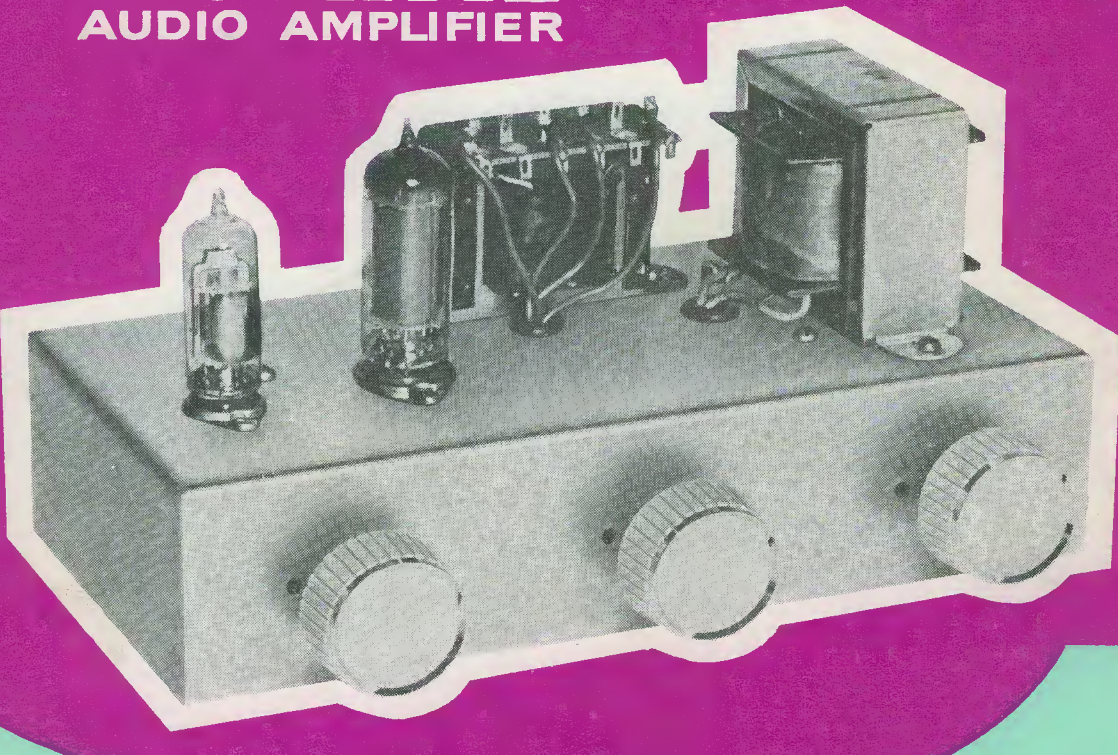
THE RADIO CONSTRUCTOR

Vol. 23 No. 3 OCTOBER 1969 THREE SHILLINGS

NEOPHYTE AUDIO AMPLIFIER



Special IN THIS ISSUE

FREE INSIDE Workshop Plans for the above Amplifier

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1N914	2/–	2N4255	8/6	BCZ11	10/4	OC19	5/–
1S113	3/–	2S018	12/6	BD121	19/6	OC20	33/–
1S120	2/6	2S024	25/–	BD123	23/6	OC22	13/–
1S130	2/6	2S034	15/–	BD124	17/–	OC23	15/–
1S131	2/6	AC107	14/6	BF152	13/6	OC24	10/–
1S132	2/6	AC126	6/6	BF167	6/6	OC25	6/8
2G301	4/–	AC127	6/–	BF173	7/6	OC26	12/–
2G302	3/9	AC128	4/–	BF181	7/6	OC28	12/–
2G339A	5/–	AC176	7/6	BF184	7/6	OC29	15/–
2G374	5/–	AC187	12/–	BFW57	7/6	OC30	7/–
2G381	5/–	AC188	12/–	BFW58	7/6	OC35	9/6
2G371	3/–	ACY17	5/8	BFW59	6/6	OC36	13/–
2N385A	15/–	ACY18	3/4	BFW60	6/6	OC41	3/6
2N388A	15/–	ACY19	4/4	BFX13	4/8	OC42	4/–
2N696	6/–	ACY20	3/8	BFX29	8/5	OC44	3/–
2N697	6/–	ACY21	4/–	BFY50	6/–	OC45	3/–
2N698	4/6	ACY22	2/4	BFY51	6/–	OC71	3/–
2N706	3/–	AD140	15/–	BFY52	6/–	OC72	4/6
2N706A	6/6	AD149	11/8	BFY53	6/–	OC73	3/–
2N708	4/–	AD161	6/–	BSX20	3/3	OC75	5/–
2N711	7/6	AD162	6/–	BSX21	8/–	OC76	2/6
2N711A	7/6	ADT140	12/6	BSY27	4/–	OC77	8/8
2N929	5/6	AF102	18/–	BTX39/600	120/–	OC810	3/–
2N930	6/6	AF114	4/4	BUY11	15/–	OC82	4/6
2N1131	9/6	AF115	4/4	BSY95A	3/4	OC82D	3/–
2N1132	7/6	AF116	4/4	BY100	5/–	OC83	4/–
2N1302	4/6	AF117	4/4	BYX10	4/9	OC84	4/–
2N1303	4/6	AF118	16/6	BYZ10	9/–	OC123	7/–
2N1304	5/–	AF124	6/–	BYZ12	6/–	OC139	8/–
2N1305	5/–	AF127	4/–	BYZ13	5/–	OC140	12/–
2N1306	6/6	AF139	15/–	GET102	6/–	OC169	6/–
2N1307	6/6	AF186	11/–	GET103	4/6	OC170	4/–
2N1308	8/–	AF239	12/–	GET113	5/–	OC171	6/–
2N1309	8/–	AFZ12	11/9	GET573	7/6	OC200	6/–
2N1613	6/6	ASY26	5/8	GMO290	10/–	OC201	10/–
2N2147	17/–	ASY27	5/8	GMO378B	6/–	OC202	16/6
2N2148	12/6	ASY28	4/4	MAT120	5/–	OC203	8/–
2N2160	14/–	ASY29	4/4	MAT121	5/6	OC204	8/–
2N2368	6/6	ASZ21	11/–	MPF102	9/–	OC205	9/–
2N2369	5/6	AUY10	39/6	MPF103	9/–	OC206	10/6
2N2369A	7/6	BA115	2/8	MPF104	9/–	OC207	7/6
2N2646	10/–	BA130	3/–	MPF105	9/–	ORP60	12/–
2N2696	6/6	BAY31	2/6	NKT216	10/5	ORP61	8/–
2N2924	5/–	BAY38	3/–	NKT217	10/5	ORP63	9/–
2N2925	5/6	BC107	2/9	NKT261	4/3	SX631	7/4
2N2926:–		BC108	2/9	NKT262	4/3	SX636	10/8
Green	2/–	BC109	2/9	NKT264	4/3	SX638	12/–
Yellow	2/–	BC113	5/–	NKT271	4/3	SZ20C	15/–
Orange	2/–	BC114	18/–	NKT272	4/3	SCC1	17/4
Red	2/–	BC115	13/6	NKT274	4/3	C426	8/3
2N3053	8/–	BC118	5/–	NKT275	3/6	P346A	6/–
2N3054	15/–	BC125	14/–	NKT276	2/6	V405A	9/3
2N3055	15/–	BC126	14/–	NKT281	5/6	EC401	5/–
2N3702	4/–	BC134	5/–	NKT403	16/–	EC402	4/8
2N3703	4/–	BC147	6/–	NKT405	15/–	C111E	18/–
2N3704	4/6	BC148	4/–	NKT713	5/6	C400	9/–
2N3705	4/–	BC149	6/–	NKT773	5/4	2C111	45/9
2N3706	3/–	BC154	12/–	NKT774	5/4	2C425	32/–
2N3707	4/–	BCY30	7/–	OA5	3/8	EA403	3/6
2N3708	3/–	BCY31	9/–	OA47	1/6	EB383	3/6
2N3709	3/–	BCY32	16/–	OA70	1/6	MJ491	30/3
2N3710	4/–	BCY33	4/8	OA73	1/6	MJ481	27/–
2N3711	4/–	BCY34	6/4	OA79	1/6	40361	13/3
2N3819	8/–	BCY38	8/–	OA81	1/6	40362	16/3
2N3820	23/6	BCY39	27/4	OA85	1/6	OAZ241	3/6
2N4058	7/–	BCY40	13/4	OA90	1/6	OAZ242	3/6
2N4059	6/–	BCY54	15/3	OA91	1/6	OAZ269	3/6
2N4060	6/–	BCY70	4/4	OA95	1/6	OAZ270	3/6
2N4061	6/–	BCY71	8/8	OA200	2/–	OCP71	18/3
2N4062	6/–	BCY72	6/6	OA202	2/–	ST140	3/–
2N4254	9/6	BCY87	86/9	OA210	6/4	ST141	5/–

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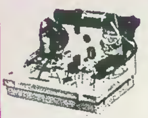

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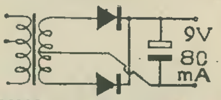

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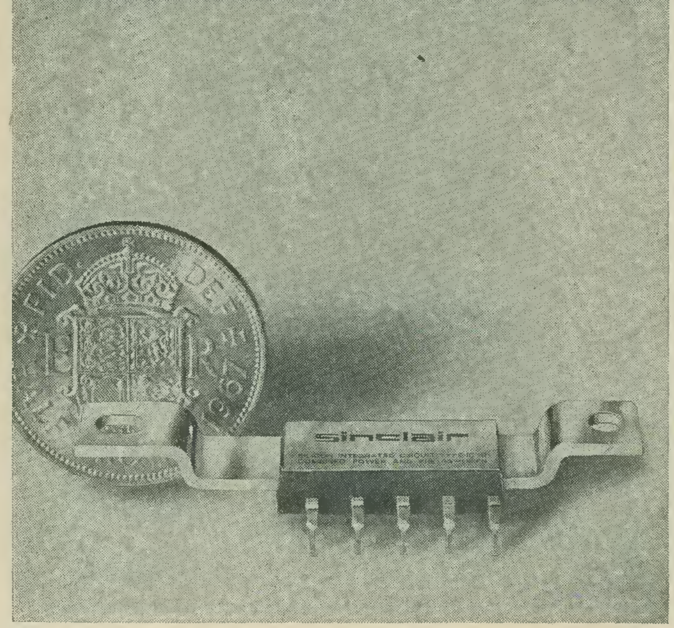
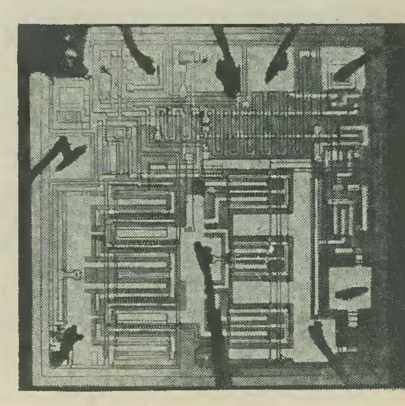


10 WATT MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP



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The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of the usual tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a 5-year guarantee on each IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

■ SPECIFICATIONS

Output:	10 Watts peak, 5 Watts R.M.S. continuous.
Frequency response:	5 Hz to 100 KHz ±1dB.
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

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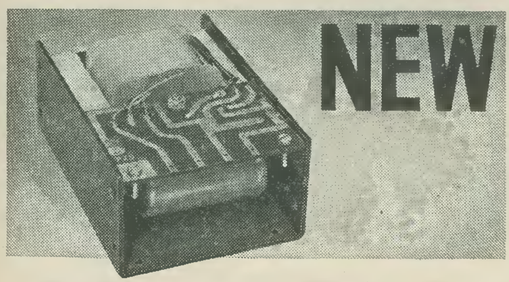

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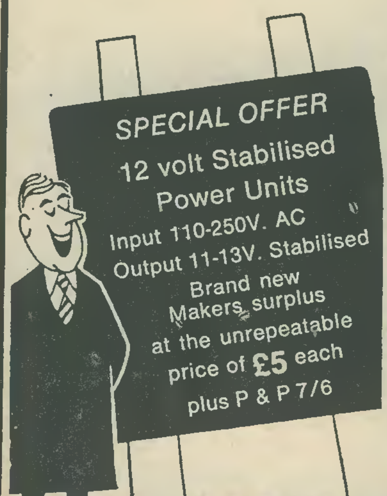

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NOVEMBER ISSUE WILL BE PUBLISHED ON NOVEMBER 1st

TRANSISTORISED G.D.O. FOR THE H.F. BANDS

(Part 1)

by

R. J. HULBERT, G3SRY

This small and efficient g.d.o. (grid-dip oscillator) covers 11 to 65 MHz in five overlapping ranges. Simple home-wound plug-in coils are employed, these operating without feedback windings. One of the many attractive features of this instrument is that it is self-powered and that no trailing mains lead is therefore required. The circuit, components and case are described this month, and the concluding instalment in next month's issue will deal with wiring up, coil winding and calibration

THE INSTRUMENT TO BE DESCRIBED WAS CONSTRUCted to assist with the building of a solid state single sideband transmitter. Several items of test equipment were is use at that time, all of which were mains powered. The mains leads proved to be a nuisance, not to mention the problem of a shortage of sockets to which they could be connected. It was therefore decided that this particular instrument should be self-powered from an internal dry battery.

The accompanying photograph shows the prototype, from which the final design described in these two articles has been developed. Originally, a variable resistor was included in series with the meter, but since this was found to be entirely unnecessary it has been deleted. This enables the case to be shortened by two inches. The final design also incorporates a currently available meter, whereas the prototype employed an ex-W.D. type.

CIRCUIT DESCRIPTION

As may be seen from the circuit diagram of Fig. 1, the g.d.o. uses an n.p.n. silicon transistor in a simple Colpitts derived oscillator circuit. M1, in conjunction with D1, R5, C6, and C7, functions as a peak indicating r.f. voltmeter. The appropriate plug-in coil is tuned by a combination of fixed capacitors (C1, C4, and C5), and the variable capacitor VC1. The ratio of fixed to variable element is such that the frequency swing on each range is less than is normally found in instruments of this nature. This provides more open scales, which are easily read, and gives better accuracy. The present design provides a range of 11 to 65 MHz in five overlapping bands. The range may be extended both at the high and low frequency ends, but only by alteration of the values of C1, C4, and C5. The values given were found to

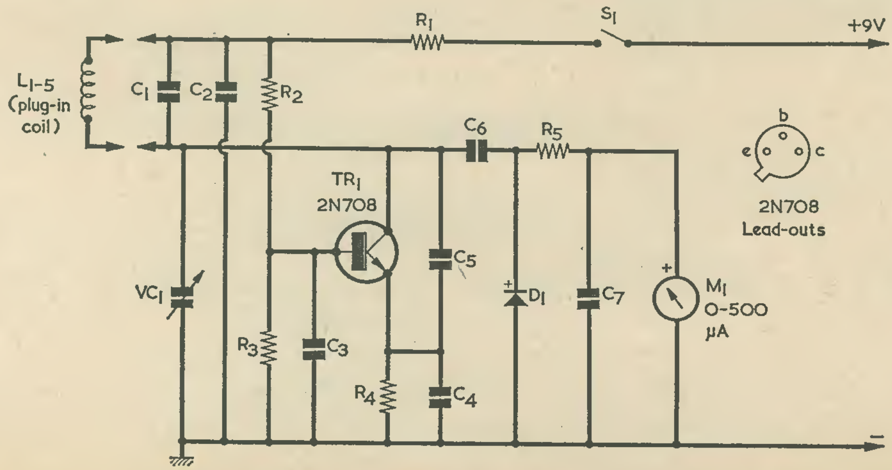


Fig. 1. Circuit diagram for the transistor g.d.o.

COMPONENTS

Resistors
(All ¼ watt 10%)

R1	100Ω
R2	22kΩ
R3	10kΩ
R4	1kΩ
R5	10kΩ

Capacitors

C1	18pF silver mica or polystyrene
C2	0.1μF metallised film
C3	0.1μF metallised film
C4	100pF silver mica or polystyrene
C5	12pF silver mica or polystyrene
C6	5pF ceramic
C7	500pF ceramic
VC1	50pF variable (see text)

Semiconductors

TR1	2N708
D1	OA91 or CG62H

Switch
S1 d.p.d.t. slide switch (see text)

Meter
M1 0-500μA meter, type MR38P (Sew)

Miscellaneous
5 Denco polystyrene coil formers. B9A, 6 spills, green (Cat. No. CR24/Green—Home Radio)
1 Chassis, reinforced corners, 6in. x 3in. x 2½in. (Cat. No. CU221—Home Radio)
1 Radiospares 6-way miniature groupboard (Cat. No. BTS13—Home Radio)*
1 Knob (seet text)
1B9A valveholder
18 s.w.g. aluminium sheet (for cover, brackets and clamp)
Matt white Formica laminate (for scale)
1/16in. Perspex sheet (for scale cover)
Battery clips
2 ¼in. spacing pillars
Screws, nuts, etc.

*Radiospares components are available through retailers only.

be the best compromise over the range used. Since the battery drain is less than 2 mA, the battery fitted will power the instrument for a considerable period of time.

COMPONENTS

Almost all of the components are standard items, and easily obtainable. To avoid the possibility of disappointing results, the writer recommends adhering strictly to the types and values specified. The one possible exception is the variable capacitor, VC1. The capacitor used here has been in abundant supply in years gone by, but is now not so easily obtained. It was used since it can be fastened to the panel by countersunk screws, and therefore does not interfere with the scale. If another variable capacitor is employed, this should be of a type secured by screws, and not by a single centre nut. In case of difficulty, the correct component may be obtained from SRY Electronics, 11 Rosedene Avenue, Croydon, CRO 3DN.

The knob fitted to VC1 in the writers' instrument is also a little non-standard since it has three holes tapped 6BA on its under surface. These provide a convenient means for mounting the scale cover, which

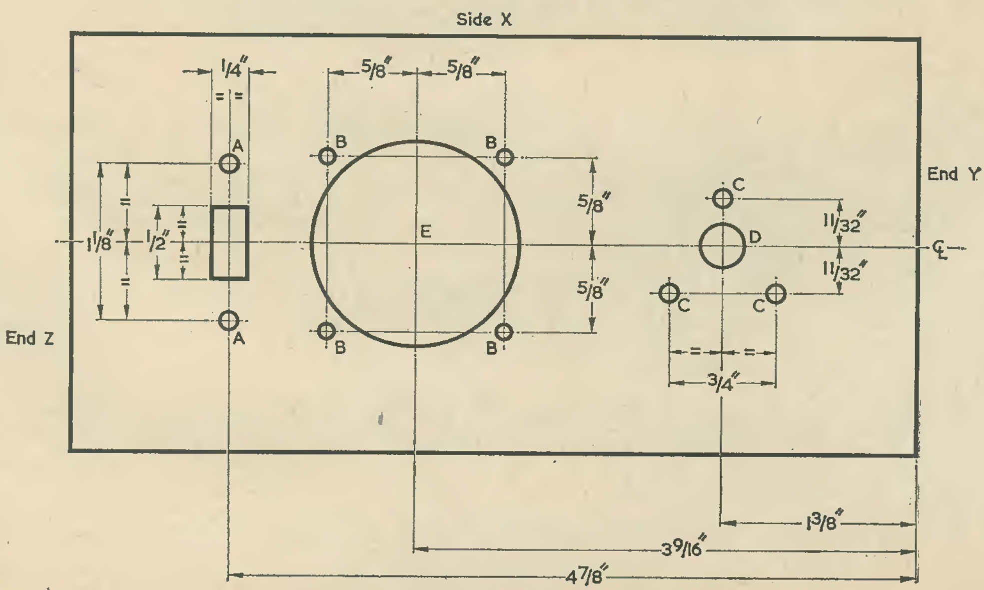


Fig. 2. Drilling details for the front panel

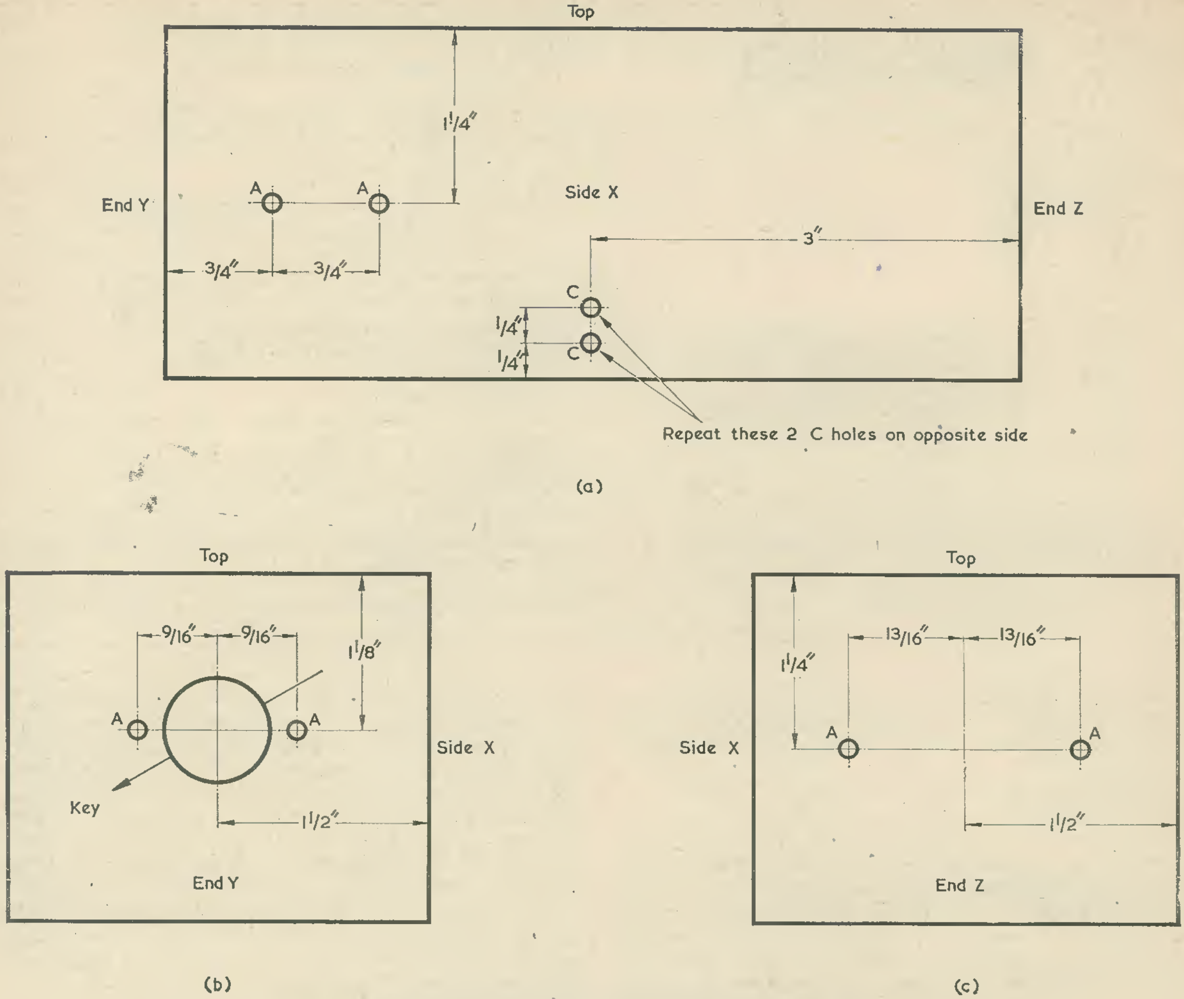


Fig. 3. The holes required in (a) the side panels, (b) the end to which the coil socket is fitted, and (c) the end to which the battery clamp is fitted

is secured to the knob. It is not essential to use a knob of this nature, as the scale cover can be mounted alternatively with Araldite general purpose adhesive, but the 6BA holes do make the assembly quicker and easier to carry out. The knob employed by the writer may also be obtained from SRY Electronics.

It will be noted in the Components List that 5 Denco coil formers are specified. These are required for the coils, whose assembly is described in Part 2, and they plug into the B9A valveholder which is also listed. The Formica laminate and Perspex sheet are (as is also described in Part 2) cut to form circles having a diameter of 2$\frac{1}{2}$in.

Two of the fixed capacitors are specified in the Components List as "metallised film". Capacitors of this type have the advantage of being small in physical size, and are available from Electroniques and other suppliers.

PREPARING THE CASE

The g.d.o. is constructed within a standard 6in. x 3in. x 2$\frac{1}{2}$in. aluminium chassis with reinforced corners. The deck of the chassis forms the front panel, and it is drilled and cut out as shown in Fig. 2. It should be noted that the three holes marked C are for mounting the variable capacitor just referred to. Alternative hole positions may be required if a different type of capacitor is employed. The rectangular slot and the two A holes are for the on-off slide switch which, in the writer's instrument, was a standard d.p.d.t. component. Before drilling, the constructor should check that the dimensions given for the holes and slot are correct for the particular switch he is employing.

One side of the chassis has four holes drilled in it, these being indicated in Fig. 3(a). The two C holes in this side are repeated on the opposite side. These two sets of holes are intended for two bottom cover fixing brackets, as shown in Fig. 4(a). The two A holes in Fig. 3(a) are for the groupboard, which is spaced off by $\frac{1}{4}$in. pillars.

The B9A valveholder is fitted at the chassis end nearer the tuning capacitor, and the holes required

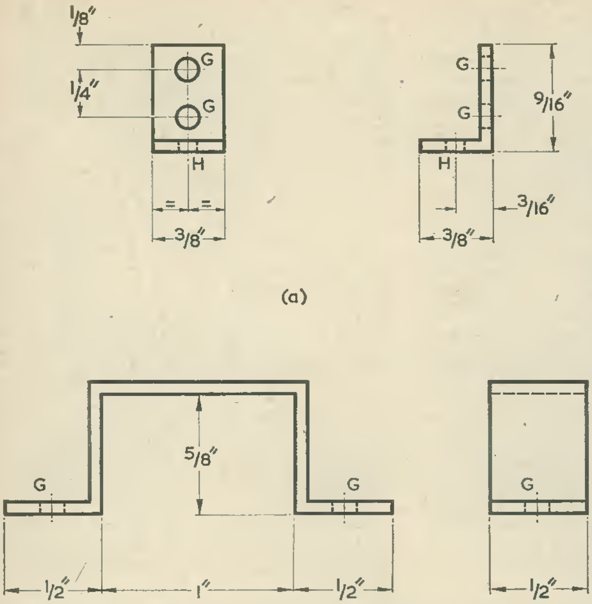


Fig. 4(a). Two bottom cover fixing brackets, made to the dimensions shown here, are required (b). Dimensions of the battery clamp. The hole positions are discussed in the text

TABLE I

Key To Hole Sizes (Figs. 2, 3 and 4)

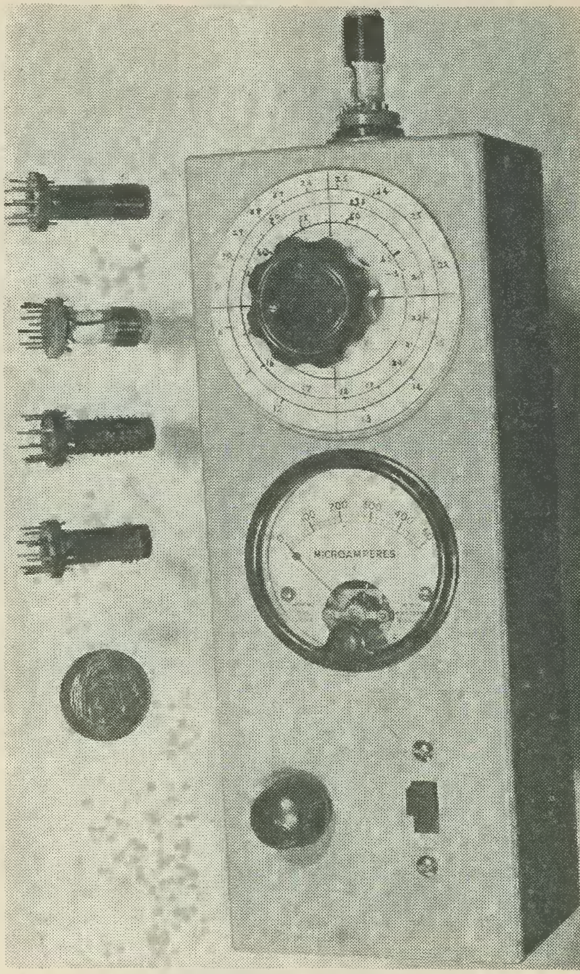
Type	Drill or Dia.	Remarks
A	No. 32	8 holes for 6BA Mush. Hd. screws
B	No. 42	4 holes for meter mounting studs
C	No. 32 and Csk	7 holes for 6BA Csk. Hd. screws
D	5/16in. dia.	Clearance for VC1 spindle
E	1½in. dia.	Clearance for meter body
F	¾in. dia.	Clearance for coil socket
G	No. 32	6 holes 6BA clear
H	——	2 holes to suit self-tapping screws

are shown in Fig. 3(b). The arrow indicates the orientation of the valveholder and points in the direction of the gap between pins 1 and 9. The other end of the case has two A holes, as illustrated in Fig. 3(c).

The two bottom cover fixing brackets just mentioned are made up as in Fig. 4(a). A battery clamp, shown in Fig 4(b), is also required, the two holes in this being marked off from the two A holes drilled in Fig. 3(c). The two brackets and the battery clamp are made from 18 s.w.g. aluminium.

