"Mini-Max" Transistor Pocket Radio, Part 2

VOLUME 10
NUMBER 9
APRIL
1957

The RADIO Constructor

RADIO · TELEVISION · AUDIO · ELECTRONICS

A MULTI-RANGE METER

by D. BIRCHON, B.Sc.

Included in this issue

LOW-COST AF AMPLIFIER
CONSOLE TV CABINET DESIGN
TWO "DIFFERENT" SUPERHETS
"ISOTRON" SELF POWERED AMPLIFIER
TELEVISION FOR THE HOME CONSTRUCTOR
DESIGN CHART No. 13

DATA Publications 1/9

The

Radio Constructor

incorporating THE RADIO AMATEUR

CONTENTS FOR APRIL

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THE EDITOR invites original contributions on construction of radio subjects. All material used will be paid for. Articles should preferably 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.

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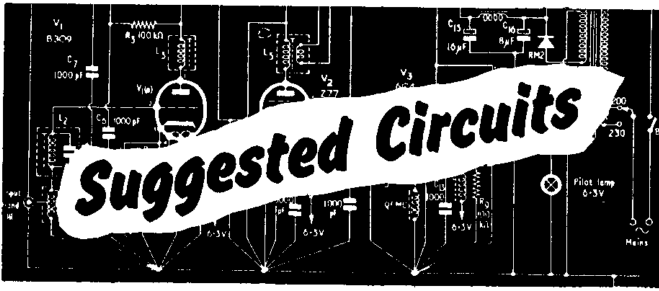


The circuits presented in this series have been designed by G. A. FRENCH, *specially for the enthusiast who needs only the circuit and essential relevant data*

No. 77. ANOTHER LOW-COST A.F. AMPLIFIER

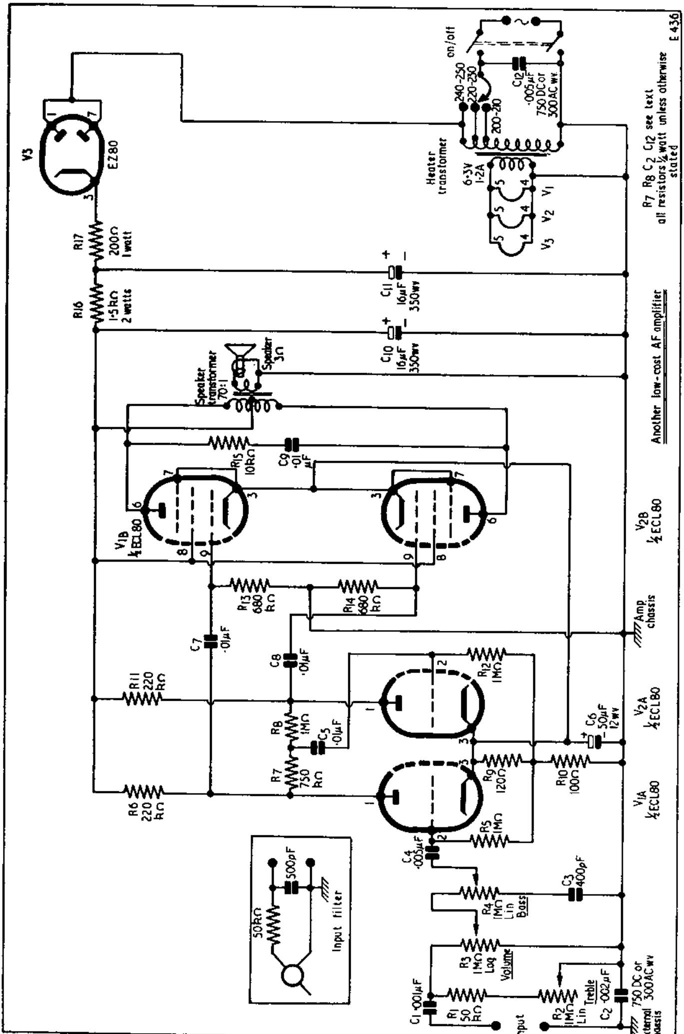
In *Suggested Circuits No.* 71 (PUBLISHED IN October 1956 issue) the writer described "A Very High Gain Low-Cost A.F. Amplifier." This amplifier employed a 12AX7 voltage amplifier followed by a 6AM5 output valve, and was intended mainly for speech applications, such as would be given in "intercom" or baby alarm installations. The main reasons for the low cost of this amplifier were that h.t. drain was low and that bass frequencies were attenuated. These two factors enabled simple power supply and decoupling arrangements to be employed, thereby keeping cost to a minimum.

Quite a number of readers have built this amplifier and have obtained satisfactory results. One or two have had hum difficulties, but this was due to the fact that they had employed no mains isolating transformer, as was particularly specified in the article. The hum cleared when the correct transformer was fitted. In consequence, the amplifier in question has successfully justified its inclusion in these columns.

The writer noticed that quite a few of the readers who built the high-gain amplifier talked of using it for record reproduction and similar purposes. As the circuit was not originally intended for such applications, and as there appeared to be considerable interest in low-cost amplifiers, the writer decided to devote a later article to another economic unit capable of giving a higher quality of reproduction. This month's *Suggested Circuit* is the result.

Design

The amplifier, whose circuit appears in the accompanying diagram, achieves the definition "low-cost" due to the fact that h.t. drain is kept to a low figure, and that only two valves (ECL80's) are required in the amplifier section proper. The unit provides an output in excess of 3 watts and incorporates two simple tone controls. The amplifier cannot, of course, be described as being in the high-fidelity class; nevertheless, it is capable of quite good quality of reproduction. This



Another low-cost AF amplifier

should be superior to that given by the conventional single-ended output valve found in the average radio receiver or lower priced radiogram. The amplifier is intended to be driven by a radio tuner unit or by a gramophone pickup.

The input to the amplifier is applied, via the isolating condensers C_1 and C_2, to R_1 and R_2 in series. R_2 functions as a treble-boost tone control in conjunction with C_1 and C_2. R_3 is the volume control, and this is followed by the bass-boost control R_4. For smooth operation R_2 and R_4 should be linear law potentiometers. R_3 is a log law component.

The input signal is next applied to the grid of the triode V_{1a}, which operates as a voltage amplifier feeding the grid of V_{1b}. V_{2a} provides phase inversion in a conventional "see-saw" circuit, the a.f. voltage at its anode being passed to the grid of V_{2b}. V_{1b} and V_{2b} form the push-pull output stage, their anodes being coupled to the output transformer in normal fashion. R_{15} and C_9, connected across the primary of the output transformer, apply a small amount of tone correction.

The power supply for the amplifier proper employs few components, as the low current consumption involved enables quite considerable economies to be made in this particular part of the circuit. A heater transformer is shown in the diagram, this providing a secondary output of 6.3 volts at 1.2 amps. V_3 functions as a half-wave rectifier, working into the smoothing condensers C_{10} and C_{11}. R_{17} is a limiting resistor, whilst R_{16} forms part of the h.t. smoothing circuit. If desired, V_3 may be replaced by a metal rectifier of 50mA rating, in which case the heater transformer output required becomes 6.3 volts at 0.6 amps only. Provided that C_{11} is capable of passing the ripple current involved, R_{17} should not be needed when a metal rectifier is employed.

The Phase Inverter

The "heart" of this particular circuit is provided by the phase inversion network around V_{2a}. The particular arrangement employed here has been chosen because it is largely self-balancing, and because it lends itself very well to use with a valve whose cathode must be kept at chassis potential so far as a.f. is concerned.

To understand the basic operation of the circuit it is advisable to commence by considering the case wherein both V_{1a} and V_{1b} deliver, at their anodes, equal voltages of opposite phase. Under this condition there must be a point along the resistors R_7 and R_8 in series where zero voltage occurs. This point will lie at the "resistive centre" of the two resistors. By tapping the grid of V_{2a} into a point which is on the "V_{1a} side" of this "centre," the necessary drive voltage for V_{2a} will then be obtained. A useful advantage of the see-saw circuit is its self-balancing action. If, for any reason, the output appearing at the anode of V_{2a} drops below that at the anode of V_{1a}, a higher proportion of the voltage at V_{1a} anode is fed to the grid of V_{2a}. In consequence the output of V_{2a} increases, tending to revert to its original condition.

Whilst the self-balancing action of the arrangement provides useful compensation for different valve characteristics, etc., it is desirable to design the circuit initially such that component values are centred around two equivalent valves. This, then, enables the circuit to reach optimum efficiency in balancing out discrepancies in either direction (i.e. V_{2a} giving higher gain than V_{1a}, or vice versa). The two components in the circuit which are most critical in this respect are R_7 and R_8, and for optimum balance the following relationship* should hold true:

$$R_8 = R_7\left(1 + \frac{6}{2A - 3}\right)$$

where A is the voltage gain of V_{2a} into the anode load resistor R_{11}. The voltage gain of V_{2a} in the amplifier is approximately 11, whereupon we obtain:

$$R_8 = R_7\left(1 + \frac{6}{2.11 - 3}\right)$$

$$\frac{R_8}{R_7} \simeq \frac{4}{3}$$

The 4 : 3 ratio between R_8 and R_7 is achieved in the circuit by specifying values of $1M\Omega$ and $750k\Omega$ respectively for these two components. So far as the home constructor is concerned, he may either obtain close tolerance components for these two resistors, or he may select two resistors which exhibit the 4 : 3 relationship from ordinary 20% stock. The 4 : 3 ratio is more important than the actual resistor values, and it would be worth while attempting to achieve this ratio within 5% or better.

The relationships between R_6 and R_{11}, or R_{13} and R_{14}, are not so critical, although it might still be advisable to attempt to match these pairs to within 10% or so. However, it is doubtful if any noticeable degradation in output would be given if the matching of these pairs was only of the order of 20% or so.

Other Points

There are several other points which require a little explanation. One of these concerns the two condensers C_2 and C_{12}. Both of these condensers are given high working voltage ratings, this being done to obviate the risk of breakdown at mains volt-

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* F. Langford-Smith, p. 526, *Radio Designer's Handbook*, 4th edition. Iliffe and Sons, Ltd.

ages. It is recommended that good quality components be employed in these two positions. The function of C_{12} is that of preventing mains modulation. With some installations, or in some localities, it may be found that C_{12} is not required. If the amplifier is intended to be used in a fixed location it would be worth while building it initially without C_{12} in circuit. If it is then found that mains modulation occurs, C_{12} can be fitted.

The speaker transformer specified has a ratio of 70 : 1 (this being the ratio between the complete primary, anode-to-anode, and the secondary). Slightly improved quality, at the cost of power output, can be obtained by increasing this ratio. The ratio should not be higher than 85 : 1. Since the anode current of either output valve is low (approximately 20mA) a large speaker transformer is not required.

