THE

RADIO CONSTRUCTOR

RADIO · TELEVISION · ELECTRONICS · AUDIO

VOL. 22 NO. 7

FEBRUARY 1969

3/-

A DATA PUBLICATION

SOLID-STATE AUDIO GENERATOR

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5-Band Preselector

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Scottish Insurance Corporation Ltd

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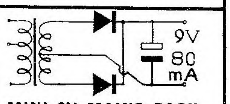

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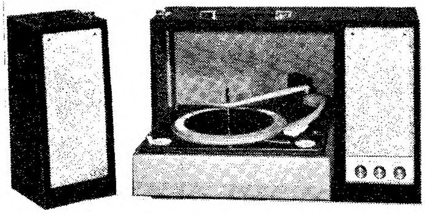

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- **Completely assembled Record Changer deck. Simply drop in and connect a few wires**
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2N4291 pnp 40V hFE over 100 at 100mA
2N3794 npn 40V hFE over 100 at 100mA complementary driver/output.
2N4292 npn 30V UHF N.F. 6dB max at 100MHz. fT 570MHz typ.
B5041 Power 1403W at 100°C base temp. 35V, hFE over 100 at 0·5A, Insulated T066 size mounting surface
Prices: 2N4285 to 2N4292, 2N3794 **2/11**; B5041 **13/6.**

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5-BAND PRESELECTOR

by

D. W. EASTERLING

Covering long waves, medium waves and short waves up to 30 Mc/s, this 2-transistor preselector is primarily intended to improve the r.f. performance of the more inexpensive class of communications receiver. Constructional and wiring problems are eased by the fact that only one coil is switched into circuit for each band, or range, covered. A list of suitable coils is suggested, but the simplicity of the tuning arrangements will allow many constructors to use coils that are already on hand

THERE ARE QUITE A NUMBER OF LOW-COST communications receivers on the market which offer good Dx performance but which suffer from the lack of an r.f. stage. The writer has a receiver in this category which tunes continuously from 500 kc/s to 30 Mc/s and is provided with very good bandspread and a clear dial.

This receiver has a built-in ferrite rod for medium waves, whilst a telescopic whip aerial is supplied for use on the short waves if required. But when a good outside aerial is applied the disadvantage of having no r.f. stage becomes at once apparent. Selectivity is not fully satisfactory and second channel interference becomes noticeably more significant as the operating frequency increases.

The preselector described here was built to overcome this problem. A preselector is, simply, a tuned r.f. stage which is connected between the aerial and the main receiver. It has, of course, to cover the same frequency range as the receiver, and so the operator has to contend with an additional wavechange switch and tuning control. In practice, however, operation is simple; the preselector is set roughly to the required frequency, the main receiver tuned in in the normal way, and the preselector finally adjusted for best results. The added r.f. selectivity provided by the preselector then ensures that second channel interference is very considerably reduced. It also improves signal strength as well.

The author's unit is cheap and simple to build. It may be used with any set and will, in particular, enhance the

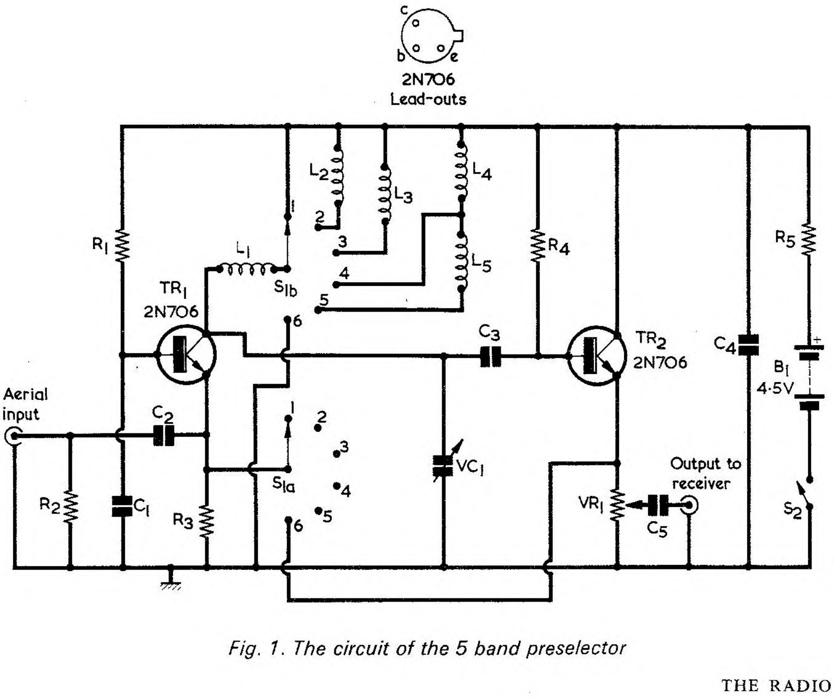
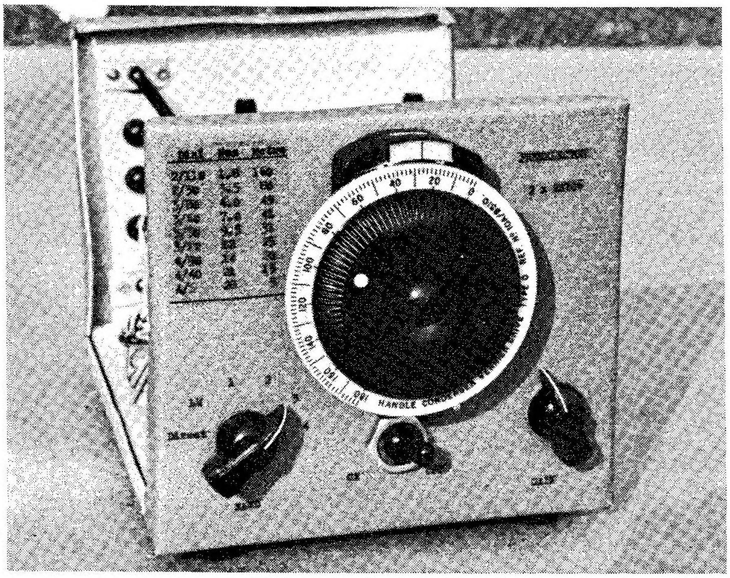


Fig. 1. The circuit of the 5 band preselector



Front view of the preselector

performance given by short wave receivers without an r.f. stage. It has other applications as well. Two typical examples are its use with a transistor portable in a car or caravan, or to improve the reception of Radio 1 or Radio 2 in localities where either of these signals is difficult to receive.

COMPONENTS

Resistors	
(All fixed values $\frac{1}{4}$ watt 10%)	
R_1	100kΩ
R_2	10kΩ
R_3	1kΩ
R_4	100kΩ
R_5	470Ω
VR_1	1kΩ, potentiometer, linear
Capacitors	
C_1	0·01μF, paper or plastic foil
C_2	1,000pF, silver-mica
C_3	10pF, silver-mica
C_4	0·1μF, paper or plastic foil
C_5	1,000pF, silver-mica
VC_1	500pF variable, air-spaced
Inductors	
L_1–L_5	See text
Transistors	
TR_1	2N706
TR_2	2N706
Switches	
$S_{1(a)\,(b)}$	2-pole 6-way rotary (see text)
S_2	s.p.s.t., on-off, toggle
Battery	
B_1	4·5 volt battery type 126 (Ever Ready) or as required
Miscellaneous	
1 slow motion drive and scale	
2 pointer knobs	
Coaxial cable and connectors	
Tagboard, 2 x 10-way	
Wire, material for case, etc.	

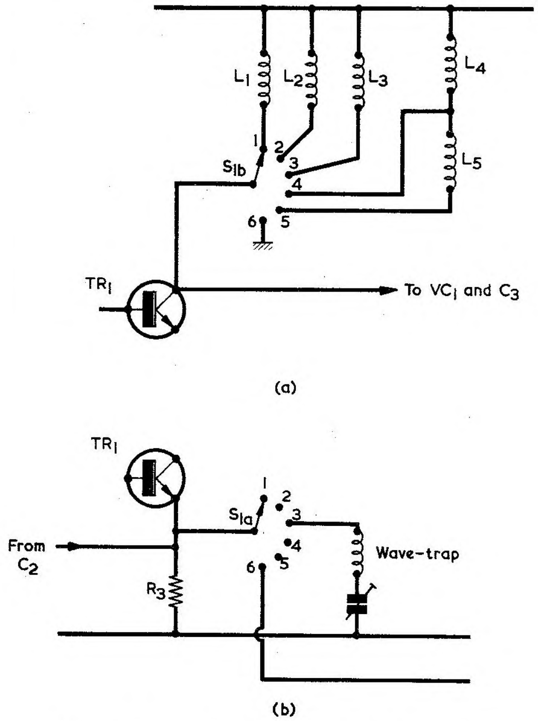


Fig. 2(a). This alternative method of connecting L_1 into the S1(b) switching circuit may be of assistance with some coils

(b). In the prototype a wave trap was switched into circuit on Range 3 to combat local interference

THE CIRCUIT

Reference to Fig. 1 will show that two 2N706 silicon transistors are used. Although these are designed mainly for high speed switching, they were found to work well in this application, and have the advantage of being extremely cheap on the surplus market. The aerial is fed via C_2 to the emitter of TR_1, which operates in the grounded base mode; its base being biased by R_1 and bypassed to chassis by C_1. The input is low impedance and untuned, and is consequently suited to most simple aerials including the wire dipole favoured by many Dx listeners. The only tuned circuit is in the collector of TR_1, and from here the output is taken to the base of TR_2 which operates in grounded collector. TR_2 provides a low output impedance for connection to the receiver via a short length of coaxial cable.

The tuned circuit in the collector of TR_1 is the appropriate coil selected by $S_{1(b)}$ in parallel with the tuning capacitor VC_1. For ease of operating, it was decided to arrange matters so that the preselector ranges had approximately the same coverage as those of the receiver, but since a spare 2-pole 6-way switch and long/medium wave coil were to hand, it was decided to provide long wave coverage as well. The sixth position of the range switch enables the transistors and tuned circuit to be bypassed. For convenience in wiring L_1 (the highest frequency coil) is in series with the wiper of $S_{1(b)}$ so that it is in circuit on all other ranges as well. No ganging is involved, and so the small extra inductance is unimportant.

Since only one coil is switched in for each range and there are no complications due to taps or coupling windings, the provision of coils L_1 to L_5 is a simple matter. In the prototype the writer employed short wave coils that were already on hand, removing turns where necessary to cover the required frequency range. A grid dip oscillator facilitates this task, although it is, of course, possible to find the coverage of an individual coil after the rest of the preselector has been completed by working with the receiver. The ranges provided are shown in the Table. It is not necessary for the constructor to obtain exactly the same coverage for each range as was chosen by the writer and he can employ whatever coils he wishes. In some cases it may be found more convenient in this respect to use the alternative coil switching circuit shown in Fig. 2(a), in which coil L_1 is switched in only on Range 1 and is not in circuit all the time. However, the Fig. 1 circuit has the important advantage of enabling L_1 to be wired into circuit with short leads.

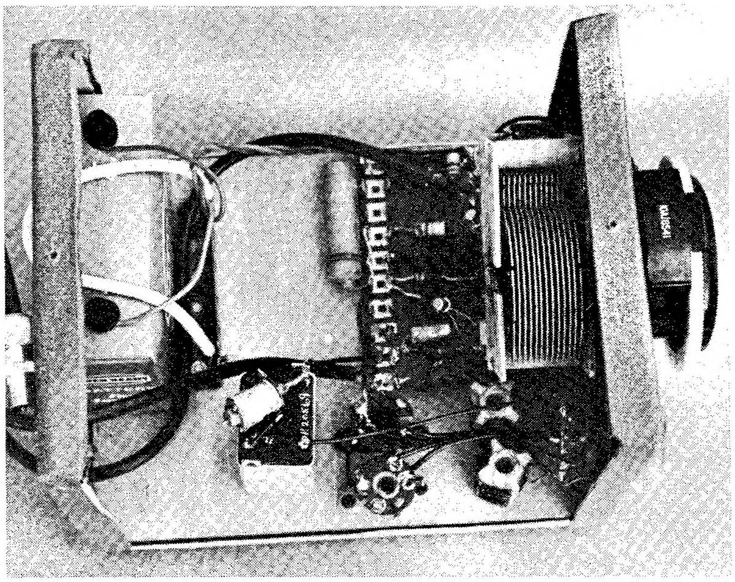
TABLE

Range coverage with the prototype

S_1 position	Range number	Range (meters)	Range (frequency)
1	1	30–10	10–30 Mc/s
2	2	60–25	5–12 Mc/s
3	3	200–50	1·5–6 Mc/s
4	4	540–190	550–1,600 kc/s
5	5	2,000–700	150–430 kc/s
6	Preselector bypassed		

If the constructor has no suitable short wave coils on hand, the frequency ranges can be provided by the following Teletron coils: Range 1, Teletron HFA4; Range 2, Teletron HFA3; Range 3, Teletron HFA7. A suitable dual range coil for L_4 and L_5 is the Repanco coil type DRR2. Note that it is the medium wave winding of this coil which is connected in the L_4 position, with both windings in series for long waves. In all cases, no connections are made to any coupling or reaction windings on the coils employed. (The Teletron coils are available from Home Radio (Components) Ltd.—EDITOR.)

On position 6, switch section $S_{1(a)}$ bypasses the main circuit and allows the aerial to be fed direct to the receiver. At the same time, $S_{1(b)}$ renders TR_1 inoperative. The writer found that the direct connection offered by $S_{1(a)}$ was not of great practical use and the facility can be omitted, if desired, whereupon it becomes possible to employ a single pole, instead of a double pole, switch for range



Top view of the unit.
The 4·5 volt supply is provided
by a bell battery

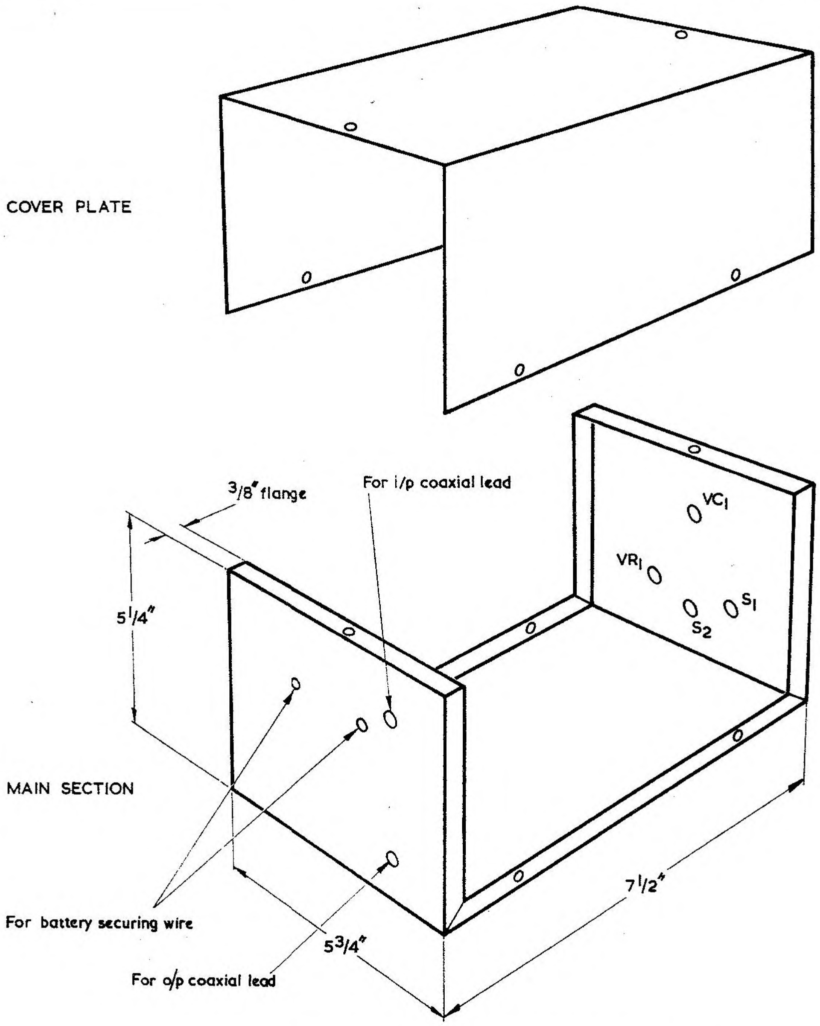


Fig. 3. Outside dimensions and method of assembling the case. The holes for controls, etc., may be positioned to suit the components employed

selection. In the writer's case, local conditions made it desirable to retain $S_{1(a)}$ for another reason and it performed the secondary function of switching in a wave-trap on position 3, as shown in Fig. 2(b). The writer lives near a powerful radio beacon which produced interference on Range 3 and this was cleared by the added wave-trap. It is doubtful if many readers will have the same problem, but the writer mentions the approach adopted in his own case as it will be of general interest. In the accompanying photograph, the wave-trap can be seen in the form of a screened coil with a trimmer mounted above it. The wave-trap is tuned to the fundamental frequency of the beacon (which is considerably higher than the band of frequencies in Range 3) and it is possible that the interference it causes on Range 3 is due to shortcoming in the main receiver.

The input and output circuits of TR_1 are in phase, and leads in these circuits should be spaced from each other to prevent excessive regeneration. The writer found that there was a tendency towards oscillation on Range 2, and this was cleared by connecting a 10kΩ resistor across L_2. (This 10kΩ resistor is not included in the components list.)

It was found impractical to apply a.g.c. to the preselector, but manual r.f. gain is an advantage. Several methods were tried, and finally it was a choice between a potentiometer in the emitter of either TR_1 or TR_2. As there is no tendency for strong signals to overload the preselector under normal conditions, the control was inserted at the output end in the emitter circuit of TR_2, where a marginal improvement of signal/noise ratio could be obtained.

Optimum performance is given when the unit is running at about 3·5 volts, when the total current drain is just under 2 mA, and so it was convenient to use a 4·5 volt battery with its voltage dropped by the R_5C_4 network. Higher voltages can be used provided the value of R_5 is adjusted to produce a supply potential between 3 and 3·5 volts. A separate on-off switch is employed, but it could alternatively be ganged with VR_1.

Capacitors C_2 and C_5 provide d.c. isolation between the preselector and its external connections, and resistor R_2 prevents any static build-up on the aerial. The preselector output may be coupled to the aerial and earth terminals of the mains receiver. *If the latter is of the a.c./d.c. type having its chassis connected to one side of the mains, adequate isolating capacitors must be connected in series with its aerial and earth input terminals, and the preselector chassis must be connected to a reliable earth.*

CONSTRUCTION AND OPERATION

The preselector is housed in a metal case which also acts as a chassis. The case used for the prototype is shown in Fig. 3, and consists of two U-shaped sections. The main section has a $\frac{3}{8}$in flange on all edges and is drilled to take the panel components; the other section is a cover plate and is secured to the flanges of the main section by small self-tapping screws. This case is larger than necessary because the height and depth dimensions were chosen to match those of the receiver. It was possible therefore to use standard components and a large 4·5 volt bell battery. A $\frac{3}{8}$in plywood baseboard is recessed within the lower flanges and helps to give the unit weight and prevent it moving about when being tuned. It also provides a convenient means of mounting the components. Other constructors may well prefer to build a smaller and lighter case, but a description of the method adopted by the writer for his own version may still be of assistance.

Aluminium sheet was used, this being drilled and bent to shape before receiving two coats of grey paint. A two-tone effect was produced by covering the front and back panels with self-adhesive vinyl film (Contact or Fablon). Red mottle was chosen by the writer, but other shades are available. The material is laid uncut over holes in the metal and, whilst held firmly fixed, holes are pierced in it with a sharp point and the unwanted material removed with a medium file.

With the case painted and panels covered, the components may be fitted. Thin washers were inserted below the control fixing nuts to prevent damage to the vinyl film. The coils were screwed direct to the wooden baseboard, as was the tagboard which is used for mounting the smaller components including the transistors. The battery is secured by a length of plastic-covered curtain wire which loops from two eyes in the baseboard over the battery, and passes in and out of two holes drilled in the back panel.

The writer used an ex-R.A.F. slow motion drive for VC_1. A suitable alternative could be the Eagle Products T502 drive.

The layout was not found to be critical, but care must be taken to keep the r.f. connections—and particularly those in the tuned circuit switched by $S_{1(b)}$—as short as possible. The two high frequency coils (L_1 and L_2) were mounted nearest the range switch. The transistors were the last to be wired in, and precautions were taken to ensure that they were not subjected to prolonged heat. The battery was not connected until the unit was completed and carefully checked. Because no non-reversible plug was used with the particular battery employed, coloured leads connect to the battery: red for positive and black for negative. Input and output are taken by coaxial cables passing through holes in the back of the case.

The operation of the preselector has already been described, and it will be appreciated that a simple tuning calibration chart is of assistance. This was placed on the front panel of the prototype. The chart enables the tuning to be positioned somewhere near the optimum point; the final tuning being carried out by ear or by reference to the receiver signal strength meter. A little practice soon teaches the operator how to avoid the second channel. Chart calibration is obtained direct from that of the receiver, and it will be found that a signal generator is more convenient than broadcast signals as a signal source.

CAN ANYONE HELP ?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time

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Ferranti RP1008 Record Player.—N. I. Hookwars, 42A Marpool Hill, Exmouth, Devon—nomenclature of valve types used in this player.

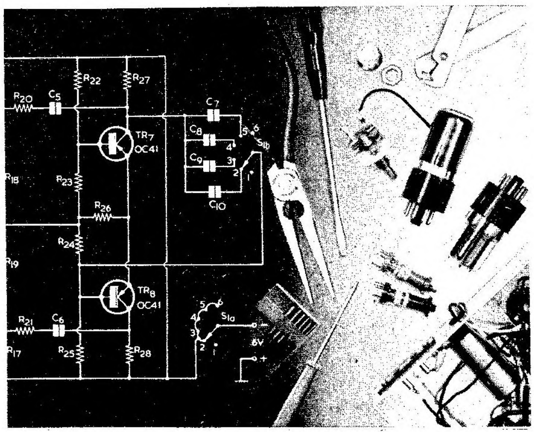
Amplifier for WS No. 19 Mk III.—G. R. Morse, Christowe, Sandford Road, Cheltenham, Glos.—circuit required of any home made design, either valve or transistor.

22 Set.—J. Walwyck, 321 Parkside Avenue, Barnehurst, Bexleyheath, Kent—loan or purchase of circuit or manual.

Magnaphon Tape Recorder.—R. J. Burr, 64 York Avenue, Sidcup, Kent—circuit or manual, loan or purchase, this recorder fitted with Motek tape deck and twin speakers.

Cossor Oscilloscope 1045K.—T. Bogg, 37 Toronto Road, Ilford, Essex—loan or purchase of manual.

SUGGESTED CIRCUIT No. 219



SIMPLE REMOTE ON-OFF SWITCH

by G. A. FRENCH

THE WRITER WAS AGREEABLY surprised, when reading "Radio Topics" in the last October issue of *The Radio Constructor*, to see a detailed reference to a remote on-off switching circuit which had originally appeared in a very early article in the "Suggested Circuit" series. Briefly, this circuit employed a relay which was initially energised by a remote battery and which then became "held-on" by the h.t. supply in the controlled equipment. The relay was de-energised by short-circuiting it from the remote point.

The circuit was popular with constructors when it first appeared and, after reading the piece by "Recorder", it occurred to the writer that it could be readily brought up to date by taking advantage of one simple component—a silicon rectifier. The writer hastens to add that the original circuit appeared many years before silicon rectifiers became available!

CIRCUIT APPLICATION

So far as application of the control circuit is concerned, it is intended for switching on and off an item of mains operated equipment from a remote point, the equipment being, say, a transmitter, receiver or amplifier. If the equipment and the remote control point are in separate buildings or, even, separate rooms in a single building, the wiring between them should not, for a number of reasons including safety requirements, be at mains potential. A simple solution to this switching problem consists of fitting a relay at the equipment end, this being controlled via a low voltage circuit from the remote point. Unfortunately, a relay consumes current continually when it is energised whereupon it becomes necessary to either devise some means of obtaining a low voltage supply from the mains or to use a battery. However, neither of these approaches is very attractive. The provision of a low voltage supply from the mains introduces unwanted complications, whilst the second alternative is expensive due to the necessity of making frequent battery replacements.

The revised remote on-off switching control circuit which will now be described suffers from none of these disadvantages. It employs a battery (sited at the remote position) but this battery is required to provide relay energising current for very short periods only and its life should not be much shorter than its shelf life. The only limitation with the circuit is that the controlled equipment must have an isolating mains transformer in its power supply section.

The circuit appears in Fig. 1 and it will be seen that it is basically very simple. Let us assume for the moment that the controlled equipment employs valves and that it has the conventional h.t. positive supply rail which appears in such equipment, the chassis being at h.t. negative potential. This chassis is isolated from the mains and one of the remote leads is connected to it.

We may start a description of circuit operation with the switch at the remote point in the "off" position. Under this condition the relay is de-energised and its contacts, RLA1, are open. The equipment is, in consequence, switched off. When the remote switch is set to "On" the battery couples to the relay coil via silicon diode D_1, the switch and the remote lines. The relay energises, causing its contacts RLA1 to close and the mains supply to be applied to the equipment. An h.t. voltage appears almost immediately if the equipment has a solid-state rectifier (e.g. silicon or selenium). If it has a valve rectifier, there is a short delay before an h.t. voltage becomes available. In either case as soon as the h.t. voltage appears a current flows through R_1 to the relay coil, R_1 having a value which causes the voltage across the coil to be slightly higher than that provided by the battery In

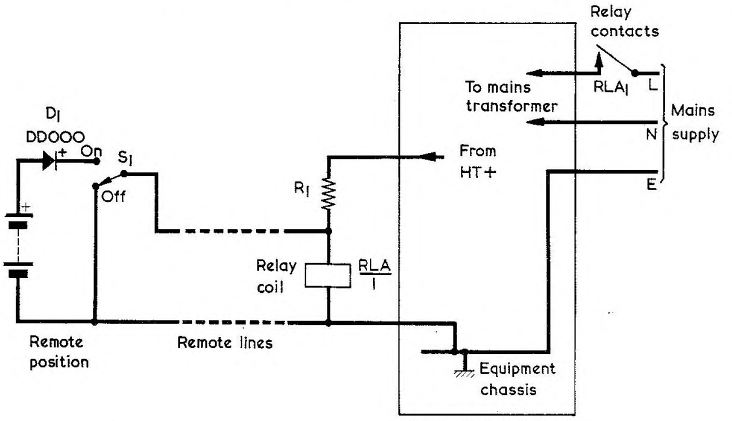


Fig. 1. The circuit of the remote control system. Current is drawn from the battery for short periods only

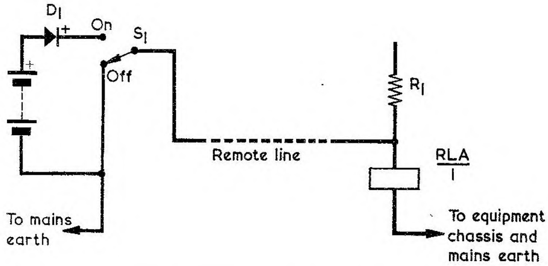


Fig. 2. If a reliable mains earth is available at the remote position only one remote line is needed

consequence, the upper terminal of the relay coil goes positive of the battery positive terminal, and diode D_1 becomes reverse-biased. Thus, the relay now remains energised by way of current from the equipment h.t. supply, and the only current drawn from the battery at the remote point is the negligibly low leakage current in the reverse-biased silicon diode.

To switch off the equipment the remote switch is set to "Off". This causes the relay coil to be short-circuited by way of the remote lines and it becomes de-energised. Its contacts RLA1 now open and the controlled equipment is switched off. It then remains in this condition until the remote switch is set to "On" again.

