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Transistor Eight Portable Superhet

VOLUME 11
NUMBER 1
AUGUST
1957

The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS

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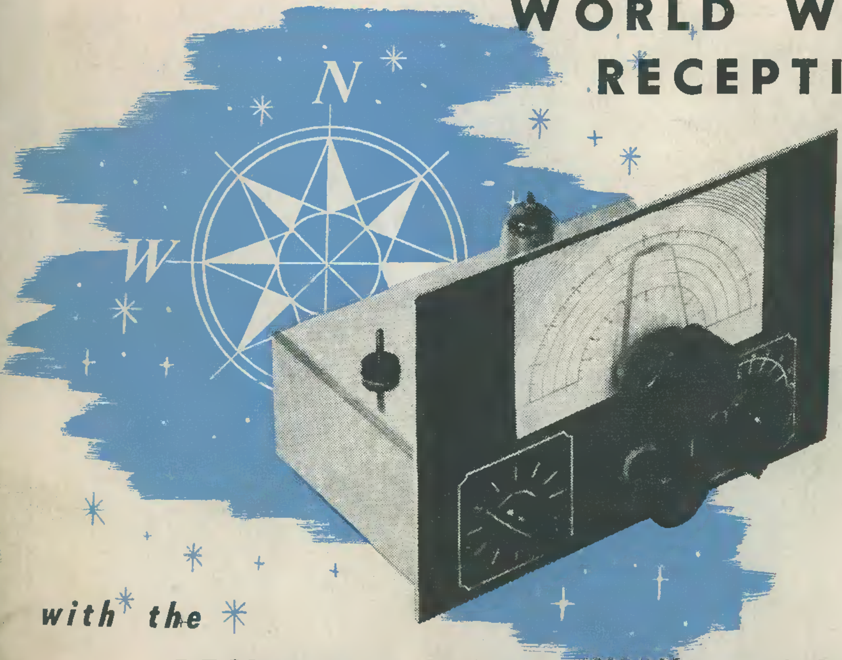

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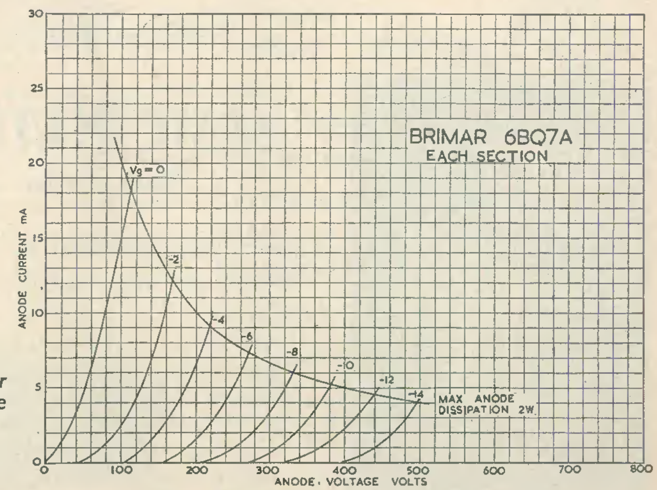

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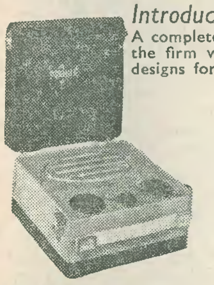

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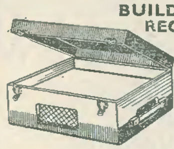

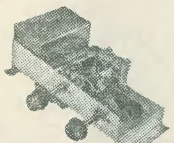

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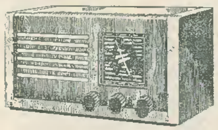

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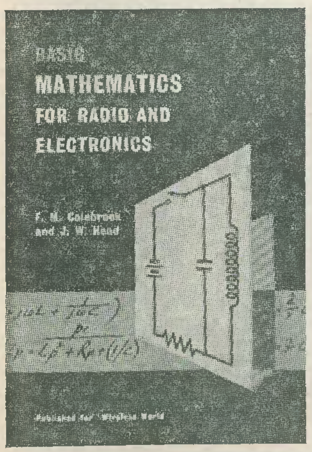

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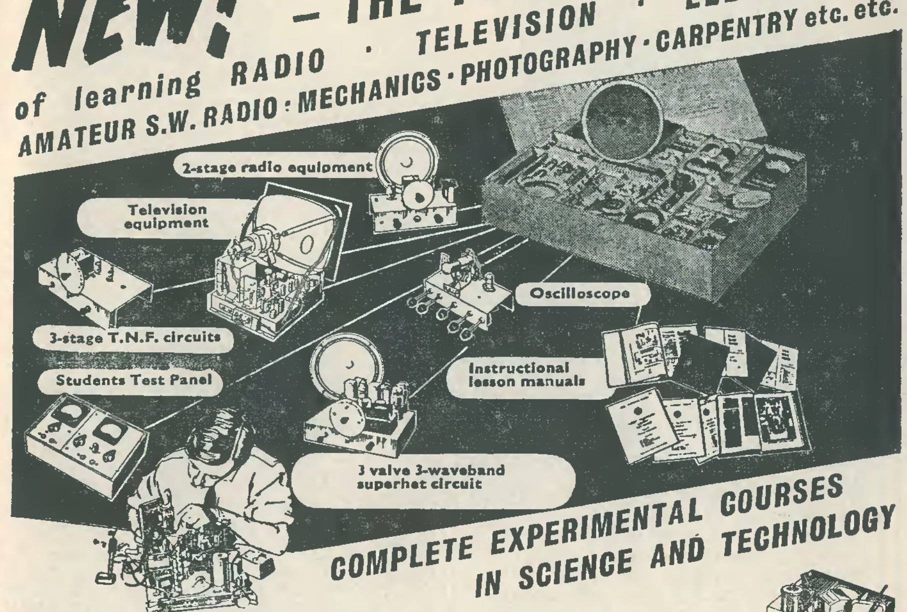

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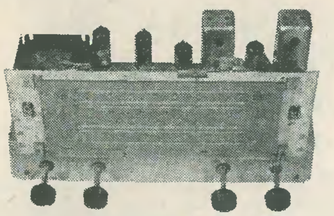

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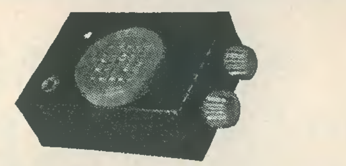

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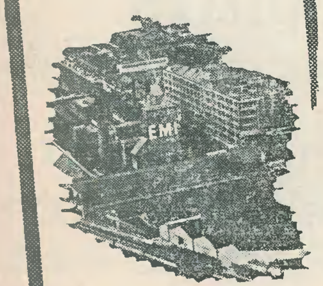

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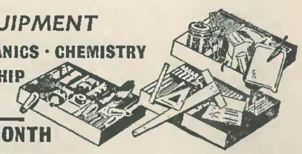

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CONTENTS FOR AUGUST

VOL. 11 NO. 1

AUGUST 1957

ANNUAL SUBSCRIPTION 21/–

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57 MAIDA VALE LONDON W9

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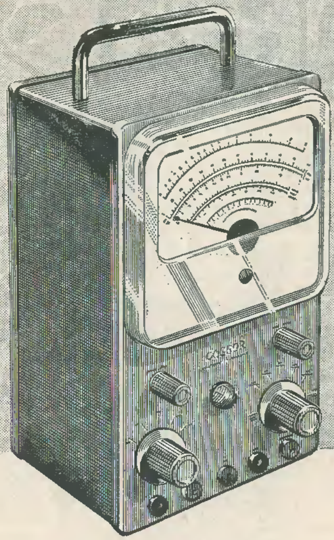

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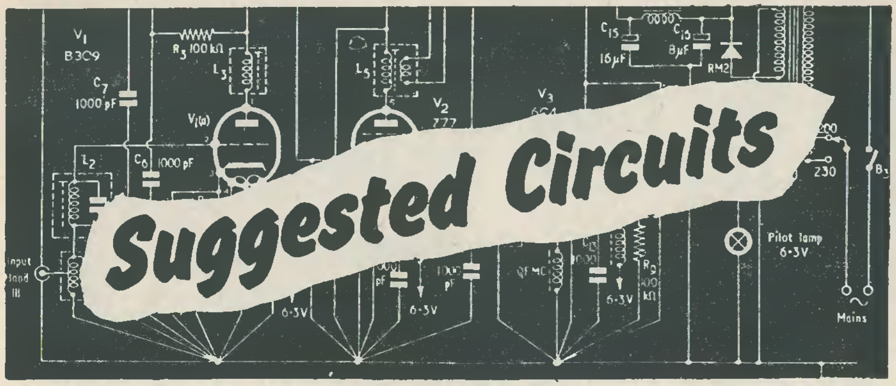


The circuits presented in this series have been designed by G. A. FRENCH, *specially for the enthusiast who needs only the circuit and essential relevant data*

No. 81. A TRIPLE-TUNED CRYSTAL UNIT FOR HIGH-FIDELITY AMPLIFIERS

Although the writer would be the first to admit that, so far as high-fidelity radio reception is concerned, there is no better means of transmission available in Great Britain today than v.h.f. f.m., it cannot be denied that quite a large number of people still reside in areas where it is possible to receive a.m. signals only. It has also to be pointed out that an f.m. receiver is liable to be a fairly costly piece of equipment, insofar that (assuming a conventional superhet) it requires a rock-bottom minimum of three valves plus their associated components and power supplies; and that this may render such a receiver unattractive to those who do not wish to dig too deeply into their pockets. Despite the loss in reproduction quality sustained, therefore, a lively demand is still evident in home-constructor circles for a.m. tuner units, provided that these are capable of offering optimum results consistent with the programme fidelity available on the broadcast bands.

The Circuit

This month's Suggested Circuit describes a relatively inexpensive a.m. tuner unit which is suitable for use with high-fidelity equipment, and which is sufficiently versatile to enable varying bandwidths to be obtained, as dictated by local reception conditions. The unit is intended mainly for use in areas of good signal strength, and it will, in many cases, require a reasonably efficient aerial. An earth connection of some sort will also be desirable, but this will, in most instances, be provided automatically by the amplifying equipment with which it is used. No power supply of any kind is necessary, and the output of the tuner unit may be coupled to any amplifier whose input impedance is 250 kΩ or more.

The circuit of the tuner unit accompanies this article. As may be seen, station selection is accomplished by one of two three-stage pre-tuned filters, the output of the particular filter selected being coupled directly into a crystal diode detector. If a third station is desired, a third filter may, of course, be added.

Starting at the aerial input terminals, and assuming that switches S_1 and S_2 are in position "A," the aerial is connected directly to the coupling coil L_1 of the first tuned circuit. This tuned circuit is provided by L_2 in parallel with C_1, the latter being a fixed condenser. L_2 is coupled to the second tuned circuit L_3–C_3 by means of trimmer C_2. The tuning condenser C_3 is, like C_1, a fixed component. A second trimmer, C_4, then couples L_3–C_3 to the final tuned circuit L_4–C_5. The crystal diode detector is connected via switch S_2 to L_4–C_5, whereupon the detected signal appears across its load R_2. The a.f. developed across R_2 is then applied, via C_{13}, to the subsequent a.f. amplifier.

When S_1 and S_2 are thrown to position "B" the tuned circuits made up by L_6–C_6, L_7–C_8, and L_8–C_{10}, are brought into use, and an alternative station may be received.

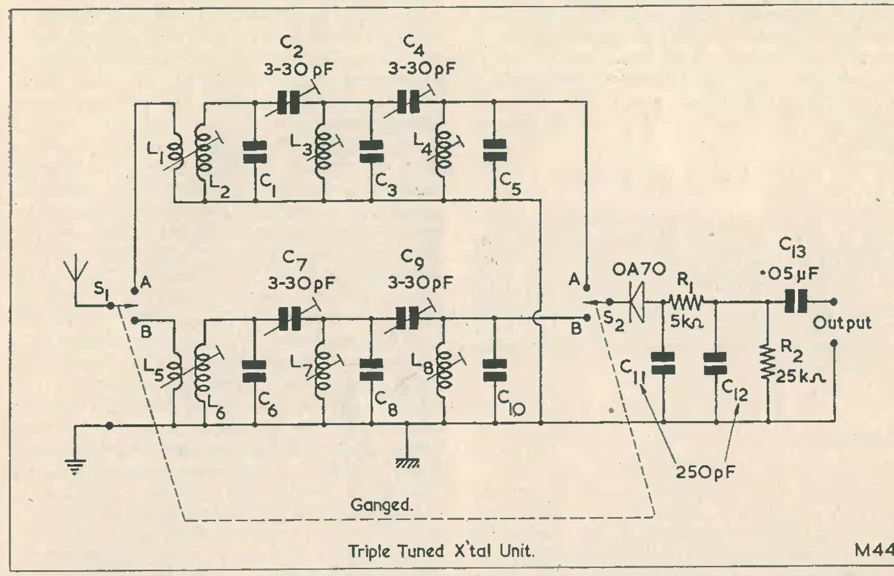
Input Impedance

It might be thought, at first sight, that the circuit of the tuner unit is somewhat prodigal in the number of coils it uses; but when the functions which are carried out are analysed, it may be seen that this is not the case.

The major difficulty incurred in any a.m. tuner wherein the a.f. output is obtained directly from the detector load is the necessity of making the a.c./d.c. detector load ratio as close to unity as is possible. The d.c. load of a conventional a.m. detector is the resistor across which the detected r.f. appears and, in the circuit we are discussing here, is provided by R_2.* Whilst detected r.f. appears across the detector load, so also does a d.c. voltage proportional to the a.f. amplitude. This d.c. voltage cannot be applied to a subsequent amplifier, whereupon it becomes necessary to feed such an amplifier via a suitably valued blocking condenser; in this case, C_{13}. The situation then arises that, whilst the d.c. load of the detector is given by the resistor connected in its immediate circuit, the a.c. load is given by that resistor *in parallel* with any subsequent impedance which may follow the d.c. blocking condenser. Thus, in the case of the tuner unit circuit discussed here, the detector has a d.c. load equal to R_2, and an a.c. load equal to R_2 shunted by the input impedance of the subsequent amplifier.

For detection of modulation depths up to 60 per cent or so, an a.c./d.c. diode load ratio of 4 : 5 is usually considered acceptable enough for conventional broadcast receivers, but for high quality work it is desirable to obtain a ratio which is much closer to unity. In the tuner unit described here, the diode d.c. load is 25 kΩ. Assuming a minimum input impedance (substantially resistive) of 250 kΩ in the following amplifier, the a.c./d.c. diode load ratio then becomes equal to approximately 22.6 : 25; this being quite a satisfactory figure for our purposes. Higher values of input impedance in the following amplifier will, of course, improve the situation still further.

A second, and almost equally important, feature of a.m. detector circuit design is concerned with the time constant given by the diode load resistor together with whatever capacity (r.f. decoupling and strays) is shunted across it. The reason for this par-



Triple Tuned X'tal Unit. M441

*Actually it is R_2 plus R_1; but the latter resistor may be ignored so far as approximate calculations are concerned.

ticular point is that, at the higher audio frequencies, the capacity across the load may not discharge into it as rapidly as the modulation envelope changes in amplitude. The trouble will only be apparent on downward modulation; i.e. during the time when the modulation envelope decreases in amplitude during the modulating a.f. cycle. When upward modulation takes place, the capacity is charged via the relatively low impedance circuit provided by the forward resistance of the diode in series with the coil across which the r.f. appears. (The distortion given by too long a time constant in the detector load is, incidentally, only peculiar to rectifying a.m. detector circuits. The distortion is non-linear in character, as opposed to the frequency distortion given by connecting top-cut condensers across a load resistor in a conventional a.f. amplifier.) Distortion caused by capacitive shunting of the diode load is negligible when the following relationship is satisfied:

$$\frac{1}{\omega CR} \geqslant \text{modulation depth},$$

where C is the highest shunt capacity permissible, R is the d.c. load resistor, modulation depth is expressed as a fraction of unity, and ω refers to the highest audio frequency to be handled. Assuming that, in the present circuit, the highest audio frequency is 8 kc/s and the greatest modulation depth 80 per cent, we then obtain:

$$\frac{1}{2\pi\, 8 \times C \times 25 \times 10^6} \geqslant 0.8,$$

whereupon

$$C = 1{,}000 \text{ pF approx.}$$

This figure for maximum permissible shunt capacity provides a considerable amount of leeway in the circuit design of the tuner, and is occasioned almost entirely by the choice of a low-value diode load resistor. We may, therefore, employ individual r.f. decoupling condensers in the tuner having values as high as 250 pF (giving a total shunt capacity of 500 pF) without incurring any risk of non-linear distortion. Such condensers will also provide adequate r.f. filtering even when the tuner is employed for long wave reception. There is also the advantage that we can allow ourselves an appreciable amount of self-capacity in the screened lead connecting the tuner unit to the amplifier without running into trouble on this score. From the point of view of top-cut, 25 kΩ paralleled by 500pF gives an attenuation of only 2 db at 10 kc/s, and so no difficulties should be anticipated on this count either.

Coil Functions

Due to the considerable advantages conferred by the low-value diode load resistor, it follows that the use of such a resistor is definitely very well worth while, even if it necessitates employing additional coils to obtain a desirable level of selectivity. In the tuner unit under discussion, and assuming that S_1–S_2 are in position "A," the diode circuit follows L_4–C_5, the third tuned circuit of the filter. It was decided to connect the diode circuit directly across L_4–C_5, rather than run it from a secondary coupling winding on the coil, as this method of operation enables a higher signal voltage to be applied to the detector. L_4–C_5 is fairly heavily damped by the diode circuit, but not so heavily that it cannot perform a useful service in providing a relatively high signal level for detection.

The first two tuned circuits are, however, hardly damped at all, whereupon these provide a selective band-pass pair whose bandwidth may be varied to suit local conditions by adjusting the trimmer connected between them.

Alignment of the circuit is best carried out with the aid of a signal generator, although good results could be obtained by using an aerial only. The signal generator should be set up to the frequency desired and its output connected to the aerial and earth terminals of the tuner with S_1–S_2 in position "A." The output of the signal generator should be audible when C_2 and C_4 are set to maximum capacity, whereupon L_4 may be adjusted for maximum volume. The value of C_5 is found experimentally, its correct capacity being that which enables the desired frequency to be selected within the core range of the coil (preferably with the core inserted some way into the coil). Final adjustments to L_4–C_5 should be made with C_4 set to as low a capacity as is consistent with sensitivity. C_2 is next set to minimum capacity, after which L_3–C_3 and L_2–C_1 are set up in the same way. Final adjustments are made by keeping C_4 at minimum capacity, and adjusting L_2, L_3 and C_2 such that the desired band-pass response is obtained. C_4 should then be increased in value until the band-pass response is just beginning to be modified. In practice, there will be a small amount of interaction between the tuning of L_4 and L_3, and both of these coils may require slight retuning whilst C_4 is being finally set up. A slight readjustment to L_2 may also be necessary when the signal generator is replaced by the aerial. As may be gathered, for best results from the circuit, a certain amount of careful alignment is desirable. After the first tuned filter has been set up, S_1–S_2 may be thrown to position "B." whereupon the second filter can be similarly aligned.

If an aerial is employed for alignment, the tuned circuits may be set up, proceeding backwards from the detector, by applying the aerial to each in turn via a condenser of some 10 pF or so, final tuning being carried out in the same manner as when a signal generator is employed, and with the aerial connected directly to the input terminal.

Practical Points

In order to prevent interaction between the coils it is necessary to ensure that mutual inductive couplings are kept to as low a value as possible. This point may be partially satisfied by mounting the coils in each individual filter several inches away from each other with their axes at right angles. Best results would be given by screening between the coils. There should be no necessity to prevent mutual inductive couplings between coils in different filters, such as, say, between L_3 and L_7, unless these are tuned to frequencies which closely approach each other. The coils employed should be dust-cored components having reasonably high Q values, those in the L_1–L_2 and L_5–L_6 positions being of the type intended for interstage coupling (i.e. their coupling coils should have fewer turns than their tuned windings). If desired, L_3, L_4, L_7 and L_8 may also be of the same type, their coupling windings being left disconnected. It is most important that coils with "over-wound" aerial coupling windings (i.e. coupling wdinings having more turns than their tuned windings) are not used at *any* position, as these coupling windings may upset the overall frequency response of the tuner due to absorption effects. The circuit shown is intended for reception of medium wave stations; but there is little reason why long wave reception should not be feasible with appropriate coils. Long wave reception may, however, necessitate the use of higher maximum values in the trimmers C_2, C_4, etc., than those specified in the circuit.

The switches S_1 and S_2 may conveniently be ganged, the best practical arrangement probably consisting of having wafers at either end of the unit coupled together on a single, long shaft. As was mentioned above, a reasonable earth connection is desirable, and this may be provided automatically by the subsequent amplifier, provided that this is mains-driven. If the following amplifier does not provide a reliable earth, an alternative earth connection would be advantageous. Finally, it must be stated that, despite the number of tuned circuits employed, the tuner unit is still basically a crystal receiver, and that the a.f. voltage available at its output terminals must, of course, be dependent entirely upon the signal voltage available from the aerial.

COURSES OF INSTRUCTIONS—EAST LONDON R.S.G.B. GROUP

The following classes organised by the East London R.S.G.B. Group in conjunction with the Essex County Council are available for all those interested in amateur radio, irrespective of whether they are members of any society or of the general public.

1. **RADIO AMATEURS EXAMINATION COURSE**
   Wednesday, 7.15 to 9.15 p.m. Eight month course for those intending to take the examination.
2. **MORSE AND CODES OF PRACTICE**
   Monday, 7.30 to 9.30 p.m. Six months course for those wishing to learn Morse, up to G.P.O. requirements for an amateur licence. Arrangements have been made with the G.P.O. for those who, in the opinion of the Masters, have reached the required speed, to be tested at the College in the evening by a representative of the Post Office.

The venue for the above classes is:

THE ILFORD LITERARY INSTITUTE,
(High School for Girls)
Cranbrook Road, Ilford, Essex.

It is adjacent to Gants Hill Station on the Central London Tube, and buses pass the door. The fee for the R.A.E. course will be £1 10s., and for Morse course £1 for those living in the Essex County Council area. Students from other parts of London will be admitted as out-county students provided the Local Authority is notified.

Enrolment nights: September 9th to 13th inclusive, 7 to 8.30 p.m.

Classes start the week commencing September 21st, 1957.

These classes have now been running for 10 years, and over 150 students have passed the R.A.E. examinations. Those interested in the first instance should write to:

MR. C. H. L. EDWARDS, G8TL,
28 Morgan Crescent, Theydon Bois,
Epping, Essex.

for reservations.

EVENING RADIO COURSES

These are to be held at Brentford Evening Institute starting in the week commencing September 23rd. All classes are from 7–9 p.m. The fee is 30s. for one class for one session; each additional class taken costs 2s. 6d. only. Enrolment is during the evenings of the week September 16th–20th.

(i) **Radio Servicing: 1st Year** (Monday evenings)
(ii) **Morse for Radio Amateurs** (Tuesday evenings)
(iii) **Radio Amateurs** (Wednesday evenings)
(iv) **Radio Servicing: 2nd Year** (Thursday evenings).

Classes (i), (ii) and (iii) are suitable for students with no prior knowledge of the subjects.

A number of readers have asked that Smithy should devote some of his time to the servicing of receivers which are not so modern. In the latter part of this episode the Serviceman, aided by his assistant Dick, attempts to satisfy these requests.

As Dick had become aware during the months that he had spent working for him, Smithy the Serviceman was liable occasionally to indulge in mildly freakish outbursts of humour. When Dick entered the workshop one morning he saw that Smithy, already engrossed at his bench, wore an expression which indicated that he was in one of these rare moods.

" 'Morning, Smithy," said Dick guardedly.

"Ah, good morning, Dick," returned Smithy heartily, as he turned round. "Please let me be the first to congratulate you."

"Congratulate me? For what?"

"For being the recipient of the N.H.T.T.", said Smithy. "In other words the Nylon Hexagonal Trimming Tool."

