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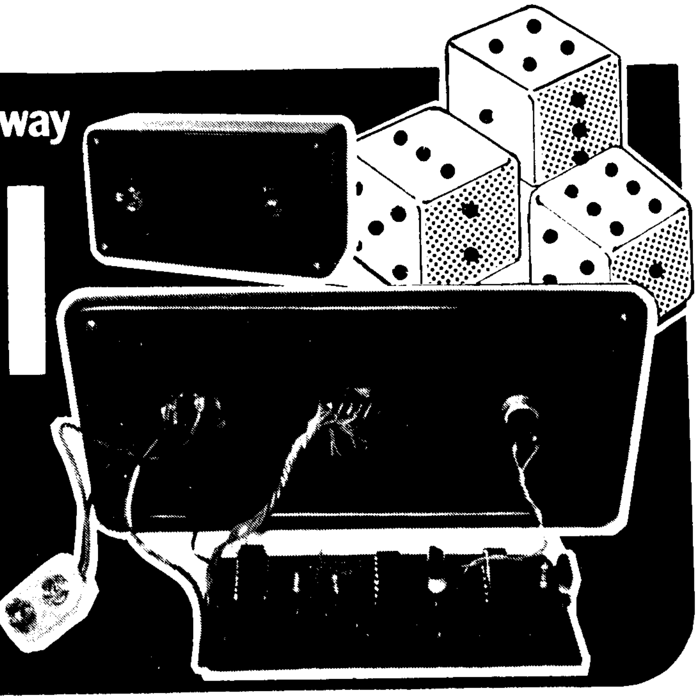
Play dice the electronic way

Digital Dice



BY R. A. Penfold

● Random non-biased number selection

Much amusement can be obtained from this simple electronic device which simulates the action of a conventional dice, or die. The unit is very simple and is based on three CMOS integrated circuits, a 7-segment l.e.d. display and very few other discrete components. It is self-contained and is powered from an internal 9 volt battery.

BASIC PRINCIPLE

The basic principle of the unit is quite straightforward, and the first steps are illustrated in the block diagram of Fig. 1. An ordinary counter and display circuit is fed from a clock oscillator by way of a normally open non-locking push button switch. The clock oscillator operates at a frequency of several hundred Hertz, the precise frequency being unimportant. Thus when the push button is operated the counter will rapidly and repeatedly count through 0 to 9 cycles, but at a speed that is far too high for anyone looking at the display to perceive. The display therefore seems to be showing a figure 8, as all the segments will be alight for part of the time.

When the push button is released the counter circuit will latch at whatever state it happened to be in at the instant the clock signal ceased. If, for example, a figure 5 was being displayed at that instant then a 5 will remain in the display after the push button is released. There is obviously no way in which the operator can determine which number will be displayed, as the counter is operating at far too high a rate. It is purely a matter of chance, and so the arrangement acts as a 0 to 9 random number selector.

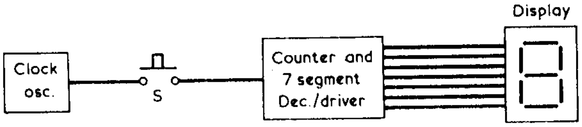


Fig. 1. A basic random number generator. This produces single digit numbers from 0 to 7

IMPROVED VERSION

So far as an electronic dice is concerned there is an obvious flaw in this circuit, in that a dice only provides numbers from 1 to 6, whereas a device of the type outlined in Fig. 1 will give numbers from 0 to 9. Some means of eliminating the figures 0, 7, 8 and 9 must therefore be incorporated.

Fig. 2 shows the block diagram of the improved version. Here the clock signal is coupled to the counter via a resistor, which ensures that the clock input coupling is of a fairly loose nature. the counter i.c. must also be a special type which has

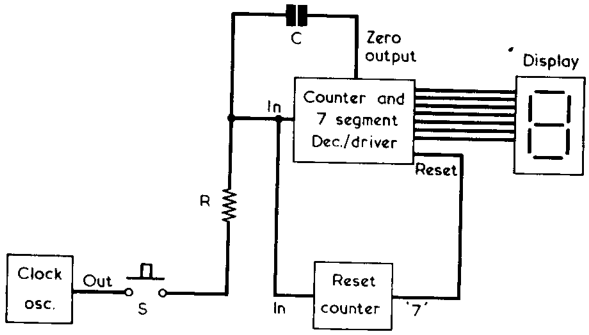


Fig. 2. A modified number generator which suppresses all numbers except 1 to 6

zero blanking. Such i.c.'s have an output which is normally low, but which goes high while the counter is at zero. This output is connected to the clock input via a low value capacitor so that when the counter goes into the zero state a pulse is supplied to the clock input from the zero output. This takes the counter on to the 1 state virtually the instant it reaches the zero state. In this way the zero is suppressed, and cannot be displayed by the circuit. Because capacitor C has a fairly low value in relation to resistor R, these components do not upset the flow of the clock signal into the clock input of the counter. They do, however, enable the pulse from the zero output to be mixed with the clock signal.

A second counter is fed from the clock signal, and this is what is usually termed a one-of-ten counter. Such a device has ten outputs which are designated 0 to 9, and the only stable state the device can have is with nine of the outputs in the low state and one in the high state. The circuit starts with the 0 output in the high state after which, with successive clock input cycles, the 1 output goes high, then the 2 output, and so on, until the 9 output goes high. With the next input cycle the device returns to the state where the 0 output is high, and then starts from the beginning once again.

In this application the one-of-ten counter has its clock input connected in parallel with that of the main counter, and so the zero output is suppressed in exactly the same way. Its 7 output is connected to both its own reset terminal and the reset terminal of the main counter. Thus, after the figure 6 has been displayed on the readout device, the 7 output of the one-of-ten counter goes high and resets both counters to zero. The pulse from the zero output of the main counter then takes the counters straight on to the 1 output state, and they then count up to 6 again in the normal way.

This provides the desired circuit action with the 0, 7, 8 and 9 output states all being eliminated.

THE CIRCUIT

Fig. 3 shows the complete circuit diagram of the digital dice. The clock oscillator is based on a 4047 i.c. which is a CMOS monostable/astable multivibrator. It is connected here in the free running astable mode with the frequency of oscillation set at approximately 150Hz, but the normal Q and not-Q outputs (pins 10 and 11 respectively) are not used. Instead, the clock signal is extracted from pin 13, which provides an output at twice the frequency of the Q and not-Q outputs, or about 300Hz in this case.

The clock signal is fed to the clock inputs of the two counter i.c.'s via push button switch S1 and

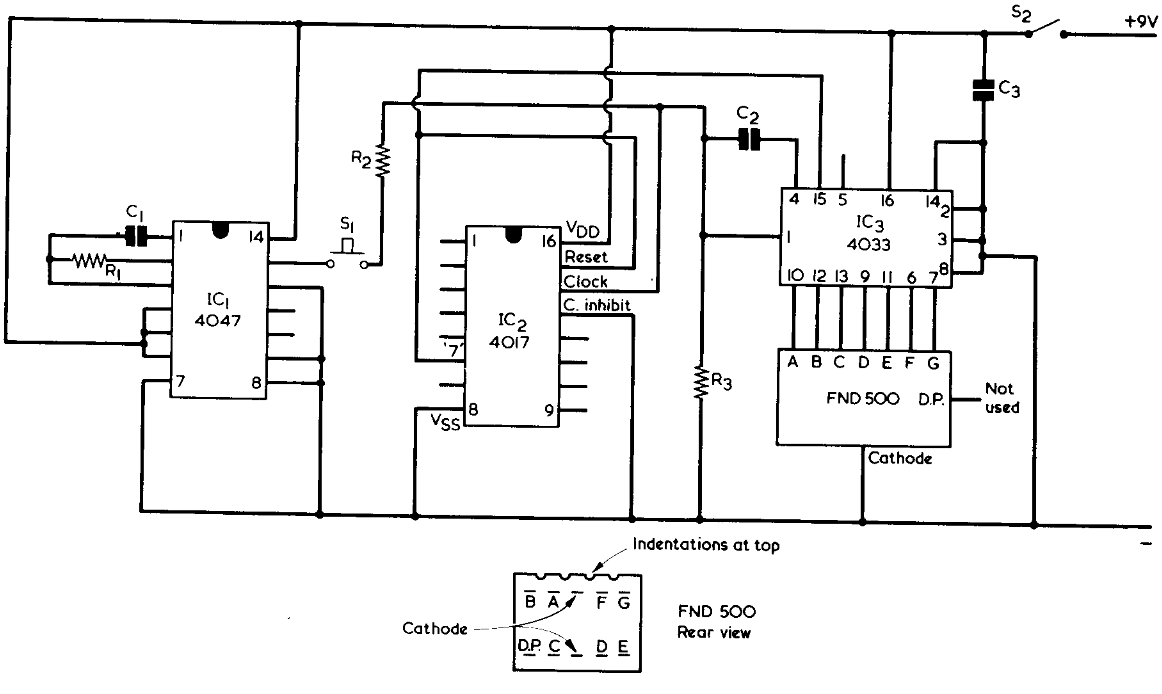


Fig. 3. The circuit of the digital dice unit. As may be seen, few discrete components are required in addition to the integrated circuits and the FND500 display

The front panel of the digital dice unit. Mounted on the left is S2, with S1 on the right. The FND500 7-segment display is positioned at the centre

COMPONENTS

Resistors
(All ¼ watt 5%) R2 1k Ω
R1 100k Ω R3 27k Ω

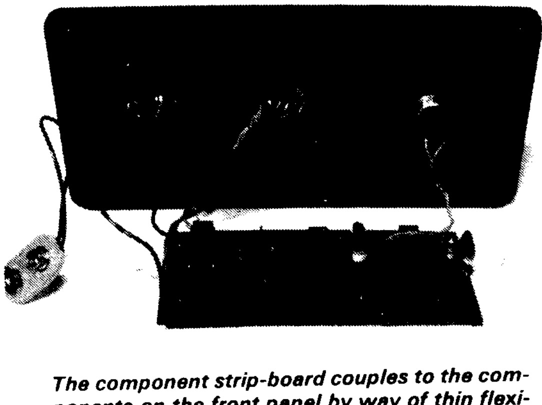
Capacitors
C1 0.015μF type C280 (Mullard)
C2 470pF ceramic plate
C3 0.1μF type C280 (Mullard)

Semiconductors
IC1 CD4047AE
IC2 CD4017AE
IC3 CD4033AE

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

Display
7-segment display type FND500

Miscellaneous
Plastic case (see text)
9-volt battery type PP6 (Ever Ready)
Battery connector
Veroboard, 0.1 in. matrix
14-pin d.i.l. socket
2-off 16-pin d.i.l. sockets
Wire, solder, etc.



The component strip-board couples to the components on the front panel by way of thin flexible leads

resistor R2. The one-of-ten counter is IC2, which is a 4017 device. The relevant pin functions of this device are shown in the diagram, and these follow Fig. 2 regarding the operation of this part of the circuit.

IC3 is the display driver and decoder i.c., and this is a CMOS 4033 device. The clock signal is applied to pin 1 and the signal from the zero output is coupled to this terminal by C2. The reset signal from IC2 is applied to pin 15 of IC3. Pins 2, 3 and 14 are inputs which are unused in this application, and so they are connected to the negative supply rail.

From a nominal 9 volt supply the 4033 i.c. can be used to directly drive a high brightness l.e.d. display of the common cathode type. An output current of only about 5mA per segment is available, and so it is absolutely essential that the l.e.d. display be an efficient type. An FND500 display is used in the prototype, and this has a character height of 0.5in.

CMOS i.c.'s require very little in the way of supply decoupling, and C3 is the sole decoupling component in the circuit. S2 is an ordinary on-off switch.

Apart from the CD4033 and the FND500 display the components are readily available. The CD4033 can be obtained from Messrs. Tom Powell, 306 St. Paul's Road, Highbury Corner, London, N1 or from Greenbank Electronics, 92 New Chester Road, New Ferry, Wirral, Merseyside, L62 5AG. The FND500 is available from Messrs. Tom Powell. It should be noted that a kit of parts for the complete digital dice project can also be provided by Messrs. Tom Powell.

CONSTRUCTION

The prototype unit is housed in a plastic case which has outside dimensions of about 150 by 80 by 55mm. Any plastic case of the same size or larger should be perfectly suitable provided it can accommodate the components. The general layout of the lid of the case, which is the front panel, can be seen from the photographs. S2 is mounted on the left hand side and S1 on the right hand side. The display is fitted at the centre, and it requires a rectangular cut-out 15mm. wide by 16mm. high. This can be made using a fretsaw or a coping saw. Alternatively, a hole about 13mm. in diameter can be drilled in the centre of the lid and then filed out to the correct shape and size using a miniature flat file. The display is glued into position using a good quality gap filling adhesive such as an epoxy resin. The indentations in the display should be at the top. No display filter is required as the FND500 has a built-in red filter.

Apart from the battery, the remaining components are wired up on a 0.1 in. matrix Veroboard panel which has 37 holes by 19 copper strips. Full constructional details of this panel are provided in Fig. 4.

Start by cutting out a panel of the correct size using a hacksaw, and then drill the two 6BA clearance mounting holes. Next make the numerous breaks in the copper strips. The components and link wires are then soldered into place.

All three i.c.'s are mounted in i.c. holders to avoid the risk of damaging them with high static voltages, as could occur if they were soldered directly into circuit. CMOS devices can easily be damaged by such voltages, although the use of internal protection circuitry and special packaging

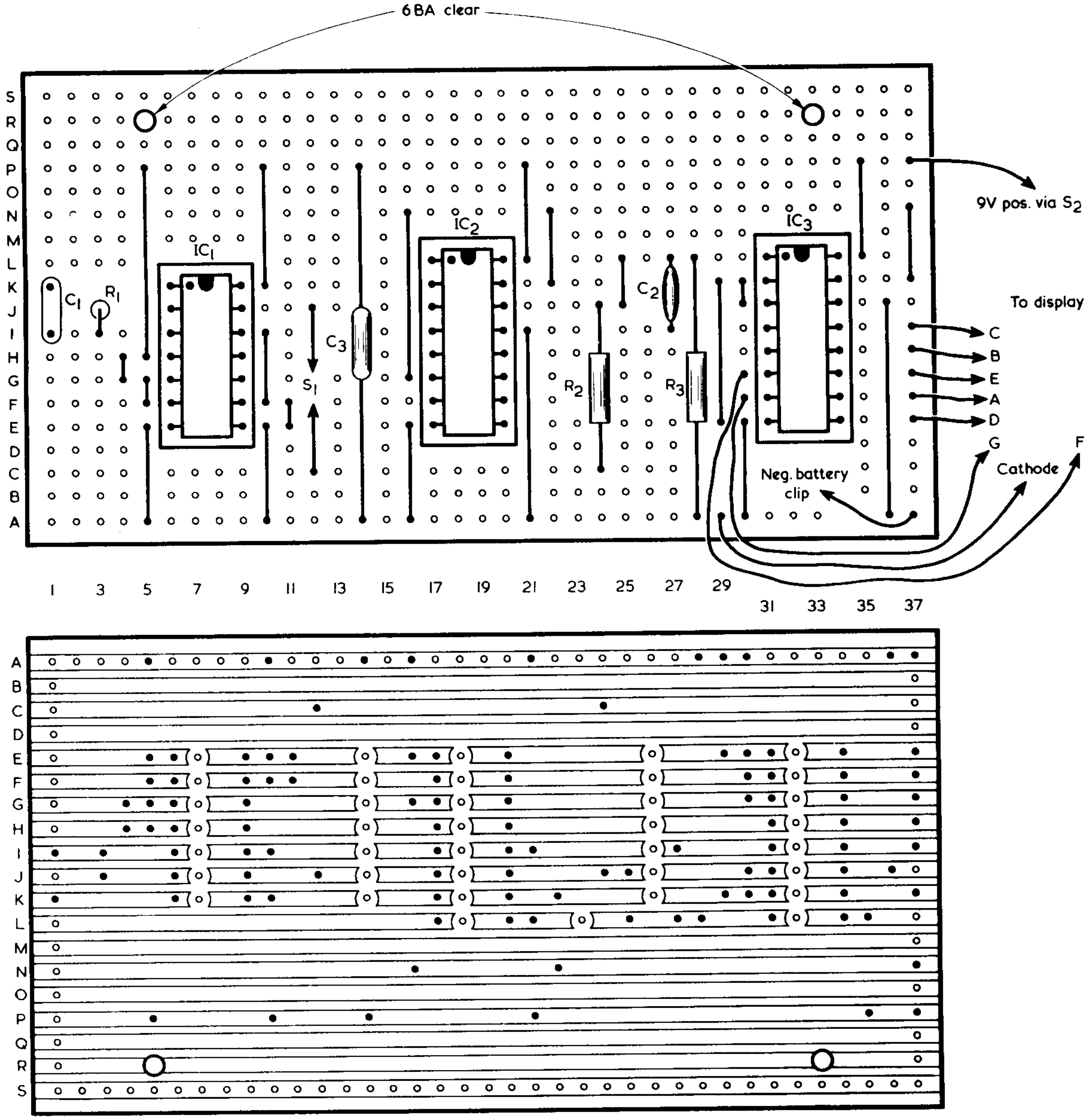
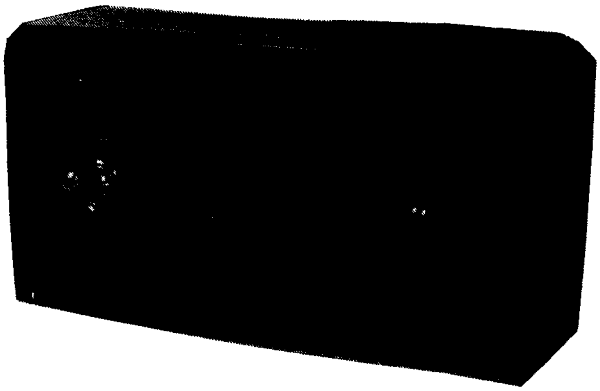
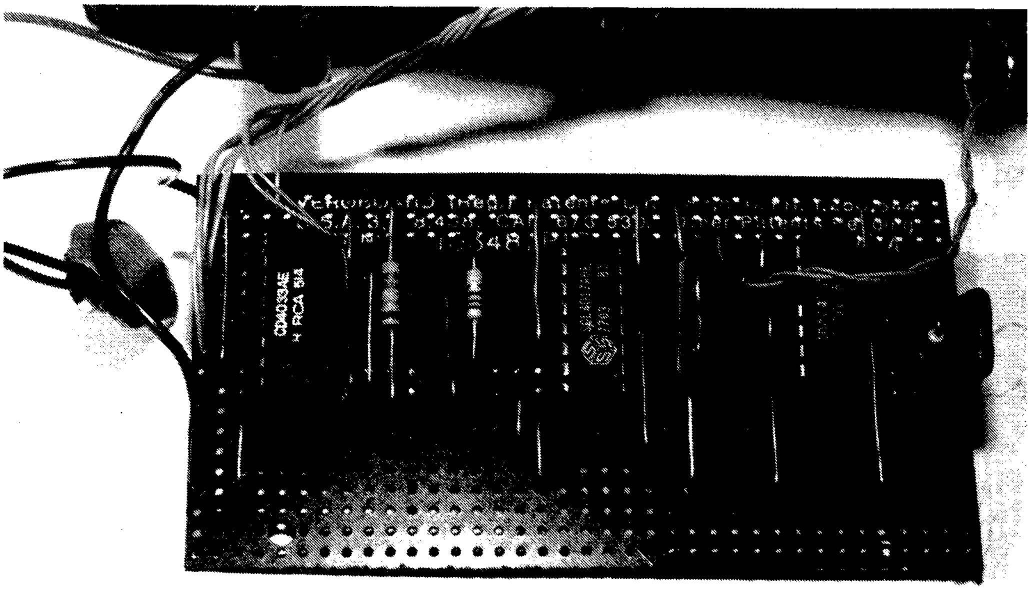


Fig. 4. Apart from the display and the two switches, all the components are assembled on a Veroboard panel. The layout and wiring are illustrated here

An angled shot of the digital dice unit





The components on the Veroboard. The three integrated circuits are fitted into i.c. holders

makes it highly unlikely that they will be damaged in this way if they are not misused or handled unnecessarily. The i.c.'s are left in their protective packaging until all other wiring has been completed, and they are then handled as little as possible.

The completed panel is wired up to the components mounted on the lid using thin p.v.c. insulated flexible leads. The battery connector is then wired into circuit. The component panel is mounted on the base panel of the case on the extreme right hand side and as far towards the rear as possible. The side of the panel having the mounting holes should be towards the front of the case. 6BA bolts about 12mm. long are used to mount the panel, and short spacing washers about 4mm. long hold the panel a little clear of the inside case surface. If spacers are not fitted it is quite possible that the panel will be strained and may break when the mounting bolts and nuts are tightened.

Power is obtained from a PP6 battery which fits into the remaining space inside the case. It can be secured with a simple home-made clip, if desired. The three CMOS i.c.'s consume very little current, and so the current consumption of the unit as a whole depends almost entirely upon what number is displayed. This varies from about 10mA with a figure 1 to approximately 30mA with a figure 6. There is, in consequence, quite good battery economy.

When the finished unit is first switched on it is likely that the display will fail to light up. This is because IC3 may initially be at zero, and the i.c. is connected in such a way that the zero will be blanked. Depressing S1 should cause the display to light up, and the circuit will then operate in the manner already described.

■

WAVEGUIDE GAS LASERS

By Michael Lorant

Using hollow waveguides of glass — tiny tubes with inner diameters about one half the thickness of a pencil lead—Peter Smith and co-workers at Bell Systems in the United States have succeeded in miniaturising gas lasers. A typical example of these lasers is about two inches long and twenty thousandths of an inch in diameter. The lasers will be employed in communications systems employing coherent light to carry large numbers of voice, picture and data signals.

Spaced at intervals along a light path, miniature gas lasers can amplify light signals to compensate for transmission losses in much the same way that communications signals are amplified in today's telephone systems. Conventional gas lasers are much too large to be used conveniently in such applications.

In most gas lasers, including the waveguide lasers, coherent light is generated by means of an electrical discharge analogous with that which causes a neon sign to glow. According to Smith, "for many gas lasers, the gain (the increase in intensity which the light experiences in passing through the gas) increases as the diameter of the discharge tube is decreased".