Due to the fact that the electrodes of two valves are inter-connected in the manner employed in the circuit, the question of layout of components raises minor queries. To prevent any possible instability it is advisable to keep the anode leads of V_{1b} and V_{2b} well away from the grid circuits of V_{1a} and V_{1b}; but no other precaution should normally need to be observed. Although the writer has not encountered such troubles in circuits of this type, there is a slight possibility that, due to a particular layout or choice of components, parasitic oscillations may occur. If such is the case, they may be cleared by inserting grid stoppers (values up to 50kΩ) in series with the grids of V_{1b} and V_{2b}. However, as has just been stated, it is doubtful if such precautions would normally be needed.

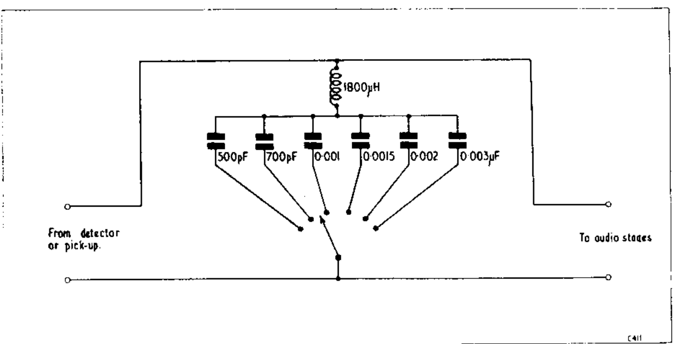
It may be found that, when certain crystal pick-ups are employed, there is an excess of "top" which cannot be balanced by the tone controls. If this occurs a low-pass filter may be inserted between the pick-up and the input terminals on the amplifier. Typical component values for such a filter are shown in the inset.

Live Chassis

It will be noted that the amplifier has a live chassis, whereupon the usual safety precautions apply. The "external" chassis depicted in the diagram refers to that of any equipment (pick-up or tuner unit) to which the amplifier may be connected. If hum is induced when the amplifier is connected to a particular item of equipment it should be possible to clear this by reversing the amplifier mains plug. Hum may sometimes be induced if the chassis of the input equipment is earthed, this being due to the small a.c. voltage existing between earth and the neutral mains line. It should not be forgotten that the amplifier loudspeaker is connected to one side of the mains.

A Simple Scratch Filter

by W. SCHROEDER



For the best reproduction of records an adjustable scratch filter is almost essential, as the noise varies a great deal with the age of a record.

A long-wave tuning coil (about 1,800μH), in series with any one of the six condensers shown in the diagram, will be found to answer the purpose admirably. The whole unit is conveniently mounted on the record-player chassis, and each record is marked with the setting of the switch which provides the best reproduction.

IN YOUR WORKSHOP

Smithy, the Serviceman, continues to run the workshop, aided and abetted by his able assistant, Dick.

WHEN HIS ASSISTANT ENTERED THE workshop one morning at the appointed hour of nine o'clock, Smithy the Serviceman noticed that he was wearing a grin which was rather wider than usual.

"You're looking very bright this morning,", remarked Smithy, suspiciously.

"I feel full of the joys of spring," replied Dick, cheerfully, "I have at last been visited by true inspiration!"

"Go on, I'll buy it."

"Of course, only creative types like me can really appreciate this sort of thing," continued Dick airily "What has happened is that I have succeeded in composing a poem. This is how it goes:

FRUSTRATION

I built a do-it-yourself T.V.,
Alas, no pictures could I see.
I wrote a letter to the designer,
Who said he'd had no pictures either!"

Smithy winced as Dick proudly quoted the last line, then chuckled.

"If I'd known that I was growing all that corn in this workshop I'd have packed in the business years ago," he remarked. "Anyway, we'd better have a few less cracks like that or you'll be having Mr. Welburn on your tail!"

"Philistine!" muttered Dick, as he donned his overall jacket.

Selecting Ion Traps

The workshop soon settled down to its normal quiet state. Smithy had decided that he would have a minor spring clean-up on this particular morning. He was busily engaged in sorting out the contents of a number of cardboard boxes which had been stowed away under the bench whilst Dick worked at the repair of a television receiver.

"Here's a little job for you," said Smithy, after a while. "When you've finished that set, you might use it to sort out some of these ion trap magnets I've unearthed. They need classifying into various strengths. As you know, every now and again we get a set on the bench whose ion trap magnet is either a little too strong or a little too weak, and it would be very useful to have some spares that are nearer the requirements of the tube."

"How do you want them sorted out?" asked Dick.

"I can't quote you any actual field strengths," replied Smithy, "so I should just sort them out as 'strong,' 'medium' and 'weak.' Subdivisions of that type are quite good enough for what we need here. You'll soon be able to find what subdivision a magnet falls into after you've checked a few. The best way of finding their strengths consists of setting up each magnet for maximum brightness on the tube in the ordinary way, and then marking it with the distance which results between the centre of its pole-pieces and the edge of the tube base. Weak magnets will need to be positioned further up the tube than strong magnets. When you've marked the distances on all the magnets you can arbitrarily divide them up into their categories of strength. It's not a very academic way of doing the job I'm afraid; but it will be helpful to us in the future if we should happen to be in a hurry and haven't got the time to sort through a lot of magnets to find one of the right strength. And don't leave the tube running for too long with an incorrectly positioned ion trap magnet, as this may have detrimental effects."

"O.K.," replied Dick. "After I've sorted out the magnets shall I put them away in the spares cupboard?"

"If you would, please," concurred Smithy. "Oh, and would you also keep them separated away from each other with one or two thicknesses of corrugated paper, or something like that? They shouldn't be allowed to touch each other for long periods of time."

"Fair enough," said Dick, and he returned to his work.

After a quarter of an hour he completed the repairs on his receiver and proceeded to check the magnets that Smithy had passed over to him. As he picked up one of the magnet assemblies a puzzled expression appeared on his face.

"Well, I've never seen an ion trap magnet like this before," he remarked.

Picture Shift Magnets

Smithy wandered over and examined the assembly that Dick had picked up.

"You'll be seeing plenty of those soon," he grinned. "It's a picture shift magnet for electrostatic tubes and not an ion trap magnet at all. Electrostatic television picture tubes in quantity are fairly new in this country, and the only reason why this particular picture shift magnet found its way into my junk box is because it came off a new set which was damaged in a fire. Otherwise, the magnet could still be in the set."

"How does it work?" asked Dick.

"Oh, it's quite simple," said Smithy, "but it's worth while having a look at the whole picture shift story before particularising on this type of assembly. As you know, with magnetically focused tubes you usually have a shuffle-plate or similar device to obtain picture centring. This shuffle-plate is basically a ring of magnetic material mounted close to the focusing magnets. The shuffle-plate becomes weakly magnetised itself and, as it is free to move vertically and horizontally, you can alter the effect its field has on the electron beam in the tube by adjusting its position. In other words, you can centre the picture by moving the shuffle-plate. An alternative explanation might be that the high permeability of the shuffle-plate ring modifies the field set up by the focus magnets, with the result that moving the ring alters the focusing field distribution, thereby shifting the electron beam and the picture. Both explanations come down to more or less the same thing. Apart from the shuffle-plate arrangement there are several other types of magnetic picture centring device, but they all work on the same principle.

"With electrostatic tubes you don't need any focus magnets because the internal structure of the tube has its own focusing electrode. To obtain picture centring you then fit a device like that you have in your hand on the neck of the tube. If you look at it closely (Fig. 1) you'll see that the picture shift assembly consists of two pole-pieces which are curved to fit round the tube neck. There is also a small round magnet which is free to rotate between the ends of the pole-pieces. The magnet is polarised across a diameter, with the result that you can make one pole-piece either north or south as you desire, whereupon the other pole-piece takes up the opposite polarity. As well as controlling polarity you can also vary the strength of the magnetising force between the two pole-pieces, by similarly rotating the magnet.

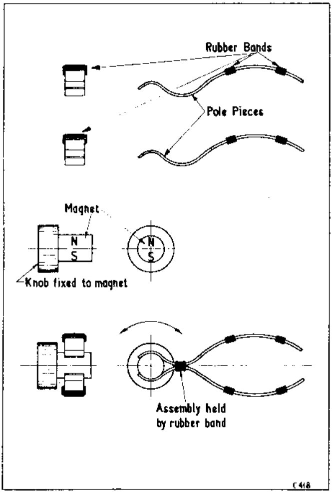


Fig. 1. The component parts of, and a complete, picture shift assembly. This drawing is not intended to represent in detail any particular assembly at present available.

"When the picture-shift assembly is slipped over the neck of a tube (Fig. 2) you can move the picture in any direction you want to. One control of shift is given by rotating the *magnet* between the ends of the pole-pieces.

A second control of shift is given by rotating the entire *assembly* around the neck of the tube."

"Very clever," remarked Dick, interestedly. "I see that this unit has little rubber bands on the pole-pieces. Surely they aren't intended for insulation or anything like that, are they?"

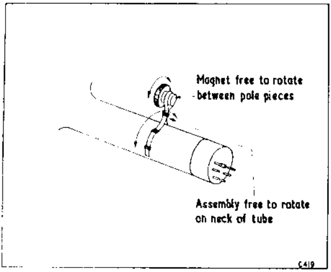


Fig. 2. How the picture shift assembly is mounted on the neck of a picture tube. As is demonstrated here, two modes of adjustment are available.

"Oh no," replied Smithy, "the main purpose of the rubber bands is to prevent the metal of the pole-pieces touching the glass of the tube neck and thereby scratching it. You should always be very careful not to scratch the neck of a tube, or any other part of its surface for that matter. A scratch weakens the glass, whereupon the tube might 'go pop' at some future date. The rubber bands probably provide a tighter grip on the tube neck as well, thus preventing the picture shift magnet being dislodged from its correct position if the set gets bumped. Some picture shift assemblies use p.v.c. sleeving, or similar materials, to perform the same function as is carried out by the rubber bands on this one."

"I see," said Dick, thoughtfully. "I must keep an eye open for electrostatic focused sets in future."

"They'll soon be plentiful enough," remarked Smithy. "I should imagine that nearly all the domestic market will be electrostatic one of these days."

"What are the advantages of electrostatic focusing?" queried Dick.

"Well, there are several points in its favour," replied Smithy. "First of all, the focusing it provides is quite good; better, in fact, than that in many of the magnetically focused sets I've encountered. Also there's a considerable saving in the manufacturing cost of the receiver, because the focus magnets and all the mounting brackets that go with them are no longer needed. A focusing control of some sort is still required, of course, but this can usually be a very cheap and simple arrangement. In practice, the potential which has to be applied to the focusing electrode for optimum focusing is not at all critical. Since, also, the current drawn by the focusing electrode is small, a high resistance potentiometer connected between chassis and boosted h.t. is probably all that is needed for most circuits. Some manufacturers don't even bother to fit a potentiometer, and simply rely on a tapping panel—this providing a choice of three or four fixed voltages."

