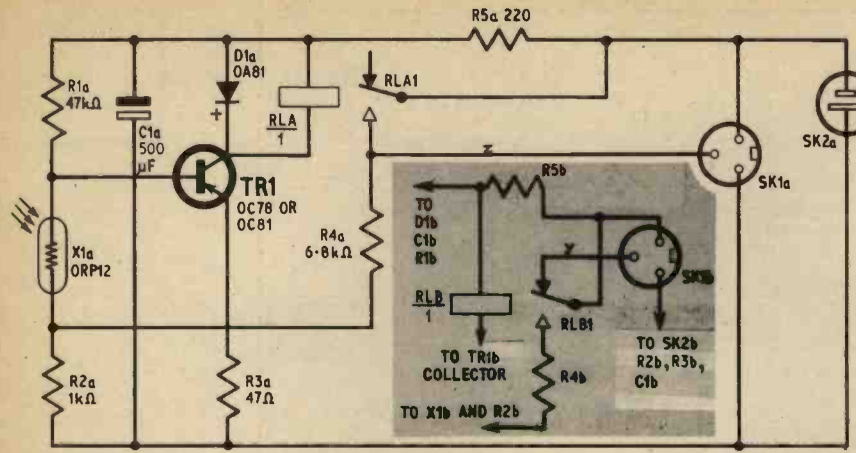


Fig. 2a. Circuit diagram of the "start" unit. The "finish" unit is identical except for the wiring to the relay contacts which is drawn in the grey panel

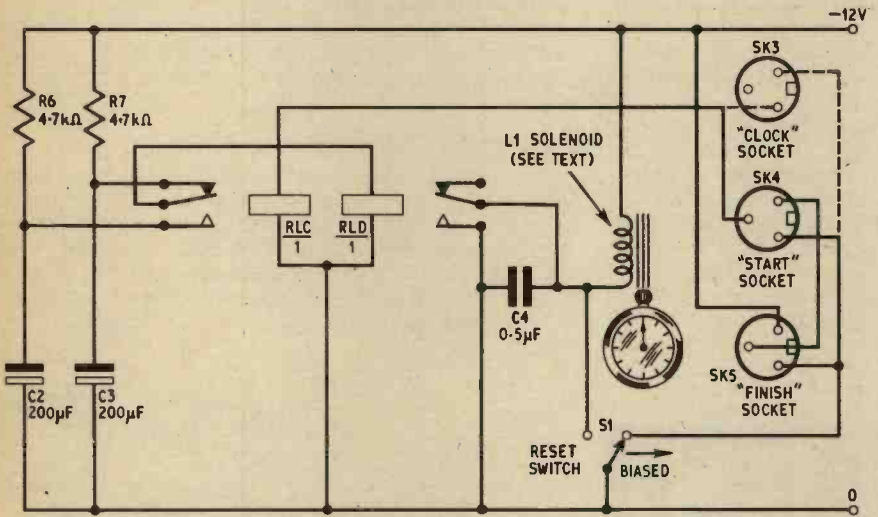


Fig. 2b. Circuit diagram of the "master control" unit

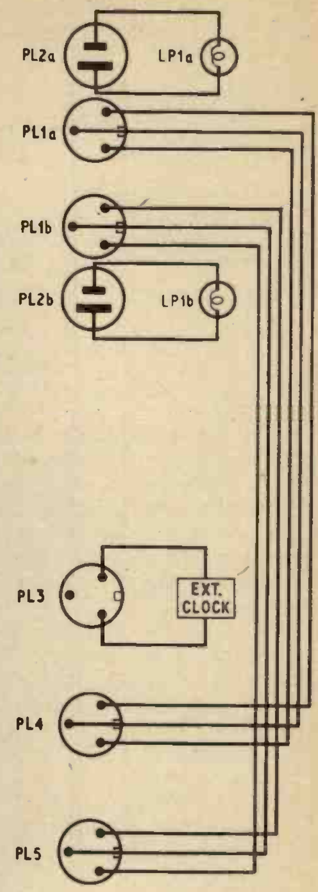


Fig. 2c. Wiring of the plugs to match the appropriate sockets alongside

The type of transistor used in the circuit is not critical and both OC78 and OC81 have been employed successfully. Probably any other similar power types would also serve. Although heat sinks are used these are only for providing a good mechanical mounting for the transistors. Heat dissipation is negligible. As there may be slight variation in different transistors, it may be necessary to try one or two values for R1 to achieve best results. Too low a value will cause the equipment to operate without breaking the beam, while too high a value may make triggering unreliable. In practice, various values from 22 kilohms to 68 kilohms were tried and found to work.

Referring to the circuit diagram, operation is as follows. Light falling on the l.d.r. reduces its resistance to around 1 kilohm. As this component is in the lower leg of the base bias network of TR1 the transistor is cut off; in this condition the relay in its collector is not energised. When the light beam is interrupted the resistance of the ORP12 immediately increases causing TR1 to conduct and operate the relay. The relay contact feeds 12 volts back long a control line to the master unit where it causes the mechanism to operate the stopwatch. This same 12 volt supply may be utilised to operate the large clock for the spectators.

It is necessary to ensure that once the start relay is energised it locks into this position automatically until reset by the operator. This locking action is accomplished by resistor R4 which provides a holding bias and keeps the transistor conducting regardless of any further changes in the resistance of the l.d.r.

As quite high voltage pulses may appear across the relay winding when the transistor cuts off, a diode is included in the circuit to suppress them and prevent damage to the transistor.

Resistor R5 and capacitor C1 perform a dual function. Firstly, they decouple the supply line and prevent variations in supply voltage affecting the operating of the light beam units. Secondly, and more important, they provide the necessary delay for resetting the units at the end of each sequence. Resetting is carried out by switching off the supply to the start and finish units at the master control and then restoring

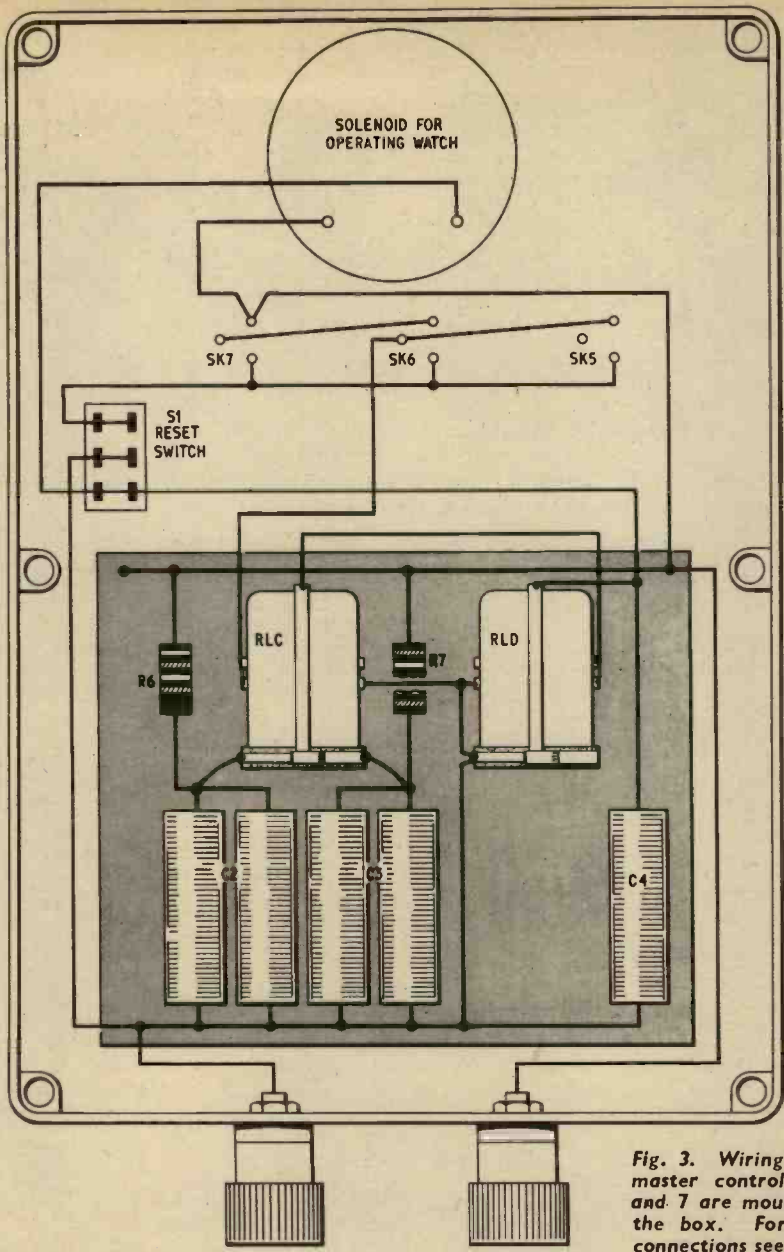


Fig. 3. Wiring on the inside of the master control unit. Sockets SK5, 6 and 7 are mounted on the top end of the box. For identification of relay connections see photographs

it again. This process releases the relays ready for the next timing sequence.

However, as the lights also go out when the supply is cut, it is possible that, when switched on again, the electronic circuits would trigger before the lamps reach sufficiently high intensity to hold the transistors off. The slight delay introduced by R5 and C1 overcomes this difficulty.

