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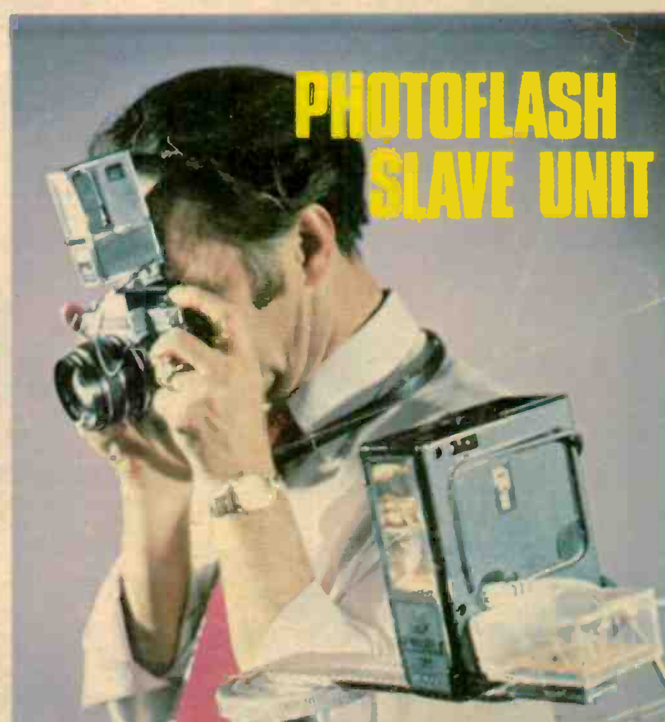

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LM389N 1·00
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76116N 1·66
76131N 1·20
76226N 1·56
76227N 1·20
76228N 1·41
76530N ·75
76532N 1·40
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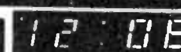

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AA129	0·09	BAX13	0·07	OA91	0·08	IN4148	0·07
AAZ17	0·18	BAX16	0·10	OA95	0·10	IN4150	0·19
BA100	0·18	BB103	0·30	OA200	0·10	IN5400	0·14
BA102	0·18	BB104	0·40	OA202	0·14	IN5401	·165
BA144	0·12		0·30	IN914	0·07	IN5402	·175
BA145	0·18	BY126	0·29	IN916	0·07	IN5404	·185
BA154	0·10	BY127	0·38	IN4001	0·06	IN5406	·225
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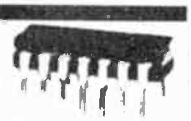

7400	0·16	7412	0·21	7438	0·55	7460	0·21	7485	1·85	74118	0·90	74160	1·41				
7401	0·16	7413	0·51	7440	0·21	7470	0·46	7486	0·41	74119	1·80	74161	1·41				
7402	0·16	7414	1·80	7441	1·03	7472	0·38	7490	0·61	74121	0·49	74162	1·41				
7403	0·16	7416	0·61	7442	0·76	7473	0·43	7491	0·98	74122	0·45	74163	1·41				
7404	0·26	7417	0·61	7445	1·35	7474	0·43	7492	0·61	74123	0·58	74164	1·23				
7405	0·26	7420	0·21	7446	1·23	7475	0·58	7493	0·61	74141	1·03	74165	1·23	74182	1·08		
7406	0·74	7423	0·39	7447	1·17	7476	0·51	7494	0·74	74145	1·06	74167	3·70	74184	2·46	74192	1·62
7407	0·74	7425	0·39	7448	1·17	7480	0·45	7495	0·78	74151	1·11	74174	1·52	74185	2·46	74193	1·62
7408	0·29	7427	0·39	7450	0·29	7481	1·10	7496	1·03	74153	1·11	74175	1·35	74188	2·00	74196	1·17
7409	0·29	7430	0·21	7451	0·21	7482	0·67	7497	4·60	74154	1·85	74176	1·23	74189	3·99	74197	1·17
7410	0·21	7432	0·39	7453	0·21	7483	1·33	74100	1·15	74155	1·11	74180	1·77	74190	1·91	74198	2·93
7411	0·29	7437	0·55	7454	0·21	7484	0·85	74107	0·43	74157	0·98	74181	3·70	74191	1·91	74199	2·93

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74C04	0·26	74C90	0·91
74C08	0·26	74C107	1·30
74C10	0·28	74C151	2·62
74C20	0·26	74C157	2·35
74C30	0·26	74C160	1·18
74C32	0·26	74C161	1·18
74C42	0·92	74C162	1·18
74C48	2·30	74C163	1·18
74C73	0·58	74C164	1·04
74C74	0·69	74C173	0·95
74C76	0·58	74C174	0·95

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16 pin	0·18	40 pin	0·55

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CD40020·24	CD40201·27	CD40431·15	CD40631·25	CD40850·81	74LS08 0·24	74LS1571·17
CD40061·34	CD40211·15	CD40441·05	CD40660·80	CD40860·81	74LS10 0·24	74LS1601·40
CD40070·24	CD40221·10	CD40451·59	CD40674·25	CD40891·77	74LS13 0·65	74LS1611·50
CD40081·10	CD40230·24	CD40461·52	CD40680·25	CD40930·91	74LS32 0·25	74LS1621·50
CD40090·64	CD40240·84	CD40471·15	CD40690·25	CD40942·13	74LS42 1·01	74LS1621·50
CD40100·64	CD40250·24	CD40490·64	CD40700·65	CD40951·19	74LS74 0·48	74LS1631·50
CD40110·24	CD40270·64	CD40500·64	CD40710·25	CD40961·19	74LS75 0·60	74LS1641·52
CD40120·24	CD40281·02	CD40511·06	CD40720·25	CD45102·00	74LS76 0·40	74LS1732.35
CD40130·60	CD40291·30	CD40521·06	CD40730·25	CD45112·30	74LS85 1·45	74LS1741·20
CD40141·15	CD40300·64	CD40531·06	CD40750·26	CD45162·00	74LS86 0·48	74LS1751·20
CD40151·15	CD40312·53	CD40541·32	CD40761·17	CD45182·00	74LS90 1·00	74LS
CD40160·64	CD40351·34	CD40551·50	CD40770·66	CD45202·00	74LS92 0·90	
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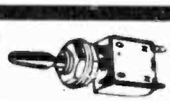

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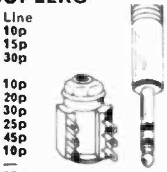
JACK ¼" mono plastic	16p	20p	20p
¼" mono screened	25p	—	30p
¼" stereo plastic	25p	25p	25p
¼" stereo screened	35p	—	45p
3·5m standard	10p	12p	10p
2·55m standard	10p	10p	—
MAINS USA 2 pin flat	15p	15p	15p



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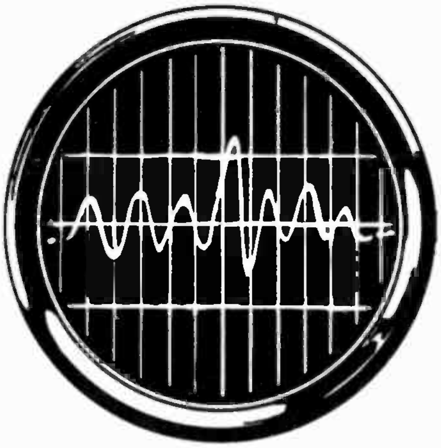

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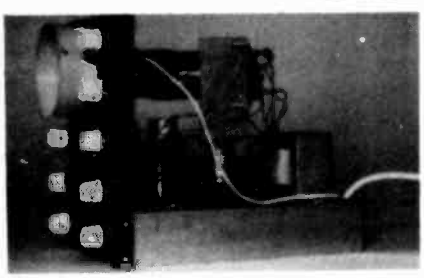

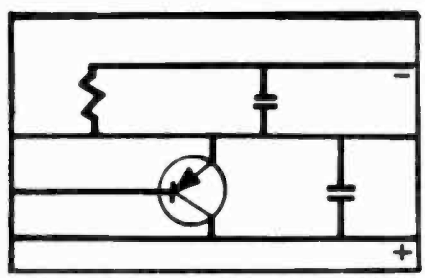

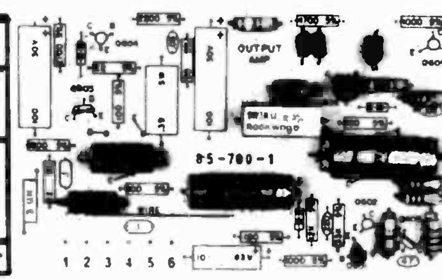

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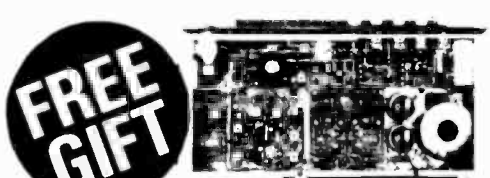

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Type	No.	Price	Type	No.	Price
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156	11in	6in	3in	£1·80*
157	6in	4¾in	1¾in	£1·25*
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No.	Length	Width	Height	Price
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160	4in	4in	1½in	62p*
161	4in	2½in	1½in	62p*
162	5½in	4in	1½in	74p*
163	4in	2½in	2in	64p*
164	3in	2in	1in	44p*
165	7in	5in	2½in	£1·04*
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Type	Order No.	Price
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Type	Order No.	Price
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400V RMS	BR2/400	£0·58
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Description	Order No.	Price
20mm × 5mm chassis mounting	506	£0·07*
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Panel mounting 20mm	509	£0·20
Panel mounting 1¼in	510	£0·30

QUICK BLOW 20mm

Type	No.	Type	No.	Type	No.
150mA	611	1A	615	3A	619
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.
1A	635	2·5A	638	4A	641
1·6A	636	3A	639	5A	642
2A	637				

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SWITCHES

Description	No.	Price
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Toggle switch SPST 1½ amp 250V a.c.	1975	£0·33*
Toggle switch DPDT 1 amp 250V a.c.	1976	£0·36*
Rotary on-off mains switch	1977	£0·42*
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Push switch—Push to break	1979	£0·18*

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BLUE	1983	£0·22*
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Description	No.	Price
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Miniature SPST toggle, 2 amp 250V a.c.	1959	£0·55*
Miniature DPDT toggle, 2 amp 250V a.c.	1960	£0·65*
Miniature DPDT toggle, centre off, 2 amp 250V a.c.	1961	£0·85*
Push button SPST, 2 amp 250V a.c.	1962	£0·65*
Push button SPST, 2 amp 250V a.c.	1963	£0·68*
Push button DPDT, 2 amp 250V a.c.	1964	£0·80*

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BDL747 0·6in single	1511	£1·50
BDL727 0·5in double	1512	£1·80

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MVR 7824 24V £1·25

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MVR 7912 12V £1·85
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Projects... Theory... and Popular Features...

In terms of projects to build it is difficult, if not well nigh impossible, to please *all* our readers *all* of the time. But we've had an especially hard try this month. Those of you who ride a motorcycle, play in a pop group, or indulge in indoor photography will certainly be happy. If you happen to do all three, you ought to be *deliriously* happy. And quite busy for the next couple of weeks or so, we guess.

Those "missed out" on this occasion still have the *Ultrasonic Remote Control System* to think about. As mentioned here last month, the possibilities for its use are endless. So we shall be pleased to hear from individuals who come up with particularly striking applications for this equipment. Send us a detailed description. The most interesting original ideas will be published, with due reward to their creators of course.

In this month's issue will be found the Index for Volume 6. This single leaf can be cut out, leaving the rest of the magazine intact, and then trimmed down to the original page size prior either to fitting into the binder holding issues dated January to August 1977, or filing with loose copies belonging to that volume.

It is no secret that a certain hiatus has been caused by the timing of the change in our format, introduced with the September issue. Ideally, this should have taken effect from the January issue, which normally starts a new volume. We again apologise to readers, many of whom have raised this matter with us. Printing and publishing exigences don't always wait for the new year, unfortunately.

One other relevant point. Readers can be reassured that the new binders made to suit the enlarged format of EVERYDAY ELECTRONICS will accommodate all *16* issues that will make up this present Volume (No. 7). Thereafter, that is from January 1979, things will return to normal.

Still dealing with domestic affairs, we have another apology and explanation to make to our readers. This concerns lateness of publication of recent issues, including this one. Re-location of our offices is the chief cause of this failure to meet the scheduled dates. However all these problems should be resolved when the current moves are completed and we are installed at our new address, hopefully before this particular issue goes to press.

STOP PRESS

Power cuts are with us alas, once more. As a service to readers we are reprinting in a slightly abridged form the *Emergency Lighting Unit* first published in our February 1974 issue. It seems this design will, regrettably, be in much demand again.

Fred Bennett

Our January issue will be published on Friday, December 16. See page 175 for details.

Readers' Enquiries

We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.

Telephone enquiries should be limited to those requiring only a brief reply. We cannot undertake to engage in discussions on the telephone, technical or otherwise.

Component Supplies

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

Everyday ELECTRONICS

VOL. 7 NO. 4 DECEMBER 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

Back Number Service and Binders

Back issues of EVERYDAY ELECTRONICS (June 1977 onwards) are available worldwide at a cost of 60p per copy inclusive of postage and packing. Orders and remittance should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.

Binders for Volumes 1 to 6 (state which) are available from the above address for £2·10 inclusive of postage and packing.

POWER CUTS

DON'T BE CAUGHT

SEE PAGE 170

AUTOMATIC PHASE BOX

By E. M. Lyndsell

INTRODUCTION

Nowadays musical effects units form an essential part of the infantry of a "pop group" or "band". It is not uncommon to find several effects used during a performance, or even during a single number.

The number of different effects available, to the author's knowledge is over twenty but from this list the most popular ones are: Fuzz, Waa-Waa, Tremolo, Treble Boost, Reverberation and Echo. Designs for some of these units have appeared in past issues of Everyday Electronics to meet public demand. A relative newcomer to this family of effects is the Phasing Unit, known generally as a "Phaser" and by all accounts is very popular.

A typical cost of a commercial phaser is about £30 with some costing much more. This was thought to be too high a price for the author and prompted him to design and build his own . . . for less than half price! Initially stripboard was used but demanded a larger housing than was required to be compatible with similar commercial units. To meet this requirement a printed circuit board was called for.

Although a p.c.b. takes a fair amount of time and effort to produce, it is usually worth it. There are no link wires to make (or forget) and no breaks to be made on the underside as with stripboard for example. It is simply a matter of inserting components in the correct holes according to the diagrams and soldering the component leads to the copper tracks on the underside of the board. Besides this the construction has a professional appearance compared to the usual construction methods.

START HERE FOR CONSTRUCTION

PRINTED CIRCUIT BOARD

The major part of the construction of this project will be in the preparation of the printed circuit board. A full-size drawing of the underside of the board showing the copper pattern to be etched is shown in Fig. 1. The black areas represent the areas of copper to remain.

Several methods of p.c.b. production are available to the amateur constructor and many p.c.b. manufacturing kits are on the market. Some include rub-down transfers and the use of these is recommended. The "pads" are intended to be rubbed down directly onto the copper side of the board and form the etchant resist. Interconnections can be made with rub-down tracks or more easily with an etchant resist from a Dalo pen.

One way of locating the exact positions of the pads is to place the printed circuit board, copper side up, immediately beneath the copper pattern of Fig. 1 and then with a needle or similar pointed object, mark through the page to prick the copper at the centre of each pad position. Next rub-down the transfers directly over this mark and then connect the pads according to Fig. 1 using the Dalo pen.

An alternative to this method is to use a board that has been treated with a photo-resist but this calls for an ultra-violet light source. Here a piece of tracing paper should be secured over Fig. 1 and the pattern traced through using Indian ink and the rub-on pads. If you have photographic equipment, you may be able to produce this pattern on film.

The film or tracing is then placed on the resist side of the board and a small sheet of glass placed on top of this to hold the two closely together. This lamination should then be exposed to ultra-violet light for about five minutes. The light source should be shielded from the eyes.

The next stage is to develop. The chemical for this is normally supplied with the photo-resist treated board in the form of pellets of sodium hydroxide. This must be dissolved in water to produce a solution. Mix details should accompany the pellets. On placing the exposed board in this solution, the areas of resist that have been exposed to the light will dissolve. After a short time remove the board from the solution using a pair of tweezers and thoroughly wash under running water. Check that all the areas to be etched away are exposed (bright copper). If not replace in the developer until this state is reached.

ETCHING

You have now reached the stage where the board is ready for etching. Ferric chloride solution is the compound to use for this. It is sold as a solid and needs to be mixed with water to form a solution. A concentration of 50gm/litre is suitable.

Ferric chloride is a very corrosive substance and contact with the skin or clothing should be avoided. It is advised that rubber gloves be worn. A suitable tray for etching in is the plastic variety used by photographers for developing. Metal trays should be avoided, especially aluminium, as the latter reacts energetically with ferric chloride.

Make the solution in the tray using warm water and then place the board face down in the tray. Agitate the contents from time to time and after about 20 to 30 minutes remove the board from the tray using your tweezers to see how the reaction has progressed.

When all the unwanted copper has disappeared, thoroughly wash the board under running water and then using a Brillo pad or other fine abrasive, clean off the remaining resist. It only remains now to drill the component lead holes. A 1mm drill will suit most components but slightly larger holes must be made for the preset, VR2.

ASSEMBLY

The layout of the components on the topside of the printed circuit board is shown in Fig. 2. Begin by inserting the resistors and capacitors followed by the integrated circuits. Finally insert and solder the two f.e.t.s. It is a good idea to

unplug the soldering iron when soldering in these devices as they can easily be damaged by leakage currents from the iron. Also use a heatshunt on the leads of these transistors to prevent thermal damage.

Connect suitable lengths of flying leads to reach the other components when fitted to the case.

The case used was an aluminium diecast box with internal dimensions of 111×60×31mm. This was found to be the smallest size that would accommodate all the components including the battery. Drill the case according to Fig. 3 and then wire up between the components and component board as shown. Note the wire connected from SK2 to the case of VR1. This was found necessary to eliminate clicking sounds originating in the oscillator.

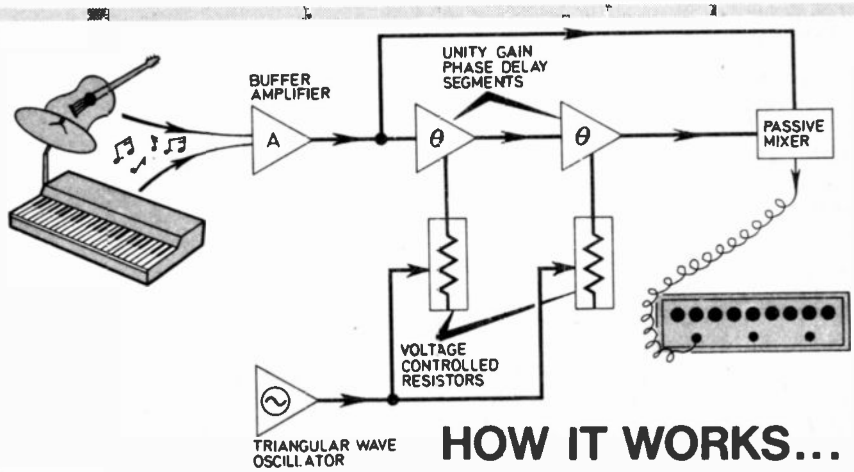
It was not found necessary to use screened cable anywhere as the leads are very short. If a larger case is used resulting in longer leads, it may be necessary to use screened cable between SK1/board, SK2/board and S1 to SK1 and SK2.

It is essential to place a piece of cardboard between the component board and the case to prevent shorting against the case. No fixing nuts and bolts were found necessary as the board was designed to fit snugly against the case sides. A piece of foam could be placed above the component board so that it is held in place when the lid is attached.

SETTING UP

The unit should be connected between the instrument and the amplifier. Input is by way of a screened lead (usual) terminated in a standard jack plug and enters at SK1. Inserting this plug also switches on the unit. Output is taken from SK2.

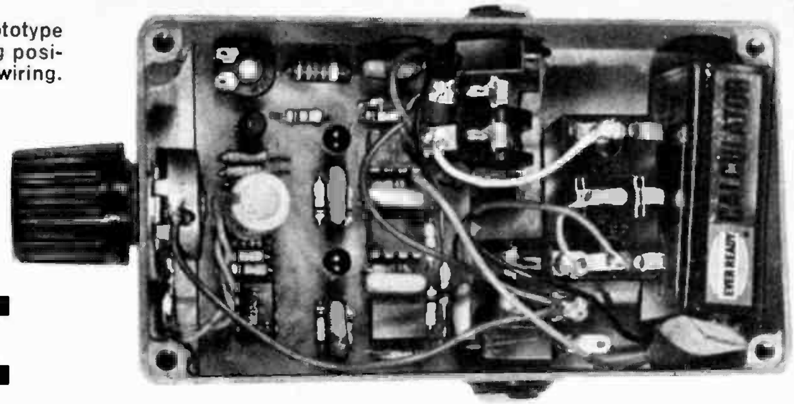
With the unit connected via a screened lead to the amplifier, plug in the instrument lead but do not have it connected to the instrument. Set VR1 to about half way. You should hear a sweeping sound in the loudspeaker. Touching the end of the input lead will produce a phased hum. Adjust VR2 until the up and down sweeping effect



HOW IT WORKS...

The input signal enters the unit at a high input impedance buffer amplifier having a gain of two. The signal is then passed through two unity gain phase delay segments to the output terminal where it is passively mixed with the original signal. One frequency will be delayed by 180 degrees and when this is mixed with the non-delayed signal complete cancellation results. Thus a sharp notch has been produced. Sweeping this notch up and down the frequency spectrum will produce the phasing effect. The sweep is accomplished by means of an oscillator controlling voltage dependent resistors in the phase delay segments.

Photograph of the completed prototype unit with the lid removed showing positions of components and inter-wiring.