The accompanying Table I gives details of the holes identified in Figs. 2, 3 and 4.

A baseplate is next cut to fit neatly inside the chassis walls, and is secured by six self-tapping screws, four to the corner flanges and one to each of the brackets located half way along each side. Due to manufacturing tolerances in the chassis, it is not possible to provide a cutting size for the baseplate. This should be cut from 18 s.w.g. aluminium to dimensions measured from the actual chassis to be used.



The original transistor g.d.o. constructed by the author. This had a variable resistor in series with the meter which was subsequently taken out of circuit

(To be concluded)

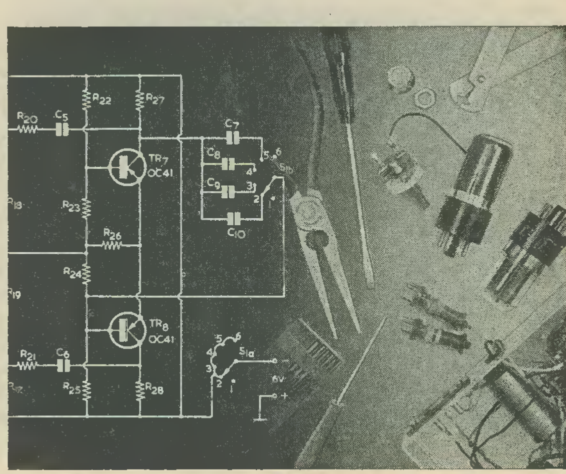
TRANSISTOR SUPERHET FOR TOP BAND

The type designations of the intermediate frequency transformers for this receiver were omitted from the components list on page 756 of the July 1969 issue. IFT1 and IFT2 are Denco type IFT13 and IFT3 is a Denco type IFT14. The omission is regretted.

SUGGESTED CIRCUIT No. 227

HIGH SENSITIVITY PROXIMITY DETECTOR

by G. A. FRENCH



THIS MONTH'S SUGGESTED CIRcuit article describes a proximity detector incorporating a crystal as a frequency selective device. The function of the detector is to switch on an external circuit if a pick-up wire or plate is approached by any person, and the design can be set up to provide a high level of sensitivity. The prototype operated when a person approached within 1 ft. of a vertical pick-up wire 4 ft. long, or when a hand was held 9 in. or less away from a flat pick-up metal plate measuring 3 by 9 ins. The effect which causes the detector to operate is the increase in capacitance to earth of the pick-up wire or plate when it is approached.

The device has a number of applications, these including the actuation of warning circuits to indicate the presence of intruders, and the operation of electrical equipment without the necessity of physically touching any switch, button or contact.

BASIC OPERATION

An important section of the proximity detector consists of an oscillating parallel tuned circuit. One end of this is connected to earth, whilst the other end is connected to the pick-up wire or plate. If, for any reason, the capacitance between earth and the pick-up wire or plate increases, the frequency of oscillation is reduced accordingly.

The output of the oscillator in which the tuned circuit appears is coupled via a crystal to a detector and d.c. amplifier which controls the external circuit by means of a relay. In the present design the relay is held normally in the energised condition, and it de-energises when the pick-up wire or plate is approached. For the more serious applications, therefore, the device offers an automatic fail-safe facility.

The full circuit of the proximity detector appears in Fig. 1. In this diagram the tuned circuit consists of L1(a), C1 and C2, the upper ends of these components coupling to the "Proximity" terminal, to which the external pick-up wire or plate connects. The lower ends of the tuned circuit components connect to the chassis and metal screening case of the detector, and thence to earth. Positive feedback to coil L1(a) is provided by TR1, to whose base is connected the coupling coil L1(b).

The oscillator output voltage at the collector of TR1 is applied by way of the crystal to the diode detector circuit around D1. The crystal is intended to operate in the series resonant mode rather than in the parallel resonant mode encountered in crystal oscillators and the like. For this reason it was decided to choose a crystal which would normally be employed for series resonant operation, and the component selected is a 455kHz crystal intended for use in the AR88 receiver. This crystal is a component with wire lead-outs, and is available from Henry's Radio Ltd. The crystal offers minimum impedance at its series resonant frequency, whereupon maximum detected voltage appears across diode D1 when the oscillator output is at this frequency. Due to the sharply selective frequency characteristic of the crystal it requires only a very small subsequent change in oscillator frequency for the crystal to exhibit a relatively high impedance, thereby causing an abrupt drop in the detected voltage across D1. Sensitivity is controlled by the preset variable resistor R5, this being adjusted to present a resistive load to the crystal which enables it to offer optimum selectivity*

Diode D1 appears in a shunt detector circuit, the requisite input series capacitance being provided by the crystal itself. The diode is connected such that the detected voltage is positive of the lower supply rail, and this voltage is applied by way of R6 and C6 to the base of TR2. R6 is given the rather high value of 100kΩ in order to reduce loading on the detector circuit. This high value is permissible because the combination of TR2 and TR3 offers an exceptionally high degree of d.c. gain, causing TR3 to be fully conductive for a base current in TR2 of only silghtly more than 1μA. To enable this high degree of gain to be achieved, it is important that TR2 be the BC168C specified. (The BC168C is available from Amatronix Ltd.) Because TR2 is a silicon transistor, it remains cut off until its base-emitter voltage approaches about 0.4 volts. There is, in consequence, an automatic delay in the functioning of TR2 and TR3 for detected voltages at TR2 base below this level. This voltage delay enhances the ability of the section incorporating TR2 and TR3 to differentiate between the conditions where the crystal is in the low impedance state (at series resonance) and where it is in the relatively high impedance state (off series resonance).

The emitter of TR3 connects to the coil of a relay, details of which are given later. The relay has a set of normally-closed contacts coupling to an external warning circuit which could consist, typically, of a bell and battery. Inserted between the positive supply line and the coil of the relay is a meter having an f.s.d. greater than the current passing through the relay coil when TR3 is hard on. This meter is required for setting-up purposes. Connected across the relay coil is the usual protective diode, its function being to prevent the appearance of a high-back–e.m.f. across

* Readers who are unfamiliar with the use of a quartz crystal in the series resonant mode are advised to consult "Understanding Radio" in the last August issue. "Understanding Radio" in the preceding July issue, it may be added, introduced the subject of quartz crystals in general, and dealt with the crystal in parallel resonant mode.—Editor.

the coil when the energising current ceases.

We may now sum up the overall operation of the circuit in the following manner. The "Proximity" terminal is connected to a pick-up wire or plate, and the oscillator circuit around TR1 is adjusted to provide an output at the series resonant frequency of the crystal. The latter then exhibits a low impedance, allowing a high detected voltage to be applied to the combination of TR2 and TR3. TR3 is in consequence hard on, the relay is energised, and its normally-closed contacts are open. If, due to the proximity of a person, the capacitance to earth at the pick-up wire or plate becomes greater the frequency of the oscillator reduces, falling outside the low impedance series resonant range of the crystal. The crystal now exhibits a relatively high impedance, whereupon the detected voltage passed to TR2 and TR3 falls, and the relay de-energises. The relay contacts close, causing the external warning circuit to be actuated.

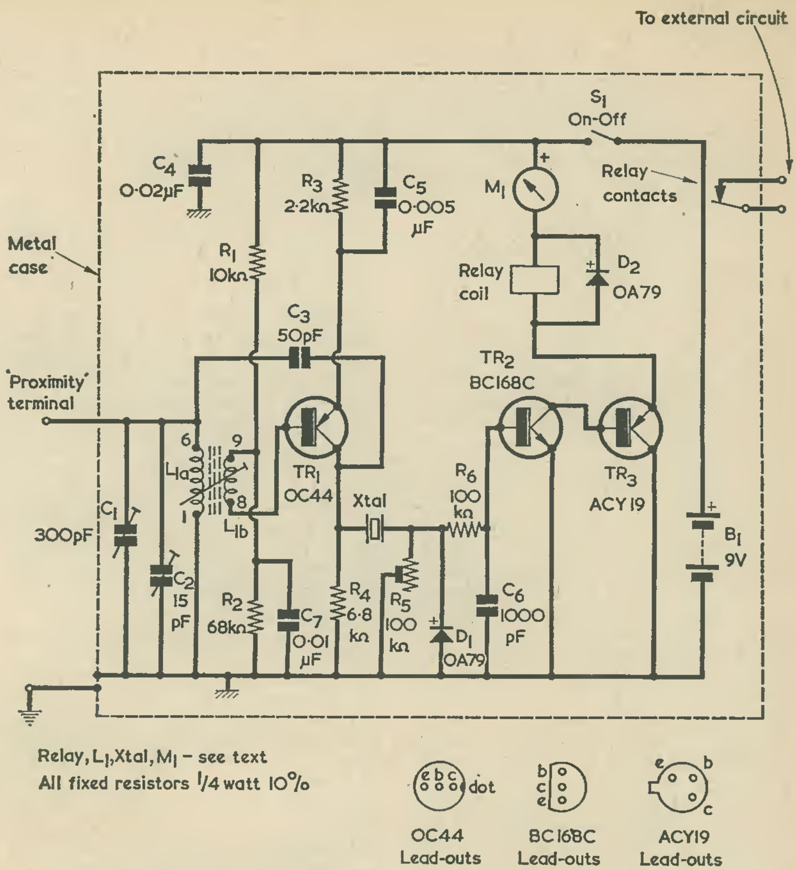


Fig. 1. The complete circuit of the proximity detector

CHOICE OF OSCILLATOR FREQUENCY

It was initially intended to have the oscillator run at the crystal frequency of 455kHz, but it was found much more convenient in practice to have the oscillator run at 227.5 kHz, whereupon its second harmonic provides the necessary series resonant frequency of 455kHz. A considerable advantage offered by having an oscillator frequency of 227.5kHz is that it then becomes a very simple matter to bring the tuned circuit to correct frequency by taking advantage of the BBC2 radio signal on 200kHz. Without this aid, the initial setting-up of oscillator frequency becomes somewhat long and tedious.

The coil employed for L1 is a Denco Miniature Dual Purpose (Valve) Yellow Range 1 coil. This coil is normally employed with valves instead of transistors, but it functions very well in the present circuit. It is designed to cover the long wave band when tuned by a variable capacitor having a nominal value of 300pF. In the present application its coupling winding, L1(b), connects to the base of TR1. The coil plugs into a B9A valveholder and the numbers alongside the windings in Fig. 1 indicate the corresponding valveholder pins.

TUNING CAPACITANCE

In a proximity detector operating on the principles just outlined, an important design point centres around the tuning capacitance across the tuned circuit to which the pick-up wire or plate is connected. If this tuning capacitance is low, the increased capacitance due to proximity will cause a greater shift in resonant frequency than if the tuning capacitance is high. It follows that, for the same frequency selective device, greater sensitivity is offered when a low tuning capacitance is employed. Opposed to this is the fact that a low tuning capacitance results in a tuned circuit which is more liable to drift due to changing stray capacitances and internal capacitances in the transistor. A high tuning capacitance tends to swamp the stray and internal transistor capacitances whereupon (provided it has a low temperature coefficient of capacitance) it reduces oscillator drift. With the present design the tuning capacitance, when properly set up, is of the order of 180pF; and it might be thought that this rather high value leans somewhat more towards the procurement of frequency stability than towards sensitivity. In practice, however, a tuning capacitance of this value is quite acceptable because of the exceptionally high selectivity offered by the crystal. It is doubtful if any significantly greater sensitivity could be achieved, whilst employing an inexpensive circuit with home-constructor components, by the use of a lower tuning capacitance.

In this context the choice of resonant frequency for the tuned circuit is of less importance, and indeed the resonant frequency depends mainly upon the capabilities of whatever frequency selective device is incorporated. In the present design tuned circuit resonant frequency is dictated by the crystal. The fact that the resonant frequency is at the relatively low figure of 227.5kHz offers the minor advantage that oscillator layout and wiring is not particularly critical.

COMPONENTS AND CONSTRUCTION

A number of the components employed in the circuit have yet to be discussed.

Although shown as a trimmer, C1 is actually a standard single-gang air-spaced variable tuning capacitor having a maximum value of around 300pF. C2 is also an air-spaced variable capacitor, and it should have a maximum value of about 15pF. A suitable component for C2 would be a Jackson Brothers variable capacitor type C804. The adjustment of C1 is extremely critical and it is for this reason that C2 is included, since the low value in C2 enables final tuning adjustments to be made more easily. Although not essential, it may be found helpful to fit C1 with a simple epicyclic slow motion drive. If C1 were fitted with a reliable slow motion drive offering a reduction of 20:1 or more, C2 could be omitted.

Capacitor C3 must be a silver-mica component. Preset resistor R5 can be a small "skeleton" type.

The relay should be capable of energising at some 7 volts or less, and its coil resistance should be between 450 and 2,000Ω. In the prototype, the writer used a P.O. 3000 relay having a 500Ω coil and two sets of changeover contacts. Fig. 1 illustrates a single set of normally-closed contacts only, but the actual relay employed can, of course, have more contact sets than this if it meets the energising voltage requirement just mentioned.

The meter in the M1 position should have an f.s.d. slightly greater than the maximum current drawn by the relay coil. In the prototype the writer used a 0-20mA meter, which corresponded comfortably with the maximum current of around 18mA which could flow through the 500Ω coil of the relay.

Only a small number of components is employed in the circuit, and construction should not raise too many problems. In Fig. 1 the whole circuit is depicted as being housed in a screened metal case. Complete screening is not entirely essential, but it is strongly recommended if the unit is to be built up in permanent form. If it will facilitate battery replacement, the battery can, if desired, be positioned outside the screening case. There is no necessity to screen the oscillator section from the components following the crystal, but it is advisable to keep these sections separate from each other. The best plan here is to assemble the oscillator components in one group, and all components to the right of the crystal in a second group, the two being linked together by the crystal itself. Capacitor C4 should be included in the oscillator group.

When finally assembled, the spindles of C1 and C2 should protrude through the front panel of the metal case and be fitted with suitable pointer knobs. A cover over these knobs is desirable, to prevent accidental maladjustment. A hole should be provided through which a screwdriver can be inserted to adjust R5. Meter M1 and S1 are mounted on the front panel. The "Proximity" terminal should be positioned well away from the front panel to avoid hand-capacitance effects whilst the panel controls are being adjusted. Also, the internal wiring between this terminal and the oscillator tuned circuit should be kept short.

The circuit has to be initially checked and set up in the unscreened condition. In consequence it is a good plan to mount the chassis and all components directly to the front panel of the screening case. This can then be finally fitted into the case for the last adjustments and for subsequent use.

SETTING UP

After the circuit has been assembled and the wiring carefully checked it may be tested and set up.

Initially set R5 to insert full resistance into circuit. Adjust the dust core of L1 so that about ⅜ in. of the brass threaded stem protrudes from the former and secure it in position by passing a 6BA nut over it to act as a lock-nut. The position of the dust core is not important, and it is merely necessary to ensure that it is held in place securely. Set C2 to half-capacitance. No connection should be made to the "Proximity" terminal at this stage. The chassis of the unit should be connected to any convenient earth, such as a mains socket earth connection.

Connect the battery and switch on. If the oscillator is running satisfactorily, meter M1 should indicate full, or nearly full, relay coil current for most of the travel of C1, the reading probably dropping noticeably as C1 approaches full capacitance. This reading is due to the detection, by D1, of r.f. from the oscillator passing via the capacitance of the crystal holder.

Obtain a transistor radio with a ferrite rod aerial and tune this to the BBC2 radio programme on 200 kHz (1,500 metres). Hold the radio about 1 ft. away from L1 and swing C1 for a heterodyne beat with the received programme. If there are several heterodynes in the range of C1 the correct one is that which still continues to be indicated by the radio as the latter is moved away from L1. With the prototype, the heterodyne was evident with the receiver 4 ft. away from L1. The vanes of C1 should be about one-half to three-quarters enmeshed for this heterodyne.

Switch off the receiver. Reduce the resistance inserted into circuit by R5 until the needle of meter M1 is just slightly deflected forwards from its zero position. Reduce the capacitance of C1 *extremely* slowly, continually observing the meter. It is possible that the meter reading will increase gradually during this adjustment of C1, due to slightly increasing r.f. output from the oscillator. This gradual increase in meter reading should be ignored. At a precise setting of C1 the meter will suddenly swing over to full relay current and the relay will energise. Further reduce the resistance inserted by R5 until the meter indicates slightly less than full relay current. Attempt, so far as is possible, to bring C1 to a position which once more gives maximum reading in the meter. This last adjustment of C1 will be found very critical. Mark on the front panel the position taken up by C1, as indicated by its pointer knob, then leave this component alone.

All further frequency adjustments are carried out by C2. It should now be possible, by adjustment of this capacitor, to take oscillator frequency right through the resonant response of the crystal, with full relay current near the centre of C2 travel and zero, or very low, relay current at either end of its travel.

The next process is to find the optimum value required in R5. As the resistance inserted into circuit by this resistor is reduced it will be found that the selectivity offered by the crystal increases, this selectivity being checked by swinging C2 throughout its range. However, too low a resistance in R5 produces an effect whereby the crystal exhibits its low impedance as the oscillator frequency approaches the crystal resonant frequency in one direction only. This effect is due to the fact that the crystal is coupled directly to the oscillator tuned circuit via C3. The final value required in R5 is that at which the resistance it inserts is just sufficiently high to prevent this last effect taking place. It will then be possible to obtain the same low impedance resonant response in the crystal regardless of the direction in which C2 is rotated. This condition can be confirmed by setting C2 to any position and switching S1 off. The same reading in M1 should be given as S1 is switched on again.

Finally set C2 to the centre of the settings at which M1 indicates full relay coil current. A finger close to or touching the insulation of the wire to the fixed vanes of C1 or C2 should cause the relay to de-energise. For ultra-high sensitivity increase the capacitance of C2 to the point where relay coil current is on the point of falling.

The adjustment procedure just outlined requires a number of critical adjustments, together with concentration on the part of the constructor. However, it does enable the optimum setting for R5 to be found, and this component should not require any further adjustment when the unit is housed in its case and the pick-up wire or plate connected. The procedure illustrates the advantage of using the 200kHz BBC2 signal to provide a starting point for oscillator adjustments. The heterodyne test with the BBC2 signal also checks oscillator functioning since, if a clear beat note is provided, the oscillator is operating correctly. In the unlikely event of oscillator squegging due to excessive feedback the beat note will have a harsh noisy background. Oscillator efficiency can be adjusted, incidentally, by increasing or decreasing the value of C5 as required, but it is doubtful if any change in the value of this component will be needed in practice.

The unit should next be fitted into its case and operation rechecked. The case will slightly alter the effective inductance of L1(a) and will also cause slight changes in stray wiring capacitances. Readjust C1 and C2 as before. The setting in C1 will be very close to that previously obtained, and there should be no need to touch R5. Next, connect the pick-up wire or plate to the "Proximity" terminal, keeping all the external capacitances to earth as low as possible. Keeping well away from the proximity wiring, finally adjust C1 and C2.

The proximity detector is then ready for use.

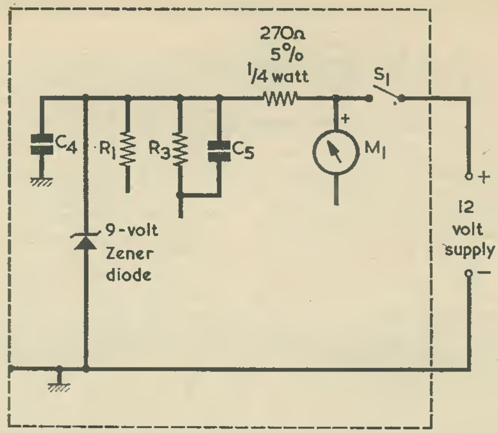


Fig. 2. For long-term operation from a 12 volt supply the oscillator section should have its supply stabilised by a zener diode having a nominal rating of approximately 9 volts. The relay section may run direct from the 12 volt supply

OSCILLATOR STABILITY

The current drawn from the 9-volt battery in the circuit of Fig. 1 consists of the energising current for the relay employed, together with approximately 1mA for the oscillator section. A standard PP9 battery should offer full terminal voltage for reasonably long periods at a current of this nature.

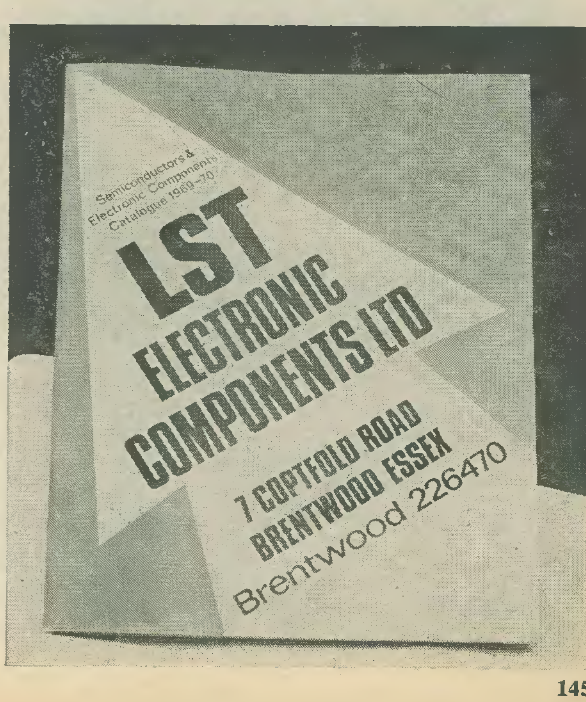
If the device is to be employed for very long periods it would be preferable to provide a mains power supply having a stabilised 9 volt output, since falling supply voltage could cause oscillator drift. Alternatively, an unstabilised 12 volt supply could be used, the oscillater supply being stablised by a 9 volt Zener diode as shown in Fig. 2. Zener diode dissipation here is of the order of 90mW and the diode passes a standing current of about 10mA.

In Fig. 2, the relay section of the circuit runs directly from the 12 volt supply. Relay requirements are the same as with the 9 volt supply apart from the fact that relay energising voltage may now be about 10 volts or less. The meter in Fig. 2 should have an f.s.d. value slightly greater than relay energising current at 12 volts.

When very long term operation is envisaged it would also be helpful to replace C2 by an air-spaced ceramic variable capacitor fitted with a slow-motion drive and having a value of 50pF, and to replace C1 with a silver-mica fixed capacitor whose value, found by experiment, causes C2 to bring oscillator frequency to crystal resonance at around mid-travel. For very long term operation the unit should be positioned in a place where ambient temperature is reasonably constant. ■

NEW CATALOGUE

Currently available is the 1969-70 catalogue of L.S.T. Electronic Components Ltd. This comprises 44 large pages listing a very wide range of semiconductor products by various manufacturers, including R.C.A., Mullard, SGS, Newmarket, Texas, General Electric, International Rectifier, Motorola, S.T.C. and Plessey. Also given in the catalogue are details of batch quantities of manufacturers' surplus semiconductor devices which may be purchased at very low prices. Further components listed are capacitors, resistors, potentiometers, nickel-cadmium cells, 40kHz transducers, chassis and hardware, reed relays, coils, transformers, meters, and many other items. The catalogue is available free and post free to readers of *The Radio Constructor* from L.S.T. Electronic Components Ltd., 7 Coptfold Road, Brentwood, Essex.



NEWS . . . AND .

NEW BIB COMPACT TAPE HEAD CLEANING KIT

Bib Division of Multicore Solders Ltd., Hemel Hempstead, Herts, are introducing a new compact size J Bib Tape Head Maintenance Kit. The kit comprises a 30 c.c. bottle of anti-static, non-inflammable Bib cleaner, two each Bib applicator and polisher tools for applying the cleaner, or alcohol for removing oxide and dirt from the tape heads and all parts of the tape path. Ten double ended cotton wool tipped sticks may be used for the same purpose for recorders, to which easy access cannot be achieved with the Bib tools. They are used also for removing oxide from baseplates of recorders, scraps of tape, etc. A Hi-Fuster absorbent cloth is provided for cleaning the soiled tools and sticks and the exterior of tape recorders.

All these components are contained in a plastic wallet, which is packed in a polythene bag attached to an attractive header card for pegboard display. Full instructions for use in English are given on the back of the card, the inside of which contains these instructions in French and German. The recommended retail price is 9s. 9d., including 1s. 11d. purchase tax.

HOW TO TREAT YOUR TRANSISTOR

Transistor radios, fresh from the factory, were recently found to be faulty on arrival in the shops. Quite a mystery, for they had all passed their final tests at the makers. The explanation turned out to be that these radios had been packed in plastic bags. These bags, like almost any dry piece of plastics material, had become charged with static electricity. It so happened that when the static discharged itself it went through the aerial into the receiver and destroyed the first transistor.

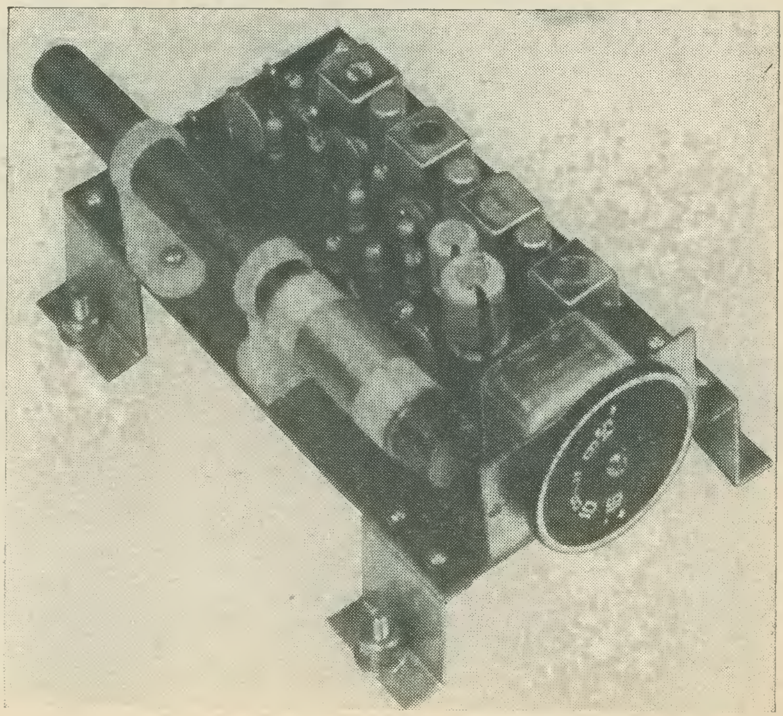
A BBC reporter warning against this trouble, stated in a recent broadcast that similar disasters have been known to overtake car radios. Cars often pick up a static charge in dry weather. If you get out and then touch the radio aerial all you feel is a slight tingle, but the radio set loses a transistor. Fortunately, there is a simple remedy. It is to connect a miniature neon tube to the aerial circuit of the receiver. When a static discharge occurs, the neon lights up momentarily and absorbs the electrical energy.

ANOTHER NEW AUDIO LINE FROM EAGLE PRODUCTS

A new sub-miniature AM Tuner Chassis – an ideal addition to those installations which are FM only where the rest of the family might want to listen to stations only available on AM. Operates from a single 9 volt battery.

Specification:
Frequency coverage: 600–1500kHz.
Aerial: Ferrite rod.

List price: £4.18.10d. inc. tax. Model No. AMT 35.



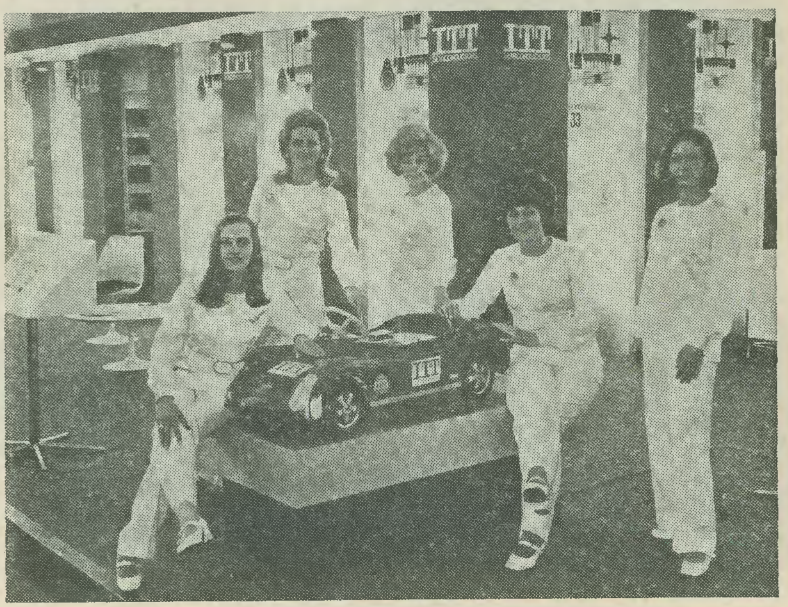
. . . COMMENT

NEW INTERNATIONAL CALL AREAS AWARD

A number of transmitting amateurs have long wanted an international award that would stimulate skilful Dx operation. A number of meetings in London and Geneva were held which resulted in the formation of a new body—the International Dx Organisation (IDXO).

The award the new organisation will be promoting is called the International Call Areas Award (ICAA), and we hope at a later date to give details of the rules.

This new body is not intended to compete with existing organisations and it is perhaps a guarantee of this that the first chairman of the board of directors is Roy Stevens, G2BVN, a former president of the R.S.G.B.



NOT JUST A PRETTY FACE!