As will be gathered from this description, the battery is only required to provide energising current for a short period after the remote switch is thrown to "On". If the controlled equipment has a solid-state h.t. rectifier the period during which it provides current will be very short indeed. With a valve rectifier the period is extended, its length depending on whether the rectifier is directly or indirectly heated, but it will still be quite short.

PRACTICAL EXAMPLE

To give an idea of the currents and voltages involved, the writer checked out the circuit with a P.O.3000 relay having a 500Ω coil which was on hand. This had a single set of make contacts, as is required here. It was found experimentally that the relay energised at 6 volts and, so, to allow for battery ageing and the fact that some 0·5 volts is dropped across the forward-conducting silicon diode, it was arbitrarily decided to use a 9 volt battery at the remote position. In practice, this could be a PP9 battery, or similar. At the same time, a suitable choice for the silicon rectifier, D_1, would be the Lucas DD000.

It is next necessary to find the required value for R_1 and this depends, amongst other things, on the h.t. voltage available in the controlled equipment. In the writer's case an amplifier having a nominal h.t. voltage of 200 volts was used. When current flows from the h.t. supply into the relay coil via R_1 it should cause a slightly higher voltage to be dropped across the coil than is provided by the battery. A voltage of the order of 10 would be adequate in the present instance, this corresponding to 20mA flowing through the 500Ω coil of the relay. Thus R_1 should, from Ohm's law, have a value of $\frac{200-10 \text{ volts}}{20\text{mA}}$, which is equal to 9·5kΩ. A 5% 9·1kΩ resistor could be used here or, alternatively, a 10kΩ resistor whose measured value was slightly less than its nominal value.

Maximum dissipation occurs in R_1 when the relay coil is short-circuited and, from $\frac{V^2}{R}$, is equal to $\frac{200^2}{9{,}100}$ or 4·4 watts. R_1 could, conveniently, be 5 watts wirewound or it could have a higher wattage if this was considered preferable.

It will be seen that, in this particular example, the h.t. supply is required to provide an additional 20mA for the relay circuit. If this appears excessive it should be remembered that relays with coils having higher resistances are capable of energising at lower currents, and that an equivalent 2,000Ω relay could be expected to energise reliably at 10mA or less. A lower relay current will also result in a lower wattage rating for R_1. On the other hand, higher coil resistances will require higher battery voltages at the remote point. Most experimenters will attempt to employ relays which are already on hand. The writer suggests that a good choice would be a P.O.3000 relay with 2,000Ω coil and high voltage twin platinum 1 amp contacts. (P.O.3000 relays made up to specification are available from L. Wilkinson (Croydon) Ltd., Longley House, Longley Road, West Croydon, Surrey.—Editor.)

Normally, it will be preferable to connect the upper end of R_1 to the h.t. reservoir capacitor in the controlled equipment rather than to the h.t. positive line after the smoothing choke or resistor. Should the equipment h.t. supply be incapable of providing the added relay current the circuit cannot, of course, be used.

The constructor, when using the switching circuit, should first ascertain experimentally the minimum energising voltage for the particular relay he will employ. He then decides upon the remote battery voltage to be employed, remembering that about 0·5 volts will be dropped across the silicon diode. The next stage is to calculate the resistance and wattage required in R_1 following the example just given. The circuit should then be assembled and finally checked by measuring the voltage across the relay coil after it has energised and when its energising current is provided via R_1 from the equipment h.t. supply. If this voltage is a volt or more in excess of that provided by the battery, the circuit is complete and ready to use. If, due to such things as low regulation in the h.t.

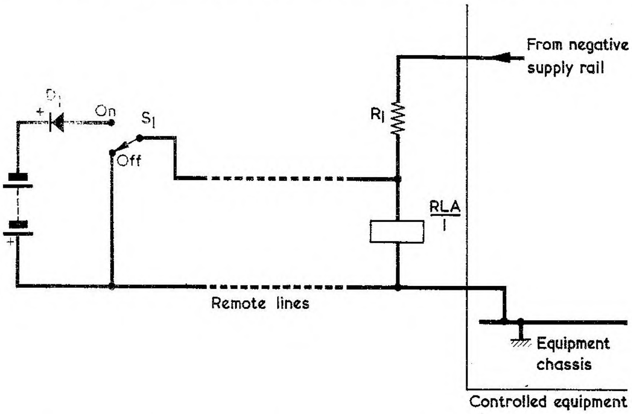


Fig. 3. With equipment having a supply rail which is negative with respect to chassis, both D_1 and the remote battery have to be reversed in polarity

supply, the voltage across the relay is equal to the battery voltage or a little less, R_1 should be slightly reduced in value. This process can be carried out by adding a suitable higher value resistor of lower wattage rating in parallel with it.

EARTHING

It is important to ensure that the relay insulation is adequate for mains voltages, and it is recommended that the chassis of the controlled equipment be connected to a reliable mains earth. If a mains earth is available at the remote position, only one interconnecting wire is needed between this position and the controlled equipment, as illustrated in Fig. 2. *The circuit must never be used if the controlled equipment has its chassis connected to one side of the mains.* When using a P.O. 3000 relay (or any other relay whose insulation is that normally associated with lower voltage operation) the chassis of the controlled equipment *must* be connected to a reliable mains earth.

TRANSISTOR EQUIPMENT

The basic circuit of Fig. 1 is also suitable for mains operated transistor equipment, but the low direct supply voltages used in such equipment may raise problems. It is desirable here to use a relay whose energising voltage is, at most, half the direct supply voltage in the equipment. Also, it should be remembered that the additional current drawn momentarily through the series resistor when the remote switch is set to "Off" will increase proportionally by a greater amount than occurs with the higher h.t. voltages encountered in valve equipment. If the transistor equipment has its chassis common to the positive supply rail, the polarities of the remote battery and the diode have to be reversed, as shown in Fig. 3. Again, the same safety requirements as for valve equipment must be observed. The equipment chassis has to be isolated and it should be connected to a reliable mains earth.

In both Figs. 1 and 3 it is necessary to ensure that the battery is connected into circuit with correct polarity and that there is no possibility of accidentally transposing the remote lines.

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PRESSURE SENSITIVE TRANSISTORS

by

J. B. DANCE, M.Sc.

These new devices give high amplitude output signals when subjected to pressures of several grams only

THE OPERATION OF PRESSURE SENSITIVE TRANSISTORS (also known as PITRANS) depends on a phenomenon known as the "Anistropic Stress Effect". This effect, which was discovered about 1961(1)(2), comprises a large change in the current passing through a diode when a stress is applied to the junction. Both the forward and reverse currents of the diode can be reversibly increased by several orders of magnitude when a force of a few grams weight is suitably applied.

In the PITRAN the sensitive emitter-base junction forms part of an n.p.n. silicon planar transistor. The sensitive junction is mechanically coupled to a diaphragm at the top of its TO-46 case.

In operation a suitable bias current is fed to the base and an output of at least 20% of the supply voltage can be taken from across the collector load for supply voltages in the range of 1–50 volts. The output is linearly related to the applied pressure.

APPLICATIONS

The device can be used in industry(3) in flow meters, weighing equipment, accelerometers, level guages, high intensity microphones, etc. It also has applications in fluidic logic circuits, in aerodynamics and can be used as a pressure sensitive switch to route electrical signals.

The PITRAN is produced at Stow Laboratories Inc. (U.S.A.) and is available in this country through Guest Electronics Ltd., Brigstock Road, Thornton Heath, Surrey.

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2. W. Rinder and I. Braun, "Resistance of Elastically Deformed Shallow pn Junctions II", J. Appl. Phys., 34, 1958 (1963).
3. "The Pressure Sensitive Transistor", Electronic Components, 9, 675 (1968).

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Now available from G. W. Smith and Co. (Radio) Ltd. is the Second Edition of this company's catalogue. Comprising 193 pages, this lists a very wide and comprehensive range of individual components as well as complete equipments, including receivers and high fidelity amplifiers. Also listed are kits for receivers and amplifiers. The amateur transmitting enthusiast is catered for, and items ranging from an s.w.r. bridge to a complete transmitter are included.

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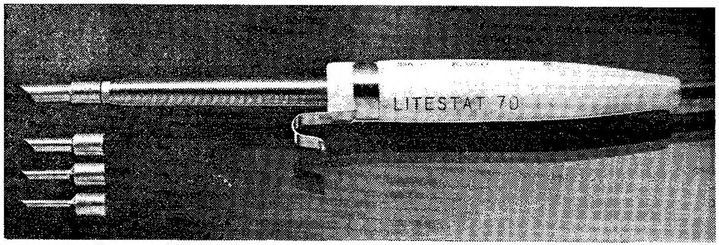
NEWS . . . AND .



The Litestat 70 for medium to large size electronic and electrical work and rapid production soldering.

Two new Temperature Controlled Soldering Instruments

Light Soldering Developments Ltd. of 28 Sydenham Road, Croydon, have introduced two entirely new thermostatically controlled models. Known as the Litestat 50 and Litestat 70, they are of 50 and 70 watts loading respectively, and are available for all voltages.

These new tools are of unusually advanced design. Temperature control (within plus or minus 2½ deg. C. during idling) is achieved by a simple and robust mechanical system in which a micro-switch mounted inside the handle is operated, through an adjustable lever, by a pull-rod, in response to thermal expansion of the copper element core unit. Since this core unit is closely coupled thermally both to the bit and the element winding, rapid response without temperature overshoot is obtained. The ample thermal capacity of the system reduces initial bit temperature drop and contributes to good thermal stability.

Operating temperature is infinitely adjustable, on load and without any dismantling, between approximately 200 and 420° C.

Unbreakable handles are moulded from translucent Nylon, to allow the internal indicator lamps fitted to show clearly when the elements are energised. This gives a useful indication that the instruments are on and that the control is operating, and is an aid to setting.

The screw-on copper bits are available in four sizes for each model, and their life is considerably longer than is the case with un-controlled tools. Philips iron coated bits are also available, giving a life of at least 10 to 20 times that of copper bits.

Making the most of those long journeys to school

School journeys have been very much in the news this winter, and we wonder whether children who have long journeys will be provided with "audiobuses", as are some children in the U.S.A.

Isolated schools in the United States have many students who spend up to 40 hours a month riding in a bus to and from classes. Now some rural schools in two states, Pennsylvania and Colorado, are experimenting with "audiobuses" to put to profitable use the lost time of long bus trips.

What they have done is to make each bus a classroom on wheels by installing stereo sound systems, with earphones for each student which are fitted with volume and channel selector controls.

The programmes available in the Pennsylvania experiment are primarily concerned with fine arts and social studies. One channel usually carries a tape, "Great Moments in History," a series of dramatisations of important events in America's past. Others carry "Great Moments in Music," etc.

The audiobus used in Colorado is more elaborate. Programmes, both group and individualised, are classified under five topics—English, social studies, science, recreation, and fine art. Students may choose materials on these topics prepared for their own age level.

The last word shall be with an "audiobus" driver who commented—"It is just great, no more bedlam on the bus, it is just a dream".

"Bleeptest" Audible Test Unit

Following many requests by customers using their "Bleeptone", A. P. Besson & Partner Ltd. have incorporated the d.c. version of this device into a circuit test unit.

To be marketed under the name of "Bleeptest" the unit is a simple hand held continuity tester for use by electronic and electrical engineers, automobile wiremen, inspectors, circuit checkers or household electricans, for any purpose where the continuity of a circuit has to be confirmed and will stand a nominal load of 12mA.

When energised the incorporated "Bleeptone" emits an audible signal and employs a built in oscillator circuit to drive a rocking armature motor unit also of Besson manufacture which is available as a separate item.

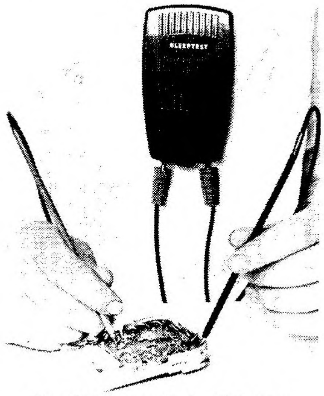
The complete tester is housed in a coloured moulded case of high impact A.B.S. the use of this material ensuring long life, freedom from breakage under normal conditions and an attractive appearance.

A feature of the tester is the provision of a stainless steel dress clip allowing the unit to be attached to the user, thereby leaving both hands free for the handling of the test leads or equipment under test.

Output sockets for the 4mm plugs supplied are provided in the bottom of the case, and access to the battery compartment is by removal of three screws and the case lid.

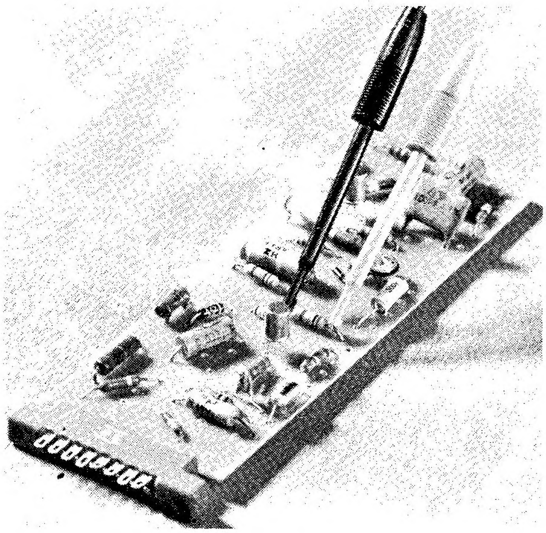
The battery used may be an Ever-Ready PP3 or equivalent 9V dry cell for which a special connector is supplied.

The address of A. P. Besson Ltd. is St. Joseph's Close, Hove, Sussex.



The "Bleeptest" Audible Test Unit in use. As can be seen, the hands are left free by the provision of a stainless steel dress clip.

. . . COMMENT



The new Probe Clip designed and manufactured by Futters (London) Ltd. in conjunction with Messrs. Radiospares. Radiospares components are available through retailers only.

Probe Clip made from ICI Plastic

A new, long-necked insulated probe clip designed and manufactured by Futters (London) Ltd. of Harlesden in conjunction with Radiospares, makes use of the toughness and resilience of "Kematal", ICI's acetal copolymer, as well as its good insulation properties.

The probe body is moulded in two parts entirely from "Kematal", in either red or black, and gives full insulation to the gold plated 0·032in wire which is threaded through the neck. This insulation ensures that the probe clip will not cause a short circuit if it touches any adjacent wiring when in use. The length of the neck enables components and connections to be reached deep down in the workings of the apparatus without the need to dismantle the circuitry. The collar part of the moulding snap-fits on to a grip on the neck and completely insulates the test leads, which can be attached by means of a screw fitting or by soldering.

The neck is spring loaded and a sliding action between finger and thumb on the grip retracts the neck so that the hook end can be fastened to the component to be tested to give a positive connection. The probe clip is marketed exclusively by Radiospares, 4/8 Maple Street, London, W.1.

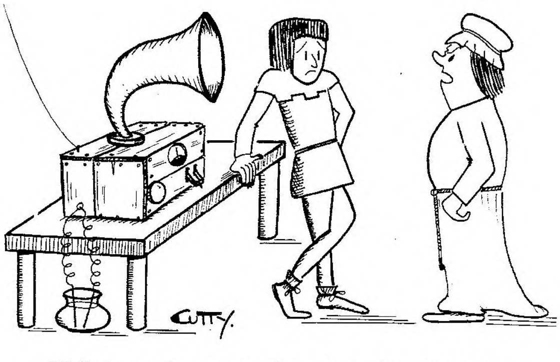
World Club Radio Club Award

For nearly half a century listeners have been reporting to broadcasters on transmission reception. In return, the BBC and other broadcasters have sent cards to verify correct reporting. The card issued by BBC External Services has been well known throughout the world as the "Big Ben" card.

Now, for the first time, the BBC is offering an Award to listeners who correctly report on a number of BBC transmissions received from different transmitting sites. The reports will be analysed by the engineering staff and the certificates will be issued by the programme, World Radio Club. This Award scheme applies to the one frequency schedule period only—March 2nd to 3rd May, though there's a possibility that the scheme will be repeated.

To qualify for the Award, listeners must give evidence of reception of three BBC transmissions from each of the following: Great Britain and the Atlantic, East Mediterranean and Far Eastern relay stations. These twelve reports (which must be received in one envelope before the end of May) should contain the following information: location, date, time frequency and a few words about programme content. In return, the Award will contain the four verifications required by the serious DXer.

To be eligible for the Award, a DXer must be a Member of World Radio Club, the programme for DXers and short-wave enthusiasts which is broadcast in BBC World Service on Sundays at 0930 GMT, Thursdays 1245 GMT, Fridays 2345 GMT and on the North American Service on Mondays at 1515 GMT. To become a Member you need simply write to World Radio Club, BBC, Bush House, London, W.C.2.



"O.K. so we have a receiver—now how long do we have to wait for someone to invent a transmitter."

I.C. RATEMETER

by
P. WILLIAMS

A low-cost integrated circuit may be made to function as an accurate ratemeter for counting positive-going pulses. In the design described in this article nearly all the circuitry is inside the i.c. itself, and few external components are required.

THIS ARTICLE DISCUSSES A SIMPLE CIRCUIT WHICH GIVES a meter reading directly proportional to the rate at which positive pulses appear. The circuit rejects pulses with amplitude less than about half a volt, making it useful for detecting pulses in the presence of noise. Pulse width is uncritical provided that it is appreciably less than the period between pulses. The pulse repetition frequency that can be measured may be as low as a few pulses per second (or even lower with a very large cross-coupling capacitor, as will become clear later) to as high as 1 Mc/s.

RTL UNIT

The unit used was the µL914, the diagram for which is shown in Fig. 1. Fig. 1 also shows the pin layout, pin 8 being identified by a "flat" on the body of the i.c. It should be noted that the pin layout in Fig. 1 is that given when the leads point *towards* the reader. (Most published information on this i.c. shows the layout from the top view, where the leads point away from the reader.) The transistors in the µL914 are equivalent to 2N708.

The µL914 is a dual two-input gate from a range of RTL (Resistor-Transistor Logic) units. If this sounds too complicated, then treat it as two pairs of transistors, each pair sharing a common collector load, and with all four emitters commoned. It is less flexible than four separate transistors, but the discipline of a fixed configuration is good for the designer's soul—the circuits that can be designed are limited but with the number of variables reduced, those which are possible can be neat and effective.

First let us look at one simple application, that of a monostable circuit, as illustrated in Fig. 2. The base resistors are effectively part of the transistors and can be thought of as merely increasing their input resistance. In the stable state, R_2 biases TR_3 into conduction causing it to saturate, with its collector voltage close to zero. TR_4 is not used in this circuit although it could be employed to "inhibit" the monostable by biasing it on when input pulses are not to be detected. Because of the almost zero potential on the collector of TR_3, TR_2 cannot conduct since its base is connected to that collector via its internal resistor. Hence the collectors of TR_1 and TR_2 are at the same potential as the positive supply. The potential difference across C_1 is thus $(V_s—V_{be3})$ or $(V_s—0{\cdot}6V)$ approximately. The V_{be} term is generally ignored with large supply voltages, but in this case makes a small difference to the theoretical result. If, now, a large enough positive is applied briefly to the base of TR_1 it conducts heavily, pulling the collector temporarily to zero. In such a short time the capacitor C_1 can neither gain nor lose any appreciable charge and hence the voltage across its

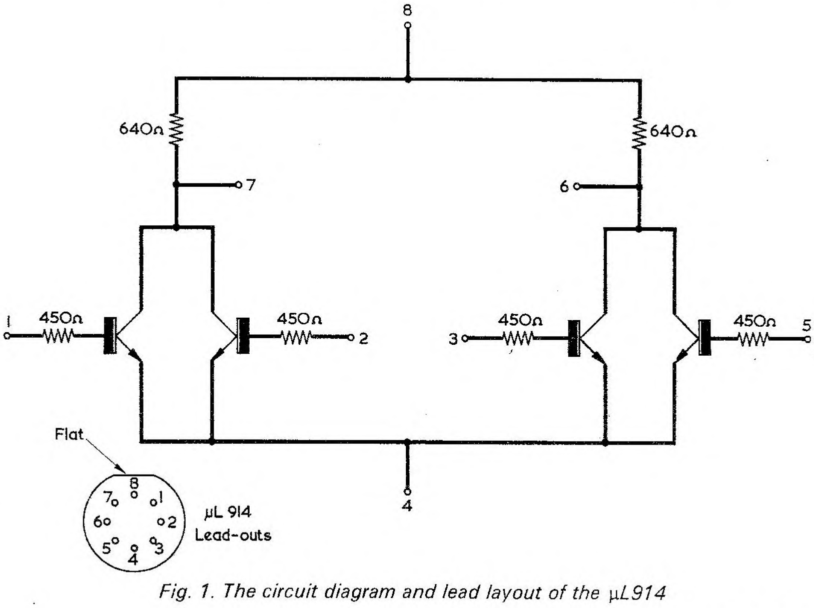
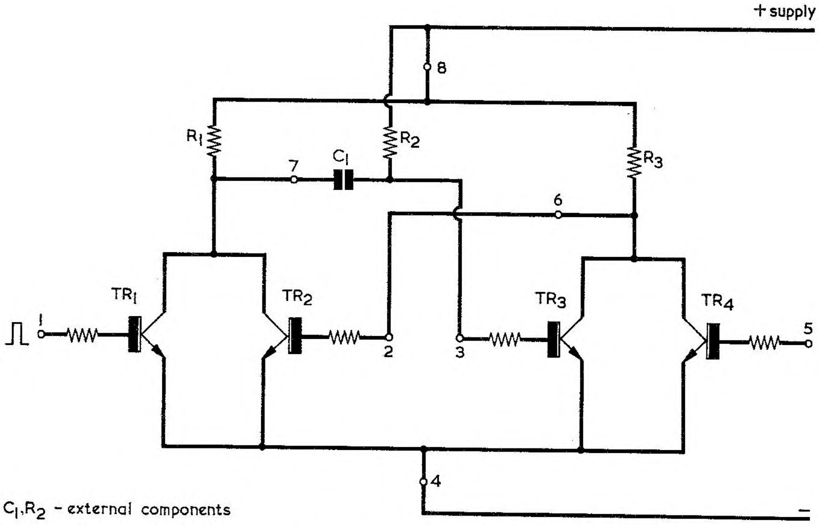


Fig. 1. The circuit diagram and lead layout of the µL914



C1,R2 - external components

Fig. 2. Practical circuit for a multivibrator based on the µL914. This is a monostable circuit but astable and bistable versions are readily constructed by duplicating the left or right half of the circuit respectively

plates remains unaltered. With one plate suddenly taken to zero, the other plate will be at a potential of (V_{be}—V_s) since the change must be the same on both plates of the capacitor.

With TR_3 cut off by this sudden reversal of bias on its base, the current in its collector resistor is diverted nto the base of TR_2. This transistor comes heavily into conduction and holds the collector potential at zero for the duration of the monostable's period. Thus the input pulse *need* only last long enough to ensure that TR_2 does come into conduction (as short as 0·1µS proved sufficient in practice) but *must not* exceed the natural period of the monostable. If it does the circuit acts only as an amplifier/limiter providing an output pulse at the first collector (where we shall require to use it) equalling the input pulse in duration. Assuming that the input pulse has disappeared

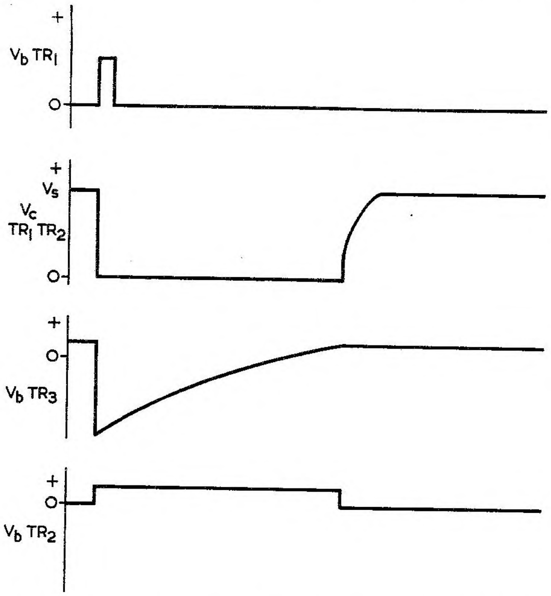


Fig. 3. Typical waveforms following a narrow triggering pulse at the base of TR_1

rapidly, the collector potential of TR_1 and TR_2 must remain at zero until TR_3 once more begins to conduct. This will happen when the base of TR_3 reaches a potential of about 0·5V again. The time taken for this to happen depends on the time constant R_2C_1, whose product when R_2 is expressed in ohms and C_1 in farads gives the time in seconds for the voltage across the capacitor to reach a specified fraction of the charging voltage.

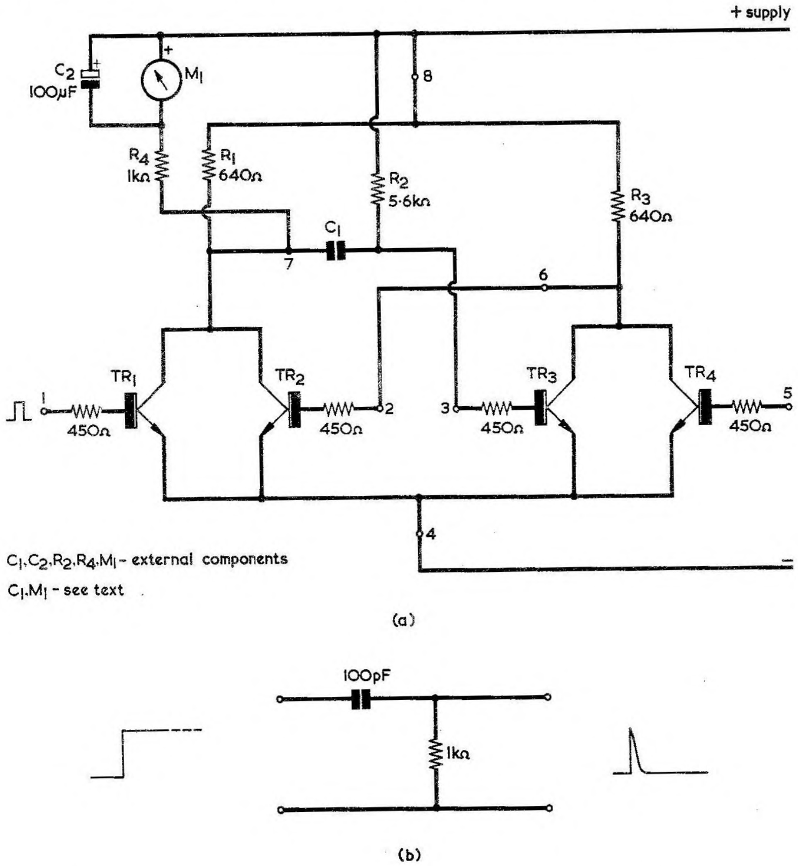
Because the base-emitter voltages cannot be ignored, the exact instant at which the circuit reverts to its stable state depends on the supply voltage, but a very wide range of periods can be obtained by varying C_1 and, to a lesser extent, R_2. This latter must always be low enough to ensure saturation of TR_3, i.e. it should not be greater than, say, 10 to 20 times R_3. No such limits are imposed on C_1 and values between several tens of picofarads and hundreds of microfarads have been successfully used. The periods that result are from a microsecond or so up to many seconds. The waveforms that occur are shown in Fig. 3.

For each incoming pulse we are now able to provide an output of specified amplitude and duration. A specified total charge flows, for example, in R_1. If this charge can be arranged to flow into a capacitor the build-up of voltage on that capacitor would be proportional to the number of pulses received. If we desire to know the *rate* at which pulses are arriving this capacitor can then be shunted by a resistor, as will be shown.

