THE
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RADIO · TELEVISION · ELECTRONICS · AUDIO

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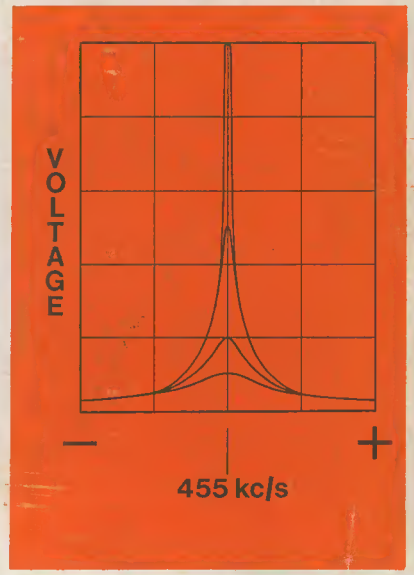

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3 NPN Germ. Trans. NKT773 Eqvt. AC130 ... ... 10/–
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2 OC73 Mullard Trans. 10/–
4 AC128 Trans. PNP High Gain ... 10/–
2 AC127/128 Comp. pair PNP/NPN 10/–
3 2N1307 PNP Switching Trans. ... 10/–
7 CG62H Germ. Diodes Eqvt. OA71 10/–
3 AF116 Mullard Type Trans. ... 10/–
12 Assorted Germ. Diodes Marked... 10/–
4 AC126 Germ. PNP Trans. ... 10/–
1 ORP61 Photo-conductive cell ... 10/–

4 Silicon Rects. 100 PIV 750mA ... 10/–
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7 OC81 Type Trans. 10/–
3 OC171 Trans. Mullard Type ... 10/–
3 2N2926 Sil. Epoxy Trans.... ... 10/–
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1 Sil. Power Trans. NPN100 Mc/s TK201A 15/–
6 Zener Diodes 3–15V Sub-min. ... 15/–
1 2N1132 PNP Epitaxial Planar Sil. Trans. 15/–
3 2N697 Epitaxial Planar Trans. Sil. 15/–
4 Germ. Power Trans. Eqvt. OC16 Mullard 15/–
1 Unijunction Trans. 2N2646 ... 15/–
2 Sil. Trans. 200 Mc/s 60Vcb ZT83/84 15/–
1 Sil. Planar Trans. NPN 100 Mc/s BSY25 ... ... 15/–
1 Tunnel Diode IN3720 (TD5) G.E.... 15/–
1 Unijunction Trans. 2N2160 TO-5 can G.E. 15/–
2 Sil. Rects. 5 A 400 PIV Stud Type... 15/–
2 Germ. Power Trans. OC28/29 ... 15/–
1 10 A Sil. Stud Rect. 800 PIV ... 15/–
1 Tunnel Diode AEY11 1050 Mc/s STC 15/–
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PIV	750mA	3A	10A	30A
50	2/–	3/–	4/6	9/6
100	2/3	3/6	6/–	15/–
200	2/6	4/6	6/6	20/–
300	3/–	4/9	8/–	22/–
400	3/6	6/–	9/–	25/–
500	4/–	6/6	9/6	30/–
600	4/3	7/–	10/–	37/–
800	4/9	8/–	15/–	40/–
1000	6/–	10/–	17/6	50/–

SCR's

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PIV	1AMP	7A	16A	30A
25	—	7/6	—	30/–
50	7/6	8/6	10/6	35/–
100	8/6	10/–	15/–	45/–
200	12/6	15/–	20/–	55/–
300	15/–	20/–	25/–	—
400	17/6	25/–	35/–	80/–
500	30/–	40/–	45/–	95/–
600	—	40/–	50/–	—

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μL 914 Dual Gate at 11/–
μL 923 J-K Flip Flop at 14/–
IC circuits data. etc. 1/6
Mullard TAA263
Lin Amp 21/–

PAK NO.

U1 120 Glass Sub-min General Purpose Germanium Diodes ... 10/–
U2 60 Mixed Germanium Transistors AF/RF 10/–
U3 75 Germanium Gold Bonded Diodes Sub-min Sim. OA5, OA47 10/–
U4 40 Germanium Transistors like OC81, AC128 ... ... 10/–
U5 60 200mA Sub-min Sil. Diodes ... 10/–
U6 40 Silicon Planar Transistors NPN Sim. BSY95A, 2N706 ... ... 10/–
U7 16 Silicon Rectifiers Top-Hat 750mA Vltg. Range 0–1000 ... 10/–
U8 50 Silicon Planar Diodes DO-7 Glass 250mA Sim. OA200/202 ... 10/–
U9 20 Mixed Volts 1 Watt Zener Diodes 10/–
U10 20 BAY50 charge storage Diodes DO-7 Glass 10/–
U11 30 PNP Silicon Planar Transistors TO-5 Sim. 2N1132 ... ... 10/–
U12 12 Silicon Rectifiers Epoxy 500-mA up to 800 PIV 10/–
U13 30 PNP-NPN Sil. Transistors OC200 & 2S104 ... ... 10/–
U14 150 Mixed Silicon and Germanium Diodes 10/–
U15 30 NPN Silicon Planar Transistors TO-5 Sim. BFY50, 2N697 10/–
U16 10 3 Amp Silicon Rectifiers Stud Type up to 1000 PIV 10/–
U17 30 Germanium PNP AF Transistors TO-5 like ACY17-22 ... 10/–
U18 8 6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV 10/–
U19 30 Silicon NPN Transistors like BC108 ... ... 10/–
U20 12 1.5 Amp Silicon Rectifiers Top Hat up to 1000 PIV 10/–
U21 30 AF. Germanium Alloy Transistors 2G300 Series & OC71 ... 10/–
U22 10 1 Amp Glass Min. Silicon Rectifiers High Volts 10/–
U23 30 MADT's like MAT Series PNP Transistors 10/–
U24 20 Germanium 1 Amp Rectifiers GJM Series up to 300 PIV ... 10/–
U25 25 300 Mc/s NPN Silicon Transistors 2N708, BSY27 ... ... 10/–
U26 30 Fast Switching Silicon Diodes like 1N914 Micro-Min. 10/–
U27 12 NPN Germanium AF Transistors TO-1 like AC217 ... ... 10/–
U28 Experimenters Assortment of Integrated Circuits, Untested. Consisting of Gates, Flip-Flops, Buffers, Registers, etc. in Flat-Pack & Dual-in-Line, 8 Assorted Pieces 20/–

Code No.'s mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

TESTED DEVICES

AC125	...	2/3	NKT78	...	5/6
AC176	...	5/6	OC44	...	1/9
AF139	...	10/–	OC45	...	1/9
AFZ12	...	10/–	ST140	...	3/–
BC107	...	5/–	ST141	...	4/–
BC108	...	5/–	2N696	...	4/6
BC109	...	5/–	2N697	...	5/–
BCY33	...	5/–	2N1090	...	4/9
BCY34	...	6/–	2N1306	...	4/–
BCZ10	...	5/–	2N2147	...	15/–
BCZ11	...	6/–	2N2894	...	8/–
BFY50	...	7/–	2N3819	...	15/–
BFY51	...	7/6	2N3820	...	25/–
BFY52	...	7/6	2S302	...	5/–
MAT100	...	3/–	2S303	...	4/–
MAT120	...	3/6	2S304	...	6/–
NKT773	...	4/–			

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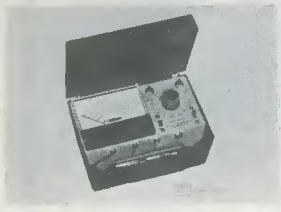
IM–17 **Kit £13.12.0** pp.6/–



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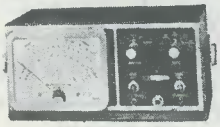

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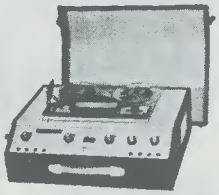

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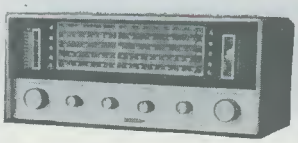

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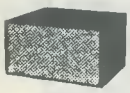

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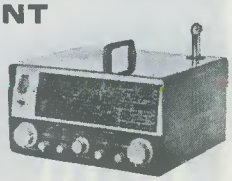

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AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160–10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage. Kit **£39.6.6** Ready-to-Use **£52.10.0** p.p. 9/–

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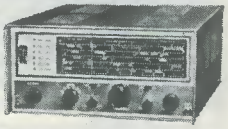

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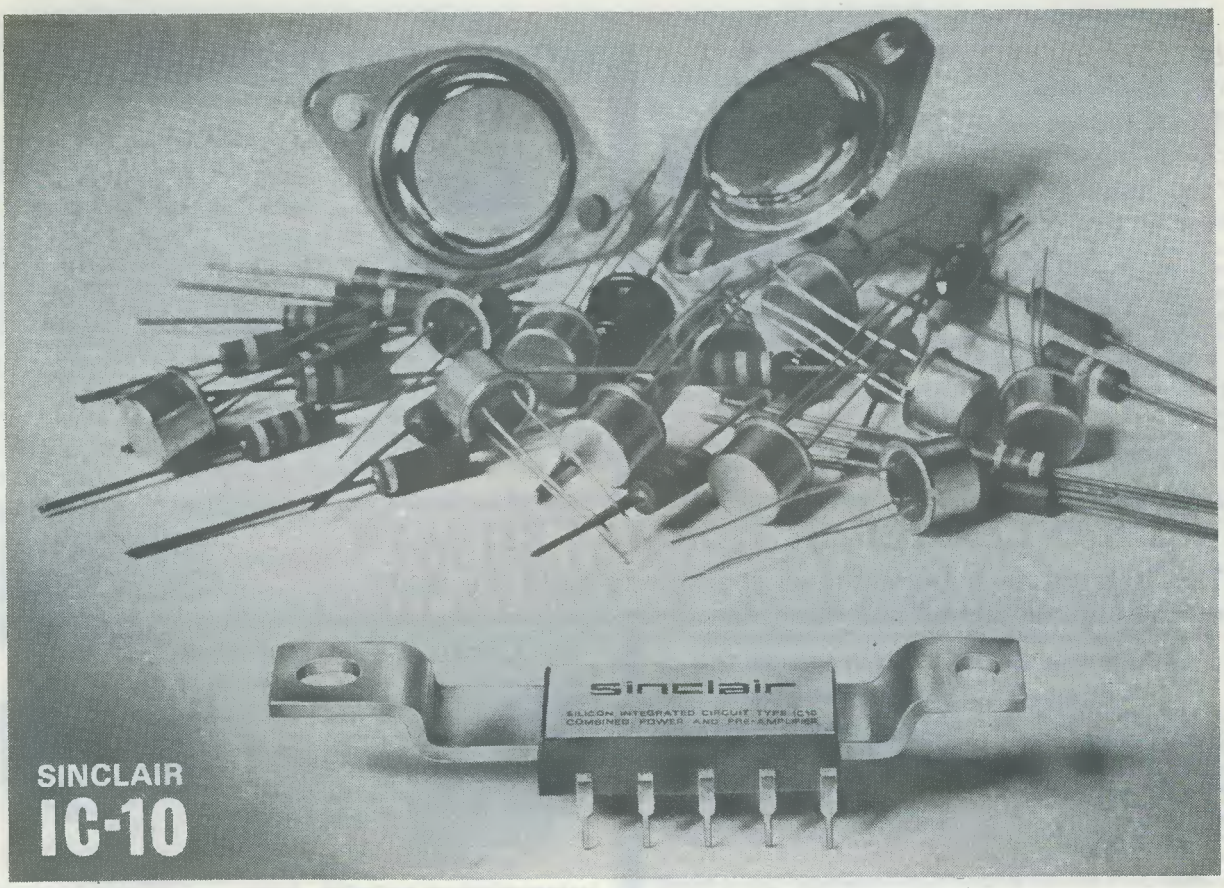

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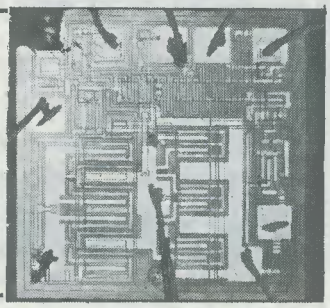
Supply voltage	8 to 18 volts
Size	1 x 0·4 x 0·2 inches
Sensitivity	5 mV
Input impedance	Adjustable externally up to 2·5 M ohms for above sensitivity

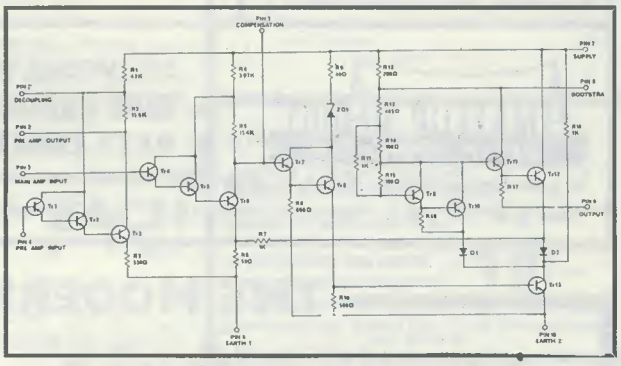
■

ABOVE SHOWS ACTUAL SIZE OF IC-10.
TO RIGHT, VIEW OF AMPLIFIER MAGNIFIED 625 TIMES.



■ Circuit Description

The circuit diagram of the 1C–10 is shown on the right. The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. The output stage operates in class AB with closely controlled quiescent current which is independent of temperature. A high level of overall negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages. Thus battery operation is eminently satisfactory.



■ Construction

The monolithic I.C. chip is bonded onto a gold plated area on the heat sink bar which runs through the package. Wires are then welded between the I.C. and the tops of the pins which are also gold plated in this region. Finally the complete assembly is encapsulated in solid plastic which completely protects the circuit. The final device is so rugged that it can be dropped thirty feet on to concrete without any effect on performance. The circuit will also work perfectly at all temperatures from well below zero to above the boiling point of water.

■ Applications

Each 1C–10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity uses. These include public address, loud-hailers, use in cars, inter-com, stabilised power supplies, electronic organs, oscillators, volt meters, tape recorders, solar cell amplifier, radio receivers.
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Three-Band 550–25 Metre Transportable Superhet

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This is an easy-to-build 3-valve receiver offering continuous coverage from 550 to 25 metres. Alignment and wave-band switching problems are minimised by the use of a ferrite rod aerial and a panel-mounted r.f. trimmer

BY USING A FERRITE ROD AERIAL WOUND FOR THREE bands and an extending telescopic aerial this receiver gives very good results without an external aerial. Coverage is approximately 550 to 25 metres, without gaps, as follows:

Band 1. 1,500–550 kc/s, or 200–550 metres, the usual "medium wave" band.

Band 2. 4.5–1.5 Mc/s, or about 65–200 metres, thus including shipping, 80m and 160m amateur bands, and other short wave transmissions.

Band 3. 12–4.5 Mc/s, or about 25–65 metres, for most long distance and general s.w. reception.

THE CIRCUIT

L_1, L_2 and L_3, shown in Fig. 1, are aerial coils, and the panel trimmer VC_3 allows the aerial circuit to be peaked up for maximum efficiency on all frequencies. The tuning drive is automatic 2-speed, and the scales are calibrated in frequencies. This gives convenient and easy tuning.

The oscillator stage is provided by the triode section of V_1, the appropriate coils (indicated as L_4 in Fig. 1) being

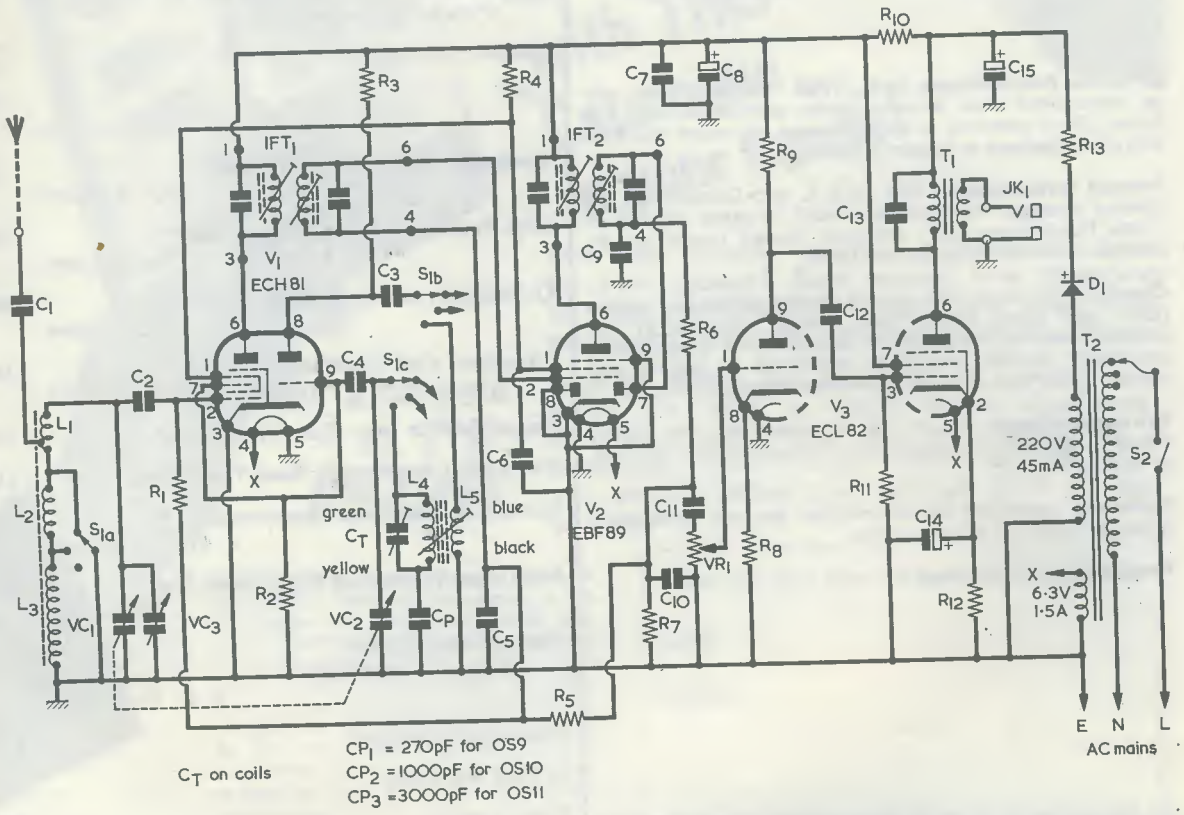

Fig. 1. The circuit of the 550 kc/s—12 Mc/s superhet receiver

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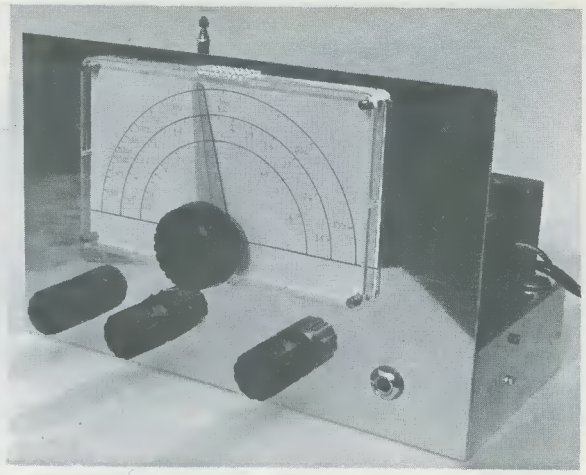
switched in by $S_{1(b)}$ and $S_{1(c)}$. There are three oscillator coils but, for simplicity of presentation, only one is shown in Fig. 1, the remaining coils having similar switching connections. Each oscillator coil is provided with its own integral trimmer, indicated as C_T, but requires an external fixed padding capacitor. The latter are listed as CP_1, CP_2 and CP_3. With the OS9 coil (1,500–550 kc/s) the black tag connects to chassis and the yellow tag to the padding capacitor, as shown in Fig. 1. The OS10 (4.5–1.5 Mc/s) and OS11 (12–4.5 Mc/s) coils have their black and yellow tags connected together, both being returned to chassis via the appropriate padding capacitor. These different methods of connection are clearly illustrated in the wiring diagram, which is discussed later.

The use of a ferrite rod aerial coil which has no coupling windings makes wavechange switching very straightforward. Some other parts of the circuit have also been simplified, without loss of efficiency. V_1 and V_2 have no cathode bias because there is no voltage delay on the a.g.c. circuit at V_2 diode, so bias is produced for V_1 and V_2 at virtually all signal levels. A small standing bias is also provided by "contact potential" in V_2 diode. A.G.C. is applied to V_1 via R_1. V_1 and V_2 have a common screen-grid supply by way of R_4, C_6 being the bypass capacitor.

The output stage gives excellent volume for a speaker,



The front of the receiver, illustrating the neat panel layout

COMPONENTS

Resistors

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

R_1	1MΩ
R_2	47kΩ
R_3	22kΩ 1 watt
R_4	22kΩ 1 watt
R_5	1MΩ
R_6	47kΩ
R_7	470kΩ
R_8	2.2kΩ
R_9	220kΩ
R_{10}	1.5kΩ 1 watt
R_{11}	1MΩ
R_{12}	330Ω 1 watt
R_{13}	100Ω 1 watt (see text)
VR_1	1MΩ potentiometer, log track, with switch

Capacitors

C_1	25pF ceramic or silver-mica
C_2	100pF ceramic or silver-mica
C_3	200pF silver-mica
C_4	50pF silver-mica
C_5	0.1μF paper or Mylar, 150V wkg.
C_6	0.5μF paper or Mylar, 350V wkg.
C_7	0.1μF paper or Mylar, 350V wkg.
C_8	32μF electrolytic, 350V wkg.
C_9	200pF ceramic or silver-mica
C_{10}	100pF ceramic or silver-mica
C_{11}	0.01μF paper or Mylar, 150V wkg.
C_{12}	0.01μF paper or Mylar, 350V wkg.
C_{13}	0.01μF paper or Mylar, 350V wkg.
C_{14}	25μF electrolytic, 25V wkg.
C_{15}	8μF electrolytic, 350V wkg.
CP_1	270pF silver-mica, 2%
CP_2	1,000pF silver-mica, 2%
CP_3	3,000pF silver-mica, 2%
$VC_{1,2}$	350 + 350pF, small 2-gang
VC_3	50pF variable. Type C804 (Jackson Bros.) or similar

Inductors

L_1, L_2, L_3	See text
L_4	Oscillator coils type OS9, OS10 and OS11 (Electroniques)
LFT_1	460 kc/s i.f. transformer type S1/DIF–1–46 (Electroniques)
IFT_2	460 kc/s i.f. transformer type S1/DIF–1–46D (Electroniques)
T_1	Mains pentode speaker transformer, ratio 45:1
T_2	Mains transformer; secondaries 220V at 45mA and 6.3V at 1.5A

Valves

V_1	ECH81
V_2	EBF89
V_3	ECL82

Switches

S_1	3-pole 3-way miniature rotary
S_2	s.p.s.t., part of VR_1

Rectifier

D_1	Contact cooled half-wave rectifier, 250V 50mA

Jack

JK_1	Phone jack

Miscellaneous

Slow motion dial type SMD2 (Electroniques)
3 knobs
3 B9A valveholders
Ferrite rod 8in by $\frac{3}{8}$in diameter, Cat. No. FR3 (Home Radio)
Telescopic aerial, 36in extended or as desired
3-way tagstrip
Chassis, 10 × 5 × 2in
Panel, 10 × 6$\frac{1}{2}$in

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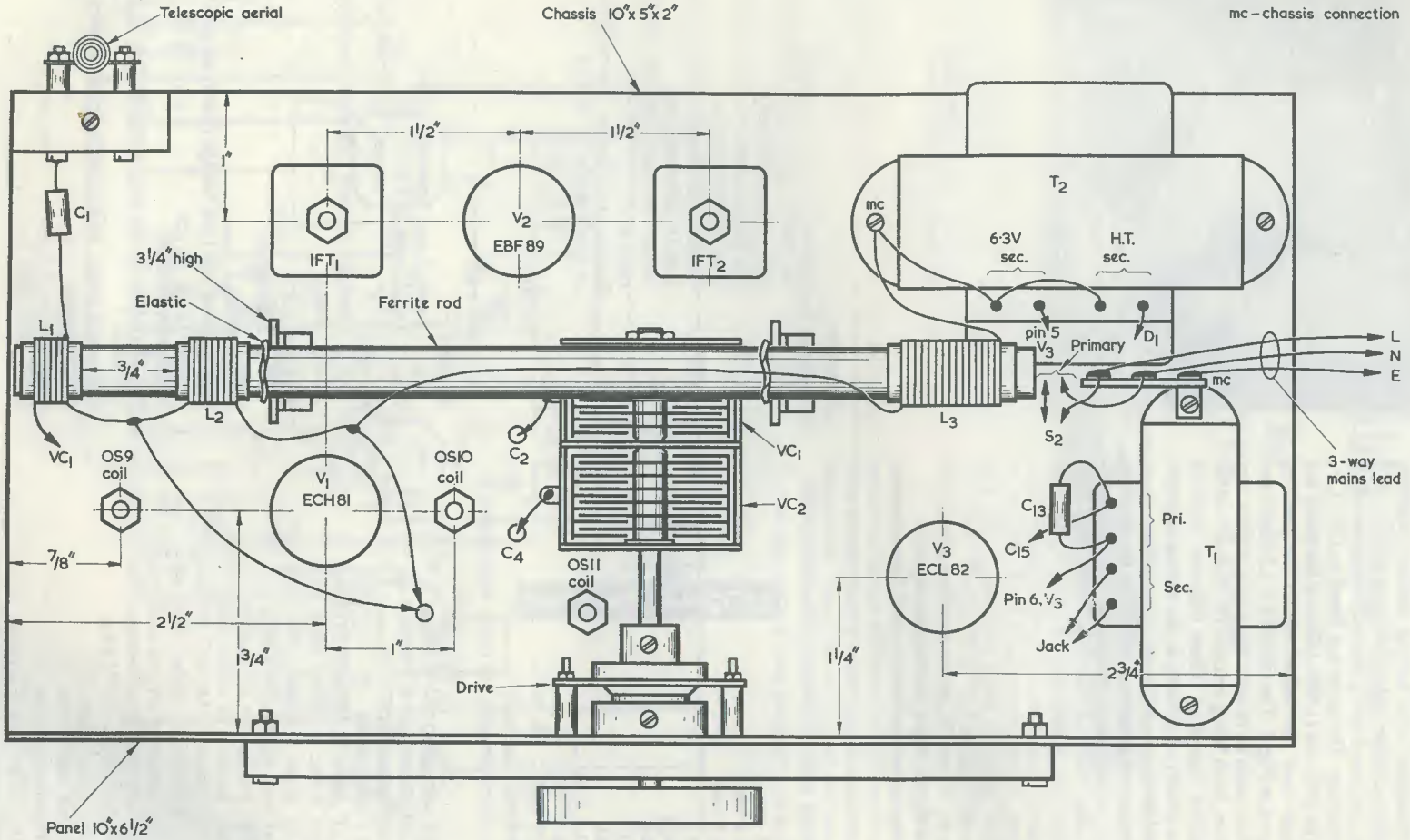

Fig. 2. The components and wiring above the chassis. The ferrite rod is secured on two vertical strips of Paxolin or similar material

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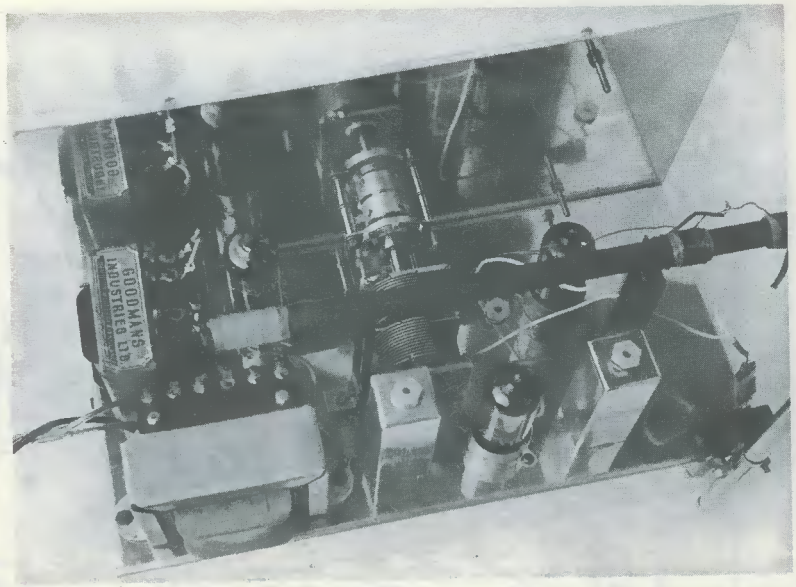

Top rear view of the chassis

but phones can be plugged in for personal listening, if desired.

A simplified power section incorporates T_2, which offers full isolation from the mains, and half-wave rectification is given by D_1 and C_{15}. Additional smoothing for the screen-grid of V_3 and earlier stages is provided by R_{10} and C_8. C_7 is a radio frequency bypass capacitor. V_3 requires only about 170 to 200V maximum for good results, and the actual working h.t. voltage, at about 175V, is lower than in most mains equipment. The performance is good even with an h.t. voltage of 150 or less.

PREPARING CHASSIS AND PANEL

The positions of valveholders and other items can be taken from Fig. 2, which also indicates the panel dimensions of 10 by 6½in. Valveholder and i.f. transformer orientation may be found from Fig. 3. All three valveholders have solder tags for chassis connections under their securing nuts. Each i.f. transformer requires seven holes—four to clear the tags, two for 6BA mounting bolts, and a central hole so that the lower core can be reached with a trimming tool.

Not shown in Fig. 2 are the holes in the chassis required for the leads to T_1 primary and secondary, the 6.3V and h.t. secondary leads from T_2, and the T_2 mains and switching leads to S_2. The positions of these holes depend somewhat on the dimensions and construction of the particular transformers employed and should be marked out and drilled accordingly. All chassis holes for the passage of wires should have rubber or p.v.c. grommets fitted to prevent lead insulation being in contact with the metal of the chassis.

The front panel is secured in place by the mounting nuts for the underchassis controls and jack (see Fig. 3 for positioning). For free, smooth tuning, the drive and ganged capacitor need to be lined up accurately. If necessary, $VC_{1,2}$ can be moved a little by elongating the chassis holes with a small file, or drilling large holes and placing washers each side.

A tagstrip anchors the three cores of the mains lead, green being Earth (to chassis). Neutral (N) connects to the transformer primary, whilst Line (L) connects to the primary via the switch, S_2. If a 13A mains plug is used, this may be fitted with a 2A fuse. The mains transformer will, normally, have taps in the primary for different mains voltages. If the transformer has insulated lead-outs for connection instead of tags, the primary tap lead-outs not required should be carefully taped up to ensure that there is no risk of these short-circuiting to the chassis or other components.

