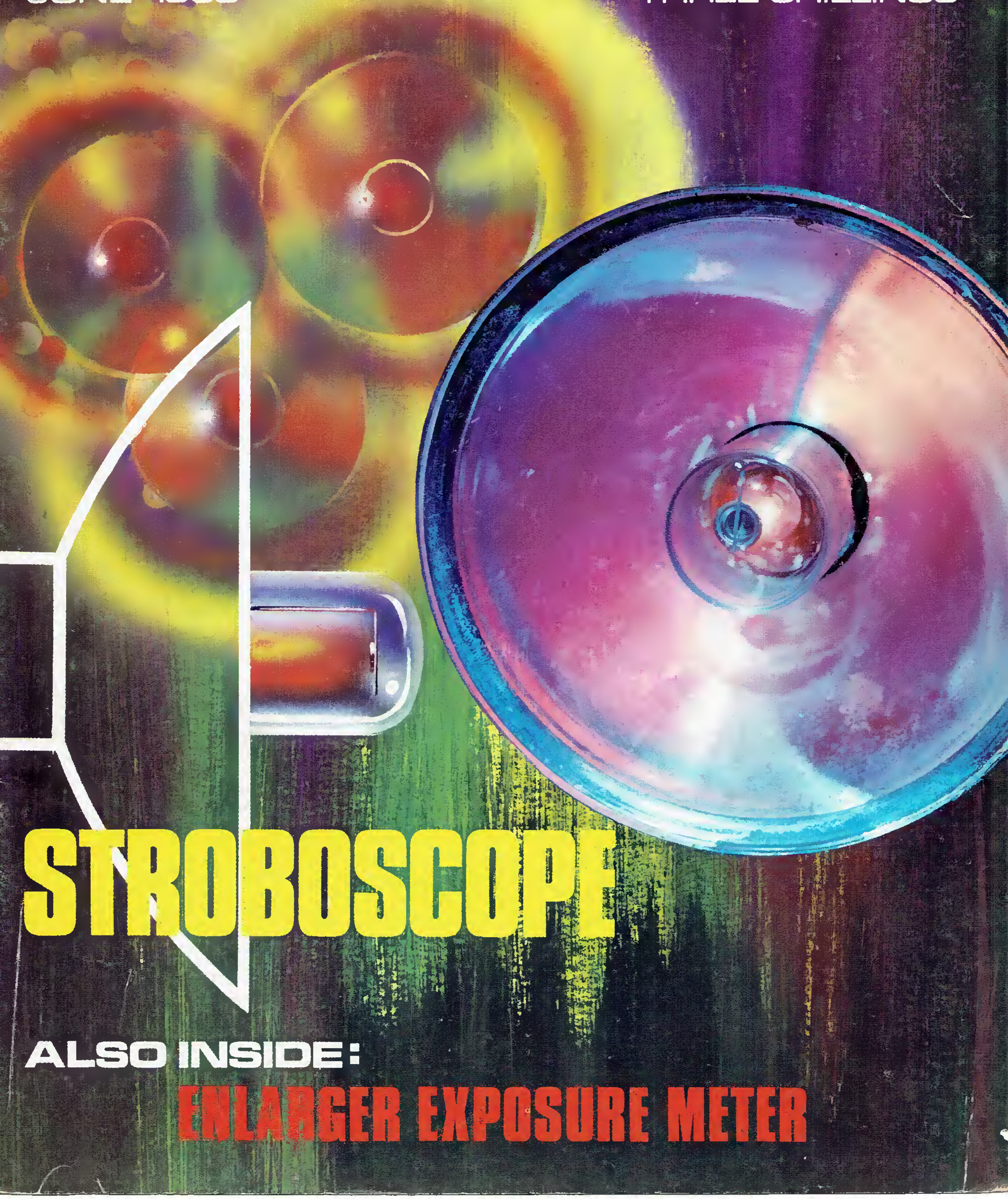
PRACTICAL

ELECTRONICS

JUNE 1969 THREE SHILLINGS



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2N4286	3/6
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AFZ12	5/6
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ASY27	8/6
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ASY29	4/6
ASZ21	4/6
BAX13	2/6
BAX16	2/9
BAY31	2/6
BAY38	3/6
BC107	3/6
BC108	3/6
BC109	3/6
BC113	6/6
BC118	6/6
BC125	13/6
BC147	5/-
BC148	4/6
BC149	5/-
BC182	4/6
BC183	4/6
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Fully Guaranteed

7"	STD	1,200'	7/3
7"	L/P	1,800'	12/3
7"	D/P	2,400'	19/-
5¾"	STD	900'	6/6
5¾"	L/P	1,200'	9/-
5¾"	D/P	1,800'	14/9
5"	STD	600'	5/3
5"	L/P	900'	7/3
5"	D/P	1,200'	10/9
3"	D/P	185'	2/3
3"	L/P	225'	3/-
3"	D/P	300'	4/-
7"	D/P Concorde	3,000'	33/6

Spools: 8¼" 6/3, 7" 2/6, 5¾" 2/3, 5" 2/3, 4" 2/-, 3½" 1/9, 3" 9d, 2½" 1/10.

CASSETTE TAPES

C-60 13/6, C-90 18/6

Post and Packing up to 3 reels 2/9, otherwise 4/6.

SPEAKERS (3 ohm)

10" × 6" 37/6,
9" × 4" 23/6,
8" × 5" 19/6,
7" × 4" 15/6,
5" × 3" 12/6
3" 9/6, 5" 14/6,
8" 27/6, 12" 39/6.

Post and Packing 1/6

THYRISTORS

1 AMP: 50V 5/-, 100V 5/6, 200V 7/-, 400V 9/6.
3 AMP: 50V 6/-, 100V 7/6, 200V 8/-, 400V 10/-.
Equivalent BYT 91/100R 15/- each
ZENERS. 1½ WATT 2·7–33V 4/6
400m/w 3·0–330 5/-

INTEGRATED CIRCUITS

R.C.A.
CA3005, 3013, 3014, 3018 30/-
CA3019, 3020 27/6 CA3011, 3036 20/-
CA3021 42/6 CA3023 32/6 CA3012 25/-
FAIRCHILD
L900, 914 11/- L923 14/-
DATA SHEETS FOR RCA DEVICES 2/- per type

Presets std., horiz. or vert. 1/6
Potentiometers, Log/Lin 3/3 each

MFD	V.	Price	MFD	V	Price	MFD	V	Price
1	15	1/6	16	450	3/3	100	15	1/6
1	40	1/9	25	6·4	1/6	100	25	1/6
2	15	1/6	25	10	1/6	100	50	2/6
2	350	2/0	25	25	1/6	125	4	1/6
2·5	16	1/9	25	50	1/6	200	16	2/-
4	15	1/6	32	15	1/6	250	25	2/9
4	40	4/9	32	40	1/6	250	50	3/9
4	350	2/3	32	450	1/6	320	10	1/6
5	15	1/6	40	6·4	1/6	400	16	2/9
6·4	6·4	1/9	40	16	1/6	500	6	2/6
8	18	1/6	50	12	1/6	500	25	3/9
8	40	1/6	50	15	1/6	500	50	4/9
8	450	3/-	50	25	1/6	640	16	3/6
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10	25	1/6	64	25	1/6	1000	16	4/-
12·5	25	1/9	80	6·4	1/6	1000	25	5/-
16	10	1/9	80	16	1/6	1000	50	9/-
16	18	1/6	100	12	1/6			

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3¾" × 2½", 3/6
3¾" × 3¾", 4/3
Cutter 9/-
3¾" × 5" 5/6
17" × 3¾" 16/-
5" × 2½" 4/3

RESISTORS

¼ watt 10%, 4d.
¼ watt 5%, 5d.
½ and 1 watt, 6d.
3 watt, 1/6
5 watt 2/-

SEND 6d. STAMP FOR CATALOGUE
P.P. for Components 1/6 per order

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COMPLETE STEREO SYSTEM

FOR ONLY **39 GNS**

CARRIAGE 35/-

The Premier Stereo System consists of an all transistor stereo amplifier, Garrard Model 2025 auto/manual record player unit fitted stereo/mono cartridge and mounted in teak finish plinth with perspex cover and two matching teak finish loudspeaker systems. Absolutely complete and supplied ready to plug in and play. The 10 transistor Amplifier has an output of 5 watts per channel with inputs for pick up, tape and tuner also tape output socket. Controls: Bass, Treble, Volume, Selector. Power on/off, stereo/mono switch. Brushed aluminium front panel. Black metal case with teakwood ends: Size 12" x $5\frac{1}{2}$" x $3\frac{1}{2}$" high (Amplifier available separately if required **£14.19.6.** Carr. 7/6).

GARRARD RECORD UNITS

1025 Stereo/Mono cart. **£7.19.6**
2025 Stereo/Mono cart. **£8.19.6**
3000 with 9TAHCD **£9.19.6**
Carriage 7/6 extra
AT60 MKII less cart. **£13.19.6**
SP25 MKII less cart. **£11.19.6**
Teak Plinth with perspex cover as above £5.10.0. Carr. 6/6 extra.

AP75 less cart. **£19.0.0**
SL75 less cart. **£29.0.0**
Teak Plinth with perspex cover **£7.10.0.** Carr. 7/6 ex.

SL95 less cost **£38.10.0.** Carriage 10/- extra.

GOLDRING RECORD UNITS

GL68 less cart. **£22.7.0.** GL75 less cart. **£35.15.5.** Carriage 10/– extra.

PICK-UP CARTRIDGES

SHURE M3D (Stereo)	£7.10.0
B.S.O. SP1 (Stereo)	£5. 5.0
PICKERING V15/AC2 (Stereo)	£8.10.0
SONOTONE 9TAHC/Diamond (Stereo)	£2.15.0
ACOS GP91/1SC (Mono compatible)	£1.13.5
ACOS GP93-1 (Stereo)	£2. 8.7
ACOS GP94-1 (Stereo)	£2.14.8
B.S.R. X3M (Mono compatible)	£1.16.5
B.S.R. X3H (Mono compatible)	£1.16.5
RONETTE 105 (Stereo)	£1.15.0
RONETTE 106 (Stereo)	£1.15.0

All complete with mounting brackets and instructions. Post and Packing 1/6 each.

WELLER SOLDERING TOOLS

"Expert" Solder Gun. Saves time and simplifies soldering in the home and service dept. Two position trigger gives instant dual heat. 100/140 watt. 240 volt A.C. **67/6** P. & P. 2/-. "Marksman" Soldering Iron. Lightweight, conventional $^3/_{16}$" pencil bit. Ideal for regular bench use and all those jobs around the home. 25 watts. 240 volt. A.C. **31/6** P & P 2/-.

"PREMIER" TAPE CASSETTES

C60 Type 60 min. **10/6**
C90 Type 90 min. **15/-**
C120 Type 120 min. **20/-**
P. & P. 1/-.

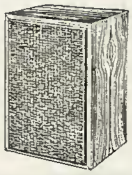
CASSETTE HEAD CLEANER
Removes unwanted deposits from delicate tape heads. Fits all cassette recorders. **15/-** P. & P. 1/-.

HI-FI STEREO HEADPHONES

Designed to the highest possible standard. Fitted Fitted $2\frac{1}{2}$" speaker units with soft padded ear muffs. Adjustable headband. 8ohm impedance. Complete with 6ft. lead and stereo jack plug. **59/6** P. & P. 5/-.

MONO HEADPHONES 2000 ohm **14/6** P. & P. 2/6.
STEREO STETHOSCOPE SET Low imp. **25/-** P. & P. 2/-.
MONO STETHOSCOPE SET Low imp. **10/6** P. & P. 2/-.

"PREMIER" SPEAKER SYSTEM



Specially designed oiled teak cabinet with vynair front. Size $12\frac{1}{2}$" high, $7\frac{1}{2}$" wide, $6\frac{1}{4}$" deep. Fitted $6\frac{1}{2}$" EMI 8ohm Bass speaker with rolled surround and matching 3" E.M.I. tweeter. Fully lagged. **£7.19.6.** Carr. 7/6.

MULTI TESTERS

MODEL D14. A really versatile instrument that makes a handy pocket size tool. Measures AC or DC voltage in three ranges of 0–15–150–1000 volts. Resistance 0–100,000 ohms. Current 0–150 mA D.C. Size only: $3\frac{3}{4}$ x $2\frac{1}{4}$ x $1\frac{1}{8}$in. Complete with battery, test leads and instructions **49/6.** P. & P. 2/6.

POCKET SIZE MODEL. With wide-angle, jewelled meter movement, ceramic long-life, low-loss switching, tough impact resisting case. Sensitivity 20,000 ohms/volt D.C. 10,000 ohms/volt A.C.
19 Ranges: 0-5-25-50-250-500-2500 volts DC. 0-10-50-100-500-1000 volts AC. 0-50 uA-2·5 mA-250 mADC. 0-6000 ohms-6 megohms, 10u uf-0·001 mfd-1 mfd. —20 to +22dB. Complete battery, test lead and instructions. **£4.19.6.** P. & P. 3/6.

WIDE RANGE OF HI-FI STEREO EQUIPMENT ON DEMONSTRATION

All leading makes available including Rogers, Armstrong, Dulci, Wharfedale, Goodmans, Goldring, Shure, etc. etc.

SPECIAL OFFER

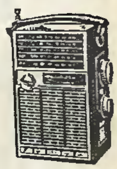
BALFOUR "PRINCESS"

4 Speed Autochanger fitted ACOS Mono Compatible t/o cartridge. Complete with TEAK BASE. ONLY **£5.19.6.** Carr. 7/6.

MONO GRAM AMPLIFIER

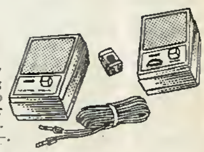
$2\frac{1}{2}$ watts output. Uses EL84 valve, double wound mains transformer. Ideal for use with any record deck. Volume/on/off and tone controls on flying leads. Output impedance 3 ohms. Size overall $5\frac{1}{2}$"w. x $5\frac{1}{2}$"d x 3"h. A.C. 200/240V. ONLY **49/6.** P. & P. 5/-.

JULIETTE NA.5018 5 BAND 18 TRANSISTOR MAINS/BATTERY RADIO



Covers AM 540–1600Kc/s. Marine 1·6–4·6Mc/s. FM 88–108Mc/s. VHF 108–134Mc/s. PB 148–174Mc/s. Ferrite bar aerial for AM/MB. Telescopic aerial for FM/VHF/PB. 4" P.M. Speaker. Operates on AC 250v. or D.C. by four 1·5v. batteries. Size: $9\frac{3}{4}$" x $5\frac{3}{4}$" x $3\frac{3}{4}$". PREMIER PRICE **33 gns.** P. & P. 10/–.

TWO STATION TRANSISTOR INTERCOMS.



Complete with battery and 50ft. connecting wire. Compact size, two way call system. Ideal for home, office, factory, etc. ONLY **49/6** P. & P. 4/–.

FOUR STATION INTERCOM. Master unit and 3 slaves. Ideal for office and home. Complete with battery and connecting wire **£7.19.6** P. & P. 5/6.

"VERITONE" RECORDING TAPE

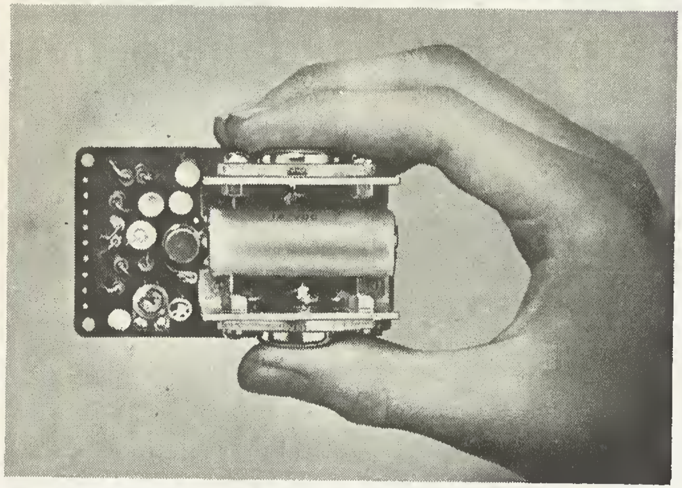
SPECIALLY MANUFACTURED IN U.S.A. FROM EXTRA STRONG PRE-STRETCHED MATERIAL. THE QUALITY IS UNEQUALLED.

TENSILISED to ensure the most permanent base. Highly resistant to breakage, moisture, heat, cold or humidity. High polished splice free finish. Smooth output throughout the entire audio range. Double wrapped—attractively boxed.

LP3	3"	250'	P.V.C.	5/6
TT3	3"	450'	POLYESTER	7/6
DT3	$3\frac{1}{4}$"	600'	POLYESTER	11/6
SP5	5"	600'	P.V.C.	8/6
LP5	5"	900'	P.V.C.	10/–
DT5	5"	1200'	POLYESTER	15/–
LP6	$5\frac{3}{4}$"	1200'	P.V.C.	12/6
DT6	$5\frac{3}{4}$"	1800'	POLYESTER	22/6
TT6	$5\frac{3}{4}$"	2400'	POLYESTER	37/6
SP7	7"	1200'	POLYESTER	12/6
LP7	7"	1800'	P.V.C.	15/–
DT7	7"	2400'	POLYESTER	25/–
TT7	7"	3600'	POLYESTER	50/–

TAPE SPOOLS 3" 1/–, 5", $5\frac{3}{4}$", 7" 1/9. TAPE CASES 5", $5\frac{3}{4}$", 7" 2/6.
Post and Packing 3" 1/–, 5", $5\frac{3}{4}$" 1/6, 7" 2/–. (3 reels and over Post Free).

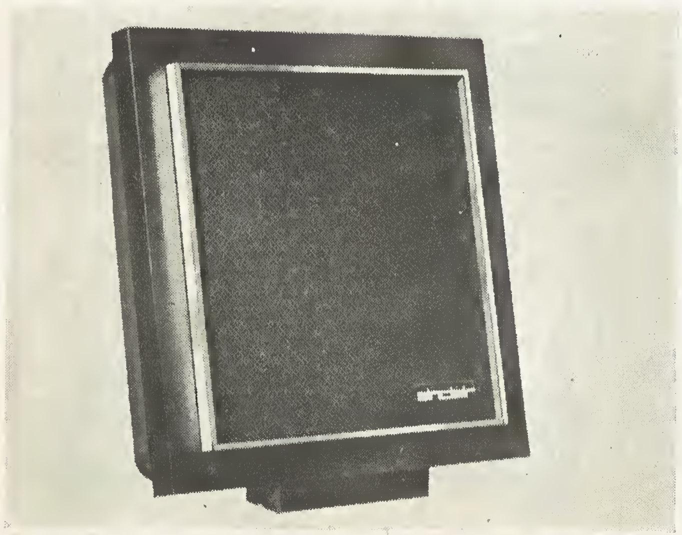
sinclair



Z.12 - for all you want from any amplifier

The Z.12 is a most versatile integrated amplifier and pre-amp in which power, compactness and true high-fidelity standards are combined within a unit of very modest price. The most widely used unit of its kind in the world, the Z.12 has an output of 12W R.M.S. continuous sine wave (24W peak) or 15W music power (30W speak). It has Class B ultralinear output which can be fed into any loudspeaker from 3 to 15 ohms. (Two 3 ohm speakers can be used in parallel.) Frequency response—15 to 50,000Hz ± 1dB; input sensitivity—2mV into 2 K/ohms. The Z.12 will operate from any power source between 6 and 20V d.c. As such, a car battery or the PZ.4 are eminently suitable, giving much wider than usual scope in the applications to which the Z.12 may be put. As well as hi-fi, these include systems for P.A. electronic guitars, organs, intercom systems, laboratory, education or industry. You will find the Z.12 in use in such instances again and again. The Sinclair Z.12 is supplied ready built, tested and guaranteed, complete with manual of circuits and instructions for matching it to your precise requirements. Two may be used in stereo when, with the Stereo 25 and PZ.4 together with two Q.14s, you will have an ideal high fidelity assembly.

89/6



Q.14 - the unique loudspeaker

New materials and original design techniques have been used to produce speaker of fantastic quality at a most attractive price. Experts and reviewers have enthusiastically endorsed its performance. The shape and size of the Q.14 make it far more adaptable to its environment than is the case with conventionally styled speakers so that it is much easier to position this speaker in the room in which it is to be heard. The Sinclair Q.14 has a substantially flat frequency response from 60 to 16,000Hz and outstandingly good transient response. It will comfortably handle up to 14W loading and is positively brilliant in stereo. Measuring 9¾in square by 4¾in deep, this loudspeaker is finished in matt black with solid aluminium bar trim.

Try the Q.14 in your own home without delay. If you are not delighted with it, your money including cost of return postage to Sinclair will be refunded immediately.

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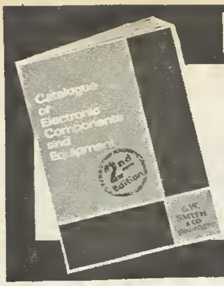

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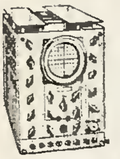

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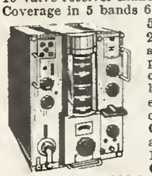

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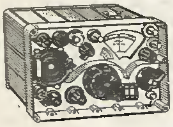

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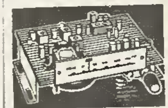

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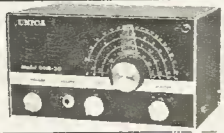

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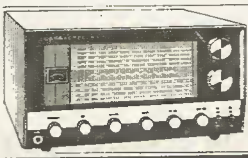

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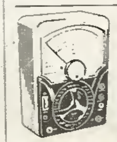

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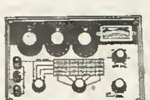

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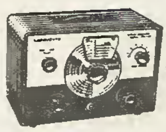

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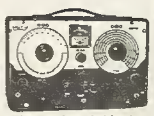

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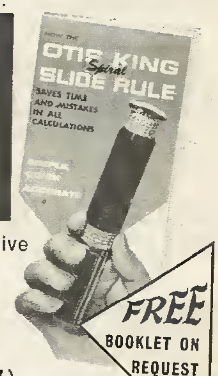

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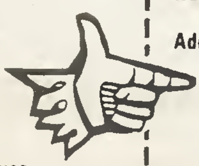

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June 1969

PRACTICAL ELECTRONICS

MAIL ORDER

A VERY large number of constructors, possibly the majority, depend upon mail order for their components. Outside London and a few other large centres, facilities for personal shopping rarely exist. It must be acknowledged that the present day large scale amateur constructional activity is sustained in the main by the suppliers who provide this service through the post. Electronics enthusiasts in the more remote parts of the United Kingdom in particular have cause to be grateful for this development in retail distribution methods. The reader in Wick or St. Davids, for example, has access to precisely the same great range of components as the reader in the suburbs of London. This is only just and fair, for the individual living in a sparsely populated area is likely to be even closer wedded to his hobby than the person who suffers from a surfeit of counter attractions in town or city.

The mail order system has its own inherent weaknesses and because of certain shortcomings, this service is often a mixed blessing to those who are entirely dependent upon it for their component needs. From readers' correspondence, a number of points of criticism emerge. A frequent complaint is the impossibility of obtaining all requirements for one particular project from a single supplier. The need to write to several firms is time consuming and the project may remain uncompleted for a long while—maybe all for the want of a single item. This is exasperating to say the least; more seriously, it may cool the reader's enthusiasm for the hobby. Often a complaint of this nature is coupled with the suggestion that mail order suppliers should be encouraged to make up complete kits of parts for constructional projects published in this magazine.

We have every sympathy for readers who suffer this kind of frustration but we are also aware of the problems of the retail trade. The huge variety of electronic components on the market today is quite staggering. The average retailer can only stock a limited range of items and generally some form of specialisation is adopted which has economic advantages to both seller and purchaser. Regarding complete kits, even where an extensive range of components is stocked, it would not be a viable business proposition to make up kits for every design published. True, the more popular projects certainly seem to offer a lucrative business but the retailer would, by and large, have to back his own hunches for it is impossible to forecast the demand any particular design will arouse.

F. E. Bennett—*Editor*

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our July issue will be published on Friday, June 13

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STROBOSCOPE

By B. HUNTER

The stroboscope is basically a flashing light, the frequency of which may be varied from a few flashes per second to several hundred per second. If a rotating or vibrating object is viewed by this flashing light, and the flash frequency is adjusted until it coincides with the speed of rotation or vibration, then the object will appear stationary (the object will also appear stationary if the frequency of the flashes is a sub-multiple of the speed of rotation).

The complete unit consists of the four basic sections described below.

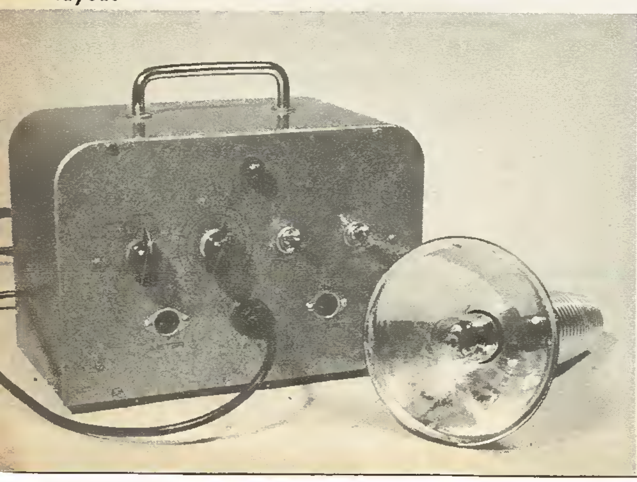
FLASH TUBE AND ASSOCIATED CIRCUITRY

The flash tube (V1) is an NSP2 type which is capable of flashing at a maximum frequency of 250Hz. The tube is gas filled and has four electrodes; the anode, the cathode and two grids or trigger electrodes.

If a voltage of between 220 and 380 volts is applied between cathode and anode, and a suitable voltage pulse is applied across the trigger electrodes, some of the gas in the tube is ionised and conducts. This conduction triggers off a discharge between the cathode and the anode, and the tube emits a flash of light.

In the circuit described here, trigger 2 (Pin 4) is held about 50V positive with respect to earth by the potential divider formed by R7 and R8; trigger 1 (Pin 5) is at earth potential. When it is required to fire the tube, trigger 1 is made negative with respect to earth, and when it is more than 50V negative, the tube will fire.

Complete stroboscope showing flash head and front panel layout



To supply the large amount of energy required for the flash, it is necessary to connect a capacitor (C10 to C15) across the tube between cathode and anode. Between flashes this capacitor charges up to supply potential, and during the flash it is rapidly discharged through the tube releasing all the stored energy in a very short period.

Although paper capacitors are recommended for the discharge capacitors, the author has successfully used polyester types. However, it is not known if polyester capacitors will last as long as paper ones but they have the advantage of smaller size for the same capacitance; the final choice of type is left to the constructor.

TRIGGER CIRCUIT

The trigger circuit consists of the capacitor C9, two resistors (R5 and R6) and the thyristor SCR1. The capacitor charges to supply potential through R5 and R6 between flashes. This means that, when C9 is fully charged, point "x" in Fig. 1 is positive with respect to point "y" which is at earth potential, since there is virtually no current flow through R6. When the thyristor is triggered it becomes a short circuit and earths point "x". At this instant, point "y" is negative with respect to earth, C9 then discharges through R6. This fulfils the trigger requirements for the tube, as stated earlier, and hence the tube fires.

Once the thyristor has been turned on, it will not turn off until the current flowing through it falls below a value known as the holding current. As soon as C9 has discharged the only current which will flow through the thyristor is from the h.t. line through R5, therefore R5 must have a high enough resistance to limit the current to below the thyristor's holding current.

DESIGN POINTS

When the holding current is known, R5 may be easily calculated from Ohm's law. If the holding current for the thyristor used is not known, R5 can be calculated by the following method.

Connect a voltmeter across SCR1 as shown in Fig. 2 (making R5, 6 kilohms). With the h.t. on, the full supply volts should appear across the thyristor. The gate of the thyristor should now be made about 4V positive with respect to the cathode. This may be conveniently arranged by connecting a battery between the gate and the cathode (Fig. 2).

When the gate is made positive, the voltage across the thyristor should fall, almost to zero, showing that the thyristor has turned on. Removing the voltage on the

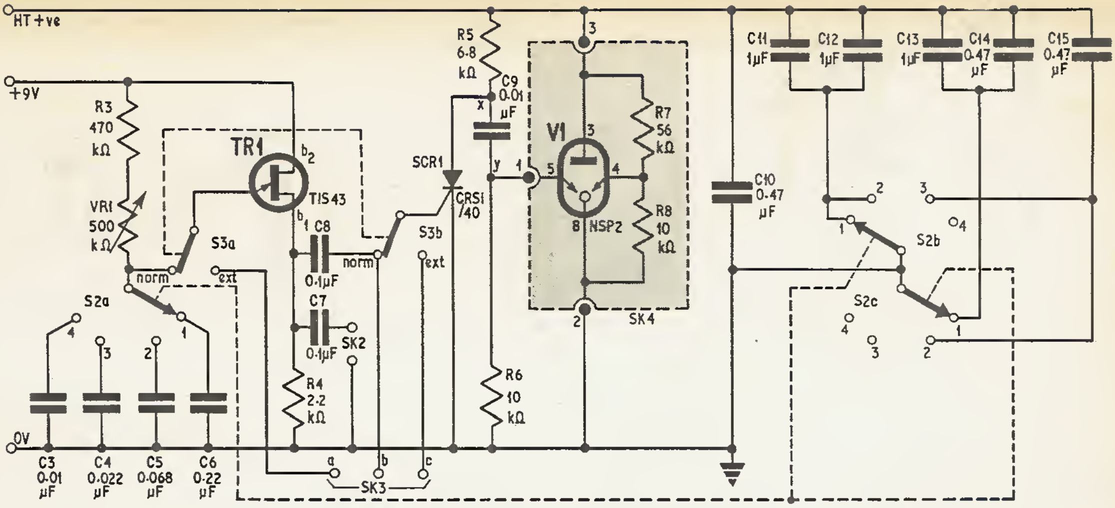


Fig. 1. Circuit diagram of the stroboscope not showing the power supply

gate, should cause the voltage across the thyristor to return to the supply voltage, showing that it has turned off.