Having used an i.c. with fixed configuration we cannot break into the circuit to measure current in R_1. But we can very easily use a second resistor in parallel with it and find the mean current in this. Using a moving-coil meter in series, the averaging effect would automatically be achieved apart from some limitations. For instance, at low pulse rates a corresponding flicker would be observed in the needle; at high pulse rates the inductive properties of the meter coil would reduce the current passed. Equally, it is sometimes desirable to have an appreciable direct voltage available for monitoring purposes. Hence we place a large capacitance in parallel with the meter, and the final circuit is shown in Fig. 4(a).

SUPPLY POTENTIALS

With the nominal supply voltage of the original logic range—3·6V—the current in R_4 will be about 3·5mA when TR_2 is conducting, and zero at all other times. Thus a mean current of 1mA is easily obtained if the period between pulses is not more than three times the monostable



C_1,C_2,R_2,R_4,M_1 - external components

C_1,M_1 - see text

Fig. 4(a). Practical circuit of rate meter. The given value for R_4 suits a 1mA meter and a 3·6V supply.
(b). A differentiating circuit which may be added at the input

"on" period. This allows a low-cost 1mA meter to be used. By adjusting R_4, meters with higher sensitivity may be accommodated, though if R_4 is too high shunt capacitance may increase the pulse output at high frequencies. Higher current meters may also be used, perhaps up to 5mA or so, but care should be taken to ensure that TR_2 remains in saturation.

Equally, a wide range of supply voltage may be used. The prototype circuit still functioned and gave a reliable performance at surprisingly low voltages. Thus, it functioned at less than 1·5V with reduced output, and gave some output even at 0·8V supply. It is more difficult to specify an upper limit since this will be linked to the voltage ratings of the transistors as well as their maximum dissipation. In particular the base of TR_3 is subjected to a sudden reverse voltage when TR_2 switches on, and this should be less than 6V, which represents a typical value for reverse base-emitter breakdown. Some sample circuits performed well at supply voltages up to 6V. It should be noted that, at the lower supply voltages, the period begins to vary strongly with voltage while the peak current remains proportional to supply voltage. (Using the μL914 at supply potentials higher than 3·6V could incur the risk of damage to the i.c. due to the correspondingly high reverse voltage at the base of TR_3. Whilst this risk is apparently negligible in practice up to 6V, it needs to be mentioned here and should be borne in mind by constructors employing the μL914 in this manner.—EDITOR.)

A word of warning is in order against using meters with high terminal p.d.'s in this circuit. Most meters of 1MA full-scale deflection need a voltage of between, say, 50mV and a quarter of a volt. Those that need more will increasingly produce non-linearity of meter current against pulse rate. This is because the large mean direct voltage across the meter and capacitor reduces the current provided by each pulse, i.e. the sensitivity falls off with increasing output.

Fig. 4(b) shows a differentiating circuit which may be added at the input if the pulse being counted is of wrong duration or has an unknown d.c. content.

Finally, the reader may wish to use the circuit for measuring the frequency of waveforms which are not pulses, e.g. sine waves. In systems such as this, such waveforms must be converted into sharp pulses and this is normally done by passing the incoming signal through a Schmitt trigger to produce square waves and then differentiating the output to give narrow pulses. The present circuit may also be used for measuring the rate of irregular pulses such as those generated by Geiger-Muller tubes, provided these are suitably amplified first.

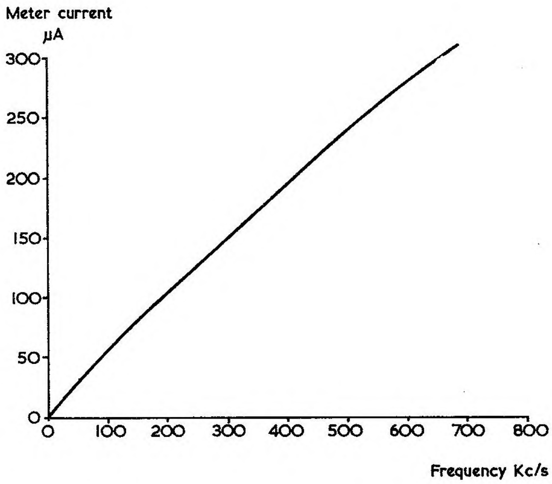


Fig. 5. Typical performance curve for a supply of 1·5V

To measure over a desired frequency range, the value of C_1 should be such that the monostable "on" period meets the requirements given earlier. The length of the monostable "on" period may be calculated approximately from

$$T = 0{\cdot}69\,C_1R_2$$

where T is in seconds, C_1 is in farads and R_2 is in ohms (or C_1 is in microfarads and R_2 in megohms). This calculation ignores the effect of V_{be}. Final calibration may be against two or more known input frequencies.

As an indication of the results given with the circuit, Fig. 5 gives a typical curve showing meter current against frequency with the supply voltage reduced to 1·5V to exaggerate non-linearity. Good linearity may be expected with meters having a p.d. less than 0·2V, and with a supply voltage greater than 3V.

MODERN BOOK CATALOGUE

The Modern Book Company is justly renowned for the extremely wide range of titles held in stock, and this fact is amply borne out in their latest Catalogue of Radio, Television and Electronics Books, now available. The catalogue has 68 pages, and lists some 2,000 books, all of which deal with electronic or allied subjects (such as lasers). American publications are distinguished by being marked with an asterisk, and any book listed can be obtained on seven day's approval against a full cash remittance plus postage.

The Catalogue of Radio, Television and Electronics Books is available from The Modern Book Co., 19–21 Praed Street, London, W.2, for 2s. post paid.

A.C./D.C. BRIDGE

by

G. W. SHORT

The bridge described here measures resistance from 1Ω to 1MΩ, with rough indications beyond these values, and capacitance (including that of electrolytic components) from 0·001μF to 100μF, with rough indications to 100pF and 1,000μF. Some aspects of the design may require selection of components on an experimental basis or may necessitate slight changes in circuit wiring. This article is, in consequence, intended primarily for the more experienced constructor who fully understands the principles of bridge operation

AN ORDINARY D.C. WHEATSTONE BRIDGE IS CAPABLE OF measuring resistance with great accuracy. But it can be rather tedious to balance, because the user has to look very carefully at the pointer of the centre-zero balance indicating meter, and this can be a tiring process.

A simple a.c. bridge presents no such problem, since balance may be obtained by adjusting for zero sound in earphones, and this is much easier. However, after making a long series of measurements with the phones on, one begins to feel rather like a dog on a leash. It is also easy to forget that the phones *are* on and, when moving away from the bench, to bring the bridge crashing to the floor. Again, background noise can be a nuisance, masking the bridge signal.

What is needed is some visual indication of balance which is easy to read. Experiments with a 100–0–100μA meter energised from a v.l.f. source so that the pointer swung to and fro showed that, at the frequency of pointer resonance (about 2·5 c/s) it was possible, with close observation, to detect 0·1μA, while the pointer movement produced by 0·3μA was easily visible from a yard away. The to-and-fro movement was much easier to "set to zero" than a steady deflection. Here, then, was a potential visual a.c. balance indicator, which required no floating output transformers, amplifiers or rectifiers.

PRACTICAL BRIDGE

This indicator principle leads to a simple bridge which operates at a frequency of a few cycles per second on a.c. and also as a d.c. Wheatstone bridge. All that is needed is a means of energising the bridge at a suitable low frequency for the a.c. measurements. In principle this could be done by connecting the battery via a Morse key and tapping at the right rate. In practice, it is more convenient to have the "tapping" done automatically. After considering various alternatives, such as flasher bulbs and relays, a non-mechanical chopper was selected. This is shown in Fig. 1 and it consists of a transistor (TR_3) in series with the bridge supply, the transistor being switched on and off by a v.l.f. multivibrator. By putting an unbypassed resistor in the emitter of the series transistor, it is turned into a "constant current" device which limits the current to a safe value (5mA in the present case). The bridge measures C and R at a.c. but the resistance of iron-cored inductors *must* be measured at d.c., because, even at a few cycles per second, the reactance is not negligible. In this case, the series transistor in association with a few silicon diodes (D_1 to D_3) acts as a source of d.c. limited to a few milliamps, and so minimises the risk of damage to components under test.

(continued on page 435)

RC/DS/21

RADIO CONSTRUCTORS DATA SHEET 21

E. R. DISSIPATION TABLE

(Voltages Below 50)

The Table gives dissipation in watts, from $W = \frac{E^2}{R}$, for resistance at commonly encountered voltages below 50. For resistances above 4.7kΩ divide down from the value shown for 1kΩ Thus, 10kΩ at 40V is 1·6 ÷ 10, or 0·16 watts. (See Data Sheet No. 22 for further details.)

Resistance	1V	2V	3V	4V	6V	8V	10V	15V	20V	30V	40V
1Ω	1	4	9	16							
2·2Ω	0·45	1·8	4·1	7·3	16						
4·7Ω	0·21	0·85	1·9	3·4	7·7	14	21				
6·8Ω	0·15	0·59	1·3	2·4	5·3	9·4	15				
10Ω	0·1	0·4	0·9	1·6	3·6	6·4	10				
22Ω	0·045	0·18	0·41	0·73	1·6	2·9	4·5	10	18		
47Ω	0·021	0·085	0·19	0·34	0·77	1·4	2·1	4·8	8·5	19	
68Ω	0·015	0·059	0·13	0·24	0·53	0·94	1·5	3·3	5·9	13	
100Ω	0·01	0·04	0·09	0·16	0·36	0·64	1·0	2·3	4·0	9·0	16
220Ω		0·018	0·041	0·073	0·16	0·29	0·45	1·0	1·8	4·1	7·3
470Ω			0·019	0·034	0·077	0·14	0·21	0·48	0·85	1·9	3·4
680Ω			0·013	0·024	0·053	0·094	0·15	0·33	0·59	1·3	2·4
1kΩ				0·016	0·036	0·064	0·1	0·23	0·4	0·9	1·6
2·2kΩ					0·016	0·029	0·045	0·1	0·18	0·41	0·73
4·7kΩ						0·014	0·021	0·048	0·085	0·19	0·34

RECENT PUBLICATIONS

HI-FI IN THE HOME. By John Crabbe. 327 pages, $5\frac{1}{2}$ x 8in. Published by Blandford Press Ltd. Price 40s.

As editor of *Hi-Fi News*, *Tape Recorder* and *Audio Annual*, John Crabbe is in an excellent position to evaluate the outlook and requirements of the non-technical music lover, and to equate these with the engineering know-how that is essential for the design, manufacture and installation of high fidelity reproduction equipment. The book under review is, indeed, intended primarily for the home music lover, although there is much that will be of value also to the younger engineer without too much experience in the hi-fi sphere.

"Hi-Fi in the Home" starts off by defining and explaining the nature of musical sounds, then carries on to the basic components required for music reproduction, these ranging from pickups and tape recorder heads to loudspeakers. Further chapters give advice on choosing and installing equipment, and on its use and operation. It is refreshing to note that when dealing with technical equipment Mr. Crabbe never loses sight of the aesthetic values that the equipment is intended to satisfy.

This is a well-written and *comprehensive* book, and can be confidently recommended to the music lover who seeks a greater understanding of the modern high fidelity equipment available in the latter part of this decade.

RADIO. By David Gibson. 88 pages, 6 x $8\frac{1}{2}$in. Published by Brockhampton Press Limited. Price 12s. 6d.

This book appears in the Brockhampton Press "Illustrated Teach Yourself" series, and is aimed at the complete newcomer to radio. The presentation is a little unusual in that the left hand margin of the text on each page is displaced from the page edge by some $1\frac{3}{4}$in, subheadings and small diagrams illustrating points in the accompanying text being inserted into this space. These pictorial aids should help in illustrating unfamiliar concepts to the reader. The right hand margin of the text is irregular, as in a typescript.

Dealing at elementary level, the book first describes the various components encountered in radio together with their operation in simple circuits, then carries on to semiconductor diodes and transistors. The next chapters are devoted to constructional projects, these being a crystal receiver, a 2-transistor a.f. amplifier, a 2-transistor reflex receiver and a 4-transistor superhet. The remaining two chapters cover aerials and short wave listening, and are followed by an appendix which details component availability and suggests books and magazines for further reading.

There is considerable use of colour, including attractive colour photographs of the complete constructional items. The book offers a useful introduction to the rudiments of radio and should enable many would-be enthusiasts, in particular youngsters of 10 years' age or more, to make their first jump into what they may previously have considered to be an incomprehensible technical world.

TELEVISION ENGINEERS' POCKET BOOK. Edited by J. P. Hawker and J. A. Reddihough. 303 pages, $4\frac{3}{4}$ x $7\frac{1}{4}$in. Published by Newnes Books. Price 21s.

This is the 5th edition of "Television Engineers' Pocket Book," the last edition being published in 1962. Many changes have been made in producing this new edition, these including the provision of two completely new chapters on hybrid receivers (i.e. transistor and valve) and on colour television. The latter chapter is based on the PAL system. Two new chapters devoted to fault finding have also been incorporated, one dealing with faults in the receiver circuits and the other with faults in the timebases. Considerable revision has also been undertaken in the remaining sections of the book to bring it up to date. Specialist contributors are D. E. A. Harvey, C.Eng., M.I.E.E., Gordon J. King and G. R. Wilding.

As in its previous editions, the present book offers a handy pocket-sized reference work for the television service engineer. It includes current data on cathode ray tubes and valves, as well as on valve equivalents.

POPULAR ELECTRONICS AND COMPUTERS. By F. G. Rayer, Assoc.I.E.R.E. 190 pages, $5\frac{1}{2}$ x $8\frac{1}{2}$in. Published by Arco Publications. Price 36s.

The main function of this book is to introduce to the reader the basic operation of many of the electronic devices which are in use today. The treatment is mainly non-mathematical, and the aim is to give sufficient information to provide the essential background for further specialised reading.

The book commences with a chapter on fundamental concepts and d.c. circuits, this being followed by chapters on alternating current, thermionic valves, power supplies, semiconductors, radio transmission and radio reception. The next two chapters cover magnetic amplifiers and devices, and an introduction to some of the techniques employed in computers. The following two chapters deal first with a.c. and d.c. measurements, and then with frequency measurement; whilst the final three chapters are devoted to v.h.f. equipment, light (including rays and radiation), and miscellaneous electronic equipment. This last chapter covers subjects ranging from electronic organs to varicap diodes.

The book is well illustrated by clear diagrams, these including circuit diagrams where applicable.

A.C./D.C. BRIDGE

(continued from page 432)

The v.l.f. multivibrator is given by TR_1 and TR_2. The electrolytic capacitors employed here (C_4 and C_5) should be components having a low leakage current.

PERFORMANCE

The bridge uses a single wirewound potentiometer, R_1, to provide variable ratio arms. Its value is not critical and may lie between 500Ω and 5kΩ. The "standard" is a fixed resistance or capacitance, switched into circuit by S_1. The

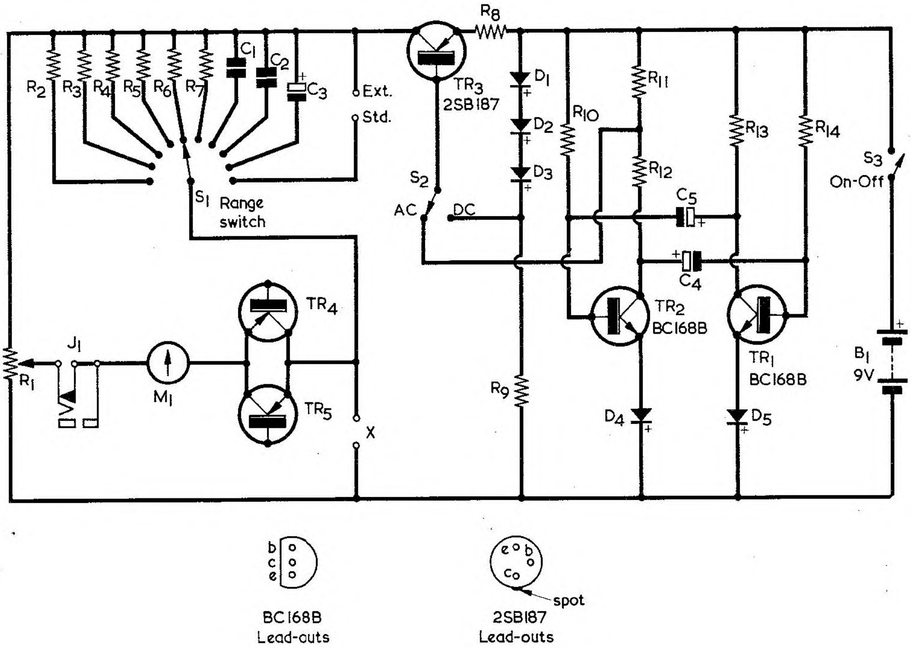


Fig. 1. The circuit of the a.c.–d.c. bridge

COMPONENTS

Resistors

R_1	500Ω to 5kΩ, wirewound linear, "instrument" type (see text)
R_2	1MΩ 1%
R_3	100kΩ
R_4	10kΩ 1%
R_5	1kΩ 1%
R_6	100Ω 1%
R_7	10Ω 1%
R_8	180Ω 5% $\frac{1}{4}$ watt
R_9	18kΩ 5% $\frac{1}{4}$ watt
R_{10}	33kΩ 5% $\frac{1}{4}$ watt (see text)
R_{11}	1·5kΩ 5% $\frac{1}{4}$ watt
R_{12}	3·3kΩ 5% $\frac{1}{4}$ watt
R_{13}	4·7kΩ 5% $\frac{1}{4}$ watt
R_{14}	33kΩ 5% $\frac{1}{4}$ watt (see text)

Capacitors

C_1	1,000pF 1%
C_2	0·1μF 1%
C_3	10μF electrolytic (see text)
C_4	10μF electrolytic, 10V wkg.
C_5	10μF electrolytic, 10V wkg.

Semiconductors

TR_1	BC168B
TR_2	BC168B
TR_3	2SB187
TR_4, TR_5	See text
D_1–D_5	Any silicon diodes (e.g. DD000)

Switches

S_1	Single pole, 10 way rotary
S_2	s.p.d.t., toggle or rotary
S_3	s.p.s.t., on-off, toggle

Meter

M_1	100–0–100μA (see text)

Battery

B_1	9-volt battery

Jack

J_1	Closed-circuit phone jack

Miscellaneous

4 test terminals

resolution varies with the setting of the ratio arms and the size of the "unknown", but over most of the measuring range it is better than 1%, so 1% tolerance standards can be utilised. Electrolytic capacitors can be tested, because the upper "X" test terminal is always positive. If the electrolytic capacitors have not been in use for some time it is advisable to form them before measurement by connecting them to a d.c. supply of the correct polarity at approximately the working voltage. Gross leaks can be detected by the bridge switched to "d.c. resistance".

Maximum sensitivity on "a.c." is only obtained if the frequency of the multivibrator can be set to produce the maximum excursion of the meter pointer. The less damped the meter movement, the more worthwhile it is to make this adjustment. The improvement with normal movements is only about twofold, however, and constructors without facilities for varying the frequency (using, say, a 2-gang potentiometer of about 100kΩ linear or up to 1MΩ log in place of R_{10} and R_{14}) will find the design as it stands quite good enough for most purposes. One word of warning: meter movements which show the slightest sign of sticking are useless as balance indicators in this design. In the prototype, incidentally, the author used a conventional 3in 100–0–100μA movement obtained through "surplus" channels.

EXTENDING THE COVERAGE

Using the meter as balance indicator, the bridge measures the commonly encountered range of resistance, but it is not sensitive enough to cover the whole range of capacitance. It is possible to measure down to about 100pF by using sensitive high resistance earphones (the writer employed war surplus type CHR with earpieces in series) instead of the meter, and adjusting RV_1 so that the capacitor-charging clicks disappear. One could improve matters by increasing the frequency to a few thousand cycles, and this can be done, if desired, by switching capacitors of 0·01μF in place of the 10μF ones at C_4 and C_5. The switching circuit required is shown in Fig. 2. With the help of earphones, transformer turns ratio can be measured more accurately, as is described later.

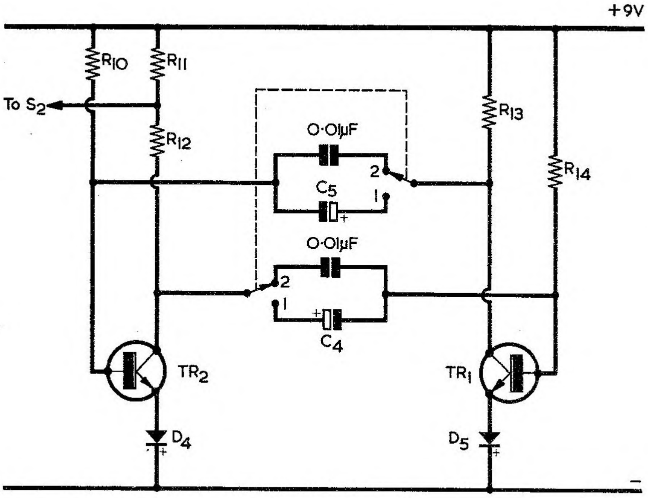
METER PROTECTION

Some form of meter protection should be incorporated. The basic method employed here is to connect a germanium (not silicon) transistor, with its base open, in series with the meter. This limits the meter current to the leakage current of the transistor. With some transistors, the leakage current is about the same in either direction, but with most types the collector-emitter leakage is greater than the emitter-collector leakage. To make limiting symmetrical, two similar transistors can be connected back to back, as are TR_4 and TR_5 in Fig. 1. This is rather a luxury, however, and provided that the transistor fitted allows a reasonable meter deflection in both directions a single transistor in series with the meter will do. Old germanium audio transistors are usually suitable for a function of this nature, and so long as both the junctions are intact it hardly matters how bad the transistor is as an amplifying device. If no suitable transistors are available, simply connect a limiting resistor of a few thousand ohms in series with the meter.

The exact f.s.d. of the meter is not very important, and almost any centre-zero microammeter, calibrated or not, will do. Ex-R.A.F. flying instruments, some of which have quite sensitive centre-zero movements, are possible candidates.

RANGE-SETTING AND CALIBRATION

If the ratio-arm potentiometer, R_1, is a large wirewound "instrument" type, fitted with a long pointer, adequate resolution should be obtained when the "unknown" is 0·1 to 10 times the standard, with rough indications down to 0·01 and up to 100 times the standard. Resistance standards with 1% tolerance of 10,100, 1,000Ω and so on are used (R_7 to R_2) but, for economy, the capacitance standards increase in multiples of 100 stead of 10. An electrolytic capacitor, C_3, is used as a standard on the highest capacitance range, but components of this type are available only in wide tolerances. A suitable electrolytic capacitor must therefore be selected or assembled from a number of lower values. If a good non-electrolytic capacitor is used for the 0·1μF standard, a capacitance of 10μF can just be measured and used in turn as a 10μF



Switch positions : 1 - V.L.F.
2 - A.F.

Fig. 2. Optional switching circuit. This enables the multivibrator to run at a.f., if desired, for some capacitor and transformer turns ratio measurements

standard. High measuring accuracy is not called for on this range (after all, the tolerance on electrolytics is usually at least 50%) but a low-leakage component is needed. Tantalum electrolytic capacitors are excellent, but expensive: they can sometimes by salvaged from surplus computer modules. Otherwise, use a newly manufactured aluminium electrolytic with a working voltage of 10V or more.

Range-setting and calibration is carried out in the usual manner required with a bridge where a single potentiometer provides two balance arms. Initial calibration may be made for resistance and consists of marking up the scale of R_1 with the ratios which exist between the standard and the unknown. These ratios will apply for all resistor standards switched in by S_2. The procedure to be described may be followed *before* R_2 to R_7 and C_1 to C_3 are wired into circuit, and it takes advantage of external uncalibrated variable resistors to determine many of the ratio points. Thus, there is no necessity to employ a wide range of close-tolerance test resistors to obtain calibration points.

From the point of view of accuracy and sensitivity, the most important calibration mark on potentiometer R_1 is the "half-way mark", i.e. the point of balance where the standard and unknown are equal. This point can be found very easily because the bridge is provided with a spare switch position which couples to External Standard terminals. (An external standard facility is very useful for matching components and measuring transformer turns ratios, and should always be provided in a general-purpose bridge.). Connect two nominally equal close-tolerance resistors of about 1,000Ω to the X and External Standard terminals, balance the bridge, and mark the setting of the potentiometer temporarily but accurately. Swap round the resistors and re-balance. Mark the balance point as before. There should now be two temporary calibration marks, close together. These are, in fact, either side of the true half-way mark, the latter can now be estimated by eye and marked in. With care, the error should be much less than 1%. (If the two resistors happen to be exactly equal, balance is of course obtained exactly at the half-way mark on both trials.).

If the two temporary calibration marks were quite close together (say within 3° on a circular scale) the two temporary standard resistors can now be used, in conjunction with an uncalibrated variable resistor, to fix the "0·5" and "2" ratio points on the ratio scale. For these, the resistors are connected in parallel to the External Standard terminals, the ratio arm potentiometer is set to "1" (which is the half-way mark), and the uncalibrated variable resistor is connected to the X terminals and adjusted until the bridge is balanced. It is now equal to half the nominal value of one of the two resistors. If one of the two resistors is disconnected and the bridge re-balanced by means of the ratio potentiometer, leaving the uncalibrated variable resistor alone, balance now occurs at the "0·5" points. By swapping the external standard and the uncalibrated variable resistor, the "2" point is found. Clearly, the process is only worth carrying out if the two original standards are really close to one another.

It is possible to fill in other points by extending the technique, but since actual standards have to be obtained sooner or later there is not much point in pressing on in this way. A few major ratios, like "0·5", "1" and "2" do, however, provide an excellent check on later calibrations, and increase confidence in calibration made with actual standards.

Further calibration is carried out as follows, before R_2 to R_7 are finally connected to the switch, and using the X or External Standard terminals as appropriate.

The 100Ω standard is first balanced against the 10Ω to provide the "0·1" and "10" points. The 1,000Ω against the 10Ω next provides "100" and "0·01" points. If the reader has any 1% or better resistors in assorted values these will provide valuable calibration check points, but a complete calibration can be done with the help of some auxiliary variable resistors only. Suppose, for example, a 100kΩ variable resistor is available. This can be set to 20kΩ against the 10kΩ standard, with the ratio arm potentiometer at "2". This temporary "20kΩ standard" can now be compared with the 100kΩ standard to obtain the "0·2" point and against the 1kΩ standard to obtain the "20" point. By connecting 20kΩ in series with 10kΩ, the "0·3" and "30" points are obtained, and the variable resistor can now be set to 30kΩ against "0·3", which in turn produces points at "0·4" and "40". Errors accumulate with this system, so great care is needed, but the checks previously provided at "0·5" and "1" now become very useful. To be on the safe side, go from "0·1" to "1" in steps of 0·1, then back again. If the "forward" points coincide with the "return" points, and the "0·5" and "1" ratios check accurately, all is well.

The bridge is now calibrated in 0·1 steps from "0·1" to "1", and these points can easily be used, in conjunction with the uncalibrated variable resistor and a different standard, to provide points "2", "3", "4" and so on up to "10". To subdivide these markings, use a series combination of a coarse standard (e.g. 20kΩ) and a fine standard set in turn to 1kΩ, 2kΩ, 3kΩ, etc.

It sounds rather complicated, but in fact the process is quite easy. All one needs is time, patience, and a selection of variable resistors. A good job for a wet weekend.

The capacitance ratio scale is the reciprocal of the resistance ratio scale. That is, the "0·25" of resistance is the "4" of capacitance, etc., so the calibration points of one give the markings of the other. However, if the reader happens to possess a stock of eleven 1% tolerance resistors of the same value (preferably in the range 100Ω to 10kΩ) these can be used to calibrate the capacitance scale directly. One is used as an external standard; two in parallel at the X terminals then give the "2" point, three the "3" point, and so on.

