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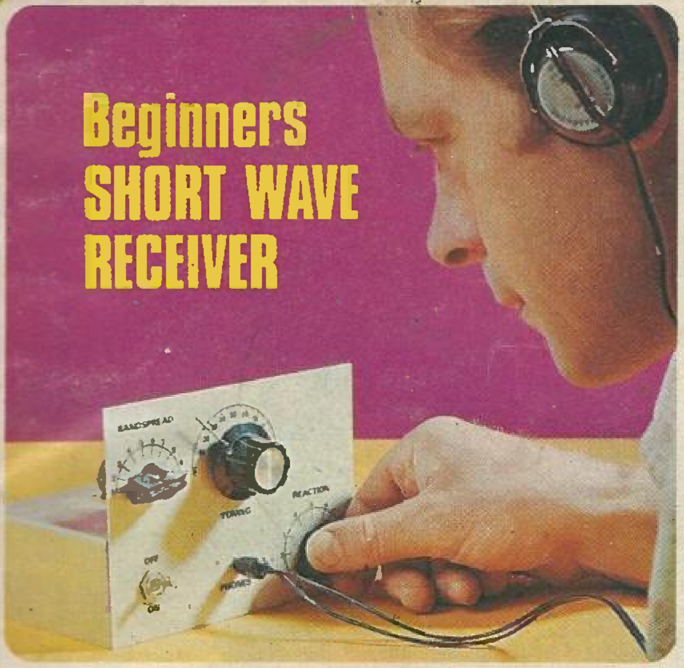

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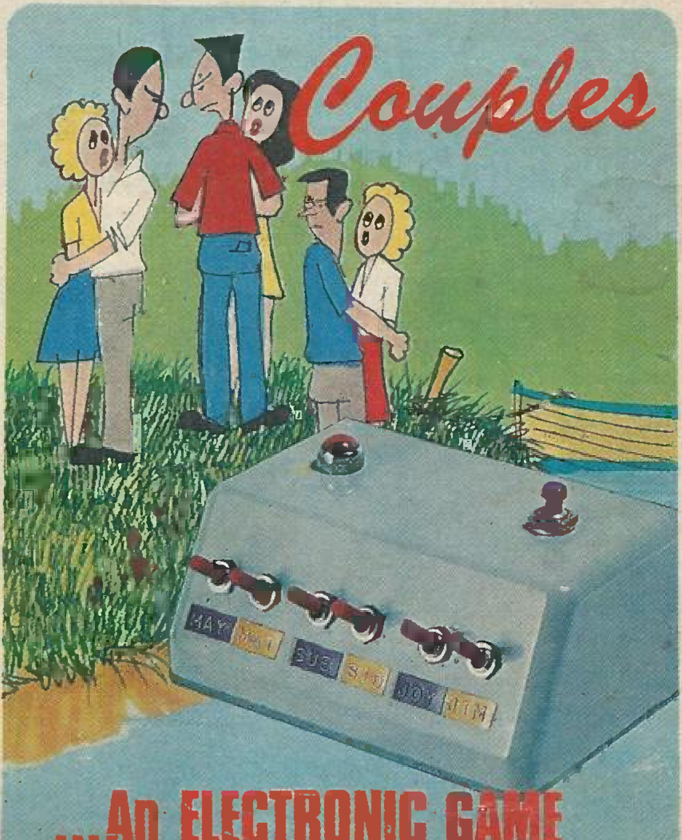

Couples ...An ELECTRONIC GAME

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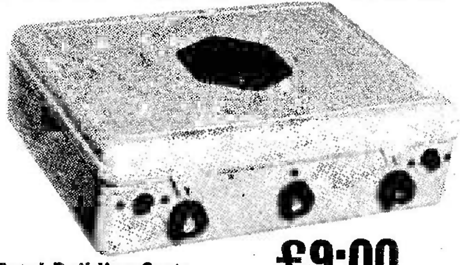
NEW EDU-KIT MAJOR

Completely Solderless Electronic Construction Kit. Build these projects without soldering iron or solder



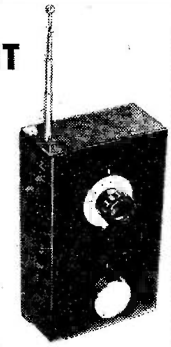
- ★ 4 Transistor Earpiece Radio
- ★ Signal Tracer
- ★ Signal Injector
- ★ Transistor Tester NPN-PNP
- ★ 4 Transistor Push Pull Amplifier
- ★ 5 Transistor Push Pull Amplifier
- ★ 7 Transistor Loudspeaker Radio MW/LW
- ★ 5 Transistor Short Wave Radio
- ★ Electronic Metronome
- ★ Electronic Noise Generator
- ★ Batteryless Crystal Radio
- ★ One Transistor Radio
- ★ 2 Transistor Regenerative Radio
- ★ 3 Transistor Regenerative Radio
- ★ Audible Continuity Tester
- ★ Sensitive Pre-Amplifier

Components include: 24 Resistors ★ 21 Capacitors ★ 10 Transistors ★ 3½in Loudspeaker ★ Earpiece ★ Mica Baseboard ★ 3 12-way connectors ★ 2 Volume controls ★ 2 Slider Switches ★ 1 Tuning Condenser ★ 3 Knobs ★ Ready Wound MW/LW/SW Coils ★ Ferrite Rod ★ 6½ yards of wire ★ 1 Yard of sleeving, etc. Complete kit of parts including construction plans.

Total Building Costs **£9·00**

P & P+Ins. 85p.

VHF AIR CONVERTER KIT



Build this Converter Kit and receive the Aircraft Band by placing it by the side of a radio tuned to Medium Wave or the Long Wave Band and operating as shown in the instructions supplied free with all parts. Uses a retractable chrome plated telescopic aerial, Gain Control, V.H.F. Tuning Capacitor, Transistor, etc.

All Parts including Case and Plans.

£3·95 P & P and Ins. 45p.

POCKET FIVE

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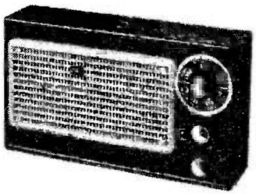
3 Tuneable wavebands. M.W., L.W., and Trawler Band, 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, attractive black and gold case. Size 5¼" × 1¼" × 3¼" approx.

All Parts including Case and Plans.

Total Building Costs **£3·60** P&P+Ins. 60p.

NEW Everyday Series



Build this exciting new series of designs.

E.V.5. 5 Transistors and 2 diodes. MW/LW. Powered by 4½ volt Battery. Ferrite rod aerial, tuning condenser, volume control, and now with 3" loudspeaker. Attractive case with red speaker grille. Size 9" × 5¼" × 2¾" approx. All parts including Case and Plans.

Total Building costs **£4·30** P & P + Ins. 50p

E.V. 6. Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt battery. Ferrite rod aerial, 3" loudspeaker, etc., MW/LW coverage. Push Pull output.

All parts including case and plans.

Total Building costs **£4·95** P & P + Ins. 55p

E.V. 7. Case and looks as above, 7 Transistors and 3 diodes. Six wavebands, MW/LW, Trawler Band SW1, SW2, SW3, powered by 9 volt battery. Push Pull output. Telescopic aerial for short waves. 3" Loudspeaker.

All parts including Case and Plans

Total Building costs **£6·35** P & P + Ins. 55p

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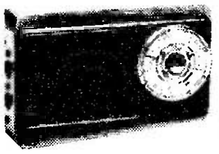

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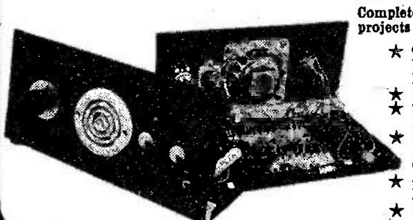

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- ★ 4 Transistor Medium Wave Loudspeaker Radio.
- ★ Electronic Noise Generator
- ★ Electronic Metronome.
- ★ 4 Transistor Push/Pull Amplifier.

All parts including Loudspeaker, Earpiece, MW Ferrite Rod Aerial, Capacitors, Resistors, Transistors, etc. Complete kit of parts including construction plans.

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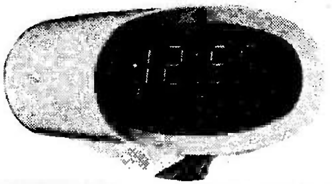

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- ★ 24 HOUR ALARM
- ★ BRIGHTNESS CONTROL
- ★ ATTRACTIVE WHITE CASE

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- ★ BUILDING TIME 1 HOUR

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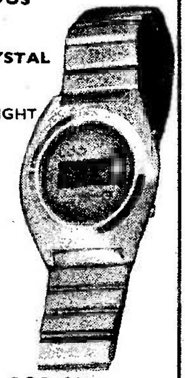
LCD MODEL TLC4

CONTINUOUS READOUT UTILISING LIQUID CRYSTAL DISPLAY

WITH BACKLIGHT FOR NIGHT READING



FEATURES—
- ★ HOURS
- ★ MINUTES
- ★ SECONDS
- ★ DATE

RHODIUM £39·95

GOLD £41·50 inc. VAT

LED MODEL TLE5

FEATURES—
- ★ HOURS
- ★ MINUTES
- ★ SECONDS
- ★ DATE
- ★ DAY OF WEEK

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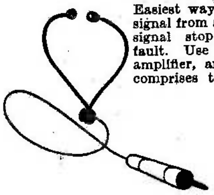
DRILL CONTROLLER

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£2·95** including post and VAT. Made up model £1·00 extra.

NUMICATOR TUBES

For digital instruments, counters, timers, clocks, etc. Hi-vac XN11 Price **£1·25** each, Post and VAT paid.

RADIO STETHOSCOPE



Easiest way to fault find, traces-signal from aerial to speaker, when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube and crystal earpiece, **£2·95**, twin stetho-set instead of earpiece **88p**, VAT & postage incl. in price

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1·75** including post and VAT.

MOTORISED DISCO SWITCHES

With nine 10 amp changeover switches, adjustable over 360° switches are rated at 10 amp each so a total of 2000w's can be controlled and this would provide a magnificent display. Mains operated. PRICE **£2·75**. DITTO BUT 12 SWITCH **£3·75** POST AND VAT PAID

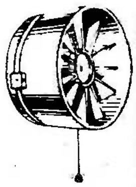
SOUND TO LIGHT UNIT

Another new kit this month is single Channel Sound to Light Unit, complete kit including plastic container, main components include 5 amp thrysitor, plus transformer, variable pot with on/off switch and theoretical circuit diagram.
PRICE **£5·95** Post & VAT paid.

WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions. All parts and instructions to make. **£3·25** post and VAT paid.

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic feet per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact. 5½" casing comprises motor, fan blades sheet steel casing, pull switch, mains connector and fixing brackets. **£4·75** INCLUDING POST & VAT. Monthly list available free; send long stamped envelope.

28 RPM GEARED MAINS MOTOR

This is a substantial motor (1" stack induction type) quite powerful definitely large enough to drive a rotating display or a tumbler for polishing stone, etc. Approximate overall size 4" × 3¼" × 2½" these are ex-unused equipment, carrying our normal ex-equipment guarantees. PRICE **£2·95** POST & VAT PAID.

INTRUDER ALARMS

These kits are for the alarm described in a back-issue of this magazine.
PRICE **£4·95**. POST & VAT PAID,

FISH BITE INDICATOR

as featured in EE March. Kit of parts to make this **£2·50** Post & VAT PAID. Case 70p extra.

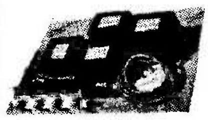
TELESCOPIC AERIALS

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

Pulse Transformer for Sound to Light and similar applications. Mu metal core, primary 11 ohms, tapped at 7, secondary 23 ohms. Price **75p** + 6p. with circuit diagram.

Battery Operated Hooter gives a loud shrill tone from 1½v. battery, metal case nickel plated, size 2" diameter by 1½" deep. **Price 80p** + 6p. Post 10p + 1p.

MULLARD UNILEX



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

LIGHT PIPE

A mains operated travelling light array. 24ft long it uses 130 miniature bulbs which flash in sequence to make bands of light move along the tube. The tube can be draped around a particular item or set and cannot fail to attract attention—complete kit consists of —24ft of translucent tubing—140 min lamps—8yds multicore cable—motorised switch—taps for quick connections and full wiring instructions. **£15 for complete kit. Post and VAT paid.**

TWIN OUTPUT POWER PACKS

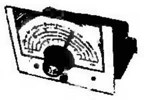
These have two separate R.C. smoothed outputs so can operate two battery radios or a stereo amp without cross modulation (they will of course operate one radio/tape cassette/calculator, in fact any battery appliance, and will save their cost in a few months). Specs: Full wave rectification, double insulated mains transformer – total enclosed in a hard P.V.C. case – three core mains lead terminal output – when ordering please state output voltage 4½v, 6v, 7½v, 9v, 12v or 24v. Price **£3·95**. Post and VAT included.

BEGINNERS SHORT WAVE RECEIVER . . .

2 Watt Amplifier . . . Touch Sensitive Alarm . . . Couples Game . . .

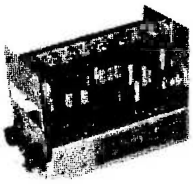
To receive parts for the projects featured this month, send the estimated price + 40p post. Any cash adjustment can be made later.

SHORTWAVE CRYSTAL SET



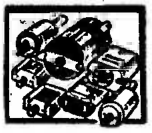
Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 31, 29 metre bands–Kit contains chassis front panel and all the parts, **£1·50**—crystal earphone 55p including VAT and Postage.

BREAK-DOWN UNIT



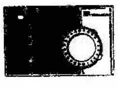
Contains hundreds of useful parts some of which are as follows—66 silicon diodes equivalent OA91, **68 resistors**, mostly ¼ watt 5% covering a wide range of values 4 × ·1 mfd 400v mfd condensers, 15 × ·01 mfd 100v condensers. 2 RF chokes 8 × B9 valve holders, 1 × 4H choke, 1 × 115v transformer, 1 boxed unit containing 4 delay lines also tag panels, trimmer condensers, suppressors, etc., on a useful chassis sized approx. 9" × 5" × 7". Only **75p** (the 66 diodes would cost at least 10 times this amount). This is a snip not to be missed. Post and VAT 75p.

ONLY £1·50 FOR SEVEN ELECTRIC MOTORS



7 powerful batt. motors as used in racing cars and power models. Output and types vary for use in hundreds of projects—Tools, toys, models, etc. All brand new reversible and for 1½-12v batts. Wiring diagrams inc. VAT, Post PAID.

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.

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc.
24in × 18in **£1·99**. Post & VAT 60p.
13in × 10in **£1·50**. Post & VAT 50p.

LIGHT OPERATED SWITCH FOR 12-24V BATTERY OPERATION

This is completely encapsulated and so make weather proof against all the elements. It can, therefore, be put to many useful applications. To name a few (1) Automatic switch for a mast head light on a boat. (2) Automatic switch on for battery operated lights or alarms in remote places. (3) Auto parking light for a vehicle, no doubt other applications would be found by our readers and we would be glad to hear about them.
Encapsulate unit measures approx. 1·6" × ·9" × 1·5" deep. This can be conveniently mounted through the front panel of a conduit box or similar.
Price **£1·95** post & VAT paid.

TERMS: Where order is under £5 please add 40p surcharge to offset packing expenses

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ITS 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—its an interesting list and its free—just send S.A.E. Below are a few of the Bargains still available from previous lists.

Motor with Gear Box by Swiss SAIA Company, makers type no. AMY5-A4SL. This is standard 220/240v. 50 HZ motor, 15 revs per minute final drive speed, the drive shaft is 4mm dia. fitted with pickup block 8mm square. Price **£2·50p**+20p. Post 15p+2p.

Motor with Gear Box made by Smiths, their type no. Q1HG. 200-250v 50 HZ operated, final drive shaft 60 rev. per minute. Drive shaft 3·5mm diameter 200mm long with flat. **Price £2·00** + 20p. Post 15p + 2p. Ditto 1 rev per hour.

Motorized Time Delay. This contains ½ rev. per minute motor for 24v 50HZ operation, with incorporated one way INC clutch made by General Time of USA, makers ref. E15450, A2398 A4. Coupled to the motor is a dial calibrated 0-120 seconds. When coupled to the mains, the motor operates and when the pre-set switch. This obviously could be used in photography or in other application where short duration switching off or on is requiredc A very expensive piece of equipment, mounted on a frame approx. 2·5" × 3" × 1½" deep with fixing feet. Price **£3·50** + 28p. Post 30p + 3p.

Motorized Stud Switch driven by 50v SAIA geared motor at 20v's per minute. This has 24 studs and a common slip ring and will rotate continuously. Obviously has many applications. Ex-equipment but covered by our normal ex-equipment guarantee. Price **£1·75p** + 14p. Post 20p + 2p.

Mains Instrument Transformer upright mounting, primary tapped evey 10v's from 200 to 240v's, 4 secondaries—130v @ 175mA, 160v @ 125mA, 6·3v @ 1·5 amp, 6·3v @ 2·25 amp. Separate screen brought to the tag panel. Price **£4·50p** + 36p. Post £1·00 + 8p.

Mains Auto Transformer 100w size chassis mounting with fixing foot; tappings at the high voltage end and at the 115v end. Very well made transformer vacuum impregnated and varnished for quiet operation. Price **£1·50** + 12p. Post 80p + 6p.

400w Power Transformer, chassis mounting with fixing feet. Normal 240v 50HZ primary. tapped 200v & 220v, 2 secondaries 50v's at 7 amps with 36v tapping and 6v's at 8 amps, made by Davenset, this weighs 15lbs and is approx. 5½" × 4½" × 3". Price **£12·50p** + £1·00. Post £1·50 + 12p.

250w Isolation Transformer for mounting under the service bench, this is in a normal frame with fixing feet. Very good quality construction with input and output terminal blocks. Price **£9·75p** + 80p. Post £1·00 + 8p.

EHT Transformer 8·7kv 23 mA's intermittently rated with normal 240v, 50HZ primary. This is made by Landon Kingsway Ltd., mainly for igniting oil fired boilers, their ref. no. 20/0347/02. This is totally encased with fixing feet, 3 core mains input lead and spark plug type e.h.t. output. Price **£8·50p** + 72p. Post £1·00 + 8p.

Car Battery Trickle Charger, normal mains input, 12v. 1 amp output, totally encased with mounting feet, 3 core mains input lead and output leads terminating with car battery size croc. clips. Price **£1·95p** + 25p. Post 25p + 3p.

Flexible Drive 12" long with threaded couplers at each end. Price **£2** + 16p. Post 30p + 3p.

Relay 3000 Type. coil consists of 3 separate swindings, 2 at 400 ohms and 1 at 570 ohms. 7 set of contacts, 3 of which are changeover, 2 others open when relay closes and the last 2 close when relay closes. Very versatile and useful relay. Price **£1·00** + 8p. Post 10p + 1p.

Plug-in 11 Pin Perspex covered Relay, coil operated by 50v AC or 24v DC, 3 sets of very heavy duty contacts, gold plated at least 10 amp rating, maker Omron type MK.3P5. Ex-unused equpment with base. Price **£1·00** + 8p. Post **15p** + 1p.

Reed Relay. Elliott ref. no. 37229/213. Uses 4 reeds, 2 of which are normally closed, the other 2 normally open. Coil detail:—voltage 12dc., resistance 2·7K ohms, MA approx. 4-6. Price **£1·75p** + 12p. Post 15p + 1p.

Latching Relays. Two relays mounted together on a common chassis, size 3" × 1·3" × 2" approx. Two relays are made to latch mechanically so that when one is energised it will stay on although its energising current is removed until the other one is energised, each relay has two pairs of heavy duty gold plated changeover contacts. Coil volts, 48v. AC or 24v. DC. Price **£2·50p** + 20p. Post 15p + 20p.

Power variable Resistor, Berco, ref. L100, 100 ohms resistance max. current 1 amp. Price **£1·50p** each + 12p. Post 10p + 1p.

Push Button Switches. Separate on/off switches, both off with rods up, first switch is spring return—will not stay down, second switch will lock down and can only be released by pressing first. Complete with with push knobs suitable for foot switch or similar, length approx 5", depth below chassis approx 2". Price £1·25p + 12p.

Polarity Reversing Switch rated 5 amps 250v's mounted on brown bakelite moulded plate, size approx. 3·2" × 1" wide with 2 fixing holes. Price **75p** + 6p.

In Line Switch, rated 2 amps at 250v, on/off this has a neon lamp to make it visible at night, originally intended for use on electric blankets and similar applications. Price **50p** + 4p.

Surface switch. A very neat Bakelite encased switch, size approx. 1·9" long, 1·2" wide and ·75" high. Rated 5 amps 250v. fixing screws hidden under cover. Price **30p** + 3p.

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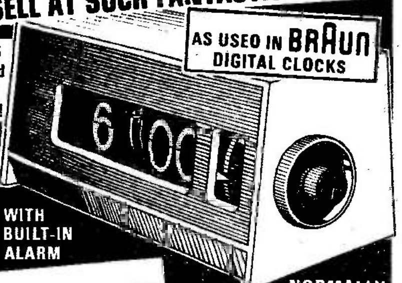

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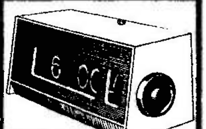

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R6. 30 ½w 1K–8·2K
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BC109	6p	BFY51	15p
*BC147	8p	BFY52	15p
*BC148	8p	2N696	10p
*BC149	9p	2N697	11p
*BC157	11p	2N698	11p
*BC158	10p	2N706	6p
*BC159	10p	2N708	8p
*BC169C	7p	2N1613	15p
*BC170	5p	2N1711	15p
*BC171	5p	2N2219A	15p
*BC172	5p	2N2369	12p
BC178	12p	2N2369A	12p
*BC182	10p	2N2905A	13p
*BC182L	10p	*2N2926g	9p
*BC183	10p	*2N2926y	8p
*BC183L	10p	*2N2926o	8p
*BC184	11p	2N3053	15p
*BC184L	11p	2N3055	36p
*BC212	10p	*2N3702	8p
*BC212L	10p	*2N3703	8p
*BC213	10p	*2N3704	9p
*BC213L	10p	*2N3705	8p
*BC214	11p	*2N3706	8p
*BC214L	11p	*2N3903	8p
BC327	12p	*2N3904	8p
BC328	12p	*2N3905	9p
BC337	11p	*2N3906	9p
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everyday
electronics
PROJECTS..
THEORY....

A MATTER OF CONCENTRATION

Some may find it rather difficult concentrating on electronics in high summer. It's understandable, what with the fine weather and all those outdoor counter-attractions. So let us offer something small and simple that will help concentrate the mind, in one sense at anyrate!