"Well, that seems fair enough," commented Dick. "Incidentally, I've sorted out these magnets now, and so I'm out of work! Have you anything else you'd like me to do?"

A.G.C. Voltages

"Yes, indeed," remarked Smithy. "You always say you like making up little bits of test gear, so here's one you can knock up for me right now. It's a gadget for controlling a.g.c. voltages during the alignment of video i.f. strips."

"Sounds interesting," commented Dick, "but I don't quite see its purpose."

"Well, the main reason for having something which can control a.g.c. voltages is that the alignment of video i.f. strips is liable to vary whenever the a.g.c. voltage changes; the variation being mainly due to Miller effect in the controlled valves. Many manufacturers specify that the a.g.c. line of a video i.f. strip be earthed, or have a certain voltage with respect to chassis applied to it, during alignment. If the video strip is lined up under this condition the alignment then holds good at all the other a.g.c. voltages liable to be given by the set in use."

"That sounds reasonable," remarked Dick. "And I suppose that the idea of using a fixed voltage is intended partly to prevent the a.g.c. circuits from working whilst you're lining up, and giving the effect of flat tuning."

"I'm afraid you've stumbled on something of a red herring there," replied Smithy. "You see, the video a.g.c. lines of most television receivers obtain a voltage derived from sync pulse amplitude or video information amplitude. The first necessitates the use of a gated a.g.c. system, whilst the second normally relies on the negative voltage available at the grid of the sync separator, this grid being biased back rather in the fashion of that of a leaky-grid detector. Unmodulated r.f. from a signal generator would cause neither of these a.g.c. systems to operate. An r.f. signal modulated by the 400 or 1,000 c/s tone found in most signal generators could cause the second type of a.g.c. circuit to operate, but not the first.

"However, as I have just said, this effect is secondary in any case, the main point being that it is desirable to apply the voltage specified by the manufacturer to the a.g.c. line during alignment in order to prevent tuning shifts. This voltage should have a low impedance to chassis, and quite a good method of obtaining it consists of using a 9-volt grid bias battery connected like this (Fig. 3). The 5kΩ potentiometer across the battery causes a constant drain of just under 2mA, but this is not excessive. With this arrangement you also get the necessary low impedance across the two points which are applied to the set. The impedance to chassis of most television a.g.c. lines is quite high, lying somewhere between 50kΩ and 1MΩ or so, according to the set. The low impedance voltage source provided by the grid bias battery and its potentiometer then ensures that the a.g.c. line takes up that voltage only. The voltmeter across the output is needed when intitially setting up the arrangement. Theoretically, the voltmeter should be kept in circuit all the time, especially if it is a low resistance instrument, because disconnecting it will alter the voltage given by the potentiometer. In practice, high resistance meters (say 10,000 ohms per volt, or better) can be disconnected after the potentiometer has been set up to the required value.

bias battery. The internal impedance of a new grid bias battery in good condition is low, so the requirement that the voltage source has low impedance is met quite satisfactorily. But you shouldn't use this idea if the battery is old or in bad condition."

"Do you want me to fix up a battery arrangement like those you've just shown me?" asked Dick.

"Oh, no," said Smithy. "Just for once I prefer to have something complicated instead of something simple! Here's the circuit of the gadget I want you to make (Fig. 5). As you can see, its just a simple variable voltage source driven from the mains. The 12.6 volt heater transformer feeds a half-wave rectifier whose output is then applied to the filter circuit given by C_1, R_1 and C_2. These components should be more than adequate to prevent the appearance of ripple across the potentiometer R_2. Since the reservoir condenser C_1 has a large value we should be able to get a good 15 volts or better across this component. This will result in something like 14 volts appearing across R_2. The rectifier I'm using is a low voltage metal component that I've salvaged, but it is possible that a germanium diode could be pressed into service here instead, provided that care is taken not to exceed the turnover voltage. The maximum inverse voltage theoretically possible across the rectifier in the circuit is 35.6 (that is, twice the peak voltage output of the transformer secondary), so 'low impedance' diodes would not cope. A limiter resistance of 500Ω or so between the rectifier and C_1 to limit forward current would also

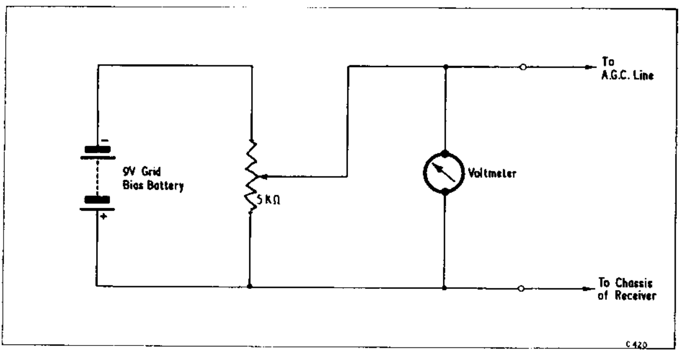


Fig. 3. A simple arrangement suitable for controlling the voltage of a television a.g.c. line during alignment.

"An even simpler arrangement is this (Fig. 4). If the manufacturer's literature states that a voltage which is a multiple of 1.5 should be applied to the a.g.c. line during alignment, all you have to do is simply tap off the required voltage directly from the grid be advisable when using the germanium diode.

"When you've finished making up the gadget you can fit the potentiometer with a scale, and calibrate this in the volts available at the output terminals. Calibration should be carried out using a valve voltmeter or a really high resistance meter, such as the Avo 8. So long as the rectifier doesn't play any tricks on us, the calibration will then hold for quite long periods of time and should not need to be checked very often."

"O.K.," said Dick, planning in his mind's eye the chassis needed for the variable bias supply. "I'll get on with it straight away. Incidentally, why do you think this is a better arrangement than batteries? And won't varying mains voltages upset the calibration?"

it to very quickly check the response at any a.g c. voltage which is likely to be given. This is particularly useful if you are using wobbulator techniques. Incidentally, a variable source of a.g.c. voltage is helpful in trouble-shooting sound receivers as well. You quite often get awkward faults in sound sets which are caused by a.g.c. troubles.

"So far as varying mains voltages affecting the calibration of the potentiometer is concerned, this might be a nuisance if we were in a district with bad fluctuations. However, the mains voltage we have here in the workshop rarely drops by more than 10 volts or so below the rated 240, and the consequent error in the output of the particular unit we are considering would then be too small to worry us.

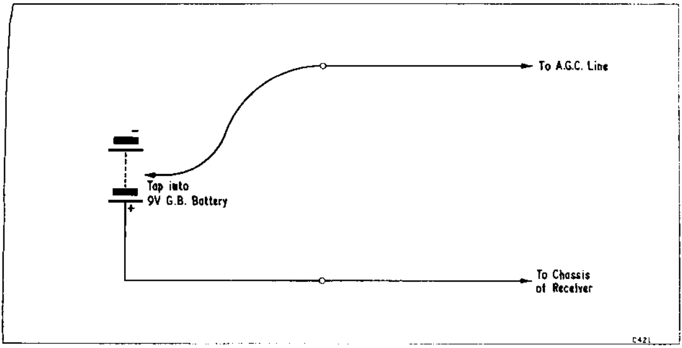


Fig. 4. If the requisite voltage is a multiple of 1.5, *the very simple arrangement shown here can be used instead of that of Fig.* 3.

"In answer to your first question, there are several reasons for my opinion," replied Smithy. "One of these is that batteries are a bit of a nuisance because they're always running down, and the types we need for this job aren't the sort of thing that people keep in stock these days. A minor point is that, after a heavy day's work, it's quite easy to forget to unclip any potentiometer that is connected across a battery, whereupon it is liable to waste away overnight. The mains driven gadget is not much larger than the battery alternative, and although it provides a variable output, the voltage calibration on the potentiometer is sufficiently reliable to enable us to dispense with a voltmeter.

"I should add that a variable output voltage (whether derived from batteries or the mains) is invaluable for checking i.f. strips *after* they have been aligned, because you can then use

"Whilst I'm on the subject, I think I should point out that 12.6 volt heater transformers of the sort we're using here are not very 'rare animals' these days, as they are advertised by several stockists. Of course, it is always possible, as an alternative, to obtain 11.3 volts from an ordinary mains transformer by connecting the 6.3 and 5 volt rectifier windings in series; this voltage being quite adequate for the purposes for which it is required. This is an especially useful idea if the mains transformer is otherwise useless due to a burnt-out h.t. winding, or something like that."

Static Voltages

Silence returned to the workshop as Smithy and Dick resumed their work. Smithy continued with his spring cleaning and Dick commenced the construction of Smithy's variable a.g.c. voltage unit.

After a while, Dick broke the silence.

"Do you remember," he remarked, as he busily filed away at a piece of metal in the vice, "mentioning some time ago that it was unwise to run a sound output transformer with its secondary unloaded because of the high a.f. voltages which might appear across the primary?"

"I do, indeed," said Smithy, "and I would like to remind you that you can get some pretty hefty a.f. potentials across the primary of the transformer even when it is loaded by the speaker. To give you a practical instance, let me tell you about a sound receiver I had in for repair some time ago. The customer complained that the set had an occasional, but very irritating, crackle. However, I just couldn't get the crackle to appear on the bench until I happened to tune the set to a musical programme whilst using a very short aerial, and whilst having the volume turned to maximum and the tone control set to minimum top cut. Quite a combination of circumstances just to get one fault to occur! I then found that whenever a certain note was played loudly a sharp 'crack' came from the speaker. Once I'd actually heard the trouble I had a fair idea where to look, and the first thing I did was to examine the output valveholder. I soon discovered that, every time the certain note was played, a little spark hopped across the surface of the insulation between the anode pin and the adjacent screen-grid pin. Since the set was working with a small aerial it was sufficiently sensitive to pick up and reproduce the interference caused by the spark, thereby giving the noise the customer had complained about. The importance of having the tone control set to minimum top-cut to bring up the trouble, incidentally, was due to the fact that when so adjusted it allowed maximum a.f. to be applied to the output stage.

"In this instance I was rather lucky in being able to *see* the spark and thereby locate its position. It sometimes happens that the spark is hidden, whereupon you have to guess where it is occurring. The most likely places for sparks of this type to appear are at the output valveholder, the tone-correction condenser connected across the speaker transformer primary, and the transformer itself.

"The same fault, or a similar trouble, can sometimes occur if the speaker frame is not connected to the earthy side of the voice coil. What apparently happens here is that static voltages appear between the voice coil and the speaker magnet, resulting presumably in occasional sparks. At any rate, coupling the two together often clears up the trouble."