If the voltage does not reappear, the current through the thyristor is above the holding current, and R5 should be increased to the next preferred value. The above procedure is then repeated until the thyristor turns off as soon as the gate voltage is removed.

The thyristor specified requires about 50mA holding current, therefore R5 is made 6·8 kilohms, limiting the current to 44mA. The dissipation in R5 at 44mA is about 13 watts, therefore R5 must be at least a 10W resistor (maximum current is only passed for part of each cycle).

Because C9 is charged through R5 and R6, the sum of these resistors must not be too great, or C9 will not charge fully at higher flashing rates. The maximum flashing rate is 250Hz (limited by the tube), therefore the shortest period of time in which C9 must charge will be four milliseconds, hence the maximum value of R5 + R6 is 40 kilohms (R6 is 10 kilohms, so that R5 + R6 will be 16·8 kilohms—well within the limit).

PULSE GENERATOR

In order to turn the thyristor on, some form of pulse generator is required. There are certain conditions which the pulse generator must meet. These are:

(1) A pulse greater than 3V is required, as this is the minimum gate turn-on voltage for the thyristor specified.

(2) The pulse should be a positive spike with a very short rise-time, in order to trigger the thyristor reliably.

(3) The pulse generator must be stable at any frequency.

(4) The generator must supply pulses over a range of frequencies from 10Hz to 250Hz.

One form of pulse generator which meets all of these conditions is the unijunction transistor oscillator (Fig. 1); it also has the advantage of simplicity.

When a voltage is applied to the oscillator, one of the capacitors C3 to C6 (depending upon the position of switch S2), begins to charge through R3 and VR1 causing the voltage on the emitter of the unijunction to rise until, at a certain voltage, the unijunction fires.

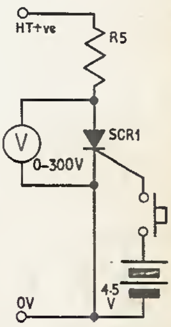


Fig. 2. Set up for finding the value of R5

The capacitor then discharges through R4, producing a very fast pulse at the gate of the thyristor which turns it on.

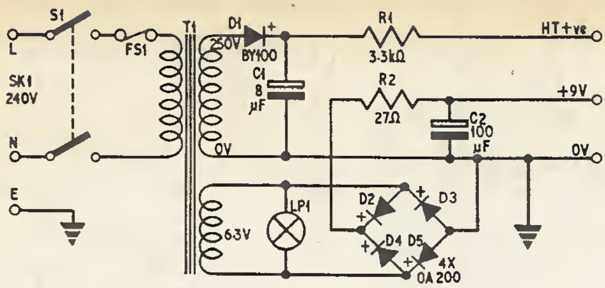
The pulse generator gives the necessary frequency coverage in four ranges, 10Hz to 25Hz, 20Hz to 55Hz, 50Hz to 110Hz, and 100Hz to 250Hz. The ranges are selected by switching the charging capacitor; frequency adjustment over each range is achieved by VR1. The range switch (S2) is a three pole switch; one pole switches the frequency range capacitors C3 to C6 and the other two poles switch the discharge capacitors C11 to C15.

EXTERNAL TRIGGERING

The unit may be triggered externally thus enabling it to be synchronised with a rotating or vibrating object. This is particularly useful for observation of rotating machinery not having a constant speed. External triggering also enables the unit to be used for timing car ignition systems.

Socket SK3 is provided for trigger inputs and switch S3 selects internal or external triggering. With the switch in the external position, two triggering circuits are obtainable.

By shorting connections "b" and "c" on SK3 a low voltage pulse applied between "a" and earth will turn on the unijunction and trigger the thyristor in the normal manner. The second triggering method is to apply a pulse directly to the gate of the thyristor via connection "c" on SK3. In this case the pulse must be greater than the minimum triggering voltage of the



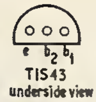


Fig. 3. Power supply circuit for the stroboscope

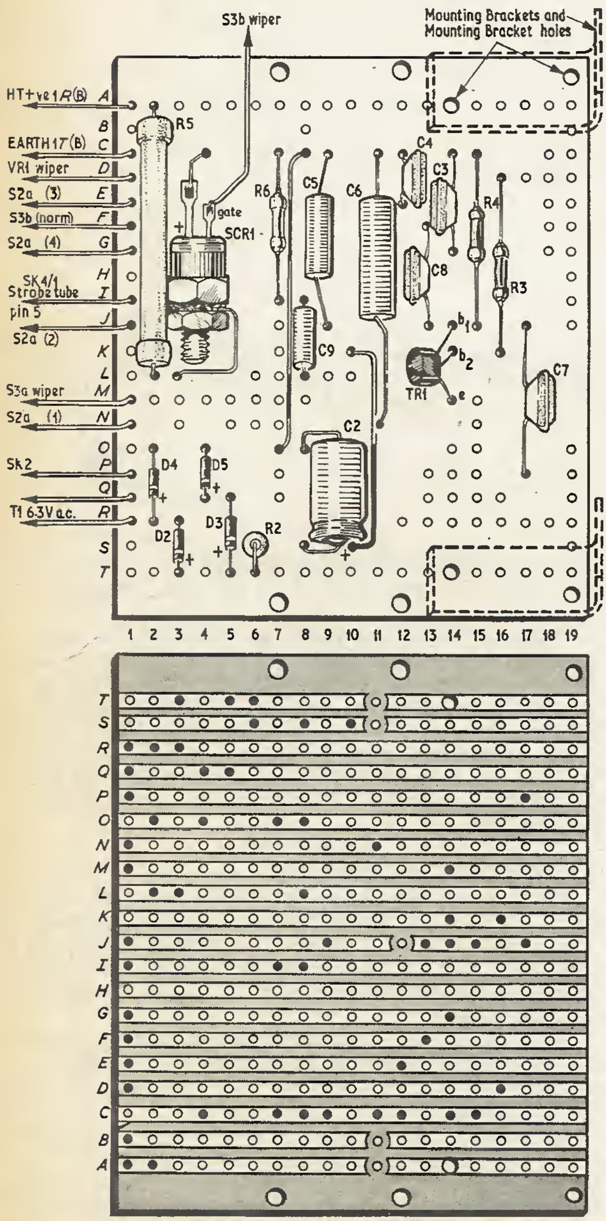


Fig. 4. Component layout and wiring of board "A"

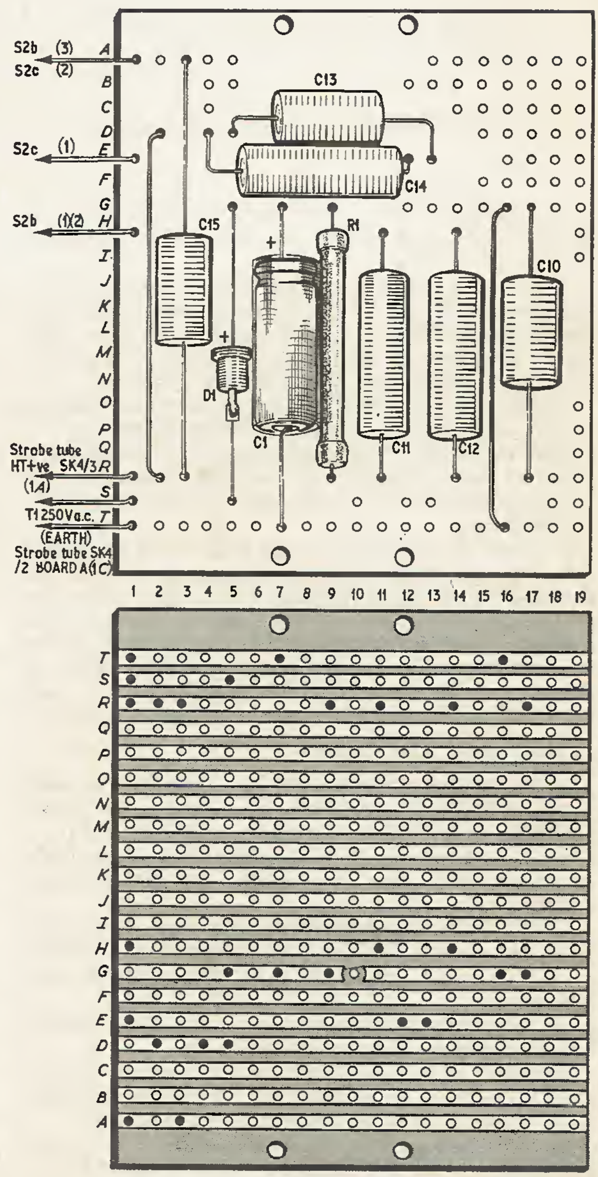


Fig. 5. Component layout and wiring of board "B"

thyristor (3V for the thyristor specified) and should have a fast rise time in order to trigger the thyristor reliably.

POWER SUPPLY

The h.t. supply (Fig. 3) is obtained by half-wave rectification of the 250V a.c. from the transformer by the rectifier D1—C1 provides some smoothing.

The low voltage required for the pulse generator is obtained by bridge rectification of the 6·3 volt heater supply from the transformer (T1) and, with smoothing provided by C2, this gives 9V d.c. Very little current is required by the pulse generator (of the order of 2mA), so almost any diodes will suffice for the bridge rectifier (D2 to D5).

COMPONENTS . . .

Resistors
R1 3·3kΩ 10W wirewound
R2 27Ω
R3 470kΩ
R4 2·2kΩ
R5 6·8kΩ 10W wirewound
R6 10kΩ
R7 56kΩ ½W
R8 10kΩ ½W
All 10%, ¼W carbon except where stated

Potentiometer
VR1 500kΩ linear

Capacitors
C1 8μF elect. 450V
C2 100μF elect. 15V
C3 0·01μF 12V
C4 0·022μF 12V
C5 0·068μF 12V
C6 0·22μF 12V
C7 0·1μF 12V
C8 0·1μF 12V
C9 0·01μF 400V
C10 0·47μF
C11 1μF
C12 1μF
C13 1μF
C14 0·47μF
C15 0·47μF
(C10–C15) 400V paper or polyester (see text)

Semiconductors
TR1 TIS43 unijunction transistor
SCR1 CRS1/40 400 p.i.v. 1A thyristor
D1 BY100
D2–D5 OA200 or OA202 (4 off)

Switches
S1 2 pole on/off toggle
S2 Maka Switch shaft unit and 3 pole, 4 way wafer
S3 2 pole change-over toggle

Transformer
T1 Mains primary; secondary 250V at 25mA and 6·3V, 1·2A (Radiospares)

Flash Tube
V1 NSP2 flash tube (Ferranti)

Sockets
SK1 Mains plug and socket (Bulgin type P429)
SK2 3 pin DIN socket
SK3 3 pin DIN socket
SK4 Mains plug and socket (Bulgin type P429)

Miscellaneous
6·3V panel lamp and holder
250mA fuse and holder
Veroboard—0·15in pitch, 4½in × 8in (see Figs. 4 and 5)
Case (see text)
Four mounting pillars (1¼in × ¼in diameter)

CONSTRUCTION

The unit is built on two pieces of veroboard; the low voltage supply components, pulse generator and trigger circuit on one board, and the h.t. supply components and the discharge capacitors (C10 to C15) on the other board. Layout of each board is shown in Figs. 4 and 5, the connections to the boards being made as shown.

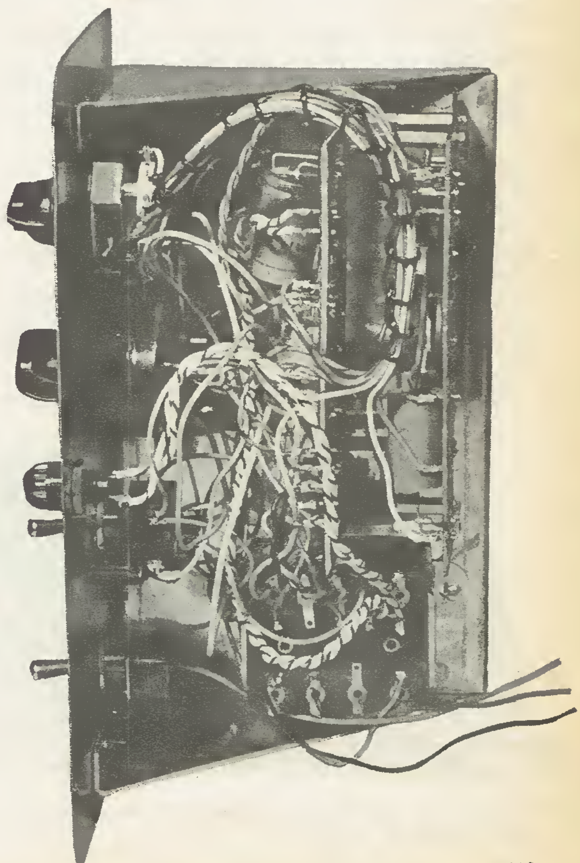
The unit is housed in a case measuring 9in × 6in × 5in, the boards are mounted upright beside the mains transformer as shown in the photograph and Fig. 6.

Board "A" is fixed to the chassis by the two mounting brackets; board "B" is then attached to board "A" by four pillars. Both boards must be mounted well clear of all other components and the chassis.

The flash tube can be housed in a torch case or a special holder can be made up. The international octal base used for the NSP2 tube is mounted behind the reflector which must be cut away to clear the tube. If a special holder is made, an old car headlamp reflector can be used (it must be the old type—not a modern sealed beam unit).

Resistors R7 and R8 are mounted on the base and a three core mains lead and Bulgin plug connect the flash unit to SK4. Care must be taken to prevent any of the base connections from shorting to each other or the case.

Interior view of unit showing component layout. See Fig.6



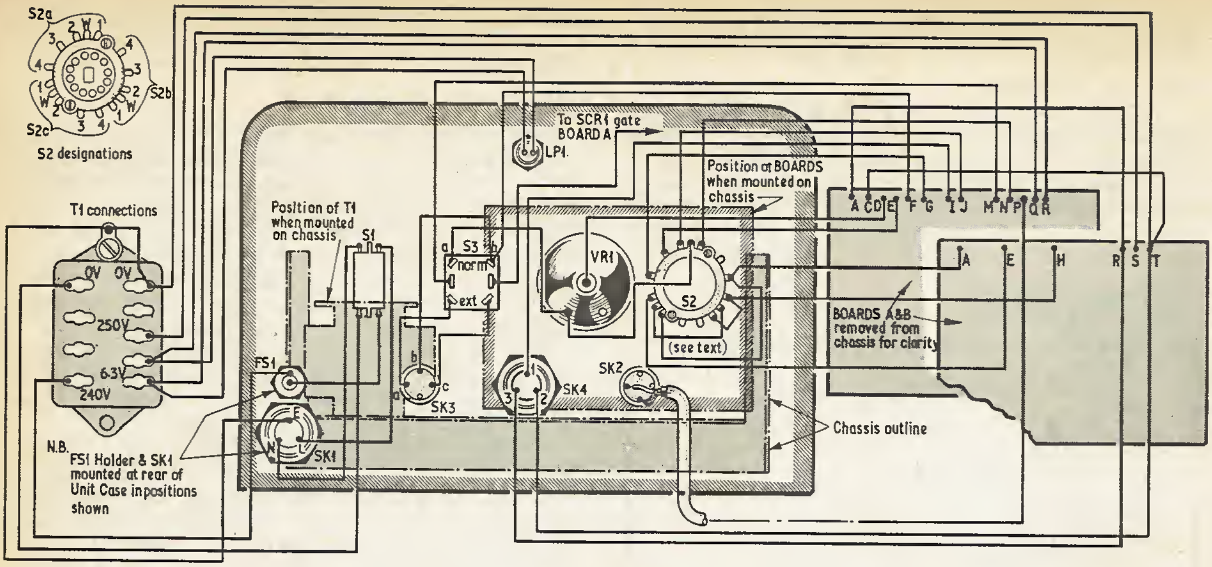


Fig. 6. Layout and wiring diagram of the complete stroboscope. Boards "A" and "B" and transformer T1 are shown removed for clarity

Wiring between components mounted on the case and the boards ("A" and "B") is given in Fig. 6. No drilling details are given as these depend on the size and shape of the case and the components used. A suggested layout is shown (Fig. 6).

Wiring can be tidied up after construction by lacing wires coming from the boards into two looms and wires from the front panel and transformer into a third loom.

A socket is provided on the case for connecting a frequency meter, to measure accurately the frequency of flashing. The signal for the frequency meter is taken from b1 of the unijunction via a capacitor (C7) to SK2.

CALIBRATION

The unit may be calibrated in several ways; the easiest is to connect a frequency meter to SK2. The meter will then give a direct reading of the flash rate, and VR1 can be calibrated (see photograph).

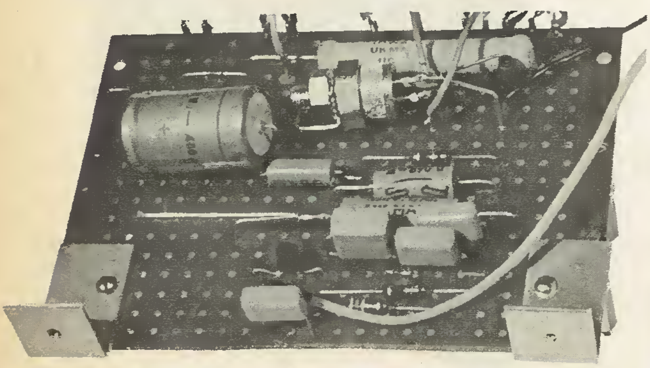
If an oscilloscope is available with a calibrated timebase, this may be connected in place of the frequency meter and the number of pulses displayed on the screen will give an indication of the frequency.

Another method makes use of a calibrated audio oscillator and an amplifier. If the oscillator is connected to the amplifier and loudspeaker, the loudspeaker can be observed by the light of the stroboscope. When the frequency of the signal from the oscillator coincides with the flash rate of the stroboscope, the cone will appear stationary; thus VR1 can be calibrated. Care must be taken with this method to ensure that the oscillator is not running at a multiple of the stroboscope frequency—the cone will also appear stationary if this happens.

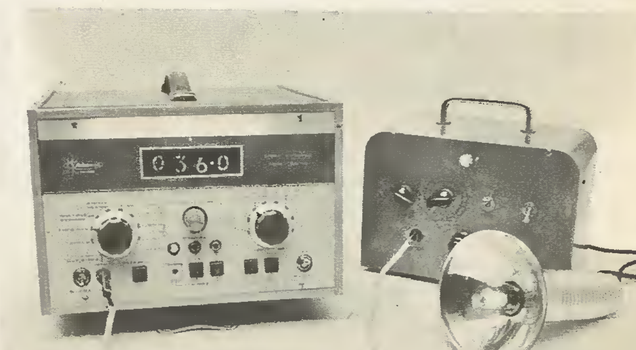
It is best to start at the slowest flash rate which is about 10 flashes per second and synchronise the oscillator. If the oscillator is now kept in step with the stroboscope, the stroboscope can be calibrated without difficulty.

These are just a few methods of calibration; no doubt others will suggest themselves quite readily. Of course, if a frequency meter is always available, it may be used in conjunction with the stroboscope to give a continuous indication of frequency and thus eliminate the need to calibrate VR1.

When making a rotating object appear stationary with this instrument, it is very easy to forget that it is rotating, therefore great care should be taken when using the stroboscope, especially with powerful machinery. ★



Photograph of board "A" showing the mounting brackets and position of components



Set up for calibrating the stroboscope using a frequency meter—see text

EXPERIMENTS WITH THE OPERATIONAL AMPLIFIER

By G. K. FAIRFIELD

The first of three articles dealing with this versatile type of amplifier and the many uses to which it may be put in measurement, test and general experimental work.

During experimental work, it is often required to make many different measurements of component values and circuit performance. The acquisition of individual bridges and meters to measure all of these can be a very expensive process. An alternative approach, suggested in this article, is to construct a circuit to do each job as it arises and take the circuit to pieces when it is no longer required.

This does not sound a very practical proposition and in the past this would have involved careful design and construction, together with the necessary calibration procedures probably not available to the experimenter. With the advent of the operational amplifier this situation has changed and it is now quite feasible to construct, for example, an accurate inductance meter in less than half an hour, provided an a.c. meter, a source of alternating current (for example, 50Hz mains voltage) and an operational amplifier are available.

Before beginning to describe the many uses to which this interesting device can be put, it will probably be necessary to explain to many readers what is meant by an operational amplifier.

WHAT IS AN OPERATIONAL AMPLIFIER?

The operational amplifier was originally developed during the 1940's for use in high accuracy analogue computers. It is basically a d.c. amplifier having a very large gain and it is always used with components added to give a large amount of negative feedback around the circuit. To understand the basic function of an operational amplifier, consider the block schematic diagram in Fig. 1.1 and carry out a few simple calculations on it.

The d.c. amplifier shown in the diagram always consists of an odd number of amplifying stages so as to provide an inverted signal at its output terminals. We can therefore state that its gain is $-A = -V_o/V_i$.

The two elements Z_i and Z_f are added to provide negative feedback. The input element has an impedance Z_i and the feedback element has an impedance Z_f. We can see from the diagram that the input signal current to the amplifier, i_i, is the sum of the current through the feedback network, i_{fb}, and that through the input element, i_s.

$$i_i = i_{fb} + i_s$$

Now if the voltages at the input and output of the whole network are v_s and v_o, as shown, and the actual voltage at the amplifier input as v_i, then using Ohm's Law:

$$i_i = i_{fb} + i_s = \frac{v_o - v_i}{Z_f} + \frac{v_s - v_i}{Z_i}$$

The design of the d.c. amplifier (assumed in Fig. 1.1) is such that it has a very high input impedance so that its grid (or base in the case of a transistor amplifier)

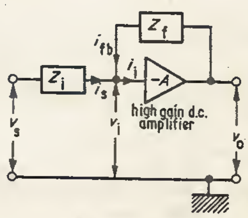


Fig. 1.1. Basic theoretical circuit of the operational amplifier

current i_i is very small indeed—in practice just a few millimicroamps. Consequently we can afford to ignore this in the calculation and put i_i as zero which simplifies the above equation to

$$\frac{v_o - v_i}{Z_f} + \frac{v_s - v_i}{Z_i} = 0$$

Substituting for v_i, and the output voltage v_o divided by the amplifier gain $-A$,

$$\frac{v_o + \dfrac{v_o}{A}}{Z_f} + \frac{v_s + \dfrac{v_o}{A}}{Z_i} = 0$$

and since A is very large, usually several tens of thousands or more, the value of v_o/A is very small compared with v_o or v_s and can also be neglected.

Consequently we can write a much simplified equation

$$\frac{v_o}{Z_f} + \frac{v_s}{Z_i} = 0$$

or by rearrangement

$$\frac{v_o}{v_s} = -\frac{Z_f}{Z_i}$$

This is the fundamental and very important relationship of an operational amplifier and shows that the input/output gain of the device depends entirely on the ratio of Z_f/Z_i and will not be affected by the internal characteristics of the amplifier itself.

Thus the transistors or valves used in the amplifier can deteriorate, or applied h.t. voltage fall off considerably, before any change in the gain of an operational amplifier is observed. This, of course, assumes that Z_f/Z_i does not become very large (less than 100) which is always the case with a practical amplifier.

As a consequence of this relationship we can, by suitable choice of components for Z_i and Z_f, make the gain of the amplifier vary in strict accordance with these impedance values. It is this fact which is made use of in the various measuring circuits to be described in the following pages.

AN INDUCTANCE METER

By using such an amplifier (a few typical designs are described later) we now have an accurate device with which to measure a number of electrical values.

Consider first the measurement of inductance. The circuit is shown in Fig. 1.2. Here Z_i is a pure resistance, of value R_i ohms, and the feedback network is an unknown inductance, value L henries. To measure its value, set the input alternating voltage at a suitable frequency and measure the output voltage on an r.m.s. reading a.c. voltmeter.

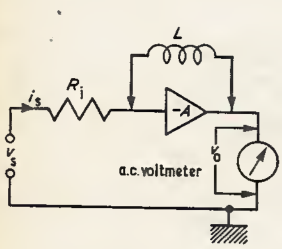


Fig. 1.2. Operational amplifier used as an inductance meter

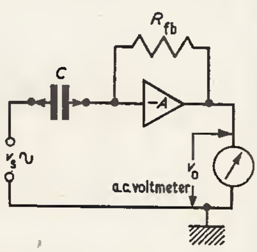


Fig. 1.3. Operational amplifier used as a capacitance meter

The inductance value is given as

$$L = \frac{v_o R_i}{2\pi f v_s} \text{ henries}$$

If a signal generator is available the frequency can be set to, say, 800Hz, and v_s as 4 volts which simplifies reading the inductance value off the meter scale.

The meter shows the direct-reading in inductance, where 1 volt a.c. represents 0·05H, 0·5H, or 5H depending on the value of R chosen.

This will be made clear in the table given below which shows the inductance range available for different values of R_i.

Table 1.1: INDUCTANCE RANGES ON METER

L-range f.s.d. (henries)	R_i (ohms)	v_o (volts)
0–0·5	1,000	0–10
0–5·0	10,000	0–10
0–50·0	100,000	0–10

If a signal generator is not available a 50Hz voltage from the low voltage secondary of a mains transformer can be used. This is, in any case, more convenient for larger values of inductance (say greater than 1H).

If we choose 6·3V r.m.s. from a transformer secondary winding then the selection of suitable values of R_i will again enable a simple-to-read meter scale relationship to be obtained (see Table 1.1).

If smaller values of inductance are required to be measured then a signal generator must be used and the frequency set at 8kHz, when the inductance ranges in Table 1 will be divided by 10.

Mathematically inclined readers may be interested in how the equation for inductance value was derived.

If the grid current, i_i of the operational amplifier is very small, and tends to zero, then the input current from the signal generator (i_s) passes through R_i and L in series and we can write for this current,

$$i_s = \frac{v_s}{R_i}$$

$$v_s = v_{s(max)} \sin \omega t$$

where $v_{s(max)}$ is the maximum value of v_s and ω is 2π times frequency f. The output voltage developed across L is

$$v_o = L\left(\frac{di_s}{dt}\right)$$

Substituting for i_s and evaluating we have,

$$v_o = L\left(\frac{v_{s(max)}}{R_i}\right)\omega \cos \omega t$$

which gives by rearrangement (ignoring the phase shift),

$$L = \frac{v_o R_i}{2\pi f v_s}$$

The point to note is that the circuit performs the mathematical operation of differentiation and this gives one reason why operational amplifiers are extremely valuable in analogue computer operation.

A CAPACITANCE METER

Exactly the same arrangement can be used in order to measure capacitance. The circuit is shown in Fig. 1.3 and, in this case, the unknown capacitor C takes the place of the input resistance Z_i in the operational amplifier circuit shown in Fig. 1.1. The feedback network is a resistance of value R_{fb} ohms. The capacitance value is given by

$$C = \frac{v_o}{2\pi f R_i v_s}$$

Here again the frequency of the signal generator can be chosen to facilitate meter reading. This can be made 600Hz and v_s as 26·5V r.m.s. The range will then depend on R_i as seen from Table 1.2.

Table 1.2: CAPACITANCE RANGES ON METER

C-range f.s.d. (pF)	R_{fb} (ohms)	v_o (volts)
0–1,000	100,000	0–10
0–10,000	10,000	0–10
0–100,000	1,000	0–10

Table 1.3: HIGHER CAPACITANCE RANGES ON METER

C-range f.s.d. (μF)	R_{fb} (ohms)	v_o (volts)
0–0·1	51,000	0–10
0–1·0	5,100	0–10
0–10·0	510	0–10

For larger values of C (say greater than 0·01μF) the mains frequency of 50Hz can be used. If the signal source is 6·3V r.m.s. as before, then the calibration for the meter (which can be a 0–10V a.c. meter) is simplified as shown in Table 1.3.

The derivation of the capacitance equation follows similar lines to that given for the inductance circuit $v_s = v_{s(max)} \sin \omega t$ as before and

$$i_s = C\left(\frac{dv_s}{dt}\right)$$

The output voltage developed across R is:

$$v_o = i_s R_i = CR\left(\frac{dv_s}{dt}\right)$$

Substituting for v_s and evaluating gives

$$v_o = CR_i \omega v_{s(max)} \cos \omega t$$

From which by rearrangement the original equation for C is

$$C = \frac{v_o}{2\pi f R_i v_s}$$

This too can be described mathematically as a differentiation circuit.

A MEGOHMMETER

Measurement of resistance values up to several hundreds of megohms can be carried out simply with the operational amplifier circuit in Fig. 1.4. A d.c. supply of up to 10V, a 10V d.c. meter, and a precision input resistance R_i are required in addition to the operational amplifier.

The resistance to be measured R_{fb} is connected across the amplifier feedback path; the value may be read on the meter scale. This will be

$$R_{fb} = R_i\left(\frac{v_o}{v_s}\right) \text{ megohms}$$

where R_i is in megohms.

