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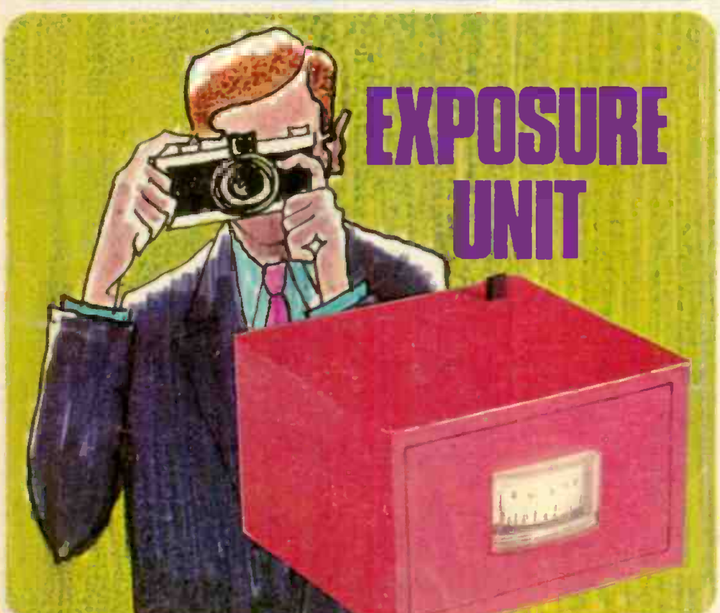

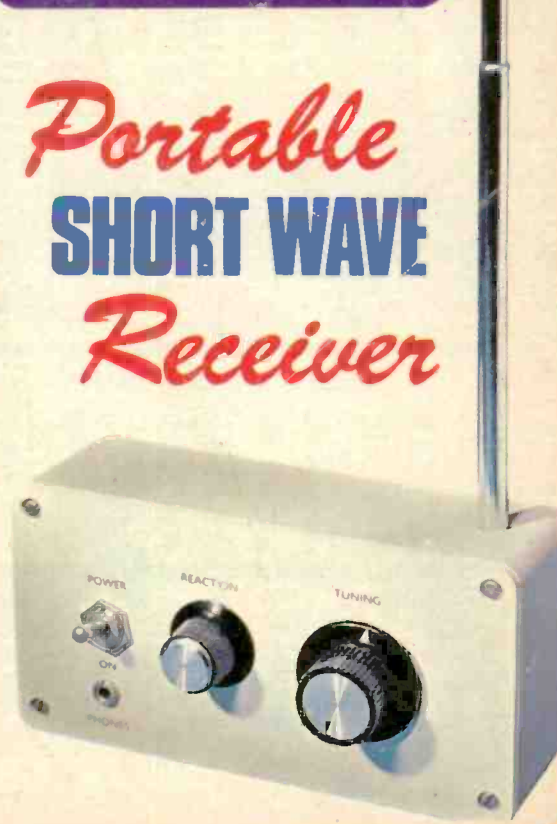

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2N2220	0·35
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40408	0·65
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40410	0·85
40411	2·85
40594	0·75
40595	0·85
40673	0·73
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AC127	0·44
AC128	0·37
AC151V	0·35
AC152V	0·50
AC153	0·49
AC153K	0·55
AC176	0·40
AC176K	0·60
AC187K	0·55
AC188K	0·55
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AD162	0·85
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BC161	0·50
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BC168	0·12
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BC170	0·10
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BC172	0·12
BC177	0·20
BC178	0·20
BC179	0·23
BC182	0·11
BC182L	0·14
BC183	0·11
BC183L	0·14
BC184	0·12
BC184L	0·14
BC207	0·12
BC208	0·11
BC212	0·14
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BC213	0·14
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BC261A	0·21
BC262B	0·19
BC263C	0·24
BC300	0·45
BC301	0·45
BC303	0·60
BC307	0·20
BC308	0·18
BC309C	0·25
BC317	0·14
BC318	0·12
BC327	0·20
BC328	0·19
BC337	0·19
BC338	0·21
BC547	0·12
BC548	0·12
BC549	0·13
BCY30	1·03
BCY31	1·06
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BF244	0·35
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BF254	0·24
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BF259	0·49
BF459	0·45
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BFS28	1·04
BFS61	0·30
BFS98	0·27
BFX29	0·38
BFX30	0·40
BFX84	0·40
BFX85	0·41
BFX87	0·40
BFX88	0·40
BFX89	1·25
BFY50	0·34
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BFY90	1·37
BRY39	0·50
BSX20	0·31
BSX21	0·32
BU105	1·50
BU205	2·20
ME0402	0·20
ME0404	0·15
ME0412	0·20
ME4102	0·10
ME4104	0·10
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MJ481	1·55
MJ490	1·35
MJ491	1·85
MJ2955	1·25
MJE340	0·58
MJE370	0·58
MJE371	0·60
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MJE521	0·65
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MJE3055	0·85
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MP8112	0·40
MP8113	0·45
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MPSA06	0·24
MPSA12	0·35
MPSA55	0·24
MPSA56	0·24
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MPSU06	0·56
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MPSU56	0·60
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TIP35A	2·50
TIP36A	3·35
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TIP42A	0·80
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TIP30c	0·65
TIP31c	0·60
TIP32c	0·75
TIP33c	1·10
TIP34c	1·20
TIP41c	0·85
TIP42c	0·95
TIP2955	0·65
TIP3055	0·55
TIS43	0·30
CA3020	1·70
CA3020A	2·29
CA3028A	1·01
CA3028B	1·29
CA3030	1·24
CA3030A	1·89
CA3045	1·40
CA3046	0·89
CA3048	2·23
CA3049	1·66
CA3052	1·82
CA3053	0·60
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CA3088	1·59
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LM709N	0·45
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LM710N	0·60
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LM723N	0·75
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LM741N	0·50
LM741-8	0·40
LM747N	0·90
LM748-8	0·50
LM748N	0·50
LM3301N	0·85
LM3302N	1·40
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LM3900	0·75
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LM3909	0·68
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MC1303	1·47
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MC1305	1·85
MC1306	1·00
MC1310	1·91
MC1312	1·98
MC1327	1·54
MC1330	0·82
MC1350	0·75
MC1351	1·20
MC1352	0·87
MC1357	1·45
MC1458	0·81
NE555	0·53
NE556	1·05
NE565	1·20
NE566	1·65
NE567	1·80
SAS560	2·50
SAS570	2·50
76003N	2·55
76013N	1·70
76013ND	1·57
76023ND	1·57
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TAA301A	1·50
TAA320A	1·15
TAA350A	2·48
TAA521	1·00
TAA522	1·00
TAA550	0·30
TAA560	1·40
TAA570	2·10
TAA611B	1·15
TAA621	2·15
TAA661A	1·12
TAA661B	1·12
TAA700	3·81
TAA930A	1·00
TAA930B	1·35
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TBA520	2·21
TBA520Q	2·30
TBA530	1·98
TBA530Q	2·07
TBA540	2·21
TBA540Q	2·30
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TBA560Q	3·22
TBA570	1·29
TBA570Q	1·38
TBA641B	2·50
TBA651	1·80
TBA700	1·52
TBA700Q	1·61
TBA720Q	2·30
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TBA750Q	2·07
TBA800	1·20
TBA810	1·10
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7406	0·74	7420	0·21	7445	1·35	7473	0·43	7490	0·61	74119	1·80	74157	0·98	74180	1·77	74196	1·17
7407	0·74	7423	0·39	7446	1·23	7474	0·43	7491	0·98	74121	0·49	74160	1·41	74181	3·70	74197	1·17
7408	0·29	7425	0·39	7447	1·17	7475	0·58	7492	0·61	74122	0·45	74161	1·41	74182	1·98	74198	2·93
7409	0·29	7427	0·39	7448	1·17	7476	0·51	7493	0·61	74123	0·58	74162	1·41	74814	2·46		
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CD4009	0·57	CD4024	0·79	CD4049	0·56
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CD4011	0·20	CD4027	0·56	CD4510	1·54
CD4012	0·20	CD4028	0·91	CD4511	1·54
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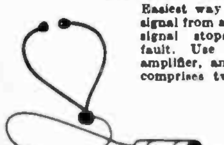

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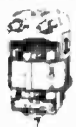

Six speeds are available 500, 850 and 1,100 r.p.m. and 7,000, 9,000 and 11,000 r.p.m. Shaft is ⅛ in. diameter and approximately 1 in. long. 230/240v. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 2 in. dia × 5 in. long. Price £2·00 including Post & VAT.

MAINS RELAYS

With triple 10 amp changeover contacts—operating coil wound for 230 volts AC, chassis mounting, one screw fixing, ex unused equipment 60p each, 10 for £5 post and VAT paid.

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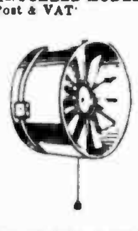
for portable car radio & transmitter. Chrome plated—six sections, extends from 7½ to 47in. 50p + 15p Post & VAT.
KNUCKLED MODEL FOR F.M. 80p + 17p Post & VAT.

EXTRACTOR FAN

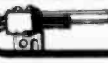


Cleans the air at the rate of 10,000 cubic feet per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact, 5½" casing comprises motor, fan blades sheet-steel casing, pull switch, mains connector and fixing brackets. £5·25 including post & VAT.
Monthly list available free, send long stamped envelope.

BLACK LIGHT

As used in disco's and stage effects etc.—virtually no white light appear until rays impinge on white collars and cuffs etc—we offer mains B.L. lamps, 175 watts plugs into any lamp holder requires no choke or control gear price £7·00 + 95 post and VAT or for glamorizing rock specimens, looking for watermarks etc a 9" 6 watt tube with starter, choke lamp holds, etc. all for £4·50 post & VAT paid.

NEED A SPECIAL SWITCH



Double lead contact. Very slight pressure, closes both contacts 12p each. Plastic pushrod supplied for operating. 10p each. 10 for 68p.

MULLARD UNILEX

A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Goodmans speakers this should sell at about £30—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £14·00 including VAT and postage.

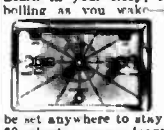
SHORTWAVE CRYSTAL SET

Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 29 31, metre bands. Kit contains chassis front panel and all the parts £1.90—crystal earphone 55p including VAT and postage.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of flex cable. Wired up ready to work. £2·75, VAT & postage 85p.

25A ELECTRIC PROGRAMMER



Learn in your sleep; Have radio playing and kettle boiling as you wake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price £2·95. VAT & Postage 60p, or with glass front, chrome bezel, £1·50 extra.

WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions. All parts and instructions to make. £3·75 post and VAT paid.

THIS MONTH'S SNIP

Breakdown Parcel—four unused, made for computor units containing most useful computors, and these computors unlike those from most computor panel, have wire ends of usable length. The transistors for instance have leads over 1" long—the diodes have approx ½" leads.

List of the major components is as follows:—17 assorted transistors—38 assorted diodes—60 assorted resistors and condensers—4 gold plated plugs in units which can serve as multipin plugs or as hook up boards for experimental or quickly changed circuits (note we can supply the socket boards which were made to receive these units). The price of this four units parcel is £1 including V.A.T. and post (considerably less than value of the transistor or diodes alone) DON'T MISS THIS SPLENDID OFFER.

MOTORISED DISCO SWITCH

With six 10 amp changeover switches. Multi adjustable switches are rated at 10 amp each so a total of 200w's can be controlled and this would provide a magnificent display. For mains operating £4·25 post & VAT Paid Ditto 9 switch £4·95 Post & VAT Paid. DITTO BUT 12 SWITCH £5·75 POST & VAT PAID.

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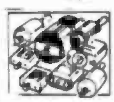

For models, Meccano's, drills, remote control planes, boats, etc., etc. £2·00.

ROTARY PUMP

Self priming, portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upon revs. Virtually uncorrodable, use to suck water, oil, petrol, fertilizer, chemicals, anything liquid. Hose connectors each end. £2·00 Post Paid.

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IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived—often bargains which sell out before our advertisement can appear—it's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lines.

Digital Thumbwheel Switch. Black face flush panel mounting, face size approx. 3⅛" x ⅜". White digits 10 positions 0-9. These can be stacked edgewise to any quantity. The right hand and left hand ends have projections for 6BA fixing to the panel. Price left-hand and right hand end switches £1·50 each + 12p. Intermediate switches £1·25 + 10p.

Mains Transformer upright mounting with top tagboard primary 0-115, 210, 240, two secondaries 115 volts 5mA, and 6·5 volt 1·25A. Note this transformer is ex-new equipment. Price £2·00 + 16p. Post 30p + 2p.

Mains Transformer, primary 0-110, 127, 150, 160 220. Secondaries (1) 3. 15-0-3. 15 (2) 2·5v, (3) 0-220v. Fitted primary screen. This is a 30w transformer, ex equipment £2·50 + 20p. Post 40p + 3p.

Three Digit Counter, resettable 12 volt coil, flush panel mounting black with white digits, ex new equipment £1·75 + 14p.

Reed Relay with double wound coil 12 volts one coil will close the read switch. 12 volts on the other coil will open the contact or still further close it depending upon whether the current is opposing or assisting. Price £1·50 + 12p Post 20p + 2p.

Relay, Clare Elliott 670 ohm. Coil sealed in metal can size approx. ⅞" by ⅞" x ⅜", two pairs of changeover contacts. This type of relay is mounted by its own leads. £1·00 + 8p.

Desk Instrument Case with sloping front, overall size of sloping front is 4" wide and 5" long. Mounted on a heavy base for stability base size 4½" × 4" with flex lock. The heavy base is easily removed if not required. The average depth below sloping panel 3" approx. Price £1·50 + 12p. Post 50p + 4p. Note the sloping front will be supplied with each of these cases but this already has quite a lot of holes in it, however, it is a simple matter to cut and bend new aluminium front if you use this as a pattern.

Rigonda 6" Mains Battery TV's for spares, these are less tubes and less knobs and will have one or two other parts missing but in the main are complete and worth having if you have one of these televisions or if you do repairs to them. Price £3·50 + 44p. Post £1·00 + 12½p.

Remember 7029. We are rapidly running out of this and if you have not put any into stock then this could well be your last chance. The price for 100 metre coil £9·50 + 76p. Carriage £2·50 + 20p.

Engine Revolution Counter. This is ex-Air Ministry item, beautifully made. As a revolution counter it is driven by a flexible shaft and having a permanent magnet field the voltage output would be dependent upon the speed. Of course it will also run as a low voltage D.C. motor and its speed will be dependent upon the applied voltage. This is dustproof and almost waterproof so it will still run in adverse conditions. One point however, is there are no brushes fitted to these motors, these are special and as yet we have not been able to find a supplier, so you will buy without brushes. The Air Ministry ref. number of the motor is 6A/7A2. We would like to hear from any customer who met this during his service career and who knows of a possible source of brushes. Price £2·00 + 16p. Post 40p. + 4p.

Nicad Battery Charger in neat plastic case size 4⅜" x 3⅜" x 2⅜" approx with mains input lead and charging output lead terminated with din plug. This is a dual output charger but contains useful mains transformer which makes it easily adaptable for many voltage cells. If not wanted as a charger could very easily be rebuilt as a power unit for receiver or other device. The plastic case has a neon indicator. Price £2·50 + 20p. Post 40p + 4p.

Panel Meter. 2½" made for Air Ministry unused but storage soiled 30mA moving coil offered at a low price but these have loose glasses which will want reglueing. Price £1·50 + 12p. Post 20p + 2p.

Garrard 4 Pole Motor, probably made for record player or tape recorder, this is 140v 40-60 cycle. We do not know the Garrard ref. no but the figure 12 is pressed on the bottom bearing cover. Price £3·00 + 25p. Post 30p + 4p.

Simmerstat by Sunvic for 2500 watts Sunvic ref 230707/10776. This is a larger than usual simmerstat dimensions approx. 2½" square by 2½" deep. Price £1·50 + 12p. Post 20p + 2p.

Smiths Time and Set Switch. 15 amp normal mains operated device intended for use with cookers, etc, which could be set to be switched on up to 14 hours in advance and for and up to one period of 4 hours. A very neat glass fronted instrument with centre control knob size approximately 4½" x 3½" x 2" deep. The Smiths ref No. C87400. One obvious use is for switching on your heating an hour or so before you come home so you come home to a warm house. Price £2·50 + 20p. Post 30p + 3p.

Flash Ernie is the name we have given to our latest disco light display because it is a random flasher and is very effective especially with coloured bulbs. Kit consists of motorised stud switch, master control switch, anti spark caps, 9 lamp holders, connecting wire and wiring diagram. Price £5 + 40p. Post 60p + 6p.

Car Cassette Power Kit. This has a stabilised output of 6v, 9v or 12v—this kit consists of transistors—zener, diode and all resistors and condensers case, and data price is only £2·60 including post and VAT.

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Emergency Light. Works from mains but automatically switches to battery should mains fail—with this your place never will be in darkness—uses PP9 battery (not supplied) otherwise complete kit with data £3·50 including post and VAT. Well or ceiling mounting case £1·50 extra.

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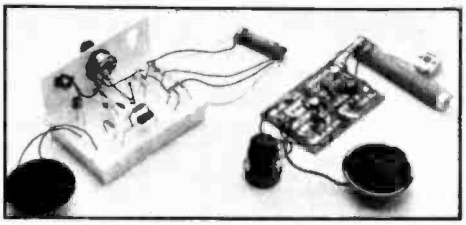

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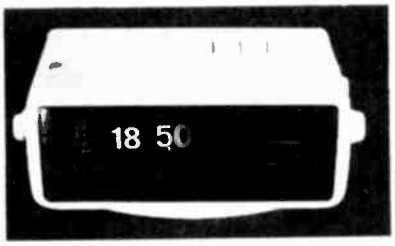

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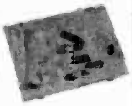

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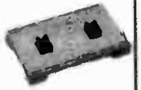

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PROJECTS..
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SCOPE FOR INNOVATION

Most projects featured in our pages are custom designed for a single definite application. Such dedicated projects are illustrated in this month's issue by the *Exposure Unit*, the *Audio Peak Level Indicator* and the *Portable Short Wave Receiver*.

There is the other kind of project which has, potentially, a number of uses and cannot be dogmatically tied to just one application. This month we have an example in the *Motor Controller*. Possibly the greatest appeal of this circuit will be found amongst radio-controlled model fans. This motor controller was indeed originally designed for use in a model motor boat. But the advantages of electronic control for small power d.c. motors will stir the imagination of others apart from the model fraternity, and so we expect this design to be pressed into service in a number of very different ways.

News of any novel and interesting applications of this particular circuit will be welcomed. Any ideas that might find wider appeal amongst our readers will be considered for publication. This is one way by which we all help further the use of electronics. It is in fact really the story of electronics—for often an original requirement is met by developing a design, and subsequently this very design is turned to additional good use in totally different fields of application.

BACK NUMBERS

We are happy to announce that the Back Numbers Service has now been restored. Full details are given on page 357.

After a closure of this service for some five years, we know this news will be welcomed by readers. We have always understood and sympathised with the frustration felt by regular readers who, for some reason or another, had been deprived of a particular issue of the magazine; likewise with new readers joining us shortly after the commencement of a series such as *Teach-In*, who naturally wished to obtain the few previous issues containing the opening parts of the series.

One note of caution needs to be given though. Exceptional demand could quickly exhaust the available stocks for any given month. Therefore we do urge that the Back Numbers Service be seen as an emergency back-up. It is still wise to place a definite order with your local newsagent, bookshop or component store.

Knowing what is planned for the coming months, we are sure you will be most annoyed to miss even just one single issue!

Fred Bennett.

Our September issue will be published on Friday, August 19. See page 373 for details.

EDITOR F. E. Bennett • TECHNICAL EDITOR B. W. Terrell B.Sc. • TECHNICAL SUB-EDITOR T. J. Johnson G8MGS

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VOL. 6 NO. 8 AUGUST 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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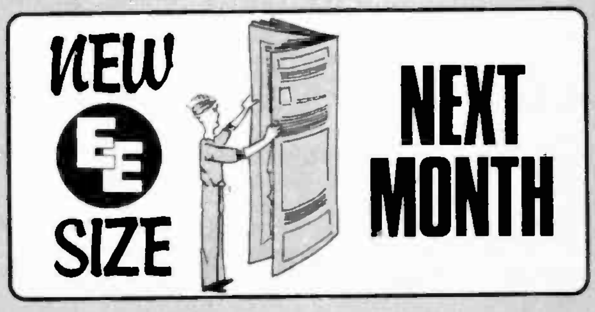
Back numbers of Everyday Electronics are now available, see page 357.



Portable SHORT WAVE RECEIVER

By R.A. PENFOLD

WHILE there is no doubt that for serious short wave reception a receiving station equipped with a good aerial system is required, a lot of fun can be obtained from a simple S.W. receiver using only a telescopic antenna. Also a surprising number of transmissions, including some from quite distant stations, can be received using such a set up.

This article describes a simple two transistor regenerative receiver that will provide a strong output to a pair of high impedance headphones or a crystal earpiece. It requires no aerial other than its built in telescopic one.

The frequency coverage is approximately 5·0 to 17·5MHz in one range. The set has been primarily designed for broadcast bands reception, and the five most popular of these bands are included in its coverage. These are the 49, 41, 31, 25, and 19 metre bands.

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CIRCUIT DESCRIPTION

The circuit diagram of the receiver is shown in Fig.1. The primary winding of L1 and C2 together form the tuned circuit of the receiver. Variable capacitor C2 is, of course, the usual tuning control. In order to obtain a sufficiently strong signal from a telescopic· aerial, a very "tight" coupling is needed between the tuned circuit and the aerial.

This is obtained in this circuit by simply connecting the aerial direct to the non-earthy end of the tuned circuit.

These signals are effectively coupled into the low input impedance of TR1 via the secondary winding of L1 and the d.c. blocking capacitor C3. Transistor TR1 is used as a regenerative detector, and it is used in the common emitter amplifying mode. L2 forms the r.f. load for TR1, and R2 is it's a.f. load. Resistor R1 is the base bias resistor.

This type of regenerative detector depends upon the fact that the current gain of a transistor varies with the level of the collector current. This causes TR1 to amplify positive going half cycles slightly more than negative going ones. This gives a rather inefficient form of rectification, and provides the required detection.

REGENERATIVE ACTION

Positive feedback is fed from TR1 collector to the tuned circuit via the third winding on L1 and C1. Variable capacitor C1 enables the amount of feedback to be controlled. This use of positive feedback is usually termed regeneration, and is also sometimes called reaction.

Regeneration has two main functions to perform. First, by recycling some of the signal the gain of the circuit is significantly increased. The second effect of regeneration, and an equally important one, is that it increases the selectivity of the circuit. Selectivity is the ability of a receiver to pick out only one of many closely spaced transmissions.

The regeneration will naturally boost signals at or near to the centre of the receiver's response much more than those lying well away from the centre and it therefore increases the set's selectivity quite markedly.

AUDIO OUTPUT

Capacitor C4 filters out any r.f. at the output of the detector, and the remaining a.f. signal is fed to the base of TR2 via C5. Transistor TR2 is used as a high gain common emitter amplifier and has base bias resistor R3 and collector load resistor R4. The output signal from TR2 collector is fed to the output socket by way of the d.c. blocking capacitor C7.

The output of the receiver is quite strong and is more than adequate to drive any high impedance phones or earpiece. It is even sufficient to drive a pair of eight ohm stereo headphones, but the use of a single low impedance earpiece is not recommended.