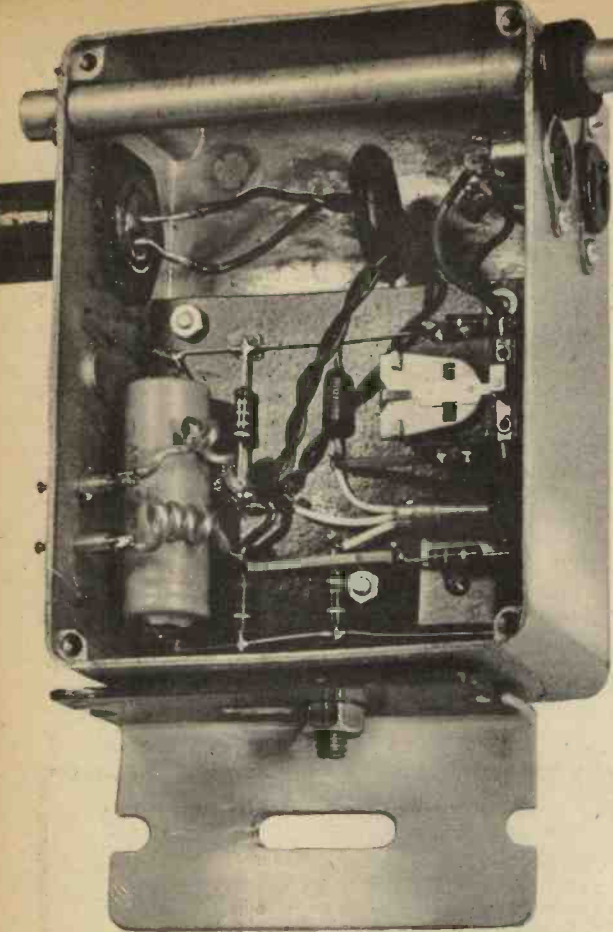
TRIGGERING THE WATCH

To operate a stopwatch, the simple switch-on action of the start unit has to be converted into an on-off pulse because unless the watch button is released it cannot be pressed again to stop.

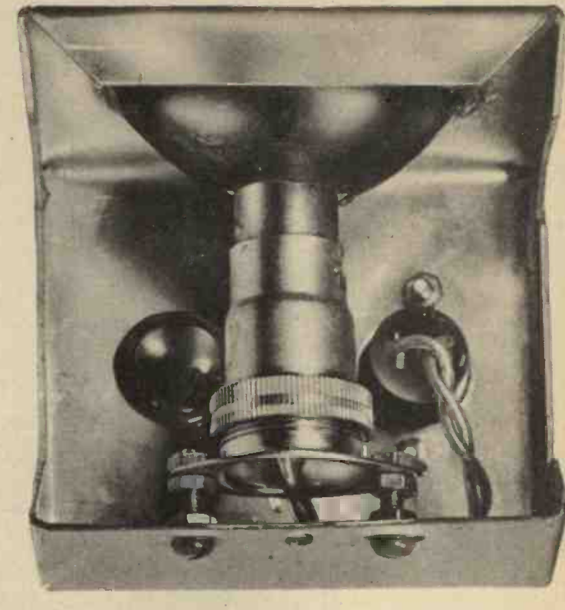
This action is carried out automatically in the master control unit. In the "rest" position, as shown in Fig. 2, capacitor C2 quickly charges up to the full supply voltage through resistor R6. Capacitor C3 on the other hand has very little charge on it since it leaks away continuously through the coil of relay RLD. The actual current flowing through RLD in this condition is limited by resistor R7 to about 2mA, not enough to operate the relay.

When the relay in the start unit closes it completes the circuit, and energises RLC whose contacts then change over. This switches the fully charged C2 across the coil of relay RLD. This causes RLD contacts to close and remain closed until the charge on C2 is exhausted. In practice RLD contacts remain closed for about one second and then open again. This section operates the solenoid to start the watch and then releases ready for the stop impulse.

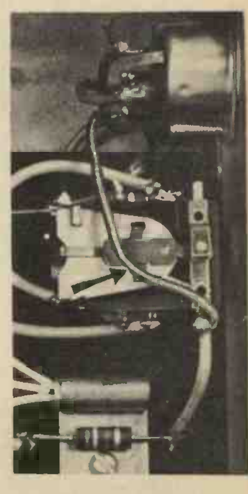
Relay RLC remains closed during the timing of the event and this allows C3 to charge up to the full supply voltage. When the relay operates in the finish light beam unit, it cuts off the supply to RLD and contact



Left: Inside of the "finish" unit. The l.d.r. is held in the tube on the left by the grommet which has been moved here for clarity

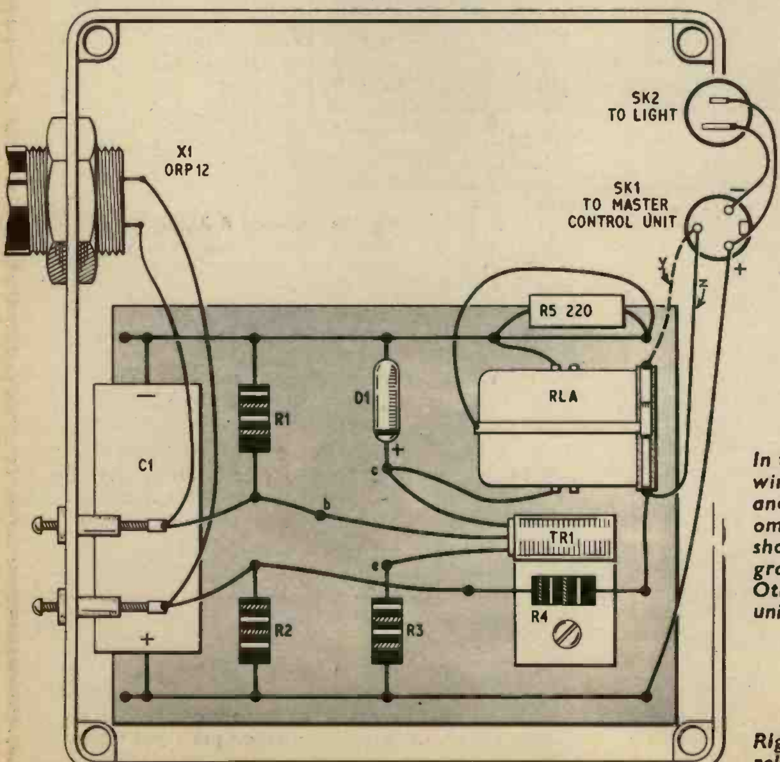


Above right: The inside of one lamp unit

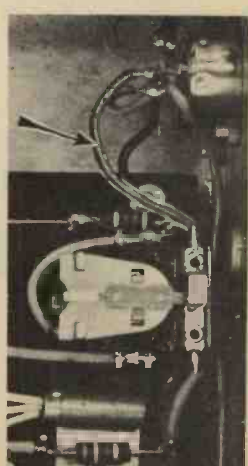


Right: Start unit relay

Fig. 4 (below). Wiring inside the "start" unit (wire "y" is not used)



In the "finish" unit wire "y" is used and wire "z" is omitted. This is shown in the photograph on the right. Otherwise the two units are identical



Right: Finish unit relay

RLC1 returns to its rest position. Thus C3 immediately discharges through the coil of RLD to provide another one-second pulse to stop the watch.

When the operator has noted the time from the watch, switch S1 is depressed for a moment and then released. This returns the stopwatch to zero and sets the start and finish units ready for the next competitor. To reduce sparking caused by the inductive load of the solenoid the contacts of RLD1 are shunted by a capacitor C4.

CONSTRUCTION

The diagrams and photographs give details of the construction of the prototype units. Building is quite straightforward and layout is not in any way critical, neither is there any need for miniaturisation.

The units are built into small diecast boxes but the stopwatch is best mounted on a separate panel so that it can be adjusted to the best position. If it is too close to the plunger of the solenoid there will not be enough power to operate the watch; if it is too far away the watch button will not be pressed far enough. If the mounting holes for the stopwatch panel are slotted, then the best position can be determined by sliding the panel to the best position, then screwing down firmly.

Part of the bell gong is cut away to allow the solenoid slug to strike the control knob on the watch. The make and break mechanism in the bell is partly removed leaving just one return spring. Using a 12V d.c. supply, the force exerted by the solenoid is quite high, but since it operates for only about one second at a time, there is no trouble with overheating. Care should be taken when initially testing to ensure the solenoid is not left permanently in the on position as this could burn out the winding.

Wiring between the units consists of a three-core cable between master control unit and each light beam unit, and a two-core cable between light beam units and lamps. As far as the operation of the equipment is concerned there is no limit to the distance between the start and finish of the race, but installation is easier and takes less cable if organisers can be persuaded to keep them reasonably close. Staggered starts on field tracks will need one set of beam units for each lane.

The stop watch is firmly held on the master control box panel by rubber knobs; a thin sheet of rubber can be positioned underneath the watch to help to cushion it.

COMPONENTS . . .

MASTER CONTROL UNIT

Resistors
R6 4·7kΩ R7 4·7kΩ
Both 10%, ½ watt carbon

Capacitors
C2 200μF elect. 15V
C3 200μF elect. 15V
C4 0·5μF polyester or paper 150V

Relays
RLC and RLD type B14/12 (B and R Relays Ltd. Temple Fields, Harlow, Essex)

Solenoid
L1 Moving slug solenoid in 4·5V a.c./d.c. bell (see text) (Gents)

Switch
S1 Single-pole changeover toggle switch, spring biased

Plugs and Sockets
PL3 and SK3, PL4 and SK4, PL5 and SK5 } 3-way D.I.N. pattern (3 sets)

Miscellaneous
Eddystone 845 diecast box
Stopwatch (minutes and seconds)
Screw terminals for battery supply (2 off)
S.R.B.P. sheet 4in × 3½in
Turret tags
Mounting plate and rubber cushions for holding stopwatch (see text)

(a) START BEAM UNIT (b) FINISH BEAM UNIT

Two sets (a) and (b) of identical components

Resistors
R1a and b 47kΩ R4a and b 6·8kΩ
R2a and b 1kΩ R5a and b 220Ω
R3a and b 47Ω
All 10%, ½ watt carbon

Capacitors
C1a and b 500μF elect. 15V

Light Sensitive Resistor
X1a and b ORP12

Transistors
TR1a and b OC78 *or* OC81

Relays
RLA and RLB Type B14/9 (B and R Relays Ltd.)