An attraction at the 1969 Paris Components Salon was the ITT hostesses in their white silk trouser suits with silver leaf embroidery. Some visitors thought they were professional models. In fact, they are ITT secretaries, each with two or three language qualifications.

Left to right are: Ursula Jahn – ITT-Cannon, Paris; Annik Fiacre – ITT Components, Paris; Rita Franz – ITT Components, Nürnberg; Germaine Kehoe – STC, London; Lise Moreau – ITT Semiconductors, Paris.

The small car was used to demonstrate ITT's solid state electronics for the automobile industry.

COLOUR TV MANUFACTURERS' FEARS

TV Trade Associations have warned the Government that there is likely to be a very serious shortage of colour TV sets when colour is introduced on three channels later this year.

The fears of a shortage stem from the hire purchase and rental regulations and the manufacturers are anxious to receive early advice of any changes because it can take up to six months to alter the rate of production.

The difficulties of assessing the likely demand when BBC 1, BBC 2, and ITV all transmit colour are immense; possible revaluation of the Deutsche Mark, change in h.p. and rental regulations, strength of foreign competition can all profoundly affect demand for home produced receivers. Even leaving things as they are we have seen forecasts vary from just over 100,000 sets per year to as many as 300,000, all these forecasts being made by knowledgeable bodies.

MANAGEMENT AND ECONOMICS IN THE ELECTRONIC INDUSTRY SYMPOSIUM

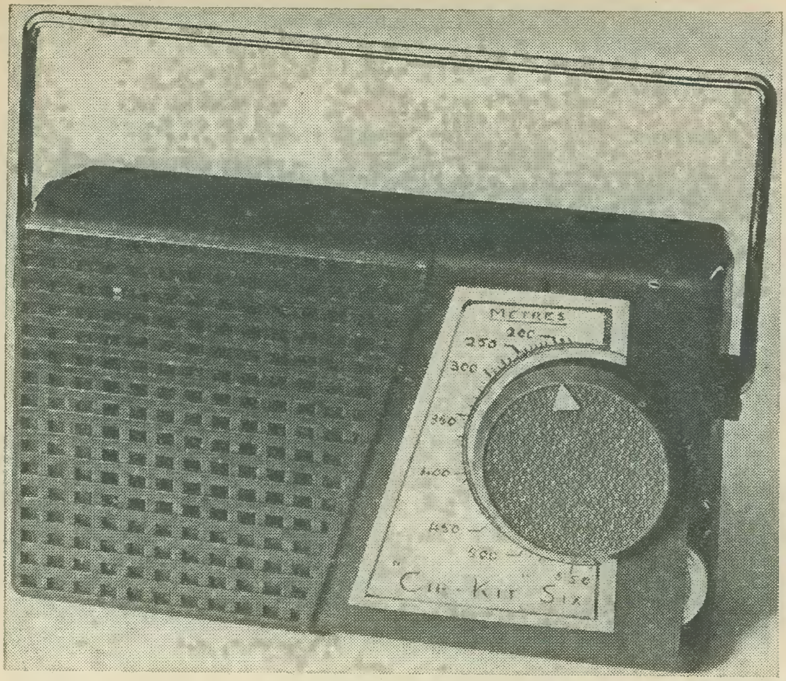
The president of the Scottish Council (Development & Industry), Lord Polwarth, is to be president of the symposium on management and economics in the electronics industry to be held in Edinburgh from the 17th to 20th March 1970.

The Scottish Council, with which Lord Polwarth has been associated for many years, has played a leading role in the establishment of a thriving electronics industry in Scotland. Since 1945 this has grown from one major company to more than eighty firms employing nearly 40,000 people.

BBC RESEARCH SCHOLARSHIP 1969

The engineering division of the BBC maintains six research scholars at United Kingdom universities, and is awarding one scholarship this year. The scholarships are intended to provide the opportunity for selected honours graduates to work for a higher degree, the subject chosen for post-graduate study being within those fields of physics or engineering which have an application to radio or television broadcasting.

Mr. P. A. Ratliff, who graduated with first class honours in electronic engineering from the University of Birmingham in June this year, has been awarded a three-year BBC Research Scholarship to undertake research in the Department of Electronic and Electrical Engineering, University of Birmingham. The subject of Mr. Ratliff's study is 'an aerial system designed to combat multipath fading in VHF mobile communications, using existing AM receivers'.



"Cir-Kit" Personal Portable Superhet

by

J. HOSSACK

Intended for the more advanced constructor, this medium-wave personal portable offers a performance fully equal to that of similar commercially manufactured receivers. A particularly interesting feature is given by the use of "Cir-Kit" Instant Circuit Board

Editor's Note. – a few of the components employed in this receiver are imported or are manufacturer's surplus, and may not be available for as long a period as are standard British parts. We have been assured that adequate supplies of such components will be available when this article is published, but we cannot guarantee that they will continue to be available at later dates. Suggestions for alternative parts are given in the article, and these alternatives may require small changes in the layout or, even, in the "Cir-Kit" layout. Such changes will be well within the capabilities of the more experienced constructor who understands the principles involved.

BASIC DESIGN

This design, which is based on a conventional six-transistor superhet circuit covering the medium-wave band, is built up on a printed circuit board using the popular "Cir-Kit" technique, and the complete receiver can be constructed for a very modest sum. Although not really suitable for the beginner, it can be built with confidence by any reader who has previously tackled one of the small transistor receivers available in kit form, and has the advantage of giving the constructor the satisfaction of making his own printed circuit board and building up his design from scratch.

For those readers who are not familiar with "Cir-Kit", it should be pointed out that this consists of a sheet of thin Paxolin board, with a roll of self-adhesive copper strip approximately $^{3}/_{32}$in. wide, together with a further sheet of copper foil for making larger conducting areas. The latter are generally at earth potential. It is important that these earthed areas are included in their entirety in any design project, since they provide an appreciable screening effect, and their omission, or replacement by copper strip alone, could result in instability. Attempts to design extremely small sub-miniature layouts with Cir-Kit present difficulties, due to the nature of the material, and the present design represents a reasonable compromise between small size and ease of construction. The author used "Cir-Kit" kit No. 3, which provides ample material for several receivers.

The cabinet employed by the author is that listed in the Components List. Three holes, tapped for 6BA bolts, retain the circuit board in position, and the corresponding clearance holes in the Cir-Kit board are shown, marked "x" in Fig. 2, which incidentally is viewed from the copper side of the board. A $2\frac{1}{2}$in. speaker is held tightly under the board once the latter is bolted into position, and further clamping should be unnecessary. The ferrite rod and battery brackets are constructed from aluminium sheet. If a cabinet of different dimensions is used, the Cir-Kit board may have to be modified to suit, but note that a clearance of 1in. above the board and $\frac{3}{8}$in. below will be required to accommodate the battery, speaker, and ferrite rod mountings with the cabinet lid in position.

THE CIRCUIT

As mentioned, the circuit, which is shown in Fig. 1, is based on a conventional superhet design, this consisting of mixer, two i.f. stages and a diode detector, these being followed by driver and push-pull output stages. The mixer stage uses an OC44 functioning as a self-mixing Reinartz oscillator. This takes the form of two small coils connected in emitter and collector circuits respectively, to which is tightly coupled a third, larger coil. Oscillation is maintained by feedback between the collector and emitter coils, while the third closely coupled coil, in conjunction with VC1(b), determines the oscillator frequency.

Two stages of i.f. amplication are employed, and the OC45 transistors used require a small amount of neutralisation, which is provided by C12 and C13. Details on mounting the i.f. transformers are given later. After detection by D1, the resulting a.f. signal is amplified by TR4 and fed to the output transistors, which consist of two OC81's in push-pull. The biasing arrangement for this stage is a little unusual, and was chosen to allow room for experimentation in the event of unmatched transistors being pressed into service for the sake of economy. In this case, an improvement in quality may be obtained by slightly altering the values of R16 and/or R17, keeping an eye on the total no-signal current while doing so. The aim is to achieve a current of around 8mA, rising to about 50 to 60mA on sound peaks, with a minimum of crossover distortion.

CONSTRUCTION

The "Cir-Kit" board is first of all cut and drilled, using Fig. 2, which is reproduced full-size, as a template for drilling and component-positioning. Before commencing the actual drilling, however, it is a wise precaution to check the sizes of the i.f., driver and output transformers against Fig. 2 to ensure that the components on hand correspond with the indicated dimensions in all respects. (Also, the notes given later in this article concerning alternative components should be consulted.) Slight variations, of the order of $\frac{1}{8}$ to $\frac{1}{4}$in., can occur with these parts, and it may be necessary to alter the "Cir-Kit" layout to allow for these small differences. Component holes are drilled with a No. 50 to 54 bit. The speaker hole can be easily cut out by drilling a series of $\frac{1}{8}$in. holes round the inside circumference and tapping out the centre, smoothing up afterwards with a half-round file. If preferred this operation can, alternatively, be carried out with a fretsaw or small hacksaw. The hole for the tuning capacitor spindle is $\frac{1}{2}$in. diameter, and the remaining fixing holes for ferrite rod brackets, etc., are all $\frac{1}{8}$in. diameter.

Special care must be taken, as already mentioned, to ensure that the fixing holes for oscillator coil, i.f. and audio transformers, and the volume control, are in precisely the correct positions. A very slightly larger drill size (say No. 46) can be used with advantage in this case. The mounting of these components will also be simplified if the holes are slightly elongated to take the corresponding lugs on the component cans (a lady's nail file is a useful tool) which should pass easily, but not too loosely, through the board. Do not bend these lugs over at this stage. Note that the volume control must be inserted from the bottom (copper) side of the board, and that only one pole of the double-pole on-off switch will be connected. It is recommended that the connections

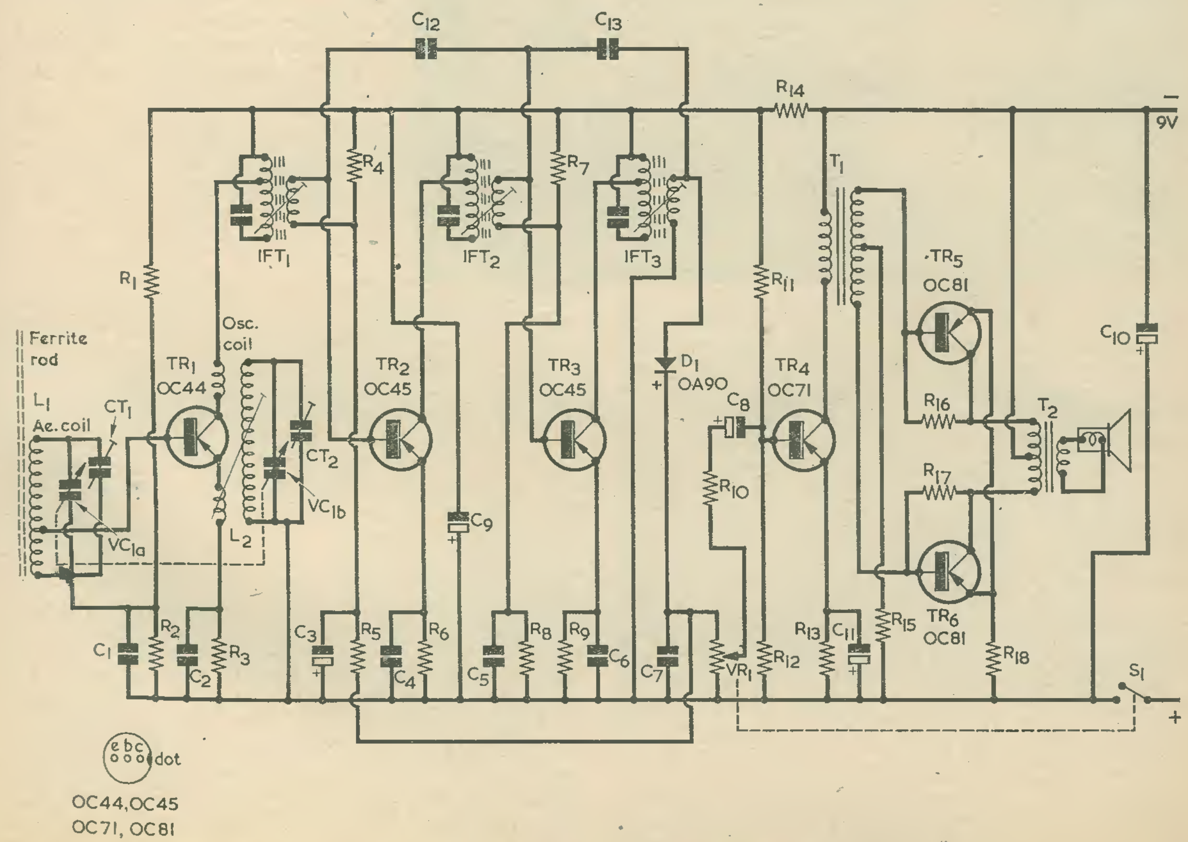


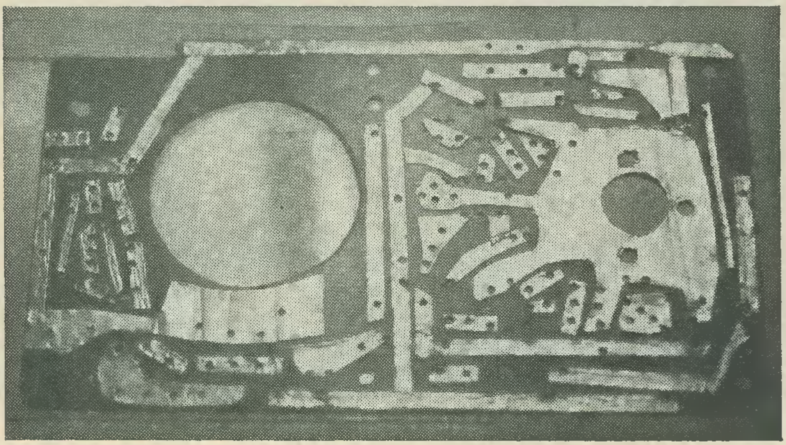
Fig. 1. The circuit of the personal portable superhet

to the particular control used are checked with a meter for correspondence with Fig. 2, since, if a different design of control is employed, it may be necessary to modify either the fixing hole points or the wiring.

After drilling has been completed, temporarily mount all the components just mentioned and, in addition, the tuning capacitor (which, incidentally, must be held by very short bolts to avoid fouling the moving vanes), and try fitting the board into its cabinet with the speaker in the position which it will finally occupy. Ensure that the tuning capacitor spindle is centrally positioned with respect to the cabinet opening, and that the board will screw fully into the cabinet with sufficient "grip" on the speaker to hold the latter firmly in position. If not, it may be necessary to bolt the speaker into position with screws inserted from the front of the cabinet, or, alternatively, to pad out with sponge rubber placed between the back of the speaker and the board. If sponge rubber is not used it will still be necessary to place an insulating ring of thin cardboard over the back of the speaker to prevent accidental contact of its metal frame to the "Cir-Kit" copper strips which are later fitted to the board.

lator coil and i.f. transformers are correctly oriented. The coil pack specified consists of the final i.f. transformer (code black), the two preceding i.f. transformers (code white) and the oscillator coil (code red). The last is the only one of the four possessing six connecting pins. The correct position of this coil on the board is achieved when the two terminals connected to the main tuned winding are positioned towards the right, viewing the board as in Fig. 2. The appropriate terminals are designated by a white spot on the base of the coil, next to one of the fixing lugs. The coil should therefore be mounted so that this spot faces right. If, because the spot is difficult to see or for any other reason, there is doubt, an ohmmeter check will locate the two terminals in question, the resistance being a few ohms. The other two windings (see theoretical circuit) will be found connected to the remaining pairs of terminals in the rows of three along both sides of the coil, each of these windings having a resistance of less than 1Ω.

The i.f. transformers are more easily oriented, since they possess only five pins and are therefore asymmetric. The first two (white coding) are mounted with the 3-pin side towards the top edge of the board, whilst the last i.f. transformer (black) has the 3-pin



The actual "Cir-Kit" copper layout before components are mounted

Having made these initial checks, remove all components from the board, and unroll a piece of "Cir-Kit" strip. With sharp scissors, cut this into the required lengths, following the plan of Fig. 2 and the photograph of the board underside. After removing the backing, press each length of copper firmly on to the underside of the board in the position shown. Next, cut the "lands" and the remaining irregular shapes from the large piece of copper sheeting supplied, and stick down similarly. If a mistake is made, the copper can be lifted and repositioned without loss of adhesion. Now, place a spot of solder on each overlap junction between strips and "lands", and between the strips themselves. If necessary, final trimming can be carried out with an old razor blade. The copper can then be pierced with a needle where it overlays each component hole, thus completing the preparation of the board. The final appearance should be similar to the photograph.

From this point onwards, construction follows normal printed circuit technique. Remount the tuning capacitor, volume control, and all transformers, bending back the lugs of the latter before soldering them into position. It is essential to ensure that the oscil-

array on the left. In cases of doubt, check back against the circuit diagram.

When soldering in the volume control, the connections may prove a little difficult of access, due to the fact that they are partially concealed by the control itself. The best plan is to leave a small gap (not more than $\frac{1}{16}$in. as otherwise the control knob will foul the side of the cabinet after assembly) between it and the underside of the board, bending the lugs back on the top side of the board and placing a spot of solder on each lug to anchor the control in position. Then solder the leads to the copper strip below the board. If, due to the use of a non-miniature soldering bit, difficulty is anticipated in obtaining access for the latter operation, it is recommended that $\frac{1}{2}$in. wire lengths be first of all affixed to the control points for subsequent connection to the Cir-kit strip itself.

Once the main components have been soldered in position and "wired" up, proceed to the smaller ones, such as resistors, capacitors, etc. Miniature fixed capacitors are used throughout, but, with a few exceptions, standard $\frac{1}{4}$ watt resistors were found to be sufficiently small, and gave a more "solid" appearance to the layout, besides being less expensive and

COMPONENTS

Resistors
(All fixed values ¼ watt 10%—see text concerning R15, R16, R17 and R18)

R1	39kΩ
R2	10kΩ
R3	3.3kΩ
R4	68kΩ
R5	10kΩ
R6	470Ω
R7	22kΩ
R8	3.9kΩ
R9	1kΩ
R10	390Ω
R11	56kΩ
R12	10kΩ
R13	470Ω
R14	390Ω
R15	47Ω
R16	8.2kΩ
R17	8.2kΩ
R18	4.7Ω
VR1	5kΩ pot., log, miniature edge, Radiospares, with d.p.s.t. switch (Home Radio, Cat. No. TRC78)

Capacitors
(See text for details of fixed capacitors)

C1	0.022μF
C2	0.01μF
C3	8μF electrolytic, 6V wkg.
C4	0.047μF
C5	0.022μF
C6	0.047μF
C7	0.047μF
C8	4μF electrolytic, 6V wkg.
C9	50μF electrolytic, 9V wkg.
C10	50μF electrolytic, 9V wkg.
C11	50μF electrolytic, 6V wkg.
C12	47pF
C13	12pF
VC1	(a) (b) 165 + 70pF with trimmers, miniature air-spaced, complete with with knob (Henry's Radio)
CT1, CT2	Part of VC1 (a) (b)

Inductors

L1	Ferrite aerial, wound on ferrite rod 4in. x $\frac{5}{16}$in. dia. (rod, Henry's Radio)
L2, I.F.T.1, I.F.T.2, I.F.T.3	Set of four 10 mm superhet coils for 455kHz, Type C10 (Henry's Radio)
T1	Sub-miniature driver transformer*
T2	Sub-miniature output transformer*

*T1 and T2 are available from Glasgow Electronic Services, 21 Old Dumbarton Road, Glasgow C.3.

Semiconductors

TR1	OC44
TR2	OC45
TR3	OC45
TR4	OC71
TR5	OC81
TR6	OC81
D1	OA90

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

Loudspeaker
3/10Ω loudspeaker, Eagle, 2½in. square (Henry's Radio)

Miscellaneous
"Cir-Kit" kit No. 3
Small Radio Cabinet, with carrying handle, 5¼in. x 3⅛in. x 1¾in. (Electronics (Croydon) Ltd., 266 London Road, Croydon, Surrey)
9-volt battery type PP3 (Ever Ready)
Battery connector
Aluminium for ferrite rod and battery brackets
6BA screws, nuts, etc.

easier to handle than the usual miniature types. Some care is required when making connections to the "Cir-Kit" strip, particularly around the i.f. transformer tags, to ensure that solder does not run on to adjacent strips and form unwanted "bridges". If this does happen, the quickest procedure is merely to lift off one or both of the offending copper strips and replace with fresh "Cir-Kit". The usual precautions should be observed when soldering in the transistors and diode. However, as about 1in. of free space is available above the board with the cabinet lid on, at least ½in. wire ends may be left on each transistor, considerably reducing the risk of heat damage when soldering them into position. The polarity of the diode must be observed, the negative end being connected to the final i.f. transformer.

Fig. 2 shows that the tap and lower end of the aerial coil each connect to a group of two component holes, one being in the strip leading from TR1 base and the other at the junction of C1 and R2. The groups of two holes allow short lengths of tinned copper wire to be threaded through to the component side of the board and firmly anchored in place, for subsequent connection above the board to the aerial coil. About ¼in. of wire above the board should be sufficient. Apart from battery and speaker connections, to which reference is made later, this completes the connections on the copper side of the board.

Referring now to the top side of the board, the ferrite rod is mounted on two aluminium brackets which hold it well clear of components. These brackets must not completely encircle the rod or they will constitute a shorted run. A third bracket retains the PP3 battery in position. Holes for mounting these should already be drilled, provided Fig. 2 has been followed in detail. These brackets should be clearly seen in the photograph of the completed receiver. The type of aerial coil required will depend, to some extent, on the length of ferrite rod. With the 4in. by $\frac{5}{16}$in. rod used by the author, 80 turns of 30 s.w.g. enamelled wire, tapped 4 turns from one end, provided excellent signal strength and sensitivity. The coil was wound with the turns side by side on a cardboard former which was made a sliding fit over the rod. A commercial coil can, of course, be used if desired. The three lead-out wires should be at least $2\frac{1}{2}$in. long so that subsequent adjustment can be carried out during alignment. The method of connecting the coil will be clear from Fig. 2, but it should be noted that the end connection from the main portion must be soldered to the *larger* (165pF) section of the 2-gang tuning capacitor which, in the present design, corresponds with the tag closest to the printed circuit board.

The battery and speaker connections consist of thin plastic-covered flex soldered to the appropriate points on the board. The method of anchoring these leads is important. After stripping the plastic back for approximately $\frac{1}{8}$in., the bare wire-end must be pushed through the appropriate hole *from the top of the board,* so that the plastic covering is flush with the Paxolin. and then held tightly in this position while it is soldered to the Cir-Kit strip below the hole. On no account must any connecting wires be soldered directly to the printed board from below, as the adhesion between board and strip is insufficient to withstand the frequent strain imposed upon it during, for example, battery replacements.

COMPONENTS

Before proceeding further, some comments should be made concerning components.

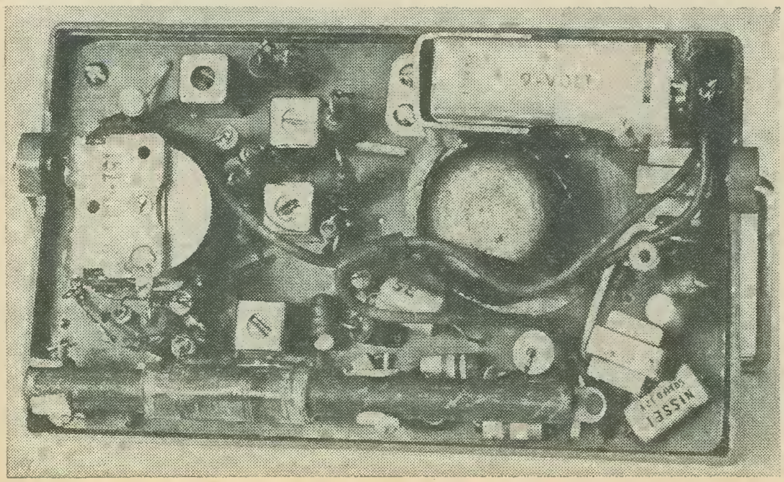
If i.f. transformers other than those specified are obtained they should, of course, be the same size (nominally 10 by 10mm) as those used here. Generally, if a complete i.f. pack is purchased a note of the colour coding for the order of the individual transformers is included. As a guide, however, red normally denotes the oscillator coil and black the final i.f. transformer, the position of the remaining i.f. transformers being unimportant. Oscillator coils suitable for the present circuit have 6 terminals. An alternative mixer circuit uses a tapped coil with 5 terminals, so it is well to check that the oscillator coil to be used is of the 6-terminal variety. An ohmmeter check will reveal the internal connections and, since the tuned winding has the highest resistance of the three, also enable the correct orientation of the oscillator coil on the board to be determined.

The audio transformers are usually coded green for driver and red for output transformer but, here again, a meter check will do no harm. The output transformer will be easily recognised by the very low resistance of its secondary, typically less than 1Ω. Sub-miniature transformers, such as those specified in the Components List, should be used. These are Japanese-type transformers measuring $\frac{9}{16}$in. between fixing lugs.

In case difficulty is experienced in obtaining the sub-miniature transformers, the standard "Eagle" LT44 and LT700 types can be used but, as these are slightly larger all round, some crowding of the components in the vicinity of the OC81's may occur. It will be unnecessary to alter the "Cir-Kit" design with the "Eagle" transformers since their leads, being flexible, will easily pass though the existing holes. As the fixing lugs are now $\frac{3}{4}$in. apart, however, the spacing of their holes in the board must be increased accordingly. In addition, R15, R16, R17 and R18 should be changed to sub-miniature types, while C10 will have to be mounted in an upright position to allow the extra space required for T1. A good idea here is to route the negative lead of this capacitor through the T2 primary centre-tap hole, which goes, via the jumper wire, to the negative battery line. T2 itself may foul the battery unless care is taken to make the mounting for this as small as possible and, in fact, it may be possible to dispense with a battery holder altogether if a piece of sponge rubber or plastic is inserted to prevent the battery from moving around.

The fixed resistors have already been mentioned. The volume control should be the Radiospares type listed.

The 0.022μF capacitors used by the author are Radiospares miniature tubular polyester, 250 volt



An internal view of the receiver with the rear cover removed

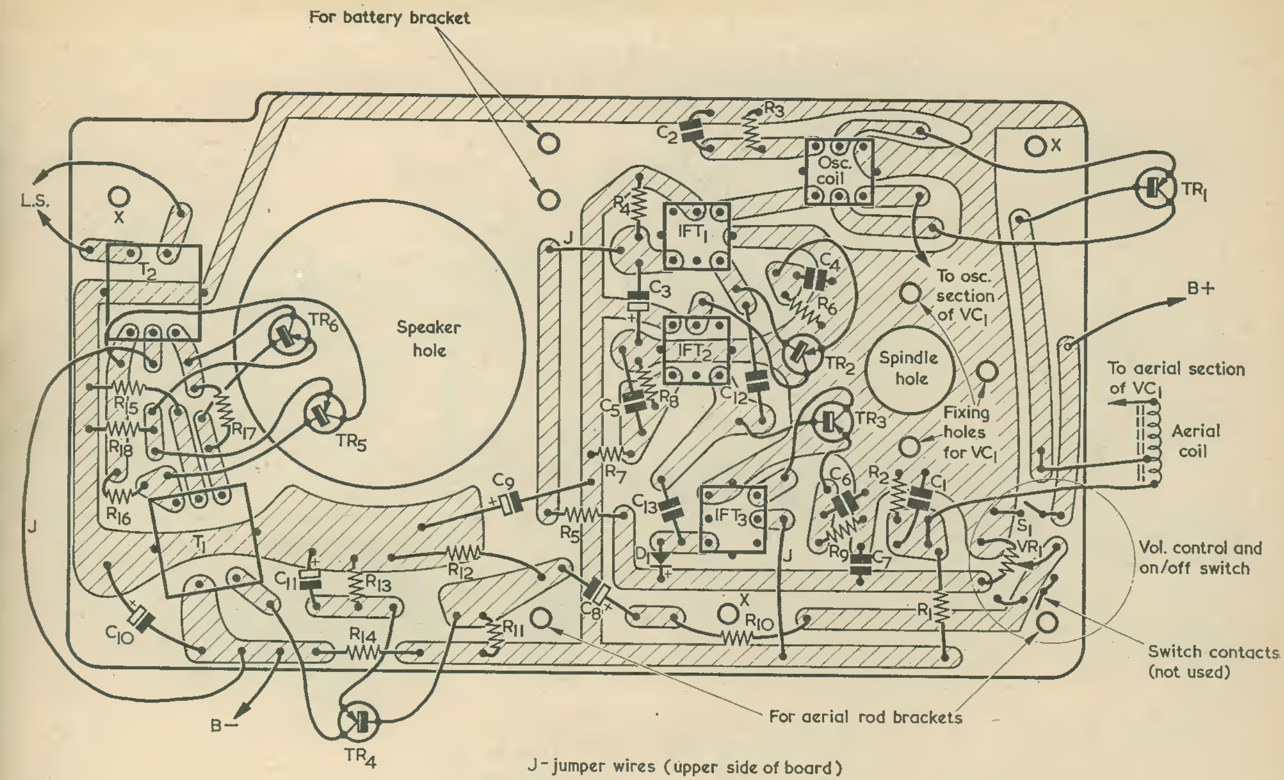


Fig. 2. The copper side of the board. This diagram is reproduced full size and may be employed as a template

working. These have a length of 0.45in. and a diameter of 0.16 to 0.2in. C2 could be a similar type in 500 volt working and having the same dimensions. Alternative capacitors should have similarly small dimensions, and it should be mentioned that Radiospares components may only be obtained through retailers. The electrolytic capacitors are all subminiature. The two neutralising capacitors, C12 and C13, are ceramic.