The tiny white circle is the inner region of the miniaturised waveguide gas laser. This region, roughly half the thickness of the mechanical pencil lead at the right, serves to channel light passing through it by means of multiple reflections from the highly polished internal walls

Peter Smith, Bell Systems scientist, demonstrates the new miniaturised waveguide gas laser. The line of light in the glass tubing at the left is passing through a waveguide configuration with a diameter of only twenty thousandths of an inch. Such lasers will appear in communications systems where light is the carrier for many channels of data, voice and picture signals.

But a smaller inner diameter is only part of the key to obtaining the required gain for gas laser action in very short lengths of tubing. With conventional gas laser designs, for instance, tubes with small inner diameters would actually block the passage of some of the laser light and would more than offset the benefit of higher gain.

To overcome this problem waveguide gas laser tubes are fabricated with very straight and highly polished inner walls. Light can be focussed so as to pass down these tubes and experience multiple reflections from the walls, allowing a beam to be efficiently transmitted with low losses. Also, the light which is guided down the tube can be effectively amplified by the gas laser discharge.

Depending on the kind of gas used to fill the tube, waveguide gas lasers have been operated at several wavelengths in the visible and near infrared parts of the spectrum. The first successful waveguide gas laser used a helium-neon discharge, and operated at 6,328 angstroms. R.F. excitation was necessary to maintain a stable discharge. A 5cm. laser tube was also fabricated, requiring only d.c. excitation.

The waveguide configuration for gas lasers should allow miniaturisation to the point where these devices can be used with integrated optical elements in many fields of communication. ■

NEWS . . . AND

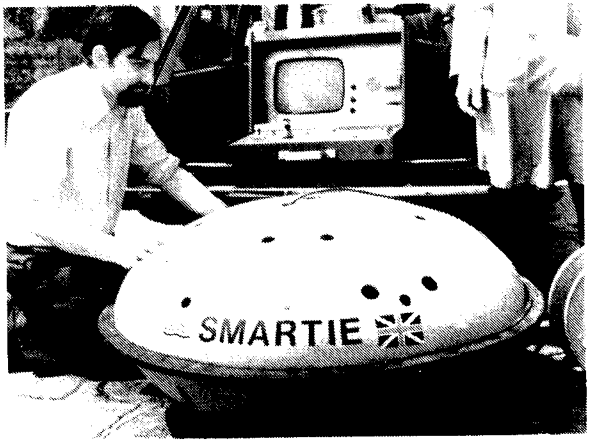
NEW BRITISH UNMANNED SUBMERSIBLE

A completely new type of microcomputer-controlled unmanned inspection system has been launched by Richmond-based Marine Unit Technology Limited.

The new vehicle — which is supported by the Department of Energy through the offshore Energy Technology Board — is lighter, smaller, more versatile, and far more controllable than other underwater inspection systems currently available, it is claimed.

The new system is code-named SMARTIE (Submarine Automatic Remote Television Inspection Equipment). It is elliptical in cross-section and is basically a highly mobile underwater vehicle equipped with a battery of underwater television cameras. These will consist of at least one low-light silicon intensified target (SIT) camera and a high resolution vidicon camera. The vehicle is driven by an electrically-powered submersible pump and is therefore propellerless.

The addition of on-board computer facilities has enabled Marine Unit to provide the offshore industry with a submersible which is much more powerful and versatile than has been available to the industry in the past. The microcomputer was designed and developed by Marine Unit Technology's research and development team headed by Dr. Brian Ray. This is the first occasion on which a microcomputer has been installed on an underwater vehicle of this type.



Marine Unit Technology staff give SMARTIE a final check before it enters the water on its recent proving trials in Plymouth. In the background is the operator's console

Apart from the relatively straightforward procedures of interpreting manually input control signals from the operator's console, and controlling vehicle speed and direction, the computer is also capable of making SMARTIE a good deal easier to operate. For low visibility work, the computer can accept input from the submersible's magnetic compass and gyro, and project an artificial navigation 'target' which the operator can follow on his video screen even though the craft may be passing through an area of zero visibility.

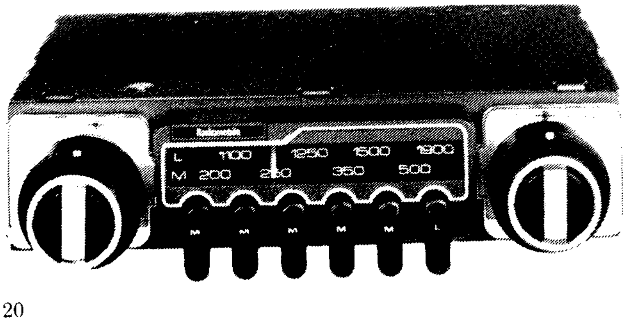
ADDITION TO RANGE OF PUSH-BUTTON CAR RADIOS

Radiomobile Limited have announced new additions to their popular range of push-button car radios — including Model 1180.

The Radiomobile 1180 is equipped with a dual output stage which makes it ideally suited for use with a separate stereo cassette deck.

The output using two matched speakers is 10 watts per channel when used as a radio and 5 watts per channel with the stereo cassette deck. There are six push-buttons giving pre-selection on five medium and one long wave station, full manual tuning, and variable bass/treble tone and balance controls.

Recommended retail price, including VAT is £78.64.



ANNOUNCEMENTS

- **We have been advised by Ramar Electronics Services Ltd., of Masons Road, Stratford-upon-Avon, Warwickshire that they can supply printed circuit boards for the CMOS Digital Frequency Meter featured in our July and August issues.**

  All boards will be on epoxy glass, roller tinned, and drilled as follows:— Schmitt etc. £2.65; Main p.c.b. £3.96; P.S.U. £1.15; Display 84p. All prices include v.a.t. and postage.

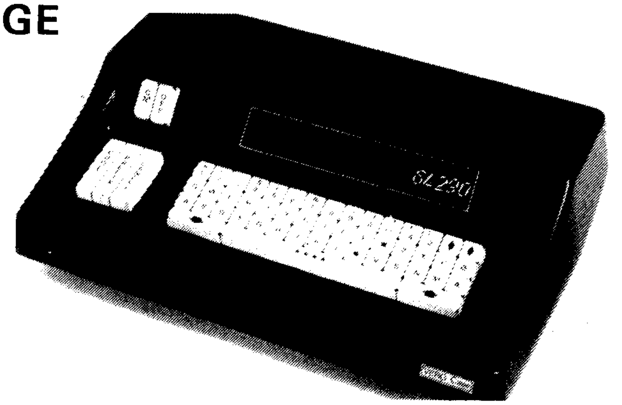
- **Messrs. Brian J. Reed of 161 St. John's Hill, Battersea, London SW11 1TQ, have asked us to draw the attention of readers to the fact that the prices quoted in their advertisements are now inclusive of v.a.t. and postage.**

- **The Torbay Amateur Radio Society are holding their Annual Mobile Rally on Sunday 27th August. The venue is the SCT/ITT Social Centre, Brixham Road, Paignton, Devon and the event is being run in conjunction with the Electronics Division of STC/ITT.**

  The Torbay Society continue to maintain the Amateur Station at the Douglas House Cheshire Home, Brixham and a percentage of the proceeds from the Rally will be donated to this worthy cause.

■ ■ ■ COMMENT

ADDITION TO CONSOLE RANGE



Vero Electronics Limited have increased their range of moulded plastic enclosures by the addition of a large sloping-front case.

Vacuum-formed from black textured ABS, the case, Order Code 75-3960E, is designed to suit applications requiring a full alphanumeric keyboard, or a standard calculator keyboard in association with a number of other controls. An anodised aluminium panel 430 mm x 115 mm is supplied with the case, but not fitted, for use as required in component mounting. A flat surface, suitable for the mounting of digital displays, is presented to the operator at a convenient angle.

RESISTOR WATTAGES

The ubiquitous miniature ¼ watt fixed resistor is so firmly established in the home-constructor field that it takes quite an effort to think back to what now seem to be the incredibly bulky ¼ watt resistors of 10 to 20 years ago. But the present delightfully small components are now virtually stock items and make the business of wiring up electronic gear a real pleasure.

However, what we hobbyists class as a ¼ watt resistor would very probably be looked upon as an eighth watt resistor by a large manufacturer of electronic equipment. The reason is simply one of obtaining a safety margin. When hundreds of thousands of resistors are assembled in widely scattered items which have been sold throughout the country it is comforting for a manufactuer's design staff to know that all these resistors are running well within their dissipation rating.

So far as the home-constructor is concerned the approach towards selecting resistor wattages is quite easy. Always make the (albeit pessimistic) assumption that a resistor is approaching its maximum dissipation when it is run at its rated wattage. So, if you put a resistor in a circuit where its calculated wattage dissipation is say 0.2 watt, don't use a ¼ watt resistor. Play safe and employ a ½ watt resistor instead.

It is often forgotten that the wattage rating of a potentiometer applies to its *whole* track. This rating then defines the maximum current which can be safely drawn from the track by the potentiometer slider. If for instance you have a 5kΩ potentiometer whose track is rated at 0.5 watt, that 0.5 watt dissipation will be given if there is 50 volts across the track, causing 10mA to flow through it. (50 volts times 10mA gives 500 milliwatts, or 0.5 watt.) It follows that the maximum current which may flow through the track, or *any part of it* between the slider and one end, is 10mA.

Fortunately, most home-constructor designs involve low voltages and low currents and we do not need to worry overmuch about excessive resistor and potentiometer dissipations. In most general cases, indeed, they are frequently well below a tenth of a watt.

DRY REED RELAYS

We are all familiar with dry reed relays in which the contacts are enclosed in a glass cartridge inserted inside the relay coil. Passing current through the coil causes the contacts inside the glass cartridge to snap together and to complete whatever circuit the relay is intended to control. The contact assembly may also be used on its own as a switch which is actuated by one or more permanent magnets.

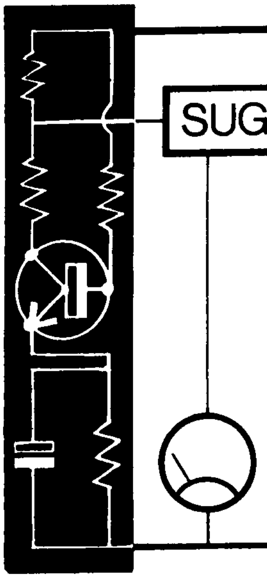
But why *dry* reed relay? Why is the word "dry" applied to the reed contacts? The answer is that the contacts are not wetted!

In telephone exchanges the type of relay employed before dry reed relays came on the scene was of the P.O.3000 type in which the contacts are open to the air. When the contacts of a relay of this type close they have a small self-wiping action which cleans off any thin film of oxide which may have formed on their surfaces. But this self-cleaning action may not be sufficient to fully remove the oxide if the relay is energised very infrequently, as can happen in some telephone applications. The result is that the completed circuit is not fully effective and the poor contact connection gives rise to crackles.

The oxide on contacts of this nature can still nevertheless be broken down if, on closing, the contacts complete a circuit across which a small direct voltage, of the order of 30 to 50 volts, is present. The tiny spark on contact closure given by the voltage is sufficient to break down the oxide and allow a crackle-free connection to be made. With infrequently operated open relay contacts which normally switch small signal voltages and currents it is the practice to apply this voltage, which is referred to as a "wetting" voltage.

Dry reed contacts are encapsulated in their glass cartridge, which is filled with inert gas. In consequence they do not oxidise and do not need a "wetting" voltage. Hence the term "dry". Simple, isn't it?

"No, son, I've no idea what your next experiment is. Should I have?"



SUGGESTED CIRCUIT

MUSICAL VOLTMETER

By G. A. French

We already have moving-coil voltmeters and digital voltmeters. Here, now is a *musical* voltmeter! It functions by generating an audible a.f. tone when a voltage of the correct polarity is applied to its test terminals, the frequency of the tone rising as the voltage increases.

This idea is by no means as outlandish as it may at first sight appear. After some experience with the voltmeter the user soon acquires a knowledge of the tone frequency for specific voltages at the test terminals, and it is readily possible, for instance, to distinguish the tone given by a partly run-down 9 volt battery against that given by a new battery. The voltmeter may also be used as a voltage monitor when it is desired to carry on with other work. If it is connected to, say, the output of a suspect power supply its changing tone frequency will soon indicate when the output voltage of the supply varies or fluctuates. For servicing work the musical voltmeter has the advantage that there is no necessity to visually consult a scale or a digital read-out; as soon as the user knows the tone frequency given by the voltage across the main supply rails of the equipment being examined it is a very simple matter to check whether the requisite lower voltages are appearing at the ends of decoupling and load resistors.

A particularly useful feature of the voltmeter is that it is completely silent in the absence of test voltage. When switched to the lowest voltage range, a test voltage of 0.1 volt is sufficient to cause it to generate its lowest frequency tone.

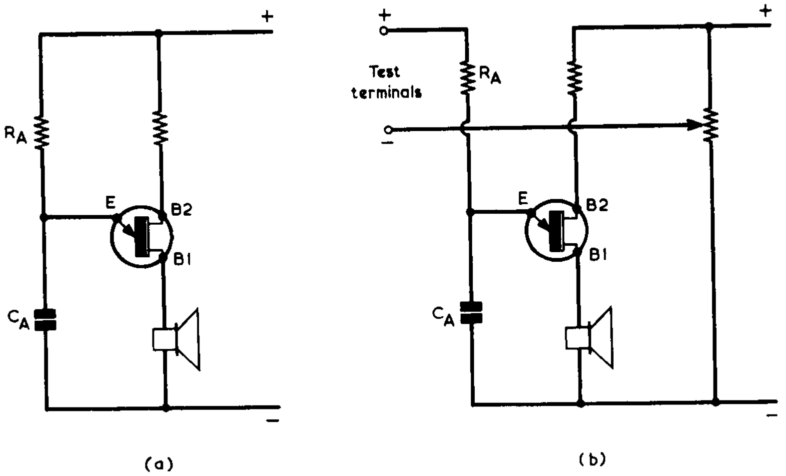


Fig. 1(a). A standard unijunction transistor a.f. oscillator circuit

(b). If the oscillator circuit is modified as shown here, the frequency of oscillation rises as the test voltage increases

TONE GENERATOR

The tone generator in the musical voltmeter employs a unijunction transistor. A standard unijunction transistor oscillator circuit is shown in Fig. 1(a). After the power is applied, capacitor CA commences to charge via resistor RA until the voltage across its plates reaches the emitter-base 1 triggering potential for the transistor. The capacitor rapidly discharges into the base 1 load, then charges once more via RA. The result is a series of evenly spaced current pulses passing through the base 1 load, their repetition frequency being governed by the values of RA and CA.

In Fig. 1(b), RA is disconnected from the upper supply rail and is connected instead to a positive test terminal. The complementary negative test terminal is returned to the slider of a potentiometer connected across the supply rails, this slider tapping off a voltage that is fractionally lower than the triggering voltage of the unijunction transistor. Should the two test terminals be connected together the circuit will not oscillate. If, however, a voltage is applied to the test terminals with the polarity shown, the upper end of RA is taken positive of the transistor triggering potential and the circuit then oscillates. It will be evident that the greater the test voltage the faster will be the rate of charge in CA between discharge pulses through the emitter and base 1 of the transistor. Thus, increasing the test voltage increases the repetition frequency of the pulses in the base 1 load.

In both Figs. 1(a) and (b) the base 1 load of the transistor is a loudspeaker. This directly reproduces the pulses in the form of an a.f. tone. With Fig. 1(b) the frequency of the tone rises as test voltage increases.

VOLTAGE FOLLOWERS

A working version of the scheme illustrated in Fig. 1(b) is given in Fig. 2. The potentiometer now appears as VR1, with R9 in series to restrict the voltages tapped off by its slider to the range which is required in practice. The voltage from VR1 is applied to the non-inverting input of the 741 operational amplifier, IC2. This has its output returned to its inverting input with the result that it functions as a voltage follower, its output voltage being almost exactly equal to the voltage at its non-inverting input. The advantage of this op-amp configuration is that it provides an output voltage at low impedance which is virtually the same as an input voltage derived from a high impedance source. The output voltage from IC2 connects to the negative test terminal of the voltmeter.

IC2 output also connects via R6 to the non-inverting input of another 741, IC1. This is also a voltage follower and its output couples to R7 which, in turn, connects to C1. These two components carry out the same functions as did RA and CA in Fig. 1(b), and their junction couples in the same manner to the emitter of the unijunction transistor TR1. The base 1 load is the 15Ω speaker, LS1.

The input impedance of IC1 is very high, being typically 2MΩ. In the absence of test voltage its non-inverting input is therefore at virtually the same potential as the output of IC2. Under these conditions, VR1 can be set up such that the output of IC1 is just below the triggering potential of TR1. When a test voltage is applied the output of IC1 then goes positive, causing the unijunction transistor circuit to oscillate.

It is found that a useful voltage range variation at the non-inverting input of IC1 is from zero to 1 volt positive. In the present circuit an arbitrary choice was made to give the voltmeter a sensitivity of 20kΩ per volt, and R6 has this value. So also has R5 whereupon Range 1, selected by S1, is 0-2 volts. The same value of resistance per volt is maintained in the further series resistors R4 to R1, giving the range voltage figures shown in the diagram.

Diodes D1 and D2 provide protection against excessive input test voltages, and they prevent the non-inverting input of IC1 from being taken more than 0.65 volt positive of the upper supply rail or more than 0.65 volt negative of the lower supply rail. Current limiting protection for the output of IC2 is given by whichever of the resistors R5 to R1 is switched in by S1.

PRACTICAL POINTS

Apart from some of the series input multiplier resistors, all the components are standard items. LS1 can be any small 15Ω speaker with a diameter of 2.5 in. or more. Speakers with this impedance are available from a number of suppliers, including Doram Electronics. The volume of the tone produced by the speaker is not great but will be more than adequate for a normal workshop environment.

The pin numbering for IC1 and IC2 applies to the 741 in its 14 pin d.i.l. package. The 8 pin d.i.l. version may alternatively be used, in which case pin 2 is the inverting input, pin 3 the non-inverting input, pin 4 the negative supply, pin 6 the output and pin 7 the positive supply. With either i.c. package, no connections are made to the unused pins.

The current drawn from the 9 volt battery is about 3mA, both when the a.f. tone is present and when it is absent. A battery type PP7 will be adequate. The voltmeter functions with falling battery voltage down to approximately 7.5 volts.

The fixed resistors can all be ¼ watt or ½ watt types, and R7 to R9 inclusive may have a tolerance of 10%. R1 to R6 may be 5% or less. R2, R5 and R6 are in the E24 series of preferred values and are offered by some suppliers in a closer tolerance than 5%. R1 and R4 do not have preferred values although the values shown for these two resistors are occasionally found amongst close tolerance types. Since this is not a pointer instrument it would be satisfactory in practice to use a 620kΩ 5% resistor for R1 and a 62kΩ 5% resistor for R4. Alternatively, R1 could consist of two 1.2MΩ resistors in parallel and R4 of two 120kΩ resistors in parallel.

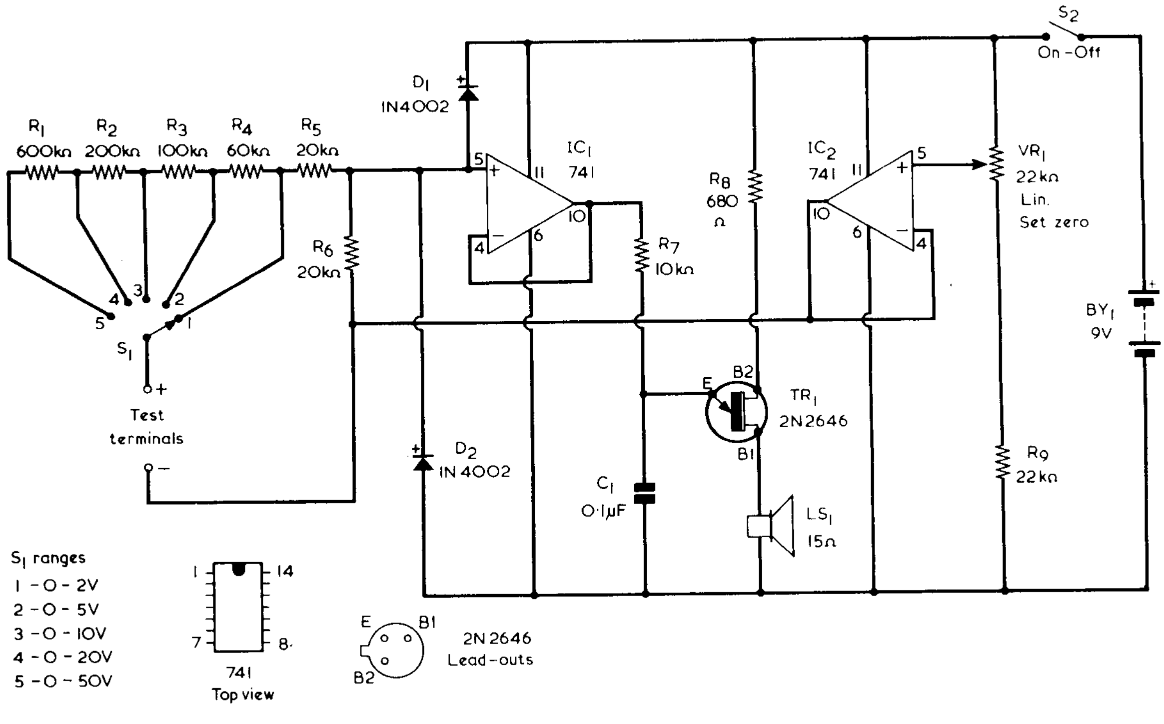


Fig. 2. The complete circuit of the musical voltmeter

The components may be assembled in any small plastic case capable of accommodating them. This will require an aperture for the speaker in the front panel, on which may also be mounted S1, S2, VR1 and the test terminals. VR1 should be wired such that the voltage tapped off by its slider goes positive as its spindle is turned clockwise.