Table 1.4: RESISTANCE RANGES ON THE METER

R-range f.s.d. (megohms)	R_i (megohms)	v_o (volts)
0–5	0·1	0–10
0–50	1·0	0–10
0–500	10·0	0–10

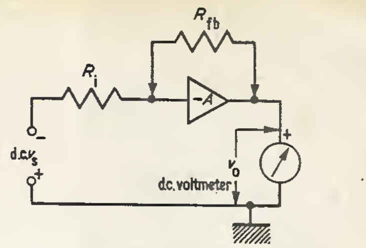


Fig. 1.4. Operational amplifier used as a megohmmeter

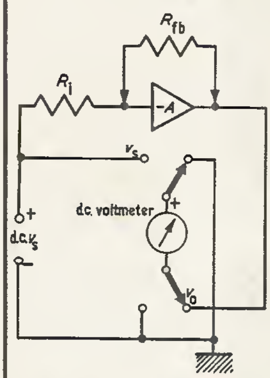


Fig. 1.5. Switching voltmeter between input and output of megohmmeter

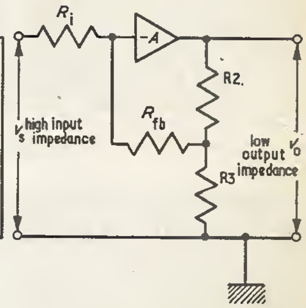


Fig. 1.6. Impedance converter attachment

Notice that an accurate source of voltage is not required. Only the ratio v_o/v_s is required; this can be read by putting the meter across input and output terminals in turn (see Fig. 1.5).

From the point of view of easy scale reading it is convenient if v_s is fixed. If v_s is chosen to be 0·2V, then the output meter can be calibrated directly in megohms as given in Table 1.4.

HIGH INPUT IMPEDANCE ATTACHMENT

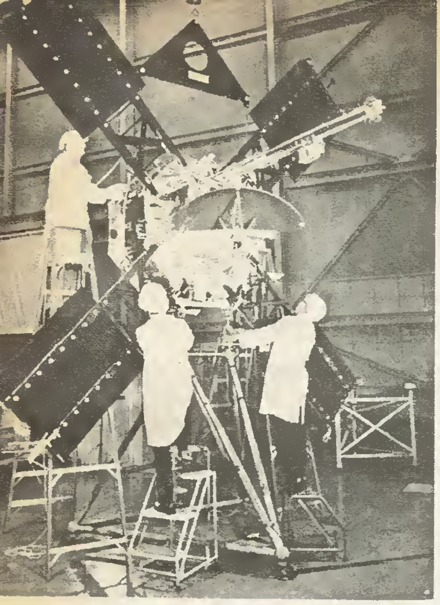
The need often arises to measure a d.c. voltage at a high impedance point in the circuit where an ordinary multi-range meter will not be suitable. This type of meter usually has an internal resistance of 20,000 ohms/volt and will load the circuit much too heavily.

The operational amplifier circuit in Fig. 1.6 will achieve this type of measurement with very little loading. The input resistance R_i can be made very many megohms; the combination of low impedance meter and operational amplifier will have the characteristics of a vacuum tube voltmeter.

Choice of component values for the feedback network is important since, if R_{fb} is too large, some noise will be introduced into the circuit.

For a gain of -1 we must make $R_2/R_3 = R_i/R_{fb}$. For an input resistance of, say, 10 megohms (R_i) and a reasonable value for R_{fb}, say 1 megohm, then R_2 could be 100 kilohms and R_3 = 10 kilohms which will give an extremely satisfactory performance.

Next month: The operational amplifier used to measure very small currents and voltages.



Checking all stages of Mariner-Venus satellite

SPACEWATCH

By Frank W. Hyde

ROBOT REPAIR SATELLITE

The Aero-Propulsion Laboratory of the U.S. Air Force awarded a contract to the General Electric Corp. of America for a study of an android type of satellite which could perform rescue and repair operations in space. It would also be required to maintain satellites in space. The robot would be operated entirely by a remote control system which could be Earth based or in a nearby space vehicle.

The scheme envisages quite sophisticated techniques since there would be a kind of "force feedback" so that the remote operator could "feel" the moment-to-moment contact operations of the manipulators. The application of manipulative methods that have been developed over the past few years, both mechanical and bio-electrical, would enable the operators to be in complete control with all data transmitted back to his hands at any moment.

Present limitations on completely remote control of such delicate actions is one of time lag. In near space, such as for vehicles in earth orbit, there would be no difficulties but for vehicles at moon distances the effect of the communication time lag would become significant. A specification based on previous work has been put forward by Richard H. Blackner of GEC.

The robot repair satellite would consist of two master slave arms and hands, the telemetry system, and a television system mounted on a manoeuvrable satellite under remote control which carries tools and spares. Remote firing of directional thrusters could bring the roving satellite to that needing attention and the television cameras would enable the remote operator to couple the two together. Experimental packages could be exchanged, mechanical maintenance of parts carried out, and so on.

One of the special purposes would be to keep satellites in longer operational condition by regular maintenance and or replacement of defective parts.

FRENCH WORK IN ROCKET ASTRONOMY

The French National Centre for Space Research have developed a rocket stabilisation system to enable small telescopes to be mounted on a rocket for measurements above the atmosphere.

The inertial platform system called "Cassiopea" can attain fine pointing on certain flights. The system can be used with solid or liquid fuel rockets. The fine pointing device has so far only been used with liquid fuel rockets.

The pointing accuracy is claimed to be one degree using the inertial platform alone and half a degree using fine pointing. Two star trackers are used to lock the system. The size of the mirror system is about 50cm.

WIND PHOTOGRAPHED BY RADIO TELESCOPE

The first photographic records of the extremely violent winds that occur in the fringe areas of the earth's atmosphere have been made in Australia. These were obtained by Dr B. H. Briggs and his team at the University of Adelaide using an aerial system of 89 aerials mounted on poles 10 metres high and carrying 16km of wire covering an area of $2km^2$.

Pulses from a transmitter are reflected from cloud like formations appearing at a height of between 80 and 640km above the Earth and picked up by the aerial system. Each aerial is connected to a radio receiver which carries the reflected impulses to a control system which varies the brightness of lamps. The moving pattern across these light screens corresponds to the upper atmosphere wind.

The array was completed by the staff and students of the University in three years at about one third the cost of putting the work out to contract.

ROCKETS TO PROBE SOLAR ECLIPSE OF 1970

At Quoddy Inlet, Canada, Nova Scotia scientists are planning to use Black Brant III rockets to probe the upper atmosphere during the eclipse of the sun next year. There will be two experiments, one carried out under Dr A. G. McNamara which will make a direct measurement of the variation of electron density and positive ion densities over the complete trajectory of the rocket. This means that there will be two measurements of the D- and E-regions.

The other experiment will be under the direction of Dr J. S. Belrose and will measure the differences in the propagation of radio waves using a ground based transmitter which radiates circularly polarised pulse pairs. This will provide a measure of the density of the electrons up to a height of 80km.

The sequence of the experiments will be arranged so that the first rocket will be fired six minutes before the moon begins to pass between the earth and the sun so that the undisturbed condition of daytime ionisation can be used as a base level. The other three rockets will be fired when about 80 per cent of the suns disc is occulted by the moon.

Previous ground based observations have shown that the greatest changes in ionisation occur between this period of obscuration, reaching a maximum some six minutes after total obscuration. The three rockets will therefore be fired at intervals of six minutes starting just before totality and ending just after the sun reappears.

CANADA'S THIRD SATELLITE

Isis–A Canada's third artificial satellite is a follow up of the two previous successful *Alouette I* (1962) and *Alouette II* (1965) both of which are still doing extremely useful work. The new addition is in a near polar orbit which is elliptical and measures 350 nautical miles at perigee and 1,890 nautical miles at apogee.

The purpose of Isis–A is similar to the previous satellites, namely to make a study of the ionosphere in time and space.

In all, ten experiments are planned and one of these will be a fixed frequency device to map horizontal electron density; another will record vertical density. The other experiments will include the measurement of particle temperature, densities, composition, and radio noise. A v.l.f. receiver will pick up signals generated by lightning.

AGAINST THE BIG BANG

A recent experiment has been performed by scientists in a joint effort between Cornell-Sidney University Astronomy Centre and the Naval Research Laboratory in Washington. This has produced results that seem to cast doubts on the big bang theory.

An *Aerobee* rocket was launched carrying a liquid helium cooled telescope to a height of 170km. Also contained in the rocket were four solid state detectors which were sensitive to a wavelength between 1·3 millimetres and 0·5 microns. The signals recorded in the range were found to be two orders of magnitude greater than was to be expected, namely 8·3 degrees Kelvin as against the 3·0 degrees Kelvin required to support the "big bang" theory.

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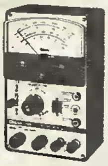

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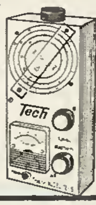

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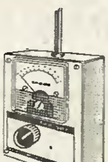

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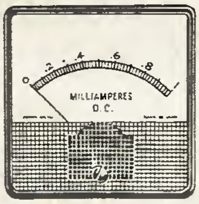

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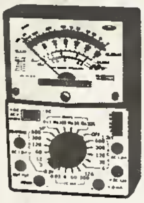

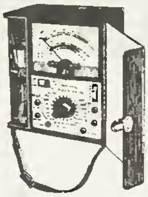

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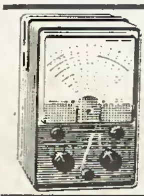

Features low price for such an instrument. Large 6in full view scaled meter. 28 ranges. **D.C. volts:** 0/1½/5/15/50/150/500/1500. **A.C. volts:** 0/1½/5/15/50/150/500/1500 r.m.s.; 0/1·4/4/14/40/140/400/1400/4000 p-p. **Resistance:** R × 10–100–1k–10k–100k–1m–10m. Range 0·2 ohm to 1000MΩ. **dB scales:** −10 to +65dB. Complete with instructions and leads. H.V. Probe, 50/–. R.F. Probe, 42/6.
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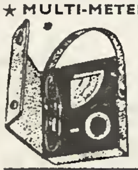

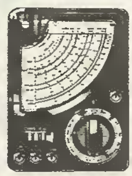

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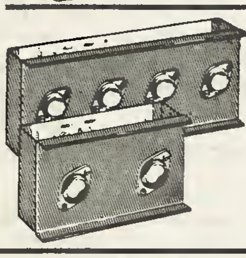

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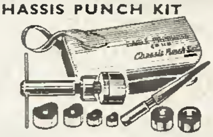

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Linear Scale OHMMETER

By A. FOORD

This ohmmeter eliminates reading interpolation difficulties, allows the use of standard linear scale meters, and can be used to test transistors safely

A CONVENTIONAL ohmmeter has a non-linear scale (Fig. 1a) which may cover several decades. Whilst this enables a multimeter to cover a wide ohmic range, a meter with a linear scale (Fig. 1b) has several other advantages.

The meter can be read more easily and more accurately, because only a ten to one range is covered and because equal scale divisions make interpolation easer.

Also a standard linear meter scale can be used. This is most important as anyone who has paid several pounds for a microammeter, in order to build a multimeter, is unwilling to attempt to calibrate an extra scale. In any event, most meters have an arrow type of pointer rather than a knife edge, so that there is no room for the extra scale.

BASIC CIRCUITS

The basic circuit for a linear scale ohmmeter is given in Fig. 2. This circuit consists of a constant current generator connected in series with the resistance to be measured (Rx). Since the current through Rx is maintained constant, the voltage measured is directly proportional to its resistance. Thus, by choosing a suitable scale, the voltmeter can be directly calibrated in terms of resistance. No zero or f.s.d. adjustments are required, because once set up, accuracy depends on the stability of current regulation rather than on adjustments to compensate for changes in battery voltage. With the circuit finally chosen a drop in battery voltage of 15 per cent has little effect on reading accuracy.

If we take an example where I is kept constant at 1mA and we can measure from 0 to 10 volts then, from Ohm's law:

$$E = IR \quad \text{or} \quad R = \frac{E}{I}$$

then, since I is constant at 1mA: $R \propto V$ in kilohms. For a 1 kilohm resistor we would measure 1V and for a 10 kilohm resistor we would measure 10V. One method of obtaining a constant current is shown in Fig. 3.

The emitter of the transistor will remain at approximately 0V, so that 1mA will flow through the transistor and the unknown resistance.

This circuit has the disadvantage that the voltmeter must take a current which is small in comparison to I, so that the majority of the current does in fact flow through the unknown resistance. While this is possible when I is greater than 1mA (using a meter of 100μA f.s.d.) this would no longer be possible if I is reduced to 100μA or less.

Fig. 1a. The non-linear scale of a conventional ohmmeter

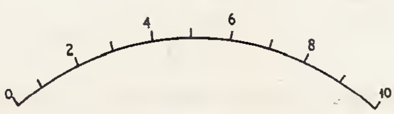
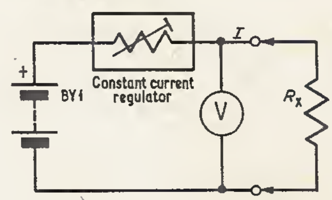
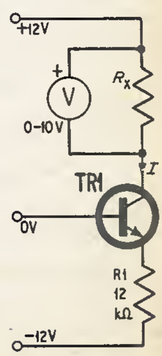


Fig. 1b. A linear-scale, as used in the linear-scale ohmmeter

Fig. 2 (below). The basic circuit of the linear scale ohmmeter

Fig. 3 (right). A simple constant current generator





An additional difficulty with this circuit is that the transistor might not have a good current gain at such a low collector current. What we require is a method of sensing the current through Rx regardless of the current through the voltmeter, and this leads to the basic arrangement of Fig. 4.

Here the current I develops a voltage V_R across a standard resistance R and this voltage is compared (by a differential amplifier "A") with a reference voltage (V_r) of 5·6 volts.

If V_R is greater than V_r the amplifier alters the base current of the series transistor (TR2 in Fig. 5) to reduce its collector current, so that V_R is made equal to V_r. The current I is maintained by this negative feedback loop at a value determined by:

$$I = \frac{V_r}{R}$$

By switching R we can obtain constant currents between 10μA and 10mA, provided we observe the following points.

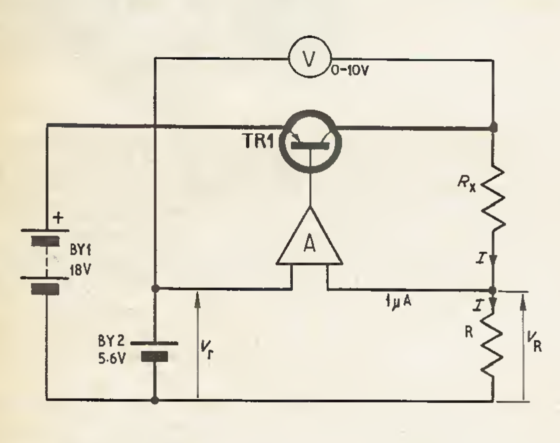


Fig. 4. Block diagram of the linear scale ohmmeter

DESIGN NOTES

The amplifier A must take much less than 10μA from the R_x, R chain. It does not matter that, in fact, it takes 1μA (10 per cent of the lowest current range) since it remains constant. Hence we can allow for the fact that, on the lowest range, 9μA rather than 10μA will flow through R; on the other ranges this 1μA drain has no significance.

If R_x is zero, M1 will read zero and no current will flow through the meter, if R_x has a finite value M1 will read and draw current through TR2; however, since this current does not flow through the sensing resistor R, the constant current I is in no way affected.

If a Zener diode is used to provide the 5·6 volt reference, I will remain constant for small changes of Zener current.

In our practical circuit V can be measured by any meter with a 0 to 10V range provided it consumes not more than 1mA for f.s.d. A 1mA meter and appropriate series resistor (10 kilohms less the meter resistance) is used, but the 10V range of a multimeter would serve equally well.

No protection device is needed to prevent damage to the meter, since even with the measuring terminals open circuit only 13V appear across the meter; although this drives the meter over full scale, no harm will result.

Table 1

R	560kΩ	56kΩ	5·6kΩ	560Ω
I	10μA	100μA	1mA	10mA
R_x	1MΩ	100kΩ	10kΩ	1kΩ

Values of R from 560 ohms to 560 kilohms give constant currents from 10mA to 10μA and ohms ranges from 1 kilohm f.s.d. to 1 megohm f.s.d. (Table 1).

PRACTICAL CIRCUIT

The practical circuit is shown in Fig. 5; there are several points worthy of mention.

On the lower current ranges (less than 1mA) the collector current of TR2 would be 2mA or less (including current demanded by the meter). This current is increased by adding R4, to avoid the drop in transistor current gain which occurs at low collector currents.

To avoid high frequency instability in what is basically a feedback stabilised power supply, two measures are incorporated which are effective on all ranges with the terminals open or short circuited.

Firstly a capacitor C2 is included across the terminals to ensure that they are always connected together as far as h.f. is concerned. Secondly C1 is connected from the collector of TR1 to the negative rail to "roll off" the amplifier frequency response at a low frequency. Since TR1 only passes a collector current of 100μA, C1 should be a low leakage type, preferably tantalum; its value is not critical.

CONSTRUCTION

Construction is straightforward and shown by the photograph and drawings. Veroboard was used for the amplifier, which is mounted on the meter terminals, as shown in Fig. 6.

The complete amplifier should be constructed and all external wires attached (Fig. 7)—these cannot be added once the amplifier is mounted. The amplifier can then be mounted to the meter terminals.

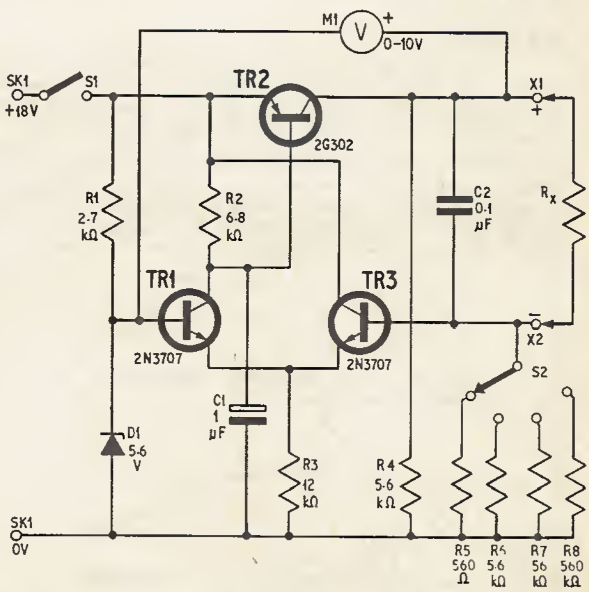


Fig. 5. Practical circuit of the linear scale ohmmeter

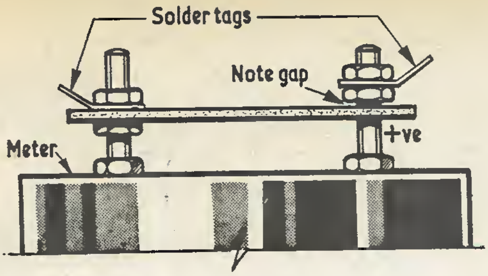


Fig. 6. Amplifier mounting details

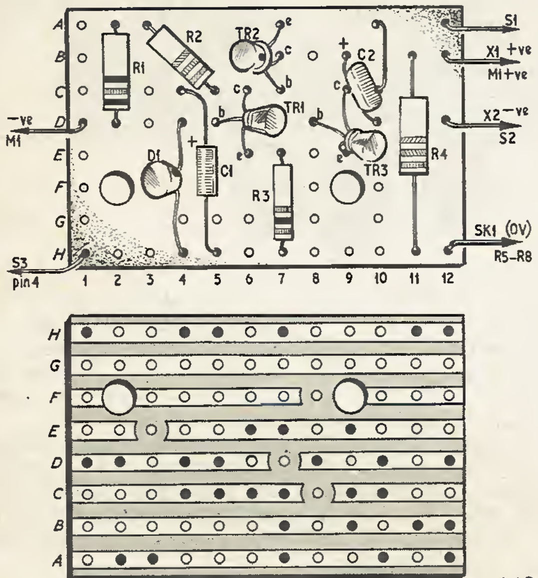


Fig. 7. Layout of the amplifier and underside of the Veroboard

COMPONENTS . . .

Resistors

R1 2·7kΩ
R2 6·8kΩ
R3 12kΩ
R4 5·6kΩ
R5 560Ω
R6 5·6kΩ
R7 56kΩ
R8 560kΩ
(R5–R8) ±2%, ¼W, high stab. (see text)
All ±10%, ¼W carbon except where stated

Capacitors

C1 1μF elect. or tantalum 24V
C2 0·1μF polyester

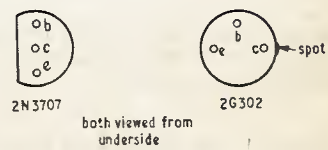
Transistors

TR1 2N3707
TR2 2G302
TR3 2N3707

Miscellaneous

M1 0–10V f.s.d. (see text)
S1 Single pole on/off switch
S2 Single pole, 4 way wafer switch
SK1 Two way polarised plug and socket
Terminals, insulated (3 off)
Diecast box 4¼in × 3½in × 2in
Veroboard
18V battery

For modification components see Fig. 9



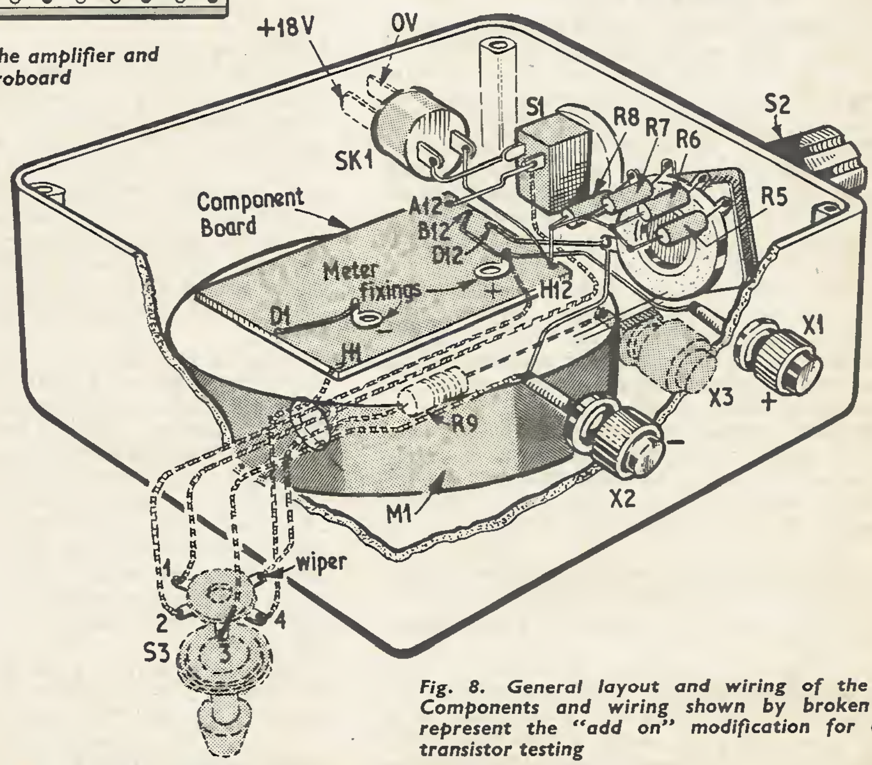


Fig. 8. General layout and wiring of the unit. Components and wiring shown by broken lines represent the "add on" modification for easier transistor testing

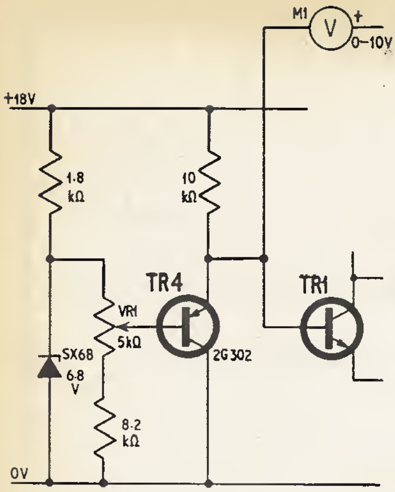
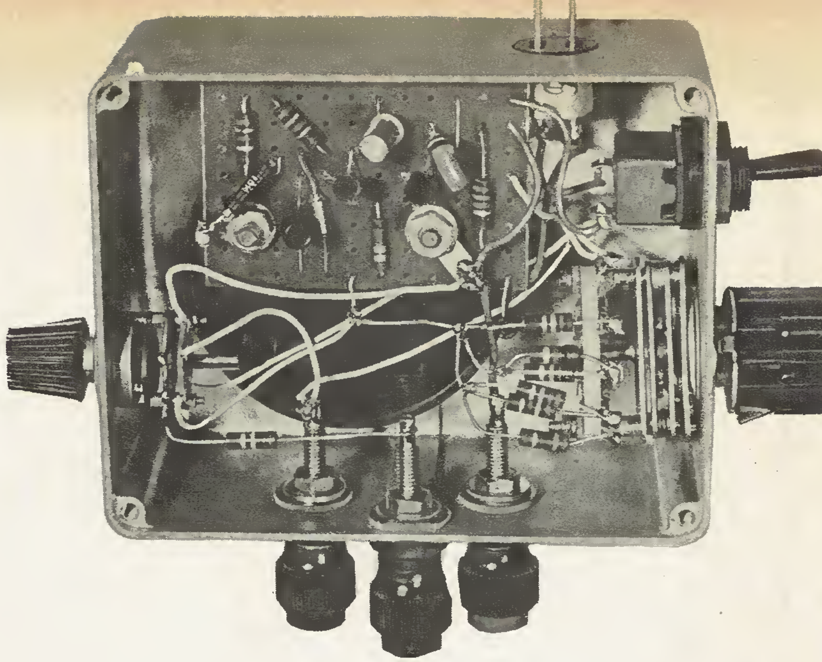


Fig. 9. Circuit modification to provide a calibration control



Due to the layout employed there is insufficient clearance on the amplifier board to anchor the board to the positive meter terminal without shorting the copper strips. The board must be spaced above the back of the meter and secured to the positive terminal only (Fig. 6).

The ohmmeter can then be wired up as shown in Fig. 8 but, at this stage, the sensing resistors R5 to R8 should not be connected.

TESTING AND CALIBRATION

Switch to range 2 (1mA current) and solder in R6 (5·6 kilohms), then switch the unit on. With the terminals open circuit the meter should read over full scale; if the battery voltage is reduced to 12 volts the meter should now read about 6·5V (12V—5·6V). If this is satisfactory return the supply to 18V. Next short circuit the terminals and check that the meter reads between 0V and 0·2V. This small voltage represents the difference in base to emitter voltages of TR1 and TR3; the mechanical zero of the meter can be adjusted to obtain a zero reading.

There are several possible methods of calibration depending on the accuracy required. If the Zener voltage is exactly 5·6V and the resistor exactly 5·6 kilohms, then the current would automatically be correct at 1mA. Our readings would then only depend on the accuracy of the voltmeter.

The simplest arrangement is to use close tolerance resistors for sensing and accept any errors due to Zener and voltmeter tolerances. Then the maximum error is:

Voltmeter error (±2 per cent f.s.d.) + Zener tolerance (±5 per cent) + Resistor tolerance (±2 per cent).

Hence, using this method, we could expect an accuracy of ± 10 per cent of f.s.d. for all ranges except the 1 megohm range (we have not allowed for the 1μA drawn by the amplifier).

A better approach is direct calibration at f.s.d. against known resistors of 1, 10, 100 kilohm and 1 megohm. If we take the 10 kilohm range as an example; connect the 10 kilohm standard across the terminals (SK1). If the meter reads high then the constant current is high and must be reduced. It is possible that another 5·6 kilohm resistor would give the required f.s.d. Select a resistor to give a low reading on the meter (going to 6·8 kilohms or 8·2 kilohms if necessary and shunt it with a higher value (start at 68 kilohms) until the meter reads f.s.d.

This can be repeated for the other ranges using appropriate values. A potentiometer and a series resistor could be used for each range provided there is room in the box. With careful setting up an accuracy of ±2 per cent of f.s.d. can be achieved, using this method for each range.

MODIFICATIONS

The setting up procedure outlined has the disadvantage that it is laborious and depends on the Zener voltage; a change of Zener diode would mean recalibrating to obtain the previous accuracy. To overcome this a modified circuit can be used to provide an f.s.d. setting arrangement (Fig. 9).

In this case the sensing resistors can be 2 per cent high stability types to maintain range to range consistency (the 560 kilohm may need adjustment). VR1 is adjusted to set f.s.d. on a known resistor. The emitter follower TR4 has to be used in order to pass the meter current.

When the test terminals are open circuited the base of TR3 is connected to 0V (via the range selection resistor) while the emitter is maintained positive and 0·6V below the Zener voltage. For Fig. 5 this amounts to a reverse bias on the base-emitter junction of TR3 of 5V, which is within the maximum rating of 6V for the 2N3707.

With the modified circuit (Fig. 9) this reverse bias could reach 6·2V (for a nominal Zener voltage of 6·8V) and is dangerously near the maximum rating. To prevent damage to the transistor should breakdown occur, a 22 kilohm resistor must be included in series with TR3 base to limit the position reverse current to a safe value.

Since under normal working conditions the current bias into the base of TR3 is small, the 22 kilohm resistor in no way affects normal circuit operation, and can also be included in the wiring in Fig. 7 as an added safety measure if required.

USES OF THE OHMMETER

The linear scale ohmmeter can be used for a variety of applications apart from its normal use as an ohmmeter. Some of these uses are described in detail below. The theory behind these uses and the limitations of each method are given where applicable.

ZENER DIODE TESTING

The unit can be used as a constant current source to test Zener diodes. The graph (Fig. 10) shows a normal Zener diode operated from 10μA to 10mA and the reverse breakdown voltage of the base-emitter junction of a 2N709 transistor. Since the junction is quite small currents of less than 1mA were used.

It is interesting to note that the transistor breakdown voltage remained constant down to low levels while the conventional Zener diode voltage fell. This is because the Zener diode was designed to pass currents of up to approximately 50mA, while the base-emitter junction of the transistor was only designed to dissipate a few milliwatts and is inherently a low current Zener diode.