Capacitor C6 rolls off the upper frequency response of the output

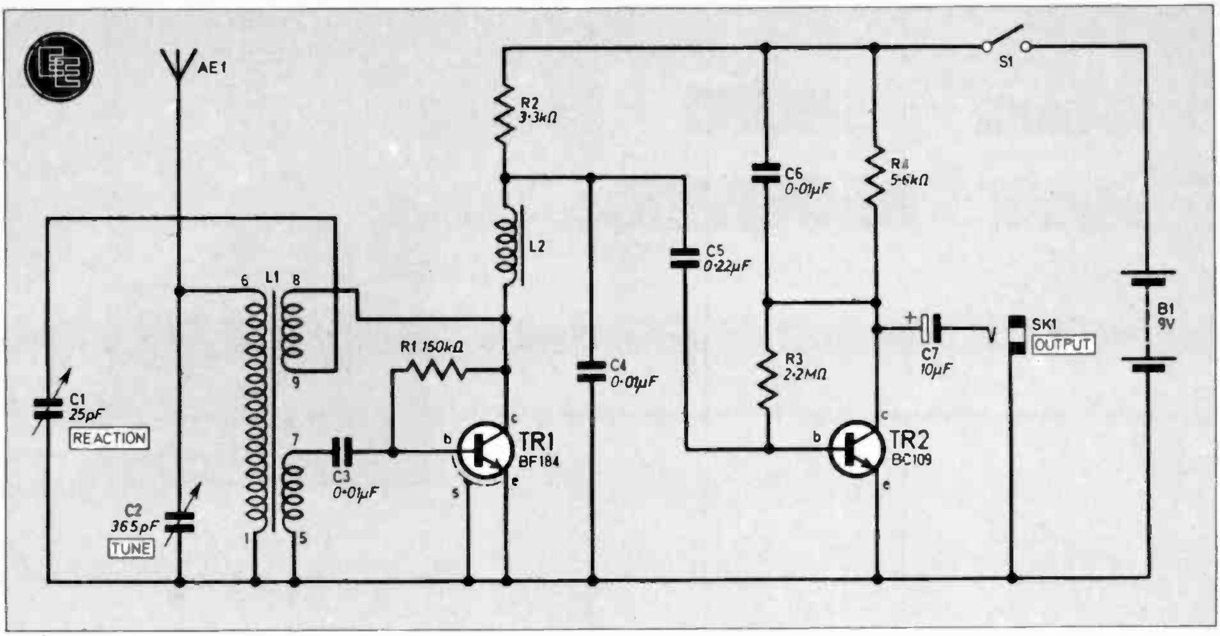
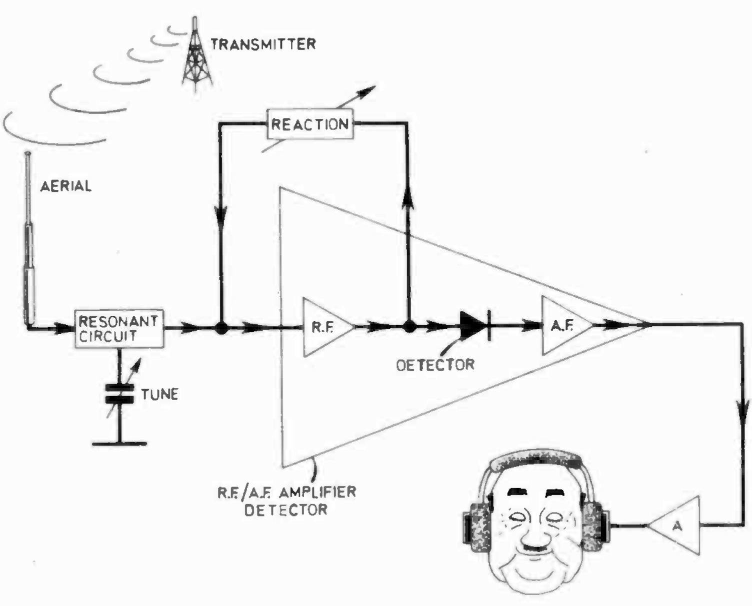


Fig. 1. Complete circuit diagram of the Portable Short Wave Receiver

HOW IT WORKS

Radio frequency signals from the transmitter are induced in the aerial and applied to the resonant circuit. This circuit allows a particular frequency, depending on the setting of the tuning capacitor, to be applied to the next stage whilst effectively blocking all other frequencies.

The amplifier design allows amplification of radio frequency signals, detection and audio frequency amplification. Some of the r.f. in this stage is fed back to the input via a reaction control which aids the selectivity of the receiver. The output from the first amplification stage is coupled to an audio frequency amplifier suitable for connection to a pair of headphones.



stage, and this gives an improved signal to noise ratio and prevents instability due to the high frequency feedback between TR1 and TR2.

CONSTRUCTION

A ready made 150 x 74 x 47mm plastic a.b.s. box makes a suitable case for the set, and this is readily obtainable. Any other box of a similar size should be suitable, but it must not be significantly smaller on any dimension as there might then be inadequate space to accommodate all the components.

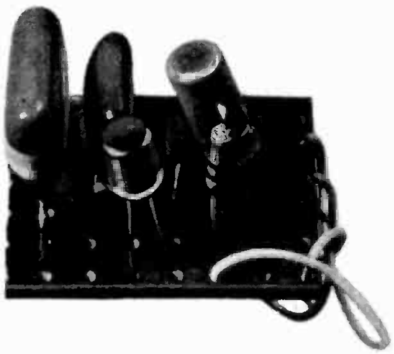
The front panel layout used for the prototype is shown in Fig.2. It is strongly recommended that this layout be as closely adhered to as possible, and this is also the case for the general layout of the set. There is not a great deal of excess space inside the case, and deviating from this layout could make it impossible to fit all the parts into the cabinet.

Also, changing the layout could cause instability or a loss of performance if the constructor is not absolutely sure what he is doing.

Capacitor C2 has a rather unusual fixing and it is fastened to the front panel using three short 4BA screws. A home made paper template can be used to help mark the positions of the holes on the panel.

To make this, simply make a hole of about 7mm diameter in

Portable SHORT WAVE RECEIVER



Close up view of the circuit board

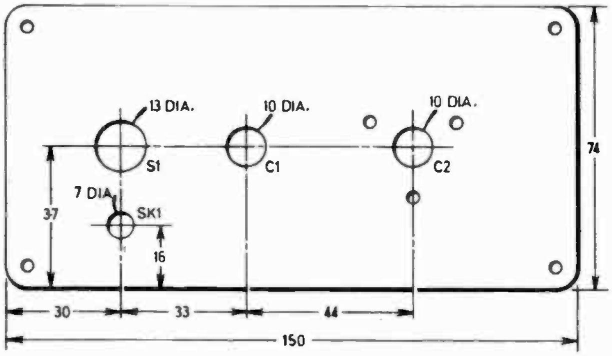
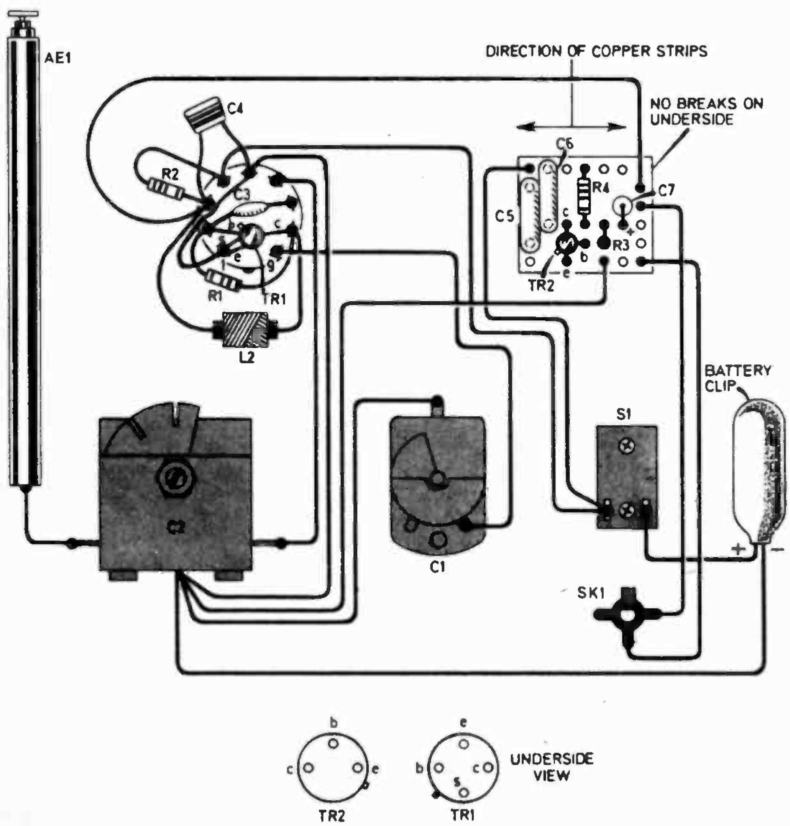


Fig. 2. The drilling details for the front panel. It is recommended that the dimensions be strictly adhered to.

(Below) Dimensions for the coil mounting bracket.



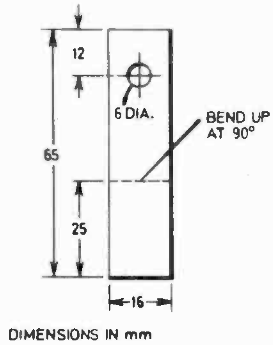


Fig. 3. Complete wiring diagram of the receiver.

The circuit board has no breaks on the underside. It is mounted in the case as shown, using the connecting wires as the support. Ensure therefore, that they are of the solid type, rather than stranded wire.

the centre of a small square of paper, and then thread this over the spindle of C2. Press it over the front of the component and then use the point of a pencil to punch three holes in the paper, one over each mounting hole in C2.

Use countersunk screws to mount C2, and make sure that these do not penetrate more than about 1mm through the front of this component. If they should penetrate too far they could jam the capacitor. If necessary, use some washers or short spacers over the screws to reduce their penetration.

Components

Resistors

R1	150kΩ
R2	3·3kΩ
R3	2·2MΩ
R4	5·6kΩ

All resistors ¼W carbon ±10%

Capacitors

C1	25pF air-spaced variable (Jackson type C804)
C2	365pF air-spaced variable (Jackson type 'O')
C3	0·01μF polyester
C4	0·01μF polyester
C5	0·22μF polyester
C6	0·01μF polyester
C7	10μF 10V elect.

Semiconductors

TR1	BF184 silicon *npn*
TR2	BC109 silicon *npn*

Inductors

L1	Range 4T blue (Denco transistor useage coil)
L2	10mH ferrite cored r.f. choke (Repanco type CH4)

Miscellaneous

S1	single-pole single-throw toggle switch
SK1	3·5mm jack socket
B1	9V type PP3 or similar
AE1	telescopic aerial 1·2 metres long

Plastic case 150 × 74 × 47mm; stripboard 0·15 inch matrix 6 strips by 7 holes; B9A valveholder for L1; battery connector; high impedance headphones or earpiece; piece of 20 s.w.g. aluminium 65 × 16mm; one large and one small control knob; connecting wire; solder; small rubber feet (4 off).

See **Shop Talk** page 367

MOUNTING THE COIL

The coil is mounted on the front panel above S1 and C1, and a simple bracket must be constructed for this purpose. It is made from approx. 20 s.w.g. aluminium and details of this bracket are shown in Fig.2.

The threaded part at the top of the coil fits through the hole in the bracket, and a plastic mounting nut is supplied with the coil. The bracket is glued to the front panel using a high quality adhesive.

AERIAL MOUNTING

The telescopic aerial is mounted on the extreme right hand side of the outer casing. The method of mounting may have to be varied from that described here, as not all aerials have a 4BA threaded portion at the bottom. A little initiative must be used here.

If the aerial used is one of the many that has a length of 4BA thread at the base, it is simply mounted by drilling a hole fractionally larger than the diameter of the aerial in the top of the case at the appropriate spot. A 4BA clearance hole is drilled immediately below this in the base of the case.

The base of the aerial is taken through the hole in the top of the case and then a solder tag is mounted on the bottom of the aerial with a 4BA nut being used to hold it in position. The 4BA thread is then taken through the hole in the bottom of the case and a 4BA nut is used to secure the aerial to the case.

Four small cabinet feet must then be glued to the bottom of the case.

WIRING

Several of the components are wired up on the coil. It is not advisable to solder direct to the pins of the coil as the plastic coil former will melt. Instead a B9A valveholder is fitted over the coil base and the connections are made to this.

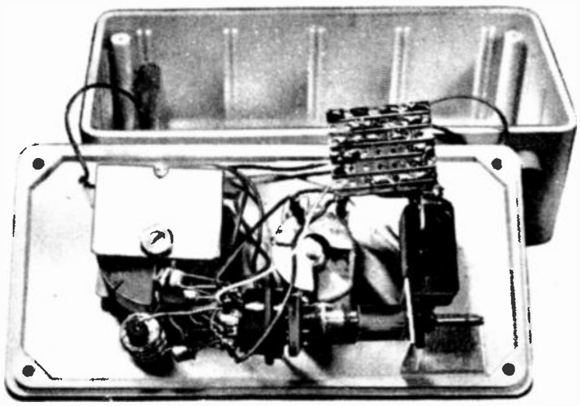
If the mounting bracket of the holder should get in the way at all, it can be prised or cut off.

All the wiring of the receiver is shown in Fig.3. Start by connecting the six components that are mounted on the coilholder. This will probably be easier to accomplish if the valveholder is temporarily removed from the coil.

STRIPBOARD LAYOUT

The audio circuitry is wired up on a 0·15 inch pitch stripboard panel having 6 strips by 7 holes. This is cut down from a larger piece of board using a hacksaw and then the various components are wired in. There are no breaks in any of the copper strips.

Next the wiring to the controls, battery clip, and headphone



Internal photograph showing the positions taken up by the coil and circuit board.

socket is completed. The component panel is positioned just below C1 and S1, and it is this wiring that provides its support. For this reason it is best to use single core rather than multistrand wire, and in either case it should be p.v.c. insulated. Keep this wiring reasonably short and direct.

Finally, complete the wiring by connecting in the lead between C2 and the aerial. It is preferable to use a flexible multistrand wire here.

USING THE RECEIVER

As supplied the adjustable core of L1 is screwed right into the coil. This should be unscrewed so that about 10mm of metal screw thread is protruding from the top of the coil. Current consumption is only about 2·5mA, and many months of normal usage will be given using a PP3 battery. There is a space for this next to S1, on the extreme left hand side of the case.

Two of the controls are quite straight forward, S1 being the on/off switch and C2 the tuning control. Capacitor C1 is not a volume control, and must be carefully adjusted for really good results to be obtained.

When initially testing the set start with the aerial fully extended and the reaction control well backed off (the two sets of vanes almost fully unmeshed). Adjusting C2 will probably result in a few stations being heard, and gradually advancing C1 should increase the number of stations and the volume from the headphones.

If C1 is advanced too far the set will oscillate, and this will be heard as a whistle from the phones as the set is tuned across a station. Both sensitivity and selectivity will be at a maximum with the reaction control set just below the threshold of oscillation.

The reaction will need slight readjustment every time the tuning control is significantly altered if the set is to be maintained at optimum sensitivity.

Often it may be found that with the aerial fully extended a strong signal on a band tends to blot out weaker signals that are just either side of it. This is due to the loading effect of the aerial on the tuned circuit causing reduced selectivity, and is the price one pays for the tight coupling that must be used between the aerial and the tuned circuit.

Usually reception of the weaker stations can be improved by reducing the length of the aerial slightly. This reduces the loading on the tuned circuit and gives increased selectivity, but will result in some loss of signal strength.

After a little experience has been gained using the receiver it should be possible to receive stations from all over Europe, and occasionally from much further afield. ⌑

Earth Leakage

Could you tell me if you have plans for publishing a circuit for an efficient "earth leakage protector" for use with high power amplifiers as used on stage by guitarists and other musicians.

As you know there have been fatal accidents on numerous occasions, and as the father of a performer, this matter has worried me for some time. I realise there are devices now being fitted in clubs etc. but these tend to be extremely expensive.

I feel that many of your readers would welcome publication of a fail-safe device which could be a life-saver.

W.S. Russell,
Merseyside

The matter of earth leakage is a serious one and needs to be treated with great respect. Many "on the road" musicians using electric amplification equipment could well be plugging in to a lethal electric system which could give the "live performance" another meaning.

If the live mains lead comes in electrical contact with chassis or other appliance earthing point, then the fuse should blow. This does not happen when there is a faulty earthing system and here the result is that the chassis and everything connected to it becomes live which usually includes such things as guitar pick-up covers and bezels, metal strings and fitments, metal jack plug casings, chassis fixing screws etc, and touching these parts gives a nasty and sometimes fatal electric shock.

It is the responsibility of the appliance user to ensure that his/her equipment is earthed as far as the earth pin on the mains plug. This applies especially to exposed metal parts/fitments mentioned above. It is the responsibility of the proprietor of the premises to ensure that the electric wiring, and in particular, the earthing system, is tested regularly to ensure that the circuit breakers (fuses) will operate satisfactorily under fault conditions.

To return your question, regrettably we have no plans to publish an earth leakage protector at present but are pleased to inform you that such a device has recently been published in our sister magazine Practical Electronics, July '77. With this device in the event of a suggestion of earth leakage, the user is isolated from the mains.

Fan Mail

I am writing to congratulate you on your fantastic magazine. I have been getting your magazine since the end of 1974 and I am so pleased with it that I am gradually aquiring all the back issues through second hand book shops.

I have just been reading your first issue and the purpose of your magazine. I think you have done a splendid job with carrying out that purpose and through your magazine I have had much enjoyment of my hobby of electronics.

It is the only magazine that I know of that caters for the beginner and hobbyist.

An absolutely first class magazine. Keep up the good work.

Brian J. Rimmer,
Rotorua, New Zealand

Thank you for your letter and for the kind remarks you make concerning this magazine. Naturally, all of us are delighted to receive such favourable comments, and it is exceptionally pleasing to hear from overseas readers such as yourself. I was interested to learn that you are currently engaged in acquiring all the back numbers through secondhand bookshops. I suppose this could become another hobby—hunt the past issues of EVERYDAY ELECTRONICS!

We shall continue publishing a varied selection of projects which are relatively inexpensive and uncomplicated. Also, regular features dealing with the theoretical and practical aspects of this hobby. So I think you can be assured of an interesting selection of articles in future months. Ed.

BOOK REVIEWS

Electronics Fault Diagnosis
Author Ian R. Sinclair
Price: £2·75 (U.K. only)
Size 215 × 140mm, 108 pages paperback
Publisher Fountain Press
ISBN 0 85242 530 9

Many constructors at one time or another have built a piece of equipment which refuses to work first time, whether it is a simple audio amplifier or a complex digital circuit. In order to have the equipment functioning again it is necessary to fault find on the circuit. Fair enough assumption, but how do you start? Firstly by reading this book.

Although no step by step instructions are given, to trace a fault, it does give the reader something else. A chance to exercise his grey cells. Throughout the eight chapters, the accent has been to present various circuits together with a table of typical voltage readings under normal working conditions and a few voltage readings under fault conditions.

It is up to the reader first to ascertain the correct set of normal readings and then by working through the circuit to deduce the fault from the remaining sets. A comprehensive explanation of the circuit is given, and by using this information the fault should be found.

Topics covered include: power supplies, oscillators, amplifiers, timing circuits, and digital circuits. The last section covers the answers and includes an explanation of the components most likely to cause the fault.

Certainly an interesting book written in an unusual manner, and is sure to be helpful to those who need to fault find.

An excellent book suited especially to readers who have finished Everyday Electronics' two series: Doing it Digitally and Fault Finding. T.J.J.

50 Projects Using Relays SCRs and Triacs
Author F. G. Rayer, T.Eng.(CEI), Assoc.IERE
Price £1·10
Size 180 × 108mm, 102 pages paperback
Publisher Babani Press
ISBN 0 85934 0406

When first reading this book, it seemed highly unlikely that so many different circuits could be designed using just relays and SCRs. However first impressions were wrong, the range included is most impressive and well thought out.

The book is divided into three sections, circuits using relays, SCRs, and triacs. The range covered is vast and would need a great deal of space to describe. The following are just an example: sound-operated switch, model train controller, rain alarm and a relay timer.

One disadvantage of the book is the lack of constructional details, the circuits are however fairly straight forward and should not prove too difficult to the average constructor. T.J.J.

Practical Repair & Renovation of Colour TV's
Author Chas. E. Miller
Price 95p
Size 180 × 108mm, 79 pages paperback
Publisher Babani Press
ISBN 0 85934 0376

A subject dear to most people, is the saving of money. Any idea of saving even pennies, is very welcome indeed. For an initial outlay of something like £40, an old TV may be purchased and repaired almost like new. It must be realised that in most cases a great deal of work, and extra cash needs to be spent before the TV is in a working condition.

This usually means that most sets have been written off by the dealer as "B.E.R." (Beyond economical Repair) and are mostly in a very sorry state.

Nevertheless for those who are willing to "have a go" the results more than justify the time and money involved.

Throughout the book, examples of the most common faults and the methods of solving them are given. It is assumed therefore that the constructor has at least a basic knowledge of colour TVs and most certainly of black and white.

The remaining chapter and the two appendices are taken up by describing suitable test equipment which may be constructed, as well as giving a run down on the spares likely to be needed.

Written by an author, who for many years has been a regular contributor to "Television" magazine, and highly experienced in the field of TV servicing. T.J.J.

Back Numbers

We are pleased to announce that the Back Numbers Service has now been reinstated and will operate from the issue dated June 1977.

This and subsequent issues of Everyday Electronics will be available at the inclusive price of 60p per copy. This includes inland/overseas postage and packing.

Orders should be addressed to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF. Cheques and postal orders should be made payable to IPC Magazines Limited.

A limited supply of earlier back issues is also available. Requests with appropriate remittance, should be sent to the above address. In the event of non-availability, remittances will be refunded.

Motor Controller

FOR SERVO SYSTEMS, MODEL BOATS AND ROTATABLE AERIALS etc.

By C. RUDDICK

THIS project was devised for use in the author's radio control model boat system. When fitted in the model boat and used with a radio control receiver and servo system it can provide an inexpensive means of controlling the speed and direction (forwards and backwards) of the craft which was powered by a low voltage d.c. electric motor.

The use of the controller, though, is not limited to the model area. It could also be used to rotate a roof, loft or indoor aerial for best reception results, as will be discussed later. Another application that springs to mind, but which will not be dealt with in this article is in model railway systems.

CIRCUIT DETAILS

The complete circuit diagram of the controller is shown in Fig. 1. The type of motor fitted to the author's model had a field winding and this was placed across the supply rails and the armature supply polarity and magnitude controlled by the circuitry. The circuit is not limited to this type of motor as the more readily available permanent magnet type can be used. In this case, there are only two corrections to the motor and any reference to the field winding should be ignored.

The direction of rotation of the armature and its speed will depend on the voltages at points *A* and *B*. These in turn are dependent on the setting of the ganged potentiometer VR1. The potentiometer is wired such that as VR1a wiper moves towards the positive supply rail, VR1b wiper moves towards the negative rail.

For midway setting of VR1 a/b, all transistors are off—not conducting. The voltage at point *A* will be equal to that at *B* and so the motor will be stationary.