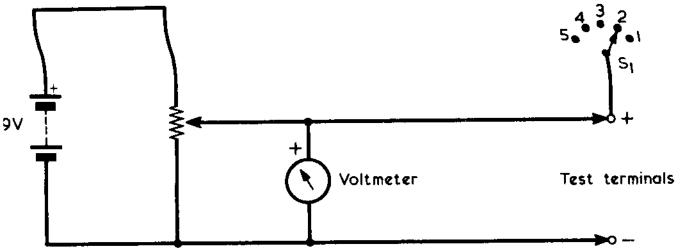


Fig. 3. Checking the completed instrument. The monitoring voltmeter across the test terminals is a standard multimeter switched to a suitable volts range

The voltmeter may be checked with the circuit shown in Fig. 3, where a potentiometer is connected across an external 9 volt battery to give differing test voltages. The potentiometer may have any value between 1kΩ and 20kΩ, and the voltage between the lower end of its track and its slider is monitored by a standard multimeter switched to a suitable voltage range. Before connecting the musical voltmeter to the test circuit it is switched on and VR1 is adjusted clockwise to the setting just below that at which oscillation commences. The musical voltmeter is then set to Range 2 and coupled to the test circuit, the potentiometer of which is adjusted to give voltages ranging from zero to 5 volts. The frequency of the tone produced by the musical voltmeter should increase noticeably as the test voltage increases. With the prototype circuit the tone frequency was approximately 200Hz at a very low test voltage, rising to around 2kHz at the maximum voltage in the range selected. The frequency should continue to rise for test voltages above the nominal maximum range voltage (i.e. above 5 volts with the circuit of Fig. 3), thereby indicating that the voltmeter has more than adequate sensitivity "in hand."

In use the musical voltmeter is employed in the same manner as an ordinary voltmeter, apart from the fact that it is necessary to set up VR1 at the start of any set of measurements. As already stated, this potentiometer is adjusted clockwise, with no test voltage applied, to the point just below that at which oscillation commences. ■

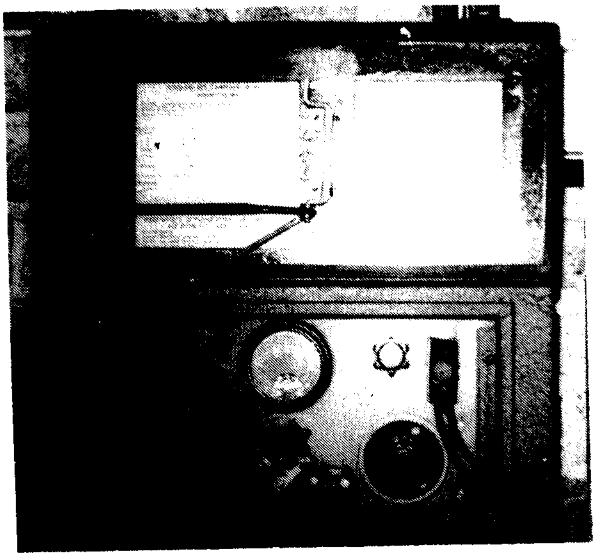
THE 58 SET

By Ron Ham

The Canadian Wireless Set No. 58 Mk 1, shown in the photograph with its lid open, is a recent addition to the author's collection of antique and wartime radio equipment. Made in 1943, it is one of the rarer transceivers employed in World War II.

PERMEABILITY TUNING

like all military equipment, the 58 set is beautifully engineered, and it has many unique features including permeability tuning and ultra slow motion tuning drives for both the receiver and the transmitter. The receiver tuning control is at the left and that for the transmitter is at the right. At bottom centre is the send-receive switch, which can be operated by a mechanical shafting when the lid is closed. Other controls are volume and receiver aerial trim at upper left, and a transmitter output trim and netting switch below the meter.



The Canadian Wireless Set No. 58, one of the more infrequently encountered transceivers from World War II. Used in conjunction with a separate back-pack power supply, this covers 6 to 9MHz

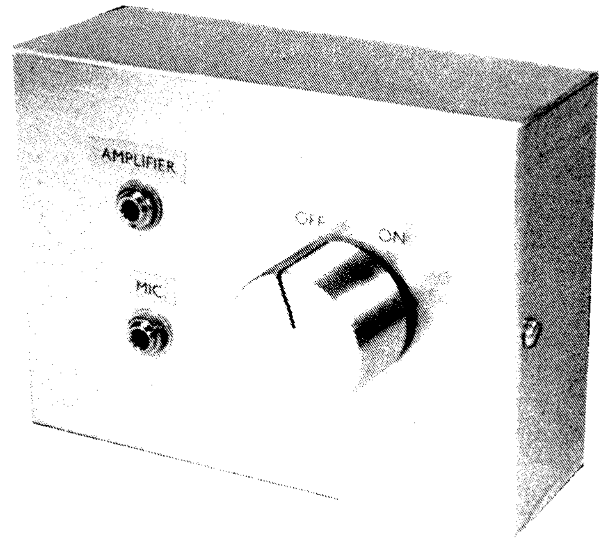
The set weighs 14 lbs. and, compatible with Wireless Sets 18, 19, 38 and 52, covers 6 to 9 MHz.

The wireless unit proper is assembled on the rectangular black panel measuring 10½ by 5in. and is 3¼in. deep, and this is housed in an inner sprung frame inside the military green case which measures 14 by 7 by 6in. with the lid closed. On the chassis behind the front panel and are eight valves, these being two 1T4's, one 1R5, three 1S5's and two loctal 1299A's. There is also a host of robust components and two fuses with the unusual marking of 1/32 amp.

A matching green back-pack, measuring 10½ by 14 by 4½in. deep and weighing 25 lbs., contains a vibrator power pack and two 2 volt lead-acid accumulators together with a set of spare fuses, valves and vibrator. Each accumulator has three coloured balls of different density to indicate the specific gravity of the acid and, hence, the state of charge. The accumulators are used individually to drive the power unit, but a switch is incorporated which can bring them both into operation when they are in a low state of charge.

A 10-way connector at the end of a power lead from the supply plugs into the left hand side of the set. There are also a pair of flying leads which enable two operators to use the set, each having a padded headset with a permanently attached microphone. ■

THE ZN424E OPERATIONAL AMPLIFIER



By P. R. Arthur

New i.c. with very low distortion features in a dynamic microphone pre-amplifier.

Although i.c. operational amplifiers were originally designed for use in general analogue computing applications, they are employed in a very wide range of uses these days. Among other things they are capable of low noise low distortion amplification and are therefore ideal for audio applications.

FERRANTI ZN424

One of the highest quality operational amplifiers in these two respects (in fact, to the best of the author's knowledge, the highest quality operational amplifier i.c. at present available) is the Ferranti ZN424. It comes in three versions which are electrically identical but have different package styles. These are the ZN424P which is an 8 pin d.i.l. device, the ZN424T which has an 8 pin TO-99 metal encapsulation, and the ZN424E which is a 14 pin d.i.l. device. The last is the only version which is readily available to the amateur user at the time of writing, and it has the pin connections shown in Fig. 1.

The main advantage of the ZN424 over alternative devices is that when operated from a dual supply voltage in the range 12 to 18 volts maximum (or 24 to 36 volts maximum if a single supply rail is used) the i.c. has a typical distortion level of less than 1.5% with a 2 volt peak-to-peak output level and the output moderately loaded. This may not seem to be particularly good, but remember that it is without any negative feedback applied. There are some audio pre-amplifier i.c.'s which offer a similar level of open loop distortion, but they have a considerably lower open loop voltage gain than does the ZN424. Thus, for a given closed loop gain the ZN424 will provide lower distortion due to the greater amount of feedback. Similarly, many operational amplifier and audio pre-amplifier i.c.'s have a much higher open loop gain than the ZN424, but also have a very much greater level of open loop distortion, so that even the increased negative feedback does not compensate sufficiently to produce an improvement on the closed loop distortion performance of the ZN424. Also, the guaranteed minimum voltage gain figure for such devices is often little or no better than that for the ZN424.

PERFORMANCE

The typical open loop voltage gain of the ZN424 is 86dB (20,000 times) with the minimum figure being 80dB (10,000 times). The absolute maximum permissible supply voltage is 18 volts positive and negative with a dual supply of 35 volts in the case of a single supply rail. It is advisable and normal to allow a safety margin of at least 10% under these figures, though. The device will work quite well from a comparatively low voltage supply such as a

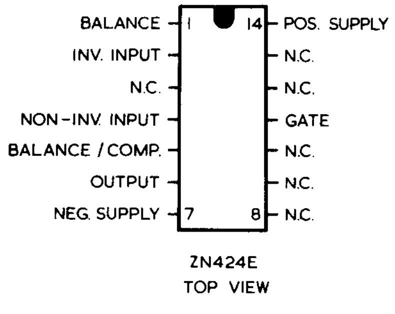
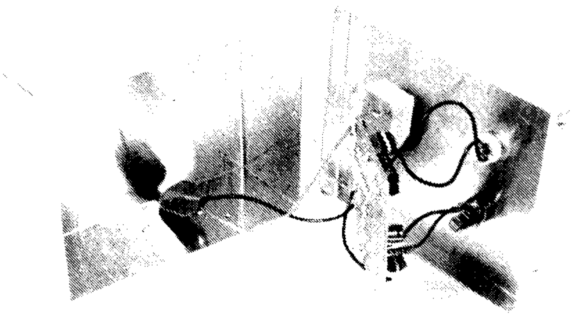


Fig. 1. Pin allocations for the Ferranti ZN424E operational amplifier



The component panel is housed in an all-metal case which provides screening

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 10%)
R1 220Ω (see text)
R2 1.5 kΩ
R3 15kΩ
R4 15kΩ
R5 68Ω
R6 1.5MΩ
Capacitors
C1 4.7μF electrolytic, 10 V. Wkg.
C2 10μF electrolytic, 10 V. Wkg.
C3 0.01μF type C280 (Mullard)
C4 10μF electrolytic, 10 V. Wkg.
C5 0.1μF type C280 (Mullard)
Semiconductor
IC1 ZN424E
Switch
S1 s.p.s.t. rotary
Sockets
SK1 3.5mm. jack socket
SK2 3.5mm. jack socket
Miscellaneous
Metal case (see text)
Control knob
9 volt battery type PP3 (Ever Ready)
Battery connector
I.C. holder, 14 pin d.i.l.
Veroboard, 0.1 in. matrix
Nuts, bolts, wire, etc.

9 volt battery. Without feedback and using the recommended compensation network the gain of the device falls to unity at approximately 4MHz and the -3dB point of the response is typically at 20kHz. The input and output resistances are typically 200kΩ and 4kΩ respectively. The maximum differential input voltage should not be allowed to exceed 5 volts.

From Fig. 1 it will be seen that the ZN424 has a gate terminal. This has the effect of isolating the input from the output when it is connected to the negative supply rail, and the gating facility can be extremely useful in a few highly specialised applications. However, in most applications the gate feature is not required and the gate terminal can simply be ignored. An offset null control can be used if necessary, and can consist of a 1MΩ pre-set potentiometer with the ends of its track connected to pins 1 and 5 of the i.c. The slider of the potentiometer connects to the positive supply rail via a resistor of about 47kΩ in value. Of course, in most audio applications the offset null control is not needed.

PRACTICAL PROJECT

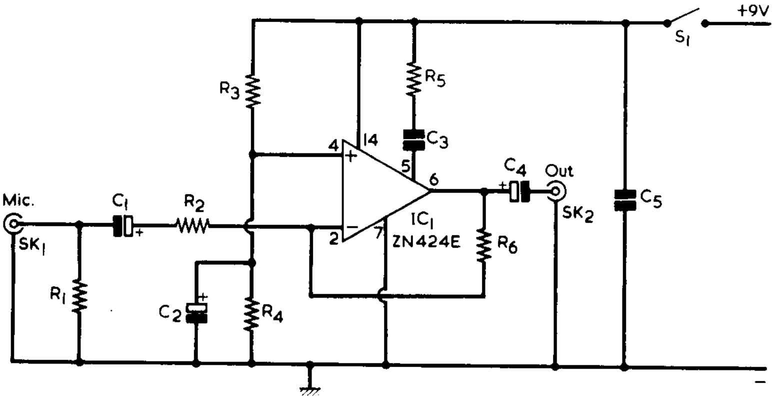
The ZN424 is suitable for use in many pre-amplifier applications, and a practical example is given in the circuit of Fig. 2. This is for a low impedance (200Ω) dynamic microphone pre-amplifier, and it can be readily adapted for 600Ω microphones simply by altering the value of one resistor. A pre-amplifier such as this is usually needed if a low impedance microphone is to be used in conjunction with an amplifier, as it is very rare for an amplifier to have a suitable input. For instance, not all tape decks and recorders have an input for this type of microphone, and so a suitable external microphone pre-amplifier is needed if a low impedance dynamic microphone is to be used successfully with such machines.

The pre-amplifier consists basically of just an ordinary inverting mode operational amplifier circuit. A single supply rail is used and so R3 and R4 are included to provide a central voltage point between the supply rails which biases the non-inverting input of the i.c. C2 provides decoupling at the non-inverting input and helps to produce good stability and a low noise level.

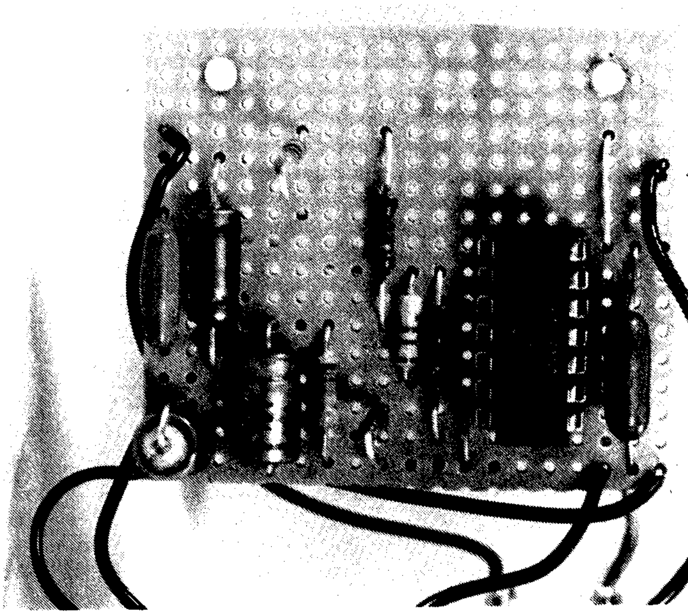
R5 and C3 are the compensation components, and these are needed in order to ensure that the i.c. remains stable.

The voltage gain and input impedance of the amplifier are set by the values in the negative feed-

Fig. 2. The circuit of a dynamic microphone pre-amplifier incorporating the ZN424E



The Veroboard panel provides a neat and simple means of assembly for the components



back network formed by R6 and R2. The voltage gain is approximately equal to R6 divided by R2 (1,500kΩ/1.5kΩ) which is obviously 1,000 times (60dB) with the specified component values. This may seem to be rather high, but it must be borne in mind that the output from a low impedance dynamic microphone is only in the region of a few hundred microvolts. A high level input on an amplifier or tape deck requires an input level in the order of a few hundred millivolts. Thus, this high level of gain is necessary.

What is termed a "virtual earth" is formed at the inverting input of the i.c. and so, disregarding R1, the input impedance to the op-amp is roughly equal to R2, or 1.5kΩ. R1 shunts the input of the pre-amplifier and so reduces the input impedance to approximately the required level of 200Ω. The value of R1 may be altered to 1kΩ if the pre-amplifier is to be used with a 600Ω dynamic microphone.

D.C. blocking is accomplished at the input by C1, and C4 provides d.c. blocking at the output. Both these capacitors, as well as C2, are specified as 10 V. Wkg., but it will be in order to use components having a higher working voltage. C5 is a supply bypass capacitor and S1 is a straightforward on-off switch. The circuit consumes only about 2mA from a 9 volt supply and so a small battery such as a PP3 makes a suitable power source for the unit.

CONSTRUCTION

All the components, apart from S1 and the input and output sockets, are wired up on a 0.1 in. pitch Veroboard panel which has 16 copper strips by 19 holes. See Fig. 3 for full details of the layout and wiring of this panel, and also for details of the other wiring. There are three breaks in the copper strips, and these can be made using either the special Vero spot face cutter tool or a small twist drill held in the hand. The two mounting holes are 6BA or M3 clear. It is not essential to use an i.c. holder or Soldercon pins for the ZN424, but as this is a comparatively expensive component it is advisable to do so.

The prototype pre-amplifier is housed in an aluminium box which has approximate outside dimensions of 4 by 3 by 1½in. This can be obtained from Harrison Bros., 22 Milton Road, Westcliff-On-Sea, Essex, SS0 7LQ. Any similar metal case which can accommodate the parts will be equally suitable. It is essential for the case to be of all-metal construction so that the circuit is well screened from mains hum and other stray electrical pick-up.

The general layout of the pre-amplifier can be seen from the accompanying photographs, and this is not at all critical. S1 is mounted towards the right hand side of the front panel, which consists of the lid of the box. SK1 and SK2 are mounted at the left hand side of the panel, one above the other with SK2 the higher of the two. S1 requires a ⅜in. (or 10mm.) diameter mounting hole. SK1 and SK2 are both 3.5mm. jack sockets and require ¼in. (or about 6.5mm.) diameter mounting holes. These two sockets should be of open construction (i.e. not insulated) because the negative supply rail connects to the metal case via their mounting bushes and nuts. The completed component panel is mounted on the rear panel of the case on the left hand side using two 6BA or M3 bolts and nuts. Spacers are passed over the bolts to hold the copper strips on the underside of the panel about ¼in. clear of the metal case. The panel must be wired up to SK1, SK2, S1 and the battery clip before it is finally mounted inside the case.

There is no need to use screened leads to connect SK1 and SK2 to the component panel as the case provides overall screening. Also, there is little likelihood of instability occurring due to stray feedback between the input and output of the pre-amplifier despite its high voltage gain, since the input is at a low impedance and the input and output are in anti-phase. The input and output cables connecting to the microphone and the amplifier should, however, be screened. There is plenty of space for a PP3 battery to the rear of S1, and if necessary some foam rubber or a similar material can be used to ensure that this battery is held firmly in position.

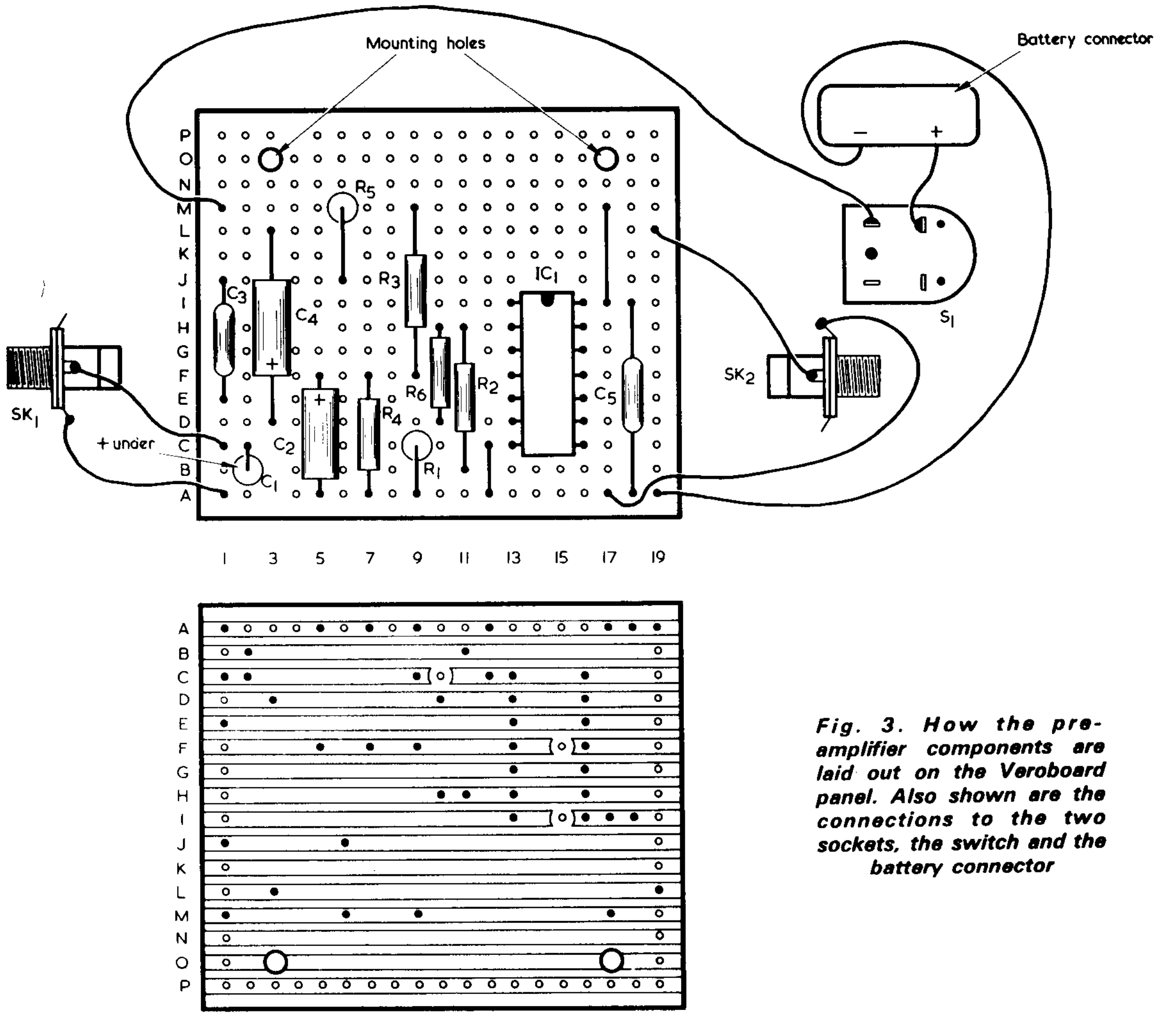
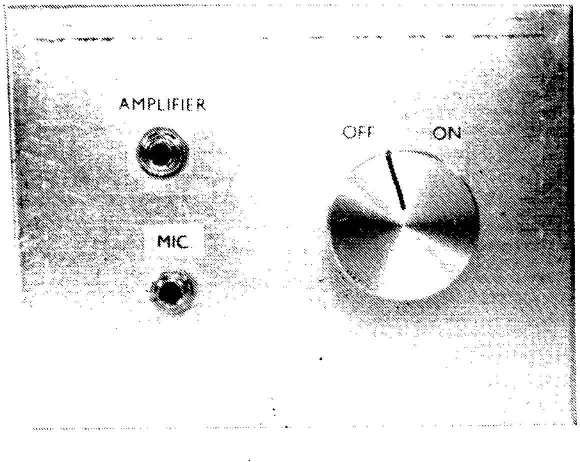


Fig. 3. How the pre-amplifier components are laid out on the Veroboard panel. Also shown are the connections to the two sockets, the switch and the battery connector

PERFORMANCE

For a 2 volt peak-to-peak output signal the ZN424 i.c. has a typical distortion level of less than 1.5%, as was stated earlier. The typical open loop gain of the device is 20,000 times (86dB) and the closed loop gain in this application is 1,000 (60dB). This means that the feedback is reducing the gain of the i.c. by 20 times (26dB) and so the distortion is similarly reduced. This would give the unit a typical level of t.h.d. of less than 0.075%. Such a figure may not be quite achieved in practice here as the i.c. is being run from a supply potential of only 9 volts, but the distortion on the prototype is certainly very low and is only in the region of the calculated figure. (The distortion was too low for the author to measure accurately with the equipment available to him.)