For it can really be said, without too much exaggeration, of a certain project that "it concentrates the mind wonderfully." As we recall, in Dr. Johnson's original immortal phrase the "it" alludes to the frightful and final prospect facing the doomed man awaiting execution. Leaving aside the macabre, there are other rather different and perhaps more trivial but quite pleasant matters or prospects which can be applied to this desirable end (mind concentration—of course).

One can study ponderous books on the subject, attend courses of instruction, try the ancient methods of yoga or the modern psychological approach. We have a much simpler, amusing and quite harmless remedy to offer our readers, who may at present be subjected to various distractions not uncommon in the summer months.

To be perfectly honest, what we offer is not entirely new, but it is an improvement and an extension of an old idea. More to the point, tests carried out amongst our acquaintances prove its unfailing attraction. The name of our game is *Couples.*

Though its effectiveness in concentrating the mind is certain, success in grappling with the precise problem which forms the basis of this game cannot be guaranteed. Strong minded men and women have been known to throw their hand in after a few hours baffled by the apparent intractability of the problem. Somewhat bemused, they return to the simpler matters of ordinary life that await their attention. *That* ought to send you scouring for your tool box and iron!

One thing remains to make clear. Our opening words may not apply universally, this we recognise. Should you therefore happen to be a fully committed all-the-year-round constructor a particular word of advice in your ear: concentrate on and complete any other project you have in mind to before starting on *Couples.* Strong willed and determined though you may be, you may still succumb like the rest to the challenge of our latest game. And we certainly don't want to be answerable for any fall in production over the next few weeks.

Fred Bennett.

Our September issue will be published on Friday, August 20
See page 417 for details.

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..EASY TO CONSTRUCT
..SIMPLY EXPLAINED

VOL. 5 NO. 8 AUGUST 1976

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BACK NUMBERS, LETTERS AND BINDERS

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TOUCH SENSITIVE DOOR ALARM

By J.H.TELFORD

A door buzzer with a difference.

THE need for a door alarm on the door of my fiancée's room in her college was the cause of the design in this article. The unit is operated by placing one's finger/hand on the touchplate such that the etched name (or number) and surrounding copper are bridged; the touch plate can be used for most internal rooms and for sheltered outdoor positions.

The volume produced by the unit is enough to be audible over a radio or record player, and can be heard over a distance of two rooms. No volume control was found to be needed.

As the device was required for long periods of operation, and 10 milliamps would be consumed, it was decided to run the device from the mains.

POWER SUPPLY

The power supply used in the prototype is a conventional one as can be seen from Fig. 1. The first neon LP1 indicates that mains power is reaching the device, the second neon LP2 tells one whether the device is switched on or off. Should the fuse FS1 blow them LP2 will not light.

Switch S1 was a push-on push-off type on the prototype. The transformer used was an Eagle type with two 6 volt 280 milliamp windings—only one winding is used.

Any 1 amp 50 volt bridge rectifier will do or can if desired be replaced by four discrete diodes (type 1N4001 for example).

Mains entering the unit is first stepped down by T1 to 6 volts and then full-wave rectified by means of diode bridge D1-D4 and is then smoothed by C1 producing a d.c. level of about 9 volts available for the multivibrator/amplifier section of the unit. Resistor R1 is included in the circuit to limit the initial current drawn while the capacitor charges up.

There is a screen on the transformer which is earthed to the mains earth together with the negative supply line as a measure of safety.

AMPLIFIER/OSCILLATOR CIRCUIT

The oscillator is composed of transistors TR1 and TR2 and associated resistors and capacitors; these form a common astable multivibrator with one component missing—a high value resistor from positive rail to TR2 base. This resistance is derived from the "skin resistance" when the remote nameplate is touched.

The output from the multivibrator is fed to a two-stage amplifier with its output connected to loudspeaker LS1. Thus touching the nameplate causes a tone to be heard in the loudspeaker; the frequency of the tone (pitch) can be altered by VR1 and is dependent on the value of the skin resistance of the caller.

If it is required to operate the unit with a loudspeaker of lower impedance than about 80 ohms, then TR4 must be modified to suit. For example, use a transistor type 2N3704 when a 35 ohm speaker is employed.

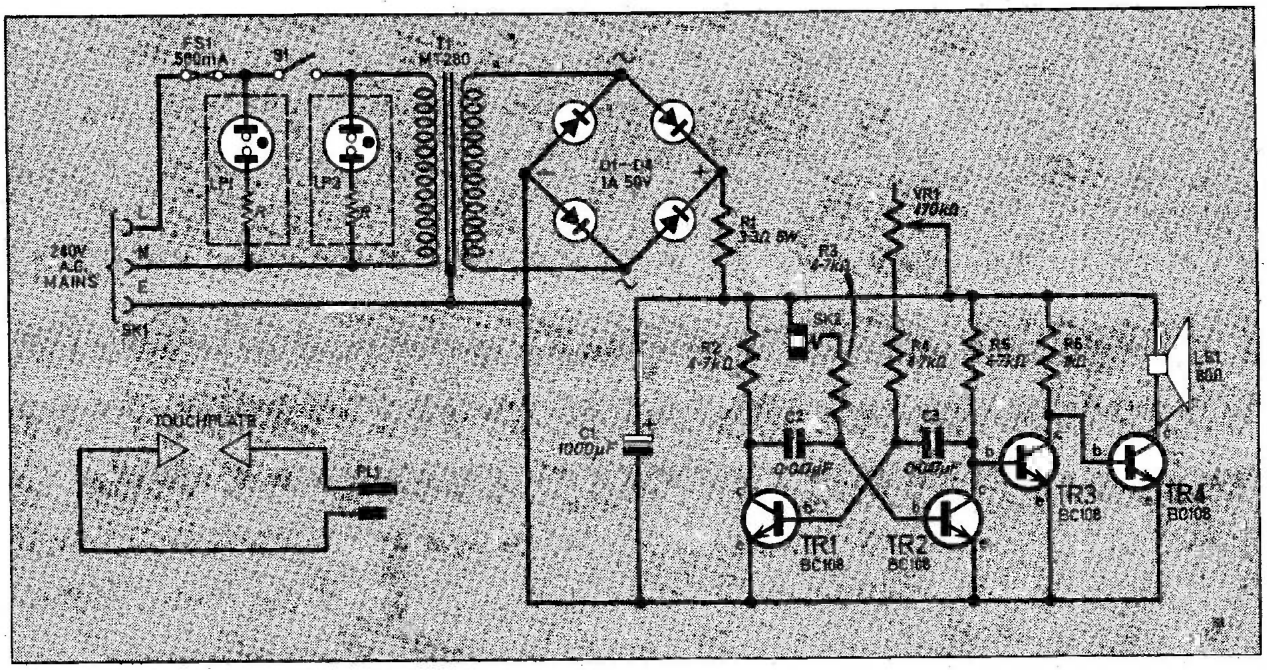


Fig. 1. Circuit diagram for the Touch Sensitive Door Alarm.

CONSTRUCTION

The prototype unit was constructed and housed in a plastic Addis food container size 240 x 125 x 80mm, but may be changed to suit individual requirements. If mounted in a metal case adequate measures should be taken to guard against possible short circuiting between component boards and case. The metal case should of course be earthed.

Most of the small components are mounted on two pieces of tagboard, 11-way for the oscillator and amplifier, and a smaller 4-way for the power supply components.

The layout of the components on the tagboards and within the prototype case and complete wiring up details are shown in Fig. 2. The layout is in no way critical and may be changed if desired.

In the prototype the speaker was glued to the base of the case which in turn forms the front panel. The remote nameplate is connected to the unit by means of a standard jack lead and is plugged in at SK2.

Begin construction by assembling and soldering the components on the tagboards and then preparing the case to accept all the other components to be mounted on the case itself. Secure all the components in position including the boards and wire up as detailed in Fig. 2.

FOR GUIDANCE ONLY

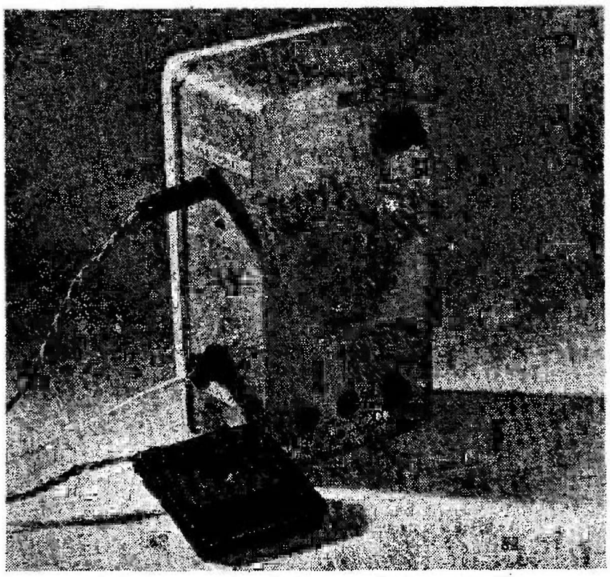
ESTIMATED COST* OF COMPONENTS
excluding V.A.T.

£4·75 plus case

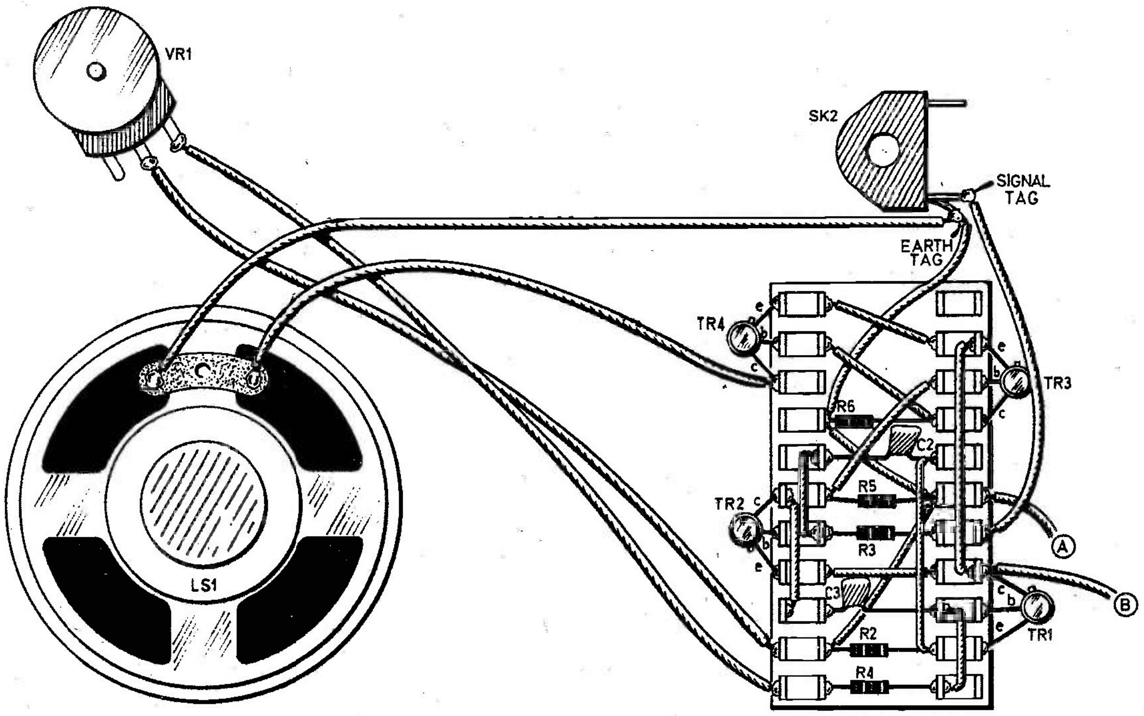
*Based on prices prevailing at time of going to press

TOUCH PLATE

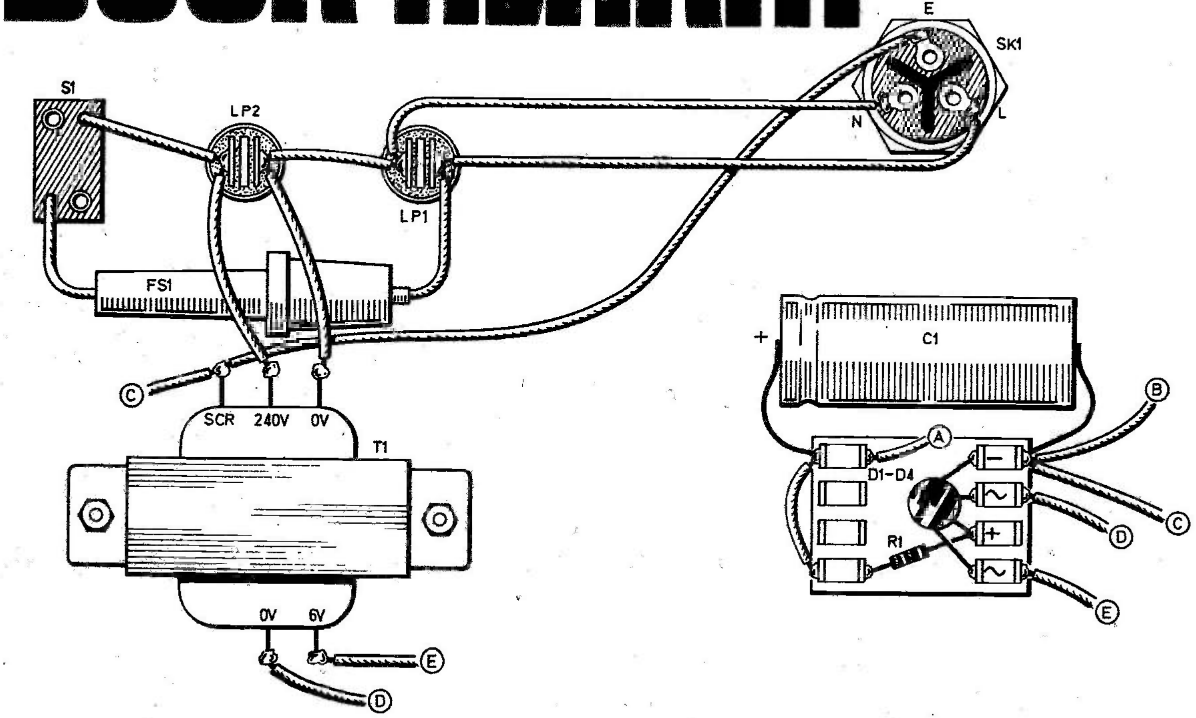
The legend on the touch plate is very much a matter of individual choice. In the example seen opposite the plate takes the form of a room/door number, but can equally be a name or symbol etched in copper as shown below. The centre portion can be solder tinned for effect as shown. One important point to make is that the legend should be one "island" enabling a bridge between the legend and the surrounding



Photograph of the prototype unit.



TOUCH SENSITIVE
DOOR ALARM



Complete wiring up details and a suggested layout for the components in the case.

"land" to be made at any point along the legend.

A wire should be connected to each, the legend and land surround and these taken via a suitable length of cable to a jack plug.

For indoor use the plate can be attached to a door or doorpost using Blu-Tak, Plasti-Tak or similar, for example, or bolts/screws as should be for outside use.

With the assistance of aluminium grille, an Isopon block (fibreglass) can be made to encase the touchplate and wiring (leaving the front exposed of course!).

TESTING AND USE

With the touchplate not plugged into the unit, temporarily connect a 330 kilohm resistor across the jack socket and plug the unit into the mains. On turning on at S1 a tone should be heard from the loudspeaker. The pitch should be variable by means of VR1. Switch off the unit at the mains and remove the 330 kilohm resistor. On switching on again, no sound should be heard from the loudspeaker.

The touchplate can now be tested by plugging in at SK2 and placing your hand across the touchplate. Sound should emanate from the speaker for as long as the hand is across the touchplate.

Operation frequency depends on hand resistance, which varies greatly. The alarm can be used in many types of environment, but outdoors in rain or other severe conditions, the alarm may double as a rain alarm if not properly sheltered.

In outdoor cases, and in the case of it facing a corridor along which a lot of people pass then screws and the Isopon casing will prove of use.

Finally, provided the instructions are adhered to, the unit will be electrically safe, and mothers need not fear for their children operating the device. ■

Components....

SEE SHOP TALK

Resistors

R1	3·3Ω 6W
R2	4·7kΩ
R3	4·7kΩ
R4	4·7kΩ
R5	4·7kΩ
R6	1kΩ

All ¼W carbon ± 10%

Capacitors

C1	1000μF 15V elect.
C2	0·047μF plastic or ceramic
C2	0·047μF plastic or ceramic

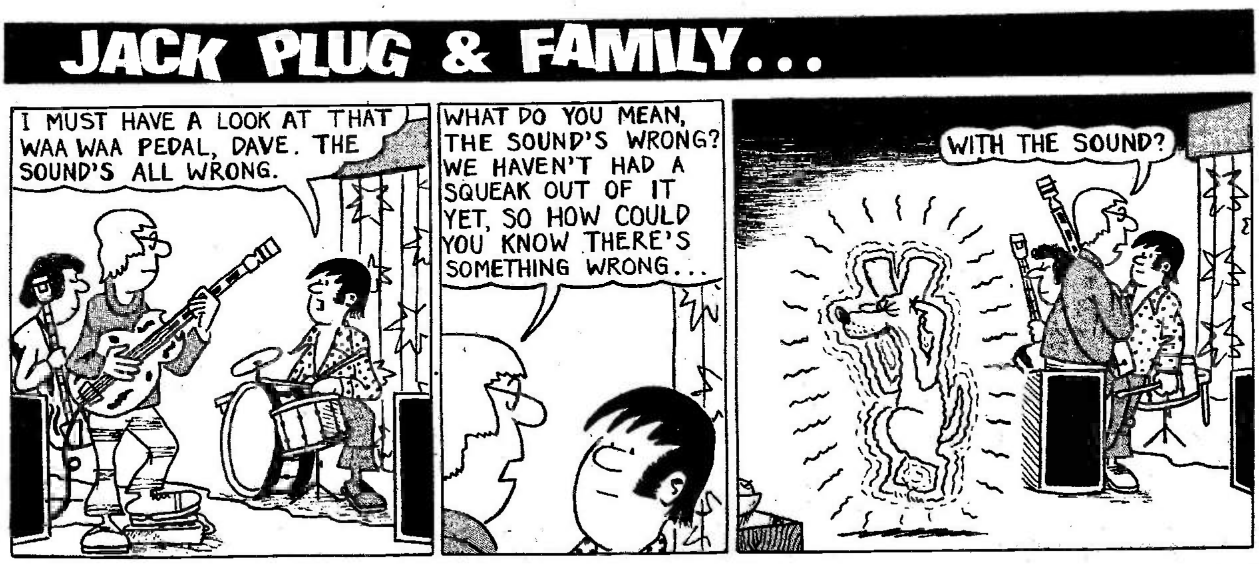
Semiconductors

TR1	BC108 silicon *npn*
TR2	BC108 silicon *npn*
TR3	BC108 silicon *npn*
TR4	BC108 silicon *npn*
D1-D4	1 amp 50 volt bridge rectifier

Miscellaneous

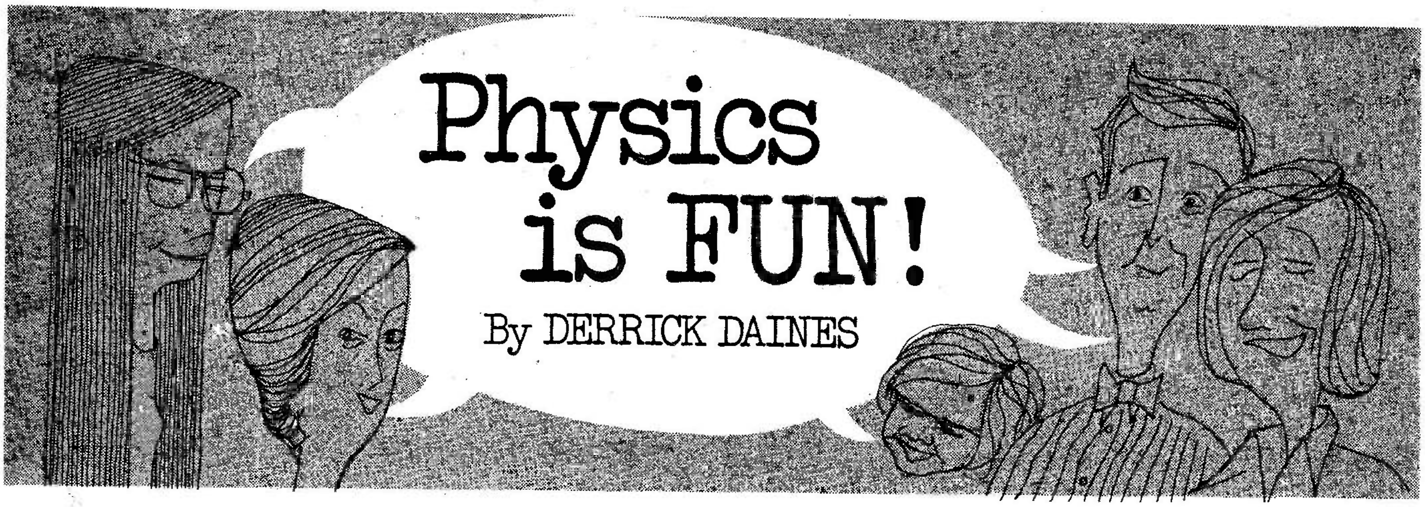
LP1, 2	mains neon (with built in *R*) (2 off)
S1	push-on push-off mains switch
T1	MT280 mains/6 volt 280mA secondary (Eagle)
LS1	miniature loudspeaker with coil impedance 80 to 100 ohms
FS1	500mA with in-line fuse holder to suit
SK1	chassis mounting mains inlet socket (Bulgin)
SK2	standard jack socket
PL1	mains plug to suit SK1
PL2	standard jack plug
VR1	470kΩ carbon log. or lin.

Tagboards: 11-way, 4-way; copper clad board for touch plate; case; knob; mains cable; two-core cable for connection of unit to touch plate.



Physics is FUN!

By DERRICK DAINES



THE DIODE RECEIVER

The diode receiver (or crystal set, as it used to be called) is more than just a museum piece. For one thing, it is easy to build and get working. For another, it will run virtually for ever at no expense and finally it forms a most valuable introduction to radio theory and can provide an interesting test-bed for experimentation.

The circuit of such a diode receiver is shown in Fig. 1. Crystal earpieces are common these days and it is unlikely that readers will have to buy one. The three capacitors and the diode should be above suspicion, so it is recommended that these be bought. Notice that one capacitor is a variable (tuning) type and ought to be fitted with a knob to prevent interaction from the hand.

Construction is not particularly critical and even the bottom of a cardboard box will suffice to hold the tuner. Connections between components should be of a fairly thin gauge plastic coated wire. Solder joints are advised, but not essential.

GOOD AERIAL AND EARTH

A good aerial and a good earth on the other hand are really essential. The aerial should be 50 to 60 feet long and rigged as high as possible. Copper wire is best, but I have had good results from control-line wire for model aeroplanes and even from a reel of garden wire. The best results that I ever got were from a disused telephone line, but not a word to Richard Marsh about that!