"Thanks," said Dick. "That's a snag I must look out for in the future."

He resumed his work, applying his file energetically to a different part of the chassis he was making. As a result he produced a shrill rasping noise that filled the workshop.

"Here, can't you do that a little quieter?" yelled Smithy above the din.

Dick grinned.

"Surrounded as I am by people who are unappreciative of my talents," he remarked grandiosely, "all I can do is try to file and forget."

He ducked, but not quickly enough to prevent a 0.01µF condenser, 350V wkg, from striking him smartly below the ear!

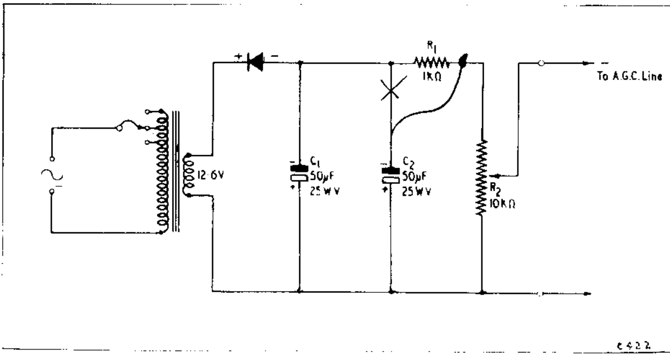


Fig. 5. A mains-driven circuit capable of offering an a.g.c. control voltage without the use of a battery. The potentiometer, R_2, may be calibrated in volts.

Radio Miscellany

Much of the success of *R.C.* can be attributed to its close contact with its readers. Both the Staff and the contributors enjoy the hobby themselves for its own sake, unlike the apparently aloof desk-type editorship which can only remotely share what the readers feel. Less still can it be alive to the changing trends of specialised interests. While *R.C.* does in some measure help to mould the constructor's tastes, to an even greater extent it serves to canalise the trend of the radio hobbyist's interest. From my own recent stocktaking of home constructional enthusiasm, pride of place must be given to the transistor. Having so wide a range of application, comparatively inexpensive and ideally suited to fresh experimental uses, this is perhaps unsurprising. What did surprise me, however, was the width of the second present-day interest—disc gramophone reproduction.

Those whose tastes lie in this direction have in recent years had numerous quality amplifiers described in our pages, plus an expanding choice of microgroove recordings. Recently, too, there have been a number of 3 and 4-speed turntables available at moderate and, more recently, even "bargain" prices.

Among radio enthusiasts in the last few months I have noted that there has been much discussion over long-play records, the best speed for high-quality microgroove recording and the future development of the 16 r.p.m. record. The latter, in this country, are still limited to Talking Books for the Blind.

Until recently I was inclined to take a simplified view of the record-buying public, feeling that the 15- to 30-year-old group bought the crooning, dance music, jazz and rock and roll 78 r.p.m. discs, while those of mature years and tastes (usually with more money to spend) invested in the long-playing records of operatic and more serious music. This may well be true of the radio minded, but it is certainly a long way out when it comes to the record buying public generally. Some 70,000,000 discs were sold last year—a big jump on recent years almost suggesting a swing back to the gramophone boom years. The best-selling records were those of the crooners and dance bands, bought presumably by those with little to spend and who spend it a little at a time! They bought well over 90% of the records sold. Those with more money to spend and more time to listen hardly bought enough to make it a worthwhile business, if it were not for the fact that these records sell over a vastly longer period.

Lovers of good music may not be greatly concerned over the selling turnover part of the business as long as the industry does not tend to neglect them on account of it, and they at least have the last laugh when they think of the longer-lasting pleasure they get from their purchases. While the percentage may seem low, the number of purchasers of serious music records is by no means inconsiderable. Indeed, in a recent article in *John Bull* on Hi-Fi, the writer estimates that the number of homes in Britain so equipped approaches the 100,000 mark. The writer of the article shares with me a recognition of the fact that they are not all true music lovers, but the figure includes a percentage of purists whose interest in Hi-Fi is more of a quest for technical perfection rather than distortionless musical reproduction. Like me, he is also shy of estimating the proportion!

An interesting fact revealed in the article is that a magazine devoted to Hi-Fi which started off less than 12 months ago with 5,000 copies has already doubled its circulation.

S.O.S.

Last month I mentioned a letter from Mr. V. Savage of Christchurch, New Zealand. Since then I have received a request for his address from one of my few regular YL readers who has relatives in Christchurch of that name. Unfortunately I no longer have the letter, so when this copy belatedly reaches you O.M. (if I remember rightly you mentioned an average delay of six weeks) will you please drop a note to the Editor or myself. *R.C.* has already served some good services in bringing together mutual-interest friendships (and pen-pals) through the medium of our "Can Anyone Help" column. Now perhaps we may find a new role—tracing lost relatives through their hobby!

Incidentally, when referring to Mr. Savage's letter I mentioned how much we would appreciate news of the state of the hobby in their part of the world from overseas readers. As a point of interest, since then I have checked up on how many countries copies of *R.C.* go to, from our Subscriber's file, and found they totalled no less than forty-nine. This figure, of course, does not include copies distributed by wholesalers. With such a world-wide circulation, this possible tracing of a "lost" relative on the other side of the globe is perhaps not so remarkable as it might appear at first sight.

Follow-up News

Once again this month there is a heavy mail from readers which I cannot manage to answer individually, so I will attempt to cover as many points as possible. The view expressed by J.D. McG. that interest in receivers, etc., described for construction is too ephemeral, found considerable support. W.J.C. (38 Curzon Avenue, Stanmore) recently built a superhet using manufactured coils which he finds disappointing on the medium waveband. He wonders if other readers have encountered the same results, and feels a Discussion Column would prove of great value to inexperienced readers. He is now building a Jason F.M. Tuner, and would like a standard of comparison to make sure he is getting the best out of it.

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

J.S.T. (Orpington) writes: "I am glad you took up the point of follow-on news on behalf of inexperienced constructors; particularly those described for beginners and those of unusual design." In this respect readers will have been pleased to see the Field Report on the "Eavesdropper" last month. He continues "As it happened I built the Jason F.M. Tuner, and was rather surprised when you wrote about it that you did not make more of its greatest virtue—freedom from the background of whistles which accompany all evening a.m. reception. I should, however, like to know if I am getting the best out of mine. With a 2-valve amplifier and a ground-floor indoor dipole I have volume to spare, but I sometimes wonder if it should not have more "punch"—not that I really need it at present, but I may later move to an area of considerably less field strength."

For the information of those inexperienced in f.m. reception, such a line-up under those aerial conditions will give ample volume (and some in reserve) for a large living-room up to 20 odd miles from the broadcast station. At greater distances or in low-lying districts an elevated outdoor dipole should be erected, or an amplifier with greater gain used to replace the conventional 2-valve arrangement used by J.S.T.

Components

Several readers were good enough to write about "Radiospares" bits and pieces, and R.H. of Dunmow, Essex, sent along a couple of their monthly lists. Unfortunately these are issued only to the Trade. He, too, has found their volume controls better than most. These lists include a very wide range of replacement components, including many of the not-so-easy-to-get sort. It is a pity this very progressive firm have not formally entered the home constructor market; although, of course, many dealers do supply them from their Service stock on request. Unfortunately, in the radio trade the Sales and the Service Departments are often poles apart. The average salesman does not seem to know the difference between a length of line cord and a couple of yards of flex—indeed it's all "wire" to him. If one asks for a component he either tries to conceal his ignorance by saying they don't supply them, or is unwilling to go to the Service Department and enquire—even if it is only at the rear of the Sales room. He's far more interested in selling receivers to awe-stricken and technically unknowledgeable customers who can be suitably impressed by facile sales talk. They don't ask awkward questions—or if they do are easily satisfied with any plausible answer! (This does not of course apply to specialist firms such as those advertising in this magazine!—Ed.)

Break!

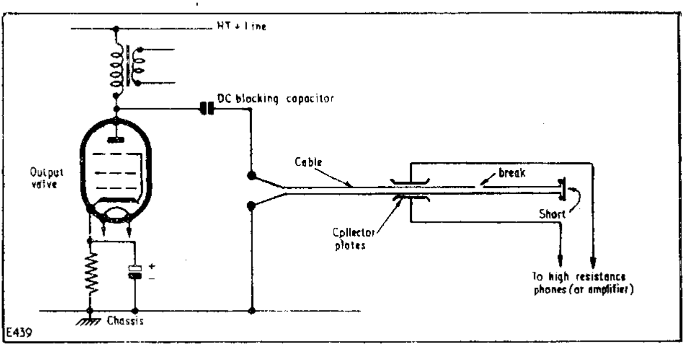
A record number of readers were kind enough to write about the problem of a break at an unknown point in a length of cable, including R.H. quoted above.

G3IRM (Knaresborough, Yorks) and others favoured pushing a sharp pointed prod through the covering and then testing for continuity by means of a battery and meter, or better still with an accurate bridge. They have all successfully used this dodge for locating breaks in line cord. As a matter of interest none of them mentioned what they do with the short ends of line cord they collect in this way. Personally, I save 'em up and then make them into electric blankets!

The actual length of cable which was the subject of the story was of the heavy bitumised rubber variety; and while this fact was not stated, the use of heavy and strong cable was implied by the fact that it was used for "haulage" purposes. A cable covering of this nature would require some penetrating even with a needle sharp point and one would undoubtedly finish up with sore fingers, as well as a few broken points. It would, too, be a rather tedious business having to check against all four ends in the case of twin wiring (two to make sure it wasn't the sound wire "found" by the point and two to check that continuity was complete to either end).

Another drawback would be that a series of pin-holes throughout much of the length of the cable would ruin its weather-proofing qualities and possibly spoil the longest undamaged length for outdoor use.

Perhaps the best method requiring nothing more than can be found in the average den is the scheme outlined by Mr. R. Wallace of Dawlish Road, Teignmouth. Moreover, he has already successfully used it to trace breaks in shorter lengths of wire. The accompanying circuit is more or less self-expanatory; and he writes, "The wire is connected in the form of an extension to a speaker, the return being via a common earth. The receiver volume control is turned well up, when it is possible to pick up the radiated a.f. from the wire by dangling one of the terminals of a pair of high impedance headphones near the wire whilst holding the other in the hand. Proceeding along the wire, a place is found where the signal disappears or grows weaker quite suddenly and the break is thus located within inches. With a long length of wire,



A few readers wrote of methods which might be tried, but all these required elaborate apparatus beyond the normal stock of the average constructor. Incidentally, no one seemed to take into account the fact that there may have been more than one break in the same wire. This, of course, was easily possible. Remember it wasn't a set problem, but an actual incident!

collector plates could be used; or alternatively the headphones could be connected to the input of an amplifier."

