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Mains Unit for Battery Portables

VOLUME 10
NUMBER 12
JULY
1957

The RADIO Constructor

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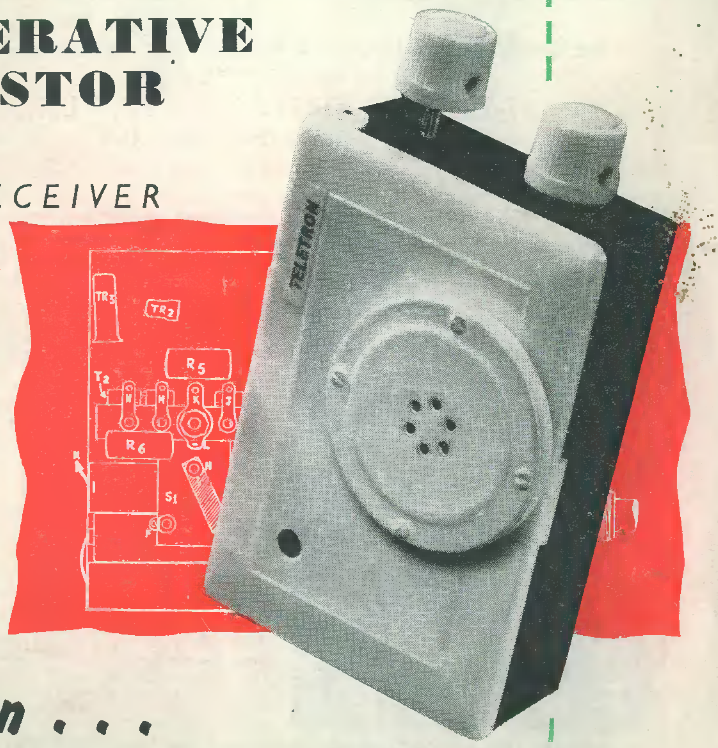

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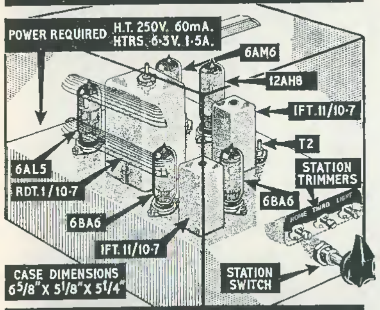

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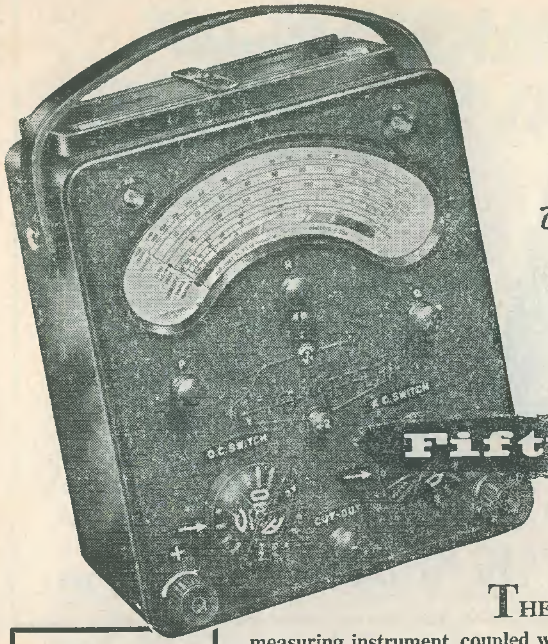

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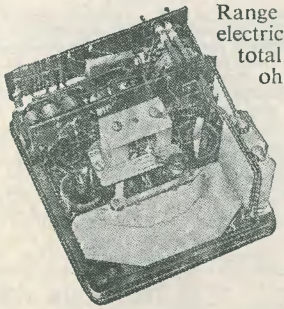

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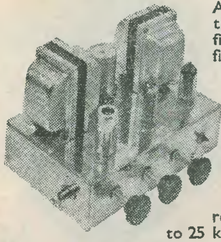

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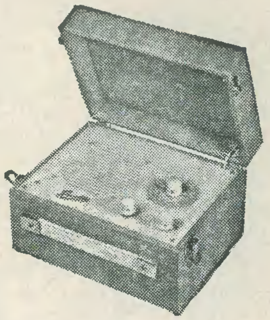

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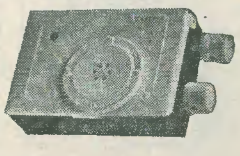

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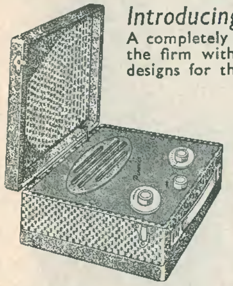

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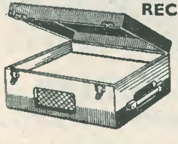

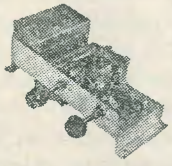

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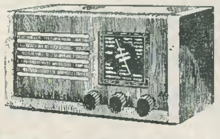

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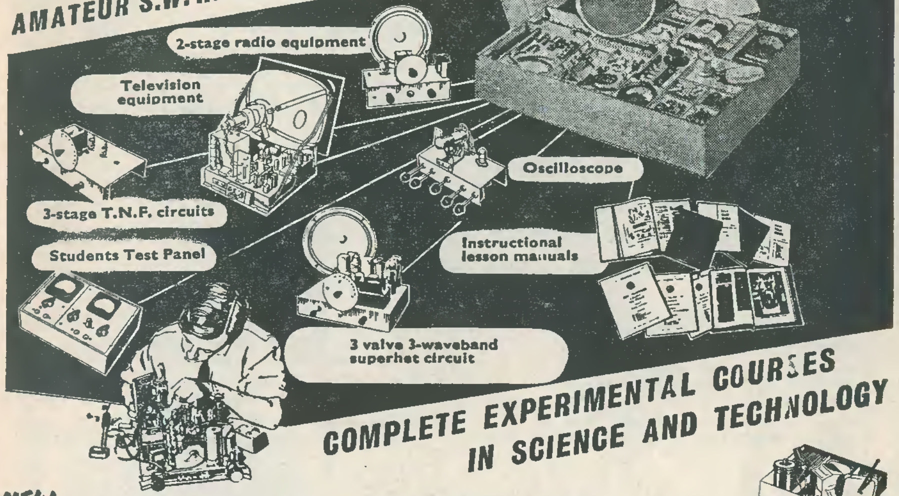

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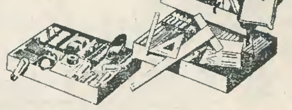

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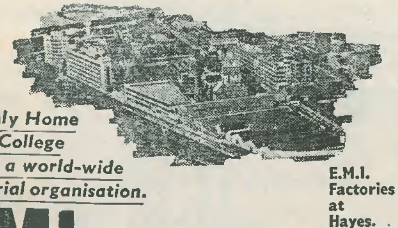

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FERRITE SLAB AERIAL TYPE FS2. A new super-sensitive aerial, Long and Medium Wave, specially designed for transistor portable receivers. Complete with fixing brackets. Length 5½″ 13/6

COMBINED OSCILLATOR AND 1st I.F. TRANSFORMER TYPE OT1 (315 k/c), fully screened, 1 3/16″ x 1 3/16″ x 1¾″ 11/6

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PUSH-PULL INTER-STAGE TRANSFORMER TYPE TT4. Ratio 1:1 ct. Stack 1⅜″ x 1 1/16″ x 7/16″ 8/6

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Miniature Iron Dust Cored Superhet Coils 465 i.f., 0.0005μF Tuning

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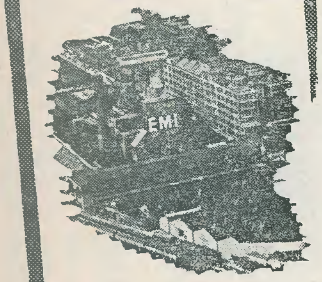

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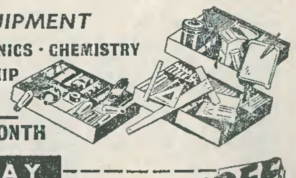

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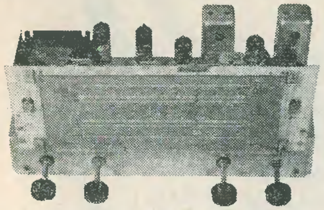

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BRAND NEW £10.10.0 Carr. 4/6

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COLLARO 1957 MODEL RC456

For 7", 10", 12" Records 16, 33, 45, 78 r.p.m.

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Designed to play 16, 33, 45, 78 r.p.m. Records 7", 10", 12". Lightweight Xtal pick-up, turnover head, two separate sapphire styli, for standard and L.P. Each plays 2,000 records. Voltage 200/250 a.c.

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Wearite M800 I.F. transformers 465 kc/s, **12/6** pair

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All isolation transformers are individually boxed, labelled and clearly marked with relevant data.

NOTE.—It is essential to use mains primary types with T.V. receivers having series connected heaters.

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HIGH STABILITY. ½W 1%, **2/–.** All preferred values 100 ohms to 10 meg.

5 watt	**WIRE-WOUND RESISTORS** 25 ohms-10,000 ohms	**1/3**
10 watt		**1/6**
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15,000 ohms-50,000 ohms, 5W, **1/9;** 10W, **2/3**

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Precision engineered. Size only 1⅜" x $\frac{3}{16}$". Bargain. Price **6/6** No transformer required

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40 CIRCUITS FOR GERMANIUM DIODES, 3/-

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Long spindles. Guaranteed 1 year. All values 10,000 ohms to 2 Meg.

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8/450V	**2/3**	**CAN TYPES**		32+32/350V	**4/6**
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16/500V	**4/–**	32/350V	**4/–**	60+100/350V	**11/6**
32/450V	**5/6**	64/350V	**5/6**	100+200/275V	
25/25V	**1/9**	100/275V	**5/6**		**10/6**
50/25V	**1/9**	50+50/350V	**7/–**	1,000+1,000/6V	
50/50V	**2/–**	500/12V	**3/–**		**6/6**

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1,200' on standard fitting 7" plastic reels

Brand new, boxed, **12/6**

Spools 5" metal, **1/6,** 7" plastic, **4/3**

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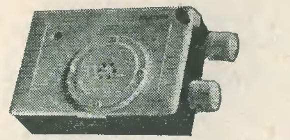

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Size. 4" x 3" x 1". A three-transistor pocket receiver. Two waveband—medium and long. Permeability tuning for sensitivity. Ferrite aerial, internal speaker. Designer specified kit, **£4.10.0.** Plans only, **6d.**

Teletron Coil FX25, **15/–;** Teletron Cabinet, **8/6;** Ardente transformers D240, D239, **10/–** each. R.F. Transistors, **21/–;** Audio **10/–** each.

JASON F.M. TUNER COIL SET, 22/6. H.F. coil, aerial coil, oscillator coil, two i.f. transformers 10.7 Mc/s, detector transformer and heater choke. Circuit and component book using four 6AM6, **2/–.** K.B. Chassis and dial, **19/6.** Complete kit, **£5.18.6.** With Jason superior calibrated dial, **£6.15.**

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Toggle Switches. s.p. **2/–,** d.p. **3/6,** d.p.d.t. **4/–.**

Nuts, Bolts. 12 of each, 2, 4 or 6 B.A., **1/–**

Knobs Gold Engraved. Walnut or Ivory. 1⅝" diam., **1/6** each. 'Focus,' 'Contrast,' 'Brilliance,' 'Brilliance-On/Off,' 'On-Off,' 'Volume,' 'Volt-On/Off,' 'Tone,' 'Tuning,' 'Treble,' 'Bass,' 'Wave-change,' 'Radio-Gram,' 'S.M.L.-Gram,' 'Record-Play,' 'Brightness.' Ditto, not engraved, **1/–**

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Tygan 4' 6" wide, **10/–** ft; 2' 3" wide, **5/–** ft.

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5U4	**8/6**	6V6G	**7/6**	ECC84	**12/6**	PCC84	**12/6**
5Y3	**8/6**	6V6GT	**8/6**	ECF80	**10/6**	PCF80	**10/6**
5Z4	**10/6**	6X4	**7/6**	ECF82	**10/6**	PCF82	**10/6**
6AM6	**8/6**	6X5	**7/6**	ECH42	**10/6**	PCL82	**10/6**
6B8	**5/6**	7S7	**8/6**	ECL80	**8/6**	PL81	**11/6**
6BE6	**7/6**	12A6	**7/6**	ECL82	**12/6**	PL82	**10/6**
6BH6	**10/6**	12AH8	**10/6**	EF39	**7/6**	PY80	**10/6**
6BW6	**8/6**	12AT7	**10/6**	EF41	**10/6**	PY81	**10/6**
6BW7	**8/6**	12AU7	**10/6**	EF50	**5/6**	PY82	**10/6**
6CH6	**10/6**	12AX7	**10/6**	Equip.		SP61	**5/6**
6D6	**7/6**	12BE6	**10/6**	EF50	**8/6**	UBC41	**8/6**
6F6	**7/6**	12BH7	**10/6**	Sylv.		UCH42	**8/6**
6H6	**3/6**	12K7	**8/6**	EF80	**10/6**	UF41	**8/6**
6J5	**6/6**	12Q7	**8/6**	EF92	**5/6**	UL41	**8/6**
6J6	**7/6**	35Z4	**10/6**	EL32	**5/6**	UY41	**8/6**
6J7	**8/6**	80	**8/6**	EL84	**10/6**	U22	**10/6**
6K6	**6/6**	954	**1/6**	EY51	**11/6**	U25	**11/6**
6K7	**5/6**	EA50	**1/6**	EZ40	**10/6**	X79	**10/6**

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incorporating THE RADIO AMATEUR

CONTENTS FOR JULY

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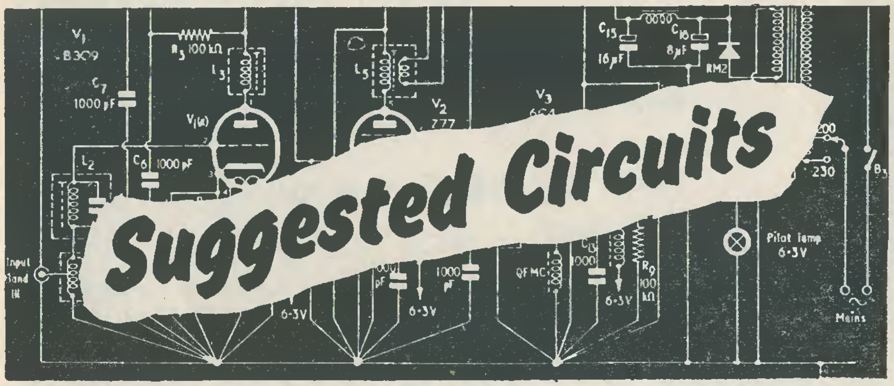


The circuits presented in this series have been designed by G. A. FRENCH, *specially for the enthusiast who needs only the circuit and essential relevant data*

No. 80. AN ADD-ON TV TUNING AID

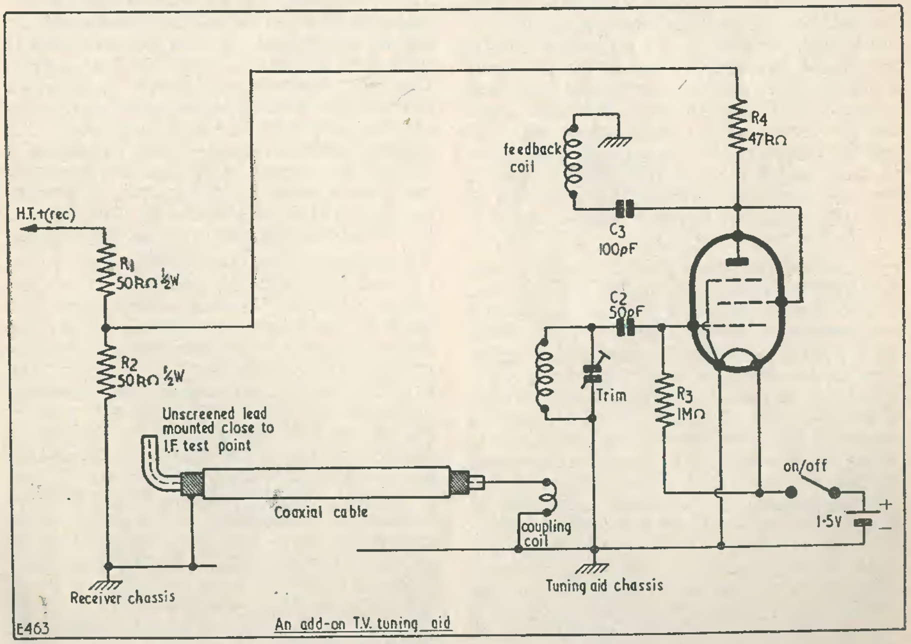
It would be an accurate appraisal of the operation of a modern television receiver if it were stated that one of the most important knobs appearing at its front panel is that which controls the fine tuner. It is the purpose of the fine tuner to set the frequency of the oscillator in the receiver exactly on tune and thereby present to the transmitted video frequencies the correct i.f. response needed for best reproduction of the picture. If the oscillator of the receiver is incorrectly adjusted only part of the video signal is handled in the i.f. strip; with the result that definition may suffer, or that smearing or poor transient response may become evident.

Whilst the necessity for adjusting a televisor fine tuner correctly is self-evident, it cannot be denied that it is often quite difficult to find the optimum positon for this control. The frequently-quoted statement that the fine tuner should be adjusted for maximum sound is by no means always correct. In some receivers, the position for maximum sound is quite definitely *not* that which gives best picture resolution, and, in others, the situation may be complicated by the "flattening" effect given by a.g.c. circuits in the sound i.f. strip. (The two points in the last sentence are, incidentally, taken from manufacturers' service literature.) In order to overcome the fine tuner problem one manufacturer has, this year, introduced a multi-channel receiver in which the fine tuner is deleted as a "customer control" altogether. Instead, the oscillator core of each channel is adjusted by the service or sales engineer when the set is first handled, after which only occasional re-adjustments may later be needed.

What is probably the most important point in this particular context is that, whilst it is usually possible for an engineer to set a television fine tuner to its correct position with reasonable accuracy, such an adjustment is sometimes quite beyond the capabilities of a layman. When a low-definition picture is being transmitted, even the engineer may sometimes find a little difficulty in obtaining the correct setting.

A Tuning Aid

It will be apparent from the above remarks that a very attractive adjunct to any television receiver employing a panel fine tuner would be a device which enabled tuning to be adjusted with complete certainty. Such a device is the subject of this month's Suggested Circuit, and the circuit of a simple "add-on" tuning aid is given in the accompanying diagram. As may be seen, the device consists of a fairly conventional oscillator which may be switched on or off as desired. The output of the oscillator is coupled loosely to the "i.f. test point" in the associated receiver. The frequency at which the oscillator functions is that of the receiver sound i.f., with the consequence that, as the receiver fine tuner is adjusted, the oscillator in the add-on unit beats with the sound i.f. given by the mixer, causing a heterodyne to be heard from the loudspeaker. When the fine tuner is adjusted at, or close to, the "zero beat" at the centre of the heterodyne, the receiver is exactly on tune. In practice there would be no necessity to tune to the exact centre of the heterodyne—so long as a fairly low beat note is evident on the sound channel this indicates that the oscillator frequency is within plus-or-minus 2 kc/s or so of correct frequency. Such a setting is more than good enough for t.v. reception.



An add-on T.V. tuning aid

The tuning aid will normally be required when first switching on the televisor, or after switching over to a new channel; whereupon all that is required is to switch it on. After adjusting the receiver fine tuner such that the requisite heterodyne is heard, the oscillator is then switched off again. The process is so quick and simple that the on-off switch shown in the diagram could quite easily be replaced by a push-button.

It will be obvious that a reasonably high degree of frequency stability with time is necessary in the oscillator in the add-on unit. Another question which needs consideration is that the add-on unit must have some form of power supply. Both these problems are overcome in the circuit by the somewhat unconventional idea of using a battery valve, h.t. being obtained from the associated receiver and filament power from a separate 1.5 volt cell.

From the frequency stability point of view, the advantages conferred by the use of a battery valve are quite considerable. One of the most troublesome causes of drift in oscillators working at the frequencies required in this particular application is temperature rise in the valve and in the components connected to it. Temperature rise is inevitable if the oscillator employs a continually-heated mains valve, and quite an undesirably large frequency drift could be occasioned in consequence. It is possible to cure frequency drift by employing a carefully designed layout and negative temperature coefficient condensers; but this course does not appear to the writer to be very attractive in this case, when all that is needed is a simple oscillator which may be built on a small compact chassis without unnecessary fuss or bother. So long as the oscillator is mounted in a reasonably cool part of the televisor cabinet, frequency drift through temperature rise can hardly occur at all. The use of a battery valve provides the secondary advantage that it is not necessary to tap into the televisor heater chain to obtain a source of heater power, with the result that the receiver chassis itself is left largely undisturbed. As the oscillator is switched on for very short periods only, a small single cell should be quite adequate for the provision of filament power, and it should have quite a long life.

As was mentioned above, the h.t. supply is taken from the receiver. This should not cause any insurmountable problems as it is usually possible to find exposed and readily accessible h.t. positive points on televisor chassis without any difficulty. The extra h.t. loading given by the fixed potentiometer network feeding the add-on oscillator is so small as to be negligible.

The Oscillator Circuit

The oscillator circuit is somewhat experimental, insofar that the frequency at which it works depends on that of the sound i.f. in the associated receiver. So far as the choice of valve is concerned, it is probable that best results would be given by r.f. pentodes, these being operated either with screen-grid and anode strapped to form a triode (as shown in the diagram), or in the correct pentode mode. It may be found that a.f. triodes, of the 1H5 class, may not give reliable results as r.f. oscillators.

Consideration must also be given to the best type of coil to use in the add-on unit. For frequencies up to 18 Mc/s or so, it should be possible to use normal commercial oscillator coils, as intended for short-wave superhets, in the tuning aid oscillator circuit. (It is important to ensure that the coil used is suitable for battery oscillators.) For frequencies above 18 Mc/s, the constructor may prefer to wind his own coils, if he has had experience in this particular field. Some difficulty may be experienced in obtaining oscillation at frequencies around 38.15 Mc/s (the sound i.f. used in modern sets) unless adequate feedback is employed. A good plan at such frequencies consists of winding the grid coil with a thick wire—around 20 s.w.g.—and interwinding the feedback coil between its turns at the earthy end. The feedback winding will need to have approximately two-thirds of the turns used on the grid coil and should be wound with thin wire of approximately 30 s.w.g. Both winding wires should, of course, be insulated, and the connection between the coil and the valveholder be kept as short as possible.

It is worth mentioning that, where difficulties are encountered in obtaining oscillation at high i.f. frequencies, a feasible alternative plan consists of having the oscillator work at half the sound i.f. frequency. The second harmonic of the oscillator will then be that which beats with the sound i.f.

The r.f. output from the add-on unit is taken from the coupling coil shown in the diagram, and this may consist of one or two turns of wire mounted fairly close to the grid coil. The coupling coil is not very critical.*

Fitting the Unit

It should prove to be quite a simple matter to fit the unit to the televisor, the only connections required being a bonding link between the two chassis (provided by connecting the outer conductor of the screen output lead to the receiver chassis), a lead for the h.t. supply, and a capacitive coupling to the i.f. test point. The necessity for the bonding link between the two chassis is obvious enough, but a few words of explanations are required for the method used for the h.t. connection. In order to keep the h.t. voltage applied to the oscillator in the add-on unit to a low figure, a fixed potentiometer is connected across the receiver h.t. supply. This potentiometer is formed by the two resistors R_1 and R_2, these drawing a continuous current of 2mA and supplying to the add-on unit a voltage of 100 (assuming a 200-volt h.t. supply in the receiver) when the oscillator is switched off. In order to prevent heat dissipation in the add-on unit, R_1 and R_2 should be mounted on the receiver chassis.

The output from the oscillator is fed to the i.f. test point of the receiver via coaxial cable. However, a *direct* connection is not made at the i.f. test point, as this would upset the performance of the televisor. In practice only a very loose coupling is necessary, and it should normally be found that adequate oscillator energy is fed into the receiver merely by positioning a short, unscreened section (say one to two inches) of the coaxial cable centre conductor close to the i.f. test point wire. Tighter coupling would be given by twisting an insulated lead once round the test point wire, but this should only be needed in rare cases. If the associated receiver does not have an i.f. test point, sufficient coupling will probably be given by inserting an inch or two of unscreened wire inside the mixer valve screening can.

---

* Readers not wishing to undertake the winding of their own coils may obtain satisfactory components from Teletron Co. The applicable sound intermediate frequency should be quoted.

Setting Up

After the oscillator unit has been constructed, and tests have shown that it may be tuned over the desired frequency range, it should finally be set to the exact sound intermediate frequency. The best method of doing this consists of feeding into the i.f. test point, the output of a signal generator adjusted accurately to the sound i.f., and of tuning the add-on oscillator for zero-beat from the receiver loudspeaker. If a signal generator is not available, the televisor itself should be set accurately on tune to a transmitted signal and the oscillator adjusted to beat with the sound i.f. given thereby.

For really accurate results in the latter case, the receiver should be switched to a Band I channel (to ensure minimum frequency drift in the mixer during setting up), whilst a transmission of Test Card C is in progress. The receiver may then be tuned to give optimum resolution of the frequency gratings consistent with good transient response and overall picture quality. A better method of finding an accurate tuning setting during a transmission is possible with some receivers, and is carried out in the following manner. First of all, the focus control of the receiver is set for best focus in the horizontal plane, and the brilliance control is turned down. Contrast is next brought up until the sound carrier appears on the screen as a 3.5 Mc/s "grain." The fine tuner is then adjusted for minimum grain, whereupon it follows that the sound i.f. is at the bottom of the sound rejector dip in the video i.f. response, and the receiver is exactly on tune. This last method assumes, of course, that the video i.f. strip is reasonably well aligned.

After the receiver has been tuned by either of the methods just discussed, the oscillator in the add-on unit is switched on and adjusted for zero-beat; whereupon the tuning aid becomes ready for normal use.

Live Chassis

Since the add-on unit is directly connected to the televisor chassis, it must be remembered that its own chassis, the filament coil, and the on-off switch wiring may all become "live." In consequence the normal safety precautions against shock must be observed.

TRADE REVIEW

THE G8KW MULTI-BAND WIRE DOUBLET WITH TRAPS

(Patent applied for)

Main features: 75 ohm co-axial feed
Only 108 feet long
Operates on six bands
Low S.W.R. on all bands
Simple to erect
No "cut and try" necessary.