A very good earthing can be obtained from a jubilee clip fastened to a cold water tap.

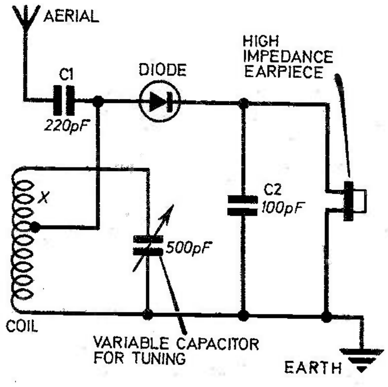


Fig. 1. Circuit of a single diode receiver.

Some readers may be a little surprised that so far I have not mentioned the coil. I have left this until now for a very real reason. The simple truth is that in these days of crammed radio waves almost *any* coil will pull in some station or other. Try it and see!

Fling a few turns of very fine copper wire round a 150mm length of ferrite rod, leaving a tapping loop out (marked *X* in Fig. 1) after putting on one third of the turns. Connect up—et voila!—some radio station or other! Turn the coil round and you will get a different station or group of stations. Substitute other coils—any coil you happen to have around—and the chances are that each time you will be able to pick up something. You may not understand it, it may be Swahili, or something, but you'll get it.

If you have a number of discarded diodes, try different ones. Try turning them round—experimenting in this fashion will teach you much more about radio in a few hours than watching somebody else. Go away and leave it. Come back in a week and the set will still be working. (Look, mum, no batteries!) Finally, when you settle for one particular radio station, wind the following coil.

COIL

Obtain 100mm of 8mm ($^{5}/_{16}$ inch) diameter ferrite rod and put on a single turn of Sellotape. Now you need about 1 metre of 38 s.w.g. copper wire. Wind on 16 turns and bring out a coupling loop. Wind on a further 34 turns, making 50 in all. Each turn should be neatly laid by the side of the others in a single layer and the whole coil should take up no more than about 25mm in the centre of the rod. Secure the coil with another single layer of Sellotape. This coil will, with the capacitors specified, give you medium wave coverage. Long wave coils can be obtained from stripped-down radio sets.

The fact that the receiver works with no batteries is adequate proof that there is energy in radio waves. We receive the signals and hear them because of the energy put out by the broadcasting station and it is because we must provide a complete circuit for the energy that such a good earth and aerial is required. Later, we can do some experiments to study the nature of radio waves.

The diode is a gadget that we can also study later. Suffice to say here that it blocks current in one direction but not in the other. The radio frequencies are picked up by the aerial and amplified by the tuned circuit (the coil and variable capacitor) and detected by the diode.

The final capacitor is chosen so that it is reactive at audio frequencies but conductive at radio frequencies, thus only audio frequencies go through the earpiece.

Many readers will probably be familiar with the "across the river" electronic and non-electronic versions of the puzzles involving a farmer with hen, fox and corn or rabbit and lettuce. Here is another electronic puzzle on the same theme, but slightly harder to solve, involving six people who wish to cross a river by small boat subject to certain conditions as detailed later.

CIRCUIT DIAGRAM

The circuit diagram of the Couples game is shown in Fig. 1. Basically it consists of a parallel lamp/audible alarm arrangement in series with a bank of switches. Certain combinations of the switches cause the lamp to light and the alarm to sound when S7 is made.

The wiring between the switches has been arranged such that if the switches are made in the correct order according to the rules, the lamp will not light, nor the alarm sound when S7 is depressed.

Components.... SEE SHOP TALK

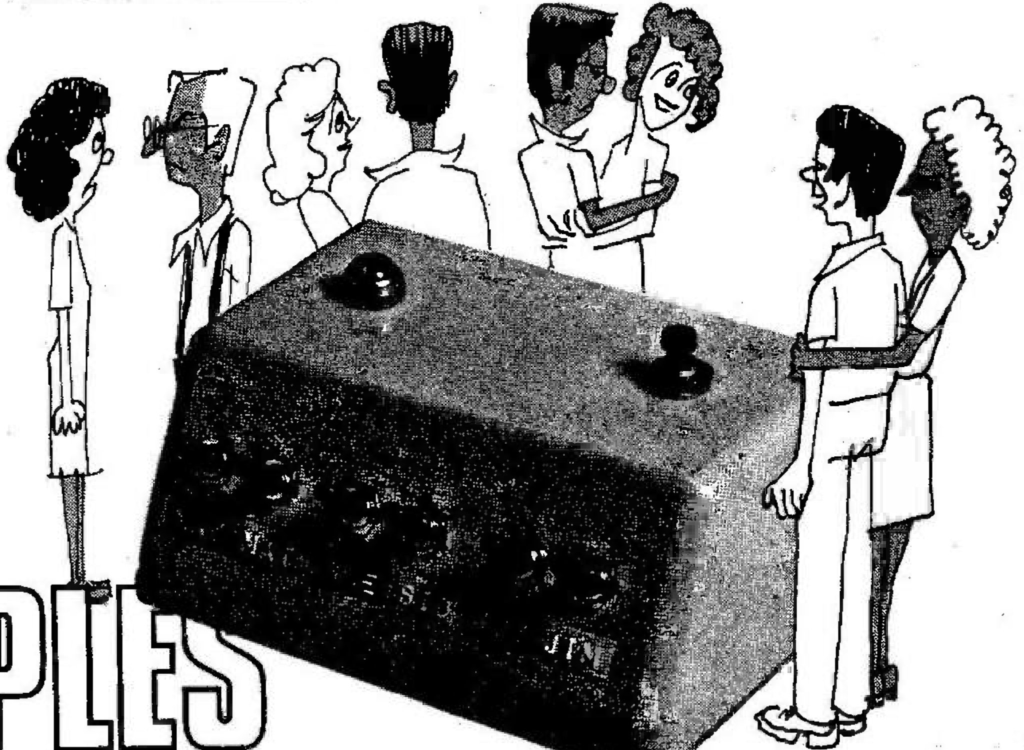
Switches
S1-S6 d.p.d.t. miniature toggle switches (6 off)
S7 push-to-make release-to-break push button

Miscellaneous
LP1 l.e.s. 12 volt 0·75 watt lamp
WD1 Bleeptone or similar 12 volt audible warning device
B1 9 volts type PP4
Case type BX56 as used in prototype (Home Radio); lampholder to suit LP1; battery connectors to suit B1; insulated connecting wire.

FOR GUIDANCE ONLY
ESTIMATED COST* OF COMPONENTS
excluding V.A.T.
£3 to £7·50
Depending on component types
*Based on prices prevailing at time of going to press

COMPONENTS

The layout of the components within the case of the prototype is shown in Fig. 2 together with complete wiring up details. The layout is not critical and may be changed to suit in-



COUPLES
an Electronic Game
By ALAN SPROXTON

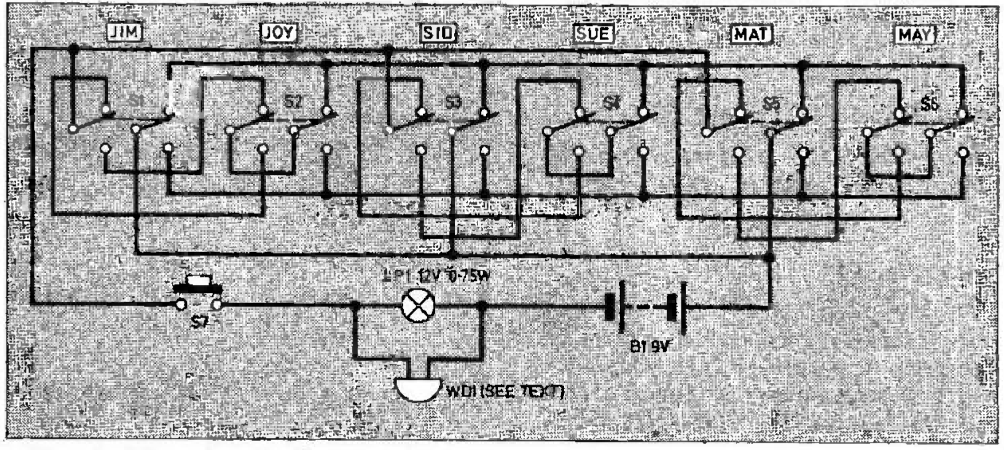
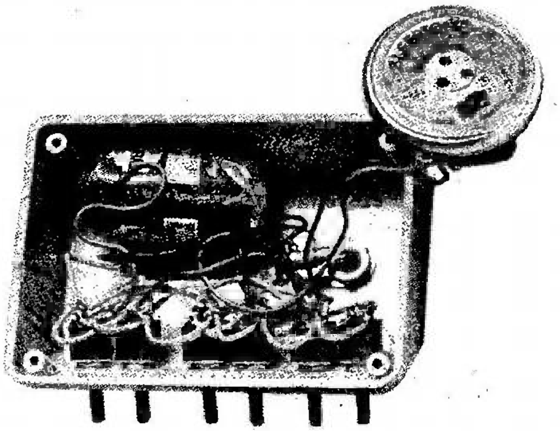


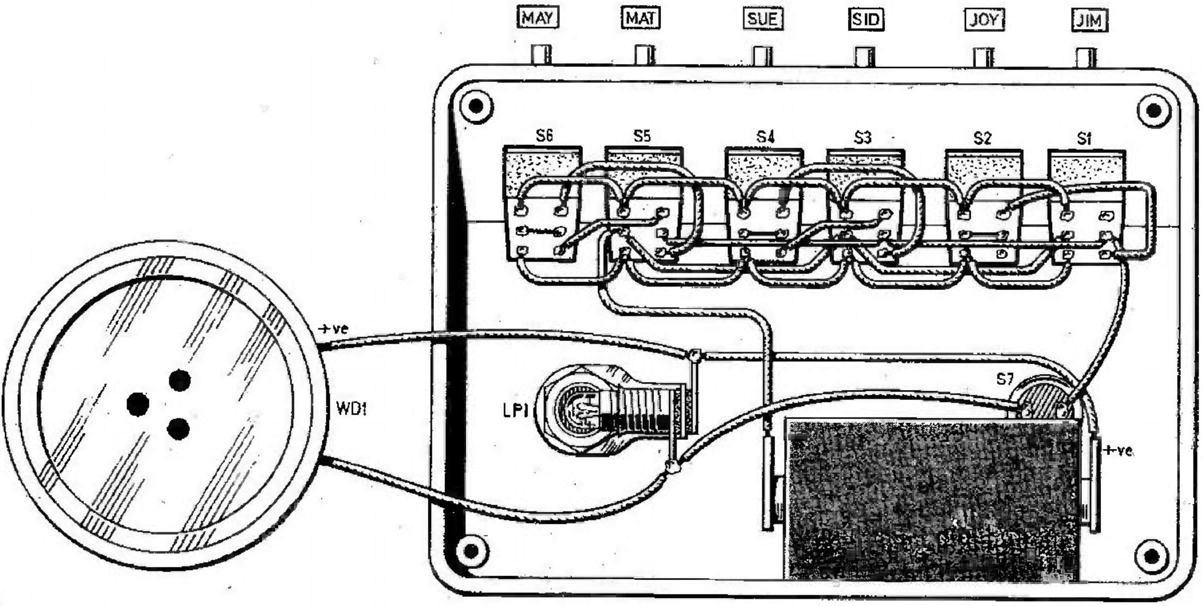
Fig. 1. The circuit diagram for the Couples game.

COUPLES



Photograph of the completed prototype with base plate removed.

Fig. 2. Layout of the components and complete wiring-up details within the case.



dividual requirements.

The miniature switches specified can prove rather expensive as is one of the other items, namely the Bleeptone. Larger, more generally available switches may be used or even the cheaper double-pole double-throw slide variety. The case will have to be made larger thereby enabling the Bleeptone to be replaced by one of the many slightly larger but cheaper audible alarm units.

WIRING-UP

Wiring up of the unit must be carried out using insulated wiring. First, with all the components to hand, a case should be chosen and then prepared to accept the components, not forgetting the battery, which when fitted in place are to be wired up according to Fig. 2.

It will be necessary to drill some small holes near to the position of the alarm unit to allow the sound to be clearly heard.

RULES, CONDITIONS AND MODE OF PLAY

The toggle (or slide) switches represent three adjacent married couples, see photograph. The object of the game is to get all the people across the river without making a wrong move. The game starts with all the switches in the down position (pointing towards the name tags) representing the couples on one side of the river bank. Crossing the river is accomplished by pushing the switches up. Now the boat available for crossing the river can hold no more than two persons at any one time, therefore no more than two switches can be moved at a time.

The husbands are all very jealous and will not allow their wives to be in a party with the other men unless they themselves are with them. After each move the push button S7 must be operated; a wrong move will be indicated by the lamp lighting up and the audible warning being sounded.

Before you start just try a quick test. Move Sue and Joy across the river, then press the button. No sound or light should be noticed. Put back Sue and Joy where they were. Now move Jim and Joy across and again there should be silence. Bring Jim and Joy back. Now move Sid and Jim across. This time you will get a buzz and a light. This is because Sue and Joy are left in a party which includes a man (Mat). Put back Sid and Jim.

Right off you go—you have to get all the switches from bottom to top, moving them one or two at a time without a buzz. Don't forget the boat has to be brought back by someone each time, and don't forget to check after each move by pressing the button.

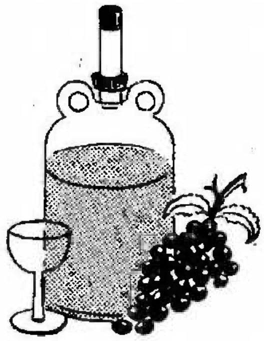
It can be done, and when you have mastered it, see what is the smallest number of moves you can do it in. ▣

NEXT MONTH

Are you making the most of electronics? Look at these useful projects which will be described in next month's Everyday Electronics.
No other hobby can rival the range of interests and possible applications offered by electronics. And Everyday Electronics comes up with an exciting selection of designs every month. It doesn't do to miss even one month!

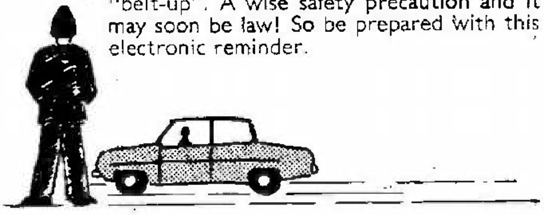
FERMENTATION INDICATOR...

An electronic bubble watcher for wine makers. Ingenious unit built into a conventional airlock. A flashing light tells all!



CLUNK-CLICK JOGGER...

This simple circuit warns the motorist to "belt-up". A wise safety precaution and it may soon be law! So be prepared with this electronic reminder.



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TEACH-IN 76

By A.P. STEPHENSON

Part Eleven

INTRODUCTION

A.C. Theory is concerned with the behaviour of coils, capacitors and resistors towards voltages and currents which are varying in a sinusoidal manner. The equations which follow are true only for sinewaves.

11.1 THE SINEWAVE

The kind of voltage variation known as a **sinewave** is shown in Fig. 11.1a. There are several important features and check points which require understanding and memorising.

Peak voltage (V_p)

There are two peak voltages, one positive and one negative. The total voltage across these two peaks is called the peak-to-peak volts (V_{pp}) or by the more descriptive term "swing".

Root mean square or r.m.s. value (V_{rms})

The r.m.s. voltage is 0·707 of the peak value and is so useful in calculations that, unless otherwise stated, it is taken for granted that the term "voltage" means the r.m.s., value, i.e. there is really no need to write V_{rms}. The r.m.s. value of a sinewave is that voltage which a d.c. voltage must be in order to produce the same heating effect in a resistor.

Example

The peak value of the mains is actually 335 volts but 0·707 of this is 240 volts which is how the mains is usually described.

The Instantaneous value (v)

The instantaneous voltage is the voltage at some specified instant of time so it can only be represented by an equation involving time which is $v = V_p \sin 2\pi ft$ where t is the time elapsed since the last zero (which was reached by rising from a negative value). This last proviso is important because there are two zeros in a cycle.

The Average Value (V_{av})

Over a full cycle, the average value must be zero because the voltage is continuously changing its direction and never getting anywhere.

If we put a sinusoidal voltage across our voltmeter it would simply tremble around the zero volts mark because the interia of the pointer would be unable to follow the changes of polarity. The average value over half a cycle is useful and mathematics tell us that $V_{av} = 2V_p/\pi = 0{\cdot}64\ V_p$ approximately.

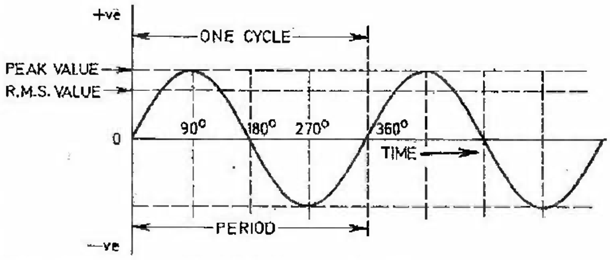


Fig. 11.1a. Important features of a sinewave.

The Period (T)

This is the time taken to complete one sequence of variation or "cycle".

The Frequency (f)

This is the number of cycles per second and is:

$$\boxed{f = 1/T}$$

The unit is the hertz (symbol, Hz, and is equal to one cycle per second).

The mains frequency is 50Hz, so its period is 1/50 second. Audio equipment has to deal with frequencies within the range 20Hz to about 20kHz, while f.m. radio is in the one hundred MHz range. Colour television is even higher frequency, but is low in comparison with radar.

The Time Axis

The horizontal time axis on the sinewave graph can be calibrated in actual time in seconds (or ms, μs etc.). It is also convenient to divide it into degrees in which case one cycle equals 360 degrees, half cycle equals 180 degrees and so on. The more scientific way is to divide it into radians: one radian is equal to 57 degrees of arc, and one cycle equals 2π radians.

11.2 THE REACTANCE (X)

When a sinusoidal voltage is applied to a resistor the current flowing is calculated by normal Ohm's law and the frequency is unimportant.

With coils and capacitance however, the current which flows is absolutely dependant on frequency. Another fundamental difference is the manner in which the current is opposed.

Resistors oppose current simply by a kind of molecular friction leading to heat, but coils and capacitors oppose by developing a voltage which is acting against the supply. This "back voltage" effect is called **reactance** but is measured in "ohms".

Inductive Reactance (X_L)

Inductive reactance (see Fig. 11.2 (a)) is the opposition in ohms of a perfect coil, i.e. no winding resistance. Such a coil, although not quite achievable in practice, will in future be called an **inductor** or sometimes an **inductance**. The formula for calculations is

$$\boxed{X_L = 2\pi fL \text{ ohms}}$$

Example

An inductance of 0·1 henry is across a 10 volt, 50Hz supply. The reactance of the inductance is $X_L = 2\pi \times 50 \times 0{\cdot}1 = 10\pi = 31{\cdot}4$ ohms. The current is therefore $I = V/X_L = 10/31{\cdot}4$ amps $= 0{\cdot}32$ amps.

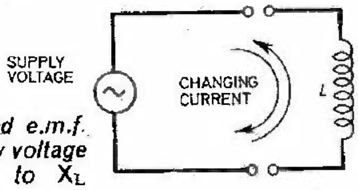


Fig. 11.2a. The induced e.m.f. just balances the supply voltage acting in opposition to X_L ohms.

Capacitive Reactance (X_C)

It is difficult to imagine how a capacitor, which is essentially two plates separated by an insulator, can pass a current. The answer is simple—it can't! At least it can't pass current straight through, but by virtue of its capacity to store electrons, a current can flow into its plates and out again see Fig. 11·2b.

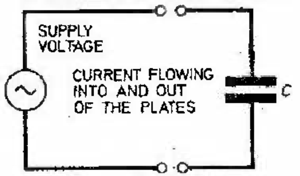


Fig. 11.2b. The current flowing is just enough to produce a voltage across C which balances the supply. The opposition is X_C ohms.

Thus an a.c. voltage across a capacitance causes a continuous flow of electrons into and out of the plates so, because we define a current as a flow of electrons or charges, there must be currents circulating. The higher the frequency the greater the circulation so it is not altogether surprising to learn that:

$$\boxed{X_C = \frac{1}{2\pi fC} \text{ ohms}}$$

(The higher the frequency, the less the opposition.)

It is very important to have at your fingertips how X_L and X_C behave to changes of frequency. Although the formulae themselves give this information, it is often more informatively shown in the form of a graph as in Fig. 11·2c. These two points should be noted (i) for zero frequency, X_C is infinite but X_L is zero (ii) for infinite frequency, X_C is zero but X_L is infinite.

The graphs are shown for some constant values of C and L, but it should be clear from the equations that X_L increases with the value of L but X_C decreases with the value of C.

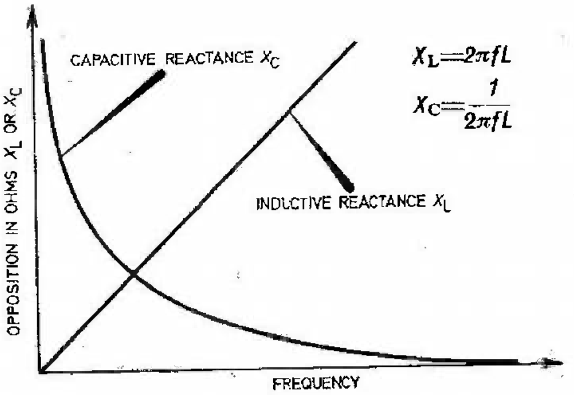


Fig. 11.2c. Graph showing how X_L increases but X_C decreases with frequency.

11.3 PHASE ANGLE (φ)

The phase angle is the fly in the ointment to students of a.c. and is responsible for the sickening number of equations which pollute the pages of text books. It is all due to the inherent laziness of current in inductive circuits (see previous graph of L/R time constants Fig. 10·3b) and the laziness of voltage in capacitive circuits (see graph of C/R times constants in Fig. 4.6a.

