RADIO & ELECTRONICS CONSTRUCTOR

FEBRUARY 1980
55p

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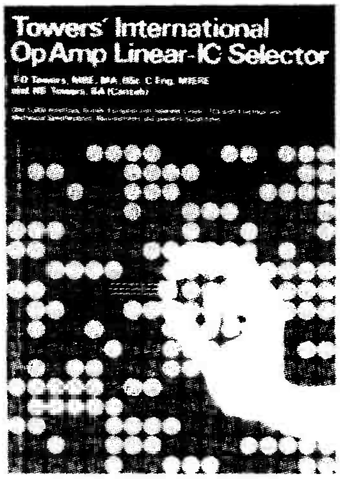


This opamp linear-IC compendium, a comprehensive tabulation of basic specifications for over four thousand opamps, offers information on:

1. Ratings
2. Characteristics
3. Case details
4. Terminal identifications
5. Applications use
6. Manufacturers
7. Substitution equivalents (both European and American)

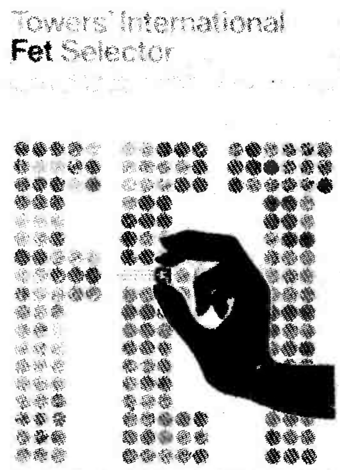
This work covers not only classical 'pure' opamps, but also several classes of 'quasi-opamps' (i.e. linear-ICs with opamp-like characteristics) such as dc-comparators, operational-transconductance-amplifiers, differential-output amplifiers, current-difference amplifiers, and voltage-follower amplifiers.

The more than 4,000 opamps covered in this self-contained volume are a selection of the more common current and widely-used obsolete types.

The coverage is international in scope and includes opamps not only from the USA and Continental Europe, but also from the United Kingdom and the Far East (Japan).

Price **£7.50** inc P&P

TOWERS INTERNATIONAL FET SELECTOR



If you deal with field effect transistors, or fet's — whether as a student, a hobbyist, a circuit engineer, a buyer, a teacher or a serviceman — you often want data on a specific fet of which you know only the type number.

Specifications apart, you may be even more interested in where you can get the device in question. And perhaps more important still (particularly with obsolete devices), you may want guidance on a readily available possible substitute.

This fet compendium, a comprehensive tabulation of basic specification offers information on:

1. Ratings
2. Characteristics
3. Case details
4. Terminal identifications
5. Applications use
6. Manufacturers
7. Substitution equivalents (both European and American)

The many fet's covered in this compendium are most of the more common current and widely-used obsolete types.

It is international in scope and covers fet's not only from the USA and Continental Europe, but also from the United Kingdom and the Far East (Japan).

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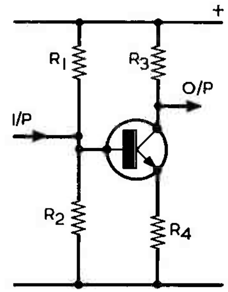
BYPASSING AND DECOUPLING

In the audio frequency amplifier circuit of (a), R1, R2 and R4 are bias resistors and R3 is the transistor collector load. A.F. voltages can develop across R4 and reduce the a.f. gain to a low level. A high-value bypass capacitor is added in (b) and it prevents a.f. voltages appearing across R4 without upsetting d.c. bias conditions. The circuit will then give maximum a.f. gain.

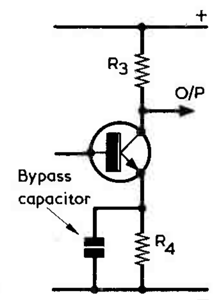
In the 2-stage a.f. amplifier of (c) the input at TR1 base is in phase with the output at TR2 collector. Should the battery develop a high internal resistance (as can occur with aging) a fraction of the output signal will be built up across that internal resistance and be fed back via the positive rail and R1 to TR1 base. The result can be instability. The situation is alleviated by connecting a high-value bypass capacitor across the supply rails, as in (d). The capacitor has a very low reactance at audio frequencies and prevents these appearing on the positive rail.

The situation is further improved in (e) by adding two decoupling components: a series resistor and another high-value capacitor. The resistor and capacitor "decouple" TR1 and its base from TR2. The series resistor has a value which still allows an adequate supply voltage to be available for TR1.

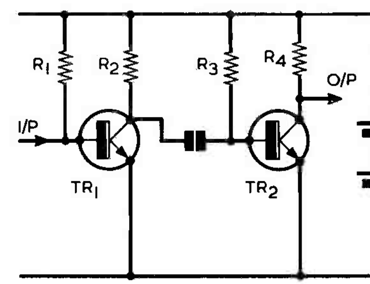
These are simple examples of bypassing and decoupling. At audio frequencies the capacitors will usually be electrolytic with values in the order of 10μF to 200μF. At radio frequencies, bypass and decoupling capacitors are normally non-electrolytic with values ranging from some 1,000pF to 0.1μF according to frequency.



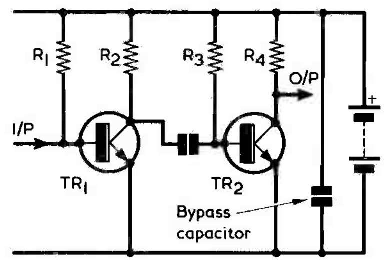
(a)



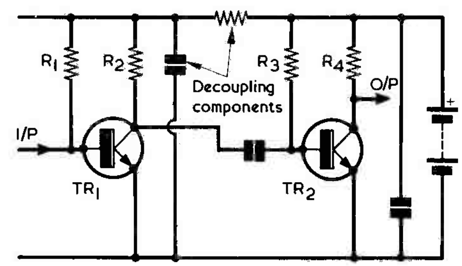
(b)



(c)



(d)



(e)

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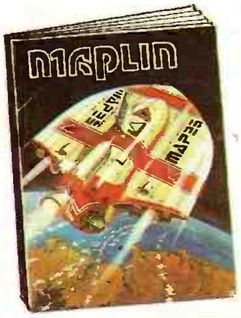

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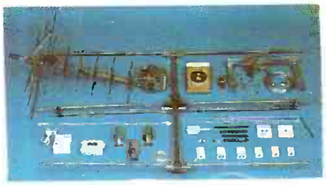

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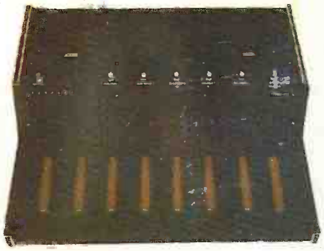

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RADIO & ELECTRONICS CONSTRUCTOR

FEBRUARY 1980
Volume 33 No. 6

Published Monthly

First published in 1947

Incorporating The Radio Amateur

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9 1SN

Telephone 01-286 6141
Telegrams Databux, London

Annual Subscription: £8.00, Eire and Overseas £9.00 (U.S.A. and Canada $20.00) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers, please pay by cheque or International Money Order.

Technical Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. We regret that queries cannot be answered over the telephone, they must be submitted in writing and accompanied by a stamped addressed envelope for reply.

Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

Production— Web Offset.

Published in Great Britain by the Proprietors and Publishers, Data Publications Ltd, 57 Maida Vale, London W9 1SN.

The *Radio & Electronics Constructor* is printed by Swale Press Ltd.

The March issue will be published early in February

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SJ12	60 Electrolytics all sorts mixed	0.50
SJ13	50 Polyester/polystyrene capacitors mixed	0.50
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SJ16	40 Low volts electrolytics mixed up to 10v	0.50
SJ17	20 Electrolytics transistor types mixed	0.50
SJ18	20 Tantalum bead capacitors mixed	0.50
SJ20	2 Large Croc-clips 25A rated	0.30
SJ21	Large 7½ mains neon tester screwdriver	0.85
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SJ23	Siemans 220v AC Relay DPDT 10A	1.00
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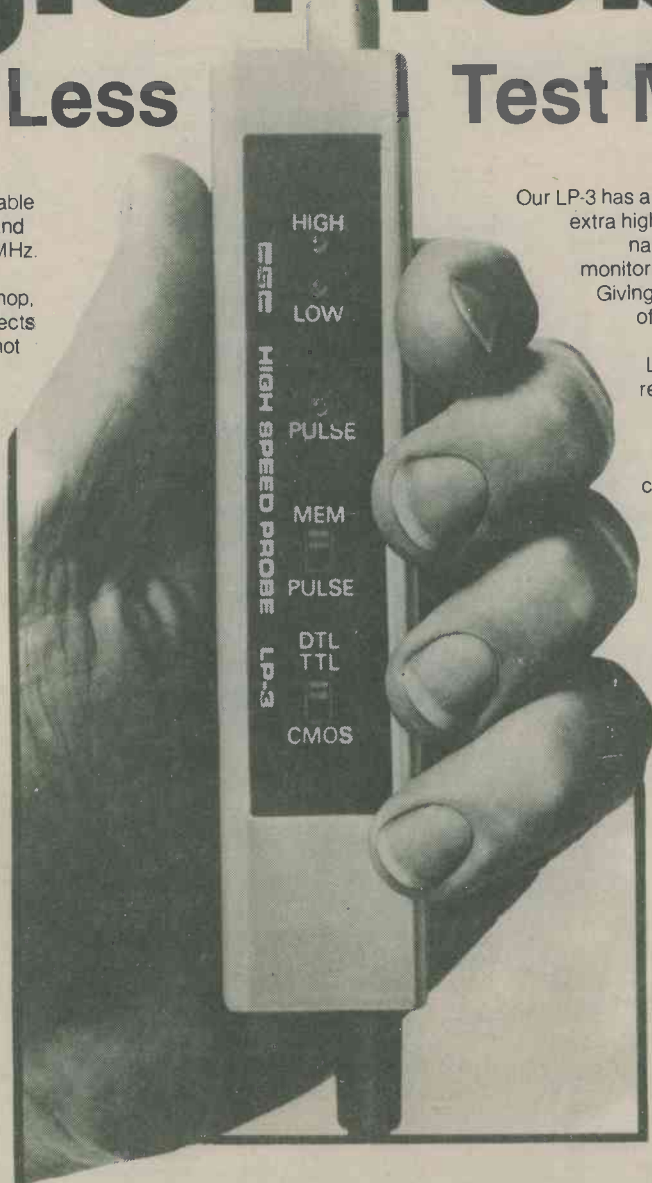

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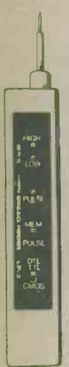

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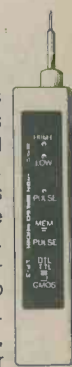

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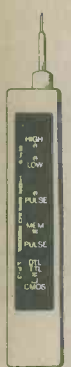

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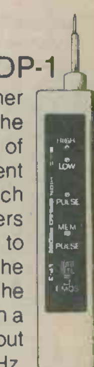

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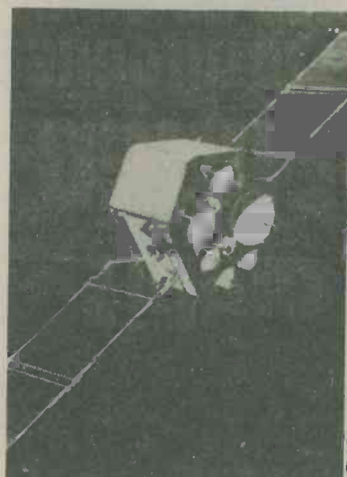

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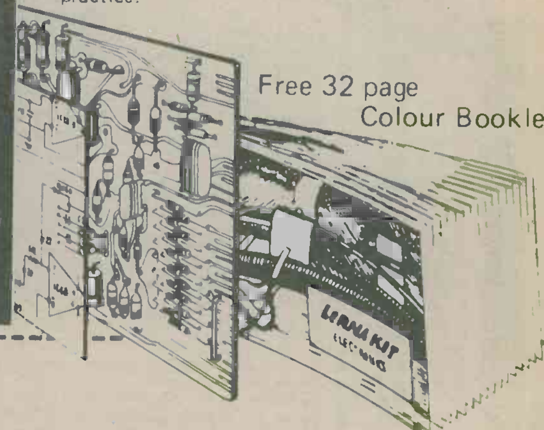

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BC177	18p	BC460	35p	BF200	28p	OC45	30p
BC178	18p	BC547	12p	BF224J	15p	OC71	25p
BC182	9p	8C558A	13p	BF241	15p	OC72	35p
BC182L	10p	BCY42	30p	8F257	28p	OC76	32p
BC183	9p	BCY70	17p	BF259	30p	TIP29A	44p
BC183B	9p	BCY71	20p	BF262	30p	TIP31A	38p
BC183L	10p	BCY72	20p	BF263	30p	TIP32A	40p
BC184	9p	BD116	54p	8F337	30p	TIP32C	70p
BC184L	10p	BD131	35p	BFT41	30p	TIP33A	65p
BC212	10p	BD132	35p	BFX84	22p	TIP41A	45p
BC212B	12p	BD135	34p	BFX89	65p	TIP42A	40p
BC212L	12p	BD136	34p	BFY50	20p	TIP3055	65p
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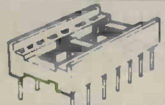

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BC184	10p	ZTX108	14p	2N5459	32p
BC184L	10p	ZTX300	16p	2N5777	50p
BC212	10p				
BC212L	10p				
BC214	10p				
BC214L	10p				
BC477	19p				
BC478	19p				
BC548	10p				
BCY70	14p				
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0.33, 0.47	10p
0.68	14p
1.0uF	17p

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	100					13p
			220			20p
25V	10	22	33	47		5p
	100					8p
		220				10p
				470		15p
	1000					23p

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3.5mm	9p	14p	8p
Standard	16p	30p	15p
Stereo	23p	36p	18p

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3pin	11p	9p	14p
5pin 180°	11p	10p	14p
5pin 240°	13p	10p	16p

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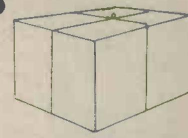

Pack of 3 x LM380	~~225p~~	200p
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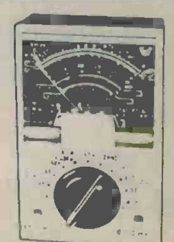

A really smart looking multimeter with an impressive specification for such a small size. The very clean scale in white and green on a black background makes this meter very easy to read. The D.C. Impedance of this meter is 4K ohms per volt which is exceptionally good compared with the vast majority of multimeters of a similar size. £5.95 each.

SPECIFICATION

DC Volts	5V 25V 250V 500V (4K ohms/V)
AC Volts	10V 50V 500V 1000V (2K ohms/V)
DC Current	250uA 250mA
Resistance	0 – 600K (7K ohms centre)

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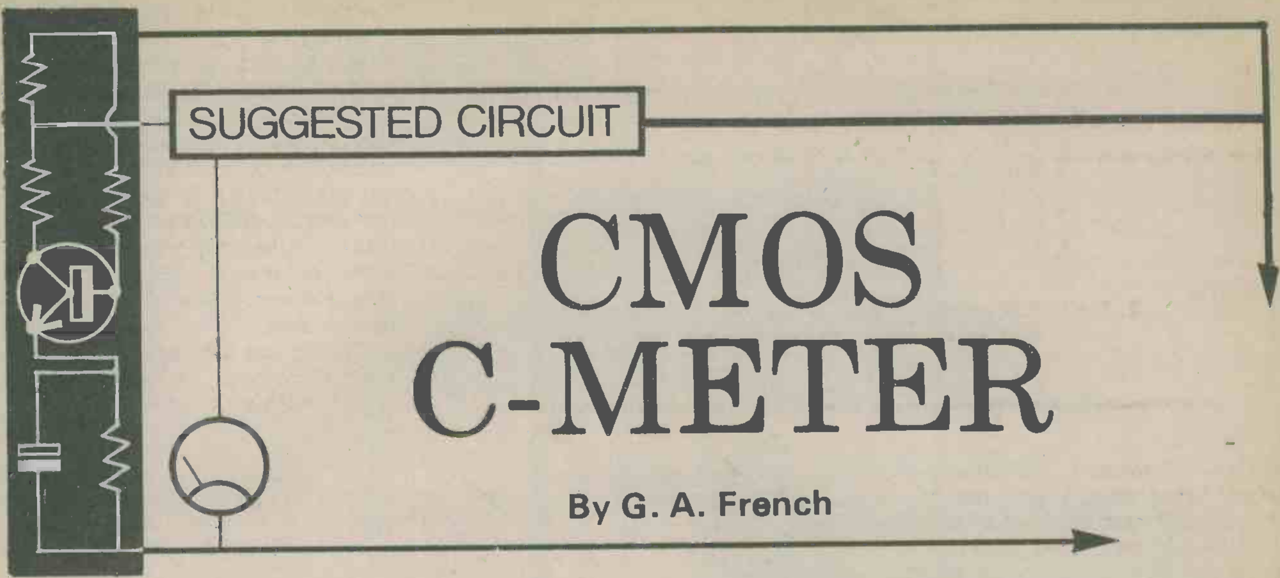


SUGGESTED CIRCUIT

CMOS C-METER

By G. A. French

The very simple and inexpensive capacitance meter to be described is intended for measuring capacitance values from less than 1.5pF to 1,500pF. This range takes in nearly all fixed capacitors likely to be encountered in r.f. circuits including, in particular, ceramic and silvered mica types whose printed value markings are most likely to be blurred or erased due to handling. The meter will also measure maximum and minimum values of variable and trimmer capacitors.

The circuit requires very few components and incorporates an ICM7555, this being the "CMOS 555". In consequence, current consumption from its 9-volt battery is exceptionally low. With the prototype circuit the current drawn was 80μA only, whereupon it becomes possible to use a small battery, such as the PP3, which will have a considerably extended working life. The meter is intended to be employed with a portable medium wave superhet radio having a tuning range of 200 to 550 metres (1,500 to 545kHz).

C-METER CIRCUIT

The circuit of the meter is given in Fig. 1, in which the ICM7555 appears in an astable multivibrator circuit whose frequency is controlled by the values of R1, R2 and C3. The pin connections are exactly the same as would be used with the older bipolar 555 i.c., but supply current is very much smaller. So low is the current drawn by the device that the current flowing through R1 becomes significant in comparison and it is preferable to use a high value resistor here. The value of 1MΩ chosen means that the current flowing from the battery to the timing components will be in the order of microamps. R1 and R2 are both $\frac{1}{4}$ watt 5%, and C3 should preferably be a polystyrene or silvered mica component. The circuit produces a rectangular wave at the pin 3 output having a frequency which is very close to 1kHz.

The output is applied via C2, which has an extremely low capacitance, to C1 and part or all of coil L1 according to the setting of range switch S1. C1 is silvered mica or ceramic. The coil is wound on a 6in. ferrite rod, and the capacitor to be measured is connected to the test terminals. The inductance selected by S1, and C1 plus the test capacitance, form a parallel tuned circuit, and this is shock-excited to produce damped oscillations at its resonant frequency by the steep pulse edges in the output of IC1. The damped oscillations may be picked up on a medium wave radio whose internal ferrite rod aerial is held parallel with and fairly close to the rod on which L1 is wound, and they are reproduced through the speaker of the radio as a 1kHz tone. The signal peaks very markedly at the resonant frequency and can be tuned in on the radio with the same resolution as an ordinary medium wave broadcast signal. Since the resonant frequency is a function of

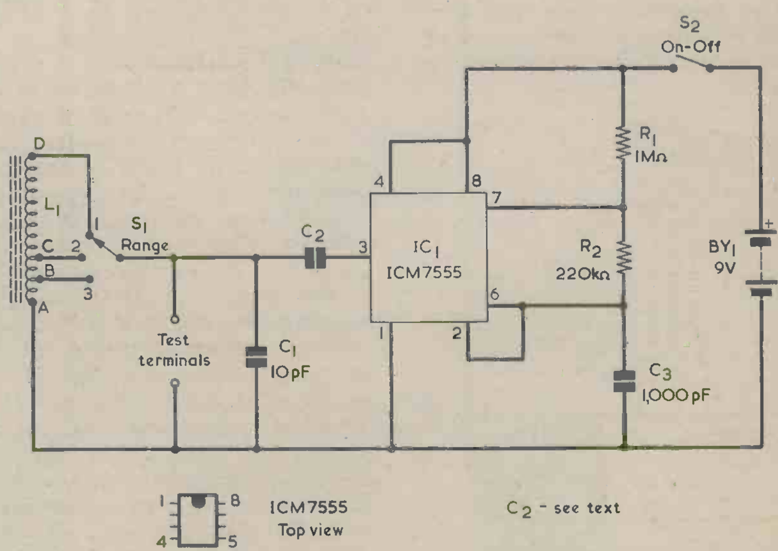


Fig. 1. The circuit of the capacitance meter. Coil L1 is wound on a ferrite rod which radiates an a.m. signal in the medium wave band whose frequency depends on the value of the test capacitance

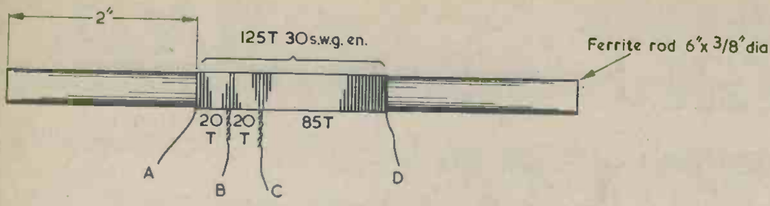


Fig. 2. Details of coil L1. This is close-wound on a ferrite rod with tappings, as shown

the test capacitance, the latter may be evaluated, using a table, from the tuning scale reading on the radio.

Details of coil L1 are given in Fig. 2. It has 125 turns overall of 30 s.w.g. enamelled wire close-wound direct onto the ferrite rod. The winding starts 2in. from one end of the rod and 20 turns are wound on before the first tap is made. The coil wire is twisted together at the tap and a further 20 turns are wound on, after which a second tap is reached. The final 85 turns are then wound on the rod. Both the coil ends may be secured by p.v.c. insulating tape. The enamel is scraped off at the two coil ends and at the twisted wires at the taps, and the bared wires are then tinned with solder to enable connections to be made to the coil. The letters "A", "B", "C" and "D" in Fig. 2 correspond with the same letters in Fig. 1.

Capacitor C2 is formed by having two insulated wires about 1in. long running very close to each other, as in Fig. 3. In this diagram they are shown soldered to two tags of a tagstrip, but any other means of securing the wire ends will be satisfactory.

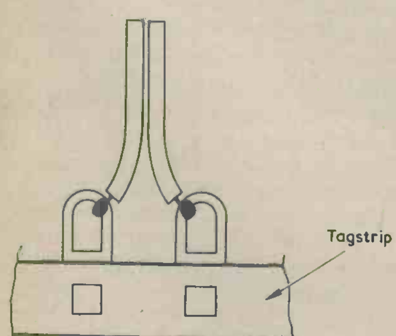
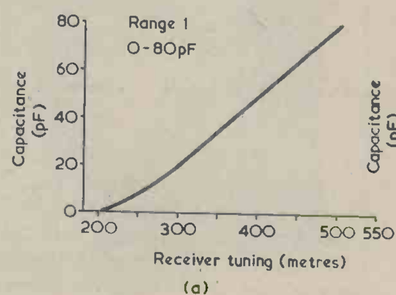


Fig. 3. Capacitor C2 is not a physical component but consists of two short insulated wires positioned close to each other



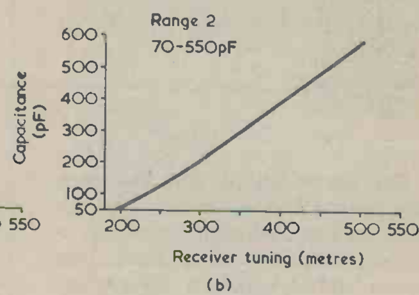
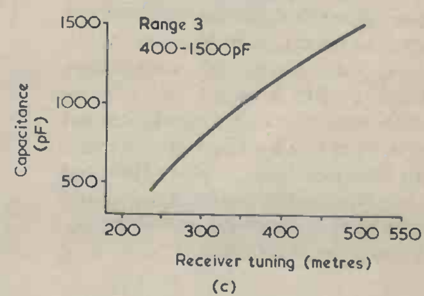


Fig. 4(a). Curve, obtained with the prototype circuit, illustrating test capacitance plotted against the corresponding receiver tuning wavelength indication

(b). Range 2 permits measurement of capacitance between 70 and 550pF



(c). On Range 3, test capacitance between 400 and 1,500pF may be evaluated

METER RANGES

On Range 1, S1 switches in all the turns of L1. This now presents an inductance which is greater than that offered by a normal medium wave ferrite rod aerial coil and, in consequence, resonates at about 600kHz (500 metres) with only some 80pF connected to the test terminals. Range 1 is therefore 0-80pF nominal, and the results obtained with the prototype circuit are illustrated in the curve of Fig. 4(a). Of particular interest in this curve is the left-hand section where the rate of change of capacitance against wavelength is slower than over the rest of the curve. This results in an effective "opening-out" of low capacitance indications. For example, a test capacitance of 5pF compared with zero test capacitance corresponds to a change in wavelength from 200 to as much as 235 metres. The lowest test capacitance which can be resolved is a little less than 1.5pF. The value of 1.5pF, itself, gives a change from 200 to about 212 metres. In the prototype circuit, zero test capacitance corresponded with 200 metres on the receiver tuning scale, but this is quite fortuitous. All that is required of the circuit is that zero test capacitance should correspond with a point at the low wavelength (high frequency) end of the receiver tuning range.

The internal self-capacitances distributed through coil L1 do not allow reliable shock-exitation to take place at a single peak frequency when there is no external capacitance connected across it, and this is the reason for having the small capacitor, C1, in circuit. C1 plays no important part on the other two ranges, apart of course from contributing a small part of the parallel tuning capacitance.

