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THE AUGUST ISSUE WILL BE PUBLISHED ON 3rd JULY

CORDLESS HEADPHONE RECEIVER

By A. P. Roberts

★ **A unique design mounting the electronics onto the headphones**

★ **Case only $2\frac{3}{4}$ x 2 x 1 in. app.**

★ **No trailing wires**

THE ULTIMATE IN PERSONAL RADIO LISTENING

Although initially designed and built for its novelty value, this receiver does have advantages over sets which feed a pair of headphones or an earphone in the conventional way. This little set differs from convention in that the electronics are built into the headphones, or perhaps it would be more accurate to say that they are built onto the headphones. A case which measures only 71.5 by 49 by 24.5 mm. houses a completely self-contained fully tuneable medium wave receiver, including a ferrite aerial and battery. As can be seen from the accompanying photographs, the set is mounted on one earpiece of a pair of inexpensive 8Ω stereo headphones.

A.M. RECEIVER

Obviously the output of the set will not be of true Hi-Fi quality as the receiver is an a.m. model. Also, the output is only monophonic, with the two headphones being wired in series. Nevertheless, results are good with regard to quality, and the set compares very favourably with most other portable receivers in this respect, regardless of whether they are of the loudspeaker or earphone output variety.

It would of course be possible to feed most monophonic receivers into a pair of inexpensive stereo headphones and obtain very similar results, but there would then be the disadvantage of a trail-

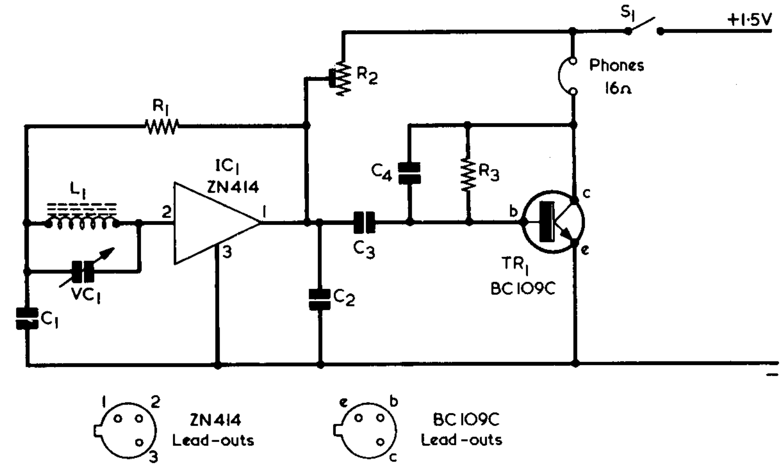


Fig. 1. The circuit of the headphone receiver. The headphones are two 8Ω units in series and give adequate volume after the a.f. amplification provided by TR1

ing lead between the headphones and the receiver. Ordinary simple earphone receivers, with which this set is roughly comparable in complexity, also suffer from the same disadvantage.

One might expect this radio to be rather difficult to build due to the small size into which the electronics must be condensed. However, this is not really the case, and construction of the project is quite simple and straightforward. All the components are standard readily available items, and power is obtained from a single HP7 1.5 volt cell. The set is therefore very economical to run, especially when one considers that the cell will have a long life even if the receiver is used extensively.

THE CIRCUIT

As can be seen from Fig. 1, the circuit of the receiver is extremely simple, and is based on the popular ZN414 integrated circuit. This device contains most of the components for a sensitive medium wave t.r.f. receiver, including the r.f. amplifier, detector and a.g.c. circuitry.

A ferrite aerial and tuning capacitor are required, and these are L1 and VC1 respectively. C1 provides an earth return path for one side of the tuned circuit, and R1 is the bias resistor for the ZN414. R2 is its load resistor, and it is across this component that the audio output signal is developed. C2 is an r.f. filter capacitor.

The ZN414 provides an audio output level of about 30 millivolts r.m.s. from a source impedance of a few hundred ohms. This is not really sufficient to adequately drive 8Ω headphones, and some additional audio amplification must be employed. The amplification is provided by TR1, which is wired as a high gain common emitter amplifier. TR1 is biased by R3, and the headphones form the collector load. C3 provides interstage coupling between the ZN414 and the transistor, whilst C4 rolls off the high frequency response. This is necessary as the frequency response of TR1 would otherwise extend well into the r.f. spectrum, which would almost certainly result in instability (especially when one considers the very compact component layout which must be used).

S1 is the on-off switch, and no supply decoupling components are required. The current consumption of the receiver is about 8mA, most of which is taken by the output stage. Some constructors may be worried by the fact that a standing current from the output stage flows through the headphones. This current is not sufficiently high to adversely affect the performance of the headphones, even in the long term. The transducers used in inexpensive stereo headphones are almost invariable similar to miniature 8Ω loudspeakers of the type that are found in small radio sets, cassette recorders and similar items.

COMPONENTS

Resistors
- R1 100kΩ ¼ watt 5%
- R2 2.2kΩ pre-set potentiometer, 0.1 watt skeleton, horizontal
- R3 47kΩ ¼ watt 5%

Capacitors
- C1 0.01μF type C280 (Mullard)
- C2 0.1μF type C280 (Mullard)
- C3 0.1μF type C280 (Mullard)
- C4 3,300pF ceramic plate
- VC1 20-250pF trimmer (see text)

Inductor
- L1 ferrite aerial (see text)

Semiconductors
- 1C1 ZN414
- TR1 BC109C

Switch
- S1 s.p.s.t. sub-miniature toggle

Miscellaneous
- Verobox type 75-1469-L
- Stereo headphones, 8Ω per headphone
- Veroboard, 0.1in. matrix
- Trimmer converter (see text)
- Control knob
- 1.5 volt cell type HP7 (Ever Ready)
- Ferrite rod, 2¼ x ¼in. (see text)
- 32 s.w.g. enamelled copper wire (for L1)
- Insulating tape, solder tags, wire, etc.

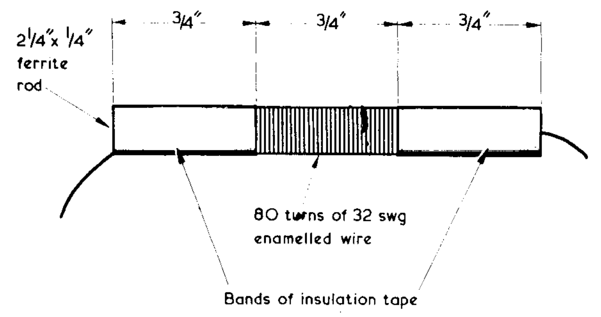


Fig. 2. Details of the ferrite rod aerial winding

FERRITE AERIAL

Commercially produced ferrite aerials all seem to be far too large for the present application, and so it is necessary for the aerial to be home-constructed. Details of this component are provided in Fig. 2.

The aerial is wound on a $2\frac{1}{4}$ by $\frac{1}{4}$in. ferrite rod. It will probably not be possible to obtain a rod of the required length, and so it will be necessary to cut a piece from a longer rod. Ferrite is an extremely hard and brittle substance which cannot be easily cut through with, say, a hacksaw. It should be possible to cut a deep groove around the circumference of the rod at the point where it is to be cut, after which the rod can be easily broken at this point by tapping it gently against the edge of the bench. This does not always produce a very neat break, but any rough protruding edges can be filed off, and any general roughness will not affect performance.

The winding consists of 80 turns of 32 s.w.g. enamelled copper wire wound around the middle third of the rod in a single layer. The turns should be spaced as closely together as possible. If it is found that the length of the winding is slightly different from the $\frac{3}{4}$in. shown in Fig. 2, so that it is not fully central on the rod, this is not of importance. Bands of insulating tape are used to hold the lead-out wires in position and to thus prevent the winding from springing apart. The lead-out wires are cut to about 50mm. in length, and then the enamel insulation is scraped off the ends of these leads so that they can be tinned with solder.

If difficulty is experienced in obtaining $\frac{1}{4}$in. ferrite rod, it is in order to use the more readily available rod having a diameter of 8mm. This is cut down from a longer piece in the same manner as the $\frac{1}{4}$in. rod, and the winding has the same number of turns. There is just sufficient room in the layout for 8mm. rod.

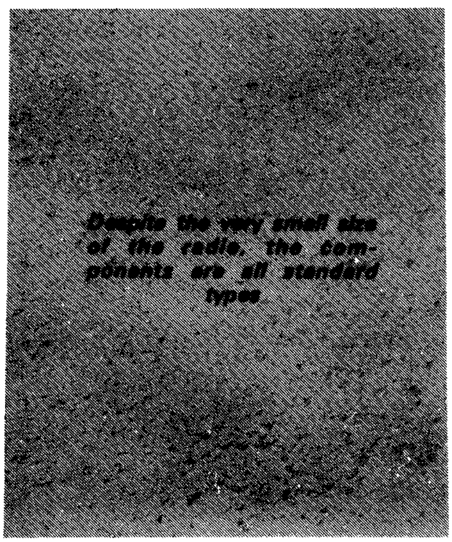
CONSTRUCTION

Most of the components are assembled on a 0.1in. matrix Veroboard panel which has 14 holes by 7 copper strips. The component layout of this panel is shown in Fig. 3.

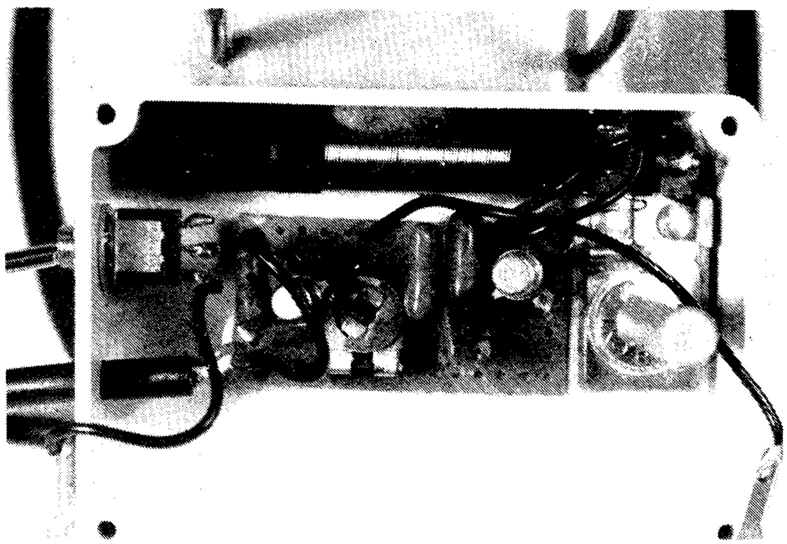
Start by cutting out a panel of the required size using a small hacksaw, and then make the single break in the copper strips. No mounting holes are drilled in the board. Then solder the components into position. Note that R2 is a skeleton potentiometer having 0.2in. spacing between track tags, and 0.4in. spacing between track and slider tags.

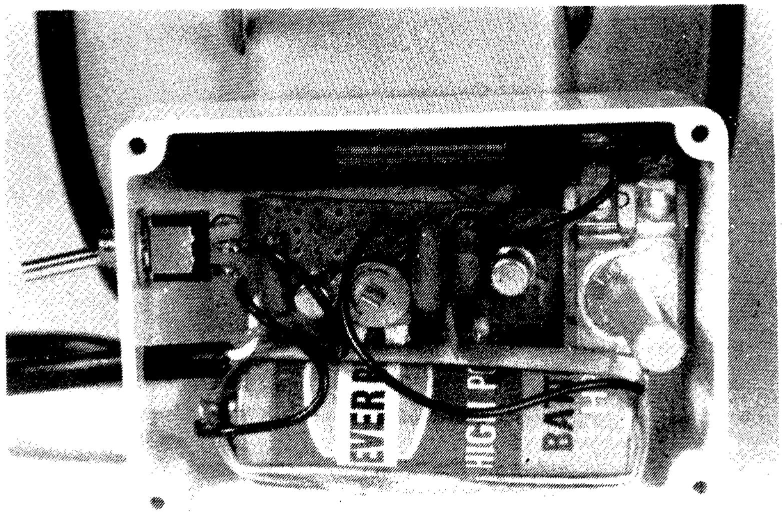
The general arrangement of the receiver can be seen from the accompanying photographs. A Verobox type 75-1469-L is used as a housing, and as the receiver has been designed to fit into this case it is probably best not to attempt to use an alternative.

The ferrite aerial is glued in position at the top of the case using a good gap filling adhesive such as an epoxy type. The HP7 cell fits into the space opposite this at the bottom of the case. A 250pF mica compression trimmer is used as the tuning capacitor, and this is fitted with a "trimmer converter" which replaces the adjusting screw and has a $\frac{1}{4}$in. shaft for a knob. The trimmer and the trimmer converter are available from Home Radio (Components) Ltd. The tuning capacitor is mounted on the extreme right hand side of the case, and its two tags must be bent forwards slightly so that they are not obstructed by the ferrite aerial. The tuning capacitor is mounted by the bush and nut which are situated at the rear of this component. It does not matter which way round the connections are made to the tuning capacitor and to the ferrite aerial.



Despite the very small size of this radio, the components are all standard types





Power is supplied by a single 1.5 volt cell type HP7 which is positioned at the bottom of the case

S1 is mounted towards the top of the left hand side panel of the case, and it is important that this be a sub-miniature toggle switch as there is very little space to accommodate it. An entrance hole for the headphone lead is made in the side of the case just below S1.

When all this has been completed the component panel can be wired up to the rest of the unit. The panel fits into the space in the centre of the case. The headphone lead is cut down to only about 5in. or so in length, and then it is soldered into the circuit. Only two of the three wires in the headphone cable are actually connected; the common lead being ignored. It is possible to determine which lead is the common one by inspecting the wiring at the jack plug. The common lead is the one which connects to the main part of the barrel of the plug, and it is usually colour coded black. (Constructors who prefer to check out the receiver before cutting the headphone lead may initially make temporary connections from the board to its jack plug. The wire may then be cut and finally fitted after tests have been completed.)

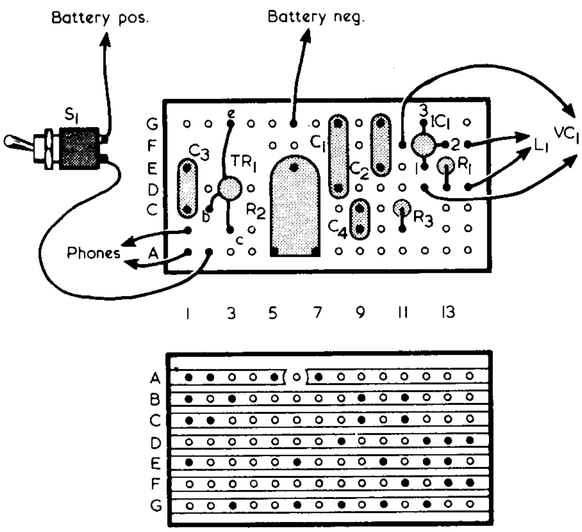


Fig. 3. Most of the components are wired up on a small Veroboard panel, employing the layout shown here

The battery leads are terminated in 6BA solder tags and these are held against the appropriate battery terminals with the aid of a rubber band. Take care to ensure that the cell is connected with correct polarity. The cell terminals will be marked with their respective polarities.

The lid of the case must be drilled with a $\frac{5}{16}$in. diameter hole through which the trimmer converter shaft can pass. The case lid can then be screwed into position and the trimmer converter shaft fitted with a small control knob. However, this cannot finally be done until R2 has been adjusted to the correct setting.

When completed, the receiver is glued to the headphone from which the headphone lead emerges. It will need to be mounted fairly low down so that it does not obstruct the headband assembly, and it is preferable for it to be mounted on a flat surface. However, if an epoxy adhesive, or other type having a good gap-filling ability, is employed it should be possible to obtain a good bond to a curved surface, if necessary.

ADJUSTMENT

R2 should be adjusted so that its slider is at approximately the centre of its track before the receiver is initially switched on and tested. If results seem to be satisfactory, adjusting the slider of R2 slightly in an anticlockwise direction will probably produce a small improvement in sensitivity and selectivity. Do not adjust R2 too far in the anticlockwise direction, though, as this will result in the circuit becoming unstable. Also, it is advisable not to adjust R2 slider to an extreme anticlockwise setting as the low value of resistance it then inserts may cause a relatively high output current to flow in the ZN414.

If there is any sign of instability when first testing the receiver (such as a whistling sound as the set is tuned across a transmission), then R2 slider should be adjusted slightly in a clockwise direction to eliminate this instability. Do not adjust it any further in the clockwise direction than is absolutely necessary, as this would cause a needless degradation of performance. R2 should be set up with a new HP7 cell connected.

NEWS . . . AND

ANALOGUE MAGNETIC TAPE RECORDER LOGS VITAL DATA IN SEA WAVE ENERGY RESEARCH

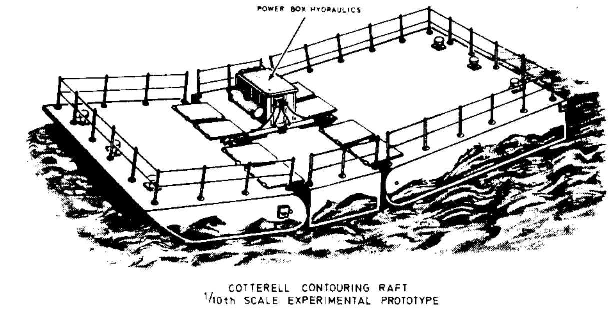
An EMI Technology high-performance magnetic tape recorder is playing an important role in the Department of Energy's continuing R&D programme for winning power from the waves around Britain's coast. One of their portable SE7000 analogue instrumentation recorders is being used with equipment provided by The National Maritime Institute (NMI) and the British Hovercraft Corporation for experiments being undertaken in the Solent by Wavepower Ltd., a company comprising Sir Christopher Cockerell (inventor of the Hovercraft) and E.W.H. Gifford and Partners (consulting engineers).

The Wavepower project* is concerned with evaluating the effectiveness of the 'Cockerell Contouring Rafts' (see diagram). These have a series of hydraulic motors/pumps situated between each raft in order to convert the energy of the raft motion into high pressure in a fluid. Initially, trials of $\frac{1}{50}$th scale raft strings were conducted by the British Hovercraft Corporation in test tanks on the Isle of Wight, and now $\frac{1}{10}$th scale trials are being held at sea in the Solent.

The recorder is being used to monitor a number of critical parameters relating to the design, efficiency and survival capability of the Cockerell Contouring Rafts (CCR). Based on an analysis of the data obtained, a full size prototype will be designed for further evaluation.

For the $\frac{1}{10}$th scale experiments the SE7000 is housed, together with all the other measuring and real-time data analysis equipment, in a 20-ton ISO container secured in the hold of a moored 60ft seagoing barge. This barge is linked to the CCR by means of an electrical 'umbilical' cable.

The tape transport is being used to record pulse code modulated (pcm) signals derived from 64 data channels. With such a large number of channels, conventional analogue tape recording would have been prohibitively expensive; pcm techniques (developed by Microconsultants Ltd in association with the NMI) were therefore used, since these enable up to 21 data channels to be recorded on only one track of the 14-track recorder.



The Cockerell Contouring Rafts are hydraulic/electrical systems whereby the wave-induced movements of the articulated sections are converted into a hydraulic pressure, which is then itself converted into electrical energy using an alternator.

The measurements being monitored relate to environmental conditions such as wind and current speeds and directions, tide and wave heights and directions (using a device developed by the British Ship Research Association), barometric pressure etc. Other parameters being recorded include the mooring forces on the CCR pontoons, loadings on the raft hinges, hydraulic pressures, electrical power output and so on. Analysis of the recorded data is finally carried out at one of the NMI's land bases, using Honeywell mainframe computers.

* In all, four R&D projects — each based on a different mode of wave-to-mechanical energy transfer — are being financed by the £$2\frac{1}{2}$-million DofE wave energy research programme. The other three — being undertaken by both private industry and Government bodies — concern the use of Salter Ducks, Oscillating Water Columns and the Russell Rectifier.

Picture shows H.R.H. The Duke of Kent discussing Multicore Solders Limited Solder Creams with Gordon Arbib the company's Managing Director. Also shown are four executives from Multicore's Hong Kong Distributors Roxy Electric Co. Ltd

MULTICORE SOLDERS AT THE BRITISH INDUSTRIAL EXHIBITION, HONG KONG

It was a question of History repeating itself when H.R.H. The Duke of Kent met Gordon Arbib, Managing Director of Multicore Solders Limited, at the British Industrial Exhibition in Hong Kong. His Royal Highness stopped at the Multicore Solders' Stand to see demonstrations of their Oxide-Free Solder Cream and special solders for the soldering of aluminium.

Twenty-eight years ago Queen Mary visited a Multicore Solders exhibition stand at the Radio Show in London where she met Mr. Arbib's father, the late Richard Arbib.

The Hong Kong exhibition attracted exhibits from 120 British Companies.

. . . COMMENT

ADDING SOUND TO CANCEL NOISE

One of the problems of working in industrial environments is that of noise, and the usual approach towards obtaining a reduction in this particular field of audio pollution has been the use of sound-proofing materials, baffling and the like. Plus, of course, attempts to reduce the level of noise generated at the source itself.

All such devices are of a passive nature, and it is of considerable interest to learn, from the National Research Development Corporation, of steps to reduce noise by an active method. A further noise is added to the original noise and achieves partial cancellation of it. To date, the technique has only been developed to the state where noise at low frequencies can be dealt with.

The work carried out has been on the low frequency noise from gas turbines, which have presented what has always up to now seemed to be an insoluble problem. However, recent research at Chelsea College into a system devised by Dr. M. A. Swinbanks suggests that the answer may lie in absorbing sound by generating additional sound to interfere with and cancel the offending frequencies.

Work on the Swinbanks system is currently being financed by the National Research Development Corporation and, at the present state of development, the method appears to be particularly appropriate for absorbing sound in air ducts and fluid pipelines.

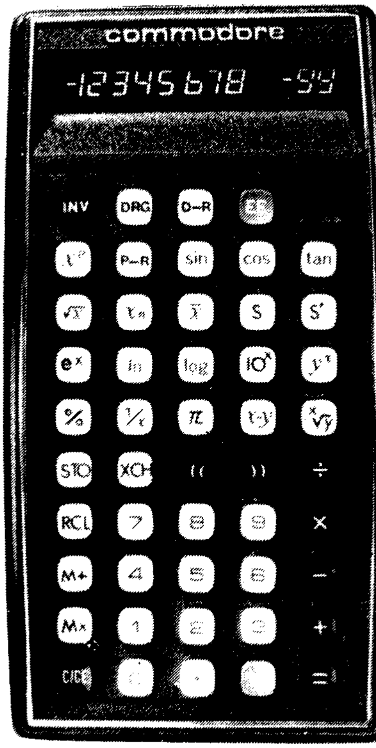
It is commonly accepted that a loudspeaker can be used to cancel sound waves in one direction at the expense of doubling the sound levels in another, but the fact that a loudspeaker can be employed to absorb sound energy (thus forming a "sound sucker") is less well known. Assuming that the noise from a fan, for instance, is travelling along a duct and that it is required to silence this noise before it reaches the area serviced by the duct, the following method is adopted.

Two microphones are placed in the duct and their outputs are combined to detect only the sound arriving from the noise source. The microphone signal is electronically processed and is then fed to two loudspeakers mounted on the wall of the duct. These operate to produce a "plane wave" which travels down the duct towards the zone to be silenced but not towards the original noise source. The plane wave has identical amplitude but opposite phase to the unwanted sound and the end result is silence in the duct downstream from the loudspeakers with an unaltered sound field upstream. Under such circumstances it can be shown that the sound energy is first "trapped" between the loudspeakers, and is then progressively absorbed by the loudspeaker nearer the microphones.

