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ELECTRONIC HAWAIIAN GUITAR, Part 2

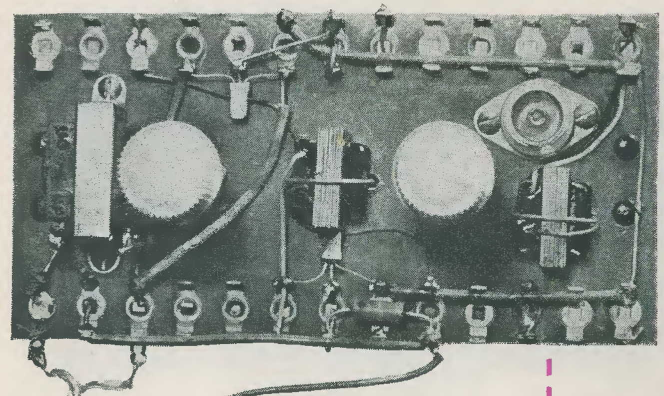
VOLUME 10
NUMBER 2
SEPTEMBER
1956

The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS

GENERAL PURPOSE TRANSISTOR EQUIPMENT

by
H. A. JENNERS



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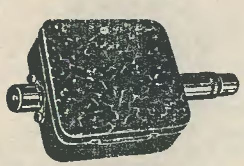

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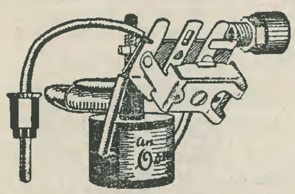

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Over to you, Mr. Davidson

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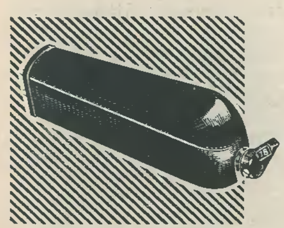

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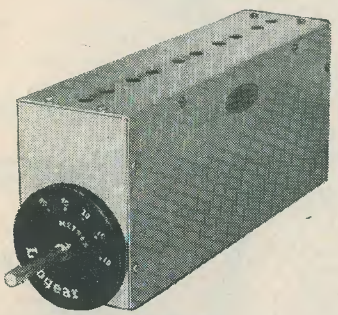

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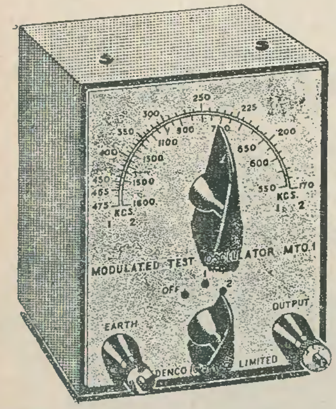

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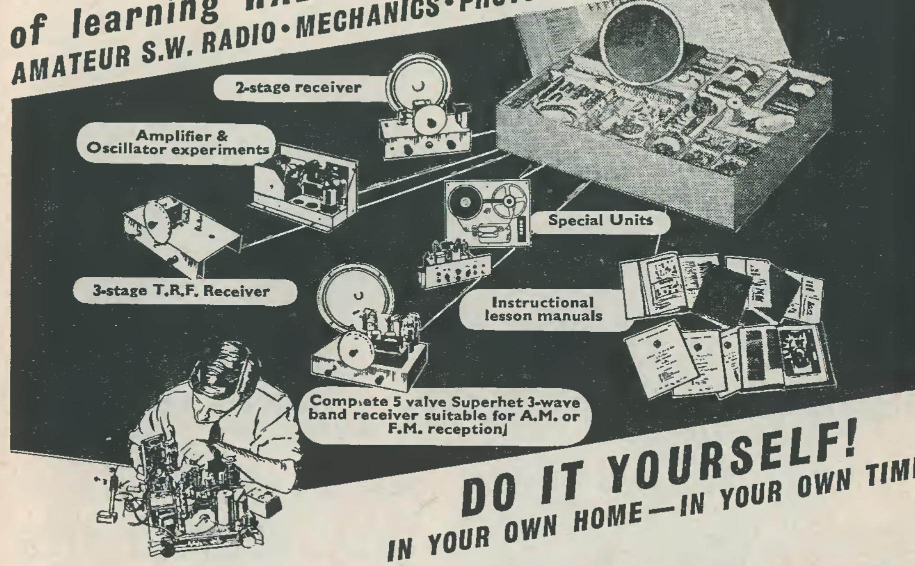

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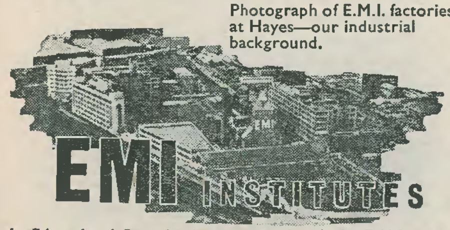

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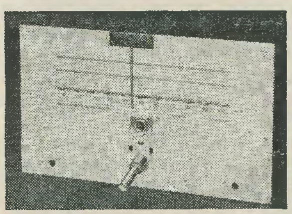

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The Radio Constructor

incorporating THE RADIO AMATEUR

VOL. 10, NO. 2
SEPTEMBER 1956
ANNUAL SUBSCRIPTION 21/–

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CONTENTS FOR SEPTEMBER

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

NOTICES

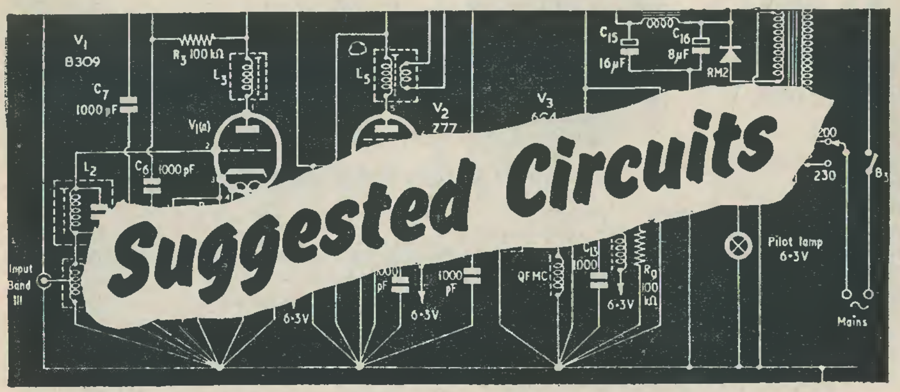
THE EDITOR invites original contributions on construction of radio subjects. All material used will be paid for. Articles should preferable be typewritten, and photographs should be clear and sharp. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included.

All MSS must be accompanied by a stamped addressed envelope for reply or return. Each item must bear the sender's name and address.

TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

QUERIES. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.

ALL CORRESPONDENCE should be addressed to THE RADIO CONSTRUCTOR 57 Maida Vale London W9



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*

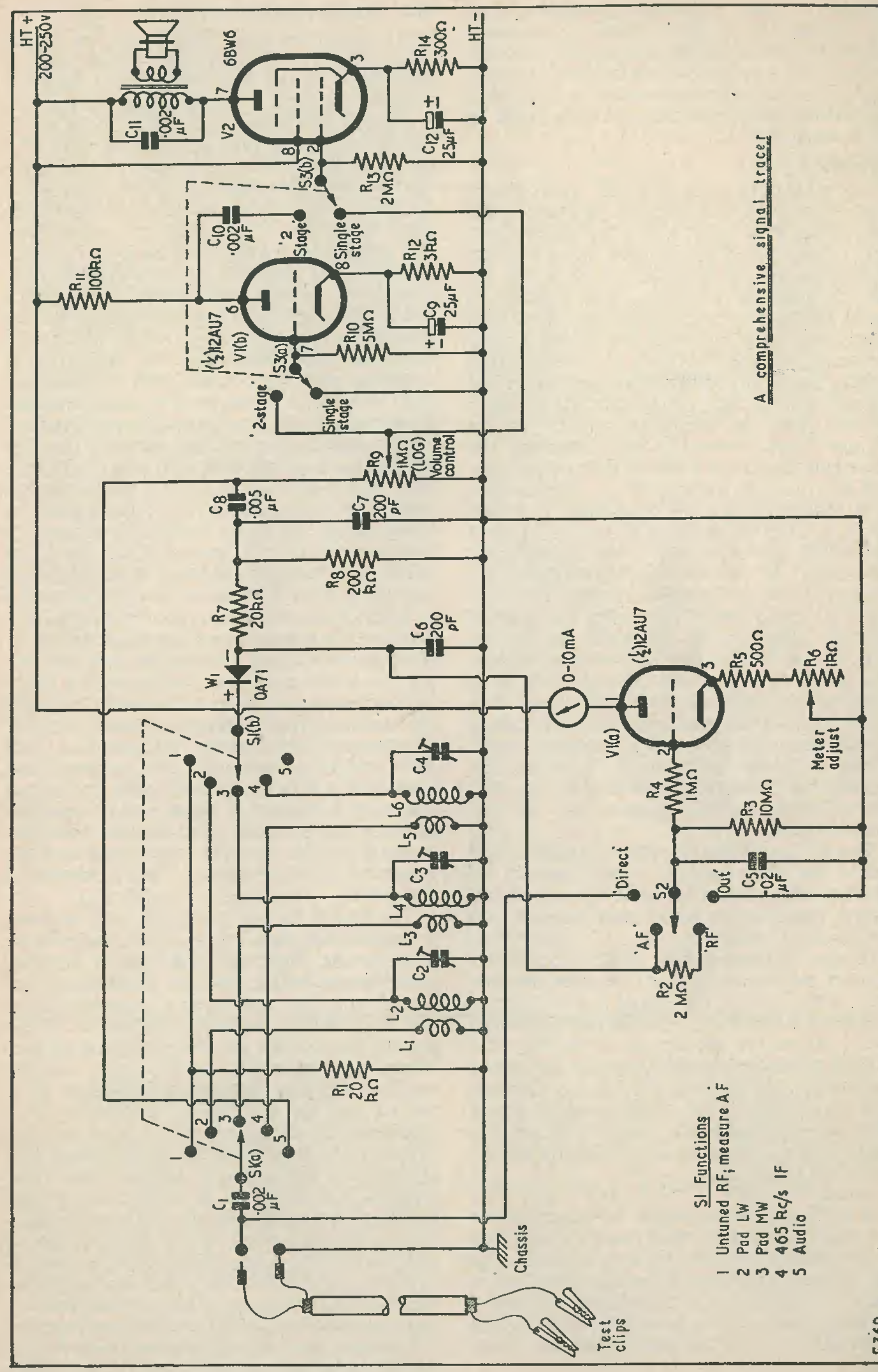
No. 70. A COMPREHENSIVE SIGNAL TRACER

Although the use of signal tracing techniques for the servicing of sound radio receivers is not as extensive in this country as it is in the United States, such techniques are still worthy of balanced and serious consideration. This is due mainly to the fact that signal tracing may frequently offer advantages not always given by conventional fault-finding methods. It is possible, further, that many British servicemen do not employ signal tracing procedure because this would necessitate their tackling their work from a viewpoint entirely different to that to which they have become accustomed.

The normal method of fault-finding in sound receivers consists of commencing at the loudspeaker and working backwards to the aerial input until the faulty stage has been located. After the cause of the fault has been located and cleared, the receiver is then re-aligned when this is considered necessary. With signal tracing technique the signal is traced from the aerial through to the loudspeaker in the reverse direction. If desired, each stage can be aligned as tracing is carried out. Thus, a significant amount of time can be saved so far as the treatment of the faulty receiver as a whole is concerned. Signal tracing methods necessitate the use of an a.f. amplifier fitted with some sort of detector circuit in addition to the test equipment required for normal service work. The a.f. amplifier and detector circuit can, however, be made up quite cheaply, since they require few components which are not available through normal home-constructor or trade channels. "Critical" components are not necessary.

The Circuit

This month's circuit depicts a rather ambitious and comprehensive signal tracer unit. Whilst, basically, it consists of a simple two-stage a.f. amplifier together with a detector, switching circuits have been provided which enable it to carry out a large number of additional service tests. One feature, not normally provided by signal tracer units, is the availability of check circuits for medium and long wave padding adjustments. These circuits enable quick and accurate padding to be carried out in receivers which have air-cored signal frequency coils (or frame, or ferrite frame,



A comprehensive signal tracer

aerials) in their frequency changer stages. The operation of these particular adjuncts will be described later in this article. A comparison valve voltmeter is also included, this enabling many alignment checks to be carried out with a greater accuracy than is given by aural methods.

Operation

The essential part of the signal tracer circuit is provided by an a.f. amplifier employing the two valves $V_{1(b)}$ and V_2. V_2 is a tetrode output valve, and $V_{1(b)}$ is half of a low-mu double triode. Since it will be necessary for the a.f. amplifier to have a gain capable of being adjusted over limits greater than those which can be given comfortably by a conventional volume control, a two-position switch, S_3, is fitted; this switching either the output valve on its own, or the two valves in cascade, into the amplifier circuit. In the "Single-Stage" position, $S_{3(b)}$ connects the a.f. appearing at the slider of the volume control, R_9, direct to the grid of V_2. At the same time, the grid of $V_{1(b)}$ is connected to chassis via $S_{3(a)}$ in order to prevent any a.f. passed via switch self-capacities being amplified in this stage. In the "2-Stage" position of S_3, the grid of V_2 is connected to the anode of $V_{1(b)}$ via $S_{3(b)}$ and C_{10}, whilst the grid of $V_{1(b)}$ is connected to the slider of R_9 via $S_{3(a)}$. Thus, both valves then work in cascade. The grids of $V_{1(b)}$ and V_2 are connected permanently to chassis via the grid leaks R_{10} and R_{13}, these resistors keeping both grids at chassis potential whilst S_3 is being operated. Owing to their relatively high values, the presence of these grid leaks should not alter the effective volume control law to any marked extent.

The a.f. applied to the volume control, and thence to the amplifier, may consist of rectified r.f. or of an audio frequency signal itself. The requisite source is selected by the five-position switch S_1.

In the "Untuned R.F. : Measure A.F." position of this switch, r.f. applied to the input terminals of the signal tracer appears across the resistor R_1. This resistor provides a d.c. return for the crystal diode W_1, and enables a detected signal to appear across the resistor R_8. R_7 and C_6, C_7 are r.f. decoupling components. The detected signal across R_8 is next applied to the volume control, R_9, via C_8. The "Measure A.F." facility will be explained later.

In the "Pad L.W.," "Pad M.W." and "465 kc/s I.F." positions, switch S_1 inserts tuned circuits and coupling coils between the input to the signal tracer and the crystal diode. In the "Audio" position, a direct connection is made from the input terminals to R_9, thereby enabling the tracer to be connected into any point in the a.f. circuits of the receiver under test.

The Tuned Circuits

An unconventional feature of the signal tracer is provided by the tuned circuits mentioned in the last paragraph, which are switched in by S_1. These tuned circuits are employed to enable alignment checks to be carried out at specific frequencies. In each case the tuned circuits concerned are coupled into the receiver under test via low impedance coupling coils, these purposely introducing some damping of the circuits to which they are connected. The coupling coil for each tuned circuit should have one-sixth to one-quarter of the number of turns employed for the tuned coil. The spacing, and hence the mutual inductance, between the tuned and coupling coils need not be critical; the coupling given by conventional r.f. coupling coils provides a measure of what is required. Conventional r.f. coupling coils could, in fact, be employed quite satisfactorily for the Pad M.W. (L_3, L_4), and Pad L.W. (L_1, L_2) coils. For the 465 kc/s coil (L_5, L_6) it may be necessary to fit a coupling coil close to a winding taken from an i.f. transformer, should a ready-made coil not be available. (A b.f.o. coil with a separate feedback winding would provide a suitable ready-wound component.)

When S_1 is switched to the "465 kc/s I.F." position the signal tracer is more sensitive to frequencies around this figure than to any other. In consequence checks can be made in the i.f. stages of the receiver under test with the certainty that unwanted signals at other frequencies are heavily attenuated. The 465 kc/s i.f. tuned coil also assists when alignment checks are made with the signal tracer level meter. A single coil of the type discussed here should give adequate response over the 456 to 472 kc/s intermediate frequencies encountered in commercial receivers.

The Pad M.W. and Pad L.W. coils perform a special function. They are intended to assist in the alignment of frequency changer aerial stages which have no padding adjustments, and they are tuned to approximately 650 kc/s (M.W.) and 150 kc/s (L.W.). These are the frequencies at which padding adjustments are normally carried out on the medium and long wave bands. When S_1 is set to one of the "Pad" positions, it is intended that the signal tracer input be connected direct to the anode of the frequency changer in the receiver under test. The receiver is then tuned approximately to the padding frequency, whereupon enough signal at this frequency (provided either by a signal generator or by a received station) should be available at the frequency changer anode to be selected by the appropriate tuned circuit in the signal tracer. When the receiver has fixed inductance signal frequency circuits, its tuning condenser should next be carefully adjusted for maximum signal from the signal tracer. This, then, corresponds to optimum tuning of the signal frequency circuits. The padding of the oscillator of the receiver is finally adjusted to ensure that the signal is tuned in by the receiver, and that it appears at the loudspeaker of the set. Almost all receivers having fixed inductance signal frequency tuned circuits are capable of oscillator padding adjustment (either by capacitive trimming or by adjustable dust cores), whereupon the procedure just described enables a direct adjustment of tracking to be obtained without guesswork. This padding process is, of course, carried out in conjunction with normal trimming procedure at the high frequency end of the appropriate band.

Meter Circuits

The meter circuit fitted to the signal tracer consists of a simple comparison valve voltmeter, this enabling really accurate alignment to be carried out whenever necessary. The valve employed is a low-mu triode ($V_{1(a)}$) and its operating position is adjusted by means of the cathode resistor R_6. This resistor should normally be set for full-scale deflection in the meter when S_2 is in the "Out" position.

The grid of $V_{1(a)}$ can be connected via S_2 to the input terminals of the signal tracer, to the crystal diode load, or to chassis when the valve voltmeter is not required. In the "Direct" position of S_2, $V_{1(a)}$ grid is applied direct to the input terminals of the tracer. In this position the meter provides a direct indication of any negative potential, with respect to chassis, which is applied to these terminals. Normally, the negative potential would be provided by the a.v.c. line of the receiver under test. It then becomes possible to align certain receivers, as well as check a.v.c. operation, using this mode of connection.

Alternatively, S_2 may be set to the "R.F." position, whereupon the meter provides an indication of the detected r.f. voltage appearing across the crystal diode load given by R_8 and R_7 in series. The series resistor R_2 prevents any marked interference with the operation of the crystal detector circuit.

In the "A.F." position S_2 connects the grid of $V_{1(a)}$ to the crystal diode load once more. In this case, however, the series resistor R_2 is taken out of circuit, and C_5 is applied directly across the crystal diode load. Due to the relatively large capacity of this condenser, the crystal diode circuit now becomes capable of rectifying audio frequencies, the amplitude of the rectified a.f. being indicated by the meter. When S_2 is in the "A.F." position, S_1 should be set to "Untuned R.F. : Measure A.F.," since this enables a return d.c. path for the crystal diode to be obtained via R_1. With this setting, a.f. is still applied to the signal tracer a.f. amplifier, but with some distortion. Nevertheless, it can still be of use for identification purposes.

Final Points

The operation of the tracer is quite simple. It is intended that a screened probe lead be connected to the input terminals, its remote end being terminated in two test clips. The clip connected to the screening of the probe lead should be connected to the chassis under test, whilst the other is moved to whatever point in the receiver circuit it is desired to test.

In the circuit shown here valves type 12AU7 and 6BW6 are specified for V_1 and V_2 respectively, but it is not essential to keep to these particular types. An excellent alternative for V_1 would be provided by a 6SN7. For the V_2 position any output pentode or tetrode capable of developing several watts may be employed. The crystal diode should be an OA71 or an equivalent.

No power pack is shown for the signal tracer as a conventional arrangement is all that is required here. A transformer-isolated supply is, of course, essential, as it is very probable that the unit will be employed to check receivers having live chassis.

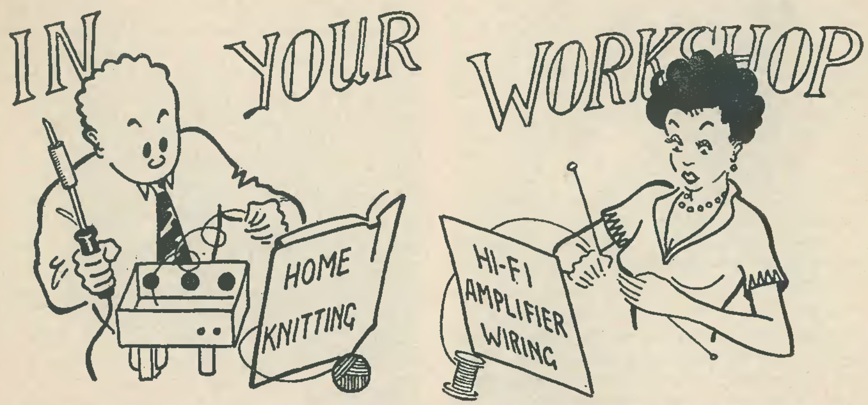
Hints and Tips

Avoid using one of the switch cleaning fluids on the tuning scale of a receiver, as these clean away the dirt *and* the paint with equal efficiency! Soap and water take a lot of beating; but even then it is wise not to rub too hard, as the heat from the dial lamps may have caused the paint to perish.

When making a miniature receiver, quite a large reduction in working temperature may be achieved by drilling a ring of small holes around the valveholder. A few holes drilled along the bottom edge of the chassis will allow cold air to enter and circulate, finding its way through the holes in the top and helping to keep the interior of the cabinet cool. Provision should also be made for the escape of the hot air at the top of the back.

Did you know that there is a correct way of connecting a tubular paper condenser in circuit? The end to which the outer foil is brought out is marked with a ring, and this end should be connected to the "earthy" end, either h.t. + or chassis, of the circuit. The "live" or "hot" end of the condenser will then be screened by the outer foil.

IN YOUR WORKSHOP



In response to many requests from readers, Smithy the Serviceman once more takes over "In your Workshop"

When Dick wandered into Smithy's workshop, the serviceman was bending over the chassis of a 13-channel turret-tuned television receiver which was lying on its side on the bench. As he heard Dick enter he glanced over his shoulder and grunted a welcome. He was preoccupied with what he was doing, and Dick, knowing his habits, sat down quietly at the bench beside him.

After a few minutes Smithy turned round.

"Could you plug this co-ax lead into the signal-genny over there for me? I've got both hands full just now."

"Certainly," said Dick, picking up the lead and taking it to the signal generator Smithy had indicated. Suddenly Dick gave a snort of disgust.

"What's up?" asked Smithy.

"I can't plug it in," replied Dick. "It's the same old story: the lead has got an ordinary coaxial plug and the generator has a Pye socket. Why don't the manufacturers standardise on these things?"

"Not to worry," remarked Smithy, "There's an adaptor in the drawer. That'll do the job."

Dick found the adaptor, examined it with some interest, and fitted it to the signal generator. Smithy grunted a little more and made a few final checks with the signal generator. Finally, he straightened up and lit a cigarette.

A.F. Distortion

"Job finished?" asked Dick.

"Yes," said Smithy, with a look of satisfaction. "It was easy enough, but just rather fiddling. This is quite a new set, but it still had several things wrong with it.

"The first thing," he continued, "was quite routine—distorted sound. The fault, incidentally, was a leaky coupling condenser to the grid of the audio output valve. You know, you don't normally get that sort of thing very often in a new receiver these days—when paper condensers go leaky it's usually only after a period of several years service—but it's bound to happen every now and again, of course."

"How did you find it?" asked Dick.

"Well, there are several ways of tackling a distorted a.f. amplifier, assuming that it's of the simple type you get in most television sets. Whenever I get distortion I always go straight to any coupling condensers which are connected between an h.t. point and a grid, because these are the components most likely to cause trouble. The nature of the distortion sometimes gives you a clue, incidentally, although this is rather a matter of practice."

He took out a pencil and scribbled a circuit on a piece of paper.