ALIGNMENT

When assembly of the board is complete, a final check should be made to ensure that all components have been inserted into their correct positions, and that all soldered joints are sound. Examine particularly the continuity through the i.f. transformers and connecting "Cir-Kit" strip; and the soldering of the latter to the "lands" and to each other.

Before connecting the battery, it is a wise precaution to measure the resistance across the battery connector with S1 on and a speaker connected. Typical values should be 250 and 2,500Ω in each direction respectively. If much lower values are found, a fault is almost certainly indicated. With a 9V supply, the approximate no-signal current should be 8 to 12mA. With the aerial coil about half-way along the rod, the local station should be audible at some point on the dial and, if so, trim the i.f. transformer cores carefully for maximum volume without instability. If some instability is evident on peaking these transformers, it is probably an indication that the particular OC45's used are not being completely neutralised and, in this case, it may be necessary to replace C12 or C13 with slightly higher or lower values. If a signal generator is available, set the cores to 455 kHz initially, then stagger-tune the first and last ones slightly to increase band-width.

Assuming no signals are heard on rotating the tuning capacitor, but slight hiss is audible (indicating that the a.f. section, at least, is functioning), try moving the aerial coil towards one end of the ferrite rod, at the same time tuning slowly over the dial. Next, turn the oscillator core first inwards then outwards about half a turn, repeating these operations. If the set still appears to be dead it is probable that either a faulty connection or component is to blame, and it will be necessary to carry out a systematic check, preferably with a multi-meter and signal generator. As a general guide, the approximate values of voltage at the transistor electrodes, as measured with a Model 8 Avometer, are given in the accompanying Table.

Once the receiver is operational and the i.f. section aligned, the aerial and oscillator sections must be set to track correctly over the full tuning range. It is helpful, when making these adjustments, to appreciate the effects which each alteration will have on the tuning. Ideally, the aerial coil must tune from 1500 kHz to 550 kHz while the oscillator simultaneously covers from 1955 to 1005 kHz, maintaining a constant i.f. difference over the full medium wave range. It should be relatively easy to set the oscillator core and the ferrite rod coil to bring in a station at the high frequency end of the band, with maximum volume, but adjustments may now be required to the ferrite coil as the tuning is rotated towards the low frequency end. *Decide, first of all, in which direction this coil has to be moved* to obtain maximum sensitivity as the frequency is decreased with the tuning capacitor. If the coil has to be pushed further on to the rod, this capacitor is not causing a sufficiently rapid decrease in frequency, and the remedy is to return to a signal at the high frequency end of the band, turn the tuning capacitor compression trimmer for the aerial gang slightly anti-clockwise, and compensate by moving the ferrite coil further on to the rod until volume is restored. Now try a station at the low frequency end and again note if the aerial coil has to be moved. If the aerial coil requires pushing away from the centre of the rod, reverse the above sequence. Repeat these operations until perfect tracking is achieved. Note that the settings of the oscillator core and oscillator trimmer will similarly alter the tracking but, in addition, station position will also be affected, and it may be necessary to adjust these two trimming elements first of all until correct station position, combined with full band coverage, is obtained.

Once the alignment has been completed, the receiver can be mounted inside its cabinet and a suitably marked dial glued in position. The set is then complete and ready for use.

TABLE

Voltages to positive line, as measured with Avometer No. 8, on 10 and 2.5 volt ranges, as applicable. (No-signal conditions and 9 volt supply applied to receiver.)

Transistor	Base	Emitter	Collector
TR1	1.35V	1.3V	7.2V
TR2	0.7V	0.6V	7.2V
TR3	1.0V	0.85V	7.2V
TR4	0.8V	0.7V	8.4V
TR5	0.25V	0.05V	8.6V
TR6	0.25V	0.05V	8.6V

WANSTEAD & WOODFORD RADIO SOCIETY

Would all who are interested in re-establishing the Wanstead and Woodford Radio Society to again be an active group forwarding radio/electronic hobbies in the London E.11/E.18 areas, please contact Ken Smith, G3JIX, at 82 Granville Road, E.17, or at The Electronics Laboratory, The University, Canterbury, Kent.

SIMPLE COLOUR PRINTER

by

A. KYPRIOTIS

The successful printing of colour photographs requires a considerable degree of skill and experience if the resultant prints are to have correct colour balance and density. This article describes an inexpensive electronic device which automatically regulates exposure time for three enlarger filters

AUTOMATIC COLOUR PRINTERS ARE USUALLY EXPENSIVE high-class instruments which are difficult to obtain by the amateur or the small-scale professional photographer. This fact directed the author's efforts in designing a really inexpensive but quite reliable instrument suitable for users in this class.

The colour printing equipment to be described need cost no more than a few pounds, and it gives about 80% acceptable prints from a wide variety of colour negatives of the same make. Its chief disadvantage is low production rate.

DESIGN CONSIDERATIONS

Between additive and substractive methods (Ref. 1) of colour printing, the first was selected because it uses only three filters and therefore requires quite a simple mechanical assembly for filter changing. With this method three separate exposures are made, these being through a 100% blue, green and red filter respectively for a suitable period of time each.

A light-sensitive device is employed to measure the amount of light passed by a specific negative for each filter. A number of light-sensitive devices are available but most are expensive, require high voltages or have to be employed in complicated circuits. However, one light-sensitive device, the light dependent resistor (or photoconductive cell), does not suffer from these disadvantages. It has a high sensitivity to white light, a very low price, and requires no high voltages or complicated circuits. An excellent black and white printer using a light dependent resistor has been described by J. L. Linsey Hood (Ref. 2) and this gave the present author the idea of developing a similar instrument for colour prints. In the black and white printer design, an l.d.r. is used to measure the light scattered from the surface of the printing paper and to control, by way of a simple integrating circuit, the exposure time. The process may be summarised by stating that a starting switch turns on the enlarger lamp and at the same time enables a capacitor to charge via the l.d.r. When the capacitor voltage increases over a certain value it actuates a relay by way of a transistor amplifier circuit, and the relay contacts then switch the enlarger lamp off. Since the resistance of an l.d.r. reduces as the brightness of its illumination increases, it follows that exposure time varies inversely as the average brightness of the image on the printing paper.

Returning to the present design, it has to be pointed out that the use of an l.d.r. as a colour sensing element presents a lot of problems due to its low speed at low light intensities, its low sensitivity to blue and green light, and its temperature dependence. These disadvantages have, however, been compensated to some extent in the design.

Low speed has been compensated for by sacrificing full automation and by making the instrument operational in two steps. First, ordinary white paper is inserted on the easel in place of the printing paper and, with the negative in place, the light value for each filter colour is "memorised" by setting up a separate variable resistor to balance a bridge incorporating the l.d.r. The variable resistors are next switched to a timer circuit and the printing paper is fitted. The timer circuit is then activated so that the enlarger lamp is lit for a period controlled by the variable resistor setting for each filter.

Of course, this procedure slows down production rate and this is the main disadvantage of the instrument.

The low sensitivity to blue and green light has been taken up by choosing suitable component values for the measuring circuits corresponding to to the appropriate filters. These component values were selected after examining the performance of an l.d.r. under real printing conditions, the results being given in the accompanying table. The measure-

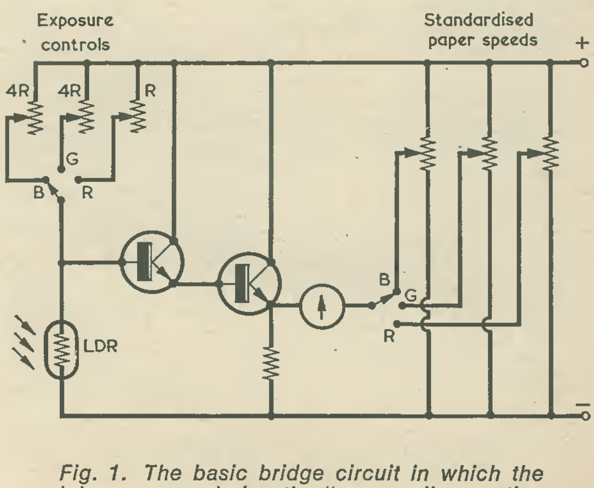


Fig. 1. The basic bridge circuit in which the l.d.r. appears during the "measure" operation

ments shown in the table were made with reflected light from a square white surface measuring 9 by 9 cm. The l.d.r. was placed at a distance of about 15 cm. from the surface. The light was integrated by a lens of 8 mm. diameter and 3 mm. focal length and focussed on a 4 by 4 mm. area of the l.d.r. The l.d.r. resistance values shown are mean values for a number of negatives considered as representative of their class. The l.d.r. was a Philips LDR03 (Ref. 3)[1]. It should be mentioned that the filters referred to in the table are not exactly the correct ones. The recomended ones are Kodak Wratten No. 70 Red, No. 99 Green and No. 98 Blue, or Agfa No. 45 Red, No. 54L Green and No. 552 Blue.

Temperature stabilisation for the l.d.r. was achieved by mounting it on a large piece of brass and ensuring that only low voltages were applied to it.

negatives, sufficient control will be provided by the three lower value variable resistors, R3, R4 and R5. R6, R7 and R8 are useful when dealing with negatives which deviate considerable from the average. The two transistors of Fig. 1 are shown as TR1 and TR2, and the three paper speed potentiometers as R14, R16 and R18. The meter is the centre-zero component M1, this being protected against excessive current by the two diodes D1 and D2 connected across it.

S2(a) to S2(e) constitute the colour selection switch, and it will be seen that section S2(e) connects to three solenoids. These solenoids actuate the filters in the manner shown in Fig. 3. The assembly of Fig. 3 is positioned 2 to 3 cm. below the enlarger lens system.

The supply to the main part of the circuit is stabilised at 18 volts by the zener diodes D3 and

TABLE
L.D.R. Resistance
L.D.R. : Philips LDR03.
Enlarger lamp : Philips Photocrescenta 150W.
Filters : Gevaert Red L 599, Green U 525, Blue U 438.

Filter	Without negative (kΩ)	Normal negative (kΩ)	Very dense negative (kΩ)	Maximum variation (kΩ)
Red	50	250	400	350
Green	200	1,000	1,500	1,300
Blue	300	1,200	1,700	1,400

CIRCUIT DESCRIPTION

Three bridge circuits are used for red, green and blue, these appearing in the basic form illustrated in Fig. 1. Since l.d.r. sensitivity for blue and green is lower than it is for red, the variable resistors in the l.d.r. side of the bridge for these two colours have four times the value of that employed for red. This simple arrangement proved quite satisfactory for compensation of l.d.r. and enlarger lamp spectral response inequalities. Variations in the brightness of a single colour are easily detected, particularly if the paper speed controls are adjusted near their centre positions. These controls are given by the three potentiometers on the right, and these are set up to accommodate the speed of the printing paper employed. Because the current in the l.d.r. section of the bridge is low, this arm of the bridge is coupled to the meter by two transistor emitter followers in cascade. (The two emitter followers also provide the required base current for the relay switching transistor, this being the main reason for their presence in the circuit.)

The full circuit diagram appears in Fig. 2. The timer section is similar to that described by J. L. Linsey Hood but has been somewhat simplified by the omission of a transistor, this being possible owing to the use of a relay which needed only 4mA to energise and because the l.d.r. used here is more sensitive.

The three variable resistors shown at the left of Fig. 1 appear in Fig. 2 as R3 to R8. For many

1 The LDR03 is available from Henry's Radio, Ltd. An equivalent is the ORP12.—Editor.

D4. These diodes also ensure that the emitter of TR3 is maintained at 8 volts positive of the lower supply rail. The relay coil A/1 appears in the collector circuit of TR3. Its contact set A1 controls the enlarger lamp and it should be noted that this contact set is closed when the relay is de-energised.

Switch S1(a) to S1(c) controls the two modes of the equipment. The setting "M" stands for "Measure" and the setting "E" for "Exposure". S4 is a s.p.d.t. push-button, whilst S3 switches the filter solenoids on and off. S3 is normally switched off when preliminary adjustments in the enlarger, such as positioning of the negative, etc., are being carried out.

The equipment is operated, with a typical negative, in the following manner. Without printing paper fitted, S3 is switched off and the negative set up. S1 should be in position "M" and S2 in position "R" (or "B" if it is intended to start in the sequence blue – green – red). S3 is next switched on, whereupon the red filter is selected by S2(e). S2(a) switches in variable resistors R5 and R8, and these are set up to give a zero reading in the meter. S2 is next switched to "G" and R4 and R7 similarly adjusted. S2 is finally set to "B", whereupon R3 and R6 are set up. The three sets of variable resistors now hold the required information concerning the brightness of the negative at the three filter colours.

S1 is now set to "E", causing the arm of S2(a) to connect to C1 via S4 and S2(b). However, C1 has already been fully charged to the 18 volt supply by way of R11, and so the arm of S2(a) also takes up this potential. The potential is also applied, by way of emitter followers TR1 and TR2, and S1(c),

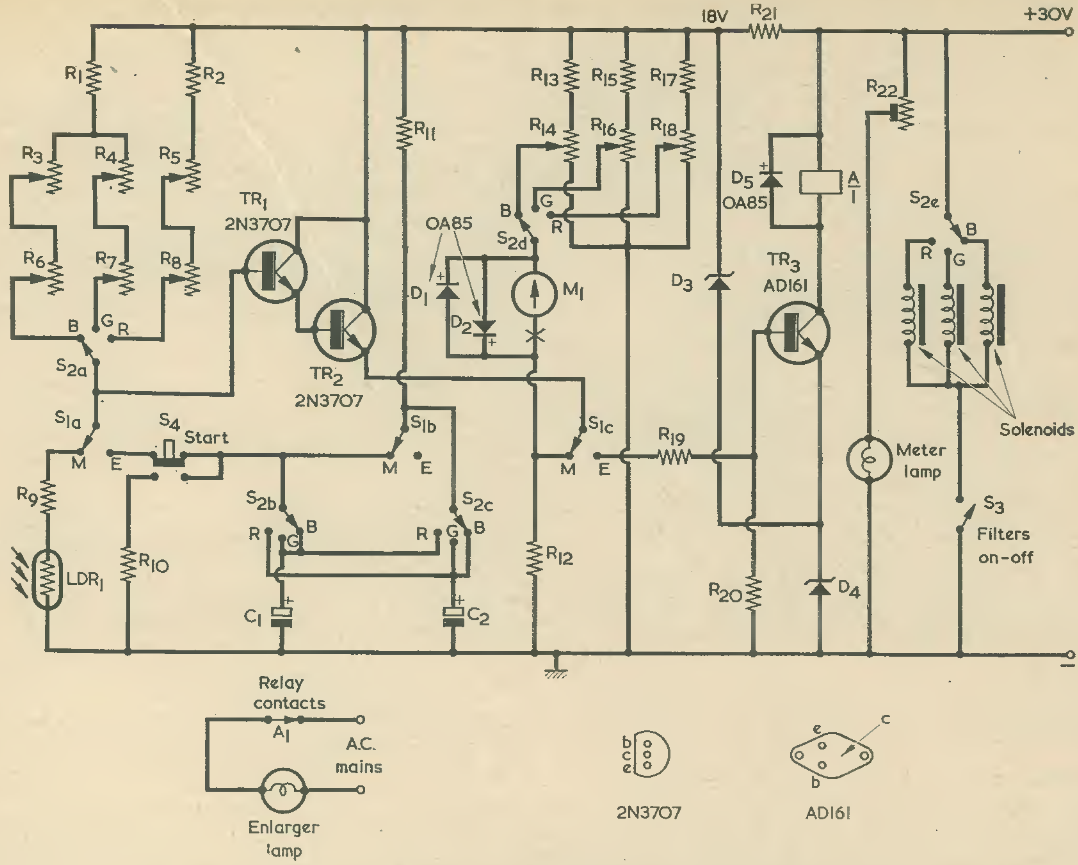


Fig. 2. Complete circuit of the automatic colour printer equipment

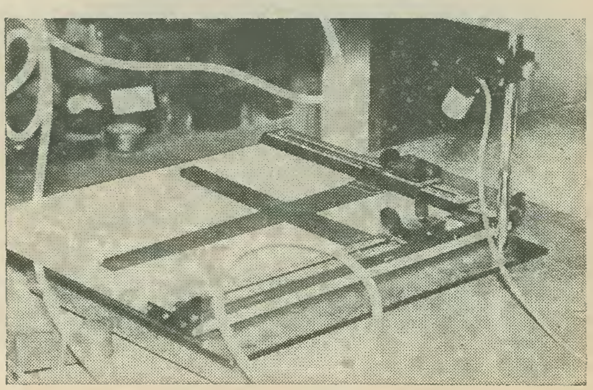
to R19. In consequence, TR3 conducts. The relay energises and its contacts open, extinguishing the enlarger lamp. The printing paper is now fitted.

The Start button S4 is next pressed, whereupon it discharges C1 via R10. When the button is released it applies the discharged capacitor to the arm of S2(a), whose potential drops to zero. So also does the potential applied to the base of TR3, whereupon this transistor becomes non-conductive and the relay de-energises. The relay contacts close and the enlarger lamp is switched on.

As soon as the Start button was released, C1 commenced to charge via the variable resistors selected by S2(a). The potential at the arm of S2(a) goes positive, as also does that at the base of TR3. When this potential exceeds that on its emitter by a sufficient amount, TR3 conducts, energises the relay and turns off the enlarger lamp.

S2 is next to "G" and the Start button pressed again, whereupon the process is repeated once more. S2 is set to "R" and the Start button finally pressed, allowing the timing action to occur once more. This time, however, the timing capacitor is C2 instead of C1. The exposures are now all complete, the length of each having depended on the settings given to variable resistors R3 to R8 during the "Measure" operation.

Some further points need to be discussed. C2 is switched in when S2(b) selects "R" because the variable resistors in the red l.d.r. bridge arm have a quarter of the value of those in the green and blue arms. Since C2 has four times the capacitance of C1 the same range of time constants is available. In practice, the maximum exposure time for each colour is about 10 seconds. It is necessary for both C1 and C2 to be maintained in the charged condition whilst S1 is in the "M" position as, otherwise, they may cause the relay to de-energise for a short period (and thereby turn on the enlarger lamp)



The measuring head, incorporating the l.d.r., in position ready for use when S1 is set to "E" or when, subsequently, C2 is switched in after C1.

Another point not yet mentioned is concerned with R22. This is connected in series with a meter lamp and is adjusted so that the meter can be read under darkroom conditions without producing excessive light.

PAPER SPEED ADJUSTMENTS

Paper speed adjustments are given by R14, R16 and R18.

Here, a good normal negative with, as far as is possible, equal amounts of red, green and blue in it is necessary. This negative must be kept as a standard for other negatives of the same make. Some trial prints should be made in order to find the right exposure times for every colour of the standard, these exposure times being set up by means of R3 to R8. R14, R16 and R18 are ignored at this stage. When the l.d.r. variable resistors have been correctly adjusted for the standard, S1 is set to "M" and R14, R16 and R18 adjusted in turn for zero indication in the meter.

If it is found that the paper speed controls are not roughly in their central positions, the process is repeated after having increased or decreased the light intensity as necessary by means of the iris of the enlarger lens.

COMPONENTS

Most of the components are standard types. All the variable resistors and potentiometers are panel mounted. If difficulty is experienced in obtaining a suitable push-button for S4, a spring-biased toggle switch may be employed instead.

D3 and D4 have nominal zener voltages of 10 and 8 volts respectively. D3 should be capable of dissipating some 240mW and D4 (according to relay coil resistance) up to about 300mW.[2]

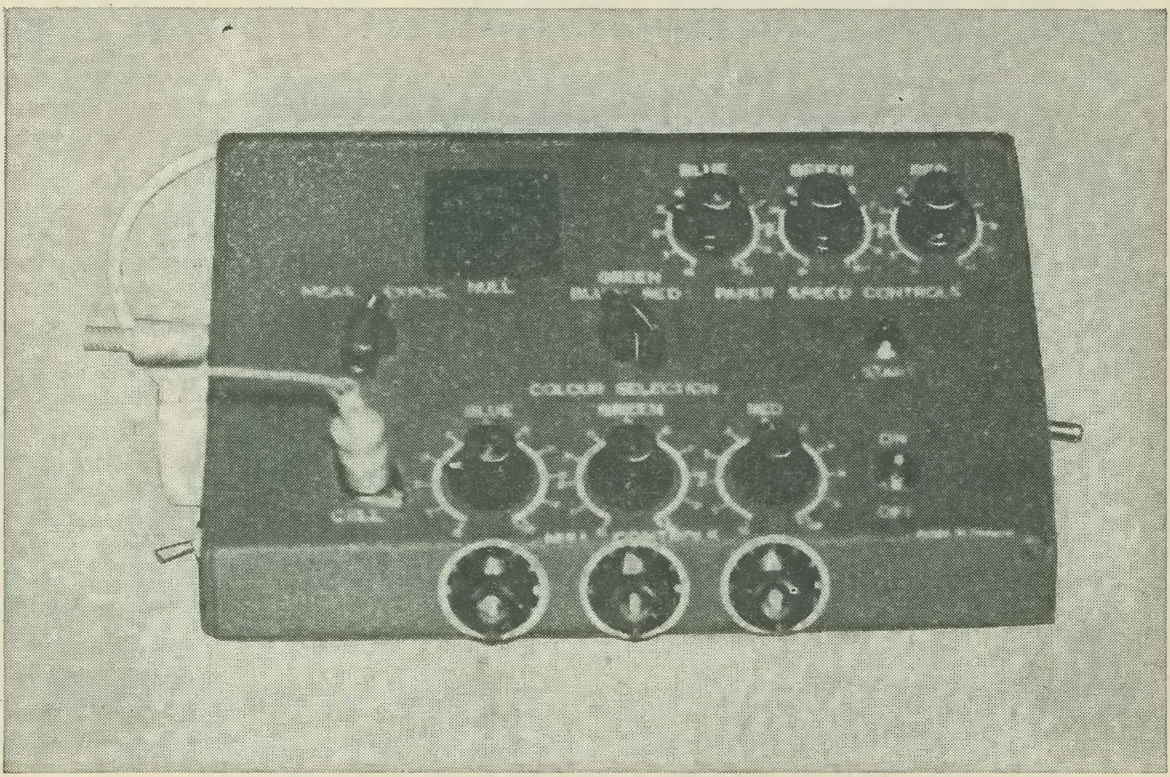
TR1 and TR2 are silicon n.p.n. transistors with a maximum collector voltage rating in excess of 18 volts and an hfe greater than 100. A wide range of transistors can satisfy these requirements, a suitable example being the 2N3707. TR3 may be a germanium transistor capable of meeting the collector voltage and current and reverse base-emitter voltage figures imposed by the circuit, and a suitable type would be the AD161. This is used well within its dissipation figure and does not need to be mounted on a heat sink. Other transistors meeting the general requirements in the circuit could alternatively be employed.

The relay used in the prototype is not generally available but a suitable alternative should not be difficult to obtain. Coil resistance should not be less than 1kΩ.[3]

The meter used in the prototype is a 200-0-200μA centre-zero instrument. If difficulty is experienced

2 Suitable zener diodes, with more than adequate dissipation in hand, are the ZL10 and ZL8 available from Henry's Radio, Ltd.—Editor.

3 A Post Office type 3000 relay with 1,000Ω coil and a single set of high voltage twin platinum break contacts would be satisfactory. Post Office type 3000 relays are available from L. Wilkinson (Croydon) Ltd., Longley House, Longley Road, West Croydon, Surrey.—Editor.



The prototype instrument. The upper three controls are those for paper speed control, and immediately below these are S1, S2 and S4. At the bottom of the sloping panel are a socket for the measuring head, R3, R4, R5 and S3; whilst R6, R7 and R8 are mounted on the front apron

COMPONENTS

Resistors:
(All fixed values ½ watt 5%)

R1	56kΩ
R2	12kΩ
R3	200kΩ potentiometer, linear
R4	200kΩ potentiometer, linear
R5	50kΩ potentiometer, linear
R6	2MΩ potentiometer, linear
R7	2MΩ potentiometer, linear
R8	500kΩ potentiometer, linear
R9	2.7kΩ
R10	100Ω
R11	56kΩ
R12	22kΩ
R13	2.2kΩ
R14	20kΩ potentiometer, linear
R15	2.2kΩ
R16	20kΩ potentiometer, linear
R17	2.2kΩ
R18	20kΩ potentiometer, linear
R19	470Ω
R20	56kΩ
R21	560Ω
R22	Preset potentiometer (see text)

Capacitors:

C1	3μF electrolytic, 25V wkg.
C2	12μF electrolytic, 25V wkg.

Semiconductors:

TR1	2N3707 (see text)
TR2	2N3707 (see text)
TR3	AD161 (see text)
D1	OA85
D2	OA85
D3	10V zener diode (see text)
D4	8V zener diode (see text)
D5	OA85

Meter:

M1	200-0-200μA centre zero meter (see text)

Switches:

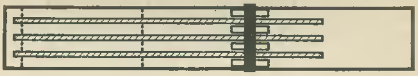
S1	3-pole 2-way, rotary
S2	5-pole 3-way, rotary
S3	s.p.s.t., toggle
S4	s.p.d.t., press button

Photoconductive Cell:

LDR1	Cell type LDR03

Miscellaneous:
Relay with single break contact set (see text)
Meter lamp (see text)
3 solenoids (see text)
Knobs, as required
Hardware for measuring head and filter unit
Plugs and sockets, as required

in obtaining a similar meter, a 100-0-100μA movement may be incorporated instead. With the more sensitive meter it may be necessary to insert a fixed resistor of some 500Ω to 2kΩ at the point marked in Fig. 2 with a cross to ensure that D1 and D2 limit needle movement within f.s.d. The meter is provided with a small lamp and it is left to the constructor to choose a suitable type, to select the required value for R22 and to devise the manner in which the lamp is mounted.



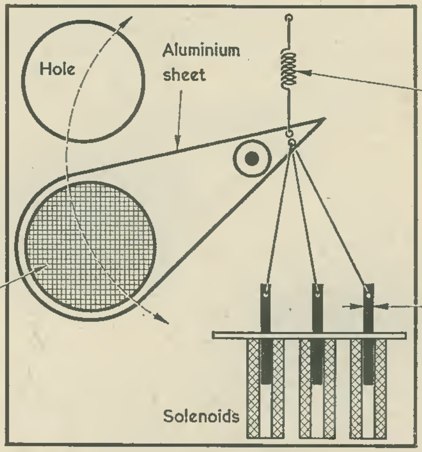
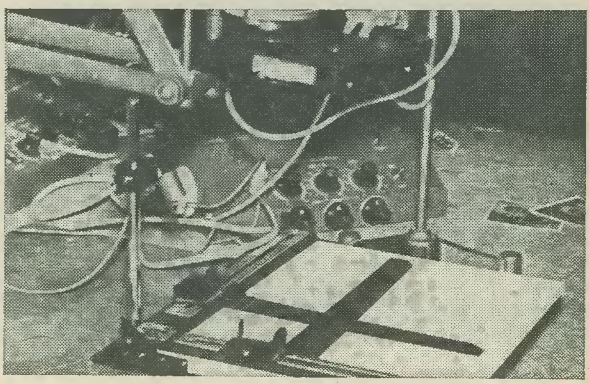


Fig. 3. The filters are selected by solenoids, as shown here

In the filter system shown in Fig. 3, three gelatine filters were fixed to three thin aluminium sheets cut to the shape shown. Each solenoid consists of 6,000 turns of 40 s.w.g. enamelled wire.

The power supply for the equipment should be capable of offering 30 volts d.c. at some 150mA plus the current drawn by the meter lamp.

All the components are fitted in a metal case which *must* be connected to a reliable mains earth. Apart from other reasons this precaution is necessary because the relay contacts switch a mains circuit. Suitable sockets are provided for connection to the l.d.r., the solenoids and the enlarger lamp circuit.



The filter unit of Fig. 3, positioned just below the enlarger lens assembly

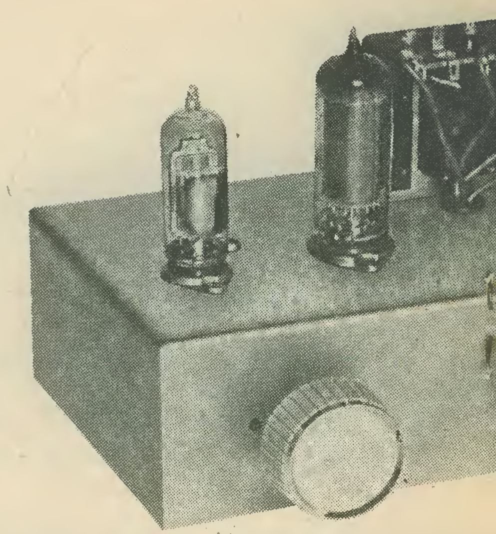
The measuring head incorporating the l.d.r. is shown in one of the accompanying photographs. It is positioned at a distance of about 15 cm. for a 9 by 9 cm. enlargement. The l.d.r. is mounted on a brass block measuring 2 by 2 by 6 cm., this having been suitably machined to take the l.d.r. contour. The lens assembly is that described earlier.