TRANSISTOR TESTING

The unit can be used to test small signal transistors, with the advantage that the possibility of damaging the transistor is reduced. The possible tests have been divided into two sections, one covering tests on *npn* transistors and the other for *pnp* transistors.

NPN TRANSISTORS

Reverse Base-emitter Breakdown Voltage

As suggested in the previous section this can be measured at currents of up to 1mA without damaging the transistor.

Collector Saturation Voltage

This can be measured as shown in Fig. 11. If the base is shorted to the emitter, the transistor will turn off and the meter will read over f.s.d. If the base is connected to +18V via a resistor, the transistor will turn hard on and the meter will read almost zero (0·3V for a germanium transistor and 0·7V for a silicon transistor).

DC Current Gain

For this arrangement the base is connected to the collector via a resistor (Fig. 12). Most of the constant current (I) is passed through the collector and the base

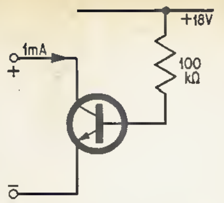


Fig. 11. Arrangement to measure collector-emitter saturation voltage in an npn transistor

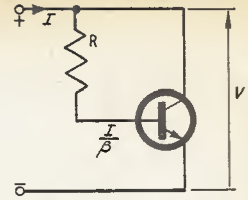


Fig. 12 Arrangement to measure current gain in an npn transistor

current has to be (I/h_{fe}) which means that the collector voltage must go to (I/h_{fe}) $\times$ R volts to maintain the correct base current.

$$\text{Collector current} = I\,\text{mA}$$
$$\text{Base current} = (I/h_{fe})\,\text{mA}$$
$$\text{Collector voltage } V = (I/h_{fe})\,R\text{ volts}$$

Rearranging:

$$h_{fe} = \frac{IR}{V}$$

We must use resistor values and constant current values appropriate to the transistor.

Example 1:

Choose $I = 1$mA, $R = 100$ kilohms

The maximum voltage which can appear across the transistor is 13V. Therefore the maximum transistor dissipation = 13mW.

These values are suitable for almost all small signal transistors with gains up to 100 times. A 2N709 transistor gave a reading of 6V.

Therefore $\quad h_{fe} = \dfrac{100}{6} \simeq 16\ (I_c = 1\text{mA})$

Example 2:

Choose $I = 10$mA, $R = 10$ kilohms
Maximum transistor dissipation = 130mW
The same 2N709 transistor now read 4V.

Therefore $\quad h_{fe} = \dfrac{100}{4} = 25\ (I_c = 10\text{mA})$

Example 3:

To observe the effects of leakage, a high gain germanium transistor was tested (2N1308).

Choose $I = 1$mA, $R = 1$ megohm

With the base open circuit the meter read 8V showing that leakage was quite high. With the 1 megohm resistor connected, the meter read 4V.

Therefore $\quad h_{fe} = \dfrac{1{,}000}{4} = 250\ (I_c = 1\text{mA})$

With a high leakage transistor it might be necessary to use a collector current of 10mA in order to avoid leakage problems.

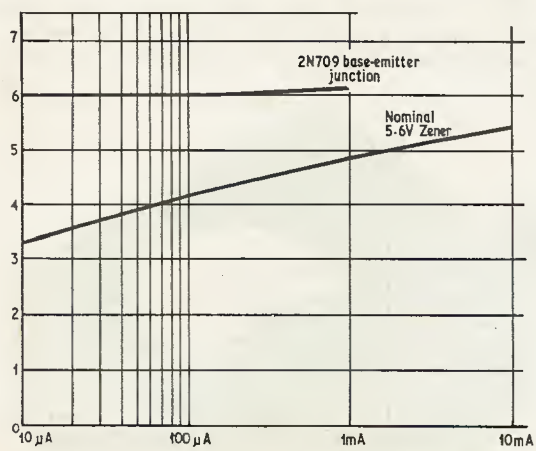


Fig. 10. Graph of results obtained when testing a 5·6V Zener diode and the base-emitter breakdown voltage of a 2N709 transistor

PNP TRANSISTORS

Reverse Base-emitter Breakdown Voltage

This can be measured in the same way as for *npn* transistors, but taking note of the reverse polarity required (Fig. 13).

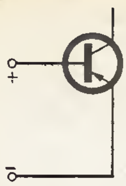


Fig. 13. Arrangement to measure base - emitter reverse breakdown voltage of a pnp transistor

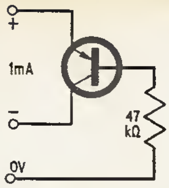


Fig. 14. Arrangement to measure saturation voltage of a pnp transistor

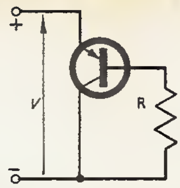


Fig. 15. Arrangement to measure current. gain of a pnp transistor

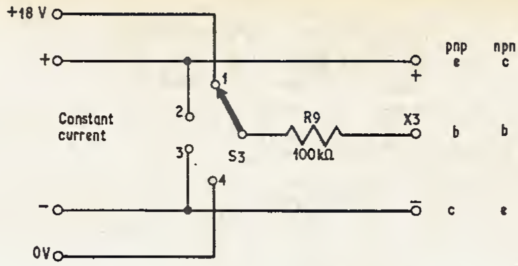


Fig. 16. The circuit of an "add on" unit designed to aid transistor testing

Collector Saturation Voltage

This can be measured at 1mA collector current by connecting a resistor to the 0V rail (Fig. 14).

D.C. Current Gain

Again, this can be measured by using a resistor between base and collector (Fig. 15).

Example 1:

A V205 transistor was tested $I = 1\text{mA}$, $R = 100$ kilohms, $V = 4\text{V}$

Therefore $$h_{fe} = \frac{100}{4} = 25$$

Example 2:

Transistor was 2G302, $I = 1\text{mA}$, $R = 100$ kilohms, $V = 1{\cdot}4\text{V}$

Therefore $$h_{fe} = \frac{100}{1{\cdot}4} \simeq 70$$

Since this collector voltage of 1·4V is lower than we would normally run the transistor, the current should be increased to 10mA (the transistor is rated at 200mW dissipation so we will be within its limits).

Using the same transistor, $I = 10\text{mA}$, $R = 100$ kilohms, $V = 6{\cdot}5\text{V}$

Therefore $$h_{fe} = \frac{1{,}000}{6{\cdot}5} \simeq 150$$

MODIFICATION TO INCORPORATE TRANSISTOR TESTER

By adding an extra terminal and a four-way switch several tests can be made (Fig. 16). For a given switch position the function measured depends on the type of transistor (*pnp* or *npn*), see Table 2. The positions and their uses are set out below for both *pnp* and *npn* transistors.

FOR PNP TRANSISTORS

Position 1

The transistor is held hard off by the resistor to a positive rail and the meter should read over f.s.d. for currents of 10mA or 1mA, unless the transistor is shorted or its collector to emitter breakdown voltage is less than 10V.

Position 2

In this position the transistor is only slightly held off by the resistor between the base and emitter. As an example the 2G302 read over f.s.d. on all ranges except the 10μA where it read 0·1V.

Table 2

Range	PNP Test	NPN Test
1	Short c-e	Saturation at 1mA
2	Leakage	Gain
3	Gain	Leakage
4	Saturation at 1mA	Short c-e

Position 3

Here the resistor is connected to the collector and gain can be measured from the formula $h_{fe} = IR/V$.

Position 4

If I is set to 1mA, the transistor will saturate (meter reads 0·3V or 0·7V) if h_{fe} is greater than 10.

FOR NPN TRANSISTORS

Exactly the same tests can be applied, except that the switch positions are reversed.

Position 1

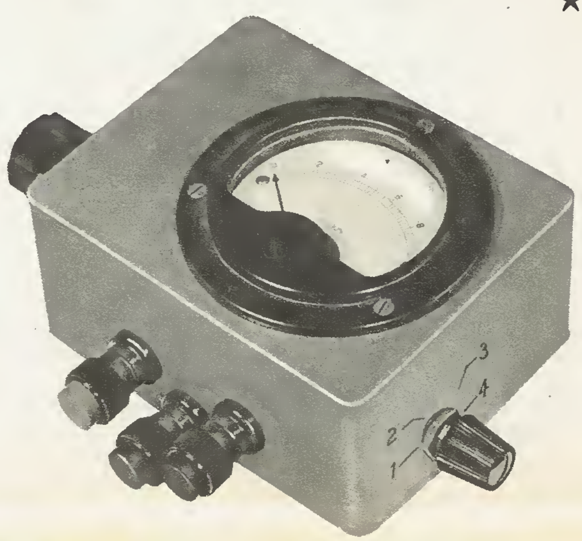
If I is 1mA the transistor will saturate, if it has a h_{fe} greater than 20 (the voltage available to force current into the base of the transistor is lower in this configuration).

Positions 2 and 3

These positions are as for the *pnp* transistors.

Position 4

Here the transistor is held off by 5·6V, which could cause the base-emitter junction to break down, but this is harmless since the current is limited to less than 0·2mA. ★



COLD CATHODE TUBES

By J. B. Dance M.Sc.

Part TWO

GAS FILLED DIODES

Gas filled cold cathode diodes have many uses in electronic circuits and it will be possible only to give details of some of their more common applications in this article. Miniature neon diodes, operating in the glow discharge region of the characteristic, are used on instrument panels as indicator lights, whilst larger neon diodes can be used for night lighting in sick rooms.

Various types of diode operating in the glow discharge and corona modes have been designed for voltage stabilising purposes. In addition miniature neon diodes are often used as circuit elements, for example, in simple relaxation oscillators, for pulse storage, for routing telephone calls, and for carrying out timing operations. However, these latter are not so widely used as the more versatile trigger tubes in this particular application.

MAIN PROPERTIES

In last month's article, it was stated that as the voltage across a cold cathode tube is increased from zero, hardly any current flows until the striking voltage of the tube is reached. At this point the gas suddenly conducts and the current through the tube is limited by the resistor placed in series with it. The voltage across the conducting tube after striking is known as the maintaining voltage and is lower than the actual striking voltage.

A group of miniature neon diode indicator tubes (Cerberus A.G.)

VOLTAGE INDICATORS

Miniature neon diodes containing two small electrodes in a glass envelope are often found in domestic equipment. The type of circuit which may be used is shown in Fig. 2.1. The diodes used have two identical electrodes so that current can flow through them in either direction without undue damage; the diode shown in the circuit is therefore represented by a symmetrical symbol, each electrode combining the anode and cold cathode symbols.

When the switch is closed, the neon diode will strike as soon as the instantaneous voltage of the alternating mains input reaches the striking voltage of the diode used. The tube will be extinguished when the mains voltage falls below the maintaining voltage of the diode towards the end of each half cycle, but will ignite again during the succeeding half cycle. Thus the tube emits 100 flashes of light per second but is seen by the eye to produce a fairly steady glow.

The resistor R1 is the current limiting resistor. If it is too small in value, the maximum current rating of the neon diode will be exceeded and the envelope of the tube may be blackened fairly quickly by sputtered material. If R1 is too large, however, the amount of light emitted by the neon will be very small.

Some neons have the series resistor incorporated in the tube holder. The optimum value of the resistor depends on the type of diode used and the supply voltage. For 240 volt mains a typical value of the series resistor is 470 to 680 kilohms for a diode rated at 0·5mA.

Neon indicator lamps have the advantage over tungsten filament lamps that they are almost entirely free from sudden failure and their current consumption

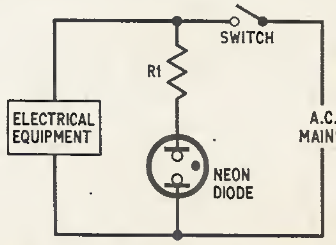


Fig. 2.1. Use of a symmetrical neon diode as a mains indicator

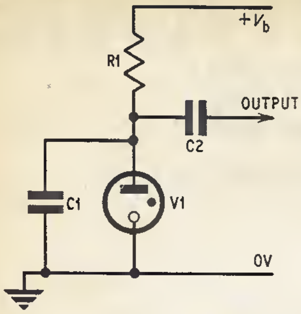


Fig. 2.2a. Simple relaxation oscillator using a neon diode

The G42 switching diode designed mainly for use in timer circuits
(Cerberus A.G.)

V1	GL6LS	GL10L
R1	8·2MΩ	560kΩ
R2	4·2MΩ	22kΩ
C1	0·33μF	0·22μF
D1	BXY10	BXY10

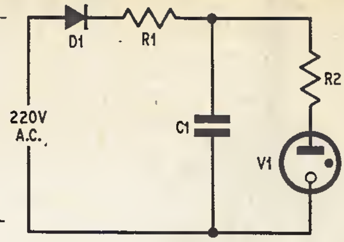


Fig. 2.3. Simple sawtooth waveform generator for a.c. mains

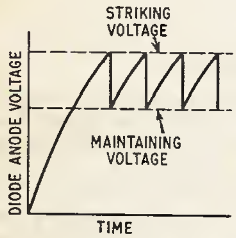


Fig. 2.2b. Graph showing the output voltage from V1 anode

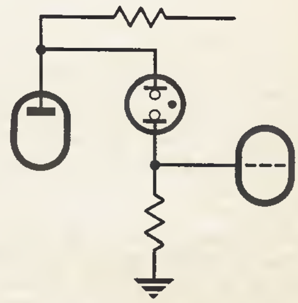


Fig. 2.4. Coupling valves with a neon diode

is negligible. After many thousands of hours of use the light emitted by a neon diode falls owing to sputtered material collecting on the envelope of the tube. The diode can then be replaced before total failure occurs.

The use of fluorescent coatings on the inside surface of a neon tube enables neon tubes to be manufactured which emit light of almost any chosen colour.

RELAXATION OSCILLATOR

Neon diodes may be used in a fairly wide variety of pulse circuits, but for many applications they tend to be replaced by the more versatile trigger tubes (to be discussed next month). However, one of the simplest possible oscillator circuits can be constructed using a single neon diode; it is shown in Fig. 2.2.

When a voltage is applied to the circuit, C1 charges up until the voltage across it reaches the striking voltage of the tube. The tube then conducts and remains conducting until the voltage supplied by C1 falls to the maintaining voltage. The tube stops conducting, the capacitor starts to recharge via R1, until the striking voltage is reached again. Fig. 2.3 shows the graph of neon diode anode voltage during charge and discharge of C1. The result is a sawtooth waveform containing even harmonics of the fundamental frequency.

The frequency of oscillation is determined mainly by the time taken for the capacitor C1 to charge through R1, since the discharging time is quite small. Thus the frequency is determined mainly by the values of C1 and R1, but the supply voltage also has some effect. Cold cathode diodes cannot oscillate at very high frequencies and if the product of the values of C1 and R1 is relatively small, the oscillations will cease. Generally R1 should be greater than about 300 kilohms. If a large value of C1 is required to produce a low output frequency, a resistor should be placed in series with this capacitor to limit the value of the current flowing through the tube. C2 is a d.c. blocking capacitor in series with the output.

The output voltage is approximately equal to the difference between the striking and maintaining voltages. Types of diode known as "difference diodes" are available in which the striking voltage is much greater than the maintaining voltage. Such diodes will provide large output voltages from the circuit in Fig. 2.2. For example, the Cerberus difference diode type G42 has a striking voltage of about 155 volts and a maintaining voltage of about 55 volts. It will therefore provide an output waveform of about 100 volts amplitude.

A practical sawtooth generator circuit (published by the Cerberus Company for their GL range of gas filled diodes) is shown in Fig. 2.3. The value of the capacitor C1 may be altered to provide the desired frequency of oscillation. The electrodes of the GL10L diode are not symmetrical; if this diode is employed, the wire terminal to the inside plate shaped electrode should be used as the cathode connection.

Neon diode relaxation oscillators are sometimes used to provide an audio modulation signal in some of the cheapest types of radio frequency signal generators.

COUPLING

Neon diodes may be used to couple two valve stages as shown in Fig. 2.4. Normally a capacitor would be used, but a neon diode has the advantage that it provides satisfactory coupling for low frequencies.

HIGH CURRENT DIODES

High current switching diodes are rather different from the normal neon diodes; they operate in the arc discharge region and can pass peak currents of up to 10A. The arc voltage across the tube is about 15 volts provided that the current exceeds 50mA. The maximum frequency is limited to about 2kHz. The BD21 tube breaks down at about 200 volts, the BD22 at about 400 volts and the BD23 at about 600 volts.

A typical use of these high current diodes is in electric fence units for keeping farm animals in a field.

GLOW STABILISER TUBES

One of the most commonly used forms of cold cathode tube is the type of voltage stabiliser which operates in the glow discharge region of the characteristic. Such tubes normally contain a central anode wire surrounded by a cylindrical cathode.

The typical circuit in which a glow stabiliser tube is used is shown in Fig. 2.5. This circuit uses the property of the normal glow discharge that the voltage across the tube is almost independent of the current flowing through it.

If the load current passing through R_L increases, the voltage across the load will remain almost constant, but less current will flow through the stabiliser tube. If the h.t. supply voltage is increased, the tube will pass a larger current, but the voltage across it will remain almost constant. A larger voltage drop will therefore appear across R1.

Thus the voltage across the load is stabilised against variations in both the load current and the h.t. supply voltage. This simple circuit will, in a typical case, produce a variation of voltage across the load of about 0·1V for an input change of 10V. The supply voltage should not normally be less than about one and a half times the voltage across the load.

The tube data sheets for any stabiliser tube specify a minimum and a maximum operating current. Variations in the load current as the load resistance changes must not exceed the difference between the specified maximum and minimum tube currents. In practice it must be appreciably less than this difference in order to allow for component and voltage tolerances.

The current passing through the series resistor (R1) is equal to the sum of the tube current (I_{V1}), and the load current (I_L). Therefore the voltage across R1 is equal to $(I_L + I_{V1})\, R_1$.

When I_L is small (or zero), I_{V1} will be a high value which must not exceed the maximum value recommended in the tube data sheets, even if the supply voltage is at its maximum possible value, and R_1 is at the minimum value to be expected from the tolerance of the resistor used.

Similarly when I_L is at a maximum, the value of I_{V1} must not be less than the recommended tube current even if the supply is low (for example, due to a low mains voltage). Simultaneously R_1 should be at the maximum value to be expected from the tolerance of this resistor.

When the h.t. voltage is first applied, the voltage across the tube before it conducts will be

$$V_s\left[\frac{R_L}{(R_1 + R_L)}\right]$$

It is essential that this voltage should exceed the striking voltage of the tube or ignition may not occur.

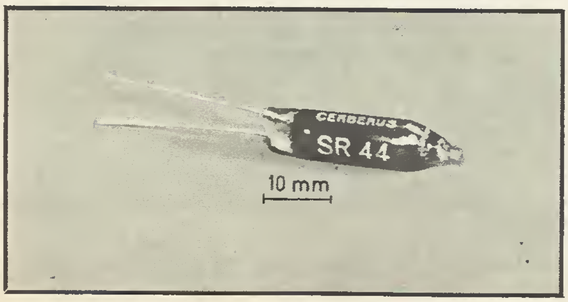
However, some tubes have an additional priming electrode which is connected through a resistor directly to the source of high tension. This ensures that such a tube will strike readily, but only a little current flows to the primary electrode.

REFERENCE TUBES

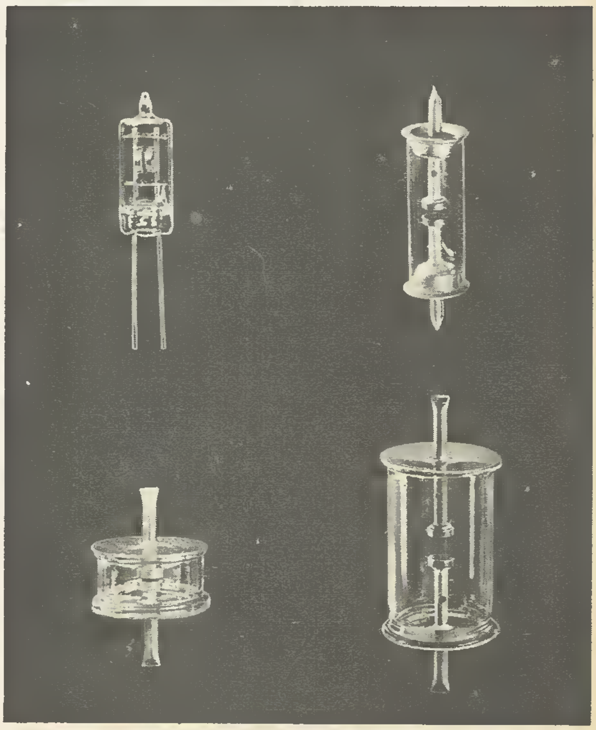
Voltage reference tubes are a particular type of stabiliser tube which are intended to provide the greatest possible voltage stability at a specified current. They should not be used in circuits in which the tube current is likely to change by more than a small amount, since ordinary stabiliser tubes give a better performance in such circumstances.

Reference tubes should therefore be used only when the load current is almost constant. They are used in the same type of circuit as ordinary stabiliser tubes (see Fig. 2.5), but are also used with thermionic valves in more complicated stabiliser circuits.

The SR44 subminiature stabiliser tube providing a stabilised output of 84 volts (Cerberus A.G.)



Precision spark gap tubes for protection circuits and other applications (Victoreen Instrument Co.)

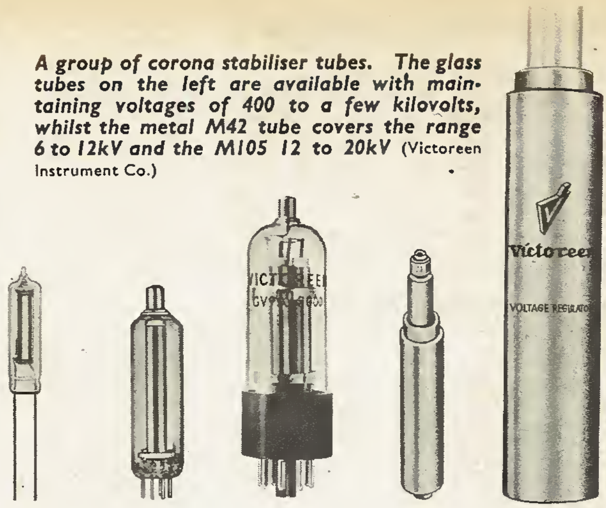


CORONA STABILISERS

Corona stabiliser tubes may be employed to stabilise high voltages at small currents. Tubes which will provide outputs in the range 340 volts to 30,000 volts are available, but the maximum permissible tube current is usually of the order of one milliamp—sometimes even less.

Corona stabiliser tubes contain a thin anode wire in the centre of a cylindrical cathode, the gas filling being hydrogen. When they are operated from a high voltage supply in series with a suitable resistor (normally some megohms), a corona discharge takes place in the tube. The circuit in which the tubes are used is like that in Fig. 2.5.

Corona discharges occur from any sharply curved or pointed surface which is at a high potential relative to its surroundings. Corona effects can cause trouble in the e.h.t. supplies of television receivers and lead to some power losses in high voltage power lines. The discharge can often be heard as well as being seen as a faint glow around the curved surface concerned.



A group of corona stabiliser tubes. The glass tubes on the left are available with maintaining voltages of 400 to a few kilovolts, whilst the metal M42 tube covers the range 6 to 12kV and the M105 12 to 20kV (Victoreen Instrument Co.)

GV3 GV5 GV9 M42 M105

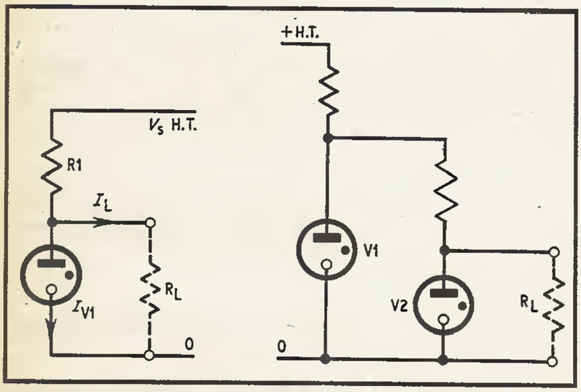


Fig. 2.5. Basic voltage stabiliser circuit

Fig. 2.6. Cascaded stabiliser tubes

The operating voltage of a corona stabiliser is determined by the electrode dimensions and by the gas pressure. Tubes with maintaining voltages up to about 7,000V can be produced in envelopes similar to those used in thermionic valve manufacture. As it is difficult to make a glass seal when the gas is at a pressure above atmospheric, corona tubes for the highest voltages are normally encased partly in metal.

One of the most notable differences between corona and glow stabiliser tubes is that the striking and maintaining voltages of corona tubes are almost equal. No special arrangements are therefore required to ensure that a corona tube will strike promptly.

CASCADED STABILISER TUBES

Glow stabiliser tubes can be used in cascade in the type of circuit shown in Fig. 2.6. The first tube, V1, reduces any voltage fluctuations in the supply considerably and the second tube, V2, reduces them still further. However, this circuit will not provide better stability against variations in the load current than the simpler circuit of Fig. 2.5. A reference tube is often used for V2, the anode resistor of which must normally be a close tolerance component.

Corona tubes can also be used in cascade, although such use is not very common.

HIGHER STABILISED VOLTAGES

The simple voltage stabiliser circuit can provide only an output voltage equal to the maintaining voltage of the tube employed. Although a potential divider circuit may be connected across the output from the circuit in order to obtain lower stabilised voltages, the stability against variations of the load current will be reduced.

If a higher stabilised output voltage is required than can be provided by a single tube, two or more tubes connected in series may replace the tube shown in Fig. 2.5. However, if the tubes are not all of the same type, care must be taken to ensure that there is an adequate overlap of their current ratings. The output voltage is, of course, the sum of the maintaining voltages of the individual tubes.

An alternative method of obtaining a higher output voltage involves the use of a multi-gap tube. Such tubes contain several discharge gaps in one envelope, so intermediate output voltages are also obtainable from circuits employing such tubes. For example, the G.E.C. "Stabilovolt" tubes provide stabilised output voltages of 70, 140, 210 and 280 volts. Two of these tubes may be connected in series to provide stabilised outputs of up to 560 volts at 70 volt intervals.

Corona tubes may be connected in series, but a capacitor of about 1,000pF should be connected in parallel with each tube to avoid the possibility of spurious oscillation.

Neither glow stabiliser nor corona tubes should be operated with tubes connected directly in parallel, since one of the tubes will probably strike first. It is improbable that any other tube will then conduct, since once one tube has ignited, the voltage across the others will be less than the striking voltage.

Both glow and corona stabiliser tubes can be used with thermionic valves in circuits which provide highly stable outputs at voltages and currents which may be quite high.

Next month: Circuits using cold cathode trigger tubes

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.

MODEL CONTROL

For model control enthusiasts a new transmitter and receiver has been released by **Radio Control Products**, 38 Franche Road, Kidderminster, Worcestershire.

The transmitter is crystal controlled on any of the specified radio control frequencies and gives an r.f. power output of 0·5W. It has a microswitch tone button, a full length telescopic aerial, and is housed in a blue vinyl covered case.

The receiver measures 2¼in × 1½in × ⅞in and is a superhet operating with an i.f. of 455kHz. A special noise suppression circuit is incorporated in the audio stages of the receiver.

Both relay and relayless versions are available; the relayless receiver has an output transistor capable of switching up to 0·5A. The contacts on the relay versions are fitted with spark quench suppressors. Both units operate from a 4·5V supply and cost £18 18s as a matched pair of units.

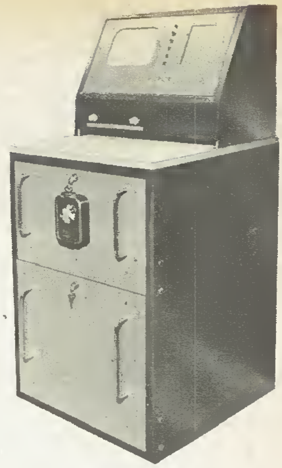
Miniature model control transmitter and receiver from Radio Control Products

TELEFILM CONSOLE

Designed as a self-contained unit for showing continuous loop film on television sets, the **Beulah** Telefilm Console should be of special interest to hotels, motels, advertising agencies, and possibly training establishments. Being completely automatic, it will operate for long periods without any attention. A time switch is built-in to programme its period of operation. The standard model has a video output and the signal can be fed via a modulator unit into a distribution amplifier.

A special optical unit designed by Beulah Electronics couples a television camera to the film projector. The control panel has a 9in monitor.

The units are usually installed by franchise operators who cover a number of hotels and motels in an area carrying out installation and maintenance. Full details can be obtained from Beulah Electronics Ltd., 126 Hamilton Road, West Norwood, London, S.E.27.



Telefilm Console from Beulah

Eagle HA.10 Stereo Headphone Amplifier

HEADPHONE AMPLIFIER

The **Eagle** HA.10 is one of the latest pieces of audio equipment to be added to their range of products. The HA.10 is a stereo headphone amplifier that can be used with any record deck and pick-up cartridge and it is claimed to give high fidelity reproduction at headphone listening level.

The output of the headphone amplifier is 50mW per channel and the inputs are: magnetic 5mV (equalised); ceramic 100mV (flat); and tuner 100mV (flat). It is powered by a 9V battery.

The price of the HA.10 stereo headphone amplifier is £11 0s 6d.

AEROSOL CLEANER

Known as Ultraclene, a new aerosol industrial cleaner is announced by **Automation Facilities Ltd.**, and available from some retailers. Its uses are numerous and it acts very quickly, the spray removing dirt, grease, and oil. Being in aerosol form it can penetrate some of those otherwise inaccessible areas and enables electrical equipment to be cleaned *in situ*, without dismantling.

