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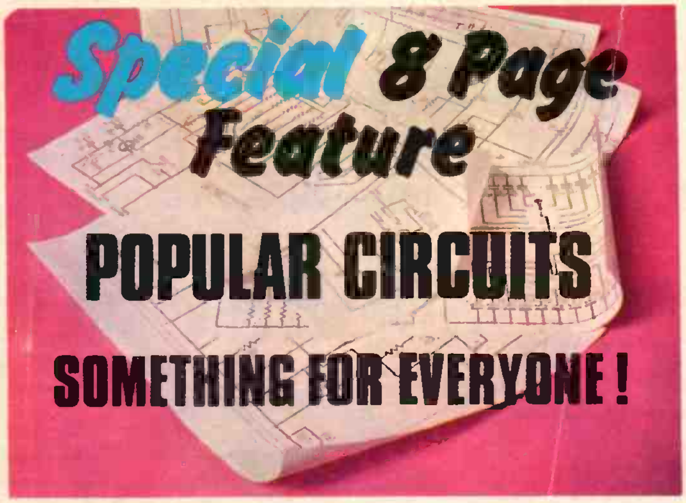

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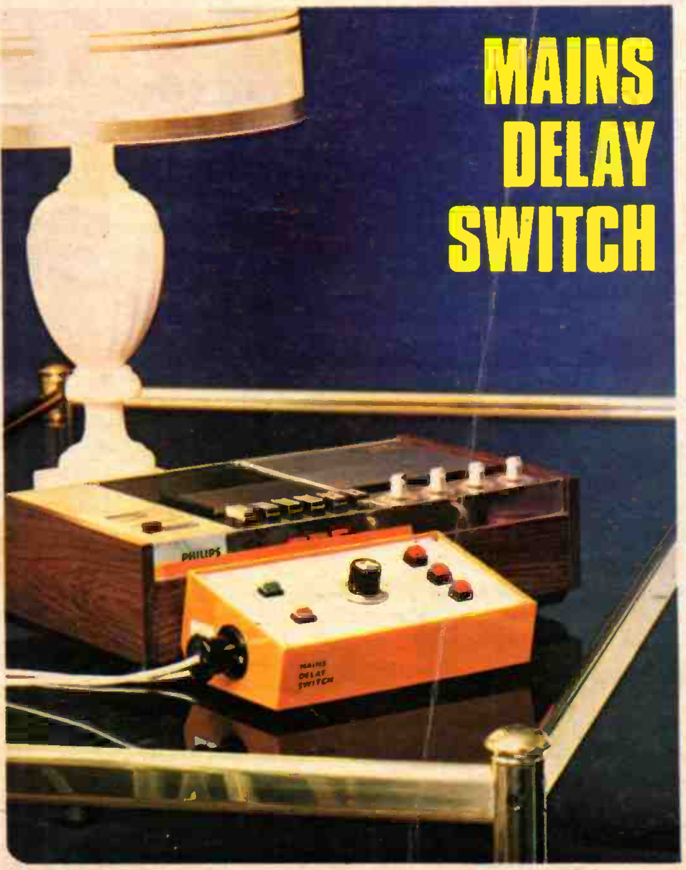

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CA3080A	1·08	MC1304	1·40	TBA510	2·21
CA3086	·60	MC1305	1·40	TBA510Q	2·30
CA3088	1·70	MC1310	1·91	TBA520	2·21
CA3089	2·52	MC1327	1·54	TBA520Q	2·30
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LM308C	1·62	NE556	1·16	TBA560Q	3·22
LM308N	1·25	NE565	1·30	TBA570	1·29
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CD4011 0·24	CD4027 0·64	CD4050 0·64	CD4071 0·25	CD4096 1·19	74LS75 0·60	74LS164 1·52
CD4012 0·24	CD4028 1·02	CD4051 1·00	CD4072 0·25	CD4510 2·00	74LS76 0·40	74LS173 2.35
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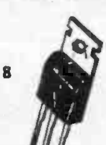

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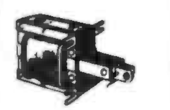

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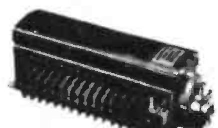
Model TT10—$1\frac{1}{2}$in. pull. Size 3 x$2\frac{1}{4}$ x 2in. **£4.50**
Prices include VAT & postage.

DELAY SWITCH

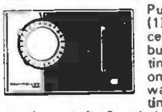
Mains operated—delay can be accurately set with pointers knob for periods of up to $2\frac{1}{2}$ hrs. 2 contacts suitable to switch 10 amps—second contact opens few minutes after 1st contact 95p.

MOTORISED DISCO SWITCH



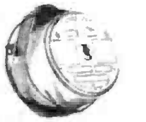
With six 10 amp changeover switches. Multi adjustable switches are rated at 10 amp each so a total of 200w's can be controlled and this would provide a magnificent display. For mains operating. 8 switch model **£5.25**. 10 switch model **£5.75**. 12 switch model **£6.75**.

SMITHS CENTRAL HEATING CONTROLLER



Push button gives 10 variations as follows: (1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only—then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off. A handsome looking unit with 24 hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold we believe at over **£15**. We offer these while stocks last at **£6·95** each INCLUDING VAT and Postage.

LOW R.P.M. MOTORS

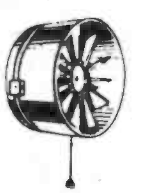


Made by Crouzet—Smiths—SAIWA—Venner and similar famous companies—all supplied ready for 230/240v 50hz mains working at **£2·75** each. Following speeds in stock when preparing this advert.

1 rev per day	6 rev per day
1 rev per hour	12 revs per hour
$\frac{1}{2}$ rev per min	1 rev per min
2 rpm	$1\frac{1}{2}$ rpm

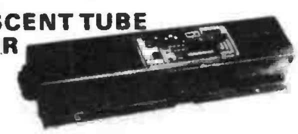
5 rpm 15 rpm 20 rpm 25 rpm 30 rpm

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic feet per hour. Suitable for kitchens, bathrooms factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact, $5\frac{1}{2}$in. casing comprises motor, fan blades, sheet-steel casing, pull switch, mains connector and fixing brackets. **£5·25** including post and VAT.
Monthly list available free send long stamped envelope.

FLUORESCENT TUBE INVERTOR



For camping – car repairing – emergency lighting from a 12v battery you can't beat fluorescent lighting. It will offer plenty of well distributed light and is economical. We offer invertor for 21" and 13 watt miniature tube for only **£3·75** with tube and tube holders as well.

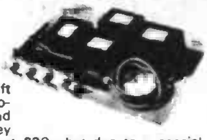
MINI-MULTI TESTER

Amazing, deluxe pocket size precision moving coil instrument—jewelled bearings—1000opv—
11 instant ranges measure:—
DC volts 10, 50, 250, 1000
AC volts 10, 50, 150, 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms.
Complete with insulated probes, leads, battery, circuit diagram and instructions.
Unbelievable value only **£5·50** + 50p post and insurance.

FREE

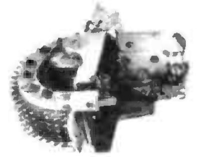
Amps ranges kit enable you to read DC current from 0-10 amps. directly on the 0-10 scale. It's free if you purchase quickly but if you already own a mini tester and would like one send **£1·50**.

MULLARD UNILEX



A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage.

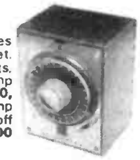
UNISELECTORS



These are pulse operated switches as used in automatic telephone switchboards etc. The pulse moves the switch arm through one position. Except where indicated the selectors are 25 position types and 50v Coil is standard. 24v or 12v operation extra at **£2** per switch.

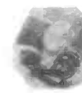
3 pole	£4·80	4 pole	£5·94
5 pole	£7·02	8 pole	£9·72
10 pole	£10·80	12 pole	£12·96
3 pole 50 way	£10·58	4 pole 50 way	£12·74

24 HOUR TIMERS



The one illustrated is 'E' controls this uses the Smiths mechanism as in their autoset. 2 On/off's per 24 hours, 13 amp contacts, override switch **£6·50**. Smiths 100 amp model one on/off per 24 hours **£10·50**, extra contacts **£1·00** per set. AEG 60 amp model with clockwork standby, one on/off per 24 hours **£9·50**, extra contacts **£1·00** per set.

INDUCTION MOTORS



One illustrated is our reference MM11 made for ITT $\frac{7}{8}$" stack $1\frac{1}{8}$" spindle **£2·25**. $\frac{1}{2}$" stack model **£1·76**. 1" stack **£2·75**. $1\frac{1}{2}$" stack **£3·25**.

MAINS TRANSFORMERS

20v $\frac{1}{2}$ amp 20w auto 230v **£1·50**. 18v $\frac{1}{2}$ amp **£1·75**. 6.3v 2 amp **£1·75**. 25v $1\frac{1}{2}$ amp **£2·25**. 24v 2 amp **£2·50**. 50v 2 amp **£4·50**. 9v 1 amp **£1·50**. 8.5v-0-8.5v $\frac{1}{2}$ amp **£1·50**. 100w auto 230-115v **£2·00**. 8·5kv **£9·50**.
Many more, send for list.

WAFER SWITCHES

6 pole 2 way	12 pole 2 way	18 pole 2 way
5 pole 3 way	10 pole 3 way	15 pole 3 way
4 pole 4 way	8 pole 4 way	12 pole 4 way
3 pole 5 way	6 pole 5 way	9 pole 5 way
2 pole 6 way	4 pole 6 way	6 pole 6 way
2 pole 8 way	4 pole 8 way	6 pole 8 way
1 pole 10 way	4 pole 9 way	6 pole 9 way
1 pole 12 way	2 pole 10 way	3 pole 10 way
all £1·32 each	all £2·41 each	all £3·12 each

Multi bank switches up to 72 pole 2 way—to 12 pole 12 way quickly made to special order.

THIS MONTH'S SNIP

Japanese made FM tuner and matching decoder. Two items for less than average price of the tuner only – **£11·20** the two. Don't miss this – stocks will not last long.

RELAYS

12 volts, two 10 amp changeover plug in **95p**. 12v three 10 amp changeover plug in **£1·28**. 12v two changeover miniature wire ended **95p**. 12 volt open single screw fixing two 10 amp changeovers **85p**. 12 volt open three 10 amp changeovers **£1·25**. Latching relay mains operated 2 c/o contacts **£2·11**. Mains operated three 10 amp changeovers open type one screw fixing **£1·25**. Many other types with different coil voltages and contact arrangements are in stock, enquiries invited.

TANGENTIAL HEATER UNIT

3KW MODEL
£5·95
+ £1·50 P & P

A most efficient and quiet running blower-heater by Solatron—same type as is fitted to many famous name heaters—Comprises mains induction motor—long turbo fan—split 2 kw heating element and thermostatic safety trip—simply connect to the mains for immediate heat—mount in a simple wooden or metal case or mount direct onto base of say kitchen unit—price **£4·95** post £1·50 control switch to give 2kw. 1kw. cold blow or off available 60 extra.

Terms. Prices include Post & VAT. But orders under £6.00 please add 50p to offset packing. Bulk enquiries – Please Phone for Generous Discounts 688 1833.

J. BULL (ELECTRICAL) LTD

**(Dept. EE), 103 TAMWORTH RD.
CROYDON CR9 1SG**

IT'S FREE!

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

FM Tuner and decoder, 2 very well made (Japan) units, nice clear dial, excellent reproduction. **£11·20** the pair,
12 Volt Heavy Duty Relay, plug in type has three pairs of 10 amp changeover contacts. A transparent dust cover, price **£1·08** suitable 11 pin base 45.
4 Changeover Relay, upright mounting 4 sets of 10 amps changeover contacts, mains voltage coil **£1·72**
12 Volt Pump. Designed we believe as a bilge pump, this is 12 volt AC/DC motor coupled by a long enclosed shaft to a submersible pump. Suitable for water or most any fluids. Price **£12·50**.
Just arrived. Fruit machines, working order, very impressive choice of several but very heavy so you must collect. **£50.**
High Load 24 Hour Clock Switch, made by the famous AEG Company for normal mains but with clockwork reserve has load capacity of 80 amps at 240V 50HZ. Therefore suitable for dealing with large loads of say shop lighting, water heating, storage heaters etc. etc. Has triggers for on and off once per 24 hours but extra triggers will be available. Price **£1·50** per pair. Size of clock approximately 8" x 5" x 5", totally encased but has lift up flap for ease of altering switching times. Price **£7·50**.
Enclosed 24 Hour Clock, with contacts for breaking 10-12 amps at 240 volts. This one has two sets of on/off per 24 hours, price **£7·00**.
Light Dimmer, our timer module with small mods makes an excellent light dimmer. Contains a 4 amp 400V SCR so it should be suitable for loads approaching 1KW. Price of module and instructions **£2.25**
Push Pull Solenoids, mains operated solenoids which will push as well as or instead of pull. Very heavy duty, estimate this at 20lbs push or pull. $1\frac{3}{4}$" x $3\frac{1}{8}$" x 4" made Magnetic Devices Co. **£7·50**
Flashing Lights, chasing lights, random flashes, strobe effects etc. etc. can easily be achieved using our disco switches. These switches are ex-equipment but guaranteed perfect and supplied suitable for mains working. To get some idea of the loading number, each switch is 10 amp. For the light pipe or Catherine Wheel effect order the 12 switch model with light pipe data model, interconnecting the switches to give fastest speed. 6 Switch model **£5.** 9 Switch Model **£9.75.** 12 Switch model **£6·20.**
Reed Switches, standard 60 watt glass type. Normal open contacts glass lengths 2" diameter $\frac{1}{16}$", 10 for **£1**, 100 for **£8**, 1000 for **£70**.
Flat Reed Switches, for stacking, greater quantity in confined space. Price **50p**.
Single Ended Types for jobs where it is not easy to bring a lead to each end. **75p** each. All these switches are normally open but can be biased to a normally closed position by fitting a magnet adjacent. The reed switch would then be opened by a magnet of opposite polarity being bought up to it.
Ceramic Magnets suitable for operating reed switches, central fixing hole. 10 for **£1**.
Music Centre Transformer 12-0-12 at 1 amp and 9 volt at $\frac{1}{2}$ amp. Normal primary, uprighting, impregnated and varnished for quiet operation. Price **£3·50.**
'W' Shaped Fluorescent Tubes for porch light, box signs or where you want light evenly spaced over a confined area of approx. 10" x 10", 30 watts, made by Philips price **£2·24**.
Extension Speakers 8 ohm 4-5 watts handling power. We have 5 or 6 different models in stock, cheapest being the Partytime at **£3·95** each, again only really a bargain for callers as postage is **£1·50** per speaker.
T.V. Monitors, an item for callers, believed to be in good working order, switchable thro' 405-525 & 625, 21" tube line systems, normal controls, volume, brightness, contrast, width etc. Price **£16·20, 12"** models **£18,** suitable for conversion into special purpose scope, etc.
Auto Transformers for working American tools and equipment, completely enclosed in sheet metal case with American type flat output socket made for computer so obviously first class 500 watts. With cang handle, offered at about half price only **£15.** These may be a bit soiled but are fully guaranteed. Similar but 1000 watt **£29·50.**
Car Starter Charger Kit. New version. We supply two 10 amp rectifiers, 250V transformer and the start charge switch with instructions, price **£9·75.** This is probably one of the most useful pieces of equipment you can have in your garage. Sooner or later you or someone will leave something on and you will have a flat battery, this starter will get you away usually in less than 5 minutes.
Resetter Counter by Veederoot Company, 230/240V mains operated. Intended for surface mounting has a fixing flange at the bottom. Price **£2·16.**
12V Drip proof Relay. Specially designed for going under the bonnet of a car, made by one of our big manufacturers, this really has a removable semi-hard rubber cover. Contacts look suitable for up to 10 amps so this could be the right one if you are thinking about making an anti-thief device. Price **£1** + 8p.
High Speed Uniselector. As many customers know, we have a very comprehensive stock of uniselectors as used in automatic telephone exchanges, light flashing device etc., etc. Just arrived, however, is a high speed model made by famous Plessey, this is 2 pole 32 way with make before break wipers, overall size approx. 4" x 3" x $2\frac{1}{2}$", price **£3·50** + 28p.
Pneumatic Ram for lifting, thrusting, pulling etc., etc. has $2\frac{3}{4}$" travel, looks large enough to open doors, lift, staircase, ventilators etc. Price **£7·00.**
Solder Gun Bargain. The ETP, this is 100 watt solder gun, a very well made tool with lamp to illuminate work, has double insulated mains transformer and is built into the shockproof thermoplastic case. Comes complete with spare tips. Mains operated of course. Price **£4·50.**
Interested in Tape Control. American made tape punches, really beautiful units full of sophisticated parts, designed we believe to automatically operate typewriters, and they can of course be used to operate other punch tape controlled machines. Reference number is NCR Class 461-2 reference 205 H8 R56. We believe these are 8 bit paper tape punches, powered from 115V 50HZ in very good condition with tape **£16·00,** carriage is £3·20.
Memories. The memory units which work with these tape punches, again by NCR, are in very good condition and we believe in working order. Price and details on request.
Tangential Blowers. 12" long with powerful induction motor ideal for blowing heaters or general air extraction or circulation, offered at low price of **£2·70.** The motors are 110V so you will have to work them in pairs or through a dropper or mains transformer. Post £1·08 for one or two.
Digital Panel made for the G.P.O. for incorporation, we understand, in push button dialling units, this has the usual 10 digits, each of which when depressed operated a two pole changeover switch. Really beautifully made size approximately 4" square. price **£3·78.**

NEW SEASON'S COMPONENTS

BRIDGE RECTIFIERS

SILICON 1 amp

Type	Order No.	Price
50V RMS	BR1/50	£0·20
100V RMS	BR1/100	£0·22
200V RMS	BR1/200	£0·25
400V RMS	BR1/400	£0·36

SILICON 2 amp

Type	Order No.	Price
50V RMS	BR2/50	£0·45
100V RMS	BR2/100	£0·48
200V RMS	BR2/200	£0·52
400V RMS	BR2/400	£0·58
1000V RMS	BR2/1000	£0·68

BOOKS BY BABANI

Purchase books to the value of £5.00 from the list below and choose any 60p pak from this page *FREE*.

BP2	Handbook of Radio, TV & Industrial & Transmitting Tube & Valve Equivalents	†60p
BP3	Handbook of Tested Transistor Circuits	†40p
BP6	Engineers and Machinists Reference Tables	†40p
BP7	Radio & Electronic Colour Codes and Data Chart	†15p
BP10	Modern Crystal and Transistor Set Circuits for Beginners	†35p
BP14	Second Book of Transistor Equivalents	†95p
BP15	Constructors Manual of Electronic Circuits for the Home	†50p
BP16	Handbook of Electronic Circuits for the Amateur Photographer	†60p
BP18	Boys and Beginners Book of Practical Radio and Electronics	†60p
BP22	79 Electronic Novelty Circuits	†75p
BP23	First Book of Practical Electronic Projects	†75p
BP24	52 Projects Using IC741 (or equivalents)	†75p
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BP27	Giant Chart of Radio Electronic Semiconductor and Logic Symbols	†60p
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BP34	Practical Repair & Renovation of Colour TVs	†95p
BP35	Handbook of IC Audio Preamplifier & Power Amplifier Construction	†95p
BP36	50 Circuits Using Germanium, Silicon & Zener Diodes	†75p
BP37	50 Projects Using Relays, SCR's and TRIACS	†1·10
BP39	50 (FET) Field Effect Transistor Projects	†1·25
129	Universal Gram-motor Speed Indicator	†8p
160	Coil Design and Construction Manual	†75p
161	Radio, TV and Electronics Data Book	†60p
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202	Handbook of Integrated Circuits (ICs) Equivalents and Substitutes	†75p
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216	Electronic Gadgets and Games	†85p
217	Solid State Power Supply Handbook	†85p
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220	Build Your Own Solid State Hi-Fi and Audio Accessories	†85p
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224	50 CMOS IC Projects	†95p
225	A Practical Introduction to Digital IC's	†95p
226	How to Build Advanced Short Wave Receivers	†1·20
RCC	Resistor Colour Code Disc Calculator	†10p

BOOKS BY NEWNES

No. 229 Beginners Guide to Electronics.
Price £2·25†

No. 230 Beginners Guide to Television.
Price £2·25†

No. 231 Beginners Guide to Transistors.
Price £2·25†

No. 233 Beginners Guide to Radio.
Price £2·75†

No. 234 Beginners Guide to Colour Television.
Price £2·25†

No. 235 Electronic Diagrams.
Price £1·80†

No. 236 Electronic Components.
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No. 225 110 Thyristor Projects Using SCRs & Triacs.
Price £2·50†

No. 227 110 COS/MOS Digital IC Projects For the Home Constructor.
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CASES

ALUMINIUM BOXES. Made from bright ali., folded construction each box complete with half inch deep lid and screws.

No.	Length	Width	Height	Price
159	5¼in	2¼in	1¼in	62p•
160	4in	4in	1½in	62p•
161	4in	2¼in	1½in	62p•
162	5¼in	4in	1½in	74p•
163	4in	2½in	2in	64p•
164	3in	2in	1in	44p•
165	7in	5in	2½in	£1·04•
166	8in	6in	3in	£1·32•
167	6in	4in	2in	86p•

INSTRUMENT CASES. In two sections vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
155	8in	5¼in	2in	£1·40•
156	11in	6in	3in	£1·80•
157	6in	4¾in	1¾in	£1·25•
158	6in	5¼in	2½in	£1·60•

SPECIAL OFFER

AGFA CASSETTES

STEREOCROM

307	C60	RRP ~~£2·05~~	Our price **£1·60**
308	C90	RRP ~~£2·54~~	Our price **£1·80**
309	C120	RRP ~~£3·49~~	Our price **£2·60**

SFD – Super Ferro Dynamic

310	C60	RRP ~~£1·48~~	Our price **£1·00**
311	C90	RRP ~~£1·89~~	Our price **£1·50**
312	C120	RRP ~~£2·62~~	Our price **£2·00**

DIODES SIL G.P.

300 mW 40 PIV (min) SUB-MIN
FULLY-TESTED
Ideal for Organ builders
30 for **50p**, 100 for **£1·50**, 500 for **£5**, 1,000 for **£8**

INTEGRATED CIRCUITS

CMOS

Type	Price	Type	Price	Type	Price
CD4000	£0·15	CD4022	£0·90	CD4046	£1·30
CD4001	£0·18	CD4023	£0·20	CD4047	£1·10
CD4002	£0·18	CD4024	£0·80	CD4049	£0·55
CD4006	£0·98	CD4025	£0·20	CD4050	£0·55
CD4007	£0·18	CD4026	£1·70	CD4054	£1·10
CD4008	£0·98	CD4027	£0·60	CD4055	£1·40
CD4009	£0·58	CD4028	£0·98	CD4056	£1·35
CD4010	£0·58	CD4029	£1·15	CD4069	£0·40
CD4011	£0·20	CD4030	£0·55	CD4070	£0·40
CD4012	£0·20	CD4031	£2·20	CD4071	£0·23
CD4013	£0·52	CD4035	£1·30	CD4072	£0·23
CD4015	£0·98	CD4037	£0·95	CD4081	£0·20
CD4016	£0·50	CD4040	£0·95	CD4082	£0·23
CD4017	£0·98	CD4041	£0·82	CD4510	£1·30
CD4018	£1·00	CD4042	£0·82	CD4511	£1·60
CD4019	£0·55	CD4043	£0·98	CD4516	£1·40
CD4020	£1·10	CD4044	£0·94	CD4518	£1·25
CD4021	£0·98	CD4045	£1·40	CD4520	£1·25

LINEAR

Type	Price	Type	Price	Type	Price
CA3011	£1·05•	MC1303L	£1·48•	709P	£0·25•
CA3014	£1·70•	MC1304P	£1·90•	UA710C	£0·40•
CA3018	£0·75•	MC1310P	£0·95•	72710	£0·30•
CA3020	£1·70•	MC1312PQ	£1·90•	UA711C	£0·32•
CA3028	£1·02•	MC1330P	£1·20•	72711	£0·32•
CA3035	£1·70•	MC1350	£1·20•	UA723C	£0·45
CA3036	£1·35•	MC1351P	£1·20•	72723	£0·45
CA3024	£1·50•	MC1352P	£1·40•	UA741C	£0·24•
CA3043	£1·85•	MC1456G	£1·40•	72741	£0·24•
CA3046	£0·80•	MC1466L	£4·50•	741P	£0·20•
CA3052	£1·60•	MC1469R	£2·95	UA747C	£0·70•
CA3054	£1·35•	MC1496G	£0·98•	72747	£0·79•
CA3075	£1·50•	NE536	£3·50•	UA748	£0·35•
CA3081	£1·50•	NE515A	£3·50•	72748	£0·35•
CA3089	£2·10•	NE540	£1·50•	748P	£0·35•
CA3090	£4·25•	NE550	£0·95	SN76013N	£1·75•
CA3123	£1·90•	NE555	£0·32	SN76023N	£1·75•
CA3130	£0·93•	NE556	£0·82	SN76110	£1·50•
CA3140	£0·90•	NE561	£3·95•	SN76115	£1·90•
LM301	£0·39•	NE562B	£3·95•	SN76660	£0·75•
LM304	£1·60	NE565A	£1·75•	SL414A	£1·95•
LM308	£1·40•	NE566	£1·50•	TAA550B	£0·35
LM309K	£1·50	NE567	£1·80•	TAA621A	£2·00•
LM320-5v	£1·50	UA702C	£0·46•	TAA661A	£1·65•
LM320-12V	£1·50	72702	£0·46•	TAD100	£1·30•
LM320-15v	£1·50	UA703A	£0·25•	TBA540Q	£2·20•
LM320-24v	£1·50	UA709C	£0·25•	TBA641B	£2·25•
LM380-14p	£0·85•	72709	£0·46•	TBA800	£0·80•
LM381	£1·55•			TBA810S	£1·05•
LM3900N	£0·65•			TBA820	£0·80•
				TBA920Q	£3·40•
				TCA270S	£2·20•

ORDERING

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2029	15V-0-15V 1 amp	£2·75•	P. & P. 66p
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Projects... Theory... and Popular Features...

If you happen to be one of the thousands of motorists planning a touring holiday this year, the *Roof Rack Alarm* is going to be well worth looking into. The outlay involved in building this unit will prove a cheap way to ensure peace of mind when cruising along the highways and byways with the family's luggage on top of the car.

Using current parlance, the *Roof Rack Alarm* would be classified as a "dedicated" project. In contrast, the *Mains Delay Switch* can be described as a versatile or general purpose project. It can perform a useful role in association with a variety of electrically powered devices or equipments. So its appeal is bound to be wide.

The *Pocket Timer* as it happens falls somewhere between the "dedicated" and the "versatile" classification. This small instrument is a time lapse reminder and is preset by the user for a given period. Once set the Timer assumes a "dedicated" role. Yet its overall versatility remains.

Why this classification? Well, the electronics world has a habit of adopting commonplace words for its own peculiar use. The word dedicated just referred to is the vogue term to define certain microprocessor chips designed for one exclusive application, as opposed to those devices that are entirely flexible in their application.

In following the trend and applying such definitions to our electronic projects we realise the dangers that lie ahead. Dedicated implies exclusiveness. But we all know that adaptation, modification, and conversion are among the more commonplace activities engaged in by the electronics enthusiast. So in our hobby dedicated must always be rather freely interpreted—or, if you prefer, taken with a pinch of salt.

For example, we know someone is certain to adapt the *Roof Rack Alarm* as a burglar alarm for his chicken coop—or something else equally improbable. Such inspired innovation is an essential part of our hobby. It is why electronics can be all things to all men. Yes, in the broader view electronics fully merits a description suggestive of non-exclusiveness, like versatile, for that's most certainly what it is.

Anyone who might feel we are overstating the case for our pet subject need only refer to the variety of useful ideas included in this month's special feature *Popular Circuits* for evidence of this versatility.

Fred Bennett

Our May issue will be published on Friday, April 21. See page 393 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. 8 APRIL 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

SPECIAL FEATURE

Back issues of EVERYDAY ELECTRONICS (June 1977 onwards—October, November, December 1977 and January 1978 NOT available) 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 7 (state which) are available from the above address for £2·85 inclusive of postage and packing.

SOMETHING FOR EVERYONE 15 POPULAR CIRCUITS

ROOF RACK

SOON, many motorists will be setting out in search of the sun, roof-racks loaded to capacity with camping gear. Whether or not they will find the sun cannot be influenced electronically—at least the author does not think so. Electronics can however help with the safety of the roof load.

DESIGN CONSIDERATIONS

The author wrote this with the experience of having nearly lost his roof-rack on holiday last year. The fittings had been checked for tightness only a few miles previously but vibration on a bumpy road had loosened them. In many parts of Europe cobbled roads are common but motorway driving can be equally dangerous as the long, smooth ride leads to a complacent "out of sight out of mind" feeling.

CHECKS

It was said on the radio recently that accidents involving roof-racks are common and it was recommended that very frequent checks should be made.

If these checks were made at every opportunity, it is unlikely that the roof-rack would part company with the car suddenly. It is more likely that trouble would be heralded by a small movement at first and if this were noticed in time then a real disaster would be averted. In the author's case, the roof-rack was visible through a roof ventilator and the small initial movement was spotted. In most cases the roof-rack is invisible and soon forgotten, so an electronic means of detecting this early movement was devised.

WARNING NOTE

In short, then, this project helps the motorist to notice any small shift of the roof load. This gives him a chance to stop before all his belongings are strewn over a large area with possible damage to oncoming vehicles and the sort of holiday-ruining trouble with gesticulating local police.

The circuit is designed to give a penetrating warning note which will not stop even in the unlikely event of the roof-rack moving back into its proper position. If the car is then gently brought to rest no harm should be done.

Gentle braking is essential here as panic could easily prove disastrous. As the circuit will only operate on rare occasions, it may be powered by its own battery. During actual operation the battery drain is fairly high but when the unit is switched on in the standby condition, virtually no current is drawn. This means that in the event of forgetting to switch it off the battery should still remain in good condition for long periods.

START HERE FOR CONSTRUCTION

The circuit is built on a piece of stripboard having 12 strips x 15 holes. Details of this board and other wiring is shown in Fig. 1. Note the correct leadouts of the thyristor and transistors.

It is preferable before the unit is finally fitted in the car to test it first. To do this simply connect a wire in place of the microswitch, and turn on the unit. If the circuit is operating correctly the tone from the speaker should remain even when the wire is removed. If

this test is satisfactory the microswitch can then be connected to the roof-rack.

MICROSWITCH

The sensing device is a microswitch mounted on the roof-rack. The operating arm of this microswitch, suitably shaped, rests on the head of a small plastic or rubber sucker mounted on the roof of the car.