(Continued on page 185)

NEOPHYTE AUDIO AMPLIFIER

by

R. J. CABORN



Designed for ease of assembly, this amp is simple for the beginner to follow an controls are provided, and an unusual negative feedback loop. To assist in diagrams are published in the spec

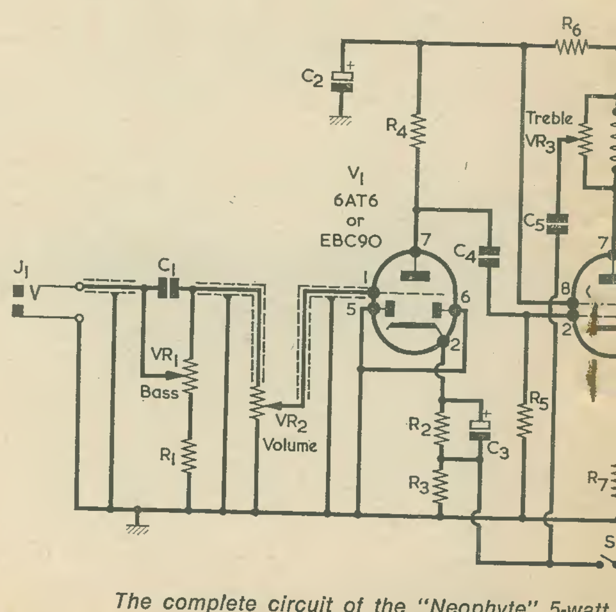
AN A.F. AMPLIFIER IS ALWAYS AN ATTRACTIVE ITEM of equipment as it not only lends itself to domestic entertainment requirements but can also be used for experimental or servicing work in the workshop. Although designed primarily for entertainment purposes, the "Neophyte" amplifier offers many more serious functions as well. An interesting departure from normal practice is the inclusion of a switch in the negative feedback loop. When this switch is opened, the amplifier offers increased gain without, of course, the benefits of distortion reduction which are imparted by feedback. With the negative feedback switch closed, the amplifier is mainly intended for monaural reproduction from a crystal gramophone pick-up. It may also accept inputs of about the same amplitude from radio tuner units and other a.f. signal sources.

It was decided to present the article describing this amplifier in a different manner to the usual form. The reader will find that the drilling and wiring diagrams are published in a special pull-out section in the centre of the magazine. If desired, the constructor may remove these diagrams and keep them directly in front of him on the bench as he proceeds with construction. There is, then, no necessity to turn the pages of the magazine to consult the drawings whilst following instructions contained in the text.

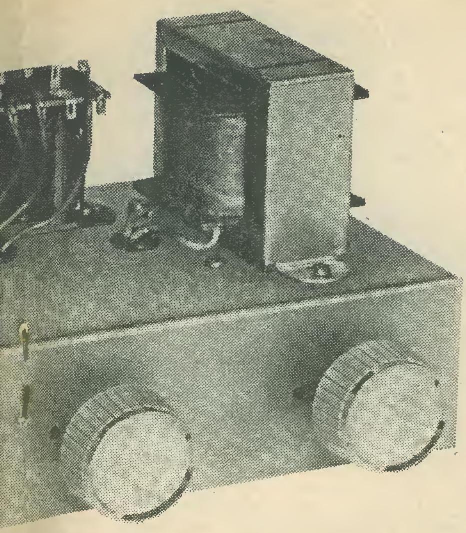
Cover Feature

THE CIRCUIT

The circuit of the amplifier appears in the accompanying diagram. Signal input is applied to jack socket J1 and then passes to the bass tone control network given by C1, VR1 and R1. The bass control network is followed by volume control VR2, the



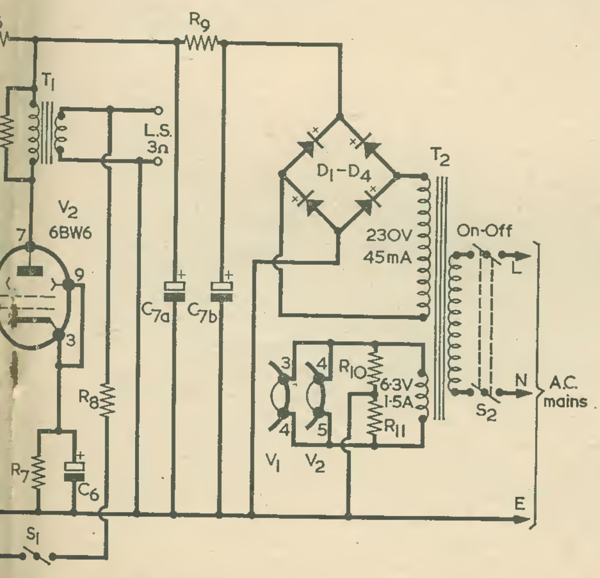
The complete circuit of the "Neophyte" 5-watt by a single contact-coo



mplifier employs a reliable circuit which and understand. Treble and bass tone al feature is the inclusion of a switched in construction, the drilling and wiring ecial removable section of this issue

slider of which couples to the grid of V1 triode. All the input circuitry is at high impedance, and is suitable for the direct connection of a crystal pick-up. The interconnecting wires inside the amplifier are screened in order to suppress mains hum.

V1 is a double diode triode, the two diodes of which are unused and are connected to chassis. The amplified signal at the anode of V1 couples to the control grid of V2 by way of C4 and grid resistor R5. V2 is a beam tetrode type 6BW6. This is the B9A version of the octal 6V6, the latter being a valve which has acquired well-earned popularity over a considerable period because of its ability to provide a low-distortion a.f. signal in non-critical single-valve output stages.



watt amplifier. Rectifiers D1 to D4 are provided -cooled bridge rectifier

The anode signal from the 6BW6 is applied to the primary of output transformer T1, this having a ratio suitable for coupling to a 3Ω loudspeaker. The treble tone control, VR3, is connected across the primary of T1 and its function is to apply a selected proportion of the anode signal to C5, and thence to the cathode of V1. This represents a negative feedback loop, the value of C5 being such that the signal level fed back increases with frequency. Thus, the circuit causes less amplification to be given to the higher audio frequencies, and provides a variable control of treble attenuation.

Another negative feedback connection is taken from the secondary of T1 and applied, via R8 and S1, to the cathode of V1. The addition of S1 is a novel feature in an amplifier of this nature, and it increases the versatility of the design at the cost of only one component, this being the switch itself. If, for any reason, a higher degree of gain is required than would be available with feedback applied, S1 is opened. The amplifier then offers increased gain, but without the reduction in distortion imparted by the feedback. The tone control offered by VR3 is still available when S1 is opened.

The power supply employs a mains transformer offering complete isolation from the mains. An extremely economical combination is provided by the use of a contact-cooled bridge rectifier (D1 to D4) in conjunction with a transformer having a single untapped 230 volt h.t. secondary. The transformer employed does not have a centre-tapped 6.3 volt heater winding and it would be normal practice to have one side of the heater supply circuit connected to chassis. However, due to the facts that V1 grid is at high impedance and that the circuit may be built by newcomers to the hobby, it was decided to provide an effective centre-tap into the heater supply by means of the two equal-valve resistors, R10 and R11, their junction being connected to chassis. This eliminates a possible cause of hum before construction is even commenced and, for the cost of two resistors, the extra precaution was considered worthwhile. In the amplifier, as built, the connections to the heaters of V1 and V2 are carried out with twisted wiring.

COMPONENTS

The components required for the amplifier are specified in the accompanying Components List, and a few words are required concerning some of these.

It will be noted that the electrolytic capacitors have their manufacture and type, or a retail catalogue number, quoted. The reader is strongly advised to obtain the types specified, as alternative components of the same capacitance and rating may prove to be bulkier in size. This point applies in particular to C7AB, which has to fit between two tagstrips.

The output transformer quoted is a type intended for operation at 5 watts, as is available from the 6BW6 in the circuit employed here, and it would be unwise to attempt to use a smaller component. The transformer is listed in the Home Radio range of economically priced output transformers, with manufacturers "as available". In consequence, the tag positioning of the specific transformer obtained by the constructor may vary from that in the transformer used for the prototype. The constructor should initially satisfy himself concerning the tags to which the primary and secondary windings connect: if no other indication is provided, it will usually be found that the secondary leads from the winding to the tags consist of the enamelled wire employed in the winding itself, whilst the primary leads from the winding are p.v.c. covered. Also, the secondary will have a very low resistance, whilst the primary will have a resistance of the order of 300Ω.

The mains transformer should have an indication as to which of its leads connect to the primary (or transformer "input") and which to the 230 volt h.t. secondary. It is usual practice for the h.t. secondary leads to be covered with red insulation. The transformer used in the prototype had no mains primary tappings. Should such tappings be provided, the constructor should select the tap appropriate to the local mains voltage, tape up the remaining primary leads separately and tuck them out of the way in any convenient manner so that there is no risk of their short-circuiting to chassis or to any other component. The 6.3 volt heater winding lead-outs will consist of the enamelled copper wire with which the heater secondary is wound.

The dimensions given in the chassis drilling diagram apply only to the two transformers specified.

The tagstrips quoted are Lektrokit types, these being 5-way with the centre-tag earthed (i.e. the centre tag is used also for mounting the tagstrip to the chassis). The four non-earthy tags have anchoring points at the upper and lower ends, and this fact is of assistance during wiring. The tagstrips are not sold singly, and it is necessary to purchase them in packets of twelve. Thus, some tagstrips will be left over for other projects after the amplifier has been built.

The three controls, VR1, VR2 and VR3/S2, will be supplied with spindles which are probably too long for most requirements. The spindles should be cut to the desired final length with a hacksaw before fitting the controls to the chassis.

A further point is concerned with the fact that a short length of single screened wire is required for connections inside the amplifier. Television aerial coaxial cable *could* be used here, but it is rather bulky for the present purpose. A neater job will result if the constructor uses the much thinner type of screened flexible cable which is intended for a.f. wiring.

The mains lead must be a 3-core type of suitable length, and it should be terminated in a 3-way mains plug with earth connection. It is preferable to use a mains lead having a p.v.c. outer sheath rather than one with a woven fabric covering, since the former is easier to handle. As is described later, a small cable clamp has to be made up to anchor the mains lead inside the chassis.

PREPARING THE CHASSIS

Drilling dimensions for the chassis are given on the first sheet of the pull-out section. The chassis material is 16 s.w.g. aluminium.

The upper drawing shows the view looking down on the top of the chassis. The $\frac{5}{8}$in. and $\frac{3}{4}$in. holes are for the B7G valveholder (V1) and B9A valveholder (V2) respectively. When these holes have been cut out, use the valveholders themselves as templates for marking out the two 6BA clear mounting holes (indicated as "A") required for each valveholder.

The three $\frac{3}{8}$in. holes are intended for rubber or p.v.c. grommets. The drawing indicates, also, the mounting holes which will be used by T1 and T2.

The centre diagram shows the front apron as viewed when looking at the front of the chassis. Three holes for the controls are required here, as indicated. The $\frac{1}{8}$in. holes alongside the bush-mounting holes are intended for the locating lugs of these controls.

The lower diagram illustrates the rear apron as seen when observing the chassis from the rear. Two sets of holes on the rear apron have to be marked out with the aid of the components themselves. First, take up the rectifier obtained for D1-D4, centralise it on the line between X and X[1], then mark out the two 6BA clear holes required for mounting along the central horizontal line. Secondly, initially drill the two $\frac{7}{16}$in. holes at the centre of the rear apron. Then, take up the 2-way terminal board, hold it against the apron in its final position and, ensuring that its internal tags and screws do not short-circuit against the edges of the two $\frac{7}{16}$in. holes, mark out its 4BA clear mounting holes. The $\frac{3}{8}$in. hole in the rear apron is for a grommet, and the remaining two holes for the jack socket and switch S1.

When drilling is complete, clean up the chassis and remove all burrs, etc. Ensure that the locating lugs of the three front panel controls fit comfortably into their $\frac{1}{8}$in. holes. Check, in particular, that there are no burrs or other projections on the holes for D1-D4 which would prevent this component from making good thermal contact to the chassis. No components are mounted at this stage.

WIRING AND ASSEMBLY

The next process consists of wiring and assembly, and the constructor should work from the wiring and layout diagram on the centre sheets of the pull-out section. Here, the front and rear aprons are shown "opened-out" for convenience of illustration. Note that the tags of the tagstrips are numbered 1 to 20 to facilitate identification. The upper anchoring points for the tags (i.e. those furthest away from the chassis) are assumed, in the diagram, to project on the opposite side of the Paxolin strip to the mounting lug. (In practice, both anchoring points are on the same side of the strip.)

In the assembly steps which will next be given, soldering at a particular tag should only be carried out when stated. This avoids the rather undesirable practice of adding a lead to a tag which is already soldered up. All soldered connections must be made with the aid of resin-cored solder, such as is manufactured by Multicore Solders Ltd. On *no* account attempt to use a paste or liquid flux.

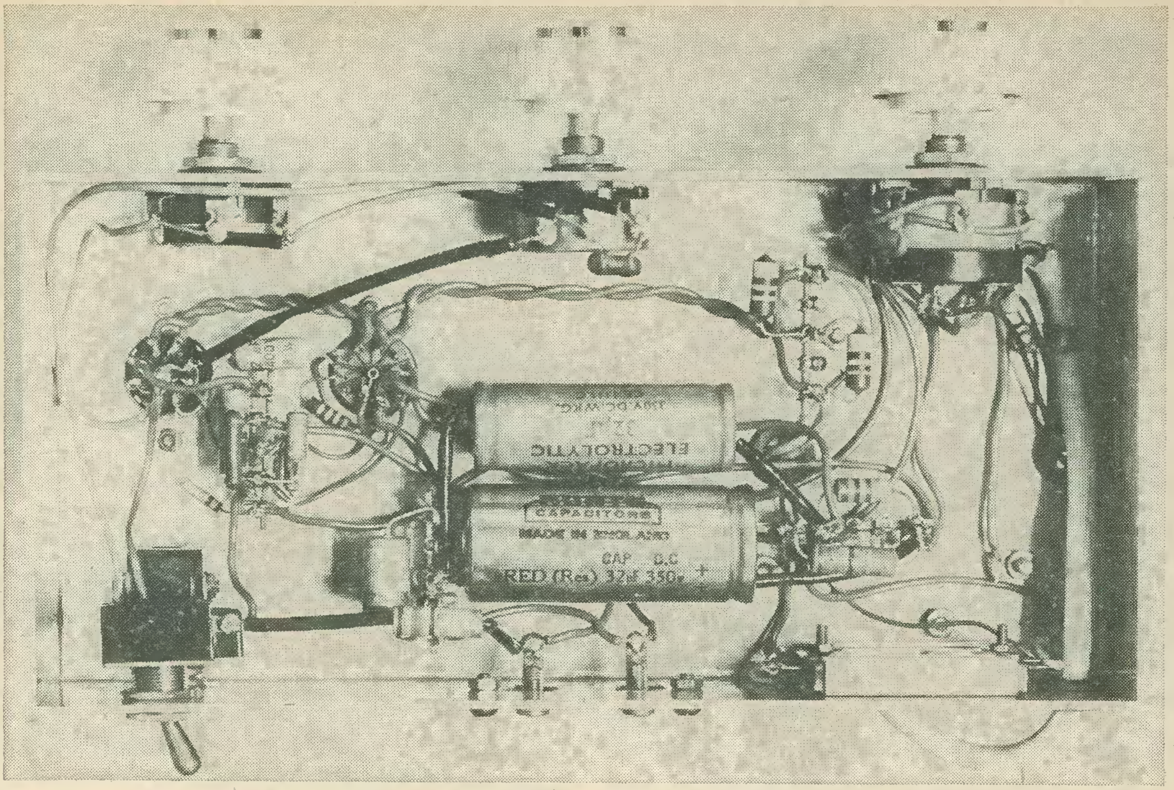


Photo 3. The layout under the chassis. Although compact, there is no crowding of components

1. Mount tagstrips 1-5, 6-10 and 16-20 with 4BA nuts and bolts, so that they take up the positions shown in the wiring digram. Be careful to ensure correct orientation.

2. Mount V1 and V2 valveholders with 6BA nuts and bolts, orientating these so that pins 3 and 4 of V1 valveholder, and pins 4 and 5 of V2 valveholder, are nearest the front apron.

3. Fit all four grommets to the top surface and rear apron.

4. Take up the mains lead and strip back its outer sheath for $3\frac{1}{2}$in. Pass the stripped end through the rear hole intended for it. Fabricate a simple cable clamp from an oddment of metal (quite an adequate clamp may be made by suitably bending a centre lug taken from one of the unused tagstrips) and clamp the cable as illustrated in the diagram, using a 4BA nut and bolt. If there is any risk of the cable sheath chafing against the clamp, wrap p.v.c. insulating tape around it.

5. Fit a 4BA chassis tag, as shown, and solder the earth mains wire (green and yellow striped with the new mains lead coding system) to this.

6. Mount the mains transformer, T2, with 4BA nuts and bolts, fitting plain washers under the bolt heads. The four secondary lead-outs pass through the grommet adjacent to tagstrip 1-5, and the primary lead-outs pass through the grommet over which the mains lead passes. If the primary has voltage taps, deal with these as described earlier.

7. Shortening as necessary, connect the 6.3 volt secondary leads from T2 to tag 1 (lower) and tag 5 (lower). Take care to ensure that the enamel on the transformer leads has been removed and that the copper underneath is properly tinned. Solder at tag 1 (lower) and tag 5 (lower). It does not matter which secondary lead connects to which tag.

8. Using two wires twisted together, connect pins 3 and 4 of V1 to pins 4 and 5 of V2. Again using two wires twisted together, connect pins 4 and 5 of V2 to tag 1 (upper) and tag 5 (upper). Solder the four connections made at V1 and V2.

9. Connect R10 (150Ω) between tag 1 (upper) and tag 3 (upper). Connect R11 (150Ω) between tag 5 (upper) and tag 3 (upper). Solder at tags 1, 3 and 5 (all upper).

10. Fit VR3/S2 to the front apron. With an ohmmeter or any simple continuity tester identify the tags of the switch sections which correspond to the switch poles, as the tag positions with some switches may differ from those shown in the diagram.

11. Shortening as necessary, connect the line and neutral wires from the mains lead to one side each of the two switch poles. (With the new coding system, brown is live and blue is neutral). Shortening as necessary, connect the two primary leads of the mains transformer to the other sides of the two switch poles. It does not matter which primary lead connects to which switch pole. Solder all four connections at S2.

12. Mount the rectifier D1 to D4, with its flat side against the chassis inside surface, using $\frac{3}{8}$in. 6BA bolts and fitting shakeproof washers both under the

bolt heads and under the nuts. The rectifier lugs should take up the positions shown in the diagram.

13. Shortening as necessary, connect the 230 volt h.t. secondary leads from T2 to the two a.c. tags (marked with a "sine wave") of the rectifier. Solder these two connections. It may be found convenient to pull a few inches of the mains lead inside the chassis and keep it out of the way whilst soldering the tag adjacent to it. It does not matter which secondary lead connects to which rectifier tag.

14. Connect a wire between the negative tag (marked −) of the rectifier and tag 8 (upper). Connect a wire between the positive tag (marked +) of the rectifier and tag 10 (lower). Solder all these four connections.

15. Connect R6 (2.2kΩ) between tag 9 (upper) and tag 6 (upper). Connect R9 (270Ω 2 watts) between tag 10 (upper) and tag 6 (upper).

16. Connect R4 (220kΩ) between pin 7 of V1 and tag 20 (lower). Connect a wire between tag 20 (lower) and tag 9 (lower). Solder at tag 20 (lower) and tag 9 (lower).

17. Connect C4 (0.02μF) between pin 7 of V1 and pin 2 of V2, so that it takes up the position shown in the wiring diagram. Similarly connect R5 (680kΩ) between pin 2 of V2 and V2 centre spigot. Connect a wire between V2 centre spigot and tag 18 (upper). Solder at pin 7 of V1, pin 2 of V2 and V2 centre spigot.

18. In this step and step 20, the components C3, C5, R2 and R3 are wired into circuit. For illustration these are shown further away from tagstrip 16-20 than they need be. The constructor should wire these components so that they are neatly parallel with the strip and close to it. Connect C5 (0.0022μF) between tag 17 (upper) and tag 19 (upper). Connect R3 (270Ω ½ watt) between tag 18 (upper) and tag 19 (upper). Connect a wire between V1 centre spigot and tag 18 (upper). Solder at tag 17 (upper) and tag 18 (upper).

19. Connect a wire between tag 17 (lower) and the centre tag of VR3, the wire following the route shown in the diagram. Solder both these connections.

20. Connect R2 (2.7kΩ) between tag 19 (lower) and tag 16 (lower). Connect C3 (25μF) between tag 19 (lower) and tag 16 (lower) with its positive end to tag 16. Solder at tag 19 (lower) and tag 16 (lower).

21. Connect a wire between pin 2 of V1 and tag 16 (upper). Solder both connections.

22. Using bare tinned copper wire, connect V1 centre spigot to pin 6 of V1 and thence to pin 5 of V1. Solder at pin 6 only.

23. Connect a wire between tag 20 (upper) and pin 8 of V2. Solder both these connections.

24. Connect a wire between pin 7 of V2 and the right hand tag of VR3 (see diagram). Solder at the tag of VR3.

25. Mount the output transformer T1 with 4BA nuts and bolts, so that its tags point inwards. Fit plain washers under the screw heads. This operation also incurs fitting tagstrip 11-15, which is secured under one of the mountings nuts for T1. Note the required orientation in tagstrip 11-15.

26. Connect together pin 3 of V2 and pin 9 of V2. (The wire used here should be normal insulated connecting wire and not bare, as was used for the inter-pin connections at V1). Connect a wire between pin 9 of V2 and tag 11 (lower). Solder at pins 3 and 9 of V2 and at tag 11 (lower).

27. Connect a wire between tag 13 (upper) and tag 15 (lower).

28. Connect R7 (270Ω 2 watts) between tag 11 (upper) and tag 15 (upper). Connect C6 (50μF) between tag 11 (upper) and tag 15 (upper), with its positive end to tag 11. C6 may be mounted above R7, and not alongside as is shown, for purposes of illustration, in the diagram. Solder at tag 11 (upper) and tag 15 (upper).

29. Connect a wire between tag 6 (lower) and the left hand tag (see diagram) of VR3. Connect a wire between tag 6 (lower) and one primary tag (it does not matter which) of T1. This wire passes through the grommet adjacent to T1. Solder at the VR3 tag, at tag 6 (lower) and the T1 primary tag.

30. Connect a wire between the remaining primary tag of T1 and pin 7 of V2, passing it through the grommet. Solder at the T1 primary tag and at pin 7 of V2.

31. Mount the 2-way terminal board, using 4BA nuts and bolts.

32. Connect a wire between one tag of the terminal board and one secondary tag of T1 (it does not matter which). Connect a wire between the remaining tag of the terminal board and the remaining secondary tag of T1. Both wires pass through the grommet. Make *temporary* solder joints at the secondary tags of T1 as it may be necessary to transpose these two connections later.

33. Connect a wire between the right hand tag of the terminal board (see diagram) and tag 15 (lower). Solder at the terminal board tag and at tag 15 (lower).

34. Mount jack socket J1, with its tags projecting away from the underside of the chassis.

35. Connect a wire between the centre spigot of V1 and the tag of J1 which connects to the jack plug sleeve contact.

36. Take up the screened wire and connect one end to the tags of jack socket J1. The braiding connects to the jack plug sleeve contact and the centre conductor to the jack plug tip contact. Solder at both tags of the jack socket.

37. Mount VR2 and VR1.

38. Run the screened wire fitted in Step 36 over the route shown in the diagram and connect its centre conductor to the centre tag of VR1. No connection is made to the braiding at this end. To reduce the risk of short-circuits to whatever braiding may be exposed, it is of advantage to fit a short length of suitable sleeving over the end of the screened wire.

39. Connect the centre conductor of a further length of screened wire to the right hand tag of VR1 (see diagram). Again, no connection is made to the braiding, and, again, a short length of sleeving is advisable.

40. Connect C1 (300pF) between the centre and right hand tags of VR1. The body of this capacitor should be close to these two tags. Solder at the two tags of VR1.

41. Terminate the other end of the screened wire fitted in Step 39 so that its centre conductor connects to the right hand tag (see diagram) of VR2 and its braiding connects to the left hand tag of VR2. Fit sleeving over the braiding between the screened lead end and the left hand tag of VR2. Solder at the right hand tag of VR2.

42. Connect a further length of screened wire to

COMPONENTS

Resistors
(All fixed values ½ watt 10% unless otherwise stated)

R1	1MΩ
R2	2.7kΩ
R3	270Ω
R4	220kΩ
R5	680kΩ
R6	2.2kΩ
R7	270Ω 2 watts
R8	2.7kΩ
R9	270Ω 2 watts
R10	150Ω 5%
R11	150Ω 5%
VR1	2MΩ potentiometer, linear
VR2	1MΩ potentiometer, log
VR3	50kΩ potentiometer, linear, with S2

Capacitors

C1	300μF, ceramic or silver-mica
C2	32μF, electrolytic, 350V wkg., T.C.C. type No. CE111LC (Home Radio Cat. No. 2CK25)
C3	25μF, electrolytic, 6.4V Max., Mullard miniature
C4	0.02μF, paper or plastic foil, 350V wkg.
C5	0.0022μF, paper or plastic foil, 500V wkg.
C6	50μF, electrolytic, 25V Max., Mullard miniature
C7A,B	32 + 32μF, electrolytic, 350V wkg., Hunts wire-ended (Home Radio Cat. No. 2DJ22)

Transformers

T1	Output transformer, 5000Ω to 3.75Ω, 5 watts. (Home Radio Cat. No. TO44)
T2	Mains transformer, secondaries 230V 45mA and 6.3V 1.5A. Osmabet (Home Radio Cat. No. TM26A)

Valves

V1	6AT6 or EBC90
V2	6BW6

Rectifier

D1 - D4	Contact cooled bridge rectifier, 250V 75mA

Switch

S1	s.p.s.t. toggle
S2	d.p.s.t. part of VR3

Jack Socket

J1	Jack socket, Igranic type P71 (Home Radio Cat. No. JH5)

Valveholders

1 B7G moulded valveholder with centre spigot
1 B9A moulded valveholder with centre spigot

Chassis

9 x 4½ x 2 in., 16 s.w.g. aluminium chassis (H. L. Smith & Co. Ltd.)

Miscellaneous

4 5-way tagstrips, Lektrokit Part No. LK-2231 (Home Radio Cat. No. LK-2231)
1 2-way terminal board with captive screws (Home Radio Cat. No. Z101D)
3 knobs, 1¼ in. diameter (H. L. Smith & Co. Ltd.)
4 grommets, to fit ⅜ in. holes
2 ft. single screened wire
3-core mains lead
1 4BA solder tag
1 cable clamp (home constructed)
11 4BA bolts, cheese or round head, ⅜ in.
11 4BA nuts
4 4BA plain washers
4 6BA bolts, cheese or round head, ¼ in.
2 6BA bolts, cheese or round head, ⅜ in.
6 6BA nuts
4 6BA shakeproof washers
Connecting wire, sleeving, etc.

VR2, with its centre conductor to VR2 centre tag and its braiding to VR2 left hand tag. Solder at the centre and left hand tags of VR2.

43. Following the route shown in the diagram, terminate this third screened wire at V1 valveholder, with the centre conductor connected to pin 1 of V1 and the braiding to V1 centre spigot. Solder at pin 1 of V1 and VI centre spigot.

44. The next component to fit is R1 (1MΩ), and it is important that its body be positioned close to the tag of VR1 to which it connects. This necessitates extending one of its lead-outs by soldering a further length of tinned copper wire to it. After extending the lead-out, connect the short wire end of R1 to the left hand tag of VR1 (see diagram) so that the body is close to the tag. Covering with sleeving as required, connect the extended end of R1 to pin 5 of V1. Solder at the left hand tag of VR1 and pin 5 of V1.

45. The main wiring is now complete and the constructor should next turn to the final wiring diagram given on the fourth sheet of the pull-out section. First fit switch S1. If this has a metal case, ensure that there is no risk of this case short-circuiting to the jack socket connection. There will be more than adequate clearance if a normal switch is used.