On Range 2 only 40 turns of the coil are in circuit, and these permit nominal range limits of 70 to 550pF. The number of turns is reduced to 20 on Range 3, and the values of test capacitance which can be measured range from about 400 to 1,500pF. The curves for Ranges 2 and 3 are given in Fig. 4(b) and (c) respectively. The curve in Fig. 4(c) shows signs of beginning to flatten off at 1,500pF, thereby indicating that the maximum test

Continued on page 341

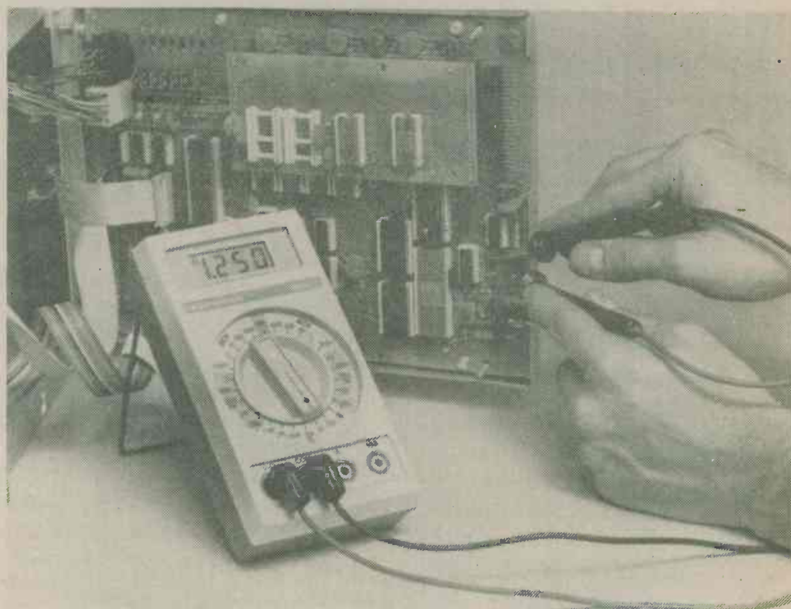
NEWS . . . AND

PORTABLE 3½ DIGIT MULTIMETER INTRODUCED

A portable, high precision 3½ digit multimeter has been introduced by Beckman Instruments. Designed to simplify test and measurement, it has features not found on any other multimeter currently on the world market, such as the Insta-Ohms™ instant continuity test indicator and the 2000 hour battery life. The instrument is available direct from Beckman or through a range of distributors in the UK, the price being £115.

Measurements can be made across five dc voltage ranges from 200mV to 1500V full scale; five ac voltage ranges spanning 200mV to 1000V full scale; five ac and dc current ranges, 200μA to 2A full scale (a separate input extends the range to 10A); and six resistance ranges with full scale values from 200 Ω to 2M Ω.

The low power resistance ranges permit in-circuit resistance measurements to be made without turning on semi conductors, which would affect the measurements. For applications that require testing of diodes and semiconductors, a separate semiconductor test function provides 5mA of test current — enough to verify the operation of most semiconductor junctions — even circuits with as low as 200 Ω of equivalent parallel resistance.



Beckman 3020 digital multimeter being used to check continuity

The Insta-Ohms™ continuity test indicator allows continuity to be checked simply and speedily. When an in-range resistance is measured an ohms symbol appears on the display in less than one millisecond.

A single 9V transistor battery provides up to 2000 hours of continuous instrument operation, giving up to 2 years typical use. During the final 200 hours of battery life a decimal point blinks on the display to warn the user to change the battery. Calibration, guaranteed for one year, requires only the simple adjustment of an internal trimming potentiometer.

A NEW BRITISH DESIGNED CASSETTE HOLDER FOR USE IN MOTOR CARS

It is extraordinary to think that the estimated sales in the U.K. alone this year for in-car entertainment equipment will reach £80m. and although motorcar manufacturers and in-car entertainment equipment manufacturers have gone to a lot of trouble on design, there has been little attention paid to the actual storage of the cassettes.

Gilfin International Ltd., has tackled this problem and produced a revolutionary new design and concept in this field.

The "TAPEMATE" cassette holder has been designed to fit behind sun visors, on the roofs, on doors and behind some glove box lids — indeed even on carpeting — giving it a flexibility that no other cassette holder has had. Furthermore, it has a system of locking the tape spindles, which up to now has not been achieved as far as automobile cassette holders are concerned.

If used on the sun visor it has a great safety factor, inasmuch as your attention is still on the traffic ahead whilst selecting the tape.

There is no fixed retail price, but it is estimated that the "TAPEMATE" will sell at between £1.50 and £2.00.

. . . COMMENT

BBC's PUBLICITY FOR AMATEUR RADIO

We read in a recent edition of the BBC's **London Letter,** an article entitled 'The worldwide fellowship of radio hams'.

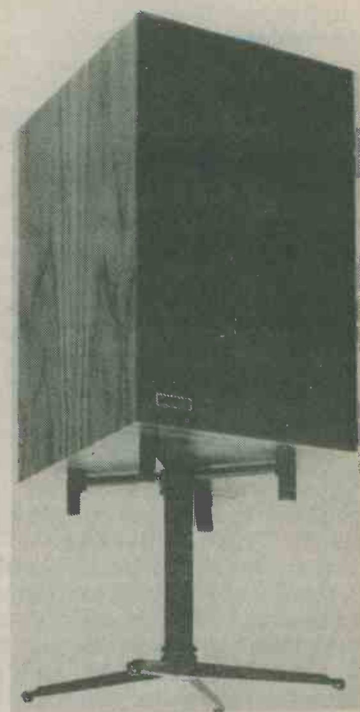
Although the information contained in the article will be familiar to our radio amateur readers, we feel it is of general interest to publish the following extracts.

"Amateur radio is radio for pleasure: but there's more than one kind of pleasure. For some people, it means pushing their equipment to the limits of its capability — achieving results under conditions which many would regard as impossible. For others, the fun lies in the opportunity amateur radio gives to invent new ways of doing things, to try out ideas. Radio and electronics are among the diminishing group of hobbies where it's still possible for the amateur, working alone with equipment built on his kitchen table, to rival the professionals with their laboratories full of apparatus. As an example, it was the radio amateurs who showed that reliable world-wide communication was possible using short-waves. In the early days of radio, the accepted wisdom had been that the short-waves were useless for all practical purposes since no one had discovered how they worked; and they had accordingly been given to the amateurs as a mere plaything. And innovation still continues. For instance, the amateur radio movement has its own space programme! Through the generous assistance of the space organisations in various countries, several communications satellites built by amateurs have been successfully put into orbit-hitching lifts on rocket launches mainly intended for some other purpose."

"Besides all this, radio amateurs have bounced signals off the moon and off the auroral curtain (the Northern and Southern Lights), they've communicated with each other by radio teleprinter and by colour TV, and they have continued to extend the practical limits of the radio spectrum."

"In addition to the personal pleasure it provides, amateur radio can give public service too. In times of disaster or civil emergency, radio amateurs are often called upon by the relief forces to help co-ordinate their work. So many countries have come to look upon their radio amateurs as a national asset, a corps of trained communicators. Yet the amateurs find themselves continually having to defend their claim to their wavelengths. Their next big test comes as the world's telecommunications administrators meet to thrash out new wavelength allocation plans for the years ahead. There will be stiff competition — nearly every radio user is clamouring for more air-space, the broadcasting stations included. Even today, there's nowhere enough space in the radio bands to satisfy everyone. So amateurs may find it a tough challenge to persuade the administrators that their place on the air should be preserved — even though their activities may seem to have no immediate economic, political or military value."

STEREO SPEAKER FLOOR STANDS



Fidelity Fastenings Ltd., of the Ridgeway, Iver, Bucks., started business in 1977 making a wall mounting bracket system, known as Model FF1.

They have now added a speaker stand, and an adjustable trolley, to the range so that they now offer mountings suitable for most stereo speakers.

Their floor stands are adjustable in height, have a unique speaker tilt device and a fine black satin finish.

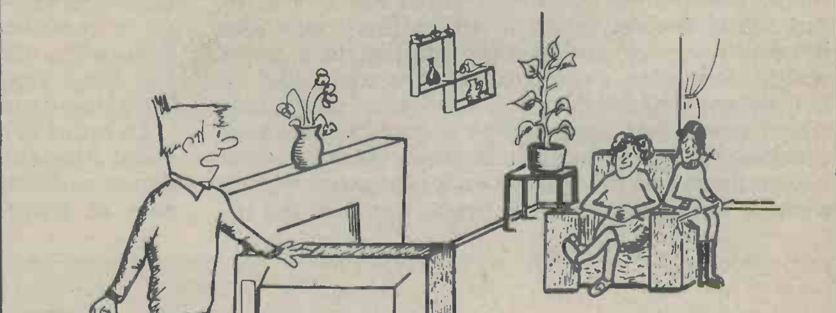
The Model FF2 is illustrated above.

RECENT IBA PUBLICATIONS

Publications issued recently by the IBA include an extended edition of "ITV & ILR TRANSMITTING STATIONS — A Pocket Guide" (16pp) and a new four-page illustrated leaflet "500 — The IBA's 500th Transmitter on Air Autumn 1979".

The pocket guide includes brief details of some 500 UHF transmitters (representing 2,000 IBA (ITV), IBA ('Fourth Channel'), BBC1 and BBC2 channels), the 47 ITV/VHF (405-line) transmitters, and 28 different ILR radio services (MF and VHF/FM). Information provided includes channel numbers (or frequencies), polarisation of signals, power, aerial height, and service date (or target service date) and national grid reference of location.

Either or both publications are available on request from IBA Engineering Information Service, Crawley Court, Winchester, Hants.



" 'Horse of the Year Show', 'Badminton Horse Trials', 'Racing from Wincanton' — The only work I get now is 'mucking out' TV sets!"

CLASS D AMPLIFICATION

By John Baker

A development of the 1960's returns to the audio scene.

While many readers will be familiar with the Class A, B and C modes of amplification employed in the output stages of a.f. amplifiers, Class D is far less well known and quite a few readers may be unaware of its existence. It is sometimes referred to as "digital amplification" (not to be confused with the pulse code modulation method of passing audio signals along a communication channel) and it uses digital techniques to render non-linearity in the amplifier driver and output stages of little consequence. This enables Class D circuits to have inherently low distortion levels which can be reduced further by the use of a comparatively small amount of negative feedback. Another advantage of Class D is the high efficiency that can be obtained in terms of audio output power and supply power. The theoretical maximum is 100% although in practice it is unlikely to be much more than 90%. This is about 20% better than most Class B designs, and something like 3 times as efficient as most practical Class A circuits. The efficiency of Class C amplifiers is roughly comparable with that of Class D types, but Class C is only applicable in practice to r.f. amplifiers, of course, and not to a.f. amplifiers.

OPERATING PRINCIPLE

A Class D amplifier uses the general arrangement shown in the block diagram of Fig. 1. The input signal is first taken to an ordinary analogue amplifying stage and is then applied to a pulse width modulator. Pulse frequency is controlled by a constant frequency clock oscillator. The pulse width modulator produces an output pulse whose mark-space ratio (the ratio between the time when it is positive and the time when it is negative during a clock frequency cycle) is proportional to the input voltage. Thus, under quiescent conditions with zero input voltage the modulator produces a square wave output with a mark-space ratio of exactly 1:1. Positive input voltages cause an increase in the positive pulse length, with peak positive input levels causing the positive pulses to almost merge into one another. Negative-going input signals reduce the mark-space ratio by decreasing the length of the positive pulse within the clock frequency cycle, and peak negative input signals can result in only very brief positive pulses being produced.

The effect is illustrated in the waveforms of Fig. 2. The waveform of Fig. 2(a) is a 1:1 square wave and is that given by a zero level input. That of Fig. 2(b) is given by a high positive input signal level, and that of Fig. 2(c) by a high negative signal input. A pulse output of the type illustrated in Fig. 3 would be given by the anologue input signal shown below it.

The output from the pulse width modulator is fed to what is virtually a conventional Class B driver and complementary output stage. However, this circuit does not need to have good linearity since it is only handling a pulse signal and not an analogue one. It is far more important for it to have a very fast switching time, so that the output pulse lengths are not altered by limitations in switching speed. For the pulse width modulation system to work properly it is necessary for the clock frequency to be higher than the maximum analogue input frequency, and for reasons to be explained shortly the clock frequency should in practice be about 100kHz or more.

In order to obtain the appropriate waveforms at these frequencies it is obviously necessary to use driver and output transistors capable of giving good gain at frequencies well into the r.f. spectrum.

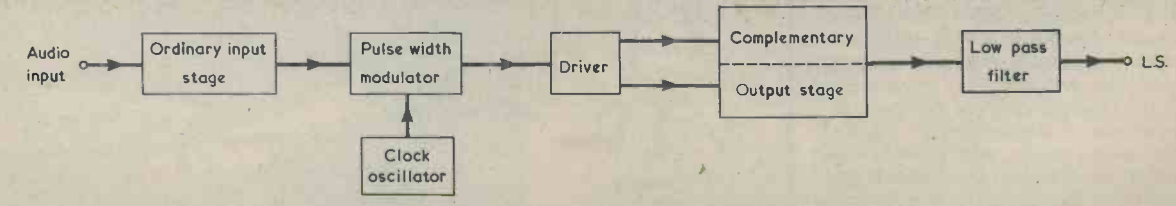


Fig. 1. A Class D amplifier has the basic stage line-up shown here. After the pulse width modulator the driver and output stage amplify pulses and not an analogue audio signal

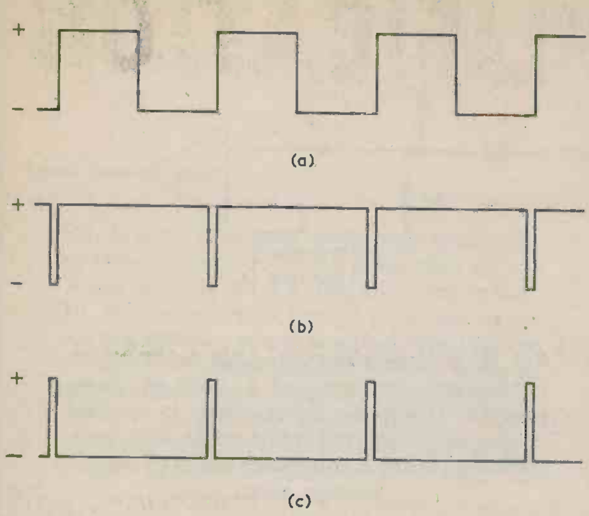


Fig. 2(a). A square wave with a mark-space ratio of 1:1 is produced by the pulse width modulator under quiescent input conditions
(b). At peak positive signal input the length of the positive pulses is increased considerably, very short negative pulses appearing between them
(c). A peak negative input signal produces the opposite effect

When Class D designs were first introduced in the 1960's, transistor high frequency performance with power devices was not exceptionally good, and this fact is possibly one reason for the failure of Class D amplifiers to achieve widespread acceptance at that time. At present, high speed silicon and f.e.t. power devices are readily available, and amplifiers having true hi-fi output powers in excess of 100 watts can be produced. The Sony TA-N88 digital audio amplifier is, for example, rated at 2 x 160 watts.

A low pass filter must be incorporated between the output stage and the loudspeaker so that the speaker is not subjected to the pulse frequency as such. This filter is normally an L-C type and, in order for it to give good attenuation at the clock frequency, it is essential for the clock frequency to be several times the maximum audio signal frequency. The filter can then give some 80dB of attenuation to the pulse signal without significantly affecting the upper audio response of the amplifier.

Although the speaker cannot respond to the pulsed output signal due to the inclusion of the low pass filter it will respond to the average output voltage from the amplifier. Under quiescent conditions the average output voltage is obviously half the supply voltage, since the output is fully positive for half the time and fully negative for half the time. Positive audio signals increase the positive output pulse lengths, giving an increase in the average positive output voltage. Negative signals decrease the positive pulse lengths and cause the average output voltage to go negative. Thus, the varying audio signal at the amplifier input produces a corresponding output signal voltage. The speaker is normally fed from the output via a high value d.c. blocking capacitor so that it receives an a.c. signal rather than a varying d.c. signal. Alternatively, if the amplifier has balanced positive and negative supply rails, with a central earth rail, the loudspeaker may be connected directly between the amplifier output and the earth rail.

The efficiency of the Class D system stems from the fact that, for nearly all of the time, each of the output transistors is either fully cut off or is turned hard on. A cut off output transistor passes no significant current and dissipates no significant power. Similarly, when fully turned on an output transistor dissipates little power because there is only a low voltage across it, and power is equal to current multiplied by voltage. The only time that a high voltage-current product appears is during the time when an output transistor is changing from the fully turned on to the fully cut off state, and vice versa. If these transition periods are kept very short, as they can be with transistors having very high switching speeds, the consequent dissipation is low.

The theoretical 100% efficiency of Class D

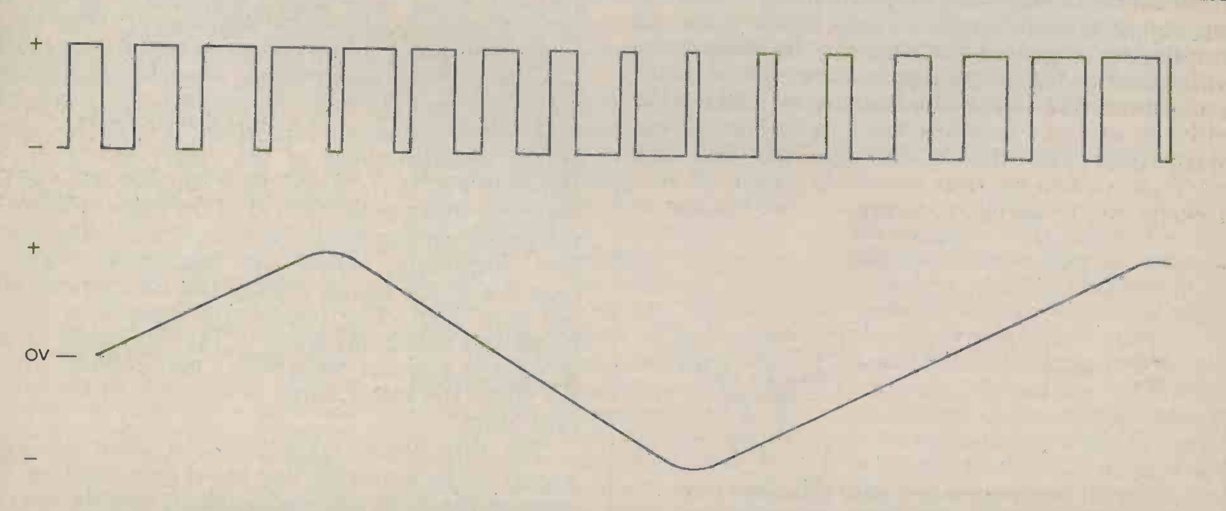


Fig. 3. Illustrating the pulse train produced by the analogue signal shown below it. The average voltage of the pulses corresponds with the voltage of the analogue signal

amplifiers cannot be fully realised in practice for three reasons. The first of these is that some voltage will still be dropped across a fully turned on transistor, even though that voltage is small. Secondly, the transition times between one output state and the other cannot be made infinitely short, and so some power, albeit very small, is still lost here. Finally, there must be some resistance in the low pass output filter, with a consequent small power loss here as well.

Despite these power losses, the basic Class D mode of operation can be made so close to 100% efficient that it is possible to employ smaller output transistors than would be needed in a Class B output stage offering a comparable amount of power. It will be appreciated that the power dissipated in the output transistors of an amplifier is virtually equal to the power provided by the power supply minus the power actually fed into the loudspeaker load.

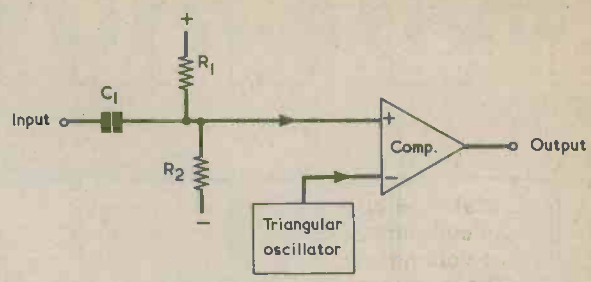


Fig. 5. A simple but effective pulse width modulator can employ a voltage comparator. The audio input signal is applied to the non-inverting input while the clock oscillator feeds a triangular wave to the inverting input

DISTORTION

Although the linearity of the driver and output stages of a Class D amplifier is relatively unimportant, since they function as switching devices, Class D circuits are not completely distortion free. Heavy output loading, given by an almost continuous positive or negative output over a number of pulses, can result in a drop in supply voltage. Audio output peaks become flattened, with a resultant generation of distortion products. This effect can be minimised by the use of a well stabilized power supply and an output stage having an extremely low output impedance.

Distortion can also be introduced by the pulse width modulator circuit if it fails to govern pulse length correctly, so that the average output voltage is not truly proportional to input voltage. In practice, this will always be the source of a certain amount of distortion, although a well designed circuit will keep the distortion within an acceptable level.

The main source of distortion in most designs is the residual clock pulse signal and, with inadequate low pass output filtering, this can result in the output signal being modulated by the clock pulse in the manner shown in Fig. 4. On high level signals the distortion is unlikely to be as bad as the diagram implies, although for very low level signals it could be even worse. Fortunately, the frequencies introduced by the residual pulses are all well above the upper limit of human hearing as well as the response of the speakers. Apart from the question of distortion the residual pulse contains r.f. components which can be radiated by the speaker leads, possibly causing r.f. interference with adjacent receivers. The radiation could even cause problems when a Class D amplifier is used with an f.m. tuner. It is therefore necessary to attentuate the residual pulse signal by as much as possible.

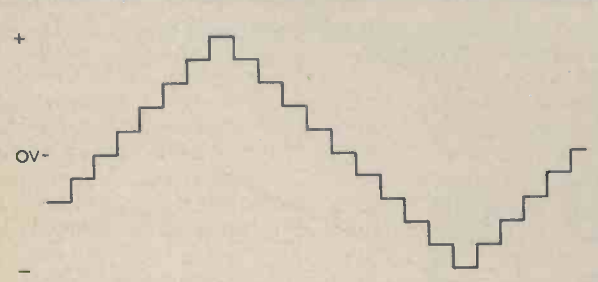


Fig. 4. Inadequate low pass filtering at the amplifier output can allow the clock frequency to modulate the average audio signal, giving a stepped waveform

A well designed Class D circuit has quite low levels of harmonic and intermodulation distortion, and negative feedback can be used in the conventional manner to further improve the distortion performance. The feedback can be taken either from the output via the low pass filter or from the output by way of a separate low pass filter.

PULSE WIDTH MODULATOR

The pulse width modulator can simply consist of a voltage comparator in the basic circuit arrangement of Fig. 5, but there are alternative methods employing a Miller integrator or a monostable. The arrangement of Fig. 5 is commonly employed, though, and is capable of excellent results despite its simplicity.

The clock oscillator must provide a high quality triangular waveform, and this can be readily achieved these days with a function generator i.c. or a discrete component alternative. The clock signal is applied to the inverting input of the comparator and the input signal to the non-inverting input. R1 and R2 bias the non-inverting input so that, under quiescent conditions, it is at the centre of the voltage swing of the triangular wave, as shown in Fig. 6(a). When the triangular wave at the inverting input goes positive of the signal voltage at the non-inverting input the comparator output goes low. Similarly, when the triangular wave is negative of the signal voltage the comparator output goes high. The comparator output is shown below the triangular wave in Fig. 6(a) and, as can be seen, is a square wave with a mark-space ratio of 1:1 when the input signal is zero, i.e. in the quiescent state.

Fig. 6(b) shows what happens when the input signal to the non-inverting input goes positive. The time in the clock cycle when the triangular wave is negative of the input signal voltage increases by a proportionate amount, giving the required increase in the mark-space ratio at the comparator output.

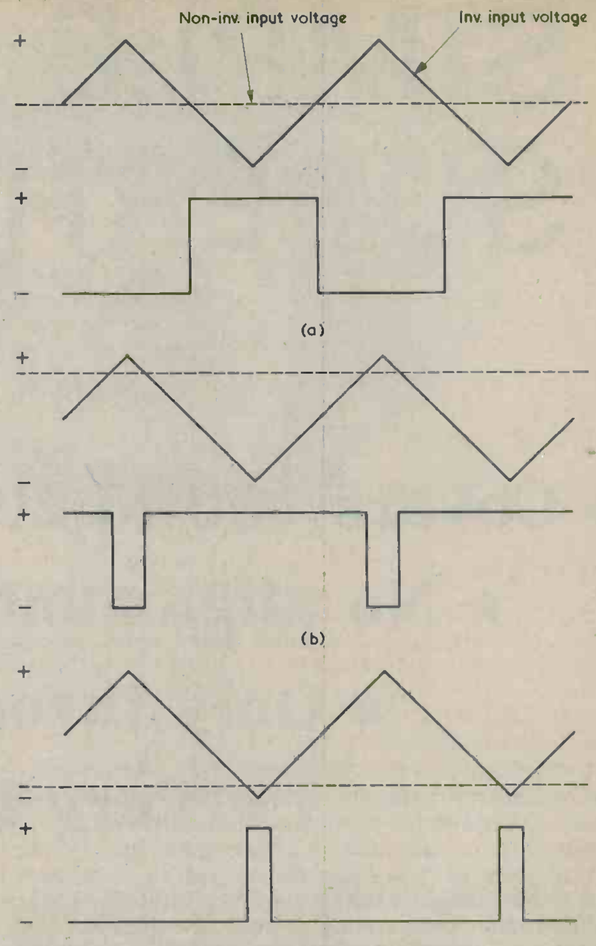


Fig. 6(a). The output pulse train produced by the comparator of Fig. 5 for zero signal input voltage at the non-inverting input (b). The comparator output goes low when the triangular wave is positive of the signal voltage; a highly positive signal voltage thus causes the comparator output to be low for only short periods (c). A highly negative signal voltage results in the comparator output going high for similarly short periods

The input signal goes negative in Fig. 6(c), whereupon the length of the positive pulse at the comparator output is reduced by a corresponding amount. It will be seen that the system produces output pulses at clock frequency having an average voltage which is proportional to the analogue input signal.

THE FUTURE

Class D amplifiers have been rather a rarity up to the present time but, with modern components and circuitry, it is now possible to produce high quality amplifiers of this type and they are likely to become more popular. On current showing they would appear to be more complex and expensive than a simple Class B design of comparable power, but pulse amplifying circuits should be basically easier to design than linear amplifying circuits and the situation could well be changed as development progresses. ■

CMOS C METER — Suggest Circuit

Continued from page 335

capacitance which can be reliably measured with the present technique is being approached.

None of the three curves of Fig 4 are linear. However, they are smooth and reasonably predictable, and should be capable of being drawn up with as few as four plotting points per range.

Constructors employing the capacitance meter should initially make it up and then calibrate it on all three ranges using known capacitors connected to the test terminals. Curves such as those in Fig. 4 are then drawn up, and the results converted to tables for easy future consultation. The radio receiver employed should have a clear and reasonably well marked out medium wave tuning scale, and it is important that the receiver which is used for calibration is also employed for subsequent measurements. This is because there will be variations in tuning scale readings with different receivers. If the receiver to be used has a scale marked in frequency rather than wavelength, then the curves and subsequent tables will, of course, be made up in terms of frequency.

The meter may be assembled in a small plastic case wide enough to accommodate the ferrite rod. The only items required on the front panel are the two switches and the test terminals. The capacitor to be measured is connected to the terminals and the medium wave receiver positioned as described earlier. The receiver is then tuned over the medium wave band until the 1kHz tone is picked up with one of the three ranges switched in. It will be found that the radiation on Range 3 is a little weaker than the radiation on the other two ranges.