He concludes by saying he enjoys this column, as indeed does G3IRM, who is also kind enough to add that it is usually the first thing he reads. Very many thanks, O.M.—that makes two of us!

TELEVISION for the HOME CONSTRUCTOR

PART 10 *by* **S. WELBURN**

This month S. Welburn, our popular contributor on television topics, concludes his discussion on wobbulator principles and techniques.

In last month's issue the writer devoted his article to a discussion of wobbulator theory and principles. He dealt mainly with wobbulator systems employing 50 c/s sinusoidal modulating and deflection voltages rather than with systems using sawtooth control, this being mainly due to the fact that sinusoidal control appears to be the more frequently encountered in modern equipment. There is also the fact that the sinusoidal system raises rather more design queries than does the more readily visualised sawtooth arrangement, with the result that comments on its functioning are of some benefit, if for this reason alone.

Last month's contribution concluded by stating that some of the disadvantages of wobbulator technique, as well as the question of injecting frequency markers, would be dealt with in the succeeding article. Together with one or two minor factors, these points will now be discussed. It should be pointed out that what follows applies equally to wobbulator equipment employing sinusoidal *and* sawtooth control voltages.

Frequency Markers

Whilst the first object of a wobbulator and oscilloscope combination is to present a visual indication of the response curve of the equipment being checked, this indication becomes of little value if it cannot be evaluated in absolute terms of frequency. Fig. 1 (a) illustrates a typical response curve as given on the tube of an oscilloscope working in conjunction with a wobbulator. We can roughly evaluate this curve, from the point of view of amplitude of different parts of the response, by the simple process of making a quick visual examination. If we require more accurate measurements of amplitude these can be made with the aid of the wobbulator attenuator. (The correct way of doing this is discussed later.) In other words, the response gives us a vertical dimension which can be measured with little trouble. On the other hand, the response of Fig. 1 (a) does not give us any information concerning its *horizontal* dimensions at all. For instance, we do not know what centre frequency the response curve has, nor do we know its bandwidth. It is extremely important in television alignment to know both these factors reliably and accurately. Should Fig. 1 (a) represent the response curve of a video i.f. strip, the picture shown by the c.r.t. of the associated televisor would be quite acceptable if the bandwidth were 3 Mc/s, but would be very poor if it were only 1.5 Mc/s.

To overcome these difficulties it is necessary to inject frequency markers into the system. These markers will show up on the trace at points corresponding to their frequencies, and direct measurement of frequency as well as amplitude of response then becomes feasible.

Absorption Circuits

The simplest and cheapest method of obtaining frequency markers consists of coupling a high-Q tuned circuit to any point along the chain before the detector which feeds the oscilloscope Y amplifier, this tuned circuit absorbing energy when the wobbulator frequency coincides with its own resonant frequency. (To "recap," it may be remembered that the wobbulator feeds, via attenuators, a frequency-modulated signal to the equipment under test. This f.m. signal has to be detected "a.m.-wise" at the output of the equipment before it can be applied to the Y amplifier of the oscilloscope. As was pointed out last month, the necessary a.m. detection may frequently be provided by circuits integral with the equipment under test, such as the video detector which follows the video i.f. strip.) Let us assume that, in Fig. 1 (a) the centre frequency of the response curve is at 30 Mc/s. If, then, our absorption tuned circuit is also set to resonate at 30 Mc/s there will be a loss of energy at this point, resulting in a "dip" in the response as illustrated in Fig. 1 (b). Should the response curve be inaccurately centred around 30 Mc/s, the marker would appear at one side in, say, the position shown in Fig. 1 (c). The dip provided by the absorption circuit functions as a frequency marker, indicating that that part of the response at which it appears corresponds to 30 Mc/s.

Absorption frequency marking is not, so far as the writer is aware, employed in commercial test instruments, but it has interesting applications so far as the home constructor is concerned. Its main disadvantages will be discussed later, although it is worth pointing out at this stage that it is not always easy to identify the marker it provides. If the dip is small or is not sufficiently sharp, it may be missed. There is also the possibility that dips in the response curve can be caused by minor faults in the test gear or in the equipment under test. To overcome these difficulties it is advisable to give the absorption circuit some form of variable frequency control, thereby enabling its marker to be moved along the response curve for positive identification. A variable frequency control assists, also, in enabling measurements of bandwidth to be made.

for applying the absorption circuit to the wobbulator itself is that it would be inadvisable to couple it into the equipment under test since the coupling arrangements employed would almost certainly alter operating conditions, and could cause detuning of the circuits adjacent to the coupling point.

Fig. 2 illustrates three basic methods by means of which an absorption circuit may be coupled to the oscillator of the wobbulator. That shown in Fig. 2 (a) represents the most obvious application, it consisting simply of loosely coupling the absorption tuned coil to the oscillator coil by mutual inductance. This method of coupling necessitates having the two coils in the same screening compartment, of course; variations in coupling being effected by altering the distance between the two coils or by rotating the axis of one with relation to the other. As may be imagined, this type of coupling is not very practicable if the absorption circuit is to be added to an existing wobbulator.

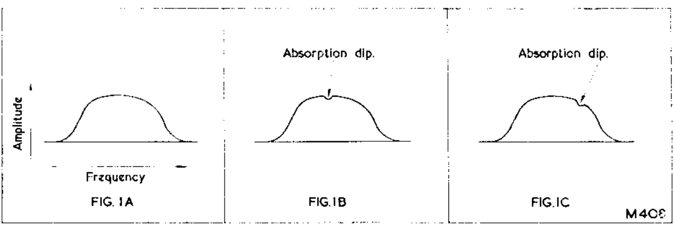


Fig. 1 (a). A typical response curve, as displayed on the tube of an osilloscope when employed with a wobbulator. (b) By means of an absorption tuned circuit it is possible to obtain a frequency marker on the response curve trace, as shown here. (c) The same absorption marker, displaced to one side of the trace.

As the absorption marker system functions by extracting energy at one particular frequency from the wobbulator signal it may, as was just mentioned, be fitted to the system at any position before the detector. In practice, however, it is preferable to apply the circuit to the wobbulator itself, the most convenient point for application being the oscillator. There are several reasons for this, one of the most important being that it is desirable to make the energy absorbed constant with respect to wobbulator amplitude in order to obtain the same amount of "dip" on all response curves exhibited by the oscilloscope. Constant energy absorption requires a carefully regulated coupling between the absorption tuned circuit and the stage to which it is connected. If the coupling is made to the wobbulator before the attenuator, the coupling can be set up for all response curves and will not need to be altered for different wobbulator output levels. Another reason

The method shown in Fig. 2 (b) is more flexible, the coupling between the two coils being effected by a link arrangement. So long as the cable coupling the two links together remains constant in length, this type of coupling enables the absorption resonant circuit to be positioned some distance away from the oscillator tuned circuit; thereby solving some of the layout problems incurred by the method of Fig. 2 (a). Any other of the well-known link coupling circuits could be employed in place of that shown in the diagram.

Fig. 2 (c) illustrates a capacitive type of coupling which, despite the layout difficulties it raises, may perhaps be found easier to put into working order than the other two schemes just discussed. In this arrangement the absorption coil has to be positioned fairly close to the oscillator coil to ensure a short coupling lead, and must be screened from it. The coupling condenser is experimental in value and, for frequencies above 10 Mc/s or so, should normally need to be less than 1 or 2pF. It is possible that sufficient coupling would be given merely by mounting a stiff wire close to one end of the oscillator coil.

As may have been gathered from the above, the idea of adding an absorption marker circuit to a commercial wobbulator raises problems owing to the necessity of making alterations to a product which was not condenser can be brought out as a front panel control, being fitted with a scale which is calibrated directly in units of frequency.

The biggest disadvantages of the absorption marker is that the accuracy of the frequency calibration it provides depends entirely on the long-term stability of the tuned circuit. The calibration of the variable condenser needs, therefore, to be checked not only when it is originally fitted, but also at fairly frequent intervals afterwards.

It should be remembered that the presence of the absorption circuit coupling components

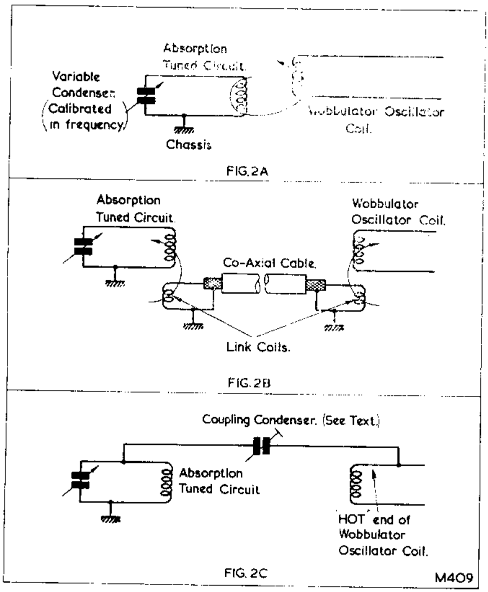


Fig. 2 (a). A very simple arrangement for obtaining an absorption marker. (b). A more practicable method of coupling the absorption coil to the wobbulator. (c) Another practicable absorption circuit.

originally designed for such a circuit. So far as home-built equipment is concerned this point may not be so important, whereupon the use of an absorption circuit becomes worth considering on account of its considerable cheapness. In order to be able to change the resonant frequency of the absorption circuit, and thereby move its marker along the trace for purposes of identification, some form of tuning control is desirable, and this can normally be a variable condenser. Such a may cause a shift of the wobbulator centre frequency; and that especially careful design has to be employed if the wobbulator has switched frequency ranges, or if its output consists of harmonics of the oscillator frequency.

Oscillator Injection

To the writer's mind, a far better method of obtaining frequency markers consists of injecting a known frequency into the chain before the detector, this being provided by a signal generator, crystal oscillator, or any similar device. It is normally undesirable to inject the frequency into the circuits of the equipment under test due to the possibility of the necessary coupling circuit causing detuning and incorrect operating conditions. It may, however, be injected at any point in the wobbulator, or its attenuator.

A very simple method of marker injection consists of combining the output of a signal generator with that from the wobbulator attenuator, this being done by employing a two-way splitter, such as that illustrated in Fig. 3 (a). This arrangement has the advantage of requiring no alterations or additions to the internal circuitry of the wobbulator. The splitter illustrated in Fig. 3 (a) has resistance values suitable for a wobbulator and signal generator having 75Ω output impedances, and should be connected to an input circuit on the equipment under test which has the same impedance. (When the input circuit of the equipment has a relatively high impedance—given, say, between a control grid and chassis—it is usual to connect an additional 75Ω resistor across these two points to maintain matching.) The two-way splitter will cause the signal applied to the equipment under test to be 6dB down on that at the wobbulator output. If the wobbulator has an input socket intended especially for marker injection, the signal generator output can, of course, be fed in at this point and no splitter is needed.