The tag positioning for T_1 and T_2 shown in Fig. 2 corresponds to the transformers used in the prototype. Other components may have different tag positioning (or may have lead-outs) and this point should, of course, be borne in mind when connecting these transformers into circuit. No specific make or type number is quoted for the two transformers as these should be generally available from a number of suppliers. A suitable transformer for T_2 is, for instance, available from Henry's Radio, Ltd.

The 6.3V winding of T_2 connects to chassis and all heaters. The h.t. secondary is connected to chassis and the rectifier, D_1. Mains and h.t. leads which pass through the chassis should be well insulated.

The primary of T_1 connects to the positive terminal of C_{15} and pin 6 of V_3. The secondary is connected to the panel jack for speaker or phones.

Bolts secure the telescopic aerial to an insulated block, which is in turn fixed to the chassis. If transportable working is not wanted, a wire aerial can be connected instead of the telescopic aerial.

FERRITE ROD WINDING

The ferrite rod is 8in long and ⅜in in diameter. Two strips of Paxolin or other insulating material 3¼in wide are cut and a notch to receive the rod is filed in the top of each. Small brackets mount the strips vertically. Elastic or string through a small hole holds the rod in place.

Gummed paper, or thin card coated with glue, is wound on the rod, making tubes for L_1, L_2 and L_3. These should be free to slide along the rod. The tube for L_1 is ½in long, that for L_2 ⅝in long, and that for L_3 1in long.

When the tubes are dry, coat each thinly with clear Bostik or a similar adhesive immediately before winding. During winding, each tube is placed on the rod itself, or on

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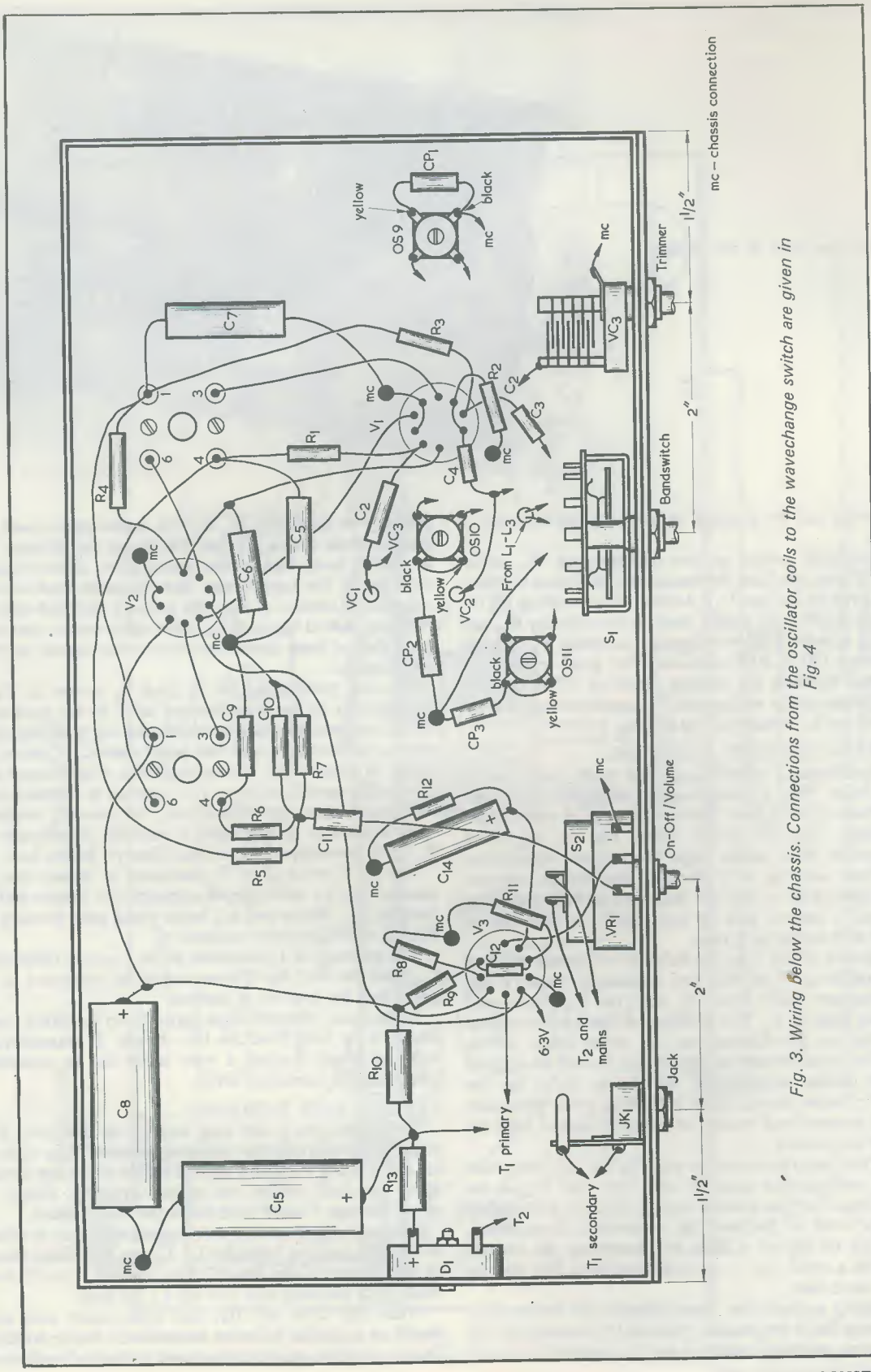

Fig. 3. Wiring below the chassis. Connections from the oscillator coils to the wavechange switch are given in Fig. 4

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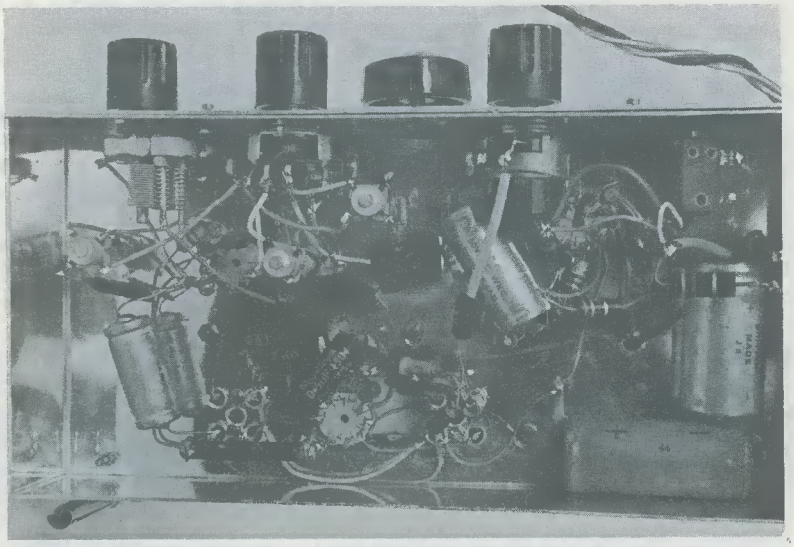

Wiring and components under the chassis

an object of similar diameter.

L_1 is 9 turns of 26 s.w.g. enamelled wire, wound side-by-side, the tapping for C_1 being 2 turns from the end which joins L_2. L_2 is similarly wound with 26 s.w.g. wire, but has 16 turns. L_3 is 60 turns of 32 s.w.g. silk covered wire, wound side-by-side.

Turns must be so wound that beginning at the VC_1 end of L_1, and continuing through L_2 and L_3 results in all turns being in the same direction.

With L_1 tube flush with the end of the rod, and L_2 tube $\frac{3}{4}$in away (see Fig. 2) trimming on the short wave bands should fall within the range of the panel control VC_3. This also applies on medium waves, with L_3 almost at the other end of the rod, as in Fig. 2. Further adjustment, to compensate for the variations in inductance to be expected with home-wound coils can easily be made as described later.

The heaters require just under 1.5A and, as already stated, suitable small transformers are readily available. For h.t. purposes, a 45mA 220V winding does well. When the heaters have reached full temperature, about 180V should be found across C_{15}, and a meter in the h.t. line immediately after C_{15} should indicate about 40mA. Some variation in h.t. voltage is not important, but if it exceeds 200V it is preferable that R_{13} be increased in value to reduce the voltage. The actual voltage depends on T_2 secondary resistance and the rectifier, as well as R_{13}.

As an incidental note, a 250V 30mA transformer has also been tried out and found satisfactory. In this case R_{13} was increased in value until h.t. current was 30mA, the h.t. line then being near 160V.

UNDER THE CHASSIS

Fig. 3 shows components and connections, and a few points here need explanation.

The oscillator coils OS9, OS10 and OS11 fit in $\frac{1}{4}$in diameter holes and each has its own trimmer, C_T, incorporated. These trimmers are adjusted from below with a screwdriver. The cores are rotated with a trimming tool from above the chassis. The coils are placed so that black and yellow lead tags take up the positions shown in Fig. 3.

Each coil has its own padder capacitor, 270pF (CP_1) for OS9, 1,000pF (CP_2) for OS10, and 3,000pF (CP_3) for OS11. The OS9 padder connects between yellow and black, the latter going to chassis. But, as already mentioned, the OS10 and OS11 coils have black and yellow tags joined, padders connecting from here to chassis.

When black and yellow tags have been wired as in Fig. 3, blue and green tags are connected to the switch as illustrated in Fig. 4. The leads to the OS10 and OS11 coils need to be short and direct. Switch S_1 is shown as 3-pole 3-way, but a 4-pole 3-way component with one section unused may be employed instead, if this is easier to obtain. In this latter case confirm, by visual inspection or with a continuity meter, the group of fixed contact tags which appear in each switch section.

Bandchange switching is actually very straightforward, but if any doubt is felt about this part of the circuit it is wise to initially wire in the OS9 coil only, with L_1, L_2 and L_3 in series connected across VC_1. Assuming that normal medium-wave reception is then obtained, the remaining oscillator coils can be connected up. This will help avoid errors in switch wiring.

The switch section, $S_{1(a)}$ short-circuits L_3, or L_2 and L_3, for the higher frequency bands. L_1, L_2 and L_3 are all in use, in series, for the medium-wave band.

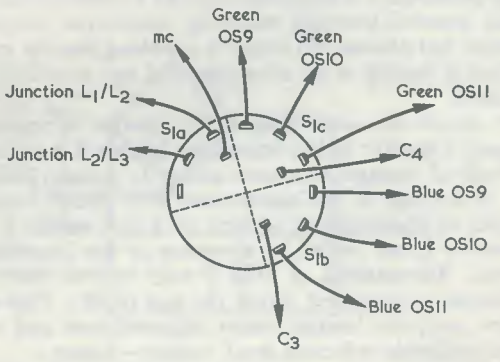

Fig. 4. The wiring to switch S_1. Leads to the OS10 and OS11 coils should be kept short and direct

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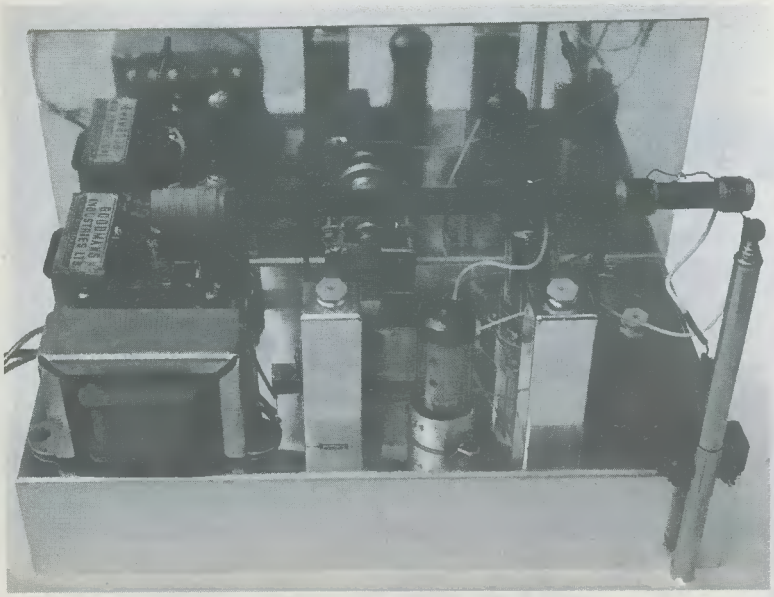

The completed receiver from the rear

The intermediate frequency transformers, IFT_1 and IFT_2, have numbered tags positioned as in Fig. 3. All tags must clear the chassis. Short pieces of sleeving may be placed on the tags to ensure this point, if desired.

The connections identified as "MC" are to solder tags bolted tightly to the chassis at the positions indicated. Many of these are provided under valveholder securing nuts.

Capacitor C_{12} should be a good, reliable component, as even very slight leakage here will upset bias conditions for the output stage. The rectifier is a contact-cooled type, bolted direct to the chassis.

SPEAKER AND PHONES

The speaker should have an impedance of 2 to 3Ω, and it needs a cabinet or baffle for satisfactory reproduction. A 3½in, 5in or larger speaker is better than a very small unit.

If phones are employed, there is an impedance mismatch, but T_1 still isolates the phones from h.t. circuits. The mismatch is less with low-impedance phones, and is usually disregarded because V_3 can supply very much more power than is normally required for headphones. A small, external low/high matching transformer between receiver and phones will improve matching, but the extra volume is usually of no advantage and can actually be a nuisance.

(It should be noted that, if the receiver is operated without a speaker or low impedance phones it is possible for high a.f. voltages to appear across T_1 primary, with a risk of damage to this component. The volume control should, in consequence, be kept at a low setting if T_1 secondary is not loaded by a speaker or low impedance phones. Alternatively, a 10Ω ½ watt resistor may be permanently connected across the tags of JK_1. This will ensure adequate loading under all conditions and will cause negligible reduction in a.f. output.—Editor.).

I.F. ALIGNMENT

For maximum sensitivity, the top and bottom cores of both IFT_1 and IFT_2 may need adjusting. Tune in any weak transmission which can be trimmed for maximum volume with VC_3. Then with the correct type of insulated tool carefully rotate each i.f. transformer core for maximum volume.

If a signal generator is to hand, this can be used in the customary manner. Place VR_1 near maximum volume, and reduce the generator output as needed for a low volume output from the speaker.

AERIAL AND OSCILLATOR

Provided VC_3 can be turned to a position which gives a quite sharp peak in volume, and is not then fully open or fully closed, maximum efficiency is obtained. However, some adjustment of the oscillator coils and trimmers (and possibly aerial coils) will allow most suitable band coverage, and will result in VC_3 having to be touched only occasionally for optimum reception of weak signals. VC_3 also compensates for changes in loading, such as is given by extending the aerial.

The medium wave band is most easily dealt with. Set the ganged tuning capacitor nearly fully open and rotate the OS9 coil trimmer to tune in a station near 200m (such as Luxembourg on 208m). Rotating VC_3 should bring volume up as described. Then tune towards the low frequency end of the band ($VC_{1,2}$ nearly closed) and move L_3 along the rod for best volume. If a known station or signal generator shows coverage is wrong, adjust the OS9 coil to correct this, and move L_3 as necessary for best results.

The same methods are used for Bands 2 and 3, but adjustments are more critical. If L_1 and L_2 are wound exactly as described, slight adjustment of the OS10 and OS11 cores and trimmers should provide suitable tuning coverage, with VC_3 capable of being peaked up for maximum sensitivity throughout each range.

The settings of VC_3 provide a guide to the adjustments needed in the oscillator circuit. If VC_3 needs to be nearly fully closed for best results, with $VC_{1,2}$ nearly open, the oscillator trimmer C_T of that range is at too high

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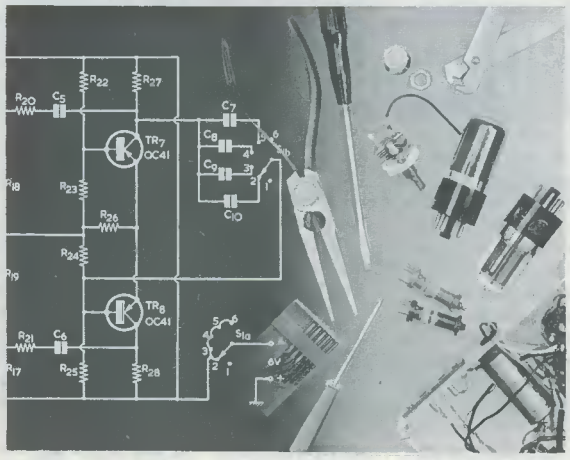
capacitance. At the low frequency end of a band, the necessity to have VC_3 nearly closed shows that the oscillator coil core for that band is too far in.

DIAL CALIBRATION

Blank scales on the dial are most easily calibrated by putting on the half cursor provided with the drive, so that pencil marks can be made along its edge. A signal generator is very convenient, because it can be set to various frequencies which are then tuned in and marked on the scale. Failing this, spot frequencies on various bands can be located by listening, and then marked.

The dial is afterwards taken off and finished neatly in ink or ball-point pen. A different colour for each band is helpful. The dial is then replaced, using the cursor having a centre line.

The blank scales have a numbered section, and this may be used to log transmissions, or to transfer readings to a graph. The latter will then provide readings for frequencies where no known stations are found, so that the dial can be completed without a signal generator.



SUGGESTED CIRCUIT No. 214

Two-Voltage Power Supply

by G. A. FRENCH

IN EQUIPMENT RUN FROM THE A.C. mains it is quite often desirable to power one or more of the stages at a potential which is approximately half the full supply voltage available from the rectifier. Typical instances are given in amateur transmitters, where the p.a. stage may be fed from the full rectified h.t. supply voltage whilst the v.f.o. and early modulation stages are run from a subsidiary supply at reduced voltage. Similar conditions can also exist in an a.f. amplifier whose power output stage requires a higher supply voltage than the preamplifier stages. In a communications superhet receiver it may, again, be desirable to have a reduced supply voltage available for application to a voltage stabiliser and, thence, to the local oscillator. Other applications of the same type will suggest themselves to the reader.

A common approach towards obtaining the reduced supply voltage is to incorporate a dropping resistor from the main rectified supply or, where better regulation is required, to connect a fixed potentiometer across the main supply rails, and take the reduced voltage from the junction of the two resistors which form this potentiometer. Both these approaches are, however, wasteful of rectified supply current. Also, if high voltages and/or currents are involved, it may be necessary to employ high wattage resistors to provide the reduced voltage, with consequent heat dissipation and loss of chassis space.

It is possible to obtain a reduced rectified supply voltage, at about half the voltage of the main supply, without employing any of the circuit devices just mentioned at all. Furthermore, this can be achieved at almost negligible cost in components. The only requirements are that a bridge rectifier be employed to give the full supply voltage, and that the mains transformer secondary feeding the bridge rectifier be provided with a centre-tap.

BASIC CIRCUIT

The circuit in Fig. 1 demonstrates the basic technique employed. T_1 is a mains transformer, and its full secondary connects to the bridge rectifier given by D_1 to D_4. This functions in normal fashion and a rectified voltage appears across reservoir capacitor C_2. The voltage on the upper plate of C_2 appears at the "+2" output terminal and (assuming no external load) its potential above chassis is equal to the peak value of the alternating voltage across the full secondary of T_1.

The circuit of Fig. 1, as described so far, represents a conventional bridge rectifier supply. However, Fig. 1 also shows an auxiliary circuit, this comprising capacitor C_1 together with a

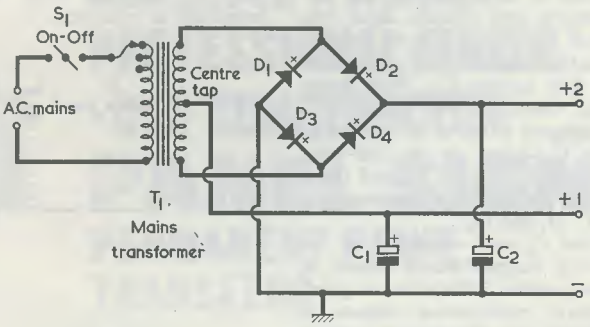


Fig. 1. The power supply, connected to give two outputs. That at the "+1" terminal has half the voltage of that at the "+2" terminal. Smoothing circuits, as required, follow the two output terminals

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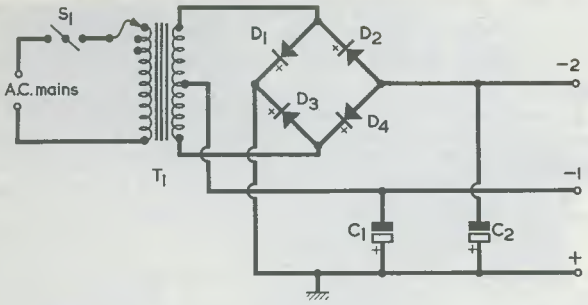

Fig. 2. The circuit of Fig. 1 rearranged to give negative outputs

connection into a centre-tap in the mains transformer secondary. As will now be explained, the rectified voltage across C_1 is exactly half the rectified voltage across C_2.

Let us consider circuit operation at an instant in the a.c. cycle when the upper end of T_1 secondary is at peak positive potential. Diodes D_2 and D_3 in the bridge circuit are then conducting, the latter diode virtually connecting the lower end of T_1 secondary direct to chassis. Half the peak positive voltage appears at the centre-tap of the secondary and is applied to the upper plate of capacitor C_1.

On the alternate half-cycle peak it is the lower end of T_1 secondary which is at positive peak potential whilst, this time, diodes D_4 and D_1 are conducting. Diode D_1 effectively connects the upper end of the secondary to chassis, and the centre-tap once more has a potential which is half the peak positive potential above chassis. Again, this potential is applied to the upper plate of capacitor C_1.

Thus, on alternate peaks, capacitor C_1 is caused to charge up to half the peak voltage across the mains transformer secondary. If a load is connected across C_1, causing the "+1" output voltage to drop below half the peak voltage across T_1 secondary, diodes D_1 and D_3 will conduct before voltage peaks, and will charge C_1 in the normal manner associated with a full-wave rectifier. If a further load is connected between the "+2" output and chassis, these two diodes will also commence to conduct as soon as the voltage from T_1 secondary exceeds that across C_2. With loads connected, therefore, both C_1 and C_2 receive charging pulses every half-cycle, those for C_1 being via the full-wave rectifier given by D_1 and D_3 and those for C_2 being via the bridge rectifier given by D_1, D_2, D_3 and D_4.

If C_1 and C_2 were omitted from the circuit, both outputs would consist of successive positive half-cycles, as given by full-wave rectification without a reservoir capacitor. The average voltage at the "+2" output would then be 0.9 times the full secondary r.m.s. voltage, and the average voltage at the "+1" output would be 0.45 times the secondary r.m.s. voltage. Should C_1 alone be omitted, the "+2" output becomes the peak value associated with a reservoir capacitor whilst the average output at the "+1" terminal continues at 0.45 times the secondary t.r.m. voltage. On the other hand, if C_2 alone is omitted, the average voltage on the "+2" output terminal is higher than 0.9 times secondary r.m.s. voltage because C_1 imparts some of its charge to the bridge circuit on each successive half-cycle. This last fact is applicable should it be intended to have the bridge rectifier output feed into a choke input filter instead of a reservoir capacitor. In such a case the full-wave output at the secondary centre-tap should also feed into a choke input (or resistor input) filter.

All the four diodes require a p.i.v. rating of greater than 1.4 times the r.m.s. voltage across the *entire* transformer secondary. This is, of course, the same rating as for normal bridge operation. The forward current in D_2 and D_4 is that flowing in the "+2" output and reservoir circuit only. The forward current in D_1 and D_3, and the current in the mains transformer secondary, is the sum of the currents in both the "+1" and "+2" outputs and reservoir circuits. Reservoir capacitors C_1 and C_2 require the values associated with the class or work for which the power supply is intended. Smoothing filters are not shown in Fig. 1 and these may be provided after the output terminals, as required.

The neat circuit trick of taking a half-output voltage from a centre-tap in the mains transformer secondary is not original to the writer, and acknowledgement is due to the German amateur radio journal *Das DL-QTC* in which the first saw this technique.[1]

APPLICATIONS

The circuit of Fig. 1 may be employed at any transformer secondary voltage, and the fact that the two outputs are positive of chassis makes it especially attractive for valve equipment. For fairly high output voltages, T_1 could be a transformer having an h.t. secondary voltage of, say 200–0–200, whereupon 400 volts r.m.s. becomes applied to the bridge. For lower power work the Radiospares mains transformer with a secondary voltage of 125–0–125 at 25mA (Home Radio Cat. No. TM39) is attractive. This last transformer could use an inexpensive contact-cooled bridge h.t. rectifier for D_1 to D_4.

Fig. 2 shows the same circuit as Fig. 1, but with output polarities reversed. This has been achieved by simply reversing the diodes and the two capacitors. The negative outputs may be more attractive for work with transistors, whereupon T_1 can have a low voltage centre-tapped secondary. Heater transformer secondaries can be improvised here or use made of a specific low voltage transformer such as the Electroniques Code No. P.9004, which has a secondary voltage of 6–0–6 at 80mA. Such low voltage secondaries can also be used to give positive outputs employing the circuit of Fig. 1.

A slightly different configuration is shown in Fig. 3. Here, the reservoir capacitor for the bridge circuit (previously C_2) is now given by C_3 and C_4 in series, whilst the half voltage output reservoir capacitor (previously C_1) is now given by C_3 on its own.[2] In this circuit each capacitor requires a working voltage of half the "+2" output, and this is an advantage if the "+2" voltage is high, as can occur with a transmitter. The two outputs in Fig. 3

[1] Karl Troster, DJ6JF, "Eine Interessante Netzgleichrichterschaltung", *Das DL-QTC*, May, 1968.

[2] This circuit was that given in *Das DL-QTC*.

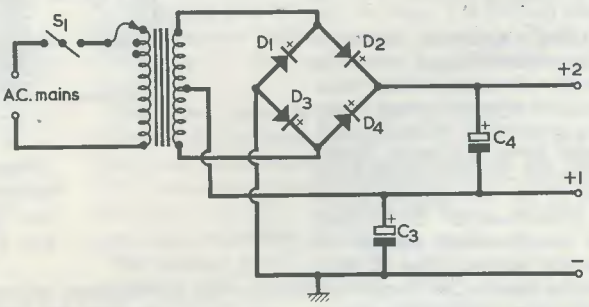

Fig. 3. An alternative method of connecting the reservoir capacitors

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are positive of chassis. They may be made negative by transferring the chassis connection to the positive plate of C_4, whereupon a full negative voltage becomes available at the negative plate of C_3, with half the output voltage available at the centre output terminal.

A final point is that it is important to ensure, in all three circuits, that the secondary centre-tap is a *true* centre-tap, and to avoid using a mains transformer whose secondary has a tap which is some way from the winding centre. Such a circumstance would occur if a transformer with a secondary having a tap near the centre (but not intended as a centre-tap) were pressed into service. If the secondary tap is too far removed from the winding centre, relatively heavy charge and discharge currents can flow in the half output voltage reservoir on successive half-cycles, and may cause this component to become overheated.

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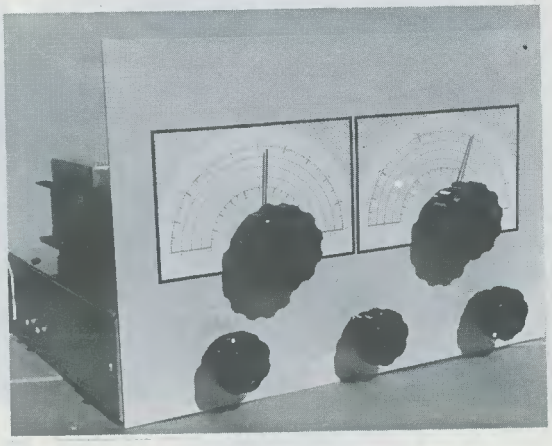

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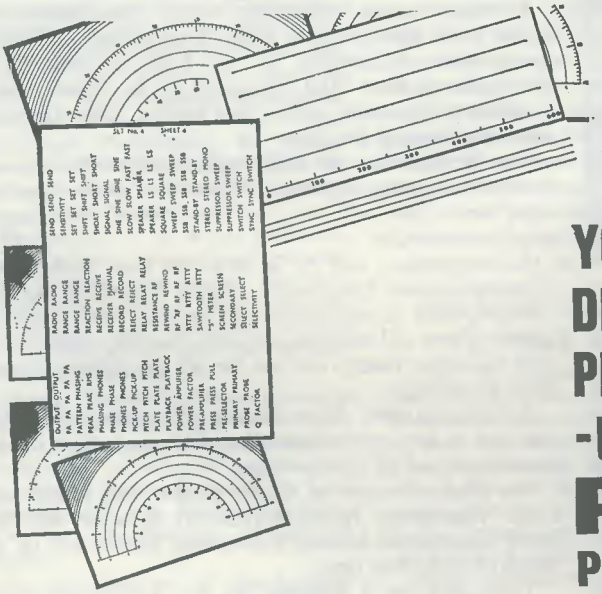

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Publicity for Amateur Radio

We visited the amateur radio station, GB2LO, operated by the Radio Society of Great Britain during the 1968 City of London Festival at a site in front of the *Daily Mirror* Building in Holborn.

Arriving in the early morning before the station was officially open, gave the writer the opportunity of chatting with Sylvia Margolis, the energetic Public Relations Officer of the R.S.G.B., about this new venture.

There is no doubt that the kindness of the *Daily Mirror* and the Festival authorities in helping and allowing the R.S.G.B. to operate GB2LO gave the society a unique opportunity to present amateur radio to the public at large. Sylvia Margolis was obviously determined that the society should take full advantage of this opening.

One or two points she made about the way to present an attractive image of amateur radio to the public are, we think, worth passing on.

Interested bystanders looking and listening to GB2LO – Photo by courtesy of the *Daily Mirror*.

Firstly, the station must be operated in a manner that will interest the man in the street, therefore it would be a mistake to use c.w. Also the public are not particularly attracted by a conversation between the operator and a local amateur (after all they may feel they can do the same by inserting 6d. in a telephone coin box), but they will probably be keenly interested in hearing a contact being made with an amateur thousands of miles away. The operators must be presentable in appearance, and a general impression of friendly efficiency given.

The foregoing considerations may seem elementary but they can be easily overlooked.

There was no doubt in the mind of the writer, as he made his way across Holborn Circus through the gathering spectators listening to the station's p.a. system, that this new venture was a success, not to be measured solely in the number of new adherents gained to the hobby but also in the increase of public interest in the ideals and needs of amateur radio.

Another venture in publicity for amateur radio, in Canada this time, can also be reported upon.

During a recent visit to Winnipeg, Manitoba, one of our editorial team was agreeably surprised to find a demonstration of amateur radio being staged by local radio amateurs in one of Winnipeg's largest shopping centres known as The Mall. He lost no time in introducing himself as a British radio amateur and was able to learn at first hand a little about the hobby in that part of Canada.

The countryside around is, for the most part, flat wheat growing country extending right to the horizon without an obstruction of any sort. It was not surprising therefore to learn that much of the local activity was on v.h.f. V.H.F. mobile operation is extremely popular and is their equivalent of our Raynet, particularly so as it is very common for farmsteads and small communities to be cut off by snow in winter time. Dx working on the lower frequencies was losing its popularity due to TVI caused by the many TV channels in use.