If the potentiometer is rotated so that VR1a wiper becomes more positive, a point will be reached where TR1 is biased on and so the potential at *A* increases (moves in a positive direction). Simultaneously TR4 starts to conduct and point *B* goes more negative. There is a potential difference across M1 and it should rotate at a fixed speed. Further rotation of VR1 causes the motor speed to increase.

If the potentiometer is now rotated in the opposite direction, a similar amount, then TR3 and TR2 conduct and the potential at *B* is greater than that at *A* and so the motor rotates in the opposite direction.

To cause the motor to rotate through a specific angle, then the potentiometer should be rotated in the desired direction and then returned to the midway position first just before the angle of rotation is reached. Alternatively S1 can be switched off after this period has elapsed. Remember that the further the control is turned, the faster the motor rotates.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£3.50

excluding battery and motor

The value of the potentiometer is not too critical, say any value between 1 and 2·5 kilohm. The only problem with higher values being a larger "dead area" in the centre position (motor stationary) and the consequent lack of fine control over the remainder of the travel since the number of ohms per degree of turn is greater. Hence the wiper will need to be closer to the end of the travel before sufficient current flows into the bases of the conducting transistors to start the motor.

Resistors R1 to R4 have been included to limit the maximum base current to a safe level.

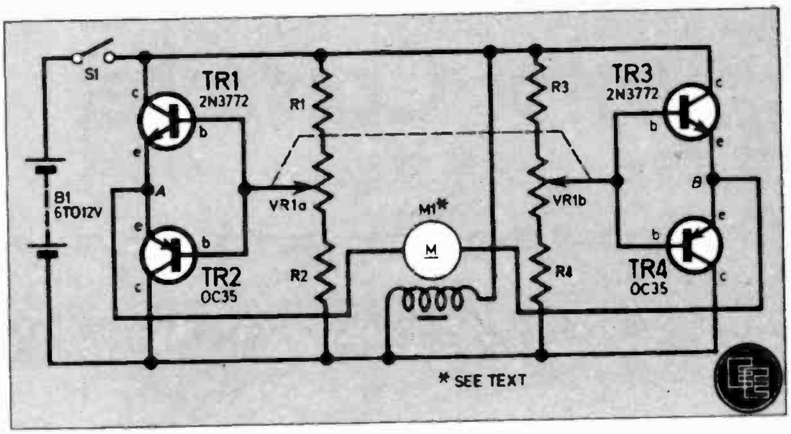


Fig. 1. Complete circuit diagram of the Motor Controller. As mentioned in the text, different types of motors may be used. In this case the field windings (shown as a coil) may be omitted.

CONSTRUCTION

The prototype unit was constructed on a piece of 16 s.w.g. aluminium sheet as shown in Fig. 2 using point-to-point wiring. The size of this panel, 120×85mm was found to be adequate for the motor used in the prototype and should be suitable for 12V motors rated at up to 5A. For higher rated motors additional heatsinking will be required and the transistors, especially TR2 and TR4, will need to be replaced by higher power types.

If the unit is to be fitted inside a boat or other model, then no case is likely to be required. If used for other applications, the panel could form the front or top of a case. It might be a good idea to remove the potentiometer and switch from the aluminium panel with the remainder of the components fitted inside a ventilated case.

Whatever case arrangement is chosen, the most important aspect of the construction is the mounting of the four transistors. This is shown clearly in Fig. 3 and should be strictly adhered to.

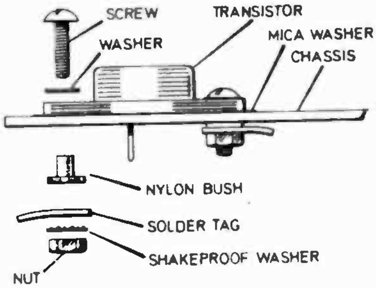
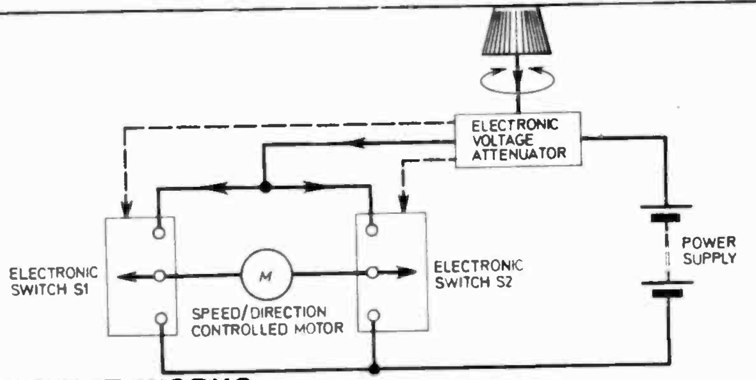


Fig. 3. Mounting details for the four transistors.



HOW IT WORKS

This unit is based on the fact that the direction of rotation of a d.c. electric motor can be changed by interchanging the connections of the motor to the power supply. Also the speed of rotation of the motor is proportional to the voltage applied to the motor up to its rated level.

In the Motor Controller, the speed is controlled by an electronic attenuator and rotational direction can be set by electronic switches S1 and S2. With the attenuator set midway, S1 and S2 occupy their 'open circuit' positions as shown. If the attenuator is rotated clockwise, S2 switches to connect the motor to the positive supply line, while at the same time S3 is caused to switch to the negative supply line. This causes the motor to rotate. Further advancement of the attenuator control increases the motor speed. If the attenuator is rotated in an anti clockwise direction past the midway point, S2 switches to connect the motor to the positive line and S1 connects it to the negative line. Thus the motor rotates in the opposite direction.

Use of heatsink compound or silicon grease is recommended. This should be applied to the surfaces between transistor case/mica washer and mica washer/aluminium panel. Stout wire rated at 5A or more should be used to wire up the components.

MODEL BOAT SYSTEM

When used as a speed controller in a model boat system, the potentiometer will be turned, via reduction gearing, by a separate low voltage electric motor operated from a radio control servo link. A suggested arrangement is shown in Fig. 6.

The position of VR1 sets the speed and direction of the propulsion motor M1. When a change in speed or direction is com-

Motor Controller

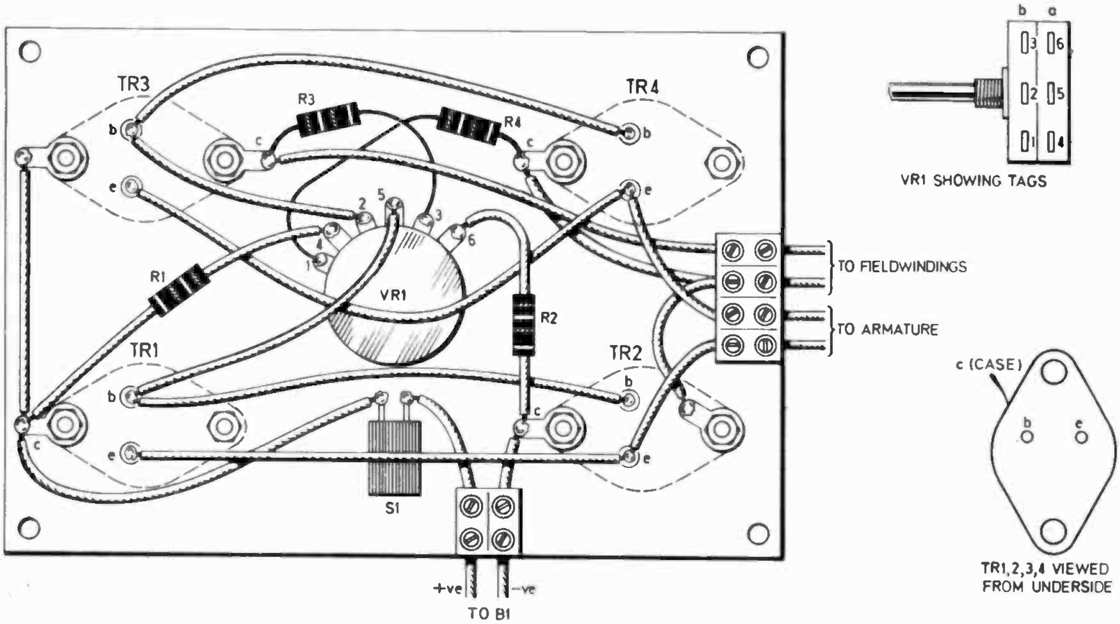


Fig. 2. Wiring diagram for the Motor Controller. This is mounted on a sheet of aluminium, which also acts as the heatsink

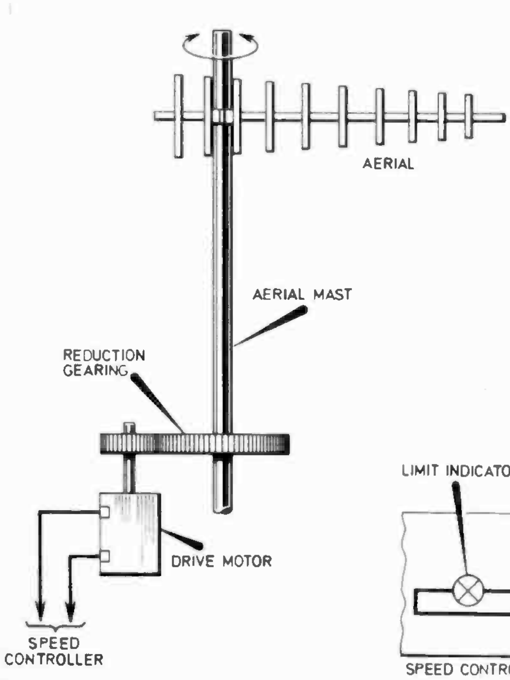


Fig. 4. Suggested arrangement for rotating a t.v. aerial.

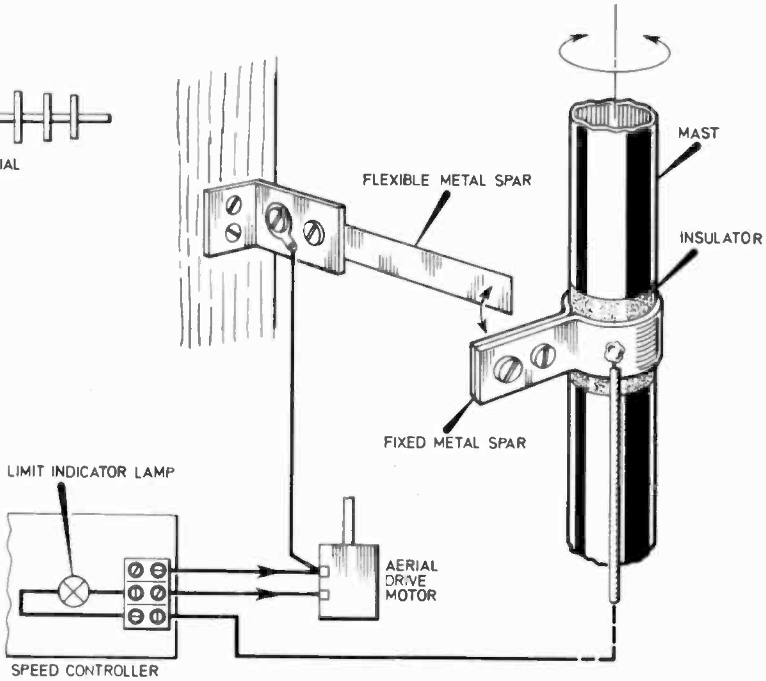


Fig. 5. Typical method of mounting the aerial mast. The two metal spars make contact when the aerial is pointing north.

manded, this signal is processed by the receiver and causes the servo to operate followed by M2 rotating clockwise or anti-clockwise. This is transmitted through the gearing to VR1 which in turn causes the propulsion motor speed to increase or decrease as required.

Stops are required on VR1 gear wheel to operate microswitches S2 or S3 to prevent VR1 being turned too far. This is achieved by placing the normally closed microswitches in series with the supply to the motor, and positioned to become open circuit on contact with the stops.

In the absence of a command signal, S4 is returned (by the servo) to its midway position thereby leaving VR1 set and the craft moving at a constant speed.

Changeover switch S4 can be a standard d.p.d.t. slide switch fitted with a rod (through its operating button) to the servo.

Components

Resistors
R1 100Ω
R2 100Ω
R3 100Ω
R4 100Ω
All 1W carbon ± 10%

Potentiometer
VR1 1 kilohm dual-ganged lin. carbon or wirewound

Semiconductors
TR1, 3 2N3772 silicon *npn* (2 off)
TR2, 4 OC35 germanium *pnp* (2 off)

Miscellaneous
B1 6 to 12V (capacity to suit motor employed)
S1 on/off type toggle or push-to-make
M1 Any d.c. motor operating on 6 to 12V requiring up to 5A (see text)
Aluminium mounting panel (heatsink, see text); TO3 mica washers (4 off); insulating bushes for transistors (8 off); heatsink compound; solder tags (6 off); 6BA fixings; 5A terminal block, 6-way; 5A connecting wire; control knob (not required for model boat application); case to suit (not required for model boat application); gearing; drive motor for VR1 (not required for aerial application); spars and bracket for aerial mast.

See **Shop Talk**

ROTATING AERIAL SYSTEM

For those wishing to rotate their t.v. or radio aerial to obtain best reception, and those in a position to receive from several transmitters (different directions), can use this unit to rotate their roof, loft or even indoor aerial whilst remaining seated in front of the t.v. set. A suggested arrangement is shown in Fig. 4.

In this application, the unit will be mounted in a ventilated case positioned close to your most comfortable armchair, and wires running to the aerial drive motor. Reduction gearing between motor shaft and aerial mast is required to reduce the strain on the motor and to allow even finer speed control.

A suitable aerial rotation speed is one revolution per minute. By noting and fixing the position of VR1 for this speed (in both directions), the angle swept by the aerial will be proportional to the time that S1 is turned on.

The total sweep angle should be limited to about 360 degrees i.e. one revolution to prevent the aerial cable from getting tangled. This can be indicated by a lamp on the front panel being illuminated when the limits are reached. The approach direction will be apparent from the setting of VR1. This safety factor requires a third wire from the unit to the base of the aerial mast connecting to a spar, clamped to, but insulated from the mast, see Fig. 5. A second flexible spar needs to be positioned in a known direction, say north, such that when the two spars are aligned, they make contact. Thus when the lamp lights, you know the aerial is pointing north.

In use, switch S1 should be operated only while the panel lamp is unlit. When the lamp lights, VR1 must be changed to the opposite mode. If VR1 is set for 1 rev/minute, then any direction may be computed easily with the aid of a wristwatch fitted with a second-hand.

No doubt many ingenious applications will be dreamed up by readers to suit their personal requirements, especially in the field of model control. We would be interested to hear of any unusual applications.

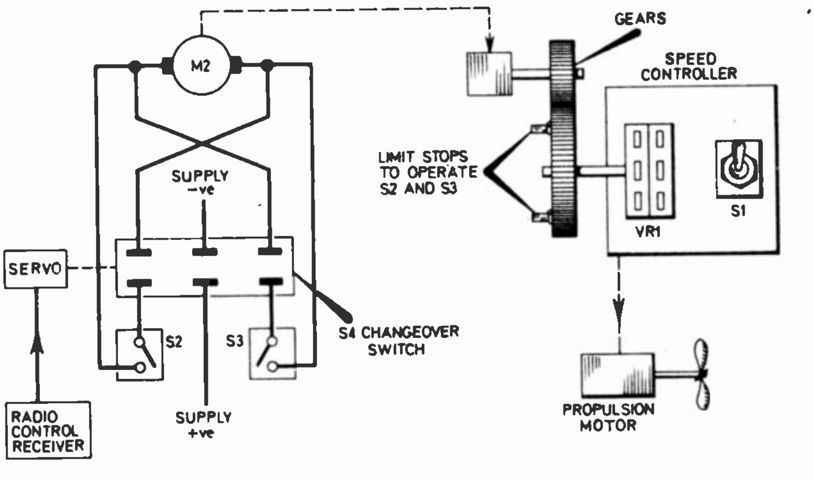
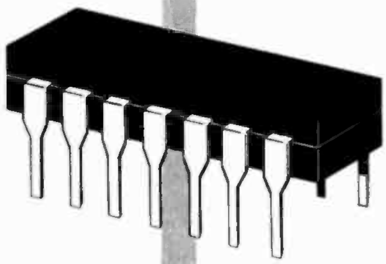


Fig. 6. Model boat system. The changeover switch S4 is a type which has a centre off position. The servo is normally available from a model shop. Make sure when purchasing, that an operating bar is also bought.

Doing it Digitally...

Part 11

By O. N. Bishop



IN THIS, the concluding part of *Doing it Digitally*, we will look at methods of using digital circuits to control model railway systems.

RAILWAY SYSTEMS

Digital integrated circuits can be very useful for controlling model railway systems. It is possible to arrange for electrically operated points to be altered, signal lights to be changed and the power to the train to be switched on and off as required.

The changes can be made to happen to a pre-arranged plan which is built into the system. The integrated circuits work so quickly that they can easily change points in good time even when a train is approaching at high speed.

It is not possible to give precise instructions on how to connect i.c.s. to a particular model railway for so much depends on the railway system concerned and what is required of it. Below are presented some ideas for various parts of the system and some examples of how to put the parts together to make a working system.

As usual it is best to start in a small way so that the knowledge gained by practical experience can be used to build up the system in easy stages.

POWER SWITCHES

Power switches (as described in Part 5) play an important part in most of the controlling circuits. They are capable of switching power to points, signal lamps or the engine itself.

Sometimes a double supply is required for operating points which means using two power switches. These must be connected so that their positive output is common to both circuits. They can be operated from the same battery supply. If the points will operate on six volts, then the same battery can be used for powering the integrated circuits and the points. The wiring for such a circuit is shown in Fig. 11.1.

When switch S1 is on, power is applied to terminals *A* and *C* of the points and they move one way. When switch S2 is on power is applied to terminals *C* and *B*, and the points move the other way.

The circuit must not allow S1 and S2 to be on at the same time. It must allow both to be off, for the coils of the points will get very hot if power is

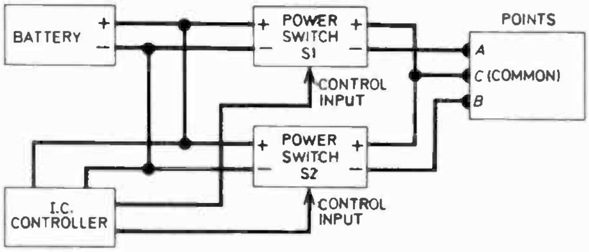


Fig. 11.1. Block diagram showing how a system using power switches can be constructed to operate a pair of electrically operated points.

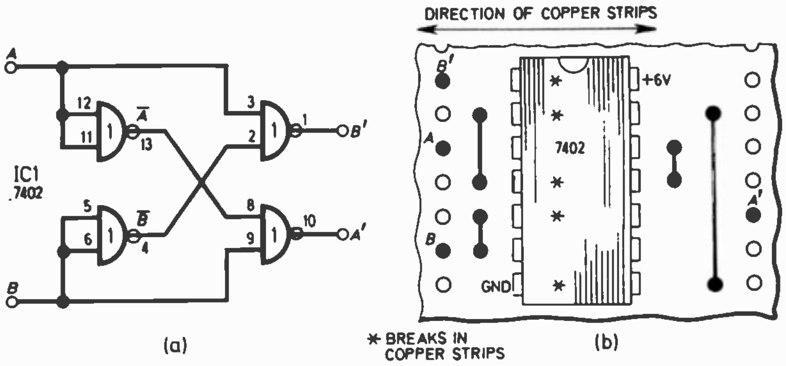


Fig. 11.2. The circuit for the i.c. controller of the points circuit in Fig. 11.1. is shown at (a) and the wiring of the 7402 i.c. at (b).

applied to them for long periods, and a lot of power will be wasted.

The control circuit is shown in Fig. 11.2a and the connections to the i.c. in Fig. 11.2b. Only a single 7402 quad NOR gate is used, two of the gates being wired as INVERTERS. The Truth Table for the circuit is shown in Table 11.1.

Output is the same as input, except when both inputs are high then both outputs are low. Thus the points will be switched when a high is applied to input *A* OR input *B* but not both.

Note that this circuit has been designed to operate a high-on power switch, as this is the type which requires only one transistor.

If many points are to be controlled it would be neater to build each double power switch and its controlling i.c. in a single box. A suitable layout is shown in Fig. 11.3a.

HEATSINKING

The transistors should have separate heatsinks, for the metal face of each transistor is in electrical connection with the collector. If both transistors are bolted to the same heatsink their collectors will be shorted and the circuit will not work.

The heatsinks need not be large as long as the switches are operated for very short periods—just long enough to switch the points. A strip of aluminium sheet will do for each (Fig. 11.3b).

The design assumes that the points will be operated from a 12 volt supply as is usual with model railways. Instead of the 12 volt battery shown, the output from the 12 volt transformer can be used (the d.c. output, not the a.c.). The i.c.s. and the controlling circuits must be powered separately by the usual 6 volt battery.

Connection of the power switches to the points is shown in Fig. 11.4. The diodes across the loads are essential and need some explanation.

PROTECTION DIODES

The points are switched by electromagnets—devices consisting of a large number of turns of wire on a metal core. The current through the wire produces a large magnetic field in the core which attracts a piece of metal connected to the points.

When current to the coils is switched off, the collapsing magnetic field produces a large voltage across the ends of the coil. This voltage is very short-lived but can be of a magnitude capable of destroying a transistor.

The diodes are placed so as to conduct this voltage thus protecting the transistors. It is a wise precaution to use diodes like this whenever the power switches are used to operate any sort of electromagnetic device such as points, relays, electric buzzers or bells.

The design of the switch described above is suitable for most model railways. It can be used to switch one or two pairs of points at the same time. If three or more are to be switched in one go then an even higher power transistor such as the 2N3055 will be necessary.

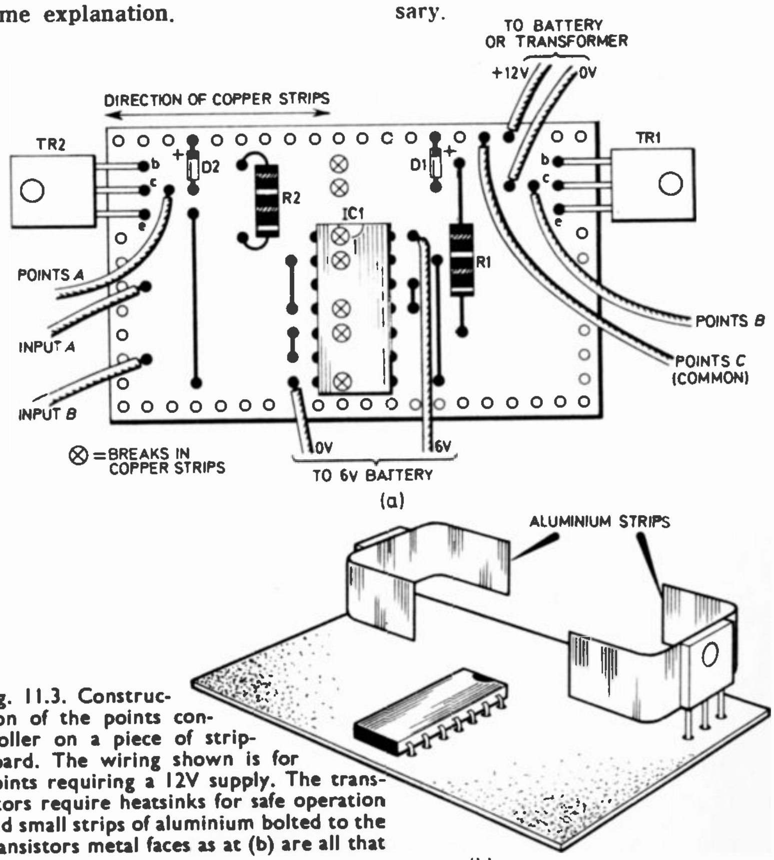


Fig. 11.3. Construction of the points controller on a piece of stripboard. The wiring shown is for points requiring a 12V supply. The transistors require heatsinks for safe operation and small strips of aluminium bolted to the transistors metal faces as at (b) are all that is necessary.