The G8KW Multi-band Wire Doublet has been specially designed to meet the requirements of those who desire operation on any of the h.f. bands, and have only limited space for aerial erection available.

The aerial consists of a centre fed dipole with a 108-ft top and utilises two resonant traps: one on either side of the feeder point and 65ft apart. Between each trap and each end of the aerial is a length of wire 21ft 6in long. Each trap consists of a high "Q" inductance and a condenser specially designed to withstand high voltage, high circulating r.f. current, and is resonant on 7.1 Mc/s. The tensile strength of these traps has been tested to 350lb and they are impregnated to withstand extreme weather conditions. It will be seen from the description that these traps must act as an isolator when the centre portion of the aerial is excited with a 7 Mc/s band emission (f_1). At frequencies lower than f_1 the traps act as loading inductances in series with the end sections, thus giving the electrical length of a half wavelength at 80 metres. At frequencies higher than f_1 the traps will not isolate the end sections of the aerial but will act as a series capacity. This will enable the aerial top to resonate at any odd harmonic of its fundamental and will provide a low impedance feed at the centre. The values of L and C in the traps and the lengths for the end sections are critical, and are chosen in particular to suit the requirements of the U.K. amateur. The system will operate as follows:

10 metres—7 half-wave top
15 meters—5 half-wave top
20 metres—3 half-wave top
40 meters—half-wave dipole
80 meters—half-wave dipole
160 metres—with feeder joined together at transmitter the system will satisfactorily operate as a top loaded Marconi aerial against ground or counter-poised.

The aerial will produce polar diagrams in accordance with patterns associated with the various resonant lengths indicated above, which may be found in various handbooks. It will, therefore, be appreciated that on 40 and 80 metres the radiation will be at right angles on either side of the direction of the wire, whilst on 10 metres four major lobes will occur at approximately 20° either side of the wire. With the aerial suitably oriented, good directivity can be obtained on 10, 15 and 20 metres with each major lobe giving more effective gain than a dipole.

It has been found that good results may be obtained even if it is necessary to bend the aerial top to suit any particular location. This will, of course, distort the polar diagram in some respects.

K.W. Electronics Limited are now offering the traps required to make this aerial, and also the aerial complete with traps, insulators, feeder cable and copper wire, assembled and ready for erection.

The weight of each trap is only 5oz and the length 5in. Price: Traps only, per pair, 50s. post paid. Complete aerial with insulators, copper wire, traps, and 90ft of semi-air-spaced co-axial cable, assembled ready for erection, £6.15.0 post paid.

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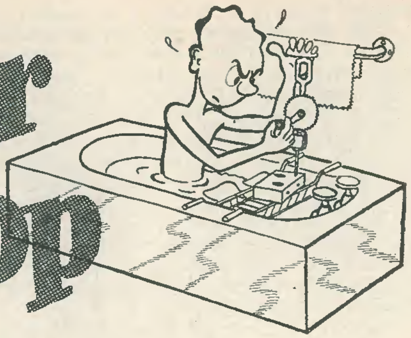

This month, Smithy the Serviceman gives his assistant, Dick, some useful advice on the best methods of curing difficult cases of hum in audio amplifiers and the a.f. stages of receivers

DICK LEANED BACK FROM HIS LABOURS and heaved a sigh of satisfaction.

"There you are," he remarked, happily, "a really hi-fi job if ever there was one!"

He looked with pride over the equipment he had been repairing. On the bench before him was the chassis of a fairly good-class radiogram, with its motor-board and loudspeaker lying alongside. Dick switched the chassis to "Gram" and played one of Smithy's test records on the turntable. The music—Smithy had rather a penchant towards symphony music—rang out through the workshop fully and clearly and, apart from a lack of bass given by the unbaffled speaker, with what seemed to be quite a nice overall response.

"Hmm," said Smithy, turning round, "it doesn't sound too bad at that."

Hum Troubles

He stopped his work and wandered over to listen to the sound more closely. As his ear approached the speaker an expression of suspicion came over his face. He took the pick-up off the record and listened again.

"What's wrong?" asked Dick, a little anxiously.

"You come and listen," invited Smithy.

Dick put his head close to the loudspeaker with a puzzled expression on his face.

"Why, I can't hear anything very bad," he commented finally. "There's just a little background hiss, and a certain amount of deep hum."

"It's the hum that I don't like," said Smithy. "Just you place your fingertips gently on the cone of the speaker."

Dick followed Smithy's bidding, and his puzzled expression increased in intensity.

"Well, I'm dashed," he said, "the cone's vibrating like anything! There must be almost an eighth of an inch movement there. Is that *all* hum?"

"Every bit of it," smiled Smithy, "although I wouldn't like to say that the cone movement is quite as much as you've just said. Anyway, it's very easily discernible with the fingertips, and I daresay that if we put an a.c. voltmeter across the voice coil we might be able to measure it quite readily."

"How come we can only *just* hear it?" asked Dick.

"Well, there are two main reasons for that," replied Smithy, "the first of which is that the speaker is at present sitting in free space without any baffle, so that the lower frequencies are largely cancelled out."

"I know what you mean," interrupted Dick. "What happens is that low audio frequencies in air do not travel in straight lines like the high frequencies do, so that low frequencies generated at the back of the cone come round and cancel out those generated at the front."

"That's pretty well what happens," agreed Smithy, "only you want to add that the cancellation occurs because the frequencies from the back are 180 degrees out of phase with those at the front. This phase relationship must exist because when, say, the cone is moving forwards to give a compression at the front, it is similarly causing a rarefaction at the rear. If you put the speaker on a baffle board, or in a simple cabinet, you put a barrier in the way of the low frequencies appearing at the back of the cone; with the result that less cancellation occurs at the front and the bass response improves. However, to ensure complete freedom from cancellation you need quite a large barrier. If the barrier is a flat piece of wood (that is, a simple baffle), it needs to be quite large to completely prevent the notes generated at the back from interfering with those at the front. A flat baffle something like ten feet square is what you require for almost complete low frequency reproduction. An ideal baffle, wherein no sound from the back could cause interference at the front, would be given by mounting the speaker on a hatchway in a brick wall dividing two rooms. You would then have the reproduced sound in both rooms, of course. This is not a very attractive proposition these days, because there are far less cumbersome and more efficient methods of ensuring good bass response."

Dick grinned.

"Well, the hatchway idea certainly seems to be a drastic method of getting good reproduction," he chuckled. "I suppose if somebody opens a door between the two rooms, in come the out-of-phase bass notes and bang goes Wagner! Seriously speaking, though, couldn't you try completely enclosing the back of the speaker so that the sound radiated at the back just *couldn't* get round to the front?"

"Yes, that's quite a good scheme," replied Smithy, "but you have to be very careful about carrying it out. If the back of the speaker is completely enclosed you get what is called an 'infinite baffle.' When you use an infinite baffle you have to ensure that there are no resonances in the volume of air trapped behind the speaker. One or two commercial speaker enclosures use the infinite baffle idea with special arrangements for breaking up the resonances present in the trapped volume of air. However, we're beginning to get on to the subject of high fidelity enclosures, which is not what I meant to start discussing just now."

"Sorry for leading you off the track," remarked Dick contritely. "Anyway, I've forgotten where we'd got to."

"We were just about to mention the second reason for not hearing a loud hum from that speaker lying on your bench," Smithy reminded him, patiently. "This second reason is because the hum voltage it is handling probably consists almost entirely of a pure 50 cycle note. Look, I'll show you."

Whereupon Smithy coupled the bench oscilloscope to the loudspeaker leads of the radiogram. Once set up, the oscilloscope displayed a trace which was almost entirely sinusoidal.

"It's surprising how insensitive most people's ears are to a pure 50 cycle note like this," continued Smithy, after having shown Dick the waveform. "It's only when the note gets distorted and becomes accompanied by harmonics that we are usually able to place it reliably. In this case, when I first went to listen to the speaker a few minutes ago I just caught a suspicion of the hum during the quieter passages of the record you were playing and, even then, I was keeping a special watch for a fault of that nature. Of course, if the speaker were put back in the cabinet the hum would become much more audible. Even then, though, I wouldn't be the slightest bit surprised if some people didn't notice it. A number of years ago I happened to be with a group of engineers who were working with public address amplifiers. Whenever a check for 50 cycle hum level became necessary nobody carried this out by listening to a speaker connected to the amplifier output. It was far easier, and much more reliable, to connect an a.c. voltmeter across the output terminals and see that its reading did not rise above a certain amount."

"That's an interesting item of news," remarked Dick. "Incidentally, I'm still a little hazy as to why the hum we have with this set should be so different from the other cases which come into this workshop. Normally we get instances of hum which are perfectly obvious and which we cure in perfectly obvious fashion. We seem to have fallen into a special case with this particular set, though."

Causes of Hum

"Not really," commented Smithy, "although I must say that pure 50 cycle hum doesn't usually make itself as evident as it has done here. Much of the unwanted hum we meet in servicing consists of harmonics of 50 cycles, which are readily audible. One of the most frequent causes of hum in domestic equipment is low capacity in the power supply filter condensers, as a result of which a ripple becomes superimposed on the h.t. line and thereby finds its way into the audio section. If the faulty power supply employs a full-wave rectifier the ripple reaches a peak for every half-cycle of mains voltage; rather like this (Fig. 1 (*a*)). As you can see, the ripple could be described as a 100 cycle waveform which—from a 'sinusoidal' point of view—is badly distorted. If a half-wave rectifier is used the ripple voltage reaches a peak for every *cycle* of the mains voltage, giving an effect something like this (Fig. 1 (*b*)). In this instance we have a 50 cycle waveform, but it is so far removed from a pure tone that it cannot help but be rich in harmonics, which then become very audible. As you may gather, therefore, one of the most prevalent causes of hum—low-capacity filter condensers—gives an audible effect in which a considerable amount of harmonic energy is present. I am not going to be so dogmatic as to say that whenever you encounter a case of almost pure 50 cycle hum you shouldn't check the filter condensers; but it is a pretty good bet that you will find the cause of the hum elsewhere.

"Another reason for the fact that we don't often find cases of almost pure 50 cycle hum is that, in cheap receivers, the hum is liable to become distorted by the a.f. amplifier, the output transformer, and the speaker; with the result that harmonics may appear in the audible output even if they aren't present at the point where the hum is injected into the circuit. It is when you get a reasonably honest amplifier and speaker, as we have here, that we usually encounter pure 50 cycle notes."

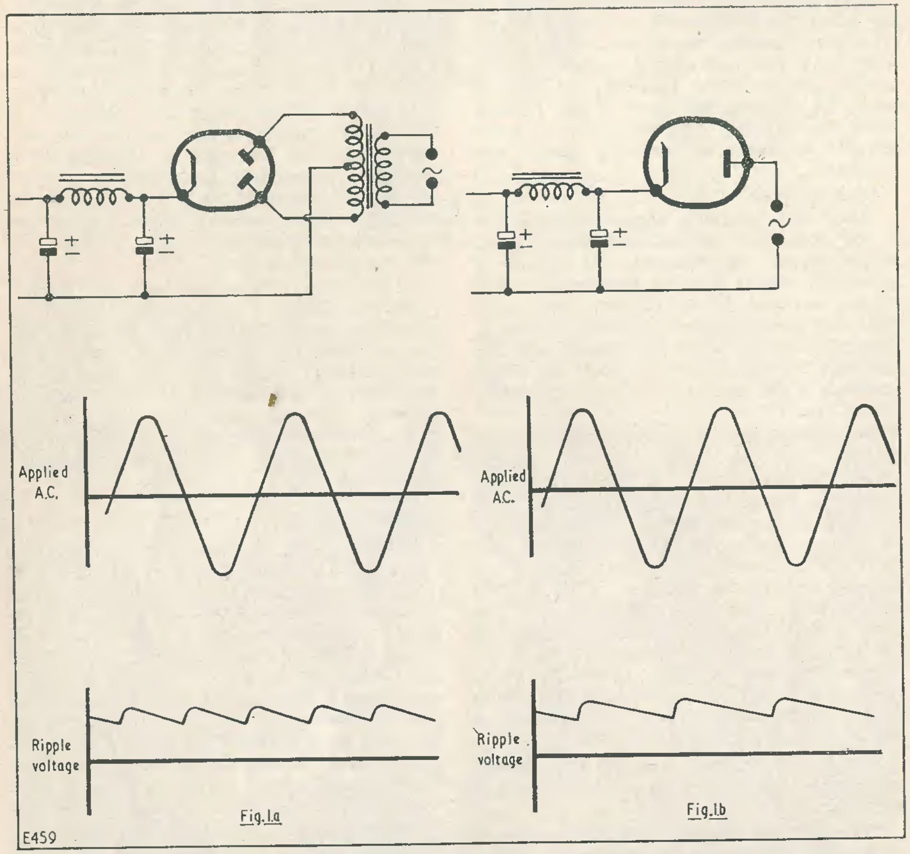

Fig. 1 (a). If the filter condensers following a full-wave rectifier go low in capacity, a 100 c/s ripple appears on the h.t. line. (b) Low capacity filter condensers following a half-wave rectifier allow a 50 c/s ripple to appear

Whilst Smithy was speaking, Dick had been carrying out some quick checks on the chassis.

"Well, I can confirm one of your points," he commented. "I have checked the h.t. filter condensers and they appear to be O.K. I've also checked the cathode bypass condensers and these appear to be O.K. too."

"Fair enough," said Smithy, "although I should point out that the method you used for checking the existing condensers—that of temporarily connecting a good component across each one in turn—doesn't entirely allow for the case where the trouble is caused by low leakage resistance in the suspect condensers. However, that's a minor point, and can usually be satisfied reasonably well, in any case, by checking the voltages across the condensers you test.

"So far, so good. We may now say that the electrolytics are above suspicion. Let's see if we can next isolate the stage in which

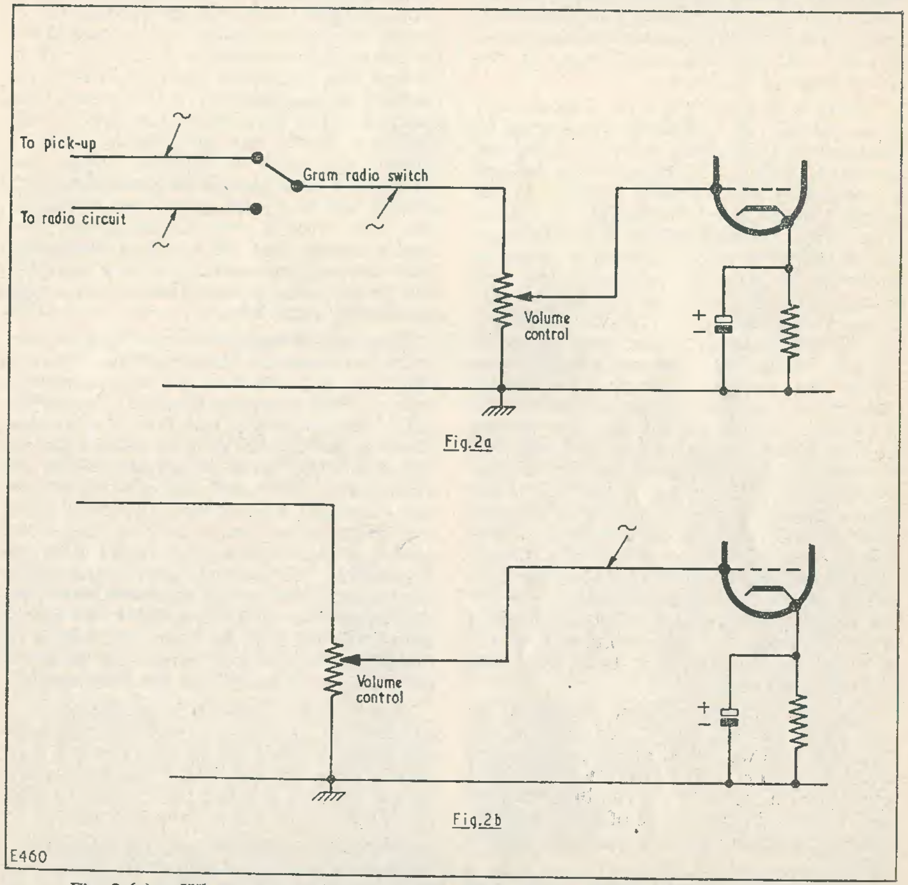

Fig. 2 (a). When unwanted hum is injected into circuits before the volume control, that control varies hum amplitude smoothly in normal fashion. (b) Unwanted hum injection immediately after the volume control may give rise to symptoms roughly equivalent to those given at (a). In this case the volume control tends to short-circuit the hum voltage in the minimum volume position

the hum appears. Now, the first thing to do is to see if the hum changes in amplitude as we adjust the volume control. Ah, that's interesting! As you can hear, the hum level remains unaltered at all settings of this control. That means that the trouble appears *after* the volume control, and we can immediately assume that the circuit before the control, including the pick-up wiring and the gram-radio switch wiring, is all O.K. If the hum *had* varied in amplitude as the volume control was adjusted we would have had two possible areas in which the fault could have appeared. The first of these is the more obvious, and would consist of hum being injected into the circuit before the volume control. Like this (Fig. 2 (*a*)). The logical thing to do then would be to see if the hum appeared on gram, on radio, or on both. If it appeared only on gram the cause would be the circuit from the switch to the pick-up, the most probable trouble being faulty screening. Incidentally, you may occasionally find, with some a.c./d.c. grams or record players, that hum in the pick-up circuit only appears when the mains plug is inserted in the socket such that the chassis connects to the live side. Reverse the mains plug and the hum clears.

"If the hum only shows up when the set is switched to radio, then the fault lies in the circuits in this section before the switch. If the hum has the same level both on radio and gram, then the trouble lies between the switch contacts and the volume control. Of course, the gram-radio switch itself should not be above suspicion in any of the above cases, especially if the same wafer that switches the a.f. circuits also carries contacts for switching dial lamps and things like that. Although you don't often meet such a fault, a little leakiness in the switch insulation could easily pass a small percentage of the heater voltage used for the dial lamps to the contacts carrying a.f.

"There is, as I said just now, a second and more unlikely area of fault which may be indicated by the volume control varying the amplitude of hum. This occurs when the hum is injected by an unwanted coupling to the circuit immediately following its slider (Fig. 2 (*b*)). What happens in this instance is that, when the volume control is turned to minimum, it tends to short-circuit the hum voltage to chassis, and gives an effect roughly similar to the first case. You can usually tell the difference between the two types of trouble. In the first, where hum is picked up before the volume control, this control changes hum amplitude quite smoothly as it is rotated. In the second case the volume control usually has little effect until you turn it to minimum, whereupon the hum attenuates abruptly. If you are in doubt you can always clinch the matter by simply shorting together the two outside terminals of the volume control. In most sets this merely infers shorting the 'top' terminal of the control to chassis with a screwdriver. For the first case, hum will disappear at all positions of the control. For the second case it will now become attenuated at both maximum and minimum settings."

"Do you remember a long discussion we had some months ago?" remarked Dick. "At that time we talked about the distorted waveform you get when you touch the input terminal of a 'scope.'* If the hum pick up we are discussing now were of a similar type, wouldn't the hum have a similarly impure nature?"

"That's rather a good point," remarked Smithy, "because so far as my own experience goes, hum picked up electrostatically due to poor screening or some similar fault shows up as a pure 50 cycle tone only rarely. There's a good case there for saying that, since the hum we have here is almost pure 50 cycles, it probably isn't caused by electrostatic coupling of this kind. Which, indeed, is what we have found, so far as the wiring before and around the volume control is concerned.

"Anyway, let's press on to the rest of the amplifier circuit. In this particular set the a.f. grid leaks are all returned to chassis, and so we can now call into use our trusty little Woolworth's insulated screwdriver. Taking care not to touch the wrong valveholder tag, we first of all short the grid of the first a.f. valve down to chassis. As you can hear, there is no diminution in hum level, so this confirms the point we made just now that the hum injection does not lie there. It's a simple two-stage amplifier so we next short the output grid to chassis as well. Ah! Now we find two interesting things. First of all the hum stops completely, which means that the trouble lies in or before this grid circuit. Secondly, there was no crackle when I shorted the grid to chassis, using that technique I told you about some time ago wherein you touch the screwdriver to chassis first then bring it over to the grid.† No crackle means that the coupling condenser from the previous anode is almost certainly free from leaks, a condition which could conceivably cause hum.

"The next thing to do is to have a very quick look around for something obvious. I can't see anything here that is outrageously wrong. Wait a minute, though! The earthy end of the output grid leak goes to a tag eyeletted to the chassis as, also, does a heater lead from the same valveholder (Fig. 3). I have never yet trusted an eyeletted chassis tag, especially when it has to carry a relatively high current, so the obvious thing to do now is to short this tag to chassis with our screwdriver. As the tag is carrying the heater current we'll need to dig the screwdriver into the chassis a little, then hold it tightly against the tag to make doubly certain we're making good contact. And—hey presto—we get a few crackles and the hum clears!"

"Very good," said Dick admiringly. "I suppose that there was a relatively high voltage being dropped across the eyeletted connection due to the heater current which flowed through it. But not enough to stop the output valve heater from operating."

"Yes, that would be so," replied Smithy, "mains valves will usually work fairly well even when their heater voltages are as low as two-thirds of that specified. They take longer to warm up, of course, but the delay may not be excessive. The 'case of the high resistance earth connection' is a bit of a classic but it *does* occur, as you've seen just now. Usually there is a certain amount of crackling, especially if the set is bumped, but this isn't inevitable. Incidentally, I think I should point out that, although it has taken me quite a time to explain the technique of hunting down this particular snag, the process itself need take only a few minutes. Just to show that I had a little something up my sleeve, I should add that I was keeping an eye open especially for hum pick up from the heater line, as this is the only source of pure 50 cycle hum in the set.

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*In Your Workshop. November 1956 and February 1957.

† *In Your Workshop.* September 1956.

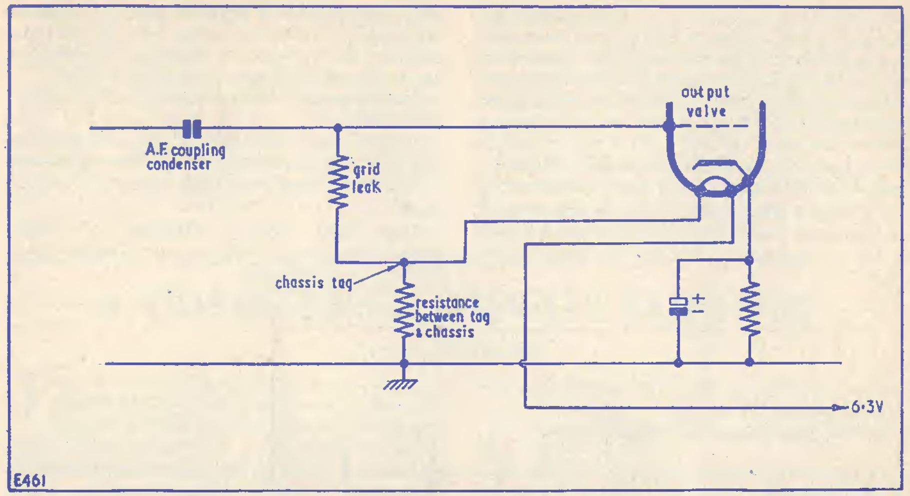


Fig. 3. A fault wherein hum was fed to the grid of an output valve. Improving the connection between the chassis tag and chassis cleared the hum

Incorrect Valve

"Funnily enough," continued Smithy, "I had a snag similar to this only a few days ago. In this case I was looking at a friend's set in his own home. The set was a table-model sound receiver whose frequency-changer oscillator had got a bit tired of life and had decided to call it a day over the top end of the short-wave band. I had guessed, when my friend told me about the trouble, that the valve was at fault, and my guess, fortunately, proved to be correct. Anyway, after I'd put the new valve in, I noticed that the set had a strong, deep hum. This, again, was nearly pure 50 cycles, and my friend said it had been present for quite a long time, but that he had not worried too much about it. The receiver had an inspection cover underneath the cabinet, and so I thought I would have a quick look to see if I could find the trouble. I *should* have asked him to bring it round to the workshop as, apart from a pocket screwdriver, I had no gear with me at the time; but you know how things are."

Dick grinned to himself. He knew Smithy's almost complete inability to listen in comfort to a faulty radio.

"When I took off the cover I found myself looking into one of the dustiest chassis I've seen for many a month. I blew a few of the cobwebs away and found that the wiring appeared to be that of a straightforward four-plus-one. I'd already checked that the volume control didn't make any difference to hum level and, as the hum was fairly pure, I risked a guess that the trouble wasn't due to filter condensers. The earthy end of the output grid leak was connected to the chassis, and so I shorted the output grid to chassis with the screwdriver. The hum disappeared. I then noticed that the output grid tag had an extra condenser connected to it, and I decided that this merited a little further investigation. The output valve fitted in the set was an EL41, and the circuit arrangement was like this (Fig. 4), the extra condenser connecting to pin 4 and, thence, to a lead which trailed off into the undergrowth, finally arriving at a 20kΩ series resistor and the tone control. Everything seemed simple enough, but there was something that puzzled me about the arrangement. And then I suddenly remembered that pin 4 of an EL41 is an I.C.—that is, Internal Connection —pin; and that it is very 'naughty' to use I.C. pins as dummy tags. It was quite possible that the hum was being injected into the output grid circuit from this pin. However, the set was of a reliable make and I could not visualise a mistake in the choice of dummy tags, so I decided to leave things as they were until I could check up on the valve connections for certain.

"Next morning in the workshop I looked up the valve book and confirmed that pin 4 of an EL41 *is* an I.C. pin. I also noted that the EL42 has identical pins to the EL41 with the exception that pin 4 of this valve is an N.C. pin. N.C.—that is Not Connected—pins canbe safely used as dummy tags. It seemed to me, therefore, that somebody had replaced an ageing EL42 with an EL41 at some time, ignoring the fact that these are not by any means identical valves. And so, indeed, it turned out. An EL42 fitted into the set a few days later cleared the hum completely."

"That's a point I shall have to watch for," commented Dick. "It certainly sounds like a bit of careless servicing on somebody's part."