46. Connect a wire between the lower tag of S1 and tag 19 (upper). Solder at both connections.

47. Fitting sleeving over its lead-outs, connect R8 (2.7kΩ) between the left hand tag of the terminal

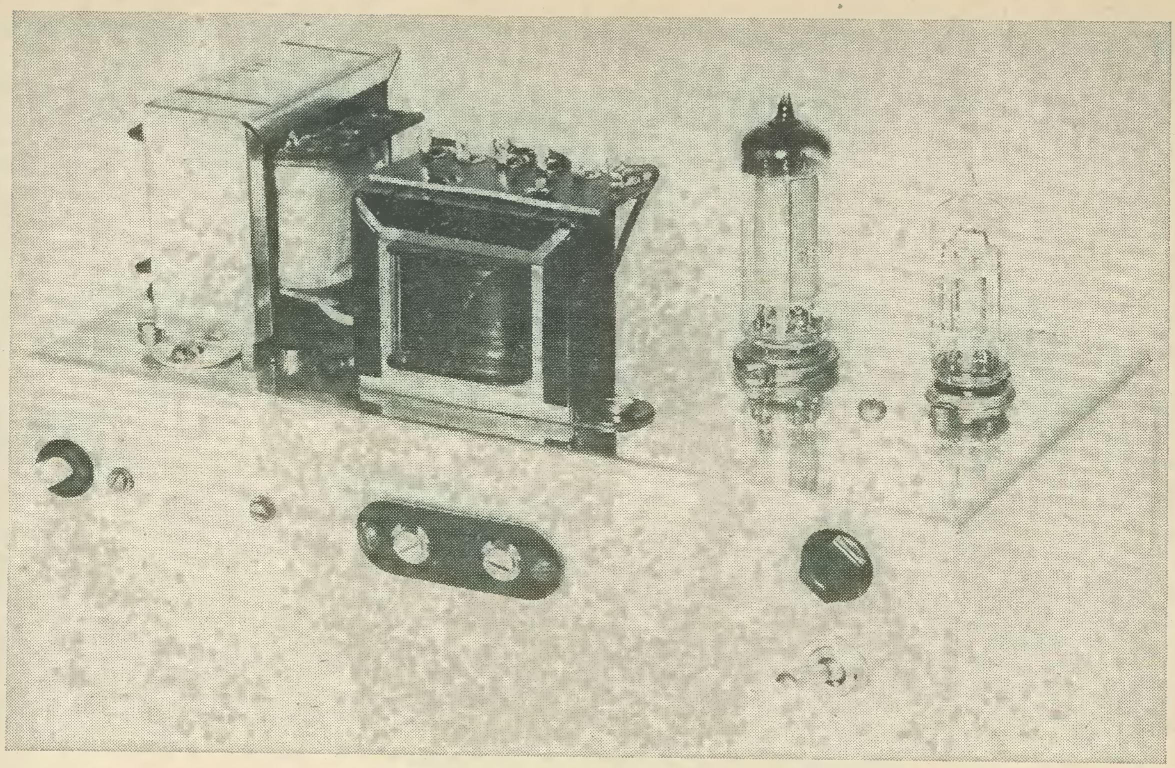


Photo 2. Rear view of the amplifier, illustrating the 2-way terminal board, switch S1 and the input jack socket

board and the remaining tag of S1. Solder at both connections.

48. Position C7AB (32 + 32μF) so that its red and yellow lead-outs take up the positions shown in the diagram, then connect the red positive lead-out to tag 10 (upper). Connect the common negative lead-out to tag 13 (upper) and, fitting sleeving over this last lead, the yellow positive lead-out to tag 6 (upper). Solder at tag 10 (upper) and tag 6 (upper).

49. Following the layout shown in the diagram, and fitting sleeving over both its lead-outs, connect the negative lead-out of C2 (32μF) to tag 13 (upper) and its positive lead-out to tag 9 (upper). Solder at both tags.

50. Fit knobs to VR1, VR2 and VR3. Insert the two valves.

51. Fit a suitable mains plug to the 3-way mains lead, taking care to ensure that the earth wire connecting to the amplifier chassis connects also to the earth pin of the plug.

TESTING

The assembly of the amplifier is now complete and it has next to be tested.

Two points have now to be mentioned so far as testing and subsequent use are concerned. First, the amplifier should not be operated without a speaker connected to it. This is because excessively high a.f. voltages may appear in the anode circuit of V2 if there is no load across the secondary of T1 and, if switch S1 happens to be open. Second, some form of supporting block should be used at the V1 end of the chassis if this is inverted on the bench. Without such a support the chassis will rest on the top of V2, with consequent risk of damage to this valve.

The first step in testing is to visually check all wiring for poor joints, short-circuits between tags and any other obvious faults. Remove any excess blobs of solder which may have fallen into the chassis. If an ohmmeter is available check the resistance between the h.t. positive supply and chassis by connecting the meter between chassis and tags 10, 9 and 6 successively. The resistance should be well above 20kΩ, the meter needle giving an initial kick due to the h.t. electrolytic capacitors charging.

The next task is to check whether the negative feedback is in correct phase. Connect a loudspeaker to the terminal board, close S1 and plug the amplifier supply lead into the mains. Switch on by means of VR3/S2, maintaining a grip on its control knob. If, as the valves achieve emitting temperature a howl or similar oscillation becomes audible from the speaker, switch off *immediately*. Reverse the connections at T2 secondary and switch on again. This time there should be no oscillation, indicating that the feedback is truly negative. When satisfied that the connections at T2 secondary tags are correct, they should be soldered up permanently.

The amplifier may now be checked finally with a suitable signal source such as a crystal pick-up. It should be found that all the controls work satisfactorily and that gain increases when S2 is opened.

Some final operating points need to be dealt with. With S2 closed there should be, at worst, a very low hum level with no input and VR2 at maximum setting. Hum level in the prototype under these conditions was negligibly low. The tags of VR1 and VR2 are very prone to capacitive hum pick-up and care should be taken to keep mains wiring away from these circuit points. Some potentiometers on the home-constructor market have metal covers which are not, by reason of the potentiometer construction, automatically connected to chassis by way of the mounting bush. The use of such potentiometers for V1 or V2 may cause the appearance of hum. If a potentiometer of this type is employed for VR2, the metal cover may, if necessary, be earthed by connecting it via a short bare wire to the left hand tag (see the wiring diagram) of this component. If a similar potentiometer is used for VR1, earth its cover to the cover of VR2 by means of a short insulated wire.

Input signals must, of course, be applied by way of screened wire. *Never attempt to obtain an input signal from an item of equipment whose chassis is connected to one side of the mains.*

It should be remembered that the primary tags of the speaker transformer above the chassis are at h.t. positive potential. If there is a risk of these tags being touched when the amplifier is in use, the amplifier should be housed in a suitable cabinet. Ventilation is required at the rear of such a cabinet for the heat dissipated by V2 and the rear chassis apron area in contact with D1-D4.

It is recommended that a speaker of some 8 in. diameter be used with the amplifier, this being housed in a large cabinet to ensure a good bass response. Very small speakers should be avoided. Such speakers may even be damaged if the full output of the amplifier is fed to them.

The assembly and operating instructions are now concluded. The "Neophyte" 5-watt a.f. amplifier is complete and ready for use. ■

HOME RADIO — CREDIT ACCOUNT SCHEME

Home Radio (Components) Ltd., 240 London Road, Mitcham, Surrey, CR4 3HD., now have a credit account scheme which, in effect, brings 8,000 components as far away from the customer as the nearest telephone. Some of the advantages are:–

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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.

Ferguson Transistor Receiver 'Flight 3132'. — I. Millar, 23 Fouracres, Brimsdown, Enfield, Middx. — loan or purchase of circuit diagram.

Wavemeter Class D No. 2.—R. J. Pratt, 61 Avonmead, Greenmeadow, Swindon, Wilts — loan or purchase of circuit or manual.

Philips Mitcham Instrument Type GM3152-15.—G. Wade, Knowle Orchard, Churchill, Nr. Bristol—any information.

Signal Generator Type 106.—R. Mohamed, 368 Attercliff Common, Carbrooke, Sheffield 9—loan or purchase of charts, operating instructions or any other information.

36 Set P.S. Unit.—G. Corris, 43 Brookside Crescent, Upton, Wirral, Cheshire—Mk. I unit, Cat. No. ZA11688, Serial No. RGD167. Also R.F. Unit Mk. I, Cat. No. ZA11689, Serial No. BD1482. Circuits diagrams or any other data.

Oscilloscope No. 11.—E. E. Ogilvie, 88 Haslemere Road, Thornton Heath, Surrey, CR4 7BE—purchase of manual, handbook or circuit for the Oscilloscope No. 11 A. A. Predictor Mk. I O.S. 1879 G.A. Reg. No. ACL564.

NEW LIFE FOR "MIDGET RECEIVERS"

by

PAUL DEWHURST

A phenomenon of the early post-war years was the appearance of a large number of commercially manufactured t.r.f. medium and long wave receivers. These sets are capable, after modification, of providing a good performance even in today's crowded broadcast bands, and our contributor describes his experiences in this direction. Of particular interest is the use of an infinite impedance detector in the modified receiver. The final circuit described here can also, of course, be made up as a home-constructed receiver in its own right

The writer was recently presented with an old receiver, made during the early 1950's and of the type then known as "midget", with a request that he make it suitable for reasonable interference-free good-quality reception of the B.B.C. a.m. programmes, as far as this was possible with present-day crowding on the medium wave band. It was also asked that the set be made capable of operating with only a few feet of wire as aerial.

ORIGINAL DESIGN

The set in question was a four-valve t.r.f. consisting of a 12K7GT r.f. amplifier, a 12J7GT leaky-grid detector, a 35L6GT output valve, and a 35Z4GT rectifier. The heaters were run in series with a line-cord across the mains, and naturally there was no isolation from the mains, meaning that the chassis could under certain conditions become live. The set tuned medium and long waves, and the aerial consisted of 25 feet of plastic covered wire which resonated the primary coil of the aerial transformer at the low-frequency end of the medium waveband, so as to increase the sensitivity of the receiver at the higher wavelengths.

The set was tried out, and sensitivity was more than adequate, reception of some of the more powerful Continental stations being possible during daylight. The quality and selectivity, however, left much to be desired.

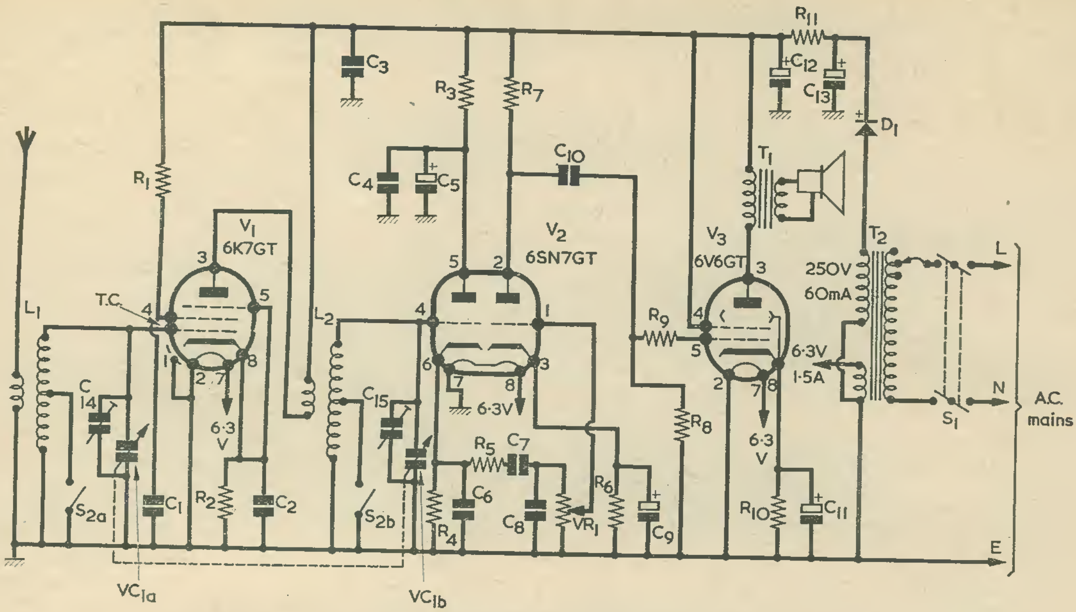
The quality was poor because the grid detector fed the output valve. This detector had to be operated at too high an input to give reasonable quality, since it had to ensure that there was enough a.f. signal for the final valve. A grid detector is only capable of giving reasonable quality when operated at a low level, and it overloads very easily. At the same time, the selectivity was poor because the grid detector damped its tuned circuit excessively. The lack of selectivity was not quite so bad at full volume, for the volume control was of the r.f. variety and was so arranged that the r.f. valve almost went into oscillation at the full volume setting. As the volume setting was decreased, on the other hand, not only was there less gain from the r.f. valve, but also the primary of the aerial transformer was gradually short-circuited to chassis. Thus, as the volume control was turned down the selectivity became worse, so that if one were listening to a fairly powerful station with another fairly powerful one adjacent, interference could only be avoided by turning up the control until the volume was far too great.

These disadvantages, together with the horrid and dangerous line-cord and the fact that the chassis was not isolated from the mains, made the set useless in the author's opinion, and obviously a completely different approach was necessary if the set was to be made usable under modern conditions.

FIRST EXPERIMENTS

The first thing to be done was to fit a small mains transformer with 6.3 volt and 250 volt secondaries. Room was made for this component by removing the rectifier valve and using a small metal rectifier instead. The heaters were then wired in parallel and 6.3 volt valves substituted, namely 6K7GT, 6J7GT, and 6V6GT. The set was now safe, and worked just the same as before. The selectivity and quality problem remained, however. So the detector, the 6J7GT, was rewired as an anode-bend detector, which type does not load the tuned circuit feeding it and does not therefore impair the selectivity of that circuit.

The set was now much better (many sets using this circuit were in fact made at that time), the selectivity being markedly increased. But the r.f. gain control was still a nuisance, and had to be operated to prevent overloading of the detector stage. It was felt that an audio gain control after the detector, as employed in the normal domestic superhet, would be more satisfactory. When tuning the set with only an r.f. gain control, it was found that one had to have a hand on



The circuit of the modified receiver, As may be seen, this incorporates an infinite impedance detector

the control all the time to prevent "blasting" from powerful stations. This was especially true when trying to find a weak station, since the control then had to be turned well up. This effect is not nearly so apparent when using an audio gain control, even if a.g.c. is not applied to the r.f. stages. Unfortunately, the anode-bend detector overloads fairly easily, precluding the use of a fixed-gain r.f. stage.

The most obvious choice for a non-overloading detector is the diode, and so a 6Q7GT double-diode-

COMPONENTS

Resistors:
(All fixed values ½ watt 10% unless otherwise stated)

R1	47kΩ
R2	330Ω
R3	27kΩ
R4	150kΩ
R5	22kΩ
R6	1kΩ
R7	150kΩ
R8	470kΩ
R9	10kΩ
R10	250kΩ 1 watt
R11	1kΩ 3 watts
VR1	500kΩ potentiometer, log, with switch S1

Capacitors:

C1	0.01μF paper or plastic foil
C2	0.01μF paper or plastic foil
C3	0.1μF paper or plastic foil
C4	0.1μF paper or plastic foil
C5	8μF electrolytic, 350V wkg.
C6	250pF silver-mica or ceramic
C7	0.01μF paper or plastic foil
C8	250pF silver-mica or ceramic
C9	25μF electrolytic, 6V wkg.
C10	0.01μF paper or plastic foil
C11	25μF electrolytic, 25V wkg.
C12	16μF electrolytic, 350V wkg.
C13	16μF electrolytic, 350V wkg.
C14	50pF trimmer
C15	50pF trimmer
VC1 (a)(b)	500 + 500 pF, twin gang, variable.

Inductors:

L1, L2	Dual range coils, aerial coil and r.f. tranformer (see text)
T1	Output transformer, 40:1, primary rating 50mA minimum
T2	Mains transformer, secondaries: 250V at 60mA and 6.3V at 1.5A

Valves:

V1	6K7GT
V2	6SN7GT
V3	6V6GT

Rectifier

D1	Metal rectifier or silicon diode, 250V at 60mA

Switch:

S1	d.p.d.t., ganged with VR1
S2 (a)(b)	d.p.s.t. wavechange switch

Speaker:

3Ω	speaker

triode was substituted, using one of the diodes as detector and the triode section as audio amplifier. The r.f. gain control was dispensed with and an audio gain control substituted, this being inserted between the diode and the triode. Results were now extremely good from a quality point of view, being much better than with either the grid detector or the anode-bend detector, and there was no overloading (it is difficult to overload the diode detector). However, the selectivity was back to the level given with the grid detector. What was required, obviously, was a detector which had the good non-overloading characteristics of the diode together with the high input impedance of the anode-bend detector.

The author had previously been experimenting with the "infinite impedance" or cathode follower detector as the second detector in superhets for amateur bands intended particularly for the reception of s.s.b.—which requires that the detector be as linear as possible—using half a 6SN7GT as the detector with the other half as b.f.o. Results had been extremely good, with very high signal handling capabilities together with a very high input impedance. It seemed that this detector circuit was a "natural" for the set being modified, for the triode used before as a b.f.o. could be employed as an audio amplifier, thus making sure that no extra valves would be involved even though in effect an extra stage was to be included. The cathode follower detector has all the characteristics required: it is practically impossible to overload; it has a high input impedance, and therefore gives good selectivity; and it offers good quality because of the high degree of negative feedback at audio frequencies. The circuit was tried in the original set, and immediately results exceeded all expectations. The selectivity was good, sensitivity more than adequate, and the quality was surprising, especially considering the small loudspeaker being used. There was no sign of any overloading and so the set was operated in the way one operates a normal superhet, just using the tuning and audio gain controls, together with the wavechange switch of course.

FINAL CIRCUIT

Being completely satisfied with the circuit, the set was "tidied up" somewhat, and the final circuit was that shown in the accompanying diagram. From this it will be seen that the first valve, a 6K7GT, is operated as a fixed-gain r.f. amplifier, after which the 6SN7GT performs the dual office of cathode follower detector and audio amplifier. This in turn feeds the 6V6GT output valve. The original coils were retained for convenience, though more modern dust cored components would certainly give better results. The tuning capacitor, output transformer, loudspeaker, and valveholders were the only other items used from the original set as it was thought wise to use new capacitors and resistors as far as possible. The metal rectifier was a selenium one taken from an old set but the obvious modern component here would be one of the silicon rectifiers, such as the BY100, which would be both smaller and more efficient. The mains transformer can be any one small enough which will give 250 volts at about 60mA and 6.3 volts at 1.5 amps.[1] The mains supply is preferably taken from a 3-pin plug via a 3-core flex, with the chassis of the receiver connected to the earthing pin of the plug.

The only alignment necessary is to adjust the trimmers at the high frequency end of the medium wave band. If dust cored coils are used the cores should be adjusted at the low frequency end (i.e. with the tuning capacitor vanes well enmeshed).

It is thought that there must be many similar small receivers around which could be converted in the above way, thus giving them a new lease of life. The cost of conversion is small, and the valves required are all in the two to three-shilling category. Such a receiver would be excellent for a second set.

Obviously, there is nothing to prevent anyone from building the set from scratch, in which case one might just as well use modern valves. Just to check that the circuit was suitable for these valves, it was tried using an EF183 as r.f. amplifier, ECC82 as cathode follower detector and audio amplifier, with an EL84 for the output valve. This receiver was found so sensitive that it was possible to receive all the B.B.C.'s programmes with only a ferrite rod aerial, which improved the selectivity, of course. All the component values were the same as with the original conversion except for the screen-grid and cathode resistors of the EF183 (39 kΩ and 120Ω respectively), the cathode resistor of the audio amplifier section of the ECC82 (680Ω), and the cathode resistor of the EL84 (150Ω). Careful screening between the grid and anode circuits of the EF183 was found necessary and between the two tuned circuits due to the extremely high gain of the r.f. amplifier.[2]

It is felt that the circuit is sufficiently "different" to be of interest to constructors. Whilst it is not a world-beater so far as Dx reception is concerned, it was certainly with mixed feelings that the writer found, on connecting a decent sized loudspeaker to the output of the original conversion, that the quality of music from Radio 3 was quite a lot better than is given by the large superhet in a huge wooden cabinet which had previously been the writer's pride and joy!

1 A midget transformer with secondaries rated at 250 volts, 60mA, and 6.3 volts 2A, is available from R.S.C. Hi-Fi Centres, Ltd., 102-106 Henconner Lane, Bramley, Leeds 13.—Editor.

2 Suitable dual range coils for a home-constructed version would be Denco type C2 and C3 (Home Radio Cat. Nos. C04 and C05) the reaction winding on the C3 coil being ignored. The output transformer for either the EL84 or 6V6 should have a ratio of approximately 40:1 for matching into a 3Ω speaker, and a primary capable of passing 50mA.—Editor.

NEW EMI LOUDSPEAKER SYSTEMS AT AUDIO FAIR

In addition to a full range of their nine well-known loudspeaker systems EMI will exhibit two new systems on Stand 56 at the International Audio Fair to be held in the National Hall, Olympia from 16th to 22nd October 1969. These are systems 215 and 315.

The 315 system consists of a new 15in. round bass loudspeaker with a rigid die-cast chassis, capable of handling 35 watts with a bass resonance of 20 Hz; two new 5in. round mid-range high-flux loudspeakers with specially designed pvc suspension; two new moulded chassis high-frequency units with the advantage of low magnetic leakage; a switch plate and a crossover network.

The 215 system consists of a new 14in. by 9in. bass loudspeaker with a rigid die-cast chassis and 2in. pole piece, capable of handling 30 watts; two of the 5in. mid-range loudspeakers and one of the high frequency units used in the 315 system; a switch plate and a crossover network.

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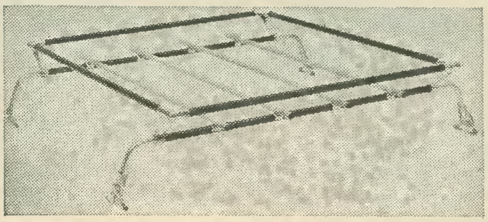

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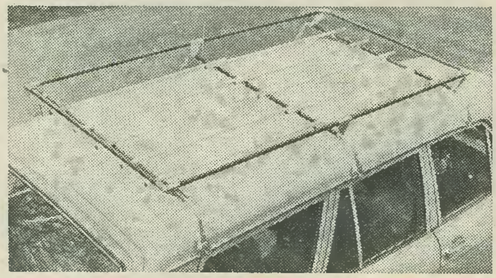

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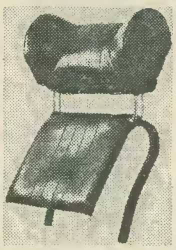

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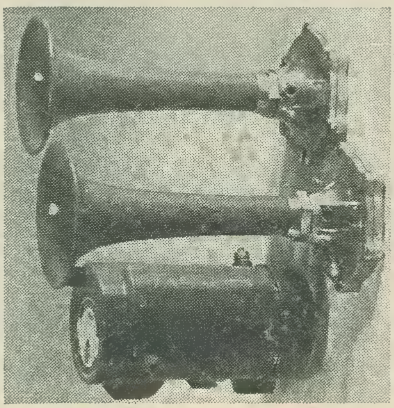

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Trade News . . . .

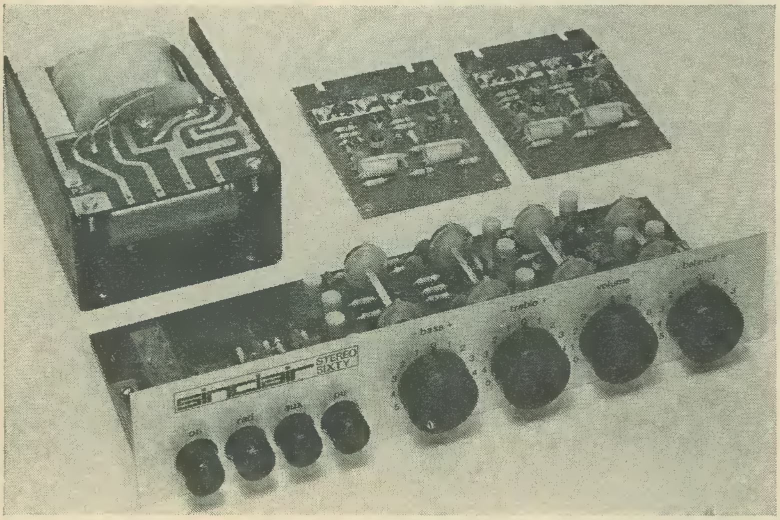
NEW SINCLAIR PRODUCTS AT THE AUDIO FAIR

Sinclair Radionics Limited will be exhibiting a new range of high fidelity modules and a new loudspeaker, the Q.16. The new module range uses silicon epitaxial planar transistors throughout and includes the Z.30 amplifier which provides up to 25 watts continuous sine wave output power. This amplifier is claimed to have a lower distortion than any other amplifier on the market.

The Stereo 60 pre-amplifier and control unit is designed to drive two Z.30 modules and uses push-button controls for input selection. The volume, balance, bass and treble controls are rotary and the front panel is in solid aluminium.

Two power supplies are available to power the Stereo 60 and two Z.30's. The first of these, the PZ.5, is recommended for the majority of domestic applications. The PZ.6 is intended for use where the absolute maximum output power is required.

The new loudspeaker, the Q.16, is based on the Sinclair Q.14. The Q.16 is completely new in appearance, however, being finished in black cloth with a solid teak surround. The retail price is £8 19s. 6d.



A complete stereo assembly. The Stereo 60 pre-amplifier is in the foreground, with a PZ5 power supply and two Z.30 amplifier modules behind.

MANUFACTURER'S SPECIFICATIONS

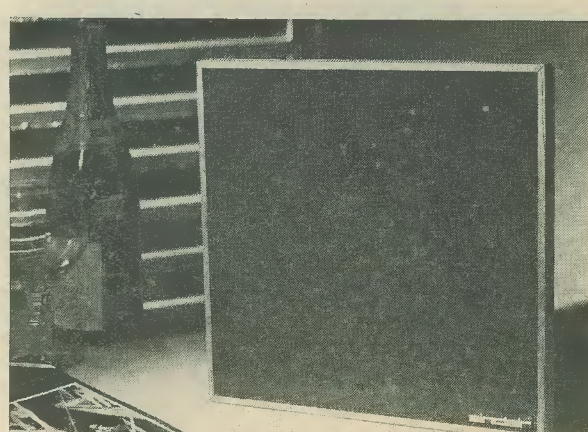
Z-30

Power output: 15 watts continuous sine wave (30 watts peak) into 8 ohms from a 35 volt supply. 25 watts continuous sine wave (50 watts peak) into 3 ohms from a 30 volt supply.
Frequency response: 20 to 300,000 Hz ± 1dB.
Distortion: 0.02% total harmonic distortion at full output into 8Ω and at all lower output powers.
Size: 3 x 2.2 x 0.5in.; 7.6 x 5.6 x 1.25 cms.
Input Impedance: 100kΩ.
Damping factor: Greater than 500.
Operating voltage: 8 to 35 volts.
Notes: Sensitivity is sufficient for operation directly from a ceramic or crystal Cartridge.
Recommended price: 89s. 6d.

STEREO 60

Controls: Mains and 3 inputs on push-buttons. Rotary controls for volume, balance, bass and treble.
Sensitivity: Up to 3mV on all inputs.
Equalisation: To within ± 1dB of R.I.A.A.
Signal to noise ratio: Better than 70dB.
Size: 8.15 x 3.4 x 1.6in.; 20.3 x 8.6 x 4.1 cms.
Recommended price: £9 19s. 6d.

PZ.5. 30 volt unstabilised power supply. Price 99s. 6d.
PZ.6. 35 volt 1.4 amp stabilised power supply. Sufficient to drive two Z.30's and stereo-60 to give 15 watts continuous sine wave on both channels at the same time. Price £7 19s. 6d.
Size: (PZ5 and PZ6) 3.95 x 2.85 x 1.9in.; 10 x 7.25 x 4.8 cms.



The new Sinclair Q.16 loudspeaker. This is finished in black cloth with a solid teak surround.

UNDERSTANDING RADIO

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

CERAMIC I.F. FILTERS

by W. G. Morley

In last month's article in this series, we continued our examination of circuit devices which are capable of improving the selectivity of the i..f. amplifier of a superhet, and we discussed the Q-multiplier. As we saw, the Q-multiplier incorporates a normal tuned circuit whose effective Q is increased to a very high level by means of carefully controlled regeneration. The Q-multiplier tuned circuit may then be coupled to a receiver i.f. amplifier in such a manner that it offers a very sharp response curve either for the acceptance or for the rejection of signals.

The Q-multiplier is normally employed by amateur transmitting enthusiasts and short wave listeners, and its basic function is to improve the selectivity of an existing superhet receiver. It is nearly always assembled in the form of a separate "add-on" unit, being coupled to the receiver i.f. amplifier by way of a length of screened cable.

We now turn our attention to another frequency selective device which may also be incorporated in the i.f. amplifier of a superhet. In this instance, however, the function of the device is not that of improving the selectivity given by an amplifier employing standard i.f. transformers. It is, instead, designed to *replace* such transformers by offering a comparable performance in terms of frequency response and gain. This performance, it should be added, is only intended to be adequate for the requirements of an a.m. domestic receiver.

The device to be discussed is designed for operation in transistor circuits rather than in valve circuits. We have not dealt with the transistor in detail in this series, but it will be assumed for the purpose of the present article that the reader has sufficient knowledge of this subject to be able to recognise and comprehend the working of a simple common emitter transistor amplifier stage. In this mode of operation the input signal is applied to the base of the transistor, whilst the amplified output signal appears at the collector. The emitter is common to both input and output circuits. The common emitter circuit, it may be added, is that which is most frequently employed in transistor signal amplifiers. Also, it is that which is most closely similar to the standard valve amplifier circuit.

CERAMIC I.F. FILTERS

The frequency selective device now to be discussed is the *ceramic i.f. filter*. Like the quartz crystal, the ceramic i.f. filter takes advantage of the properties of a piezoelectric material, and the knowledge we have acquired in recent articles concerning series resonance and parallel resonance in the quartz crystal will be of assistance to us when considering its operation.