"Look," he said, "here's the circuit of the audio output stage used in this set (Fig. 1). As you can see, there's nothing at all out of the ordinary in it. To start off with, let us assume that the grid coupling condenser (C_1) has developed a *low* resistance leak. If this happened, the grid of the output valve would carry quite a considerable positive potential with respect to chassis. Indeed, it is quite possible that the anode of the output valve would become red-hot in consequence, whereupon you would see the trouble straight away. If you measured the voltage between chassis and grid with a normal voltmeter, you would get a marked positive voltage reading and the fault would be easy to identify. Mind you, there would also be a possibility that the valve itself had an internal short-circuit, but this isn't a very frequent occurrence. Nevertheless, it might be worth while changing the valve for a known good one before isolating the grid condenser itself for a final test, if you felt it worth while. The snag with these sets is that it isn't advisable just to pull the valve out to see if the positive voltage on its grid clears, because you would then break the series heater chain."

"In other words," remarked Dick, "it's really a toss-up as to which way you isolate the fault. You either change the valve or disconnect the condenser."

"That's pretty well the case," agreed Smithy. "But, in any event, coupling condensers with low resistance leaks are usually easy to find. It becomes more difficult when the leak in the coupling condenser has a high value of resistance. However, such condensers can still cause trouble. If, for instance, the anode to which a leaky condenser is connected had a voltage, say, of 150, and the following grid leak a value of 500kΩ, just under one-twentieth of 150 volts would be applied to the grid even when the leak in the condenser was as high as 10MΩ. That would be approximately $7\frac{1}{2}$ volts positive; quite enough to make any ordinary a.f. valve give a distorted output. If you tried to measure the positive voltage at the grid with the average low-resistance testmeter you would get very little deflection because of the high series resistance in the condenser.

"Whenever I am checking for distortion in a simple a.f. amplifier, and don't get a definite positive reading on the output grid, I usually make doubly certain that nothing is wrong with the coupling condenser by turning the volume back to minimum and short-circuiting the grid leak. Nearly always this can be done very quickly by simply shorting the grid down to chassis with a screwdriver. If the coupling condenser is not leaky the grid will already be at chassis potential via the grid leak, whereupon the short circuit provided by the screwdriver causes no change in circuit potentials. The short circuit, will therefore, cause no crackles in the loud speaker. Should the grid *not* be at chassis potential, due to a leaky coupling condenser, I would hear a definite crackle in the speaker as I shorted the grid to chassis. For this check the screwdriver should be in contact

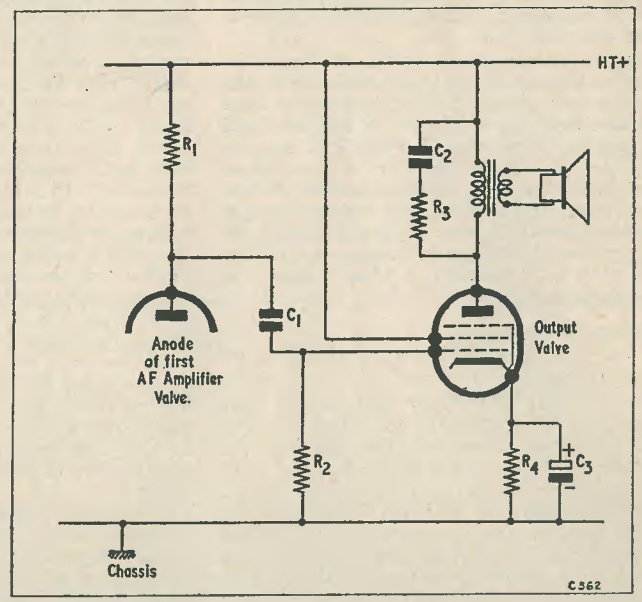


Fig. 1. The televisor a.f. output stage referred to in the text

with the chassis before it touched the grid, of course.

"And that's all there is to it. If you hear a crackle something is wrong! It needs a little time to explain it, but the test takes only a moment to carry out. You have to keep an eye open to see that the output grid leak *is* returned to chassis, of course, before you start applying the screwdriver. And, also, you need to keep the screwdriver well clear of the anode and screen-grid!"

"Well, that's interesting," commented Dick. "And something more I've learnt as well. You said just now that you can often make a guess at the cause of distortion by its nature. How do you do that?"

"Well," said Smithy, a little guardedly, "this isn't a thing where I would like to lay down the law with any certainty. Nevertheless, after a little practice you can sometimes guess fairly accurately whether the trouble is in the speaker or is a particular type of distortion caused by the amplifier itself. If the speaker is faulty, the distortion occasionally has a "mechanical" sound. A torn cone, for instance, often causes distortion of a "buzzing" nature, frequently set off by one particular frequency. Speaker distortion is, in any case, easy to locate. All you have to do is to connect another speaker in place of the suspected unit.

"Distortion in the amplifier itself may be due to non-linear amplification in one of the stages and, normally, all frequencies and volume levels are distorted. Distortion *could* be caused by supersonic oscillation, but this is rare in two-stage amplifiers of the type we are discussing now. In the case of oscillation you sometimes find that a.f. below a certain volume level is distorted, but that it becomes clear above that level. However, as I said, I certainly would not like to be at all dogmatic on these points."

Oscillator Tuning

"What was the other fault in the set?" asked Dick.

"Ah, that was fairly easy also," said Smithy. "All that had happened was that the set had gone off-tune on Band III. As you know, Band III is rather a new thing for us in this district, but the snags you run into aren't very different from the sort of things we had with Band I. In this case, the oscillator had gone a wee bit off frequency and you could only get a picture right at one end of the fine tuner's travel. A properly defined picture was outside its range.

"Now, this is the sort of snag where the serviceman has to think for his customer as well as for himself. He could, for instance, take the stand that, if the oscillator had gone off-tune by the 3 Mc/s or so indicated by the performance of the fine tuner, there would be a fair possibility that the r.f. circuits had drifted off by as much also. Theoretically, therefore, he should re-align the whole turret on the channel concerned with a wobbulator and 'scope. But this would take time and would mean a bigger bill for the customer. Would it be worth while charging him that much extra if the improvement in the picture caused by the re-alignment was hardly noticeable? It's just one of those little problems that servicemen have to solve for their customers without the customer knowing!

"Anyway, this time I decided to re-align the oscillator coil only and see what happened. There didn't, incidentally, appear to be any need to change the triode-pentode frequency changer, which *might* have caused the trouble, since the gain of the set as a whole was quite adequate.

"This particular receiver was one of those in which you can't get at the oscillator coil slug when that coil is switched into circuit in the turret. You can't retune the oscillator whilst watching the picture, therefore, and you have to fall back on what I could best call a logical second-hand technique.

"The first thing to discover is the end of the fine tuner range at which the picture is obtained. The dielectric constants of the insulating materials employed for fine tuner vanes are, so far as I know, all greater than that of air. So, if you just get your picture when the fine tuner vane is all out of the fixed metal vanes, then this corresponds to the lowest capacity in the fine tuner. The oscillator, in consequence, is running at too low a frequency. In other words, the highest frequency given by the fine tuner is still not high enough to enable a picture to be resolved. The reverse holds true. If the vane has to be all in to obtain the picture, the oscillator is running at too high a frequency. All one has to do then is to take the requisite oscillator coil segment out of the turret tuner, give the oscillator coil slug a turn in the desired direction, put the segment back in the turret and check the result. After several attempts you should be able to get the oscillator core in just the right position, with optimum picture bang in the middle of the fine tuner's travel."

"Well, that doesn't sound too hard," remarked Dick. "But does it always work out as easily as that?"

"It does if you are careful about it," replied Smithy, "and care is definitely needed on a job like this. First of all, the set should be allowed to warm up for at least twenty minutes before you tackle the adjustment, just in case it has a tendency to drift. Secondly, any coil segments you take out of the turret should always be handled gingerly because they can sometimes be quite fragile. Some manufacturers apply their own patented 'Muckite' to the core to hold it in position after it has been aligned at the factory, so the core should always be adjusted *very* carefully at first. Give it a sharp wrench and you may find bits of coil former lying on the bench. Don't forget also that frequency goes *up* when you screw a brass core *into* a coil. Finally, and this is probably the most important point of all, never touch any core until you have positively identified that it is that of the oscillator coil. If you adjust cores experimentally without knowing which is which you will almost inevitably completely wreck the r.f. alignment of the turret; whereupon you *have* to use a wobbulator and 'scope to get things back to normal."

"Well, there are enough warnings there!" said Dick. "How do you identify the oscillator coil?"

"Preferably from the service manual," replied Smithy. "But if you have no information on the set a little circuit tracing may help. For instance, the oscillator coil is almost certain to be near the fine tuner, in order to keep the turret internal wiring short, and so on."

Coaxial Adaptor

Smithy glanced up at the clock.

"It's later than I thought," he commented. "Time I wasn't here!"

With Dick's help, Smithy commenced to clear up the work-bench and switch off his equipment. Just as they were about to leave, Dick gave an exclamation.

"I've just remembered a question I was going to ask you immediately after I got in!" he said.

"Oh, yes, what's that?"

"I just wanted to know where you got that neat little adaptor I used on the signal generator. You know, the one which allows ordinary coaxial plugs to be fitted to Pye sockets."

"Oh, that!" chuckled Smithy. "I made that one up myself. All you need is a Belling-Lee metal coaxial plug, type L.734P, and a Pye plug. You remove the clamping nut from the Belling-Lee plug, whereupon you should find that the threaded body just screws nicely into the threaded portion of the Pye plug. At any rate it does so with every Pye plug I have ever encountered myself! Add a wire to complete the centre connection, and the adaptor is complete (Fig. 2).

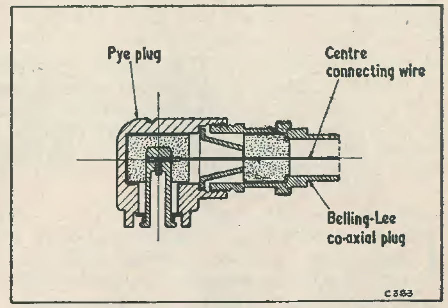


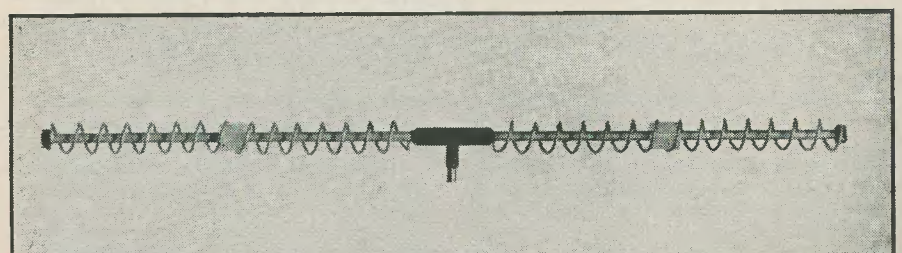
Fig. 2. Smithy's adaptor for coupling coaxial plugs to Pye sockets

"If you want a socket instead of a plug termination you can add an L.616 adaptor (two sockets back-to-back) to the plug. The whole thing forms one of those useful little gadgets which fill the proverbial long-felt want."

After which, Smithy gave one last look around, locked up the workshop, and gave Dick a glance which even that young man could only interpret as a definite "closing of the hangar doors" for the day.

New Labgear Dual-band Indoor T.V. Aerial

The illustration shows a new indoor t.v. aerial developed by Labgear (Cambridge) Ltd., Willow Place, Cambridge, for use on Bands I and III. It can be fitted directly to most televisors, so making the set transportable, and is suitable for use at ranges up to 10 miles from the transmitter, with either vertical or horizontal polarisation. It is priced at 39/6 retail; a suitable outlet box is available, if required, at 4/6. Both are obtainable from local dealers.



TELEVISION for the HOME CONSTRUCTOR

PART 3.

by S. WELBURN

This month S. Welburn has some further comments to make concerning linearity in the frame timebase. He also deals in detail with other faults peculiar to this section of the television receiver

In last month's issue we commenced a discussion on frame timebase and scanning circuits, devoting our space to their basic functioning, together with some words (partly attenuated for reasons of space) on frame linearity and linearising arrangements. We also considered two circuits which could be employed for improving linearity. These operated by introducing a negative feedback loop between anode and grid of the frame output valve.

Variable Cathode Bias

In addition to negative feedback circuits, a further extremely useful method of controlling frame linearity can be obtained by altering the cathode bias on the frame output valve. The simple circuit shown in Fig. 1 is all that is required for this purpose. In Fig. 1, R_3 is a wire-wound potentiometer having a value of approximately 500Ω, and it is connected in series with a fixed resistor R_2. The purpose of the fixed resistor is to prevent the possibility of zero bias being applied to the frame output valve, and its value should normally lie between 200 and 300Ω. The cathode itself is decoupled to chassis via the electrolytic condenser C_2.

Adjusting R_3 varies the position at which the input waveform is applied to the dynamic I_aV_g curve of the valve. Fig. 2 may make this point clear. In this diagram it can be assumed that the result of adjusting R_3 in Fig. 1 is that the input waveform is moved bodily to the right or to the left. As will be seen, moving the input waveform too far to the left (the condition corresponding to high bias voltage) causes negative excursions to be applied to a non-linear part of the curve. Similarly, moving the input too far to the right (low bias voltage) causes grid current to be passed on positive peaks. (The amount of grid current which will occur in practice is rather problematic since the leaky-grid action given by the grid input components—grid condenser C_1 and grid leak R_1—will cause the coupling condenser to take up a charge which will automatically provide partial bias.) When the input waveform is positioned at points in between the two extremes just mentioned a useful adjustment of linearity can still be obtained. This is due to the fact that the most linear part of the valve curve is still not necessarily a perfectly straight line. A further important fact is that when the position of the input waveform is varied along the linear part of the valve's curve the average anode current of the valve varies. In consequence the current in the frame output transformer primary also varies, thereby altering the permeability of its laminations. Such a change in operating conditions may cause quite noticeable alterations in frame linearity, even when these changes are not obviously provided by the characteristic curve of the valve itself.

Assuming that we were attempting to design a frame output stage in which we wished to obtain greatest linearity before adding an n.f.b. loop, it would seem that the best adjustment for R_3 would be that in which the input waveform is applied at the furthermost negative part of the linear section of the frame output valve's I_aV_g curve. This would result in linear amplification, together with maximum inductance in the frame output transformer. In most conventional televisors the negative part of the input waveform applied to the grid of the frame output valve corresponds to the top of the picture. In consequence, therefore, we would increase the bias given by R_3 of Fig. 1 to the point just before the top of the picture commenced to cramp. It is possible that we might find that this did not give a final answer, however, and it is quite on the cards that we might eventually have to employ R_3 to purposely introduce non-linearity in order that it may cancel out non-linearity caused elsewhere!

Despite that last statement, the range of adjustment given by the circuit of Fig. 1 is sufficiently attractive to make its use worth while for those who appreciate really good results from their television sets. Adjustment of frame output bias is a feature which can often be added with advantage to commercial televisors which are not quite up to the mark so far as frame linearity is concerned. An incidental feature is that the potentiometer R_3 does not need to be connected into the circuit via short leads, since it is fairly adequately decoupled via C_2.

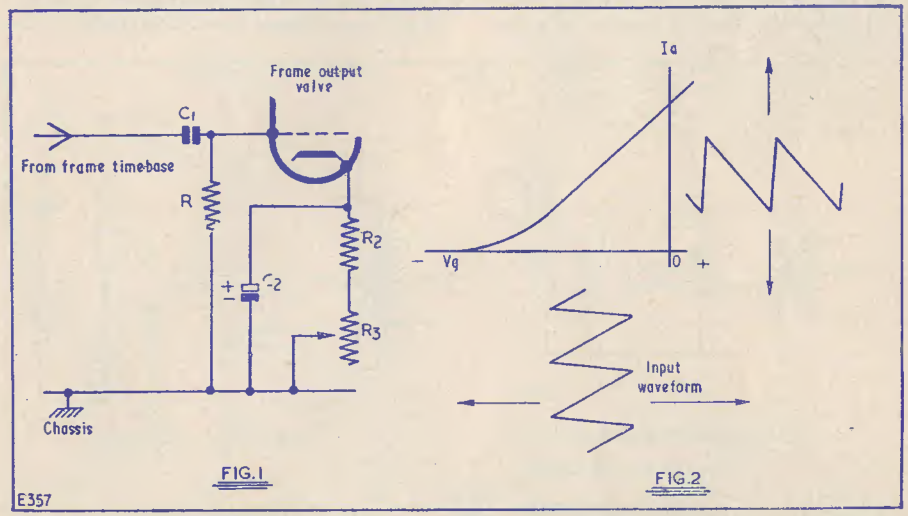


Fig. 1. A useful control of frame linearity may be obtained by controlling the cathode bias of the frame output valve. Fig. 2. The dynamic I_aV_g curve of the valve of Fig. 1. Adjusting R_3 has the effect of moving the input waveform bodily to right or left

will be doomed from the start. The grid leaks of many frame output stages have values between 1 and 3MΩ, so, even if the leakage in the coupling condenser has a value as high as 40MΩ, it can still cause trouble. It is always advisable to use a component of reliable make and source in this position—the same applies, incidentally, to any condensers in n.f.b. loops which are connected between frame output anode and grid.

The cathode decoupling condenser C_2 is rather an important component so far as linearity is concerned. The average design employs a 50μF component in this position and no trouble seems to result thereby. However, the time constant of a 50μF condenser paralleled by a 500Ω resistor (a normal cathode bias value) is 0.025 of a second, and this might appear to be running rather close to frame cycle frequency. It could possibly be worth-while increasing C_2 experimentally to 100μF or more if non-linearity is troublesome, although the writer has had no trouble himself from this particular component.

The Coupling Condenser

A most important point is provided by the coupling condenser C_1 of Fig. 1. This component is almost always connected to the previous anode in the timebase. In consequence, if it should happen to become leaky, a positive potential will be applied to the frame output grid, and any serious attempts at providing good frame linearity

Frame Ringing

As is to be expected in a transformer-coupled arrangement of the type employed in frame output stages, ringing is quite likely to occur every cycle, following the shock-excitation given by the flyback pulse. As in a line output stage, the ringing consists of a damped train of oscillation, and occurs mainly at the resonant frequency of the transformer leakage inductance plus the inevitable stray capacities in the circuit. Fortunately, frame ringing does not provide many headaches in practical designs because it can be "killed" quite easily by the "brute force" tactics of heavily damping the transformer secondary with low-value resistors. The loss in efficiency sustained in consequence can easily be made up due to the reserve of power in the ordinary frame output stage. Values around 1kΩ connected across the transformer secondary are conventional. If the frame deflector coils are connected in series, instead of in parallel, it is better to connect the damping resistors across each coil instead of across the secondary alone. The two damping arrangements are illustrated in Fig. 3. The reason for connecting across each coil, as is done in Fig. 3 (b), is to ensure that possible ringing in the individual coils is damped out. The transformer secondary is then, of course, still damped by the two resistors in series.

Cross-Talk

An annoying form of picture distortion, and one which can cause quite a little trouble to the television designer, as well as to the home-constructor who is making up his own equipment, is due to the defect known as cross-talk. Cross-talk is caused by random couplings between the line and frame circuits, and results in the line scanning waveform modifying the frame waveform. The usual result is that line ringing voltages cause similar voltages to appear in the frame scanning circuits. Unless chassis design has been careless, or a fault has developed, the random couplings causing the cross-talk occur usually in the deflection yoke itself.

In Fig. 4 a set of line and frame deflector coils is shown, together with the major stray coupling capacities introduced by the yoke construction. These stray capacities would normally have unequal values. Usually, the line deflector coils are connected into the line output transformer at a point on the winding that is not at chassis potential so far as line scanning voltages are concerned. The resultant effect is that the entire line deflector coils carry a potential which is changing at line frequency. This is in addition to the line frequency voltage appearing *across* the coils, and which is itself not balanced with respect to chassis.

Since the line deflector coils of Fig. 4 carry unbalanced line frequency voltages, and since the stray capacitive couplings between line and frame coils are not always symmetrically

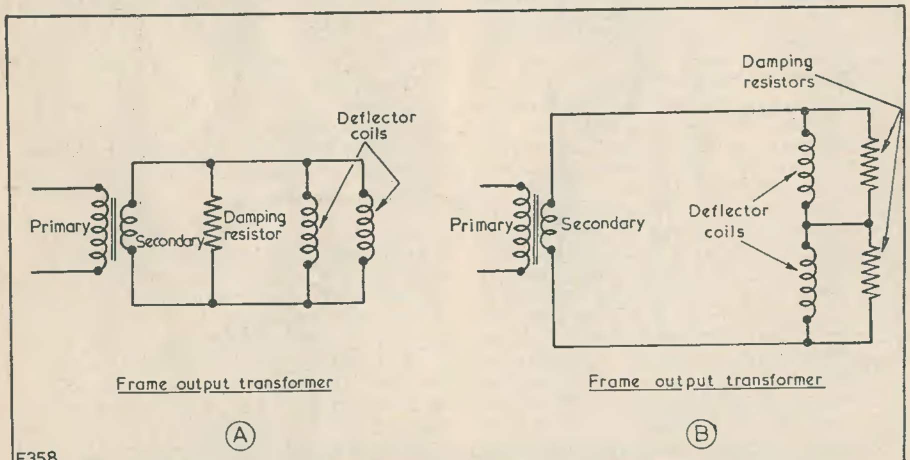


Fig. 3 (a). Connecting a damping resistor to obviate ringing in the frame deflector circuit. Fig. 3 (b). When the deflector coils are connected in series this method of damping is preferred

It is always a little difficult to specify a wattage rating for resistors employed in the circuits of Fig. 3, owing to the fact that relatively high pulse currents pass through them, and because normal carbon resistors are liable to be unpredictable in service of this sort. Half-watt resistors seem to cope adequately in most cases, although they are liable to go rather mysteriously high-value or open-circuit every now and again.

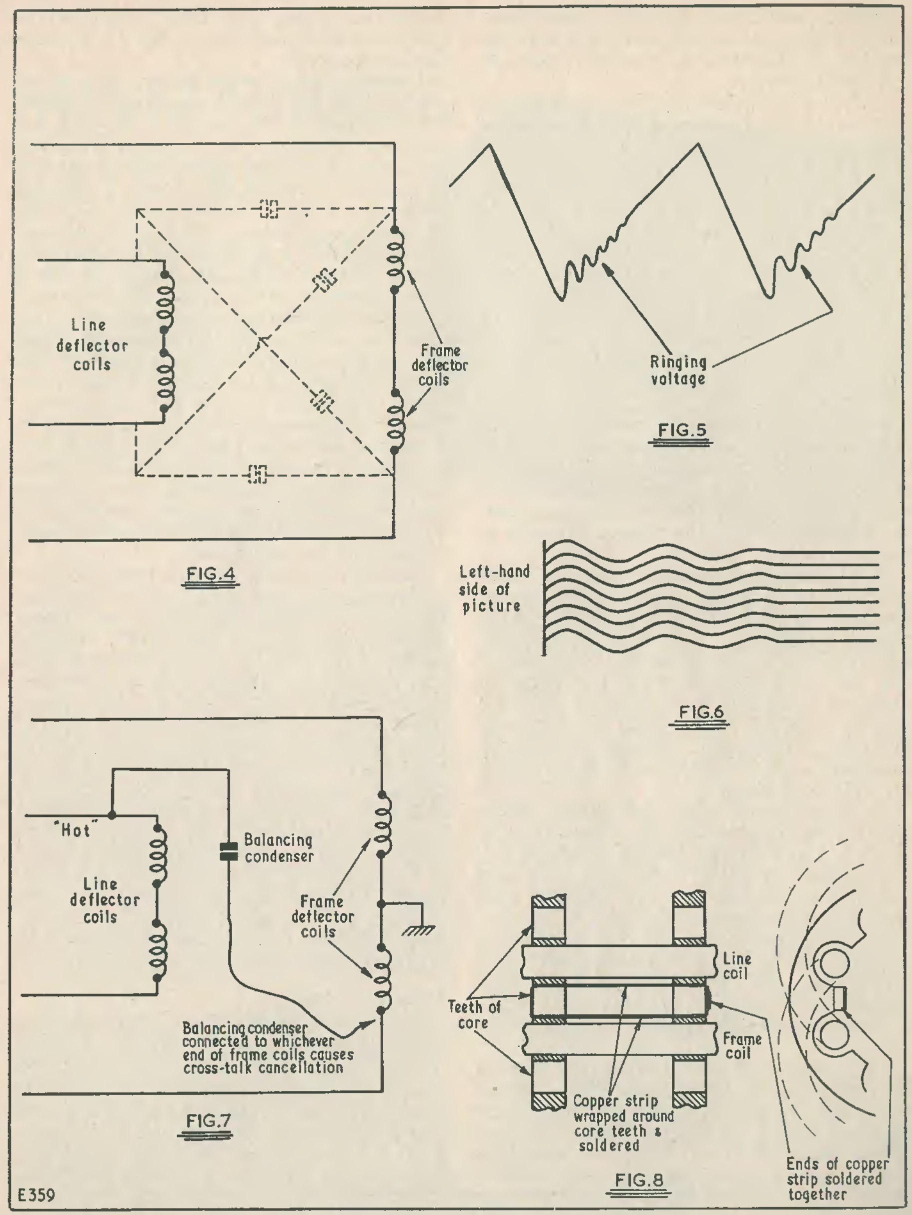


Fig. 4. The major coupling capacities in a deflection yoke. Fig. 5. A line sawtooth waveform, showing ringing voltages. Fig. 6. The effect of cross-talk on the left-hand side of the picture. Fig. 7. One method of connecting a balancing condenser to cancel out cross-talk. Fig. 8. How a damping ring (actually a single "shorted turn") is fitted to the core teeth of a deflection yoke

balanced, interference with the frame scanning waveform by the line waveform becomes feasible. This interference is the cross-talk referred to above.