Diode
D1a and b OA81

Plug Sockets
PL1a and b, SK1a and b 3-way D.I.N. pattern (2 sets)
PL2a and b, SK2a and b 2-way non-reversible (2 sets)

Miscellaneous
Eddystone 650 diecast boxes (2 off)
Conduit pipe or tube ⅝in diameter × 8in (2 off)
¾in diameter × 6in (2 off)
S.R.B.P. sheet 3in × 2½in (2 off)
Turret tags

LAMP UNITS

(Two of each item are required)

Lamps
LP1a and b 12V 6W double contact m.b.c. side lamp bulbs

Lampholders
Miniature bayonet cap double contact

Reflectors
Cycle front lamp reflectors

Boxes
Made from 20 s.w.g. tinned iron sheet or hardboard mounted on angle iron or wooden posts (see text)

BEAM UNIT ALIGNMENT

The light cell is mounted at the end of a long tube (in the prototype—conduit) to shield it from extraneous light. The secret of successful operation of this type of equipment lies in precise alignment of the light beam and the cell tube. This is a fairly easy task inside a workshop but it can be almost impossible to do outside on a sunny day unless provision is made for this. In the equipment described, a simple and effective method of alignment has been evolved.

A second tube, thinner than the light cell tube, is fitted in the beam unit as a sighting tube. It is parallel with the main tube and by looking through it the unit can be aligned on to the centre of the lamp. This operation does not ensure that the light beam is shining directly into the cell tube, so a further adjustment is required to set the lamp correctly. For this adjustment the properties of the light cell itself are used.

On the beam unit two connections are brought out through insulated tags on the box; inside the unit they connect to the l.d.r. A clip-on extension lead is connected temporarily between these tags and an ohmmeter placed near the lamp. It is now possible to set the direction of the lamp precisely by adjusting to the position giving the lowest reading on the meter.

When carrying out this adjustment it is advisable to disconnect the equipment from the battery and run the lamp from an independent supply. The beam unit does not require any power for this operation. The reading will vary depending on which way round the ohmmeter is connected due to the action of the 500μF capacitor across the supply. The correct way to connect the meter is the one which gives the greatest variation of reading between light and dark. The swing is typically from about 1 kilohm to 50 kilohms or more.

For car events the beam units are about 18 inches above the ground but it is important that all units are the same height so that whichever part of the car starts the timing operation so the same part will stop the watch.

If there is any choice it is usually better to have the light beam units facing the sun and the lights shining in the same direction as the sun. This avoids the possibility of erratic triggering due to reflections from light coloured objects nearby.

Although no difficulty has been experienced in strong sunlight, it is a good idea to fit a small shield, like a camera lens hood, over the end of the light cell tube to shield it from full sunlight. One advantage of having the light units facing towards the operator is that this gives a quick check that the equipment is ready for use since both lights should be on in this condition.

In wet weather a polythene bag is usually slipped over the units, leaving the light tube exposed of course. Avoid the immediate proximity of flags or bunting near the light beam units. If it is a breezy day and bunting waves across the path of the light beam some erroneous times will be registered. ★

Meetings . . .

SOCIETY OF ELECTRONIC AND RADIO TECHNICANS

SOUTHAMPTON

Date: April 20
Title: Hospital Broadcasting
G. A. Allcock
Time: 7.30 p.m.
Address: College of Technology, East Park Terrace, Southampton

CARDIFF

Date: April 20
Title: U.H.F. Tuners
B. M. Goodwin
Time: 7.30 p.m.
Address: Llandaff Technical College, Western Avenue, Cardiff

LONDON

Date: April 21
Title: The Fleming Memorial Lecture
"The Strange Journey from Retina to Brain"
Dr. R. W. G. Hunt, B.Sc., F.R.P.S., D.I.C., A.R.C.S.
Time: 7 p.m.
Address: Royal Institution, Albemarle Street, London, W.1.
Admission to this lecture is by ticket only. Tickets are obtainable from The Secretary, 166, Shaftesbury Avenue, London, W.C.2.

THE INSTITUTION OF ELECTRICAL AND ELECTRONICS TECHNICIAN ENGINEERS

DURHAM

Date: April 26
Title: Post Office Tower
T. Kilvington, B.Sc.(Eng.), C.Eng., F.I.E.E.
Time: 7.30 p.m.
Address: Science Laboratories, University of Durham, South Road, Durham.

JOINT MEETINGS

LONDON

Date: May 10
Title: The Education of Computer Engineers
Time: 6 p.m.
Address: London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.
(Sponsored by the I.E.E. and I.E.R.E.)

BRISTOL

Date: April 26
Title: Super Conductivity
Dr J. G. C. Milne
Time: 7 p.m.
Address: University of Bristol, University Walk, Clifton, Bristol, 8.
(Sponsored by the I.P.P.S. and I.E.R.E.)

PLYMOUTH

Date: May 2
Title: Microelectronics
Dr. S. S. Forte
Time: 7 p.m.
Address: Plymouth College of Technology, Plymouth
(Sponsored by the I.E.E. and I.E.R.E.)

Field Effect TRANSISTORS

PART ONE

By G. B. Clayton, B.Sc., A.Inst.P

FIELD effect transistors (f.e.t.) are not new devices; as early as 1935, O. W. Heill took out a patent on what would be now called a field effect transistor. The semiconducting materials available in those days were very limited and Heill's device was never commercially developed. In post-war years the principles of f.e.t.s were developed further, but it was not until comparatively recently that the advances in the various semiconductor technologies culminated in the production of practical and viable field effect devices.

MAIN FEATURES

Commercially available types may be used together with conventional transistors and for certain applications they possess definite advantages over conventional types. The most marked difference between f.e.t.s and conventional transistors is their much greater input impedance, resembling thermionic valves in this respect.

On first acquaintance with a device it is necessary to become familiar with the terms used to describe various features of it. The operating principles and electrical characteristics of f.e.t.s differ from conventional transistors but a correlation may be found between the familiar terminals of a valve, a conventional transistor, and an f.e.t. The f.e.t. has three terminals: source, gate and drain, corresponding to the emitter, base and collector of a conventional transistor, and to the cathode, grid and anode of a triode valve.

Fig. 1 shows the conventional circuit symbol for f.e.t.s. There are two different types commercially available: the junction gate f.e.t. (reverse-biased diode f.e.t.) and the insulated gate f.e.t. (metal-oxide semiconductor transistor, m.o.s.t.). As *pnp* and *npn* transistors are available, so are *p* and *n* channel f.e.t.s.

The gate terminal of an f.e.t. takes extremely small currents (about 10^{-10} A for a junction gate f.e.t. and 10^{-13}A for an insulated gate f.e.t.). Its potential controls the current between source and drain. There is a close similarity here to the action of the control grid in a thermionic valve, and a marked difference from the action of the base in a conventional transistor, for in this device it is the base current which is normally thought of as controlling the collector current.

The characteristic curves of junction gate f.e.t.s and insulated gate f.e.t.s are similar and resemble the anode characteristics of a pentode valve. Typical characteristics are illustrated in Fig. 2 with those of a pentode valve shown for comparison purposes. Beyond the "knees" of the characteristics, any increase of voltage produces little change in current in both the f.e.t. and the pentode. This region of the f.e.t. characteristic is referred to as the "pinched-off" region, the significance of this term will be discussed later. Below the "knees" the pentode curves tend to run into one another but those of the f.e.t. are quite distinct.

The non-pinched-off characteristics (those for small values of drain voltage) are illustrated in Fig. 3. They are almost linear and in this region the f.e.t. acts as a resistor whose magnitude is determined by the gate voltage. There are interesting applications of f.e.t.s as voltage dependent resistors, such applications are of course not possible with conventional transistors. Some of these applications will be discussed later.

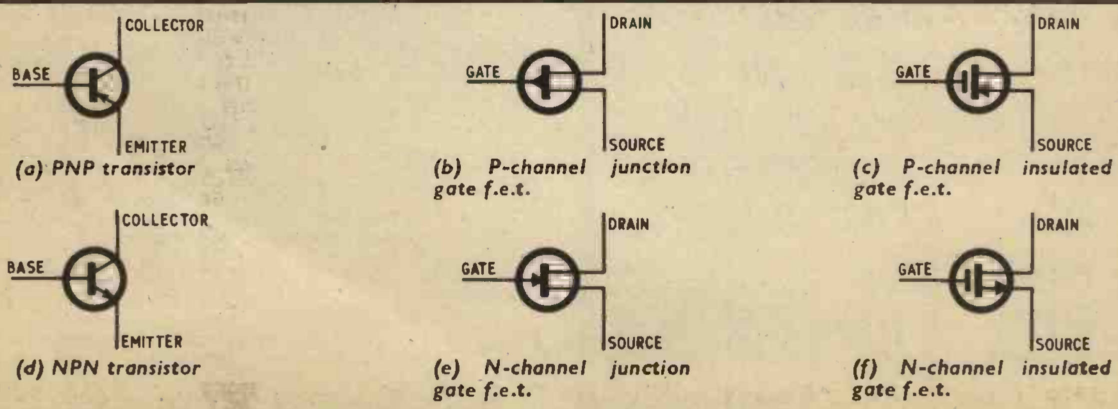


Fig. 1. Circuit symbols of transistors and f.e.t's

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SINGLE PLAY UNITS		AUTOCHANGE UNITS	
BSR GU7	£4.19.6	BSR Superslim	£5.19.6
Garrard SRP12	£4.19.6	Garrard 1000	£5.19.6
Garrard SP25	£10.19.6	Garrard 2000	£6.19.6
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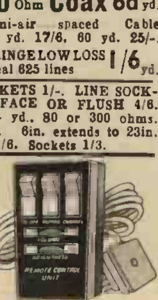

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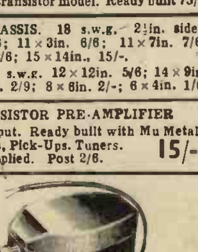

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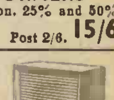

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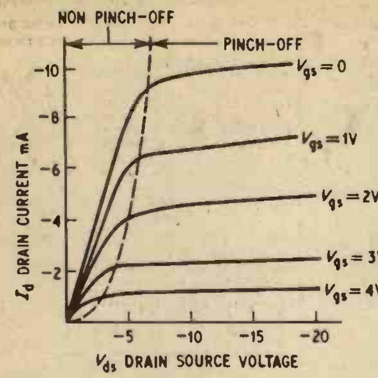

Fig. 2a. Drain characteristics of p-channel junction gate f.e.t.