A number of synthetic piezoelectric materials have been introduced over the last three decades, the first of these being a ceramic, barium titanate. Another synthetic piezoelectric material, lead titanate zirconate, appeared later and this has been employed in ceramic i.f. filters. Since these piezoelectric materials are in the form of ceramic, it is possible for them to be made up to different shapes and dimensions far more readily than the naturally

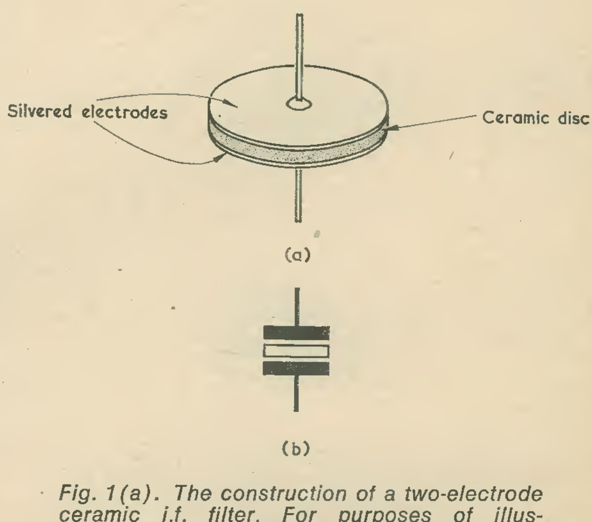


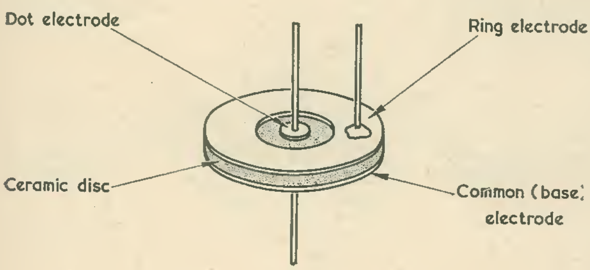
Fig. 1(a). The construction of a two-electrode ceramic i.f. filter. For purposes of illustration, the silvered electrodes are shown with exaggerated thickness
(b). Circuit symbol for the two-electrode filter

occurring crystalline quartz. One of the manufacturing processes in the preparation of the piezoelectric ceramics consists of applying a high electric voltage across two opposite faces. This process is referred to as "polarisation", and it enables the material to afterwards exhibit its piezoelectric properties.

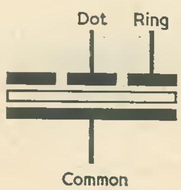
The simplest type of ceramic i.f. filter is illustrated, together with its circuit symbol, in Figs. 1(a) and (b). It consists basically of a circular disc of piezoelectric ceramic with electrodes, to which external connections may be made, on either side. Each electrode is provided by a layer of silvering deposited over all, or very nearly all, of the ceramic surface. The construction resembles that of a quartz crystal in its housing, and the filter functions in a similar manner. Like the quartz crystal it exhibits mechanical resonance when a signal at the resonant frequency is applied to its two electrodes. Also like the quartz crystal, it offers a series resonant frequency (at which its electrical impedance is low) and a parallel resonant frequency (at which its electrical impedance is high). Yet again like the quartz crystal, the parallel resonant frequency is slightly higher than the series resonant frequency.

On the other hand, the two-terminal ceramic filter of Fig. 1(a) does not present as high an effective Q as does the quartz crystal, Nevertheless, it is still capable of offering a degree of selectivity which makes it attractive for use, together with other ceramic filters and/or i.f. tuned circuits, in the i.f. amplifier of a domestic a.m. radio receiver. In this application advantage is taken of its low impedance at series resonant frequency, this impedance being typically less than 20Ω.

A three-terminal ceramic filter is illustrated in Fig. 2(a). Again, a disc of piezoelectric ceramic material is employed. One surface of the disc is covered with a single silvered electrode whilst the other has two silvered electrodes, these consisting of a central circular section and an outside concentric ring. These



(a)



(b)

Fig. 2(a). The three-electrode filter
(b). The circuit symbol employed for the three-electrode filter

two electrodes are referred to as the *dot* and *ring* electrodes respectively. The single electrode on the other side of the disc is described as the *common* or *base* electrode. The circuit symbol for the three-terminal filter is given in Fig. 2(b).

The input signal to the three-terminal ceramic filter is applied between the dot electrode and the common electrode, the output signal being taken from the ring electrode and the common electrode. At the appropriate frequency the disc exhibits mechanical resonance due to the piezoelectric properties of the material of which it is made, whereupon it is capable of passing a band of frequencies at or near this resonant frequency.

The selectivity offered by the three-terminal filter is affected both by the external impedance to which the ring electrode is coupled and by the impedance of the input signal source coupled to the dot electrode. A further complicating factor is that an impedance transformation occurs in the filter itself, the ratio between its input and output impedances depending upon the relative areas of the dot electrode and the ring electrode.

Due to the large number of varying factors involved, the three-terminal filter cannot be resolved into an equivalent circuit which is as simple as that for a quartz crystal. Indeed, some three-terminal filters are manufactured to function at a specific series resonance frequency (whereupon the transfer of energy from input to output electrodes is dependent upon the operation of the crystal in its series resonant mode) whilst others are manufactured for a specific parallel resonant frequency. In the latter case, the performance of the filter approaches that of a network having a parallel resonant circuit across the input and output, with series impedance in either one or both of the input and output circuit paths.

A range of practical ceramic i.f. filters has been available in the U.K. over recent years, these being marketed by the Brush Clevite Company, Ltd. They are available to home-constructors through component retailers and are intended for use in domestic transistor radio receivers at a number of intermediate frequencies, these including 455kHz, 465kHz and 470kHz.

Three of the Brush Clevite range, types TF-O1A (455kHz), TF-O1B (465kHz) and TF-O1D (470kHz), are two-terminal devices similar to that shown in Fig. 1(a). They are fitted in housings whose dimensions, excluding tags, are slightly smaller than 0.3 by 0.4 in. These devices are series resonant at their nominal frequencies.

A further three, types TO-O1A (455kHz), TO-O1B (465kHz) and TO-O1D (470kHz), are three-terminal devices in which the ceramic elements are manufactured to exhibit a series resonance at the nominal frequencies. Another three, TO-O2A (455kHz), TO-O2B (465kHz) and TO-O2D (470kHz) are also three-terminal devices, and are intended to operate at the parallel resonance of the piezoelectric material. All the filters with the TO prefix appear in housings measuring some 0.65 by 0.75 in., excluding tags.

In passing, it should be mentioned that the terms "resonant" and "anti-resonant" are sometimes employed in references to piezoelectric frequency selective devices. These terms correspond to "series resonant" and "parallel resonant" respectively. This point is mentioned here as the reader may encounter the alternative terms in literature dealing with

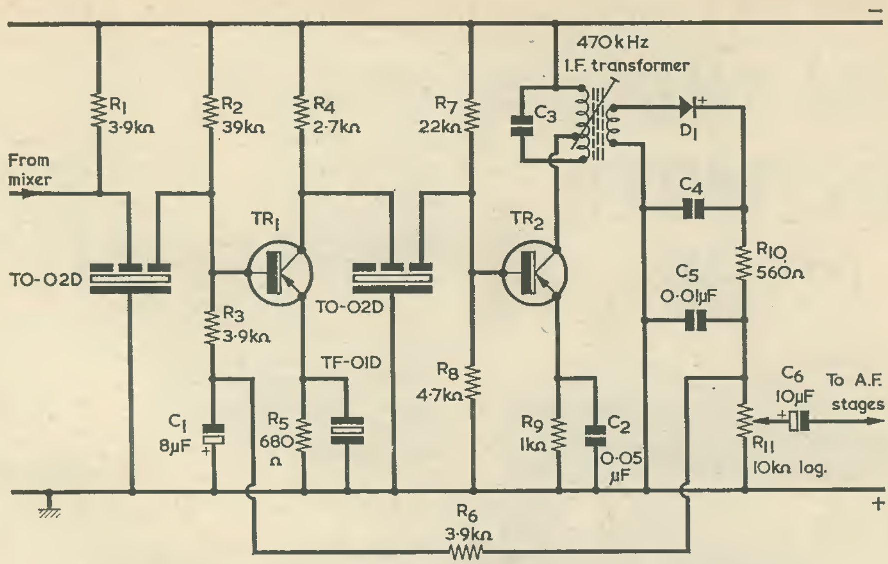


Fig. 3. A practical 470kHz i.f. amplifier employing ceramic filters. Note the low resistance and high capacitance values which reflect the low impedances at which transistors operate. C3 and C4 are housed in the i.f. transformer can. The receiver circuits in which this i.f. amplifier appears are powered by a 9 volt battery.

ceramic i.f. filters. A further point of terminology concerns the fact that the Brush Clevite i.f. filters are referred to as "Transfilters".

As already mentioned, the two-terminal filters with the TF prefix are series resonant at their nominal frequencies. These frequencies are the fundamental frequencies for the piezoelectric discs employed. Unfortunately, it is rather difficult to manufacture three-terminal filters using discs which are similarly resonant at about 460kHz, because the relatively small size of the disc raises problems in processing and handling. In consequence, the three-terminal filters employ larger discs with a fundamental frequency around 180kHz, these having an *overtone* response at the nominal filter frequencies in the 455 to 470kHz range.[1]

The three-terminal devices offer a response at the fundamental frequency in addition to the overtone frequency. In consequence, it is undesirable to employ them on their own in an i.f. amplifier, since such an amplifier would amplify at the fundamental frequency as well as at the required overtone frequency. It is necessary to have some means of suppressing the amplifier response at the fundamental frequency, and a suitable solution consists of including in the amplifier a single i.f. transformer of conventional type tuned to the required intermediate frequency. This provides adequate rejection of the fundamental frequency, whereupon all the remaining frequency selective components in the i.f. amplifier can be of the ceramic filter type. It is preferable for the conventional i.f. transformer to be fitted immediately after the frequency changer stage since the risk of cross-modulation between the two sets of frequencies in later stages is then eliminated. However, practical receiver designs have been produced in which the conventional i.f. transformer appears at the end of the i.f. amplifier. A measure of suppression of the fundamental frequency may, incidentally, he provided by incorporating one or more two-terminal filters in the i.f. amplifier design. A further point which is of significance here is that, in a medium and long wave receiver having an accurately aligned high-Q aerial tuned circuit (as is possible with a ferrite rod aerial) there will be, in any case, an appreciable level of rejection to aerial signals which could cause the fundamental filter frequency to appear after the frequency changer.

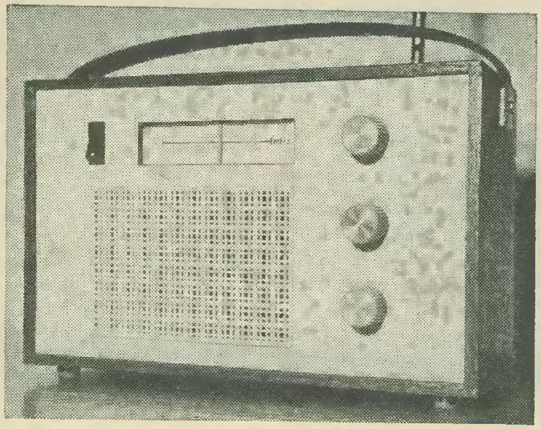
A practical 470kHz i.f. amplifier incorporating ceramic filters is shown in Fig. 3, this being part of a successful home-constructor design for a medium and long wave receiver.[2] This circuit is very helpful in illustrating the simplicity imparted by ceramic i.f. filters. The overall i.f. gain and response curve of the amplifier is commensurate with that of an amplifier using the same transistor types and conventional i.f. transformers.

In Fig. 3 an i.f. output from the collector of the mixer transistor is applied to the dot electrode of the first ceramic filter, the ring electrode of which then couples to the base of the following i.f. transistor, TR1. The collector of TR1 next couples via a second three-terminal filter to the base of TR2. A conventional i.f. transformer follows, this feeding into a detector diode D1, the a.f. output from which is passed to the a.f. amplifier stages of the receiver via volume control R11 and C6. The two ceramic filters, in company with the i.f. transformer, allow the

1. It is possible to make a quartz crystal or similar piezoelectric device exhibit mechanical resonance at a frequency which is approximately a multiple of its fundamental frequency. The term "overtone", rather than "harmonic", is preferred in this instance, bcause the higher frequencies are not an exact multiple of the fundamental frequency.

2. "The 'Good Companion' Mk. II Transfilter Portable", *The Radio Constructor*, August, 1962. The component suffix numbers given in Fig. 3 differ from those in the circuit originally published.

IN THE NOVEMBER ISSUE



The "Airlane" 7-Transistor Aircraft Band Receiver

A super-regenerative design having a frequency coverage from 108 to 140MHz (approx). With slight modification the receiver can also be used on the 144MHz amateur band.

Two-Transistor Converter for 'Ten'

A simple transistor converter for the 10 metre amateur band having an output at 6.5MHz. Aerial designs are also featured.

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desired band of frequencies to pass to the detector.

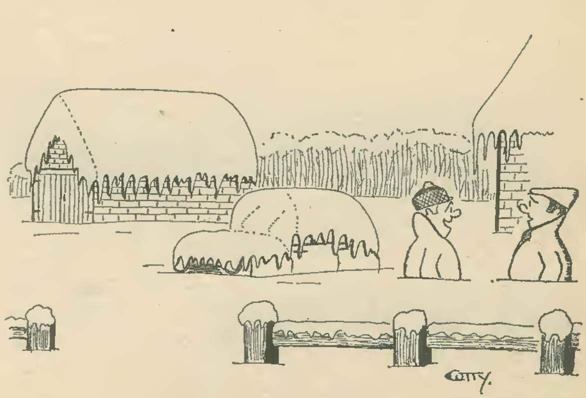
A little additional selectivity is required for the circuit to be comparable with one using standard i.f. transformers and this is provided by the two-terminal filter connected across R5, in the emitter circuit of TR1. Normally a bypass capacitor similar to that connected across R9 would appear across R5, this offering negligible reactance at intermediate frequencies and thereby preventing degeneration of gain in the transistor. In this respect, the capacitor would function in the same manner as the normal bypass capacitor which is connected across the cathode bias resistor of a valve. The two-terminal filter connected across R5 takes the place of the bypass capacitor, and it offers a high impedance for frequencies removed from its resonant frequency, and a low imdance for frequencies close to or at its resonant frequency. Thus, the gain offered by TR2 is significantly reduced, due to degeneration, for all frequencies except those close to or at the resonant frequency of the filter, and the overall selectivity offered by the i.f. amplifier is enhanced.

Since no direct current flows through the ceramic i.f. filters, it is possible to connect their electrodes direct to the appropriate input and output circuit points, regardless of the direct potentials existing at such points. No blocking capacitors are needed.

It has been necessary to use a transistor circuit to demonstrate a practical application of ceramic i.f. filters, because these filters are expressly designed to function at the low impedances which appear in such circuits. Included in the diagram for completeness are the components R6 and C1, these appearing in a simple a.g.c. circuit. When signal strength at the detector diode increases, the voltage at the upper end of R11 goes positive with relation to the lower supply line. The increasing positive voltage is then passed to the base of TR1 via R6 and R3, TR1 being of a type whose gain decreases as its base is made more positive. C1 is merely an a.g.c. bypass capacitor.

NEXT MONTH

In next month's issue, we shall turn to a new subject, and shall commence to examine measuring instruments.



" . . . . I see your windscreen wipers have gone solid-state!"

In your work-shop

This month we find Smithy in enquiring mood. Aided as always by his able assistant Dick, we follow a series of experiments instigated by the Serviceman, these culminating in the appearance of a novel and unusual phase-splitting circuit which offers quite a number of significant practical advantages

Smithy picked up his screwdriver and applied it to the surface of the tea in his disreputable tin mug. Deftly, he flicked out a floating tea leaf, returned the screwdriver to his bench, then regarded the contents of the mug abstractedly.

"Anything wrong?"

Smithy directed an absent-minded eye at his assistant.

"What?"

"I asked," repeated Dick, "if anything was wrong."

Smithy looked surprised.

"Why, no," he replied. "So far as I'm concerned, everything's fine."

He turned his attention away from his assistant and once more contemplated the surface of his tea.

An exasperated expression appeared on Dick's face.

"What *is* it," asked Dick, "that you're looking for? A smiling face?"

Once more the Serviceman roused himself and gazed at his assistant.

"What's this," he asked perplexedly, "about smiling faces?"

"If," remarked Dick, sarcastically, "you look at a glass of Guinness for long enough you're supposed to see a smiling face on the top. I was just wondering if you are trying to do the same with your tea."

CONSTANT CURRENT DEVICES

"You have a mind," returned Smithy dispassionately, "that moves along strange and devious paths."

"Perhaps it does," snorted Dick. "But at least it doesn't cause me to completely withdraw myself from my fellow-men as *you've* been doing ever since tea-break started."

"Oh, it's *that* which has been worrying you, is it?" said Smithy. "Well, seeing that I have about as much privacy in this Workshop as a goldfish in its bowl, I suppose you're now expecting me to tell you what it is I've been thinking about."

"That," replied Dick graciously, "is up to you, of course."

Smithy's air of preoccupation suddenly vanished. It was obvious that he had come to a decision.

"Right," he pronounced briskly. "I shall now proceed to satisfy your curiosity. What's been taking up my thoughts since our tea-break started has been the fact that nobody these days seems to take account of all the things you can do with constant current devices."

"Constant current devices?"

"Constant current devices," repeated Smithy gravely. "Of which perhaps the easiest to set up is given by a common or garden transistor in grounded base. If you come over here I'll start off by giving you some gen on why a grounded base transistor gives a constant current."

Dick walked over to Smithy's bench, whilst that worthy drew his notepad towards him.

"Now," said Smithy, "the transistor amplifier stages we most frequently encounter employ the transistor, not in the grounded base, but in the grounded emitter mode. If we have an n.p.n. transistor in grounded emitter, its emitter couples to the negative supply rail and the input signal is applied to its base. The bias current flowing into the base is from a d.c. source of the same polarity as the collector supply. I'll show you what I mean with the aid of batteries so that you can see the polarities more clearly."

Smithy drew out a circuit (Fig. 1 (a)) whilst Dick looked on.

"That circuit," remarked Dick, "seems nice and obvious to me."

"Good," said Smithy. "If we next draw a series of collector current-collector voltage curves for the transistor in grounded emitter we then get something like this. (Fig. 1(b)). Each curve is drawn for a different base current. Now, the straight sections of these curves have what is known as a 'slope resistance'. If, following the 50μA curve in my sketch, for instance, I change the collector voltage from eight to four volts, the change in collector current along the curve is only about a milliamp. (Fig. 1(c)). Thus, a change of four volts causes a change in current of 1mA, which corresponds to a slope resistance of 4kΩ. Got it?"

"I think so," replied Dick a little dubiously. "At any event, keep at it!"

"Right-ho," said Smithy obligingly. "Now, at six volts along our 50μA curve the actual collector current drawn by the transistor is about 4mA, and these two figures correspond to an actual resistance of 1.5kΩ. Which is quite a lot lower than the 4kΩ of the slope resistance."

"My impression," said Dick frowning, "of what you're driving at is that, so far as a battery supplying the transistor is concerned, the transistor is no different, at six volts, from a 1.5kΩ resistor. At the same time though, so far as a varying voltage at the collector is concerned, the transistor acts like a 4kΩ resistor."

"You're right first time," confirmed Smithy. "For the present discussion you don't need to worry any more about this slope resistance business except to remember the obvious fact that, as the current-voltage curve becomes nearer to horizontal, the slope resistance goes up."

Smithy pulled his pad towards him again.

"After having introduced the slope resistance concept," he said, "I will now turn to the transistor in grounded base, which has been the real subject of my recent thoughts. Here it is, complete with batteries for collector supply and for bias. (Fig. 2(a)). In this case, however, the bias goes to the emitter, and it comes from a battery terminal of opposite polarity to that which supplies the collector. Once again, I've assumed an n.p.n. transistor."

Smithy indicated the transistor with his pencil.

"As you can see," he continued, "the grounded base transistor really has the same sort of supply potentials as does the grounded emitter. As before, the collector goes to a positive supply. We now bias the emitter negative of the base which, so far as potentials are concerned, is pretty well the same as biasing the base positive of the emitter. However, the collector current is now drawn from the negative terminal of the collector supply battery via the base of the transistor instead of via the emitter, and this has a very marked effect on the collector current-collector voltage curves. These now appear like this."

Smithy sketched out a further set of curves on his pad. (Fig. 2(b)).

"Stap me," exclaimed Dick. "The straight bits of these curves are practically horizontal."

"They are indeed," confirmed Smithy. "In fact, a grounded base transistor offers an almost fantastic performance in this respect. The collector current-collector voltage curves are so near to being horizontal that it's almost impossible to measure any change in collector current over quite wide changes in collector voltage. The current is as near as dammit to being constant, whereupon we refer to the grounded base transistor as being an exceptionally efficient 'constant current device'. I don't want to go on any further with this theoretical stuff except to remark on one point. Since the straight parts of these grounded base curves are very nearly horizontal, they correspond to an extremely high slope resistance. In practice, this slope resistance can be of the order of 20kΩ to 200kΩ."

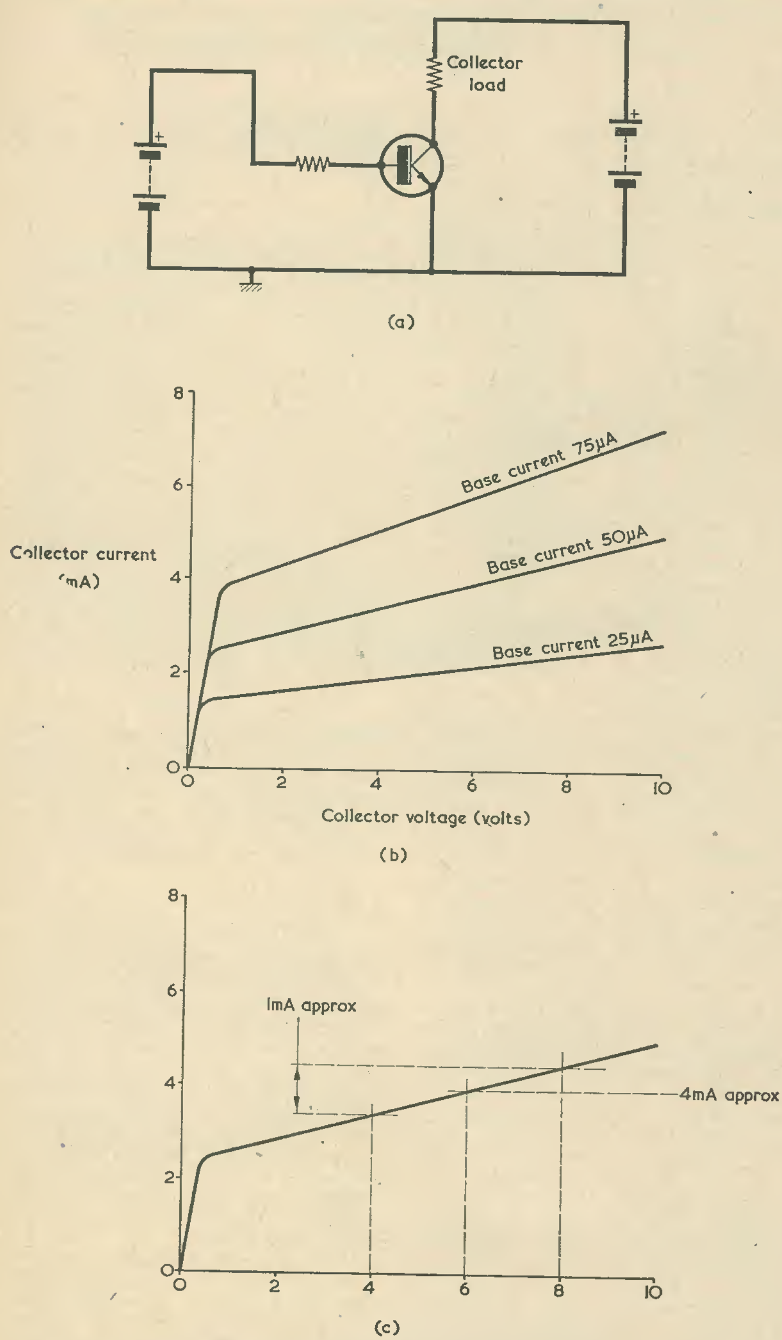


Fig. 1(a). Collector supply and base bias polarities for an n.p.n. transistor in grounded emitter
(b). A typical family of collector current-collector voltage curves for a grounded emitter transistor
(c). Illustrating the concept of 'slope resistance'. The curve shown here is the central curve of (b)

INITIAL EXPERIMENT

Dick frowned.

"All this," he remarked critically, "is really quite interesting, but I don't see why it should have caused you to go into a state of limbo like you did just now."

"I was undertaking," explained Smithy, "a little bit of cogitation. I wasn't thinking about constant current devices in themselves, but of constant current device *applications*. Before you so rudely interrupted my train of thought I'd just about finished working out in my mind a gadget using a constant current transistor which could prove to be quite impressive."

"What sort of gadget is that?"

"I shan't tell you yet," replied Smithy cagily. "Over the years, I've become too cautious to start committing myself on things which are based only on theory. I like to check them out in practice first!"

"Are you," asked Dick interestedly, "going to check this idea out in practice, too?"

"I am," replied Smithy decisively. "What's more, if you feel like wieldign the odd soldering iron for me, you can join me in this little enterprise as well."

"That would be fine," exclaimed Dick eagerly. "It will make a very pleasant change from ordinary servicing."

"Then we'll get started right now," stated Smithy. "I first of all want to carry out an initial experiment, after which we'll get down to the main thing. So, Dick, could you hunt around and see if you can find an odd chassis somewhere on which we can temporarily mount a few components? It needn't be anything special, just a bit of metal which will take several tagstrips, a couple of pots and a B9A valveholder. There's bound to be something knocking around with a few holes of convenient size in it. In the meantime, I'll dream up a little circuit for you."

The Workshop fell into silence, broken only by the clanking of metal upon metal as Dick sorted through a miscellaneous collection of oddments contained in one of the many mysterious cardboard cartons stored under his bench. There was a sudden triumphant cry.

"I've found something here," Dick called out, "which should be just the job. It's got a couple of B9A holes in it and there are stacks of holes in it for pots and tag-strips as well."

"Excellent," pronounced Smithy, putting down his pen. "And I've just finished the circuit for our first experiment. Here it is."

Dick looked distrustfully at Smithy's diagram. (Fig. 3).

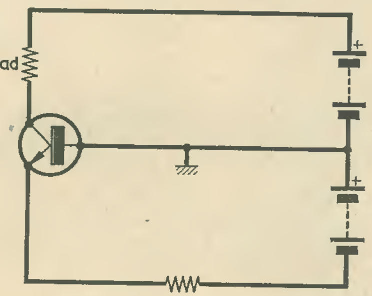
"I don't get it," he remarked eventually. "Is that transistor in grounded base or is it in grounded emitter?"

"It's in grounded base," replied Smithy. "The 2.2kΩ resistor from the positive supply line causes a forward current of some 5 to 6mA to pass through the silicon diode, which means that the upper terminal of the diode is always about 0.5 volts positive of the negative supply line. In consequence, that upper terminal can be looked upon as a point of fixed potential. We then vary the emitter current by adjusting the 500Ω preset potentiometer."

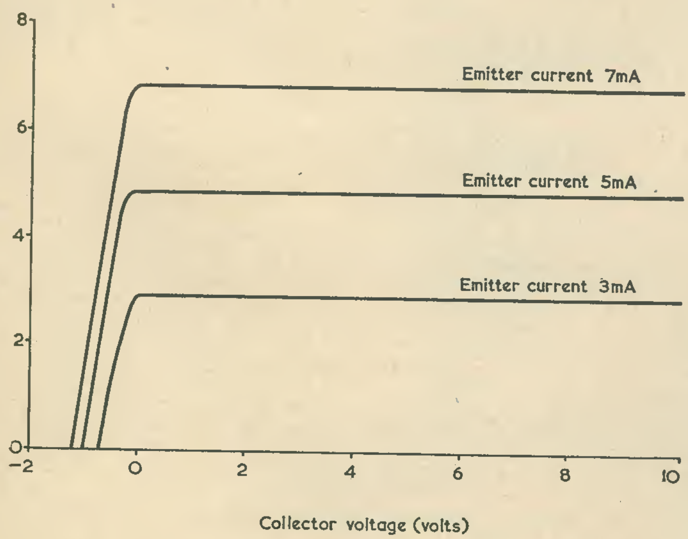
"What's the 50Ω resistor for?"

"It's merely a limiter resistor," explained Smithy. "It prevents excessive current flowing if you should accidentally set the 500Ω pot to too low a resistance. By the way, please use new batteries for the 12V supply. I want the actual supply voltage to be rather higher than 12 volts."

"All right," said Dick. "What



(a)



(b)

Fig. 2(a). An n.p.n. transistor in grounded base has the collector supply and emitter bias polarities shown here
(b). Typical collector current-collector voltage curves for a grounded base transistor. These incidentally reflect the fact that current gain in grounded base is always less than unity

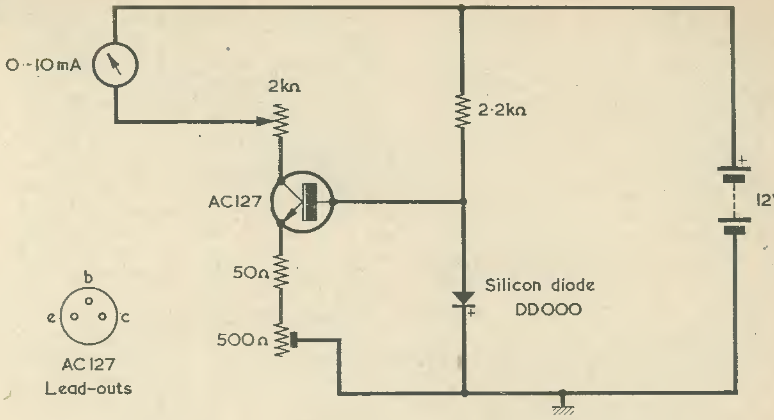


Fig. 3. The first experimental circuit checked by Smithy

about this 10mA meter you've put in the collector circuit? Have we got any 10mA meters in stock?"