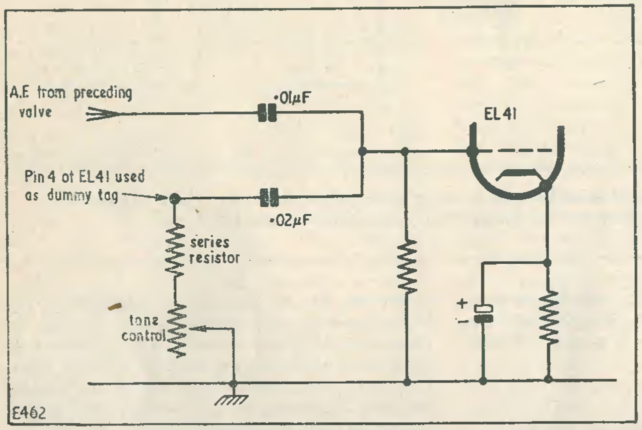


Fig. 4. Illustrating an instance where a high hum level was caused due to an incorrect replacement valve being fitted to a receiver

"I'm afraid so," responded Smithy. "I hate pointing morals to any story, but this one does indicate how careful you have to be when changing valves for what are supposed to be 'equivalents.' And I haven't even mentioned the fact that the EL41 loads the power supply more than does an EL42. Anyway, I hope you'll agree that I've given you a good hum for your money."

Dick shuddered.

"That's even worse than the worst of my own gags," he remarked. "But I'll let it pass! By the way, I've often wondered why it is that when we try to provide a.f. amplification without hum we deliberately introduce hum into the amplifier circuits by means of the heater line."

"Hum from the heater line is a big trouble in high gain amplifiers," said Smithy, "particular examples being given by the first valve or valves of tape recorder amplifiers or hi-fi pre-amplifiers. That's why you sometimes find that the heaters of these valves are fed with d.c. or r.f. The Teletron S.S.O. oscillator coil is a very interesting example of an r.f. heater supply, this giving 6.3 volts at any frequency between 25 and 100 kc/s or so, which you may care to select. The S.S.O. idea is really clever because you can use the same coil as a source of erase voltage in a tape recorder if you want to, thereby incurring no extra expense. A very ingenious scheme."

Smithy paused for a moment and looked at the clock.

"Here, it's about time I stopped gassing and got on with some work!" he exclaimed. "We'll never make a living this way!"

Dust

Dick and Smithy returned to their respective jobs. After a while, Dick's voice became audible again.

"Your remark about the dusty chassis you looked at has reminded me about something else," he said. "Have you ever noticed that some chassis come into the workshop almost as clean as when they were new, and that others are thick with dust and grime."

"So far as I know there is quite a good reason for the difference," replied Smithy over his shoulder. "And that is that you usually find that the clean chassis come from houses in which vacuum cleaners are used at regular intervals. In such houses there is far less dust in the air and, therefore, far less to settle in the set.

"Incidentally, even when vacuum cleaners are used, you may still find quite a marked difference between sets which come in for repair from large industrial towns and sets which come in from country districts. Sets from the town are nearly always by far the dirtiest. It makes you wonder sometimes just how much muck the town-dweller carries around in his lungs."

Smithy was silent for a moment, and Dick decided to chance another question.

"Isn't it true," he asked, "that the home of the future will have a very high potential electrode in each room, so that all the dust is attracted to it and there is no necessity for cleaning?"

Smithy laughed.

"We're half-way towards that state of affairs already," he chuckled. "Most homes with t.v. sets have a high potential tube which doesn't do too badly at picking up dirt. Which reminds me that I have quite a few t.v. sets on the shelf whose tubes will be about 100% brighter after you've done a little cleaning job on them!"

Dick sighed.

"Isn't it tragic," he remarked, to no one in particular, "how the enthusiasm of someone who is sincerely in search of knowledge may be so cynically diverted by authority to the performance of menial and soul-destroying tasks."

"You'll find the cotton-wool and detergent by the sink," laughed Smithy in reply, "and you can use as much of the latter as you like. It's fourpence off the packet this week!"

A TRANSISTORISED SINEWAVE GENERATOR

by **M. WRIGHT**

THE OSCILLATOR WAS DESIGNED PRIMARILY as a cheap audio source for the workshop. The components used are all standard and easily obtainable. Specially wound inductors or transformers are not necessary.

The performance of the oscillator compares favourably with similar simple valve circuits for stability.

In the circuit given below, the constants are given for 1 kc/s. Output is of the order of 3 volts peak to peak, with a high Q inductor. Battery drain is less than 50μA.

A readily available transistor was used, namely a Mullard OC71. Any equivalent would suffice.

The circuit is of the Colpitts type, in-phase feedback from collector to emitter being effected by capacitors C_1 and C_2. The optimum feedback ratio $C_2 : C_1$ was found to be about 10 : 1, but can be higher, up to about 50 : 1, depending upon the impedance and Q of the inductor used. Adjusting either C_1 or C_2 will give a change in frequency.

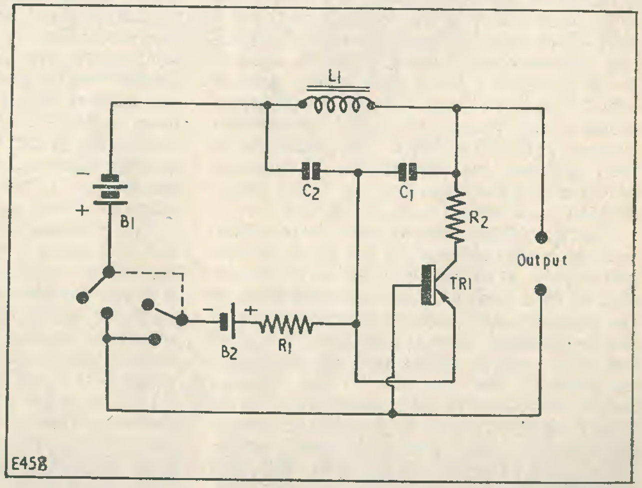
R_1 determines the output voltage and also the battery drain.

R_2 limits the reverse collector current flow during the positive half cycle of the collector. With $R_2 = 0$ the waveform tends to be flat topped, but improves rapidly as R_2 is increased to 1kΩ. Increasing the value further gives little improvement in waveshape. At $R_2 = 39k\Omega$ the oscillator ceases to function. With ordinary silicon-iron laminated chokes R_2 may not be ncessary.

By varying L_1, C_1 and C_2, the frequency range can be increased to 500 kc/s and may be as high as 1 Mc/s, depending upon the transistor characteristics.

Whilst the oscillator will operate with supply voltages over 3 volts (within the ratings of the transistor), the only advantage is an increase in voltage input. This can more easily be effected by adjusting R_1.

$R_1 = 22k\Omega$
$R_2 = 10k\Omega$
$B_1 = 3V$
$B_2 = 1.5V$
TR_1 = OC71 or similar
For $L_1 = 5H$, then
$C_1 = 0.01\mu F$,
$C_2 = 0.1\mu F$
For $L_1 = 10H$, then
$C_1 = 0.005\mu F$,
$C_2 = 0.05\mu F$.



IMPROVING TV AUDIO

In the temporary absence of our regular contributor, S. Welburn, this month's article on television topics is provided by T. Chambers

IT IS AN IRONIC COMMENT ON PRESENT-DAY television design that, despite the fact that the television sound channel is capable of providing a degree of sound quality which is comparable to that given by f.m., the audio systems fitted to many television receivers fall well within the "low-fidelity" category. The reasons for poor quality reproduction are easy enough to appreciate and do not necessarily detract from the manufacturer's desire to provide the best technical value for the money which is paid for his product.

Commercial television manufacture is a competitive business, and the highest sales appeal is provided by the set which provides the best picture at the lowest price. In order to achieve a low price, economies have to be effected elsewhere in the set than in the circuits which control the quality of the picture. The greatest economy which may be made is in the cabinet—a costly item in any receiver—and televisor cabinets in the lower priced ranges usually reach a successful compromise between cost and styling. The usefulness of such cabinets as loudspeaker enclosures hardly enters the situation, and audio reproduction is, in consequence, liable to suffer.

The necessity of cost-saving in the television receiver is also reflected in the audio circuits themselves. It would obviously be impracticable to fit a push-pull audio output stage in the cheapest of a manufacturer's range of receivers; apart from the additional cost of the extra output valve and its associated components, the increase in h.t. loading might necessitate further expenditure on the power supply circuits. As a result the cheaper television receivers inevitably use a single-ended a.f. output stage, this normally employing the simplest of circuits and working into a small and inexpensive loudspeaker.

The above remarks do not necessarily apply to the more expensive television receivers, especially those which enter the "console" range. In these sets the manufacturer usually retains his basic video circuits and is able to provide better facilities for good sound reproduction. Sometimes a console receiver merely implies a table model chassis fitted into a console cabinet with a larger speaker. Even here, nevertheless, a considerable improvement in sound quality can be effected.

The Loudspeaker

In this article the writer intends to pass on some hints concerning simple methods of improving the sound quality of some of the cheaper television receivers. For obvious reasons it is impossible to refer to individual makes or models, and his remarks must be considered as being of a general nature only.

A very weak link in any a.f. amplifying chain is the reproducer, and this fact is especially true of the cheaper television receiver. (By "reproducer" is meant the loudspeaker plus its enclosure.) If it is considered worth while attempting to improve this section of a TV receiver, there are two main methods of attack. The first consists of attempting to fit a better loudspeaker into the existing cabinet, and the second consists of employing a reproducer external to the existing cabinet.

The problem of fitting a better—which in this case infers a larger—speaker in an existing cabinet is not always easy to solve. This is due to the fact that the manufacturer often provides what approaches the best unit which is capable of being mounted in the limited space available for it. Nevertheless, when very small loudspeakers are provided, it is often worth while attempting to fit larger models in their place. Elliptical speakers are particularly capable of being squeezed into tight corners and may prove helpful here. The writer does not recommend making extensive alterations to an existing cabinet in order to accommodate a larger speaker, as these are not always necessary. For instance, even when the cone diameter of the replacement speaker is considerably longer than that of the opening provided in the cabinet, improved quality may still be given by that speaker in that cabinet. It must be pointed out that fitting a better loudspeaker to an existing cabinet does not give *guaranteed* improved quality; the process should be considered in the light of an experiment which may often be worth trying out.

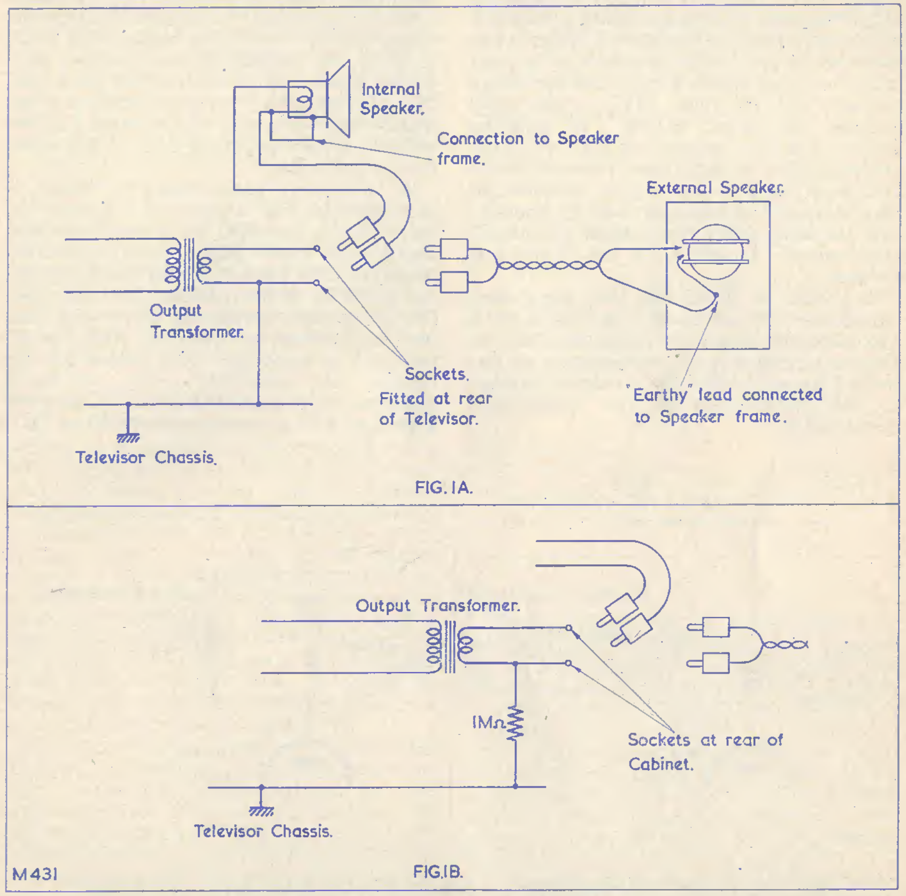


FIG. 1A.

FIG.1B.

Fig. 1 (*a*). *A simple arrangement by means of which either the internal speaker or an external reproducer may be connected to the output transformer secondary.*
Fig. 1 (*b*). *The risk of shock from the external reproducer leads is reduced by the use of this circuit*

Connecting a good external reproducer to the output of a televisor frequently gives improved results. It is necessary, of course, to position the external reproducer close to the receiver in order to preserve illusion, but this need raise no insurmountable problems. Apart from the necessity of providing extension loudspeaker sockets in the existing televisor, this idea has the advantage of eliminating any basic alterations to the receiver circuitry. It is important to note that the secondary of the receiver output transformer will almost certainly be connected to the chassis, with the result that the extension loudspeaker leads will become "live."

Fig. 1 (*a*) illustrates a suitable output circuit capable of feeding either an extension speaker or the internal speaker. Since, when it is connected up, the external wiring becomes "live," the necessary precautions against shock must be observed. As an additional precaution the sockets and plugs shown in Fig. 1 (*a*) should be of a suitably shrouded type. When the external speaker is not required, the internal speaker is, of course, simply plugged in in its place. A somewhat safer arrangement may be obtained by breaking the direct connection between the speaker transformer secondary and chassis, and replacing this with a 1MΩ resistor, as shown in Fig. 1 (*b*). Such a circuit can be employed if the secondary does not enter a negative feedback loop in the receiver a.f. stages. The purpose of the 1MΩ resistor is to prevent static voltages building up in the secondary circuit, and its high value considerably reduces the shock hazard. It must be pointed out that the circuit of Fig. 1 (*b*) is not perfectly safe, since reliance is placed on the insulation between the output transformer secondary and its laminations or its primary; and the same safety precautions should still be observed. However, the *risk* of shock is reduced.

It should be mentioned that the output transformer should always be loaded by a loudspeaker whenever the set is switched on. Otherwise, excessive a.f. voltages may appear in the primary circuit with consequent damage to the transformer or the components connected to it.

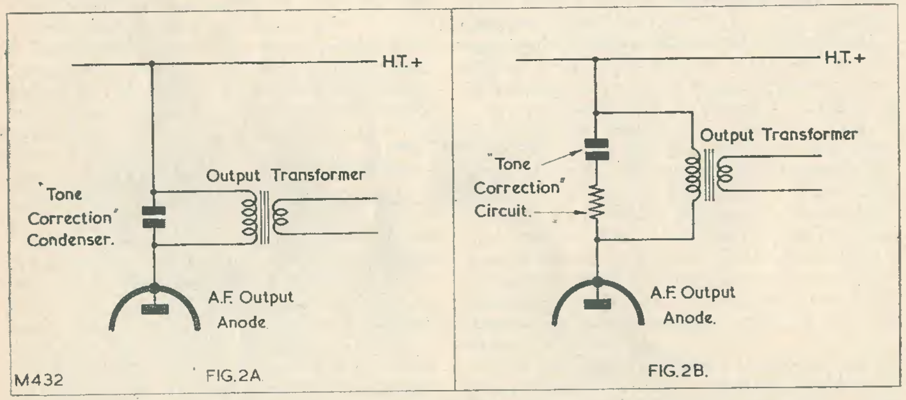


Fig. 2 (*a*). *The "tone-correction" condenser fitted in many audio output stages.*
Fig. 2 (*b*). *An improvement can be obtained by using a resistor and condenser in series to give "tone correction"*

Improving the Circuit

It often happens that it is possible to improve the audio reproduction of a televisor by carrying out one or two simple modifications to its circuit. For instance, one occasionally encounters an output transformer circuit wherein a "tone-correction" condenser is connected directly across the primary of the output transformer in the manner shown in Fig. 2 (*a*). The purpose of this condenser is to reduce the third harmonic distortion given by an output pentode and to provide a certain amount of top-cut. The latter may be considered necessary in order to overcome background hiss and to reduce the effects of interference. Frequently, the top-cut provided by the condenser is excessive and, if the set-owner resides in a district of good signal strength, can often be reduced without the emergence of too high a background level. There is also the fact that the use of a condenser connected in the manner shown in Fig. 2 (*a*) provides, with the inductance of the transformer primary, a resonant circuit which will very probably peak in the audio frequency range.

A far better "tone-correction" circuit is illustrated in Fig. 2 (*b*). In this case the correction is provided by a condenser and resistor in series across the transformer primary. The resistor damps the tuned circuit provided by the condenser and the transformer primary inductance in parallel, and peaking becomes less evident. Also, the cut provided is smoother. The values for the resistor and condenser may be found experimentally; and it will probably be found best to give the resistor a value of 10 to 20kΩ initially, adjusting the condenser value until the most pleasing response is obtained. As was just mentioned, it may be found that, in areas of good signal strength, the amount of top-cut required to overcome background hiss, etc., is quite low when the receiver is switched to a live channel. With reduced top-cut, however, the background may become quite high when the set is switched to a dead channel, and its a.g.c. voltage drops.

In such a case the obvious solution consists of fitting a condenser which caters only for the live channel.

In some sets it will be found that the circuit of Fig. 2 (*b*) is already fitted. Even here it is still worth while experimenting with a reduced condenser value in case the set designer has catered for fringe areas with attendant high noise levels. It is also worth while experimenting with the condenser value even when the transformer lies inside a negative feedback loop, as the amount of feedback in amplifiers of the type we are considering here may be low. In this instance, care should be taken to ensure that very small condenser values do not cause the feedback to become positive.

It is possible for top-cut components to appear elsewhere in the a.f. stages than across the output transformer primary. In such cases it once more becomes possible to alter their values, if desired, in order to provide a pleasing response relative to the background level under the conditions in which the set is to be used.

Increasing Bass Response

It is normally rather a risky process attempting to increase the bass response of a television receiver of the cheaper type we are discussing here. The main reason for this is that the fidelity of reproduction may actually be reduced thereby, the increased bass being evident merely as a louder "thump" rather than as an enhanced frequency response. It is possible in any case that the manufacturer, mindful of the fact that the average public taste tends towards this sort of reproduction, has already provided as much bass response as he feels the set will take. It should be remembered that increased bass response may also worsen microphony conditions.

If, despite this, it is desired to increase bass response, a suitable circuit is illustrated in Fig. 3. This may be inserted in a suitable high impedance point in the a.f. chain, the best position being at the control grid of any amplifying valve. The circuit includes a potentiometer, and this may, if the layout allows, be brought out as a panel control. Usually, the potentiometer need be a preset component only, whereupon it can be fitted in the most convenient place on the chassis. The circuit of Fig. 3 should not be fitted inside any negative feedback loop which may be present.

Valve Potentials

It is sometimes found that, in order to save components, the a.f. stages of the more inexpensive television receivers work under conditions which are not conducive to maximum quality of reproduction. In instances of this type it is occasionally worth while adding the few components which are needed to ensure optimum performance. A typical part of the circuit where improvements may be effected is given by the bias components employed, and it may prove advisable to study the appropriate valve literature to ascertain the bias conditions required for best operation. Whilst minor alterations to valve operating conditions may not normally provide a dramatic improvement in quality, they represent a point which should not go unnoticed.

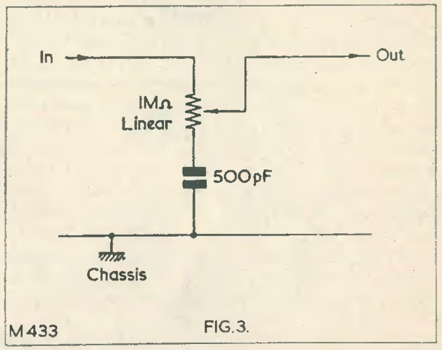


Fig. 3. *A simple "bass-boost" circuit which may be fitted in a grid circuit of an a.f. amplifier*

Negative Feedback

The audio circuits of many commercial televisors have far more gain than is required for most purposes, this being especially true when the receiver is operated in a "soak" (i.e. high signal level) area. The existence of excessive audio gain makes it possible to apply quite an appreciable amount of negative feedback to the amplifier section, with a consequent increase in quality. The addition of the feedback does not, of course, limit the power output of which the amplifier is capable; it merely reduces its gain.

There are various simple ways in which feedback may be applied over the output stage of the amplifier which, whilst not causing *considerable* increases in quality, may still improve this by quite an appreciable mount. The easiest method of applying n.f.b. to the output valve consists, quite simply, of omitting the electrolytic bypass condenser connected across its cathode bias resistor. If the cathode bias resistor is shared by the output valve and another valve, as occasionally happens, the other valve should be provided with its own separate bias resistor and bypass condenser. The deletion of the cathode bias condenser provides current feedback in the output stage, causes

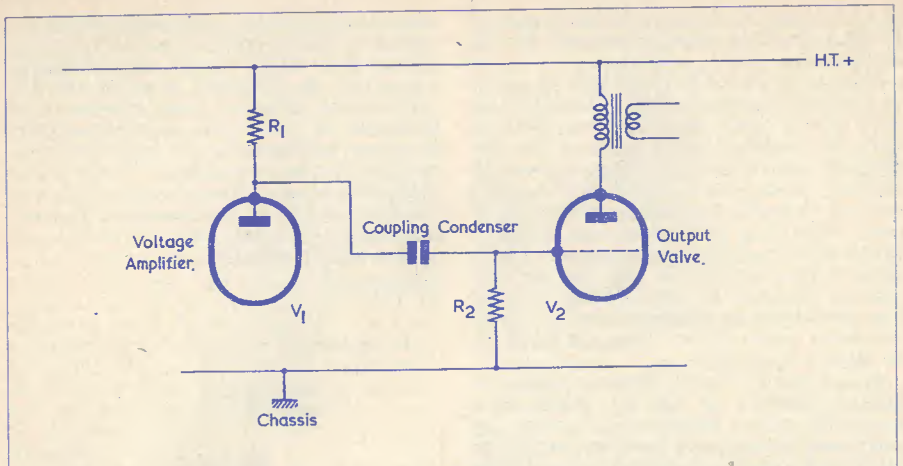


FIG.4A.

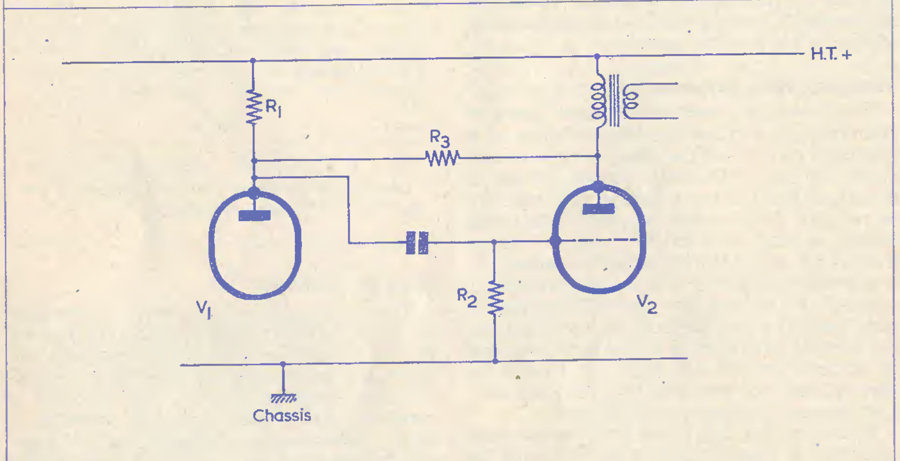


FIG.4B.

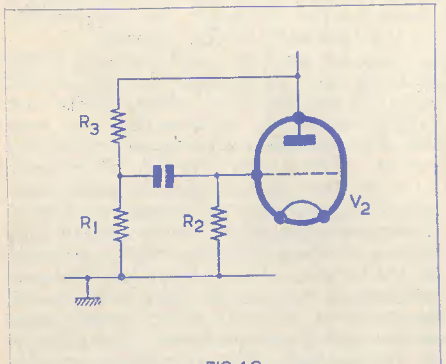


FIG.4C.

Fig. 4 (a). A typical two-stage a.f. amplifier. Fig. 4 (b). A negative feedback loop may be set up by adding R_3, as shown here. Fig. 4 (c). Illustrating the action of R_3 in (b)

a drop of about 6 db (a voltage ratio of 2 : 1) or so in gain, and usually gives a noticeably improved output response. The advantage of this particular method of applying feedback is the extreme ease with which it may be carried out. Since the heater of the audio output valve will probably carry a fairly high a.c. voltage with respect to chassis (due to its position in the heater chain), deleting its bypass condenser may sometimes cause hum to appear in its cathode circuit, and to be consequently reproduced by the loudspeaker. This point should only be troublesome in isolated instances.

Another very simple method of applying feedback over the output stage is shown in Fig. 4 (*a*) and (*b*). Fig. 4 (*a*) illustrates, in skeleton outline, a typical t.v. audio amplifier, in which the voltage amplifier V_1 follows the sound detector and drives the output valve V_2. By the simple process of connecting a resistor between the two anodes, as is shown in Fig. 4 (*b*), a negative feedback loop is set up between the output valve anode and grid. The operation of the circuit may be seen more clearly by examining Fig. 4 (*c*), wherein it may be noted that the audio voltage appearing at the anode of V_2 is applied to a potentiometer network consisting of R_3 (the additional resistor) in series with R_1 and R_2 in parallel. The tap between R_3 and the R_1, R_2 combination enables a proportion of the anode voltage to be applied to the grid. Since the anode voltage is 180 degrees out of phase with the voltage impressed on the grid, degeneration occurs.

In practice, the arrangement of Fig. 4 (*b*) usually works quite well. The value of the additional resistor, R_3, is found by experiment, greater feedback being given as this is reduced in value. Values between 10MΩ and 200kΩ should provide good results in practice.

The two methods of obtaining feedback which have just been described have the considerable advantage of simplicity, and are, therefore, to be recommended. They do not, unfortunately, offer a comprehensive solution as they cause an n.f.b. loop to be provided over the output valve stage alone. Better results would be given if the output transformer could also be included in the loop. The a.f. voltage given at the secondary of the output transformer is relatively low, but feedback is still quite feasible when the receiver a.f. amplifier employs two valves in cascade.

to be concluded

Can Anyone Help?

Requests for information are inserted in this section free of charge; subject to space being available

T. FREEBURN, Orritor, Cookstown, Co. Tyrone, N. Ireland, wishes to know if any reader can tell him where he can buy a Top Tuning Scale for a CR.100 receiver.