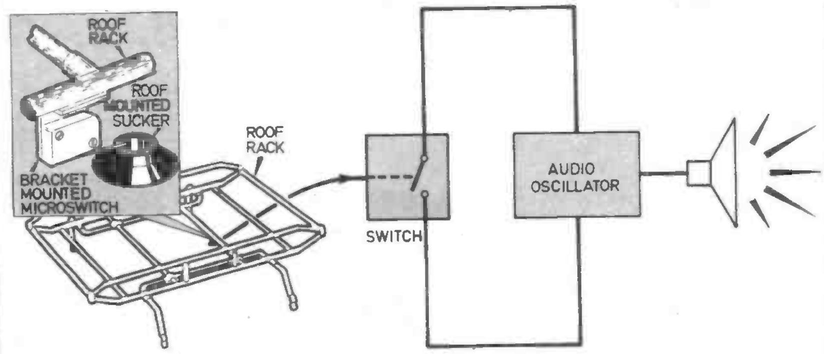
A fairly flat part of the roof should be chosen for this and the sucker should be checked for security before the circuit is constructed. In particular, the sucker must be capable of staying in place for sufficiently long periods. The alarm will "fail safe" if the sucker becomes detached and sound a warning.

Suitable suckers may be bought from chain stores very cheaply. Half an hour with an old box of toys may well furnish some very good ones, arrows for toy guns are one idea. If the head of the sucker is too large and flat, a self-tapping screw or similar may be used to make it smaller and sharper.

The microswitch has one pair of normally closed contacts and the sucker presses its actuating lever against the spring into the off position. The microswitch may have other pairs of contacts too but only the normally closed pair will be used. A small battery and bulb may be used to identify the correct contacts if necessary.

When the operating lever moves off the top of of the sucker due to a small movement of the roof-rack, the electronic circuit is triggered and a warning note will sound. This can only be cancelled by switching off the unit inside the car.

The exact type of microswitch chosen for this project will be ruled largely by the clearance which



HOW IT WORKS

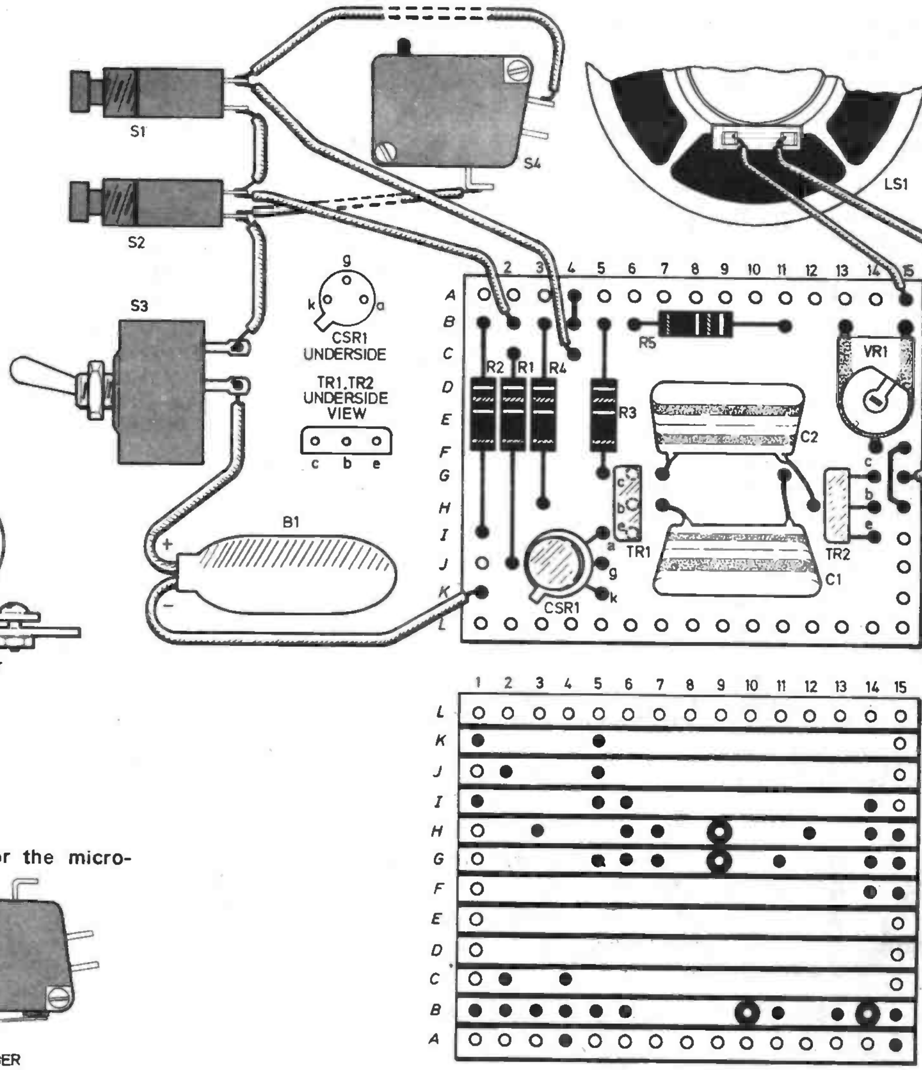
Normally a load on the roof rack of the car is still. However, if for some reason, say a very bumpy road, the load should shift this will cause the microswitch to close and complete the circuit to the *switch*. The *switch* is in fact a thyristor, a semiconductor device which allows current to flow when triggered by an external source. Once triggered the device will remain on until the current through it is reduced to zero.

As the *switch* is now operated by the microswitch, a path is completed to allow the *audio oscillator* to operate. This part of the circuit produces a tone in the speaker to inform the driver of the precarious position of the load.

ALARM

By T. R. de Vaux-Balbirnie B.Sc.

ROOF RACK ALARM



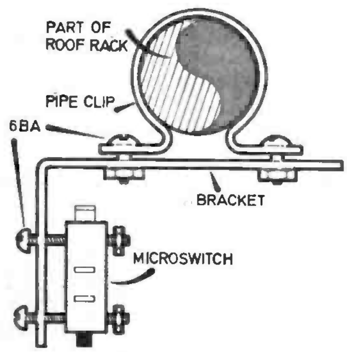


Fig. 3. Mounting details for the microswitch.

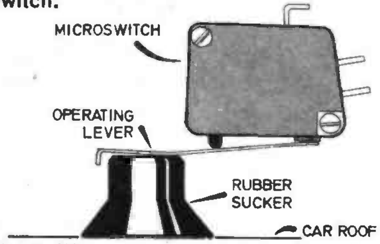


Fig. 2. The operating lever is shaped and positioned.

Fig. 1. Wiring details for the unit. Also shown is the stripboard layout and underside view.

COMPONENTS

Resistors
R1 10kΩ
R2 10kΩ
R3 1kΩ
R4 10kΩ
R5 1kΩ
All ¼W carbon ± 10%

Potentiometer
VR1 4·7kΩ horizontal preset

Capacitors
C1 0·1μF polyester
C2 0·1μF polyester

Semiconductors
TR1 ZTX300 silicon *npn*
TR2 ZTX300 silicon *npn*
CSR1 TAG1/100 or similar thyristor rated at 1A 50V or more

Miscellaneous
S1 push-to-make release to break push switch
S2 push-to-break release to make push switch
S3 single-pole single-throw toggle switch
S4 lever operated microswitch
LS1 loudspeaker 70/80 ohms about 50mm diameter
B1 9V PP3 battery
Stripboard 0·1 inch matrix 12 strips × 15 holes; small plastic case as required; connecting wire; battery clip; pipe clip and bracket (see text); rubber sucker; solder.

See **Shop Talk** page 373

exists between the roof-rack and the roof of the car. It will also depend on the ingenuity of the constructor to make a reliable sensing device to suit his particular car and roof-rack. It may be possible to use an ordinary small lever-arm microswitch, with the lever carefully shaped to the contour shown in Fig. 2.

This may be done with fine-nose pliers. The lever will then bear directly on the top of the sucker. In other cases it may be better to use the type of microswitch which operates through the action of a piece of wire passed through the operating spindle.

LOW TORQUE

The type shown is called a *low torque* microswitch and it is used for coin operated machines and the like. These switches have the advantage that the actuating wire may be long, and shaped to suit the particular application. If wire is used it must be chosen very carefully—it should be workable but fairly rigid.

It must not be so sloppy that the microswitch tends to operate when the car is jumping around or in the course of normal driving.

MICROSWITCH MOUNTING

One satisfactory way of attaching the microswitch to the roof-rack is shown in Fig. 3. A small metal bracket is used, bolted to the microswitch with 6BA nuts and bolts. A plastic pipe clip, of the type used by plumbers to attach water pipes to the wall, is mounted on this bracket. The size of the clip must be such that it will spring tightly into position on a suitable part of the roof-rack frame.

Twin wire must be connected to the appropriate contacts of the microswitch using suitable connectors allowing removal of the rack / microswitch combination. Stranded wire must be used rather than single which would not withstand vibration for long. A fairly light gauge of wire may be used, as the current which it carries is negligible.

The wire is fed through a convenient point on the car to the unit inside. The unit itself may be built into a small plastic box, a soap box is one idea. This may be suitably

CIRCUIT DESCRIPTION

The circuit of the unit shown in Fig. 4 operates in the following manner.

When the microswitch operates, current flows to the gate of the thyristor CSR1, through R1 and "fires" it. Thyristors which once fired, will remain conducting until the current flowing in the anode/cathode circuit is interrupted or falls to a very low value. Resistor R2 is provided to ensure that the current never falls below this threshold value during operation.

In this way, current is allowed to flow to the rest of the circuit which consists of an astable multivibrator. The suggested component values give a very rapid oscillation which, when fed to the loudspeaker, gives an audible tone. The frequency of this tone may be adjusted through quite a wide range by means of the preset resistor VR1.

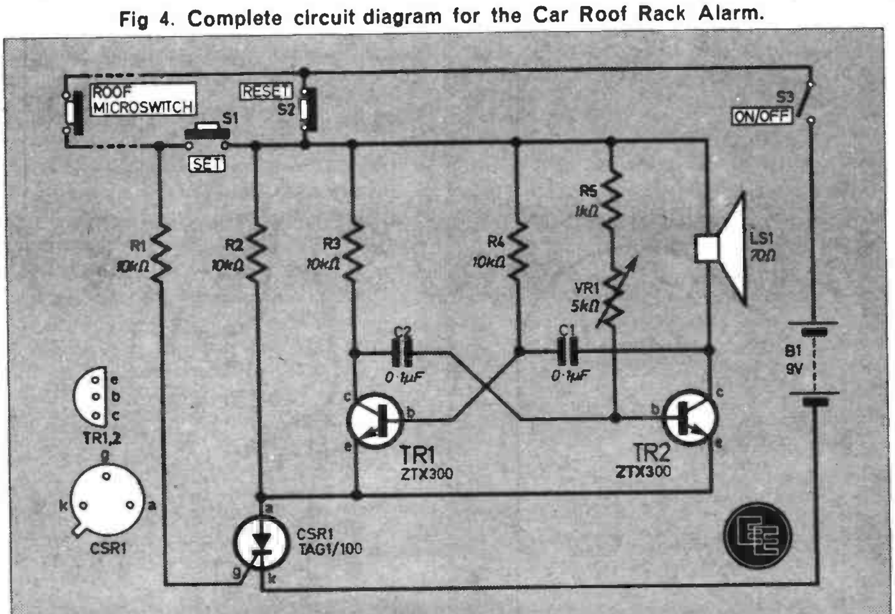
The signal will sound until the unit is switched off using switch S3.

Two press button switches are provided on the unit with which the circuit may be checked at any time. Switch S1 operates it and S2 cancels it. It should be noted that this only checks the system electronically as to the state of the battery and circuit. It does not check the condition of the wires leading to the microswitch or the microswitch itself.

It will be seen from the circuit diagram that there is a resistor, R5, in series with VR1. This is to prevent excessive base current flowing in TR2 in the event of VR1 being set to too low a value. This would destroy the transistor. It would be possible to omit R5 if great care were taken during adjustment of VR1 but the very small savings in terms of cost and size are hardly worthwhile.

If the specified transistors cannot be obtained then any medium or low power silicon *npn* transistor of a similar type should do. The very common 2N706 is one such possibility.

Fig 4. Complete circuit diagram for the Car Roof Rack Alarm.



sited inside the car. It would be better to avoid a position where books and maps could be placed on top of it as this could obscure the sound.

TESTING

With the circuit finally constructed and checked, VR1 is adjusted to obtain the desired note. It will probably be found that a high pitched tone will be heard best above the engine and other noise inside the car. The miniature loudspeaker deserves special mention. It goes without saying that it should be as small as possible, 50 to 70 mm or so. At one stage a small dynamic microphone insert was used in place of the loudspeaker.

This gave very encouraging results, as well as making the project much smaller. This idea cannot be recommended, however, as this is obviously not the correct use for microphone inserts and they may easily be damaged by the rather high current. It would be most unwise to experiment along these lines with anything but a scrap insert.

This little project really should give peace of mind on camping holidays but, before setting out for the first time, it is essential to test the sensing arrangements and adjustments made, as necessary, to ensure reliable operation.

In particular the unit may alter its characteristics when a load is placed on the roof-rack. One final point is to provide some simple protection for the microswitch against rain. ⌘

Treasure Hunters

I have been building metal detectors of the b.f.o. type for some time now, and until recently have been unable to achieve a really satisfactory sensitivity and depth of penetration.

My most recent modification however, has improved both of these important characteristics by approximately 200 per cent, at no extra cost of materials. The modification involves altering the search coil formation as shown in Fig. 1.

The effect is to strengthen the field and produce a secondary field across the centre of the coil.

Results found using this coil pattern are detection of ½p coin at a depth of 5in. and a 6in. saucepan lid at a depth of 2ft 8in.

K. Stephens.
Hythe, Hants,

Treasure Locator

With reference to the *Treasure Locator* in the October issue, could you please advise me where to obtain the 20nF 1 or 2 per cent capacitors.

I have tried several mail order companies without success.

R. N. Warren,
Kent.

During our investigations of the prototype we found that these capacitors are not too critical in tolerance, also they cannot be readily obtained on the amateur market. The closest value which can be used is 10nF, and two of these may be wired in parallel. As tolerance is not too important 5 per cent Mylar types may be used. These can be obtained from Watford Electronics. This company can also supply the 1250pF trimmer and 50pF air spaced trimmer.

Crossed Lines

In connection with the *For Your Entertainment* article by Adrian Hope on page 215 of the January 1978 issue, I would like to correct an inaccurate statement in the section headed Telephone Tones.

Mr. Hope is correct in saying that on any telephone call e.g. local, STD or even ISD the ringing current is generated at the called subscribers end, in the case quoted London. But, he is wrong in saying that the ringing tone heard is locally generated, i.e. Birmingham, and out of sync with London as the ringing tone also comes from the distant end.

The tone/current generating machines used by the BPO have 3 phases of ring current/tone and it is true to say that the phase used to ring the called subs bell need not be the same phase as being heard as a ring tone. This would mean that two rings "from" (i.e. heard in Birmingham) could only be one or two bursts of ring current in London and not three as the third ring current burst would be after the second ring tone.

If you dial abroad you always hear the ring tone of the foreign country and not a locally generated BPO tone, which also demonstrates that the tone and current both originate at the distant end.

M. Tott,
Enfield,
Middlesex.

Mr. Hope replies. . .

I am grateful to readers for picking up this point. I checked the item with the Post Office prior to publication and reported my understanding of what was said.

But the main point of the item remains the same, namely that one phone ring in the callers ear is not necessarily one phone ring at the other end.

Thus prearranged "call signs" relying on fixed numbers of rings are inherently unreliable—even though many people rely on them.

Teach In

Concerning the *Teach-In* series, I have bought a ferrite rod which is the right width, but which is too long. Is there any way in which it can be shortened?

M. Rogers,
Glos.

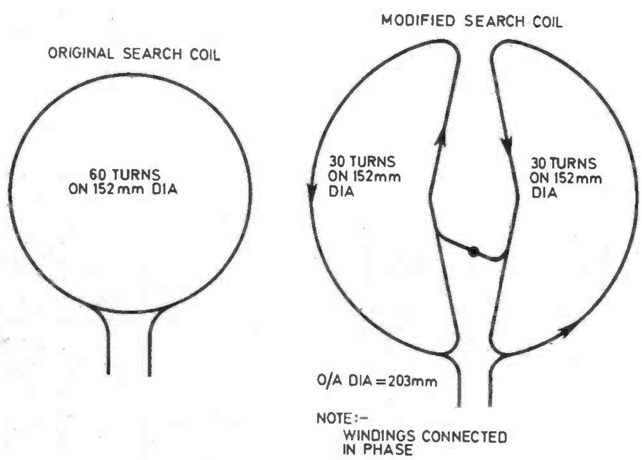
Any ferrite rod which is found to be too long can be easily shortened. First make two V shaped cuts opposite each other at the position required using a small triangular file. Then holding the required section tap the excess smartly on the edge of a table. You should then find the excess has broken away cleanly.

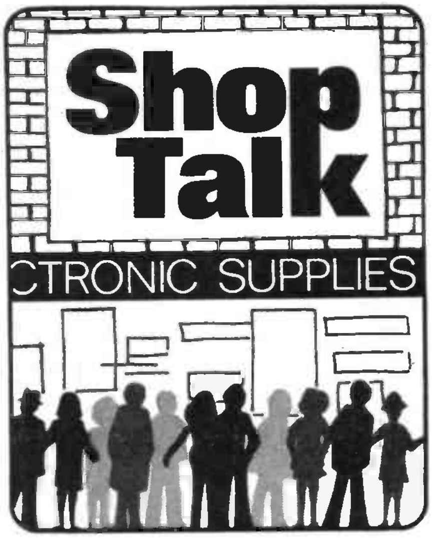
TV Games Modifications

A great many of the popular TV games have either been built or purchased, the majority based on the 8500 i.c. Various modifications are possible, but definitely the cheapest, in my opinion, is to rewire the manual serve switches across the ball speed selector.

Each player can then increase the ball speed at will, ideally when his opponent is positioning to intercept the ball. The extra switches adding a whole new element of skill.

D. Ian,
Hampton Court,
Surrey.





By Brian Terrell

New products and component buying for constructional projects.

THE *Automatic Phase Box* article that appeared in our December 1977 issue has been giving trouble to some constructors, so we hear. In most cases, the oscillator has been observed to be operating satisfactorily and that signals are passing through the phasing segments with a slight increase in gain (to be expected since the first stage has a gain of two) but phasing is absent. Also some constructors are disappointed at the lack of what they call "depth" of phase.

What these readers call depth is obviously different from our interpretation of this term. Depth is the ratio of the amount of phased signal mixed with the original, and in the published circuit is the maximum obtainable since equal amounts are mixed at the output giving complete annihilation when the signal is shifted by 180 degrees. What is probably being observed is a lack of phasing range which can be overcome by the modifications below.

The symptoms suggest that the problem lies in the referencing of the sweeping control voltage being applied to the gates of the field effect transistors TR1 and TR2, with respect to the d.c. level of their source terminals. As already mentioned, the sweep range in some cases is inadequate but can be cured by reducing the effect of the attenuator network (R13, R14) across capacitor C2. An increased peak-to-peak control signal can be realised by increasing the value of R14 or even omitting it completely to obtain maximum swing.

The d.c. level of the source terminals of TR1 and TR2 can be adjusted by VR2 (1 kilohm) but this only allows minor adjustment of this datum line and is inadequate to cater for the characteristic spreads of the 2N3819 f.e.t.s. It is recommended that this preset be increased in value to 22 or 47 kilohms, allowing much greater choice of datum line level.

Component Catalogue

A new catalogue from an established component supplier, The Component Centre, 7 Langley Road, Watford, Herts. is now available at a cost of 40p which includes postage. We have received an advance copy of this large format (300 × 210mm) 36 page catalogue which includes price lists. We are pleased to see that the prices are V.A.T. inclusive. No additional postal charges are to be added to the total bill as this expense has been taken into account in the pricing.

The well laid out catalogue carries an extensive range of components which should suit the majority of the needs of the E.E. constructor and includes semiconductors, TTL, CMOS, cases, test equipment, switches, plugs/sockets, resistors, capacitors etc. The text is generously supplemented by drawings and photographs of the listed components.

Each catalogue is accompanied by four vouchers each worth 25p and can be used when ordering goods over £5 (1 voucher per £5).

The Component Centre apologise to readers for the delay in sending out their Teach-In 78 kits. This was attributable to some components being out of stock (due to heavy demand) and waiting for manufacturers deliveries. These problems have now been resolved and Teach-In kits are ready for immediate despatch.

The AVO DA116 digital multimeter.

Digital AVO

Probably the best known manufacturer of multimeters, Avo Ltd., have recently added a new product to their range. This is a digital multimeter called the DA116.

This portable instrument with liquid crystal display employs the latest l.s.i. (large-scale integration) technology and has extensive measuring capabilities: 200mV to 1000V full scale, 200µA to 10A full scale on both a.c. and d.c. ranges. There are six resistance ranges allowing measurements up to 20 megohms to be made.

A special feature on this model is the "high speed ohms" setting providing rapid read-out stabilisation, especially useful when carrying out multiple continuity tests. Another interesting feature on this instrument is the facility for checking semiconductor junctions, such as diodes and transistor emitter/base and collector/base, both under forward and reverse bias conditions.

The cost of the instrument is £99 plus V.A.T. at 8 per cent and is available through the usual Avo outlets. Further information can be obtained from Avo Limited, Archcliffe Road, Dover, Kent CT17 9EN, Tel: Dover 202620.

Constructional Projects

Most of the components required to build this month's constructional projects are available from a number of sources and should therefore present few buying problems. Just a few components require a mention here, the first being the silicon controlled switch, type BRY39, specified for the *Pocket Timer*. This device has never been used in EVERYDAY ELECTRONICS until now and will be unfamiliar to many readers. We have contacted Marshall's, (whose address can be found in the advertisement section in these pages) and they tell us that they hold stocks of this device.

In the *Mains Delay Switch* project, a mains transformer is called for having two 6V secondary windings. As can be seen from the circuit diagram, these windings are wired in series, therefore any transformer rated at mains/12V 500mA centre-tapped secondary will be suitable.

Lastly, the microswitch in the *Roof Rack Alarm* project. The type used in the prototype was of the lever variety. There are three types of microswitch, the standard or button, the lever and the roller. The roller version could be used but the button type will need some modification.

The lever type microswitch can be obtained from The Component Centre (address above) at a cost of 45p including V.A.T. and postage. Order as microswitch type MS3.

TEACH-IN 78 Part 7

BY GEORGE HYLTON

VALVES—FETS—TRANSISTORS

WE CONTINUE this month with our main subject of amplifiers. One new subject which we shall introduce is that of *mutual conductance*. However, since amplifiers are used a great deal, in one form or another in electronics, we shall discuss in detail the most important parameters. These are, voltage gain, decoupling, noise, and matching.

Later a practical working amplifier can be built and these ideas tested and proved.

DECOUPLING

You should in fact find that the circuit Fig. 6.11. oscillates, well what causes the oscillation? As you know, the basic cause of all oscillation is positive feedback, part of the output of a non-inverting amplifier fed back to the input. Your two-stage amplifier is non-inverting.

The first stage inverts a positive signal to a negative one and the second inverts it back to positive again. Overall the circuit is non-inverting; i.e, a positive input gives a positive output. The gain is high, say 10,000. So if only one ten-thousandth part of the output is fed back oscillation is produced.

The reason for the oscillation when the input is connected to the positive rail is that, contrary to our earlier assumption, the battery does have some impedance to a.c. signals. Some of the output of TR2 Fig. 6.11. flows through its d.c. collector load resistance and hence through the battery's impedance r.

Connecting C1 to the positive rail feeds back any voltage across r to the amplifier input, promoting the oscillation. In any amplifier with *three* or more stages this kind of positive feedback via the d.c. collector load of the first stage is liable to take place. To avoid it, decoupling components are added to the basic amplifiers. Fig. 7.1.

First, a large capacitance C_{D1}, say 1000μF is connected across the power supply to keep its a.c. impedance low. A resistance R_D is put in the positive side of the supply as shown and a second large capacitance C_{D2} connected across the supply line, so that any feedback which gets through R_D is again given a low impedance to flow *through* rather than flow *into* the early stages.

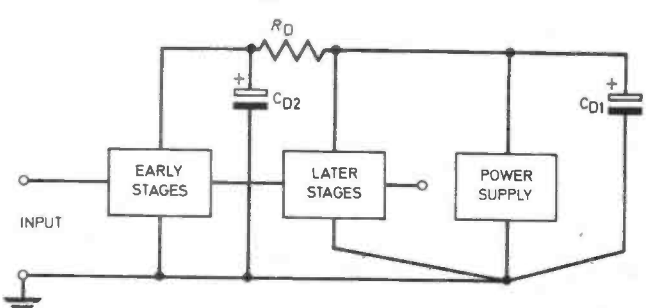


Fig. 7.1. Using various decoupling components as shown here, forms of oscillation can be avoided.

Positive feedback can also be caused by the impedance of the connections to the earthy side of the power supply. To avoid this, separate connections are made from the early and later stages to the power supply, and if an actual earth or chassis connection is used it is made at the input, as shown.

VOLTAGE GAIN

So far we have been using voltage amplifiers. But we do not really know yet how a transistor can amplify a *voltage*. The only measurements we have made show that it can amplify a *current*.

It is clear, in a general way, that this can lead to voltage amplification as well. But we need to know in some more direct way how the input voltage affects the output voltage. Like many difficult problems this one yields to patient analysis.

First, the output voltage is the result of the output current flowing through the collector load impedance. So if we know how the input voltage affects the output current that is good enough.

The magic formula is;

$$\frac{\text{Change in collector current}}{\text{Change in base voltage}} = 40 \times I$$

Here I is not so much a current as a number, the number of milliamps of collector current. In practice it is perhaps best to think of millivolts of base voltage and microamps of collector current.

The formula then says that a change in base voltage of 1mV causes a change of collector current of 40μA, when the d.c. collector current is 1mA. If the d.c. collector current is reduced, the effect of the base voltage is reduced.

For a collector current of 100μA, a change in base voltage of 1mV produces only 4μA change of collector current. However, if the collector current is reduced it is usually possible to increase the collector load resistance. So the result of it all is that the voltage gain is 40 times the number of volts dropped in the collector load. This was the basis of our estimate of the voltage gain of a single stage amplifier.

The collector load dropped about 5V so the gain was $5 \times 40 = 200$.

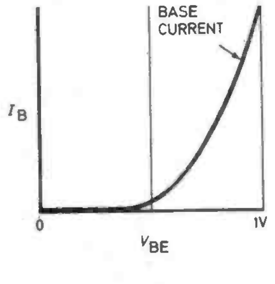


Fig. 7.2. Increasing the voltage on the base/emitter junction causes a corresponding increase in the base current.

MUTUAL CONDUCTANCE

The relation between the base voltage and collector current is called the **mutual conductance** or **transconductance**. It is measured in the same units as ordinary conductance and is based on the idea that:

One ohm will allow one ampere to flow when one volt is applied.

Conductance is therefore measured in amperes per volt, but as this is a rather cumbersome expression a conductance of 1A/V is called one **siemens** symbol S.

The input impedance goes down as the input current goes up.

The reason is that the base/emitter part of a transistor is a semiconductor diode which passes a rapidly increasing current as the voltage is increased Fig. 7.2. The collector current is just the base current multiplied by the current amplification.

A transistor which has high current amplification need have only a small base current. So the input impedance increases as the current amplification increases. The a.c. current amplification is called h_{fe} and the a.c. input impedance is roughly;

$$\text{Input impedance} = \frac{h_{fe} \times 25}{I_c}$$

Thus a transistor operated at 1mA with an h_{fe} of 100 has an a.c. input impedance of $100 \times 25 =$ 2,500 ohms. You can see that for high input impedance the currents must be low. At audio frequencies silicon transistors still work with quite small collector currents, down to 10μA or less.

However the distortion may be too high at these low currents and for the first stage of an audio amplifier a collector current of 30μA is fairly typical.

VALVES, FETS, TRANSISTORS

VALVES

The transistor, more properly called the bipolar junction transistor, is just one of a family of amplifying devices. The first, the radio valve or vacuum tube, is the easiest to understand Fig. 7.3.

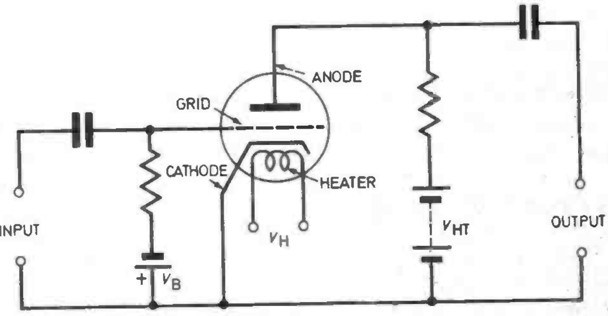


Fig. 7.3. Representation of a valve. The type shown is called a triode—containing three electrodes.

A heated **cathode** is coated with metal oxides which emit electrons into the vacuum inside the glass envelope. The negatively charged electrons are attracted to the positively charged anode. Their passage is controlled by the **control grid**, a negatively charged electrode placed between the cathode and the anode. The grid has spaces through which the electrons can stream to the anode, but the rate at which they do so is controlled by the negative charge. The signal voltage is applied to the grid and the output taken from a load resistance in the anode circuit.

A valve has infinite input resistance and a transconductance of typically 3mS. Its disadvantages are that it is physically large, requires considerable power from the heater supply V_H to heat its cathode, needs a high voltage for the anode V_{HT} of 100V or more, and wears out.

FIELD EFFECT TRANSISTORS

The field effect transistor (f.e.t.), though a relative newcomer is rather like a valve in many respects, but it has enormous advantages, see Fig. 7.4. The **source**

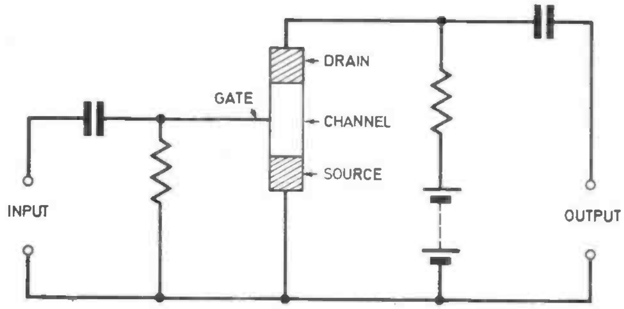


Fig. 7.4. The f.e.t. is in many ways similar to the valve. One big difference is the f.e.t. does not consume large amounts of power.

emits electrons or holes into the channel. These *current carriers* are then attracted by the charge on the **drain**. Their passage along the channel is controlled by the charge on the **gate**.

The f.e.t. is a solid device. It needs no heating because the source emits electrons at ordinary temperatures. The drain needs only a low voltage, like an ordinary transistor. The input impedance is virtually infinite and the output impedance is high. The transconductance is about the same as that of a valve.