Because of the relatively high inductance required of L1 on Range 1 there is a slight possibility that, due to the use of a ferrite rod having a slightly low permeability, some coils wound to the specification of Fig. 2 may still not have sufficient inductance for present requirements. After the meter has been completed it should be switched to Range 1 with a capacitor of between 30 and 50pF connected to the test terminals. The resultant signal from L1 should then be picked up by the receiver at a fairly central setting in the medium wave band. The test capacitor should then be removed, leaving L1 tuned by C1 alone. If the radiation can then be peaked on the receiver at around 200 metres, all is well. Should the signal now be at a frequency just outside the medium wave range of the radio an extra 10 or 20 turns may be added to the coil at the end marked "D" in Fig. 2. The inductance switched in on Ranges 2 and 3 is by no means as critical, and no problems are envisaged here.

■

SIMPLE S.W. SUPERHET —PART 1

By R. A. Penfold

★ Covers 180 to 20 metres
★ No alignment problems
★ Only three transistors
★ Very low battery current

A high quality short wave superhet communications receiver can be both complicated and costly, and many people are probably deterred from buying a ready-made set because of the expense. Constructing one's own receiver allows **considerable savings in cost to be** made, but the building of a complex design is not within everyone's capabilities. The very simple set described here has been specifically designed to enable a beginner to assemble a short wave receiver of reasonably good performance at low cost. The circuit is unusual but it gives perfectly satisfactory results in practice.

The set is powered by its own 9 volt battery, and its output is suitable for high impedance magnetic headphones with a resistance of 2,000Ω or more a crystal earpiece. It needs the usual long wire type of aerial, and an earth connection can also be provided if desired. Denco plug-in coils for Denco Ranges 3 and 4 are used, these covering approximately 1.7 to 5.5MHz (180 to 55 metres) and 5 to 15MHz (60 to 20 metres) respectively. The set is therefore capable of receiving all the low frequency short wave broadcast and amateur bands as well as a good proportion of the high frequency bands. The completed set requires no r.f. and oscillator alignment whatsoever, as separate tuning controls are employed in these circuits. When correctly adjusted, these enable peak sensitivity to be maintained on all received frequencies. The single i.f. transformer employed is supplied pre-aligned and does not require further adjustment for acceptable operation. If the constructor wishes to fully optimise the i.f. tuning, however, a small adjustment to the appropriate i.f. core may be carried out. The procedure is very simple and requires no test equipment. The set receives normal amplitude modulation (a.m.) signals and can also give quite good resolution of morse (c.w.) and single sideband (s.s.b.) signals, both of which are extensively used in the amateur bands.

STAGE LINE-UP

The basic stage line-up of the receiver is shown in the block diagram of Fig. 1. The aerial is coupled to the aerial tuned circuit, which selects the required signal and attenuates those that are removed from it in frequency. The selected signal is next passed to the mixer-oscillator stage. This incorporates a single transistor which oscillates at a

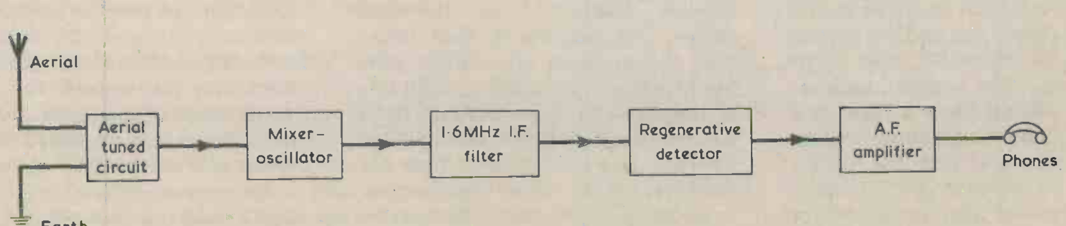


Fig. 1. Block diagram illustrating the stage line-up of the short wave superhet

The use of a ready-made metal case makes the construction of this simple short wave superhet even simpler. Plug-in coils obviate the necessity for a wave band switch

frequency 1.6MHz higher than the signal frequency and which also mixes together the oscillator and signal frequencies. The output of the mixer-oscillator includes the original signal and oscillator frequencies, a frequency equal to the sum of these two frequencies and a frequency equal to their difference. The last frequency is the one which is of importance here and, since the oscillator frequency is 1.6MHz above the signal frequency, the difference is of course 1.6MHz. This is the intermediate frequency (i.f.) for the receiver.

The mixer-oscillator stage does not employ a conventional bipolar transistor circuit. Instead, a dual gate MOSFET device is used with one gate being in the aerial signal circuit and the other in the oscillator circuit. This gives a better performance than is offered by a bipolar transistor circuit and is also less prone to instability.

It is an easy matter to obtain good gain and selectivity with the relatively low 1.6MHz intermediate frequency and this is the reason for using a superhet receiver (as the present type of receiver is known) instead of the simpler type of tuned radio frequency (t.r.f.) set. With the latter, all the gain and selectivity before the detector has to be provided at the reception frequency, which results, in general, in a low level of performance.

The 1.6MHz intermediate frequency next passes through a double tuned 1.6MHz i.f. transformer before it passes to a regenerative detector. Normally, an i.f. filter having only two tuned circuits would not be considered as offering adequate selectivity, but the selectivity provided in the i.f. circuit of this receiver is increased very considerably by the use of a regenerative detector stage in which a positive feedback path is set up by way of the second 1.6MHz tuned circuit in the i.f. transformer. The regeneration also increases the gain at the intermediate frequency to a level which allows good overall receiver sensitivity to be achieved without the necessity for an actual i.f. amplifying stage. The result is a pronounced simplification in the design of the receiver.

The feedback in the regenerative detector circuit can be adjusted by means of a panel control so that it can be taken to a point just below that at which oscillation takes place, and in this condition the receiver is at its most sensitive and selective for the reception of a.m. signals. If the control is taken just beyond the oscillation point the detector oscillation will beat with the signal intermediate frequency to enable c.w. signals to be received or provide a carrier frequency which allows s.s.b. signals to be resolved. The feedback control gives results similar to those obtained with a reaction control in a t.r.f. set.

Some readers may query the choice of an intermediate frequency at 1.6MHz instead of the more conventional frequency of around 470kHz. The 1.6MHz frequency is used because it gives better protection against image interference. When the receiver oscillator is running at 1.6MHz higher than a desired signal it is possible for an unwanted signal 1.6MHz above the oscillator frequency to mix with the oscillator frequency and produce a difference 1.6MHz signal which will also be accepted by the i.f. filter. The unwanted signal is at the "image" frequency for the receiver and is spaced from the required signal frequency by twice 1.6MHz, or 3.2MHz. With an i.f. at 470kHz the image frequency is only 940kHz above the signal frequency. Obviously, an image frequency spaced from the required signal frequency by 3.2MHz can be rejected by the aerial tuned circuit much more effectively than can one spaced away by only 940kHz.

The higher intermediate frequency in a more conventional receiver design would result in a slightly reduced i.f. selectivity and gain. However, these two factors are raised to acceptable levels in the present receiver because of the regenerative detector.

The output from the detector is passed to a standard a.f. amplifier stage, which then feeds the headphones or earpiece.

All in all, this extremely simple receiver offers very good results. There are obviously one or two drawbacks, such as the lack of automatic gain control (a.g.c.) which cannot be incorporated into the circuit. Nevertheless, when operated correctly the set is capable of world-wide reception.

COMPONENTS

Resistors

(All fixed values ¼ watt 5% unless otherwise stated)
R1 1MΩ
R2 330Ω
R3 2.2MΩ 10%
R4 4.7kΩ
VR1 5KΩ potentiometer, linear, with switch S1

Capacitors

C1 100μF electrolytic, 10V. Wkg.
C2 0.015μF type C280
C3 1,000pF polystyrene
C4 330pF polystyrene
C5 270pF ceramic plate
C6 0.01μF ceramic plate or type C280
C7 2.2μF electrolytic, 63V. Wkg.
C8 10μF electrolytic, 25V. Wkg.
VC1 365pF variable, type 01 (Jackson)
VC2 365pF variable, type 01 (Jackson)
VC3 10pF variable, type C804 (Jackson)

Inductors

L1 Miniature Dual Purpose coil, Blue, transistor usage, Range 3T and 4T (Denco)
L2 Miniature Dual Purpose coil, White, transistor usage, Range 3T and 4T (Denco)
L3 10mH ferrite cored r.f. choke (see text)
IFT1 1.6MHz double tuned i.f. transformer type IFT18-1.6MHz (Denco)

Semiconductors

TR1 MEM616 or 40673
TR2 2N3819
TR3 BC109C

Switch

S1 s.p.s.t. toggle, part of VR1

Sockets

SK1 insulated wander socket, red
SK2 insulated wander socket, black
SK3 3.5mm. jack socket (see text)

Miscellaneous

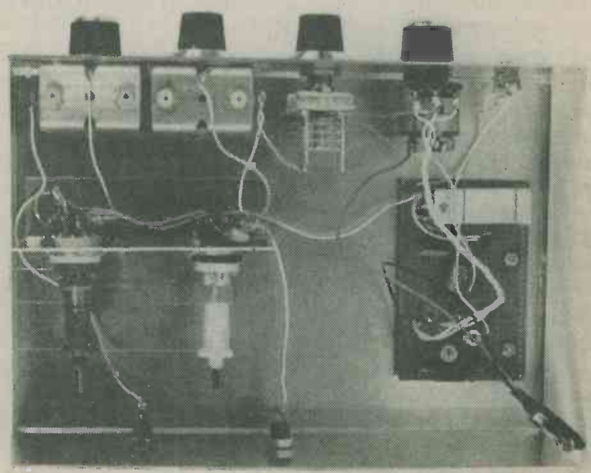
Metal instrument case (See text)
2-off B9A valveholders
9-volt battery type PP3
Battery connector
4-off control knobs
20 s.w.g. aluminium sheet (for coilholder bracket)
Veroboard, 0.1 in. matrix (see text)
High impedance magnetic headphones or crystal earpiece with 3.5mm. jack plug.
Nuts, bolts, wire, etc.

CIRCUIT DIAGRAM

The full circuit of the Simple S.W. Superhet is given in Fig. 2. In this, TR1 is the mixer-oscillator transistor, TR2 is the regenerative detector transistor and TR3 is the a.f. amplifier.

Looking at the circuit in greater detail, L1 is in the aerial signal circuit and L2 is in the oscillator circuit. Both L1 and L2 are plug-in Denco coils, and the numbers alongside the ends of the windings indicate the corresponding pin numbers. The tuned winding of L1 connects to pins 1 and 6, and the aerial is coupled to it via the low impedance winding connecting to pins 8 and 9. Aerial signal tuning is adjusted by VC1. As may be seen, the aerial input circuitry is associated only with gate G1 of TR1. The input impedance at this gate is extremely high, whereupon it becomes possible to connect the tuned circuit to it directly.

The oscillator tuned circuit couples to this second gate, G2, of TR1. Feedback to the tuned winding of L2 is provided by inserting the coupling winding (pins 8 and 9) between the drain of TR1 and the primary of the i.f. transformer, IFT1. There are two oscillator tuning capacitors, these being the high value capacitor VC2 and the low value capacitor VC3. The first is the Bandset capacitor, and is used for bringing the receiver tuning to the centre of the band to be searched for signals. Fine tuning is then carried out by adjusting the Bandspread capacitor, VC3. C3 and C4 are padding capacitors, and their function is to ensure that the oscillator frequency range corresponds with the aerial signal frequency range. C4 is the padding capacitor required by the Range 3 oscillator coil and C3 is the capacitor needed on Range 4. The lower end of the tuned winding is brought out to different pins on each oscillator coil, so that the correct padding capacitor is automatically selected when the coil is inserted in its holder. The values specified for the two capacitors are preferred values which are very close to the values quoted for the coils by the manufacturer. Since the tuning of the aerial and



Apart from the front panel components, nearly all the remaining parts are wired up as two modules. These consist of the coilholder bracket assembly, which is dealt with this month, and the Veroboard panel assembly, which will be described next month

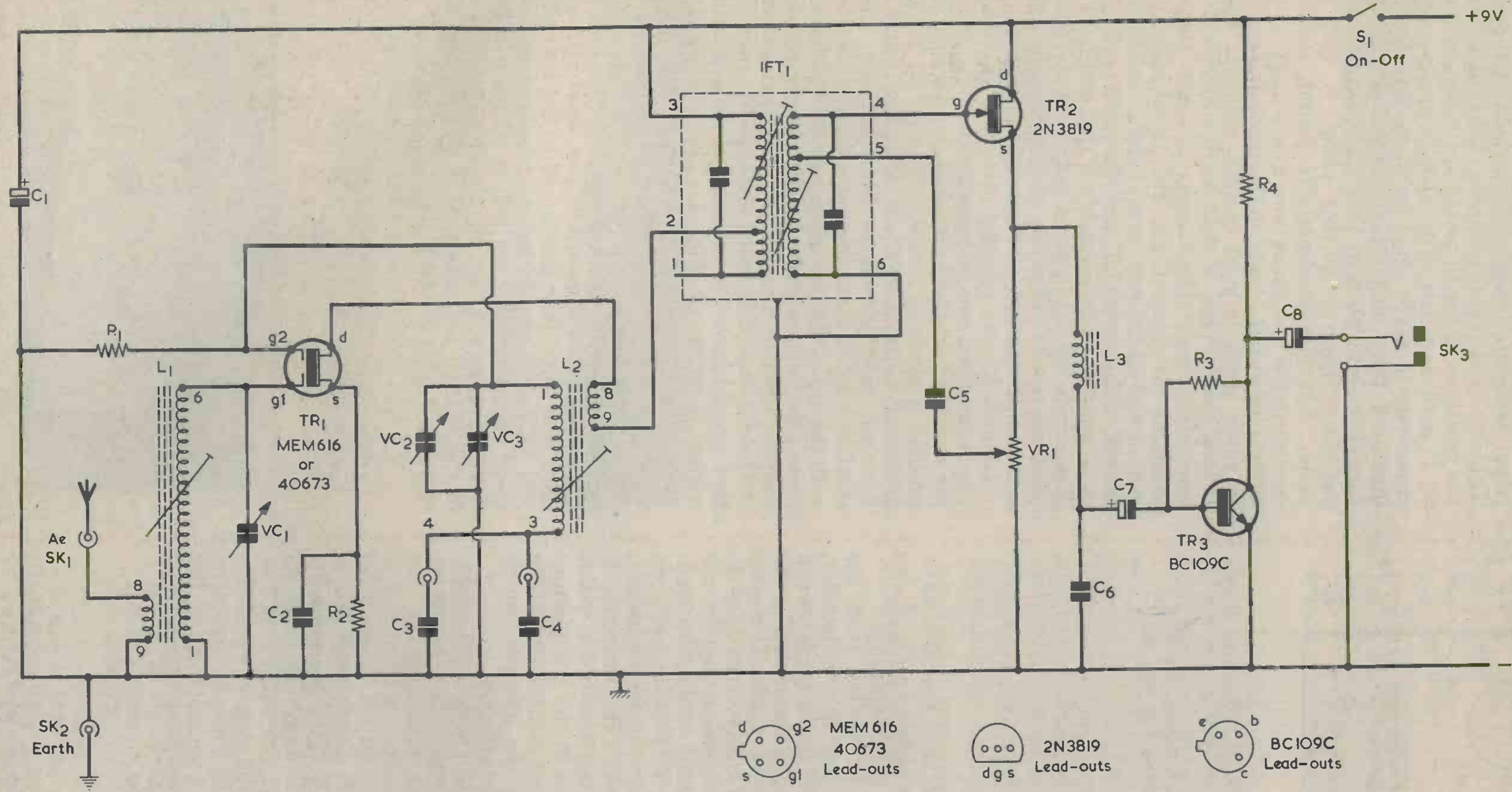


Fig. 2. The circuit of the Simple S.W. Superhet. Although this provides full superhet operation, the components required are minimal

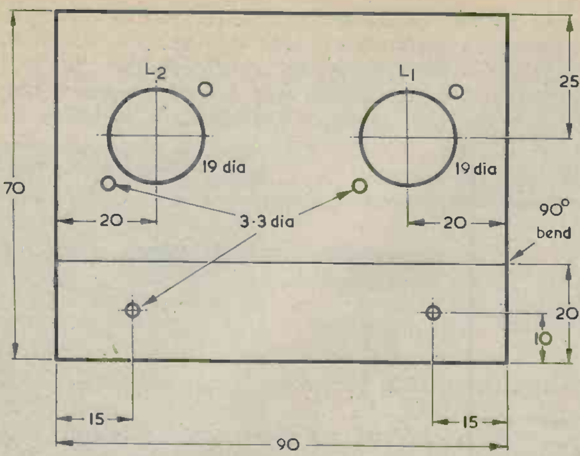


Fig. 3. The coil mounting bracket. Details not shown here are described in the text

oscillator circuits is not ganged there is no necessity to use precisely the manufacturer's recommended values.

Both the aerial and oscillator coils specified have a third winding, which is not shown in Fig. 2. No connections are made to the third winding.

ITF1 selects the 1.6MHZ i.f. output from the mixer-oscillator and couples this to the detector, TR2. The gate of TR2 is biased to the negative rail by the secondary of IFT1 and is connected in the common drain, or source follower, mode. This gives a gain of slightly less than unity from gate to source. The track of VR1 provides a load for the source, whilst a variable amount of positive feedback is provided by coupling VR1 slider back, via C5, to a tapping in the i.f. transformer secondary. Despite the unity gain offered by TR2 the feedback can still be taken beyond the oscillation point because of the voltage step-up in the transformer secondary. The two unmarked capacitors in the circuit symbol for IFT1 are the internal tuning capacitors fitted by the manufacturers.

TR2 provides detection due to non-linear operation, in that it gives greater amplification to one set of half-cycles. The effect is enhanced by the positive feedback, and a detected a.f. output is available at TR2 source. L3 and C6 remove the 1.6MHz i.f. signal, and the a.f. signal is applied to the base of TR3 by way of C7. TR3 is a straightforward common emitter a.f. amplifier, and its collector couples to the phone jack socket via C8.

S1 is the on-off switch, and is ganged with VR1. C1 is the only supply decoupling capacitor required by the circuit. The current consumption of the receiver is about 3 to 4 mA, allowing economic running from the 9 volt battery.

CONSTRUCTION

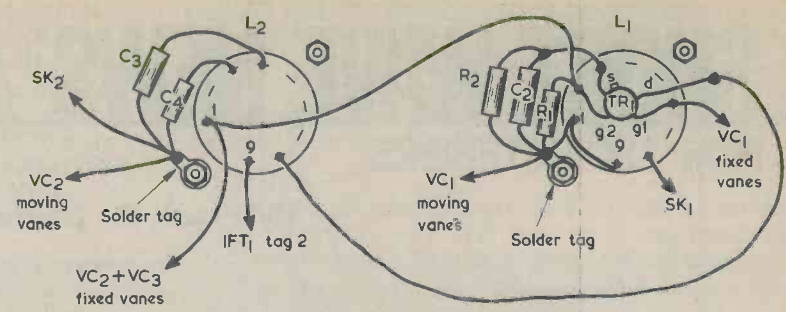
The receiver is housed in a metal instrument case having approximate dimensions of 8 by $5\frac{1}{2}$ by $2\frac{1}{2}$ in. This is a case type BC3, available from Harrison Bros., P.O. Box 55, Westcliffe-on-Sea, Essex, SS0 7LQ. The simple front panel layout can be seen in the photographs. Looking at the receiver from the front the front panel components, from right to left, are VC1, VC2, VC3, VR1/S1 and SK3. VC1 and VC2 are each mounted by means of three short 4BA bolts passing through tapped holes in the front plate of the capacitor. The hole positions may be marked on the front panel with the aid of a paper template having a $\frac{1}{4}$ in. hole in the centre. This is passed over the spindle of the capacitor, and the positions of the three tapped holes are marked on it with a pencil. The 4BA bolts securing the capacitors in place must be short, and their ends must not pass more than marginally inside the capacitor front plate as they will then damage the capacitor fixed or moving vanes. A very much easier, but less mechanically sound, method of mounting the two capacitors is to simply cut out a central hole abut 14mm. in diameter and glue them in place using a good quality adhesive such as Bostik No. 1. They should be mounted with their connecting tags uppermost, so that these are available for connections. The aerial socket, SK1, is mounted on the rear panel behind and slightly to the left of the aerial coil, and the earth socket, SK2, in a similar position behind the oscillator coil. These coils are not in place yet, of course, but their positions can be judged by an examination of Fig. 3 and the photograph of the receiver interior.

L1 and L2 are plugged into B9A valveholders, which in effect now become coilholders, and these are mounted on the bracket shown in Fig. 3. The bracket is made of 20 s.w.g. (or slightly thicker, if preferred) aluminium sheet. After the 19mm. holes for each coilholder have been cut out, the two smaller 3.3mm, mountingholes may be marked out with the aid of the coilholder itself. The 20mm. section at the bottom of the bracket is bent through 90 degrees towards the reader. When mounted, the coilholder tags also point towards the reader, and they should have the orientation illustrated in the wiring diagram of Fig. 4. The coilholders are mounted by means of two 6BA or M3 bolts and nuts each, a solder tag being fitted under the lower nut in each case.

The completed bracket is secured to the base of the metal case by means of two short 6BA or M3 bolts and nuts. It is positioned to the rear of VC1 and VC2, but should not be mounted so close to these capacitors that coilholder wiring will be difficult to carry out. Nor should be positioned so far to the rear of the case that it will be difficult to remove or plug in the coils.

The insulated sockets for the aerial and earth connections are mounted on the rear panel of the case. Precise positioning is not important

Fig. 4. The r.f. wiring around TR1



R.F. WIRING

The r.f. wiring is shown in Fig. 4. This is of the point-to-point variety, and all leads should be kept reasonably short. There is a wire from one solder tag to the moving vanes tag of VC1 and another from the second solder tag to the moving vanes tag of VC2. The two wires are essential if these two variable capacitors are glued to the front panel, and are desirable if the two capacitors are bolted to the panel. The chassis connection to VC3 moving vanes is made by way of its mounting bush and nut. A lead from pin 1 and L2 coilholder passes to the fixed vanes tag of VC2, and a second lead from VC2 connects to the nearer fixed vanes tag of VC3. A lead about 6 in. long can be soldered to pin 9 of the L2 coilholder. Its other end, shortened as necessary, will be soldered to tag 2 of 1FT1 later, after this transformer has been mounted in place.

TR1 is a MOSFET device and should be soldered into circuit with an iron having a reliably earthed bit. Many 40673 and MEM616 devices are fitted with integral protective diodes and are not easily damaged by static voltages. If, however, the device is supplied with a small piece of wire short-circuiting together all the lead-outs, it is advisable to leave this short-circuiting wire in place until all the r.f. wiring has been completed, after which it may be removed. A little care is needed with TR1 lead-outs to ensure that they do not touch each other after wiring has been carried out. Pin 2 of L1 coilholder is used as an anchor tag for the connection to the G2 lead-out. Pin 3 is similarly employed as an anchor tag for the source lead-out. The connection to the drain lead-out is made last, and the joint is not supported by any tag.

On the front panel, the headphone jack socket is to the left. Next to it is the regeneration control, VR1, followed by the bandspread tuning control, VC3, and the bandset tuning control, VC2. The aerial tuning capacitor, VC1 is at the extreme right

COMPONENTS

The full Components List appears this month, although some of the components will not be referred to until the concluding article appears. The Veroboard employed in the receiver has 17 copper strips by 30 holes, and is cut down from a larger size board. The 10mH r.f. choke employed for L3 is the component retailed by Maplin Electronic Supplies. The 3.5mm. jack socket required for SK3 should have an open construction, i.e. it should not be an insulated type. The transistor required for TR1 is available from several suppliers including Ambit International.

NEXT MONTH

In next month's concluding article, further constructional details will be given, these applying mainly to the Veroboard component panel on which the remainder of the circuitry is assembled. The article will also deal with the optional i.f. alignment and the operation of the receiver.

(To be concluded)

Mail Order Protection Scheme

The publishers of this magazine have given to the Director General of Fair Trading an undertaking to refund money sent by readers in response to mail order advertisements placed in this magazine by mail order traders who fail to supply goods or refund money and who have become the subject of liquidation or bankruptcy proceedings. These refunds are made voluntarily and are subject to proof that payment was made to the advertiser for goods ordered through an advertisement in this magazine. The arrangement does not apply to any failure to supply goods advertised in a catalogue or direct mail solicitation.

If a mail order trader fails, readers are advised to lodge a claim with the Advertisement Manager of this magazine within 3 months of the appearance of the advertisement.

For the purpose of this scheme mail order advertising is defined as:

"Direct response advertisements, display or postal bargains where cash has to be sent in advance of goods being delivered."

Classified and catalogue mail order advertising are excluded.

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT   *Frequencies* = kHz

Those elusive signals from the Far East are 'in focus' just now and 'observations' tend to show that it will be a good season for Malaysia, Indonesia and all points East etc. Chinese regional stations are featured on the following page.

● SRI LANKA

Colombo on a measured **4902** at 1913, religious chants on a full-moon day. This is the Home Service 1 in Sinhala and is schedule from 0015 to 0230, 1030 to 1715 but on full-moon days this is extended to 2400. The power is 10kW.

● SINGAPORE

Radio Singapore on a measured **5052** at 1540, YL with identification "This is Radio Singapore" followed by a programme of orchestral music. This is the English Service which operates from 2230 through to 1630 (1700 on Sundays). The power is 20kW.

● INDONESIA

RRI (Radio Republik Indonesia) Banda Aceh, on a measured **4954** at 1543, YL with local-style songs, YL announcer. The schedule is from 2300 to 0015 (Sundays to 0600) and from 0800 to 1600 (during Ramadan has been reported closing as late as 2115) the power is 10kW.

RRI Sorong, on **4875** at 2225, YL with song in Indonesian with local-style orchestral backing, OM announcer. This one has a schedule from 2100 to 2330 and from 0800 to 1400. The power is 10kW.

● SARAWAK

Radio Malaysia, Sibu, Sarawak, on **5005** at 2212, YL with song backed by drums and other local-type percussion instruments. The schedule is from 2200 to 2300, 0400 to 0500 and from 1000 to 1500. The power is 10kW.

AROUND THE DIAL

● BRAZIL

Radio Cultura do Para, Belem, on **5045** at 0259, OM with announcements and identification in Portuguese. Sign-off without the National Anthem at 0301. The close down is sudden, immediately after the announcements — watch the S-Meter drop back when the carrier goes off the air — and then LISTEN CAREFULLY. If you are very lucky, you may hear Radio Altiplano, La Paz, Peru. All other (there are two of them) South American stations also sign-off at 0300 or thereabouts. La Paz has a 24-hour schedule but only broadcasts irregularly, which is a pity. It has, however, been reported by several European Dxers over the past few years. Radio Cultura has a power of 10kW whilst La Paz has only a meagre 1.5kW. Good luck with the Peruvian logging!