"Come off it," Dick grunted. "You know I don't wake up till I've had my ten o'clock cup of tea. I reckon it's a dirty trick to start pulling my leg immediately after I arrive in the morning."

Smithy ignored Dick's protests and, with a flourish, handed him a chipped and cracked saucer on which reposed a long thin white object.

"There you are," he said, "there's your new trimming tool. And look after it carefully, because replacements cost me a bob each!"

Hexagonal Cores

Dick picked up the trimming tool and examined it carefully.

"This looks interesting," he remarked, still with an edge of suspicion in his voice. "I suppose that you *are* being serious when you say that this is for trimming?"

"Perfectly serious," Smithy replied, lapsing into his normal manner. "What's happening is that set manufacturers are at last doing something to get away from threaded iron dust cores with screwdriver slots. You know how we've cursed such cores in the past when the material around the slot breaks away and they become impossible to turn."

"I had one in a t.v. set only a couple of days ago," interrupted Dick. "It must have been adjusted four or five times since the set left the factory, and the slot had become completely non-existent. The coil concerned had two cores in the one former, so the only way I could get the faulty core out was to remove the second one and engage my screwdriver with the remaining 'good' slot at the other end of the faulty core. I refitted the faulty core into the coil the other way round so that its 'good' slot was on the outside, and then I had to completely re-align the whole coil."

"In other words," summed up Smithy, "you had to waste a considerable amount of time and patience in putting right what was really a very simple fault indeed. I might add that, if your faulty core had 'seized up' in the former—as happens now and again—you would have had a far worse job on your hands. Anyway, to get back to the new trimming tool, many set manufacturers are now fitting a new type of core to their coil formers, and have been doing so for some months. This new core doesn't have a screwdriver slot at all. Instead, it has a hexagonal hole all the way through, like this." (Fig. 1.)

"I see," Dick said, "and I suppose that the result is that, however badly the core gets chipped, you are still almost certain to have a small amount of hexagonal section left so that you can get a purchase on the core."

"Well, I don't think that the people who've introduced this core look upon it quite in that light," chuckled Smithy, "but you've got a good point there! There is the further advantage for the serviceman that, since the core is not completely solid, you should be able to break away a 'seized up' core much more easily. The hole through the middle provides space for the broken bits to fall inwards. However, I should imagine that that point was not in the designers' minds either. The trouble with this servicing racket is that, whenever a new design appears, you spend your time looking pessimistically for easy ways of repairing it when it goes wrong rather than studying the advantages it gives whilst it is working properly.

"Really, though, there shouldn't be as many casualties with the hexagonal type of core as there have been with the slotted type. If you look at the nylon trimming tool I have just presented you with (Fig. 2), you'll see that it has a hexagonal section at each end. That hexagonal section engages with the full length of the hole in most cores you are liable to encounter, so that far less mechanical strain is exerted during adjustment."

"There's one question I would like to ask," said Dick, who had been examining the tool carefully. "I see that one end of the tool has a thick round section leading up to the hexagonal part, whilst the other end has a thin round section. Is there any particular reason for that?"

"Oh yes," replied Smithy, "there's a very good reason indeed. If you want to adjust and that you have maximum mechanical coupling. The thin end of the tool allows you to trim both cores of a two-core coil from one end of the former. In this case you pass the hexagonal section through the top core and allow it to engage with the hole in the bottom core (Fig. 3 (*b*)). The thin round section does not interfere with the top core, whereupon you can adjust the bottom core independently."

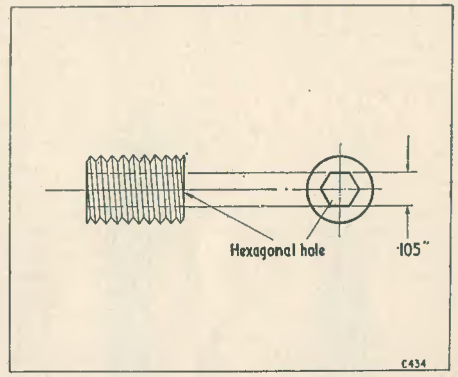


Fig. 1. *A dust core with hexagonal bore*

"That's a very neat idea," commented Dick approvingly. "With this scheme you could trim all the coils in a set from one side of the chassis."

"Exactly," replied Smithy. "Whereupon

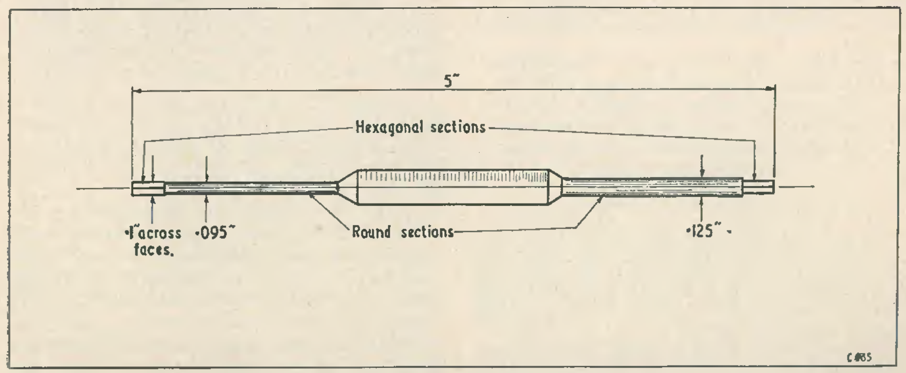


Fig. 2. *A trimming tool suitable for adjusting hexagonal bore cores. The dimensions given in this diagram and Fig.* 1 *are meant to be representative only*

a core which is immediately available to you, you insert the thick end into the former. When the tool cannot be inserted further (Fig. 3 (*a*)), you then know that all the hexagonal section is engaged with the core you can save a lot of time with chassis which are awkwardly positioned relative to the cabinet or, in the case of t.v. sets, to the tube as well. Mind you, when you use the thin end of the trimming tool you have to fish around a bit before you fully locate into the bottom core but you soon get used to it. I think I should warn you, incidentally, that you may find hexagonal cores in chassis which, up to now, have employed slotted cores; so you want to be careful that you don't cause any damage to new sets by starting to trim with the wrong tool."

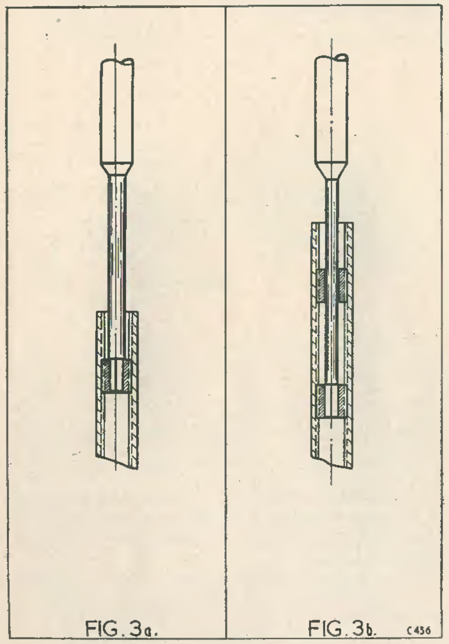


Fig. 3 (*a*). *The thick round section of the tool enables accurate coupling with the core to be obtained*

Fig. 3 (*b*). *The thin end of the tool may be passed through one core to adjust another underneath*

"Fair enough," said Dick. "I shall keep my eyes open for that point. By the way, have you noticed how threaded cores in some sets are very tight in their formers whilst others are quite loose?"

"Yes I have," replied Smithy, "and I must admit that, in this case, my sympathies are with the set designers. First of all, it is almost impossible to ensure that a threaded core fits tightly into an internally threaded former by reason of mutual interference alone. Everything mechanical has to be made within certain dimensional tolerances, and the tolerances you meet in the commercial manufacture of cores and formers just don't allow a requirement of this type to be met. In the past a number of mechanical designs have been used, with varying success, in order to keep the core in position whilst also providing something with which its threads may engage. The most successful idea seems to consist of having a former with a plain inside surface and a piece of springy wire passing through a slot in its periphery. The spring bears on the thread and also keeps the core in position after it has been adjusted. When mechanical devices of this type aren't used, manufacturers often apply a core-locking compound to the core before it is inserted into the former. Core-locking compounds are specially 'gooey' substances which never set hard. Another idea which, fortunately, may be on the point of dying out, consists of putting a length of rubber string through the former, before the core is inserted. Rubber string is something of a menace if you want to adjust a core over a considerable distance, because it gets very easily tangled up. If you *have* to make a large adjustment the best plan is to try and hold the string taut whilst you turn the core. If the former has two cores you can do this fairly easily without needing three hands. As I said just now, however, rubber string is a menace; and the sooner it disappears altogether the better it will be for everyone concerned."

"What you mean," Dick chipped in brightly, "is that, like the sergeant-major, rubber string is rotten to the core!"

Smithy shuddered.

A Vintage Receiver

The Workshop soon took on an appearance of industry as Dick and Smithy settled down to their respective tasks. After a while, Smithy looked up and turned to Dick.

"I wonder if, later on, you could have a go at the sound receiver on the shelf over there," he remarked, pointing to a set in a pre-war cabinet. "I told the customer I'd try and get it fixed to-day."

"O.K." said Dick, over his shoulder.

Some thirty minutes later he finished the job he had been handling and carried the receiver Smithy had indicated over to his bench. He took the back off its cabinet and took a look inside.

"Gosh," he remarked, "this set must have come out of the Ark. Look at those old gold-painted coil cans! And side-contact valves, too! Where'd you dig out this relic, Smithy?

"I'll agree it's pretty old," said Smithy, "but it should still have some life left in it. Fortunately, medium and long wave reception of the B.B.C. is pretty reasonable in this part of the world, or I wouldn't otherwise have liked to take on a t.r.f. of this type. Side-contact valves aren't quite as ancient as you think, incidentally—they were used right up to the start of the war."

"Yes, but even accepting that we can get this venerable old crock to work," protested Dick, "wouldn't it be fairer to tell the customer he would be better off with a new set?"

"Under normal conditions, yes," Smithy said, "but in this case the customer is rather hard-up. Actually, the set belongs to that old lady who lives a couple of doors down the road. As you may know, she's living on her own, she is hardly ever able to get out, and the only money coming in is that from her pension. Pretty well the sole thing that keeps her going these days is the entertainment she gets from this old set, so I reckon it's just up to us to see if we can get it fixed up for her."

"I know her fairly well," chuckled Dick. "I remember her ticking me off some years ago for smoking. She said I was too young!"

"And so you probably were," commented Smithy severely. "Anyway, I'll leave you to get on with it."

Smithy returned to his own work and left Dick gazing dubiously at the old set. A further twenty minutes elapsed before Dick's voice became audible again.

"Got any spare side-contact valves, Smithy?" he called out.

"None serviceable," replied Smithy, "but there are some broken ones in a box in the cupboard."

"Phew," commented Dick. "Talk about the magpie instinct! What on earth is the use of harbouring old broken valves?"

"There's plenty of sense to it if you know *why* I keep them," replied Smithy, a little heatedly. "Anyway, let's have a progress report on that set."

"Well, here's the story to date," said Dick. "First of all I had a quick look around and switched the set on. It was completely dead, and so I next removed the chassis from the cabinet. As it's an old receiver the first thing I looked at were the h.t. electrolytics. The set had still got the original wet electrolytics in, but they had erupted so much electrolyte over the chassis that the only obvious thing to do was to whip them out and clean things up a bit. Incidentally, I checked the old condensers with a meter on the ohms range and they caused its needle to give a very slight flick; so they must, even now, have a small amount of capacity left in them. Plus plenty of leakage. I put new electrolytics in and switched on again, but the set was still dead. The valves were lighting up O.K., so the next thing I checked was the h.t. line. There were no volts here, nor was there any short between the h.t. line and chassis. The rectifier is a full-wave job and so I then checked for a.c. volts between each anode and chassis. Each anode was getting 250 volts a.c. relative to chassis from the mains transformer, and a further check confirmed that there were no d.c. volts on the rectifier cathode pin itself. Just in case the rectifier might be making poor contact to the valveholder I waggled it around but there was nothing wrong here. After which," concluded Dick, pompously, "my innocent question re spare side-contact valves in general—this being intended to lead up to the subject of a replacement rectifier in particular—was answered with the completely irrelevant news that you had a few broken valves in a junk box."

"As I said, they're there for a purpose," grinned Smithy, "which you may see as we proceed. Anyway, the story so far is interesting. I have no doubt that the old lady would have just put up with the pretty hefty hum given by those old electrolytics and that something must have happened to make the set completely useless before she finally decided to see about getting it repaired. If, therefore, we fit a new rectifier, we should be able to get some sort of performance straight away. Had it been a half-wave rectifier I would have advised you to fit a metal component in place of the valve. However, it's a full-wave job and a new valve is really what is called for. In this case, I think you'll find that the easiest plan consists of fitting an octal valveholder to the chassis in place of the side-contact one. This would be the quickest solution because there aren't many connections to the valveholder and it's easily accessible. We will then fit an octal equivalent of the duff rectifier."

Instability

Smithy sat down, lit a cigarette, and watched Dick changing over the valveholder. The chassis hole left by the side-contact base was much larger than that required for the octal valveholder, so Dick started by securing one end of the new valveholder to one of the original fixing holes. A quick search in a spares box soon located a simple flat piece of metal capable of holding the other hole for the new valveholder (Fig. 4), and a few more minutes work was sufficient to finish wiring up.

"Very good," grunted Smithy approvingly." "Now pop the new rectifier in and switch on."

Dick did as he was bid and, after a few moments, the set came to life. Dick twirled the dial and was surprised to find that the old receiver exhibited quite a reasonable amount of sensitivity and selectivity, although he noted that volume was low and that there was an occasional loud crackle. He gave the chassis an experimental tap, whereupon the set immediately burst into oscillation—each station being received against a violent heterodyne whistle.

"Dash it all," he grumbled despondently, "another snag! We should never have started on this crock at all."

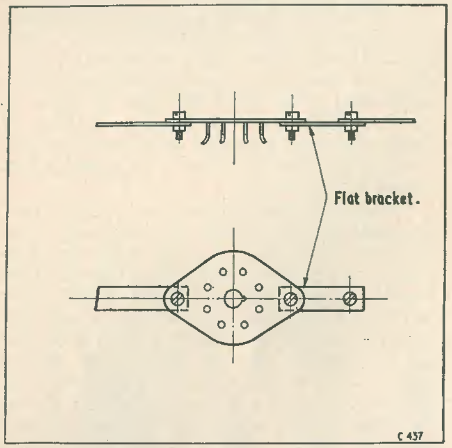


Fig. 4. A very simple flat bracket enables a valveholder to be mounted securely to an over-size chassis hole

"Nonsense," replied Smithy briskly. "Instability in these old sets is usually one of the simplest of faults to clear. As you can see, the set uses valves with metallized screening. Now, one of the most common snags with metallized valves is that, as they grow older, the metallizing comes adrift from its earth connection."

Smithy carefully touched the metallizing of the r.f. valve with his finger. At once the heterodyne from the speaker changed in note. Smithy next rocked the valve gently, and showed Dick that the oscillation ceased when he pushed the valve in one direction, and returned when he allowed the valve to resume its original position.

"Right first go," he remarked, with some satisfaction. "Now the next thing to do is to repair the faulty earth connection to the metallizing. Since the glass bulb of this valve is loose I have to be careful whilst pulling it out of the socket, as otherwise I'll leave its base behind. Ah, that's got it. You can now see (Fig. 5 (*a*)) how the metallizing around the bottom of the bulb has broken away from its earth wire. I next squirt a little Durofix down between the glass and its base so that, when it becomes set, as it will be after twelve hours or so, the glass will once more be firmly stuck in place. I then wrap a few turns of thin tinned copper wire around the bottom of the metallizing, twist the ends together, and bring them down the outside of the base to the earth pin of the valve (Fig. 5 (*b*)). A dab of solder at the pin, and the valve is as good as new. By the way, this particular type of repair doesn't only apply to Ye Olde Radio Sette of the type we're considering now. There are plenty of post-war radios *and* t.v.s which use metallized valves, and in which similar faults can, and often do, occur."

Whilst he was speaking Smithy replaced the valve and switched the receiver on again. The instability was now absent and, apart from the intermittent crackle and low volume, the receiver was giving a fairly reasonable account of itself.

"Well, that didn't take long," commented Dick, "but we're still not out of the wood yet. So far as I can see, the output valve is on the point of expiry as well. It's probably this valve which is causing the low volume and intermittent crackle because, when I tap it, not only do I get the crackle but also a beautiful snowstorm demonstration from its cathode! The trouble is that it is going to be very difficult to fit a new valveholder in this case because the present one is hidden under one of the coil cans. It would take us ages to get that coil can out of the way before we even *thought* of changing the valveholder over."

"Not to worry," said Smithy serenely. "There are several quite simple ways out of the difficulty, provided you're prepared to take a little care. One simple solution would consist of fitting a new valveholder to a side-contact base taken from an old valve—thereby giving you an adaptor. However, there's another method which I used quite frequently during and after the war and which is worth while trying out here. You first of all obtain an octal equivalent of the side-contact valve, run a file round the pins to remove the plating, and solder tinned copper wire to them."

Smithy hunted around in the valve cupboard, found the valve required, and soldered wires to the pins in the manner he had just described (Fig. 6 (*a*)).

"The next thing is to find a side-contact base from an old valve," he continued. "This, incidentally, explains why I keep those old broken valves. I next clean out the holes in the pins of the side-contact base and insert the wires from the octal valve through them. The wire from each octal pin must, of course, go through the corresponding pin of the side-contact base, but you will find that, with the exception of the heater connections, the pin positions between the two valve types tie up quite well. If two of the wires cross, such as may occur with pin 8—cathode—and pin 7—heater—from the octal valve, I put a little rubber sleeving over one of the wires. I next pull the wires through the holes in the side-contact base, tightening each in turn, then I finally wrap the wires round the pins and solder. The result is an octal valve which is fitted, very securely, to a side-contact base (Fig. 6 (*b*))."

As Smithy spoke he proceeded with the job he was describing. After some minutes he had completed his task.

"I wouldn't have believed that you could carry out a job like that till I had seen you do it," commented Dick. "Anyway, I've timed you on it, and it took you just about twelve minutes, which is infinitely shorter than the time which would have been needed to change the valveholder."

"Well, I would be the first to admit that a repair like this isn't the sort of thing one often encounters in modern servicing," remarked Smithy, "although the case may arise, as it has just now, where the idea can definitely prove to be very useful and time-saving. I daresay there are quite a few old receivers knocking around which could be brought into working order with little difficulty by following one or two of the dodges we have discussed just now. Many pre-war sets are capable of giving quite good performance, you know. Anyway, let's plug in our new hybrid output valve, and see how it copes."

Smithy fitted the new valve and switched on the receiver. As he had anticipated, the volume was now restored to a satisfactory level, and the intermittent crackle had disappeared. After a few moments testing, Smithy decided that the set was in full working order.

"Well, that seems to be O.K. now," he remarked, "and I'll ask you to pop the chassis back into its box again. Perhaps you could take the set back to the customer, later on in the day."

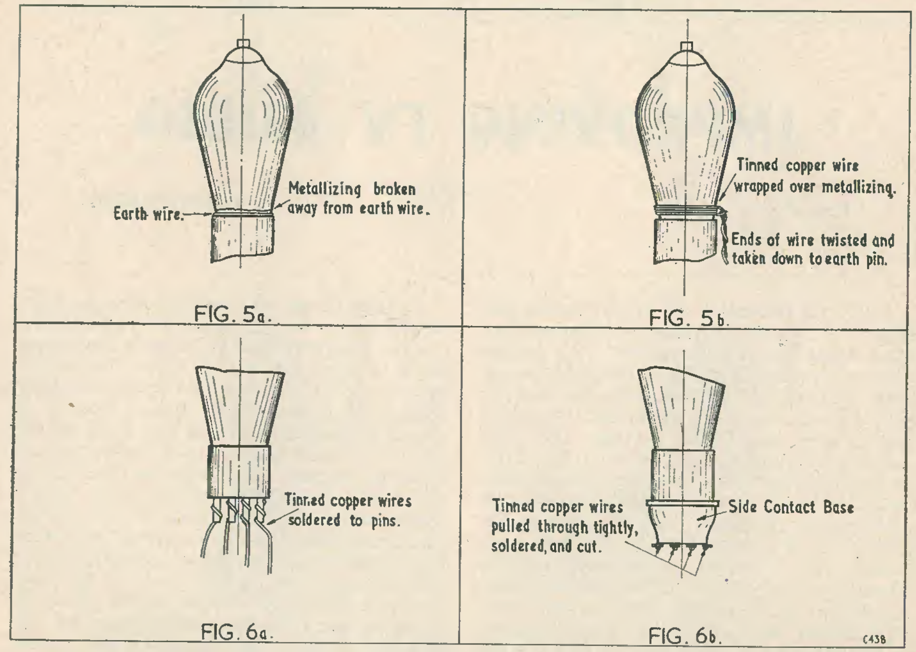


Fig. 5 (a). A frequent fault with metallized valves is shown here, the metallizing having broken away from its earth wire. Fig. 5 (b). Re-connection to the metallizing may be effected by wrapping several turns of wire around the metallizing, and soldering this to the appropriate earth pin. Fig. 6. How Smithy was able to fit an octal valve to a side-contact base in an old receiver. After soldering wires to the octal valve pins (a), these were passed through the side-contact pins, pulled tight, and soldered (b)

Payment

The rest of the morning passed uneventfully and, just before lunch, Dick reminded

Smithy about delivering the old receiver. Before he left the workshop with the set, he raised another question.

"By the way, Smithy," he asked, "how much are you going to charge for that repair?"

Smithy mentioned a sum; and Dick whistled in surprise.

"We'll never get rich that way!" he exclaimed. "Why, the new parts alone are worth much more than the figure you've just mentioned."

"Can't be helped," grunted Smithy. "It may be unethical and it may be bad for business, but there it is. One advantage of working on my own, as I do here, is that I can fix my own prices. I work out my overheads every year to include losses on occasional jobs; and we will just have to count this set as one of those losses. I'm not the only person in the servicing game who puts out an occasional low charge, although I must admit I do usually try to get receivers of this nature done in my spare time."

"O.K. Robin Hood," chuckled Dick. "Anyway, I think I'd better get on my way."

"Off you go, then," said Smithy. "I should leave that cigarette behind!"

When Dick returned, he looked pleased with himself and was busily chewing.

"Hello, Friar Tuck," commented Smithy, "what's that you're eating?"

"It's an old-fashioned humbug," replied Dick. "My reward for not smoking!"

IMPROVING TV AUDIO

Part 2

by **T. CHAMBERS**

Fig. 5 (*a*) illustrates the output anode and input valve cathode circuits of a typical two-stage amplifier. In t.v. circuits V_1 is almost always a triode and V_2 an output pentode. A very satisfactory feedback loop can then be set up by feeding a proportion of the output transformer secondary voltage into the cathode circuit of V_1, as is shown in Fig. 5 (*b*). In this diagram an extra resistor, R_6, is connected in series with the cathode bias resistor and bypass condenser, and this forms the lower half of a potentiometer which is completed by R_7. The ratio of R_6 to R_6 plus R_7 determines the fraction of the output transformer secondary voltage which is applied to V_1 cathode. R_6 needs to have a low value (to avoid altering the existing triode bias voltage by too large an amount) and should normally lie between 20 and 40 ohms. The fact that V_1 cathode bypass condenser is not now connected directly to chassis may cause hum (from the heater) to appear in the a.f. amplifier, although the risk of this happening is low. The hum may be diminished by giving R_6 a value lower than the range just mentioned, reducing this to as low as 5 ohms or so; although it should be pointed out that the hum might, in any case, clear when the feedback loop is finally put into operation. The value of R_7 is found by experiment, negative feedback increasing as its value is lowered.