AUTOMATIC PHASE BOX

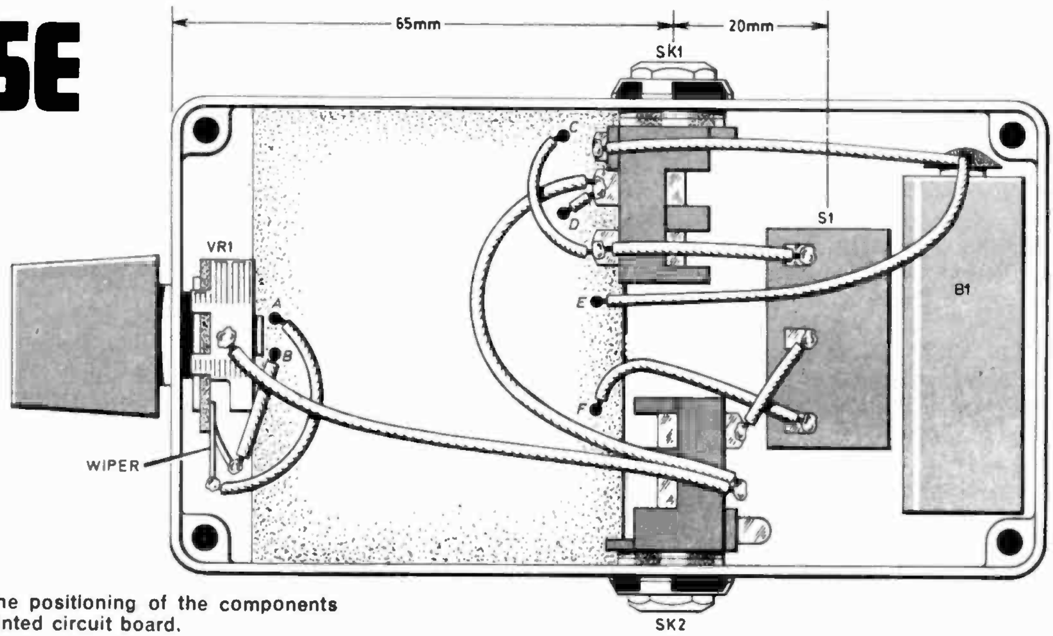
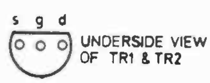


Fig. 2 (below). Shows the positioning of the components on the topside of the printed circuit board.



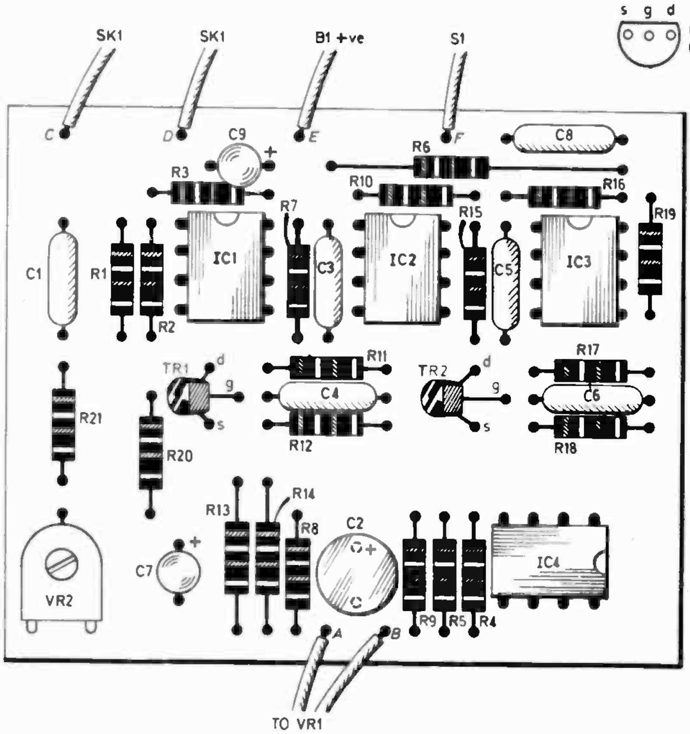
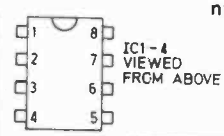


Fig. 3. The layout of the components in the case showing position and wiring up details. Note that VR1 is spaced away from the inside of the case with an extra nut to allow the lid to fit in place.



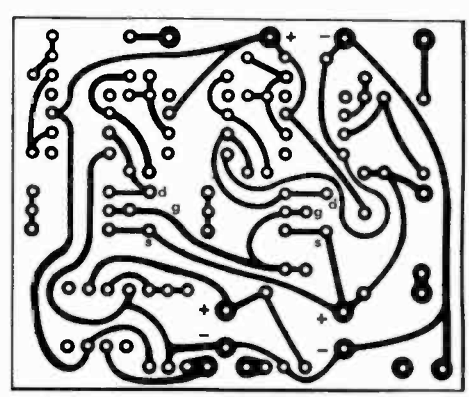


Fig. 1. The underside view of the printed circuit board. The black regions show the areas of copper to remain after etching. Shown full size.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Automatic Phase Unit is shown in Fig. 5. Input is at SK1 via d.c. blocking capacitor C1 to the buffer amplifier composed of IC1 and associated components. This has an input impedance of 150 kilohms which makes it suitable for most electric guitars and organs.

The buffer amplifier consists of a differential operational amplifier type 741 operated in a non-inverting mode and having a gain set at two. The output of IC1 is directly coupled to the first of two identical phase delay networks, IC2 and associated components. The action of this circuitry will be better understood by re-drawing this particular section with a slight modification as shown in Fig. 4, and with the aid of some mathematics.

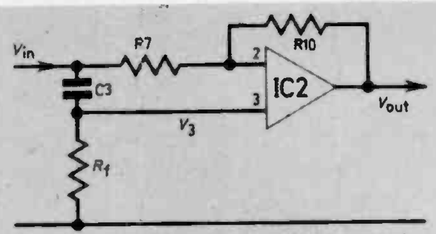


Fig. 4. A simplified phase delay segment.

Consider an input signal V_{in} at the junction of $C3/R_f$. The signal reaching the non-inverting input (pin 3) is derived by the potential divide effect of C3 and R_f and is given by:

$$V_3 = \frac{R_f V_{in}}{R_f + X_c}$$

where X_c is the impedance of C3 and equal to $\frac{1}{j\omega C3}$ where $\omega = 2\pi f$

Therefore

$$V_3 = V_{in}\left(\frac{R_f}{R_f + \frac{1}{j\omega C3}}\right)$$

$$= \left(\frac{j\omega C3 R_f}{1 + j\omega C R_f}\right) V_{in}$$

Now IC2 is operated in the differential mode so the output is equal to the difference in voltage at the two inputs. That is,

$$V_{out} = V_{in}\left(1 - \frac{j\omega C3 R_f}{1 + j\omega C3 R_f}\right)$$

which can be re-written after some mathematical manipulation as

$$V_{out} = \frac{V_{in}(1 - j\omega C3\ R_f)}{1 + (\omega C3\ R_f)^2}$$

Students familiar with complex numbers will notice that this last equation is of the form

$$V_{out} = a + jb$$

where a represents the magnitude and b information regarding the phase (in fact this is the tangent of the phase lead or lag).

In our equation we can see that this is a lag (because of the −ve sign) on the original signal by an amcunt given by

$$\tan\theta = \frac{\omega C3 R_f}{1 + (\omega C3\ R_f)^2}$$

which can be simplified to yield

$$\tan\theta/2 = \frac{1}{\omega C3 R_f} = \frac{1}{2\pi C3 R_f}$$

The values of C3 and R_f are chosen such that for a frequency within the required range, there is a phase lag of 90 degrees. Substituting this value in the above equation gives

$$1 = 2\pi f C3 R_f$$

$$\text{or } f = \frac{1}{2\pi C3 R_f}$$

Comparing Figs. 4 and 5, R_f is seen to be equivalent to the resistance obtained between the source and drain terminals of the field effect transistor TR1. The value of this resistance is dependent on the voltage appearing on the gate of TR1 with respect to that on the source. This voltage must be negative. Therefore the frequency that receives the required phase lag can be controlled by a voltage on the gate of TR1.

It can be seen that the network around IC2 is identical to that around IC3. It follows therefore that a frequency can be selected that differs in phase from the original by an amount equal to 180 degrees i.e. in anti-phase. When this is mixed with the original via R19 and R6, cancellation results.

Components

See Shop Talk page 174

Resistors

R1	150kΩ	R12	10kΩ
R2	10kΩ	R13	820kΩ
R3	10kΩ	R14	270kΩ
R4	10kΩ	R15	10kΩ
R5	10kΩ	R16	10kΩ
R6	10kΩ	R17	10kΩ
R7	10kΩ	R18	10kΩ
R8	1·2kΩ	R19	10kΩ
R9	3·3kΩ	R20	10kΩ
R10	10kΩ	R21	4·7kΩ
R11	10kΩ		

All resistors ¼ watt carbon ±5%

Potentiometers

VR1 10kΩ carbon lin.
VR2 1kΩ miniature horizontal preset

Capacitors

C1 0·01μF type C280
C2 100μF 6V elect.
C3 0·047μF type C280
C4 0·01μF type C280
C5 0·047μF type C280
C6 0·01μF type C280
C7 10μF 10V tantalum
C8 0·01μF type C280
C9 10μF 10V tantalum

Semiconductors

IC1, 2, 3, 4 differential operational amplifier type 741 8 pin d.i.l. (4 off)
TR1, 2 2N3819 *n*-channel f.e.t. (2 off)

Miscellaneous

SK1 Jack socket type SR 25
SK2 Standard jack socket (or as SK1)
S1 Single-pole double-throw successional action push switch
B1 9V type PP3
Printed circuit board size 60 × 50mm; battery clip; aluminium diecast box type 939 (internal dimensions 111 × 60 × 31mm); knob; connecting wire; etching materials and equipment; etchant resist pen and/or transfers; solder.

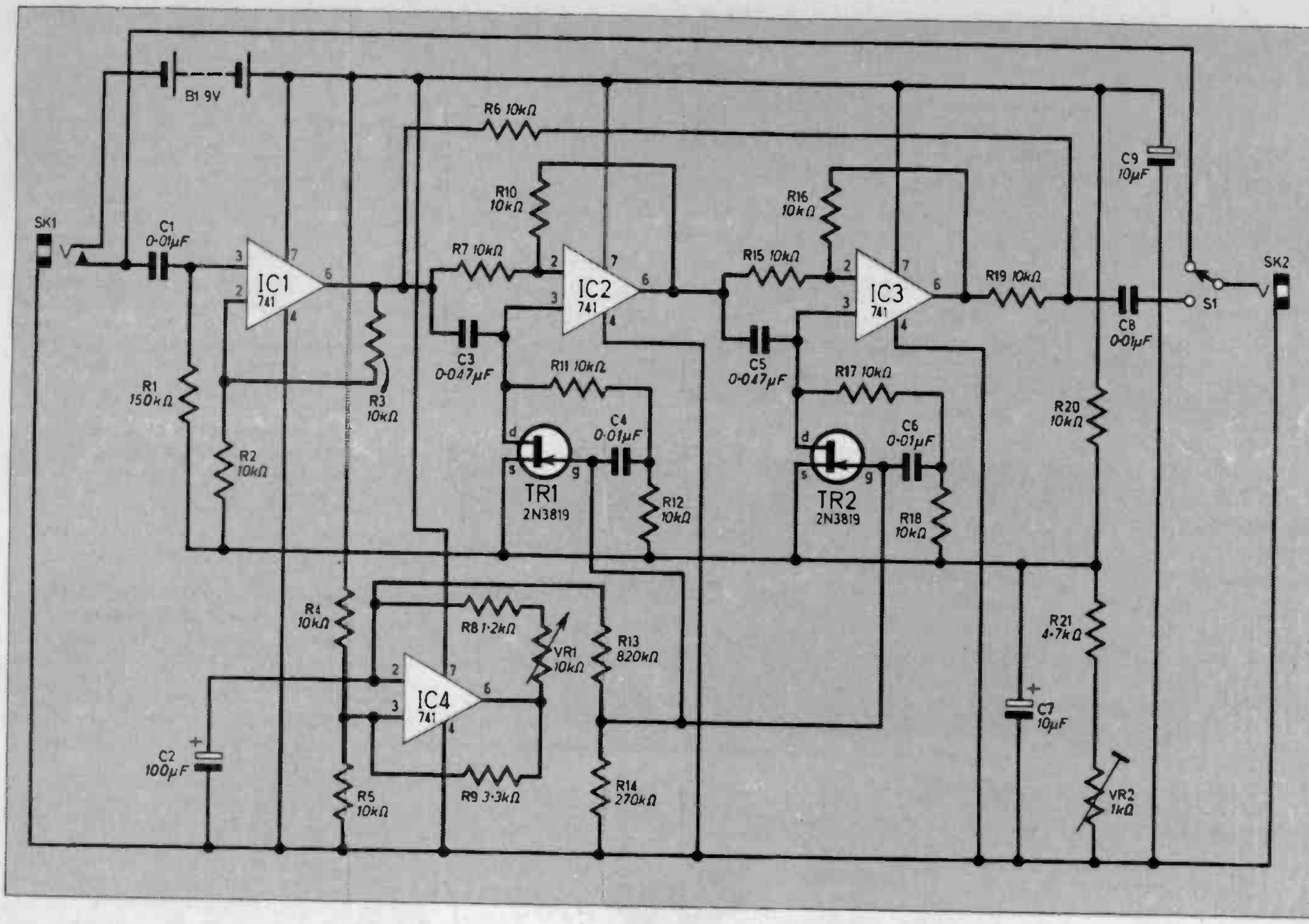


Fig. 5. The complete circuit diagram of the Automatic Phase Box.

Other frequencies are unaffected and are available at the output.

Now by varying the voltage on the gates of TR1 and TR2, the frequency at which cancellation occurs also varies. This can be viewed as a "notch", sweeping up and down the audio spectrum. It is this action that produces the "phased" effect.

Field effect transistors TR1 and TR2 are used as voltage controlled resistors, and provided the drain/source a.c. voltage level is low, they have a near linear voltage/resistance relationship. One disadvantage is that they will produce harmonic distortion. This can be virtually eliminated by feeding the gate with half the a.c. signal appearing on the drain terminal. This is accomplished by the network composed of R11, R12 and C4 (R17, R18 and C6 in the case of TR2).

SWEEP OSCILLATOR

Integrated circuit IC4 is wired as an astable multivibrator producing a square wave at its output as the capacitor charges and discharges between threshold levels set by R9, and causes it to switch. Components VR1 and R8 control the rate of charge and discharge and therefore the frequency of this oscillator.

The square wave is unsuitable for feeding to the gates since a gradual changing voltage level is required. A suitable waveform, approximately triangular is available across the capacitor (charge and discharge curves). A peak-to-peak control voltage of about 1·5 to 2 volts is required to vary the resistance of each f.e.t. to cover the selected phasing range and is obtained by the potential divide effect of R13 and R14, the junction of these being fed to the gates of TR1 and TR2. This voltage needs to be negative with respect to the voltage on the source terminals, the latter being finely adjustable by means of preset VR2.

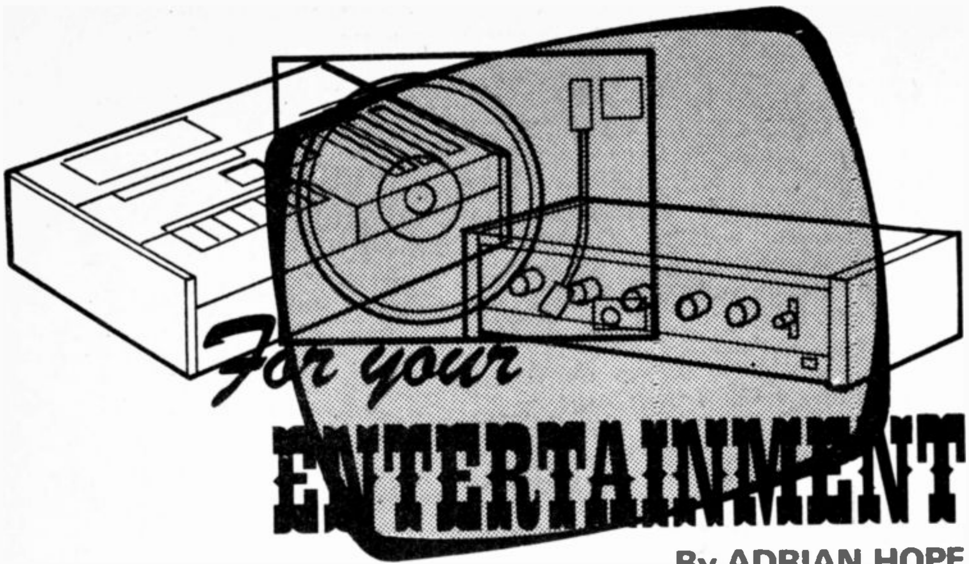
The unit is switched on by inserting the input jack plug into SK1. A successional action footswitch is incorporated so that the unit can be by-passed when required.

is symmetrical. If there is not enough control to reach this condition, reduce or increase slightly the value of R21 as required. The next preferred value either side of that recommended may need to be installed, i.e. 5·6 or 3·9 kilohm. Turning VR1 anticlockwise will prolong the sweep time whereas clockwise rotation will produce a fast rate of phase.

If all is well the unit can be dismantled for painting. It is not necessary to disconnect any wires because with a little manipulation the whole assembly can be removed in one piece.

The prototype was rubbed down with "wet and dry" after any sharp edges and burrs were removed and then sprayed with a red oxide primer. When dry the case/lid was given a few coats of satin finish spray-on paint (sold in garages etc for use on cars) and later labelled with Letraset to produce a professional appearance.

In use the unit will probably be sited on the floor, and to prevent sliding it is advisable to attach rubber feet to the base. ⌑



For your ENTERTAINMENT

By ADRIAN HOPE

ANY ELECTRONICS enthusiast harbouring a secret desire to go and see the new James Bond film, The Spy Who Loved Me, and wanting an excuse, can always say they went to see Professor Eric Laithwaite's *linear motor*. During the film, as one of the obligatory death-dealing gadgets, a tray of tea hovers in the air and shoots along a track to decapitate a dummy. It isn't trick photography: it's the real thing, borrowed from Laithwaite's laboratory for the film and with Laithwaite's assistant on screen.

When the history of linear motors is finally told, it will make a fascinating story. Professor Laithwaite is himself writing a book about it all at the present time, but for political reasons it's highly unlikely that everything he wants to say will get into print.

Linear Motors

Briefly, the basic idea of a linear motor, effectively a rotary motor strung out along a track, is not new, but it was Laithwaite who made it a practicable possibility for vehicle transport. In the late Sixties the British company Tracked Hovercraft Limited were working on a transport system which relied on an air-cushioned hovercraft guided along a massive concrete track. Laithwaite became consultant to the company in 1967, and worked on a linear motor to provide a drive for the hovering craft. Eventually, and this is where much unreported politics comes in, the project was scrapped.

For a while a length of track and a prototype vehicle sat forlorn in a field at Cranfield; but I understand that bulldozers have now moved in. It was during Laithwaite's involvement with the company and shortly before the project was scrapped, that Laithwaite made the crucial discovery that could have (and perhaps still can) changed the face of transport. It had also been known for some time that magnetic fields could be used to levitate metal objects in the manner of an air cushion. But such levitation was always unstable.

Magnetic Rivers

By juggling with the direction of the current and coils, Professors Laithwaite and Eastham produced the so-called "magnetic river", which is a linear motor that at the same time lifts, guides and propels a metal object, all through a single set of coils. And it can do so with an efficiency of up to 95 per cent. At a stroke, the use of an air cushion becomes unnecessary, and the way is open for fast, silent and cheap monorail transport.

Currently other countries are working on other systems, and although magnetic rivers are being used in industry for all manner of guidance and conveyor systems there is no sign yet of a magnetic river transport system being developed. On paper it all sounds rather fanciful; but if you see the Bond film, watch out for the magnetic river in brief action and judge for yourself.

Teletext

Of course it's all very exciting that the commercial TV companies have now started transmitting a full-time, almost continually updated, Oracle service. But something said at the launching press conference was actually far more dramatic. Only a few technical journalists present leapt at it, and the point wasn't widely reported in the national press. While working on Oracle at the Winchester Laboratories, the IBA engineers devised a local paging system. They introduced code words into the spare digital space present in the Oracle system (only about half the possible 800 pages are being transmitted) and devised bleep-style paging receivers to respond to individual code words. Then it dawned on the engineers that there was more than enough digital space in the system to provide an individual code word for *every single member* of the British population!

Paging System

From there was born the idea of a nation-wide paging system. It would work like this. Every member of the population would be assigned a digital code word, and if they wished to subscribe to the paging system would buy or hire a pocket receiver tuned, or tunable, to their local ITV frequency. This receiver would not have a screen or loudspeaker but simple circuitry to produce an audible bleep when triggered by reception of the users digital code word buried in the TV wave-form. The bleeped individual would then call a central telephone number, to receive whatever message was there for him. There is of course, no guarantee that the Home Office would allow the IBA to run such a scheme, and the IBA has not yet thought the idea fully through. But they have no doubt that it would be feasible.

The main technical problem would be field strength and receiver sensitivity. Here a good guide of practicality can be had from what the police are currently doing with their walkie-talkies. Police on the beat are equipped with u.h.f. transceivers, which work on u.h.f. bands a little below those used for TV. The short wavelength enables them to have conveniently short aerials.

The police walkie-talkies pick up signals transmitted from very low-powered transmitters (around 10 watts a time) on the roof of the local police stations, and there is no doubt that the system works well. Indeed, if it didn't, the police wouldn't use it. Whereas the police system is analogue speech, the Teletext paging system is digital, and in fringe areas it can be more difficult to receive than conventional TV pictures. This suggests that digital reception is rather more tricky than analogue. But provided a digital bleep call were repeated many times, it would stand a good chance of triggering the intended receiver as it moved around with the wearer through areas of good and bad field strength.

