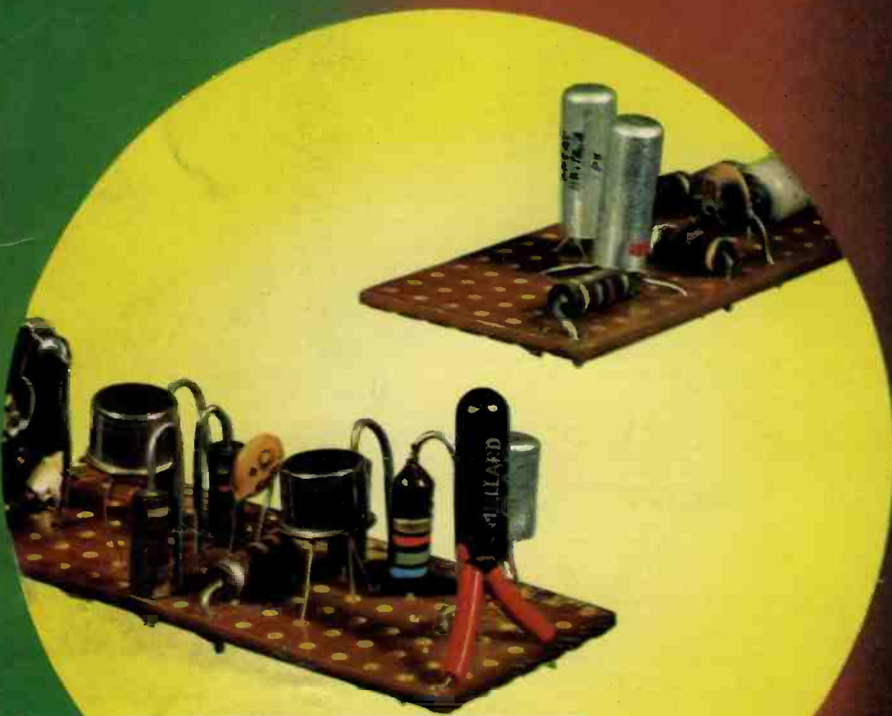
PRACTICAL

ELECTRONICS

OCTOBER 1968

THREE SHILLINGS



CONTENTS INCLUDE—

SOUND LIGHT & COLOUR PART 3....

Completing the c.r. colour pattern display

****

INTEGRATED CIRCUIT PROJECT... PICK-UP PRE-AMPLIFIER

FREE! INSIDE

PRINTED WIRING BOARD with 2 Projects to build

LIGHT OPERATED MAINS SWITCH

VARI WINDSCREEN WIPER

Lasky's Radio

SPECIAL INTEREST ITEMS!

OUTSTANDING HI-FI BARGAIN

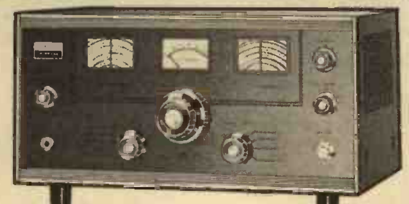
AFX-3U AM/FM STEREO TUNER

Superbly engineered by world famous manufacturer, the Model AFX-3U is an ultra sensitive AM/FM stereo multiplex tuner using 14 valves and 9 diodes. The extra wide bandwidth of the tuner and unique multiplex circuitry ensures the finest possible FM reception with optimum stereo separation of over 38dB. Stereo signal beacon with special circuitry unaffected by external noise, simplifies FM stereo broadcast selection. 3 gang variable condenser provides highly sensitive reception on both bands. The multiplex circuit is completely free from subcarrier leakage and permits direct tape recording without any beat noise interference. An MPX noise filter is also fitted. **Brief specification:** 14 valves, 2 Germanium diodes and 2 Silicon diodes. **Frequency range:** FM—80–108Mc/s, AM—535–1,605kc/s. **Sensitivity:** FM—1·9μV/98Mc/s, AM—2μV/100kc/s. **Output** FM/FM Stereo 2V, AM—3V. **Frequency response:** FM—20–20,000c/s. **Distortion** less than 1%. **Special Circuits:** FM Stereo indicator, AFC, Noise filter. Output for direct tape recording. Hammer enamel and brushed alloy finish. Cabinet size 14¾ × 5 × 9¾in. For 220/240V a.c. Mains (50 or 60c/s) operation. Complete with operating manual. **List Price 55 Gns.**

Lasky's Price 26 Gns. Carriage and Packing 7/6

COMMUNICATION RECEIVERS

TRIO



MODEL 9R-59DE

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

Lasky's Price £39.15.0 Carriage and Packing 12/6

MODEL JR-500SE

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

Lasky's Price £68.0.0 Carriage and Packing 12/6

FOSTER HF-204 COMBINED MICROPHONE/HEADSET

High quality moving coil headphones and sensitive dynamic microphone combined in one lightweight unit. For use with tape recorders (provides constant monitoring), communications equipment, PA (crowd or traffic control), stage direction, language labs, etc. Extremely comfortable to wear for long periods—adjustable foam padded cushions, vinyl covered headband. Headphone imp. 8Ω, max. input 100mW. Microphone imp. 25Ω. Weight 8·8oz. Single cable contains both headphone and microphone leads. **List Price 7 Gns.**

Lasky's Price 59/6 Post 2/6

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NEW LASKY'S SOLID STATE INCAPSULATED MODULES

7 completely new special function circuit modules. Size of each module only 2¼ × 1¼ × ¾in. Ready for immediate use—just connect to power source (usually 9V batt.), input and output. Incapsulated modules are shock proof and almost indestructable. Complete with full instructions. Post 1/6 each.

E-1311 Phono Pre-amp Module—max. output 3V, RMS, input 50mV, input imp. 100Ω, gain 28dB, RIAA compensation.	29/6
E-1312 Tape Head Pre-amp Module—max. output 3V, RMS, input 50mV, input imp. 100kΩ, gain 25dB, NARTB compensation.	29/6
E-1313 Microphone Pre-amp Module—max. output 4V, RMS, input 50mV, input imp. 100kΩ, gain 28dB, response 10·50kc/s.	29/6
E-1314 Power Amplifier Module—max. output 300mW, input imp. 1kΩ, gain 20dB, response 50·10k/cs, distortion 3% at 20mW.	29/6
E-1315 Electronic Organ (tone oscillator) Module—frequency 200–1,000c/s, output 80mW. For use with keyboard, variable resistors and 8Ω speaker.	25/-
E-1316 Morse Code Practice Oscillator Module—frequency 400c/s, output 80mW. For use with morse key and speaker.	25/-
E-1317 Modulated Wireless Signal Transmitter for use in test bench fault finding—frequency 400c/s–30Mc/s, tone freq. 400c/s. For use with any AM receiver.	25/-
E-1318 Lamp Flasher Module—flashes two miniature lamps alternately. For use with 6V, 100/200mA bulbs and 6V power supply.	25/-

TEST EQUIPMENT

MINIMETER BARGAIN
TTC Model C-1000

A really tiny 1,000 O.P.V. pocket multi-tester with "big" meter performance. Precision 2 jewel meter movement. Hand calibrated to ±3% accuracy on full scale of d.c. ranges, 4% on a.c. ranges. 2¼in square meter. **SPECIFICATIONS** a.c./V ranges: 0–10, 50, 250, 1,000V at 1K/O.P.V. a.c./V ranges: 0–10, 50, 250, 100V at 1K/O.P.V. D.c.current: 0–1–100mA. Resistance: 0–150K/ohms (3,000 ohms centre scale). Decibels: −10 to +22dB. Operated on one penlight cell. Two colour buff/green case—size only 3¼ × 2¼ × 1in. Click stop range selection switch. Ohms zero adjustment. Complete with test leads, battery and instructions with circuit data.

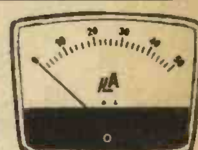
Lasky's Price 39/6 Post 2/6

TTC Model C-1051

A completely new design 20,000 O.P.V. pocket multimeter with built-in thermal protection circuit and mirror scale. Exceptionally large easy to read meter with D'Arsonval movement. Colour coded scales. Single positive click-in, recessed selection switch for all ranges. Ohms zero adjustment. Range spec. a.c. volts: 0–6–30–300–1,200V at 10K/ohms/V. D.c. volts: 0–3–15–150–300–1·2KV at 20K/ohms/V. Resistance: 0–60K–6megs. D.c. current: 0–60μA—300mA. Decibels: −20dB to +17dB. Hand calibration gives extremely high standard of accuracy on all ranges. Uses one 1½V penlight battery. Strong impact resistant plastic cabinet—size only 4¾ × 3¼ × 1¼in. Two colour buff/green finish. Complete with test leads and battery. Orig. list price £5.5.0.

LASKY'S PRICE 75/- Post 2/6

LASKY'S CLEAR PLASTIC PANEL METERS



Precision made in Japan by HIOKI. Each meter boxed and fully guaranteed with all fixing nuts and washers. Sizes are of front panel. Add 1/6 P. on each. (Quotes for quantities.)

Type KR-52 3 × 2½in (illustrated).

1mA	38/6	50μA	56/-
5mA	38/6	1mA S Meter	39/6
100mA	38/6	100μA	52/6
300V	35/-	500μA	45/-

Type MK-38A 1⅝in square

1mA	29/6
5mA	27/6
100mA	27/6
300V	27/6
50μA	37/6
1mA S meter	29/6
100μA	37/6
500μA	29/6

Type MK-45A 2in square

1mA	29/6
5mA	28/6
100mA	28/6
300V	28/6
50μA	49/6
1mA S meter	32/6
100μA	42/6
500μA	35/-

Type KR-65 3¾ × 3in

1mA	38/6
5mA	37/6
100mA	38/6
300V	36/-
50μA	59/6
1mA S meter	42/-
100μA	56/-
500μA	46/-

Type MK-65A 3in square

1mA	35/6
5mA	36/-
100mA	38/6
300V	36/-
50μA	59/6
1mA S meter	38/6
100μA	52/6
500μA	42/-

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6AG7	6/-	10P13	15/-	DK92	8/9	EF89	6/3	PCF84	9/-	UCF80	9/6
6AK5	5/-	10P14	16/-	DK96	8/-	BF91	4/-	PCF86	9/-	UCH42	10/-
6AL5	3/-	12AT6	5/-	DL92	5/-	EF92	4/-	PCF800	15/-	UCH81	7/-
6AM6	4/-	12AT7	4/-	DL94	6/-	EF183	7/-	PCF801	10/-	UCL82	8/-
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6AS6	6/-	12AX7	6/-	DY86	6/6	EL33	17/6	PCF805	14/-	UF41	10/-
6AT6	5/-	12BA6	6/9	E88CC	12/6	EL34	11/-	PCL82	7/6	UF80	7/-
6AU6	5/9	12BE6	6/3	EABC80	7/-	EL41	9/9	PCL83	9/6	UF85	7/6
6BA6	4/9	12BH7	6/6	E180F	15/-	EL42	11/-	PCL84	8/-	UF89	7/6
6BE6	5/3	12Q7	5/6	EAF42	9/6	EL81	9/-	PCL85	9/6	UL41	10/-
6BH6	8/-	12SQ7	7/6	EB91	3/-	EL84	5/-	PCL86	9/-	UL84	7/-
6BJ6	8/-	19AQ5	6/-	EBC41	9/6	EL85	8/6	PFL200	12/6	UY41	7/6
6BR7	11/-	20F2	14/-	EBC81	7/-	EL91	4/-	PL36	10/6	UY85	6/6
6BZ6	7/-	20L1	13/-	EBF80	7/6	EL95	5/3	PL81	7/6	VR105/30	
6C4	3/6	20P1	12/-	EBF83	9/-	EM80	7/6	PL82	7/-		5/6
6C6	4/-	20P3	12/-	EBF89	7/6	EM81	8/-	PL83	7/-	VR150/30	5/-
6CD6	20/-	20P4	22/6	ECC40	11/6	EM84	7/6	PL84	6/9	MANY	
6CH6	6/-	25L6	6/6	ECC81	4/-	EM87	7/6	PL500	14/6	OTHER	
6CL6	10/-	25Z4	8/-	ECC82	5/-	EY51	7/6	PY33	9/9	TYPES IN	
6D6	3/-	30C15	13/6	ECC83	6/-	EY86	7/-	PY80	5/6	STOCK.	

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2N744	4/-	BC107	4/6	BSY56	17/3	OC25	7/6
2N753	4/6	BC108	3/6	BSY65	4/6	OC26	6/-
2N914	4/6	BC109	4/6	BSY78	7/6	OC28	8/6
2N916	4/6	BC170	3/-	BSY79	7/6	OC35	8/6
2N929	4/6	BC172	3/3	BSY95A	12/6	OC36	8/6
2N930	5/-	BC173	3/9	BUY10	3/6	OC41	5/-
2N1613	5/-	BCY31	4/6	GET106	4/6	OC42	5/-
2N1711	6/6	BCY34	4/6	GET113	5/-	OC44	4/0
2N1893	8/-	BCY39	4/6	GET873	4/6	OC45	3/6
2N2160	14/11	BCY42	5/-	GET874	4/6	OC70	3/-
2N2147	17/6	BCY43	5/-	MAT100	7/9	OC71	3/-
2N2926	3/-	BF115	4/6	MAT101	8/6	OC72	4/-
2S102	6/6	BFX12	6/6	MAT120	7/9	OC73	5/-
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2S104	6/6	BFY10	4/6	NKT210	5/-	OC75	4/6
AC107	4/6	BFY11	4/6	NKT211	5/-	OC76	4/6
AC126	4/6	BFY17	4/6	NKT212	4/9	OC77	4/6
AC127	4/6	BFY18	4/6	NKT213	5/-	OC78	5/-
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SILICON POWER DIODES

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700 P.I.V.	100amp	35/-
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2·4 / 2·7 / 3 / 3·9 / 4·3 / 13 / 16 / 18 / 20 / 30 / 33V. 5/- each.
Z series. All voltages from 3·9 to 50V. 250MW 2/6 each. 1·5W 4/- each. 7W 5/- each.

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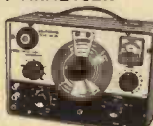
TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120Kc/s - 260 Mc/s on 6 bands, Directly — calibrated. Variable R.F. attenuator. Operation 200 / 240V a.c. Brand new with instructions, £15.0.0. P. & P. 7/6. S.A.E. for details.

LAFAYETTE TE46 RESISTANCE CAPACITY ANALYSER



2pF–2,000 mfd 2 ohms–200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c.

Brand New £17.10.0 Carr. 7/6.

ARF-100 COMBINED AF-RF SIGNAL GENERATOR

AF. SINE WAVE 20-200,000c/s. Square wave 20-30,000 c/s. O/P. HIGH IMP. 21V P/P 600Ω 3·8V P/P.
TF. 100kc/s-300 Mc/s.
Variable R.F. attenuation int/ext. modulation. Incorporates dual purpose meter to monitor AF. output and % mod. on R.F. 220/240V a.c. £30.0.0. Carr. 7/6.

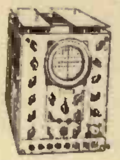
T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: ·01 / ·003 / ·1 / ·3 / 1 / 3 / 10 / 30 / 100 / 300V. R.M.S. 4c/s.-1.2Mc/s. Decibels—40 to + 50dB. Supplied brand new complete with leads and instructions. Operation 230V a.c. £17.10.0. Carr. 5/-.

AVO CT.38 ELECTRONIC MULTIMETERS

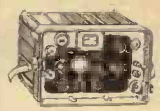
High quality 97 range instrument which measures a.c. and d.c. Voltage, Current, Resistance and Power output. Ranges d.c. volts 250mV–10,000V. (10megΩ–110megΩ input). D.c. current 10μA 25 amps. Ohms: 0–1,000megΩ. A.c. volt 100mV–250V (with RF measuring head up to 250Mc/s). A.c. current 10μA–25 amps. Power output 50 micro-watts–5 watts. Operation 0/110/200/250V. C. Supplied in perfect condition complete with circuit lead and RF probe £25. Carr. 15/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES



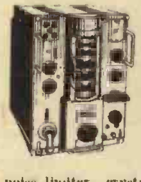
An excellent general purpose D/B oscilloscope. T.B. 2c/s–750 kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33mV/CM. Operating voltage 0/110/200/250V a.c. Supplied in excellent working condition. £22.10.0. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20–80Mc/s. AM/C.W./FM. Incorporates precision dial, level meter, precision attenuator 1μV-100mV. Operation from 12V d.c. or 0/110/200/250V a.c. Size 12×8½×9in. Supplied in brand new condition complete with all connectors fully tested. £45. Carr. 20/-.

ADMIRALTY B.40 RECEIVERS



Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650kc/s – 30Mc/s, I/F 500 kc/s. Incorporates 2 R.F. and 3 I.F. stages, band-pass filter, noise limiter, crystal controlled B.F.O., calibrator I/F, output, etc. Built-in speaker, output for phones. Operation 150/230V a.c. Size 19½ × 13¼ × 16in. Weight 114lb. Offered in good working condition. £22.10.0. Carr. 30/-. With circuit diagrams. Also available B.41 L.F. version of above 15kc/s–700kc/s. £17.10.0 Carr. 30/-.

MARCONI CT44/TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts

£20. Carr. 20/-.

AVOMETERS

Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions. Model 47A £9.19.6. Model 8 £18. P. & P. 7/6 each.

CLASS D WAVEMETERS

A crystal controlled hetrodyne frequency meter covering 1·7–8Mc/s. Operation on 6 volts d.c. Ideal for amateur use. Available in good used condition £5.19.6. Carr. 7/6. Or brand new with accessories £7.19.6. Carr. 7/6.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.

150 W.	£1.12.6,	P. & P. 3/-
300 W.	£2.7.6,	P. & P. 3/6
500 W.	£3.10.0,	P. & P. 6/6
1,000 W.	£5.10.0,	P. & P. 7/6
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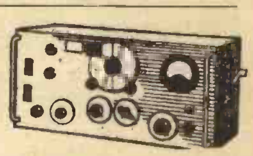

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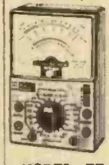

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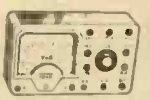

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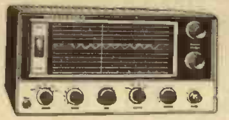

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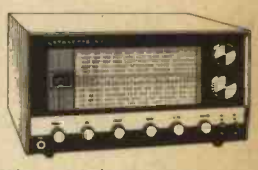

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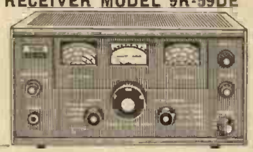

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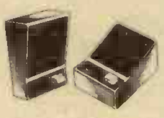

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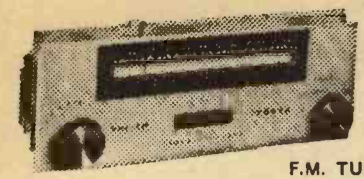

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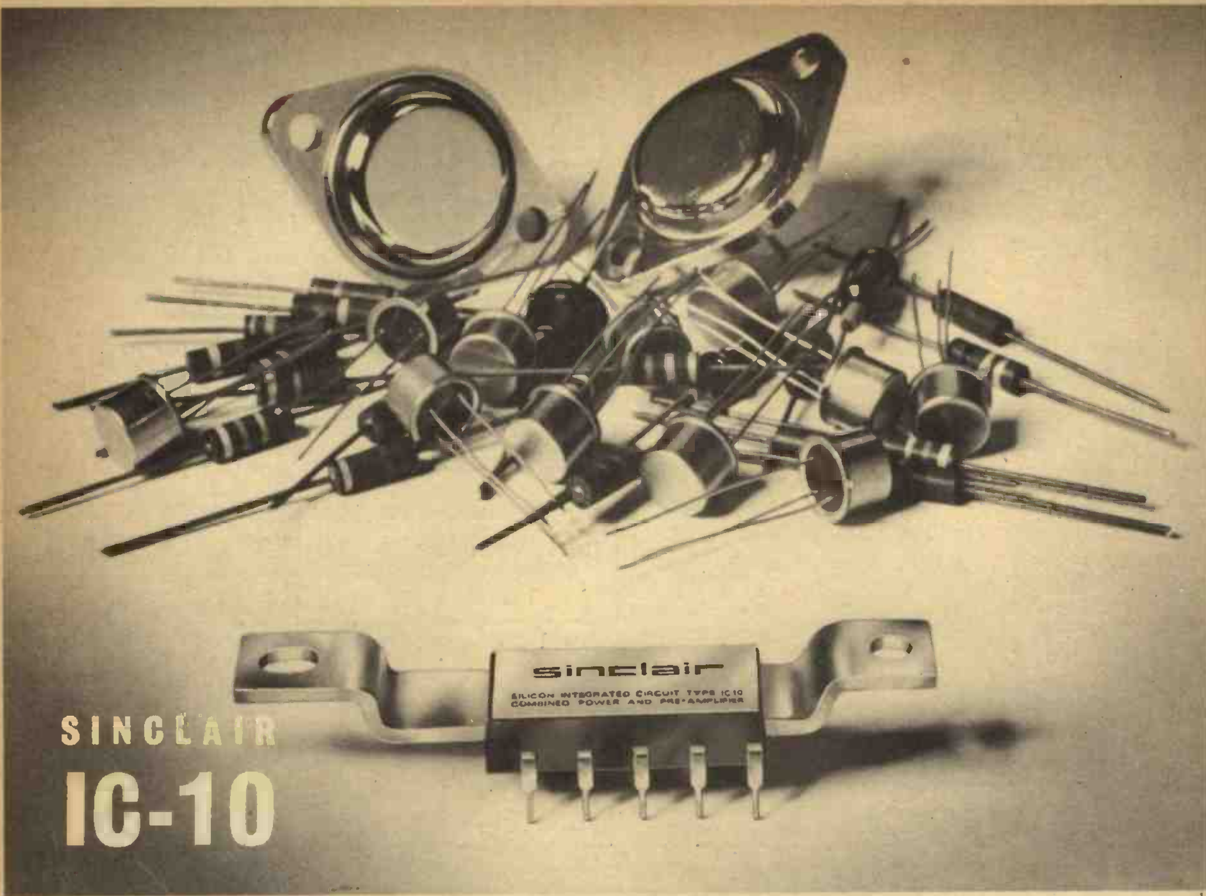

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Monolithic I.C's. were originally developed for use in computer and space applications where their extraordinary toughness and reliability were even more important than their minute size. These same advantages make them ideal for linear applications such as audio amplifiers, but hitherto they have been confined to low power applications. The IC-10 thus represents a very exciting advance. Not only is it far more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

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The photographic masks required for producing monolithic I.C's. are expensive but once made, the circuits can be produced with complete uniformity and at very low cost. So we are able to sell the IC-10 at a price far below that of the components for a conventional amplifier of comparable power. At the same time, we give a 5 year unconditional guarantee on each IC-10 knowing that every unit will work as perfectly as the original and do so for a lifetime.

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10 WATT MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER

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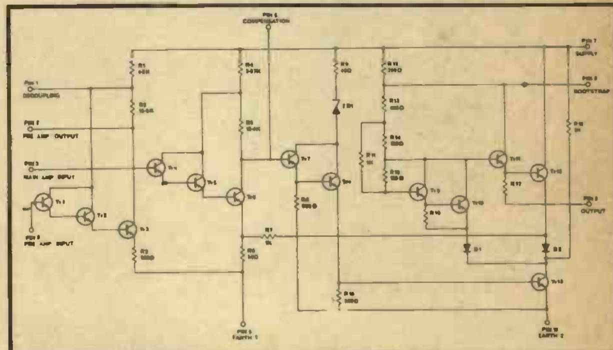
Power Output	10 Watts peak, 5 Watts R.M.S. continuous.
Frequency response	5 Hz to 100 KHz ±1dB.
Total harmonic distortion	Less than 1% at full output.
Load impedance	3 to 15 ohms.
Power gain	110dB (100,000,000,000 times) total.
Supply voltage	8 to 18 volts.
Size	1 x 0.4 x 0.2 inches.
Sensitivity	5 mV.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

■

ABOVE SHOWS ACTUAL SIZE OF IC-10.
TO RIGHT, VIEW OF AMPLIFIER MAGNIFIED 625 TIMES.



■ Circuit Description

The circuit diagram of the IC-10 is shown on the right. The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. The output stage operates in class AB with closely controlled quiescent current which is independent of temperature. A high level of overall negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages. Thus battery operation is eminently satisfactory.

■ Construction

The monolithic I.C. chip is bonded onto a gold plated area on the heat sink bar which runs through the package. Wires are then welded between the I.C. and the tops of the pins which are also gold plated in this region. Finally the complete assembly is encapsulated in solid plastic which completely protects the circuit. The final device is so rugged that it can be dropped thirty feet on to concrete without any effect on performance. The circuit will also work perfectly at all temperatures from well below zero to above the boiling point of water.

■ Applications

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity uses. These include public address, loud-hailers, use in cars, inter-com., stabilised power supplies, electronic organs, oscillators, volt meters, tape recorders, solar cell amplifier, radio receivers.
The transistors in the IC-10 have cut off frequencies greater than 500 MHz so the pre-amp section can be used as an R.F. or I.F. amplifier making it possible to build complete radio receivers without any additional transistors.

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IC-10

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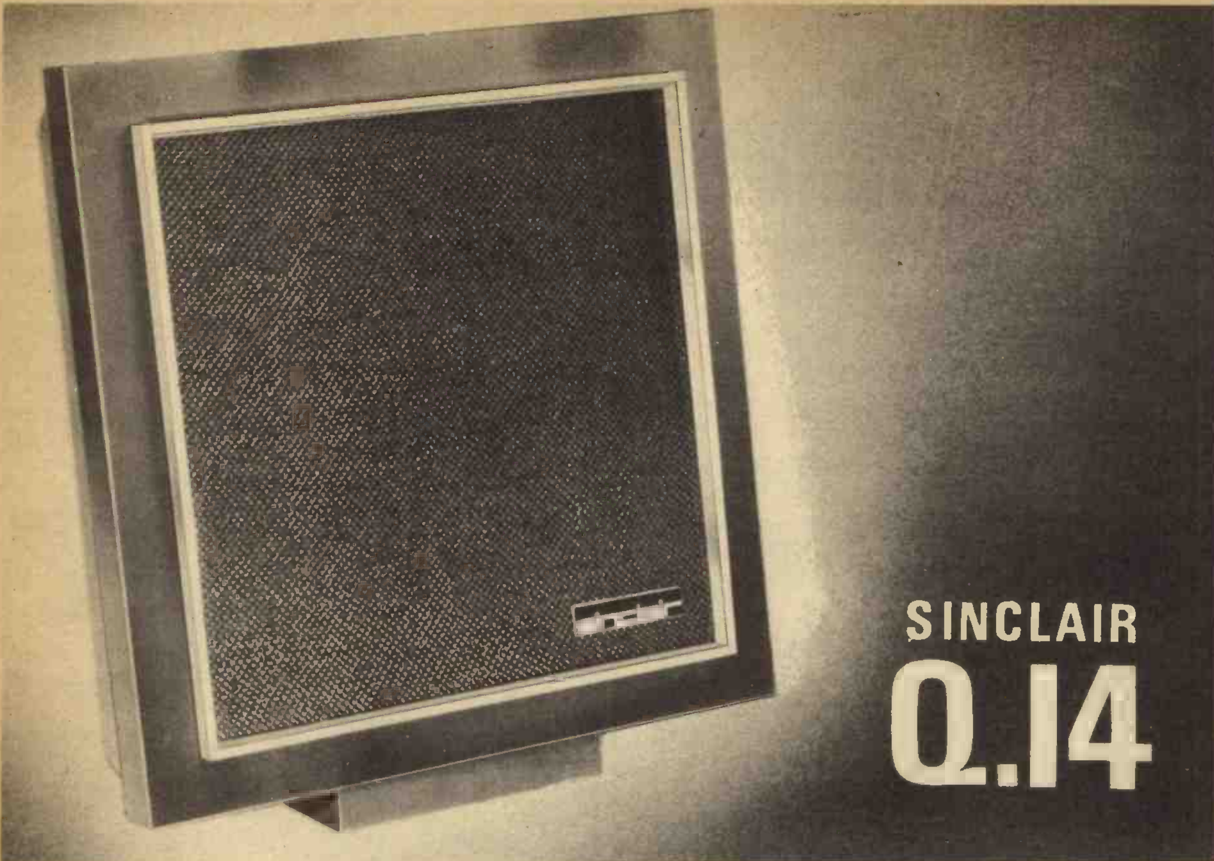

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It costs about a quarter of what you would expect to pay for a good stereo speaker system when you choose Q.14s. This is because of the considerable amount of research and experimentation into the acoustic properties of special materials that went into the design of this excellent speaker. It resulted in an instrument so outstandingly good that experts, reviewers and the public alike were unanimous in their praise for the Q.14 at this year's Audio Fair. The Q.14 is very compact, measuring only $9\frac{3}{4}$in square on its face by $4\frac{3}{4}$in deep. Its unusual contours permit it to be positioned where no ordinary speaker could be used to advantage. The neat black matt finish with aluminium bar trim keep this speaker pleasantly in conformity with modern design trends. The Q.14 has acoustically contoured and sealed sound chamber. Smooth response from 60–16,000Hz. Loading up to 14 watts. 8 ohms impedance. Brilliant transient response. Size $9\frac{3}{4}$in square on face. Finished black matt with aluminium bar trim. Detachable pedestal base. *Hear the Q.14 in your own home. If you are not delighted with it, send it back, and your money, including cost of return postage to this office, will be refunded in full.*

£7-19-6

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SINCLAIR RADIONICS LTD., CAMBRIDGE

Sinclair IC-10 a revolutionary new amplifier-See previous pages-

SINCLAIR MICROMATIC

The smallest radio set in the world

The Sinclair Micromatic is available ready built or in kit form. This latter now comes in a convenient new presentation pack complete down to a generous free supply of solder. The moulded polystyrene interior enables you to check the contents in an instant, and helps to make building even easier and surer. Now, the Micromatic is better than ever—more powerful and better sounding to assure superb listening. Selectivity is better than many larger sets. Whether you build it, or buy your Micromatic ready built, it is the best and the smallest personal radio in the world—and it's British. In elegant aluminium fronted black case with slow motion tuning.

- $1\frac{4}{5} \times 1\frac{3}{10} \times \frac{1}{2}$in
- Tunes over medium waves
- Plays anywhere
- Magnetic earpiece
- In kit form or complete

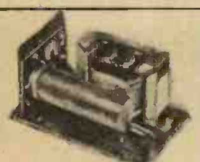
Complete kit inc. magnetic ear-piece and instructions. **49/6**

Ready built and tested **59/6**

Mallory Mercury Cell RM.675 (2 needed) each 2/9.

IN THE NEW KIT PACK

This attractive new presentation pack enables you to check the contents of your kit instantly. Everything is there down to the last nut and includes easy to follow instructions and generous supply of free solder.

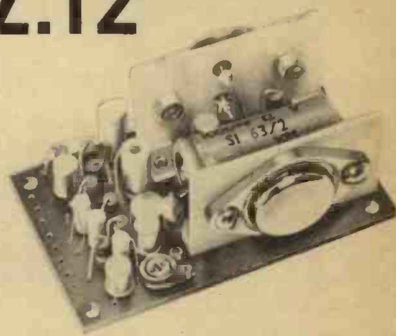


SINCLAIR
PZ.4
STABILISED POWER SUPPLY UNIT

A heavy duty a.c. mains power supply unit delivering 18V d.c. at 1·5A. Designed for Sinclair IC-10 or for assemblies using two Z.12s and stereo 25 unit.
Ready built and tested. **99/6**

SINCLAIR Z.12

12 WATT AMPLIFIER AND PRE-AMP



The Sinclair Z.12 has fantastic power-to-size ratio, and great adaptability. It will operate from batteries or PZ.4 mains power supply unit, and gives superb stereo reproduction for modest outlay. Thousands are in use throughout the world—in hi-fi, electronic music instruments, P.A., intercom systems, etc. This true 12 watt amplifier is supplied ready built, tested and guaranteed together with the Z.12 manual which details control circuits enabling you to match the Z.12 to your precise requirements. For complete listening satisfaction use your Z.12 system with Q.14 loudspeakers. It assures superb quality with substantial saving in outlay.

★ **IDEAL FOR BATTERY OPERATION**

$3 \times 1\frac{3}{4} \times 1\frac{1}{4}$in ● Class B Ultralinear output ● 15–50,000Hz ± 1dB ● Suitable for 3, 5, 8 or 15Ω speakers. Two 3Ω speakers may be used in parallel ● Input—2mV into 2kΩ ● Output—12 watts R.M.S. continuous sine wave (24W peak) 15W music power (30W peak) ● Ready built, tested and guaranteed.

89/6

SINCLAIR GUARANTEE

Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full at once and without question. *Full service facilities available to all purchasers.*

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PE1068

DE LUXE PLAYERS

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

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

SUPERIOR AMPLIFIER. Built and tested. Better sound! Isolated AC Mains Transformer. 3 watt ECL82 triode pentode valve. Volume and tone controls with knobs. Quality Loudspeaker. **89/6**

Post 5/6 each item

SINGLE PLAYERS	MONO	AUTOCHANGERS	MONO
Staar (9 volt)	£2.19.6	BSR Superslim	£6.19.6
EMI Junior	£2.19.6	Garrard 1000	£6.19.6
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All fitted LP/78 stylii and pickup crystal complete.

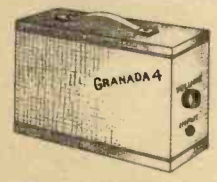
GARRARD TEAKWOOD BASE WB.1. Ready cut out for mounting 1000, 2000, 3000, SP25, AT60. **GARRARD PERSPEX COVER SPC.1** for WB.1 **65/- EACH**

PICK-UP ARM Complete with ACOS LP-78 Turnover GP67 and Stylii 25/-; GP67 15/-; Stereo 35/-.