● NETHERLANDS ANTILLES

Radio Nederland Relay at Bonaire on **9715** at 0836, OM with news of the Netherlands and the Common Market in the English programme directed to Australia and New Zealand, scheduled from 0830 to 0925. An earlier English programme intended for the same areas is radiated from the Bonaire Relay from 0730 to 0825 on **9715** and in parallel on **9770**.

● PAKISTAN

Karachi on **17910** at 1500, OM with announcements in the World Service Urdu programme intended for the Persian Gulf and Middle East areas, YL with identification. This programme is scheduled from 1330 through to 1600. According to the schedule, the frequencies used for this transmission should be **17640**, **21485** and **21755** but Radion Pakistan frequencies are often subject to variations — to say the least!

● CZECHOSLOVAKIA

Prague on **11855** at 0830, OM with identification in the English programme beamed to Africa, the Far East, South Asia and the Pacific areas. Followed by a newscast and commentary in the Asian and Pacific Service, the schedule of this transmission is from 0830 to 0900 (to 0925 on Saturday and Sunday). The parallel channels are **17840** and **21700**.

● POLAND

Warsaw on **15120** at 1255, YL with identification, OM with a newscast in the English programme for Africa, scheduled from 1230 to 1300 on this channel and in parallel on **9525**, **9675** and on **11840**.

● HUNGARY

Budapest on **15160** at 1050, YL and OM with the English programme intended for Australia, New Zealand and Japan, scheduled here from 1030 to 1100 and also in parallel on **9585**, **9835**, **11910**, **17785** and on **21525**.

● KUWAIT

Radio Kuwait on **21605** at 1148, YL with songs in local-style, OM announcer in Arabic in the Domestic/External Service, scheduled from 0815 through to 1505 on this frequency.

● WEST GERMANY

"Deutsche Welle — the Voice of Germany", Cologne, on **21590** at 1200, OM with station identification and the commencement of the German programme directed to South America, scheduled from 1200 to 1220 on this channel and in parallel on **15245**, **17715** from Cologne transmitter and on **11705**, **11785** and on **15185** from the relay station at Kigali in Rwanda. For QSL card collectors, listen for the English programme to West Africa, scheduled from 1200 to 1245 on **17875** and **21600** from Cologne and on **15410** and **17765** from Kigali.

● BELGIUM

Brussels on **21475** at 1208, OM with a newscast in the Dutch programme for Africa and South East Asia, scheduled from 1200 to 1230 and in parallel on **17740**. This was the programme for Missionaries, radiated on Tuesday, Thursday and Sunday. On Saturdays there is a programme for seamen in Dutch and French on these two channels plus **15210** and **21460**.

English programmes from Brussels are currently broadcast as follows — from 0015 to 0100 to the Americas on **11705** and on **15190**; from 1610 to 1700 to Africa and Northern Europe on **17740** and on **21475**.

● FRANCE

Paris on **21595** at 1310, OM with the French programme for Africa, scheduled on this frequency from 1100 to 1800.

Paris on **21645** at 1313, OM with a talk in French in a relay of the Domestic Service 'France Inter' to North America and the Caribbean, scheduled from 1145 to 1715.

● ISRAEL

Jerusalem on **17630** at 1347, OM with songs, YL announcer in the Domestic Service Network 'B' (in Hebrew) to Europe, the Middle East and North America, scheduled on this frequency from 0400 through to 2310, also being directed to South Africa from 2000.

Jerusalem on **21495** at 1222, OM with a talk about local affairs in the English programme for Europe, the Middle East, South and East Asia, North America, Australia and New Zealand, scheduled from 1200 to 1230 on this channel and in parallel on **7465**, **11655**, **17565**, **17685**, **21575**, **21675** and on **25640**.

● SOCIETY ISLANDS

Papeete, Tahiti, on **15170** at 0325, soft Polynesian songs and lullabies (presumably!), OM with announcements in French. OM news in Tahitian from 0330 to 0340 followed by OM with songs in Tahitian. "Radio Tahiti", France Regions 3, is on the air from 1600 sign-on to 0800 sign-off. The frequencies are **6135** and **9750** (both 4kW) and **11825** and **15170**, the latter channel providing the best chance of reception here in the U.K. The listed power of the latter two transmitters is 20kW. According to the schedule, programmes in French are as follows — from 1600 to 2045, 2200 to 0300 and from 0600 to 0800. In Tahitian from 2045 to 2200 and from 0300 to 0600. In English from 1900 to 1915. When logged here however, as will be noticed from the above timings, some announcements in French were being made at 0329.

● COSTA RICA

Faro del Caribe, San Jose, on **5050** at 0307, YL and OM in English with a programme about English folk songs. Identification at 0322 and again at 0338 with the announcement "Faro del Caribe — Lighthouse of the Caribbean" then a religious programme in English. The schedule is from 1055 to 0400 with the English programme listed as being from 0300 to 0400 but the writer has logged them on other occasions prior to 0300 in English, a recent occasion being on a Sunday morning at 0250. The power is 5kW and they are liable to vary in frequency from that shown up to **5055** at times!

● CHINA

Urumqi, Xinjiang, on **4500** at 1800, chimes when opening, id, OM and YL announcers, "Govorit Peking". This is a relay of the Radio Peking Foreign Service in Russian, scheduled on this channel from 1800 to 2100.

Yunnan People's Broadcasting Station, Kunming, on **4760** at 2210, Chinese opera. This is Yunnan 1, scheduled from 2150 to 0600 and from 0920 to 1600 but the writer has heard them much earlier in our evenings, around 1930, when the signal strength is slowly increasing from a mere whisper — and often on a measured **4761**. Last year they were often operating on **4759**!

Lanzhou, Gansu, on **4865** at 2314, OM with a talk in Chinese. This one has a schedule from 2120 to 0100, 0320 to 0600 and from 1000 to 1600.

Nanning, Guangxi, on **4905** at 2013, YL in Chinese in the Domestic Service 1 Programme, scheduled from 2000 to 2300 and from 1100 to 1735. It relays Peking 1.

Nanning, Guangxi, on **4915** at 2234, OM in Chinese. The schedule is from 2105 to 0005 and from 0845 to 1605.

Hohhot, Inner Mongolia, on **6840** at 2217, OM and YL alternate with announcements (presumably in Mongolian). The schedule of the Inner Mongolia People's Broadcasting Station is from 2145 to 0100, Sundays from 2145 to 0635.

Yunnan, Kunming on a measured **6937** at 2235, Chinese music on piano and flute. The schedule is from 2225 to 0230, 0325 to 0530 and from 1055 to 1605. This is Yunnan 2.

● MONGOLIA

Ulan Bator on **4830** at 2225, classical music on the piano, OM with announcements in Mongolian at 2230. This is the Domestic First Programme scheduled from 2200 to 1500.

● NOW HEAR THIS

Radio Pampas, Pampas-Tayacaja, Huancavelica, Peru, on a measured **4854.5** at 0340, OM announcer in Spanish, YL with ballad, OM with love song. This one may be heard after R.C. do Para, Brazil, on **4855** closes at 0335 (sometimes varies to 0400) usually with 'Anchors Aweigh' and announcements.

"How am I receiving you? Right now pretty sick!"

SAW FILTERS

By
R. J. Caborn

Surface acoustic wave filters, or SAW filters, are fitted in the i.f. stages of the latest Ferguson colour television receiver, model TX9. These devices can replace all the tuned circuits which would otherwise be required in the television i.f. stages, or they may be used in conjunction with a single tuned coil. The advantages are exceptional. With ordinary TV i.f. tuned circuits all the coils have to be manufactured to high standards of accuracy, after which they have to be carefully aligned on the production line to provide the necessary passband response. Furthermore, if the i.f. tuned circuits fall out of alignment in the field, the service engineer has to re-align them with the aid of quite complex and expensive test equipment. Both the problems of i.f. coil manufacture and subsequent alignment are eradicated at one step with the use of a SAW filter, which is manufactured to provide exactly the required response and which needs no adjustment at all during the working life of the receiver in which it is installed.

How does a SAW filter work? It has a length of flat piezoelectric ceramic material with an input transducer arrangement at one end and an output transducer arrangement at the other end. It is basically a four terminal device with two input terminals and two output terminals. The input terminals connect to two sets of thin electrode strips deposited on the ceramic which are interleaved with each other in the same way that you can interleave your fingers, with the difference that the number of electrodes is much greater than the number of your fingers. Signals at the input strips disturb the surface of the ceramic material at the input transducer end and these disturbances then travel along the surface towards the output transducer end in much the same way as waves travel along the surface of a liquid. The output transducer is like the input transducer, and when the disturbances reach the output electrode strips the reverse piezoelectric effects creates voltages in them.

The surface waves travel along the surface of the piezoelectric ceramic at a constant velocity. The i.f. selectivity is given first by arranging the spacing between transistor electrodes such that successive electrodes for one terminal are in phase as the travelling wave passes them at the frequencies it is desired that the filter should pass. The response can then be doctored to the final shape required by judicious control of the length and width of the electrodes. Not an easy process, and it is recalled that work was being carried out on the filters way back in 1971. (See "In Your Workshop" in the issue for May of that year.) Plessey have now overcome the development problems for colour television i.f. applications, and the SAW filter in the Ferguson TX9 receiver is a Plessey type SW153 device. This is housed in a round encapsulation rather smaller than a $\frac{1}{2}$ pence coin.

Unlike tuned circuits, which help to boost the signal, SAW filters incur a loss, but this is to be expected when the mode of operation is considered. In a typical circuit the loss can be of the order of 15dB, or 6 times voltage-wise. This is a mere nothing, with high gain i.c. amplifiers available to recover the loss, when it is compared with the considerable advantages that SAW colour TV i.f. filters provide. ■

EDITOR'S NOTE: For a more extensive treatment of the subject refer to last month's *In Your Workshop*

BACK NUMBERS

For the benefit of new readers we would draw attention to our back number service.

We retain past issues for a period of two years and we can, occasionally, supply copies more than two years old. The cost is 70p inclusive of postage and packing.

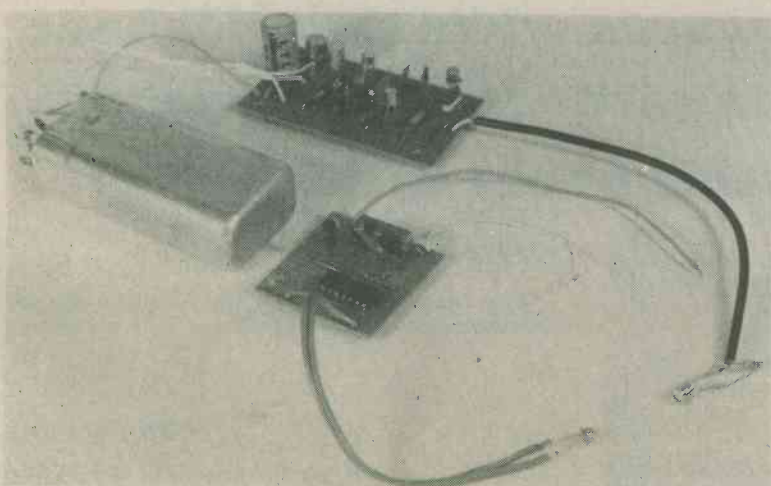
Before undertaking any constructional project described in a back issue, it must be borne in mind that components readily available at the time of publication may no longer be so.

IN OUR NEXT ISSUE

STEREO MIXER UNIT

This Unit mixes high impedance dynamic microphone, and music inputs. With modern i.c.'s it gives excellent performance at a low cost.

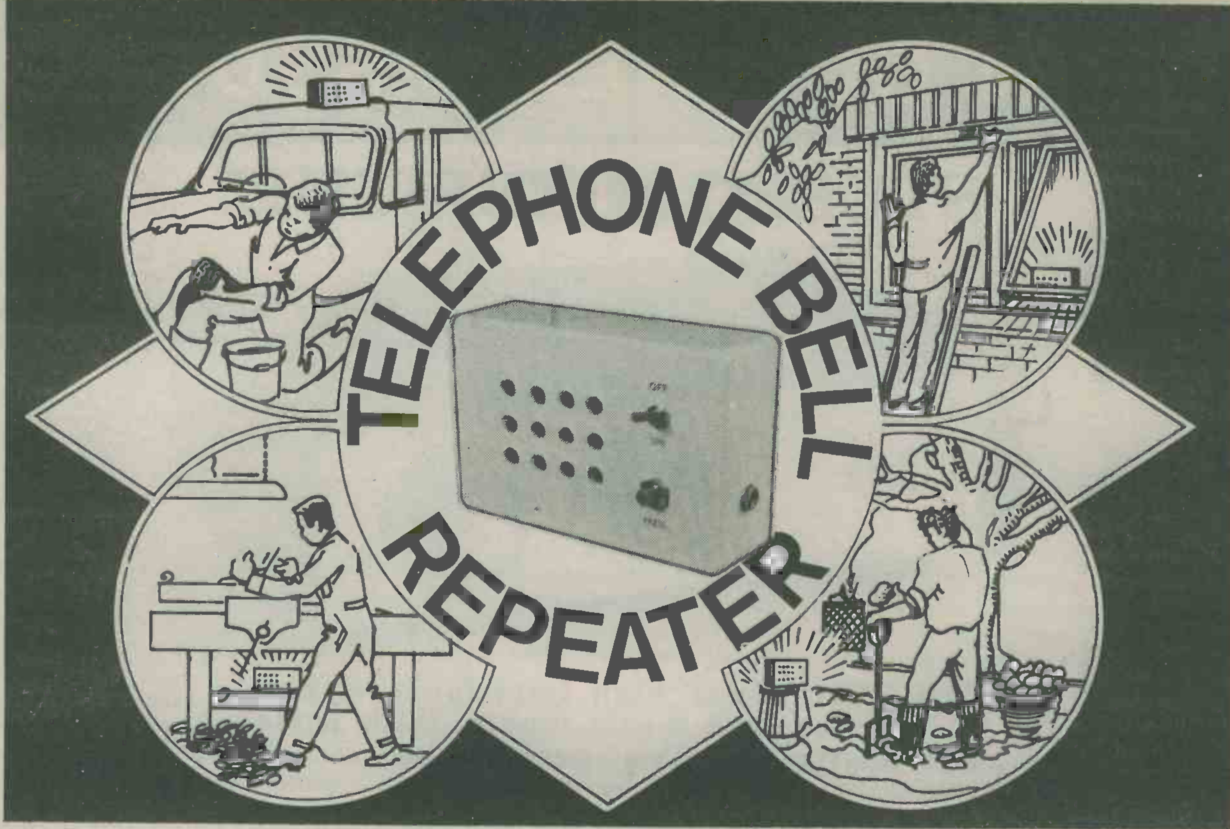
INFRA-RED INTRUDER ALARM



This alarm uses the breaking light beam principle, but in this case the beam is infra-red, and therefore invisible to the human eye. Automatic alarm circuit latching.

IN YOUR WORKSHOP — Questions on Resistors and capacitors for the beginner.
VIDEO A.C. COUPLING — How some black and white TV sets distort picture brightness.
THE 'WATERSPORT' — Part 2 of this popular Medium-Long Wave Portable.
ELECTRONICS DATA — Contact Bounce.
SUGGESTED CIRCUIT — ICM7555 Touch Buttons.

PLUS MANY OTHER ARTICLES



By I. M. Attrill

Remote unit warns when the telephone rings. You can garden happily without missing phone calls.

This simple household device is designed to eliminate the problem of a ringing telephone bell being missed when one is working in an outbuilding or in the garden. Of course, it can also be of value on other occasions when the telephone bell is inaudible for some reason, as occurs when listening to loud music or to a short wave radio using headphones.

The unit consists of a microphone connected to an amplifier and a.f. oscillator circuit via a long 2-way cable. The sound of the telephone bell is picked up by the microphone, amplified and used to trigger on the oscillator, the output of which is coupled to a small loudspeaker. This produces an audible alarm signal which, although less loud than a telephone bell, will still attract the attention of the user because it is in close proximity to him.

A battery powered circuit is used, but this is quite economical to run because the unit has been designed to have a very low stand-by current consumption. Provided the oscillator, when triggered on, is not allowed to run for extended periods, the battery should have a long useful life.

It is necessary to use a microphone to pick up the sound of the telephone bell because, of course, direct connections into telephone equipment are not permitted by the telephone authorities.

OPERATING PRINCIPLE

The block diagram of Fig. 1 shows the general arrangement of the telephone bell repeater. The

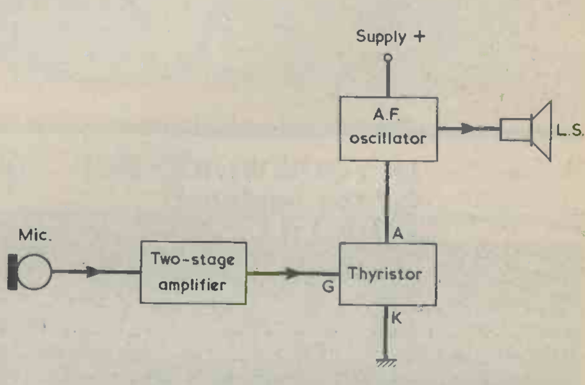


Fig. 1. Block diagram illustrating the basic operation of the telephone bell repeater. The sound of the bell is picked up by the microphone and the amplified signal then triggers the thyristor on, thus completing a supply circuit to the a.f. oscillator

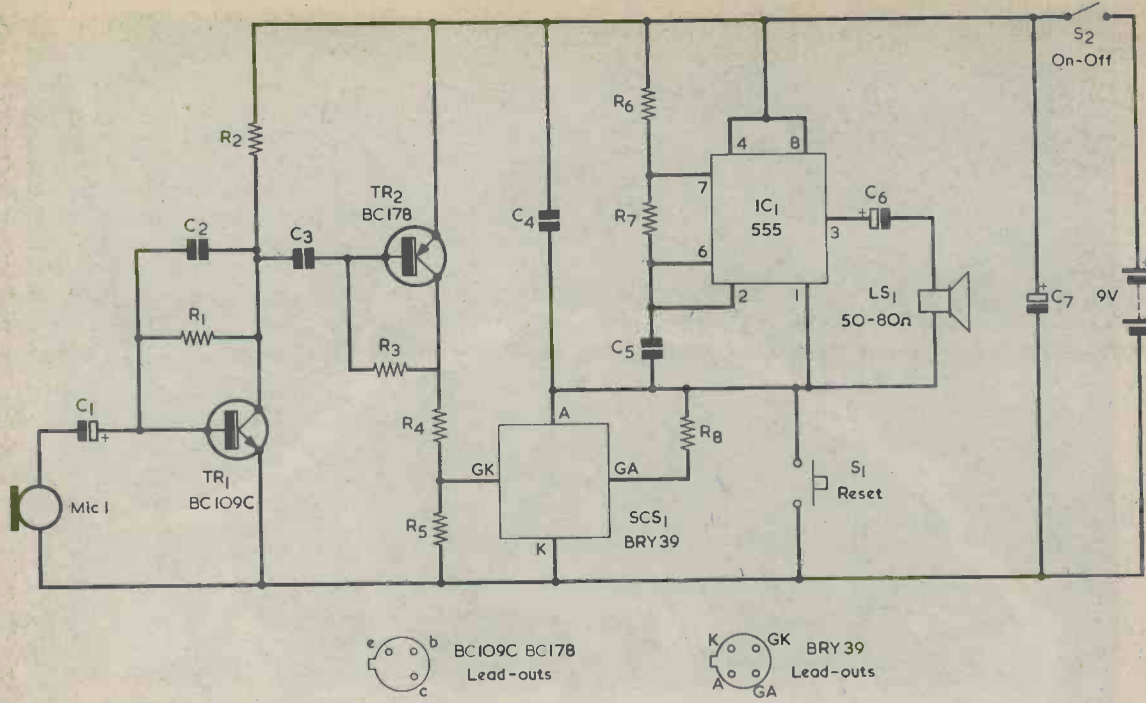


Fig. 2. The circuit of the repeater. The 2-stage amplifier incorporates TR1 and TR2, these feeding into SCS1 which functions as a sensitive thyristor. The a.f. oscillator is given by the 555 i.c. and associated components

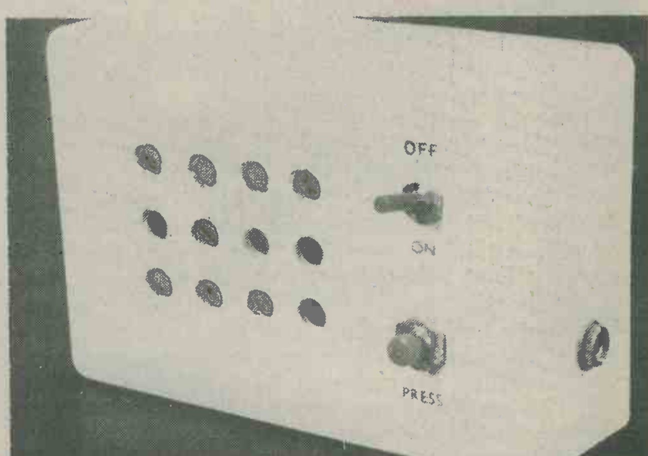
microphone is actually a miniature high impedance loudspeaker, which now functions as an inexpensive moving coil microphone. Even though it can be placed quite close to the telephone bell, the output signal level from it is not likely to be more than a few millivolts. It is therefore necessary to considerably amplify the signal to bring it up to a suitable level for turning on the oscillator, and the requisite amplification is provided by a high gain 2-stage common emitter amplifier.

The output of the amplifier is coupled to the gate of a thyristor. Normally, the thyrisitor is off, but it will be turned on when a positive-going signal half-cycle of sufficient amplitude is applied to the gate. The thyristor will then cause nearly the full supply voltage to appear across the oscillator. Once it has been triggered the thyristor remains turned on until the unit is reset or switched off.

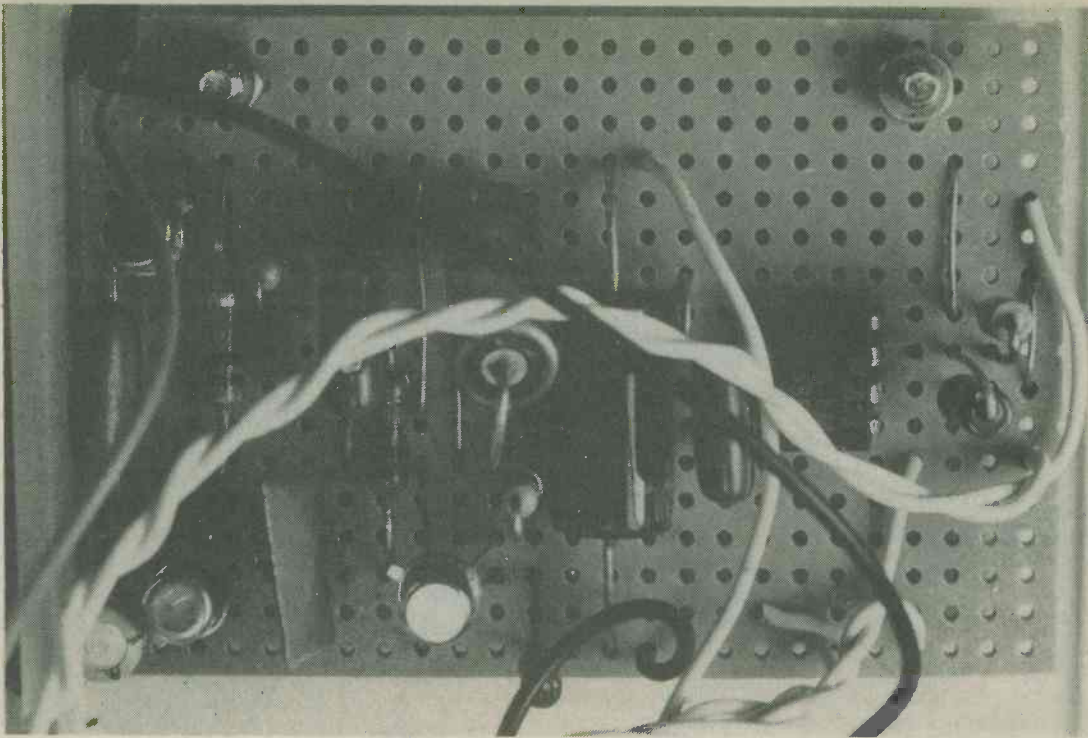
THE CIRCUIT

The full circuit diagram appears in Fig. 2. TR1 and TR2 are in a fairly conventional 2-stage capacitively coupled amplifier, the input signal from the microphone being passed to the base of TR1 via C1, and the amplified output being built up across R4 and R5 in series which provide the collector load for TR2, Both transistors are operated at low collector currents in order that the quiescent current consumption is kept small, thereby allowing economic battery running. The total quiescent consumption of the unit is only about 250μA. C2 rolls off the high frequency response of the input stage to remove the possibility of instability due to stray feedback.

The thyristor is not a 3-terminal silicon controlled rectifier but is, instead, a 4-terminal silicon controlled switch. This is a BRY39 and it has two integrated transistors, one p.n.p. and the other n.p.n., internally connected to form a thyristor type device. The silicon controlled switch has been fully covered earlier in this journal ("Silicon Controlled Switch Circuits" by John Baker in the December 1978 and January 1979 issues) and does not therefore need to be described in detail here. The



Apart from the microphone, all the repeater circuitry is housed in a small plastic case. The microphone connects to the 2-stage a.f. amplifier via the 3.5mm. jack socket on the right-hand side of the case



Assembly is simplified by the use of a Veroboard panel on which are mounted nearly all the smaller components

silicon controlled switch has the advantages of high triggering sensitivity and low hold-on current. It can be triggered by a gate current of less than 1mA, and an anode-to-cathode current of this same level is sufficient to hold the device in the on state. The corresponding figures for most 3-terminal thyristors are about 20 times this level.

In the present application, the GA terminal is not required and it is returned to the anode via R8 to prevent spurious triggering. The GK terminal is driven directly from the split collector load of TR2, the quiescent voltage applied to the gate being below the triggering level of about 0.5 volt. When the telephone bell rings, the positive half-cycles of the amplified signal which appear across R5 take the gate above the triggering level.

The a.f. oscillator which forms the anode load of the silicon controlled switch is a straightforward 555 astable multivibrator. Its frequency of operation, controlled by R6, R7 and C5, is approximately 300Hz. It passes a rectangular output waveform via C6 to a high impedance loudspeaker, producing quite a loud and penetrating sound.

After the unit has given warning that the telephone bell is ringing, it is switched off at on-off switch S2 while the user goes to answer the phone. On his return, the unit may be switched on again at S2. The oscillator may also be silenced by pressing S1, which short-circuits the anode and cathode of the silicon controlled switch, thereby reducing to zero the current which flows through it. The silicon controlled switch will then be off when S1 is released. However, since the telephone bell will still be ringing, the silicon controlled switch will then be turned on once more. The main purpose of S1 is to function as a reset button, and it can be pressed to silence the oscillator if, as may happen, the silicon controlled switch becomes triggered at switch-on.