To keep things on a practical level it might be advisable at this stage to describe the practical steps needed to convert the circuit of Fig. 5 (*a*) to that of Fig. 5 (*b*). First of all, the circuit of the televisor audio amplifier should be examined to ensure that it is rougly equivalent to that of Fig. 5 (*a*). If the two valves in the amplifier employ a common cathode resistor the cathodes should be separated, individual resistors and bypass condensers being provided for each valve. The circuit should then be checked to ensure that it functions properly, with these new bias components. R_6 should next be inserted, choosing initially a resistor in the 20 to 40 ohms range; and the performance of the amplifier should be checked once more. There should be little alteration in gain or quality and any hum that may appear should be ignored. A resistor of some 5 to 10kΩ in value should then be temporarily fitted in the R_7 position, and the receiver switched on once more. It is important to keep a hand on the receiver on-off switch at this stage because, should the feedback happen to be positive, the amplifier will break into violent oscillation which may, if sustained, damage the speaker. Should oscillation become evident (usually in the form of a howl) the receiver should be switched off at once. The positive feedback may then be converted to negative feedback by reversing the connections either

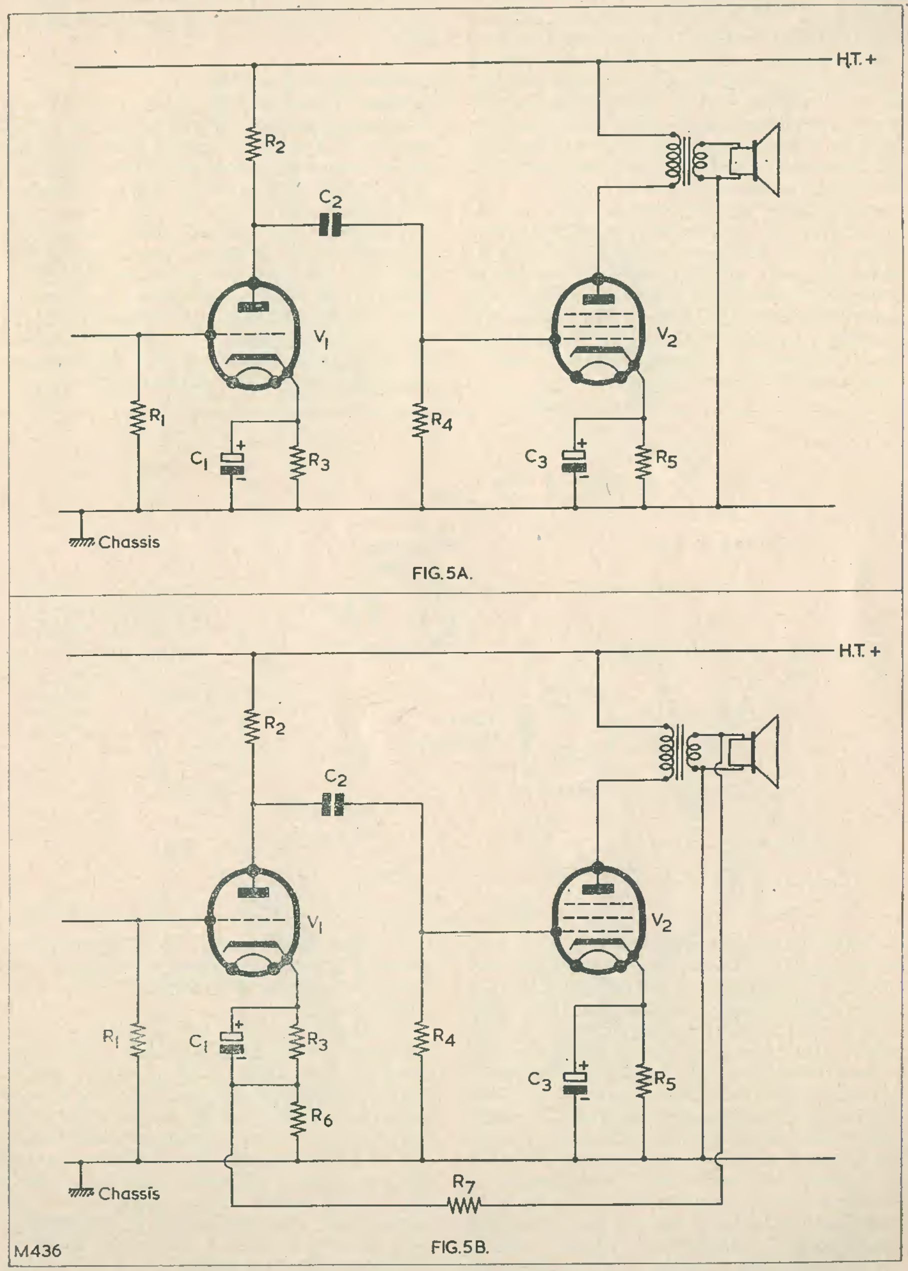


Fig. 5 (a). A two-stage a.f. amplifier without feedback. Fig. 5 (b). Feedback overall may be added very effectively by the use of this arrangement to the output transformer primary, or to its secondary. When the feedback is negative it will probably be found that amplifier gain is reduced with, even at this stage, quite a noticeable increase in quality of reproduction. If it is doubtful (due to low gain in the particular amplifier being modified) that the n.f.b. loop is working correctly, its operation may be checked by short-circuiting the junction of R_6 and R_7 to chassis with a screwdriver. This should cause an increase in gain to the original level. The feedback is set up to what is finally required by reducing the value of R_7 experimentally until the desired amount of gain is provided by the amplifier. (If any hum introduced by the initial insertion of R_6 is still present, this resistor should be reduced to a lower value—as mentioned above—and a new value for R_7 determined.)

circuit of Fig. 5 (*b*) often causes an improvement in quality which is quite rewardingly high.

Converting to Push-Pull

What is probably the most attractive and imaginative method of improving the sound quality of a televisor having a single-ended audio output stage consists of modifying this stage to push-pull working. Such a modification is best carried out by the more experienced constructor and, only then, after a study has been made of the receiver circuitry and the characteristics of the valves involved. There is, of course, little point in changing over to push-pull working if the speaker in the receiver is too small to satisfactorily handle the improved output given. In receivers employing a speaker of reasonable proportions and performance, and especially in consoles fitted with single-ended chassis, the change to push-pull is definitely well worth consideration.

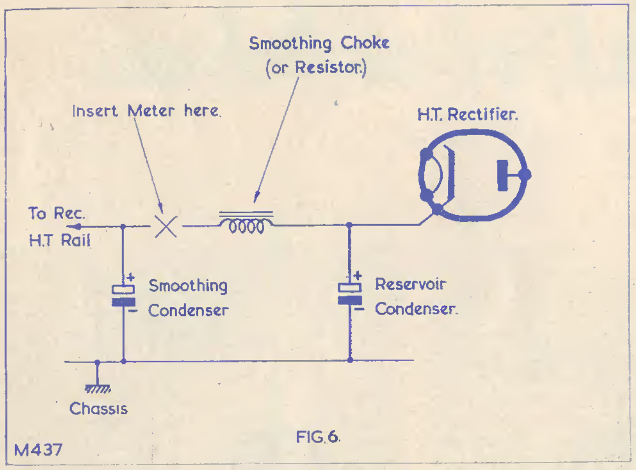


Fig. 6. When measuring total h.t. current, the milliammeter should be inserted after the reservoir condenser

Although phase shifts in a simple two-stage amplifier should not be very troublesome, it is possible that the circuit may break into oscillation when R_7 is reduced to a value which gives a relatively high degree of feedback. The type of oscillation to be expected is usually supersonic in frequency, whereupon it makes itself evident as a hiss combined with an obvious deterioration in overall quality. The effect may sometimes be partially cleared by connecting a condenser of some 200pF or so between the anode of V_1 and chassis. If oscillation due to the feedback loop becomes the limiting factor to the amount which can be applied, R_7 should be left finally with at least twice the value at which oscillation commences.

Although it requires rather more care to put into operation than do the simple n.f.b. arrangements mentioned previously, the

A simple method of carrying out the modification is described later, and this involves the addition of a triode phase-splitter, an output valve similar to that already employed in the receiver, and a new output transformer. Extra resistors and condensers will also be required. The additional valves and components will need to be fitted close to the existing sound output stage, and it will probably be most convenient to mount them on a small sub-chassis. As may be gathered, the modification is liable to incur a certain amount of expense and work.

The addition of the two extra valves necessitates a preliminary examination of the power supply capabilities of the receiver.

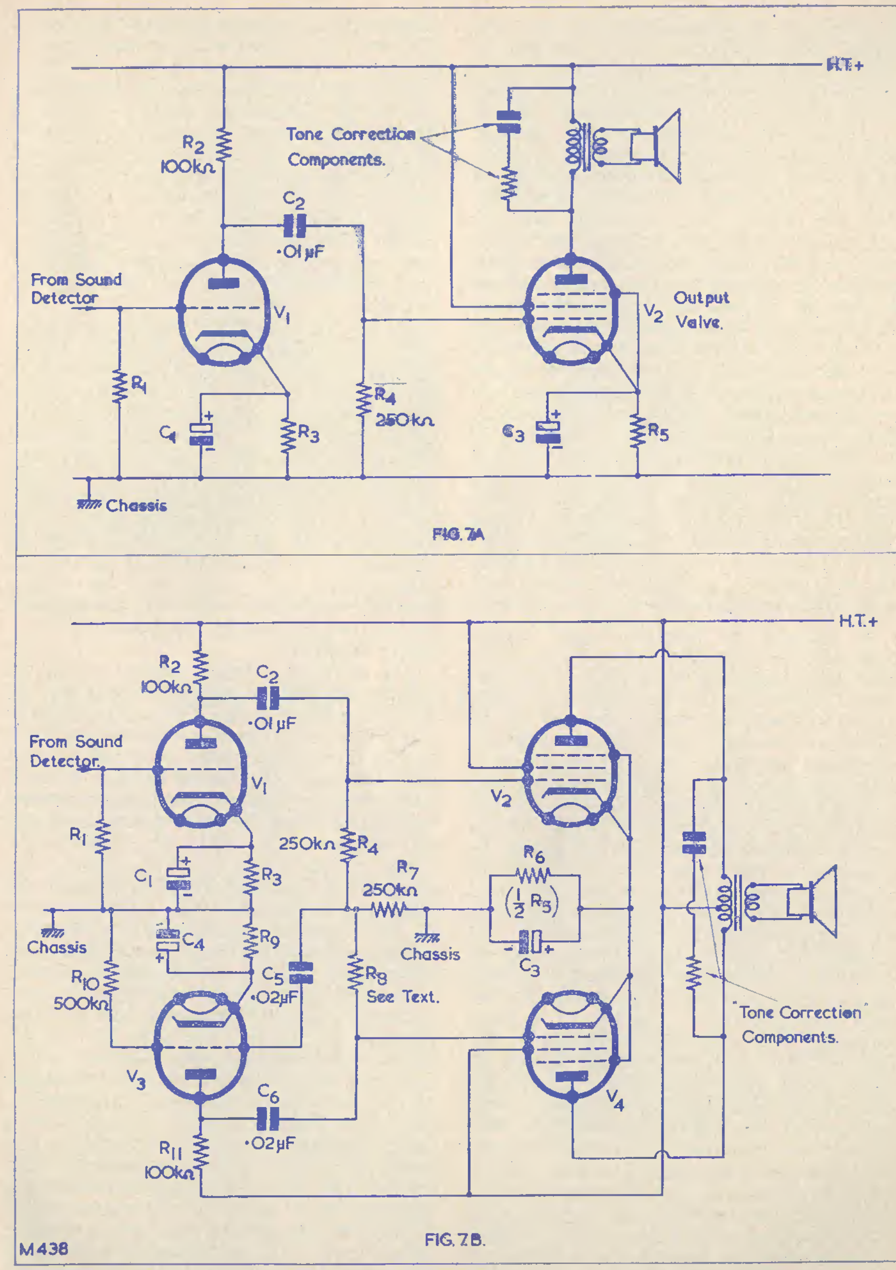


Fig. 7. A single-ended output stage may be converted to push-pull working by carrying out the modification shown here. The arrangement at (b) is particularly applicable to television a.f. amplifiers, wherein valve heaters may carry high a.c. potentials with respect to chassis. Values for the "tone correction" components in the push-pull arrangement are best determined by experiment

Both the triode phase-splitter and the new output valve will require heater supplies. If all is well, there may be sufficient "spare volts" available in the heater chain to heat these two valves, whereupon the dropper value will need to be modified accordingly. To prevent excessive alterations to the receiver's functioning the two new heaters should be inserted "well up" the heater chain (i.e. well away from the chassis end), care being taken to ensure that the limiting cathode-heater voltage ratings of the two valves, and those above them in the chain, are not exceeded. If one or both of the two extra valves cannot be accommodated in the heater chain, a separate 6.3 volt heater transformer could be fitted, 6.3 volt equivalents of the valves in the set being run therefrom. Unfortunately, 6.3 volt equivalents cannot always be found, whereupon the additional heater transformer may be required to give an "awkward" output voltage. When the set works from mains in excess of 220 volts, additional heater volts could be obtained by abandoning the dropper resistor section between the 200/210 and 220–230 volt tappings. Care should be taken to ensure that the h.t. rectifier mains tap network is not disturbed thereby.

In addition to possible heater supply problems, the two additional valves may also raise difficulties from the h.t. point of view. Whilst the h.t. current drawn by the phase-splitter will be negligible, that taken by the additional output valve could seriously embarrass the receiver h.t. rectifier which, in many receivers, may already be working very close to its maximum rating. Before attempting to carry out the change to push-pull, the service literature for the televisor should be examined to ensure whether the particular h.t. rectifier employed will provide the extra current needed. If the service literature does not provide sufficient information, the receiver h.t. current can be measured by inserting a milliammeter (switched to a range capable of reading the 200 to 300mA current anticipated) in the h.t. circuit at a point following the reservoir condenser. See Fig. 6. H.T. current readings should be taken under "worst" conditions, i.e. with the line and frame hold controls at their normal settings and with the set switched to a dead channel (or with the aerial disconnected). This precaution ensures that a.g.c. voltages are at minimum and that the timebases, particularly the line timebase, are working in the unsynchronised state (wherein h.t. current consumption is usually slightly higher). Dead channel conditions will, of course, exist if the set is switched on before transmissions commence, or if transmissions break down during a programme. To be really accurate, h.t. current measurement should be taken some 15 minutes or so after the set has warmed up, since it usually takes this amount of time for the line timebase to settle down to its proper operating current.

If the above checks show that the existing rectifier is capable of passing the extra current needed by the additional output valve, all is well. If the additional circuitry will overload the existing power supply, a larger rectifier may be fitted, or some alternative h.t. supply made available for the two output valves. This latter idea is not very attractive, however, and the more ingenious constructor may find alternative solutions which are not as clumsy.

As will be seen from the last few paragraphs, the major problems raised in changing over to push-pull output are not due to the a.f. circuitry involved. Instead, they occur almost entirely in the provision of the extra power needed. Fortunately, the situation is not as black as may be apparent, because quite a number of sets will be capable of providing the power required without any difficulty at all. Paradoxically enough (and fortunately for the person carrying out the alterations) it will probably be found that the cheaper sets—i.e. those with the lowest number of valves—will be those most capable of providing the extra heater and h.t. power required!

The extra a.f. circuitry needed should, in most cases, be fairly simple to add, the only restricting factor being that the phase-splitter triode will need to have its cathode decoupled to chassis via a large value condenser in order to prevent hum injection via its heater. Thus, the conventional phase-splitter circuit wherein the load resistor is divided between anode and cathode cannot be used in this application.

Fig. 7 (*a*) shows a typical triode and pentode a.f. amplifier, of the basic type found in most television receivers. (If the two valves in the amplifier section share a common cathode resistor, the circuit must be changed to separate resistors and bypass condensers before the push-pull modification is commenced.) Fig. 7 (*b*) shows the amplifier modified to push-pull operation with the aid of a self-balancing phase-splitter. The operation of the circuit is very similar to that of the well-known "see-saw" arrangement, the major difference being that the balance circuit appears in the output grid leak network rather than in the preceding anode loads. The circuit is largely self-balancing, although it is advisable to choose initial resistor values which suit the particular valves used. The additional output valve, V_4, must be a direct equivalent of that already fitted, V_2; and the triode, V_3, should be a reasonable equivalent to the existing triode, V_1. In some receivers the amplifier will employ a combined triode pentode (V_1 plus V_2), whereupon the two additional valves will become a similar triode pentode. Both pentodes and triodes will then automatically match each other. The new output transformer will need to have approximately twice the ratio (anode-to-anode to secondary) as was given by the original component. (For *optimum* quality the valve literature should be consulted to determine the best ratio.) The two condensers C_5 and C_6 should each have twice the value of the existing condenser C_2; whilst R_6 requires half the value of R_5 in Fig. 7 (*a*).

A major advantage of the arrangement of Fig. 7 (*b*) is that little alteration is needed to existing circuitry, and that all cathodes are at chassis potential so far as a.f. is concerned. Care needs to be taken with some of the resistor values for best results. Thus, the two anode resistors, R_2 and R_{11}, should be closely matched. So also should R_4 and R_7. The value for R_8 depends upon the voltage gain given by triode V_3. If V_3 has an amplification factor around 100 (as specified in the valve tables) then R_8 may be matched to the same value as R_4 and R_7. In practice it will be difficult to match the resistors exactly, whereupon R_8 should be the resistor having the greatest value. If V_3 has an amplification factor around 60, the ratio $R_4 : R_8$ (or $R_7 : R_8$) should be approximately 1 : 1.1. When V_3 has an amplification factor around 20 the ratio $R_4 : R_8$ should be approximately 1 : 1.2. Intermediate values of amplification factor in V_3 will require roughly proportionate intermediate ratios of $R_4 : R_8$.

The component values shown in Fig. 7 (*a*) are "conventional" and will be those found in most sets examined. So long as the matching between the various resistors just discussed is maintained, existing values which do not differ greatly from those shown in Fig. 7 (*a*) may be retained in the modified circuit.

If the original circuit had n.f.b. applied to one valve or overall, this should be removed before commencing the modification. Overall feedback from the transformer secondary to the grid or cathode circuit of V_1 may be added to the push-pull circuit (using an arrangement similar to that shown in Fig. 5 (*b*)) after completion.

Can Anyone Help?

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

B. GOWER, 21 Bismark Street, Leeds 11, wonders if any reader can help him to obtain the circuit and constructional details of a stroboscope?

* * *

H. TALBOT, 2 Rye Errish Cotts, Beaulieu, Brockenhurst, Hants, is in need of a point-to-point wiring diagram of an a.c./d.c. 7 or 8 valve S.W. receiver, for which he is willing to swop 25 old copies of *Radio Constructor*, one copy *Inexpensive Television*, and two volumes *Radio and Television Servicing*.

* * *

D. R. LETT, 24 Dodge Street, Liverpool 7, Lancs, wishes to obtain details of the R.1155 coil pack.

* * *

G. A. DAWE, 19 Coy Ranby (R.A.S.C.), Retford, Notts., wishes to borrow or buy a copy of the November '55 issue of *The Radio Constructor*, and would also like to hear from anyone who has usefully converted the Canadian 19 Set Mk. II.

* * *

M. OSBORNE, 24 Randolph Crescent, London, W.9, would like to obtain any data or manuals of the Eddystone 358X (B34) receiver, or advice from any reader who has operated a similar model.

P. R. CHEETHAM, 30 Waverhill Road, Handsworth, Birmingham 21, would like to buy or borrow the manual or circuit diagram of the Air Ministry Oscilloscope type 7 (10SB/102).

* * *

D. BAILEY, 111 Hatherop Road, Hampton, Middx, Molesey 6527, wishes to borrow or purchase the manual of the Oscilloscope type 11, ref. 10S/562, or to know the valve line-up.

* * *

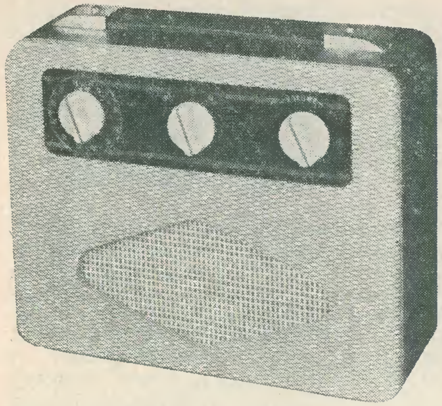
F. W. HATTEMORE, 20 Baroness Place Penarth, Glamorgan, wishes to learn where he can obtain a tuning scale for the Eddystone 358X receiver. Letters to regular advertisers have brought negative results.

* * *

E. L. SIMPSON, 4 Beacon Square, Fell Lane, Penrith, Cumberland, wishes to buy or borrow any manuals on the Pye communications receiver (P.C.R.) using both EL31 and 6V6 output.

* * *

A. NELSON-SMITH, 34 Grove Lane, Camberwell, London, S.E.5, wishes to obtain the circuit or service data of the Philips TG.704A television receiver.



TRANSISTOR EIGHT PORTABLE SUPERHET

designed by S. NEAGLE (Henry's Radio Ltd.)

This article describes a portable battery superhet capable of exceptionally high sensitivity and selectivity. The receiver employs a push-pull output stage, and functions both on the long and the medium wave band

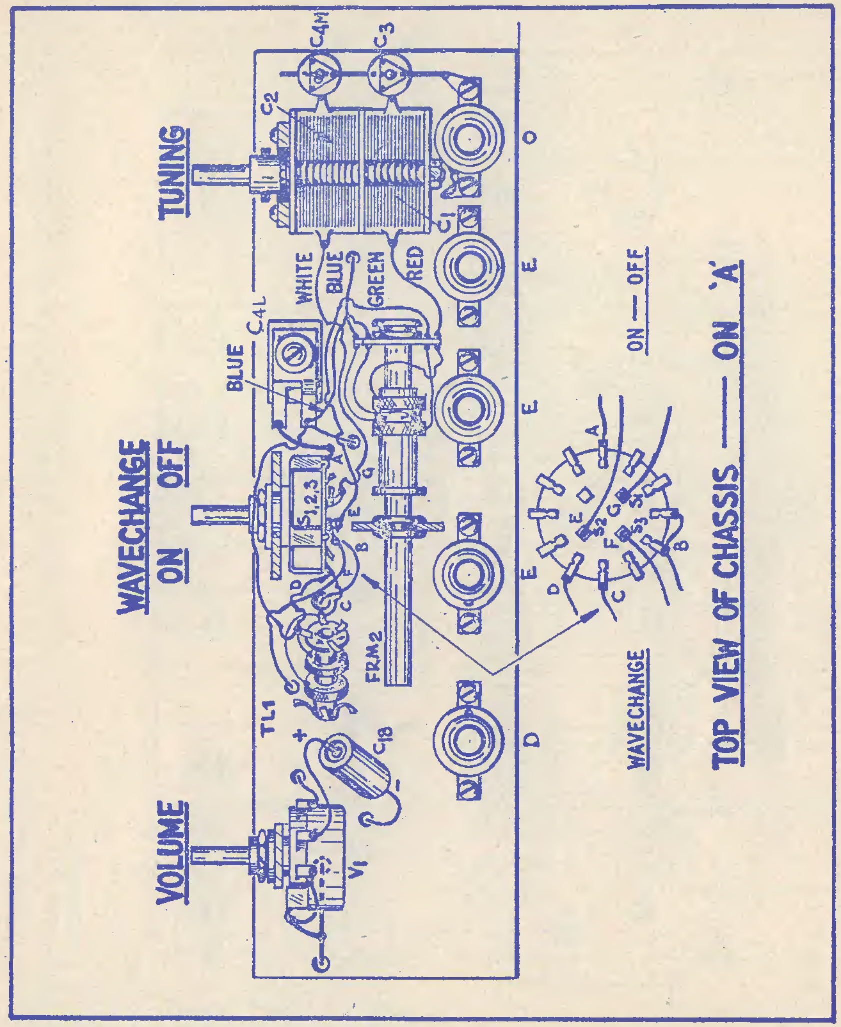
Amateur-built transistor receivers are, at present, proving to be an extremely popular subject for home-constructor interest. As readers will be aware a number of very successful transistor circuits have already been described in *The Radio Constructor*, and many receivers have been built to their published designs. The set discussed in this article is the latest and most comprehensive that has yet been offered, and it makes a worthy successor to the models which have preceded it. The present receiver could quite truthfully be described as meeting a "de-luxe" specification, insofar that it is completely portable, has excellent selectivity and sensitivity, gives a very adequate high-level audio output of 250mW, and is capable of providing reception both on medium *and* long waves. Despite these advantages the set does not raise any difficulties from the constructional point of view, its assembly being similar in nature to previous superhet designs. A single 7.5-volt battery is all that is required in the way of h.t. supplies, and the use of a class B output stage assists in ensuring battery economy.