CRYSTAL MIKE INSERTS

1½ × ⅜in. 6/6; ACOS 1½ × ⅜in. 8/6. BM3, 1" dia. 9/6
MOVING COIL MIKE with Remote Control Switch 19/6

PORTABLE TRANSISTOR AMPLIFIER



Many uses, Intercoms, Baby Alarms, Guitar Practice, Telephone or Record Player Amplifier. ONE WATT OUTPUT Wooden cabinet 12 × 9 × 4in. Rexine covered two tone grey. Four transistors, 7 × 4in. speaker. Volume control. Jack socket. Uses PP9 battery. OUR PRICE **79/6** Post 5/6. Worth double

BATTERY RECORD DECKS

2 speed model 33 1/3 and 45 r.p.m. 9v. operated. Complete with pick-up fitted crystal cartridge. Plays 7, 10, 12in. records. Fitted auto, stop and start. Ideal for use with above transistor amplifiers. OUR PRICE **59/6** POST 2/6
4 speed Model 9 volt, 10/- extra.

THE ABOVE GRANADA AMPLIFIER AND PLAYER DECK POST FREE IF PURCHASED TOGETHER

WEYRAD P50—TRANSISTOR COILS

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

Telescopic Chrome Aerials 6in. extends to 23in. 5/-.

VOLUME CONTROLS

Long spindles. Midget Size 5 K. ohms to 2 Meg. LOG or LIN. L/S 3/-. D.P. 5/-. STEREO L/S 10/6, D.P. 14/6. 5K. S.P. Edge type, 5/-.

80ohm Coax 8d. yd.

SEMI-AIR SPACED 40 yd. 20/-; 60 yd. 30/-.

FRINGE LOW LOSS Ideal 625 lines **1/6** yd.

VEROBOARD 0·15 MATRIX

2½ × 5in. 3/8. 2½ × 3¾in. 5/2. 3¾ × 3¾in. 3/8.
EDGE CONNECTORS 16 way 5/-; 24 way 7/6.
PINS 36 per packet 3/4. FACE CUTTERS 7/6.
S.R.B.P. Board 0·15 MATRIX 2½in. wide 6d. per 1in., 3¾in. wide 9d. per 1in.; 5in. wide 1/- per 1in. (up to 17in.).

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ALUMINIUM PANELS 18 s.w.g. 12 × 12in. 6/6; 14 × 9in. 5/6; 12 × 8in. 4/6; 10 × 7in. 3/6; 8 × 6in. 2/6; 6 × 4in., 1/6.

Q MAX CHASSIS CUTTER

Complete: a die, a punch, an Allen screw and key
½in. 16/- ⅝in. 17/6 1⅛in. 19/6 1⅜in. 24/- 2³⁄₃₂in. 44/3
¾in. 16/- 1in. 19/6 1¼in. 20/6 1⅝in. 29/- 2½in. 57/3
⅞in. 16/9 1⅛in. 19/6 1½in. 21/6 2in. 39/- 1in. sq. 36/6

'SONOCOLOR' CINE RECORDING TAPE

5" reel, 900' with LP strobe markings, also cine light deflector-mirror for synchronisation. 14/- each.

Tape Spools 2/6. Tape Splicer 5/-. Leader Tape 4/6.
Reuter Tape Heads for Collaro models 2 track 21/- pair.
UNIVERSAL TAPE CASSETTES Type C60. OUR PRICE 14/-.

"THE INSTANT" BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER

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

BARGAIN STEREO PARCEL

E.A.R. STEREO PLAYER CABINET suitable for B.S.R. Player Decks with 4 + 4 STEREO AMPLIFIER and TWO 6½in. LOUDSPEAKERS BUILT INTO CABINET AND LID Post 10/6 **£13.19.6.**

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2/350V	2/3	100/25V	2/-	8/600V	9/6
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8/450V	2/3	500/25V	4/-	16+16/500V	7/6
16/450V	3/-	8+8/450V	3/6	32+32/250V	3/6
32/450V	3/9	8+16/450V	3/9	50+50/350V	7/-
25/25V	1/9	16+16/450V	4/3	60+100/350V	11/6
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SUB-MIN. ELECTROLYTICS. 1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 250mF 15V 2/-; 500, 1000mF 12V 3/6; 2000mF 25V 7/-.
CERAMIC. 500V 1pF to 0.01mF, 9d. Discs 1/-.

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SILVER MICA. Close tolerance 1%. 5-500pF 1/-; 560-2,200pF 2/-; 2,700-5,600pF 3/6; 6,800pF-0·01, mfd 6/-; each
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SHORT WAVE. Single 10pF, 25pF, 50pF, 75pF, 100pF, 160pF, 5/6 each. Can be ganged. Couplers 9d each.
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250V RECTIFIERS. Selenium ½ wave 100mA 5/-; BY100 10/-.
CONTACT COOLED ½ wave 60mA 7/6; 85mA 9/6.
Full wave Bridge 75mA 10/-; 150mA 19/6; TV rects. 10/-.
RESISTORS. Preferred values, 10 ohms to 10 meg.
¼ w., ½ w., 1 w., 20% 3d.; 1½ w. 8d.; 2 w. 1/-; ½ w. 10% 6d.
HIGH STABILITY. ½ w. 1% 10 ohms to 10 meg., 2/-.
Ditto 5%. Preferred values 10 ohms to 22 meg., 9d.

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

10K, 15K, 20K, 25K, 68K, 10W. 3/-

FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12v. outputs. 1½ amp. 8/9; 2a., 11/3; 4a., 17/6.
CHARGER TRANSFORMERS. P. & P. 5/-. Input 200/250v. for 6 or 12v., 1½ amps., 17/6; 2 amps., 21/-; 4 amps., 30/-

WIRE-WOUND 3-WATT POTS. T.V. Type. Values 10 ohms to 30 K., Carbon 30 K to 2 meg. **4/6**

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

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NEW MULLARD TRANSISTORS 6/- each

OC71, OC72, OC81, OC44, OC45, OC171, OC170, AF117.
REPANCO TRANSISTOR TRANSFORMERS.
TT45. Push Pull Drive, 9:1 CT, 6/-. TT46 Output, CT8:1 6/-.
TT49. Interstage, 20:1, 6/-; TT52 Output 3 ohms, 4·5:1, 6/-.

TRANSISTOR MAINS POWER PACK. FAMOUS MAKE. FULLY SMOOTHED. FULL WAVE CIRCUIT **49/6**
9 Volt 500mA Size 5 × 3½ × 2in.
TRANSFORMER ONLY. Size 2½ × 1¾ × 1½ in 9 volt 10/6

MAINS TRANSFORMERS

Post 5/- each

250-0-250 50 mA. 6.3 v. 2 amps, centre tapped	19/6
250-0-250 80 mA. 6.3 v. 3.5 a. 6.3 v. 1 a, or 5 v. 2 a.	30/-
350-0-350 80 mA. 6.3 v. 3.5 a. 6.3 v. 1 a, or 5 v. 2 a.	35/-
300-0-300 v. 120 mA., 6.3 v. 4 a. C.T.; 6.3 v. 2 a.	45/-
MINIATURE 200 v. 20 mA., 6.3 v. 1 a.	12/6
MIDGET 220 v. 45 mA., 6.3 v. 2 a.	17/6
HEATER TRANS. 6.3 v. 1½ a., 8/6; 6.3 v. 4 a.	12/6
Ditto tapped sec. 1.4 v., 2, 3, 4, 5, 6.3 v. 1½ amp.	12/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a.	30/-
1 amp., 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60,	35/-
3 amp., 0-12 v. and 0-18 v.	19/6

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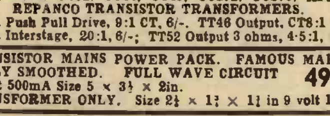
JACK PLUGS Std. Chrome 3/-; 2·5mm 1/9; 3·5mm 2/6; DIN 3-pin 3/6; 5-pin 5/-.
WAVE-CHANGE SWITCHES WITH LONG SPINDLES.
2 p. 2-way, or 2 p. 6-way, or 3 p. 4-way 4/6 each.
1 p. 12-way, or 4 p. 2-way, or 4 p. 3-way, 4/6 each.
Wavechange "MAKITS" 1 p. 12-way, 2 p. 6-way, 3 p. 4-way, 4 p. 3-way, 6 p. 2-way, 1 wafer 12/-, 2 wafer 17/-, 3 wafer 22/-
TOGGLE SWITCHES, sp. 2/6; sp. dt. 3/6; dp. 3/6; dp. dt. 4/6

1968 GRAM CHASSIS



Post 6/-
Three Wavebands: Long, Med., Short, Gram. Five Valves: ECH81, EF89, EBC81, EL84, EZ80. 12-month guarantee. A.C. 200-250v. Ferrite Aerial 5 watts 3 ohm. Chassis 13½in. × 7in. × 5in. dial size 13in. × 4in. Two pilot Lamps. Four Knobs. Aligned calibrated. Chassis isolated from mains **£10.19**
DE LUXE STEREO GRAM CHASSIS V.H.F., MW, SW 19-50m. SW 60-180m. Magic eye, push buttons. 6 valve plus rect. Size 15 × 7½ × 6in. high. **£19.19**

BAKER MAJOR £8

30-14,500 c.p.s., latest double cone, woofer and tweeter cone together with a special BAKER magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 45 c.p.s. Rated 20 watts. Voice coils available 3 or 8 or 15 ohms. Price £8, or Module kit, 30-17,000 c.p.s. with tweeter, crossover, baffle and instructions. £10.19.6.

LOUDSPEAKER CABINET WADDING 18in wide, 2/6ft

BAKER "GROUP SOUND" SPEAKERS—POST FREE

'Group 25'	'Group 35'	'Group 50'
12in 25 watt **6gns.**	12in 35 watt **8½gns.**	15in 50 watt **18gns.**

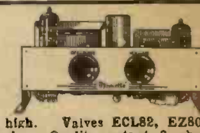
ALL MODELS "BAKER SPEAKERS" IN STOCK

E.M.I. Cone Tweeter 3½in square, 3-20kc/s, 10W 17/6.
Quality Horn Tweeters 2-18kc/s, 10W 29/6. Crossover 16/6.
LOUDSPEAKERS P.M. 3 OHMS. 2½in, 3in, 4in, 5in, 7 × 4in. 15/6 each; 8in 22/6; 6½in 18/6; 10in 30/-; 12in. Double cone 3 or 15 ohm 35/-; 10 × 6in. 30/-; 8 × 5in. 21/-.
E.M.I. Double Cone 13½ × 8in. 3 or 15 ohm models, 45/-.
SPECIAL OFFER! 8 ohm, 2½in; 80 ohm, 2½in, 2½in; 25 ohm, 6 × 4in; 35 ohm, 3in; 15 ohm, 10 × 2½in., 7 × 4in. **15/6** EACH TYPE
SPEAKER FRET Tygan various colours, 52in. wide, from 10/- ft.; 26in. wide from 5/- ft. SAMPLES S.A.E.
EXPANDED METAL Gold or Silver 12 × 12 in., 6/-.

ALL PURPOSE HEADPHONES

H.R. HEADPHONES 2000 ohms General Purpose	19/6
H.R. HEADPHONES 2000 ohms Super Sensitive	35/-
LOW RESISTANCE HEADPHONES 3-5 ohms	35/-
DE LUXE PADDED STEREO PHONES 8 ohms	79/6

MINETTE AMPLIFIER



For Hi-Fi Record Players. A.c. Mains Transformer. Chassis size 7 × 3½ × 4in high. Valves ECL82, EZ80. Two stage negative feedback. Quality output 3 ohm matching. Bargain offer complete with engraved control panel, valves, knobs, volume and tone controls, wired and tested. Post 5/6 **79/6**

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SUPPLIED AT LOWEST PRICES

BARGAIN AM TUNER. Medium Wave. Transistor Superhet. Ferrite aerial, etc. **79/6**

BARGAIN DE LUXE TAPE SPLICER Cuts, trims, joins for editing and repairs. With 3 blades. **17/6**

BARGAIN 4 CHANNEL TRANSISTOR MIXER. Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. **59/6**

BARGAIN TRANSISTOR FM-LW-MW TUNER: 10 semi conductors Calibrated tuning dial. 9 v. operation. FM 88-108 Mc/s; MW 190-560 metres. LW 850-2000 metres. Size 2½ × 8 × 5¼in. **£14/19/6**

BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready built, with volume control **69/6**

40-PAGE EAGLE CATALOGUE 5/- Post Free

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Radio Valve Guide, Books 1, 2, 3, or 5 each	5/-
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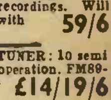
SANGAMO 3 inch SCALE METERS **45/-**
Various calibrations/movements. 100 Microamp; 1 Milliamp; 50-0-50 Microamp, etc. S.A.E. for list.

POCKET MOVING COIL MULTIMETER. 0-1,000 A.C./D.C. ohms 0 to 100k, etc. **49/6**

SUPERIOR MOVING COIL MULTIMETER 0-2-500v. D.C. 20,000 ohms per volt, 0-1,000v. A.C. Ohms 0 to 6 meg. 50 Microamps (Full list Meters S.A.E.) **99/6**

BRAND NEW QUALITY EXTENSION LOUDSPEAKER



Cream plastic cabinet, 20ft. lead and adaptors. For any radio, intercom, tape recorder, etc. 3 to 15 ohm. PRICE Size: 7½" × 5¼" × 3". Post 2/6 **30/-**

RETURN OF POST DESPATCH *Minimum Post and Packing charge 2/6.* *C.O.D. 5/- extra. Full List 1/-.* *CALLERS WELCOME*

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TRANSISTORS PRICE

AC107	3/–	OC170	3/–
AC126	2/4	OC171	4/–
AC127	2/4	OC200	3/6
AC128	2/4	OC201	7/–
ACY17	3/–	2G301	2/6
AF114	4/–	2G303	2/6
AF115	3/6	2N711	10/–
AF116	3/6	2N1302-3	4/–
AF117	4/6	2N1304-5	5/–
AF118	3/6	2N1306-7	6/–
AF119	3/6	2N1308-9	8/–
AF186	10/–	2S303	5/–
AF139	10/–	**Power**	
BFY50	4/–	**Transistors**	
BSY25	7/6	OC20	10/–
BSY26	3/–	OC23	10/–
BSY27	3/–	OC25	8/–
BSY28	3/–	OC26	5/–
BSY29	3/–	OC28	10/–
BSY95A	3/–	OC35	5/–
OC41	2/6	OC36	7/6
OC44	1/11	AD149	10/–
OC45	1/9	2N2287	20/–
OC71	2/6	**Diodes**	
OC72	2/6	AAY42	2/–
OC73	3/6	OA10	2/–
OC81	2/6	OA70	1/9
OC81D	2/6	OA79	1/9
AF102	12/6	OA81	1/9
OC139	2/6	OA182	2/–
OC140	3/6	IN914	1/6

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EXCITING NEW PAKS
FOR AMATEURS, PROFESSIONALS, FACTORIES, ORGAN BUILDERS, AND THOSE PEOPLE THAT JUST USE LARGE QUANTITIES OF TRANSISTORS.

XA PAK

Germanium PNP type transistors, equivalents to a large part of the OC range, i.e. 44, 45, 71, 72, 81, etc.

PRICE £5 PER 1000

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VOL. 4 No. 10
October 1968

PRACTICAL ELECTRONICS

THE EASEL'S OUT, MAN

THE Arts are now on more than nodding terms with the world of science and technology. This fact is well demonstrated at the international exhibition "Cybernetic Serendipity" currently running in London.

Modern technology, particularly in the field of electronics, has presented greater opportunities than ever for artistic experimental work. For example, the electronic computer and the cathode ray display have been enthusiastically seized upon and made to perform in a manner their original designers never contemplated—not even in their wildest dreams!

True, the methods employed can sometimes evoke amusement, or perhaps even downright disapproval, among electronic engineers. Sometimes the artist seems to be groping with a complex toy he does not intimately understand. But, to be fair, he is really concerned only with the final effect: *this* is his own creation.

One example of the more primitive approach is the conjuring up of visual patterns and effects by deliberately distorting television pictures. The service engineer will wistfully recall the hours he has spent trying to banish trapezium distortion or to trace the source of interference responsible for some other surrealist interpretation of Coronation Street. Must he, and his clients, now recognise themselves as mere philistines?

But apart from such fortuitous works of art, more thoughtfully *engineered* artistic creations are being revealed. The oscilloscope can produce really beautiful constantly evolving patterns based on the Lissajous figures well known in every electronics laboratory; while quite exquisite patterns can be achieved by the appropriate programming of computerised plotters. And this is really significant. Many of these works of art have been initiated by electronics engineers and technicians or by computer operators and programmers. Their technically trained minds evidently suggested this rather flippant diversion from normal strictly functional work; and, in turn, the success of their experiments must have given them a new appreciation of graphic art.

Can we therefore see the artist and the engineer coming closer together, using the same equipment and sharing a common experience? Maybe the traditional sharp demarcation line between arts and science will become increasingly blurred and distorted until eventually it is beyond all recognition. Just like some of this new art, you may be tempted to say.

F. E. Bennett—*Editor*

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

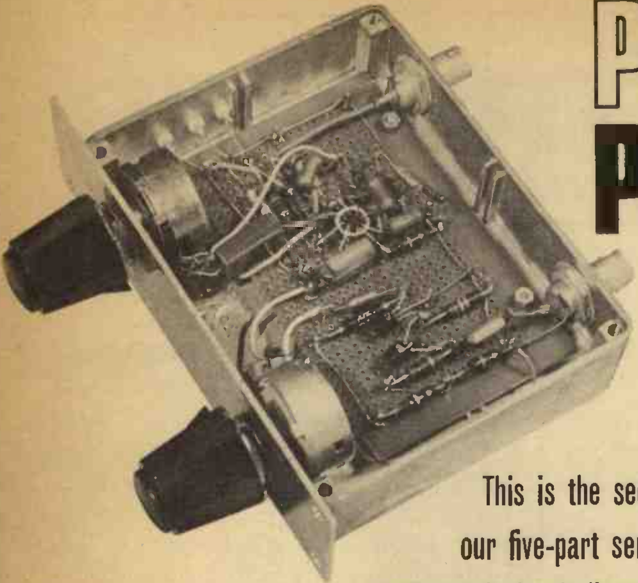
GENERAL FEATURES

BEGINNERS

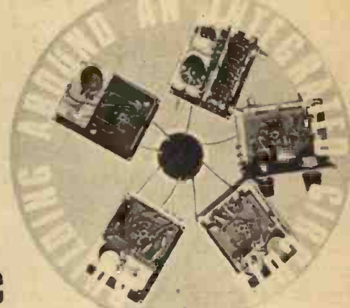
NEWS AND COMMENT

Our November issue will be published on Friday, October 11

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., 15/17 Long Acre, London, W.C.2. Phone: 01-836 4363. Telegrams: Newnes London. Subscription Rates including postage for one year, to any part of the world, 42s.



PICK-UP PRE-AMPLIFIER



This is the second project in our five-part series featuring the integrated circuit linear amplifier Type SL701C

NO ONE would deny that the best method of record reproduction is to use a magnetic cartridge, but there are occasions when a ceramic cartridge may be pressed into service. For a modest system or for 45s only, the ceramic cartridge cannot be beaten on a cost/performance basis. Since the emphasis here is on simplicity with a reasonable performance, only a top cut tone control has been included in this design for a pick-up pre-amplifier.

The normal requirement for a ceramic cartridge is that it should feed into a high impedance load, so that the low frequency output of what is essentially a capacitive source may be preserved. For a cartridge of (say) 1,000pF and a load resistance of 8 megohms, the low frequency 3dB down point will be 20Hz (assuming the cartridge itself is still maintaining full output!), and this represents the order of input impedance we have to provide for our amplifier.

This could be achieved by using ordinary germanium transistors in a compound emitter follower arrangement, but we would need to keep the bias resistors low (to maintain d.c. stability) and bootstrap them. We could also use an integrated circuit as a non-inverting amplifier, but the bias resistor to earth would again have to be kept low in value (to avoid offset due to input d.c. current flowing through it to bias the integrated circuit) and bootstrapped.

HIGH TO LOW IMPEDANCE CONVERTER

However, if we discard these two ideas and use high gain silicon transistors, we can operate at low collector and base currents and high base bias resistors, to obtain a high input impedance directly, without fear of any bias problems. This high to low impedance converter is shown in Fig. 1.

The two transistors chosen are inexpensive plastic encapsulated high gain types. By using a complementary emitter follower arrangement, the emitter of TR2 can be connected directly to the collector of TR1 to bootstrap it. This means that the collector to base potential of TR1 is held at a constant 0·7V even at

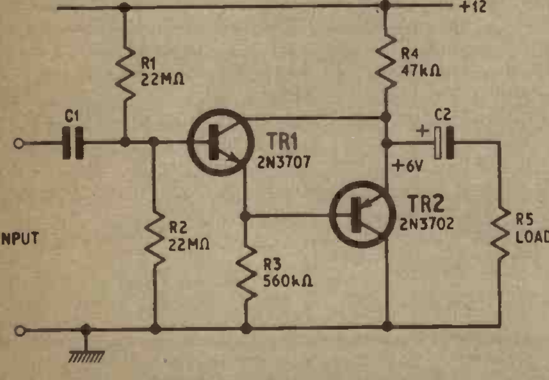


Fig. 1. A high to low impedance, unity gain, converter circuit

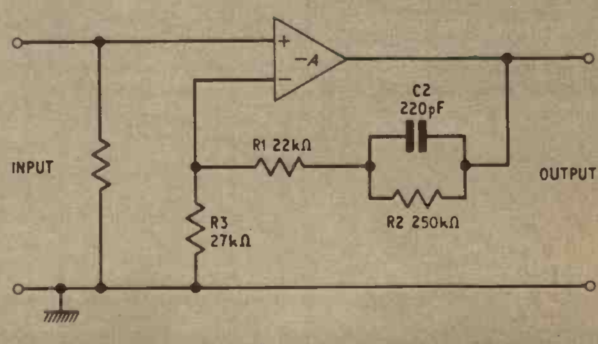


Fig. 2. The basic diagram of the amplifier and tone control arrangement

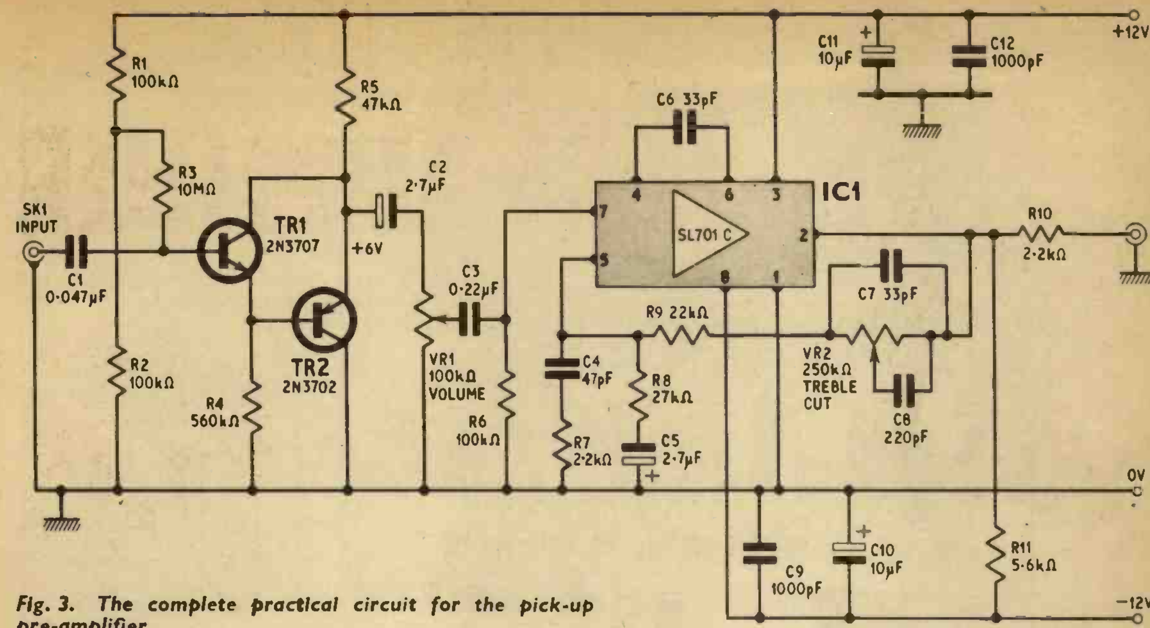


Fig. 3. The complete practical circuit for the pick-up pre-amplifier

high signal levels, and this helps reduce the effects of internal collector to base capacity in TR1 and to maintain frequency response.

It is worth noting that the high input impedance does not have to be maintained over a wide frequency range since the capacitive source impedance is also reducing with frequency. The bias resistors will shunt the input, but we can still achieve input impedances of the order of 6 or 8 megohms without difficulty.

Since ceramic pick-ups have a reasonable output (of the order of 100mV r.m.s.) we do not need to provide much gain to feed a power amplifier, so we added our volume control after the impedance converter rather than after the tone control, since this reduces the possibility of the tone control amplifier limiting on peaks.

TONE CONTROL

The tone control amplifier is designed around an integrated circuit; the basic functional diagram is Fig. 2. If we assume for the moment that C2 does not exist, then the gain of the amplifier is given by:

$$\text{Gain} = \frac{V_o}{V_i} = 1 + \frac{R1 + R2}{R3}$$

Which in our case is 11 times or 21dB. If C2 were large (compared with R2), then from the a.c. point of view R2 is short circuited and our gain is now given by:

$$\text{Gain} = \frac{V_o}{V_i} = 1 + \frac{R1}{R3}$$

In our case this is 1·8 times or 5dB, a reduction of 16dB. By choosing a suitable value for C2 we can obtain a gain characteristic which is flat at a gain of 21dB up to 1kHz, and then reduces gradually above this frequency towards a limiting gain of 5dB; which gives us our treble cut.

This is a particularly useful characteristic since it gives treble cut between 1 and 12kHz where we might require it, but gives very little extra cut above 12kHz where we would expect the output from our cartridge to be falling off. Increasing C2 to 470pF would give treble cut from 500Hz to 6kHz, but little extra cut from 6kHz to 20kHz. The control is made variable by making R2 a potentiometer and taking C2 to the slider.

THE PRACTICAL CIRCUIT

The complete practical circuit is shown in Fig. 3. Transistors TR1 and TR2 comprise the emitter followers. Since it may be difficult to obtain the 22 megohm resistors shown in Fig. 1 for biasing, we have used an alternative approach of 100 kilohm resistors for the divider chain and a single 10 megohm resistor to the base of TR1, since this gives similar conditions. The output of the emitter followers will limit at 3V peak to peak with a total load of 50 kilohms, should readers wish to use this circuit for other purposes.

The potentiometer VR2 completes the bias path for the integrated circuit, and so this should not be disconnected unless a 220 kilohm resistor is inserted to maintain the correct bias conditions for testing purposes. The 33pF capacitor C7 restricts the bandwidth to 20kHz when VR2 is in the flat position.

Since we are restricting the closed loop bandwidth to 20kHz we are not interested in frequency compensating the integrated circuit for a maximum bandwidth performance, but merely wish to ensure that the amplifier is stable with the closed loop gain we require (1·8 times to 11 times). This is achieved by the 33pF capacitor C6 between pins 4 and 6 and the 2·2 kilohm resistor R7 and 47pF capacitor C4 from pin 5 to earth.

For a low output pickup the gain may be increased by decreasing the value of R8, though this will slightly affect the tone control characteristics.

The performance of the complete amplifier is shown in Table 1.

CONSTRUCTION

The construction is straightforward, and is shown in Fig. 4 and photographs. To fit the potentiometers into the chosen box we had to cut the lid, but smaller (and more expensive!) potentiometers might alleviate this problem. We would definitely advise some form of screened box because of the high input impedance.

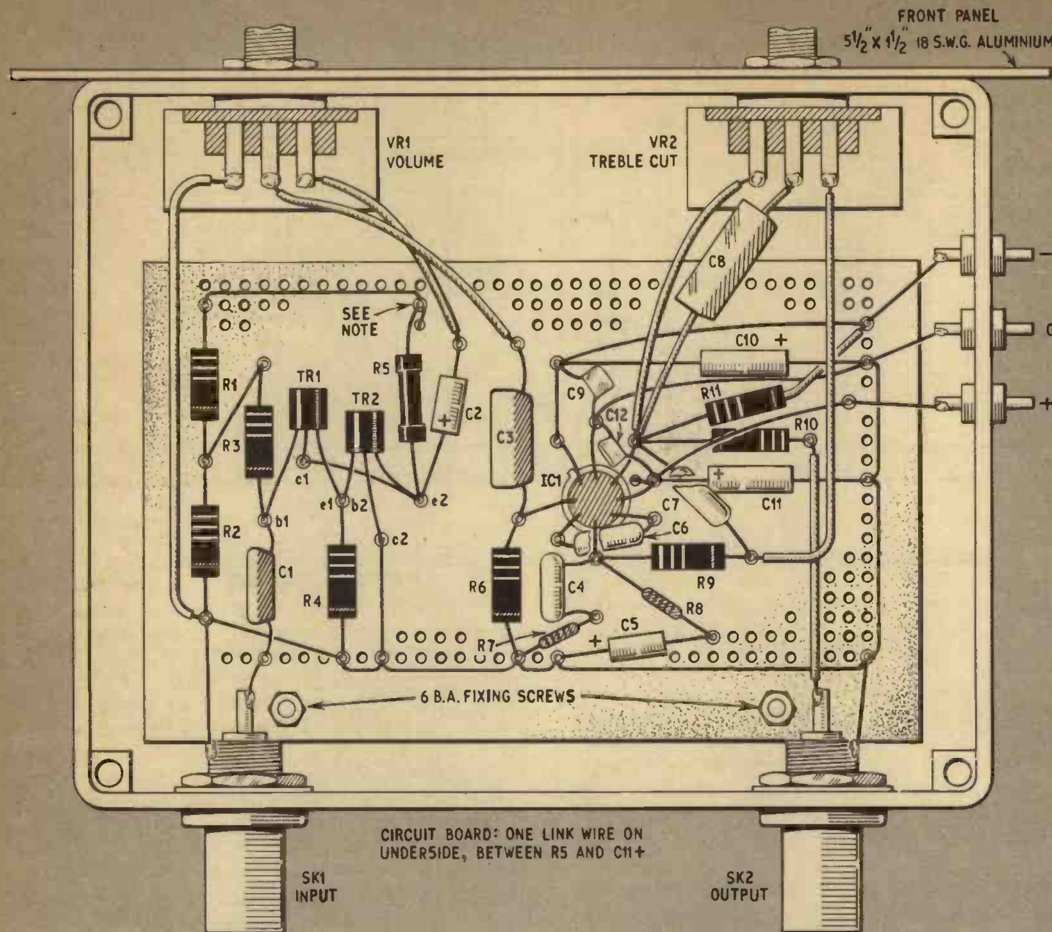
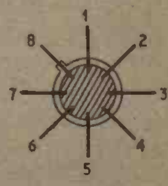


Fig. 4. *Layout and wiring of the pick-up pre-amplifier*



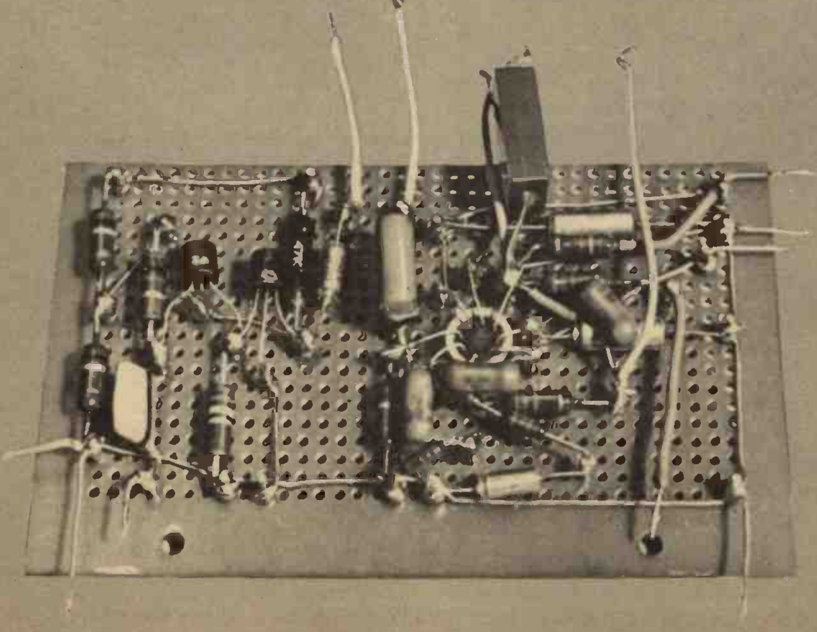


Table 1. PERFORMANCE OF THE PICK-UP AMPLIFIER

Input impedance	greater than 6 megohms at 1kHz
Gain	10 times
Nominal input	100mV r.m.s.
Maximum input	3V peak to peak
Nominal output	1V r.m.s. (no load)
Maximum output	7V peak to peak (no load)
Output impedance	2·2 kilohms
Noise referred to input	0·1mV peak to peak
Frequency response	25Hz–20kHz flat within +0dB, −3dB
Tone control	13dB cut at 12kHz

L.F. response depends on cartridge capacitance.

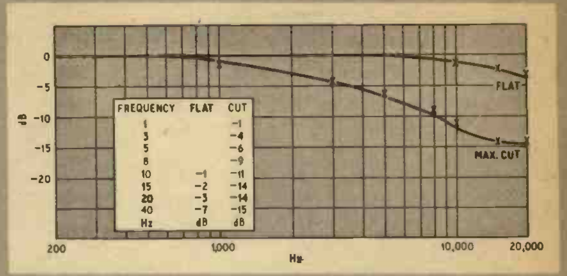


Fig. 5. Frequency response of the pick-up pre-amplifier

Holes must be drilled in the sides of the box to suit the input and output coaxial sockets, the feed-through power supply terminals, and the two potentiometers. A small panel, made from 18 s.w.g. aluminium is attached to the front edge of the box (secured by the potentiometers' nuts). The holes in the four corners provide means for mounting the completed unit in a record player cabinet, or elsewhere as required.

A piece of perforated s.r.b.p. board measuring 4in × 2½in is used for mounting the IC and other components. Soldering pins are inserted as shown in Fig. 4 and the components mounted and wired up accordingly. Note there is just one link to be made on the underside of the board, between R5 and C11+ soldering terminal pins (see Fig. 4). This board is then secured to the bottom of the die-cast box with two 6 B.A. screws. Two extra 6 B.A. nuts are required to act as suitable spacers between board and die-cast box.

The final wiring between the board and the box-mounted components can now be undertaken.

COMPONENTS . . .