The main supply decoupling capacitor is C7, with C4 providing decoupling for the 555 section of the circuit. Current consumption when the repeater is sounding is about 30mA.

CONSTRUCTION

An inexpensive plastic box type PB1, available from Maplin Electronic Supplies, is used as a housing for the prototype. This has approximate outside dimensions of 114 by 76 by 38mm. Some constructors may prefer to use a larger 9 volt battery than a PP3, whereupon a larger plastic case will be required to accommodate this and the other components.

The simple front panel layout can be seen in the photographs. Some form of speaker aperture is required, and this merely consists of a matrix of twelve holes about 6 to 7mm. in diameter. The loudspeaker is carefully glued in place behind these holes, using a good quality general purpose adhesive such as Bostik No. 1. The glue should be applied only to the periphery of the speaker, and none must be allowed to get onto the cone or its surround. Be careful to leave sufficient space for the PP3 battery to fit between the speaker and the left-hand side panel of the case. Switches S1 and S2 are mounted on the front panel to the right of the speaker, with S2 above S1. A 3.5mm. jack socket is mounted on the right-hand side panel, and the microphone lead is terminated in a 3.5mm. jack plug for connection to this socket.

COMPONENT PANEL

Most of the components are wired on a Veroboard of 0.1in. matrix having 17 strips by 25 holes. This is a non-standard size and must be cut from a larger Veroboard using a hacksaw. The two mounting holes are then drilled out, after which the six breaks in the copper strips are made. The components and link wires can then be soldered into place. Full details of the board are given in Fig. 3.

Two 6BA clear holes are drilled in the rear panel of the case for mounting the board, and their positions can be marked out with the aid of the board itself. The board is positioned on the right-hand side of the rear panel, behind S2 and S1. The board is finally mounted in place after all the connections between it and the components in the main body of the case have been completed. It is secured by two 6BA bolts and nuts, with spacing washers between the board and the rear panel to give clearance for the soldered connections under the board.

USING THE UNIT

As was mentioned earlier, the microphone connects to the main part of the repeater circuit via a long 2-way cable terminated in a 3.5mm. jack plug. In some locations, where there is little mains wiring, it may be possible to use unscreened 2-way cable but, in general, screened wire is much more preferable as it will prevent spurious triggering due to pick-up of mains hum, mains transients and other noise. The screened wire requires only one lead inside the braiding, and this connects to the tip contact of the 3.5mm. jack plug. The braiding then connects to the sleeve contact of the plug. At the other end the centre lead connects to one tag of the loudspeaker employed as a microphone and the braiding connects to the other tag. Thin flexible screened wire will be quite satisfactory and, since the input circuit is at a fairly low impedance, it can be many metres long.

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 5% unless otherwise stated)
- R1 8.2MΩ 10%
- R2 10kΩ
- R3 8.2MΩ 10%
- R4 1kΩ
- R5 1kΩ
- R6 2.2kΩ
- R7 22kΩ
- R8 100kΩ

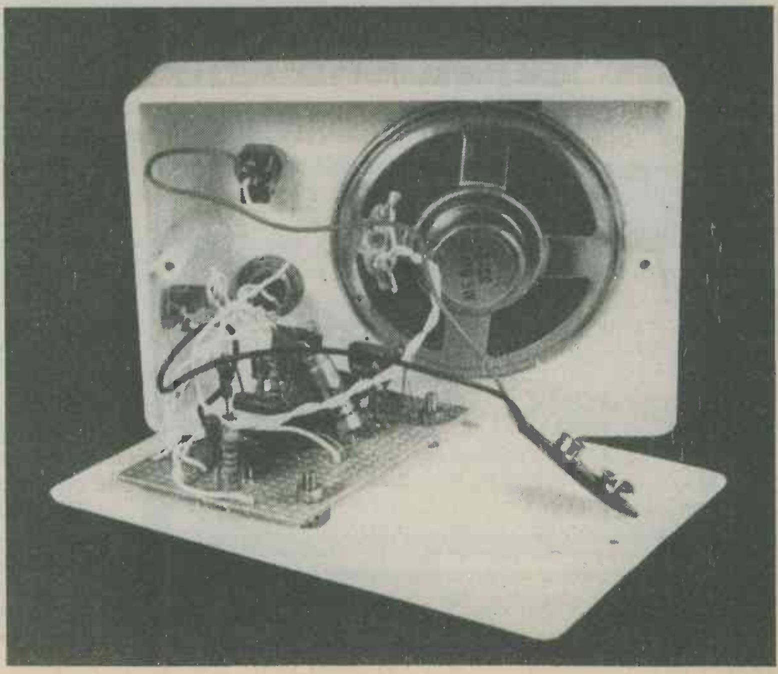
Capacitors
- C1 1μF electrolytic, 63 V. Wkg.
- C2 560pF ceramic plate
- C3 0.1μF type C280
- C4 0.1μF type C280
- C5 0.1μF type C280
- C6 100μF electrolytic, 10 V. Wkg.
- C7 100μF electrolytic, 10 V. Wkg.

Semiconductors
- IC1 555
- SCS1 BRY39
- TR1 BC109C
- TR2 BC178

Switches
- S1 push-button, press to make
- S2 s.p.s.t., miniature toggle

Transducers
- MIC1 miniature loudspeaker, 50 to 80Ω
- LS1 miniature loudspeaker, 50 to 80Ω

Miscellaneous
- Plastic case type PB1 (see text)
- Veroboard, 0.1in. matrix
- 3.5mm. jack socket
- 3.5mm. jack plug
- 9-volt battery type PP3 (see text)
- Battery connector
- 2-way microphone cable (see text)
- Nuts, bolts, wire, etc.



The Veroboard is bolted to the lid of the plastic case, which now becomes the rear panel of the housing. The board should take up the position illustrated here

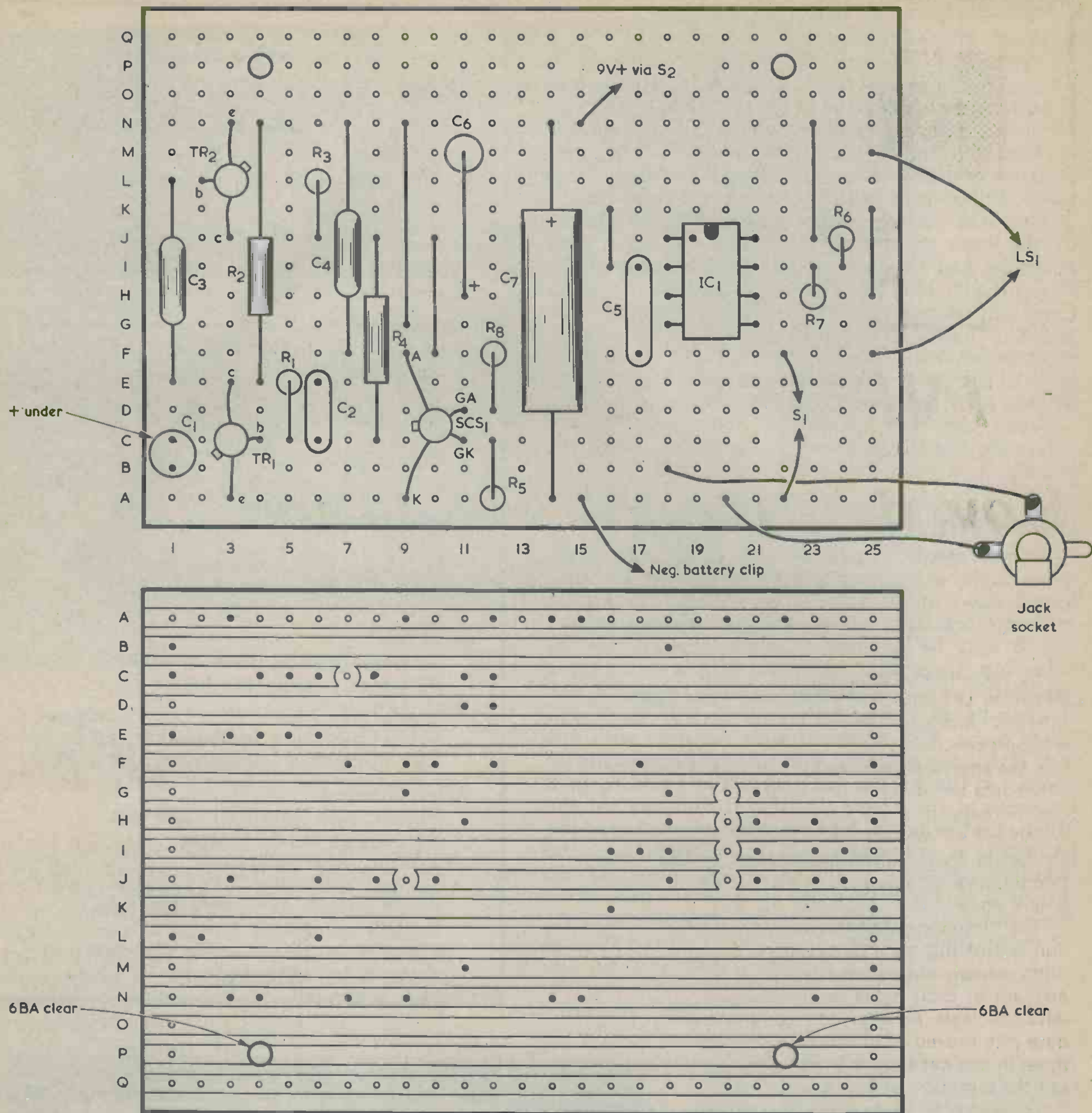
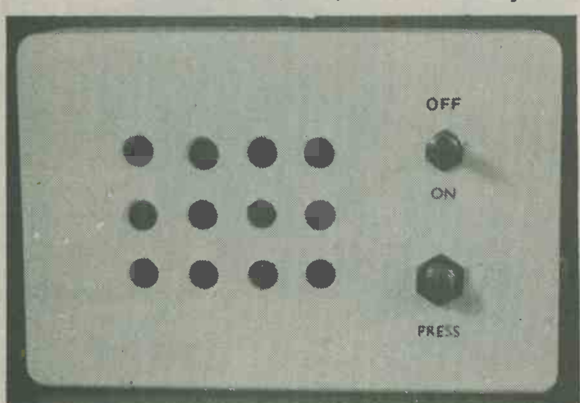


Fig. 3. The layout of components on the Veroboard panel. The microphone couples to the panel by way of a 3.5mm. jack socket, which is viewed here from the rear



The speaker aperture consists of a matrix of 12 holes. To the right of this are S2, above, and S1, below

The loudspeaker acting as the microphone should be mounted in a small case of its own, if only to protect its delicate cone. An aperture in the case will be required so that the sound waves from the bell can reach the cone, and a simple matrix of holes, as used on the main part of the repeater, may be drilled. The unit should be found to trigger reliably with the microphone positioned anywhere within some 300mm. of the telephone, but to be on the safe side it is advisable to place it right next to the telephone.

If the oscillator should happen to trigger on when the repeater is initially switched on, it may be silenced by momentarily pressing S1. ■

DATABUS series No. 7

really explains microprocessors

By Ian Sinclair

INPUTS AND OUTPUTS

How data is entered into and acquired from the microprocessor

So far, all the data bytes we've mentioned have been stored in program, for IMMEDIATE loading, or in data memory spaces, usually RAM. This is fine if the microprocessor is being used just to crunch numbers for fun, but any useful application of a microprocessor will involve data being fed in, perhaps from a keyboard, and fed out, perhaps to a display of some sort or to thyristors which will switch motors on. The data might equally well be fed in from a transducer of some sort, perhaps a temperature or distance measurement converted into binary code.

The arrangements that are made for shifting data into and out of the microprocessor system are called in/out ports, usually abbreviated to I/O. Since data is moved in and out in 8-bit bytes, a port must have at least eight data terminals. An alternative arrangement is to have the data bits moved in or out of a port serially — one at a time. In this case, there is only one single in/out terminal, but the bits have to be entered into or clocked out of an 8-bit register so as to assemble or dismantle a complete byte for the CPU.

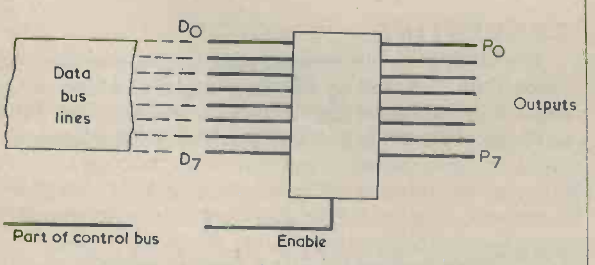


Fig. 1. A simple port. The output lines are connected to the data lines of the CPU when ENABLE is at logic 1. A simple octal latch can be used in this way. The next stage of complexity is to use a 2-way latch, so that inputs or outputs can be connected

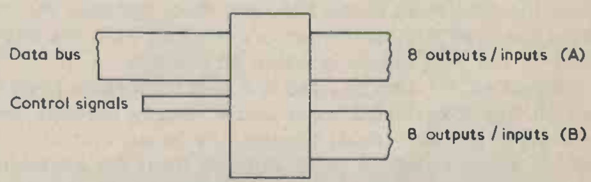


Fig. 2. A more complex port. This example has two sets of output/input lines and a set of control lines which allow programming as inputs or outputs on each set of IN/OUT lines

DESIGN VARIATIONS

The ways in which different types of CUP deal with inputs and outputs vary considerably from one design to another. The Fairchild F8, for example, has two 8-bit I/O ports on the CPU chip. These take up sixteen pins which replace the normal sixteen pin address lines that are used on most other CPUs — the F8 has no built-in memory addressing on the CPU, all the memory addressing is done by another chip which also contains the ROM program. A much more usual method is to connect an I/O port chip to the address bus lines and the data bus lines. The I/O port chip, usually known as PIA (Peripheral Interface Adaptor — how these people love long names!) is a massive chip, the same size as the CPU and also using 40 pins. For its action each part of the PIA has to be addressed, just as if it were a memory location, and in addition the CPU has to send a coded signal to specify whether the port is sending data out or taking it in. All of this must be done under program control, which is why a monitor program in ROM is always needed for any CPU. The stages of a simple input/output would be something like this.

First of all, the program would have a read-from-memory instruction, which would be followed by the address of the PIA port, or a displacement number which can be added to the program count or to the number in an index register to instruct the CPU to put out the correct address on the address bus lines. Because the in-

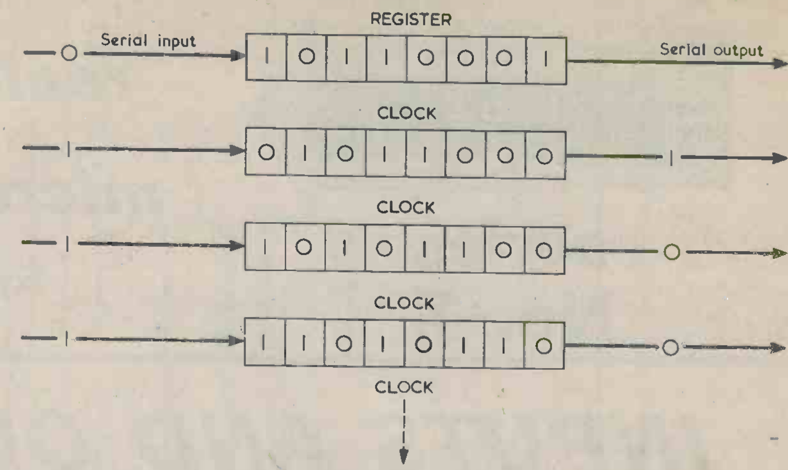


Fig. 3. Using a serial shift register as a serial IN/OUT port

struction is a read-from-memory instruction, the PIA will also have received a signal which gates its circuits to read data bits in. The byte which is on the port input lines will then be transferred to the accumulator register of the CPU, just as if it had been read out of memory. To feed this byte out again through another port, the program has to continue with a write-to-memory instruction, followed by the address of the port which is being used as the output. The data byte in the accumulator is then passed out over the data lines to the PIA, and then, because the instruction was a write-to-memory one, out from the eight pins of the port which is being addressed.

When a CPU is to be used in a microprocessor system which has a keyboard input and a display readout, the operating program must contain the in/out instructions which allow numbers to be entered from the keyboard into the accumulator, and also instruct the accumulator to transfer a byte out to the display. Unless this part of the program is repeated each time a key is pressed, no numbers can be entered, and no display will be seen. Part 8 will go into more details of the most common method of connecting keyboards and displays to the CPU.

IN/OUT LATCHING

Precisely what happens depends very much on the design of the In/Out chip. Many of these chips contain latching so that, for example, when a microprocessor CPU writes out a byte, that byte is stored at the port until cancelled. If we connect the pins of the output port to a set of l.e.d.'s then the l.e.d.'s will remain lit in the pattern of the byte (lit for 1, out for 0) until another different byte is delivered to the output port. Similarly at the input, a byte from the keyboard is held stored at the In/Out chip until a new key is pressed. In all cases, the program of the CPU decides when an output is transferred to the output port, or when an input is taken from the input port.

Several types of I/O port use only a few address lines, and rely on the chip select signals from the CPU to ensure correct addressing. A few CPUs reserve certain address numbers exclusively for I/O ports, some types of CPU must therefore use only the PIA chip which is designed to fit them — such a chip is called a "dedicated support chip". Other varieties of CPU have practically no dedicated support chips, and the user is free to select PIAs made by any manufacturer, provided that the necessary operating signals can be obtained to operate the PIA correctly. When adjustments have to be made they usually take the form of some logic gates which are needed to select the chip or correct the addressing.

Not all IN/OUT signals are in the form of 8-bit bytes, however, as we indicated earlier. A simple example is the recording of a program on tape. Unless you happen to be using an 8-track tape recorder, parallel 8-bit outputs are of very little use to you. What is needed is a method of delivering each byte one bit at a time, a serial output. For reading the program in tape form again, a similar serial input is needed. When a signal is converted into serial form it can be transmitted down a single line, instead of needing the eight lines of a parallel output data bus. Serial operation makes it possible to carry digital information along telephone lines, into TV receivers, and to and from tape recorders.

Any shift register will convert from parallel to serial, or serial to parallel, provided it has the necessary inputs and outputs brought out to pins; all that is needed is a method of clocking all the flip-flops of the register. Fig. 3 shows an example of this, loading a register from serial bits or unloading it to a serial output.

CONVERTING

Converting is the easiest part of the exercise, but it takes time. To load or empty a register which contains eight bits will need eight clock pulses into the register (and not every clock pulse of the CPU will be used for the

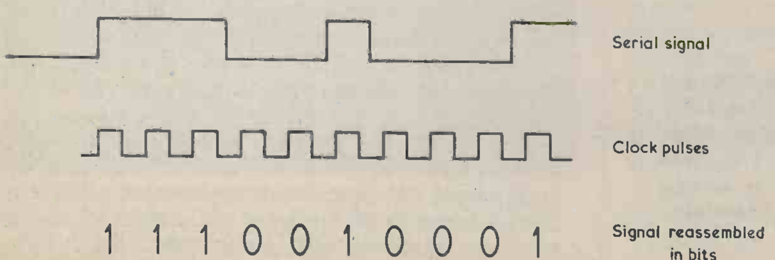


Fig. 4. Using the clock pulses to separate the bits in a serial signal

register) and the CPU must not use this register for any other purpose while loading or unloading is taking place. This problem is nearly solved in the INS 8060 (SC/MP) by providing the serial IN/OUT on the CPU itself. The register which is used is called the extension register and, since a data byte has to be copied from the accumulator into this extension register and then fed out bit by bit under program control, nothing else can upset the loading or emptying of the register. In general, whether the serial/parallel conversion is done in the CPU or by a separate chip, the conversion is under program control.

The next problem is that converting from parallel to serial results in a continuous string of bits coming along one single line. How do we know which bit is the start of

TRANSMISSION SYSTEMS

In a synchronous transmission system the serial output operates all the time, sending out a byte for each eight clock pulses whether there is any data present or not. If data is being clocked out of a register these data bytes are sent out, but if there is nothing to send the signal consists of a "dummy" or "sync" byte which gates the receiver off. Similarly, if such a signal is input to a CPU system, the PIA does not pass the sync bytes to the CPU — if it did, each sync byte would be treated as a number in the usual way. Each transmission of data in a synchronous system starts with two sync bytes (in the commonly-used ASCII code this sync byte is 01101001) and at the receiving end of the serial signals two of these

Fig. 5. Synchronous transmission — bytes are transmitted continually, even when there is no data to transmit. Sync bytes are used to fill the spaces between data bytes

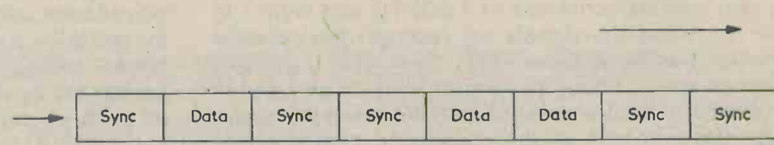


Fig. 6. Asynchronous transmission. Each string of bits is more than a byte long and contains start, stop and parity bits

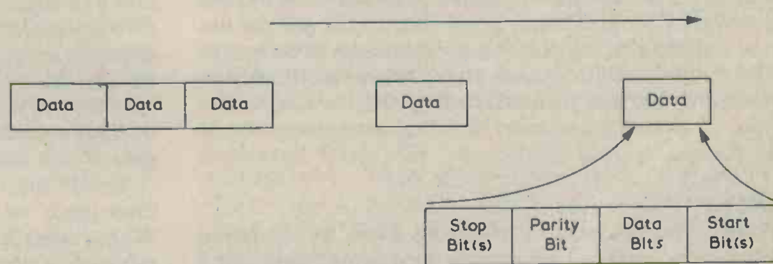
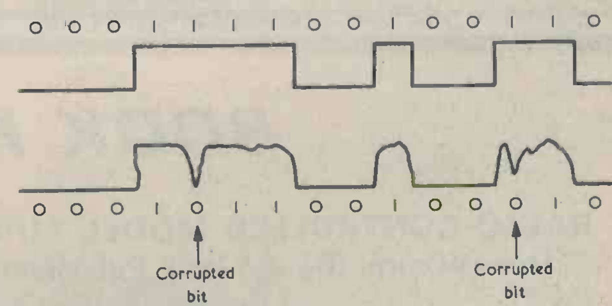


Fig. 7. How tape drop-outs can cause bits to be changed from 1 to 0. Changes like this are referred to as corruption of the signal



a word byte and which is the end? How do we know whether a given pulse is a single 1 bit, two together, or more? The second problem is comparatively easy to solve by using the clock pulses as a guide. If the serial output is high for the time of three clock pulses, then it consists of three 1 bits in a row; if the output is low for two clock pulses, it consists of two 0 digits together. Using clock pulses to gate the serial information thus breaks up the stream into bits which are identified as 1 or 0.

The first problem is not so easy to solve, especially as bits may go missing (for example, because of tape drop-outs) or be added (for example, noise pulses) to a serial stream of pulses. Different methods of dealing with the problem are used according to the way in which the serial data pulses are transmitted — synchronous or asynchronous.

bytes signal that data will be arriving.

Asynchronous transmission is not continuous; the bytes are sent along the line only when there are data bytes to send. In this type of transmission each byte has to be identified by signal bits, one or more start bits (logic 0) at the beginning of each byte, and one or more stop bits at the end. At the receiver, gating has to be able to identify the start bits(s), count out the data bits, and then shut off when the stop bits(s) arrive(s).

In addition to all this, the signals may need still further processing. We use special codes for serial transmission, not the binary code which is used for all the number crunching in the CPU, and some conversion may be needed. In addition, we can't record a string of data bits onto tape without losing a few bits due to drop-outs, and the risk of loss is greater when a lot of 1 bits occur

Fig. 8. Parity. The parity bit is added to a signal byte so as to make the number of 1's in the signal add up either to an even or an odd total, depending on whether even or odd parity is being used. This enables a single fault in a byte to be detected

Signal byte	Parity bit (even parity)	Parity bit (odd parity)
1 1 0 0 0 1 0 0	1	0
0 1 1 1 0 0 1 1	1	0
1 1 0 1 0 0 0 1	0	1
0 1 1 0 0 1 0 1	0	1

together (Fig. 7). For tape recording the logic signals are usually converted into tone signals. For example, the logic zero may be converted to 1,200 Hz and logic 1 to 2,400 Hz; when the signals are replayed the opposite conversion has to be done.

How do we go about it? To start with, some types of CPU will have dedicated serial/parallel converter chips, making the first part of the conversion comparatively easy. For example, the 8080 CPU (Intel) has a corresponding 8251 "communications interface" chip which will carry out either synchronous or asynchronous conversion. This chip is selected by a chip-select signal, and a one-byte program instruction is needed to select what job the chip must carry out. The program instruction will, for example, specify at what rate the serial bits are to be handled, the number of bits in each coded character (from 5 to 8 according to the type of coding that is used), the number of stop bits and start bits, the synchronisation, if used, and parity.

PARITY

Parity? That's a way of detecting a lost or unwanted bit. When we send out a byte, the number of 1 bits in the coded character may be odd or even. The most popular code for serial transmission uses seven bits for each character, and the eighth is a "parity bit". This parity bit is set so that there will be an even number of 1's in the byte — a system called even parity. When these bytes are played back, gates count the number of logic 1's, and test for parity — even or odd. A single missing or unwanted bit will cause the parity to be wrong. We can't of course correct the byte, because the circuits can't decide which bit is the wrong one, but at least the grouping of the bits into bytes is not upset.

Quite a lot of CPUs have no dedicated chips for this job, so that we need to use a general-purpose one called a UART (Universal Asynchronous Receiver/Transmitter). Similarly if we want to code the serial signals for tape recording, we use a MODEM chip (Modulate/Demodulate). How we connect these up depends very much on the design of the particular chips as well as on the design of the CPU; it boils down to reading the manufacturer's literature rather carefully and making enquiries to their applications department — but only if you are a manufacturer yourself!

So far, we've assumed that each input and output will take place whenever the program decides that it will. What happens if a signal is put in at a time when the program is not ready for it? That's an interrupt, and it will be described in detail in Part 8.

(To be continued)

BOOK REVIEW

RADIO CONTROLLED MODEL AIRCRAFT. By Adrian Vale. 191 pages, 210 x 140mm. ($8\frac{1}{4}$ x $5\frac{1}{2}$in.). Published by Gresham Books. Price (U.K. only) £4.25.

Adrian Vale is a very active radio control enthusiast and runs one of the largest specialist R/C model shops in Britain. After launching his business he soon discovered that much of his time was being taken up in offering advice to newcomers to the hobby, whereupon he produced his own beginner's guide in booklet form. This booklet, which ***Aeromodeller*** magazine stated "should be compulsory reading for the non-modeller", went through many editions reflecting the author's continuing experience, and it now appears, expanded, updated and illustrated, in its present published form.