Each Ultraclene aerosol contains 16 ounces of solvent and is claimed to be a suitable alternative to carbon tetrachloride.

LITERATURE

The fifth edition of the Home Radio Catalogue is now available from **Home Radio (Components) Ltd.**, 234 London Road, Mitcham, Surrey.

The price of the catalogue has been increased for the first time since 1965 to 8s 6d, but an extra 1s coupon has been added and there are now six 1s-in-the-£1 discount coupons enabling some of the cost of the catalogue to be recovered on subsequent orders. These coupons are supplied separately and readers should make sure that they ask for coupons when purchasing this excellent catalogue.

Many sections have been completely revised and brought up to date and numerous new items added. Also supplied with the catalogue is a new component prices supplement.

The 1969 edition of the **Mullard** Data Book, just published, follows the same successful formula introduced last year and embraces the complete Mullard ranges of valves, television picture tubes, semiconductors and components for entertainment applications.

For easy reference different coloured paper is used for each of the main product sections.

Equivalents and earlier types are listed in the valve section, replacement details are given in the television picture tube section and information about comparables is shown in the semiconductor section. Symbols and abbreviations are explained in a separate section.

Continuing the practice started last year, this 138-page book is available, through radio and television retailers, to electronics enthusiasts outside the trade. This arrangement is being continued and the recommended retail price remains unchanged at 3s 6d a copy. If there is any difficulty in obtaining copies readers should contact Mullard Ltd., at Mullard House, Torrington Place, London, W.C.1.

PE ORGAN PART 2

By Alan Douglas, Sen. Mem. I.E.E.E.

We left the last instalment with the two keyboards in position. Now they must be removed from the console, as we have to attach the key contact system. In any organ of this kind which uses frequency division, the generators all run continuously. Not only this, but some of the actual notes or pitches may be used simultaneously for the upper manual, lower manual and pedals. So two things have to be considered; how to key the signal and how to prevent this multiple usage from reducing the signal strength.

If one cuts into any waveform abruptly, there will be a transient signal of an unpleasant nature. It will be a click or a thump and it may occur again on releasing the key. Clearly it is an advantage if we can eliminate this irritating effect and this is possible if we use resistance keying.

The really unpleasant transient is of very short duration and often of very high frequency. So if we cause a graphited surface to contact either an incorrodible metal or another graphite surface, we will have a momentarily high resistance, rapidly decreasing with increased pressure to a lower value. This attenuates the transient and in favourable conditions removes it altogether.

MANUAL CONTACT ASSEMBLIES

Unfortunately, such graphited switches require precision in assembly and special treatment if they are to have a long life; so it is not too easy to make them. We also know that we need signals of different pitches from any one playing key, so that a great deal of cross-connecting is called for. For these reasons, we have specified the manual contact assemblies made by Harmonics Ltd.

We require a four bank unit for the upper keyboard, wired for 16, 8, 4 and 2ft; and a two bank unit for the lower keyboard, wired for 8 and 4ft. The distribution of these pitches from common oscillators and dividers is effected by printed wiring as in Fig. 2.1, which shows part of the upper unit. This saves the constructor some hundreds of soldered joints and is very neat, a useful feature as there is not too much room between the keyboards.

In addition to the printed wiring, these contact assemblies have integral anti-robbing resistors. As stated, it is necessary to ensure that use of the same signal more than once does not reduce the overall volume. By inserting resistors in series with the divider outputs, we can control this. Indeed, should two notes coincide on two manuals, or through the use of two pitches, then the resistor value will be halved and the notes will become louder as indeed they should. Therefore, when ordering these switch units, we ask for 100 kilohm resistors to be fitted to each switch contact wire.

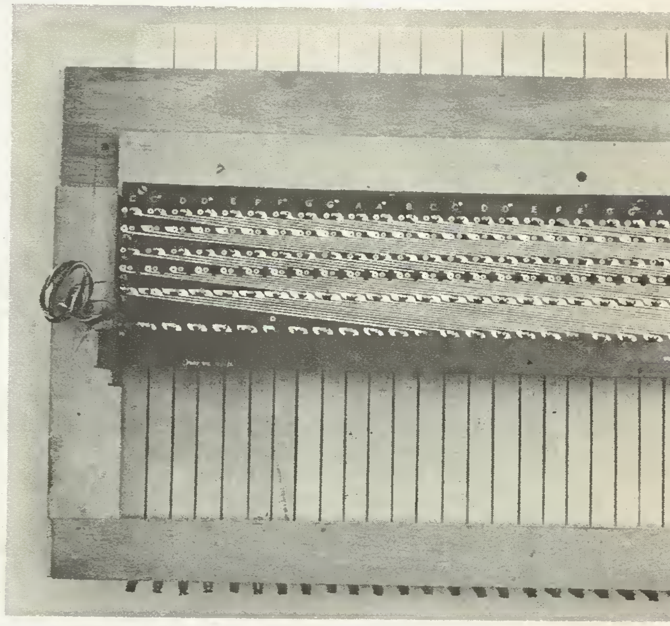


Fig. 2.1. View of the underside of the upper manual contact assembly showing the pitch connections to the printed circuit board. Note the hardwood strip which fixes the board to the keyframe

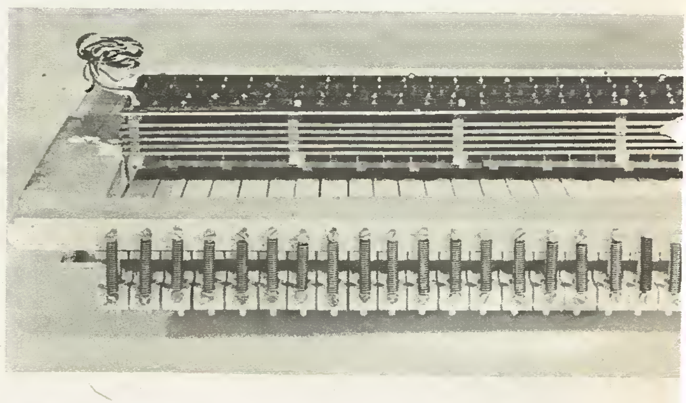


Fig. 2.2. Upper manual contact assembly shown in perspective with one hardwood strip removed

This series is expected to extend to 12 parts
Total cost of material for the organ is likely to be around £250

ATTACHING TO THE KEYFRAMES

As supplied, the switches have the printed coupler wiring on the bottom, and the switch finger wiring on a small side panel. This panel faces the front of the keys, when the keyboard is turned upside down.

The plungers contact the respective keys, and the units are fastened down by seven screws each side to strips of hardwood across the keyframes. These strips must be of such a thickness that the flat end of the plungers projects from the printed wiring side by about $\frac{1}{16}$in with the keys at rest. Do this very carefully, or erratic keying could result.

Fig. 2.2 shows one end of the upper keyboard assembly with one wood strip removed and Fig. 2.3 shows the whole affixed to the keyboards. Note also the fixing of the duralumin thumper bar in this picture.

If the hardwood strips are correct, there will be no clearance between the underside of the keys and the ends of the plastic dollies. Of course, the thumper bars must be in position to check this.

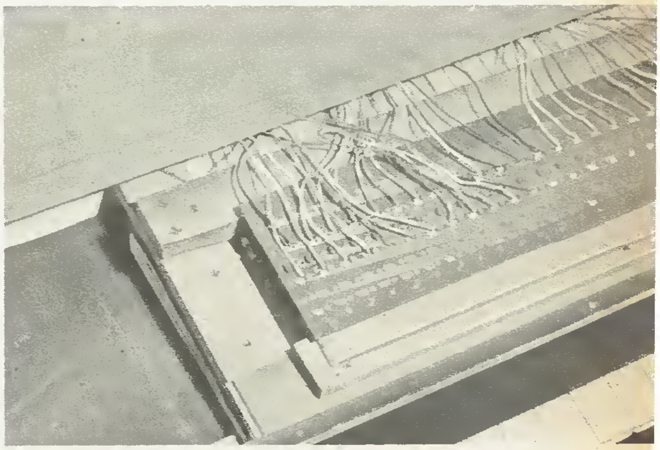
We can now put the two keyboards back to check the touch and clearances, but the next step will be to solder the generator output wires to the printed wiring so they will have to come off again when the dividers are completed.

ALTERNATIVE KEYING

It is possible, of course, to use direct metal-to-metal key contacts such as gold clad bronze wire, and this is much cheaper. However there is almost a certainty of transients at high pitches here.

Then again, diode or transistor keying could be used; or the electrolytic system devised by Arthur le Boutillier of the Electronic Organ Constructors Society. We have to try to suggest a system which is known to work well, be little trouble to the builders, and to remain reliable.

Later on, we will discuss possible alternative methods of keying. Suffice it to say that graphite keying has been proved entirely satisfactory by the Baldwin company for more than 20 years.



Underside of the lower manual showing printed board wired and mounted to keyframe via hardwood strips

P.S.U. FOR OSCILLATORS AND DIVIDERS

Now we must turn our attention to the oscillators and frequency dividers, and strange though it may seem, we start by making up the power supply unit (P.S.U.1) for these.

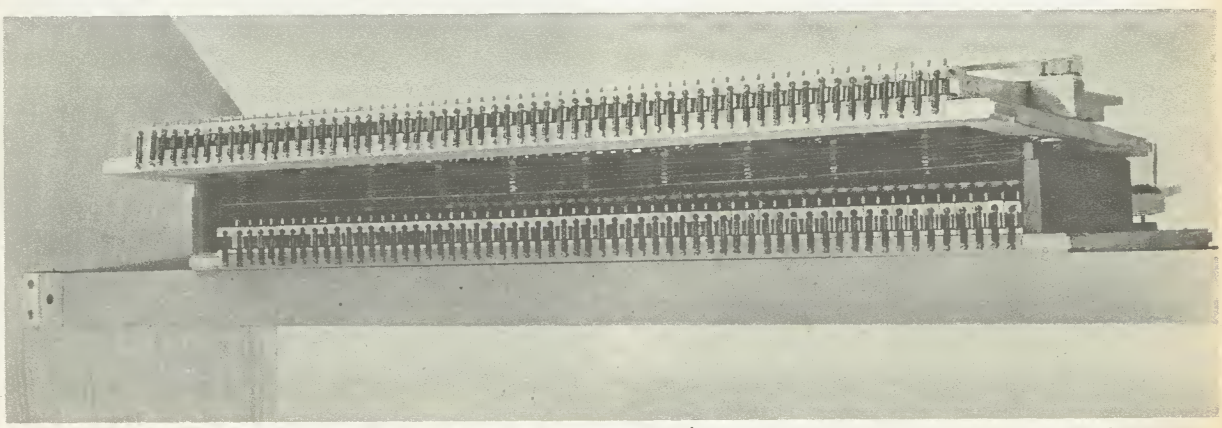


Fig. 2.3. Upper and lower manuals complete with contact units in position on keyboard support rails

P.S.U.I FOR GENERATOR AND DIVIDER UNITS

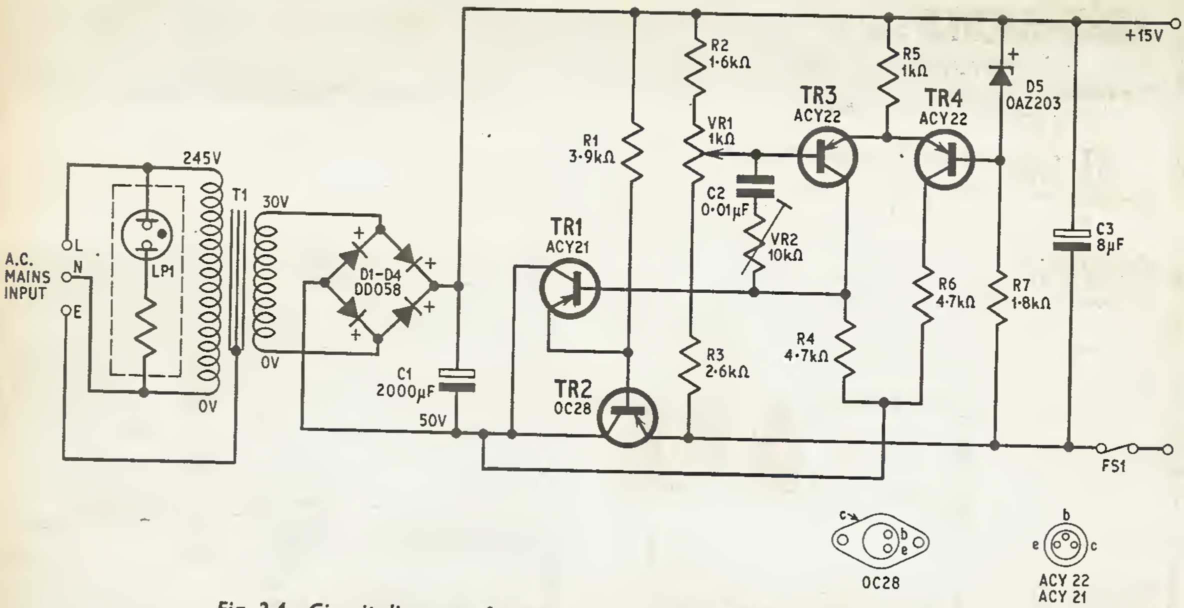


Fig. 2.4. Circuit diagram of power supply unit for generators and dividers

Although the inherent stability of the oscillators is very good, testing such circuits with dry batteries is to be deprecated for two reasons; firstly, the high and variable impedance of a battery. And secondly, the question of earthing and hum pickup which could be misleading with batteries.

The d.c. load on this power unit is constant, about 320 milliamps at 15 volts which together give the low-power consumption figure of under 5 watts. Nevertheless, an inexpensive stabiliser is desirable and this also reduces ripple giving a very low output impedance which in its turn makes decoupling easier.

OPERATION

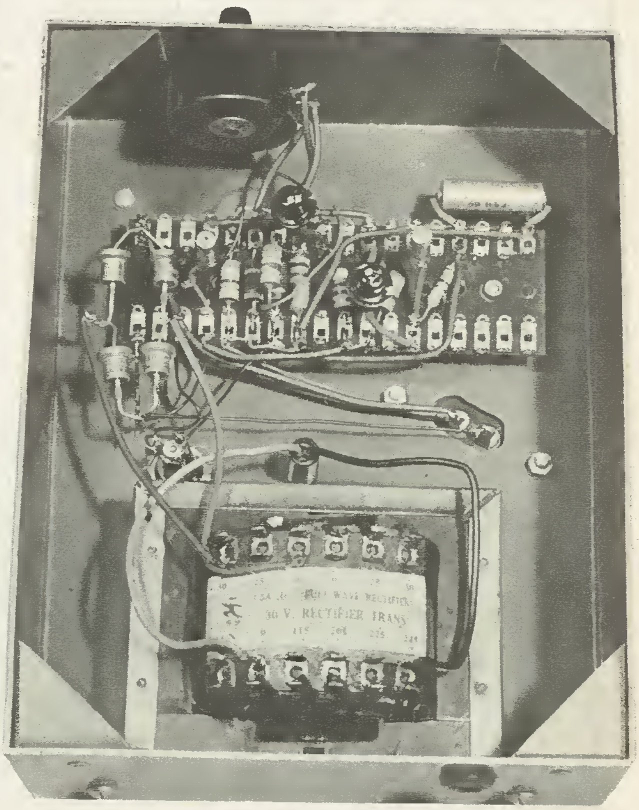
To achieve the current output and low output impedance, TR1 and TR2 are strapped as a modified Darlington pair as shown in Fig. 2.4.

The comparator transistors TR3 and TR4 are arranged in a long-tailed pair configuration where the voltage across R5 is equal to the difference between the reference voltage of D5 and the base to emitter voltage of TR4.

A change in the emitter to base voltage of TR4 produces an equal and opposite change in the voltage across R5. Since TR3 and TR4 are the same type, the effect of temperature change on the former is nullified by a similar effect on TR4 and the change in voltage across R5.

The value of the output voltage is adjusted by means of potentiometer VR1 which alters the fraction of the output that is compared with the reference voltage. After amplification, this is fed back to the Darlington pair.

C2 and VR2 are included to eliminate any tendency for the circuit to oscillate. If such oscillations are apparent the resistance of VR2 should be increased from zero until such disturbances disappear.



Chassis underside of power supply unit, see Fig. 2.5 for details

POWER SUPPLY WIRING

COMPONENTS . . .

POWER SUPPLY UNIT I

Resistors

R1 3·9kΩ
R2 1·6kΩ
R3 2·6kΩ
R4 4·7kΩ
R5 1kΩ
R6 4·7kΩ
R7 1·8kΩ

Capacitors

C1 2,000μF elect. 50V
C2 0·01μF polyester
C3 8μF elect. 25V

Potentiometers

VR1 1kΩ wirewound preset
VR2 10kΩ carbon slider preset

Transistors

TR1 ACY21
TR2 OC28
TR3 ACY22
TR4 ACY22

Diodes

D1–D4 DDO58 (Lucas) 4 off
D5 OAZ203 (Mullard) 6·2V Zener

Transformer

T1 Rectifier transformer. Primary: 200–240V tapped; secondary 30V (Radiospares)

Miscellaneous

FS1 500mA fuse
Fuse holder
LP1 Neon indicator
Miniature tag board 4½in long
Heat sink 4in × 4·875in
Terminal strip
Chassis 9in × 6in × 2½in

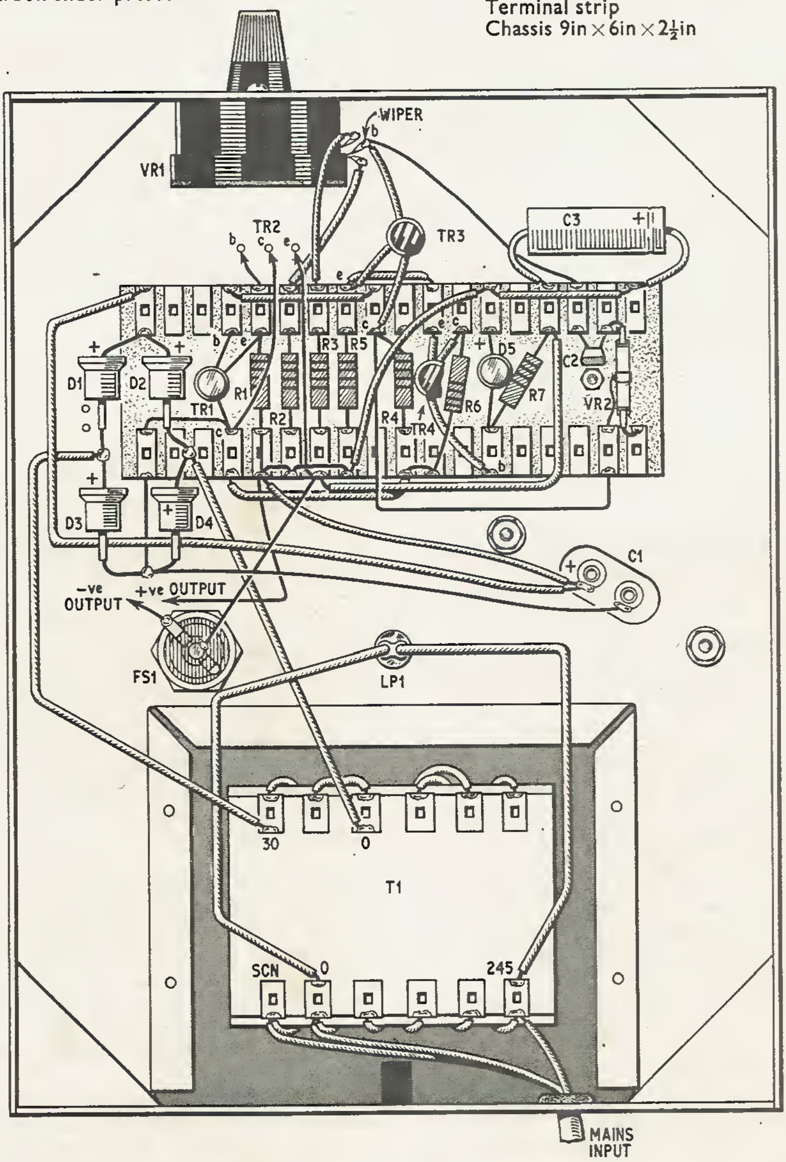
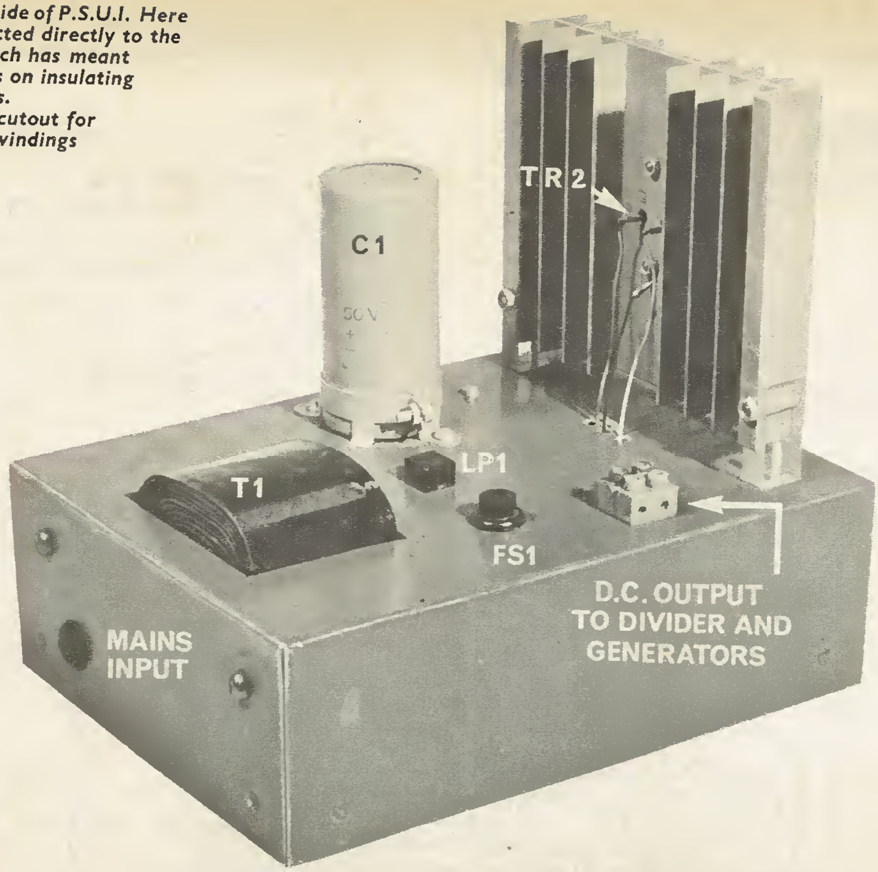


Fig. 2.5. Wiring layout for P.S.U.I. The d.c. output wires are taken to a terminal strip mounted on chassis top, see Fig. 2.6

Fig. 2.6. Topside of P.S.U.I. Here TR2 is connected directly to the heat sink which has meant mounting this on insulating perspex posts. Note chassis cutout for transformer windings



CONSTRUCTION

Nearly all of the small circuit components are assembled on a 4½in miniature tag board as shown in Fig. 2.5. When this is done the chassis should be cut for the transformer and drilled for all chassis mounting screws.

To stand off the tag board, this should be mounted on four ¾in spacers with 1in 6B.A. nuts and bolts.

Wiring of all chassis components should now proceed as shown in Fig. 2.5.

The extruded heat sink for TR2 can be seen in Fig. 2.6 and this is insulated from the chassis unless mica washers are fitted under the transistor; be very careful about this question of insulation or the OC28 will be destroyed.

The output voltage can now be set by adjusting VR1 and to do this we must connect a dummy load across the line. Assuming a current drain of 300mA at 15V, we can use a 3 watt resistor of 50 ohms to simulate the collective oscillator and divider load.

With a meter across the load VR1 can now be adjusted for 15V.

HARTLEY OSCILLATORS

Now that we have the power available, it is time to look at the oscillator units. As we know, there are 12 oscillators for the top 12 notes and all the other octaves downwards are obtained by 2 : 1 bistable frequency dividers. Thus, there are but 12 notes to adjust to tune the whole organ, a decided advantage in an organ of this kind, although it cannot give the greatest realism.

From the many possible oscillator designs, we chose the circuit invented by J. V. L. Hartley nearly fifty years ago. It is simple, stable, economical and can be adjusted to give different kinds of waveforms. Of course, the original circuit used valves, and some adaptation is required for transistors.

The average amateur finds his greatest difficulty in obtaining stable capacitors. The Hartley oscillator has but one in the critical tuning position, though of course this will require selection and padding to give the correct frequencies. At the present time imported polyester and polystyrene low voltage capacitors are readily available at economical prices, therefore the use of this type of dielectric is recommended throughout the generator system.

SILICON TRANSISTORS

At the outset it was explained that silicon was to be used in preference to germanium transistors. From every point of view the encapsulated planar device scores. For small signals, the leakage current is infinitesimal; for large signals, the danger of thermal runaway is virtually non-existent. Apart from this, the price is in many cases lower than germanium, and this will reduce still more.

The relatively high temperatures which silicon can withstand during processing permit the fabrication of all kinds of complicated integrated circuits. Although we do not use these, one day they will be commonplace for organs. So we are able to use one type only for all the oscillators, dividers, pre and post amplifiers and emitter followers.

MAJOR COMPONENTS

In a project of this magnitude it is to the constructor's advantage to bulk purchase those components which will appear in fairly large numbers. It is for this reason we include the following list of resistors and capacitors required in quantities of 12 or more. The semiconductor and inductor complement is also included

Individual component lists will, of course, be published with each circuit diagram as they occur

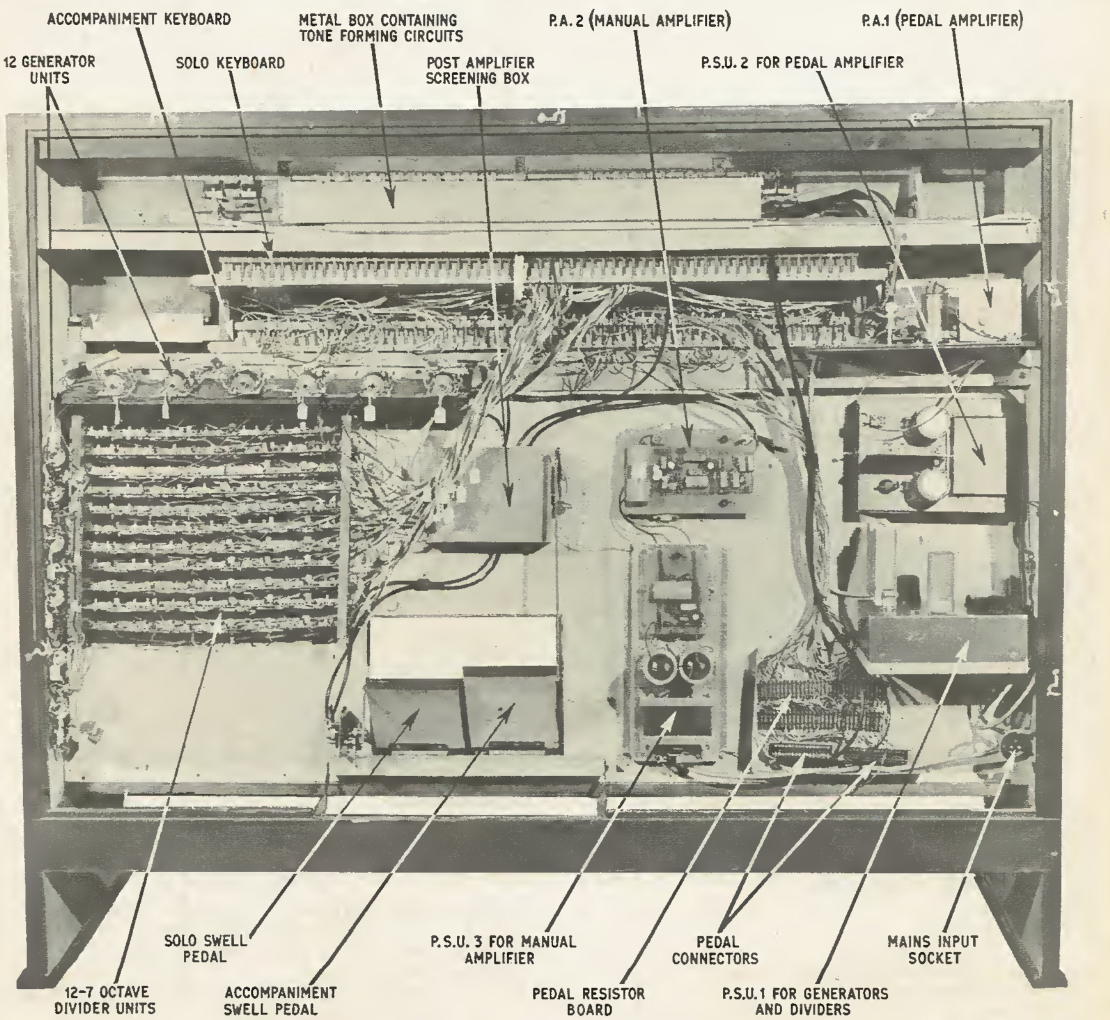
Resistors	Quantity
100Ω	18
330Ω	14
470Ω	12
1kΩ	13
2·2kΩ	282
3·3kΩ	13
18kΩ	170
33kΩ	30
68kΩ	13
100kΩ	92
All 10% ½ watt carbon	

Inductors	
Mullard Vinkor type LA2300	12
Mullard Ferroxcubes type LA2	5

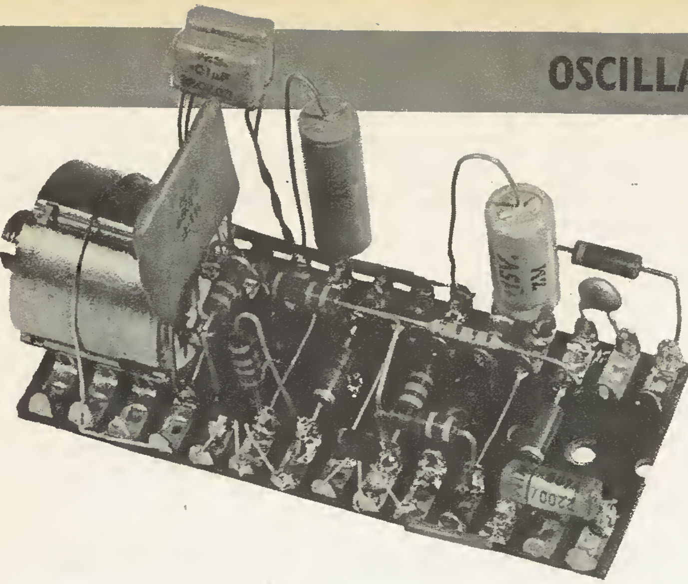
Capacitors	Quantity
1,000pF polystyrene	96
2,200pF polystyrene	12
4,700pF polystyrene	253
0·01μF polyester	33
0·1μF polyester	72
0·22μF polyester	12
100μF elect. 25V	12

Diodes	
ZS170 (Ferranti)	7
ZR12 (Ferranti)	4
KR54 (Ferranti)	1
KR56 (Ferranti)	1
DDO58 (Lucas)	4
OAZ203 (Mullard) 6·2V Zener	1

Transistors	Quantity
ZTX300 (Ferranti)	216
ACY22 (Mullard)	2
ACY21 (Mullard)	1
OC28 (Mullard)	1
ZT1701 (Ferranti)	4
ZT1613 (Ferranti)	6
ZT44 (Ferranti)	1
ZT1700 (Ferranti)	1
ZT3055 (Ferranti)	2
ZTX302 (Ferranti)	2

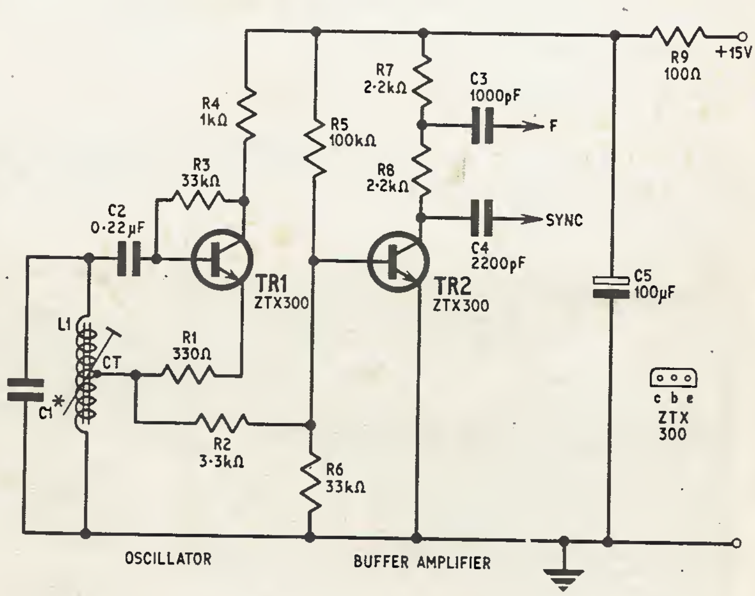


Rear view of organ console showing general layout of all sub-assemblies



Perspective view of one oscillator unit (tagboard version)

Fig. 2.7. Circuit diagram of an oscillator unit. Here the output F is a 2ft pitch frequency and SYNC the input to the first stage of the relevant divider unit. Values for the tuning capacitor C1 vary for each of the 12 oscillators and these will be given in a later article



COMPONENTS . . .