Private aircraft are a favourite form of transport and amateur radio v.h.f. mobile activity is used by those amateurs owning such aircraft. There are a growing number of flying enthusiasts in Winnipeg and they were also staging a publicity drive at the same shopping centre. To judge from the crowds making enquiries at both stands it appears that both private flying and amateur radio are likely to have considerable support in the near future.

Finally we come to amateur radio's showpiece in this country, the International Radio Engineering and Communications Exhibition to be held at the Royal Horticultural New Hall, Greycoat Street, Westminster, London, S.W.1. from 2nd to 5th October, 1968. Here are some preliminary details:—

For the first time the Diplomatic Wireless Service will be exhibiting, showing some of their latest communication equipment. They will also be responsible for the centre stage presentation.

An innovation will be a series of four lectures on 'Communication Equipment', 'Single Side Band (s.s.b.)', 'Aerials', and 'Communication Research and Developments'. These will take place on the Thursday and Friday, with Saturday being reserved for all the Armed Forces general meetings.

A Manufacturers' Silver Plaque will again be awarded outright to any new outstanding communication equipment displayed for the first time.

The Radio Society of Great Britain will feature the Radio Emergency Network (RAEN) at work, and the latest constructed Mobile Operations Room will be on display for the first time.

There will be a competition for home-constructed equipment for which silver trophies will be awarded, also the Organiser's Silver Plaque for 1968 and additional prizes.

The opening will be supported by the Armed and Radio Services, and international invitations to the Exhibition will be on a wider scale than ever before.

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COMMENT

THE ROYAL TELEVISION SOCIETY

Formed in 1927, The Royal Television Society has for over 41 years played a major part in acting as a discussion ground in many aspects of television. Now a new sphere of activity – the field of educational technology – is being added to the Society's work.

A special Royal Television Society seminar entitled 'Television in Educational Technology – what is its role?' is being held in London on October 11th 1968 at 3 p.m. The seminar will include the following speakers: Guthrie Moir (Rediffusion Television Ltd.), Professor J. Black (UGC Committee on Educational Technology), J. C. Wykes (ILEA), G. Sattin (Eothen Films), Dr. R. C. G. Williams (ICETT), Dr. Gerald Vaughan (Guy's Hospital), E. Stones (Birmingham University).

Admission is free to both members and non-members of the Royal Television Society. Applications for tickets should be made to The Secretary, The Royal Television Society, 166 Shaftesbury Avenue, London, W.C.2. Tel: 01–836 3330/3788.

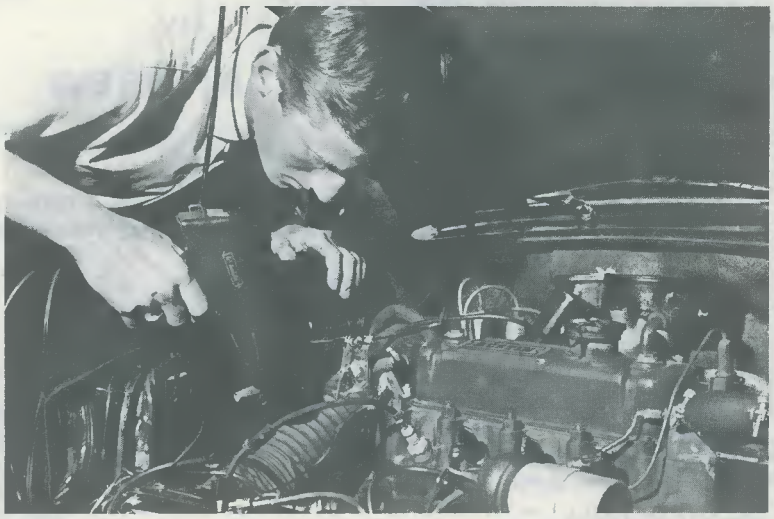
An Educational Television and Technology Committee has been set up to plan the first year's activities. The chairman is Dr. P. D. Whitaker (University of Birmingham) and the other committee members are: M. H. Cox (ABC Television), I. Gilman (BBC), B. Groombridge (ITA), G. Moir (Rediffusion Television Ltd.), T. Neil (Thomson Foundation Television College), J. Ware (Ware MacGregor Partnership), D. Whittle (David Whittle Associates), Professor R. Warwick (Guy's Hospital Medical School), J. M. Wright (ICETT).

Membership of the Royal Television Society will now be open to educationalists, lecturers, professors, teachers, educational television organisers, administrators, local education officers, Service instructors, industrial training officers and students.

The aim is to enable common problems of educational technology to be discussed in the open and neutral forum which the Society can provide. Educationalists, programme producers, engineers and administrators will, for the first time, have an all-enhancing professional Society.

The full facilities of the London secretariat of the Society and its eight centres in Bristol, Cardiff, Devon and Cornwall, Leicester, Manchester, Midlands, Northern Ireland and Nottingham, will be available to further the aims of the new members.

All enquiries to:
The Royal Television Society.



Checking engine ignition timing with the Knight Stroboscopic Timing Light KG-371. The KG-371 is one of the many "Knight-Kit" construction kits now being marketed in the UK and Europe exclusively by Electroniques (prop STC Ltd.). "Knight-Kits" are easy to assemble kits which enable anyone, regardless of their technical knowledge, to assemble professional standard apparatus. Taking only about one hour to assemble the KG-371 is suitable for 6V or 12V car battery operation – without any adjustment – and checks the operation of manual and vacuum automatic advance and retard ignition systems.

TELEPHONING BY LIGHT BEAM

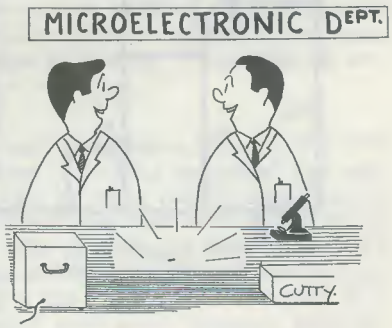
A portable telephone recently produced by Britain's Associated Electrical Industries uses a beam of light instead of wires. In a BBC scientific programme, Noel Ernst of A.E.I. explained that this new short-range communications system will be very useful on building sites, making it possible to speak to the top of a building from the ground without having to lay cables. It can also be used in surveying, enabling surveyors to speak to each other across a river without the expense of a radio telephone and the formalities of a frequency allocation. Technically, the new system is a modulated light source, the filament of a lamp being modulated by the voice. At present the range is just over a mile but research engineers hope to extend this very soon.

COLOUR CODING OF FLEXIBLE CABLES

H.M. Government have decided to make regulations under the Consumer Protection Act requiring the core colours of three-core flexible cords fitted to domestic electrical appliances, when offered for sale in Great Britain, to comply with the following international coding recently agreed by most of the countries in Europe:

Green-and-yellow striped core Earth
Brown core .. .. .. Live
Light blue core .. .. Neutral

Up to a date to be specified in the new statutory regulations, it will be admissible as an alternative to offer for sale appliances having cords in accordance with the British coding at present specified in the IEE Wiring Regulations.



"We're on to something BIG here Dodsworth!"

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SHORTED TURN TESTER

by

A. N. DREW

A sensitive test instrument which employs non-critical transistors, and which functions on readily understood principles

HAVING CONSTRUCTED SEVERAL COILS WHICH PROVED unsatisfactory due to short-circuits between turns, the writer decided to make a simple shorted turn tester. The result is described in this article and has proved to be both reliable and sensitive in use.

CIRCUIT DETAILS

The circuit of the tester is given in Fig. 1. In this diagram, TR_1 is an oscillator for which the tuned circuit is given by L_1 and the series combination of C_1 and C_2. Coil L_1 is wound on one end of a ferrite rod, over which are passed the coils to be tested.

The supply to TR_1 is stabilised by zener diode D_1, whilst control of oscillation is provided by R_5. This potentiometer is set up such that TR_1 is just oscillating.

The oscillator voltage at TR_1 collector is passed, via C_3, to TR_2, which functions as an emitter follower. This transistor is inserted in the circuit to minimise the load on the oscillator. The output from TR_2 is next passed to TR_3, which amplifies as a common emitter transistor.

The signal appearing at TR_3 collector is next applied to diodes D_2 and D_3, these being connected in a voltage doubler circuit. The rectified voltage from these diodes is

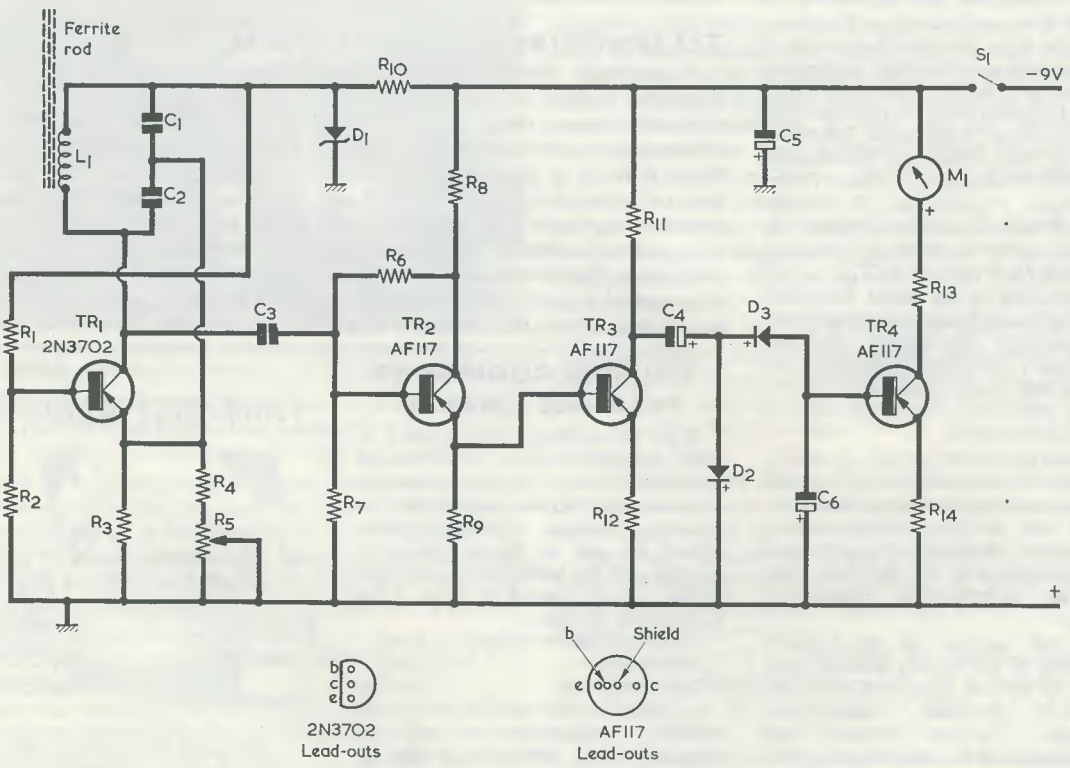

Fig. 1. The circuit of the shorted turns tester

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COMPONENTS

Resistors
(All fixed values $\frac{1}{4}$ watt 10%)

R_1	15kΩ
R_2	1.5kΩ
R_3	1kΩ
R_4	470Ω
R_5	1kΩ potentiometer, linear
R_6	150kΩ
R_7	47kΩ
R_8	100Ω
R_9	1kΩ
R_{10}	470Ω
R_{11}	5.6kΩ
R_{12}	560Ω
R_{13}	see text
R_{14}	820Ω

Capacitors

C_1	0.068μF paper or plastic foil
C_2	0.0068μF paper or plastic foil
C_3	0.1μF paper or plastic foil
C_4	1μF electrolytic, 6V wkg.
C_5	100μF electrolytic, 10V wkg.
C_6	1μF electrolytic, 6V wkg.

Inductor

L_1	see text

Semiconductors

TR_1	2N3702
TR_2	AF117
TR_3	AF117
TR_4	AF117
D_1	5.6 volt zener (OAZ201, etc.)
D_2	OA81 or similar
D_3	OA81 or similar

Meter

M_1	0–100μA to 0–1mA moving-coil

Switch

S_1	s.p.s.t. on-off

Miscellaneous

Ferrite rod, 3in × $\frac{1}{4}$in dia.
9-volt battery
Knob (for R_5)

finally applied to TR_4, which feeds the meter.

When TR_1 is oscillating the rectified voltage from D_2 and D_3 causes TR_4 to pass a relatively high collector current. When TR_1 ceases to oscillate (as would occur if a shorted turn were placed over the ferrite rod) there is no rectified voltage from D_2 and D_3, and TR_4 passes negligible current.

COMPONENTS

In the writer's version, TR_1 was a 2N3702, whilst TR_2, TR_3 and TR_4 were AF117's. However, these last three transistors may be any p.n.p. types, silicon or germanium (provided, in the case of germanium, that they exhibit low leakage current). The transistor in the TR_1 position must be silicon because, with germanium transistors, varying junction temperatures cause backlash in the control exerted by R_5 to become excessive. The writer used a 2N3702 here, but any other similar silicon type should be

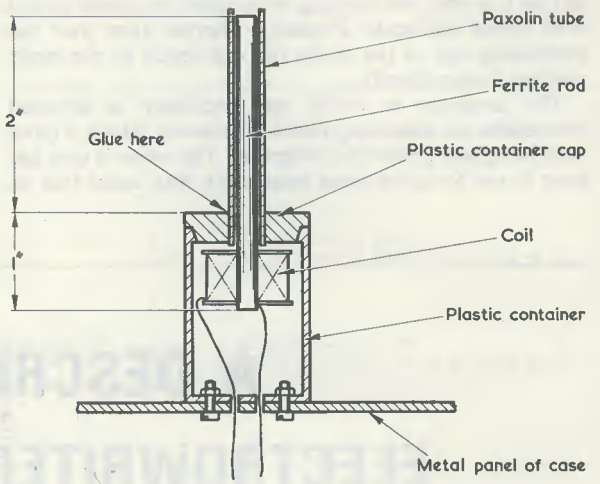

Fig. 2. Cross-sectional view showing how the coil and ferrite rod are mounted. Any conveniently sized circular household plastic container and cap may be used for the assembly

quite satisfactory. All the transistor types specified in the diagram were used because they happened to be on hand. The shield lead-outs of the AF117's were left unconnected.

D_1 is a 5.6 volt zener diode, and the maximum current it could be called upon to pass in the circuit is of the order of 7mA. Any small zener diode, such as the OAZ201, may be used here. D_2 and D_3 are germanium diodes.

It must be possible for potentiometer R_5 to cause the oscillator to stop running as its slider is advanced since, otherwise, the tester cannot be brought to its most sensitive condition. With some transistors in the TR_1 position it may be necessary to adjust the value of R_4 to enable R_5 to cover the required range. An alternative method of controlling the oscillator could consist of connecting a potentiometer of around 1kΩ across the zener diode, the supply for TR_1 being taken from its slider. This idea has not been tried by the writer, but is presented as a basis for experiment.

The meter M_1 may have any full-scale deflection between 100μA and 1mA. Resistor R_{13} has to be found experimentally, and it should have a value which prevents the meter from reading more than f.s.d. when the oscillator is running at full amplitude. The meter current should be a few microamps only with the oscillator stopped. In some cases it may be helpful to adjust the value of R_{14} to ensure that a wide difference in readings is given for the two oscillator conditions.

THE COIL

Coil L_1 uses the basic construction shown in Fig. 2. It consists of 3,800 turns of 30 s.w.g. enamelled wire pile-wound at one end of a $\frac{1}{4}$in ferrite rod 3in long. The coil should be positioned well away from metal objects, which will give the same effect as a shorted turn. The writer's tester is assembled in an Eddystone diecast box measuring $4\frac{7}{16} \times 2\frac{7}{16} \times 1$in, with the coil mounted externally in a plastic housing which gives good clearance from the metal case. The protruding section of the ferrite rod is protected by a Paxolin tube.

In use, the tester is switched on and the oscillator is set

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so that it is only just running, whereupon the meter should read about half-scale. Placing a shorted turn over the protruding end of the ferrite rod will result in the meter reading falling sharply.

The accuracy to which the oscillator is adjusted determines the sensitivity of the instrument, which is more than adequate for normal purposes. The writer's unit has been in use for quite some time and it was found that its operation was quickly mastered, the sensitivity being such that it can detect a sixpenny piece held 1½in from the end of the ferrite rod.

(Editors Note. If M_1 is a 0–100μA meter, start with a value of around 90kΩ for R_{13}, reducing as required for the final reading. For a 0–1mA meter, a suitable starting value for R_{13} is around 9kΩ.).

A DESCRIPTION OF ELECTROWRITER INSTRUMENTS

The Electrowriter can be briefly described in the following way:—One writes with a ball-point pen on regular paper as on a note pad, and as the pen is moved, the remote receiver(s) instantaneously and faithfully reproduces the copy, as it is written. No extraneous power supplies are required. The instruments are self-contained and fully transistorised.

Electrowriter instruments can be attached to a telephone system, permitting alternate written messages and voice service. Messages between electrowriter stations will pass automatically through a dial exchange, in the same manner as telephone calls.

Electrowriter instruments can also be used in any combination over G.P.O. leased or customer-owned lines of any distance with or without associated telephone sets.

Unlike true facsimile equipment that can be referred to as reproducting equipment (photo-scanned reproduction) of original data, the Electrowriter is an electro-mechanical pantograph, giving the facility that one can write to other points by remote control. This is done by creating two frequencies transmitted down a pair of wires compositely, one of which is governed by a horizontal movement and the other by vertical movement, thus giving a true analogue device, unlike a teleprinter which relies upon single pulses, (therefore a digital device).

A receiving unit has a mechanical response to a varying frequency on the line. The input is filtered in such a way that it splits the composite signal into two distinct frequencies each of which is then able to operate the vertical and horizontal pantograph motors, which in turn operates the pen. The action of the pen nib is achieved by the frequency modulation of one channel. This is then detected and converted into pure d.c. to operate a solenoid which, by mechanical linkages causes the pen to touch paper. This sequence of events is touched off at the transmitter, by the operation of a gravity switch within the stylus and thereafter by a spring loaded plunger which operates the pen-down mechanism.

The receiving machine is inactive until a signal appears at the input, thus operating a squelch relay and bringing the whole machine into the receive condition. As both vertical and horizontal frequencies 1310–1490 c/s/2060–2340 c/s are within the voice bandwidth, it is then obvious that whenever voice reception is possible this system will operate. Therefore we now have a machine which can transmit written messages or sketches to any point, however distant, over telephone or radio circuits.

Appropriate signal lamps are provided to indicate power on, transmit or receive conditions, and busy line conditions.

The Electrowriter is considered to be one of the most viable methods of communications for both industry and commerce available on world markets today. Electrowriter instruments are manufactured by Modern Telephones (Great Britain) Ltd. – a member of the Shipton Automation Group.

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CUT ALONG THIS LINE

RC/DS/13

RADIO CONSTRUCTORS DATA SHEET 13

PARALLEL-R, SERIES – C TABLE

The Table gives the total resistance of two resistors in parallel, or the total capacitance of two capacitors in series, for 20% preferred values from 1 to 100. Use appropriate multipliers: thus, 3.3MΩ in parallel with 15MΩ gives 2.7MΩ, or 47pF in series with 22pF gives 15pF. All results to 2 significant figures.

	1	1.5	2.2	3.3	4.7	6.8	10	15	22	33	47	68	100
1	0.50	0.60	0.69	0.77	0.82	0.87	0.91	0.94	0.96	0.97	0.98	0.99	0.99
1.5	0.60	0.75	0.89	1.0	1.1	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.5
2.2	0.69	0.89	1.1	1.3	1.5	1.7	1.8	1.9	2.0	2.1	2.1	2.1	2.2
3.3	0.77	1.0	1.3	1.7	1.9	2.2	2.5	2.7	2.9	3.0	3.1	3.1	3.2
4.7	0.82	1.1	1.5	1.9	2.4	2.8	3.2	3.6	3.9	4.1	4.3	4.4	4.5
6.8	0.87	1.2	1.7	2.2	2.8	3.4	4.0	4.7	5.2	5.6	5.9	6.2	6.4
10	0.91	1.3	1.8	2.5	3.2	4.0	5.0	6.0	6.9	7.7	8.2	8.7	9.1
15	0.94	1.4	1.9	2.7	3.6	4.7	6.0	7.5	8.9	10	11	12	13
22	0.96	1.4	2.0	2.9	3.9	5.2	6.9	8.9	11	13	15	17	18
33	0.97	1.4	2.1	3.0	4.1	5.6	7.7	10	13	17	19	22	25
47	0.98	1.5	2.1	3.1	4.3	5.9	8.2	11	15	19	24	28	32
68	0.99	1.5	2.1	3.1	4.4	6.2	8.7	12	17	22	28	34	40
100	0.99	1.5	2.2	3.2	4.5	6.4	9.1	13	18	25	32	40	50

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RECENT PUBLICATIONS

AMATEUR RADIO CIRCUITS BOOK. Compiled by G. R. Jessop, C.Eng., M.I.E.R.E., G6JP. 119 pages, 5½ x 8¾in. Published by the Radio Society of Great Britain. Price 10s. 6d.

More than 180 individual circuit diagrams appear in this book, each being accompanied by sufficient text to enable any home constructor of reasonable experience and ability to build the circuit and bring it into operation. Layout and mechanical assembly diagrams are provided where essential, but in most cases it is the circuits themselves which tell the story. Some circuits are for a single or double stage, whilst others are for a complete equipment.

There is an exceptionally wide range of subjects, these including aerial matching units, receiver pre-amplifiers, converters, i.f. filters, detectors, noise limiters, transmitters, modulators, amplifiers, power supplies and test gear. The variety is so great, indeed, that it is impossible to attempt a complete list here. Suffice it to say that, as one reads through the book, one encounters such things as f.m. modulators, s.s.b. modulators, an electronic key, grid dip oscillators, a varactor tripler for 432 Mc/s, and two reflectometers. As is to be expected, some of the circuits will provide most assistance to the amateur transmitting enthusiast but the book will still be of considerable interest to the home constructor and experimenter as well. In either field it certainly offers excellent value for money.

This is the second edition of "Amateur Radio Circuits Book", and is an enlarged and revised version of the first, 1964, edition. It may, if desired, be obtained direct from R.S.G.B. Headquarters, 28 Little Russell Street, London, W.C.1., at 11s. 6d. post paid.

RADIOISOTOPE EXPERIMENTS FOR SCHOOLS AND COLLEGES. By J. B. Dance, M.Sc. 212 pages, 5 x 7¾in. Published by Pergamon Press, Ltd. Price 27s. 6d. (hard cover) or 17s. 6d. ("Flexi-cover").

The author of this book is well known to regular readers of *The Radio Constructor*, and we have in the past published a number of articles from his pen on the general subject of radioactivity. In the present work, Mr. Dance devotes himself mainly to the student, teacher and lecturer; although anybody interested in radioisotope work can profit from the book.

"Radioisotope Experiments for Schools and Colleges" gives a description of all matters dealing with radioactivity, introducing the experiments referred to in the title when the preceding explanatory text has given the reader sufficient information to appreciate their usefulness. Careful stress is placed upon the health factor and the special precautions which have to be observed when working with radioisotopes in educational establishments. A feature which will be of particular help to the teacher is that suitable manufacturers are quoted for particular items of equipment, and that attention is drawn to the Government regulations involved in handling radioactive materials.

This is a very useful book which well deserves to become a standard text-book in its field.

TAPE RECORDING. By C. N. G. Matthews. 128 pages, 5½ x 8½in. Published by Museum Press, Ltd. Price 20s.

This book, intended more for the lay owner of a tape recorder than for the veteran electronic or recording engineer, deals simply and concisely with all the main requirements which have to be observed if optimum results are to be obtained with a recorder under domestic conditions. The first seven chapters give a clear general description of the electrical and magnetic processes involved in recording and reproduction, starting with the nature of sound and working through to equalising circuits. A following chapter then discusses microphones and loudspeakers.

The next three chapters give lucid advice on tape recorder operation, the subjects dealt with including story dramatisation (with a sample script for a play), sound effects, tape splicing, editing, "trick effects" such as the deletion or transposing of words and phrases, and recording production. These are followed by a chapter on elementary tape recorder servicing and a final short chapter describing specific commercially available recorders.

"Tape Recording" offers plenty of useful common-sense advice for the newcomer as well as for the more experienced user who wishes to learn more about the possibilities offered by his machine.

STEREO HANDBOOK. By G. W. Schanz. 135 pages, 8½ x 5¾in. Distributed by Iliffe Books Ltd. Price 16s.

This book is in the Philips Paperback series, and has been translated from the German by J. V. Randeraat. Whilst it covers no new ground it does provide, within two covers, a detailed summation of all the more important principles of stereophony. It is aimed mainly at the technician and the stereo enthusiast, and the approach is essentially non-mathematical.

Subjects covered at the start of the book include stereo sound fundamentals, room acoustics, and stereo recording and reproduction. A long section of the book then deals with stereophonic transmission and reception, giving particular emphasis to the pilot tone system. The remainder of the book describes the testing of stereo a.f. equipment and decoders, with a final chapter devoted to test equipment.

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Q S X

by L. SAXHAM

(All times GMT)

A report on the stations – both amateur and broadcast – that may be logged by the s.w.l. on the various short wave bands; compiled by a Dx'er whose QTH is located near the S. Suffolk coast.

●Topic

In the world of the short wave listener there are, generally speaking, two main types of operator. The first, and largest group, is composed of those are interested in listening on the Amateur bands almost exclusively. The second group is made up by those who primarily operate over the Broadcast bands and are relatively small in number. There does happen to exist, however, an even smaller band of enthusiasts who cover both fields of operation and it is the writer's opinion that more s.w.l's should endeavour to become interested in both types of operation – Amateur and Broadcast – if the full enjoyment of short wave listening is to be savoured.

The Broadcast bands operator has a much more difficult time than his Amateur band counterparts and this is the probable reason why he is in the minority. To be anything like successful he must be equipped with an *accurately* calibrated communications receiver fitted with a crystal filter or a Q multiplier, a high-gain and stable preselector, a frequency measuring standard (100kc/s crystal, and preferably with a 10kc/s multivibrator), and graph charts of bandspread dial readings against frequencies. Additionally, a knowledge of transmission schedules and the recording of the continually changing station frequencies and a smattering of some languages are required. Furthermore, to be a 'top flight' operator (of which there are several) a tape recorder is almost a necessity if the rapidly spoken S. American station announcements are to be 'put on ice' for later identification where this is difficult at the time of operation. Last but not least, he must have endless patience. Should any amateur band s.w.l. like to have a try at the broadcast stations, a list of possible targets is included under the appropriate section.

●Amateur Bands

With the sunspot cycle at its near maximum, there is plenty of Dx to be heard by those who can spare the time for operating. As usual, 14Mc/s s.s.b. produced the most varied selection of Dx as may be seen below.

21 Mc/s

CW: PY2DN, 2OU, 2RT, TA2BK and 5Z4LE. These were logged in one short session on this band.

14 Mc/s

CW: CR6AI, 6AL, CX1OP, 2AM, JA5VQ, PY1CNQ, 6ABD, 7APS, 7NJ, VK7RX, ZS6JK. SSB: CP6HJ, CR6HN, 6LI, EL8J, HI3ELJ, HK0BKW, HK3RQ, 5BFA, HV3SJ (Vatican), KZ5NH, LU6AHI, MP4DAT, OD5BFA, PY1HX, 2ALI, 4AH, 7VKZ, TG7KJ, 9AG, TI2RSR, 2W, VK3AUH, 3JM, 3JS, 4LA, 6FD, 7WH, VP7NP, YS1FQM, YV1EC, 5AA, 5AMP, 6EX, 6GL, XE4PW, 4A1MZ, 1TTS, 5Z5KL and 9L1KZ.

7 Mc/s

Very little time is spent on this band by the writer except for the occasional Sunday morning sessions listening to the semi-locals. The commercial intruders continue to provide unabated QRM but despite this, Dx is there for those who operate at night or early mornings – especially on c.w. One late night session on c.w. *did* provide W4RAE and PY1DDY.

1·8 Mc/s

Among other considerations, Dx is relative to the band in use and 'Top Band' can provide some very good results – especially when summer static is absent.

CW: GI3AOB, 3OQR, 3PDN, GM3FSV, 3OXX, GW3REQ, 3UMB, 3VPL, 8PG, OH2VO, OK1ARZ, 1IDK, 1ISK, 1SM, 2AOP, 2MW, 2OU, 3CIT/1, OL1AJM, 1AKG, 4AJF, 6AIU. SSB: GW3BAC, 3MSY, 3TMH, 3UDJ, 3UMB, 3UTD, 3VPL, 3VYF, PAØPN.

●Broadcast Bands

Like the amateur bands, some of these frequencies have shown a marked tendency to produce Dx signals of late. This is particularly so if one is interested in the smaller powered S. American stations that are very often difficult to log. For these stations, a listening watch should be kept during the small hours. An example of this was the reception of HCWE1 on 4685kc/s at 0230 with station identification "R. Nacional Espejo la primera y mas potente emisora del pais". Situated in Quito, Ecuador, this station verifies by QSL card.

4790 0414
YVQN Ondas Portenas, Venezuela, with Ident. and Latin American music.

4880 2045
Kinshasa, Congo Dem. Rep. – with light music.

4880 0310
YVPA R. Yaracuy, S. Felipe, Venezuela-with rhumbas.

4881 0504
HIJP R. Commercial, Santa Domingo, Dominican Rep. – with Ident. and closing with N. Anthem.

4890 0304
YVKB R. Dif, Caracas, Venezuela – with Latin American music. Caracas is the capital city and is located 8 miles inland from its port of La Guaira. Alt. 3,000ft.

4923 0435
HCRQ1 R. Quito, Ecuador – with Latin American Music.

4955 0350
HJCQ R. Nacional, Colombia – with song programme.

4995 0345
ZYX9 R. Brazil Central, Brazil – with Latin American music.

6000 0400
YVNL R. Miranda, Caracas, Venezuela - with chimes and Ident.

6060 0435
LRA31 Beunos Aires, Argentina – with Latin American music.

6140 0015
HJNE Radio El Sol, Cali, Colombia – with Ident. Cali is the main town of Valle de Cauca province of Colombia and is situated on the Cauca river, exporting coal and copper. Pop. 160,000.

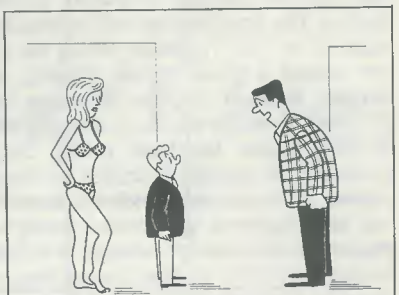
6540 2000
Pyongyang, N. Korea – with programme in English.

●Now Hear This

7106 2245
Thai TV Co., Bangkok – with programme in vernacular. SINPO 33343. Bangkok, capital of Thailand, is a seaport on the Menam river some 20 miles inland. Main exports are rice, tea and teak.

●Last Look Round

Reader – "What's all this SINPO 33343 business"? Answer – "We'll be dealing with this as the Topic next time round – November issue.



"You fool—not a model—a module."