* * *

CPL. FORD, Signals Section, R.A.F. Jever, B.A.O.R. 25, wishes to obtain a circuit diagram and other details of the BC.453 receiver, 190–550 kc/s—payment where necessary.

* * *

I. COTTERILL, 287 Reddish Road, Reddish, Stockport, Cheshire, wishes to obtain a circuit for a Hand Capacity Organ. Can anyone help?

* * *

G. V. HAYLOCK, G2DHV, 63 Lewisham Hill, London, S.E.13, would like to obtain a circuit diagram of the type MCR.1 receiver. Beg or borrow, or what magazine article and issue was it published in?

* * *

H. BURNS-PRICE, "Bryn Afon" House, Bontddu, near Dolgelley, Merionethshire, Wales, wishes to obtain connections circuit for a "Delco-Light" 12V 750W Argine Generator No. 7-B-12.

ROBERT R. HOSIE, 101 Castlemilk Drive, Castlemilk, Glasgow, S.5, would like to obtain a service sheet for the H.M.V. 4811 12-in model console televisor. He would also like to obtain data relating to the MW36-22 14-in rectangular cathode ray tube.

* * *

L. A. BROWN, 32 Craikhill Avenue, Immingham, Lincs., would like to borrow a manual on the R.209 receiver or information on it, in particular the valve line-up and frequency coverage.

* * *

W. P. JENKIN, 16 Trelawney Road, Camborne, Cornwall, would like to hear from any reader who is willing to sell him a copy of the 4th edition of "Inexpensive Television," Data Book No. 4.

* * *

G. A. PETTER, 37 Parsons Green, Haslemere, Surrey, would like to obtain information on an "Echo Box" such as is used by dance bands for echo effects.

* * *

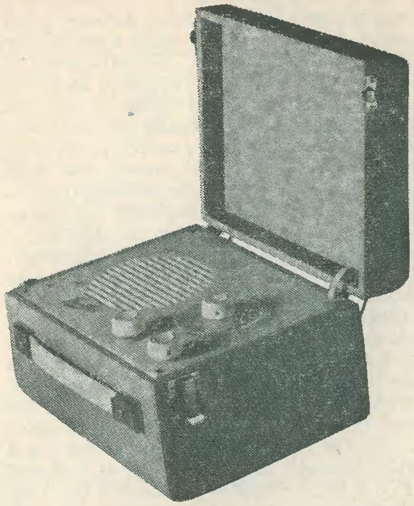
F. E. HARNDEN, 13 Ansell Avenue, Chatham, Kent, wishes to obtain the handbook for the Collins TCS.12 Receiver and Transmitter, and is in particular need of information on the power supplies for the 16 and 12-pin connectors.

(continued on page 833)

The "RAMBLER" PORTABLE SUPERHET

(In this, the last instalment of the series, is described a mains unit suitable for "The Rambler" and for other all-dry portables.)

by JAMES S. KENT



HAVING COMPLETED BOTH THE construction and alignment of the "Rambler" receiver as described in the last two issues of this magazine, many readers may wish to construct a mains unit in order to complete the equipment. The advantages of such a unit are obvious in that the considerable saving on the expenditure of batteries, which this equipment obviates, will alone recover the cost in a very short period of usage. In addition, the receiver may be used as the main domestic radio, or kitchen, or bedside set, drawing its power requirements direct from the mains.

It will occur to some, already owners of an all-dry portable receiver, to obtain and construct one of these units for use with their particular set. The many users of battery short-wave receivers may also find their answer to the dry-cell replacement problem in the building of this little mains supply pack. Providing the power requirements do not exceed 90V h.t. at 10mA and 1.4V at 0.25A, this unit will admirably fill the bill.

Circuit

Reference to Fig. 1 will show that the circuit consists of a double-wound mains transformer (MT), having primary tappings at three mains voltages. The h.t. supply is rectified by a metal rectifier (MR$_1$) with C$_1$, C$_2$, R$_1$ as the smoothing components, this delivering ripple free h.t. to the output sockets. The l.t. side of the circuit is composed of MR$_2$ as the rectifier with C$_3$, C$_4$, and the choke as the smoothing components. R$_2$ tends to stabilise the voltage at the output sockets.

The circuit is extremely simple and standard, and need not cause the beginner any qualms, either about the construction or the mains voltages involved. The double-wound mains transformer isolates the complete unit from the mains supply, and consequently once completed, it may be used without fear of shock. The primary tappings ensure that any mains a.c. supply between 200–240V may be used with the unit. Both the h.t. and the l.t. supplies are isolated from the metal outer case, these being terminated in a three- and two-pin socket respectively.

Assembly Instructions

Commence the assembly by placing the choke and the mains transformer into the case as shown in Fig. 2. These are not secured in any way except by the condenser case of C$_1$–C$_2$, once this is bolted into position by means of the fixing clip. Once this has been done, these two transformers are then securely held in position between this condenser casing and the end of the case itself. To ensure that this is so, before fastening the clip, push the condenser hard against both the choke and mains transformer. The fixing clips are tapped 4BA and 4BA × $\frac{1}{2}$-in countersunk screws are supplied for this purpose.

Both of the capacitors C$_3$ and C$_4$ should first be covered with PVC sleeving, in order to completely isolate them from the chassis, before they are fixed into position by means of the two fixing clips and the 4BA screws (see Fig. 2).

MR$_1$, the h.t. rectifier is next mounted in the case by means of a 4BA × 1$\frac{1}{8}$in countersunk bolt, inserting a shakeproof washer between the lower end of the rectifier and the chassis. The l.t. rectifier MR$_2$ is already fitted with a 4BA bolt, and it is only necessary to fit a shakeproof washer between the rectifier and the chassis, when a 4BA nut on the outside of the case holds it securely in position.

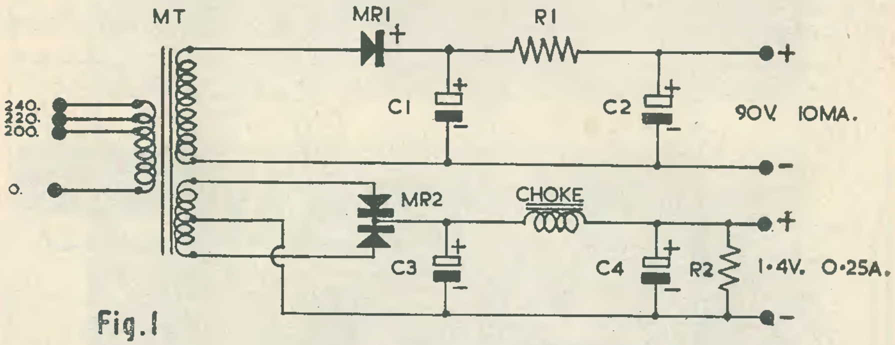


Fig.1

Before proceeding further, ensure that the plates of both MR$_1$ and MR$_2$, and the wire ends of C$_1$ and C$_2$, are not touching the case.

Dealing with the panel last, bolt into position both of the paxolin output sockets, the three-pin type being fitted nearest the top of the panel. The panel itself is fixed to the case, once the wiring-up process has been completed, by four self-tapping screws. This completes the assembly details.

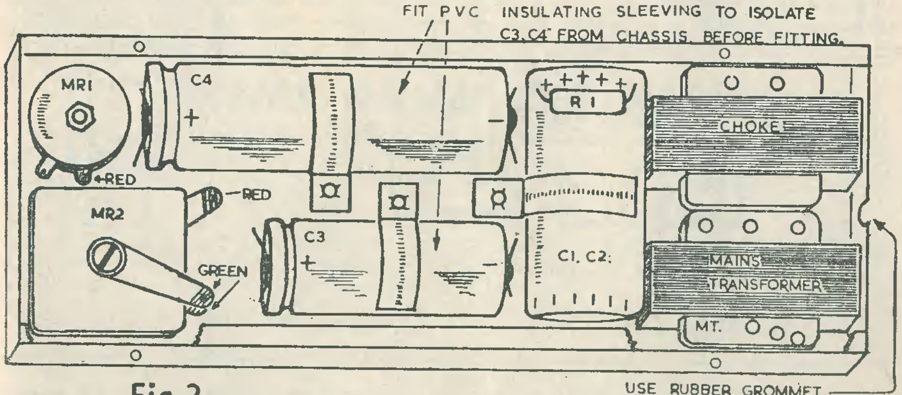


Fig.2

Wiring the Mains Unit

Before actually soldering any connections, it is necessary to cover the unused primary connections on the mains transformer with insulating tape. The colour code for these primary tappings are given in Fig. 3.

The wiring diagram is shown, in exploded form, in Fig. 3. It will be found best to commence the actual wiring up with the mains transformer. Sleeving must, of course, be fitted over all bare wiring.

Provided Fig. 3 is carefully studied while the job of soldering and wiring is going on at the same time, no difficulty should be encountered. The drawing is self-explanatory and the whole process simple in the extreme.

The wire ends of C$_1$ and C$_2$ should be bent over the top of the condenser, looking at the unit from the top (as in the photograph), and R$_1$ soldered across the two positive wires. The latter resistor should not, of course, be allowed to come into contact with the casing.

The mains lead should be fed through the case via a rubber grommet, and once soldered to the appropriate primary windings, the two soldered joints should be effectively covered with adhesive tape. Note especially the knot tied in the mains lead just inside the casing itself; this is to ensure that no undue stress will be placed on the two soldered joints just referred to above. Once the wiring has been completed and checked, and before the panel is secured into position on the casing, the unit should be tested.

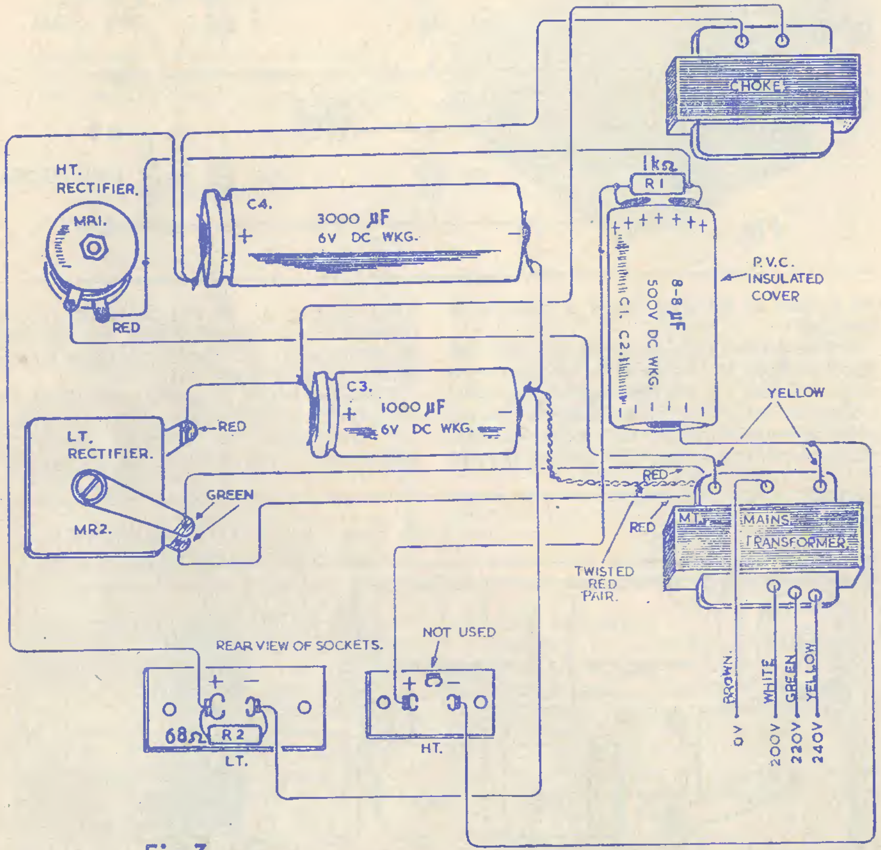


Fig.3

Voltage Measurements

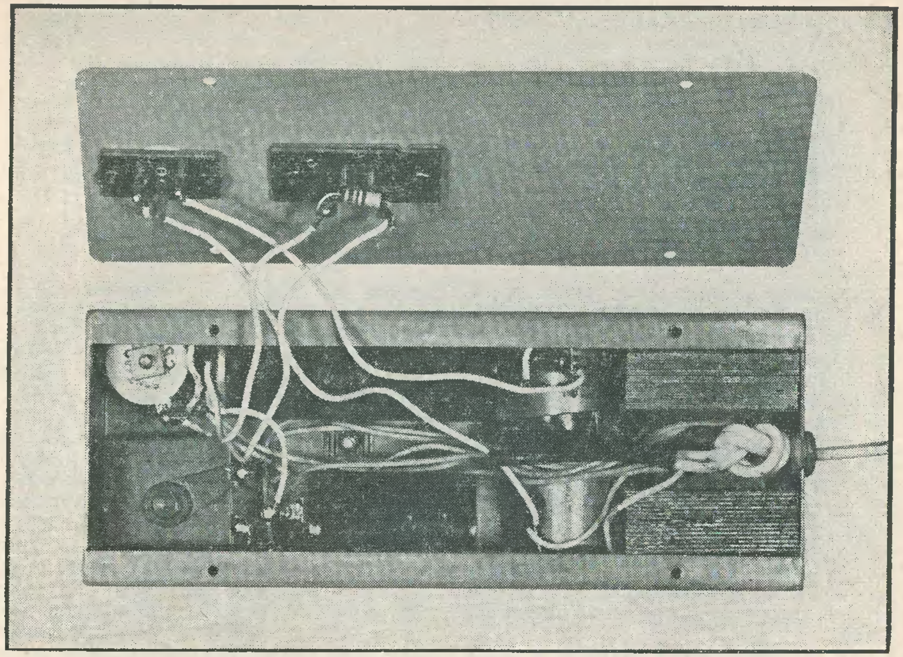
The voltages delivered from the mains unit before connection to the receiver should be approximately 3.5 to 3.7 volts l.t. and 170 to 180 volts h.t.

The unit, once on load, should produce from 1.25 to 1.35 volts l.t. and 80 to 90 volts h.t. If the l.t. voltage should drop below 1.25 volts, it will then be necessary to alter the primary voltage tapping on the mains transformer to a lower-rated tapping, i.e., should the 240V tap be in use, then this must be lowered to the 220V tapping.

The above measurements having proved satisfactory, the panel may now be secured into position, and the mains unit is now complete.

Conclusion

This little mains unit performs extremely well when connected to the "Rambler" portable receiver, no trace of hum or ripple being apparent. It takes only a moment to make the change from the batteries to the unit, and the consequent advantages are soon apparent, with the unlimited use of the receiver in the household without the ever present consideration of the battery wastage problem. Capable of being used with any similar portable battery set, it is a worthwhile addition to the equipment of those owning such receivers.



View of mains power pack with panel removed to show interior

PHILIPS AM/FM CAR RADIO

What is believed to be the first AM/FM car radio to be launched in this country by a leading manufacturer, was introduced by Philips Electrical Ltd. on 1st June, 1957. Known as Model X61V, this new high-quality receiver sells at a retail price of 49 gns. (list £37.16.8, including £2.9.6 for suppression equipment, plus P.T. £13.12.4). It employs seven valves and rectifier and covers long, medium and f.m. wavebands. There are push buttons for station and waveband selection. An outlet socket for operating the "Philishave" dry shaver is incorporated.

A separate power supply unit is provided, and the set can be adapted for 6V or 12V operation.

Specification

Valves:	*a.m.*	*f.m.*
R.F. amplifier	EF89 }	ECC85
Frequency changer	ECH81 }	
1st i.f. amplifier	EF85	EF89
2nd i.f. amplifier		EF85
3rd i.f. amplifier		EF42
Detector and a.f. amplifier	EABC80	EABC80
A.F. output	EL84	EL84
Rectifier	Metal	Metal

Wavebands: Long, 1053–2000m. Medium, 186–583m. F.M. 87/5–100 Mc/s.

Controls: On/off volume. Tuning. Tone (continuously variable). Five push buttons for station and waveband selection.

Power Supply: 6V or 12V.

Consumption: 55 watts.

Cabinet: Metal, dark grey lacquer. Chome-plated escutcheon.

Dimensions: Control unit, 6⅞"×2⅛"×5½". Power supply unit 8¼"×3¾"×5⅛".

Features: High sensitivity. Small dimensions for easy mounting. Push button operation for station and waveband selection.

Speaker: 7" complete with baffle and "Philite" housing.

Price: 49 gns (tax paid).

Radio Miscellany

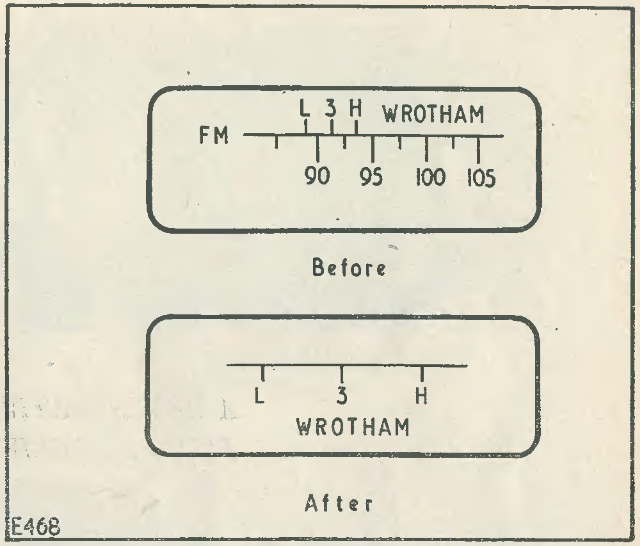
Still more readers have taken up the point of "follow-up" news and readers' experiences of receivers described in the pages of *The Radio Constructor*. Mr. E. C. Johnstone, of 71 Marlow Crescent, Twickenham, also expresses the hope that the idea will extend to the less publicised sets and not be confined to those that prove widely popular. Provided the idea is sufficiently supported the Editor will find space for any items of interest under this heading. News of modifications and points which readers think good or not so good must, of course, appear as a separate feature, but by way of starting the ball rolling, here are one or two points from the more interesting letters.

Our old friend, Mr. C. Brewer, of South Shore, Blackpool, writes to describe a neat method he has used for attaching high-resistance headphones to the All-dry Portable, using a miniature 2-pin plug and socket. The leads to the speaker transformer are cut and connected to a second miniature plug which emerges through the panel adjacent to the point where the socket is fitted. Thus headphone listening can be speedily selected on those occasions after the rest of the family have retired, or when they are playing cards or filling up their Pools coupons.

CENTRE TAP *talks about* *Items of General Interest*

Mr. W. J. Culverhouse, 38 Curzon Avenue, Stanmore, who wrote on this idea (April issue) had one direct reply from a Midlands reader. He has now heard a Jason in operation and was favourably impressed. He hopes shortly to start construction and looks forward to hearing readers' hints, tips and performance opinions either through the pages of *The Radio Constructor* or direct to his home address.

The Jason F.M. Tuner seems to have found its way a lot in this column in recent months and Mr. A. E. Thompson, of 14 Wellington Square, Oxford, keeps the ball rolling. However, no apology is needed, as the Jason, either as a tuner or as a complete receiver, is still being widely built. Indeed the reprint of it is now in its fifth edition. He describes the idea of "band-spreading" the tuner unit version. This means, of course, that for those who want to hear only the three B.B.C. programmes, the wave-range coverage will be reduced but the length of the scale over which the broadcast programmes are spread will be much expanded. The accompanying sketch gives an idea of the effect. He writes: "By using components of the values recommended the tuning scale is expanded by approximately three times and the parts of the tuning range which, from a broadcast point of view, are virtually valueless, are cut off. All but one of the moving vanes of each section of the tuning capacitor are removed by means of a pair of fine-nosed pliers. A 6-8pF fixed and a 10pF maximum variable Philips air spaced trimmer are then connected in parallel with each gang. The tuning coils remain untouched so the required capacitance for a particular station remains as before. The 10pF trimmer in parallel with VC$_2$ is adjusted to bring the Third programme to the middle of the tuning scale and the other 10pF (in parallel with VC$_1$) is adjusted for maximum signal, preferably with a sensitive meter and resistor connected across R$_{10}$. The 6-8pF fixed capacitors (20% tolerance) are of the ceramic type and have not introduced warming-up drift. If this does occur it would of course be eliminated by using negative temperature coefficient capacitors. The single moving vane of each gang left remaining must be an inside one otherwise the tuning range would be too drastically reduced. The additional capacitors should be mounted with the shortest possible leads so that they are self-supporting, and must be on the upper side of the chassis where the temperature is more constant. No difficulty should be experienced in keeping them compact and they should be earthed at a single point between the two gangs."



Showing the effect on the tuning scale of band-spreading the Jason F.M. Tuner, following the modifications described here by reader A. E. Thompson

Tuppence Coloured

Last month it was only possible to fringe on the vexed question of colour t.v. when I expressed the view that it would be a long time before a regular service would be in operation in Great Britain. The two obvious difficulties, band-width and high cost, are not the only restricting factors. Public demand has also to be considered. Sure, they would like it as a novelty but would they go to the extra expense—and the risk of trouble? In the United States where a 4-hour daily programme has been on tap for some time, it was quickly discovered that everyone who was supposed to be so eagerly awaiting colour, developed a very marked sales resistance. As the growth of both sound radio and monochrome t.v. closely followed American trends it is not unreasonable to expect the same tendency will be repeated here.

Colour t.v. would be easily possible in a few weeks but even its most ardent supporter must admit that it is still insufficiently developed. To-day's production cost for a receiver would be in the region of £500 and few would be prepared to readily put down a sum of that order. Even quantity production is unlikely to reduce that figure to £350 very quickly, especially in the face of probable slow sales.

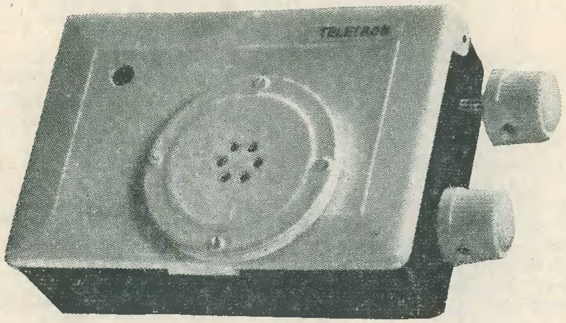
Assuming that there are no new basic developments and that the system to be used is fundamentally that which could be put into service to-day, what will the viewer get for his £500? The answer, I am afraid, is a highly complicated box of tricks, very bulky, and which for satisfactory reception would require him to be continually jumping up to twiddle the knobs. Granted a few people might enjoy that sort of thing—the type that love doing the projection in home movie shows! I had a cousin a few years older than myself who was a born twiddler. When we were kids the electric gramophone motor was unknown and whenever anyone decided to play a few records, it was his delight to sit beside the motor, slowly and silently winding it so that the family could sit and enjoy a non-stop performance. When he wasn't winding he was getting a new needle and the next record lined up for a lightning change. I am sure he and his kind would simply love monitoring a colour t.v. but even they might jib at paying £500 for it.

The average viewer, however, is liable to soon get fed up with a receiver requiring constant adjustment especially as the colour, still rather garish, would add little to many of the programmes. Undoubtedly the advertisers would like it. Their products, packaged

(*continued on page 844*)

THE . .

"COMPANION"



A REGENERATIVE TRANSISTOR '3' POCKET RECEIVER

Described by **R. A. LANGIS**

IN RECENT MONTHS THE TREND AMONG THE home constructor fraternity has been the concentration more and more on miniaturisation of completed assemblies and the greater use of transistors, and this, coupled with the advantages of both techniques, has led to the development of small but highly efficient receiver and other designs. The latest of these is the Teletron "Companion," a three transistor pocket receiver incorporating a regenerative feedback circuit in the detector stage. The "Companion" transistor receiver is a two-waveband design providing high selectivity with adequate sensitivity, and having extreme portability; it is completely self-contained and does not require to be connected to an external aerial or earth. Designed and produced by the Teletron Company, and available from several of the advertisers in this magazine, it is shown on this month's front cover.

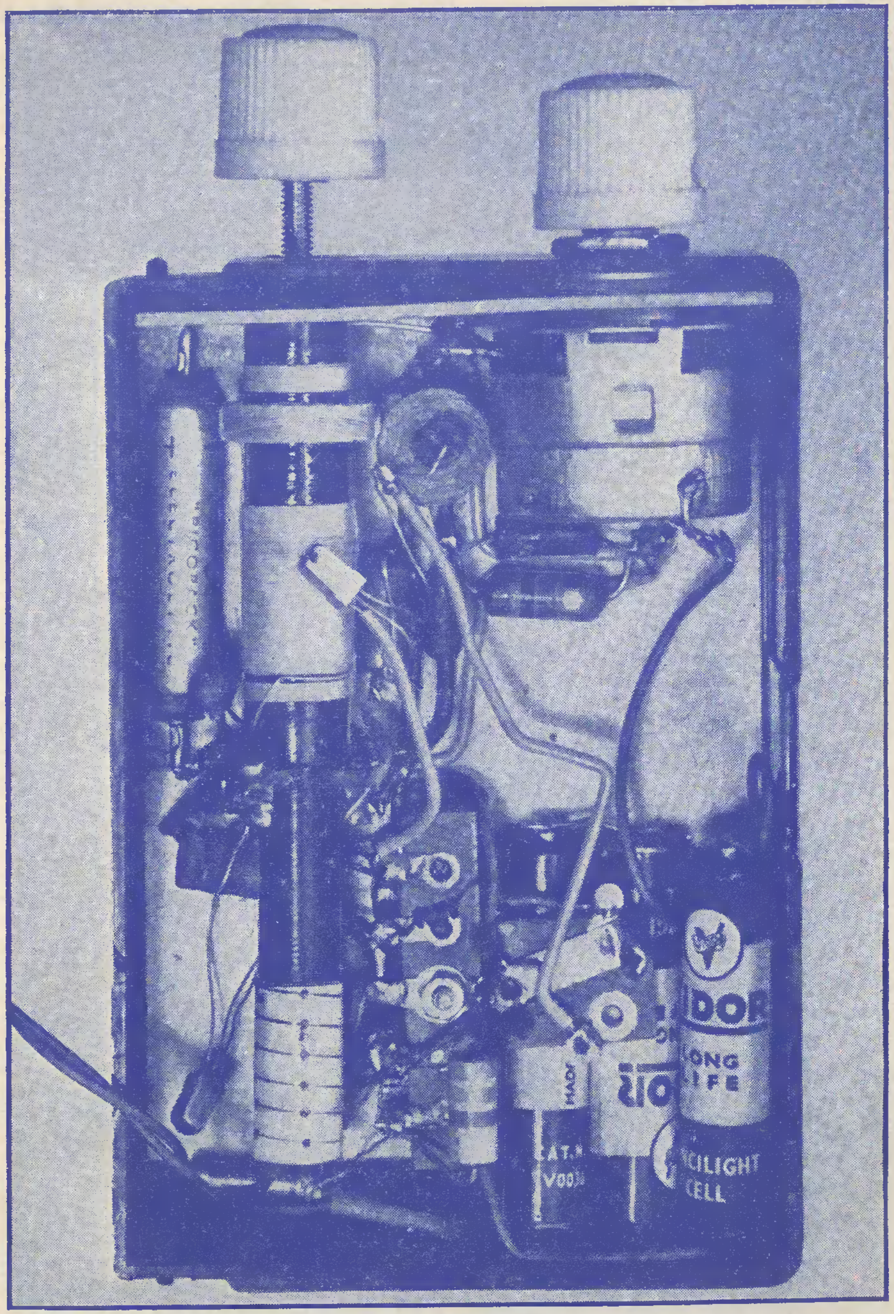
General Description

The whole receiver is contained within a plastic case having a hinged lid, the whole measuring some 4¼in × 3in × 1¼in approximately. From the illustrations shown herewith, it will be seen that the balanced armature earpiece is mounted on the front panel or lid, thereby forming a small speaker assembly, while the small aperture allows perception of the tuning scale contained on one end of the rotating Ferrite rod assembly.