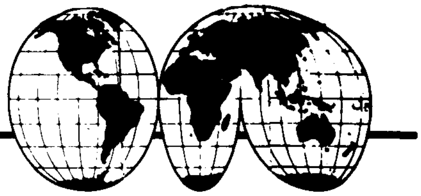
The front panel of the pre-amplifier. Mounted here are the input and output sockets and the rotary on-off switch

The wideband output noise of the prototype was measured at 1mV, which was a little disappointing since it represents a signal-to-noise ratio of -54dB with reference to an output level of 500mV r.m.s. However, further investigation showed that much of this noise was well above the upper limit of the audio spectrum, and filtering out the ultrasonic noise content produced a signal-to-noise ratio of better than -63dB. Proper weighting would almost certainly produce an even better figure.

The pre-amplifier will produce an output of just under 2 volts r.m.s. from a 9 volt supply without clipping. If necessary, the overload margin can be increased if the supply voltage is raised to 18 volts by using two PP3 batteries connected in series. There is plenty of room for these inside the case.

■

SHORT WAVE NEWS
FOR DX LISTENERS



By Frank A. Baldwin

Times = **GMT** *Frequencies* = **kHz**

● LATIN AMERICA

South American stations are always of interest to most Dxers but for the successful logging of many of these transmitters, many early morning listening sessions are required — and I mean early — anytime between 0100 and 0500.

Some of the LA transmitters recently heard here are listed below.

● PERU

La Voz de la Selva, Iquitos, on **4825** at 0355, OM with identification in Spanish followed by local-style music and songs.

● HONDURAS

La Voz Evangelica, Tegucigalpa, on **4820** at 0409, OM with a talk about travel in the U.S. and religion, all in English.

● COLOMBIA

Radio Guatapuri, Valledupar, on **4815** at 0130, 3 chimes and identification in Spanish by OM, LA dance music.

● VENEZUELA

Radio Carora, Carora, on a measured **4907** at 0142, OM with identification, commercials, local pops on records.

Radio Impacto, Valencia, on **3355** at 0335, YL with love song in Spanish, OM announcer, LA music.

Radio Universidad, Merida, on **3395** at 0225, local-type dance music and songs, OM announcer.

● BRAZIL

Radio Brazil Central, Goiania, on **4985** at 0435, local pop records, OM in Portuguese.

CURRENT SCHEDULES

● SAUDI ARABIA

The Broadcasting Service of the Kingdom of Saudi Arabia operates the Holy Qur'an Station from Riyad both in the Domestic and External Services. Reading from the Holy Qur'an may be heard from 0630 to 1010 on Fridays only on **15365**; from 1500 to 1800 on **15350** daily and from 1800 to 2100 on **11820** daily.

● THAILAND

"Radio Thailand" has an External Service in which programmes in English are radiated from 0415 to 0515 and from 1055 to 1155 on **9655** and on **11905** beamed to both Asia and Europe. Programmes in various languages are featured on these two channels from sign-on at 0415 through to sign-off at 1425. Additionally, there is a further programme in English from 2330 to 0155 on the same channels.

● MALAYSIA

The "Voice of Malaysia", Kuala Lumpur, broadcasts in English from 0625 to 0855 on **6175, 9750** and on **15295.**

● NIGERIA

The Nigerian Broadcasting Corporation, Lagos, radiates programmes in the Domestic Service (national Programme) mostly in English on **4990** from 0430 to 1000 and from 1700 through to 2305, also on **7255** from 1000 to 1700.

Programmes in the Domestic Service from regional centres are as follows — Enugu, Anambra State, from 0430 to 2305 on 6025; Benin City, Bendel State, from 0430 to 2305 on **4932**; Maiduguri, Borno State, from 0430 to 2305 on **6100**; Calabar, Cross River State, on **6145** from 0430 to 2305; Kaduna, Kaduna State, from 0430 to 2305 on **3396**; Ilorin, Kwara State, from 0430 to 2305 on **7145**; Sokoto, Sokoto State, from 0425 to 2305, on **6195.**

● ETHIOPIA

The "Voice of Revolutionary Ethiopia — National Service", Addis Ababa, is one of the Domestic Service transmitters operating mostly in Amharic from various times from 0330 through to 2000 on **4905, 5985** and on **7110.**

● CHINA

For 'China watchers', the following information will be of interest. While all of the channels are not mentioned here, those that should provide targets for most SWL's are included.

● FUKIEN FRONT

The Fukien Front station operated by the People's Liberation Army, broadcasts both in Amoy and Standard Chinese to Taiwan and other Offshore Islands.

From 1415 to 2400 on **2490**; from 1444 to 2310 on **3000**; from 1600 to 2233 on **3535**; from 1600 to 2233 on **3640**; from 1000 to 0530 on **4045**; from 1415 to 2400 on **4330**; from 1000 to 1559 and from 2234 to 0530 on **5240** and from 1000 to 1559 and from 2234 to 0530 on **5265**. All of the foregoing are part of the First Network in Standard Chinese.

The Second Network operates in Amoy from 0230 to 0745 and in Standard Chinese from 0745 to 0930. From 1515 to 1900 on **2600**; from 1400 to 1900 on **3200**; from 1515 to 1900 on **3300**; from 1400 to 1900 on **3400**; from 1515 to 1900 on **3900**; from 1121 to 1900 on **4140**; from 0230 to 1900 on **4380**; from 0230 to 1900 on **4840** and from 0230 to 1900 on **5170**.

RADIO PEKING — DOMESTIC SERVICES

The Radio Peking Domestic Service (Summer/Autumn Schedule) lists the following channels likely to be of interest to the Dxer.

First Programme from 1403 to 1735 and from 2000 to 2300 on **4460**; from 1100 to 1735 and from 2000 to 0100 on **4800**; from 1100 to 1735 and from 2000 to 2300 on **4905**; from 1103 to 1735 and from 2000 to 2400 on **5320** and from 1100 to 1735 and from 2000 to 0100 on **5860**.

Second Programme from 1403 to 1700 and from 2100 to 2215 on **4250**; from 1433 to 1700 and from 2102 to 2240 on **4850**; from 1333 to 1700 and from 2100 to 2400 on **5075** and from 1333 to 1700 and from 2100 to 2400 on **5163**.

RADIO PEKING — EXTERNAL SERVICES

Programmes in English directed to Europe are now as follows — from 2030 to 2230 on **6590, 6860, 7590** and on **8660,** this last channel being used for the SSB transmission.

A programme in English directed to North and West Africa may be heard from 2030 to 2130 on **6550, 7620, 8345** and on **9470.**

AROUND THE DIAL

● MAURITANIA

Nouakchott on **4845** at 2045, OM with announcements in French after a programme of African music. This transmitter operates on weekdays from 0600 to 0900 and from 1800 to 2310 (Fridays and Saturdays until 2400), Sundays from 0600 to 0900 and from 1700 to 2400. The power is 100kW.

● GHANA

Accra on **4915** at 2249, OM with a talk in English on local affairs. Programmes are in English and vernaculars and the schedule is from 0530 to 0805 (Sundays through to 2300) and from 1200 to 2300. The power is 10kW.

● KENYA

Nairobi on a measured **4804** at 1850, OM disc jockey with U.K. made pops on records in the English programmed Home Service, the schedule of which is from 0255 (Sundays from 0330) to 0630 and from 1300 to 2010 (Saturdays until 2110). The power is 1kW.

Nairobi on a measured **4934** at 1920, OM announcer with a programme of local-type music and songs. This transmitter formerly operated on **4915** but has been on this channel for some months now. The schedule is from 0255 (Sundays from 0330) to 0630 and from 1430 to 2015 (Saturdays until 2115). This is the Home Service in Swahili. The power is 10kW.

● CONGO

Brazzaville on a measured **4764** at 0400, choral 'Internationale' and Moslem chants at sign-on. The schedule is from 0430 to 0700 (Sundays from 0400); from 1700 to 2400 and the power is 50kW.

● UGANDA

Kampala on a measured **5026** at 1845, OM in vernacular followed by a newscast in English at 1900 with station identification. This is the National Programme, the schedule being from (weekdays) 0300 to 1130 and from 1300 to 2110 (Saturdays and Sundays until 2110 continuous throughout). The power is 7.5kW.

● CAMEROON

Radio Garoua on **5010** at 0428, interval signal repeated (drums and Tam-Tam), OM with identification at sign-on. The schedule of this 30kW transmitter is from 0500 to 0700 and from 1700 to 2200. An English programme is radiated daily from 1830 to 1845.

● RWANDA

Radio Rwanda, Kigali, on **3330** at 1802, OM's with a discussion in vernacular in the Home Service. The schedule is from 0300 to 0600 (Saturdays and Sundays from 0700); from 0900 to 1200 (Saturdays and Sundays until 2100) and from 1330 to 2100. The power is 5kW.

● GABON

Franceville on **3350** at 1909, OM's with a discussion in French. This 20kW transmitter in the Regional Network operates from 0430 to 0700 and from 1700 to 2200.

● ANGOLA

Radio Nacional, Luanda, on **3375** at 0444, OM with a talk in Portuguese. The schedule is from 0430 to 2400 continuous and the power is 10kW.

● YEMEN

Aden on **5060** at 1920, YL with songs in Arabic-style, OM announcer. This transmitter radiates to East Africa according to the following schedule. From 0300 to 0530 (Fridays through to 2200) and from 1100 to 2030 (during Ramadan through to 2300). The power is 7.5kW.

● SWAZILAND

TWR (Trans-World Radio) Mpangela on **3240** at 0438, OM in vernacular, light music Euro-style. This one operates in Afrikaans and vernaculars from 0315 to 0415 and from 1800 to 1905 daily. The power is 30kW.

3 BAND SHORT

Part 1 (4 parts)

***Comprehensive circuit covering 1.6 to 25 MHz.**

***Mech**
filter pl
tiplier
na
banc

Short wave radio has for many years been a very popular hobby, and it is probably more popular now than ever before. With the current high cost of ready built communications receivers there is a strong incentive to construct one's own set and, of course, many people prefer to build their own receivers anyway. In view of this there is presumably a demand for a modern design, aimed at the home constructor, which provides a fairly high level of performance without being excessively complex and expensive.

The short wave receiver which forms the subject of this 4-part article has been designed to meet the above requirements. Its coverage is from about 1.6 to 25MHz in three switched ranges and it therefore provides reception on most of the amateur and broadcast short wave bands. A signal strength "S" meter is incorporated, and so is a product detector for the reception of s.s.b. and c.w. signals. Good selectivity is provided by the use of an inexpensive mechanical filter and a Q multiplier circuit.

BLOCK DIAGRAM

A block diagram showing the stages which comprise the receiver appears in Fig. 1. The receiver has no r.f. stage and the aerial signal is coupled direct to the mixer via the usual aerial tuned circuit. A dual gate MOSFET mixer is employed in the receiver together with a separate Jugfet oscillator.

Dual gate MOSFETs make really excellent mixers since they provide a low noise level and low levels of cross-modulation noise. This noise is produced by strong input signals being distorted in the r.f. (if fitted) and mixer stages of a superhet. Because the r.f. bandwidth of a superhet is far wider than the i.f. bandwidth, cross-modulation noise can be produced by transmissions which are well away from the reception frequency.

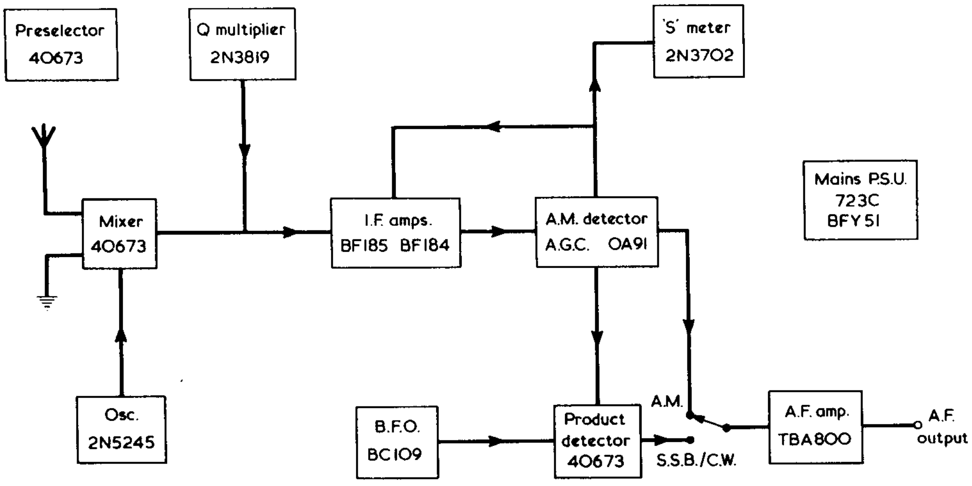


Fig. 1. Block diagram illustrating the various stages in this comprehensive receiver. The preselector and mains power supply unit are optional extras which will be described in future issues

WAVE SUPERHET

By R. A. Penfold

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width.

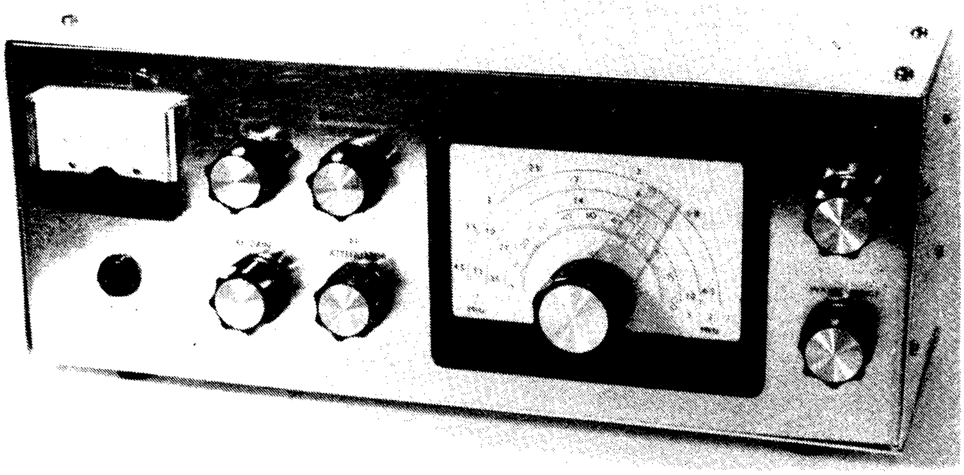
***Provisions for-**
upper or lower
s.s.b. reception.

A good practical test of a receiver's cross-modulation performance is to try it out on the 40 metre amateur band after dark. This band overlaps the 39 metre broadcast band, and the weak amateur transmissions can be easily drowned in cross-modulation noise caused by powerful broadcast transmissions. When the prototype was tested in this way it managed to produce readable signals from two American and one Japanese station, and its cross-modulation performance is extremely good.

There are two disadvantages with this simple input arrangement, however, the most obvious one being that the lack of an r.f. stage results in a loss of sensitivity. With the present set this is not a serious drawback since the receiver is still very sensitive without the r.f. stage. Of greater importance in practice is limited image or second channel rejection at the higher frequencies due to the fact that there is only a single tuned circuit ahead of the mixer. This situation can be improved by the use of a tuned preselector connected between the aerial and the receiver input, and a simple unit employing a single dual gate MOSFET will be described in a later article. This preselector is a completely independent unit which has its own battery supply.

The i.f. amplifier has a fairly conventional 2-stage circuit but, instead of the usual i.f. transformer at the input a mechanical filter is employed. The Q multiplier also operates in this part of the i.f. amplifier. The provision of a high level of selectivity ahead of the i.f. amplifier transistors virtually eradicates i.f. cross-modulation.

The a.m. detector and a.g.c. circuitry is quite conventional. The "S" meter appears in an extremely simple circuit employing one transistor and very few other parts, and is operated by the a.g.c. voltage.



Front panel layout of the completed short wave superhet receiver

The product detector incorporates another dual gate MOSFET, the b.f.o. signal being provided by a Hartley oscillator. A switch selects the output from either the envelope detector or the product detector and feeds it to the audio stages. Only one active device is used in the audio amplifier, and this is a TBA800 i.c. which will provide an output of up to about 500mW r.m.s. into an external 8Ω speaker. It can also be used to feed any normal type of headphones or earpiece.

The receiver is powered by an internal PP9 9 volt battery, and both the local oscillator and b.f.o. supplies are stabilized by zener diode regulators. If preferred, the receiver can be operated from a separate mains power supply unit. A combined mains power supply and speaker unit has been designed for use with the set and, like the preselector, will be described in a following article.

It is worth noting that because a product detector is used for s.s.b. reception, rather than the more common method of loosely coupling the b.f.o. signal into the i.f. amplifier stages, the a.g.c. and "S" meter circuits work normally with the set switched to the s.s.b. mode. However, due to the intermittent nature of an s.s.b. signal, neither of these circuits are 100% efficient on this mode of reception. They both have fast attack and fast decay times, whereas for s.s.b. reception a system having a fast attack and slow decay (usually termed a "hang a.g.c." system) is better. A modification to slow the decay will be described in Part 4.

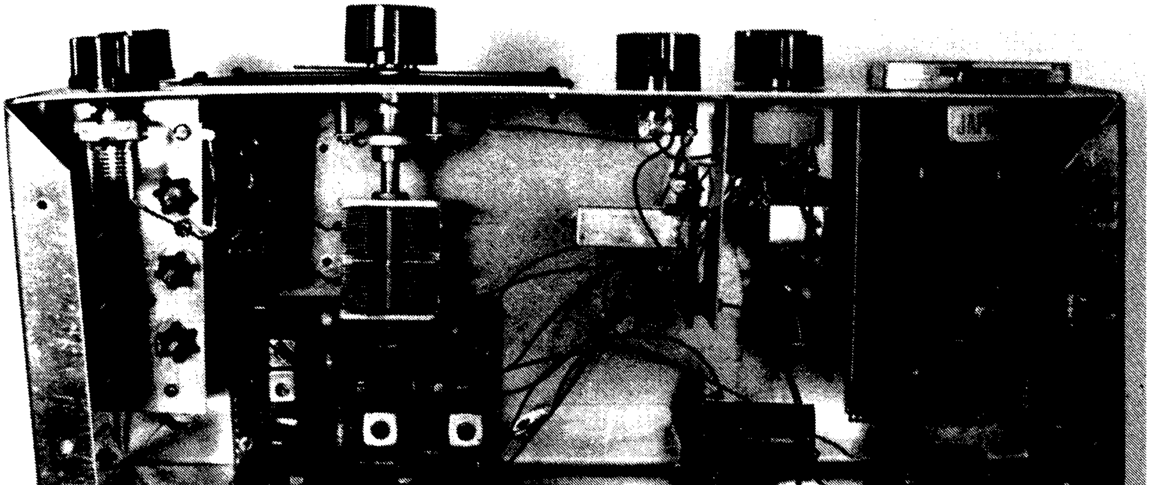
RECEIVER CASE

The receiver is assembled on four circuit boards and also has a home constructed coilpack assembly. Despite the consequent simplification of construction the receiver is still not really a suitable project for a beginner. The prototype is housed in a metal case, details of which are shown in Fig. 2. Commercially made cases of a similar size are available and one of these should also be suitable.

The material for the case is 18 s.w.g. aluminium sheet and most of its construction is quite straightforward. The "S" meter employed in the prototype is a 170Ω unit obtainable from Doram Electronics Limited, and this fits into a 39mm. circular cut-out. This cut-out can be made with either a fretsaw or a miniature round file. The positions of the four mounting holes around the cut-out are then located with the aid of the meter itself. The tuning drive is a Jackson type 4103/A (listed by some suppliers as 4103) and is available from several sources. One way of making the large central hole this requires is to first punch out a circular hole of 25mm. diameter and then cut out the two notches at the side with a miniature round file. As with the "S" meter the four small mounting holes can be located by means of the drive itself. It will be noted that there are two 6mm. diameter holes in the front flange of the chassis. These enable it to clear the lower pair of mounting screws and nuts of the drive, and the holes can be marked out and drilled after the corresponding holes have been made in the front panel.

The rectangular cut-out in the front of the chassis is made by first making the two 25mm. cuts with a hacksaw. A sharp modelling knife is then used to deeply score the metal along the remaining 50mm. cut. If the metal is then repeatedly bent up and down along this scored line it will fatigue, and this part of the chassis will then break off leaving the required cut-out.

The front, rear and sides of the case are bolted together using short 6BA screws with nuts. The top and bottom panels are secured by means of eight self-tapping screws. The top and bottom panels are not shown in Fig. 2. Each consists of a rectangle of 18 s.w.g. aluminium measuring 343 by 144mm. Both panels have four mounting holes which are clearance size for the self-tapping screws. The holes correspond with those in the flanges of the sides and are positioned 30mm. in from the long edges and 10mm. in from the short edges.