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DESIGNING WITH INTEGRATED CIRCUITS

by
P. WILLIAMS

One of the difficulties of employing integrated circuits in home-constructor applications is, of course, the fact that each integrated circuit type is intended for its own specific purpose only. In this article our contributor discusses an approach which enables integrated circuits to be used for functions other than that for which they were designed, and describes experiments carried out with the Fairchild μL900 buffer amplifier. It must be emphasised that some of the techniques described here may result in the risk of damage to the device concerned, and that they should only be used by readers who understand the principles involved and are prepared to accept the risk.

PERHAPS THE TITLE OF THIS ARTICLE IS A MISNOMER SINCE only one integrated circuit is to be considered. What it is hoped will emerge is an attitude of mind that gets most out of i.c.'s—if at all possible more than the manufacturer put in. To do this it is not enough to merely read the manufacturer's data sheet since this gives only the information that is important for the original task. In addition, the other parameters of the circuit must be scrutinised for clues to alternative applications. It may be that going just outside a manufacturing limiting value in a controlled manner gives a valuable characteristic that can be used.

A good example, for single devices, is the use of the base-emitter junction of planar transistors as reference diodes. The specification will normally give a maximum value of reverse V_{be} below which the leakage current will not exceed a given figure. Forcing a somewhat larger current through the p-n junction in the appropriate (reverse) direction results in a stable voltage usually some 20–50% above the limit rating. No damage is done provided the current is limited by some series resistance chosen in conjunction with the supply voltage. Thus, as was just suggested, the device is being used in a controlled manner outside one of its limits. A strong word of warning is necessary here: if, due to exceeding a rating, damage is done to a circuit don't blame the manufacturer—or the writer.

Interested readers will find a great deal of information from the makers of operational amplifiers on the many and diverse functions they can perform by combining such amplifiers with suitable input and feedback networks. The i.c. versions are still relatively expensive (a dangerous statement likely to be outdated before publication) so this has been taken as the excuse for tackling a digital circuit instead.

It should be realised that the emphasis throughout this article is on novel applications of a circuit designed for a single basic function. In every case a better result could be obtained from a specifically designed unit, whether conventional or i.c. Any choice would then revolve around the usual questions of cost, simplicity, flexibility, etc. For the individual designer the benefits from unorthodox approaches are the stretching of the mind and the increasing familiarity with the limitations of his chosen circuits. In the writer's opinion, these outweigh the extra effort involved in the initial design.

Integrated Buffer Circuit

Consider the circuit shown in Fig. 1. It is a buffer circuit type μL900, part of a series intended for logic operation from a supply voltage of 3.6V. The manufacturers specify such characteristics as noise immunity, speed, fan-out capability, etc., for such circuits. Looking at it through the eyes of, say, an intelligent student without prior knowledge of its intended function, we would see a common emitter input stage driving an emitter follower. The emitter follower has a transistor as load, also controlled by the input, whose

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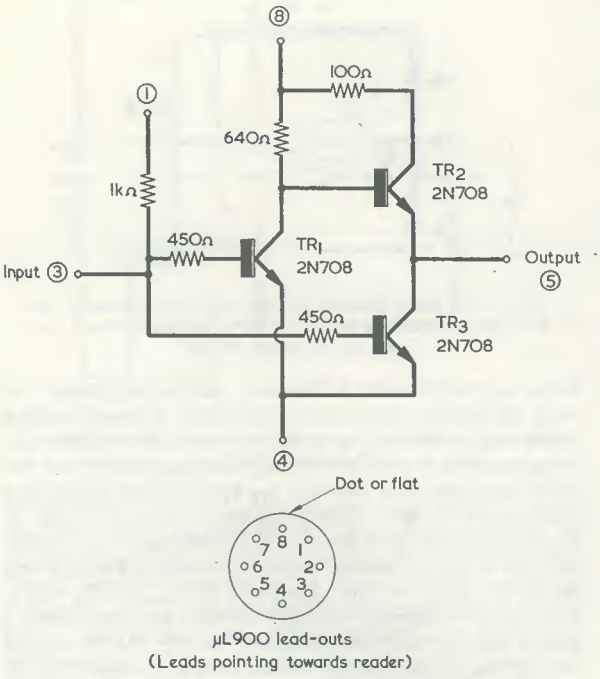

Fig. 1. The internal circuitry of the Fairchild µL900 buffer integrated circuit

current demand falls as the input voltage falls, i.e. as the output voltage rises. More current will be released for any external load, just when it is most needed, and we might reasonably expect a slightly lower output impedance than from the emitter follower alone. Because there are two similar transistors in parallel at the input, the input impedance and current gain will both be roughly halved. All these points we might expect an unprejudiced observer to deduce. If, instead, we consider the reactions of a circuit designer, then we move forward to possible applications. Naturally a designer working on digital circuits will recognise it as a circuit eminently suited for "buffering" the output of say, a flip-flop for feeding into multiple gates. Someone used to analogue circuits, either from the audio or video fields, would probably see it immediately as a "d.c. feedback pair", only minus the feedback and plus an extra transistor. Such is the ability of the mind to recognise familar patterns in the presence of unfamiliar detail. A typical example of the basic circuit is shown in Fig. 2, and most manufacturers of integrated circuits have used similar designs to produce wide-band amplifiers. Equally the circuit has always found favour with audio designers, its applications ranging from tape-head preamplifiers to audio mixers.

Video Amplifier

To take the more obvious of the linear applications first, the µL900 is illustrated again in Fig. 3 with the appropriate coupling and feedback elements. Under the conditions in Fig. 3 the circuit can offer a power gain of 16dB and a frequency response as shown in Figs. 4 (*a*) and (*b*). The original intention was that it should form part of a matched 75Ω video distribution system, but the presence of a limiting 100Ω resistor in the collector of TR_2, which is not accessible, reduces the maximum efficiency for such loads. None-the-less, the very wide bandwidth makes it an attractive circuit for low-power video and pulse amplifiers. Bandwidth can be traded in for increased gain in the usual way by decreasing the negative feedback. It would not be easy to construct a discrete-components version without degrading the high frequency performance through stray capacitance (and possibly series inductance?). Thus, at quite low cost we have a wide-band amplifier with a very respectable performance.

The video amplifier was checked at a supply potential of 10V without apparent damage to the integrated circuit. An r.f. bypass capacitor was connected directly across the supply leads to the circuit. (To reiterate the statement in the introduction to this article, readers employing the integrated circuit at supply voltages higher than those specified by the manufacturer must be prepared to accept the risk of possible damage to the device.—EDITOR).

Voltage Regulator

A very different aspect of the circuit is used to make it perform its second suggested function, that of a voltage regulator. The base-emitter voltage of TR_1 is proportional to the natural logarithm of its collector current over wide ranges of current. To a first approximation this current will have a linear dependence on supply voltage and so the base potential of TR_1 changes much more slowly than does the supply. Unfortunately, the impedance at the base of TR_1 is not particularly low and no appreciable power can be withdrawn. Fig. 5 indicates how a potential divider network ensures that the output voltage is a direct multiple network ensures that the output voltage is a direct multiple of this base-emitter voltage provided that the divider current is much greater than the base current of TR_1.

then, $V_{out} \approx \frac{R_2+R_1}{R_1} V_{be}$. By the chosen ratio of resistors in this chain we may obtain any output voltage down to V_{be} as a minimum and somewhat less than supply voltage as a maximum. (For the author's experiments, R_2 was the internal 1kΩ resistor in the i.c.).

The output impedance is now that of the augmented emitter follower previously described, further appreciably enhanced by the negative voltage feedback due to the potential divider. Temperature drift remains an important feature of the circuit's imperfections, and will again be determined primarily by that of the base-emitter voltage of TR_1. This is close to —2mV/°C in 600mV, i.e. a little over —0.3%/°C. Used in typical laboratory environment with temperature swings less than 10°C, the change in

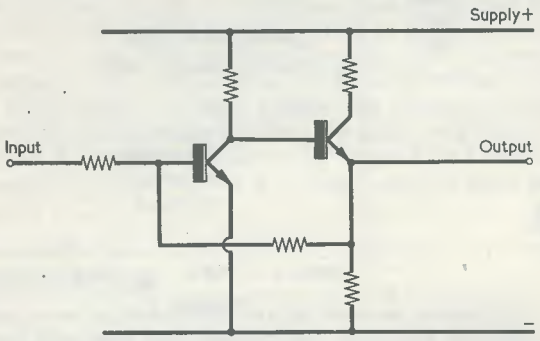

Fig. 2. Typical form of linear i.c. used for wideband amplification. Shunt feedback stabilises the operating points and increases bandwidth

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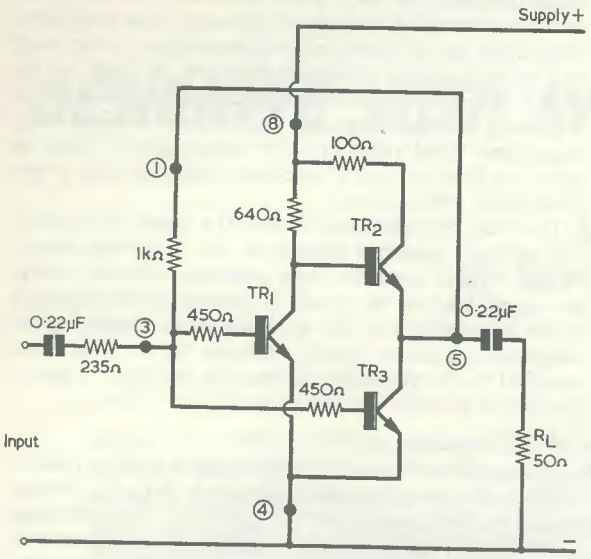

Fig. 3. The μL900 used as a video amplifier. (Note that terminal 1 is commoned to terminal 5.) This offered a power gain of 16dB with a bandwidth of greater than 25 Mc/s

output voltage will be about 3%. This is not good but may be acceptable for some applications. In summary we have a circuit which reduces input voltage swings by at least a factor of ten, has a low output impedance and moderate temperature stability.

Improving Performance

This performance is sufficiently encouraging to make an attempt at improvement worth-while. Ideally, we would like to be able to tackle each of the limiting features in a way that produces no interaction with the others, e.g. to bring the output impedance close to zero without degrading the temperature characteristics. Fortunately

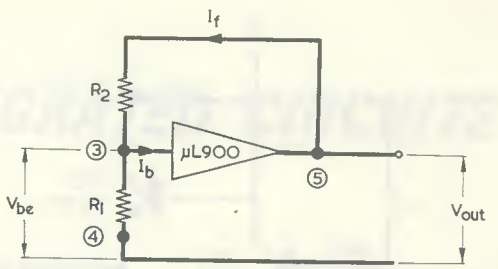

Fig. 5. The basic form of voltage regulator, in which the base-emitter voltage of TR_1 in the integrated circuit acts as the reference voltage

there are well-known techniques, which compensate for such variations. The methods adopted are summarised below but it should be noted at the outset that *exact* compensation is possible at only one combination of the other variables. For example once the output impedance has been set to zero, then a change in supply voltage or temperature will spoil the precise compensation. Similarly each set of compensating elements are valid for only one setting of output voltage. Since it is the V_{be} of TR_1 that is the effective reference voltage for this regulator then a simple method for compensating for the fall in output voltage due to increasing load current is shown in Fig. 6. As the load current increases so does the voltage drop across R_3. The voltage across R_1 must equal the sum of the above voltage plus that of the V_{be} of TR_1 and hence can be held constant by adjusting the value of R_3 to compensate for the natural fall in V_{be} with rising load current.

A similar method is adopted to correct for supply induced variations in the output, as indicated in Fig. 7. As the supply voltage increases so does the current injected into R_1 via R_4. There is thus less required via R_2, the voltage across which will fall slightly, and this fall can be adjusted to cancel the natural increase in all the circuit p.d.'s due to the increasing supply. To test the effectiveness

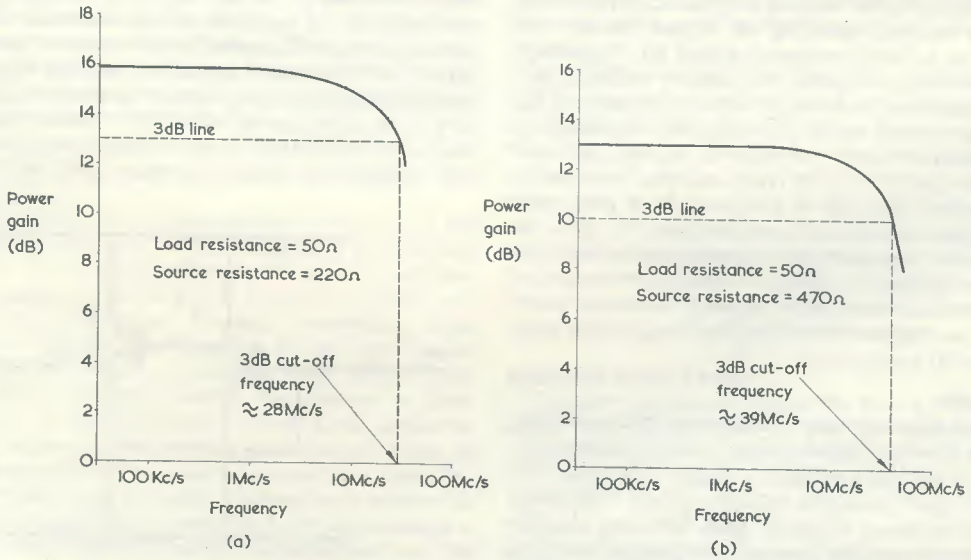

Fig. 4(a). Power gain versus frequency for the circuit of Fig. 3 when source resistance is 220Ω
(b). Greater bandwidth at less gain is given for a source resistance of 470Ω

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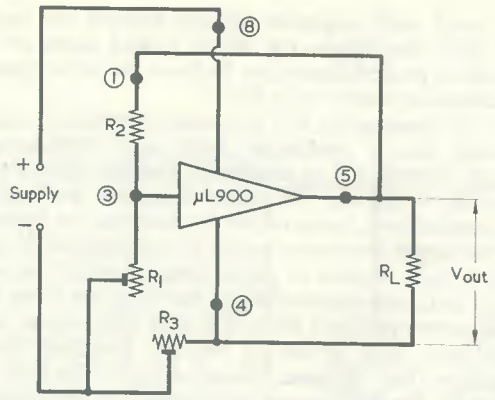

Fig. 6. Adding R_3 to boost the base potential of TR_1 as output current increases. R_1 may be adjusted for the required output voltage

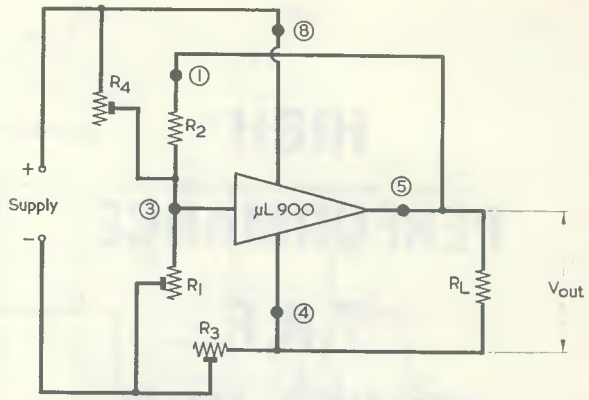

Fig. 7. Changes in supply voltage are also catered for with R_4 in circuit

of these methods the circuit was set up as in Fig. 7 using the internal 1kΩ resistor for R_2. One possible use for the circuit is to provide a stabilised supply for other integrated circuits in the same range at their nominal operating voltage of 3.6V. The integrated circuit under test was taken well outside its normal operating conditions in doing this, with supply voltages ranging from 7 to 10V and load currents from 2 to 20mA at an output set to 4V.

This last figure corresponds to the manufacturer's maximum rated value of supply voltage for correct operation in the original switching applications (3.6V+10%). There was no sign of any damage to the unit tested, though the temperature must have been fairly high at maximum output, since there was a small but noticeable fall in output voltage continuing for some time after the application of the maximum supply voltage. With careful adjustment of the resistors, R_1, R_3 and R_4, the output was held to within ±1% for the above range (i.e. 4V output at 2 to 20mA with supply voltage varying from 7 to 10V). For the particular μL900 used in this experiment, R_4 was 8.7kΩ, R_1 was 142Ω and R_3 was 0.4Ω.

To verify that this stability was achievable for other values of output, R_1 was reduced for outputs of 2V and 1V respectively, with a correspondingly lower value of supply. Using the same load currents and adjusting R_3 and R_4 to suit, the stability was again kept to similar limits. At an output of 1V the minimum supply voltage was as little as 4V even at the maximum output current of 20mA, which would drop 2V across the internal T_2 collector resistor. This supply voltage is less than that required for the lowest voltage Zener diode commonly available (3.3V) and the performance as regards supply and load changes is better. There is the further advantage that the circuit is continuously variable over a wide range.

The major defect of the circuit as described so far is its temperature dependence. Even under laboratory conditions, the figure quoted earlier of —0.3%/°C is going to dominate over the other sources of output change, making the benefits of precise compensation illusory. A considerable improvement is obtained by placing a germanium diode, in the forward conducting direction, in series with R_1. This has a temperature drift of comparable magnitude to that of the V_{be} of TR_1, and the resulting drift of current in R_1 is likely to be about +0.1%/°C. When R_2 is much larger than R_1, it is this change in current that will dominate the overall voltage drift at the output. For R_2 at zero, the drift will be that of the base-emitter voltage of TR_1, i.e. —0.3%/°C. Clearly, there will be some intermediate ratio of R_1:R_2 at which the drift is close to zero, and this appears to be for R_2 between three and four times R_1. Unfortunately at the time of testing this circuit it was not possible to do an accurate temperature run and the above estimate has to stand for the time being. An additional factor which can be made use of is that the internal 1kΩ resistor has a small positive temperature coefficient. Used as part or all of R_1 it could provide a means of getting near-zero temperature drifts at any value of output voltage; using a diode as above for temperature compensation would work exactly for only one ratio R_2:R_1 and hence for only one value of output voltage. In summary, the drift in output voltage with temperature can probably be reduced to +0.1%/°C with little difficulty and may be adjustable to zero in some cases.

Different Functions

The two applications described in this article have, perhaps, been covered in rather more detail than they warrant intrinsically. Nevertheless, it is hoped that the article has shown how simple i.c.'s may be used to perform functions quite different from those for which they were designed. Thus, a circuit described by its manufacturer as a buffer circuit for logic systems has become a video amplifier and a voltage regulator. To take Lewis Carroll's advice through Humpty Dumpty: "When I use a word, it means just what I choose it to mean—neither more nor less".

THE RADIO CONSTRUCTOR

We regret that the May, June, July and August issues were published late due to reasons arising from the sudden cessation of business of the old-established firm who had printed this magazine for more than 20 years – see Note on inside back cover of the May 1968 issue.

Regular readers will have noticed that we are gradually bringing the publication date forward and we hope that we will shortly be on sale on the 1st of each month again – the due date.

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HIGH PERFORMANCE T.R.F. TUNER UNIT

by

J. MORLEY

The simple medium and long wave tuner unit incorporates an unusual r.f. amplifier circuit to obtain a high level of selectivity and sensitivity

THE MAIN DISADVANTAGE OF SIMPLE "STRAIGHT" receivers is their lack of selectivity. The inherent low input impedance of a transistor in the normal common emitter configuration loads the preceding tuned circuit and reduces the effective "Q" of its coil. The result is poor selectivity and, at worst, the overlap of signals. Tertiary windings on the coils help but are not, at any rate in the writer's experience, a successful answer to the problem.

LONG-TAILED PAIR

In order to produce a simple high performance tuner that could really separate stations without the use of field effect transistors, the writer looked again at the long-tailed pair configuration. Its basic use in the present application is illustrated in Fig. 1.

In this diagram the first transistor, because of current feedback, has a reasonably high input impedance—enough, anyway, not to drastically load the type of coils the writer would use. The second transistor is effectively in grounded base, being driven by the common emitters, and the output impedance would also be reasonably high.

With these factors in mind some experiments were carried out, these culminating in the complete tuner unit circuit shown in Fig. 2. Here, TR_1 and TR_2 are the long-tailed pair, these appearing between standard Denco Miniature Dual Purpose Transistor coils. The coils are Range 1T for long waves and Range 2T for medium waves, and may be plugged into B9A valveholders as required. The numbers alongside the windings in the circuit diagram indicate the valve pins to which connections should be made. The two coils should be screened from each other.

The coils are tuned by the 2-gang capacitor C_1C_2, with trimmers C_3 and C_4. Normally the trimmers may be set up for best results at the high frequency end of the medium wave band.

The output from the second tuned circuit is fed into transistor TR_3, which is biased back on the lower part of its characteristic curve to work as a detector in rather a similar manner to the old anode-bend type. The a.f. output is obtained via L_{11}.

In practice, the circuit works extremely well, with very effective selectivity and good audio quality.

Before concluding, some points need to be made concerning components. An OC170 is specified for TR_3, and it was found that this was the only type that would function as an efficient detector with the component values given for the circuit. Its shield lead-out can be left unconnected.

It may be found of advantage to experiment with R_5 to meet the requirements of specific transistors in the long-tailed pair. The value of R_5 may be raised or lowered until the selectivity and sensitivity are at best proportions. TR_1 and TR_2 may be OC44, GET874 or OC170. If the last, the shield lead-outs, should preferably, be connected to chassis.

The value specified for C_{11} is applicable if the tuner output feeds into a subsequent transistor stage. If the following amplifier has a high impedance input, as would occur with a valve amplifier, C_{11} may have a value of 0.05μF.

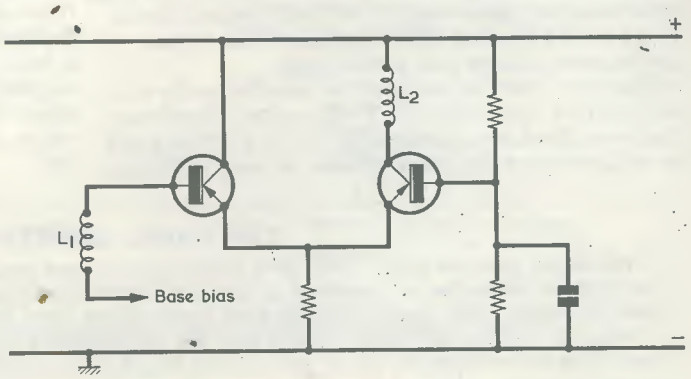

Fig. 1. The basic long-tailed pair r.f. amplifier

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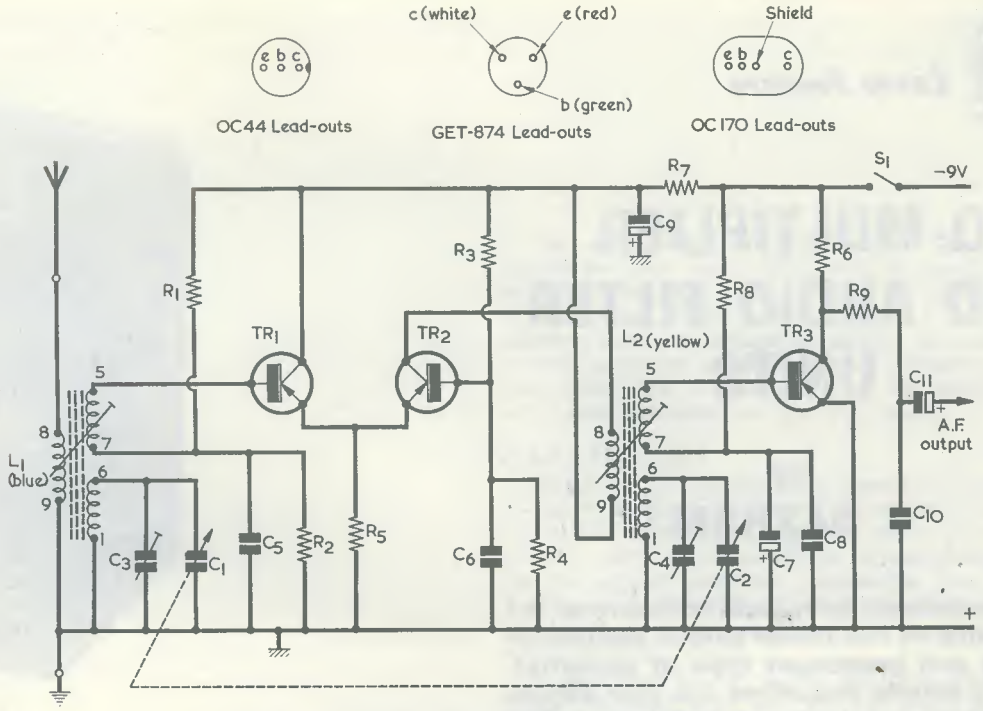

Fig. 2. The complete a.m. tuner incorporating the long tailed pair. TR_3 is the detector

COMPONENTS

Resistors
(All ¼ watt 10%)

R_1	47kΩ
R_2	5.6kΩ
R_3	47kΩ
R_4	5.6kΩ
R_5	270Ω (see text)
R_6	33kΩ
R_7	470Ω
R_8	2.2MΩ
R_9	1kΩ

Capacitors

$C_{1,2}$	2-gang variable, 310+310pF
C_3	30pF, trimmer
C_4	30pF, trimmer
C_5	0.1μF
C_6	0.1μF
C_7	100μF electrolytic, 6V wkg.
C_8	0.04μF
C_9	4μF electrolytic, 10V wkg.
C_{10}	1,000pF
C_{11}	50μF electrolytic, 10V wkg. (see text)

Inductors

L_1	Miniature Dual Purpose Transistor Coil, Blue, Range 1T and 2T (Denco)
L_2	Miniature Dual Purpose Transistor Coil, Yellow, Range 1T and 2T (Denco)

Transistors

TR_1, TR_2	GET874, OC44 or OC170
TR_3	OC170

Switch

S_1	s.p.s.t. on-off

Battery
9-volt battery

DIRECT BROADCASTING FROM SATELLITES

IEE Colloquium, Savoy Place, 4 November 1968

The Institution of Electrical Engineers are planning a one-day colloquium on the subject of direct broadcasting from satellites, to be held at Savoy Place on Monday 4 November 1968.

The scope of the meeting will cover the general problems of terrestial broadcasting and the possible advantages of broadcasting from space, discussion of possible frequency bands, required field strength and power from the space vehicle. Satellite-aerial stabilisation, probable size of space cract, performance of aerial systems, power supplies and problems of space-vehicle transmitter design will also be discussed.

On the receiving-equipment side, it is hoped to cover modulation systems, low-cost domestic aerials, head amplifiers and local oscillators.

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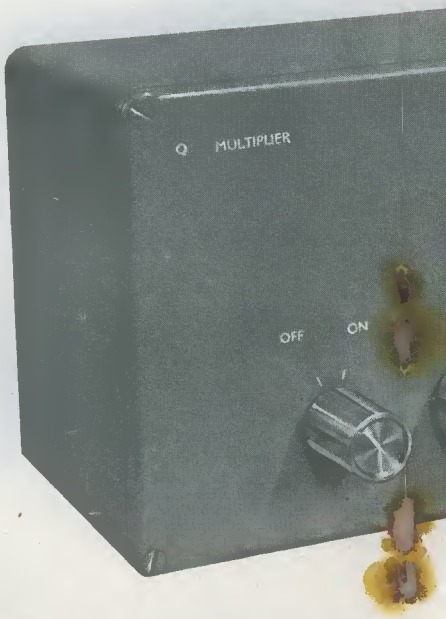
Cover Feature

Q-MULTIPLIER AND AUDIO FILTER UNITS

by

L. SAXHAM



It is a relatively easy task to improve the selectivity of the lower priced communications and broadcast type of superhet, and this article describes the two simple units which are designed to this end. The Q-Multiplier enhances the i.f. selectivity, and the audio filter unit assists in selecting the desired signal from heavy background noise and interference. Both units can be added to an existing receiver, which requires only slight modification.

RECENTLY REQUIRING A GENERAL-COVERAGE COMmunication receiver, the writer decided to invest a modest sum in one of the medium priced equipments currently available on the market. The receiver selected was the Trio 9R-59D.[1] From the literature provided, it appeared that this receiver was ideal for short wave listening over both the amateur and broadcast bands. For a single conversion superhet the selectivity figures quoted (±5 kc/s at −60dB; ±1.3 kc/s at −6dB) are quite good, this being mainly due to the use of two mechanical filters in the i.f. stages. Excellent in all other respects, the writer decided that an improvement in the selectivity characteristic would greatly enhance the performance of this receiver.

[1] This receiver was reviewed in our issue dated December 1967.—Editor.

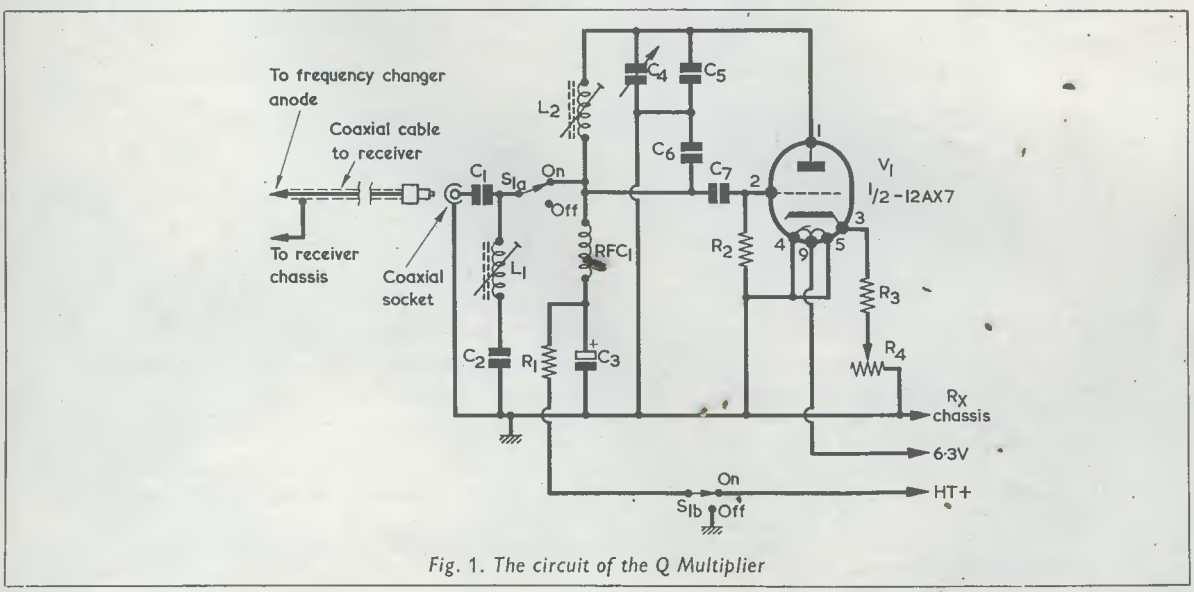


Fig. 1. The circuit of the Q Multiplier

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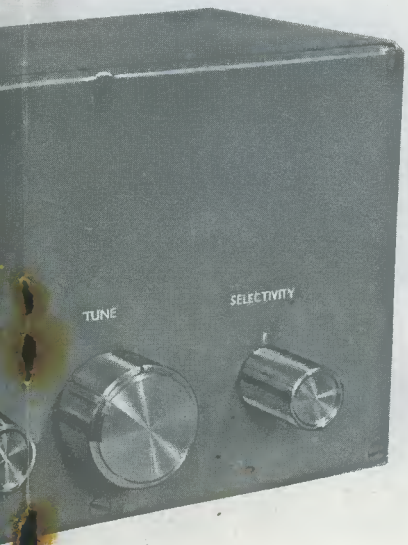

To achieve this end, two simple units were constructed and the receiver slightly modified, the end result being a much improved selectivity response. The modifications to the receiver are simple and are capable of being carried out even by the beginner. No originality is claimed for the circuits published here although they may be new to many beginners—for whom this article has mainly been written. One of the units is a Q-multiplier, and this may be added to any valve superhet whose chassis is isolated from the mains supply by a double-wound mains transformer. *This unit must not be used with receivers whose chassis is connected to one side of the mains.* The second unit is a very simple switched audio filter, and is merely plugged into the headphone output jack of the receiver.