A minor snag which occurs with many amateur receiver designs is overcome in this particular case by the fact that an attractive rexine-covered cabinet, especially designed for the chassis, is available to constructors. A view of this cabinet is given in the photographs which accompany this article, whereupon it may be seen that it presents an extremely pleasing appearance with modern, contemporary styling. A ready-drilled plastic chassis is also available as are a set of knobs and engraved panel which set off the cabinet colour scheme. All components and details for the receiver are being distributed by Henry's Radio Ltd., of Harrow Road, London, W.2.

The Circuit

The complete circuit of the 8-transistor superhet is illustrated in Fig. 1. Examining this diagram, it may be observed that the circuit is somewhat more extensive than those of previous designs, the more obvious features being the high-gain i.f. strip and the dual-range frequency changer stage.

It would be advantageous to describe the functioning of the circuit by commencing at



The wire marked "White" running from front section of 2-gang should be deleted, and instead a wire should be taken from "G" on switch to tag 1 on oscillator coil

this frequency changer stage. The signal frequency tuned circuit employed in this part of the receiver is provided by the ferrite frame coil L_1, this being tuned by C_1 (one section of the 2-gang condenser) and the trimmer C_3. A secondary winding, L_2, is fitted to the ferrite frame, this giving the requisite low impedance coupling required by the first transistor TR_1. L_2 connects effectively to the base and emitter of this transistor. The ferrite frame coil, L_1, is employed as a single tuned winding when medium wave reception is desired. For long wave reception, S_1 causes the long wave loading coil L_3 to be brought into circuit, whereupon the additional inductance inserted into the aerial tuned circuit enables this band to be covered.

Transistor TR_1 is the frequency changer. The particular transistor specified for this position is a "white-spot" type, this type being especially capable of functioning efficiently at the frequencies involved. The frequency changer oscillator coil is provided by L_4, L_5; L_4 being the tuned winding and L_5 the coupling winding. The mode of operation is quite straightforward, feedback from the collector to the emitter of TR_1 being maintained by normal inductive coupling between the two windings. The emitter of TR_1 is tapped into a portion of L_4 in order to pro-

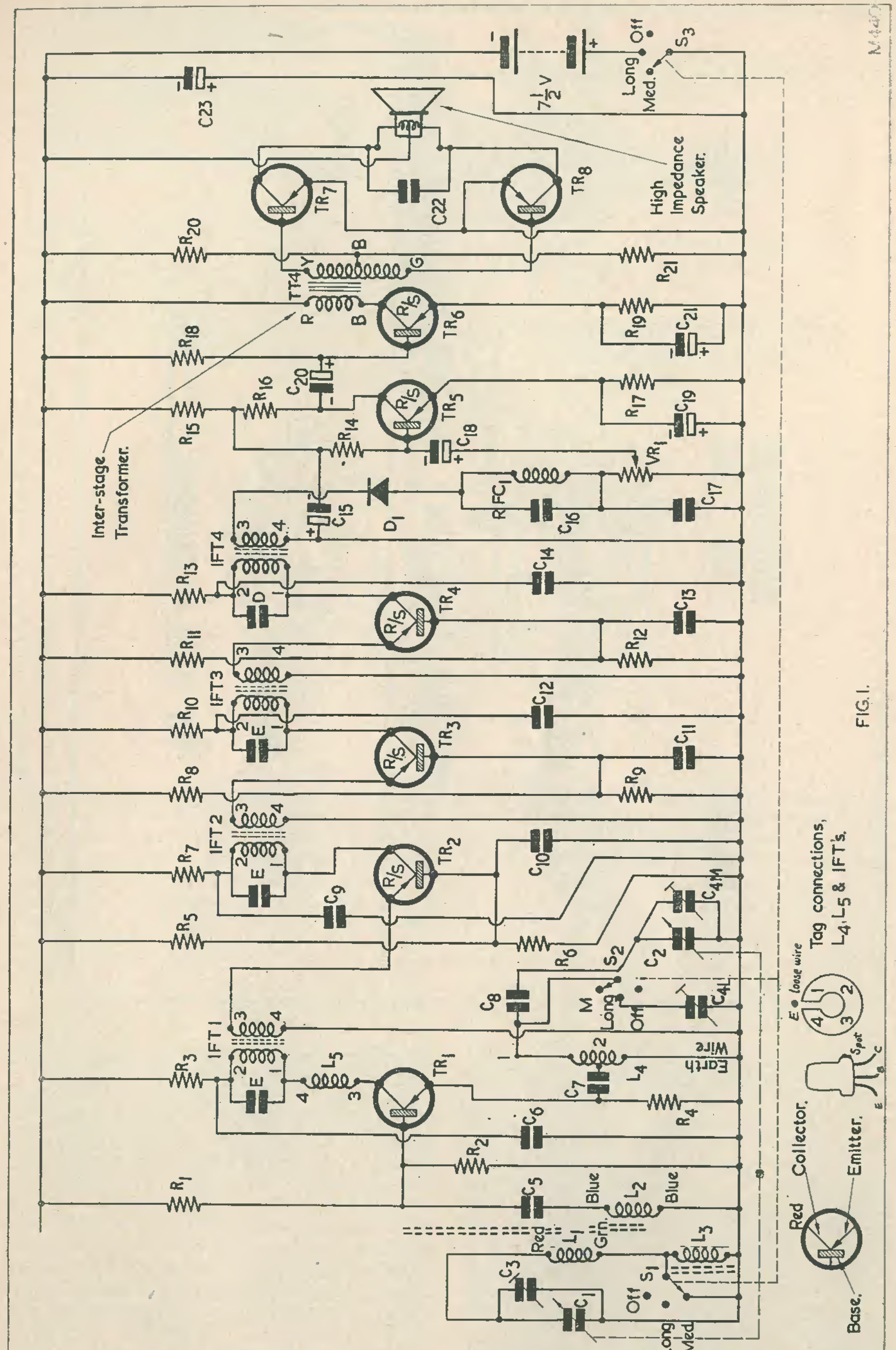


FIG. 1.

vide a low impedance connection. On medium waves L_4 is tuned by the remaining half of the 2-gang condenser, C_2, in parallel with trimmer C_{4M}. On the long wave band additional capacity is given by C_{4L}, this component being connected across the coil by means of S_2. C_{4L} is a multi-leaf compression trimmer having a range of 150 to 700pF. Padding on both medium and long waves is provided by the series fixed condenser C_8.

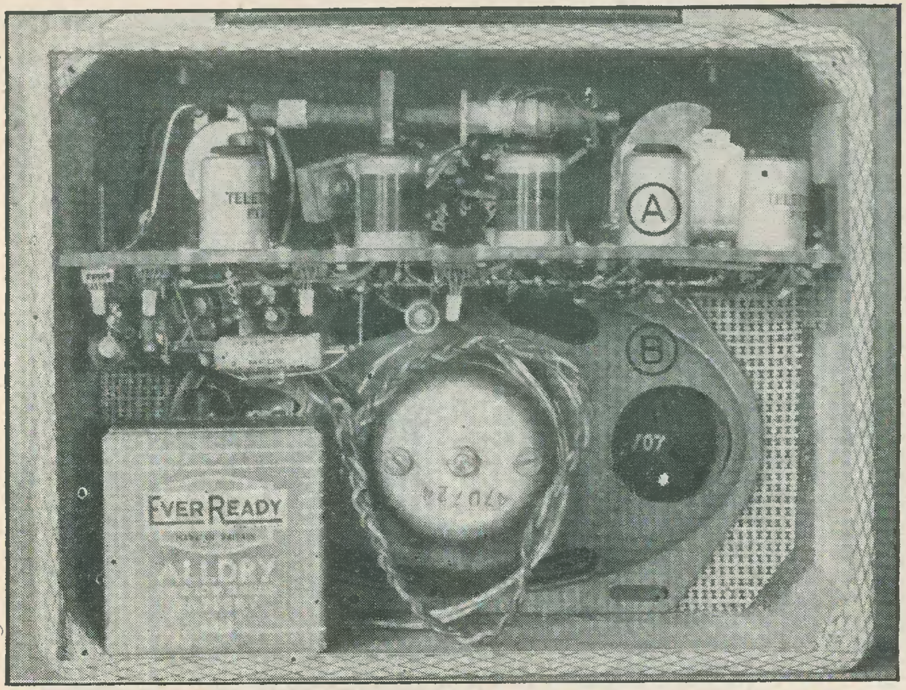
The output of the frequency changer transistor is applied to the first i.f. transformer IFT_1, and thence to the remainder of the i.f. strip. Three "red-spot" transistors, TR_2, TR_3 and TR_4 are employed in the i.f. strip, these being connected in the earthed base mode. The reason for using earthed base amplifiers here is that this method of connection offers more stable operation at the intermediate frequency than does the earthed emitter mode. Although individual stage gains may be slightly less with earthed base transistors, the overall gain and sensitivity are much superior with a three-transistor i.f. strip of this type than with a two-stage earthed emitter strip. The i.f. amplifier employs conventional circuit design, the collector load of each transistor being decoupled from the h.t. line by its own individual condenser and resistor. Bias is provided by fixed resistor potentiometers connected across the h.t. supply. The intermediate frequency is 315 kc/s.

Detector and A.F. Stages

The final transformer of the i.f. amplifier, IFT_4, feeds into the crystal diode D_1. An OA74 is desirable in this position, in order to provide optimum detection efficiency with the necessarily low-value diode load, VR_1. Detection efficiency is further increased by the use of an r.f. choke, RFC_1, in place of the filter resistor normally fitted in this position. The low impedance presented to a.f. by the r.f. choke ensures that maximum detected signal is developed across VR_1. VR_1

Component List—set out for easy reference to Fig. 1

Resistors	
R_1	1MΩ
R_2	220kΩ
R_3	2.2kΩ
R_4	1kΩ
R_5	1MΩ
R_6	50kΩ
R_7	1kΩ
R_8	100kΩ
R_9	50kΩ
R_{10}	1kΩ
R_{11}	1MΩ
R_{12}	50kΩ
R_{13}	1kΩ
R_{14}	2.2MΩ
R_{15}	470Ω
R_{16}	3.3kΩ
R_{17}	470Ω
R_{18}	2.2MΩ
R_{19}	1kΩ
R_{20}	6.8kΩ
R_{21}	180Ω
VR_1	25kΩ, volume control
Condensers	
C_1, C_2	365pF, 2-gang
C_3, C_{4M}	30pF max., trimmers
C_5	0.001μF
C_6, C_7	0.01μF
C_8	0.001μF
C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}	0.01μF
C_{15}	2μF
C_{16}, C_{17}	0.01μF
C_{18}	5μF
C_{19}	2μF
C_{20}, C_{21}	25μF
C_{22}	0.5μF
C_{23}	5μF
C_{4L}	150–700pF, trimmer
Transistors	
TR_1	White spot
TR_2–TR_6	Red Spot
TR_7, TR_8	Red-Green, or OC72
Intervalve Transformer	
TT4	Repanco
Speaker	
Elac elliptical 7in × 4in high impedance voice coil	
Diode	
D_1	OA74
Coils	
L_1, L_2	Ferrite frame type FRM2. Teletron
L_3	Long wave loading coil type TL1. Teletron
L_4, L_5	Oscillator coil type FTO2. Teletron
IFT_1, IFT_2, IFT_3	I.F. transformer type FT3E. Teletron
IFT_4	I.F. transformer type FT3D. Teletron
RFC_1	R.F. choke. Henry's Radio
Miscellaneous	
Cabinet, knobs, and ready-drilled chassis. Henry's Radio	
1 3-pole 3-way miniature wave-change switch. Henry's Radio	
8 Transistor holders. Henry's Radio	
1 7.5-volt battery, type AD38. Ever-Ready	
1 battery plug	



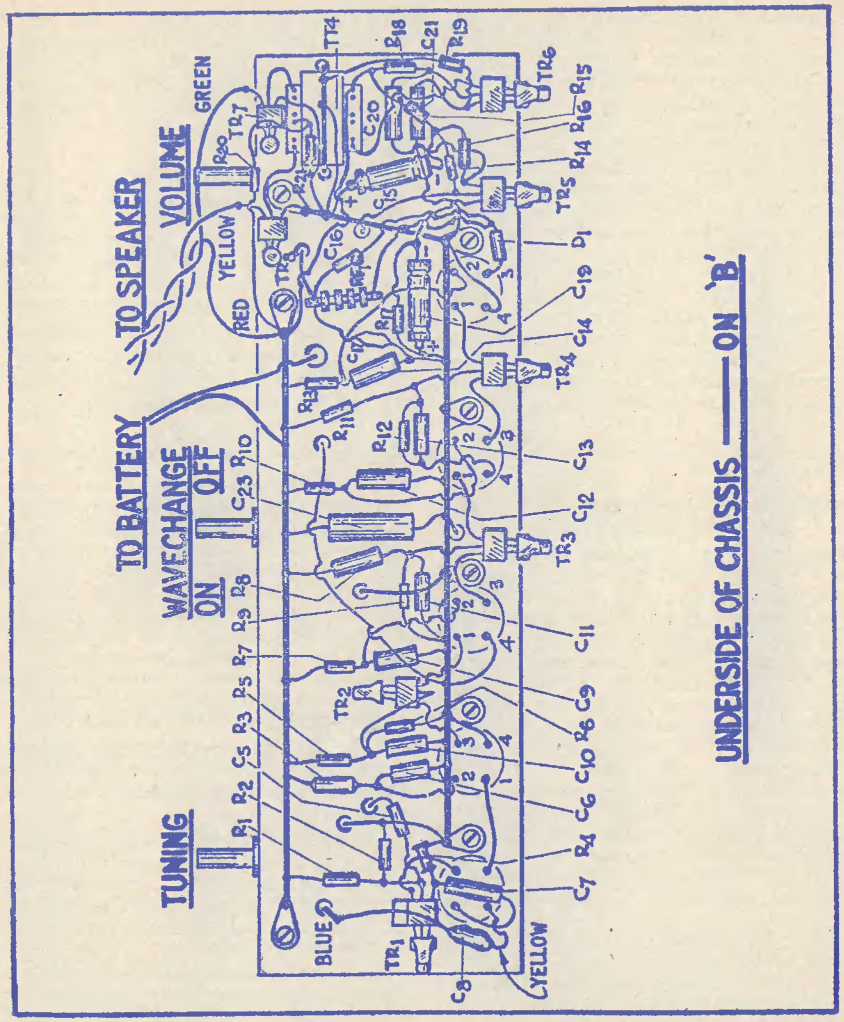
Rear view showing method of assembly in cabinet

functions also as the volume control, the signal tapped off by its slider being passed to the first a.f. amplifier, TR_5, via C_{18}.

TR_5 operates in the usual fashion, its collector circuit being decoupled by R_{15} and C_{15}, and its output being applied to the driver transistor, TR_6, via condenser C_{20}. Like TR_5, TR_6 functions as an earthed emitter amplifier, and its output is applied, in its turn, to the interstage a.f. transformer. The centre-tapped secondary of this transformer couples into the bases of the two push-pull, class B, output transistors TR_7 and TR_8, which then feed finally into the centre-tapped high impedance voice coil of the loudspeaker. The direct connection to the loudspeaker voice coil obviates the necessity for an output transformer, and also ensures that minimum power wastage occurs. "Red-green" transistors are required for the TR_7 and TR_8 positions, these providing an output level which should be more than adequate for any normal purposes. If desired, OC72's can be employed instead of the "red-green" transistors, with the result that an even higher output level will be realised. Use of the OC72's does not incur any alterations to the circuit or to component values as they may be connected directly in place of the "red-green" types. The OC72's are, however, rather more expensive.

Construction

The construction of the receiver is quite simple to carry out, and layout diagrams are given in Figs. 2 and 3. As was stated earlier, a ready-drilled plastic chassis is available and this will assist in ensuring that the various components are positioned accurately. In order to make certain that all applicable components are reliably earthed, an h.t. positive bus-bar wire runs along most of the length of the chassis. All coil cans are earthed to this wire via their mounting screws. A somewhat shorter h.t. negative bus-bar wire also runs along part of the chassis, the appropriate components being soldered to this wire at the points indicated in Fig. 2. Both the h.t. positive and negative bus-bars need to be made with relatively heavy-gauge tinned copper wire (16–18 s.w.g.) in order to obtain rigidity and low circuit resistance, and it is advisable to slightly pre-stretch the wire used before fitting it to the chasis. Pre-stretching the wire causes it to be free from kinks and less liable to bend or sag during wiring. It



must be emphasised that all earth connections made to the h.t. positive wire need to be carefully and reliably made, as this wire carries out the function normally given by a complete metal chassis. In Fig. 2 the h.t. positive wire is shown as terminating at a solder tag positioned between TR_8 and TR_7. It is possible that the constructor may obtain a later version of the interstage transformer (designated "TT4" in Fig. 2), which is fitted with a shroud, whereupon one of the screws holding this shroud to the chassis may also secure—in a slightly different position—the solder tag just mentioned.

Above chassis, the two trimmers C_3 and C_{4M} are soldered to a short length of heavy-gauge tinned copper wire of the same type as that used for the h.t. bus-bars. The method of mounting these trimmers is clearly visible in Fig. 3. Also mounted above the chassis is the ferrite frame aerial. It is advisable to make the mounting and wiring of the ferrite frame the last process in the whole assembly as, otherwise, its windings may become damaged whilst the chassis is handled during construction.

In order to avoid the risk of overheating the transistors if soldered connections were employed, suitable holders are available for this receiver. These holders may be secured to the chassis by means of Perspex cement, and it will be found that a saving in space may be achieved at some positions by removing their securing flanges. To obviate the possibility of accidentally inserting transistors into their holders the wrong way round after assembly, it would be worth-while applying appropriate markings to the holders when they have been connected into circuit. The transistors should be fitted into the holders such that they hang downwards from the underside of the chassis, thereby clearing the inside walls of the cabinet and its back.

Alignment of the receiver follows conventional practice, the i.f. transformers being adjusted first, followed by the oscillator and r.f. coils. The oscillator and r.f. circuits should be primarily set up with the receiver switched to medium waves, final alignment being carried out on the long wave band. The trimming process includes setting up the sliding coil on the ferrite frame rod, the optimum position for this coil being approximately 1.5in from the end. A signal generator will be of assistance during alignment, although this process may also be carried out quite successfully with the aid of received signals.

A final point is concerned with the long wave loading coil, L_3. It has been found that increased sensitivity on the long wave band may be obtained in some instances by shunting this coil with an additional 150–700pF trimmer of the type used in the C_{4L} position. The trimmer is, of course, adjusted to provide maximum gain. If, therefore, an increase in long wave sensitivity is desired, it may be found that this may be attained with the use of a trimmer of this type.

BIRMINGHAM JAMBOREE WILL GO OUT ON SHORTWAVE

Amateur radio enthusiasts all over the world will be hearing unusual messages coming over the air during August this year.

That is the month when 37,000 scouts from 86 different countries, including Russia and Hungary, meet at Sutton Park, near Birmingham, for the World Scout Jamboree. The Jamboree celebrates both the Golden Jubilee of the movement, and also the birthday centenary of its founder, Baden-Powell.

The unusual messages that will be heard will come from a special amateur radio station which the Slade Radio Society of Erdington, Birmingham, are setting up at the Jamboree. During the Jamboree the radio station will transmit goodwill messages to owners of shortwave sets throughout the globe.

One of the men who will be operating the station is Mr. Arthur Goble, of 150 Trinity Road, Aston, Birmingham, who works for British Oxygen Gases Ltd. Says Mr. Goble: "We hope to man the station day and night, and we want to contact as many people as possible over the air to tell them about the Jamboree."

BRITISH T.V. CELEBRATES 21 YEARS' PROGRESS

Radio Show will mark World's First Service

Five thousand visitors from more than 120 countries are expected at the National Radio Show, Earls Court, London, which takes place this year from Wednesday, August 28, to Saturday, September 7, with a pre-view for trade, press and overseas visitors on Tuesday, August 27.

This, the 24th National Show organised by the manufacturers, will celebrate the 21st anniversary of the start of the world's first high-definition television service, which was from the Radio Show (then known as "Radiolympia") on August 26, 1936. Some of those who took part in the first B.B.C. broadcast will appear in anniversary programmes, reminding viewers that Great Britain was the pioneer in this, as in many other branches of radio and electronics.

The B.B.C. will operate from a large studio specially constructed for the Exhibition and using all the latest techniques in camera and studio control.

Commercial television will, for the first time, play a major part in the Exhibition, the independent programme companies pooling their resources to give from their own arena performances by their stars practically non-stop for 10 hours daily.

More than 100 manufacturers, including all the leading makers of radio and television sets and sound reproducing and recording equipment will show their latest models.

Many new designs of television receivers will be seen, including more portable or transportable sets, and radio sets will include transistorised models only a little more than 2lb in weight.

The Radio Industry Council, organisers of the Exhibition, will demonstrate in full public view the simultaneous control of two different television programmes. Technicians, programme officers and announcers will be seen at work behind glass walls.

The Royal Air Force and the General Post Office are among exhibitors. The Exhibition is to be opened by Lord Brabazon. H.M. The Queen is Patron.

BOOK REVIEWS

BOOK REVIEWS

COPYRIGHT IN SOUND RECORDINGS. By Peter Ford, LL.B. (Hons), F.R.S.A. 10 pages. Published by The British Sound Recording Association, 3 Coombe Gardens, New Malden, Surrey. Price 1s. 0d., postage 2d.

Revised and reprinted from an article which appeared in the February 1957 issue of the Association's official journal, this small booklet sets out briefly and in plain language some of the points in the Copyright Act, 1956, and shows how new legislation differs in some ways from the earlier Acts. It fulfils its function of being a handy guide but no more, as is to be expected in a short treatise on a lengthy subject. This booklet should appeal to those who make and reproduce recordings, both tape and disc.

TRANSISTORS WORK LIKE THIS. By Egon Larsen. 64 pages, 56 diagrams and illustrations Published by Phoenix House Ltd., 38 William IV Street, Charing Cross, London, W.C.2. Price 9s. 6d.

When one reads on the jacket of this book that it is for Young People, one could, perhaps, be excused for assuming the contents to be no more than a story. In a sense it is written in this way, for it traces the development of the transistor from the crystal detector to the present-day version of semi-conductor technique. Young people are not the only ones who could improve their knowledge by reading the book, for it appears to be of value to those who are not fully matured in matters radio. On the other hand, all who are in this embryo stage would need to have means of understanding many of the technical terms used, and one is left with the impression that the young people, of undefined ages, would almost of necessity have to be child prodigies in order fully to comprehend some of the text.

Nevertheless, the author can hardly simplify a rather deep technical subject by using words of one syllable, nor can he escape the need to use proper terms. On the whole, the text achieves its aim to describe simply the theory of operation of transistors, their uses, and possible future development.

The penultimate chapter describes the construction of a transistor radio receiver which could be undertaken by anyone with no previous knowledge of the subject.

HI-FI YEAR BOOK, 1957 Edition. Edited by Miles Henslow. 208 pages, 291 diagrams and illustrations. Published by Miles Henslow Publications Ltd., 99 Mortimer Street, London, W.1. Price 10s. 6d.

Although 60 pages at the end of this book are devoted entirely to manufacturers' advertisements, there is a fair amount of useful technical reading in the remainder. Ten authors contribute articles on subjects in which they are recognised authorities. These short articles are essentially factual, designed to impart simple information rather than technical theory. They provide a useful short cut to quality reception and reproduction for those who are interested mainly in listening, since the technical types are well catered for elsewhere.