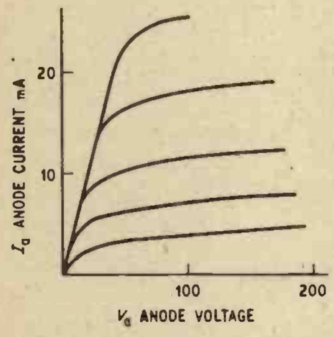

Fig. 2b. Anode characteristics of pentode valve

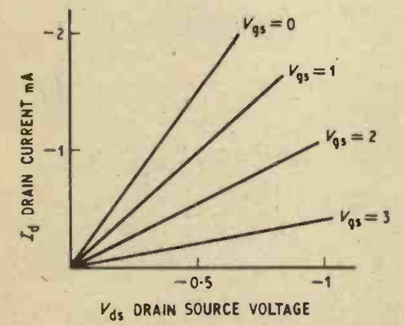

Fig. 3. Drain characteristics for low values of V_{ds}

CONDUCTION IN SOLIDS

Before considering the theory of operation of an f.e.t. it is useful to review very briefly the nature of the conduction process in semiconductors and the conditions that exist at the junction between a *p* and *n* type semiconductor.

In order that a solid should be a conductor of electricity it is necessary for it to contain mobile charges; an electrical field applied to the solid will then be able to superimpose a drift motion on top of the random thermal motion of these mobile charges. Such a drift of charges through a solid constitutes the electric current in the solid. An insulator contains no mobile charges, all charges in it are "bound" and cannot move under the action of an applied electrical field.

In *n*-type semiconductors the mobile charges are predominantly negatively charged electrons. These electrons are given ("donated") to the solid by suitable impurity atoms (donor impurities) which are introduced into the material. The impurity atoms are fixed in the crystal structure of the solid and when they have lost one of their electrons they have an excess positive charge.

In a *p*-type semiconductor the mobile charges are predominantly mobile positive holes. The presence of these positive holes is primarily due to impurities that are present in the solid. The impurity atoms are of a different type to the donor impurities in an *n*-type semiconductor and are called "acceptor" impurities. These acceptor atoms capture electrons from neighbouring valency bonds between atoms of the solid and thus create vacancies in these bonds. It is these vacancies that have an excess positive charge associated with them that are mobile and constitute the positive holes. The acceptor atoms are fixed in the crystal structure and when they have captured an electron they then have an excess negative charge.

BEHAVIOUR OF *PN*-JUNCTIONS

The conditions that exist at a junction between a *p*- and *n*-type semiconductor may be conveniently visualised by imagining the two materials initially separated being brought into contact (Fig. 4). The random thermal motion of electrons and holes will result in a diffusion of electrons from the *n*- to the *p*-type material and of holes from the *p*- to the *n*-type material.

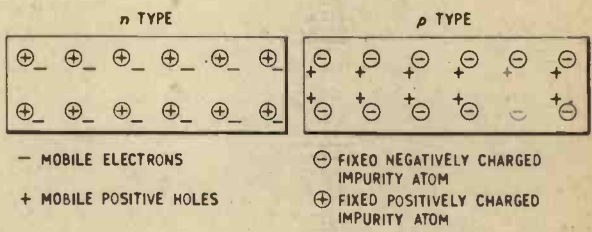

Fig. 4a. N- and p-type semiconductors before contact

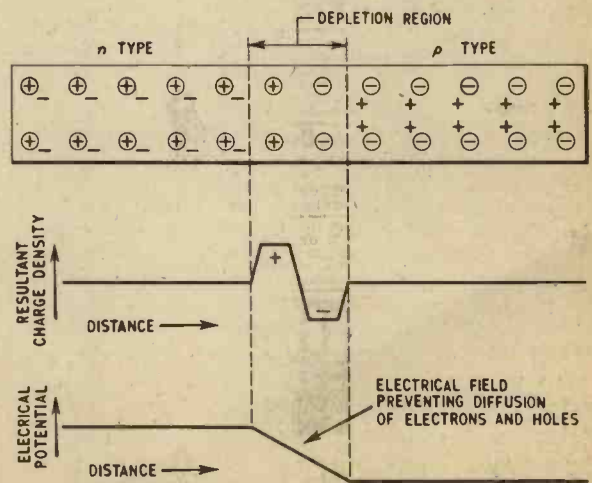

Fig. 4b. N- and p-type semiconductors after contact equilibrium conditions

In the immediate vicinity of the junction recombination of electrons and holes will "uncover" (leave unneutralised) the charges on the impurity atoms that are fixed in the material. A double layer of unneutralised charge will thus exist at the junction in a region containing very few mobile charges.

The double layer of charge will produce an electrical field in this region which will sweep electrons and holes out of the region and tend to prevent diffusion of electrons and holes across the junction. This region at the junction is called a depletion region because it contains very few current carriers.

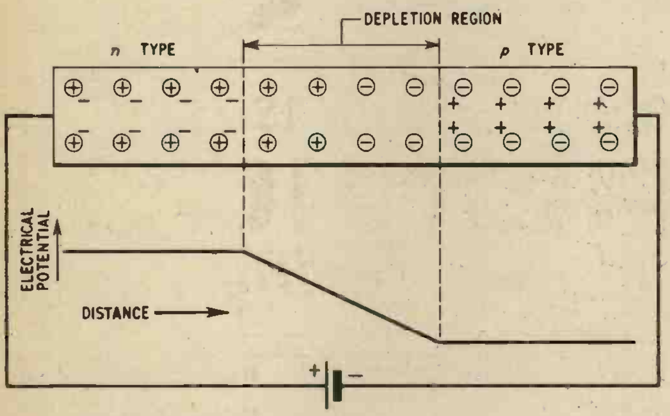

Fig. 5. P- and n-junction with reverse bias

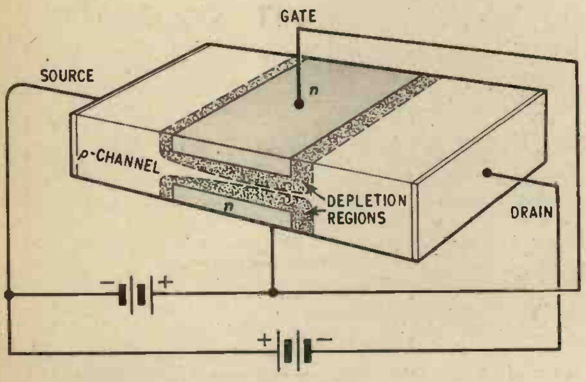

Fig. 6. P-channel junction gate f.e.t.

The rectifying action of a junction depends on the presence of a depletion region. A reverse bias applied to the junction (*p*-type made negative with respect to *n*-type) pulls electrons and holes away from the junction and increases the thickness of the depletion region (Fig. 5). The extremely small currents that pass through such reversed biased junctions are carried by electron-hole pairs created by thermal vibrations of the atoms of the material, they depend markedly on the temperature.

JUNCTION GATE F.E.T.

Reversed-biased diode f.e.t.

In its simplest form a junction gate f.e.t. consists of a semiconductor bar as shown in Fig. 6 with ohmic contacts at both ends. One of the contacts is called the source, the other is called the drain. The current carriers (positive holes in the case of a *p*-channel device), pass through the bar from source to drain. At the middle part of the bar, regions of opposite conductivity type to the bar are formed and a contact is made to them called the gate.

In use the *pn*-junctions thus formed are reverse biased by a voltage applied to the gate. The thickness of the depletion regions associated with the *pn*-junctions is varied by varying the gate voltage. The depletion regions extend into the channel and restrict the effective cross section through which the channel current can pass, the gate voltage thus controls the drain current.

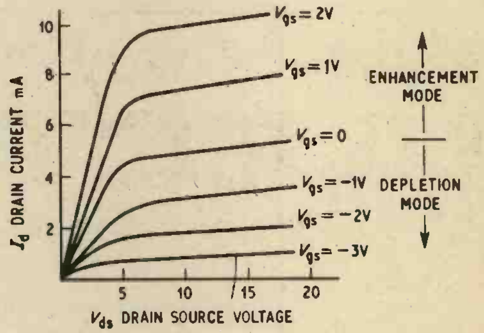

Fig. 7. Drain characteristic of depletion type n-channel m.o.s.t.