The two controls shown at the end of the case are, at the top—the micrometer adjustment (tuning); at the bottom—gain and reaction control.

A single tuned radio frequency circuit permits the selection of any receivable programme by means of the micrometer adjustment provided on the high "Q" aerial inductor type FX25. The small tubular scale mounted on the end of the travelling Ferrite rod, and normally viewed through the small aperture in the lid of the case, permits the ready identification of the Medium wave programmes. For reception of the Long wave programme, radiated on 1,500 metres, the core requires to be withdrawn almost into the body of the former.

A plastic pre-punched chassis assembly is provided, and on this the receiver may be completely assembled and wired prior to fitting in the cabinet.



Larger-than-life view of inside of the "Companion" prototype—compare with Fig. 2

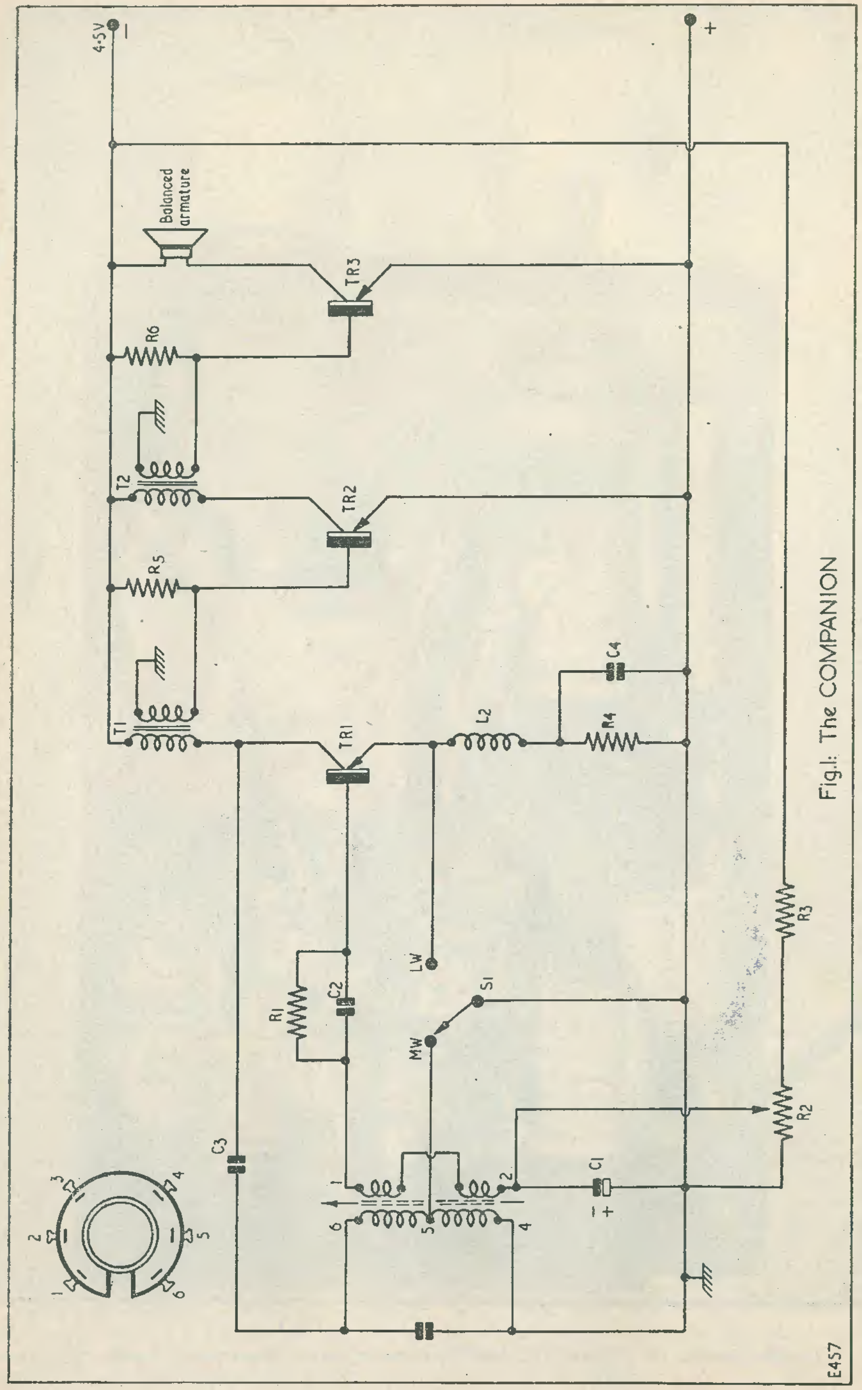


Fig.1: The COMPANION

Circuit

The circuit of the receiver is shown in Fig. 1, from which it will be seen that it consists of a regenerative detector stage followed by two transformer-coupled audio stages feeding into the balanced armature earpiece.

The high "Q" inductor Ferrite rod aerial assembly is switched for both Medium and Long waves by means of S_1. The circuit arrangement shown is that specifically designed for use with the popular "Blue Spot" r.f. transistor (TR_1), and the compensating network in the emitter network is essential. When junction r.f. types such as the Mazda XA102 or Mullard OC44 are used, the emitter should be connected directly to C_4/R_4, with L_2 omitted. Regeneration is obtained by variation of R_2, thus varying the base bias; C_3 being the feedback component from the collector to the tuned winding. The condenser shown connected across the tuned winding (unmarked), has a value of 500pF, and is supplied with the coil unit. The function of this is to pre-set tune the winding, thus allowing the micrometer adjustment to effectively tune over the normal broadcast ranges.

The condenser and resistor combination C_2 and R_1 connected between the base winding and the transistor base are the normal detector input components. The inductor L_2, inserted in the emitter line, extends the frequency cut-off of the transistor type specified, thus allowing adequate positive feedback to obtain sufficient reaction and to increase further the sensitivity of the detector stage as a whole.

The output from the collector of the detector is transformer coupled into the first audio stage TR_2. The base supply resistor R_5 is specified at 8.2kΩ, but this may be varied, experimentally, between that value and 15kΩ. Due to the wide tolerances of differing transistors, much will depend on the actual component used as TR_2. That value stated for both R_5 and R_6 (see component list), is also dependent upon the specified inter-stage transformers being incorporated into the design. Both the transistor base supply resistors, in conjunction with the secondaries of the inter-stage transformers, form a potentiometer across the h.t. supply. Thus the d.c. resistance of these secondary windings, where transformers other than those specified are used, will have an appreciable effect both on the value of the supply resistors and the collector current flow measurement. With the values and components shown, the current for TR_2 would be 0.5mA, and that for TR_3 approximately 3.0mA. The collector current rating for TR_1 is approximately 0.002mA.

The output of TR_3 is fed into the balanced armature earpiece; but where it is desired to use a pair of headphones in place of the earpiece shown, these may be connected in series with the collector of TR_3. Alternatively, headphones may be connected in series with the collector of TR_2, omitting both T_2 and TR_3. Where a low impedance "deaf-aid" type earpiece is required to be used, this should be connected across the secondary of T_2. In the prototype shown on the front cover, the balanced armature earpiece has been left "bare." In the production models, a suitable plastic clip-on shield, complete with cut out fret, is supplied.

Component List

R_1	2.2kΩ $\frac{1}{8}$ watt
R_2	25kΩ pot (with switch) Egen type 105
R_3	100kΩ $\frac{1}{8}$ watt
R_4	100Ω $\frac{1}{8}$ watt
R_5	8.2kΩ $\frac{1}{8}$ watt (see text)
R_6	4.7kΩ $\frac{1}{8}$ watt (see text)
T_1, T_2	Ardente type D240 (T_1), D239 (T_2)
S_1	Teletron Co.
Balanced armature earpiece	
Batteries	Three 1.5V Penlight (U16 or Vidor VO036)
C_1	2μF, electrolytic
C_2	500pF, tubular ceramic
C_3	50pF, silver mica
C_4	0.01μF, type W99 (150V), Hunts
L_1	Type FX25 (Teletron Co.)
L_2	Teletron Co., type 24
Case & Chassis	"Companion," Teletron Co.
TR_1	Blue Spot or R.F. Junction
TR_2	Red Spot
TR_3	Brimar TS3

The nominal value for C_3 is shown as 50pF but, due again to the wide tolerance values in transistor characteristics, it may be necessary in some cases to increase this value to either 75pF or 100pF in order to allow regeneration to continue down to approximately 210 metres.

Coil connections for the Ferrite aerial assembly are shown inset to Fig. 1.

Assembly and Wiring

This may be carried out prior to fitting into the cabinet. Most of the small components are mounted directly into the wiring, and the layout of these should be strictly adhered to as shown in the drawing, Fig. 2, and the photograph.

In order to facilitate wiring, the FX25 core should be completely removed. The inter-stage transformers T_1 and T_2 are mounted on either side of an inverted 6-BA bolt, followed by the switch S_1 and the 4-way tag strip; a double-ended solder tag then being fitted to the bolt and the complete assembly then being locked into position by means of a 6-BA nut. The lead-out wires from both T_1 and T_2 are then soldered to the 4-way tag strip in the following order: T_1 primary, Blue to M and Yellow to I. T_1 secondary, Red to J and Green to L. T_2 primary, Blue to M and Yellow to collector of TR_2. T_2 secondary, Red to L and Green to N.

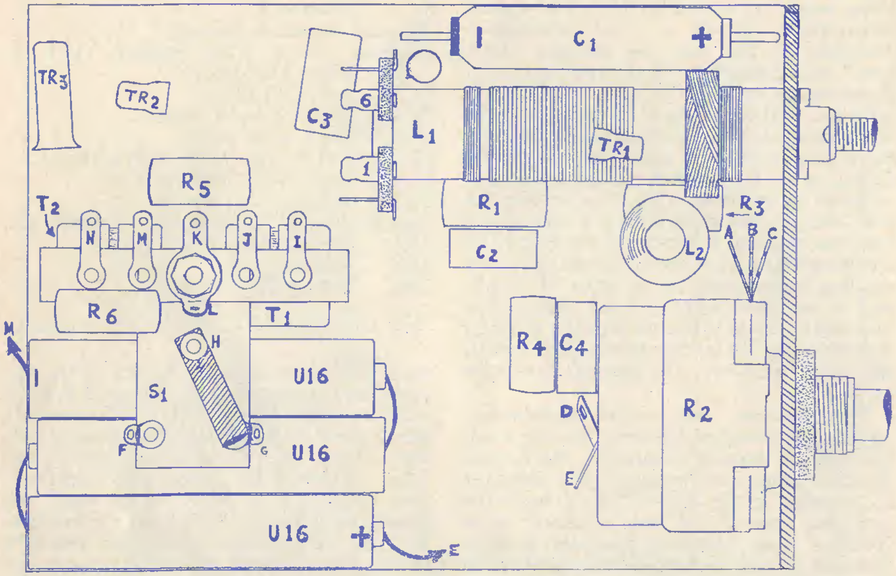


Fig. 2. General layout of the components on the completed chassis assembly. Note: The Ferrite rod material has been omitted for clarity

The transistor lead-out wires should *not* be cut short. All wiring should be kept close to the chassis and connected in the following order (see Fig. 2). Connect D to C of the potentiometer (left-hand tap looking at rear); next solder D to 4 of L_1. Connect L (one side of double-ended solder tag held by bolt in centre of 4-way tag strip) to 4 to L_1; join L to H (centre pivot of wavechange switch). Join the positive end of C_1 to C of the potentiometer (left-hand tag); join adjacent ends of R_4 and C_4 to D of the potentiometer. Connect R_3 between M (tag of tag strip), and A (right-hand tag of potentiometer looking at rear); B of potentiometer to 2 of L_1 and the negative end of C_1.

Join 5 of L_1 to G (one side of wavechange switch S_1). Next, connect adjacent ends of R_1 and C_2 to 1 of L_1; follow this by soldering the other ends of R_1 and C_2 to the base wire of TR_1. Solder the lower end of L_2 to the adjacent ends of R_4 and C_4 and the other end of L_2 to the emitter of TR_1 and F (one side of wavechange switch).

Continue by soldering C_3 between 6 of L_1 and I (tag of tap strip). Join one end of R_5 to J of tag strip and the other end of R_5 to M (tag of tag strip). Solder one end of R_6 to N (tag strip), and the other end of this resistor to M (tag strip). Next, connect emitter of TR_2 to 4 of L_1, and follow this by connecting the base of TR_2 to J (tag strip). Join the collector of TR_2 to the yellow lead of T_2.

Quickly solder the emitter of TR_3 to K (other side of double-ended solder tag). Next connect the base of TR_3 to N (tag strip), and continue by soldering the collector of TR_3 to one side of the balanced armature earpiece. The other side of the earpiece should now be connected to M (tag strip). (Note: With the receiver assembled and working, once the lid is closed a certain amount of oscillation may take place owing to the close proximity of the earpiece assembly to the winding of L_1. Should this occur, the remedy is to reverse the earpiece connections,)

To complete the wiring, connect the three small battery cells together as shown in Fig. 2, with the positive end connected to E (potentiometer) and the negative end connected to M (tag strip). E (potentiometer switch tag) should be connected to the case of the potentiometer if this is of metal. This completes the wiring of the "Companion" receiver.

The FX25 inductor (L_1) should be correctly positioned in the specially shaped cut-out of the chassis panel, and retained in place by means of the spring clip supplied with the assembly. A reducing bush is supplied so that the tuning knob will fit securely on the adjustable screwed rod of this inductor.

The Companion cabinet is supplied ready pre-punched. Once fitted, the earpiece is securely held in position by two 8-BA screws approximately 3/16ths inch long; these being fitted from the inside of the lid, at the same time taking care that each screw is fitted with a small metal washer.

The smaller aperture in the casing lid is utilised as the viewing window of the tubular paper tuning indicator (see Fig. 3). This aperture should be covered internally with a small length of Sellotape, or similar material, across the centre of which an ink line is drawn to act as the tuning cursor. From Fig. 3 it will be seen that the paper tuning indicator, once cut out and glued end to end, should be fitted to one end of the actual Ferrite rod exactly as shown. Stations may then be marked on this rotating paper drum, thus allowing of easy resetting at any future occasion.

Having completed the above, the chassis assembly may then be fitted into the cabinet by inserting both the volume control spindle, and that of L_1, into the pre-punched holes in the side of the case; finally holding R_2 into position by means of the potentiometer bush and fixing nut, not forgetting to insert the Paxolin spacing washer between the chassis panel and the cabinet wall.

Tuning

Programme selection is obtained by adjustment of the screwed Ferrite core of L_1. The volume control R_2 should be set to not more than mid-travel. When the control knob of L_1 is adjusted to approximately the centre position of the tuning scale, as viewed through the aperture, a loud whistle will be heard in the reproducer as the programme is tuned in. Careful adjustment of the volume control R_2 will remove the whistle. Further adjustment of each control will then provide normal and clear reception.

In some areas, where the signal emanating from a given station is somewhat weak, reception may be improved by connecting a small "throw-out" aerial of some 2 yards in length. One end of this wire should, therefore, be connected to tag 1 of L_1. This procedure may also be of some assistance during the initial testing of the completed receiver.

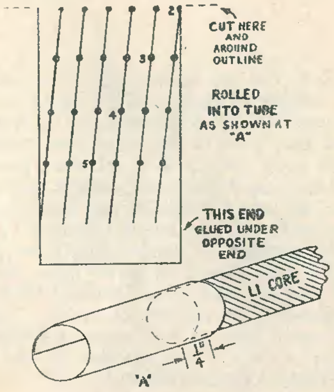


Fig. 3. Showing method of assembly of the tuning scale, and a scale which may be cut out and used for this purpose

The "Companion" transistor receiver has been thoroughly tested in a large number of locations within the Home Counties and has been found to be satisfactory in all respects. It is extremely sensitive, selective and highly efficient as a local station portable receiver. Taking only a very short time to construct, it is relatively cheap, the components are easy to obtain, and it is a very fine little receiver to use either at home, at the office or on holiday.

Can Anyone Help?

continued from page 821

J. GUNN, 24 Goldhanger Cross, Basildon, Essex, wishes to obtain information on a Signal Generator by the McMurdo Co. of U.S.A., Range 90 kc/s to 170 Mc/s A.M./F.M., using 9 valves. Present trouble is no modulation. All circuits will be returned, but would like to purchase one if possible.

C. R. OSBORNE, 2 Swindon Lane, Harold Hill, Romford, Essex, purchased a Pattern Generator, range 41.45–66.75 Mc/s, not quite completed and minus valves. He would like to obtain the address of the manufacturers, J.V. Radio & Television Ltd., Plymouth (if still in business), or a circuit diagram and/or valve line-up.

RIGHT—*From the Start*

PART 16

MATTERS ARISING

by A. P. BLACKBURN

SINCE THE BEGINNING OF THIS SERIES A number of aspects of the radio art have been briefly presented, and it is appreciated that none of them has been examined in any great detail. It is felt that, generally speaking, an introduction which may make more advanced reading and experiment a little easier is all that is required of such articles as these. However, from time to time queries and criticisms have been received from readers, and most of these have been concentrated on matters of detail. It might be a good idea at this stage, therefore, to devote a little time to two of the most frequently occurring points.

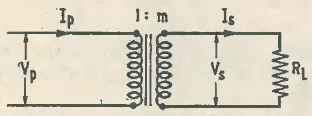


FIG. 1.

C429

Transformers

At various times matching has been mentioned, and also the fact that transformers may be used for this purpose. How they achieve this is certainly not immediately obvious.

In the following we will always assume that the transformer is 100% efficient. This means that all the power entering the primary is delivered from the secondary. Note that it is *power*, not voltage or current alone, that decides the efficiency.

Fig. 1 shows a transformer with V_p volts applied across the primary winding, which produces V_s volts across the secondary. The primary is carrying a current of I_p amps and the secondary I_s amps; the load is R_L and the turns ratio from primary to secondary is 1 : m.

Now the power in the primary is V_pI_p watts and in the secondary V_sI_s watts. As the transformer is 100% efficient

$$V_pI_p = V_sI_s \quad .\ .\ .\ .\ (1),$$

i.e. the power entering the primary is equal to the power leaving the secondary.

Now the voltage at the secondary will depend upon the applied voltage and the turns ratio, in the following manner:

$$V_s = \frac{V_p}{m} \quad .\ .\ .\ .\ (2);$$

for example, if the turns ratio m were 5 to 1 and V_p were 250 volts, the secondary voltage V_s would be 50 volts. If we now substitute the result of (2) in (1), we get:

$$V_pI_p = V_p/m \times I_s$$

$$\therefore I_p = I_s/m \quad .\ .\ .\ .\ (3).$$

We can see from this that the currents in primary and secondary are dependent upon m also. Taking our 5 to 1 transformer again, if the current on the secondary side were 5 amps, the primary current would be 1 amp.

So far this agrees with the equal power on both sides condition. We have 250 volts 1 amp on the primary, i.e. 250 watts and 50 volts 5 amps on the secondary; 250 watts again. Notice that if the voltage is stepped down, the current is stepped up, and vice versa.

Effect of Loading

So far the secondary current has flowed without reference to R_L. Consider now a more practical case. Fig. 2 shows a transformer feeding a loudspeaker which has an impedance of 5Ω. The ratio of the transformer is 40 : 1 step down from primary to secondary. If 200 volts are applied at the primary, the secondary voltage will be 200/40 = 5 volts. The power in the loudspeaker will be:

$$\text{Power } V^2/R = 25/5 = 5 \text{ watts},$$

and the current in the secondary will be 1 amp.

Now the power in the primary is the same, 5 watts, so the current in the primary will be 1/40 amps, or 25mA. If we have a given voltage in a circuit and a given current there must also be a resistance in the circuit of appropriate value to cause that current to flow. In the secondary case the resistance is, of course, the 5Ω load, but where is the resistance in the primary?

Its value must be equal to the voltage divided by the current, in this case:

$$\frac{200 \text{ volts}}{1/40 \text{ amps}} = 8\text{k}\Omega.$$

The resistance is "reflected" from the secondary, as shown in Fig. 3. It appears in series with the primary, and if R_L is varied, the reflected resistance varies also. Looking into the primary in the direction of the arrow, an external circuit is presented with this reflected resistance which has a value which depends upon R_L and m, in the present case of value 8kΩ when R_L is 5Ω and m is 40 : 1.

Now if the optimum load impedance of the valve in Fig. 2 were 8kΩ it would be matched because the transformer is presenting just that load when a 5Ω speaker is connected to the secondary.

Usually we have a given valve, the optimum working load being stated by the manufacturer, and a given loudspeaker of known speech coil impedance. We have to choose a transformer of correct turns ratio to match one to the other. The point in matching, it will be recalled, is to transfer the maximum power from the valve to the loudspeaker.

Now the power in the secondary is $\frac{{V_s}^2}{R_L}$ and in the primary $\frac{{V_p}^2}{R_p}$, where R_p is the reflected resistance. As these powers must be equal:

$$\frac{{V_p}^2}{R_p} = \frac{{V_s}^2}{R_L}$$

$$\therefore \left(\frac{V_p}{V_s}\right)^2 = \frac{R_p}{R_L}$$

but $\frac{V_p}{V_s}$ = m the turns ratio

$$\therefore m^2 = \frac{R_p}{R_L}, \text{ or } m = \sqrt{\frac{R_p}{R_L}}$$

For matching, R_p should equal the optimum load impedance of the valve.

Therefore, turns = ratio =

$$\sqrt{\frac{\text{optimum load impedance of valve}}{\text{speech coil impedance}}}$$

If we take our original example of a valve with 8kΩ impedance and 5Ω speech coil we get

$m = \sqrt{\frac{8000}{5}} = 40$, as before. The transformer needs to have a 40 : 1 ratio step down.

There are a few points arising in the above which are of interest. Firstly, because the transformer is step-down in voltage from primary to secondary, it is step-up in current. The secondary current was shown earlier on to be 1 amp. The leads connecting the transformer to the speaker should be of heavy gauge wire in order that the power loss in them may be kept to a minimum.

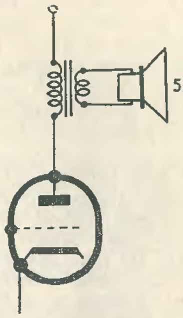


FIG. 2.

C430

The assumption of a perfect transformer is quite valid in this case. The losses due to resistance and the iron core are sufficiently small not to cause a serious mismatch. The more important effect is upon the frequency response; but that is another story.

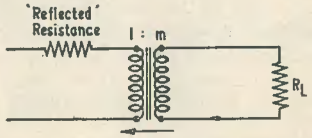


FIG. 3.

C431

Sums

A rather different topic which crops up fairly frequently is the matter of getting the right answer to the calculations one is inevitably faced with. The main trouble seems to be with the units involved. A good example is the resonant frequency of a tuned circuit.

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

where L is the inductance in Henrys,
C is the capacity in Farads,
and f is the frequency in cycles/sec.

Now farads and henrys are something of a nuisance—particularly farads, they are so big! To take an example, if C were 100pF and L were 64μH, we wish to find f.

Written out in full:

$$f = \frac{1}{2\pi\sqrt{0.000000001\ \text{(Farads)} \times 0.000064\ \text{(Henrys)}}}$$

Now this is indeed a formidable looking sum! In fact, in that form we will not even attempt to find the answer. Fortunately a simple shorthand may be used. I make no apology for attempting to explain some useful aspects of indices; many will be perfectly familiar with the process, but to those who are not, it may save a lot of time and wrong results.

We will start with raising ten to various powers, viz. 10^2, 10^3, etc. These are another way of writing 100 and 1000, of course. One million becomes 10^6, and what is particularly important to us is that *one-millionth* is written 10^{-6}, which is another way of writing $1/10^6$, which, of course, is one-millionth. One microfarad is one-millionth of a Farad, so 1μF may be written 10^{-6} Farads. A pF is a millionth of a microFarad, so it may be written 10^{-6}μF, or 10^{-12} Farads. The last point brings out the useful rule that multiplied numbers may have the indices added; for example:
$100 \times 1{,}000 = 10^2 \times 10^3 = 10^{(2+3)} = 10^5$ and $0.01 \times 0.001 = 10^{-2} \times 10^{-3} = 10^{-(2+3)} = 10^{-5}$.

To return to our problem, we can write it much neater as follows:

$$f = \frac{1}{2\pi\sqrt{100 \times 10^{-12}\ \text{(Farads)} \times 64 \times 10^{-6}\ \text{(Henrys)}}}$$

A further simplification may be made if the 100 is written as 10^2, thus:

$$f = \frac{1}{2\pi\sqrt{10^2 \times 10^{-12} \times 64 \times 10^{-6}}}$$

By adding the indices:

$$f = \frac{1}{2\pi\sqrt{64 \times 10^{-16}}}$$

Now to take the square root of 10^{-16} all we have to do is to divide the index by 2, because if $10^2 = 100$, the square root of 100 is 10, i.e. 10^1; the index has been divided by 2.

$$\text{Therefore } f = \frac{1}{2\pi \times 10^{-8}\sqrt{64}} = \frac{1}{16\pi \times 10^{-8}}$$

That 10^{-8} in the denominator may be taken "upstairs" if the sign of the index is changed.

$$\therefore f = \frac{10^8}{16\pi} = 2 \times 10^6 \text{ c/s approx. or } 2\ Mc/s \text{ approx.}$$

If the numbers involved are being divided instead of multiplied, the indices are subtracted. Say 1,000 volts is being applied to a resistance of 1MΩ, what would be the current?

$$I = V/R = \frac{10^3\ \text{volts}}{10^6\ \text{ohms}}$$

$$= 10^{(3-6)} = 10^{-3} \text{ amps., or } 1mA$$

To go a little further with this example, what would be the wattage dissipated in the resistor?

$$\text{Watts} = \frac{V^2}{R} = \frac{(10^3)^2}{10^6} = \frac{10^6}{10^6} = 1 \text{ watt.}$$

Note that squaring the 10^3 merely means multiplying the index by 2.