TURNS RATIO

To measure turns ratio in iron-cored transformers, connect one winding to the X terminals, the other to the External Standard terminals, and use earphones. These may be plugged into the closed-circuit jack in series with the meter. If balance is unobtainable, reverse the connections to *one* winding. Complete balance is not likely to be obtained, but adjusting for minimum sound gives fair accuracy. To find the ratio of tapped windings, connect the tap to the live (upper) X terminal and the ends to the "dead" X and External Standard terminals. The reason why phones are better than the meter is that they actuate the higher-frequency harmonics of the signal. The balance point is less blurred by the resistance of the windings at the harmonic frequencies than at the fundamental. (This is because the reactance/resistance ratio is higher.). It may also be helpful to switch the multivibrator to the higher frequency when checking turns ratio. ✱

ADDITIONAL RANGES FOR THE "BANDSPREAD H.F. BANDS SUPERHET"

by

F. G. RAYER, G3OGR

The usefulness of the popular "Bandspread H.F. Bands Superhet" can be enhanced by adding further coils, as is described here. Since some of the new coils are mounted above the chassis, additional chassis holes are needed to allow the connecting leads to pass through. New 6BA clearance holes are also required for mounting the coils

THE ORIGINAL RECEIVER, DESCRIBED IN *The Radio Constructor* for October, 1968, covers approximately 32 to 7 Mc/s in two switched bands. By adding coils for the low frequency bands, the scope of the receiver is greatly increased, and the modification should be of interest to many constructors.

The original ranges are obtained with PA4 and PA3 aerial coils, and PO4 and PO3 oscillator coils. Additional PA aerial coils and PO oscillator coils will allow coverage from about 32 Mc/s through to about 600 kc/s, in five switch-selected bands.

The accompanying Table shows the ranges which can be obtained with the additional coils. The two ranges at the top, utilising the PA4 and PA3 coils are those already existing and cover 32 to 7 Mc/s. The three ranges below are new: PA5 and PO5 give 8 to 3·3 Mc/s, PA6 and PO6 give 3 to 1·4 Mc/s, and PA2 and PO2 give the medium wave range of 1·5 Mc/s to 600 kc/s.

The existing wavechange switch is replaced by a new 4-pole 5-way switch. This is a "Maka-Switch" assembly made up by the constructor from a "shaft assembly" and two 2-pole 6-way wafers (Home Radio Cat. Nos. WS27 and WS29 respectively). The switch mechanism has an adjustable stop, thereby allowing five positions only to be available. One wafer is used for the aerial coils, and one for the oscillator coils.

TABLE

Frequency Ranges and Padding Capacitances

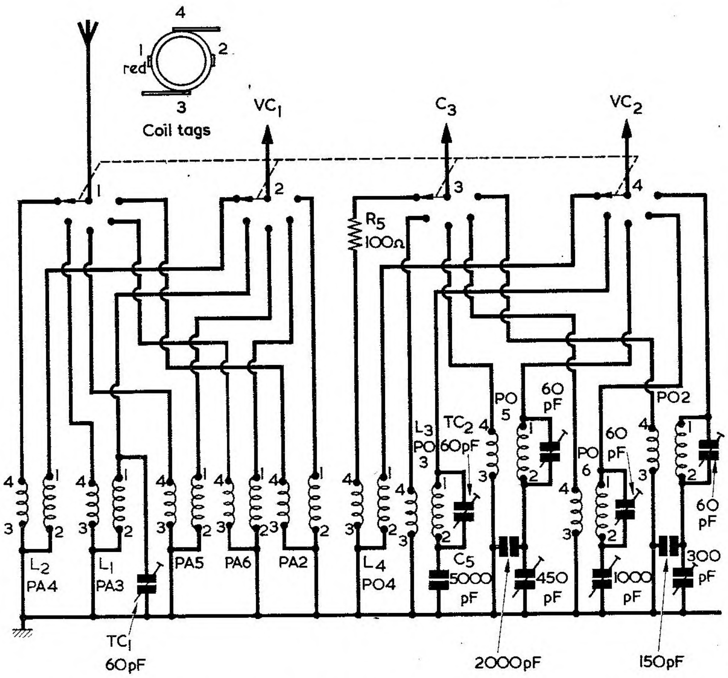
(as applicable to modified "H.F. Bands Superhet")

Coils	Frequency Range	Approx. Padding Capacitance
PA4, PO4	32 Mc/s–10·5 Mc/s	None
PA3, PO3	14 Mc/s–7 Mc/s	5,000pF
PA5, PO5	8 Mc/s–3·3 Mc/s	2,400pF
PA6, PO6	3 Mc/s–1·4 Mc/s	900pF
PA2, PO2	1·5 Mc/s–600 kc/s	450pF

MODIFIED CIRCUIT

The modified circuit appears in the accompanying diagram, in which the four poles of the new wavechange switch are numbered 1, 2, 3 and 4. Pole 1 switches the aerial to the required aerial winding; Pole 2 switches the signal frequency section of the two-gang capacitor, VC_1 (that nearer the front of the receiver) to the required aerial tuned winding; Pole 3 switches the oscillator grid capacitor, C_3, to the required oscillator coil feedback winding; and Pole 4 switches the oscillator section of the two-gang capacitor, VC_2, to the required oscillator tuned winding. Components which are numbered (e.g. L_1, TC_1, etc.) are those already fitted. Components without circuit reference numbers are new.

Apart from the fact that they now couple to the remainder of the receiver via a new switch, the PA4, PA3, PO4 and PO3 coils remain in an unaltered circuit. The new aerial coils, PA5, PA6 and PA2 couple into the receiver in obvious manner and need no further comment so far as the circuit is concerned. The three new oscillator coils, however, require some further words of explanation because each of these needs a *variable* padding capacitor. For the prototype receiver, variable padding capacitances were obtained by utilising a 450pF (max.) mica trimmer, and a multiple unit incorporating a 300pF (max.) trimmer and a 1,000pF (max.) trimmer on a single mounting. These were employed in the following manner. The PO5 coil requires an adjusted padding capacitance in the range of 2,400pF, and this was given by the single 450pF trimmer with a fixed 2,000pF silver-mica capacitor connected across it. The PO6 requires about 900pF and this was provided by the 1,000pF section of the multiple trimmer.



The modification to the "H.F. Bands Superhet" consists of adding three further ranges, using the coil switching circuit shown here. Components with circuit references are already fitted

The PO2 coil requires about 450pF, and this was given by the remaining 300pF section of the multiple trimmer with a fixed 150pF silver-mica capacitor connected across it. Other methods of making up the desired padding capacitance will be suitable provided that the final capacitance can be varied over a reasonable range about the nominal figure shown in the Table.

COMPONENTS

REQUIRED FOR MODIFICATION

(Cat. Nos., where quoted, apply to Home Radio (Components) Ltd.)

Coils

PA5 (Cat. No. CO83E)
PO5 (Cat. No. CO85E)
PA6 (Cat. No. CO83F)
PO6 (Cat. No. CO85F)
PA2 (Cat. No. CO83B)
PO2 (Cat. No. CO85B)

Capacitors

2,000pF, silver-mica
150pF, silver-mica
450pF trimmer (Cat. No. VC29R)
300pF+1,000pF multiple trimmer (Cat. No. VC54)
Three 60pF mica trimmers

Switch

Shaft assembly (Cat. No. WS27)
Two 2-pole 6-way wafers (Cat. No. WS29)

Three additional 60pF mica trimmers also are needed for the new oscillator coils. These are soldered directly across tags 1 and 2 of each coil.

PRACTICAL WORK

When the new switch has been fitted, it is best to wire in the PA and PO coils for one band only, and test the receiver. Any wiring fault can then be located before proceeding further. Assuming all is in order, add the PA and PO coils for other bands, testing each time if preferred.

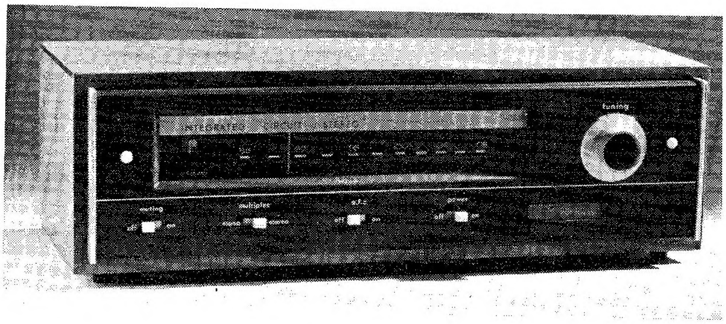
The original coils are left as fitted. As there is not a great deal of space, and extremely short leads are not important for the l.f. bands, the PO2 oscillator coil and the additional aerial coils are placed above the chassis, and the PO5 and PO6 oscillator coils under the chassis.

ADJUSTMENT

Treat each band individually. Tune in a transmission with the ganged capacitor nearly open, and adjust the oscillator trimmer so that the panel aerial trimmer peaks for best results, and is not fully open or fully closed. Then tune towards the low frequency end of the band, and adjust the oscillator coil padder as necessary, so that the panel aerial trimmer can still be peaked for best results. Repeat these adjustments a few times. Full efficiency is obtained when the aerial timmmer allows signals to be peaked up, throughout all bands, and is not at its full minimum or maximum capacitance. If the aerial is fairly long, it is worth trying a 50pF or 100pF variable capacitor between its lead-in and the receiver. ✱

TRADE REVIEW

NEW TRUVOX INTEGRATED CIRCUIT STEREO TUNER



The New Truvox Series 200 I.C. Stereo Tuner

THE FIRST BRITISH FM STEREO TUNER USING INTEGRATED circuits and field-effect transistors has been introduced by Truvox Ltd. (of Hythe, Southampton), a member of the Controls and Communications Group. In technical terms it represents an important development in hi-fi equipment design. In user terms it means much better performance, greater reliability and more value for money.

Designed from the outset specifically for stereo reception (mono reception is of course automatic when stereo is not being received), the new model is designated the Truvox Series 200 IC Stereo Tuner. As the name implies, it joins the recently introduced Truvox Series 200 range: hi-fi amplifier, tuner, loud-speakers, mono and stereo tape recorders.

Except for the legend "Integrated Circuit Stereo" on the tuning scale and a peak programme meter in place of the flag-type indicator, the new model is externally identical with the current FM200 tuner, which is basically a mono unit with optional plug-in stereo multiplex decoder. Balanced and unbalanced aerial inputs, outputs variable from 0 to 0·7V, flywheel tuning, stereo beacon and front panel switches (power on/off, a.f.c. on/off, stereo/mono and muting on/off) are as on the FM200, but internal design and performance are entirely new.

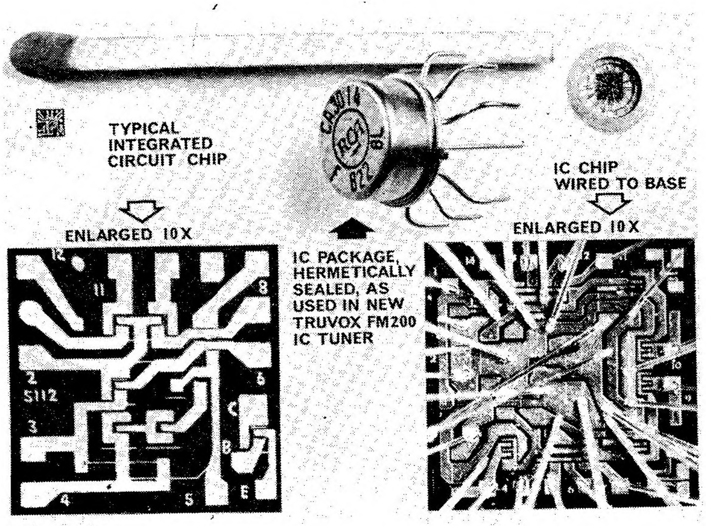
In place of the previous mono circuit and its optional plug-in decoder, both of which used only discrete components, there is now a single circuit using integrated circuits (i.c.'s) and field-effect transistors (f.e.t.'s). Technically the "front" (aerial input) end of the circuit is a dual-gate f.e.t., which is coupled to an i.f. (intermediate frequency) "strip" comprising two linear i.c. amplifiers and a few associated components.

The f.e.t. and i.c.'s are made by RCA, the world's leading supplier of linear i.c.'s suitable for communications and hi-fi equipment, which demands devices quite different from the better-known integrated (logic) circuits widely used for computers and the like. Though designed for civil audio applications, both the i.c. "chips" and "packages" are manufactured on the same production line and under the same conditions as those for the aerospace industries and the military.

The first i.c. in the circuit effectively comprises 7 diodes, 10 transistors, 11 resistors and all connections needed to form a complete i.f. amplifying section, all diffused on a single chip of silicon. The second i.c. is even more complex, with 12 diodes, 12 transistors and 14 resistors. Both are mounted on miniature ten-lead bases sealed in standard size (TO5) transistor cans, which only require coupling capacitors and transformers to complete the i.f. strip. Decoder, a.f.c., output stages and similar sections are all mounted on the same board, so the overall circuit size and number of discrete components are substantially reduced.

Properly designed into a circuit, the life of an i.c. is indefinite, and the reliability of the whole circuit is vastly improved. Better stereo reception (frequency response 20 c/s to 15 kc/s ±dB before de-emphasis and notch filters, channel separation better than 30dB at 1 kc/s, distortion less than 0·5%), higher sensitivity (2·0μV for 30dB quieting, 3μV for —3dB limiting), lower noise (a.m. rejection better than —50dB) and less drift (2μV signal held against 2V at 0·5 Mc/s difference) are among the technical benefits.

Prior to the introduction of stereo broadcasts, mono tuners were deservedly popular, and the optional plug-in



Integrated circuits (I.C.'s) in various stages of manufacture, as used in the completely redesigned Truvox FM200 IC Stereo Tuner

stereo decoder was a logical extension. For the many present owners of Truvox mono tuners, this decoder will continue to be available. But with stereo broadcasting spreading, and already covering much of the country, an integral stereo tuner is a technically simpler and more satisfactory solution for anyone buying a hi-fi tuner today. The Truvox IC stereo tuner is ahead of the market in terms of technology, with performance, facilities, styling and price to satisfy the most demanding user.

SPECIFICATION

Sensitivity:	2·0μV for 30dB quieting IHFM 1·5μV for —3dB limiting 5·0μV for 200 kc/s bandwidth
Rejection (with receiver tuned to 98 Mc/s):	IF (10·7 Mc/s) —85dB ½IF (103·35 Mc/s) —70dB Image (119·4 Mc/s) —55dB Double-½ i.f. (206·7 Mc/s) —70dB AM —50dB
Frequency response:	20 c/s to 15 kc/s ±1dB before de-emphasis and steep notch filters
Pilot tone suppression:	40dB
Stereo separation:	30dB at 1 kc/s 22dB at 10 kc/s
Distortion:	0·5% (40 kc/s deviation)
Tuning range:	87·5—108·5 Mc/s
Tuning indication:	flywheel cursor, centre-zero meter
Tuning stability:	will hold 2μV signal against 2V at 0·5 Mc/s separation
AFC:	Switched, ±200 kc/s pull-in, temperature-compensated
Stereo beacon:	lights automatically on reception of stereo programme
Switched controls: (on front panel)	power on/off, AFC on/off, stereo/mono override, interstation muting on/off
Aerial inputs:	balanced 300 Ω unbalanced 75 Ω
Outputs:	0–0·7V r.m.s. for each channel
Circuit:	silicon solid-state, with RCA dual-gate f.e.t. front end and i.f. strip comprising two R.C.A. i.c.'s on single printed board with multiplex and output stages, fed by 12V zener-stabilised supply
Voltage:	100–120V or 200–250V a.c., 50–60 c/s
Finish:	teak, grey panel, white/silver trim
Dimensions:	16 × 6⅞in (41 × 17·5 × 13 cm)
Weight:	10 lb. (4·5 kg)
Panel mounting cut-out:	14 15/16 × 3¾in (38 × 95 cm)

EMI SOLID-STATE RADIATION DETECTORS

The Valve Division of EMI Electronics Ltd., recently announced the introduction of two new solid-state radiation detectors.

The SB2 is a silicon surface barrier diode detector with very good energy resolution, primarily designed for the detection of charged particles of proton mass and greater and is available in a range of active surface areas and depletion depths.

The SB3 silicon probe is suitable for Alpha or Alpha plus Beta monitoring. The detector head is mounted on a six-inch angled handle, terminating in a coaxial socket. It is intended for use with charge sensitive input ratemeters, with a counting threshold of approximately 1MeV equivalent for Alpha counting, and approximately 100KeV equivalent for Beta counting.

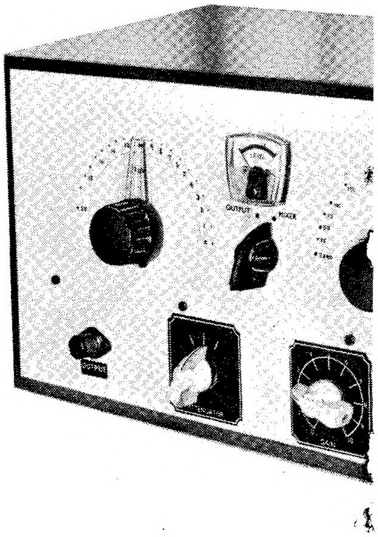
Cover Feature

SOLID-STATE AUDIO GENERATOR

PART 1

by

G. A. STANTON, G3SCV



By taking advantage of simple basic principles, this carefully engineered design offers a sine wave output having an amplitude continuously variable up to 1·5 volts r.m.s., and a response ranging from 10 c/s to 20 kc/s within ± 2dB. Two frequency controls are provided, one offering a "bandspread" from zero to 500 c/s. Inexpensive high performance silicon transistors are used throughout and total consumption is only 14mA from a 9 volt supply. It should be pointed out that an oscilloscope is required for final setting up, as is described in the concluding part to be published next month. The concluding article will also give constructional details

PRIOR TO THE SECOND WORLD WAR, ALMOST ALL AUDIO Frequency Signal Generators worked on the beat frequency principle. In these the audio output was obtained by "beating" together two radio frequency oscillations. Since the War this type of generator has been superseded by types based upon the Wein Bridge oscillator, in which the output is generated directly by resistance-capacitance networks. While the Wein Bridge generator has the advantage of simplicity over the earlier types, nevertheless the Beat Frequency Generator still offers a number of useful features. By careful design, for example, the Beat Frequency Generator can cover the whole audio spectrum in one range, and yet at the same time, by having "bandspreading" facilities, be accurately set to any specific frequency within that range. An in-built calibration check can also be provided quite easily. The instrument to be described is of the Beat Frequency type and does, in fact, bring an old idea fully up to date.

PRINCIPLE OF OPERATION

The principle of operation can be understood from a study of Fig. 1. In this blocks A and B are two oscillators producing frequencies f1 and f2. If these are fed into a suitable mixing network (M) four frequencies will be

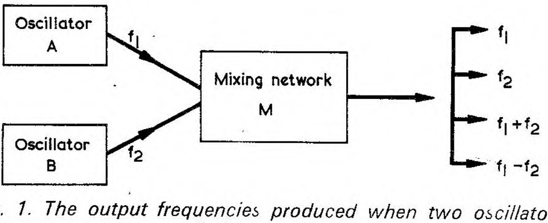
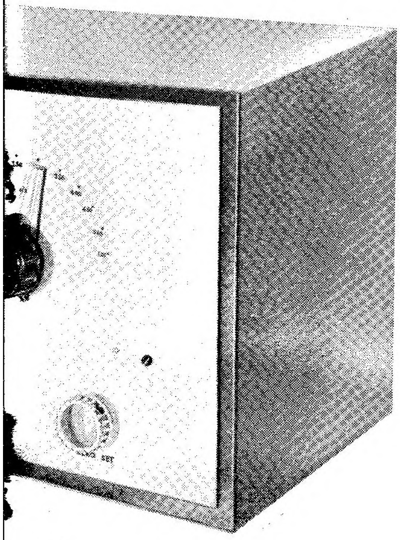


Fig. 1. The output frequencies produced when two oscillators are applied to a mixing network

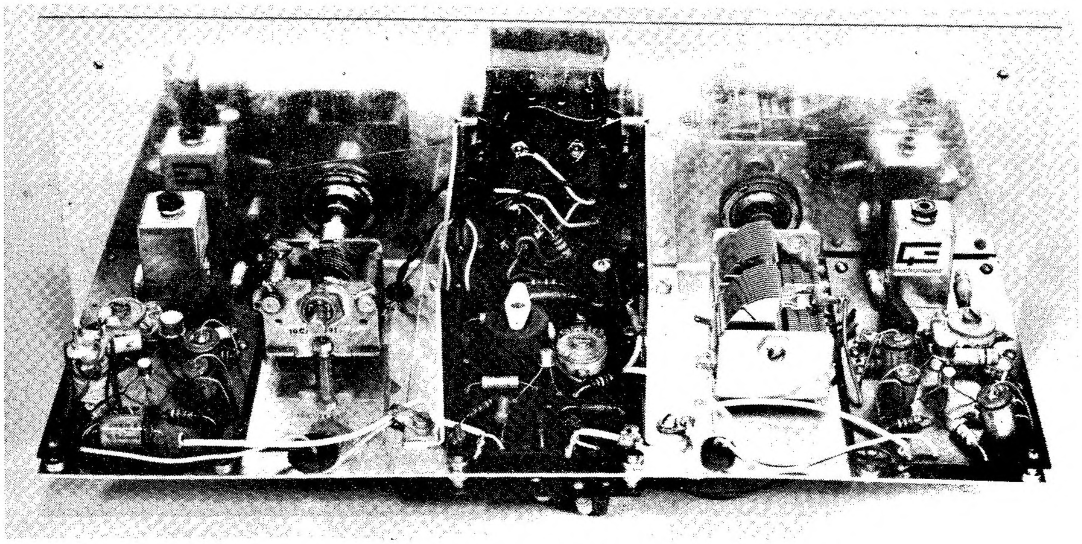


present at the output. These will be the original f1 and f2, plus the sum of the two frequencies (f1+f2) and the difference between them (f1—f2). The principle illustrated by Fig. 1 is, of course, well known, and is the basis of every superhet receiver. It also represents the standard method of receiving c.w. signals in communication receivers.

If, in Fig. 1, oscillator A is fixed at 100 kc/s and B is made variable from 100 kc/s to 120 kc/s, then the output of the mixer will include a frequency in the range 0–20 kc/s according to the setting of the variable oscillator. This provides the audio range. The "bandspreading" feature mentioned previously can readily be provided by making oscillator A variable by a small amount—say from 100 kc/s to 100·5 kc/s. This will then enable the output to be varied by amounts up to 500 c/s. For example, if oscillator A is set at 100·5 kc/s and oscillator B at 110 kc/s, the output will include a frequency of 9·5 kc/s (110 kc/s minus 100·5 kc/s.) If a frequency of 14·9 kc/s is required, oscillator A can be set at 100·1 kc/s and oscillator B at 115 kc/s. (115 minus 100·1 = 14·9.) The control dials tuning the oscillators should, of course, be calibrated in terms of the audio range, whereupon any specific frequency within that range can be easily selected.

While the principle of operation just outlined is relatively simple, a number of problems are involved in producing a satisfactory practical design. In the first place, it will be obvious that both the stability and the waveform purity of the output of the generator will depend upon the stability and waveform purity of the basic oscillators. These must be as stable and as free from harmonic production as possible. In earlier designs it was a standard practice to make both the oscillators identical in the hope that any frequency drift occurring in one would be neutralised by a similar drift in the other. It was also standard practice to filter the output of at least one oscillator to ensure freedom from harmonics. As will be seen, both these practices have been followed in the present design.

A second problem arises from the fact that two oscillators working in close proximity have a tendency to "pull" each other. If the oscillators happen to be working on frequencies that are but a few cycles per second apart, then the tendency is for them to synchronise.



Rear view behind the front panel. Printed circuit panel A is at the left with VC_1 alongside, whilst printed circuit panel B, with VC_4/VC_5, is to the right. Printed circuit panel C is in the centre, with vertical screens on either side.