Resistors

R1	100kΩ	R7	2·2kΩ
R2	100kΩ	R8	27kΩ
R3	10MΩ	R9	22kΩ
R4	560kΩ	R10	2·2kΩ
R5	47kΩ	R11	5·6kΩ
R6	100kΩ		

All ±10%, ¼W carbon

Potentiometers

VR1 100kΩ log.
VR2 250kΩ lin.

Capacitors

C1	0·047μF polyester	C7	33pF ceramic 10%
C2	2·7μF elect. 15V	C8	220pF ceramic 10%
C3	0·22μF polyester	C9	1,000pF ceramic
C4	47pF ceramic 10%	C10	10μF elect. 15V
C5	2·7μF elect. 15V (see text)	C11	10μF elect. 15V
C6	33pF ceramic 10%	C12	1,000pF ceramic

Semiconductors

IC1 Linear integrated circuit, d.c. coupled amplifier—SL701C. (Available direct from the makers: The Plessey Co. Ltd., Components Group, Cheney Manor, Swindon, Wiltshire. Price: 18s.)

TR1 2N3707
TR2 2N3702 } Texas Instruments

Miscellaneous

SK1, 2 Coaxial socket (2 off)
Die-cast box 4¾in × 3¾in × 1in (Electroniques 46R.043A)
Perforated s.r.b.p. 4¼in × 2½in
Three insulated feed-through terminals
22 s.w.g. plastic covered wire
Two control knobs

CONCERNING COMPONENTS

Ceramic capacitors are needed for decoupling the supply close to the integrated circuit IC1, but elsewhere only nominal values of electrolytic capacitors are required, provided the power supplies are reasonably well smoothed elsewhere.

The 2N3702 transistor chosen for the *pnp* TR2 position is not in fact specifically intended for low current applications, even though it has a reasonable current gain at the level we are operating it. Constructors might like to try the more recently introduced but slightly more expensive 2N4058, though it is doubtful if the input impedance would be noticeably increased in this particular application, since the input is in any case shunted by the bias resistors.

The voltage across C5 is nominally zero, and so we have difficulty deciding on its polarity. We can either use a tantalum capacitor (which can stand a small reverse voltage) or we can use two ordinary 5μF electrolytics "back-to-back".

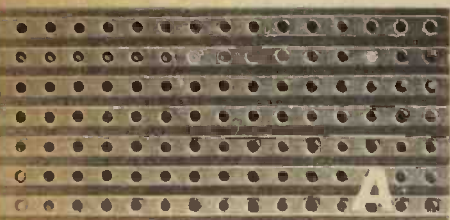
A third alternative which could be tried is to remove C5 and earth the appropriate end of R8; there will be a d.c. offset at the output which will depend on the value of the bias current drawn through R6, but this may be small for the particular integrated circuit specified. In our case it was about 0·5V, and this would not appreciably limit the peak to peak swing obtainable at the output.

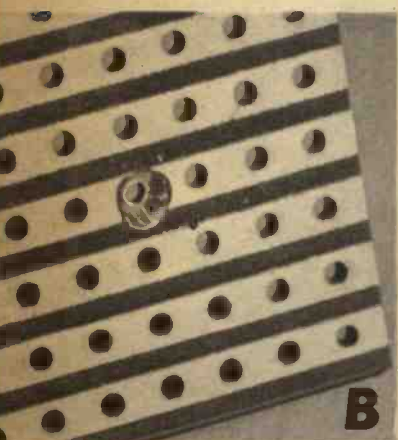
Next month: A sensitive D.C. Voltmeter design, using the same type IC.

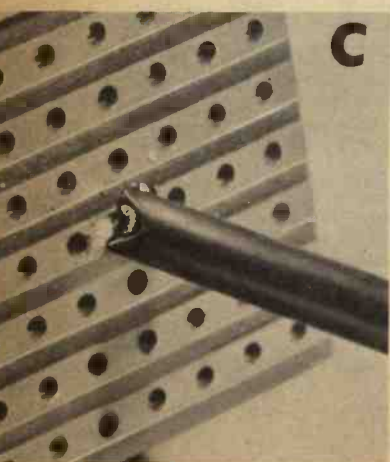
PRINTED WIRING BOARD

THE SMALL sample piece of Veroboard given free with this issue of PRACTICAL ELECTRONICS can be used to build any number of projects. Six examples of popular appeal will be presented in this and the next two issues and are designed specifically for building on the board.

The board has a standard 0·15in matrix of 112 holes (Photo A); additional boards can be cut from one of the common larger sizes available on the retail market. In each of the associated articles the wiring layout is given and it will be noticed that the holes are coded with letters and numbers (in italics) for easy reference.







Where a large number of components are mounted on the board it is sometimes necessary to cut the copper strips (breaks) to isolate two or more distinctly different parts of the circuit (Photo B).

When cutting the copper with a spot-face cutting tool or knife be careful not to nick adjacent strips (Photo C). Any unwanted piece of copper can be gently lifted with a thin knife; do not let the knife slip and damage the remaining copper (Photo D).

If there are insufficient copper strips, or if two parts of the layout have to be connected together, link wires can be inserted in the appropriate holes (Photo E).

WIRING

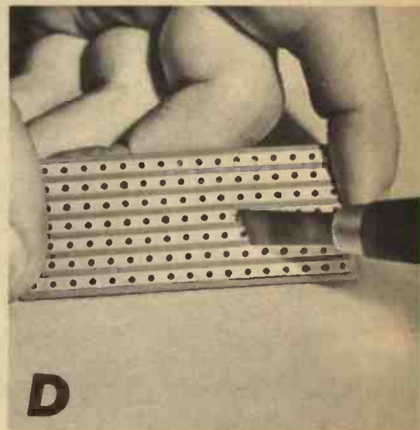
Start construction of the selected project by cutting the copper strips if this is necessary. Insert the link wires on the plain side of the board and solder the wires on the copper strips. (Notes on soldering are given in an accompanying article.)

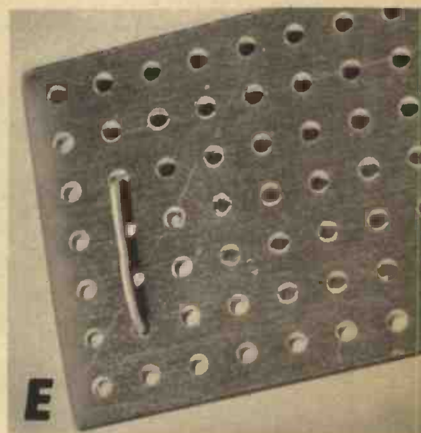
There are bound to be flying leads for connection to a battery, switch, and other components. These are also inserted through the appropriate hole and soldered in the same way.

The components can be mounted next, making sure that the wires are inserted in the correct holes. Start mounting at one end of the board and work your way to the opposite end. It is a good idea to leave transistors until last so that they do not suffer accidental damage from the heat of the soldering iron (Photo F).

For the most efficient soldered joint, insert the wire through the hole, bend over about $\frac{1}{16}$in of the tip to 90 degrees, and solder to the copper. The bent-over part of the wire should lay lengthways along the copper strip.

Most of the components are mounted on end with the top lead bent down to pass through a nearby hole. The body of the component should not touch the board, but be left standing about $\frac{1}{8}$in above the board; the connecting wires will support it. It is better to leave wires too long rather than too short. ★





SOLDERING WITHOUT TEARS

SOLDERING is an art that can be perfected by practice and careful observation of a few basic rules. The pictorial series here is intended to show how to make and recognise good sound soldered joints, and how to avoid dry joints which can cause instability problems.

Before starting to solder, make sure that you have the right tools for the job; these (shown in Fig. 1) are a soldering iron, a pair of wire cutters, a pair of long-nosed wiring pliers, and solder. Wire strippers may be found useful (see later). Solder can be obtained in different grades according to the job in hand; this article will confine itself to the jointing of wires, tags, pins and copper laminate, found in most electronic circuits. Plastics-covered tinned copper wire is recommended for wiring of circuits.

SOLDERING IRONS

Choose the right iron for the job. For most wiring work a 23–27 watt iron will suit most purposes. If soldering delicate wires or printed circuit boards a 15 watt pencil bit iron will prevent excessive damage to the insulation or bonded copper.

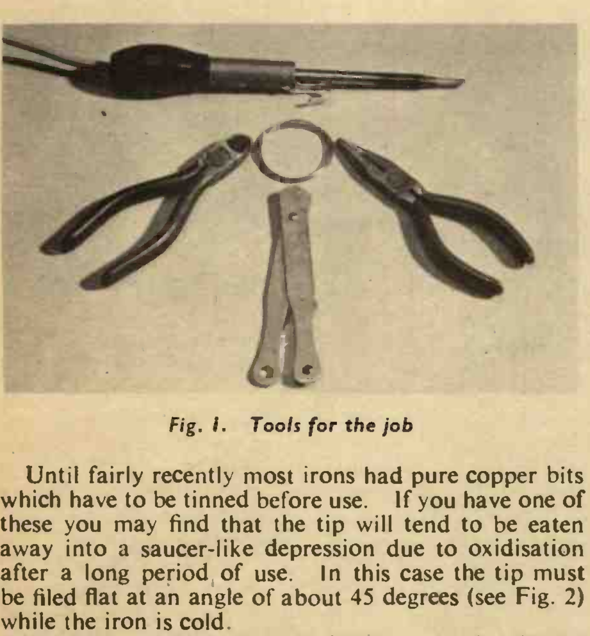


Fig. 1. Tools for the job

Until fairly recently most irons had pure copper bits which have to be tinned before use. If you have one of these you may find that the tip will tend to be eaten away into a saucer-like depression due to oxidisation after a long period of use. In this case the tip must be filed flat at an angle of about 45 degrees (see Fig. 2) while the iron is cold.

The iron should be tinned when hot, that is, given a thin coating of solder, to ensure maximum transfer of heat and prevention of dirt ingress (Fig. 2). New irons are usually supplied with the tip already shaped and tinned. Some iron tips are shaped to a point or some other form for special purposes.

More recently soldering iron tips have become available which are treated with iron plating to obviate corrosion; these should not need to be tinned or filed, although they will acquire a coating of solder when used.

It is well worth investing in a stand for your iron to guard against accidental burning when not in use (Fig. 3). Never hook an iron on to the nearest convenient nail or chassis, or the penalty may be the cost of a new jacket or shirt (Fig. 4).

Soldering irons can be dangerous tools if not treated with care, but with controlled handling can give many years of successful soldering as found in industrial equipment.

SOLDER

There are two basic classes of soft solder: the type sold in bar form that has no flux inside is intended for sheet metalwork in conjunction with a flux paste; modern solders with flux inserted inside are suitable for all electronic wiring and light metalwork. This is often called "cored solder". The flux is injected during manufacture of Ersin Multicore solder into five tubes inside the solder in the correct proportion to the amount of solder alloy. No additional flux is required;

Fig. 2. The tip must be flat and tinned

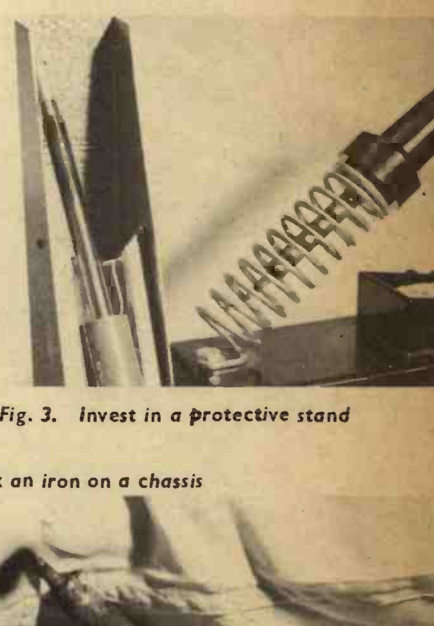


Fig. 3. Invest in a protective stand

Fig. 4. Never hook an iron on a chassis

in fact the use of flux paste for wiring is detrimental and should be avoided.

Solder is a metal alloy composed of tin and lead. The proportions of this mixture are carefully controlled, different ratios being applied for different grades of solder according to their application. The most suitable grade for high quality wiring where a low melting point alloy is required is 60/40 (60% tin, 40% lead). The recommended minimum bit temperature for this grade is 248 degrees C.

A specially prepared alloy, containing a small amount of copper, is made which slows down the process of copper bit corrosion. This is Multicore Savbit which is made in a variety of alloy ratios, but grade No. 1 is generally the most widely used for wiring applications. The alloy in this type of solder contains a small amount of copper which is transferred to the solder joint, preventing the deposit of copper from the bit of the soldering iron.

OTHER TOOLS

The other tools which will be most useful are wire cutters and thin long-nosed pliers; both should have insulated handles if working near live equipment.

A pair of wire strippers may be found useful for cutting wire and baring the ends, the cutting notch being adjustable according to the size of wire being stripped.

For soldering heat sensitive components, particularly subminiature resistors, diodes, transistors, etc., a useful tool is the heat shunt clip. This can be made by using a crocodile clip and soldering solid copper faces to the jaws. By clipping this to the component wire, both hands are left free to carry out the soldering process. Having selected the tools for the job in hand, a few notes are worth inserting here before getting down to soldering.

between them in a molten state. The solder must clearly melt at a lower temperature than the pieces of metal to be jointed which in electronic work are usually a wire and tag.

For the joint to be firm and sound the fluid solder must "wet" the surface of each part of the joint, just as a drop of water wets a piece of dry wood and spreads out to form a damp patch. The solder must penetrate a little way into the surface of the components being jointed. When that happens a sound joint results; on cooling down, the harder metals are firmly locked together by a thin and now solid layer of the softer metal laying between them, that is rooted into their surfaces. Inefficient soldering where the two parts are not electrically sound, are called dry joints.

When any soldering is being undertaken the parts that are to be joined must be clean. However, even that is not sufficient because when metals are heated, an oxide forms and makes it difficult for the solder to penetrate into the surface of the metal. Consequently a flux is used, and an efficient one will not only remove the surface oxide which already exists but will prevent it forming when the metal is heated.

When undertaking the soldering of electronic or electrical equipment it is essential to ensure that the flux is not corrosive, that is, the flux residue must not absorb moisture from the air which may subsequently cause the joint or the metal to be "eaten" away by corrosion. Liquid or paste fluxes which can be used effectively for non-electrical joints are quite unsuitable for this reason.

SOLDERING WIRES TO TAGS

Insulated wires and component wires require the same treatment. Fig. 5 shows a plastics-covered

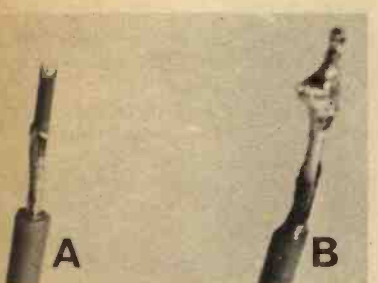


Fig. 5. (a) Good tinned end (b) bad blob and melted plastics

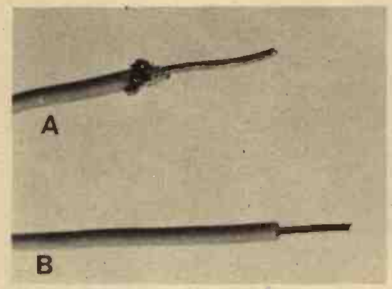


Fig. 6. (a) Stripped insulation by hot iron (bad) and (b) with strippers (good)

Fig. 7. The bare wire end may be tinned

TIPS ON THE METHOD

The soldering iron is subject to temperature changes according to environmental conditions. If working out of doors the heat from the iron will tend to be reduced by a cool atmosphere or breeze. If working in the garage or workshop do not allow draughts from open doors or windows to come into contact with the iron; again the temperature may drop. Such a loss of heat will result in difficult soldering and bad joints.

If the iron is in good condition and properly prepared with a smooth flat tinned tip, maximum heat transfer will take place. Remember that the iron is supposed to heat the wires as well as melt the solder.

When holding the iron, grip the handle like a pen; gain control of the iron—be firm but careful and do not let the iron become your master.

To make a soldered joint between two pieces of metal a small amount of 18 s.w.g. solder is made to run

tinned copper wire which has to be connected to a tag strip. Strip about ¼in of insulation from the end with strippers, wire cutters or knife. Make sure the actual copper wire is not nicked at this point or it may fracture at a later date. If it is, cut the wire and try again. Do not strip plastics insulation by melting with a soldering iron; this will spoil the appearance of the wiring and make the iron tip contaminated, making subsequent soldering more difficult (Fig. 6).

Next, the bare wire end may be tinned, that is, a thin coating of solder deposited on the wire. This will help to achieve a sound joint. Fig. 7 shows this being done. Hold the iron on the wire just long enough to melt the solder and make it flow along the wire. If the iron is held on the wire too long the insulation may melt back along the wire (Fig. 5b). If there is excessive solder on the wire in the form of a blob, reheat the solder and quickly wipe off the surplus with a piece of rag.

Fig. 8. Tinned clean tags and wire fitted

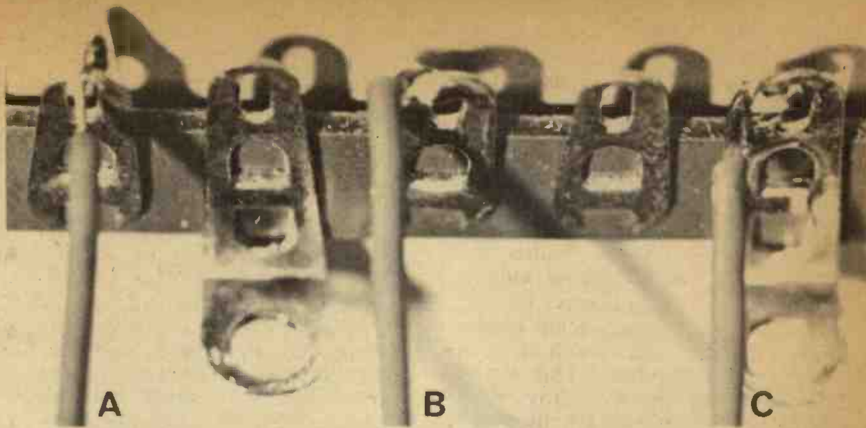


Fig. 10. (a) Lack of solder, insulation melted BAD JOINT; (b) Even flow of solder, insulation maintained GOOD JOINT; (c) Wire not gripping tag, quick solder blob BAD JOINT

Fig. 9. Apply iron to tag and wire, then the solder

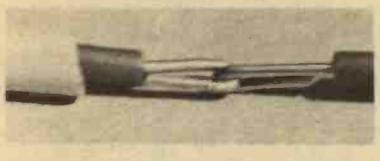


Fig. 11. Two wires bent and squeezed

Fig. 12. Even flow of solder, insulation maintained

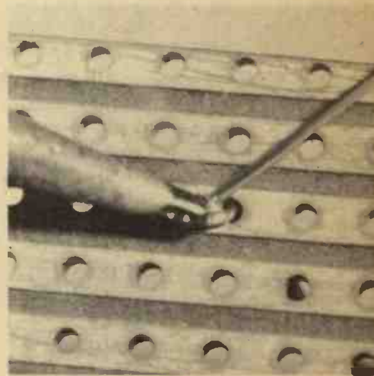


Fig. 13. Allow the solder to flow evenly over copper and wire

Fig. 8 shows the tag. Most tags are supplied already tinned but if they are a dirty grey colour or untinned a thin coating of solder must be applied in the same way. Sometimes the tags can be so badly soiled that the solder will not adhere at all. Then all the dirt and oxide on the tags must be cleaned off with fine emery paper or scraped with a knife first. This also applies to some component wires that have been in store for a long time.

The wire is now fitted to the tag (Fig. 8). Bend the wire and pass it through the taghole (if there is one) or wrap round the tag once only. Squeeze the wire with pliers so that it grips the tag firmly. Apply the iron tip to the tag and wire, then the solder (Fig. 9). Do not obtain a blob of solder on the iron and carry it to the joint, or the flux will not perform its duty in making the solder flow over the joint. Do not use too much solder, just enough to coat the wire and tag evenly. The solder should not settle as a blob or a "dry" joint is very likely to result.

Fig. 10 shows a good joint in the centre and bad joints on either side. On the good joint, you will also see that the plastics sleeving is maintained right up to the tag. Surplus solder is carried away by the iron then removed with a piece of rag. Some constructors tend to shake the iron to remove the surplus solder, but it could finish up on your clothing and soil it.

A hot iron held too long on a component tag or wire, particularly transistors, can cause the component value to change completely. Make sure your iron is at the correct temperature to heat the parts to be soldered without any delay whatsoever. Any deposits of dirt or excess solder on the iron tip can be wiped off with a piece of rag.

JOINING TWO WIRES

The example given here shows two pieces of plastics-insulated wire jointed and sleeved. The same rules about preparing the wire apply as before.

Fig. 11 shows the two wires bent and squeezed ready for soldering. A piece of sleeving is passed over the wire ready for fitting firmly over the joint.

Fig. 12 shows the finished soldered joint, again not in blob form. Finally slide the sleeve right over the joint.

WIRING PRINTED BOARDS

With the advent of microelectronics, there is an ever increasing need for the use of smaller soldering irons with careful heat control and fine cored solder (22 s.w.g.) in order to make a perfect electrical soldered joint. A suitable alloy for this purpose is 60/40 or Savbit due to its melting properties. Extra care must be exercised in preventing too much heat reaching the heart of components such as transistors, diodes and miniature resistors. Maintain as long a length of the component lead as possible to facilitate re-use later and to help to apply a heat shunt as mentioned before.

Again the rules are the same. Pass the bare tinned wire end through the hole in the board and allow the solder to flow evenly over the wire and copper (Fig. 13). Trim off any surplus wire with cutters. When wiring to printed circuit boards or Veroboard it is best to use an iron with a smaller bit (as found on 15 watt models) so that heat is not excessively spread over a wide area, at the risk of loosening adjacent joints.

Finally to check that the joint is good, grip the wire with the pliers and give a gentle pull. If a loose joint is evident, clean and resolder. ★

GALAXY OF THOUGHTS

Time and again in science new ideas and theories are put forward only to be rejected by the majority, and time and again there is a return to the ideas and theories as originally proposed or with slight modifications. The latest of these revivals has to do with quasars.

Some ten years ago the Soviet astronomer, academician V. A. Ambartsumian suggested that galaxies might have their origins in very dense concentrations of matter. He suggested that from these there could be ejections of matter which would form stars and groups of stars building up into galaxies. The core of such a structure could eject large lumps, as it were, and there would appear jets similar to those which appear in some strong radio galaxies.

SPACEWATCH

By Frank W. Hyde

The theory was not taken seriously at the time it was proposed, but now recent observations at the Mount Wilson and Palomar Observatories by Dr. H. Arp show that many objects classified as "peculiar galaxies" are associated with radio sources and are also in the process of ejecting matter in a specific direction. In 1966 Dr. Arp had suggested that many quasars were associated with the "odd" type of objects which are observed. At that time, his views were also questioned by astronomers at Herstmonceux.

BIG BANG QUASARS

The new observations, however, fit Dr. I. D. Novikov's extension of the Ambartsumian theory. It has been generally held that quasars, the very small, distant, and energetic radio sources, were regions in which the collapse of massive objects to one single atom (known as a mathematical "singularity") was taking place. Dr. Novikov has put forward the suggestion that in fact there is an expansion from the singularity exactly as the "Big Bang" universe. Novikov's investigations show that all the optical requirements of quasars are met and in addition the ejected matter will produce radio noise.

It could be then that the quasar is an expanding object, which in the course of time becomes a calmer object where matter condenses back into stars around the remaining nucleus. It would seem that the differences we observe between objects are, in fact, stages in the evolution of galaxies and stars.

PULSARS

The discovery of Pulsars by Dr. A. Hewish with his team at the Mullard Radio Observatory at Cambridge has marked a new milestone in radio astronomy. It was natural that the discovery made other observatories very active. The first of these remarkable objects was found at a frequency of 81·5MHz. Prof. J. G. Davies recorded signals from one of the pulsating sources at a number of different frequencies at Jodrell bank using the Mark I telescope of the Nuffield Radio Astronomy Laboratories. These were 151, 240, and 408MHz. The pulse duration was found to be the same at all frequencies and this is consistent with the Cambridge discovery.

An interesting fact that emerges from these particular data is that, since the starting time of all three frequencies began at about the same time, the emissions come from regions which are not more than 1,000km apart. But the duration of the pulse (about 0·3 second in this case) means that the spread of the sources is not more than say 10,000km. All this bears out the Cambridge theory that the radiation is most likely to be associated with white dwarf or neutron stars.

The distance for the origin was given by Cambridge as 60 paraseconds (198 light years, see Table 1) and this leads to the calculation that the pulse power is some 10^{21} watts and therefore the energy radiated is 2×10^{14} joules. On the size that has been given the field strength would be around 10,000 volts per metre.

A special meeting was held by the Royal Astronomical Society on the subject of Pulsars and was a notable one for the attendance and participation of leading figures in Radio Astronomy. Follow up work by Prof. Sir Martin Ryle at Cambridge with Dr. Judy Bailey, made use of the "one mile" radio telescope at Cambridge; the frequencies chosen were 408 and 1,407MHz. The mean position of one of the stars proved to be RA 19h 19m 37·0s ± 0·2s.

The noise ratio to the signal level at 1,407MHz precluded precise position measurements but did provide information about the flux density. The mean spectrum indicates that the surface brightness of the star must be a hundred thousand times brighter than the quasars. This result coupled with the fact that there seems to be no cut-off at low frequencies suggests that the radiation is not due to synchrotron effects.

A more likely explanation is that the radio signal is the result of the movement of electrons in a plasma. This is the mechanism that is responsible for the emission from sun-spots and also that from the low frequencies in the Crab Nebula.

Dr. Frank Drake who directs the 300 metre telescope at Arecibo, Puerto Rico, for Cornell University has confirmed that the pulsations are rapid and regular. He has contributed the information that at a frequency of 111MHz the received radiation was ten times greater than at any other frequency.

JAPAN JOINS THE SPACE CLUB

The satellite programme of the University of Tokyo's Institute of Space and Aeronautical Science has a three-year schedule of ten satellites to be launched by their M-4S rocket. The first of these satellites designated No. 1 Scientific satellite will be put up this year as soon as agreement can be reached with the local villages where the site is located.

Table 1.

One light year	=	Distance travelled by light in one year
	=	$5·86 \times 10^{12}$ miles
	=	0·307 paraseconds
Paraseconds	=	3·259 light years
	=	$19·16 \times 10^{12}$ miles

Three more similar types of satellite will be launched in 1969 and another five during late 1969 or 1970/71. The Japanese have concentrated their efforts in fields not having had major attention by the United States and Russia. These fields will enable the Japanese to make full use of their highly advanced observation techniques.

The M-4S is a four stage rocket bigger than the American Scout but perhaps slightly less efficient. It is 23ft tall and weighs about 40 tons at lift-off. The first stage is 4·5ft in diameter and can produce 100 tons of thrust. Using eight strapped-on solid fuel boosters the thrust is doubled and should be able to put a 280lb payload into a 500km orbit. So far the Japanese have had three attempts which were aborted by third stage difficulties putting the programme behind schedule.

The No. 1 satellite is intended to orbit at 500km above the earth and obtain data on electron and ion densities. It will also observe radio noise at high frequencies and cosmic rays in space. The satellite will be used to monitor time variations in radiation of radio noise from the sun during abnormal emissions from the sun. The reactions of electrons and protons as they are ejected from the sun toward the earth will form part of the cosmic ray experiments.

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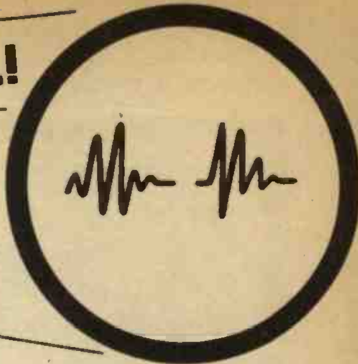

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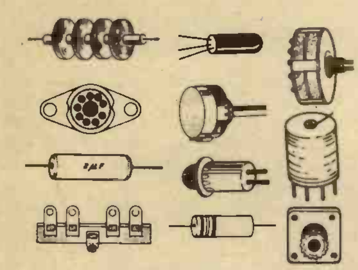

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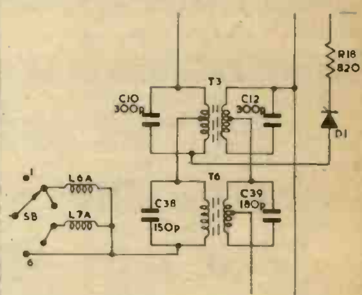

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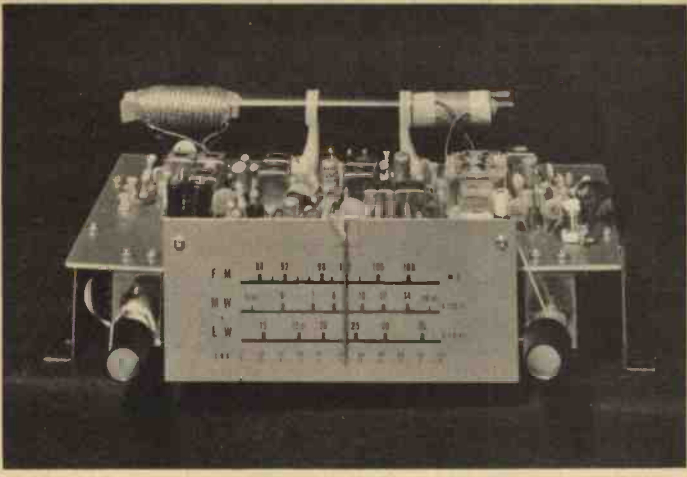

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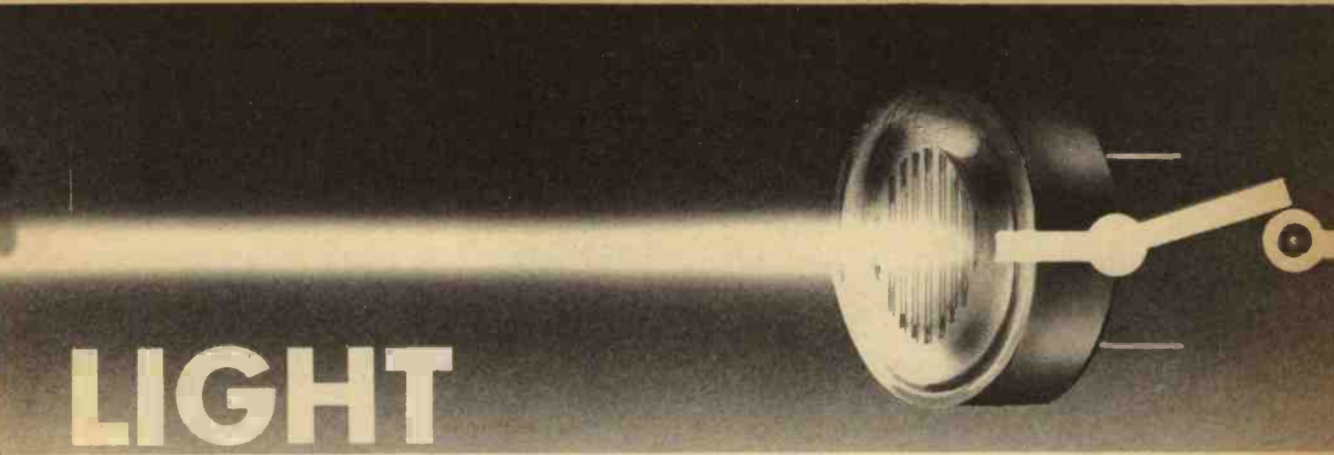


LIGHT OPERATED SWITCH

HAVE you ever wished that you could have some electrical appliance switched on automatically when darkness falls. It could be the light in the porch, dark room, or sick room or anywhere; it could be a single bar 1 kilowatt fire. No doubt readers will have their own ideas.

This simple device can be made up on the sample piece of printed wiring board given free with this issue. Details of the housing is omitted deliberately because the constructor will probably wish to incorporate it either in a plain box or in some existing installation.

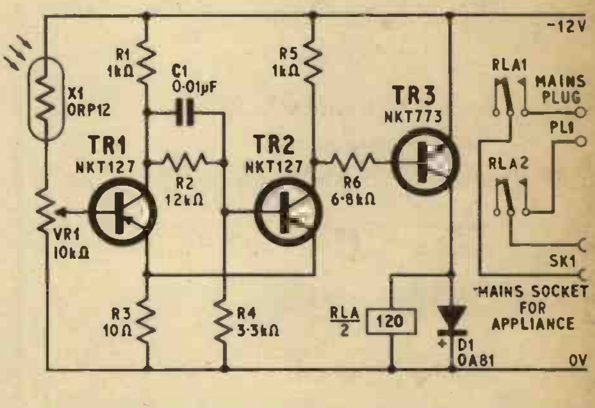


Fig. 1. Complete circuit of the Light Operated Mains Switch

TRIGGER SWITCH

The circuit uses three transistors in a Schmitt trigger and switch configuration (Fig. 1). The light sensitive device X1 is a light dependent resistor (l.d.r.) or cadmium sulphide cell. During full daylight conditions the l.d.r. will be of low resistance, about 75 ohms; in darkness it will be as much as 10 megohms.

The potentiometer VR1 is set to determine the ambient lighting conditions that will operate the trigger circuit. During daylight transistor TR1 conducts, the low resistance of the l.d.r. having little effect on the base bias supplied via VR1 to TR1.

Transistors TR2, and hence TR3, will remain in a non-conducting state, so the relay will be in the neutral non-operative condition. Relay contacts RLA1 and RLA2 remain open-circuit and the mains supply is unable to reach the appliance.

Potentiometer VR1 can be set so that at dusk or darkness, the high resistance of the l.d.r. influences the bias supplied to TR1, switching this transistor off. As it does so, TR1 collector voltage goes more negative and biases TR2 into a state of conduction. The third transistor has been chosen as an *npn* type deliberately, so that the positive going voltage on TR2 collector biases TR3 into conduction.