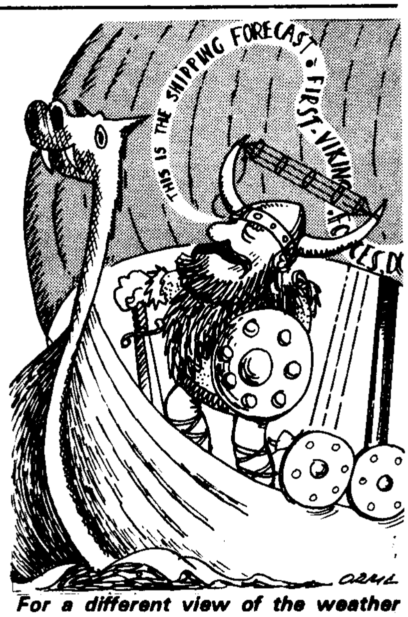
The experimental system has significantly cut random noise over the range of 30 to 200Hz in a duct measuring approximately 300mm. square. With a fan having a broad noise peak at 160Hz, the attenuation over the range was 14dB. The precise attenuation and frequency range of operation is largely governed by the need to ensure accurate reproduction of the initial sound field; for example, 20dB attenuation corresponds to 90% accuracy in the operation of the loudspeakers.

Following upon the above interesting news item we express the hope that sound pollution from radios etc. will not be a feature of outdoor life this summer. The position has certainly improved since the first advent of transistor portables, and we can all set a good example.

NEW SCIENTIFIC CALCULATOR



The student market is particularly well catered for with the introduction of Commodore's new scientific calculator, which represents a breakthrough in calculator features/price: Model SR4912 is an 8+2 digit LED calculator, and undoubtedly represents fine value in students' scientific models. At a price of £12.50, it features 50 key functions including log and trig, mean and standard deviation, polar rectangular conversion and many more power keys.



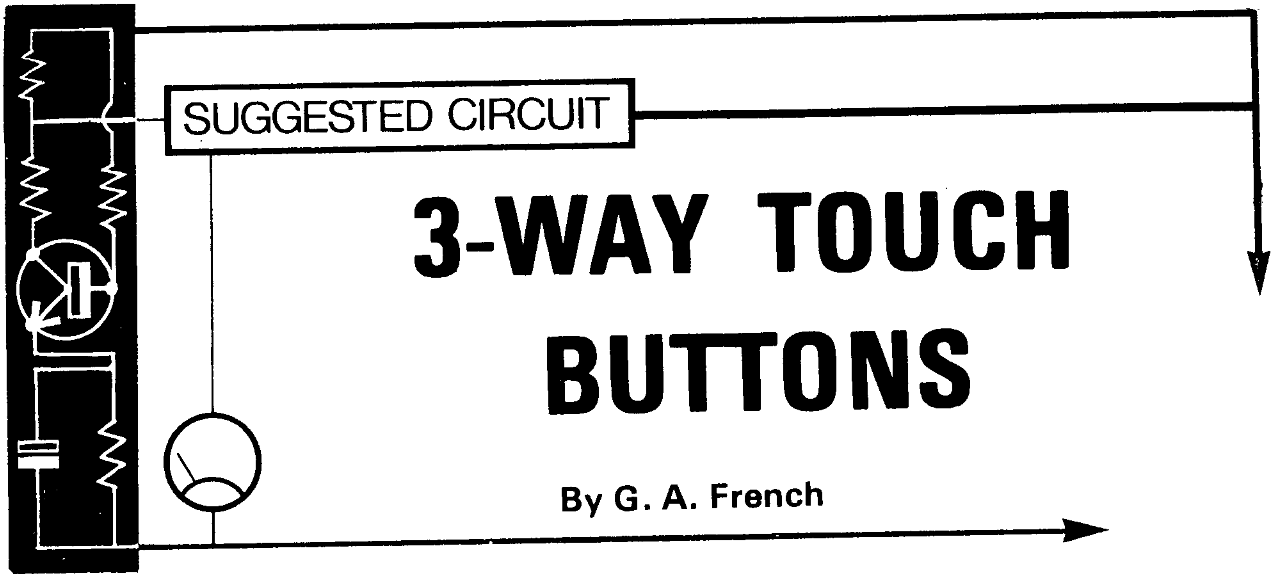
For a different view of the weather see page 684

PRINTED CIRCUIT BOARDS AVAILABLE

Messrs. Ramar Constructor Services of Masons Road, Stratford-on-Avon, Warwickshire CV37 9NF, inform us that they can provide printed circuit boards for the 'Duette' Stereo Amplifier described in our January issue and for the 2 Metre Converter described in our February issue.

The p.c.b.'s for the 'Duette' are priced at £2.45 the pair including VAT and postage. The boards being in fibreglass, roller tinned and fully drilled.

The p.c.b. for the 2 Metre Converter is produced as a double sided board, one side being plain for screening on fibreglass, roller tinned and drilled. The price is £2.38 including VAT and postage.



SUGGESTED CIRCUIT

3-WAY TOUCH BUTTONS

By G. A. French

The current availability of CMOS digital i.c.'s makes it possible to make up a number of simple logic circuits which would be relatively difficult to bring into practical operation with the earlier t.t.l. devices. Also, CMOS i.c.'s have the advantages of not requiring a regulated power supply, and of having symmetrical input and output switching from high to low voltages and vice versa, exceptionally low current consumption and virtually infinite gate input resistance. On the debit side is the fact that many CMOS gates have a low output current capability, with the result that external discrete transistors are required if a CMOS device is to control a load having a current requirement in excess of a few milliamps.

The circuit to be described in this month's 'Suggested Circuit' article highlights both these advantages and the disadvantage.

LATCHING CIRCUIT

Fig. 1 shows a theoretical latching circuit incorporating three 2-input NAND gates. As readers will be aware, the output of a 2-input NAND gate is high (positive) when either both its inputs or only one of its inputs is low (negative). The NAND gate output goes low only when both its inputs are high.

In the circuit the output of gate A connects to one input of gate B and to one input of gate C. Similarly, the output of gate B connects to one input of gate A and one input of gate C, whilst the output of gate C connects to one input of gate A and one input of gate B.

The circuit has three stable states: either the output of gate A is low and the outputs of the other two gates are high, or the output of gate B on its own is low, or the output of gate C on its own is low. The operation of the circuit can be readily visualised. If, for instance, the output of gate B is low, so also is one input of gate A and one input of gate C, causing the outputs of gate A and gate C to be high. These high outputs connect to the inputs of gate B, firmly latching its output in the low condition. Similar reasoning will show that gate A output may alternatively be latched in the low condition on its own, as may the output of gate C. Whatever gate output is low, the remaining two gate outputs are high reinforcing, as it were, the low output of the first gate.

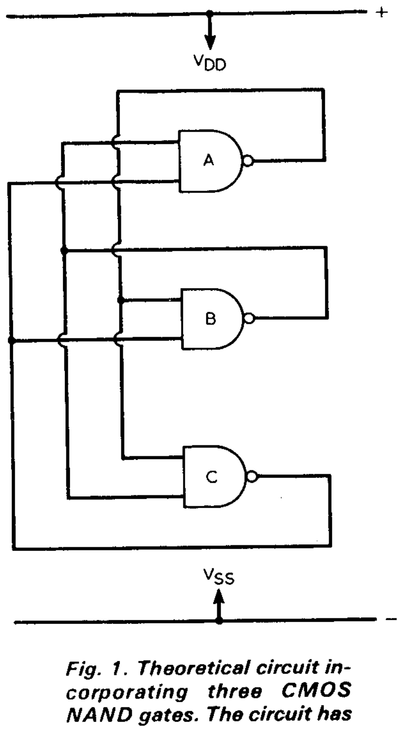


Fig. 1. Theoretical circuit incorporating three CMOS NAND gates. The circuit has three stable states

The circuit of Fig. 1 has little practical use because, once the supply has been switched on, we cannot change it from whichever of the three states it chooses to select. If we attempt to force any input low or high we will find that we are short-circuiting a gate output to an opposite polarity from that which it holds, with a consequent risk of damage to the gate and, certainly, the flow of excessive current.

The situation alters dramatically if we introduce three current limiting resistors in series with the outputs, as we do in Fig. 2. These resistors have values which limit the gate output current to a safely low value when it is desired to change the state of the circuit. Also included in the circuit is a flying lead from the negative VSS supply rail for the gates. Let us say that the output of gate C is low and that we want to alter the state of the circuit so that it is gate B output which is low. To do this we apply the flying lead to pont Y, thereby taking this circuit point low. Although the output of gate B is high, the current which flows from it is still at a safe level because of the series current limiting resistor. The negative connection to point Y causes one input of gate C to go low, whereupon its output goes high. The output of gate A, which is already high, remains unaltered. In consequence, both inputs of gate B go high and its output goes low. When the negative connection is taken from point X, gate B output is low and remains low, with the other two outputs high. Note that the output of gate B is not *forced* low by the negative connec-

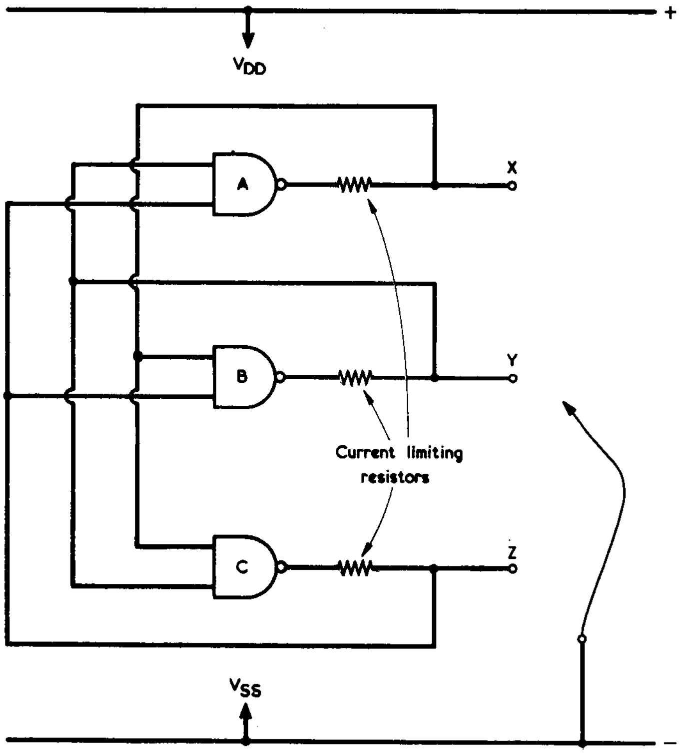


Fig. 2. Adding output current limiting resistors enables the circuit to be changed from one state to another

tion to point Y. The sequence of operations is that the negative connection causes both its inputs to be high by way of the other two gates, whereupon its output goes low following standard NAND gate principles. In practice, the negative connection to point Y may be of a momentary nature only. If we next want to make the low output that of gate A, we momentarily apply the negative connection to point X. Subsequently applying the negative connection to point Z will then make the output of gate C go low. Should we apply the negative connection to, say, point X when the output of gate A is already low nothing happens; both ends of the associated current limiting resistor are at the same potential and the circuit state is unaltered.

The circuit of Fig. 2 can be made to operate with t.t.l. gates but the choice of current limiting resistor value is rather critical if we are to ensure that gate output current ratings are not exceeded and that gate input current requirements are satisfied. Also, the presence of resistors between one gate output and the input of another gate means that the circuit is not operating to proper t.t.l. standards. None of these difficulties is present with CMOS gates. The fact that virtually

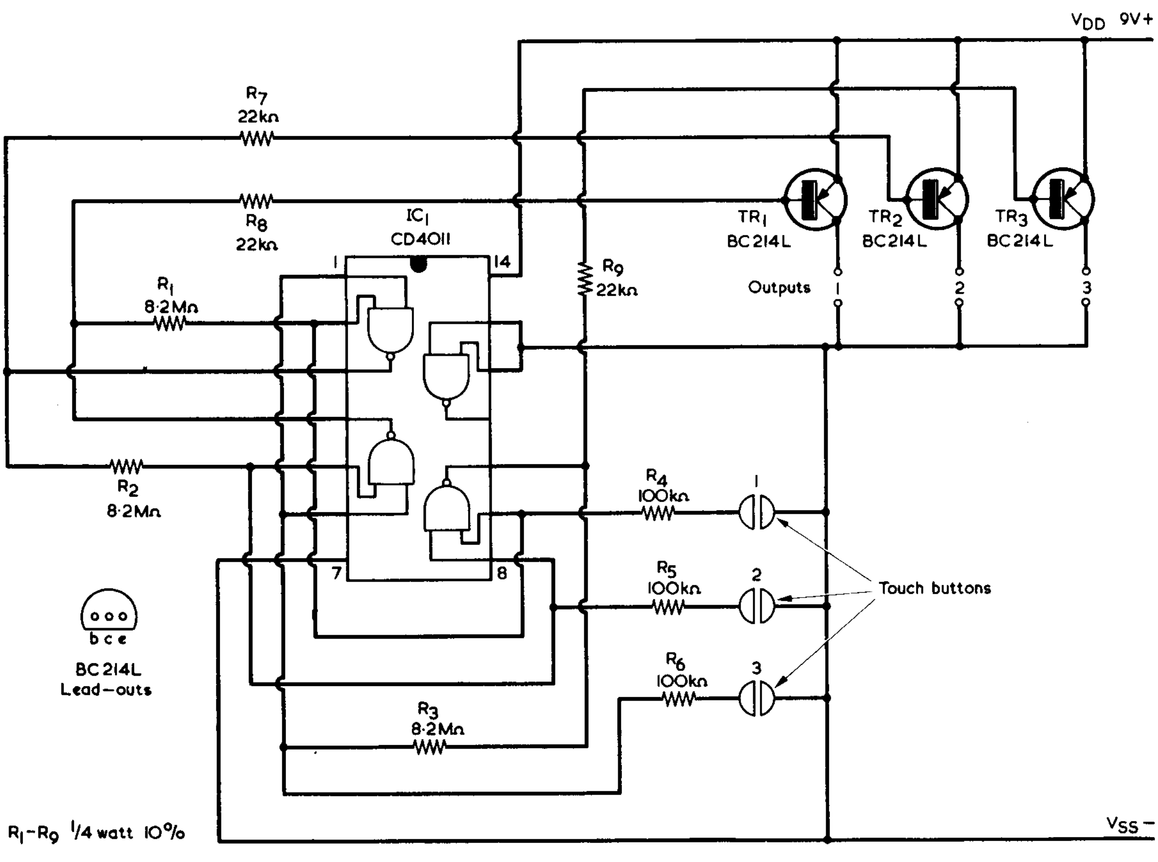


Fig. 3. A practical circuit in which three outputs can be provided by momentarily touching one of the three touch buttons

zero current flows into a CMOS gate input means that the resistors can have any value above that which limits gate output currents to a safe value.

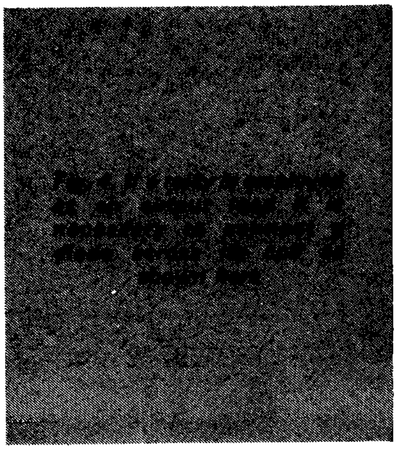
TOUCH BUTTON OPERATION

One obvious application for a 3-way CMOS latch is as a touch-button switch, in which one of three outputs can be selected by applying a finger to the appropriate touch button. A working 3-way touch button circuit is illustrated in Fig. 3, where it will be seen that the CMOS i.c. employed is a quad 2-input NAND gate type CD4011. Only three of the gates in the i.c. are used. The fourth has its inputs at pins 12 and 13 taken to the negative rail, and no connecton is made to its output at pin 11.

The three remaining gates are connected in the circuit of Fig. 2, the three current limiting resistors being R1, R2 and R3. If the circuit is traced through it will be seen that the output of each gate connects first to its current limiting resistor and then to one input of each of the other two gates.

In Fig. 2 the right-hand ends of the current limiting resistors were taken negative by means of a direct connection. In Fig. 3 the corresponding circuit points are taken negative by way of the touch buttons; bridging the two contacts of any touch button with a finger tip provides the negative coupling. Although the resistance across the touch button will be of a relatively high value it will still be much lower than the values of R1, R2 and R3, thereby taking the appropriate gate inputs sufficiently low to change the circuit state. R4, R5 and R6 are included in the touch button circuits to limit any input currents which may flow because of static voltages to a level which can be reliably handled by the protection diodes inside the i.c.

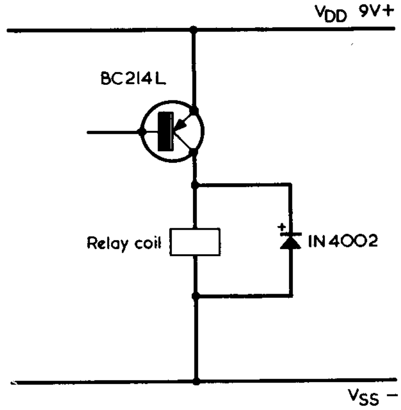
The gate outputs also connect, via R7, R8 and R9, to the bases of



the three p.n.p. transistors, TR1, TR2 and TR3. When any gate output goes low, the corresponding transistor passes collector current, and can supply output loads up to some 30mA or so.

When touch button 1 is touched, pins 9 and 2 of the i.c. are taken low. The output of the remaining gate, at pin 4, also goes low, causing TR1 to turn on. If touch button 2 is bridged, pins 8 and 5 go low, as also then does the remaining gate output at pin 3. TR2 is thereby made conductive and output 2 is turned on. Bridging touch button 3 takes the negative coupling to pins 1 and 6 of the i.c., with the result that pin 10 goes low and TR3 conducts.

It is a little difficult to devise a simple means of biasing the circuit such that a particular output is always the first one to be turned on when power is applied, which may be a desirable feature in some applications. In practice, however, it would seem that this facility is automatically provided by the nature of the circuit itself, since there must be a difference in the current gains of the three gates. With the prototype circuit it was found that the same output always came on first whenever the supply was applied. Such a performance cannot be guaranteed with all CD4011 i.c.'s, of course, and the



particular output which comes on first will vary between one i.c. and the next.

The outputs to be controlled depend upon the requirements of the constructor. If a relay is to be used in an output circuit, it will require the usual reverse connected diode across its coil, as is illustrated in Fig. 4.

The three touch buttons will need to be home constructed, each consisting of two small pieces of metal having a shiny surface which gives good contacts to the skin of the finger. The heads of two nickel-plated bolts of around 4BA or 2BA mounted close to each other on a piece of insulating material can provide a simple and easily made touch button. The touch buttons themselves should be spaced apart such that there is little risk of two buttons being inadvertently touched at the same time. This will not cause any damage to the i.c. but may prevent correct output selection. If the equipment in which the touch button circuit is employed has a chassis which is at earth potential, this may be made common with the touch button negative supply.

On no account must the circuit be so used with equipment having a live chassis connected to the mains supply, as occurs with many television receivers. ■

ULTRASOUND DISPLAY SYSTEM

By Michael Lorant

X-ray-like TV displays employ colour changes to indicate varying densities in human tissue.

John E. Jacobs, executive director of the Northwestern University Institute's Biomedical Engineering Centre in the United States has, with a team of graduate students, developed the first ultrasound imaging system capable of producing X-ray-like coloured images on a television screen of the inside of a human finger, muscle or any other living tissue.

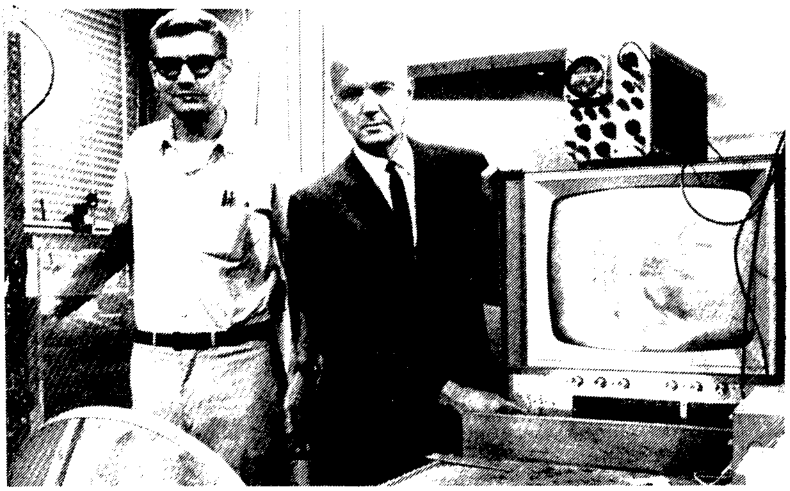
Clearly discernible blood vessels in the fingers of a hand appear as pulsating blue, green or orange lines. The array of colours shifts as the hand changes position in a tank of water containing the transducer device.

The colours do not represent real colours in the internal structure of the hand. Instead, they represent varying rates at which ultrasound waves pass through the hand when it is dipped in a tank of water in the path of the waves.

A normal unimpeded sound shows up on the TV screen as red. Sound waves arriving slightly later, and thereby at different phases, appear successively as purple, blue, green and orange. All hues recognisable by the human eye on a standard colour scale appear as the sound wave phase patterns alter.

Ultrasound wave interference patterns are set up by the varying arrival times of the waves on a two-inch round quartz plate operating at 3.58MHz. The plate is part of an imaging tube at one end of the tank which translates the ultrasound waves emanating from the other end into the different colours seen on the TV tube.

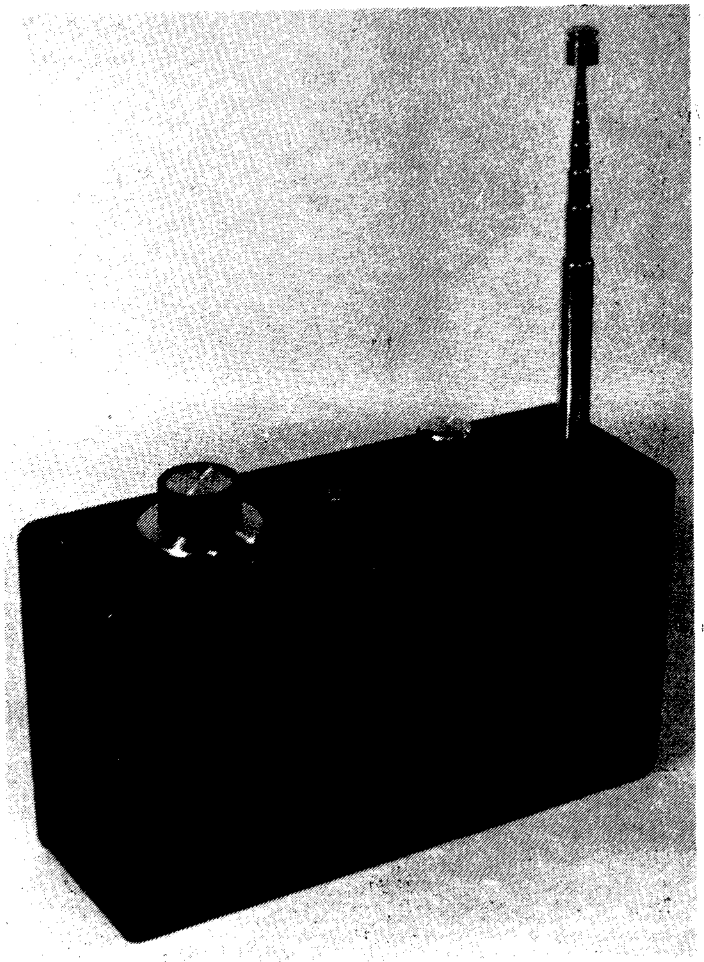
There are three important advantages of the system which will allow it to be used as a medical diagnostic tool. First, it can produce bright simultaneous images of pulsating blood vessels in muscle and other tissues not normally visible by conventional X-rays. Second, the colour television system is 20 to 40 times more sensitive to tissue changes than existing black-and-white displays of ultrasound images. Finally, by using scattering and reflecting techniques, similar to those employed in SONAR, the system could be used to diagnose diseased conditions in human tissue. ■



Working with the first ultrasound colour imaging system, John E. Jacobs, executive director of Northwestern University Technological Institute's Biomedical Engineering Centre, watches the image on the colour TV screen given by the hand of the graduate student on the left. The student's hand is immersed in a tank of water containing the 3.58MHz ultrasonic receiving transducer. (In the American N.T.S.C. colour TV system, 3.58MHz is the chrominance subcarrier frequency.)