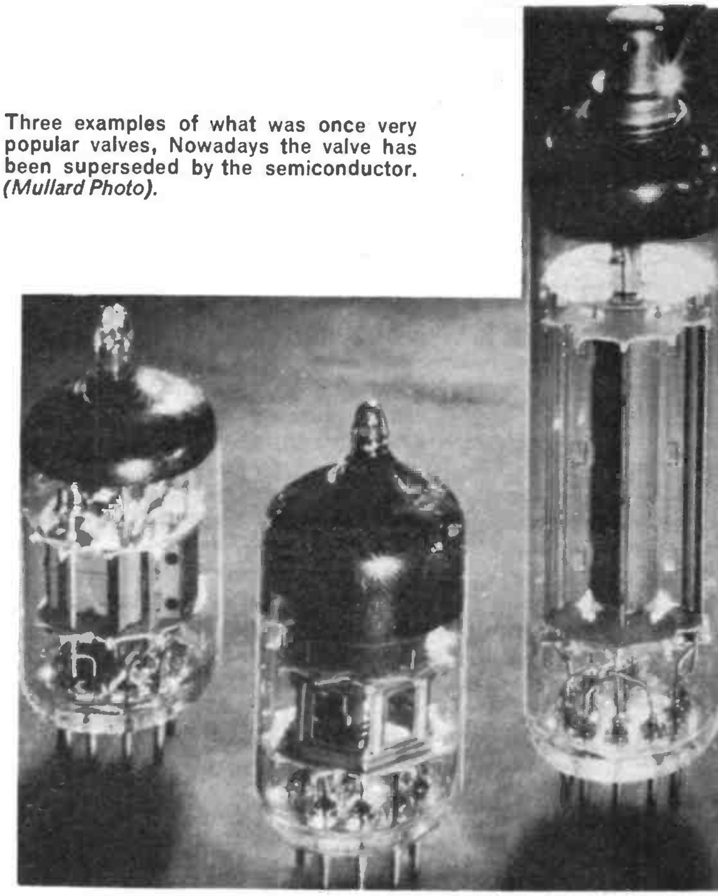
TRANSISTORS

The bipolar transistor can be thought of as a very good f.e.t. spoiled by having a low input impedance. Its transconductance, at similar currents is higher. Its output impedance is high and its voltage requirements moderate.

You can see that despite the different names of their various electrodes all three devices have similar features. They all have some sort of emitter which releases current carriers, some sort of control electrode which regulates their flow and some sort of collector which takes them to a load. It can be shown that in all three devices the flow of carriers is really controlled by the *charge* on the control electrode.

In the case of a bipolar transistor however the low input resistance allows the charge to leak away all the time so current must be supplied to the base to maintain the charge. Another feature of bipolar transistors is that both electrons and holes are present during their operation.

The physics of transistor operation is very complicated. Fortunately you do not need to understand it to use the devices. One thing which may be helpful, however, is the *transistor equivalent circuit*. This is a



Three examples of what was once very popular valves, Nowadays the valve has been superseded by the semiconductor. *(Mullard Photo)*.

"translation" of a transistor into standard electrical elements which work together to produce the same behaviour as a real transistor. There are many possible equivalent circuits. The simplest, Fig. 7.5, is a good starting point.

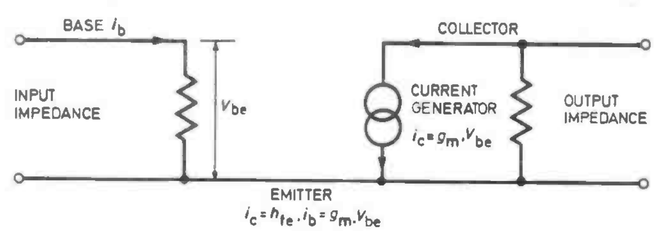


Fig. 7.5. A transistor can be simplified for most explanations by the circuit shown here.

It shows the transistor as a circuit with an input resistance, an output resistance, and a current generator. The current generator expresses the transconductance, g_m.

It gives out a current which depends on the base/emitter voltage, as we saw earlier. The output impedance is usually so high compared with the load impedance (which is connected across the output impedance, a.c. wise) that it can be forgotten about.

Virtually all the current from the generator flows out to the load. The equivalent circuit for a valve or f.e.t. can be drawn in the same way but with different values of impedance and transconductance.

Missing from this simple equivalent circuit is **internal feedback, which is important at high** frequencies.

SIGNALS AND NOISE

SIGNALS

When Marconi registered in his log book the first trans-Atlantic radio communication he wrote "signals" and the time.

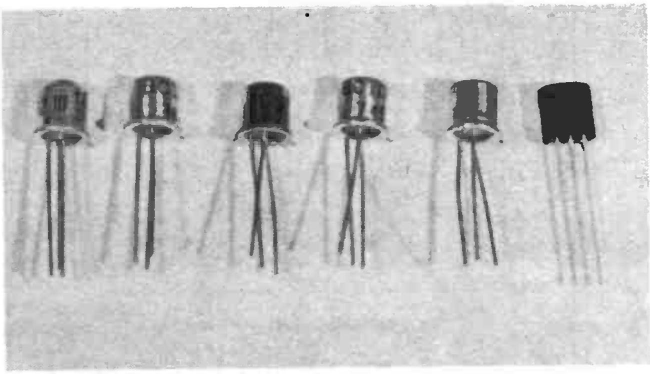
This was a natural thing to write. The Morse code which he was using was the electrical equivalent of earlier codes, using flags, flashing lights, beacon fires, and so on.

All these were called signals, so it was reasonable to call Morse code messages signals. When, later, it became possible to transmit speech, engineers used the same word signal for the electrical currents and voltages which carried the speech sounds. From then on the word "signal" has come to mean anything which conveys information.

NOISE

Noise in electronics means anything which tends to blot out wanted signals. Especially, however, it means the sort of "hash" (random noise) which comes out of a sensitive radio receiver or audio amplifier when the gain is high and there are no signals to mask this background noise.

Noise is inevitable. Anything capable of absorbing power is a generator of noise. This means that all the resistances in a circuit generate noise. How?



The transistors shown here are typical of the wide variety manufactured today. They are shown here near full size.

Well, the electrons in a resistor are not bound rigidly to their atoms. Given sufficient energy, an electron can leave its parent atom and move from atom to atom through the substance of the resistor.

A movement of electrons is an electric current. An accumulation of electrons is an electric charge —a voltage.

In the resistor, the electrons acquire the energy to skip from atom to atom from heat. Unless the resistor is cooled to the absolute zero of temperature, it still contains some heat, that is some thermal energy.

It is this thermal energy which agitates the electrons and so to speak shakes some of them loose.

A free electron can move in any direction. If two free electrons move in opposite directions at the same time, their effects tend to cancel. On the other hand, if they move in the same direction, their effects reinforce one another. In a real resistor there are millions of free electrons, all moving about randomly.

The laws of chance, applied to this situation, show that over any limited period of time there will be enough occasions when the electrons help one another to produce a definite amount of **noise power.** Since raising the temperature increases the energy and creates more free electrons, the noise power is directly dependent on the temperature. It also **depends on the bandwidth.**

If your radio or amplifier has a treble control and you alter it while listening to the random noise, the character of the noise changes. With treble cut, it becomes softer, with treble lift more crisp and hissing in tone. This is because the audio bandwidth is changed by the control, and treble lift lets through more noise.

Resistor noise is often called thermal agitation noise. It is the absolute minimum amount of noise in a circuit. All practical circuits are noisier than this, because the amplifying devices, transistors etc, generate their own special kinds of noise as well and carbon resistors generate extra noise when a current flows through them.

RATIOS

You can see from this that there is no point in trying to make a receiver or an amplifier infinitely sensitive. If, for example, one transistor amplifies 100 times, two transistors may amplify 10,000 times and three 1 million times. If, however, the first transistor generates 10 microvolts of noise, this will have grown to 10 volts at the output of the third transistor. Small input signals of a few microvolts will get lost in the noise.

For speech and music, the signals at the input must be at least 10 times the noise voltage for reasonable intelligibility and 1000 times for good quality. These figures are usually expressed in decibels and called **signal-to-noise ratios.**

For just intelligible speech, a signal-to-noise ratio of 20 decibels will do. For hi fi, you need 60 decibels or better, which means that signal voltages must be 1000 times the noise voltages. You can see from the last figure why audio pre-amplifiers do not need much voltage gain. To be at least 1000 times greater than an amplifier noise of $3\mu V$, the audio input must be at least 3mV. If the pre-amplifier has to drive a power amplifier which needs an input of 100mV, the gain required is only $100 \div 3 = 33$.

The transistors in these pre-amplifiers are capable of much higher gains, of course, but the gains are reduced to what is needed by applying *negative feedback* which reduces distortion as well.

NOISE FIGURES

So far we have talked rather loosely of amplifier noise. All the transistors and all the resistors in an amplifier generate noise. However, since the noise of the first stage gets amplified most you can generally forget about the noise generated by the later stages. There are various processes going on which produce noise in transistors.

It is convenient to lump them all together in some way. Sometimes, for example, an equivalent input noise figure is given. This is the amount of noise voltage which, fed into a noiseless amplifier, would produce the same amount of noise at the output as is produced by the real amplifier. Often, however, you will find in transistor data a noise figure, expressed in decibels.

The noise figure says how much extra noise is added to the input signal. As we have seen, all real resistances generate noise. Now, the sources of signals invariably have some resistance, so there is always thermal noise mixed up with the signals. In other words the signal source *itself* has a signal-to-noise ratio.

The amplifier makes this ratio worse, by adding its own quota of noise. The noise figure tells you how much worse. For example, if a tape playback head produces a signal with 62dB signal-to-noise ratio, and this is then applied to an amplifier with a noise figure of 2dB, the overall signal-to-noise ratio is degraded to 60dB.

Noise can only be generated by things which are also capable of absorbing power. Pure inductance and pure capacitance are noiseless, because they can only store energy, not dissipate it. Practical inductors have resistance, and practical capacitors have leakage and dielectric losses.

It is these which cause the noise, not the inductance and capacitance themselves. A device like a capacitor microphone can be made relatively noiseless by keeping down the losses, and some field-effect transistors have very good noise figures. By combining the two, you could in theory make a microphone and a preamplifier with exceedingly low noise.

In practice, however, while low electrical noise is worth having, there are other sources of noise which cannot be avoided. Even the quietest recording studio is full of small noises, made by the air conditioning system, thermal convection currents, vibrations from the traffic outside, the breathing of the performers, rustling of clothing, and so on. There is little point in reducing electrical noise far below the level of this physical noise.

If it could be done, and all interference of an electrical kind eliminated, there is still a fundamental barrier. This is the random motion of the air molecules.

They too, are in a state of thermal agitation and knock against the diaphragm of the microphone. If enough happened to strike at the same time, a perceptible output would be generated. This random motion is greater than you might think.

BROWNIAN MOTION

This random motion was first observed, not in air but in water, by a Scottish botanist called Richard Brown.

As he was looking through a microscope at pollen grains in water he noticed that from time to time a grain would make a sudden movement as if it had been kicked as indeed it had, by water molecules. This "Brownian motion" as it then came to be known attracted the attention of physicists, and in time one of them wrote a learned paper about it.

If there is no point in making a microphone sensitive enough to detect Brownian movement it follows that there would be no point in having ears which would hear it either. The sensitivity of the human ear is, in fact, just comfortably above the average level of Brownian noise, so you do not notice it, even in very quiet surroundings.

TUNED FILTER

Suppose you *must* use a microphone to pick up very faint sounds. Is there any way of combatting all the noises, physical and electrical, which gets in the way?

One trick which is sometimes useful is to tune the amplifier to the wanted sounds. Noise occurs simultaneously at *all* frequences. Signals usually occupy only a limited range of frequencies. The classic example is the radio operator using Morse code.

Here there is just one frequency and the operator sets his receiver to produce whatever pitch of Morse he finds it easiest to hear. He can then pick it out from quite strong background noise.

It is not quite true that only one frequency is required, because, when you switch a note on and off, as in Morse, other frequencies, close to the main note, are generated. In slow Morse signalling, however, they are so close that the bandwidth required is only about 10Hz. So a filter which passed, say, 995 to 1005Hz would be adequate. This is a sharply tuned filter, which calls for a 1kHz tuned circuit with a Q of 100, Fig. 7.6.

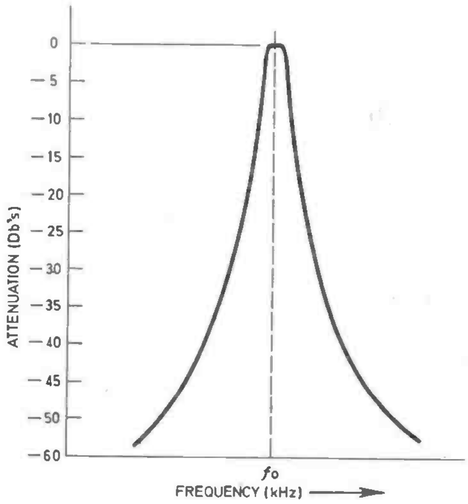


Fig. 7.6. Typical of many high Q filters is their ability to attenuate frequencies outside the required bandwidth.

This is a fairly high Q at that frequency, in terms of practical tuned circuits. It needs a good coil with a ferrite core. If the wanted range of frequencies is more spread out, then the tuning process is less effective in reducing noise.

For reasonably intelligent speech, a range of 300 to 3000Hz is required. By using filters which cut out signals below 300Hz and above 3kHz some noise is removed, but quite a lot can still get through.

For hi fi, where you need virtually the complete audio range, filtering does not help at all.

PRACTICAL AMPLIFIERS

The best low-noise audio amplifiers and radio-frequency amplifiers too, use field effect transistors. However, to get the best out of an audio f.e.t. it really needs to be driven by a signal from a high-impedance source such as a capacitor microphone.

The reason is that there is an optimum **signal source resistance** for any amplifier. Only when signals come from the optimum source impedance does the amplifier give its lowest noise figure. For f.e.t.s, which are high input impedance devices when used in audio amplifiers, the optimum source impedance is high.

Ordinary bipolar transistors are much more versatile. The general rule for low noise is that the input impedance of the amplifier itself should be many times the signal source impedance. With a transistor, the input impedance depends on the current.

The same transistor, used at half the collector current, has about twice the input resistance, and so on. It is possible, by making use of this fact, to adjust the input impedance to suit the signal source impedance.

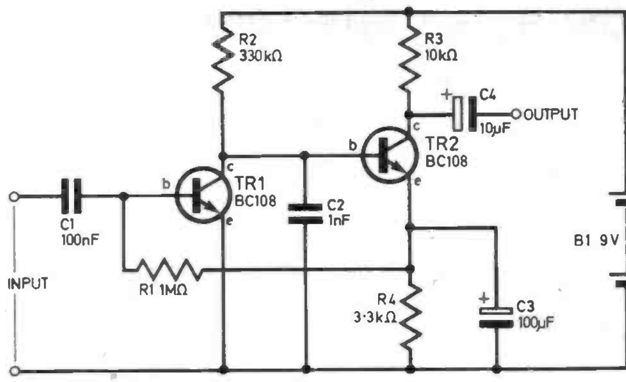


Fig. 7.7. Practical circuit for our low noise amplifier. This particular circuit uses negative feedback via R1.

AMPLIFIER DESIGN

The best performance of all is obtained when the transistor current is optimised for a source impedance of about 10kΩ. When this is done, good performance is still obtained when the source impedance is not exactly 10kΩ but anything in the range 1 to 100kΩ. Fairly good performance is obtained for 100Ω to 1MΩ.

How do you design an amplifier to be optimum for a 10kΩ source? Well, first, choose the right transistor. It must have low noise at the working frequency. For audio work, this means 30 to 15,000Hz. Some makers quote an overall noise figure, others take a spot frequency, usually 1kHz, and quote it for that alone.

The noise is not uniform over the audio band. It rises below about 500Hz and above about 10kHz. Fortunately, the sensitivity of the ear falls at these noisy parts of the audio spectrum so for speech and music amplification the effect is not as serious as it seems.

The second essential is that the transistor must have high current amplification at the working current. The minimum acceptable is 50. This may seem an easy requirement to meet, since the usual high-gain low noise audio transistors; BC109; 2N3707 etc, have a.c. current gains, h_{fe} of several hundred. But h_{fe} is often quoted at a collector current of 1mA or 2mA.

For low-noise amplifiers designed to work with 10kΩ sources, the collector current has to be reduced to a few microamps. The h_{fe} is much lower at such low currents. Quite a lot of the standard low-noise transistors have an h_{fe} of about 100 at an I_c of about 10 to 100µA. Taking these figures, and assuming that the noise performance is not too far from optimum if the input impedance is 10 times the signal-source impedance, it becomes possible to make a rough-and-ready but quite useful rule. This tells you what collector current you must use to get a good noise figure for a particular source impedance.

The rule is:

$$\text{Collector current in } \mu A = \frac{250}{\text{Signal source impedance in k}\Omega}$$

Thus, if the source impedance is 10kΩ, the collector current should be 25µA. You will remember that we said earlier that a typical current for input stages of hi fi amplifiers was 30µA.

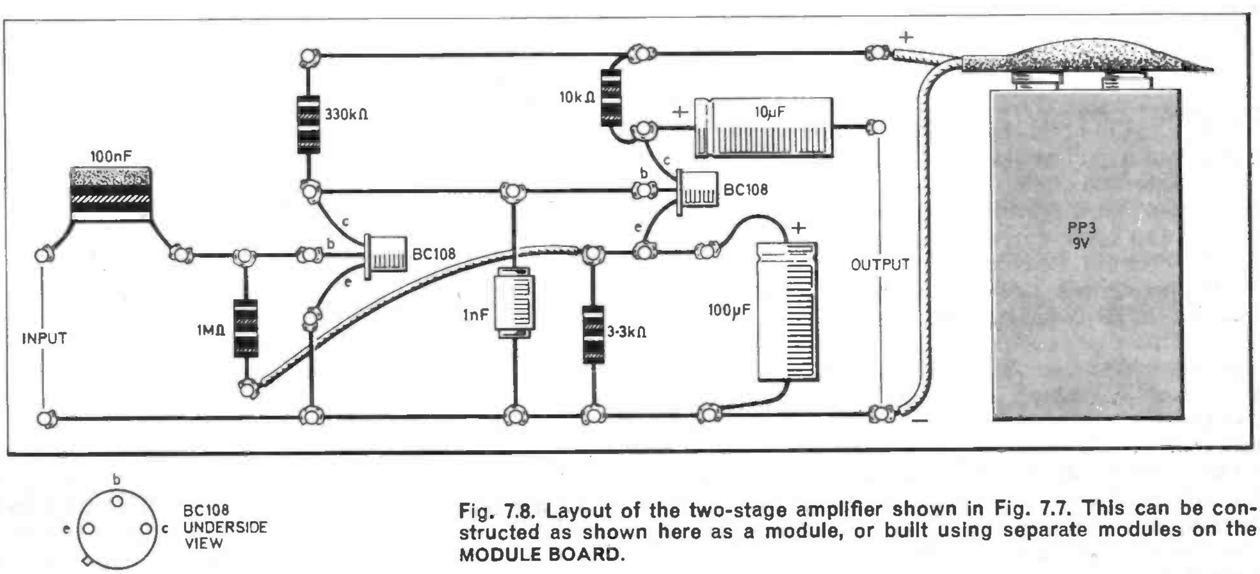


Fig. 7.8. Layout of the two-stage amplifier shown in Fig. 7.7. This can be constructed as shown here as a module, or built using separate modules on the MODULE BOARD.

LOW NOISE AMPLIFIER

Now build a two-stage low-noise audio amplifier. The circuit, Fig. 7.7 uses a negative feedback bias system which involves both stages at once.

This circuit can be constructed in two ways. The first involves the use of the NPN modules and the associated components required, built as always on the MODULE BOARD.

The second way in which it can be built involves the circuit as a separate module. If this is done then it could be used later on in the series or kept once the series has finished and used in other projects. Having said all that however, it is an advantage if it is built as a module. The required layout is shown in Fig. 7.8.

HOW IT WORKS

The first thing to do then is find out how it works. The best starting point is a rough idea of the collector current of TR1. Since this transistor has a d.c. collector load of 330kΩ, the absolute maximum current it can pass would flow when all the 9V supply was dropped in this 330kΩ resistor. This gives an upper limit to the current of 9V÷330kΩ=27μA.

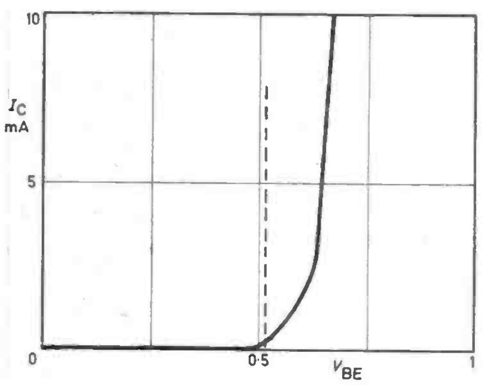


Fig. 7.9. Typical graph of base/emitter voltage versus the collector current. This is for TR1 in the amplifier circuit.

Let us guess that the real collector current is about 20μA and assume that the h_{fe} of TR1 has the rather low value of 100. The d.c. base current must then be 0·2μA. The graph of Fig. 7.9 shows V_{BE} against I_c, and that the base/emitter voltage of TR1 is roughly 0·5V. However, the base current also flows in R1, where 0·2μA drops 0·2V. So the voltage at TR2 emitter must be roughly 0·5V+0·2V=0·7V. But this 0·7V appears across R4. So R4 is passing a current of 0·7V÷3·3kΩ which is 210μA or roughly 0·2mA. You can, of course check the current in TR2 by measuring the voltage drop across R3, which gives the current in R3, by Ohm's law.

Note that if V_{BE} for TR2 is 0·6V the base of TR2 must be at 0·6V+0·7V=1·1V above earth. This voltage is also the collector voltage of TR1. So the 330kΩ must drop about 8V, giving a current of 24μA. Some of this is base current for TR2, the rest collector current for TR1, confirming our guess of about 20μA.

BIAS SYSTEM

How does the bias system work? Well, TR1 gets its bias from the voltage across R4 because this is what drives the base current through R1. If, for any reason, the voltage drop in R4 tries to increase, more current goes through R1 and TR1 collector current increases. But this pulls down TR1 collector voltage, taking the base voltage of TR2 with it, so TR2 passes less current, and the drop in R4 does not increase much, after all.

Negative feedback strikes again. Only this time, the value of TR1 base bias resistance is not so important. In your single stage amplifier the corresponding resistance had to be h_{fe} times the collector load to set up the correct collector voltage.

Here, even if you reduced R1 to zero, the effect on the transistor current would be rather small.

With R1=0, R4 would drop 0·5V (the required V_{BE} for TR1) instead of 0·7V. So the current in TR2 would be a bit lower, that is all. Evidently, so long as R1 is not too large its effect is not very important A good rule of thumb is to make the drop in R1 not more than 0·2V for a TR1 with the *lowest* current gain. The circuit will then work more or less independently of the variations in transistors.

A way to check that your low noise amplifier is working is to measure the voltages at TR2 emitter and collector. At the emitter you should have roughly 0·7V which is just detectable on the VOLTAGE INDICATOR. At the collector you should have round about 7V. If something near these d.c. voltages is obtained then at least you know that the transistors must be passing the right currents.

What is the purpose of C3? It is to reduce a.c. voltages across R4 by providing an easy low impedance parallel path for a.c. This is done to avoid unwanted negative feedback. If an audio unit is applied and C3 is not present, an inverted audio voltage appears across R3 and is fed back to the input via R1.

This reduces the gain and also, by a rather subtle process, the input impedance.

EQUIVALENT CIRCUIT

The effect on R4 (without C3) on TR2 merits a closer examination. You will remember that a transistor has a rather low input impedance. If you consider the effect of R4 on this you should find that it increases the input impedance of TR2. To demonstrate this we will use the a.c. equivalent circuit for a transistor.

This is the bit inside the dotted line of Fig. 7.10. To the transistor equivalent is added R3 and R4.

For a positive half-cycle of the input V_{in} (it is customary to use small letters for a.c. quantities and capitals for d.c.) the directions of voltages and currents are as shown. The signal voltage V_{in} drives base current i_b downwards through the input resistance r_{in}.

Both i_b and i_c flow downwards in R4, producing a voltage drop as shown. If you think of this voltage as an e.m.f. you can see that it must be trying to drive current through r_{in} in the *opposite* direction to V_{in}. The result is that the input current i_b is reduced.

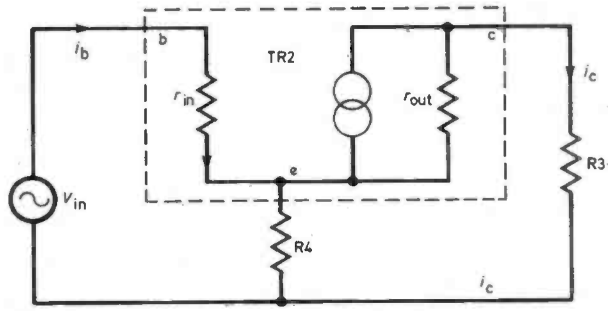


Fig. 7.10. Using the equivalent circuit for TR2, we can represent that part of the circuit around TR2 as shown here. Again this is useful in understanding how the circuit works.

But V_{in} of course is just the same whether R4 is there or not. If the same voltage produces a reduced current it means that the circuit impedance has been increased. The effect of R4 is to increase the input impedance, at the expense of reduced gain Emitter resistors like R4 are often used when it is necessary to increase the input impedance of a transistor.

A common arrangement is Fig. 7.11. Here the emitter resistance is the load and the output voltage taken from it. Because of the way the feedback works, the output voltage is always less than the input voltage.

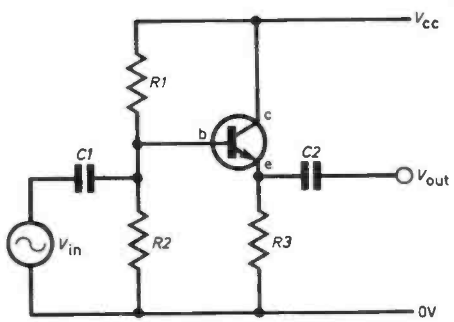


Fig. 7.11. The emitter follower. Having a gain of less than one and a low output impedance, this is one of the most often used circuits.

The circuit is called an emitter follower because the output voltage at the emitter "follows" the polarity and level of V_{in} closely. It has the additional virtues of low distortion and low output impedance. The method of biasing the transistor shown also makes use of the negative feedback in R3.

Here R1 and R2 form a voltage divider which applies a certain fraction of V_{cc} (usually about half) to the base. The emitter voltage is less than this by the base emitter voltage which is never far from 0·7V for a working silicon transistor.

Any tendency for the current in R3 to change, and alter the emitter voltage, is opposed by the feedback action.

RADIO RECEIVERS

What you are going to do now is to make use of that ferrite rod which you wound when you were exploring oscillation. Connect it as shown in Fig. 7.12 using the amplifier of Fig. 7.7. Instead of the original 10nF capacitor use a tuning capacitance, CT of 1nF.

If you listen carefully while sliding the ferrite rod slowly in and out of the coil you should be able to pick up an a.m. radio station. If you cannot, check the circuit by tapping the top end of the CT with the blade of a screwdriver. This should produce a click in the earphone.

You can then attach an aerial to the top of CT. Use about 3 metres of insulated wire, with one end soldered to CT and the other held up in the air and not connected to anything. If you get nowhere try a different value for CT, such as 330pF.

When you have got the radio working and amused yourself with it, reflect on this. Radio transmissions

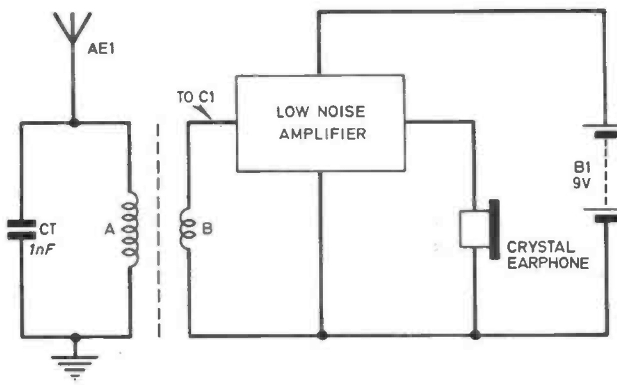


Fig. 7.12. Using the amplifier of Fig. 7.7. it can be turned quite easily and effectively into a simple radio.

are sent out on frequencies from about 150kHz upwards. Your receiver should tune to a station somewhere in the medium waveband (520 to 1650kHz). None of these frequencies is audible. They are all well above the audio range.

So why are you hearing a broadcast programme? If the amplifier merely amplified you would hear nothing. But it does something else as well, it distorts. This has a special effect on an incoming signal. The mechanism can be understood by examining the way in which the collector current of TR1 responds to input voltages.

As we saw earlier, the collector current is just an amplified version of the base current, and the base current increases rapidly when the base voltage is increased. You can get a fair idea of the overall effect of base voltage on collector current by making measurements Fig. 7.13.

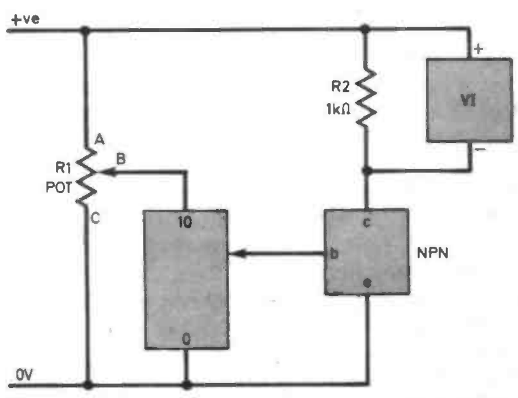


Fig. 7.13. Using one NPN module and the VOLTAGE INDICATOR various voltages may be obtained, which when plotted as a graph leads to the most used in transistor work—the *characteristic curve*.

To begin with turn the POT so that B is at C. Set the RESISTOR CHAIN to 1. Set the VOLTAGE INDICATOR to a maximum sensitivity. Turn up the POT until the l.e.d. on the indicator just lights. This means that collector current is now flowing in R2, producing a voltage drop equal to $I_c \times R2$. Leave the POT as set from now on. Tap the base connection (b) of the NPN module to 1, 2, 3 etc on the RESISTOR CHAIN, measuring and recording the voltage drop across R2 at each step.

Plot a graph of the results Fig. 7.14. This shows that once current begins to flow, equal increases of base voltage produces progressively bigger increments of collector current, giving progressively bigger voltage drops in R2. Eventually all of the supply voltage is used up in R2 and no further change can take place. The general shape of the base voltage/collector current curve for an *npn* silicon transistor Fig. 7.9 is similar for *all npn* transistor types. Only the actual voltages and currents differ.

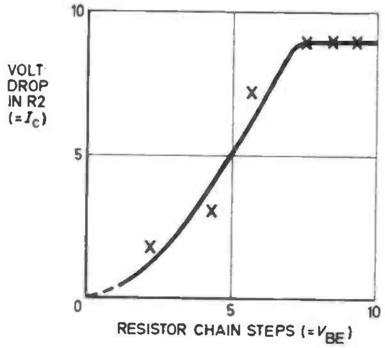


Fig. 7.14. Graph showing how the collector current varies with base voltage.