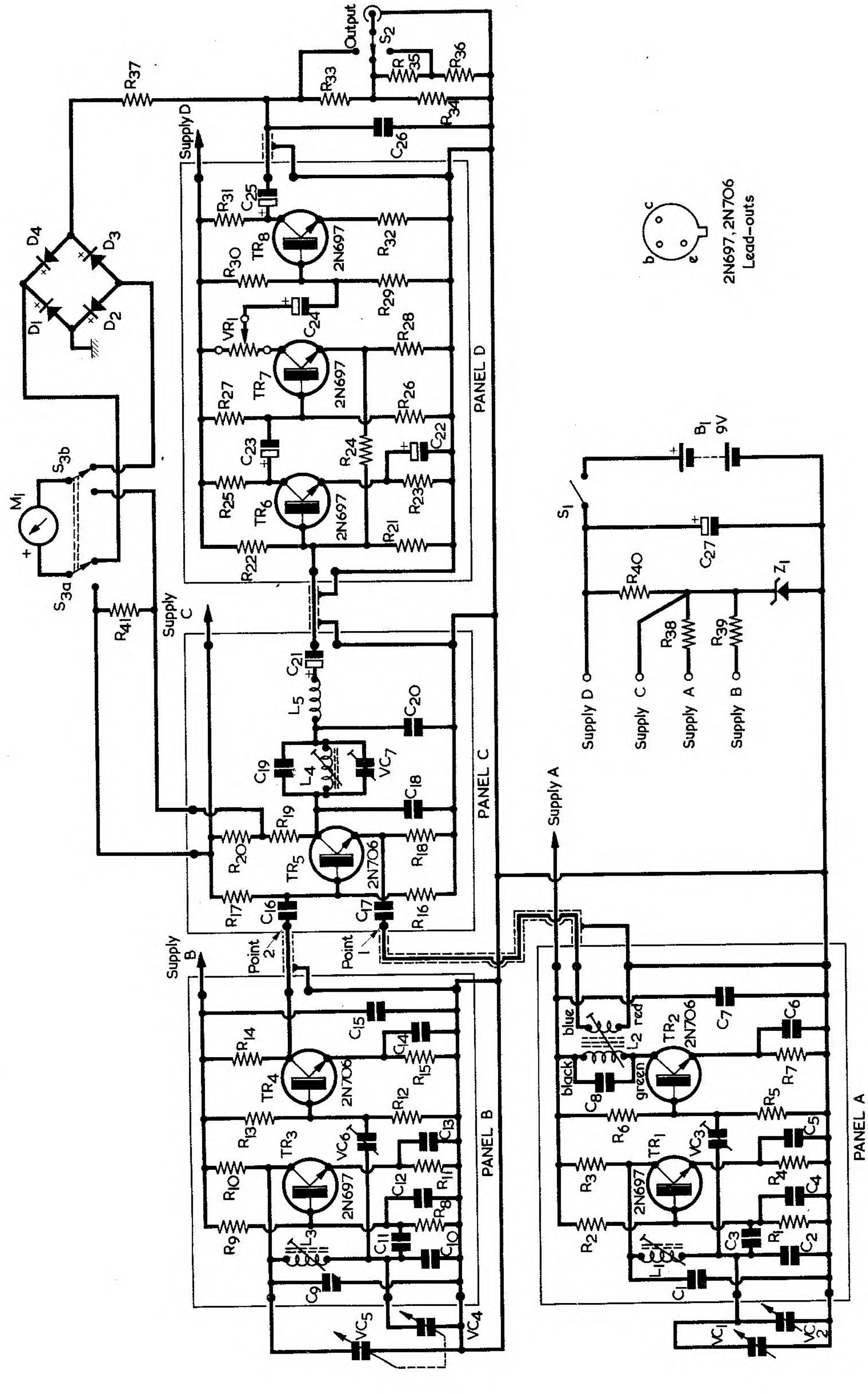


Fig. 2. Full circuit diagram of the Beat Frequency Audio Signal Generator

COMPONENTS

Resistors

(All fixed values $\frac{1}{4}$ watt 10% unless stated otherwise)

R_1	10kΩ	R_{22}	20kΩ
R_2	30kΩ	R_{23}	820Ω
R_3	4·7kΩ	R_{24}	22kΩ
R_4	2·7kΩ	R_{25}	4·7kΩ
R_5	4·7kΩ	R_{26}	8·2kΩ
R_6	22kΩ	R_{27}	47kΩ
R_7	1kΩ	R_{28}	1kΩ
R_8	10kΩ	R_{29}	2·7kΩ
R_9	30kΩ	R_{30}	20kΩ
R_{10}	4·7kΩ	R_{31}	2·7kΩ
R_{11}	2·7kΩ	R_{32}	330Ω
R_{12}	4·7kΩ	R_{33}	18kΩ 5%
R_{13}	22kΩ	R_{34}	2·2kΩ 5%
R_{14}	5·6kΩ	R_{35}	18kΩ 5%
R_{15}	1kΩ	R_{36}	2kΩ 5%
R_{16}	1kΩ 5%	R_{37}	See text
R_{17}	15kΩ 5%	R_{38}	470Ω
R_{18}	470Ω 5%	R_{39}	470Ω
R_{19}	39kΩ	R_{40}	330Ω
R_{20}	3·3kΩ	R_{41}	See text
R_{21}	2·2kΩ		
VR_1	5kΩ potentiometer, linear, with switch S_1		

Capacitors

C_1	1,500pF polystyrene 10%
C_2	1,500pF polystyrene 10%
C_3	100pF silver-mica
C_4	1,000pF polystyrene
C_5	0·33µF paper
C_6	0·1µF paper
C_7	0·33µF paper
C_8	820pF polystyrene or silver-mica
C_9	1,000pF polystyrene 10%
C_{10}	1,000pF polystyrene 10%
C_{11}	100pF silver-mica
C_{12}	1,000pF polystyrene 10%
C_{13}	0·33µF paper
C_{14}	0·1µF paper
C_{15}	0·33µF paper
C_{16}	100pF ceramic or silver-mica
C_{17}	500pF ceramic or silver-mica
C_{18}	0·01µF ceramic or paper
C_{19}	560pF polystyrene or silver-mica 5%
C_{20}	0·01µF ceramic or paper
C_{21}	16µF electrolytic 10V wkg.
C_{22}	250µF electrolytic 3V wkg.
C_{23}	4µF electrolytic 10V wkg.
C_{24}	10µF electrolytic 10V wkg.
C_{25}	100µF electrolytic 10V wkg.
C_{26}	1,000pF ceramic
C_{27}	250µF electrolytic 10V wkg.
VC_1	3–60pF air-spaced variable, chassis mounting
VC_2	3–15pF air-spaced variable, panel mounting
VC_3	3–10pF miniature ceramic trimmer, silvered disc type
VC_4, VC_5	500+500pF 2-gang, Jackson Type L or similar
VC_6	3–10pF miniature ceramic trimmer, silvered disc type
VC_7	10–50pF miniature ceramic trimmer, silvered disc type

* If VC_1 is panel mounting, an additional bracket is required

Inductors

L_1	4·7mH coil, type SHQ-Y/PC (Electroniques)
L_2	3·2mH coil, type Qoilmax MX8 (Electroniques)
L_3	4·7mH coil, type SHQ-Y/PC (Electroniques)
L_4	Home-wound (40 s.w.g. enamelled wire) on Neosid pot core type 10D (Pot core—Henry's Radio)
L_5	2·5mH r.f. choke, type CH1 (Repanco)

Semiconductors

TR_1	2N697
TR_2	2N706
TR_3	2N697
TR_4	2N706
TR_5	2N706
TR_6	2N697
TR_7	2N697
TR_8	2N697
D_1–D_4	OA90 or similar
Z_1	6·2V zener diode (see text)

Switches

S_1	s.p.s.t., part of VR_1
S_2	1-pole 3-way Yaxley
S_3	2-pole 2-way break-before-make Yaxley, or toggle

Meter

M_1	50µA meter (see text)

Battery

B_1	9-volt battery type PP9 (Ever Ready)

Miscellaneous

- 4 printed circuit boards, each $4\frac{1}{2}$ x $2\frac{1}{2}$in
- 2 epicyclic slow motion drives with flange, Cat. No. 4511/F (Jackson Bros)
- Coaxial socket
- 5-way tagstrip
- Knobs, as required
- 16 s.w.g. aluminium sheet for chassis and panel
- Data Panel-Sign transfers, Set Nos. 4 and 6.
- Wire, nuts, bolts, etc.

In the type of instrument being described "pulling" must be prevented at all costs. This means careful screening and adequate "buffer" stages to prevent the output of one oscillator coupling back into the other.

As already mentioned, several unwanted frequencies will be present at the output of the mixer circuit. Careful filtering is therefore necessary at this point to ensure that only the required audio signals are passed on to the output stages of the instrument. The problem here is to design a filter that will completely remove the unwanted radio frequencies without at the same time attenuating the higher audio frequencies. This is best achieved by a combination of tuned circuits and suitable chokes.

PRACTICAL DESIGN

The circuit of the Audio Frequency Signal Generator which forms the subject of this article is given in Fig. 2. The instrument meets the following specification.

Range: 0 to 20 kc/s in one range with a bandspread of 0 to 500 c/s over entire range.
Output: Sine wave 1·5 volts r.m.s.
Response: ±2dB from 10 c/s to 20 kc/s.

It will be seen in Fig. 2 that eight silicon transistors are utilised, and at first sight this may appear to be rather extravagant. Further study will, however, show that only two types are used, and both are readily available on the market at very low prices.

To simplify construction, the instrument is built in four units, the components in each unit being mounted on small panels of printed circuit board. In Fig. 2, panel A comprises the "fixed" oscillator, TR_1 operating in a Tesla circuit at approximately 100 kc/s. This particular circuit was adopted because of its inherent stability. The tuned circuit is made up of L_1, C_1 and C_2, with VC_1 and VC_2 in parallel with C_2, the former of the two variable capacitors being the "bandspread" control and the latter the zero re-set. The "bandspread" control is capable of increasing the frequency of oscillation by approximately 550 c/s. TR_2 is a buffer stage and output from the oscillator is fed to it via the small pre-set capacitor, VC_3. The collector load of TR_2 is a parallel tuned circuit adjusted to 100 kc/s. The high C/L ratio of this combination is chosen in order to attenuate any harmonics that may be generated by the oscillator.

Panel B contains the variable oscillator, TR_3, together with its associated buffer stage TR_4. This oscillator is basically similar to the one already described except that it is designed to tune from 100 kc/s to 120 kc/s by means of a standard two-gang 500 pF capacitor, VC_4 and VC_5. The buffer stage on this panel is untuned.

Output from the two oscillators is fed via screened leads to the mixer mounted on Panel C, where the mixing process is carried out by TR_5. This is biased to operate as a product detector, output from the fixed oscillator being injected into the emitter circuit and from the variable oscillator into the base. The resulting action is very similar to that of a frequency changer in a superhet, and output is taken from the collector circuit. At this point the unwanted radio frequencies are separated from the audio by means of a filter circuit. This follows standard practice but has been "tailored" to match the input of the following stage. The filter itself contains a parallel tuned circuit (L_4, C_{19} and VC_7) adjusted to resonate at 100 kc/s. This presents a very high impedance to the fundamental radio frequencies which are consequently bypassed to earth by the capacitors C_{18} and C_{20}. Any residual radio frequencies are prevented from reaching the audio stages by L_5, which is a standard 2·5 mH r.f. choke.

It should be mentioned that in the prototype the filter circuit was found to be the most critical part of the whole instrument. Any wide divergence from the values given can seriously affect the higher end of the audio range. The components used are standard and are readily available.

A home-wound pot core assembly whose construction is described next month is employed for L_4, but early checks with the prototype indicated that a Repanco 5 mH choke type CH2 would function equally well. If, however, the reader uses such a choke instead of the pot core coil it should be on an experimental basis only, and it may be necessary to alter the value of C_{19} to obtain the requisite filter frequency. Also, the choke must be mounted at right angles to L_5 to prevent interaction. With the pot core assembly and the values shown in Fig. 2, L_4 resonates at the correct frequency, and this fact has been carefully checked in practice.*

Panel D contains a three stage audio amplifier of conventional design in which generous use of negative feedback keeps distortion to a low level and also allows for differences in the individual transistors used. The feedback is provided over the first two stages by R_{24} and in the final stage by R_{32}. A sinewave of 1·5 volts r.m.s. is available from the collector of TR_8 but this can be reduced as required by the gain control (VR_1) in the collector circuit of TR_7. The gain control is ganged to the on-off switch of the instrument for convenience.

In order to make the instrument more versatile two additional refinements are included in the design. A 3-step attenuator given by R_{33} to R_{36} and S_2 provides for the output to be reduced by 20 dB stages, the output impedance being kept reasonably constant at around 2 kΩ. A meter is also included to monitor the output, which can then be adjusted as required.

It will be noted that besides indicating the output voltage, the meter can also be switched to read the collector current of the mixer stage. This is to enable the instrument to be accurately "zeroed" for, as the zero frequency position is approached, the mixer collector current fluctuates slowly enough for the meter needle to follow. The zero is adjusted until the needle oscillates at as low a rate as possible. The instrument is then set to within a few cycles of zero frequency. This process, in itself, provides a check upon the calibration of the unit.

For economy reasons, the meter used in the prototype is a 50μA "level indicator" as used on some tape recorders. R_{37} is adjusted so that the level mark on the meter indicates 1 volt r.m.s. and is, in fact, an 18kΩ resistor in parallel with a 56kΩ resistor. If a standard 50μA is used, R_{37} should be adjusted for the meter to read 2 volts full scale deflection. The exact value will depend upon the internal resistance of the meter used and upon the diodes used in the meter bridge. It should be around 18kΩ. The value of R_{41} will also depend upon the internal resistance of the meter, and should be such that the meter reads half-scale when switched to the "mixer" position. In the original, R_{41} is 820Ω.

It should be noted that, if a Yaxley switch is employed for S_3, it must have break-before-make contacts.

Power requirements for the instrument are extremely modest, the total current consumption from a 9 volt source being 14mA. The zener diode used by the author in the Z_1 position was a Texas 1S7062A, but any 5% 6·2 volt zener diode stabilising at around 5mA will be satisfactory. (A type 1S7062, which meets these requirements, is available from Henry's Radio, Ltd.) By using a

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*The author states, in answer to a query from ourselves, that varying values in C_{18} and C_{20} ranging from 0·001μF to 0·02μF have little effect on the tuning of L_4.—EDITOR.

PP9 type of battery the instrument can be made self-contained. Alternatively an external power supply could be used, preferably a type of supply with some form of stabiliser included.

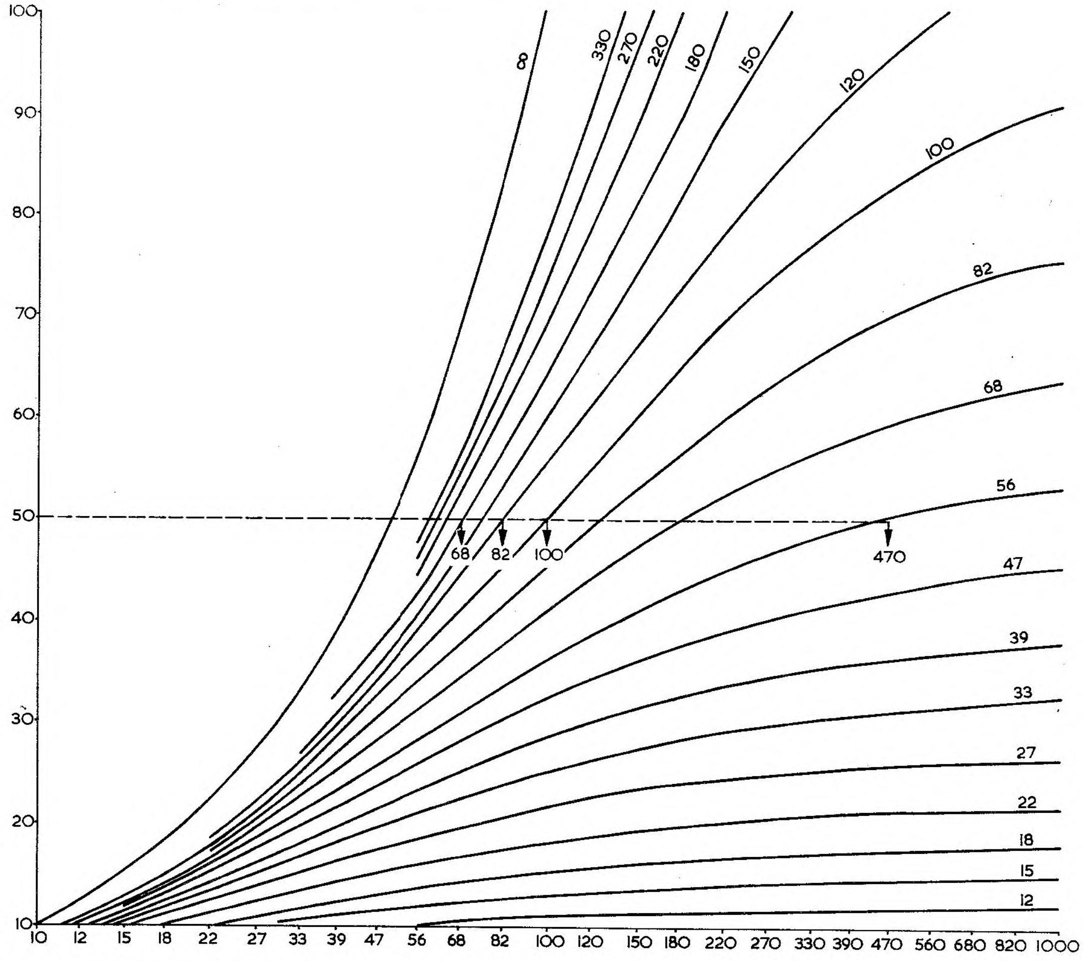
(To be continued)

Ready Reckoner for Parallel-R and Series-C

by

R. M. BLACKALL

An ingenious diagram which enables parallel resistor and series capacitor problems to be solved without recourse to calculation



THE ACCOMPANYING DIAGRAM HAS BEEN DESIGNED TO give scales that are as free from convergence as possible. The horizontal scale is logarithmic, so that the preferred values are well spaced and cover a wide range. The vertical scale gives the resultant value and this is linear.

The diagram gives parallel resistance or series capacitance from the equations

$$R_{total} = \frac{R_1 \times R_2}{R_1 + R_2}$$

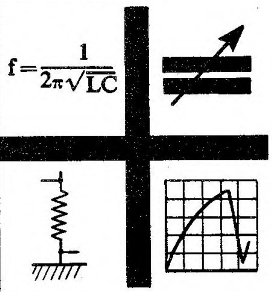
$$C_{total} = \frac{C_1 \times C_2}{C_1 + C_2}$$

where R_{total} or C_{total} is the resultant value and R_1 and R_2, or C_1 and C_2, are the individual values.

As an example of how the diagram may be used, consider the resultant values given by 68 (ohms, kilohms or megohms) in parallel with 180, 82 in parallel with 120, 100 in parallel with 100 and 470 in parallel with 56. In each case the resultant value is equal to (or very nearly equal to) 50, as shown by the dashed line. ✱

UNDERSTANDING RADIO

A.G.C. VOLTAGE



$$f = \frac{1}{2\pi\sqrt{LC}}$$

by W. G. Morley

In last month's contribution to this series we examined a.g.c. diode circuits as are employed in valve a.m. sound radio receivers, dealing first with circuits in which an a.g.c. voltage is produced for all input signal amplitudes and then carrying on to circuits in which an a.g.c. voltage is produced only with signals whose amplitude exceeds a predetermined level. The second class of circuit provides what is described as "delayed a.g.c.", the word "delay" applying to voltage and not to time. We saw that both classes of a.g.c. are employed in valve a.m. receivers, despite the advantages in performance conferred by the delayed a.g.c. system. The delayed a.g.c. circuit also has the minor disadvantage that it can introduce distortion with low strength a.m. signals whose amplitude at the a.g.c. diode is close to the delay voltage. However, this distortion can be reduced to an acceptable level if the delay voltage is of the order of 2 to 3 volts and if the i.f. signal for the a.g.c. diode is taken from the anode of the last i.f. amplifier valve.

We shall now examine the manner in which the a.g.c. voltage is applied to the controlled valves.

APPLYING A.G.C. VOLTAGE

The a.g.c. system in a receiver functions by applying the negative voltage produced by the a.g.c. diode back, as a bias voltage, to the control grids of the valves which precede the diode, and it will be recalled that these valves are the r.f. amplifier valve (if fitted), the frequency changer, and the i.f. amplifier valve or valves. All the controlled valves have variable-mu characteristics, whereupon their mutual conductance varies "smoothly" as their grid bias voltage alters. As is required of an a.g.c. system in a valve receiver, the a.g.c. voltage goes negative as the signal amplitude passed to the a.g.c. diode increases.

Fig. 1(a) illustrates one method of applying the a.g.c. voltage to a controlled valve. In this case the a.g.c. voltage is applied to the grid of an r.f. amplifier valve. Capacitor C_1 is a d.c. blocking capacitor and has a fairly low reactance at the frequency applied to the control grid. A typical value, for frequencies in the long, medium and short wave bands, would be of the order of 100 to 200pF. Resistor R_1 should have a value which does not cause any excessive damping (i.e. reduction in effective Q factor) of the tuned circuit and could, typically, be 1MΩ. The valve has cathode bias components, these allowing it to have its normal bias voltage when the a.g.c. voltage is zero.

An alternative method of applying a.g.c. voltage is shown in Fig. 1(b) and, here again, an r.f. amplifier stage is chosen as an example. In this instance, a capacitor, C_2, having a very low reactance at the resonant frequency of the tuned circuit is inserted between the lower end of the tuned coil and chassis, the a.g.c. voltage being applied to it via R_2. A representative value for C_2 would be 0·1μF, whilst R_2 may lie between 100kΩ and 1MΩ according to receiver design. It will be noted that the lower terminal of the tuning capacitor in Fig. 1(b) remains at chassis potential, as is desirable when this is one section of a ganged capacitor having the normal construction employed for such components. It is necessary for C_2 to have a very low reactance at the resonant frequency of the tuned circuit because it would otherwise cause an undesirable reduction in the tuning range available from the tuned coil and the tuning capacitor. The latter will be ganged with the variable capacitor controlling the oscillator frequency, whereupon the oscillator padding capacitor must have a value which takes account of the presence of C_2, or receiver tracking will suffer. This last point is of particular importance when the oscillator padding capacitor has a value approaching that of C_2, as can occur on the short wave bands of conventional superhets.

The method of a.g.c. voltage application shown in Fig. 1(a) is frequently referred to as "parallel feed" and that in Fig. 1(b) as "series feed". As we have noted, with parallel feed it is necessary for the feed resistor (R_1) to have a value which does not cause objectionable damping of the tuned circuit. Also, with series feed it is necessary for the capacitor inserted at the chassis end of the coil (C_2) to have a very low reactance (i.e. high capacitance) and to choose a value of oscillator padding capacitance which allows for its presence.

Both the circuits of Figs. 1(a) and (b) are suitable for use in an r.f. amplifier stage. They may also be employed at a frequency changer stage, in which case the a.g.c. voltage is applied to the signal frequency grid of the valve.

With an i.f. amplifier, the series feed method is preferable, and the appropriate circuit is shown in Fig. 1(c). This differs slightly from Fig. 1(b) because the added capacitor employed in the a.g.c. system, C_3, does not enter the i.f. transformer tuned circuit. The tuning capacitor for the latter is a fixed component and it is not required that one of its terminals be at chassis potential. There is no necessity for C_3 to have quite as large a capacitance as does C_2, of Fig. 1(b), although a value of about 0·01μF or more is still desirable. The parallel feed type of a.g.c. voltage application is not attractive for i.f. amplifier grid circuits, because the effective Q factor of a tuned i.f. transformer secondary, which is of course expressly designed to operate at a single frequency, is higher than is that of an r.f. tuned circuit, and the added grid resistor would cause significant damping.

TIME CONSTANT

Fig. 2 illustrates the components used in a simple a.g.c. circuit, as is encountered in domestic a.m. valve superhets having no r.f. stage and a single i.f. amplifier valve. Resistor R_3 is the a.g.c. diode load, whilst R_2 and C_2 are the low-pass filter components which ensure that no i.f. signal is present on the a.g.c. voltage. C_2 also carries out the same function as did C_3 in Fig.1(c). Thus, the a.g.c. voltage is applied to the i.f. amplifier control grid via a series feed arrangement. At the same time, the a.g.c. voltage is passed to the frequency changer signal grid via the parallel feed method of Fig. 1(a). The circuit of Fig. 2 is typical of the a.g.c. systems incorporated in many domestic long, medium and short wave a.m. receivers, and the component values are representative of standard practice. We shall now refer to this circuit as an example for the explanation of a.g.c. *time constant*.

Let us imagine that a signal is suddenly applied to a receiver employing the a.g.c. circuit of Fig. 2. As soon as the signal appears, the a.g.c. diode immediately applies a negative-going voltage to the right hand end of R_2. It will be apparent that the *speed* at which this negative voltage is fed back to the controlled valves, and thereby reduces their gain, depends upon the values of R_2 and C_2. Both these components have relatively large values, and an appreciable time will elapse before C_2 becomes charged such that the full a.g.c. voltage appears across its plates. There will also be a time delay due to the presence of C_1 in the parallel feed circuit to the signal grid of the frequency changer but, since C_1 has a very much lower value than C_2, this secondary time delay will be negligible and can be ignored. Another point is that the internal impedance in the a.g.c. diode when it produces the a.g.c. voltage is low, and this may be similarly ignored. Thus, as already stated, the two components which control the speed at which the negative a.g.c. voltage is applied to the controlled valves are C_2 and R_2.

Let us next assume that the signal is suddenly removed. At once the a.g.c. diode will cease to conduct, whereupon C_2 will commence to discharge and the negative a.g.c. voltage on the grids of the controlled valves will fall to its previous value, the speed at which it falls being that at which C_2 discharges. Since the a.g.c. diode does not now conduct, the discharge path for C_2 is given via R_2 *and* the diode load R_3. Thus, C_2 has to discharge through a higher resistance (R_2 plus R_3) than that through which it charges, and it follows that the speed at which the a.g.c. voltage falls is slower than that at which it rises. In consequence, an a.g.c. circuit of the type shown in Fig. 2 operates more quickly with signals that are increasing in amplitude than it does with signals which are decreasing in amplitude. This effect is unavoidable. In practice, it is not particularly troublesome provided that R_3 is lower in value than R_2.

An a.g.c. system has to be fast-acting if it is to be effective with signals which are subject to rapid fluctuations in strength due to fading. At the same time, however, it must not be so fast-acting that the a.g.c. voltage responds to the lower audio frequencies modulating the signal being received. If this were to occur the a.g.c. system would, as a first effect, cause these frequencies to be attenuated. As a second effect, the alternating audio frequencies in the a.g.c. voltages applied to the controlled valves could, due to waveform distortion introduced by the filter components in the a.g.c. circuit, amplitude modulate other audio frequencies as well.

The normal approach in domestic a.m. receivers is to make the speed of a.g.c. operation with increasing signal

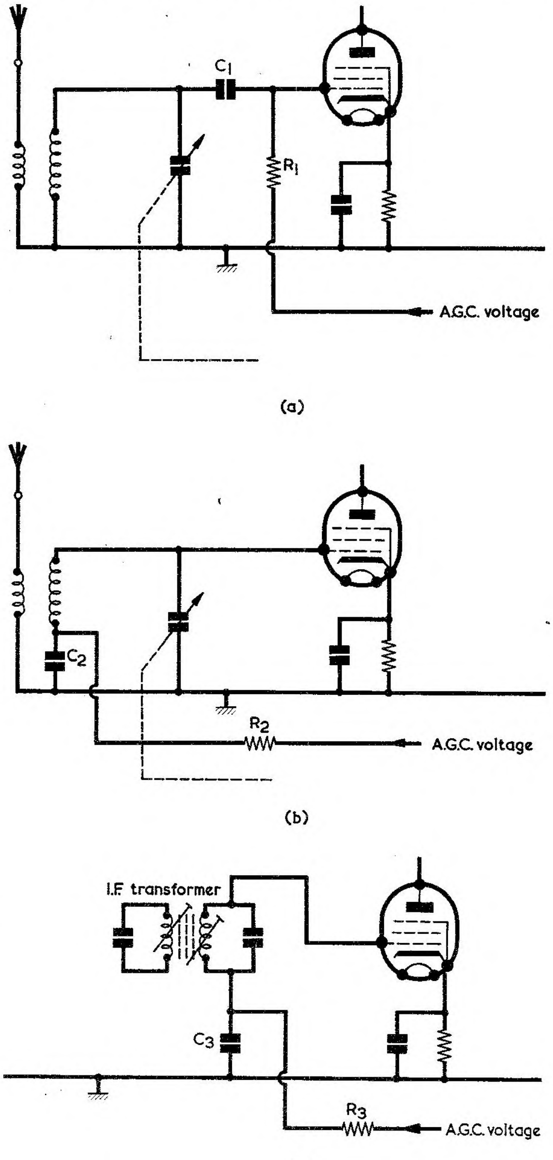


Fig. 1 (a). Applying an a.g.c. voltage to an r.f. amplifier by the parallel feed method
(b). The series feed method of applying the a.g.c. voltage
(c). The series feed circuit as used with an i.f. transformer

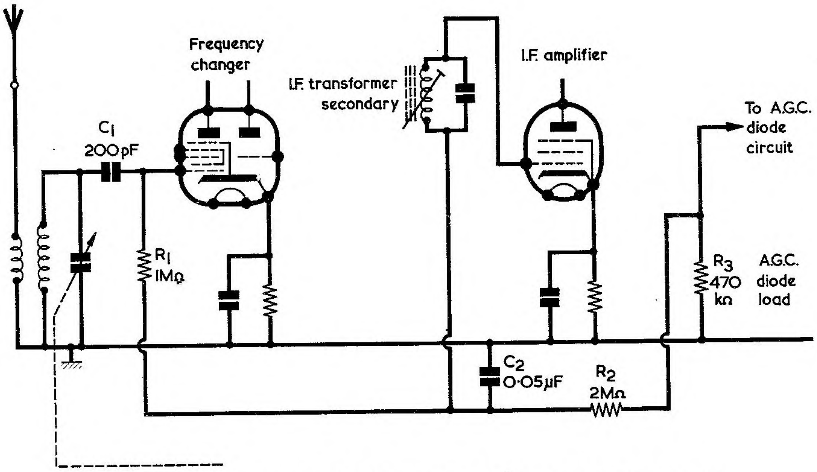


Fig. 2. A typical a.g.c. circuit with representative component values, as encountered in domestic a.m. radio receivers. The components with circuit reference numbers are those in the a.g.c. circuit proper

strength (i.e. when C_2 of Fig. 2 *charges*) several times slower than that at which feedback of the lowest audio frequencies to be reproduced can occur. The speed of operation when signal strength decreases will then be automatically slower and the a.g.c. system as a whole will not respond to a.f. modulating signals.