The layout of the individual circuit modules inside the superhet case. Their positioning is explained in the text, with much of the constructional information being given in next month's issue

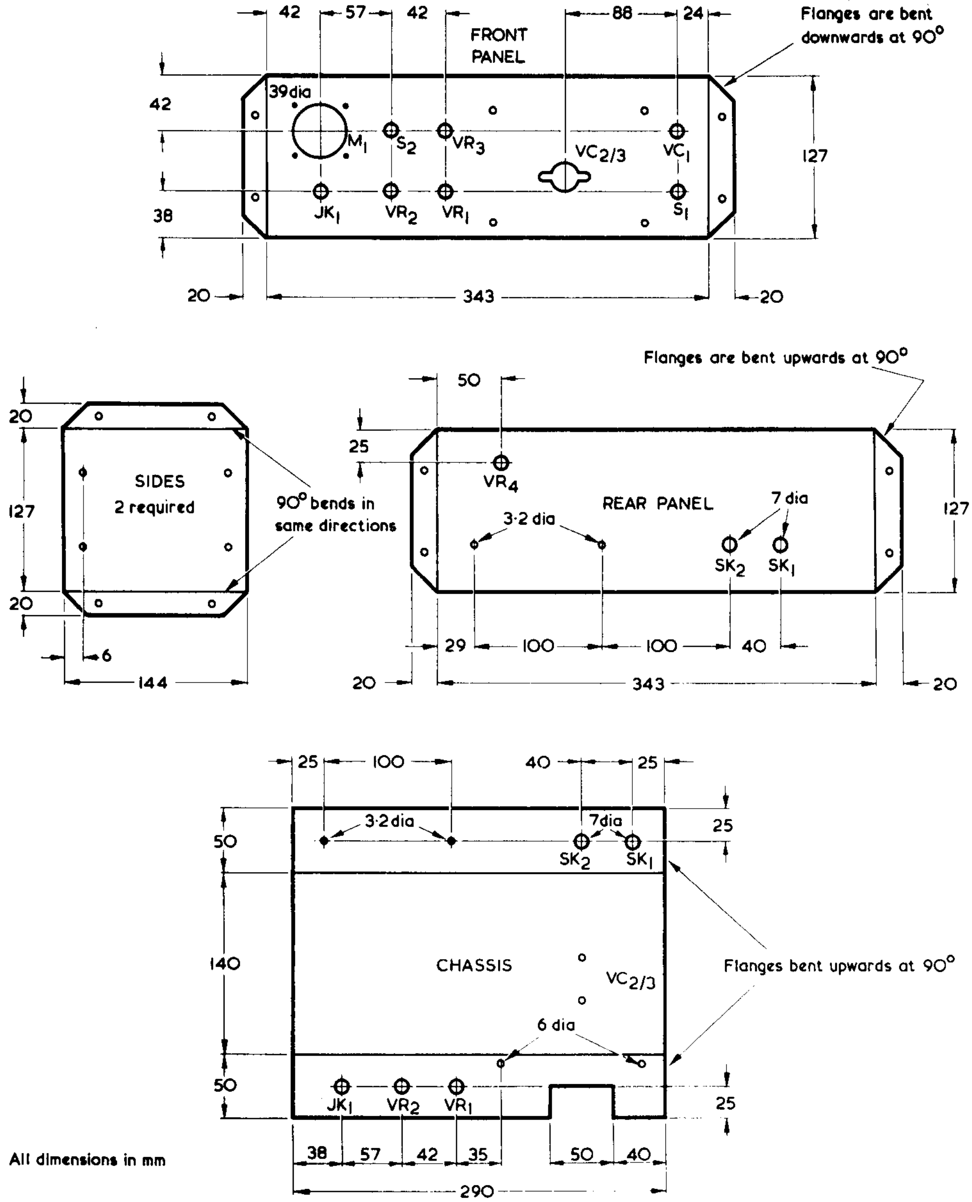


Fig. 2. The parts which make up the chassis and case of the receiver. The material is 18 s.w.g. aluminium sheet. Holes for control bushes and for JK1 are 10mm. diameter. The large hole for the tuning drive is discussed in the text

No dimensions for the mounting holes in the flanges of the front and rear panels are given. The positions of these are found using the side panels as templates. This method is used as it is obviously essential for the sets of holes to accurately correspond. The top and base panels are similarly used to locate the positions of the mounting holes in the flanges of the side panels.

The chassis is secured to the rear panel by means of two 6BA screws and nuts together with the two sockets SK1 and SK2. (Two further sockets are visible in the photograph of the rear of the receiver. These are added later if the receiver is to be used with the mains power supply and speaker unit). The front panel and the chassis are secured together by the mounting bushes and nuts of JK1, VR2 and VR1. Note that the chassis flanges point upwards. The two mounting holes for VC2/3 are 4BA clear and are located with the aid of the capacitor, which is temporarily fitted to the drive for this operation. The two 4BA screws pass into threaded holes in the base of the capacitor and it is most important to ensure that their ends do not penetrate too far into the capacitor body as they would then damage the metal vanes. The screws should not be more than about 20mm. long, and they pass through the chassis from its underside and then through 4BA spacers about 13 to 14mm. long before entering the tapped holes in the capacitor. Since the case and chassis are home-made there will almost certainly be some small dimensional differences between one unit and the next, whereupon it is the constructor who must finally provide a satisfactory mounting for the variable capacitor which allows it to be accurately aligned mechanically with the tuning drive and

COMPONENTS

Resistors

(All fixed values ¼ watt 10%)

R1 560kΩ
R2 1.8kΩ
R3 120kΩ
R4 39kΩ
R5 680Ω
R6 390Ω
R7 470kΩ
R8 68kΩ
R9 680Ω
R10 5.6kΩ
R11 3.9kΩ
R12 680kΩ
R13 2.2kΩ
R14 12kΩ
R15 1kΩ
R16 10kΩ
R17 33Ω
R18 100Ω
R19 10Ω
R20 1.5MΩ
R21 120kΩ
R22 120kΩ
R23 2.2kΩ
R24 2.2kΩ
R25 820Ω
R26 3.3kΩ
R27 1kΩ
VR1 1kΩ potentiometer, linear
VR2 25kΩ potentiometer, log, with switch S3
VR3 22kΩ potentiometer, linear
VR4 1kΩ potentiometer, linear

Capacitors

C1 470pF polystyrene
C2 0.01µF type C280 (Mullard)
C3 4.7 or 5µF electrolytic, 10V. Wkg.
C4 0.1µF type C280 (Mullard)
C5 0.01µF type C280 (Mullard)
C6 0.1µF type C280 (Mullard)
C7 0.022µF type C280 (Mullard)
C8 0.01µF type C280 (Mullard)
C9 6.8pF ceramic
C10 0.1µF type C280 (Mullard)
C11 0.22µF type C280 (Mullard)
C12 33pF polystyrene
C13 150pF polystyrene
C14 5.6pF ceramic
C15 4,700pF polystyrene
C16 0.015µF type C280 (Mullard)
C17 100µF electrolytic, 10V. Wkg.
C18 100µF electrolytic, 10V. Wkg.
C19 100µF electrolytic, 10V. Wkg.
C20 270pF polystyrene or silvered mica
C21 2,200pF polystyrene
C22 680µF electrolytic, 10V. Wkg.
C23 0.1µF type C280 (Mullard)
C24 680µF electrolytic, 10V. Wkg.
C25 0.1µF type C280 (Mullard)
C26 82pF polystyrene or silvered mica
C27 2.2pF ceramic
C28 8.2pF ceramic
C29 6.8µF electrolytic, 10V. Wkg.
C30 0.015µF type C280 (Mullard)
C31 0.1µF type C280 (Mullard)
C32 100µF electrolytic, 10V. Wkg.
C33 0.047µF type C280 (Mullard)
C34 330µF electrolytic, 10V. Wkg.
CP1 3,000pF polystyrene (see text)
CP2 1,100pF polystyrene (see text)
VC1 50pF variable, type C804 (Jackson)
VC2-3 365+365pF 2-gang variable, type 02 (Jackson)

Semiconductors

TR1 40673
TR2 2N5245
TR3 BF185
TR4 BF184
TR5 2N3702
TR6 BC109
TR7 40673
TR8 2N3819

IC1 TBA800
D1 BZY88C4V3
D2 OA91
D3 OA200
D4 BZY88C6V2

Inductors

L1 Miniature Dual-Purpose Coils, Blue, valve usage, Ranges 3, 4 and 5 (Denco)
L2 Miniature Dual-Purpose Coils, Red, valve usage, Ranges 3, 4 and 5 (Denco)
L3 I.F. transformer type IFT14/470kHz (Denco)
IFT1 I.F. transformer type IFT13/470kHz (Denco)
IFT2 I.F. transformer type IFT14/470kHz (Denco)
IFT3 I.F. transformer type IFT18/465kHz (Denco)

Filter

MF1 455kHz mechanical filter type MFH41-T (Toko)

Meter

M1 "S" meter, 0-1mA (see text)

Sockets

SK1 Insulated wander socket
SK2 Insulated wander socket
JK1 in. jack socket

Switches

S1 4-pole 3-way rotary
S2 4-pole 3-way rotary
S3 S.P.S.T. toggle (part of VR2)

Miscellaneous

Tuning drive type 4103/A, 6:1 and 36:1 (Jackson)
Large control knob
7 medium size control knobs
18 s.w.g. aluminium sheet
Plain perforated s.r.b.p., 0.1in. matrix
Plain perforated s.r.b.p., 0.15in. matrix
9-volt battery type PP9 (Ever Ready)
Battery connectors
Veropins, 0.15in. and 0.1in. types
Wire, solder, bolts, etc.

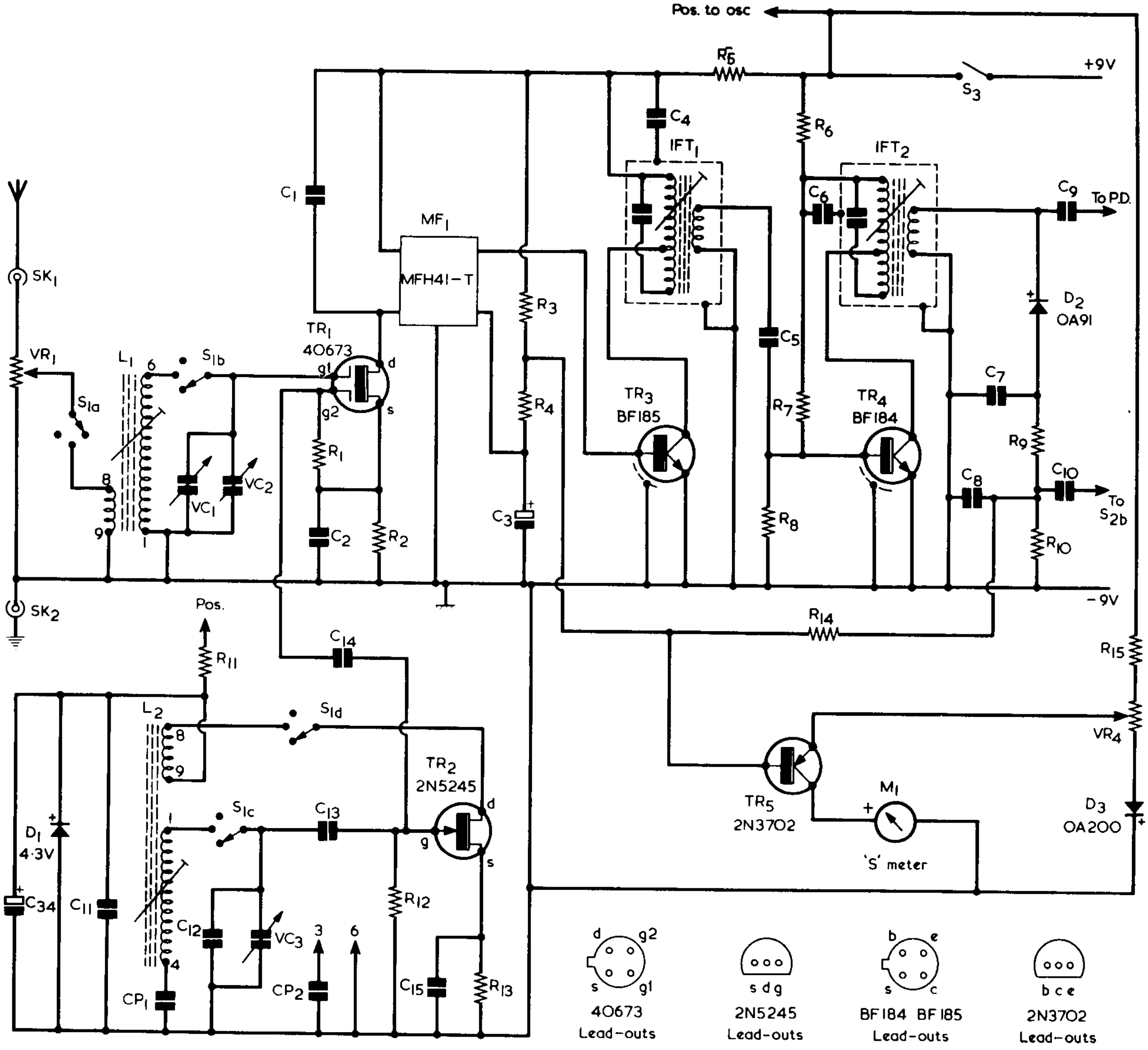
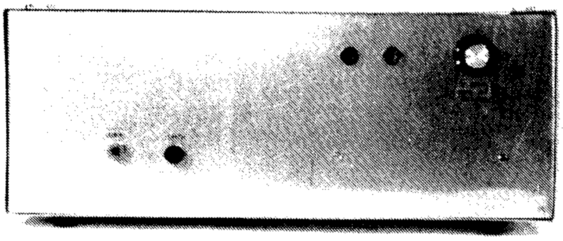


Fig. 3. The circuit of the mixer and oscillator stages, together with the i.f. amplifier and the "S" meter driver stage

with which the mounting bolt ends do not penetrate excessively into the capacitor.

Four solder tags are fitted at this stage. Two of these are mounted under the securing nuts which hold the chassis and rear panel together. A third is positioned at the top left-hand mounting screw of the tuning drive, and the fourth at the bottom right-hand screw of the "S" meter.

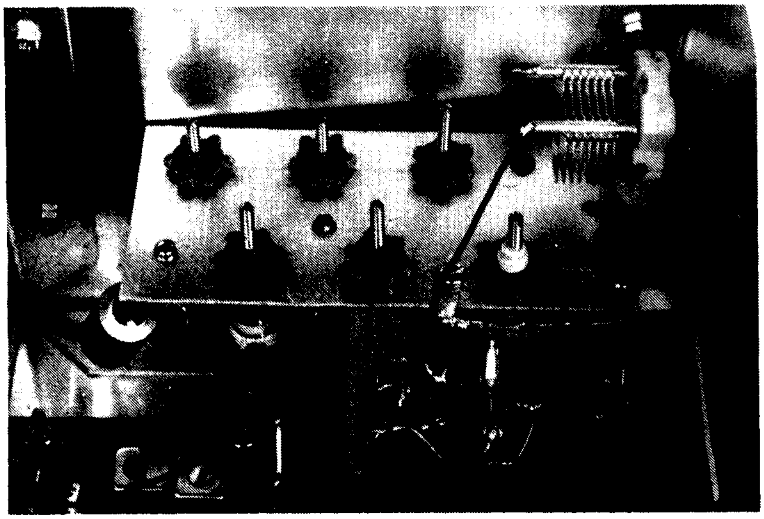


The rear panel of the case. The control visible here is that for zero-setting the "S" meter. The aerial and earth sockets are at the lower left. The two upper sockets are not used in the present version of the superhet, and are a modification which allows an external power supply to be applied

MIXER AND I.F. STAGES

The circuit of the mixer, oscillator and i.f. stages is given in Fig. 3. Also shown are the envelope detector and a.g.c. circuit, as well as the "S" meter stage. VR1 is a variable aerial input attenuator, and this control is incorporated for two reasons. First, due to the set's sensitivity it is possible for exceptionally strong signals to overload the receiver, and these can be reduced in intensity by the control. Secondly, it is not advisable to have maximum aerial coupling to the mixer as powerful signals may then take it into a non-linear mode with severe cross-modulation resulting, making it difficult to copy even quite strong signals. The effect is particularly noticeable on the 40 and 80 metre amateur bands and can be removed by appropriate adjustment of the potentiometer.

L1 is the r.f. input transformer and its primary couples to the aerial. The secondary connects direct to the gate 1 of the mixer transistor and is tuned by one section of the 2-gang variable capacitor, VC2. VC1, mounted on the front panel, is the aerial trimmer, and this is set up for optimum reception



Top view of the coilpack, mixer and oscillator assembly

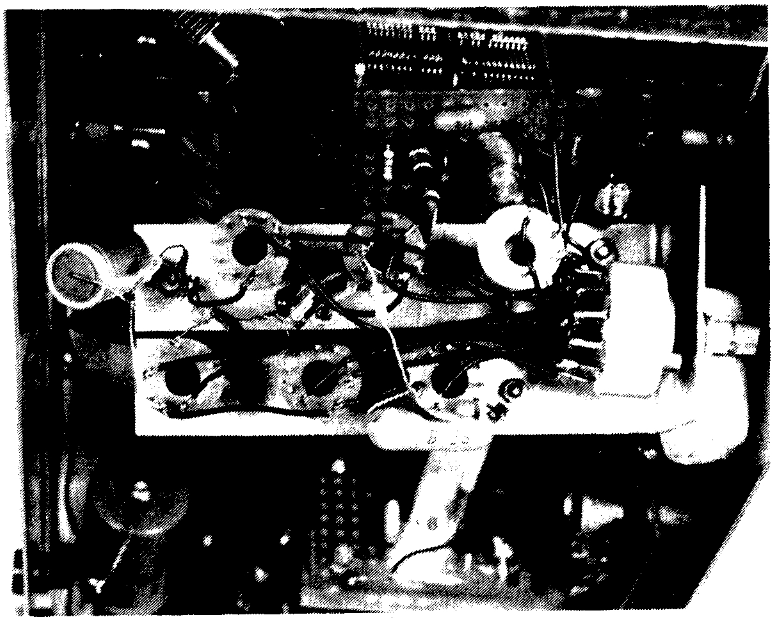
on the particular range of frequencies being received. The use of this trimmer eliminates the need for a trimming capacitor to be connected across each tuned coil and greatly simplifies the alignment procedure. There are three r.f. input transformers but, for simplicity, only one is shown in the diagram.

Again, only one of the three oscillator coils is shown, this being identified as L2. All the coils for L1 and L2 were originally designed for valve usage, in which the tuned coil couples direct to the valve grid. They may, with equal efficiency, be connected direct to the gate of an f.e.t. TR2 is the oscillator transistor and its output is coupled to the gate 2 of the mixer via C14. Zener diode D1 stabilizes the oscillator supply voltage. It was found that a slight frequency modulation of the oscillator was apparent with s.s.b. and c.w. signals on the 15 and 20 metre bands when the volume was set to a medium to high level, with consequent loading of the battery. The addition of C34 across the zener diode virtually eliminated this problem.

The 4-pole switch, S1, is the wavechange switch, and its arms switch the non-earthy ends of the windings. As already stated, only one of the three coils for L1 and L2 is shown. The approximate frequency ranges covered are: Range 3, 1.6 to 4.6MHz; Range 4, 4.5 to 12MHz; Range 5, 10 to 25MHz. The range numbers are these ascribed to the coils by their manufacturer. The oscillator coils have the earthy ends of the tuned windings terminated in different pins on each range. On Range 4 this is pin 4, and it connects to chassis via padding capacitor CP1. CP2, connecting to pin 3 of the Range 3 coil, is the padding capacitor for that range. The Range 5 coil does not require a padding capacitor, and its pin 6 connects direct to chassis. The padding capacitors have rather unusual values and it may be necessary for these to be made up of two capacitors in parallel. In the prototype, CP1 consisted of two 1,500pF capacitors in parallel, and CP2 of a 1,000pF and a 100pF capacitor in parallel.

The output from the mixer is fed to a conventional two stage 455kHz i.f. amplifier. The mechanical filter does not have an internal tuning capacitor across its tuned input winding, and so C1 is used to perform this function.

The coilpack assembly removed from its position on the front panel so that the coils may be seen



A.G.C. is applied to the first i.f. transistor via R14, and the a.g.c. action causes the voltage at the junction of R3, R4 and R14 to be reduced on strong signals, with a consequent reduction in the base bias current for TR3. The stronger the received signal the lower is the voltage at the resistor junction, and this voltage is also used to operate the "S" meter circuit.

This last circuit is based on TR5 which is connected as a common emitter amplifier with the meter forming its collector load. VR4 is adjusted so that the voltage at TR5 emitter is about 0.6 volts higher than its base voltage when no input signal is present. When a strong signal is received, TR5 base goes more negative and thus the base-emitter voltage of TR5 is increased, whereupon it passes collector current and causes a deflection in the meter. The collector current increases with increasing negative voltage at TR5 base and therefore meter deflection is proportional to the a.g.c. voltage. The function of D3 is merely to reduce the impedance in the emitter circuit of TR5 and thereby allow it to pass an adequate collector current.

NEXT MONTH

The full Components List accompanies the present article and the availability of two of the components, the "S" meter and the tuning drive, has already been dealt with. The 455kHz mechanical filter type MFH41-T can be obtained from Ambit International. The i.f. transformers listed have nominal frequencies of 470kHz or 465kHz, but they will tune down to the 455kHz frequency at which the mechanical filter operates.

In next month's issue we shall carry on to the construction of the coilpack assembly, which contains the mixer and oscillator circuitry. This assembly appears in two of the accompanying photographs.

(to be continued)

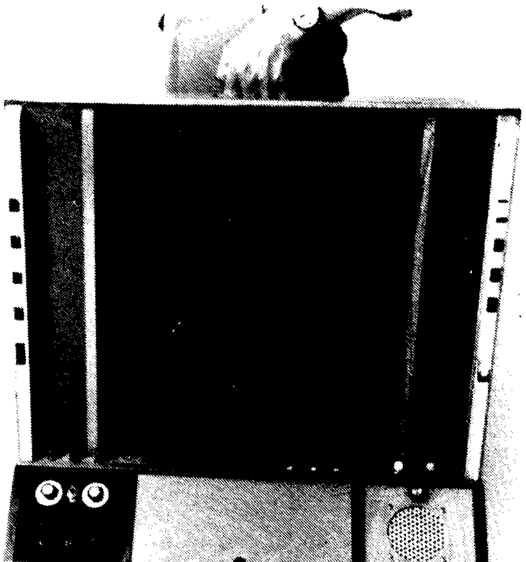
A PORTABLE WORKSHOP

Ideally suited for constructors who have limited working space is the "Electronic Workshop" now introduced by Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey, CR4 3HD. This comprises a solid table top bench, made up in wood, which can be placed on any table when required, and which may be just as readily removed when the table is required for other purposes. The working surface is 2 ft. wide by 20 in. deep, with the centre portion covered by a thick removable rubber mat. Two 3 in. strips on either side can take such items as an iron stand and a vice. The outer edges have slots into which tools may be fitted.

The sloping panel back section is divided into three compartments. In the left hand section is a 35Ω speaker and volume control whilst in the right hand compartment is a variable voltage power pack offering zero to 20 volts d.c. at 1 amp. The 12 in. wide central section has a lock and key and can be opened to take tools and any work that is currently in progress. If the bench has to be removed quickly all items may be stowed in this compartment and the bench picked up and taken out of the way. There are rubber feet under the flat section and also on the rear panel, so that it may stand upright when not in use.

Further facilities are two 13 amp mains sockets, terminals for aerial and earth, three receptacles for solder and wire, a neon indicator lamp for the mains supply, and a pilot light to show when the power supply is switched on. A flexible lead from the bench can be plugged into any conventional mains socket.

The assembled bench, complete in every detail but unwired, is available at £45 or, fully wired, at £54. Wiring includes the assembly of the power supply. To either price should be added £2.06 VAT and £2.50 carriage.