Since some readers may also have a Trio 9R-59D receiver, brief instructions for adding the Q-multiplier to this particular set are included. However, as was just stated, the Q-multiplier may be added to any valve superhet having an isolated chassis.

Q-MULTIPLIER

Details of this simple unit, shown in circuit form in Fig. 1, were, to the best of the writer's knowledge, introduced into this country many years ago. Although differing slightly with respect to the components used, the principle of operation remains the same. Articles dealing with the problem of obtaining an increased i.f. selectivity response had also appeared in the American radio press.[2]

In the circuit of Fig. 1, one half of a double-triode 12AX7 has been used, and the unit tunes across the i.f. pass-band of the receiver when the i.f. stages are *accepting* the signal selected by the operator. In some more complex versions of the Q-multiplier, a second triode (which could be the remaining half of a 12AX7) is connected into an additional circuit that will *reject* an unwanted signal. However, the writer has found by experience that the reject facility takes rather a long time to set up correctly, and feels that this fact outweighs any advantages it may have for normal operating purposes. In the circuit of Fig. 1, therefore, only the *accept* application is incorporated.

[2]O. G. Villard, Jr., and W. L. Rorden, "Flexible Selectivity for Communication Receivers", *Electronics*, April 1952, page 138. K. S. Champlin, "Flexible I.F. Channel Selectivity", *CQ*, October 1953, page 31. Frank A. Baldwin, A.M.I.P.R.E., "Electronic Selectivity Filter", *The Radio Constructor*, April 1954, page 533.

COMPONENTS

Resistors
(All fixed values ½ watt 10% types)
R_1 33kΩ
R_2 2MΩ
R_3 10kΩ
R_4 5kΩ pot. linear track

Valve
V_1 12AX7

Valveholder
B9A with skirt and screening can

Chassis
6 x 2½ x 2in deep
(H. L. Smith & Co., Ltd.)

Switch
$S_{1(a),(b)}$ 2-pole, 2-way

Inductors
L_1 Coil type QL10 (Electroniques)
L_2 Coil type QL4 (Electroniques)
RFC_1 2.4mH choke, type CH1 (H. L. Smith & Co., Ltd.)

Capacitors
C_1 1,000pF silver-mica, 2%
C_2 1,000pF silver-mica, 2%
C_3 8μF, electrolytic, 450V wkg.
C_4 100pF, variable, Jackson Bros, type C804
C_5 1,000pF silver-mica, 2%
C_6 3,000pF silver-mica, 2%
C_7 500pF silver-mica

Cabinet
Eddystone die-cast box, 7⅜ x 4 11/16 x 2 1/16 in. (Home Radio Ltd., Cat. No: E845)

Miscellaneous
Knob, 2 tagstrips (4-way, end tags earthed), nuts and bolts, connecting wire, coaxial cable, coaxial plug and socket, etc.

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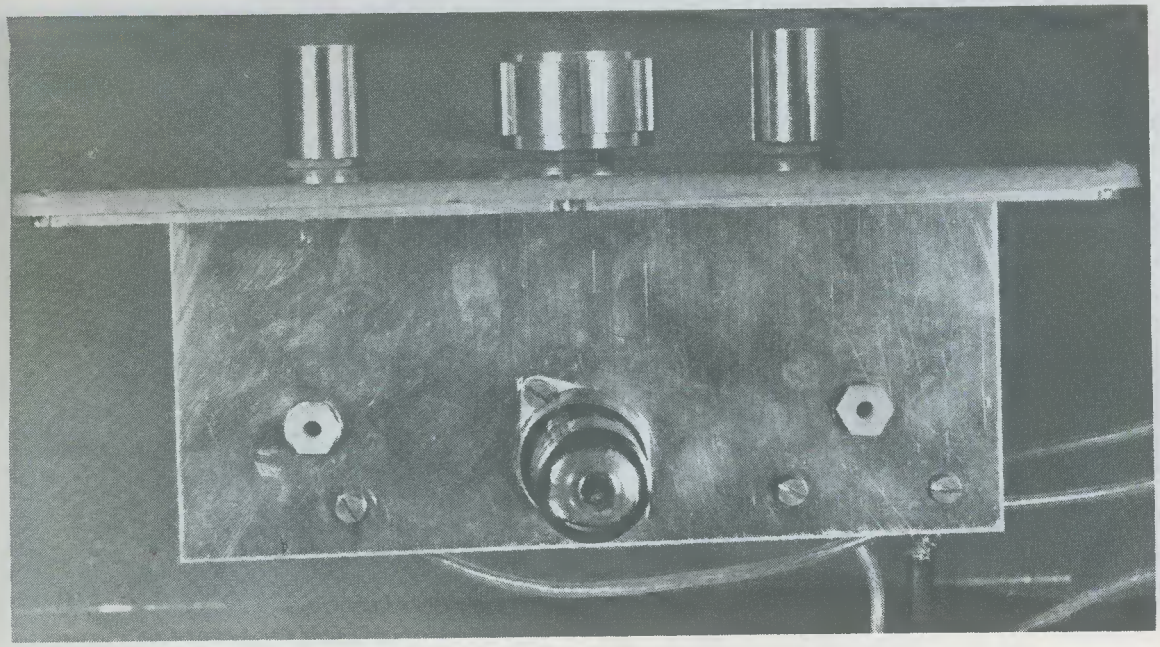

Above chassis view of the Q-multiplier unit. The Inductor L_1 is at the right and L_2 at the left-hand positions.

In use, the unit is connected to the receiver power supply, or to a separate power pack where this is not considered desirable, and the anode of the receiver frequency changer valve wired to the input socket of the Q-multiplier via a short length of coaxial cable. After some adjustment of both the Q-multiplier and the receiver first i.f. transformer, an extremely high degree of selectivity is obtained by virtue of the positive feedback employed between the anode and the grid of the 12AX7. Operators of a "straight" or t.r.f. receiver will have noted the high degree of selectivity and sensitivity obtained when the reaction control of such a receiver has been adjusted such that it is in its most sensitive state. The operation of the Q-multiplier is very similar in these respects, it being adjusted such that the Q-multiplier valve is just below the oscillation point. The Q-multiplier tuned circuit then offers a very high impedance at its resonant frequency and a relatively low impedance at neighbouring frequencies, with the result that only the signal at the resonant frequency remains unattenuated. The selectivity offered is very much greater than is possible with normal i.f. transformer stages.

In Fig. 1, C_1 and L_1 correct the detuning of the first i.f. stage introduced by the coaxial cable connecting to the frequency changer anode, with the result that, when $S_{1(a)(b)}$ is set to Off, the receiver functions in the same manner as before.

With $S_{1(a)(b)}$ in the On position h.t. is applied to the valve circuit via RFC_1, whilst the receiver i.f. stage is coupled into the tuned circuit given by L_2 in combination with C_4, C_5 and C_6. The triode appears in a Colpitts oscillator configuration. However, R_3 and R_4 provide degeneration in the cathode circuit and the valve can be maintained just short of the oscillating condition by suitable adjustment of R_4. When the unit is correctly set up, C_4 tunes across the i.f. pass-band, enabling the required signal to be picked out from those being handled by the receiver i.f. amplifier.

In the writer's installation, where the Q-multiplier is used in conjunction with a 9R-59D receiver, the unit functions at the receiver i.f. of 455 kc/s. However, the inductors specified for L_1 and L_2 are satisfactory for intermediate frequencies ranging from this figure up to 470 kc/s and the unit can, in consequence, be employed with other receivers having these intermediate frequencies. Alternative coils are also available from Electroniques for intermediate frequencies outside the range just mentioned and these are listed in the accompanying Table. They may be employed in the circuit of Fig. 1 without alteration of component values apart from C_5 and C_6.

C_3 is a bypass capacitor and ensures that there is no interaction between the Q-multiplier circuit and any other circuit sharing the same h.t. supply. The value specified for R_1 is suitable when the h.t. input is around 160 volts (as occurred in the writer's case). R_1 may be increased in value, if desired, for higher input voltages. The required value is not very critical, and all that is necessary is to ensure that the voltage at the triode anode is of the order of 150 volts when R_4 is inserting maximum resistance.

It will be noted that $S_{1(b)}$, in the Off position, connects the lower end of R_1 to chassis. This is a desirable circuit feature and it ensures that C_3 discharges rapidly after switching off. The reason for this method of connection is that it is possible for the Q-multiplier, if just below oscillation point with $S_{1(a)}$ in the On position, to go into oscillation when $S_{1(a)}$ is set to Off and removes the input loading from L_2 and its associated capacitors. This oscillation may continue for a short period if C_3 is not quickly discharged, as is done in the present unit, and it can cause interference with received signals.

The value specified for R_3 is, at 10kΩ, somewhat higher than that usually encountered in Q-multiplier circuits of this type, but this value was found necessary to ensure that oscillation occurred with R_4 at about

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Coils (with Electroniques type numbers) for Q-multiplier operation at different intermediate frequencies.

Freq.	L_1	Type No.	L_2	Type No.	C_5	C_6
85 kc/s	—	—	1.0–2.0mH	QL9	2500pF	7500pF
100 kc/s	—	—	1.0–2.0mH	QL9	1800pF	5400pF
239 kc/s	4.0–8.0mH	QL12	250–500μH	QL6	1200pF	3600pF
460 kc/s	1.5–3.0mH	QL10	120–150μH	QL4	1000pF	3000pF
600 kc/s	1.0–2.0mH	QL9	90–140μH	QL4	900pF	2700pF
735 kc/s	0.7–1.4mH	QL8	70–100μH	QL3	750pF	2250pF
915 kc/s	250–500μH	QL6	60–90μH	QL3	500pF	1500pF
1.6 Mc/s	50–100μH	QL3	40–60μH	QL2	250pF	750pF

the centre of its travel. It is assumed that this effect is due to high i.f. impedances in the 9R-59D receiver, which uses mechanical i.f. filters, these high impedances presenting only a low loading on the Q-multiplier tuned circuit. If it is found, in units built up to the design and which couple into conventional i.f. transformer circuits, that oscillation does not occur at any setting of R_4, the value of R_3 may be reduced until oscillation is given at a convenient point in the travel of this potentiometer. Normally, it should not be necessary to have R_3 lower than 5kΩ.

An important point concerns C_1, C_2, C_5, C_6 and C_7. It is *essential* that these capacitors be silver-mica types. Do *not* use ceramic components here because, apart from possible difficulties due to frequency drift with temperature change, the larger value ceramic capacitors are normally offered at very wide tolerances on value.

A final point concerns the unused triode of the 12AX7. The electrodes of this triode may be earthed by connecting pins 6, 7 and 8 to chassis.

CONSTRUCTION

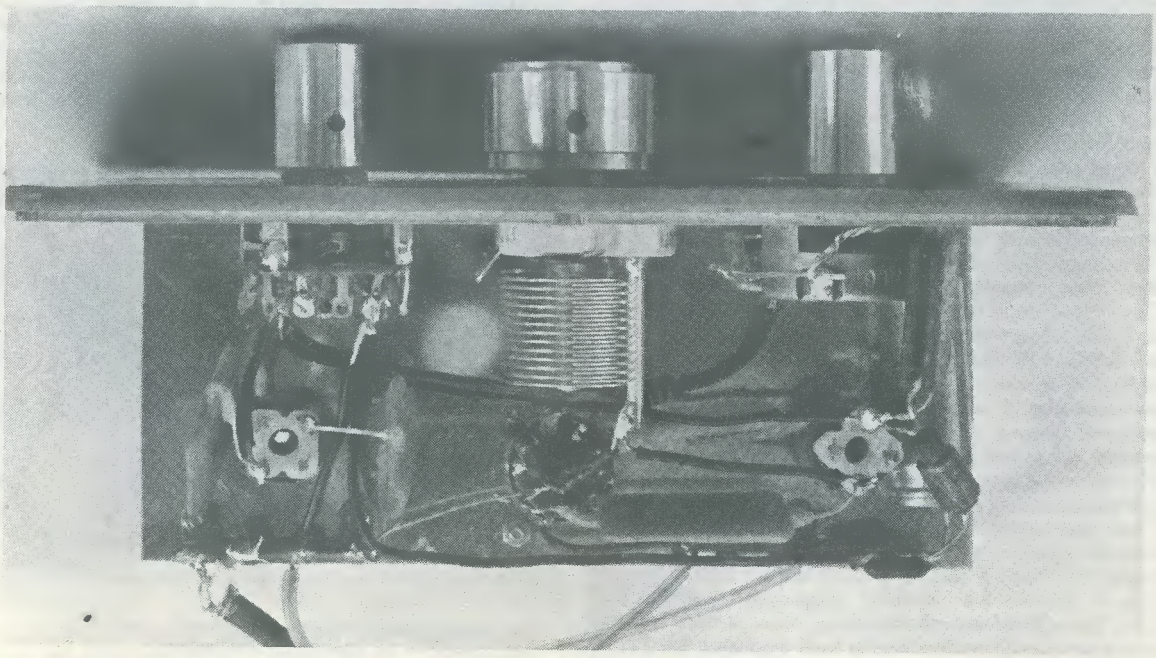
As may be seen from the illustration, the unit is fitted in an Eddystone die-cast aluminium case, a small chassis being secured to the front panel by means of the nuts and threaded bushes of S_1, C_4 and R_4. Two 4-way tagstrips have been used, one being utilised for the power input and the other for securing the components R_2, C_5, C_6 and one end of the r.f.c. mounted around the valveholder.

The rear of the die-cast case should have an entry for the power supply, suitably fitted with a rubber grommet, and for the coaxial cable input. The rear of the case should also have three ¼in holes drilled through to provide ventilation, these being made at the top of the panel. As shown, the unit has been fitted with four rubber feet, but this is not, of course, essential. Looking at the unit shown here, the left-hand control is switch S_1, the variable tuning control C_4 is in the centre and the feedback control R_4 is to the right.

The unit is delightfully simple to construct and no layout has been included here, this not being critical with respect to performance.

ADJUSTMENTS

Some readers may prefer to have the Q-multiplier permanently wired, via coaxial cable, to the anode of



Above chassis view showing the layout of the main components. L_1 at left and L_2 at the right-hand positions.

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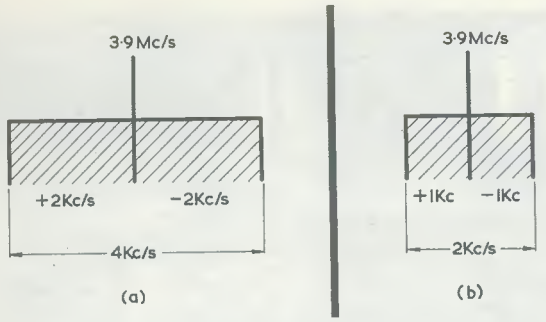

Fig. 2. The results achieved in a simple practical test (a) with the Q Multiplier switched out of circuit ahd (b) with the unit switched into circuit

the frequency changer, whilst others may wish to have the Q-multiplier capable of being plugged in, when required, by way of a socket on the receiver. In the latter case a short length of coaxial cable is needed to couple the frequency changer anode to a coaxial socket on the rear of the receiver chassis, the braiding being earthed at both ends. The first i.f. transformer will then have to be re-trimmed to take up the added capacitance resulting from this cable. Obviously, the cable should be kept as short as possible. Note that this i.f. re-trimming is *only* to cater for the coaxial cable added inside the receiver chassis and that it is *not* intended to take up the capacitance in the external coaxial lead to the Q-multiplier when the latter is plugged in. The external self-capacitance is corrected for by C_1 and L_1 in the Q-multiplier unit. For the permanent connection into the receiver, the coaxial cable to the Q-multiplier is wired to the frequency changer anode and a nearby chassis point, and no re-trimming of the first i.f. transformer is required.

To set up the Q-multiplier the receiver should initially, for the permanent connection, have the centre conductor of the coaxial cable close to but disconnected from the anode of the frequency changer valve. For the plug-in connection, the receiver should initially have its internal coaxial cable fitted and adjusted for, but without the Q-multiplier plugged into the socket. The receiver should be set to receive a.m. transmissions.

Tune in a steady signal on the receiver, using a signal generator connected to the aerial input via a 0.01μF capacitor if such a test instrument is available. The aerial should be disconnected from the receiver if the signal generator is used. The frequency used by the writer for this procedure was 3.9 Mc/s although any frequency that can be accurately read from the receiver dial may be used. If a signal generator is not available then a steady broadcast transmission should be tuned in, one that is not suffering from fading and causing variations in the S-Meter readings. Set the receiver r.f. gain at maximum. Note the S-meter reading.

For the permanent connection, next switch off the receiver, quickly solder the coaxial centre lead to the frequency changer anode, and switch on again. For the plug-in connection, simply plug the coaxial lead from the Q-multiplier into the rear socket. Apply power to the Q-multiplier. It will be appreciated, of course, that both the receiver and the multiplier unit must be thoroughly warmed up and not subject to frequency drift prior to proceeding further with the adjustments.

With the unit connected to the receiver, a serious drop in signal strength will be noted on the S-Meter. In the writer's case this was approximately 2 S-points. Using a hexagonal-ended trimming tool, and with $S_{1(a),(b)}$ set to off, adjust the core of L_1 until the S-Meter returns to its former reading, or as near to this reading as possible. Providing the coaxial cable connecting the receiver to the unit is short, adjustment of L_1 should largely balance out the capacitance of the cable thereby allowing the S-Meter to return to its earlier reading. The writer found that, due to the length of coaxial cable involved in the present case, a net loss of half an S-point was apparent. Note this second S-Meter reading.

Switch the Multiplier On with R_4 set at the minimum position (maximum resistance) and with C_4 at exactly half-capacitance. Using the trimming tool, adjust the core of L_2 until it is at exact resonance with the signal, causing the S-Meter to return to its former reading. Slowly advance R_4 until oscillation occurs. Slightly back off R_4 until the oscillations just cease, ensuring that L_2 is finally adjusted such that, with C_4 at mid-position, exact resonance is still maintained. The receiver is now at its most sensitive and selective condition.

CHECKING THE PERFORMANCE

To check the performance obtained with the Q-

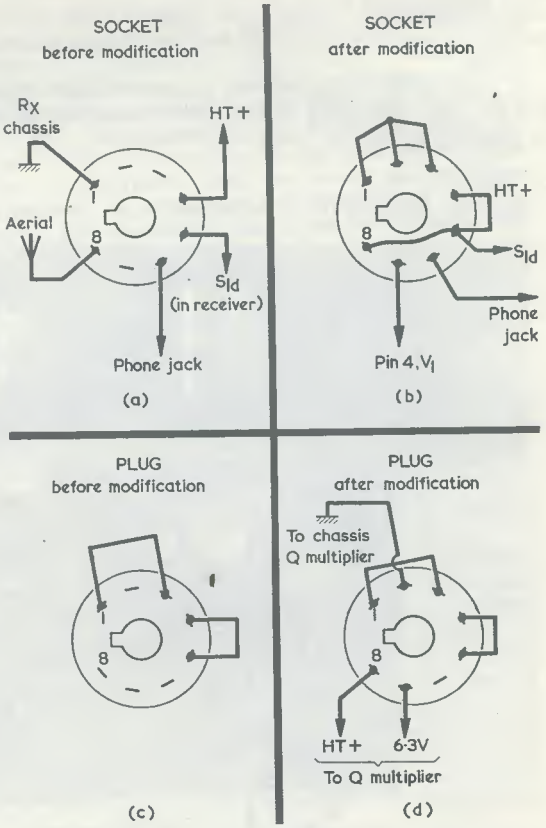

Fig. 3 (a). The receiver socket prior to modification (b) after modification (c) the connecting plug before modification and (d) after modification

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COMPONENTS

Capacitors

C_1	0.01μF
C_2	0.004μF
C_3	0.001μF
C_4	300pF
C_5	100pF

Switch

S_1 single-pole 6-way, miniature rotary (see text)

Plug

P_1 Jack plug, Igranic (H. L. Smith & Co., Ltd.)

Socket

J_1 Jack socket, Igranic (H. L. Smith & Co., Ltd.)

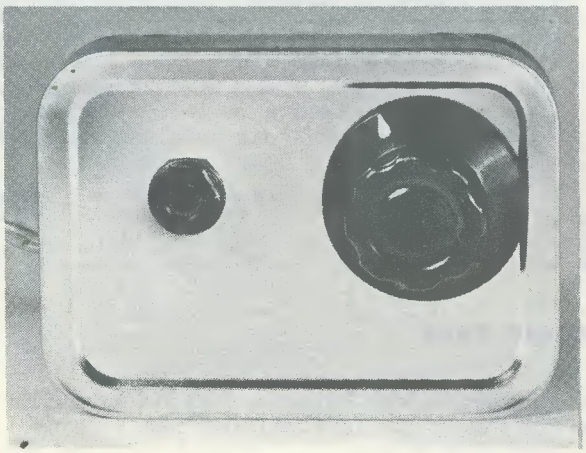
Miscellaneous

Knob, 2-oz tobacco tin or similar, connecting wire, etc.

multiplier at its most sensitive condition, and using the signal generator set to 3.9 Mc/s as previously described, the following results were obtained. This practical check may be carried out by any reader, incidentally, and a broadcast transmission can be used if a signal generator is not available.

Note the bandspread dial reading, it being assumed here that this dial is capable of being read to fine limits. Tune the bandspread dial above the signal frequency until the signal is inaudible and note the reading, return the bandspread dial to the limits of audibility at the lower frequency side and again note the reading.

Switch the Q-multiplier out of circuit and repeat the above test, noting the bandspread dial readings at the two limits of audibility and compare the results of the two tests. It will be found that selectivity is improved enormously with the Q-multiplier in circuit, and Fig. 2 shows the results obtained by the writer. From this it will be seen that without the Q-multiplier in circuit the injected signal was audible over a 4 kc/s limit whilst, with the unit in circuit, this was reduced



The 2-oz tobacco tin body to which the headphone jack J_1 and the switch S_1 are secured. The tin is placed at a convenient operating position near the receiver with which it is used

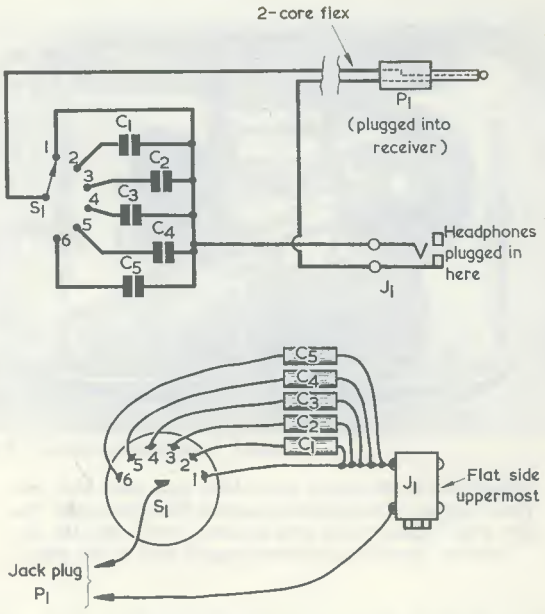


Fig. 4. The circuit, and point-to-point wiring diagram, of the simple audio filter unit

to a total of 2 kc/s, thus representing an improvement in selectivity of 100%.

In operation, it will be found that with the Q-multiplier in its most sensitive condition a.m. or s.s.b. signals will exhibit a "boomy" response due to the elimination of the sidebands, this being a feature of high selectivity. The effect may be counteracted by slightly detuning C_4 or, if less selectivity is required, by slightly backing off R_4. By using the simple audio filter described later, however, an acceptable balance may be readily obtained.

Additionally, the Q-multiplier may be made to function as a b.f.o. by causing the multiplier circuit to gently oscillate, whereupon c.w. and s.s.b. signals may be received. The s.s.b. signals may be easily resolved by slight variation of C_4.

MODIFICATIONS TO THE 9R-59D RECEIVER

To accommodate the Q-multiplier unit, this receiver may be easily modified both for the supply of power and the inclusion of a coaxial socket on the chassis rear apron.

Fig. 3 (*a*) shows the octal socket mounted on the rear apron of the receiver chassis prior to modification, both this and a mating plug being included for remote operation when using the receiver with a transmitter. This facility is not required in the present instance, whereupon the plug and socket provide an ideal power outlet, after modification, for the added unit. Fig. 3 (*b*) shows the octal socket after modification. Tags 1, 2 and 3 are connected together, as also are tags 4, 5 and 8. Tag 7 is connected, via a short length of p.v.c. covered wire to pin 4 of V_1. The aerial wire (tag 8) is *completely* removed.

Fig. 3 (c) shows the plug before modification and it will be noted here that pins 1 and 3, and 4 and 5 are already connected together by the manufacturer. It was decided not to remove these jumper wires—hence the

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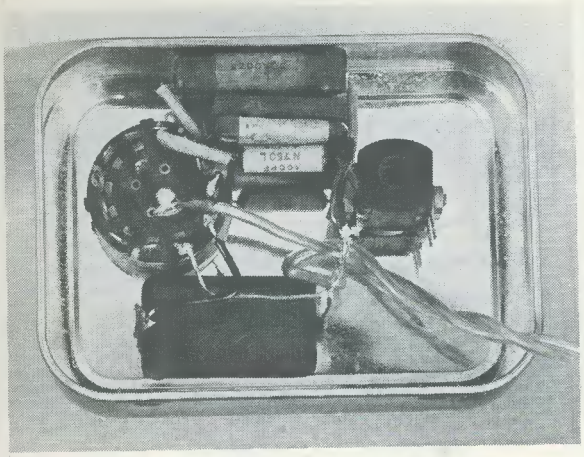

Inside view of the simple audio filter unit. Note here that four mica and one ceramic capacitor have been used, the flat mica types, except one, packing neatly into the tin. Tubular capacitors will serve equally well in this unit

modifications described above to the socket—it being rather difficult to resolder the plug pins satisfactorily after the wires have been removed, Fig. 3 (*d*) shows the plug wiring after modification. The leads of a 3-core cable from the Q-multiplier are connected to the plug pins in the following manner. One lead, whose other end connects to the Q-multiplier chassis, connects to pin 2 of the plug, whilst the lead for the 6.3 volt heater supply connects to pin 7 and the lead for the h.t. positive supply connects to pin 8.

On the chassis rear apron of the receiver will be found a small square of metal secured by two small self-tapping screws, this being simply a cover-plate for a coaxial socket (American pattern) for use when a coaxial aerial input is required. It will be noted that the ready-drilled hole is much larger than that needed for a British coaxial socket. The small metal square must therefore be drilled, in the exact centre, with a $\frac{7}{16}$ in hole and a coaxial socket fitted and secured to the plate by means of two 6BA nuts and bolts, an earth tag being mounted under one of the nuts. Ensure before drilling the two securing holes in the plate that the whole assembly, when completed, will re-fit the chassis hole. The original self-tapping screws are employed to secure the plate back in position.

A short coaxial wire is now soldered at one end to tag 5 of V_2 (frequency changer) and at the other end to the coaxial socket centre connector. The braiding of this length of coaxial cable should be connected at one end to the chassis tag at the coaxial socket and, at the other end, to the nearby chassis tag alongside the coilpack.

The matching transformer to the first i.f. mechanical filter should now be adjusted to take up the self-capacitance added by this coaxial cable.

AUDIO FILTER UNIT

Fig. 4 shows the simple audio filter unit referred to at the beginning of this article and which may be used in conjunction with the Q-multiplier to assist in selecting the desired signal from those adjacent to it. The unit costs very little in terms of cash outlay and time spent in construction, and yet it provides quite a remarkable attenuation of unwanted audio frequencies.

In Fig. 4, plug P_1 is inserted into the headphone jack of the receiver. Its sleeve connects to the corresponding contact of socket J_1 whilst its tip connects to the arm of S_1, a single-pole 6-way switch. The headphones are then plugged into socket J_1.

When S_1 is switched to position 1, the receiver output connects direct to socket J_1 and the filter unit has no effect on the signal passed to the headphones. On positions 2 to 6 the switch connects in series capacitors of increasingly lower value, these ranging from C_1 at 0.01μF to C_5 at 100pF. The capacitors apply increasing degrees of low frequency attenuation and it will in many cases be found that the subjective effect is to give the required signal greater clarity, particularly when some classes of background interference are in evidence. The bass-cut introduced by capacitors C_1 to C_5 also counteracts the attenuation of the higher audio frequencies resulting from use of the Q-multiplier. The switch is set to the position which offers the best results for the particular signal being received. It may be found necessary to increase audio gain for switch positions 4, 5 and 6. The unit is, of course, external to the set and will not affect reproduction via the receiver loudspeaker.

As may be seen from the accompanying photographs, the writer's audio filter unit is fitted in a 2-oz tobacco tin. This is secured to the operating bench at a convenient position. The capacitors may be ceramic, paper or plastic foil, or silver-mica. It may be found difficult to obtain a single-pole 6-way miniature rotary switch for S_1, as 6-way components of this type are usually available in double-pole. A double-pole 6-way switch may be used instead with no connections made to one pole and, as may be seen from the photograph, such a switch is employed in the writer's filter unit.

The unit is intended for use with high impedance headphones.

NORTHERN AUDIO FAIR

The Northern Audio Fair will be held on Friday, Saturday and Sunday September 20th to 22nd 1968, from 1100 to 2100 hrs, at the Hotel Majestic (Rooms 158–160, on the 1st Floor) Harrogate, Yorkshire.

Among other exhibitors, Daystrom Ltd. (Heathkit) will be displaying their latest audio equipments and demonstrations of Heathkit hi-fi stereo amplifiers, tuners, receivers and speaker systems. Also on display will be stereo record players and tape recorders.

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"AMATEUR" COIL CONSTRUCTION

by

A. S. CARPENTER G3TYJ

Whilst dealing generally with coil construction from the point of view of the radio amateur, this article also gives details of a simple aerial matching unit which can be used to advantage either for transmitting or for receiving on the short wave amateur bands

IN THE EARLY DAYS OF RADIO RATHER CUMBERSOME coils and components were required for the reception of programmes. Large outdoor aerials were also in fashion, since the now familiar ferrite road aerial had not been invented. Little of this early equipment remains, the trend towards miniaturisation continuing unabated.