SINGLE TUNED CIRCUIT F.M. RECEIVER

By P. R. Arthur



Local Station v.h.f. receiver using the synchronous detector principle.

Simple v.h.f. broadcast receivers can make an interesting alternative to the more usual a.m. receiver project. They provide good quality relatively interference-free reception of B.B.C. and commercial stations in areas of reasonably good signal strength. The main disadvantage of a simple v.h.f. set is that it is not really suitable for use in mediocre or poor reception areas. A simple v.h.f. detector can be very sensitive, but tuning and adjustment become excessively critical on very weak signals, and there is a marked loss of audio quality. The prototype is used approximately 25 miles away from the B.B.C. Wrotham transmitter, and excellent results are obtained.

The receiver uses four transistors including a Jugfet, and it provides an output which is suitable for high impedance headphones or a crystal earpiece. In fact it will even drive any reasonably sensitive pair of low or medium impedance headphones. The set has a telescopic aerial and is powered from an internal PP3 battery. It is thus completely self-contained.

This is not intended to be a miniature pocket type receiver, and the unit is built into a case which measures approximately 185 by 109 by 60mm. This, coupled with the use of varicap diode tuning, enables good freedom from hand capacitance effects to be obtained.

THE CIRCUIT

The circuit of the receiver appears in Fig. 1. It has four stages: a grounded gate input stage, a synchronous detector, a common emitter audio preamplifier and a common emitter output stage.

Whilst the grounded gate Jugfet in the TR1 position provides a small amount of gain, its primary function is to isolate the aerial from the detector, TR2. Such isolation is necessary because the detector is oscillating in use, with the result that the receiver could otherwise radiate a signal which would interfere with other sets. R1 is the source bias resistor for TR1 and no input tuned circuit is employed as the aerial couples directly to the source. L1 is a low value r.f. choke which forms the drain load for TR1, and the output from this stage is coupled to the detector via C1.

TR2 is the synchronous detector and appears in a grounded base Colpitts circuit which is adjusted, by means of VR2, to the point where it is just gently oscillating. In this state the oscillator will tend to lock onto any similar or very close frequency, which in this case is an f.m. transmission.

As the input signal deviates around its central frequency the oscillator follows it, resulting in fluctuations in the amplitude of the oscillations and, in turn, the current consumption of the oscillator circuit. The oscillator current flows through R4, the

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)

- R1 1kΩ
- R2 1kΩ
- R3 120kΩ
- R4 2.2kΩ
- R5 18kΩ
- R6 10kΩ
- R7 220Ω
- R8 1.2MΩ
- R9 4.7kΩ
- R10 220Ω
- R11 2.7kΩ
- R12 560kΩ
- R13 56Ω
- R14 1kΩ
- VR1 10kΩ linear, with insulated spindle (see text)
- VR2 5kΩ log, with switch S1

Capacitors

- C1 1.8pF ceramic or silvered mica
- C2 220μF electrolytic, 10V. Wkg.
- C3 220μF electrolytic, 10V. Wkg.
- C4 0.01μF disc ceramic
- C5 4.7pF ceramic
- C6 0.001μF disc ceramic
- C7 0.47μF electrolytic, 10V. Wkg. (see text)
- C8 100μF electrolytic, 10V. Wkg.
- C9 0.01μF disc ceramic
- C10 0.1μF type C280 (Mullard)
- C11 0.015μF type C280 (Mullard)
- C12 100μF electrolytic, 10V. Wkg.
- C13 100μF electrolytic, 10V. Wkg.
- TC1 25pF trimmer, type C801 (Jackson)

Semiconductors

- TR1 BF244B
- TR2 BF194
- TR3 BC109
- TR4 BC109
- D1 BZY88C7V5
- D2 BA102

Switch

- S1 s.p.s.t., part of VR2

Socket

- SK1 3.5mm. jack socket

Miscellaneous

- Plastic case, 185 by 109 by 60mm. (see text)
- 9 volt battery type PP3 (Ever Ready)
- Battery connector
- Telescopic aerial (see text)
- Veroboard, 0.1in. matrix
- 18 s.w.g. aluminium sheet
- 2 control knobs
- Enamelled wire, resistor, for L1, L2 (see text)
- Grommet, nuts bolts etc.

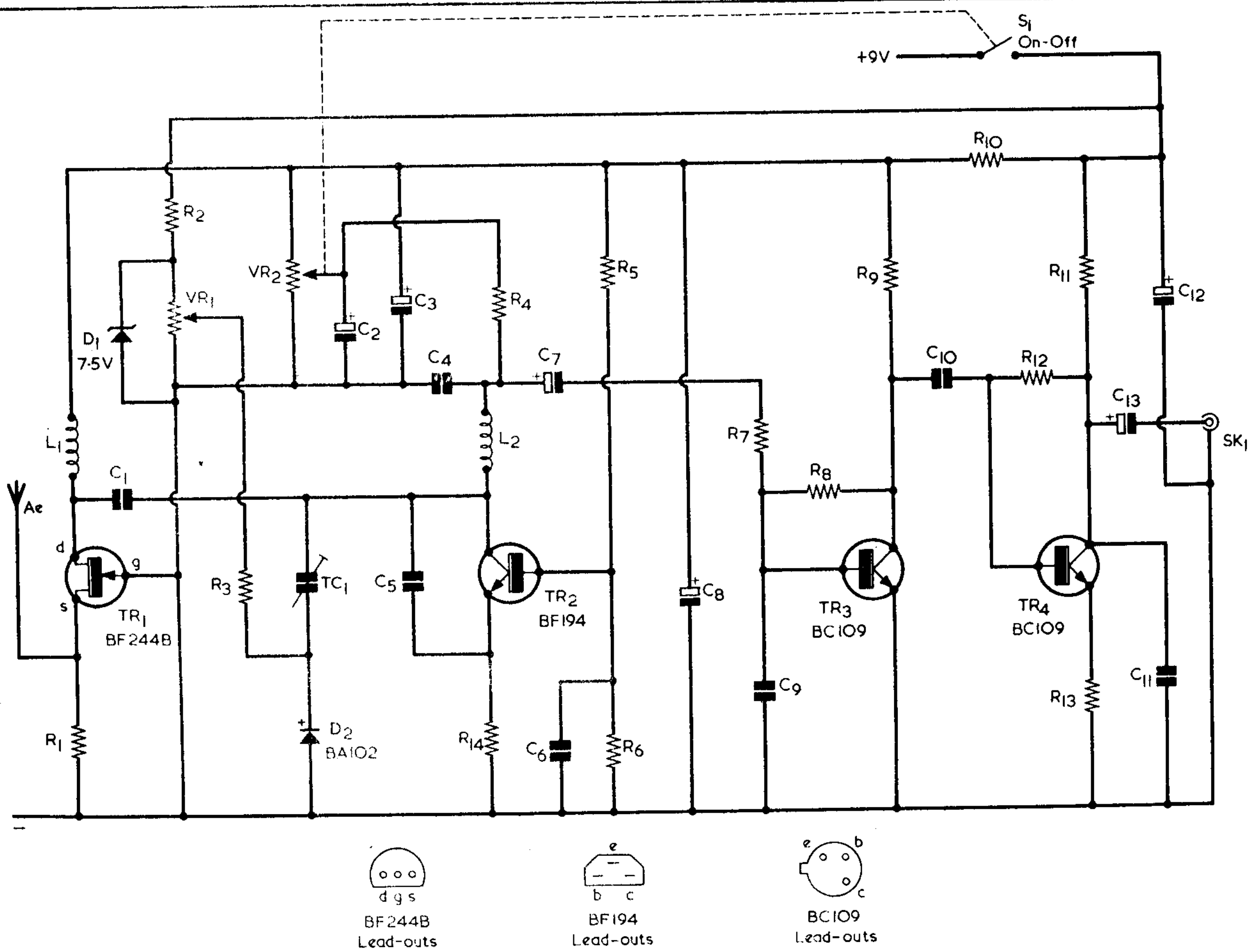


Fig. 1. The circuit of the single tuned circuit f.m. receiver. Tuning is carried out by VR1 and varicap diode D2

voltage across which varies in sympathy with the oscillator current, and these voltage changes then constitute the audio output of the detector. Capacitor C4 provides r.f. filtering and decoupling.

The detector is tuned over the f.m. band by varicap diode D2 which, in company with the series trimmer TC1 and L2, completes the oscillator tuned circuit. R2 and D1 form a zener shunt regulator circuit which provides a stabilized voltage for the tuning potentiometer, VR1. The voltage tapped off by VR1 slider is applied to D2 through R3, and the circuit can be set up for a tuning range of about 88 to 100MHz.

C7 couples the audio output from the detector to the base of TR3. R7 and C9 provide additional r.f. filtering, and this is necessary since both audio stages have responses which extend into the v.h.f. spectrum. Instability could easily result if a significant amount of oscillator signal were to be allowed to enter the audio stages. The filter components also provide the necessary de-emphasis to the audio signal. This de-emphasis is merely a small amount of treble attentuation which compensates for the treble boost (pre-emphasis) applied to the audio signal at the transmitter. The purpose of the pre-emphasis is to provide an improved signal-to-noise ratio.

Both the audio stages are conventional high gain common emitter circuits. R13, the emitter resistor for TR4, is unbypassed and provides a measure of negative feedback in the output stage. This reduces what is otherwise a marginally excessive gain, and also slightly improves the audio quality.

Supply decoupling in the various sections of the circuit is provided by C2, C3, C8, R10 and C12. S1 is the on-off switch and is ganged with VR2. The current consumption of the receiver is approximately 6mA only, whereupon the PP3 battery has a reasonably long life.

COMPONENTS

The telescopic aerial employed with the receiver has a closed length of 176mm. and an extended length of 1.1 metres, and is hinged for operation at different angles. This is available from Maplin Electronic Supplies. It has a bracket on the lowest section which is not required here; this bracket can be removed by drilling out the two rivets which secure it to the aerial. Other telescopic aerials of about the same length with the hinged facility and a 4BA tapped hole in the centre of the base should also be suitable.

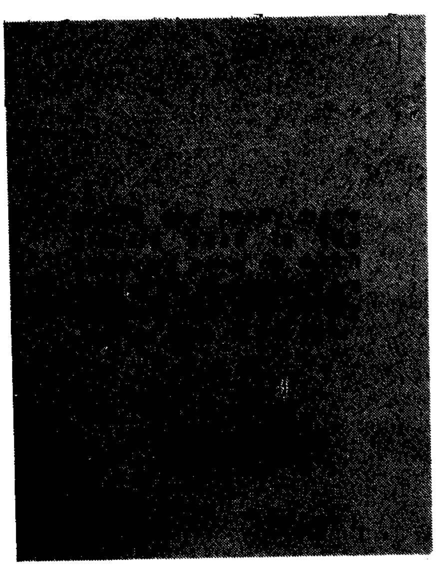
C7 is specified as 0.47µF electrolytic 10V. Wkg., but in practice it will be found very difficult to obtain an electrolytic capacitor of this value at such a low working voltage. It will be quite in order to use a capacitor having a much higher working voltage, even as high as 100 volts. The BF244B specified for TR1 is available from several suppliers, including Electrovalue. The 185 by 109 by 60mm. plastic case in which the receiver is assembled is retailed by Messrs. Brian J. Reed. Finally, the C801 trimmer capacitor specified for TC1 can be obtained from Home Radio.

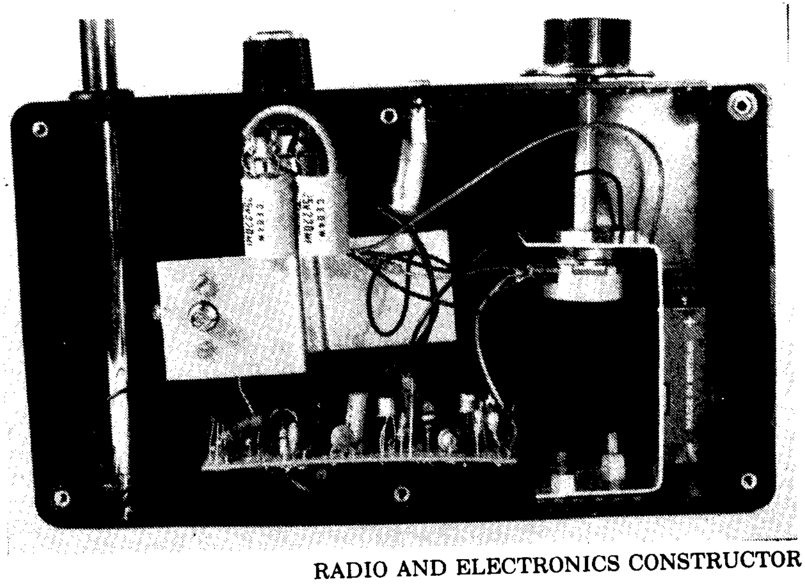
COMPONENT PANEL

Most of the components are assembled on a 0.1in. pitch Veroboard having 32 holes by 14 strips. Veroboard is not often used in r.f. and v.h.f. constructional projects as the capacitance between strips can cause problems. This was not found to be the case here, and an early prototype was successfully built on a T-Dec! Details of the panel are shown in Fig. 2, which also illustrates the other wiring.

Both L1 and L2 are home-constructed components. L1 consists of about 40 turns of 0.18mm. diameter (or 36 s.w.g.) enamelled copper wire scramble-wound on an ordinary 270k ● ¼ watt 10% resistor. The resistor has a body diameter of around 0.1in. The ends of the winding, after scraping and tinning, are soldered to the resistor leadout wires close to the resistor body, so that the winding cannot spring apart. The lead-out wires of the resistor then act as the lead-out wires of the choke. The value of the resistor is not important, provided that it is 100kΩ or more, since it is merely being used as a former.

L2 is a tuned winding and has to be wound with reasonable precision. It employs 0.9mm (or 20 s.w.g.) enamelled copper wire and is self-supporting. It has exactly 4 turns and is wound on a temporary ¼in. diameter coil former. The coil ends are bent down and pass through holes in the Veroboard which are 0.3in. apart. The turns are





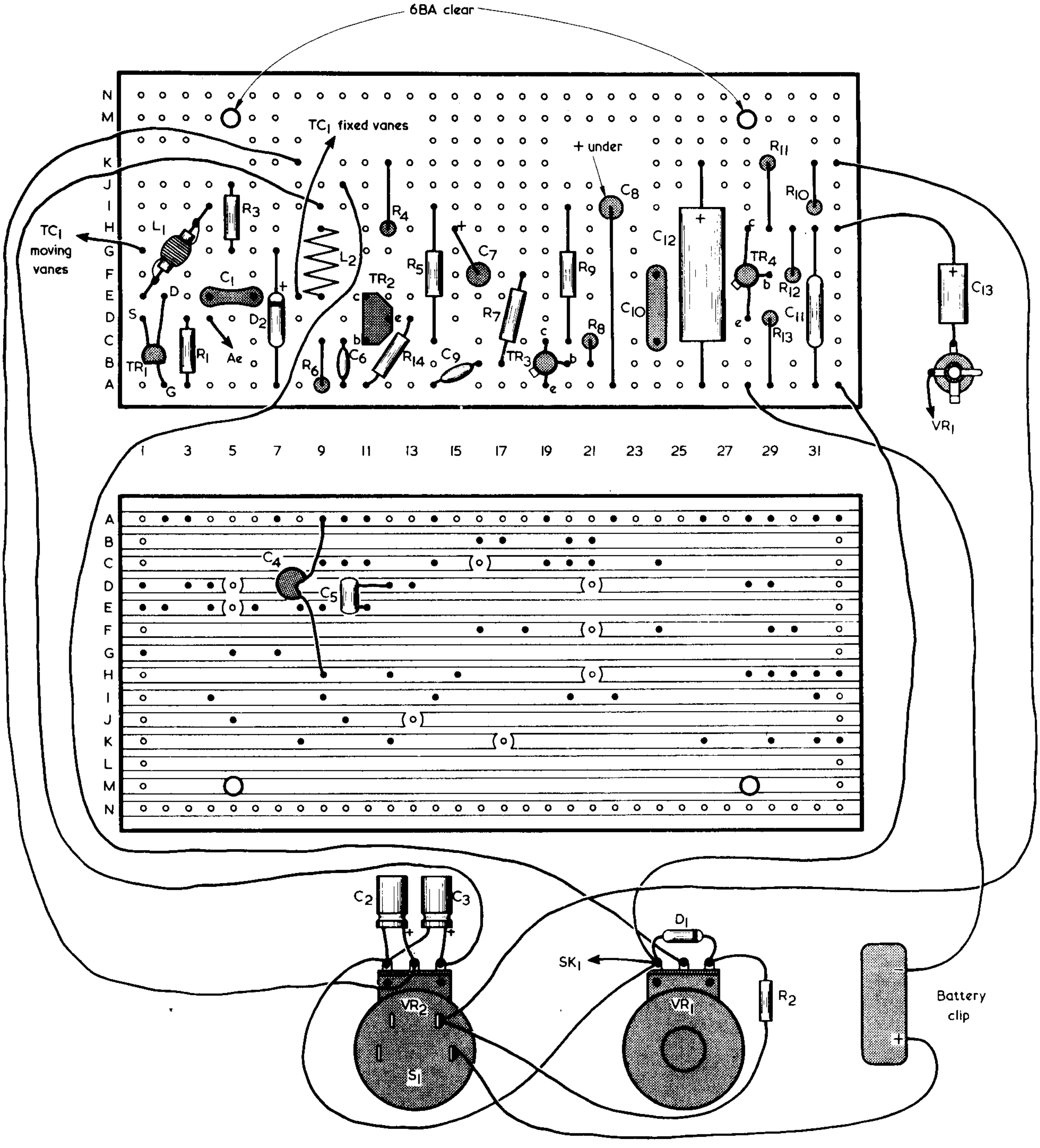


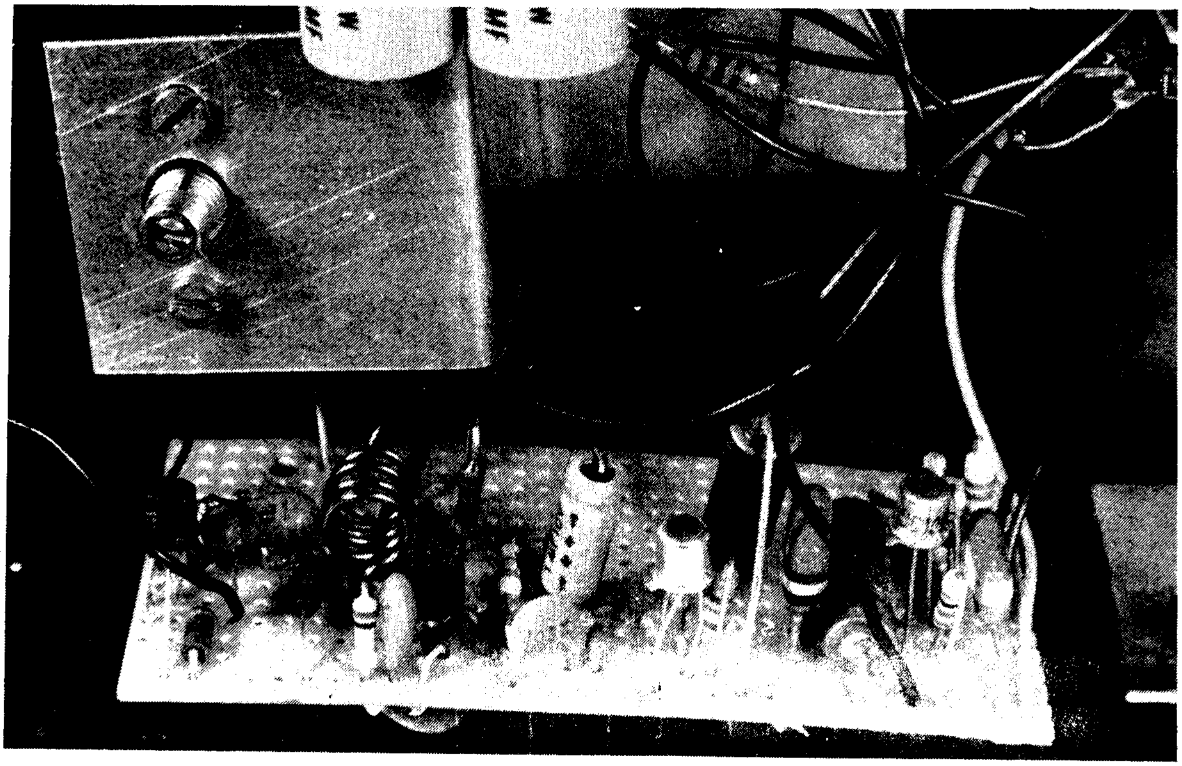
Fig. 2. The wiring of the receiver. Nearly all the parts are assembled on the Veroboard panel

spaced out over this length. The coil ends are scraped clean of enamel and tinned before being soldered to the appropriate strips of the Veroboard.

The Veroboard panel is initially cut to size by means of a small hacksaw and the two mounting holes are next drilled 6BA clear. The 8 breaks in the copper strips are then made, after which the board components are mounted and soldered in position. Note that C4 and C5 are mounted on the copper side of the panel. Their lead-out wires should be kept as short as possible. Those of C4 are covered with sleeving to prevent short-circuits to the copper strips over which they pass. In fact, the lead-out wires of all components in the r.f. circuitry should be no longer than is reasonably necessary.

CASE LAYOUT

The photographs help to show the general layout inside the case, and it is strongly recommended that this is not radically altered in any way. In this application the lid of the case becomes the rear panel, with the controls, output socket and aerial appearing at the upper face. VR1 can be mounted



Detail illustrating the Veroboard assembly more closely. The board was not bolted to the case when this shot was taken

direct to this upper face, but greater freedom from hand capacitance effects will be given if it is a type having a long plastic spindle and if its body is positioned lower down, fitted to a metal bracket. This bracket is made up, as shown in Fig. 3 (a), from 18 s.w.g. aluminium sheet and it is bolted to the base of the case by two countersunk 4BA bolts with nuts. It should be positioned, as shown in the photograph of the interior, such that there is just room for the PP3 battery between its upright section and the adjacent corner pillar of the case. It will be necessary to alter the length of the upright section of the bracket if the spindle length of the potentiometer differs from that of the component used by the author, and this point should be checked before making up the bracket.

The mounting bracket for TC1 is also made from 18 s.w.g. aluminium sheet, and this is shown in Fig. 3 (b). The trimmer is secured to it by two short 6BA bolts and care should be taken to ensure that the adjusting spindle and bush do not touch the inside edge of the central hole. The capacitor is mounted with its moving vane tag pointing away from the bend in the bracket. The bracket is glued to the inside surface of the front panel with a good quality adhesive such as an epoxy type. Those who prefer to do so may alternatively drill two holes in the panel and the bracket to take countersunk 4BA bolts with nuts, but this will mean [illegible] heads will be visible from the front of the set.