In theory, the potentially most troublesome parts of the line scanning waveform, so far as cross-talk is concerned, are the line flyback pulse and any line ringing voltages which may be present. This point is to be anticipated, since the reactance of the stray coupling capacities will obviously be lower to those parts of the line waveform which have the higher frequency. In practice, the line flyback pulse does not appear to cause a great deal of trouble, although this is probably due to the fact that its effect is lost during the line blanking period. Line ringing voltages, on the other hand, often cause serious picture distortion.

Ringing in the line deflection circuits may have quite a high amplitude before noticeable degradation of the horizontal scan becomes apparent. Fig. 5 shows a sawtooth waveform with a fairly high amplitude ringing voltage. As is to be expected, the ringing decreases as the scan cycle progresses.

If this ringing voltage is applied, by means of cross-talk couplings, to the frame deflector circuits, a vertical deflection takes place at the ringing frequency. The result is shown in Fig. 6. This illustrates the left-hand side of the picture and shows how the lines are deflected vertically by reason of the line ringing voltage. The effect is extremely annoying, incidentally, because it shows up markedly even when the vertical deviations are only very small.

In really serious cases, the vertical deflection caused by cross-talk can extend over as much as 3 to 4% of the overall picture height.

Cross-talk is liable to be most prevalent when either the line or frame deflector coils have high impedance windings. In the first case this is due to the fact that the line coil ringing voltage has a correspondingly high amplitude. In the second case, high impedance frame coils are more susceptible to having cross-talk voltages built up across them.

One method of curing cross-talk consists of balancing the frame coils about chassis potential. If successful, this will then result in the cross-talk voltages in either coil cancelling each other out. A typical example is given when two frame deflector coils are connected in series and their centre-tap is connected to chassis (or to the h.t. positive rail in some sets).

Unfortunately, most deflector yokes are so made that the stray capacities between different parts of the line and frame coils are not equal, whereupon any attempts to balance the frame coils about chassis cannot provide a complete cure for the trouble. In such instances it is often possible to clear cross-talk by connecting a balancing condenser between the line deflector coils and a point on the frame deflector coils. In Fig. 7 we see a typical application of this idea. A condenser is connected between the "hot" end of the line deflector coils (i.e. the end connected to the line output transformer tap nearer the line output anode) and to whichever end of the frame coil results in cross-talk cancellation. The capacity between line and frame coils in a conventional yoke is about 20 to 60pF, and a condenser having a value within these limits (and capable of withstanding pulse voltages) may then provide the required cancellation. The final condenser value will, of course, have to be found by experiment.

Another approach towards clearing cross-talk consists of attempting to reduce the stray capacities between the line and frame deflector coils in the yoke itself. Careful design of the yoke layout will help to achieve this condition, although such a process is hardly within the scope of the home-constructor. Advantage can also be taken of the electrostatic screening provided by the metalwork of the yoke. As is known, if an earthed screen is placed between two electrodes, the capacitive coupling between them can be reduced to zero. Many modern yokes employ castellated cores of Ferroxcube or Caslam, these being assembled in a metal band. Earthing that metal band will often provide quite a useful measure of electrostatic screening between line and frame coils, and may reduce cross-talk considerably.

Inductive Couplings

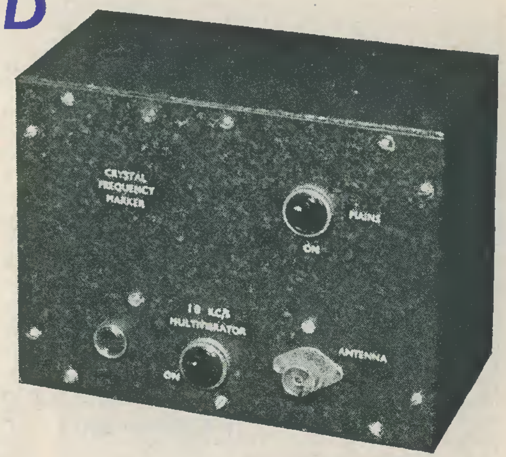
Cross-talk can also be caused by magnetic couplings through the core material employed in the yoke. With castellated cores this coupling can often be reduced by fitting "damping rings" to the four teeth of the cores which lie between the line and frame coils. Fig. 8 shows these damping rings and illustrates the method in which they are fitted.

CATALOGUES RECEIVED

Southern Radio & Electrical Supplies, Sorad Works, Redlynch, near Salisbury, Wilts. Contains 54 pages, well produced and comprehensively illustrated, listing practically every item likely to be wanted by the constructor. Catalogue No. 10 is available to readers at 6d. post free.

Classic Electrical Co. Ltd., 352–364 Lower Addiscombe Road, Croydon, Surrey. Believed to be the most comprehensive catalogue devoted to Hi-Fi Equipment yet issued in this country, this 32 page 1956 edition is available free of charge to all readers interested in true reproduction.

MINIATURISED CRYSTAL FREQUENCY MARKER



PART 2

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

In Fig. 5 is shown the circuit diagram for a similar instrument designed to operate from a.c./d.c. mains. Here, a Brimar 12AU6 is used for V_1 instead of a 6AM6 to obtain a 12V 0.15A heater. The 12AT7 is retained for V_2, with heater wiring taken to pins 4 and 5 only, pin 9 being left blank, so that series connection of the two heater sections results in a 12V 0.15A heater. A Brimistor type CZ2 is used in the series-connected heater circuit, the required dropping of excess mains voltage being effected with a dropping resistor R_d and a length of resistance line cord. The resistor R_d can be mounted on the outside of the rear panel, and covered with perforated sheet metal for ventilation and protection. The tapping on this resistor can be set to provide the correct heater current.

High tension supply is derived from two SenTerCel type RM-0 selenium rectifiers in series, smoothing being by the 50μF reservoir and single stage L-C filter L_1, C_7. It is possible to adopt an L-C filter in this version of the instrument since the smoothing choke can be mounted in place of the mains transformer of the a.c. version. As rectification is now half-wave, the additional smoothing provided by the choke and high value capacitors is necessary to remove ripple. Ventilation of the instrument by means of holes in the case is of more importance now, for the RM-0 rectifiers can be damaged if they are subjected to too high a temperature. Their full rating of 30mA at 35°C is more than adequate for the instrument, but as this rating is reduced to 15mA maximum at 55°C they should be run as coolly as possible. Further, it is important to mount them so that the discs are vertical to allow free airflow around the elements to carry off such heat as may be generated.

The common earth connections of the circuit now being directly connected to the neutral side of the mains, the instrument case should be isolated with an 0.01μF capacitor rated at not less than 750V d.c. working. The antenna is already isolated by the small silver mica capacitor C_5, but to ensure against insulation breakdown an additional capacitor C_9 of 0.01μF of similar rating to C_{10} is wired in series. It is also necessary to ensure that the mains lead of the instrument cannot be connected to the mains in a reversed condition. The obvious way to deal with this is to use a 3-pin plug and socket, correctly wired so that the earthy side of the instrument is joined to the neutral side of the mains.

Calibration of the frequency marker is quite a simple process, the degree of accuracy obtained being entirely dependent on the amount of patience possessed by the constructor.

The first requisite is a known frequency of dependable accuracy, and fortunately there are several places where we can find one if we know where to look. One source is the 200 kc/s long-wave transmission of the B.B.C. The frequency stability of this carrier is one of the most accurate in the world. There are others, such as the standard frequency transmissions radiated by the American Bureau of Standards from station

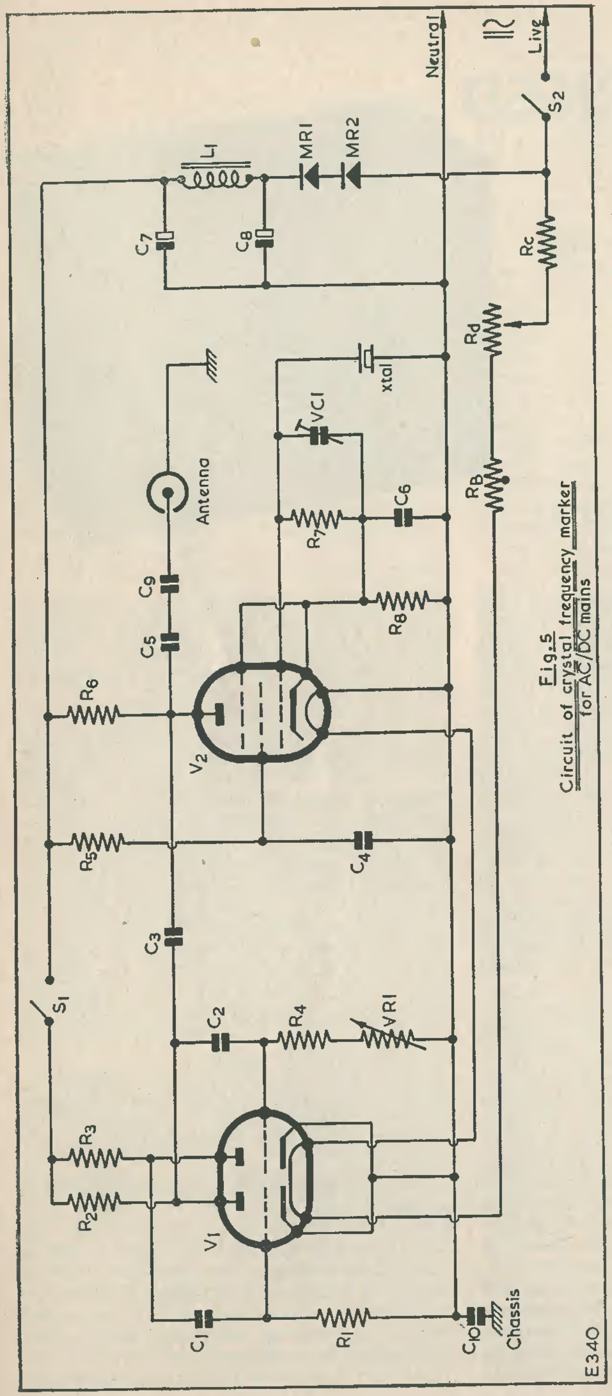


Fig. 5 Circuit of crystal frequency marker for AC/DC mains

PARTS LIST, Fig. 5

R_1, R_6—22kΩ ½W
R_2, R_3—47kΩ ½W
R_4—20kΩ ½W
R_5—100kΩ ½W
R_7—470kΩ ½W
R_8—10kΩ ½W
R_B—Brimistor type CZ22
R_d—1,000Ω 0.2A dropper with adjustable tap
R_c—300Ω 0.15A line cord*

VR_1—5kΩ miniature pot. (Dubilier)
C_1, C_2, C_6—0.001 350V paper
C_3—3/30pF concentric trimmer (Philips)
C_4—0.1μF 350V paper
C_5—50pF ceramic
C_7, C_8—50+50μF 350V electrolytic
C_9, C_{10}—0.01μF 750V (min) paper
VC_1—100pF trimmer
V_1—Brimar 12AT7

V_2—Brimar 12AU6
MR_1, MR_2—SenTerCel type RM.0
L_1—30H 20mA choke
Xtal—100kc/s Brookes type G
S_1, S_2—Single pole toggle
1 B7G v/holder and screen (V_2)
1 B7G ceramic v/holder (Xtal)
1 B9G v/holder and screen (V_1)
1 L.604 socket (Belling & Lee)

* Start with 2 yds and trim as required.

WWV, and similar transmissions, nearer home, from the MSF station at Rugby.

Almost any broadcast receiver can be pressed into service to use the 200 kc/s B.B.C. carrier. If the receiver can tune to this with as little "spread" as possible, so much the better. A useful aid to obtaining the correct tuning point is an output meter such as a low-reading a.c. voltmeter connected across the output transformer secondary. As a steady reading cannot be obtained during normal programme transmissions, the best time to choose is the period prior to opening of programmes when the carrier is modulated with an 800 c/s tone. Using this signal, tune the receiver for maximum reading on the output meter. It can be mentioned here that the output meter need not be calibrated, but sensitivity to small changes is required rather than accuracy of reading.

The receiver and crystal frequency marker should have been switched on some ten or fifteen minutes before calibration is undertaken so that they reach their normal operating temperatures. This will reduce drift due to rising temperature, and is a normal procedure for test instruments.

When the modulated 200 kc/s transmission has been *accurately* tuned in, remove the aerial lead and replace it with a length of wire long enough to produce a note in the speaker which is just audible with the volume control at maximum. Loosely couple the antenna of the crystal frequency marker to this lead, leaving the tuning of the receiver undisturbed. A heterodyne note should be heard which is the second harmonic of the crystal beating with the 200 kc/s carrier. Adjust the trimmer VC_1 of the frequency marker so that this note runs down to zero beat. The 800 c/s note will still be heard, and if you wait until this goes off you can make final adjustment to VC_1 to produce a dead zero beat. This is where some patience is needed, for you may not be successful first time, and will have to wait until the next morning for another check!

If a communications receiver is available, the MSF transmissions can be used at 2.5 Mc/s, 5 Mc/s or 10 Mc/s. These will give further check points which are available more readily than the B.B.C. 200 kc/s carrier. Only slight adjustment of VC_1 should normally be required, and such alterations to it should be carried out delicately.

For calibrating the multivibrator it is better to go back to the 200 kc/s tuning point on the broadcast receiver, since dial readings are fairly widely spaced. Check that frequency marker pips are heard at 200 kc/s (1,500 metres) and 300 kc/s (1,000 metres), carefully noting the dial readings at which they are heard. Switch on the multivibrator, and starting at the 200 kc/s marker, gradually tune the receiver through to 300 kc/s. In doing so, you should hear nine 10 kc/s markers between the 100 kc/s markers. If more or less than nine intermediate points are heard, the multivibrator is not operating at 10 kc/s. Adjust VR_1 until nine markers are heard. It should be found that the multivibrator jumps quite suddenly into tune, and holds its tune for a fair amount of movement of VR_1. Set it, therefore, at the mid-point.

It now remains to adjust the variable capacitor C_3. With the multivibrator running, adjust C_3 with an insulated trimming tool so that the minimum capacity commensurate with stable locking of V_1 is obtained. You now have a very accurate frequency standard in a very small space, and one which will have long-term accuracy if it is treated with care.

It will probably now be apparent that having calibrated the frequency marker, a ready means of checking the frequency of a transmission heard on a receiver is available. To make such a measurement the antenna lead of the instrument is loosely coupled to the aerial lead of the receiver. Fig. 6 represents a portion of a typical tuning scale and will serve to illustrate the method of interpolating the scale readings for calculating the unknown frequency. First, with the multivibrator switched off, the unknown frequency Fx is seen to fall at a *scale* reading Dx=34.6. Tuning the receiver each side of this point reveals 100 kc/s marker points at 1.7 Mc/s and 1.8 Mc/s, so Fx lies somewhere between these two frequencies. Now switch on the multivibrator, and starting from the 100 kc/s marker at 1.7 Mc/s, tune the receiver towards 1.8 Mc/s and count the 10 kc/s markers as they are tuned through, noting that the 5th and 6th fall each side of Dx at points indicated by D1 and D2, the *scale* readings being 34.2 and 35.3 respectively. As Dx is now between 50 kc/s and 60 kc/s above 1.7 Mc/s, the unknown frequency is obviously between 1.75 Mc/s and 1.76 Mc/s. This frequency can now be calculated relative to the 1.75 Mc/s marker from the following formula:

$$Fx = 1.75 + \left\{ \frac{(Dx - D1)}{(D2 - D1)} \times 10 \text{ kc/s} \right\}$$

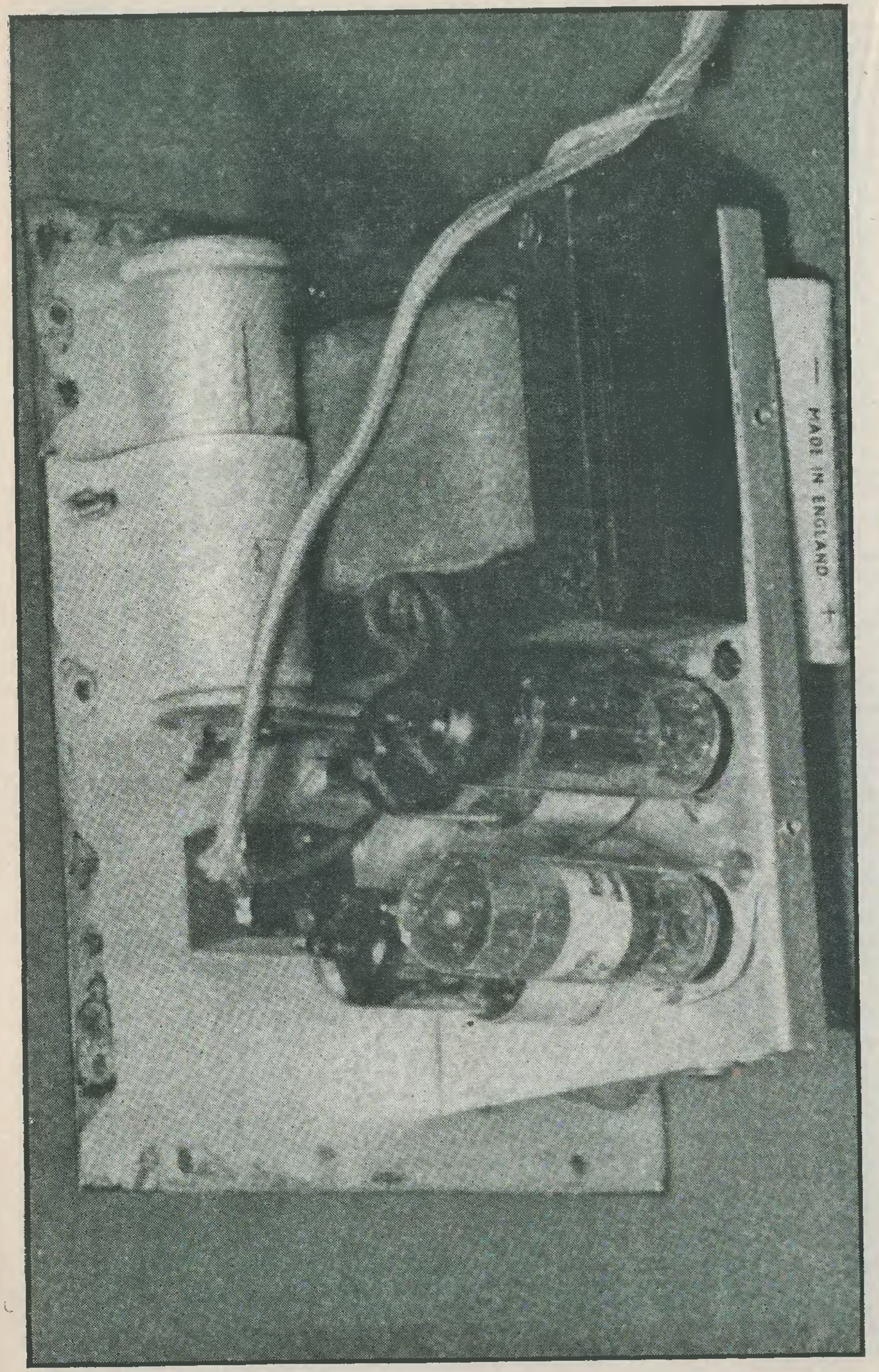
$$= 1.75 + \left\{ \frac{(34.6 - 34.2)}{(35.3 - 34.2)} \times 10 \text{ kc/s} \right\}$$

$$= 1.75 + (0.364 \times 10 \text{ kc/s})$$

$$= 1.75 + (3.64 \text{ kc/s})$$

$$= 1.75364 \text{ Mc/s, or } 1753.64 \text{ kc/s.}$$

It is to be noted that the frequency or wavelength markings on the receiver tuning



Above-chassis layout, a.c. mains version

dial are not needed for determining the actual frequency; one merely uses *scale* divisions for the calculation. The method is therefore applicable irrespective of whether or not the frequency calibration on the dial bears any relation to the scale divisions.

To calibrate a signal generator the receiver can be tuned to each 100 kc/s check point in turn. As each point is accurately tuned in, the frequency marker can be disconnected from the receiver and replaced by the output lead from the signal generator under test. If a modulated r.f. output is used, the correct tuning point can be found by adjusting the tuning dial of the signal generator until a maximum reading is obtained on the output meter, leaving the tuning of the receiver undisturbed. If necessary a close check can then be made by temporarily coupling the frequency marker loosely to the receiver. If a beat note is heard, the signal generator can be adjusted until zero beat is obtained. Normally, little if any adjustment should be necessary.

Having calibrated as many 100 kc/s points as possible, the 10 kc/s points between them can be found. Not all of them will be capable of direct calibration, of course, especially on the higher frequencies. If fine division of scales is considered desirable, visual division will be good enough for most purposes.

If a normal broadcast receiver is being used as the detector for calibration purposes, there will be a gap in frequency coverage between about 550 metres (545 kc/s) and 800 metres (375 kc/s). The common i.f.'s centred around 465 kc/s fall within this gap, so to calibrate frequencies of this order it is necessary to extend the medium waveband in some way. This can conveniently be done by temporarily connecting additional trimmers across the tuning capacitor sections and adjusting these for maximum response on the output meter at a convenient position of the tuning dial for each 100 kc/s marker as it is found. Obviously, extreme accuracy of tuning is not required in adjusting the trimmers so long as a clear indication from the signal generator is obtained on the output meter.

With an accurate frequency marker of this sort available, it is relatively easy to secure very accurate calibration of a receiver tuning dial after the tuning circuits have been aligned and ganged with a signal generator. The small errors which arise due to drift of the signal generator, or perhaps the difficulty of bringing its dial reading dead on the correct tuning point, can be corrected by a check over the frequency band covered by the receiver. Check points every 100 kc/s will soon reveal the trend of any error, and this can be corrected by hand calibrating the scale to agree with the marker points.

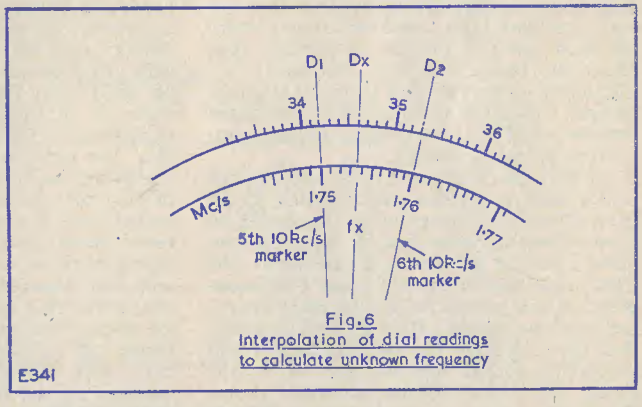


Fig. 6
Interpolation of dial readings to calculate unknown frequency

The author wishes to acknowledge the help of his friend J. L. Warne, who produced the photographs which appear in this article.