DETECTION

In your low noise amplifier TR1 is biased so that V_{BE} is about 0·5V d.c. Dotted line in Fig. 7.9. If an a.c. voltage is now added to V_{BE} the positive half-cycles cause a sharp increase in I_c but the negative half-cycles cause only a small decrease. The consequence is that, averaged over a period of time, I_c shows a steady increase.

When a radio signal is tuned in, this increase in I_c takes place. However, an a.m. radio signal varies in strength in sympathy with the sound in the studio. Amplitude modulation means "variation in strength". So the increase in I_c is not steady, but follows the audio frequency variations in the programme being broadcast. These audio frequency variations in I_c provide an audio input signal to TR2, which is what you hear.

The purpose of C2 is to get rid of the radio frequency signals, now that they have done their work, by providing an easy path to earth.

This process of turning radio frequency signals into audio frequency signals is called **detection** or **demodulation.** In transistor receivers it is often carried out by a semiconductor diode which has roughly similar characteristics to the V_{BE}/I_c curve.

QUESTIONS

7.1. What value capacitor would you connect across the supply to an amplifier to prevent oscillation?
a. 1000μF
b. 10μF
c. None at all

7.2. A transistor is operated at 10mA with an h_{FE} of 10. The a.c. input impedance is:
a. 250 ohms
b. 25kΩ
c. 50 ohms

7.3. A movement of electrons is:
a. an electric field
b. an electric current
c. an electric charge

7.4. Noise can be generated in:
a. inductors
b. capacitors
c. resistors

7.5. To filter out noise you would use a tuned filter with:
a. a high Q and small bandwidth
b. a high Q and a large bandwidth
c. a low Q and a small bandwidth

ANSWERS *(To Part Six)*

6.1. 120 (b)

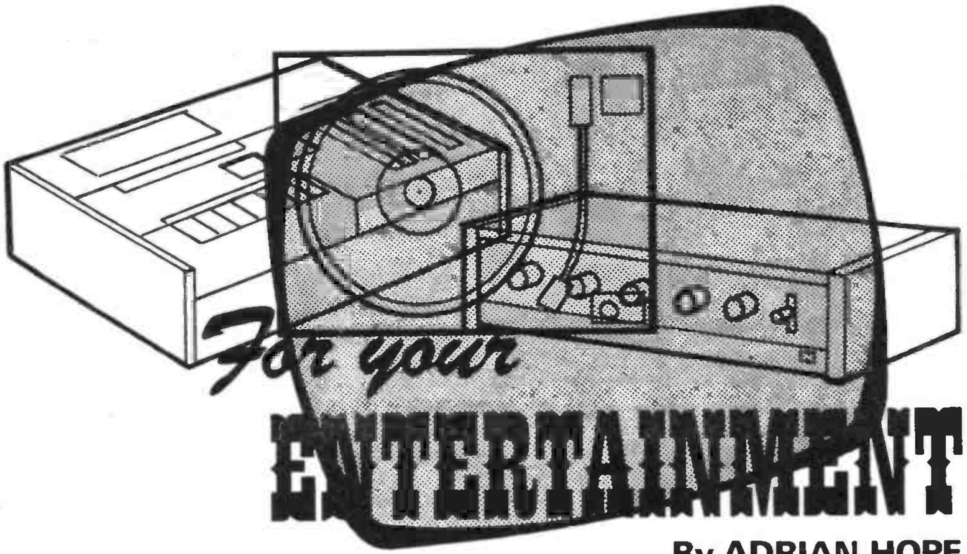
6.2. 25kΩ (a)

6.3. resistors (b)

6.4. 30 (b)

6.5. using a directional microphone (a)

Next month we shall continue with amplifiers and introduce a new subject on Power.



For your ENTERTAINMENT

By ADRIAN HOPE

Close Shave

NEXT time your lights flicker or seem to go a little bit dim or bright, due to a small voltage drop or surge, think for a while what that simple flicker may have meant to some people.

Take, for instance, a recording studio with a cutting lathe. A cutting lathe is really just a highly sophisticated gramophone, working "in reverse", the turntable carrying a blank lacquer and tracked by a diamond stylus which cuts a groove in the blank.

To cut a groove requires a considerable amount of energy (if there is to be high fidelity) and the Neumann lathe found in many studios now has a transistor amplifier that can deliver a full kilowatt of power peaks to the coils of the cutter head. This order of power is needed if the cutter stylus is to cut high frequency, high intensity signals, for instance fairly loud musical patches from a synthesiser.

Although the BBC used converted crystal pickups on portable recorders during the war, they were very "lo fi." I was recently shown a lacquer that was being cut when the power suddenly surged just 10 volts. The effect on the cutter head was so violent that it lifted right off the lacquer and bounced all over the surface. This is because a 10-volt change at the cutter amplifier input can mean a 30-volt change elsewhere in the circuit.

By a miracle the cutter coils and diamond survived in this case. And it was a happy miracle, because to replace a cutter head costs £4,000!

Cutting records is as much an art as a science, and it is only now that cutting rooms are finally replacing their old and trusted valve amps with the new kilowatt transistor models. The London Studio that showed me the damaged lacquer had, for instance, changed from valves to transistors mainly as a result of mains supply problems.

Their valve equipment had an unstabilised power supply and even gradual changes in the mains voltage, over the range 220-250 volts, had produced circuit changes of up to 100 volts and these had killed £80 worth of valves in one week. It is worth noting that although by law the Electricity Board must keep voltage variations in the mains supply within ± 6 per cent, this represents a legal swing of 29 volts on a nominally 240 volt supply!

I well remember working on an RAF transmitter station, where the valve-powered transmitter circuits were protected from voltage surges by a bank of relays. If the mains voltage dropped suddenly, all the relays fell out with a rifle-shot bang.

This was to protect the valves from the likelihood of a violent surge as the voltage came back up again. (There is, I can vouch from personal experience, no more distressing way to wake up from forty winks illegitimately taken behind a nice, warm, valve-powered transmitter, than to hear a gang of heavy-duty relays drop out in unison!).

Mains Frequency

Even now, with stabilised power supplies and transistorised drivers for the cutter heads, many disc cutting lathes in modern recording studios run at a speed dependent on the mains frequency. They are locked to the 50-cycle waveform, rather than to a crystal oscillator that is independent of mains frequency.

Over 24 hours the mains frequency always averages out at exactly 50 Hz (this ensures that electric clocks are accurate if taken over a 24-hour period), at any one time an error of ± 1 per cent is allowed by law and thus there can often be a drift of around 0·5Hz either up or down from the nominal 50Hz.

This has an interesting bearing on a current hi fi fad. A 1 per cent frequency drift means a 1 per cent speed error on the cutting lathe turntable. Ergo, many records cut today have a 1 per cent speed error, and as any record pressed from that master cut will inevitably have exactly the same speed error, it is safe to say that many records in your collection will also have a built-in speed error of plus or minus 1 per cent.

The current hi fi fad is for domestic turntables that run at incredibly precise speeds (± 0·025 per cent) under the control of a crystal based oscillator. So quite often the hi fi enthusiast will be spending money on a speed control system that is forty times more accurate than the records which it will be required to play.

Time Check

In a Manchester recording studio recently I saw a tape timer gadget which gave remote digital readout at various points round the studio for a whole string of information options, for instance how much tape time had elapsed, how much time remained on the spool, and where the last recording take had started, and so on.

The gadget also gave remote readout of the time of day, using a standard clock chip. Everything worked but the time of day reading was haywire. "Oh yes," said the maintenance engineer, "someone's been using an unsuppressed drill. We've fixed all our drills, but a workman came in yesterday with his own, and they always foul up the time readout."

This immediately made me wonder how many people have hunted high and low for non-existant faults in mains-powered digital clocks of the type which tells the time of day by counting the mains waveform cycles. Although these can vary slightly from the basic 50-per-second for 50Hz mains over a 24-hour day, there is over-the-day averaging to a high standard of accuracy.

If an unsuppressed gadget like a heavy duty electric drill is used on the same mains circuit, it feeds the chip vicious interference spikes at random frequency especially as the drill is switched on and off. The clock is thrown totally off beam by these spikes, and gives a crazy time readout, from which there is no automatic recovery.

So, if you encounter a mains-powered digital clock that is suddenly reading out ridiculous times, look for an external source of interference before looking for an internal fault.

I AM frequently astounded at the speed of change in electronics. It reminds me of the pre-war Shell advert of a man with two heads, one looking left and one looking right and underneath the caption "That's Shell—that was!" Presumably meaning to indicate that if you filled your tank with Shell petrol your car would go at something approaching the speed of light.

Such rapid change makes the lot of the poor old electronics retailer a hard one. Valves disappeared and were replaced by transistors. We had almost become adjusted to that, when bingo! transistors were being ousted by integrated circuits. We are in the process of digesting these, when already dark hints are being dropped that integrated circuits may give way to microprocessors. We pedal like mad to stay where we are, and the moment we falter we are left miles behind in the race. Even a new jargon has grown up with it, just to confuse us.

In the old days we would talk about "Specifications" now it has to be "Parameters". "Separate Components" becomes "Discrete Components".

Unchanging Principles

I suppose the only thing that consoles us is the fact that the basics do not change, so there are no short cuts for these youngsters clamouring to learn electronics. For a time anyway, we can meet them as equals, and when they finally draw ahead, I say good luck to you my friends, you will soon be pushing the barrier of knowledge further forwards, which is as it should be.

Sign Of The Times

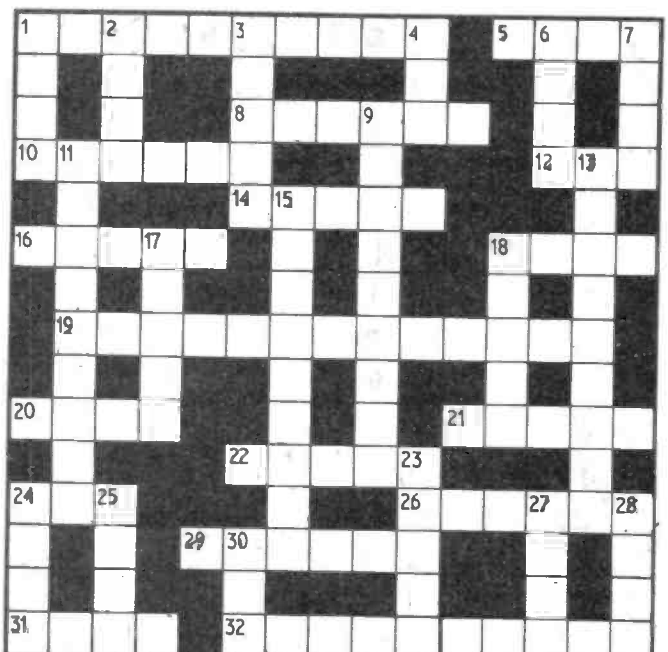
You really have no idea how standards have deteriorated over the last few years. Time was, when around Christmas, our suppliers were so grateful to us for selling their goods, they used to give us presents, like a bottle of brandy. Little by little it all went until finally there was just one supplier who unfailingly sent us two boxes of crystallised fruits. This year, no fruits, but two large diaries including everything from vintage wine to Boolean Algebra! Was I enraged, crystallised fruits I can understand, Boolean Algebra, not at all!

CROSSWORD No 2

BY D. P. NEWTON

ACROSS

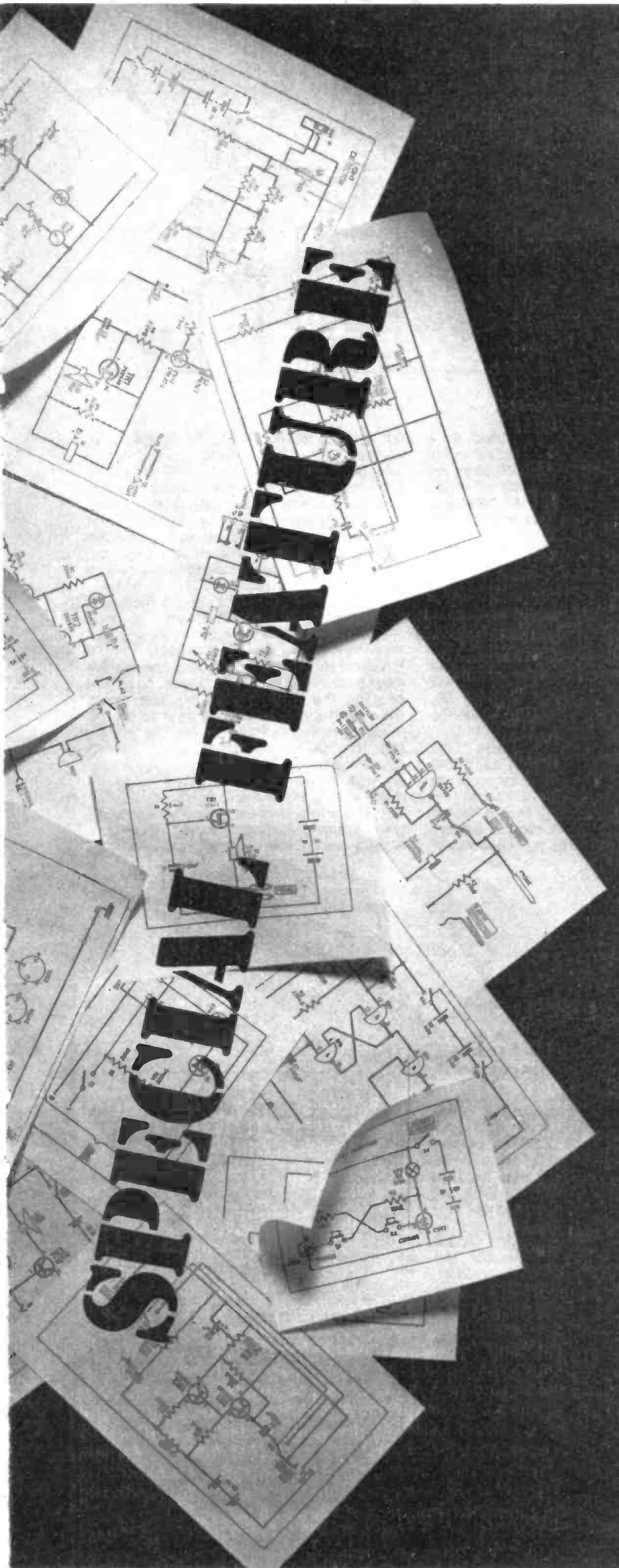
1 A device for maintaining electronic calm.
5 The form in which energy can be transmitted.
8 The outer covering of a cable.
10 Partly revolve to develop.
12 Cunning.
14 Radio detection and ranging.
16 Watchful.
18 A tear to be paid for regularly.
19 A shake up gives an oscillator.
20 A supporting rope hangs about.
21 The operating part of a cat's whisker.
22 Try 15 down for these thrills.
24 Globe.
26 Aircraft housing.
29 The forerunner of an electrical couple.
31 No current or voltage is found here.
32 This phase change is not uncommon. (5,5)



DOWN

1 Adjacent, where we might expect to find the band.
2 Running by itself.
3 Producer of a narrow beam of bright light.
4 An animal of the rodent species.
6 Tramps partly are a measure of current flow.
7 Knowing Edward well gives this current.
9 A secure store for computer material, some say. (I,4,4)
11 Without this, potential difference would be almost immeasurable.
13 LF waves are often this in terms of distance. (4,5)
15 A real party type, in a shocking way. (1,4,4)
17 A race for a circuit controller.
18 Comparison of two, numerically.
23 Caught like this, some circuits burn out.
24 Such a circuit would use no power.
25 Sections of the dial.
27 Some capacitors collect in these aggressive groups.
28 To estimate worth.
30 Female part of a hertz.

Solution on page 408



POPULAR CIRCUITS

Something for Everyone

Here is a choice selection of 15 useful circuits from past Everyday Electronics projects. They embrace a wide field of application and every reader should find at least one of these circuits of immediate interest.

Although no construction details are included, all essential information concerning the components is given—either on the circuit diagram or in the accompanying technical descriptions.

Translating any of these circuits into a practical form onto circuit stripboard, or plain matrix board, or even a p.c.b., will be a good exercise for the constructor.

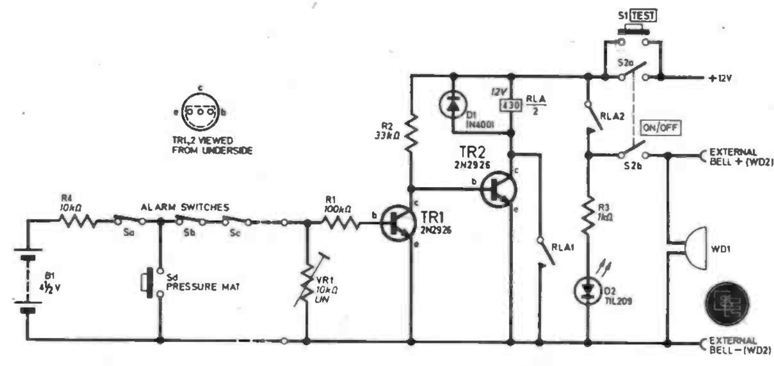
Even inexperienced newcomers to electronics should not shrink from this task; they will find it most instructive. The observant reader will find plenty of guide lines to the practice of circuit construction in the illustrations to our main constructional projects.

CONTENTS

1 INTRUDER ALARM

Anyone wishing to install an intruder alarm in their own home has many decisions to make concerning the equipment used and the method of operation, for instance, the unit may be mains powered, battery powered, or mains powered with battery standby, each having its attendant advantages and disadvantages.

Equipment that is powered only by batteries is independent of mains and if the current drawn is very small the working life of the batteries would be almost as long as the shelf life. Another point is that being perfectly safe the beginner may build such a unit with confidence.



Basically there are two types of alarm, the normally open circuit, and the normally closed. A very simple alarm can be made using normally open switches. However, failure of one of the switches or a break in the wiring would prevent the alarm working.

If a closed circuit is used, wiring and alarm switches are checked when switching on. A circuit of this type if wired in twin wire could be rendered inoperative by shorting the two conductors together. This being undesirable in a burglar alarm, further precautions must be taken.

If a separate battery is placed at the furthest point from the control unit and a current from this battery is passed through the alarm switches to the control unit, then either a short-circuit or open circuit anywhere in the wiring will prevent this current reaching the unit and activate the alarm. The circuit described here is of this type.

The current from the remote battery, through the alarm switches, holds TR1 on, which switches TR2 off. Should one of the alarm switches be opened or a short circuit occur, no current flows in the base of TRI, which switches off, allowing R2 to switch TR2 on, the relay operates and is latched by one pair of contacts, the other pair providing voltage for the warning device.

A 10 kilohm resistor is connected in series with the remote battery so that a short across the wiring will not cause excessive current drain. This also enables the use of pressure mats (switch trigger mats) in the alarm wiring.

Switch S1 is pushed to test the circuit before switching the alarm on, in the event of a fault the light emitting diode D2 will light indicating an open door etc; S2, preferably a key operated switch, is the on/off switch.

Potentiometer VR1 adjusts the sensitivity of the unit and is set such that the unit will activate if the resistance of the alarm wiring increases by 10 kilohms or more. To set the sensitivity the 10 kilohm resistor in series with the remote battery is temporarily replaced by a resistance of 20 kilohms (two 10 kilohm resistors in series), VR1 is set to maximum resistance and the unit switched on; VR1 is slowly reduced in value until the alarm activates. The 10 kilohm resistor is then reconnected.

The audible warning device WD1 (Doram) provides internal alarm and the bell, e.g. Friedland underdome bell, can be mounted in any convenient position externally if it is required.

The use of magnetic reed switches is recommended mainly because of their reliability, but also because their small size makes them easy to conceal.

When setting the alarm and leaving the house one needs some method of bypassing the switches on the exit route, the obvious way of doing this is to mount a key operated switch outside the house, say in the door frame, which short-circuits the relevant switches. Use could also be made of a concealed magnetic reed, with a removeable magnet.

The alarm is most easily wired using twin figure-8 stranded wire; all joints should be soldered and insulated.

2 BOILING LIQUID ALARM

This device provides an audible warning at the onset of boiling of either water or milk. It requires no electrical connection to the cooker or mains, being battery powered and using a submersible temperature probe.

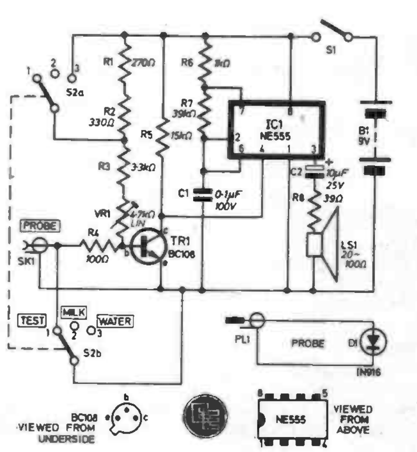
The circuit of the alarm is built around an NE555 integrated circuit and an ordinary silicon diode. The diode is mounted in the probe tip and acts as the actual temperature sensor. The forward voltage variation with temperature change of the diode, normally a nuisance in most diode applications, is fully exploited in this circuit. The NE555 is connected as an astable multivibrator and drives the earphone or speaker (20 to 200 ohms) to give an audio tone.

When the temperature of the diode increases the current into the base of TR1 decreases, turning it off. The voltage at pin 4 of IC1 rises enabling it to oscillate.

Potentiometer VR1 permits the trigger temperature to be correctly set while S2 gives switching for milk/water and a battery test facility. In position 2, R1 and R2 are in circuit and the unit will trigger when the probe approaches the boiling point of milk. In position 3, R1 and R2 are shorted out and the unit now triggers at the boiling point of water. With S2 in position 1 the probe is shorted out and IC1 oscillates freely.

An old transistor can (OC81, OC200 etc.) makes an ideal housing for the diode. This should be sealed with Araldite. A crocodile clip fixed to the supporting wires will permit the probe to be clipped to edge of a saucepan.

If the unit is required to trigger at some lower temperature R1 or R2 can be increased in value. Also the output tone can be increased/decreased in frequency by decreasing/increasing the value of C1.

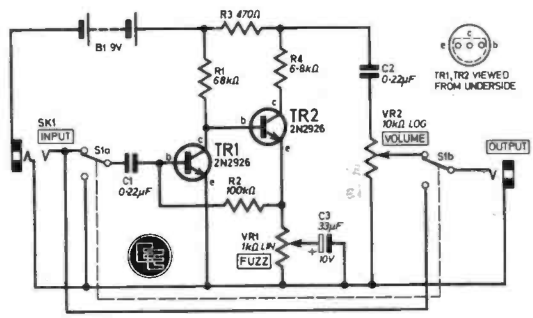


3 FUZZBOX

The Fuzz Box is still one of the most used effects units in the world of "pop music".

It is used most by the lead guitarist but has on occasion been found useful for the bass guitar and organ to produce an exciting and dramatic sound.

The Fuzz Box described here is simple to build, is inexpensive (compared with commercially available units) and incorporates a footswitch that enables "fuzz" or "straight-through" operation. It is powered by a single PP3 9 volt battery, and since current drain is in the order of 1 milliamp, the battery should last a long time.



The Fuzz Box a simple two-stage amplifier incorporating negative feedback between the stages.

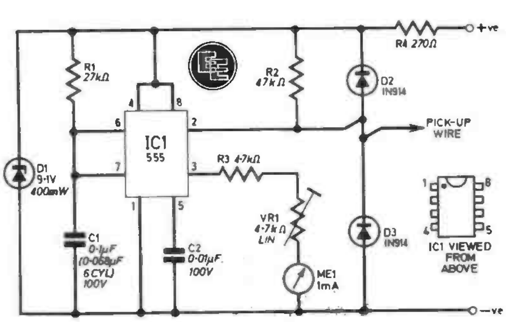
Transistors TR1 and TR2 are wired in a d.c. feedback pair configuration giving high gain which is virtually independent of individual transistor gains. Base bias for TR1 is derived from the emitter of TR2 via feedback resistor R2. The biasing has been arranged such that TR1 is biased close to saturation level.

The positive half cycles of the input wave-form cause the transistor TR1 to move further towards saturation and to become saturated on the peaks. The point at which saturation is reached is determined by the amplitude of the input and the setting of the fuzz control. The negative excursions of the input waveform may also produce a clipped output if the input signal is of sufficient amplitude.

The single or double-clipped waveform is then directly coupled to the base of TR2 where it is further amplified to produce a double-clipped waveform with very short rise time. The output is approximately a square wave.

The output at the collector of TR2 swings by 9V, peak-to-peak. This is too high to be applied to an amplifier and is attenuated by using a split collector load and taking the output from the junction of R3 and R4. This arrangement attenuates by a factor R3/(R3+R4) to give a peak-to-peak swing of approximately 600mV which is coupled to the volume control VR2 by C2, functioning as a d.c. blocking capacitor.

The circuit formed by C2 and VR2 is that of a differentiator whose time constant has been designed to produce "spiking" at low frequencies. This enhances the sharpness of the fuzz effect at low frequencies.



4 CAR REV. COUNTER

This very simple and neat Car Rev. Counter will work with either polarity system (positive or negative earth), and connection couldn't be simpler, there being no need to break into the ignition system to detect voltage or current wave-forms, as in most commercially available models. Another advantage is that no converter is needed for using it with electronic ignition systems.

In a conventional 4-cylinder, 4-stroke car, each revolution of the engine causes two sparks to be produced by the ignition coil. At an engine speed of 3,000 r.p.m., say, there will therefore be 100 sparks, or pulses, per second.

If now each pulse fires a monostable multivibrator with an astable period of T, and the areas contained under the pulses are added and then divided by time (or integrated) a voltage will be produced which is proportional to the engine speed.

In this design, the waveform is mechanically integrated using the meter movement's inertia and return hairsprings. This produces a very linear speed/deflection relationship.

The period T is set such that, at the maximum displayed engine speed T is fractionally less than the period between adjacent sparks at that speed; i.e. 3·75mS in this case. Different speed ranges and engines with more or less cylinders can easily be accommodated.

The common "555" timer is used in its standard monostable configuration, the period being set at 1·1 X C1 X R1; approximately 3mS.

As the trigger input (pin 2) on this i.c. has a high input impedance, the only load seen by the pick-up wire is 47 kilohms (R2) and this is sufficiently high to use inductive pick-up for triggering it. In fact all that is necessary is to place the pick-up wire near the ignition coil. Diodes D2 and D3 are included to limit the voltage to pin 2 to within the circuit limit.

The output (pin 3) is fed via R3 and the calibration pre-set VR1 to the 1mA meter movement.

A simple stabiliser R4 and D1 is used to allow for variations in the car voltage supply. No decoupling was found necessary but C2 was included to prevent possible spurious triggering of the i.c. by noise on the power rail.

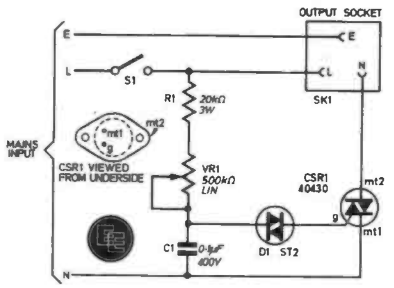
The meter used is edgewise reading, model PE70. The original scale is calibrated 0-1mA in forty steps. This is immediately suited for re-calibration to 0-8,000 r.p.m. in steps of 200 r.p.m.

With a bit of patience and a steady hand re-calibration is fairly easy.

Calibration must be done before installation in the vehicle and with the case top half removed to gain access to VR1.

The best method is to use a square-wave oscillator set at 100Hz (150 for a 6-cylinder engine) and amplitude between 10 and 20V. Connect one wire to the unit negative power terminal and the other, via a 100pF capacitor, to the pick-up socket. A dry battery is sufficient to power the circuit which takes less than 10mA. Adjust VR1 to give a reading of 6,000 r.p.m.

The unit may alternatively be calibrated in another vehicle which already has a rev. counter fitted, adjusting VR1 to give the same readings.



5 MAINS POWER CONTROLLER

There are innumerable instances in the home, studio or workshop when it would be advantageous to have some means of regulating the power supplied to mains operated apparatus, typical examples being electric motor or drill speed control, electric heater output or lighting filament brightness variation.

Possible means of achieving this control are by use of a voltage dropping transformer, which is clumsy and unsuitable for many purposes, a rheostat, which generates a large amount of heat, or the far more elegant method of using a solid-stage switching device, as employed in this unit.

The switching device that forms the central component of this circuit is the triac CSR1, which functions as follows. CSR1 will conduct between mt1 and mt2 in either direction (making it ideally suited to a.c. applications) when a gate (terminal "g") voltage of either polarity is applied and will continue to conduct, even with the gating voltage removed, until the forward current falls below a low level called the "holding current". For practical purposes the device will switch off at the end of a mains voltage half-cycle.

To regulate the power supplied by the triac, all that is necessary is to control the point in the mains cycle at which it turns on. At the end of the half-cycle it turns off, since the mains voltage (and hence the triac current) falls to zero, and will not conduct again until re-gated. Operation in negative and positive half-cycles is identical.

Control of the gate (g) of the triac CSR1 is achieved by means of the network formed by R1, VR1 and C1. The voltage on C1 will lag behind the mains waveform by a time dependent on the setting of VR1 and will be attenuated to a lower level.

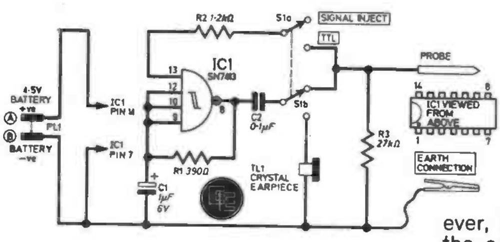
The diac D1 has the property that it will not conduct until the voltage across it reaches about 30V and will turn off again when the current drops to zero. It is used to provide a reference level, for when the voltage on C1 reaches the diac breakdown voltage, D1 will conduct, discharging C1 into the gate of CSR1, turning it on for the remainder of the half-cycle.

With component values as specified the switch-on point can be varied over the entire half-cycle, thus giving control from zero to full power.

APPLICATIONS

The unit may be used to control the power of electric lighting, heating, electric drills and other tools or motor drive equipment. It will not, however, work satisfactorily with discharge devices such as fluorescent lighting.

The components specified allow for a maximum load of six amps or 1400 watts, but higher rated triacs may be used if desired to control greater loads provided that appropriate switching and wiring is used. No changes are necessary in the gating control components.



6 SIGNAL INJECTOR & LOGIC PROBE

The circuit described in this article provides an instrument that will give clear indication of an open circuit, logic "0" and logic "1" or by flicking a switch, an audio frequency signal (approx. 1kHz) suitable for injection into audio and radio equipment.

The circuit centres around IC1, which is a four-input NAND Schmitt trigger. The Schmitt trigger action is such that if a rising voltage is applied to the inputs of the device, when this voltage reaches a certain level (1·7V in this circuit), the output will fall sharply to 0·4V. If the input is now allowed to fall back towards zero, as it reaches 0·8V, the output will rise sharply back to 3·3V. This delay in the switching action that the device possesses, known as hysterisis, makes it ideal for use as an *RC* multivibrator.