All this brings us back to James Bond. In the film, Bond receives a teletype message through a wristwatch receiver. The audience laughs and thinks, "How ridiculous!" In the light of the IBA idea for nation-wide paging using existing u.h.f. TV transmitters, it doesn't seem quite such a crazy idea after all.

"I must ask you not to touch those touchplates, sir."

INTRODUCTION

A HAZARD warning system is a very valuable addition to any vehicle, so car drivers and motorcyclists will benefit from this design. Newer vehicles are fitted with such a device, but the vast majority on the roads are not. This system is suitable for cars and motorcycles operating on 12 volts. It is not however suitable for 6V vehicles.

For the benefit of those readers who are not familiar with such a system a short description is given.

When the hazard switch is operated all four existing direction indicator lamps flash together even with the ignition switch off. It must only be used for real emergencies. For example, when the vehicle has broken down in such a position as to present a real and immediate danger to traffic. In this respect, it is particularly valuable at night.

DESIGN POINTS

There have been several published designs for this purpose so it was decided to take a fresh look and to bear the following points in mind.

It had to be inexpensive to build—electronic circuits are all very well and may be fun to build but the whole exercise is not worthwhile if a commercial non-electronic unit is cheaper. It had to be reliable and use no moving parts apart from the switch and existing flasher unit.

Although originally designed for negative-earth vehicles, it was thought essential to allow its use in positive-earth vehicles with only minor changes.

In some designs a complicated switch is required. It was therefore decided to look into the price of 3 and 4 pole switches with the correct current-carrying capacity. The cost was prohibitive being very much greater than the more usual double-pole-double-throw type. It was also found that there was little choice in the appearance. For the present design, it was therefore considered essential to use a d.p.d.t. switch. This simpler type of switch has one disadvantage which the operator will have to remember each time he uses the unit. This point will be amplified later—sufficient to say at the moment the inconvenience is very small as the project is for occasional use only.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS

£3·00

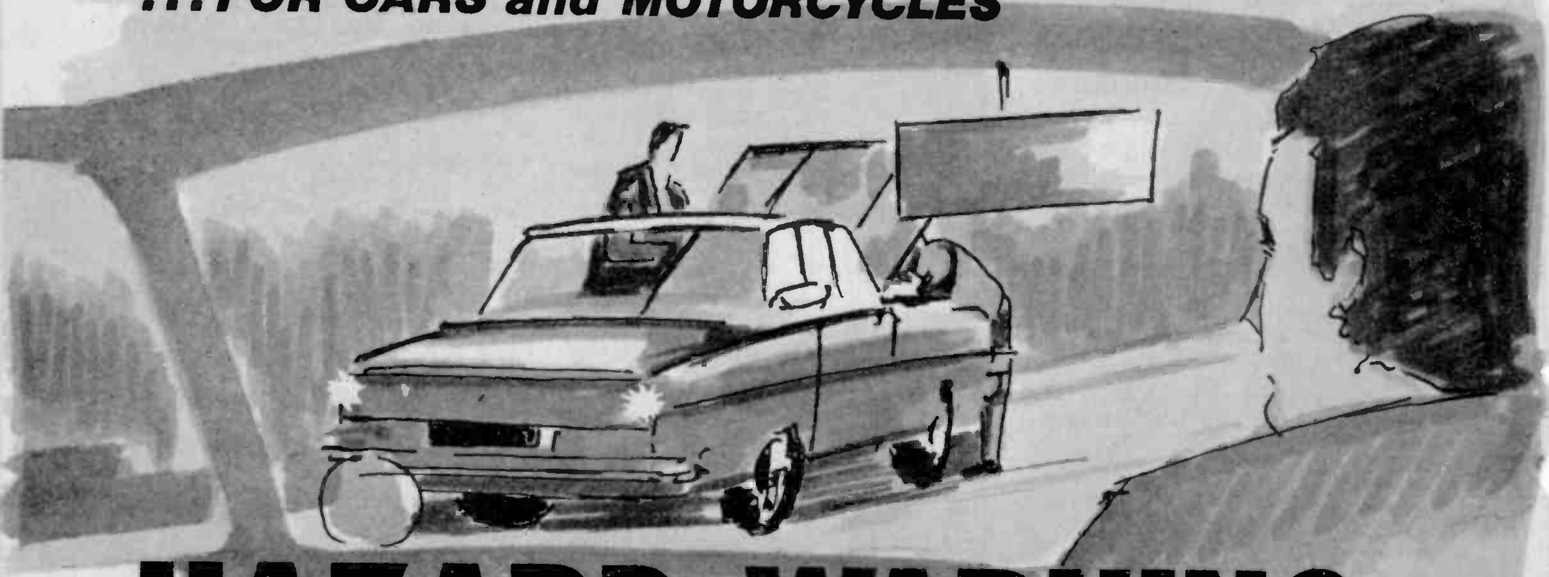
Coming out of all this is a circuit so simple that it makes an ideal beginners project.

As there is a drop of approximately one volt across the circuit, the nearside set of lamps will operate slightly more dimly than the offside pair. The effect is small and of little significance. It could even be argued that the life of the affected lamps will be increased on account of the under-running.

EXISTING UNITS

Normal flasher units fitted to vehicles operate with a load of 42 watts i.e. two standard 21 watt

...FOR CARS and MOTORCYCLES



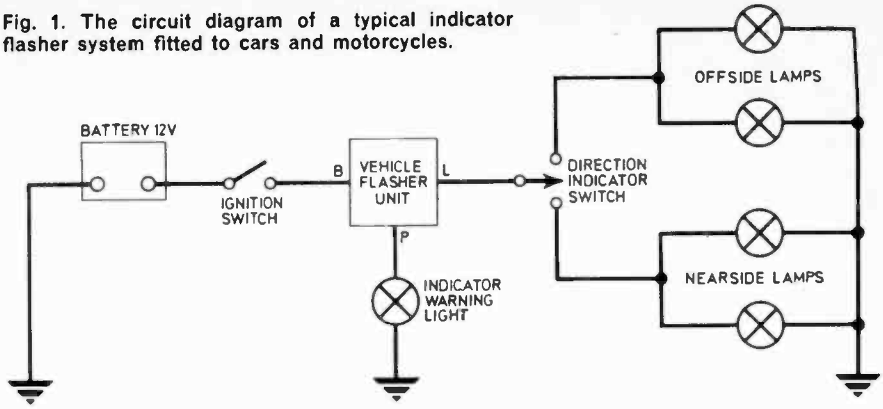
HAZARD WARNING SYSTEM

By T. I. R. de Vaux-Balbirnie

direction indicator bulbs, as shown in Fig. 1. Being current-sensitive, the rate of flashing will be affected by relatively small changes in load. It would, therefore, be quite out of the question to operate all four bulbs by simply connecting them directly to the standard unit.

This project retains the existing flasher unit to operate the offside pair of bulbs in the normal manner but a connection from it actuates a transistorised "repeater" circuit. Two transistors do the actual job of switching the current to the nearside bulbs, the connection simply provides a small triggering current so the extra load imposed on the flasher unit is negligible. All four bulbs will therefore flash in unison at the correct rate between 60 and 120 flashes per minute provided the existing unit is in good order.

Fig. 1. The circuit diagram of a typical indicator flasher system fitted to cars and motorcycles.



START HERE FOR CONSTRUCTION

THE SWITCH

The hazard switch S1 fulfils the functions of completing the circuit to the repeater device and enabling the system to be used with the ignition switch off. When the hazard system is on, the existing warning lamp will operate and the flasher unit will tick in the familiar way. It is considered essential, however, to fit an additional warning lamp, preferably of a bright type in a prominent position. This will ensure that the driver will not drive away until the system has been cancelled. This lamp is not required for the motorcyclist.

It will be seen that the switch, if needed to interrupt the current to four bulbs would need a rating of 7 amps (four bulbs at 21 watts = 84 watts. $I = W \div V = 84 \div 12 = 7$ amps.) A rather lower rating, say 5 amps, is quite suitable and saves on cost.

When choosing a switch beware of figures given for a.c. operation, these are generally higher than the corresponding figure for d.c. applications and are therefore misleading. If the figure is given for 30 volts d.c. then it may be uprated a little for 12 volts use.

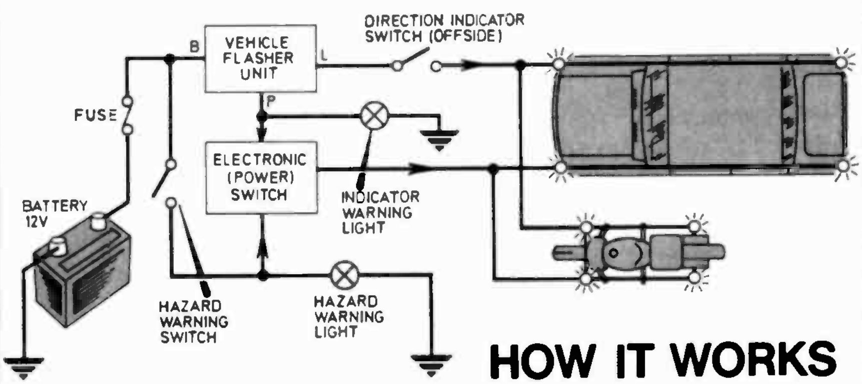
Switches rated at 5 amps have been used in both positive and negative-earth prototypes with complete satisfaction. Do not be tempted to use a miniature slide switch, this would give little service.

COMPONENT PANEL

The electronics of the unit are constructed on a small three-way group board, the layout for each version is shown in Figs. 2 and 3. If the back of the board is not insulated a piece of insulating material must be fixed between it and the tin. This is very important otherwise short-circuits which may occur could be dangerous. Wires leading from the circuit to the tags of TR2 must be particularly sound and should be kept clear of one another.

The circuit itself must be built in a small metal box. This is important as it is used as a heat sink carrying excess heat away from TR2. The method of fixing TR2 to the tin is shown in Fig. 4. It is important to bolt TR2 tightly to ensure good mechanical stability and to ensure good heat transfer.

When the unit has been built, the lid may be attached in a convenient position on the car with self tapping screws. The rest of the tin is then simply pressed into place. External connections to the circuit are made by way of the terminal block, attached on the outside of the tin.



HOW IT WORKS

To obtain the "Hazard Light" effect the direction indicator is switched to the offside position, i.e. right turn. This completes the circuit to the flasher unit via the offside lights thereby turning them on and off in the normal manner. At the same time the P output from the flasher unit supplies a pulsating voltage which turns the vehicle's indicator warning light on and off.

When the hazard switch is operated, this provides power to the electronic switch, and illuminates the hazard warning lamp. The pulsating voltage at P is also used to switch the electronic switch on and off, thereby supplying power to the nearside lights, thus turning them on and off. Thus all four lamps flash together giving the "hazard" effect.

HAZARD WARNING SYSTEM

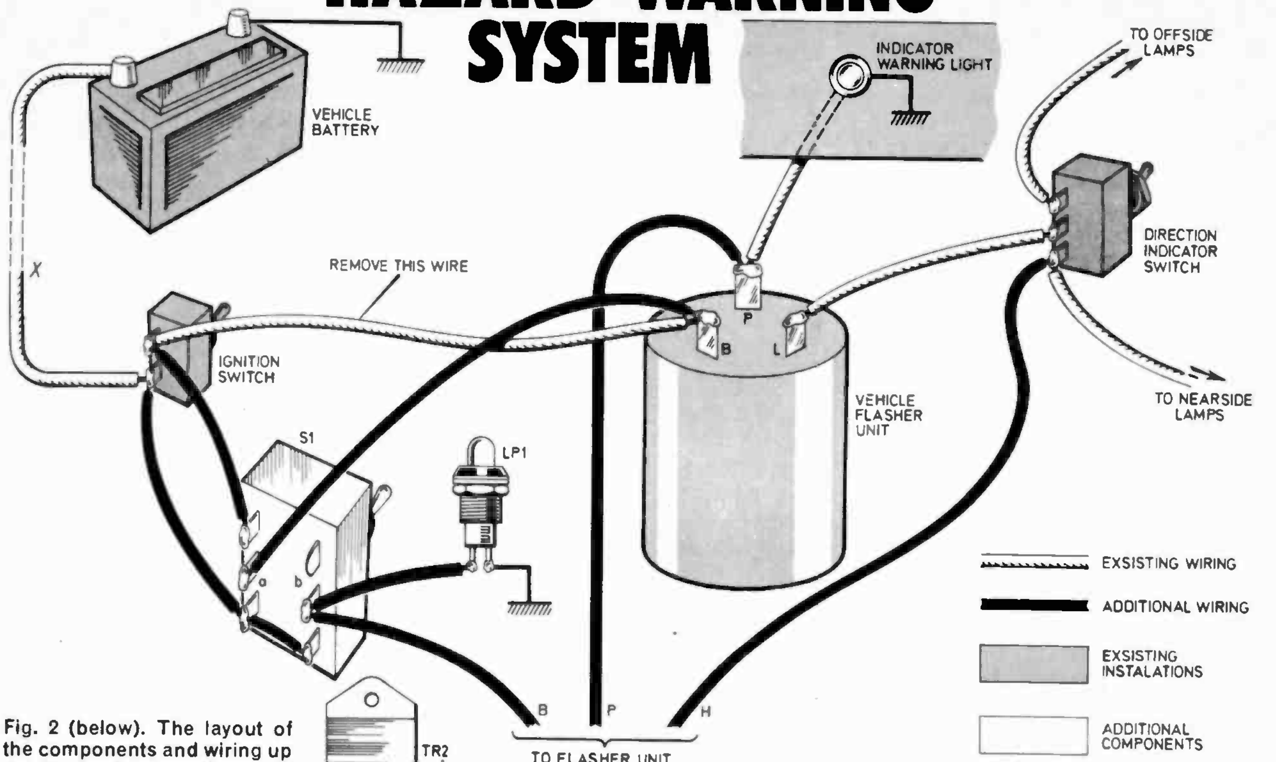
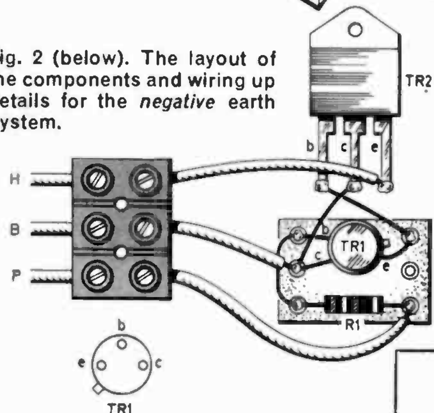
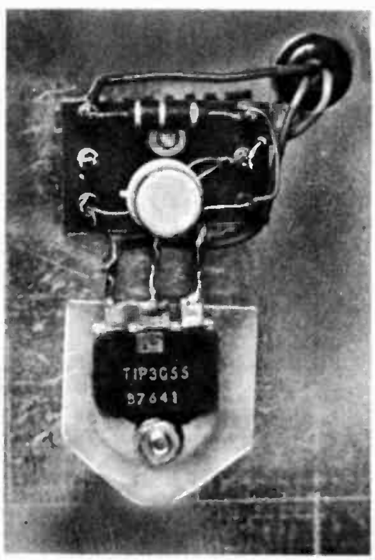


Fig. 5 (above). Complete connection details of the unit to the existing vehicle wiring and additional wiring to be made. The existing wire between flasher (*B*) and the ignition switch needs to be removed as indicated.
Connection *X* should be made to the fuse side of the ignition switch as explained in the text. All connections have been shown as soldered joints but will be by the usual push-on types fitted to most vehicles.

Fig. 2 (below). The layout of the components and wiring up details for the *negative* earth system.





Prototype negative earth unit.

COMPONENTS

Resistors
R1 470Ω carbon ¼W ± 10%

Semiconductors
TR1 { BFY50 silicon *npn* (for negative earth vehicle; BC461 silicon *pnp* (for positive earth vehicle)
TR2 TIP3055 silicon *npn*

Miscellaneous
S1 d.p.d.t. toggle switch (see text)
LP1 12V 3W lamp.
Small metal box about 90mm × 80mm × 25mm (a tobacco tin will suffice); insulating kit for TR2; three way group board; bulb holder for LP1; three way 10 amp terminal block; rubber grommet; connecting wire; push-on connections as required.

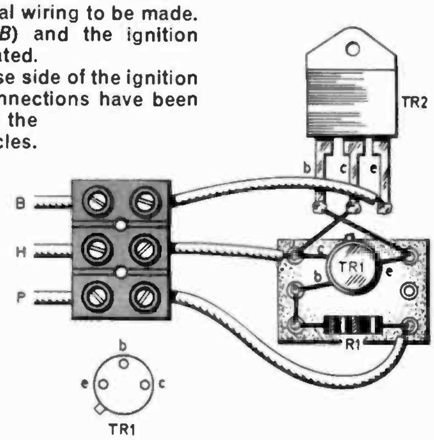


Fig. 3 (above). The layout of the components and wiring up details for the *positive* earth system.

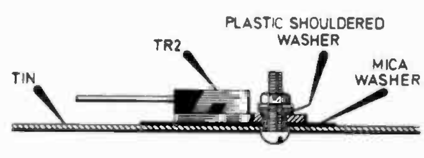


Fig. 4. Details of mounting the power transistor to the case. It is imperative that a mica washer and insulated bush be used to electrically isolate the transistor from the case. The case is used as a heatsink for TR2.

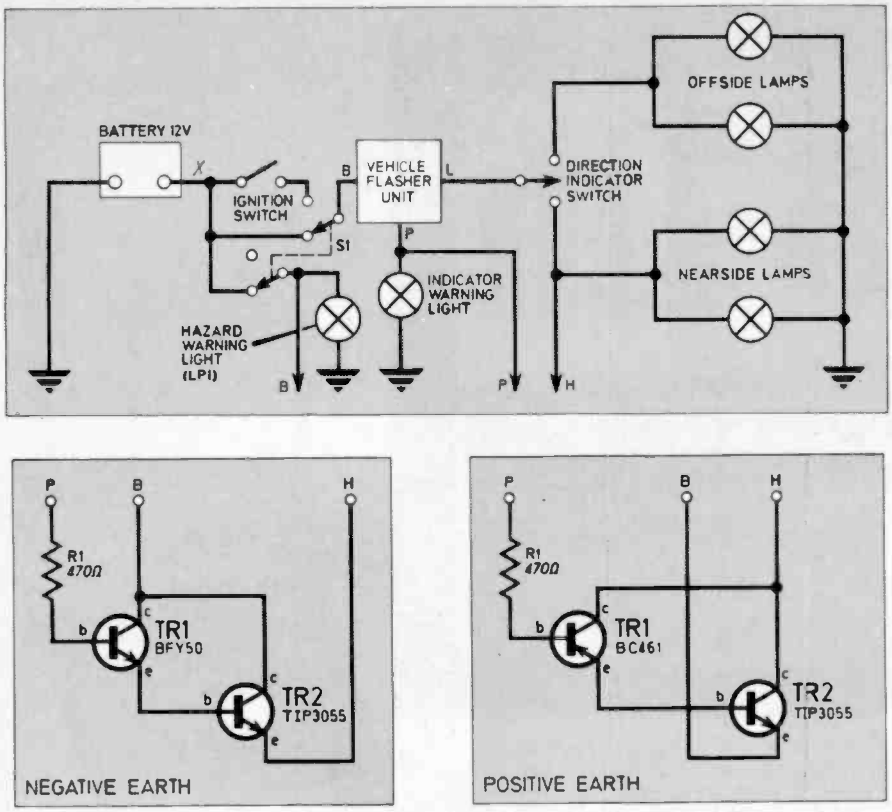


Fig. 6. The complete circuit diagram of the Hazard Warning System for both negative and positive earthing systems.

CIRCUIT DESCRIPTION

NEGATIVE EARTH SYSTEM

Consider the circuit shown in Fig. 6 the two transistors, TR1 and TR2 are connected as a Darlington pair. This type of transistor configuration provides a large current gain. This gain is approximately equal to the product of both transistor's H_{fe} value times the base current of TR1. Expressed as an equation;

gain=
$h_{FE}1$ (TR1)$\times h_{FE}2$ (TR2)$\times I_b1$ (TR1)

A small amount of current flowing into the base of TR1 would result in a large amount of current flowing through the emitter of TR2. Resistor R1 limits this amount to a safe value.

When the pulse from the *P* output on the flasher unit goes high, the Darlington pair is turned on, TR2 in effect is acting as a switch. When the pulse goes low the transistors are turned off, no current then can flow, the lights therefore turn off.

A regeneration effect then takes place with the offside lights turned on and off in unison. The offside lights by the vehicles own flasher unit, the nearside lights by the transistors.

POSITIVE EARTH SYSTEM

The positive earth system as shown in Fig. 6 operates in a similar manner, except TR1 is a *pnp* transitor, this being turned on by a negative pulse, the output is then taken from TR1 collector.

FITTING THE UNIT

Proceed carefully, following the diagram shown in Fig. 5. It should be noted that there is a small difference according to whether the flasher unit fitted to the vehicle is of the two or three terminal type. There are probably more three terminal types in use and on these the *P* connection is made to the centre terminal which feeds the existing indicator warning lamp. This is often labelled *P* on the unit itself but may be identified in case of doubt by removing the wires one by one with one set of indicators working in the usual way. When the indicator warning lamp fails to work but everything else does, then the correct terminal has been located. A piggy-back connector will be found particularly useful to make the *P* connection.

The *B* connection will, again, probably be so marked but if necessary it can be found by the following method. A small 12 volt test bulb is made up and one side is earthed. When the other end is touched on the terminals of the flasher unit with the ignition switched on the bulb will glow continuously. This connection goes straight to the ignition switch.