Musical Electronics with a Hawaiian Guitar

continued from page 104

Stainless steel sheet is specified only because of strength and cheapness compared with chrome plated brass. If stainless steel is favoured it is better to have the two pieces cut to size when purchasing. Drilling and bending is not difficult, but to simplify the work the holes could be drilled to allow studs or chrome screws to pass through into the wood for about ¾in, leaving the head clear enough to allow the loop to hold on.

MUSICAL ELECTRONICS with a HAWAIIAN GUITAR

PART 2. *by* G. F. WEBSTER

This Home-made Guitar is easy to construct and can be played through your home radio.

The Nut

Use a piece of brass $3\frac{1}{8}$in long × $\frac{1}{2}$in × $\frac{3}{8}$in to make the nut and, when the saw cuts are set correctly, buff it up and send it to be chromium plated. Buy a set of Hawaiian steel guitar strings before making the saw cuts, and make the latter the correct width for each string to prevent movement; then check the bridge saw cuts the same way. These strings are different from other guitar strings, and if the wrong type is purchased the steel will make whistling noises when moving along the strings.

To find the position for the nut, set the bridge unit in position and measure 25.2in from where the strings leave the bridge to a point on the centre line of the body, and draw a line at 90° to the centre line. The right angle side of the nut meets the fingerboard at this point, the sloping side towards the machine heads. It is as well to check that the top edge of the fingerboard will fit snugly against the nut and be in line along the body before screwing down. When the position is fixed, remove the nut until final assembly.

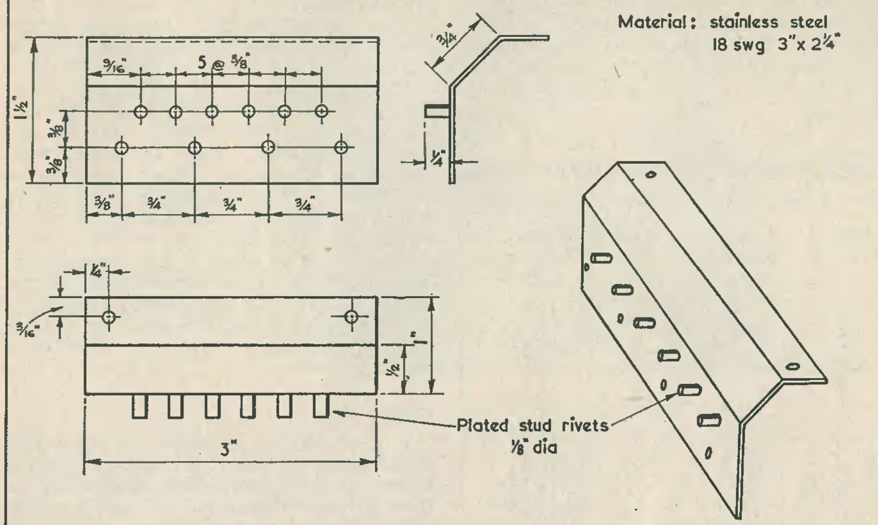
The Fingerboard

This is 22in long, 2in wide and $\frac{3}{32}$in thick. If a thicker material is used, the nut may have to be raised to prevent the vibrating strings from touching the fingerboard. Scribe the fret positions across the width by placing a small metal square and the fingerboard against a straight edge. All positions are measured from one end, and this starting end is the one to be placed against the nut. Measure 1.4in from the end for the first fret position, as shown in the table, then 2.75in from the end for the second fret position, and so on to the end. The following check should be made. The twelfth fret is 12.6in from the end; this is the central position between nut and bridge and gives the first octave of the open string. The 24th fret gives the second octave of the open string. If these are in correct position, the 5th and 7th frets give harmonics of the open string.

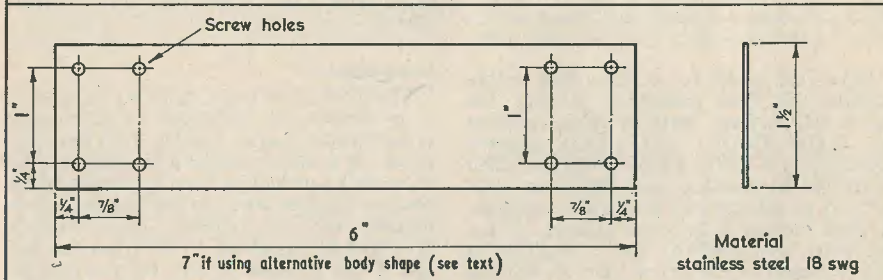
Material for the fingerboard can be hardwood or plastic sheet, so a wide choice of colour is possible. If the body is to be french polished, a hardwood fingerboard with inlaid veneer in the fret positions could be fitted. On the other hand, it is much easier to fit plastic sheet and polishing is unnecessary. Strips of guillotined plastic film $\frac{1}{16}$in wide can be cemented into deeply scored fret positions to give either contrasting or two tone effects. The edges should be buffed, and it is better to order the piece ready made in this way. The scope for plastic work on the fingerboard is unlimited, and with the simple markings required it would not cost much if done commercially for those who wish to do so. The fingerboard can be screwed or cemented to the body and the heads covered with space markers. These markers can be any shape to suit the designer, such as squares or circles cut from the plastic film and cemented in the spaces.

The usual positions for the markers are in the third space, between second and third frets, then in the 5th, 9th, 12th, 15th, 19th, 21st, and 24th spaces. Two markers could be used in the 3rd and 15th spaces and three in the 12th and 24th spaces to hide the screw heads, if the screws are countersunk and the markers cemented on in the final assembly. The screw positions should be marked in for later reference. After a check over to see that the body is ready for all the parts, it can be rubbed down and the grain filled.

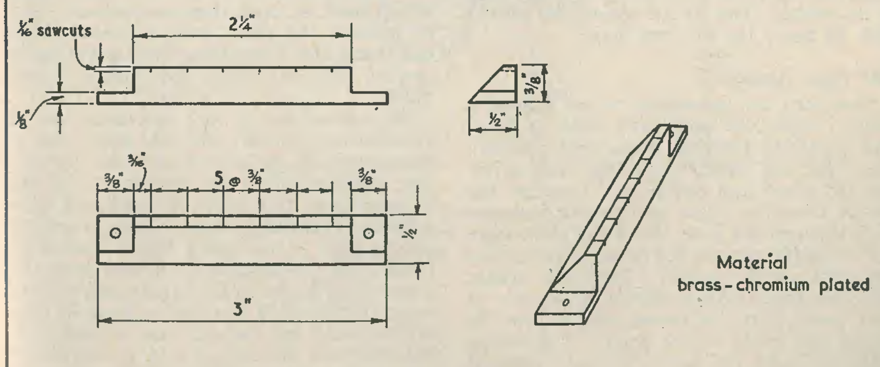
It is recommended that the body be left in a warm dry place for at least forty-eight hours to remove all moisture before polishing is started. If a paint spray is available, an unusual and attractive finish can be



TAIL PIECE



TAIL PIECE COVER



THE NUT

G264

given by one coat of metallic type cellulose, followed by one coat of clear cellulose when the first is hard. If cellulose is used it is better to round off the edges all over the body. The scope here for finish is again unlimited; and for those who cannot polish, the cost of having it done would be small.

TABLE OF FRET MEASUREMENTS

Fret No.	Distance from nut Inches	Fret No.	Distance from nut Inches
1	1.4	13	13.3
2	2.75	14	13.97
3	4	15	14.6
4	5.2	16	15.2
5	6.3	17	15.76
6	7.38	18	16.29
7	8.4	19	16.79
8	9.3	20	17.26
9	10.2	21	17.7
10	11	22	18.12
11	11.84	23	18.52
12	12.6	24	18.9

Leave the body for a few days before starting the final assembly, so that the polish will harden. Spray or brush cellulose the Bridge Pick-up unit to the required colour, or if a buff is handy it can be buffed to match the stainless steel tail piece, then sprayed to prevent rust with clear cellulose. A third method is to stove enamel. If the coil has been checked for continuity, it can be immersed in shellac until all bubbles disappear, if thought necessary. The coil should fit tightly on the pole piece and be mounted with the wire ends near the hole to the socket. The six sub-assemblies should now be ready for the final stage.

The Final Assembly

The units are assembled in the following order. Stand the body with base to floor, and screw the machine heads into position. Place flat on bench or table, then screw the tail piece and cover on. Unscrew the bridge extension piece and thread the wire ends through the hole. Bare the ends when cut to length, replace the sleeving and solder the ends to the socket. Push the socket into position, taking the extra length of wire back into the recess, and screw the socket end plate to the body. The bridge unit can now be bolted in the balanced position shown in the drawing, and the extension piece screwed back into place.

Fix the nut in position. If a plastic fingerboard is being fitted, smear a thin coat of plastic cement on the back and drop it into position without sliding. The plastic cement should bind to the cellulose. Cement the markers over the screw heads as stated.

The strings can now be put on and tuned. With the tail piece on the right, the first stud takes the thickest string and the last stud the thinnest. Tune up with guitar pitch pipes for testing. Make sure that the strings do not touch the fingerboard at any time when playing. Adjust the pick-up by raising the coil pole piece as near as possible to the strings to allow a full strong strum with the finger pick without causing the strings to touch the pole piece. Tighten up in this position, and check again for a closer position at volume when the amplifier is working.

Design Note

If it is decided to simplify construction by adopting the alternative body shape, the recess can be cut out before assembling the three pieces. This shape can also be used to design a twin, or double guitar, for more advanced playing later. The second unit could have four strings tuned to a different chord.

Experimental

The alternative shape can also be used, if it is desired, to construct an unpolished experimental model quickly for test purposes. If a shorter model is wanted, this can be made by deducting from the length of the neck an amount equal to the distance of the number of frets omitted. For example, the third fret position is 4in from the nut, and if this position is used for the nut, 4in must be taken from the total length. The other positions are then marked as listed but from 4in behind the nut. The strings would then be tuned three semi-tones higher to balance the three frets removed. It is surprising how fascinating these experiments can be, even to anyone not trained to read music.

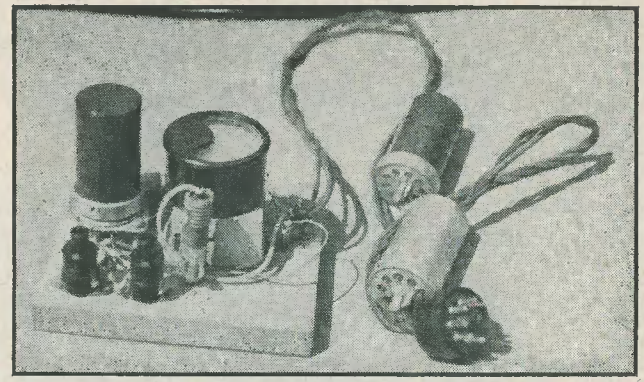
As appearance is not important in an experimental model, the tail piece can be eliminated and six screws or nails sunk into the positions given for the studs. If this is considered too crude, a brass tail piece without cover can be used. There is another simple type of tail piece which uses small metal bobs threaded on to the strings so that a slot is sufficient to hold the string without using the loop. In this case, a piece of brass rod, as used for the nut, has six deep saw cuts to take the strings and is screwed in the position shown for the tail piece studs.

(*continued on page 101*)

Simple EF50 Tester

and Occasional Valve Voltmeter

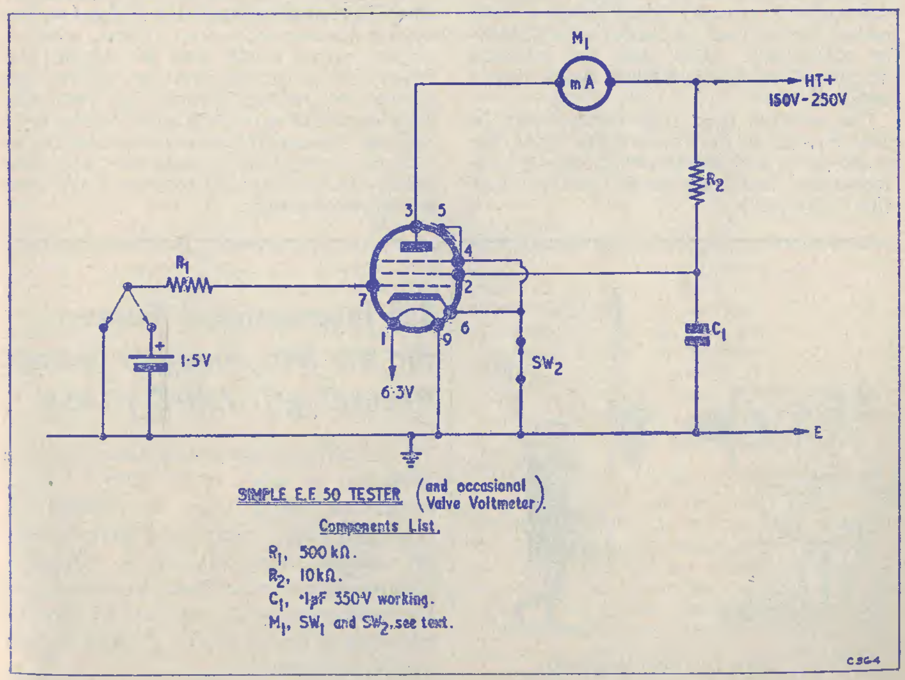
by **J. P.**



EF50's (OR EQUIVALENTS SUCH AS THE VR91) abound in home constructed equipment such as timebases, sound and vision units, and test equipment. They are also found in quantity in certain well-known makes of television equipment and in the usual ex-service units.

The EF50 is prone to contact troubles at its holder, and considerable variations in characteristics between one valve and another are frequently found in a test batch from random sources. Substitution in equipment becomes rather a hit-and-miss affair, and sometimes leads to confusing results and an accumulation of valves which are doubtful, or usable only for certain applications.

The tester illustrated has been in use for over a year and has enabled dozens of valves



See p 315 (Dec '56) for improved design.

to be tested and the duds discarded. Although originally designed to test by comparison (*a*) emission, and (*b*) mutual conductance, by simply "keying" the cathode, it will also test (*c*) heater-to-cathode insulation up to several megohms with the filament hot. The unit costs only a few shillings to construct, and might have been even cheaper had triode connection been used. However, this expedient was not considered a fair test for an r.f. pentode.

Construction

A B9G valveholder was mounted on a strong wooden base, supported by two spacers held by heavy screws. Do not use a paxolin valveholder, as this type grips the valve pins tightly, and excessive force is needed to insert and remove valves. Choose a valveholder with an easy sliding fit. A ceramic holder was used in the unit illustrated, and the remaining components were grouped compactly under the holder, with the exception of the meter, switches and battery which were grouped nearby. Pins 4, 5, 6, 8 and 9 and the centre spigot may be joined by a short length of 18 s.w.g. tinned copper wire, as all are at earth potential with SW_2 closed.

The meter may be the 0–10mA range of a multimeter temporarily connected in circuit, or as in the example shown, a surplus meter shunted by a small coil of resistance wire so that the needle gives a mid-scale reading on emission. Any meter which gives a clear reading may be used, as the device is basically for comparison rather than for standard measurements, unless the latter are specifically required.

The switches used may conveniently be press buttons of the "meter-push" type, but simple plugs and sockets work equally well. (Remember that the cathode lead is "hot" with SW_2 open.)

The power supply to the unit is 6.3 volts at 0.3 amps for the filament, and a few milliamps of h.t. at any voltage from 150–250 volts. If a separate power pack is not available, connections may be made to appropriate valve sockets on any a.c. mains receiver (but not to a.c.–d.c. sets with heaters in series and a "live chassis").

Operation

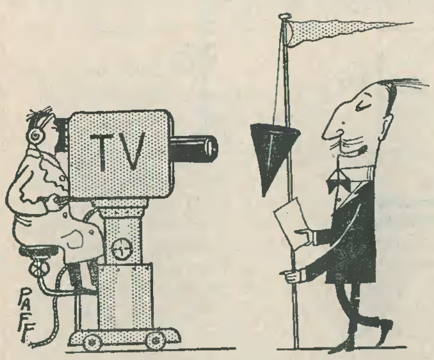
The valve is plugged in and allowed to reach operating temperature, and the emission is noted. A *gentle* tap will indicate whether it is stable under vibration.

The grid leak is then switched to the 1.5 volt cell, and the anode current will increase. This difference of currents will enable the mutual conductance to be estimated, and is a more valuable test than mere emission. The greater the change, the greater the mutual conductance. If a fairly accurate record of mutual conductance is needed, divide the change of current in milliamps by 1.5.

$$\text{Mutual Conductance} = \frac{\text{change of anode milliamps}}{\text{change of 1 volt at the grid.}}$$

When the cathode switch SW_2 is opened, the anode current should drop to zero. The slightest trace of anode current will indicate a heater to cathode leak.

With a valve inserted, the unit may be used as a simple valve voltmeter by taking leads from grid pin 7 and earth, and is useful for checking changes in operating voltages on low voltage sources such as a.v.c. lines, where a normal meter would load the circuit too heavily; although its main use has been in testing and grading EF50's. The lesson has been learned of never judging EF50's by their external appearance. Many which looked as though they had had a hard life have been found efficient and reliable, and have been marked accordingly.

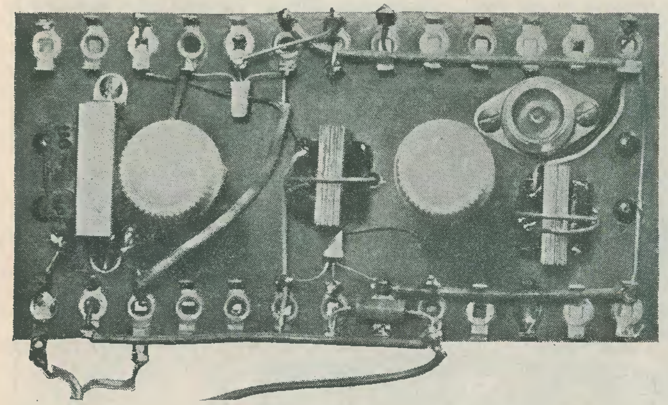


. . . *Here is a Gale Warning!*

5th International Contest for the Best Amateur Sound Recording (I.A.R.C.) 1956

The British Sound Recording Association has forwarded us details of the 1956 I.A.R.C., entries for which must be received by September 15th. Entry forms and rules may be obtained from Mr. H. J. Houlgate, 12 Strongbow Road, Eltham, London, S.E.9. We understand that the B.B.C. may be interested in British efforts, if a high enough standard is reached.

GENERAL PURPOSE TRANSISTOR EQUIPMENT



by

H. A. JENNERS

In this article our contributor describes the construction of two general-purpose transistorised units, a high-gain a.f. amplifier and a relaxation oscillator

Now that transistors are becoming readily available on the home-constructor market, amateurs have an excellent chance to make themselves familiar with the interesting departures from old-established practice which these miniature devices make feasible. Indeed, insofar as transistors are applicable to the field of domestic radio, the amateur constructor is already noticeably better off than is the person who purchases factory-made equipment. This is due to the fact that, apart from hearing aids, the number of manufactured transistor receivers and a.f. amplifiers available in this country is very small indeed; whilst, on the other hand, little prevents the home experimenter from making, without too heavy an outlay, his own transistorised equipment.

The Amplifier

In this article two simple but effective items of gear incorporating transistors are described. The transistors employed are junction types and are available from Henry's Radio Ltd., as are also the inter-stage and output transformers.

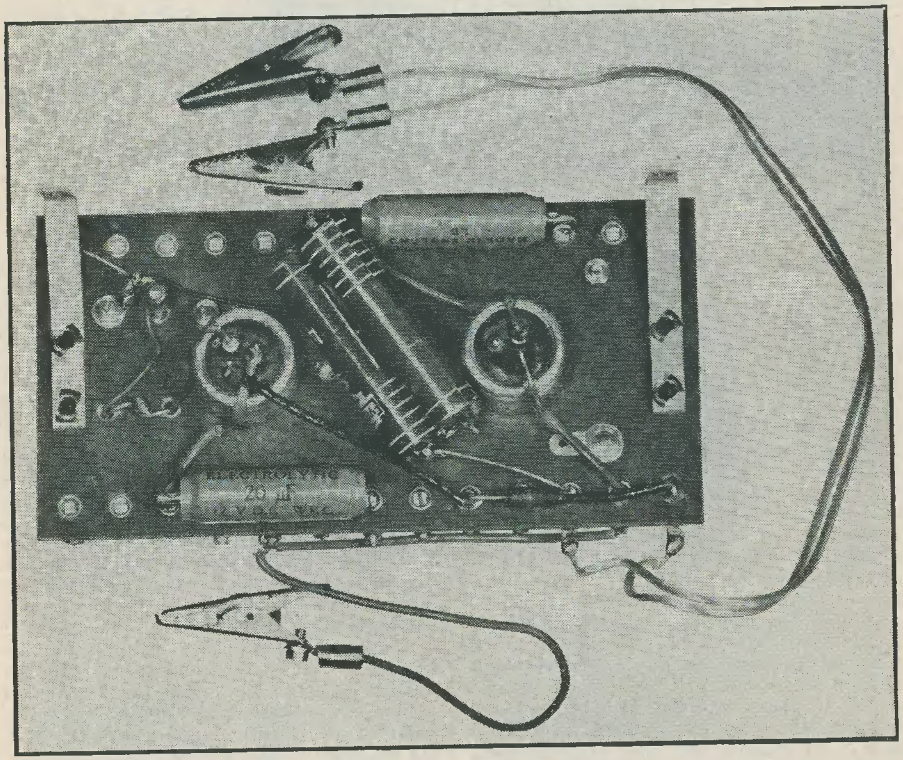
Fig. 1 gives the circuit of an a.f. amplifier using two of these transistors. This amplifier gives quite a considerable amount of gain, and has several interesting features which are worthy of attention.

Perhaps the most useful of these features is the careful employment of impedance-matching transformers wherever these are necessary. The most popular method of employing junction transistors in a.f. amplifiers consists of operating them in the earthed emitter mode. Input is then applied between base and emitter, whilst the output appears between collector and emitter. This method of connection enables two advantages to be obtained. Firstly, the transistor gives a high amount of gain. Secondly, it is possible to obtain emitter-base bias current from the main h.t. rail. This second feature obviates the necessity of having a separate source of bias supply.

Unfortunately, with the earthed emitter mode of connection, the input and output impedances of the transistor vary considerably. The input impedance (between base and emitter) is low, whilst the output impedance (between collector and emitter) is high. It is frequent practice to ignore these differing impedances in practical amplifiers, and to directly couple two earthed emitter transistors in cascade by means of a condenser. Despite the considerable mismatch which results, a useful amount of gain is still obtained; and the circuit has the advantage of requiring few components.

In the circuit of Fig. 1, more detailed attention has been paid to the question of matching than is usual in average practice. Thus, transformer T_1 matches the input to the first transistor, T_2 provides an accurate coupling between the two transistors, and T_3 steps down the output impedance to suit that of low impedance headphones. (The output terminals of the amplifier may also be connected to the voice coil of a loudspeaker, if desired. This should preferably have an impedance of 15 ohms, but quite good results can be obtained with a 3 ohm speaker.)

directly to the input terminals of the amplifier. Another interesting source of programme would be given by a high impedance gramophone pick-up. A particularly useful input signal would be available from a crystal pick-up. This would necessitate the use of an input filter, and a simple suggestion is shown in Fig. 2. In this diagram the values of both the resistor and condenser are experimental. The value of the resistor would normally lie between 50kΩ and 2MΩ, and should be chosen for best overall quality consistent with adequate volume. The condenser will require a value of 100 to 500pF, and provides a variable amount of top lift. The arrangement shown in Fig. 2 is not meant to be in the high fidelity class, of



The two-stage amplifier. For reverse layout and wiring see illustration on previous page

The input impedance of the amplifier varies somewhat with the setting of the volume control but, at full volume, should lie between the limits of 25 to 100 kΩ. This compares quite favourably with the conventional 250 kΩ input impedance of valve a.f. amplifiers. It is possible to connect the output of a simple crystal a.m. receiver

course, but it should be capable of offering quite good results. As readers will appreciate, the possibility of a transistorised record player is not unattractive, and it is well worth being made the subject of some experiment.