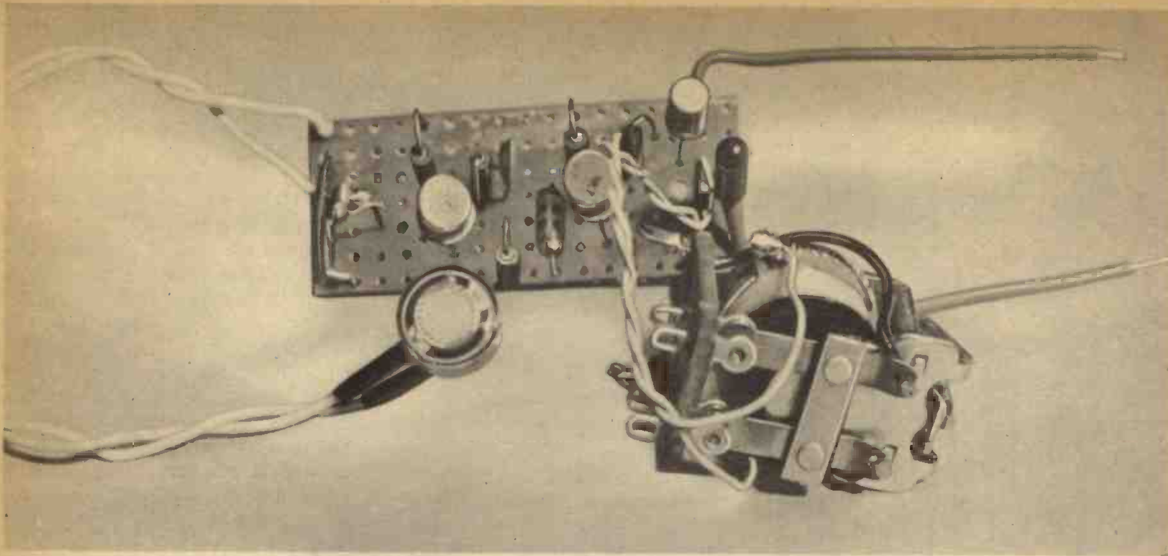
The relay is connected into the collector circuit of TR3, is energised, and changes over the contacts, switching on the appliance. The capacitor C1 is a "commutating" capacitor inserted to speed up the switching process and avoid relay chatter. Diode D1 suppresses transient spikes due to back e.m.f. from the relay coil, which would otherwise possibly damage TR3.

The maximum current rating of the NKT773 is 300mA so it should be able to handle the maximum 100mA, which the relay could take, without resorting to the use of a heat sink. If a metal case is used to house the device, it might be a good idea to use this as a heat sink for TR3 just to be on the safe side. In this case, no other wire or connection should be taken to the case.

Do not exceed a 1 kilowatt rated appliance on the 5A relay contacts.

CONSTRUCTION

Construction work is very simple if the basic rules outlined in the special article on printed wiring board (elsewhere in this issue) are followed. The component layout on the board is given in Fig. 2 with the plan of copper strip breaks and connections on the underside.



Prototype layout of light operated switch showing externally connected l.d.r. and relay. Note that l.d.r. is sleeved at soldered connections to board flying leads

COMPONENTS . . .

Resistors

R1 1kΩ	R3 10Ω	R5 1kΩ
R2 12kΩ	R4 3·3kΩ	R6 6·8kΩ

All 10%, ½ watt carbon

Potentiometer
VR1 10kΩ skeleton preset

Capacitor
C1 0·01μF polyester

Transistors
TR1 NKT127 (Newmarket)
TR2 NKT127 (Newmarket)
TR3 NKT773 (Newmarket)

Diode
D1 OA81

Light Dependent Resistor
X1 ORP12 (Mullard)

Relay
RLA 120Ω, 12V (Radiospares type 11) with two sets of heavy duty changeover contacts rated at 5A for 250V a.c. minimum

Miscellaneous
Printed wiring board, free in this issue
PL1 Mains plug to suit house wiring and appliance
SK1 Mains socket to suit appliance (see text)
Battery 12V with clips, on-off toggle switch, case to house all components

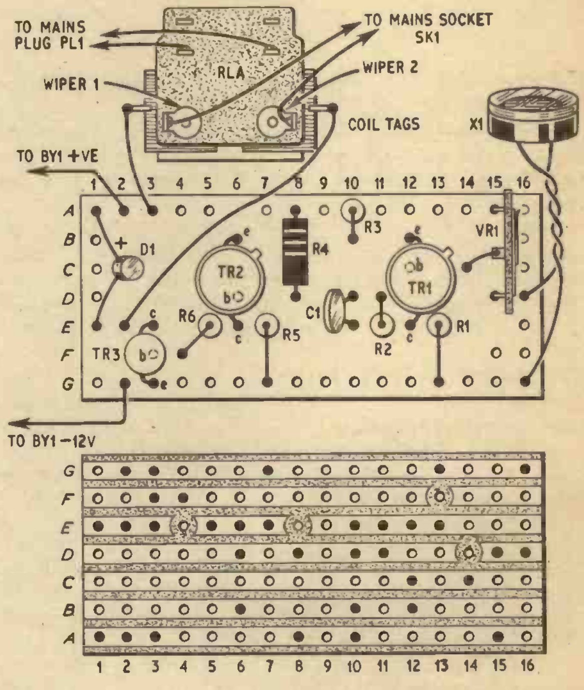


Fig. 2a. Component layout on the board with connection details to other components

Fig. 2b. Underside view of the board showing the breaks in the copper strips and connections

The l.d.r. is push fitted in a rubber grommet fitted in the case. Obviously the relay cannot be mounted on the board; it can be fitted to the case by means of the single hole nut fixing. Make sure that none of the copper strips or tags touch the case or disaster will result. The board can have small pieces of foam plastics or rubber glued to the underside for subsequent fitting in the case. Arrange the board so that a hole in the case corresponds with the screwdriver slot in VR1 for easy adjustment. Bring out the relay wiper contact connections to a mains socket SK1 (preferably 3-pin, 13A) mounted on the case so that the appliance can be directly plugged in. A flying lead with a mains plug PL1 is connected to the relay contacts.

All that is needed now is a small 12V battery to supply the electronic ciruit, and a toggle switch to switch off the battery when not in use. ★

By M. A. Colwell

THERE tends to be a lull in the launching of new equipment immediately following the Audio Fair, presumably because most manufacturers go hell-for-leather to get their ideas geared to this particular event. Some do not seem to worry too much and let progress proceed along the lines that suit their programmes better. Those who miss the boat usually look forward to showing their wares at the Northern Hi Fi and Radio Exhibition later in the year but, alas, this year there will not be one (see later).

In our review of the Audio Fair in London, several items had to be omitted due to space restrictions, but mention is now made of the new Truvox equipment. Designated the Series 200, this equipment includes a variety of tape recorders: mono, stereo, three-speeds, two-track, four-track, according to your needs. The price is £124 14s 2d mono, £147 17s 4d stereo. To these are added the TSA200 transistor stereo amplifier (£54 12s), FM200 tuner (£36 19s 4d), MPX100 stereo multiplex decoder, and LS200 shelf loudspeaker (£21 19s 2d).

Standard Radio cassette tape recorder model SR101 from Denham & Morley

The TSA200 amplifier boasts a frequency response of ±1dB, 15Hz to 30kHz at 1 watt or 20Hz to 20kHz at full output for 0·25 per cent distortion. The FM200 tuner has provision for taking the slide-in stereo multiplex decoder, and includes a centre-zero tuning meter and stereo broadcast indicator.

Denham & Morley (Overseas) Ltd. announce that the new Standard Radio cassette tape recorders will take the Philips type tape cassettes. These models, SR107 (27 guineas) and SR101 (38 guineas) are available from stock and are intended for portable use, having a 600mW amplifier and 2½in loudspeaker. The SR101 has a recording level meter and is supplied with a leather case.

Tape splicers are available in abundance in various forms. It is interesting, therefore, to see that one manufacturer has reduced the price. The "Bib" ¼in splicer by Multicore Solders has been reduced from £1 3s 10d to 19s 6d. At the same time a new Model 20 has now been marketed with a plastics cover, non-slip base, and cutter. The price of the new model is £1 3s 10d.

SUPER AUTOMATIC TURNTABLE

A preview was given at the Audio Fair of the Perpetuum-Ebner PE2020 automatic/manual turntable and pick-up arm and is now available from Highgate Acoustics. This turntable can track every record at the desired 15 degree vertical stylus tracking angle during manual or automatic play of every record. This factor is of importance to record reproduction in maintaining minimum tracking distortion, and is being accepted by an increasing number of manufacturers as an industry standard.

The pick-up head shell is fitted with an adjustable device for ensuring this feature and will take all cartridges with ½in standard mountings. An anti-skating control can be set according to the stylus radius and for "wet" and "dry" playing. The base of the arm has a knob which can be adjusted for steady stylus pressure with skating force compensation. The complete unit is available at a basic price of 49 guineas: base and cover, and Goldring G800 cartridges can be fitted as optional extras.

New "Bib" splicer by Multicore Solders

For those who use professional audio equipment the Leevers-Rich Audio Equaliser Model A501 offers a very wide range of combinations of filter circuits to suit almost any recording or replay characteristic. The interesting feature here is that the slider controls on the front panel given immediate visual indication of the

The Perpetuum-Ebner PE2020 automatic/manual turntable with base and transparent cover

frequency response characteristic set up on the instrument, in graphical form. The manufacturers state that this equipment is available for industrial and professional studios only at a net price of £166.

EXHIBITIONS

For readers who might be in France in March next year, why not have a look at the International Festival of Sound, High Fidelity, and Stereophony. This function is as well known as our Audio Fair and will be held at the Salons du Palais d'Orsay, Paris, from March 6 to 11. The biennial radio and television show at Lyons is in full swing from September 14 and closes on September 23.

Finally, on a rather ironic note, we received news of the cancellation of the Northern Hi Fi and Radio Exhibition, originally planned for Stockport in September, due to insufficient support. On the same day, we also received an announcement that from August 10 the stereophonic programmes on Radio 3 were to be extended to v.h.f. listeners in the Holme Moss area. A case of shutting the doors in the face of progress? ★

(below) A Truvox quartet consisting of the FM200 tuner, TSA200 amplifier, PD204 four-track stereo tape unit and LS200 shelf loudspeaker

MORE ON DENTOPHONICS

By. S. A. HARDY A.S.E.R.T.

DENTOPHONICS is concerned with the relationship of sound to the mouth, and with practical applications of sound transmission through body tissues. Before giving an outline of various systems, it is as well to give a warning to those interested in practical experiments in this field.

At the present time, the medical profession states that there appears to be some link between high power audio noise levels and cardio-vascular diseases and cancer. Therefore care and advice should be taken regarding experiments involving the direct propagation of high power audio frequencies through body tissue of living subjects.

Furthermore hobbyist experimenters are advised to use transistor battery powered equipment, taking extreme care over electric shock precautions.

Direct transmission of audible sound through solids is relatively inefficient when compared with ultrasonic frequencies. The power required to drive a transmitting transducer in the speech range of 300Hz to 3kHz is much larger than that for 30kHz.

SONIC PROBES

The term "sonic probe" is applied to specialist transducers used for transmitting into, or receiving from, a material and means quite literally sound probe. There are three types of transducer commonly used in this application, piezo-electric, dynamic (moving armature) and variable reluctance. For transmission and reception purposes, the easiest probe for construction by the amateur is of the dynamic type, the basic design being shown in Fig. 1.

One method of making a probe is to obtain an ex-Government oxygen mask assembly and remove the microphone insert. This has a bright soft metal case which is carefully stripped off, the diaphragm assembly then pulls apart easily from the microphone body. The diaphragm alone is then replaced over the pole pieces and secured to the body with rubber impact adhesive.

An insert modified in this fashion may be used as a surface contact probe; an unmodified throat microphone cell may be used for the same purpose. For surface contact usage, as in the case of body tissues, acoustic coupling is improved by using MS4 silicone grease between the skin surface and the probe face (diaphragm).

For localised transmission and reception at a point, the diaphragm may be fitted with some form of socket assembly so that it can accept various types of probe head. In the author's case these were household sewing needles and a bodkin as may be seen in Fig. 2. However, in this case the original brass diaphragm retaining ring from the microphone insert is best refitted and secured with adhesive to add to the robustness of the assembly. Care should be exercised in the choice of material for the probe head, and its length, to prevent the introduction of resonances caused by the natural springiness of the material (modulus of elasticity) when stressed.

These microphone inserts have a nominal impedance of 200 ohms, connections on the plastic base marked 1 and 2 are connected to the coil and the connection marked C goes to the case.

A point contact reception probe can be made by modifying, or replacing, the stylus from a pick-up cartridge. Ceramic cartridges are best suited for this purpose due to their natural robustness and relatively high signal output voltage. Also a reception probe of this type and construction is not susceptible to external ambient noise, as are the types that have a diaphragm as a part of their construction.

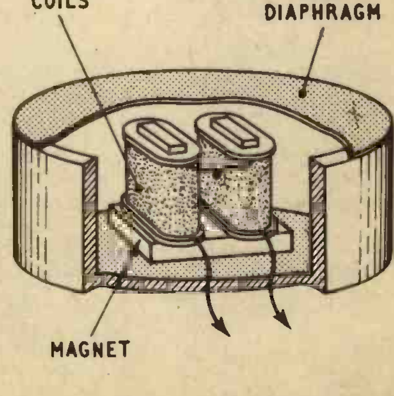


Fig. 1. A dynamic moving-iron transducer, e.g. headphone insert

A modified microphone of the aforementioned type was mounted on a denture (shown in Fig. 3) for experiments regarding a possible design for an artificial larynx (vocal chords). This was also found to be suitable for usage in experiments concerning Dentophonics and the Audio Dental Phenomenon.

THROAT MICROPHONES

These are basically similar in design to normal dynamic microphones, except the diaphragm has a slightly higher compliance (stiffness) and an interface pad of chamois leather covering the external face of the diaphragm. Two cells are used as part of a neck band and are designed to pick up the vibrations of the human vocal chords via the external walls of the cartilagenous structure of the larynx. Thus, these cells are ideally suited for use as sonic probes. The nominal impedance of complete throat microphone assemblies, available on the surplus market, is usually 200 ohms.

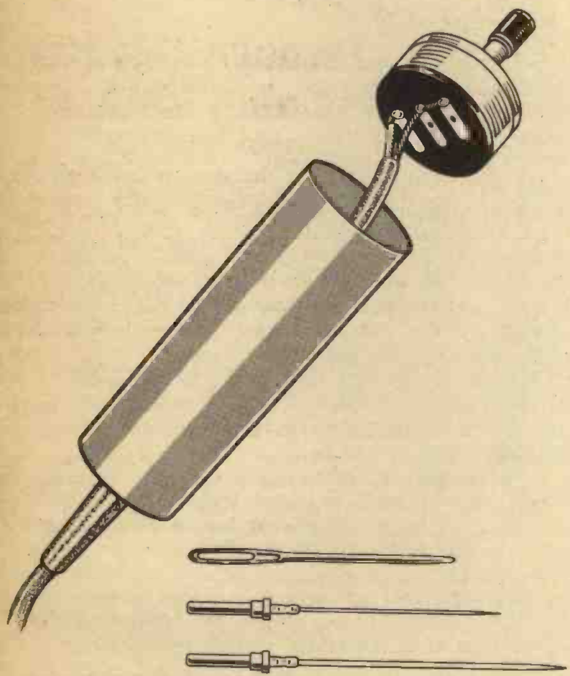


Fig. 2. A sonic probe for localised contact. The microphone diaphragm has been fitted with a socket which will receive various types of probe heads

ANCILLARY EQUIPMENT

Microphone inserts and throat microphone cells will handle continuous sine wave powers of up to 250 milliwatts at audio frequencies when used as transmission probes. Thus low power transistor amplifiers may be used for driving transmission probes and an amplifier having a rating of five watts is more than adequate.

However, the voltage levels obtained from reception probes are usually very small and a pre-amplifier capable of dealing with inputs of the order of 1 millivolt is a necessity. Also care must be taken with earth loops, electrical and acoustic screening to

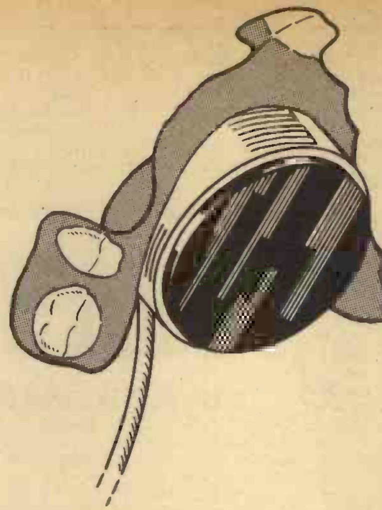


Fig. 3. An experimental denture-microphone assembly

prevent hum and/or noise pick-up. This also avoids an experiment being marred by minute audio frequency electrical currents travelling through the human body during tissue investigations.

OCCLUSION

In experiments where it is necessary to muffle the human ear to shut out extraneous noises, it is best to use a set of the ear defenders now available. These specialist devices are primarily designed to protect the hearing of individuals working in high ambient noise levels. An example is that of airport personnel working in close proximity to running aero-engines. Ear defenders are worn like a normal headset, in fact some models have inbuilt telephone earpieces.

The ear pads are soft plastics cushions filled with glycerine, or plastic foam, and the streamlined hard plastic case cavity is filled with fine grain plastic foam. As an example of their efficiency a wearer in a quiet room can only just hear a domestic radio running at a normal listening level.

Ear defenders are manufactured by Anticoustic, Amplivox and Denis Ferranti Meters Limited.

CONCLUSION

Professional equipment is available; a variable reluctance bone conduction microphone is manufactured by Spembley Electronics, Enham Arch, Newbury Road, Andover, Hants. This item has a nominal impedance of 300 ohms, delivers 100 microvolts and has a twisted pair lead out. Accessories, such as line amplifiers, are also available from this firm.

Shure Electronics Limited, 84 Blackfriars Road, London, S.E.1, manufacture a high impedance crystal vibration pick-up. The model number is 61CP, and it is designed for research purposes.

Surplus throat microphones, inserts and dynamic telephone earpieces are available from suppliers including those given below.

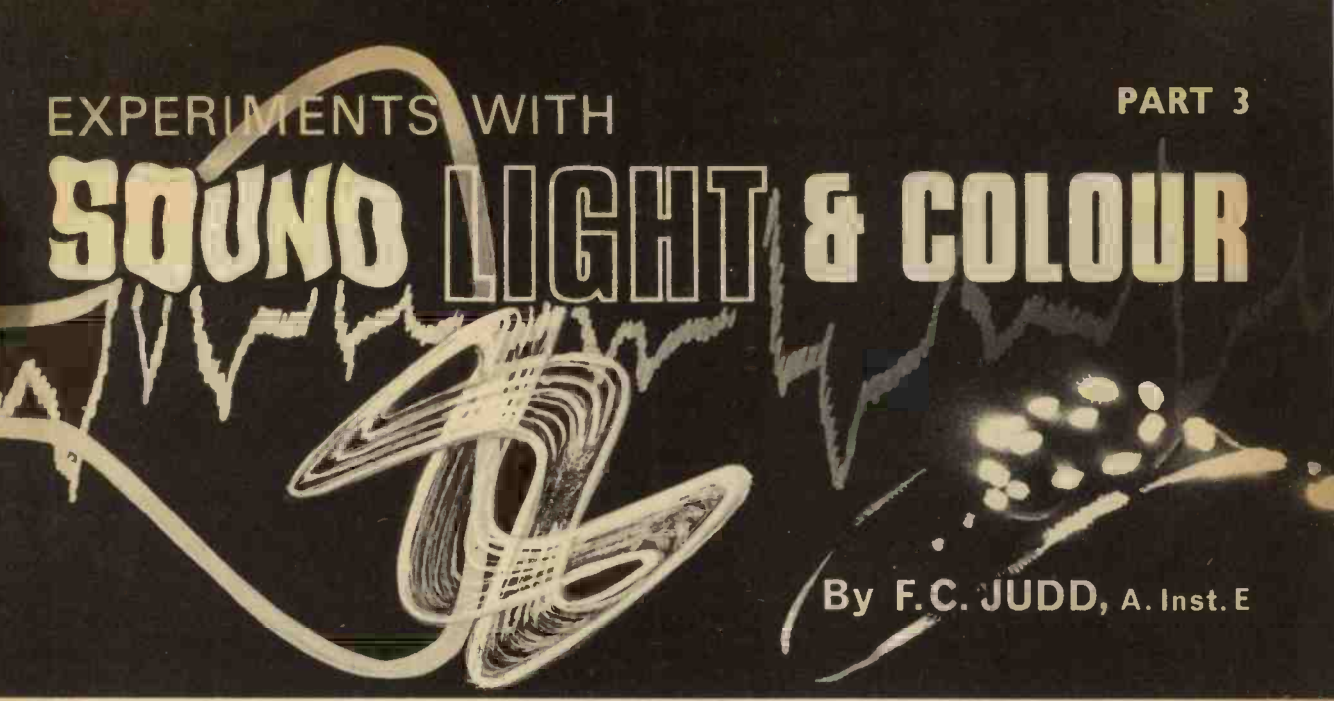
London Central Radio Stores, 23 Lisle Street, London, W.C.2.

Samsons (Electronics) Limited, 9 & 10 Chapel Street, London, N.W.1.

Job Stocks Limited, St. Mary Road, Walthamstow, London, E.17 (callers only). This firm also has occasional stocks of surplus ear defenders. ★

PART 3

EXPERIMENTS WITH SOUND LIGHT & COLOUR



By F.C. JUDD, A. Inst. E

THIS month we complete the description of the conversion of an old TV receiver to provide a colour display.

DEFLECTOR COIL AMPLIFIERS

The four essential circuits required for the c.r.t. display to produce colour patterns similar to those shown on the front cover of the August issue of PRACTICAL ELECTRONICS are two deflector coil amplifiers and two pulse generators. The phase shift network involves only a few components. The two deflector coil amplifiers, one for horizontal and one for vertical deflection, are identical and the circuit for both is given in Fig. 3.1.

The circuit is quite straightforward except for the direct negative feedback between anode and grid to preserve linearity over a wide frequency range. Each amplifier has an ordinary output transformer with a 5 ohm or preferably 15 ohm secondary which will provide a better match with typical television deflector coils. With an average 500mV sine-wave input, full deflection of the c.r. tube beam should be obtainable in either direction over most of the audio frequency range.

Aside from this nothing else is required of the amplifiers or the deflector system of the c.r. tube except that the input of each amplifier could be provided with a gain control for adjustment to the level of the input signals.

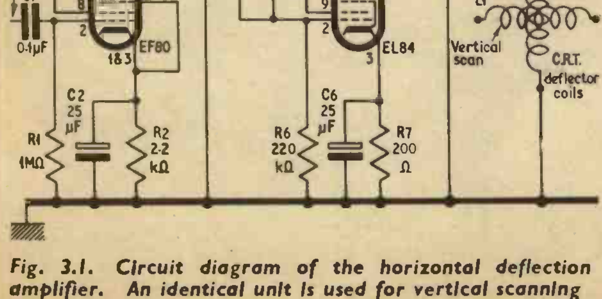


Fig. 3.1. Circuit diagram of the horizontal deflection amplifier. An identical unit is used for vertical scanning

MOUNTING ARRANGEMENTS

The deflector amplifiers and the pulse generators were each constructed on a small chassis fixed to the existing TV chassis, but they could, of course, be directly assembled on the TV chassis.

The photographs (Figs. 3.2 and 3.5) suggest a way of mounting the c.r. tube and its chassis in order to

Fig. 3.2. Rear view of the complete c.r.t. display. The separate deflector amplifier and pulse generator chassis are visible beneath the neck of the tube

accommodate the rotating colour scanner. In the original, as can be seen in the photos, a wooden platform was built up upon a baseboard. This baseboard formed the bottom of the outer case (see photo on page 575 in Part 1, August PRACTICAL ELECTRONICS), the case itself being made of hardboard covered with adhesive woodgrain patterned plastics sheet.

GRID PULSE GENERATORS

Next comes the low frequency grid pulse generator shown in Fig. 3.3. This is a conventional multivibrator circuit operating at approximately 10Hz with an over-driven amplifier from which a positive going square wave of approximately 50V amplitude is obtained. This pulse is applied to the c.r.t. grid via a 150 kilohm resistor, which may require adjustment in value one way or the other.

The pulse should bring the c.r.t. to full brilliance from cut-off. Set the brilliance control so that the beam is just cut off. When the pulse is applied it should bring the beam back to normal brilliance but which should automatically be cut on and off at the pulse repetition rate, i.e. around ten times per second. The brilliance control can still otherwise be adjusted in the normal way for viewing.

The second pulse generator is similar but operates in the region of 500Hz to 800Hz. The circuit is given in Fig. 3.4. The output should be approximately 50V in amplitude fed to the c.r.t. grid via a series resistor. The value of 220 kilohms given in Fig. 3.4 may also require changing one way or the other.

CHECKING CORRECT PULSING

In order to check correct pulsing of both generators feed a sine wave signal into one of the deflector amplifiers. This will produce a straight line across the c.r.t. with the brilliance fluctuating at the repetition rate of the low frequency pulse generator. If the scanner is rotating slightly faster or slower than the repetition rate, i.e. at plus or minus 10 revs per second, the "line" on the tube will slowly change colour. If the amplitude of the higher frequency pulse generator is correct the line should be broken into a series of dashes. The effect is shown in Fig. 3.6 in which two different waveforms were used, one to each deflection circuit. The higher frequency pulse provides the "dashed" line effect.

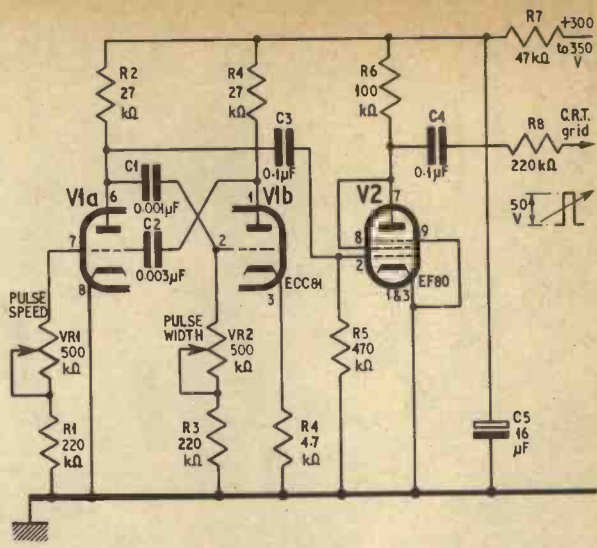


Fig. 3.4. Circuit of the 500Hz to 800Hz grid pulse generator

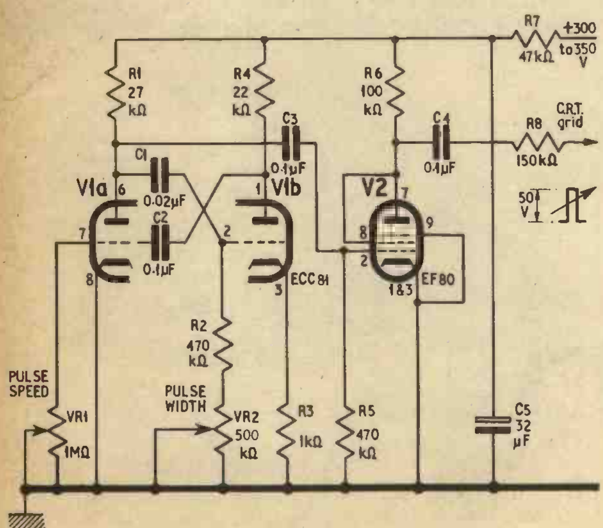
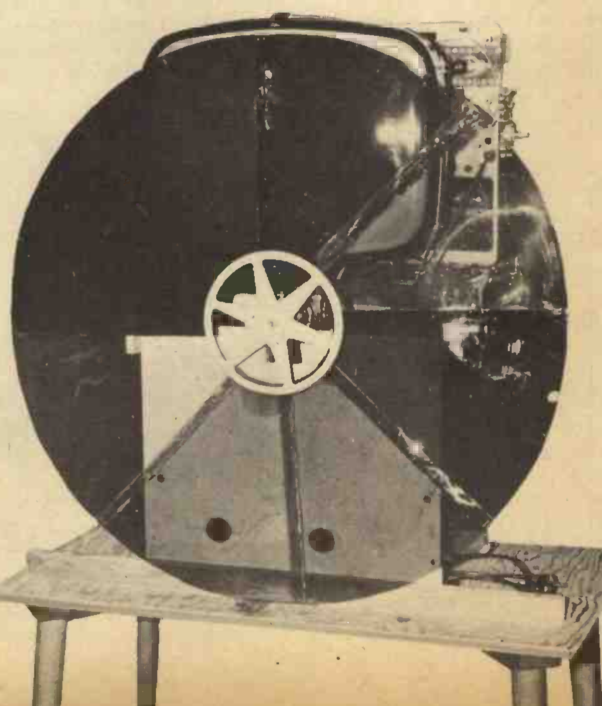


Fig. 3.3. Circuit of the low frequency (approx. 10Hz) grid pulse generator

SOLID LINE PATTERNS

In order to produce solid line patterns it is only necessary to switch off the higher frequency generator. A switch could be connected so as to short circuit the grid of one of the multivibrator valves or to switch off the h.t. supply. This generator is, however, essential for the production of circular patterns made up of colour segments, as will be dealt with later in methods of "programming" the display. (Circular patterns

Fig. 3.5. The c.r.t. display with colour scanner in position



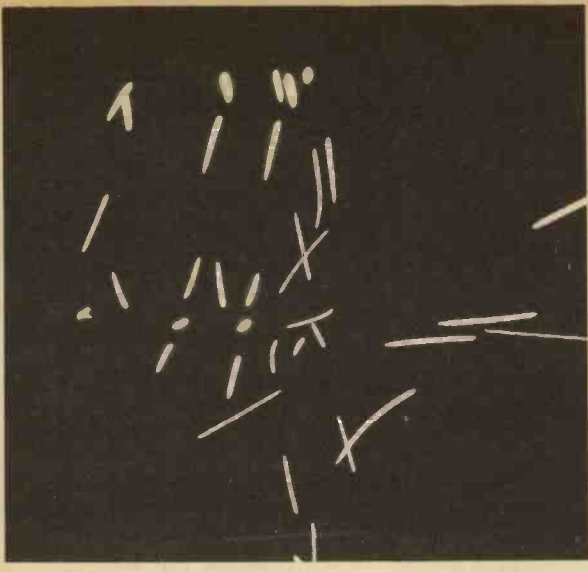


Fig. 3.6. The display produced by feeding different waveforms to the two deflection circuits. The higher frequency grid pulse produces the broken line effect

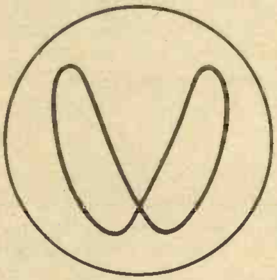


Fig. 3.7. Lissajous pattern created by feeding the scanning amplifiers with frequencies in the ratio 2 to 1

of this nature were shown on the front cover of the August issue of PRACTICAL ELECTRONICS.)

PRODUCING PATTERNS

Probably the best way of checking out the display as a whole is to feed a sine-wave of around 100Hz into one amplifier and another, at say 50Hz, into the other amplifier. Adjust the amplitude of each until full or nearly full deflection is obtained from each. Adjustment to the frequency of one should now produce a typical 2 to 1 Lissajous pattern as in Fig. 3.7. If the two sine-waves are now set to identical frequencies a circle will be produced and its size controllable by adjusting the amplitude of both signals.

By feeding in sine or square wave signals of different frequencies and amplitudes, all kinds of patterns can be produced with or without the dotted line effect and by using frequencies around that of the low frequency grid pulse generator, i.e. around 10Hz to 20Hz, patterns will appear to be made up of different colours.

Now continue the experiments by feeding music signals into one deflector amplifier and sine or square waves into the other, or music signals into both amplifiers. It will soon become apparent that complex patterns can be produced which fluctuate and change colour in time with the music.

PHASE SHIFT NETWORK

We can now take the production of patterns a step further by introducing a simple phase shift network into the input of one amplifier as shown in Fig. 3.8.

When a sine-wave of the right frequency is fed into the two amplifiers simultaneously stationary circular patterns will be produced or square if a square wave is used. The frequency of the input signal must correspond to that at which the phase shift network will produce the necessary 180 degree phase shift. If, however, the frequency is changed one way or the other, oval shaped patterns will be produced.

MULTIPLE INPUT SIGNALS

One can now go on *ad infinitum* and feed in two, three, or even four signals of different frequencies and produce something like that shown in Fig. 3.9, which, due to the colour scanner was displayed in multi-colour. This applies also to Fig. 3.6, in which the separate "dashes" appeared in different colours.

The effects that are possible are almost without limit, but a large variety of these and the methods of producing them will be dealt with next month. Details concerning programming with a tape recorder will also be included.