Here is another one that frequently occurs. A Short wave station is said to operate on a frequency of 20 Mc/s; what is the wavelength? The formula connecting frequency and wavelength is:

$$\text{Wavelength} = \frac{\text{Velocity of light}}{\text{Frequency}} = \frac{3 \times 10^8}{f}$$

where wavelength is in metres, frequency is in cycles/sec. Thus, in our example,

$$\text{wavelength} = \frac{3 \times 10^8}{2 \times 10^7} = \frac{3 \times 10^{(8-7)}}{2} = \frac{3}{2} \times 10$$

$$= 15 \textit{ metres.}$$

A snag which sometimes occurs is that one gets something like:

$$\sqrt{3 \times 10^7}$$

Now we saw before that to find the root of 10^7, all one has to do is to divide the index by 2. But in this case we would get:

$$\sqrt{3} \times 10^{3\cdot5}$$

This is correct, but $10^{3\cdot5}$ is awkward to deal with. A better thing to do is to multiply the 3 by 10 and divide the 10^7 by ten and we get

$$\sqrt{30 \times 10^6}$$

which now becomes:

$$\sqrt{30} \times 10^3$$

Returning right to the beginning of this section, the important thing to remember when dealing with a formula is to get all the units right. If one forgets to write 3mA as 3×10^{-3} amps it may lead to a completely incorrect result, if the other items in the formula are not consistent with it.

The golden rule is, never use a formula unless the units are specified. If they are not, look it up elsewhere.

A Modern Three Valve Superhet

by **S. E. ADDIS**

THE RECEIVER ABOUT TO BE DESCRIBED IS offered to the home constructor as something different from the usual "Four Plus One" designs that are so often encountered, and it should appeal to those who wish to build an economical receiver with a good performance.

Three all-glass B9A based valves are used in a superhet circuit, and by the use of an internal aerial a very compact receiver can be built.

A feature of the set is the very simple wavechange switching, and this should appeal to those about to build their first superhet.

A point of interest to the beginner is that it has been found possible to build this receiver and to obtain good results without the use of a signal generator.

Another feature of the set is the form of construction which allows easy mounting of resistors and condensers without being hampered by chassis ends and sides.

Circuit Description

The medium and long waveband aerials L_1 and L_2 are tuned by C_2 and trimmed by C_1 for medium waves and by C_4 for long waves.

Switching is effected by S_1 which is closed for medium waves and open for long waves. V_1 is a Brimar 12AH8 triode hexode operating as a frequency changer. It will be noted that only one oscillator coil is used. This coil is of the medium waveband type and is shunted by a 300pF silver mica condenser and a 100pF trimmer for long waveband operation. At this point it should be mentioned that the value of C_8, 300pF, will only hold good for the make of oscillator coil specified. If another make of oscillator coil is used, a new value for C_8 will have to be found, and this will probably be between 250pF and 500pF.

Switching of the oscillator for long waveband operation is carried out by S_2, which is open for medium waves and closed for long waves. The padding condenser, C_{10}, 470pF is common. Apart from the critical value of C_8 it will be noted that the circuitry in connection with V_1 is quite straightforward and that the waveband switching can be carried out by a simple two-way on-off type of switch. A Mullard ECH81 triode hexode may be used in place of the 12AH8 if desired; slight wiring modifications for this valve are required, and the pin connections are different—see Fig. 1, inset. As the ECH81 has no internal coupling this must be carried out externally by connecting pins 7 and 9 together on the valveholder. The performance is the same with either valve.

V_2 is a Mullard EBF80, which is a double diode r.f. pentode. The pentode section operates as i.f. amplifier in conjunction with IFT_1 and IFT_2, 465 kc/s i.f. transformers. One diode in the valve is used as signal detector and a.v.c. diode, and the other diode is connected to chassis and not used.

V_3 is a Mullard ECL80 triode pentode, the triode section operating as first l.f. amplifier and the pentode section driving the 5in loudspeaker via the output transformer, with tone correction by C_{17}, 0.005μF.

It will be noted that the cathode bypass condenser of V_3 is rather large, but this is desirable in order to avoid any form of instability. V_1 and V_2 have their cathodes joined to chassis, R_1, R_4 and C_{18} forming the bias and a.v.c. network for these valves and the i.f. being filtered by R_6 and C_{19}, C_{20}.

The power supply for the receiver is obtained from a small mains transformer and a contact cooled rectifier. Although the h.t. may be drawn direct from the mains via the rectifier, this method makes the chassis "live" and is inclined to give noisy reception with an internal aerial.

As the power requirements of the receiver are very small, a "pre-amplifier" type of transformer may be used providing its rating is within the requirements of the receiver, which are 6.3V 0.9A for the heaters, and 200V 25mA for the h.t.

It will be seen from the circuit diagram that the anode of the output section of the ECL80 is fed direct from the rectifier. This enables R_{11}, 2.2kΩ smoothing resistor, to be of a much lower wattage rating than would otherwise be required, and in addition it reduces

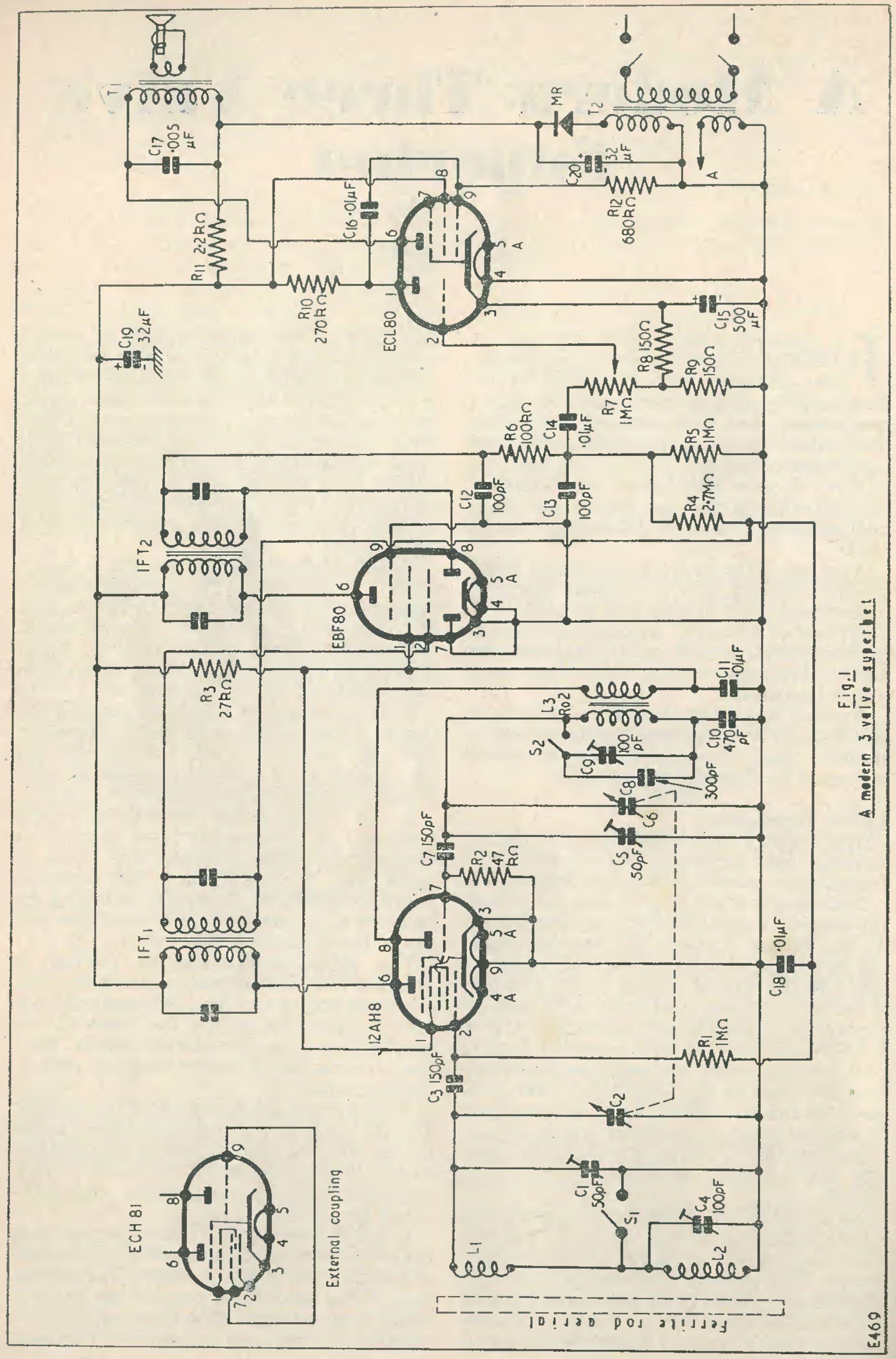


Fig.1 A modern 3 valve superhet

Components Used in Prototype

Resistors

R_1	1MΩ
R_2	47kΩ
R_3	27kΩ
R_4	2.7MΩ
R_5	1MΩ
R_6	100kΩ
R_7	1MΩ pot
R_8	150Ω
R_9	150Ω
R_{10}	270kΩ
R_{11}	2.2kΩ
R_{12}	680kΩ

All ¼-watt except R_3 and R_{11}, which are 1 watt
3 B9A valveholders
1 5in Elac loudspeaker

Condensers

C_1	50pF trimmer
C_2	500pF tuner*
C_3	150pF silver mica
C_4	100pF trimmer
C_5	50pF trimmer
C_6	500pF tuner*
C_7	150pF silver mica
C_8	300pF silver mica
C_9	100pF trimmer
C_{10}	470pF silver mica
C_{11}	0.01µF tubular
C_{12}	100pF silver mica
C_{13}	100pF silver mica
C_{14}	0.01µF tubular
C_{15}	500µF 6VW electrolytic
C_{16}	0.01µF tubular
C_{17}	0.005µF tubular
C_{18}	0.01µF tubular
C_{19}	32µF electrolytic
C_{20}	32µF electrolytic

* Ganged tuners
1 medium and long waveband ferrite rod aerial
1 Repanco RO2 oscillator coil
1 wavechange switch, 2 pole on-off
1 1MΩ (R_7) volume control with switch
1 pair 465 kc/s i.f. transformers
1 contact cooled rectifier 250V 30mA
1 output transformer, mains pentode
1 mains transformer, mains input to 200/250V 25mA and 6.3V 0.9A
Valves, 12AH8 or ECH81, EBF80, ECL80
3 control knobs
1 tuning scale

the heat generated in this part of the circuit and gives no noticeable rise in hum level. A double-pole mains switch is shown in the circuit diagram; this is fitted because it completely isolates the mains when the receiver is switched off.

Construction

The receiver is constructed on an aluminium panel, size 8in wide and 7¼in high with the top 2in bent at right-angles to carry the tuner, wavechange switch and volume control. In the prototype an extra ½in was allowed on each side of the panel and was bent up at right-angles to add strength to the assembly, but this is not important if stout metal such as 16 s.w.g. aluminium is used. It is an advantage to carry out the drilling before bending the metal. After all the metal work has been completed, the components can be mounted. It is best to commence with the controls on the right-angle part of the panel, otherwise some difficulty may be experienced in getting the controls in position—particularly if the i.f. transformers have been mounted. In the prototype some of the resistors and condensers were mounted on miniature tag strips in order to make a neat appearance. If this form of construction is used, some of the bolts supporting other components may be used to hold the tag strips in position, but care should be taken to see that the tags are quite clear of the metal chassis.

The contact cooled rectifier may be of the type with two fixing holes and, if this is the case, every care should be taken to see that the rectifier is bolted flat to the panel with an even pressure on each bolt. This will ensure that the metal surfaces are flat together and that any small amount of heat given off by the rectifier can be conducted away by the metal panel. Although the amount of heat generated will be very small, some precaution should be taken to see that no wax-covered component is mounted close to the panel on the side opposite to the rectifier, as this may cause trouble if the receiver is used for a prolonged period.

Mounting strips for the ferrite rod aerial may be made of Paxolin or other insulating material, and these can conveniently be fixed to the panel by small metal brackets. As an alternative, the ferrite rod aerial may be mounted on metal brackets with rubber grommets inserted in ½in holes to support the rod. This method of mounting will sometimes alter the inductance of the coils on the ferrite rod, but this can be overcome by cutting a small portion of the bracket away so that the ½in hole becomes a slot or U-shaped opening. It should be remembered that the ferrite rod aerial should be kept as far away from the metal panel as possible.

If the rod is too close, poor signal-to-noise ratio will result. It was found that a bracket of about 3in was ideal, as it enabled a good signal pick-up to be obtained, and at the same time did not give too much depth to the size of the receiver.

A round hole must be cut in the panel to allow the magnet of the loudspeaker to pass through. For the Elac speaker specified, a hole of 1¾in diameter is required. The speaker may be mounted in the cabinet and the panel fitted over it, or the speaker may be mounted on the panel itself, so making a complete unit of the set—which assists in alignment and servicing. For mounting the speaker on the panel, a 1¾in vertical mounting electrolytic clip is required. The clip is mounted on the back of the panel directly over the 1¾in diameter hole. The speaker magnet is then passed through the hole. Tightening the clip will secure the speaker. When fixing the assembly in the cabinet, care should be taken to see that the speaker presses firmly against the front of the cabinet, otherwise any baffle effect may be lost.

Alignment

Having completed the wiring, the set should be plugged into the mains and switched on. After having allowed a short period for warming-up, a click can be produced in the speaker by touching pin 2 on V_3 with a screwdriver. This operation should be carried out with the volume control turned to maximum. If the click is heard it can be assumed that the I.f. stages of the receiver are working.

With the volume control still at maximum, the set should be switched to the medium waveband and the tuning condenser slowly rotated until a station is heard. If no signal can be found, a short length of wire may be attached to the input grid of V_1 and the tuning condenser again rotated until a station is heard. It may be found helpful to rotate the receiver when looking for a station, as the ferrite rod aerial is directional.

Having found a station, the cores of the i.f. transformers may now be adjusted for maximum volume. The top core of IFT_1 should be adjusted first, followed by the bottom core; and then the same adjustments should be carried out on the second i.f. transformer. The volume control should be turned down as volume increases.

Tune the receiver to a station near 200 metres. When the station has been identified, adjust trimmer C_5 for correct calibration and trimmer C_1 for maximum signal strength. Tune the receiver to a station near to 500 metres and adjust core of L_3 for correct calibration. For maximum signal strength, slide L_1 along the ferrite rod from the end towards the middle until the station is peaked. Tune the set to the 200-metre end of the band again and adjust C_5 and C_1 once again, repeating these adjustments until no further improvement can be made. Switch receiver to the long waveband and tune to 1,500 metres. Adjust C_9 long waveband trimmer until the Light programme is heard, and adjust C_4 for maximum volume. If C_4 will not peak, i.e. *screwing the trimmer right in does not peak the station*, the long wave coil on the ferrite rod aerial may be moved slightly towards the centre of the rod. Returning to trimmer C_4, it should now be found that this will peak. If maximum volume is found to be when the trimmer is unscrewed, then the long waveband coil should be moved out towards the end of the rod. The trimmer may then be screwed in and a peak point found.

While the alignment adjustments are being carried out, make certain that the coils on the ferrite rod aerial do not move. To ensure this, they should be lightly sealed with wax and then fixed when final alignment is complete. Do not use sealing compounds that set hard, otherwise further adjustment, which may be required at a later date, may become impossible.

When aligning the long waveband, on no account must the core of the oscillator coil be adjusted—as this will upset the alignment of the medium waveband.

Having completed the alignment, tune the receiver to the Light programme on 1,500 metres, rotate the set until the volume is at *minimum* and adjust the volume control until the station can only just be heard. Now very slightly re-adjust the cores of the i.f. transformers for maximum volume. Tune the receiver to 200 metres and check performance, re-adjusting C_1 if required. The receiver should now give a good performance.

It will be noted that no particular tuning scale has been specified for this receiver. The author used a small perspex tuning scale with a direct drive tuning knob.

We have received from Messrs. R. Fagelston of 46 Hardwicke Road, London, N.13, some samples of Tygan speaker aperture fabric. This fabric is extremely attractively styled in various shades, mixtures and texture. It is reversible—each side producing a differing pattern of style and distinction. Tygan is washable and will neither rot, fade, nor crease. Used with a home-constructed receiver, it will add tremendously to the appearance, and impart that professional finish much desired by the hobbyist. Samples of this fabric are available from the above advertiser provided a shilling postal order is included with the request. This is subsequently credited when the selection and order are made.

DESIGN CHARTS FOR CONSTRUCTORS

No. 15 CONTROLLED TREBLE CUT EQUALISER CHART

by HUGH GUY

A PREVIOUS ISSUE (CHART NO. 13) GAVE design details for simple bass and treble cut circuits. The common disadvantage of each of these circuits is that the amount of attenuation so obtained is not controlled. In the case of the treble cut filter the attenuation is continuous, falling almost steadily at 6 db per octave. Whereas this is satisfactory for many tone control circuits, there are several in which only a predetermined degree of attenuation is required; and above this frequency, the response should remain flat, or at least not further attenuated.

A good example of such a requirement is found in the equaliser stage of a tape recorder playback amplifier. Fig. 1 shows a typical tape playback characteristic before equalisation is applied, and it will be noted that the output at low frequencies is very much less than at the frequency f_c (generally termed the cross-over frequency), there being in some cases a difference of 20 dbV between the two frequencies. The function of the playback equaliser is to produce an output which is as flat as possible over this band, and therefore a filter or equalising network must be incorporated having the exact inverse frequency characteristic as is shown dotted in Fig. 1. From 50 c/s to 1.5 kc/s in the figure the required equaliser characteristic is seen to fall at approximately 6 dbV per octave, and at first thought it might appear that the simple treble cut filter previously described would suit the demand. However, beyond the cross-over frequency of 1.5 kc/s the response is required to rise again and, therefore, a slightly modified filter is called for which, even if it does not cause the response to rise as required, must at least flatten out as indicated in the dashed curve of Fig. 1. The rising characteristic can be contributed by a simple resonant filter connected elsewhere in the equaliser circuit.

So much for the principal use of the network which, by virtue of the restricted frequency range over which it is required to attenuate, is termed a controlled treble cut equaliser.

How it Functions

The basic circuit of the arrangement is shown on the design chart together with the formula for the attenuation in terms of the ratio of the shunt and series resistors αR and R, and the frequency f relative to a frequency described earlier as the 3 dbV frequency f_o. (To avoid confusion it should be pointed out that this latter frequency is no longer the 3 dbV frequency for this chart but is quoted as a reference to permit last month's chart to be used to interpret capacitance and resistance values in terms of f_o, thereby making the whole design process purely mechanical.) At low frequencies capacitor C has a high reactance, and very little signal current will flow through the shunt arm comprising αR and C. At low frequencies, therefore (i.e. at low values of f/f_o) practically all the signal applied to the input will appear at the output. As the frequency increases, however, the impedance of the shunt arm reduces and the output voltage is correspondingly reduced. A limit will be reached when condenser C has negligible reactance and is, therefore, to all intents and purposes a short circuit. At and above this frequency, the network is almost purely resistive and the attenuation will be constant. Fig. 2 shows the equivalent networks at very low and very high frequencies. The rate at which the attenuation increases at mid-frequencies is determined by the ratio of the two resistances and the product CR, and the chart shows the responses of six different filter arrangements in which the ratio of the shunt to series resistance varies from 0.1 to 2. In the case where the shunt resistance takes the form of a variable resistance, as it often does in continuously variable tone controls, then α may very well cover all these values in providing a smooth control of attenuation.

Design Procedure

Considering in the first instance the case where a fixed control is to be used, the total required attenuation must be known. Assume, for instance, that a typical design calls for an attenuation of approximately 15 dbV. The chart is examined to find the appropriate value of α. In this case the curve for $\alpha=0.2$ shows that a total attenuation of 15.5 dbV is obtained, and for the specified 15 dbV f/f_o is 13.5.

Next the frequency band over which this attenuation is required must be specified.

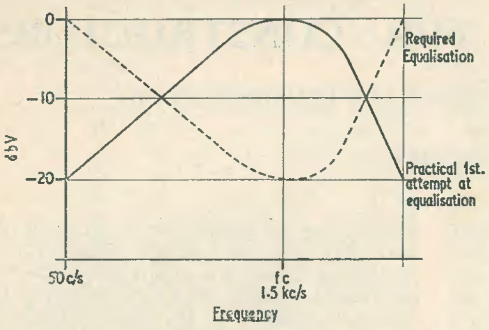
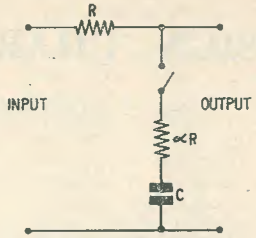
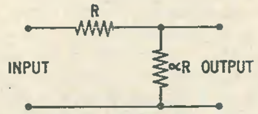


FIG. 1. TAPE EQUALISATION CHARACTERISTICS



(a) NETWORK AT LOW FREQUENCIES



(b) NETWORK AT HIGH FREQUENCIES

FIG. 2. LOW AND HIGH FREQUENCY EQUIVALENT CIRCUITS OF FILTER

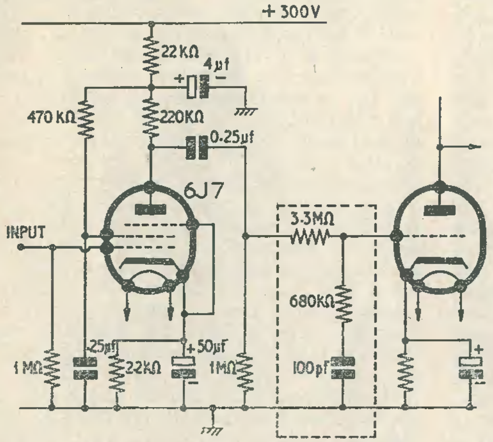


FIG. 3. FILTER (shown in outline) CONNECTED AFTER TYPICAL HIGH GAIN PRE-AMP STAGE

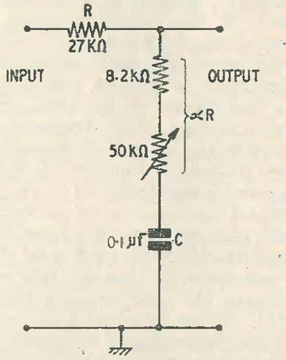


FIG. 4. CIRCUIT ARRANGEMENT FOR VARIABLE FILTER WITH TYPICAL VALVES (see text)

G 438

Let us assume that the amplifier for which we are designing this filter requires its response to be attenuated 15 dbV at 6.5 kc/s.

With f=6.5 kc/s and $f/f_o=13.5$, then clearly $f_o=6.5/13.5$ or 0.482 kc/s.

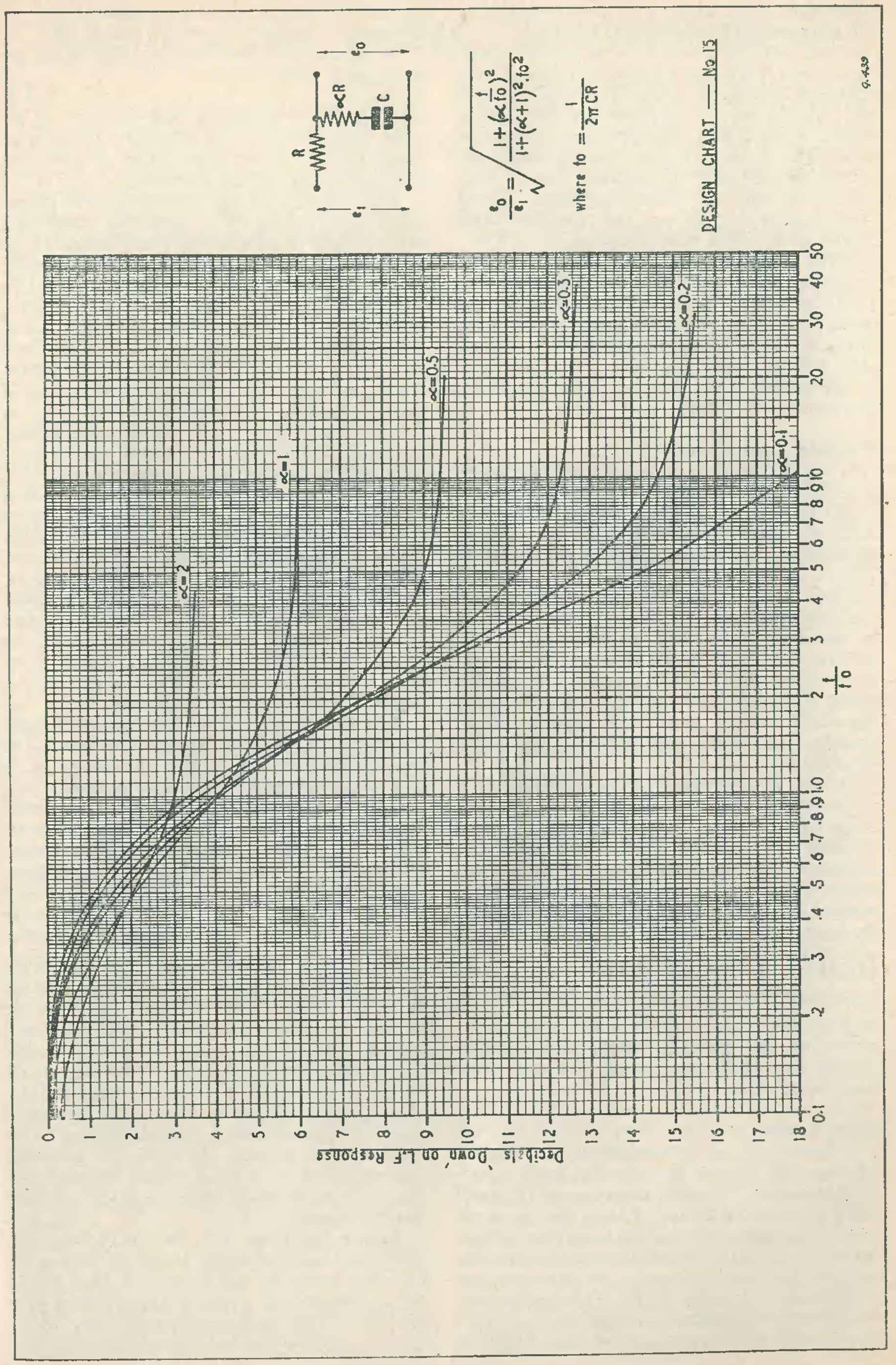
At this point, Chart No. 14 may be used to determine suitable values for C and R at $f_o=0.482$ kc/s.