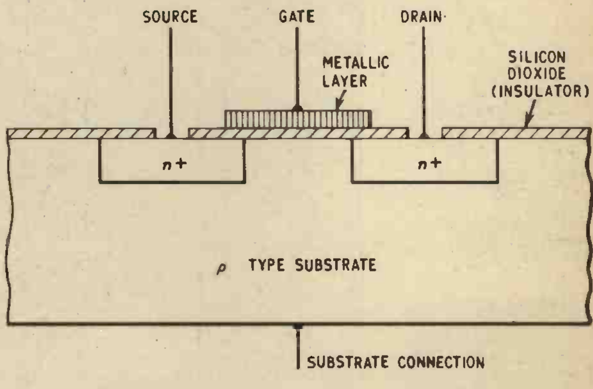

Fig. 8. Insulated gate f.e.t. structure of n-channel enhancement device

The control voltage applied between gate and source is effectively applied to a reverse biased diode and this accounts for the extremely small value of the gate current.

The depletion regions are thickest nearest to the drain because it is here that the greatest reverse bias exists across the junctions. If the gate voltage is held constant and the voltage between source and drain increased, the two depletion regions eventually meet, restricting the drain current to a near constant value. This is called the pinch-off condition.

Junction gate f.e.t.s are called "depletion mode" devices because a voltage must be applied to the gate terminal in order to turn them off. Insulated gate f.e.t.s are available as either "depletion mode" or "enhancement mode" devices. An enhancement mode device needs a voltage applied to its gate terminal before any drain current can pass (see Fig. 7).

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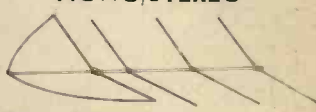

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The input resistance of the insulated gate f.e.t. is even higher than that of the junction gate f.e.t. because its gate terminal is insulated from the semiconducting material by a thin layer of insulating material. Two very rich *n* regions (sometimes called n^+ regions) are diffused on a *p*-type silicon substrate as shown in Fig. 8. These regions form the source and drain contacts and are very close together.

The structure shown is that of an *n*-channel enhancement device. Under conditions in which no voltage is applied to the gate, the source-channel-drain circuit is equivalent to two *pn* junctions back to back. No *n* channel in fact exists between source and drain and no drain current can flow whatever the magnitude or polarity of the applied drain-source voltage. (This is true up to the point at which one of the junctions breaks down.)

A simplified theory of the operation of the device is illustrated in Fig. 9 (not to scale). Fig. 9a shows the equilibrium situation with no voltages applied. If a small positive voltage is applied to the gate the action of the electrical field produces a depletion region (1) just below the surface of the substrate (Fig. 9b). In Fig. 9c an increase in gate voltage extends region (1) deeper into the bulk of the semiconductor and produces region (2). In this region the electron density actually becomes greater than the hole density; it behaves as if it were *n*-type material.

Even though the substrate is doped with acceptor type impurities, there are always some electrons present in it that have been generated by thermal energy; these are attracted to the surface by the positive gate to give region (2). It is called an inversion layer. A voltage applied between source and drain can now produce a current carried by electrons through the inversion layer.

As the drain voltage is increased the electrical field attracting electrons to the surface of the substrate becomes less near the drain and the conducting *n* channel decreases in thickness here (Fig. 9d), eventually becoming pinched off. The drain current then remains almost constant as the drain voltage is increased

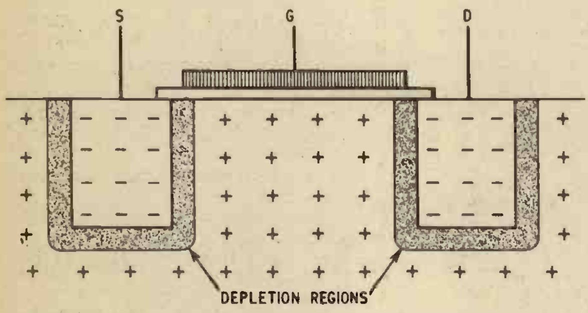


Fig. 9a. Equilibrium situation, no voltage applied

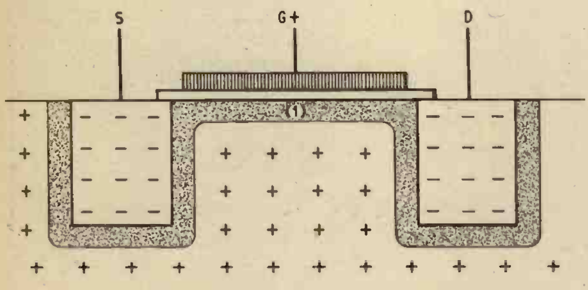


Fig. 9b. Gate made slightly positive

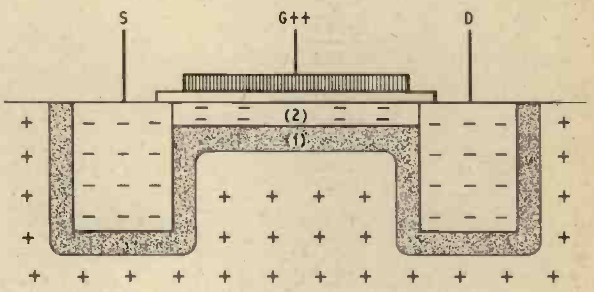


Fig. 9c. Gate made more positive, inversion layer (2) formed

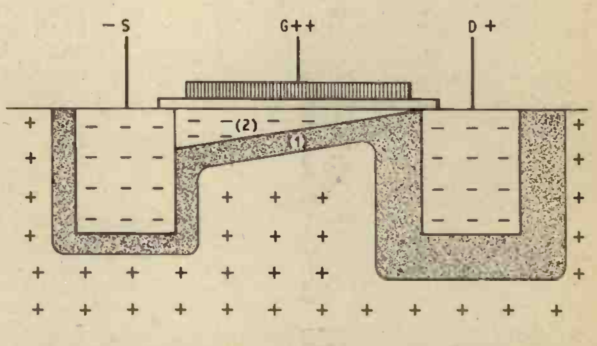


Fig. 9d. Voltage applied between source and drain

Some insulated gate f.e.t.s are made with a layer of *n*-type material formed at the surface of the substrate under the gate and connecting source and drain. Conduction is then possible between source and drain through this layer even though no gate voltage is applied. A negative gate voltage has to be applied to deplete this region of electrons in order to cut off the drain current.

Devices such as this are working in the depletion mode, although they can also be made to work in the enhancement mode by the application of a positive gate voltage.

The treatment that has been given has referred to an *n*-channel insulated gate f.e.t.; *p*-channel devices are also available. The explanation of the theory of action of these devices is similar to that for *n*-channel devices with the polarity of all voltages reversed. ★

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.

RESISTORS AND CAPACITORS

New resistors and capacitors are always being introduced each month, as more stringent specifications and processes are being implemented. A new range of miniature low value wirewound resistors, types TW and TP. especially developed to meet the requirements of modern transistor equipment, is the latest product from the Resistor Division of the **Plessey Components Group.**

Finished in green silicon cement, type TW and TP resistors have an overall resistance range from 0·22 ohms to 6·8 kilohms at 1 watt rating. Available with both wire and printed circuit terminations these resistors are scaled down versions of this Company's proven glassfibre cored resistors.

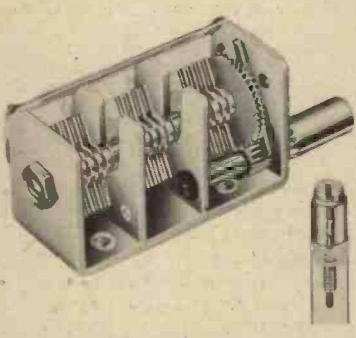
The **Davall** Type 72 miniature moulded track potentiometer is claimed to offer a substantially longer life than conventional sprayed track potentiometers now in use.

The type 72 has the insulating base, solid carbon track and terminals moulded into a single solid integrated unit. The potentiometer has a power rating of 0·5W (linear) and 0·25W (non-linear) at 55 degrees centigrade and a resistance range of between 50 ohms and 2 megohms. The maximum working voltage is 500V d.c.

Just one of the many new capacitor ranges is the **Erie** 801 Series of Disc Ceramicons which measure 0·36in maximum diameter. The 500V working standard version is available in 24 individual ceramic bodies to suit all applications, has an overall capacitance range of 6pF to 7,000pF and is obtainable in either the conventional wire termination form or the Erie "Pluggable" form for printed circuits.

Specially designed for printed circuit mounting is a new piston-type trimmer introduced by **Wingrove & Rogers Ltd.**, Polar Division, 75, Uxbridge Road, Ealing, London, W.5. The trimmer, type S60-01, has an overall diameter of 0·25in with 0·2in fixing centres and is variable from 2pF to 25pF by means of a screwdriver slot in the rotor. These trimmers are available in polystyrene dielectric or p.t.f.e. dielectric for operation in extreme temperatures.

Another new type is the CG80-03, a miniature three-gang capacitor designed for v.h.f. receivers. Each section has a capacitance of from 2·5pF to 17pF. An internal gear and pinion drive gives a 3:1 reduction. High-grade ceramic posts insulate the stator from the frame, and the capacitor is 1·5in long, 0·65in wide and 0·85in high overall.



The CG80-03 and the S60-01 capacitors from Wingrove and Rogers

GOOD BUYS

The Testmaster is a new mains tester screwdriver (price 7s 6d) from **Vitrex (Sales) Ltd.**, 457-463 Caledonian Road, London, N.7. This screwdriver differs from others in that it has a cartridge fuse testing socket as well as the usual neon mains tester.