The book is packed with common-sense practical advice for anyone starting from the beginning in radio control, and introduces the reader to elementary aerodynamics as well as to the necessity for ***learning*** to control a model aircraft if it is not to fly itself disastrously into the ground. Engines, fuels and propellers are also dealt with in addition to radio control itself, and the book devotes several pages to legal matters including the obtaining of a radio control licence and insurance. The text is accompanied by photographs and cartoons by "Raf".

The book will be found to be of considerable use to the beginner in R/C aero modelling, and its well written and often humourous contents amply demonstrate the enthusiasm and expertise of its author.

AUDIO DELAY LINE

By I. M. Attrill

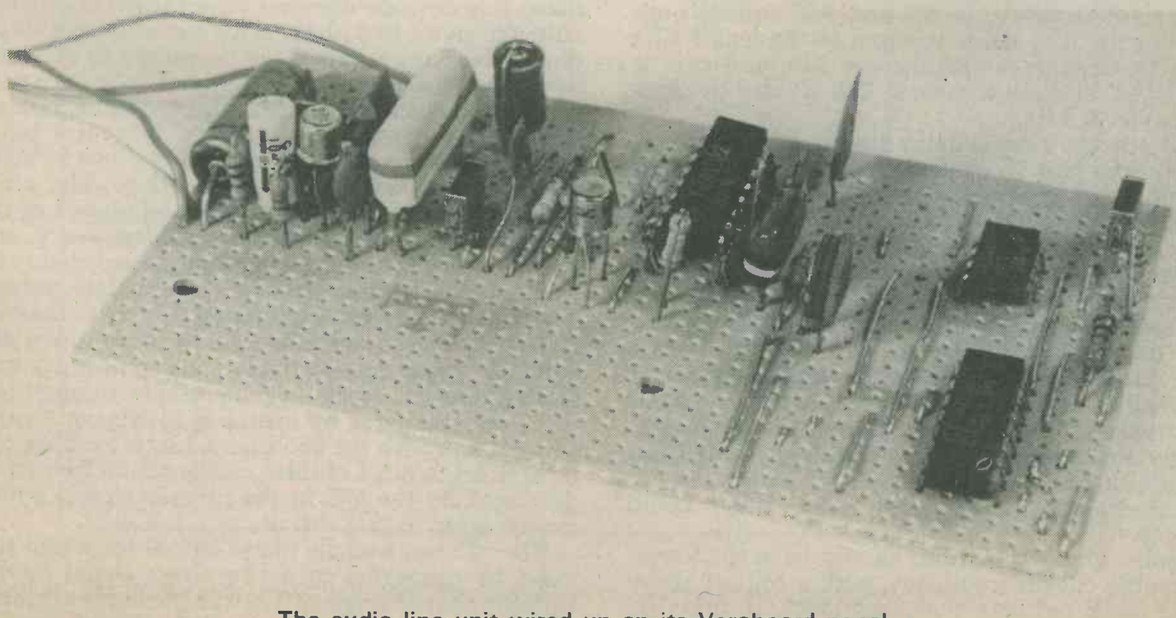
"Bucket Brigade" i.c. gives delay for entire audio spectrum

Fairly recently introduced integrated circuits are the "bucket brigade" delay lines, and these offer numerous possible applications to the electronics experimenter. More correctly known as charge couple devices (c.c.d.) or charge transfer devices (c.t.d.), they enable signals covering the full audio bandwidth to be delayed by a few milliseconds with little loss of quality. The signal is delayed purely by electronic means, and there is no need for mechanical or electro-mechanical components such as spring lines or tape loops.

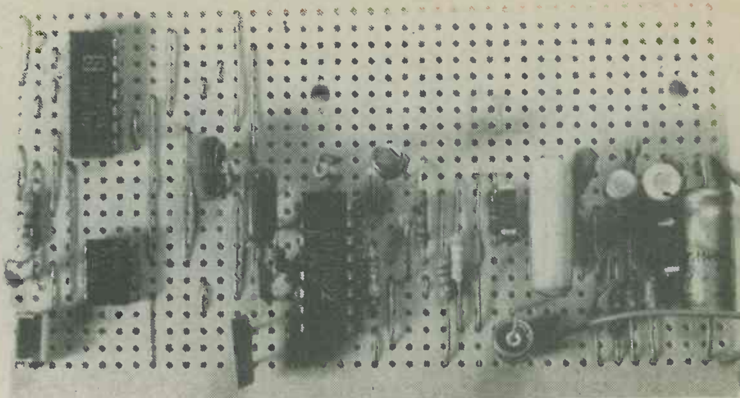
BASIC PRINCIPLE

The basic method by which the delay line i.c. operates is relatively simple, and it relies upon an electric charge being fed along a series of capacitors. This is analagous to buckets of water being passed along a human chain, hence the use of the term "bucket brigade".

The device is controlled by a clock oscillator, and the operating frequency of the clock determines how often the input signal amplitude is sampled by an input gate and capacitor and how often the sampled charges are fed through the device to the output. Obviously, it is not possible for the capacitors in the delay line to pass their charge to the following stage whilst simultaneously receiving a charge from the preceding stage, and so it is necessary to have anti-phase clock signals. One clock phase controls the odd numbered stages (first, third, fifth etc.) whilst the other clock phase controls the even numbered stages (second, fourth, sixth, etc.). Thus, the delay line is arranged so that on one clock half-cycle the even stages are switched to pass on their charges to the odd stages, whilst on the other half-cycle the odd stages are switched to pass on the charges they have just received to the even stages. The charges therefore move one stage



The audio line unit wired up on its Veroboard panel



Looking down on the Veroboard panel. This accepts the components comfortably without excessive crowding

down the line for every clock half-cycle.

The time taken for an input sample to be passed right down the delay line depends upon the clock frequency and the number of stages in the line. The delay line device employed in the present project has 513 stages, although it provides only 512 stages on delay. The function of stage 513 is to maintain the output when stage 512 is switched to receive the charge from stage 511 and is not itself providing an output. Mixing the outputs from stages 512 and 513 provides a continuous output signal, apart from a small and insignificant glitch as the clock signals change state.

It is the clock frequency which is set up to give the desired delay time, and most delay line devices will work using clock frequencies lying between a few kHz and more than 500kHz. However, if the output signal, after the appropriate delay, is to be a good copy of the input signal, it is obviously necessary for the input to be sampled a number of times during each cycle at the highest input frequency. In practice this makes it necessary for the clock frequency to be at least more than twice the maximum input frequency and, ideally, at least three times that frequency. If the full audio bandwidth is to be delayed, minimum clock frequency should be 40kHz or, preferably, 60kHz. With a single delay line device these frequencies correspond to delays of 6.4 and 4.27 milliseconds respectively. The delay is equal to the length of a single clock cycle multiplied by 256, and can be calculated, in milliseconds, as 256 divided by clock frequency in kHz.

The output from a delay line is a stepped frequency and can be looked upon, roughly, as the original input frequency modulated by the clock frequency. This gives a reasonably acceptable audio output as the clock signal will normally be well above the upper frequency limit of human hearing. But the output signal will be improved if the clock frequency can be filtered out as it could have undesirable effects on the equipment into which it is fed (heterodynes in tape equipment, overloading of tweeters in loudspeakers systems, etc.) and so it is normal to remove the clock frequency at the output of the delay line. The output filtering also attenuates the clock switching glitches and the audio background noise these could produce.

Ideally, the output filter should have the lowest acceptable cut-off frequency, with a roll-off above this of 36dB per octave or even more. In practice, when the clock frequency is not much lower than about 70kHz, a filter having a much lower roll-off rate will give adequate results, with considerably simplified circuitry as a result.

Again, a high slope top cut filter should be used at the input, to remove frequencies which could react with the clock frequency and give audio frequency products at the output. However, it is possible in most instances to obtain good results with relatively uncomplicated input filtering whereupon, once more, circuitry can be considerably simplified.

THE CIRCUIT

There are three delay line i.c.'s available to the amateur user at the time of writing, and the one employed in the unit described here is the TDA1022. This was chosen since it is the least expensive and is the most readily available device. It may be obtained, for instance, from Maplin Electronic Supplies. In passing, it may perhaps be mentioned that the other delay line i.c.'s are the SAD1024 and the SAD512, both of which have n. channel MOSFET circuitry. The SAD1024 has two delay lines whilst the SAD512 has a single delay line. The TDA1022 uses p. channel MOSFET circuitry and contains a single 512 stage delay line.

The complete circuit of the delay line unit is given in Fig. 1. The TDA 1022, like other current delay line devices, does not have the necessary circuitry to give a two-phase clock signal from a single phase clock input, and it is necessary to generate the anti-phase signals externally. The mark-space ratio of the clock signal does not need to be precisely 1:1, or even particularly close to this ratio, but it does need to have a peak-to-peak amplitude virtually equal to that of the supply voltage. The clock signal is generated by IC2, a 555 employed in the astable mode, whereupon the clock frequency, and hence the delay time, can be set quite accurately by using timing components of appropriate values. There is no need for a trimming control to take up frequency errors, as can occur in alternative circuits. In some applications, such as vibrato and similar special effects, it is necessary to modulate the clock oscillator by means of a varying control voltage, and with the 555 such a control voltage can be applied to pin 5 of this i.c. The actual frequency produced by the 555 in the present circuit is discussed later in this article.

The 555 has a single phase output only, and this must be converted to a two-phase signal having suitable characteristics. The conversion is achieved by coupling the output to three CMOS buffer-

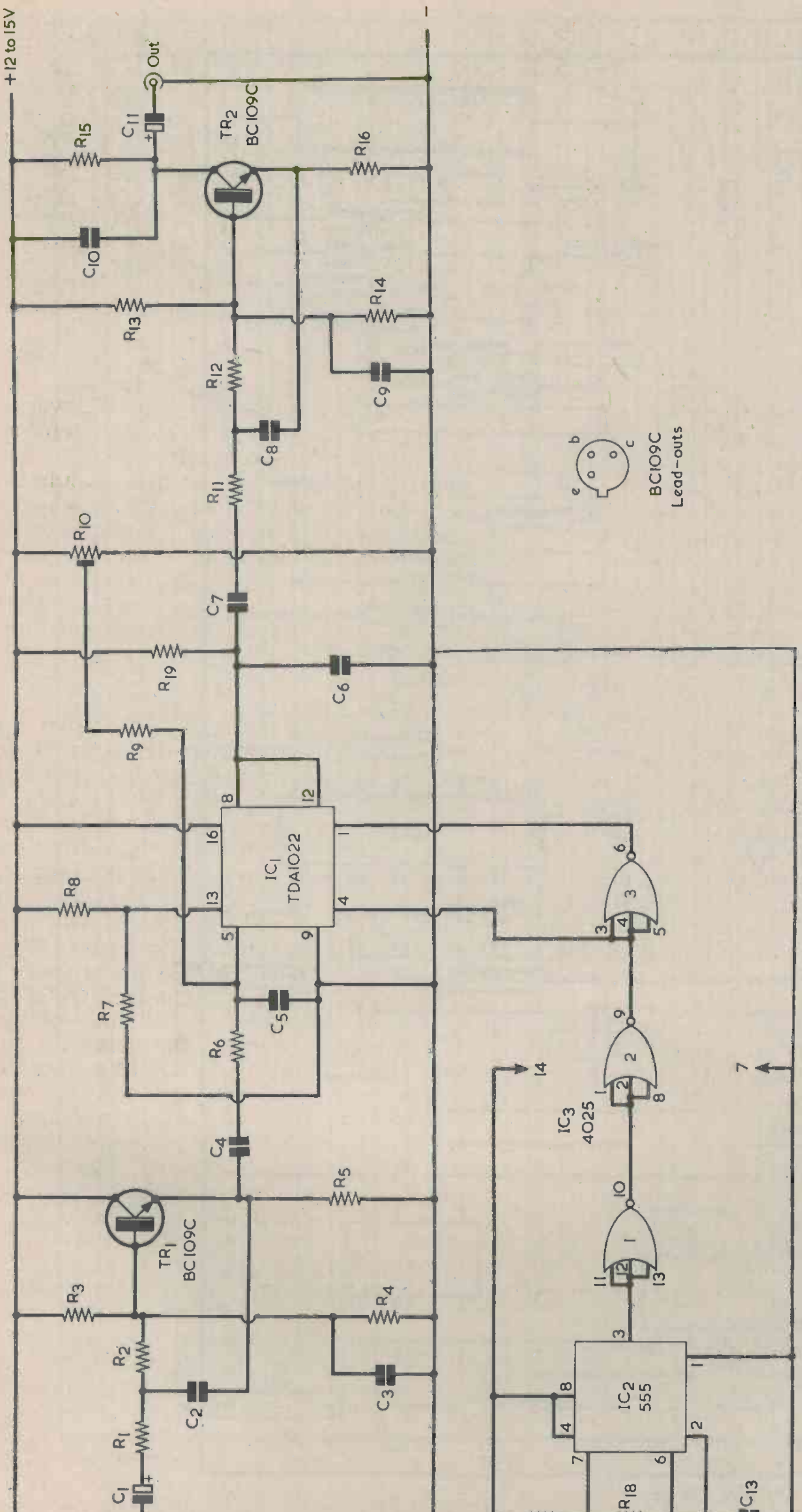
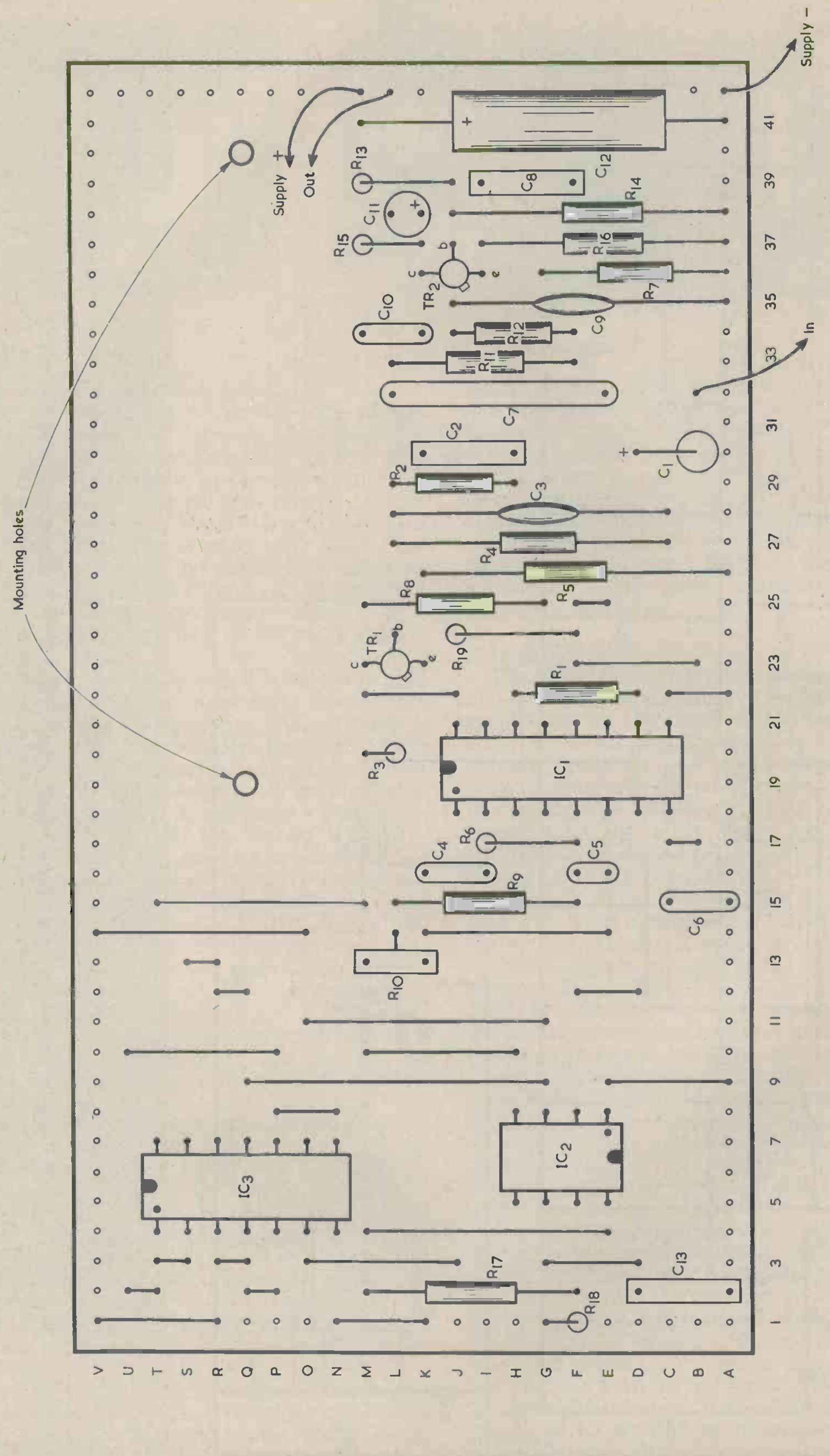


Fig. 1. The full circuit of the audio delay line unit. This offers delays of 1.8 or 2.7 milliseconds according to the value chosen for C13



inverter stages, and then taking the anti-phase signals from the outputs of the second and third stages. Each of the buffer-inverter stages consist of a 3-input NOR gate with the inputs strapped together. The three NOR gates are in a CMOS i.c. type 4025.

The input filter before the delay line i.c. is based upon TR1, and this is a conventional second order

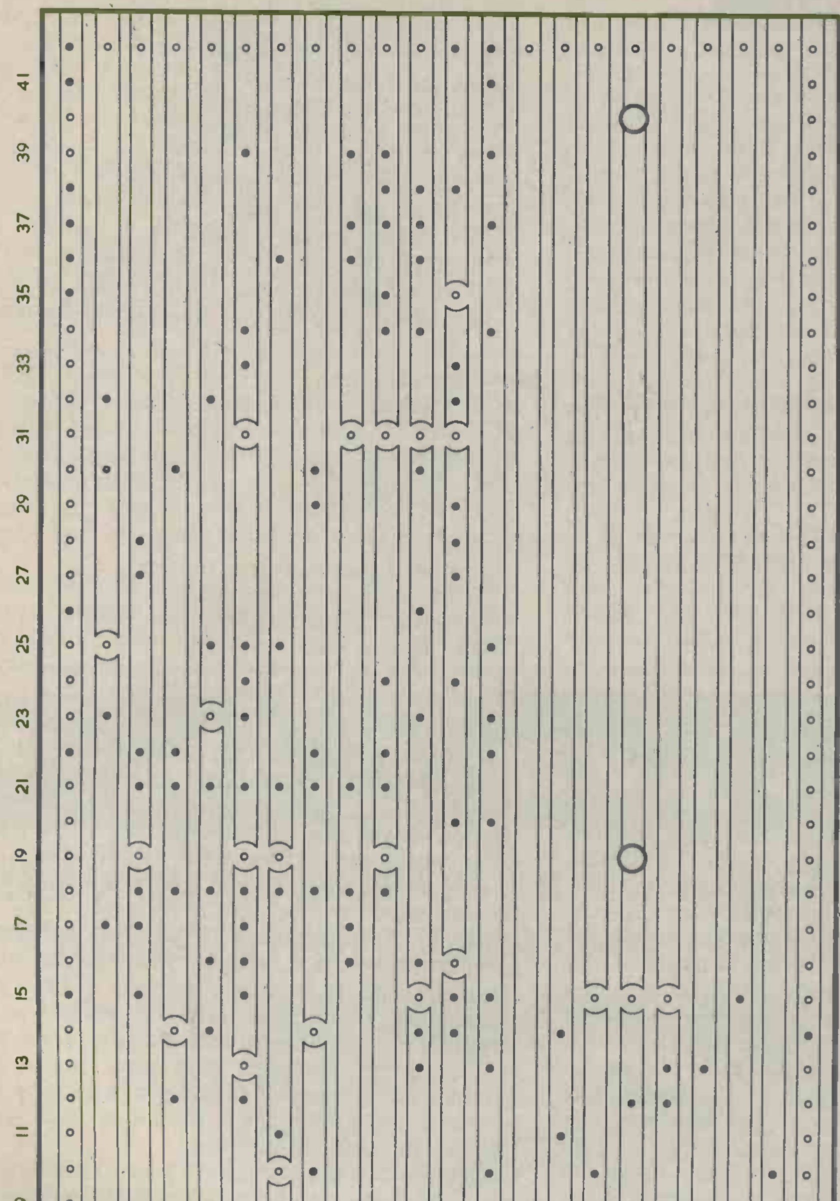


Fig. 2. A Veroboard layout for the delay line unit. IC1 should be the last component to be connected to the board and it should preferably be fitted in an i.c. holder or soldercon sockets

low pass filter giving a nominal roll-off rate of about 12dB per octave. The delay line i.c. is IC1, and the output from TR1 emitter is coupled into its input via d.c. blocking capacitor C4 and a simple low-pass filter consisting of R6 and C5. The input is biased by R9 and R10, the latter being adjusted to optimise the signal handling capability of the circuit. When R10 is correctly adjusted an input of 2.5

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
- R1 22kΩ
- R2 18kΩ
- R3 390kΩ
- R4 390kΩ
- R5 5.6kΩ
- R6 8.2kΩ
- R7 1.5kΩ
- R8 18kΩ
- R9 120kΩ
- R10 1MΩ pre-set potentiometer, 0.1 watt vertical
- R11 22kΩ
- R12 18kΩ
- R13 1MΩ
- R14 330kΩ
- R15 4.7kΩ
- R16 2.7kΩ
- R17 1kΩ
- R18 4.7kΩ
- R19 47kΩ

Capacitors
- C1 2.2μF electrolytic, 16 V. Wkg.
- C2 0.001μF polycarbonate
- C3 150pF ceramic plate
- C4 0.1μF type C280
- C5 330pF ceramic plate
- C6 220pF ceramic plate
- C7 0.47μF type C280
- C8 0.001μF polycarbonate
- C9 150pF ceramic plate
- C10 0.001μF ceramic plate
- C11 10μF electrolytic, 16 V. Wkg.
- C12 100μF electrolytic, 16 V. Wkg.
- C13 0.001μF or 0.0015μF polycarbonate (see text)

Semiconductors
- IC1 TDA1022
- IC2 555
- IC3 4025
- TR1 BC109C
- TR2 BC109C

Miscellaneous
- Veroboard panel, 0.1in. matrix
- 16-wat i.c. holder (see text)
- Input and output sockets (see text)
- Wire, solder, etc.

volts r.m.s. results in an output t.h.d. level of 1%. At lower signal levels the distortion figure is substantially smaller.

R7 and R8 bias internal circuitry in the i.c. by way of pin 13. Pins 8 and 12 are the outputs from stages 513 and 512 respectively of the TDA1022, and these are simply wired in parallel to give a continuous output. R19 is the load resistor for the output stages, and C6 gives the first stage of output filtering. The main output filtering is provided by the active filter circuit around TR2, this being similar to the input filter with the obvious difference that TR2 has a collector load resistor. TR2 functions as an emitter follower so far as the filter circuitry is concerned, and also as a common emitter amplifier to enable an output from the unit to be taken via d.c. blocking capacitor C11. The configuration permits a small amount of voltage gain to be provided by TR2, and this compensates for the attenuation of about 4dB through IC1 plus the small in-band losses given by the filter circuits. The overall gain of the unit, from input to output, is thus made almost exactly equal to unity.

The circuit requires a supply potential of between 12 and 15 volts, the current consumption being in the region of 25mA. The supply voltage must not be in excess of 18 volts. If a mains power supply is used it must have a low ripple and noise content in its output to allow the unit to provide a good signal-to-noise ratio. The TDA1022 is capable of a signal-to-noise ratio of 74dB, but this high figure might not quite be achieved in the present simple circuit and it assumes that the peak input level will drive the device to the threshold of clipping. If the input level is well short of this amplitude, which is about 2.5 volts r.m.s., then it would probably be best to use an external amplifier before the input of the unit to boost the signal to the required level. An attenuator can be connected to the output of the unit to bring the overall voltage gain back to unity.

CONSTRUCTION

The delay line unit can be assembled on a piece of Veroboard of 0.1 matrix, and a suitable layout is shown in Fig. 2. The board has 42 holes by 22 copper strips, and is provided with two mounting holes which are drilled 6BA or M3 clearance.

Both IC1 and IC3 are CMOS devices which can be damaged by high static voltage. They will be supplied in some form of protective package, such as conductive foam, and they should be left in the package until it is time for them to be connected into circuit. IC3, and finally IC1, should be the last components to be wired into circuit, and it is essential that the soldering iron used has a reliably earthed bit. Since IC1 is a fairly expensive i.c., it is worth-while employing a socket or soldercon connectors for this component.

For the benefit of readers who like to trace out a Veroboard layout, it should be mentioned that pins 2, 3, 6, 7, 10, 11, 14 and 15 of the TDA1022 are all "Not Connected" pins.

ADJUSTMENT AND APPLICATIONS

Only one adjustment needs to be made to the finished assembly, and that is to set R10 for optimum signal handling performance. It can be adjoined with the aid of a sine wave signal generator and an oscilloscope. The signal generator should feed a signal of about 3 volts r.m.s. into the input of the unit, with the oscilloscope monitoring the output. R10 is then adjusted to produce a symmetrically clipped output signal. In the absence of suitable test equipment, R10 can quite simply be given any setting that results in a clean-sounding output which is free from serious distortion at peak signal levels.

The timing components for the clock oscillator are R17, R18, and C13. The last may be either 0.001μF or 0.0015μF. If it is 0.001μF the clock frequency is 140kHz, and the time delay is 1.8 milliseconds. With C13 at 0.0015μF the clock frequency is 94kHz, giving a time delay of 2.7 milliseconds. Raising the value of C13 increases the time delay and reducing it decreases the time delay. The circuit will not give good results with a clock frequency below about 60kHz, giving a delay of 4.27 milliseconds, and the TDA1022 should not be used with a clock frequency of more than 500kHz, which gives a delay of 0.512 milliseconds. (Clock frequency with C13 at 0.0022μF is 64kHz, with a delay of 4 milliseconds, and the clock frequency with C13 at 300pF is 468kHz and the corresponding delay is 0.55 milliseconds).

This article is primarily aimed at the experimenter, who will probably find numerous uses for the delay line unit. One application for units of this nature is in voice control of tape recorders or transmitters. A difficulty with simple voice activated switches is that a short time elapses before the switch turns on the tape recorder or the transmitter, whereupon part or all of the first word may be lost. When a delay line unit is available, a non-delayed signal can be employed to activate the switch whilst a delayed signal is fed to the recorder or transmitter. The controlled equipment is then fully turned on when the delayed message is fed to it.