The current in a pure inductance is always lagging behind its voltage by exactly 90 degrees but in a capacitive circuit it is the voltage which is lagging behind its current by 90 degrees. It is conventional however to state (and remember) these facts in a

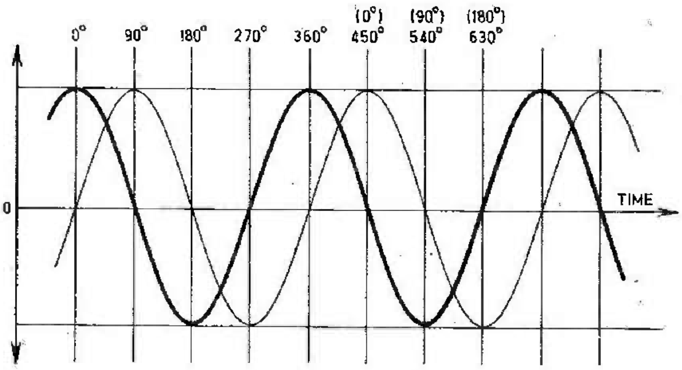
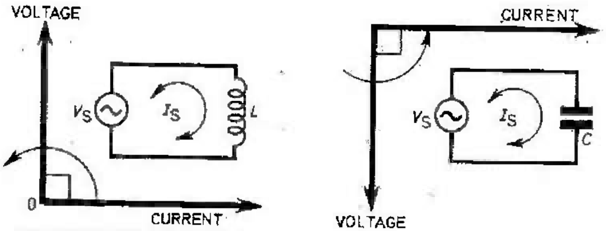


Fig. 11.3a. Phase difference between sinewaves. The "heavy" curve is "leading" the "light" one by 90 degrees, so the latter is "lagging" by 90 degrees.

slightly different way: Current Lags in inductive circuits Current Leads in capacitive circuits.

This is illustrated in Fig. 11.3a but does require a little assistance. A "leading" waveform is one which reaches its *positive* peak first!

It has been customary for many years to represent these angle differences ("phase-angles") by vector diagrams, i.e. straight lines drawn at some fixed angle to each other. To distinguish between lag and lead, which after all are purely relative terms, the convention is that "all vectors are assumed to *rotate* anticlockwise"; Fig. 11.3b shows how vector diagrams can be used to show phase angles between voltages and currents.



VOLTAGE LEADS ON CURRENT BY 90 DEGREES

CURRENT LEADS ON VOLTAGE BY 90 DEGREES

Fig. 11.3b. Phase angles in vector notation.

11.4 IMPEDANCE (Z)

It is very seldom that practical circuits will contain only a single capacitor or inductor, in most cases there will be mixtures which include resistors as well. The general term for any mixture of either X_L, X_C, or R is called **impedance** and because it represents the combined opposition, is measured in ohms. For any complex network, the current is always,

$$\boxed{I_S = \frac{V_S}{Z}}$$

where V_S is the supply voltage and I_S is the supply current.

The trouble is finding Z for a particular network because here we meet some weird kind of arithmetic. For example we might expect that a 3 ohms resistor and 4 ohms inductive reactance in series would have an impedance of $3 + 4 = 7$ ohms. But this would be ignoring the effects of phase angle.

The current through and the voltage across a resistor are in phase with each other but a reactance such as X_L has a 90 degree phase shift between its voltage and current. When we draw the vector diagram for such a combination and perform a little pythagarous we find that the resultant opposition Z is $\sqrt{(3^2 + 4^2)} = 5$ ohms instead of 7, see Fig. 11.4a.

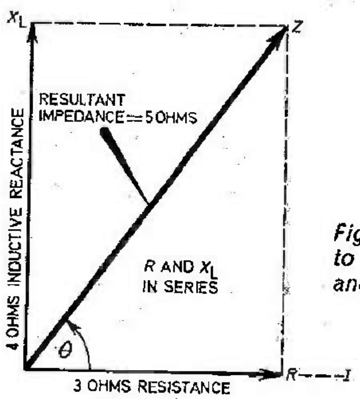


Fig. 11.4a. Using vectors to find impedance of R and X_L in series.

For X_C and R in series, see Fig. 11.4b. Those of us who remember a little trigonometry will see that the angle between Z and the reference dotted line I can be found from the equation,

$$\Theta = \tan^{-1}\frac{X}{R} = \tan^{-1}\frac{4}{3} = \tan^{-1} 1{\cdot}33$$

which from mathematical tables yields $\Theta = 53{\cdot}13$ degrees. (Anyone who can't be bothered with trigonometry needn't worry—just draw the ohms to scale and measure the resultant Z with a ruler and the angle with a protractor).

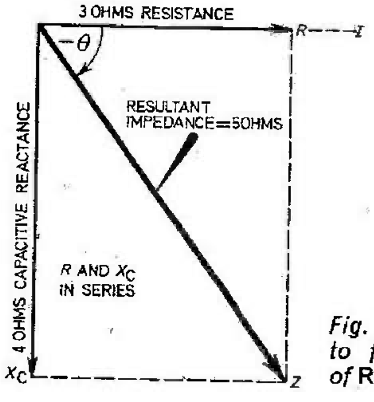


Fig. 11.4b. Using vectors to find the impedance of R and X_C in series.

From all this we can write general equations as follows:

R and X_L in series $Z = \sqrt{(R^2 + X_L{}^2)}$, $\Theta = \tan^{-1}\frac{X_L}{R}$

R and X_C in series $Z = \sqrt{(R^2 + X_C{}^2)}, \Theta = -\tan^{-1}\frac{X_C}{R}$

We can also draw vectors which illustrate how voltages divide and they would be exactly the same as in Fig. 11.4a and b, except the horizontals would be V_R, the verticals V_L or V_C and the resultant V_S; Fig. 11.4c shows the voltage distribution for a 5 volt supply across a 3 ohms resistor in series with a 4 ohm inductive reactance. To justify this we note that $Z = \sqrt{(3^2 + 4^2)} = 5$ ohm which makes the current $I = 5$ volts/5ohms $= 1$ amp. This makes $V_R = IR = 3$ volts and $V_L = IX_L = 4$ volts.

Some readers will, quite rightly, look at the voltages of Fig. 11.4c with horror. What has happened to old Khirchoff—why don't the voltages add up to 5 volts?

The answer is that Khirchoff in a.c. theory must be re-worded to "the *Vector Sum* of the voltages must equal the supply voltage". In general if A and B are at right angles, the vector sum is $\sqrt{(A^2 + B^2)}$ instead of $(A + B)$.

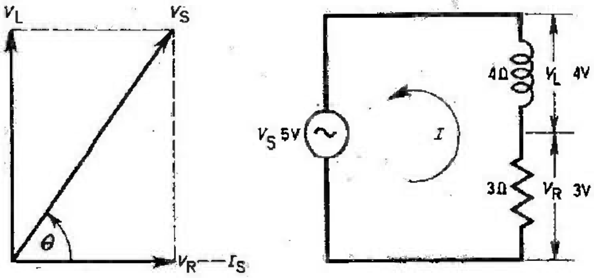


Fig. 11.4c. Voltage vectors of a series LR circuit.

11.5 OPERATOR (j)

A useful little dodge to simplify the appearance of vector sums and to aid their manipulation is to introduce **operator j**. The symbol j before a number (or symbol) means *rotate 90 degrees anticlockwise.* Thus instead of drawing a vector diagram for R, X_L and Z, we can convey the same information by writing

$$\dot{Z} = R + jX_L$$

Also, by using $(-j)$ to represent 90 degrees clockwise rotation the equation for R, X_C and Z may be written as, $\dot{Z} = R - jX_C$.

(The "dot" over the $\dot{Z}$ is a warning that the equation is in vector form). Equations written in this way are called *Rectangular Form,* i.e. in terms of the rectangular components of the resultant. The j terms are called **imaginary** to distinguish them from the non j terms which are called **real**.

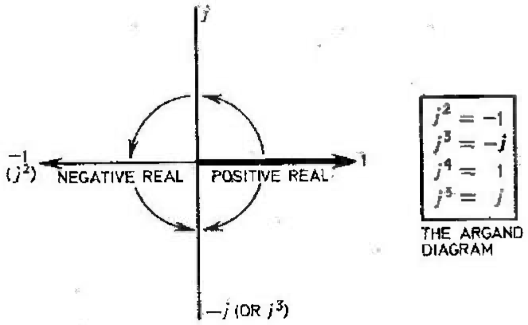


Fig. 11.5a. The so-called Argand diagram.

Resistances are always drawn horizontally and reactances vertically in vector diagrams, hence horizontals are real, verticals are imaginary. The Argand diagram of the system is shown in Fig. 11.5a. which may help to explain these absurd terms. If j means rotate 90 degrees, then $(j \times j)$ brings the vector to -1 which means $j^2 = (-1)$ or $j = \sqrt{(-1)}$. But mathematicians refuse to believe in the square root of a negative number so they say that j is imaginary. An unfortunate choice of terms because there would be nothing imaginary about the coffin if you touched j1000volts!

There is an alternative method of expressing a vector known as *Polar Form* in which the resultant is given in the form of a magnitude (called the modulus) and an angle (called by another silly name, the argument). Thus a polar form equation would look something like

$$\dot{Z} = |\ Z\ | \arg\Theta \text{ or } \dot{V} = |\ V\ | \arg\Theta$$

A numerical example may help the understanding and to distinguish the difference between polar and rectangular form.

Example

A series combination of 3 ohms resistance and 4 ohm inductive reactance would be written in rectangular form as $Z = 3 + j4$. If we now convert to polar form it becomes

$$\dot{Z} = \sqrt{\left(3^2 + 4^2\right)} \arg\tan^{-1}\frac{4}{3} = |\ 5\ | \arg 53°$$

It is a little more difficult to convert from polar to rectangular but study of Fig. 11.4a plus a little elementary trigonometry will show the method; If $\dot{Z} = |\ 5\ |$ arg 53° then $R = 5\cos 53°$ and $X_L = 5\sin 53°$ which gives $\dot{Z} = 3 + j4$ back again.

Those of you who possess scientific calculators may be able to perform these conversions direct—it is becoming quite common place for these devices to include "Polar to Rectangular" (or vice versa) at the touch of a button.

More Complex Examples

Previous calculations have been simple in two respects, (a) the chosen figures 3, 4, and 5 is a natural set of numbers which ensures easy arithmetic and (b) only two components at a time were involved.

If a multitude of series components are to be handled, the rule is, "add the resistors, then add the j terms separately until the network reduces to one resistor and one reactance in the from $Z = R + jX$. To find the resultant impedance and phase angle simply convert this to Polar Form.

TEACH-IN '76 EXPERIMENTS AND EXERCISES

EXPERIMENT 11A

To demonstrate half wave rectification.

WARNING

These experiments involve connecting the bell transformer to the domestic electricity supply. So it is wise to learn an elementary rule at the outset.

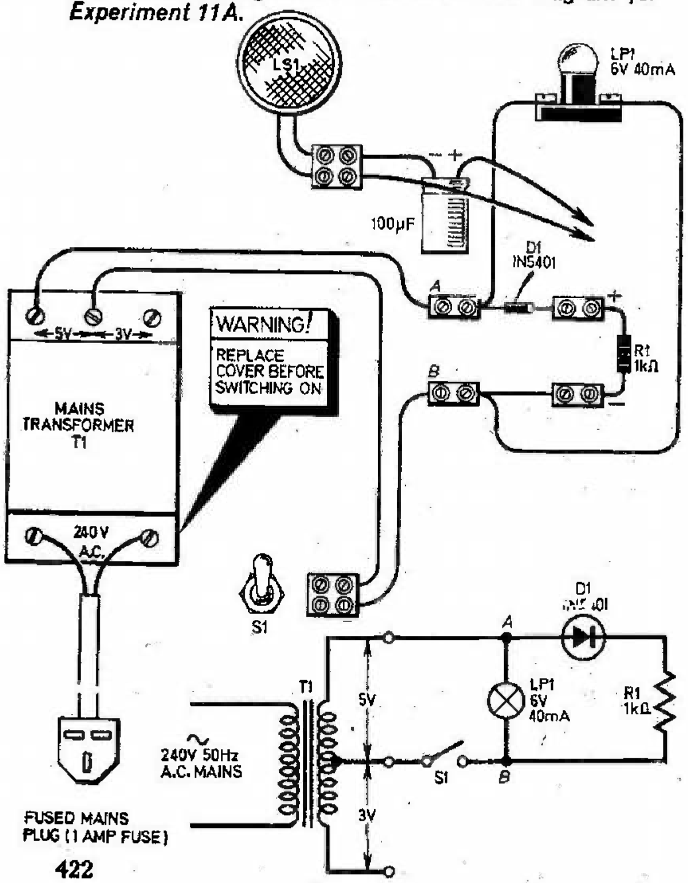
This rule is just the common sense acceptance that 240 volt 50Hz mains is lethal and no experiments or voltage measurements must be carried out on the primary 240 volt side of the bell transformer. If you have no previous experience or are very young, it is wise to enlist the aid of someone experienced to connect up the primary cable and the mains plug for you.

Always switch off at the mains when making adjustments and **keep the plastic cover in position on the transformer.**

PROCEDURE

1. Assemble the components as shown in Fig. 11A.1 using twin mains cable from the primary to the live and neutral of the plug. Leave the switch on the Circuit Deck in the off position. The speaker and capacitor will be used later.
2. Insert the mains plug and switch on the mains. Wait a few moments, keeping an eye out for smoke or other signs of protest from the transformer.
3. Close the switch S1 and lamp LP1 should light which proves two things—the transformer is doing its job and the secondary circuit is safe because if there was a lethal voltage the lamp would have blown.

Fig. 11A.1. Wiring details and theoretical diagram for Experiment 11A.



4. Using the meter on the 10V range, measure the voltage across *AB*. The meter should read zero because the 5 volts present is pure a.c. which has an average value of zero.
5. Connect the speaker with the $100\mu F$ capacitor in series across *AB*, and note the faint 50Hz hum. The speaker, due to its very small size, is capable of responding efficiently to such a low frequency. If you have a larger speaker you can try it out but remember the power dissipation! If your speaker has say an impedance of 8 ohms, direct connection across the 5 volts r.m.s. winding would deliver a power of $(5)/8^2 = 3.13$ watts. If your speaker is less than this power rating the speech coil may be damaged. It would be wise to connect the 50 ohm potentiometer in series to reduce the power if there is any doubt. Disconnect the speaker before continuing with the next step and unscrew the lamp.
6. Measure the voltage across the 1 kilohm load, R1. Because the diode is now in series producing half wave rectification the meter should read the average voltage which is Vp/π minus the small drop across the diode. The transformer is stated to deliver 5 volts r.m.s. which is $5 \times 1{\cdot}41 = 7{\cdot}07$ volts peak and therefore $7{\cdot}07/\pi = 2{\cdot}25$ volts average. Allowing for the diode volts drop expect something around 2 volts although reasonable deviation should not cause undue alarm (or disgust with a.c. theory) because bell transformers are not high accuracy devices—neither is the mains supply.
7. Connect a $1000\mu F$ capacitor in parallel with the load resistor R1 (remembering an electrolytic has poarity). This should bring the d.c. voltage across the load almost up to peak volts because of the reservoir action. Measure this voltage, which should be around $5 \times 1{\cdot}41 = 7{\cdot}07$ volts. Note the capacitor has about *trebled* the voltage available.

EXERCISES

11.1 An 0·1 henry coil is carrying a.c. current at a frequency of 500Hz. What is the inductive reactance?

11.2 At what frequency will a $100\mu F$ capacitor have a reactance of 10 ohms?

11.3 If the r.m.s. voltage is 20V what is the peak to peak voltage?

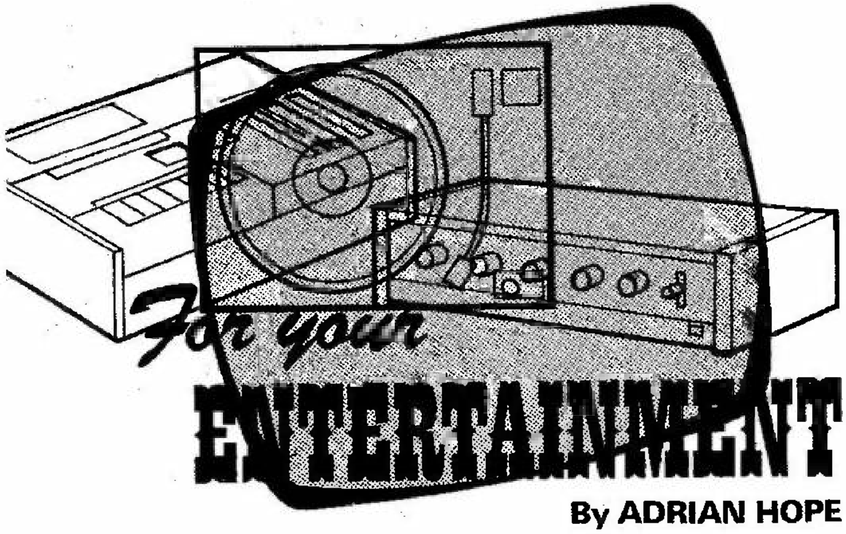
11.4 If a 230 volt supply is across a 1000 ohms impedance, what current will flow?

11.5 Write the impedance (in rectangular form) of the following circuits:
  (a) $R=8$ ohms; $X_L=3$ ohms; $X_C=7$ ohms
  (b) $R=22$ ohms; $X_C=17$ ohms; $X_L=5$ ohms.

11.6 Convert to polar form:
  (a) $Z=8+j34-j28$
  (b) $Z=5+j10-j5$

Answers

11.1 314 ohms. **11.2** 159Hz. **11.3** 56·4 volts. **11.4** 0·23 amps. **11.5** (a) $Z=8+j3-j7$ (b) $Z=22+j5-j17$. **11.6** (a) $Z=10$ arg 37° (b) $Z=7{\cdot}07$ arg 45°



For your ENTERTAINMENT

By ADRIAN HOPE

CITIZENS BAND

How long will the Home Office be able to maintain its position over refusing to allow Citizens Band Radio in the U.K. —and is its position justified or not? These are two questions which have already been touched on in this column and which we shall doubtless be returning to in the future.

To re-cap briefly, the Home Office has the power to say yea or nay to CB radio in the U.K. and the Post Office is entrusted with enforcing the current nay. But although it is illegal to manufacture, import or use CB transceivers, they can quite legally be bought, sold and advertised.

The official reason for refusing to allow CB use is that although the sets are all nominally tuned only to the frequencies around 27MHz, they may generate spurious harmonics which interfere with normal reception of radio and television. But is interference really a real risk?

CB is now a way of life in the U.S.A. and several Continental countries (including Germany) and so far we have heard little about actual interference problems.

Also there has been a credibility gap in the U.K. on the whole business of interference since some very questionable arguments over "jeapordising vital services" were used to justify the legal sinking of the pirate radio ships. But if readers have any concrete evidence of CB interference problems, here or abroad, do please tell us.

REGULATIONS

A point little appreciated, but important to note, is that if anyone is contravening the laws of the airwaves it is probably the Home Office for refusing us permission to use the 27MHz bands for CB!

The Radio Regulations agreed by the International Telecommunication Union at Geneva in 1959 clearly set aside the 27MHz band for "industrial, scientific and medical" use and added the proviso that "radio communication services operating within those limits must accept any harmful interference that may be experienced from the operation of industrial, scientific and medical equipment". In other words, if you use the 27 megahertz band for voice communication you cannot complain that hospital equipment or bleep paging systems are interfering with you.

But the clear and inescapable implication is that we should be entitled to use the band for voice communication if we wish.

CREDIT CARDS

It is always interesting to see how different countries apply modern technology to everyday life. A friend staying recently at a large Paris hotel was given a perforated card and told it would answer his every need. Sure enough, it did.

In each bedroom a refrigerator contained drinks which could be released by the simple expedient of posting the card momentarily into the requisite slot. When he checked out of the hotel, he was required to hand over the card to a girl, who posted it into another slot. Immediately an IBM golfball typewriter sprang into action and typed out and itemised (completely accurately) an account of every drink bought. All the "purchase" slots throughout the hotel were linked to a central computer.

I encountered a similar system recently in Japan. There, the hotel bedrooms were equipped with refrigerators which, at the push of a button, dispensed (very expensive) drinks. Each button was, again, directly linked with a central accounting computer.

In the lift of a Tokyo hotel one day I was worried by what appeared to be the sound of wild birds trapped in the lift shaft. Then I heard the same sound in the restaurant and again in the foyer. It turned out to be electronically produced imitations of wild birdsong. The irony is that in one of the ancient temples in Kyoto a much more pleasant sound of imitation birdsong is produced by the ages old system of mounting the floorboards on squeaky nails.

VIDEO GAMES

Video games are even more fashionable in Japan than here and on the Continent. In Osaka I noticed several amusement arcades with all manner of sophisticated extrapolations from the basic video ping-pong game with which we are all now so familiar.

One required a driver to steer the video image of a car round a tortuous track; another enabled him to shoot down UFO's; and another took the form of a rifle range, with a light sensitive rifle pointed at the screen obliterating a bright video target whenever a "hit" was scored.

The most fascinating of all gadgets was a colour video game, in which several contestants back the winner of a horse race. The console contains a range of different video cassette tapes (or more likely film cassettes scanned by a telecine system), which are selected and displayed on a large colour TV screen, completely at random. Each film is a version of a horse race, but with a different winner. To play the game the contestants place a bet to predict the winner; and there is automatic pay-up to whoever has backed the display on the screen.

Your Career in ELECTRONICS

By Peter Verwig

THE ROYAL NAVY

A career in electronics is an exciting prospect! Month by month our contributor Peter Verwig explains what working in electronics is all about, how to prepare yourself for a rewarding career, and the job opportunities available in the world's fastest growing industry.

IN THE April 1976 issue of EVERYDAY ELECTRONICS I described a career in the Merchant Navy as a ship's radio and electronics officer. A few readers, nearing or at the end of their courses, wrote that they were having great difficulty in getting an appointment and expressed the opinion that the tone of the article was far too optimistic.

Of course they were right on the first point and the reason is not hard to find. A large number of ships have been laid up during the world trade recession and, because of the shortage of jobs ashore, many sea-going officers have naturally tended to stay in their present positions who would otherwise have elected to leave the service and created more sea-going vacancies.

On the second point, that of presenting the story in a tone of optimism, it needs to be remembered that a young person starting a course now would not complete training until 1978 and by that time we all hope that world trade, on which we all depend for our prosperity, will once again be at a high level of activity.

EMPLOYERS CHOICE

The present situation is that for nearly every form of occupation the balance is in favour of the employer. From a stream of applicants for every vacancy he can pick and will pick only the cream and quite wisely so. That is why I have stressed over and over again the importance of obtaining professional qualifications.

It may be true that a person without, say, ONC can do a particular job equally as well as a person with ONC or even HNC, but when applying for a job at least your prospective employer knows that you have the ability to absorb knowledge, have been able to express yourself well and demonstrate your knowledge and skill through an examination process and, as you have the proof in the form of a certificate, he can concentrate on assessing factors like personality and enthusiasm.

Remember too, that all employers have to be much more careful these days in their selection of people. A few years ago an employer, if he took on a "bad egg" by mistake, could easily rectify matters by the simple expedient of instant dismissal. Today the employer is far more circumscribed in what he can do.