Assuming that IC1 output is initially at logic 1 and C1 is discharged, C1 will then charge towards logic 1 via R1 until it reaches the 1·7V threshold, when the output will fall to logic 0. Capacitor C1 then discharges back through R1 until the lower threshold of 0·8V is reached, when the output rises back to logic 1. The cycle then repeats itself until the supply is removed.

Removing the supply voltage, however, is not the only way of controlling the oscillatory action of the circuit. The device has four NAND inputs, this means that if one of these is held at logic 1 (or left floating) then the output will always be the inverse of the input (as before, when all inputs were connected together).

However, if this input is now taken to ground, then the output will go to a logic 1 and stay there regardless of what appears at the other inputs. Thus one input can be used to switch or gate the multivibrator action of the device.

With switch S1 in the "signal inject" position the gating input is left floating and hence the circuit oscillates normally, the output being taken via a d.c. blocking capacitor, to the probe.

With the switch reversed, in the TTL position, the gating input is connected to the probe via a current limiting resistor, R2 and the output goes to the crystal earpiece TL1. When the probe is not connected to any external circuit a note of about 1kHz can be heard through TL1.

If the probe is now touched on a point at logic 1 a slightly lower note is heard and if a logic 0 point is touched then the note will cease altogether. Without R3 there would be no difference in the notes of a complete open circuit and logic 1.

The circuit can be powered either from 4·5V dry cell battery or from 1·5V mercury cells.

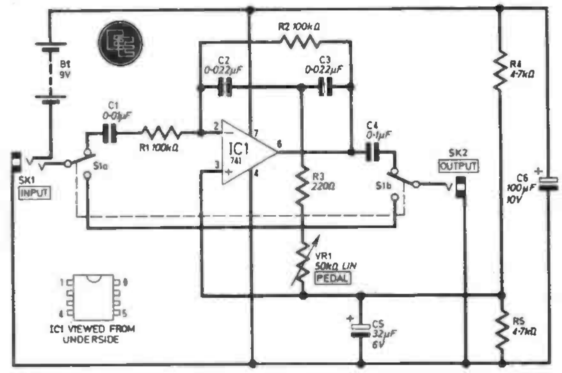
The Signal Injector & Logic Probe must not be used on equipment possessing voltage levels greater than the working voltage of C2, e.g. some valve equipment. Also, the TTL probe must never be taken to a voltage greater than 5·5V. Failure to observe these two points will result in destruction of the device.

As the TTL probe gives a note when there is open circuit between probe and chassis connector, and no note when this circuit is closed, the device can be used in this mode as a continuity tester.

If different frequencies of operation are required C1 can be altered. To increase the frequency, decrease the capacitance and vice versa.

7 WAA WAA PEDAL

The sound produced by the waa waa pedal is very pleasant to listen to and "easy on the ear" and can be used to inject a wide variety of feeling into music, ranging from tranquility to excitement and tension depending on the manner in which it is used.



The circuit of this Waa Waa Pedal is based on the versatile integrated circuit type 741. This is a differential operational amplifier and is operated in the inverting mode with frequency dependent negative feedback formed by the bridged-T network consisting of R1, C2, C3, VR1 and R3. The effect of the T-network is to modify the "value" of the feedback resistor R2.

It can be shown that the effective feedback resistor "peaks" at a frequency determined by the value of (VR1 + R3) for constant C2 and C3. By varying VR1, the peak can be moved along the frequency axis. This movement of the peak to-and-fro produces the waa waa sound effect.

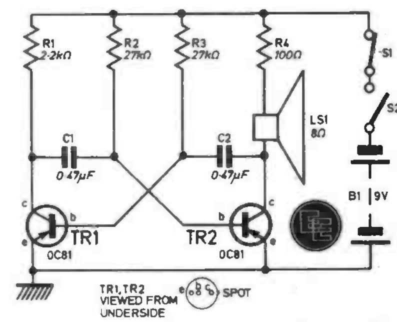
The *Q* of the circuit (a measure of the sharpness of the peak) is a function of C1 and R1 and the values shown have been chosen to give the effect desired by the author. Readers may wish to experiment with these values to tailor the unit to their exact requirements.

It has been arranged that the unit is switched on when the lead connecting the unit to the instrument is plugged into the Waa Waa Pedal. This is common practice for many guitar effects units and ensures that the unit is only switched on when in use.

As the unit will be situated on the floor, and the effect will need to be switched in and out instantly without the player removing his hands from the instrument, a push type successional action switch 81158 has been incorporated which is operated by pressing the pedal fully down. Operation of the switch causes the signal from the instrument to enter the electronic circuitry, or bypass it.

8 ANGLER'S BITE INDICATOR

This is a simple project that will be of special interest to the fisherman who ledgers, or uses two rods (one for float fishing and one for ledgering. The rod is placed on the bite indicator (after casting out); when the fish take the bait and pull the line a bleep will be heard and the rest is up to the skill of the fisherman to catch the fish.



The circuit is a simple multivibrator, oscillation is achieved by TR1 and TR2 switching on and off alternately, at a frequency determined by C1, C2 R2 and R3; these are chosen to provide oscillation in the audible frequency range. As TR2 switches on and off, it causes an audible tone to be heard in the loudspeaker LS1. Resistor R4 limits the current flowing in TR2 but allows enough to provide a reasonable output.

Switch S2 is the normal on/off switch whilst S1 is a special spring-loaded switch which is held open by the line being passed through it. When the line is pulled by a fish it slips out of S1 allowing it to close and sound the alarm.

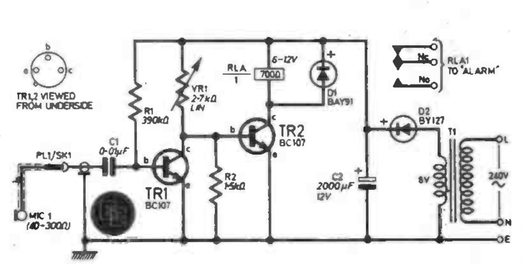
Switch S1 was made from two brass saddle clips straightened out, cut to size, bent into shape and bolted to the box containing the circuit assembly with two 4BA screws. The contacts are set so that the clips are touching each other making the switch closed.

In use a rod is rested on the unit and the line threaded through S1 holding it open, when the line is pulled by a fish it slips out of S1 and the alarm is set off.

9 TELEPHONE REMOTE MONITOR

This instrument should mean an end to all those moments of thinking "is that the TV or our phone", more so if you have a large house or where an occupier is hard of hearing. Also, it will be a boon to the hobbyist working in the garden shed.

It must be stressed that the Post Office will not allow tampering of any kind with their installations, the idea therefore had to be based on a system which does not contravene their wishes. It was decided to "pick up" the rings with a microphone and turn the received signal via an amplifier and slave relay into an electronic switch. This can then be used to operate a lamp, bell or any device suitable to the user.



Signals received at the input socket SK1 from the microphone MIC1 (40 to 300 ohms) are fed into the amplifier via capacitor C1. The amplifier proper is a two-stage d.c. coupled circuit in the common emitter mode, whose output operates a relay, which in turn can switch on lamps, bells or any other transducer.

The load in the collector circuit of common emitter amplifier TR1 is a 2·7 kilohm potentiometer, and as it is directly coupled to the base circuit of TR2 it also governs TR2 base/collector current. As the resistance of this potentiometer is reduced the collector current in TR2 increases, thus providing a "sensitivity" control to facilitate final setting up.

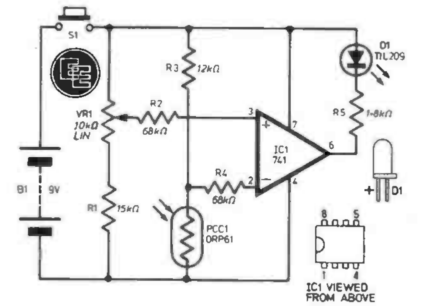
The relay employed here has a coil resistance of 700 ohms, but this can vary from 500 to 1,000 without complication, as the operating current of TR2 is ample. Diode D1 is wired in parallel with this coil to stop any back e.m.f. affecting TR2.

Due to the basic "on/off" function of our amplifier an elaborate power supply is not required. Therefore, the 8V a.c. output from the bell transformer (T1) is earthed at one end, the other being fed to the anode of a BY127 rectifier. The half-wave output at the cathode of this diode is then simply applied to the 2,000μF smoothing capacitor C2. If required a 240V neon could be wired in parallel with T1 primary to provide an on/off indication.

The microphone can be mounted on a platform of plywood cut to suit the base outline of the telephone and arranged so that the microphone is directly beneath the telephone bells.

10 ENLARGER METER

This Enlarger Meter is designed to eliminate the need for test strips in determining the exposure time required for making an enlargement. The instrument has a range of approximately four to 40 seconds, which should cover most needs in the amateur's darkroom.



The 741 operational amplifier is connected without any feedback so it amplifies the voltage between its input terminals (pins 2 and 3) about 200,000 times. Any small voltage difference between the input terminals greater than a few millivolts will therefore cause the output to swing to either zero volts or 9V i.e. the voltage limits determined by the supply voltage.

A potential divider is formed by resistor R3 and light dependent resistor PCC1. The voltage at the junction of these components depends on the resistance of PCC1 which in turn is dependent on the amount of light incident on its face.

Varying the position of the wiper of VR1 will bring the voltage at pin 3 of IC1 equal to that at pin 2. At this point the light emitting diode (D1) will go from on, to off, or vice versa. By using a calibrated scale on the potentiometer VR1, the on/off position can be used as a measure of the amount of light falling on the light dependent resistor.

If the l.d.r. specified cannot be obtained, other types may be used although some adjustment of the values of R1 and R3 may be needed.

The on/off switch is a push-to-make type and is depressed only when taking a reading. This eliminates the possibility of leaving the instrument on and wasting the battery.

The most simple way to calibrate the unit is as follows. Place the Enlarger Meter on the baseboard of the enlarger and select an unexposed part of the negative, e.g. the strip between exposures, for the light to shine through on to PCC1.

Adjust VR1 until the on/off point of the light emitting diode is reached. The l.d.r. takes a couple of seconds to fully respond to the light so do not rush any reading.

Note the scale reading on the knob.

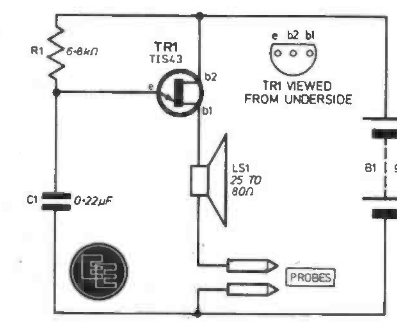
Use the usual method of test strips to determine the correct exposure time of the rest of the negative.

Repeat the procedure of several different values of light intensity, noting the scale reading of VR1 and corresponding exposure time. Construct a graph of these readings.

A different exposure time/scale reading graph must be constructed for each different type of printing paper. The exposure time for any print is then obtained by using the device as described to measure the light value and then reading the correct exposure time on the graph.

Alternatively, if only one type of printing paper is used, use a pointer knob instead of a scaled knob and print the exposure times directly onto the unit.

The instrument is most useful for normally exposed negatives; under-exposed or over-exposed negatives will need some alteration to the exposure time as read from the graph.



11 CONTINUITY TESTER

A multimeter switched to an ohms range is a popular form of continuity tester, but this does suffer from the disadvantage that it is necessary to look away from the test prods to look at the meter when checking for continuity. If the two test prods are awkwardly placed, as they frequently are, this can prove to be rather difficult, and also it can become rather tedious if there are a large number of tests to be made

The very simple tester described here overcomes this difficulty by producing an audible tone to indicate continuity. The unit is very simple to construct and is also quite inexpensive as few components are used.

The circuit consists of a relaxation oscillator feeding a miniature speaker.

A unijunction transistor, TR1 forms the active component in the oscillator. Unijunction transistors have little in common with ordinary bipolar transistors except that they are also three terminal devices. The terminals are named differently though, being called base 1(b1), base 2(b2) and emitter (e).

With no voltage present at the emitter, the base 1 and base 2 terminals have a resistance of about three to 10 kilohms across them. Therefore, when the test prods are short-circuited, a current of about a couple of milliamps will flow through the loudspeaker via the unijunction.

This does not, of course, take into account that C1 will have charged to the supply potential within a fraction of a second of the battery being connected and so there is about 9V at the emitter of TR1.

If more than about half the supply potential is present at this terminal the emitter input impedance (which is otherwise extremely high) suddenly falls to a very low level and the base 1 to base 2 resistance of the device falls to about half its previous level.

Thus, at the instant the test prods are touched together, C1 discharges into the emitter of TR1 and a pulse of current is fed to the loudspeaker via the b1, b2 terminals of TR1.

Once C1 has largely discharged, TR1 operates as previously described until C1 is charged via R1 to the trigger voltage once again. Then C1 will again discharge and another pulse of current will be fed to the loudspeaker. This will continue in rapid succession causing a continuous tone to be emitted from the loudspeaker as long as the test prods are connected together.

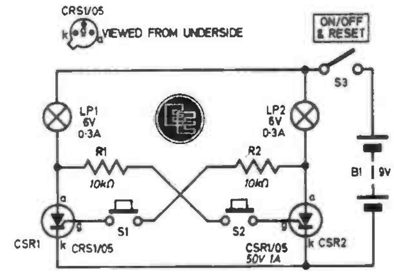
If a resistance of more than a few hundred ohms is present between the two test prods, TR1 will cease to function and no audio tone will be generated.

This is an important feature, as, if the unit produced a tone even with a resistance of many kilohms across the test prods, as would be the case if the prods were connected in the positive supply for instance, misleading results could be obtained.

No on/off switch is required because, when the test prods are not connected together, the only current flow in the circuit is the leakage current through R1 and C1 which is so minute as to be of no consequence.

12 SNAP INDICATOR

When playing snap, arguments often arise as to who screamed "snap!" first. This type of disagreement can be stopped before it starts if a snap sequence indicator is used. The indicator described here is cheaper and is well worth building to keep the peace.



The simplicity of the circuit is immediately apparent, but unlike transistorised equivalents it uses thyristors which enable the lamps to be lit brightly.

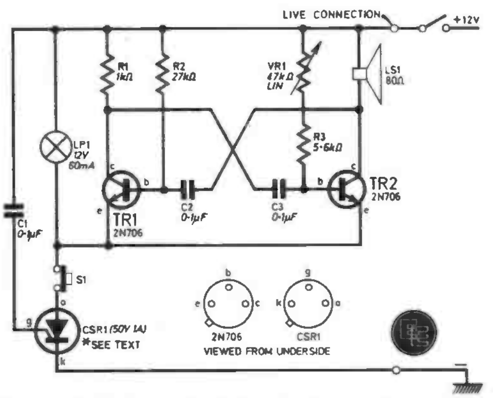
The use of thyristors also means that a memory is incorporated into the design in that, even if the player to respond first releases his button, the circuit will still indicate the correct sequence.

The symbol for a thyristor is very like that of a diode and this is not by coincidence. In its "off" state, i.e. with no current having been fed into its gate terminal, the thyristor acts almost like an open circuit—very little current will flow between anode (a) and cathode (k) no matter which way round the battery is connected.

However, if we pass current into the gate (g) terminal the thyristor will conduct and act just like a diode. If the current flowing from anode to cathode is of sufficient magnitude (this will depend on the particular device used) the thyristor will continue to conduct even when the gate current is stopped.

When S1 is closed, gate current flows into CSR1 via LP2 and R2. This switches CSR1 "on" and LP1 lights. If C2 is now pressed, no gate current can flow into CSR2 because the voltage at the anode of CSR1 is very low (it is heavily conducting) so R1 is virtually grounded.

Switch S3 is used to reset the circuit by stopping all current flowing.



13 CLUNK-CLICK JOGGER

Whether the law insists or not, the wearing of seat belts in cars is sensible practice.

For the absent-minded, some sort of memory-jogger is necessary and the circuit to be described fulfils this need. It was decided not to make connections to the seat-belt mechanism itself—this could be dangerous and certainly rather difficult. Rather than this, a device which emits a high-pitched whistle when the ignition is switched on was constructed. This reminds you to attach your seat belt. The whistle is silenced by pressing a small button.

The most tricky part of the design is to prevent the switched-on ignition circuit from simply causing the device to operate again after the silencing button has been released. Silencing it with a normal type of switch was thought to be out of the question as it could be inadvertently left in the "off" position. A button was essential.

To overcome this problem a silicon controlled rectifier, often called a thyristor, was used. Although this looks like a transistor it behaves very differently.

The thyristor, unlike a transistor, is a four-layer device, *pnpn*. Like a diode it will allow current to pass in one direction only. Unlike an ordinary diode, however, it will only do this if a positive pulse is applied to the "gate". In the absence of such a pulse, current will flow in neither direction. Once the pulse has been given the thyristor "fires" and after that the gate loses all control over its action. That is why only a short pulse is required.

If the current passing through the device is stopped or allowed to fall below a certain threshold value, then the thyristor fails to conduct and another pulse will be necessary to make it work again.

In the present circuit the pulse is given via capacitor C1. After the pulse the capacitor will be kept charged and will not keep the thyristor conducting as it would if the gate were connected straight to the positive line. Pressing the push button S1 cuts the current through the device momentarily and, in the absence of a new pulse, the circuit remains switched off. It will, of course, trigger again if the ignition is switched off then on again. In fact, if this is done fairly quickly it is unlikely to start conduction as the charge on C1 will take several seconds to die away sufficiently.

The rest of the circuit is fairly straightforward. It consists of two transistors and other components connected as a multivibrator. This is a type of oscillator and will give a tone from the loudspeaker which depends on the setting of VR1. With the values given, the frequency in the prototype was that of a good high-pitched whistle. Resistor R3, placed in series with VR1, is to prevent excessive base current from destroying TR2 if VR1 is set to near-zero.

The transistors chosen were 2N706's because they are cheap but various types could be used with success. Again, the thyristor (CSR1) may be any small type with a working voltage of, say, 25 volts or more and a current carrying capacity of 1 amp.

It will be noted that there is an indicator lamp LP1 in the circuit. This is so that CSR1 will pass a reasonable current when it is conducting. If it did not i.e. if all it had to do was pass the small current needed for the multivibrator section, then this would probably be below the threshold value of current mentioned earlier. This would mean that the thyristor would fail to remain "fired" after the gate pulse had stopped.

The loudspeaker should be a small type of approximately 60mm diameter. It must have a high-resistance coil, of about 80 ohms.

The circuit may be checked by making up about 12V with batteries before fitting it to the car. When fitting it, a suitable connection must be found which becomes live only when the ignition is switched on. The wiring diagram for the car, or a little common sense will help. Either this connection may be taken direct to the fusebox or to a wire already in use for an existing accessory.

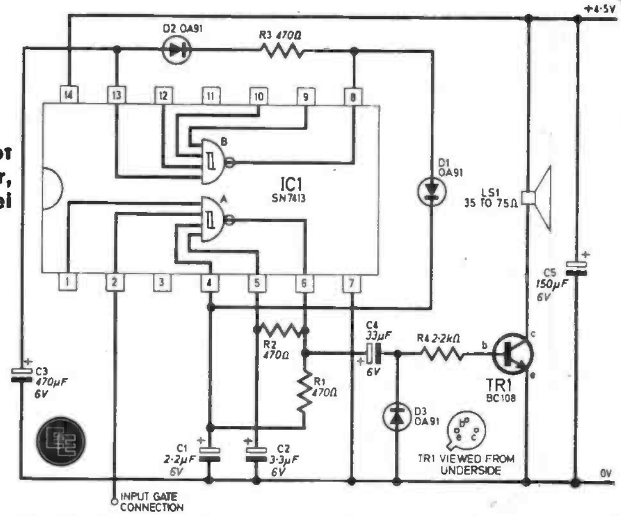
Wherever this connection is made it must be done properly using an appropriate connector and light-duty auto type wire. Never use single strand wire for this type of work or any of the ordinary wire used in general electronic work. Wires to be passed through metal must be protected with a grommet.

The only other connection to be made is an "earth". If a suitable earth point cannot be found, a small hole will need to be drilled through a metal part and a self-tapping screw fitted. The earth wire is secured to this by an earth tag.

Potentiometer VR1 should be finally adjusted so that the loudspeaker emits a really penetrating and annoying noise. It will get on your nerves but should keep you out of trouble.

14 TWO TONE AUDIO OSCILLATOR

This versatile two tone oscillator is suitable for a variety of applications, e.g. door "bell", intercom call tone generator, alarm circuit for electronic digital clocks, klaxon horn for model fire engines, trains, etc., or even as an excess voltage alarm.



The circuit is built around an SN7413 dual 4-input NAND Schmitt trigger, one Schmitt wired as a switchable frequency audio multivibrator and the other as a low frequency tone switching circuit.

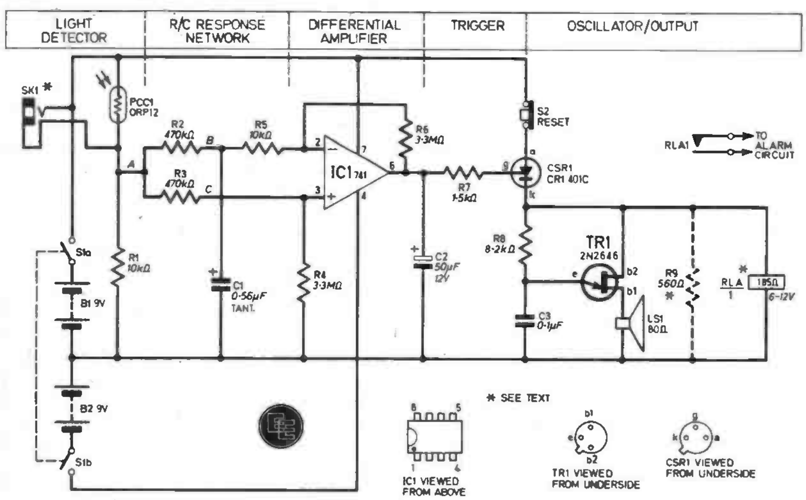
With the component values given, tones of approximately 650Hz and 950Hz with a switching speed of 1Hz will be generated. The pitch of either tone can be raised or lowered by using smaller or larger capacitors respectively for C1 or C2 or raised by increasing the resistors R1 or R2. The amount by which these resistors can be modified is dependent on the characteristics of the particular i.c. used, a typical maximum is around 1 kilohm.

If the value of C3 is reduced to around 100μF a warble effect will be produced. This will be found preferable in applications requiring short bursts of operation, e.g., door bell circuit etc.

The discharge resistor R3 in the switching circuit is chosen to give an even mark/space ratio to the switching waveform, and may need slight alteration in value to achieve this end. It may also be necessary to reduce the value of this component to ensure correct working of the switching circuit.

If C1 and R1 are removed and a jumper wire used to replace D2, the circuit will operate as a single tone "bleeper".

The output stage is designed to draw no power until the oscillator is working.



15 ELECTRONIC WATCHDOG

The Electronic Watchdog is different because it does not simply rely on light level. It is not triggered by slow changes of light such as occur at dusk or dawn, or when clouds pass by. It responds only to rapid changes, such as might occur when a person passes between it and a window or a room lamp, or when a torch is shone on it at night—or even a single match struck a few feet away.

The device responds to many kinds of movement in its vicinity, for a moving person or object nearly always causes an alteration in the balance of light and shade sufficient to trigger the circuit. It can look out for intruders, spot the car headlamps of expected guests, or keep guard on almost any object.

The unit uses a light-dependent resistor, or photo-conductive cell (PCC1) wired in series with a resistor to make a potential dividing chain. As light intensity increases the resistance of PCC1 decreases, and the voltage at point A therefore increases. Voltage at A is about 0·1V in darkness, and rises to about 8·5V in bright sunshine.

The next stage in the circuit is designed to respond to rapid changes in this voltage, even though these changes may be relatively small—of the order of 0·05V.

If the voltage at A rises there are corresponding rises at B and C. Voltage at C rises virtually at once, but the rise at B is delayed.

Note that it does not matter what the voltages are; if B is 1·1V and C is 1·2V (difference is 0·1V or if B is 6·75V and C is 6·85V (difference is still 0·1V) we get the same output from the amplifier. If B and C are both equally low in dim light or both equally high in bright light, this has no effect on the output of the amplifier, which remains at zero. It is only when a rapid increase of light occurs, and A rises, causing C to be greater than B, that the output of the amplifier increases.

The circuit used in the Electronic Watchdog responds only to positive going outputs, and this simplification is no great loss, for usually a movement in the vicinity of PCC1 will produce both decreases and increases of light intensity—often many fluctuations in succession—and the alarm will be triggered.

The "trigger circuit" can be seen on the complete circuit diagram shown in Fig. 4. The output of IC1 passes through a resistor to the gate of the thyristor, CSR1.

To obtain a really loud alarm the thyristor can be wired to a relay, as shown. This can be additional to the oscillator or instead of it. In the latter case, you can then omit R8, C3, TR1 and LS1. The relay can then be wired to switch on an electric bell (or bells) when its coil is energised.

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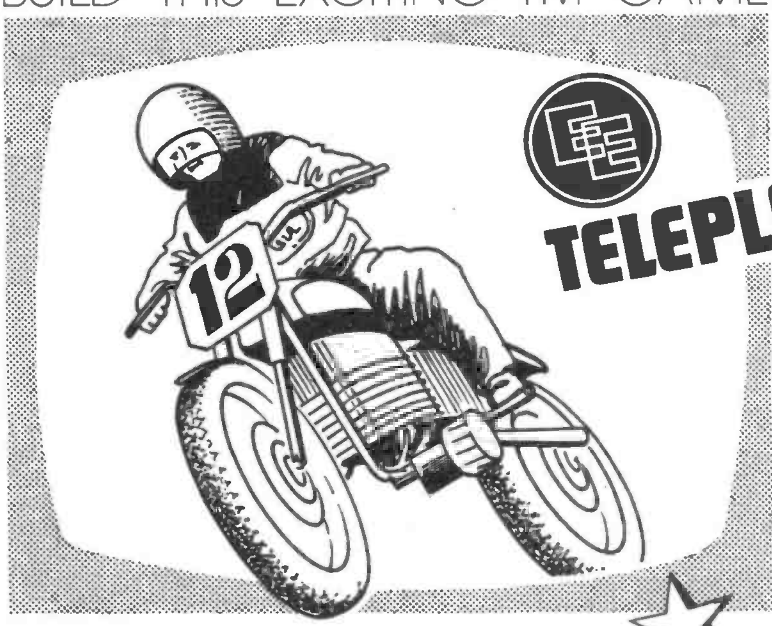

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MAY ISSUE ON SALE FRIDAY, APRIL 21

MAINS DELAY SWITCH

By A. R. WINSTANLEY

An adaptable time switch with delays of up to one hour.

THIS project was originally inspired by a "snooze timer" on a digital clock/radio which switched off the radio after a delay of up to one hour. It was thought that a general purpose unit might find several uses in the home. Alternatively a "dedicated" unit could be built for a specialised application, using the principles outlined in this article.

IC THEORY

The device is centred around the NE555 timer i.c. in its monostable mode. This configuration is illustrated in Fig. 1.

A monostable is a circuit which has only one stable state. It can be triggered into its other state temporarily by an external trigger signal, but the monostable will return to its steady state after a certain delay. In Fig. 1, this delay period is determined by the formula;

$$T = 1{\cdot}1\ R \times C$$

where R is in ohms
C is in farads
and T is the delay in seconds.

The value of T can lie between microseconds and hours, but in general, the maximum delay which the NE555 can be considered to generate accurately is one hour.

The triggering signal is applied to the i.c. at pin 2. To trigger it, this pin must be taken down to a potential of less than one-third the supply rail voltage. In the Mains Delay Switch, the i.c. is triggered by shorting pin 2 to ground (zero volts).

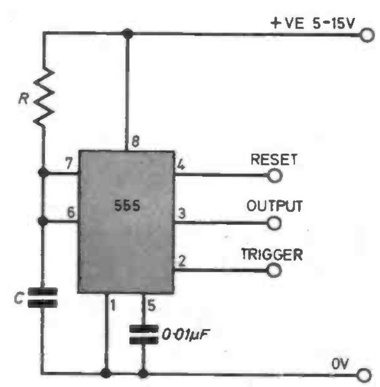


Fig. 1. Typical configuration for the 555 timer i.c. as a basic monostable.

Once the i.c. has been triggered into its timing state, if now further triggering signals are applied to pin 2, then this will have no effect on the output unless the i.c. happens to "time out".

Once the timing period T is up, the i.c. will return to its stable state. If it is desirable to cut short the timing period, this can be effected by shorting pin 4, the reset pin to ground.

The output of the monostable is available at pin 3. When the i.c. is in its stable state, this pin is almost at ground potential. When the i.c. is triggered, the voltage at pin 3 immediately rises to that of the supply rail voltage. From the output we may drive more timers, small bulbs, relays or other *output* devices.

Pin 5 of the i.c. can normally be left unconnected or taken to 0V via an optional $0{\cdot}01\mu F$ capacitor. Finally, the supply rail connections; pin 8 must be connected to the positive rail, and pin 1 to 0V. The i.c. will operate correctly from any supply voltage between 5 and 15V d.c.

START HERE FOR CONSTRUCTION

The whole of the circuit is arranged on 0·1 inch matrix stripboard, 24 strips by 37 holes, and construction should commence here, Fig. 3.

Start by drilling clearance holes in each corner to take the mounting supports—take care when drilling them to ensure that the corners of the board will not break off.

Now lay the drilled board on the base of the box and mark out the drilling centres on the bottom of the case. This will ensure that the board will align perfectly with the mounting holes when it is mounted in the case. Next make all the breaks in the copper strips, using either a hand-held drill or the proper Vero-tool. Now insert all the Veropins, if used.

SOLDERING

It is most advisable to use an i.c. socket with the integrated circuit, and this should now be soldered into place. The jumper wires should be soldered into place, using insulating sleeving if you think that there is a danger of the wires touching other components.

Now solder in all of the components, the large capacitors should be soldered in last of all. Note carefully the polarity of the diodes and capacitors.

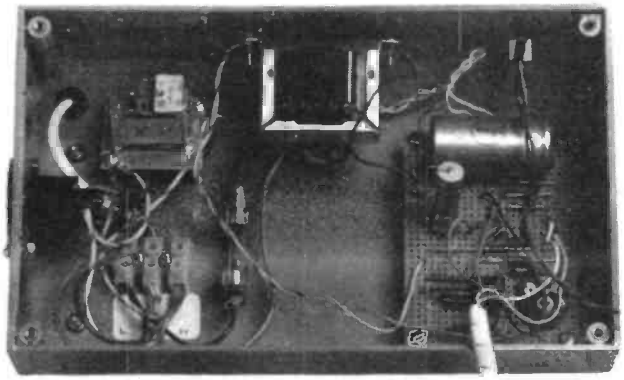
Carefully inspect the underside of the board, checking for things like whiskers of solder bridging adjacent strips, wrongly-polarised components etc. Finally insert the i.c. into its socket, taking care to get it the right way round.

TIMING COMPONENTS

The timing resistors R3 to R7 are mounted on the terminals of the rotary switch. Because 1-pole 6-way switches are not available, then one half of a 2-pole 6-way switch must be used. Resistors R10 and R11 are mounted on their respective indicator lamps.