For new readers the formula relating f_o and the product CR may be used. This is:

$$CR=\frac{1}{2\pi f_o}$$

and in this instance, CR will be 330 where C is in pF and R is in MΩ. Two suitable components giving this product are capacitor C of 100 pF and series resistor R of 3.3 MΩ. Because the curve for $\alpha=0.2$ was used, then the shunt resistor R automatically becomes 0.2×3.3MΩ or 660kΩ. The nearest standard value would be used in practice—in this instance 680kΩ—illustrating a typical design compromise.

Fig. 3 shows a filter using these values and its mode of connection between two stages of a pre-amplifier. Notice that the grid leak (1MΩ) is connected before the filter. If it were connected in its normal place adjacent to the grid of the second stage, that is at the



other end of the filter, then it would modify the attenuation characteristic.

It is as well to note here that under certain conditions it is more desirable to connect the grid leak actually at the grid of the valve it is serving, if only to suppress parasitic oscillations when a grid "stopper" resistance fails to do the trick. In such cases, which are extremely rare, and are usually due to poor circuit layout, the filter resistance values should be kept small, and the capacitor value increased to offset this reduction.

Were such a procedure necessary in the design example just considered, then the 1MΩ grid leak would be connected at the other end of the filter and the series and shunt filter resistors would be reduced to 330kΩ and 68kΩ respectively (i.e. reduced by a factor of ten) and the capacitor would be increased to 1,000pF.

Variable Tone Control

A slight variation on this design procedure is called for if a continuously variable treble cut is required. In this arrangement αR is made a variable resistance with a small fixed resistance in series with it, and is illustrated in Fig. 4.

This time, for the design to be carried out, the maximum and minimum treble cut must be specified at the required frequency. This in turn will result in two values of α, but still only one value of f/f_0 and hence f_0. From this latter value suitable values are determined for the series resistor R and the capacitor C in exactly the same manner as previously described.

Having determined R, the two values of α are now used to solve two values for αR. Of these two values the greater will be the total resistance in the shunt arm due to the variable resistance with the small fixed resistance in series, while the lesser value is due to the fixed resistor alone, since at this attenuation the variable control will be reduced to a minimum.

To make the procedure crystal clear an example is given below.

Example for Variable Treble Cut

A tone control is required to give a variation of treble cut from 4 dbV to approximately 12 dbV at 1.2 kc/s.

The first part of the procedure is to assess what two values of α give the respective attenuations when the "cut" has flattened out. In this example a total attenuation of 4 dbV is approached by the curve for $\alpha=2$, and at the other limit, the curve for $\alpha=0.3$ gives a little more than 12 dbV when the attenuation is constant. This state of affairs is obtained when f/f_0 is about 20. The specification states that f is to be 1.2 kc/s, and therefore f_0 must be 60 c/s. If R is made 27kΩ and C is 0.1μF, then f_0 becomes 59 c/s, which is a close enough approximation. Now the greater attenuation is obtained when the variable control is at zero, when $\alpha=0.3$, and this enables us to determine that the fixed resistor in the shunt arm must be 0.3×27kΩ, which yields 8.2kΩ to the nearest standard value. When $\alpha=2$, the total shunt arm must be 2×27kΩ or 54kΩ. But the fixed resistor already contributes 8.2kΩ towards this, and so the variable control should ideally be 54kΩ minus 8.2kΩ, or 45.8kΩ. Since, however, the nearest practical value is 50kΩ a slight compromise must be made.

Fig. 4 shows the values that would be used for such a filter, which would be connected in exactly the same way as that shown in Fig. 3. It is of no consequence, of course, which way round the capacitor and resistor in the shunt arm are connected, although from a layout point of view it is frequently more convenient in the case of the variable tone control to have the potentiometer connected to the "earthy" end of the filter.

Radio Miscellany

(*continued from page 827*)

in gay and attractively coloured wrappers to which skilful lighting might add further appeal and brilliance, would become positively irresistible.

Long Service

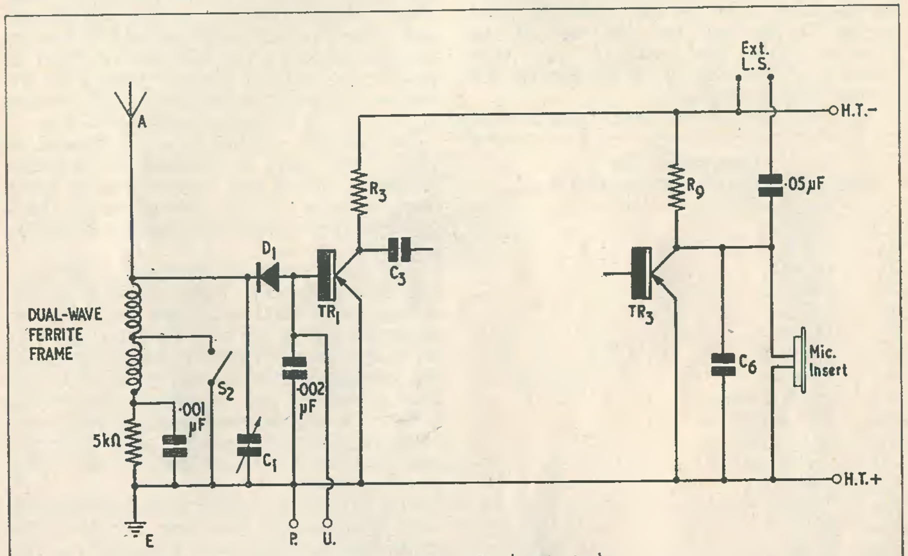
I have had an interesting letter from a 78-year-old Harrow reader who must assuredly be awarded the first place as our "senior" hobbyist, unless I am shaken by an even greater surprise next month. He was before retirement a professional chemist (acids and explosives) and took out an experimental licence in February 1905. His guide was Bottone's "Wireless Telegraphy." Incidentally he still has his first Permit. His first successful coherer was made from a revolver cartridge shell filled with silver filings (illegally shaved from a sixpence). Anyone else thinking of making one these days will have to wait a long time for a silver sixpence to come his way! The de-coherer was made from the hammer of an electric bell. In those days, and right up to the early 'twenties, more or less everything "wireless" had to be made or improvised. His relay, for instance, was actuated by a clock wheel balance and the solid wire aerial was insulated by beer bottle stoppers!

At the outbreak of the 1914 war his apparatus was "interned" for security reasons, just the same as my own and that of all other holders of transmitting licences was in 1939. Two gentlemen from the G.P.O.

(*continued at foot of opposite page*)

Modifications to the "Eavesdropper"

We have received some interesting notes from a young reader concerning the "Eavesdropper" transistor receiver. The reader, 14-year-old M. J. Rogers of Henleaze, Bristol, has modified his receiver to operate on long waves, and has also fitted sockets to enable a pick-up and a larger speaker to be plugged in when desired. Mr. Rogers found that he obtained increased volume by deleting the first transformer T_1, and his modified circuit is reproduced herewith.



The modified circuit (omitting TR_2).

The ferrite aerial used in the modified receiver is an R.E.P. dual-wave model, type FR1. Two new condensers are needed for the altered arrangement, one being a 0.002μF component following the diode, and the other being a 0.05μF component in series with the external speaker circuit. The external speaker must have its own output transformer. Good results are claimed with an 8in speaker.

It should be pointed out that the improvement given by taking the first transformer out of circuit may not be apparent in all models constructed. It is possible that better selectivity from large aerials would be given if these were connected at the *lower* end of the ferrite frame, and not as shown in the circuit.

RADIO MISCELLANY *continued*

very carefully catalogued and collected mine, restoring it to me neatly labelled and intact after the war. It was then so old-fashioned that most of it went straight into either the junk-box because the nuts and bolts might be useful, or the dustbin. Indeed they carefully took into their custody coils and bits and pieces I could easily have replaced in half an hour. I didn't point this out to them but even if I had no doubt I should have been solemnly assured that "Orders is orders."

This veteran, who prefers to remain anonymous, also got his gear back but I should imagine it was even more useless than mine when it was restored to him. By 1919 valves of a sort (and only one "sort" at that) were in more or less general use and so he had to start again with an entirely new technique. Right through the years he has remained faithful to our hobby and his main current interest is in transistors.

Congratulations and best wishes to H.R.N. whose claim to senior veteranship is the best yet, but with a hobby such as ours one never knows and we all might be shaken next month. Marconi's successes in the opening years of the century must have excited the imagination of many youngsters who may well be still with us having followed its fascinating developments ever since.

An AC/DC Amplifier

by N. FOX

The amplifier described has been built over a year or so, using chiefly Government surplus components, and any others which may have been to hand, or easily and cheaply obtainable. The amplifier is fed from a tuning unit, and at the same time is used on the gramophone portion of a radio gramophone. In the present layout, the tuning unit is bolted to the side of the cabinet, the amplifier is in the base, and the loud speaker is mounted on the front of the amplifier chassis by means of two steel strips, but this method of supporting the speaker is only temporary.

No tone control has been incorporated because the members of the household are quite pleased with the reproduction as it is, although there is ample space within the chassis if any maker should desire one.

The chassis is about 14in long, 8in wide and 3in deep. The general layout does not appear to be critical, because during the experimental period the various components and valves have been considerably moved about without ill-effect; so that the chassis now looks like a Meccano set rather than an amplifier chassis. The final aim has been to position the items so that any part of the set can be worked upon with ease, and without any danger of damaging any other section.

The variable resistor, R_{18}, has a value of 10kΩ, and gives a measure of negative feedback; but if any builder has to hand fixed resistors of 5 or 10kΩ, one of these could be tried before purchasing a potentiometer.

The components are mounted as follows: output transformer, metal rectifier, mains dropper, one electrolytic, and the Brimistor surge resistor on top of the chassis; the two inputs, mains and from the tuning unit, and the resistors R_1 and R_{18} on the front of the chassis, and all the remaining components below. During the construction it was found better to remove the rectifier, mains dropper, and electrolytic until the bulk of the wiring was completed.

The bulk of the resistors and condensers were mounted on two tag panels. The mounting was done before placing the tag boards in position, and wires cut to the correct lengths were soldered on beforehand for connecting to the valveholders.

Voltages

The readings given were taken by a home-made meter constructed from a kit.

	Anode	*Screen*	*Cathode*	*Junction*
V_1	110	45	1.5	
V_2	120	0	35	30
V_3	180	170	15	
V_4	180	170	15	

Voltage drop across smoothing choke and 500 ohm resistor = 35.

Final Notes

At no time have any of the values been found to be really critical, and an EF39 and an EF36 have, during the trials, been substituted for the 6J7, although I think this valve with the given circuit is rather better.

In operation the amplifier has been found to be free from hum, and when switched on, if no station is tuned in, the dial lights are the only indication that the set is working.

Component List

Where not otherwise stated are ½ watt.

R_1	1MΩ pot
R_2	330kΩ
R_3	10kΩ
R_4	100kΩ
R_5	1,000Ω
R_6	100Ω
R_7	1MΩ
R_8	22kΩ 1 watt
R_9	1,000Ω
R_{10}	22kΩ 1 watt
R_{11}	5kΩ 1 watt
R_{12}	5kΩ 1 watt
R_{13}	1,000Ω pot
R_{14}	220kΩ
R_{15}	220kΩ
R_{16}	30Ω
R_{17}	30Ω
R_{18}	10kΩ pot
R_{19}	330Ω
R_{20}	500Ω 10 watts
R_{21}	Mains dropper for 0.3A
R_{22}	Brimistor CZ1
Valves	V_1 6J7, V_2 6C5, V_3 and $_4$ 43
C_1	0.1μF 350 volts
C_2	0.5μF 350 volts
C_3	0.1μF 350 volts
C_4	0.1μF 350 volts
C_5	25μF 25 volts
C_6	8μF 350 volts
C_7	16μF 350 volts
C_8	16μF 350 volts
C_9	8μF 350 volts
C_{10}	0.1μF 750 volts
C_{11}	0.1μF 750 volts

Metal rectifier DRM2B
1 smoothing choke, 10H
1 push-pull O/P transformer for 3 ohms speaker
2 I.O valveholders
2 six-pin valveholders
Chassis, about 14in × 8in × 2½ or 3in
Screws, wire, sleeving, tag boards, etc.

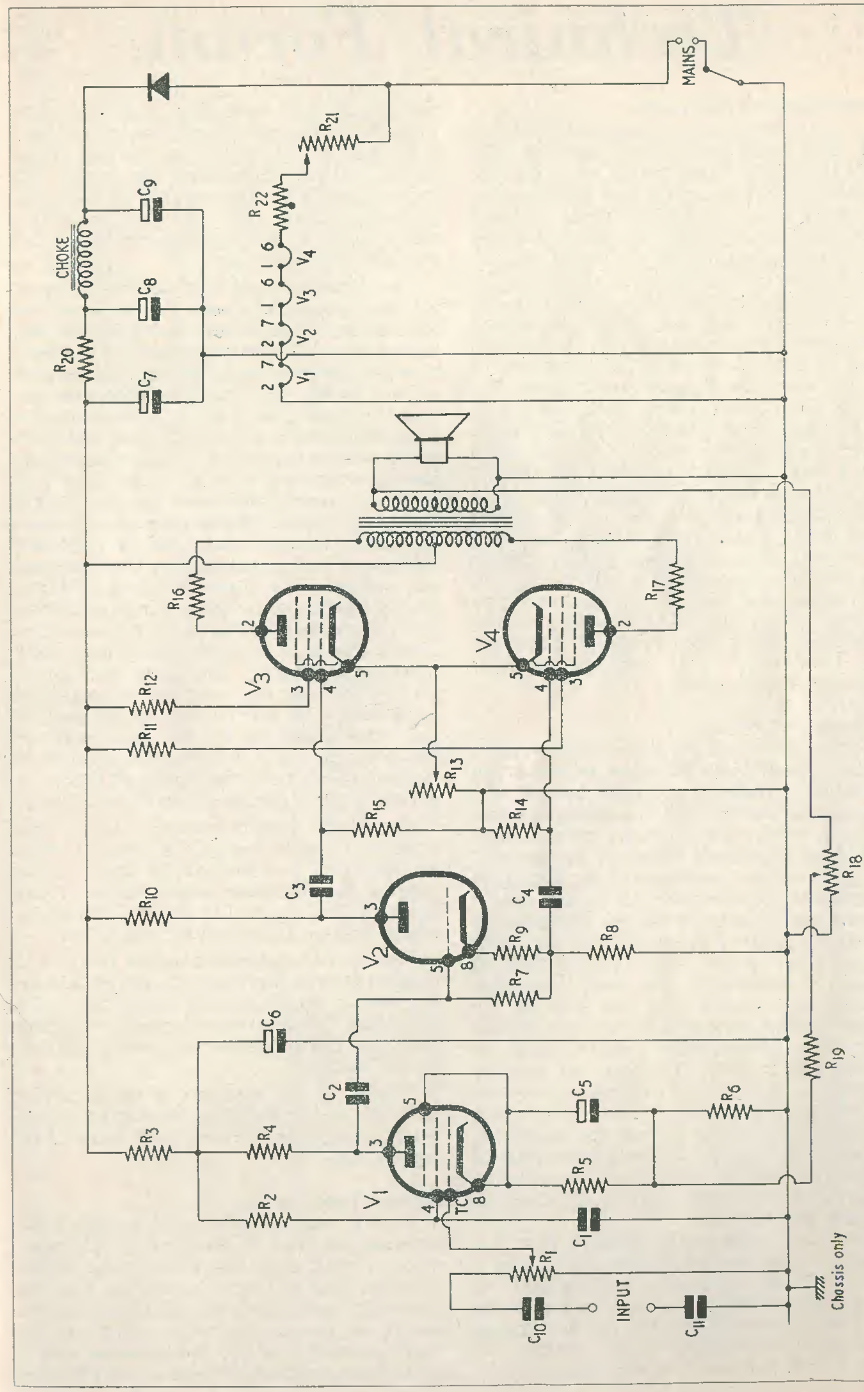


FIG. 1. AN A.C./D.C. AMPLIFIER.

Technical Forum

Receiver Safety Precautions

A NEW ISSUE OF THE BRITISH STANDARDS Institution publication dealing with the safety requirements of radio and other electronic apparatus has prompted us to prepare this short article for the guidance of constructors. Whilst the publication has been prepared mainly for the use of receiver manufacturers, there is much of interest to the home constructor whose receivers are used by members of his family, and where safety precautions are equally important. News of fatal accidents in the home due to electrocution are happily quite rare—but they *do* occur, and in many cases a little forethought may have prevented the occurrence entirely. Also, any reader who has been near a large television picture tube when it has imploded will be left in no doubt as to the need for protecting the viewer against flying glass. Fortunately, cathode ray tubes are so well made these days that the chance of an implosion occurring is very small; but, nevertheless, the need for taking safety precautions is very real. The following recommendations taken from the B.S.I. Specification (No. 415, 1957) are of particular interest to the constructor.

Prevention of Shock

Under this heading the specification deals in some detail with the degree of protection a receiver cabinet must offer against the prying fingers of children in ventilating holes. Suffice it to say that any holes in the cabinet should be sufficiently small to prevent any live parts within the cabinet being accessible from without. However, there are certain precautions which may be less obvious and are thus worthy of mention here; they refer in particular to the "live" chassis type of receiver in which there is a direct connection between the chassis and one side of the mains. Usually the spindles of the control knobs are in electrical contact with the chassis and it may, therefore, be possible for the operator's fingers to come into contact with the grub screws used to retain the knobs in position. If these screws are accessible, they should be covered after being tightened in position with a good quality insulating material. Chattertons Compound or wax is suitable for this job.

In many receivers the speaker frets are covered by an expanded metal mesh, and it is possible for the chassis of the speaker to be in contact with this mesh, perhaps via the fixing screws. Now the speaker chassis is usually connected to the set chassis; but even if it is not, one cannot always rely on the speech coil insulation, and it is thus possible for the metal mesh to become live—a dangerous state of affairs, and one which to the writer's knowledge has caused one serious accident. The speaker chassis must be well insulated from the mesh, usually a simple thing to arrange but one which can so easily be overlooked.

The aerial terminal of a receiver is usually readily accessible from the rear of the cabinet and should not, therefore, be connected either directly or indirectly to a "live" chassis. An isolating capacitor shunted by a resistor is normally employed for this purpose as shown in Fig. 1. The capacitor must be capable of withstanding the peak mains voltage indefinitely. Mica components having a working voltage rating of at least 750V d.c. are recommended for use in aerial and earth circuits. Remember that a capacitor rated for a certain d.c. voltage will seldom, if ever, withstand a similar peak a.c. voltage. The resistors shown in Fig. 1 are for the purpose of preventing any electrostatic charge building up on the aerial circuits. Such a charge, if allowed to exist, may intermittently leak away and cause interference on the receiver, and may even damage the capacitors. An alternative leakage path to the aerial occurs via the two coils shown in the diagram, and it is recommended that the insulation of the coupling coil must be adequate to withstand a 1,500V test voltage.

Should the cabinet have any large metal areas or be made entirely of metal, it must be connected to earth via the third (green) wire of the three-core mains cable. Apart from this, it is normal to employ a twin core mains lead on radio and television sets.

The use of headphones with a live chassis receiver is only permissible if the phones are fed from a double-wound transformer. The secondary winding must be very well insulated and not connected to earth or any part of the receiver.

Finally, in this section it is recommended that all mains switches should be of the double-pole type to break both leads of the supply line.

Picture Tube Safety

As the size of television picture tubes increases, so does the danger from an implosion. Flying glass can cause quite serious damage, and a special series of tests are normally conducted by receiver manufacturers to ensure that their products can withstand the effects of an implosion without glass being projected at high velocity through holes in the cabinet, or through a shattered safety screen. The B.S.I. test calls for a series of twelve tubes to be imploded, and requires that in no case should any fragment of the safety screen in front of the tubes be projected more than 1 ft in front of the cabinet. Obviously no home constructor could think of conducting such an expensive test, and he is, therefore, likely to ask for details of the type of implosion guard which is to be recommended. Unfortunately, there is no definite answer to this question, as much depends upon the method by which the guard is mounted and the degree of ventilation in the cabinet. In general, the greater area over which the guard is supported and the greater the cabinet ventilation the better. However, from tests which have been conducted to date, it is possible to give some indication of the type of guard which should be safe. For 21-inch all-glass tubes, a guard of ⅜-inch thick armour plate glass should suffice; whilst for 17-inch tubes ¼-inch armour plate glass or ¼-inch perspex may be used. There are many different types and grades of glass, and it should not be assumed that any receiver which does not appear to comply with these recommendations is dangerous, as it will most likely have been thoroughly tested and found satisfactory by the manufacturer.

X-Radiation

On this subject the specification gives maximum dosage rates, which are in general very much in excess of the radiation which is given off by the average television set; as a matter of interest, this is often much less than that from a luminous watch. To take a practicable view of the position, it may be assumed that no radiation is present with tubes working below 16kV, and between 16 and 18kV the soft X-rays present will be absorbed by the safety screen and sides of the cabinet.

The only other source of radiation in a television set is the e.h.t. rectifier which, under a fault condition, can produce X-rays well in excess of the maximum dosage rate. This condition occurs when the heater circuit is open but the full e.h.t. voltage is applied to the valve. As it is most unlikely that the receiver will be worked in this condition for any length of time, this possibility is included largely as a matter of interest.

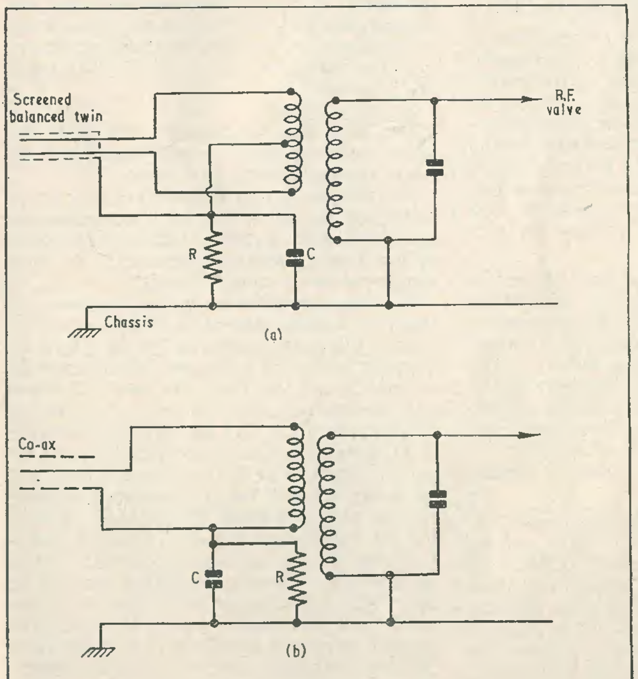


Fig. 1
Showing methods of isolating the aerial circuit of a T.V. set. Typical values are R = 0·5MΩ, C = 0·001–0·01μF mica capacitor.

E470

THE TELEVISION SOCIETY

Speaking at the 28th Annual General Meeting of the Television Society, held at 164 Shaftesbury Avenue, London, W.C.2, on Friday, 10th May, 1957, the Chairman of Council, Mr. D. C. Birkinshaw, M.B.E., M.A., M.I.E.E., said that the Society's transmitter was now in regular operation at Norwood Technical College. Transmissions were taking place on Mondays, Wednesdays and Fridays from 7–9 p.m. with Test Card C and a tone.

In addition to offering a service to the radio industry for testing Band IV reception, the Society hoped that the transmission would serve as a means of training students at the College and that in future it might be possible to televise some of the lectures given there.

TWO STEPS TO INFINITY

by **A. S. CARPENTER**

THE METHOD OF ADAPTING METERS TO SUIT various voltage, current, and series-ohms requirements is generally well-known and consists merely of switching the necessary series or shunt resistors.

While a complete circuit of a two-range d.c. voltmeter plus two-range ohmmeter will be given, the main object of this article is to show how the shunt resistance measurements can be incorporated. Relating various scale readings to ohms is not easy when the resistor under test is connected shunt fashion; indeed, the whole business can be most perplexing; however, like most problems it is surmountable. While the normal series method might permit a resistance range of say 500Ω–2MΩ, a shunt range added would allow further measurements of from 3Ω–2,000Ω. As no additional components are required to incorporate this range, the asset is obvious.

Neither a detailed, nor a comprehensive explanation of ohmmeter design will be given, and mathematics will be kept at minimum. A certain amount of the latter are, however, inevitable—indeed essential—as meter movements are so many and so varied that for the reader who wishes to adapt a meter of his own it is essential for him to understand how the various calculations are made; he can then compute the figures for his own particular movement.

The more common method of series-resistance measurement is readily understood. With the test terminals shorted, a meter is made to read full-scale by means of a battery in conjunction with a limiting resistor. The resistor to be tested is then placed across the test terminals, viz., in series with the circuit, and the meter pointer drops back from f.s.d. If the scale is calibrated in ohms (f.s.d. = zero ohms) the unknown value is readily measured.

Consider Fig. 1. The limiting resistor R, (made variable in order that "zero" can be set from time to time) is adjusted so that "M" the meter, reads f.s.d. when the test terminals are shorted; infinity is indicated when they are open-circuit. An unknown value resistor placed across the terminals causes the pointer to drop back as already mentioned. Now, if the test terminals are shorted and a resistor of, say, 500Ω, is connected *across* the meter, viz., from point A to B, Fig. 1, the pointer will again drop back—the meter is "shunted," and by this shunt method we can obtain a completely different range of resistance measurements.

Why the pointer moves back is not difficult to understand. The meter movement has a certain amount of resistance (100Ω is often the case in 0–1mA movements) and the resistor connected externally at points A and B acts in parallel with the meter resistance. When two resistors are connected in parallel, the current passing through the circuit is shared between them, that resistor having the higher value passing the lower current. Zero resistance across the meter—a short circuit—causes the pointer obviously to return to zero while f.s.d. (nothing across A and B) indicates infinity. The pointer thus reads in the opposite direction to the series-resistance measurement circuit. Another result of shunting the meter movement is that the resistance in circuit becomes less, and the current passing greater, since two resistances in parallel have an effective resistance lower than that of either one by itself. But more of this later.

So far, so good.