OSCILLATOR UNIT
(12 required)

Resistors

- R1 330Ω
- R2 3·3kΩ
- R3 33kΩ
- R4 1kΩ
- R5 100kΩ
- R6 33kΩ
- R7 2·2kΩ
- R8 2·2kΩ
- R9 100Ω

all 10% ½ watt carbon

Capacitors

- C1* See text
- C2 0·22μF polyester
- C3 1,000pF polystyrene
- C4 2,200pF polystyrene
- C5 100μF elect. 25V

Transistors

- TR1 ZTX300 (Ferranti)
- TR2 ZTX300 (Ferranti)

Inductors

- L1 100 plus 100 turns of 32 s.w.g. enamelled copper wire wound in Mullard Vinkor type LA2300

Miscellaneous

- Miniature tag board 3½in long
- Bakelite backing plates to suit

SUPPLIERS

Manual contact assemblies: Harmonics (Bromley) Ltd.
For 18, 8, 4, and 2ft pitches (loff): Clarion Works
For 8 and 4ft pitches (loff): Napier Road, Bromley, Kent
When ordering ask for 100 kilohm resistors to be fitted to each switch contact wire

OSCILLATOR WIRING

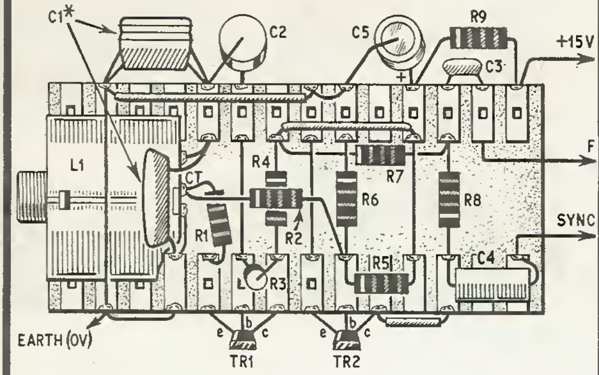


Fig. 2.8. Tagboard mounting and wiring of oscillator components

PRINTED CIRCUIT ALTERNATIVE

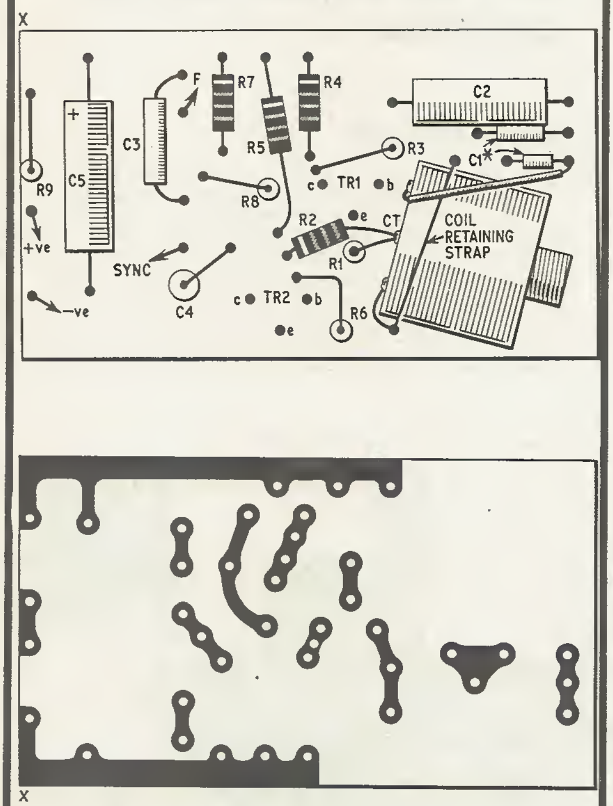


Fig. 2.9. Printed circuit board layout and wiring for oscillator assembly

INDUCTORS

The oscillator circuit is shown in Fig. 2.7. The inductance coil L1 is a Mullard Vinkor type LA 2300, but although this ensures the greatest stability and the minimum of crosstalk, these coils are expensive.

As the frequencies of the oscillators all lie between 8kHz and 4kHz, it is possible to use less costly iron dust cores such as the Denco Neosid. So far as is possible, the Vinkors are to be strongly recommended.

BUFFER STAGE

The Hartley circuit oscillates vigorously, and since we want to use these frequencies for 2ft pitch, a buffer stage is added to isolate the actual oscillator from the keying load. This also shapes the sine wave so that the first divider is properly triggered.

From an audible point of view this high pitched note could have almost any waveshape since the ear would not be able to resolve harmonics above the concordant second which is the octave of the fundamental. But higher harmonics are present, so some slight degree of filtering is applied through later tone forming circuits.

CONSTRUCTION

The oscillators are constructed on miniature tag boards, one of which is shown in Fig. 2.8. This is convenient since the oscillators are spaced somewhat away from the dividers they feed, and in addition the actual dimensions of the components may vary according to the source of supply.

The 12 oscillators used are identical in their component complement with the exception of the tuning capacitors shown as C1 in the circuit diagram of Fig. 2.7. This uniformity means that the component layout on all 12 tag boards follows that of Fig. 2.8.

100 plus 100 turns of 32 s.w.g. enamelled copper wire are wound on to the pot core bobbin. When winding on the second lot of 100 turns it is essential to maintain the same winding sense.

With the wire ends cleaned these are then taken and soldered to the tags. The bobbin is then placed in the core assembly and the clamps tightened down.

The tuning capacitor and associated padders shown as C1 will be given values in a later article.

It is, of course, possible to use a printed circuit board construction for the oscillators and this with component layout is shown in Fig. 2.9.

FUNCTIONAL CHECKS

As each oscillator unit is completed a functional check should be made. To make this test the power supply unit, P.S.U.1, should be set to +15V.

First solder a 30,000pF capacitor across the coil L1 at either one of the C1 connections shown in Fig. 2.8. Now connect the +15V supply.

If an oscilloscope is available, examination of the outputs at either C3 or C4 should provide a square wave. If not, check the output at the collector of TR1. Here a clipped sinusoidal wave should be evident.

These checks will resolve a defective stage.

Providing your hearing is good, these procedures can be undertaken using a pair of high impedance phones.

When you are satisfied that all 12 oscillators are working both these and the power unit should be placed to one side.

Next month we will start construction of the frequency divider units with wiring details of their associated assemblies.

To be continued

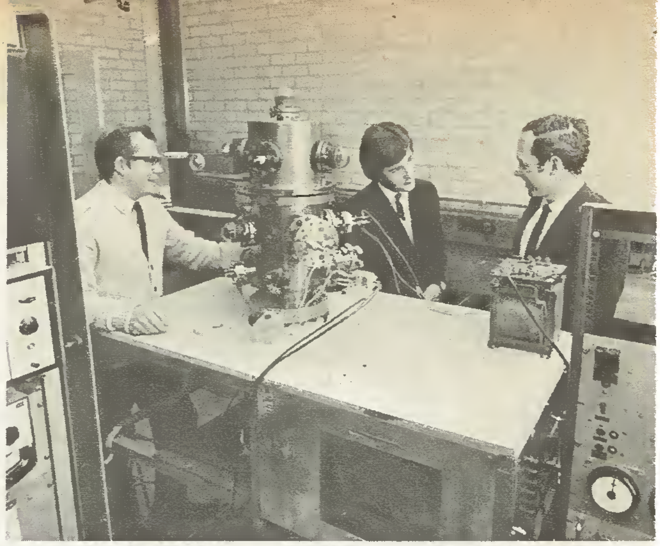
Thin Film Circuits

As the use of thin film circuits becomes more widespread in the electronics industry, methods of measuring and improving the properties of thin films are being carefully studied at the National Physical Laboratory (N.P.L.) at Teddington.

Good adhesion of thin films to their substrates and to one another is essential for microelectronic and optical applications. Existing methods of measuring adhesion have always been inadequate; N.P.L. have studied these methods and introduced new ones.

Using the new measuring methods, it has been found that superior adhesion is achieved more efficiently by "glow-discharge" cleaning of the substrate prior to deposition of the thin film. The process of "glow-discharge" cleaning can be introduced into a production line relatively simply.

In order to isolate the factors which most affect adhesion, it is necessary to be able to deposit films in the presence of controlled amounts of contaminants. This is carried out at N.P.L. in the ultra-high vacuum system illustrated right.



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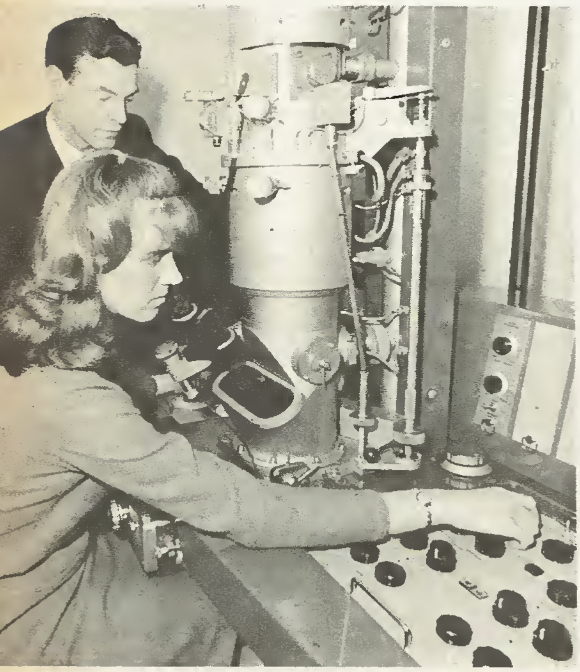
ELECTRO

VISITS THE NATIONAL PHYSICAL LABORATORY



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Electron Microscopy

The photograph left shows an A.E.I. EM802 electron microscope being used to study grain boundaries in an alloy of considerable technological importance. Investigations aimed at improving the properties of materials require very sophisticated techniques. This instrument is a 100kV electron microscope which allows the specimen to be examined at magnifications up to 160,000 times at resolutions better than 0·5 microns. The National Physical Laboratory have recently taken delivery of a new high voltage microscope to assist in their study of the properties of materials.

N.P.L. Ultrasonic Tank

In conventional ultrasonic flaw detection apparatus a short ultrasonic pulse is transmitted through the solid material. When flaws or discontinuities are present in the material being checked they are shown up at the receiver as secondary ultrasonic sources. In the N.P.L. apparatus shown right, a pulsed beam of ultrasonic sound is propagated through a tank of liquid which can be maintained at any desired temperature. When a sample of material is interposed at an angle in the beam, refraction occurs at the interface and it is possible to transmit both longitudinal and shear waves. A change from one type of wave to the other is made by reorientating the sample. Measurement of the wave velocities in several directions makes it possible to calculate longitudinal elastic stiffness coefficients as well as shear and rigidity coefficients.

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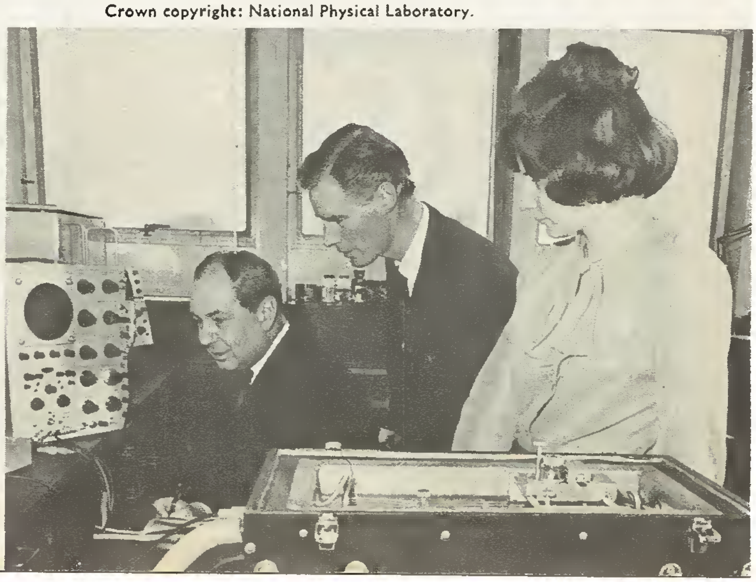
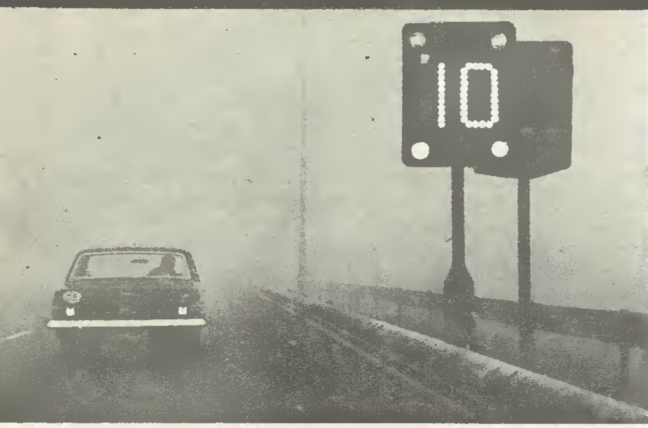


Control centre for M4 Signalling System showing the control desk, mimic diagram and closed circuit television monitors. Situated on the desk is the control for emergency telephones, police radio and closed circuit television

NORAMA



Post mounted signal situated on the central reservation, showing 10 m.p.h. speed restriction

Gantry mounted signals at the Lionel Road Interchange showing a diversion

M4 TRAFFIC CONTROL

At the official opening, on March 21, of the new remotely controlled signals on the M4 motorway, the Joint Parliamentary Secretary to the Ministry of Transport, Mr R. Brown, had the following words to say:

"Today's switch-on is a major step forward in increasing road safety—and we hope it will reduce the number and severity of motorway accidents".

The new computer controlled system was manufactured and installed by GEC–Elliott Traffic Automation Ltd., and developed in collaboration with the Ministry of Transport. This first installation covers an 11 mile stretch of the M4 between Chiswick Flyover and Langley Interchange and is operated by the Metropolitan Police from a control centre at Heston Service Area.

The display of signals is controlled by an Elliott 900 series computer which first checks the typed instructions; if the instruction is valid the computer allows it to be passed to the signals.

The system incorporates check routines that automatically interrogate responders to ensure continued normal operation. In addition, impact detectors on posts and gantries provide immediate alarm should any signal be hit by a vehicle. Meteorological sensors can be added to give automatic warning of weather hazards. Comprehensive protection is also incorporated to prevent dangerous situations arising from power failure or equipment malfunction. The system includes closed circuit TV cameras controlled from Heston, providing surveillance of important points on the motorway.

The proposal to introduce signal systems throughout the motorway network by the mid-1970's was announced in November 1966. Aimed at reducing accidents and securing safer all-weather driving conditions on motorways, these automatic signals will gradually replace the temporary flashing amber signals.

Photographic Enlarger EXPOSURE METER

By A.M. RUDKIN, B.Sc.,(Eng.)

AND G.D. RUDKIN

THE INSTRUMENT to be described in this article was designed for use with a photographic enlarger to determine the exposure times required for any particular enlargement.

Although it requires calibration for each grade of printing paper, the instrument is very easy to use once calibrated and the results obtained are consistently good.

DESIGN ASPECTS

Any device connected to the mains supply is a potential danger unless it is built very carefully. A low voltage battery operated unit is safer to use.

The exposure meter is operated in low light conditions and it is essential that the operator can adjust it easily in such conditions when the need arises.

The reading of the exposure meter should not change, despite changes in the supply voltage due to mains voltage fluctuations or to battery ageing effects.

The photographer may use a number of different grades of printing paper; the meter has been designed to accommodate any grade.

The total cost of the meter has been kept to a reasonably low level without sacrificing its performance.

In designing this exposure meter the above requirements have been met with a simple transistorised circuit using a photosensitive resistor as the light sensing element.

A photosensitive resistor or light dependent resistor (l.d.r.) has a very high resistance in total darkness. The resistance falls as the light intensity increases until, in bright light, the resistance is as low as 100 ohms.

To meet the stability requirement a bridge circuit is incorporated. Although a d.c. or a.c. bridge circuit could be used, the latter is more convenient in this application since it can provide an audible indication of balance when optimum exposure conditions are set up.

CIRCUIT

The complete circuit diagram is shown in Fig. 1. The first two transistors TR1 and TR2 are used in a simple multivibrator circuit which oscillates at a frequency of about 500Hz. The output of the oscillator is used to feed the bridge circuit containing the photosensitive resistor.

By adjusting the potentiometer VR1 the a.c. voltage developed across the l.d.r. can be balanced against the voltage across the lower part of the potentiometer. In this condition the voltage across the transformer primary will be at a minimum and consequently the sound output from the earpiece will also be at a minimum.

The transformer isolates the bridge circuit from the amplifier circuit formed by transistors TR3 and TR4. TR3 is connected as a common emitter amplifier and is directly connected to the emitter follower stage.

Since the output impedance of this stage is low, almost any magnetic earpiece can be used as the indicator. The prototype used a balanced armature earpiece of 30 ohms impedance.

COMPONENTS AND CONSTRUCTION

A suggested component layout is given in Fig. 2 and the photograph of the complete unit shows the positions of the controls.

The values of R5 and R6 were found to be correct for the l.d.r. used in the prototype (ORP12), but if a different l.d.r. is used these values would probably need adjustment.

The transformer was obtained from a television chassis, but any transformer having a ratio of about 4:1 could be used, for example the Ardente D239 or D189 which have ratios of 4·5:1 and 3·66:1 respectively.

The circuit has been designed so that almost any transistors can be used in the various stages. The

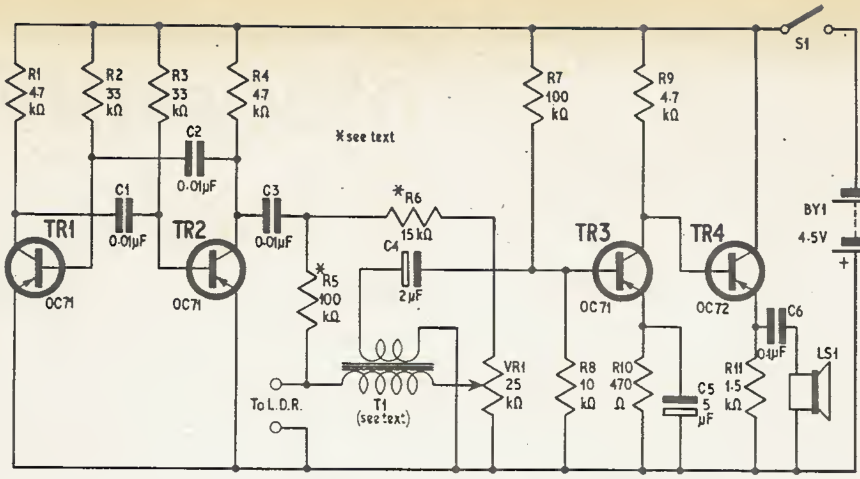


Fig. 1. Complete circuit of the enlarger exposure meter

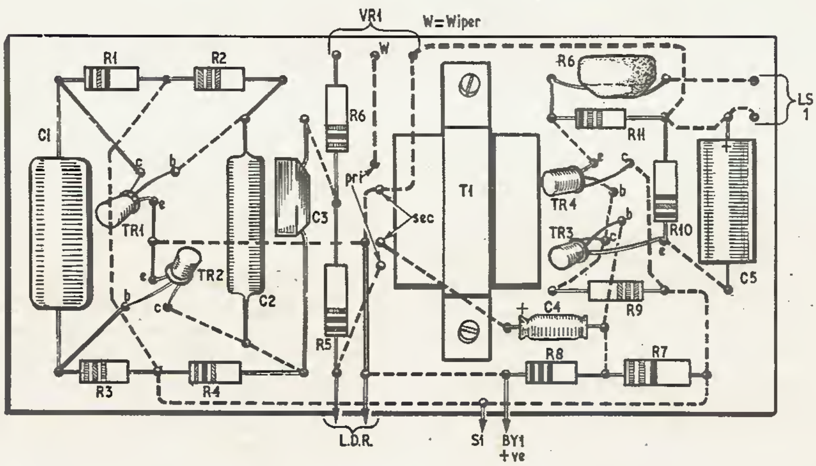


Fig. 2. Layout of components on the perforated wiring board. Underside wiring is shown as dotted lines

COMPONENTS . . .

Resistors

R1 4·7kΩ
R2 33kΩ
R3 33kΩ
R4 4·7kΩ
R5 100kΩ } see text
R6 15kΩ }
R7 100kΩ
R8 10kΩ
R9 4·7kΩ
R10 470Ω
R11 1·5kΩ
All ±10%, $\frac{1}{4}$ watt carbon

Potentiometer

VR1 25kΩ linear carbon

Capacitors

C1 0·01μF }
C2 0·01μF } polyester
C3 0·01μF }
C4 2μF elect. 15V
C5 5μF elect. 15V
C6 0·1μF polyester

Transistors

TR1, 2, 3 OC71 *or* OC45 (3 off)
TR4 OC72 *or* OC84

Transformer

T1 Small signal transformer 4·5 : 1 (D239 *or* TT49)

Miscellaneous

LS1 Balanced armature earpiece 30 ohms
X1 Light dependent resistor, type ORP12
BY1 4·5 volt flat battery
S1 Single pole on/off switch
Perforated component board and solder pins
Hardboard or $\frac{1}{4}$in plywood for case (Fig. 3)
Expanded metal grille, knob with pointer, sockets for l.d.r.

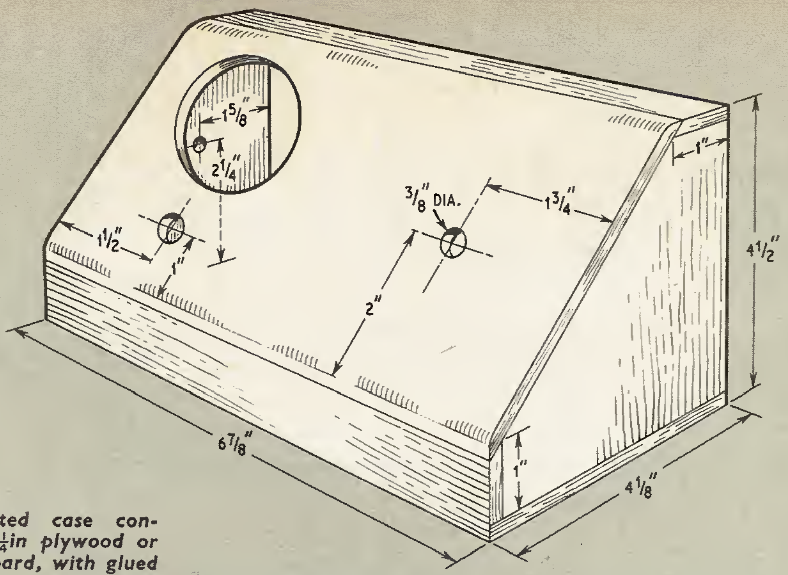


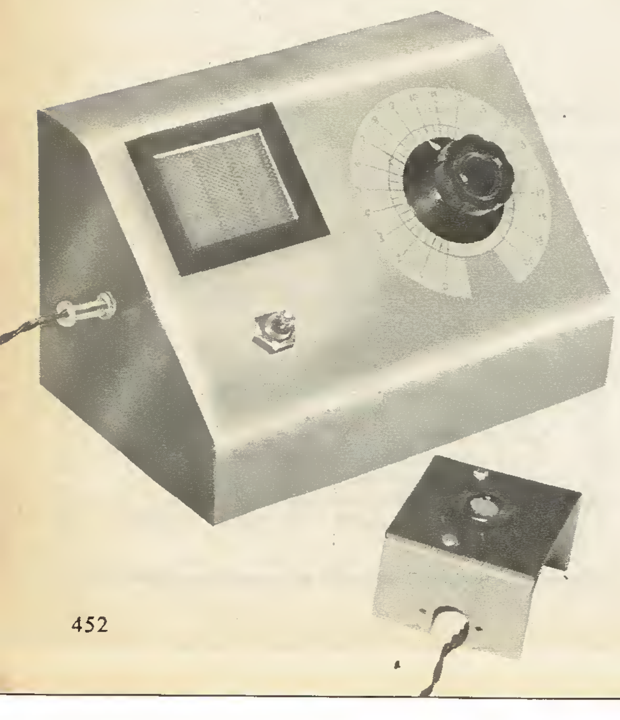
Fig. 3. Suggested case construction from ¼in plywood or standard hardboard, with glued corner fillets

multivibrator circuit will work with transistors having current gains of ten or less. For the TR3 position a transistor having a higher gain is desirable. Satisfactory operation was achieved using four OC71s, but very cheap transistors of low gain are equally suitable.

The majority of the circuit is built on perforated wiring board (Fig. 2), although there is no reason why other construction methods should not be used. The whole unit is assembled in a home-made wooden case (Fig. 3).

The l.d.r. is mounted on a strip of s.r.b.p. with the photosensitive area facing uppermost.

The photograph shows the paper scale with the inked markings. Units were marked every 15 degrees with half-units marked midway between them. This gives a scale having 20 major divisions since potentiometer spindles usually rotate through 300 degrees between the end stops. Low readings on the scale correspond to high light intensities and the high scale readings to low intensities.



CALIBRATION

The scale on the meter has linear markings and it now remains to show how these markings are used with the printing paper. Calibration graphs are prepared for each different grade of printing paper in the following manner.

The instrument is taken into the darkroom and a clear piece of film from a blank exposure is placed in the enlarger. Having switched off all light sources (except the enlarger) the detector head is placed on the enlarger easel and the balance control is set to some reading on the scale.

The aperture ring of the enlarger is adjusted until a balance point is heard (i.e. when the sound from the earpiece is at a minimum). Having found this balance point the enlarger is switched off and a narrow strip of printing paper is used to make a test strip (see Fig. 4).

Stripes on the test strip can be obtained in steps of one second. After developing and fixing the strip the result will be similar to that shown in Fig. 4 where the gradual transition from white to black can be seen. The numbers below the strip indicate the exposure times in seconds and the arrow indicates the exposure that gives the first black stripe.