The operating speed of an a.g.c. system is expressed in terms of the *charging* time constant of its filter components as signal strength increases. In the circuit of Fig. 2, this time constant is that offered by C_2 and R_2. Now, the time constant of a resistor and capacitor is defined as the time taken for the voltage across the capacitor, when initially discharged, to rise to 63% of an e.m.f. suddenly applied via the resistor,* and it is equal to the capacitance multiplied by the resistance where time constant is in seconds, capacitance is in farads and resistance is in ohms. The farad is a very large capacitance, and it is usually more convenient to calculate time constant, in seconds, from microfarads and megohms. (Since one quantity is divided by a million and the other is multiplied by a million their product remains the same).

In Fig. 2 the time constant for the a.g.c. system is given by C_2 (0·05µF) multiplied by R_2 (2MΩ) and works out as 0·1 second. This is a typical a.g.c. time constant for a domestic a.m. receiver and, because it corresponds to one half-cycle at 5c/s, can be expected to afford good protection against unwanted a.g.c. operation by modulating audio frequencies. The same time constant would be given if, say, C_2 were 0·1µF and R_2 were 1MΩ, since the product once more works out as 0·1 second. In general, the a.g.c. time constants in domestic receivers intended for long, medium and short wave a.m. operation lie between 0·05 and 0·2 seconds, these offering sufficient speed of a.g.c. operation to counteract most types of fading likely to be met. If the receiver is intended for high fidelity reproduction, where the lower audio frequencies are reproduced at greater level than in more inexpensive domestic equipment, it is preferable to use a slightly longer a.g.c. time constant, from around 0·2 to 0·4 second. Such receivers will normally be used for listening to transmissions offering good signal strength and which are not subject to high speed fading, whereupon a fast-acting a.g.c. system is not so necessary. Incidentally, the last type of receiver will normally be made in the form of an "a.m. tuner unit", this comprising all the stages of a superhet up to and including the signal detector and a.g.c. diode. Its a.f. output is then coupled to a separate high fidelity a.f. amplifier.

Specialised a.m. receivers, as are used for communications reception and the like, have different a.g.c. requirements, and it is a common practice to fit a switch which can select one of two a.g.c. time constants. Typical time constants are of the order of 0·2 seconds for telephony (speech) and 0·5 seconds for telegraphy (morse transmission). A communications receiver will also have a switch to cut the a.g.c. system out altogether, this being accomplished by short-circuiting the a.g.c. feed, after the filter resistor immediately following the a.g.c. diode, to chassis. Manual controls are then employed to control the gain of the r.f. and i.f. stages.

A.G.C. COMPONENT VALUES

As we have seen from the simple a.g.c. circuit of Fig. 2, an important requirement of the filter components C_2 and R_2 is that they should provide the time constant desired for the particular receiver in which they are fitted. There are other requirements which also affect component values in the a.g.c. circuit. If, for instance, the a.g.c. voltage is taken from the detector diode load instead of from a separate diode, R_2 requires a high value in order to reduce a.c. loading on the detector circuit. A further point, which we have already mentioned, is that whilst C_2 functions as a low-pass filter component it also acts as a bypass capacitor at intermediate frequencies for the i.f. transformer secondary, with the result that it requires a reasonably large value in order to provide a low reactance at such frequencies. Another reason for giving C_2 a large value is that it also decouples the a.g.c. feeds to both the i.f. and frequency changer grid circuits,

(continued on page 453)

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*Or for the voltage across a charged capacitor to fall to 37% of its initial value when the resistor is connected across it. Time constant was discussed in detail in "Understanding Radio" in the October 1962 issue.

RC/DS/22

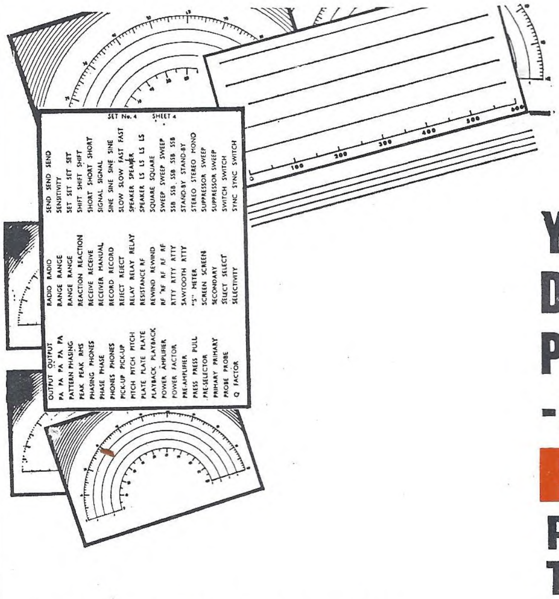
RADIO CONSTRUCTORS DATA SHEET 22

E.R. DISSIPATION TABLE

(50 Volts and above)

The Table gives dissipation in watts, from $W = \frac{E^2}{R}$, for resistance at commonly encountered voltages from 50V to 500V. For resistances above 1MΩ divide down from the value shown for this resistance, using the method detailed in Data Sheet No. 21. For reliable working, carbon resistors require ratings at least 1·5 times the wattage figure given here or in Data Sheet No. 21.

Resistance	50V	60V	80V	100V	120V	140V	160V	200V	300V	400V	500V
470Ω	5·3	7·7	14	21							
680Ω	3·7	5·3	9·4	15	21						
1kΩ	2·5	3·6	6·4	10	14	20					
2·2kΩ	1·1	1·6	2·9	4·5	6·6	8·9	12	18			
4·7kΩ	0·53	0·77	1·4	2·1	3·1	4·2	5·4	8·5			
6·8kΩ	0·37	0·53	0·94	1·5	2·1	2·9	3·8	5·9	13		
10kΩ	0·25	0·36	0·64	1·0	1·4	2·0	2·6	4·0	9	16	
22kΩ	0·11	0·16	0·29	0·45	0·66	0·89	1·2	1·8	4·1	7·3	11
47kΩ	0·053	0·077	0·14	0·21	0·31	0·42	0·54	0·85	1·9	3·4	5·3
68kΩ	0·037	0·053	0·094	0·15	0·21	0·29	0·38	0·59	1·3	2·4	3·7
100kΩ	0·025	0·036	0·064	0·1	0·14	0·2	0·26	0·4	0·9	1·6	2·5
220kΩ	0·011	0·016	0·029	0·045	0·066	0·089	0·12	0·18	0·41	0·73	1·1
470kΩ			0·014	0·021	0·031	0·042	0·054	0·085	0·19	0·34	0·53
680kΩ				0·015	0·021	0·029	0·038	0·059	0·13	0·24	0·37
1MΩ				0·01	0·014	0·02	0·026	0·04	0·09	0·16	0·25


SET No. 4 SHEET 4

SOLID-STATE DIGITAL CLOCK

Part 3

by

A. J. EWINS

In the third section of this 4-part series, the technical description is completed by examining the AM/PM light switching circuit and the chime oscillator. Details of construction are then commenced

AM/PM LIGHT CIRCUIT

THE AM/PM LIGHT CIRCUIT, SHOWN IN FIG. 11, LOOKS very much like a Schmitt trigger, but its operation is essentially different in that each transistor is either "hard-on" or "hard-off". It might, in fact, be termed a "saturated Schmitt trigger".

The input to the circuit is obtained from the output of binary B25 (see Fig. 1). When the output from B25 is "up", TR_1 will be fully conducting. The values of R_2, R_3, R_4 and R_5 are chosen so that TR_3 is also fully conducting with the result that the base of TR_2 is below its emitter voltage, hence TR_2 is "off". Thus the lamp PL_2 is lit.

The lamps are 6V 0·04A types. R_5 is chosen to be 150Ω so that when either TR_2 or TR_3 is fully conducting the voltage supply needs to be (150 x 0·04)+6=12V. (This is the unsmoothed 12V supply obtained from the power supply in Fig. 5.)

When the output of B25 is "down", TR_1 is non-conducting with the result that the base of TR_2 is fed from the supply rail via R_2. Thus TR_2 becomes fully conducting, PL_1 is lit and, due to the values chosen for R_4 and R_6, TR_3 becomes non-conducting as its base voltage falls below its emitter voltage.

COMPONENTS

(Fig. 11)

Resistors

R_1	100kΩ
R_2	5·6kΩ
R_3	4·7kΩ
R_4	5·6kΩ
R_5	150Ω
R_6	27kΩ

Transistors

TR_1, TR_2, TR_3 BC168 (or suitable alternative—see text)

Lamps

PL_1, PL_2 6V 0·04A (see text)

Lamps PL_1 and PL_2 are 6V 0·04A rear lamps, as used in bicycle dynamo lighting systems. If any difficulty is experienced in obtaining these, they are usually available at Woolworth's stores.

The transistors specified for TR_1, TR_2 and TR_3 are BC168. However, any n.p.n. transistors with h_{fe} greater than 100 may be employed instead.

CHIME OSCILLATOR

The chime oscillator circuit is given in Fig. 12. Except for the addition of TR_3 with its associated base resistors and C_2, the circuit is a conventional free-running multivibrator. C_2 was added experimentally and found to produce a more "pure" tone with a slight reduction in frequency. The input to the base of TR_3 is fed, via R_5, from the output of the NAND gate (see Fig. 2). When TR_3 is non-conducting the oscillator is allowed to run freely, but when TR_3 is fully conducting the base of TR_2 is held down at near earth potential with the result that the oscillator is held with TR_1 "on" and TR_2 "off", i.e. not

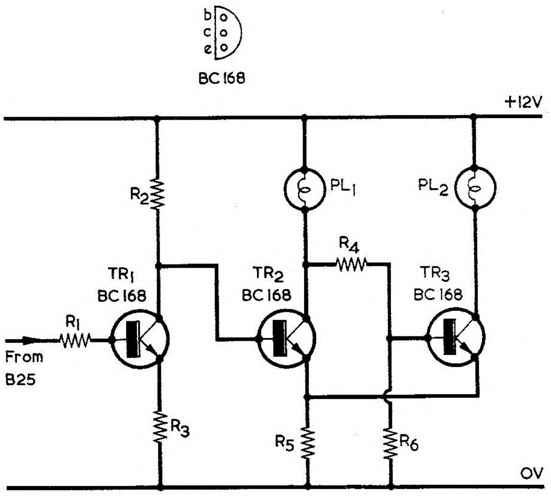


Fig. 11. The AM/PM light switching circuit. The input is obtained from bistable B25 of Fig. 1 (published in Part 1 of this series)

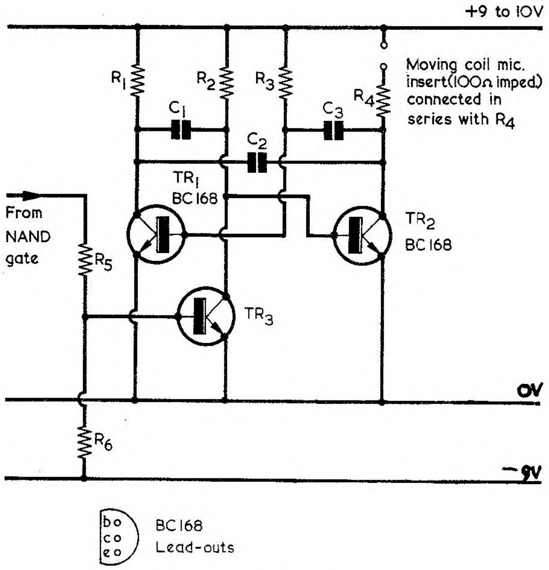


Fig. 12. The chime oscillator. This is controlled by the output from the NAND gate via transistor TR_3

COMPONENTS

(**Fig. 12**)

Resistors

R_1	4·3kΩ
R_2, R_3	33kΩ
R_4	1kΩ
R_5	100kΩ
R_6	820kΩ

Capacitors

C_1–C_3 0·02μF disc ceramic (as small as possible)

Transistors

TR_1, TR_2 BC168 (or suitable alternative—see text)

TR_3 silicon planar transistor

Reproducer

Moving coil mic. insert (see text)

free-running. The collector resistor of TR_1, R_1, is chosen to be as high as is practically possible so that the current consumption of the oscillator, when it is in its non-operative state, is at a minimum. The sound is provided by a moving coil microphone insert connected in series with the collector resistor of TR_2, R_4. Further details on this insert, which functions here as a reproducer, were given under "Notes on Components" published in Part 1 of this series.

Transistors TR_1 and TR_2 are specified as BC168, but any n.p.n. transistor with h_{fe} greater than 60 could be employed instead.

CONSTRUCTIONAL DETAILS

The various electronic circuits of the clock are wired up on three 0·1in pitch Veroboards and one 0·15in pitch Veroboard.

Board 1 consists of binaries B1 to B20 and the monostable, M1, of the basic circuit of the clock (see Fig. 1). Board 2 consists of the remaining binaries of the basic circuit, B21 to B25, the AM/PM light circuit (see Fig. 11) and the read-out circuit (see Fig. 4). Board 3 takes the

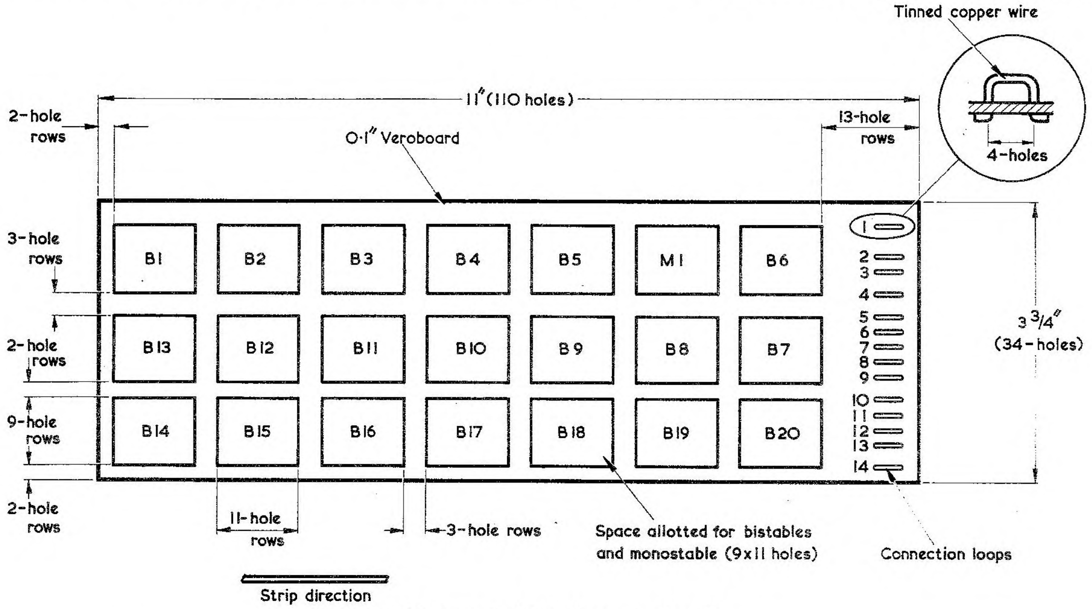
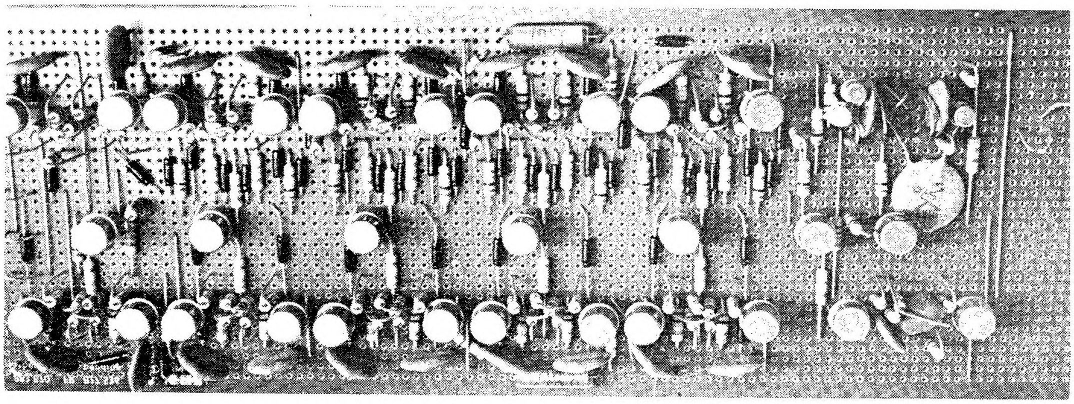


Fig. 13. Layout of the stages on Board 1



The chime circuit. This board, No. 3, holds all the components required for the chime function

chime circuit in its entirety. Finally, Board 4 is the combined power supply and Schmitt trigger (see Fig. 5).

Because of the obvious complexity of the construction of the four boards and the great number of words that would be necessary to describe it in detail it is proposed to give only an outline of the layout of the individual building blocks, leaving it to the constructor, with careful study of the photographs, drawings and circuits, to work out for himself the interconnections between the building blocks and the four boards. This, after all, is part of the fun of construction.

BOARD 1

A photograph of Board 1 was given in Part 1 of this series. This photograph should be studied in conjunction with Fig. 13, which illustrates the positions taken up by the bistables B1 to B20 and monostable M1. It should be noted that only the actual bistable and monostable components appear in the space allotted for them in Fig. 13. The additional components—shown outside the blocks in the basic circuit of Fig. 1—are similarly positioned outside the "allotted spaces" of Fig. 13.

Figs. 14 and 15 show the basic layouts of the components of a bistable and a monostable respectively. The view is looking down on the component side, with the copper side underneath. In Fig. 14 all components are mounted vertically except the diodes and the 100kΩ resistors from collectors to diodes. In Fig. 15 all the components are vertical apart from the 100kΩ and 10kΩ resistors which connect to the d.c. output. The transistor identification in Fig. 15 corresponds to that in the circuit diagram of Fig. 7. Both the bistables and the monostable take up a matrix of 11 x 9 holes. This layout is suitable for transistors with small TO-18 cans. If the constructor uses transistors with larger TO-5 cans the binary layout may be altered to that given for the chime binaries in Fig. 19. This altered layout occupies the same 11 x 9 holes. Both layouts appear in the author's prototype as he had both types of transistor on hand.

The size of the board is 11 x 3¾in, which is 110 x 34 holes. Referring to Fig. 13, the building blocks are arranged so that 3 columns of holes are left free between the columns of building blocks, 2 columns of holes are left free on the left-hand side of the board and 13 columns are left free on the right-hand side of the board. A space of 3 rows of holes is left between the top and middle rows of building blocks, 2 rows of holes are left between the middle and bottom rows of building blocks leaving 2 rows of holes below the bottom row of building blocks. Laying out the building blocks of Board 1 as described leaves plenty of space for the additional components of Fig. 1 interconnecting the binaries B1 to B20 and the monostable.

At the far right-hand side of the board can be seen 14 "connection loops". Board 1 is used as a master board,

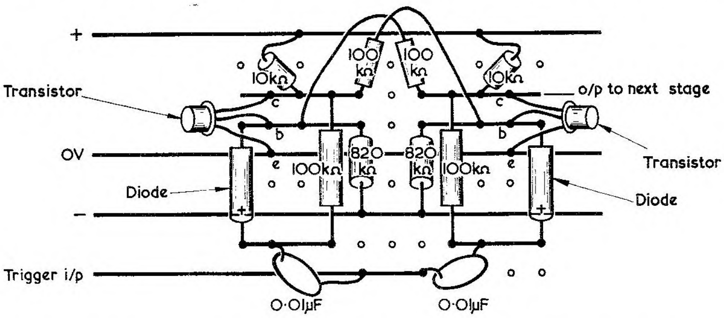


Fig. 14. Basic component layout of a bistable. In this and the similar diagrams which follow, the component side of the board is towards the reader

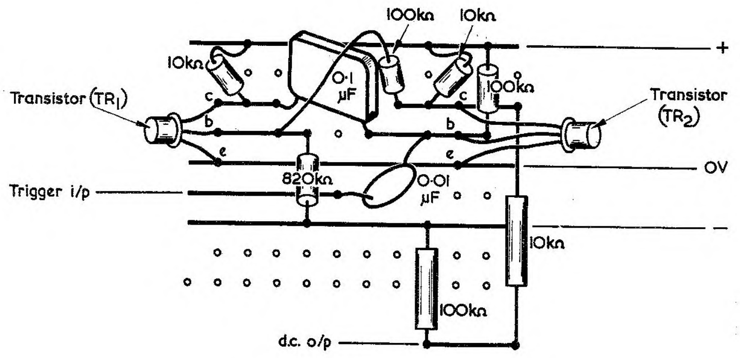


Fig. 15. Monostable component layout

connections to all the other boards being taken from it. The "connection loops" are simply loops of tinned copper wire soldered to the Veroboard strips as shown in the inset. External connections are made to these rather than to the Veroboard strips since it is easier to add and remove the external connecting wires. Also, the Veroboard copper strips might become damaged or lift from the board if repeated connections and disconnections were made to them directly.

The 14 "connection loops" provide the following services:

(1) Positive stabilised rail from power supply (Board 4)
(2) 0 volts or earth rail from power supply (Board 4)
(3) Negative rail from power supply (Board 4)
(4) 50 c/s square wave input from Schmitt trigger (Board 4)
(5) Positive supply rail to chime circuit (Board 3)
(6) Positive going second pulse to chime circuit (Board 3)
(7) 0 volts or earth rail to chime circuit (Board 3)
(8) Negative supply rail to chime circuit (Board 3)
(9) Negative going second pulse to push-buttons, S_2–S_5
(10) Positive supply rail to Board 2
(11) Hour pulse to chime circuit (Board 3)
(12) 0 volts or earth rail to Board 2
(13) Negative supply rail to Board 2
(14) Hour pulse to Board 2

Visible in the photograph of Board 1 (but not shown in Fig. 13) are 14 connecting leads from the component side of the board. These provide the connections between the outputs, 1 to 14, from the binaries B7 to B20 and the inputs, 1 to 14, of the meter read-out circuit (Board 2). Just visible in the photograph are vertically mounted diodes and resistors associated with binaries B1 to B6 (near the top right hand corner of each binary). These should be ignored. They were originally designed to reset the binaries B1 to B6 but were later omitted from the circuit.

After assembling the binaries and monostable it should be a fairly easy matter for the constructor to work out the positioning and connection of the remaining components of Fig. 1 associated with Board 1. As may be seen from the photograph, "jumper" wires are used where convenient to connect spaced copper strips together. Probably the trickiest thing to work out is the positioning of the holes that need to be cleared of copper (i.e. where the rows of copper conductors must be "broken") so it

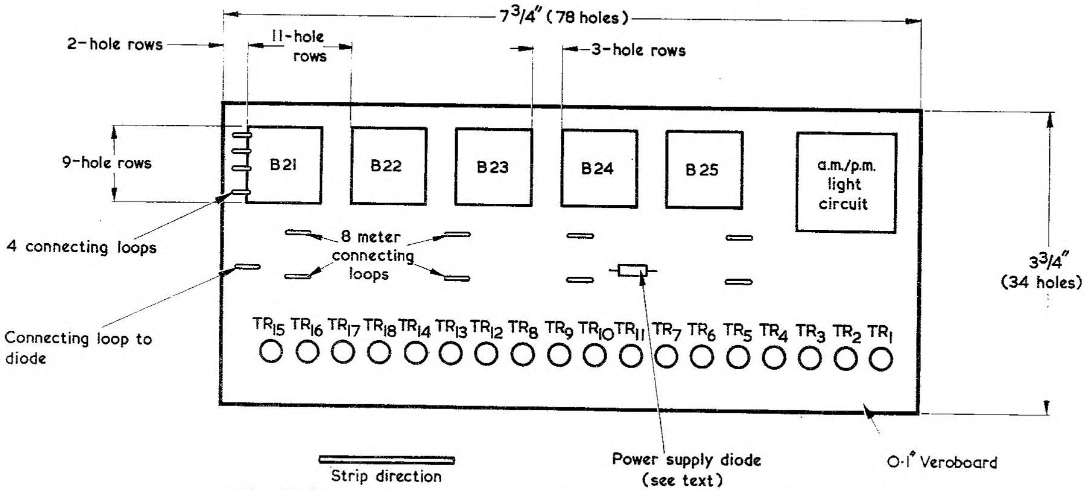


Fig. 16. The positions taken up by the stages and read out transistors of Board 2

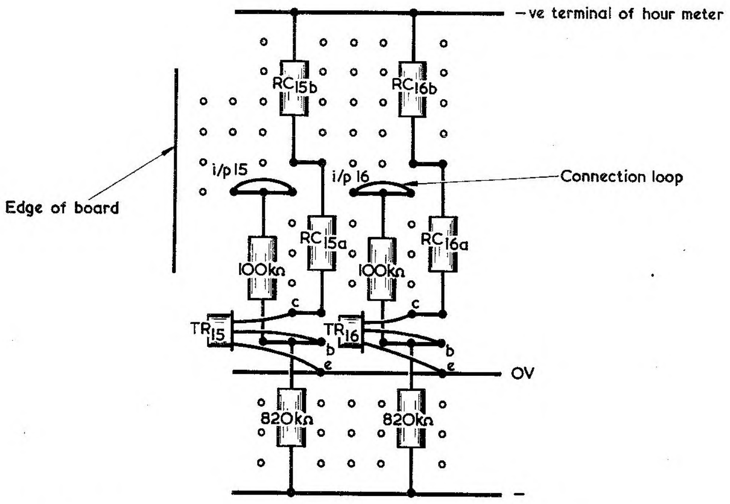


Fig. 17. Component layout for the first two transistors in the read out circuit

is advisable to double check everything before applying any electrical tests. Further general advice is given at the end of the constructional details.

BOARD 2

A photograph of Board 2 also appeared in Part 1 of this series, and it should be examined in company with the layout diagram of Fig. 16.

The top half of the board contains, from left to right, the binaries B21 to B25 of Fig. 1 and the AM/PM light circuit. The component layout of the binaries is as shown in Fig. 14. The lower half of the board contains the read-out circuit of Fig. 4. It will be seen that there are 19 transistors in the photograph instead of 18 as shown in the circuit diagram and Fig. 16. The extreme right-hand one should be ignored. (The author had thoughts of the seconds pulse operating a magnetic counter or some similar item.) The layout of the first two transistors (from the left) and their associated resistors is shown in Fig. 17, the layout of the others following the same pattern. All resistors are mounted horizontally. It must be noted that the order of the transistors, from left to right, is *not* TR_1 to TR_{18}, but TR_{15} to TR_{18}, TR_{14} down to TR_{12}, TR_8 to TR_{11} and TR_7 down to TR_1. The repositioning of the transistors and their associated resistors was carried out in order that the interconnections between the various binaries and the readout circuit should be as short as possible when Boards 1, 2 and 3 were mounted in their final positions. The size of Board 2 is approx. 7¾ x 3¾in (78 x 34 holes). The binaries were again mounted with a space of 3 columns of holes between them and a space of 2 columns of holes on the left of the board. It is left to the constructor to design a suitable layout for the AM/PM light circuit at the top right of the board.