The connection remaining on the flasher unit is generally labelled *L* and it will not be used unless the unit is of the two terminal pattern. In this case the *P* connection from the component board will be taken to it.

The *H* connection is made to a suitable connector which feeds the nearside lights. A block of connectors may usually be found near the steering column and these will have to be removed one by one to find the required point. A suitable connector will need to be used to enable the connection to be made without spoiling the existing one.

Another connection worthy of mention is that called *X* in the circuit diagram. This needs to be taken to a suitable fuse which supplies current with the ignition switch *off*. Be sure to make the connection to the correct side of the fuse so that it is not bypassed. The test bulb can be used for this checking that it goes out when the fuse is removed. See that the fuse rating is sufficient to meet the needs of the present circuit (7 amps) plus whatever current is needed for existing equipment connected to it.

Stranded wire of 7 amp capacity should be used for all external wiring and the runs should be kept as short as practicable. All connections must be made with the correct type of connector. These should be of the insulated type. Do not break wires or make twisted taped connections. These will not last long. As mentioned previously piggy-back connectors are useful where it is necessary to double up on spade connections.

IN USE

In use the hazard switch is operated, and the existing traffic indicator is put to the offside position. As was mentioned earlier this is inconvenient but necessary.

One day this design may save your life or that of others. In terms of the very modest outlay it is very worthwhile. ✠

TEACH-IN 78 - Part 3

BY GEORGE HYLTON

RESISTANCE AND CAPACITANCE

WE SHALL take the opportunity this month to expand on the subject of resistance and capacitance. Later, we shall build our POT and VOLTAGE INDICATOR, both of which will be used widely in our experiments.

RESISTANCE

Early experimenters thought of an electric current as the flow of an invisible fluid, which somehow managed to run through solid conductors as water runs through pipes. The American Benjamin Franklin originated this idea. It made people ask questions.

How far, they wondered, did the resemblance to water in pipes go? In the case of water, the longer the pipe the harder it is for the water to flow. Also the narrower the bore of the pipe the harder it is to flow. To get the same amount of water through a 10mm bore pipe as, say a 15mm bore the pressure has to be increased.

In an electrical circuit, the voltage of the battery seemed to be equivalent to the pressure in a water system. Was it also true that thin wires, like narrow pipes, resisted the flow of water?

To be able to do so it was necessary to get away from cumbersome ideas about length and thickness and so on. In place of all these it is possible to substitute one simple quantity which tells you how much the flow of current in a circuit is impeded, without going into details about the shape and size of the conductors. This quantity is **resistance**.

A long wire offers more resistance to the passage of current than a short one of the same material. A thin wire has more resistance than a thick one. To push the same amount of current through a high

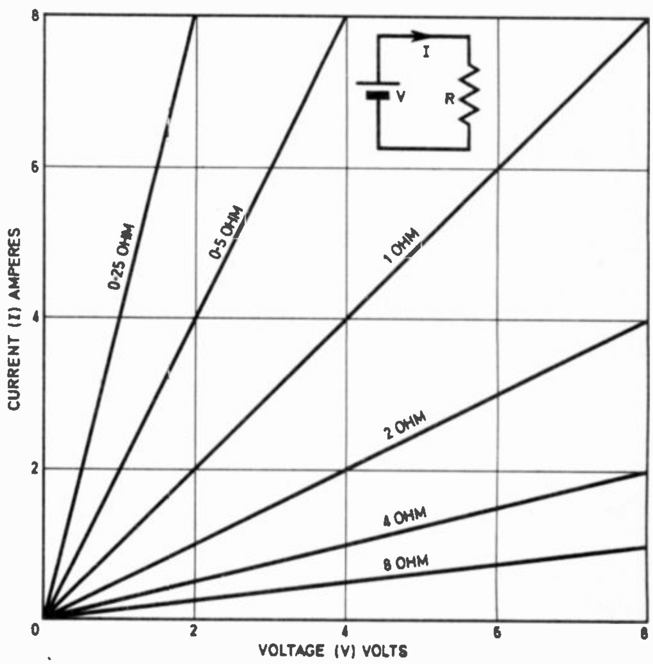


Fig. 3.1. Typical graphs drawn to illustrate the relationships between voltage (V), current (I), and resistance (R).

TABLE 3.1. RESISTOR COLOUR CODE

Colour	First band 1st figure	Second band 2nd figure	Third band Multiplier	Fourth band Tolerance
Black	0	0	×1	—
Brown	1	1	×10	1%
Red	2	2	×100	2%
Orange	3	3	×1000	—
Yellow	4	4	×10,000	—
Green	5	5	×100,000	—
Blue	6	6	×1,000,000	—
Violet	7	7	×10,000,000	—
Grey	8	8	×100,000,000	—
White	9	9	×1,000,000,000	—
Gold	—	—	÷10	5%
Silver	—	—	÷100	10%

Examples; Red—violet—orange—brown = 27kΩ, 1%
Brown—black—gold—red= 1Ω, 2%

resistance as through a low one the voltage must be increased, and more energy expended.

The way in which the three quantities, voltage, current and resistance, are related to one another can be illustrated by drawing graphs, Fig. 3.1.

These show how much current flows when a certain voltage is applied to a certain resistance. Taking the line marked 1 ohm, you can see that 8 volts applied to 1 ohm makes 8 amperes flow. But 8V to 2 ohms makes only 4 amperes flow. Doubling the resistance halves the current. Reducing the voltage reduces the current. So 4 volts to 1 ohm drives only 4 amps. Reducing the resistance increases the current: 4 volts to 0·5 ohm drives 8 amps.

UNITS

By electronics standards, an ampere is a fairly large amount of current. In most circuits the currents are in thousandths of amperes (milliamperes, mA) or millionths (microamperes, μA). Similarly you may find yourself dealing with millivolts (mV) and microvolts (μV). The symbol, μ, meaning micro or one millionth is really a small "m" in the Greek alphabet (called MU and pronounced like the word MEW).

As for resistance, in electronics circuits you seldom have to deal with much less than 1 ohm, but frequently with thousands of ohms and millions of ohms. The Greek capital letter omega Ω is used for ohms, the prefix kilo, small k, for thousands and mega, capital M, for millions.

The words kilo-ohms and mega-ohms are a bit hard to say, so we slide the two halves together to make kilohms and megohms. There is nothing specially remarkable about very large numbers of ohms. This is reflected in the price of resistors. A 1MΩ resistor costs no more than a similar 1Ω resistor.

TOLERANCE

In electronics, as in other forms of engineering, precision costs money. For this reason resistors with precise values are expensive. Fortunately, in most circuits, great precision is not needed. If a circuit specifies a resistance of 100 ohms, the chances are that anything from say 90 ohms to 110 ohms will do.

We need not pay good money for a resistor guaranteed to be very close to 100 ohms. This idea of a permissible deviation from the nominal value is called the **tolerance**, which means that a nominal 100 ohm resistor could be as low as 95 ohms or as high as 105 ohms. For resistances above 1 megohm, 5 per cent tolerance may be more expensive so we shall put up with 10 per cent types.

PREFERRED VALUES

One of the first things a beginner notices about electronic circuit diagrams is that they are full of odd-looking resistances like 27 kilohms or 82 ohms or 5·6 megohms. These odd-looking numbers are really quite sensible. Most of the resistors in common use belong to what is called the E12 series. This series contains these basic numbers:

10, 12, 15, 18, 22. 27, 33, 39, 47, 56, 68, 82.

Each number in this series is about 20 per cent greater than the previous one. So you can always find, in the E12 series, a resistance within about 10 per cent of the value needed by your design calculations. For higher or lower resistances you just multiply or divide the basic numbers by 10, 100, 1000 and so on.

The value of resistance is usually indicated by printing a colour code on the body of the resistor. Each figure in the series 0 to 9 is represented by a colour.

The tolerance is also indicated, by a fourth band. Table 3.1 sets out the code.

CAPACITORS

A capacitor is a storage device, what it stores is an electrical charge. The idea of a stored charge is familiar but in a different context. When you rub a plastic ball-pen on your sleeve and pick up tiny bits of paper with it, an electric charge is at work.

You know that the plastic remains charged for a certain time after you stop rubbing it, but the charge in time slowly leaks away.

A capacitor is deliberately made to be efficient at storing charge. Most capacitors are designed to store a lot of charge in a small space. As the ball-pen example shows, charge can be stored by an insulator. In a capacitor, the insulator often takes the form of a thin sheet of insulating material, such as paper or plastic film. The electrical connections are made by sandwiching the insulating sheet between sheets of metal, called plates. A particularly neat construction uses an insulating sheet which is coated with a very thin film of metal on each side to form the plates. Fig. 3.2.

and this enables capacitances of up to a few tens of microfarads to be packed into a reasonably small space. However the amount of voltage the dielectric will withstand is reduced as the film is made thinner. All capacitors have a maximum **working voltage** which must not be exceeded in case the film is punctured.

An electrolytic capacitor achieves high capacitance in small volume by exploiting various constructional

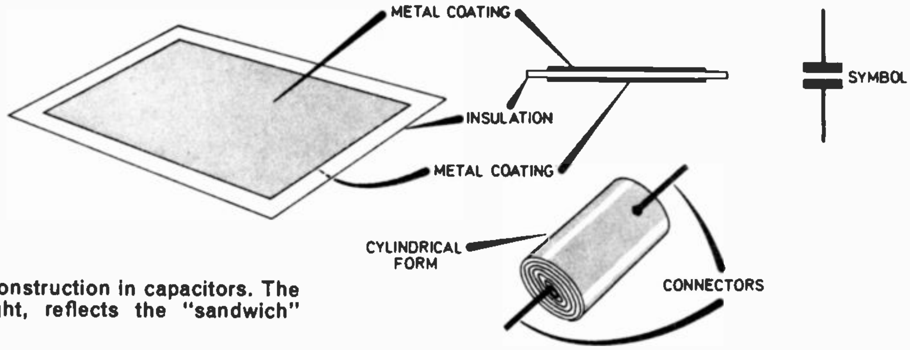


Fig. 3.2. A typical form of construction in capacitors. The symbol shown to the right, reflects the "sandwich" construction of a capacitor.

A long strip of this can be rolled up to form a compact capacitor. Two connections are provided—one to each plate. A special manufacturing process enables plastic film to be metallised without melting the plastic. The sandwich construction of a capacitor is reflected in the symbol for capacitance—two lines representing the metal with a gap in between for the insulator. The insulator is in this case called a **dielectric**, which means something which allows an electric field to pass through. It is clear then, that an electric current cannot pass through, since the insulator stops it.

If a battery is now connected to a capacitor, positive to one plate and negative to the other, the capacitor "charges up" to the battery voltage. There is a brief flow of current, which stops when the dielectric has absorbed as much charge as it can. If the battery is removed, the capacitor remains charged to the battery voltage.

A charged capacitor is something like a battery in that, if connected across a resistor, the stored charge now flows out again as a current. The big difference is that while a battery can go on delivering a constant current to a resistor until it runs down a capacitor cannot. It starts to run down at once, that is the voltage falls as soon as *any* current is drawn out.

CAPACITANCE

The electrical size of a capacitor, called its capacitance, depends on the quantity of charge it can store when charged to one volt. The amount of capacitance which stores enough charge to enable one ampere to flow out for one second is called a farad.

A farad is a very large capacitance. Practical capacitors have capacitances which are measured in microfarads (μF—millionths of a farad); nanofarads (nF — thousand-millionths); or picofarads (pF — million-millionths).

The capacitance increases if the plates are brought closer together, for example, if the dielectric layer of the sandwich is made thinner. Plastic film can be made down to the thickness of a few micro-metres,

tricks. First, its dielectric is an extremely thin film of aluminium oxide formed on the surface of aluminium foil which gives support and also acts as one plate. Some dielectric substances store more charge than others. The oxide film is one of these, so this too helps to increase the capacitance. If aluminium foil is immersed in acid its surface become pitted with holes. This increases the surface area when the dielectric is formed, and this "etched foil" technique also increases the capacitance.

If a **reverse voltage** is applied the film breaks down in a few seconds and current can then flow through the capacitor.

Despite these disadvantages, its ability to pack a relatively large capacitance into a small volume makes the electrolytic capacitor one of the most frequently used types in electronics, especially in circuits where the signals are at d.c. or low frequencies. By using tantalum instead of aluminium better electrolytics are possible but at a higher price.

POTENTIOMETERS

The word "potentiometer" originally meant a device for measuring voltages. However, it has come to mean just any variable resistance with three terminals. The volume control in a radio receiver is a potentiometer in this sense. Technicians usually abbreviate the word to "pot".

To understand its function, take another look at your RESISTOR CHAIN. This has ten equal resistances and you are by now reasonably certain that when it is connected across the battery each resistance absorbs one-tenth of the voltage. Such a chain of resistances is called a **voltage divider.** The reason is fairly obvious. With your voltage divider you can put in 10V and by selecting the appropriate tap take out 1V, 2V, 3V . . . etc up to 9V. The 1V tap divides the voltage by 10, the 2V by 5, the 3V by 3·3 and so on. Evidently you would get the same voltages with *any* ten *equal* resistances. They do not have to be 1 kilohms resistances: ten 330 ohms would give the same selection of outputs.

Your resistance chain has ten resistances, and gives nine different divided voltages. If you wanted only one voltage, you could get it by using only two resistances of the appropriate value. For 3V, for example, you could combine all the seven 1kΩ resistances above point 3 into one single 7kΩ resistance and the three below it into one 3kΩ resistance. By using different resistances, you could divide the input voltage by any number you like. In experimental work, of course, you may want to divide by all sorts of different numbers, and you do not know, in advance, what they would be. If you want to divide 10V by 20 to get 0·5V you cannot do it with your RESISTOR CHAIN. It would be a nuisance if you had to build a different chain every time you needed a different voltage.

When used as a volume control the connections are made in such a way that a clockwise turning of the control shaft moves the slider towards *A*, increasing the volume. When used as a variable resistance, only two terminals are required. If connections are made to *B* and *C* the resistance increases when the shaft is turned clockwise.

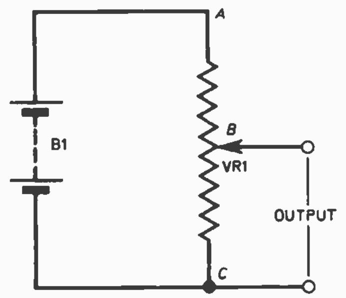


Fig. 3.3. Circuit symbol for a variable resistor. The zigzag line represents the *track*, the arrow head the *wiper*.

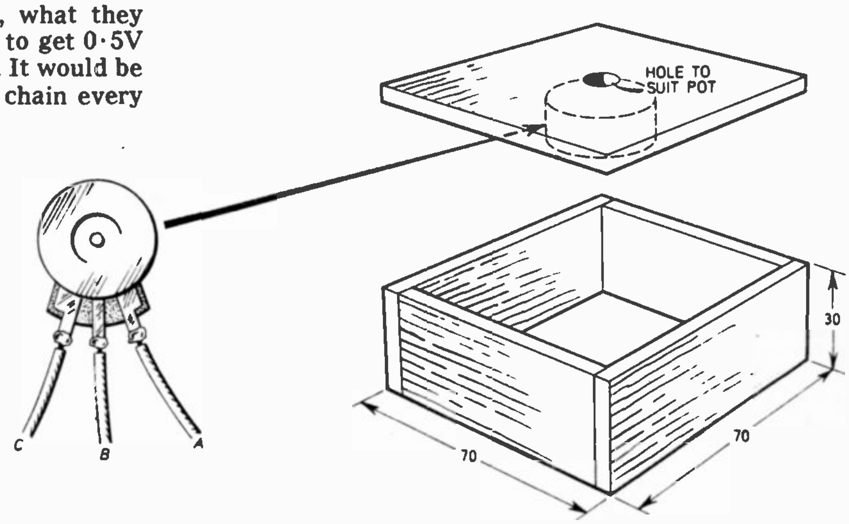
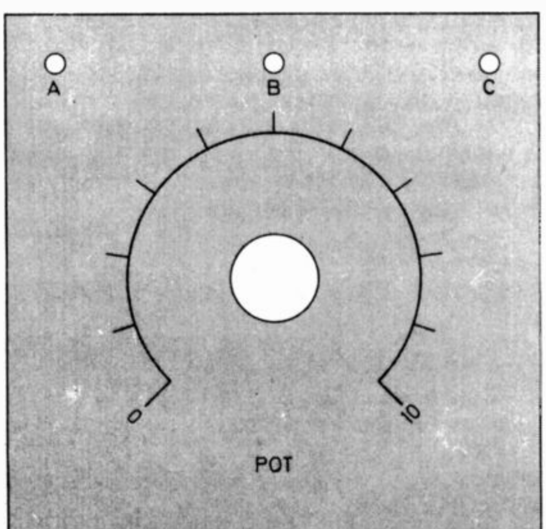


Fig. 3.4. Constructional details for the POT module. The three wires, A, B, and C are terminated on the nails which have been pushed through the holes shown in Fig. 3.5.

To avoid this, we use a variable divider, which can be adjusted to give any division you like, within reason. This is a potentiometer, and its circuit symbol, Fig. 3.3, gives a picture of how it works. The variable "tap" (*B*) slides up or down the resistance. In doing so it climbs from 0V at the bottom to the full battery voltage at the top, passing through every possible intermediate voltage on the way. So it can be set to divide by any number.

CONSTRUCTION

For our next experiments we shall use a "pot" (potentiometer) constructed in a similar style to our previous modules, only this time it is constructed in a small box. Constructional details are shown in Fig. 3.4. The top is covered with a piece of white card onto which is drawn a circular scale. Fig. 3.5. The precise value of resistance is not too important, so



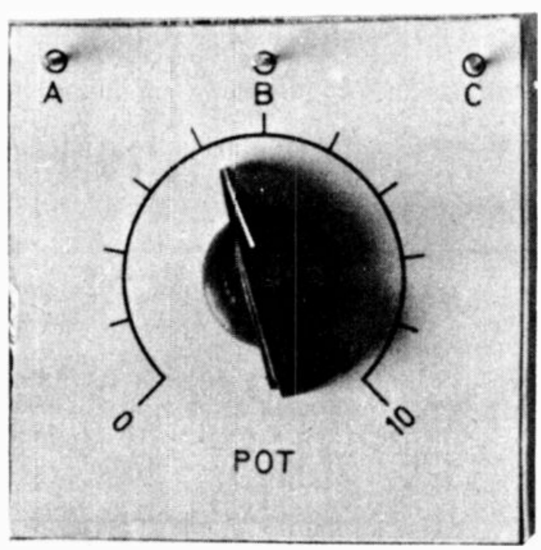


Fig. 3.5. Covercard required for the POT module. This is shown full size and may be traced. The individual markings are correct. Shown alongside is a photograph of the completed module.

long at it is at least 100 kilohms. A log law is required, and since this type is easily obtainable this is the type we shall use.

Most "pots" require a mounting hole 10mm in diameter. If your drill is too small, drill the biggest hole you can and widen it with a round file. Many pots have a small projection on their bodies to prevent accidental slipping as the shaft is turned. To prevent this getting in the way you can either drill a small hole for it to fit into, or just cut it off.

Fix the pot firmly and then attach the knob in such a way that when turned round it covers the rotation as shown.

Connect the modules as shown in Fig. 3.6. Here we can see that the LED is being driven by an amplifier. An unknown voltage is applied across the POT at points *A* and *C*, the pot is then adjusted so that the

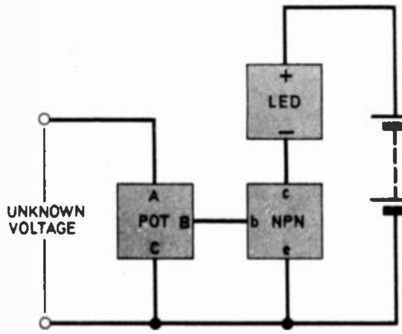


Fig. 3.6. In this experiment we are using an amplifier, driven by a voltage from the POT to light the LED

LED just lights. The position of the pointer on the scale now depends on what the unknown voltage is. If we can mark off the scale in 1 volt steps by applying a known voltage and setting the pointer correctly for each value, then we can afterwards use the device to measure unknown voltages. With a new battery connected, your RESISTOR CHAIN gives you 10 volts in 1 volt steps, we can therefore use this to calibrate the scale. But don't be in a hurry. After checking out the circuit you will make up a special VOLTAGE INDICATOR with its own pot inside, and keep this separate pot for general experiments.

First, however, let's use it to test the idea that each 1kΩ of the RESISTOR CHAIN drops 1V. Connect the pot (*A* and *C*) to 1 and 0 as in Fig. 3.7 then set the pointer so that the LED just glows, not brightly. Take *A* from tap 1. Charge a 1000μF module to 1V then apply the charge to the pot, leaving the pointer alone.

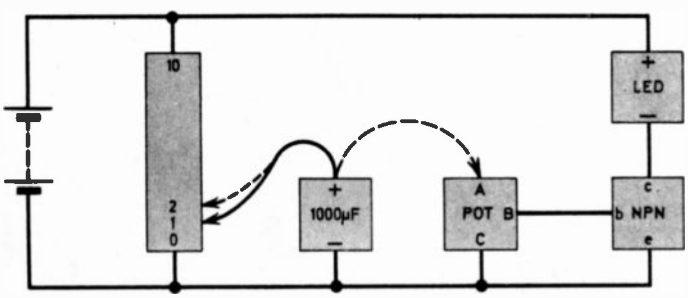


Fig. 3.7. Using a capacitor module to test the idea that the RESISTOR CHAIN really does divide the battery voltage by ten.

The LED should just glow as before. Leaving the pointer alone, charge the 1000μF by connecting it across each 1kΩ in turn. (Allow 30 seconds charging time.) You should find that the LED glows equally each time, though there may be a small variation in brightness, due to the fact that the resistors are not all exactly the same value.