But how can we calibrate the scale for shunt measurements? And how can we relate the scale readings to ohms?

For this we must at all times keep the meter resistance in mind. In the series-resistance case we largely ignore it, letting it add itself to the limiting resistor resistance; for shunt requirements we cannot do this.

To illustrate the necessary calculations, the study of a particular meter is now essential, and for this purpose refer to Fig. 2. The scale depicted is that of a Weston instrument with a scale length of 2½in, five main divisions and twenty-five sub-divisions. A current of 500μA gives f.s.d. and the internal resistance is 90 ohms. Used as a d.c. voltmeter readings can be obtained at 2,000 ohms per volt, and by using a 9-volt battery resistance readings can be obtained from 500Ω–2MΩ. Except for the battery and the series limiting potentiometer we are not concerned with this at the moment. However, we will connect it up as in Fig. 1 and adjust R so that the meter reads f.s.d. with the terminals shorted. The current flowing is now 500μA and the value of R (assuming the battery to have no internal resistance) is $R = \frac{E}{I} = \frac{9\times10^6}{500} = 18{,}000\Omega$, less 90Ω, the resistance of the movement = 17,910Ω.

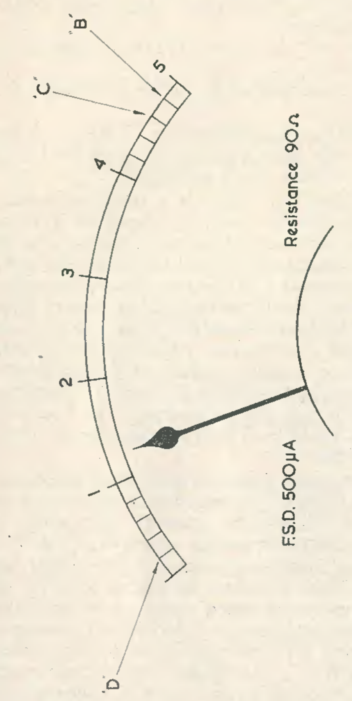


FIG. 2

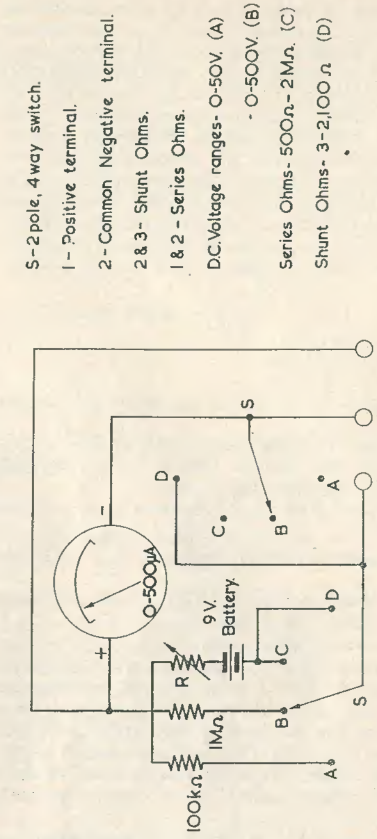


FIG.4

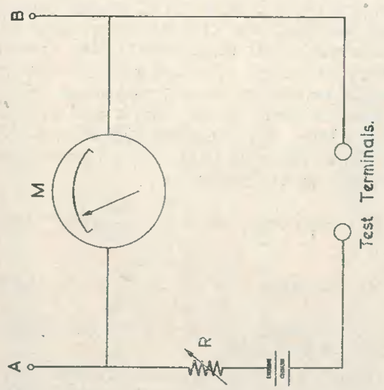


FIG.1.

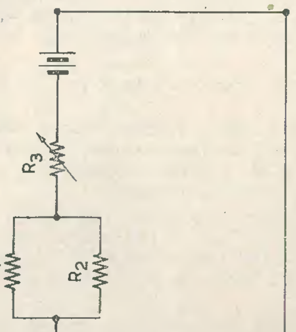


FIG.3.

As mentioned earlier, the current flow will increase as external resistors are connected across points A and B, and if we now connect such a resistor the circuit will become as in Fig. 3, where R_1 is the meter resistance, R_2 the unknown external shunt resistor and R_3 the 17,910Ω limiting potentiometer. The value of R_1 will remain unchanged, and by gradually reducing the value of R_2 we proportionately increase the current flow in the circuit until R_2 becomes 0 ohms, when R_1 will be short-circuited. At this point the current flow is at maximum as only R_3 remains in circuit, and the value of this current will be:

$$I = \frac{E}{R} = \frac{9}{17{,}910} = 502.51\mu\text{A}$$

a rise of 2.51μA.

From $\frac{2.51}{5} = 0.502$, we obtain the current increase for each major scale division, thus "5" on the scale = 500μA, "4" = 500.502, "3" = 501.004, and so on.

Each of the twenty-five minor scale divisions represents a current change of $\frac{2.51}{25} = 0.1004$ μA, thus division B, Fig. 2, will represent 500.1004μA; and so on.

Now that we know the total circuit current at each point on the scale it is a simple matter to calculate what each one will represent in external shunt ohms. For instance: what will be the value of a resistance connected across the meter if the indicator points to "3" on the scale? In other words, what value of shunt resistor does "3" on the meter scale indicate?

As the f.s.d. is 500μA (corresponding to "5" on the scale), "3" is equivalent to 300μA. From earlier calculations we see that at this point on the scale the total circuit current is 501.004μA, therefore 300 of these will be flowing through the meter and 201.004 through the shunt. From $R = \frac{I_m}{I_s} \times 90$ we obtain the shunt resistor value, namely, 134.32Ω, where I_m = current through the meter and I_s = current through the shunt, and 90, the meter resistance.

From a similar calculation we discover that at division "B," Fig. 2, the external resistance would be 2,149Ω and at point "D" 3.5Ω. We thus have a useful range to add to the series range.

Using the same battery enables us to measure from 500Ω to 2MΩ series-fashion, therefore in two steps we can read from 3Ω to 2MΩ!

The series range is easily worked out as follows. Referring to Fig. 1 and assuming that when the terminals are shorted, the meter reads 500μA (f.s.d.) in conjunction with a 9-volt battery, the circuit resistance equals 18,000Ω. Each scale division is calculated as in the following example. If an unknown resistor across the terminals brings the pointer to point "3" on the scale, what resistance will this represent?

Point "3" indicates 300μA, therefore, as $R = \frac{E}{I}$, R will equal $\frac{9}{300} \times 10^6 = 30{,}000\Omega$, less 18,000Ω circuit resistance = 12,000Ω. (Note that at this same point on the scale we obtain 134.32Ω when shunt reading!)

Marking out scales is a difficult business and one to be avoided, therefore a better method is to draw up two charts, one for shunt measurements and the other for series measurements. While the calculations given are shown to three decimal places in some cases, this is not essential in practice as in any case the decreasing battery voltage and increasing battery resistance causes errors. For accuracy a bridge is essential; nevertheless, it is not always necessary to know the precise value, and here the ohmmeter proves invaluable.

In any case, a certain amount of inaccuracy results in the foregoing shunt calculations due to the maximum current quotation of 502.51μA, given earlier where R_1 (Fig. 3) is assumed to be short circuited. In actual fact, this current value will be nearer 502.5125μA, but in order to avoid unnecessary complication two decimal places have been considered sufficient. Those who wish to calculate a range for a particular meter movement should take the figures given as a means to an end and not an end in themselves.

By including a switch, the meter can also be made to read volts as mentioned in the first part of this article, and a complete circuit is given in Fig. 4. A.C. ranges have not been included, the circuit dealing only with d.c. volts, 0–50 and 0–500, plus the two resistance ranges. Current requirements can usually be met by measuring voltage drop at a suitable place in the circuit and applying Ohm's law. The resistors 100kΩ and 1MΩ should be accurate to ± 1%. Their value is worked out as follows:

$$\text{500 volt range:} \quad R = \frac{E}{I} = \frac{500}{500} \times 10^6 = 1\text{M}\Omega$$

$$\text{50 volt range:} \quad R = \frac{E}{I} = \frac{50}{500} \times 10^6 = 100\text{k}\Omega$$

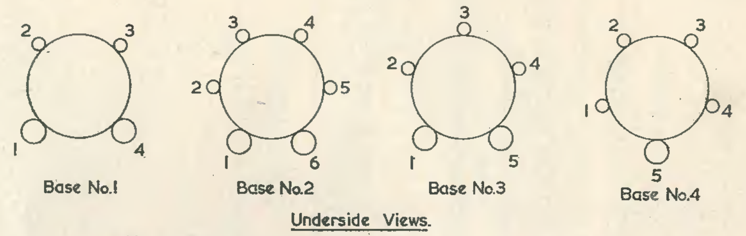
Other ranges, say 0–5 volts, are likewise obtained if desired.

(*Note*: To avoid accidentally overloading the meter, R, the limiting potentiometer, should be made up of a 500Ω variable control in series with a fixed resistor.)

VIBRATOR BASING DATA

PART 1

Compiled by E. G. BULLEY



KEY

P_1 – Primary Contact.

P_2 – Primary Contact (May be connected internally to Magnet Coil instead of P_1.)

R – Vibrating Reed.

S_1 – Secondary Contact (Closes when P_1 closes.)

S_2 – Secondary Contact (Closes when P_2 closes.)

A – Live connection into Vibrator.

R_S – Secondary Reed in Dual Reed Vibrators.

R_P – Primary Reed in Dual Reed Vibrators.

M439

Type	*Base*	1	2	3	4	5	6	7	*Remarks*
3223	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
325	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
T4S	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
8511	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
PJ4	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
298	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
442	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
NP6	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
3226	2	P1	Blank	Blank	Blank	R	P2	—	6 pin UX base
3260	1	R	P1	P2	Blank	—	—	—	4 pin UX base
340	1	R	P1	P2	Blank	—	—	—	4 pin UX base
T3SP	1	R	P1	P2	Blank	—	—	—	4 pin UX base
8523	1	R	P1	P2	Blank	—	—	—	4 pin UX base
1703	1	R	P1	P2	Blank	—	—	—	4 pin UX base
859	1	R	P1	P2	Blank	—	—	—	4 pin UX base
405	1	R	P1	P2	Blank	—	—	—	4 pin UX base
404	1	R	P1	P2	Blank	—	—	—	4 pin UX base
NP476	1	R	P1	P2	Blank	—	—	—	4 pin UX base
V5105	1	R	P1	P2	Blank	—	—	—	4 pin UX base
NSB6	1	R	P1	P2	Blank	—	—	—	4 pin UX base
3261	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
T6S	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
8512	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
449	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
NP61	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
V5495	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base

(continued overleaf)

Type	*Base*	1	2	3	4	5	6	7	*Remarks*
NSB6	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
3262	1	R	P1	P2	Blank	—	—	—	4 pin UX base
8524	1	R	P1	P2	Blank	—	—	—	4 pin UX base
2605	1	R	P1	P2	Blank	—	—	—	4 pin UX base
415	1	R	P1	P2	Blank	—	—	—	4 pin UX base
406	1	R	P1	P2	Blank	—	—	—	4 pin UX base
3263	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
8513	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
NP65	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
3264	1	R	P1	P2	Blank	—	—	—	4 pin UX base
324	1	R	P1	P2	Blank	—	—	—	4 pin UX base
T3	1	R	P1	P2	Blank	—	—	—	4 pin UX base
8508	1	R	P1	P2	Blank	—	—	—	4 pin UX base
PJ3	1	R	P1	P2	Blank	—	—	—	4 pin UX base
294	1	R	P1	P2	Blank	—	—	—	4 pin UX base
403	1	R	P1	P2	Blank	—	—	—	4 pin UX base
NP481	1	R	P1	P2	Blank	—	—	—	4 pin UX base
3283	3	S1	P1	R	P2	S2	—	—	5 pin UX base
503	3	S1	P1	R	P2	S2	—	—	5 pin UX base
T55	3	S1	P1	R	P2	S2	—	—	5 pin UX base
8618	3	S1	P1	R	P2	S2	—	—	5 pin UX base
PJ55	3	S1	P1	R	P2	S2	—	—	5 pin UX base
270B	3	S1	P1	R	P2	S2	—	—	5 pin UX base
705	3	S1	P1	R	P2	S2	—	—	5 pin UX base
SP50	3	S1	P1	R	P2	S2	—	—	5 pin UX base
3320	1	R	P1	P2	A	—	—	—	4 pin UX base
324C	1	R	P1	P2	A	—	—	—	4 pin UX base
T1	1	R	P1	P2	A	—	—	—	4 pin UX base
8522	1	R	P1	P2	A	—	—	—	4 pin UX base
PJ1	1	R	P1	P2	A	—	—	—	4 pin UX base
507P	1	R	P1	P2	A	—	—	—	4 pin UX base
407	1	R	P1	P2	A	—	—	—	4 pin UX base
NP41	1	R	P1	P2	A	—	—	—	4 pin UX base
3356	2	Blank	P1	Blank	Blank	P2	R	—	6 pin UX base
T14S	2	Blank	P1	Blank	Blank	P2	R	—	6 pin UX base
3417	1	R	P1	P2	R	—	—	—	4 pin UX base
8504	1	R	P1	P2	R	—	—	—	4 pin UX base
J22	1	R	P1	P2	R	—	—	—	4 pin UX base

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10 x 4 x 2½	6/4	12 x 5 x 3	7/11	12 x 9 x 2½	8/11	17 x 10 x 2½	11/3
9 x 7 x 2	6/6	12 x 7 x 2½	8/–	14 x 7 x 3	9/6	17 x 9 x 3	11/6
12 x 4 x 2½	6/10	11 x 8 x 2½	8/3	13 x 10 x 2½	9/9	17 x 10 x 3	12/3

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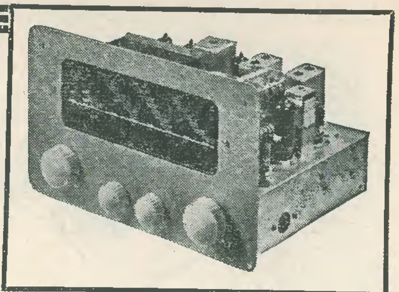

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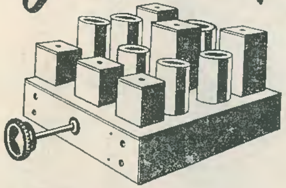

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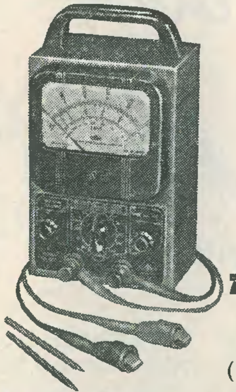

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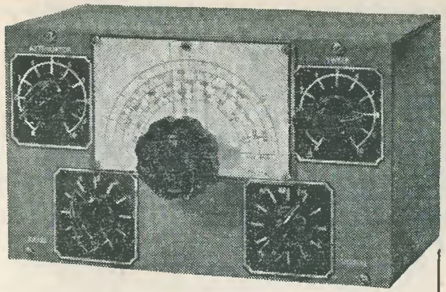

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JUNCTION TYPE P-N-P
(British Manufacture)

RED-SPOT 800 kc/s Audio Frequency ...	**10/–**
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WHITE-SPOT 2.5 Mc/s R.F. and I.F. Amp.	**20/–**

All Transistors are Tested and Guaranteed

N.B.—The Red-Spot is similar to Mullard OC71

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Push-pull Portable Superhet

Can be built for £11/10/-

This Portable 8 Transistor Superhet is tunable for both Medium and Long Waves and is comparable in performance to any equivalent Commercial Transistor Set. Simplified construction enables this set to be built easily and quickly into an attractive lightweight cabinet supplied.

TEN STAR FEATURES

- ★ 8 specially selected Transistors
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- ★ Medium and Long Waves
- ★ Internal Ferrite Rod Aerial
- ★ 7″ x 4″ elliptical High Resistance Speaker
- ★ Drilled plastic Chassis 8½″ x 2½″
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- ★ Economical. Powered by 7½V battery
- ★ Highly sensitive
- ★ Attractive lightweight contemporary case

We can supply all these items including cabinet for **£11.10.0**
All parts sold separately

Send for circuit diagrams, assembly data, illustrations and instructions, and full shopping list **1/6**

N.B.—Pair of OC72's supplied at additional cost of **40/–**
Call and hear demonstration model

"EAVESDROPPER"

THREE-TRANSISTOR POCKET RADIO

(No Aerial or Earth required)

Pre-selected to receive the Light and Home stations. Total cost, as specified including Transistors, Transformers, Coils, Condensers and Battery, etc., with circuit and plastic case.

All items sold separately **77/6** POST FREE
With single 'phone **82/6.** With Amos Mike, **90/–**
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THE TELETRON 'COMPANION'

THREE-TRANSISTOR POCKET RECEIVER

Medium and Long Waves No Aerial or Earth

Tuned R.F. Circuit. Ardente transformers. 3 transistors. Drilled plastic chassis and cabinet size 4½″ x 3″ x 1″, and all components. Balanced armature output.

Total cost **89/6**

ALL PARTS SOLD SEPARATELY

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Build this Push-Pull Amplifier which is ideal for Crystal or Magnetic Pick-up Amplification, Baby Alarm, Microphone Amplifier, etc. Powered by 6-volt Dry Battery lasting for months. **Complete Kit of Parts including 4 Transistors and all Components with Circuit (less Speaker), £4.10.0.**

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Comprising the well-known BC625 and BC624A Uni s. The complete unit is in very good condition having very useful parts, including relays, transformers, condensers, etc. Less valves **45/–** (carr. 5/–).

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DK92	**9/–**	EF80	**9/–**	PL82	**10/–**	6AM6	**9/–**
DAF96	**10/–**	EF85	**10/–**	PL83	**12/6**	6AQ5	**10/–**
DF96	**10/–**	EF86	**12/6**	PY81	**10/–**	6AU6	**8/6**
DK96	**10/–**	EF89	**10/–**	PY82	**10/–**	6BA6	**8/6**
DL96	**10/–**	EF92	**9/–**	PY83	**12/6**	6BE6	**10/–**
DM70	**9/–**	EL41	**10/–**	U25	**14/–**	6BW6	**10/–**
EABC80	**10/–**	EL42	**10/–**	UABC80	**11/–**	6C4	**6/6**
EAF42	**12/–**	EL84	**11/–**	UAF42	**11/–**	6U4	**12/6**
EBF80	**11/–**	EM34	**10/–**	UBC41	**10/–**	6X4	**7/6**
EBF89	**11/–**	EM80	**10/–**	UBF89	**11/–**	7C6	**10/–**
EBC41	**10/–**	EM81	**11/–**	UCC85	**11/–**	7Y4	**9/–**
ECF80	**14/–**	EM85	**11/–**	UCL82	**15/–**	12AH8	**12/6**
ECF82	**12/6**	EY51	**10/–**	UCH42	**12/6**	12AT6	**8/–**
ECC40	**14/–**	EY86	**12/6**	UCH81	**12/6**	12AT7	**9/–**
ECC81	**9/–**	EY91	**10/–**	UF41	**10/–**	12AU6	**9/–**
ECC82	**9/–**	EZ40	**8/–**	UF80	**12/–**	12AU7	**9/–**
ECC83	**9/–**	EZ80	**10/–**	UF85	**12/–**	12AX7	**9/–**
ECC84	**11/6**	EZ81	**10/–**	UF89	**11/–**	12BA6	**9/–**
ECC85	**10/–**	PABC80	**15/–**	UL41	**10/–**	12BE6	**10/–**
ECH42	**11/–**	N78	**12/6**	UL84	**11/–**	14S7	**14/–**
ECH81	**11/–**	PCF80	**12/6**	UY41	**9/–**	19AQ5	**11/–**
ECL80	**10/6**	PCC84	**11/–**	UY85	**9/6**	20L1	**14/–**
ECL82	**14/–**	PCF82	**11/–**	3A5	**10/–**	35W4	**8/–**
EF40	**12/6**	PCL82	**12/6**	3Q4	**9/–**	50B5	**10/–**
EF41	**10/–**	PCL83	**17/6**	6L18	**12/6**	50C5	**10/–**
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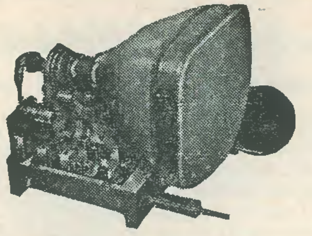

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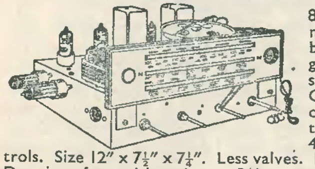

8-valve latest models. 3 w/band and gram switched. Over 10 watts output. Full tone range, 4 knob controls. Size 12" x $7\frac{1}{2}$" x $7\frac{1}{4}$". Less valves. Ins., carr. 5/6. Drawings free with order or 3/6.

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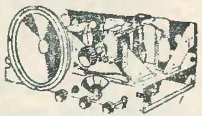

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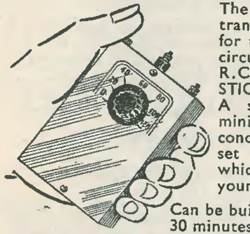

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WANTED complete to designer's specification and in working order, one only ST900, 700 or 600 receiver, also typical 3 or 4-valve set of 1920-30 period.—Box No. E139.

continued on page 863

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2X2	3/6	6SJ7M	7/6	866A	12/6	EY51	11/6
3A4	7/–	6SK7M	6/6	811	45/–	EZ40	8/–
3A5	9/6	6SL7GT	7/6	1616	7/6	EZ80	8/–
3D6	5/–	6SN7GT	6/6	1629	4/–	GZ32	10/6
3Q5GT	9/6	6SQ7M	7/6	DAF96	9/6	HK24G	25/–
3Q4	8/6	6V6GT	7/6	DF96	9/6	EY86	13/6
5R4GY	10/6	6U4GT	12/6	DK96	9/6	KT33C	9/6
5U4G	8/6	6X4	6/6	DL96	9/6	PCC84	10/6
5Y4G	6/6	6X5GT	7/6	DL33	9/6	PCF80	12/6
6AC7M	5/–	7B7	9/–	EA50	1/6	PCF82	11/–
6AG5	3/6	7C5	9/–	EABC80	10/–	PL82	9/6
6AG7M	10/–	7C6	9/–	EAF42	10/6	PL83	11/6
6AK5	5/–	7S7	10/–	EB34	2/6	PCL83	12/6
6AL5	7/–	7Y4	8/6	EB91	7/–	PY80	9/6
6AM6	7/6	12A6M	7/6	EBC33	7/6	PY81	10/–
6AQ5	8/6	12AT6	8/–	EBC41	10/6	PY82	9/6
6AT6	8/–	12AU6	9/–	EBF80	10/–	R19	12/6
6AU6	8/6	12AU7	8/6	EBF89	10/–	SP61	3/–
6B8G	4/6	12AH8	12/6	ECC82	9/6	TT11	4/–
6BA6	8/6	12BE6	8/6	ECC83	9/6	UAF42	10/6
6BE6	7/6	12C8M	7/6	ECC84	11/–	UBC41	10/6
6BR7	11/6	12J7GT	9/6	ECC85	10/6	UBF89	10/6
6C4	5/–	12Q7GT	9/–	ECF80	13/6	UCC85	10/–
6C5M	5/6	12K7GT	9/–	ECF82	11/6	UCH42	10/6
6F6M	6/6	12SC7M	2/6	ECH42	10/6	UF41	10/6
6F8G	4/6	12SK7M	7/6	ECH81	10/–	UF89	10/6
6F13	12/6	12SQ7M	8/6	ECL80	10/–	UL41	10/6
6G6G	4/6	12SR7M	7/6	EF36	4/–	UY41	8/–
6J5GT	5/–	20FZ	10/–	EF37A	8/6	UY85	10/–
6J5M	6/–	35L6GT	9/6	EF39	5/–	UABC80	10/6
6J6	4/–	35Z4GT	8/6	EF41	10/6		
6K7G	5/6	35Z5GT	8/6	EF50	5/6	VR105/30	8/6
6K8G	8/6	42	7/6	EF55	7/6	VR150/30	7/6
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6H6M	3/6	80	8/6	EF85	10/–	VS70	3/–
6L6G	9/6	446A	17/6	EF89	10/–	XP1.5	3/–
6L6M	11/6	801A	10/6	EF91	7/6	Z77	7/6

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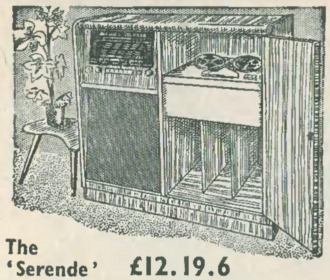

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1T4	7/6	6SL7GT	8/–	DK96	9/–	EL32	7/6
3S4	7/6	6SN7GT	8/6	DL92	7/6	EL41	10/–
3V4	8/6	6SS7	6/6	DL94	8/6	EL84	10/6
5U4G	8/6	6V6G	7/6	DL96	9/–	EL91	7/6
5Y4G	7/–	6V6GT	7/6	EA50	1/6	EY51	11/6
5Z4G	9/6	6X4	7/6	EB91	6/6	EZ35	8/–
6AG5	6/9	6X5GT	7/6	EBC41	9/6	EZ40	8/–
6AM6	8/6	12AT7	9/–	EBC33	8/6	KT33C	7/6
6AL5	6/6	12AU7	9/–	EBF80	10/–	KT66	11/6
6AT6	8/–	12AX7	9/–	ECC81	10/6	PCF82	11/–
6B8	7/6	12K8GT	10/6	ECC84	11/6	PL81	10/6
6B8G	7/6	12K7GT	8/6	ECF82	11/–	PL82	10/6
6BA6	8/6	12Q7GT	8/6	ECH81	10/6	PY81	10/6
6BE6	7/6	35Z4GT	8/6	ECH42	10/–	PCC84	11/6
6BR7	10/6	35L6GT	9/6	ECL80	10/6	U76	8/6
6BW6	8/6	807	6/9	EF36	7/6	UBC41	10/–
6G6G	4/9	5763	10/6	EF37A	14/6	UCH42	10/–
6J5G	5/6	DAF91	7/6	EF39	5/6	UF41	10/–
6J5GT	6/6	DAF96	9/–	EF41	10/–	UL41	10/–
6K7G	5/6	DF91	7/6	EF80	9/6	UY41	8/–
6K8G	9/6	DF96	9/–	EF85	10/6	W76	8/6
6L6G	9/6	DH76	8/6	EF91	8/6	X65	10/6

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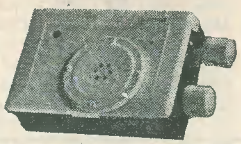

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