Table 11.1: Truth Table of Fig. 11.2

Inputs A	Inputs B	Outputs A'	Outputs B'
L	L	L	L
L	H	L	H
H	L	H	L
H	H	L	L

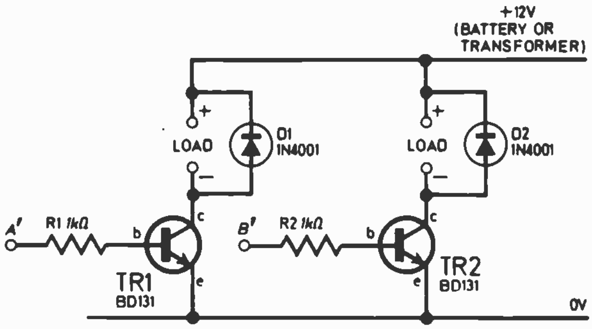


Fig. 11.4. Circuit of the power switches suitable for operating points. The diodes are necessary to protect the transistors from the high voltages produced by the point coils as current is switched off.

INPUTS TO THE I.C.s

The switching of points, operation of signal and station lights, electrically operated crossing gates and also the engine can all be controlled by i.c. circuits, but what inputs do the i.c.s require?

Apart from general inputs causing the i.c.s to take over or give up control, the i.c.s may need data on the position of the train. There must be some kind of device that can tell where the train is—sometimes it might also be useful to know in what direction the train is travelling.

To tell where the train is a light operated switch can be used. For fast moving trains, the phototransistor type may be essential, but for slow-moving trains or long ones that take half a second or so to pass a point on the track, the cheaper ORP12 type can be used.

For best results there should be a lamp on the opposite side of the track, but often the light from a distant room light or windows will be sufficient (except when someone walks between the light and the light operated switch .

Another way of arranging things is to have the light operated switch below the baseboard on which the track is mounted. A small hole must be bored through the baseboard and track —usually 5mm diameter is sufficient. No special lamp is then needed as light reflected from the ceiling will be adequate. The latter method is the neatest in many ways as it is almost invisible; Fig. 11.5 (a) and (b) illustrates the two methods.

TRACK LAYOUT A

A track layout which can be controlled electronically is shown in Fig. 11.6. Points *A* are manually operated and are placed near to the train controller. Points *B* on the far side of the layout are to be automatically controlled by i.c.s.

Two light operated switches are needed (which could share a single lamp—if a lamp is used), and one power switch using BD131 transistors. The controller operates points *A* and controls the direction of travel of the train.

If the train approaches points *B* along line *X*, it triggers the light operated switch on that line, the output of which goes high (assuming an ORP12 type is used—if a phototransistor type is used then a 7400 i.c. is necessary to invert the output . The output can be taken directly from an ORP12 type switch to one input of the power switch and from there to a pair of contacts on the points. Choose the pair that will make the points change so as to accept the oncoming train.

Provided that the train does not approach the junction too fast, the light operated switch will have time to respond and switch points. The other light operated switch on line *Y* is connected to the other input of the power switch which is connected to the other points terminals.

Thus if the train is brought down line *Y* the points will switch to accept the train. If the train approaches the points from line *Z* it will then pass along line *X* or *Y* depending on which way the points were last switched.

If the layout has signal lamps, the power supply to these can be connected to the power supply to the points so that the correct signal lights are displayed.

We will now look at a completely automatic layout—all the controller has to do is to stop and start the train.

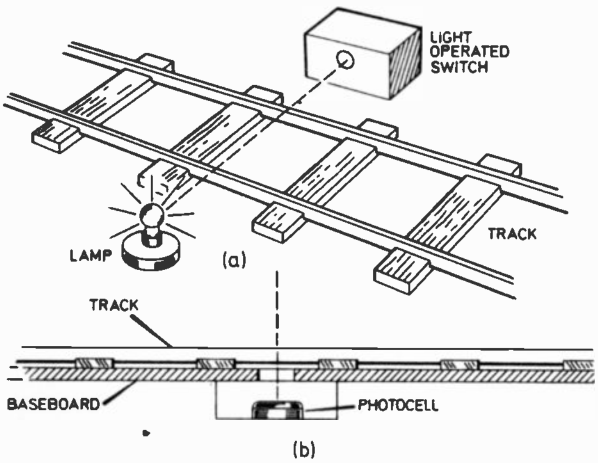


Fig. 11.5. Two methods of using photocells to detect the presence of the train. In (a) the light operated switch is mounted on one side of the tracks and the lamp on the other; (b) is more elegant with the photocell mounted under the baseboard, light entering through a small hole drilled in it.

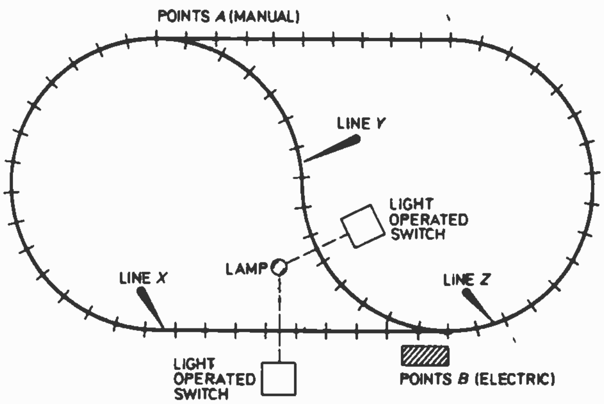


Fig. 11.6. Track layout A. Points A are manually operated and are placed near to the operator.

TRACK LAYOUT B

The second layout requires only one light operated switch, one power switch and two sets of electrically operated points. The layout is shown in Fig. 11.7.

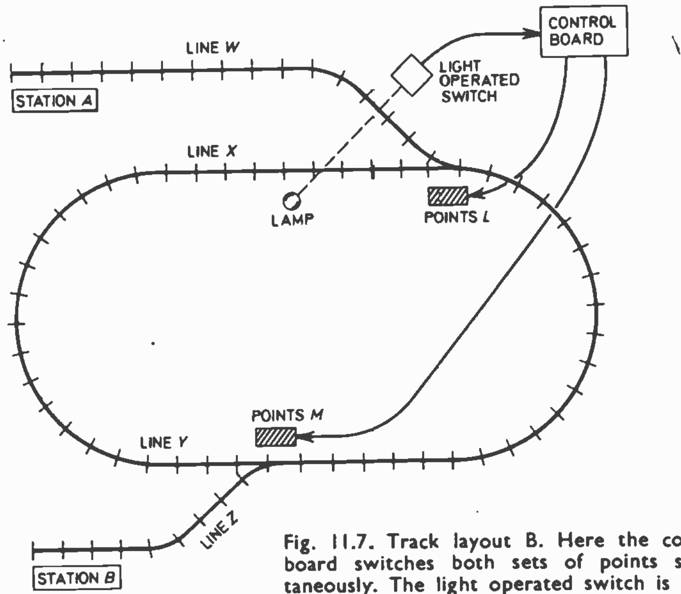


Fig. 11.7. Track layout B. Here the control board switches both sets of points simultaneously. The light operated switch is operated by the train approaching along line X or W.

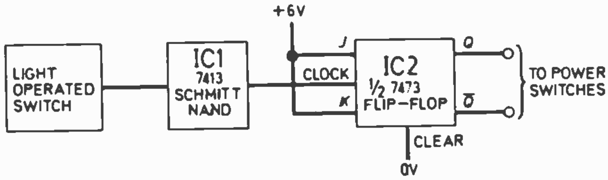


Fig. 11.8. Block diagram showing how the control board in Fig. 11.7. is constructed. The Schmitt is used to "clean up" the output of the light operated switch.

The points *L* and *M* are wired together so that when the input *A* of the power switch goes high, the points will switch to lines *W* and *Y*; and when input *B* goes high they change to lines *X* and *Z*.

The light operated switch is operated by a train on line *W* or on line *X*. The output from the light operated switch which goes high when a train comes along *W* or *X* is passed to a 7413 Schmitt NAND (Part 7) which inverts it and gives a clear cut pulse suitable for operating the next stage which is the clock input of a J-K flip-flop. The outputs of the flip-flop go to the power switch. A block diagram of the circuit is shown in Fig. 11.8.

The sequence of events is as follows:

(1) The train is at station *A*, the flip-flop is cleared, *Q* is low, $\overline{Q}$ is high and so the points are switched to lines *X* and *Z*.

(2) The train is started by the controller.

(3) As it goes along *W* it triggers the light operated switch whose output goes high, the output of the NAND goes low and the flip-flop changes state (*J* and *K* are permanently high . Output *Q* now goes high and the points are switched to *W* and *Y*.

(4) The train now travels on to the main oval and round it, along line *Y* until it approaches points *L* along *X*. At this stage the light operated switch is triggered again. The flip-flop is wired to change state each time so the points switch again to *X* and *Z*.

The train continues around the oval past points *L* but when it gets to points *M* it is routed along line *Z* to station *B* where it must be stopped by the controller.

Thus the effect of this fairly simple i.c. control system is that the train leaves station *A* goes round the oval one and a half times and then branches off to station *B*.

If the train is reversed, without resetting the flip-flop it will go back along the same route.

Make sure that the light operated switch is far enough from points *L* to allow the rear end of the train to clear the points before they are switched.

This type of circuit does all the points switching, leaving the operator in the role of train driver.

One snag of this circuit is that because one output or the other of the flip-flop is always high, one of the coils of the points is always energised. This is a waste of power and can lead to overheating. Thus the circuit should not be used for long periods.

PULSE GENERATOR

What is really required for the above system is a brief pulse to the points each time the flip-flop changes state. This pulse producer between the flip-flop and the power switch must act for long enough to allow the points to be pulled across then switch off.

The problem did not arise with the first circuit as the output of the light operated switch was high only as long as the train was passing it. Here we have one or other of the coils energised the whole time—unless a pulse generating circuit is used. Such a circuit was described in Part 7 and with a resistor of about 270 ohms and a capacitor of about 47μF a suitable pulse is produced.

With the pulse generator in use the points signal cannot be used to operate signal lights. If this is required then a separate circuit without pulse generators is needed. In Fig. 11.9 a block diagram of the system is shown with the pulse generators included.

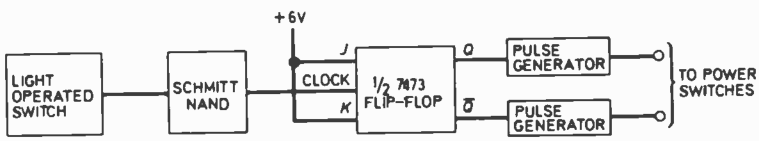


Fig. 11.9. The addition of two pulse generators ensures that the points are not supplied with power continuously.

AUTOMATIC ROUTE SELECTOR

As with many logic circuits, things can get quite complicated when more complex systems are planned. Sometimes the simpler systems are the most satisfactory.

To finish with, here is another simple system which can be built. It has no light operated switches but rather more logic circuits.

The idea of this circuit is that the route the train is to travel is selected by simply pressing a button. The logic sets the points and all the operator has to do is drive the train. With sets of signal lamps linked to the points, this could be an interesting system to build.

The layout is shown in Fig. 11.10. There are four stations and three points. The operator has four keys (the keyboard of Part 7 can be used), one for each station. The key of the station at which the train is standing is pressed and at the same time the key corresponding to the destination. The points are then set for the correct route.

The only journey that cannot be set is from *A* to *B* or *B* to *A*

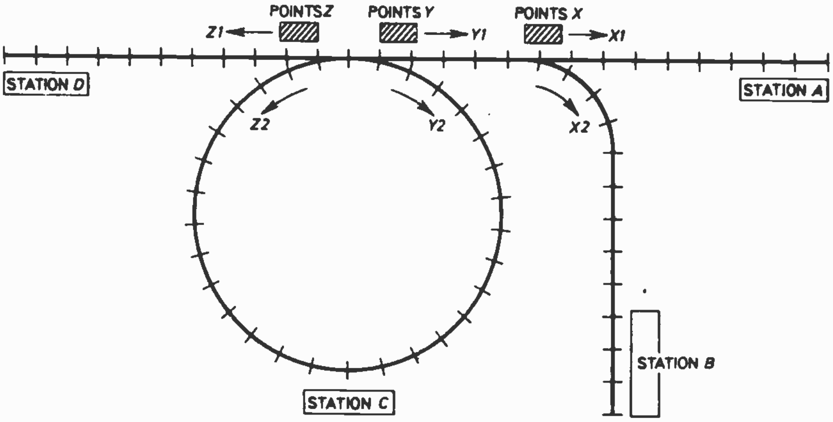


Fig. 11.10. Track layout C. Here the route is selected by the operator before the train is started. Each set of points can take one of two positions as indicated by *X1*, *X2*, *Y1* etc.

Table 11.2: Point settings for journeys selected

Journey (or return)	Keys * *A*	*B*	*C*	*D*	Points Energised X1	X2	Y1	Y2	Z1	Z2
A to *C*	L	H	L	H	H	L	H	L	L	H
A to *D*	L	H	H	L	H	L	H	L	H	L
B to *C*	H	L	L	H	L	H	H	L	L	H
B to *D*	H	L	H	L	L	H	H	L	H	L
C to *D*	H	H	L	L	any		L	H	H	L

*L = key pressed

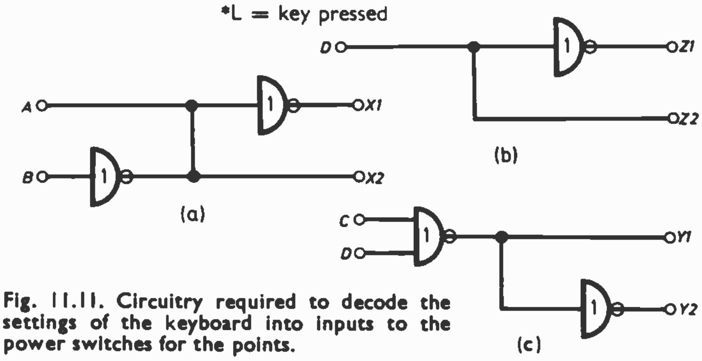


Fig. 11.11. Circuitry required to decode the settings of the keyboard into inputs to the power switches for the points.

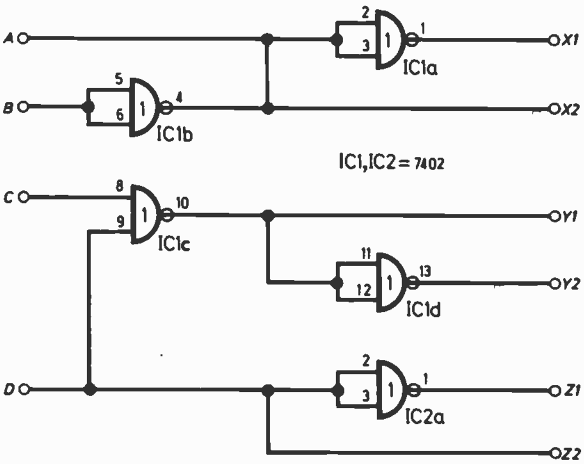


Fig. 11.12. The complete circuit of the controller for Fig. 11.10 using two 7402 i.c.s. All the outputs must go to pulse generators (six off) and then to power switches.

Components

Power Switch

Resistors
R1, R2 1kΩ ¼W carbon ±5% (2 off)

Semiconductors
D1, D2 1N4001 (2 off)
TR1, TR2 BD131 silicon *npn* (2 off)
IC1 7402

Miscellaneous
0·1in stripboard 12 strips × 20 holes
Strips of aluminium 50 × 10mm (2 off)

Track Layout A
Light operated switches (2 off)
Electrically operated points (1 off)
Power switch (1 off)

Track Layout B
Light operated switch (1 off)
Electrically operated points (2 off)

Integrated Circuits
Pulse generators (2 off)
Power switch (1 off)
IC1 7413 Schmitt NAND gate
IC2 7473 J-K flip-flop

Track Layout C
Electrically operated points (3 off)

Integrated Circuits
Pulse generators (6 off)
Power switches (3 off)
IC1 7402 (2 off)

for that involves a change of points during the journey. To allow for this a light operated switch is needed between points *X* and *Y* to reverse the points after the train has passed. This is possible and not too difficult but the reader is left to work out the details.

In planning the circuit the various routes are written out as a table, showing what keys are to be pressed and what point settings would be required. This is seen in Table 11.2.

On looking through the table we see that *X1* is always high when *A* is low, and low when *A* is high; *X2* is, of course, the reverse so the circuit is very simple, see Fig. 11.11a.

Journeys involving station *B* simply require points *X* to be the opposite way to journeys involving *A* so an input from key *B* can be added to the same circuit (remember *A* and *B* cannot be pressed at the same time).

The inputs for points *Z* are also easy—Z1 is high for any route involving *D* (Fig. 11.11b).

Output Y1 is high except when both *C* and *D* are pressed so we use a NOR gate as in Fig. 11.11c. The complete circuit is shown in Fig. 11.12.

The inputs are from the keyboard, the common rail of which is connected to negative. When two keys are pressed indicating present position and destination their lines are grounded and the outputs from X1, X2, Y1, Y2, Z1, and Z2 take the values needed to operate the points.

These outputs should each go through a pulse generator and then to the power switches. Thus six pulse generators and three power switches are needed.

The five gates used in the logic above will need two 7402's (or one 7402 and one 7400) and the pulse generators will need three 7400's making a total of five i.c.s altogether. These are all cheap but the wiring is quite a long job.

If a bit more routing with no extra electronics is desired try making some of the power switches operate two or more sets of points.

By the way if it is essential to go from *A* to *B* go from *A* to *C* first, then from *C* to *B*! Bon voyage.

By Brian Terrell

New products and component buying for constructional projects.

HOW DO YOU buy your components? Do you buy them as and when you need them or do you draw from a stock of standard components and need only buy the special items then required?

Getting it together

How does one go about getting together a useful set of components for building projects?

There are several ways to start stocking and one is to take advantage of the component packs being offered by advertisers in this magazine from time to time. A vast range of packs are on offer, including resistors, capacitors, potentiometers, semiconductors, and lots more.

The final method of collection to be mentioned here is by ordering a few extra components (intended solely for stock) when you are buying components for projects in hand. If you need to order say two 10 kilohm resistors and one 47 kilohm resistor, increase your order to six 10 kilohm resistors and three 47 kilohm ones. Just for good measure, buy one or two values between these, say, 33 kilohm and 22 kilohm—pocket money permitting of course.

In this way you will slowly but surely build up a stock of components that you have used in the past and are sure to need again. Don't forget solder, wire and component board—you can't do much without these.

This Month's Projects

There are only six components required to build the *Exposure Unit* this month, but each warrants a mention. The resistors called for are ¼ watt types, chosen by the author for their small physical size. If you are not restricted to a small size, use any wattage size above that stated that are available. For those who are determined to build the circuit into their camera (I wouldn't myself) these low wattage resistors (and even smaller) are available from Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey. A momentary-action microswitch is listed but any switch available can be used if space is not limited.

The meter used by the author carried no type number, so we chose an inexpensive type with similar dimensions. Resistor values for R1 and R2 were calculated based on the chosen type, listed in the Maplin catalogue as "edgewise level meter" page 84. Other meters can be used with revised resistor values.

There are many different light dependant resistors available, and any can be used. Check the sunlight resistance and modify circuit values accordingly. The resistance can be measured with a standard multimeter set to ohms.

The remaining component, a 1·2 volt battery should be available from most chemists—Boots are sure to have one.

The type of motor required for the *Motor Controller* (if this has to be purchased) will depend on the application that the constructor has in mind. The circuit can cope with ratings up to 12 volt 5 amps d.c., and should suit most modellers' needs. Electric motors of this type should be available from craft modelling shops, who will also be able to supply gearing.

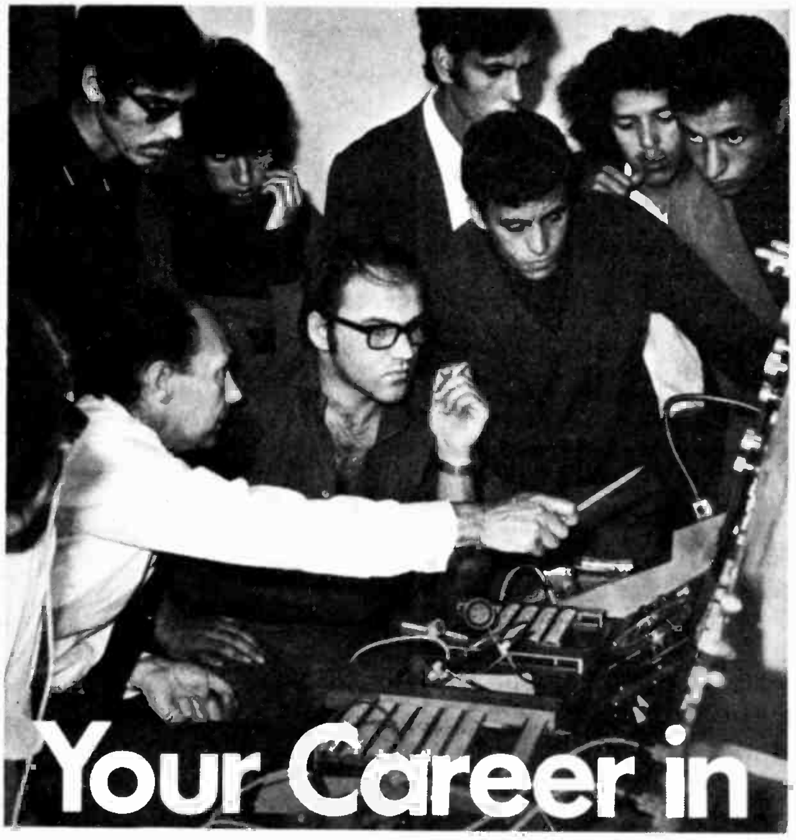
The modelling motor is not suitable for the rotating aerial application, as the rotational speed is very high. A much slower motor is desirable which together with the controller will be able to reach the recommended 1 rev/minute. A suitable motor may be found at the car-breakers from those used to power windscreen wipers, fan blowers, electric fuel pumps etc. Try to find out its current consumption before buying. Remember it must be about 5A or less.

One final point, for the aerial application a heavy duty battery such as that used in a car will be required, alternatively, a mains power supply can be used instead.

Most of the components required for the *Portable S.W. Receiver* are easily obtainable. If you experience difficulty in obtaining the Denco coil and its B9A base, they can be obtained direct from Denco (Clacton) Ltd., 357/9 Old Road, Clacton-on-Sea, Essex CO15 3RH.

The aerial used in the prototype was a five section telescopic one. A suitable type is available from Maplin and ordered as "telescopic aerial 4ft".

All components for the *Audio Peak Level Indicator* are available from many sources and should present no buying problems.



Students from Morocco learning the rudiments of ATC on a radar control simulator at IAL's School of Air Traffic Control.