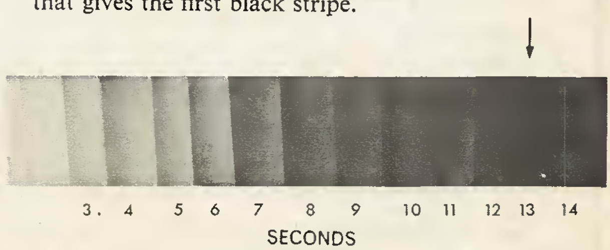


Fig. 4. Graduated tone scale for set exposure times

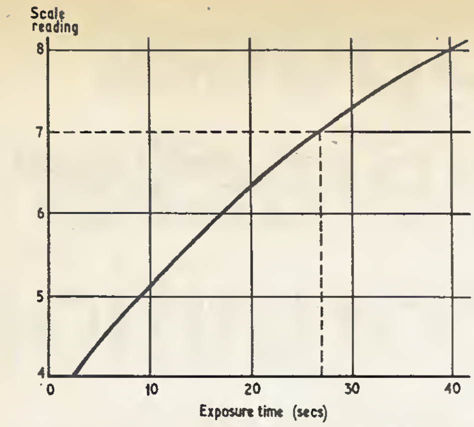


Fig. 5. Calibration graph for indicating exposure time against scale reading

This exposure time is recorded together with the scale reading of the exposure meter and by taking test strips for various scale readings a calibration graph can be drawn. A typical calibration curve is shown in Fig. 5. For higher scale readings it is more convenient to make exposure strips at two or four second intervals.

This procedure must be repeated for all other types of printing paper used but after the first calibration curve has been plotted subsequent calibrations will be easier since the operator will already have some experience of the meter and his paper. For example, an exposure of two seconds would very rarely be encountered for a 10in × 8in print from a 35mm negative!

EXPOSURE TIMING

The correct exposure for any normal negative where all tones are to be preserved may be found by placing the detector head under the magnified image of the clear margin of the negative, and adjusting the balance control until a balance point is found. The correct exposure time is then found from the calibration graph. For example, if the scale reading was 7 and we assume that Fig. 5 is the correct calibration curve, then the correct exposure time would be 27 seconds.

Difficulty is only encountered when extreme negatives are printed on normal grade paper but this is only to be expected and in these cases a reading will provide the basis for making an accurate test strip.

Many special effects may be created by placing the detector under any part of the negative that one wants printed black and exposing for the corresponding time. This is particularly successful for silhouettes.

Some difficulty may be found when attempting to obtain balance points corresponding to high scale readings (i.e. in low light intensity levels) since the minimum is not too distinct, but the error involved is only very small and should not affect the quality of the finished print.

ADVANTAGE

The main advantage of the exposure meter is that it saves the operator having to make test strips for every different enlargement and consequently leads to a saving in time and materials.

This exposure meter can be built for as little as 50s, which is considerably cheaper than any comparable commercial instrument. A wooden cabinet costs only a few shillings to make, but any wood, plastic or metal box could be used with equal success. ★

APAE EXHIBITION

It is always a pleasure to visit the Public Address Exhibition, as this exhibition is held in one of the most convivial and friendly atmospheres encountered at any such shows. This does not mean that the proceedings are not taken seriously, far from it. The amount of professionalism that is put into the proceedings is immediately apparent when one visits the stands and attends the lectures held each day throughout the exhibition.

This year's exhibition, held at the King's Head Hotel at Harrow-on-the-Hill, on March 11 to 13, was the 21st anniversary of the exhibition and there was a special display on the lower floor devoted to early equipment and papers of historic interest. The exhibition was slightly smaller than previous years; this was due to a similar exhibition held abroad the week before and the lack of time to transport equipment back to England. Nevertheless, the 27 companies taking part represented the best in the P.A. industry, and quality was the main theme.

Customer package deals and interchangeable or add-on units were evident at many of the stands. Of these the Private Communications Division of STC broke new ground with their range of complete public address equipment for particular requirements. The kits are designed to be able to cater for small churches and halls, social and sports centres, office intercom, and background music units.

A complete range of Philips P.A. equipment and a newly styled range of indoor cabinet and column loudspeakers, ranging from a small cabinet handling 1/3 watt to a speech and music column capable of handling up to 20 watts was exhibited on the Philips Sound Division of Pye T.V.T.

Microphones obviously paid an important part in the exhibition, as no equipment can meet manufacturers' data unless the "front end" delivers the "goods". Of the numerous microphones on display the FC range of condenser microphomes from Fi-Cord Co., carry an unconditional five year guarantee against any kind of maltreatment. These microphones are suitable for pop music groups due to the falling bass response below 200Hz, thus minimising acoustic feedback—not to mention the current trend of stage acts of complete break-up of instruments during a performance.

Many new and improved design power amplifiers and loudspeakers were evident at most stands. Reliance exhibited their Buxford flameproof loudspeaker, which is claimed to be incapable of causing a fire or explosion.

Finally, the Association took the opportunity to introduce a special 45 r.p.m. double-sided test record of sounds and phrases for microphone and system testing. The record provides 3 minutes of male speech, with a special 30 second off-mic speech to illustrate the importance of correct microphone technique. Female speech follows and runs for 3 minutes.

Side two comprises selected intelligibility phrases for phonetic balance and general performance of the complete installation; 1,000Hz tone and warble tone, for equipment line-up and measurements with sound level meters, and a reference level for individual equipment. The inclusion of white and pink noise, while of limited application without auxiliary equipment, are for aural evaluation of loudspeakers, pick-ups, tone controls, and filter circuits.

Although prepared primarily for A.P.A.E. members the record is available for general (*bona fide*) professional use. The record costs 15s, plus 1s postage and packing, and applications for copies should be made to the A.P.A.E. Sales Office, 394 Northolt Road, South Harrow, Middlesex.

Optical Character Recognition

By P. J. POBGEE (National Physical Laboratory)

As computers play an ever-increasing part in our daily lives the need to communicate with them also increases. We find it convenient to mark symbols on paper in the shape of bills, cheques, and other documents. Before a machine can process this information it has to be translated into another form, such as a code of electrical impulses.

UNFORTUNATELY, the problems in constructing a device to recognise just the numerals 0 to 9 are far from trivial and at the present time large numbers of people are employed merely translating this data into a more acceptable form.

For example, the code, which the Post Office has introduced for postal addresses to aid the sorting of mail, has to be re-marked as a pattern of fluorescent dots to be readily detectable electronically.

Conversely, the software outputs of computers often have to be duplicated in both machine and human languages. An example is the overprinting of punched cards with alphanumeric symbols used by insurance companies.

MAGNETIC INK

A compromise is reached by banks using magnetic ink. The characters printed at the bottom of cheques are specially shaped to be distinguishable by a machine and yet remain intelligible to the human eye. As the cheques are fed through the machine the strip of magnetic printing ink is used in a similar way to a piece of magnetic tape being played back by a tape recorder.

Although the required quality and accuracy of printing is expensive to produce, the reading head is not affected by irrelevant marks such as date stamps or the pattern of the paper.

However, what is really needed is a device capable of recognising ordinary writing. One approach is to imitate the retina of the human eye by constructing an array of light sensitive elements. These divide the field of view into cells and a large number of elements are required to give adequate resolution. They are so connected that when a pattern covers the appropriate cells the machine's logic emits the corresponding signal.

This highlights two difficulties: if the pattern occurs in a slightly different place another group of cells is covered, requiring the logic to be repeated; the logic has also to decide whether each element is seeing ink or blank paper. The latter problem arises because, for other than perfect printing the patterns are not just black and white but contain intermediate shades of grey.

The intensity we call black depends on the background surrounding that area. For example, a badly printed 5, with a faint top and a heavily smudged bottom, gives false information that the open part of the loop is darker than the top stroke of the character; this must be ignored.

"CYCLOPS"

An interesting alternative known as *Cyclops* will now be discussed in some detail.

If the image of a raster on a cathode ray tube is projected on to a document and the reflected light is collected by a photocell, a video signal is produced. This flying spot technique is the type of television camera often used for transmitting cine films. The three dimensions of horizontal and vertical position and grey value are represented by the two dimensions of time and electrical amplitude.

If this video signal is passed through a pure time delay the effect is the same as if the pattern had been in a different place. Times equivalent to the durations of line scan correspond to horizontal shifts, and fractions of a line period to vertical shifts. (It is most convenient in this case to have the fastest scan in the vertical direction.)

Fig. 1 shows the effect of delaying the signal by a complete line period and also by an additional quarter of a line. If we measure the correspondence between these copies, at any instant we relate the ink density at three points, such as ABC, separated by the distances determined by the time delays.

Since we are comparing the signal only with itself the correspondence is unaffected by the position of the original pattern. We call such an arrangement of points an n-tuple and design it to fit on a characteristic feature of the patterns to be identified. Any number of points may be so grouped, including negative ones. The latter are realised by inverting the video waveform so that the presence of white, such as the centre of a zero, may also be detected.

LOG CIRCUITS

It is necessary to measure the correspondence by multiplying the signals at each point together, since we wish the answer to be zero whenever any of the points do not fit. Mere addition still gives a sum even when one of the components are zero.

Fortunately the voltage across a forward biased semiconductor junction approximates to the logarithm of the current flowing through it and economic multiplication can be performed by adding the logarithms as in Fig. 2.

The output of the antilog circuit represents a continuous measure of the fit of the *n*-tuple as the raster scans the input pattern. If this output is integrated over the whole field of view a measurement is obtained which depends on the overall shape of the original pattern but is independent of its actual position.

We may extract a set of such measurements by using several different *n*-tuples simultaneously. Each one will measure the amount of its appropriate feature but will also vary with the contrast of the ink with paper, although they will tend to move in sympathy with each other. For example, a pattern with a poor contrast will give a low output on all the measurements.

To cope with this problem *Cyclops 1* uses 20 *n*-tuples feeding 10 numeral wires through resistors, these being chosen to correspond with the relative fits of the *n*-tuples expected for that numeral. By selecting the wire with the largest signal the answer is only dependent on the ratios of the *n*-tuple measurements and not their absolute values.

Using these techniques *Cyclops* is able to recognise a strip of ten unknown numerals in inferior printing in less than 4 milliseconds.

HANDPRINTING

There is still a long way to go to approach the performance of a human reader who interpretes the enormous variety of shapes and sizes produced by handwriting.

The *n*-tuple technique just described has the advantages of speed and simplicity for machine generated printing where the patterns are of predetermined shape, although their outlines are generally not well defined.

A hand printed character, however, often has a sharp outline but consists of a sequence of strokes whose relative positions are variable. The strokes may be treated as mini-characters and recognised by the *n*-tuple method.

If the order in which they appear is noted, a parts list can be prepared to match with a catalogue built into the machine. For example, if the strokes are labelled horizontal *h*, diagonal down to right *r*, diagonal down to left *l*, and vertical *v*, then a 5 when scanned from top-to-bottom and left-to-right could be coded *hvhrvlhr*>. This code may be represented by a series of pulses and compared with similar pulses stored in the machine.

Yet another system ignores positional information by tracing around the outline of the unknown character and forming a list of the directions travelled from point to point. The length of a list obviously depends on both the size and shape of the pattern but Mullard Research Laboratories are successfully reducing such lists to a standard number of measurements. By presenting measurements from typical patterns to a computer they are able to use it to adapt a decision mechanism to recognise handprinted numerals.

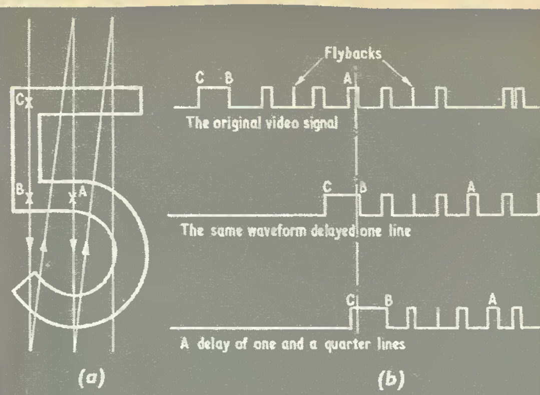


Fig. 1a. Basic raster pattern superimposed on a figure 5. (b) Wave forms corresponding to recognition response on the figure 5

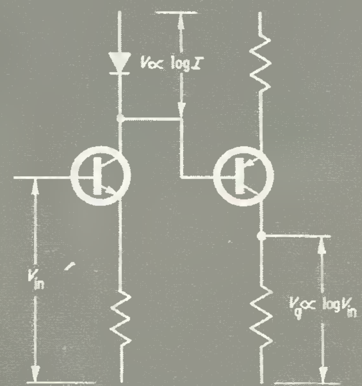


Fig. 2a. Basic theory of the log-generator

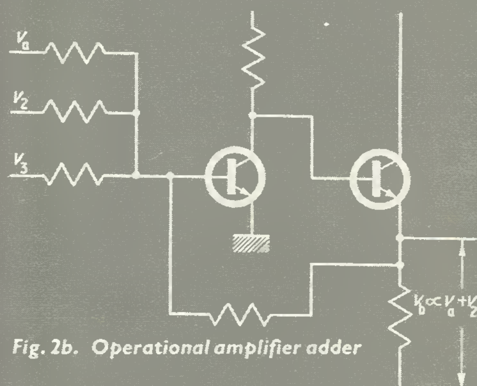


Fig. 2b. Operational amplifier adder

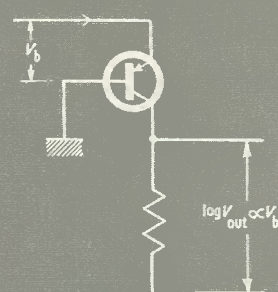


Fig. 2c. Antilog circuit using a base-emitter diode

Fig. 2. Simple analogue multiplier

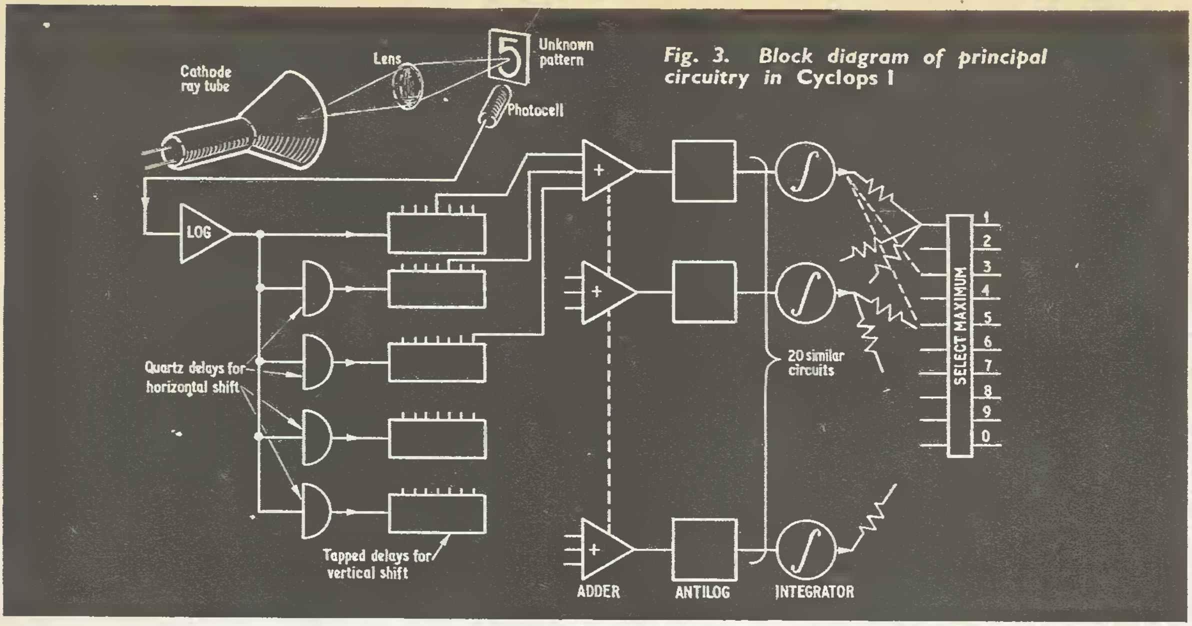


Fig. 3. Block diagram of principal circuitry in Cyclops I

The process is analogous to that of training the resistive network, to which n-tuple measurements are applied, in the *Cyclops* system to modify itself when a wrong answer is obtained.

OPTICAL METHODS

Other investigations being carried out allow processing of all the elements of a pattern in parallel at the speed of light. An obvious method is to compare the unknown with a set of photographic masks. The difficulty arises in fitting the pattern on the masks. Any difference in shape or position reduces the correct fit and may increase the wrong one.

Consider a simple pattern composed of alternate black and white lines. By scanning across it a "temporal" frequency, of so many peaks per second, could be obtained but this value would depend on the speed of the scan. By using the concept of "spatial" frequency, of so many peaks per millimetre, the pattern is described without reference to time. Complex patterns can be built up from a Fourier series of spatial frequencies in the same way that a complex electrical waveform may be obtained from a set of sine waves.

By using a transparent pattern as the aperture of a lens a Fourier transform can be obtained at the focal plane of the lens. This transform is, in effect, a graph of the spatial frequencies present in the pattern against axial distance. The finer the detail the more the light is diffracted from the optical axis. A blank pattern produces a bright spot of light at the focus since it corresponds to zero spatial frequency. These transforms are independent of the input position thus removing one variable. Unfortunately, the transformed patterns appear to be even more difficult to separate into character types.

If a filter is placed in the focal plane to suppress certain frequencies the detail present when the original pattern is reformed may be enhanced or reduced as an aid to recognition.

HOLOGRAMS

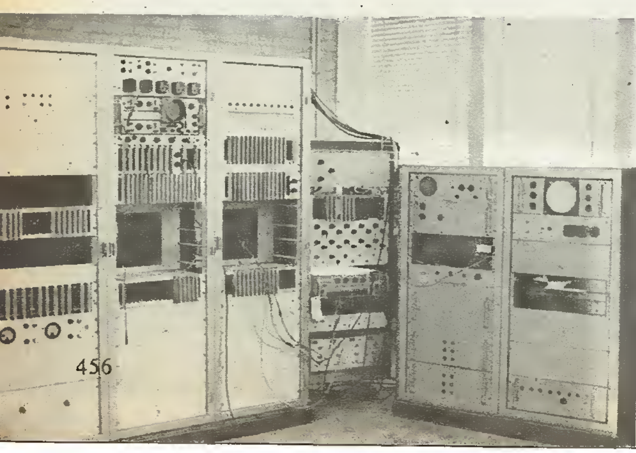
A recent article explained how holograms can be formed by using a single reference beam. By illuminating the hologram with a similar beam the original pattern may be reconstructed.

One can also make a set of holograms on a single photographic plate using a different beam or code of beams for each example of a character. When this plate is illuminated by a similar pattern the appropriate beam or code is reconstructed. If the unknown pattern is only slightly different from the appropriate one of the hologram the resulting beam may be lost in the spurious light generated by incorrect fits.

Although photographic emulsion can store an enormous amount of information it is obviously impracticable to store examples of every type of distortion expected.

This problem and the need to produce the input data in transparency form appear at present to place optical processing at a disadvantage with the ease with which complex functions can be performed by integrated circuits.

Cyclops I character recognition machine



ACKNOWLEDGMENT

The author is grateful to the Directors of National Physical Laboratory, Ministry of Technology, for permission to publish details of the *Cyclops* character recognition machine, built in the Computer Science Division. ★

NEWS BRIEFS

Computer Aided Design

THREE YEARS ago the Racal Group Chairman, Mr E. T. Harrison, announced the commencement of a research programme at Tewkesbury to study the possibilities of designing electronic circuits and equipment with the aid of a computer. The idea has now become a reality and, with the support of the Ministry of Technology, REDAC (Racal Electronic Design and Analysis by Computer) is being offered as a consultative service to the electronics industry.

The established breadboard development technique using discrete components is replaced by a more reliable method, involving the application of stored information to mathematical and theoretical problems.

Reliability is improved, costs stabilised and predetermined at the design stage, and marketing of an original concept can be considerably speeded up. As an example, where a printed circuit board can take about three weeks to design by conventional methods using drawing office facilities, REDAC can do the work in less than a week at about the same cost. Multilayer integrated circuits can be designed by using a cathode ray tube graphic display machine developed by Elliott Automation.

Mr E. Wolfendale, Deputy Managing Director, has spent much of his time in computer aided design and has travelled to many parts of the world to lecture on the subject. In describing the system, he emphasised the possibilities of taking into account a sensitivity analysis and "worst-case" or statistical tolerance performance, so that the designer can re-analyse, re-optimise and re-tolerance to provide for these factors.

Because electronics is becoming so complex, Racal believe that time and money will not be available in the future for traditional manual design methods employing such a wide range of components. It is not expected that Racal will monopolise the system idea; indeed, they are offering a tutorial service to customers' engineers which will enable them to computerise on their own premises.

Inevitably a design language is needed for the computer and the mathematical and languages group have developed a special circuit calculation language for the designer to use. Input specifications or updating data are sorted by the computer into component generic types, then classified in data form into a manner easily accessible to the designer.

Off-line data links are provided between the design centre and the customer by G.P.O. Datel links.

Skynet

THIS year will see the introduction of Skynet—the United Kingdom's Defence Satellite Communications System. The overall system has been designed by Mintech to satisfy stringent Ministry of Defence requirements. The System will comprise nine earth stations and two satellites, one operational and one standby (procured from and launched by the United States), in a closely defined synchronous orbit some 23,000 miles above the Indian Ocean.

Five of the earth stations will be placed at fixed locations, two installed in the assault ships HMS *Fearless* and HMS *Intrepid*, and two air transportable mobile stations will be held available for rapid deployment to meet contingency requirements. The network of stations and the satellites will provide better and more reliable communications for all arms of Britain's forces, and will provide a national communication capability from the Atlantic to the Far East including Hong Kong.

International Apprentice Competition

SELECTION tests for this year's British entrants in the International Apprentice Competition took place at Southgate Technical College during April. Two sections of the competition, which covers a large variety of skills and involves apprentices from all over the world, were dealt with at Southgate. They were: the Industrial Electronics section, looked after by Mr Smith of Nottingham College of Technology, and the Radio and Television Servicing section under the watchful eye of Mr Hicks of Southgate Technical College.

The results of the examinations are placed before a committee who decide on the placings of apprentices and award Gold, Silver and Bronze medals to the first three apprentices in each section. The first apprentice in each section is sent to the final which is to be held at Brussels in July and the second apprentice is a non-travelling reserve.

This year's winners were:—

Industrial Electronics section:
- 1st Mr P. Guttridge; Mintech.R.A.E. Farnborough.
- 2nd Mr G. Clarke; Mintech.E.Q.D. Aquila.
- 3rd Mr D. Bracknel; Mintech.R.A.E. Farnborough.

Radio and Television Servicing:
- 1st Mr R. Pheasant; Alex Owen Ltd.
- 2nd Mr D. Throup; Fairbank Harding Ltd.
- 3rd Mr M. Hobs; R. P. Jones.

Electronics Help Beat Crime

INDUSTRIALISTS in Birmingham will be the first in the country to have the opportunity of being connected to a new type of equipment to monitor burglar and fire alarms installed on their premises.

Securitas Alarm Limited have developed the Securifon, which will enable a constant "electronic" watch to be kept on alarm systems installed in subscribers' premises in the Birmingham area. The system, operating over normal GPO telephone lines, uses the principle of telemetry.

Data on the current state of burglar alarms in up to 100 subscribers' premises is fed into a satellite station usually located within a two mile radius. Coded signals are then fed from the satellite station via a single telephone line and displayed on a control unit located at a central station, manned 24 hours a day by security personnel.

POINTS ARISING

POCKET RADIATION MONITOR (*April 1969*)

The specified transformer T1 was made by Messrs Fortiphone three years ago; it was a standard 6V–800V 1 watt inverter type (6V–400V plus doubler). Messrs Fortiphone are still the suppliers of either: L1320/4; L1320/8; L1321/4 and L1321/8, all of which will function well in the circuit.

D.C. FEEDBACK PAIR (*December 1968*)

In Fig. 7 on page 855 the output from TR2 should be taken from the emitter and not the collector.

ELECTRONIC SPIROGRAPH PATTERNS (*May 1969*)

The first caption on page 371 should be: *Hypocycloids, loops now peaked*

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OC139	2/6	OA73	2/-
OC140	3/6	IN914	1/6

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AN INTERNATIONAL TECHNICAL LANGUAGE

BY R. SPATHAKY B.A.

Language standardisation is the kind of process that took place when in 1921 the International Commission for Radio and Visual Signalling Techniques persuaded nearly all countries to replace the English term two-*electrode valve*, French *tube à deux électrodes*, German *Zweielektrödenröhre*, and Swedish *tråelektrodrör*, by the international word DIODE.

Interlinguistics is the new branch of linguistics which studies how far the above process can and should go. This is of great importance in the scientific and technological fields. Naturally nobody would want to see an international version of "Hamlet" processed and standardised!

AMATEURS and professionals in electronics may be interested to know that Dr Eugen Wüster, the Austrian who is a prominent member of the International Electrotechnical Commission, is also one of the pioneers in the removal of linguistic barriers between technologists by standardisation of units and of names for components. He not only keeps the wires humming in the technical sense but makes common-sense suggestions as to the verbal shape of the messages going along the wires.

To illustrate the kind of schemes for the future that Wüster is interested in, we give the following example of standardised language.

INDICATORES DE VOLTAGE

Minuscule diodos a neon que contine duo parve electrodos in un inveloppo de vitro es sovente installate in apparatos domestic. Le specie de circuito que pote esser usate es monstrate in Fig. 2.1. Le diodos usate ha duo electrodos identic de maniera que le currente pote fluer a transverso illos in cata direction sin injuria significante; le diodo monstrate in le circuito es ergo representate per un symbolo symmetric, cata electrodo combinante le symbolos pro un anodo e un cathodo frigide.

Quando le commutator es clause le diodo a neon operara al momento quando le voltage instantanee del conductor a currente alternante attingera le voltage liminal del diodo empleate. Le valvula essera extinguite al momento quando le voltage del currente conductor essera inferior al voltage minimal del diodo, verso le fin de cata semicyclo, ma reaccendera durante le semicyclo succedente. Assi le valvula emitte 100 fulgores cata secundo ma le oculo lo vide producer un lumine basse satis continue.

Well, if you haven't identified the original yet, the above is an international rendering of the third and fourth paragraphs of the article entitled *Cold Cathode Tubes* on page 435 of the present issue of P.E. This is one of the types of standardisation of terminology in which Wüster is interested.

MINIMUM OF GRAMMAR

The bugbear of most people in learning languages is the complexity of grammar. As Dr Alexander Gode, who "discovered" the above interlingua has remarked, you really need no grammar at all to be able to read a passage such as the one just cited. In order to write or speak it, enough grammar to cover both sides of a postcard will do, i.e.

Article: le electrodo / un electrodo — **Plural:** le electrodos

Adjective: un symbolo symmetric — symmetric symbolos

Adverb: recente gives recentemente
frequente gives frequentemente
(-mente is our -ly).

plus practic que (more . . . than)
minus que (less . . . than)
le circuito le plus practic—the most practical circuit.

Persons

Subject	*Object*	*Possessive*	*Subject*	*Object*	*Possessive*
io	me	mi	nos	nos	nostre
tu	te	tu	vos	vos	vostre
ille	le	su	illes	les	lor
illa	la	su	illas	las	lor
illo	lo	su	illos	los	lor

(All words in -self = se)

Complete Table of the Verb. (*Filtrar—to filter*). *Present* (*Past when -va added*)

io filtra	-va	*Pluperfect* habeva filtrate
tu filtra		*Future Perf.* habera filtrate
ille filtra		*Condit. Perf.* haberea filtrate
illa filtra, etc.		*Pres. Passive* es filtrate
		Past Passive esseva filtrate
Pres. Part.	filtrante	*Fut. Passive* essera filtrate
Past Part.	filtrate	
Imperat.	filtra!	*Condit. Passive* esserea filtrate
		Perf. Passive ha essite filtrate
Future	filtrara	*Pluperfect. Pass.* habeva essite filtrate
Condition	filtrarea	*Future Perf. Pass.* habera essite filtrate
Perfect	ha filtrate	*Condit. Perf. Pass.* haberea essite filtrate

Using as tintacks a handful of particles like a—to, at; ab—from, since; ante—before; circa—around, one should be able to express most technical prose.

CONTROL LANGUAGES

The above schema is enough for those who are not linguists but merely wish to handle the tool. For those who would like to know where the language came from; it is based on prototypic forms derived from the paradigm of each word in all the Romance languages and taking into account English, German and Russian.

In rather imprecise terms one can say an "average" word has been made out of the various European forms. Oriental and African languages are not included in the control languages because they are eager importers of Greco-Latin technical terms. This is how the "averaging" process works:

abberation of light (*Eng.*)	aberration de la lumière (*Fr.*)	aberración del luz (*Sp.*)
aberrazione della luce (*Ital.*)	Lichtabirrung (*Ger.*)	aberratsiya (*Russ.*)

From this series the interlingual form is *aberration del lumine.* What is not shown in the above, however, is how words in the rest of the total paradigm, such as our *luminous,* also influenced the final form.

Of course there are occasional hard nuts to crack when one comes to extract these standard European forms from the control languages. Perhaps those readers who also happen to be linguists would care to advise the author on the problem of the series:

B battery (*Eng.*)	batterie de tension anodique (*Fr.*)	batteria B *Sp.*)
batteria anodica (*Ital.*)	B-Batterie (*Ger.*)	polosa (*Russ.*)

I would opt for the interlingual form *batteria* (*de tension*) *anodic.* Would anybody say that *batteria-B* is a better international form?

WHY NOT ENGLISH?

Some will say that all this is unimportant because English is all set to become the world language of science. It is true that it is a hot favourite, but there are other sturdy competitors like Russian and Chinese.