Having checked that the RESISTOR CHAIN really divides the voltage into ten equal parts you know that it can be used to calibrate a "pot". However, there is one more improvement to be made first. This is to increase the current amplification. If it takes 10mA to light the LED, and the current amplification is 100, then a current of 10mA/100 has to be applied to the amplifier. This current (0·1mA or 100μA) is still large enough to upset circuit conditions. To reduce it further we amplify the current twice, by taking the output of one transistor and connecting it to the input of another. Then if each transistor amplifies by 100 the combination amplifies by 100 x 100 or 10,000 and the input current needed is now only 1μA.

The current could be reduced further by adding a third stage of amplification, but two are enough for our purposes.

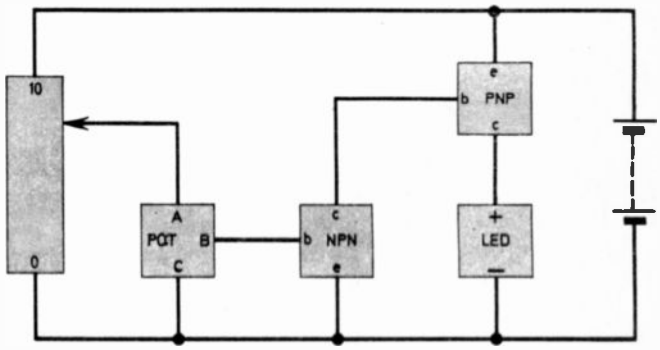


Fig. 3.8. Using the transistor modules to prove that a much reduced current may be used to light the LED.

Connect the modules as shown in Fig. 3.8. Experiment with the POT by varying the voltage on the base (b) of the NPN module. You should find that a smaller voltage is required to light the LED. Now work out how much less voltage is needed and compare this with the value in your previous experiment.

This setup with the modules is rather a messy arrangement for most practical purposes, so instead we combine all the modules into one circuit. This is shown in Fig. 3.9. This is our VOLTAGE INDICATOR which we shall use over and over again in our experiments. After the series it will still remain a useful tool when constructing other projects.

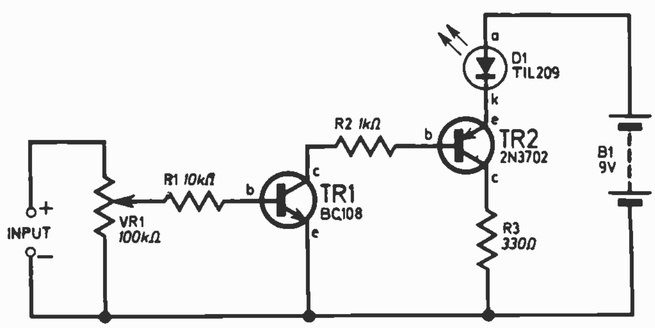


Fig. 3.9. A more compact version of the previous figure. This is the circuit diagram of our VOLTAGE INDICATOR.

CARD A

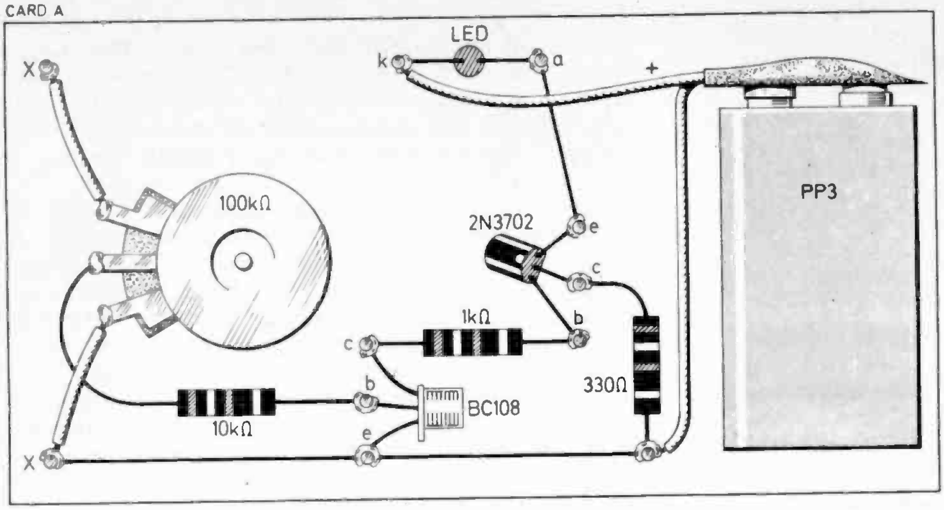
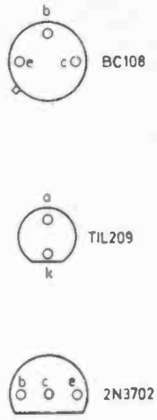


Fig. 3.10. The card required to go inside the box, glued to the inside of the lid. Nails or pins are mounted in all positions as shown. Be careful when inserting the pins that they do not come all the way through the other side. The two nails marked X are the only two to be inserted from the outside of the box. They then form the terminals.



UNDERSIDE VIEWS

CARD B

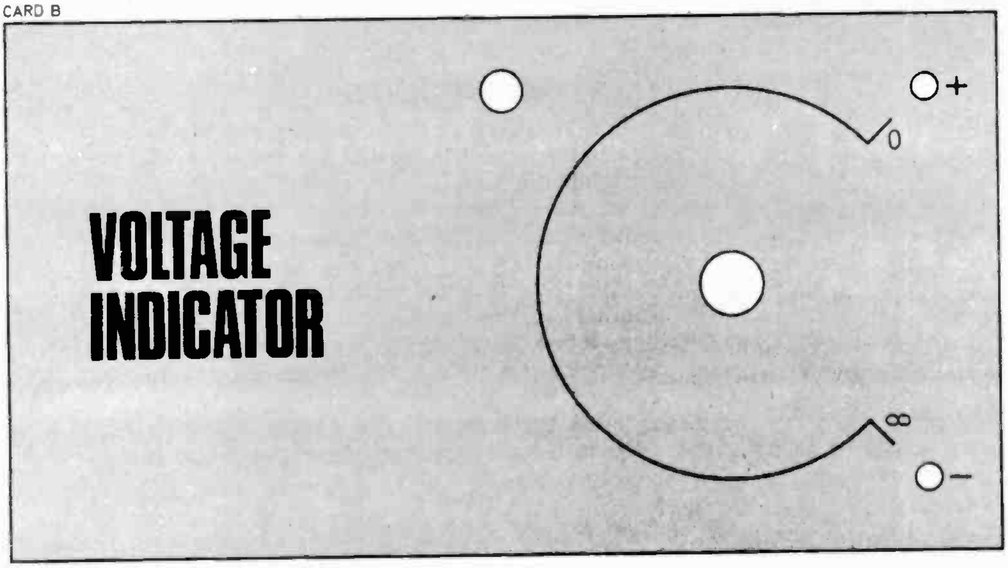


Fig. 3.11. The covercard required, shown full size, to be affixed to the top. No intermediate markings have been given, as the position of each depends on the individual tolerances of the components used to construct the module.

VOLTAGE INDICATOR CONSTRUCTION

The VOLTAGE INDICATOR is constructed in a small box with overall dimensions of 130mm×70mm×38mm. This can be plywood or hardboard as preferred. The top is permanently glued to the four sides, whereas the bottom is removable, this facilitates easy replacement of the internal PP3 battery.

The top card (B) is stuck onto the outside of the top, and holes made to suit the components. As the drawing is full size the hole sizes given should be correct for most components. Letter the card as shown.

Card A, goes on the inside of the top and is glued in place. When wiring the components it might be easier to temporarily remove the top.

The VOLTAGE INDICATOR can then be calibrated in one volt steps, marking the values on the scale. A small pointer knob is used on the potentiometer for this purpose. The RESISTOR CHAIN provides a good source of one volt steps.

ANSWERS *(To Part Two)*

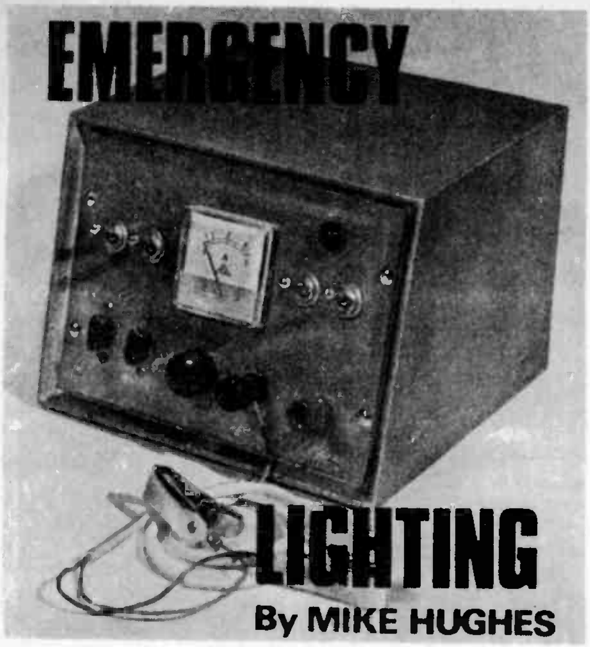
1. cathode end (b)
2. last (a)
3. 4 volts (a)
4. 3·3μF 100V electrolytic (c)
5. 100 (a)
6. 6 (b)

QUESTIONS

1. If V = 10 volts, I = 2 amps. Calculate the resistance.
2. When I = 2 amps and the voltage V is 20 volts, what is the resistance?
3. A current of 5 amps flows through a circuit with a resistance of 10 ohms. What is the voltage?
4. A voltage of 12 volts is applied across a resistor of 3 ohms. What is the current flowing?
5. Calculate the current flowing through a resistor of 46 ohms, if the voltage applied is 23 volts.

Answers next month

Next month we shall introduce the subject of transistor measurements.



EMERGENCY LIGHTING

By MIKE HUGHES

Automatically switches on an auxiliary lighting system when mains supply fails

INTRODUCTION

In these days of perpetual electricity failures it is convenient to have an auxiliary source of lighting in the home. It is mandatory that clubs and public areas have an emergency lighting circuit capable of running from a source independent from the mains.

The simple solution, in either case, is to have a circuit, or circuits, running 12 volt bulbs from an accumulator. This, however, requires that the accumulator is in a constant state of charge. This project is basically a battery charger that is used to keep the accumulator "topped up" but wired into it are two switchable output sockets for running auxiliary lighting and facility is built in for automatic change over to the emergency system, should the mains fail.

CIRCUIT

The circuit is shown in Fig. 1. A tapped input mains transformer is used that gives a nominal output of 12V r.m.s. (17V peak) at up to 5A. This is fed to a low voltage, high current bridge rectifier giving a full wave rectified output that is fed via a switchable series limiting resistor R2 and ammeter circuit to the terminals of the unit. The stand-by accumulator would be connected to these terminals.

With the series resistor in circuit charge current is limited to about 0·5 to 1A (for trickle charge purposes) but when shorted out with S2 the circuit current is limited only by the internal resistance of the transformer, the resistance of the ammeter circuit and the state of charge of the accumulator. Current could be up to 5A (and even greater). Should there be some major fault with the accumulator or the output was shorted then current could exceed the 5A (maximum) and a fuse is inserted to prevent overheating etc.

LIGHTING CIRCUITS

The auxiliary lighting circuits are taken from the battery terminals via the relay contacts to switches S3 and S4 to output sockets on the front panel. These circuits are connected on the front side of the same fuse. Because the relay (normally held in by the 12V a.c. from the transformer) is connected with its "normally closed" contacts in the auxiliary circuit, current cannot flow through the bulbs unless the mains fails. When this happens the relay drops out and current from the battery flows the other way through the fuse into the auxiliary circuit. Thus both circuits are protected by the single fuse.

CURRENT

If the unit is to be run from the mains via a fused 13A plug there is no need for an internal fuse on the mains input but take note that this is essential if the unit is to be run from non-ring main domestic wiring (a 500mA fuse is sufficient).

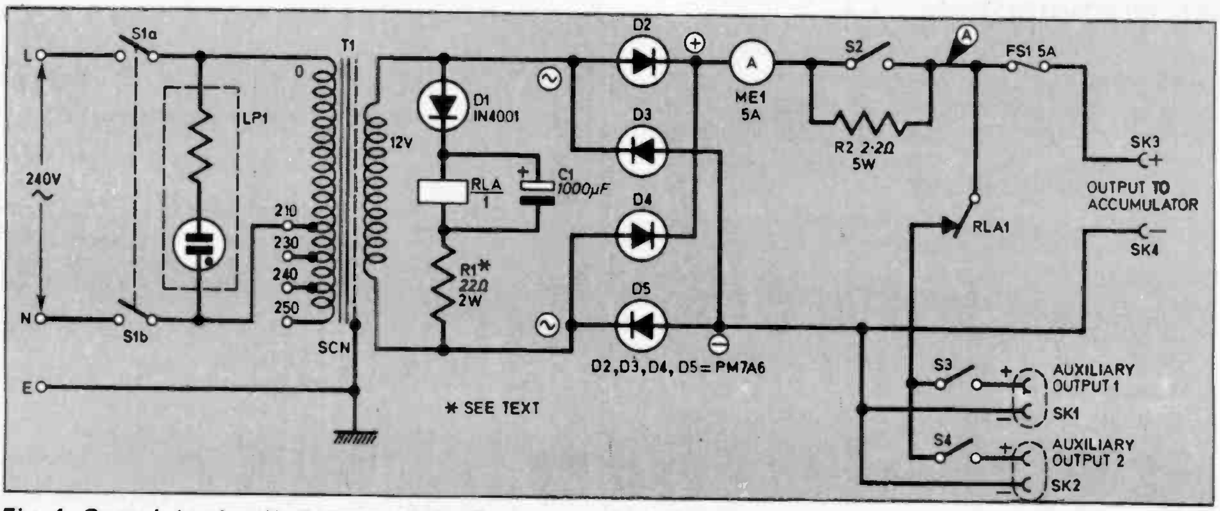


Fig. 1. Complete circuit diagram of the Emergency Lighting Unit.

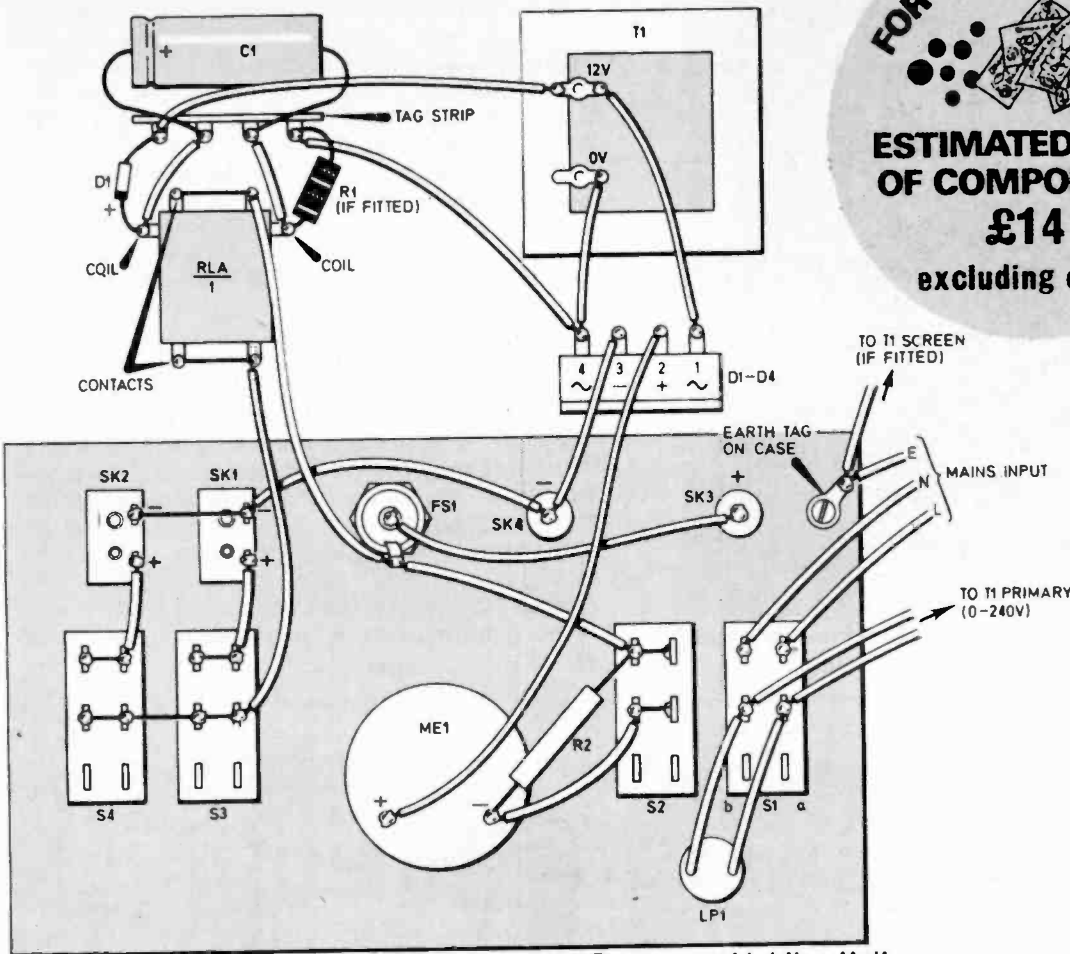


Fig. 2. Layout and wiring of the Emergency Lighting Unit.

With this system the maximum output current to the bulbs is 5 amps (not displayed on the meter) thus the total power loading **must not** exceed 60 watts. In a domestic situation this is more than is necessary and in practice two circuits with a loading of 2 amps each is quite sufficient. Switches S3 and S4 allow selection of either or both external circuits.

Remember that this unit provides high currents, consequently heavier gauge wire than usual should be used (10 amp rating preferably) for all internal and external connections (Fig. 2).

COMPONENTS

Resistors
R1 22Ω 2 W (see text)
R2 2·2Ω 5W

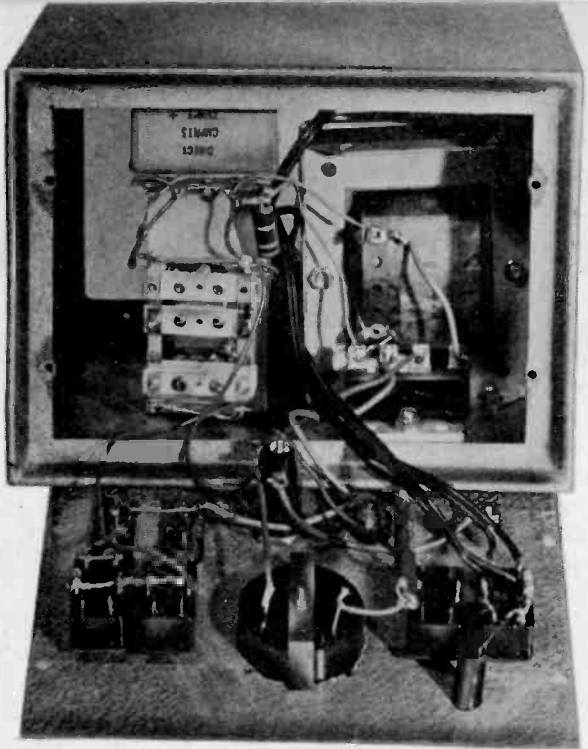
Capacitor
C1 1,000μF elect. 25V

Semiconductors
D1 1N4001
D2, D3, D4, D5 — 5A, 24V silicon bridge rectifier (AEI type PM7A6) or equivalent wired group of 5A rectifiers (4 off)

Switches
S1, S2, S3, S4 — Two pole 3A 240V on/off toggles. (Both poles shorted together for S2, 3 and 4)

See Shop Talk Page 174

Miscellaneous
ME1 5A moving iron meter
RLA1 6V coil, 26ohms with 5A changeover contacts
LP1 240V neon indicator—incorporating limiting resistor
T1 Mains transformer. Primary 0-210, 230, 240, 250. Secondary 12V at 5A (Douglas type MT 85AT)
FS1 Bulgin panel mounting fuse holder and 5A fuse
SK1/2 2 plug/socket pairs for auxiliary circuits (5A capacity)
SK3/4 1 red, 1 black 5A screw terminals,
2 large crocodile clips for accumulator. Heavy gauge insulated wire, 3 core mains lead, grommet and cable clamp. Case approx. 200mm x 150mm x 150mm.



The completed unit with front panel removed to show construction.

INSTALLATION

When installing the equipment make sure the accumulator is in a well ventilated area because hydrogen and oxygen are liberated during charging—a localised build up of these gases could cause an explosion if exposed to a naked flame. Ideally it should be contained in a wooden (frost protected) box outside.

When charging a badly exhausted accumulator it is best to charge at the trickle rate for an hour or two before changing to full rate—otherwise current in excess of 5 amps might be drawn. Use can be made of the tapped mains input of the transformer (if such a transformer has been used) to slightly increase or decrease the maximum charging rates. The output of 12V r.m.s. assumes the supply is connected to the input tapping of the same magnitude (e.g. 240V). If, however, you connect 240V across the 210V tappings the output voltage will increase by about 15 per cent. Connecting to higher voltage tappings will reduce the output voltage and hence the charge current. Should the maximum charge current be higher than required a 0·5 or 1 ohm resistor (5 watt) should be inserted between S2 and FS1 at point A Fig. 1).

What do you know?

TRANSFORMERS

1. What are eddy currents?
2. A transformer has a turns ratio of 3 to 1. Is this a step-up or step-down type?
3. 240 volts is applied to a transformer with a turns ratio of 6 to 1. Assuming a "perfect" transformer, what is the output voltage?
4. The input to a transformer is rated at 2·4 watts of 240 volts. If the total current drawn from the secondary is 100mA. What is the output voltage? Assume negligable losses.