Large outdoor aerials and bulky coils *are* still in use however and—ignoring public and commercial undertakings—these exist mainly at radio amateur stations. This does not mean that radio amateurs are out of touch with modern trends; many are in fact well ahead of the times. A very great deal of the short wave "communication" of today is the outcome of work done by the keen radio amateurs of yesterday!

Since licensed radio amateurs are permitted to transmit as well as to receive, their need for large aerials is obvious, for it would indeed be difficult to put a respectable signal into, say, the States via a small ferrite rod aerial! But even with a large aerial it may not be possible to get good contacts, because the G.P.O. sets a limit to the transmitter input power that radio amateurs may use. Nevertheless, many amateur stations consistently work distant stations using quite low power, this being of the order of 30 to 40 watts or so.

If low power signals are to "get out" it is essential for the aerial to be correctly designed; additionally the transmitter and aerial impedances must be carefully matched lest precious power be wasted. A resonant aerial system is also essential for any serious receiving purposes that may be contemplated and confers a degree of readability which would otherwise be lost.

The "shack" end of an aerial feeder can be 1000Ω or more, whilst the actual impedance required by the transmitter or receiver may be only 70 to 100Ω. Fortunately, the aerial and the equipment may be matched correctly by employing a special aerial matching unit, or a.m.u.

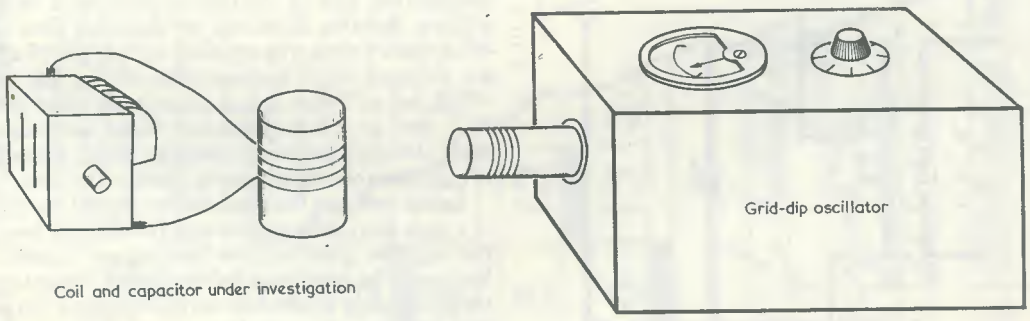

Fig. 1. Using a grid-dip oscillator to find the frequency coverage of a coil and capacitor combination

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Basically, an a.m.u. consists of some form of coil and capacitor combination, and this is a particularly common application requiring the use of large coils.

Six popular amateur bands in regular use are: 1.8–2.0 Mc/s (Top Band–160 metres), 3.5–3.8 Mc/s (80 metres), 7.0–7.1 Mc/s (40 metres), 14.0–14.35 Mc/s (20 metres), 21.0–21.45 Mc/s (15 metres) and, when conditions permit, 28.0–29.7 Mc/s (10 metres). It is possible to operate on each of these bands via a single aerial through a suitable a.m.u. Although a single switched coil and capacitor combination could be used in the a.m.u., separate plug-in coils for each band, tailored to suit, are much preferred in order to minimise losses. Normal receiver-type coils cannot be used in transmitter-to-aerial couplings, and since commercially produced types hardly exist it is both necessary and instructive to construct them.

The coils employed in an a.m.u. are normally air-cored, and a fairly thick gauge of wire should be used. Long narrow coils are, incidentally, unsuitable, and tend to behave more like chokes.

The frequency coverage and "goodness" of a newly constructed coil and capacitor combination, when unconnected to an external circuit, may be found by bringing a reliably calibrated grid-dip oscillator (g.d.o.) nearby, as in Fig. 1. When the g.d.o. coil is tuned to the resonant frequency of the coil and capacitor a sharp kick of the g.d.o. meter needle will be noted. With a poorly made coil the g.d.o. needs to be brought quite close but a "good" coil will give an indication when the g.d.o. is as much as 10 to 12in distant. Experience with a particular g.d.o. will soon enable one to use it for estimating the efficiency of a coil and capacitor combination.

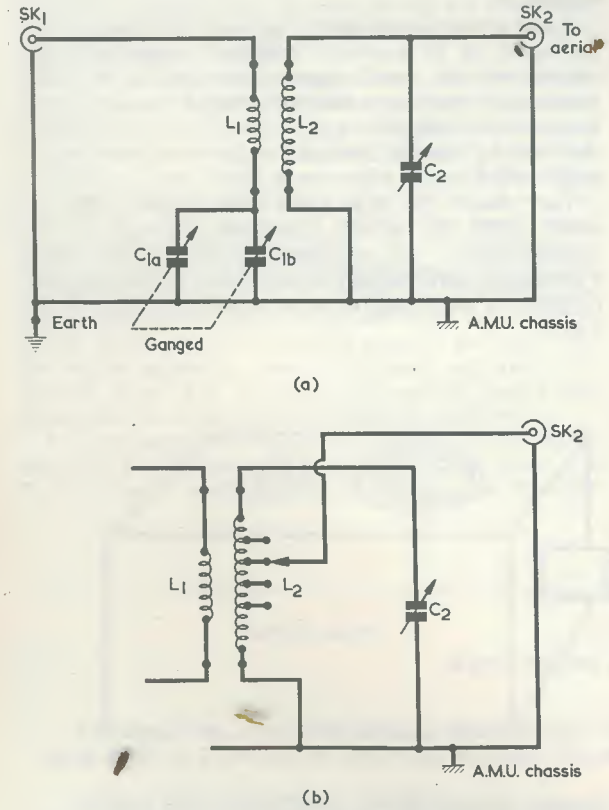

Fig. 2. The circuit diagram of the simple aerial matching unit described in this article

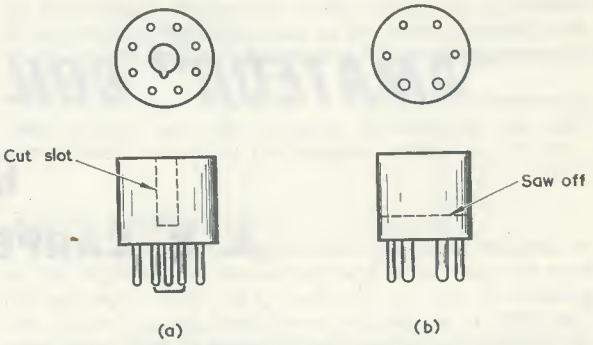

Fig. 3. Old valve bases may be used as plugs for the a.m.u. coils. The constructor can choose whichever pins he desires to take the connections L_1 and L_2

A PRACTICAL AERIAL MATCHING UNIT

The circuit diagram of a thoroughly practical unit for use with a single feed line aerial is given in Fig. 2 (*a*). This can be easily constructed on a chassis measuring about 8 by 4in. The transmitter or receiver is connected to socket SK_1 and the aerial is plugged in at socket SK_2. Coils L_1 and L_2 are a combined plug-in assembly to be described. Inter-coil coupling is electrically variable due to $C_{1(a)}$ and $C_{1(b)}$, which may be a 470 + 470pF (nominal) twin-gang capacitor with both sections in parallel. Capacitor C_2 (150pF max) tunes coil L_2 to the operating frequency; the vanes of this capacitor should be adequately spaced if used with a transmitter to avoid flashover.

To accommodate the coil unit a four-pin socket is required but if a tapped coil is used, as is sometimes beneficial, a five-pin item is needed; see Fig. 2 (*b*). Band changing usually means coil changing too, together with readjustment of the a.m.u. tuning capacitors to positions previously noted; these will be found at the setting up stage.

PRACTICAL A.M.U. COIL CONSTRUCTION

Experience has shown that the use of available commercial plug-in type coil former-base units can be rather a costly venture. There are various inexpensive alternatives, and for the coil socket a valve base may be utilised. Suitable bases can be obtained from discarded or obsolete valves. The obsolete valve types 77 and 78 are, for example, ideal because they are on the UX6 base which has no centre spigot. Unwanted valves such as the 6K7, etc., on the International Octal base may also be used, although the central locating spigot limits the types of coil assembly which may be fitted to the base.

Valves selected for demolishing should be placed, one at a time, in a strong plastic bag. Holding the base through the bag the glass bulb is then tapped smartly with a hammer. The remaining debris is soon cleared away, and the connecting wires removed by holding a hot soldering iron against each pin in turn.

Valve bases with or without centre spigots may have a slot cut as shown in Fig. 3 (*a*). These then accept the edge of a flat "former" of the type illustrated in Fig. 4. Bases

(*Continued on page* 113)

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HOW TO MAKE FULL USE OF YOUR DIARY

Underline the dates of both personal and radio events in which you are interested or concerned, as shown in the illustration below, and enter brief details of these in the Diary Notes. A list of forthcoming events of radio interest taking place during the fourth quarter (October to December inclusive) is shown alongside. Detach your Diary from the magazine and affix to the workshop wall. An Easy-View diary for the next quarter (January to March 1969 inclusive) will be published in the December issue.

SUGGESTIONS FOR YOUR **EASY-VIEW** DIARY

OCTOBER

2–5	RSGB International Radio Engineering & Communications Exhibition
5–6	RSGB Third 432Mc/s (Open) Contest
5–6	VK/ZL Oceania Phone Contest
5–6	ISWL Amateur Bands CW Listeners Contest
12–13	RSGB 28Mc/s Phone Contest
12–13	RSGB Second 1296Mc/s (Open) Contest
12–13	VK/ZL Oceania CW Contest
13	S. Coast R/Control Gala, R.A.F. Tangmere
19–20	11th Jamboree on the Air
26–27	RSGB 7Mc/s CW Contest
26–27	CQ WW Dx Phone Contest

NOVEMBER

2–3	Okinawa (KR6) Contest
2–3	ISWL Amateur Bands AM Contest
5–16	Do-it-Yourself Exhibition (City Hall, Manchester)
9–10	OK CW Dx Contest
9–10	RSGB 7Mc/s Phone Contest
9–11	ARRL SS Phone Contest
11	RSGB Seventh 144Mc/s SSB Contest
16–17	RSGB Second 1·8Mc/s Contest
16–18	ARRL SS CW Contest
23–24	CQ WW Dx CW Contest

DECEMBER

1	RSGB Fourth 7Mc/s CW Contest

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THE RADIO CONSTRUCTOR'S 'EASY VIEW' DIARY

FOURTH QUARTER 1968

	OCTOBER					NOVEMBER					DECEMBER				
Sun		6	13	20	27		3	10	17	24	1	8	15	22	29
Mon		7	14	21	28		4	11	18	25	2	9	16	23	30
Tues	1	8	15	22	29		5	12	19	26	3	10	17	24	31
Wed	2	9	16	23	30		6	13	20	27	4	11	18	25	
Thur	3	10	17	24	31		7	14	21	28	5	12	19	26	
Fri	4	11	18	25		1	8	15	22	29	6	13	20	27	
Sat	5	12	19	26		2	9	16	23	30	7	14	21	28	

DIARY NOTES

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"AMATEUR" COIL CONSTRUCTION

(continued from page 110)

without centre spigots may alternatively be cut as in Fig. 3 (*b*), whereupon they may be fitted with coil formers of the type shown in Fig. 6.

Dealing first with the flat "formers", these consist of rectangles of Perspex $\frac{1}{8}$in thick. See Fig. 4. Four rows of small holes just large enough to take the wire thickness to be used may be drilled centrally along lines "A" and "B". Coil L_1 will occupy rows B and coil L_2 will occupy rows A. To wind such coils neatly, commence with the inner coil, and place the required number of turns plus two on a $2\frac{1}{4}$in diameter dummy former. Release the winding to obtain a loose spiral then feed this carefully through the Perspex holes using a screw-like action. One turn at each end will then be pulled out to form connecting wires and the remainder can be secured with polystyrene cement.

The edge of the Perspex "former" is next fitted to the slot in the valve base, as in Fig. 5, and secured with Durofix or a similar adhesive. It will be seen from Fig. 4 that there is an extra $\frac{1}{2}$in between one edge and the adjacent row of A holes, and this is the edge which fits into the valve base slot. The slot should, of course, be cut to take the Perspex comfortably. The coil ends are finally taken down to the appropriate valve base pins and soldered.

Valve bases cut as in Fig. 3 (*b*) may take the coil assembly shown, in exploded form, in Fig. 6. An unusual but effective and inexpensive former material is given by oddments of modern plastic drain water pipe, obtained as a "Marley" product from Do-it-Yourself stores. This is available in diameters of approximately $2\frac{1}{8}$in (for L_1) and $2\frac{5}{8}$in (for L_2). Each coil former, after winding, is secured to

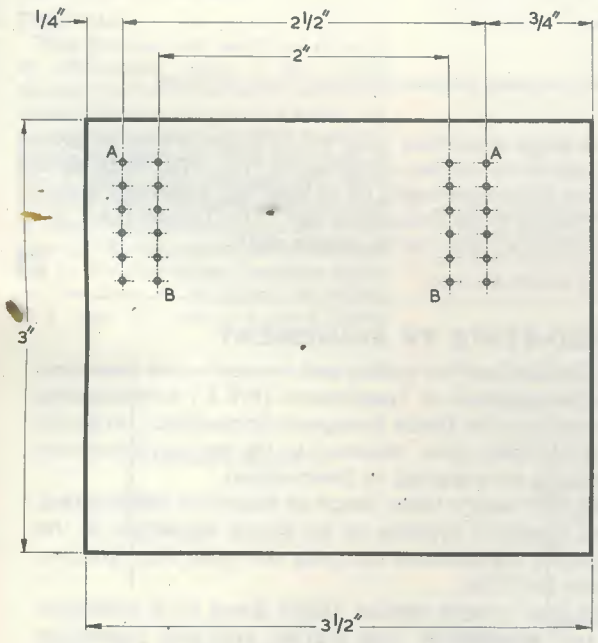

Fig. 4. A flat coil "former" which enables a low-loss assembly to be made up

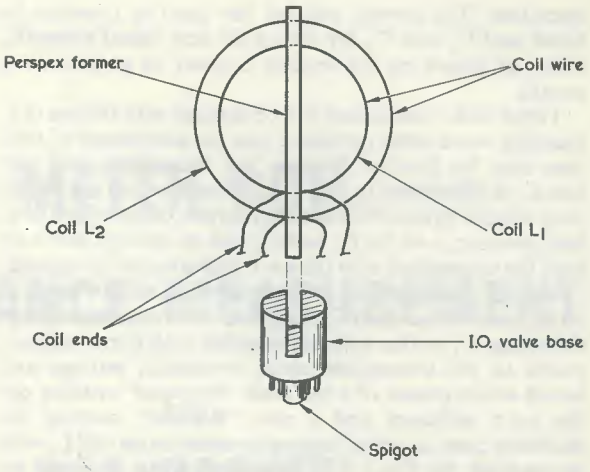

Fig. 5. How the Perspex "former" is located in its valve base

a circular Paxolin cheek of 3in diameter with Durofix or similar, the cheek then being fixed centrally on the valve base with the aid of a 6BA nut and bolt. Suitably positioned holes are previously drilled in the formers and Paxolin cheek to allow coil ends to pass through to the pins.

COIL WINDINGS

Details of suitable windings for L_1 and L_2 for the various bands are given in Table I, these applying primarily to the coil former assembly of Fig. 6. The coil wire is 22 s.w.g. and the turns should be spaced by wire thickness. The same number of turns may be used for coils fitted to the Perspex flat "formers" but in this case it will be difficult to achieve the same close turn spacing. A slightly increased turn spacing is, however, quite permissable.

As a further guide Table II gives details of frequency coverages, using the same wire guage and turn spacing, but for a coil former diameter of $2\frac{3}{4}$in, tuned with a 150pF variable capacitor. No external connection was made to the tuned circuit when making up this Table.

THE A.M.U. IN USE

Setting up the a.m.u. for use with a receiver is a simple

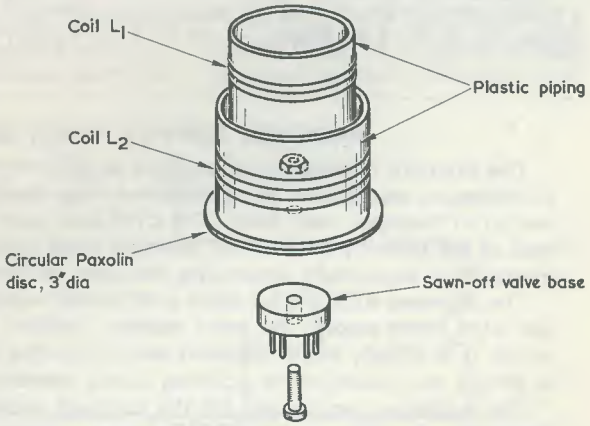

Fig. 6. An alternative assembly using inexpensive former material

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operation. The correct coil for the band in question is fitted, and C_1 and C_2 are set up for best signal strength, either as shown by the receiver S-meter or as perceived aurally.

Those with transmitters will be familiar with the use of a standing wave ratio indicator, and an instrument of this type may be inserted between the transmitter and the a.m.u., as illustrated in Fig. 7. Interconnections are made with coaxial cable. With the appropriate coil plugged in a trial position is set for C_1 and C_2 and an attempt made to load the transmitter with the s.w.r. indicator set to indicate "Reverse". Initially the s.w.r. indicator will show a reading on its meter whereupon C_2 is adjusted to lower the reading. Capacitor C_1 is also adjusted together with minor adjustments to the transmitter until, eventually, settings are found which permit of a full scale "Forward" reading on the s.w.r. indicator and a zero "Reverse" reading. In stubborn cases an aerial tapping connection on coil L_2 will do the trick. See Fig. 2 (*b*). Thereafter it is but necessary to fit scales and pointer knobs to the a.m.u. for subsequent ease of operation.

CONCLUSION

It may be seen, in conclusion, that the construction of a simple aerial matching unit is clearly not too tedious a task. It is certainly a rewarding one. When the prototype was used with a 50W c.w. rig to a Windom aerial many pleasant QSO's were enjoyed, despite heavy QRM.

A simple aerial based on Windom principles is given by a horizontal long wire cut for the lowest frequency band required (132ft for 3.5–3.8 Mc/s, or 67ft for 7.0–7.1 Mc/s). A single wire feeder some 45ft in length is then connected one third of the way along the flat "top". The feeder should run off at right angles for at least 16ft, preferably more, in relation to the horizontal "top". Don't forget that a good earth is a "must" at the station end!

TABLE I

Turns		Band (Mc/s)
L_1	L_2	
7	28	3.5–3.8
3	10	7.0–7.1
2	4	14.0–14.35 and 21.0–21.45
1	2	21.0–21.45 and 28.0–29.7

TABLE II

Turns	Coverage (Mc/s)
30	1.9–4.5
20	2.5–5.5
13	3.0–7.0
9	5.0–10.0
5	7.0–13.0
3	9.5–22.0
2	10.0–29.5

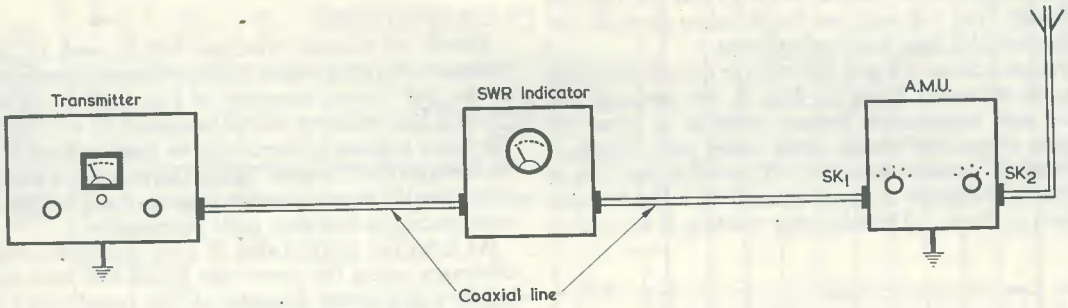

Fig. 7. Using the a.m.u. with a transmitter and an s.w.r. indicator for optimum matching to the aerial

MARCONI SUPPLY FIRST SOLID-STATE TV EQUIPMENT

The Marconi Company has received an order from Switzerland for colour and monochrome television transmission equipment to be installed in a Postes, Telegraphes et Telephones (P.T.T.) broadcasting station in Bantiger, near Bern. The £185,000 order, won against fierce European competition, includes four of the recently announced Marconi solid-state u.h.f. drive units, believed to be the first broadcast transmitting equipment employing transistor technology to be supplied to Switzerland.

The Marconi B7311 u.h.f. drive unit is used with the Company's latest range of television transmitters, and puts them among the most modern, reliable and compact systems to be found anywhere in the world. It is already being supplied with thirty-five Marconi transmitters currently on order from stations in Britain and Scandinavia requiring colour transmission facilities.

The additional equipment for the contract includes four vapour-cooled 10kW Band IV/V television transmitter amplifiers, type B7315, four combining unit assemblies, type B8144, and two paralleling units.

Marconi will install the equipment in the Bantiger station at the end of this year.

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METER COIL RESISTANCE MEASUREMENT

by

P. A. GRAVES

Of particular interest to the beginner, this article describes a simple method of finding the resistance of a moving coil meter

A DILEMMA FACING MOST CONSTRUCTORS at one time or another is that of having a sensitive moving-coil meter whose coil resistance is unknown. This resistance cannot be measured by the usual methods—using a resistance meter or bridge—as these could pass an excessive current through the coil, causing the meter needle to wrap itself round the end-stop!

CURRENT SHARING

The problem can, however, be readily overcome by employing a technique which takes advantage of the fact that the meter whose resistance is to be measured is itself capable of indicating the current which flows through it.

To start, consider the circuit shown in Fig. 1, in which a constant current, I, flows through the resistor R. If a second resistor having the same value as R is connected in parallel with R, as in Fig. 2, the fixed current I divides equally between the two resistors. The current flow through R is then one-half of its previous value. Conversely, if R were unknown and the second resistor is a variable component which is adjusted until the current in R falls to half its previous value, then the resistance in the variable resistor is equal to R.

With a moving-coil meter, the deflection of its needle is directly proportional to the current flowing through it. We can, therefore, pass a fixed current through the meter which causes it to read full-scale deflection, then connect a variable resistor across the meter and adjust it until the meter reading is half its full-scale value. The resistance of the variable resistor is then equal to that of the meter.

TEST RIG

This principle was employed recently by the author when it was found necessary to find the actual resistance of a batch of 50μA meters, each of which had a nominal resistance of 800Ω. A simple test rig was made up, using the circuit of Fig. 3. Here, both R_1 and VR_1 have values of 100kΩ, the latter being adjusted to cause 50μA to flow from the 9-volt battery. VR_2 has a resistance of 1kΩ and can be switched across the meter under test by means of S_2. Since the values of R_1 and VR_1 are very much higher than the meter resistance, the current which flows from the battery can be considered as being constant regardless of whether S_2 is open or closed.

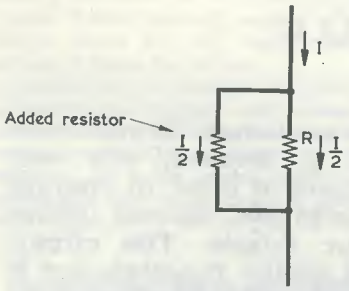
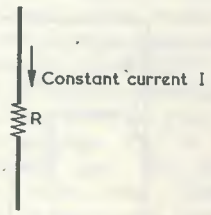


Fig. 2. Adding a second resistor having the same value as R causes the current to divide equally between the two resistors

VR_2 is fitted with a pointer and scale and is initially calibrated by opening S_2 and connecting a resistance meter (Avo or similar) across its terminals. Graduations can then be marked on the scale at 100Ω intervals, with intermediate graduations over the range (in this case around 800Ω) where it would be required to obtain more precise measurements.

To use the rig, S_1 and S_2 are opened, and VR_1 and VR_2 adjusted to insert maximum resistance. The meter is con-



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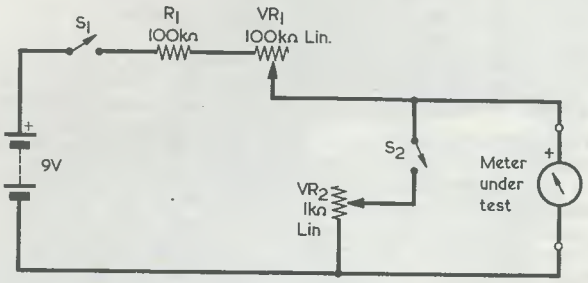

Fig. 3. The test set-up used to find the actual resistance of 50μA meters whose nominal resistance was 800Ω

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Fig. 4. The test requires that each meter gives an indication of full-scale deflection and then of half full-scale deflection

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The principle illustrated by Fig. 3 may be employed with meters having different full-scale deflection figures, the values of R_1, VR_1 and VR_2 being altered to suit. The values of R_1 and VR_1 must always be much higher than the anticipated resistance of the meter, and with less sensitive movements this may necessitate the use of a bettery voltage greater than 9 volts.

Solid State Windscreen Wiper Delay Unit

by J. VELLA

In our August 1967 issue we published "Windscreen Wiper Programmer" by T. J. Daborn, this unit allowing the windscreen wipers of a car to operate once every 2 to 30 seconds as desired under conditions of light rain or drizzle. The circuit described here carries out a similar function, but it incorporates a thyristor (silicon controlled rectifier) to control the motor instead of a relay, as in the previous design. It is intended for use in cars with 12 volt systems

THE CIRCUIT TO BE DESCRIBED, WHICH can only be used with windscreen wipers having the self-parking facility, gives a delay which can be continuously varied from 2 seconds to about 45 seconds. The delay unit can be instantly overruled by switching on the manual wiper switch.

THYRISTOR OPERATION

If a thyristor is connected as shown in Fig. 1 a gate current flows. If R_2 is slowly reduced in value the gate current increases until eventually the thyristor fires and conducts heavily, the anode current being limited only by R_1. The thyristor continues to conduct irrespective of what happens to its gate drive, and it can only be returned to its non-conductive state either by removal or by reversal of the supply. The minimum gate current (and hence the maximum value of R_2) needed to initiate conduction varies even between thyristors of the same type, and the final circuit (Fig. 2) has been designed to deal with a wide spread in this characteristic. In the prototype the minimum gate current was 13mA, corresponding to a value in gate resistance (R_2 of Fig. 1) of 980Ω, when the supply was 17V.

THE CIRCUIT

In the circuit given in Fig. 2, C_1 charges via R_1 and RV_1. As the charge on C_1 starts to build up, TR_1 draws a base current and becomes more conductive, allowing a gate current to flow in the thyristor. This gate current increases with the charge on C_1. Due to the presence of R_3 in the emitter circuit of TR_1, capacitor C_1 can charge to a high voltage before collector current is sufficient to fire the thyristor.

Once the thyristor has fired the wiper motor starts. Also, the diode D_1, now being forward biased, allows C_1 to discharge very rapidly through it and the limiter resistor R_1. The first few degrees of wiper movement close the self park switch, short-circuiting the thyristor and thereby returning it to its non-conducting state.

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TOLERANCES AND CONSTRUCTION

Components are not particularly critical. Any medium gain p.n.p.

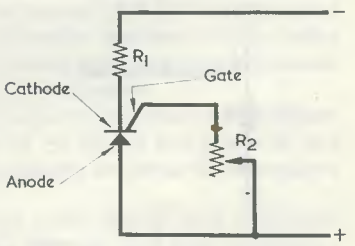

Fig. 1. Basic operation of the thyristor

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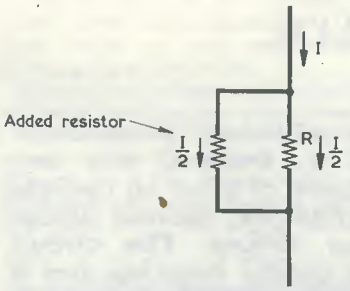

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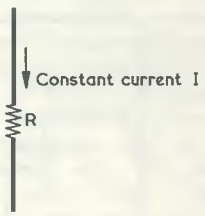

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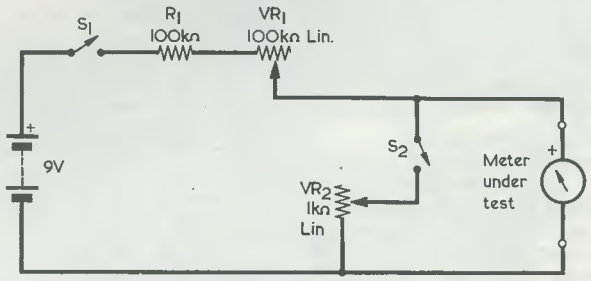

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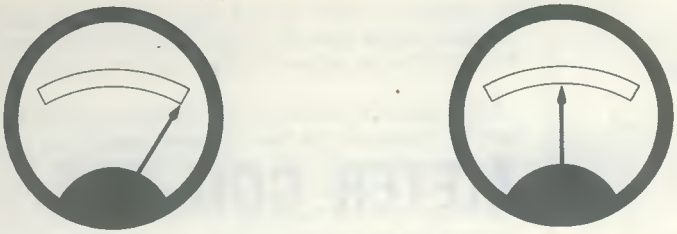

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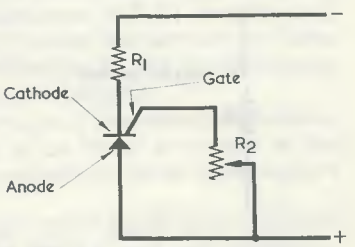

Fig. 1. Basic operation of the thyristor

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COMPONENTS

Resistors
(All fixed values ½ watt 10%)

R_1	150Ω
R_2	10kΩ
R_3	560Ω
RV_1	10kΩ potentiometer, log track, with switch S_1

Capacitor

C_1	2,500μF electrolytic, 18V wkg.

Semiconductors

D_1	OA10
D_2	DD4520 or 1S420
TR_1	OC81, AC128 (see text)
SCR_1	Thyristor (10A min. 100V p.i.v.) BTY87-100R

Switch

S_1	s.p.s.t., part of RV_1

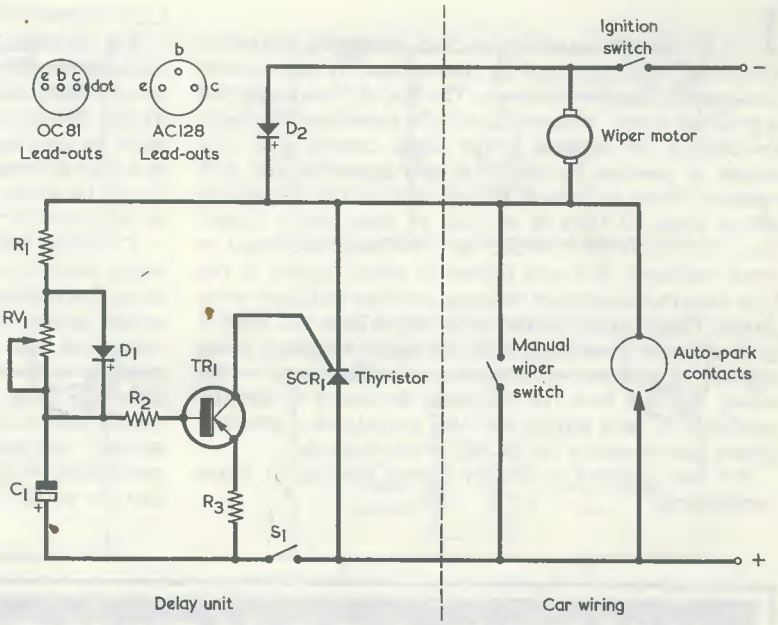


Fig. 2. The complete circuit of the solid state windscreen wiper delay unit. Delays range from 2 seconds to about 45 seconds

transistor capable of a collector current of at least 20mA will do for TR_1. Using an OC81, it was not found necessary to mount it on a heat sink. Both the DD4520 and 1S420 quoted in the Components List have maximum forward currents of 10A. The p.i.v. of the DD4520 is 50V and that of the 1S420 is 100V. The writer obtained all his semiconductors from Bi-Pak Semiconductors.