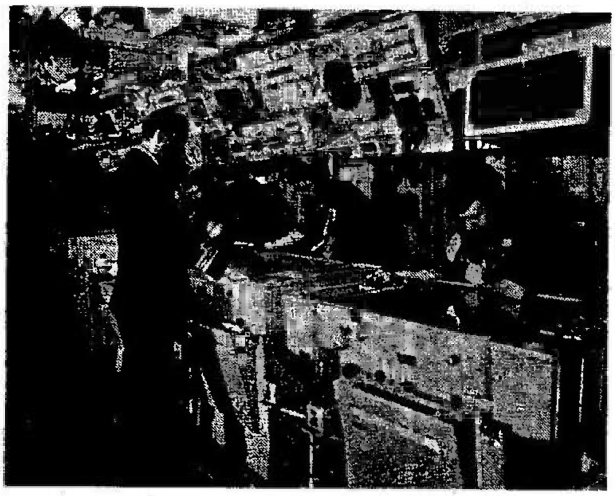
It is right that employees should enjoy protection from unfair dismissal and have other forms of protection but this has had its effect in making employers far more selective in the first instance.

This month I have chosen the Royal Navy as a career for intelligent young people who like the idea of long term security laced with an active and often adventurous life. The Royal Navy will train you in electronics, encourage your promotion up through the ranks, will look after you in sickness and health, pay you well while you are serving and give you a cash gratuity or pension, or both, when you leave depending on your length of service.

ENLISTING

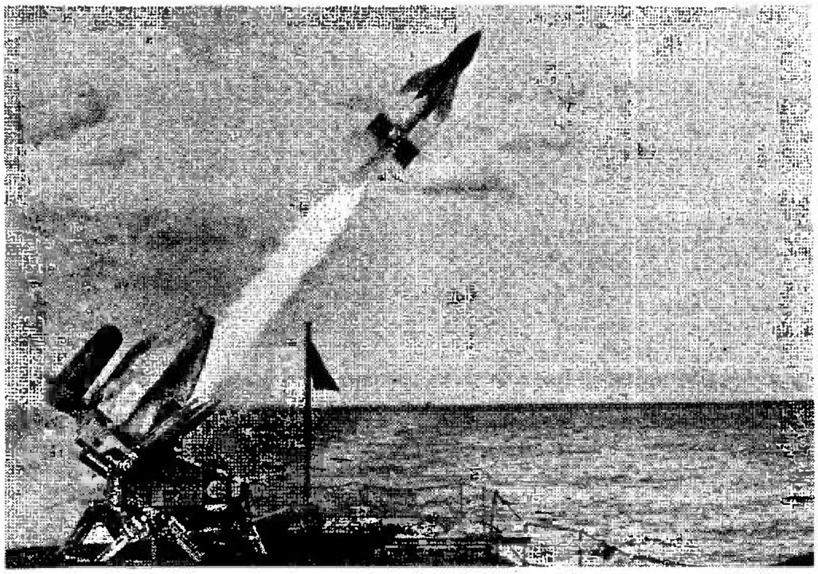
But don't imagine that you can just walk into a recruiting office and sign on in one of the Royal Navy's technical branches because these are regarded as being for


Sea King, anti-submarine warfare helicopter.


Computer Assisted Action Information System (CAAIS) installed in H.M.S. Torquay.

the elite. The Royal Navy is just as careful as any civilian employer in selection of engineering recruits. In fact more so, because as well as the natural intelligence to succeed in a trade, the Royal Navy also looks for character and leadership qualities and a high standard of physical fitness.

If you are accepted, you represent a very heavy investment in training and re-training throughout your career and such investment is not made lightly. And because of its heavy investment in people, the Royal Navy tends to favour the long-service engagement.



A Shorts Seacat surface-to-air missile leaving the launcher.

THE ROLE OF THE NAVY

In thinking about the Royal Navy as a career you will no doubt reflect on the fact that there is great pressure from some quarters for cuts in defence expenditure and this may lead you to believe that a naval career has little long-term prospect. This is not so.

The form of the Royal Navy may change in response to new tasks and new defence technology, as it has done ever since the days of Nelson, but the need for an efficient navy is as great as ever it was. In fact new tasks are at hand in the protection of Britain's oil installations in the North Sea and possibly in the Celtic Sea if oil or natural gas is found there, and the Royal Navy's role in NATO is well established and the need for strong participation is increasing rather than diminishing.

It is true that in numbers of ships the Royal Navy of today shows a big reduction, but this is more than compensated for by increases in mobility, more effective sensors of all types, and infinitely more powerful weapons systems.

ELECTRONICS AFLOAT

Perhaps the best example of how electronics has now dominated naval operations in the past twenty years or so is that the ship, except for the smaller sizes. is no longer fought from the traditional bridge but from an operations room below, which is crammed with electronic displays and data-processing equipment. This is the nerve centre which accepts all the inputs from the ship's own radars and sonars, from other friendly naval forces and air support, where all movements of friend and foe are tracked, threats evaluated with the aid of computers, and appropriate weapon deployment decided.

A complete action can be undertaken without actually seeing an adversary with the naked eye, the whole tactical situation being displayed electronically and the weapons trained onto targets and fired automatically.

Action Data Automation (ADA) systems of this type may be of varying complexity depending upon the level of computer participation. For example, a comparatively low-cost system may employ only computer assistance rather than a fuller measure of control and the system then becomes a Computer Assisted Action Information System (CAAIS) which still retains a high level of human decision-making.

Some idea of the complexity of such equipment can be gathered from the digital display system ordered from Plessey for H.M.S. Invincible which alone represented a contract worth £1 million.

If we turn to another area, naval communications, we find equally dramatic advances. The Royal Navy was the first in the world to have a fully operational shipboard satellite communications system. This is the SCOT system, supplied by Marconi and operating through the Skynet II military communications satellite, also built by Marconi, launched in November 1974 into geostationary orbit 22,000 miles up over the Indian Ocean.

In the more traditional sphere of radio communications, modern technology in the Royal Navy is based on the Integrated Communication System Stage 3 (ICS3), a modular system which can be built to any degree of complexity. It can not only provide all the external radio links ship-to-ship, ship-to-shore, and ship-to-air for tactical and strategic use in the low, medium and h.f. bands but also has an interface to v.h.f. and u.h.f. systems and controls distribution of messages and facilities throughout the ship.

Various users, for example, can be rapidly switched to any equipment. A feature is a telegraph message handling system with electronic storing and sorting of messages.

ICS3 has been such a marked success that a similar system is to be fitted to the next generation of warships under construction for the Royal Netherlands Navy "S" class frigates.

It would be quite easy to take up the whole of this article with brief reviews of other technical developments in surveillance, target illuminating and tracking radars, in underwater sonar equipment, and in missile guidance systems, or even in new advances in ship's navigation systems. Let it suffice that for any given volume of space, the modern warship will have a higher density of electronics than is to be found anywhere except, perhaps, in a modern military aircraft such as the MRCA Tornado.

FIGHTING FIT

What emerges from the above is that the Royal Navy needs men with exceptional skills to keep this technical equipment (on which it is now wholly dependent) in fighting fitness.

If you believe you have good ability, your prospects can be bright as an artificer which involves a four-year apprenticeship.

The artificer in the Royal Navy is primarily a technical manager able to trace faults himself and to direct the necessary repairs. If he stays in the ranks he can rise to Fleet Chief Petty Officer drawing over £80 per week but many artificers graduate to officer rank and nearly half of all engineer officers in the Royal Navy started their careers as artificers.

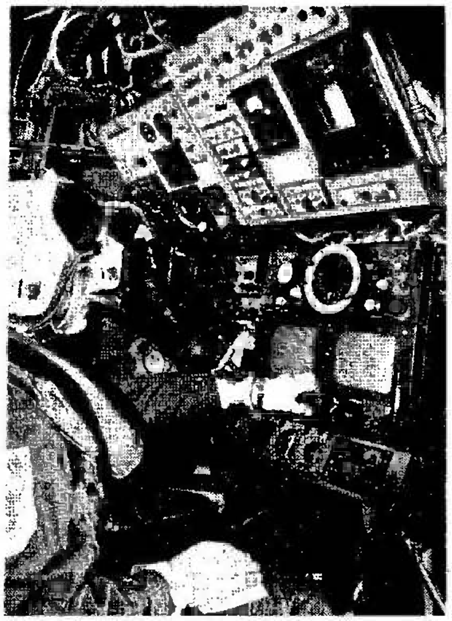
QUALIFICATIONS AND REQUIREMENTS

All artificer candidates must be between 16 and 21 years old and they are selected by interview and aptitude tests at a Naval Careers Information Office of which there are some 60 throughout the British Isles.

Successful candidates (who must be medically fit) are then required to pass a written qualifying examination in three subjects, Mathematics, Science and English, unless they are exempted by having appropriate passes at "O" levels or their equivalent. Details of the exemptions and copies of previous examination papers can be obtained at R.N. Careers Offices.

If you already have four "O" levels (including mathematics and a science subject) you might qualify for a shorter training period and, thus, faster promotion.

Plessey Type 195 Dunking Sonar fitted in a Sea King helicopter.



All artificer apprentices spend their first year at H.M.S. Fisgard at Torpoint near Plymouth which, with naval overtones, is very much like a technical college accommodating some 500 students.

From the start the apprentice artificer wears the appropriate uniform, the double-breasted jacket and peaked cap. His duty time is broadly divided into 45 per cent in the classroom, 20 per cent in workshops and the remainder on general navy training and other activities including sport. He may also spend a week at sea. There are three terms in the year with 21 days' leave at the end of each term.

After the first year, students go for advanced training to one of three establishments, H.M.S. Caledonia, H.M.S. Collingwood or H.M.S. Daedalus. The first is for marine engineering, the second and third, respectively, for advanced training in weapons and aircraft and it is in H.M.S. Collingwood or H.M.S. Daedalus that future electronics artificers are to be found.

The specialities of particular interest to readers of E.E. are Control Electrical Artificer, Radio Electrical Artificer, Radio Electrical Artificer (Air), and Electrical Artificer (Air).

ACTIVITIES

The titles conceal rather than reveal the scope of activities. The control artificer, for example, looks after the electronic computer, the navigation equipment and submarine detector equipment, while the radio artificer not only has responsibility for the general radio communications equipment but also surveillance radars and other specialised equipment including that used for signal cryptography.

One problem is getting a place in the speciality of your choice. Your aptitude will be assessed during your first year but there is also the question of immediate vacancies and the future requirements of the Service. In practice about 80 per cent of apprentices get their first choice and anyone with a real flair for electronics should manage to get into one of the four electronics categories even if not one of their first choice.

On completion of his third year the young apprentice is promoted Artificer 3rd Class which is Leading Rating. The following year he becomes Artificer 2nd Class (Petty Officer) and after one or two years more he may expect to become Artificer 1st Class, Chief Petty Officer at the age of 23 or 24, drawing pay of some £70 per week.

MECHANICS

If you are too old for entry as an artificer apprentice or feel you are not quite up to the standard, you can join as a mechanic at any age between 16 and 33 and still get your training at H.M.S. Collingwood or H.M.S. Daedalus. If you are showing particular promise you may be selected for advanced training to artificer standard and attain P.O. or C.P.O. rank, but you can also reach these ranks as a mechanic or mechanician.

DEGREE COURSE

If you are a high-flyer in the academic sense you can read for your engineering degree with the Royal Navy and get a commission. The Royal Naval Engineering College runs degree courses or you can take a University Cadetship, and read for a degree at the university of your choice, spending up to six weeks a year in the RNEC workshops. It is also possible to enter the Royal Navy with a commission if you have already graduated.

One of the first questions potential recruits ask is "if I join am I stuck with what may become a lifetime of misery? Can I change my mind?"

The last thing the Royal Navy wants is unhappy people. Yes, you can opt out with an early discharge during your initial period of training but you may have to pay £20 for the privilege.

You may also, when signing on, opt for what is called a Notice Engagement which allows you to give 18 months' notice of intention to leave.

The Career Engagement runs for a full nine years plus 12 years on reserve with the option of signing on for longer periods. The Career Engagement carries a higher rate of pay.

New products and component buying for constructional projects

SHOP TALK

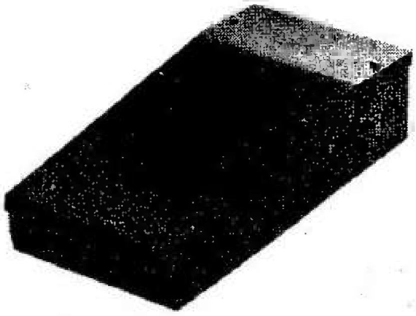
By Brian Terrell

FROM time to time we feature in Everyday Electronics, circuit designs for musical effects units such as Fuzz, Waa-Waa, Tremolo etc. for use with electric guitar, electronic organ etc.

A problem encountered by many designers and constructors is finding a suitable case to house the completed circuitry. Ideally the case needs to be of metal for screening purposes.

Normally effects units are to be situated on the floor to be operated by foot (for speed and convenience) and so must be of robust construction and able to take a "bashing", with the top panel strong enough to hold a footswitch. Another important factor is that the case size should not be too large, but large enough to house a component board, reasonable battery size, several controls and input and output sockets—usually jacks. Finally the cost of the case must be reasonable.

With these requirements known, Olson Electronics have made available the case shown below in the photograph. The case has a gentle sloping front panel suitable for mounting a footswitch, made from 18 s.w.g. steel plate; the base, internal welded edges, is made from 20 s.w.g. steel plate.



Photograph of a prototype version of the Olson type M20 case. The production models will have countersunk screws.

The size of the case is 205 x 100mm being 50mm tall at one end and 25mm at the other. The lid is removeable. The case is designated M20 and is hammer finished in a range of colours comprising orange, blue and silver-grey. The cost is £2·60 including V.A.T., post and packing and is available from Olson Electronics Ltd., 5-7 Long Street, London E2.

2W Amplifier

Although there is a high component count for the *2W Amplifier* project, no difficulties should be encountered in obtaining them. The transformer used in the prototype and shown in the wiring up diagram appears somewhat unusual on the primary side. In fact the type used had two 0-120V windings connected in series.

The "triple" input sockets used are not essential and single ones may be substituted. The case used to house the unit is a matter of individual choice but for those readers who wish to use the one in the prototype, this can be obtained from H. L. Smith, Edgware Road, London.

Couples

To enable the components to be fitted in the case chosen by the author for the *Couples Electronic Game*, the choice of components was rather limited to miniature types which tend to be expensive. If the size of the case is unimportant to the constructor, then standard, and cheaper components may be used.

The most expensive single item in the unit is the Bleeptone. If one looks through the advertisements and/or in local electronic component shops, many cheaper audible alarms such as buzzers and bells will be found.

As mentioned in the article, the d.p.d.t. toggle switches may be replaced by the relatively cheap and readily available slide types. The battery voltage and its capacity will eventually be determined by the audible warning device chosen which will also affect the bulb rating.

An alternative sounder has recently been introduced by ITT and is now available through R.S.T. Valve Mail Order Co., 16a Wellfield Road, London SW16 2BS. The sounder is a piezo ceramic type which works from 5-16V, takes only 10mA and produces a clear penetrating tone. The price including postage and V.A.T. is **£1·88.**

S.W. Receiver

There should be no buying problems for the *S.W. Receiver* project. Your local Radio/TV repair shop should be able to help out with the supply of the valveholder.

You will note that a different coil is required for each of the ranges discussed in the article. If you have difficulty in obtaining these coils, you can obtain them from the manufacturers, Denco (Clacton) Ltd., 357/9 Old Road, Clacton-on-Sea, Essex. The costs are £1·08 for 1 coil, £2·00 for two coils, and £2·99 for all three. These prices include V.A.T. and post/packing.

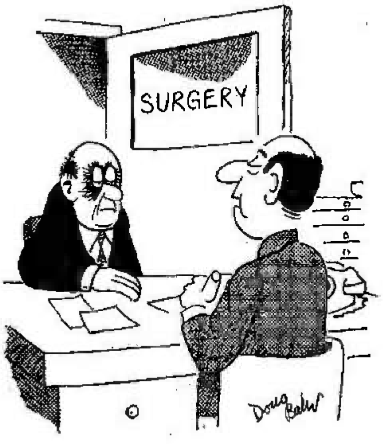
Touch Sensitive Door Alarm

The components for the *Touch Sensitive Door Alarm* should not present any purchasing headaches. Note that the 3·3 ohm resistor called for is a high wattage type. If you use a lower wattage than specified your attention will be drawn to this fact by smoke rising from the unit.

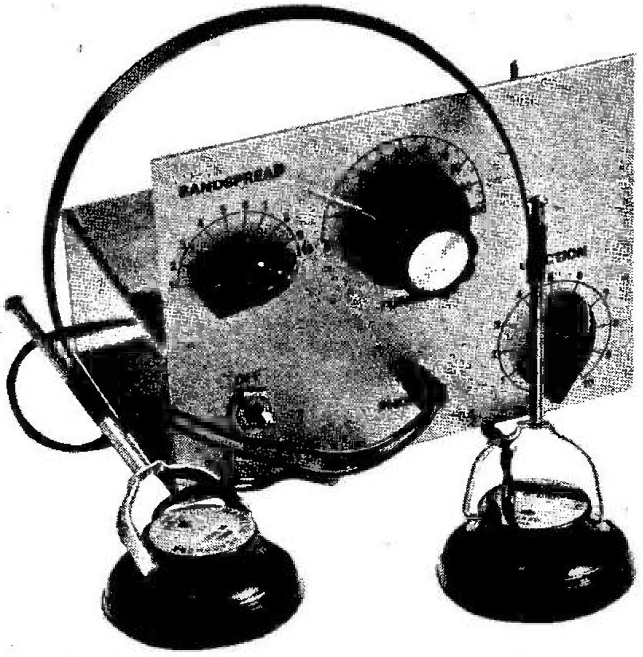
Although an Eagle type M280 transformer is specified in the component list for this project, this is by no means critical as any mains/6 volt 250 to 300mA secondary will do. In fact the M280 has an additional secondary winding redundant in this application.

Help!

It helps us to help you if you *always* mention this magazine when purchasing parts for our projects—**wherever they are coming from.**



"Try counting the sheep in your head—not on your calculator."



Beginners SHORT WAVE RECEIVER

By R.A.PENFOLD

Uses ready-wound plug-in coils for extensive range.

ALTHOUGH this receiver uses only a single active device (a field effect transistor), it provides reception of a large number of amateur and broadcast stations over a wide range of frequencies. Plug-in ready-made coils are used to extend the coverage. Frequency coverage is from approximately 1·67 to 31·5MHz in three ranges, the coverage of each band being approximately as follows:

Range 3 1·67 to 5·3MHz (180 to 57 metres)
Range 4 5 to 15MHz (60 to 20 metres)
Range 5 10·5 to 31·5MHz (28 to 9·5 metres)

The range numbers quoted are those used by the manufacturer of the ready made coil units.

As so few components are used in the design, it is very inexpensive and simple to construct. The current consumption from the PP3 battery is a little less than 1 milliamp, the receiver can be used extensively for many months before the battery becomes exhausted.

THE CIRCUIT

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

Signals received by the aerial are coupled into the primary of L1. The tuned winding of L1 selects the signal at the desired frequency and couples this into the gate of TR1, but it rejects other signals. Capacitor C1 provides an a.c. return to earth for one end of the tuned winding.

The potential divider formed by R1 and R2 provides a small forward bias to the gate of TR1, which is coupled to TR1 gate via the tuned winding of L1. Variable capacitor C3 is the main tuning capacitor, and C2 is the electrical bandspread capacitor.

The field effect transistor, TR1 operates as a regenerative detector, and consists basically of a grounded source r.f. amplifier having L2 as its drain load. This stage is purposely biased in such a way that it distorts the r.f. signal by amplifying one half cycle of the signal more than it amplifies the other. In this way it acts as a form of rectifier, and thus detects the r.f. signal.

The detected output appears at the junction of L2 and R3, and is coupled to the output socket via C7; C8 filters the r.f. content of the output signal leaving only the audio signal.

Decoupling for the source bias resistor of TR1, R4, is provided by C5 and C6; C6 provides decoupling at audio frequencies, and as electrolytic capacitors are not very efficient at high radio frequencies a separate r.f. decoupling capacitor is used, and this is the function of C5.

Regeneration is applied to the circuit from the drain of TR1 via a third winding on L1. The level of regeneration is controlled by VR1, and C4 provides d.c. blocking.

Regeneration is the process of sending some in-phase r.f. signal from the output of TR1, back to the input for amplification for a second time. This will have the obvious effect of increasing the amplification of the circuit, and perhaps less obviously, it will increase the distortion level of TR1, and so increase the detection efficiency of the circuit.

If too much regeneration is applied, the circuit will oscillate continuously, and so VR1 is kept adjusted just below this point in order to provide the best sensitivity.

FOR GUIDANCE ONLY

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

£8·00 including coils but excluding case

*Based on prices prevailing at time of going to press

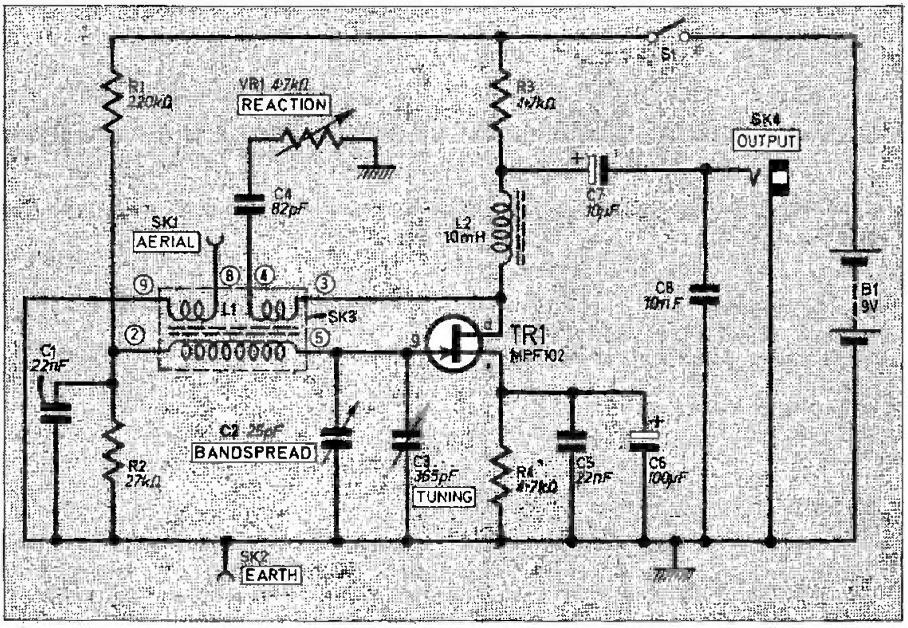


Fig. 1. Circuit diagram of the Short Wave Receiver.

METALWORK

The front panel of the receiver is home made from 18 s.w.g. aluminium, and is 150×115mm. The layout of the components on the front panel are shown in photograph below.