The lonely-looking diode, centre right on the board, is one half of the full-wave rectifier for the unsmoothed supply to the AM/PM light circuit. This diode connects to one half of the 12–0–12 volt winding of the mains

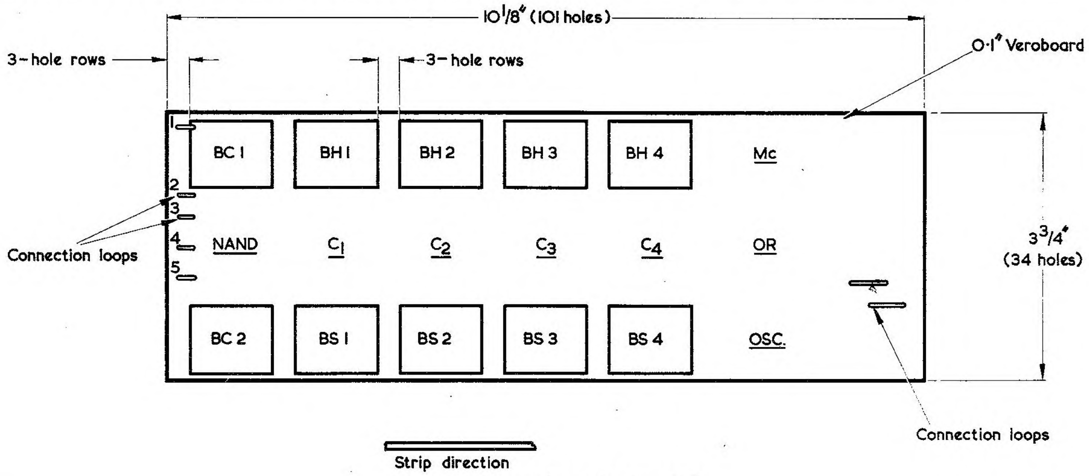


Fig. 18. Stage layout for Board 3

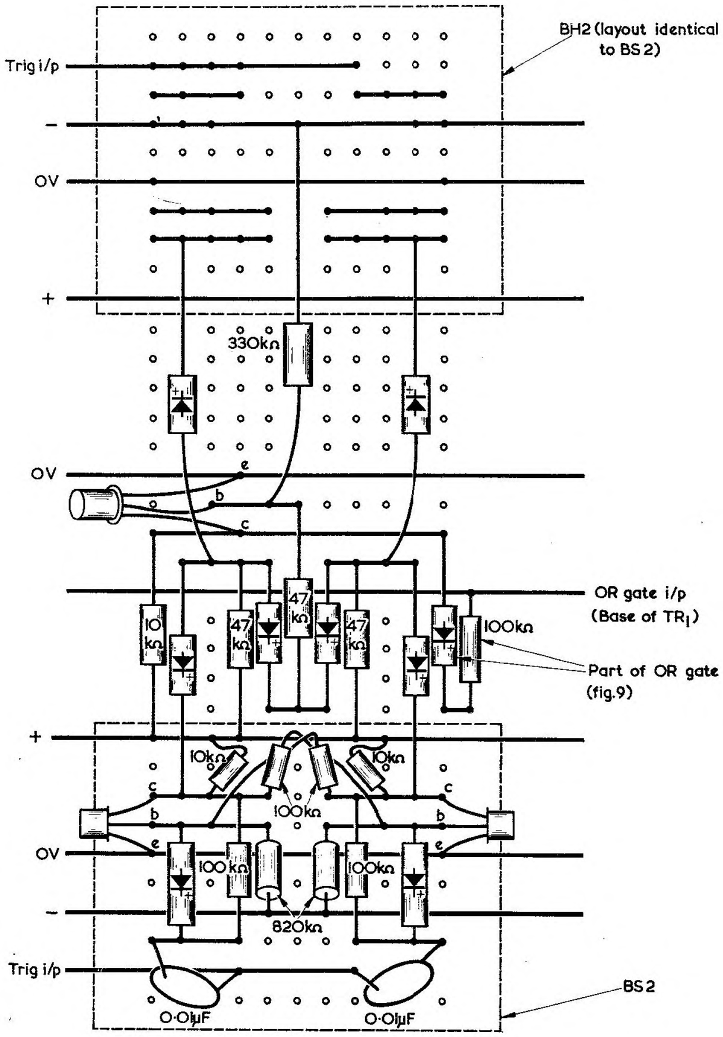


Fig. 19. The interconnections between an hour binary, a comparator and a seconds binary on Board 3

transformer on Board 4 via a "connecting loop" at the extreme left. It was originally intended to use a half-wave rectified unsmoothed supply for the circuit but as it was found to be unsatisfactory (the light bulbs were not bright enough) the second diode, to give a full-wave rectified supply, was added. It is suggested that the constructor mounts a second diode on the row above the one occupied by the present diode, the right-hand side of it being connected to the right-hand side of the existing one and the left-hand side of it being connected to the other half of the 12–0–12v winding on the transformer.

At the top left-hand side of the board are four connecting loops. These are, from top to bottom:

(1) Positive supply rail from Board 1
(2) 0 volts or earth rail from Board 1
(3) Negative supply rail from Board 1
(4) Hour pulse from Board 1

Indicated in Fig. 16 are the approximate positions of 8 "connecting loops" for the meters, the top loop in each case being the positive supply rail. Returning to Fig. 17, which shows the view from the component side of the board, it will be seen that each of the read-out transistors has a small "connecting loop" also, this allowing an external connection to be made to its input 100kΩ resistor. (Actually, there is no need for this loop with TR_{15} to TR_{18}, since these are coupled to binaries on the same board.) Finally, it will be noted that the read-out transistors proceed along the board on a "4-hole matrix", as indicated by Fig. 17.

The layout and connections of the remaining components (those associated with B21 to B24) and the various jumper wires are left to the constructor's judgement.

BOARD 3

The photograph appearing in this issue is of Board 3, and stage layout is given in Fig. 18. On this board is constructed the entire chime circuit of Fig. 2. The layout of the 18 building blocks on the board is the same as on the circuit diagram, that is, BC1 at the top left-hand side of the board then BH1 to BH4 and the monostable at the top right-hand side of the board, and so on. The layout of the binaries is a little different from those on Boards 1 and 2 because, as was mentioned when discussing Board 1, the transistors used were of TO–5 construction instead of TO–18, the larger can requiring a slight reshuffling of components. The interconnections between an hour binary, a comparator and a seconds binary and the basic layout of the components are shown in Fig. 19, with the components side of the board towards the reader. All resistors can be mounted horizontally except for the cross-coupling 100kΩ and collector 10kΩ resistors in the bistable. All the diodes are horizontal. Note that an input diode and 100kΩ resistor of the OR gate (Fig. 9) appears in the layout of Fig. 19. The layouts of the monostable, the oscillator, the remaining components of the OR gate, and the NAND gate, are left to the constructor to design and will be found to fit easily into the remaining spaces. The board is approx. 10⅛x3¾in. (101x34 holes). The two connection loops at the right of the board are for connection of the oscillator output to the moving coil microphone insert. The five connection loops at the left of the board are, from top to bottom:

(1) Hour pulse from Board 1
(2) Positive supply rail from Board 1
(3) 0 voltage or earth rail from Board 1
(4) Negative supply rail from Board 1

(5) Positive going second pulses from Board 1

Again, great care must be exercised that the copper conducting strips are "broken" in the correct places and these should be double checked before testing.

NEXT MONTH

Next month's concluding article will commence with a description of Board 4, after which general constructional and setting-up details will be given.

(To be concluded)

TRADE REVIEW

NOMBREX WIDE RANGE TRANSISTORISED R.F. GENERATOR MODEL 29S.

This instrument is the latest addition to that range of test equipment currently marketed by Nombrex Ltd., of Exmouth, Devon. This standard model has the general specification shown below and is the result of many years of design, development and manufacturing experience of solid-state signal generators. Of completely new design, it incorporates every function and facility at a reasonable price, and forms a versatile all purpose portable instrument ideal for the service engineer, technical training colleges and for the amateur radio technician.

The instrument has a wide frequency coverage, 150 kc/s to 220 Mc/s in 8 overlapping bands, each band having a separate scale—see illustration herewith. The 8 bandspread scales have a total length of 40 in, the rectangular tuning scale being 5½ x 2¼in, the scale discrimination being 0·6% to 1·5% of the indicated frequency. A smooth vernier tuning control having a ratio of 7½:1 with a magnifier tuning cursor, for easy and accurate adjustment, is fitted. An optional extra is that of a rapid spin wheel tuning device.

The r.f. output has an average maximum of 100mV on all ranges, the modulator-buffer output stage eliminating load-frequency variations. The output has a 600Ω resistance, constant at all attenuator settings.

For calibration purposes, an electronic calibrator panel control, providing scale accuracy adjustment within 0·05% against an external standard frequency signal, is fitted.

The variable modulation depth is from 0 to 100%, the modulation frequency being adjustable from 400 to 1,000 c/s. An a.f. jack is provided for external modulation.

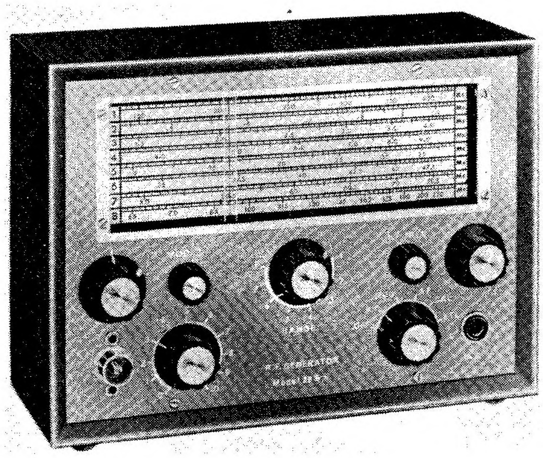
The stability of the r.f. circuits is stabilised against variations in battery voltage. Easy access to the battery is provided by the removal of a small rear cover and the instrument employs a standard transistor 9V battery—Ever-Ready PP4 or Drydex DT4.

The attenuator is continuously variable being nominally calibrated from 0 to 10.

A jack socket provision for operation from an external 9V battery or mains supply unit is provided. Insertion of the jack automatically disconnects the internal battery.

A printed circuit assembly is used throughout, this ensuring long-term stability and reliability.

The case dimensions are 7½in wide, 5¾in high and 3¾in deep, being of steel and stove enamelled in a medium grey colour, the panel being recessed and anodised medium blue. The scales and characters are in satin-silver, the control knobs being black and having a fluted grip with spin disc styling inserts.

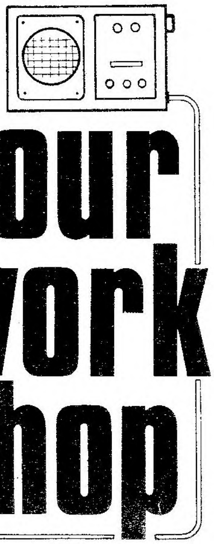


The accessories are supplied with the instrument, these being a coaxial r.f. test lead 36in long terminated by 2 clips, an audio jack plug, circuit diagram, full components list and operating information.

Model 29-X incorporates all the features of the Standard Model 29-S plus an integral crystal oscillator module providing harmonic calibration check points on all ranges, employing a unique electronic calibrator panel control, to a check-point accuracy of ±0·02%. The marker signal, level adjustable by the attenuator, is available separately at the r.f. output socket for use with external equipment.

The spin wheel tuning is available as an optional extra on both models to special order. It provides rapid traverse of scale combined with smooth vernier adjustment. Add suffix –/SPIN when ordering.

In your work-shop



Smithy's last incursion into the field of binary numbers (in the March 1967 issue) resulted in a number of appreciative comments from readers. This month Smithy returns to the subject and demonstrates to his able assistant, Dick, some of the many neat mathematical tricks that can be carried out with the aid of this simple notation. (Newcomers to binary may find that the information given in Data Sheet No. 16—published in the last November issue—will be helpful here)

"I must say," said Dick enthusiastically, as he energetically snipped away with his scissors, "that these Data Sheets aren't half a good idea."

Smithy glanced up over his after-lunch mug of tea as Dick placed the latest Workshop copy of *The Radio Constructor*, now bereft of its Data Sheets, down on his bench.

"They are, indeed," he agreed. "What I like about them is that they so often give you the sort of gen which you otherwise waste ages in working out. It was a stroke of genius, for instance, to have a Data Sheet which gave calculated values for capacitance and resistance in a multivibrator. It's always a fiddling job calculating multivib CR values, but there's no necessity now there's a table available."

BINARY NUMBERS

Dick pulled what appeared to be a slim hard-cover book towards him, opened it up and consulted its contents.

"Ah yes," he remarked. "Now, that multivibrator CR table *was* a good one. It appeared, incidentally, in the last October issue."

"Are you," asked Smithy, interested, "keeping these Data Sheets on file?"

"Oh definitely," replied Dick. "I'm cutting them out and making them up into a book, complete with index."

"Very good," commended Smithy, impressed by this spare-time activity on the part of his assistant.

"The Data Sheet that intrigued me most," continued Dick, "was the one which gave decimal to binary conversions. It appeared in the last November issue."

"Binary numbers," commented Smithy, "shouldn't be a particularly new thing so far as you are concerned. We've talked about them already in the past."

"I know we have," said Dick, "but the binary numbers *we* talked about were all whole numbers greater than one. Some of the binary numbers given in the November Data Sheet were equivalents of decimal *fractions*! And I just don't understand how it's possible to have fractions expressed in terms of binary numbers."

Smithy chuckled.

"I can see," he said, "that you haven't got this binary number business fully buttoned up yet. Well, there's plenty of time left before we start work again so, if you feel like, we can have a further gen-session on them right here and now."

"That would be smashing," said Dick promptly. "Anything I can learn about binary numbers is bound to be of advantage to me at some time. After all, Smithy, we might be *servicing* computers in this Workshop ourselves one of these days!"

"Do you know," replied Smithy, "I don't think that that remark is as fanciful as it might at first appear to be."

The Serviceman fell into a thoughtful silence for some moments. Suddenly his expression lightened.

"I was just pondering," he announced, "on what would be the most interesting way of giving you some further gen on binary numbers; and I've had a little brain-wave which should not only help in explaining the binary equivalents of fractions but which will also give you some insight into binary multiplication as employed in computers as well."

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 44
 17
---
308
44
---
748
```

Fig. 1. A simple multiplication problem calculated in normal manner

"That," remarked Dick appreciatively, "sounds as though it will be just the job!"

"Right," said Smithy briskly. "Well, I'm going to start off first by asking you to do a straightforward multiplication using two decimal numbers. Any two numbers picked at random will do, so let's say they're 44 and 17. Now, Dick, get your pen out and multiply 44 by 17 in the way you would normally do this calculation, using standard decimal procedure."

Obligingly, Dick pulled his note-pad towards him. He very soon had the calculation completed. (Fig. 1).

"The answer," he called out, "is 748."