The starting current of the wiper motor can be as high as 7A. The thyristor that is used must handle at least 10A—allowing for a stalled motor. The BTY87-100R can handle 12A maximum and has a p.i.v. of 100V.

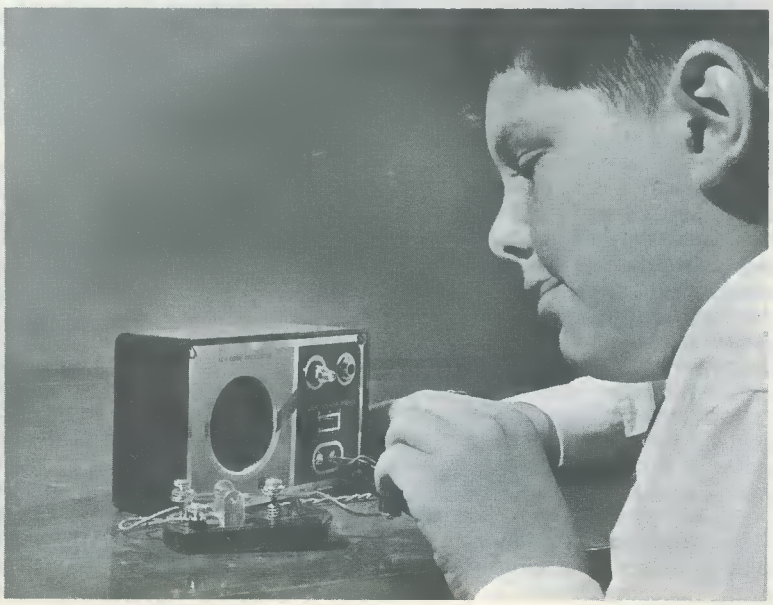
The maximum delay given varies with the ambient temperature. It can be as high as 65 seconds at 70°F, falling to 35 seconds at 115°F. Under normal driving conditions 10 to 15 seconds is typical of what is usually required. The longer delays are very useful when driving in fog or fine drizzle.

The unit may be fitted anywhere in the car (apart from the engine compartment) and preferably reasonably close to the manual switch. The thyristor can be mounted on a few square inches of aluminium, this being insulated from metal parts of the car body if the car does *not* have a positive earth. If the car is positive earth the stud end of the thyristor, being the anode, can be bolted directly on to the car. D_2, which should be insulated from earth, does not have to be mounted on a heat sink.

At the time of writing the prototype has been in use for some months and has stood up well to bad weather. On one occasion it worked non-stop for a period of 4 hours. All components are operated well within their ratings. ✱

Knight-Kit LC-1 Code Oscillator

Learning morse on the Knight LC-1 code oscillator, one of the many instructional devices which can be easily assembled from the "Knight-Kit" range of construction kits now being marketed in the UK and Europe exclusively by Electroniques (prop STC Ltd.). Capable of being assembled by anyone, regardless of their technical knowledge, the LC-1 enables young and old alike to quickly learn the rhythmic tappings of the morse code, the key output being indicated by built-in lamp, speaker or earphones.



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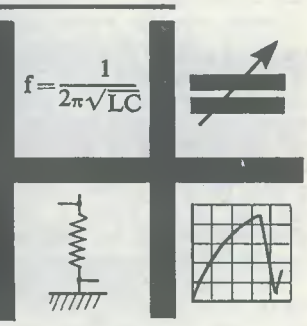
UNDERSTANDING RADIO

Mixer Functioning



by W. G. Morley

In last month's article in this series we examined two mixer valve circuits of the type commonly encountered in domestic superhet receivers. The first of these employed a grid leak mixer, with which both the signal and oscillator frequencies are applied to the single control grid of a triode or pentode by way of a grid capacitor and grid resistor. Mixer circuits of this type are used at frequencies above some 40 Mc/s or so, and we examined a typical f.m. receiver circuit in which the valve also functioned as local oscillator. We next turned to mixer circuits of the type used in receivers for the long, medium and short wave bands. These employ mixer valves which have two control grids screened from each other, the signal frequency being applied to one grid and the oscillator frequency to the other. We saw how the difference frequency is actually produced in such mixers and also considered a practical circuit incorporating the ECH81 triode heptode.

We now proceed to further factors relating to mixer functioning.

TERMINOLOGY

In our discussion up to the present we have referred to the valve which produces the difference frequency as the mixer. Another term which is applied to valve functions in this section of the superhet is "frequency changer". Of these two terms, *mixer* applies to the valve (or other device) to which both signal and oscillator frequencies are applied and which produces the difference frequency. *Frequency changer* applies to a valve which generates the local oscillation frequency as well as mixing it with the signal frequency. A grid leak detector which is fed by a separate local oscillator is a mixer valve, whilst the triode heptode we discussed last month is a frequency changer (since it incorporates a triode local oscillator and a heptode mixer).

The two terms tend to become confused when applied to a single valve which functions, in itself, both as oscillator and as mixer. A typical instance of this method of operation occurred in the f.m. circuit we discussed last month, and in which a triode oscillator also provided the difference frequency. Such a valve is often referred to as a mixer.

In American texts the term *frequency converter* or, simply, *converter*, is normally used. This is synonymous with "frequency changer".

CONVERSION CONDUCTANCE

The function of a mixer valve differs from that of an ordinary amplifying valve because the required output at its anode is at a different frequency to the signal applied to its grid. We can assess the usefulness of a normal amplifying valve by quoting its mutual conductance, i.e. the change in anode current resulting from a change in grid voltage. It will be recalled that mutual conductance is expressed in milliamps per volt.

A similar measure of usefulness is employed with a mixer valve and it is referred to as its *conversion conductance*. Conversion conductance is the relation between the anode current at the *intermediate frequency* to the grid voltage at the *signal frequency*. The similarity of this quantity with mutual conductance is clear, the main difference being that conversion conductance applies to specific alternating frequencies at anode and grid, whereas mutual conductance may be determined under d.c. conditions. With mutual conductance it is understood that the anode voltage is constant. The same is assumed for conversion conductance, the condition being expressed by the statement that the anode load (through which the current at intermediate frequency flows) has zero impedance. It is more difficult to measure conversion conductance than mutual conductance and the process requires fairly complex laboratory equipment. Like mutual conductance, conversion conductance may be expressed in milliamps per volt although, since most conversion conductance values are lower than 1mA per volt, it is usually more convenient to work in microamps per volt. The symbol for conversion conductance is g_c, and it is sometimes alternatively described as *conversion transconductance*.

The conversion conductance of a mixer valve varies, as is to be expected, with anode voltage and, if applicable, with screen grid voltage. In a mixer having two control grids it varies, again, with the bias applied to the signal grid. A particularly important factor is that it also varies (and very widely) with the amplitude of the local oscillator signal applied to the mixer. In consequence of this last factor, it is standard practice for valve manufacturers to issue curves for their products which show conversion conductance plotted against oscillation amplitude at the

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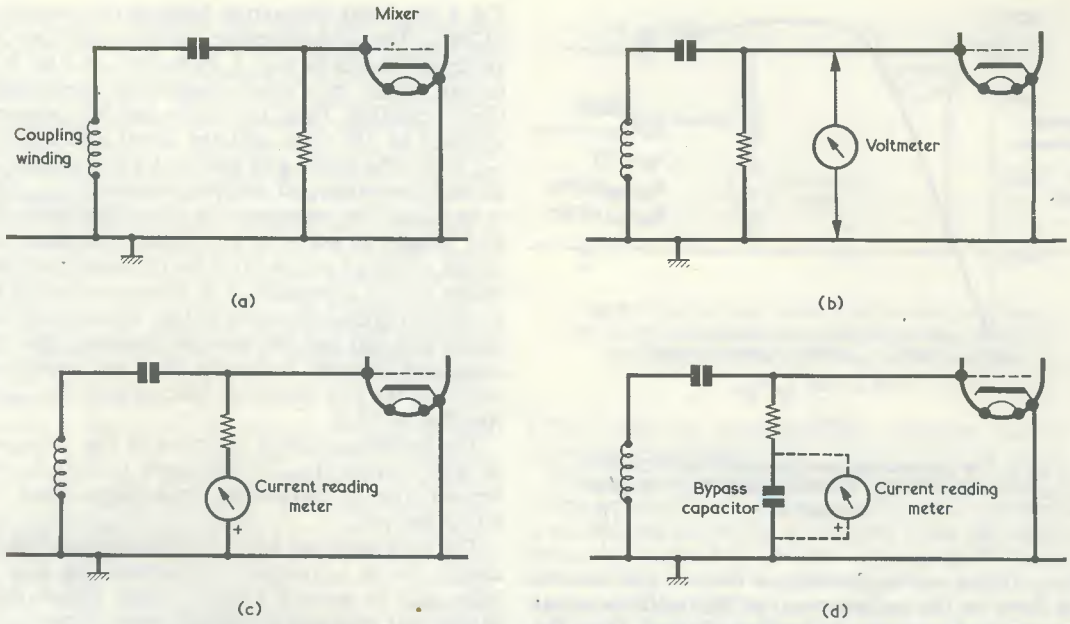

Fig. 1 (a). Applying the local oscillator voltage (by way of a coupling winding) to the grid of a superhet mixer

(b). A possible method of measuring oscillation amplitude at the grid

(c). A much simpler method of indicating oscillation amplitude

(d). If the insertion of the meter of (c) is liable to upset circuit conditions it may be bypassed by a capacitor of suitable value

mixer grid. We have not yet discussed how oscillation amplitude may be measured, and so we must next digress a little and examine this particular point in detail.

Fig. 1 (*a*) shows the grid of a mixer to which is applied a signal from a separate local oscillator. It is assumed that the oscillator signal is provided by a coupling winding (which couples to the oscillator tuned circuit) because this shows the external circuit paths from grid to cathode most clearly. A standard grid capacitor and grid resistor input circuit is employed. If we wished to measure the amplitude of the oscillator signal it would appear that all we need to do is to connect a suitable a.c. voltmeter between the grid and chassis, as in Fig. 1 (*b*). In practice, unfortunately, this approach is not always entirely convenient, because it is necessary to use a voltmeter having a very high impedance between its terminals (otherwise it will cause the oscillator amplitude to drop) and to ensure that its connecting leads do not upset conditions elsewhere in the circuit. A much easier method of measuring oscillator signal amplitude is to insert a current reading meter in series between the lower end of the grid resistor and chassis, as in Fig. 1 (*c*), this giving us what we can look upon, for the moment, as a circuit incorporating its own voltmeter. The grid of the valve rectifies in normal leaky-grid fashion by conducting on positive peaks of the applied oscillator signal, whereupon the subsequent d.c. voltmeter formed by the current reading meter and the grid resistor (which acts in the same way as a voltmeter series resistor) gives an indication of the average negative voltage appearing at the grid. Since this voltage is negative with respect to chassis, it is necessary for the negative terminal of the current reading meter to be the one which connects to the grid resistor. Obviously, if oscillation amplitude increases so also will the reading in the meter, whereupon the latter gives an indication of that amplitude. This is a much more convenient method of indicating oscillation amplitude that is that of Fig. 1 (*b*), because all that is required is the insertion of a simple low-cost instrument into a part of the circuit which is already at low r.f. potential. The resistance of the meter will be very much smaller than that of the grid resistor, and inserting it into the circuit causes negligible disturbance of r.f. conditions. Even if any serious risk of such circuit disturbance exists, as is feasible if for instance the meter were connected by long leads, this can be completely eradicated by adding a bypass capacitor (of around 0.05μF for normal r.f. work) close to the grid resistor as shown in Fig. 1 (*d*).

We have described the combination of grid resistor and series current reading meter in Fig. 1 (*c*) as a d.c. voltmeter, because looking upon the circuit in this light when it is first encountered makes it easier to appreciate why the meter reading is proportional to oscillation amplitude, and why it is the negative terminal of the current reading meter which connects to the grid resistor. If we wished we could, indeed, calibrate the meter in terms of oscillation voltage amplitude. With a little further consideration, however, we may see that there is no necessity to provide such a calibration. It so happens that the meter indicates, on its *existing* scale, the average grid current resulting from the oscillator signal!

This last point may be a little puzzling to the beginner, particularly when it seems very clear from Fig. 1 (*c*) that the meter is patently not in series with the grid circuit in

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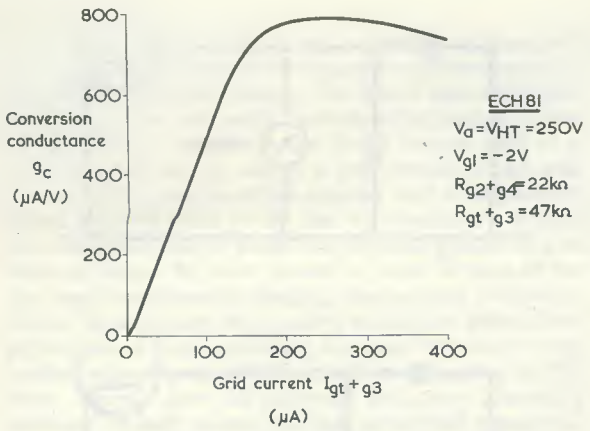

Fig. 2. The conversion conductance—grid current curve for the ECH81. (Acknowledgement, Mullard Limited.)

any way. What occurs, however, is that the grid current which flows on the positive peaks of the oscillator signal causes the grid capacitor to become charged. Over the rest of the cycle the capacitor then discharges via the meter because, since the valve grid is not then conductive, no other discharge path is available for it.

Let us suppose that the grid of the valve in Fig. 1 (*c*) is taken out of circuit for a period. The meter will then give a zero indication because any current it passes on positive half-cycles is balanced out by the current it passes on negative half-cycles. If we reintroduce the grid this equilibrium is upset. A current then flows into the grid capacitor on positive peaks and flows from it through the meter over the remainder of the cycle. Thus the meter indicates, albeit at second hand, the average value of the current which has upset the equilibrium; and this current can only be the average grid current of the valve.

CHARACTERISTIC CURVE

Our digression, by way of the explanation illustrated in Figs. 1 (*a*) to 1 (*d*), shows us that a very simple method of determining the oscillator signal amplitude applied to a mixer grid is to insert a current reading meter at the chassis end of the grid resistor. We can then work in terms of the average grid current that this indicates. It is also necessary to specify the value of the grid resistor. With mixers of the type employed in long, medium and short wave receivers the average grid current is usually of the order of hundreds of microamps, whereupon the grid current meter could, in practice, be a 0–1mA instrument. Mixers intended for higher frequencies usually run at lower grid current figures and a more sensitive instrument is required.

We may next return to our earlier statement that valve manufacturers issue curves for their products showing conversion conductance plotted against oscillation amplitude, and we can now also see that the latter may be expressed in terms of grid current.* A typical example of a conversion conductance-grid current curve is given in Fig. 2, this being taken from Mullard information for the ECH81. The corresponding circuit conditions for the valve are shown in Fig. 3. Note that, in Fig. 2, all the factors which may affect conversion conductance are firmly specified. Thus, the anode and h.t. potentials are specified as 250 volts, and the signal grid bias (V_{g1}) as −2 volts. The screen grid potential is not quoted in volts. Instead, the screen grid dropping resistor (R_{g2+g4}) is stated to be 22kΩ. This represents the same conditions of screen grid supply as occur in a practical frequency changer circuit. (Since g2 and g4 carry out the same function as the screen grid in a pentode, it is common practice to refer to the two grids collectively as the "screen grid".). As the triode grid (gt) and the heptode oscillator grid (g3) are connected together externally they are treated as one item, and the grid resistor is referred to as R_{gt+g3}. This is specified as 47kΩ.

The horizontal axis of the curve of Fig. 2 is graduated in grid current (I_{gt+g3}) from zero to 400μA, and the vertical axis in conversion conductance from zero to 800μA per volt.

The most apparent feature of the curve of Fig. 2 is the abrupt rise in conversion conductance for grid current from zero to around 150μA. Above 150μA the curve flattens out, reaching a "broad" peak at around 250μA grid current, then dropping slowly aboye this figure. If we had to design an efficient frequency changer circuit around the ECH81 our first aim would be to ensure that the local oscillator circuit always provided a grid current which was comfortably above the 150μA figure. The drop in conversion conductance below 150μA grid current is so marked, in comparison with the rest of the curve, that working on this part of the curve should be avoided if at all possible. A sensible practical approach would be to aim for a grid current of around 200 to 275μA, and this would give a reasonable amount "in hand" for subsequent valve aging and the like. In order to keep well above the 150μA point it might, at first sight, be thought desirable to work at higher grid current up to 400μA or even more, since the drop in conversion conductance at these figures is

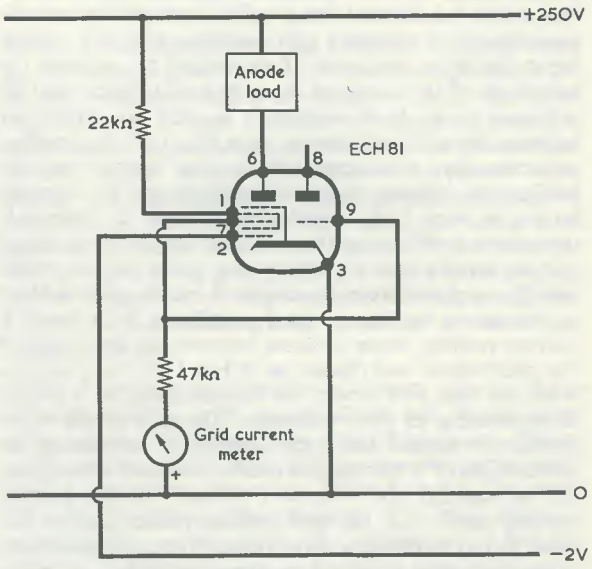

Fig. 3. The ECH81 voltage and current conditions indicated by Fig. 2

* Some v.h.f. triode and pentode mixer valves do, however, have oscillator amplitude expressed in r.m.s. voltage, this usually being done if the valve can operate as a mixer with a small resistor in the cathode circuit. If such a valve is operated with the cathode connected directly to chassis the r.m.s. oscillator voltage is the meter grid current multiplied by the grid resistor value (which gives the peak value from Ohm's Law) times 0.7.

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obviously not high. However, too high a grid current can result in the oscillator harmonics having appreciable amplitude, whereupon they become more liable to produce intermediate frequency signals with strong interfering aerial signals. In receivers having simple signal frequency tuning circuits, excessive oscillator harmonic amplitude can cause interference in the form of "whistles" on some transmissions.

A factor which complicates oscillator circuit design is given in superhets covering fairly wide frequency bands in a single sweep of the tuning capacitor, as occurs in long, medium and short wave receivers of the domestic type. It is often difficult to maintain a reasonably constant oscillator amplitude over all of a single band, it being found that grid current is usually lower at the low frequency end where the oscillator tuned circuit is least efficient. Nevertheless, it should still be possible to keep the grid current within the top broad part of the conversion conductance curve (say from 175 to 300μA in Fig. 2) at all settings of the tuning capacitor. The conversion conductance-grid current curve of Fig. 2 is typical in *shape* to that for virtually all standard mixer valves, whether these be of the grid leak type with a single control grid or like the ECH81 with two control grids. The conversion conductance curves for all these similarly exhibit the same sharp rise from zero to a broad peak, followed by a gradual fall for higher grid currents. Naturally, the actual grid current figures will be different for valves other than the ECH81 and the manufacturers' literature has to be consulted accordingly.

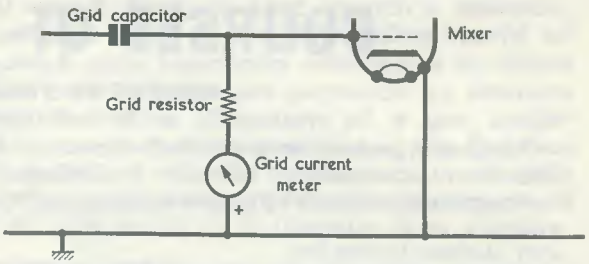

Fig. 4. Any grid leak mixer, whether self-oscillating or fed by a separate local oscillator, may have grid current measured in the manner shown here

For grid leak mixers, either self-oscillating or running with a separate local oscillator, grid current measurement is carried out as in Fig. 4. In both cases the oscillator should be designed to offer the optimum grid current, as shown from the valve manufacturers' curves, in the same way as with the ECH81 just discussed.

NEXT MONTH

In next month's article we shall conclude on the subject of the superhet mixer and shall carry on to the i.f. amplifier.

CATALOGUE RECEIVED

ELECTRONIQUES (S.T.C.) LTD.

Electroniques have now published the second edition of their Hobbies Manual. This new and entirely revised 1968 issue containing 960 pages is divided into twelve sections and is twice as large as the old edition.

There is a full range of kits for the practical man who enjoys the satisfaction of building his own high performance equipment but lacks the experience to design it himself. For the electronics enthusiast who prefers to build and design his own circuits there is an extensive components section incorporating both commercial and professional grade products. Every item listed is fully detailed and specified together with photographs and drawings where appropriate.

For those preferring to purchase ready-built equipment there are the Audio and Hi Fi, Shortwave Listening, Home and Hobby, Motoring and Amateur Radio sections from which to choose. Kits can be supplied assembled at extra cost. Other sections include books, test equipment, Hallicrafters receivers and a separate valves and semiconductors section with many new devices.

The new Manual has a much increased product range and now includes microscopes, telescopes, hi fi, tape recorders, car radios, seat belts, engine tuning kits as well as all the products previously available. In the components sections there are many new additions such as a new range of RCA American receiving valves and a much wider range of transistors including FET's. The index covers 20 pages.

As in the previous edition there are numerous pages of technical data, abacs, formulae, designs and hints of practical use to the constructor.

Although the price this year is 16/6d. this has been offset by vouchers valued at £25 which could save the cost of the Manual many times over when purchasing the goods listed in it.

The Hobbies Manual (price 16/6d.) is available from Electroniques Dealers throughout the country, or direct from Electroniques, Edinburgh Way, Harlow, Essex.

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COURSES OF INSTRUCTION

COVENTRY TECHNICAL COLLEGE

Butts, Coventry, CV1 3GD.

A course in preparation for the Radio Amateurs' Examination (C. & G. 55) held by the City and Guilds of London Institute will be offered at this College for the next session beginning in September 1968.

Attendance will be on Wednesday evenings from 7.00 until 9.00 p.m. Tuition in Morse Code will be available, as an extension of the course after the examination in May 1969 until the session ends, in July, without further fee.

Enrolment will be during the period 9th to 12th September the course fee being £2 0s. 0d.

The College has a well equipped transmitting station (call sign G3UVW) and students are encouraged to operate the station under the supervision of the Organiser, Mr. F. J. S. Chandler, G3HHM who will welcome enquiries from intending students.

SOUTHALL

Southall College of Technology, Department of Electrical Engineering, Section 47/48, Beaconsfield Road, Southall, Middlesex

Full-time Course in Basic Electronics

There is a rising demand for technicians to work in the fields of *(a)* automation and computer technology and *(b)* television, including colour. City and Guilds of London Courses 47 and 48 cater for these requirements, taking five years to reach final level. The courses are similar up to Intermediate level, i.e. for the first three years.

In view of the acute shortage of skilled personnel, a full-time course has been arranged. This will cover the requirements, for Intermediate, in nine months, September to May, and will lead to City and Guilds certificates.

The course includes extensive practical work and, on completion the students will be competent to carry out test procedures, using modern test gear, repair, or assist in the construction and modification of, electronic equipment, using circuit diagrams.

If required, final level courses, in either specialisation, are available on a part-time basis, i.e. one day per week.

The full-time course is ideal for school leavers, both boys and girls, also for those who wish to enter any branch of the electronics industry for the first time.

There are no ffes for school leavers under 18, and for others the fee is £19. Overseas students, with 'O' level English or equivalent, may have to pay £170 if they have no U.K. residence qualification.

Enrolment on 11th September, 10–12.00 or 2–4.00 p.m.

BROMLEY

Radio Amateur Examination

You may wish to inform your readers that a class in preparation for the Radio Amateur Examination will be held at the Adult Education Centre, 28 Beckenham Road, Beckenham, Kent.

The class meets on Thursdays from 7.00 – 9.00 p.m., commencing 26th September 1968.

Fees are graded according to age.

Enquiries to: M. D. Bass, B.Sc., (G30JE), 42 Clevedon Road, London, S.E.20. A Morse class will be held in addition, if numbers are sufficient.

TUNBRIDGE WELLS

The West Kent College of Further Education, Tunbridge Wells, Kent, are running full-time courses in Radio and Television Servicing, and Electronics Servicing, to intermediate City and Guilds Certificate standard.

Courses commence 16th September 1968, and applications can be considered from students outside the County of Kent. Further details may be obtained from the Registrar, West Kent College of Further Education, St. John's Road, Tunbridge Wells, Kent. (Tel: Tunbridge Wells 28276).

WALTHAMSTOW E.17

Marsh Street Youth Centre

Radio Amateurs' Examination Course

Course No. 2 is being organised for commencement early in September 1968. The topics covered will be suitable for anyone beginning radio studies, and will cover the material required for the Examination for the Transmitting Licence. It is hoped to make the Course an informal one with plenty of time for discussion and difficulty solving.

As well as being suitable for the R.A.E. the Course should be eminently suitable for anyone thinking of a refresher or study course on elementary radio and electronics.

Enquiries regarding the Course should be addressed to K. L. Smith, G3JIX, 82 Granville Road, Walthamstow E.17.

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In your work-shop

Readers will recall that, in last month's episode, Smithy introduced Dick to the intriguing world of fluidics, in which gate functions analogous to those given by electronic circuits are provided by devices which control the flow direction of a gas under pressure. This month Smithy completes the fluidics story by describing fluidic symbols, a fluidic oscillator and the general trend of fluidic development

"And how," asked Dick brightly, "is Smithy on this sunny and shimmering September morn?"

Smithy turned a distrustful eye upon his assistant, then carefully shut the Workshop door behind him.

"All right, I suppose," he replied guardedly.

"Do you," continued Dick cheerfully, "feel in the pink of condition, with all your corpuscles bashing around your body at top efficiency?"

Smithy considered this question gravely.

"I think," he replied after a moment, "I'm holding together *reasonably* well."

"Full of energy?"

"Sufficient to get me by."

"Sprightly and alert?"

"Now, look," snorted Smithy irately. "What the dickens is all this leading up to? Not only have you, by some miracle, actually opened up the Workshop this morning before I even got here, but you next proceed to ply me with all manner of questions concerning my health. Have you suddenly acquired an agency for Phyllosan or something?"

RETURN TO FLUIDICS

"On no," replied Dick soothingly, "it's nothing like that at all. It's just that we should be having a quiet hour or so before our van-driver dumps the next lot of sets on us for repair, and I was hoping you'd be feeling fit enough to keep your promise to me."

Smithy turned to the "For Repair" racks. They were empty. He glanced warily at his assistant.

"What promise?"

"The promise that we'd be having a follow-up discussion on this fluidics business. Don't you remember you told me you'd do this at the end of our last gen-session?"

"Why, so I did," said Smithy, his face clearing. "Well, now, that's a promise I *don't* mind keeping, because I'm just as interested in fluidics as you are. We've certainly got nothing else to do for the time being so I'd be only too happy to pass on a little more gen on the subject."

Somewhat taken aback at Smithy's ready acceptance of his suggestion, Dick faltered momentarily then decisively carried his stool over to Smithy's bench. That worthy was already settling himself down and had pulled his note-pad towards him.

"How much," he asked, "do you remember from our last natter about fluidics?"

A monstrous frown appeared on Dick's brow as he concentrated his thoughts.

"Well," he said slowly, "you first started off by telling me about Coanda effect. You said that if a fluid, which could be liquid or gas, is pumped under pressure through the aperture of a nozzle into the open air it forms a jet which just goes straight outwards. But if you put a side wall close to the nozzle aperture the jet flows, instead, along the surface of that wall, a little bubble of air being trapped in the corner between the side wall and the nozzle surface."

"That's right," confirmed Smithy, busy with his pen on his note-pad. "What you've just described is the basic Coanda or wall attachment effect. I also told you how this effect enabled a fluidic flip-flop to be made up, like the one that I've just drawn here. (Fig. 1). The side walls in this flip-flop are symmetrical on either side of the nozzle aperture whereupon, when a gas is initially fed in under pressure at the supply port, it will choose the side wall to which it first becomes attached in random fashion. Thus, the supply has can initially pop out at either of the output ports, just as occurs with an electric flip-flop. But you can easily flip the jet over from the right hand output port to the left hand one, if you want to, by feeding in gas under pressure at the right hand control port. And vice versa."

"You also," put in Dick, "told me about jet deflection."

"True enough," agreed Smithy, "and that led us up to the fluidic monostable which could function as a NOR gate. In the fluidic monostable there is a vent coupling to one of the side walls, with the result that Coanda effect cannot take place at all on that particular wall. The vent is on the left in the monostable I've sketched out here (Fig. 2) and so, in the absence of control inputs, the output is always at the right hand output port. But the output shifts to the left hand output port if there is an imput at either one of the two control ports or at both of them. Just what you need for an OR gate. Since an output at the right hand output port is the inverse of one at the left hand output port, this device can also function as a NOR gate."

STABILITY

"Right," said Dick eagerly, "let's now press on from there!"

"As you like," replied Smithy equably, "What do you want to deal with next?"

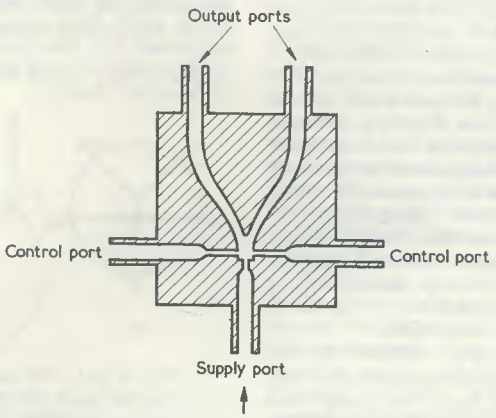

Fig. 1. The internal structure of a fluidic flip-flop. Coanda effect may take place on either side

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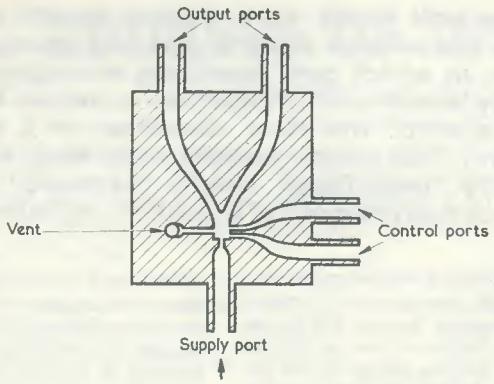

Fig. 2. A monostable with two control ports, as here, can function as an OR/NOR gate

"For the moment," said Dick, "I want to get myself more fully at home with the basic operation of these gadgets. How stable, for instance, is a fluidic gate when it's operating on Coanda effect?"