The major part of the book is, naturally enough, given over to directories of hi-fi equipment; it covers pick-ups and arms, amplifiers and control units, radio tuners (a.m. and f.m.), f.m. aerials, motor units, tape recorders and amplifiers, stereo equipment, microphones, speakers and cabinets, and components for home constructors. There is a considerable amount of material in these directories, and they are particularly well illustrated.

PORTABLE ELECTRIC TOOLS. By H. Banus. 150 pages, 72 illustrations. Published by George Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 15s. 0d.

The home handyman will find this book of considerable value, no matter where his interests lie. The portable electric power tool has reached such a stage of development that it can replace many conventional hand tools and operations. Numerous accessories enable difficult or tedious tasks to be undertaken with ease and speed, and in many cases produce superior results.

The author describes the various power tools and their accessories very clearly. He also explains in detail the operations that can be performed with them, and the proper way of doing so. Particular emphasis is placed on care and maintenance of tools. It is also good to see that safety precautions are so strongly stressed, for mechanical and electrical hazards could be dangerous to life and limb if due regard is not paid to them.

One chapter is devoted to descriptions of various timbers, their working properties, and uses. Another gives working instructions and plans for several items of household furniture and fitments, and some toys. A few useful tables and an index are included.

Although this notice says there are 72 illustrations, there are many more, in fact, for a considerable number of diagrams and plans have not been included in the count. The publishers declare more than 160 illustrations, which is true if everything apart from photographs is accounted for.

INDUSTRIAL RECTIFYING TUBES. By Members of Philips Electron Tube Division. 126 pages, 100 diagrams and illustrations. Obtainable from The Cleaver Hume Press Ltd., 31 Wrights Lane, Kensington, London, W.8. Price 15s. 0d.

This is the latest addition to the Philips Technical Library, being Book XIII in the series on electron tubes. As with others in the range, this text book not only gives full data of several tubes; it also provides a great deal of design data for equipment in which the valves can be used.

The first chapter defines basic principles of operation, construction, tube life, efficiency, installation and ratings. In the second chapter the design of battery chargers is discussed at some length, covering simple bi-phase circuits to multi-phase rectification. This data also deals with the design of suitable mains transformers, and current-limiting chokes for both primary and secondary sides of the transformer. The worked examples for typical battery charger designs are clearly explained, and should prove valuable in formulating designs for other requirements.

Chapter 3 covers the use of rectifiers for the wider application of industrial purposes, such as magnetic chucks, small d.c. motors, electromagnets, power station auxiliaries, etc. There are discussions on rectifiers for outputs less than, or more than, 220V. Suitable circuit designs are presented for such purposes. A useful feature of this chapter is the section on rectifiers operated without mains transformers. There is also some information on the use of auto-transformers.

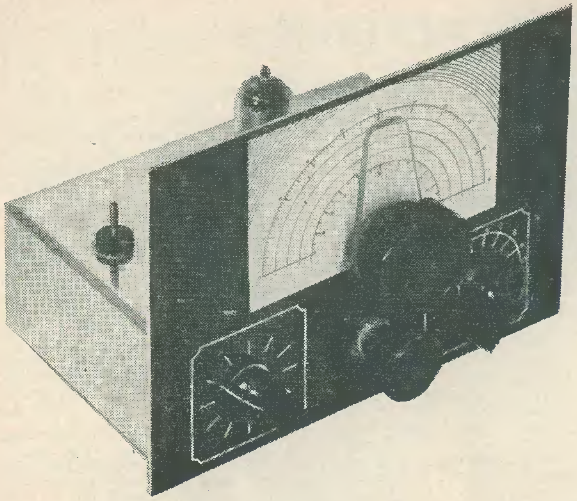
The fourth and fifth chapters are devoted respectively to cinema rectifiers and welding rectifiers. They are both rather short, that on welding being little more than a brief note, but suitable design data is to be found in the earlier chapters.

In the next forty pages or so are given descriptions and data for eighteen different rectifying tubes. There are additional notes on ignition units (for use with tubes having ignition electrodes), barretters, and bi-metal delay tubes. The tube selection chart at the end of the book is particularly ingenious and informative; with it, one can select a suitable tube for a particular purpose in a matter of seconds.

Although the book is not large, the adherence to brevity in the text has produced a volume with a size/utility ratio of a fairly high order. The only error noticed is trivial, the caption to Fig. 57 giving the tube type as 467 instead of 367.

If the writer of this review can be allowed a personal note, it can be stated from actual experience that the average tube life claimed in the book of 10,000 hours minimum and five to six years operation under proper conditions can be realised in practice. A type 367 rectifying tube was used some 25 years ago; this ran continuously for nearly three years under conditions which were not ideal, yet even after this representative 25,000 hours operation the tube was still up to standard when taken out of service.

W. E. Thompson



WORLD-WIDE RECEPTION with the

Beginner's Short Wave Receiver

by E. GOVIER

FOR MANY DYED-IN-THE-WOOL RADIO enthusiasts, the first delights of early days were those of constructing one's own single valve receiver, getting it to work satisfactorily, and listening to those stations which abound on the short waves. This is probably also true of to-day's beginners, as the demand for simple, inexpensive, and easy to construct receivers seems to be as high as ever it was in the past.

With the design now offered in the pages that follow, certain limitations have been observed. Proffered as it is for the beginner, the circuit has been kept as simple as possible, consistent with reasonable results and minimum outlay of cash—always a deciding factor with the young and budding enthusiast. All the components used are currently available on the market from advertisers in this journal, and no trouble should be experienced in this respect.

For the intending constructor, about to build his first receiver, it should be mentioned here that the results achieved will depend in no small measure on the aerial that is to be used with this receiver.

In order to avoid the possibility of errors, the wiring of the receiver is described stage by stage, so that even the veriest beginner should have little difficulty in building this little one-valve receiver.

Circuit

This is shown in Fig. 1, and from this it will be seen that it is an "economy" circuit in that only the barest essentials, consistent with reasonable results, have been incorporated into the design.

The inset to Fig. 1 contains details of the coil connections. The circuit is that of a simple leaky grid detector incorporating two coils (Osmor Type SWQ1 and SWQ2) which are switched from the front panel by means of the Yaxley type switch. The frequency coverage of these coils is from 31 to 11 Mc/s and 12 to 4.5 Mc/s with a nominal 150pF variable condenser. With the circuit as shown, with its additional bandspread condenser and stray capacities, the coverage is somewhat different—as may be expected. The coils have adjustable iron dust cores and this will not only affect the reaction obtainable at various positions of the variable condensers, but will also vary the coverage somewhat according to their position. The frequency range, as measured with the prototype receiver, was 21.0 to 9.6 Mc/s and 11.2 to 4.7 Mc/s approximately.

C_1 is the bandsetting condenser, while C_2 is the bandspread condenser. For best results these should be of the type specified, as they are of heavy silver-plated brass, rigid and dependable in operation. The grid condenser C_4 is of the ceramic type and this, together with R_1, has a value chosen to provide a time constant which will, with the other circuit values, produce positive feedback or reaction free from overlap or backlash. This is important if maximum sensitivity is to be obtained from the receiver.

The valve chosen to operate as the detector is the well-known 1T4 miniature variable-mu r.f. pentode, this being available both on the new and the surplus market at the present time. For those who may already have some valves on hand of the 1.4V filament type, the following types are direct equivalents, and the substitution of any one of these for the 1T4 specified will not require any alteration with regard to circuit values. The equivalents are: Mullard DF91, Osram W17, and Mazda 1F3. The numbers shown around the valve in Fig. 1 refer to the actual pin numbers of the valve base.

Reaction is obtained by positive feedback, this being controlled by the variable condenser C_3, sometimes called the "throttle" control. R_2 is the anode load, and R_3, together with C_5, ensures that the screen grid operates at maximum efficiency under the conditions imposed by the remainder of the circuit.

The phones are inserted into the h.t.+ line. Power supplies are obtained from an Ever-Ready type B103 90V h.t. plus 1.4V l.t. dry battery.

Physical Layout

The physical layout of both the chassis and the panel may be seen, at a glance, from the photographs and from Fig. 2, the front panel, and Fig. 3, the chassis deck and backdrop.

The first item to be drilled is the panel, and the required measurements for this are shown in the drawing. Should the beginner not have the facilities for drilling holes of the required diameter, the largest sized drill to hand should be used and the hole enlarged with a small round file. An "Abrafile" is ideal for this purpose. Once the front panel has been completed as shown in Fig. 2, the

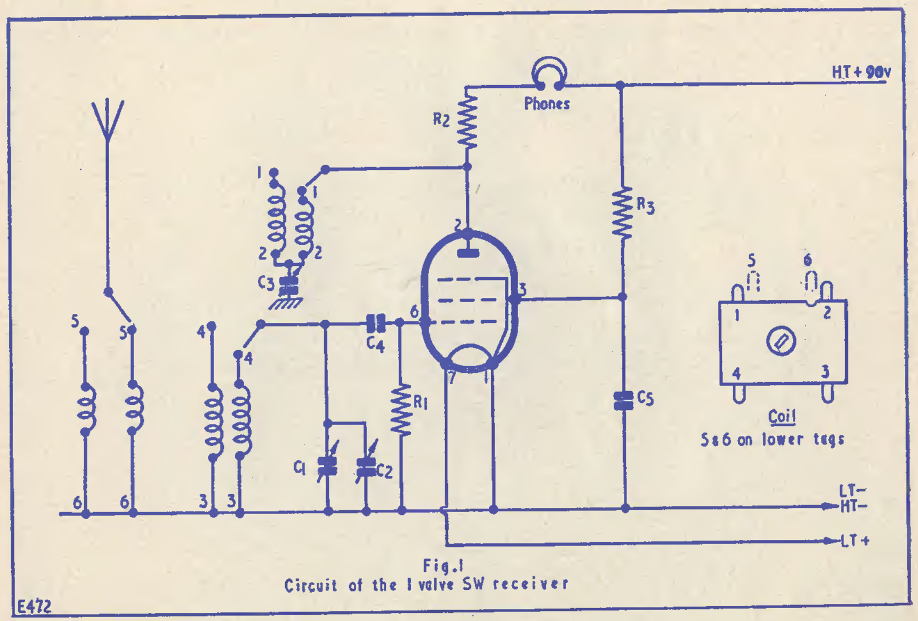


Fig. 1
Circuit of the 1 valve SW receiver

Component List

R_1 2MΩ ⅛ watt
R_2 10kΩ ½ watt
R_3 22kΩ ½ watt
C_1 140pF variable, Eddystone type 586
C_2 25pF variable (Home Radio)
C_3 100pF variable, Eddystone type 585
C_4 100pF ceramic (Home Radio)
C_5 0.1μF, TCC type CP45N
Battery—Ever-Ready type B103
Headphones—2000Ω
Coils—Osmor types SWQ1, SWQ2
Wavechange switch—Yaxley type, 3-pole, 2-way
Aerial/Earth socket, etc.
Chassis—6in × 4in × 2in—H. L. Smith & Co. Ltd.
Panel—7in × 5in—H. L. Smith & Co. Ltd.
Knobs—H. L. Smith & Co. Ltd.
Valve—Brimar 1T4, with McMurdo holder
Grommets
Panel-Signs—Set No. 1

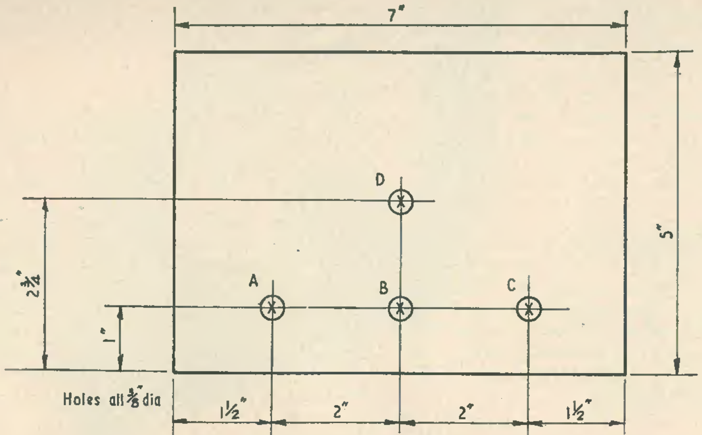


Fig.2
Front panel details

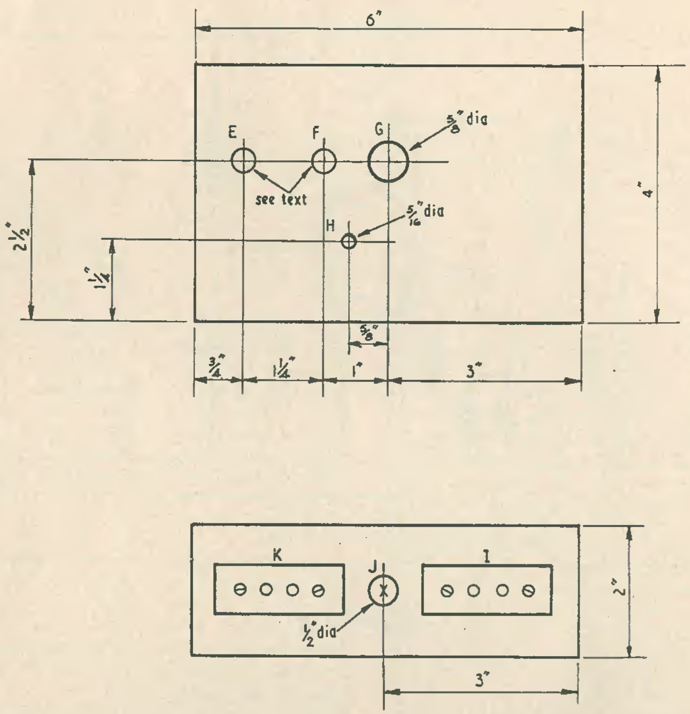


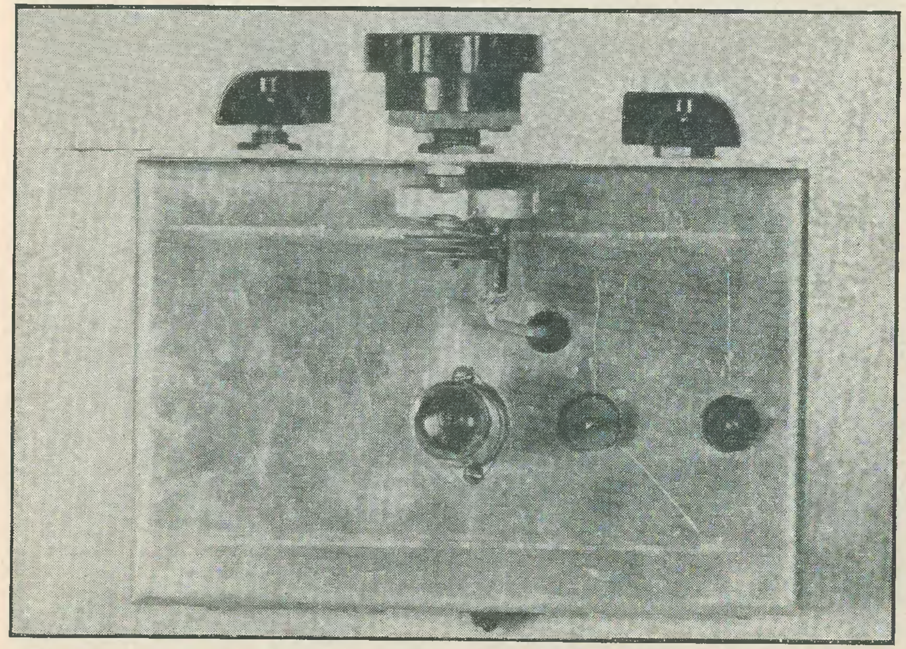
Fig.3
Chassis & backdrop

E473

lower three holes (A, B and C) should then be used as a template for the front-drop of the chassis. In this manner both the panel and the chassis holes will coincide once these two are fixed together.

Next, the chassis deck should be tackled. Measurements for this are given in Fig. 3. Note should be made here of the fact that, in the prototype, holes have been drilled through the chassis into which the coil bodies have been force fitted. Some constructors, however, may prefer to mount these two coils on a Paxolin strip and mount this strip to the chassis wall by means of stand-off insulators. If this latter method is adopted, then clearly a slightly different layout will be required. The holes E and F are those for the coils, G that for the valveholder, and H is that to which the small rubber grommet is fitted at a later stage.

the tuning condenser (hole C). Next, secure into position the small bandspread condenser (hole D). A glance at the photographs and diagrams will clarify the foregoing. Having completed this, mount the valveholder and the coils. Dealing with the valveholder first, ensure that this is mounted correctly positioned, with pin 1 furthest from the coil, and pin 5 nearest to the coil. The coils should now be force fitted into position. Note how these are oriented from the under chassis photograph. The last stage of assembly is the mounting of the Paxolin strips on the backdrop. Care should be taken when mounting these that none of the female sockets make any contact at all with the chassis itself; this is very important. Having placed these into position, note that in each case the screw nearest the centre of the chassis backdrop has an earth tag fitted to it.



Above-chassis Component Layout

The chassis backdrop contains the aerial and earth Paxolin strip (I), the large rubber grommet for the power input lines (J) and a further Paxolin strip for the headphones (K).

Having drilled both the chassis and front panel, we now proceed with the assembly work. Fix the panel and chassis together by securing into position the wavechange switch (hole A), the reaction condenser (hole B) and

The rubber grommets should now be placed into position both on the chassis deck and backdrop. This completes the assembly work and the next stage is the wiring up of the circuit.

Wiring the Circuit

The best plan here is to commence with the power input leads, but before doing so, the beginner should have the circuit diagram before him so that as each wire, or component, is soldered into position, the appropriate portion of the diagram may be inked in or crossed out according to preference in method.

The h.t.+ lead should be soldered on to that tag of the headphone Paxolin strip nearest the centre of the chassis; the lead should be about 12 inches in length (as with all the other leads connected to the battery). The l.t.+ lead should now be soldered to pin 7 of the valve base. The h.t.— and l.t.— leads should now be soldered to that earthed tag on the chassis backdrop nearest the headphone strip. Note here that only one lead is required for both the h.t.— and the l.t.— power connections. The other end of this particular lead should be connected to both the h.t.— and l.t.— connections on the battery at the appropriate time. Having completed the foregoing, feed all the power leads through the rubber grommet on the backdrop.

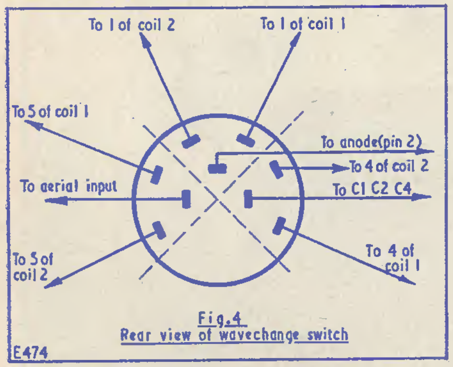


Fig. 4
Rear view of wavechange switch

From the right-hand tag of the headphone strip (looking at the underside of the chassis) * solder one end of both R_2 and R_3, ensuring before so doing that both of the wires supporting these resistors are cut to the correct length and thoroughly tinned before soldering finally into position. The other end of R_2 should now be connected to pin 2 of the valveholder, and the other end of R_3 to pin 3 of the valveholder. To pin 3 of the valveholder also solder one wire of C_5, the other end of which should be soldered to that earthed tag mounted with the aerial and earth strip. Note that the condenser should be correctly wired into position, with that end having a coloured line around it being soldered to the chassis.

From the earthed tag to which the h.t.—/l.t.— lead has been soldered, connect a short length of bare wire to the central spigot of the valveholder, and from there to pin 1 of the holder. Pins 4 and 5 of the valveholder are left blank. To pin 6 solder one end of R_1, the other wire of which should now be connected to pin 1. To pin 6 also solder one end of C_4, the other end of which should be soldered to the wavechange switch (see Fig. 4 for all wavechange switch connections).

From the earthed solder tag mounted with the aerial and earth strip, solder a length of bare wire to tag 3 of both coils (see Fig. 1). Next, connect a short length of wire from tag 3 of each coil and connect the other end to tag 6 of each coil. Solder tag 4 of each coil to the wavechange switch by means of a short length of wire. Connect tag 2 of each coil to one side of C_3 (the reaction condenser). Note that this connection should be made to the stator, or fixed, vanes. Connect the rotor, or moving, vanes of C_3 by means of a short length of bare wire, to the earthed metal portion of one of the wavechange switch supporting shoulders (see photograph). Connect tag 1 of each coil to the wavechange switch. Connect tag 5 of each coil to the wavechange switch.

Solder a length of wire from the anode of the valve (pin 2) to the wavechange switch. Connect a length of wire from the aerial input strip (extreme left-hand tag) to the wavechange switch. Next, join the earth connection of the same strip to that earthed solder tag which has previously been fixed with it. From the wavechange switch, connect a length of wire to C_1 (mounted under the chassis), and from the wavechange switch also connect a length of wire to the bandspread condenser C_2, passing this wire through the chassis deck via the small rubber grommet.

The wavechange switch shown in Fig. 4 is a 3-pole, 2-way type, this being the recommended component. That shown in the prototype photographs differs somewhat from the type recommended, but this is only for the reason that it happened to be on hand at the time.

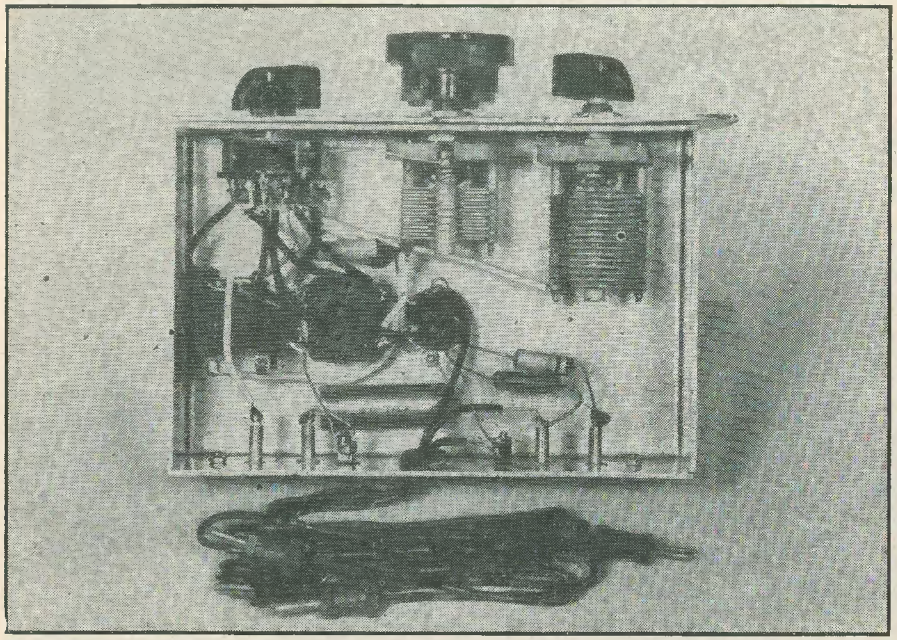
This has completed the actual wiring of the receiver; and the beginner is advised here to check over the foregoing, together with the circuit diagram, in order to obviate any errors which may have occurred during the wiring-up process. A few moments spent doing this may save much trouble later when the testing of the receiver is carried out.

Testing the Receiver

Having checked the wiring with the circuit, the next procedure is to test the receiver. Insert the valve and connect the aerial and earth, together with the headphones, into their appropriate sockets. Next, connect the l.t.— and l.t.+ plus into the correct battery terminals. Upon doing this, the valve filament should glow, but in order to see this, it may be necessary to "cup" the valve with one's hand in order to exclude any external light source. Should the valve not "light up," then it would indicate that the l.t. wiring is "open circuit," i.e. incomplete, between the battery and valve; assuming, of course, that the valve is itself not unserviceable. Having proceeded so far, with the filament glowing, connect the h.t.+ lead to the connection on the battery. Adjusting the reaction control just below the oscillation point until a slight breathing sound is heard, rotate the tuning condenser until a signal of some sort is received.

surrounding earthed objects, such as trees or gutters, and as long as permissible in individual circumstances. The earth should ideally be to ground and not connected to an internal water pipe, etc.