Injecting a marker frequency into the wobbulator system by means of a signal generator causes beats (due to the presence of the detector following the equipment under test) to appear on the trace of the response curve near to, and at the point where the wobbulator frequency and signal generator frequency coincide. An idealised marker is illustrated in Fig. 3 (b). What happens here is that, as the wobbulator frequency approaches that of the signal generator, the beat frequency produced between the two becomes lower in frequency and, therefore, more readily capable of amplification by the Y amplifier of the oscilloscope. Maximum beat frequency amplitude occurs over the range of frequencies at which the Y circuits offer greatest amplification, these being normally the lower audio frequencies. The result is that a peak in the marker amplitude occurs when the two frequencies are almost identical to each other. In actual practice the response of the Y amplifier will normally drop below some 25 c/s or so, causing the exact centre of the marker to be small in amplitude, rather after the manner shown in Fig. 3 (c). However, at operating frequencies of the kind likely to be encountered in television alignment, the width of this central part of the marker is so small that it cannot be seen on a normal tube presentation, and the general impression given is that of Fig. 3 (b). It may be deduced from the above that, to achieve a well-defined marker, it is necessary for the Y amplifier to have a restricted high frequency response; whereupon it follows that Y amplifiers having wide range responses may present markers whose central points are difficult to identify. If such a case occurs in practice, it may be alleviated by purposely restricting the Y amplifier response by means of a low-pass filter in its input circuit. Usually, however, the r.f. decoupling arrangement following the detector provides sufficient attenuation of the higher frequencies; and this attenuation can always be increased by raising the value of the filter condensers. It is worth mentioning that, when 50 c/s modulating and sweep voltages are employed, a Y amplifier response which is flat up to 5 kc/s or so is normally quite adequate for purposes of presentation.

The marker shown in Fig. 3 (b) represents, as was mentioned, an idealised state of affairs. It frequently happens, especially when working at relatively low frequencies, that the marker is not as well defined as it is in this diagram. In such instances it is possible for individual beat frequencies to appear on the trace, such as that shown in Fig. 3 (d). These presentations are different for each sweep, with the result that a flickering effect is produced. However, markers of this type are still perfectly capable of identification, and it is quite easy to judge their centre.

The simplicity of the signal generator method of injecting markers renders it a very effective adjunct to practical wobbulator techniques. There are two minor disadvantages, however, the first of these being that the frequency accuracy of the marker is no greater than the calibration accuracy of the signal generator; and the second being the minor point that the signal generator output level may have to be re-adjusted for each alignment run to ensure that the markers on the trace are not too large or too small. In a way, this second point has something to commend it as well, insofar as it brings out the fact that the scheme enables marker amplitude to be readily controlled.

It is possible to inject more than one frequency into the wobbulator system, should this be desired. Because of this, the frequency calibration of the signal generator may be checked *on the trace* by injecting a crystal oscillator into the system as well. When the marker of the signal generator lies on that of the crystal oscillator the frequencies of the two are coincident. Incremental adjustments of signal generator frequency (say up to ±5 Mc/s or so) will then be sufficiently accurate to enable bandwidth measurements

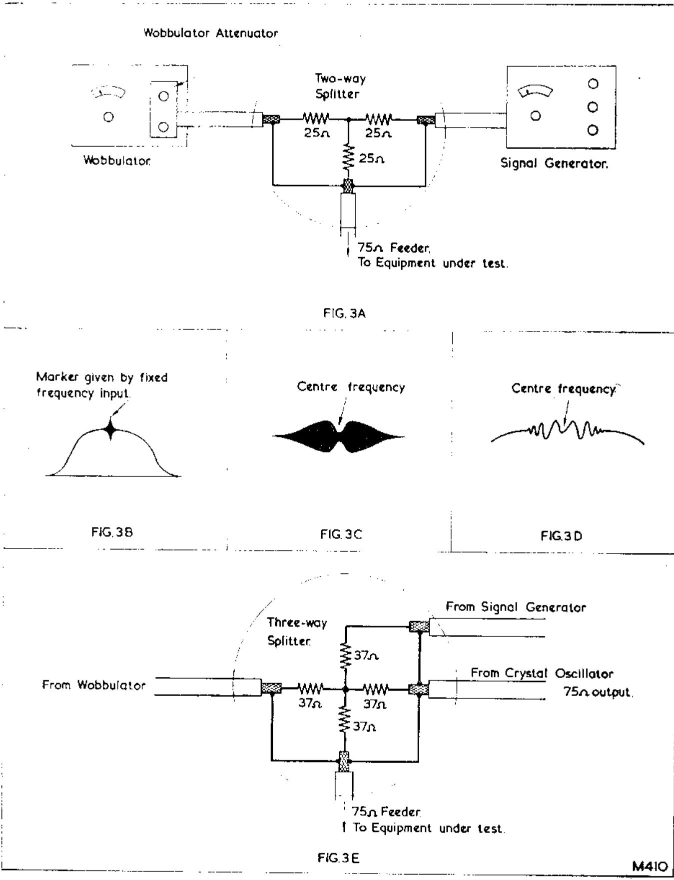


Fig. 3 (a). Frequency markers may be obtained by injecting a signal generator into the wobbulator system, as shown here. (b) An idealised frequency marker, given by the circuit of (a). (c). If sufficiently magnified in the horizontal direction, the frequency marker would have the appearance shown here. (d). At low frequencies, the marker may have this appearance (in which the horizontal dimension has been somewhat magnified), individual beats appearing on the trace. (e). A 3-way splitter, enabling a crystal oscillator and a signal generator to be simultaneously fed into the wobbulator system.

to be made. A 3-way splitter, enabling a crystal oscillator with 75Ω output impedance to be injected into the system, is illustrated in Fig. 3 (e).

An interesting possibility is offered by modulating the signal generator output (or that of a crystal oscillator), with a 1 Mc/s crystal oscillator which is rich in harmonics. Modulation of this type could be achieved by detecting the two signals together, before applying them to the wobbulator system. The result will then be the appearance of a "family" of markers on either side of the signal generator marker, each of these being spaced from its neighbour by 1 Mc/s. Such a display is very useful, since it enables bandwidth to be determined at a single glance. The writer has had no practical experience of constructing equipment providing this particular facility, and it is possible that the circuitry involved may be a little tricky. Nevertheless, the idea represents an interesting field of investigation to the experimenter.

response. In a response curve of the type illustrated in Fig. 4 (a) it might, for instance, be desirable to measure the difference in amplitude between the peaks and the trough.

The best method of doing this consists of adjusting the attenuators on the wobbulator and observing the changes which result on the trace. Thus, the difference between the peaks and the trough of Fig. 4 (a) may be evaluated by decreasing wobbulator attenuation (i.e. increasing its output) such that the trough rises to the same height on the tube face as was originally given by the peaks. Alternatively, attenuation may be increased such that the peaks occupy the same height on the tube face as was originally held by the trough. The different displays given by this technique are illustrated in Fig. 4 (b) and (c). If it is necessary to decrease attenuation by 3dB (as marked on the wobbulator attenuator) to achieve the display of Fig. 4 (b), then the trough is 3dB down on the peaks. An increase of 3dB should be similarly required

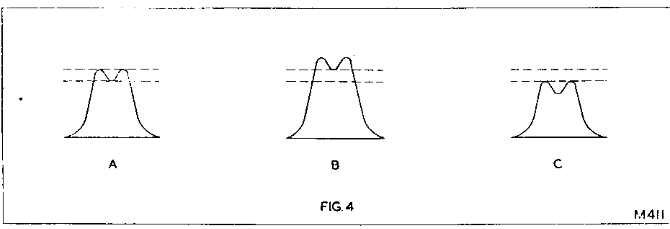


Fig. 4. The appearance taken up by the trace when amplitude measurements are made. The process is described in the text.

Amplitude Measurements

It was mentioned earlier in this article that it is possible to roughly measure the vertical dimension of a response curve given by a wobbulator and oscilloscope combination quite easily by visual examination; and that more accurate measurements can be given with the aid of the wobbulator attenuator. It would be worth while devoting a few paragraphs to this point before proceeding further; and it must be mentioned that the technique requires that the wobbulator attenuator be calibrated in dB. When a wobbulator trace is displayed on the tube of an oscilloscope we see a response curve whose vertical dimensions lie between zero output from the equipment under test (the base line of the display), and maximum output (the highest point in the display). It often becomes necessary to measure accurately the difference in level between two points on the

to obtain the display of Fig. 4 (c); this indicating that the peaks are 3dB up on the trough.*

It is worth while attempting to think in terms of dB when comparing response amplitudes in this manner as, apart from the fact that the wobbulator attenuator would almost certainly be calibrated in these units, such a method of thinking enables results to be more easily evaluated. So far as a video i.f. strip is concerned, it is normal to consider a change in amplitude of 2dB as being sufficiently "flat" for presentation on the c.r.t. of a television receiver, even though this looks comparatively large on a wobbulator display. (Another useful ratio to remember

* To be fully accurate, the above process requires that the base line should be in the same position after adjusting the attenuator as before. If necessary, a slight adjustment of the Y shift control of the oscilloscope will ensure this.

is that for rejection. If an interfering signal is 35dB down on a desired signal, interference on a c.r.t. picture will probably only *just* be visible. Approximately the same figure applies to the sound channel rejection which is needed to prevent sound on vision.)

Wobbulator Disadvantages

Although a wobbulator presents considerable advantages over the single frequency and output meter method of alignment, it also possesses several disadvantages.

The first of these is that, when a wobbulator is applied to the input of an item of equipment possessing a large number of tuned circuits, it is often difficult (unless the operator has had considerable experience) to know what frequency each individual circuit is tuned to. This is especially important so far as video i.f. strips are concerned, for several reasons.

One of these reasons is that many modern video i.f. strips employ staggered tuning (or a combination of staggered and band-pass tuning) plus an a.g.c. line. When the voltage of the a.g.c. line varies, Miller effects in the controlled valves can cause detuning of the associated grid tuned circuits. In a well-designed i.f. strip Miller effect is largely neutralised by setting the coils concerned to centre frequency. Alternatively, the i.f. bandwidth may be made to decrease for decrease in a.g.c. voltage not an undesirable feature. It is possible, with the wobbulator technique, to align a video i.f. strip such that an excellent response is given for one a.g.c. voltage, but that this becomes quite bad at another a.g.c. voltage. The only guarantee against obtaining this condition, when using wobbulator techniques, consists of checking the response curve at a number of different a.g.c. voltages and ensuring that no degradation results.† If the operator is fortunate he may be able to achieve this state of affairs at the first attempt. If he is unfortunate and degradation *does* occur, it becomes necessary to resort to guesswork by trying different combinations of the cores, whereupon the time-saving advantage of the wobbulator system becomes lost.