Another possible application is in stereo simulation with a mono signal. Here, an undelayed mono signal is fed into one channel of a stereo system and the delayed version is fed into the other. The random phasing of the two signals tends to give a stereo image extending from one speaker to the other, although of course this does not give true stereo reproduction of the conventional type.

Delay lines are much used in special effects equipment, such as reverberation, chorus generator or phasing effects units. An interesting and novel phasing effect can be given simply by mixing a degree of delayed signal with a non-delayed signal. The random phasing results in some frequencies (where the signals are in phase) being boosted and others (where the signals are out of phase) being attenuated. The effect can be enhanced by using a low frequency oscillator to frequency modulate the clock oscillator, so that there is variation in the frequencies that receive most boost and cut.

The author's prototype unit was housed in a metal case which was made common with the negative supply rail and which had input and output coaxial sockets mounted on the front panel. There was then no need to screen the input and output leads to the Veroboard.

If the unit is used in environments where the input and output wiring can pick up hum and noise it is necessary to use screened leads, the braiding of the leads being connected to the negative supply rail. ■

Trade News . . .

SALES AND MANUFACTURING RIGHTS FOR RANGE OF THERMOSTATIC SOLDERING IRONS ACQUIRED

S & R Brewster Limited of 86-88 Union Street, Plymouth, PL1 3HG have announced that they have acquired the manufacturing and sales rights formally held by Cardross Engineering Co. Limited of Dumbarton, of the Ceco Vari-Stat range of thermostatic soldering irons, these irons are now made at the company's Plymouth factory, enabling S & R Brewster Limited to offer the following range of soldering irons.

1) The S.R.B. "Mighty Midget" Type 1 Soldering Iron 18watt, with interchangeable bits, etc. 2) The Ceco Vari-Stat Model 'D' 50watt Temperature Controlled Soldering Iron. 3) The Ceco Vari-Stat Model 'H' 150watt Temperature Controlled Soldering Iron. 4) The Ceco Vari-Stat Model 'I' 500watt Temperature Controlled Soldering Iron.

The S.R.B. 18watt soldering iron is ideally suited for use with modern electronics.

The whole Ceco Vari-Stat range are primarily designed for industrial use, but have a wide variety of uses in the hobby and other retail markets as well. The Model 'D' and the Model 'H' feature a range of four different sized interchangeable bits for each model, while the Model 'I' is fitted with a removable bit suitable for most uses found for this soldering iron.

THE "WATERSPORT" MEDIUM-LONG WAVE PORTABLE Part 1

By Sir Douglas Hall, Bt., K.C.M.G.

3-transistor reflex design with integral wave trap for interfering transmissions

The medium and long wave receiver to be described makes use of a very old but infrequently used device, the acceptor wave trap. The rejector wave trap is quite often met. It can for instance be tuned to the intermediate frequency of a superhet and inserted in the aerial input, whereupon it prevents reception of signals at the intermediate frequency which could otherwise cause interference. The rejector wave trap consists of a parallel tuned circuit, and presents a very high impedance to signals at the frequency of resonance whilst offering a low impedance to frequencies away from the resonant frequency. If a receiver employs an external aerial the rejector wave trap, again inserted in the aerial input, can be very useful in reducing the signal input from a powerful local station to a level consistent with that from weaker and more distant signals. This reduces blasting or swamping by the powerful signal.

The completed "Watersport" receiver. The tuning control is at the top and is fitted with a simple home constructed tuning scale

A rejector wave trap is not really practical for use inside a portable receiver having its own self-contained ferrite-rod aerial, and it is here that possible use of the acceptor wave trap can be made instead. The acceptor wave trap has an inductor and capacitor in series, i.e. it is a series tuned circuit, and this offers a very low impedance approaching a virtual short-circuit at its resonant frequency and a medium impedance at other frequencies. At resonance, high signal frequency voltages appear across both the inductor and the capacitor but these are of opposing phase and cancel each other out. Off resonance, the impedance is equal to the difference between the impedance of the capacitor and the impedance of the inductor. With normal medium wave inductance and capacitance values the off-resonance impedance is only of the order of a few thousand ohms. Although much greater than the impedance at the resonant frequency, the relatively low off-resonance impedance prevents the acceptor wave trap from functioning usefully in high impedance circuits.

However, the author's Super Alpha "Spontaflex" reflex circuit has an r.f. point which is at medium impedance, this occuring at the coupling between the two transistors in the Darlington pair. If an acceptor wave trap having an off-tune impedance that is higher than usual is coupled between this point and the receiver negative rail it will have very little effect on signals at off-resonant frequencies but will still present a near short-circuit to a signal at the resonant frequency, bypassing this to the negative rail. The higher off-tune impedance can be produced by giving the wave trap inductor a higher value than is customary and the capacitor a lower value. A further advantage will be given if the wave trap

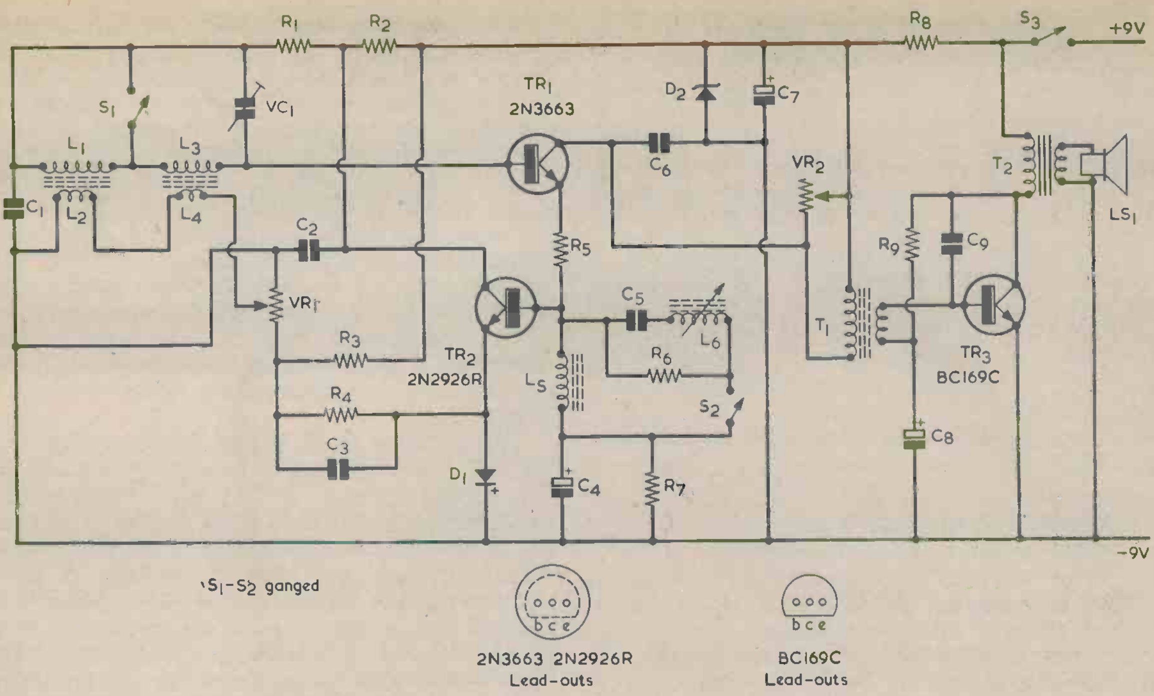


Fig. 1. The circuit of the "Watersport" medium and long wave receiver. L6 and C5 constitute an acceptor wave trap which can be adjusted to suppress any powerful transmission on the medium wave band

resonant frequency can be adjusted by a front panel control in the receiver in which it is fitted, since this will enable it to accept (and bypass to the receiver negative rail) any powerful transmission which is close in frequency to the signal being received.

A tunable acceptor wave trap of this nature is incorporated in the "Watersport" receiver.

THE CIRCUIT

The circuit of the receiver is given in Fig. 1. Regular readers who have retained their back issues will find that the circuit is similar to that employed in the author's "Superalphadyne" receiver (described in the May and June 1976 issues). Apart from some small modifications, the major change is the addition of the wave trap, which consists of C5 and L6 and which can be switched in or out of circuit by S2. Readers who have built the older design and would like to replace it with the present one will find that they have quite a number of the components required.

The circuit functions in the following manner. Signals are picked up by L3 on medium waves, or by L3 and L1 in series on long waves, and are applied to the base of TR1. At r.f. this is the first transistor of a Darlington pair, and its emitter couples via R5 to the base of the second transistor, TR2. The choke L5 provides an intermediate load for TR1 emitter. When the wave trap, C5 L6, is switched into circuit by S2, the trap forms a potentiometer in conjunction with R5, so that only a very low signal voltage is applied to the base of TR2 at the wave trap resonant frequency. S2 is ganged with S1, whereupon both switches are open for long wave reception when the wave trap is not required. In practice, S1 and S2 are the two switches on a potentiometer, the spindle of which couples mechanically to a ferrite rod moving in and out of coil L6 to vary its inductance and the wave trap frequency. If the wave trap is not required on medium waves the potentiometer spindle is only rotated sufficiently far to operate the two switches. This causes the ferrite rod to be fully inside the coil, whereupon the wave trap has no effect as it is then tuned to above 550 metres. Advancing the potentiometer spindle moves the ferrite rod out of the coil and tunes the trap over the medium wave band. At the extreme end of the spindle rotation the ferrite rod is completely withdrawn and the wave trap resonance is below 200 metres. The potentiometer is employed merely because it offers a very convenient mechanical means of ganging the two switches and the tuning of the wave trap. The potentiometer tags are not connected into the receiver circuit (apart from one tag which is employed as an anchor tag) and it can have any value.

The received signal is next amplified by TR2 and is applied to diode D1. The diode operates at very low impedance due to the current flowing through it from the emitter of TR2 plus a further current through R3 and R4. VR1 is the reaction control and it carries out two functions. As its slider travels down its track it increases the feedback in r.f. signal from the diode to the reaction windings, L4 and L2, which couple to the tuned coils L3 and L1. At the same time it reduces the direct current available for the diode from R3. When the slider of VR1 is moved in the opposite direction, towards the negative rail, it reduces the r.f. feedback to L4 and L2 and allows increased current to flow through R3 to D1. Damping of the diode is thus increased. The combined effect of variable feedback and variable

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 10kΩ
R2 47kΩ
R3 5.6kΩ
R4 390Ω
R5 470Ω
R6 4.7kΩ
R7 3.3kΩ
R8 680Ω
R9 560kΩ
VR1 2.2kΩ or 2.5kΩ potentiometer, wire-wound, 1 watt
VR2 22kΩ potentiometer, log, with switch S3, type P20 (Electrovalue)

Capacitors
C1 1,000pF silvered mica or ceramic
C2 1,000pF silvered mica or ceramic
C3 1,000pF silvered mica or ceramic
C4 22μF electrolytic, 3V. Wkg.
C5 39pF silvered mica or ceramic
C6 3,300pF silvered mica or ceramic
C7 1,000μF electrolytic, 3V. Wkg.
C8 10μF electrolytic, 3V. Wkg.
C9 1,000pF silvered mica or ceramic
VC1 100pF variable, type C804 (Jackson)

Inductors
L1, L2, L3, L4 see text
L5 2.5mH r.f. choke (Repanco)
L6 see text
T1 Driver transformer type LT44 (Eagle)
T2 Output transformer type LT700 (Eagle)

Semiconductors
TR1 2N3663
TR2 2N2926 Red D1 OA10
TR3 BC169C D6 BZY88C6V8

Switches
S1, S2 d.p.s.t. part of potentiometer of any value (see text)
S3 s.p.s.t. part of VR2

Speaker
LS1 3Ω, 8 x 5in., ceramic magnet (see text)

Miscellaneous
9-volt battery type PP9
Battery connectors
3 small knobs (approx ¾in. dia.)
1 large knob (see text)
Ferrite rod ⅜ x 6in.
Ferrite rod ⅜ x 4½in. (see text)
Ferrite rod ⅜ x 3½in. (see text)
28-way tagstrip (see text)
1¼in. drive drum (see text)
Nylon cord
Materials for "chassis" and case
Coil winding wire (see text and Fig.3)
Clips, nuts, bolts, washers, etc.

damping of the diode results in a smooth and easily adjusted control of reaction.

The diode detects the signal, and the resultant a.f. is next amplified by TR2, acting this time in the common base mode with R2 as its collector load. This amplified signal passes via R1, L1 (when S1 is open) and L3 to the base of TR1, which functions as a common emitter a.f. amplifier. Because of TR1's high gain, the low collector current which passes through it and the negative feedback given by R5, the input impedance at its base is much higher than would usually be the case with a common emitter transistor, and there is good matching to the collector impedance of TR2. It should be added that there is a high r.f. impedance at TR1 base also, this not only enabling the signal tuned circuit to be coupled directly to it but also allowing it to have a high ratio of inductance to capacitance. A variable capacitor of only 100pF maximum tunes the whole of the medium wave band when S1 is closed and the whole of the long wave band when S1 is open. The signal tuned circuit gives a high voltage magnification on consequence, allowing the receiver to have a high sensitivity.

The primary of T1 forms the a.f. collector load for TR1, with VR2 acting as an a.f. volume control. The supply voltage for TR1 and TR2 is stabilized by the zener diode D2. The secondary of T1 couples to the base of the output transistor, TR3, which in turn couples to the speaker by way of T2. The power output is modest but is very adequate for a normal sized room provided a high gauss 8 by 5 in. speaker is used. A fairly large speaker with a strong magnet will offer many times the volume given by a miniature speaker in similar circumstances. The author would much rather have a 50mW from a large speaker than 250mW from a miniature component. A speaker with a ceramic magnet is specified in order to minimise interaction with the two aerial ferrite rods, as could be given by an old fashioned metal magnet with its large external field.

The current drawn by the receiver from the 9 volt battery is about 12mA.

COMPONENTS

Some notes need to be made at this stage concerning components. Dealing first with the semiconductors, the 2N3663 and the 2N2926 Red are available from Electrovalue. The OA10 diode is listed by Bi-Pak Semiconductors. As has already been mentioned, the two switches S1 and S2 are part of a potentiometer which can have any value (or even have a damaged track). The only requirement of this potentiometer is that it should have a spindle length of 1⅜in. or more. A large knob is required for VC1 and this can be a home-made circular assembly fitted with a tuning scale. It will be dealt with in Part 2. A ⅜in. by 6in. ferrite rod is available from Maplin Electronic Supplies, and the two remaining ferrite rods can be 6in. (or longer) rods cut down by filing around the rod at the appropriate point and snapping the excess away. An 8in. ferrite rod, if cut, will provide both the 4½in. and the 3½in. rods. The 1¼in. drive drum is available from Home Radio.

The tagstrip employed in the prototype was an RS Components Miniature 28-way strip having a length of 194mm. (or 7.6in.). Readers who do not have access to RS Components parts may obtain a 28-way tagstrip of similar dimensions from Electrovalue. The Electrovalue strip has 0.25in. tag spacing. The speaker is specified as 3Ω, 8 by 5in. with ceramic magnet. Readers who rely on mail order for obtaining components and have difficulty in obtaining a speaker of precisely these dimensions may employ the 3Ω, 8 by 4in. speaker with ceramic magnet which is listed by Home Radio.

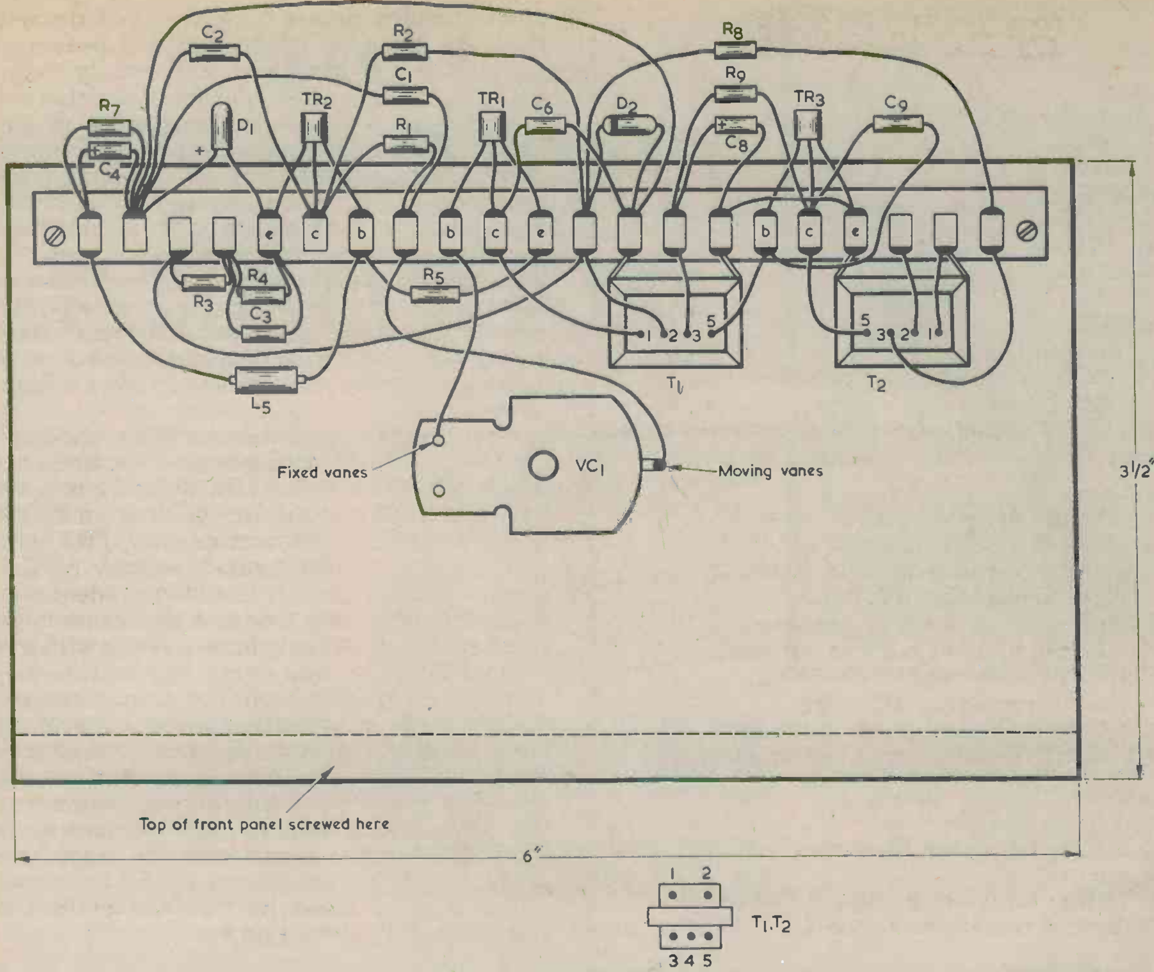


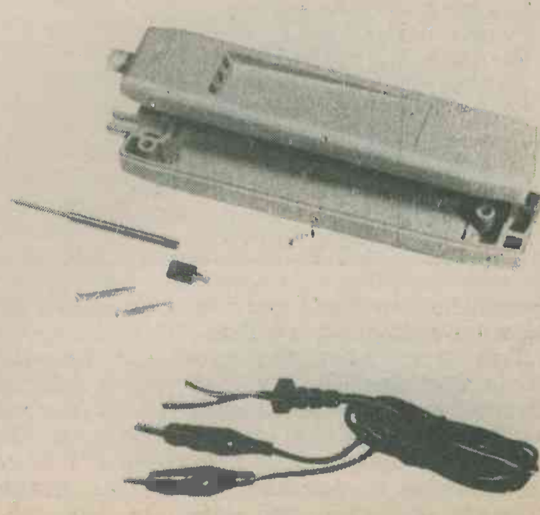
Fig. 2. This component panel appears at the top of the receiver. It is horizontal and is affixed to the receiver front panel in the manner shown here

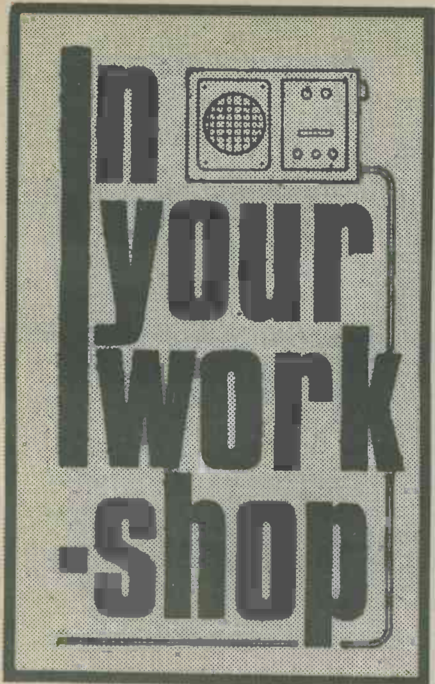
Constructional details will be given next month

New Product

PROBE CASE AND ASSOCIATED HARDWARE

Now available from Continental Specialties Corporation, of Shire Hill Industrial Estate, Saffron Walden, Essex, the CTP-1 probe case comes complete with associated hardware, and is ideally suited to housing electronic test accessories such as signal injectors, logic probes, small counters, voltage and resistance probes, and continuity checkers. Based on the case used in CSC's LPK-1 logic probe kit, the moulded grey plastic case measures 5.8 x 1.0 x 0.7 inches (147 x 25 x 18 mm), and is supplied complete with a 3ft-long two-wire lead with a moulded strain reliever and alligator clips attached, a nickel-plated screw-in probe tip, a mating tapped hex probe-tip connector, assembly screws, and a blank printed-circuit board pre-cut to size. The probe case is available in customer-specified colours for orders of 1000 or more.





The THIEF-PROOF HANDBAG

"Never out of trouble!"

Smithy, reaching for his raincoat preparatory to leaving for home, turned round absently.

"Who's never out of trouble?"

"Joe," said Dick.

"Do you mean Joe of Joe's Caff?"

"That's right."

"I never," sighed Smithy, "cease to marvel at the goings-on in that place. Well, if you don't satisfy my curiosity now I'll be wondering about it all night. Just what *is* happening to Joe?"

"He's got a phantom handbag nicker."

THE ART OF SPIKING

A gleam of intense interest entered Smithy's eye, to be suppressed almost immediately. He assumed an expression of mild interest.

"Perhaps," he remarked, "you'd better start at the beginning."

"Oh, all right. You see, Joe launched this new disco of his a month or so ago."

"Joe's running a *disco*?" queried Smithy incredulously. "In that crummy little place of his?"

"Well, it does get pretty heaving at times," admitted Dick. "But you know what Joe's like, always ready to start something new. So he runs this disco every Tuesday and Friday evening."

"I thought there was a regular disco in the area which opens every night."

"There is," agreed Dick, "but Joe's is cheaper. It's quieter too. In the regular disco they get a bit careless at times and take the sound level just a decibel or two above the threshold of pain. So Joe operates what you could call a soft disco. His amplifier is a mere 150 watts per channel."

Smithy blanched.

"What has this to do with the handbag stealer?"

"The present difficulty," explained Dick, "is that someone in Joe's disco has started to pinch handbags. When a girl gets up to dance she leaves her handbag on her table. Then, when she gets back again she finds it's been lifted. This has happened three times already and Joe's getting dead worried about it."

Smithy pondered for some moments.

"What you want to do," he said eventually, "is plant a spiked handbag."

"A spiked handbag?" repeated Dick, puzzled. "Do you mean that the handbag should be nailed to the table?"

"Of course not, you idiot. By 'spiked' I mean that the handbag should be fixed in some way that will incriminate the thief. A good scheme is to put some sort of gadget in the bag which will let everyone around the thief know that something is wrong."

"How do you mean?"

"One obvious idea," said Smithy thoughtfully, "would be to have a loud electric bell in the handbag. If this goes off, say, thirty seconds after the bag has been nicked, it's bound to draw attention to the thief."

"Hey, that's a great idea, Smithy!" said Dick enthusiastically. "How about installing a microswitch in the bottom of the bag which closes when the bag is lifted off the table? This could then turn on the bell directly."

"I'm not keen on the idea of a microswitch," said Smithy. "For one thing it means messing up a perfectly good handbag and for another you'd need an unusual sort of handbag with a hard flat bottom. Also, you don't want the bell to go off immediately the handbag is lifted. The gentle art of spiking con-

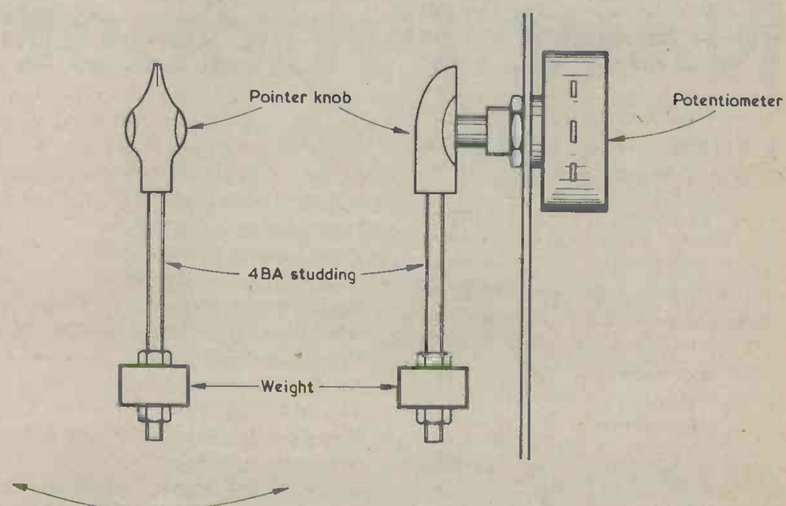


Fig. 1. Fixing a weight to a potentiometer spindle. The potentiometer setting is altered if the panel on which it is mounted is tilted. Other methods of coupling a weight to the potentiometer spindle can be readily devised

sists of *incriminating* the thief, and so you must have a time delay so that, when the bell goes off, the thief has to explain why the handbag is in his or her hands."

"If the microswitch scheme is out," said Dick, suddenly inspired, "how about having a gadget which is set off by the handbag being moved? Like the old 'tilt' warning devices on pin tables."

"Now, that is a good suggestion," said Smithy approvingly. "The whole alarm gadget could then simply be made up in the form of a smallish box which can be placed inside the handbag without having to alter the bag in any way. Let me have a little think about this."

Musingly, he glanced over the surface of his bench. He absently picked up a potentiometer and idly turned its spindle between his fingers. A thought occurred to him and he rummaged in a box of odd items of hardware on the bench. He located a small pointer knob and a two inch length of 4BA brass studding. Removing the knob grub screw he found that this was also 4BA, and he screwed one end of the studding into the knob in its place. He next secured the knob on the potentiometer spindle by tightening the studding and then looked around for a small and fairly weighty object. He found a large steel washer and fastened it to the end of the studding with two nuts. (Fig. 1.)