ANSWERS

1. Eddy currents are small electrical currents induced in the iron core itself, which dissipate themselves as heat.
2. A step-down type. A ratio of 3 to 1 means that for 3 volts in at the primary, 1 volt is available at the secondary. Conversely a ratio of 1 to 3 means that for 1 volt in 3 volts appears at the secondary.
3. 40 volts.
4. 24 volts. In a perfect transformer the power in (P_{in}) = power out (P_{out}). In this instance the power in is 2·4 watts, therefore the power out is also 2·4 watts. A simple application of watts = volts × amps gives the answer.

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

STORAGE

When finding storage space for small components such as transistors and resistors, it can be expensive if plastic drawers are purchased. To solve this problem ordinary matchboxes can be glued together to form a matrix. Handles may be made from paper fasteners fixed to the trays. Using this method a simple storage system can be built up with very little outlay.

C. Walker, Darwen.

WIRE STRIPPERS

An idea which came to me recently is to use the end teeth of small crocodile clips as wire strippers. Simply place the end of the wire to be stripped in the end of the crocodile clip, hold the clip firmly at the end and pull. This action effectively strips the wire with very little or no damage to the wire itself.

Different sizes of clips can be tried for different size wires.

A. Moore, Preston.

SQUARE ONE ...FOR BEGINNERS

WE ARE HERE TO HELP YOU – NO MATTER HOW NON-TECHNICAL YOU MAY BE, JUST READ ON!

TOLERANCE

ONE OF the first things a beginner finds when using various components. is the wide range of different tolerances. If a circuit specifies a resistor with a tolerance of plus or minus ten per cent, then quite naturally the beginner would make an all out effort to obtain such a resistor, when in fact a smaller tolerance component would suffice.

Why is this? First however let us consider the manufacturer, who produces resistors. When looking through electronic component catalogues you will observe various types of resistors and note that there is a vast range of different types, all constructed differently. For example; carbon composition, metal film, wirewound, etc. Exactly how they are made is beyond our scope for the present, suffice to say that many thousands are produced each week.

Now on a large scale such as this it is very difficult for the manufacturer to keep an accurate check on the tolerance of each individual resistor. To do so would waste valuable time, not to mention the money involved. So instead the manufacturer specifies to his client that the resistors he makes will be within a certain tolerance.

In this way once a production run of say 10,000 resistors is completed they are tested by taking random samples of, say, every 500 thus insuring the manufacturing process has done its job properly, and the resistors are within the required tolerance. Certainly some rogue resistors will pass through the system and will be sold to the client. However since the manufacturing process has already been kept within tight limits, this is usually a very rare occurrence.

So much for how they are made, what is the importance in EVERYDAY ELECTRONICS?

Well, let us suppose that a circuit calls for a 100 ohm ±10 per cent carbon resistor, and you have either been supplied from a retailer or bought yourself a 100 ohm ±5 per cent resistor. Would this be suitable? The simple answer is, yes.

Table 1. Typical tolerances for resistors and capacitors.

Capacitors		Resistors	
Type	Tolerance	Type	Tolerance
Electrolytic	−10% to +100%	Metal oxide	±1% or ±2%
Silver mica	±1pF or ±1%	Metal film	±1%
Polystyrene	±2·5pF to ±10%	Carbon film	±5% to ±10%
Ceramic	±0·5pF to ±10%	Moulded carbon	±5% to ±20%
Polyester	±5% to ±20	Wirewound	±5% to ±10%

Although these are typical of components made today, wide variations are often found. The tolerance is usually marked on the body of the component in some form of coloured band or other marking.

When building a circuit, the designer has calculated the values of resistors exactly. For instance his calculations may reveal that a 97·56 ohm resistor is called for. Since no one makes a resistor to such a precise (if not weird!) value, the desginer uses the nearest standard value, in this case it is 100 ohms. He relies then on the 100 ohm resistor to be some other value than that specified. This is where tolerance comes in.

A nominal 100 ohm 10 per cent resistor may have a value anywhere between 90 and 110 ohms, it thus encompasses our wanted value of 97·56 ohms.

Okay, what about our 5 per cent resistor, will this be suitable in our circuit? Simple arithmetic tells us that the value may lie between 95 and 105 ohms, it thus still encompasses our wanted value. Very good you might say, what if I have a 1 per cent resistor, with a range of 99 to 101 ohms, will this be suitable? In most circumstances it would. With our example the difference is only one and a half ohms, this in most circuits should not affect the operation of the circuit, in others it might. It all depends on the type of circuit. Timing circuits for example need close tolerance resistors, such as 2 per cent types, in which case 10 per cent types would *not* be suitable for the same accuracy.

One point to notice is that the majority of circuits already have varying tolerances. For example a transistor amplifier may be designed using high tolerance resistors in the bias circuit to give a specific gain with a certain supply voltage. It is not much good if the supply voltage can vary by as much as 25 per cent! It is surprising in fact how the different tolerances in a circuit virtually cancel each other out. A simple rule is:

You may substitute a close tolerance resistor for a wide tolerance type, but not the other way round.

That is you cannot put a 10 per cent type in place of a 2 per cent type and expect the same results.

CAPACITORS

Capacitors are, of course, a completely different story. We saw last month how many types of common capacitors there are.

The main factor which determines the tolerance of capacitors is basically the same as with resistors; the manufacturing process. Expense is also another factor which is largely predominate. We cannot comment on all the types in the space available here, so instead a few general points will be considered.

1. In timing circuits high tolerance components is of course a necessity.

2. In r.f. circuits where a capacitor is made to resonate at a particular frequency with other components, the variation in the value could cause a shift in frequency. Again close tolerance components are used.

3. In circuits where it is desired to couple one stage with another, at say, audio frequencies, the wide variation is of no great importance.

In general then, if a circuit calls for a 100μF capacitor and a 125μF is the only type available then it would be perfectly in order to use it.

The same rule which is applied to resistors applies to capacitors, the only difference being the voltage rating of capacitors. A subject we hope to deal with later on this page.

By Brian Terrell

New products and component buying for constructional projects.

Automatic Phase Box

Regular readers of EVERYDAY ELECTRONICS will notice the different construction techniques used in the *Automatic Phase Box* article. As a rule, our constructional projects employ general purpose boards such as stripboard and plain matrix boards. These can be adapted for almost any circuit. From time to time boards that are dedicated to one particular circuit are devised, taking the form of a printed circuit board (p.c.b.). This is the case here. A requirement of the project is the production of a p.c.b. Two methods are outlined in the text and both require a chemical for etching, ferric chloride solution.

This is a very corrosive substance and is not available in liquid form by mail order. Your local dispensing chemist may be able to supply you if you explain your requirements. It can be obtained in anhydrous form from Crescent Radio Limited., 1 St. Michael's Terrace, Wood Green, London N22 4SJ at a cost of £1·35 including V.A.T. for a 1lb package. Also, Greenweld, 443 Millbrook Road, Southampton, SO1 0HX can supply a 1lb package for £1·02 including V.A.T. Their advertisement last month contained details of a p.c.b. kit.

Printed circuit transfers, if required can be obtained from P.K.G. Electronics, Oak Lodge, Tansley, Derbyshire; a starter pack of 5 sheets costs £1·45 including post and packaging.

For those wishing to use the photo-resist method, we have been unable to find a supplier of the treated board. However, Doram tell us that they can obtain such a board, size 203 x 114mm at a cost of £2·25 excluding V.A.T. Order as Photo Resist Copper-Clad Board type 434-166. There is a minimum order charge of £5·00.

For those not wishing to get involved in the production of the p.c.b. we have contacted a p.c.b. manufacturer, Proto Design, 4 Highcliffe Way, Wickford, Essex who can supply the board ready tinned and drilled for a cost of £1·15 inclusive. They can also supply a complete set of electronic components, excluding the case and battery for an additional £7·00.

It is important to obtain the miniature resistors and capacitors as specified in the component list, since the p.c.b. has been designed to accommodate these. Larger types will not fit on the board.

The prototype used two SR25 jack sockets, but these are not essential SK1 could be a stereo jack and SK2 a standard jack, but they should not be too large if they are to be fitted in the specified case. The SR25 are manufactured by Re-An Products who say their products are now available from many musical shops. They do not supply direct to readers. Still on the subject of component size, for similar reasons given above, VR1 should be of the "midget" variety.

The diecast box can be obtained from Home Radio, 240 London Road, Mitcham, Surrey at a cost of £1·60 inclusive of V.A.T. and postage/packing. Order as "Case type 939".

Photoflash Slave Unit

A Darlington type phototransistor, 2N5777 is called for the component list of the *Photoflash Slave Unit* which may present a buying problem for some readers. In case of difficulty this may be obtained from Arrow Electronics Ltd., Leader House, Coptfold Road, Brentwood, Essex, for an inclusive cost of £1·25.

Two very high valued resistors are specified being 10 megohms each and need to be of small physical size to be accommodated on the component board. If you experience any supply difficulties for these components, a suitable type, CR25, can be obtained from Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey, who hold stocks of this value.

The unit required a socket for connection to the second flashgun. Unfortunately these are not available (as far as we know), however, a flashgun extension lead is: this has a female connector at one end and a male type at the other. The plug needs to be cut off and this end of the lead soldered to the board. Photographic shops will be able to supply this extension. We have contacted Dixons Photographic who can supply at a cost of £1·95.

Ultrasonic Remote Control System

The transducers required for the *Ultrasonic Remote Control System* were discussed in *Shop Talk* last month. The relay used in the prototype unit was a type available from Doram Electronics Ltd., P.O. Box TR8 Wellington Industrial Estate, Wellington Bridge, Leeds, LS12 2UF. Their Catalogue number is 72-730-9 and the cost is £2·16 inclusive of V.A.T. postage and packing.

The remainder of the components should be readily available. You may be interested to know that Arrow Electronics can supply a complete set of electronic components for the transmitter and receiver, including cases, at an inclusive cost of £14·32. See above for their address.

Hazard Warning System

Not many components are required to build the *Hazard Warning System* and all should be easily obtainable. Make sure you use the correct type of transistor (TR1) to suit your vehicle earthing system. It is important that the insulating washer and bush be used for mounting TR2 to the case/heatsink so order the correct type to suit the transistor case. The 2N3055 is available in two versions, flat plastic case as shown, and a TO3 package.

The best place to buy the switch is probably a car/motorcycle accessory shop. They should have many different types to choose from to suit other dashboard switches (in the case of a car). We understand that switches are available that have a hose-clip type fixing to secure to motorcycle handlebars.

The "piggy-back" type push-on connectors should be available from the same stockists. If you have a choice, select the insulated type.

Emergency Lighting

Let's hope that by the time this issue reaches you the power workers' problems have been resolved and the miners reach a peaceful settlement. In case this is not the position we have included the *Emergency Lighting* project that first appeared in the February 1974 issue of E.E.

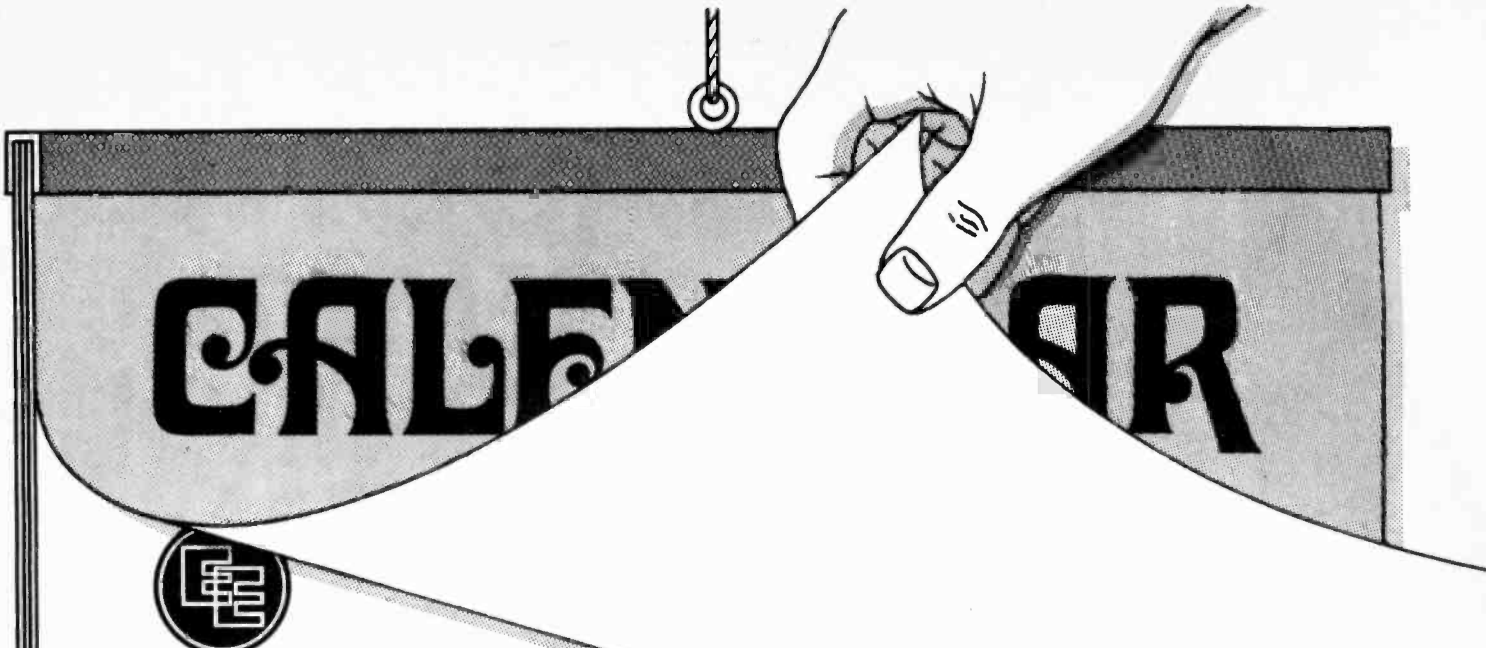
The prototype used an AEI bridge rectifier type number PM7A6. This is in fact rated at 9 amps 500V but any bridge with a minimum rating of 5A 24V will do. Observe any heatsinking requirements of the device you obtain. Alternatively you can make up a bridge using four discrete stud rectifiers (5 amps each) which are available from a number of sources. They should however be bolted on to a panel of insulating material prior to fixing in the case.

Ideally a 12V a.c. coil relay with 5 amp contacts should be used straight across the secondary of T1, but relays with low voltage a.c. coils are rare. If you can locate such an animal, D1 can be omitted along with R1. The prototype used a 6V d.c. 26 ohm coil, hence the inclusion of D1 and R1. If you can only obtain a 12V d.c. type, R1 should be omitted. The type used in the *Ultrasonic Remote Control System* project (Doram 72-730-9) is suitable.

A suitable meter is available from Maplin Electronic Supplies, P.O. Box 3, Rayleigh, Essex at an inclusive cost of £3·96. Order as type M1/5A.

TEACH-IN 78 REPRINTS

Owing to great demand the October and November issues of EVERYDAY ELECTRONICS have completely sold out. To help those readers who wish to follow the *Teach-In 78* series but have missed parts 1 and 2 that appeared in these issues, reprints of *Teach-In Part 1* and *Part 2* are available at a cost of 35p each, inclusive of postage. Orders (specifying Part required) with remittances should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.



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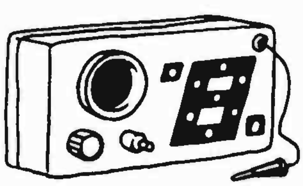
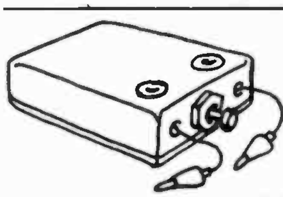
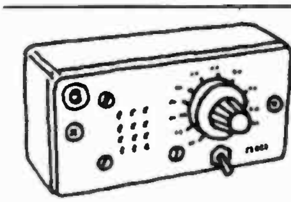
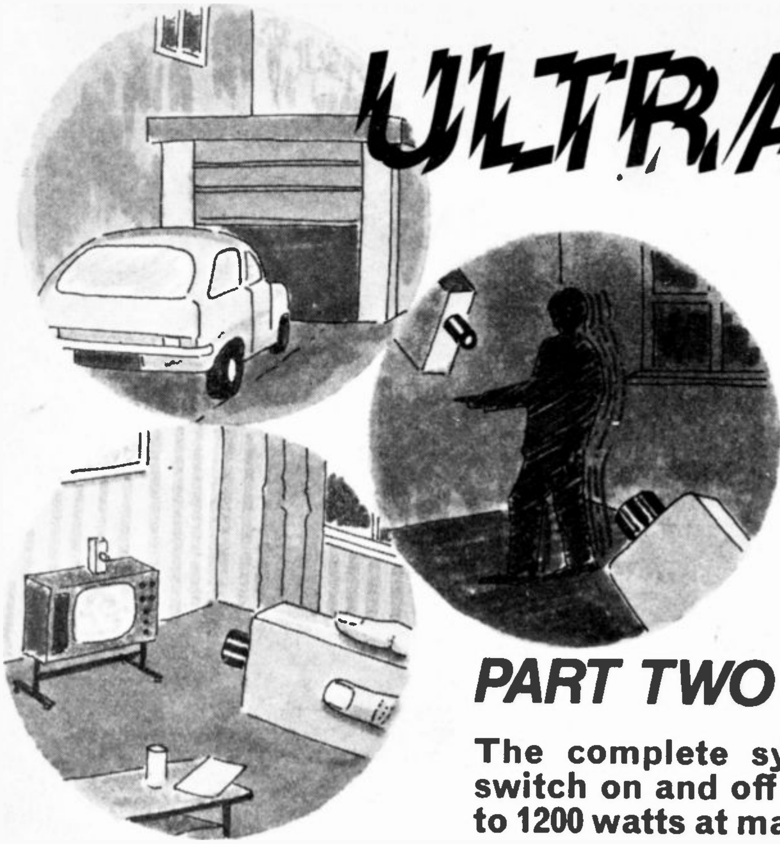
	**CODE SCRAMBLER**	This unit will turn ordinary letters and figures into cipher signals and can also be used to recover the original letter.
	**RAPID DIODE CHECK**	Ideal for quickly checking those barga n packs of diodes and instantly identifying polarity.
	**audible/visual METRONOME**	An aid for music practise that produces an audible timing reference together with a light flashing in step. Beat range 40 to 210 beats per minute.

Also
TOUCH SWITCH FOR BATTERY POWERED EQUIPMENT

Everyday ELECTRONICS

OUR JANUARY ISSUE WILL BE ON SALE FRIDAY, DECEMBER 16



ULTRASONIC REMOTE CONTROL SYSTEM

By R. A. Penfold

PART TWO THE RECEIVER

The complete system can be used to remotely switch on and off electrical appliances rated at up to 1200 watts at mains voltage.

INTRODUCTION

LAST month we gave full constructional details for the transmitter section of this project and outlined the operation of the complete system. We continue this month with full constructional details of the receiver-half with hints on use.

START HERE FOR CONSTRUCTION

Provided a minature relay is used, a plastic or metal case measuring about 130mm × 100mm × 38mm will be large enough to house all the components.

The transducer is mounted on one of the smaller sides of the case, which then becomes the front of the unit. Mount the transducer using the same method that was adopted for the transmitter. Two 4mm sockets are mounted on the left hand side of the case, towards the front, and these are the power input sockets. Two further sockets are mounted opposite these on the right hand side of the case, and these will then be connected to the relay contacts.

RELAY

The relay is mounted next to these sockets, and it will be necessary to construct a simple mounting bracket for the relay. If the specified component is used, this can consist of a piece of plain 0·1 inch matrix stripboard having 19 × 13 holes. Five of the holes in the board are enlarged using a 2mm diameter drill so that the relay will fit onto it. The tags of the relay are then bent over at right angles on the underside of the panel so that it is securely fixed to the board.

Leads about 100mm long are then connected to the four relay terminals which are used. This assembly can then be bolted in position, with approximately 6mm long spacers being used to hold the relay contacts clear of the base panel of the case.

COMPONENT PANEL

All the remaining components are mounted on a 0·1 inch matrix stripboard having 44 holes by 17 copper strips. Full details of this panel are shown in Fig. 2, which also shows all the other wiring of the unit. This panel is constructed in the same manner as the one for the transmitter. The i.c. is mounted in a 16 pin d.i.l. socket. All three diodes are germanium types, and as such are easily damaged by heat. It is therefore advisable to use a heatshunt on each of their leadouts as they are soldered into circuit. The i.c. being of the CMOS type is very sensitive and easily damaged by static. Be careful therefore when inserting the device into the socket taking care not to touch any of the pins.

When the panel has been completed, it is wired up to the rest of the unit before it is mounted at the rear of the case. Again 6mm long spacers are used to hold the panel clear of the case.

The connection to the transducer must be made via screened cable, about 100mm long, which is terminated in a phono plug.

Finally, the two leads from the relay contacts are connected to the appropriate sockets.