A second disadvantage also applies to the alignment of video i.f. strips. In the better class of commercial television receiver care is taken to ensure a good transient response (i.e. abrupt changes in brightness on the picture) and this is a function of the i.f. strip alignment. It is, in consequence, possible to obtain an excellent response with the wobbulator system, but the final picture may have poor transient response.

So far as video i.f. strips are concerned, the writer feels that the wobbulator is invaluable for the alignment of television receivers without a.g.c. lines, or of receivers for which inadequate service information is provided. For receivers having a.g.c. lines he feels that it is best to use single frequency methods initially, employing the figures given in the manufacturer's service manual; fiinally tuning up, if necessary, with the aid of the wobbulator.

A second disadvantage of the wobbulator system is that false indications may sometimes be given if incorrect conditions exist in the test equipment. A possible source of false readings is hum pick-up in the detector circuit and the Y amplifier of the oscilloscope. Hum pick-up can be especially troublesome when a 50 c/s sweep and modulating voltage is employed, as a constant distortion of the response curve may result. The reason for this is that the hum pick-up is in phase with the modulating voltage and causes the same distortion each time the response curve is traced. Frequencies other than those injected into the equipment under test may also cause misleading readings. The detector following the equipment under test is no respecter of frequencies, and will pass an output voltage to the Y amplifier which is composed of the detected result of all the frequencies applied to it. Care has to be taken, therefore, to ensure that the only frequencies applied to the detector are those of the wobbulator and the marker frequencies.

† The writer understands that "Smithy the Serviceman" is dealing, in this issue, with a simple device for controlling and varying television a.g.c. voltages during alignment. In consequence this particular aspect will not be discussed here.

THE SCIENCE MUSEUM RADIO SOCIETY. The next meeting will be held in the Lecture Theatre of the Science Museum at 6 p.m. on Thursday, April 11, when Mr. Christian of the G.P.O. (Eng.) will lecture and demonstrate "The Practical Approach to Transistors." Non-members wishing to attend are asked to contact Mr. G. Voller (G3JUL) Ken 6371, Ext. 237.

Next Month . . .

The "Rambler" Portable Superhet

A Receiver for Home and Countryside

The "ISOTRON"

A New Self-powered Amplifying Device

by **PETER PENLENHAM,** *A.M.S.D.B.*

Our contributor gives advance details of an amplifying device which may well revolutionise our entire outlook on the science of electronics.

SOME CONSIDERABLE INTEREST HAS BEEN aroused in higher engineering circles by recent developments in the sphere of applied radio-activity. Much of the important work that is now being carried out in this field is unknown to the general public, this being due to the fact that the only results which have been published have appeared in advanced journals, many of which are of limited circulation only. The writer has, for a number of reasons, been able to maintain contact with engineers engaged on research into applied radio-activity and is thereby enabled, in this article, to give brief details of an amplifying device which should, in his opinion, almost completely revolutionise the electronics industry as it stands today.

Before proceeding to a description of the device, the writer feels that it would be to advantage if he embarked on a brief summary of the development of signal amplification methods as used in electronic work up to the present time. It will be recalled that the first purely electronic amplifying device consisted of the three-electrode valve. In this valve electron flow from a cathode to a positively charged anode was controlled by means of a grid placed in between the two electrodes. Varying voltages applied to this grid resulted in changes in the electron current from cathode to anode. By choosing a suitable impedance for insertion between the anode and its source of positive voltage, a signal could be obtained which was greater than that impressed on the grid. In consequence, the three-electrode valve provided signal amplification. Later, more complicated versions of the three-electrode valve have been developed, but these all consist basically of maintaining an electron stream whose intensity can be controlled by the voltage applied to a grid.

A much more recently developed electronic amplifying device is the transistor. In the transistor the flow of electrons or holes (a hole denotes the absence of an electron and thus represents a positive charge of electricity) in semi-conductor material is controlled by varying the potential of part of the path traversed. Once again amplification takes place. Despite its short existence, the transistor had already ousted valves in many applications. The transistor is a more efficient device than the valve, since it requires less energising power to achieve a given output.

Another important type of amplifying system is provided by the electron multiplier. This device consists of a cathode whose emission is controlled by the signal it is desired to amplify. Electrons from the cathode strike the first of a series of anodes. This anode is made of a semi-conducting material which allows a number of secondary electrons to be emitted when it is struck by a single primary electron from the cathode. The secondary electrons from the anode are attracted towards a further anode having a higher positive potential, whereupon they release even more secondary electrons. The process is repeated over a relatively large number of anodes, each having a progressively higher positive potential, until the final anode is reached. A load is connected in series with this anode, enabling a signal voltage to be obtained which is proportional to, and much larger than, any voltage which affected the emission at the original cathode.

To date, electron multipliers have been only occasionally employed as voltage amplifiers; their main applications lying in the field of photo-electrics. A photosensitive electron multiplier ("photomultiplier") has a cathode whose electron emission varies according to the amount of light which falls on it. The amplified signal given by the final anode is then proportional to the light intensity at the cathode.

The "Isotron"

With the advent of the "Isotron" the valve, transistor and electron multiplier all become out of date. This is because the Isotron is *self-powered. It needs no external source of supply at all.*

Up to the time of writing, the Isotron electronic amplifier exists in the laboratory stage only. As soon as minor patent matters have been adjusted, however, it is anticipated that limited production can commence without delay. Some additional hold-ups have been occasioned by the necessity of keeping X-ray radiation (a by-product of the Isotron method of operation) within safe limits. At present it is claimed that X-ray radiation from the Isotron has a level lower than that given by television cathode ray tubes.

The writer has seen several Isotrons in operation. One of these, a low-gain model, provides the same amount of gain as is given by the combined triode and pentode output a.f. stages of a conventional radio or television receiver. This Isotron requires no external power at all and is, indeed, *never switched off*. It employs a cylindrical glass envelope measuring approximately seven inches in length and two inches in diameter. A magnet assembly fitted a third of the distance up the cylinder increases the diameter at this point to four inches. At a production rate of 7,500 a week only, it is considered that this particular Isotron could be *retailed* at £2 10s. 0d.

At the time being Isotron development is concentrated mainly on operation at audio frequencies. However, satisfactory amplification up to 10 Mc/s has been achieved with experimental models, and there is no reason to doubt that the Isotron will eventually be able to function up to at least several hundred megacycles before the limiting factor of transit time becomes excessive.

Operation

The basic operation of the Isotron is relatively simple, despite the fact that considerable ingenuity is needed in the design of the magnetic deflection system. For obvious reasons, full details of the deflection components cannot be published in this article, but the simplified description given below may be of assistance.

The self-powering emissive agent in the Isotron is a radio-active salt (barium tetrahydride was employed in earlier models), which is enclosed in a perforated sphere made of chemically pure nickel. The fact that the salt is radio-active (the name of the device derives from the term "isotope") results in its emitting alpha, beta and gamma rays.

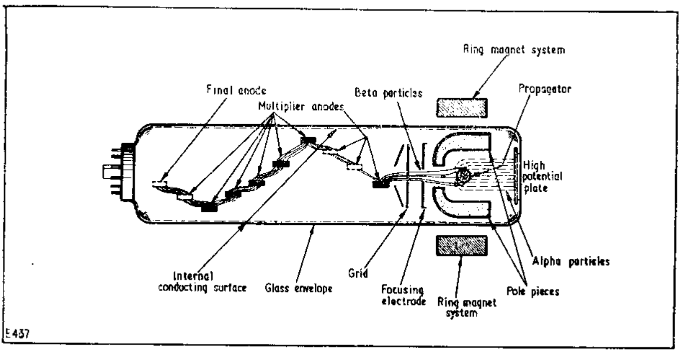


Fig. 1. Simplified diagram showing the internal construction of the Isotron. Details of the pole-pieces and multiplier anodes may not necessarily correspond with later development models.

A larger Isotron is capable of providing a 5-watt a.f. output for an input voltage of 20mV. This version, which requires little further development before being capable of mass production, is slightly more than a foot in length and has an approximate diameter of seven inches at the magnet assembly. This Isotron should retail at £11. *On its own it replaces the entire amplifying circuitry of a high fidelity amplifier.*

Sufficient radiation for the smaller Isotron mentioned above can be obtained from only 0.72 grs. of this radio-active material. It is because very small quantities of radiating agent are required that the low cost of the Isotron becomes feasible.

In the Isotron we are concerned only with alpha and beta radiations. As most readers will be aware, these "radiations" consist, in actual fact, of the emission of particles. The alpha particles are made up of helium nuclei, and are positively charged. The particles which constitute the beta "rays" are negatively charged, and may be treated as electrons.

Being electrically charged, both alpha and beta particles may be deflected from their paths by means of magnetic fields. What is, perhaps, of more importance in this context is that, since the two different particles represent opposite charges of electricity, a single magnetic field causes them to be deflected in opposite directions.

of excessive X-ray radiation. A lead shell outside the glass is not required.

Surrounding the propagator is the Isotron's deflection assembly. The basic function of this assembly is that of ensuring that a strong field exists at the propagator, the lines of flux being at right angles to the length of the glass cylinder. In practice the energising magnet is mounted outside the envelope, whilst specially shaped pole-pieces (not shown in detail in the diagram) are fitted inside in order to concentrate the field at the desired points.

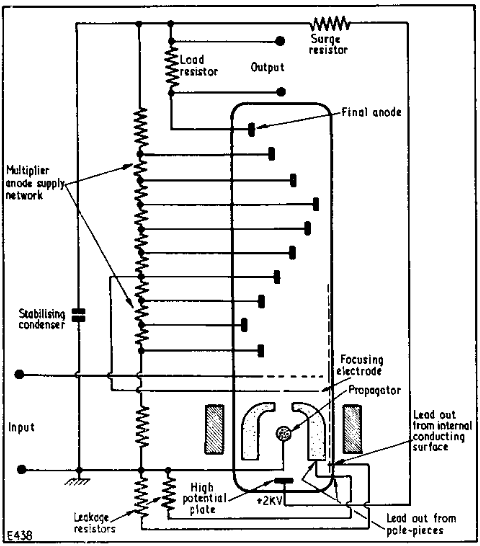


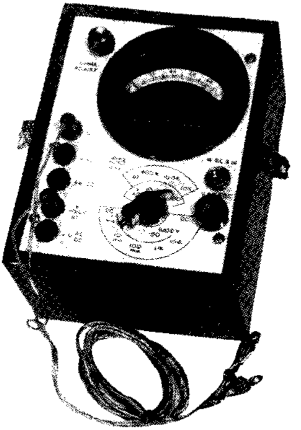
Fig. 2. A typical circuit application employing the Isotron. In earlier models the leakage resistors were made variable in order to control leakage current.