In operation, the reaction condenser should be advanced or retarded in step with the main tuning condenser and so adjusted that it is always just below the point of oscillation. This requires some little practice at first, but the beginner will soon become used to this and become quite expert in a short time. For c.w. (morse) reception, of course, the reaction condenser must be advanced just into the oscillating position, when it will then be possible to hear morse signals.



Under-chassis component layout

Operational Notes

With the receiver now working, it should be possible to obtain reaction over the whole range of both coils. Should this not be so, then the coil iron-dust cores should be positioned about midway in each coil. This will alter the frequency coverage somewhat, but it will allow smooth reaction to be obtained over the entire range of the receiver.

Another point to remember with a simple receiver of this nature is that the length of the aerial will have a large effect on the performance. The golden rule here is to erect an aerial as high as possible, away from

Conclusion

Having tested the receiver and found it working satisfactorily, the next, and last, task will be that of making the panel look something like the prototype shown herewith First, the panel should be painted with black enamel obtainable from the local walk-round store. When this is thoroughly dry, cut out and apply the "Panel-Signs" transfer to the panel. The method of doing this is fully described on each packet of transfers. In this case, the varnish will not be necessary, it only being required to fix the transfers with the gum contained on the rear of them.

* incorrect – R2 should be connected to the outer tag, and R3 to the inner tag, to which the HT + lead is also connected. (See p115, Aug.'57)

RIGHT—*From the Start*

PART 17

HIGH FREQUENCIES AND SHORT WAVES

by A. P. BLACKBURN

The range of frequencies used in communication nowadays is truly amazing. Twenty years ago the highest frequency normally encountered was of the order of 30 Mc/s and, as an extreme case, 50 Mc/s for early television systems. Now one hears of 10,000 Mc/s as a commonly used band for radar and special short range communication systems. Generating these higher frequencies has led to a great number of problems, some of which are not completely solved to-day. Why, then, has so much trouble been taken to work in these regions? The answer depends upon the system, whether it be radar, communication, broadcasting for entertainment purposes, secrecy and so on. But from the aspect which interests the amateur most, the answer is space. Band space, that is; space for an ever-increasing number of transmitters within this vast radio spectrum.

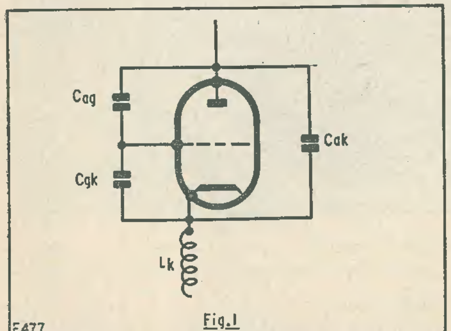


Fig.1

Bands

We will briefly look into this space question before going any further.

First, consider the long waveband. It extends on broadcast receivers from approximately 1,000 metres to 2,000 metres; this represents a frequency range of 300 kc/s to 150 kc/s. If all stations are separated by 10 kc/s, then only 15 stations can be accommodated over the complete band. The medium waveband, which extends over a range of approximately 600 kc/s to 1.5 Mc/s, can accommodate 90 stations with 10 kc/s separation. The short waveband, on domestic receivers, is usually of a range of 15 to 80 metres, or 20 Mc/s to 6 Mc/s. The number of stations here is something like 14,000.

Do not imagine from this that the medium waveband does only contain 90 stations, and the short waveband mentioned only 14,000. All this is assuming that every station is 10 kc/s away from its nearest neighbours; unfortunately, this situation does not exist; many more are packed in.

Television, for example, needs a bandwidth of 3 Mc/s in order to transmit all the picture detail. Obviously, if an attempt were made to transmit this on the medium waveband a single station would take the complete band!

As it is, there is so little room on Band 1 that television is already being transmitted in the hundred megacycle region. Radar signals may require anything up to 100 Mc/s bandwidth, so there is the long, medium short and VHF bands all used for one radar signal! So much for space. There are other reasons, however, which make the use of higher frequencies attractive.

Aerials

The broadcast transmitter is designed to do just what the name implies—broadcast its signal far and wide. Ideally, the signal strength at any point on the circumference of a circle drawn around that transmitter should be the same. But for long distance communication it is often an advantage to get as much of the transmitter power concentrated in a particular area as possible. To achieve this it is necessary to beam the signal in the required direction, searchlight fashion. Now the aerials required for beaming radio signals are often complex and their physical size is dependent upon the wavelength of the signal. The shorter the wavelength (i.e. the higher the frequency) the smaller the aerial. One can see this by comparing a 45 Mc/s television aerial (the H and X types are "directional" aerials) and a VHF aerial.

This beaming becomes more necessary as the frequency is raised in order that the reflecting effect of the ionised layers above the earth may be used. At low frequencies a signal "follows" the contour of the earth to some extent and considerable ranges can be covered quite easily. At higher frequencies the range becomes shorter, so beaming the signal upwards toward the ionised layers so that it is reflected back toward earth, ensures an extended range. This bouncing between the layer and earth may occur a number of times before the signal reaches its destination. These are a few of the justifications for using higher frequencies, now to some of the snags.

Difficulties

The first awkward problem associated with generating high frequency signals is finding suitable valves. Fig. 1 shows an ordinary innocent valve with some of its hidden components. The capacities we have met before—the strays. They can be troublesome enough at high audio frequencies, but at a few megacycles they begin to look like a short circuit. A newcomer is L_k. This is the cathode lead inductance. Even a straight piece of wire has an inductance; and in pre-war valves, where this length might be an inch or so, the inductance represented a fairly high impedance in series with the cathode. As the impedance of an inductance rises with frequency, so L_k becomes more and more of a nuisance as the frequency increases.

The effect of L_k is to reduce the gain of the valve, in a manner rather similar to negative feedback.

A further difficulty results from the time taken for the electrons in the valve to pass through the grid. Let us imagine that an electron takes one-tenth of a millionth of a second to pass through the grid. If a signal of 10 Mc/s were applied at the grid, a complete cycle would take one-tenth of a millionth of a second to complete. As the signal swings toward the positive peak the electron will speed up, but as the signal begins to go negative the electron will be retarded and finally, as it leaves the influence of the grid, the cycle of signal will be complete, and the electron will carry on toward the anode as though no signal had been applied to the grid at all.

Modern valve technique has improved matters considerably. Transit times have been reduced, capacities reduced, and cathode lead inductance reduced, all having been achieved mainly by reducing the physical size of the valves.

Components also become more and more difficult at higher and higher frequencies. For example, an ordinary tuned circuit to operate at 200 Mc/s becomes fairly tricky. Say the capacity is chosen at 15pF, then the inductance will only be 0.04μH. This would be something like the inductance of a short piece of wire. The capacity could be reduced, but eventually the time will come when the strays will be all that remain and these may easily be 5pF or more, so the inductance will still be only 0.12μH. Capacitors themselves have some inductance due to their leads or form of construction; one type, for example, has sufficient self-inductance to form a complete tuned circuit at 100 Mc/s.

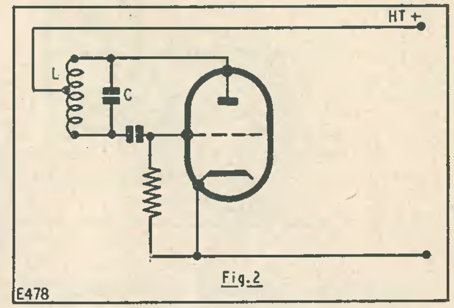


Fig.2

Lines

The solutions to these and many other problems associated with high frequency working have led to some very clever circuits. A typical example is the use of resonant lines instead of tuned circuits. Fig. 2 shows one type of conventional oscillator used at lower frequencies. The tuned circuit L and C is made up of the usual coil and capacitor combination. If the required frequency is too high to make this practicable, the circuit of Fig. 3 may be used. This is a most unfamiliar looking beast to those whose experience has been only of ordinary short wave or medium wave working.

The lines are merely two stiff pieces of wire or rod parallel to one another, just as shown in the diagram. Tuning is carried out by moving the shorting bar along the line. The oscillator will operate at a frequency decided by the "resonant length" of the line. The principle is rather like that of a "Swanee whistle," where the pitch is altered by changing the resonant length of the chamber with a plunger.

The actual length of the line is $\lambda/2$, where λ is the wavelength. If we wished to operate on 2 metres, the line would be 1 metre long. At least, in theory it would be, but the valve capacities shunted across the line effectively lengthen it, and the frequency of oscillation would be somewhat lower, i.e. the wavelength would be longer.

Very High Frequencies

As the operating frequency becomes higher the effect of the ionised layers above the earth becomes less, and eventually a frequency is reached where no reflection occurs at all. Thus it is possible to achieve radar echoes from the moon, because at the enormously high frequency used by the radar transmitter no reflection takes place.

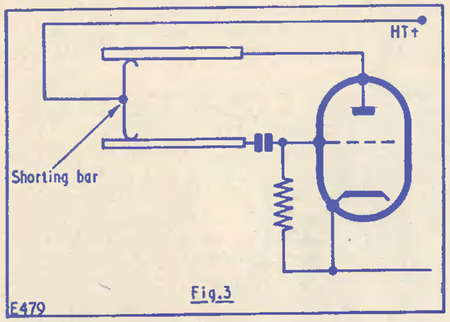


Fig.3

This means that the higher frequencies are of no use for long distance communication, and as they do not bend around the earth's surface, they are only suitable for line of sight communication. However, because of the very small physical size required of the aerial at such frequencies, very complex aerials may be conveniently used and a very small beam width achieved, thus saving power. At the receiving end, too, a highly directional aerial may be used which has the effect of adding gain to the receiver.

A typical difficulty encountered at v.h.f. is transferring the transmitter power to the aerial. Merely connecting wires in a more or less haphazard fashion will not do, because the power would be radiated from them and none—or very little—would reach the aerial. A special configuration of wires called a feeder is used. Feeders may take many forms; two examples are simple open wire and co-axial. Television users and experimenters will be familiar with the latter as this is used almost universally for connecting the aerial to the receiver.

Open wire feeders are arranged rather like the tuning lines on the oscillator of Fig. 3, being connected to a pick-up loop coupled into the transmitter at one end and connected at the other end to a matching arrangement to feed the aerial. The remarkable feature of these feeders or lines is that the impedance presented to the transmitter, say, is the same irrespective of the length of the line. Thus one often hears "70Ω coax." referred to. This means that providing a 70Ω resistor, or a circuit that has a resistance of 70Ω, is connected across the output end of the line, the input resistance will be 70Ω whether the cable is 100ft long or 1,000ft long. There will be some loss of power along the line, of course; nature is never that kindly disposed that anything is perfect. But it can be too small to be important over reasonable lengths.

Short waves have always been the special domain of the amateur. Firstly, because he was permitted to use them when they appeared to have little commercial significance, and secondly, because it was, and still is, such a fruitful and absorbing field for experiment.

"PLESMIN" PAPER CAPACITORS

The advent of the transistor with its low operating potentials has necessitated reductions being made in the physical size of paper capacitors, without, as far as practicable, impairing their electrical performance. To meet this need The Plessey Company Limited have recently introduced the "Plesmin" range of paper capacitors.

Physical sizes are considerably smaller than those made entirely by orthodox methods, the smallest capacitor of the new range measuring only ⅜in long and ⅛in in diameter, and the largest 1¼in long and 19/32in diameter. The range extends from 0.001μF up to 1.0μF, with a normal tolerance of ±20% for 0.01μF and above, but below this the normal tolerance is ±25%.

Voltages normally covered by "Plesmin" capacitors are 12, 25, 50 and 100V, but working voltages up to 150V d.c. are also obtainable if ordered specially. An insulation resistance of 1,000 Ohm-Farad minimum at 20 C. at the rated d.c. working voltage can be obtained.

Catalogue Received. From Gardners Radio Ltd., Somerford, Christchurch, Hants, a most useful catalogue fully detailing the current ranges of transformers and chokes, for the manufacture of which this firm is very well known.

A.C./D.C. Amplifier, July issue, p. 846. In this article, the author stated that he had tried an EF39 and an EF36 in place of the 6J7 specified. It should be noted that, if this is done, it will be necessary to wire a shunt resistor across the valve heater in order to bring up the current passing to 0.3A. The shunt will need to pass 0.1A, and the nearest value in the preferred range will be 62Ω. It should be rated at not less than 1 watt.

A CRYSTAL HETERODYNE FREQUENCY METER

by **J. H. BRAZZILL, G2WP**

By far the most popular form of frequency control with amateurs, under present-day conditions on the amateur bands, is the variable-frequency oscillator. Such an oscillator, if built with care, paying special attention to the electrical and mechanical stability, can prove a very satisfactory source of frequency drive, and give results equal to that of a crystal. However, the matter doesn't end with the building and installation of the v.f.o.; for the G.P.O. rightly insist that where the transmitter is not crystal controlled, some form of frequency meter must be used to ensure operation within the authorised frequency bands. The accuracy of the frequency meter employed must be ±0.1% or better for band edge working. A large number of amateurs employ the American type BC221 (0.01%) to meet the official requirements; and it is also believed that the G.P.O. themselves use this frequency meter to check on the frequencies of amateur stations.

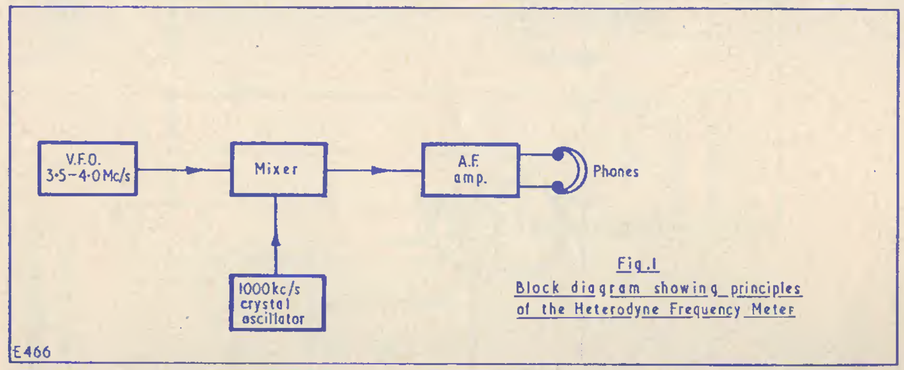


Fig.1
Block diagram showing principles of the Heterodyne Frequency Meter

Principles of Operation

Briefly, for those readers not familiar with the system, the arrangement is shown in the block diagram, Fig. 1. A crystal oscillator operates on a frequency of, usually, 1,000 kc/s, and forms the frequency standard portion of the instrument. The output of this oscillator is fed into a mixer valve, together with the output from a v.f.o. which tunes from 3.5 to 4.0 Mc/s. As a result of the mixing of the two oscillators, beats will occur between harmonics of the v.f.o. and harmonics of the crystal oscillator, and zero beat will occur whenever a harmonic of the v.f.o. is exactly divisible by 1,000 kc/s. To quote an example: if the v.f.o. is tuned to 3,500 kc/s, zero beat will occur since its second harmonic of 7,000 kc/s will beat with the 7th harmonic of the crystal. If the frequency is shifted to 3,501 kc/s, then a 1 kc/s beat note will be heard in the phones. Again, if the v.f.o. is tuned to 3,666.67 kc/s, its 3rd harmonic will be 11.0 Mc/s and will beat with the 11th harmonic of the crystal, and so on.

It is, of course, not essential to use a crystal frequency of 1,000 kc/s as our frequency standard. Frequencies of 100 kc/s or 500 kc/s would be equally satisfactory. In this case, zero beat will occur every time a harmonic of the v.f.o. is exactly divisible by 100 kc/s or 500 kc/s respectively. However, 1,000 kc/s is the most convenient value to work with, as it makes for easier identification of the beat notes. Rather more beat notes would be heard if a 100 kc/s crystal is used, but extreme care will be necessary in order to avoid confusing one beat note with another.

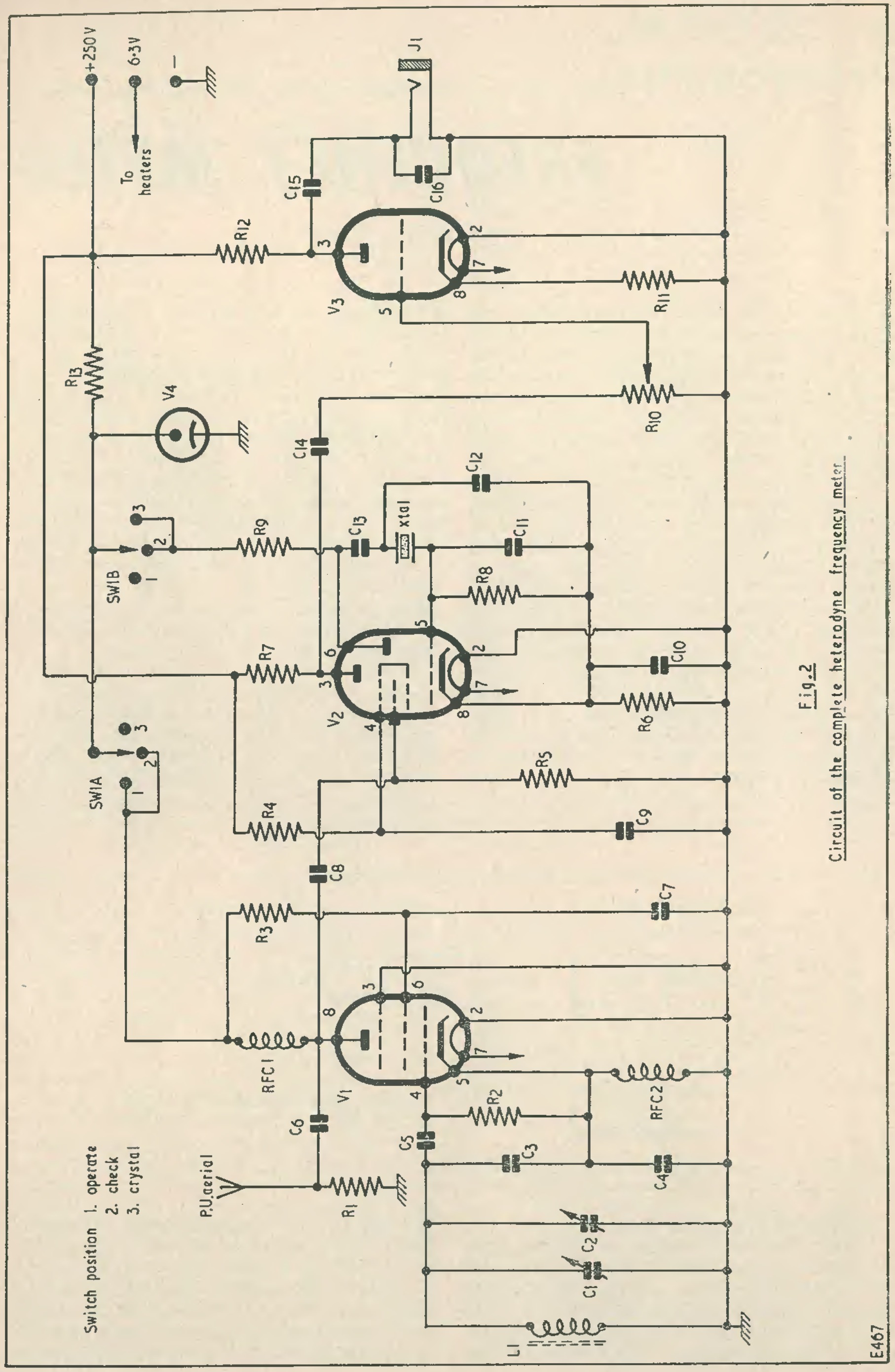


Fig. 2 Circuit of the complete heterodyne frequency meter

The Circuit

Not being fortunate enough to possess a BC221, the writer set about building a similar instrument for himself. The circuit is shown in Fig. 2, and it will be seen that the v.f.o. is a Colpitts, which is then fed into a combined mixer-crystal oscillator circuit, using a 6K8 type of valve. The oscillator section of this valve forms a crystal Colpitts circuit, and has the advantage that no tuning coil or condenser is required; it will oscillate satisfactorily with crystals widely differing in frequency; and, by itself, will radiate a sufficiently strong signal to be heard up to at least 30 Mc/s if used to plot 1 Mc/s markers on the receiver. The v.f.o., which uses a 6SJ7, has been found to be very stable after an initial warming-up period of about ten minutes, and has proved very satisfactory in practice. The circuit has the advantage of rendering the use of a tapped coil unnecessary; and also, by the introduction of a single-pole multi-way switch, other coils can be switched in to extend the frequency range of the instrument, if required. It is advisable in the interests of stability to use a good quality component for the main tuning condenser C_1, and it will be found that using the type recommended, and the coil wound as specified, the meter will cover from 3.5 to 3.9 Mc/s—a coverage which comfortably spreads the 3.5–3.8 Mc/s band over the major portion of the dial.

However, a good quality condenser of 100pF or 160pF could be used instead of that specified. Such values will result in the instrument tuning from 3.5–3.8 Mc/s, and from 3/5–4.0 Mc/s respectively. Switch SW_{1A-B} enables the crystal oscillator to be switched in or out as required. In the first position, h.t. is removed from the oscillator section of V_2. This is the position normally used for frequency measurement. Alternatively a pair of phones can be plugged into the phone jack, when the instrument becomes a very satisfactory monitor—r.f. being picked up on a short rod connected to the pick-up aerial terminal. If used frequently for this purpose, a further phone jack can, with advantage, be wired in parallel with the existing one. The headphones are then plugged into one jack and the other jack is connected to the phone jack of the receiver, via a length of twin flex terminated at each end by a phone jack-plug. It is then not necessary to transfer the phones when changing over from monitor to receiver. The second position of the switch connects 150 volts of stabilised h.t. to the oscillator section of V_2. This position is used to check the calibration of the meter.

The third position of the switch provides a signal from the crystal oscillator only, and it is coupled to the pick-up aerial through the electron stream of the hexode section of V_2, and via C_8 and C_6 to the aerial terminal. H.T. is left connected to V_3; by doing this it simplifies the switching and also maintains a reasonably constant load on the h.t. supply.

The anode and screen voltages of V_1 are fed from the stabilised line in order to assist stability. A VR150/30 tube is employed for this purpose.

C_2 is a correcting trimmer, which is used in conjunction with the crystal check position of SW_1. Its use ensures that the calibration of the main dial holds true at all times. Power supply requirements are 250V at 50mA for the h.t., and 6.3V 0.9 amps for the l.t.