One would think that the speakers of the most important languages would be able to come to some agreement, especially about technical terms. It is natural that their languages will continue to capture each other's speakers and readers; this is an industrial and commercial struggle as well as a linguistic one. But agreement could avoid the worst effects of the language-struggle.

The "Big Three" would agree to teach each other's languages more than they do at present. Secondly, they would adopt a universal technical code, probably based on the roots common to English and Russian. Chinese and Japanese are importers of these basic words (though the Chinese have probably stopped during the recent cultural revolution). They fit them as best they can into the tone-system of their languages. Here are recent imports into Japanese:

maika chikudenki	mica condenser
maikurohon zatsuon	microphone noise
magunetto sen	magneto wire
rotari shiki	rotary system
refurekkusu zofuku	reflex amplification
homodaim jushiu	homodyne reception
ichi eherugi	potential energy

The basis for agreement upon either a code or an interlingua between Anglo-Saxons and Russians is shown by the following equivalents: (*Eng., Russ.*) crane, cran; electric, electricheski; battery, batereya; telegraph, telegraf; machine, mashina; platinum, platina; hypothesis, gipoteza; selenium, selen; motor, motor.

PRONUNCIATION

The problem of how an interlingua should be pronounced is a highly technical one, which has been written about by Troubetzkoi, the founder of practical phonology and therefore, in a way, of all accoustic and hi fi studies.

The American A. Gode says that the Greek and Latin rootwords can only be given one feasible appearance and pronunciation, a slightly southern European one. That is why the extract at the beginning of this article probably reminded you of Spanish. But it would remind a Spaniard of Italian, an Italian of English. It is Standard European.

Finally, the standardisation of terms has some importance for education. When Greek and Latin studies were more widespread they at least ensured a supply of future scientists who could compose the terminology of their work. Realising that such a class of philologists hardly exists,some Swedish schools have recently introduced classes in General Linguistics for their pupils, along the lines of the interlingua described in this article. ★

LABEX INTERNATIONAL 1969

LABORATORY APPARATUS & MATERIALS

Another international exhibition at Earls Court was nearly postponed due to a go slow by workmen. However, the LABEX exhibition was opened as planned on March 25 by The Rt. Hon. Edward Short, M.P. The completion of some of the stands continued into the second day and at one time there was talk of Pye Unicam's stand—the largest in the exhibition—being taken down and rebuilt, as enthusiastic Pye staff had violated the go-slow over the preceding weekend to finish their stand.

Laboratory apparatus and materials of a fantastic variety were displayed by over 550 firms, half of them from the U.K., some 70 from America and others from Germany, Switzerland, Sweden and Japan in that order. During the exhibition a series of lectures and discussions took place and these, too, covered a wide variety of subjects from "Detection of Flavour in Food" to "Computers in the Laboratory".

Several new instruments made their debut at LABEX. These included the Philips PW 1410 Manual X-ray Spectrometer which allows quicker and more accurate analysis of elements than was previously possible. An experimental computer complex was displayed on the Pye stand, designed to link a number of gas chromatographs and spectrometers to a small computer. Stanton Instruments were displaying a newly developed low temperature differential thermal analyser, which covers a temperature range of between −180 and 450 degrees C. The most interesting feature of this device is its fast cooling rate—from 450°C to ambient temperature in 10 minutes.

Bosch Ltd., and Leitz U.K. Ltd., exhibited a new Iconometric Analysis Microscope which uses an optical electron computer for quantitive analysis and evaluation of optically perceptible structures. The apparatus comprises a very high quality television camera which is attached to a microscope. The video signal from the camera is analysed and evaluated in the main control unit. The picture is also displayed on a monitor, thus enabling an operator to insert marker pulses and an adjustable mask; by this means any area of the picture can be selected for evaluation.

The machine has a wide application in medical, metallurgical and chemical fields.

A number of new low cost Infrared spectrometers were displayed on many stands; some appeared at half the cost of previous instruments: this shows a trend in the laboratory apparatus industry—specialised instruments becoming available at greatly reduced cost and, in many cases, the equipment is more compact and easier to set up and use.

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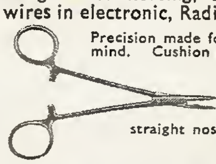
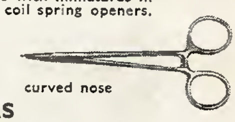


straight nose



curved nose

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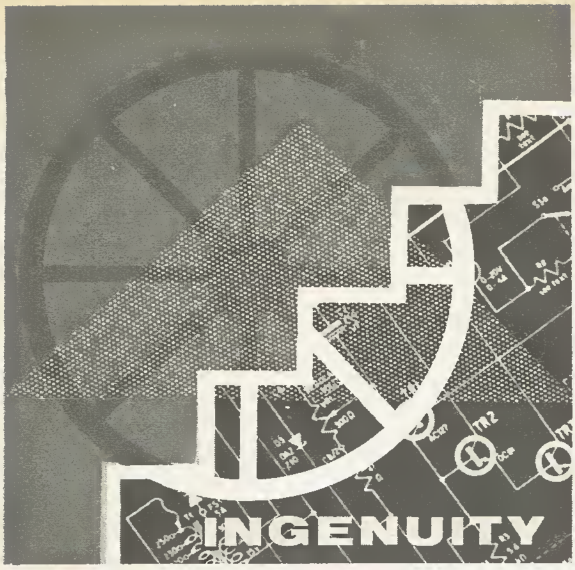


UNLIMITED!

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.

SPOT ON

THE CIRCUIT in Fig. 1 was designed as a gimmick for a dance, the idea being to have a spotlight directed on to a doorway, so that whenever people walked in or out the spot came on.

With a light focused across the doorway on to a ORP12 light dependent resistor, the resistance is low and insufficient voltage is available to trigger the thyristor SCR2. When the light beam is interrupted the change in resistance value is sufficient to trigger the thyristor. The firing point of the thyristor is controlled by VR2.

If the lamp (load) is allowed to switch from the off to on state rapidly it would have a very short life span, and components R1, C1, D1, VR1, and SCR1 are included in the circuit to protect the lamp. This timing circuit is set by VR1 so that when SCR2 is in the off state the lamp is glowing as dimly as possible, thus when the light beam is interrupted the light flashes from "just-on" to "full-on". This keeps the lamp filament hot enough to prevent large surge currents from flowing.

The photo-beam was provided by a 4·5V 0·5A bulb, powered by a mains transformer, housed in a torch case. The transformer was just small enough to fit into the battery compartment.

The circuit can also provide a "strobe" effect simply by pointing the ORP12 at the controlled light. This sets up a form of feedback and the speed can be varied by VR1 and VR2.

Resistor R2 was placed across VR2 because it was found that VR2 has a tendency to change resistance due to heating, leaving the light permanently on.

A. K. Draper,
Norton St. Philip,
Bath.

TIME SWITCH

NEARLY four years ago I made the clock with the cold cathode numeral indicator tubes as described in PRACTICAL ELECTRONICS.

After a year I had trouble with worn contacts on the first digit single pole 10-way switch, which I replaced with a new one (this switch makes and breaks nearly ½ million times a year!).

I have now substituted a rotary switch made from 10 dry reed switches, type 6–RSR, length 1·45in × 0·125in diameter. The reed switches are mounted between two perspex discs with a permanent magnet Araldited to the spindle of an old volume control, see below.

As these reed switches are good for 10^8 operations, the estimated life of my clock is now over 2,000 years!

D. B. Pearce,
Abbey Wood,
London, S.E.2.

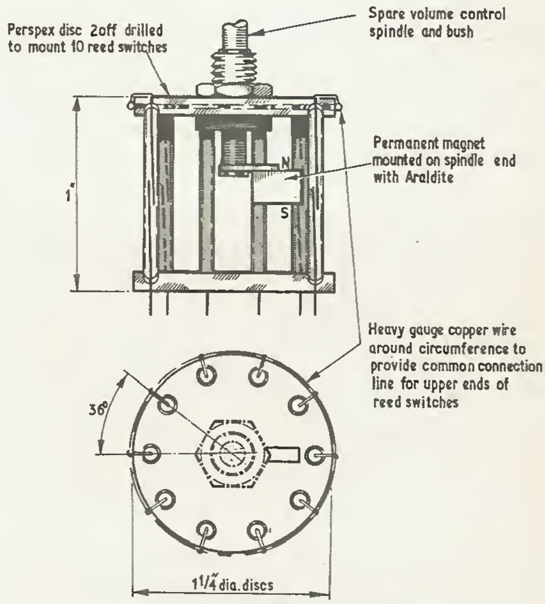


Fig. 2. Single-pole, 10-way reed switch

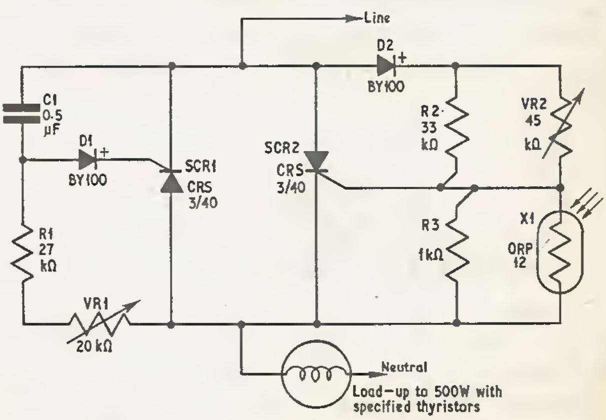


Fig. 1. Automatic spotlight control switch

BASS-MAKER

The circuit was designed and built for a 6-string "lead" guitar to produce bass guitar notes.

This bass conversion cannot be done satisfactorily using filtering techniques, but must involve frequency division. In this case, the basic string frequencies are effectively halved.

This is achieved by converting the fundamental signal into a pulse train whose p.r.f. (pulse repitition frequency) is equal to fundamental frequency. This pulse train is made to drive a bistable switch, so that the bistable makes one change of state for each input pulse. Since two changes of state in the bistable constitute a complete cycle, it is seen that two pulses in, produce one cycle output. When this square wave train is filtered to remove the unwanted harmonics it can sound remarkably like the true bass sound.

The only, perhaps major, limitation of the device is its inability to cope with a very complex input signal, i.e this must be predominantly fundamental in nature. For example: one guitar note only must be injected at a time. Two or more produce an erratic bistable drive train, and in general, a "grating" noise at the output.

It is interesting to note that, when using a microphone input, singing or talking produced the grating output (additional to that already present) whilst the human whistle, nearly sinusoidal in form, was nicely lowered an octave, losing, however, its characteristic tone.

DESIGN NOTES

The component values given were arrived at by design and must be considered only as a guide for any adventurous constructors see Fig. 3.

The resistors marked with an asterisk must be found by experiment since they control the base currents of TR1, TR2, TR3 and TR4 and will vary considerably in value between transistors of the same type due to the gain spread. If 6 volts is chosen as the supply voltage, then R3 is adjusted so that TR1 collector is quiescent at about 3V. Resistor R5 is adjusted so that TR2 emitter is quiescent at about 3V, but should be fairly low around 2 kilohms to maintain a low output impedance for TR2.

Resistor R7 is adjusted so that TR3 collector is quiescent at about 5·5V. R10 is adjusted so that TR4 collector is quiescent at about 1V. Transistor TR5 is not biased but acts as a grounding switch for D2 and D3, the bistable steering diodes. R9 is used to "stop" oscillations, but may not be necessary where lower gain devices are used, or where layout is improved. It was found easier to use this resistor rather than decoupling.

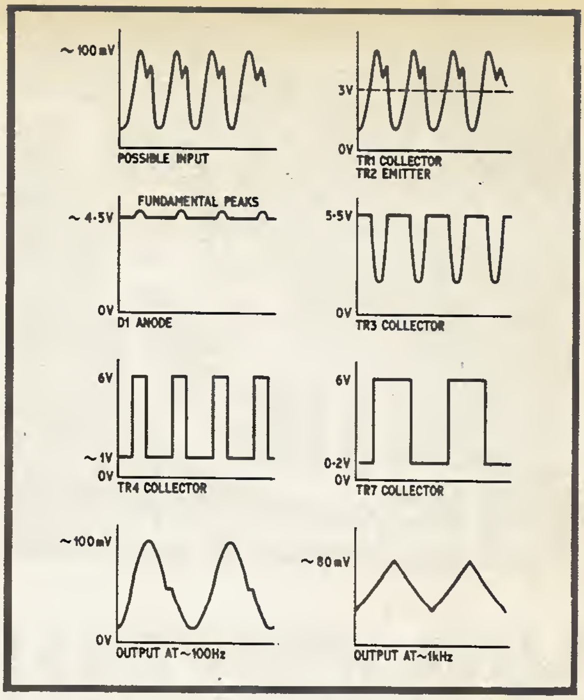


Fig. 4. Wave shapes at different stages of the circuit

Negative feedback in the form of resistance in the emitter, or from collector to base of TR3 and TR4 must be avoided, since such feedback causes spikes on the drive pulses, which can cause malfunction of the bistable. The waveforms shown in Fig. 4 should be observed at the stated points when the circuit is operating correctly.

The amplitude of output is maintained nearly constant over the guitar frequency range due to the use of the low "Q" filter C7/L1. A high resistance (1kΩ) iron cored coil (from a relay) was tuned by increasing the value of C7 until the correct sound was obtained using the guitar 6th string. The bass sound is obtained over a restricted range, but is quite acceptable even on the fourth string.

Resistor R17 reduces the loading on the bistable and attenuates the 6V signal to 100mV. Total quiescent current drain is approximately 4mA. To set up the circuit for use, adjust VR1 until only the fundamental is amplified by TR3.

P. E. Clancy,
Ashton-under-Lyne.

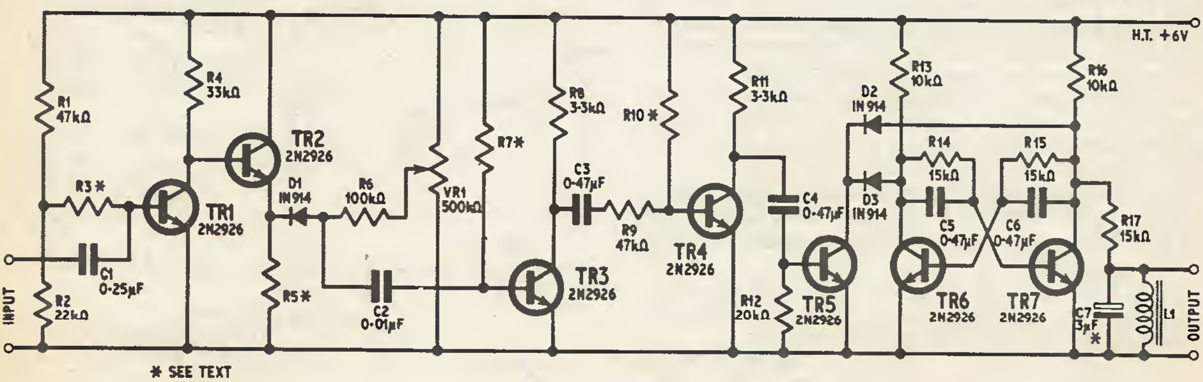


Fig. 3. Circuit diagram of the guitar bass-maker

THE PHYSICS EXHIBITION

IN AN exhibition of this kind it is impossible to detect a dominant theme, since it is concerned with the unique display of several developments, from ideas to final production. (The Physics Exhibition, sponsored annually by the Institute of Physics and Physical Society, was held at Alexandra Palace, London, from March 10 to 13.) Out of this event, commercial concerns cannot expect to reap immediate financial rewards. However, it is frequently forgotten that, if it were not for the "back-room seedsmen", many companies would not have any produce to take to market.

The field of technical knowledge covers several acres but the harvest depends largely on the applications to human needs. Typical here is the growing quest for diagnosis and treatment of diseases, in which several branches of physics technology can plough through the problems.

HIDDEN CONTOURS REVEALED

It should come as no surprise to many that holography is an obvious choice in showing three-dimensional views of internal human organs, as opposed to the two dimensions from x-ray plates. Some indication of proportions and contours can become apparent—a breakthrough in diagnostic interpretation. This work is being carried out at A.W.R.E., Aldermaston.

The Acoustics Group of the Institute held a collective display of acoustic and ultrasonic techniques in collaboration with organisations concerned with medical research. Of particular interest was the ultrasonic transducer "Diasonograph" which makes two dimensional scans of, among other organs, the liver. The transducer is moved over the surface of the skin and, using liquid paraffin as a couplant, provides pulse echo information from the liver area to modulate the brightness of a cathode ray tube beam.

Although potentially valuable in finding abnormal shapes due possibly to foreign growth, this method has so far presented difficulties in applications, due to natural variations between individuals in the transmission loss of the anterior abdominal wall.

These variations can reduce diagnostic accuracy, but suspicions of diseases, such as cirrhosis, cancer, and cyst, can help localise and concentrate further investigation on a reasonably sound basis. This work is sponsored by the Medical Research Council with the Board of Governors of United Bristol Hospitals.

CLOSE STUDY IN SCHOOLS

The experimental and close study techniques employed by university laboratories has been attracting the interest of secondary grade schools (with sufficient financial incentive) enough to encourage basic research work in science projects. Consequently it is encouraging to see an enlarged section devoted to school projects and educational techniques at most levels.

Typical in this group is the belief by The King's School, Gloucester, that a precision, frequency locked, electronic counter can be made a basic laboratory instrument, operating at 100kHz, for accurate time and frequency measurement, temperature and electrical resistance, inductance and capacitance measurememt. The system developed at this school uses comparison techniques, whereby the oscillator frequency is made the analogue of the parameter under investigation. The actual counter is the means of measuring this frequency.

Readout—
A SELECTION FROM OUR POSTBAG

correspondents wishing a reply must enclose a stamped addressed envelope

The right level?

Sir—As a regular subscriber to PRACTICAL ELECTRONICS for the past 18 months, I should like to offer some criticism (more praise really) and suggestions, which I hope you may find of interest.

Firstly, a word of praise for your subscription department and general publishing policy. It is much appreciated that overseas subscriptions do not cost more than at home, and that the magazine reaches me here no later than it appears on the news-stands at home. My special thanks, incidentally, for sending on any free gifts at no extra charge—the same can, unfortunately, not be said of many U.K. publishers.

With regard to the magazine itself, I hope you will continue to steer clear of television and radio topics, and in particular of amateur radio. This latter field surely has outlets enough as it is, and the "fraternity's" peculiar love of esoteric abbreviations and home-brewed jargon can make a non-enthusiast's teeth grind.

Through my work, and also through acquaintances, I manage to see most of the amateur "electronics" magazines published in Europe, plus a few of U.S. origin, and I honestly think that yours is the best. This is because, I believe, *you* have managed to hit on exactly the right level of technical "difficulty" in your practical projects, which are also almost always eminently practical.

This is not intended to imply that I am not in favour of articles such as the recent series on *Bionics*, which I consider to be an excellent idea.

G. J. Phillips,
The Hague,
Netherlands.

Aroused from the chair!

Sir—I have just finished reading my first copy (April 1969) of PRACTICAL ELECTRONICS—prompted by the advertisement in PRACTICAL MOTORIST—and I am most impressed!

Indeed, it has re-awakened my interest in electrical gadgetry. I'm sure your editorial was aimed at me since this browser and second time beginner is about to become a "doer".

I found the constructor's guide supplement most useful—especially the construction materials (I've seen transistors and printed circuits of course, but I hadn't realised it was so readily available to the amateur) and the circuit symbols.

The article *Theory into Practice* is also very useful—comprehensible without being over-simplified, and the *Pocket Radiation Monitor* was most interesting, since I am an X-ray technician, but far too expensive for the amount of radiation I am exposed to, but invaluable to industrial technicians I think.

A little adverse criticism now if I may . . . I personally would find it very useful if the approximate total cost of materials was quoted in the components box as I am right out of touch with costs these days—and this would indicate whether the project was within spare cash range.

Thankyou for giving me a table-top hobby—it will be a change from being "under the bonnet" after the sun goes down.

B. P. E. Lawrence,
Smethwick,
Worcs.

Kits please

As a schoolmaster running an electronics club I find it difficult to obtain lots of components called for in your various plans and this is a cause for most boys giving up a project early.

Could you not come to some arrangement with some firms to supply a complete set of components as is done with some jobs in other magazines? This would make a lot more people take up the practical work, particularly your coming attraction of the Electronic Organ. I feel sure that the financial attraction would make component suppliers keen to go to some trouble to make up sets of parts to the magazine specifications so that one could order by post or go to one shop and know that the whole job could be purchased.

I am going to try and get the School to finance the making of the Electronic Organ and I do hope that my suggestion of suppliers might be carried out on this job and I feel sure that many more schools and individuals will "make the jobs" to the advantage of everybody concerned with the electronics industry.

S. Orford,
New Eltham,
London, S.E.9.

We would certainly like to see kits advertised, but this is really a matter for the component suppliers rather than ourselves. See this month's editorial comment—Ed.

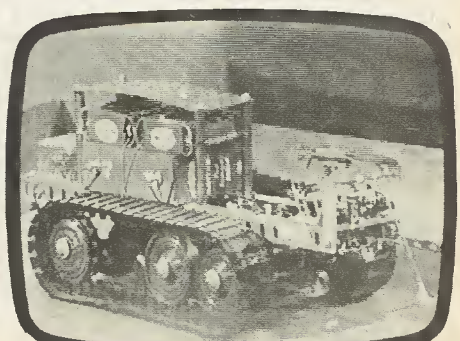
Of considerable value

Sir—We would very much appreciate it if you could mention in your next issue that anyone who is interested in the British Amateur Electronics Club should contact the Hon. Secretary, Mr J. G. Margetts, 12, Adenfield Way, Rhoose, Barry, Glamorgan.

I would like to take this opportunity of congratulating you on an excellent issue and your supplement (April) will be of considerable value to experimenters, such as the members of the B.A.E.C.

C. Bogod,
Chairman, B.A.E.C.,
Penarth.

. . . . talking of Bionics, here are two photos taken from the TV screen during transmission of the Southern Television programme "HOW" a few weeks ago. Our author G. C. Brown is shown demonstrating one of his electronic animals which is shown in close-up in the second picture



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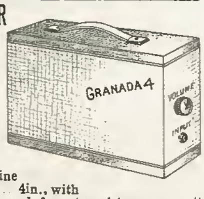

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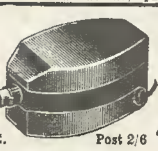

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10 WATT **55/-** CARR. 5/-

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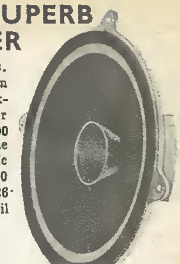

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E.M.I. Double Cone 13½ × 8in, 3 or 15 ohm models, 45/- or with twin tweeters, X/over and ceramic magnet 79/6.

SPECIAL OFFER! 8 ohm, 2½in; 6 × 4in; 80 ohm. 2½in, 2½in; **15/6** EACH TYPE 25 ohm, 6 × 4in; 35 ohm, 3in; 15 ohm, 10 × 2½in., 7 × 4in.
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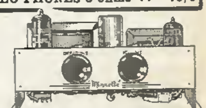
MINETTE AMPLIFIER



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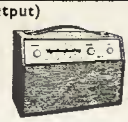
THE DORSET (600mW Output)

7-transistor fully tunable M.W.–L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulised and pre-alignment techniques make this simple to build Sizes: 12" × 8" × 3". MAINS POWER PACK KIT: 9/6 extra.

Price £5.5.0 plus 7/6 p. & p. Circuit 2/6 FREE WITH PARTS.

THE ELEGANT SEVEN MK. III (350mW output)



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Price £4.9.6 plus 7/6 p. & p.
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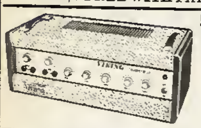


50 WATT AMPLIFIER A.C. MAINS 200–250V

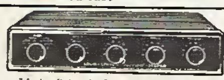
An extremely reliable general purpose valve amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organs, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

Price 27 gns. plus 20/- p. & p.

THE RELIANT 10W SOLID-STATE HIGH QUALITY AMPLIFIER

Specifications: *Output*: 10 watts R.M.S. *Output impedance*: 3 to 4 ohms. *Inputs*: 1. Xtal mic 10mV; 2. Gram/radio 250mV. *Tone controls*: Treble control range ±12dB at 10KHz; Bass control range ±13dB at 100Hz. *Frequency response* (with tone controls central): Minus 3dB points are 20Hz and 40KHz. *Signal to noise ratio*: better than −60dB. *Transistors*: 4 silicon Planar type and 3 Germanium type. *Mains input*: 220–250V a.c. *Size of chassis*: 10¼" long, 4¾" wide × 2½" deep. A.C. Mains, 200–250V. For use with Std. or L.P. records, musical instruments, all makes of pick-ups and mikes. Separate base and treble lift control. Two inputs with control for gram. and mike. Built and tested. 8" × 5" speaker to suit: Price **14/6 plus 1/6** p. & p. Crystal mike to suit: **12/6** plus 1/6 p. & p. Mk. I as above, less teak case 5½ gns. + 7/6 p. & p.
RELIANT MARK II 6½gns + 7/6 p. & p. In teak-finished case

THE VISCOUNT



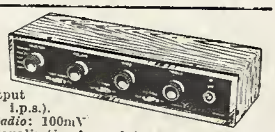
Integrated High Fidelity Transistor Stereo Amplifier

SPECIFICATIONS: Output: 10 watts per channel into 3 to 4 ohms speakers (20 watts monoral). Input: 6 position rotary selector switch (3 pos. mono and 3 pos. stereo), P.U., Tuner, Tape and Tape Rec. Sensitivities: All inputs 100mV into 1·8M ohm. Frequency response: 40Hz—20KHz±2db. Tone controls: Tone controls flat (Baxandall type), separate bass and treble controls. Treble 13db lift and cut at 15KHz. Bass 15db lift and 25db cut at 60Hz. Volume controls: Separate for each channel. AC Mains input: 200-240v. 50-60Hz. Size 12½ × 6 × 2¾in. in teak-finished case. Built and tested. **PRICE 13½ gns.** Postage & Packing 7/6 extra.

DUETTO Integrated Transistor Stereo Amplifier

SPECIFICATION: R.M.S. power output: 3 watts per channel into 10 ohms speakers. **INPUT SENSITIVITY:** Suitable for medium or high output crystal cartridges and tuners. Crosstalk better than 30Ma at 1Kc/s. **CONTROLS:** 4-position selector switch (2 pos. mono & 2 pos. stereo) dual ganged volume control. **TONE CONTROL:** Treble lift and cut. Separate on/off switch. A balance preset control is also incorporated inside amplifier, which is set to provide equal gain on both channels. The unit is fuse protected and offered in an elegantly styled teak finished case, size 10½" × 4¾" × 2½" with contrasting front panel. Built and tested. **PRICE 9 GNS.** plus 7/6 p. & p.

THE CLASSIC



Controls: Selector switch. Tape speed equalisation switch (3¾ and 7½ i.p.s.). Volume. Treble. Bass. 2 position scratch filter and 2 pos. rumble filter.

Specification: Sensitivities for 10 watt output at 1KHz. *Tape head*: 3mV (at 3¾ i.p.s.). *Mag. P.U.*: 2mV. *Cer. P.U.*: 80mV. *Radio*: 100mV *Aux.*: 100mV. *Tape/Rec. output*: 100mV. Equalisation for each input is correct to within ± 2dB (R.I.A.A.) from 20Hz to 20KHz. *Tone control range:* Bass ± 13dB at 60Hz. Treble ± 14dB at 15KHz. *Total distortion*: (for 10 watt output) <1·5%. *Signal noise*: <−60dB. A.C. mains 200–250v.
Size 12½" long, 4½" deep, 2¾" high. Teak finished case. **Price 8½ gns.** p. & p. 7/6.

POCKET MULTI-METER

Size 3⅝ × 2½ × 1⅜in. Meter size 2½ × 1⅜in. Sensitivity 1000 O.P.V. on both A.C. and D.C. volts. 0–15, 0–150, 0–1000 D.C. current 0–150mA. Resistance 0–100kΩ. Complete with test prods, battery and full instructions, 42/6. P. & P. 3/6. **FREE GIFT** for limited period only. 30 watt Electric Soldering Iron value 15/- to every purchaser of the Pocket Multi-Meter.

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G.E.C. 13 amp surface mounting switched sockets in brown. Listed at 6/6.

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This tape deck takes 5¾" spools complete with two-track heads. Size 13¼" long by 8¾" wide.

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A complete Loud Speaker system on one frame, combining three matched ceramic magnet speakers with a low loss cross-over network. Peak handling power 10 watts. Impedance 15 ohms. Flux density 11,000 gauss. Resonance 40–60c/s. Frequency range 50c/s to 20kc/s. Size 13½" × 8 1/16" × 4½". By famous manufacturer. List price £7. Our price **74/6** plus 5/- p. & p. Similar speaker to the above minus tweeters in 3 & 15 ohms **44/6** + 5/-p. & p.

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1μF	20 volt	4μF	25 volt	25μF	6 volt	320μF	4 volt
1·25μF	16 volt	5μF	6 volt	25μF	12 volt	320μF	10 volt
2μF	3 volt	6μF	6 volt	25μF	25 volt	400μF	6·4 volt
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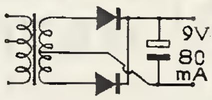

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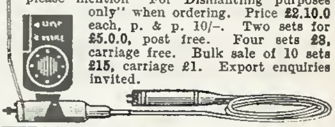

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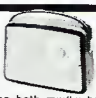

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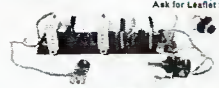

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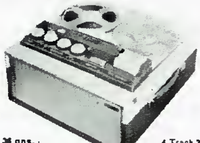

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