CASE

The delay switch was housed in a very attractive "Mini Console" type case of dimensions 215× 130×75mm. Any strong plastic or metal case will do, but if a metal one is chosen, then make sure it is well earthed during final wiring up.



Positioning of components within the plastics case.

It was discovered, using the Mini-Console, that it was not too easy to arrange the switches on the front panel so that they would not touch any internal devices in the box once the lid was in place.

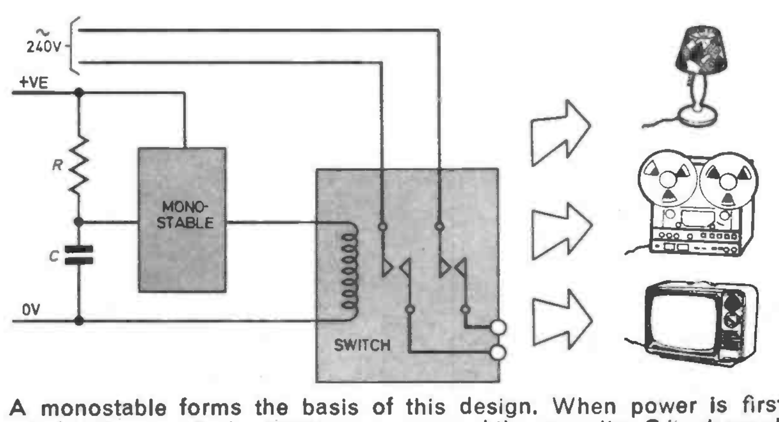
If therefore a similar case is used, then an interior and front panel arrangement roughly like the prototype's should be used. A great deal of care must be exercised when arranging the components around the box. Of course, if a larger case is used, then no difficulties should be met in this respect.

FRONT PANEL

The front panel of the case should now be prepared to take all the switches and lamps. It can be lettered with Letraset or similar transfers and then sprayed with clear lacquer to protect the transfers. Another possible method is to cover the front panel with clear adhesive film, of the type used on book covers.

The case should now be drilled to take all the internal fixtures. A hole is drilled in the back to take the mains input cable, this hole should have a grommet inserted

HOW IT WORKS



A monostable forms the basis of this design. When power is first applied to the circuit, the SWITCH operates and the capacitor C is charged up via R. When a certain voltage on the capacitor is reached the MONOSTABLE detects this and turns off the SWITCH.

Different time delays may be selected by altering the value of R. In practice the SWITCH is replaced by a heavy duty relay which is able to switch mains voltages. With the addition of a manual switch and a remote unit the possible applications are numerous.

MAINS DELAY SWITCH

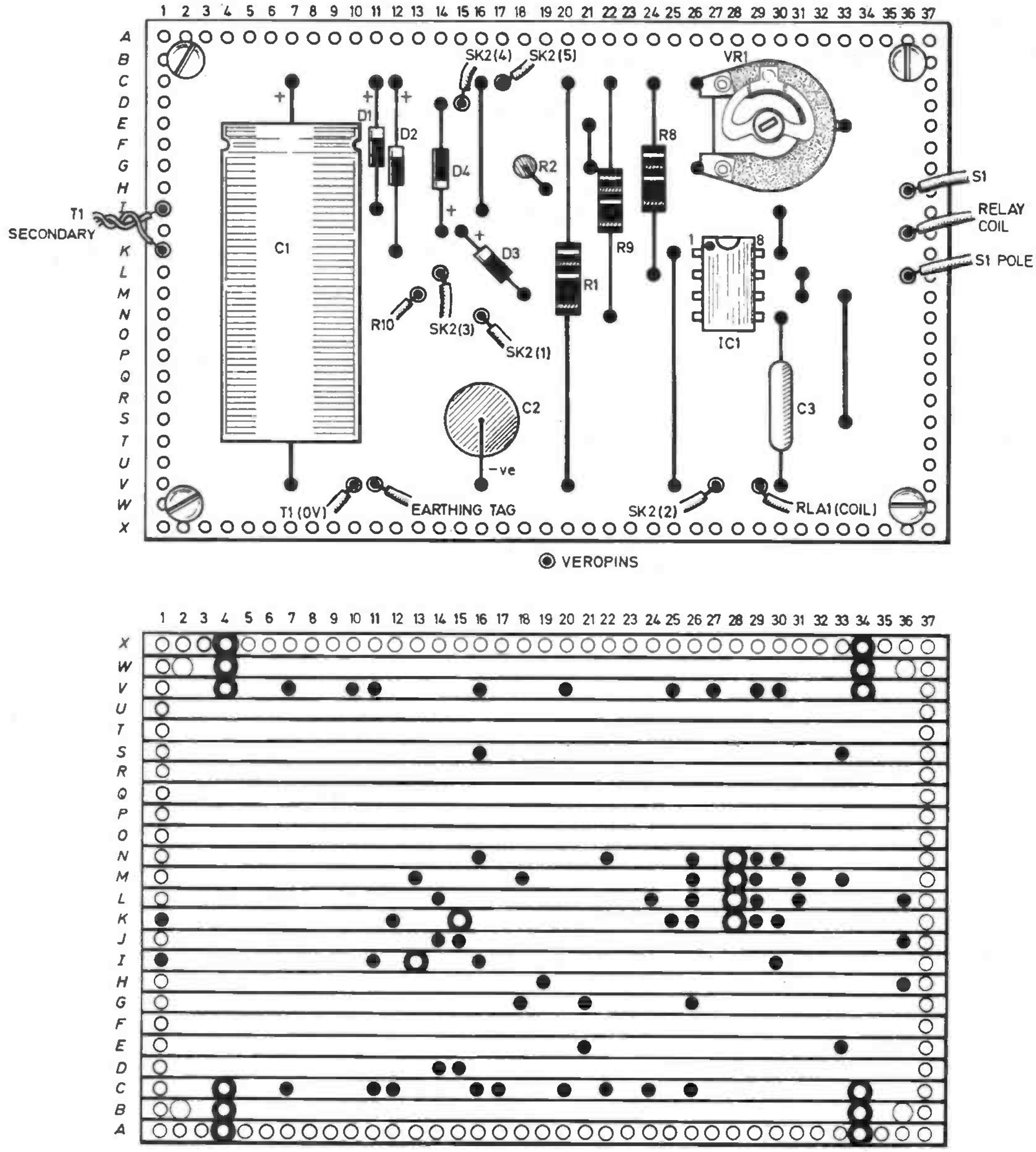
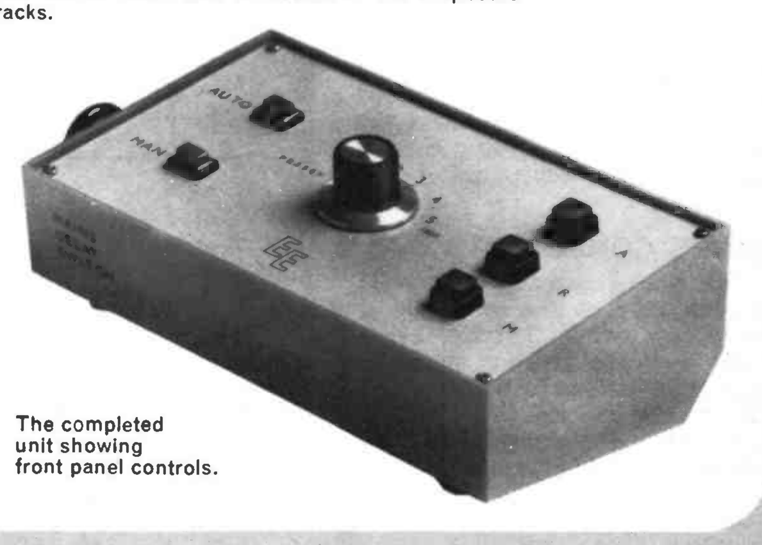


Fig. 3. Component layout for the circuit board and underside of the stripboard showing breaks in the copper tracks.



The completed unit showing front panel controls.

into it. A small hole may also be drilled for the DIN socket.

The mains outlet socket was mounted on the side of the case, but constructors may need to fix it elsewhere, depending on the type used.

The specified relay was mounted using a special aluminium sub-chassis. However, these are not now generally available. Therefore, either the relay cover could be glued upside down to the base of the case, or otherwise the special 2-pole changeover socket must be bought with it.

If another type of relay is used, then it is left up to the individual's ingenuity to mount it.

COMPONENTS

Resistors
R1 2·2kΩ
R2 2·2kΩ
R3 to R7 680kΩ (5 off)
R8 2·2kΩ
R9 2·2kΩ
R10 47Ω
R11 47Ω
All ½W carbon ± 5%

Potentiometer
VR1 470kΩ horizontal preset

Capacitors
C1 1500μF 25V elect.
C2 330μF 16V elect.
C3 0·01μF polyester

See Shop Talk page 373

Semiconductors
IC1 NE555V timer i.c.
D1 to D5 IN4001 (5 off)

Miscellaneous
T1 mains/0-6V, 0-6V 500mA secondary
RLA 185Ω 12V coil with two sets of normally open contacts rated at least mains 3A, (Doram 348-920) see text
LP1 240V mains neon
LP2, 3 6V 60mA LES bulb with holders (2 off)
FS1 2A fuse with chassis mounting holder
SK1 3 pin mains socket (size as required see text)
SK2 5-pin DIN socket
S1 2-pole 6-way rotary switch
S2, 3 single pole push to make release to break push switch (2 off)
S4 single pole push to make, release to break
Stripboard 0·1 inch matrix, 24 strips × 37 holes; "Miniconsole" type case or similar; mounting hardware for relay; one large round knob; i.c. socket; 6BA hardware and solder tags; connecting wire; solder.

COMPONENTS FOR REMOTE UNIT

PL1 5 pin DIN plug to suit SK2
S5 single pole toggle switch
S6, 7 single pole push to make, release to break (2 off)
Five core screened cable; small plastic box, 65 × 40 × 25mm or similar

WIRING

The mains cabling should be soldered to the relay before it is put into place. The joints on the relay contacts must be of a high quality—they must not be "dry" or physically weak. Sleeving should be used over the joints to prevent any possible shorts occurring. The e.m.f. suppressor diode is mounted straight across the relay coil. Make certain that it is soldered the *right way round*. If you are particularly unlucky, you could destroy the i.c. if it is connected incorrectly.

The transformer is earthed by means of a solder tag under one of its mounting bolts. The 0V rail is earthed similarly, using a flying lead terminated at the same solder tag. The front panel is earthed by means of a solder tag under the panel at one corner via one of the panel fixing bolts.

All interwiring between the circuit board and front panel can be carried out using general-purpose lightweight hook-up wire as detailed in Fig. 4. For the rest of the wiring, mains cable should be used, with a rating to suit the sort of loads likely to be used. It is advised that wire with a *minimum* 6A at 250V rating is chosen.

Put a fuse in the plug, again depending on the sort of loads likely to be used. Check carefully *all* of the wiring before proceeding to the testing stage.

TESTING

When all of the wiring has been thoroughly inspected, the unit should be tested using, if possible, an ohmmeter set to a low ohms range.

Check to see that there is a virtual short circuit (low resistance) between the earth pin of the plug and the transformer mounting bolts, socket earth pin, relay mounting bolt and the front panel when fitted. There should exist infinite resistances between the live pin of the plug and live output of the socket; the same applies to the neutral line.

AUTO OPERATION

With testing completed, the delay switch can now be plugged in. Pressing the AUTO button will cause the AUTO lamp to light up, and also the relay to click in. Pressing the RESET button should reset the time delay. Preset VR1 can be set to give a desired preset delay when the rotary switch is placed in the PRESET position. You can, if you want, go through the switch settings and check the delay settings —this should take about $1\frac{1}{2}$ hours!

MANUAL OPERATION

Check that the MANUAL switch operates the relay manually and also illuminates the MANUAL lamp. If the remote unit is also used, check that it too switches the relay on and off.

You can now fix the front panel into place. The device should be operated under test conditions for about half an hour or longer, and then, if all appears well, can be put into use afterwards.

MAINS DELAY SWITCH

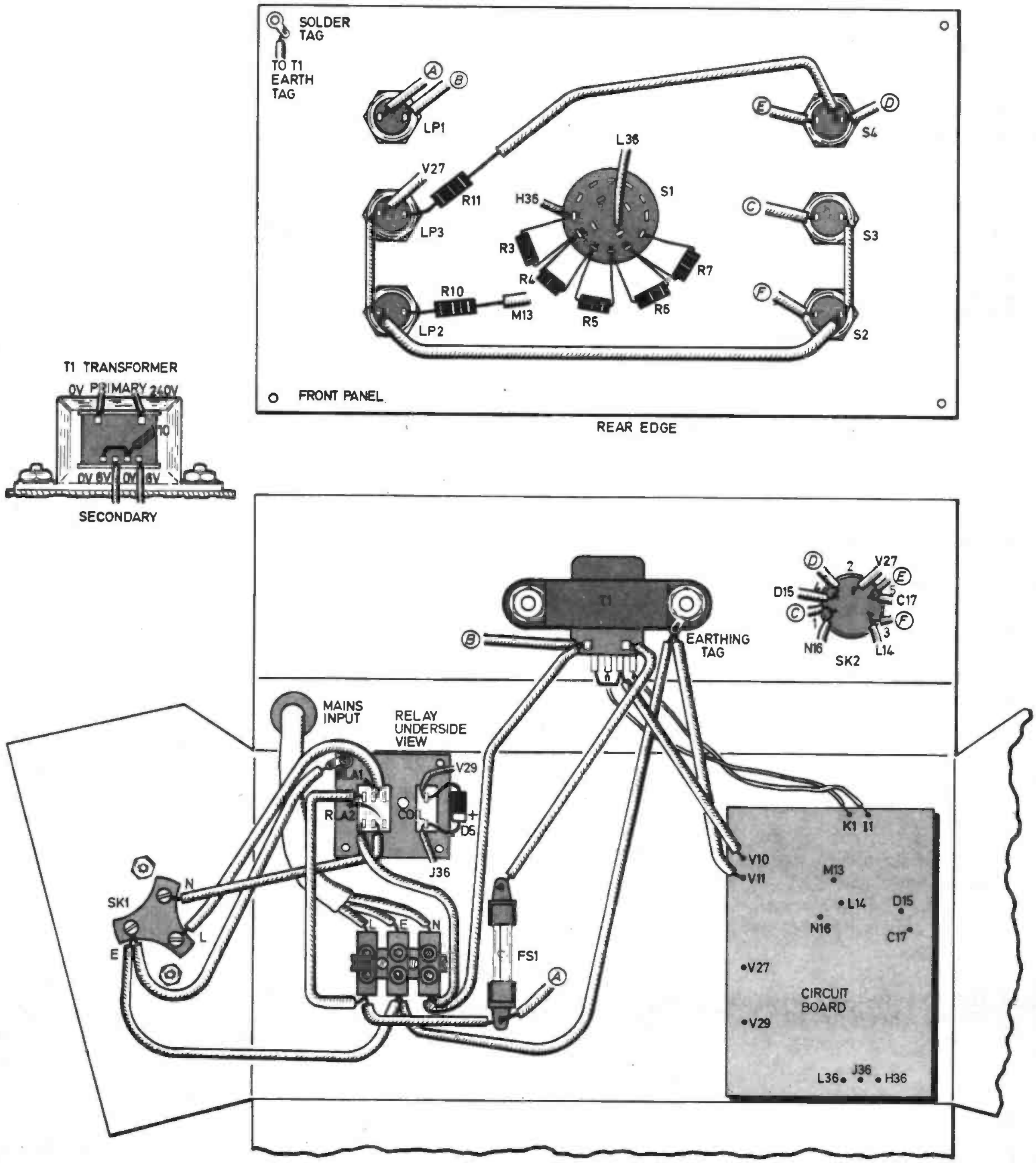


Fig. 4. Interwiring details for the front panel, relay, fuse, circuit board, mains socket and mains transformer. The mains transformer connecting tags are shown more clearly in the small diagram on the left. Note that a mains neon LP1 has been included in the wiring diagram but this does not appear on the author's prototype as shown in photographs.

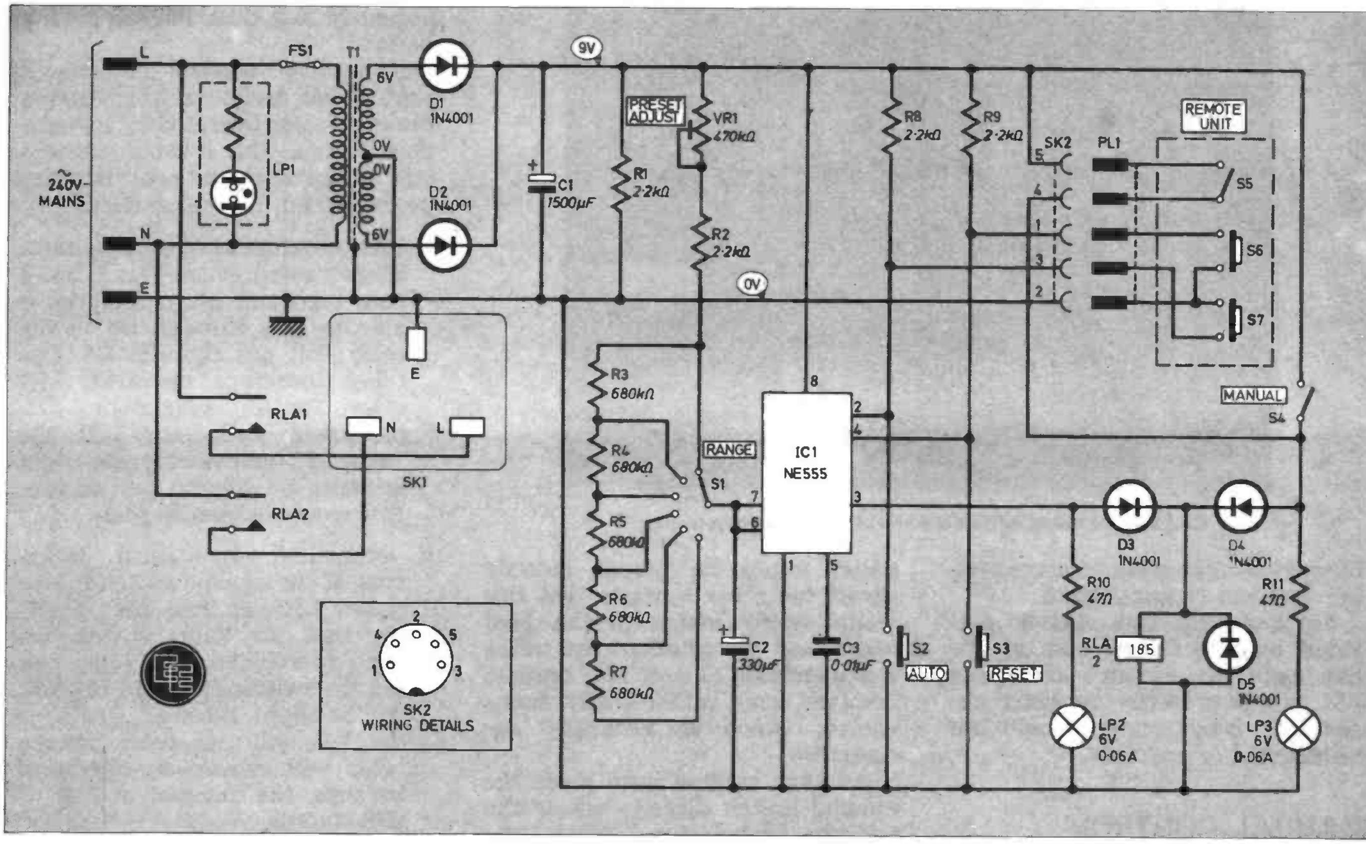


Fig. 2. The complete circuit diagram for the Mains Delay Switch.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Mains Delay Switch is shown in Fig. 2. If we compare this with Fig. 1, we can see that *R* is formed by R2, VR1 and R3 to R7; *C* is actually C2. The capacitor remains fixed in value, but the rotary switch S1 can select different values of *R*, thereby varying the monostable period to give different time delays.

The preset VR1 has been included so that one timing period, which has previously been preset, can be chosen when the delay switch is used for a particular function. Using the values of *R* and *C* shown in Fig. 2, delay intervals of roughly 5 minutes can be expected. This means that the maximum delay obtainable is about 30 minutes. The formula for *T* given earlier will give only the approximate delay. In practice component tolerances result in differences between calculated values of *T* and those actually obtained.

The timing sequence is initiated by pressing S2. Switch S3 can be pressed to reset the time delay. The two resistors R8 and R9 bias the trigger and reset pins to the positive supply rail and prevent false triggering by line transients, etc. If the reset pin is not used, it is usual to connect it straight to the positive line.

The output of the i.c. operates a relay, RLA which applies the mains voltage to the output socket through the contacts RLA1 and RLA2.

Important notes about the socket and relay are given later on.

POWER SUPPLY

The timer operates from a 9V supply, and draws about 180mA of current maximum, depending on the relay used.

Because the circuit will demand at *least* 120mA for quite long periods, it was decided that the i.c. should operate from a mains derived supply. Modifications to allow a battery to be used instead are detailed at the end of the article. The use of a mains supply does, however, obviate the need for battery replacements, and should be incorporated if at all possible.

MODIFICATIONS

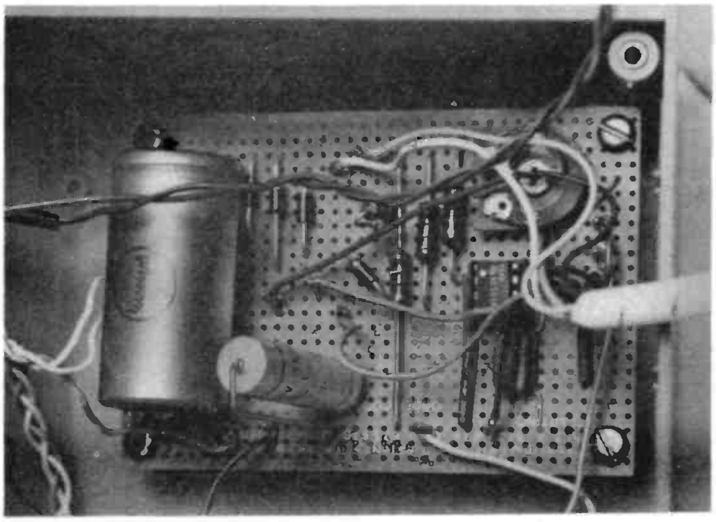
The following notes are given for those who wish to modify the unit to suit their own requirements.

The specified relay will theoretically switch loads of up to 3A, but to do so would result in severe contact wear. If heavy loads are likely to be switched, e.g. a photographer's enlarger lamps, then a heavier duty relay MUST be used. For example an "Octal" (348-756) or "H/D Open" (348-835) from the Doram range would appear to be suitable, having 10A contacts. Under no circumstances must a relay having a coil resistance of less than 75 ohms be used.

MAINS SOCKET

The mains socket may also need uprating. The type used on the prototype was rated at 5A, and it would appear that the next size up would be a standard 13A square pin type, in which case a larger case may well be needed.

In general, if any modifications are carried out which enable the delay switch to drive heavier loads, then you must make certain that all mains-carrying components are likewise up-rated. This includes



Close-up of the circuit board showing component layout.

the mains-input cable, interconnecting wire and terminal block.

Further protection may be provided by inserting a fuse in the live lead to the output socket. Fuse FS1, which protects the timer circuit and transformer, should *not* be changed or omitted.

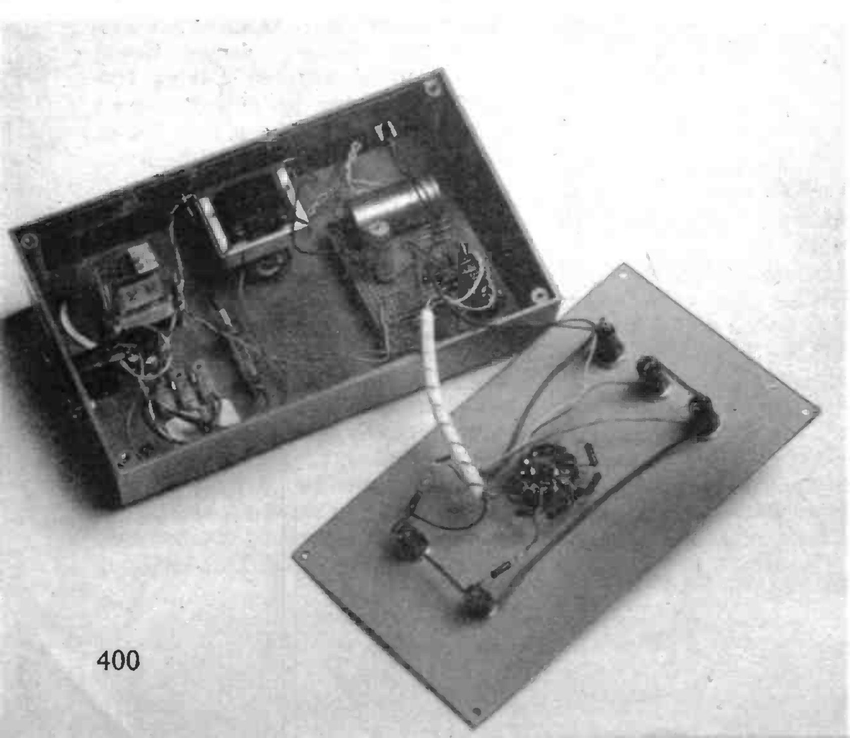
MANUAL CONTROL

In many instances a "manual over-ride" control would prove to be useful. This would switch on the mains load irrespective of the state of the monostable. Some sort of indicator lamp should also be incorporated which illuminates when the manual switch is on.

There are several methods of inserting a manual control. A switch could be placed directly across the relay contacts, and this would apply mains to the load regardless of whether the relay was operating or not. This method involves some rather tricky mains wiring, which is generally undesirable.

Another method is to place the manual switch directly across the trigger push-button. When the manual switch is closed, the i.c. would be fed with a constant trigger signal. As soon as the i.c. had timed out, it would retrigger; the relay would not have time to drop out. Unfortunately, when the manual switch was opened, the relay would remain operative until the i.c. had completed its timing period, unless the device was reset.

The completed delay switch with the front panel removed. Note the timing resistors mounted directly on the switch S1.



This is true only if the triggering period is less than the *RC* timing period.

A superior method of manual control was designed, which allows the relay to be operated by a single-pole switch. This is S4 in the circuit diagram, and its operation can be explained in three sections:

a. AUTOMATIC DELAY OPERATION ONLY. When the i.c. is triggered, pin 3 goes high and source current is able to flow through D3 to the relay, but not through D4. The relay therefore operates. LP1 (the "auto" indicator) illuminates as well. Lamp LP2 (the "manual" indicator) cannot light because D4 blocks any current that would otherwise pass.

b. AUTOMATIC AND MANUAL OPERATION. If the manual switch is now closed, LP3 can illuminate, showing that the delay switch has been overridden. The relay will remain switched on, and LP2 will still be alight. When the i.c. times out, LP2 will extinguish, but the relay will remain in operation because the manual switch is still closed.

c. MANUAL MODE ONLY. If the i.c. is untriggered, and S4 is now closed, the relay will switch on and LP3 will light up. Current cannot "sink" into pin 3 because D3 is now reverse-biased, so that it does not allow current of a significant magnitude to flow. Diode D3 also prevents LP2 illuminating when the manual switch is closed.

Finally, diode D5 prevents back e.m.f., generated when the relay coil suddenly switches out, from reaching the rest of the circuit.

DIFFERENT DELAYS

Different timing values can easily be arranged, using the formula given at the beginning of the article. The delay is largely determined by the resistance between R3 to R7, and this resistance can be altered at will, but should not exceed 11MΩ with a 9V rail.

The value of C2 can also be changed, as needed. If the time switch is to be used where only one delay is ever needed, then the rotary switch could be omitted and R3 to R7 replaced with a jumper wire. This means that VR1 is the timing resistor, and should be preset to give the required delay.

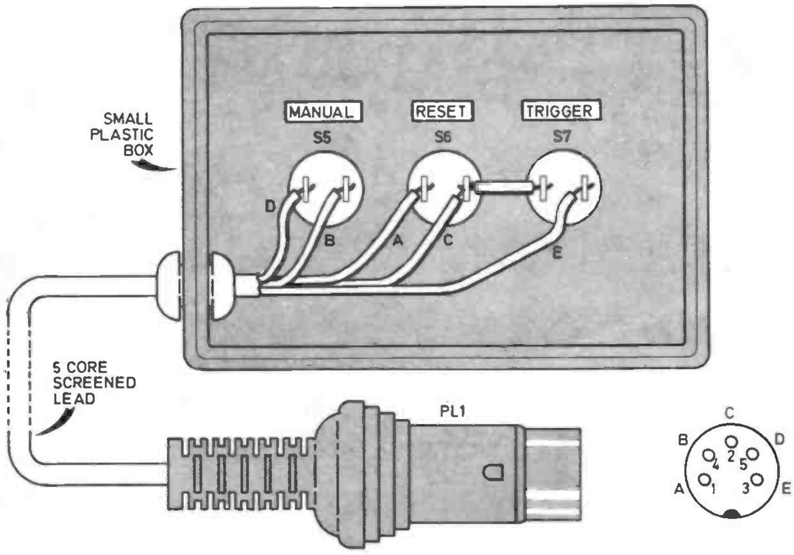


Fig. 5. Wiring details for the Remote Unit.

If shorter delays, less than 2 minutes are wanted, then the value of VR1 should be reduced to 220kΩ.

Resistor R2 should always be included as shown in the circuit diagram. Its presence ensures protection for the i.c. in the event that the timing resistor is shorted out.

RELAY

The specified relay operates from a nominal supply of 12V. In fact it has an operating range of 8 to 17V, and switches with ease at 9V. However, 6V bulbs cannot be used directly with a 9V rail, of course, because they would quickly burn out. Therefore a series 47 ohm resistor is included with each bulb to facilitate 9V operation.

The transformer specified in the parts list has two separate secondaries (wired to give 6-0-6V), each of which is rated at 500mA. This is more than enough to do the job. If available, a transformer rated at 6-0-6V at 200mA could be used, but it will be found that it will get very warm during operation.

No mains neon was included with the prototype, because it was thought that there were enough lamps and switches already! A neon would serve as a reminder that the unit was plugged in, and so the wiring diagram will assume that a neon is used.

BATTERY OPERATION

For those not wishing to incur further expense on transformers, etc, battery operation is feasible providing certain modifications are carried out to reduce the operating current of the circuit. First, the indicator lamps could be replaced with standard light emitting diodes and series resistors.

A further reduction must be effected by using a relay with much higher coil resistance—for example, a relay with a coil resistance of 1640 ohms. Using this relay the l.e.d.s reduce current consumption to just 20mA. If battery operation is opted for, then FS1, T1, D1 and D2 can be omitted. Capacitor C1 should be replaced with a smaller capacitor of 100μF in value.