Calibration

This is best done with the aid of a receiver roughly calibrated over the range 3.5–4.0 Mc/s. The frequency meter should first be switched on and allowed to warm up for

Component List—set out for easy reference to Fig. 2

C_1	140pF Eddystone Cat. No. 586 (see text)
C_2	15pF
C_3, C_4	0.001µF silver mica
C_5	100pF silver mica
C_6	15pF ceramic
C_7, C_9, C_{10}	0.01µF
C_8, C_{11}, C_{12}	50pF ceramic
C_{13}, C_{14}, C_{16}	0.001µF
C_{15}	0.05µF
R_1	4.7kΩ ¼ watt
R_2, R_8	47kΩ, ½ watt
R_3	56kΩ ½ watt
R_4, R_7, R_{12}	22kΩ 1 watt
R_5	1MΩ ¼ watt
R_6	330Ω ¼ watt
R_9	10kΩ ½ watt
R_{10}	500kΩ potentiometer
R_{11}	1,000Ω ½ watt
R_{13}	6.8kΩ 10 watt
J_1	open circuit type jack
SW_1	Three-way double-pole switch
XTAL	100/500/1,000 kc/s crystal ±0.025%, see text
RFC_1, RFC_2	2.5mH choke (preferably dissimilar types)
L_1	16 turns No. 22 enam.s.w.g. close wound on ½in diam. former slug tuned. Turns doped
V_1	6SJ7
V_2	6K8
V_3	6J5
V_4	VR150/30

Fig. 3. Beat Notes in the range 3.5–4.0 Mc/s using a 1Mc/s crystal

VFO frequency kc/s	*VFO harmonic*	*Crystal harmonic*	*VFO frequency kc/s*	*VFO harmonic*	*Crystal harmonic*
3,500	2	7	3,727.27	11	41
3,538.46	13	46	3,750	4	15
3,545.45	11	39	3,777.77	9	34
3,555.55	9	32	3,800	5	19
3,571.43	7	25	3,818.18	11	42
3,583.33	12	43	3,833.33	6	23
3,600	5	18	3,857.14	7	27
3,625	8	29	3,875	8	31
3,636.36	11	40	3,888.89	9	35
3,666.67	3	11	3,909	11	43
3,700	10	37	4,000	1	4
3,714.3	7	26			

10 or 15 minutes with SW_1 in the first position. Then proceed as follows: set the correcting trimmer to mid-position and the main dial near the point of maximum capacity. Tune the receiver to 3.5 Mc/s and adjust the iron-dust core of L_1 until the signal is heard on the receiver. Switch SW_1 to the second position—crystal check—plug in a pair of phones to the frequency meter and readjust L_1 until a strong beat note is heard. At this setting the frequency meter will be tuned to approximately 3,501 kc/s. Next tune the frequency meter to the h.f. end of its range and locate the frequency on the receiver. This will be from 3.8 to 4.0 Mc/s, depending on what value capacity is being used for C_1. Adjust L_1 until the frequency range is comfortably accommodated over the dial. Should the highest frequency fall a bit too low, it is recommended that C_3 be reduced to about 750pF, and L_1 readjusted at the low end of the range. The instrument is now ready for calibration.

Tune to the low end of the range and adjust the main dial to bring the original 3,501 kc/s beat note to zero beat. This will set the dial to 3,500 kc/s exactly. Note the dial reading. Now tuning through the range will provide numerous other beat notes, and our next job is to sort them out—a project requiring plenty of patience! If the calibration of the receiver is fairly accurate it can be used to approximately locate other frequencies from the frequency meter; but too much reliance should not be placed on this method, it should only be used as a guide.

Reference to the table (Fig. 3) will provide the reader with a list of beat notes in the range 3.5–4.0 Mc/s; those marked with an asterisk being the strongest. The writer has only calculated beat notes up to the 46th harmonic of the crystal, but these should be ample to enable a very accurate calibration to be plotted. Other beat notes can be obtained by dividing higher orders of harmonics by 12 and upwards. Start by identifying those frequencies marked with an asterisk. These will be heard stronger than the rest and should easily be identified. Tune each to zero beat; note the dial readings and plot them on a rough graph to start with. From this graph the position of other crystal check points can be obtained, and their exact position found on the dial by very carefully tuning until a beat note is heard at about the position indicated on the graph. These frequencies should be brought to zero beat, their readings noted, and a more accurate graph compiled; from which other beat notes can be determined with a progressively higher order of accuracy. When the final graph is completed, it is then recommended that further graphs be plotted to cover each 50 kc/s of the range covered by the instrument. Each graph should have clearly marked on it a crystal check point within that range. Then all that is necessary to set the frequency meter up to any desired frequency is to first of all set the main dial exactly to the reading of the check point, switch to the crystal check position, and adjust the correcting trimmer to give a zero beat in the headphones plugged into the meter. This ensures that over the appropriate range covered by the graph the initial calibration remains correct.

After making all the graphs, the reader will find it very convenient for quick reference to compile a table in the form of log tables, showing the dial reading of each kilocycle covered by the instrument. See Fig. 4.

All the foregoing may seem very laborious, but the final result will be a frequency meter possessing a high order of accuracy which will fully satisfy G.P.O. requirements.

There is nothing critical about the wiring of the complete instrument, though it is recommended that all leads associated with the tuned circuit should be made in a heavy gauge wire and run as direct as possible. The tuning condenser and compensating trimmer should be firmly bolted to the chassis or panel and nothing should be suspended in the wiring. All components should either be wired straight across their respective valveholders or mounted on tag board assemblies.

Provided the instrument is both mechanically and electrically stable, the only other thing which will limit the accuracy of the finished job is the dial. A suitable dial is the Muirhead or Eddystone type having a vernier capable of reading to within 1/10th of a degree, providing an effective scale of 1,000 degrees and enabling the meter to be read within 500 c/s. At 3,500 kc/s, this means that the frequency can be read to within 0.014%.

The writer uses a dial originating from ex-Service equipment. It is engraved from 0–100 degrees in a half-circle of 3in radius, and provides a 200–1 reduction via a small vernier knob capable of reading to within 1/20th of a degree. Direct drive is also available by pulling out the vernier knob slightly. This dial provides the equivalent of 2,000 degrees reading. Readings to within 250 c/s should easily be attainable with such a dial. The error is thus half of that quoted above. When reading the dial, always approach it from the same direction in order to counteract any tendency for backlash. In other words, if the initial calibration was done in a clockwise direction, always rotate the dial in the same direction when reading the instrument. To take care of the tolerance in dial reading, the crystal should preferably have an accuracy no worse than 0.025%. This will provide an *overall* accuracy of within 0.04% if the Muirhead type of dial is used. That is, 2½ times better than official requirements.

FIG. 4. LOG TABLE METHOD OF LISTING FREQUENCIES

Example: Dial reading = 8.9. Frequency = 3,535 kc/s

First 3 figures kc/s	*4th figures kc/s. Dial reading* 0	1	2	3	4	5	6	7	8	9
350	0.5	0.8	1.0	1.2	1.4	1.7	1.9	2.1	2.3	2.5
351	2.7	2.9	3.2	3.4	3.7	3.9	4.3	4.6	4.8	5.0
352	5.3	5.5	5.8	6.0	6.2	6.4	6.7	6.9	7.2	7.5
353	7.8	8.0	8.2	8.4	8.7	8.9	9.2	9.5	9.8	10.2
354	10.4	10.7	10.9	11.2	11.5	11.8	12.0	12.2	12.5	12.7
355	13.0	13.3	13.6	13.9	14.1	14.4	14.6	14.9	15.3	15.5

WIRELESS TELEPHONE COMPANY PUBLICATION ON I.F. TRANSFORMERS

A new publication issued by the Wireless Telephone Company Limited is designed to give a general introduction to a new and specialised range of Intermediate and Radio Frequency Transformers and Coils produced by the company.

These include a new range of single tuned, sub-miniature, intermediate frequency transformers (⅝in dia. × 11/16 in high), oscillator and ferrite aerial coils designed for use in transistorised circuits; side trimming I.F. transformers and R.F. coils; F.M. and A.M./F.M. I.F. transformers and ratio detectors; and television I.F. transformers.

Details of frequency, Q values, Can sizes and methods of mounting, etc., are given in the publication together with information on the design and application of each component. Copies are obtainable from the Sales Department, Wireless Telephone Company Limited, Hallamgate Works, Sheffield 10.

DIRECT T/V REPLACEMENTS

Sole Distributors of "Allen Components" for Home Constructors Sets

Arrangements have been completed between Allen Components Ltd. and Direct T/V Replacements, whereby the latter company are now the sole distributors of the complete range of "Allen Components" used in home constructor sets, including the "Teleking," "Wide Angle Viewmaster," "Magna-View" and the "Supervisor."

Immediate delivery of all the R.F. : I.F. and timebase components is offered. The line output transformers will now be manufactured by Direct T/V Windings Ltd., the construction remaining as in the original.

All enquiries should be sent direct to Direct T/V Replacements, 134/136 Lewisham Way, New Cross, S.E.14, who would also be pleased to co-operate with designers of home constructors' units of all types.

TUNGSRAM VALVES

With the complete integration of Siemens Brothers & Co. Ltd. and The Edison Swan Electric Co. Ltd. as from July 1st, the company will no longer be distributing Tungsram valves.

Orders will now be taken by the British Tungsram Radio Works Co. Ltd., West Road, Tottenham, London, N.17.

Radio Miscellany

ALMOST CONCURRENTLY WITH THE APPEARance of my comments last month on the drawbacks of present-day t.v., letters of similar purport appeared in the correspondence columns of *The Times*. A letter of defence from someone connected with an interested party (R.C.A.) made out an excellent case to show that the progress of colour t.v. in the United States (and incidentally the reliability and stability of colour t.v. receivers) was far more rapid and successful than is generally believed over here. His figures, showing that American black-and-white t.v. receivers require an average of two service calls in the first three months are rather alarming. I should have expected better from the sleek looking receivers and glowing phrases in the advertisement pages of U.S. magazines! Colour t.v.'s required two and a half.

When I touched upon the subject I was raising the query: "Do viewers *really* want colour t.v."—that is, do they want it so badly that they are prepared to pay the extra cost and suffer the "disadvantages" I outlined. The answer to that question is obscured by wishful thinking from two opposite points of view—those holding an interest in the colour systems likely to be used, who obviously see the rosy side, and those concerned with the manufacture of ordinary sets for whom (if colour t.v. were only a matter of weeks or months away) current-model production would come to a standstill. Obviously, when colour t.v. is imminent, or even believed to be "just around the corner," the public are not going to buy models which are likely to be outmoded before the third instalment is due!

It is patently true, as I pointed out, that the demand for colour t.v. is largely by people who, when the time comes, will wait to see how it turns out before they dream of buying one. While history is hardly likely to repeat itself in this matter, appreciation of the course of development of black-and-white t.v. is at least illuminating. Full daily broadcasts started in 1936 (present system), and for a while viewers could be counted in hundreds. Even by the outbreak of war in 1939 they could still be comfortably counted in thousands. For several years following its post-war resumption, receiver possession was still comparatively limited to the few.

I am not suggesting that the growth of colour t.v. will be quite as modest as that, but are people with a serviceable and satisfactory receiver going to rush to buy colour sets at such a rate as to make possible drastic price cuts in production costs? Cinemagoers can judge for themselves how much greater is the appeal of technicolor over monochrome films. Not being a filmgoer I dare not give a judgment, but as a colour photographer I do know how the average viewer loves my projected colour transparencies. They watch with real pleasure, delightedly commenting on the colours (which incidentally reproduce beautifully, often better than natural!), when black-and-white projection would leave them cold. Obviously colour for its own sake has a tremendous appeal, and successful demonstrations, especially of subjects to which the colour adds pleasing interest, are likely to win over hosts of waverers into buying colour receivers. Yet much of this is based on novelty appeal. I am quite sure the popularity of my colour projections will decline to disappearing point when colour t.v. becomes commonplace. Judging by the reactions of discriminating filmgoers, I imagine they would rather see a good monochrome film than an indifferent colour one.

The question is, therefore, a very open one, and extensive sales are more likely to be decided on how cheap it is, rather than how good it is. A de-luxe car is very much more satisfying than a "popular" one, but the vast majority of us have to be satisfied with the latter sort—that is providing we can afford even that.

A few really keen types may have seen the B.B.C.'s successful experimental transmissions after ordinary programme hours, which may well give rise to a hope of early daily programme transmissions. Unfortunately, the success of these experiments has no real significance. They cannot go ahead with any definite plans until they are given the signal by the Government's T.V. Advisory Committee. It is unlikely that their report will be ready until late next year, and there are a tremendous number of factors, technical, financial, public interest and even export trade, to be taken into consideration. My guess, 1962, still holds.

Tip

Apparently quite a lot of readers have already used "impact" adhesives which I mentioned last month. A few have written to say it is the finest thing they have yet found for sticking sheets of metal foil to the insides of radio and t.v. cabinets for screening. Other purposes successfully served include fixing rubber feet to table models and bonding metal aerial elements to rubber mountings.

When Amateurs were Amateurs!

In the early days after the war, when ex-W.D. gear was cheap and plentiful, many old-timers viewed with some disapproval the tendency for transmitting amateurs (and to a lesser extent broadcast receiver constructors) to use Services type gear rather than build up their own. Many openly voiced the view that it wasn't cricket—or rather, wasn't radio—or in modern parlance, that it was non-U. Before the war transmitting licences were granted only for experimental work. The actual communications side was merely incidental, and was intended to be used for the purpose of testing and proving. Hence the opening gambit "Calling Test" used by British amateurs, instead of "Calling CQ" as in post-war years.

specialising in providing amateurs with professionally built equipment, and an increasing number of amateurs are buying it, some of whom have never built anything worth mentioning of their own. Such a state of affairs would have been considered unthinkable in pre-war Britain, although the tendency had already started in the United States.

An examination of the lists of leading stations in any of the recent contests will reveal (where the equipment used is specified) that they all used professionally made gear. A strange contrast to the 'thirties when self-respecting amateurs even made their own microphones and a shack without a workbench would have been looked on as a sham! An unfortunate aspect of this use of commercially equipped "amateur" stations is the unfair advantage gained by those with the deepest pocket. Indeed, since writing the preceding part of this paragraph, a correspondent in the R.S.G.B. "Bulletin" questions the ethics of using expensive commercially-built equipment in contests.

With these thoughts in mind I made a hurried survey of the equipment in current use in amateur stations belonging to my friends, fellow club members, etc. The analysis of the fifteen I managed to get done

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

Although at first it was considered slightly *infra dig* it was regarded as excusable in view of the difficulty in getting new suitable components. With the success, and extraordinary cheapness of ex-W.D. surplus, plus a large number of new entrants to the hobby not so deeply imbued in the pre-war traditions, the use of services and commercial gear became more and more widespread. Even until fairly recently many of the old-time amateurs yearned for the days of low power, although they recognised that design was a more exact science rather than the trial-and-error methods of yesteryear. However, that would have been amply covered by the widened range of cheap technical books. Indeed, a very good case can be made out for a modernised form of pre-war licensing conditions.

For several years now, what remained of the old tradition has completely gone by the board. Today's fashions are not limited to converted ex-W.D. equipment, but the fully-built, ready for immediate use, maximum-powered amateur transmitting station is definitely "in." A half a dozen firms are

in time shows the following:

	Home-built	*Professional*
Receivers	None	15
Converters and Pre-selectors	5	4
Transmitters ..	4	11
Modulators (including those built-in)	7	8
Receiver Power Supplies inc. those built-in	1	14
Transmitter Power Supplies (inc. those built-in) ..	5	10
Aerials	6	9
Aerial matching devices	8	7

How many of us in 1939 would have believed that in a mere 20 years a third of the amateurs in a given locality would even buy the aerial complete and ready to hang up. Come to think of it, four of the nine who purchased complete aerials hired someone else to put 'em up!

(*continued on page 56*)

DESIGN CHARTS FOR CONSTRUCTORS

No. 16 A.F. OUTPUT TRANSFORMER RATIOS

by **HUGH GUY**

THE MULTI-RATIO OUTPUT TRANSFORMER IS a very popular component these days; and though not eminently suitable for use in the really hi-fidelity amplifier, provides the constructor with an economical and versatile matching transformer whose use is not confined merely to one output-valve/loudspeaker combination.

As most readers are well aware, the whole function of the output transformer is to enable the energy developed at the output stage of an audio amplifier to be converted from the unsuitable impedance level at which it appears, to the impedance level of the loudspeaker being fed, with both the minimum loss of power, and the maximum uniformity of phase and frequency. In fact, the whole art of designing audio transformers is bound up in fulfilling these requirements.

The output impedance of the power stage varies widely from one valve to another. Furthermore, the distortion of the output signal is very dependent on the impedance appearing here. As a result, valve manufacturers generally quote a value of output impedance which offers a compromise between maximum output power under stated operating conditions and minimum distortion.

This compromised impedance is quoted in valve data as the optimum load impedance.

It is the loudspeaker impedance which is instrumental in providing this optimum load, and this it does by means of the output transformer, or matching transformer as it is more fittingly known.

The transformer provides an impedance conversion which is determined by the ratio of the number of turns in the primary (to which the anode circuit of the power valve is connected), to that of the secondary, across which the loudspeaker is connected.

To be specific, the turns ratio (i.e. primary turns to secondary turns) is exactly equal to the square root of the impedance ratio (optimum load to speech coil).

That is:

$$\frac{\text{Pri. turns}}{\text{Sec. turns}} = \text{Turns ratio} = \sqrt{\frac{\text{O.L.I.}}{\text{S.C.I.}}}$$

The loudspeaker speech coil impedance is a quantity which appears in a "popular range of values" varying slightly from one manufacturer's models to another's.

The impedances themselves are generally measured at 400 c/s but differ only slightly over the audio frequency band.

Thus a speaker with a quoted impedance of 2Ω at 400 c/s will probably have a resistance of about this value.

Matching Output Stages

Invariably the problem confronting the constructor occurs in the following manner:

An amplifier has been constructed for which a specific output valve has been selected. A speaker is also available together with a multi-ratio output transformer. How does one determine the best turns ratio?

The answer is either provided by simple substitution and calculation in the formula quoted above, or by use of the chart.

Reference to the latter shows that it covers a wide range of optimum load impedance values; viz. from 1kΩ for low impedance output triodes to 50kΩ for battery output tetrodes, or high gain valves not normally used as output stages.

The vertical scale covers a range of turns ratios from 10 : 1 to 150 : 1, and diagonal lines interpret the speech coil impedances of most loudspeakers that the constructor is likely to encounter.

Some simple examples best demonstrate the use of the chart.

Using the Chart

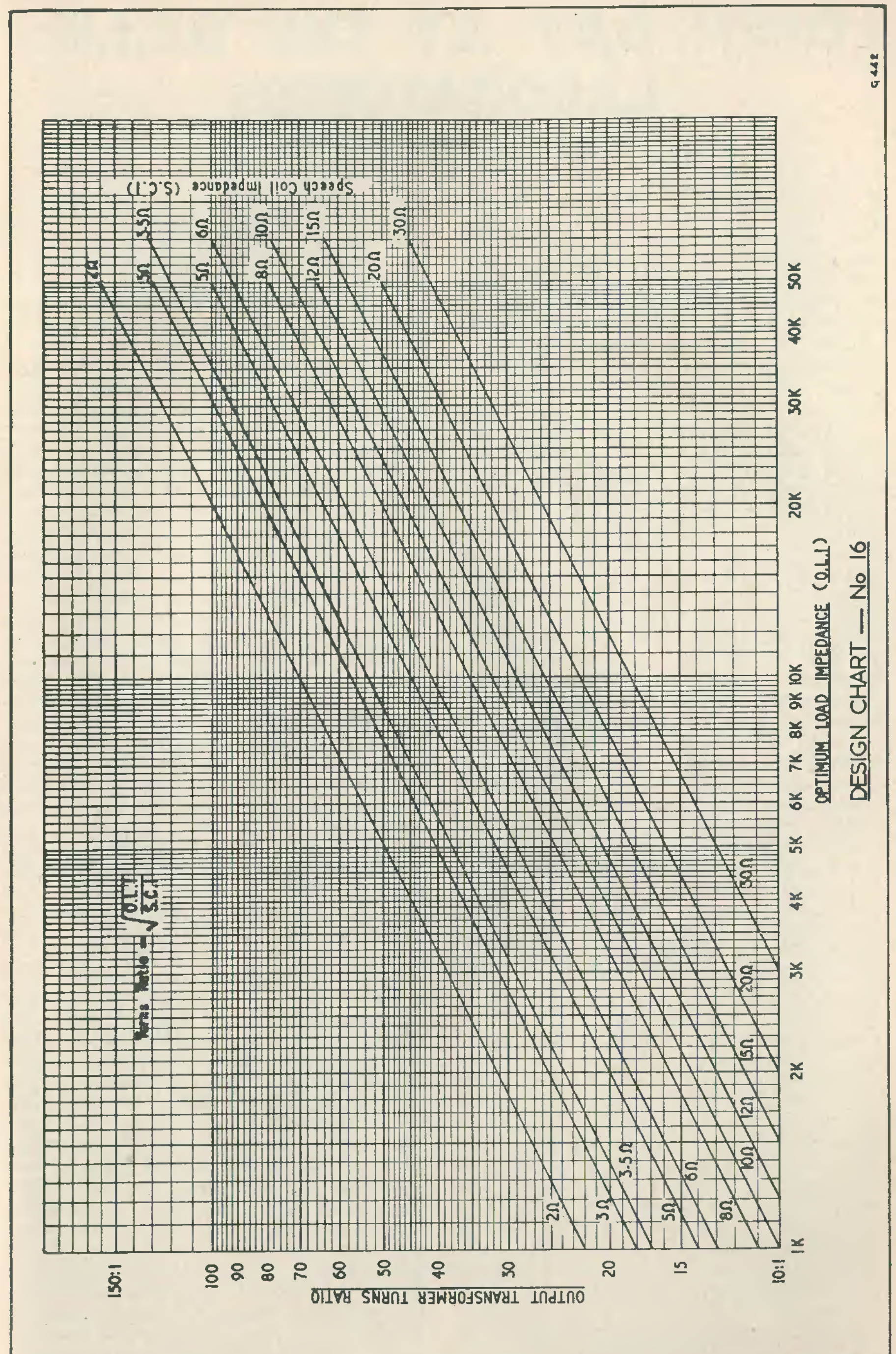
Example 1. Valve data quote the optimum load impedance of the 6L6 beam power tetrode as 4,200 ohms; and when two are connected in push-pull, as 9,000Ω, class AB1.

What turns ratio is required of the matching transformer to match a 15Ω loudspeaker in each case?

In the first case, the 4,200 (4.2kΩ) ohm impedance line is seen to intersect the 15 ohm speech coil impedance diagonal when the turns ratio is about 17 : 1.

In the second case, the turns ratio obtained by the same means, will be approximately 24 : 1.

(*continued on page 56*)



OPEN DAY AT THE D.S.I.R. LABORATORIES

by W. E. THOMPSON, A.M.I.P.R.E.

On Wednesday the 19th June, Dr. A. C. Gee, G2UK, of Data Publications Ltd., and the writer, representing this journal, were pleased and privileged to tour the new laboratories in response to invitations extended to us by the Department of Scientific and Industrial Research. The occasion was an open day, for Press representatives only, to inspect the work of the Station and to see the new buildings in which the department is housed.

Admirable arrangements had been made to convey visitors to and from London, for the Radio Research Station is at Ditton Park, near Slough. A special coach had been laid on for those travelling from London, but for others who wished to travel under their own steam, full details had been given how and where to find the place. The writer made a 100-mile car journey from the coast and got caught up with the traffic bound for Ascot races in the process. The main features of Windsor Castle are, as a result, firmly imprinted in mind, for a quarter-hour crawl in a nose-to-tail queue of vehicles in Windsor Great Park gave full opportunity to see little else. It was noticed, however, that many roads giving access to the Research Station were suitably marked with the familiar yellow direction signs.

There must have been 50 or more of the Press in attendance at the venue, but hardly a one of us can now say that Government Departments and the D.S.I.R. in particular are entirely without human feelings. The programme of events indicated that lunch would be taken with Dr. R. L. Smith-Rose, Director of the Research Station, and so we did, but it was gratifying to find that most of the necessary vitamins were of the bottled variety eaten out of glasses. There was a free-and-easy intermingling of Press and Station staff in the lounge, and judging from the frenzied activity of the serving-maids and the mounds of empties around them, a real good meal was had by all. To exercise the teeth various sandwiches and other delicacies like cheese and onions were to be had. The whole atmosphere revealed that someone at the Station had a pretty shrewd idea of creature comforts, and especially those which soften up the Press to get them into a receptive and tolerant frame of mind. Fortunately the liquid food was not of the sort to stimulate the singing attributes of its imbibers, for everyone conducted themselves with proper decorum and no sound of "Nellie Dean" was heard; on the other hand, invisible barriers miraculously dissolved under its influence in the way that no other medium can hope to achieve.

It was a good idea to provide everyone present with a small label to wear prominently or conspicuously, stating who they were and where they came from, but one found it somewhat disconcerting and perhaps a little embarrassing to gaze searchingly at female emblems without giving a false impression that there was duplicity of purpose in so doing. If some eyes goggled, one must assume that what they saw was writ exceeding small.