The aerial is bolted, in the position shown in the photographs, to the bottom of the case by means of a 4BA countersunk screw. A solder tag is fitted over this screw between the bottom of the aerial and the case, and connection to the aerial is made via this tag. The aerial passes through a suitable hole in the top of the case, and a grommet can be fitted here to produce a neat finish.

The component panel is secured to the bottom of the case by means of two 1in. long countersunk 6BA screws. Spacing washers, or spacing nuts suitably positioned, are employed to ensure that the copper side is clear of the centre bottom mounting pillar. The board is oriented such that the holes in row No. 1 of Fig. 2 are nearer the aerial. It is not finally mounted until all connections from it have been made to the other components. As can be seen from Fig. 2, C2 and C3 are mounted on the tags of VR2, D1 and R2 on the tags of VR1 and C13 on one of the tags of SK1.

As already mentioned, the battery fits between the bracket for VR1 and the adjacent side mounting pillar of the case. A piece of foam rubber or plastic will hold it in position when the rear of the case is screwed on.

ADJUSTMENTS

Initially, TC1 should be adjusted for almost maximum capacitance (i.e. its vanes should be nearly fully enmeshed). With an earphone or headphones plugged into SK1, the set can then be turned on and VR2 advanced. It will probably not [illegible] station by means of VR1 until VR2 is well advanced. If VR2 is advanced too far it will not be possible to produce a proper audio output from the set as the oscillating detector will not lock on to the carrier of the received signal, and all that will be heard is the beat note produced by the carrier of the transmission heterodyning with

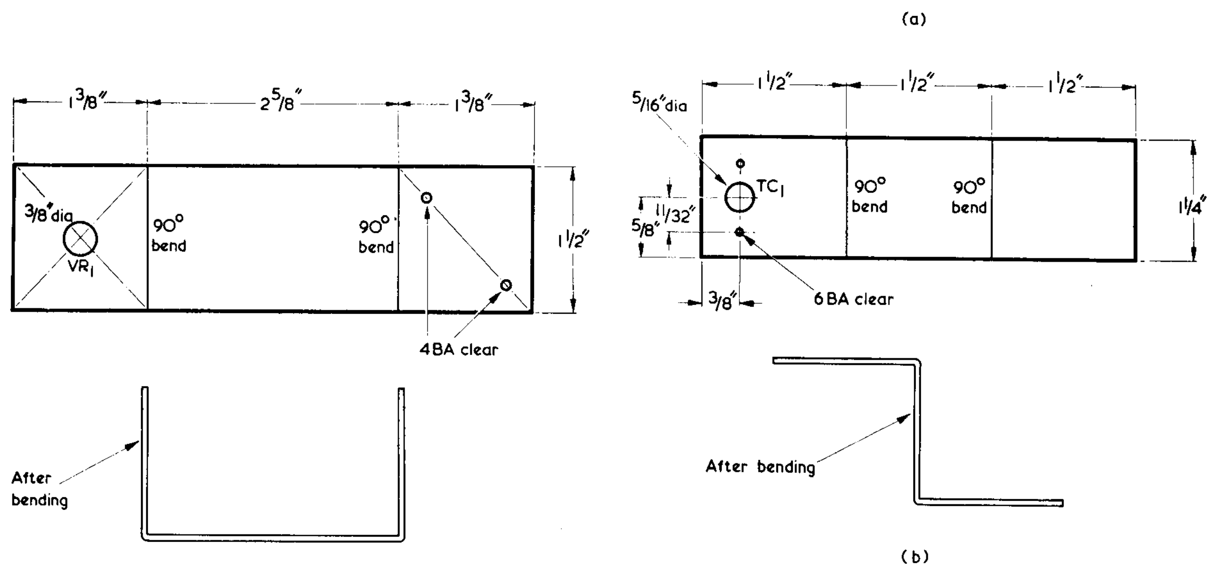
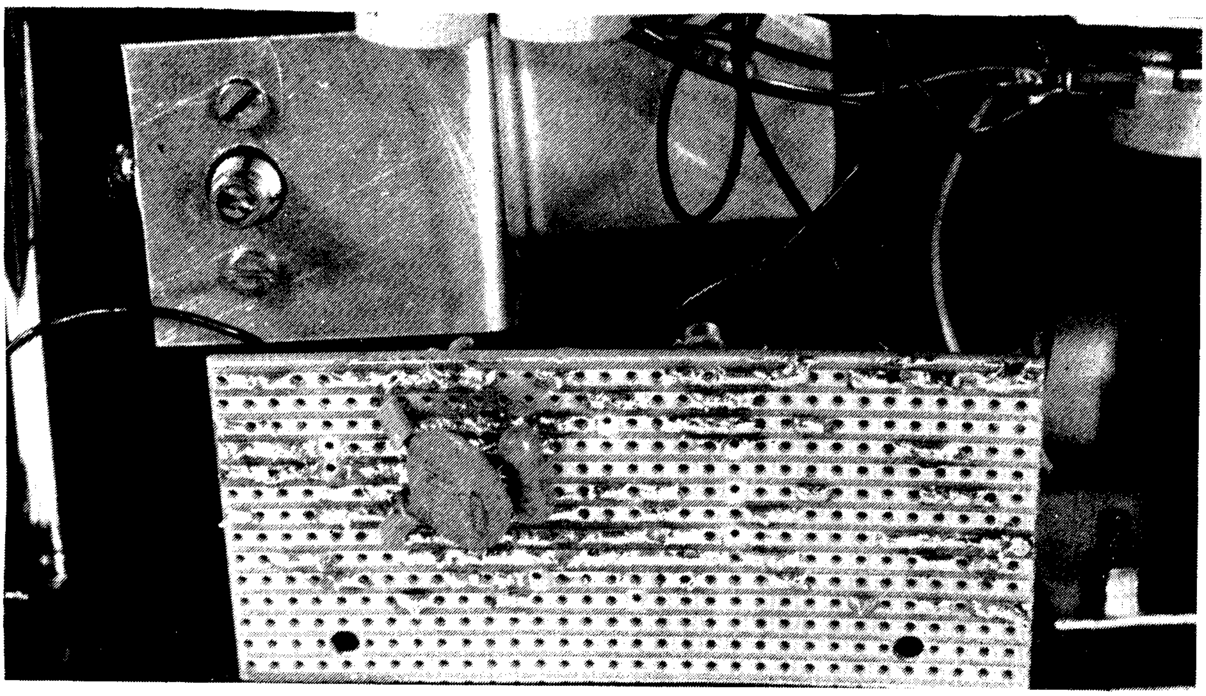
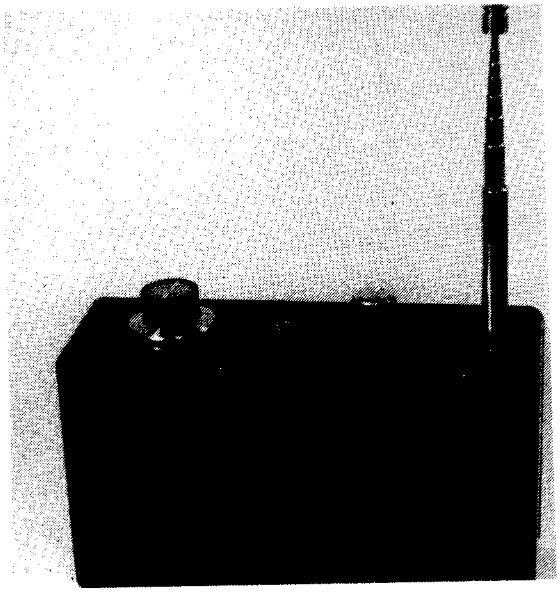


Fig. 3. (a) The mounting bracket for VR1. If this component has a non-standard spindle length, bracket dimensions may need to be modified as described in the text
) The mounting bracket for VC1



Two of the r.f. bypass capacitors are soldered into circuit on the copper side of the board



Another view of the receiver. The telescopic aerial is slightly more than one metre in length when it is fully extended

the oscillating detector. VR2 should then be turned back almost as far as is possible without oscillation ceasing. It is obvious when oscillation has been lost as no signals, other than background noise, are produced. If VR2 is adjusted too close to the point where oscillation ceases the audio output level will be rather low and output quality will be a little poor. Careful adjustment of VR2 is needed for optimum results.

Virtually all f.m. broadcast transmitters use horizontal polarization, and so the telescopic aerial should be slanted at 45 degrees rather than left in a vertical position. It should be rotated to the position which gives the strongest signal, bearing in mind that the seting of VR2 becomes less critical as signal strength increases. A strong signal also gives broader and easier tuning.

Tuning range at the low frequency end of the band is controlled by TC1. Adjusting TC1 for increased capacitance extends the range in the low frequency direction. If the range does not extend low enough with TC1 at maximum capacitance, coil L2 can be compressed slightly to increase its inductance.

Conversely, when there is insufficient coverage in the high frequency direction, L2 can be stretched out slightly in order to reduce its inductance. In this situation, do not adjust TC1 for decreased capacitance, as this would reduce the overall tuning range.

When one considers the simplicity of the circuit, the audio quality output of the prototype is very good if used with low impedance 16 Ω headphones or high impedance 4,000 Ω headphones. Although still acceptable, results are not as good with a crystal earpiece. This gives a noticeably reduced bass and lower middle frequency response which, subjectively, results in a lower signal-to-noise ratio. ■

DECIMAL R AND C VALUES

By R. D. Smith

Combining two E12 resistors or capacitors to obtain "round number" decimal values.

We occasionally require resistance and capacitance values which are in the decimal series of 10, 20, 30, 40, 50, 60, 70, 80 and 90, and it can be a little frustrating when we find that the only components we have on hand or can purchase have values in the "preferred" E12 series. This, you will recall, runs in the following manner: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82. There is no provision for the decimal values of 20 to 90.

If, however, we are prepared to use two E12 resistors in parallel or two E12 capacitors in series we can readily make up combinations which calculate precisely at a decimal value, or which calculate at the decimal value with an error of 0.5% or less.

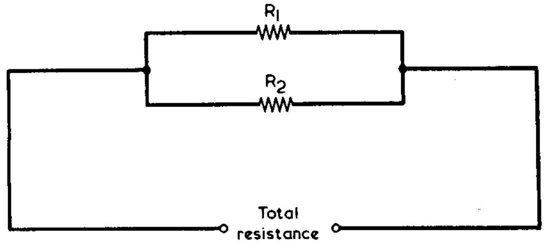
PARALLEL-R SERIES-C

The total value of two resistors in parallel, as in Fig. 1, is

$$\frac{R1 \times R2}{R1 + R2}$$

where R1 and R2 are the values of the individual resistors.

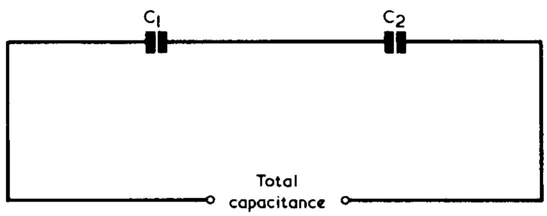
Fig. 1. Two resistors connected in parallel



Similarly, the total value of two capacitors in series is

$$\frac{C1 \times C2}{C1 + C2}$$ where C1 and C2 are the individual capacitor values. The capacitors are shown in Fig. 2.

Fig. 2. A series combination of two capacitors



TABLE

Parallel-R or Series-C	Total Value
22 and 220	20
33 and 330	30
47 and 270	40
100 and 100	50
100 and 150	60
82 and 470	70
100 and 390	80
180 and 180	90

The Table shows how two E12 values of parallel resistance or series capacitance can be combined to give total values in the decimal series. Two of the entries are glaringly obvious; 100 and 100 must give 50, and 180 and 180 must give 90. Not quite so obvious, at first sight perhaps, is that 100 and 150 give exactly 60.

It is a minor matter of mathematical moment that 22 and 220 give precisely 20, and that 33 and 330 give precisely 30. The remaining values are not quite so exact. 47 and 270 give 40.0 to three significant figures, the calculated value working out at 40.03. 82 and 470 work out to 69.8 instead of 70 precisely; the error is 2 out of 700 or two-sevenths of 1%. 100 and 390 are the worst, these calculating out to 79.6. Compared with 80, this represents an error of 4 out of 800 or one-half of 1%. In practice, not too much to worry about.

Lets try out the Table with a few examples. If we want a 4.0kΩ resistance we may use a 4.7kΩ resistor in parallel with a 27kΩ resistor. If we want a 30pF capacitance we can connect in series a 33pF capacitor and a 330pF capacitor. Another example: an 800Ω resistance is conveniently given by the parallel combination of a 1kΩ resistor and a 3.9kΩ resistor.

You may find it convenient to cut out or copy out the Table and put it up on the wall of your workroom. It could save you quite a little head-scratching in the future, particularly with the more awkward combined decimal values of 20, 30, 40, 70 and 80. ■

RECENT PUBLICATIONS

OP-AMPS — THEIR PRINCIPLES AND APPLICATIONS. By J. Brian Dance. 96 pages, 215 x 135mm. ($8\frac{1}{2}$ x $4\frac{1}{4}$in.) Published by Newnes Technical Books. Price £2.25.

In terms of time, it is not so long ago when one of the first integrated circuit operational amplifiers, the 702, was introduced to the electronic scene. This was in 1965, and the 702 was soon followed, in 1965/66, by the immensely successful 709. But 13 years is a very extended period so far as the exuberant field of integrated circuit development is concerned, and the present-day user of i.c. operational amplifiers can choose from a wide range of monolithic devices, each having its own individual characteristics.

Mr. Dance's book deals with current op-amps in an uncomplicated and very informative style. The approach is non-mathematical, and there are numerous circuits complete with component values.

The first part of the book covers operational amplifier basics in terms of the 741, which is inexpensive, is easy to experiment with and readily demonstrates operational amplifier principles. Other integrated circuit op-amps are then dealt with, as also is frequency compensation. The book then turns to devices with f.e.t. inputs, audio power circuits and low noise audio pre-amplifiers. These are followed by a glossary and a good index.

The book will be of excellent value to anyone who is commencing work with operational amplifiers, and will appeal in particular to the non-academic technician and the home constructor.

HIGH PERFORMANCE LOUDSPEAKERS. By Martin Colloms. 246 pages, 215 x 135mm. ($8\frac{1}{2}$ x $5\frac{1}{4}$in.) Published by Pentech Press Limited. Price £8.95.

The development of high fidelity loudspeakers has resulted in considerable improvements in performance over the last decade, and this book deals with these as well as with virtually all other aspects of modern high quality loudspeakers and their enclosures. It hardly needs to be stated that in the high fidelity chain of reproduction the loudspeaker is the component which is most dependent on subjective evaluation, although it is possible nowadays for much of a loudspeaker's functioning to be judged by objective analysis and measurement.

After a general review, the book deals with theoretical aspects of diaphragm radiators, practical diaphragms, acoustic loading, low frequency system analysis, moving-coil direct drive radiators, crossover systems, enclosures and the assessment of loudspeaker performance. Each chapter is followed by an extensive listing of references, and the book takes in work originating in the U.S.A., Japan and Australia as well as in the U.K.

The book will appeal to a wide range of readers, from do-it-yourself enthusiasts to students of electronics, and is written at a depth which will make it of value to professional loudspeaker designers, studio engineers and technical writers on hi-fi subjects. There is a minimum of mathematics, and the work clearly reflects the author's personal involvement in practical loudspeaker design and manufacture.

MODEL RADIO CONTROL, Third Edition. By Paul Newell, B.Sc. 136 pages, 210 x 140mm. ($8\frac{1}{4}$ x $5\frac{1}{2}$in.) Published by Radio Control Publishing Co. Ltd. Price £2.95.

Radio control of models, including in particular model aircraft, has itsown special fascination. The present book has become a standard reference in the U.K. and appears, enlarged and revised, in its new third edition. The book is available from model shops or may be obtained direct from ***Radio Modeller*** magazine, High Street, Sunningdale, Berks, SL5 0NF.

The book starts with a brief historical section then proceeds to its main theme, proportional control systems. These are considered in great detail, and included are chapters on digital transmitters, digital receivers, digital decoders and digital servo amplifiers. The text is accompanied by clear diagrams, and there is also a wealth of photographs of models and equipment. Further to be found are circuits and printed board layouts for an advanced i.c. digital system.

This is definitely a book for the radio control buff.

CMOS DIGITA FREQUENCY M

Part 1 (2 parts) By R. A. Penf

Range: 10Hz to 42MHz

For the ultimate in accuracy and convenience in use, a digital frequency meter easily betters the alternative methods of frequency measurement. The unit which is described here is capable of measurements from low audio frequencies up to a typical maximum of about 50MHz (42MHz minimum) with a minimum resolution of 10Hz. The accuracy of the unit is largely dependent upon the adjustment of the clock oscillator, and should be within 0.1%. The unit is quite sensitive and at middle frequencies requires an input level of only about 20mV r.m.s. However, the sensitivity does fall away somewhat towards the upper and lower limits of the operating range.

Digital frequency meters tend to be rather complicated instruments, and although this particular unit has been designed to be as simple as possible without sacrificing accuracy or sensitivity, it is still quite an involved project which is only suitable for the more experienced constructor. The circuitry is largely based on eleven CMOS i.c.'s, but three other i.c.'s and ten transistors are also employed in the unit. An r.f. signal generator is required for checking and adjusting the meter after it has been completed.

BASIC PRINCIPLE

The manner in which a digital frequency meter operates is very simple. In fact, in this respect it is probably the most simple form of frequency meter. The block diagram of Fig. 1 shows the basic arrangement.

The input frequency is displayed on an electronic counter which shows the answer in ordinary denary form. There are several types of digital display which can be used in this application, and the type actually used here are seven-segment l.e.d. displays. The functioning of these displays has been described a number of times in previous issues of this journal and so need not be considered further here. In the present unit a four digit display is employed.

An electronic switch operating as an enabling gate appears at the input of the counter, and this only allows the input signal to pass the counter when a suitable pulse is applied to a second input of the gate. A precision pulse generator feeds this second input, and it is the length of the pulse that this generates which determines the range of measurement provided by the unit. If, for example, the length of the pulse is 1 second then a four digit counter will operate as a 0 to 9.999kHz frequency meter. A little consideration will show that this is the case. If the input signal were 1kHz then 1,000 input signal pulses would be fed to the counter during the 1 second period. The counter will then display 1,000Hz or 1.000kHz according to the position of its decimal point. It follows that the maximum frequency which can be measured is 9.999kHz, as any frequency higher than this will cause the counter to overflow.

Higher ranges can be provided by using shorter gate enable pulses. A gate time of 100 milliseconds, or 0.1 second, would increase the range to a max-

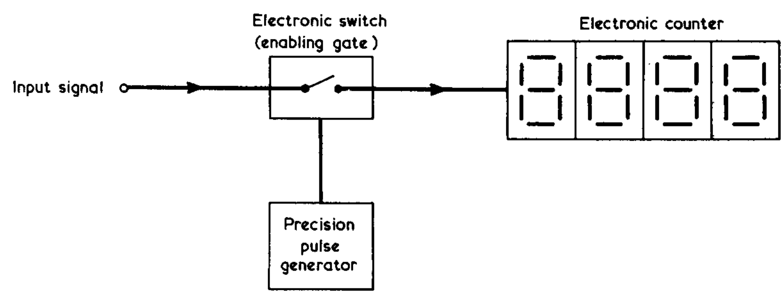


Fig. 1. The basic form of a digital frequency meter. The enabling gate is held closed for a pre-determined period and the counter then displays the number of input signal cycles which have passed through

AL
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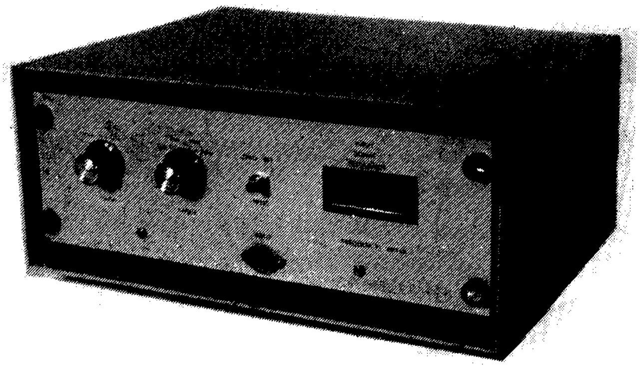


Crystal controlled gating pulse
Printed circuit modular construction

imum of 99.99kHz as there would be only one-tenth of the previous time for the maximum count to be reached, and therefore ten times the input frequency would be needed to achieve this. Shortening the gate time to 10 milliseconds would produce a range of up to 999.9kHz, further shortening it to 1 millisecond would increase the range to 9.999MHz, and so on.

In the present unit the frequency ranges have maximum figures of 99.99kHz, 999.9kHz, 9.999MHz and 99.99MHz. As was mentioned earlier this last range is operable in practice up to a typical figure of 50MHz.

ACTUAL ARRANGEMENT

A practical digital frequency meter tends to be very much more complicated than the diagram of Fig. 1 would suggest. This will become immediately apparent with reference to the block diagram of the unit which is shown in Fig. 2.

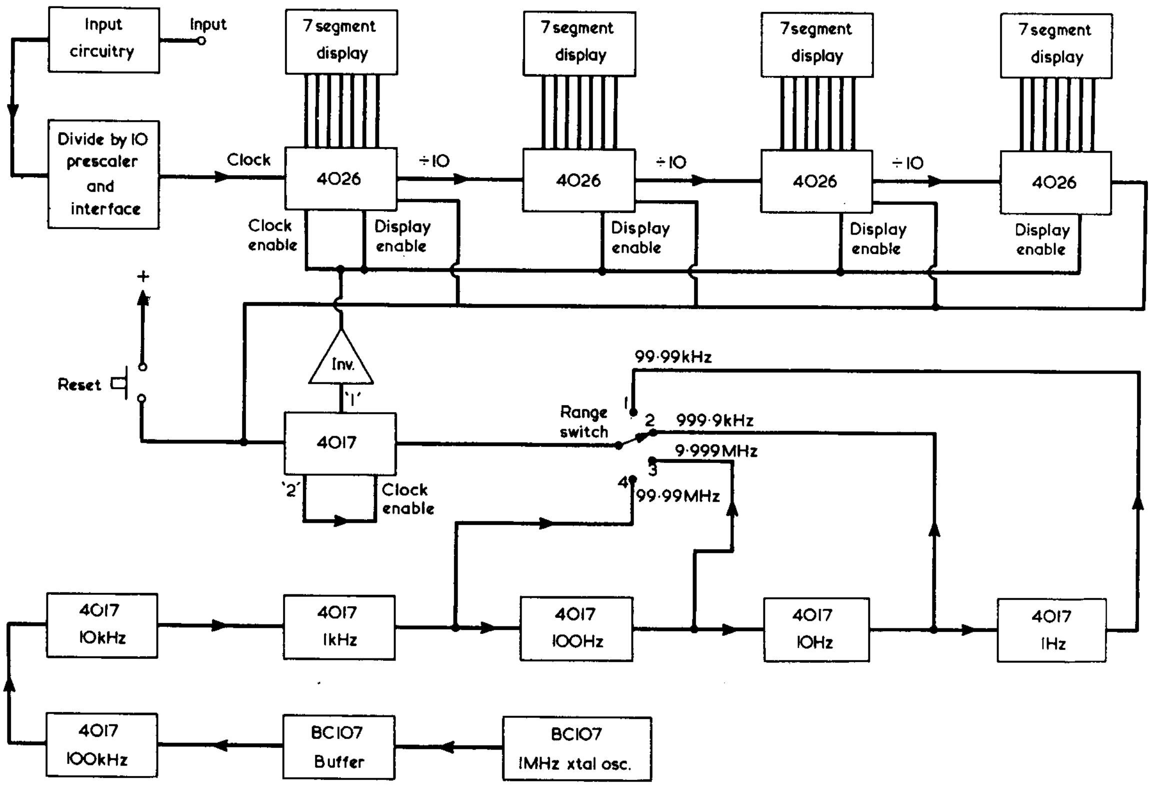
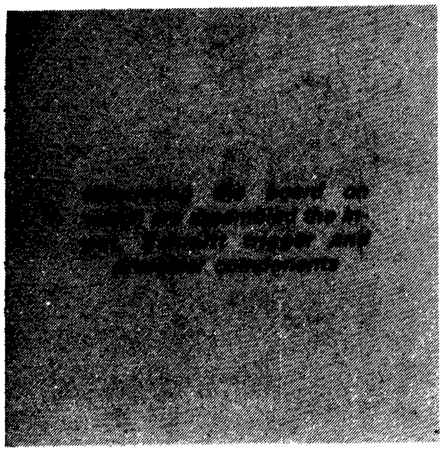
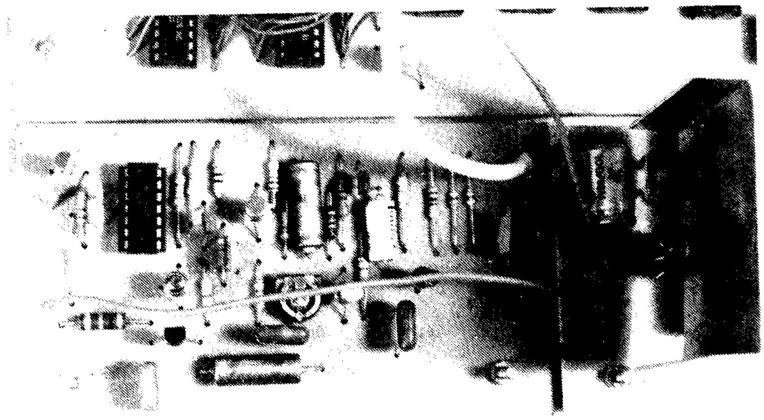


Fig. 2. In practice the frequency meter is more complicated than is evident from Fig. 1. However, the use of integrated circuits simplifies construction to a considerable extent





4017. It is only necessary to connect the inverted control pulse to the clock enable input of the first counter since, if the input signal is blocked at the first counter it obviously cannot reach any subsequent counter. The three other 4026 i.c.'s therefore have their clock enable inputs permanently connected to the negative supply rail.