The secondary of T_1 connects to the volume control R_1, and thence, via the condenser C_1, to the base of TR_1. Bias for this transistor is

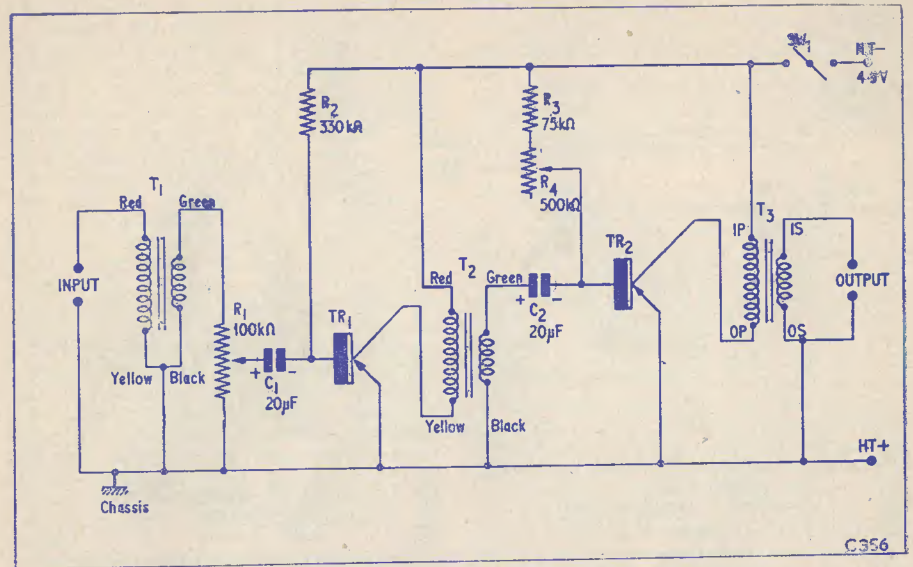


Fig. 1. The circuit of the general purpose transistor amplifier

TR_1, TR_2	Junction Transistor (Henry's Radio, Ltd.)	R_1, R_4	Potentiometers, miniature, values as shown in circuit diagram (Henry's Radio, Ltd.)
T_1, T_2	Interstage Transformer, 5 : 1 (Henry's Radio, Ltd.)	R_2	330kΩ, ¼ watt
T_3	Output Transformer, 24 : 1 (Henry's Radio, Ltd.)	R_3	75kΩ, ¼ watt
C_1, C_2	20μF, 12WV, electrolytic	SW_1	on-off switch, s.p.s.t.

Fig. 2. A simple input filter for use when a crystal pick-up is connected to the amplifier. Component values are discussed in the text

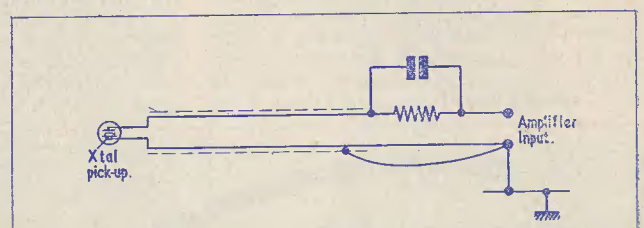


FIG. 2.

Fig. 3. An experimental n.f.b. circuit which could be applied to Fig. 1

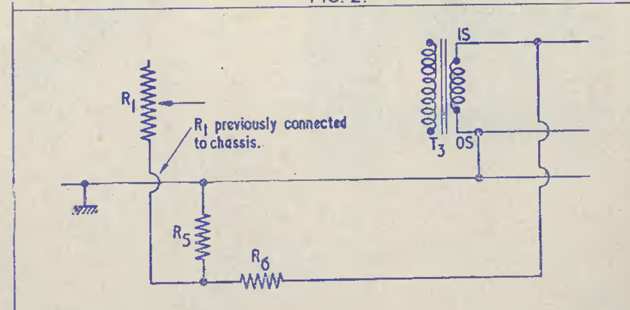


FIG. 3.

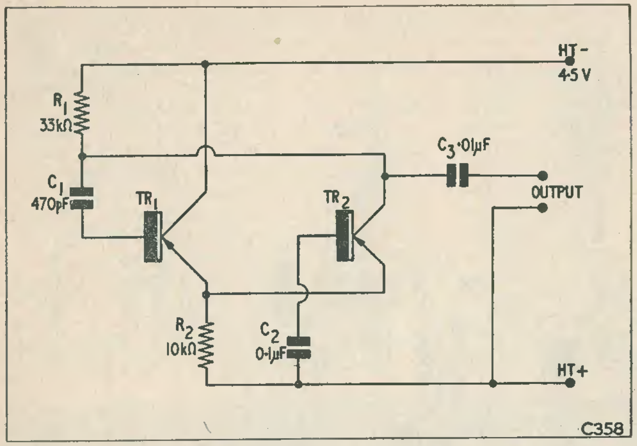


Fig. 4. The circuit of the a.f. oscillator

TR_1, TR_2	Junction Transistor (Henry's Radio, Ltd.)	C_3	0.01μF, paper 150 WV
C_1	470pF, ceramic or mica	R_1	33kΩ, $\frac{1}{4}$ watt
C_2	0.1 μF, paper 150 WV	R_2	10kΩ, $\frac{1}{4}$ watt

obtained via the resistor R_2. The value shown for this resistor, 330kΩ, should cope comfortably for most transistors, although no harm would be done if alternative values were tried out in individual amplifiers. The value of R_2 should not, however, be reduced below 150kΩ. Normally, the optimum value will lie between 200 and 470kΩ. It should be pointed out, incidentally, that if the value of R_2 is adjusted experimentally, this should be done under working conditions with the ultimate aim of obtaining optimum gain and freedom from distortion. Too low a value for R_2 will cause a high collector current. This may reduce the permeability of the core of T_2, causing loss of gain, particularly at the lower frequencies. This effect should be guarded against. Also, the amplifier should always be switched off when components are being changed.

Inter-Stage Coupling

TR_1 couples into TR_2 via the step-down transformer T_2, and the coupling condenser C_2. Since TR_2 is in the output stage and it is desirable to obtain optimum power output here in addition to gain, this transistor has a bias current which may be varied manually. Bias variation is carried out by means of the potentiometer R_4, a "safety" resistor, R_3, being connected between the top end of its track and the h.t. negative rail to prevent the possibility of excess bias current. R_4 should be adjusted, also under operating conditions, for maximum undistorted output. If it is found, in a particular amplifier, that the setting of R_4 is not very critical, it should always be left in the position which inserts the greater amount of resistance into the circuit without reducing performance.

As was mentioned above, the output available from the amplifier may be applied to low-impedance phones or to a loudspeaker. It is to be expected that a great deal of loudspeaker volume will not be available from a single-ended transistor output stage, but there should still be sufficient to enable the amplifier to be used in a bedside receiver, or for some similar application. Fortunately, it is possible to run the output stage into overload on programme peaks without introducing too high a degree of distortion. Overload causes the output transistor to draw a *reduced* collector current, so no harm to this component can result. This does not imply, of course, that the output stage should be overloaded by a ridiculously excessive a.f. signal.

The h.t. potential required for the amplifier is only 4.5 volts, and the current consumed should lie between 3.5 and 6mA. Current consumption will vary according to the setting of R_4.

Negative Feedback

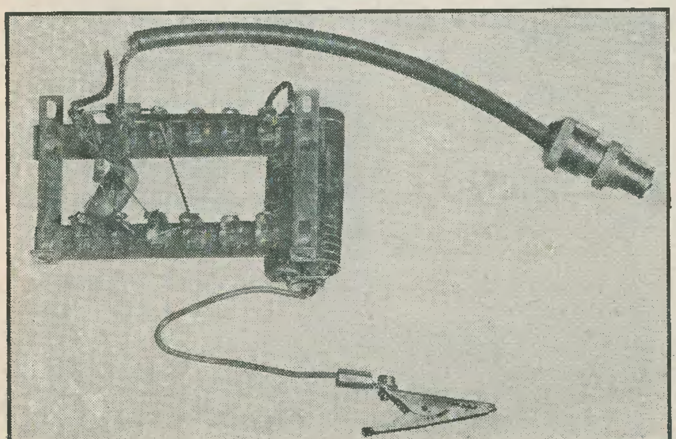
In an amplifier of this nature, the possibility of applying negative feedback is attractive but rather difficult to carry out in practice. The difficulty is due to the fact that the amplifier contains a large number of reactive couplings (the coupling condensers and transformers), whereupon the risk of a 180° shift in phase at any one frequency becomes almost inevitable. Also, the phase shift in the transistors themselves at higher frequencies is unknown.

Nevertheless, no harm could result if a little experimenting were carried out, and a suggested arrangement is illustrated in Fig. 3. The ratio $R_5 : R_6$ in this diagram governs the amount of feedback applied, and its effect may be judged whilst the amplifier is operating by short-circuiting R_5. The value of R_5 plus R_6 should lie between 10 and 20kΩ. Due to the mode of connection employed, feedback will increase as R_1 is adjusted towards the minimum volume position, and this is not an entirely undesirable state of affairs. If oscillation occurs due to the feedback loop it may quite possibly be at a supersonic frequency, in which case it can be identified by measuring the total h.t. current consumed by the amplifier. Oscillation will normally be indicated by a reduction in h.t. current. If the current increases by a marked amount due to oscillation, the amplifier should be switched off at once. In some instances, it may be possible to prevent oscillation when n.f.b. is applied by reducing high frequency response at a single point in the amplifier, e.g. by connecting a condenser across the secondary of T_2.

It should be pointed out that the feedback circuit shown in Fig. 3 is experimental only, and that its effectiveness may differ from amplifier to amplifier.

The Oscillator

The second part of this article is concerned with a simple oscillator employing two junction transistors in the circuit shown in Fig. 4. The arrangement comprises an emitter-coupled multivibrator, and it provides a square waveform with excellent transient characteristics. Due to the particular waveform generated, the output provides two basic tones and a large number of harmonics spreading through the a.f. spectrum. The oscillator consumes only 300μA at 4.5 volts and is an ideal adjunct for signal-tracing service techniques, since it may be made up, complete with h.t. battery, in a very small space indeed. The output of the oscillator can be brought out into a probe which may then be applied at various points in a faulty receiver or amplifier.



A practical translation of the circuit shown in Fig. 4.

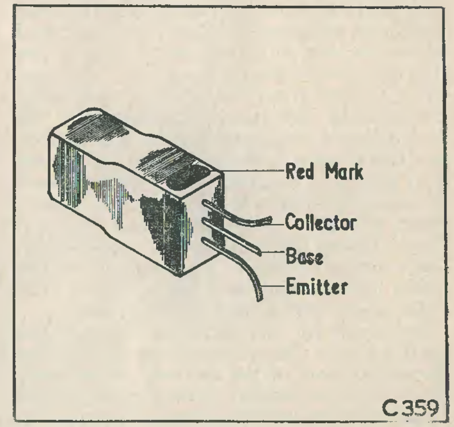


Fig. 5. The lead-out connections of the transistors employed in the equipment described in the text

Transistor Connections

As was mentioned above, the transistors employed in the amplifier and oscillator described in this article are those available from Henry's Radio, Ltd. These have the lead-out connections illustrated in Fig. 5.

The photographs accompanying this article show the two circuits used in special demonstration assemblies. As will be realised, both items can be constructed in a much smaller space than is depicted in these photographs.

HI-FI LAYOUT for the AVERAGE SITTING-ROOM

An attempt to integrate high fidelity, comfort and aesthetics

by K. V. R. BOWERMAN

The Problem

There is no doubt that the all-in-one radiogram makes a handsome piece of furniture, but many hi-fi enthusiasts feel that the optimum in musical reproduction cannot be obtained from an instrument that houses speaker, turntable and amplifier in one box, however cunningly designed. Mechanical vibration from the speaker conducted through the woodwork, together with the sound waves generated within the cabinet, are bound to affect the pick-up. This not only results in distortion during loud passages but also contributes to record wear. Record wear produces more distortion, which is amplified and fed back again by the speaker, and so on *ad infinitum*. The speaker can also affect the amplifier itself, especially if some valve stages are inclined to microphony.

So much for the technical aspect. But there are also disadvantages which affect the bodily comfort of the listener. How many times during a musical evening have you had to get up from your comfortable armchair to change records, or change the turntable speed or pick-up head, when playing a mixed batch of standard and L.P. records? Even when listening to radio, you have to get up occasionally to change the programme.

The solution

The solution is, of course, to use separate units. But at this point the XYL usually has a say. She is inclined to complain that "it's all so untidy." It needn't be. Have a look at Fig. 1. It shows a neat installation which can be set up in any convenient corner of the room (in this case, an average fireside recess). The speaker is in an acoustic corner cabinet, for which most manufacturers can supply plans. Flanking the speaker are shelves with compartments for records. At the far end of the shelf fixture, away from the speaker, is a compartment containing the main amplifier, which can be of your own design, or one described in *R. C.*, or one of the popular commercial jobs advertised in these pages, such as the "Mullard" 5–10 or the "Osram" 912.

Now here's where we really become unconventional. Next to the amplifier is a separate unit, built to match the shelves. It contains the turntable and pick-up unit in a drawer, and the A.M. or F.M. tuning unit. What's different about that? The difference is that this unit is *mobile*. Mounted on rubber-tyred castors (as fitted to dinner wagons), the unit can be pulled out of position and can be wheeled over to your favourite armchair. It has shelves to accommodate the evening's record programme, and once comfortably seated you need not get up again throughout the "concert." When finished with, the mobile unit can be wheeled tidily back into place.

The Circuit

Obviously, to reap the full benefit of mobility, long leads will have to be employed. To avoid hum and instability, the signal-carrying leads will have to be well screened. It would, therefore, be as well to use co-axial cable for this purpose. That used for t.v. aerials is ideal. Another pair will also be required for the a.c. supply to the turntable and power pack on the remote unit. Flat twin flex is suitable, and may be taped neatly to the co-axial cable. Unfortunately, there is a problem arising out of the use of long screened leads, and that is the capacity effect.

This tends to attenuate the higher audio frequencies. However, there is a way to avoid this effect, or at least minimise it, by reducing the impedance of the line terminations. To achieve a low impedance output from a high impedance source (such as a crystal pick-up), a cathode follower circuit is used. As a cathode follower gives a "gain" of less than unity, it is advisable to boost the output from the pick-up first. This has been done in Fig. 2. A triode, V_1 (6C5 or similar valve), is used in a simple pre-amplifier circuit which feeds a cathode follower, V_2 (also a 6C5 or equivalent).

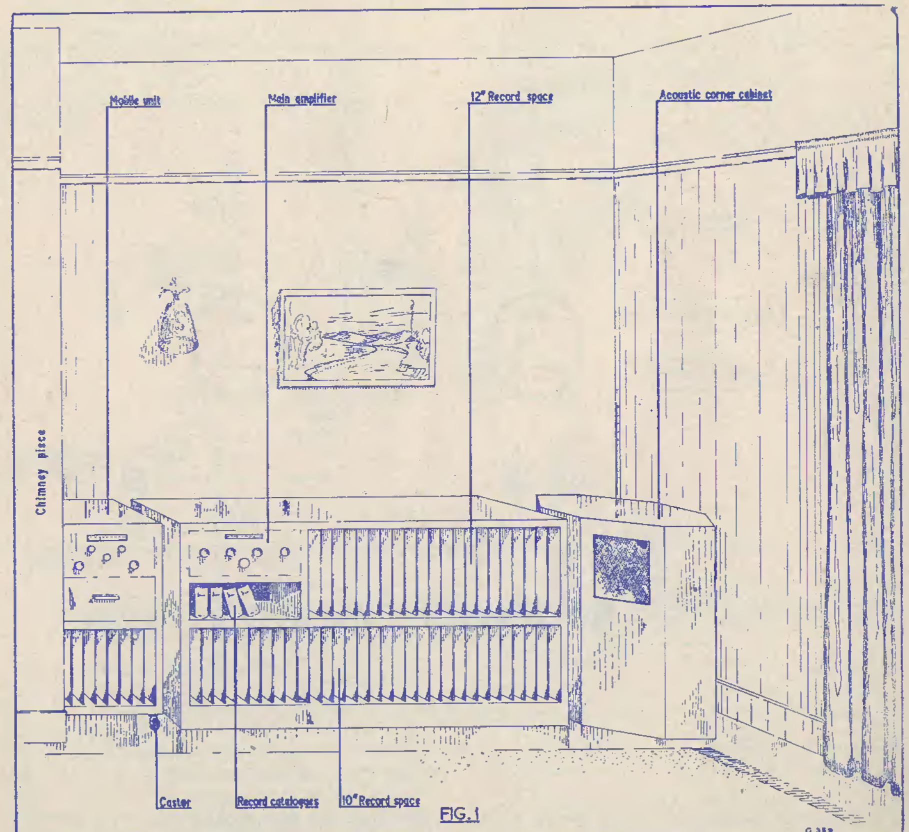


FIG. 1

Fig. 2 is a combination of block and schematic diagram, thus affording the reader plenty of scope for including his own particular preferences as to radio feeder unit and pick-up compensating circuits.

The output from the pick-up is filtered either through the 78 r.p.m. or the L.P. correction network according to the setting of switch SW_1, and is then amplified by V_1. The output from V_1 is passed via condenser C_1 to one side of switch SW_2. The tuner unit feeds the other side of SW_2 via C_2 (which is normally part of the tuner output stage). Either pick-up output or radio output can thus be selected by operation of SW_2. If necessary, a further pair of contacts on SW_2 could be arranged to short out the aerial of the radio unit when playing records. The signal from SW_2 is developed across the 500kΩ volume control VR_1. This control ensures that the first stage of the main amplifier is not overloaded. The signal developed across VR_1 is fed to the grid of V_2 and appears, slightly attenuated but at comparatively low impedance, at the junction of R_1–R_2. The inner of the co-axial cable is connected via C_3 to this point and the screen is connected to h.t.— (earth).

If the tuner unit incorporates its own power pack, the h.t. and heater supplies for V_1 and

V_2 could be drawn from this source. Make sure the components of the pack can cope with the extra current though. (For the two valves, about 15mA h.t. and 0.5A for heaters.) Alternatively, a separate power pack could easily be incorporated in the mobile unit. A third possibility is to take power supplies from the main amplifier, but this involves extra components at each end of the line. V_1 and V_2 will work quite satisfactorily with any h.t. voltage between 200–250 volts. Screened leads must be used for the pick-up and valve grid connections. Wiring must be kept very short and it may even be necessary to screen each stage completely.

Constructing the Mobile Unit

Fig. 3 shows the salient points. Note the use of door stops of the foot-operated spring-loaded variety to steady the unit during use. An optional refinement could be added in the form of an adjustable screw mounting for the turntable, so that it could be levelled to suit an uneven floor surface.

Radio enthusiasts who are also carpenters could no doubt suggest many improvements in the design. Perhaps somebody can devise a "retracting undercarriage" system which would allow the castors to be withdrawn into the case and would do away with the need for door stops.

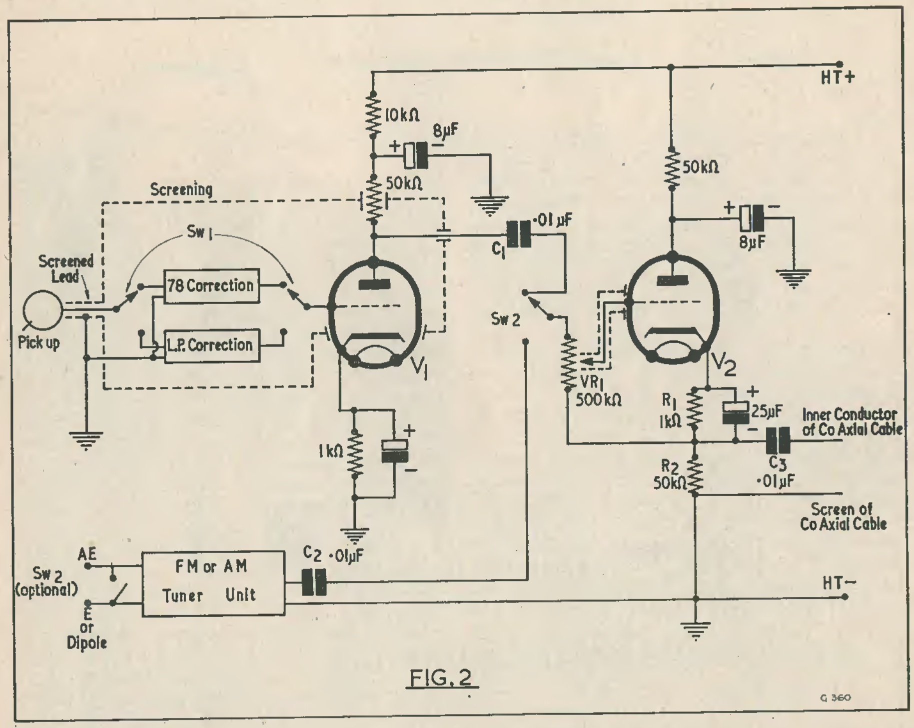


FIG. 2

How about the aerial? Well, for an A.M. tuner the Ferrite rod aerial system is ideal. Ferrite rod aerials have tuning coils wound on them, and can be obtained for T.R.F. or superhet circuits. For an F.M. tuner some form of folded dipole could be devised from stout copper wire, insulated with sleeving, and fixed to the framework of the remote unit. Within the service area of the local F.M. transmitter such an aerial could work very well.

Operating the Installation

Make sure that both the main amplifier and the remote unit are adequately ventilated. A number of holes should be drilled in the shelf supporting the main amplifier to allow air circulation beneath the chassis and a slot should be cut at the rear of the upper shelf to allow warm air to escape from the top of the chassis. In the mobile unit a detachable back made on the lines of a "meatsafe" door is suggested. The covering material can be speaker fabric or fine metallic gauze.

When using the equipment, set the main controls of the amplifier to suit your taste and turn the main amplifier volume control up to the three-quarter mark. You may now retire to the armchair and from the remote unit you can make any volume compensations which may be necessary during the evening. You can also change records, record speed, pick-up head or radio programme, all from your armchair without the slightest inconvenience.

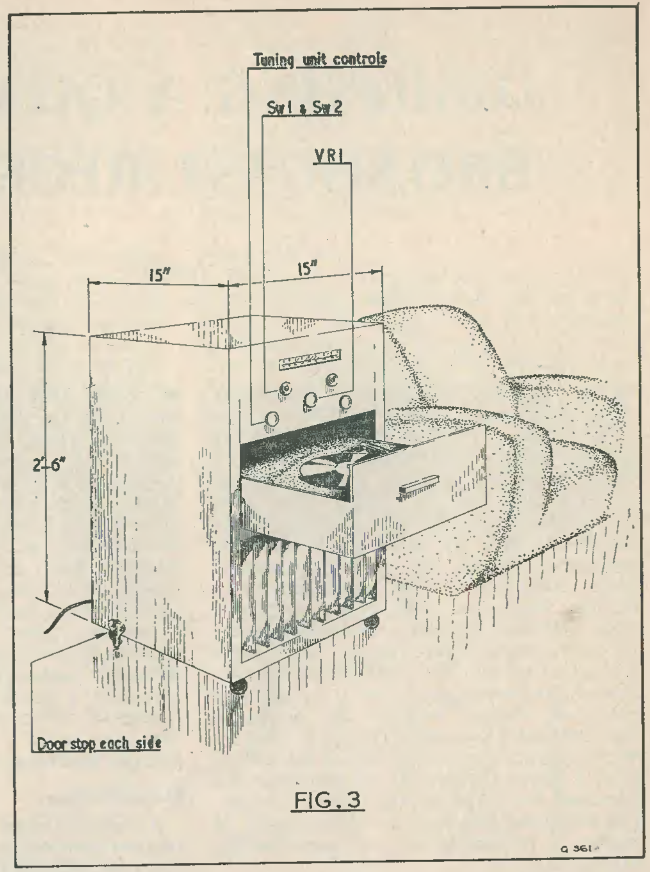


FIG. 3

Fig. 3 Details of the Mobile Unit

Philips Universal Measuring Instrument

An extremely versatile and compact instrument which can be used for measuring A.C. or D.C. voltages and currents, resistances and capacitances, is now available from Philips Electrical Limited. Measurements—except those of direct voltage and current—are made electronically, achieving, it is claimed, greater accuracy than is possible with conventional moving-coil instruments.