Construction of the front panel is quite straightforward, except for the three small mounting holes for C3. The positions of these are most easily located by making a paper or cardboard template using the front of C3 as a pattern. The three holes are all drilled for 4BA clearance, and are all countersunk. Three short 4BA countersunk screws, which, incidentally, are not supplied with C3, are used to mount the latter. Make sure that these screws do not penetrate too far so as to foul either its fixed or moving plates, and if necessary space it off the front panel slightly using some washers or 4BA nuts, so as to prevent this.

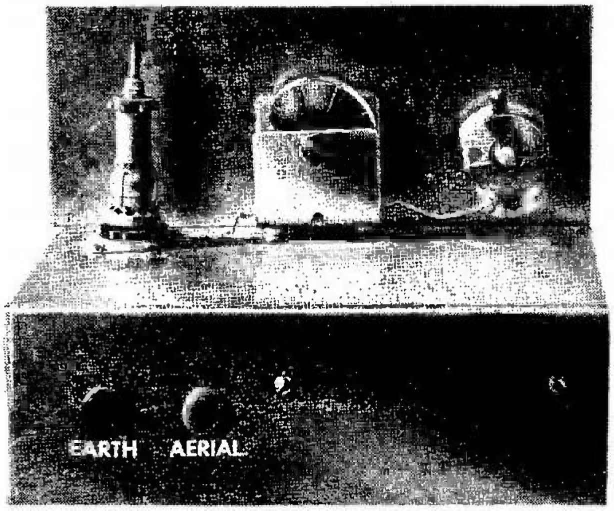
The 16 s.w.g. aluminium chassis measures 150×100×50mm (approx.), and can be purchased ready made. The front apron of the chassis is drilled to match the lower part of the front panel, and then SK3, S1, and VR1 are used to fasten the chassis and front panel together.

The rear apron of the chassis is drilled to take SK1 and SK2, and the battery mounting bracket, which is mounted by two short 6BA bolts.

A 19mm diameter hole is required for the coil-holder, and this is best cut using a 19mm chassis punch. The two smaller mounting holes for the coil-holder should be drilled for 6BA clearance using a No.3 twist drill, and their positions are located by using the coil-holder as a template.

Ensure that the pins of the coil-holder are orientated into the same position as those on the prototype receiver, with pin 1 towards the front of the receiver, see Fig. 2. A solder tag is mounted on each of the mounting bolts of the coil-holder, on the underside of the chassis. A 3mm diameter hole is drilled near one of the tags of C3, where a lead connecting C2 and C3 to the under chassis wiring will pass through the chassis. Do not carry out any drilling while C2 and C3 are mounted on the panel, as this could easily result in them being damaged.

The general layout of the chassis can be seen clearly in the accompanying photographs, and although the exact layout is not critical, this general layout should be adhered to. Do not mount the coil-holder too far forward, or it will be difficult to wire it up.



Rear-view of the prototype unit.

Components....

SEE SHOP TALK

Resistors

R1	220kΩ
R2	27kΩ
R3	4·7kΩ
R4	4·7kΩ

All ¼W carbon ± 10%

Capacitors

C1	22nF plastic or ceramic
C2	25pF air spaced variable (Jackson C804)
C3	365pF air spaced variable (Jackson type 00)
C4	82pF polystyrene or ceramic
C5	22nF plastic foil
C6	100μF 10V elect.
C7	10μF 10V elect.
C8	10nF plastic foil

Semiconductor

TR1	MPF102 *n*-channel field effect transistor

Miscellaneous

VR1	4·7kΩ carbon lin.
S1	on/off toggle
L1	Denco miniature dual purpose coil Green Ranges 3, 4 and 5 (3 off or as required)
L2	10mH r.f. choke (Repanco CH4)
SK1, 2	wander sockets 1 red, 1 black (2 off)
SK3	B9A unskirted valveholder
SK4	3·5mm jack socket
B1	9 volt type PP3

Aluminium chassis size 152 x 100 x 50mm 16 s.w.g. or material to build; 18 s.w.g. aluminium for front panel and battery bracket; two pointer knobs; one large diameter knob for tuning; crystal earpiece (or headphones 4000 ohms) fitted with 3·5mm jack plug.

WIRING

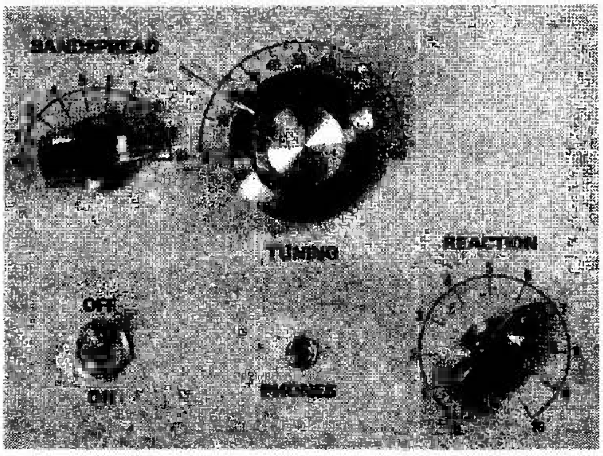
A point to point wiring system is used, and is shown in Fig. 2.

Clean and tin the solder tags and leads of the components before trying to solder them. Where more than one component is connected between the same two points (as are R4, C5, and C6 for instance), they should first be connected together, and then soldered into the rest of the circuit. Make all the wiring as short and direct as possible, insulating the leads where there is any danger of a short circuit occurring.

To finish the receiver, transfers, including dials around VR1, C2, and C3 if required, can be affixed to the front panel as seen in photograph, and then the control knobs are fitted.

AERIAL AND EARTH

With any receiver of this type a good aerial is absolutely essential for good results to be obtained. A suitable aerial consists of a long length of insulated 7/22 or 18 s.w.g. aerial wire, set out of doors, and as high as possible. A length of 20 metres or more is preferable, although it is not an absolute necessity for the aerial to be quite this long.



Photograph showing the front panel of the receiver.

A short indoor aerial will provide reception of a number of stations, but results will not be comparable to a proper outdoor aerial.

An earth connection merely consists of a metal plate, pipe, or other metal object having a fairly large surface area, buried in moist earth a couple of feet or so down. A short lead made from a fairly heavy guage wire (aerial wire is suitable) is used to connect this to the receiver.

An earth is not really necessary for reception on Ranges 4 and 5, but is virtually essential for good reception on Range 3, as is a long aerial.

NOTES ON USE

When initially testing the receiver it is best to use Range 4. The desired range is selected by plugging the appropriate coil into the coil-holder. Plug a pair of high impedance headphones, or if preferred a crystal earpiece, into SK3, and switch the receiver on. Start with VR1 adjusted almost fully anticlockwise.

Adjusting the main tuning knob will probably provide reception of a few stations, and if VR1 is gradually advanced in a clockwise direction, the number of stations should increase. The volume from these stations will also increase. If VR1 is advanced too far the detector will break into oscillation, and there will be a tone of varying pitch as the set is tuned across a station.

For maximum sensitivity and selectivity VR1 should be adjusted just below this point. It will need readjustment virtually every time either C2 or C3 are adjusted, in order to keep the receiver properly peaked.

For the reception of c.w. (morse) and s.s.b. (single sideband) signals, VR1 should be adjusted just beyond the threshold of oscillation so that the detector is just gently oscillating. The

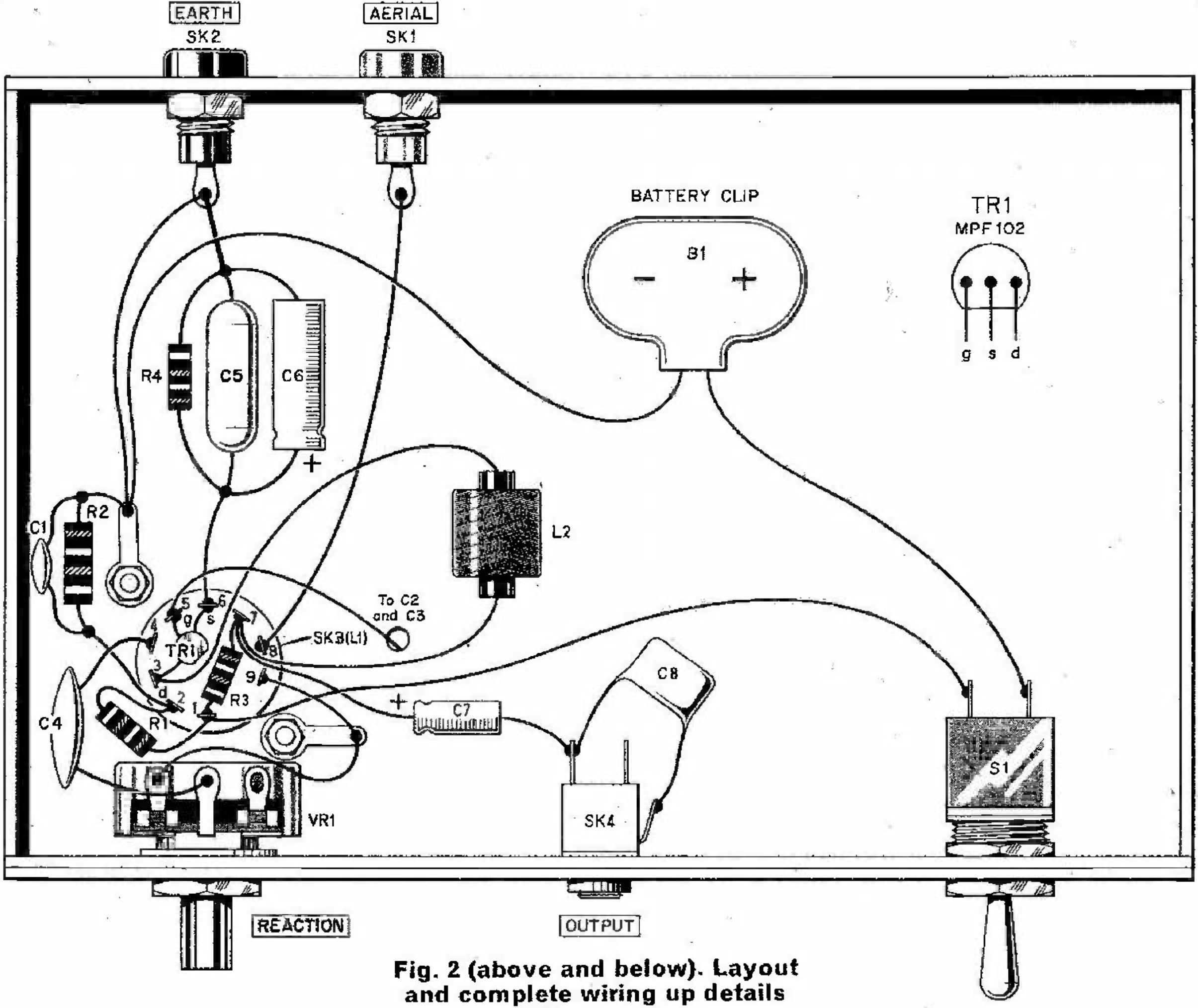
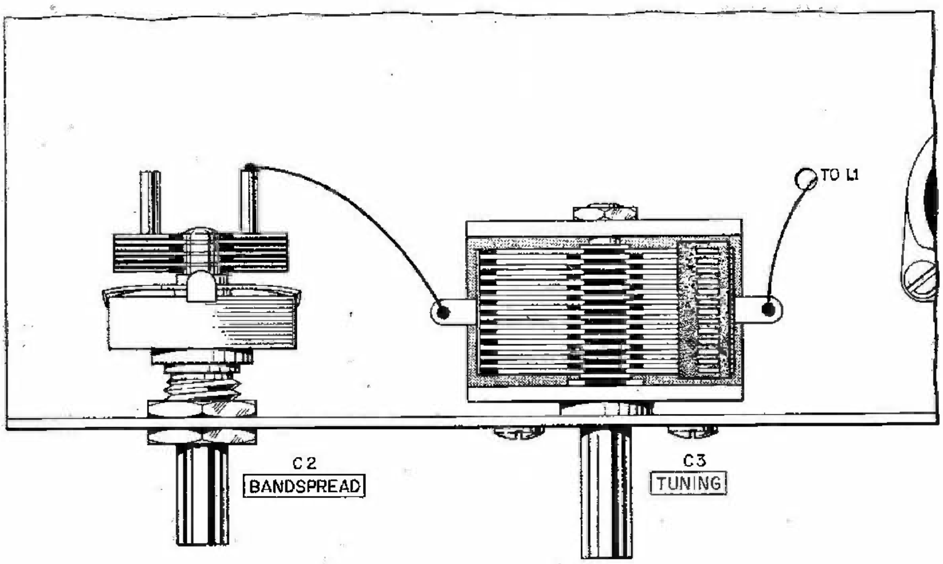


Fig. 2 (above and below). Layout and complete wiring up details of the receiver.



SHORT WAVE RECEIVER

bandspread control is then adjusted to give the required c.w. pitch, or in the case of an s.s.b. transmission, to clarify the signal.

On strong s.s.b. signals VR1 can be further advanced if there is a loss of audio quality caused by the detector being swamped; c.w. and s.s.b. are the main forms of transmission used on the amateur bands.

Fine tuning is rather difficult using the main tuning control, and so C3 is set to the part of the band which is to be searched for signals, and then C2 is used to scan this area of the band. As C2 has a much lower value than C3, it only covers a small part of the range, and so tuning is much less cramped using C2.

Range 4 is likely to be the range of major interest as it contains most of the popular s.w. broadcast bands, and will usually provide reception of a number of interesting stations. Range 5 provides reception of the h.f. s.w. bands, and the level of activity on this range will depend very much upon the prevailing atmospheric conditions at the time. Included in the coverage of this band is the 20 metre amateur band, which is the best amateur band for DX listening. Range 3 covers the trawler band, and will provide reception of numerous maritime transmissions. Probably of principal interest on this band though are the 80 and 160 metre amateur bands.

Note that the coils as supplied have their cores screwed right in. In use the core of the Range 5 coil should be adjusted so that about 4mm of the metal threaded part of the core is protruding from the top of the coil. The Range 3 and Range 4 coils are similarly adjusted, but so that about 10mm of this metal thread protrudes from the top of the coil.

COUNTER INTELLIGENCE

By PAUL YOUNG

I sometimes wonder, if, while we have been dabbling into the realms of electronics, we may have inadvertently strayed into realms that the gods regard as their exclusive territory, and in return they are exacting a terrible revenge. I assure you it's all happening. They have placed on Earth an assorted group, of cretins, morons, and incompetents, put them in a little box at Westminster where they now control our fate.

The first step was to make them introduce a scheme of tax called V.A.T. This caused a fair number of bankruptcies, suicides, besides causing many component dealers to be incarcerated in asylums. This obviously failed to assuage the gods anger, so they made the little men bring out a multi-rate V.A.T. and to complete the job shower us with regulation upon regulation of which I here give you a sample:

"Delete the whole of Note (4) and the operative date and substitute the following: (4) Item 1 of the items overriding the exceptions relates to item 1 of the excepted items; Items 2 and 3 of the items overriding the exceptions relate to item 2 of the excepted items and items 4 to 6 of the items overriding the exceptions relate to item 4 of the excepted items."

Jolly stuff isn't it? You do not like it? Repeat it a second time, it might grow on you. To me it sounds like a Marx Brothers script, but more non-sensical!

Bear in mind this is one part, of one page, of one pamphlet, of which we have had so many in the last few years, that even laid flat, one upon another would now measure a foot high. The biggest joke is that this V.A.T. was supposed to simplify everything (their word not mine). Those of us who have survived have only done so by pretending it is not there. Well you know what they say, "Those whom the gods would destroy, they do first make mad."

Turning to more pleasant things which is not difficult, in my last article but one, I talked about exhibitions; now at least three of them are over. All splendid shows, but I will just briefly talk about the last one at Birmingham International.

I mentioned that, due to British Rail, this would be as easy to visit as Olympia, and I was right. I boarded the train at Euston at 11.40 a.m., had lunch on the train, and at 1 p.m. as I was paying the bill, we were pulling into Birmingham International. I was very impressed with the sheer size of the halls, and my only criticism, is that I think a few more seats could be provided for the weary.

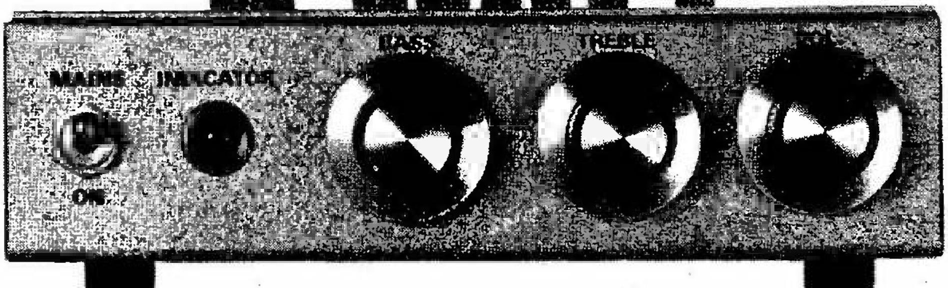
One aspect which depresses me, is the way the Postal Service has deteriorated lately. At the beginning of the month of May, all Sunday collections were discontinued and the last collection from my local box is now 5.15 p.m. instead of 6.45 p.m.

The amateur constructor is bound to depend on mail order services for 90 per cent of his wants, because even if he is London based, component shops are very few and far between, and the difficulty in the provinces must be even greater.

Now the most likely time he would be sending off his orders is the week-end. As it stands, unless he catches the early post Saturday morning, it will not be collected until Monday, which means that I and my colleagues will not receive it until Tuesday or Wednesday.

I think the only answer is, for other mail order firms to do as we have done. Arrange for their customers to open accounts, and then install an answerphone. We have run this system for about six years. It works extremely well, and I think the facility is much appreciated by the enthusiasts.

2 WATT AMPLIFIER



By
R.A. PENFOLD

A compact mono amplifier for a variety of needs.

AMONG the most useful and popular of electronics projects are the various types of amplifier that frequently appear in the amateur electronics journals. Although most of these are designed for some specific purpose, the amplifier described here is a general purpose unit which is equally well suited to being a workshop amplifier as it is to being used for entertainment applications.

When using an 8 ohm speaker a good quality output of up to 2 watts r.m.s. is available. The unit is mains powered but has a very low hum and noise output level.

The output power and distortion figures are not up to hi fi standards, but listening tests show that the unit provides a very acceptable volume and output quality.

A brief specification for the unit is shown in the table below.

There are three inputs to the amplifier, each providing a different input impedance and sensitivity. Together these should cater for most signal sources, such as musical instruments, tuners, ceramic and crystal cartridges, etc.

SPECIFICATION

Input Sensitivity

Input 1 500mV into 1·25MΩ
Input 2 200mV into 500kΩ
Input 3 18mV into 50kΩ
For an output of 2W r.m.s. into an 8 ohm load at 1kHz

Signal to Noise

67dB, all inputs open circuit, unweighted, maximum volume, flat response

Frequency Response

+0 to −3dB (with reference to 1kHz) 40Hz to 20kHz

Total Harmonic Distortion

0·9% for 1 watt into 8 ohms
2·2% for 2 watts into 8 ohms

CIRCUITRY

For the sake of simplicity the circuit has been based on an audio amplifier integrated circuit. Apart from reducing the number of components required, thus bringing the unit within the scope of the beginner, this also gives economic advantages over a discrete component equivalent. The complete circuit diagram of the amplifier is shown in Fig. 1.

The preamplifier is based on a common emitter amplifier, TR1; R6 provides a degree of negative feedback to this stage, which reduces noise and distortion and increases the basic input impedance of the stage.

Each of the three input sockets is coupled to the base of TR1 via its own series resistor, and d.c. blocking capacitor C2. The purpose of the series resistors is to increase the input impedance and reduce the sensitivity of the preamplifier to the required levels. These resistors, together with the input impedance of TR1, in fact form three simple attenuators.

There is some loss of treble response at inputs 1 and 2 due to the high values of R1 and

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£8·00 plus case

*Based on prices prevailing at time of going to press

R2 combining with the input capacity of TR1 to form a treble cut filter. The treble tone control can more than compensate for this loss, however.

The output from the collector of TR1 is coupled to the tone control networks via C3. These can provide both cut and boost of the bass and treble responses; VR1 is the treble control and VR2 controls the bass.

This is a passive tone control system and therefore has a considerable loss of signal between its input and output. However, the output stage is quite sensitive, and requires an input of only about 20mV for full output. This high gain is used to compensate for the losses in the tone control networks.

POWER AMPLIFIERS

The volume control (VR3) is fed from the output of the tone controls and in turn feeds the non-inverting input of the integrated circuit type TBA820.

Negative feedback is internally applied to the inverting input (pin 5), and an external resistor (R11) and capacitor (C8) are used to decouple some of the feedback. These set the voltage gain of the device at the required level. With R11 at the value shown, a voltage gain of about 46dB (200 times) is produced.

Capacitor C9 decouples the positive supply line to the preamplifier section of the i.c., and helps to reduce the level of mains hum at the output; C12 reduces the high frequency response of the device, which would otherwise extend well beyond the audio spectrum with the consequent risk of instability resulting.

Capacitor C10 forms the capacitive section of an *R-C* network connected across the output of the device. These compensate for the fact that speaker impedance rises with frequency, and they thus aid stability.