```
44     17          44       17
22     34          22       34
11     68          11 —     68      68
 5    136           5 —    136     136
 2    272           2      272
 1    544           1 —    544     544
                                   ---
                                   748
                                   ---
      (a)                 (b)
```

Fig. 2. An alternative method of finding the product of two numbers. In (a) one number is continually halved (ignoring remainders) and the other continually doubled. In (b) the right hand numbers alongside odd left hand numbers are added together to give the product

"Good," replied Smithy. "Our next step is to do that multiplication in an entirely different way. Start a new sheet in your note-pad and write the numbers 44 and 17 side by side at the top. Then continually divide the 44 by 2 until you get down to 1. Write each number in a column going downwards." (Fig. 2(a)).

"Okey doke," said Dick obligingly. "Well, the first number is 22 and the second is 11. Hang on a minute, though. The third number is 5 with a remainder of 1. What do I do about the remainder?"

"Forget it," replied Smithy. "Just put down the 5. The same applies for the following division by 2. 5 divided by 2 is 2 with a remainder of 1. Simply ignore the remainder and put down the 2."

"Righty-ho," said Dick cheerfully. "Well, that brings me down to 1 at the bottom of the column."

"Excellent," approved Smithy. "You next need a matching column of numbers underneath the 17. Only, this time, you *multiply* by 2 each time, with the result that the number immediately under the 17 is 34, the next one down is 68, and so on. Got it?"

"Sure," replied Dick. "I'll get this little lot done in no time."

Dick soon had his second column of figures written out.

"Now," said Smithy, "go down the column under the 44 looking for odd numbers. Whenever you encounter an odd number, put down the corresponding figure from the column under the 17 into a third column on the right."

"As you like," said Dick in a puzzled tone. "Well now, the first odd number on the left is 11."

"What's the corresponding number under the 17?"

"68."

"Then put 68 in the new third column you're making up."

"I don't understand this at all," complained Dick. "However, I'll do it just to see what happens! The number under 11 is 5, and that's odd, too, so I'll put the corresponding 136 in the third column. The only other odd number on the left is the 1 at the bottom and this corresponds to 544. So *that* goes over, too." (Fig. 2(b)).

"What," asked Smithy, "have you now got in the third column?"

"68," repiled Dick, "136 and 544."

"Add them up."

There was silence for a few seconds as Dick totted up the figures.

"Blimey, Smithy," he gasped, "it's 748! That's the same answer that I got when I multiplied 17 by 44 directly."

"Exactly," grinned Smithy. "And you can use that system of multiplication for *any* two decimal numbers. Make up two columns under the numbers, dividing each time by 2 as you go down the left hand column and multiplying each time by 2 as you go down the right hand column. Then, add together all the right hand numbers corresponding to odd numbers on the left and you get the product of the two original numbers."

17	—	44	44
8		88	
4		176	
2		352	
1	—	704	704
			748

Fig. 3. If the process in Fig. 2 is repeated with the two original numbers transposed, the same answer is still given

"Gosh," exclaimed Dick, "this is something *entirely* new to me. What would happen if I repeated the process with the 17 on the left and the 44 on the right?"

"Try it."

Eagerly, Dick carried out the procedure once more, this time with the 17 on the left and the 44 on the right. (Fig. 3).

"There's only two odd numbers on the left," he announced, "and they're the 17 at the top and the 1 on the bottom. Which means that I add up the corresponding 44 and 704. Corluvaduk—that's 748 again!"

BASE OF 2

Dick gazed at the Serviceman with a new respect.

"How on earth," he asked, "does this multiplication system work?"

"I can't answer that one yet," replied Smithy, "except by saying that you're multiplying decimal numbers with the aid of a binary technique. You'll understand it soon enough, though, after I've gone through the remainder of the stuff on binary I'm going to talk about today."

"I call that a bit of a dirty trick," said Dick, indignantly. "You've got me well and truly hooked now. I've *got* to stay with you to the end, if only to satisfy my curiosity over that multiplication process!"

"I'm glad," said Smithy equably, "that I've got your undivided attention. Well, we've had a session in the past about binary numbers, and I hardly need to remind you that, whereas the base is 10 with decimal notation, with binary notation the base is 2."

"Yes, I know all that," replied Dick, a little impatiently. "The numbers in binary going up from zero are 0, 1, 10, 11, 100 and so on. Since you can't go higher than a 1 in binary, the next number above 1 is 10, this being followed by 11 which, in turn, is followed by 100."

"You've got it," commented Smithy. "If you work from the right and check the 1's, you can easily change a binary number into decimal because each 1 stands for a decimal number in the series 1, 2, 4, 8, 16 and so on. Thus, 110101 in binary is equal, in decimal, to 1, no 2, a 4, no 8, a 16 and a 32 which adds up to 53."

"I understand *that*, too," said Dick, the edge of impatience in his voice sharpening.

"Then," commented Smithy urbanely, "you will be in a position to make up a little table having decimal numbers on the left and binary equivalents on the right. Just from 0 to 10 will be adequate."

Irritably, Dick carried out Smithy's bidding. (Fig. 4).

"Now," continued Smithy as Dick's pen came to rest after completing the table, "what do you do if, in decimal, you multiply a number by 10?"

"Well," said Dick, a little confused by Smithy's sudden change from binary to decimal, "you bung a nought on the end of it."

"Could you," asked Smithy, "be a wee bit more precise? Say you had the original number displayed on one of those little electro-magnetic counters which register any number from 0000 to 9999. Rather like the mileometer in a car. How would you multiply by 10 then?"

"You'd still," said Dick frowning, "bung in a nought at the right hand end. Wait a minute, though, I'm beginning to see what you're driving at. You couldn't bung in a nought at the right hand end *just* like that because there wouldn't be room for it. You'd have to move the original number over to the left and *then* put the nought in."

"That's the idea," said Smithy approvingly. "That's exactly what you would do. In other words, you shift the number one place over to the left, and *then* insert the nought. Now, take any number, say 243, and multiply it by 10 in the way they first taught you to do it at school."

Obligingly, Dick carried out the simple calculation on his note-pad. (Fig. 5(a)).

Do you see what I mean?" queried Smithy, rising and looking over Dick's

DECIMAL	BINARY
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

Fig. 4. A table showing binary equivalents of decimal numbers from zero to 10

shoulder. "What you've really done is to shift the original number one place to the left and then inserted a nought at the right hand end."

"I can see that now," admitted Dick, "but I'm not at all certain what the outcome of all this is going to be."

"Think about that electro-magnetic counter," replied Smithy. "Now, when you multiply any number it displays by 10, you *have* to shift it one place to the left in order to obtain the mechanical space needed for the insertion of the nought. This is a limitation imposed by mechanical space in the counter. With numbers written down on paper there is no mechanical space limitation, but there is still a limitation which makes it necessary to shift the number one place to the left. And that limitation is the decimal point."

"Decimal point?" queried Dick. "What decimal point? Blimey, Smithy, I haven't as much as even written a decimal point yet!"

"Nevertheless," persisted Smithy, "the presence of a decimal point was understood in all the decimal numbers you've written down up to now and it exists after the last right hand digit. There was no need to actually put in a decimal point with the numbers we've been dealing with so far but it's still automatically assumed to be there. When you multiply a decimal number by 10 you shift the number one place to the left *away from the decimal point*, and you then insert the nought."

"Fair enough," said Dick carelessly, "but what's all this got to do with binary numbers?"

"You'll find out in a moment," Smithy promised him. "Now, as you've just gathered, when you multiply a decimal number by 10 you shift the number one place to the left and insert a nought at the right hand end. Now, that's because the base in decimal is 10. The base in binary is 2, which means that when you multiply a binary number by 2 you similarly shift it one place to the left and insert a nought at the right hand end. Blow me, that's a rough old set of fillings you've got in those bottom teeth of yours!"

Dick slowly closed the sagging jaw which had fallen open during Smithy's reference to multiplication by 2 in binary.

"Gosh, Smithy," he gasped. "You don't half spring these things on me! I'd never even realised before that you add an extra nought in binary when you multiply by 2. Let's have a look at that table I made up. Blimey, it's true in every case! The binary for 2 is the same as that for 1 with an additional nought at the right, and the same applies to the binary equivalents for 2 and 4, 3 and 6, 4 and 8, and 5 and 10. This is one of those things that's dead obvious, but only after somebody's pointed it out to you!"

"We live and learn," chuckled Smithy. "Anyway, let's get back to decimal again. What happens if, next, we divide a decimal number by 10? Say, for instance, that the number is the 2430 you wrote down just now."

"We lop off the right hand nought," replied Dick promptly, "and shift what's left over to the right, whereupon it becomes 243." (Fig. 5(b)).

"And," added Smithy gently, "if we divide *that* number by 10?"

"Well," said Dick thoughtfully. "There's no nought at the end to lop off, but we should still shift it one place to the right."

"And how do we do that?"

"By inserting the decimal point."

"Precisely," said Smithy triumphantly. "That all-important decimal point! If we'd divided the particular number I chose, it would become 24·3. In binary there's exactly the same sort of point as well, the only difference being that it's called the binary point instead of the decimal point. We've already established that if we multiply a binary number by 2 we shift it one place over to the left, just as we do, with 10, in decimal. If, conversely, we divide a binary number by 2 we shift it one place to the right. Again, just as in decimal. Also, and once more following what happens in decimal, if the number we're dividing doesn't end in a nought, we have to shift the digit at the right hand end *past* the point."

"This sounds intriguing," said Dick. "Go on, Smithy!"

"Let's say," continued Smithy, "that we are going to continually divide binary 10 by 2 (Fig. 5(c)). Our first division shifts the 1 one place to the right, giving us binary 1. The next division by 2 *must* then take it past the binary point, giving us 0·1. The next division by 2 makes it 0·01, the next again makes it 0·001, and so on."

"Why, you *cunning* old devil," exclaimed Dick inelegantly. "You've done it again! Without my even realising that you were leading up to it you've just explained these binary equivalents for decimal fractions which I said at the beginning were puzzling me so much. Why, it's as clear as anything now! The binary equivalent of $\frac{1}{2}$ *must* be 0·1, and the binary equivalent of $\frac{1}{4}$ must be 0·01, and so on."

MULTIPLICATION

"I'm so glad," grinned Smithy, "that I've sorted out that little matter for you."

"There's still," replied Dick quickly, "something else outstanding. You haven't yet explained the mystery of that peculiar method of multiplication using two columns."

"I'll get round to it before we finish," said Smithy. "But, before that, we must tackle a spot of binary multiplication as it could be done by a computer. We'll start off with a nice simple problem, which you can do quite easily yourself. Multiply together, in normal fashion, the binary numbers 1001 and 1001011."

Dick started a new sheet of his note-pad and settled down to the calculation. (Fig. 6(a)).

"Here we are," he announced proudly, after several moments, "how's this?"

Smithy examined Dick's calculations.

"That's perfectly correct," he remarked, "and, of course, you use the same procedure as applies in a similar type of decimal multiplication. I see that you've had to add a couple of 1's together several times, whereupon you've quite rightly put a nought and carried 1. If you look at that multiplication a little more closely you'll see that it has been a very simple one to carry out because all you've actually done is to *copy* the top number—whose correct name, by the way, is the 'multiplicand'—whenever the appropriate multiplier digit is a 1. At the same time you've done nothing when the multiplier digit is a nought. Let me have your note-pad for a moment."

Dick handed Smithy the pad.

"Right," said that gentleman, taking out his own pen, "let's modify that calculation so that it shows a simplified manner in which a computer could tackle it. The only bit of new gen I have to give you here is that it is a relatively easy task for a digital computer to shift all the digits of a binary number one place to the left or to the right. This having been said, an imaginary computer would tackle that multiplication of yours in the following way. It works in steps. In the

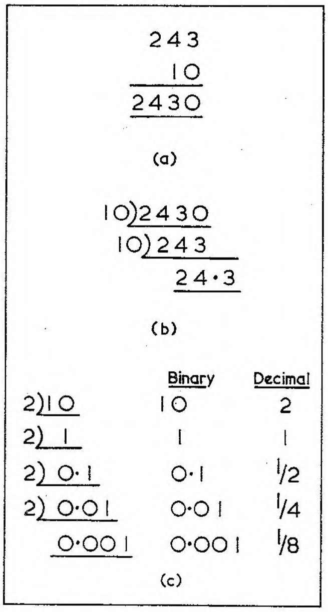

Fig. 5 (a). Multiplying a decimal number by 10
(b). Continually dividing a decimal number by 10
(c). Continually dividing a binary number by 2

first step it examines the right hand end digit in the multiplier, in the second step it examines the next digit to the left and so on. If the right hand end digit in the multiplier is a 1, the computer copies the multiplicand after which it shifts it one place to the left. If the end digit in the multiplier is a nought, it does not copy but merely shifts. In your calculation the end right hand digit in the multiplier is a 1, so the computer copies then shifts. The next digit in your multiplier is also a 1, so the computer again copies, then shifts. The next digit along is a nought, so the computer does not copy before it shifts. After that the next digit is a 1, so the computer copies and then shifts. And so the process goes on. I've written the sequence of events for each line, alongside the partial products." (Fig. 6(b)).

"The partial *what's-it's*?"

"The partial products," repeated Smithy. "This is the name given to the lines of digits between the multiplier and the answer."

"The process you've just described," stated Dick critically, "is pretty well the the same that I did myself. It's just that the individual steps are described differently."

"True enough," agreed Smithy. "Another point is that I was giving you a simplified idea of computer operation. In practice it is not very convenient for the computer to get all the partial products together and then add them all up in one go. It's more convenient, instead, for each partial product to be added as it appears. I'll give you an example to show what I mean. I'll use slightly smaller numbers this time, so that the example won't take up too much space."

Smithy wrote out the multiplication with individual addition of partial products. (Fig. 6(c)).

"There you are," he said. "That's an easier procedure for a computer to use. There is another version of this process which can be even more convenient for the computer and that consists of keeping the multiplicand still and shifting the multiplier and sum to the *right* after each copy or 'non-copy' operation. The right hand end digits of the multiplier are then presented in turn to the computer for examination, which is what would have been needed, incidentally, in the previous instance. At the same time, though, the right hand end digit in each individual *sum* can be taken off after each shift. Once the right hand end digit of each sum has been produced it does not alter later, and so it can be extracted after each addition and used in making up the final answer."

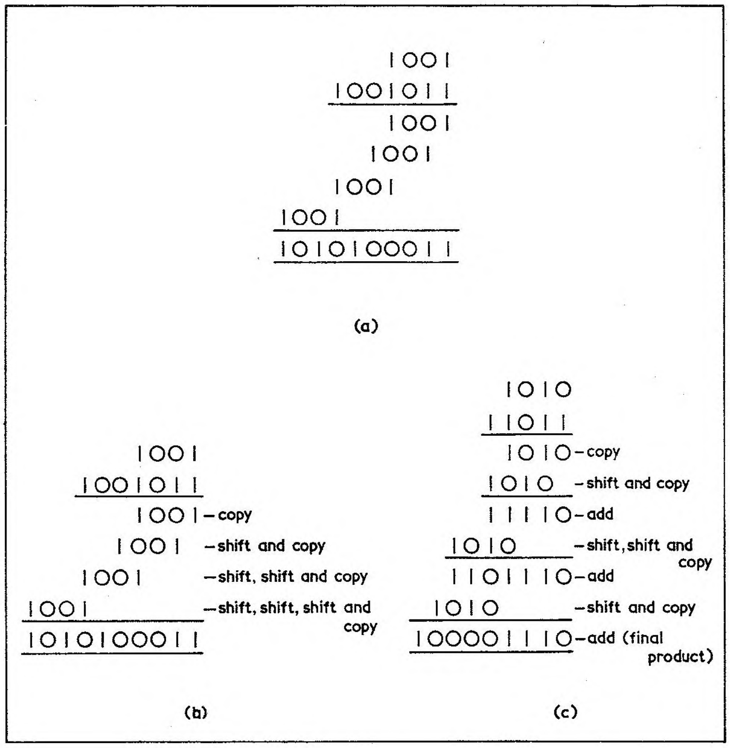

Fig. 6 (a). A simple multiplication of two binary numbers
(b). The multiplication process described in computer terms
(c). Binary multiplication with individual addition of partial products

"I see," said Dick thoughtfully. "Of course, shifting the sums over to the right is really the same as shifting the multiplicand over to the left, isn't it?"

"Oh yes," confirmed Smithy. "The basic idea of shift and copy or 'non-copy' remains unaltered."

"I must say," remarked Dick, "that this computer method of multiplication seems to be jolly long-winded."

"It is rather," admitted Smithy. "But, then, practically all digital computer operations are long-winded when you break them down into their basic form. What you have to remember is that the computer scores because of the speed in which it carries these operations out. I should mention, incidentally, that the methods of multiplication I've just described aren't the only ones which can be used by computers. Nevertheless, they give you a useful insight into how computers tackle jobs of this nature. They also enable you to see the considerable advantages bestowed by carrying out the calculations in binary."

Smithy turned to his bench and scribbled a few calculations on a corner of the top sheet in Dick's note-pad, then tore it off.

"To finish off with," he said, 'I've just arranged a little multiplication exercise for you to carry out. Using what I had best describe as the 'human method' of multiplication, in which all the partial products are added together at the end in one operation, multiply binary 10001 by binary 101100."

"Right you are," said Dick obligingly.

There was silence for a few moments as Dick concentrated on the problem.

"All finished," he called out.

"Good," said Smithy. "Next work out the decimal equivalents for the multiplicand, the multiplier, the partial products and the answer, using the progression 1,2,4,8, and so on in the usual manner. This will take you a bit of time because some of the decimal figures are pretty large, so I'll get myself a spot of tea whilst you're working at it."

Smithy refilled his mug from the Workshop teapot then slowly sauntered back to his stool.

"I've got a feeling," said Dick suddenly, as he struggled with his figures, "that you're pulling another one on me here."

"You finish those calculations," replied Smithy firmly, as he sipped his tea, "before you start to make any wild accusations."

"Dash it," said Dick, putting his pen down after writing in his last figure. "It's true! You *have* pulled another one!"

MYSTERY SOLVED

Dick pointed with a trembling finger to the multiplication with decimal equivalents he had just completed. (Fig. 7).

"All those decimal numbers," he exclaimed accusingly, 'are exactly the same as the numbers in that 44 by 17 multiplication you started this session off with!"

"Of course they are," laughed Smithy. "That was the whole object of the exercise. What is more, we've now proved what I said at the time. Which was that we were multiplying two decimal numbers with the aid of binary techniques."

"We may have proved it to your satisfaction," retorted Dick. "But I'm darned if I can see it myself!"

"Don't worry about it," replied Smithy. "Because I shall now explain the whole procedure. I must warn you that you'll need to concentrate a bit, though, because the steps are a little difficult to understand at first. It's helpful, also, to have the binary and decimal versions of the calculation side by side if you're to follow what happens. You also want to bear in mind that, in both versions, the 44 is the multiplier and the 17 is the multiplicand. Now, the first thing to remember is that all even numbers in decimal end in nought in binary, and that all odd numbers in decimal end in 1 in binary. You only need to look at the table you made up earlier to confirm *that* point."

Smithy settled himself more comfortably on his stool.

"At the top of the decimal version," he resumed, "we have the even number 44. This corresponds to *all* the multiplier in binary version, and it ends in nought. So, to use computer parlance, we do not copy the corresponding 17 in the right-hand column. We now divide the 44 by 2, getting 22, and this is the same as shifting the binary equivalent one place to the right, for inspection of the next right hand end number. The binary equivalent thus becomes 10110. It still ends in nought so again we do not copy. If we *had* copied, we would have copied the multiplicand moved one place to the left; that is, multiplied by 2. We next arrive at 11 in the decimal version, or 1011 in the binary version, whereupon the decimal is odd and the binary ends in 1. So we copy the multiplicand shifted two places to the left or multiplied by 4. Which is exactly what happens in both the binary and decimal versions."

"I'm beginning to see what goes on now," exclaimed Dick suddenly. "The next decimal number down is 5, corresponding to the multiplier shifted again to the right. The binary equivalent is 101 and it again ends in 1. So we copy the multiplicand multiplied a further time by 2 in decimal or shifted a further place to to the left in binary."

10001	17
101100	44
1000100	68
10001	136
10001	544
1011101100	748

44	17	
22	34	
11	68	68
5	136	136
2	272	
1	544	544
		748

Fig. 7. Illustrating how the calculation in Fig. 2 (b) (repeated here for convenience) is really another way of depicting a binary multiplication

"Exactly," confirmed Smithy. "As I said, the process is a bit difficult to grasp at first but, once you have done so, you can feel you've got a really good understanding of the relationship between decimal and binary. Returning to the decimal version of the 17 times 44 business, the continual division by 2 of the multiplier carries on till you get down to the 1 in the left hand decimal column, this corresponding to the initial left hand 1 in the binary equivalent."

"There's still one little point that's puzzling me."

"What's that?"

"When we originally did the decimal version," said Dick, "you told me to ignore any remainders when I was dividing by 2 in the left hand column. What happens to those remainders?"

"Ah," replied Smithy. "Now *that* can be explained with the aid of your newly acquired knowledge concerning the binary equivalents of decimal fractions. If you look at the left hand column of the decimal version you'll see, for instance, that we divide 5 by 2, whereupon we get 2 with a remainder of 1 left over. Another way of putting this is to say that when we divide 5 by 2 the answer is $2\frac{1}{2}$. Now the binary equivalent of $2\frac{1}{2}$ is 10·1, and so our division by 2 has not really caused the appearance of a remainder. Anyway, let me sum it all up. By continually dividing by 2 in the left hand decimal column and seeing whether the result is even or odd, we're actually *sampling* the last digit before the binary point of the binary equivalent to see whether it's a nought or a 1. Any remainders that appear in the process merely hop over to the other side of the binary point to become 0·1!"

"Phew," said Dick, musingly. "Well, you've certainly given me plenty to think about today. Wait a minute, Smithy, I think I can dream up something which should end this session very nicely."

Smithy looked up sharply, to see that his assistant, who occasionally conceived some of the most agonising verse ever to appear in italics, had assumed the vast scowl that betokened the process of composition. Recognising the symptoms, Smithy prepared for the worst.

Suddenly Dick's face cleared.

"Here we are, Smithy," he said exultantly. "Just listen to this!

"If ten fingers, not two, were the primary
Cause for counting to ten, please advise me
Why an infinitesimal
Number in decimal
Needs so many more digits in binary!"

Dick beamed proudly at Smithy as he brought his latest excursion into doggerel to an end. And, to his credit, the shuddering Serviceman did at least manage to bestow a thin, albeit wavering, smile of encouragement on the youthful composer.

Whereupon we must now, after having dutifully recorded Dick's closing comments on the vagaries of decimal and binary notation, make our own quick departure. A situation which might well be described as copy and shift.

AERIAL MAST FOR HEATHFIELD (SUSSEX) BBC-2

The BBC recently placed an order with Techwork (Structures) Limited, of Southampton, for the design, supply and erection of the 480 ft. aerial mast for the Heathfield BBC–2 transmitting station. This new station is now being built half a mile east of Cross in Hand, near Heathfield.

It is expected that Heathfield will be brought into service towards the end of 1969, on its BBC-2 channel, 52, with horizontal polarization. Later it will also transmit BBC–1 and ITV programmes on 625 lines. It will serve some quarter of a million people in East Sussex and parts of Kent.

RECENT PUBLICATIONS

ELECTRONIC COUNTING CIRCUITS. By J. B. Dance, M.Sc., B.Sc. 390 pages, 7¼ x 9¾. Published by Iliffe Books, Ltd. Price 85s.

This book is intended to cover all the electronic counting circuitry encountered in modern electronic equipment and it thereby fills a gap in "the literature" which has been evident for many years. It is written, in particular, for engineers working in nucleonics, for designers and users of industrial counting equipment, and for senior service engineers. A valuable feature is that each chapter after the first, which introduces the basic principles employed in counting circuitry, is complete in itself. Thus, information on any specific type of counting circuit may be obtained without the necessity of reading preceding chapters. So far as technical ability is concerned, all that is required of the reader is that he should have a basic knowledge of simple physics and electronics. No previous experience with pulse techniques is needed.

The main chapters of the book deal with all types of counting circuit, ranging from electro-magnetic counter circuits through gas-filled, EIT and beam switching tube circuits, and valve and solid state scaling circuits, to ratemeter circuits. Further chapters give details on readout, together with counting circuit applications not dealt with under the previous chapter headings.

There are, throughout the book, 281 clear and detailed diagrams, those which give circuits providing component values. There are, also, 8 pages of art plates. Numerous references, an appendix listing valve equivalents and a comprehensive index complete the volume, which exhibits the care and attention to detail which is always evident in work from Mr. Dance's pen.

AMATEUR RADIO TECHNIQUES. By J. Pat Hawker, G3VA. 160 pages, 7¼ x 9¾. Published by the Radio Society of Great Britain. Price 12s. 6d.

Readers of the *R.S.G.B. Bulletin* and (under its more recent name) *Radio Communication* will be familiar with the lively "Technical Topics" feature which appears in each issue. This presents interesting new ideas, techniques and circuits culled from journals and manufacturers' publications throughout the world, and is accompanied by an easy-going commentary by Pat Hawker which both maintains continuity and highlights the salient points of each item.

"Amateur Radio Techniques" provides a selection, from the ten years during which "Technical Topics" has been running, of what are considered to be the items of most lasting value in the series. As in the journal, the reader is carried easily through the items by G3VA's lucid and eminently readable style. This is a second edition, incidentally, the first (published under the title "Technical Topics for the Radio Amateur") having appeared in 1965.

Apart from presenting individual items of interest to the amateur receiving and transmitting enthusiast, the book also gives sound basic advice and information on components, including virtually all the semiconductor devices which the amateur is likely to encounter and use. There are over 350 diagrams and the subjects covered range from cleaning the panels of old receivers to the use of P-I-N diodes.

If desired, the book may be obtained direct from R.S.G.B. Headquarters, 35 Doughty Street, London, W.C.1, for 13s. 3d. post paid.

THE PEGASUS BOOK OF RADIO EXPERIMENTS. By F. G. Rayer, A.I.E.R.E., G3OGR. 214 pages, 5 x 7¾in. Published by Dobson Books, Ltd. Price 16s.

This book is full of descriptions of simple experiments which may be carried out by the newcomer to radio, each experiment being accompanied by explanatory text which describes, at elementary level, its purpose and functioning. A noteworthy feature of the book, and one which is to be commended, is that the risk of injury by shock is in all cases negligible as there are no experiments which require that connection be made to the mains supply for power. The author gives quite a few experiments incorporating valves, but the valves he employs are 1·4 volt battery types with h.t. voltage obtained from a dry battery.

The experiments range from simple electronic circuits up to t.r.f. receivers and small a.f. amplifiers. The book contains a great deal of practical common-sense information which will be of especial value to the complete beginner, and all points are delivered in a simple economic style with the very minimum of mathematics.

WORLD RADIO TV HANDBOOK 1969. Edited by J. M. Frost. Published by World Radio-Television Handbook Co. Ltd., Denmark. 360 pages, including 9 World Charts, 5¾ x 9in. Price 42s.

This annual publication has by now become a virtual necessity for all those engaged in the reception of worldwide short wave stations. Additionally, it is of equal interest to those who range over the medium and long waves or who are interested in TV Dx. This latest edition has been fully revised and is presented in a new format of handy and compact size.

The Contents are many and varied but some of the more interesting are listed here—Broadcasts in English, List of Dx Programmes, Dx Clubs of the World, List of Long and Medium Stations of the World, List of Stations broadcasting News in English, Predicted Reception Conditions for 1969, List of Recorded Music Libraries, Short Wave Stations of the World (20 page list), Solar Activity 1969, Standard Frequency and Time Signal Stations, World TV, and 9 World Charts which are extremely useful to the Dx enthusiast.

This Handbook is eagerly awaited, year by year, by many enthusiasts throughout the world. It has earned a well-deserved reputation for accuracy and reliability and is fully up to date when published (December 1968). The station lists are complete and accurate and form a reliable guide for those tuning over the various bands from Long to Short and TV frequencies.

For those interested in short wave reception, this book supplies all the information that could possibly be required. Each country is listed separately and under such headings, station powers, call signs, locations are all listed. Where applicable, the musucal annotation of the interval signal is shown. Information on station schedules and if verification is by letter or QSL card are all included.

The present edition is an absolute mine of information and should undoubtedly be on the operating desk of all those interested in radio and TV reception. The Handbook is available in this country from the Modern Book Co., 19 Praed Street, London, W.2, packing and postage charge is 2s.

VACATION SCHOOL—AERIALS

The IEE Electronics Division is organising a vacation school on aerials. This will be held at the University of Birmingham from the 7th to 19th July, 1969.

It is expected that the school will prove attractive to the younger graduate entering the field of aerials whether in research, development or application. The course has also been designed as a refresher course for the more experienced person and as an introductory course for those transferring to aerial work from other disciplines.

The course will commence with a survey of basic concepts and theoretical methods. This will be followed by accounts of recent work on: wideband dipoles and frequency-independent aerials; linear, circular and planar arrays and beam-scanning; microwave aperture aerials and feeds; travelling wave tubes.

Also, lectures will be arranged on the following topics: synthetic aperture techniques; self focusing arrays; within-pulse scanning; holography; satellite-communication earth-station aerials.

BBC CONVERTER TO BE MARKETED ABROAD

Television audiences throughout the world can now look forward to high quality colour transmissions from America thanks to new British electronic equipment developed by the BBC. It was announced recently that the BBC has agreed with Rank Precision Industries Limited for the British firm to manufacture under licence and market abroad the BBC's new Advanced Field-store Television Standards Converter.

The BBC used this equipment for the first time during the Mexico Olympics for a total of 170 hours of transmission via satellite relay across the Atlantic. The high quality pictures were seen in nine other European countries in colour and nineteen more in black-and-white. Audiences were estimated at 200 million for black-and-white and 1 million for colour.

Radio Topics

By Recorder

One way of getting over the balance of payments crises which continually bedevil us these days is to get back to first principles and apply an adaptation of Kirchhoff's First Law.

As you all know, Kirchhoff's First Law states that when a number of current-carrying conductors meet at a single point the algebraic sum of the currents at that point is zero. Thus, if we have five conductors meeting at the point, and two of these carry currents I_1 and I_2 towards the point whilst the remaining three carry currents I_3, I_4 and I_5 *away* from the point, then $I_1 + I_2$ must be equal to $I_3 + I_4 + I_5$. By giving the currents going towards the point plus signs and those going away from the point minus signs, we can say:

$$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

or,

$$I_1 + I_2 - (I_3 + I_4 + I_5) = 0$$

Which is just the same as saying $I_1 + I_2$ is equal to $I_3 + I_4 + I_5$. Actually the whole thing is really self-evident because all the current flowing to the point via one or more conductors must inevitably flow away from the point via the remaining conductor or conductors because there's nowhere else for it to go.

MONEY IN MEGACOULOMBS

Let's now turn to affairs of international lolly and assume that the entire world changes over to a unit of money known as the Coulomb. Since all international monetary calculations nowadays seem to be in the staggering dimensions of millions of units, the practical unit of money we shall use will be the Megacoulomb.

So far so good, Now, every country in the world capable of producing anything trades with other countries, thereby forming a vast complicated network of trade where there are linkages between almost every two individual countries. Goods and services travel along these linkages in either direction; and in the opposite direction flow the Megacoulombs which pay for those goods and services. The rate of flow of Megacoulombs (which can be expressed in Megamps) into any one country will never, at any single instant, be equal to the rate of flow of Megacoulombs out of that country. If we refer to the rate of flow of Megacoulombs *into* a country as a quantity of positive Megamps and the rate of flow of Megacoulombs *out of* a country as a quantity of negative Megamps, then every country will exhibit a monetary condition which, at any time, can be expressed in terms of positive or negative Megamps.

I propose that, at any instant in a stable system, the algebraic sum of all the negative and positive Megamps throughout the world is zero.

If any country exhibits a positive Megamp over a lengthy period it accumulates Megacoulombs whilst, if it continually exhibits a negative Megamp figure it suffers a deficit of Megacoulombs. Whilst a country can amass any quantity of Megacoulombs, the system goes into local instability if a country has a marked deficiency of Megacoulombs. A quantity of Megacoulombs are then artificially induced to pass from the country with the excess to the country with the deficit in order to return to stability.

In practice we don't, of course, use Megacoulombs as units of money. But we do use monetary units which are closely tied to each other by very nearly constant rates of exchange, whereupon they are not too far removed from the Megacoulomb concept. It follows that some countries must inevitably exhibit what are effectively negative Megamp figures at some time or another. And we all know that local instability *does* result if the negative Megamp is maintained for too long a period.

For long-term stability of the monetary system it is necessary, of course, to avoid showing a negative Megamp figure for an excessively long time. And I really must apologise for stating the obvious fact that a positive Megamp figure, indicating Megacoulombs going *in*, is directly proportional to the goods and services going *out*.

Readers requiring further information on world-wide monetary matters, as developed from the First Law of the good Gustav Kirchhoff, may contact me via *Poste Restante*, Hotel Splendide, Zurich.

THE MINI-KLUDGE

Electronic engineers working for Boeing in the American space programme have introduced a delightful new term for some of the more sophisticated one-off items of electronic equipment they use for such purposes as resolving detail in the video tapes produced by satellites after lunar orbits. The term is "kludge" (pronounced *klooge*) and it is defined as "a device which is much too complicated to explain, and you wouldn't believe it anyway."

Smaller kludges are referred to as "mini-kludges."

LAX LOGGING

As one of the self-employed of this country, it is my dubious pleasure every week to buy my own National Insurance stamp from the Post Office, stick it on to my own National Insurance card, then cancel the darned thing by writing the date across it.

After 52 weeks the card is full, whereupon I visit the local Social Security office, where a girl takes it, copies my name, address and National Insurance number from it on to a new empty card, and then hands the latter over to me. After which I collect and cancel another 52 stamps and, one year later, repeat the process.

The simple procedure involved in transferring the information from the old card to the new one rather fascinates me, and I sometimes have a wild desire to alter the figures in my National Insurance number (I's to 7's, 3's to 8's and so on) just to see how many new cards with the incorrect number I could get through before the error was spotted.

I mention this because it reminds me of the astounding performance of a war-time transmitter I heard about when I was doing my little bit in the R.A.F.

Many of the larger R.A.F. camps positioned their more powerful R/T and W/T transmitters a mile or two outside the camp boundary so that they were well spaced from the associated receivers. The transmitters were pretty reliable (even including the old T1087 that had so many relays and solenoids clattering around inside it that it was known as the "animated meat safe") with the result that the airman who found himself posted to "Transmitters" was onto a very jammy number indeed.

But some people are never satisfied. One of the few duties required at the transmitter site in question was that a record be kept of all meter readings on each transmitter, these to be entered every morning in a log book which had vertical columns ruled out for them. That log may well have been properly kept at the beginning, but on days when he was feeling particularly lazy the airman on duty had fallen into the habit of simply copying the previous day's readings. Unless checked, bad habits tend to worsen, and the eventual outcome was that all the log books were hastily entered up once a week, with all the entries merely copied down the column. What made it worse was that even these were copied inaccurately and such things as losing or acquiring a nought tended to occur when the log went over to a fresh page.

Suffice it to say that, when an inspecting officer *did* eventually check the log, he was amazed to find, amongst other discrepancies, that one perfectly serviceable transmitter had, apparently, been running for months with an h.t. voltage of 18, an m.o. anode current of 1mA, a p.a. grid current of no less than 550mA and a p.a. anode current of 14mA.

I can conclude by saying that the subsequent 252 (the Form Number of an R.A.F. Charge Sheet) was *not* inaccurate!

DENTAL ELECTRONICS

Every trade has its own terminology and, quite often, a single word has quite different meanings in different crafts. Thus, a "tap" as conceived by the radio engineer, is by no means the same thing so far as the metal-worker or, for that matter, the plumber, is concerned. As a further instance, two other words taken at random—"accumulator" and "condenser"—have quite different connotations for the bookmaker and illicit still operator respectively.

This was brought home to me very forcibly one morning a few weeks ago when I had occasion to visit the dentist for the extraction of four upper teeth which had ceased to be allies of mine. After the initial local anaesthetic jab had taken effect, the dentist picked up one of the most fearsome of his pliers and asked his assistant: "Have you got the receiver ready?"

I had visions of her switching on a little transistor radio so that I would be soothed for the next few moments by the Jimmy Young Show, but this was not to be. The "receiver" turned out to be nothing other than a little enamelled dish in which the dentist delicately deposited, in turn, each of those four old choppers of mine.

See you next month!

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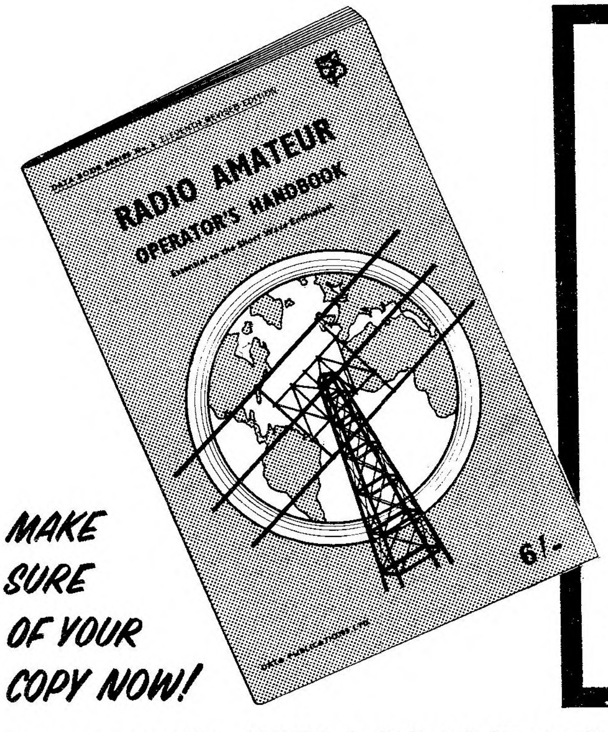

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(*continued on page* 474)

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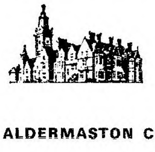

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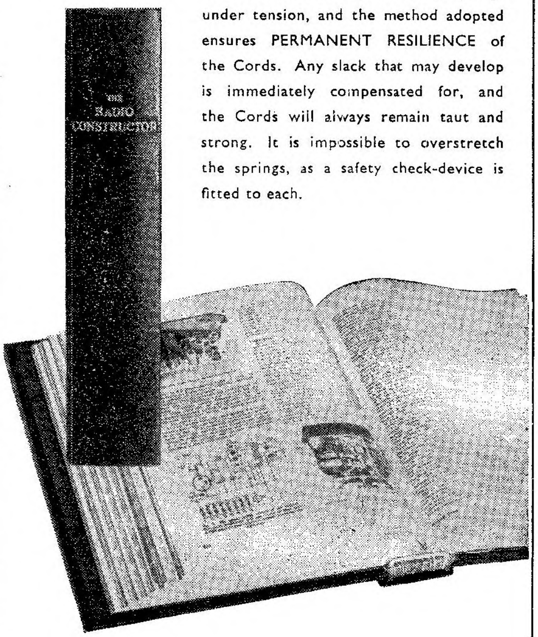

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continued from page 473

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(Continued on page 475)

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continued from page 474

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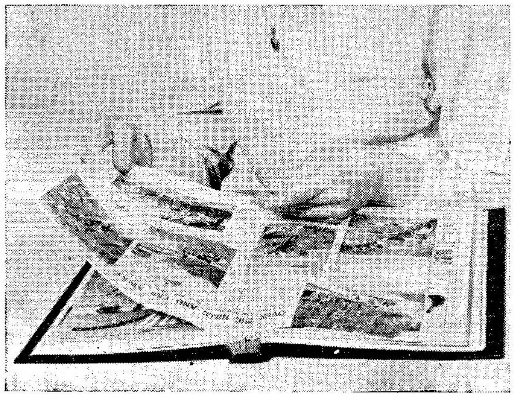

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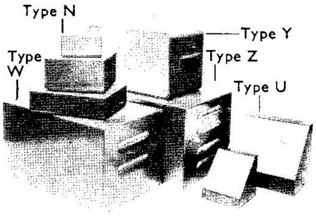

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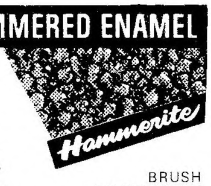

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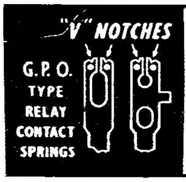

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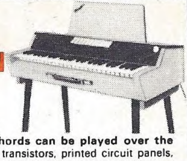

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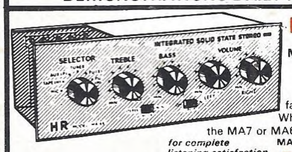

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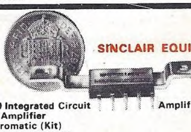

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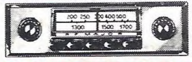

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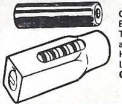

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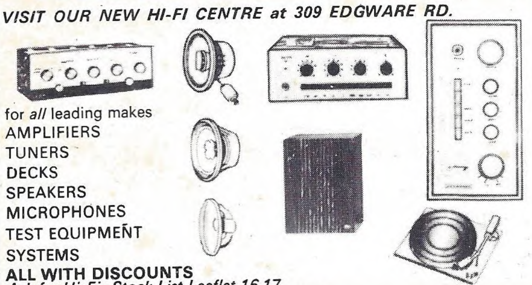

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