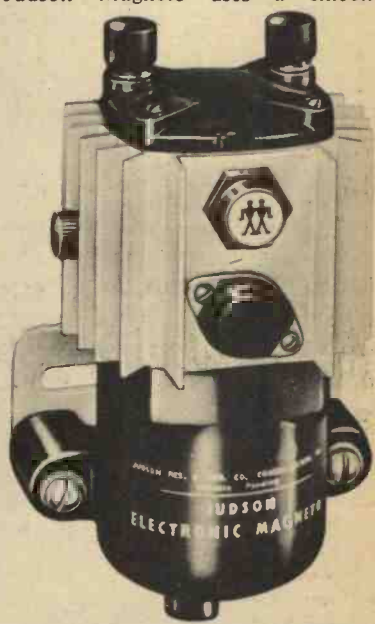
Most mains cartridge fuses have opaque tubes and it is practically impossible to tell visually whether the fuse has blown. But by inserting the suspect fuse in the fuse socket in the head of the Testmaster, and following the instructions as indicated on the card provided, it becomes a simple process to test the fuse.

Vitrex Testmaster Screwdriver

The handle is moulded tough nylon, has high voltage insulation properties and is fitted with a high intensity neon and plated chrome vanadium blade. The fuse socket in the handle houses a spare fuse.

Beulah Electronics Ltd. have been appointed sole U.K. distributors of an electronic ignition system from Judson Research and Manufacturing Corporation of America. Known, in the U.K., as the Beulah-Judson Electronic Magneto it costs £21, uses a silicon transistor, is fully protected by zener diodes and components are completely sealed to prevent corrosion.

It is not uncommon for temperatures of up to 200°F to exist under the car bonnet and it is for this reason that most manufacturers of transistor ignition systems, particularly those using germanium transistors, recommend that the transistor should not be mounted in the engine compartment. The Beulah-Judson Magneto uses a silicon transistor which will continue to function at 420°F; high engine temperatures are no problem.



Ignition System imported by Beulah Electronics

The system is one complete unit and it is simple to instal by transposing three wires from the present ignition coil and connecting one additional wire to ground; it is simple to revert back to the old system by replacing the three leads.

Tests have been carried out over a period of two years in the U.S.A. on cars and boats; it carries a three year warranty regardless of mileage or hours placed on the engine. The same unit may be used on 6 or 12 volt systems, single or dual point ignition distributors, and will not interfere with radio reception. Two models are available, for either negative or positive "earth" systems.

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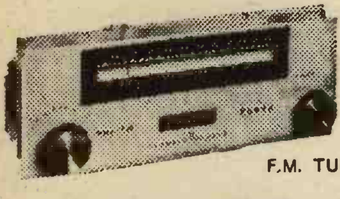

F.M. TUNER

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You can do so much with MARTIN kits. The system of using pre-fabricated transistorised units which can be interlinked in a variety of ways enables you to assemble the combination of your choice and then extend it unit by unit until you possess a full stereo gramophone and radio assembly. When new units are produced, they can be added to existing equipment very easily with the advantage that you can continue to use equipment you already have, so that your installation is always up to date. Most important of all is the power and quality which MARTIN Audiokits give you. Their sturdy construction assures compactness without sacrifice to quality or efficiency. They offer excellent value, are very easily installed and will give years of unfailing service. That is why people prefer MARTIN — it's simple to instal, good to listen to, and looks completely professional.

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JOHN VALENCE

COLOUR ARRIVES

What the Postmaster General has described as "the biggest single technical step forward which British TV has ever taken" is about to be made . . . colour comes to BBC2 in the autumn and to BBC1 and ITV during the course of the next three years.

Welcome news, especially to the TV receiver manufacturers and the retailers. Just the shot in the arm they need, because this particular section of the electronics industry has been almost moribund for the last 12 months or more.

The long drawn out discussions over the choice of a colour system, and then the long awaiting for the final go ahead signal from the government have exasperated many folk both within the industry and outside. After all, it has been pretty galling to watch the progress of other nations in the field of colour while this country which pioneered TV broadcasting in 1936 remained immobilised at the starting line.

Come to think of it, I suppose there is a compensatory side of the coin. We at any rate do start off with the benefit of much accumulated experience to draw upon. Highly satisfying though it may be to pioneer a new field, there are nevertheless certain penalties to be suffered ultimately, witness the original choice of a 405 line standard. This has not been favoured by any other country and with the advent of colour is now conceded to be obsolescent.

The move up into the ultra high frequency band is almost obligatory on technical grounds. It does, however, fill me with some trepidation concerning the kind of reception many a viewer will get. Blanket coverage of the country is definitely *out* on u.h.f. The behaviour of these frequencies cannot be predicted with any certainty for any given location; as experience with the present BBC2 transmissions indicates, "blind spots" are likely to occur which no elaborate aerial array, no matter however painstakingly orientated, will overcome.

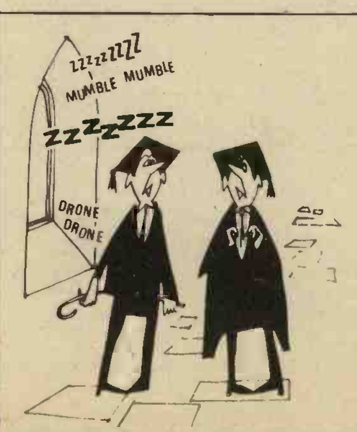
I hope I am not being too pessimistic, but surely it will be only prudent to have a proper survey and field strength tests carried out in our homes before we invest in a £300 colour receiver! A Technicolour snowstorm may be somewhat enthralling to watch—but even this spectacle is likely to pall very quickly, particularly when we recall the cost!

Is it not likely that we shall see more and more "piped" TV than the "wireless" variety in the future? The vagaries of u.h.f. signals may indeed accelerate this development.

PREP WITHOUT TEARS

That wonderful assembly of electronics sometimes referred to by the more vulgar types as the goggle box, and nowadays taken so much for granted, has made a tremendous impact upon our everyday lives (yes, even in glorious black and white). One of the problems it has introduced into many a domestic scene is due to the magnetic attraction it holds over younger members of the family. This is often to the detriment of their homework and other studies.

Despairing parents can take heart. It seems that our old friend the electron in yet another of his varied guises may provide the answer to this vexed problem.



"Actually old Hargreaves has been teaching subliminally for years"

Subliminal teaching aids are now being made for use in residential schools for sleep-learning. Some equipment of this kind I have been reading about is marketed by a firm called Inductive Learning. Either disc or tape recordings can be used and one unit will feed up to 20 pillow speakers. The equipment can be set to repeat time and time again the recorded "lesson".

Well, what is good enough for the school boarder should be good enough for the day boy. So just install this prep machine in young Johnnie's bedroom and let him gaze at the one-eyed monster till close down, if he wishes. This way you will achieve domestic peace, while retaining a clear conscience as a dutiful parent.

PROGRAMME MUSIC

Getting down to silicon diodes, computers for all their outward air of sophistication actually lead quite prosaic lives. Their working hours are normally spent disgorging a flood of figures—all very important to those directly concerned, but not frightfully exciting to the outsider.

But now and again we hear of a computer indulging in some frolic or other with the connivance of its (or should it be *his* or *her*) human attendants. Such fun-and-games antics, like playing chess or picking out compatible couples, seem to endow the machine with almost human-like qualities.

If any of these machines have any pretensions to musical artistry, now's the time to get flip-flopping. The International Federation for Information Processing has just announced a competition for a piece of music forming an artistic whole and composed by a computer. Medals will be awarded for the three best compositions which will be performed, it is hoped, in Edinburgh during the 1968 Congress of the IFIP.

Messrs. Mozart, Beethoven, Tchaikovsky, and the rest didn't know how fortunate they were living in the pre-electronic era.

Readout—

A SELECTION FROM OUR POSTBAG

Let's be square!

Sir—Though I agree with your comments regarding the use of Hz instead of c/s (see March 1967 Editorial), I feel that your description of the continental resistor symbol as "a rectangular nonentity", or "an empty block", to be a trifle erroneous. Some continental manufacturers use a code to fill the symbol, this enables one to determine the rating and tolerance of the component at a glance. The same sort of system is used for capacitors; this saves a lot of time in searching through a parts list to determine a component's characteristics.

Also spare a thought for the electronics draughtsmen; no more patiently drawn "zig-zags", and inductor symbols, as used at present.

S. A. Hardy,
Chippenham,
Wilts.

Stay British

Sir—I was shocked by your support of the Hertz as a replacement for the c.p.s. or c/s which we are all used to. Can you give any logical reason for this change? There are many reasons in my mind why Hertz should not be used, perhaps the most sensible one being: we've managed without it up to now! Why make things awkward by introducing meaningless symbols?

If these new symbols made life easier then I would support the proposed move. As this does not seem the case it can only make things more difficult.

Later on in the same editorial you write: "Why discard a symbol which is the acme of perfection, explicit, simple to draw (or print) and economical in space . . ."

May I ask you the same question, WHY?

You've got the guts to dig your feet in on the question of whether it should be a simple zig-zag or a rectangle, then dig your feet in on the question of simple c/s or confusing Hertz, this "move" is more important to us who try to keep up with your magazine, than to anyone else as far as you are concerned.

If you wish to change over then do so. I can't, and about 95 per cent of your readers will probably agree.

Up to the March 1967 issue I have enjoyed the articles and have been able to understand them. I don't want to give up taking P.E. but Mr Hertz might make me.

Dig your feet in, throw them both out, let's stay British.

E. Davies, G3PGM,
Reading,
Berks.

Continental origin

Sir—Of course you are right to resist those little empty boxes of continental origin, for the internationally recognized traditional resistance symbol has no equal on all the counts that matter. The experts of the I.T.C. have become too arbitrarily-minded once again.

Frankly, I am all with those journals in other countries which have already rejected the Hearse—sorry!—Hertz (including U.S.A.—despite their N.B.S.) and have declared their adherence to c/s—or better still, the symbol "~". This beats everything else for conciseness, simplicity and unmistakability, it is universally accepted—and has always been widely used by German Industry itself!