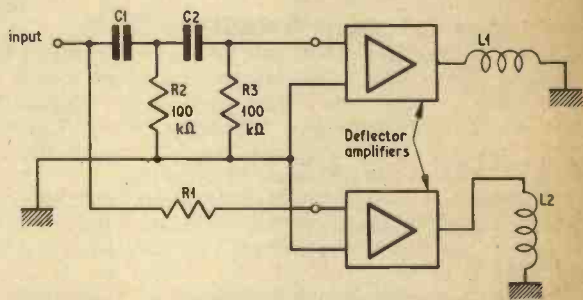


Fig. 3.8. Block diagram illustrates use of phase shift to produce more complex patterns. C1 and C2 are chosen according to frequency: a value of 0·01μF each will produce approximately 180 deg. phase shift at 100Hz. R1 should be up to 100 kilohms to equal the attenuation of the phase shift network

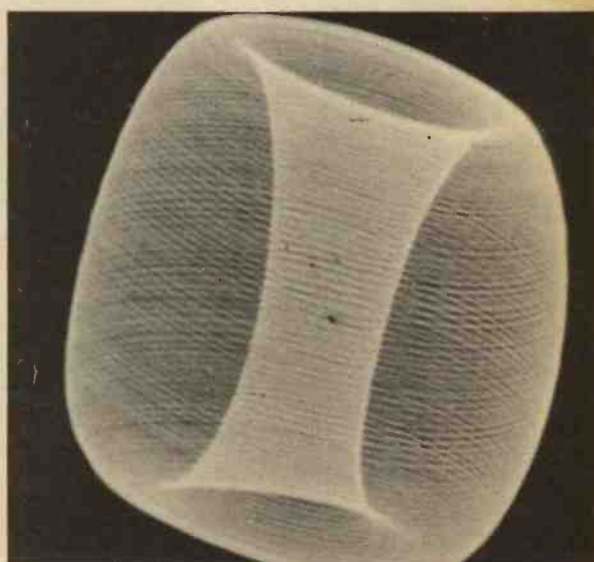
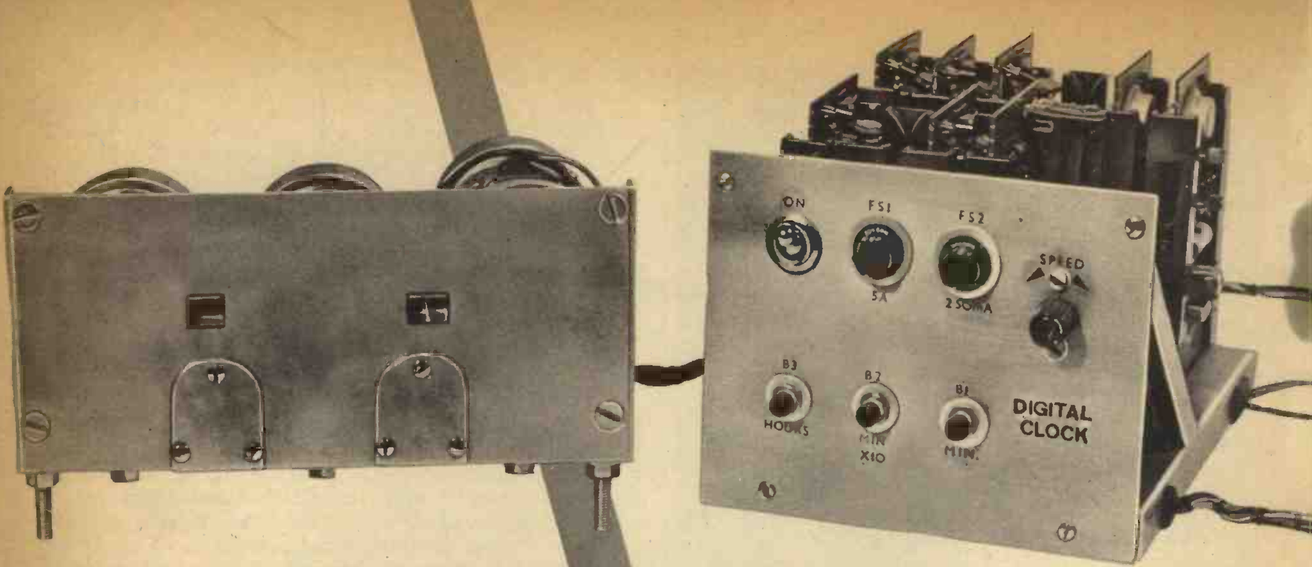


Fig. 3.9. Abstract pattern generated by several input signals. The original was in brilliant colour



DIGITAL CLOCK

By G. HOLLOWAY

CIRCUITS and operational details of the crystal clock were completed last month. In this second and final article constructional and setting up details will be presented.

ELECTRONIC SUB-ASSEMBLIES

Each of the ten stages constituting the electronics of the clock are assembled on uniform pieces of Veroboard which plug into edge connectors. Beside enabling the circuit boards to be easily removed from the equipment, this method ensures that reliable electrical contact is made when plugged in.

To determine correct plug-in location, moulded guides are used; these share the same screw fixing as the edge connectors and stand off vertically from the main chassis.

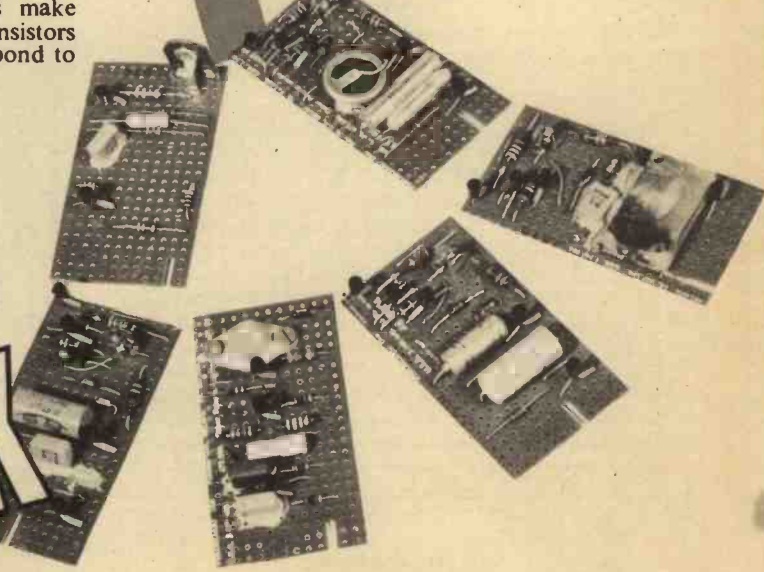
Positioning of each board in relation to individual connector contacts is controlled by a small block, which may be easily inserted in one socket position after first removal of contacts. The layout and wiring details of each board are given in Fig. 8 and should present no problems to those experienced with this type of board. When assembling the cards make absolutely sure of polarities of capacitors, transistors and diodes; the locating key slot must correspond to the socket block. Six divider boards must be made, each conforming to the same circuit (see Fig. 3, last month); R2, C1, and C2 must be used according to the values quoted in Table 1 last month.

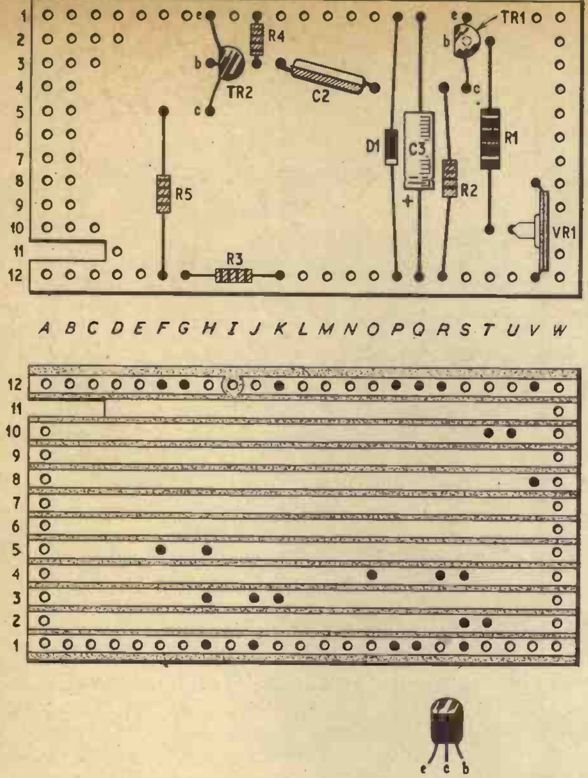
CHASSIS ASSEMBLY

Figs. 9 and 10 give complete drilling and cut out details of the chassis and front panel of the clock. When this is completed, edge connectors, moulded guides and valve base should be fitted in the positions shown in Fig. 11. Similarly the on/off switch S6, speed controls VR1 and VC1, fuses and the time altering press switches S3, 4, and 5 should be added to the front panel.

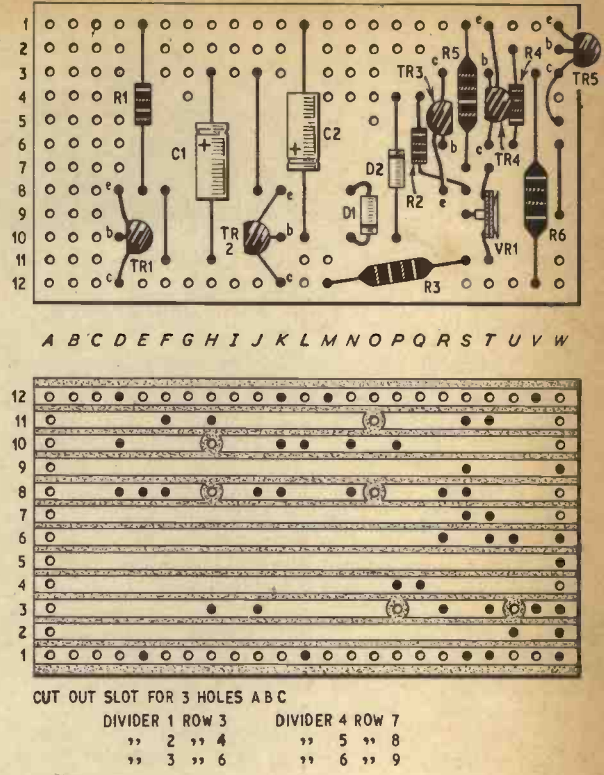
Wiring of the underchassis should now be completed following the wiring diagram of Fig. 12. All wiring runs should be laced to form a loom which, besides being neat, is much more easily managed when terminating at the eight way terminal strip of the display unit and the front panel controls and fuses.

At this stage cards should not be inserted.

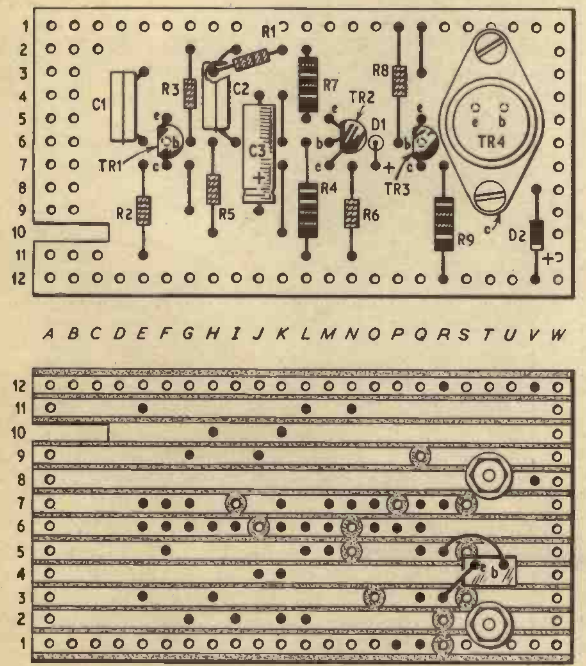




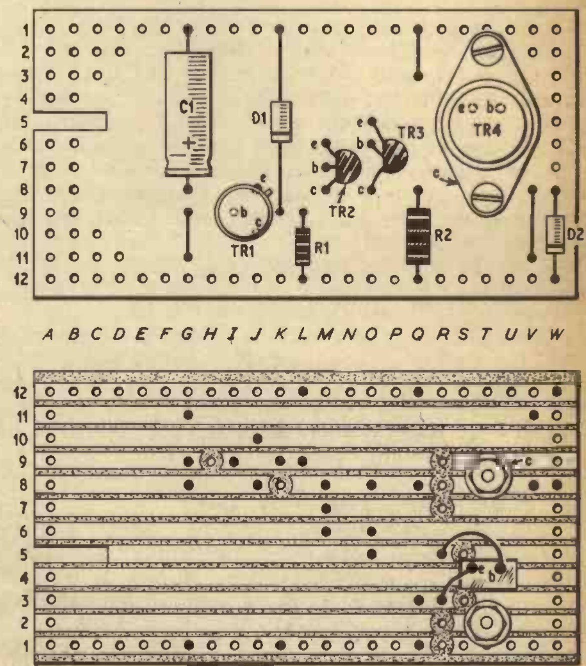
(a) Oscillator and pre-amplifier squarer



(b) Frequency divider



(c) Pulse unit



(d) Stabiliser and power amplifier

Fig. 8. Layout and wiring of the electronic sub-assemblies

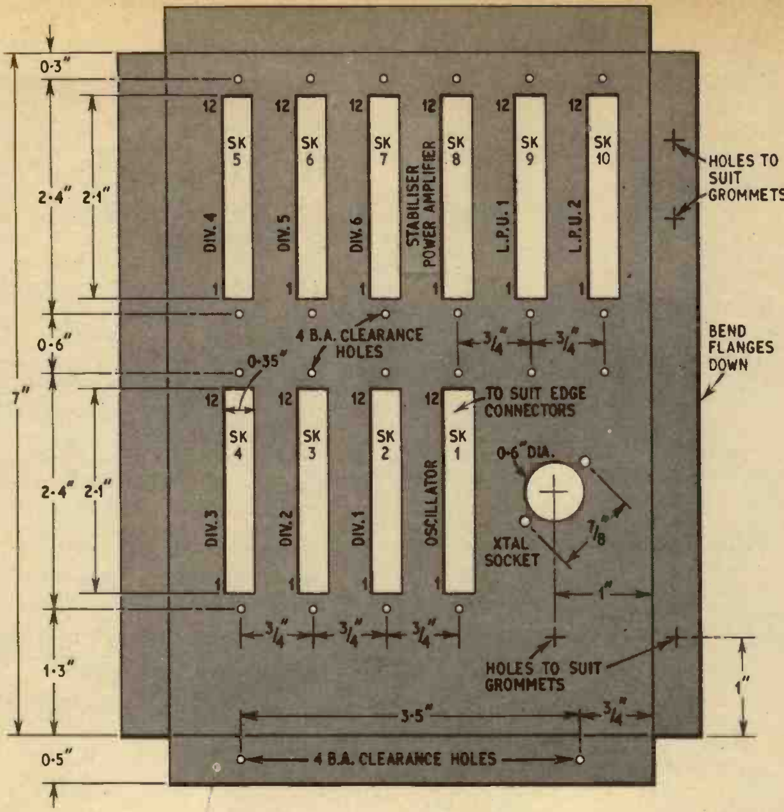


Fig. 9. Drilling and cut-out details of the control chassis

CONSTRUCTION OF DISPLAY

The display unit consists basically of three Ledex rotary switches mounted side by side. One displays minutes, the second tens of minutes and the other hours in the form of numbered discs attached to the spindles. The minutes Ledex is elevated with respect to the other two, this being necessary to make the minutes and tens of minutes numbers coincide. The Ledex switches should be mounted on a flat base as near as possible to one another without the discs touching. In the prototype, a $\frac{1}{8}$in plate of s.r.b.p. was used as a base. The wiring of the wafers is given in Fig. 13.

Simple illumination may be achieved by mounting two bulb holders below the display on this plastics base. The unit may then be mounted behind a panel with Perspex viewing windows fitted in appropriate positions. Holes are drilled in the Perspex so that the bulbs may be projected through for edge lighting.

SETTING-UP AND TESTING

Two pieces of test equipment are required for setting up and testing: a double beam oscilloscope and a 20,000ohms/volt multimeter with ranges 0–10V d.c., 0–25V d.c., and 0–100mA d.c. A schedule for testing the cards is given in Table 2.

With S6 in the off position, and display unit disconnected from the control chassis, connect a 12V battery to the supply wires and insert the power stabiliser card. Connect the voltmeter to the zero common line (negative) and pin 8 of the power stabiliser and switch on S6. It should read 7·5V within a fraction of a volt. Switch off and plug in all cards except the

Table 2: METER TEST SCHEDULE FOR SUB-ASSEMBLY CARDS

Card	Pin	Approx. voltage	Remarks
Oscillator	5	4	square wave output
	8	7·5	power supply line
Dividers (all)	5	0 to 0·2	saturation of TR5
	9	4 to 6	variation of VR1
	12	7·5	power supply line
Power amplifier and	7	0 to 0·2	input from divider
stabiliser	10	12	collector of TR1
	12	12	power supply line
Pulse units	3	0	input
	5	2·5	emitters of TR1 and TR2
	7	7·5	collector of TR1
	9	7·5	collector of TR1
	10	2·6	collector of TR2
	11	7·5	power supply line (stab.)
	12	12	power supply line (amp.)

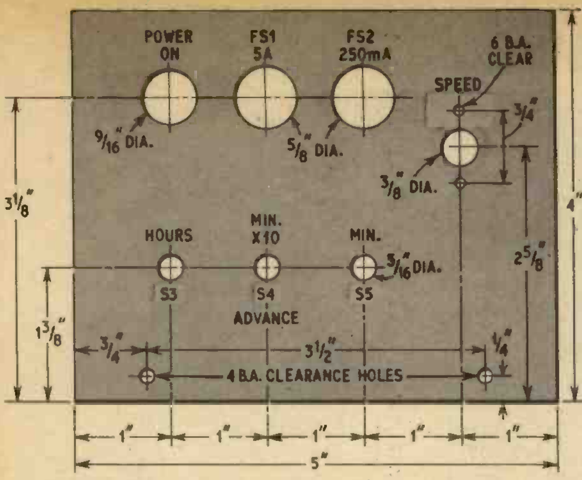


Fig. 10. Drilling and cut-out details of the control panel

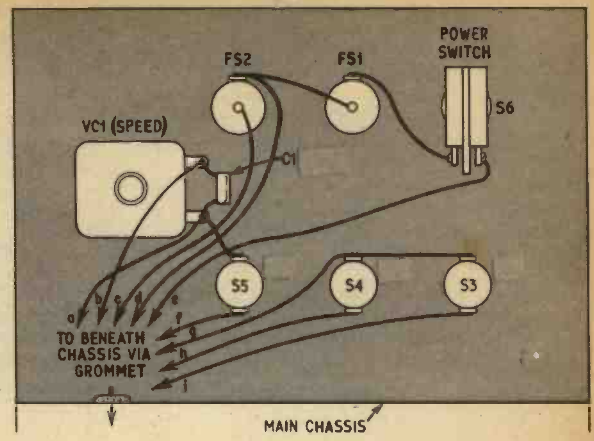


Fig. 11. Location of edge connectors and moulded guides

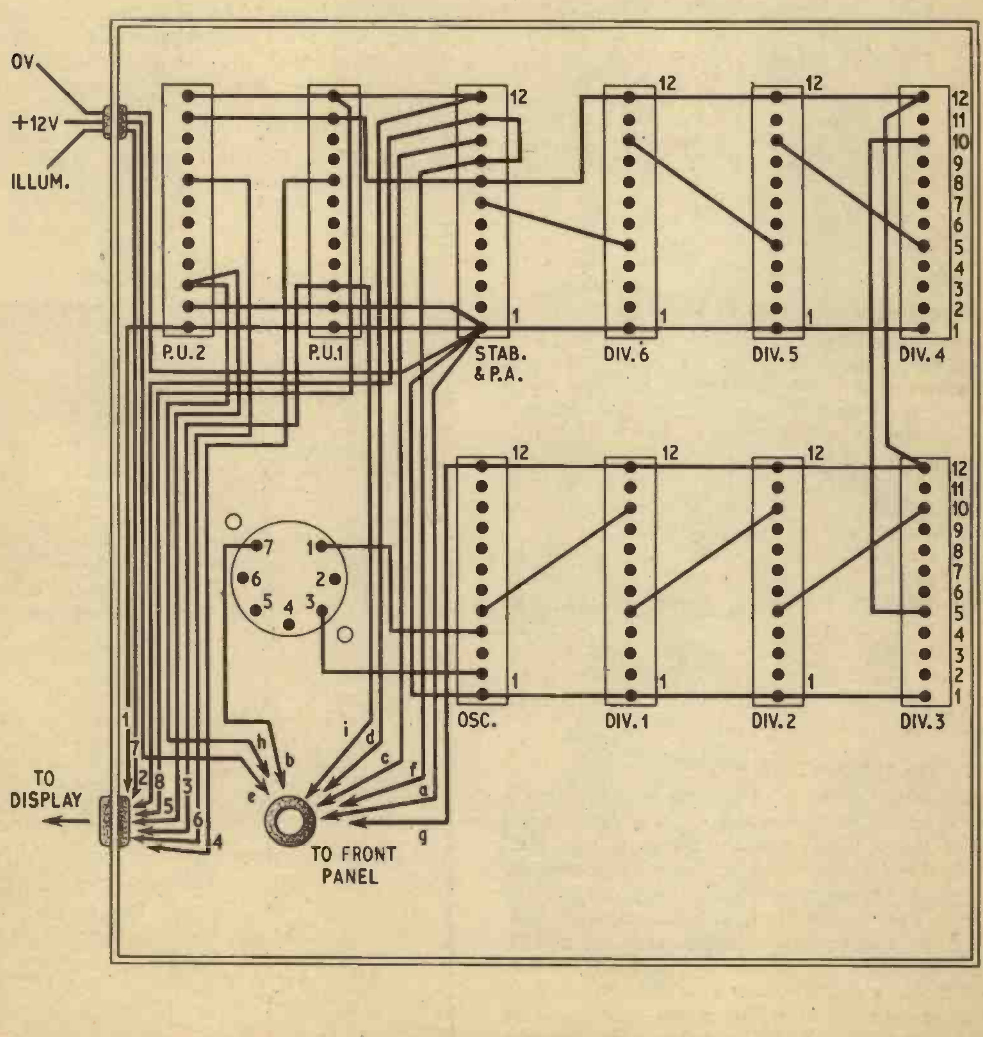


Fig. 12. Wiring of the control chassis

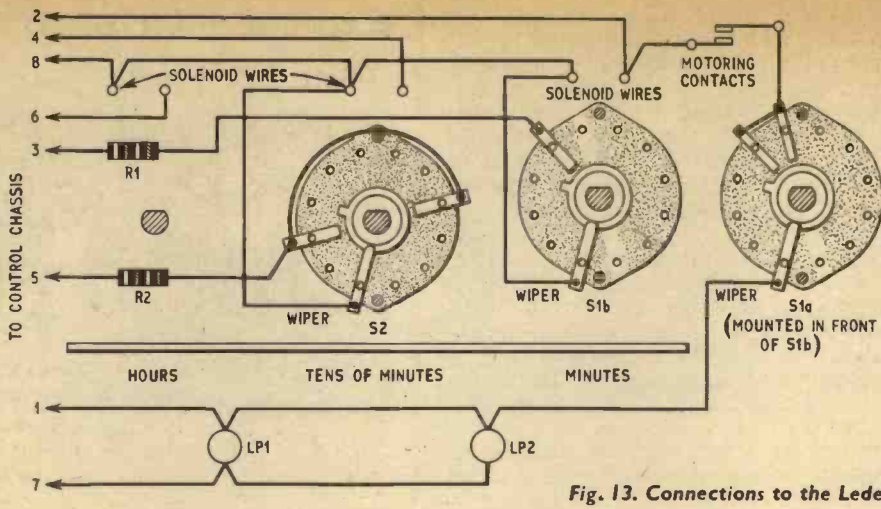
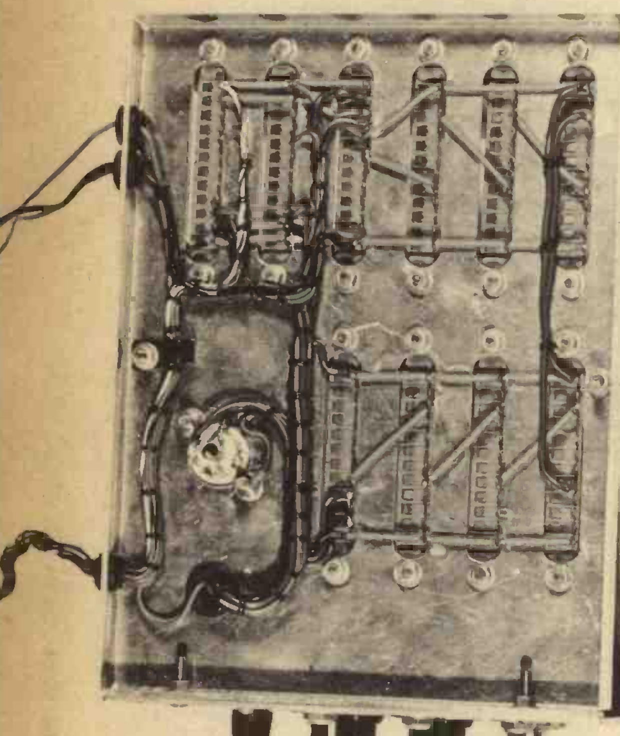


Fig. 13. Connections to the Ledex wafers



oscillator. Connect the meter in series with the positive supply line; set to the 100mA range on the meter.

Switch on and the meter should indicate about 40mA. Switch off and remove the meter. Reconnect the supply and check the voltages on each board with the negative lead of the meter connected to the common line (0V) for each test.

Now remove the meter, plug in the display unit, press S6 for a second, then release. The minutes Ledex should pulse round. Press S4 and hold down. The tens of minutes Ledex should pulse round, and similarly for S5 and the hours Ledex. Switch off.

PULSE RATE ADJUSTMENT

It may be found desirable to disconnect the display unit for the next test. Plug in the oscillator card and switch on. Connect the "common" terminal of the oscilloscope to the 0V line and using one beam only, look at the waveform with the other scope lead on pin 5. It may be necessary to adjust VR1 until the best quality square wave is obtained. Now monitor in turn the waveforms produced at positive end of C2 in each divider. A staircase waveform should be seen on the scope.

It is now necessary to use both beams of the oscilloscope and the voltmeter. Short the oscilloscope test leads together and set the traces in the lower half of the screen with Y1 amplifier trace above Y2. Connect

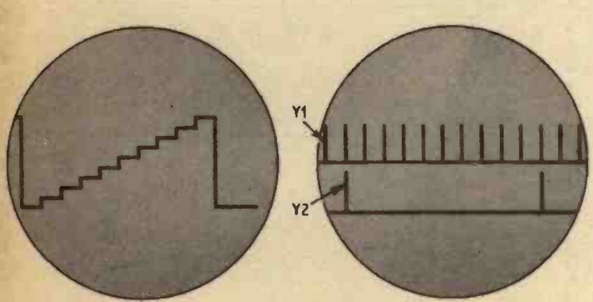


Fig. 14. Pulse train waveform on a double beam oscilloscope display

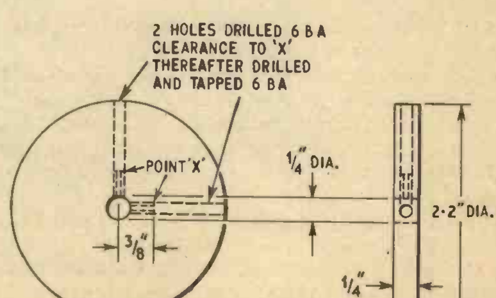


Fig. 15. The three display discs on the Ledex spindles

Y1 lead to pin 10 of divider 1, Y2 to pin 5, and the voltmeter to pin 9. VR1 should be adjusted so that for every ten pulses on Y1 there should be one on Y2 (see waveform in Fig. 14).

Difficulty may be experienced in seeing these pulses as they last for a very short time. The oscilloscope should be set to trigger from Y2. Now set VR1 so that the division ratio is just on nine and note the voltmeter reading. Do this also for a division ratio of eleven.

Set VR1 so that the voltmeter reading is midway between these two. Repeat this for each divider up to number 5. Because the pulse rate is so slow in divider 6 it is necessary to measure the time interval between two output pulses with a watch. A 12V bulb may be connected between output wires 2 and 8 to the display unit.

Set VR1 so that the bulb flashes once a minute and slowly adjust it until the bulb starts to flash once every 50 sec, noting the voltage on pin 9. Now slowly adjust VR1 in the other direction for a flash every 70 sec and again note the voltage on pin 9. Set VR1 to the midway position.

If difficulty is experienced in setting VR1 (i.e. reaching end-stops and still not obtaining satisfactory division), the value of C1 must be changed slightly, either increasing, if the voltage on VR1 wiper needs to be reduced or *vice-versa*. If satisfactory results have been obtained, the electronics side of the clock should be set up and require no more adjustment, unless maybe a critical divider component is changed.

DISPLAY NUMBERING

Fit three discs (Fig. 15) to the Ledex spindles. It is left to the constructor how he numbers the discs. The prototype used "Letroset" number transfers. The method of determining the correct numbers is as follows.

Remove the crystal from its holder and switch on. Press button S5 several times until the minutes disc suddenly "motors" and then stops. At the same time the tens of minutes disc should move round. Attach the number 0 to the minutes disc, just below the centre line at the perimeter, nearest the tens of minutes disc. Press S5 once and attach the number 1 to this position, and so on until 9 is attached. The remaining two spaces may be left blank.

Now press S3 until the hours disc moves. Attach the number 0 at the position on the perimeter where the tens of minutes disc coincides with the number displayed on the minutes disc. Press S3 once and attach the number 1 to this position, and so on until number 5 is attached. The next position will be 0 again and so on to finish at 5. There should be no spaces left.

The hours disc may then be numbered from 1 to 12, clockwise with no specific starting point.

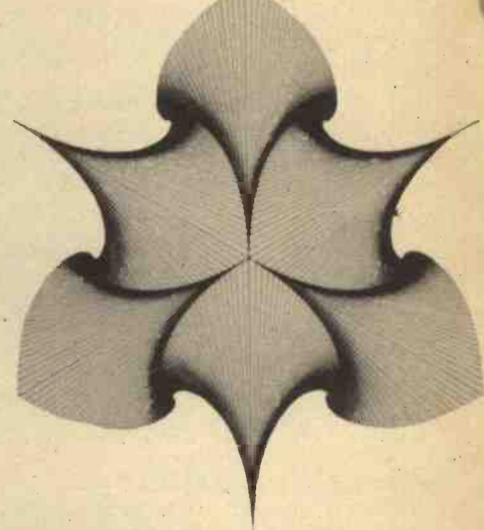
For a final check it is necessary to press S5 repeatedly about once every 2 seconds and check that the numbers display follows the pattern 60 min to 1 h (i.e. the tens of minutes disc rotates once every ten presses of S5 and the hours disc rotates once every sixty presses of S5).

The small screw fitted plates on the front panel of the display provide easy access to the lamps.

Upon replacing the crystal, the clock should be fully operational, the only adjustment required being that of the speed, which cannot be achieved in a short time. It is suggested that this adjustment should be left for a few months to enable the crystal to settle down. ★

CYBERNETIC
the computer

A computerised electronic music studio by Peter Zinovieff



WHERE should you seek the most *avant-garde* art exhibition now running in London? Not amidst the glitter and bustle of show biz London, but just a little off from Piccadilly and Leicester Square, in The Mall, just beyond Admiralty Arch. Here in this principal processional route of traditional London, you will find the plain sober-faced terrace which is Nash House. It is now the home of the Institute of Contemporary Arts.

Step over the threshold, and in a microsecond or so you will be transported from an environment reminiscent of past national glories to another which must be one of the most advanced and outward-looking in a rather different realm—that of art. For here we see exhibited numerous artists' attempts to use modern technology for their creative purpose, just as their predecessors employed brush and palette or pen and ink.

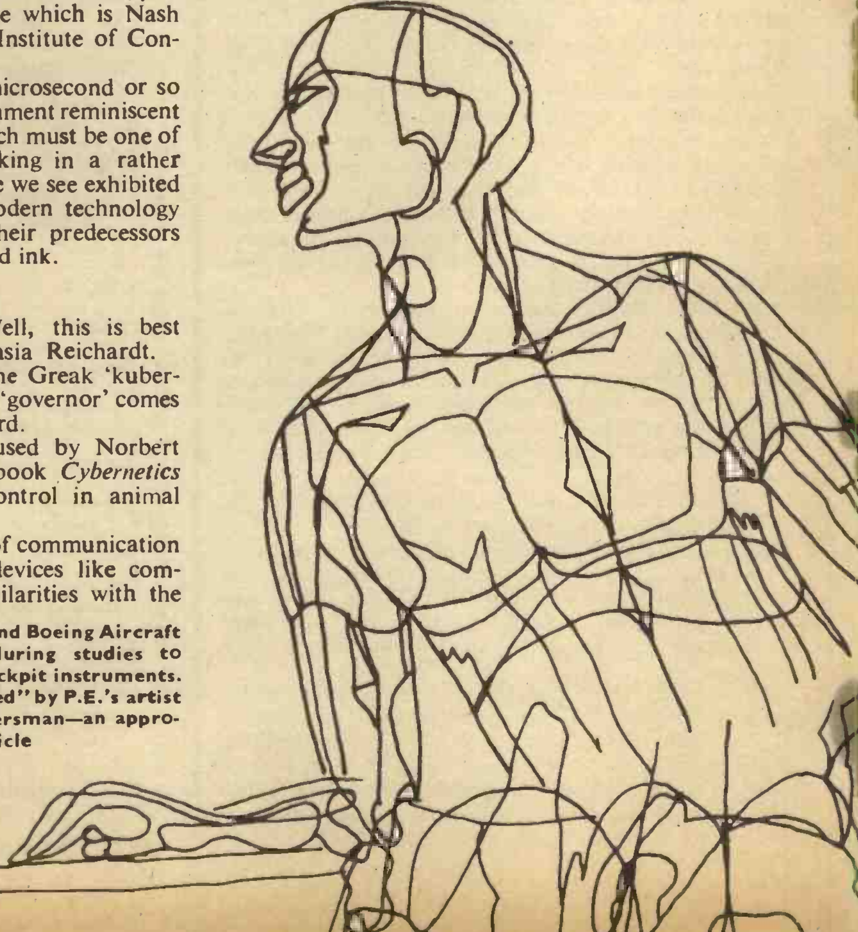
WHAT DOES IT MEAN?

The title of this exhibition? Well, this is best clarified by quoting the organiser Jasia Reichardt.

"*CYBERNETICS*—derives from the Greak 'kubernetes' meaning 'steersman'; our word 'governor' comes from a Latin version of the same word.

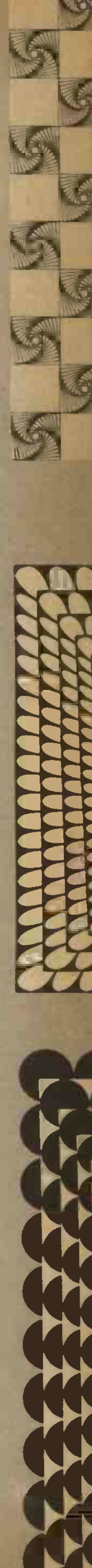
"The term cybernetics was first used by Norbert Wiener around 1948. In 1948 his book *Cybernetics* was subtitled 'communication and control in animal and machine'.

"The term today refers to systems of communication and control in complex electronic devices like computers, which have very definite similarities with the



A creation of American Air Force Data and Boeing Aircraft designers, this man was produced during studies to determine optimum arrangement of cockpit instruments. This 20th Century pilot has been "adopted" by P.E.'s artist and put into the role of an ancient steersman—an appropriate symbol for the subject of this article

SERENDIPITY
. . . and the arts



processes of communication and control in the human nervous system.

"A cybernetic device responds to stimulus from outside and in turn affects external environment, like a thermostat which responds to the coldness of a room by switching on the heating and thereby altering the temperature. This process is called feedback.