Known as the G.M.6008, the equipment has ranges of:

Direct Voltage: 20mV to 1kV (an HT probe can be supplied for 1–30kV).

Alternating Voltage: 100mV to 300V at 20 c/s–100 Mc/s (for frequencies in excess of 100 Mc/s a separate diode probe can be supplied).

Direct Current: 10 micro-amps to 1 amp.

Alternating Current: 0.1 micro-amps to 10mA at 20–1,000 c/s. 10 micro-amps to 1 amp at 20 c/s–100 kc/s.

Resistance: 1 ohm to 1,000 M/ohms.

Capacitance: 30pF to 3 micro–F.

The instrument is provided with a switch to reverse polarity when measuring positive and negative voltages in succession. Calibrating voltages of 1V and 30V are built in, and the instrument is fully protected against overloading.

Contained in a grey lacquered case measuring 13in × 8¾in × 7½in., the GM.6008 weighs approximately 18½lb.

DESIGNING A QUALITY BROADCAST RECEIVER

by **R. HINDLE**

The design of sound broadcast receivers seems to have settled down into a routine of the four valve plus rectifier superhet, with the alternative of a.c. operation for the larger and universal mains operation for the smaller receivers. The designer gives the receiver three wavebands, long, medium and short, and his valve combination is frequency changer, i.f. amplifier, double diode, probably combined with an audio amplifier stage, and finally a tetrode output valve. He then leaves the cabinet to mould the individuality of the receiver. Now there is a lot to be said for standardisation, particularly for factory produced items, and one must not assume because the design is standard that it is necessarily wrong. But we who construct our own receivers can afford to give closer thought to the problem and determine for ourselves the optimum design. This magazine has been in the forefront, of course, in presenting ways of avoiding the conventional.

Taking it by and large, one has to admit that the majority of people for most of their listening time tune to their nearest Light programme and regional transmitters. It is a fiddling business with the average receiver to tune in a transmission on the short wave band, and it is, perhaps, more by good luck than management that one finds one's way around this band; consequently very few listeners make any use of it. There are many, of course, whose listening interest centres chiefly on the shorter waves, but they want something rather different in receivers, the design of which is quite a different matter to that of the all-purpose instrument now being considered. Their listening, too, is a more personal matter, and no doubt the majority of them have to provide an alternative "household" receiver for those who just want to listen.

Now if one had endless money all possible requirements could be met in a single receiver, and at times some very lovely (and pricey) designs are met with, but the majority of people have only a limited amount to spend and the object is to derive the best possible benefit from that money. Most people are interested in having the best possible quality of reproduction from the local stations, and the search for foreigners takes second place, so that one feels disposed to insist that as large a proportion of the available funds as possible be spent on the quality end and only a minimum on the station-getting facilities.

Another point that must have been brought home to readers is that so few non-technical listeners are capable of tuning manually a good receiver to get the best quality of reproduction. Indeed, why should they have to go to such trouble for the two stations that form the bulk of their needs?

Design Factors

The basic design factors of the household receiver now emerge. At one end it should have the selection of two stations at the turn of a switch, and at the other it should have a good, high fidelity audio circuit. Of course, there are the occasions when a change from the two local transmissions is desired so long as it is obtainable at not too great a cost, and additional positions of the switch (or additional push-button positions if preferred, though these days the more compact switch is perhaps better) can be provided for other channels. These add to the cost of the receiver out of all proportion to the use to which the predetermined frequency would be put.

The proposed solution to the "front end" problem is, then, as follows. The usual set has a long wave range, but there is nothing on that range except the Light programme of interest, so the range is in fact made into a fixed-tuned position for the Light programme. Where the Light programme is taken from a medium wave transmitter, of course, this position would have an appropriate tuned circuit for that transmitter. The short wave range being of so little use, in its place would be a circuit fixed at the frequency of the desired regional station and a manual tuning over the medium range to give the occasional choice of the third and of more distant transmitters. The majority of one's listening is then obtained at a turn of a switch, and the tuning is carefully done in advance so that the most ham-fisted listener cannot fail to get optimum results.

What Circuit?

Superhet, then, or straight? Both types will have their exponents. Some people are near enough to their transmitters to be able to use simple, straight circuits, but far more need the extra selectivity of the superhet, particularly as manual tuning is to be provided for an occasional tour of the Continent. Two further points can be made in favour of the superhet. Firstly, it is easier to construct because the two tuned circuits have different resonant frequencies and consequently no particular care need be taken to screen one from the other; the difficulty that used to be stressed for those without test gear was the setting up of the various tuned circuits, but this need no longer hold any terrors so long as the pre-aligned i.f. transformers now available are used. The second point may come as a shock to many. The straight circuit is prone to more severe sideband cutting than the superhet. Remarkable claims for the sensitivity and selectivity of straight sets are often made and they are quite justified. These extraordinary results are very likely due to positive feedback, not sufficient to cause instability but still enough to act as unintentional reaction—with the inevitable distortion. Construction to avoid this would have to be very careful indeed. Superhet, then, is decided upon.

Tuned Circuits

Two tuned circuits have to be switched, and a simple, single wafer switch will be quite suitable. A three-way switch is commonly available in four-pole assembly, and it will be convenient to use this. The circuitry is a little simpler if double-wound coils are used in the oscillator stage, and this will require two poles. It is necessary to switch coils because a long wave position is required; if the Light programme is to be taken from the medium wave transmitter some economy could be obtained by switching in capacitors to tune a single coil for all the positions of the switch, but it has been found more satisfactory to switch complete tuned circuits even in this case, where only medium waves are required. Two poles are left, and these could be used for switching double-wound aerial coils, but it is handy to have a spare pole to

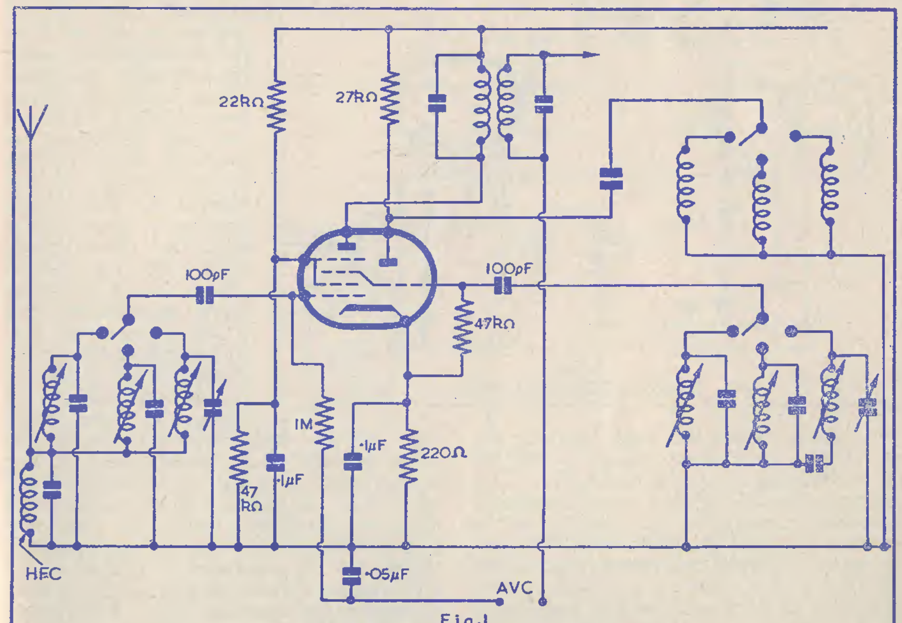


Fig.1
Frequency changer & tuning circuit

switch signal lamps. Fortunately the bottom-end coupling scheme requires only single-wound coils, and so only a single pole of the switch is used. The fourth bank is used to switch on dial lamps at the manual tuning position and could also switch on indicators to show which of the switch-tuned stations is being received. Bottom-end aerial coupling is very satisfactory except that the coupling capacitor presents a high reactance to hum frequencies such as are generally picked up by the aerial lead. This hum is presented direct to the grid of the frequency changer where it cross-modulates the signal. This is entirely prevented by putting a good quality r.f. choke across the capacitor. It is usual to feed the a.v.c. voltage to V_1 via the bottom of the tuning coils; a.v.c. is wanted in the present set because of the manual tuning, and some people need it even for their local stations.

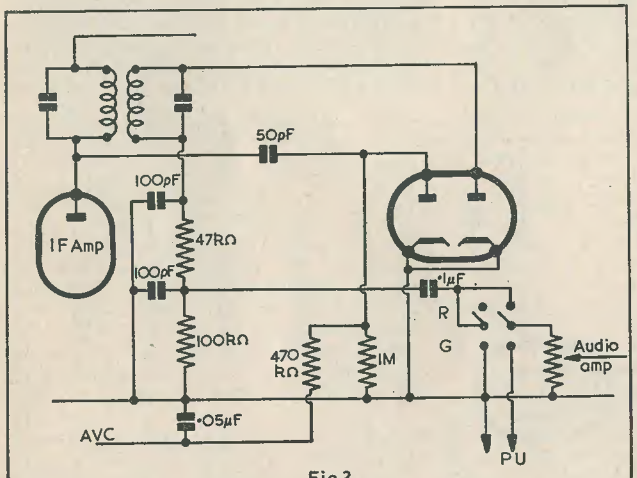


Fig.2
Detector & radio/gram switch

If the usual method was used, however, the r.f. choke would short the a.v.c. out, so parallel feeding of a.v.c. is resorted to. This will be seen to offer further protection against hum being presented to V_1. Fig. 1 gives the resulting frequency-changer circuit. The only change from normal convention is seen in the oscillator circuit. There is a padder capacitance only in the manual tuning position; a padder is not needed in the other two positions because there is no question of tracking a variable capacitor there. The valve chosen, in keeping with modern practice, is the miniature Brimar 12AH8.

I.F. Stage

A perfectly conventional i.f. stage follows and is quite satisfactory. The number of tuned circuits give a better bandwidth than would be obtained with a straight receiver; and variable selectivity, which is very difficult to obtain without causing a lop-sided characteristic, is considered hardly worth while. If, when the receiver is completed, it is found that some selectivity can be sacrificed, a handy way to do this is to slightly off-tune one transformer, one side to a lower and the other side to a higher frequency. This has the effect of reducing the Q as well as spreading the peaks, which is all to the good. A.V.C. is fed conventionally to the bottom of the i.f. transformer winding.

A little thought is needed at the detector stage. An infinite impedance detector (i.e. a biased-back cathode follower), may well be contemplated. This has the effect of reducing the damping on the last i.f. transformer, but that is not serious for our present purpose. A.V.C is not easily obtained from the circuit, however, and also the circuit is prone to instability due to the possibility of the inter-electrode capacitances forming a sort of Colpitt's circuit. If not causing instability, this often results in positive feedback sufficient to narrow the pass band and so introduce distortion. The homely diode is the alternative. They both require a large signal input for distortionless results, but the present circuit should give that on the stations for which it will be used; the distortion due to differential loading is not so serious as has been made out at times, and then occurs only at the highest modulation levels. It is certainly quite unnoticeable in the present case, using the specified diode load of 100kΩ. A separate diode is used for a.v.c. as usual, and this is fed from the primary instead of from the secondary of the second i.f. transformer. This gives the a.v.c characteristic rather less selectivity than the audio characteristics, and so holds down the sensitivity of the receiver at the edge of a carrier when manually tuning, so that it is pleasanter to the ear. Fig. 2 gives this part of the circuit.

Audio Circuit

The amplitude of audio signal available from the detector depends upon the size of signal fed in from the aerial, of course, but a

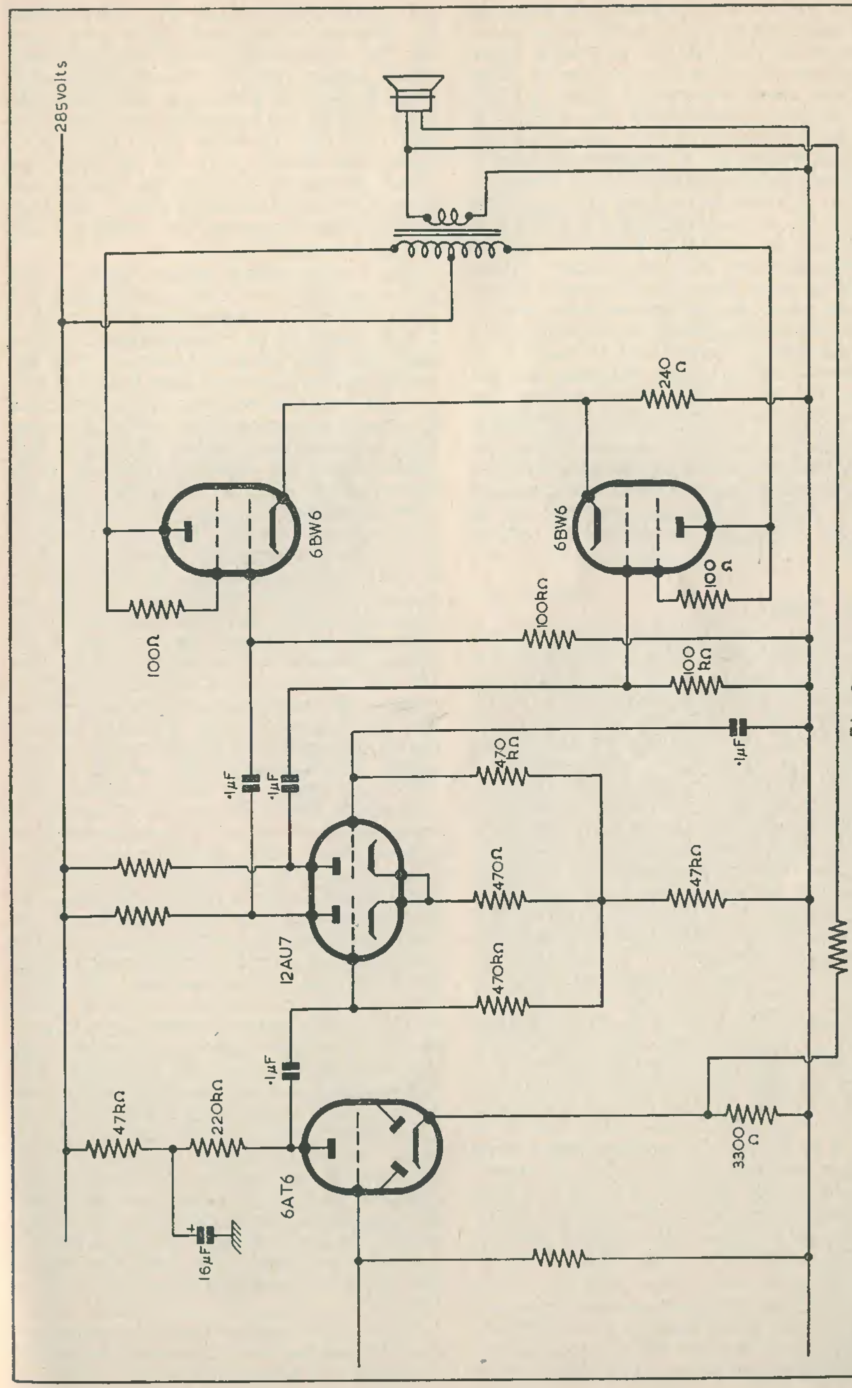


Fig.3
Audio amplifier circuit

peak of some 1 to 2 volts can be expected in most cases. In fact, it is worth while installing an aerial that will give as good a signal as possible to the receiver, except in those locations where a swamping signal is available, so as to ensure that the detector is working at high level and consequently giving the least distortion. A gramophone input is very likely to be required on such a receiver as this. A crystal pick-up will give an output comparable to the detector of the radio circuit, and so the logical place to introduce the pick-up is here, after the detector. There is nothing more annoying than radio breakthrough when playing gramophone records, and in view of the expressed aim for high-level working this is very likely to occur. A double-pole switch is used, therefore, and this mutes the radio by short-circuiting the detector load when switched to gramophone.

A glance at current price lists shows quite clearly that one has to pay handsomely for a power supply giving more than 350 volts, and so the audio design has generally to be brought within the capabilities of such a supply.

Output Stage

The audio design begins at the output end. Push-pull will undoubtedly be used because it is the easiest way to reduce second harmonic distortion to negligible proportions, besides preventing the introduction of hum at the output stage; the nicest way to avoid third harmonic is to stick to triode output if sufficient output power can thus be obtained. A 15 watts output stage is attractive and good theoretical reasons for going up to this figure for high-quality domestic equipment could be given, but one has to remember that one has to live with one's neighbours and maybe the baby upstairs! If 15 watts is insisted upon it will be difficult to obtain from triodes and it will certainly be expensive. A pair of 6L6's triode connected, for instance, can give 6 watts (with only 0.6% distortion) and a pair of KT66's need 400 volts h.t. to give 14.5 watts output. The purist who asks for so many watts may well consider, however, that these figures are used, if available, only on very occasional peaks, and that it is very much more than the equivalent audio power that he is likely to get from his favourite orchestra when sitting in his favourite seat. In fact, experience shows that very much smaller powers give very satisfying results and are much cheaper to set up. The modern speaker requires appreciably less drive than its forebears.

So, looking through the valve data, and again keeping to the modern practice of all-glass valves, the Brimar 6BW6, in triode push-pull, will give over 3 very good watts at only 0.5% total distortion and it is a joy to listen to. The experimenter, with little trouble, can try the comparison of his amplifier with triode output and with tetrode output with much higher audio wattage by retaining the same 6BW6's and modifying the connections and the bias—12 watts with only 1% is obtainable at 285 volts h.t. drawing only 80mA by merely altering the output load from 4,500 ohms to 8,000 ohms. But still, for the domestic receiver, the 3 watts of triode output is adopted.

For the conditions decided upon a *peak* grid-to-grid input of 38 volts is called for, and at the input is something of the order of 1 volt under normal circumstances. Feedback will alter all this, however. The distortion level of the output stage is already very low, but negative feedback will help to clean up the whole reproduction and at the same time will ease the problem of hum. This, applied from the output transformer to the beginning of the audio amplifier, has the effect of reducing the input, and we shall be wise to budget for only a tenth of the input previously mentioned, i.e., about a tenth of a volt. An amplification of 380 times is required, therefore, before the input to the last valves; this is more than could conveniently be obtained by a single stage. Phase inversion is also required and, unless the inverter stage itself will amplify, three stages will be required before the output valves. Fortunately there is a phase invertor circuit that gives amplification and is very good. This is the cathode coupled or long tailed pair circuit and this is adopted. The twin triode 12AU7 is used and it requires an input signal of about 3½ volts to load the output stage. The preceding stage, therefore, which is to be the first of the audio chain, needs to give a gain of 35 times. The Brimar lists again point to a suitable valve in the miniature range, and a triode too! The triode part of a 6AT6 can give a gain of 40 times with the voltage available. The valve line-up of the amplifier then becomes 6AT6, 12AU7, and push-pull 6BW6, triode connected. The consumption of the whole, with the radio circuits, is within the capacity of a 5Z4 rectifier valve, and the mains transformer should ideally be one giving 300 volts h.t. at 120/150mA; but 350 volt components are easier to obtain and such was actually obtained for this receiver. Surplus volts are extracted by means of a resistor in series with the smoothing choke to bring the voltage applied to the h.t. rail to 285 volts, the maximum permissible for the output valves. The complete amplifier circuit is given in Fig. 3.

A complete receiver based on the above development has been constructed and will be described in a future issue.

RIGHT—*From the Start*

PART 8. THE SUPERHET

by A. P. BLACKBURN

Reaction, as we mentioned last time, is an economical way of improving the performance of a simple receiver without introducing more valves. However, like all things in nature, we pay for this improvement by sacrificing quality of reproduction. Just to recap for a moment, you may recall that the loss of quality is brought about by the reaction increasing the selectivity to such a degree that the upper sidebands are lost.

This then, is the problem as we left it last month. A compromise between selectivity and quality.

The story does not end with the reacting detector however; several attempts have been made to improve upon this compromise, and we will deal with the most common in this article.

Staggered Circuits

Just as a reminder, Fig. 1 has been re-introduced here to show the difference between the ideal tuning circuit response shape and the practical one. If a number of tuning circuits were used, each one tuned to a slightly different frequency, a reponse more nearly the ideal could be obtained, as shown in Fig. 2.

These tuned circuits could be part of separate r.f. stages, with all the tuning capacitors ganged, i.e. the moving vanes on a common shaft. Such a circuit might look like Fig. 3. The practical difficulty with such a circuit is to keep the circuits in alignment for full range of the tuning capacitor. Slight differences in the coils and the stray wiring capacities, etc., will cause the resonant frequencies of the three circuits to differ from one another by changing amounts as the tuning capacitor is rotated. For example, Fig. 4 shows two possibilities at extreme ends of the tuning range. These do not have the symmetrical look of Fig. 2.

Circuits of the Fig. 3 type are not likely to be used therefore for "staggered" operation, unless it were to be used at a fixed frequency, when the resonant frequencies of the three circuits could be set up and left. To be permanently tuned to one station has its obvious disadvantages, so a receiver circuit is used which combines the advantages of staggered circuits (if required) and continuous tuning.

The Superhet

To give the principle its full name of "superheterodyne" is a little long winded, so it is normally shortened to superhet. A block diagram showing the system may be found in Fig. 5. Briefly the operation is as follows.

The incoming signal is fed to a circuit which changes the frequency to a lower one, say from 1 Mc/s to 500 kc/s. The second frequency is referred to as the "intermediate frequency" or i.f. The signal at this new frequency is passed through a tuned amplifier called the i.f. amplifier and is passed on to the detector in the normal way. Now the significant thing is that the i.f. amplifier is tuned to the same frequency (500 kc/s in the case quoted) whatever the frequency of the received signal. The amplification may be carried out, therefore, with as many tuned stages as may be necessary, without troubling about alignment of the individual circuits when the tuning capacitor setting is altered.

The really new feature in this circuit is the frequency changer, which requires a little more explanation therefore.

Frequency Changing

A typical frequency changer circuit is shown in Fig. 6. A type of valve that we have not met so far in this series is usually used. The type shown is a triode hexode. The triode is connected as an oscillator and its grid is common with a grid in the electrode stream of the hexode. The signal from the aerial is tuned by L_1C_1 and applied to the signal grid of the hexode. The current through the valve is affected, therefore, by two "signals," the oscillator and the received signal. At the anode we shall find strange things.

A number of frequencies will be present here. If we call the signal frequency fs and the oscillator frequency fo, there will be $fs - fo$, $fs + fo$ and more that do not concern us very much. If the signal frequency were 2 Mc/s and oscillator 1.5 Mc/s, frequencies of $2 - 1.5 = 0.5$ Mc/s and $2 + 1.5 = 3.5$ Mc/s would be present. If a tuned circuit were placed in the anode circuit as shown in Fig. 6 (L_3C_3), tuned to 0.5 Mc/s, that frequency would be selected and the 3.5 Mc/s frequency rejected (and, incidentally, all other by-products of the frequency changer). From an input signal at 2 Mc/s, then, we have now a signal at 0.5 Mc/s. If a signal of 3 Mc/s is now to be received all we have to do is to retune L_1C_1 to 3 Mc/s and the oscillator (L_2C_2) to 2.5 Mc/s, and once again we have a signal at the anode of 0.5 Mc/s.

The anode signal can now be fed to an amplifier tuned to 0.5 Mc/s, a detector fed from the amplifier output, and the job is done. And this is where the snags begin.

Let us assume the input signal from the aerial is 3 Mc/s again, the oscillator is running at 2.5 Mc/s and the i.f. is, therefore, 0.5 Mc/s. If a signal of 2 Mc/s is also picked up by the aerial, it can produce an i.f. of 0.5 Mc/s also when mixed with the oscillator. There is a chance, therefore, of an unwanted signal getting in and receiving a full share of amplification in the i.f. amplifier. However, the first tuned circuit L_1C_1 should reject such a signal fairly completely, because it was tuned to 3 Mc/s and the unwanted signal has a frequency of 2 Mc/s. But you will remember in the last article it was pointed out that a tuned circuit does not completely reject an unwanted signal; it accepts less and less of it, the further away in frequency the unwanted signal is. A weak wanted signal at 3 Mc/s and a very strong unwanted one at 2 Mc/s may therefore cause some interference. It is necessary then, for L_1C_1 to be a fairly selective tuned circuit.