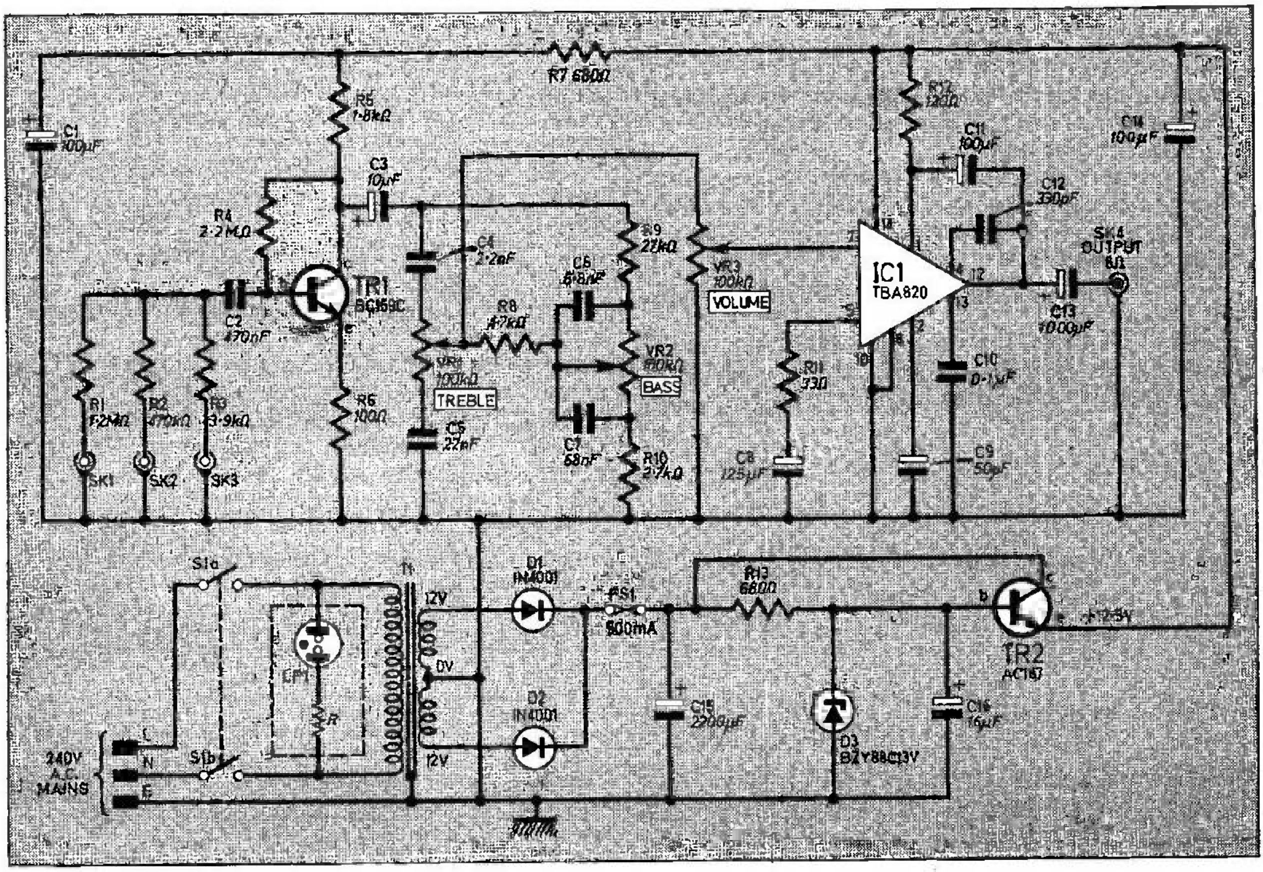
Components C11 and R12 provide what is termed "bootstrapping", between the output and driver stages. This produces a higher efficiency by providing a higher output voltage swing for a given supply voltage.

The output is coupled to the speaker via a d.c. blocking capacitor, C13; C1, R7, and C14 are supply decoupling components and these prevent instability due to positive feedback through the supply lines.

POWER SUPPLY

As the TBA820 i.c. has no form of thermal shut down protection circuitry, **it must not be run from a potential greater than about 12V when using an 8 ohm speaker.** It is then impossible to damage the device through overheating.

Fig. 1. The complete circuit diagram of the 2W Amplifier.



A speaker of less than 8 ohms impedance must not be used.

It is safe to use a speaker having an impedance of more than 8 ohms, but the maximum available output power will be reduced.

In order to ensure that the TBA820 is operated safely, a regulated power supply is used. This provides an output of about 12·5 volts.

A centre tapped transformer, T1 feeds a push-pull full-wave rectifier using D1 and D2; C15 provides considerable smoothing for the rough d.c. output of the rectifier network.

Components R13, D3, C16 and TR2 provide an emitter follower regulator and electronic smoothing circuit of conventional design. Only an extremely small ripple content is present on the output, at TR2 emitter, the actual figure for the prototype being 500 microvolts.

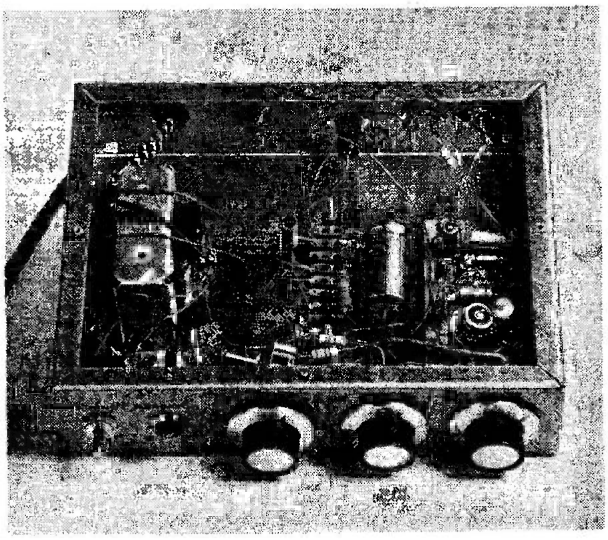
CASE

It is best to use a metal case as this will screen the wiring from possible sources of electrical intereference. A ready made aluminium case is used for the prototype, and this has approximate outside dimensions of 200 x 150 x 50 mm and has a removable lid.

Any case of a similar size would be satisfactory, and it is not too difficult to construct a suitable case from aluminium oneself.

The layout of the components within the case is shown in Fig. 2. Detailed dimensions are not shown for the mounting of components, as the requirements here will vary according to the particular make of component employed. In many cases the components themselves can be used as templates to help mark out the case ready for drilling. The beginner should not attempt to radically alter this general layout.

The large oval cut-out for the input sockets can be cut out using a fretsaw. With some sockets it is possible to use the more simple method of drilling three 8mm diameter holes to



Photograph showing the prototype amplifier with lid removed.

Components....

SEE SHOP TALK

Resistors

R1 1·2MΩ
R2 470kΩ
R3 3·9kΩ
R4 2·2MΩ
R5 1·8kΩ
R6 100Ω
R7 680Ω
R8 4·7kΩ
R9 27kΩ
R10 2·7kΩ
R11 33Ω
R12 120Ω
R13 680Ω

All ¼W carbon ±10%

Capacitors

C1 100μF 10V elect.
C2 0·47μF type C280
C3 10μF 16V elect.
C4 2·2nF polystyrene
C5 22nF type C280
C6 6·8nF polystyrene
C7 68nF type C280
C8 125μF 10V elect.
C9 50μF 16V elect.
C10 0·1μF type C280
C11 100μF 10V elect.
C12 330pF ceramic
C13 1000μF 16V elect.
C14 100μF 16V elect.
C15 2200μF 25V elect.
C16 16μF 16V elect.

Potentiometers

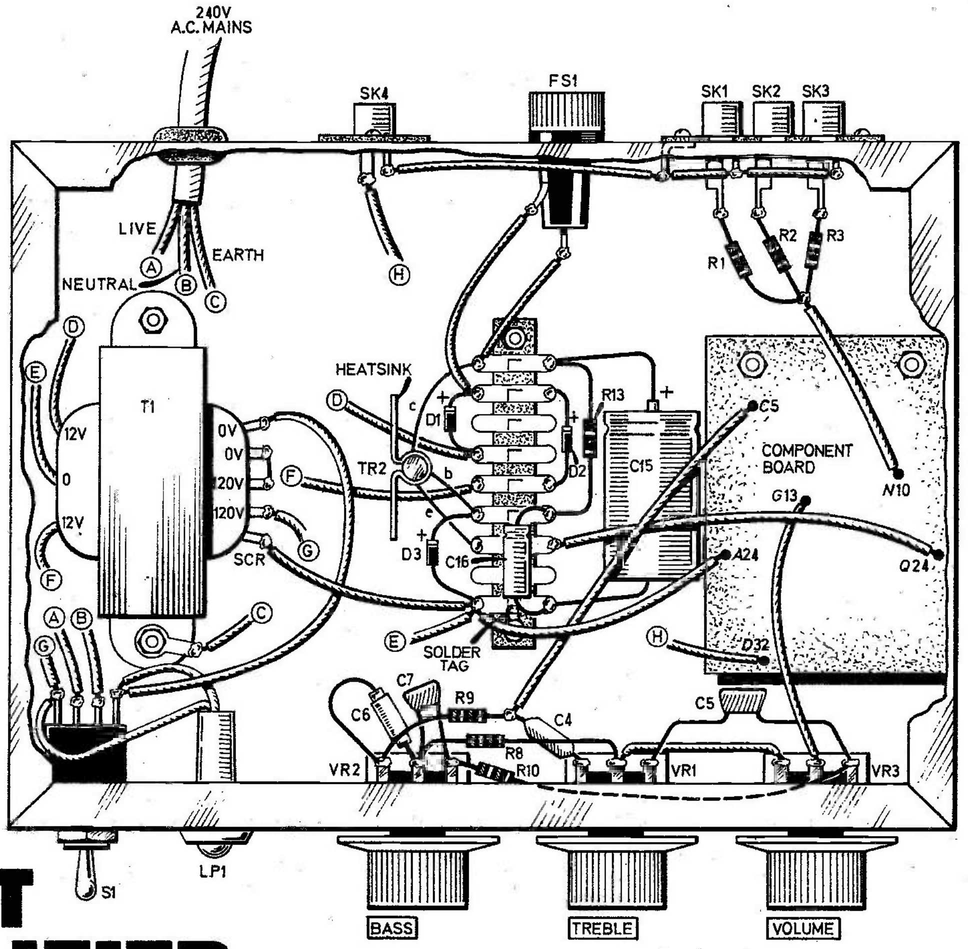
VR1 100kΩ carbon log.
VR2 100kΩ carbon log.
VR3 100kΩ carbon log.

Semiconductors

IC1 TBA820 audio frequency 2W amplifier
D1 IN4001 or similar
D2 IN4001 or similar
D3 BZY88C13V Zener diode 13V 400mW
TR1 BC169C silicon *npn*
TR2 AC187 germanium *npn*

Miscellaneous

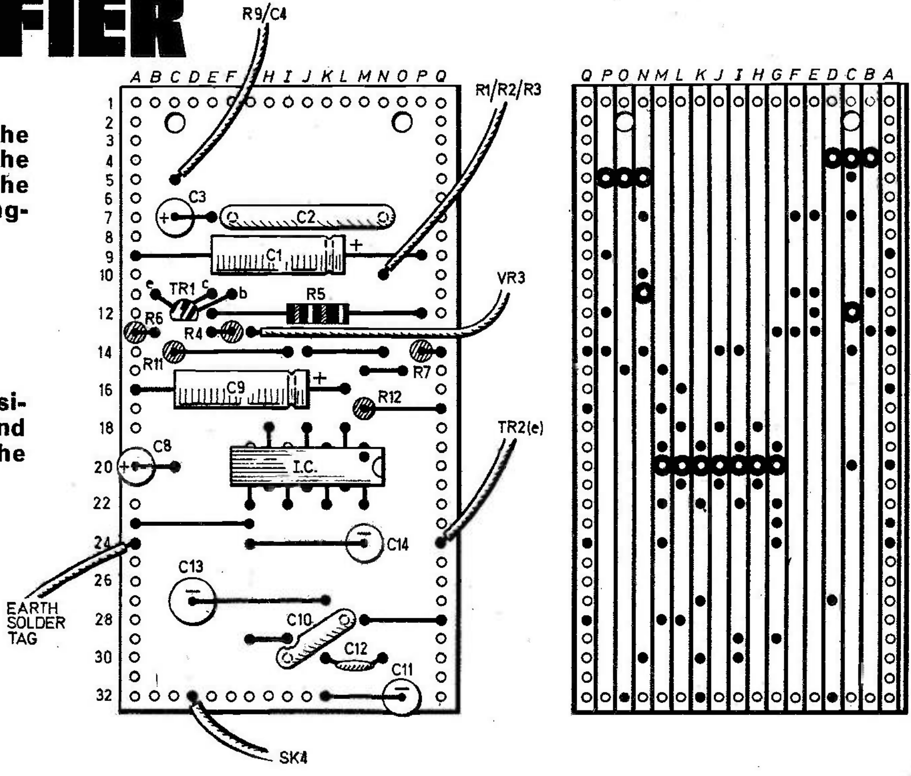
T1 mains/12–0–12V 500mA secondary
LP1 mains panel neon with built-in resistor
S1 d.p.d.t. toggle
FS1 500mA 20mm long fuse and panel mounting holder
SK1, 2, 3 triple phono socket (1 off)
SK4 phono socket
Veroboard: 0·1 inch matrix Veroboard size 17 strips by 32 holes; 9-way tagstrip; clip-on heatsink for TR2; control knobs (3 off); case size 200 x 150 x 50mm (minimum); rubber feet (4 off); mains lead



2 WATT AMPLIFIER

Fig. 2 (above). The suggested layout of the components within the case and complete wiring-up details.

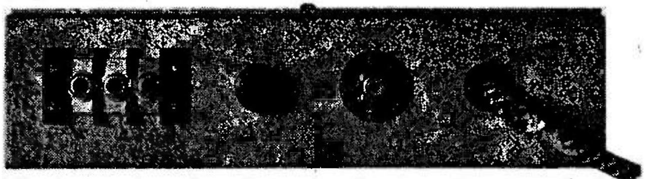
Fig. 3. Component positions on the Veroboard and breaks to be made on the underside.



accommodate the the terminals of the sockets. Phono, DIN, and jack plugs are commonly used as terminations on speaker leads, and the output socket should be of a type which is commensurate with the plug fitted to the speaker lead.

In order to obtain a low level of mains hum it is necessary for T1 and the component panel (when completed) to be mounted at opposite ends of the case.

The transformer is mounted using a couple of short 4BA bolts, and the input sockets require a fixing of four short 6BA bolts. A solder tag is mounted on one of the mounting bolts of T1, and another is secured under one of the upper fixings of the input sockets. This last tag is used as an earthing point for the outer connectors of the input and speaker sockets. It is important to fit the mains input lead hole with a grommet.



Photograph showing back panel mounted components.

COMPONENT PANEL

All the amplifier components, except the controls and R1 to R3, are mounted on a piece of 0·1 inch matrix Veroboard having 32 holes by 17 copper strips. Details of this are illustrated in Fig. 3.

First cut out a panel of the correct size and then drill the two 4BA clearance mounting holes using a No.24 twist drill. The breaks along the copper strips should be made next, and if the special tool for this purpose is not available, a small hand held twist drill can be used.

The various components are then mounted and soldered in, with the i.c. and TR1 being left until last. Veropins were used at the six points where leads connect to the panel.

The panel is mounted by use of a couple of 25mm long 4BA bolts. A couple of extra nuts are used over each bolt in order to space the panel a little way clear of the case.

Resistors R1, R2, and R3 are mounted on the appropriate tags of the triple phono socket. With the layout of Fig. 2, the lead which connects these to the component panel is very short, and need not be screened. The leads connecting the panel to SK4 and the centre tag of VR3 are also wired up at this point.

TONE CONTROLS

The tone controls are wired up using a point to point wiring system. This wiring is shown in Fig. 2 and is quite straightforward. When soldering the components into circuit it is important that the leadouts are well tinned with solder. A dry joint is likely to result if the constructor ignores this advice.

Try to keep this wiring as short and neat as possible.

POWER SUPPLY WIRING

A 9-way tagstrip acts as a constructional basis for the power supply circuitry. A suitable tagstrip can be cut down from a longer one; Fig. 2 shows complete details of the power supply wiring.

Again, make sure that all leads and tags are well tinned with solder prior to making a connection. As TR2 is a germanium transistor it is easily damaged by excessive heat, and a heat-shunt should be used on each leadout as it is soldered into circuit; TR2 is fitted with a small clip-on heatsink to help with heat dissipation.

A solder-tag is used to earth one tag of the strip via one of the mounting bolts. The tagstrip is mounted in much the same way as the component panel, except using 6BA bolts. Once it has been mounted, the remaining wiring can be completed.

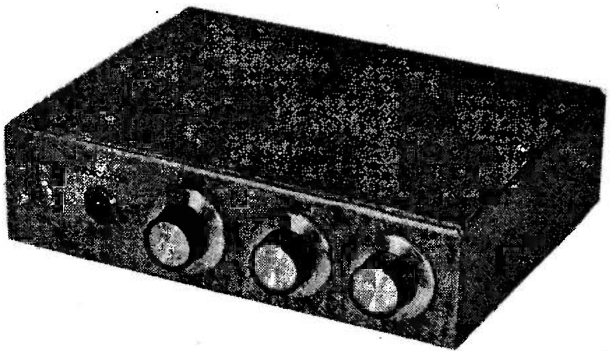
USING THE UNIT

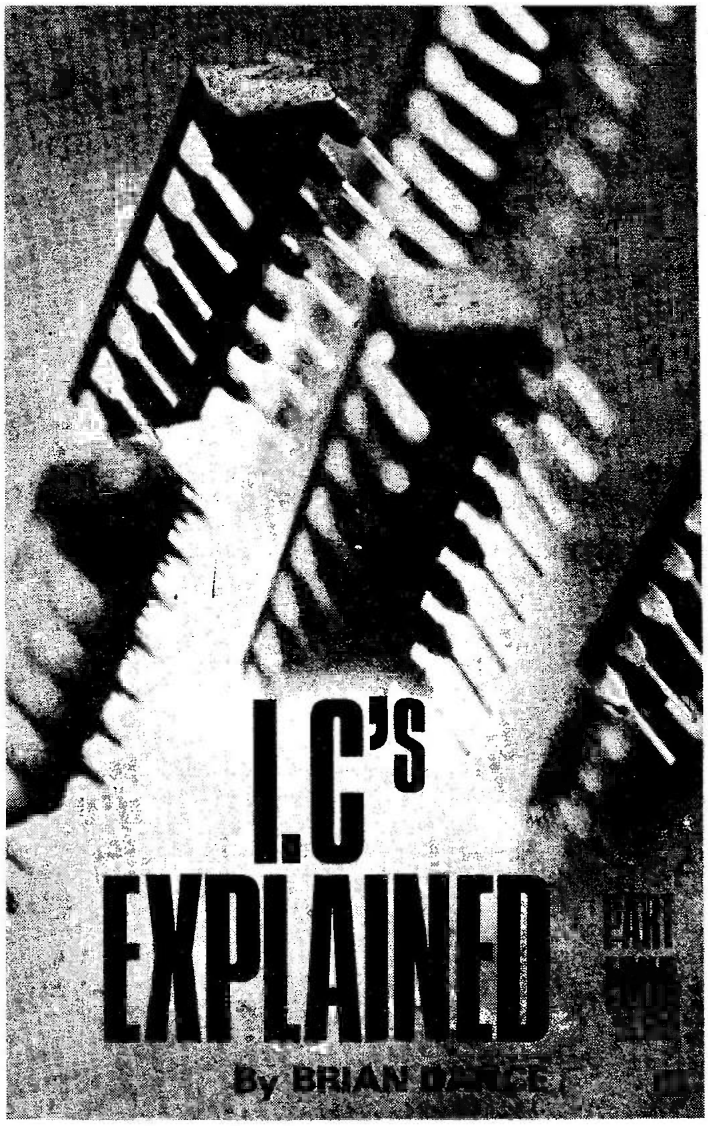
It is advisable to thoroughly check the wiring of any freshly completed project before connecting the power and switching on, but in cases such as this where the mains is involved, it is especially important.

An external speaker in its own cabinet is required, and this must be capable of handling at least 2 watts r.m.s. and have an impedance of 8 ohms. A speaker having an impedance of more than 8 ohms can be used, but with a 15 ohm speaker, for instance, the maximum output power will be only a little more than one watt.

If in doubt as to which input should be used for a particular piece of equipment, results will usually be best if the least sensitive input which gives adequate volume is used. Screened leads must always be used at the inputs.

The desired input is merely selected by plugging the ancilliary equipment into the appropriate socket, with the other two sockets left unconnected. ▣





I.C'S EXPLAINED

PART FOUR

By BRIAN DANCE

A NEW development is the recent introduction by Fairchild of their low power Schottky and micrologic family; these devices operate with about one-fifth of the current required by standard TTL devices, but can also operate at higher speeds. This family includes, for example, the 9LS00/74LS00 low power version of the 7400 mentioned earlier, whilst the 9LS90/74LS90 is a decade counter which can be used up to about 50MHz and consumes only about 9mA.

TTL DECADE COUNTING

As a typical application of TTL devices, we will discuss a decade counting circuit. Counters are based on individual flip-flops which can, for example, be made from two NAND gates with the output of each gate connected to one of the inputs of the other gate.

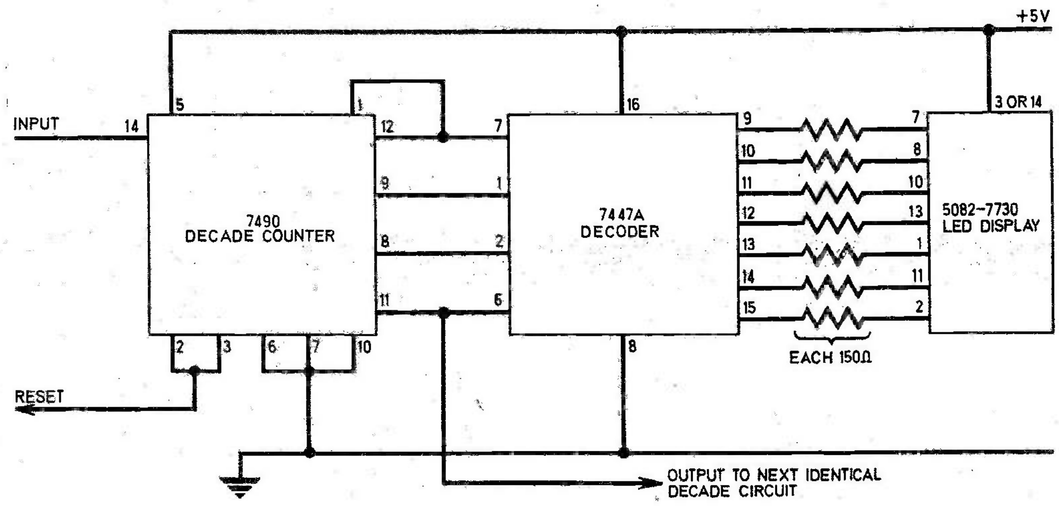
A typical decade counter is shown in Fig. 4.1. The well-known 7490 TTL device performs the actual counting, whilst the TTL 7447A device changes the coding of the information so that it is suitable for driving a Hewlett-Packard 5082-7730 light-emitting-diode digital display. The latter shows the state of the count in the 7490 as an illuminated red digit.

The circuit shown in Fig. 4.1 counts up to ten and indicates one digit. If more than ten pulses are to be counted, the output from pin 11 of the 7490 counter can be fed to the output of another identical circuit which counts the number of tens. The output from the latter can be fed to further circuits until the required number of digits is obtained.

The input pulses to the circuit of Fig. 4.1 must be standard TTL pulses. The voltage in their 1 state should be between 2 and 5V, whilst their low or 0 state should be less than 0·8V.

These pulses drive the 7490 counter which contains four flip-flops and three gates. It counts in the binary coded decimal system but automatically returns to zero at the tenth pulse. The 7490 device contains a divide-by-two and a divide-by-five counter in one package.

Fig. 4. 1. Basic TTL decade counter with digital l.e.d. display.



The reset line may be momentarily connected via a 1 kilohm resistor to the positive 5V line if it is required to reset the count to zero. Any number of reset lines can be "commoned" through 1 kilohm resistors so that all of the digits can be simultaneously reset to zero.