I am appalled by the weak attitude of the B.S.I. and the number of British firms which have readily accepted this push-over. Would they jump at using M Om. for megohm instead of MΩ in the same way? To be logical they would have to; the symbol Ω is merely a letter of lingual antiquity, not a contraction of Ohm's name, and conveys no technically self-evident meaning, whereas ~ decidedly does—and everyone knows it.

We have never been a nation of dupes before—and we don't have to be now. Not even about pedantic trifles. The procurement of international standards is a laudable motive as such, but if it means retrogression we are better off without it, as left to itself, good sense tends to emerge unassisted.

J. R. C. Moore,
Little Melton,
Norwich.

Duty to readers

Sir—I feel that I must protest about your decision to adopt the symbol Hz as the unit of frequency in place of the excellent c/s.

It seems strange that you should adopt this controversial symbol without any prior warning to your readers and yet reject the rectangular box symbol for a resistor, which has been officially recognised by the British Standards Institute.

Do not think though that I am in favour of the adoption of the rectangular box symbol. I reject it on the same grounds as your magazine appears to, but why confine these grounds only to the box symbol, surely the same applies to the symbol Hz?

I feel, however, that you have a duty to your readers and that if you, or your staff, have a leaning towards the intruder "Hertz" then the fairest way to decide the issue is to have a ballot among your readers and let the majority vote dictate the action of your magazine.

Normally your magazine maintains a very high standard in policy and productions, but here I think you have slipped, and slipped badly.

D. Newman,
Leicester.

Still waiting!

Sir—In your March issue you published a letter from a Mr H. M. Sherry, complaining of lack of attention from advertisers.

As a newcomer to the fascinating science which you propagate in your excellent monthly, I must agree with your correspondent. I am amazed at the indifference and lack of courtesy shown by some dealers. Three weeks after sending cash I'm still waiting. Surely, after a fortnight it would not be too much trouble to send a card explaining the delay.

Like Mr Sherry, I'm learning, and have begun a process of elimination.

C. G. Thorne,
Sutton Coldfield,
Warks.

QUICK CUPPA

Mini Immersion Heater 350w. 200-240v. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. 19/6, post and insurance 1/6.

9 VOLT PRECISION MOTOR.

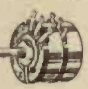
Intended for driving battery operated tape recorders and record players. Laminated, 6 Pole Armature with Brush Gear and Rapid start switch. Normally 25/-. Our Price 7/6 plus post and insurance 1/6.

MINIATURE WAFER SWITCHES
NUMBER OF POSITIONS

	2	3	4	6	12
1 pole	3/6	3/6	3/6	3/6	3/6
2 pole	3/6	3/6	3/6	3/6	
3 pole	3/6	3/6	3/6		
4 pole	3/6	3/6			

Any 12 switches ordered together 36/-.

GANGED POTS



Standard type and size with good length of spindle—made by Morganite. List price is 10/- each but if you act quickly you can have them at 12/- doz. (or 1/6 each if less than doz.). Following values in stock all "lin" — 5K + 5K — 10K + 10K — 100K + 100K — 500K + 500K all new and unused. Post 2/9 on 1st doz. then 1/- per doz. 6 doz. or more post free.

ROLLER BEARINGS

You will find plenty of uses for these under anything which has to be moved, trolleys, sliding trays, etc. Made by Hoffman, approx. 2¾in. o.d. Offered at 4 for 10/-, post 4/6 extra.

VACUUM CLEANER FLEX

Non-kinkable ribbed rubber, most pliable but very tough. 24/36 Cores. Normally 1/9 per yard, offered at £3 per 100 yard coil, post and insurance 8/6.

SUB-MINIATURE SILICON DIODES

General purpose type with gold plated leads, 1/- each, 10/- per dozen.

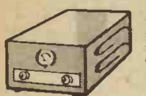
20W. SPEAKER (BRITISH RATING)

This is a beautifully made Hi-Fi reproducer with heavy duty 10,000 line magnet and 3in. voice coil, gives really fantastic results. In Sapele veneered enclosure £7.15.0 plus 10/- carriage and insurance. Guitar model in fabric covered carrying case £7.15.0. Either speaker supplied less enclosure, £4.19.6 plus 10/- carriage and insurance.

TWIN TWISTED 14/36 FLEX CABLE

Maroon cotton covered still the best for lighting drops, 50 yard coil 15/-, post 4/6.

BUILDING SOMETHING?



This may save you a lot of time and money. Ex Rediffusion Noise Limiter Unit has most useful power pack with 250-0-250v. 100 m.a. H.T. plus 2-6·3v. secondary windings and standard primary fused and with adjustment 200-250v. H.T. is provided by EZ80 rectifier and 4 smoothing condensers. The power unit is housed in the very nice louvred metal cabinet, size approximately 10in. × 10in. × 7in., on the front is a 2in. flush moving coil meter scaled d.b. Also five pre-set controls behind a removable panel. Within the unit is a 10in. × 10in. chassis on which the power pack is mounted. There are also five valve holders, but a lot of clear space for anything you want to fit. Below the chassis there is an assortment of tag panels and components. All new and unused, offered for less than the value of the power pack alone, 49/6 plus 10/- carriage and insurance.

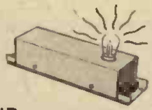
SEMI-CONDUCTOR BARGAINS

Type No.	Price	Type No.	Price	Type No.	Price
2N1727	15/-	MAT101	8/6	OC71	3/6
2N1728	10/-	MAT120	7/9	OC72	5/-
2N1742	25/-	MAT121	8/6	OC75	6/-
2N1747	25/-	OA5	5/-	OC76	5/-
2N1748	10/-	OA10	6/-	OC77	7/-
AC107	9/-	OA47	3/-	OC78	5/-
AC127	9/-	OA70	2/-	OC78D	5/-
ACY17	8/6	OA79	2/6	OC81	5/-
ACY18	5/6	OA81	2/6	OC81D	5/-
ACY19	6/6	OA85	2/6	OC82	5/-
ACY20	5/6	OA90	2/6	OC83	5/-
ACY21	6/-	OA91	2/6	OC84	6/-
ACY22	4/6	OA200	3/3	OC139	8/6
AF114	7/-	OA202	4/3	OC140	12/6
AF115	6/6	OC22	10/-	OC170	5/-
AF116	7/-	OC23	17/6	OC171	6/-
AF117	5/-	OC24	15/-	OC200	9/-
AF118	10/-	OC26	7/6	OC201	12/6
AF139	12/6	OC28	15/-	OC202	13/6
AF186	17/6	OC29	17/6	OC203	12/6
AFZ12	15/-	OC35	12/6	OCP71	15/-
ASZ21	15/-	OC36	15/-	ORP12	8/6
BC107	14/6	OC42	6/6	ORP60	5/-
BY100	4/6	OC44	4/-	SB078	6/6
BYZ13	7/6	OC45	3/6	SB305	8/6
MAT100	7/9	OC70	4/-	SB251	10/-

CAPSTAN DRIVEN TAPE RECORDER

This is a truly portable self-contained instrument with built-in microphone and loudspeaker using a 7 transistor amplifier with P.P. output and suitable for operation from mains or by chargeable batteries. Tape capacity is 25 minutes on easily change 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 neat case with carrying handle, overall size of which is approximately 6½ × 7¼ × 2in. Price with tape and mains unit but less batteries. £5.19.6 (rather less than 1/3 original price). Postage and insurance 7/6. Unused and in perfect working order.

OZONE AIR CONDITIONER



For removing smells and generally improving oppressive atmosphere. In neat hammer finish box. Uses Philips ozone lamp and mains unit. Lamp easily replaceable. Only 39/6 plus 6/6 carriage and insurance.

THIS MONTH'S SNIP

An assortment of radio panel bulbs, all made by the famous Philips company. Their cost if bought retail would exceed 30/-. Offered as a parcel for 10/- post free. Parcel comprises 12 × 6·3V, ·3A, 6 × 12V, ·1A, 6 × 24V, ·05A, 6 × 12V, ·6A, 6 × 6·3V, ·1A. All M.E.S. cap.

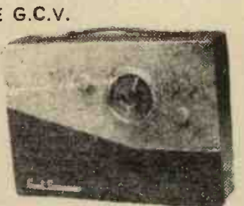
EX-WD BARGAIN—Easily rebuildable into Short Wave Radio, etc.

This is the 46 Receiver/Transmitter. It has a range of approx. 5 miles. Operates from dry batteries. Complete with six valves and in metal case. Size approx. 12in. × 6in. × 3¼in. Complete but less crystal, not tested nor guaranteed. 19/6 plus 4/6 post and ins. Should not be used as a transmitter in U.K.

SOLID STATE IGNITION

Big things are claimed of electronic ignition systems and if you would like to try for yourself a circuit was described in "Practical Electronics" (Sept., 1966). This requires a silicon controlled rectifier, four transistors and other components available as a kit. Price £6.15.0 post free.

SUPERTONE G.C.V.



Saves you work
It's partly built

Like its predecessors this latest Companion has full fi performance such as only a good wooden cabinet and biflux speaker can give, and due to its being partly built you will have it going in an evening. Note these features:

- All Mullard Transistors including 3 × AF117.
- Two-tone Cabinet, size 11 × 8 × 3in.
- All circuit requirements—Push-pull output—A.V.C. and feed back, etc.
- Printed circuit board all wired only connections, e.g. to Volume control—W.C. Switch and Tuning Condenser.
- Pre-aligned IF stages complete with full instructions. Price only £3.19.6 plus 6/6 post and insurance.

HALF PRICE—Proprietary Tapes

brand new, unused and guaranteed perfect and not second in any way—a connoisseur's tape on normal spools and in normal boxes.