Tracking

Another difficulty met with in superhet receivers is that of keeping the output frequency constant at the i.f. as the receiver is tuned. There would be no difficulty if C_1 and C_2 were separate capacitors, each operated individually. This would be inconvenient in a domestic receiver, so the two are ganged.

The inductances L_1 and L_2 are of fixed values, and if the capacitors C_1 and C_2 are of the same type and variable for tuning purposes, it can be shown that if the correct combinations of L_1C_1 and L_2C_2 are chosen to give the required i.f. at any particular frequency, as C_1 and C_2 are varied simultaneously the i.f. will vary by a small amount. As an example, if the signal frequency were to be changed from 2 Mc/s to 1 Mc/s the oscillator frequency would have to change from 1.5 Mc/s to 0.5 Mc/s. The signal frequency has changed by a ratio of two to one and the oscillator by three to one.

With similar capacitors for C_1 and C_2 this is obviously impossible. If the receiver were in line and producing the correct i.f. at 2 Mc/s, then at 1 Mc/s the oscillator frequency would be 0.75 Mc/s instead of 0.5 Mc/s. The i.f. would be 1 Mc/s minus 0.75 Mc/s, which is 0.25 Mc/s. As the i.f. amplifier is tuned to 0.5 Mc/s, there would be a considerable loss of gain at 1 Mc/s.

The circuit of Fig. 7 shows how tracking errors are minimised. The capacitor C_{10} called a "padding capacitor" is included in series with the inductance of the oscillator tuned circuit.

The Complete Circuit

A frequency changer, i.f. stage and second detector in a superhet receiver are shown in Fig. 7. The frequency changer is a triode hexode once again. The second and fourth grids in the hexode are screen grids and merely supply isolation between oscillator grid and signal grid, and signal grid and anode. The first i.f. transformer L_3C_3, L_4C_4 feeds the i.f. signal into the grid of the i.f. amplifier V_2. This valve also has an i.f. transformer in its anode which is connected to the second detector diode (the term "second detector" is used because the frequency changer is sometimes known as the first detector). The valve V_3 contains two diodes and a triode, the latter being used for audio amplification of the signal before the output stage. A valve of this type is called a double diode triode.

The capacitor C_{10} is the padding capacitor to assist tracking as already explained. The small preset capacitors C_7 and C_8 are trimmers. These are preset to adjust the main tuning capacitors C_1 and C_2 to the same value to allow for stray wiring capacities and slight differences in the construction of C_1 and C_2. The i.f. transformers are tuned by the fixed capacitors C_3, C_4 and C_5, C_6. Once again small trimmers are included to tune the i.f. circuits exactly to the required frequency.

A.V.C.

A refinement often found in modern receivers is automatic volume control. This device is intended to minimise changes in volume due to fading of the signal. The principle is quite simple. The output of the final i.f. stage is rectified and the resultant d.c. fed back to the i.f. stage or stages as a grid bias. The stronger the signal, the larger the

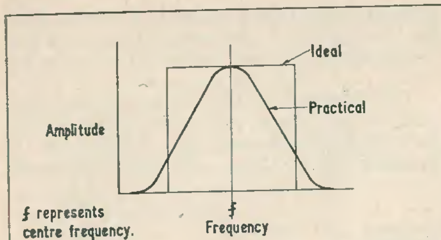


FIG. 1.

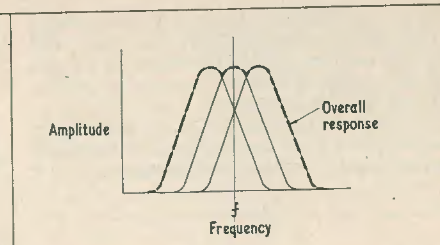


FIG. 2.

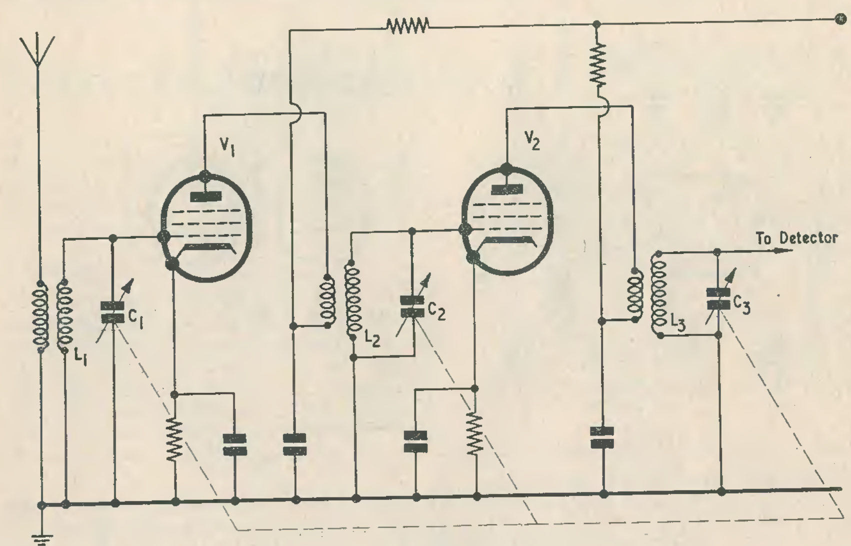


FIG. 3.

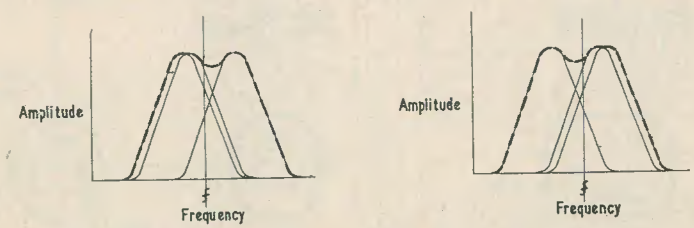


FIG. 4.

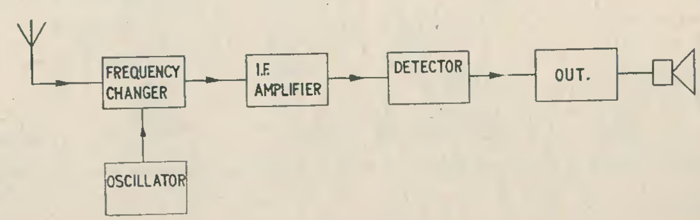


FIG. 5.

C360

grid bias and the less the gain of the receiver. If the signal should fade, the bias will decrease and the gain of the controlled stages will rise. The output of the receiver is thus held reasonably constant.

Fig. 8 shows how an A.V.C. system may be used in practice. The resistor R_1 is the diode load and a d.c. voltage is developed across it proportional to the i.f. signal at the anode of the i.f. amplifier. The audio components are by-passed by C_1 and further filtered out by R_2C_2.

The difference in the circuits of the audio detector and the A.V.C. diode is very small. In the audio detector (Fig. 7) the d.c. is blocked off by C_{20}, and only the audio passes. (Remember that a diode detector gives the audio *plus* d.c. In the a.v.c. circuit, C_{20} is omitted, and the audio is by-passed and filtered as already mentioned.

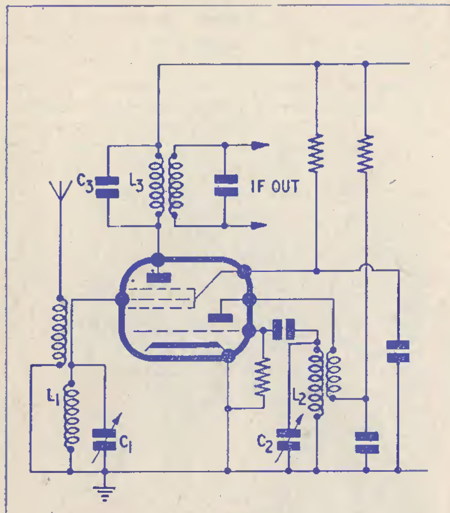


FIG. 6.

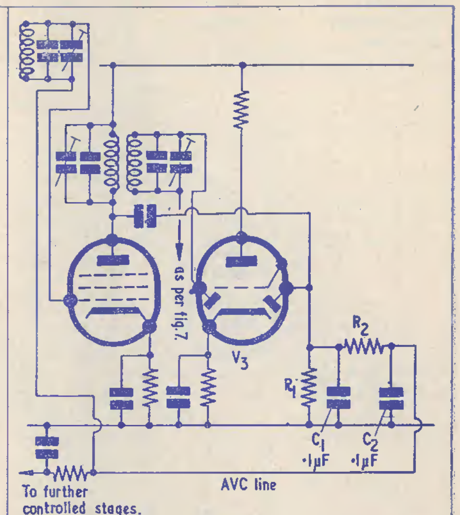


FIG. 8.

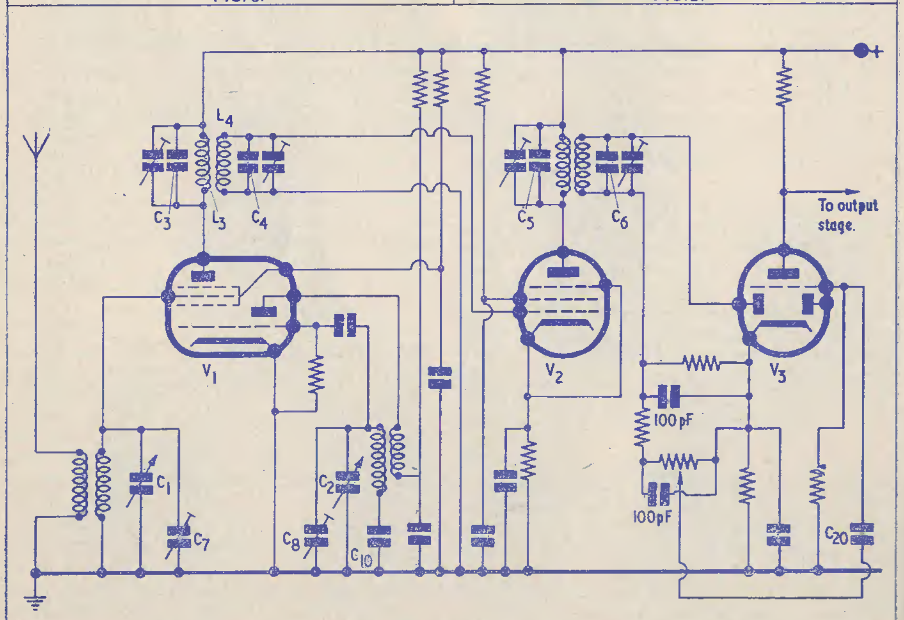


FIG. 7.

Refinements

The superhet receiver is so commonly used nowadays that many refinements and modifications have been introduced to meet specific requirements.

For communications work, that is, reliable communication over great distances, elaborate receivers are used. When speech transmission only is considered, the receiver may be designed to be more selective than for music transmissions, and for morse the selectivity may be increased to such a degree that speech becomes unintelligible.

To mention just a few of these variations would take more space than is available here, so these matters will have to be held over for a further article.

Can Anyone Help?

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

W. G. Phillips, 151 John Amery Drive, Stafford, is in need of the service sheet and/or the circuit of the Ultra 506 receiver, and is willing to purchase.

* * *

P. Ridgley, 21 Whitethorn Avenue, Yiewsley, Middlexex, wishes to buy or borrow the circuit and power pack details for the Marconi AD.50C receiver, P.S. no. 7583D, Inst. no. 50436. Frequency range 250/500 kc/s, 190–250 kc/s, and valves MS4B (2) and MH4, date of manufacture 1937.

* * *

W. R. J. Vanderwerff, 10 Broadwater Avenue, Letchworth, Herts, wishes to buy or borrow the manual and/or servicing data of the receiver type R.1475—Receiver Unit 88, ref. no. 10D/1541.

* * *

4146246 Cpl. Woods P.R., Hut 4A, 4.G.R.S.S., R.A.F., Chigwell, Essex, requires information consisting of the circuit and any other details of the U.S. Navy V.H.F. Receiver type R–3A/ARR–2X. All letters will be answered and all information paid for.

* * *

L. Wheeler, 3 Capella House, Victoria Way, Charlton, London, S.E.7, wishes to hire, or purchase, a blueprint, service sheet or any data relating to the Ultra 22 radiogram.

* * *

T. W. Butt, 20 Norman Street, Failsworth, Manchester, wishes to obtain the plug connections, voltages, etc., and any conversion data for the Rx type 18 Mk. 3, and for the Amplifier type 1134A, and is willing to purchase same.

E. L. Strong, 6 Spurling Road, East Dulwich, London, S.E.22, would like to obtain details of the portable radio for mains and battery use, type 5A7A (Chassis HS-62A) manufactured by Motorola of Chicago.

* * *

J. Pringle, 7 Ferniehill Medway, Edinburgh 9, wishes to buy a copy of Data Booklet 4, "Inexpensive Television," or the circuit details for dividing sound and vision in the R1355 I.F. Strip.

* * *

J. H. Jones, 4 Oak Road, Hooton, Wirral, Cheshire, wishes to purchase the service manual for the G.E.C. T.V. Console B.T.4640, inst. no. 5494.

* * *

J. Bell, G3DII, "Ennerdale," 10 Greenfield Road, Stafford, requires the circuit of the Danish receiver "T.I.K. Regina" and the characteristics of the following Dutch valves: UBF11, UCH11, UCL11 and UY11.

* * *

A. Routhorn, BRS.20914, of 1 St. Benets Grove, Rosehill, Carshalton, Surrey, would like to obtain the manual or circuit diagram of the National H.R.O. receiver type H.R.O.-MX.

* * *

F. Vale, 103 Charles Street, Leichhardt, Sydney, Australia, would like to obtain some information or the manual on the Oscilloscope type 11, ref. no. 10S/562, and would also like to correspond with anyone who has made the Wobbulator by J. W. Bagnall, described in the April '55 issue of this magazine.

Radio Miscellany

THE GREATLY INCREASED NUMBER OF letters from readers this month, coupled with the disorganisation resulting from holiday-making, finds me hopelessly in arrears with individual replies. In my long association with the amateur radio movement (despite vague claims of "hundreds of letters" by over-enthusiastic editors and writers), the only time I can recall such a heavy mail was in the early days of the original *Short Wave Magazine*. In the years preceding its birth, radio-minded readers had suffered the mortifying experience of seeing their many radio periodicals disappear one by one. It came as such a relief to see a new, and promising, venture make its début, that literally dozens of well-wishers sat down to write a few words of congratulation and encouragement. Those letters were greatly appreciated by Basil Wardman (G5GQ) and his henchman in the uphill struggle they had undertaken, and I have often felt that the writers were duly rewarded by the freshness and original features their encouragement helped to inspire in the period of 5GQ's editorship.

Two or three readers wrote supporting my comments regarding the use of the word "ham" which so readily lends itself to a disparaging connotation. E.A.W. (Reading) points out that the word has gained universal acceptance. While this is perfectly true, its use is confined *within* the hobby as I suggested and dropped when speaking to others. In the Australian Society's *Amateur Radio* we find "Hamads," and the *Kleinanzeiger* (small ads.) in the German National Society's monthly are entitled *Ham-börse*. Use of the phrase is often found in magazines from many parts of the non-English speaking world, but always *within* the hobby. With them it has only one meaning, and it cannot carry any derogatory implication.

WSEM

While on purely amateur topics mention should be made of a couple of letters regarding the mystery of this call. I use the word amateur in its narrowest sense, meaning transmitting amateur. The first, from Cpl. Nicolaides (ZC4AM), who writes that he frequently heard the call on the 20-metre band when he was stationed in Cyprus, and he still hears it occasionally used now, in Habbaniya. While he has never discovered exactly what the letters stand for, it was used as a behind-the-Iron-Curtain-only CQ call, and UA operators always ignored all replies from the outer world. Whether the politically reliable Russian types granted transmitting licences were *allowed* direct communication with amateurs of other countries is quite another question. Hence my original query, and it doesn't really seem sufficient justification for using something different from the internationally accepted CQ call whether you acknowledge replies or not.

Bryan Meaden (G3BHT) writes: "Bearing in mind the differences in the Russian alphabet, Gospodx so wsemi wami translated means "God be with you all," apparently an old stock Russian greeting." Its usage, however, he observes, made it appear to mean *all* or *anybody* just as CQ does. He does not mention any contacts resulting from WSEM calls. Personally, I answered a number and, while I cannot be certain my replies were ignored, they always went back to another station. Yet during the same period I received at least ten cards from Russian listeners!

Most of those listener cards are quite elaborate, but none were individual. A space was left during printing and a rubber stamp impression of the listeners' numbers fills the space. No addresses were given other than the usual Post Box 88. The name of the town was written in, following the letters QRA or QTH. Noticeably, all the older cards had QRA—then, apparently, they gradually followed the inexplicable change among Western amateurs and started using QTH. To me, quite how that change came about is another mystery. Everyone just followed it as if afraid the use of QRA would make them appear to be old-fashioned.

Home Brewed

Correspondence regarding home-made wind-driven generators continues. I certainly had not realised that interest in this subject was so widespread, and I am left wondering how many of those who were good enough to write brew their own current as a matter of necessity. When I used to operate on the 7 and 3.5 Mc/s bands I had contacts with several stations (usually in the remoter parts of GM and the Scottish islands) who ran their transmitters from generators. One I remember particularly was pedal driven, which left the operator so breathless that you could hear him panting as he spoke into the mike!

In pre-war years, when I carried out a few experiments on these lines, I did it as a matter of interest, for the achievement of building something out of junk parts, and perhaps partly for the pleasure of testing out whatever mechanical ingenuity I possessed. Those with a genuine taste for practical experiment often build items (especially test gear) for the pleasure of doing it, or the satisfaction gained from overcoming difficulties, rather than the real use they may be able to put it to. Sharing this characteristic myself, I wonder how many of the wind-driven generator builders did it purely for such reasons when a simple mains charger would do the job with far less trouble—but also far less fun! Several Radio Amateur Emergency Network enthusiasts have evinced considerable interest, especially in planning a conveniently sized portable outfit.

CENTRE TAP *talks about* AMATEUR RADIO TERMS / WIND-DRIVEN GENERATORS / HIGH VOLTAGE SHOCKS

Points from Letters

Mr. F. G. Wall, of Plymouth, overcame the problem of mounting his revolving platform by using the headgear of cycle steering parts. He prefers a two-bladed propeller to the multi-bladed type, on account of its increased speed. So far everything has worked out well, but apparently being something of a perfectionist, he is seeking to still further improve his drive with bevel gears (already on hand) as they are easy to weatherproof. Points scheduled for further experiment—automatic lubrication and a quicker means of turning the propeller out of the wind when not in use.

Mr. J. Jelley, of Graveney, near Faversham, has built a very successful 12V windcharger, which he modestly describes as "the unholiest mess you have ever clapped eyes on." It uses a Riley Nine gearbox at 4½ to 1, and an ex-bus dyno at 500 revs, with a corrugated iron propeller. It cost £3 and, given a fair wind, merrily charges at 5 amps plus.

Mr. F. W. Street, of Birkdale, Southport, has designed a plant using scrap which he claims might well be duplicated by any handyman at a cost of 30s. (excluding the generator); that is, providing you have a well-stocked tool chest and a week of free evenings!

I am passing this correspondence to my good friend Dr. Arthur Gee (G2UK), who is well known to readers for his R.A.E.N. activities, radio and model work, so that he can investigate a final inexpensive basis of design from the most easily adaptable ideas. He will be pleased to hear of further experiences and suggestions from those who have carried out practical work along these lines. Please write to him c/o *The Radio Constructor*.

Lethal Power

Last month I wrote on fatalities caused by contact with low voltage circuits, and of cases where the human body had successfully withstood high voltage shocks. These comments were followed immediately by the case of a 14-year-old schoolboy at Shiney Row, Co. Durham, who fell and *stuck to* a 65,000-volt conductor after climbing a 50-ft pylon. Supplies over the county were shorted out. Firemen brought him down and took him to hospital, severely burned but still surviving. Whether he finally recovered or not has not yet been reported, but survival after such a shock seems incredible.

By further coincidence, the same week I read of an incident in a most entertaining book "Memoirs of a Sword Swallower." During a violent rainstorm on a fairground, a mentalist running for shelter suddenly rolled over into a deep puddle like a shot rabbit. An attempting rescuer received a shock that threw him backwards numbed all over. The electric cable was not buried deep enough. Eventually a rescue was made by throwing a plank over the puddle and "tight-roping" across it so that the mentalist, conscious but very stunned, could be dragged out by his coat-tails, though not without an unpleasant shock by those touching him. In this case, apparently, no one stopped to measure the voltage—it was still raining too hard!

Technical Forum

Servicing the C.R.O.

THE CATHODE RAY OSCILLOSCOPE is undoubtedly one of the most useful of the electronic instruments, and sooner or later most serious experimenters and constructors get around to either buying or making one. Whichever is the case, the day must come when the instrument develops a fault, and in general an effort will be made to effect a home repair. Sometimes an oscilloscope under construction will be found to have what appears to be an inherent fault which defies correction. It is confidently expected that many of these problems can be solved by reference to the following notes.

When tackling any repair job there are two basic methods of approach. One is born of much experience in handling a particular type of equipment when it becomes known that a certain defect is invariably due, for example, to one capacitor becoming open circuit. Years of servicing brings a store of such knowledge which may successfully be applied with only a hazy idea of the basic mode of operation of the equipment. The other way of servicing is basically the better, it is the one where consideration of the fault leads one to the conclusion that the trouble lies in a certain section of the circuit, then a further series of measurements are made to pinpoint the fault. This is the more instructive method and in the long run the one which produces the best results.

Logical fault finding in the c.r.o. thus begins with a block diagram of the various sections of the complete circuit as shown in Fig. 1. Careful consideration of the type of fault will lead one to make a more detailed examination of one of these sections so that the offending component is located.

No Trace

If, after the oscilloscope has been given a reasonable time to warm up, no manipulation of the controls will produce a spot or trace of any sort on the screen, first check to ensure that the tube heater is alight. If O.K. take an insulated screwdriver (5kV) and touch the blade lightly on the e.h.t. pin or terminal of the tube. Even with as little as 2kV a very small spark will be obtained if a potential is present. If not, check the e.h.t. rectifier, smoothing capacitors and resistor. The "screwdriver" test may also be applied to the e.h.t. winding on the mains transformer, where no spark indicates a defective transformer. Having checked that e.h.t. is present, use a high resistance voltmeter (0–250V) to measure the tube bias between grid and cathode. This voltage should vary with the brightness control from a few volts to about 100V. If this test is satisfactory, check the centring circuit (see below).

Trace Off-Centre

If, as the brightness control is turned towards its maximum position, a faint glow appears on the screen, it indicates that the trace is considerably off-centre. This can usually be traced to a defect in the centring circuit or a leak in one of the capacitors feeding the deflector plates. Should this test be unsuccessful, try shorting the "X" plates together and the "Y" plates together, and if this does not bring up a spot on the screen the tube must be suspected of being faulty. Keep the brightness turned down to the absolute minimum during this test.

If, with the deflector plates shorted, the spot appears somewhat off-centre on the screen, the fault may be due to a stray magnetic field from some adjacent metal parts. It is very rare to find a tube which has an offset gun causing the effect.

Bad Spot Shape

Whilst the deflector plates are shorted, the centre spot focus should be checked. If a sharp circular spot is not obtained it may be caused by one of the following:

1. Hum on e.h.t. Check e.h.t. smoothing capacitors and resistor.
2. 50 c/s magnetic field cutting the axis of the tube. Check mu-metal screen for position and fixing.
3. Tube may be defective, most likely having a poor vacuum.

Should the centre focus be good but deteriorate as the spot is deflected towards the sides of the screen, make sure that both halves of the push-pull deflection amplifier are functioning. This applies only to tubes which are intended for symmetrical operation. The balance of the amplifier may be checked by disconnecting each deflector plate of a pair in turn. Each disconnection should reduce the scan by an equal amount if the balance is correct. If incorrect, check the push-pull amplifier valves, preferably by substitution.

Large Defocused Spot

A large defocused spot or badly defocused trace which cannot be controlled by the brightness knob indicates that one of the resistors in the e.h.t. resistive chain has become open circuit. The current in this chain is usually between 0.5 and 1mA.