"How do you mean?"

"How long does the jet remain attached to a wall after it's been initially held there by Coanda effect?"

"The Coanda effect continues indefinitely," replied Smithy, "provided that the correct supply pressure is maintained at the jet nozzle. The Coanda effect doesn't take place at all until the jet pressure achieves a certain critical figure which depends on nozzle dimensions, wall spacing, and so on. The effect is then present for all jet pressures above this up to some 40 times the initial critical pressure. In consequence, provided you can maintain jet pressure within this very wide range, Coanda effect causes the jet to stick like a limpet to the side wall that has been selected for it. I may add that typical nozzle aperture diameters for gas are of the order of 0.015 inch, and that complete devices of the type we've been considering up to now are made in flat rectangular packages about an inch long, three-quarters of an inch wide and a quarter of an inch deep. These dimensions exclude any projecting pipes which are fitted for interconnection."

"Fluidic devices are quite small, then."

"Oh yes," confirmed Smithy. "The coupling tubing between fluidic devices is quite small, too. It's only about an eight to a quarter of an inch in diameter according to the manufacturer of the devices it's used with. Again, the supply pressure is quite low, being of the order of 10 lbs per square inch or so."

"The supply pressure," remarked Dick thoughtfully, "is very similar to the supply voltage which causes current to flow in an electronic system."

"True enough," agreed Smithy. "There are other similarities as well, too. For instance, there's a fairly well established set of symbols for fluidic devices, and these appear in circuits that are much the same as the ones you have in electronic circuits. The tubing which couples devices together is shown as lines in these circuits, in the same way as the wiring coupling electronic devices is drawn. The symbol for the bistable flip-flop we considered just now is drawn like this. (Fig. 3 (*a*)). The total symbol is enclosed in a circle, and you'll see there's a smaller circle at the bottom. This smaller circle represents the nozzle and is usually given the letter S for 'supply', or J for 'jet'. The two arrows pointing inwards are called C1 and C2 and represent the control inputs. The two output ports are called O1 and O2 respectively. If there were two control ports on either side of the bistable nozzle, the symbol could be drawn like this (Fig. 3 (*b*)). Note that there's a tendency to keep the odd numbers for the C and O elements on the left and the even numbers on the right, although not all manufacturers follow this convention. The monostable OR–NOR gate with two input controls which I drew just now is shown like this (Fig. 3 (*c*)) and I've written alongside it the logic equations which correspond to its action. The first equation means that you get an output O1 when either input C2 *or* input C4 *or* both together are present of *not*-C2 and *not*-C4. Don't bother your head about that second equation, though, unless you're keen enough on logic to appreciate that this corresponds to the NOR condition of the device by way of D. Morgan's Rules."

"As a matter of fact," said Dick, "I remember you nattering about De Morgan's Rules some time ago, and so I've got a pretty good idea about what you're getting at there."

"Fair enough," said Smithy laconically. 'Before we go any further there's one important little point I want to clear up. Up to now, and particularly during our last session, I have referred to the fluid which flows in the devices as being a gas other than air. In actual practice, the fluid will normally be air itself, this being used both at the supply nozzles and in the control ports and channels. With air you'll still get all the effects I've described, including the trapped bubble at the corner of the nozzle surface and side wall which occurs with the Coanda effect. If air is the fluid this now becomes a bubble of air trapped by a jet of air, instead of a bubble of air trapped by a jet of gas. The main advantage of referring to gas in an initial explanation of fluidic devices is that you can then show the jet shaded in your diagrams in order to differentiate it more readily from the air around it! But, to reiterate, the jet and control inputs can all use ordinary air under pressure to carry out the functions I've described."

"I notice," remarked Dick, "that in all your sketches you've shown the channels through which the air travels as having gently curved sides."

"That's a very necessary feature of fluidics design," said Smithy. "There *must* be gradual bends and gradual changes in dimensions in the paths through which the fluid flows or you get vortexes appearing, and these can upset operation. A point I haven't mentioned is that manufacturers sometimes deliberately introduce vents or cavities along the output channels for the jet, this being done to reduce vortexes and to ease the problems of matching the output to the connecting tubing and to other devices. The techniques used here tend to vary from maker to maker and the presence of such vents or cavities doesn't affect the explanations of jet switching which I've just given you."

"Are there any really *complicated* fluidic devices?"

"Quite a few," replied Smithy. "You

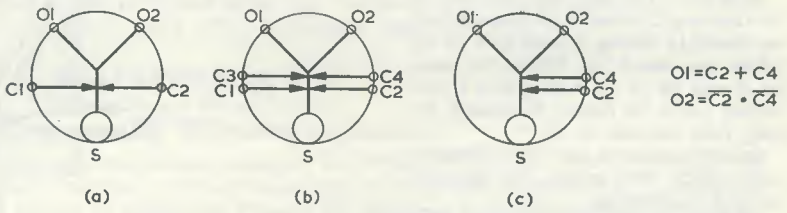

Fig. 3 (a). The circuit symbol for a bistable flip-flop with a single control port on either side. The lower circle may alternatively be identified by the letter J (for "jet") instead of the letter S
(b). The symbol for a bistable with two control ports on either side
(c). The sumbol for the monostable of Fig. 2 with two control ports

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can, for instance, get fluidic binary counters, Schmitt triggers, and the like. These are given by combining a number of individual devices and gates together and are often made up in a single unit which incorporates the interconnections in channels instead of using external tubing. Just like integrated circuits!"

"Phew," remarked Dick wonderingly. "Integrated fluidics!"

"Then again," continued Smithy, "you can have a fluidic proportional amplifier with two control ports on either side of the jet. The side walls are positioned so that this works entirely by jet deflection with no Coanda effect taking place at all, and the jet is deflected between the two output ports by the pressure in the control inputs. Now, here's another application which I find *quite* intriguing."

Smithy drew again on his note paid. (Fig. 4).

"What's this?" he asked.

"Don't ask me," replied Dick helplessly. "I haven't a clue."

"It's an oscillator," replied Smithy. "The device is biased to output port O1 by having a vent to prevent Coanda effect on the right, just as in the monostable we looked at earlier on. Also, there's a fairly long external channel or length of tubing between output O1 and control port C1. The result is that, as soon as the supply jet first appears it goes out at O1 and carries on into the long external channel. After a period depending upon the length of the external channel, the output appears at C1 and deflects the jet over to O2. This continues until the pressure in the external channel drops, whereupon the jet reverts to O1 and the process repeats. The result is a continuous oscillation, together with a pulsating output from O2."

SENSITIVE AMPLIFIER

"Gosh," said Dick, "*that's* neat."

Smithy nodded his head in agreement, then drew a further sketch on his note-pad. (Fig. 5).

"Now here," he announced, "is something even neater. This is a fluidic circuit for a very sensitive digital amplifier which has been developed by the Plessey Company, and you'll see that the bottom stage consists of an oscillator similar to the one we've just looked at. It's function is to pass a pulsating supply to the stage above, which is a monostable having one input. This monostable is a bit different to the previous one we looked at, and Coanda effect can take place on both sides. However, the side walls are so dimensioned that the jet always has a slight bias towards initial attachment to the right hand wall. The function of the control input is to flip it over to the left, where it can similarly be held due to Coanda effect."

"Why," asked Dick, "does its supply come from the oscillating stage?"

"To answer that question," replied Smithy, "I must return to an earlier point I made. You'll remember I said that the Coanda effect is always present provided that the supply pressure in the nozzle is higher than a certain critical figure. Below that figure the jet simply goes straight outwards regardless of the presence of side walls at the nozzle aperture. Now, if the supply pressure is gradually increased from a low figure it will reach a certain pressure, just below the critical minimum figure needed for Coanda effect, where the jet is in an unstable condition and can be readily deflected by a very small control signal pressure. In our present instance, the supply for the monostable is the pulsating output from the oscillator, and this supply pressure falls below the minimum critical Coanda figure once each oscillator cycle, after which it rises above it. Therefore what happens is that, once in each oscillator cycle, the supply to the monostable goes through the sensitive region, just below the critical Coanda minimum, where the jet is capable of being deflected to the left by a very small control input. As the supply pressure increases up to and passes the

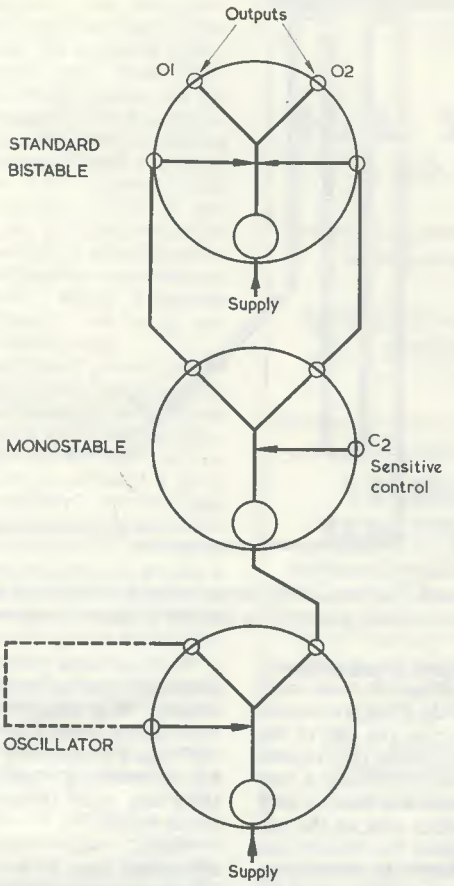

Fig. 5. The Plessey sensitive digital amplifier. All parts and channels are integrated into a single unit

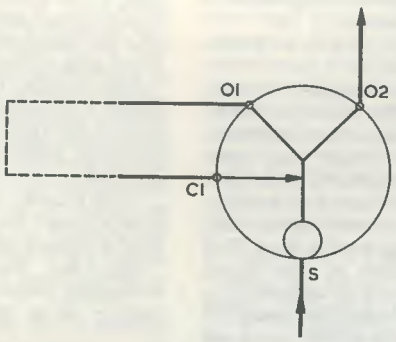

Fig. 4. A fluidic oscillator. This gives a pulsating outport at port O2

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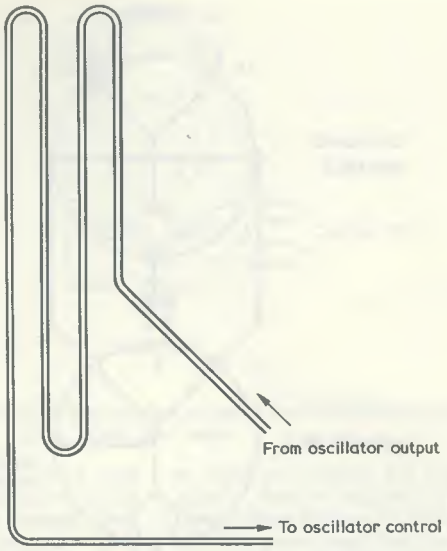

Fig. 6. The oscillator feedback channel of Fig. 5 is folded on itself in the manner shown here so that it fits into the complete integrated unit

Coanda minimum figure the jet is already deflected to the left and it then stays there until the Coanda effect is momentarily lost once more at the end of the oscillator cycle. The process then repeats and the overall result is that only a very small control pressure is needed to keep the monostable output over to the left. With no control signal, the built-in bias in the monostable keeps the output over to the right. For the small fraction of the oscillator cycle when it offers an output below the sensitive region the monostable will offer an output from both output channels. But since, during this period, the pressure from the oscillator is very much lower than over the rest of the cycle the effect of such low pressure outputs is negligible."

"What's the third stage?"

"That's just a standard bistable having its own supply," said Smithy. "The outputs from the monostable are, in turn, derived from the oscillator output, so they're also of a pulsating nature. They couldn't be applied directly to other fluidic devices. They are, in consequence, fed to the bistable, which acts as a sort of buffer, or smoothing, amplifier. The bistable enables a smooth output to be provided that is suitable for feeding to other fluidic components."

"Well," said Dick, impressed, "that's a *really* cunning scheme."

"Isn't it?" confirmed Smithy. "Incidentally, all the three stages are integrated into one assembly having four ports only. The first is the supply port, which feeds both top and bottom stages, the second is the sensitive control port, and the two remaining ones are the output ports."

"What about the feedback channel for the oscillator? Doesn't that have to provide a pretty long path?"

"It does," said Smithy, "but it's still integrated into the combined unit, and it consists of a channel folded back on itself several times. Like this." (Fig. 6).

"Well, I've certainly learned a good bit this morning," rekarked Dick. "Are there any other things I should know about fluidics?"

"Well," said Smithy, "at this elementary stage it's useful to know how a fluidic system couples into the external processing machinery which the system is to control. Quite a few established methods of automatic process control rely on pneumatics, whereupon a fluidic system could, theoretically, be coupled into these directly. Other methods of automatic process control rely on electrics or electronics, with the result that transducers are needed to convert electrical signals to fluidic signals and vice versa. A simple example of the first is a solenoid, or modified relay which, on being energised, opens or closes a valve and allows or prevents the passage of fluid. For a transducer in the reverse direction you can have a diaphragm-operated switch. This closes, or opens, according to whether or not pressure is applied to the diaphragm."

Smithy put his pen back in his pocket with an air of finality.

"And that," he continued, "pretty well gives you all the picture so far as elementary fluidic basics are concerned. I should mention though that, apart from industrial applications, there have also been some really advanced developments in fluidics recently, particularly in the aviation and missile field. One advantage of fluidics is that fluidic systems can work at high temperatures, whereupon they become very useful for control applications in aircraft jet engines and things like that. Again there's even a fluidic stepper motor which is rather similar to a uniselector. It has a rotor which moves round one position for each pulse of pressure applied to it, and it can be used to indicate the numerical output from a fluidic computing device."

THE VAN-MAN COMETH

"Blimey," said Dick. "Fluidics certainly seems to be hotting up! For the moment, though I think I'd prefer to stick to the simple stuff, and I've got just one more question I'd like to ask."

"Fire away!"

"How quickly," asked Dick, "do fluidic systems operate?"

"As I said during our last discussion," replied Smithy, "they're much slower than the corresponding electronic devices which they replace. Switching time in a single fluidic device like the monostable and bistable we have been talking about is of the order of a thousandth of a second, and you can get complete systems running at quite a few hundred pulses per second. This will be speeded up with further development but, as things stand, the speed is still more than high enough for most automatic control applications. And, of course, these fluidic systems can function under conditions of temperature and vibration which would make electronic systems curl up completely. Again, it's claimed that the inherent simplicity and robustness of fluidic systems makes them less subject to failure. Here, though, some care has to be taken to ensure that impurities in the air passing through the system don't wear out or block up jet nozzles. If a system is used in a location where there's a great deal of impurity in the air, the air has to be filtered before application to the system. On the other hand you can't, at any rate, break down a fluidic device by connecting it up incorrectly, as you can with some electronic gadgets!"

"For someone like me," grinned Dick, "that's the best advantage of the lot! By the way, Smithy, a thought that occurs to me is that a keen amateur could have quite a bit of fun making up his own experimental fluidic systems."

"Indeed he could," agreed Smithy. "A useful approach would be to use water as the fluid, since this would work with much wider jet orifices than are needed for air, and it would be easier to see if the devices were operating properly. Hullo, that sounds like our van!"

And, in fact, the sound of the van engine had become fully audible in the Workshop. There was a sudden squeal of brakes, followed by a heavy metallic clangour.

"Hell's teeth," snorted Smithy. "He's done it *again*! I'm convinced he's got a grudge against that dustbin of ours."

But, five minutes later, Smithy completely forgot about the Workshop dustbin as he and Dick surveyed the

(*Continued on page* 129)

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Radio Topics

By Recorder

VIRTUALLY ALL OUR MODERN civilisation is based on an assumption.

We rely on electricity to light our homes, to run our radio and television receivers, to operate much of our hospital apparatus, to start and maintain our automobiles in motion, to provide communication and navigational information to our aircraft, and to run the computers which do our calculations for us. We have satellities poised over the earth re-transmitting signals sent to them from over the horizon, as well as space vehicles that are capable of sending us pictures of the surface of the moon. And, of course, we rely on electricity for very much more besides.

All this gigantic range of electrical and electronic equipment is wholly conceived, designed, developed, manufactured and operated on the basis of a single assumption: that an electric current consists of a flow of electrons.

Yet nobody has ever even *seen* an electron!

THEORY AND PRACTICE

Every part of our work in electricity and electronics is based on the theory that a flow of electrons constitutes an electric current. Not only can we explain the operation of all our devices in terms of this theory but we also create new applications which similarly depend on the electron concept.

I raise this point because it is occasionally a beneficial exercise just to stop and think about the foundations on which our present knowledge and activities are based. The theory that electric current consists of electrons in motion is a jolly good one and has certainly never been disproved. But it's nothing more than a theory, despite the fact that all our experience tells us that it must be correct and that its accuracy has been confirmed by a myriad of practical examples. True enough, but could it still not be that it is a theory which has fitted all our experience *up to the present time*?

I am reminded, here, of the reliance placed by 18th century scientists on the theory of phlogiston. The phlogiston theory was introduced by Georg Ernst Stahl and it fitted the available knowledge of the time very comfortably. Stahl speculated the phlogiston was the inflamable "principle" that enabled combustible objects to burn. According to his theory a combustible substance of "calx", or ash, together with phlogiston whereupon, when it was burned in air, the phlogiston escaped and the calx was left. A given quantity of air could only absorb a certain amount of phlogiston, after which it became fully "phlogisticated" and could not support further combustion.

The phlogiston theory sounds almost incredibly naïve to our 20th century minds, but it represented an excellent working hypothesis for its day and age. It lasted throughout the 18th century, during which time it provided a good basis for further experiment, investigation and scientific advance. Part of its success was due to the fact that it was too far from the truth as we see it today. If what we now call a combination with oxygen were described as a "loss of phlogiston," the phlogiston theory ties in fairly well with the facts. And it certainly agreed with the facts closely enough to facilitate the work that was then in progress.

There were some tricky bits, though. Just to show how men's thoughts can twist themselves to fit a particular circumstance, one of the facets of the phlogiston theory was that phlogiston imparted levity. *That* got round the awkward observation that some bodies were found to increase in weight after combustion. (This was due, of course, to the added oxygen). The explanation for the increase in weight was that since, due to combustion, the body had lost the levity imparted to it by the phlogiston it previously held, it was bound to be heavier!

Phlogiston finally disappeared into the history books when, later, Lavoisier showed that combustion was the combination of a substance with oxygen. But it had had a good and useful run till then.

Perhaps the day may dawn when someone, carrying out an electrical or electronic experiment somewhere, will find that his results don't *quite* agree with what is expected of well behaved electrons. This may lead to further experiments along the same lines until—who knows?—a completely new theory will be evolved to explain all the electrical phenomena that currently exist and to provide even more accurate and reliable guide-lines for the future.

Don't forget phlogiston—it's happened before!

PROJECTOR LAMP LIFE

In our last April issue we published an article, "Increasing Projector Lamp Life" by T. R. Balbirnie, which described how switch-on surges with slide projector

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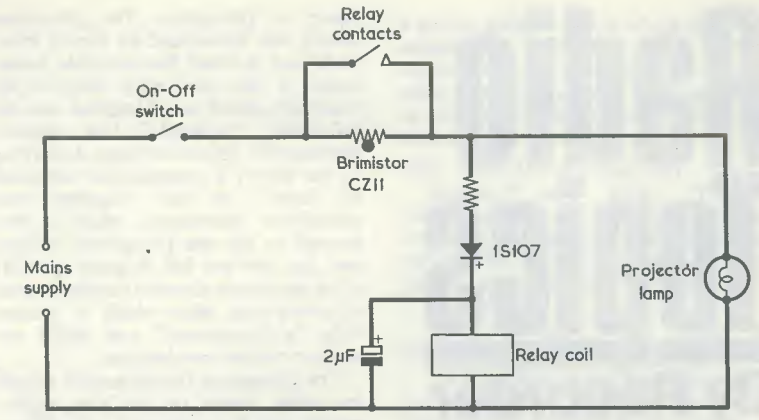

An automatic switching circuit which extends the life of slide projector lamps.

lamps can be eliminated by wiring a resistor or thermistor in series with the lamp. The use of a thermistor was preferable with lamps of 250 or 300 watts, a suitable type being the Brimistor CZ11. The thermistor (or resistor) can be short-circuited by a switch after it has allowed the lamp filament to initially warm up.

Several readers have since written to us to describe automatic systems for short-circuiting the thermistor, and the accompanying diagram shows the scheme used by P. N. Arnold of Bishop's Stortford. Circuit operation here is very simple. On closing the on-off switch, the mains supply is applied to the thermistor and projector lamp in series. As the thermistor warms up its resistance decreases, and the lamp becomes brighter. When the voltage across the lamp is sufficiently high the relay energises, whereupon its normally-open contacts short-circuit the thermistor and allow full mains voltage to be applied to the projector lamp which then runs normally. At the same time, there is no voltage across the thermistor and it commences to cool. Should the projector be inadvertantly switched off and on a few minutes later the lamp will still be fully protected. The relay contacts will open on switching off and the thermistor will have returned to its high resistance condition.

Mr. Arnold states that he has been using this circuit for several years now, employing a Brimistor type CZ11. The 1S107 silicon rectifier shown in the diagram has a p.i.v. of 800 and a maximum forward current of 750mA. The value of the resistor in series with the rectifier will have to be found by experiment and it should be such that the relay operates when the voltage across the lamp approaches mains voltage. Most relays with fairly low energising current requirements should cope and the contacts should be capable of switching about 1.5 amps and have insulation suitable for mains voltages. The relay used by Mr. Arnold has two normally-open contact sets and these are wired in parallel. The working voltage of the 2μF electrolytic capacitor must be equal to or greater than the final voltage appearing across the relay coil after the relay contacts close. It might be wise to employ a working voltage of at least twice the relay energising voltage, since this will allow a safety margin for errors when initially finding the value needed in the series resistor.

For the record I may add that the CZ11 has a maximum operating current of 1.5 amps. There is a heavier thermistor in the Brimistor range, this being the CZ12, or CZ12A, with a maximum operating current of 2.5 amps.

Mr. A. Torrance, London, W.2., has sent us a similar circuit, and my thanks go to both these readers for passing the information on to us.

PI TO 30 PLACES

"May I have a large container of coffee?"

You may recall that this was the mnemonic for π that I passed on last May. The number of letters in each word of the sentence represents, in order, the first eight figures of π.

I seem to have started something here, and D. J. Davies of Bromley, Kent, has now sent me the following letter which I reproduce here for the benefit of everyone.

"Your reference in the May issue to a mnemonic for π," writes Mr. Davis, "is very interesting and useful. It reminds me of one I learnt many years ago giving 30 places of decimals and reads as follows.

"'Now I, even I, would celebrate in rhymes inept the great immortal Syracusan rivalled nevermore, who in his wondrous love passed on before left men his guidance how to circles mensurate.'

"3.14159265358989323846264338327".

Follow *that*!

COLOURED "FLOAT" GLASS

Living as we do in a world of continuing technological advance it is

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becoming almost commonplace to hear about new and unusual applications which involve the use of electric current. Nevertheless, a very recent innovation in the manufacture of coloured plate glass is more than worthy of especial attention because so many unusual processes are involved. With the new technique it is possible to tint or colour plate glass whilst in the molten state by merely closing a switch.

To obtain the background to this new production method it is first of all necessary to gain a basic understanding of the manufacture of "Float" glass, as developed by Pilkington Brothers of St. Helens, England. In the "Float" process, a stream of molten glass leaving the furnace is distributed over a bath of molten tin which, being very much denser than molten glass and having an ideally flat and level surface, imparts a surface of equal flatness to the underside of the glass which flows over it. This glass then passes into a subsequent annealing furnace where it becomes sufficiently rigid to be transferred to rollers, for final cooling and cutting up, without being marked. Thus, "Float" glass is produced in a fully transparent form and does not require the subsequent grinding and polishing operations needed with previous methods of glass manufacture.

Coloured or tinted glass has, up to now, been uneconomic to produce by the "Float" process (or, indeed, by earlier methods of manufacture) because of the necessity of melting an excessive amount of glass carrying the desired colour before starting each colour run.

Now, however, colours and tints can be introduced to "Float" glass by adding a molten metal *above* the glass after it has been formed and as it continues along over the molten tin. Both metals are in intimate contact with the glass, and an electric current is passed through the path given by the upper metal, the glass itself and the tin underneath, whereupon ions of the upper metal migrate into the upper surface of the glass to produce the desired colour effect. Don't forget that glass, when hot enough, is quite capable of passing electricity, as was demonstrated in the short article "Making Glass Conduct" which appeared in our May 1966 issue. The depth and hue of the colour can be varied by suitable choice of the upper metal and the current which flows.

Three colours in the range grey-bronze to copper-bronze are already available. These are produced by a concentration of exceptionally fine particles of the upper metal just inside the glass surface, where they are impervious to abrasion or chemical action. Apart from decorative effects, the colouring can also be designed to eliminate glare and to filter out heat rays. Typical applications currently envisaged are coloured plate glass windows for shops, houses and other buildings, with tinted safety glass for cars as a particularly promising outlet.

The main advantage with the new process is its ease of use on the production flow line. As little as a mile of coloured glass can be started, with no interruption to production, merely by closing a switch. When sufficient coloured glass has been produced the current is cut off, and the standard transparent material appears once more.

Modern manufacturing methods are always a source of interest, but this is one of the most intriguing I've heard of for quite a while. I am indebted for the main details, incidentally, to the Journal (No. 77) of the Tin Research Institute, Fraser Road, Greenford, Middlesex.

IN YOUR WORKSHOP

(continued from page 126)

stock of television and radio receivers with which the van-driver had presented them. All, it may be remarked, intended to operate by courtesy of the ubiquitous electron rather than by pumping puffs of air through piping.

With a little sigh, Smithy dismissed the world of fluidics and returned to his more accustomed environment. Electronics was not, of course, without its own particular fascination, but it had been pleasant to dwell for a short while on a new and allied science which had so many intriguing points of similarity.

ACKNOWLEDGEMENTS

Some of the information given in the last two episodes of "In Your Workshop" is taken from technical literature by Aviation Electric Limited, Montreal, Canada (whose U.K. factors are Bendix Electronics Limited, High Church Street, New Basford, Nottingham) and Electrosil Limited, Pallion Trading Estate, Sunderland, Co. Durham (who handle Corning fluidic devices). Another source has been *Component Technology*, (Vol. 2, No. 6) published by The Plessey Company Limited, Ilford, Essex, who also manufacture fluidic devices and systems.

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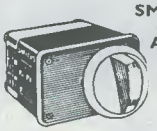

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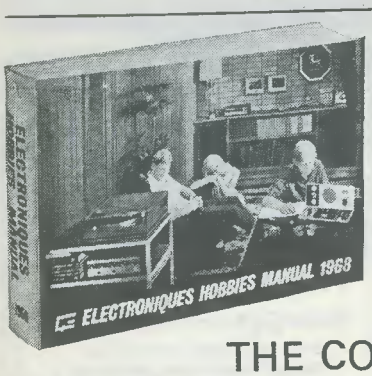

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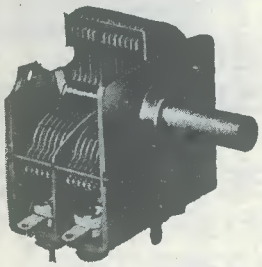

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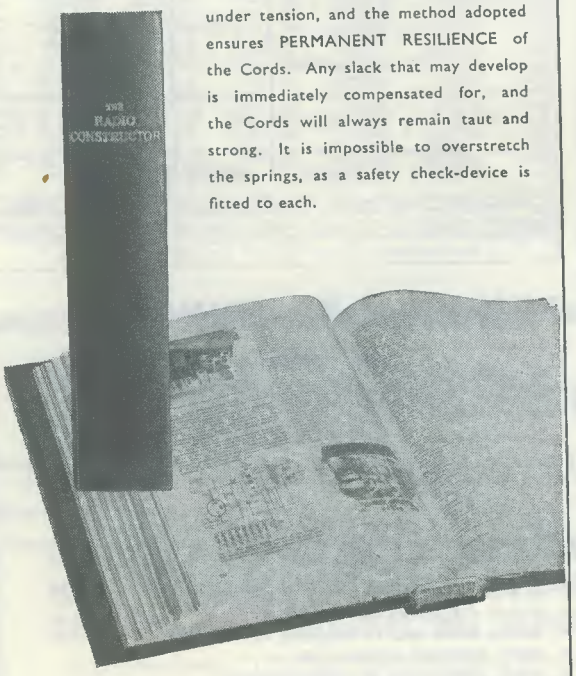

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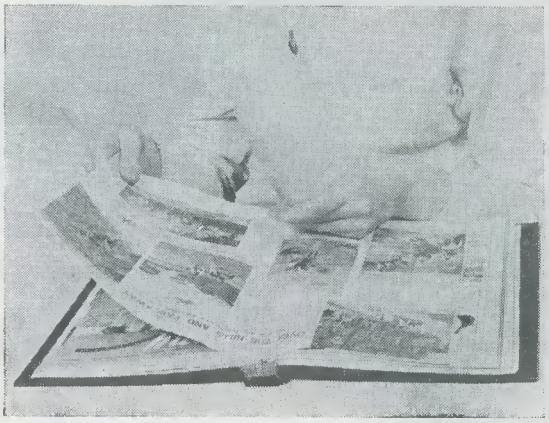

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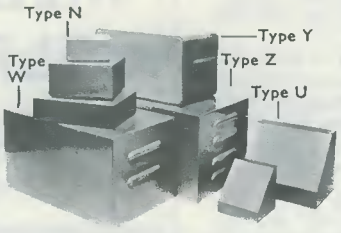

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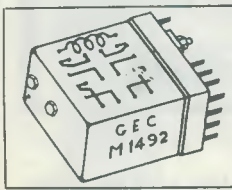

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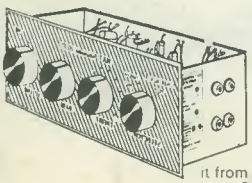

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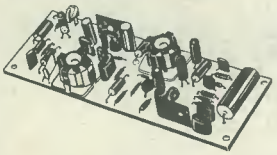

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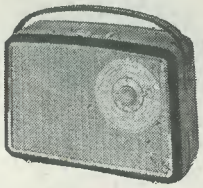

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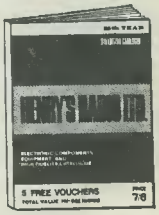

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