Standard Play	5in.	600ft	9/-	Long play	5in.	900ft	11/6
	5¾in.	900ft.	11/6		5¾in.	1,200ft.	16/-
	7in.	1,200ft.	16/-		7in.	1,800ft.	23/-

£3 post free otherwise add 2/- post and insurance.

750 mW TRANSISTOR AMPLIFIER

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

SCR's (THYRISTORS)

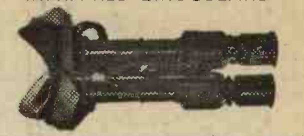
PIV	50V	100V	300V	400V
1 amp	6/6	7/6	12/6	15/-
3 amp	7/6	8/6	14/6	17/-
25 amp	30/-	35/-	47/6	60/-

DRILL CONTROLLER

Correct drill speed electronically without loss of power. Complete kit, case, thyristor, rectifiers, wire wound pot, etc.

ONLY 19/6. P. & P. 2/6

See in the Dark INFRA-RED BINOCULARS



These infra-red lit led 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 T.V. 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.

FLUORESCENT LIGHT KITS

Comprising choke, lampholders, starter and two chrome tube clips, 20 watt 19/6, 40 watt 11/6, Super Silent 40 watt 17/6, 80 watt 17/6, 65 watt 19/6. All 4/6 P. and P.

THERMOSTATS

Type "A" 15 amp. for controlling room heaters, greenhouse, airing cupboard. 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/-.

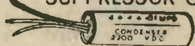
Type "B" 15 amp. This is a 17in. long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550°F. Internal screw alters the setting so this could be adjustable over 30° to 1000°F. Suitable for controlling furnace, oven kiln, immersion heater or to make flamestat or fire alarm 8/6, plus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

TRANS/CEIVERS

Communicate without connecting wires. Wonderful present for child. All transistor, crystal controlled with telescopic aerial and push button operation. Uses P.P.3 batteries. Pair of instruments, complete and ready to use £5.9.6 the two plus 5/- post and insurance. These cannot be used in U.K.

SUPPRESSOR CONDENSER



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

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v. 9v. 12 volts for up to 500 mA (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 500 mfd. condensers, Zener diode and instructions. Real snip at only 14/6, plus 3/6 postage.

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 + 1/- post.

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 & insurance.

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Tested and guaranteed

750mA	100v. 1/3		1 Amp	100v. 3/-
	200v. 1/6			200v. 4/6
	400v. 3/6			400v. 6/-
3A	100v. 3/6		10 Amp	100v. 9/6
	200v. 5/-			200v. 12/6
	400v. 7/6			400v. 14/6
	600v. 9/6			

Sub-miniature glass encased—only approx. ⅜in long wire ended.

750mA 50v. 1/6 100v. 2/6
200v. 4/6 400v. 6/6

Where postage is not definitely stated as an extra then orders over £3 are post free. Below £3 add 2/9.

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EDUCATIONAL

(continued)

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TECHNICIANS/JUNIOR TECHNICIANS required; (a) experienced in electronics and preferably with ability in the use of machine tools for applied acoustics research laboratories, and (b) to do interesting work for research laboratories, including photographing and electronic assembly. Salary Junior Technician £366-£624 p.a., Technician £698-£1,078 depending of qualifications and age. Application forms obtainable from Superintendent of Laboratories, Physics Department, CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY, Manresa Road, London, S.W.3. Tel. FLA. 6421, ext. 28.

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A number of suitably qualified candidates are required for permanent and pensionable employment (mostly in Cheltenham, but from time to time there are some vacancies in other parts of the U.K. including London). There are also opportunities for service abroad.

Applicants must be 19 or over and be familiar with the use of Test Gear, and have had practical Radio/Electronic workshop experience. Preference will be given to candidates who can offer "O" Level GCE passes in English Language, Maths and/or Physics, or hold the City and Guilds Telecommunications Technician Intermediate Certificate or equivalent technical qualifications.

Pay according to age, e.g. at 19–£747, at 25–£962 (highest age pay on entry) rising by four annual increments to £1,104.

Prospects of promotion to grades in salary range £1,032–£1,691. There are a few posts carrying higher salaries.

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Application forms available from:

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PYE TELECOMMUNICATIONS LTD.
CAMBRIDGE

Due to rapid expansion of this Company in the communication field and the progressive promotion within the organization, a number of vacancies exist for engineers.

Ideally we are looking for men capable of fault finding and checking to an exacting specification V.H.F. and U.H.F. communication equipments involving valve and transistor circuitry. Training will be given to all applicants with the right background.

Suitable applicants will join our permanent staff and will enjoy the benefits of a Company which is offering first class financial rewards and rapid advancement within the organization.

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R. & R. RADIO & TV SERVICE

Dept. P.E.

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EF80	1/6	30P4	7/-	30FL1	5/-
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SPEAKERS Ex TV 3 ohm imp. 5" Rnd. and 6" X 4" 3/6. 8" Rnd. 6/-. Post 2/6.

BY100, Rectifiers complete with 10 watt res. 6/-. Post 6d. Fireball Tuners, less cover cans 9/- post paid.

Ekco line o/p trans, U26 type 35/- post paid. Ferg line O/P 406T 30/-. Ferg 306 type, New, 70/-. Cyldon type 'C' tuners 15/- post 2/-.

S.A.E. with all enquiries.

9 X 4 Envelope for lists.

2N2926 3/6, OC71 3/6, OA81 1/9, 850V, ½A. Rectifiers 4/-, ½W 5%, H.S. resistors 4d. add 6d. pp. Discount on 10 and up. A. P. ROBSON, 41 Thunder Lane, NORWICH.

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★ **ASSORTED TRANSISTORS**—6 Tested A.F. Devices 9/6

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OC44, 45, 70, 71, 72, 81 and 81D Equivalent, each 3/-

(P. & P. 1/6 per order, C.W.O.)

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AF115	4/-	OC29	19/-	OC81	3/-
AF116	4/-	OC35	12/-	OC81D	3/-
AF117	4/-	OC36	20/-	OC82	4/6
BC107	7/9	OC41	3/6	OC83	4/-
BC108	7/6	OC42	4/-	OC170	4/-
BC109	8/3	OC44	3/-	OA5	4/-
BCY30	8/3	OC45	3/-	OA10	3/-
Full Mullard range in				OA81	1/6
stock. See our Cat. 1/-				OA200	4/-

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150 yards PVC wire 4 colours	11/-

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Postage 9d. Callers Welcome

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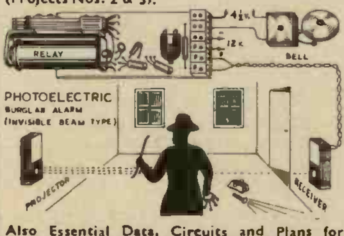

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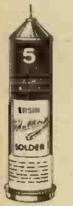

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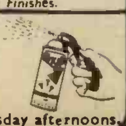

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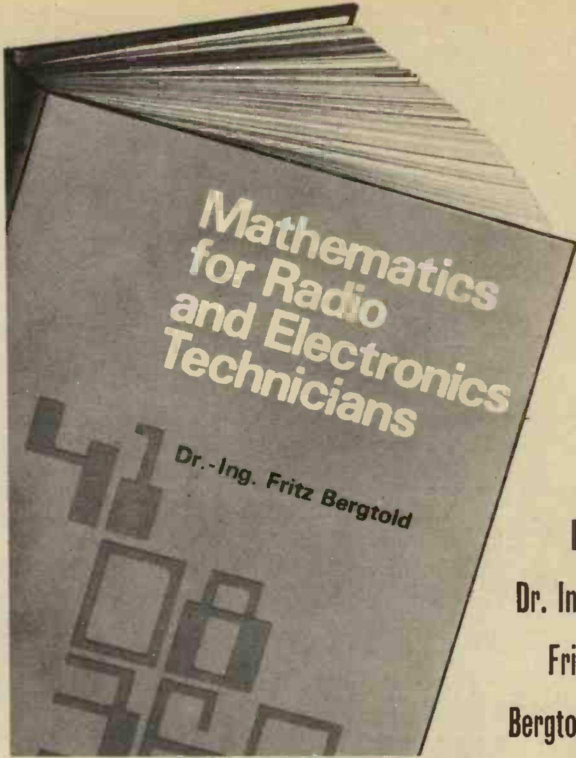

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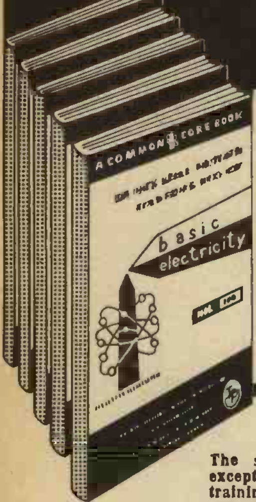

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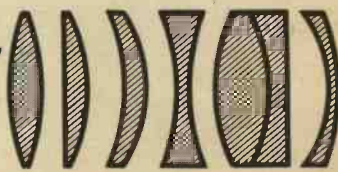

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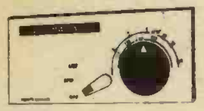

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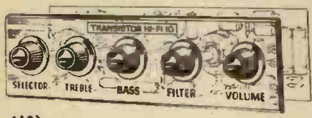

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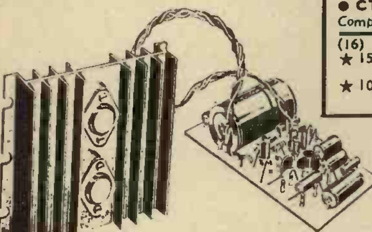

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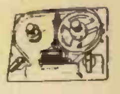

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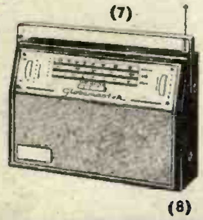

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