"Exhibits in the show are either produced with a cybernetic device (computer) or are cybernetic devices in themselves. They react to something in the environment, either human or machine, and in response produce either sound, light or movement.

"*SERENDIPITY*—was coined by Horace Walpole in 1754.

"There was a legend about three princes of Serendip (old name for Ceylon) who used to travel throughout the world and whatever was their aim or whatever they looked for, they always found something very much better. Walpole used the term serendipity to describe the faculty of making happy chance discoveries.

"Through the use of cybernetic devices to make graphics, films and poems, as well as other randomising machines which interact with the spectator, many happy chance discoveries were made."

INTERNATIONAL FLAVOUR

That this is truly an international exhibition is clear from the personalities and organisations behind this project. The original idea came from Prof. Max Bense of Stuttgart University; encouragement from the Ministry of Technology, financial help from the Arts Council, and practical assistance in the form of films, exhibits, and technological information, from IBM. British industry was also approached. Their representatives seem to have applied the Nelson touch all right. Telescope to blind eye—they could "see" no need or future in this art business! Perhaps their vision will be restored after a visit to "Cybernetic Serendipity".

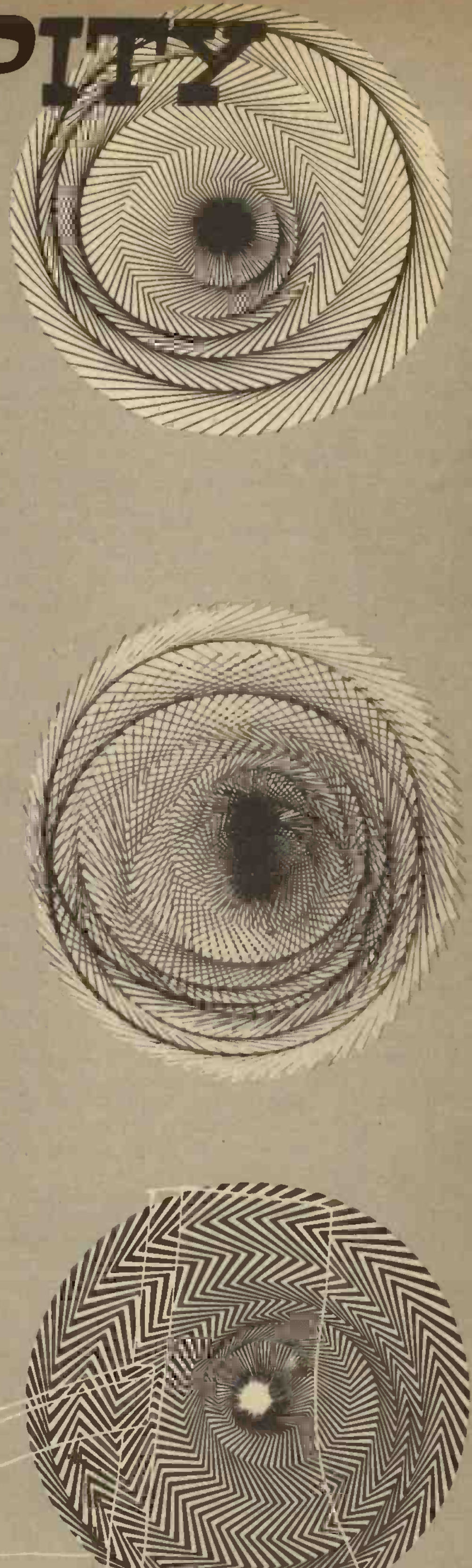
The international flavour is also evident from the names of the various artists participating: contributions have come from France, Germany, Israel, Italy, Sweden and U.S.A., as well as the U.K.

The exhibition is divided into three sections:

1. Computer generated graphics, computer animated films, computer composed and played music, and computer verse and texts.
2. Cybernetic devices as works of art, cybernetic environments, remote control robots, and painting machines.
3. Machines demonstrating the uses of computers and environment dealing with the history of cybernetics.

During the course of the exhibition there are lectures on Tuesdays and Thursdays. There are also daily film shows in the auditorium of films either made with the aid of computers, or dealing with the relevance of computer technology to the humanities, the arts, and communications generally.

We now give some impressions arising from our visit on Preview Day.



Examples of computer composed graphic art

TORTURED TELEVISION

Some artists have been quick to appreciate the possibilities offered by "the box". No doubt malfunctioning TV receivers gave them the idea. Now they use huge permanent magnets to distort the image and to produce fantastic patterns and shapes (just to think, *we* are always struggling to *eliminate* such misshapen pictures!)

This is one of the cruder methods used by Nam June Paik from U.S.A. More electronically elegant are his Lissajous figures displayed on a colour receiver.

Even more exciting visually we thought were the Lissajous patterns produced on a monochrome set with pre-recorded control signals fed in from a tape loop. Entitled "Sidebands 1968", this is the joint work of two electronic engineers from London, H. Riddle and A. Pritchett. It seems capable of producing an infinite number of different graphic forms.

ELECTRONIC MUSIC

Electronic music flows from loudspeakers in the floor of igloo-like listening chambers. Not the easiest art-form to savour and appreciate critically in this kind of exhibition. Perhaps all the animated graphic displays make one want to continue prowling. We had a quick listen, but it must be admitted, were soon seduced away by the visual attractions.

COMPUTER COMPOSERS

The most sophisticated apparatus to get into the hands of the artist is of course the computer. And here one can see the feats these electronic calculators have achieved—with certain aid from the human operator.

Computer composed and played music—well that's not strikingly new, but Peter Zinovieff's multi-rack electronic set-up, heard interpreting in various harmonious forms a simple melody whistled into the microphone by the visitor, is quite an outstanding development in this field.

From its more prosaic work in the drawing office, the computerised drafting machine has now additionally a more relaxed occupation—the creation of graphic art. Computer produced patterns on display provoked murmurs of admiration. They will make the most imaginative doodler green with envy.

The computer's entry into the world of literature was shown by examples of "poems" produced by this versatile and able machine. Anyhow, the results surely are hardly more incomprehensible than some contemporary hand-produced works (!)

ROBOTS AND HUMANOIDS

The most obviously electronic-cybernetic works of art in the exhibition are the remote control robots. Although just how much is "art" in these cases seems a debatable point. But technologically speaking, these automata are of tremendous interest and always attract attention.

Rosa Bosum by Bruce Lacey is an electronic actress who has played with live performers on the stage. At least her legitimacy as "art" cannot therefore be challenged.

WORTH A VISIT

If you are in town between now and October 20, do make a point of visiting this unusual and inspiring exhibition. You will probably get some ideas to try out yourself. But careful with that magnet around the family TV set. *That* is really not to be recommended.

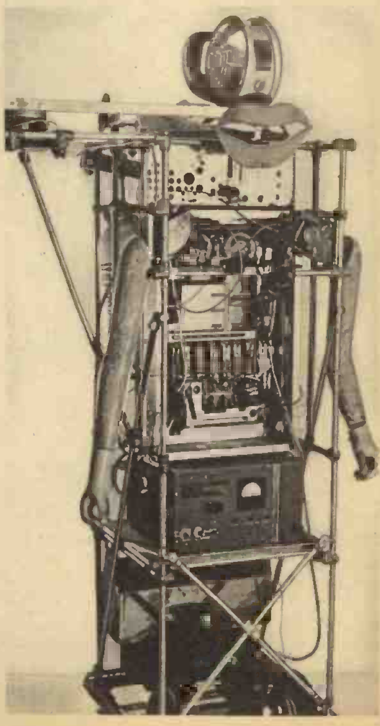
★

CYBERNETIC SERENDIPITY
August 2–October 20, 1968
Times of opening:

Tuesdays, Thursdays, Saturdays	11 a.m. to 6 p.m.
Wednesdays, Fridays	11 a.m. to 9 p.m.
Sundays	2 p.m. to 6 p.m.
Mondays	closed

During the course of the Cybernetic Serendipity exhibition a series of lectures will be held on Tuesdays and Thursdays at 8 p.m. in Nash House, The Mall, London, S.W.1. Admission 7s 6d. Lectures still to come include:

Thursday, September 19	"The Computer as an Aid to Literary Studies" The Rev. A. Q. Morton Pioneer on the use of computers in New Testament studies and Greek literature in general
Tuesday, September 24	"The Computer in Music" Pietro Grossi Composer and founder of the Studio of Musical Phonology in Florence
Thursday, September 26	"The Social Implications of Art with Computers" Professor Abraham Moles of Strasbourg University, sociologist and cybernetician concerned with the application of cybernetics and information theory to aesthetics and music
Tuesday, October 1	"The Contribution of Computers to the Art of Education" Professor R. A. Buckingham of the Institute of Computer Science in London
Tuesday, October 8	"Varieties of Information" Professor John Cohen of the Department of Psychology, Manchester University
Thursday, October 10	"Automatic Mechanical Self-replication" Professor Lionel Penrose Emeritus Professor of Human Genetics at London University
Thursday, October 17	"Talking to Computers" Robin McKinnon Wood Computer System Designer and Principal Investigator at the Cambridge Language Research Unit



Radio operated simulated actress Rosa Bosum by Bruce Lacey. Originally designed to integrate with live performers in production of Three Musketeers, at the Arts Theatre 1966, where it played the Queen of France

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.

MONOLITHIC IC

A new package deal is announced by **Sinclair Radionics Ltd.** They are offering a monolithic integrated pre-amplifier and power amplifier to be called the IC-10. It follows the external appearance of moulded case integrated circuit modules, but the heart of the device contains the equivalent of 13 transistors, 3 diodes, and 18 resistors on a silicon chip. The circuit requires only the addition of tone and volume controls and a power supply.

The claimed r.m.s. output is 5 watts at less than 1 per cent distortion. Frequency response is said to be $\pm$1dB from 5Hz to 100kHz. The price of 59s 6d compares favourably with the equivalent in discrete components, but it is high in comparison with other linear integrated circuits.

BENCH ACCESSORY

The new Lektrokit No. 6 electronic construction kit enables numerous experimental circuits to be neatly stacked vertically instead of the usual sprawl across the bench, and allows "shelving" of an experiment if space on the bench is required for some other project.

The kit consists of a bench rack with two chassis assemblies on which discrete components and integrated circuits can be mounted and wired. A front panel of grey enamelled aluminium alloy is also provided for indicator lamps, meters, switches, and controls. The base tray is ideal for carrying power supplies and other auxiliaries.

The price of the Lektrokit No. 6 is £7 10s, and further details can be obtained from the manufacturers, **A.P.T. Electronic Industries Ltd.**, Chertsey Road, Byfleet, Surrey.

TAPE SYNC

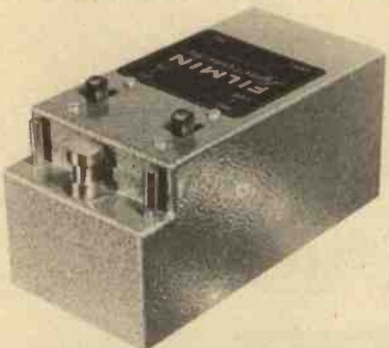
There has been a lot of correspondence and conjecture over the problems of tape cine sync in this magazine over the past few months, and ideas from readers have been received thick and fast at the office.

As there seems to be a strong following in this field readers may like to investigate the Mark II Syncronette camera and projector synchroniser from **Films in Miniature Ltd.**

The Syncronette, measuring 5½in × 2¾in. × 2½in, is designed to synchronise an electric cine camera or projector with a standard tape recorder. A special perforated tape is used, with holes punched in track three, corresponding to the sprocket-holes in the film. Tapes are available for use at 3¾ or 7½ i.p.s., and filming speeds of 16 or 25 f.p.s.

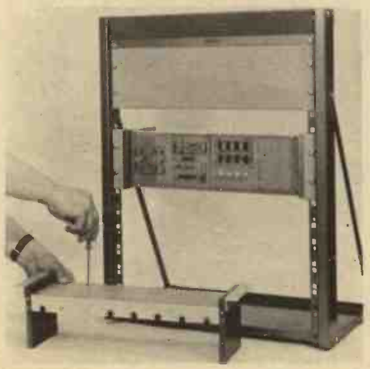
The unit features solid-state circuitry and is powered by two internal battery packs each containing six HP7 cells, enough for up to 5,000 ft of film projection. The standard model will control projectors rated up to 250V 2·5A a.c. and cameras up to 300mA at 9V d.c.

The unit operates by scanning the perforations in the tape with a phototransistor, and receiving a pulse from a contact in the camera once per frame of film. The phase relationship of the two sets of impulses is used to vary the power reaching the camera motor, and hold it in synchronisation with the tape. Damping circuits prevent the camera "hunting".



Syncronette Mark II Lip-synchroniser for camera and projectors from Films in Miniature

Sinclair IC-10 monolithic integrated pre-amplifier and power amplifier



Lektrokit No. 6 construction kit manufactured by A.P.T. Electronic Industries

The Syncronette is connected to a camera by a single three-core flex. Modification of the camera is necessary at an extra cost from £3 to £10 depending on type of camera. The basic cost of the Syncronette is £29 3s 5d including purchase tax.

Further details can be obtained from Films in Miniature Ltd., 30 Straight Mile, Romsey, Hampshire.

LITERATURE

A new revised 960-page edition of the **Electroniques** *Hobbies Manual 1968* is now available, price 16s 6d, from Electroniques, Edinburgh Way, Harlow, Essex.

Divided into 12 sections, the manual provides full information on the very extensive range of components, kits and products for the home constructor and experimenter that is available through Electroniques excellent postal dispatch service.

Many new kits and components have been included since the first edition was published, including microscopes, telescopes, car radios, seat belts and engine tuning kits. In the components section the range of transistors as been expanded, including more integrated circuit devices and now lists field effect transistors.

Included in the manual are pages of technical data, abacs, formulae, designs and hints for the practical handyman.

The latest technical information on **Motorola's** new high-speed MECL 11 series of integrated circuits has been compiled in booklet form. The loose-leaf bound brochure with over 100 pages, includes current data sheets for 56 new high-speed logic integrated circuits (29 different functions). Each data sheet contains application "ideas" for that circuit function.

In addition space is reserved at the beginning of the brochure for insertion of the MECL 1 brochures currently being used.

Data pertinent to all the MECL series is categorised for instant reference. The loose-leaf nature of the brochure allows the addition or replacement of individual pages, or complete sections, as the MECL line is expanded.

A 10-page general information section discusses MECL 11 design, and summarises system characteristics; also, it outlines general rules for system design and layout.

An added feature of the brochure is an index to all current Motorola application notes and recent technical articles related to MECL products and applications.

The MECL data booklet can be obtained by writing to Motorola Semiconductors Ltd., York House, Empire Way, Wembley, Middlesex.

We now consider the use of the multiplier UNIT "D" in solving equations.

THE MULTIPLIER IN EQUATION SOLVING

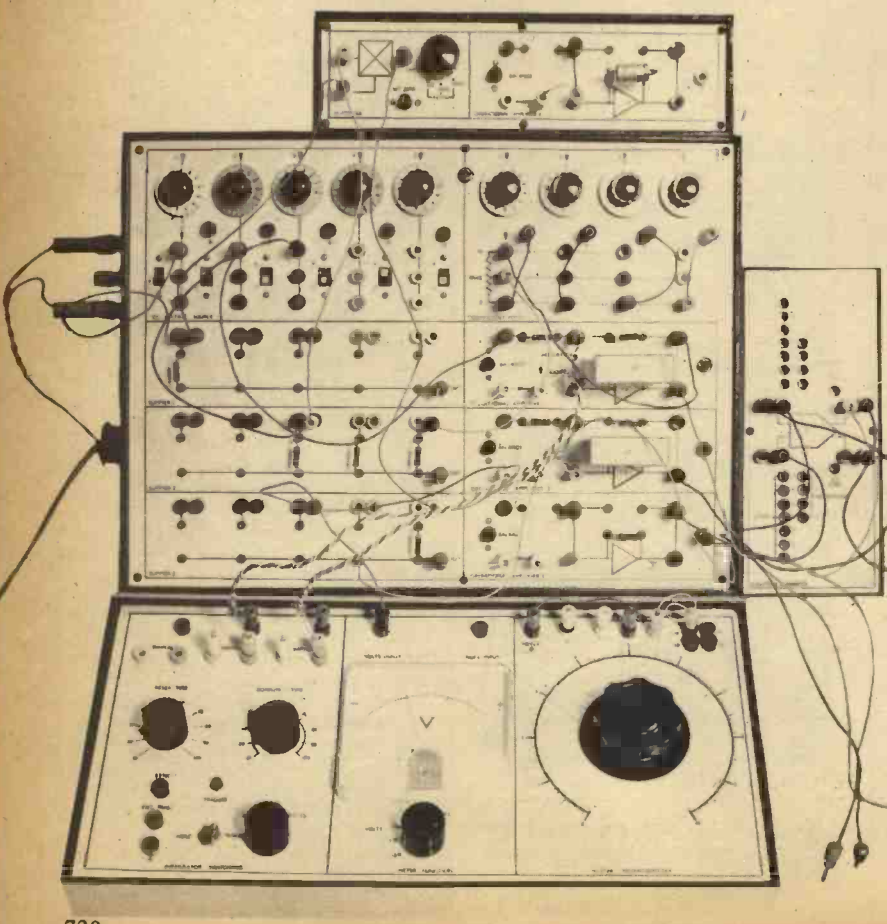
Fig. 10.1 sets out four multiplier configurations to show how equation terms may be handled. As a self-contained computing element, UNIT "D" will multiply input voltages X and Y to give a product $XY/10$, see Fig. 10.1a. Note that arrows are normally used with the multiplier symbol to identify input and output terminals.

Division of two variable voltages is achieved, in Fig. 10.1b, by placing the multiplier in the feedback loop of an operational amplifier. However, with division, certain limitations are imposed. The Y input must be of single polarity, which rules out a.c. waveforms unless they are d.c. biased above or below $Y = 0$, but ramp or step functions will be accepted if they do not change their sign. With the X input, voltages can be 0 to ± 10V d.c., or a.c. peak.

Because an extra filter capacitor (shown dotted in Fig. 10.1b) is needed to prevent amplification of low-level carrier ripple by the open-loop, high gain amplifier, frequency response is restricted to 10Hz for the division operation, when switch S11 is in the 50Hz position. It is sometimes possible to arrange a problem so that the reciprocal is multiplied, and thus avoid the limitations of Fig. 10.1b division. A related configuration in Fig. 10.1c gives an output $XY/(1 + X)$, for inputs of $\pm X$ and $\pm Y$.

In the final example of Fig. 10.1d, the multiplier is combined with integrators, and therefore handles time varying voltages. By solving the equation $\mathrm{d}A/\mathrm{d}t = 2\pi R \times \mathrm{d}R/\mathrm{d}t$, which describes the rate at which the area of a circle changes with a growth of radius, the layout of Fig. 10.1d can be used to investigate,

ANALOGUE COMPUTER



PE AC

By D. BOLLEN

The Practical Electronics Analogue Computer in its complete and comprehensive form. The whole of this equipment has been fully described in this series of articles which is concluded this month say, the build-up of tape on a spool, the expansion or contraction of metal discs and cylinders when heated, or the surface area of a liquid in a conical reservoir.

SPECIAL ANALOGUE COMPUTER CIRCUITS

Apart from the analogue computing elements already covered are a few specialised diode circuits which are used for simulating various mechanical phenomena. Ordinary silicon diodes, such as the OA202, can be employed with the circuits of Fig. 10.2, and are inserted into the computing component sockets of UNIT "A".

Dead Zone. Amplifier gain in Fig. 10.2a is zero until the limits

$$E_{in} = -\frac{R1}{RB_1} \times 10$$

or

$$E_{in} = \frac{R2}{RB_2} \times 10$$

are reached, thereafter gain will depend on the slope given by R_f/R1 and R_f/R2.

Limiter. In Fig. 10.2b, amplifier gain is constant between the limits set by

$$E_o = \frac{R1}{RB_1} \times 10$$

and

$$E_o = -\frac{R2}{RB_2} \times 10$$

When the limits are exceeded, the gain falls to zero.

Friction. A frictional force generated by moving surfaces in contact is virtually constant for all values of

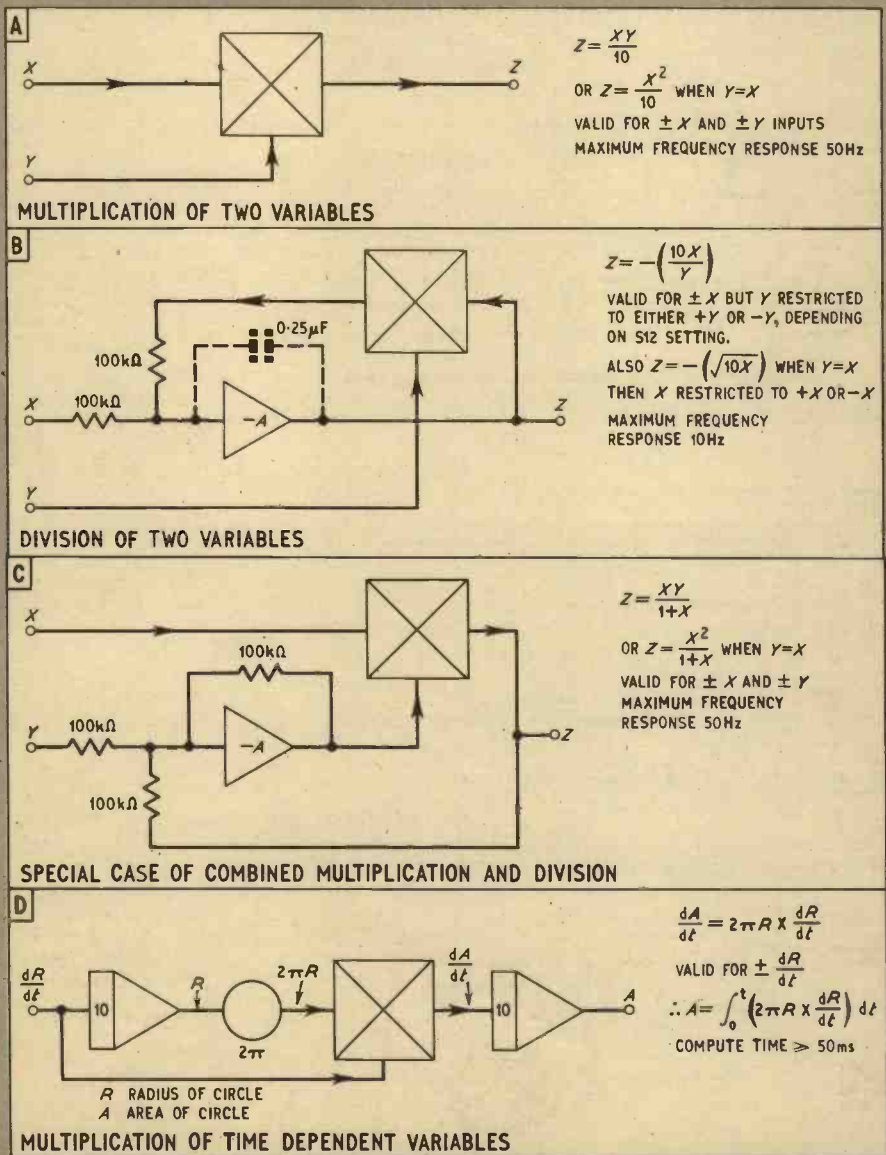


Fig. 10.1. The multiplier used for equation solving

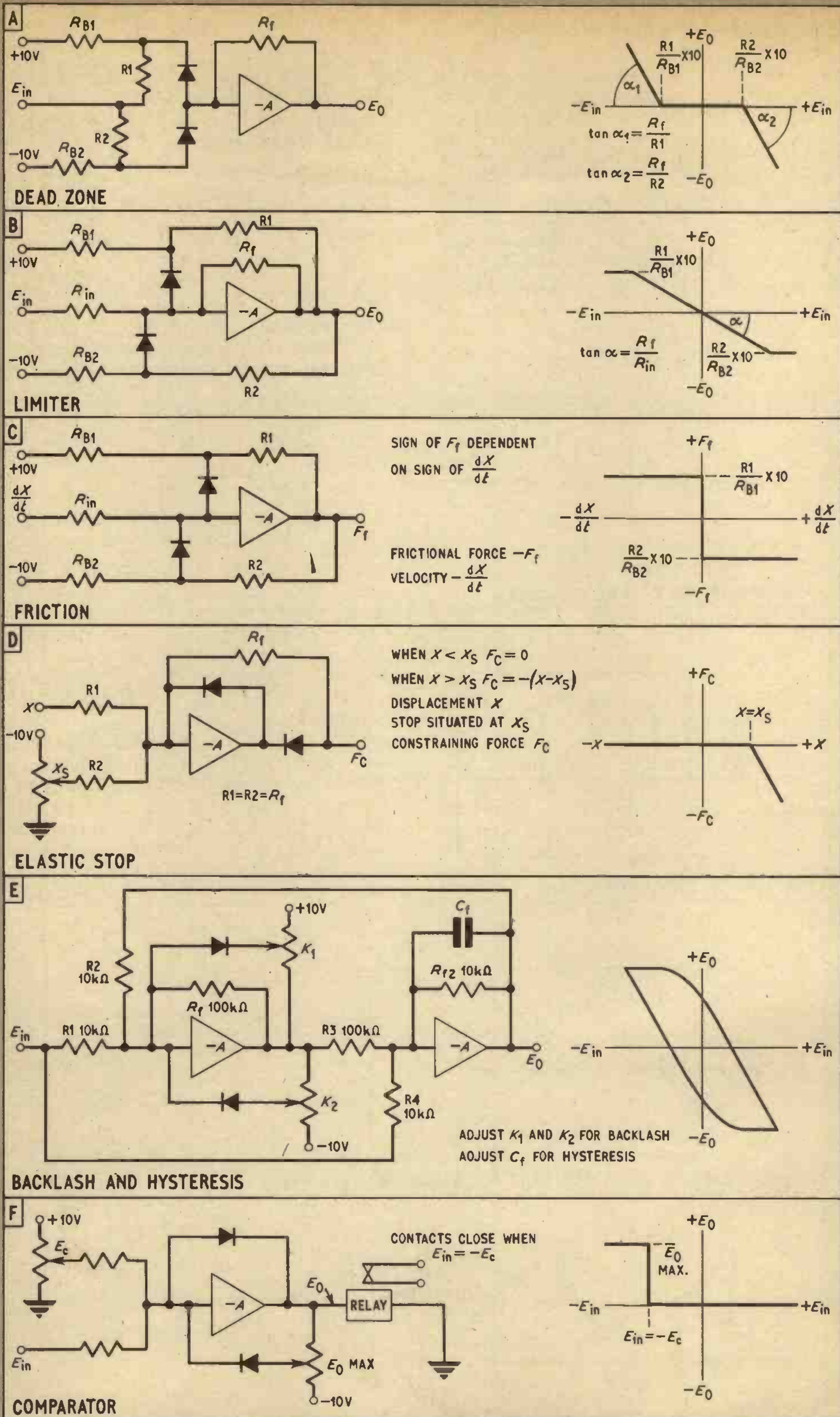


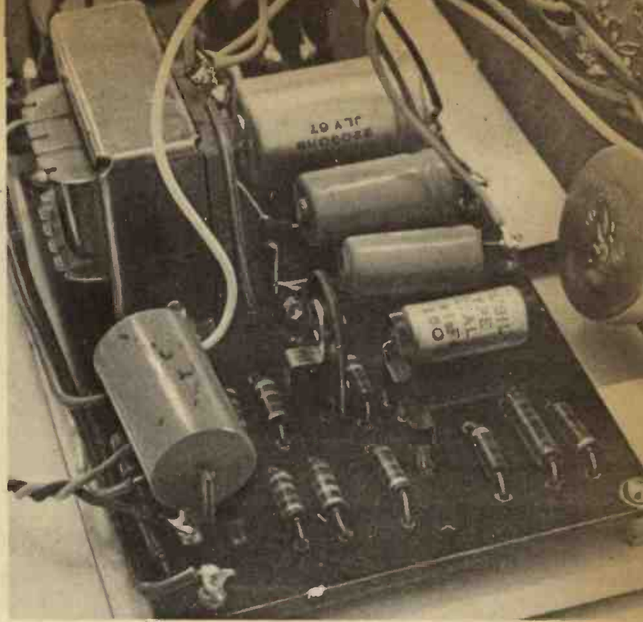
Fig. 10.2. Special circuits for simulating mechanical phenomena

velocity, but will change sign when the direction of the velocity is reversed. Circuit Fig. 10.2c satisfies the above conditions and generates a voltage proportional to a frictional force F_f.

Elastic stop. When an object makes contact with an elastic stop, the resulting constraining force is proportional to the penetration of the object into the stop. In Fig. 10.2d, term X_s represents the position of the elastic stop, while X is the displacement of the object. When $X \geqslant X_s$, the amplifier provides an output F_c which represents the constraining force.

Backlash and hysteresis. Mechanical linkages, gear trains, and some electrical circuits will often exhibit backlash and hysteresis, which are simulated by the circuit of Fig. 10.2e, using a dead zone and an integrator. Apart from K_1, K_2, and C_f, adjustments to R2, R3, and R4 will allow a wide range of characteristics.

Comparator. As its name suggests, the comparator of Fig. 10.2f compares one voltage with another, and enables some action to be taken at a pre-arranged input level. The comparator can be applied to the simulation of impact forces, where the constraining force is proportional to the *rate* of penetration; when $E_{in} = -E_c$, the relay contacts will close and insert a voltage representing velocity into an equation.



Product amplifier circuit panel

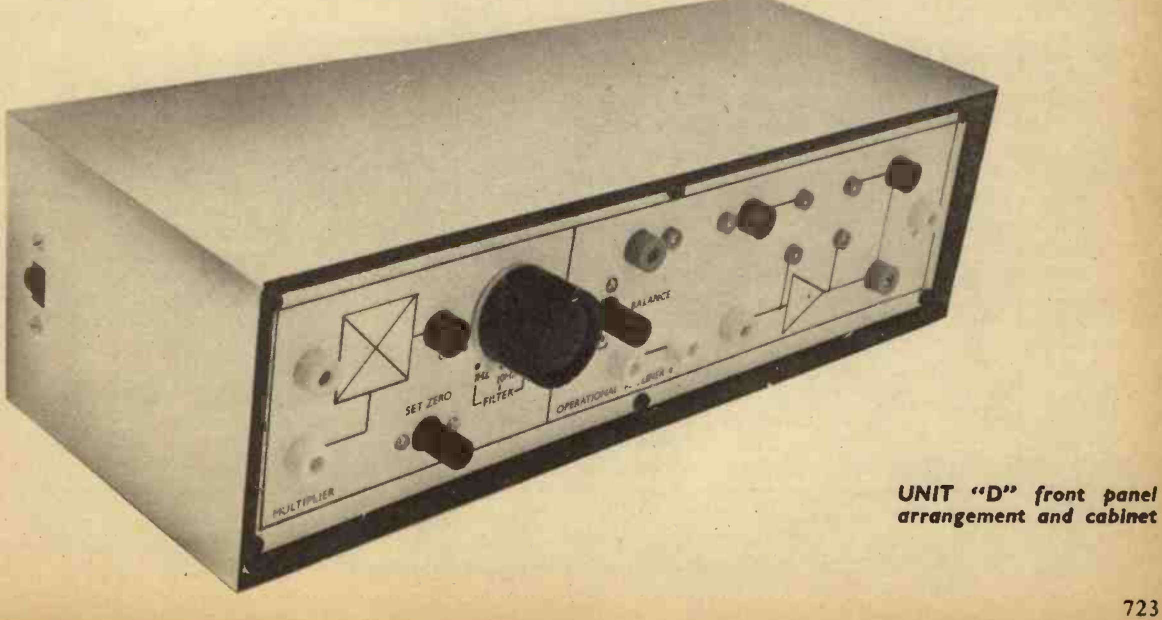
CONCLUDING NOTES

A brief mention should be made of those aspects of analogue computer usage which were considered to be beyond the scope of the present series. It would have been difficult to include the more complex Calculus problems which PEAC is capable of solving, and also transfer function techniques were avoided because they would have demanded some knowledge of Laplace transforms and the like.

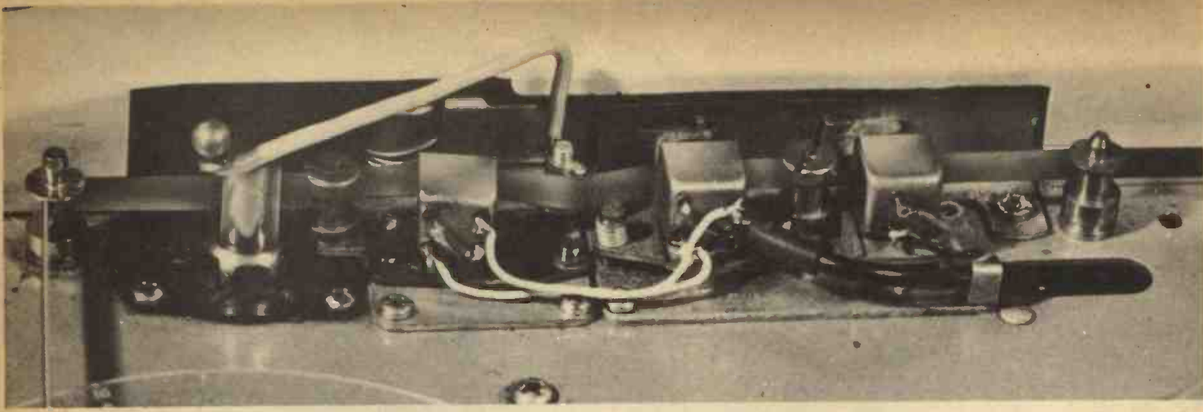
A very important field is the use of analogue computers in controlling processes and evaluating data, so called "In-plant" applications, but here fairly elaborate sensing equipment and servomechanisms are called for, to act as intermediaries between the external process and the computer.

An important omission, brought to light by a reader's letter, concerns the use of a temporary feedback resistor when checking the coefficient of a potentiometer which is employed for division (Fig. 4.1f). If the feedback resistor is not present, the operational amplifier summing junction will no longer be at virtual earth when the potentiometer is disconnected for measurement purposes, and this can lead to serious errors. Therefore, when checking a division potentiometer coefficient, always insert a 10 kilohm feedback resistor into OA/SK11 and SK12.