Your Career in Electronics

by Peter Verwig

SYSTEMS ENGINEERING

EVEN a casual glance at the situations vacant columns in the press reveals that there is not only a vigorous demand for systems engineers but also, where salaries are quoted, that a systems engineer can command a very good income.

Systems engineering is not for the beginner. This will become clear as you read on. But if you are taking up a career in electronics it is probable that at some stage of your training you might be attached to a systems engineering team to get first-hand experience. But even if you spend your whole working life in a development laboratory, or on testing, or as a field engineer or in a dozen other categories of employment you will certainly come into contact with systems engineers and should know something of their work and their problems.

WHAT IS SYSTEMS ENGINEERING?

Let's start from fundamentals with a box of electronic components. Resistors, capacitors, transistors, integrated circuits, connectors. These are all made by component manufacturers to meet the demands of equipment designers and manufacturers. The components are specified and purchased by the equipment people to secure an end result which, for example, might be an assembly called an audio amplifier.

The audio amplifier will be built to meet a desired specification. For a certain voltage input it will provide a certain power output. The specification will set down the limits of distortion permissible in the amplifying process and there will very likely be some signal processing circuits to boost or attenuate certain frequencies and some form of gain control. It may have two channels of amplification to provide stereo facilities, or even four channels for quadraphonic reproduction.

We can now see emerging that very familiar central piece of a hi fi system. It may be a very complicated piece of equipment with its volume, bass, treble, and balance controls and perhaps a rumble filter and certainly switches for a variety of inputs. But it is still only a piece of equipment which can do nothing by itself. It needs input equipment such as a pick-up, or magnetic tape, or a radio, and output equipment in the form of loudspeakers. When all these items are assembled together we have a hi fi system.

Many electronic hobbyists have, perhaps unwittingly, been systems engineers. They scan the catalogues, compare specifications and price, buy all the items separately and build them into a system. It's great fun but you need to know what you are doing.

The overall system will work effectively only if the individual equipments in the system are interfaced correctly in respect of input and output impedance matching.

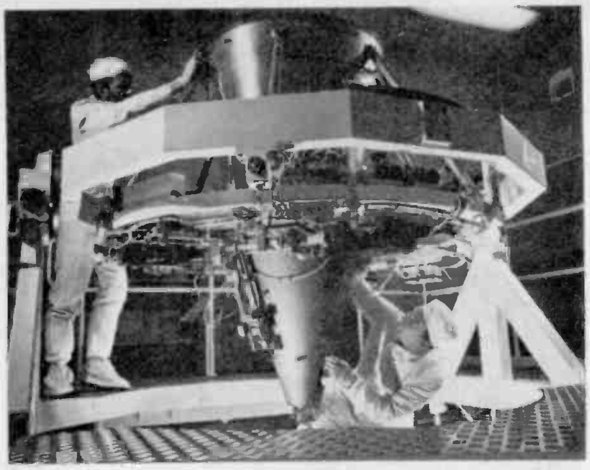
Anyone who has gone through the process will know that there is an enormous number of possible permutations of equipment and that it is quite easy to make costly mistakes.

An insurance against making mistakes is provided by a complete systems package already fully engineered and matched and often supplied in a single cabinet called a "music centre". All you need to do is to plug into the mains and connect a couple of speakers supplied with the equipment and you're in business.

Of course the purchase of a music centre is not so much fun for the person who likes tinkering about, but if you just want to be entertained by records or tapes or radio without bothering with technicalities then the purchase of an engineered system can be the wisest buy.

PROFESSIONAL ELECTRONICS

Let's now look at the same principle applied to professional



British-built Skynet II military communication satellite, a system itself within the British global military communications system.

Nimrod maritime reconnaisance aircraft crew trainer which reproduces realistically all the navigation, target acquisition and attack systems on the real aircraft. The Nimrod is now being redeveloped to carry the British Airborne Early Warning (AEW) system.

electronics. For the audio amplifier lets substitute a central processor as the heart of a computer system. As with the audio amplifier, the central processor by itself can do nothing. It, too, needs its input and output equipment, called computer peripherals, and these need to be interfaced into a workable system.

Again the possible permutations are endless and the choice of suppliers is very wide. And whereas you will have your hi fi system in a single room, a computer installation may have terminals in other areas of the building where it is installed or remote terminals at various parts of the country or even overseas, all demanding data transmission links.

Let us take another case, that of an air defence system. This will generally involve a whole chain of radar stations, a communications network and a weapons system which may be a mix of interception aircraft, surface-to-air missiles and anti-aircraft guns, all co-ordinated through a large computer complex and can cost hundreds of millions of pounds.

Or take an international project such as satellite communications. A proposed satellite system to succeed the present Intelsat IV system was jointly put forward by one of the bidders for the contract as a consortium of 17 different companies in 10 countries, each responsible for one or more sub-systems with an overall systems co-ordinator.

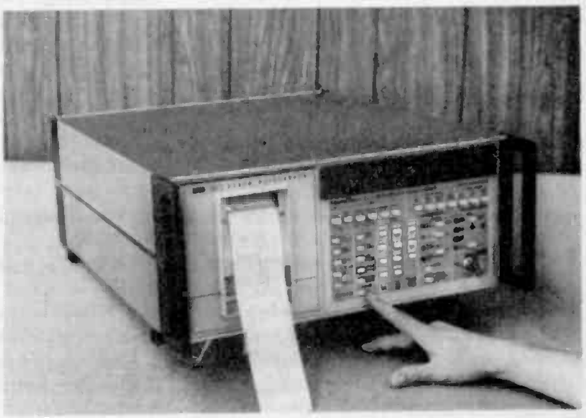
SYSTEMS, LARGE AND SMALL

Systems can be comparatively small and relatively simple such as an office intercom system, or very large and costly and demanding entirely different levels of skill in design. If we look around the world we find that some countries have engineering skills and some haven't.

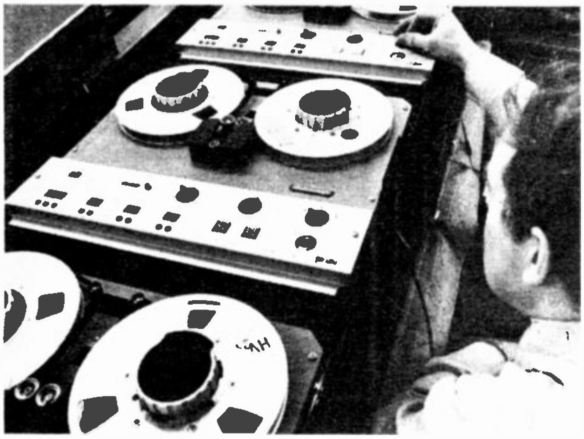
If we take the case of an air defence system, countries like the United States and Britain, France and West Germany to name but a few obvious ones, have the skill and the engineering capacity to build their own and make it work.

But if, for example, we go to the Middle East or most African countries and South America, systems engineering skills are either absent or in very short supply. Going back to our example of the hi fi system, the same principle applies. Those who have the skills can engineer a system using a wise choice of individual items of equipment. Those who haven't

This high-grade receiver would once have been regarded as a major system in its own right. Today it is a building block, one of many in a complex system.



A programmable data logger by Fluke. This is the sort of instrument that might be specified by a systems engineer or an industrial automation system. It can scan and record up to 60 different inputs in the form shown, up to 1,000 inputs with ancillary equipment.



These special quality tape recorders by Racal-Thermionic are merely equipment modules for systems engineers, in this case those specialising in systems or recording and analysis of seismic data.

Part of the control console and, through the window, the antenna of the satellite earth terminal in Bahrain. Part of a world telecommunications network, it was built by Marconi and is operated by Cable & Wireless.

the knowledge and experience will do better by buying a music centre as a complete package. At least they know it will work to a given standard for a given price.

In recent years a number of countries with low engineering skills have become remarkably rich. The best examples are the oil producers, but other countries fortunate enough to have large commodity reserves such as copper are also getting richer.

Such countries are in a rapid state of development and modernisation. They are spending the money on schools, hospitals, airports, telecommunications networks and other capital projects. One day they will acquire the skills to undertake such major operations but in the meantime they are natural customers for complete systems packages. So complete, in fact, that the packages are called turnkey projects.

TURNKEY PROJECTS

A turnkey project is one where a main contractor undertakes every aspect of the work down to the last detail. Let us take a simple example where there is a need for a telecommunications network between, say, the capital city and three newly developing townships.

A company undertaking the project would first of all study the projected growth of the new townships to determine the ultimate traffic capacity required during the next 10 or 20 years. Initially the system would have a low capacity but would be capable of expansion to meet the expected demand. It will also be designed to be integrated into the existing network.

With the requirement now defined the next stage would be to determine the best method in terms of reliability and economics within the framework of routing of the network. Cable or radio, or a combination of the two, will depend on the distances involved and the terrain. There will have to be site surveys. A pair of suitably located mountain peaks may be ideal for a microwave link.

When it is decided how the job will be done there is the detailed work of ordering the equipment and interfacing it into a system.

In a turnkey project the main contractor is responsible for everything. This will include employing architects to design the buildings, building contractors to build them, generally using local labour, and electrical contractors for wiring. The technicians who will be classed as installation and commissioning engineers will install and test the network and obtain acceptance from the customer.

But the contract almost certainly will not stop at this stage. Some operating staff will have had training during the constructional stages but in many cases the main contractor will keep his own engineers on site for a year or two while further training of local staff takes place. In some cases the main contractor will undertake the operation and management for unlimited periods.

The turnkey project also may include the design, building and equipping of maintenance workshops.

Many such contracts have unusual features. In countries were the political situation is unstable there will be a requirement for security protection with intruder alarms and other measures to discourage saboteurs.

There are frequently climatic problems, and irregularity in power supplies which may need something special in standby and emergency generating plant to keep the system operational. In remote areas there may be siting constraints because there are no roads. How do you transport heavy equipment over cart tracks? Load-lifting helicopters have eased this burden.

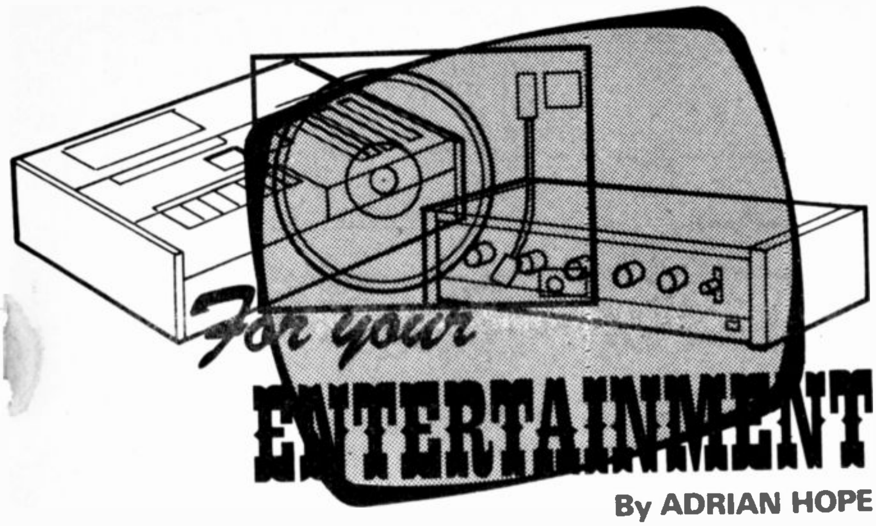
A systems planning office is thus a very busy place demanding many levels of expertise and enormous responsibility. Even small mistakes can be very expensive, especially on overseas projects.

An installation engineer held up for a week because of a silly thing like wrong plugs and sockets has a hotel bill of over £80 a night for a bed in the only hotel in Riyadh, Saudi Arabia. His firm not only has to foot the hotel bill but also his meals, his laundry, his overseas allowance and his salary.

EXAMPLE

A good example of systems engineering is the contract re-

Continued on page 387



By ADRIAN HOPE

sensed by the telephone exchange and route the caller accordingly. In this country we still use the old Strowger system, whereby when a number is dialled a string of pulses is mechanically created and used by the exchange equipment to route the call.

However, because of the essentially electronic nature of the American system, it can work much faster than the mechanical British system. So, many phones in the USA are touch phones where the number is dialled by rapidly punching it out on a calculator style keyboard. Such touch phones can only be used in the UK if they use a memory. This stores the signals produced by rapidly punching out a phone number on the keyboard and feeds them out at the slower rate which the British exchange equipment can handle.

So far so good. But an interesting thing is now happening in the USA.

Remember This?

Touch-dial phones are now being sold which, as an optional extra, incorporate the kind of memory essential in British touch-dial phones. The memory in the American phones has a recall time of about ten minutes, so that once you have dialled a number that you want, you can recall that number any number of times over the next ten minutes, simply by pressing a single extra button.

This can be extremely useful if you are trying to call a number which is continually engaged for short periods of time, for instance a booking office or foreign country, but here's the odd part The memory in the British touch-dial phone is wiped clean every time the dialled number is called. What a missed opportunity this seems. We could have turned the disadvantage of the British phone system into the very positive advantage of being able to re-dial an engaged number over and over again without punching out the full number every time.

In case anybody thinks the memory system would not work, I can tell you for sure it would. How? Because a friend coming back from the Far East stopped off in Singapore and spent £30 on a touch-dial phone with a memory built into it's Strowger conversion circuitry. You punch in a number and press the "go" button, and the circuitry churns out Strowger pulses for that number.

The memory then holds that number overnight, so that if it's engaged or unobtainable all you need do is press the button again to re-dial. Anyone who has wasted time trying to dial strings of long distance or intercontinental digits over and over again will positively yearn for the legitimate sale of such a gadget in the UK. I am told that the Post Office has plans to test some this winter.

If the test is in my area I will be first in the queue.

Since writing on nickel-cadmium rechargeable batteries, I have become increasingly disillusioned with their cost-effectiveness at domestic level.

For instance, the cells of two rechargeable electric razors I have used over recent years have needed replacement long before any other working part. A rechargeable flash gun was the next to fail despite loving care. One interesting suggestion is that nickel-cadmium cells work better in industrial situations, where they are treated rough with brutal discharge and recharge, more than at home with leisurely trickle charge and discharge.

Buying dry cells is not only becoming increasingly expensive, but is also fraught with pitfalls for the unwary. Apart from the leak risk previously mentioned, ordinary zinc carbon dry cells have a limited shelf life. So be very wary about buying bargain offer dry cell batteries. If they are old stock they will almost certainly let you down. And never ever buy such batteries in bulk and keep them in the cupboard at home, because by the time you need them the chances are they will be useless.

As a general rule, try always to buy dry cells from supermarkets or busy shops that have a fast turnover, so that what you buy is likely to be fresh stock.

Rechargeable Cells

An interesting new development of an old idea in batteries comes from Pulsar Developments Limited of Marlow, Bucks. Pulsar are importing into the UK some rechargeable batteries which, like car batteries, work on a lead acid principle but, unlike car batteries, are completely spill-proof. The electrolyte in these cells is in solid gel form, that is to say a paste round the electrodes, which is no more likely to spill than the paste from an ordinary dry cell. So they can be used on their side, upside down, or in any other position.

Of course, one of the ironies of modern technology is that although scientists have put Man on the moon, recorded colour TV on a disc similar to a gramophone record, and flown passengers at Mach two, no one has yet cured the common cold, photosynthesised carbohydrates as efficiently as grass does every day, or really improved on the age old lead-acid battery principle.

Although solid gel lead-acid cells have previously been available, these new batteries from the States are special, in that they are dimensioned to be exact replacements for existing batteries. For instance the EP640 is a direct replacement for a standard lantern dry cell. At £7, it costs seven times the cost of a dry cell, but can be charged and re-used an average of 300 times, using either a trickle or a 12 volt car battery with a series resistor.

It can also deliver up to 15 amps for short periods, which of course no dry cell can ever do. What I shall now be interested to see is whether Pulsar or others widen the range of solid lead-acid rechargeables, for instance producing versions suitable for portable tape recorders which gobble up dry cells at a truly horrifying rate.

According to an independent specialist in the field with whom I talked, the only disadvantage of a lead-acid gel battery is that it's plates can be fairly easily damaged by physical impact, e.g. if the battery is dropped. This is why the military stick to ni-cad cells.

Touch Telephones

In the USA when you dial a number on the telephone, you generate a series of differently pitched notes, like short musical whistles, which are

Physics is FUN!

By DERRICK DAINES

Induction

The galvanometer we made last month illustrates that current flow can cause deflection of a magnet. The reverse is also true, that movement of a magnet can cause current flow.

Wind approximately 10 turns of fairly thick copper wire into a flat coil and put this in series with the galvanometer as shown in Fig. 1. If a magnet is now moved backwards and forwards within the coil, the needle of the galvanometer will move in sympathy. Since we know that the needle moves by application of a current, the only place that current can come from is movement of the magnet. Notice that if the magnet is held stationary within the coil no current is produced—it is only movement of the magnet that does it.

Magnetic Field

For the next series of experiments a small bell transformer is necessary. We call the coil that is normally connected to the mains, the **primary** and the part that is normally connected to the bell, the **secondary**. Connect a battery and a switch to the primary and the galvanometer to the secondary shown in Fig. 2. Opening and closing the switch will cause the needle of the galvanometer to be deflected first one way then the other, but whilst the switch is either closed or open, no deflection is observed.

This is interesting since it shows that the magnetism inducing the current which deflects the galvanometer does not actually need to **move**, it is enough if the magnetism is building up or collapsing. This is such an important point that it bears repeating: "a magnetic field collapsing or building up induces current flow in an adjacent coil".

Steady magnetism does not have this effect.

Neon Oddity

If we substitute a 90 volt neon lamp for the galvanometer as shown in Fig. 3, we may observe another oddity. This time as we open and close the switch we will observe that the lamp lights briefly only when the circuit is **broken** i.e., when the magnetic field is collapsing. (If it also lights when the circuit is closed, reduce the supply voltage.) Usually, two or three times the supply voltage is needed to make the lamp flash while closing the switch.

Move the neon lamp to a position across the low voltage battery, as in Fig. 4. Leave the secondary winding open circuit, it is not used in this experiment. Again, the neon lamp lights briefly when the switch is opened. This is a very puzzling phenomenon. Clearly the coil has somehow managed to induce current in itself; moreover, a current that is greater than the original supply! Is that true?

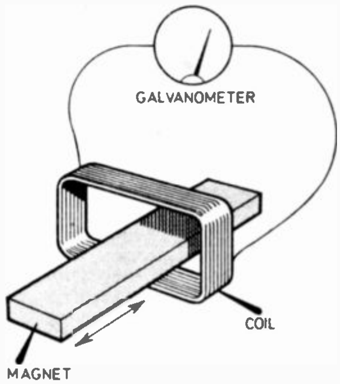


Fig. 1. When the magnet is moved to and fro a current flows and registers on the meter. No movement—no current.

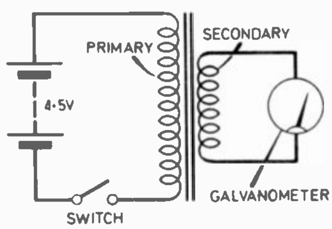


Fig. 2. Only when the switch is turned on and off does the meter needle deflect.

Self Induction

No, it is not. What has happened is that a *voltage* greater than the original has been induced in the primary coil. Curioser and curioser! However, regular readers of this magazine will have learnt already all the necessary ideas needed to put together a picture of the complete effect. However, for those readers who are still in the dark, the following explanation will make things clearer.

As the switch is closed, a magnetic field is formed about the coil. Upon opening the switch the magnetic field rapidly collapses, inducing in the coil a short-lived high-voltage current sufficient to "strike" the 90 volt neon lamp. This phenomenon goes by the name of "self induction" and next month I shall describe how to make a shocking coil utilising the effect. I do ask you however, to remember that the particular experiment described in Fig. 3 forms a good introduction to hysteresis. A subject we will discuss in a future issue.

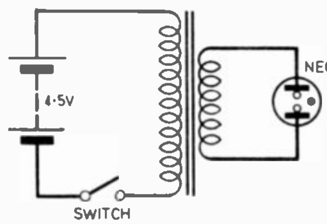


Fig. 3. When the switch is turned on, nothing happens, but when it is turned off, the neon flashes once. For a neon to flash, it needs 90 volts across it—so this is a strange happening!

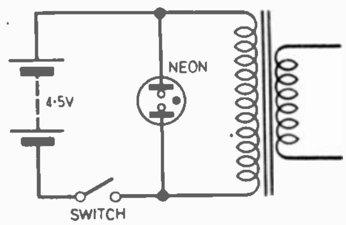


Fig. 4. Even on this side of the coil, the neon flashes when the switch is opened. Nothing happens when it is closed.

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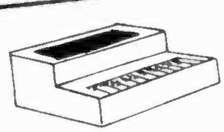
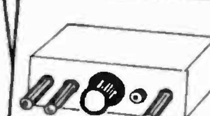
4 Varied projects of wide appeal...



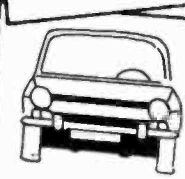
PROBOPHONE

A portable stylus operated mini-organ fitted with loudspeaker. Has variable vibrato.



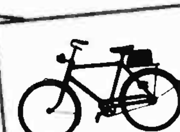
ADD-ON CAPACITANCE UNIT

Enables capacitor values from 1nF to 500nF to be read directly on standard multimeter.



FLASHER BLEEPER

Emits an audible tone when the car indicators are flashing.

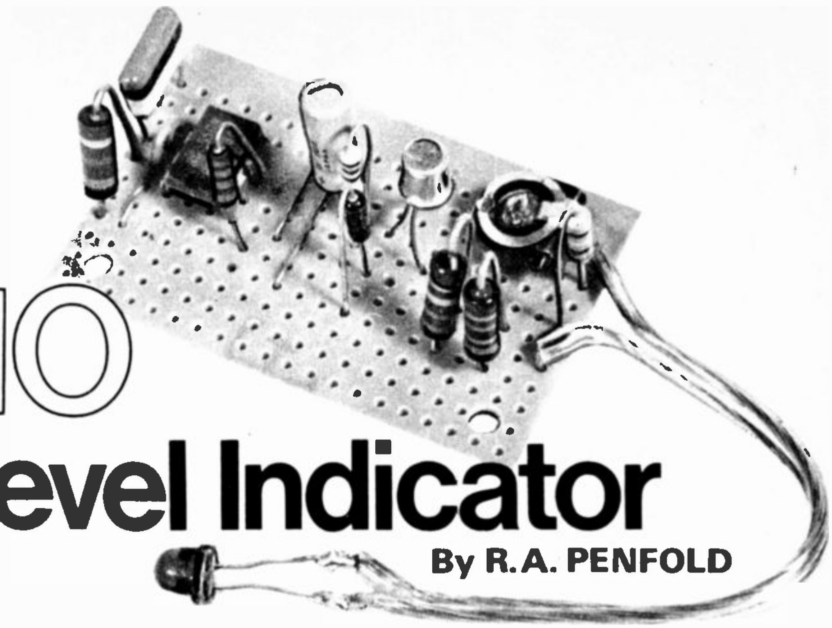


DYNAMO BACK-UP

A safety aid for cycles fitted with dynamo lighting—gives lights even when cycle is stationary!!!

Everyday ELECTRONICS

SEPTEMBER ISSUE
ON SALE
FRIDAY
AUGUST 19



AUDIO Peak Level Indicator

By R.A. PENFOLD

Eliminate distortion and keep your amplifiers happy.