When we had been plied with refreshment, Dr. Smith-Rose gave a pleasant and brief address to the assembly, in which he mentioned the various activities which could be seen around the Station, and gave everyone *carte blanche* to go where they liked, when they liked, and generally make a confounded nuisance of themselves during the afternoon. In short, the place was as open as the proverbial barn door.

There was much to see; too much. It did not take long to find that out. The staff were so happy and anxious to describe everything in detail that time soon became a scarce commodity.

A goodly number availed themselves of the free two-and-nines in Room 7 to see the film entitled "Scatter Sounding" made by the D.S.I.R., in which a new technique for examining propagation conditions is explained simply and diagrammatically. It was shown how radiations reflected by the E and F layers in the upper atmosphere can be detected as primary and secondary reflections when they return to the earth's surface. These back reflections, when detected on a receiver at the transmitting site, can be used to plot a scan on a Plan Position Indicator (PPI) similar in nature to the sort used for radar. The display shows on a map the regions where reflections are received from, and are described as "illuminated" areas. Observations taken over long periods, and recorded photographically, can thus provide permanent records of propagation conditions for future studies. It was particularly interesting to see, in a speeded-up display period, how the conditions change throughout the day, and day to day, in various parts of the world during different ionization conditions. Information of this sort is useful in forecasting propagation conditions for various radio services.

A great deal of work centres on forecasting the M.U.F. for short-term and long-term purposes. The Research Station analyses and co-relates information received from many stations throughout the world, and publishes data obtained from these studies. The Station has developed its own equipment for transmitting a range of frequencies covering a wide spectrum, which, in turn, are reflected from the ionospheric layers and detected. Displays on a cathode ray tube graph the reflections, which are photographed to produce data for study and analysis. The equipment operates automatically, switching itself on at regular hourly intervals, and switching off after the hourly record is taken. Normally it can run for three days unattended before a change of film is required, but it is usual to change films daily so that up-to-the-minute information can be dispensed to interested bodies. During the period of the I.G.Y., for which the Station is making wide preparations, this particular record will be taken at 15-minute intervals.

Another study involves the examination of radio noise. The effects of atmospheric static are displayed on cathode ray tubes, and compared with standard noise levels at different frequencies. By this means it is possible to forecast and calculate times and power of radiations for a particular radio service to ensure satisfactory reception. An example of the results of such experiments was to be seen in a display of several similar phrases reproduced by a teleprinter at a receiving station under different noise level conditions. Counts of the number and types of errors enable the most reliable channel to be selected or forecast.

The siting of stations for navigational aids is a problem with many aspects that technically are more involved than would appear at first sight. Due to absorptions, reflections and refractions, depending on the nature of the terrain traversed by the radiations, certain errors in direction finding and position plotting occur. In some cases correction factors can be applied to give a true bearing or position, but it was learned that there are still random errors, the exact nature of which are not properly understood, for which suitable correction has not yet been devised. Investigations are proceeding with a view to solving the problems. One can well appreciate that with air travel services expanding (to select one possible example) the present-day need for faultless navigation poses problems of primary importance.

Extensive research is being undertaken into the properties and uses of semi-conductors and ferrite materials. These studies extend into the regions of micro-waves, and a goodly amount seems already to have been found out about the life of transistors, their uses at high frequencies, and so on.

The library must be the energetic book-worm's idea of paradise. Many a town would be proud to possess such a room and as many books as mere books, but there can hardly be a town anywhere which could boast such an array of fine technical books. There are literally hundreds of volumes on almost every conceivable scientific subject. Bound volumes of the world's technical journals are prolific, and an ingenious cabinet holds current issues of the more important monthlies ready for immediate access. If it were possible to assess the value of this fabulous collection in terms of hard cash, the figure could easily assume astronomical proportions.

The workshop has the size and appearance of a small factory. One would judge the hall to be a good 100ft long and about 30ft wide. Within its well-lighted and airy spaciousness there is an impressive array of machine tools, each with its own motive power. Equipment for the Station, and its counterparts in this country and other parts of the world, are designed and made in this section. Some of the work on view was a model of skill and fine craftsmanship, both in conception and finish.

A fair amount of use seems to be made of surplus equipment such as any of us can buy in the well-known shops, and in some instances it was noticed that precision measurements were being made with what looked like nothing less than a box of junk. Better-looking stuff must have been thrown away by the likes of you and me, but it seemed to be doing valuable work at Ditton Park. The writer at least has one more ready-made excuse for hoarding piles of the stuff.

So far as the station itself as a whole is concerned, it would seem that the Ministry of Works has really let its hair down and produced an edifice to do justice to any of the glossy magazines, American or other nationality. Though mildly futuristic in many ways, it is neither offensive to the eye nor too far ahead in conception. The fullest use seems to have been made of modern ideas in architecture, with the emphasis on utility. Air, light and space has obviously commanded first considerations; the mood has seen fulfilment by the use of modern furnishing and fittings, and the result is a fine building which displays as much art as it does science. No one could possibly get cold feet in the place, for even the floors are warmed by heating elements embedded in them. If colour enlivens the occupants, the place should be as busy as a hive of bees. Interior decorators seem to have had the time of their lives, but with most pleasing results.

It was a pity to have to bid *au revoir* to the many helpful people we met in the Station, for they had explained their work and projects in terms which were clearly understandable to their visitors. There was certainly no sign of the thick-lensed professors who could talk only in terms meaningless to less knowledgable folk. Each and everyone obviously knew his subject down to the last dot on the I's and could discuss it entertainingly. It was more than pleasing to enjoy their full hospitality, too.

Like the other visitors, we hope, Dr. Gee and the writer are not exactly goons when it comes to radio and some of its allied subjects, so we were able to enter into discussions with many of the Station staff in a way which we, at least, could understand. We flatter ourselves that we have given them at least one tangent along which to proceed when we asked if there was any known effect on ionospheric conditions due to H-bomb fall-out as compared with, say, the much larger though more distant hydrogen explosions on the sun which produce sunspot activities. We have no means of telling whether such a conception is our brain-child, but it was to be noticed that there was a micro-metric lifting of an eyebrow and a guarded admission that it might be an idea! Who knows, out of the mouths of babes and casual visitors . . .

Radio Miscellany

(*continued from page 51*)

Tap! Tap!

Many readers will have found amusement in reading the sensational reports of 'phone tapping in the popular Press. At the moment of writing, political leaders of the main parties are still in a huddle about it. Happily they will be fortified by much good advice and are unlikely to be stampeded by the imagined threat to the freedom of the individual.

Contrary to general belief, there is nothing the least bit difficult about 'phone tapping. Anyone owning a few bits of equipment normally found in the possession of every constructor, plus a little know-how, can do it. Those who served in the Royal Signals will no doubt already be experts at it! Again, contrary to general belief, those whose conversations are overheard will not have the faintest suspicion that the line is tapped. There certainly need be none of the tell-tale clicks which have become part of the stock-in-trade of the fiction writer.

I once heard of an instance of a tapped line which defied an expert to detect where the tapping was made. It was done by painting "wiring" along the woodwork from a junction, with finely-powdered metallic (silver or copper) dust, which led off to a tape-recorder some distance away. The "wiring" was, in turn, painted over to match the original paintwork leaving no trace to show that a "branch line" existed. Even those knowing a tapping had been made took a long time to trace it down.

Perhaps fiction writers don't like to introduce this sort of ingenuity. For one thing it may be too technical for readers; and for another it might spoil the story if the hero didn't cleverly hear the tell-tale click to warn him of the villainy threatening (*a*) the ends of justice, or (*b*) the fair maiden—depending on whether the story was written primarily for men or women.

Design Charts for Constructors

(*continued from page 52*)

Example 2. A 60 : 1 output transformer is to be used in conjunction with a 3V4 battery output tetrode having an O.L.I. of 10kΩ. To what loudspeaker impedance is this combination best suited?

The two values, 60 : 1 and 10kΩ are located on the chart, and at their intersection the nearest speech coil impedance is seen to be 3Ω, thus fixing the required impedance.

Admittedly this last version of the problem is rather like finding a shirt to fit a button, but that is very often the way in which the constructor, sparse of components, is obliged to work.

"ALTERNATIVE SUPERHET"—(*Correction*)
On page 767 of the June issue it states as follows: "If R_{17} is reduced, distortion will be decreased—as will be output." This should read: "If R_{10} is reduced . . ." Also, in the Components List, R_{17} should be omitted. The author wishes to apologise for this error, which occurred when typing the MS(A.S.C.)

ERRATA.—The "Companion" Transistor Receiver. At the top of p. 832, July issue, it was stated that the Red lead of T_2 secondary was connected to I; this should have read "connected to L." No connection was given for the collector of TR_1; this should be taken to I.

VIBRATOR BASING DATA

PART 2

Compiled by E. G. BULLEY

For base connections and key see July issue

Type	*Base*	1	2	3	4	5	6	7	*Remarks*
253	1	R	P1	P2	R	—	—	—	4 pin UX base
403	1	R	P1	P2	R	—	—	—	4 pin UX base
NP4	1	R	P1	P2	R	—	—	—	4 pin UX base
3461	4	P1	S1	S2	P2	R	—	—	Special 5 pin
508	4	P1	S1	S2	P2	R	—	—	Special 5 pin
T54	4	P1	S1	S2	P2	R	—	—	Special 5 pin
8621	4	P1	S1	S2	P2	R	—	—	Special 5 pin
2682	4	P1	S1	S2	P2	R	—	—	Special 5 pin
J54	4	P1	S1	S2	P2	R	—	—	Special 5 pin
273C	4	P1	S1	S2	P2	R	—	—	Special 5 pin
704	4	P1	S1	S2	P2	R	—	—	Special 5 pin
SP51	4	P1	S1	S2	P2	R	—	—	Special 5 pin
3503	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX bas
3786	3	P2	P1	R	Blank	Blank	—	—	5 pin UX base
4256-12	1	R	P1	P2	C	—	—	—	4 pin UX base
4256-32	1	R	P1	P2	C	—	—	—	4 pin UX base
4414	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
525	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
T63	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
8268	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
2687	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
PJ57	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
249	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
719	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
SP72	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
QD6	2	P2	S1	Blank	Blank	S2	P1	—	6 pin UX base
4608	2	RP	P1	S2	P2	S1	RS	—	6 pin UX base
5300	1	R	P1	P2	Blank	—	—	—	4 pin UX base
8540	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
495	1	R	P1	P2	Blank	—	—	—	4 pin UX base
404	1	R	P1	P2	Blank	—	—	—	4 pin UX base
5300–32	1	R	P1	P2	Blank	—	—	—	4 pin UX base
2324	1	R	P1	P2	Blank	—	—	—	4 pin UX base
32T3S	1	R	P1	P2	Blank	—	—	—	4 pin UX base
8704	1	R	P1	P2	Blank	—	—	—	4 pin UX base
32PJ3S	1	R	P1	P2	Blank	—	—	—	4 pin UX base
F294	1	R	P1	P2	Blank	—	—	—	4 pin UX base
554	1	R	P1	P2	Blank	—	—	—	4 pin UX base
32NP42	1	R	P1	P2	Blank	—	—	—	4 pin UX base
5301	1	R	P1	P2	Blank	—	—	—	4 pin UX base
5303	1	R	P1	Blank	P2	—	—	—	4 pin UX base
335	1	R	P1	Blank	P2	—	—	—	4 pin UX base
T9	1	R	P1	Blank	P2	—	—	—	4 pin UX base
8528	1	R	P1	Blank	P2	—	—	—	4 pin UX base
PJ9	1	R	P1	Blank	P2	—	—	—	4 pin UX base
852	1	R	P1	Blank	P2	—	—	—	4 pin UX base
435	1	R	P1	Blank	P2	—	—	—	4 pin UX base
NP480	1	R	P1	Blank	P2	—	—	—	4 pin UX base
5305	1	R	P1	P2	Blank	—	—	—	4 pin UX base
5306	2	R	P1	Blank	Blank	P2	Blank	—	6 pin UX base
5308	1	R	P1	P2	Blank	—	—	—	4 pin UX base
347	1	R	P1	P2	Blank	—	—	—	4 pin UX base
8539	1	R	P1	P2	Blank	—	—	—	4 pin UX base
839	1	R	P1	P2	Blank	—	—	—	4 pin UX base
5309	1	Blank	P1	P2	R	—	—	—	4 pin UX base
328	1	Blank	P1	P2	R	—	—	—	4 pin UX base
T8S	1	Blank	P1	P2	R	—	—	—	4 pin UX base
8510	1	Blank	P1	P2	R	—	—	—	4 pin UX base
2090	1	Blank	P1	P2	R	—	—	—	4 pin UX base
PJ18	1	Blank	P1	P2	R	—	—	—	4 pin UX base
854	1	Blank	P1	P2	R	—	—	—	4 pin UX base
440	1	Blank	P1	P2	R	—	—	—	4 pin UX base
408	1	Blank	P1	P2	R	—	—	—	4 pin UX base
NP43	1	Blank	P1	P2	R	—	—	—	4 pin UX base

(*to be continued*)

TRANSISTOR PHOTO-CELLS AND AMPLIFIERS

by C. J. STONE

The Photo-Cell

In a past issue of *The Radio Constructor*, mention was made of the Transistor Photo-Cell. The effect of increased electron activity due to light and thermal incidence in semi-conductors has been known for many years, but with the advent of present-day production type transistors, the photo-transistor has received added interest on account of its very great sensitivity, small physical size, and low operating potential.

Although these photo-transistors are now being produced in quite large quantities, it may well be that the average experimenter may experience some difficulty in obtaining these locally, especially where only one is required, and it is the purpose of this article to show how a suitable substitute can be made, together with some useful applications.

It is well known that the present-day transistor suffers from two serious defects—sensitivity to both light and heat—and it is for the former reason that all transistors are encapsulated to prevent light entry. A common type to-day employs a small glass tube which is painted black to prevent light reaching the germanium junction. This black covering can easily be removed with a little acetone or trichlorethylene, provided care is exercised so that this does not come into contact with the wire seal. It should now be possible to quite clearly see the actual junction, and if a milliammeter is connected as in Fig. 1, the current variation due to light falling on the junction can be observed.

Considerable "spreads" occur in transistor parameters, so that it is difficult to forecast the actual current to be expected for a given collector voltage and illumination, but a little experimental work should enable one to obtain a good idea of the particular working characteristics. With an illumination of 50 to 100 ft/candles and a potential of 5 to 10 volts, it should be possible to obtain a current of 2-4mA, with a "dark" current of perhaps 150µA. It is obvious that such a cell offers vast advantages over a normal conductive photo-cell where currents of perhaps 50µA result, and where high potentials are required; i.e. much less amplification is required.

For many applications a light source of 50-100 ft/candles is impractical, although magnifying stages can be employed to overcome this difficulty as in Fig. 2. With the use of this circuit one can obtain greatly added sensitivity, so that a relay can be easily operated from a light source of some 5-10 ft/candles. If access can be obtained to a Mullard OCP71, it is suggested that this can be used, but if not, the circuit will work quite satisfactorily using a transistor which has been modified as above. The circuit is so simple that construction details are not necessary and a brief description of the operation is given in the following paragraphs.

The Direct Coupled D.C. Amplifier

Referring to Fig. 2, the photo-transistor (PT) derives its collector voltage from R_1, which also has the function of stabilising TR_1 on its working point; although the value is given as 100kΩ, this may vary in individual cases.

In the "dark" condition little current is passed by PT and therefore the collector current of TR_1 is determined largely by its base potential, by virtue of R_1. On the incidence of light the photo-transistor conducts, causing a fall in potential at V_b followed by a corresponding decrease in I_c. Since the transistor can be considered as a current amplifier I_b increases also, but for the purpose of simple explanation it is easier to consider the voltage condition. The transistor TR_2 derives its bias from the collector load (R_2) of TR_1, which is made variable, so that the working point of TR_2 can be fixed upon the knee of its characteristic to enable a small change in I_{b2} to effect a large change in I_{c2}. It will be seen that when I_{c1} decreases on the conduction of PT, the collector current I_{c2} now drops very considerably due to the amplification factor. With a sensitive relay in the collector circuit of TR_2 we now have a useful means of operating an external circuit from small light variations on the photo-transistor. In practice, it has been found that satisfactory operation can be obtained with an illumination of approximately 5 ft/candles on the cell. Using a system of lenses and reflectors, there is no doubt that this could be improved upon and it would make an extremely sensitive unit capable of detecting small light changes.

Mention should be made of the effects of temperature upon such a unit, especially where the sensitivity is pressed to the utmost limit. As already mentioned, the collector current of a transistor tends to increase with temperature, and one should remember that since there are three transistors virtually in series, then the effects due to temperature are multiplied. In practice, the author has found

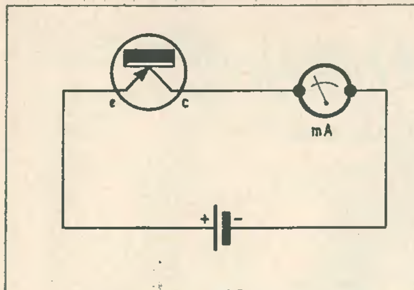


FIG. 1.

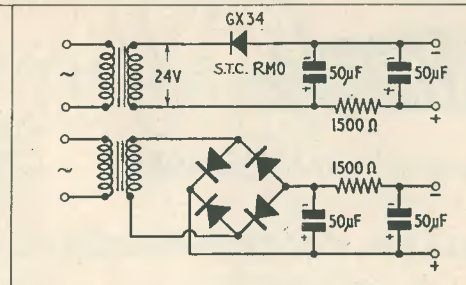


FIG. 3.

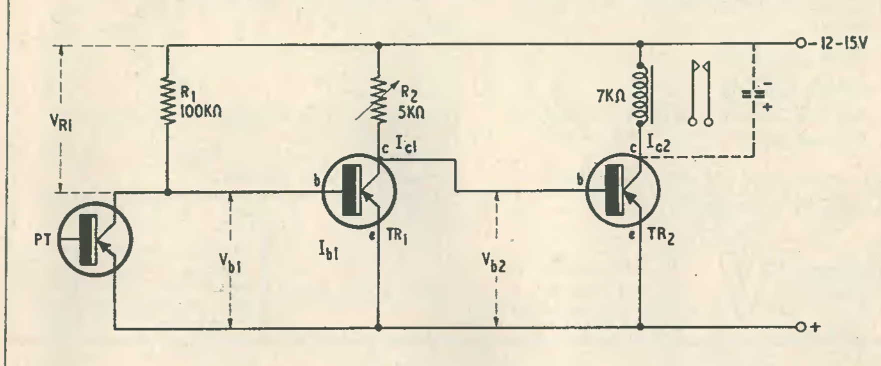


FIG. 2.

C439

that variations in normal room ambients of 20° to 30°C do not affect the unit to any great extent, but above 40°C trouble may be encountered due to "standing" collector current in the dark condition which may cause the relay to hold in one position. It may be possible to overcome this by means of a push-pull circuit, whereby the errors are cancelled.

The author has constructed a unit similar to the one described, which was mains operated, and with the relay connected to a small electro-magnetic counter. This has been in operation over a long period for the purpose of counting the interruptions of a light beam, and under normal temperatures no trouble has been experienced.

Several types of relay have been tried, including those designed for model control. These can be obtained from Electronics Development Ltd. of Kingston, Surrey. Another very suitable relay is the miniature plug-in type, Manning-Carr P53C, available from Simmonds Ltd., Harrow. The sensitivity of this relay is stated to be some 25mW, but this can be increased by careful fine adjustment of the contacts, which are capable of carrying 0.25A at mains voltage.

When initially adjusting the amplifier described, it is advisable to insert a meter in the relay circuit, in series with the coil, and adjust R_2 until a reading of approx. 2mA is obtained with the cell in the dark condition. When exposed to light the TR_2 collector current should fall to approx. 200µA. In some applications it may be desired to make the relay slow-operating; a simple time delay may be obtained by means of a capacitor across the coil. This can be an electrolytic of low working voltage and size. It has been suggested that the high inductive load due to the relay coil may be the cause of damage to the transistor, by virtue of the back e.m.f. Although this would seem possible, the author has some doubt if this is likely to occur in practice, and believes that most transistors are capable of withstanding the small transient overload.

Little mention need be made of the mains power unit, as this follows conventional practice, except that it should be very well smoothed to avoid ripple. Although a bridge rectifier unit as in Fig. 3 (*b*) may be preferable, a normal half-wave circuit can be used with 50µF minimum value for the capacitors. If it is desired to keep the whole unit as compact as possible, a germanium diode could be used in place of the metal rectifier (S.T.C. type RMO), since the current should not exceed a few milliamperes. In view of the low current, the regulation of the transformer is unimportant.

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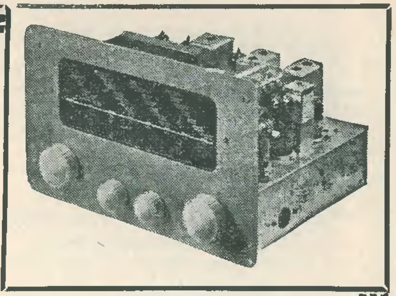

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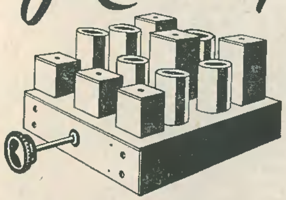

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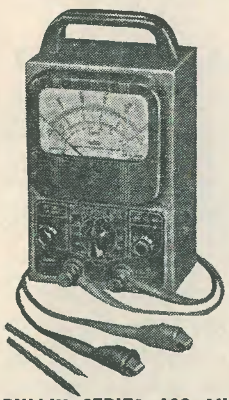

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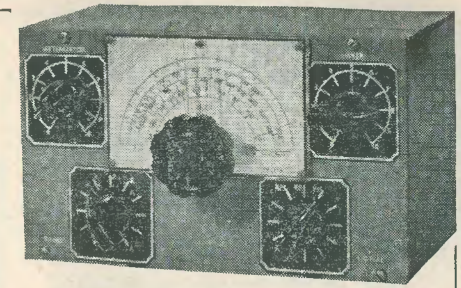

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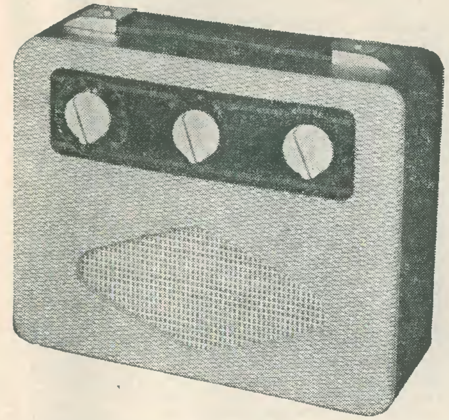

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Call and hear demonstration model

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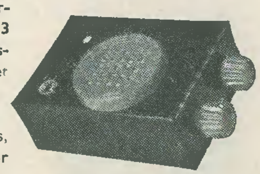

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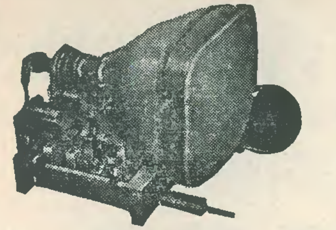

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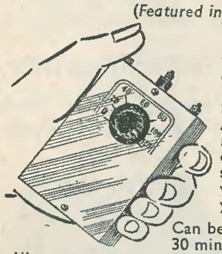
(*Featured in June Issue*)



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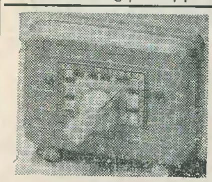

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6BA6	8/6	12C8M	7/6	ECF80	13/6	UCC85	10/–
6BE6	7/6	12J7GT	9/6	ECF82	11/6	UCH42	10/6
6BR7	11/6	12Q7GT	9/–	ECH42	10/6	UF41	10/6
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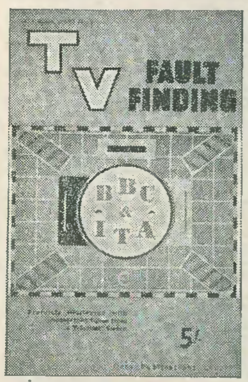

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