The 4017 i.c. also has a clock enable input, and its "2" output is connected to this input. During circuit operation as so far described the "2" output is low, allowing the 4017 to operate normally, but after the "1" output has gone high for one output cycle the "2" output goes high. It thereby takes the 4017 clock enable input high as well, and the circuit latches in this state with the "2" output high and the input clock signal received from the divider chain blocked.

The length of the output pulse of the 4017 i.c. depends upon the position of the range switch. If this switch connects a 1Hz clock signal to the device, then obviously an output pulse of one second (i.e. the length of one input cycle) will be produced. 10Hz, 100Hz and 1kHz input frequencies produce output pulses of 100 milliseconds, 10 milliseconds and 1 millisecond respectively. Therefore, allowing for the fact that the input signal is divided by ten by the prescaler, the unit has the following four ranges: 0 to 99.99kHz, 0 to 999.9kHz, 0 to 9.999MHz and 0 to 99.99MHz Again, it must be carefully noted that the upper limit on the last range is likely to be much less than 99.99MHz since, as already explained, it is determined by the capability of the prescaler and the first counter stage i.c.

INPUT CIRCUIT

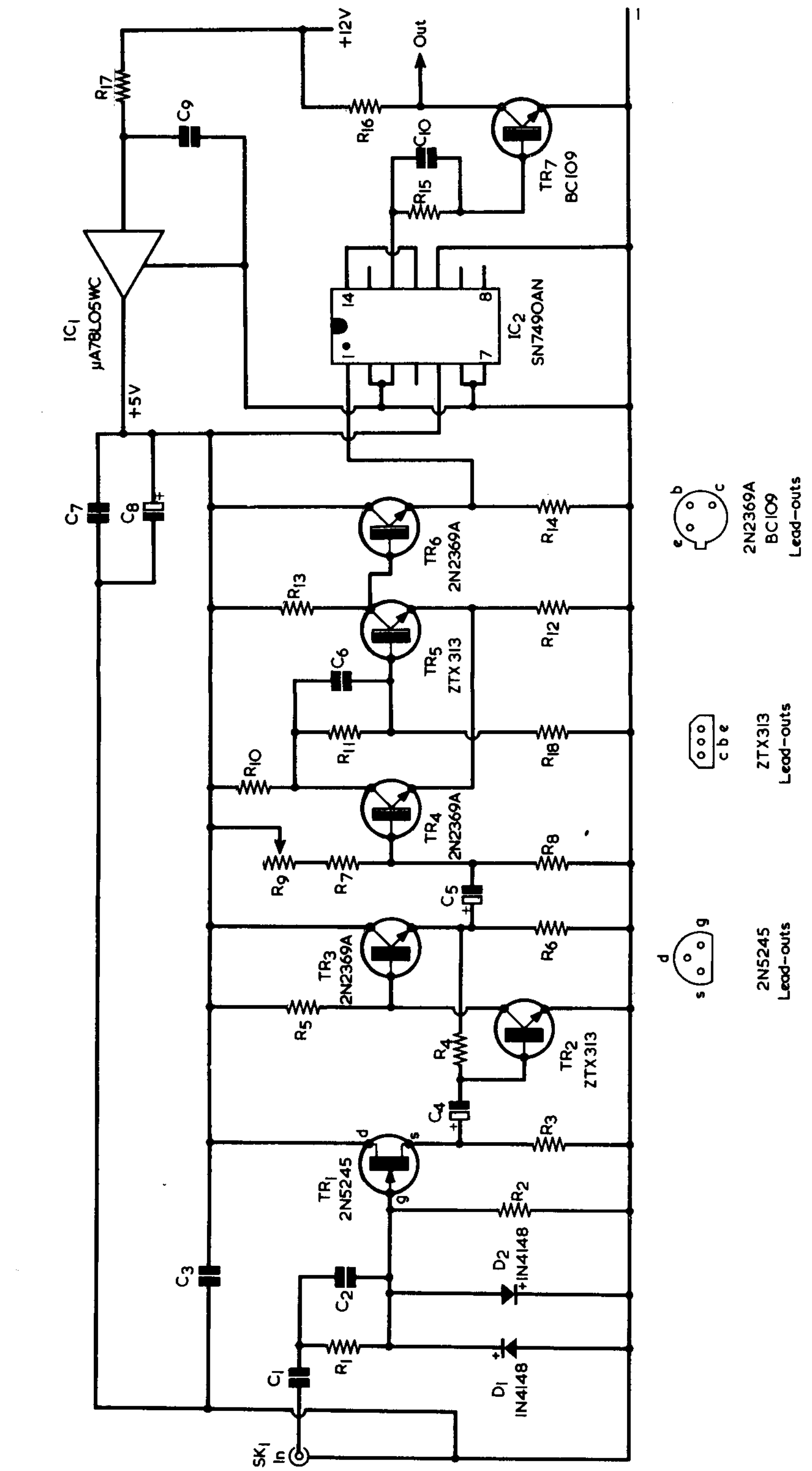
The circuit diagram of the input and prescaler stages is shown in Fig. 3. The input buffer amplifier is the Jugfet source follower, TR1. This stage provides a high input impedance of about 1MΩ as well as a low input capacitance. C1 gives d.c. blocking at the input, and R1, D1 and D2 provide overload protection. With high level inputs the two diodes clip the signal at TR1 gate to about 1.3 volts peak-to-peak, with R1 providing current limiting. A very large input signal level would be needed to damage any of the input components. C2 bypasses R1 at high frequencies, thereby preventing a top cut filter effect which would be given by R1 and the following input capacitance and which would greatly reduce the sensitivity of the unit at such frequencies.

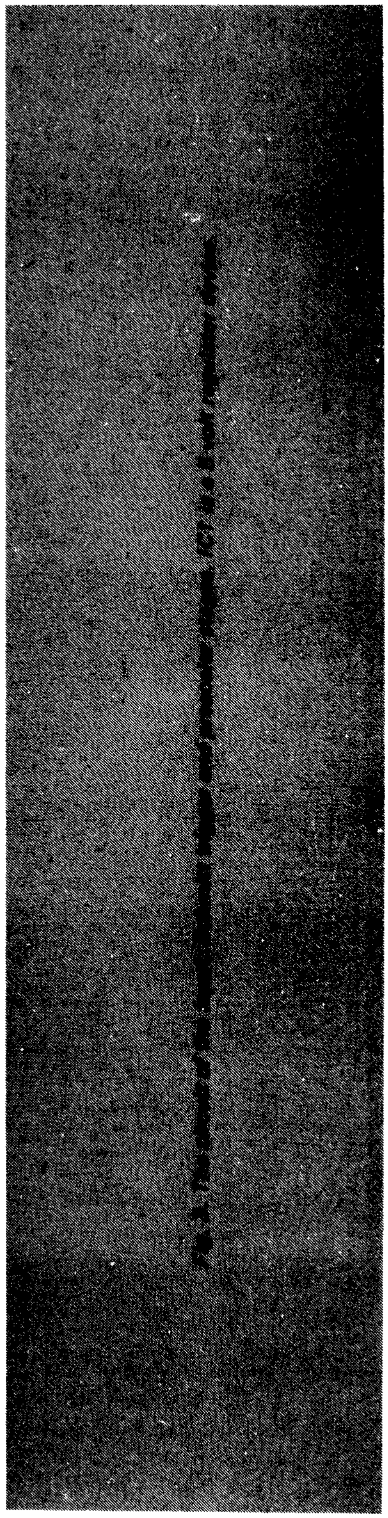
C4 couples the output from TR1 source to the base of the common emitter amplifier, TR2. This is direct coupled to the emitter follower, TR3, with R4 acting as a bias resistor controlling both stages. At first sight, an emitter follower at the output of the amplifier may seem superfluous, since it provides no voltage gain. The load resistor values may also seem rather on the low side. However, it must be remembered that this amplifier has to function at frequencies up to about 50MHz, and so it has to employ high speed transistors (TR2 to TR6 have an fT of 500MHz) which require comparatively high operating currents. Also, the input impedance of the subsequent stages tends to fall considerably at high frequencies and so the use of an emitter follower buffer stage helps to maintain the high frequency response.

TR4 and TR5 form a fairly conventional Schmitt trigger circuit, and this drives the prescaler by way of another emitter follower, TR6. R9 is adjusted to produce the best possible sensitivity. At audio and low radio frequencies the setting of this potentiometer is not particularly critical, but in order to obtain good sensitivity at very high frequencies it must be set up quite accurately. C6 is a speed-up capacitor which bypasses R11 at high frequencies and provides an improved high frequency response.

The SN7490AN decade counter actually contains a divide-by-five and a divide-by-two counter. It must be connected to first divide by five and then by two as the divide-by-five counter will operate up to at least 42MHz, whereas the divide-by-two counter will only operate up to about 16MHz or so. It must be noted that an ordinary SN7490N decade counter is not suitable for use in this circuit as it will only operate satisfactorily up to about 16MHz. The SN7490AN can be obtained from Maplin Electronic Supplies, who can also supply the transistors type ZTX313 and the voltage regulators specified for IC1 and IC14. The remaining semiconductor devices, apart from the l.e.d. displays, are available from Maplin Electronic Supplies and from other suppliers.

TR7 is a common emitter amplifier which provides interfacing between the t.t.l. and CMOS





circuits. This transistor is powered from the main 12 volt supply line so that it provides virtually 12 volts peak-to-peak for the following CMOS counter. R15 limits TR7 base current to a safe value and C10 is a speed-up capacitor.

The prescaler and input stages are powered from a 5 volt line which is derived from the main 12 volt supply by means of the monolithic voltage regulator, IC1. R17 lowers the voltage at the input of the regulator and thus reduces its dissipation. C3, C7, C8 and C9 are the usual supply decoupling capacitors. It should be mentioned that some data tables show the source and drain lead-outs for the 2N5245 transposed from the layout given in the lead-out inset. The 2N5245 functions satisfactorily with the lead-out connections given in Fig. 3.

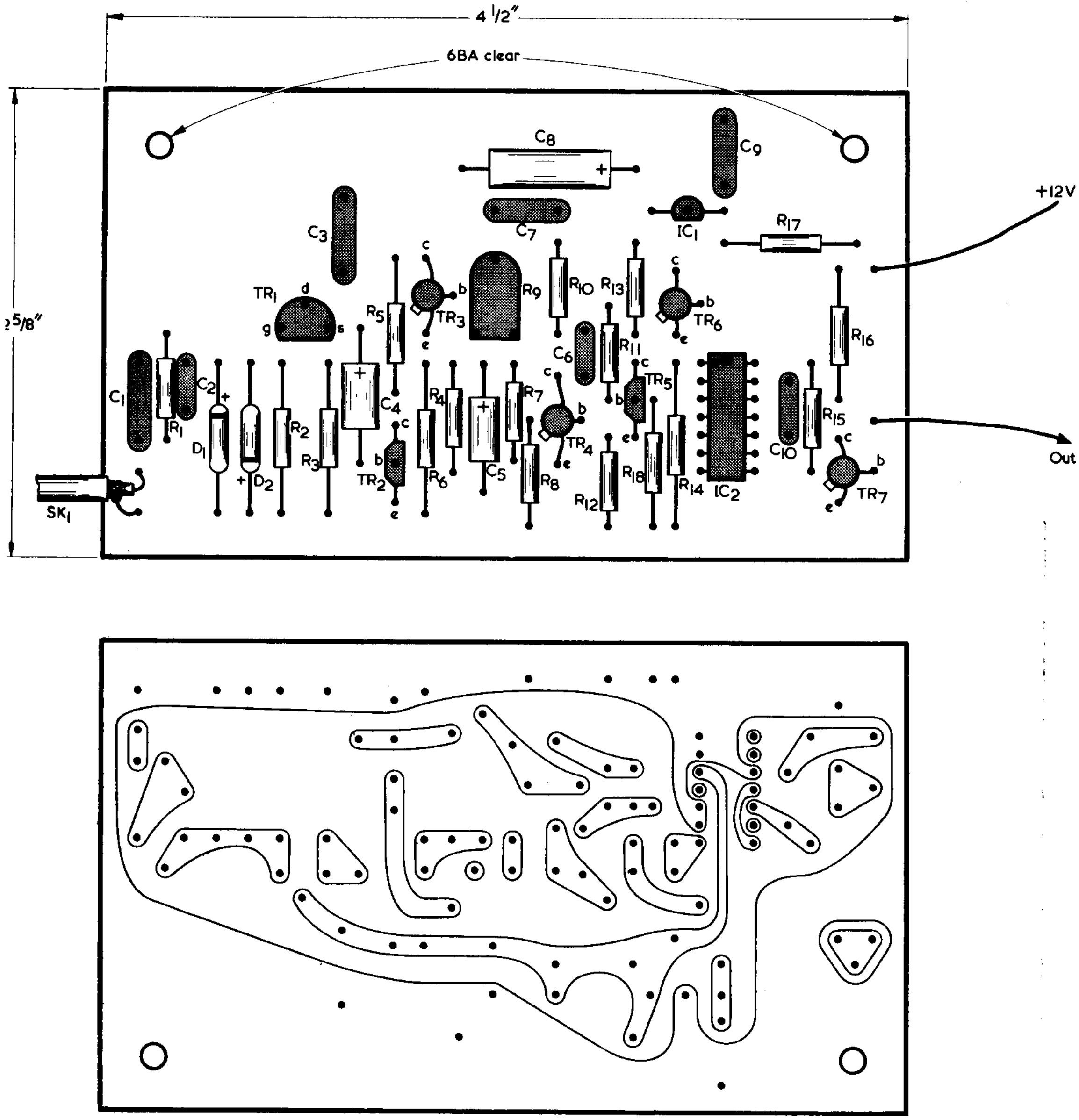


Fig. 4. Component and copper sides of the printed board on which are assembled the input, Schmitt trigger and prescaler stages. The board is reproduced full size

CONSTRUCTION

Nearly all the components are mounted on four printed circuit boards. One board contains the input and prescaler circuitry, whilst the others are for the mains power supply, the counter/divider chain circuits and the l.e.d. displays.

Details of the input circuit and prescaler printed circuit board are shown in Fig. 4. This shows both the component layout of the board and the copper backing pattern. The diagram is reproduced actual size so that it can be easily copied. This board, like the other three which will be described later, is fairly complex, but it is not difficult to produce if a p.c.b. etch resist pen having a fine point is available. The two mounting holes are drilled for 6BA clearance.

DISPLAY AND DIVIDERS

The circuit diagram of the oscillator, divider chain, counter and display sections of the unit is shown in Fig. 5. TR8 is the crystal oscillator, and this uses the well-known Pierce configuration. C11 enables the oscillator frequency to be trimmed to within less than 1Hz of the nominal crystal frequency. TR9 is a buffer stage, and this is a straightforward common emitter amplifier.

The six 4017 integrated circuits, IC3 to IC9 inclusive, form the 1MHz divider chain. The input signal is applied to the clock input (pin 14) of each device, and the divided output is obtained from pin 12. The clock enable (pin 13) and reset (pin 15) terminals of each i.c. are simply taken to the negative supply rail, and the ten unused outputs are ig-

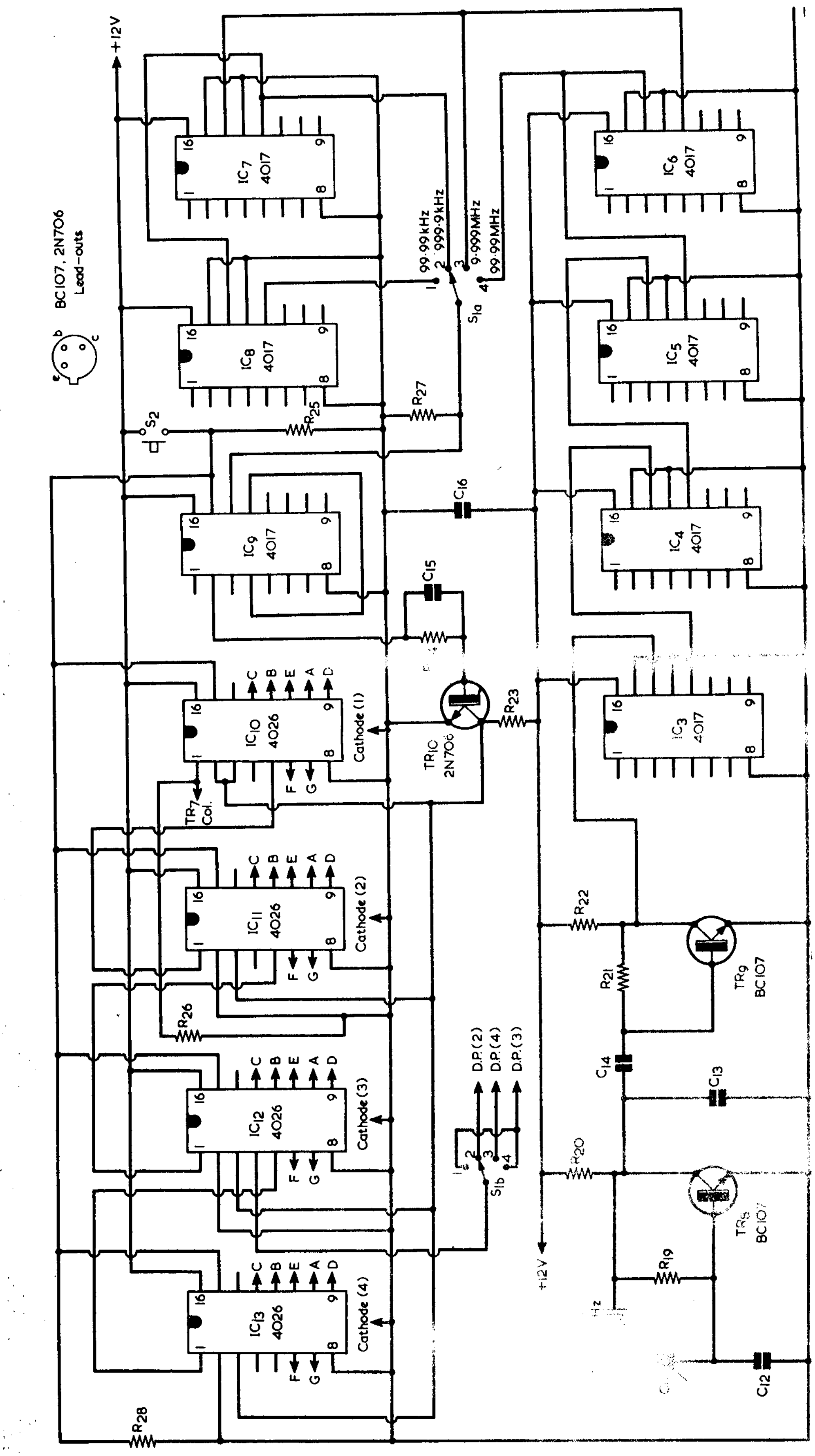
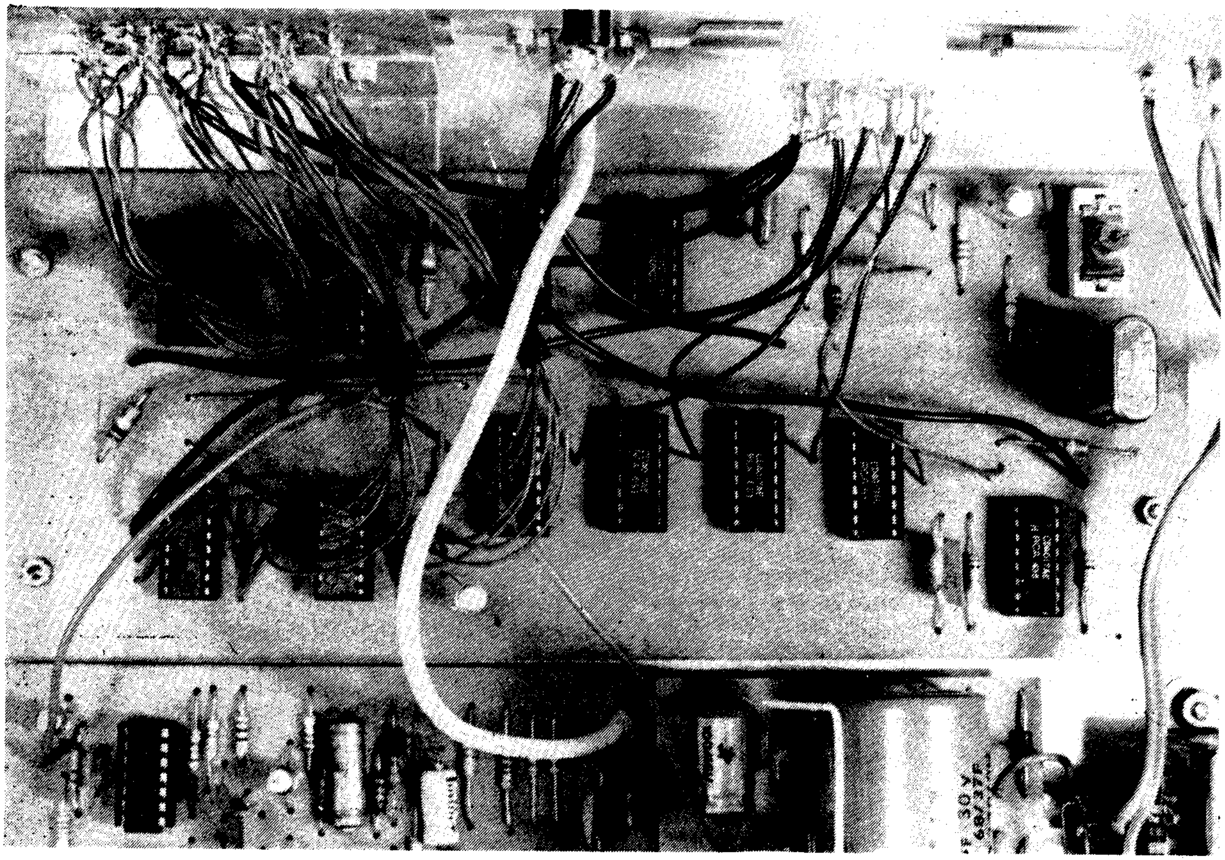


Fig. 5. The divider and counter chains which form the main section of the digital frequency meter



The main board with the divider and counter i.c.'s. The leads from this travel to the pins of the l.e.d. displays

nored, with no connections made to their pins.