REMOTE UNIT

The remote unit used with the prototype enables users to switch the relay on and off manually, and allows remote trigger and reset facilities. It was not thought worthwhile to extend the indicator lights to the remote unit.

Five-core cable will be required, and this should be terminated in a five-pin DIN plug. Cable length can easily be in excess of 6 metres, which should be enough for most needs. The wiring for this unit is shown in Fig. 5.

FURTHER APPLICATIONS

The delay switch can if calibrated correctly, be used as an exposure timer in conjunction with a photographer's enlarger. This will almost certainly entail recalculating the values of the timing resistors and capacitor, using the formula given.

In fact it might be a good idea to use all presets instead of fixed resistors, thus allowing exact calibration to be achieved. Ensure that the pilot lights will not interfere with the photographic processes in the darkroom.

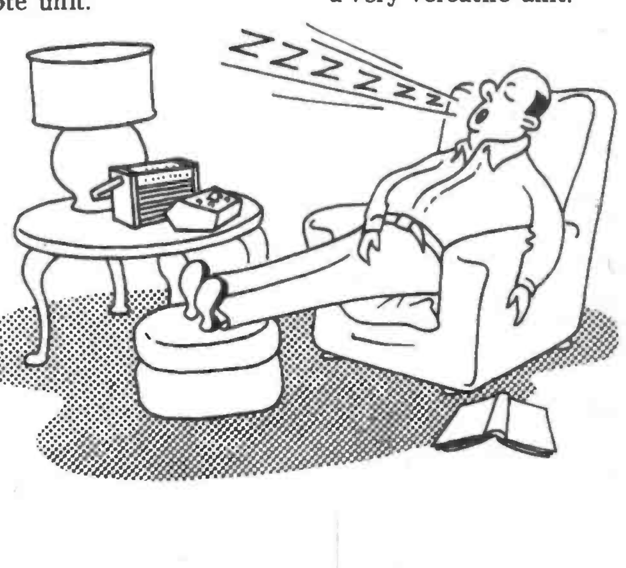
SLEEP TIMER

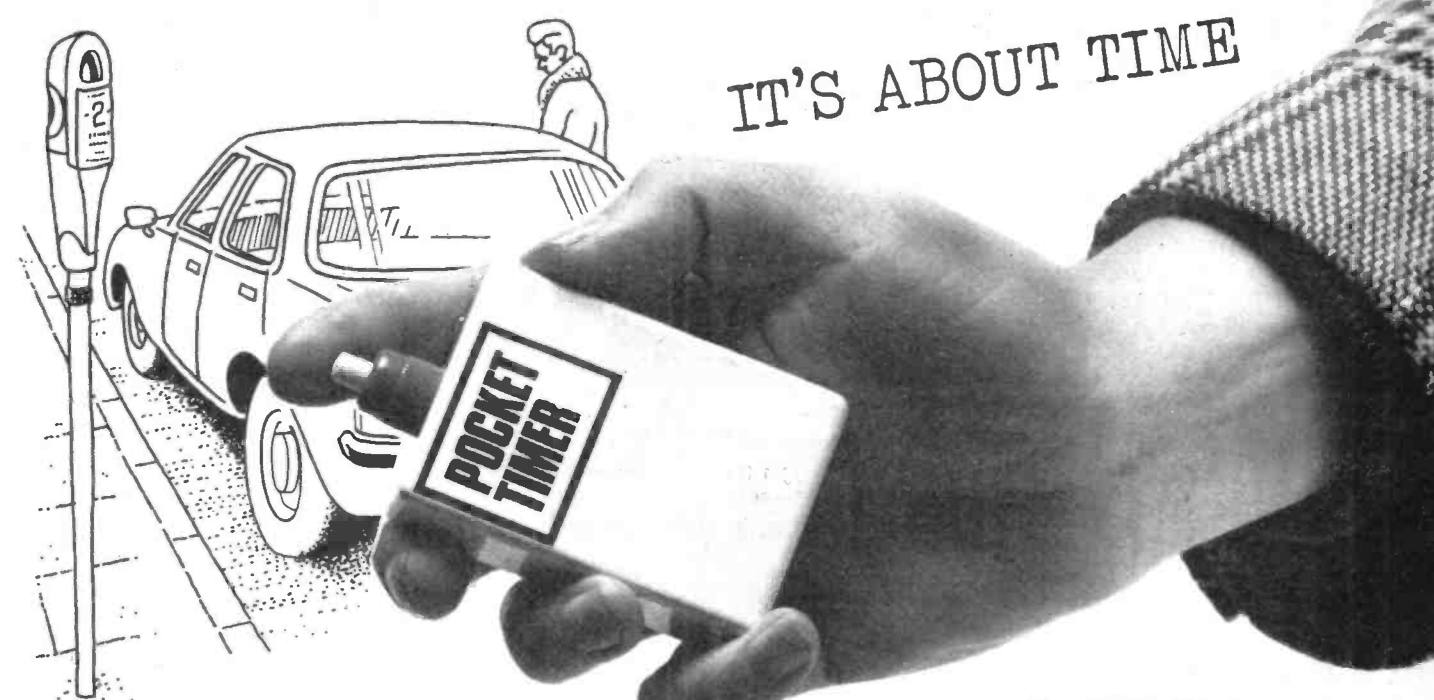
The delay switch could also be used with mains radio as a "sleep timer", so that one can fall asleep with the radio playing. If you select a particularly boring programme on the radio, you might fall asleep even sooner!

It might be useful in controlling exterior lights, particularly if the lights happen to be fixed to garden shed walls. In this case, you could leave the shed and arrive indoors with the outside area illuminated —very useful in the winter months!

Alternatively, the unit could be used to drive a small lamp mounted in the garage. The lamp could be triggered for a short delay, allowing you to see to lock the car door at night and retire to the house without having to switch off any lights.

No doubt readers may well find other uses for what is potentially a very versatile unit. ⌑





By O.N. Bishop

POCKET TIMER

THIS cheaply made and pocketable fixed period timer owes its simplicity to a novel circuit design. It employs only two active semiconductor devices yet, by a suitable choice of timing capacitor, can be made to cover periods ranging from a few seconds to several hours.

It has many applications:

Timing moves in games such as Scrabble or chess

Egg timer

Parking-meter reminder

Tucked in the top pocket of a jacket or shirt, it is inconspicuous, yet the warning lamp is easily visible in that particularly sensitive region at the edge of your field of vision.

START HERE FOR CONSTRUCTION

CASE

It is best to find a suitable case first, then design the layout of the circuit board battery and switch to fit inside it. Any small commercially-made instrument case will hold the circuitry, a Verocase was used in the prototype.

Instead of a light emitting diode you can use an ordinary flashlamp bulb. If D1 is replaced by a 6V 0·06A filament bulb, R4 should be replaced by a resistor of 22 ohms.

A suitable layout is shown in Fig. 2. You could adapt this to a more compact layout if you intend to use a case smaller than that used, but beware of the difficulties of soldering components in close formation. The recommended layout is probably as close as the average beginner is likely to find convenient. In the prototype, the leads from the l.e.d. were lengthened by soldering about 1cm of wire to each. This gave the added length and flexibility necessary when pushing the l.e.d. up through the hole drilled for it in the case.

TESTING AND ADJUSTING

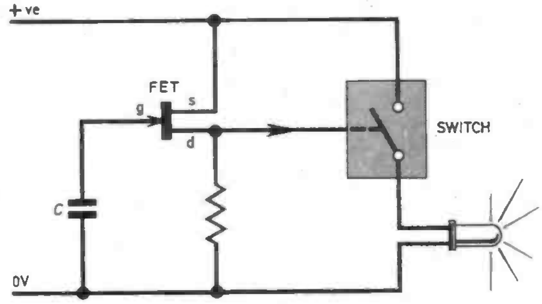
Set VR1 to maximum position and switch on. With *gk* of CSR1 thus grounded, the lamp should not light. Switch off and set VR1 to minimum position, switch on. With the potential at the wiper of VR1 going immediately to about 3·5 volts, the l.e.d. should light immediately. If either of these tests fail, check wiring, components and soldering. Look for dry joints, and for blobs of solder causing short circuits between adjacent copper strips.

Switch on and off, gradually moving the wiper of VR1 from its minimum value by a few degrees turn at a time, toward the maximum end of the scale. After switching off after each test allow about 10 seconds before switching on again, as charge stored on the capacitors may cause unwanted triggering of CSR1. This delay between switching off and on should also be observed when operating the device. Proceeding from minimum to maximum, you will eventually find a position at which the l.e.d. does not light at switch-on. The timer is now set for its minimum period of operation. You may find that the l.e.d. flashes once at switch-on, due to current surges, but this can be ignored. If you continue to turn VR1 further toward its maximum value the timer can be set for longer periods. It is best to approach a maximum setting gradually, testing and timing at each step, for if VR1 is turned too far toward the maximum end, the potential of its wiper never reaches the triggering threshold.

THE TIMER IN USE

Whilst running, the average current consumption of the circuit is only about 1mA, so a PP3 battery will provide many hours of use. However, once the l.e.d. has been triggered, current consumption increases to 20mA or more, so the

HOW IT WORKS



We can think of the f.e.t as being a variable resistor whose resistance between source (s) and drain (d) depends on the potential applied at the gate (g). If the f.e.t. is connected across a supply with the gate unconnected, then the current flowing through this junction produces a rising potential on the gate. The rate at which this potential rises can be controlled by introducing a capacitor across the gate and 0V. The rise will now depend on the capacitance of that capacitor.

A voltage across the resistor is now produced, this voltage thus operates the electronic switch which in turn illuminates the l.e.d. A preset is included in the actual circuit which can be used as a preset to set the delay required.

Table. 1. Value of C1 required for elapsed times

Maximum time required	Value of C1
4 minutes	10,000pF
50 minutes	0.033μF
3 hours	0·22μF

COMPONENTS

Resistors
- R1 10kΩ
- R2 180kΩ
- R3 100kΩ
- R4 330Ω
- All ¼W carbon ±10%

Potentiometer
- VR1 100kΩ sub-miniature horizontal preset

Capacitors
- C1 See Table 1
- C2 0·47μF polyester
- C3 0·1μF polyester

See Shop Talk page 373

Semiconductors
- TR1 2N3819 n-channel f.e.t.
- CSR1 BRY39 silicon controlled switch
- D1 TIL209 red light emitting diode

Miscellaneous
- B1 9V PP3 battery
- S1 s.p.s.t. push switch
- Stripboard 0·1 inch matrix, 8 strips by 24 holes; battery clip; Veropins as required; Verobox or similar size, 70 × 50 × 25mm; connecting wire; solder.

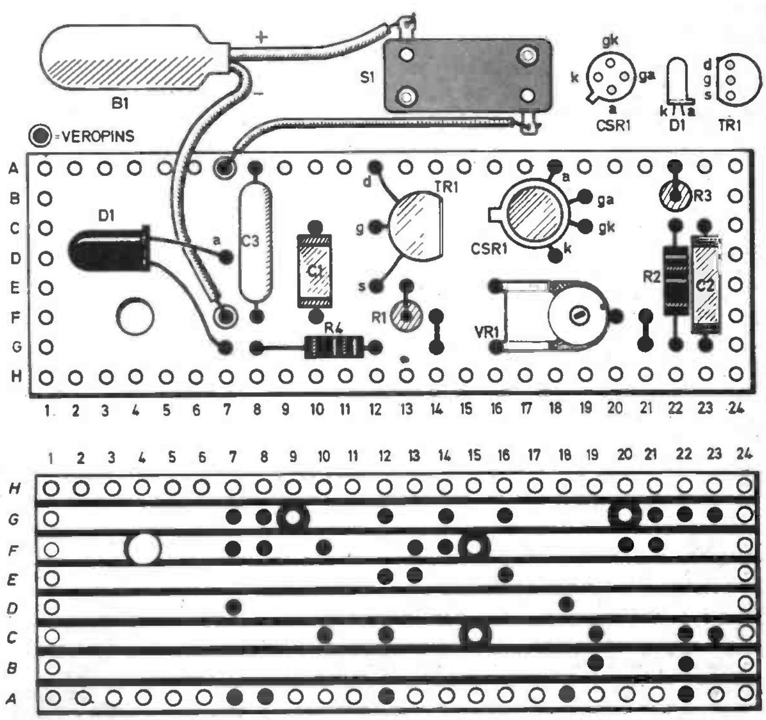


Fig. 2. Circuit board component layout, interwiring and underside of the stripboard showing breaks in the copper tracks.

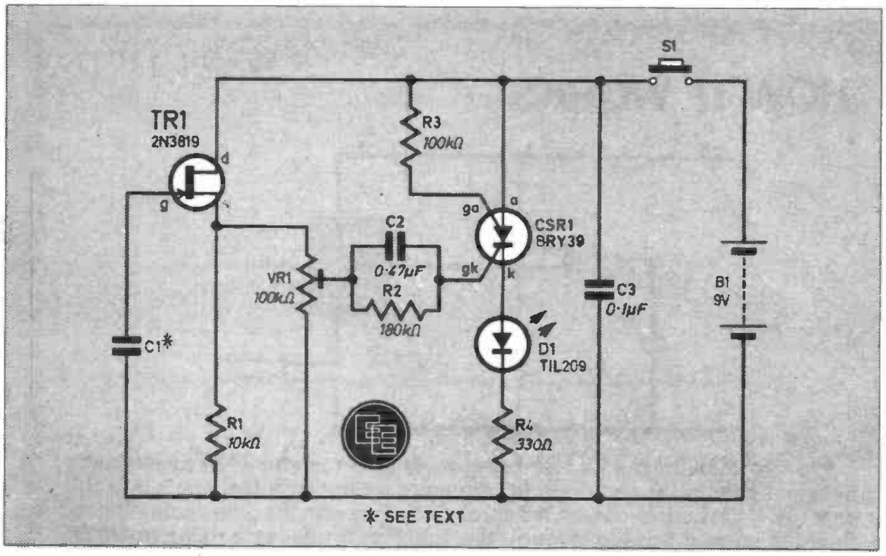


Fig. 1. Circuit diagram for the Pocket Timer.

CIRCUIT DESCRIPTION

The circuit for the Pocket Timer is shown in Fig. 1.

The semiconductors used in this circuit are two of the less commonly used devices, the field effect transistor and the silicon controlled switch. From the moment the circuit is switched on, the f.e.t. generates a slowly rising potential. When this potential reaches a predetermined value it triggers CSR1, which switches on the warning lamp.

The slowly rising potential is a consequence of the slow rise of gate potential. This rises slowly because of the extremely small current that flows into the gate of an f.e.t. The smallness of the gate current also has the important consequence that we can use a timing capacitor of relatively low value.

The majority of simple timing circuits require large value capacitors when timing periods in excess of 10 minutes. This implies the use of electrolytic capacitors. These are bulky and have the considerable disadvantage that their capacitance changes with age, and after periods of disuse, making them unreliable as the basis of a timing circuit. In this circuit the value of the timing capacitor is less than 1µF, so we can use silver-mica, polycarbonate or other types of capacitors; these are small in size and stable in value.

The effective drain/source resistance of the f.e.t. falls from a few kilohms at switch-on to a few hundred ohms in a number of seconds, minutes, or hours, depending on the capacitor. If the f.e.t. is connected as shown, the potential at the source is about 3·5V at switch-on, when the resistance of the f.e.t. is somewhat greater than that of the 10 kilohm resistor. As the resistance of the f.e.t. falls, the potential across it falls in proportion, giving a correspondingly greater potential-drop across the resistor. In short, the potential of the source gradually rises from around 3·5 V to almost 9 V. The exact values obtained depend on the exact characteristics of the individual f.e.t. used.

The potential at the source is too high for triggering CSR1, which needs only about 0·4V at *gk*. The variable resistor VR1 thus acts as a potential divider and sufficient current can be drawn from this to trigger CSR1. By varying the setting of VR1 we can adjust the time at which triggering occurs, over a limited range. Though it would be possible to use a full size potentiometer in this circuit to give a variable-period timer, the extra space required for potentiometer and control knob would make the device less pocketable.

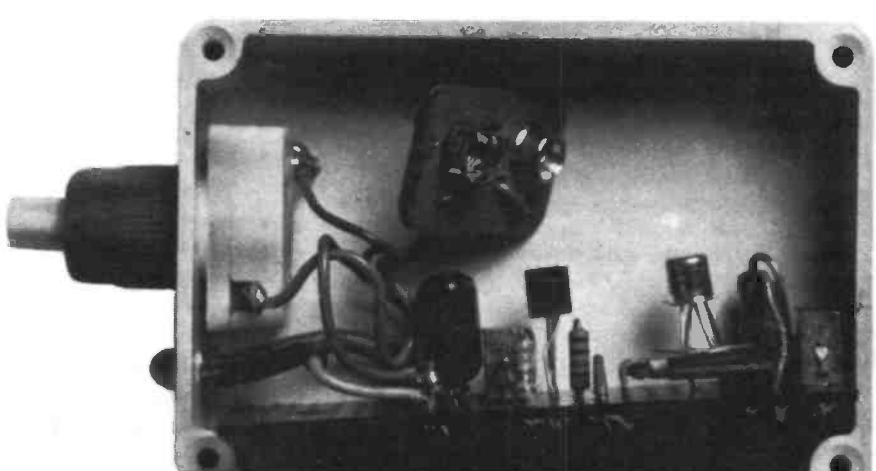
circuit should be switched off as soon as the warning has been noted.

This is not a precision timer. High precision is too much to expect from such a simple circuit. For periods within the range up to 1 hour, its reliability seems to be better than 5 per cent, which is more than adequate for the applications that have been mentioned.

If you are using it for periods in excess of one hour it is probably just as well to adjust it to run for a slightly shorter time than you actually require. For a two hour period, for example, adjust it to trigger at around 1 hour 50 minutes.

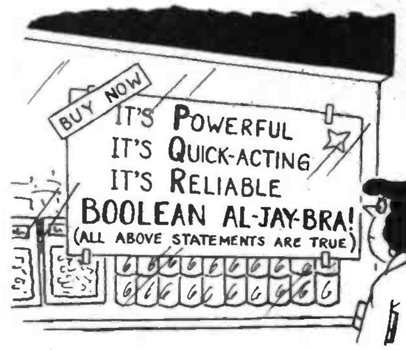
This gives you time to spot the warning lamp and still get down to the parking-meter in good time to avoid the wrath of the traffic warden! ⌑

Interior of the Pocket Timer showing the compact method of mounting the components inside the small case.



feminine Logic?

julie hurst



"TRANSISTORS, capacitors etc. are out" announced husband, nightschool file bristling with multi-coloured felt tips all a-quiver, "it's all logic now!" A mind boggling picture of a dozen chiton clad men sitting under a dead elm tree on a Cotswold winter's night, earnestly discussing Platonian principles. Odd, I thought he was going to electronic classes!

Poor Boole

Smatterings of a new language drifted above the clatter of the cocoa tin. "Boolean Algebra was published in the 1880's, but no use was found for it until very recently." Poor Boole, inventing a product with no use before the Ad-man-era. (Do you suffer from dry hair/B.O./shrunken woolies? Try New! Improved! Laboratory Tested! Boolean Al-Jay-Bra!!!)

Black bodied centipedes with silver legs and long numbers on their backs crept onto the work bench—chips for everything they are. Each is equivalent to numerous conventional components and capable of performing vastly complex functions.

Part of "the works" are called Logic Gates and the miniscule masterminds are photographed onto the chip material, electronically and untouched by human hand, I believe.

I had never caught my husband's enthusiasm for electronics, but have resignedly forgotten what the kitchen window sill looks like, so long has it been hidden by batteries, meters, lights and wires from the various windmills which have sprouted behind the garden shed.

However, the non-electronic aspect of logic appealed to me especially after reading the dictionary definition of the logic gates (variously AND, NAND, OR and NOR) e.g. NAND; A logical operator having the property that if *P* is a statement, *Q* is a statement, *R* is a statement ... then the NAND of *PQR* ... is true if, and only if at least one statement is false, false if all statements are true. Yes!

According to an example in another book, if all inputs (statements) = 0 (earth), then output (NAND) = 1 (24 volts). Suddenly my feminine logic shifts to top gear, overdrive even; all we need are NAND gates (or would NOR be better?) all over the country with their little input feet firmly on the ground and their outputs plugged into the National Grid. Then we can tell OPEC to . . . Yes, but it's not quite like that . . . nonsense I've drawn a logical conclusion.

Not to worry, Boole had to endure ridicule and wait 90 years for recognition; in 2067 the "Hurstean Theory will shake the world.

On the Mend

When these evening classes started I harboured a faint hope that the hi fi amplifier would get mended. It has an "intermittent" (crucial word, that!) distortion rendering it more lo-fo than hi fi; sometimes Beethoven's Pastoral revellers sound one over the bucolic eight before the third movement is a few bars old.

"If it packed up altogether I could soon find the fault." That could be arranged . . . Silence those heretical thoughts that the money spent on demo boards, components, text books and class fees would buy a new one. It's the doing that counts, not the end results; fortunately because the "black box" trouble shooter fitted to the central heating boiler did not shoot the bit that actually went wrong.

Lemon Power

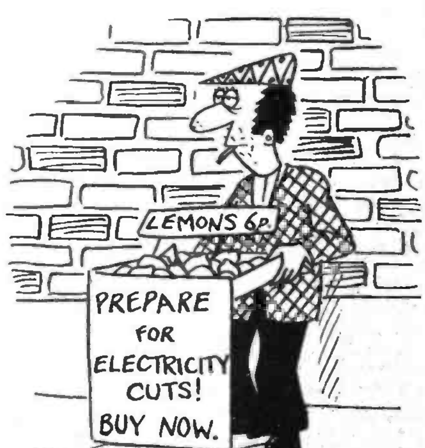
One advantage to we lesser mortals of this recent electronic wizardry is an incredible reduction in price and size for solid state equipment, a fact readily apparent from kit advertisements in all those past copies of EVERYDAY ELECTRONICS nestling in their bright cheerful binders. How unfortunate they do not really match the decor!

I am also unconvincingly assured that there is nothing to go wrong. I must confess to having an inherent distrust of our calculator which retaliates by launching into a flat battery St. Vitus' dance when least convenient.

However, I can see that digital electronics is (?are) a thing of the future; but all is not futuristic. An enquiry whether the pancake day lemon was real or squeezy was not of culinary interest. "You can light a bulb with half a lemon, you know." I didn't, but convalescence from an electricity bill tempered my disbelief so I passed the lemon.

In truth I must admit that it did not actually light the bulb, thus dashing my hopes of novel lighting, but it did produce a measurable amount of electricity. (EVERYDAY ELECTRONICS, January 1975). Maybe it could combine with my earthy NAND gates and save the nation.

So, march on logical operators for the truth; now, what did he say? "The not of the not of the not A and B . . ."



Everyday News

COMPUTER POWER FOR THE MASSES

Blazing a new trail in the computing field, PET (Personal Electronic Transactor) made its first European appearance at a London exhibition last month. This home or personal computer is being marketed directly by the makers, Commodore Business Machines of Slough, Berks.

Keen interest is reported with over 70 firm orders being placed during PET's initial public exposure.

The price of £695—formidable though it may seem—represents a breakthrough in computer terms. Professional men and women, small business owners, educationalists, and computer hobbyists will all find a multitude of uses for this self-contained computer.

Operating in BASIC language, PET is available with 8K of Random Memory (user memory) and 14K bytes of ROM memory.

The 9in enclosed, black/white high resolution c.r.t. offers a 1,000 character display arranged in 40 columns by 25 lines, or 8 x 8 dot matrix for characters and continuous graphics. A standard cassette system is built in for program storage and transference.

The Keyboard incorporates 73 alpha-numeric keys as well as 64 additional graphic characters for plots, games or artwork. Special screen and keyboard control keys allow the cursor to move in four directions, reversing of characters and background and inserting or deleting of characters, i.e. full editing facilities are available. Lower case letters can be accessed in addition to capitals.

Summer school

The Department of Electrical Engineering Science at the University of Essex will be holding its annual electronics summer school for teachers during the week July 10-14, 1978. This year, as well as running two established courses in linear circuit design and digital circuit design, a third course in electronics systems is being introduced.

The new course is closely related to the AEB Electronics Systems "A" level; the objective being to cover some of the more difficult material on the AEB syllabus as well as discussing the teaching aspects of the "A" level. A programme of laboratory work is included on each course so that the lecture material is fully supported.

Teachers who require further information on the summer school should contact R. J. Mack at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SQ.

There are now over 465,000 licensed radio amateurs in Japan. In the UK the figure is less than 30,000 including mobile and t.v. transmission.

STAR WARS

A major recording role in the production of "Star Wars", the classic space fantasy that has captured the imagination of both the British and American public was played by Teac sound equipment.

The sound effects for the galactic languages and creature sound, planetary vehicles, robots, weapons, and starship battle scenes in space were created, under the direction of Ben Burtt, using an A-7300 and a 2300 open reel deck with a 2340 four-channel open reel deck and a Teac Tascam Model 5 mixer.

The manufacturers of automatic test equipment (ATE), Membrain, have received their largest ever single order from Plessey Telecommunications Ltd.

Link-up

It is hoped that British phone users will benefit from the recent launch of Intelsat IVA, a new high-capacity communications satellite which will give improved telephone, data-transmission and telex links with 43 countries.

The main areas to be covered by the satellite will be the Indian Ocean region, from the Middle East to Australia and from Korea to Zambia.

VIP treatment

Shown at the Microsystems '78 Exhibition in London in February was RCA's COSMAC VIP (Video Interface Processor) described as a low-cost hobby computer kit although it costs £190 plus VAT. Its output interfaces direct with a monochrome c.r.t. display or through a suitable modulator with a t.v. receiver.

Among the programs in the hobbyist manual are 20 video games which can be self-programmed using a hexadecimal keyboard. The programs can be stored in audio cassettes for ease of retrieval and use.

COMPUTER TALK

How long will it be before every home has its own "talking computer" which the wife can argue with about the best cuts of meat to purchase and the husband the best route to take when he takes the family out for a ride in the car?

This cannot be too far off with the announcement recently from EMI Threshold of the export to New Zealand and West Germany of a system (Threshold 500) which allows a person to talk directly to a computer.

The technical name for this equipment is Threshold 500 Voice Data Entry System and has been delivered to the Gear Meat Co. of New Zealand and the Gesellschaft für Mathematik und Datenverarbeitung of Bonn, West Germany.

The equipment will be used with computers to aid personnel grade meat and prepare accurate charts and maps.

London Transport's computer system for train regulation on the Northern and Victoria lines will commence operations later this year.

—ANALYSIS

HOW OLD IS OLD HAT?

THE Soviet spy-satellite with an on-board nuclear power unit which wobbled back into earth re-entry, instead of being shot into an outer-space parking orbit where its radioactive components would decay harmlessly, reminded us all that space technology is still accident-prone. The record of dazzling successes tends to overshadow the failures which are soon forgotten.

The first *Intelsat IVA* launched in September 1977 from Cape Kennedy was a costly failure, destroyed by ground control when the launch vehicle broke up immediately after lift-off. The stand-by, successfully launched in early January at a cost of £25 million, will now be nudged into geo-stationary orbit over the Indian ocean ready to enter service by mid-year with 6,000 telephone channels plus TV when required. Marvellous!

You'd think that the old-hat submarine telegraph cable would have been dead by now. Fifty years ago the experts said the cable would be killed by that clever invention of beamed short-wave radio. A later generation of experts said the cable would be killed by the invention of satellite communications. But the experts are not always right and the cable lives on.

Not, of course, the old single-channel telegraph cable of 100 years ago. Cable technology, too, has advanced.

The first Atlantic telephone cable laid 20 years ago had 35 telephone circuits, the most modern have 4,000 even 8,000, with submerged repeaters with a design life of at least 20 years of unattended operation. And, of course, it's much easier to find and repair an underwater cable than to go 23,000 miles into space to repair a satellite.

The fact is that satellite communications and submarine cable communications are now regarded as complementary in linking the world's 400 million telephones in a global system. Neither system, by itself, could handle traffic demands.

As for old-hat h.f. radio, you might think that between them the satellite and submarine cable would have dented the demand. But h.f. radio is still a booming industry. Old-hat germanium transistors are still the preferred type for some applications.

As for the old-hat contraption known as the valve, both the Russians and Americans are working hard on a type called the Gyrotron which can churn out kilowatts of power at millimetric wavelengths and no ultra-modern solid-state device can do that—yet.

It seems there is often just as much real benefit in improving old-hat devices and systems as in inventing new ones. Perhaps more.

Brian G. Peck.

Over 1,000 Marconi v.h.f. a.m. radiotelephones have been ordered by Air Call Ltd who operate a nation-wide car telephone service.

A selective calling system alerts the car occupant, wherever he may be, that there is a call waiting. If absent from his car a warning light remains lit to indicate, on his return, that he is wanted.

Video disc

An optical video disc system for high-rate digital data recording and reproduction has been described in a paper written by three RCA engineers.

The system, which has a direct read-after-write capability, is expected to find applications in mass data storage and expanded memories for mini and microprocessors.

Communications '78, to be held at the National Exhibition Centre April 4-7, will be officially inaugurated by the Duke of Kent. The exhibition will be three times the size of the last event held in 1976. Over 250 communications companies will be exhibiting.

TOP OF THE POPS

The UK t.v. games manufacturer, Videomaster, has sold £1·5 million worth of MPU-based door chimes to the USA. Deliveries will extend over the whole of 1978.

Videomaster was founded in 1973. Turnover is expected to be running at £20 million a year by the end of 1978.

LASER CONCERTS IN LONDON

ANY READERS who can find time to visit London's Planetarium are in for a treat. They are currently putting on two laser shows entitled "Laserium" and "Laserock".

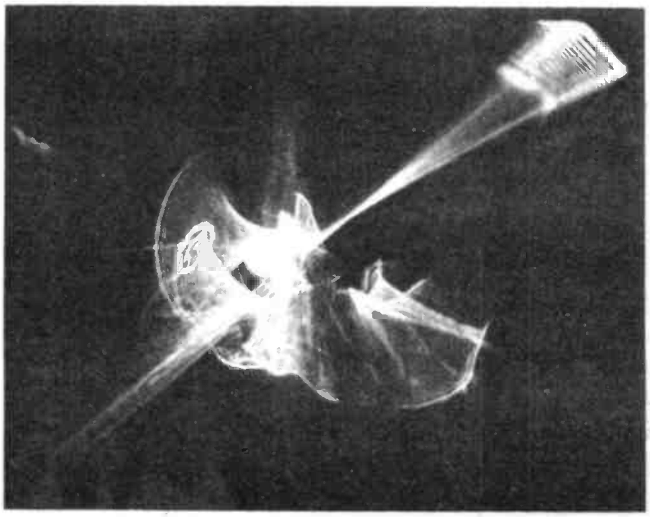
Claimed to be "a new experience in sight and sound" these shows create unusual effects using music and a single laser beam.