A solution to the problem of insufficient working space. The Home Radio "Electronic Workshop" may be placed on any flat surface whenever it is desired to carry out constructional work. All the usual facilities of a full sized workshop are provided

VARIABLE — C A. F. GENERATOR

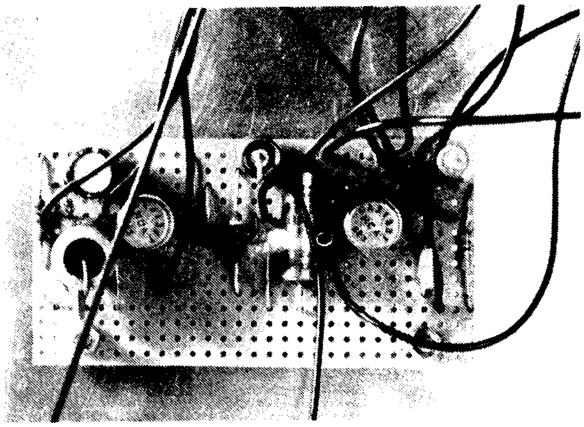
Part 2 (Conclusion)

By P. R. Arthur

Concluding details on construction

The prototype signal generator is housed in a metal instrument case having approximate outside dimensions of 7 by 8 by 3in. This is a case type C3, available from Harrison Bros., 22 Milton Road, Westcliff-on-Sea, Essex SS0 7LQ. Any similar all-metal case can be used provided that it can accommodate the parts, and it need not be quite as large as that employed by the author, particularly in the front to back dimension. An all-metal case is needed to provide screening and to prevent the pick-up of mains hum and other noise at the non-inverting input of IC1.

The general layout of the front panel can be seen in the photographs. Here, S2 is at upper left and S3 upper central with, below, S1 at lower left and VR1 lower central. The large control knob at the right is for VC1-2. The general layout is not particularly critical.



Component layout on the Veroboard panel

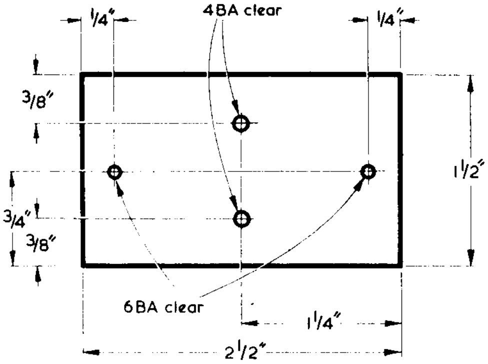


Fig. 3. The metal frame on the dual-gang variable capacitor is insulated from chassis, and it is mounted on the s.r.b.p. panel shown here

It is essential that the metal frame of VC1-2 be insulated from the metal case. The capacitor frame, common with the moving vanes, connects to the non-inverting input of IC1. The fixed vanes of VC1 then connect to the junction of R2 and R3, and the fixed vanes of VC2 to the arm of S1(b). VC1 is mounted on a small panel of s.r.b.p. having the dimensions shown in Fig. 3. The two 4BA clear holes here correspond with 4BA tapped holes in the bottom of the capacitor frame and the hole positions shown in Fig. 3 meet the requirements of the dual-gang capacitor used by the author. Before marking up and drilling the 4BA clear holes, the constructor should verify that they conform with the positions of the tapped holes in the particular capacitor employed by him. If there are any discrepancies the hole positions in the s.r.b.p. panel should be modified accordingly. The main criterion is that the capacitor body be central on the panel, with the two 6BA clear holes on either side. The 4BA bolts passing into the tapped holes in the capacitor frame must be short, and their ends should not pass more than marginally past the metal bottom of the frame as they could then damage the fixed or moving vanes of the capacitor. Also, spacing washers are required over the bolts between the s.r.b.p. panel and the capacitor frame to provide clearance for protruding items on the bottom of the frame. A solder tag under one of the bolt heads may be used to provide connection to the capacitor frame.

The s.r.b.p. panel is secured to the bottom of the case by two 6BA bolts about 1in. long. The capacitor spindle passes centrally through a hole of ½in. diameter in the front panel, and the 6BA bolts are provided with spacers and are positioned to allow the spindle to be concentric in the front panel hole. The capacitor must not be fitted with a control knob of all-metal construction.

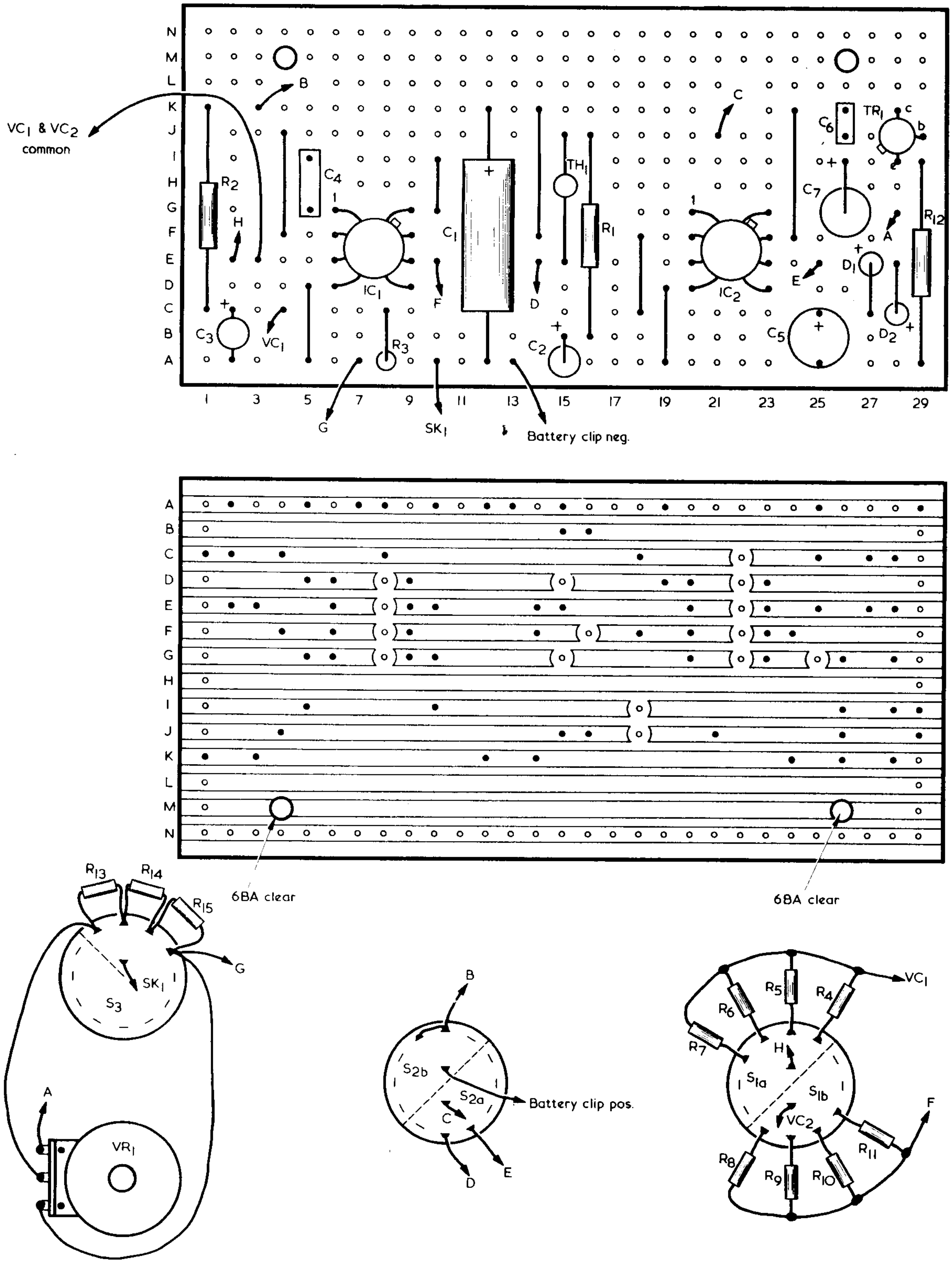
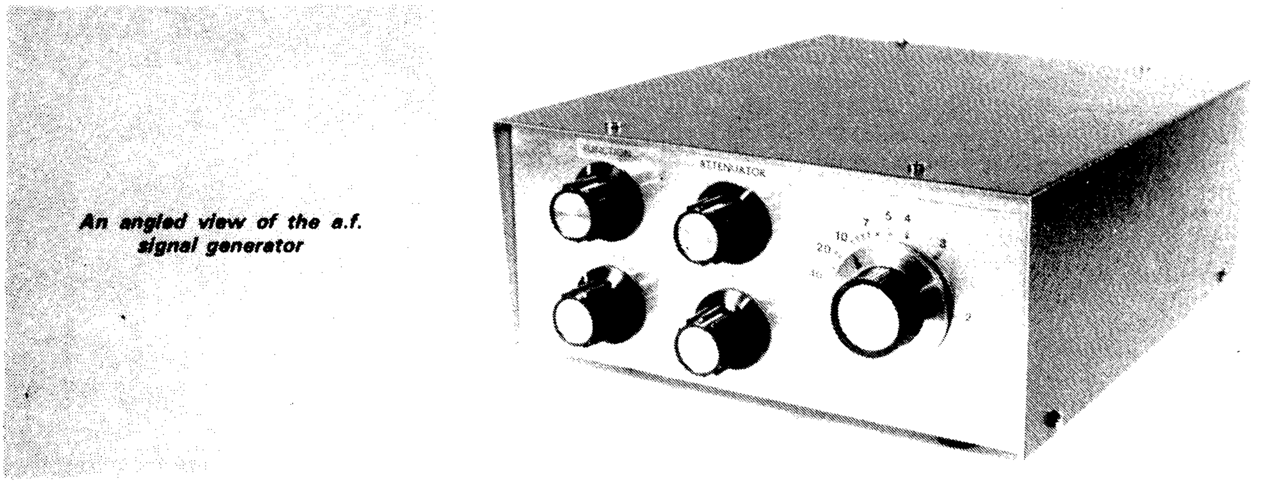


Fig. 4. Details of the wiring on the Veroboard and to the front panel components



An angled view of the a.f. signal generator

Many of the components are assembled on a Veroboard panel of 0.1in. having 14 copper strips by 29 holes. Details of this panel, and of the remaining wiring, are given in Fig. 4. As can be seen, the Wien network resistors and the attenuator resistors are soldered direct to the tags of S1 and S3 respectively. Before wiring to the rotary switches check the relative positioning of the inner tags and the corresponding outer tags; with some switches this may differ from the positioning shown in Fig. 4. Interconnections between the Veroboard panel and the front panel components are indicated by the letters A to G. The lead from hole E3 of the board connects to the frame of VC1-2, whilst that from hole C4 connects to the fixed vanes of VC1, as also does a lead from the common connection of R4 to R7. The arm of S1(b) connects to the fixed vanes of VC2. In the prototype, VC1 is the front section of the dual-gang capacitor and VC2 the rear section.

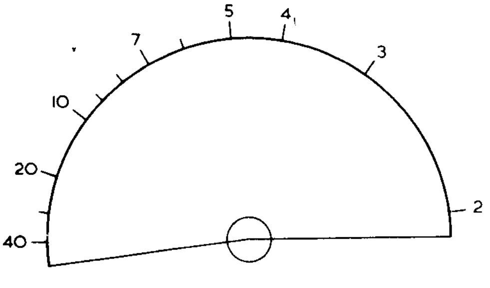


Fig. 5. The frequency scale as made up with the prototype a.f. generator

The output socket, SK1, is fitted to the rear panel of the case, and it should be a type having open construction, i.e. not insulated. A lead from Veroboard hole A10 passes to its "sleeve" contact, and this lead provides the chassis connection to the case. The arm of S3 connects to the socket "tip" contact.

The Veroboard is mounted at the centre of the case bottom using two 6BA screws and nuts with spacing washers to keep the board underside clear of the metal of the case. Copper strip A is towards the front. The board cannot be finally mounted until all the connections to it have been completed. There is plenty of space inside the case for the battery and, if desired, this can be held in place by a simple aluminium bracket.

CALIBRATION

If suitable test equipment is available, such as a frequency meter, a calibrated a.f. generator or an oscilloscope, this can be brought into service to calibrate the dial of the unit, and it is assumed that readers having such equipment will know how to utilise it for the function.

An alternative method is to simply copy the scale reproduced in Fig. 5, this having been obtained with the prototype signal generator. The frequency selective components have close tolerances and so the use of this scale should provide quite accurate calibration for units built to the same design.

(Concluded)

THYRISTOR SENSITIVITY BOOSTER

By P. D. Southern

Add a transistor and make a super-sensitive silicon controlled rectifier.

A standard thyristor or silicon controlled rectifier circuit appears in Fig. 1(a). Until it is triggered the thyristor is non-conductive and passes, in practice, an insignificant leakage current which is in the order of microamps only.

If the gate of the thyristor is slowly taken positive of the cathode, forward current will flow through the gate-cathode junction of the device at a voltage of about 0.6 volt. The gate current may then be increased until it reaches a critical level at which the thyristor suddenly triggers on, causing the full supply, less a small voltage dropped in the conducting thyristor, to be applied to the load. If the current drawn by the load is above the "holding" value for the thyristor the latter will then remain conductive regardless of whether the gate current is maintained or removed. It follows that the thyristor will also turn on and remain turned on if the gate current, at or above triggering level, is applied in the form of a very short pulse.

GATE CURRENT

The gate current required to trigger on a thyristor is not small and can be typically in the range of 0.5 to 20mA or more according to the thyristor type employed. It occurred to the writer that sensitivity could be considerably increased by the simple process of adding an n.p.n. transistor in the manner shown in Fig. 1(b).

In this new circuit the input triggering current is applied to the base of the transistor, which functions as an emitter follower. The gate current passed to the thyristor is then equal to the input current multiplied by the current gain of the transistor. At the instant of triggering the transistor collector receives an adequate collector supply voltage by way of the load. After triggering the voltage available to the collector will be very low, but this does not matter because the purpose of the circuit, that of turning on the thyristor with a low input current, has been achieved. If an input current still flows it will merely pass through the forward biased base-emitter junction of the transistor and the similarly forward biased gate-cathode junction of the thyristor.

PRACTICAL CHECK

It is always a good plan to check out theory in practice, and the author next made up the test circuit of Fig. 2(a). The load is a 470 Ω resistor, a voltmeter being connected across it to monitor the state of the thyristor. Gate current is supplied by a variable 10k Ω resistor with a current reading meter (shown as a circle enclosing the letter "I") in series. The particular thyristor chosen is a small device in a TO5 case which has the same characteristics as the CR1/051C and other small thyristors in similar encapsulations.

The resistance inserted by the variable resistor is decreased until the thyristor triggers, as is indicated by the sudden appearance of the full load

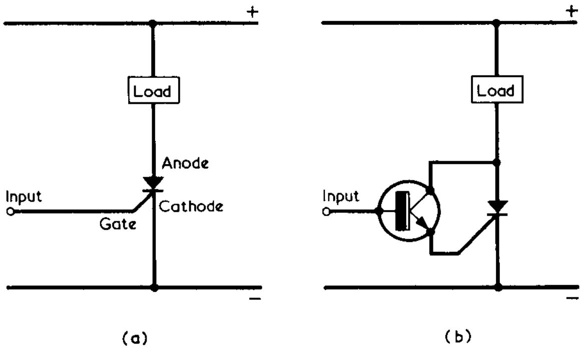
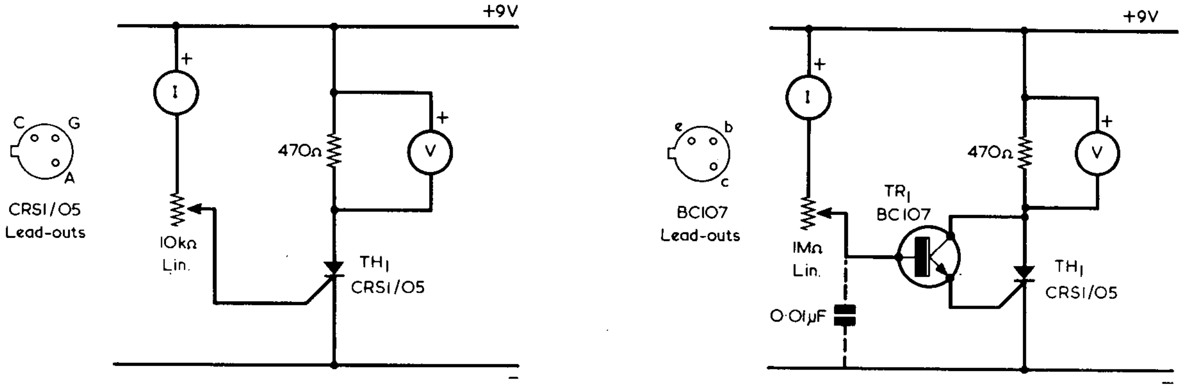


Fig. 1(a). A standard thyristor circuit. The thyristor is turned on by taking the gate positive of the cathode
(b). A considerably lower trigger current is theoretically possible if a transistor is added, as here



(a) (b)

Fig. 2(a). Practical test circuit to determine the gate triggering current of a thyristor (b). Evaluating the reduced input current required for the transistor and thyristor combination

voltage across the 470 Ω resistor. With the thyristor employed the triggering gate current was just under 5.5mA.

The n.p.n. transistor was added as in Fig. 2(b) and the variable resistor value increased to 1M Ω. Input triggering current was found to be 30µA only, whereupon it can be seen that the addition of the transistor is definitely worth-while if sensitive thyristor operating conditions are required. The impedance at the base of the transistor is much higher than that at the gate of the thyristor with the result that false triggering may be caused if the base wiring is long and picks up mains hum or static voltages. Should it occur the false triggering effect can be eradicated by adding the 0.01µF bypass capacitor which is shown in broken line.

If you want to try out the circuits of Figs. 2(a) and (b) always ensure that the variable resistor inserts maximum resistance at the start, and then decrease the resistance slowly. Should the resistance inserted into circuit to be too low the current reading meter may be wrecked and the potentiometer track could even be burnt out. ■

TRADE NOTE

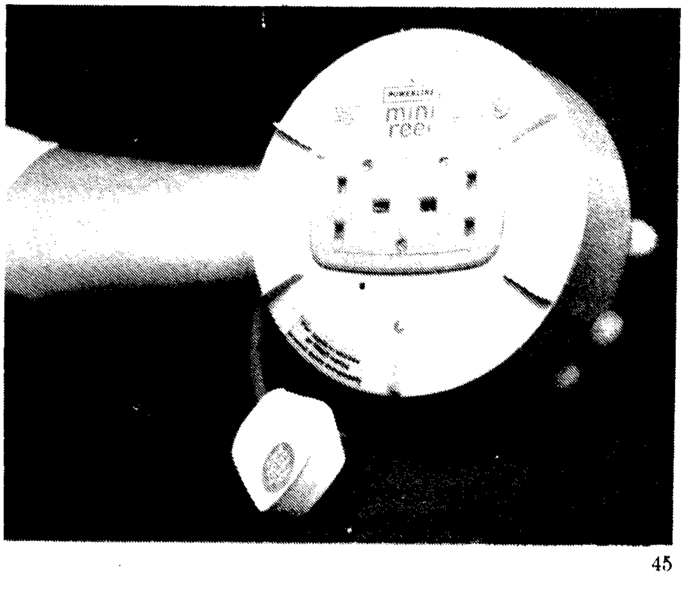
EXTENSION REEL

Whenever you need electrical power and a proper socket is not available in the vicinity, the "mini-reel" shown in the photograph could solve the problem for you. This has just been introduced by Burgess Power Tools Limited, of Sapcote, Leicestershire, LE9 6JW, and it follows the success of their already established larger Powerline Safety Cable Reel.

The mini-reel is 178mm. (7in.) in diameter, and is claimed to be one of the safest, toughest and most versatile extension cable reels on the market. It is fitted with twin socket outlets and has 8 metres (26ft.) of 3-core cable. A thermal and current overload cut-out is fitted to ensure safety.

The mini-reel is small enough to be held in the palm of the hand, it allows easy pull-out and rewind of the cable and it may be used with appliances taking a total of 6 amps or less at one time. The twin socket outlets are particularly useful, as they avoid the inconvenience of changing over from one tool to another. Alternatively, of course, one outlet can be used to provide a lighting supply when the other is in use with an electric tool. The weight of the mini-reel is 0.9Kg (2lb.)

The original Safety Cable Reel is, incidentally, also provided with two outlet sockets, and this has 19 metres (60ft.) of 3-core cable.



The Burgess Power Tools "mini-reel". Despite its small size this has 8 metres of 3-core extension cable. It is fitted with a thermal and current overload cut-out

THE "HYBRID" ALL WAVE RADIO -- Part 2 (Conclusion)

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

Concluding details on construction

We now continue with the constructional details for this receiver. In doing so, we will need to refer to Figs. 2, 3 and 4, all of which were published last month.

CAPACITOR MOUNTING

The tuning capacitor, VC2, has next to be mounted to the item of Fig. 4(b) using three short 4BA bolts passing into tapped holes in the front plate of the tuning capacitor frame. Place a piece of paper with a ¼in. hole in its centre over the spindle of the capacitor and mark out the positions of the tapped holes on this with a pencil. Then, using the paper as a template mark out the corresponding holes on the item of Fig. 4(b) and drill these 4BA clear. Then fit the tuning capacitor. The three 4BA mounting bolts need to be short because their ends must not pass more than marginally past the capacitor front plate or they will damage the fixed or moving vanes.

Pass two countersunk bolts, 1¼in. long, through the 4BA clear holes in the front panel and tighten them with two nuts on the inside. Run on two further nuts to about the centres of the bolts. Fit the tuning drive to the spindle of VC2 and pass the item of Fig. 4(b) over the 4BA bolts, using the drive to mark out a 6BA clear hole on the front panel to take a bolt securing the drive anchoring lug. Drill out the hole and then finally assemble the piece of Fig.4(b), the tuning drive and the variable capacitor to the front panel. Two further nuts are passed over the 4BA bolts and these and the two previous ones are all tightened at the appropriate positions along the bolts.