If difficulty is experienced in zero-setting a UNIT "A" operational amplifier after construction, by adjustment of VR1 on the amplifier panel, it may be that transistor "spreads" are greater than has been allowed for in the design. The simple cure is to increase R1 (Fig. 3.7) to 4·7 megohm if the amplifier output is fixed close to the negative supply rail voltage, or, when the output remains clamped near to the positive rail, decrease R1 to 3·3 megohm. ★



UNIT "D" front panel arrangement and cabinet



(above) Modified Magnavox tape deck showing the phasing lever and parallel connection of heads

SIMPLE PHASE

BY. L. G. ELLISON

WHETHER you regard it as a "psychedelic freak-out" or as an abominable distortion, musical phase is one of the weirdest effects yet adopted by the pop record industry. An article last month investigated the theory of phase—or "skying"—and some of the many ways in which it may be achieved: this article describes how a simple domestic tape recorder can be converted into an efficient phase-producing machine by adding two components—an extra record/play head to scan the lower track, and an eccentric guide capable of varying the length of tape between this and the existing head.

The method has advantages over systems using pairs of recorders or record players. There is no difficulty in maintaining the very slight delay needed to produce phase (rather than plain echo) and by using two similar heads in parallel, with only one amplifier in circuit, close matching of the two signals is assured.

PRACTICAL LAYOUT

The drawing (Fig. 1) shows a practical layout. The additional head is mounted to scan the bottom half of the tape, and a switch connects it in parallel with the existing upper track head. The extra head must be electrically similar: if a popular type of recorder is used, replacement heads will be obtainable from the makers of the deck. Half-track working is illustrated, but quarter track machines may be similarly modified.

To use the equipment, the programme (or whatever) is recorded simultaneously on both tracks with the phasing lever set at "0". On playback, both tracks—although staggered by a few inches—will reproduce exactly in step to give a normal replay, as conditions are the same as they were for recording. On moving the phasing lever, however, the length of tape between the heads is varied and the top and bottom track versions of the signal are replayed fractionally out of step through the common amplifier. Thus the recording can be "skyed" at will.

An alternative method is to operate the lever while recording and to leave it at "0" during playback. This produces exactly the same effect, but does not allow the recordist to monitor his efforts.

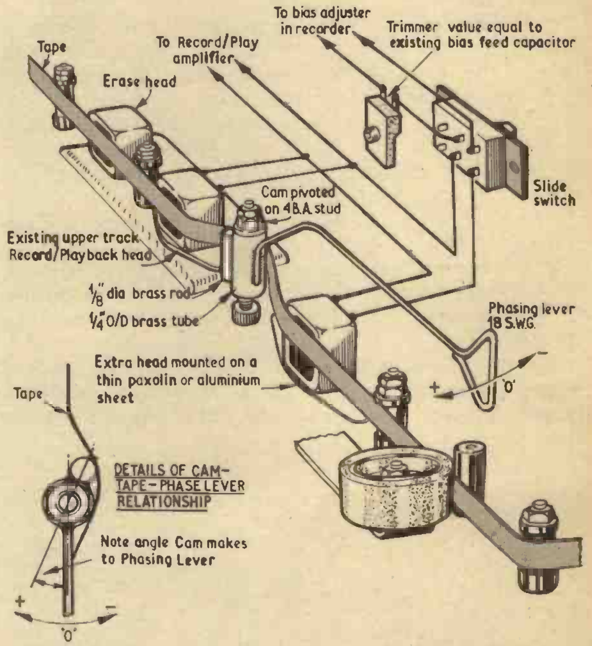


Fig. 1. A mono, half-track tapedeck adapted for phase operation. The required deflection of the tape is very small—sufficient to cause a sideways movement of about $\frac{1}{10}$in across the gap of the extra head. With the head placed slightly forward of the normal tape path, no pressure pad is needed. A short spring beneath the eccentric introduces friction to prevent the phasing lever moving of its own accord

SIMPLE MODIFICATION

In most cases good results will be achieved with no further modification to the recorder. Connecting heads in parallel will cause a slight drop in playback level because of the reduced impedance, but the loss is to some extent made good by the combination of two signals.

There remains a possibility of inadequate h.f. bias in the record condition, particularly if the recorder is a low-cost machine in which the bias has been adjusted to a bare minimum to emphasise treble. If the double-headed reproduction is "toppy" and granular in quality, increase the bias level by raising the value of the bias feed capacitor in the recorder, or by reducing the value of the bias adjusting rheostat (if one is fitted). For optimum results, record at a slightly higher level than normal and use the fastest tape speed.

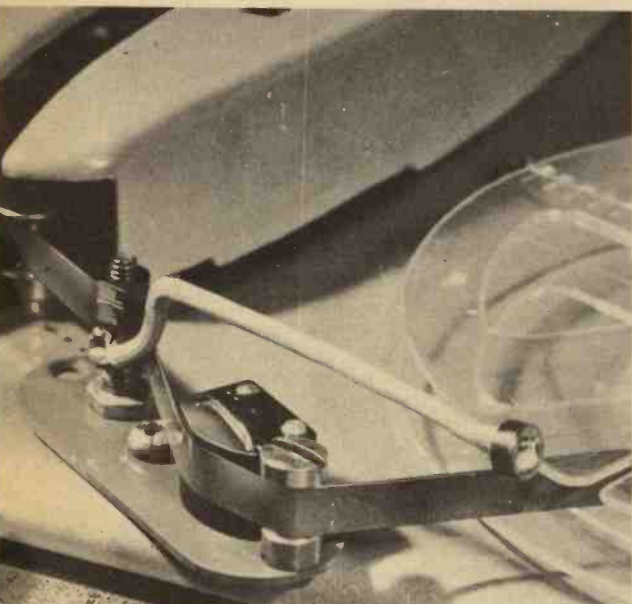
Note: The drawings and photographs are based on a common type of recorder having a single record/replay head. Machines with separate heads for recording and playback can be converted for phase operation—but will need *two* extra heads, one for record and one for replay, connected in parallel with their existing counterparts and having precisely the same mutual spacing.

BULK ERASED TAPE

Possibly the ideal recorder to adapt would be a stereo machine, as this is already equipped to erase two tracks at once. Mono recorders may not satisfactorily drive an additional erase head, so it is suggested that new, pre-erased or bulk-erased tape is used—a bulk eraser can be home-built by removing the "I" laminations from a TV-type smoothing choke, connecting the device to a.c. mains and then scanning the open ends of the core over the full reel of tape.

Azimuth alignment of the extra head is not critical as the track it lays will not normally be played on another machine. But it must not, of course, overlap the upper track.

As in all sound processing, a second recorder is most useful. It can be used to dub a pre-recorded performance into the phase machine thus leaving both hands free to control the effect, and subsequently it can take a copy of the processed recording ready for playback on any conventional machine. ★



Alternative "outrigger" assembly can be mounted between capstan and take-up spool if the recorder has no provision for an additional head

BOOK REVIEWS

FUNDAMENTALS OF RELIABLE CIRCUIT DESIGN—VOLUME 3

By Mel Xlander
Published by Iliffe Books Ltd.
156 Pages, $8\frac{1}{2}$in × $5\frac{1}{2}$in. Price 30s.

In the December 1966 issue I reviewed volumes 1 and 2 of this series and readers who have subsequently found these as valuable as I have, will want to invest in volume 3 just published. For newcomers, particularly students, let me repeat that if you are studying electronics theory this series of books will appeal to you.

Mel Xlander has shown previously that with a logical and simplified approach to basic circuit analysis, almost any circuit can be readily understood. Mathematics can tend to put off many people from reading text books, but here the maths is kept simple but adequate.

This third volume studies basic a.c. theory and its relationship to passive and active networks. Of course, the discussion is continued in terms of transistors, but this time the emphasis is on small signal audio circuits. One of the primary features of such circuits is negative feedback and this receives considerable treatment.

What is probably of special interest to prototype designers, with a view to quantity production, is the chapter devoted to "worst-case" design, where account is taken of wide spreads and tolerances in components. Several worked examples are given with answers at the back of the book.

A. M.

POINTS ARISING

RADIO CONTROL SYSTEM FOR MODEL BOATS
(June—August 1967)

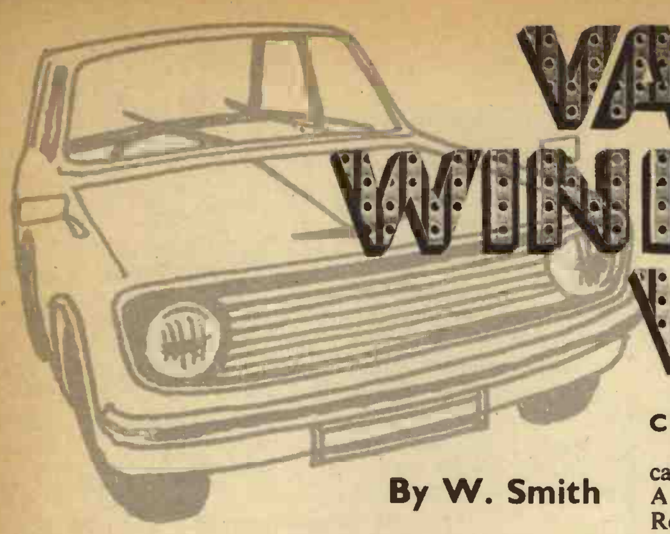
In the receiver circuit, Fig. 2, C5 should be connected from TR2 collector to the positive line and *NOT* Emitter.

In the components list for the receiver, L2 should read "2 turns 28 s.w.g. enamel wire, wound on top of L3 at TR2 collector end".

In the text, August issue, under RECEIVER ALIGNMENT, section 2. The third sentence should read "If no oscilloscope is available the current in the 'earthy' end of R7 should be adjusted by means of L2/L3 so that it is a minimum." The paragraph continues and should read "If the optimum appears to be out of range of the core make *small* adjustments to C7 and C5."

Further work on this circuit has revealed that a more positive tuning may be achieved if C7 is progressively increased to 40–50pF and C5 progressively reduced to 10pF, optimise by experiment.

The case outline for TR1, 2 and 3 of the Transmitter is incorrectly drawn in Fig. 14. To identify the c, b and e leads on these components use the diagram given in Fig. 6 (June issue). *The actual wiring in Fig. 14 is correct.*



VARI WINDSCREEN WIPER

By W. Smith

When driving a car in pouring rain, the windscreen wipers are put to full use to maintain reasonable visibility. But what about the occasional light shower, so light that the windscreen is covered in immobile drops of water. You switch on the wipers, but only a couple of sweeps may be sufficient to restore visibility. Half a mile down the road the windscreen is covered again.

Well we all know of the tedium of switching the wipers on and off at regular intervals. We don't like leaving the wipers running for long in these conditions because the windscreen soon dries up and makes the wiper stick and bend, and sometimes even scratch the windscreen. Not only that, but the wiper motor doesn't take kindly to frequent switching and suffers an extra strain in driving the wiper blades without lubrication from rainwater.

The "Variwiper" circuit described here does much to eliminate these snags, automatically looks after the wiper sweep frequency, and allows the driver to have full control of the vehicle in wet and foggy conditions.

Switching on this attachment starts a timing circuit, the time constant of which is variable by means of a control mounted near the driver. This determines when the windscreen wipers are switched on for one sweep and then switched off, re-triggering the timing circuit to repeat the cycle of operations as required.

CIRCUIT OPERATION

Fig. 1 shows the circuit diagram for positive earth car electrical systems with dotted line connections at A and B for modification for negative earth systems. Referring to Fig. 1 the sequence of events is as follows: closing S1 switches on the timing circuit where C1 and R1 plus VR1 give the time delay. At the instant of switch-on the base bias of TR1 is zero, hence TR1 and TR2, which comprise a super-alpha pair, do not conduct, and consequently the gate voltage of the thyristor SCR1 is zero (neglecting the very small amount of leakage in either transistor), so the thyristor remains untriggered. Capacitor C1 slowly charges and TR1 and TR2 go into a state of conduction, causing the gate voltage of SCR1 to increase.

At the instant when the gate is approximately 3V positive with respect to the cathode, the thyristor will fire, switching on current to the motor via resistor R4. This, as will be explained later, limits the starting current to prevent overheating of the windings.

Thyristor SCR1, now having fired, effectively shorts out the timing circuit and, as the motor is now switched on to approximately two-thirds power, the wipers start to move, closing the integral self-parking contacts and putting the motor on to full power. These contacts short circuit the thyristor, which ceases to conduct. At the end of this wipe the contacts open and the timing circuit starts again.

The normal running current of the windscreen wiper motor is 6 to 8A from a 12V battery, and the switch-on current surge with the motor stationary can be up to eight times this value.

At the instant of switch-on, I^2R heating power loss equals the power consumed which can be as much as 768W whereas the I^2R loss when running normally is a mere 96W. So it can be seen why continuous switching can burn out the motor. Introducing a 0·5 ohm resistor (R4) in series with the motor reduces the initial I^2R surge loss to 209·5W and the running power to 72W. R4 need not have a high wattage rating, as it is in circuit for only a fraction of a second before the self-parking contact takes over continuity. A 3-watt type may be enough.

The Variwiper can, of course, only be used if the windscreen wipers are of the self-parking type.

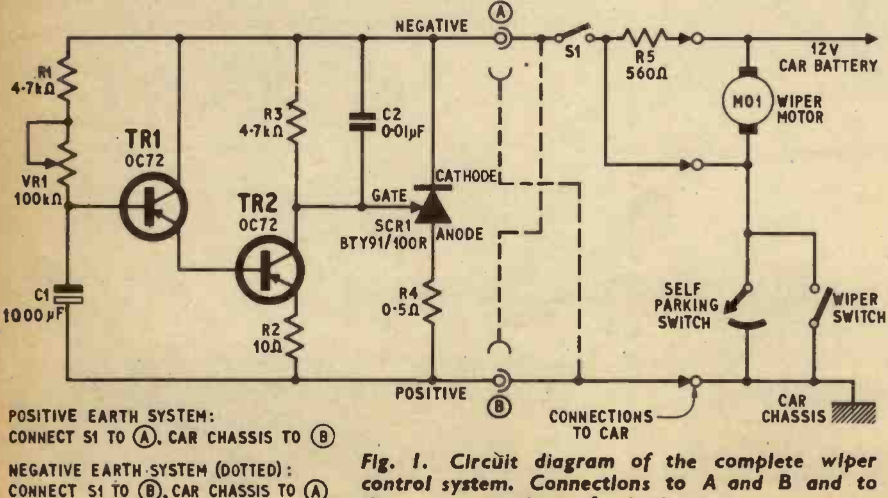


Fig. 1. Circuit diagram of the complete wiper control system. Connections to A and B and to the car are as shown for both cases

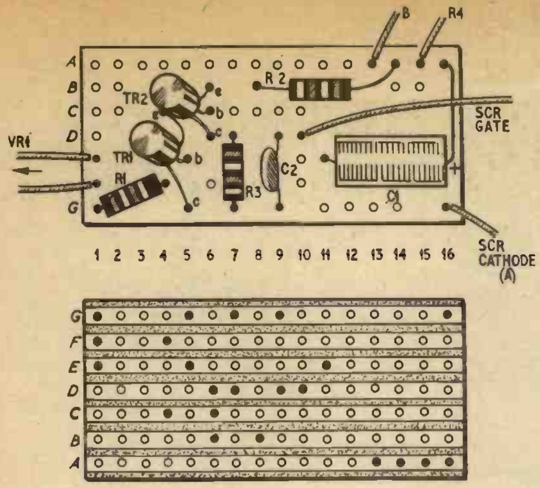


Fig. 2. Component layout on the printed wiring board with wires for connection at points A and B (see Fig. 1). Resistor R4 is connected between hole 16A and the anode of SCR1

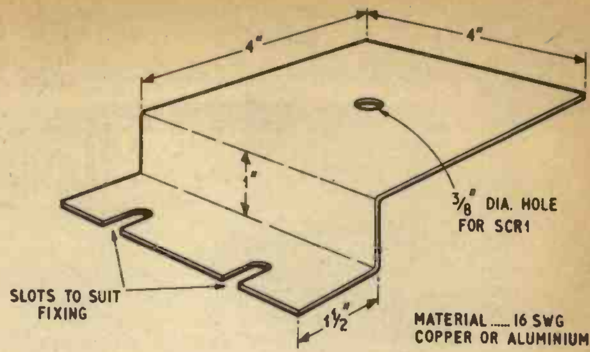


Fig. 3. Suggested dimensions for SCR1 heat sink

COMPONENTS . . .

Resistors

R1	4·7kΩ	10%	½W carbon
R2	10Ω	10%	½W carbon
R3	4·7kΩ	10%	½W carbon
R4	0·5Ω		3W wirewound
R5	560Ω		1W carbon

Capacitors

C1 1,000μF elect. 15V
C2 0·01μF ceramic 150V

Potentiometer

VR1 100kΩ linear carbon

Semiconductors

TR1 OC72
TR2 OC72
SCR1 Mullard type BTY91/100R or similar

Miscellaneous

S1 Single-pole, on-off switch rated at 10A, 12V.
Aluminium for heat sink.
Sample piece of Veroboard (free in this issue)
Thick car cable (see text)

CONSTRUCTION

First determine which earth system your car has and select the *correct* circuit from Fig. 1. The printed wiring board layout is the same for both.

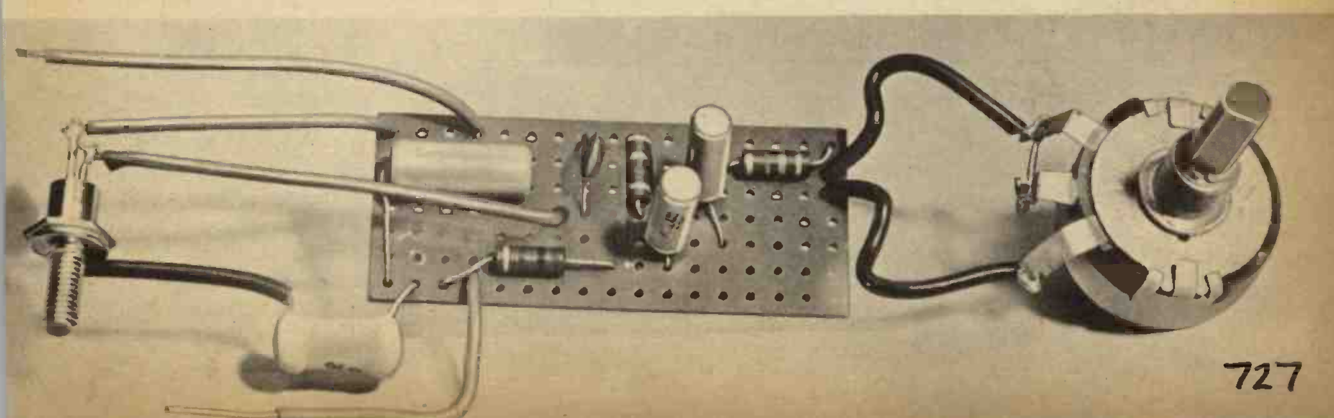
The timing circuit is built up on the sample Veroboard as indicated in Fig. 2; no copper strip breaks are necessary for this project. Thyristor SCR1 is mounted on a heat sink made to the dimensions given in Fig. 3 and this is then attached to a convenient part of the car, but insulated from the chassis by a block of wood or large nylon screws. Connection points to the existing car wiring are indicated by arrowheads in Fig. 1. *Use the correct connections for your car, or components may be damaged.*

INSTALLATION

Connections between the controller and the car wiring must be made with the heavy gauge wire sold by car accessory dealers, but ordinary insulated 18 s.w.g. tinned copper wire will suffice for the leads from the Veroboard to SCR1 and VR1.

A quick glance under the bonnet (or in the boot) will establish whether the negative or positive pole of the battery is connected to chassis. Up to about 18 months ago most British cars used positive earth systems, but there has since been a gradual swing to negative earth and it is now not uncommon to find two models of the same make using different systems. If in doubt consult the handbook for your particular model.

This system was designed specifically for 12V car batteries. If it is required to modify for 6V use, the values of resistors will have to be reduced according to the gate current required by the thyristor used. ★



NEWS BRIEFS

Conference on Pattern Recognition

A SHORT while ago scientists of many different disciplines met to exchange views on a topic of common interest. This was at the Conference on Pattern Recognition held at the National Physical Laboratory, Teddington, last July.

The problem under discussion related to visual and auditory pattern perception and the design of systems based on the most complex of computing systems—the human brain. Psychologists and physiologists with their experience of living organs and systems, and engineers with experience of automatic pattern recognition devices joined together in this interchange of ideas. Some 30-odd papers were presented by eminent authors from North America and Europe.

The three-day conference was organised by the Control and Automation Division of the Institution of Electrical Engineers, with the support of the N.P.L. and MinTech.

Satellite Broadcasting

DIRECT broadcasting from satellites will be discussed at a meeting of the Institution of Electrical Engineers, Savoy Place, London, W.C.2, on November 4. Topics will include the general problems of terrestrial broadcasting and the possible advantages of broadcasting from space, and the design of suitable transmitters, receivers and aerials.

Airport Television

HEATHROW Airport is being fitted with a new flight installation display system to keep staff in touch with arrivals and departures. The heart of the system is an RCA (Great Britain) Ltd. digital-to-video converter which feeds information via a Rediffusion h.f. distribution system to 265 display monitors. Nearly 10 miles of cable is involved.

New Underground Movement

REMOTE control equipment which enables one supervisor at Blidworth Colliery to control nine underground conveyors is to be extended to cover 15 conveyors with the aid of new telemetry equipment ordered by the National Coal Board from English Electric.

Depth Sounding Development

A UNIQUE system which provides a profile of sound velocity against depth has been designed and built by the marine systems division of the Plessey Electronic Group for use on the French naval research vessel *Henri Poincaré*. The system plots sound velocity against depth and records these parameters in both digital and graphic form. The information obtained will be used to correct the readings from the ship's sonar ranging and position fixing equipment.

Computer Strikes Gold

RUSSIAN scientists have programmed a computer to discover deposits of gold and other rare metals in Siberia and the Soviet Far East. Fed with information on the geological character of an area, the machine will indicate deposits of rare materials and estimate their reserves.

Study Tour Award

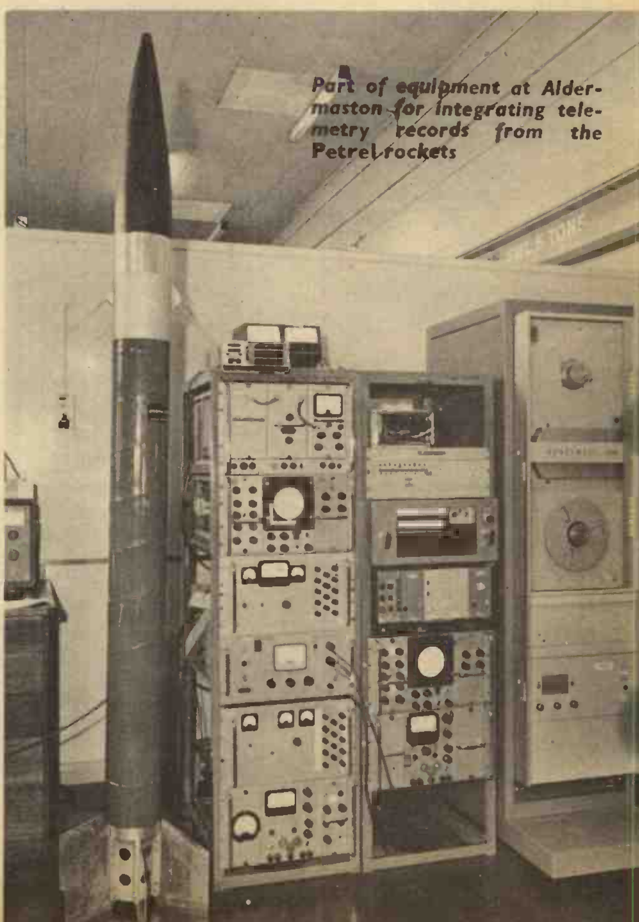
A 22-YEAR-OLD electronics student has won the 1968 John Logie Baird Travelling Award—and a trip to America to study his subject. Anthony Roma Taylor is at the University College of North Wales evaluating the potential of solid state devices using plasma principles. He describes the award as his first "big break" and hopes his studies in the U.S. will eventually be of benefit to Britain.

The award, made annually by the Royal Television Society in conjunction with the Radio Rentals Group, is given to a post graduate student in a United Kingdom educational establishment in recognition of Baird's contribution to television. It is worth £200 and is intended to assist the winner in spending up to about 10 weeks abroad investigating some aspect of electronic engineering, television or allied technology.

Eyes on the Sky

A MOBILE recording and telemetry unit has been set up at South Uist, Scotland, to record data in the *Petrel* rocket programme. This rocket sounding study in the Hebrides is investigating physical and scientific phenomena in the ionosphere, above the 50-mile limit of research balloons and below the 200 mile satellite range. One of the studies will probe the origin of the Aurora Borealis.

Each rocket sends, during its six-minute life span, 24 pieces of information 80 times a second. The data is recorded on two Honeywell recorders and the tapes are then sent to Aldermaston for analysis by computer. The *Petrel* programme is sponsored by the Science Research Council for use in space research projects by universities and other organisations.



Part of equipment at Aldermaston for integrating telemetry records from the Petrel rockets

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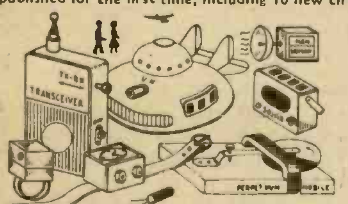

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Readout—
A SELECTION FROM OUR POSTBAG

Make it simple

Sir—Mr. D. Bollen (Readout, August) seems to be condemning the argument for simplicity. In many cases, simplifications are essential for any commercial device. I am certain that the *simple* PAL colour TV set will soon make its appearance on the market. The "de-luxe" PAL colour set with its expensive delay lines, matrices and what-have-you, is all very well if you have £300 to spend and want excellent performance where cost is no object.

But cost must come into consideration! If one has a small fortune, by all means go ahead with masses of superfluous circuitry developed from a basic idea, but if a circuit is going to be practical, and above all reliable and easy to service, make it simple.

We are not concerned with "offerings of free gifts". Any man will choose the most luxurious equipment if he is getting it for nothing. It is not much use producing a computer "for the housewife" if it costs a few thousand pounds, simply because of its "frills" and gimmicks. We should be concerned with value for money—something rather rare, nowadays.

Norman J. McLeod,
Montrose, Angus,
Scotland.

Plus or minus?

Sir—According to *The Concise Oxford Dictionary* "anode" is a positive pole and "cathode" is a negative pole.

I am familiar with the "old" valve applications of these terms but now and again I find myself confused when I seek to relate them to published semiconductor circuits.

Perhaps the classic example of my difficulty was contained in the diagrams on page 202 of the March 1966 issue which contained No. 17 in the series of *Beginners Start Here . . .*

In Figs. 17.la and Fig. 17.lb are depicted, among other things, a valve diode with the words "anode" and "cathode" in the positions I would expect in relation to the valve. But the semiconductor diode cathode is marked + (plus) and this is confirmed in the note to Fig. 17.lb. I have always linked the sign + with positive.

Please sort me out ! !

W. Thompson,
Edinburgh, 9.

Regarding the polarity of diodes, the electron current actually flows through the diode from cathode to anode. The plus sign is given on the circuit symbol to indicate the terminal that is usually marked with a red band or spot. Conventional current is generally accepted as being from positive to negative external to the device. The diagram Fig. 1 illustrates this and can be compared with a battery circuit.

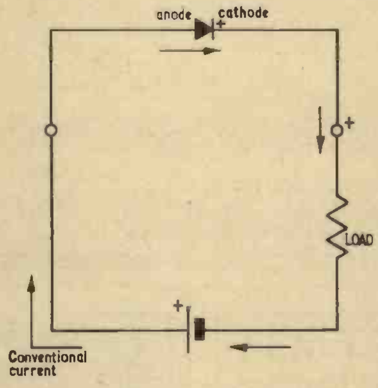

Fig. 1.

The conventional current inside a battery flows from negative to positive. Outside the battery it flows from the positive terminal through the load to the negative terminal. The triangle part of the diode symbol forms an arrow head indicating conventional positive current.
—M.A.C.

Unwanted radiation

Sir—I have read with interest the article by E. J. Pepper on *Radio Control for Model Boats*.

Whilst he has taken admirable care to reduce the level of radiation from the receiver described, the transmitter seems designed to produce interference. Was it really necessary and, indeed, within the G.P.O. regulations to 100 per cent modulate the carrier with, of all things, a square wave? It would seem that sidebands at up to 600Hz intervals must extend far outside the permitted band, and I wonder if Mr. Pepper has tried the experiment of tuning a receiver through, for example, the 28MHz Amateur Band in the vicinity of his transmitter?

If this is a case of anything being allowed at the low power level involved, then a listen to the U.S. Citizens' Band should demonstrate that low power can be very effective at 27MHz.

C. J. Webster,
Ringwood, Hampshire.

As you have noted, considerable care was taken to minimise the effects of unwanted radiation, which was far more apparent in the case of the receiver (without buffer stage) than with the transmitter itself. The band allocated to model control is 26·96–27·28MHz and the transmitter carrier is 27·255MHz, and hence, strictly speaking, the sidebands should be confined to 25KHz. This was not overlooked in the design stages, but indeed, for simplification purposes, the modulation was described as "square" in the text.

You rightly point out that deep square wave modulation can cause high order sidebands, and indeed for a pure square wave will appear as odd harmonics of the fundamental modulation frequency (600Hz) of power (strength) reducing as the square of the reciprocal of the harmonic number. Hence for a pure square wave the power in the $\frac{25KHz}{600} = 41st$ *harmonic will be reduced 1,700 times on that at 600Hz, which in itself is exceptionally small.*

However, the square wave is not pure and in fact it can be shown that when the period of the harmonic approaches the rise and fall times of the square wave the power in the harmonic tends towards zero.

An attempt was made to measure the modulation rise and fall times at TR4 (Fig. 13) and was of the order 30–50ms (virtually negligible as far as the operation of the control is concerned). This suggests that the harmonics of 30KHz or so can be ignored in any case.

In the testing period it was pointed out that the unbuffered receiver gave considerable interference on TV receivers when placed, say, 8 ft from the aerials. On two TV receivers, on all bands, there was no interference evident when the transmitter was placed 3 ft from either aerials or receivers. One receiver has an i.f. of 30MHz, and in my opinion, would have given some indication, if interference was likely to be a problem, although it is agreed that this was not a test for 28MHz.—E.J.P.

See also POINTS ARISING on page 725.

COURSES . . .

Syllabus: *RAE Course and Morse Practice*, by P. G. Martin, B.SC., G3PDM, at Durham Technical College, Framwellgate Moor, Durham. Commences September 27—6.30 to 9.30 p.m.

Syllabus: *RAE Course*, at Carbridge County School. Commences mid-September. Further details can be obtained from V. Allison, G3TNX, 14 Silverdale Drive, Winlaton, Co. Durham.

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A major breakthrough in electronics rivalling in importance that brought about by the transistor has been achieved by recent research on semiconductors. A whole new family of semiconductor devices is being developed, which will in time do for microwave electronics what the transistor has already done for the present-day application of electronics in the domestic and industrial fields. This important development depends on the ability of a semiconducting material, gallium arsenide, to emit microwaves when a voltage is applied to a slice of the material. Before describing these new gallium arsenide (GaAs) devices, this article first recapitulates general semiconductor theory.

AT PRESENT, microwave generation is almost entirely carried out by power-consuming valves like klystrons, which are the equivalents at microwave frequencies of triode and pentode valves. These microwave valves have been the main obstacle to the wider application of microwaves in the commercial and industrial fields.

When the transistor was invented, its potential lay in the replacement of the large power-consuming valves necessary in electronics to generate and amplify electric signals. Similarly, these GaAs devices will be able to generate and amplify microwaves much more easily and efficiently than present microwave valves and will be much smaller than them.

The importance of microwaves lies in its two main applications—radar and communications. Microwaves are electromagnetic waves of much higher frequency than those used in conventional radio communication, being of about 1GHz to about 300GHz. Electromagnetic waves of this frequency range have transmission properties through space similar to those of light. They tend to travel and be reflected in narrow beams.

This is made use of in radar, where microwave signals are transmitted; the reflected signals from an object are detected and compared with the transmitted signal to determine the distance and velocity of the object.

The importance of microwaves in communications lies in the tremendous amount of information that can be carried by electromagnetic waves at such high frequencies. A microwave carrier wave at 10GHz could carry 100 times more information than a v.h.f. signal at 100MHz.

In order to understand how this exciting new method of generating microwaves works, it is necessary to review briefly some fundamentals of electronic theory.

THE GENERATION OF ELECTRICAL OSCILLATIONS

The basic circuit of an oscillator consists of a resonant LC circuit (Fig. 1). If this contained a pure inductance and capacitance, an electrical oscillation of frequency $1/(2\pi\sqrt{LC})$ would be set up and maintained forever.

However, every practical inductance and capacitance has a real resistance in addition to its L or C (Fig. 2), and it is through this resistance that the oscillation loses its energy and dies down. Even if the inductance

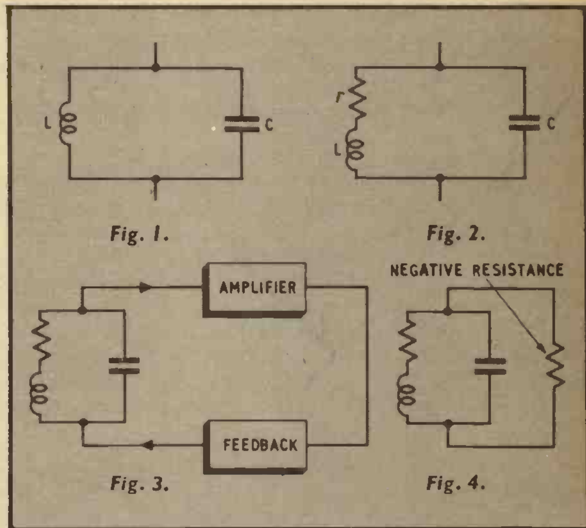

Fig. 1. Fig. 2. Fig. 3. Fig. 4.

and capacitance were pure, we would still want to draw off the oscillating electrical energy for our use, and thus there would have to be some means of maintaining the oscillations anyway.

Now, if we could amplify the oscillations and feed back part of the amplified signal, in such a way that it reinforced the original oscillations to make up for losses due to real resistances and the drawing off of energy, then the oscillations could be maintained and used. This, of course, is the actual basic circuit of most electronic oscillators (see Fig. 3).