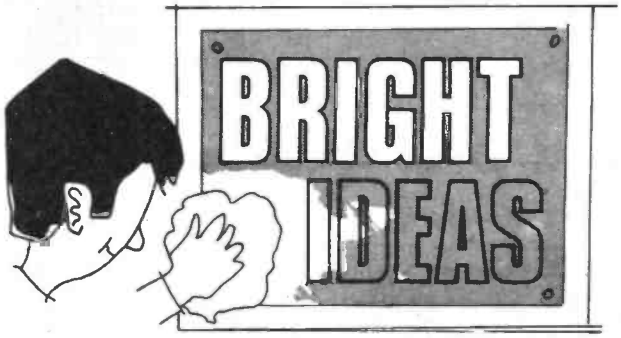
The cosmic laser rock concert is like watching a 10-metre diameter (60 foot) coloured oscilloscope. The very brightly coloured patterns and shapes chasing, overlapping and filling the whole domed roof were occasionally complimented by the additional night sky effect of the famous Planetarium projector. The lights seemed to be freaking out, then getting it together again, they were having fun; chasing, hitting, merging and at one point they even seemed to be clapping!

For those readers not too keen on loud rock, which is on Tuesdays, Wednesdays and Sundays, there is another presentation Laserium on Thursdays, Fridays and Saturdays when the music is more classical.

The content here includes such classics as "Neptune" from the Planets by Gustav Holst, the "Blue Danube" by Johann Strauss and "Adagio" from Concerto Grosso Op. 6, No. 9 by Arcangelo Corelli. One of the most effective pieces in this show was titled *Electron Cloud* with music from "Timesteps" by Walter Carlos.

The background effects (e.g. clouds) are the only things pre-recorded the rest is very much a "live" performance and well worth seeing if you are in town.



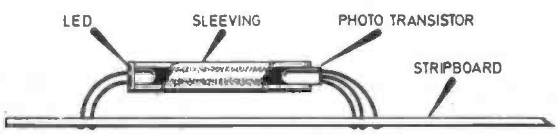


Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

OPTO ISOLATOR

When experimenting with opto isolated circuits, a good idea is to use a red l.e.d. in conjunction with a photo transistor. Instead of having to place them both in a light proof box for testing, an alternative and better method is to mount them one at each end of a short piece of black neoprene sleeving.

P. Hart,
Hucknall,
Nottingham

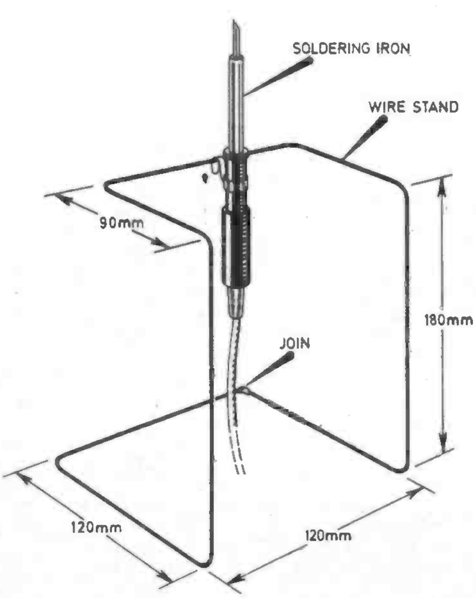


SOLDERING IRON STAND

Whilst soldering it is almost a necessity to have a stand for your soldering iron.

In the diagram below are the dimensions for an inexpensive stand. All you will need is one wire clothes hanger and a pair of strong pliers. The clothes hanger is then simply bent to the shape shown.

M. Loasley,
St. Austell,
Cornwall

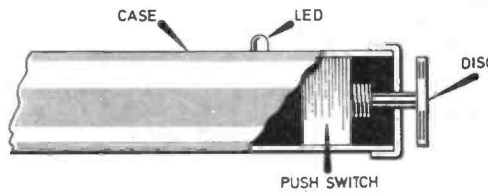


PUSH TO TEST

In the *Probe-less Continuity Tester* in the November 1977 issue I thought the operating of the switch could be combined into the test of the component, etc. This is done by using a push switch instead of the slider. The disc is then fastened on to the switch. See drawing below.

When testing the component, place against disc, hold as normal and then push.

A. M. Heritage,
Stevenage,
Herts



P.C.B. VICE

I have an idea which is useful for holding stripboard or any other type of board while components are being soldered. First a wire nail about 75mm long is knocked into a block of wood and the head is sawn off. A crocodile clip is then soldered on to form a vice to hold the board. Cheap, easy to construct, and very effective.

D. Wakefield,
Market Drayton,
Salop

I.C. INSERTOR

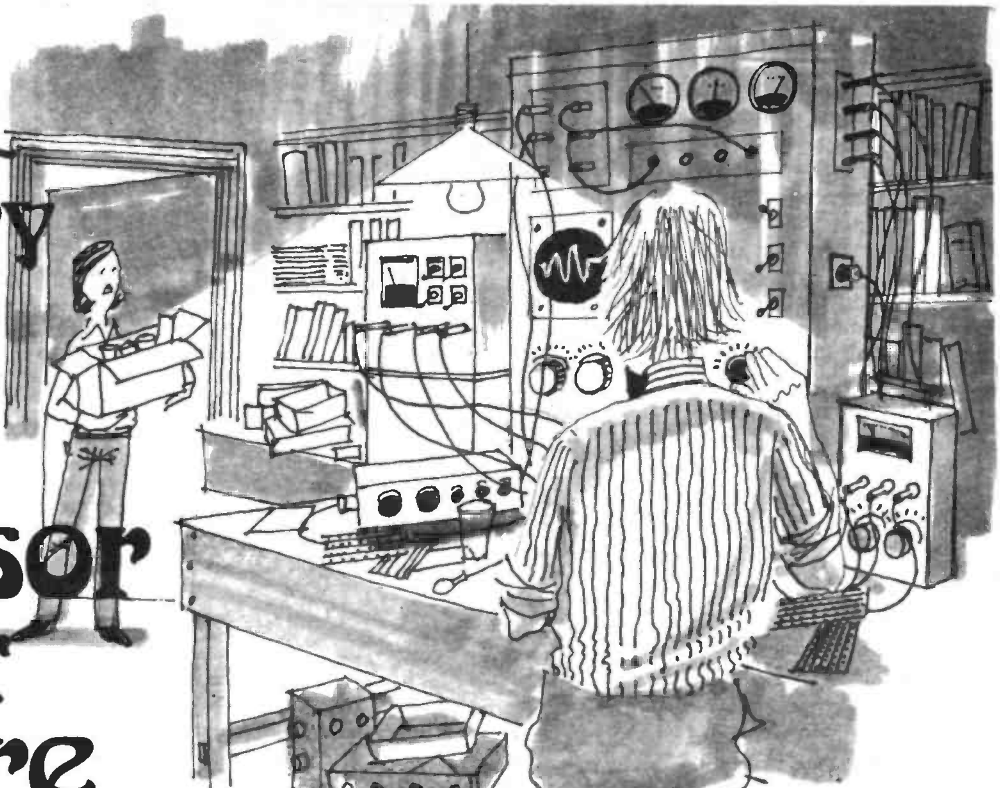
I have recently discovered a method of inserting integrated circuits. I have been using a large "bulldog" type paper clip. The i.c. is easily held by the upper parts of the pins.

This helps avoid damage to pins, and also acts as a very effective heat shunt when expensive integrated circuits are being soldered into place.

R. Hayes,
Brough,
N. Humberside

Crossword No. 2—Solution

The Extra-ordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

LAST month the Prof. and Bob had been interrupted while carrying out some experiments in dowsing by Tom and Maurice, who needed some assistance with an electromechanical money box they called "The Thing".

Tom and Maurice are in the laboratory, dismantling the money box. Meanwhile, Bob has asked the Prof. to tell him about the circuitry of the "Radiesthetic Preamplifier" which they have been using in some experiments in dowsing.

AN INTERESTING SUBJECT

"When Lilian, the lady who originally demonstrated the amplifier, first asked for my assistance regarding her occupation as a dowser," said the Prof. "we tried a number of different amplifiers, all of which appeared to work. Some were better than others, and the various reasons for these differences could make a very interesting subject for study.

"Most interesting to Lilian, however, were the smaller preamplifiers as she required an easily portable piece of equipment. So we then concentrated on audio preamplifiers which would operate from a single 9V battery.

"We found that the preamplifiers gave a much better result if the equalisation network (in the case of disc and tape preamplifiers) were removed."

"What does this mean, Prof?" Bob enquired.

"It has the interesting implication that the high frequency response of the preamplifier is important in its use as an aid to dowsing investigations.

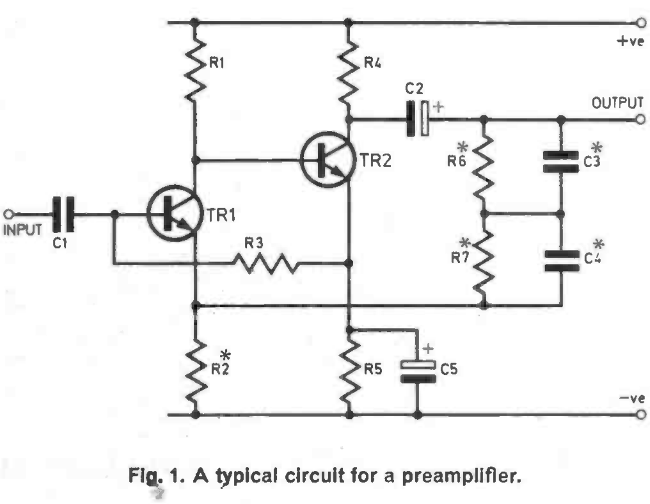


Fig. 1. A typical circuit for a preamplifier.

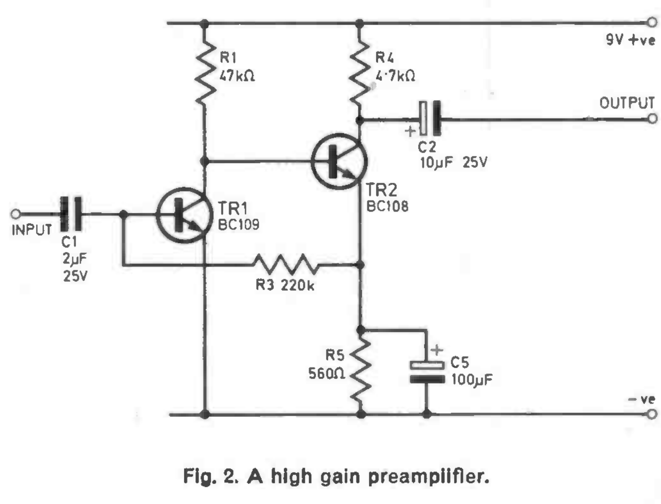


Fig. 2. A high gain preamplifier.

"The equalisation network is a type of treble-cut circuit which is usually incorporated in the negative feedback circuits of a playback amplifier for tape or disc. It reduces the high frequency response of the preamplifier to compensate for the treble boost, which is usually applied when recording the signal, in order to obtain advantages in recording."

EQUALISATION NETWORK

The Prof. drew out a sketch (Fig. 1). "Here is a typical circuit for a preamplifier."

The Prof. marked each of the equalisation network components with an asterisk. "By removing these components from the circuit we obtain a circuit of higher gain, especially at the upper audio frequencies" (Fig. 2).

"Although the first circuit (Fig. 1) gave a good response, the response which Lilian obtained when she dowsed over the output terminal of the second circuit (Fig. 2) was even better. Here is another circuit which we tested (Fig. 3) and this also gave a useful response.

"Many different circuits could be tried and in view of the apparent effects of the equalisation networks, interesting effects might be observed from the use of other types of filter circuitry."

"Did you try any amplifier circuits which use valves, field-effect transistors or integrated circuits, Prof.?"

"Yes, Bob, and we also tried amplifier circuits with both inverting and non-inverting configurations. All of them appear to work, but we finally used this circuit (Fig. 2) because it is compact, has high gain and a simple power supply requirement.

DISTORTION

"Now that you've removed the negative feedback components from the circuit, won't it produce distortion, Prof.? This circuit looks very much like the circuit of a guitar fuzz box which I have seen, and this is deliberately designed to produce a lot of distortion."

"You're right, Bob. With the 560 ohm resistor bypassed by the 100μF capacitor there is very little negative feedback for audio or input signals. Although, there is still some negative feedback which provides d.c. and low frequency stability.

"The audio frequency gain is very high and, like the fuzz box, this circuit could also easily distort an audio signal. The effects of such distortion on a dowsing signal appear, however, to be yet another field for investigation."

Bob began to sketch a diagram, Fig. 4, on a piece of paper and showed it to the Prof.

"If we tried a tunable circuit using a variable inductor, and a variable tuning capacitor, would it not be possible, by varying both the inductor and the capacitor, to cover a very wide frequency range. The effect of the frequency response of the circuit on its use for dowsing might be investigated at any spot frequency. What do you think, Prof.?"

"It seems quite a good idea, Bob. The simple *LC* tunable circuit which you have drawn would shunt away any frequency other than that to which it is tuned. However, I must mention that the scientific investigation of dowsing phenomena is often difficult as there are problems which are not easy to overcome.

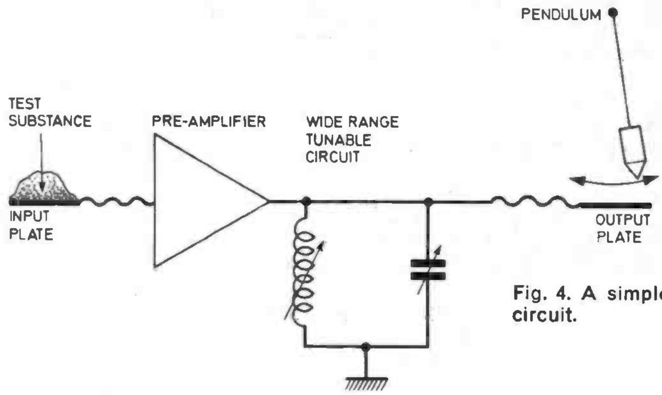


Fig. 4. A simple LC tuned circuit.

SUBJECT RESPONSE

"One of these is the problem of subjective and variable responses. Each dowser responds in an individual way which is slightly different, or may be entirely different, from any other material. Also, the responses of each individual will vary and change from time to time.

"This is because the dowsing reactions rely upon very delicate responses from the nervous system. These may be altered by such factors as health, discomfort, and many other human attributes."

"What we need, then, Prof., for strictly scientific reasons, is a totally emotionless, non-human dowser, whatever that might be!"

Suddenly, from the nearby work bench a loud clatter and a "whoop" of victory, as the last of the blobs of plastic which had sealed up the money box mechanism gave way. The "works" fell out onto the workbench and the secret of "The Thing" was at last revealed.

To be continued

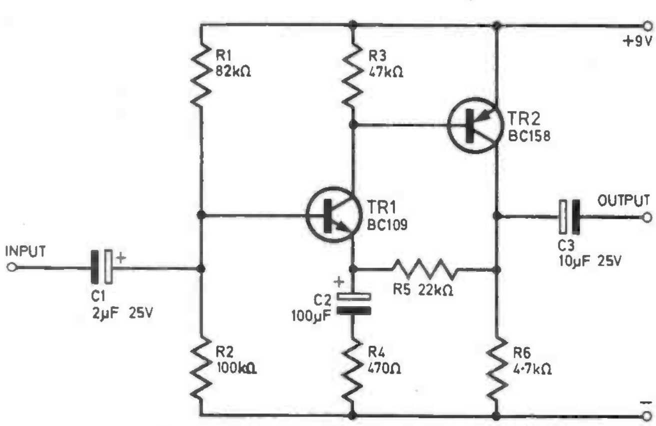


Fig. 3. Another version of the high gain preamplifier.

GEORGE HYLTON brings it down to earth

When Is A Capacitor More Than A Capacitor

A READER has queried the function of decoupling capacitors. He explains how he cured an otherwise intractable 100Hz hum in his portable radio by connecting a 1000pF capacitor across the d.c. output of a mains power unit he'd made for it.

Looking at EVERYDAY ELECTRONICS for November 1976, however, he finds that the designer of the scratch and rumble filter in that issue (back issue not available) prescribes 100nF (100,000pF) capacitors for decoupling. Why the enormous difference? And how do you calculate the size of capacitors needed?

Well, now, I don't know the circuitry of our reader's mains power pack but there's no doubt about the one in the scratch and rumble filter article. It's a centre-tapped d.c. output job of the kind commonly used for powering op-amps, with a positive side, a negative side and a neutral or "earth" in between.

The striking thing about it, from the point of view of decoupling, is that each part of the supply has a 220μF electrolytic capacitor across it. The 100nF decoupling capacitors fall across these 220μF ones. (Fig.1)

So why are the 100nF ones needed? After all, 100nF must have 2200 times the impedance of 220μF so surely it makes next to no difference to connect it in parallel?

There are two good reasons for including the "extra" 100nF capacitors. One is that the connections to the 220μF smoothing capacitors may, in a practical circuit, be long enough to have an appreciable impedance to high-frequency currents. By connecting the 100nF's close to the actual working parts of the circuit this lead impedance is bypassed.

It's important to do so in any circuit which may suffer from the instability (oscillation) caused by feeding unwanted high-frequency voltages back from the output to the input or intermediate parts of an amplifier. The scratch and rumble filter uses op-amps which have quite a high gain at low radio frequencies so there is a definite risk of oscillation.

More probably, however, the cause of trouble in such a circuit is not the impedance of the connection but of the smoothing capacitor!

This may seem ridiculous. A 220μF capacitance should present a very low impedance to radio frequencies (less than a hundreth of an ohm at 100kHz). It should, but it doesn't. Because of the way electrolytics are made they are not pure capacitances.

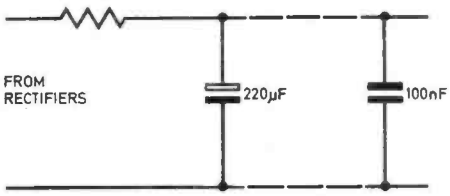


Fig 1. The inclusion of the 100nF capacitor reduces possibility of high frequency oscillation.

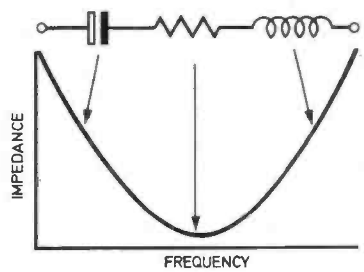


Fig. 2. Typical impedance-frequency response of an electrolytic capacitor.

They all behave as if they had a small amount of resistance (say 0·5 ohm) in series, and also a small inductance.

The consequence is that the impedance of an electrolytic does not go on falling as the frequency is raised. It falls at first, as you would expect (Fig.2) but then, after reaching a minimum, it rises.

As a matter of fact all capacitors have some series inductance because even a straight connecting lead has a certain amount of inductance. So all capacitors have a response which dips then rises like Fig. 2. But some non-electrolytics are so constructed that their inductance is very low. The Mullard C280 metallised polyester film capacitors specified for the scratch and rumble filter have a low-inductance construction, which is no doubt one reason why they were used.

It is possible to set a capacitor to a minimum impedance condition at any one frequency by cutting the leads to the correct length to form the inductance of a series-tuned circuit, the capacitance itself being the other element.

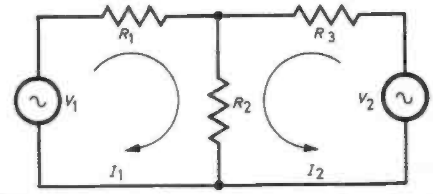


Fig. 3. The two voltage generators are coupled by R_2.

Manufacturers' data sheets sometimes tell you how to do so. In the case of a 100nF C280 capacitor, for example, the data sheets give the self resonance frequency for 10mm total lead length (i.e. 5mm each side) as 5MHz.

Decoupling

I've been going on about decoupling capacitors without mentioning what "decoupling" means. For readers not too familiar with the term I should explain that it means removing unwanted coupling between circuits.

Circuits can be coupled (linked together) in various ways. Usually the coupling element is an impedance which is common to both circuits. That is, currents from both circuits can flow through it.

In Fig. 3 the two voltage generators are coupled by R_2. Its effect is to make the current from one generator

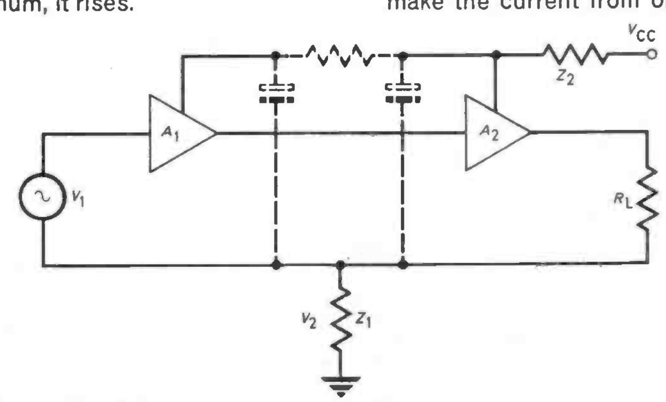


Fig. 4. Decoupling between stages is accomplished by incorporating components shown dotted.

depend to some extent on the current from the other.

If R_2 is short-circuited I_1 and I_2 can flow freely without interacting But once R_2 is there some of the current from V_1 finds its way via R_3 to V_2 and some of the current from V_2 flows into V_1 via R_1.

In electronics we aren't usually concerned with coupling between generators but we are very concerned with couplings between amplifiers (or parts of the same amplifier). The circuit Fig.4 illustrates two common types of accidental coupling which can cause problems.

Here Z_1 is the impedance of the common (shared) earth connection. Current from A_2 flowing to earth via its intended load R_L sets up a voltage across Z_1. This voltage is in series with the legitimate input voltage to A_1, V_1.

At some frequency these voltages add. Since V_2 is itself derived from an amplified V_1 it is a voltage which has been fed-back. At frequencies where V_1 and V_2 add in phase the feedback is positive and if Z_1 is big enough the circuit oscillates

If the output current of the amplifier (through R_1) is 1 amp, and Z_1 is 0·01 ohm then the feedback voltage is 10mV. This is often of the same order of size as the legitimate input and big enough to provoke oscillation.

In audio amplifiers coupling via Z_1 is usually avoidable by proper layout of the wiring. However, Z_2 is then unavoidable. It is the impedance of the unearthed side of the power supply.

You may be able to avoid coupling in the earthed side by careful layout but you can't earth both sides. Not without shorting the power supply. So you are stuck with Z_2.

Clearly currents flowing from the power supply into A_2 set up voltages across Z_2. These are coupled to A_1 where they may cause feedback trouble.

The usual solution is to put decoupling capacitors across A_1 and A_2 and a decoupling series resistor in between, shown dotted in Fig.4. The resistance discourages currents from flowing where they aren't wanted; i.e. from A_2 to A_1 and the capacitors encourage them to flow to earth directly rather than pass through the amplifier circuitry.

In most cases electrolytic capacitors are adequate since usually only low frequencies are involved, the high frequencies having been dealt with inside the amplifiers. Incidentally, these decoupling capacitors also serve another purpose: they help to smooth the d.c. supply

Calculated Guess

The case of our reader's radio is rather special. It's clear that his 1000pF decoupling capacitor was necessary to bypass high-frequency currents. The impedance of 1000pF at low frequencies is far too high to matter here. It's not at all clear therefore, why connecting 1000pF of decoupling stopped a "mains hum" at 100 Hz. I can only guess.

My guess is that there was enough 100Hz ripple on the d.c. output of the power unit to cause the gain of the radio-frequency part of the circuit (e.g. the i.f. amplifier) to vary at the rate of 100Hz. The effect would then be to modulate (vary the strength of) any r.f. signals present. Thus all incoming programmes would get a 100Hz audio modulation impressed upon them inside the receiver. This could cause hum when the signals were detected.

In our reader's receiver the effect was somehow aggravated by r.f. feedback. The 1000pF decoupler removed the feedback and hence reduced the hum to an acceptable level.

There is no practical way that I know of to calculate the size of decoupling capacitor needed. It depends on so many unknown quantities

PLEASE TAKE NOTE

Add-on Capacitance Unit *(September 1977)*

A link wire is missing on the stripboard layout. This should go between C3 and F13.

Automatic Phase Box *(December 1977)*

See *Shop Talk* page 174.

Car System Alarm *(February 1978)*

Integrated circuit IC1 CD4001AE is a Quad 2-input NOR not a NAND as stated in components list and depicted in the circuit diagram Fig.2, page 260.

Chaser Light Display *(February 1978)*

Fig.1, page 277. The end of the vertical copper strip at the centre of the board (left of the EE insignia) should be joined to the large copper mass (common OV) below.

With reference to Fig. 4, the live wire (L) from the terminal block should go to the junction FS1/S1 and not "T1 PRIMARY 240V" as stated. Similarly modify Fig. 2.

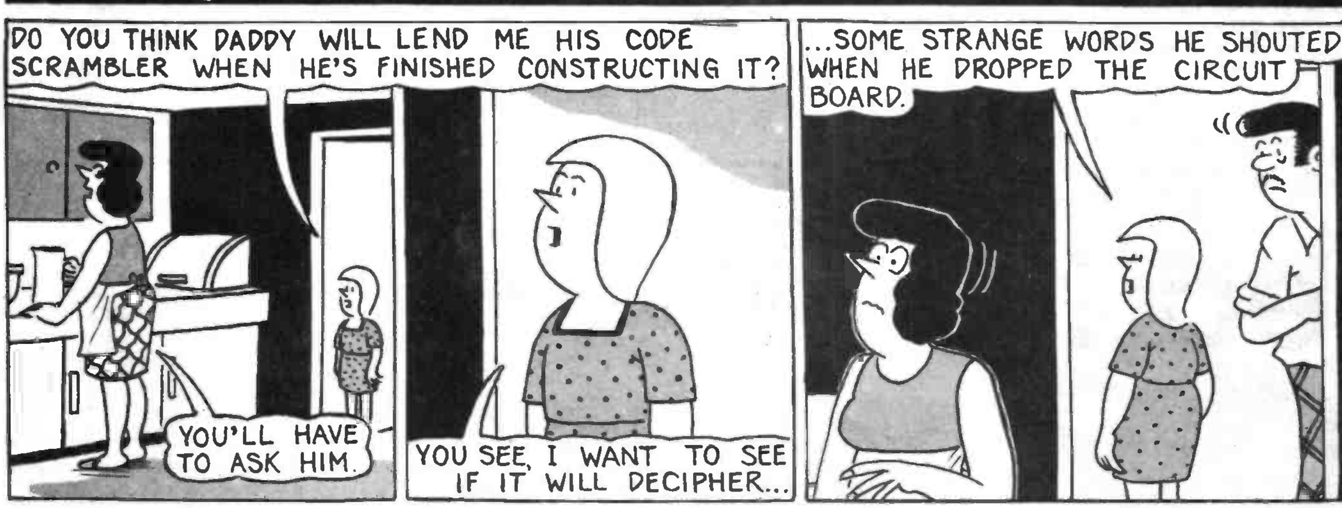
Teach-In Part 6 *(March 1978)*

The batteries in the circuits of Figs 6·5 and 6·6 are shown the wrong way round.

On page 327, under the heading "Calculations", the formula given is incorrect; R2 and R1 should be transposed.

JACK PLUG & FAMILY...

BY DOUG BAKER



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2·2/63V	10p
4·7/63V	10p
10/63V	10p
10/25V	10p
22/25V	10p
47/25V	10p
100/63V	25p
100/25V	10p
220/25V	25p
470/63V	37p
470/25V	34p
1000/63V	46p
1000/25V	54p
2200/25V	85p

Tantalum

0·47/35V	14p
1·0/35V	14p
2·2/35V	16p
4·7/35V	17p
10/25V	21p
22/16V	24p
47/6·3V	24p

Polyester-Radial

0·001	7p
0·0022	7p
0·0047	7p
0·01	7p
0·022	7p
0·047	7p
0·1	8p
0·22	9p
0·47	18p
1·0	18p
2·2	36p

Polystyrene Value (pF)

10	6p
22	6p
33	6p
47	6p
100	6p
150	6p
220	6p
330	6p
470	6p
680	6p
1000	6p
1500	6p
2200	6p
3300	6p
4700	9p
10000	9p

Ceramics 50V (Pack 3) 10p
22
33
47
100
150
220
270
330
470
560
1000
2200
4700
0·01μF
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BC109	13p
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BC143	30p
BC147	10p
BC148	10p
BC149	11p
BC154	16p
BC157	12p
BC158	12p
BC159	15p
BC161	32p
BC167	12p
BC168	11p
BC169	12p
BC170	16p
BC171	11p
BC172	13p
BC173	14p
BC177	19p
BC178	19p
BC179	19p
BC182L	11p
BC183L	11p
BC184L	11p
BC186	25p
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BC207	11p
BC208	11p
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BD135	41p
BD136	39p
BD137	40p
BD138	45p
BD139	42p
BD140	47p
BF180	35p
BF181	35p
BF194	13p
BF195	13p
BF196	13p
BF197	13p
BFX84	24p
BFX87	29p
BFX88	29p
BFY50	23p
BFY51	23p
BFY52	23p
BSX20	21p
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MJ481	155p
MJ490	137p
MJ491	173p
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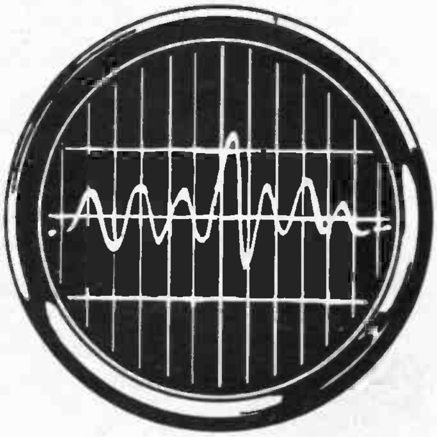

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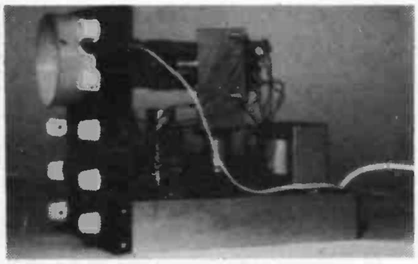

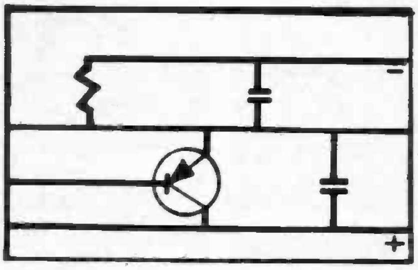

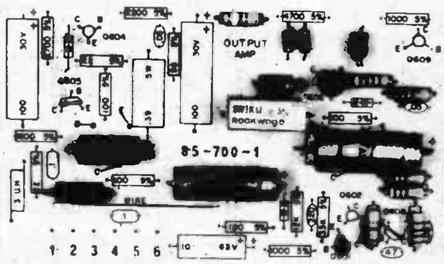

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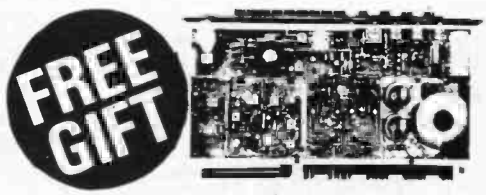

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