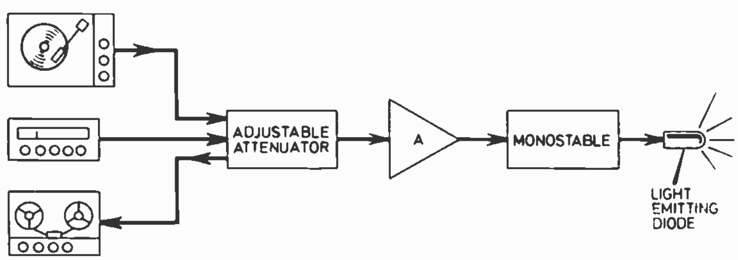
IT IS A fairly well known fact that misleading readings can be obtained from the average reading VU (volume units) meters which are fitted to most tape decks and certain other items of equipment.

This is due to the mechanical intertia of the meter needle preventing the meter from properly indicating high level signals of short duration. A very spiky signal can easily exceed the OVU peak level while the VU meter will only indicate the average level of the signal, which may only be about minus 6dB, or even less, in a practical situation. This leads to the input level controls being set incorrectly, which, in turn, leads to an annoying degree of distortion.

One method of overcoming this is to use a form of peak reading VU meter, but only a few of the most expensive pieces of audio equipment incorporate this feature.

A second, and increasingly popular method of solving this problem, is to fit the equipment with a peak level indicator, or two such devices in the case of stereo.

A peak level indicator is merely a circuit that causes an indicator light to be briefly illuminated when a certain peak level is exceeded. This is used in conjunction with the usual average reading VU meter rather than instead of it.



HOW IT WORKS

Signal from a microphone, tuner or disc system are fed to the parallel combination of the tape deck (recorder) and the Peak Level Indicator. Input to the unit is via a variable attenuator which is set to accommodate the level of the input signal. The signal next passes to an amplifier whose output is connected to the trigger point of a monostable. When the output from the amplifier is of sufficient amplitude, the monostable is activated. This is indicated by the illumination of a light emitting diode for more than 0·5 seconds. Thus even a very brief trigger signal will cause the l.e.d. to light for long enough to be noticed, thus indicating a "record overload".

CIRCUIT DESCRIPTION

A practical circuit for a peak level indicator is quite simple and must carry out two main functions. First, and fairly obviously, the circuit must be triggered by a peak level and not

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ESTIMATED COST OF COMPONENTS *
excluding V.A.T.

£2.00
excluding case

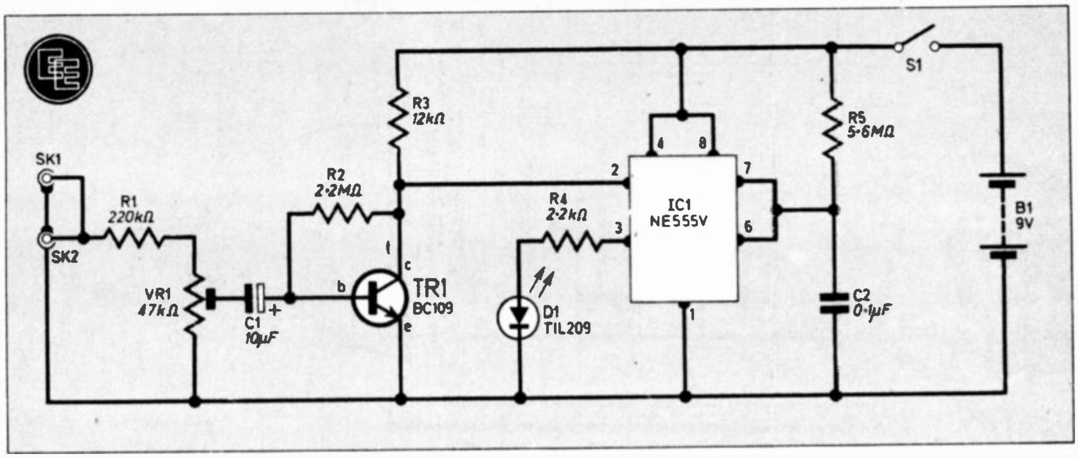


Fig. 1. Circuit diagram of the Audio Peak Level Indicator.

by an average one. Secondly, it must lengthen the duration of the brief peaks in order to provide a more noticeable indication.

It is possible to add this feature to equipment which does not already have a peak level indicator (or indicators), and Fig. 1 shows the circuit diagram of the Audio Peak Level Indicator. This is based on an NE555V timer i.c. used in the monostable mode.

The output from pin 3 of the NE555V operates an l.e.d. panel indicator via current limiting resistor, R4. When pin 2 of the i.c. is taken below one third of the supply voltage, even if only very briefly, the circuit is triggered.

Pin 2 of the i.c. is fed from the collector of a common emitter amplifier, comprising TR1 with R3 as the collector load resistor and R2 providing the base bias current. The input signal is fed to the base of TR1 by way of R1, VR1 and C1.

A quiescent voltage of something over one third of the supply voltage is present at the collector of TR1. If an input of sufficient amplitude is present at the base of the transistor, this will cause the transistor to conduct.

The collector voltage will now tend to fall to zero, in doing so it will fall below the required voltage needed to trigger the i.c. As was mentioned before this is slightly less than one third of the supply voltage.

The i.c. now having been triggered, (by what is effectively a very short duration pulse), proceeds to lengthen this pulse to a time dependent on the values of R5 and C2. The values shown produce a flash of about 0·6 seconds duration.

The output thus produced at pin 3 is used to illuminate the l.e.d.

Potentiometer VR1 enables the trigger sensitivity of the circuit to be varied from less than 100mV peak up to several volts peak. Resistor R1 reduces the maximum input sensitivity of the unit to a realistic level and also greatly increases the input impedance.

CONSTRUCTION

A suitable layout for the Audio Peak Level Indicator is shown in Fig. 2. This is constructed on a piece of stripboard 20 holes by 11 strips. Two methods may be used to connect the equipment to the level indicator. One is where the Peak Level Indicator may be mounted in a suitable aluminium box, containing its own battery and connecting leads.

In this case a connection should be made from the TAPE OUTPUT socket on the amplifier to SK1 on the level indicator. A second lead is then connected between SK2 and the INPUT socket on the tape deck.

The second method is used when it is possible to fit the unit inside the equipment in use. In this instance only one lead is required from SK1 to the VU

Components

Resistors
- R1 220kΩ
- R2 2·2MΩ
- R3 12kΩ
- R4 2·2kΩ
- R5 5·6MΩ
- R6 see text
- All resistors carbon ¼W ±10%

Potentiometer
- VR1 47kΩ sub-miniature horizontal preset

Capacitors
- C1 10µF 10V elect
- C2 0·1µF polyester

Semiconductors
- TR1 BC109 *npn* silicon
- D1 TIL209 red light emitting diode
- D2 BZY88C9V1 9·1V 400mW Zener diode
- IC1 NE555V timer i.c.

Miscellaneous
- SK1, 2 standard twin phone socket
- B1 9V type PP6
- S1 single-pole single-throw toggle switch
- Stripboard 0·1 inch matrix 20 holes by 11 strips; panel holder for D2; 8 pin d.i.l. i.c. socket; screened lead; battery clip; connecting wire; solder.

See **Shop Talk** page 367

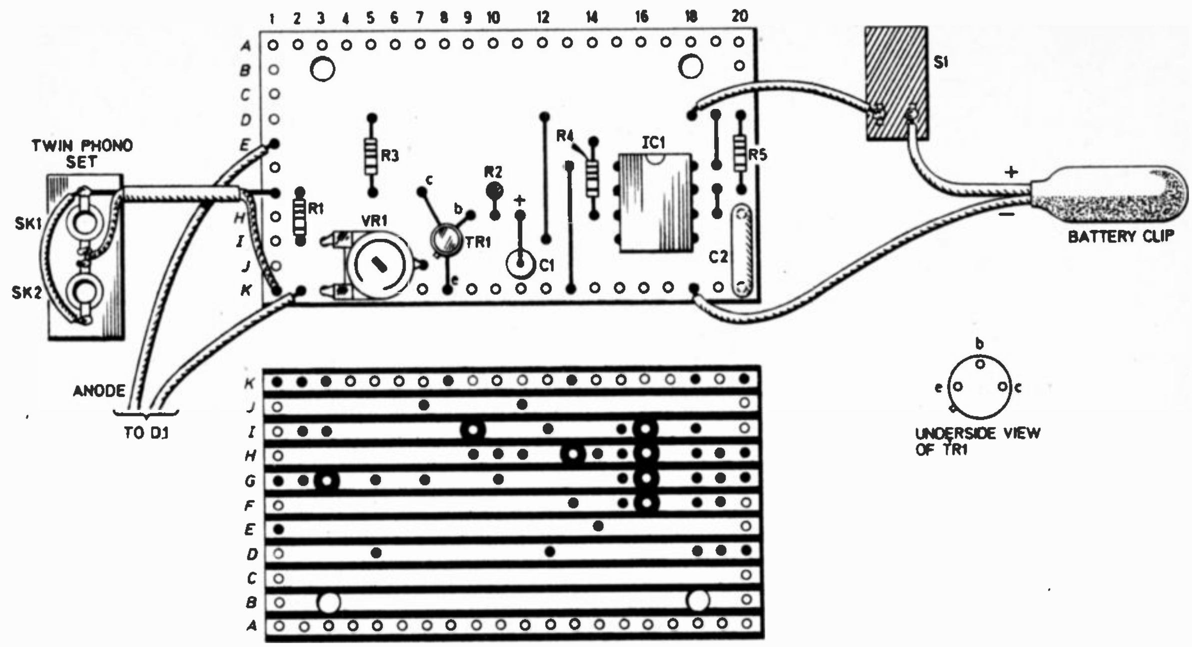


Fig. 2. Stripboard layout, also showing the breaks required on the underside.

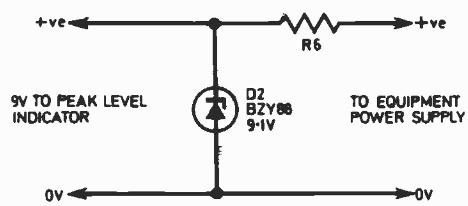


Fig. 3. This circuit is only required if the equipment supply is more than 9V.

meter. The usual point to take this connection is just ahead of the rectifiers, usually however most meters have integral rectifier circuits. The connection can then be taken direct from the meter terminals.

The l.e.d. is mounted in a suitable position on the front panel of the equipment, connected to the circuit board by a length of twisted connecting wire.

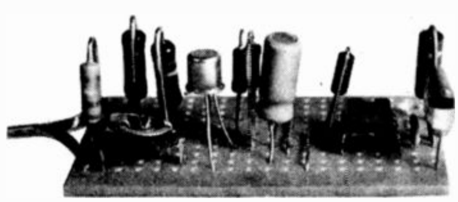
If a supply voltage of more than 9 volts is present in the equipment this will have to be reduced by the simple circuit of Fig. 3. If this is done then S1 and B1 may be omitted.

The value required for R6 will vary according to the nominal supply input voltage. The required value can be calculated from the equation: supply voltage minus 9·1 divided by 0·01. Perhaps a more simple way of looking at it is to allow about 100 ohms for every supply volt above the 9·1V Zener voltage. Thus R6 is 300 ohms for a 12V supply, 560 ohms for 15V, 820 ohms for 18V, and so on. This gives a current consumption of about 10mA or so.

SETTING UP

Potentiometer VR1 can be adjusted so that a sinewave input to the recorder (or other equipment) which gives a OVU reading on the meter *just* causes D2 to light. However, as short "peaky" waveforms can overmodulate to a certain degree without causing significant levels of distortion, it is more usual to adjust this type of circuit to indicate a level of +3dB or even +6dB on the meter.

The input impedance of the device is about 270 kilohms, and therefore loading on the main equipment should be negligible. ⌑



Photograph of the completed unit

PRINCIPLE OF OPERATION

The principle of operation is simply to wire a light sensitive unit, a cadmium sulphide light dependent resistor, PCC1, into a straightforward ohm-meter circuit. It has been assumed that the vast majority of photographs will be taken in daylight conditions, avoiding conditions of dusk and gloom; this means, in photographic terms, that the range to be covered is no more than about six to eight "stops" (one stop is a change in intensity of light, double or half), and can be accommodated in one range. A second range can be added to this instrument by those whose interest includes "available light photography" indoors or in the dusk. In this case a range switch could be added together with a second voltage of perhaps 10 volts, with appropriate range resistors.

If the l.d.r. is simply wired in series with a battery and a meter as shown in Fig. 1a, the result

Exposure Unit

By D. I. FRASER

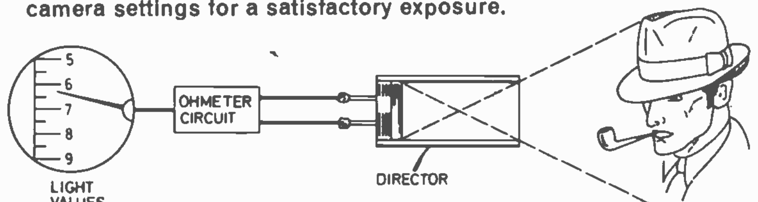
ALTHOUGH cameras in the higher price range tend these days to be equipped with some sort of built-in exposure control, there are still very many without this facility. Separate exposure meters can be bought at a variety of prices, but since this sort of device is in essence very simple, there may well be readers who will want to construct their own, which will give the inevitable satisfaction of "doing it yourself" and also of saving a good proportion of the cost of a bought exposure meter.

HOW IT WORKS

The device is pointed in the direction of the model/scene to be photographed, to receive light from this area. This light passes down a "directional" tube with the photocell located at the end.

The resistance of a photocell is proportional to the amount of light falling on its face. The photocell is connected in a resistance measuring circuit adjusted for the non-linearity of the photocell light/resistance relationship.

The scale of the meter has been recalibrated to give a reading in "light value" which can easily be used to calculate the correct camera settings for a satisfactory exposure.



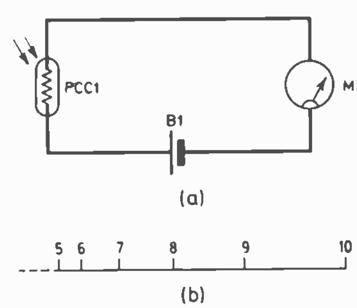


Fig. 1. This arrangement produces an unsatisfactory scale as shown.

is an exposure with a very non-linear scale with most of the calibration marks in the lower quarter of the scale length, see Fig. 1b. This fault is easily remedied by adding a series resistor as shown in Fig. 2a. This produces a very acceptable result, with some cramping of the highest and lowest marks on the scale, Fig. 2b, but with sufficient accuracy for most photographic purposes.

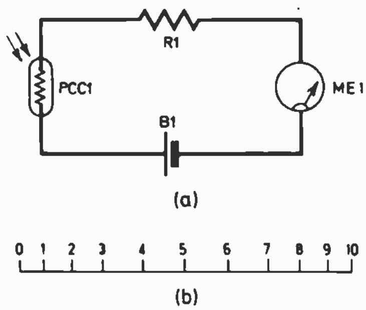


Fig. 2. By adding a series resistor the scale is made more linear.

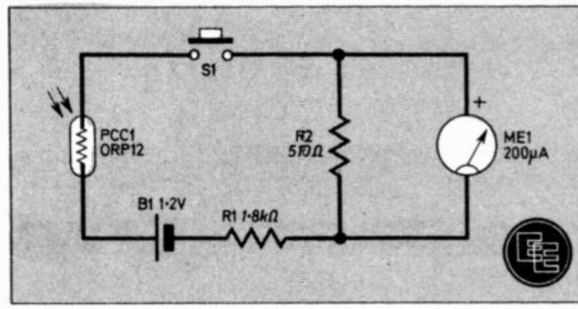


Fig. 3. The complete circuit diagram of the Exposure Unit. Values for R1 and R2 have been calculated for the meter listed in component box and R_d equal to 100 ohms.

CALCULATIONS

Calculation of the value of the series resistor, R_s is not difficult. First measure the resistance of the l.d.r. in full daylight, call this R_d. Then if the exposure meter is to cover n stops, double the value of R_d a number of times given by half the number of stops less one. This gives the total resistance (R_t) in series with the cell, including R_m, the meter resistance. In mathematical terms,

$$R_t = R_m + R_s = R_d\,(2)\left(\frac{n}{2}-1\right) \quad (1)$$

Meter resistance and sensitivity now need to be taken into account to ensure that the 10 light values (LV) are spread right across the scale of the meter face, without going beyond the full scale end stop.

To avoid the need for adjustment as the voltage source ages, a deaf aid cell is used which gives about 1·2 volts.

To determine the maximum current flowing in the circuit, divide this voltage by the total series resistance: thus

$$I_{max} = \frac{1{\cdot}2}{(R_d + R_t)} \text{ amps} \quad \ldots\ldots (2)$$

It is unlikely that this will yield an available f.s.d. so choose a meter with a full-scale deflection *less* but near to this value. A shunt resistor will next need to be worked out to produce the required f.s.d. under full daylight conditions.

If the f.s.d. of the chosen meter is I_m, then the value of the shunt resistor (R_{ms}) is given by

$$R_{ms} = \frac{R_m}{(I_{max}/I_m) - 1} \quad \ldots\ldots\ldots (3)$$

The final calculation gives the net value of the series resistor R_s. This is obtained from equation (1) with the modified value for R_m, since its effective resistance is the parallel combination of R_m and R_{ms}.

These calculations enable the constructor to use almost any l.d.r. and any reasonably sensitive meter movement; any meter can be used in this circuit, even down to the small cheap type used to indicate battery condition.

For those not wishing to get involved in working through formulae, a small readily available meter has been selected and the values calculated in accordance with the above. The circuit diagram of this arrangement is shown in Fig.3.

CONSTRUCTION DETAILS

The prototype unit was built into the upper body of an Ilford Sportsman camera and formed part of the complete camera. For this reason the smallest components that could be found were used. Normal push-on switches are on the large size, and so a mini microswitch was employed. Some constructors may prefer to have a separate unit so a suggested layout is shown in Fig.4.

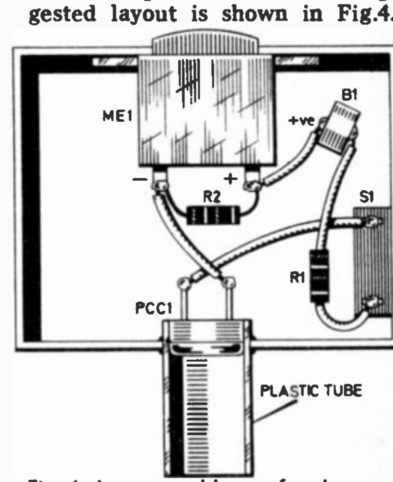


Fig. 4. A suggested layout for the components in a case separate from the camera.

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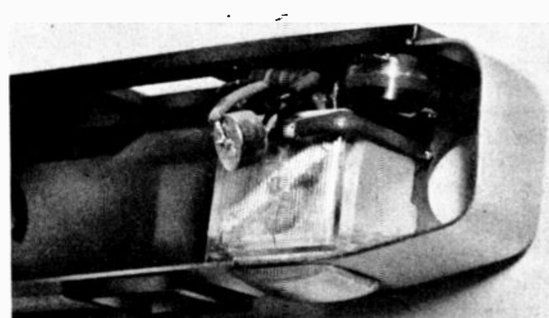
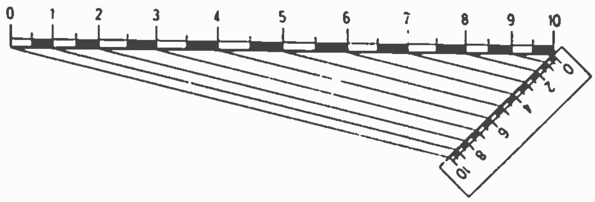
ESTIMATED COST OF COMPONENTS excluding V.A.T.

£4.50 excluding case



Construction details of the author's model built into the upper body of his camera. View finder acts as "director".



Method of producing a meter scale from the master. Draw a line at any angle to master scale to pass through '10'. Measure length of scale from '10' along angle. Join this point to master '0', then draw lines parallel to this from 1, 2, 3, 4 etc. to meet angle.

The component count does not warrant the use of a piece of circuit board. The box need only be about 50×50×40mm and can be made of any material. The l.d.r. should be mounted at the inner end of a tube whose diameter is that of the cell, and whose length is twice that dimension; this gives the instrument directionality. The microswitch can be glued in place with a suitably placed cut-out in the case top so that the nib of the switch can protrude without interference.

A master scale to suit most edgewise meters is shown in Fig.5 together with details of reducing the scale to a size to fit your meter. The scale is for a maximum of 10 stops.

USING THE UNIT

If the meter is shown sunlight, or pointed directly at and close to an electric bulb, it should read 10 if the calculations have been made correctly. If not check your wiring or figures. The scale markings are not that critical; an exposure error of half a stop is rarely of great significance.

Four variables must be related together: meter reading (light intensity), film speed, camera shutter speed, and lens aperture. The last two quantities can often be linked to give an "exposure value" (EV) as a mark on the shutter speed ring relative to a scale on the lens ring. These EV numbers will be higher for shorter exposures and for smaller apertures, in just the same way as the light values (LV) on the exposure unit are bigger in brighter light. The numerical difference between LV and EV is simply the film speed, so one has only to add a filmspeed number to the reading of the exposure unit to get the correct EV for the camera. This film speed number will have to be determined by experiment according to the following method.

(1) Assign the value of 10 (EV) for the combination of f/2·8 and 1/125 second.

(2) Using film rated at ASA 125 (DIN 22), assume a film speed number of 6.

(3) In varying light conditions, add 6 to the meter reading, to get the exposure value (EV).

(4) Assess these trial negatives for correct density and contrast: if obviously over-exposed, add 1 or 2 to the film-speed number assumed in (2); if under-exposed, then subtract from this number.

(5) Assess this series of trial negatives for uniform density: if the calibration of the scale is correct, negatives exposed in bright conditions will be very similar to those exposed in gloomy conditions.

When this method has been completed, make a brief list of the commonly used film-speeds, and list beside each the appropriate number which is to be added to the meter reading. Then you are in business! ☐

Components

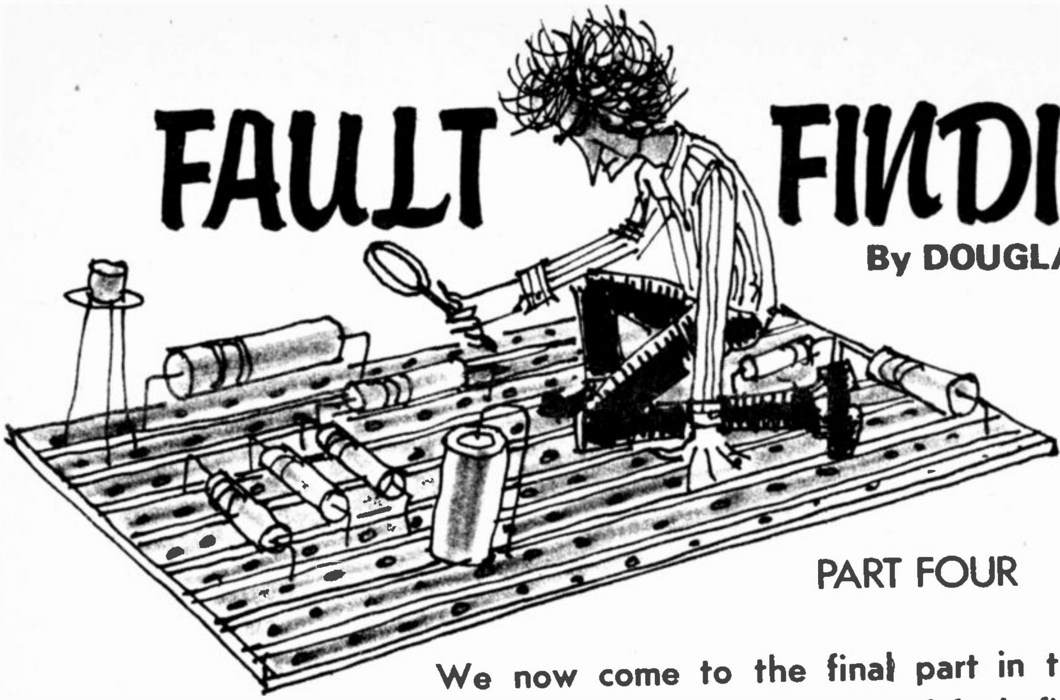
See Shop Talk

Resistors

R1 1·8kΩ } (see text) ¼W Carbon ± 5%
R2 510Ω }

Miscellaneous

S1 push-on, release-off microswitch
ME1 200μA d.c., internal resistance 1200 ohms miniature edgwise meter (see text)
B1 1·2 volts deaf aid or camera type
PCC1 ORP12 or similar light dependent resistor
Connecting wire; materials for case; 10mm diameter, 20mm long tube for director.