Next cut out two 4-way tagstrips from the group panel and secure these to the upper side of the "chassis" deck as in Fig. 5, using the same procedure as was employed with the 9-way tagstrip on the underside. TR3 is mounted on a heatsink made from a piece of aluminium sheet of around 18 s.w.g. measuring 3 by 2½in. One 3in. edge is bent

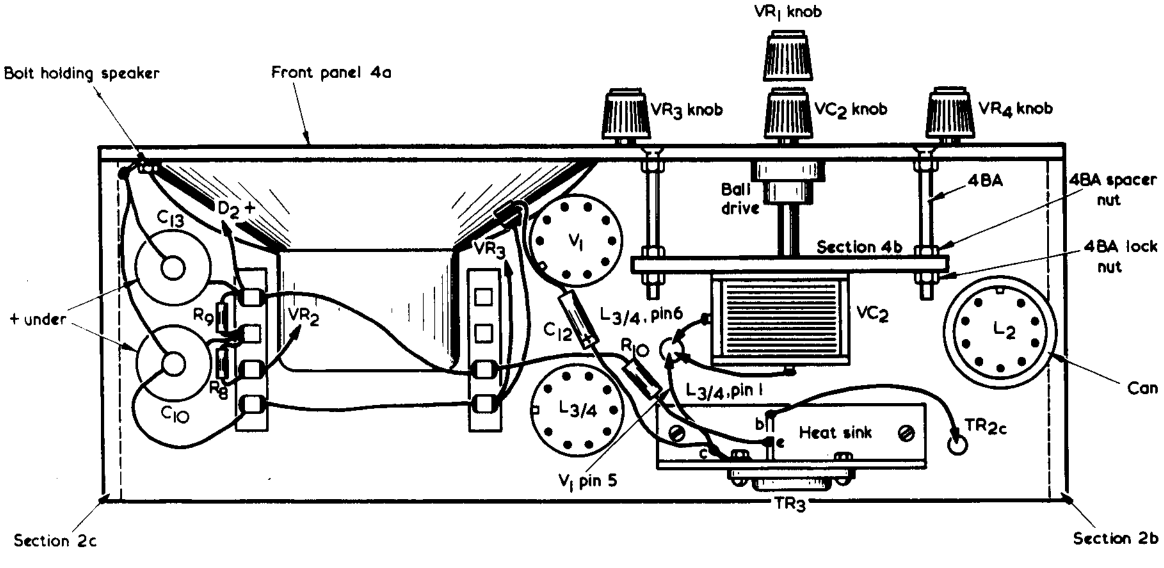
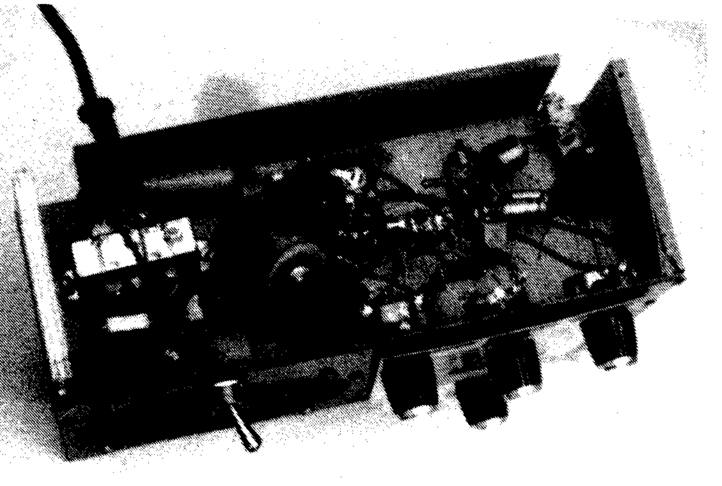


Fig. 5. The components which are fitted and wired above the "chassis" deck



Wiring and components below the "chassis" deck of the receiver

through 90 degrees ½in. in to make a ½in. wide mounting flange. Drill out the heatsink to take the emitter and base lead-outs of the transistor, as well as its two mounting bolts. Also drill two mounting holes in the ½in. flange and secure this to the "chassis" deck with small woodscrews. The transistor is not insulated from the heatsink and a solder tag for connection to its collector is fitted under one of its mounting nuts. Cut out the 2in. square aperture in the item of Fig.4(C) so that its position matches that of the heatsink.

Wiring may now be carried out. Fig. 3 shows the positioning of the mains transformer and the wiring under the "chassis" deck, whilst Fig. 5 illustrates that above. The bridge rectifier is a small light component and may be suspended in the wiring. When the smoothing capacitors are positioned and wired as shown, the hum level is so low that it is difficult to tell whether or not the receiver is switched on. Hum appears, on the other hand, if C9 is mounted alongside C10. It is important that the negative ends of C10 and C13 be connected to the earthy tag of VR3, and that of C9 be connected to the cathode pin of the valveholder. The negative leads of C10 and C13 connect also to a solder tag at one of the speaker mounting nuts.

At this stage do not finally fit the lead between TR1 collector and pin 8 of L3/L4.

It has to be remembered that, when the set is completed and plugged in to the mains supply, mains voltages are accessible at the on-off switch and at the primary of T1. Until the set is fitted in its case all the usual precautions against accidental shock must be observed. The mains lead should be secured to the "chassis" deck with a suitable plastic or plastic covered clamp.

The back may be finally affixed at this stage. A 4BA bolt with spacing washer passed through the back and the heatsink for TR3 will give added rigidity.

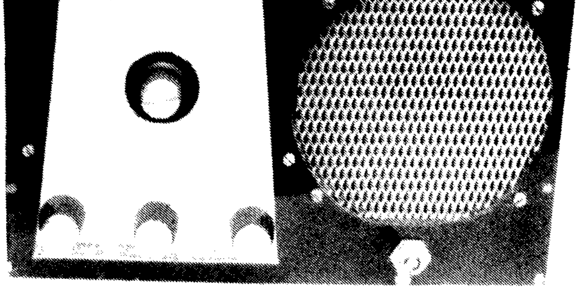
It is next necessary to add a wire link between pins 3 and 4 of the Range 4 coil. This link brings R4 into circuit when the coil is plugged in. Fit the coil into a B9A valveholder to act as a heatsink, then quickly solder the wire between the upper ends of its pins 3 and 4. Wait until the pins are completely cool before removing the coil from the valveholder. The plastic material in which the pins are imbedded melts readily with heat.

SETTING UP

Set the sliders of VR2 and VR5 so that they are fully anti-clockwise as shown in Fig. 3. Also, set VR3 fully anti-clockwise. Plug in the Range 4 coil. Connect a meter switched to give a clear reading of 6.3 volts across C12, with the same polarity as that component. Switch on the receiver then slowly adjust VR5 clockwise until a 6.3 volt reading is obtained.

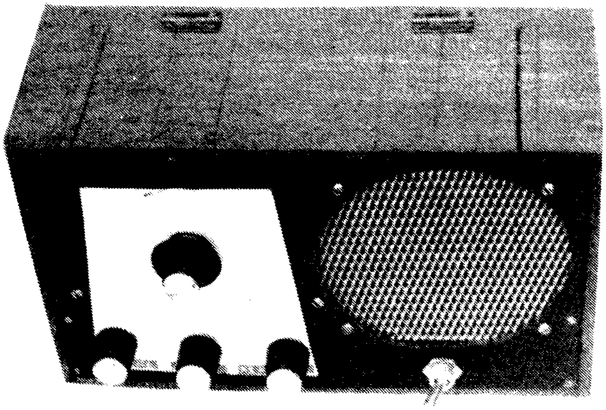
Next, switch the meter to give a clear reading of 500μA and connect it between the collector of TR1 and pin 8 of L3/4, with positive to the collector. Adjust VR2 until a 500μA reading is given. Switch off and complete the connection between TR1 collector and pin 8 of L3/L4.

Try out the receiver with the Range 4 coil inserted. Plug in the aerial, set VR4 at maximum and VR1 near maximum, then adjust VR3 while stations are being tuned in by VC2 so that the receiver is on the verge of oscillation. Remember that the valve takes about 30 seconds to warm up after switching on, during which time the receiver is dead. Adjust the core of the coil so that the 16 metre band is received with the vanes of VC2 nearly fully open. 16 metres should be considered as being about the highest frequency at which reliable reception may be obtained. The low frequency end



Front view of the receiver. This is provided with a tuning scale calibrated in terms of wavelength and short wave bands

The receiver installed in its cabinet. This may be varnished or painted, as preferred by the constructor



of the coverage offered by the Range 4 coil, with VC2 at maximum capacitance, should take in the 49 metre band.

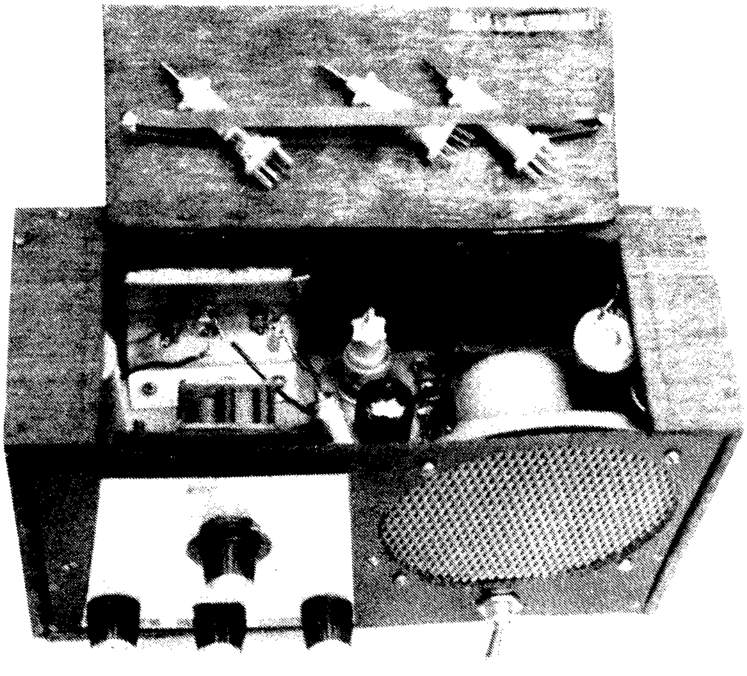
Plug in the Range 3 coil and adjust its core so that the high frequency end of the 49 metre band is received with the vanes of VC2 fully open. When VC2 is at maximum capacitance the range should extend to near the low wavelength end of the medium wave band. Adjust the cores of the Range 2 coil (medium waves) and the Range 1 coil (long Waves) in a similar manner.

It will be found that, with the Range 4 coil, VR3 will need to be continually advanced for the near-oscillation setting as frequency of reception decreases until, at about 50 metres, it is just about fully advanced. There may still be some further clockwise movement available in VC2 but it may prove impossible to achieve oscillation above the 50 metre setting. The appropriate frequencies here are, of course, covered by the Range 3 coil. Using the Range 3 coil, oscillation will commence with VR3 less far advanced, and will be easy to obtain over the full range offered by VC2. Oscillation will start at quite a low setting of VR3 with both the Range 2 and the Range 1 coils, although some advance of the regeneration control will be needed as VC2 capacitance is increased.

SELECTIVITY CONTROL

VR1 should be used as a selectivity control. As it is turned anti-clockwise it will be found increasingly easier to separate stations, though there will be a fall in volume and a consequent necessity for VR2 to be set more critically. VR1 should be set back a little if overloading occurs, as is shown by a tendency for strong stations to break through due to cross-modulation. Otherwise, VR4 should be used as a volume control since setting back VR1 reduces the a.g.c. effect. It will not, of course, be

There is a hinged lid in the cabinet top panel which allows coils to be changed. The unused coils are secured by an elastic band stretched between two woodscrews



possible to hold *weak* fading stations steady.

When operation is satisfactory, the wave trap consisting of VC1 and L2 is set up to reduce the effects of any strong local medium wave station, should this be present. The core adjusting screw of L2 need only project slightly above the coil former, so that there is no need to drill a hole in the top of the screening can, and adjustments are made by means of VC1. Set VR1 to maximum and tune in the station concerned, then adjust VC1 until the volume from that station is at a minimum. VC1 is then left alone and need only be re-adjusted (and, if necessary, a trimmer of different value wired in as was described last month) if the receiver is taken to a new locality or if other factors, such as a frequency re-allocation, cause the interfering signal to be on a different wavelength.

A suitable case is illustrated in Fig. 6, in which the material is ¼in. plywood. This has a hinged lid at the top to provide access for coil changing. Fig. 6(h) shows how two small woodscrews and a large elastic band may be fitted to the lid underside to hold the three coils not in use, and this will prevent them becoming lost. The dimensions in Fig. 6 are intended only as a guide since they allow no tolerances and assume that the receiver has been built exactly to the sizes given in the previous diagrams. In practice, the case should be dimensioned against the receiver, as built. When completed it may be varnished or painted.

As can be seen from the photographs the front panel of the receiver is fitted with a tuning scale. This may be made up from stout white card and marked up according to the constructor's tastes and requirements. A perspex cursor, or two stiff wires, may be secured to the flange of the tuning drive by means of two 8BA bolts.

(Concluded)

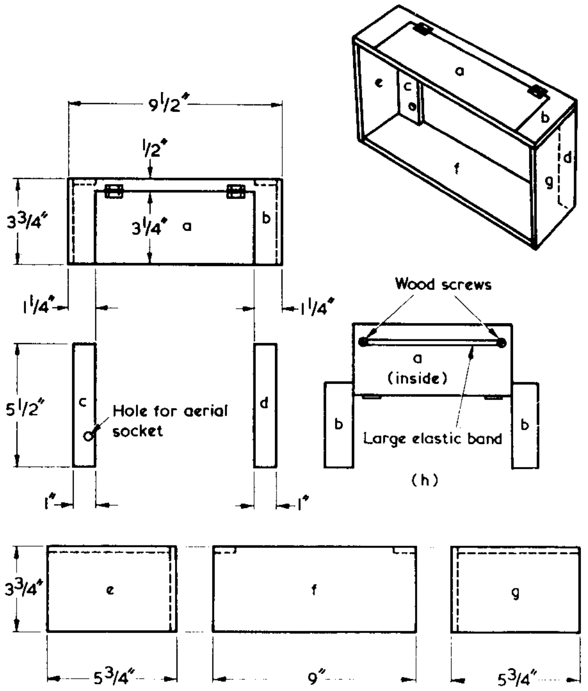
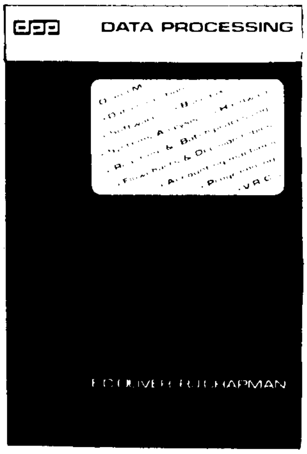


Fig. 6. Details of the assembly of a case for the receiver. Dimensions are for guidance only and may need to be modified slightly to suit the receiver as built



In your work-shop

DOOR BELL MONITOR

Did anyone call while you were out?

"Now," said Dick anxiously, "you will be careful what you say, won't you?"

"What d'you mean, be careful?" responded Smithy irately. "I'm always careful what I say."

"Not always you aren't," stated Dick accusingly. "You do tend to get yourself all worked up every now and again."

"That," snorted Smithy, "is because it's *you* who gets me all worked up. In fact, you're beginning to get me all worked up right now. I'm already regretting that I'd agreed to spend our annual day off together over at your Auntie Eff's."

"Well, she heard about these door bell monitors of yours which you've knocked up for some of your friends, and she thought she'd like one herself. After all, they are rather unique."

DOOR BELL MONITOR

Mollified, Smithy slowed down his impatient stride. Dick, carrying a small shopping bag, changed his step accordingly.

"It's funny," remarked Smithy, "how popular simple little electronic devices can become. All that these door bell gubbinses of mine do is tell you whether anybody has called while you were out of the house. My mates who have got them say they're really useful. You could, for instance, be waiting for a delivery of furniture or for a service engineer to call or something like that, and you find you have to leave the house for just a few minutes. When you get back again my little circuit can tell you at once if anybody called in your absence. If it shows that they didn't you then have the satisfactory feeling that you haven't missed anything important."

"Am I correct," queried Dick, "in saying that you just connect your device to the front door bell?"

"That's right," confirmed Smithy. "However, you have to check first whether the existing bell circuit is going to be suitable. We should be nearly there, shouldn't we?"

"There's not far to go now," said Dick. "We just turn down into this side street here."

The pair walked comfortably, in the warm August afternoon sun, along the quiet pavement. They soon arrived at a small wooden gate in the wall. Dick unlatched this and Smithy followed him through a neat and meticulously kept garden. At the front door Dick pressed the bell-push, whereupon the door was opened almost immediately to reveal a white haired beaming little old lady

"Hello, Auntie Eff. I've brought Smithy along, as I promised."

Auntie Eff eyed Smithy appraisingly, then extended a diminutive white gloved hand. Smithy shook it delicately with a murmured greeting.

"Now, do come in," enthused Auntie Eff in tinkling bell-like tones. "And don't forget to wipe your feet."

Dutifully, the pair wiped their shoes on the front door mat and entered the hall. An antique dealer would have immediately commenced slobbering at the treasures this contained. Smithy's gaze was drawn to an elephant's foot umbrella stand, and he was momentarily unnerved to see the head of a tabby cat rise above its upper surface and scan the surroundings laterally like a submarine periscope, before it silently descended out of sight again. Auntie Eff led them into a living-room, with the same style of furnishing as existed in the hall. On a sideboard was visible a three-tier wooden cake stand on whose shelves nestled a rich array of chocolate eclairs, meringues and similar confections. Dick noticed Smithy's face visibly blanch at the sight.

"We're in a bit of a hurry, Auntie," he said hastily. "Perhaps we'd better get working on the bell first."

"As you wish," she cooed obligingly. "And after that you dear boys can both have something to eat and drink."

"Well," said Dick to Smithy, "the bell is at the back of the hall. Did you say you wanted to check it first?"

"That's right," said Smithy, as they returned to the hall, leaving Auntie Eff alone in the finery of her living room. "You see, what my doorbell monitor does is detect the presence of voltage across the bell when anyone presses the bell-push at the front door. This voltage then triggers an electronic latch from one state to the other. The only snag here is that domestic front door bell systems vary considerably from one installation to the next. Some systems were installed well before the last war and may still be in quite good working order. But goodness knows what condition the insulation of the bell wiring is in. Again, some electric bells are very

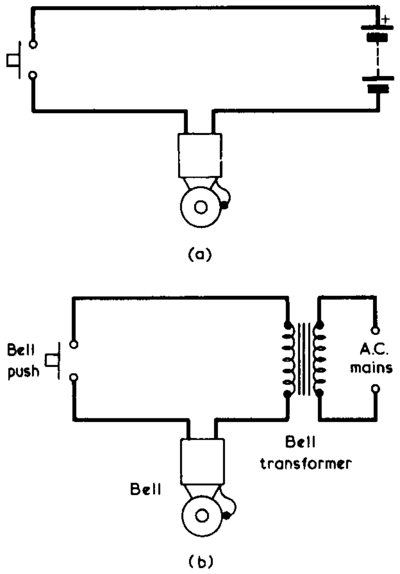


Fig. 1. There can be few circuits simpler than that of the usual front door bell system. In (a) the bell is powered by a battery, and in (b) it is powered from the mains by a bell transformer

sensitive and will work with surprisingly low voltages and currents, whilst others are dead insensitive affairs which require quite high currents to operate."

"There's also the question of whether the bell works from a battery or a mains bell transformer, isn't there?" (Figs. 1(a) and (b).)

"That's true," agreed Smithy. "If the system works from a battery, the voltage appearing at the bell may be too low for the monitor. With battery systems, though, you can at least be certain that the insulation of the bell wiring is in pretty good nick."

"Why's that?"

"Because," stated Smithy, "if there was any serious leakage between the two wires going to the bell-push the battery would need replacing much too frequently. Good grief, something's attacking me!"

CHECKING THE BELL

Frenziedly, Smithy clutched at his shoulder, to find a cat locked securely to the right of his neck, its claws imbedded in the cloth of his jacket. From the corner of his eye he spied a thick ginger striped furry tail. The cat rubbed its head against Smithy's sparse locks, purring deafeningly in his ear.

"I should have warned you about that ginger cat," said Dick in a matter-of-fact tone. "He always does that to strangers. He perches on the top of the hall-stand and then jumps them."

"Blimey," gasped Smithy. "He just about scared me out of my wits. Here, get him off me, will you?"

Deftly, Dick unhooked the ginger cat's claws and then placed him gently on the floor. The cat sat and looked up at Smithy with an intense unblinking gaze.

"He likes you," commented Dick dispassionately. "Anyway, tell me how you check the door bell system when it's powered by a battery. How d'you do that?"

Smithy smoothed down the cloth of his coat.

"You simply connect a multimeter set to a low d.c. volts range across the bell," he answered after some moments. "You should then get a zero volts reading in the meter when the bell-push isn't pressed, and a reading of 1.5 volts or more when the bell-push is closed. If you get both these voltage readings then the bell circuit is suitable for use with my door bell monitor. This test also enables you to find which of the bell terminals has the positive supply polarity applied to it. You mark up this terminal or make a note of which one it is." (Fig. 2.)

"That seems fair enough," commented Dick. "What about bells which are run off a bell transformer?"

"You have to use a little test rig consisting of a series combination of a rectifier and a capacitor. The rectifier can be any silicon type having a p.i.v. of 100 volts or more, and the capacitor can be either non-electrolytic or electrolytic. If it's electrolytic it needs a working voltage of at least 50 volts. The capacitor can have any value between 1 and 10μF. You couple a multimeter switched to a lowish d.c. volts range across the capacitor and apply the ends of the test circuit to

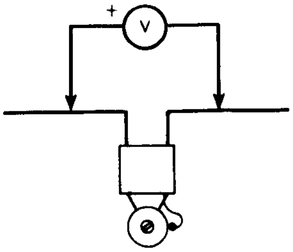


Fig. 2. Before constructing and connecting Smithy's door bell monitor it is first of all necessary to check that the existing bell system is suitable for it. With battery powered bell systems this merely involves taking direct voltage measurements across the bell

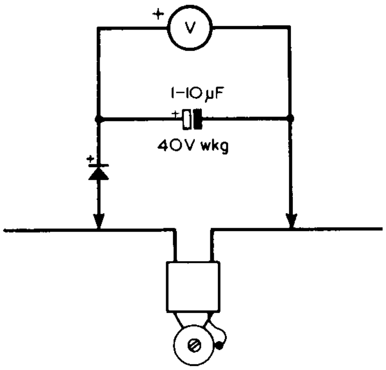


Fig. 3. A simple rectifier and reservoir capacitor circuit is required for checking the suitability of a.c. bell systems

the bell terminals." (Fig. 3).)

"That 50 volts is a pretty high capacitor working voltage, isn't it?"