ULTRASONIC REMOTE CONTROL SYSTEM

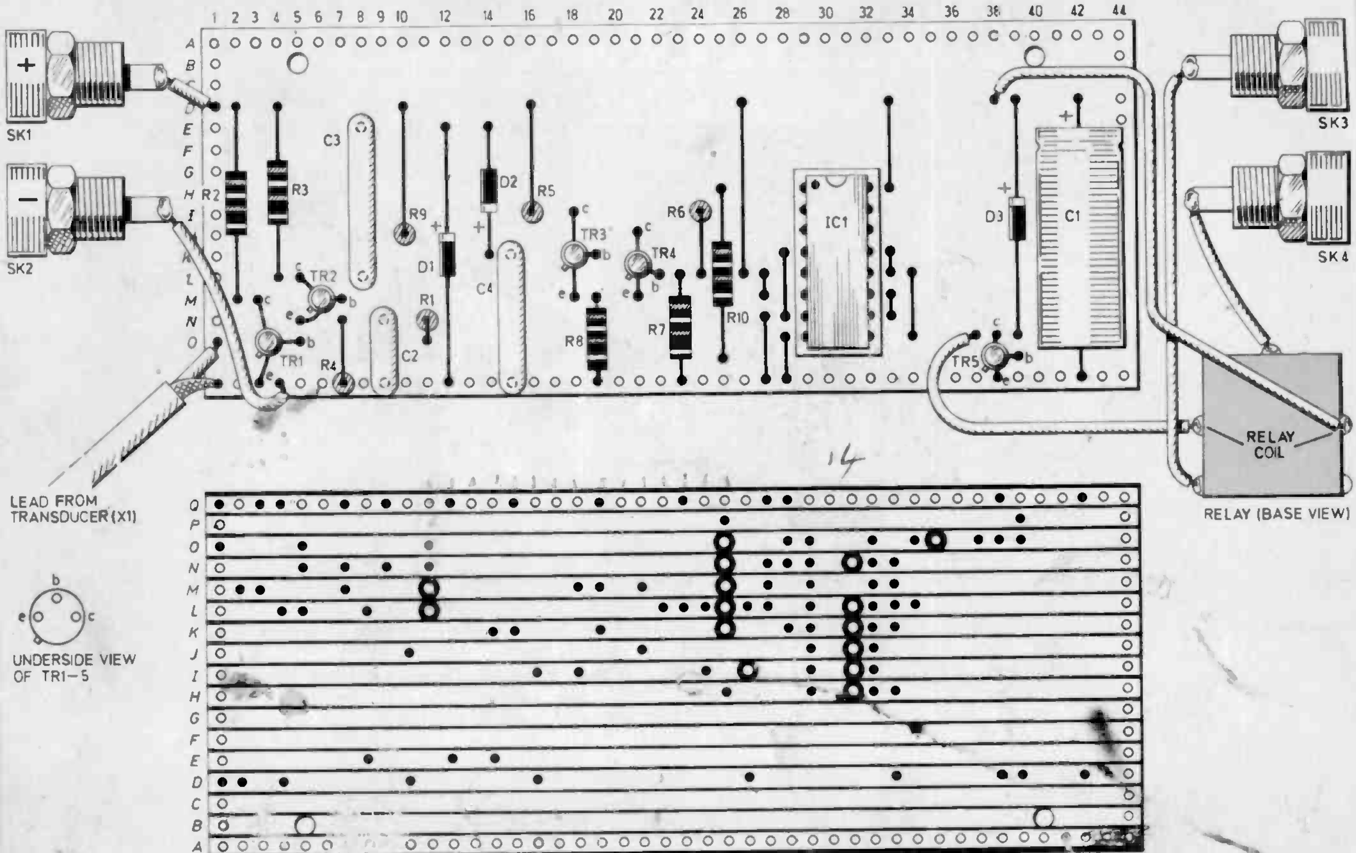


Fig. 2. The layout of the components on the stripboard and the breaks to be made on the underside

COMPONENTS

Resistors

R1 1·2MΩ	R6 15kΩ
R2 10kΩ	R7 12kΩ
R3 5·6kΩ	R8 680Ω
R4 10kΩ	R9 4·7kΩ
R5 8·2kΩ	R10 12kΩ

All resistors are carbon ¼W ± 5%

See Shop Talk Page 174

49½

Capacitors

C1 100μF 10V elect.	C3 470nF polyester
C2 100nF polyester	C4 220nF polyester

Semiconductors

TR1 BC109 silicon *npn*
TR2 BC109 silicon *npn*
TR3 BC107 silicon *npn*
TR4 BC107 silicon *npn*
TR5 BC109 silicon *npn*
IC1 CD4027AE CMOS dual J-K flip-flop
D1 to D3 OA91 germanium (3 off)

Miscellaneous

X1 RAB40K4 40kHz transducer (Arrow Electronics)
RLA miniature relay, coil resistance 410Ω with mains/5A contacts (Doram 72-730-9)
B1 PP3 9V battery
SK1 to 4 4mm wander sockets (2 red, 2 black)
PL1 standard phono
Plastic or aluminium case, 130mm × 100mm × 38mm; stripboard 0.1 inch matrix 44 holes by 17 strips; plugs to suit sockets (4 off); 16 pin i.c. socket; screened cable; connecting wire; 6BA hardware; solder.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS

£6 excluding transducer

ULTRASONIC RECEIVER

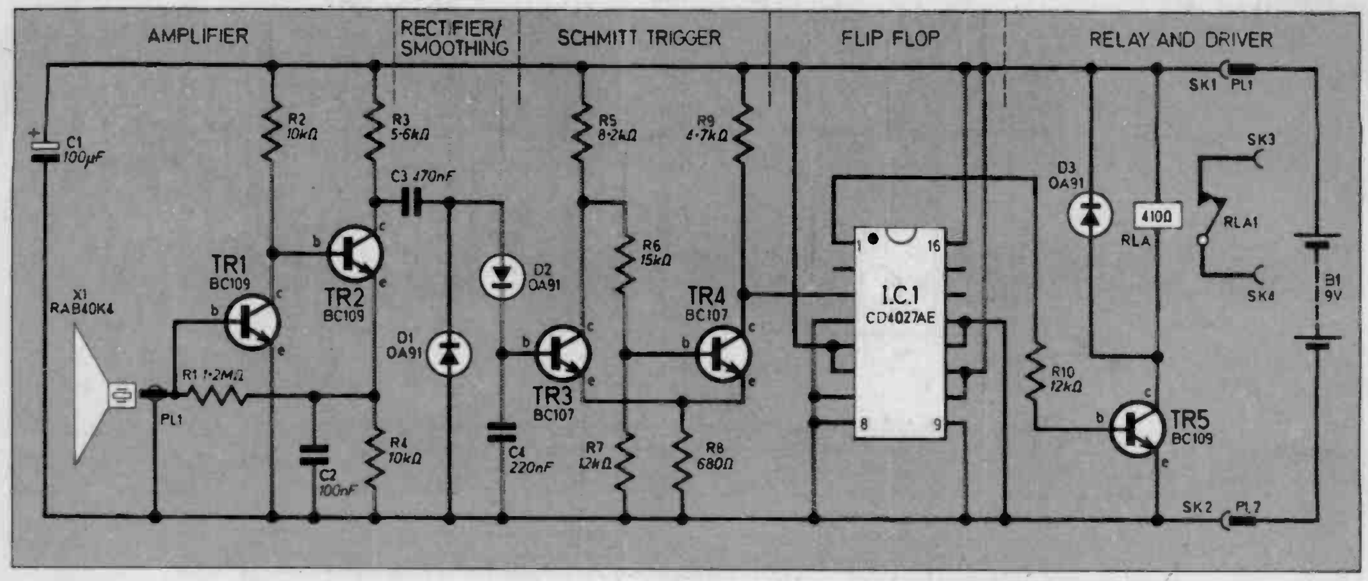


Fig. 1. Circuit diagram of the receiver section of the Ultrasonic Remote Control System.

CIRCUIT DESCRIPTION

AMPLIFIER

Transistors TR1 and TR2 are both used as high gain common emitter amplifiers, and they are connected in a simple direct coupled arrangement. The transducer, X1 is coupled direct to the base of TR1 with no d.c. blocking capacitor being necessary here. This is due to the fact that the transducer has an extremely high resistance, and so it does not upset the biasing of the amplifier. Neither does the small voltage at TR1 base have any detrimental effect on the transducer.

Although the transducer is not very sensitive to audio frequencies, it does produce some output from such signals. In order to prevent spurious triggering of the device by ordinary sounds it is necessary to use an amplifier which has only a relatively low gain at audio frequencies. In this circuit the required a.f. roll off is achieved by using a low value emitter bypass capacitor for TR2. Due to the low value of C2, TR2 has a voltage gain of less than one at audio frequencies, whereas at 40kHz it has a gain in the hundreds.

This seems to be quite effective in practice since nothing short of physically hitting the unit, or blowing hard into the transducer will cause spurious triggering.

The amplifier has a considerable gain regardless of gains of the particular transistors used. However, if the system is to be used near the limit of its range, the high gain BC109C transistors should be used in TR1 and TR2 positions. This will then give improved reliability.

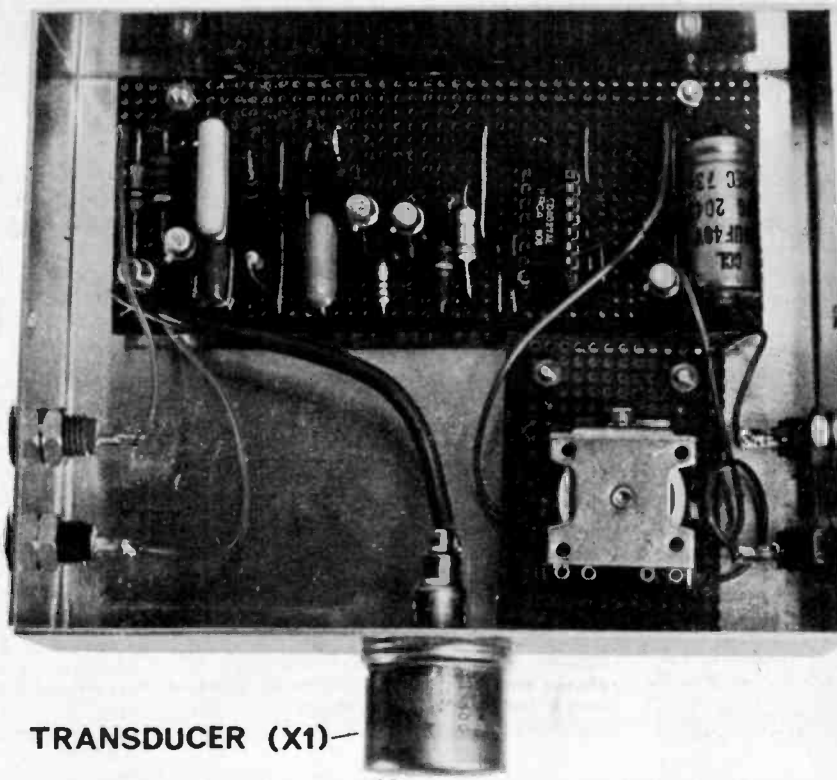
Capacitor C3 couples the output of the amplifier to a simple rectifier and smoothing network using D1, D2, and C4. The d.c. voltage produced across C4 in the presence of a suitable input signal is fed to the Schmitt trigger.

SCHMITT TRIGGER

The active devices of the Schmitt trigger are TR3 and TR4. With a zero input signal, TR3 is cut off while TR4 is biased into saturation by the base current it receives via R5 and R6.

When an input potential of about 1·65V, or so is reached, TR3 will begin to conduct, and it's collector voltage will begin to fall. This reduces the base current to TR4, which in consequence conducts less heavily. This reduces the voltage across R8 which is the emitter resistor common to both transistors. Decreasing the emitter voltage of TR3 causes it to conduct more heavily, as this increases the base/emitter voltage. This further reduces the base current to TR4, which results in a further drop in the voltage across R8.

A regenerative action is taking place here, and this continues until TR3 is biased into saturation and TR4 is cut off. Thus, when the input threshold voltage of the Schmitt trigger is reached, TR4 very rapidly switches from the "on" to the "off" state, and this produces a rapid positive going output pulse at TR4 collector. This



Interior view of the receiver showing positioning of component board, relay, transducer and sockets.

happens regardless of the speed at which the input voltage is rising, and so the slowly rising input signal is speeded up to a level which will reliably operate the next stage.

When the input signal is removed, the trigger circuit resumes its original state.

FLIP FLOP

The output of the Schmitt trigger is connected to the clock input of a 4027 CMOS JK flip flop. This device can be used to perform quite complex functions, but here it is connected as a simple divide by two circuit. The output of the device (pin 1) will therefore change state each time a positive input pulse is received.

The output of the flip flop is used to drive a common emitter amplifier, TR5, via a current limiting resistor R10. Transistor TR5 has the relay coil as its collector load, and the relay is activated whenever the output of the flip flop is in the high state. Diode D3 is the usual protective diode which *clips* the high back e.m.f. voltage which would otherwise be developed across the relay coil each time it was turned off.

USING THE SYSTEM

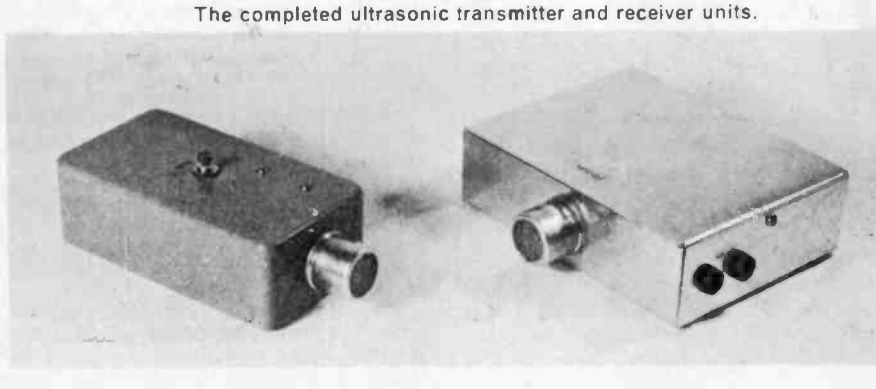
The unit has a current consumption of about 2·5mA when the relay contacts are open, this increasing to approximately 25mA when the relay contacts are closed. Since in virtually all applications it will be necessary to leave the receiver switched on for long periods, economic operation from internal dry cells is not really practical. For this reason the receiver is equipped with sockets which enable an external rechargeable battery or mains derived supply to be used. A nominal supply voltage of between 7·5 and 12V is required.

It is not essential for the relay to be of the specified type, and any relay which will physically fit into the case, has a coil resistance of about 200 ohms or more, an operating voltage of 6V (nominal), and has suitable contacts, should be perfectly suitable.

When using the system, remember that the ultrasonic beam emitted from the transmitter is fairly directional and it is necessary to aim the beam at the receiver's transducer. This effect may not always be apparent if the system is used indoors, where it may well be found that correct operation is even obtained if transmitter is pointed in completely the wrong direction.

This is due to the soundwaves being reflected around the room. ☐

The completed ultrasonic transmitter and receiver units.



GEORGE HYLTON brings it down

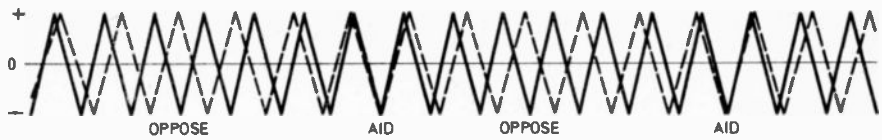


Fig. 1. Two waves of different frequency superimposed to show how beats are generated. The beat frequency is a function of the difference in frequency of the two waves.

A READER asks how the b.f.o. (beat-frequency oscillator) in his communications receiver works, and wonders if the same principles are used in other equipment. In particular, he suggests that a b.f.o. might be a convenient device for generating an audio voltage of variable frequency.

Tremolo Effect

Let's start by saying what a beat frequency is. Most of us will be quite familiar with the phenomenon that when two instruments such as violins or clarinets play the same note and sustain it, a sort of "wobble" or tremolo is heard. Instead of the steady . . . OOOOOOO . . . of a single instrument you hear a sound which gets periodically louder and softer, a sort of . . . OOWOOWOOWOOW . . . The effect arises when the two instruments are not absolutely in tune. If they are playing the note A, which should be 440Hz, but one is really playing 441Hz, you hear a wobble at the difference frequency of 1Hz. That is the volume rises, falls and comes back again once a second. The wobble is a beat note, beat tone, or beat frequency.

If you have a piano, you can produce beats by putting your foot on the sustaining pedal and striking two notes which are an octave apart. In this case the upper note has twice the frequency of the lower. However, the piano generates harmonics, that is multiples of its notes. So striking the lower note also produces a "second harmonic" which is double its frequency. This *should* be exactly equal to the higher note, but it seldom is (not for long, anyway). So you hear a beat note.

Troughs and Peaks

Ok so far? Right. But I can hear you asking; *why* do I hear the beat note? Leaving the physiology of the ear out of it, the basic reason is pretty clear. Two identical audio waves can reinforce one another, if they are in phase (peaks at the same points in time). Or they can weaken one another if the peaks of one coincide with the troughs of the other. But if the two waves are *not* identical in frequency they can't behave like this. The faster wave's peaks keep catching up on the slower one's.

At these moments they add. But then the faster peaks overtake the slower ones, and begin to catch up on the slower troughs. So the two waves now oppose one another. Then, having overtaken the troughs, the faster wave begins to catch up on the slower peaks, so they add again, and so on. If the two frequencies, though different, are constant, the process follows a regular timing, producing a steady sequence of reinforcement, weakening, reinforcement, weakening . . . the beat note, in fact.

Waveforms

This process is illustrated in Fig. 1, where two waves of different frequency are superimposed. You can see how they drift in and out of step. One important point, however, is that there are still only the two original frequencies present. To produce a real third frequency, the beat frequency, this getting in and out of step must somehow be changed into a genuine variation of energy. If the waveforms in Fig. 1 are not sound waves but voltages or currents then the beat frequency can be made real by rectifying the composite waveform.

A diode, for example, will conduct only when the instantaneous sum of the two waves happens to be positive. The result is that after the output of the rectifier is given a certain amount of smoothing to remove the instantaneous ups and downs a sine wave appears at the beat frequency.

The BFO

So far we've been talking about situations in which both the original frequencies are audio frequencies. However, it is quite possible to have beats between frequencies above audio. Since the beat occurs at the *difference* frequency this can be an audio frequency even when both the original frequencies are radio frequencies.

This is what happens in a radio with a b.f.o. The signal carrier frequency arrives at the aerial and is frequency-changed to some standard intermediate frequency, such as 455kHz, then amplified and filtered. The b.f.o. is usually tunable over a short range, from a few kilohertz below the intermediate frequency to a few kilohertz above, say 452 to 458 kHz.

Simultaneous application of signal and b.f.o. frequencies to a detector (rectifier) then generates a beat note variable in the range 3—0—3kHz; i.e. anything from 3kHz down to zero and up again to 3kHz.

The audio beat is thus variable over 0 to 3kHz. It is quite feasible to make the range much greater. For example, if the signal is replaced by a fixed oscillation at say 100kHz and the b.f.o. by a variable oscillation of 100 to 120kHz, the beat varies from 0 to 20kHz, covering the entire audio range in one sweep. This is the basis of the suggestion that a b.f.o. could form a useful audio-frequency source.

There was a time when b.f.o.'s were almost the standard form of variable a.f. source. They have the great advantage that a large frequency range can be covered in one "sweep". They have gone out of fashion because distortion and variation of output as the frequency is changed are worse than what is obtained with a well-designed R/C oscillator of the Wien Bridge type.

Nevertheless the b.f.o. still has its uses. A common application of the b.f.o. is in a metal detector. This is based on the fact that when a piece of metal comes into the magnetic field of a coil which forms the tuning inductance of an oscillator the frequency of the oscillator changes. The change is often very small. For example, when a coin is situated an inch or two away from a 100kHz oscillator the frequency may change by 5Hz. It is not easy to detect such a small change at 100kHz. But if the 100kHz oscillation is "beaten" against another on nearly the same frequency, to produce a beat of, say, 200Hz, the change of this from 200Hz to 205Hz is easily detectable by the ear.

to earth

PLEASE TAKE NOTE

Physics is fun *(November 1977)*

In the last paragraph on page 115, the voltage should be measured with the lamp still *in* circuit. Not removed as stated in the text.

V.H.F. Portable Radio *(November 1977)*

In Fig. 2. The link from the collector of TR5 should go to the junction of C16/R13, not as shown.

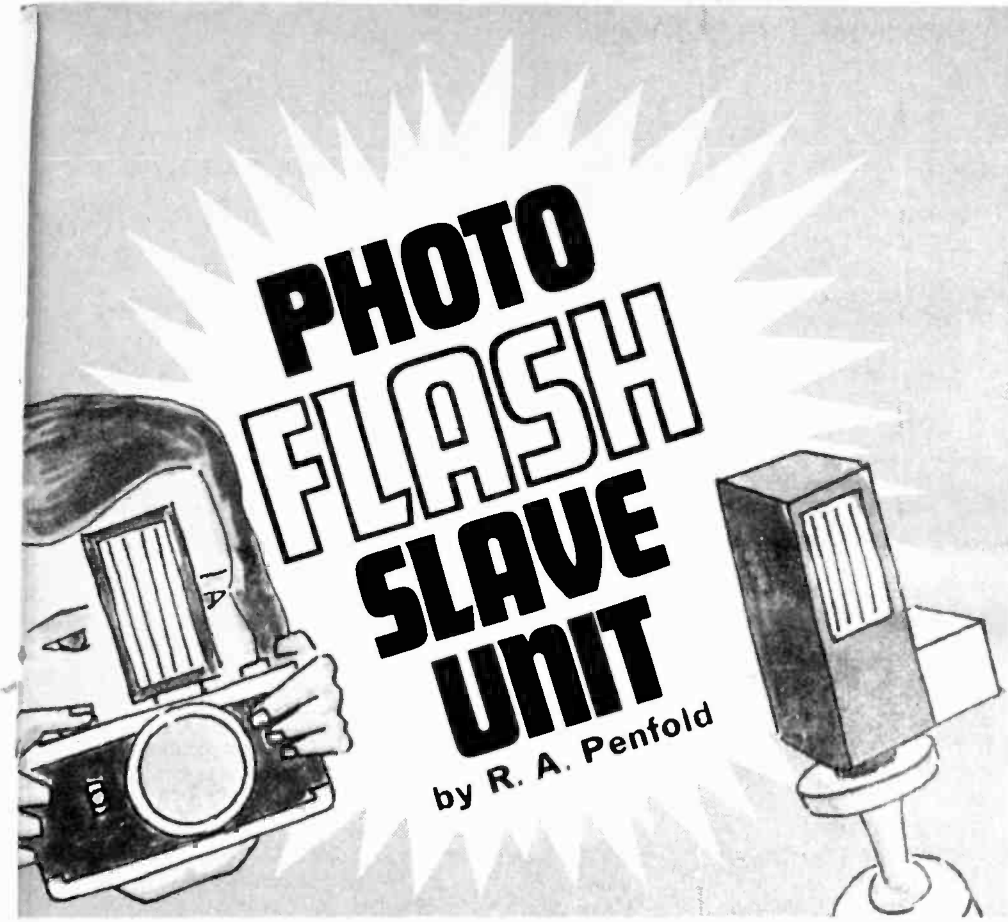


PHOTO FLASH SLAVE UNIT

by R. A. Penfold

INTRODUCTION

There now seems to be a very wide range of electronic aids available to photographers, and most such aids appear to be fairly complex devices. Although a photoflash slave unit is probably the most simple of these devices it is nevertheless one of the most useful.