S1(a)(b) is the range switch, and this connects the output of the appropriate 4017 divider to the 4017 pulse generator, IC9. The manner in which IC9 produces the control pulse has already been discussed, and so will not be considered further here. The common emitter amplifier, TR10, functions as an inverter stage. R24 limits its base current to a safe value and C15 is a speed-up capacitor.

It is essential that S1(a)(b) is a break-before-make type. If a make-before-break switch were employed, two of the divider i.c. outputs would be briefly short-circuited together when changing from one range to the next. Since the outputs could well be at opposite logic states when this occurs there would be a high risk of damage to the i.c.'s concerned. Break-before-make rotary switches are currently listed by Maplin Electronic Supplies, and the type employed should be a 3-pole 4-way switch, with connections made to only two of the poles.

The 4026 decoder-driver i.c.'s can drive the seven-segment l.e.d. displays directly, and there is no need to use output current limiting resistors. With the 12 volt supply which is used here, an output current of about 10mA per segment is obtained. This is more than adequate for high brightness displays such as the DL704 devices which are specified. The letters "A" to "G" around each 4026 apply to the appropriate display segments.

Each 4026 i.c. has a display enable output, but only that of IC12 is used here. This output drives the applicable decimal point via S1(b), which is, of course, part of the range switch. Incidentally, the DL704 displays have a right-hand decimal point.

S2 is the reset switch, and when this push-button is operated the reset terminals of IC9 to IC13 are connected to the positive supply rail. This resets them all to zero, and they are held in this state until the switch is released. The unit then makes a measurement of the input frequency in the manner described earler.

R26, R27 and R28 are included to ensure that at no time is an input of any i.c. left floating. This could otherwise occur with the modular form of construction which is employed here if it happened that external connections to the printed board were not completed. A floating i.c. input is highly undesirable as CMOS i.c.'s can be damaged if high static voltages appear at an input.

One advantage of CMOS i.c.'s is that they have a high degree of immunity to noise and therefore require very little in the way of supply decoupling. In this case only one decoupling component is used, this being C16.

NEXT MONTH

In next month's concluding article we shall carry on to the construction of the printed board on which is assembled the circuitry of Fig. 5.

For convenience a full Components List accompanies this article, although it will be appreciated that the functions of some components will not be fully apparent until they are dealt with in the constructional details to be given in next month's issue. Nevertheless, some notes on the components here will be of value.

The availability of the semiconductors has already been dealt with. The mains transformer employed in the unit is the type "M1N TR 15V" retailed by Maplin Electronic Supplies. The 1MHz crystal and holder are available from several outlets. The display filter is an optical filter suitable for red displays and that employed by the author was the Electrovalue type PNF21. The author's frequency meter was assembled in a Veropak case type 49-1470L, which has dimensions of 11 by 4.4 by 8.6 in. This has a p.v.c. clad steel shell and an anodised aluminium front panel, and should be available from stockists of Vero cases or from Retail Department, Vero Electronics Ltd., Industrial Estate, Chandlers Ford, Hants., SO5 3ZR. Other metal cases of the same dimensions or larger may also be used. The DL704 displays can be obtained from Ambit International.

Dealing with smaller matters, switch S3 should be suitable for switching mains voltages. The horizontal skeleton potentiometer, R9, should be a type having 0.2 in. spacing between track tags, and 0.4 in, spacing between track and slider tags. The 18 s.w.g. aluminium sheet is used for making a chassis, a bracket and a heat sink, and details of these will be given next month.

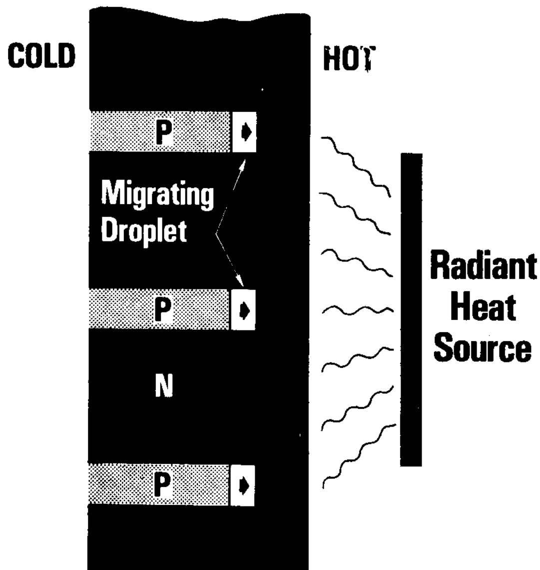
(To be concluded)

THERMOMIGRATION

by Michael Lorant

New doping process could herald a fantastic advance in semiconductor manufacture.

Dr. Thomas R. Anthony and Dr. Harvey E. Cline, staff research scientists of General Electric Research and Development Centre, Schenectady, N.Y., have developed an entirely new technique, called "Thermomigration", which reduces the time required to fabricate a semiconductor device by as much as a *thousandfold.* In addition the novel technique, which relies on a temperature gradient to drive a liquid dopant through a silicon wafer, reduces fabrication temperatures and increases processing yields.



This drawing demonstrates General Electric's "Thermomigration" process. Droplets of dopant in the silicon wafer migrate from the cold side of the slice towards the hot side, taking one-thousandth of the time needed for the introduction of dopants with previous techniques

The patented innovation is also expected to result in another important by-product: a significant saving of energy in the production of semiconductor components.

In the manufacture of a semiconductor device a crystal of silicon is first grown at the highest possible purity and is then sliced into thin wafers. Next, precise amounts of an impurity, called a "dopant", are introduced into the wafer to change its electrical properties and turn it into a semiconductor device with n and p regions.

In the new process one side of the silicon wafer is heated whilst the opposite side is cooled. The temperature difference forces the dopant, in the form of a droplet of liquid, to migrate through the wafer from the cooler side to the hotter side.

The thermomigration technique can be accomplished in minutes. By contrast, the best previous commercial method for equivalent doping of wafers requires nearly a week of processing time. Also, the new process can be performed at a temperature several hundred degrees Fahrenheit below that required up to now.

With established techniques, excessive wafer breakage is often a problem because shallow dopant penetration, of around two to three thousandths of an inch, necessitates the use of correspondingly thin wafers. With the new approach it is possible, by manipulating wafer alignment and temperature, to control the size, shape and concentration of doped regions in the wafer.

The end result of this new technology can be the creation of whole new classes of semiconductor devices which never existed before. ■

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

We commence this month by listing some stations on the LF bands for the interest of the Dx-er, much that follows being on the higher frequencies.

● CHINA

Radio Peking on **4460** at 2210, YL in Chinese in the Domestic Service 1 programme, scheduled here from 2000 to 2300 with this transmission.

Radio Peking on **4800** at 2110, YL in Chinese in the same programme as above.

Harbin, Heilongjiang, on **4840** at 2113, YL in Chinese. The schedule is from 0825 to 1430 and from 2040 to 0635.

Lanchow, Gansu, on **4865** at 2215, OM and YL alternate in Chinese, scheduled here from 0950 to 1600, 2120 to 0100 and from 0320 to 0600.

Urumchi, Xinjiang, on **4970** at 1728, signing-off with choral rendition of the 'Internationale'. In addition to local programmes, this transmitter relays the Peking Domestic Service in Kazakh, the schedule is from 2300 to 0030 and from 0130 to 1730.

● COLOMBIA

Emisora Nuevo Mundo, Bogota, on **4755** at 0417, Latin American music, OM with song in Spanish. This station has a 24-hour schedule and a power of 1kW, sometimes identifying as Radio Caracol.

Ondas del Meta, Villavicencio, on **4885** at 0245, OM with identification in Spanish and into a programme of local-style dance music. The schedule is from 0900 to 0500 and the power is 1kW.

● VENEZUELA

Radio Frontera, San Antonio, on **4760** at 0232, local-style pops, OM announcer, YL with songs in Spanish. The schedule is from 1000 to 0300 and the power is 1kW.

AROUND THE DIAL

● ISRAEL

Jerusalem on **21500** at 1220, pops, commercials in English, identification, announcements and into French at 1230. Announced to Western Europe and North America in parallel on **11655, 15405** and **17815** and to Asia on **15570.**

● E. GERMANY

Berlin on **21540** at 1241, OM with announcements and identification at the end of the English programme to South East Asia. Announced in parallel on **15115** and **17880.**

● SOUTH AFRICA

Johannesburg on **21535** at 1356, programme in English about crocodile conservation, identification and time check at 1400 followed by a local newscast. Announced in parallel on **11900** and **15220.**

● NORWAY

Oslo on **21730** at 1405, OM and YL with a talk about Norwegian affairs in English. Identification at 1411.

● EGYPT

Cairo on **17670** at 1419, local-type music, YL and OM in Arabic in the Domestic Service General Programme, scheduled from 1300 to 1830 on this channel with programmes intended for the Arab World, East and Central Africa and Southern Europe.

● PORTUGAL

Lisbon on **17895** at 1608, YL with news of Portuguese affairs in the English programme directed to the Middle East, scheduled from 1600 to 1630 (not Sundays).

Lisbon on **9740** at 2030, OM with identification followed by the news in English for Europe, scheduled from 2030 to 2100 (English programme) and in parallel on **6025.**

● TURKEY

Ankara on **9515** at 2132, OM with a local newscast in the English programme to Europe and North America, scheduled from 2130 to 2255 and in parallel on **7170.**

Turkiye Polis Radyosu (Turkish Police Radio), Ankara, on **6340** at 1519, local-type music, YL with songs, OM in Turkish. Scheduled from 0600 to 1100, 1200 to 1600 and from 1730 to 1900.

● **GREECE**

Athens on **17830** at 1532, typical local-type music, OM and YL alternate with announcements in Greek.

● **PAKISTAN**

Karachi on **6235** at 1943, OM with a talk in Urdu in the World Service to the U.K. and Europe, scheduled here and in parallel on **4718** and **7095** from 1915 to 2115 in Urdu and from 2115 to 2145 in Sylheti.

● **W. GERMANY**

Cologne on **6100** at 0130, OM with a newscast in the English programme intended for the East Coast of North America, scheduled from 0130 to 0200 and transmitted from the relay station at Cyclops, Malta, on this channel.

● **AUSTRALIA**

Melbourne on **11900** at 1519, YL with the programme 'Australian Editorial Opinion' in the English transmission to Asia and the Pacific. Time check, 5 pips and a newscast in English after station identification at 1600.

Melbourne on **11705** at 0946, YL with listeners record requests in the English programme to the Pacific Islands.

Melbourne on **9670** at 1450, OM with the English programme to Papua/New Guinea, identification and world news at 1500.

● **NEW ZEALAND**

Wellington on **11820** at 0900, OM with time check, station identification and the news in English.

● **PHILIPPINES**

FEBC (Far East Broadcasting Company) Manila on **11765** at 0918, OM with a religious programme to Australia, New Zealand and New Guinea.

Radio Veritas, Manila, on **11955** at 1415, YL with a talk on travel in the Far East in the English programme, scheduled from 1400 to 1500 on this channel.

● **CHINA**

Radio Peking on **9945** at 1135, YL in Vietnamese, Chinese music in a programme for Vietnam, scheduled here from 1130 to 1200, also from 1330 to 1430.

Radio Peking on **9920** at 1430, OM and YL in the Kazakh programme Domestic Minority Groups, schedule from 1400 to 1455.

Radio Peking on **9880** at 1425, Chinese orchestral music in a programme intended for Indonesia, scheduled from 1400 to 1430.

Radio Peking on **9390** at 1440, YL in Tagalog to the Philippines, scheduled from 1430 to 1500.

Radio Peking on **11650** at 1428, OM in the English programme for South East Asia, scheduled from 1400 to 1500.

Radio Peking on **11695** at 1433, OM with a programme for Cambodia, scheduled from 1400 to 1500 on this channel.

● **BRAZIL**

Radio Relogio, Rio de Janeiro, on **4905** at 0258, OM in Portuguese with announcements, time pips, off at 0302 without National Anthem.

A Voz do Oeste, Cuiaba, on **4775** at 0015, OM with identification in Portuguese, local-style music. Schedule is from 1000 to 0300 and the power is 1.5kW.

Radio Pioneira, Teresina, on a measured **5016** at 0242, announcements in Portuguese, OM with ballad. Schedule is from 0800 to 0330 and the power is 1kW.

Radio Ribamar, Maranhao, on **4785** at 0126, folk music and songs, identification by OM at 0130. The schedule of this one is from 1100 to 0400 and the power is 5kW.

Radio Borborema, Campina Grande, on **5025** at 0210, OM in Portuguese, several mentions of "Campina Grande". Schedule is from 0830 to 0500 and the power is 1kW; sometimes wanders down to 5023 and/or identifies as A Princesa do Sul.

Emisora Rural, Santarem, on **4765** at 0238, local-style music, love song by OM in Portuguese — quite a torried affair I gathered! The schedule is from 0830 to 0400 and the power is 5kW.

● **WORLD RADIO TV HANDBOOK**

There must be many readers of these columns who would like to know more about the world of short wave listening and the short wave stations mentioned here month by month but do not know where to obtain such information. It is to this type of reader that the following review is presented.

The 1978 issue (32nd Edition) of the World Radio TV Handbook comprises 512 pages packed with facts, figures and information about short wave stations, frequencies, schedules, interval signals, addresses, callsigns, powers and personalities. Quite apart from complete details of Long and Medium wave stations and TV transmitters, there is also a wealth of information about such matters as DX programmes of the world, maps complete with time-conversion charts, broadcasts in English, frequency lists, standard frequency and time-signal stations, solar activity for 1978, co-operators and monitors and co-operating operating DC clubs, together with much other information of assistance to the modern-day short wave enthusiast.

Also included between the covers of the WRTH is a separate section entitled Listen to the World, the contents of which include the following chapters — Eight New Short Wave Receivers (a review of receivers currently being offered to SWL's); Antennas for Broadcasting Reception (several practical aerial designs suitable for the stated purposes); DXing in Paraguay (listening results obtained by Tony Jones, a well-known Dxer resident in that country); Frequency Counters for the Dxer (learn all about measuring frequencies); Build Your Own Log-Periodic Antenna (high-gain switchable or rotatable aerial systems for the SWL) and Unofficial Radio (all about radio pirates and suchlike).

The 32nd Edition of the World Radio TV Handbook is thoroughly recommended to all who operate over the short wave spectrum and it is available direct from The Modern Book Company, 19-21 Praed Street, London W2 1NP at £8.16 inclusive of postage.

WATCH THE WEATHER

By T. F. Weatherley

Red sky at night . . . seaweed, rain before seven, all are traditional ways of telling the weather but today things are different. Today there are weather satellites continually sending cloud cover pictures of the earth from 1,000 miles up. These pictures can be received here on earth by anyone equipped with a ground station to receive them and it needn't cost a fortune. A sophisticated satellite receiving station can be built for less than £50.

The interested reader should first write to the Home Office Radio Regulatory Dept for permission to receive satellite signals from satellites operating in the 135-138 Mhz band and a letter granting authority will allow:

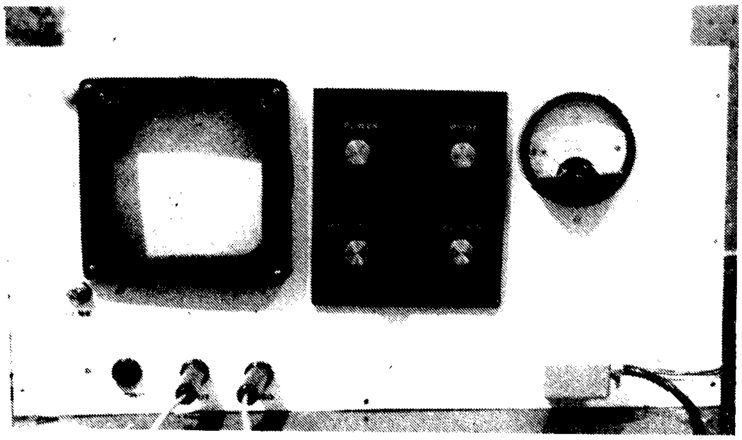
> "authority to receive signals emitted by artificial earth satellites engaged in scientific space research for the purpose of making observations on the technical characteristics of such signals or otherwise carrying on technical investigations into radio technique."

Obviously a receiver to receive this band is required. The author's route was to feed the output from a converter into a VHF receiver. A suitable converter for the satellite band can be purchased or built. The 2M converter in the RSGB handbook can be readily adjusted to cover 136-138 Mhz.

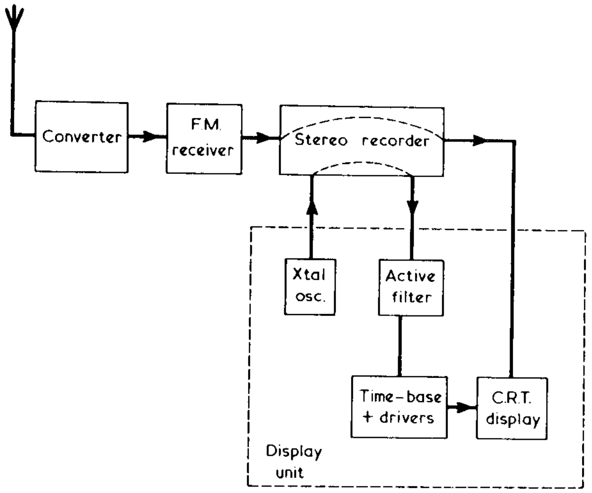
At the present time (1977) there are two American satellites in orbit NOAA4 and NOAA 5. The prime satellite is NOAA 5 transmitting on 137.5 Mhz with NOAA 4 as back up on 137.62 Mhz. The signal from the satellite is transmitted as a wideband FM signal with a 2.4 Mhz AM subcarrier, to the ear this sounds like 'lub-dub'. The satellite passes overhead at about 10.30 am local time each day.

NOAA 5 visible light depression off Greenland

NOAA 5 Same depression over UK



The Display unit



Block diagram of Satellite Receiving set up

NOAA 5 Composite of two photos cloud cover over Western Europe and UK at night photographed in Infra Red Light

The block diagram (Fig. 1) shows the sections of the display unit. On receive the unit generates a 2.4 Mhz reference tone which is recorded on one track of a stereo recording while the satellite signal is recorded on the other. In the display mode the received signal and the reference tone are replayed into the display unit. The received signal is cleaned up with an active filter and is used to brighten the trace on a Cathode Ray tube. The reference signal is phase locked and used to generate the horizontal time base (4/5 Hz). The vertical time base is seven minutes and is reset with a switch.

With such a slow picture build up a conventional CRT will not display a picture but an ex radar tube with an orange phosphor gives a reasonable picture in a darkened room. The picture is best recorded photographically and the photographs show some of the results to date.

The interested experimenter will find the "Weather Satellite Handbook" published by 73 Magazine gives much useful constructional information. ■

CLOCK AUTO-DIMMER

By R. A. Penfold

A neat little unit which dims digital clock display brightness under dark conditions.

This device has been designed primarily as an add-on unit for the "Single I.C. Digital Clock" which was described in last month's issue. Some digital clock i.c.'s have an auto-dim facility built in, so that very few external discrete components are required to add this feature. However, such is not the case with the AY-5-1224A device which is employed in the "Single I.C. Digital Clock", as this i.c. was chosen to cater for a good and very simple basic clock design.

The auto-dimmer circuit to be described is quite simple and can easily be added to the clock with a minimum of modification to its design. The experienced constructor could probably adapt the circuit to operate with similar clocks incorporating the AY-5-1224A, but this has not been checked by the author and should not be attempted by anyone who is not fully competent.

The purpose of the auto-dimmer is to reduce the brightness of the display under very dark conditions. Under such conditions the display can become a little difficult to read due to glare, and the facility is especially useful if the clock is to be used in a bedroom.

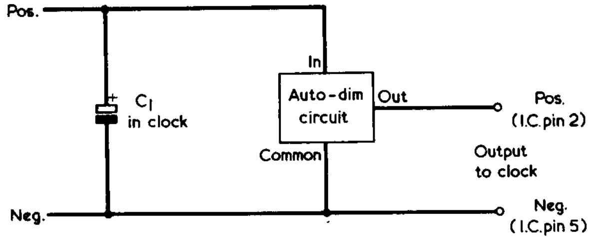


Fig. 1. How the auto-dimmer unit functions. It takes up the positive and negative outputs of the clock power supply and then varies the positive supply voltage fed to the clock itself

THE CIRCUIT

Fig. 1 shows the manner in which the auto-dimmer is added to the clock. It is connected between the positive output of the clock power supply and the positive input to the clock circuit. The dimmer has two output states: one where the output voltage is virtually equal to the input voltage, and one where the output voltage is at about half this level. The former is the normal state of the circuit, and the latter occurs when the clock is in almost total darkness. It will be apparent that the circuit does not just reduce the voltage supplied to the clock display but it also reduces the operating voltage for the entire clock. In practice this does not adversely affect clock operation provided the dimmed output voltage is not made excessively low. (It may be noted that in Fig. 1 the positive supply rail is shown above the negative rail, whereas in the clock circuit in last month's issue the positive rail was the lower one.)

The complete circuit of the auto-dimmer appears in Fig. 2. Here, a photoconductive cell type ORP12 is coupled to the input of the Schmitt trigger consisting of TR1, TR2 and their associated components. The output of the Schmitt trigger couples to the emitter follower TR3.

The circuit is arranged such that TR1 is turned off in the dark condition, with its base-emitter voltage being below the 0.6 volt level required for a silicon transistor to pass collector current. TR2 is then made conductive by way of the base current it receives via R3 and R4. In a more conventional Schmitt trigger R7 would have a value which is much higher than that of R6, so that the output voltage at TR2 collector would be only slightly positive of the negative rail. But in the present application the output voltage needs to fall to only about half that on the positive rail, and this requirement is achieved with the values of R6 and R7 which are specified. The resistor values around TR2 are, also, such that this transistor does not turn hard on when it becomes conductive, as is

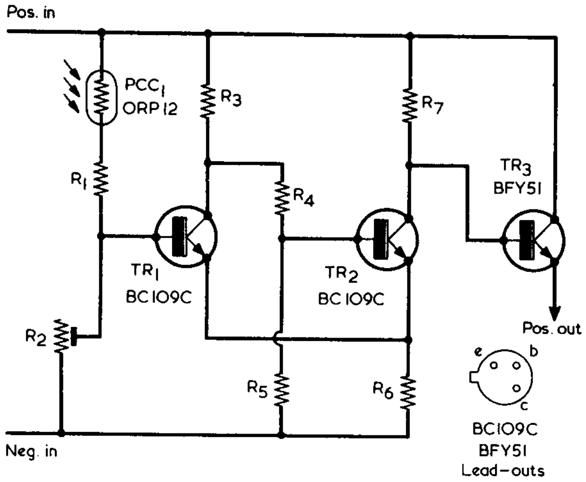


Fig. 2. The auto-dimmer circuit. TR1 and TR2 form a Schmitt trigger which is actuated by the voltage on TR1 base. TR3 is an emitter follower feeding the clock circuit

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 2.2k Ω
R2 50k Ω or 47k Ω pre-set potentiometer, 0.25 watt horizontal
R3 3.9 Ω
R4 22k Ω
R5 12k Ω
R6 390 Ω (see text)
R7 560 Ω

Semiconductors
TR1 BC109C
TR2 BC109C
TR3 BFY51

Photoconductive Cell
PCC1 ORP12

Miscellaneous
Printed board materials
Wire, solder, etc.

usual with the more common versions of the Schmitt trigger.