"Not really," chuckled Smithy. "You'd be surprised at some of the voltages which appear in electric bell circuits. Corluvaduk, there's another cat here now!"

A black and white cat had appeared whilst Smithy was talking. Ranged alongside the ginger cat it, too, regarded the Serviceman with an unwavering intense stare.

"My Auntie Eff's bell system uses a transformer," pronounced Dick. "I know because I put it in myself."

Smithy turned a distracted glance from the cat to his assistant's face.

"Did you?" he remarked absently. "Well, with a.c. powered bells the test conditions which have to be satisfied are zero volts in the meter when the bell-push isn't pressed and 1.5 volts or more when it is."

"Why are you so fussy about these test voltages?"

"For the simple reason," explained Smithy, "that there's no point in making up and fitting the door bell monitor if the existing bell system isn't suitable for it."

"That seems reasonable enough," stated Dick. "Incidentally, I haven't even seen a circuit of the monitor yet."

Smithy took out his wallet and extracted a piece of paper. He carefully unfolded this and passed it to his assistant. (Fig. 4.)

"There you are," he pronounced proudly. "Here's the full works. The heart of the gadget is a 2-way latch circuit incorporating two 2-input NAND gates. Each of these has its inputs connected together so that it acts as a CMOS inverter."

"How does the latch circuit work?"

LATCH OPERATION

"It has two stable states," replied Smithy. "In one of the states the input of the lower gate, or inverter now, is high, whereupon its output is low. The low voltage is passed to the input of the upper inverter, whose output is therefore high. This high output is applied via a 47kΩ resistor, which I've marked up as R4, back to the input of the lower inverter. So the latch circuit holds itself stable under these conditions. The second stable state is with the input of the lower inverter low. Its output is then high, as is the input of the upper inverter. The consequent low output of the upper inverter is then coupled, by way of the 47kΩ resistor, to the input of the lower inverter."

"I think I can follow that pretty easily. Can you change the state of the latch?"

"Oh yes," stated Smithy. "You do it by altering the voltage at the input of the lower inverter. If this input is low and you momentarily take it up to the positive supply rail the circuit will take up the alternative state with the input of the lower inverter high. You can bring it back to the previous state by momentarily connecting the input of the lower inverter to the negative rail. That input will then stay low after you remove the connection. The 47kΩ resistor, R4, prevents excessive currents at the output of the upper inverter when you make these changes."

"Gosh, that's neat. How about a rundown on the whole circuit?"

"All right," said Smithy obligingly. "To start off with, let's say that you're going out and you want to leave the door bell monitor set up to tell you if anyone has called whilst you're away. You can do this by pressing the 'Reset' push-button. This ensures that the input to the lower inverter is high. When the 'Reset' button is released, this input will stay high. For the time being we'll assume that the door bell is powered by an a.c. bell transformer. Two wires, one from the anode of diode D1 and the other from the negative rail connect to the bell. Okay so far?"

"Oh yes," said Dick. "Let's see what occurs if nobody presses the bell before you return."

"As you wish," replied Smithy. "The circuit will then be in the same state as it was when you left. To find out if anyone has called you press the 'Interrogate' button. Since the output of the upper inverter is high so also will be the voltage at the base of the emitter follower, TR3. Pressing the 'Interrogate' button completes a circuit via R5 to the 'No' l.e.d., and this will light up to tell you that nobody has called."

"I like that word 'Interrogate'," grinned Dick. "Let's say next that somebody *did* call while you were out."

"In that case," responded Smithy, "they would have rung the bell, causing an alternating voltage to be passed to D1 and C1,

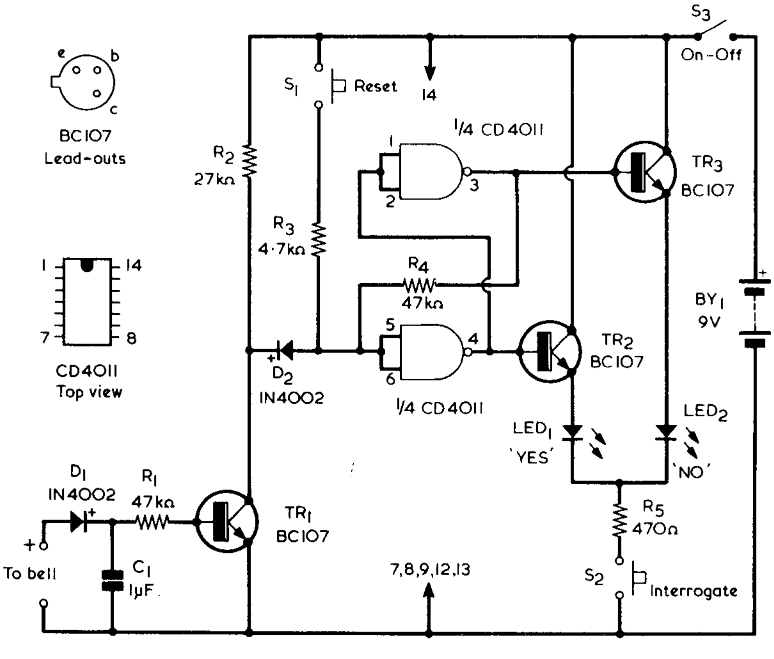


Fig. 4. The circuit of the door bell monitor. The resistors are ¼ watt 10% types, and LED1 and LED2 can be any small light-emitting diodes. If desired, LED1 may be green and LED2 red. C1 is a polyester capacitor

and giving a rectified positive voltage on the upper plate of C1. This causes TR1 to turn on. Its collector voltage falls to nearly the negative supply rail potential, and it takes the input of the lower inverter low by way of diode D2. When the bell-push is released, TR1 will turn off again and its collector voltage will go high. But the input to the lower inverter will still stay low because diode D2 is now reverse biased."

"Ah," said Dick, his eyes gleaming. "I can see what happens next. This time it will be the output of the lower inverter which is high so that, when the 'Interrogate' button is pressed, the 'Yes' l.e.d. will light up."

"That's it precisely," stated Smithy. "A minor point is that the 'Yes' l.e.d. will light up if more than one person has called. But you will at least know that *someone* has called. Yee-augh!"

Dick looked up in surprise to see the Serviceman's face contorted in agony. Glancing down, Dick noticed that a Persian cat had joined the feline throng around Smithy, and was reaching up gracefully with its claws sunk deep in the Serviceman's ample right calf.

"He's only sharpening his claws," Dick remonstrated mildly. "All cats like to sharpen their claws."

"Not on my flaming leg they don't," grated Smithy through clenched teeth. "For the love of Mike pull it off me."

For the second time that afternoon, Dick disengaged the claws of one of his aunt's cortege of cats. Smithy hitched up his trouser leg and examined the damage to his leg anxiously.

"The sooner we get out of this cat-infested house the better," he announced darkly. "I've probably got tetanus now. It'll be rabies next."

But Dick was more interested in the circuit of Smithy's door bell monitor.

"What do you do," he asked, "if the bell happens to run from a battery?"

"You connect to the bell in the same way as you do to an a.c. driven bell," stated Smithy, gingerly massaging his leg, "remembering this time that the anode of D1 has to connect to the terminal of the bell which you have previously determined has the positive voltage. It may seem surprising that you still need a rectifier when the bell is driven by a direct voltage, but it's the only simple way of ensuring that any high reverse back-e.m.f.'s generated in the bell do not get into the monitor circuit, where they can cause erratic performance. It's quite important, also, to connect the monitor to the bell right way round when it's battery operated. If you don't, D1 and C1 may upset the operation of the bell itself."

MONITOR CURRENT

"Blow me," protested Dick, "we're only talking about an ordinary inoffensive electric bell. Don't tell me that a diode and capacitor connected across it wrong way round will cause any unusual effect."

"You'd better believe it," stated Smithy forcibly. "What you refer to as an ordinary inoffensive bell can be an absolute little demon so far as inductively generated high voltages are concerned. Anyway, let's get back to the circuit. The two NAND gates in this which act as inverters are parts of a quad-NAND gate type CD4011. This has the positive supply going to pin 14 and the negative supply going to pin 7. The inputs of the remaining two gates, at pins 8, 9, 12 and 13, are taken to the negative rail, and no connections are made to the outputs at pins 10 and 11."

"What about current consumption from the 9 volt battery?"

"When the bell sounds," replied Smithy, "the current drawn is about 0.3mA through R2. And when you press the 'Interrogate' button the current drawn by either LED1 or LED2 is about 14mA. If neither of these things happen the current taken from the battery should be less than a microamp. The CMOS i.c. draws very nearly zero current and the remaining current is leakage current in TR1, and in D2 as well if the input of the lower inverter is low. In the practical circuits I've checked, the current drawn from the battery in the quiescent state does not even cause a perceptible movement in the needle of a 0-50μA meter. So you should get a very long life from, say, a PP7 battery."

"That seems to tie everything up," said Dick. "No it doesn't! Why have you got that 4.7kΩ resistor, R3, in series with the 'Reset' button?"

"It could happen," explained Smithy, "that someone might press the bell-push at the same time as you're pressing the 'Reset' button. If this does occur, R3 will limit TR1 collector current to a safe level of around 2mA. A final point is that, when you switch on at S3, the latch may take up the state where the input of the lower inverter is low. You can always guard against this by pressing S1 after switching on."

He looked around at the group of three cats which now surrounded him.

"If," he continued, "I can find my way through this feline forest, I'll next check if your Auntie Eff's bell system is suitable for the monitor. You'll find an a.c. test rig consisting of a rectifier and capacitor in series in that bag I gave you to carry. Couple it up to the bell and see what happens."

Dick quickly found the a.c. test components and connected them to the bell terminals. He took a multimeter from the shopping bag, set it to a 0-10 volt d.c. range and clipped its leads across the capacitor. The needle indicated zero volts.

"So far, so good," stated Smithy approvingly.

He walked to the front door, followed by his retinue of cats. He opened the door, leaned out and pressed the bell-push several times. After closing the door, he returned to his assistant and raised an enquiring eyebrow.

"Did you get a suitable voltage?"

"I'll say I did," said Dick. "Most of the time the needle hovered around 6 volts or so when the bell was ringing. But when you released the bell-push the last time, it shot right off-scale!"

"I told you," grinned Smithy, "that these bells can produce some pretty high voltages. Anyway, seeing that everything is satisfactory perhaps you could now connect the monitor unit up to the bell. I should add that, so far as wiring is concerned, it is always advisable to keep the wires from the bell well clear of the wiring in the monitor including, in particular the wiring to the CMOS inverter inputs."

Smithy fished in the shopping bag and produced a small plastic case in which the monitor was housed, together with a length of twin cable. Dick took these items from him and, placing the monitor on the hall-stand, proceeded to run the cable from its input terminals up to the bell. (Fig. 5).

"I've just thought of something," he remarked as he worked on the cable. "What about those bell systems where the bell-push is illuminated?" (Fig. 6.)

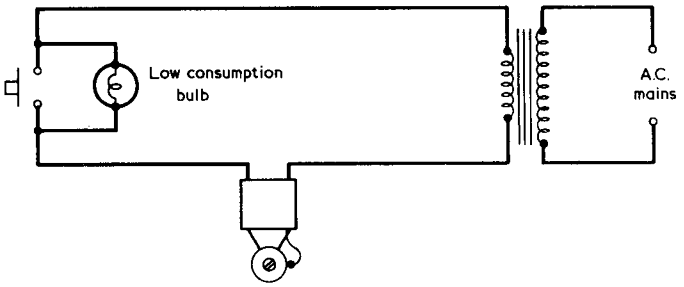


Fig. 6. A.C. powered systems frequently have a low consumption bulb connected across the bell-push. This bulb has to be removed because of the consequent voltage dropped across the bell, particularly if its armature contacts are worn

"In those," remarked Smithy, "there is a low-consumption bulb across the bell-push contacts. This lights up when the bell-push is not pressed, the current it draws being too low to operate the bell. You'd have to remove the bulb if you wanted to use such a system with my bell monitor."

"Fair enough. And what about those two-tone ding-dong type bells?"

"I haven't tried out my gadget with any of them," admitted Smithy. "But it should work all right if the voltages across the two-tone bell meet the requirements I stated earlier on."

It was not long before Dick had completed the wiring to the bell, whereupon the bell monitor was ceremonially checked out, with Dick at the front door bell-push and Smithy operating the monitor. It functioned satisfactorily on every occasion.

A TOUCH OF COMFORT

The intermittent ringing of the bell had brought out the tabby cat residing in the elephant's foot umbrella stand, as well as two further cats from the upper regions of the house. It also brought out Auntie Eff. She was quickly instructed in the operation of the monitor unit, and pronounced herself extremely pleased with its efficiency.

She then led Dick, Smithy and all six cats back into the living-room, on the centre table of which was now arrayed a silver tea-pot on a stand, a silver milk jug, a silver sugar bowl and a tea set of delicate bone china.

"Time for tea, boys," she sang gaily as she poured out a diminutive cup of tea and handed it to her nephew. Smithy, accustomed to his capacious tin mug in the Workshop, eyed the tiny cups on the table with apprehension.

"But for we more grown-up ones," she pronounced, beaming at him benignly, "perhaps something more fitting for this lovely August afternoon."

The bemused Smithy found a large glass on the table in front of him. A similar glass had appeared at Auntie Eff's place. She rose and opened a beautifully finished old oak cabinet.

"Let me see," she trilled happily, "I have Smirnoff, Booth's, Gordon's, Grant's, Teacher's and Johnny Walker."

Smithy's mouth dropped open.

She giggled.

"Bell's would be very appropriate, wouldn't it? Or possibly my own little favourite — a touch of Southern Comfort."

As Smithy remarked to himself later on in that eventful day, Dick's Auntie Eff was certainly well preserved for her years. Or, perhaps, 'pickled' would be the more appropriate term. ■

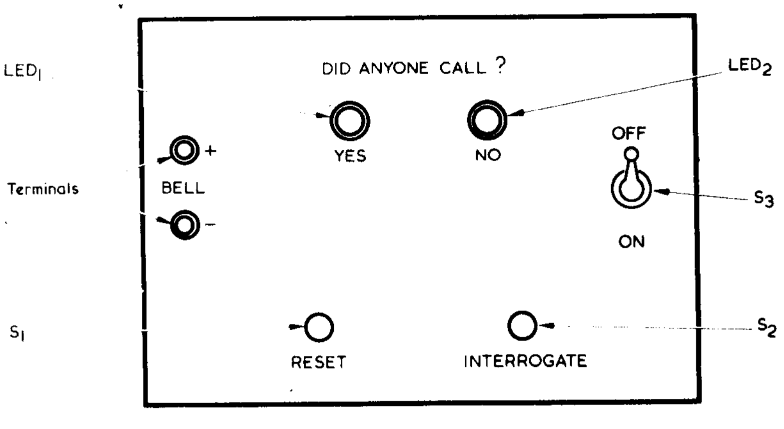


Fig. 5. The bell monitor can be assembled in any plastic case capable of accommodating the components and battery, and having a front panel layout similar to that shown here. Whatever method of construction is employed, the two wires from the bell must be kept well clear of the circuitry following C1

Radio Topics

By Recorder

★★★★★★★★★

The name of the communications game these days is security, and a new dimension to this has just been announced by Marconi Space and Defence Systems Limited in the introduction of their Crypflex high grade secure speech system.

Crypflex is the latest addition to the Marconi "Cryp" range of cryptographic equipment for use in the diplomatic, military, commercial and civilian fields. It has been designed to provide long term security for voice communications over so-called "difficult" links, primarily in the high and very high frequency radio bands, or over other links which are below the minimum standard for normal data transmission.

SPEECH SECURITY

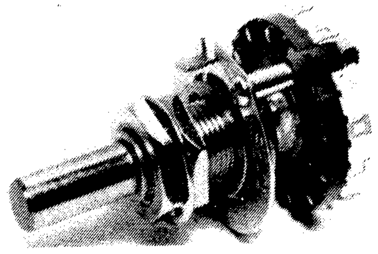
Two versions of Crypflex equipment are available, one being designed for vehicle installation and the other for 19 inch rack mounting. The latter is more suitable for larger fixed installations. Three functions are carried out by the Crypflex units. In the transmission mode a vocoder (a device which converts speech to an alternative signal form) digitizes the speech, a cryptographic stage encyphers the ensuing data stream and finally a multi-tone modem (modulator — demodulator) turns the data stream into a signal suitable for transmission. On receipt of the coded signal, Crypflex's modem feeds the demodulated signal to the cryptographic stage for decoding, after which the vocoder reconstitutes the speech from the decoded data.

Crypflex is stated to be the first equipment to combine all these functions in a single unit small enough for vehicle mounting. Before the advent of Crypflex a system embracing the h.f. radio band required the use of equipment so large and expensive as to restrict it to specialist applications where size and cost were of relatively low significance. By taking advantage of very advanced digital signal-processing techniques, but using standard digital mircocircuits, Crypflex provides the facilities in a single housing of convenient size and at a drastically reduced cost.

The Crypflex vocoder converts speech to a data stream at only 2.4 kilobits per second and in the receive mode converts the data stream back again to speech. With a quality of reproduced speech comparable with that of speech digitizers working at a speed ten times that of Crypflex, listeners quickly become accustomed to the vocoder sound and can easily recognise individual speakers. The low bit rate of Crypflex is the major factor in making speech encryption feasible over narrow band channels.

The cryptographic unit, employing highly advanced cryptographic techniques, processes the vocoder data output into an apparently random bit stream at the same rate of 2.4 kilobits per second; in the receive mode the vocoder data is recovered from the apparently random bit stream. Bit-by-bit digital encryption is applied using keystreams which cannot possibly cycle in periods of several months of continuous operation and which are so complex that analysis is virtually impossible by any form of cryptanalysis known to the designers.

Operation of the Crypflex equipment is simple. Apart from making the required code setting, which takes about 30 seconds, and setting the mode switch for clear or secure operation, no further operator attention is necessary. Each user is allocated an exclusive group of over one million million codes, and code selection is made quickly and simply by setting 10 thumbwheel switches. The code settings must, of course, be the same on the Crypflex unit at each end of the link before any decrypted intelligence can be obtained.



Miniature moulded wafer rotary switch from N.S.F. features 12 contact positions and exceptionally small rearward projection

SPACE SAVER SWITCH

The accompanying photograph shows a new miniaturised wafer switch now being manufactured by N.S.F. Limited, Keighley, Yorkshire, BD21 5EF. This has been evolved to meet the increasing emphasis with instrument layouts towards decreasing internal measurements and the use of miniature components. The switch combines the N.S.F. Type A mechanism with moulded wafers Type MA.

The switch has 12 contact positions and measures only 19.05mm. from the mounting face to the switch end.

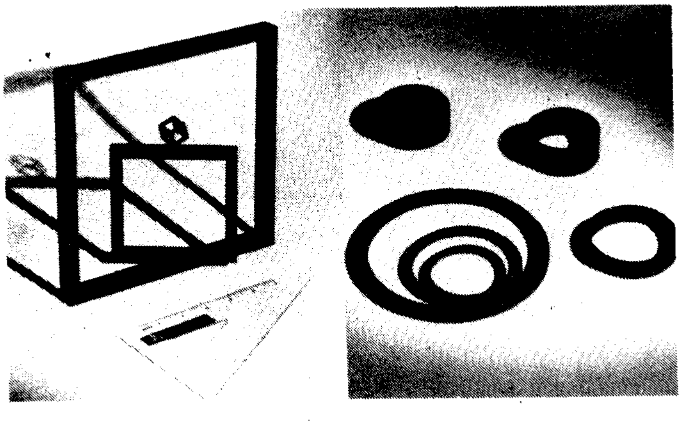
TOP FERRITES

The selection of exotic shapes you can see in the second photograph will gladden the eyes of any pulse transformer designer. They are manufactured by Ceramic Magnetics Inc., for whom Walmore Electronics have been appointed exclusive agents in the U.K.

Components produced by Ceramic Magnetics have the distinction of being the most expensive ferrites currently available. All parts are machined from solid rods or ingots under very carefully controlled conditions, resulting in products which are both homogenous and stress-free and which conform to extremely strict dimensional, mechanical and magnetic tolerances.

The nature of the processes used not only allows reproducibility of products but also offers the capability of manufacturing complex specials to very high standards in a comparatively short period of time. The components can be produced from a variety of high performance materials, such as the MN60 high permeability low-loss ferrite which gives the lowest power loss currently possible with today's materials.

Full details on the ferrite products may be obtained from Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, London, WC2H 9BS.



Some of the wide range of ferrite shapes which are being currently marketed by Walmore Electronics Ltd.

F.E.T. AMPLIFIER

Way back in July of 1976 I mentioned that field-effect transistors capable of handling high audio powers were being developed in Japan, and that these could be employed in the output stages of hi-fi amplifiers. In this application they give the same "smooth" amplification which is associated with the old triode valve.

I see now that Hitachi have unveiled a new MOSFET high fidelity stereo amplifier with, presumably, high power f.e.t.'s in the output stages. The new Hitachi amplifier, model HMA-7500, will deliver 75 watts r.m.s. per channel with a total distortion of 0.01% across the entire range of 20Hz to 20kHz. At 40 watts r.m.s. the distortion is only 0.005%.

It is refreshing to see an entirely new technique emerging in what is one of the liveliest branches of domestic electronic equipment. It has been occasionally stated that if the f.e.t. had appeared *before* the bipolar transistor, our transition from valve to semiconductor technology would have been vastly different. Circuitry would have then changed much less abruptly from the valve approach to that required with the roughly analogous field-effect transistor. Late starter though it may be, the f.e.t. certainly seems to be doing its best to catch up!

NEW MANUFACTURER

A new name to add to semiconductor devices manufactured in the U.K. is that of International Devices Inc. This company has now established a U.K. manufacturing plant at Harlow in Essex. The British operation, known as IDI Semiconductors Ltd., has moved into a 6,000 square ft. factory, and will initially specialise in the manufacture of germanium power transistors with further product lines to follow.

International Devices Inc. has its headquarters near Los Angeles International Airport, and its total product line covers about 2,300 types, including germanium small-signal and power transistors, silicon n.p.n./p.n.p. small-signal and power transistors, plastic power devices and Darlingtons, diodes, rectifiers and thyristors.

In addition, devices are produced to special customer specifications, and replacements can be offered for obsolete or discontinued transistors in a variety of packages.

The British company is already receiving large-quantity orders for devices to be made at the new plant, and plans to conduct a high level of exports, mainly to the E.E.C. countries. The full address of the new company is IDI Semiconductors Ltd., The Fairway, Bush Fair, Harlow, Essex. ■