Conventionally an adapter is used when multiple flash lighting is employed, and this enables the switch contacts of the camera to fire the flashguns simultaneously. A wire to connect each flashgun to the adapter is required with this method which is, in consequence, rather inconvenient. There is also a tendency for the cables to become entangled and a source of hinderance.

SLAVE UNIT

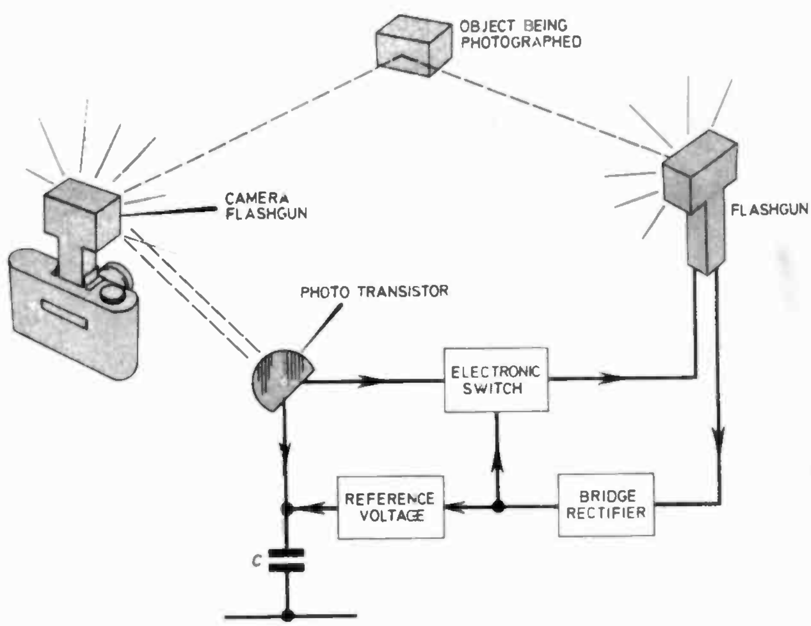
A flash slave unit overcomes this problem by triggering a secondary flashgun when it receives a pulse of light from the main flashgun. It would not be completely true to say that the flashguns are fired simultaneously by this method, since it is obviously necessary for the first gun to fire before the second one is triggered. However, in most practical situations the delay before the second gun fires is too short to be of significance.

POWER SOURCE

The current commercial practice seems to be to use a batteryless circuit. This has the obvious advantage of no running costs, and it also enables a smaller, lighter unit to be produced.

Perhaps the most obvious way of achieving this is to use a solar battery to generate the trigger pulse for the control device (which is invariably a thyristor). This is not quite such a good idea as it may seem as solar cells tend to be more expensive than other photo-electric devices, and in general they respond far too slowly.

HOW IT WORKS



The high voltage (low current) which is normally available from the flashgun is rectified by the bridge rectifier. This provides the correct polarity for the electronic switch to function correctly. Capacitor *C* then charges up to the reference voltage. When light from the main flashgun strikes the photocell, capacitor *C* discharges quickly, thus providing the necessary high current. This high current is enough to turn the electronic switch on. Thus the switch operates and fires the secondary flashgun.

The entire action takes place almost instantaneously as the camera flashgun fires.

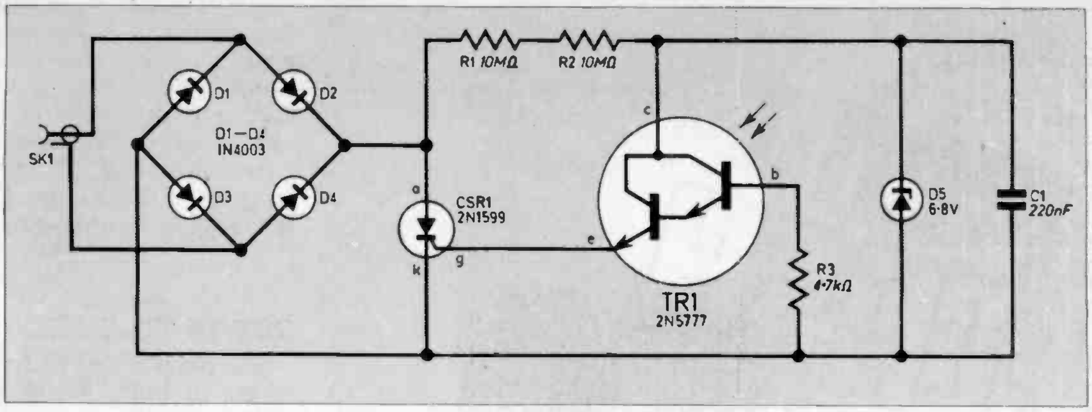


Fig. 1. Complete circuit diagram of the Photoflash Slave Unit.

CIRCUIT DESCRIPTION

The complete circuit diagram of the unit is shown in Fig. 1.

A thyristor is a unilateral device, and it will therefore only function properly if it is fed with a voltage of the correct polarity. In order to avoid any problems here, a bridge rectifier consisting of D1 to D4 has been added in series with the flash lead, and this provides a signal of the correct polarity to the thyristor (CSR1) regardless of which way round the flash lead is connected.

Resistors R1, R2, and diode D5 form a simple Zener shunt regulator, and these limit the voltage which can be fed to the gate of CSR1 via the photo-Darlington amplifier TR1. Capacitor C1 is needed in order to provide the current required to trigger CSR1. As we pointed out earlier, the current available across the flash lead is inadequate. All that happens here is that when the flash gun is charged up, a voltage will appear across the flash lead, and C1 will then charge up via R1 and R2 until the Zener voltage is reached.

While C1 charges up it is receiving a current of only a few micro amps for about one second. When the light from the main flashgun is received by the photocell (TR1), it's normally very high resistance falls to a level of only about a few hundred ohms. This happens extremely quickly, and as a result C1 almost instantaneously discharges through TR1 and into the gate of CSR1. Because the charge on C1 is released so rapidly, the discharge current is many times greater than the charge current. It is thus sufficient to switch on CSR1 which then places a low impedance path across the flash lead and so fires the flashgun.

After the flashgun has gone off, the current through CSR1 falls to virtually zero and this component switches off. The circuit is then ready to start a fresh cycle when the flashgun is recharged again.

The photocell used in this circuit is an inexpensive photo-Darlington amplifier type 2N5777. This has a very fast response time but is a little oversensitive for this application. Resistor R3 has therefore been included to reduce its sensitivity. Without this component the ordinary ambient light level would be sufficient to turn on TR1, and the current through R1 and R2 would be diverted away from C1 and through TR1 and the gate of CSR1. Capacitor C1 could not then charge up sufficiently, and the unit would be unable to trigger the flashgun.

It is also necessary to use two series connected resistors in the position taken up by R1 and R2 since a single resistor of this value is not readily available.

PRACTICAL METHOD

A more practical method, and the one used in the device described here, is to obtain the power for the slave from the flashgun. There is no need to modify the gun in any way because it is possible to tap off power direct from the flash lead. Only one real problem exists here, and that is due to the fact that the flash lead supplies something in the region of 175 volts at only a few microamps, whereas a thyristor needs a trigger signal of less than one volt with the current being in the order of a few milliamps.

START HERE FOR CONSTRUCTION

All the components are wired up on a 0·1 inch matrix stripboard panel which has 11 copper strips by 14 holes. Details of this panel are shown in Fig. 2. There are no breaks in any of the copper strips.

When assembling the components on a small board such as this it is probably easier to solder the components into position on one corner of a large panel and then carefully cut out the required piece of board, rather than the usual method of initially cutting out the board.

The unit should preferably be housed in a small transparent plastic case, but any small case can be used. If a metal case is employed it will be necessary to take steps to insulate the wiring from the case. Drill a hole in the case adjacent to the curved side of the photocell (this being the light

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS

£4.20

sensitive area), if an opaque housing is used. This hole then enables the photocell to receive light from the main flashgun.

Whatever type of case is used it will be necessary to drill a small hole in the case so that a lead can be threaded through. It is not possible to make connection to the flashgun via a chassis mounted socket since these sockets seem to be unobtainable. Instead a flash extension lead must be used. The plug is removed from this, and then this end is threaded through the hole in the case and connected to the appropriate points on the component panel.

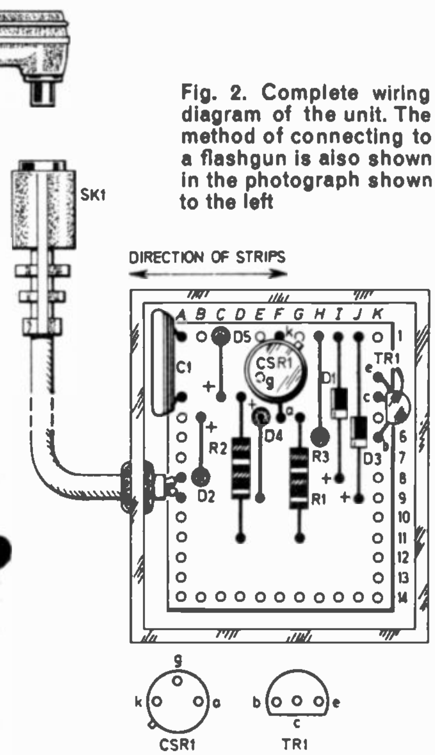


Fig. 2. Complete wiring diagram of the unit. The method of connecting to a flashgun is also shown in the photograph shown to the left

Three extra rows of holes are provided on the component panel so that there is space for mounting holes to be drilled, should it be necessary to bolt the panel to the case. It was not in the case of the prototype because the panel was found to be a firm fit into the housing.

USING THE UNIT

The circuit will operate in the presence of a fair amount of ambient light, but it is still quite sensitive and can normally be triggered at distances of up to about 5 metres without any difficulty. It is usually irrelevant as to which direction the photocell is aimed, but it may sometimes be necessary to aim it at the main flashgun.

It is possible to considerably increase the sensitivity of the unit, if required, by increasing the value of R3. Note though, that the more sensitive the circuit is made, the greater the risk of the circuit action being blocked by the ambient light level. ⌑

COMPONENTS

See Shop Talk page 174

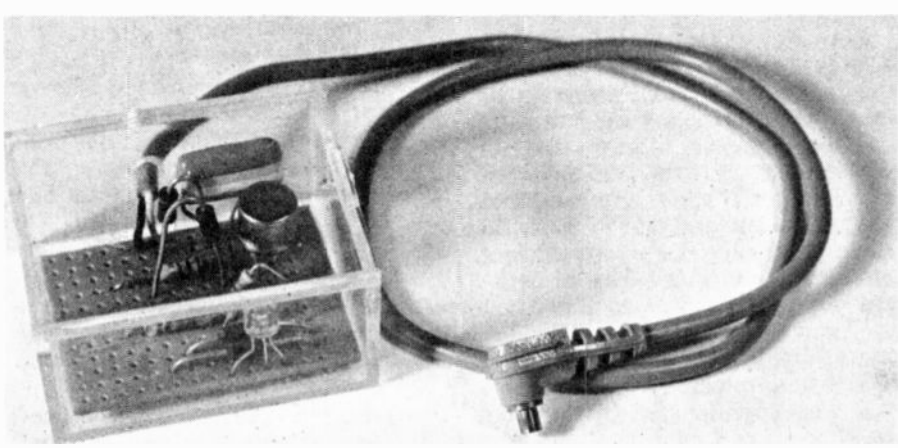
Resistors
R1 10MΩ
R2 10MΩ
R3 4·7kΩ
All resistors are carbon ¼W ± 10%

Capacitors
C1 220nF polyester

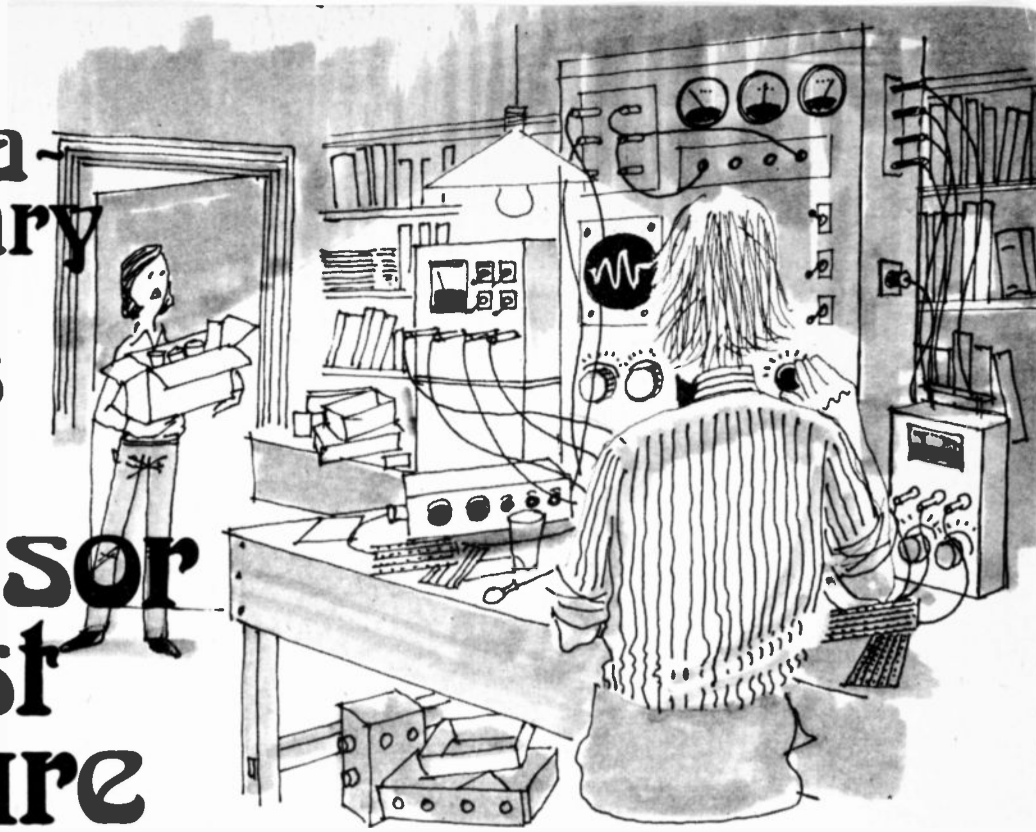
Semiconductors
TR1 2N5777 photo darlington *npn*
CSR1 2N1599 200V 1A thyristor or equivalent
D1 to D4 IN4003 rectifier (4 off)
D5 BZY88C6V8 6·8V 400mW Zener

Miscellaneous
SK1 extension lead for flashgun (see text)
Small transparent plastic case, 50mm × 40mm × 25mm; stripboard 0·1 inch matrix 11 strips × 14 holes; small rubber grommet; solder.

Photograph of the completed prototype unit



The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

WE CONTINUE this month by discussing further the source follower, and introduce the subject of *quantisation*. The Prof. continued.

"There is another interesting property of follower type circuits, such as source followers, emitter followers, cathode followers and so on, which you might wish to consider in your study of them, and this is their very useful ability to absorb and 'damp out' various forms of interference. This can be extremely useful where long lengths of signal carrying cable are used, and interference can be a big problem, I have been examining this f.e.t. pre-amplifier with the unmarked faulty transistor, and have decided to let you tackle the problem!"

Bob saw that the Prof. had brought back the pre-amplifier together with a small selection of f.e.t.s, most of which did not look anything like the faulty one, in whose place the Prof. had soldered a transistor socket. He soldered the pre-amplifier back in place in the microphone, but with sufficient length of connecting wire to make the circuit accessible to Bob.

"Somewhere in this little lot, there should be at least one suitable transistor. See if you can find it!" The Prof. handed Bob a small assortment of f.e.t.s.

"Do you have a book which gives the information as to lead-out wires on all of these, Pro?"

"The information is scattered about in a number of books and data sheets, Bob, and to save you the trouble of looking them all up I will let you use one of my computers."

The Prof. quickly showed Bob how, by pressing a few buttons on one of the computers, he could feed in the type number of the transistor. On the viewscreen of the computer he could then see a large, clear diagram showing the position of the source, drain and gate leads of each transistor together with other specifications. Guided by this information Bob was able to try the transistors by inserting them, one at a time, into the transistor socket.

Many of the transistors did not appear to work at all in the circuit, and Bob found that when he used a multimeter to measure the voltage between the source and the battery negative, the full 1·5 volts was indicated.

"These transistors require an offset bias voltage greater than 1·5 volts and are unsuitable for use in this circuit," the Prof. informed him.

Bob tried some more of the transistors and found a number which worked in the microphone. Some were better than others, and when Bob measured the source voltage of each he obtained a different reading for each transistor.

The transistors with the highest source voltage readings of 1 volt or more were the least satisfactory. Although most of them gave a reasonably clear sound at low volumes, at higher volumes there was obviously distortion.

Bob tried a number of transistors which gave a reading below 1 volt, and although he could not exactly match the reading of 0·6 volts given by the original transistor before the fault appeared, he eventually found one which gave a reading of about 0·7 volts and which gave a good sound even at high volume levels.

Bob removed the transistor socket and very carefully soldered the replacement transistor into place on the tiny p.c.b.

He carefully re-assembled the pre-amplifier into the microphone body, and before finally closing up the microphone to complete the repair, took a note of the type number of the transistor he had used, for future reference. This was a MEF102 type.

Now with the microphone all in one piece, and plugged into the amplifier, Bob was jubilant.

Continued on page 188

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"All systems go!" he shouted into the microphone, "Prof I've just made a great invention! It's fantastic!"

"What is it, Bob?"

"It's a field effect transistor with a tiny adjusting screw to alter the offset-bias voltage that it requires. As this voltage varies from one transistor to the next, and obviously has a big effect on its performance, why not make each transistor adjustable?"

"How does your invention work, Bob?"

"I don't know, Prof.," Bob admitted, "it's only an idea!"

"Maybe we'll see about that later!" the Prof. commented.

STRANGE EQUIPMENT

As Bob looked around the Prof's laboratory, crammed with strange inventions, computers and gadgets, most of which had been constructed by the Prof. with the superhuman assistance of his experimental robot, he spotted a newly arrived piece of apparatus. It was standing amongst the remains of the crate in which it had arrived, and which had just been carefully demolished by the robot. As the robot whisked away the packing from around it, Bob examined this newly arrived piece of equipment, but could not understand it at all.

"Whatever is this, Prof?" Bob called out, puzzled.

The Prof. came over.

"It is an experimental magnetic-line-of-force communicator", he told Bob, "which has been sent to me because the experimenter who has been building it has been having difficulties with the magnetic transducers, and has asked for my assistance. He has some unusual and unconventional ideas about magnetic fields, lines of force and transducers, and some very interesting thoughts about the possibilities of long-distance communication, and the detection of distance phenomena, by means of magnetic effects. So he has been struggling mightily to use his ideas, in an attempt to overcome some of the problems associated with the *Inverse Square Law* which seems to affect in a very adverse way, most attempts to detect magnetic fields at great distances."

INVERSE SQUARE LAW

"We have been learning about the *Inverse Square Law* at school, Prof. It affects light, sound, radioactivity, radio waves, electric fields, magnetic fields, gravitational and all sorts of phenomena, whose effect diminishes in proportion to the square of distance from the source. According to this law, Prof, your friend should have just as much difficulty as anyone else who has attempted to use magnetic fields for long-distance communication."

The Prof. agreed. "I warned him about this, Bob, but he claims that he has some ideas on a way of overcoming the difficulty, and has built this apparatus in an attempt, unsuccessful so far, to prove his claims. His idea is that, since magnetic lines of force are theoretically capable of extension to immense distances, it should be possible to link his apparatus to almost any point by means of a magnetic line of force directed by rotating a magnet in the apparatus. Then by vibrating the magnet, or by other means to cause a vibration to travel along the line of force that it can be detected at the distant point which he has chosen."

"But Prof., we have been taught at school that the lines of force are simply a notion and do not really exist, and that the magnetic forces are in the form of a uniform field whose strength diminishes very rapidly with distance. How does this compare with your friend's experiments?"

MAGNETIC QUANTA

"Some of the latest theories of magnetism", the Prof. informed Bob, "tend towards *quantisation* of the field, and according to these theories the field itself is just a notion, with the magnetic forces being exerted by myriads of tiny quanta of magnetic energy, travelling rapidly through the space in which the field is perceived. Now the man who has built this apparatus believes that the lines of force are tracks through space, along which magnetic quanta travel. So he believes in lines of force as a working proposition and basis for his experiments. This is a subject we shall discuss at a later date."

To be continued

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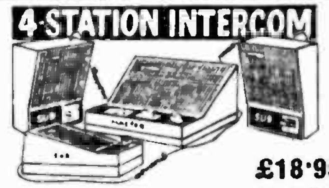

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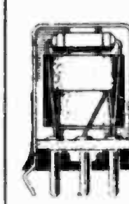

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