FAULT FINDING

By DOUGLAS VERE

PART FOUR

We now come to the final part in the series. We have presented the art of fault finding, not as a necessary evil, but as a pleasurable activity.

Most multimeters and volt-ohm meters (VOMs) have a.c. voltage ranges. On the face of it, these would seem to be useful in signal-tracing. If you can measure the a.c. signal at different points in an amplifying circuit you should be able to find out how much it is being amplified, and detect the exact spot where it disappears as the result of a fault.

Unfortunately, the majority of a.c. voltmeters are not nearly sensitive enough, since they do not respond equally to all frequencies. Sometimes even the higher audio frequencies get lost in the meter. The chief value of a.c. voltage ranges is in measuring mains frequency voltage in power supply units.

Here the low sensitivity doesn't matter very much, and a few simple measurements can often pinpoint a fault.

SAFETY

Safety precautions are important. Remember that the mains can be lethal. Remember also that you are dealing with **faulty** equipment. The mains voltage may be present at points where it **shouldn't** be. With some faults, it may even be there when the equipment is switched off! So don't take chances.

There are two standard precautions. First, wear rubber or plastic-soled shoes and stand on a well-insulated floor, **not** concrete, unless it's covered with insulating tiles or matting. Secondly, work one-handed. If you are right handed, keep your left hand in your pocket and connect up the meter, one terminal at a time, with your right hand only.

If you use both hands, and get them across the mains, the resulting hand-to-hand current goes through your heart.

It's a good idea to unplug the equipment, connect the meter, put one hand in your pocket and then plug in using your other hand. Repeat the procedure for each measurement.

A typical mains power unit is shown in Fig. 4.1.

On the primary side of the mains transformer the mains connection is often connected via a fuse FS1 (which may be rated at some current other than 1A, depending on how much current normally flows).

FUSES AND NEONS

Fuses are rated in terms of the current they can carry *without* blowing. They blow only when subjected to several times that current. A 1A fuse and 240V mains implies a power of 240W, which is a lot of power in electronics. Fuses are commonly made with carrying currents down to 50mA. A fuse may alternatively be placed somewhere in the secondary side of the transformer, like FS2, where the current is higher than on the primary side.

The mains switch, if single-poled as here (one pair of contacts) is placed in the "live" lead of the mains. If a double-pole switch is used, one contact is placed in each lead. If the switch is single-poled, and the mains connections are reversed so that N becomes L, the transformer primary is "live" even when the switch is off. A faulty switch may cause a similar danger, whether single or double-poled.

A neon lamp, if fitted, is usually placed across the mains as here, so that it comes on when the mains switch is turned on. Sometimes, however, it is so placed that it comes on as soon as the equipment is plugged in, whether or not the mains switch S1 is closed.

The series resistor R1 (usually around 100kΩ) is essential. If the lamp fails to light, check the series resistor and if its value has wandered far from what it should be, replace both lamp and resistor. (Neons are often supplied as complete packages containing

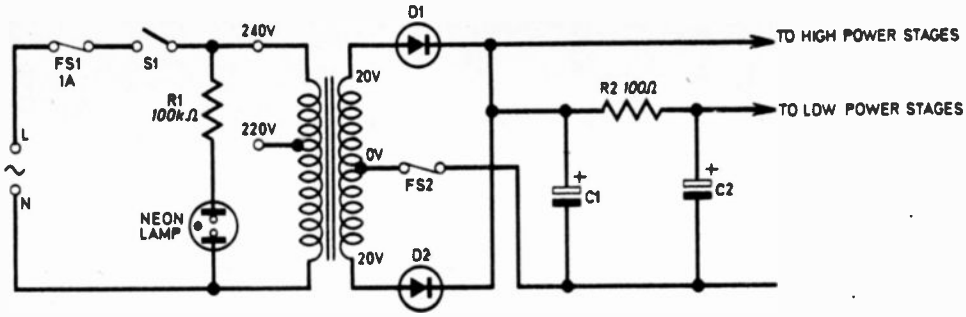


Fig. 4.1. A typical mains supply unit, using full wave rectification.

lamp and resistor in a plastics moulding with built-in lens.)

TRANSFORMERS

Common faults in mains transformers are open windings and short-circuited turns. If the primary is open, no voltage appears at either half of the secondary. If voltage appears at one half secondary but not the other, the most likely fault is an open circuit half secondary.

Windings can be checked (**with the equipment unplugged**) with the ohmmeter part of a VOM. The primary is likely to have a resistance of a few hundred to a few thousand ohms. Smaller transformers have higher resistances.

The low-voltage secondaries have resistances from a fraction of an ohm to a few tens of ohms. Resistance goes up as the voltage goes up and as the size goes down. There is no way of making a safe and satisfactory do-it-yourself repair to a mains transformer. **It has to be replaced.**

Short-circuited turns are a troublesome fault which cause loss of voltage, overheating, and often a buzz from the laminations. This fault, if in the primary, is often difficult to detect. If in one half of the secondary it may cause a substantial reduction in voltage in that half.

A short-circuited rectifier (either D1 or D2) allows a.c. to flow freely from one half of the secondary through capacitor C1 and the centre tap. Both the transformer and C1 are likely to be damaged, and possibly R2 and C2 also. An open rectifier causes some drop in d.c. voltage output and an increase in hum.

Badly leaking C1 or C2 cause overheating of the transformer, reduction in d.c. output, and possible damage to D1, D2 and R2.

POWER MEASUREMENT

Before leaving the subject of a.c. measurements, a brief further note on frequencies other than the mains frequency. One audio measurement which can be made with a VOM is the output voltage of an audio power amplifier. This is the voltage across the loudspeaker.

To get a reasonably accurate measure of the voltage it is necessary to apply to the amplifier a sine wave signal at a "mid-band" frequency, i.e. round about 1 kilohertz. The amplitude is then increased until distortion is just audible. The voltage across the speaker then gives a rough indication of the audio power, which is the voltage squared divided by the speaker impedance.

Be warned, however, that many of the cheaper amplifiers are not capable of handling sustained sine wave signals big enough to drive them to full output power. They are rated for music signals only. In music the **peak** power is the same but the average power is much less than the sine-wave power.

The sensitivity (ohms per volt) of a VOM is often lower on its a.c. ranges than on d.c. This does not matter when measuring across low impedances such as loudspeakers but it may cause large errors if measurements are attempted elsewhere in the circuit.

For h.f. measurements (which are beyond the capacity of most VOMs) it is sometimes possible to improvise using a rectifying probe (Fig. 4.2) which turns the r.f. into d.c., measurable on the d.c. ranges of the meter. The rectifying circuit used (which is a half-wave voltage doubler) imposes a load on the circuit to which it is connected.

This load is one quarter of the meter resistance. Capacitor C1 and diodes D1 and D2 should be mounted inside the probe close to the tip. With the diodes shown the probe will detect voltages up to a few volts at frequencies up to around 100 megahertz.

It is not accurate for small voltages, below about 500 millivolts peak. The voltage indicated is the peak-to-peak voltage, which is 2·8 times the r.m.s. voltage.

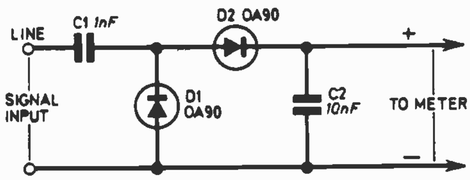


Fig. 4.2. Rectifying probe, which can be used with VOMs to measure r.f. voltages.

OHMS RANGES

We now come to the ohmmeter function of the VOM. The first point which must be made concerns safety. Not your safety, but the safety of the meter. The meter is often in its most vulnerable state when switched to an ohms range. This is because many of the protection circuits used in VOMs do not operate properly in the ohms ranges.

On these ranges, the internal battery of the meter drives current through the resistance under test (R3 in Fig. 4.3.). Inside the meter is a standard resistance R2 and a "set zero" variable resistance R1. The "set zero" is used for compensating changes in the battery voltage as it grows old and tired.

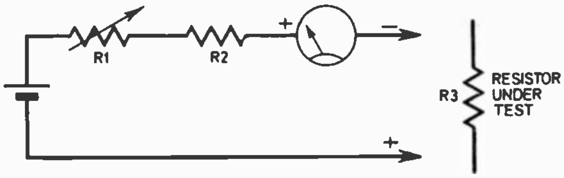


Fig. 4.3. Typical ohmmeter circuit used in many multimeters and VOM's

To set up the ohmmeter you connect the test leads together, which means that the resistance under test is zero, and adjust R1 so that the meter in fact reads zero ohms. It is then ready for use on that particular range.

Now, there is nothing here which could possibly damage the meter. The resistance R2 is large enough to limit the current from the battery to a safe value. So where's the problem? The problem, in a way, is in the mind of the user. If you connect the meter across a resistance in a piece of equipment with the equipment switched on, then a large current may flow from the equipment into the meter, and wreck it. The rule is "OBO," which means Off Before Ohms.

There is one danger which the "OBO" rule doesn't quite eliminate. Capacitors store electricity. A large value capacitor may still contain a significant amount of charge some time after the equipment has been switched off. You must either wait or discharge the capacitor artificially, by connecting a low resistance (e.g. 100 ohms) across them for a few seconds.

A wise precaution is to switch to a safe d.c. voltage range before making ohms measurements, and test the circuit for any lingering voltages.

LOOKING FOR ZERO

So much for safety. Now for measurements. The simplest is not really a measurement at all, but merely a test. A piece of wire connects point X to point Y. But does it really connect? Is there an invisible break, or a bad joint? An ohmmeter applied to X and Y should show zero ohms because the resistance of the connection should be so low that it looks like zero on the meter.

If there's a break, of course, the meter does not read zero. What it does read depends on the actual circuit. In most circuits you get some sort of resistance reading between any two points, because the current can usually find its way from one meter terminal to the other by wandering through various unlikely looking paths in the circuit.

This doesn't matter, in a continuity test such as this. You are looking for zero. If you get some resistance, the connection is bad. Some meters are fitted with a buzzer for continuity testing. The test leads and the connection under test simply apply the internal battery to the buzzer. If the circuit is continuous (no breaks or bad joints) the buzzer sounds.

DIODES AND TRANSISTORS

The ohms ranges of a multimeter can be used to test some semiconductor devices. A diode should pass current easily in one direction but block it in the other. That is, it should appear to the meter as a low resistance one way and a high one the other.

Looking at Fig. 4.4 you can see how the resistance should look with the meter leads connected first one way then the reverse way round. A very important point is that the lead which is marked positive (+) is in fact connected to the **negative** terminal of the internal battery.

You can see why if you look back to the ohmmeter circuit on Fig. 4.3. It has to be like this or the current from the battery would make the pointer go backwards. Remembering this point will enable you to find the polarity of unmarked diodes and transistors.

Fortunately the polarity markings which are printed on the bodies of some diodes do correspond with the meter markings. (That is if the + and − of the meter are applied to the + and − of the diode it should conduct.)

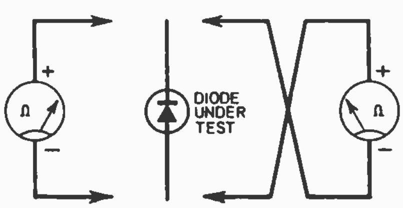


Fig. 4.4. Testing a semiconductor diode

The meter never reads zero on a good junction diode. Although it is quite true, as I said just now, that a diode passes current freely in one direction, it uses up a certain amount of the battery voltage in the process. For a germanium junction diode or gold-bonded diode this is about 0·25V. If the meter battery is 1·5V, only 1·25V is left for driving current, so the needle can't go more than about five-sixths of the way across the scale. For silicon diodes the forward voltage drop is about 0·5 volt so a 1·5 volt battery cannot push the pointer more than two-thirds the way to ohms zero.

This difference in meter deflection can be used to distinguish between germanium and silicon devices. Note, however, that my figures of five-sixths and two-thirds are upper limits and only apply if the ohmmeter battery is 1·5 volts.

In practice, you need to test some good working devices both silicon and germanium and note the deflections obtained. You can then tell, which unknown devices are silicon and which are germanium.

If the meter reads zero, the device must be shorted. Point contact diodes such as the germanium detector diodes still commonly used in radios do not behave quite like junction diodes. With some very sensitive meters they may allow the needle to go nearly all the way to zero and still be good. In any case, you should always test both ways. A good diode shows a high resistance when "reverse biased".

Since an ordinary bipolar transistor (*pnp* or *npn*) has two junctions in it, you can test each one in turn. Each junction should behave like a diode. You can tell the polarity from the way the meter is connected, if when the junctions are forward biased a low ohms reading should be obtained (Fig. 4.5).

You cannot usually distinguish between collector and emitter by an ohmmeter test. The base-emitter junction behaves in the same way as the base-collector junction. If you have an unknown but good transistor these tests can tell you which is the base connection, but not which is the emitter or collector.

Germanium transistors may show measurable (but high) resistances in the reverse direction. This is because a germanium junction allows a *leakage* current to flow.

With silicon the leakage is too low to measure except in some large power transistors. An ohmmeter can show an appreciable deflection when applied to collector and emitter of a germanium transistor, leaving the base unconnected. This is the largest of the leakage currents.

In transistors with the same type number this leakage is usually greatest for specimens with the highest current amplification factor (h_{FE}).

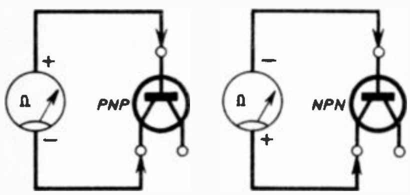


Fig. 4.5. Checking one of the two junctions in a transistor.

IN-SITU MEASUREMENTS

When measurements are made on complete circuits, containing mixtures of resistors, transistors, capacitors, etc., it becomes impossible to measure just one resistance at a time. They interact because they are connected to one another. However, a bit of common sense usually enables you to find out what you need to know. For example, an internal 'short' between two electrodes of a transistor shows up quite clearly in a circuit such as Fig. 4.6.

If there is a short between collector and emitter the ohmmeter must read zero whichever way round it is connected. If there is no short, it will read high both ways. But it won't read infinity, because there are two conducting paths across the collector and emitter terminals. One goes through R4, R3, R1 and R2. The other is through R3, R5, R6 and R4. If the meter probes are applied to *b* and *c* there will be a low resistance one way (when the base-collector junction conducts). The other way a small current can still flow via R3 and R1.

When checking resistors in transistor circuits make sure that the internal battery of the ohmmeter turns the transistor junctions off: i.e., in the non-conducting direction. If it doesn't, you will get a low reading. If, for example, you try to measure R2 with the negative (as marked on the meter) lead to base and the positive to earth current will flow via the base-emitter junction and R4 giving a false low reading.

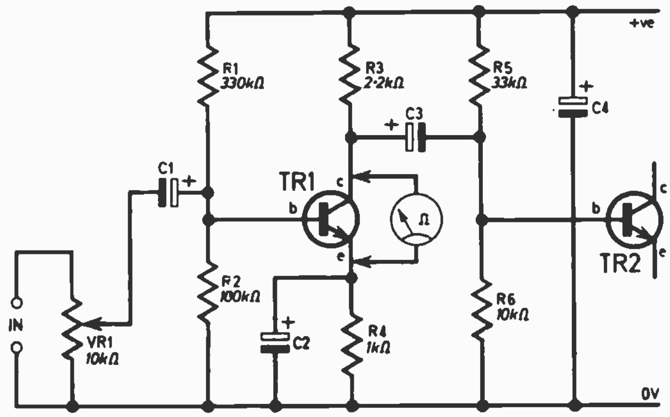


Fig.4.6. The first stage of a modern amplifier, shown here to illustrate typical fault conditions.

ELECTROLYTIC CAPACITORS

Electrolytic capacitors can confuse ohms measurements. There is often a large electrolytic (C4) across the battery or power supply (between the positive and negative rails).

This may take a charging current when the meter is applied. It will do so, for example, if the meter is connected across R5, since current flows directly to C4 from one meter terminal and indirectly, via R6, from the other. It may save time in measurements to charge C4 first, by putting the meter across the supply rails before making other measurements.

The correct polarity should be observed. Remember that "ohmmeter negative" is internal battery positive. Unfortunately, charging C4 (or any other large electrolytic) does not always solve the problem. As we've seen, you may well want to connect your meter in such a way that transistor junctions are reverse biased. This polarises C4 the wrong way and it may then take a fairly large persistent leakage current.

Similar considerations apply elsewhere in the circuit If you connect across R2 in the direction which turns TR1 base-emitter diode off, the positive plate of C1 receives a negative voltage and the negative plate a positive voltage, via VR1. This may cause C1 to de-form and take a large leakage current.

One dodge is to make measurements quickly before the capacitor has time to deform. Another trick, which sometimes works, is to switch to a higher resistance range and make the measurement with the meter polarity such that C1 receives the correct positive and negative voltages.

Normally, this would turn on TR1 and spoil the measurement. However, in order to turn TR1 (base-emitter diode) on it is necessary to apply more than a certain minimum voltage. For silicon transistors, this is about 0·5 volt. If a higher resistance range, still operated from a 1·5 volt cell in the meter, is used, TR1 never gets enough voltage to turn it on.

You can see why from Fig. 4.3, if you imagine that the test is being made with a diode across the resistance under test. If the internal meter resistance (R1 plus R2) is much higher than the resistance under test (R2) nearly all the cell voltage is absorbed inside the meter and only a little appears across the circuit outside.

If this external voltage is insufficient to turn on the diode then a true measurement of the resistance is obtained. To estimate how much voltage is appearing externally forget about the ohms scale and think of the meter as having an ordinary linear d.c. voltage scale of 0 to 1·5 volts. If the resistance under test is zero, all the 1·5 volts is absorbed by the meter, which reads full-scale.

If 1 volt is absorbed, leaving 0·5 volt outside, the pointer moves two-thirds of the way to full scale. If deflection is somewhere between two-thirds and full scale then the voltage across the circuit under test is substantially less than 0·5 volt, and true readings are obtained if the semiconductors are silicon.

FAILURE

You can see from this that there is a risk that your meter will *fail* to test diodes (and transistor junctions) if its ohms circuitry is not capable of applying enough voltage to the diode to make it conduct. Since the battery in the meter is always at least 1·5 volt, the usual "ohms" circuitry of Fig. 4.3 is adequate for diode testing if there is no resistance across the diode.

However, there are a few expensive meters which use a different arrangement for measuring ohms, and these are often deliberately engineered so that only a low voltage appears across the circuit under test. This is to make measurements of resistances across diodes and transistors easy. If you are lucky enough to possess such a meter, you will generally find that diodes can still be checked by switching to a higher ohms range. (The test voltage usually goes up on the higher ranges.)

One final word about diode tests. Some meters use a 9 volt battery for their 'megohms' ranges. This voltage is more than enough to cause *reverse breakdown* of the base-emitter junction of many silicon planar transistors and some germanium transistors.

This gives a false low resistance reading in what should be the non-conducting condition of the diode.

THE BEGINNING OF THE END

Fault-finding calls for both strategy and tactics. Strategy, as described in the first part of the article, enables you to discover quickly which part of a complex circuit is faulty. Tactics is then brought into play to pinpoint the fault.

Successful tactics calls for some understanding of circuit operation and some knowledge of the use of test instruments. Only the minimum equipment required (ie a VOM supplemented by simple accessories which you can make for yourself) has been mentioned in these articles. Should you wish to go further, the next most useful piece of gear is an audio oscillator. After that, depending on where your interests lie (audio or radio) either a radio frequency signal generator or an oscilloscope.

At all times, use two "instruments" which cost nothing, your imagination, and your powers of observation. Expect the unexpected.

Once, for instance, I found that a mysterious mains hum suddenly appeared in an audio noise generator I was building. I tried everything I could think of but failed to find the cause. Then I noticed that the hum was reduced if I covered part of the circuit with my hand, without touching anything.

This led to the explanation. My hand was keeping *light* from the electric bench lamp off a glass-encapsulated germanium diode in the circuit. This diode was operated in a reverse-biased condition. In this condition, germanium is very sensitive to light. Enough light was getting through the clear-glass envelope to affect the reverse resistance of the diode significantly.

Since the light from the bulb ran off a 50Hz mains supply, the flickering (invisible to the eye) explained the hum.

A piece of black sleeving slipped over the diode cured it. The experience was useful, in that it also showed me a way of obtaining, for the price of a diode, a rough-and-ready kind of photocell. Fault finding can be an educational process.

Good luck with yours! ¤

I tried everything I could think of but failed to find the cause.

Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

A NOVEL CASE

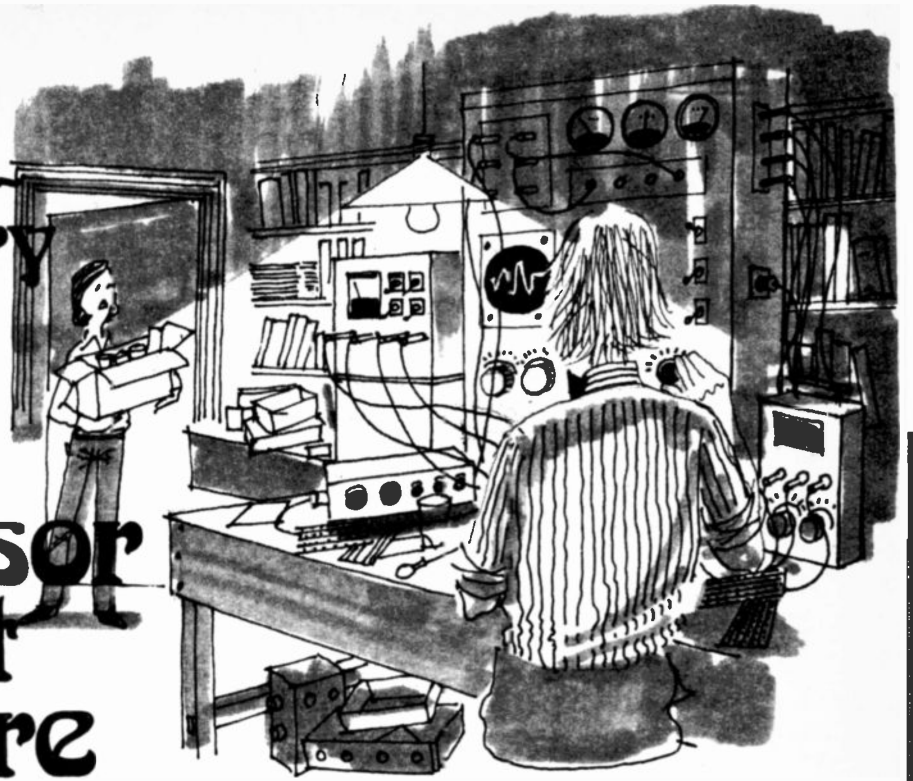
An inexpensive, versatile, and very attractive case for a circuit can be made from the interlocking plastic drawers used for component storage.