If the voltage at TR1 base is caused to go positive, a level will be reached at which TR1 commences to pass collector current. This will cause the base current available to TR2 via R3 to be reduced, whereupon a lower voltage is dropped across R6. This further increases the base-emitter voltage of TR1 and a regenerative action takes place which concludes with TR1 turned fully on and TR2 cut off. The change of state in the transistors takes place, of course, in a minute fraction of a second and is triggered when the appropriate voltage is applied to TR1 base. With TR2 cut off the output voltage of the auto-dim circuit is only slightly lower than that on the positive rail.

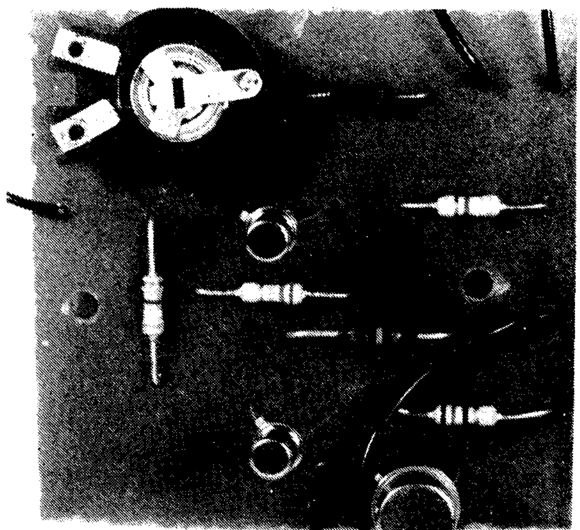
The circuit will revert to its previous state if the base of TR1 is taken negative, but the voltage at which the changeover occurs will be lower than that at which TR1 was turned on. This hysteresis effect is a characteristic of Schmitt trigger operation and is useful here as it ensures that the trigger does not continually change states for very small changes in input potential.

The output current available from TR3 when TR2 is turned off is that flowing through R7 multiplied by the current gain of the transistor. Despite the relatively high current drawn by the clock circuit the voltage drop across TR3 under this condition is only about 0.7 volt, which is not significant.

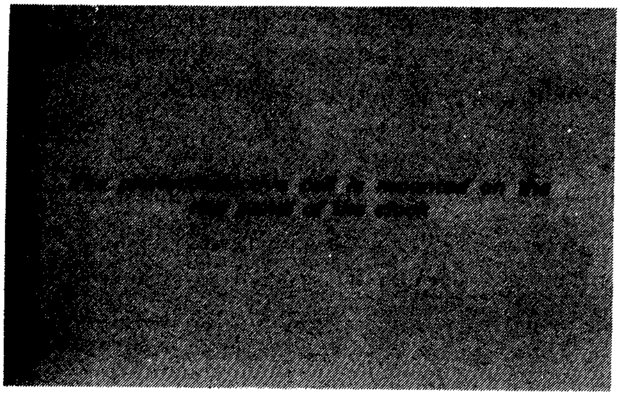
The base of TR1 is fed from a potential divider circuit of which one arm consists of the photoconductive cell PCC1 and current limiting resistor R1, whilst the other arm consists of the pre-set variable resistor, R2. Under light conditions PCC1 exhibits a low resistance, this increasing to a very high value, in excess of several megohms, under very dark conditions. In consequence, light conditions cause the base of TR1 to be taken sufficiently positive for this transistor to be turned on and TR2 to be cut off, whereupon the auto-dimmer output is at its maximum level. If PCC1 is in a dark situation its resistance is high, and TR1 base goes sufficiently negative for it to be turned off and the Schmitt trigger to change over to its alternate state. The darkness level at which the Schmitt trigger operates is chosen by adjusting R2.

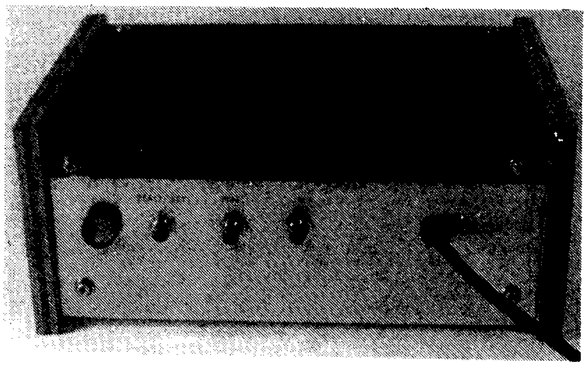
CONSTRUCTION

The auto-dimmer is constructed of a small printed circuit board, and the copper pattern and component layout of this are illustrated, actual



The auto-dimmer components assembled on their printed board





size, in Fig. 3. Note that R2 is a standard and not a miniature pre-set potentiometer. It is advisable to mark up the three holes it requires from the tags of the actual component, as these may vary slightly from the hole positioning shown in the diagram. The two mounting holes are 3 to 3.5mm. in diameter. Insulated leads about 150mm. long are connected to the board at the points where it will eventually connect to PCC1 and the clock circuit.

The photoconductive cell is mounted on the rear panel of the clock case, between the zero reset switch and the adjacent end cheek. It is mounted by first drilling two holes of about 3mm. diameter through which its leads, covered by sleeving, can pass. The photocell is then glued in position by means of a good quality adhesive such as an epoxy type. Make absolutely certain that its lead-outs do not short-circuit to the case.

The printed circuit board is mounted on the inside of the right-hand end cheek of the case, using two small short woodscrews. It is necessary to fit several washers over these screws between the board and the case, as otherwise there is a strong risk of the board cracking when the mounting screws are tightened.

CLOCK MODIFICATIONS

After the board has been fitted in position it can be connected to the photoconductive cell lead-outs. All the insulated leads from the board are shortened as necessary when they connect to the cell and to the main printed board of the clock.

The next process is to modify the clock, whereupon it becomes necessary to consult the printed circuit board diagram which was published as Fig. 5 in the article describing the clock. First identify the copper track which carries the negative supply rail. In the view of the copper side of the board this is the track which runs along the bottom and up the right of the board, connecting to the emitters of TR1 to TR4. Drill an additional hole through this track at any convenient point and solder the negative input lead from the auto-dimmer board to the track.

At the upper centre edge of the diagram of the copper side of the main clock board is the positive supply track, which connects to the positive lead-out of C1 and to C3. Make a small break in this track between the connections to these two capacitors. The break can be made quite easily with a sharp modelling knife. Drill additional holes

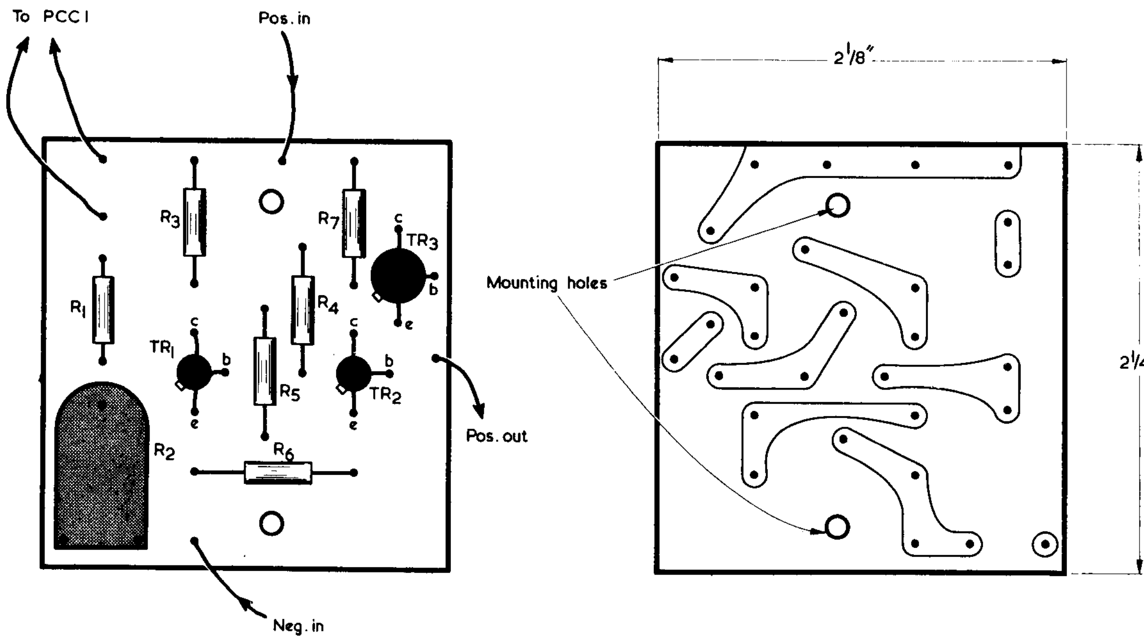
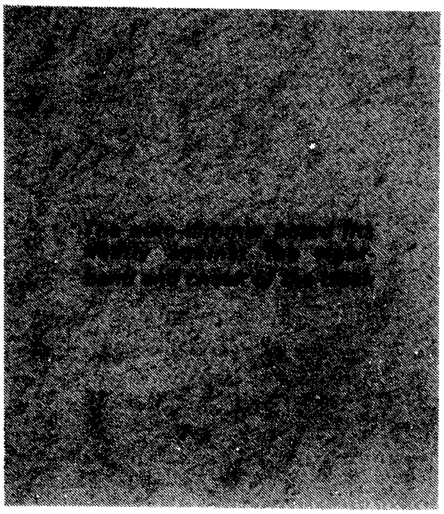
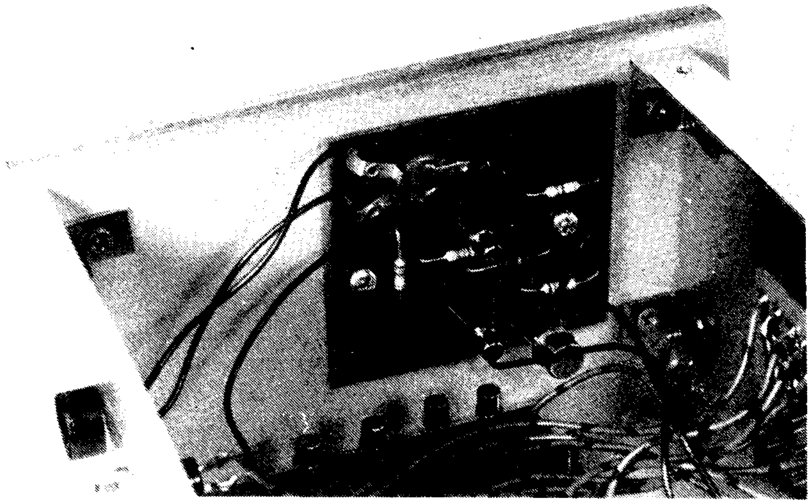


Fig. 3. Details of the printed board, which is reproduced full size





through the track on either side of this break. The hole nearer C1 positive lead-out provides the positive input to the auto-dimmer and the hole nearer C3 takes the auto-dimmer positive output.

This completes the modifications to the main printed board of the clock. The board can now be remounted in the case.

R2 may next be set up, although in most instances it will probably be found satisfactory to simply leave it with its slider at about the centre position of the track. The reason is that the most usual requirement of the auto-dimmer will be that it should operate when the clock is in virtually total darkness, and this will be achieved at almost any setting of R2. It is, however, possible to adjust R2 so that the display will dim under semi-dark conditions.

R2 slider should not be turned fully clockwise, whereupon minimum resistance is inserted into circuit, if there is a possibility of the photoconductive cell being brightly illuminated during the day by sunlight or an electric lamp. This is because the cell will then exhibit an extremely low resistance, giving a slight risk of excessive current flow in the potentiometer track. The risk disappears if the potentiometer adjustment is such that it always inserts about 5k Ω or more of resistance into circuits. 5k Ω is, of course, just one-tenth of the total track resistance.

If desired, it is possible to vary the dimmed display brightness to some extent by altering the value of R6. Raising its value will cause an increase in brightness, and reducing it will have the opposite effect. Its value should not, however, be increased to more than 470Ω or reduced to less than 300 Ω.

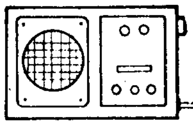
TR3 will run rather warm but there is no need to fit it with a heatsink, even if the clock circuit has been modified to providc an increased display current (as was described at the end of the article on the clock). ■

BOOK REVIEW

TEST EQUIPMENT FOR THE RADIO AMATEUR, Second Edition. By H. L. Gibson, C.Eng., M.I.E.E., G2BUP. 151 pages, 245 x 185mm. ($9\frac{3}{4}$ x $7\frac{1}{4}$in.) Published by Radio Society of Great Britain. Price £3.75.

The amateur radio transmitting enthusiast requires basic test equipment not only for servicing but also to ensure that he is satisfying his licence conditions. Further test equipment is desirable and much of this can be home-constructed with a corresponding saving of cost and increase in experience. The book under review gives detailed information on the building of test equipment and the manner in which it may be used. The present second edition has a completely revised text and has many new designs, including digital instruments and microwave test gear.

The test equipment covered includes everything that can conceivably be required for normal amateur work, and takes in the measurement of voltage, current, frequency, r.f. power, noise, aerial standing waves and many other quantities. The book also has the attractive well-drawn diagrams which are associated with R.S.G.B. publications. The price at the head of this review is that applicable in the U.K., and the volume may be obtained direct from Radio Society of Great Britain, 35 Doughty Street, London, WC1N 2AE, at this price plus (at the time of writing) 67p postage and packing.



In your workshop

Scan and Flyback Rectification

The Line Output Power House

Cheerfully, Dick plugged an aerial lead into the 14 inch black and white television receiver, after which he inserted its plug into one of the mains sockets ranged along the rear of his bench. He switched the set on, whereupon the sound signal from one of the local u.h.f. channels became audible from its speaker. Expectantly, he waited for the cathode ray tube to warm up and the consequent appearance of a picture.

Nothing happened. There was no picture; not even a blank unmodulated raster.

He leaned forward, located the brightness control, and adjusted it experimentally. The screen remained blank at all settings of the control. Returning it to a central position, Dick frowned as he mentally totted up the faults which could cause the loss of raster and picture: a faulty tube, a faulty tube heater supply, a failure in the e.h.t. voltage supply to the tube final anode, incorrect operation of the line output, line oscillator or line driver stages, or an unserviceable supply to any of the remaining tube electrodes.

"Blimey," he muttered glumly, "this one's going to be a stinker."

He switched off the receiver. At once the screen of the tube lit up, to fade away into its previous darkness after a few short moments.

BRIGHTNESS CONTROL

Incredulously, Dick gaped at the receiver. With a trembling hand he turned it on again, with the result that the sound signal became audible once more. The face of the picture tube repeated its performance and remained completely blank. Dick waited for a minute then turned the set off. The screen became illuminated for a brief period before it returned to its previous darkness.

"Hey, Smithy!"

The Serviceman, preoccupied with a dismembered music centre on his own bench, gave no indication that he had heard his assistant.

"Hey, *Smithy!*"

Irritably, Smithy put down his test prods.

"For goodness' sake, what is it now?"

"I've got a set here that's haunted. It only comes on when I switch it off!"

With a sigh, Smithy got up from his stool and walked over to Dick's bench.

"Show me."

Dick demonstrated the behaviour of the receiver. Smithy watched, unimpressed, when the screen came momentarily to life as Dick switched the set off.

"There's nothing very complicated there," he commented. "I should look for a snag in the brightness control circuit. In fact, I should check the brightness control potentiometer itself. Perhaps there's an open-circuit between one end of the track and its tag. You can do a simple d.c. ohms test there."

With which words, Smithy stumped back to his music centre. Deflated, Dick took the television set plug from its mains socket, removed the back of the receiver and, after manipulation of the printed board, found himself able to reach the tags of the brightness potentiometer. He switched his testmeter to an ohms range and applied its test clips to two of the potentiometer tags. (Fig. 1(a).)

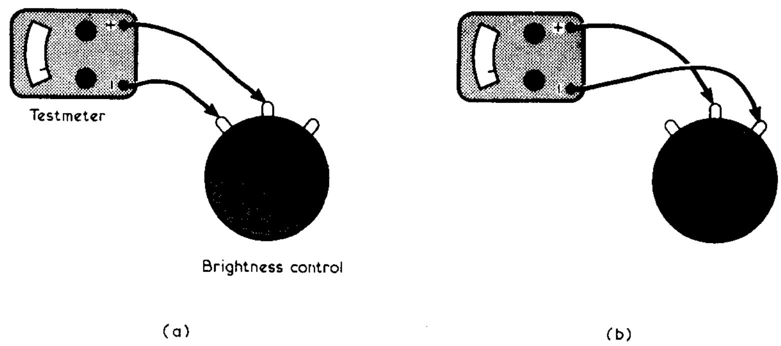


Fig. 1(a). Following Smithy's bidding, Dick checked the continuity of the brightness control potentiometer track in his faulty monochrome TV receiver

(b). When he checked between the slider and the track tag, when the control was turned fully clockwise he found an open-circuit between the track end and the tag

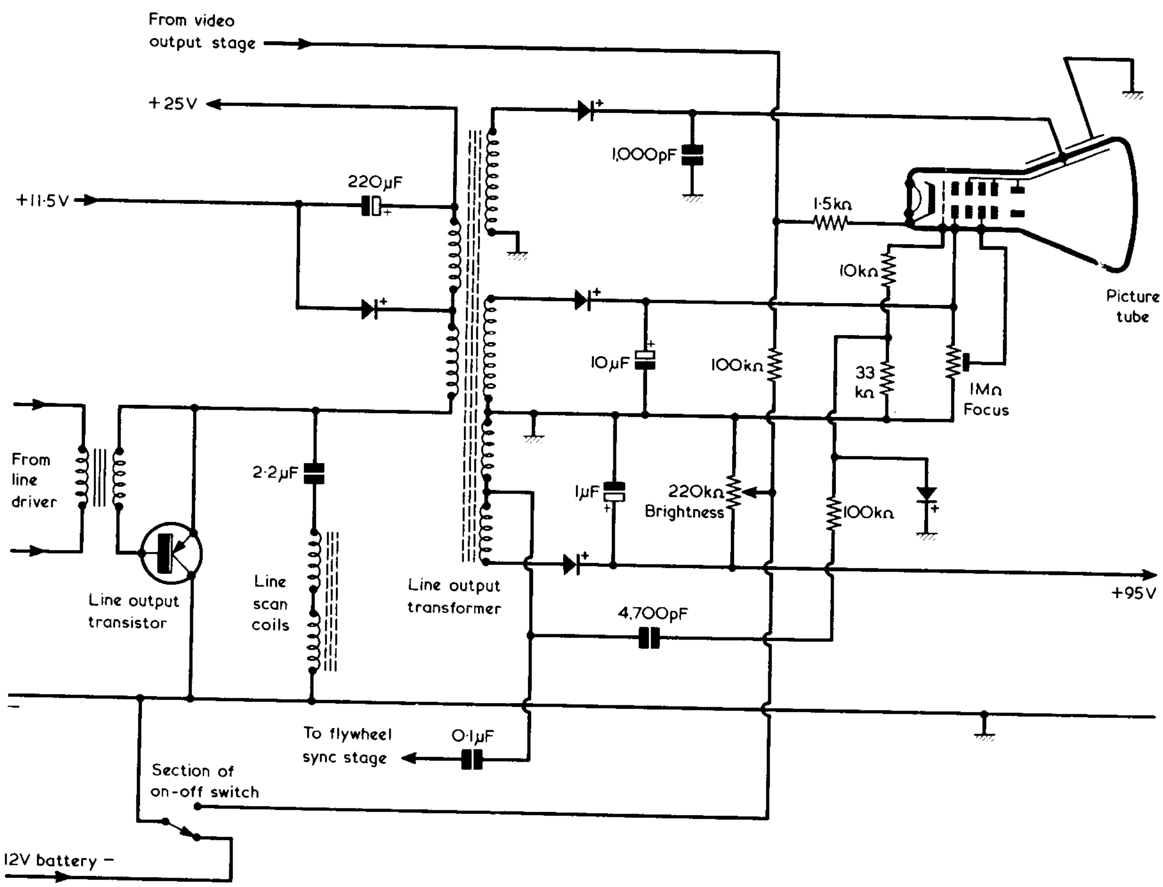


Fig. 2. Line output stage of a monochrome mains/battery television receiver. (This is a slightly simplified version of the circuit employed in the Thorn 1590-1591 Series of television receivers.)

He turned the control in an anticlockwise direction. The meter needle fell to a near-zero reading as the potentiometer slider reached the end of its track. He transferred one of the clips to the other end of the track, then adjusted the control so that its slider approached and reached the fully clockwise end of its track. This time the meter continually indicated a high resistance reading. It was obvious that Smithy's diagnosis was completely correct. (Fig. 1(b).)

"Hey, Smithy! You must be having me on!"

Absent-mindedly, Smithy looked round.

"I beg your pardon."

"I said you must be having me on. You must have had a look at this set yourself, because the fault was an open-circuit to the brightness control track, exactly like you said."

"Was it?" said Smithy, pleased. "Despite my declining years, I haven't lost my grip then. No, I haven't examined the particular set you've got there but I do know the model fairly well. I made a guess at the snag, working from that knowledge, and it looks as though my guess was pretty inspired."

"But I don't get it," wailed Dick. "How on earth can the symptoms of the screen lighting up at switch-off lead you so directly to the brightness control pot?"

Resignedly, Smithy rose and walked over to the filing cabinet in which the service sheets were kept. After some moments he removed a manual, carried it over to Dick and laid it alongside the television receiver. He opened out the pages bearing the receiver circuit and indicated the line output and picture tube section. (Fig. 2.)

"I need the receiver circuit to be able to answer your question," he remarked. "Now, if you look at that circuit you'll see there's a winding on the line output transformer which feeds scan pulses via a rectifier diode to a 1µF electrolytic and the brightness control pot."

"Here, hang on a minute, what's all this about scan pulses? And what's a winding doing on the line output transformer providing these scan pulses, anyway? I thought that all a line output transformer is supposed to do is to feed the line scanning coils and generate e.h.t. for the final anode of the picture tube."

"Even in an ordinary monochrome receiver where the h.t. is derived direct from the mains, the line output transformer does more than just that. It so happens that the set you have here is one of the popular current models which can run either from the mains or from a 12 volt battery. If you connect a battery to it the battery voltage passes to a stabilizing circuit which provides a regulated output of around 11.5 volts. And when you connect the mains to it, the mains is passed to a step-down transformer and a rectifier and smoothing circuit, the output of which also goes to the stabilizing circuit. So, whether it's mains or battery operated the set still has to work with a supply of only 11.5 volts."

BOOSTED H.T. SUPPLY

"Humph," grunted Dick. "Well, let's go back to the ordinary type of TV where the power supply is obtained direct from the mains. What extra job does the line output transformer do in these sets?"