The binary coded decimal outputs from the 7490 are fed into the 7447A binary-coded-decimal to 7 bit decoder. This relatively complex device which contains a total of nearly fifty gates and inverters provides seven outputs suitable for driving the seven segments of the 5082-7730.

DISPLAY

The 5082-7730 indicator will fit into a standard dual-in-line socket. It contains the seven segments shown in Fig. 4.2. When all are passing a current, the digit 8 is shown, but if all except segment 4 are illuminated, the digit 0 is shown. Any of the ten digits can be displayed by allowing a current to flow in the appropriate segments.

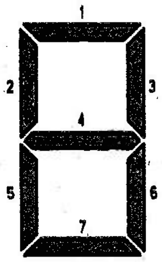


Fig. 4.2. Arrangement of a seven segment indicator.

It may be noted that whilst one could construct the Fig. 4.1 cricuit using separate bistable circuits and gates, this would involve far more effort than the use of the 7490 and 7447A m.s.i. devices; in addition, the circuit would occupy far more space.

The 7490 requires a current of about 32mA (max. 53mA), whilst that required by the display depends on the digit being indicated. Maximum current is required for an 8 when all of the segments are glowing and minimum current for a 1.

VARIATIONS

If the numerical display is not required (or not required in all of the decades), the 7447A and the 5082-7730 may be omitted where they are not required.

If the 7490 is replaced by a 7493 integrated circuit, the input pulse frequency will be divided by a factor of 16 instead of 10, but the additional 6 states will not produce normal digits on the display. A 7492 device can be used to divide by 12. Division by many other factors can be obtained using these devices.

Another possible modification involves the use of gas discharge Nixie numerical indicator tubes instead of the 5082-7730 l.e.d. display. The 7490 outputs would then be fed to a 74141 decoder instead of the 7447A; the 74141 changes the binary-coded decimal signals to decimal information and its ten outputs can control the current to the cathodes of the numerical indicator tube.

COUNTING APPLICATIONS

Counting circuits, such as the ones described, are used in a wide variety of applications including the counting of objects coming off a production line and the counting of the pulses from nuclear particle detectors. Counting circuits are also used in accurate timers where the number of pulses counted is proportional to the time interval involved.

An early use for counting circuits was for pulse dividing in electronic clocks. The 50Hz mains pulses were divided in frequency by 5 and then by 10 to produce 1Hz pulses. A seconds counter displays the number of these pulses; at the 60th pulse it is reset to zero and an output pulse is sent to the minute counter. Similarly the minutes pulses are divided by 60 to provide the hour pulses.

We shall see later that large numbers of counting circuits are no longer used as individual integrated circuits in electronic clocks. A single complex device performs all of the functions required.

Continued next month.

PLEASE TAKE NOTE

In the *Auto Cool* article (July '76 issue), the fuse rating quoted is a continuous rating. If a British type car fuse is used this would normally be quoted at its "Blow rating" and should thus be 10 amps to pass 5 amps continuously.

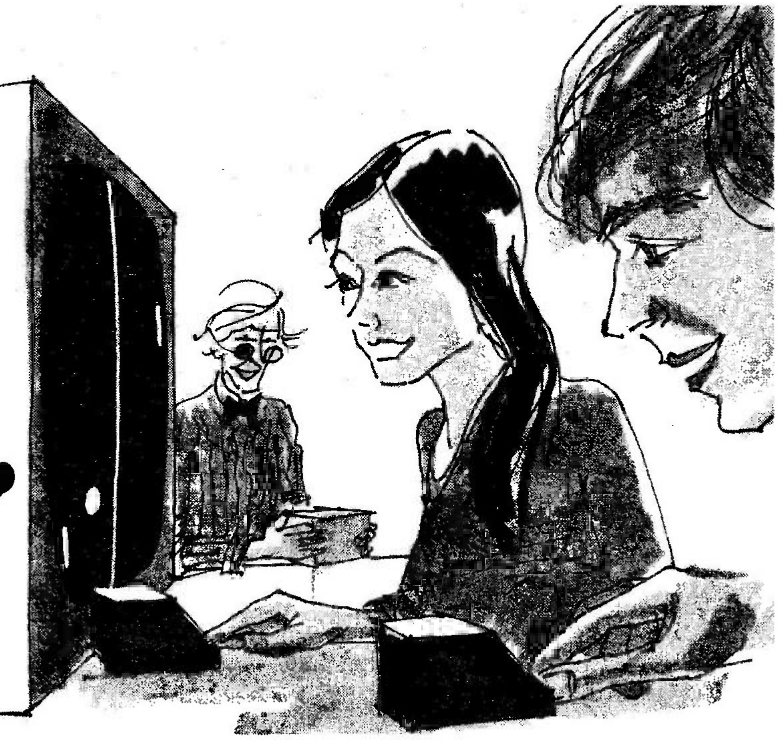
Most British type car fuses now show both the blow rating (at which they are quoted) and the continuous rating (which is half the blow rating). Continental car fuses are normally marked in continuous rating as are normal mains fuses.

Not only is the British car industry the odd one out it has in certain cases also developed its own symbols for various other electrical items such as capacitors and potentiometers, which all helps to confuse everyone.

TEACH-IN 76

It has been brought to our attention by Mr. R. D. Bonathan of Bristol, that under the heading 10.2 Electromagnetic Induction, the equation should be modified to read: Induced volts = − L × rate of change of current.

The Extra-ordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

At first Suzy and Bob saw what looked like a number of ordinary TV-tennis and football electronic games, but each having a number of extra control knobs or buttons.

"See what you think of this one," remarked the Prof., plugging one of the sets into the control console of a large viewscreen. "At first it seems to be very much like any other of the TV games which are available, but with an added feature of interest. I have used a couple of random noise generators similar to that which Bob has just built, to inject low frequency random noise into the ball-position circuits.

"On the screen, one moving dot is the 'ball' and two vertical lines, which can be moved by means of potentiometers controlled by the players, are the players 'bats'."

GOOGLY BALL

"Normally the ball moves in straight lines across the screen, but the random noise turns it into a 'googly ball', which moves rather less predictably, like one of those trick rubber balls which have a weight inside."

Bob and Suzy each took one of the control-units which was wired to the main cabinet of this first games unit and enabled each player to control a bat (for tennis) or a 'man' (for football).

A switch allowed them to select goalposts, tennis nets, etc., to appear on the viewscreen according to the game being played.

As Bob switched on the unit a tennis net appeared on the screen, and Suzy immediately pressed the 'serve' button on her control unit. The moving dot, which was the ball, appeared almost immediately, moving diagonally in a straight line towards Bob's side of the viewscreen.

Bob moved his bat into position to intercept the ball, but as he did so, Suzy leaned over to the master unit and pressed the 'googly ball' switch.

Now the ball no longer moved in a straight line, and Bob once again found himself facing a moving dot controlled by random low-frequency electronic 'noise' signals.

"I can see that I can leave you two with these electronic games for a while—there are quite a few different ones for you to try."

The random-noise generators, together with the googly ball switch circuit, make these TV games quite a lot more challenging and exciting, thought the Prof.

However this was only the first of the Prof's. experimental electronic games that Suzy and Bob had tried, and after a while although Bob was doing quite well Suzy was still leading—but only just.

Whilst Bob and Suzy were playing on the electronic games machine, the Prof. had been receiving a series of visitors, who had each come along to consult him on some kind of practical problem.

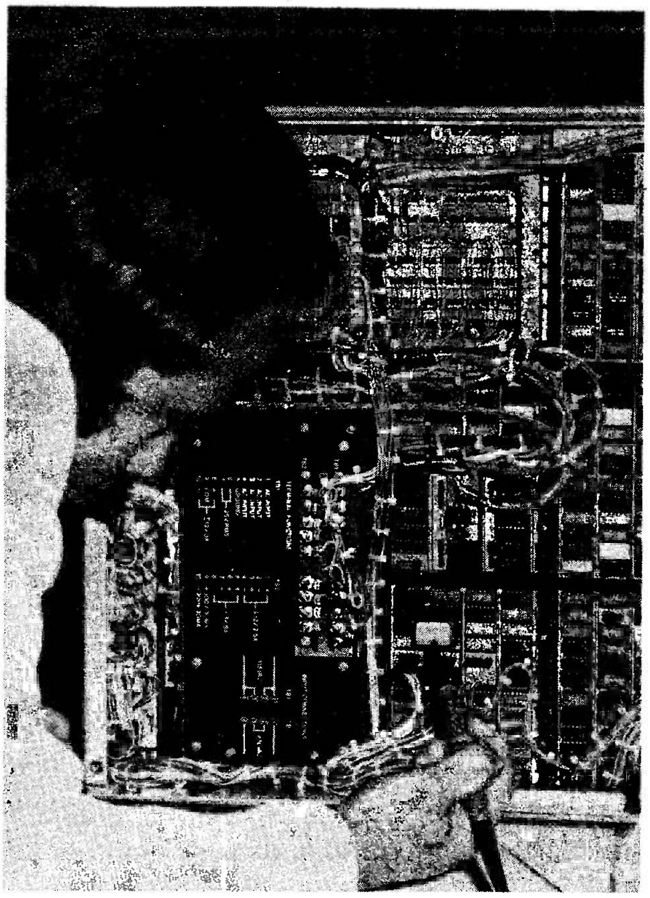
CAPACITORS

The Prof's. experimental Robot had been kept busy forming and testing a number of electrolytic capacitors, including one which Suzy had brought.

The Prof., together with his latest visitor, had been observing Suzy and Bob as they played on the electronic games machines, and now as the Prof. brought the visitor across to where they were playing the latest match, at the same time he delivered the electrolytic capacitor to Suzy.

"This capacitor is all right now, Suzy," the Prof. informed her. "One section was faulty, according to the tests performed by the Robot, and it took a long time, charging it at a low current to bring it up to the correct working voltage. The other sections were not as bad, and they reached the correct voltage much more rapidly."

"How does the Robot know, Prof. how long it should take to test a capacitor which is not faulty, and how long it should



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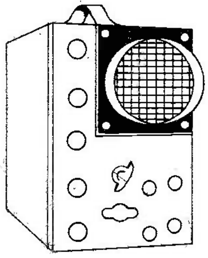

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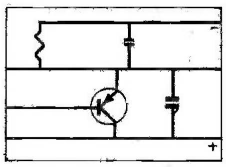

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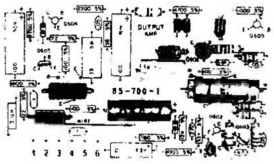

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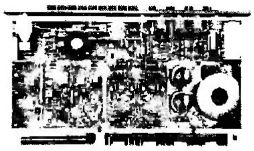

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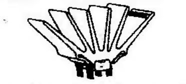

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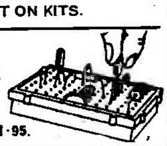

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take to form a capacitor which is faulty?" Bob wanted to know.

"The first is easy to answer, Bob. This can be found by the definition of capacitance:

> **One Farad is the capacitance of a capacitor which, when charged with a current of one amp for a period of one second, will undergo a change of one volt in the potential difference between its electrodes.**

"So if the Robot knows the value of the capacitor in microfarads, and continually adjusts VR1 and views the milliameter to give a steady charging current as the voltage across the capacitor rises from zero towards the working voltage, he can easily calculate the time it should take, which naturally varies according to component tolerance.

"The capacitance stated on the can of an electrolytic capacitor is usually not an accurate statement of its value in microfarads, but only an approximate guide.

"This is because it is quite difficult, during manufacture, to accurately control the final capacitance of the finished product, so that each capacitor in a batch has a value slightly different from that of most of the others.

INCREASING VALUE

"Also the value of an electrolytic capacitor changes with time. Usually the capacitance in microfarads increases slightly as the capacitor grows older. This is because the dielectric slowly becomes thinner, and in effect this decreases the distance between the 'plates' of the capacitor. As it becomes thinner, this not only increases the capacitance, but it may also cause the working voltage of the capacitor to fall below the rated maximum. Then the capacitor fails, like yours did, Suzy.

"Another reason why the capacitance may rise, is that the surface of the aluminium anode may become rough and pitted with age, and this effectively increases the area of the capacitor, as a rough, pitted surface has a greater surface area than a smooth one of the same measured dimensions."

"What causes the dielectric to become thinner, Prof.?" Suzy enquired.

"The dielectric gradually dissolves into the electrolyte and this reduces its thickness, especially if the capacitor is left standing unused for a long time, it is wise to test and re-form any aluminium electrolytics.

"I wish that I had known that earlier," said Suzy, "This capacitor has come from our spare TV set, which has been in storage for a while. Then I got it out again because my young brother wanted to watch the other channel at just the times when my favourite science programmes came on, and when I switched it on the capacitor failed and the fuse blew. Now I should be able to get home and put it back in again before the programmes starts!"

'There's no need to hurry off right now", the Prof. said, inviting her to stay a little longer. "You and Bob can both watch the science programme on the giant colour viewscreen which is attached to one of my computers. It has been fixed up to receive colour TV, and also Ceefax, the TV information service."

"Oh goody!" remarked Suzy, "that makes me look forward even more to the Science Programme.

"Can I ask you just one or two more questions about electrolytic capacitors, and what happens when you form them?" asked Suzy.

"Yes, certainly, Suzy," invited the Prof. who, although he had been answering the questions of a number of visitors who had consulted him whilst Bob and Suzy had been playing on the experimental electronic games machines, showed no signs of tiring.

"Well, Prof., if when you put an electrolytic capacitor through the forming process, it thickens the dielectric, will this not change the capacitance? And if so, could this be used to bring the capacitance to a known value by deliberately forming it to a voltage slightly different from its rated working voltage?"

"When you form a capacitor, yes it will have these effects. As the dielectric becomes thicker the capacitance will become less, as this is equivalent to increasing the distance between the plates of a capacitor. But unless you considerably exceed the rated working voltage, the value of the capacitor should not go outside the ratings of tolerance.

"With capacitors of low working voltage, below, say, 100 volts, it is often possible to form the capacitor up to a voltage 50 per cent higher than its rated voltage, and sometimes even more, and by this means you could trim the value to the required number of microfarads. But remember that in a few weeks' time it will probably have drifted away from that value once again, so this is not a very good means of adjusting capacitance.

"I have heard about variable electrolytic capacitors where the value can be increased by dipping the anode deeper into a liquid electrolyte, and decreased by drawing it out again. But these are usually clumsy affairs, as they depend upon the force of gravity to keep the electrolyte in place, and also there is the likelihood of difficulties in keeping the electrolyte in good condition.

"Now variable capacitors of hundreds, or even thousands of microfarads are not easy to produce. But electronic circuits have been made to simulate them, and these are very useful."

"This all sounds very complicated to me!" remarked the Prof's. visitor, Dr. Angus R. Paterson, the foot specialist, who had been dancing impatiently from one foot to another whilst Bob, Suzy and the Prof. had been discussing electrolytic capacitors. Dr. Paterson had a problem with his patients which was why he was visiting the Prof., but more about that next month.

Continued next month.

"This all sounds very complicated to me!"

DOWN TO EARTH

By GEORGE HYLTON

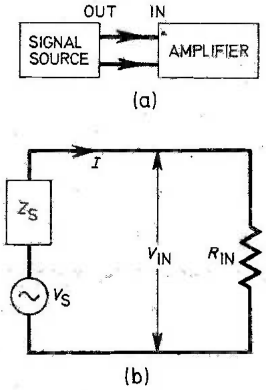
MEASURING INPUT IMPEDANCE

Mr. L. L. Hawkins of Newport, Gwent writes about a problem which must afflict a number of readers. "I am aware", he says "that to obtain the best response from an amplifier one must match the source impedance to the amplifier impedance. My difficulty with a 10 watt valve amplifier is that I do not know its input impedance".

So the question is, how do you find out? Stripped of irrelevant details, the situation at the input of an amplifier is illustrated in Fig.1a. A source of signals (eg. a microphone or gramophone pickup) is connected to the amplifier. The source generates a voltage V_S (Fig.1b). The signal source has its own *internal impedance* Z_S. This is the *source impedance* referred to by Mr. Hawkins. The amplifier has an input impedance, but as this impedance is nearly always a resistance (at audio frequencies) I'm showing it as R_{IN} rather than Z_{IN}.

Current I is driven by V_S through Z_S and R_{IN}. Since this current produces a voltage drop in Z_S it follows that the amplifier receives not the full V_S but only a portion of it. I've called it V_{IN} here.

If it strikes you as odd that the source should deliver less than its own voltage, reflect on the fact that if you short-circuit the source it obviously can't deliver any voltage at all!



(a)

(b)

Fig. 1. Impedances and voltages associated with source and amplifier.

This means, in terms of Fig.1b, that a short-circuit corresponds to R_{IN} equal to zero. The current I still flows, but there is no longer any resistance across which V_{IN} can be developed. The whole of V_S is absorbed inside the source, as a voltage drop across Z_S.

If R_{IN} is now increased from zero to higher and higher values, more and more of V_S is developed across it. In the limit, with infinite R_{IN}, the whole of V_S is delivered to the amplifier.

Infinite R_{IN} means that the source is *open*-circuited as opposed to short-circuited. For this reason the output of a signal source is sometimes described on makers' data sheets as "open circuit output voltage" or "output voltage into infinite load".

IN PRACTICE

In practice, of course, the load (R_{IN}) is not infinite and some of V_S is lost. To find out how much, you need to know both Z_S and R_{IN}. Common sense tells you that if Z_S equals R_{IN}, half of V_S is lost and the remaining half appears as V_{IN}. Common sense is a fine thing, and it gives the right answer if Z_S is a resistance. But if the signal source is a capacitance (e.g. crystal microphone) or an inductance (e.g. tape playback head) the answer is wrong.

You find, if you measure it, that when Z_S equals R_{IN} in these cases, 70 per cent of V_S gets through instead of the expected 50 per cent. This is not a serious error, but a serious consequence follows from it. If Z_S is not a resistance but an inductive or capacitive *reactance* then it varies with frequency. To get an even frequency response it is necessary to ensure that R_{IN} is at least equal to Z_S at all audio frequencies (I should point out, in passing, that pickups and tape heads need an *uneven* frequency response, for *equalisation*, but that's another story.

Devices such as crystal or electret microphones, which are capacitances, do need an even response, so I'll think in terms of them from now on.)

If the source is a crystal microphone with a capacitance of 1000 picofarads and the lowest frequency of interest is 32Hz then Z_S equals 5 megohms. So you can see that getting a big enough R_{IN} may be a problem. Often, it's necessary to use a high-input-impedance buffer amplifier between the source and the amplifier itself.

METHOD OF MEASUREMENT

To get back to the question: how do you measure R_{IN}? Great accuracy is not needed, so an ohmmeter type of measurement will do. No need for bridges. One way of doing it is to substitute an audio signal generator (test oscillator) for V_S and a variable resistor for Z_S.

Set "R_S" to zero. Apply a small V_S (not big enough to overload the amplifier) and measure V_{IN}. Increase R_S until V_{IN} falls by 50 per cent. Now R_S equals R_{IN}. (You can measure R_S on an ohmmeter, or try different known fixed resistances instead, until you find one which halves V_{IN}.)

There are snags, because V_S is in millivolts and also because the impedance of the voltmeter, which falls across R_{IN}, reduces the apparent input resistance. A high-impedance millivoltmeter is needed—and of course you haven't got one.

Never mind. Switch your ordinary multimeter to its lowest "a.c. volts" range and use it to monitor the *output voltage* of the amplifier. So long as you make your measurements at a fixed frequency, around 500 to 1000Hz, and keep the signals down so that they are well within the amplifier's handling capacity the measurement will be quite accurate enough. The output voltage, as before, falls by half when R_S equals R_{IN}.

In general, the amplifier input impedance is satisfactory so long as it is greater than the source impedance at all frequencies of interest. This means that at least half V_S is delivered to the amplifier input.

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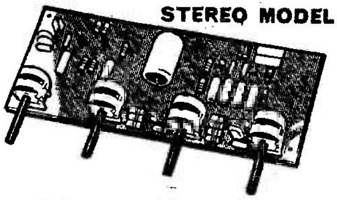

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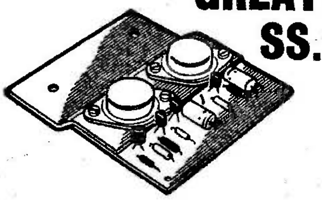

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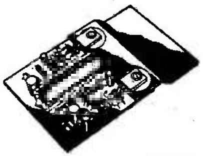

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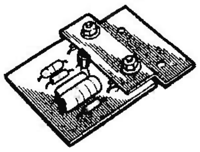

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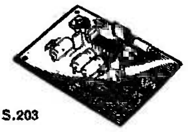

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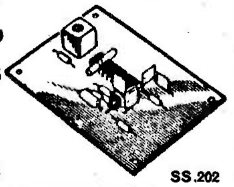

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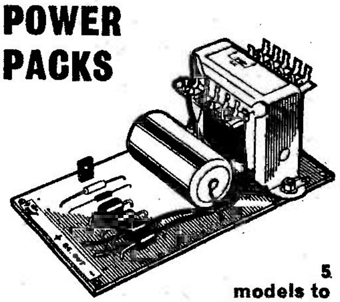

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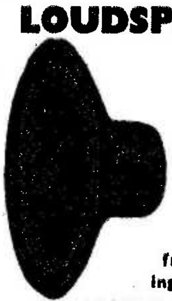

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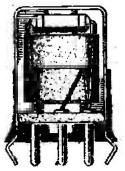

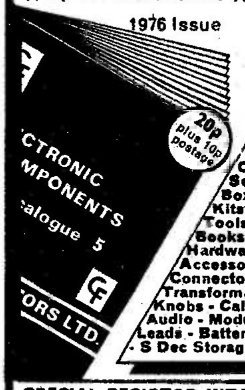
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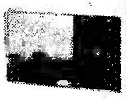

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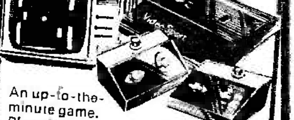

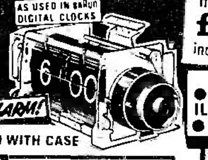
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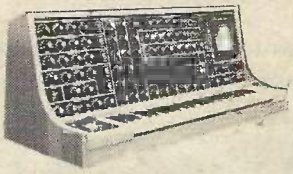

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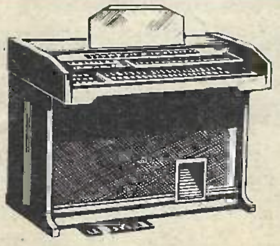

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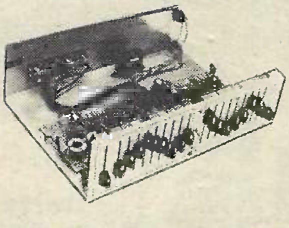

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