"Just use your testmeter switched to its 10mA range," replied Smithy. "Remember, I only want this circuit made up in lash-up form, and you don't need to bother about layout or anything like that. Incidentally, so far as the semiconductors are concerned, the silicon diode isn't critical, and one of those little Lucas DD000 types would be perfectly adequate here. I've decided to use a germanium transistor rather than a silicon one because a germanium transistor requires a lower emitter-base voltage to become conductive, and that enables me to use a single silicon diode for the fixed potential at the base. An AC127 will do fine, and we've got plenty of them in the spares cupboard."

Dick soon found the components required for the circuit, after which he immediately settled to work on its assembly.

"All finished, Smithy," he called out after five minutes. "I haven't connected the 12 volt supply yet, though."

"Fair enough," responded Smithy, as he walked over to Dick's bench and inspected his assistant's handiwork. "You'd better start off by setting both pots to insert maximum resistance. Then connect the battery and slowly reduce the resistance inserted by the 500Ω pot until the meter reads 6mA."

"No sooner asked," replied Dick cheerfully, "than carried out! I'm adjusting the 500Ω pot now. And I'm getting that 6mA reading just as you ask."

"Good," said Smithy. "Next reduce the resistance inserted by the 2kΩ pot."

Carefully watching the meter, Dick slowly turned the spindle of the 2kΩ potentiometer. The meter reading remained unaltered. Unbelievingly, Dick continued rotating the spindle until, eventually, the potentiometer inserted zero resistance.

"Corluvaduk, Smithy," he remarked incredulously. "That meter needle's stayed at 6mA all the time!"

"I told you," chuckled Smithy, "that a grounded base transistor was a constant current device. You've now confirmed that fact for yourself! Well, I'm very pleased with the results so far because they mean that an essential part of my final circuit will be all right. I'd better make another check, though. Just borrow the testmeter off my own bench, switch it to an appropriate voltage range and couple it between the collector of the transistor and chassis. Then adjust the 2kΩ pot over its range whilst the 6mA current is flowing, and see what the maximum and minimum collector voltages are."

Smithy watched patiently whilst Dick set about this task.

"The collector voltage," announced Dick, ranges from 0.7 to just a little more than 12.5 volts."

LONG-TAILED PAIR

"Excellent," pronounced Smithy. "The 0.7 volts, incidentally, will be given by the 0.5 volts dropped across the silicon diode plus 0.2 volts in the collector-base junction of the transistor. And you get a maximum voltage slightly above 12.5 volts because, as I asked you to do, you used new batteries. The current would have fallen below 6mA if there were more than 2kΩ in the collector circuit because 6mA can't flow through a resistance higher than 2kΩ at a voltage of 12. Anyway, we have now confirmed that our AC127 transistor offers a steady 6mA for all collector voltages from 0.7 to more than 12 volts. We now carry on to my main experiment."

Dick glanced at the Workshop clock. Its hands indicated that tea-break had ended more than 20 minutes ago.

"Shouldn't we," he asked a little anxiously, "be doing a spot of official work by now?"

"Nonsense," boomed Smithy. "Just for once we're going to use this Workshop as a research establishment."

A gleam came into the Serviceman's eye.

"I've often wondered," he continued, an unconscious note of wistfulness tingeing his voice, "what my life would have been like if I'd spent it designing sets instead of repairing them. At any event, I'm jolly well going to check out *this* particular idea of mine. And until I've done just that, blow the servicing!"

Followed by an astonished Dick, Smithy returned to his bench and proceeded to draw out a further circuit. (Fig. 4).

"Now this," he said, "is what is known as a 'long-tailed pair', and it forms what is perhaps the simplest phase splitter going. You put an input signal into the grid of the left hand triode whereupon its cathode current increases or decreases in sympathy with the signal voltage, thereby changing the cathode voltage of the right hand triode. If the left hand grid goes positive so also do the two cathodes, and the effect in the right hand triode is the same as if its grid went negative. The output signals at the anodes are out of phase and, provided the common cathode resistor has a high enough value, are virtually equal in amplitude. The triodes have similar characteristics, of course, and each offers half the gain it would give if employed on its own in a standard voltage amplifier circuit."

"That long-tailed pair," commented Dick, "is something I learned about ages ago. It may well be a very simple phase splitter, as you say, but I haven't seen it used very often in practice."

"That's because," replied Smithy, "to get a high enough value of resistance in the common cathode resistor you need the auxiliary negative supply I've shown, and an auxiliary negative supply is something of a nuisance in a practical design. You *can*, mind you, use the circuit without the auxiliary supply by biasing the two grids at a point positive of chassis, but this tends to introduce complications. If all goes well, that constant current transistor of ours will enable both the grids to be biased at chassis potential and an auxiliary h.t. negative supply won't be required."

Smithy turned to his pad yet again to sketch out a further circuit. (Fig. 5).

"This," he announced proudly, "is the circuit for our final experiment, and it represents what seems to me to be the phase splitter to end all phase splitters! The ECC82 appears in a long-tailed pair configuration but, instead of a high value resistor coupling the cathodes to an auxiliary negative supply, we now have our constant current transistor coupling the cathodes to the standard h.t. negative line. We know that, so far as change in collector voltage is concerned, the slope resistance offered by a transistor in grounded base is very high. Looked at in that light alone, the transistor in this circuit offers the requisite high resistance for a long-tailed pair. And we also know, from experiment, that our AC127 offers a con-

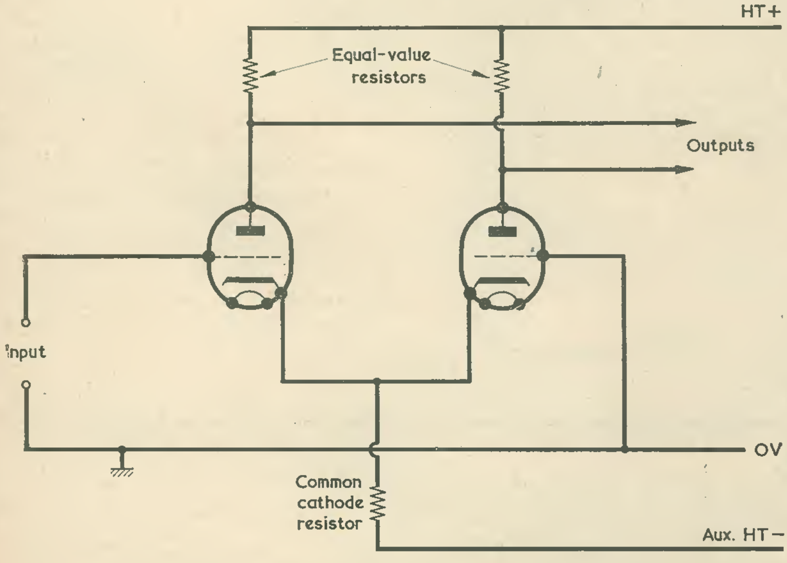


Fig. 4. The basic long-tailed pair, using triode valves. The auxiliary h.t. negative supply is negative of chassis

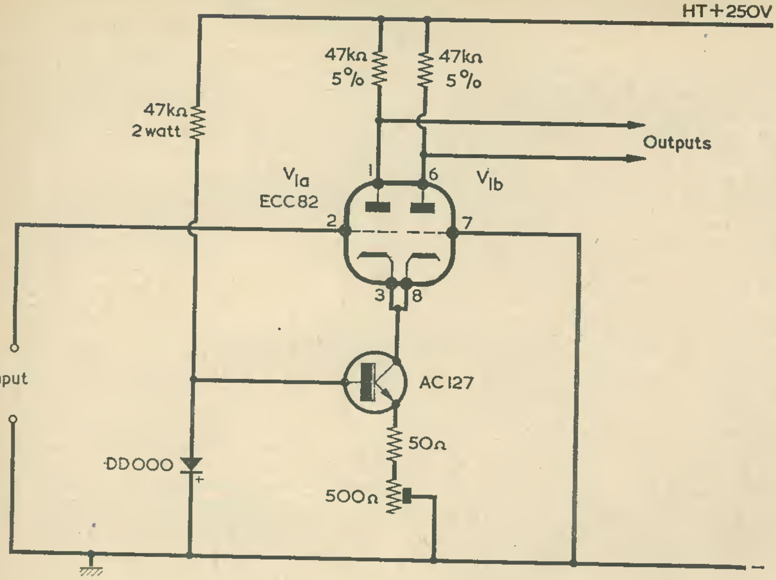


Fig. 5. Smithy's constant current long-tailed pair phase splitter circuit

stant current of 6mA for all voltages from 0.7 to greater than 12. If we set up the AC127 in this circuit for a constant current of about the same value those two triodes *must* share that current between them. So they *must* then function as a true phase splitter."

Dick looked impressed.

"You certainly," he remarked, "appear to have been doing some heavy thinking on this circuit. Incidentally, why are you now feeding the silicon diode via a 47kΩ resistor?'

"The grounded base circuit here," said Smithy in reply, "is essentially the same as the previous one with the 12 volt supply. But as we're now using the much higher supply voltage associated with valves, a larger value of resistance is needed to draw the necessary forward current through the diode. In the present circuit the diode passes just about the same forward current as it did in the 12 volt one. Now, what I want you to do next is to wire up this circuit on that chassis you've been using. Some of the previous components and wiring won't need to be altered for the new circuit. You can get an ECC82 out of the cupboard, and we've got an old power supply unit knocking around from which you can take 250 volts h.t. and a 6.3 volt heater supply."

As Dick rushed away enthusiastically to make up the new circuit, Smithy walked over to the bookshelf, picked out the Workshop copy of the Mullard Maintenance Manual and opened it at "ECC82". After briefly studying its contents he rummaged around in the cupboard under his bench and produced a spare multi-testmeter.

"I've nearly got this circuit finished," called out Dick, as he worked feverishly with his soldering iron.

Several minutes later Dick announced that the experimental circuit was complete. Smithy examined the wiring carefully.

"That's fine," he commended. "Now the Mullard gen I've just been looking up states that, with 250 volts h.t. and a 47kΩ anode load, each triode of an ECC82 gives a voltage gain of 13.5 at a cathode current of 3mA, and with a cathode bias resistor of 1.2kΩ. Under these conditions, therefore, the cathode bias voltage is 3.6 volts. The first thing to do with this circuit is to connect the grid of the left hand triode, which I've identified as V1(a), to chassis, and to adjust the 500Ω preset pot till the two cathodes are 3.6 volts above chassis. The total current in the two triodes should then be about 6mA, so that the 500Ω pot will require pretty well the same setting as it had in the 12 volt circuit."

PROOF OF THE PUDDING

Quickly, Dick coupled his testmeter between the cathodes and chassis, connected V1(a) grid to chassis, switched on the supply unit and waited for the ECC82 to warm up. As Smithy had predicted, the 500Ω potentiometer needed very little adjustment. Dick switched off the supply and looked expectantly at the Serviceman.

"We're on the last stage now," pronounced Smithy. "And that consists of finding out whether this darned thing works or not! Couple a voltmeter between each of the anodes and chassis, and add an input supply which will enable the grid of V1(a) to swing positive and negative of chassis. You can do this by first connecting two 6 volt batteries in series with their junction to chassis, and then connecting a pot of around 20kΩ across them with its slider to V1(a) grid." (Fig. 6).

"How do I know the voltage that will be going to that grid?"

"With the aid of this spare multitestmeter I've unearthed for you," replied Smithy, handing his assistant the instrument. "You'll have to change its leads over, of course, when the input goes from positive to negative and vice-versa. Our ordinary bench meters will do for the anode voltages. Since they're both of the same make and type,

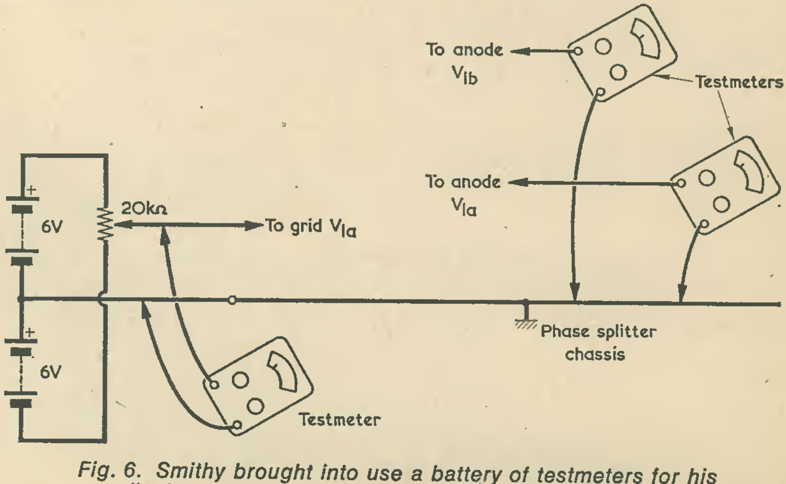


Fig. 6. Smithy brought into use a battery of testmeters for his final performance check of the phase splitter circuit

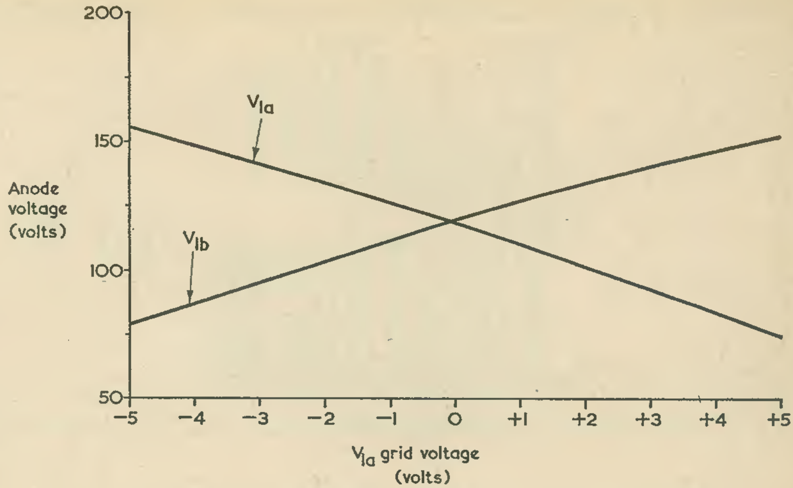


Fig. 7. Curves showing anode voltage of V1(a) and V1(b) of Fig. 5, plotted against V1(a) grid voltage

they'll offer the same loading on the circuit."

"This is becoming really interesting," remarked Dick. "Especially having all these meters in use."

"It *is* getting rather exciting," admitted Smithy, his usual phlegmatic manner deserting him as the moment of truth approached. "So let's get those extra bits wired up without too much delay."

It was not long before Dick had coupled up the additional components. As he completed the last connection, a suddenly impatient Smithy moved over and switched on the power supply. As he waited for the ECC82 to warm up, Smithy unclipped the meter monitoring the input voltage and set the 20kΩ input potentiometer to mid-travel.

Several seconds later the needles of the two anode voltmeters started to rise, both steadying after a moment at about 120 volts. With a shaking hand Smithy turned the spindle of the input potentiometer.

One anode voltmeter needle went up. The other anode voltmeter needle went down.

The elated Serviceman turned the input potentiometer in the opposite direction.

The first anode voltmeter needle went down. The second went up.

"That's it!" exclaimed Smithy jubilantly. "The circuit works *exactly* as I thought it would!"

"It certainly *seems* to be acting as a phase splitter," remarked Dick cautiously. "But are you completely sure that the two outputs have equal amplitude?"

"Well," said Smithy, "the needle swings of both meters certainly *looked* equal. However, we'll check that point by drawing anode voltage-grid voltage curves for these two triodes. I've got a spot of graph paper in the cupboard, so what you can do is to adjust that input pot in half-volt steps on either side of chassis potential up to, say, 5 volts each way. At the same time, call out the corresponding anode voltages."

SATISFACTION ASSURED

For the next quarter of an hour the Workshop did, indeed, take upon itself the rarified atmosphere of your actual Research and Development laboratory. Dick busied himself with his meters whilst Smithy plotted the readings on his graph paper. After the last reading had been taken, Smithy drew two lines through the points he had plotted and gazed at them with considerable satisfaction (Fig. 7).

"There you are, Dick," he said to his assistant, who had joined him after announcing the final reading. "Within experimental error, these two curves are almost exact mirror images of each other. So that circuit really *does* function as a high performance phase splitter. I see that for a grid voltage swing of 10 volts we get a change in anode voltage of about 70 volts, which means that each of those ECC83 triodes is giving a voltage gain of 7. Which ties in very nicely with basic theory, because this figure of 7 is just about half of the gain given by an ECC83 triode under normal voltage amplifier conditions."

Dick looked once more at the phase splitter circuit with the constant current transistor in the common cathode circuit.

"Do you know, Smithy," he remarked admiringly. "You really *have* produced something today."

"As this circuit stands," stated Smithy, "it is of main use for a.f. amplifiers and things like that. But there are a lot of other potential applications I've got in the back of my mind for this constant current long-tailed pair arrangement, and I'm going to look into these at a future date. For the moment, though, I'm satisfied. I suppose we'd better now cease these experiments and get down to a bit of the set repairing we're paid to do."

"Smithy," commended Dick warmly, "your talents are wasted here. I reckon you're a genius, mate."

Smithy acknowledged this praise with a modest dusting of the finger nails on the lapels of his overall jacket. Then, doffing his R and D cap and donning the more accustomed headgear of a service engineer, the Great Man turned back to the little transistor radio he had been working on before tea-break, and continued with the replacement of its noisy volume control. ■

DAYSTROM AT AUDIO FAIR

Daystrom Ltd., Gloucester will be exhibiting the latest Heathkit Hi-Fi stereo amplifiers, tuner-amplifiers, F.M. tuners, stereo 'compacts', loudspeakers, etc. A selection of these will be on demonstration in the Audio Studio on their stand.

New models this year include two stereo 'compacts' models AD–17 and AD–27. The AD–17 comprises a BSR MA65 turntable with Shure M44–MB magnetic cartridge and a 10 watt (rms) per channel stereo amplifier all mounted on a teak or walnut plinth. The AD–27 is similar but uses the MA70 turntable and includes an FM stereo tuner. In this case the 'plinth' is better described as a small cabinet. It has a 'roller shutter' lid and is available in teak or walnut.

A new loudspeaker has been added to the Heathkit range. The 'Ambassador' is a first class hi-fi loudspeaker. The cabinet comes ready assembled and finished in teak or walnut to match other current Heathkit equipment. It uses three loudspeaker units – a 12in. bass unit, a 5in. mid range and a small tweeter.

Radio Topics

By Recorder

SOME STORIES, EVEN THOSE CONcerned with electronic matters, have a sting in the tail. There is a particularly noxious sting at the end of the story which I am now about to relate and which deals with, of all things, the fitting of mobile radios to a city's buses.

As mentioned in News and Comment last month, by the time these notes appear, 37 of the Corporation buses in Coventry will be fitted with mobile radio installations to enable their drivers to keep in constant touch with a new traffic control centre in the centre of the city.

BUS INSTALLATION

The installation for each bus consists of the G.E.C. high power v.h.f. frequency modulated transmitter-receiver type RC/600. This equipment is fully transistorised except for the 20 watt power output and driving stages in the transmitter, which use "quick-heat" valves. The transmitter with its power supplies is housed in a single unit, mounted under one of the bus seats. The receiver and system controls are in a small unit, mounted in the driver's cab. The receiver itself can be withdrawn from its mounting and carried by the driver to keep him in touch with the base if he should have to leave his cab for any reason. The RC/600 provides an extremely flexible communication system, capable of working throughout the whole area of operations of the Coventry bus service.

The bus systems are augmented by eleven G.E.C. "Courier" v.h.f. pocket transceivers, these being employed by inspectors patrolling the routes and also by the management.

Why has all this equipment been installed? One of the reasons is that the communication system keeps the drivers in touch with the transport centre and enables them to increase overall efficiency by reporting breakdowns, accidents and traffic jams.

But that isn't the main reason. The main reason is that the bus installations provide a measure of protection for drivers against attack by the hooligans and thugs who infest so many of our cities these days. The question of driver protection is particularly important with the newer "pay-as-you-enter" buses, where the driver is completely on his own. It is anticipated also that the radios will enable vandalism to be reduced. So, yet again, we see public expenditure and time being spent in the fight against hoodlums and drop-outs.

I said that this story had a sting in its tail.

PROGRAM PATTER

Computers, in the intervals when they are not engaged in sending me a final reminder for the gas bill a fortnight after I've paid it, certainly seem to be very productive machines. They are not, however, directly responsible for the many colourful new terms which have now been added to our language by those who design, build and tend them. Such terms can be a little confusing when first encountered, and so I have compiled a short glossary of those which tend to appear most frequently in articles and news items devoted to computer technicalities. Some readers will, of course, be already familiar with these terms, but the definitions which follow may be helpful to others.

Alphanumerical system. A system which handles both alphabetical characters (i.e. letters) and numbers.

Bit. Short for "binary digit", e.g. 1 or 0.

Buffer store. An item of equipment which by means of data storage, enables a computer to be coupled to an input or output device when their operating speeds differ.

Data. The facts and/or figures fed to a computer or produced by a computer.

Data processing. The operations which process data for further use, for future reference or for revision of existing information.

Digital computer. A computer which processes figures directly (as opposed to an analogue computer which deals with quantities).

Hardware. The computer and its peripheral electrical, electronic and mechanical equipment.

Interface. An interface appears at the point of coupling between two equipments having different functions.

On line working. Applied to a computer coupled directly to data producing equipment, sometimes via a buffer store.

Peripheral equipment. The items of equipment coupled to, and operating with, the computer.

Program. A sequence of instructions which controls the processes carried out by a computer.

Real time working. Applied to a computer which deals with external events at the same time as they occur.

Software. The program.

Store. An item of equipment which can retain information for later retrieval. May also be referred to as a "memory".

Word. A sequence of binary digits processed as one group.

NEAT FINISH FOR PANELS

I am indebted to a reader, Mr. W. L. Brunsdon of Wallasey, Cheshire, for details of a very neat and convenient method of providing a protective finish for metal panels. Basically, the idea consists of applying a thin transparent adhesive film over the panel surface. The film employed is known as "Coverlon", is made by the manufacturers of "Fablon", and should be available at any good stationer's and, in particular, at any branch of W. H. Smith and Sons. The cost of "Coverlon" is only a few shillings for a piece measuring 13 by 36in., and it can be obtained in various colour tints or in neutral.

The panel to which the film is applied must first have its holes drilled, and it must be free from all blemishes since any marks will show through on the finished job. It must also be clean and well burnished, a requirement which is easily met with the aid of fine grade steel wool.

When applying the film to the panel, the main thing to bear in mind is to press and work from the centre, so as to ensure that no air bubbles are formed. The film must be well rubbed down. Overhanging film at edges and corners can be removed with a fine file or the abrasive side of a match box. Small holes can be pushed through with a match stick.

The film gives the finished panel an extremely attractive appearance, and further advantages are that it may be applied quickly, easily and cleanly, without all the fuss and mess which accompanies a painting job. Panel-Sign transfers can be affixed either under or over the film and impart a "professional" look to the completed panel. "Coverlon" is tough and durable, and it adheres very firmly to the surface to which it has been applied.

Mr. Brunsdon says that he has used the film on the panels of quite a lot of home-constructed equipment, and his friends have been extremely impressed by the results obtained. This is certainly an excellent idea to my mind, and my thanks are due to Mr. Brunsdon for passing along the details.

SWITCH RATINGS

Some years ago, whilst doing a little servicing work on a valve communications receiver, I bumped into a little resistor whose function puzzled me for a few minutes. This receiver had a wafer function switch which, on certain of its positions, short-circuited the a.g.c. line to chassis. The short-circuit was taken to a point along the a.g.c. line which was by-passed to chassis by a $0.1\mu F$ capacitor, and the receiver designer had seen fit to insert a 150Ω resistor between the switch and the capacitor.

After a while, light suddenly dawned on me. Without that resistor in series the switch would, of course, be applying a dead short across the $0.1\mu F$ capacitor whenever a.g.c. was switched out. The capacitor could, typically, be charged to some 15 volts and there would then be a small surge current when the switch contacts closed. The short-circuit surge current from a $0.1\mu F$ capacitor charged to 15 volts is hardly in the epoch-making bracket, but the set-designer had presumably considered it of sufficient importance to merit the inclusion of a series limiter resistor, with consequent increase in the useful life of the switch.

Which brings me to a topic that is not always fully appreciated by newcomers to radio, this concerning the current and voltage ratings quoted by switch manufacturers for their products. The current rating is, normally, either the maximum current which can be interrupted by the switch or the maximum current which can flow at the instant of closing, whichever is the greater. Usually, the current a switch can carry *after* it has closed and *before* it opens is significantly greater than the rated current. If current rating figures are exceeded the useful contact life of the switch will almost certainly be shortened.

The voltage rating of a switch is governed by the distance of contact separation, the rate at which the contacts separate, and the insulation employed in the switch.

The switch ratings quoted are normally for resistive loads. A capacitive load (like that a.g.c. capacitor in the communications set) causes a heavy initial current to flow when the switch closes. An inductive load can cause flashing across the switch contacts when they open, this being due to the high back-e.m.f. produced when the current in an inductor suddenly ceases. Both these points require attention when a switching circuit is being worked out for capactive or inductive loads.

Some purely resistive loads can be a little tricky, too. The best example here is given by the common or garden electric light bulb, whose filament has a much lower resistance when cold than when it has reached full temperature. The switch employed to turn the lamp on and off should be capable of switching on the current which flows in the *cold* lamp resistance.

Finally, a point about d.c. and a.c. ratings. These are normally specified with switches which are slow-acting or which have small contact separation when open, the a.c. ratings being higher than the d.c. ratings. This is because the arc which is formed when a d.c. circuit is broken stays maintained until contact separation is too great to sustain it. An a.c. arc, on the other hand, tends to cease when the voltage drops to zero on each half-cycle.

CHEERS FOR NOW

I see that I've once more come to the end of my allotted space so I'll say cheerio for the time being.

See you next month!

■

A SIMPLE COLOUR PRINTER

(Continued from page 159)

CONCLUSIONS

About 1,000 prints were made with the prototype model from a wide variety of negatives of the same make. The success percentage was about 80%. The instrument was simultaneously correcting both optical density and colour balance. Manual corrections were only necessary with negatives varying considerably from normal. The production rate achieved was about 40 prints per hour.

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ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks to Mr. Evangelos Rigopoulos for his invaluable assistance during design and construction of the instrument.

Also, thanks are due to Dr. K. Georgopoulos for helpful discussions on colour photography and Dr. D. Bersis for instructions in constructing the lens.

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3. Phillips Data Handbook "Components and Materials" part II, November, 1967.

■

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Continued from page 187

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Continued on page 190

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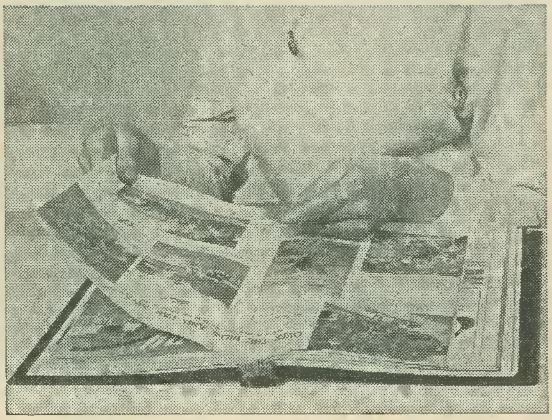

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The Table lists cubes of numbers from 1 to 100.

Number	Cube	Number	Cube	Number	Cube	Number	Cube	Number	Cube
1	1	21	9,261	41	68,921	61	226,981	81	531,441
2	8	22	10,648	42	74,088	62	238,328	82	551,368
3	27	23	12,167	43	79,507	63	250,047	83	571,787
4	64	24	13,824	44	85,184	64	262,144	84	592,704
5	125	25	15,625	45	91,125	65	274,625	85	614,125
6	216	26	17,576	46	97,336	66	287,496	86	636,056
7	343	27	19,683	47	103,823	67	300,763	87	658,503
8	512	28	21,952	48	110,592	68	314,432	88	681,472
9	729	29	24,389	49	117,649	69	328,509	89	704,969
10	1,000	30	27,000	50	125,000	70	343,000	90	729,000
11	1,331	31	29,791	51	132,651	71	357,911	91	753,571
12	1,728	32	32,768	52	140,608	72	373,248	92	778,688
13	2,197	33	35,937	53	148,877	73	389,017	93	804,357
14	2,744	34	39,304	54	157,464	74	405,224	94	830,584
15	3,375	35	42,875	55	166,375	75	421,875	95	857,375
16	4,096	36	46,656	56	175,616	76	438,976	96	884,736
17	4,913	37	50,653	57	185,193	77	456,533	97	912,673
18	5,832	38	54,872	58	195,112	78	474,552	98	941,192
19	6,859	39	59,319	59	205,379	79	493,039	99	970,299
20	8,000	40	64,000	60	216,000	80	512,000	100	1,000,000