Another way of maintaining the oscillations would be to cancel out the effect of the real resistances and any load resistances used for abstracting energy. Suppose we had a device which had a negative value of resistance and put it into the circuit (Fig. 4). If it were of the right value it would cancel out the effects of the positive resistance in the circuit, and thus the oscillations would be maintained. This is actually the way in which the GaAs devices work.

The generation of electrical oscillations thus depends on devices which either amplify or exhibit negative resistance. Such devices are called active devices.

In order to gain some insight into solid state active devices, it is necessary to understand some of the properties of semiconductor materials, of which practically all these devices are made.

ELECTRICAL PROPERTIES OF SEMICONDUCTORS

Semiconductors are materials of intermediate conductivity between metals and insulators. Conductivity in solids depends on the properties of the electrons in them that make up the electric currents through them.

These electrons have various energies in every solid, which can be depicted by a diagram (Fig. 5) showing the energy levels that the electrons can occupy. Each level can hold only two electrons so that the electrons in a solid are arranged in an ascending series of energy levels. Actually the levels are so close together that they form an almost continuous band. This is illustrated by the filled levels in Fig. 6.

In all solids, there exists a range of energy levels which cannot be occupied by the electrons. This forbidden range or gap separates two energy bands which may contain electrons, called the conduction and valence bands. This is illustrated in Fig. 7a.

When a voltage is applied to a material, for a current to flow the electrons must be able to accelerate and move freely. They must be able to acquire energy in order to move. An insulator does not conduct electricity because its electrons are not able to acquire this extra energy. The valence band in an insulator is completely filled and the conduction band is empty (Fig. 7b).

The electrons in the valence band cannot move to form a current as there are no higher energy levels for them to occupy as the energy levels in the forbidden gap are not open to them. In a metal, the valence band is also full but the conduction band is half full (Fig. 7c).

The electrons in the conduction band have plenty of higher energy levels to occupy and thus can move to constitute a current. Thus a metal is a good conductor of electricity. A semiconductor is like an insulator in that its valence band is full and its conduction band is empty, but it has a much smaller forbidden energy gap than an insulator.

If an electron at the top of the valence band can be given an energy E_g (Fig. 8), it will be able to jump across the gap to the bottom of the conduction band as shown in Fig. 9.

When it does this, it leaves behind a "hole" in the valence band which is really just the absence of an electron, but behaves just as if it were a positively charged particle. In the energy level diagram, a downward movement in the hole level means an increase in hole energy. The electron in the conduction band has plenty of energy levels to which it can go; thus it can move under an applied voltage and constitute a current.

INTRINSIC SEMICONDUCTOR

The energy gap in semiconductors is so small that at room temperature an appreciable number of electrons can be given enough heat energy to be transferred to the conduction band, so that the semiconductor can conduct an appreciable current.

The holes created by the transference of the electrons can also move and add to the current as there are plenty of energy levels below them to which they can move. Such a semiconductor is called an intrinsic semiconductor (Fig. 10) since its conducting electrons and holes which are equal in number, arise from its own energy levels.

When certain impurities are introduced into semiconductors, they can give rise to extra electrons and holes in the conduction and valence bands respectively. If arsenic is introduced into the semiconductor germanium, each arsenic atom has an electron which is in an energy level in the forbidden gap. This level is shown in Fig. 11a. These levels are so close to the conduction band that the electrons in them are nearly all transferred to the conduction band at room temperature. Thus many more free electrons are available to take part in conduction (Fig. 11b).

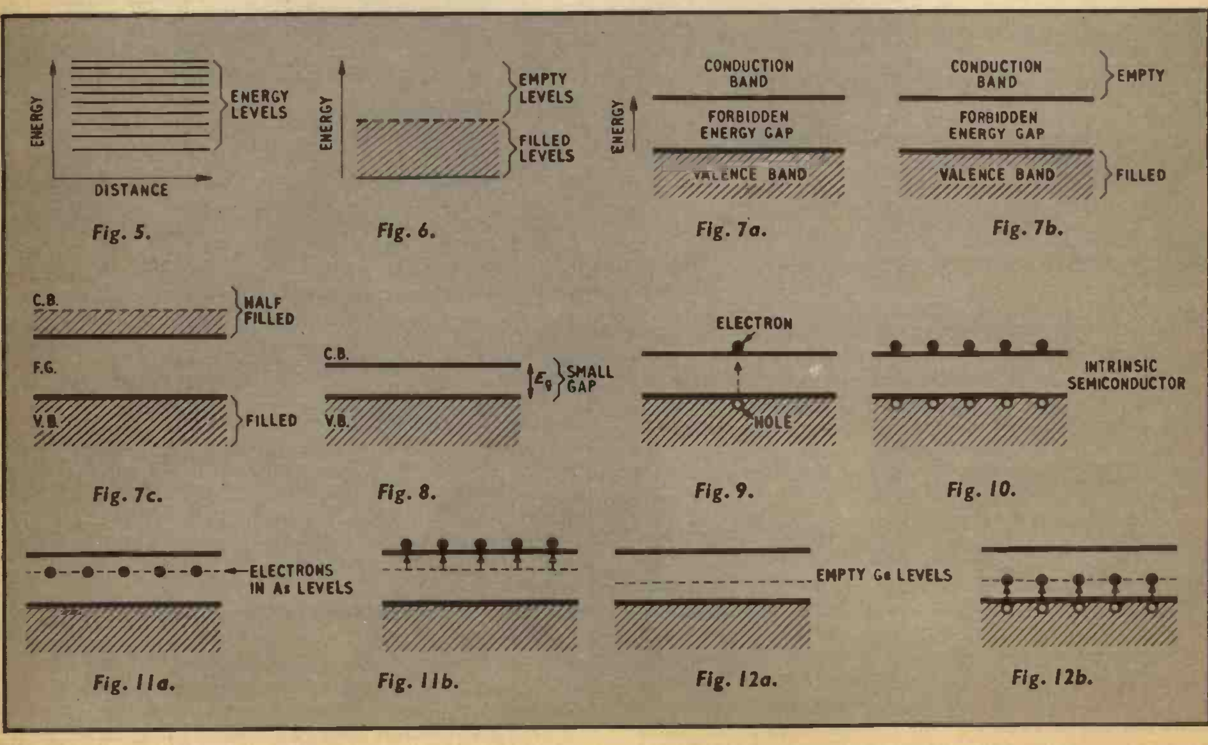

Fig. 5. Fig. 6. Fig. 7a. Fig. 7b. Fig. 7c. Fig. 8. Fig. 9. Fig. 10. Fig. 11a. Fig. 11b. Fig. 12a. Fig. 12b.

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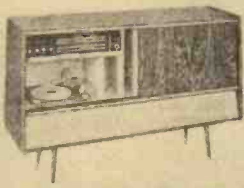

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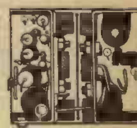

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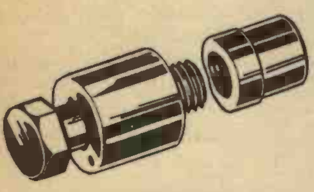

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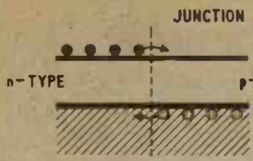

Fig. 13a.

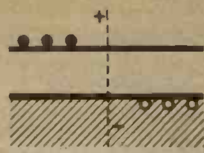

Fig. 13b.

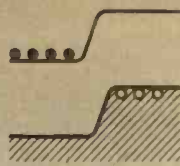

Fig. 14a.

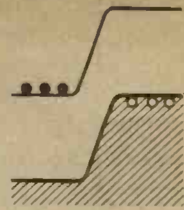

Fig. 14b.

Fig. 14c.

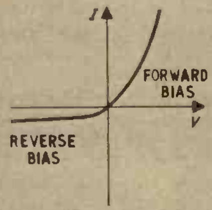

Fig. 15.

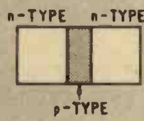

Fig. 16a.

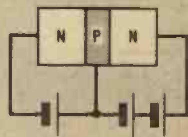

Fig. 16b.

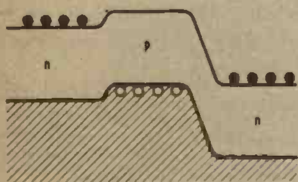

Fig. 17.

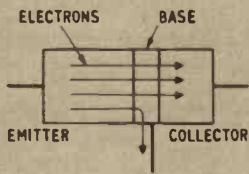

Fig. 18.

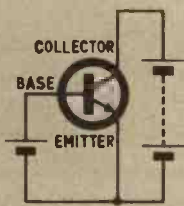

Fig. 19.

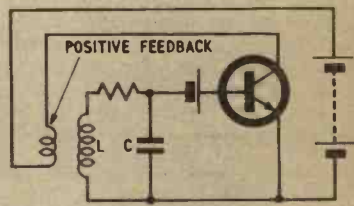

Fig. 20.

These "donated" electrons are usually much more numerous than the intrinsic electrons and holes, and thus the current in such a semiconductor is mainly carried by electrons, and is called an *n*-type semiconductor (*n* for negative electrons). The arsenic atoms are known as "donor" atoms. Other kinds of impurities like gallium when introduced into germanium give rise to empty energy levels, one for each gallium atom, in the forbidden gap (see Fig. 12a).

These empty levels are very close to the valence band, and thus the top electrons in the valence band can be easily transferred to these empty levels, leaving behind holes in the valence band as shown in Fig. 12b. These holes are also able to give rise to a conduction current, and are usually much more numerous than the intrinsic electrons and holes.

Such a semiconductor in which the current is mainly carried by positive holes is called a *p*-type semiconductor. The gallium atoms are known as "acceptor" atoms. Thus germanium can be made into either *n*- or *p*-type material by the introduction of suitable impurities, a process known as doping. The more heavily doped a semiconductor is, the more highly conducting it becomes.

POTENTIAL DIFFERENCE

When an *n*- and a *p*-type semiconductor are placed next to each other to form a junction, the electrons in the *n*-type and the holes in the *p*-type can diffuse across the junction as indicated by the arrows in Fig. 13a. Before this happens, the materials on either side are electrically neutral. When the negative electrons diffuse across, they leave a net positive charge in the *n*-type material. Similarly, the diffusing holes leave a net negative charge in the *p*-type material.

Eventually, these charges form a potential difference across the junction that prevents further diffusion of electrons and holes (Fig. 13b). This potential difference can be shown on the energy level diagram as a difference in the relative heights of the *n*- and *p*-type materials (Fig. 14a).

The potential difference and the difference in levels increases with the doping on either side. One may think of the electrons in the diagram as being able to run downhill but not uphill. The energy levels in the diagram have an exact analogy with mechanical potential energy. The holes on the other hand are able to run uphill but not downhill, as they are of opposite charge to the electrons.

The electrons and holes are actually in random motion due to heat energy, and a few of them do gain enough energy to overcome the p.d. at the junction. Now, if an external voltage is applied to the junction which was in the same direction as the junction p.d., the height of the p.d. would be increased. When this happens the flow of electrons across the junction is very much reduced and practically ceases (Fig. 14b). If we apply an opposite bias, we can reduce the junction p.d. and thus reduce the obstacle to the electron and hole flow as in Fig. 14c.

The current across the junction thus becomes much greater, and increases further as the bias is increased. The junction thus allows a much greater current flow when it is biased in one direction (forward) than in the other direction (reverse). This is shown in Fig. 15.

Junction diodes are thus used as current rectifiers and signal detectors. The *pn* junction is also the basis of a whole family of semiconductor devices, the most important of which is the transistor.

THE TRANSISTOR—A SEMICONDUCTOR AMPLIFYING DEVICE

The transistor was the first active semiconductor device. It was the result of intensive research at the Bell Telephone Laboratories (U.S.A.) in 1949 by W. Shockley, J. Bardeen and W. H. Brattain. It consists of three layers of differently doped semiconductor material, either *npn* or *pnp*.

An *npn* transistor can be thought of as being made up of two *pn* junctions with the centre *p* region common to both. Fig. 16a illustrates the block make-up of such a device.

One junction is given a small forward bias voltage while the other is reverse biased with a much larger voltage as shown in Fig. 16b. In practice the centre region is made very thin and is much less heavily doped than the two outer regions. Thus the holes in the *p*-type region are much less numerous than the electrons in the *n*-type regions.

Neglecting the action of the holes in our simple analysis, the resulting energy level diagram can be deduced from our diagram for one junction (Fig. 17).

The electrons in the left *n*-type region can travel easily across the forward biased junction but those in the right *n*-type region cannot do so across the reverse biased junction. The electrons that have travelled across the forward biased region almost immediately reach the area near the second junction as the centre region is so thin.

Now, to these electrons, the second junction is biased in the direction that aids their movement across it, and thus nearly all of them go on to the other *n*-type region. The rest (say about 5 per cent) of the original number that entered the *p*-type region) enter the bias circuit. This is depicted in Fig. 18. The three regions are termed the emitter, the base and the collector.

In practice, the transistor is often biased such that the emitter is common to both bias circuits as in Fig. 19. The current flow out of the base into the emitter-base circuit is always the same small percentage of the total electron current through the emitter-base junction. The larger current travels on through the base-collector junction into the emitter-collector circuit.

Thus a small current change in the emitter-base circuit gives rise to a corresponding large current change in the emitter-collector circuit, and the transistor can act as an amplifier. It can also be used in an oscillator circuit to generate electrical oscillations. See Fig. 20.

A *pnp* transistor works in the same way with the voltages reversed and holes taking the place of electrons. If we try to generate high frequency oscillations with a transistor oscillator circuit, the transistor will have an upper frequency limit imposed by the time taken for the electrons to traverse the base region, which is a transit-time limitation. This is why the base region is made as thin as possible, but there is obviously a physical limitation on the ultimate narrowness of the base when fabricating a transistor.

In drift transistors, the material in the base is doped unevenly so that a voltage gradient is obtained which helps the electrons to travel across it faster. Even with such modifications, the ultimate useful high frequency response of transistors is limited to the lowest frequencies of the microwave band.

Next month: Negative Resistance and the L.S.A. Device.

NEWS BRIEFS

G.P.O. Cuts a Dash with Dots

A MAJOR step toward establishing Britain's first fully automated postal sorting office is being taken by the Post Office with the aid of a now established electronic coding system.

Known as the coding desk translator, the system substitutes the written postal code or address on letters with a code that can be understood by machines used for mail handling in an automated post office.

At the sorting office an operator copytypes the six-digit code on an electronic keyboard. The equipment then translates the data into two binary code patterns. One represents the "post town" of the address and the other the street or road. The patterns are printed on the envelope as two rows of luminescent dots which are almost indiscernible to the human eye but which can be read by all mail-sorting machines. If the sender of a letter does not write the post code on the envelope, the translator will convert selected characters from a town or street name into the required binary code.

Following trials at the GPO's research station at Dollis Hill, London, the first system, supplied by the Plessey Automation Group, will be installed at Croydon.

Contributing to Concorde

NUMERICAL control systems for use in building the Concorde airliner are being delivered by the Plessey Automation Group to Marvin Machine Tools Ltd. Some of the completed systems will be used by the British Aircraft Corporation for the production of air frames and others will be used in the Royal Ordnance Factory, Nottingham, and at the Hawker Siddeley Works, Kingston.

I.E.E.T.E. in Ireland

AN expansion of membership of the Institution of Electrical and Electronics Technician Engineers is expected in Ireland following a series of open meetings there.

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Personal Earpiece with switched socket for private listening 5/- extra.

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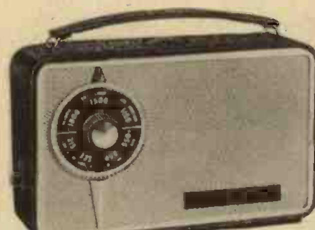
NEW LOOK melody six



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A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merit.

SOUNDS FAMILIAR

DURING the last year I have developed a sound effects unit which is capable of producing an unlimited number of sounds.

While experimenting with an old intercom, I discovered that I could make some rather peculiar noises when I altered some connections and put in some extra components, and during the next few months I developed the circuit published here.

It can be used in school plays or if one has a lot of patience, it can be "doodled" with for hours on end.

The interesting thing about it is that it can produce cyclic sounds, that is, sounds that have a pattern, and when that pattern is completed, it starts all over again. These cycles can last from about ½ second to about 45 seconds. To make these sounds, S4 and S6 must be closed, and either VR4 must be at minimum resistance or S5 must be closed.

A typical cycle is what I call "the chicken". It sounds like a chicken clucking, running along a wall, and flying away, still clucking. The combination is as follows.

All the switches are closed except S1, S10, and S3, VR2 is at maximum resistance, VR3 is two-thirds the way to minimum, VR5 is seven-eighths of the way to minimum.

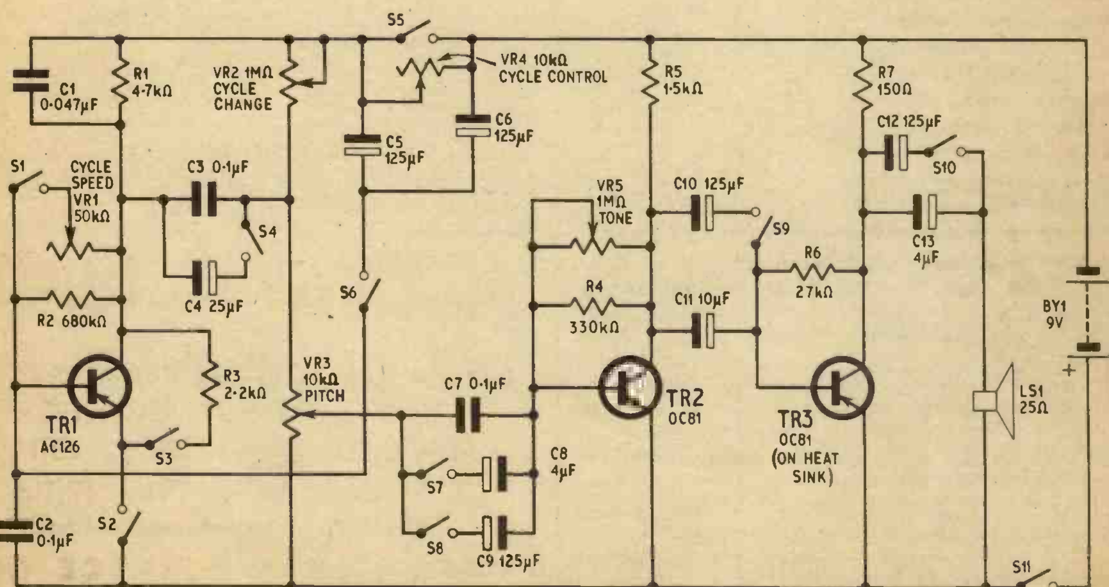
Another example is "jungle bird noises". S6, S1, S7, and S4 are closed, VR2 is at maximum resistance, VR3 is half way, VR5 is seven-eighths of the way to minimum resistance, VR4 is half way.

VR1, which is switched into the circuit by S1, controls the speed of the cycles; VR2 changes the sound; VR3 is the pitch control; VR4 is the cycle control; VR5 is the tone control; S5 is an override switch for VR4; S2, S7, S8, S9, S10 are used to change the sounds; S3 is used for slowing down the cycles; VR1, 5, and 2 should not be more than about nine-tenths towards minimum resistance, and VR3 should not be more than three-quarters of the way to minimum resistance for cycles.

The circuit is powered by a small 9 volt battery, but is such that some of the combinations only work when the battery is partly run down.

A lot of fun can be had if the operator has patience and ingenuity in selecting the desired combination of sounds.

Ian Loveday (age 13),
London, W.2.



ACCURATE LOW VOLTAGE SOURCE

A SIMPLE method of deriving any very low voltage with a known amplitude, for calibrating sensitive home-built test equipment, is shown in the attached diagrams.

If a 1 volt a.c. signal from a transformer is applied across the input of the network, then the output across the 1 ohm resistor will be 1μV (Fig. 1) or 1mV (Fig. 2). The impedance seen by the test equipment will be very low so the network output should be connected in series with a dummy source resistance in the input of the test equipment.

The accuracy of the network output voltage depends on the accuracy of the input voltage and the resistors used. The values of the resistors can be chosen to suit the output voltage required, but the combined value should be at least ten times greater than the source impedance.

G. J. Hankins,
Birmingham

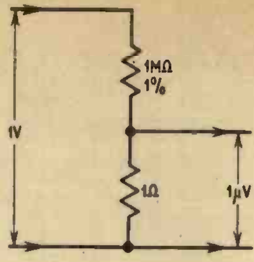


Fig. 1.

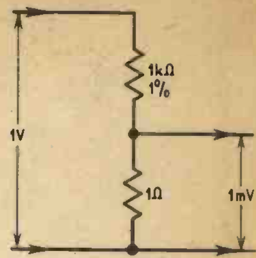


Fig. 2.

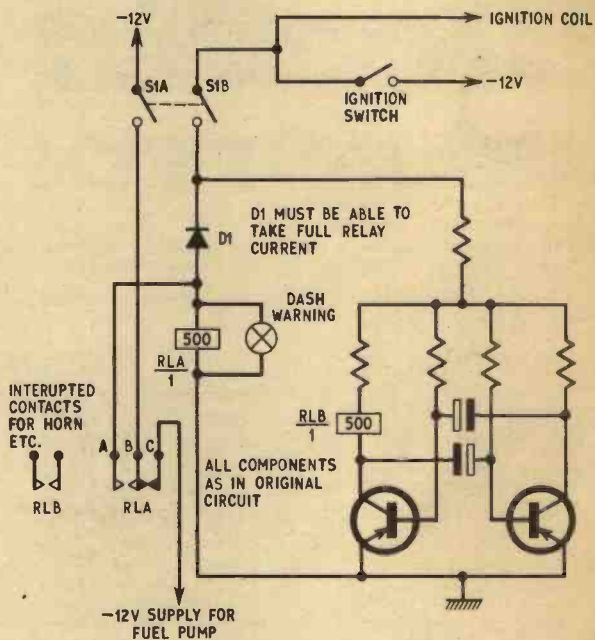
CAR ANTI-THEFT ALARM

I HAVE been experimenting with the Car Anti-theft Alarm (February 1968). By redesigning the switching circuit as shown here, the same sequence of events occur, but there is a saving in the cost.

If S1a and S1b is on and the ignition switch closed, the supply is fed to the multivibrator (TR1 and TR2), and RLA and D1. Relay RLA will close, breaking the fuel pump supply by the changing over of contacts RLA1, which also hold in the relay. As soon as the supply is disconnected from the ignition switch, the multivibrator stops, but RLA remains energised until S1a and S1b are switched off.

Relay RLB controls the supply to the horn.

Cpl. T. D. Wagg,
B.F.P.O. 64.



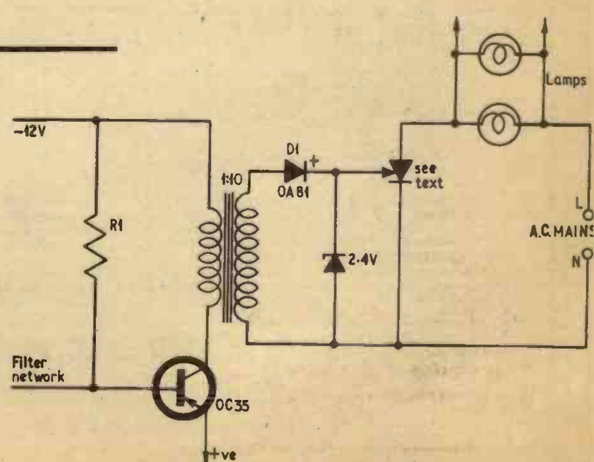
MAINS LIGHT DISPLAY

FOR some time now I have been interested in light-sound synchronisation and suggest a simple modification to F. C. Judd's coloured light display circuit to enable high power mains voltage lamps to be controlled.

Each set of nine low current lamps are replaced by a 1 : 10 ratio transformer, which provides positive pulses to the gate of the thyristor via diode D1. The Zener diode limits the gate firing voltage. Bias resistor R1 is necessary for optimum operation.

I have successfully constructed a 1,000 watt display using readily available 100 watt coloured lamps. Any number of lamps may be controlled if a thyristor of suitable current rating is used.

J. L. Ryder,
Leicester.



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

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

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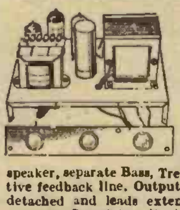

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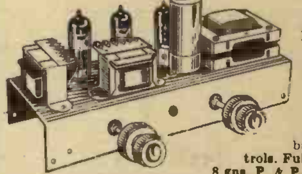

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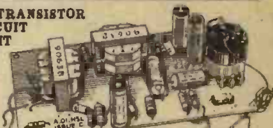
Type TA1



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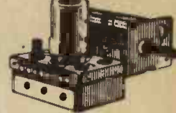

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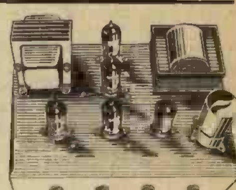

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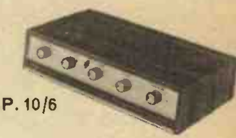

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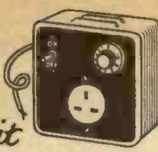

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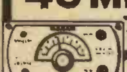

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2N3703	4/6	BCY39	6/6			OA91	1/6
2N3704	4/6	BCY70	6/6	MAT120	6/6	OA95	1/6
2N3705	4/6	BCY71	10/6	MAT121	6/6	OA200	2/-
2N3706	4/6	BCY72	6/6	NKT261	4/6	OA202	2/-

COMPONENTS

Veroboard
3¾" × 2½" 3/6; 3¾" × 3¾" 4/3; Cutter 9/-; 3¾" × 5" 5/6; 17" × 3¾" 16/-; 5" × 2½" 4/3.

Resistors:
¼ watt 4d; ½ watt 5d; 1 watt 6d; 2 watt 1/-; 3 watt 1/6; 5 watt 2/0.

Electrolytics:
15V 1mF up to 100mF 1/6. 25V 25mF or 50mF 1/6, 100mF 2/-, 250mF 2/9, 500mF 3/9.

Presets:
STD Horizontal or Vertical 1/6.

Fairchild I.Cs.
L900 11/-
L914 11/-
L923 14/-

Post and Packing for Transistors and Components 1/- per order. Send S.A.E. for complete list.

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Duxford, Cambs. (Sawston 3031)

MINIMUM ORDER VALUE 5/-

C.W.O. Post and Packing 1/-

DISCOUNT 10% over £2, 15% over £5

ELECTROLYTIC CAPACITORS (Mullard).—10% to +50%.

Subminiature (all values in μF)

4V	8	32	64	125	250	400
6·4V	6·4	25	50	100	200	320
10V	4	16	32	64	125	200
16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/6	1/3	1/2	1/-	1/1	1/2

Small (all values in μF)

4V	800	1,250	2,000	3,200
6·4V	640	1,000	1,600	2,500
10V	400	640	1,000	1,600
16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
Price	2/6	3/4	4/2	5/2

POLYESTER CAPACITORS (Mullard)
Tubular 10%, 160V: 0·01, 0·015, 0·022μF, 7d. 0·033, 0·047μF, 8d. 0·068, 0·1μF, 9d. 0·15μF, 11d. 0·22μF, 1/-. 0·33μF, 1/3. 0·47μF, 1/6. 0·68μF, 2/3. 1uF, 2/8.
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, 6d. 6,800pF, 0·01, 0·015, 0·022μF, 7d. 0·033μF, 8d. 0·047μF, 9d. 0·068, 0·1μF, 11d. 0·15μF, 1/2. 0·22μF, 1/6. 0·33μF, 2/3. 0·47μF, 2/8.
Modular, metallised, P.C. mounting, 20%, 250V: 0·01, 0·015, 0·022μF, 7d. 0·033, 0·047μF, 8d. 0·068, 0·1μF, 9d. 0·15μF, 11d. 0·22μF, 1/-. 0·33μF, 1/5. 0·47μF, 1/8. 0·68μF, 2/3. 1μF, 2/9.

POLYSTYRENE CAPACITORS: 5%, 160V (unencapsulated): 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 5d. 1,000, 1,500, 2,200pF, 6d. 3,300, 4,700, 5,600pF, 7d. 6,800, 8,200, 10,000pF, 8d. 15,000, 22,000pF, 9d.
1%, 100V (encapsulated): 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 1/-. 1,000, 1,200, 1,500, 1,800, 2,200, 2,700, 3,300, 4,700pF, 1/3. 5,600, 6,800, 8,200, 10,000, 12,000, 15,000pF, 1/6. 18,000, 22,000, 27,000, 33,000, 39,000pF, 1/9. 0·047, 0·056μF, 2/-. 0·068, 0·082, 0·1μF, 2/3. 0·12uF, 2/9. 0·15, 0·18μF, 3/-. 0·22μF, 4/-. 0·27, 0·33μF, 5/-. 0·39μF, 5/9. 0·47μF, 6/3.

POTENTIOMETERS (Carbon), miniature, 1in × ¼in spindle. Lin. 100Ω to 10MΩ. Log. 5kΩ to 5MΩ, 2/3.

SKELETON PRE-SET POTENTIOMETERS (Carbon): Lin. 100Ω to 5MΩ. Horizontal and vertical P.C. mounting. Miniature (0·3W), 1/-. Submin. (0·1W), 10d.

RESISTORS (Carbon film), very low noise. Range: 5%, 4·7Ω to 1MΩ; 10%, 10Ω to 10MΩ.
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SEMICONDUCTORS: OA5, OA81, 1/9. OC44, OC45, OC71, OC81, OC81D, OC82D, 2/-. OC72, 2/3. OC170, OC171, 2/6. AF115, AF116, AF117, 3/-, OC73, 3/3. OC140, 4/3.

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PRINTED CIRCUIT BOARD (Vero).
0·15in Matrix 3¾in × 2½in, 3/3. 5in × 2½in, 3/11. 3¾in × 3¾in, 3/11. 5in × 3¾in, 5/6.
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Send S.A.E. for May, 1968 Catalogue

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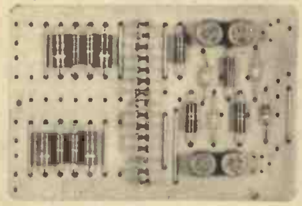

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4,000 Mfd. 72v. D.C. wkg.	16,000 Mfd. 30v. D.C. wkg.
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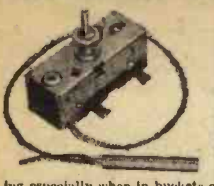
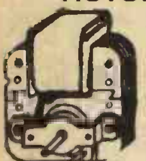


This has a sensor attached to a 15A switch by a 14in. length of flexible capillary tubing — control range is 20°F to 150°F so it is suitable to control soil heating and liquid heating especially when in buckets or portable vessels as the sensor can be raised out and lowered into the vessel. This thermostat could also be used to sound a bell or other alarm when critical temp. is reached in stack or heap subject to spontaneous combustion or if liquid is being heated by gas or other means not controllable by the switch. Made by the famous Teddington Co., we offer these at 12/6 each. Postage and insurance 2/9.

CAPSTAN DRIVEN TAPE RECORDER
Only £5/19/6

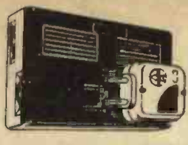
(Batteries extra) Portable with built-in microphone and loudspeaker using a 5 transistor amplifier with P.P. output. Operation by chargeable batteries. Tape capacity 25 mins. Tape position indicator. Recording level automatically preset. Inter-lock prevents unintentional erasures. Tape speed controlled by flywheel driven capstan. Neat case with carrying handle, size approx. 6¼ × 7¼ × 2in. Postage and insurance 7/6.

MOTOR BARGAIN



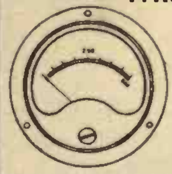
Silent running mains motor by very famous maker. Ideal for gramophone, tape recorder, fan, etc., etc. 200/250 volts a.c., shaded pull start. Size approx. 2¾ × 2½ × 1¾in. 1,400 r.p.m. Spindle diameter 5/32in. Spindle length ⅜in. Brand new, guaranteed. Price 9/6, plus 3/- post.

DON'T BUY ANOTHER BATTERY



Nickel Cadmium cells are rechargeable from the mains so if these replace the normal batteries in your radio and if you fit a battery charger to it—the radio will still remain portable but will in fact be mains operated. Our outfit comprises (1) full wave battery charger with high/low switch; (2) 9 volt (approx.) 120mA hour Battery stack; (3) full instructions for fitting. Price is 29/6 (less than regular price of battery stack) plus 2/6 post and insurance.

THIS MONTH'S SNIP



2½in. MOVING COIL METER

Meters are always being needed and they are jolly costly when you have to buy them in a hurry. So it's sensible to take advantage of this offer: 2½in. (3in. o.d.) flush mounting moving coil meters only 8/6 each. These are scaled 0–300mA but once the internal shunt is removed the f.s.d. is usually about 10mA so you can make it into almost anything by adding shunts or series resistors. These are Ex. W.D. of course but are all new and unused. Price only 8/6 each plus 2/6 post. 12 or more post free.

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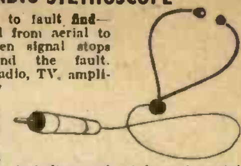
Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12V for up to 500mA (class B, working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises mains transformer rectifier, smoothing and load resistor, condensers and instructions.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

BARGAIN OF THE YEAR

MICRO-SONIC 7 transistor Key chain radio in very pretty case, size 2¾ × 2¼ × 1¼in.—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne. Frequency range: 530 to 1,600Kc/s. Sensitivity: 5mV/m. Intermediate frequency 465Kc/s or 455Kc/s. Power output: 40mW. Antenna: ferrite-rod. Loudspeaker: Permanent magnet type. In transit from the East these sets suffered slight corrosion as the batteries were left in them, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. 19/6 plus 2/6 post and ins., less batteries. A pair of rechargeable everlasting batteries 3/6 each (2 required).

RADIO STETHOSCOPE



Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece 29/6—twin stetoset instead of earpiece 7/6 extra—post and insurance 2/9.

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THIS MONTH'S BARGAINS

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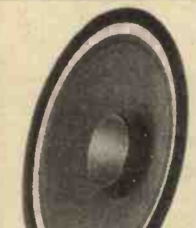

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