Intensity Varies

Should the intensity of the trace vary from point to point, an effect which may be more noticeable at some speeds than others, it is a sure sign of unwanted modulation on the grid or cathode of the tube. Check the decoupling components to these electrodes, and test the flyback blanking circuit by temporarily disconnecting it to see if any improvement results. Also make sure that the heater supply for the tube has not been accidentally connected to chassis.

In the case of the brightness changing along the length of the timebase scan, this can be caused by bad scanning linearity.

No Deflection

Assuming all connections in order, this most likely indicates no h.t. voltage. Check h.t. rectifier and associated components.

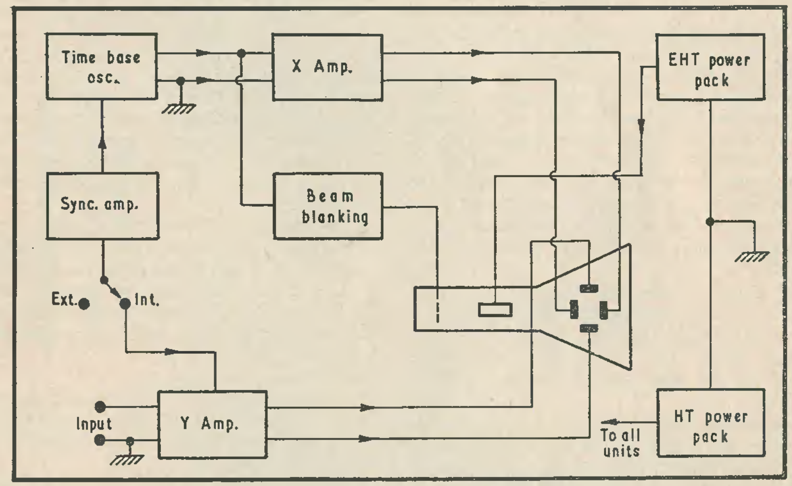


Fig. 1
Block diagram of typical oscilloscope

No Horizontal Deflection

Caused by a defect in the timebase oscillator or horizontal amplifier. Check the valves by making a quick substitution, and if results are not obtained localise the fault as follows. Earth one "X" plate and connect a 0.1μF 1kV capacitor to the other. The other lead from the capacitor is then temporarily joined to the anode of the oscillator valve, which if operating will give a short deflection of the spot on the screen. If the spot is static the fault is in the oscillator circuit. Should the oscillator pass this test, transfer the capacitor to the anode of the first horizontal amplifier valve, where a somewhat larger deflection should result. This procedure is repeated for subsequent amplifier stages until loss of deflection indicates the position of the trouble.

No Vertical Deflection

Use a procedure similar to that given above, but take one of the "Y" plates via the capacitor to the anode of the first and subsequent vertical amplifier stages in turn. It is convenient for this test to use a 50 c/s signal obtained from the valve heater supply and attenuated to about 0.5V, to be fed into the input of the "Y" amplifier.

Hum on Amplifiers

This appears as inability to obtain a straight timebase line even when the input to the "Y" amplifier is shorted to earth. Check h.t. smoothing and valves in the amplifier for bad heater-to-cathode insulation. As unbypassed cathode resistors are frequently employed in these amplifiers to linearise the frequency response, this leakage can prove troublesome. Hum on the "X" amplifier will appear as a side-to-side movement of the timebase line, which is particularly noticeable when the oscillator is running near the mains frequency. If the fault persists, see the recommendations under the heading "Bad Spot Shape" above.

We propose to consider next month the factors which may adversely affect the frequency response of the amplifiers in an oscilloscope, and show how a quick check can be made on this response.

DESIGN CHARTS FOR CONSTRUCTORS

No. 9 INDUCTANCE-CAPACITY-FREQUENCY CHARTS FOR LOW FREQUENCIES

by HUGH GUY

FOR ALL PRACTICAL PURPOSES, THE resonant frequency f of a parallel tuned circuit comprising an inductance L and a capacitance C is given by

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

where f is in cycles per second, L is in Henrys and C is in Farads. The simple relation between the frequency of oscillation of such a tuned circuit and the wavelength to which it is tuned has been used in the four preceding design charts to relate inductance, capacity and wavelength. However, in the audio range covered by this month's chart, one seldom requires to know wavelengths, and the data is more conveniently expressed as a relation between inductance, capacity and frequency.

The chart is used in exactly the same manner as its predecessors; the only difference is in one of the data lines, previously referred to as the "λ Line," but here, sloping in the opposite direction, labelled "F Line."

Four scales permit detailed circuit calculations over the range 10 c/s to 100 kc/s, using components whose values vary from 100pF to 30μF in capacity, and from 10mH to 100H in inductance. Corresponding scales must be read in conjunction with one another, however.

Two examples will now be considered to illustrate the operation of the chart.

Example 1

Determine suitable component values for a parallel tuned L–C mains filter to resonate at 50 c/s.

The steps involved in this example are shown in dotted outline on the chart. The frequency of 50 c/s (occurring on the first scale) is produced to cut the "F Line," and this intercept transferred vertically to the "Key Line."

Through this second intercept a diagonal line is traced parallel to the existing diagonals. Any value of inductance crossing a value of capacitance on this line will give suitable component values, provided that these values are each read on the first of their scales. Thus values of inductance ranging from 10H to 100H will resonate at 50 c/s with values of capacitance from 1μF to 0.1μF.

Obviously a far greater range of component values will produce the required resonant frequency, but to have extended the range would have resulted in a rather unwieldy chart. Should the values resulting from its use prove impractical, however, then more suitable values may be chosen by multiplying the capacitance value by 10 say, and dividing the capacitance value by the same number, or vice versa.

To quote one particular result to this example, it can be seen that a condenser of value 0.5μF requires an inductance of 20.5H.

As a check, the formula may be used to show that such values would really give a frequency of 49.7 c/s, which is a tolerance of less than 1%.

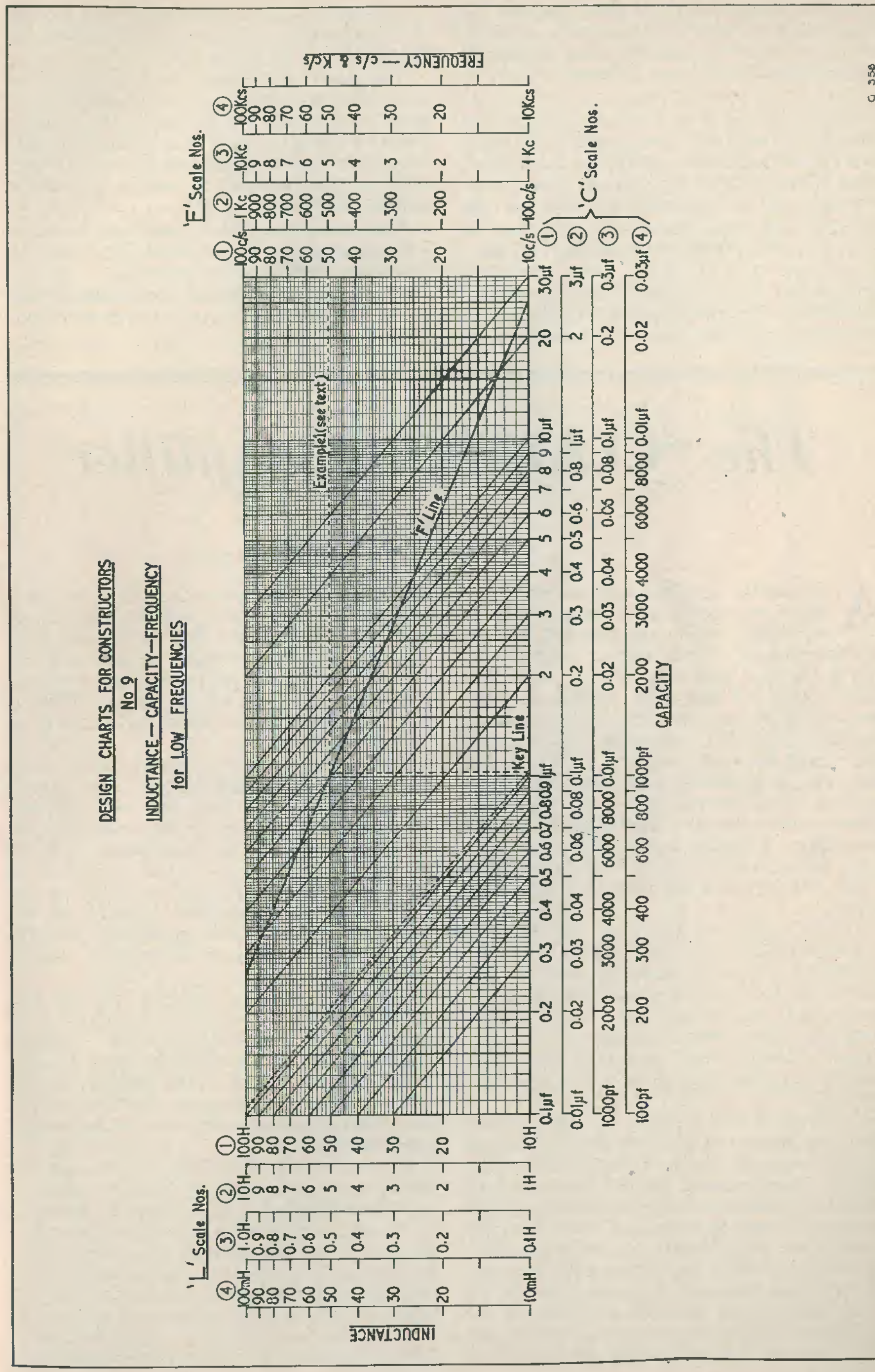
Example 2

At what frequency will an inductance of value 1.5H, and a capacitance of value 0.2μF resonate, when connected in parallel in an oscillator stage?

The inductance value 1.5H is located on the second "L" scale and, therefore, the capacitance value must likewise be located on its second scale.

The intersection of these two component values is observed and the diagonal line through their intersection traced back to the "Key Line." In this problem, the required diagonal line cuts the "Key Line" at the point 3 as read on the first capacitance scale. (This is mentioned for reference purposes only to enable the reader to follow the steps clearly.) Now this point on the "Key Line" is transferred vertically to the "F Line," and this intersection, when projected horizontally on to the second frequency scale, is seen to give the result as 290 c/s.

The formula gives the answer as 291 c/s, and the chart, therefore, gives an accuracy of better than 1%.



Other uses to which the chart may be put occur when a particular frequency of oscillation is required, and the value of one of either of the components is known.

Example 3

The erase and bias oscillator for a tape recorder is required to resonate at 75 kc/s. If a coil of inductance 12mH is being used, what is the required capacitance value?

This type of problem proceeds as the previous one: The intersection of the "75 kc/s" (on scale number 4), with the "F Line," is referred to the "Key Line," and the appropriate diagonal line through this point traced out. This latter process can either be achieved by actually drawing in the line, or by laying a rule along the chart, or by mentally interpolating the distance between the diagonal lines on either side.

The stated inductance value of 12mH on scale number 4, is now observed where it cuts this diagonal line and obviously the required value of capacitance is read from here, also on scale number 4, and found to be 380pF. Once again the result is within 1% of the calculated value.

The same procedure is carried out when the inductance value is required for a known frequency and given capacitance.

In the next and subsequent issues of *The Radio Constructor*, charts will be given on coil design.

The "CLARIBEL" *Amplifier*

by C. NOALL

A PERENNIAL REQUIREMENT AROUND ANY radio workshop is a small, reliable amplifier, which can be used for the reproduction of records, testing radio tuners, and a hundred and one other jobs of that kind. Such an amplifier should be both simple and robust; and the author believes that the "Claribel," described here, meets both these needs admirably. Although but one valve is employed, performance is equal to that of a normal two-valve amplifier; whilst construction is a matter of the utmost simplicity. A further desirable feature is the quite remarkable degree of miniaturisation which can be achieved with this particular circuit.

The "Claribel" is based on the Mullard PCL83, which contains within a single envelope a triode l.f. amplifier and a normal output pentode. It is a modern miniature type; and its economical "two-for-one" design is a great help in effecting a compact layout. There is also a saving of one valveholder, and the wiring is correspondingly simplified.

Referring to the diagram, it will be noted that the power supply is not of the true a.c./d.c. variety, the 6.3V required for the PCL83's heater being derived from a small mains transformer. The inclusion of this component, rather than line cord, may be justified on the grounds of cooler running. The writer, having had some experience of the damage caused by overheating in miniaturised gear, favours this method of powering equipment where a.c. mains are available. As the l.t. loading of the PCL83 is quite light, the secondary of this transformer need not be rated at more than 1 amp. If a larger transformer has to be used, then the applied voltage should be controlled at its nominal figure by wiring dial lamps or w/w resistors in parallel with the heater. If this is not done, the PCL83's career may prove to be brilliant—and short.

H.T. is derived from a metal rectifier connected directly to the mains. This means that the chassis is live, and suitable precautions should, therefore, be observed when adjusting or servicing the amplifier. If one of the new "contact-cooled" rectifiers is employed, it should not be fixed to the chassis in the immediate vicinity of the smoothing block. Resistor-capacity smoothing is used; this is quite adequate in view of the low h.t. load.

From an electronic point of view the two halves of the PCL83 should be regarded as independently functioning valves. Section V_{1a} is the triode l.f. amplifier, and V_{1b} the pentode output stage. (The partially dotted outlines enclosing the valve symbols indicate that the valve is actually a two-stage single-envelope type.)

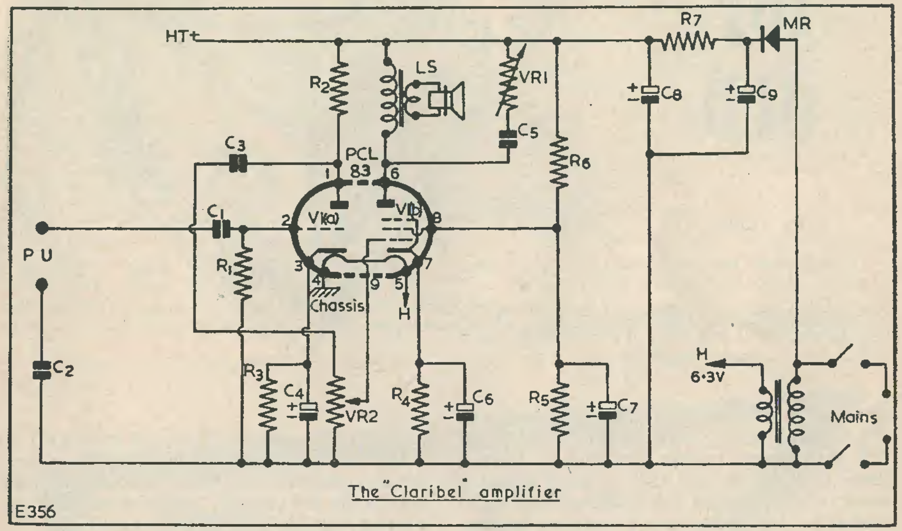
Examining the circuit, the first point to be noted is the provision of the two isolation input capacitors, C_1, C_2. These are essential to ensure safety with a.c./d.c. gear, particularly under workshop conditions, where metal benches and racks, etc., are likely to be encountered. Gain is controlled by VR_2, to which a double-pole, on-off switch is fitted. VR_1 is the tone control. It is used in a typical R/C "top-cut" circuit—quite adequate for an amplifier of this unpretentious type. A reasonable degree of a.f. decoupling has been included, but otherwise simplicity and economy are the keynotes of this design.

If extreme miniaturisation is required, the power pack may be modified as follows: replace the C_8—C_9 smoothing block by a 16 + 16μF combination, and R_7 by a 1,000 ohm resistor. These may not give quite such effective smoothing as the components specified, but this would hardly be noticeable, using a small loudspeaker. It is not recommended that the "standard" type output transformer be replaced by a miniature type, however.

The circuit of the amplifier is so simple that the layout is practically pre-determined. If a "strip" type chassis is used, the author recommends grouping the power pack components at one end, with the valve in the centre, and the L.S. transformer at the other extremity. Dress is not critical, but use screened lead for the grid input, and keep the volume control connections as short as possible.

The writer experienced no difficulties arising from instability with this circuit, but differences in layout and operating conditions might conceivably result in the appearance of this trouble. A cure in most cases could be obtained by wiring a series 4.7kΩ resistor directly to each input grid terminal on the valveholder. If the constructor wished to be absolutely on the safe side, these components could be regarded as an integral part of the circuit, and wired in during the initial building. Their inclusion will in no way adversely affect the "Claribel's" performance.

The "Claribel" is capable of being constructed on a chassis to fit a very small cabinet. One suggestion the author has to make is that the amplifier could be built into one of the miniature radio cabinets which are offered for sale from time to time in the advertisement pages of *The Radio Constructor*. These often have three apertures for controls already cut; the spare one could be utilised for a dial lamp. If a separate loudspeaker is employed, then an extremely small cabinet may be used. One of the small plastic boxes available from ex-W.D. sources should prove admirable for this purpose.



The "Claribel" amplifier

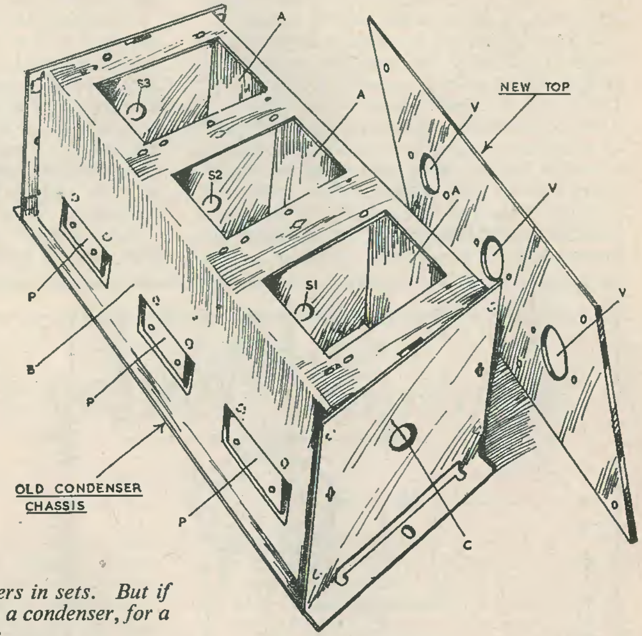
Component Values

C_1, C_2	0.002μF 500VW	R_3	1.5kΩ
C_3	0.01μF	R_4	470Ω
C_4	25μF, 25VW	R_5	100kΩ
C_5	0.01μF	R_6	500Ω, 2 watts
C_6	25μF, 25VW	R_7	300Ω, 2 watts
C_7	8μF, 350VW	VR_1	25kΩ
C_8	100μF, 350VW	VR_2	250kΩ
C_9	60μF, 350VW	MR	250V, 40mA
R_1	250kΩ	L.S. transformer	Standard Pentode type.
R_2	100kΩ		

NB: PCL83 heater voltage is 12·6V.
(ECL83 is 6·3V) J.B. 3006 ii.95.
See p 205 (Oct 56)

NEW CHASSIS for OLD

by G3XT



You have often put condensers in sets. But if you would like to put a set in a condenser, for a change, read on . . .

SOME OF THE FACTORY-BUILT RECEIVERS OF bygone years incorporated very bulky three-gang variable condensers. Even if these components are still in good working order, their physical size renders them quite useless for rebuilding into a compact modern set.

But some of them can be put to another and better use. If they are of a type that can be easily dismantled, strip out and discard the three rotor and stator vane assemblies; you will then have left a screened framework or case which resembles *a small chassis.* Add a flat sheet of aluminium to form a new top, suitably drilled for valveholders, etc., and you have a very robust and efficient chassis for a modern miniature transmitter, short-wave receiver, amplifier, modulator or power-pack.

The sketch illustrating this article was drawn from a typical three-gang condenser which the writer salvaged from an old discarded set. The vane assemblies were removed bodily by just taking out a few screws, etc., and the metal "shell" which remained formed an excellent miniature chassis measuring 8in × 3½in × 3in, needing only a new top "deck" of steel or aluminium to complete it. After cutting any necessary holes (such as those marked "VVV" for valveholders), construction can be simplified by mounting the valveholders and wiring up the small associated components such as condensers and resistors *before* securing the new top to the old chassis, while the various connecting tags are still readily accessible.

Interstage connections can be taken through the existing spindle holes (marked "S1" and "S2") in the screens, after fitting rubber grommets. Screened wire is advisable, as the leads pass close together through the hole. A three-core cable for h.t. and l.t. leads to the power-pack can pass through the hole marked "S3" in the sketch.

The chassis can be orientated in whichever way is more convenient, i.e., either the side marked "AAA" or the end marked "C" can be used as the front, a suitable panel being bolted thereto. (Don't forget that the height of the panel must be sufficient to cover the valve height above chassis!) If there are paxolin insets ("PPP") in the back, "B," these form good mounts for aerial, earth, pick-up, extension speaker or microphone input sockets.

Probably the only extra drilling required on the old chassis will be suitable fixing-holes for miniature two-gang variable condenser, volume-control, tone-control and wavechange switch.

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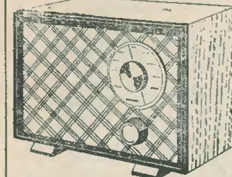

This is a 2-valve plus-metal rectifier set useful as an educational set for beginners, also makes a fine second set for the bedroom, workshop, etc. All parts, less cabinet, chassis, and speaker, **19/6.** Post and ins. 2/6.

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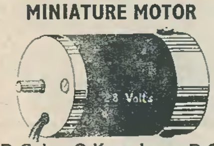

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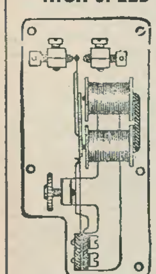

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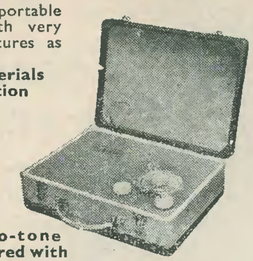

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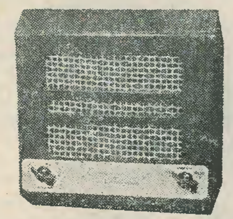

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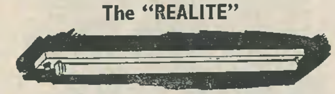

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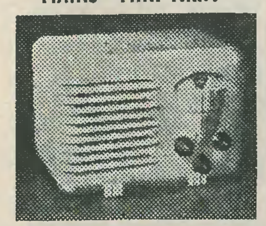

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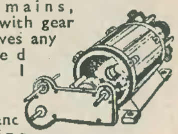

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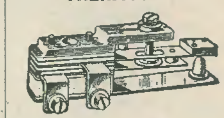

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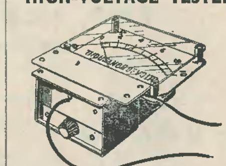

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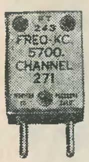

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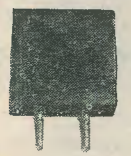

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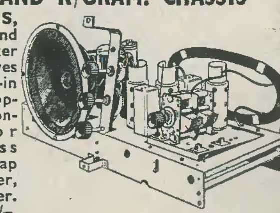

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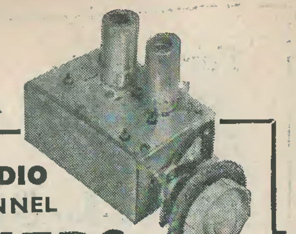

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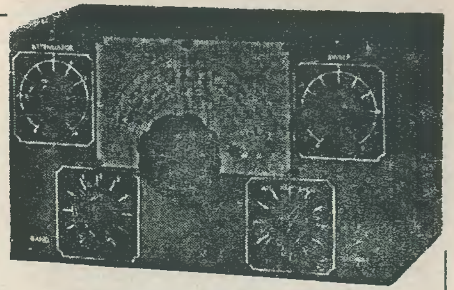

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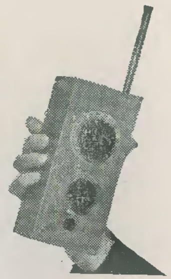

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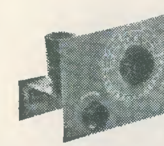

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