The name-tag holder and handle are sawn or filed off, and the drawer is then reversed so that the scratched front is hidden, and two holes drilled to match the mounting holes in the back of the cover. The other end is then drilled to take the controls, etc of the circuit, and then painted on the *inside* with model paint. Two bolts through the back hold the drawer in place in its cover, and feet may be glued or bolted to the base if the cases are not to be used in the interlocking mode.

The finished appearance of the cases is very impressive, and as the drawers are available in several sizes, most circuits can be housed.

**N. Riddiford,
Tyne & Wear.**

The Extra-ordinary Experi-ments of Professor Ernest Eversure



by Anthony John Bassett

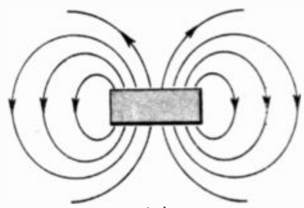
THE Prof. began with some comments on the practical experiments described last month, to describe to Bob some properties of electrical polarisation of insulation.

"One of the most interesting of the phenomena which the electrophorus demonstrates, Bob, is that an electrically charged insulator may carry a charge below the surface of the material. When you lowered the uncharged metal tile onto the surface of the charged plastic tile, and *earthed* the metal tile by touching it with your finger, this did not remove all of the charge from the plastic tile, as might be expected if the charge resided on the surface.

"On the ccontrary, as the charge carried by the plastic tile could not escape by this route, it induced a charge of opposite polarity in the metal tile, which became obvious when you lifted the metal tile away from the plastic tile using the insulative handle.

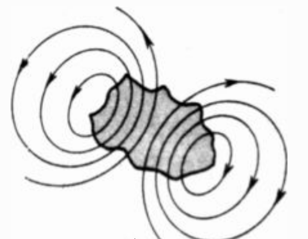
"Then a strong electrostatic charge appeared on the metal tile, causing your model electrophorcraft to take off and hover in mid air.

"But the charge carried by the plastic tile still remained, and this can be used to charge, by induction, any number of metal tiles in the same way."



(a)

Fig. 1a. Typical magnetic field produced by a bar magnet.



(b)

Fig. 1b. Solid wax, as shown here also produces a similar field.

"Prof." remarked Bob, "I have noticed that my plastic tile gradually seems to lose its charge, and I cannot seem to recharge the metal one from it too many times before it begins to weaken. If the charge is below the surface, as you say, how can it be lost from inside the insulator? And if the plastic is such a good insulator, how can an electrical charge be placed under its surface to begin with?"

ELECTRETS

"Aha!" remarked the Prof. "In your first question you are making an unscientific assumption! How do you know that the charge is lost from inside the insulator? It might be there all the time, and only seem to weaken! If the external electrostatic field produced by the charge inside the insulator were to be partly neutralised, the charge would seem to disappear or weaken, and the ability to charge the metal plate by electrostatic induction would weaken as you have observed.

"There is a way in which this can occur very readily; the charged plastic tile will attract to itself tiny particles of opposite charge which then stick to the surface, and eventually because of their opposite charge and increase in quantity, will neutralise the external field, without actually removing the original charge.

"Now by rubbing the surface vigorously with a dry cloth, or as you do, in the hair, the surface charges can be removed, and the external field will then reappear.

"Now it frequently happens that in various ways plastic can become electrically charged during manufacture, and as the plastic is shaped and moulded to its final solid shape, the electrical charges can become trapped below the surface. Another related phenomena is the production of electrets, which are very useful in electret microphones and pickups. These consist of pieces of insulative material which exhibit an electrostatic field, but without carrying an overall electric charge.

"This means that although the electret is neither positively charged nor negatively charged, it produces an electrostatic field."

"How on earth does it manage that, Prof?" asked Bob intrigued.

CARNAUBA WAX

"The first electrets to be made experimentally were produced by a Japanese scientist, Motataro Eguchi, in the year 1920. He found that by allowing molten Carnauba Wax to solidify in the presence of an electric field, the electric field appeared to become *frozen in* to the solid wax, which continued to show an electric field even though it had not been given either a positive or a negative charge. The wax became polarised with *positive* and *negative* poles analogous to the north and south poles of a magnet, and with the field passing through the material from one pole to the other and manifesting externally as opposite fields at each pair of poles." Fig. 1.

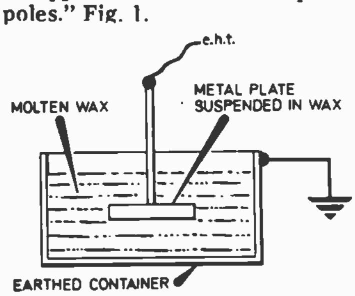


Fig.2. Apparatus required to produce a "wax" electret.

The professor drew a sketch depicting the type of apparatus which could be utilised to produce an experimental electret by solidification of a molten insulator in the presence of a strong electrostatic field Fig. 2.

"The high voltage may be produced by traditional means such as the Wimshurst machine, or by means of a more modern electronic e.h.t. generator. When the wax has solidified, the source of the high polarising voltage may be removed and the wax broken up. It should then be found that each piece produces its own electrostatic field, the field may then be detected by moving the wax about in the vicinity of an electroscope.

"If the electroscope is partially charged already, it can then be seen how opposite sides of the electret produce an opposite field, causing the electroscope to give both positive and negative indications for the same piece of material.

"One very important point to be very careful of when producing an experimental electret is the purity of the material."

The Professor showed Bob a sample of Carnauba Wax, a hard brown solid.

"This is the hardest known wax to occur in quantity in nature, and is also the wax which is imported into England in large quantities for making wax polishes and for many other purposes.

"When there is relative movement between electret and the input terminal of an amplifier, this induces movement of electric charges in the terminal, and these produce an output from the amplifier. In an electrostatic microphone, for instance, the diaphragm itself is an electret." (Which is, however, made of plastic, not wax.)

ELECTROSTATIC MICROPHONE

The Professor began to draw a sketch of an electrostatic microphone, Fig. 3.

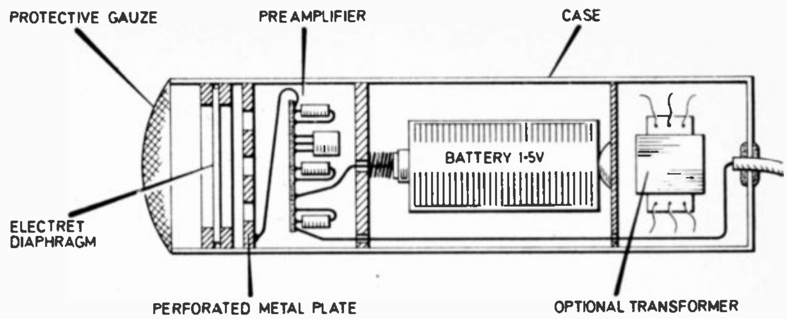


Fig.3. Construction of an electrostatic microphone.

"It is placed near to a metal plate which is connected to the input of an f.e.t. amplifier, which matches the high impedance of the signal source. The metal plate is perforated for acoustic reasons which assist in giving good frequency and directional responses, and avoid trapping air between the plate and the diaphragm when the diaphragm vibrates."

A friend of the Prof. had bought a large number of electret condenser microphones, and found a small number of these were faulty.

"These are very good microphones," he told the professor. "But I have been told that the faulty ones are unrepairable."

"He left a few of the faulty microphones with me," the Prof. told Bob, "so that I could investigate, and tell his regular repairman what to do. Fortunately, I have found that, with care, most of these microphones may be mended very easily. Look, I'll show you."

REPAIRS

The professor plugged one of the faulty microphones into an amplifier and spoke into it. The resulting output was very quiet.

"Turn up the volume, Bob", he said, and as Bob gradually turned up the volume-control the Prof's voice came from the loudspeaker.

"It sounds distorted, Prof, and not very loud although I've set the volume up full," Bob observed.

"Okay, Bob, turn it down again." The Prof. disconnected the microphone and carefully opened it up.

"Here is the electret diaphragm, trapped between two plastic washers," he showed Bob.

The Prof. carefully lifted the washers and the diaphragm away to reveal the perforated plate,

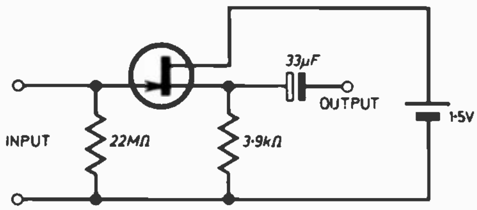


Fig.4. Typical circuit used in many electrostatic microphones.

and gently ran a finger over the surface of the plate.

"Feel this, Bob," he suggested, as Bob began to touch the metal plate. "Do you notice anything?"

"Yes, Prof., the edge of one of the holes in this plate is very rough; it feels as though there is a piece of metal sticking up around the edge of one of the holes: this one."

"That's right," the Prof. confirmed. He used a fine curved blade to carefully scrape around the edge of the hole until the irregularity had been removed and the metal felt smooth and level, then carefully positioned the diaphragm and spacing washers over the plate, fixed them in place and reassembled the microphone. Now when he tried it the microphone sounded loud and clear.

"That seems to me to have been an easy repair, Prof.," remarked Bob, "Can I try to do one?"

"Yes, why not?" remarked the professor, "Go ahead." Carefully copying the Prof.'s previous actions, Bob gingerly took the delicate microphone to pieces, being very careful not to bend or otherwise damage the electret diaphragm.

However, he could find no rough edges on the perforated plate. The Professor handed Bob a large sheet of clear white paper.

"Shake it over this," he suggested, and as Bob did so, a minute particle of metal came out from amongst the holes in the perforated plate and settled upon the paper.

"There's the culprit, Bob! The complaint about that microphone was that it rattled and crackled!"

When Bob had carefully reassembled it, this microphone also sounded loud and clear, without any trace of rattle or crackle.

"Hooray," shouted Bob jubilantly into the microphone, "but Professor that was easy, why do they say these microphones are unrepairable? What else is there to go wrong?"

"Not much," replied the Professor. "Behind the perforated plate is an f.e.t. pre-amplifier, and sometimes there is a matching transformer."

The professor quickly sketched out a circuit diagram, Fig. 4.

"Not much to go wrong there. These microphones are unrepairable if you don't know how to do it, but when you know how, it's easy!"

To be continued

Continued from page 370

Your Career in Electronics

cently awarded to Marconi-Elliott Avionic Systems for the electronics in the British Airborne Early Warning system. As main contractors, MEAS will have work for some 2,000 people and it is estimated that another 2,000 people at sub-contractors will be employed on the project. The job is worth £100 million to companies in GEC-Marconi Electronics.

The systems engineering on AEW is not confined to radar surveillance. The aircraft will also have sophisticated data handling equipment to co-ordinate target plots with sensors which determine the type of target, and with the aircraft's own navigational system. It is also a flying control centre with a communications system for directing interception.

The radars and communications must ideally be immune from all forms of enemy jamming. And everything must be crammed into the confines of an aircraft. A mammoth operation for which there will be a need for several teams of systems engineers working on specific task cells.

The composition of the teams embraces scientists and engineers of many disciplines. Of course there will be digital and analogue circuit specialists, software programmers and mechanical designers, reliability engineers, microwave specialists and test equipment designers. But there is also a call for stress analysts and mathematical modellers.

Once the prototype hardware becomes available there will be plenty of work for practical systems development both on the ground and in the air by trials engineers.

It is safe to say that some engineers on this single project will still be working on it in 10 years time because even when the system is flying there are constant up-dates and redesigns to cope with changes in the military requirement to meet new or different types of threat. It is also safe to say that many young engineers just entering the profession of electronics will be posted to the project in its lifetime after they have completed their training and acquire some experience.

CHANGING WORLD OF ELECTRONICS

The pattern of electronics is changing. Many advanced technology components once manufactured only in the industrialised countries are now made in faraway places where labour costs are low. This trade has been lost by advanced countries like the UK.

The same applies to comparatively simple and cheap assemblies such as transistor radios. But those countries which have recently acquired the basic skills to fabricate components and manufacture the simpler assemblies are completely unable to engineer large systems of the type we have been discussing. There is no chance of advanced systems engineering contracts going to Taiwan or Korea.

As I have explained, systems engineering is a big and important job. But there is no need to be frightened of it. There are lots of clever people involved, they have to be clever; but they are by no means all geniuses. The team leader was once a brash newcomer and there are plenty of first year apprentices today who will be in systems engineering in five or 10 years time, even though they may not know it yet.

GEORGE HYLTON brings it down to earth

A reader asks: "Why *operational* amplifiers? After all, they are just amplifiers, and they'd be no use if they *didn't* operate!"

Quite. But the *operational* in "op. amp" has a special meaning. It refers to the ability of some circuits containing amplifiers to perform *mathematical* operations. In these days of digital computing it is easy to forget that there is another kind of computing, analogue computing. This is where the operational amplifier was first used.

Analogue computing is in certain cases simple and fast. An important use of analogue computing is to carry out the difficult mathematical operation called integration. This is done with the very simple circuit of Fig. 1. If the input current is made to be proportional to whatever you want to integrate then the output voltage is proportional to what mathematicians call its time-integral.

Perfect Integration

Working out integrals can be a formidable task, to a mathematician, but the circuit does it effortlessly. With one snag, though. Analogue computation is not precise.

One reason for errors is that in a circuit like Fig. 1 the amplifier itself can upset the operation. To perform a perfect integration all the input current should flow in to the capacitor, and none into the amplifier. In other words the amplifier should have infinite input impedance.

Connecting some kind of load (such as a second op. amp) to the output should not affect the output voltage. This means that the amplifier's output impedance should be zero. For perfect precision the amplification should be infinite.

Naturally, no real-life amplifier can meet this specification. But adequate

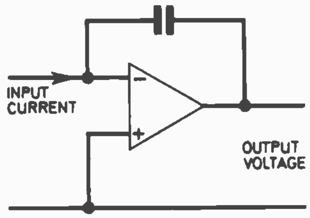


Fig. 1. Fundamental circuit for an integrating op. amp.

precision is obtained if the gain is very high, the input impedance very high, and the output impedance very low.

External Circuitry

There are one or two further common requirements. In many operations it is necessary to connect a resistance from the amplifier output to the amplifier input. This must not upset the working of the amplifier. To provide this facility, the normal d.c. voltage at the output of the amplifier must be the same as at the input. (Usually this requires that the power supply should be of the "split" type, with a positive rail, a negative rail and a neutral or earth rail at an intermediate voltage.) Another useful facility in modern op. amps is **differential inputs.** This means that there are two input terminals, and the amplifier responds to the *difference* between signals at these terminals. Thus if one terminal is at 120mV and the other 121mV the effective input is 1mV. This is very useful when the input signals come on leads which pick up interference. In the example just given, 120mV of each signal might be unwanted mains hum, present on both leads. The odd 1mV would then be the wanted signal. The amplifier would almost ignore the hum. This property is called **common mode rejection**, a common-mode signal being one present at both terminals and of the same strength and polarity.

An amplifier with all these properties is suitable for use in most "operational" circuits and is therefore an op. amp. Naturally, it can be used for purposes other than computing, too, but there are limitations. It may be rather noisy. Its bandwidth is usually limited, making it unsuitable for high frequency amplification. Its power output is generally small. It is essentially a "voltage amplifier"; with the ability to handle signals from d.c. to a few tens of kilohertz.

The first op. amps were big, clumsy valve affairs, but with the arrival of integrated circuits they have become so compact that four of them can be incorporated in one dual-in-line package. Most of the recent op. amps have what is called built-in frequency compensation: this means that a capacitor is incorporated which restricts the bandwidth and so helps to keep the amplifier stable.

Some are designed for use with a simple, untapped power supply. Some incorporate field-effect transistors in the input-circuits to give an extremely high input impedance. Op. amp techniques such as differential inputs are used in other i.c. amplifiers such as audio power amplifiers.

Offset and Drift

An important use of op. amps is the amplification of small d.c. voltages, and this is where their limitations show up. All op. amps behave as if there were a small d.c. voltage signal at their input even when none is there. This spurious input signal is called the **input d.c. offset voltage** and is often a few millivolts. It can be removed by making adjustments and many op. amps have special terminals for connecting offset nulling circuits. Unfortunately, the adjustment is correct only for one temperature, so another important quantity is the temperature drift. An op. amp with a temperature drift of $10\mu V$ per degree Celsius will show a change of $10\mu V$ in offset voltage for every 1 Celsius degree rise or fall of temperature. Drift makes the amplification of microvolt d.c. signals difficult but op. amps are gradually being improved and are already much better than the d.c. amplifiers of the last generation.

General Purpose Amplifiers

Since the development of genuine op. amps the need has arisen for cheap general purpose low frequency amplifiers with some of the characteristics of the real thing but not such a stringent specification. These are still referred to as op. amps in price lists and data sheets.

In addition, the op. amp design philosophy has spilled over into general amplifier theory. You may find circuits with only one recognisable live input terminal which are nevertheless shown on block diagrams as op. amps with two input terminals (inverting and non-inverting).

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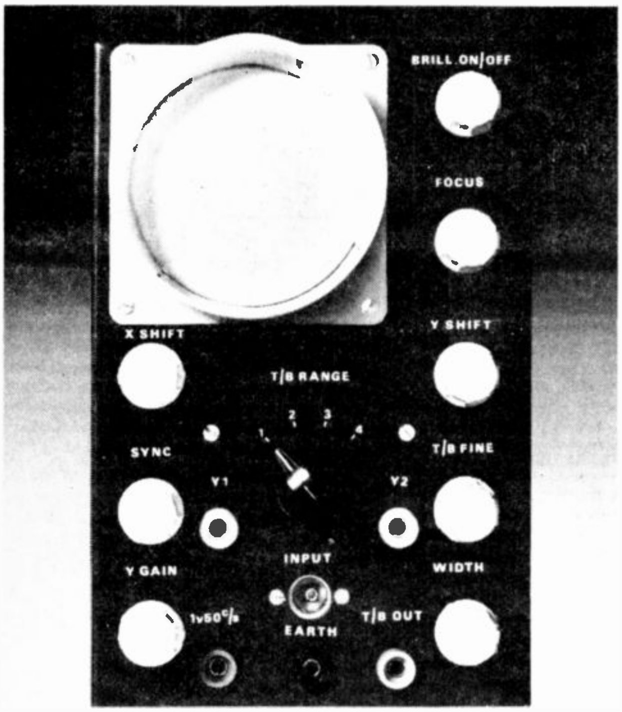

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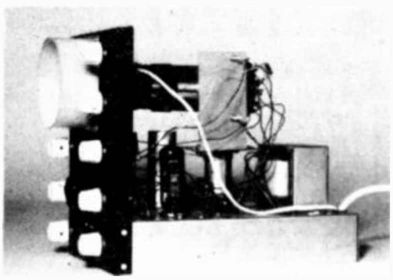

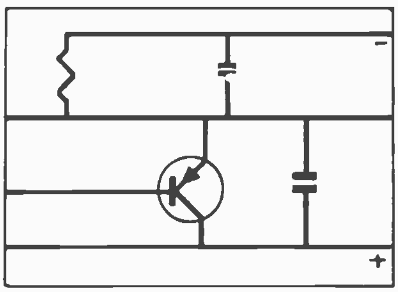

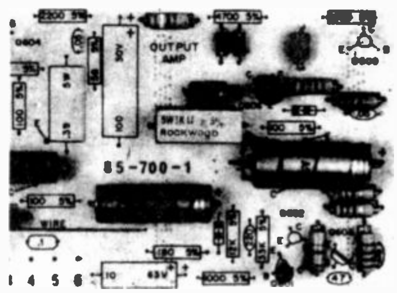

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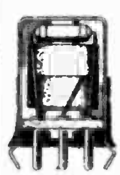

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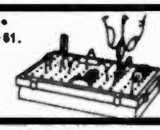

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½in 2BA	844	£0·63	½in 6BA	849	£0·30
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Type	No.	Price	Type	No.	Price
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Type	No.	Price	Type	No.	Price
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2BA	860	£0·15	6BA	862	£0·12

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Type	No.	Type	No.	Type	No.
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250mA	612	1·5A	616	4A	620
550mA	613	2A	617	5A	621
800mA	614	2·5A	618	All 5p each	

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2·5A	628
250mA	623	2A	626	3·15A	629
500mA	624	1·6A	627	5A	630

All 7p each

QUICK BLOW 1¼in

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

All 7p each

Type	No.	Type	No.	Type	No.
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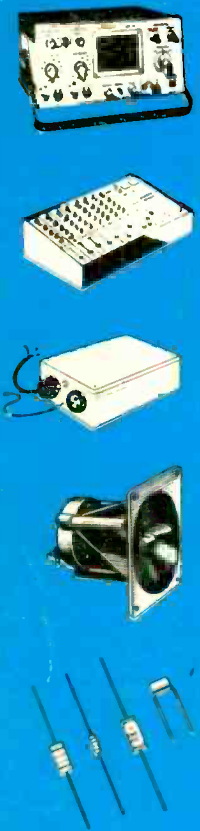

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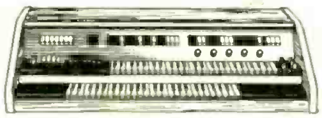

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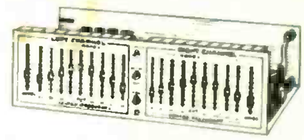

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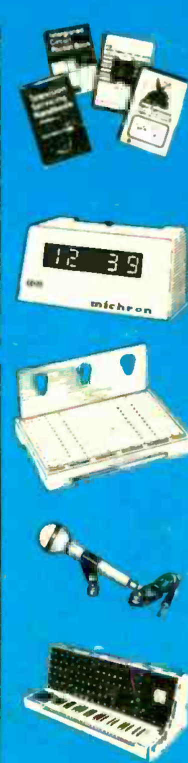

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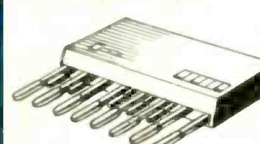

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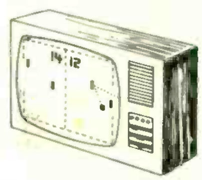

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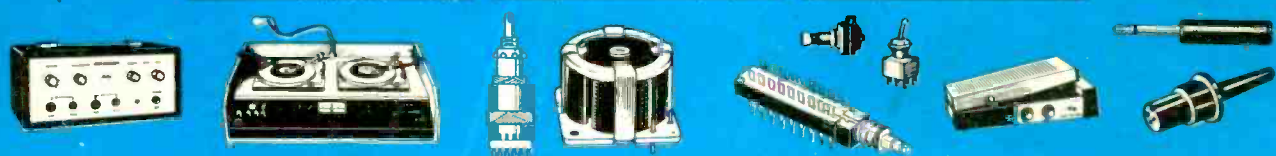

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