"It provides boosted h.t.," replied Smithy promptly. "The simplest example here is given with the earlier sets having line output valves rather than line output transistors because the circuitry is a little easier to understand. Here's part

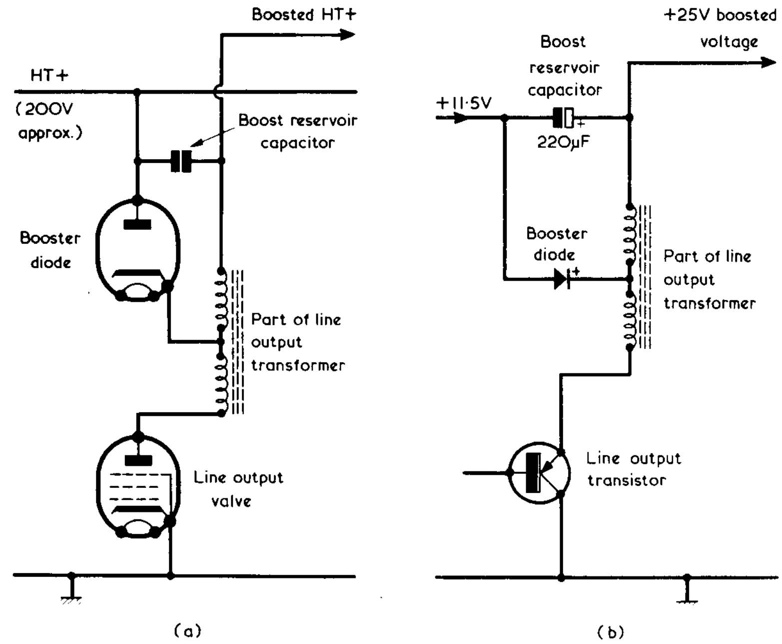


Fig. 3(a). A look at one of the earlier valve line output stages readily demonstrates the formation of a boosted h.t. voltage. With the h.t. voltage shown, the boosted h.t. voltage would be of the order of 500 volts

(b). Virtually the same circuit is given the more modern semiconductor version

of a typical valve line output stage."

Smithy pulled Dick's note-pad towards him, took out a pen and sketched out a circuit on its top page. (Fig. 3(a).)

"We haven't got time to go through the whole line output cycle," he went on, "but, as we're only interested in the boosted h.t. supply we need only consider part of it anyway. And I need only show you the line output transformer primary winding, which produces the boosted h.t. Now, during the latter half of the scan section of the line cycle, when the spot is being deflected horizontally across the screen of the picture tube, the line output valve is on and is drawing a continually increasing anode current from the positive h.t. rail through the booster diode, and through the line output winding below the cathode of the booster diode. Since the lower end of this winding is negative of the booster diode cathode, simple transformer action causes the top end of the winding, above the booster diode cathode, to be positive. The result is that the boosted h.t. reservoir capacitor charges up, causing a voltage which is considerably positive of the h.t. positive rail to be available on the terminal of the capacitor which connects to the top end of the winding."

"And that's the boosted h.t. voltage?"

"It is," confirmed Smithy. "The capacitor loses a bit of its charge during the first part of the scan section of the cycle but it still retains enough to provide a voltage which is considerably positive of the h.t. positive rail. With simple line output transformer circuits you can always find the boosted positive voltage, because it's sitting at the top end of the winding whose bottom end goes to the line output valve. Or, nowadays, to the line output transistor. In the older sets the boosted h.t. voltage was normally used to supply the frame timebase oscillator and do similar jobs where fairly high voltage was needed."

"Is there a boosted positive supply in this transistor circuit?"

Smithy pointed to the circuit in the service manual. (Fig. 3(b).)

"There it is," he stated, "right at the top of the line output transformer primary winding, just as with the valve version. Since the supply voltage in this set is only about 11.5 volts, the boosted voltage is correspondingly low. In practice it's approximately 25 volts, and it's used for supplying the i.f. stages and part of the video amplifier. But it does not supply the video output stage, which requires a much higher voltage."

Humph," repeated Dick.

He thought for a moment.

"What voltages, he asked, "does the line output transformer provide other than the boosted supply voltage?"

"As you've already mentioned," said Smithy, "it supplies the extra high tension voltage for the final anode of the picture tube. In this particular circuit the e.h.t. is provided by its own separate winding. Since the current drawn by the final anode is quite small, being about a tenth of a milliamp or so, the winding is connected so that it feeds positive-going flyback pulses to the e.h.t. rectifier. The consequent e.h.t. voltage, with this set, is then about 11kV." (Fig. 4.)

"Flyback pulses I can understand," complained Dick, frowning. "Just now, though, you were talking about scan pulses."

"Ah yes," said Smithy, picking up his pen again. "Well, let's next take a look at the voltage which is induced in that e.h.t. winding. It will have a waveshape something like this, with spaced-out high voltage pulses appearing at flyback and long comparatively flat sections between these pulses. The average voltage of the waveform will be just slightly above the flat sections, which represent the scanning part of the line output waveform during

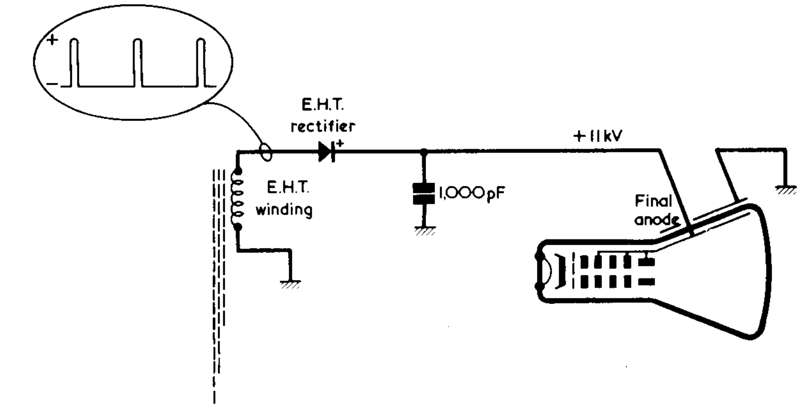


Fig. 4. The e.h.t. section of the line output stage. In most receivers the e.h.t. reservoir capacitor is given by the capacitance between the inside and outside graphite coatings of the picture tube. In this receiver a 1,000pF capacitor is added in parallel

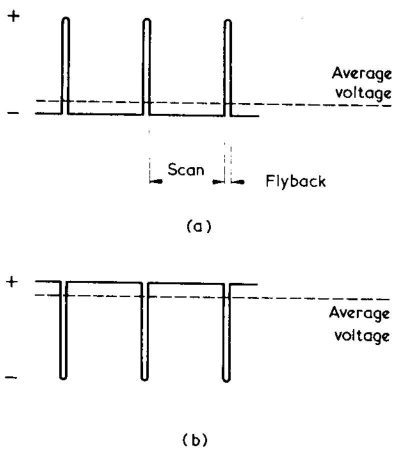


Fig. 5. According to the way connections are made to it, a winding on a line output transformer may produce flyback pulses which are positive-going with respect to chassis, as in (a), or scan pulses which are positive-going, as in (b)

which the spot travels across the picture tube screen."

Smithy drew the waveform with its average voltage carefully. (Fig. 5(a).)

SCAN PULSES

"Now that waveform," said Dick musingly, "is the one that's passed to the e.h.t. rectifier."

"That's right," agreed Smithy, "and, as we've already said, it's got positive-going flyback pulses."

An agonised expression creased Dick's face.

"I think I'm beginning to understand what this scan pulse business is about," he stated slowly. "Am I right in saying that it is all right to pass spaced-out positive-going flyback pulses to the e.h.t. rectifier because the e.h.t. current is so small?"

"You are. The e.h.t. reservoir capacitor is charged up by each pulse, and the small e.h.t. current only discharges it a little bit before the next pulse comes along."

"Right," said Dick briskly. "Now what happens if we want the line output transformer to supply a circuit that requires a high current? could we do that by turning the waveform upside-down so that the flyback pulses go negative?" (Fig. 5(b).)

"We could."

"Blimey," remarked Dick delightedly. "I think I've discovered something here! If we turn the waveform upside-down so that the scan sections are positive-going and then apply *this* to the rectifier, we'll also get a positive rectified voltage output. The positive input to the rectifier will be present nearly all the time too, won't it? That is to say, not spaced out like the flyback pulses are. This means that the rectified output will be much better regulated and will be able to supply quite a high current with only a small value of reservoir capacitor."

"You're exactly right."

"Am I? Gosh!"

"To use the usual terms," continued Smithy, "you can get a much higher rectified output current from scan rectification than you can from flyback rectification. But there's a snag."

"When isn't there?"

"Can you," asked Smithy gently, "see it?"

"Let me think about it," said Dick. "Now, when we have flyback rectification the peak rectified positive voltage will be the voltage by which the flyback peaks go positive of the waveform average voltage. I think that's right, isn't it?"

"Apart from the very small forward voltage dropped in the rectifier, which can be ignored here, you're completely right."

"Good," said Dick, encouraged. "Then, when we use scan rectification, the peak rectified voltage is the maximum amount by which the scan part of the waveform goes positive of the average voltage. For a given line output transformer winding this will be very much smaller than the peak flyback rectification voltage. Now, what does that bring us to?"

Suddenly his face lit up.

"I've got it!" he said excitedly. "I've got it! If you want a certain rectified voltage with scan rectification you need a lot more turns on the line output transformer winding than you do to get the same voltage with flyback rectification."

"That," remarked Smithy approvingly, "is it precisely. The last thing the TV set-maker wants to do is to put an unnecessary number of turns on the line output transformer and so, if he wants to obtain a supply voltage for a low current circuit, he uses flyback rectification. It is only when the supply voltage has to feed a high current circuit that he uses scan rectification. The polarity of the waveform is governed, of course, by the end of the winding which is connected to chassis. In this particular TV circuit we've already seen the flyback rectification for the e.h.t. supply. Can you see another case of flyback rectification?"

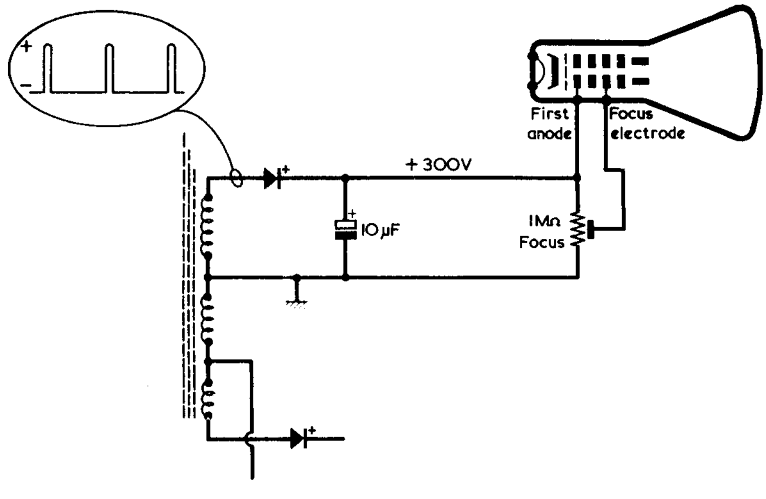


Fig. 6. Flyback rectification is used to feed the tube first anode and the focus potentiometer

FOCUS CIRCUIT

Dick peered anxiously at the circuit.

"Could it," he asked eventually, "be after the winding which supplies the focus pot circuit?" (Fig. 6.)

"You've hit it first go. Dear me, you're in very good form today."

"I must admit," stated Dick modestly, "that I have the occasional flash of genius."

"Right, then . . ."

"Down at Joe's Caff, for instance, they look upon me as being exceptionally brainy."

"Okay, so let's . . ."

"Naturally, I have to draw a cloak over my brilliance."

"This flyback rectification . . ."

"Otherwise people might look upon me as being big-headed."

"Will you flaming well belt up!"

"Blimy, Smithy, what's up with you?"

"I want to get on with this discussion," retorted Smithy heatedly. "Not listen to you and your mouth."

"Fair enough," replied Dick equably. "Well, if you remember, we were talking about the flyback rectification bit which, as I just pointed out, is used in the focus control circuit."

Smithy slowly simmered down.

"And," he grated, "you were right in pointing out that flyback rectification is used there. Now, let me collect my thoughts. Ah yes! The associated winding on the line output transformer applies positive-going flyback pulses to the rectifier and the following 10µF reservoir capacitor, and the resultant positive voltage then supplies the focus pot, the slider of which connects to the focus electrode of the tube. The rectified voltage, which is around 300 volts, also goes to the first anode, incidentally. The first anode and the focus electrode both draw very small currents and so flyback rectification is quite in order here."

"There's another rectifier," remarked Dick, "and that's at the bottom of the same winding which passes positive-going flyback pulses to the focus pot circuit rectifier. There's a chassis tap into the winding in between, too." (Fig. 7.)

"And that," remarked Smithy, "is the scan rectification circuit I referred to right at the beginning. From the way that the complete winding is drawn in the diagram you would expect the waveform at its bottom end to be of opposite polarity to that at the top end. And so, in practice, it is. This last part of the line output transformer circuit gives scan rectification and a relatively high voltage, of the order of 95 volts, appears across the 1µF reservoir capacitor following the rectifier. This voltage feeds the collector load of the video output transistor. It also feeds the brightness control pot, which is the one you found to be faulty. It will be almost certain that the track was open-circuit at the high brightness end, where it connects to chassis."

"That's right," agreed Dick. "It was the end where the knob was turned fully clockwise. Which reminds me all over again: how on earth did you know that the fault was there?"

"Because this particular set has a rather unusual on-off switching circuit which we haven't talked about yet," replied Smithy. "The on-off switch has three poles, two of which switch the mains supply whilst the third switches battery negative to chassis when the set operates from a 12 volt battery. When this third pole goes to the 'off' position it connects the slider of the brightness control pot to chassis, whereupon the tube passes a fairly heavy current between cathode and final anode, and largely discharges the e.h.t. reservoir capacitance. The result is that you don't get that little spot appearing on the centre of the screen after you switch off whilst the tube cathode is still hot. Also, you don't have a lot of e.h.t. volts hanging around."

"Of course, of course. I see it now!" said Dick. "When the set was on, the open-circuit to the pot track meant that the tube cathode was always highly positive with respect

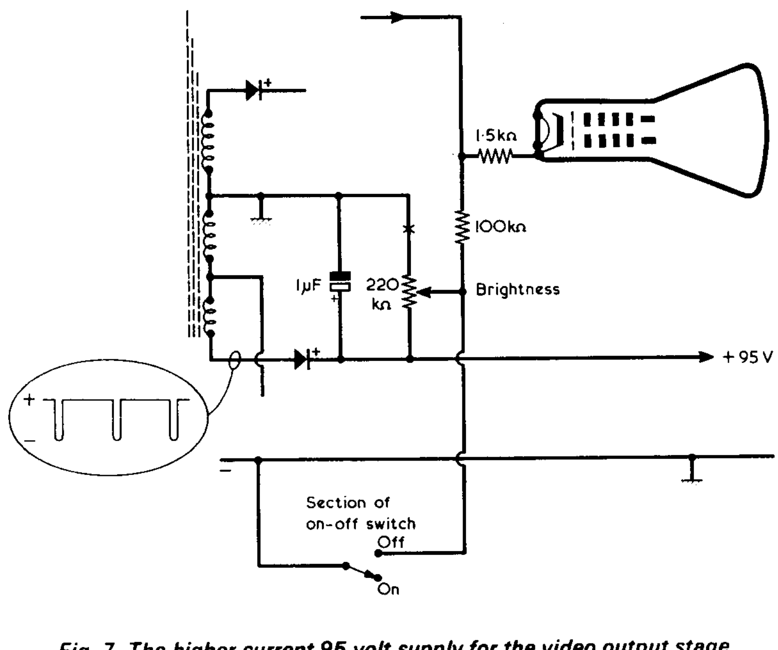


Fig. 7. The higher current 95 volt supply for the video output stage is provided by scan rectification. The cross indicates the position of the open-circuit in the faulty brightness control potentiometer

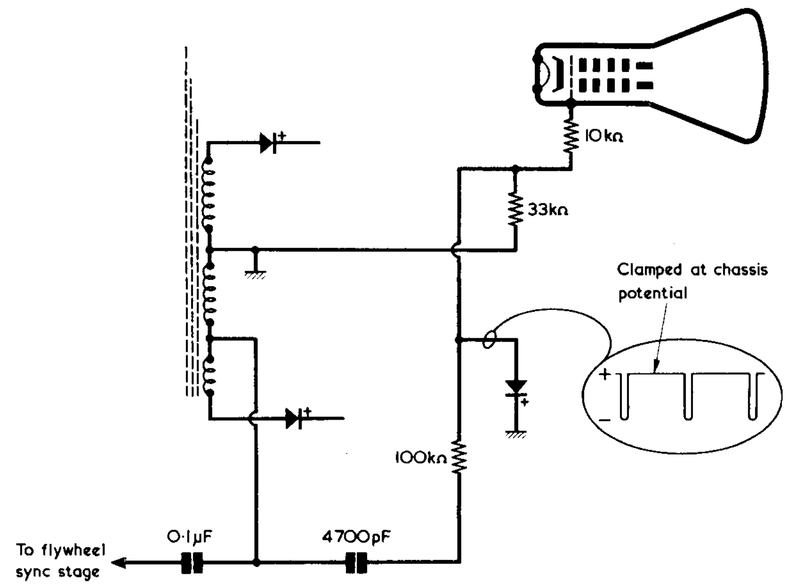


Fig. 8. Yet some further outputs from the line output transformer. The tap in the lower winding provides line blanking pulses for the picture tube grid together with negative-going flyback pulses to the flywheel sync stage

to the tube grid regardless of the position of the pot slider. Switching off shorted the pot slider to chassis and took the tube cathode sufficiently negative for the tube to pass current and light up the screen. It's obvious now, when you look at it."

POWER HOUSE

"Exactly," chimed in Smithy. "Taking the tube cathode highly positive of the grid caused the tube to cut off, because this is the same as taking the grid highly negative of the cathode. As you can see from the main circuit, the grid is held at chassis potential by way of the 10kΩ and 33kΩ resistors which couple it to the chassis. So there you are, Dick. You've got a TV set in front of you which has a positive supply rail of only 11.5 volts feeding the line output stage. And the line output stage, with its transformer, acts like a veritable power house. It knocks out a boosted supply voltage of around 25 volts for the i.f. stages and some of the video circuitry, it produces an e.h.t. voltage of about 11kV for the final anode of the tube, it generates some 300 volts for the tube first anode and the focus potentiometer and, finally, it gives 95 volts for the video output transistor and the brightness control circuit. That's not bad going for just one stage."

"I'll say it isn't," agreed Dick. "Stap me, Smithy, I've just noticed another diode! There's a tap in that last winding we dealt with and it connects via a 4,700pF capacitor and a 100kΩ resistor to this diode. It also goes by way of a 0.1µF capacitor to another part of the circuit. Blimey, there's no end to the external circuits which are tacked on to this line output transformer!" (Fig. 8.)

"That last diode," chuckled Smithy, as he glanced down at the service manual, "is in the line blanking circuit, and it clamps the waveform with positive-going scan pulses so that the most positive parts are held at chassis potential. The result is that the grid of the tube is at chassis potential during the scan period and then goes negative during the flyback period, causing the tube to be cut off during that period. And the waveform passed via the 0.1µF capacitor goes back to the line flywheel sync diodes. The important parts of the waveform in this case are the negative-going flyback pulses. These make the flywheel sync diodes conductive, but I don't intend to start digging into *that* part of the circuit now. Especially as the only thing that started off this particular gen session was a faulty brightness control pot!"

"Well," said Dick, "you've certainly opened my eyes so far as the line output stage of this set is concerned. It's a very busy little stage, isn't it?"

It certainly is," replied Smithy. "Which reminds me that it's time that I became busy too, and got back to my work instead of spending my time nattering away like this."

"Still, it's nice to have a little break from work every now and again."

"I suppose so," conceded Smithy, "provided it doesn't happen too often."

"With us," grinned Dick, "it only happens once a month!" ■

Radio Topics

By Recorder

ARALDITE PACKS

I should imagine that few readers will require an introduction to that excellent adhesive, Araldite. In the Recorder household, for instance, this epoxy resin has been used for many jobs ranging from the mounting of radio components on a chassis to the successful blocking of holes in, of all things, an enamel bucket. In industry, Araldite is widely employed for the potting of components and small electronic assemblies. And it is made up by combining the requisite amounts of resin and hardener.

Araldite has been available in two-part sachets containing 500 grams of the material for industrial potting applications, and the manufacturer now announces the introduction of smaller 200 gram sachets. These should be of special interest to users who need to employ potting resins only occasionally, or whose applications do not merit the use of an automatic metering machine to obtain the correct mixture of resin and hardener.

Araldite from a 200 gram sachet being poured to form a small potted assembly. The resin and hardener are in separate halves of the sachet, being brought together just before use by removing a clip

The 200 gram pack is in two parts, one containing the resin and the other the hardener, with the two sections kept apart by means of a clip. When the clip is removed the two component materials come into contact with each other and can be thoroughly mixed by manipulation. The bag is then pierced at one end and the mixture squeezed out to be used as required. In the photograph it is being poured into a can containing electronic components. As can be seen, there is no requirement for the operator to come into physical contact with the mixture at all.

The performance of epoxy resins can depart from specification if the two components are not mixed in the correct ratio, and the two-part sachet is a good way of ensuring that optimum performance is achieved. The resin and hardener differ in colour, whereupon the operator has a visual means of checking that they are thoroughly mixed before use.

The mixture consists of CW 1404 GB resin and HY 956 hardener. This has a low shrinkage on curing, low exothermic temperature rise and a low coefficient of thermal expansion. As with other epoxy resins, the electrical properties are particularly good.

The hardener was chosen to give the mixture rapid curing properties at moderate temperatures, and it is therefore particularly suitable for small castings. The mixture will cure fully at 25°C in 24 to 36 hours, but will cure in as little as 3 hours at 60°C. Once mixed, the system has a life at 25°C of about 2 to 3 hours. Further details on the 200 gram sachets may be obtained from Ciba-Geigy Plastics and Additives Company, Plastics Division, Duxford, Cambridge, CB2 4QA.

DOING TIME

Although we do not always pay much attention to the fact, as soon as we change, in any electrical or electronic work, from direct voltage and current to alternating voltage and current we are introducing a completely new dimension. All alternating quantities, whether they be the u.h.f. television signal you pick up on the roof-top aerial, the audio output from a hi-fi amplifier, or the mains supply which is brought to us by courtesy of the Central Electricity Generating Board, are precisely defined in terms of time. It may be that the time element becomes partly hidden because virtually all the measurements are expressed as the number of cycles which exist within the fixed period of 1 second. The change of terminology from cycles per second to Hertz may also be responsible for shifting the time concept one layer lower in our thinking.

We can control the timing of electronic circuits by mechanical means, as with a quartz crystal, or by purely electronic means. In the latter case we take advantage of the properties of capacitance and inductance, of capacitance and resistance or inductance and resistance. When we combine capacitance and inductance we have, of course, a tuned circuit. Capacitance and resistance can be directly related to time because we can make up oscillators which are dependent upon the time taken for a capacitor to charge or discharge, via a resistor, to a specific voltage. Notable examples here are the two-transistor symmetrical multivibrator and circuits incorporating the 555 timer i.c. It is a lot more difficult to give an example of timing control by inductance and resistance, so far as generating an alternating voltage is concerned, because it is impossible in practice to obtain inductance on its own without self-capacitance stealing onto the scene. A blocking oscillator incorporating an iron-cored transformer is a rough approximation to frequency control by means of inductance and the inevitable resistance in the inductance, and the inductance of a TV line output transformer (and the line scanning coils) certainly controls the timing of a line output stage during the scanning section of the line output cycle.

Perhaps the most fascinating of time controlling circuits are those employing capacitance and resistance, because it is so easy to select the timing by choice of capacitance value. If you haven't got an oscilloscope available and you want to see the waveform given by, say, a 555 oscillator, you can simply slow it down a bit by using a large value electrolytic for the capacitance. Several hundred microfarads in conjunction with resistances in the order of 100kΩ can give an overall cycle lasting some 10 or 20 seconds. Just connect a voltmeter across the output of a 555 slowed down in this manner and you can *see* its waveshape.

It pays every now and again just to remember that all the alternating voltages and currents we deal with are all accurately determined in what is perhaps the most ephemeral dimension of them all: time itself. ■