"Here we are," he said cheerfully, "here's a device for detecting movement of the handbag. If this pot is mounted to a panel on the box in the handbag, the weight will turn the spindle round, so that the pointer nob is always pointing upwards. If the handbag is then picked up, the weight will cause the pot spindle to be turned to different positions as the handbag is moved about."

Smithy held the potentiometer in his hand and rotated its body in the vertical plane. As the body turned round the weight remained in its bottom position, patently turning the potentiometer spindle in relation to its body. The slight stiffness between the spindle and its bush caused the spindle movement to be a little jerky, but the alteration in spindle positioning as the potentiometer's body rotated was, nevertheless, very evident.

"There you are," said Smithy triumphantly. "This basic weight arrangement can be made up by anybody with a little ingenuity and access to odds and ends of hardware. To demonstrate the scheme I've used a knob which happened to accept a length of 4BA studding, but any other means of attaching a small weight rigidly to a pot spindle could be used instead. For instance, a 6BA clear hole could be drilled through the spindle and a length of 6BA studding used. What is important about the idea is that it is capable of converting movement into an electrical signal."

"Could any pot be used?"

"Well, you'd need to try and select one which has pretty free spindle movement, but most pots fall into this category. A suitable value would be 10k Ω linear."

CIRCUIT DETAILS

"How," asked Dick, "would the pot give a signal when movement takes place?"

"By applying a fixed direct voltage across its track," said Smithy. "After the handbag with the weighted pot in it has been placed on a table the weight will cause the pot spindle to take up a certain position. Obviously, things must be arranged such that the pot slider will be able to move in both directions along its track, and that its slider is not hard up against one end of the track. Picking up the handbag will then cause the pot spindle to be moved and a different voltage to be present at its slider."

Dick frowned.

"I don't like the sound of this," he said. "It seems as though after you've put the handbag on the table you'll have to set up another pot, like in a Wheatstone bridge."

"Oh, the voltage from the pot slider isn't treated as a direct voltage," said Smithy. "It's treated as an alternating voltage. The sort of alarm circuit I'd use would detect a *change* in the pot slider voltage regardless of what the previous voltage was. What I'd do is have a time delay circuit which inhibited detection of the voltage for a period after the alarm device has been switched on. This delay would be necessary for electronic reasons, but it would also offer the advantage that the device could be switched on even *before* the handbag is put on the table. Provided that the pot spindle and its weight are at rest in a final position before the time delay comes to an end, it doesn't matter how much pot spindle movement occurs during the delay period itself. This fact enables the device to be casually switched on whilst the bag is opened for cigarettes to be taken out, or something like that, and the process of switching on would then attract no attention at all."

"Gee," said Dick. "I'd like to see the sort of circuit you have in mind."

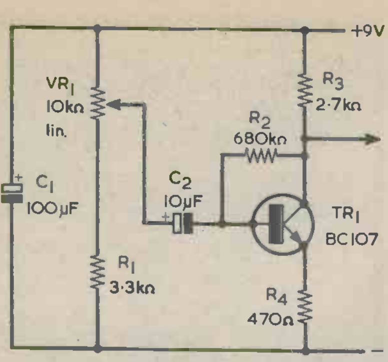


Fig. 2. An amplifying stage coupled to a potentiometer and weight assembly. The potentiometer is shown here as VR1

Smithy pulled his note-pad towards him and, after a little thought, drew out a small circuit. After scribbling a few calculations he marked up the component values, tore off the page and passed it over to his assistant.

"Here's a suitable amplifier circuit to which the pot could connect," he remarked. "I've shown the pot as VR1 and, as I mentioned just now, it can have a value of 10kΩ linear. The amplifier output connects to a voltage detector stage."

"Hey, I could knock this up in lash-up form right away," exclaimed Dick eagerly. (Fig. 2.)

"There's rather more to the complete circuit than just one transistor and a few other components," said Smithy. "Rough check, there'll be three CMOS integrated circuits and another transistor."

"That won't matter," replied Dick keenly. "I've got a piece of 0.1 inch Veroboard with i.c. holders on it all prepared for making quick experimental i.c. circuits. And so far as CMOS is concerned, my soldering iron has got the most reliably earthed bit in the neighbourhood!"

"All right then," conceded Smithy. "There's no need to make up a pot and weight assembly for this check circuit. Just fit a knob to the pot and we can check circuit action by turning the knob slightly."

Dick examined the circuit closely.

"That transistor is connected up in rather a weird manner," he stated. "Why have you got that 470Ω resistor between the emitter and the negative rail? And why do you have a 100μF electrolytic across the supply rails?"

"Taking your questions in reverse order," said Smithy, "the 100μF electrolytic is a supply bypass capcapacitor which will serve the whole circuit. It might as well go in right at the beginning. And the 470Ω resistor gives a high input impedance at the transistor base. In company with the 2.7kΩ collector resistor, it also causes the voltage gain of the transistor to be a little less than 6 times. Remember that it's a changing voltage signal that we want to detect, and that is why the slider of VR1 couples to the transistor base through C2. I've given C2 a high value so that the transistor responds to a voltage which changes slowly, as would occur if the handbag in which the pot and weight are installed were handled very gently."

"Why do you want a gain of slightly less than 6 times?"

"Dear oh dear me," moaned Smithy. "You and your questions." He consulted the calculations he had made when he drew up the circuit. "We don't want the device to be too sensitive or it could be triggered by tiny tremors or even by noise on the pot track. A sensitivity which causes triggering for a pot slider movement of about 2 degrees seems to be reasonable. In the circuit there's about 6 volts across the pot track and if we assume that the total slider rotation is 300 degrees, then 2 degrees corresponds to 6 divided by 150, or 0.04 volt. This voltage multiplied by the transistor gain of slightly less than 6 times comes to a little over 0.2 volt. As you'll see in a minute, the next part of the circuit is triggered by approximately 0.2 volt, so the current you've got there gives just about the voltage gain required. Okay?"

"Blimey, yes" responded Dick, sligthly taken aback by the speed with which Smithy had produced the sensitivity figures. "Well, I'll make up this bit of circuit now."

Dick unearthed an oddment of metal on which he mounted several tagstrips. He then quickly proceeded to wire up Smithy's circuit. As he did so, Smithy returned to his note-pad and drew some further circuit diagrams.

FIRST CHECKS

"All finished!" called out Dick as he returned his soldering iron to its rest.

"Good show," responded Smithy, rising from his stool and walking over to his assistant's bench. "Can you connect the circuit to a 9 volt battery, please?"

Dick pulled over a PP9 battery and clipped two leads from his circuit to its terminals.

"I've done that, Smithy."

"Right," said Smithy leaning over his shoulder, "connect a testmeter switched to read volts between the negative rail and the transistor collector."

Dick switched his battered multimeter to a 0-10 volt range and applied its clips to the circuit. It indicated about 7 volts. Smithy put out his hand and slowly adjusted the potentiometer so that its slider moved a small distance towards the negative end of the track. The voltage reading increased sluggishly and then just as sluggishly returned to the 7 volt reading. A similarly sluggish reading in the other direction was given when Smithy adjusted the potentiometer slider slightly towards the positive track end.

"Very good," he commented. "The slow changes in the readings are due to C2 charging and discharging into the base sircuit of the transistor. Now, here's the next bit of the overall alarm circuit."

Smithy produced one of the circuits he had prepared. (Fig. 3.)

"What bit is this?" asked Dick.

"It's the voltage detector," replied Smithy. "R5 and R6 hold the base of TR2 at about 0.4 volt above the negative rail, so that it's normally cut off and the voltage at its collector is high. The output goes low, to trigger the following part of the circuit, if a signal voltage passed via C3 takes the base up to 0.6 volt above the negative rail."

"That seems fair enough," commented Dick. "I see that this part of the circuit requires a 1N4002 diode. Have we got any of these in stock?"

"There's plenty in the spares cupboard. Actually, you'll need five of them by the time the circuit is completed, so you might as well pick up the other four as well."

Dick took the diodes from the spares cupboard after which, with Smithy watching, he soon wired up the second circuit. When it was completed he looked expectantly at the Serviceman.

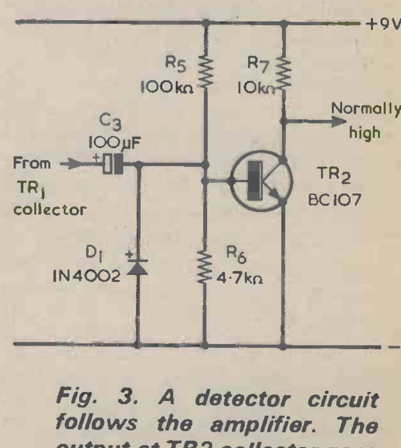


Fig. 3. A detector circuit follows the amplifier. The output at TR2 collector goes low if the potentiometer slider is moved along its track

"Put your testmeter between the collector of TR2 and the negative rail," said Smithy, "then connect up to the battery again."

Dick connected the battery. The meter needle rose slowly from its zero reading to one slightly below 9 volts.

"That slow rise in voltage," stated Smithy, "is due to C3 being initially discharged. Because of this, TR2 is turned on after switch-on until the capacitor charges."

Smithy adjusted the potentiometer slightly so that its slider moved towards the negative end of the track. The meter reading quickly dropped to zero then returned to its previous high indication.

"That's okay then," he stated. "The detector output goes low for just a small movement of VR1 spindle."

"Hey, wait a minute," put in Dick, "there's something wrong here!"

"How come?"

"This circuit detects a negative-going movement of the pot slider because TR1 changes the slider voltage to a positive-going signal before passing it on to TR2 base. But a positive movement of the pot slider won't have any effect at all, because the signal passed to TR2 base will then be negative-going and will keep TR2 cut off. So the pot and weight arrangement will only trigger the circuit when the pot is tilted in one direction."

"That's not entirely true," replied Smithy. "The circuit will also cause TR2 output to go low if the pot slider moves in a positive direction, although the sensitivity is, admittedly, a lot lower. If the pot slider movement causes the right hand plate of C3 to go negative of the negative rail by 0.6 volt, diode D1 starts to conduct and any further signal excursion discharges C3. When the signal ceases, the discharged C3 takes the base of TR2 positive again until C3 charges up once more. I'll show you."

Smithy gave the potentiometer spindle a small turn in the positive direction. The meter reading stayed at its high level for a second or so after Smithy had adjusted the potentiometer and then suddenly dipped momentarily to zero again.

LATCH CIRCUIT

"Blimey," said Dick, impressed. "You really believe in covering all eventualities, don't you, Smithy?"

"I like to keep things in order where I can," stated Smithy modestly. "Now here's the next bit of the alarm device to wire up."

He handed another circuit to Dick. (Fig. 4.)

"The two left hand gates in this circuit form a standard CMOS latch," went on Smithy, "and they couple to a third gate which, like the other two, is connected as an inverter. The latch is in its normal condition when pins 1 and 2 of the first gate are high. This causes the output at pin 10 to be low. TR2 collector connects via R8 and D2 to the input of the first gate so that, if TR2 collector goes low due to the handbag being picked up and the potentiometer setting altered, the latch is pulled to its alternative state with pins 1 and 2 low and pin 4 high. The latch stays in its new state when TR2 collector goes high again, because D2 is then reverse biased."

"Why have you put R8 in the circuit?" asked Dick.

"You'll find out in a jiffy. Just wire up that little lot, will you?"

"Okeydoke," said Dick agreeably.

Dick took up the piece of 0.1 inch Veroboard which he used for experimental i.c. circuits. It was not long before he had completed the assembly of the latch, whereupon Smithy took over from him. Smithy

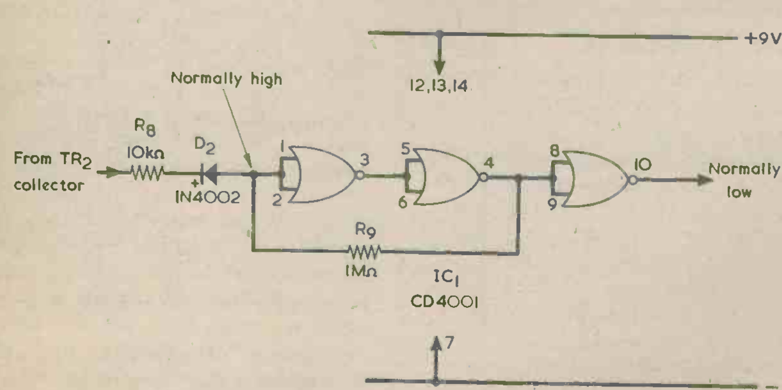


Fig. 4. The CMOS latch circuit. When the output at pin 10 goes high an output timer is enabled

applied the testmeter between pin 10 of the third gate and the negative rail, and connected up to the battery. The meter gave a reading of 9 volts.

"Hey," protested Dick, "that pin 10 gate output is high. According to you it should be normally low."

"It goes high at switch-on," explained Smithy, "because, as we saw just now, the collector of TR2 is low until C3 charges up."

He took up a piece of wire and momentarily short-circuited pins 1 and 2 of the first gate to the positive rail. The voltmeter reading dropped to zero and stayed there. Smithy reached over and made a slight adjustment to VR1. The testmeter returned to the 9 volt reading, which it retained steadily.

"Excellent, excellent," said Smithy happily. "The complete circuit is nearly finished now. All we need are two timing circuits. Here's the first one."

Smithy gave the circuit to his assistant. (Fig. 5.)

"Hallo," remarked Dick. "You're using an ICM7555 here. Is that the new 'CMOS 555'?"

"It is," confirmed Smithy. "I got a batch of them in recently to play around with. You'll notice also that I've now introduced an on-off switch. This is S1 (a), which is one pole of a double-pole double-throw toggle switch. The timing circuit is very simple. When the switch is in the "Off" position C4 is discharged via R11. When S1 is put to 'On' power is applied to the circuit and C4 commences to charge via R10. The i.c. output at pin 3 is high until the voltage across C4 reaches two-thirds of the supply voltage and then it suddenly goes low and stays low. When the output is high it holds pins 1 and 2 of the CMOS latch high even when, after switch-on, the collector of TR2 goes low. TR2 collector cannot pull the latch input low because of the presence of the 10kΩ resistor, R8."

"Ah," said Dick, pleased. "That explains why you put in that resistor."

Smithy brought over from his bench a piece of polystyrene foam bearing a number of ICM7555 integrated circuits and Dick at once set to work. Again, only a short time passed before he announced the completion of the wiring. He looked a little doubtfully at what was now becoming quite a complex tangle of wires on his bench.

"This," he stated apologetically, "is beginning to look like the proverbial rat's nest, Smithy. It's not the nice and tidy sort of wiring job I normally like to turn out."

"Not to worry," said Smithy soothingly. "I can't expect you to make a neat assembly when I keep springing additional bits of circuitry onto you, and when you're doing it in a hurry in any case. Right, we'll put the meter back on pin 10 of the gate following the CMOS latch and the negative rail and connect up to the battery again. Also, now we've got an on-off switch, we'll switch on in proper style."

Smithy carried out these actions. The testmeter reading was now low. It stayed low even when Smithy adjusted the potentiometer, VR1."

"As you can see," continued Smithy, "the output of the timer i.c. is holding the latch input high and is also inhibiting it from operating when I adjust VR1. The timer period is about 15 seconds, which will have passed shortly. Hang on a bit and then try adjusting the pot again, Dick."

After a short wait, Dick reached over and adjusted the potentiometer. The testmeter needle immediately rose to indicate 9 volts and stayed at that level.

"Gosh Smithy, this circuit really is behaving as it should."

"It is, indeed," replied Smithy, obviously pleased with the successful turn of events. "Now, let's summarise things up to now. We are making up a circuit for fitting in a handbag which includes a potentiometer actuated by a weight. When the handbag is moved, the potentiometer sends an alternating signal to an amplifier and detector which, in turn, cause a CMOS latch to change from the normal state to what we shall now call the alarm state. However, that latch is inhibited for a period after switch-on by the timer circuit you've just completed. This delay period overcomes false triggering at switch-on and, what is more important, allows the handbag to be moved around after

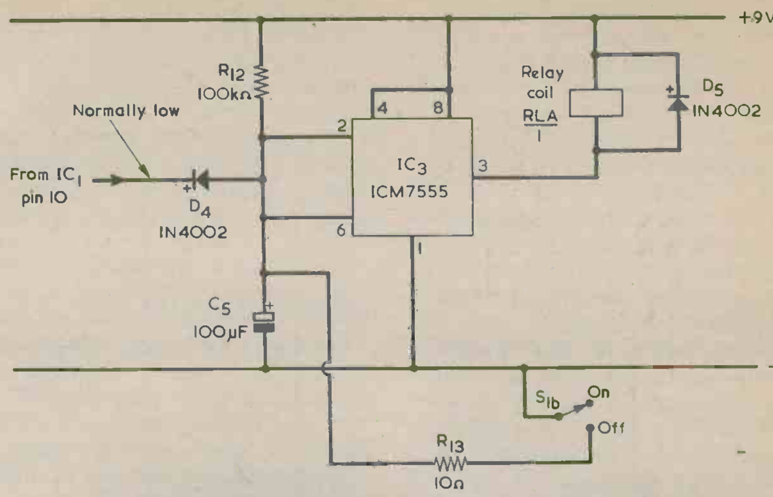


Fig. 6. The output timer. The relay causes a bell to sound a pre-determined time after the alarm circuit has been triggered

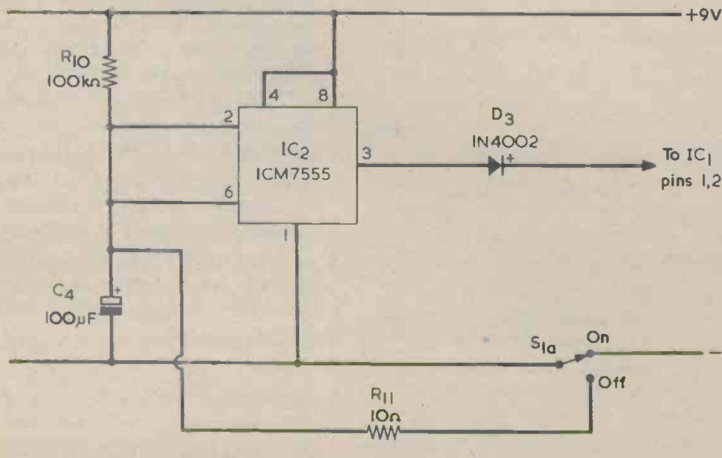


Fig. 5. This timing circuit inhibits the latch for a period after switch-on

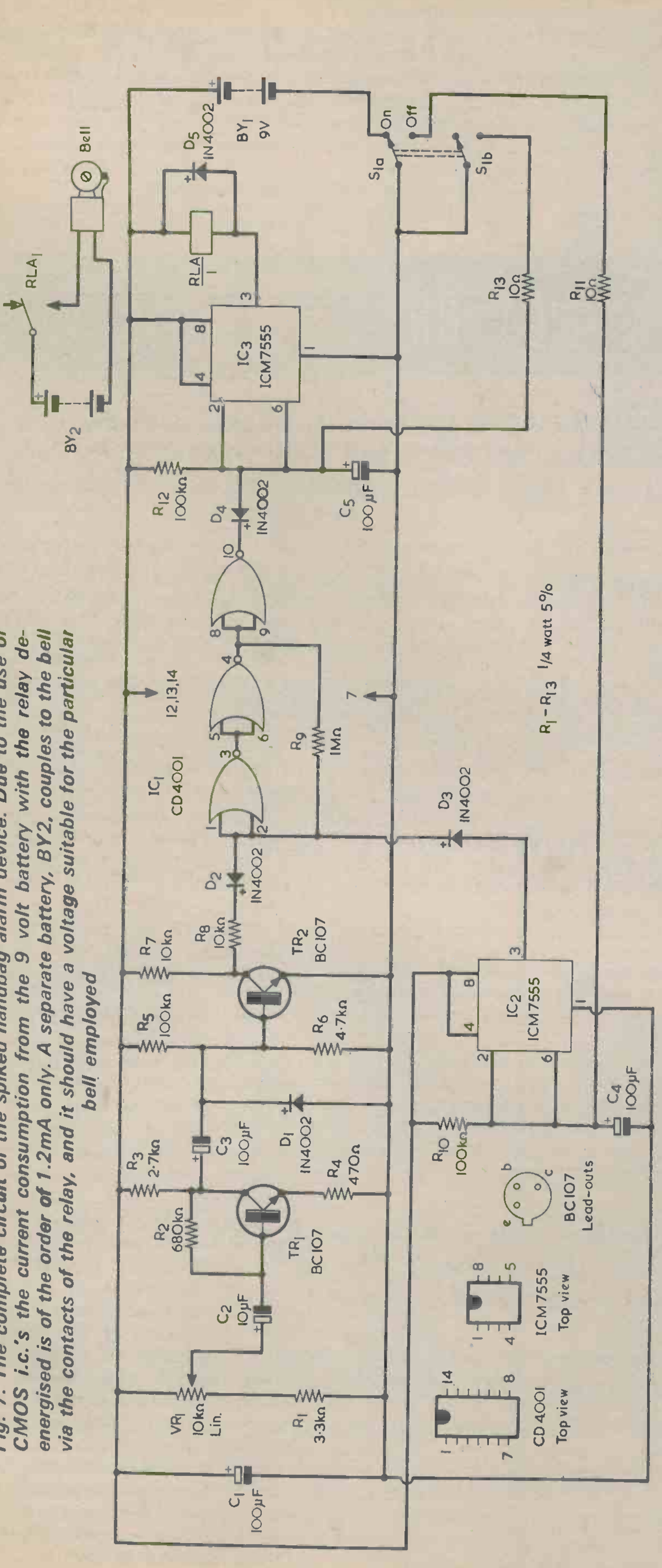


Fig. 7. The complete circuit of the spiked handbag alarm device. Due to the use of CMOS i.c.'s the current consumption from the 9 volt battery with the relay de-energised is of the order of 1.2mA only. A separate battery, BY2, couples to the bell via the contacts of the relay, and it should have a voltage suitable for the particular bell employed

switching on before the circuit is ready to operate. This delay period can be extended by increasing the value of C4. If it is made say 1,000μF, the time delay is about 150 seconds, or two and a half minutes. A person carrying the handbag could switch on the circuit unobtrusively at some point and then carry the handbag over to a table and leave it there. That's what I call real ***sneaky*** spiking!"

"How long is the delay given by the timer?"

"In seconds, it's approximately equal to the value of C4 in microfarads multiplied by 0.15," replied Smithy. "C4 can have any value between 100μF and 1,000μF. I chose 100μF because we don't want to hang around for long periods whilst we're trying the circuit out."

FINAL SECTION

"All we need now," stated Dick, "is something that will ring an electric bell when the CMOS latch goes into the alarm atate."

"And here's the circuit for that bit," replied Smithy. "It uses a second ICM7555 in an identical timing circuit, apart from the fact that the timer output energises a relay. Here you are."

Dick gazed at the final circuit which Smithy now passed on to him. (Fig, 6.)

"You've given the timing capacitor, C5, a value of 100μF," he remarked. "Will that give a timing delay of about 15 seconds, too?"

"It will," confirmed Smithy. "C5 can have any value between 100μF and 1,000μF and exactly the same remarks apply to it as applied to C4. After switch-on, C5 is held discharged by the normally low output pin 10 of the first i.c. When the CMOS latch goes to the alarm state, because the handbag has been picked up, that normally low output goes high, allowing C5 to charge. Then, after the pre-arranged time, pin 3 of the second timer goes low, the relay energises and the electric bell in the handbag starts ringing. A suitable relay, incidentally, will be the 410 Ω 'Open Relay' which is sold by Maplin."

Dick spent several evenings assembling Smithy's circuit in neat and proper form, and also drew out the complete circuit of the alarm from the scraps which Smithy had given him. (Fig. 7.)

Then, on the following Wednesday morning, a jubilant Dick burst open the Workshop door.

"It worked, Smithy!" he called out gleefully. "It worked like a charm last night. We caught the girl who was pinching the handbags just as she was leaving. She was carrying the spiked handbag and the bell in it suddenly started ringing like an old-fashioned fire engine. Ye gods, you should have seen her face!"

"I'm glad it was successful," commented Smithy smoothly. "Perhaps you could lend me the alarm device for a few days now that you've caught your thief."

A suspicious look passed over Dick's face.

"All right then," he said reluctantly. "But what do you want it for?"

"Well," replied Smithy, "about a fortnight ago my club committee asked me to help them out with a problem they have. It appears that, at the club, there have been a few handbag thefts . . ." ■

RECENT PUBLICATIONS

TOWERS' INTERNATIONAL OP AMP LINEAR-IC SELECTOR. By T. D. Towers, M.B.E., M.A., B.Sc., C.Eng., M.I.E.R.E. and N. S. Towers, B.A. (Cantab). 192 pages, 245 x 170mm. ($9\frac{3}{4}$ x $6\frac{3}{4}$in.). Published by W. Foulsham & Co. Ltd. Price £6.95.

After "Towers' International Transistor Selector" and "Towers' International FET Selector" comes the present volume. It lists more than 5,000 American, British, European and Japanese linear i.c.'s, giving 24 specifications for each device, as well as lead functions and European and U.S.A. substitutes. The data is presented in the tabular form familiar with the two previous books, but in this case the information on each i.c. is spread over two facing pages.

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INTEGRATED CIRCUITS — HOW TO MAKE THEM WORK. By R. H. Warring. 133 pages 215 x 130mm. ($8\frac{1}{2}$ x $5\frac{1}{4}$in.). Published by Lutterworth Press. Price £3.95.

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ELEMENTS OF ELECTRONICS 1. By F. A. Wilson C.G.I.A., C.Eng., F.I.E.E. F.I.E.R.E., M.B.I.M. 219 pages, 180 x 105mm. (7 x $4\frac{1}{4}$in.). Published by Bernard Babani (Publishing) Ltd. Price £2.25.

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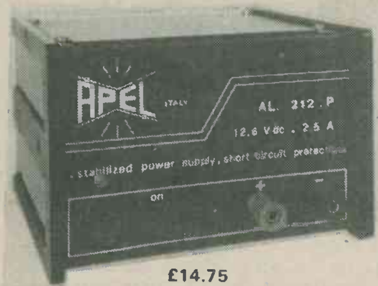

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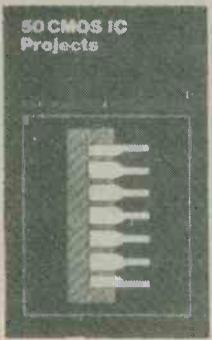

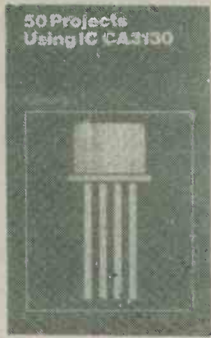

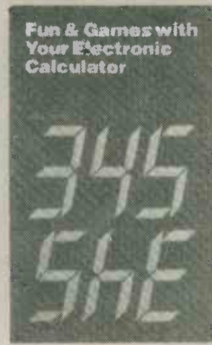

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