Fig. 1 shows a simplified view of an Isotron in cross-section whilst Fig. 2 provides a typical circuit application. The radioactive salt enclosed in its nickel shell is mounted near the base of the device and is called the "propagator." (This term has been coined to prevent confusion with such words as "cathode" and "emitter.") The propagator, together with the remaining electrodes of the Isotron, is mounted in an evacuated glass envelope. The glass with which the envelope is made has a high lead content, this having been found to be adequate for the prevention

As a result of the magnetic field around the propagator, most of the alpha particles which are radiated become deflected towards the base of the envelope, whilst most of the beta particles are deflected up the cylinder. In actual fact, about 95% of both particles are deflected in this manner, the remainder striking the pole pieces or the sides of the glass envelope. The latter is coated on the inside with a conducting material. The charges resulting from "stray" particles are allowed to leak away from the conducting

continued on page 623

A MULTI-RANGE METER



by **D. BIRCHON**, *B.Sc., A.I.M.*

THERE MUST BE MANY AMATEURS WHO, like myself, have longed to possess multi-range equipment which they have been unable to afford. A few instruments, each perhaps adapted for some particular measurement, are accumulated over the years, but the desire for a general purpose meter remains. The 13-range meter described stemmed from this desire and the parallel need to keep its cost to the minimum. It is strictly a general-purpose meter, having a resistance of only 1,000 ohms/volt.

With the exception of the meter movement, rectifier, and some of the resistances, it was built entirely from the "spares box." There was no access to other equipment for checking, so that no claim is made to a high order of accuracy in its performance. Precision resistors are now available at reasonable cost (see later) and their use would both simplify the construction of the meter and greatly improve its accuracy. Unfortunately I was unable to obtain similar components when the meter was built. Nevertheless, since then it has provided readings where before there were none!

The assortment of non-precision resistors used, together with the Heath Robinson methods adopted to check some of the ranges, were such that some friends even enquired if the meter was of any use at all! Recently the opportunity was afforded to check the meter against an almost new Model 8 Avometer, and the results were as follows:

Range		*Maximum error in range*
D.C. volts	1,000	-10%
	100	5%
	10	+5%
	1	-2%
	0.1	1%
D.C. amps	10	16%
	1	+8%
	100mA	10%
	10mA	10%
	1mA	1%
A.C. volts	1,000	-5%
	100	-10%
	10	2%

Ohms not determined.

The completed instrument with leads, prods, battery and lid weighs a little under 3lb, and measures $6\frac{5}{8}'' \times 5\frac{1}{2}'' \times 5\frac{1}{8}''$.

Since the meter cost less than £2 and a month of spare time to build, I was quite satisfied, particularly since its value is now enhanced by the addition of a calibration chart. It should be emphasised that the above results were obtained with ordinary resistors and much better ones would be expected if precision resistors were used, especially if coupled with one or two cross checks on other instruments during construction.

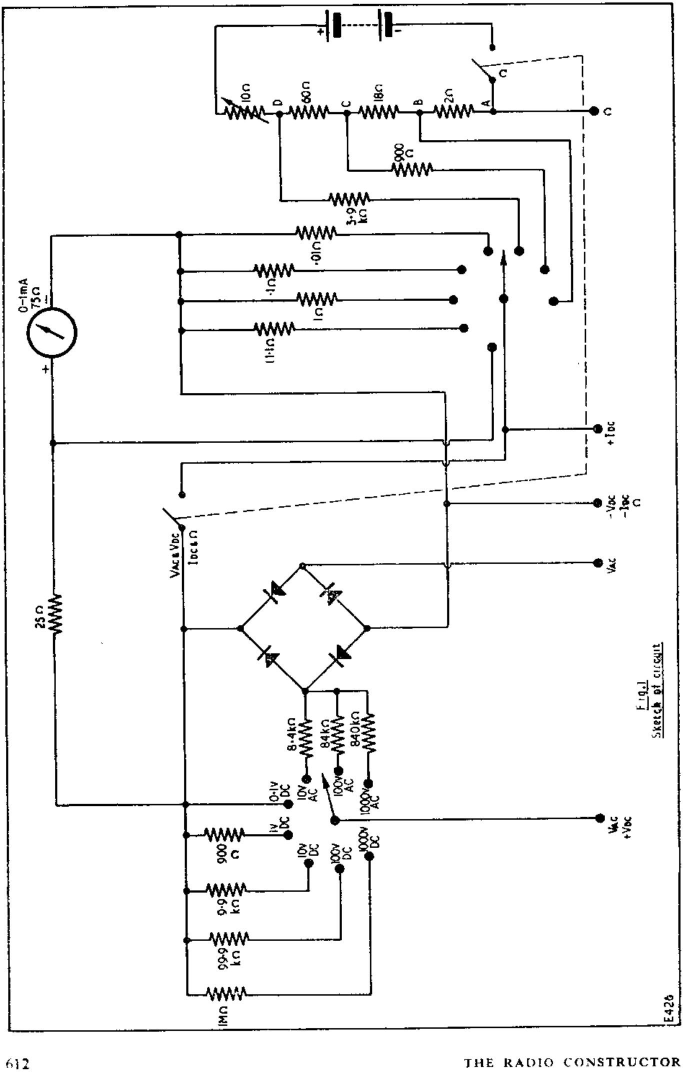


Fig. 1
Sketch of circuit

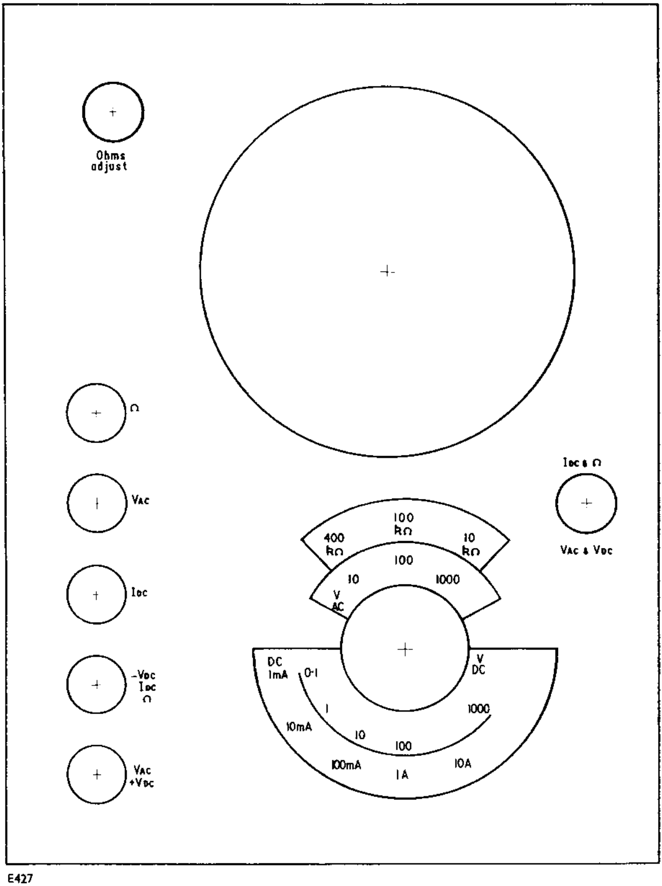


Fig. 2 Panel

Preliminary Design

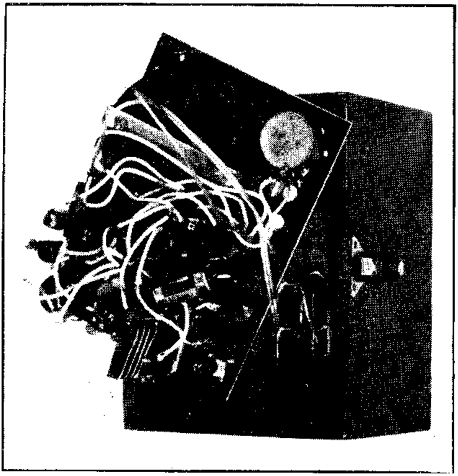
After much thought it was decided to provide a.c. and d.c. voltage ranges to 1,000 and direct current to 10 amps, together with resistance ranges of 10kΩ, 100kΩ and 400kΩ respectively by an internal battery, these last ranges to be extended as required by an external battery. Alternating current ranges were considered but excluded since the small amount of work normally requiring such measurements did not (to my mind) justify them. I decided that if I had to measure alternating current it would be done as the voltage drop across a suitable resistor.

The advantages of breaking up each range in multiples of 1 and 3 are obvious, but on grounds of simplicity the "3" ranges were excluded. The complete circuit is shown in Fig. 1.

Construction of Panel and Case

With the exception of the battery, all components were mounted on the panel which was made of 1/8″ Paxolin. A similar piece of 1/16″ thick Perspex was subsequently used on top to cover the panel markings (in indian ink on stout drawing paper). For the benefit of any readers desiring to use the same ranges, a printed panel is given in Fig. 2. The Perspex and Paxolin sheets were cut to 4½″ × 6″ and clamped together for piercing as shown in Fig. 3. The socket, switch and potentiometer holes are straightforward, but the meter hole is best cut with an Abrafile. For the benefit of any beginners who may not be familiar with this tool, a description may not be out of place. It consists of a steel rod 9″ long × 1/16″ in diameter bearing a set of helical teeth along the surface. It may be purchased for a shilling together with two links which enable it to be held in an ordinary hacksaw frame. If a ¼″ diameter hole is drilled just inside the circular aperture required for the meter, the Abrafile may be inserted and a hole cut. (Any shape may be cut to a depth limited only by the depth of the frame of the hacksaw.) A piece of plywood clamped at the back of the panel in the vice will eliminate chattering during cutting.

The box was made from 5/16″ thick oak, but any hard wood may be used, or even



The interior of the meter, showing the way in which the components are mounted on the back of the panel.

Components

The meter used was a Weston 2½″ scale 1mA 75 ohm internal resistance moving coil type. Similar meters are currently advertised by well-known suppliers. A Westinghouse 1mA bridge meter rectifier was purchased, but in cases of difficulty any reliable make of instrument rectifier with a similar rating is suitable. My own rectifier is of the cylindrical type ⅝″ diam. by ⅝″ long with an axial hole tapped 6-BA for fixing purposes. It should be noted that leads are usually provided already attached to these rectifiers, and these should not be removed as the heat from a soldering iron can damage the elements. Precision resistors are now advertised (e.g. H. L. Smith and Co., 287/289 Edgeware Road, London, W.2) at ¼ and ½ watt ratings at 1% tolerance, and their use would be well advised The only other pieces are "run of the mill" with the possible exception of the resistance wire. I used Eureka wire, approximately 3ft of 22 s.w.g., 1ft of 20 s.w.g. and 2ft of 18 s.w.g.

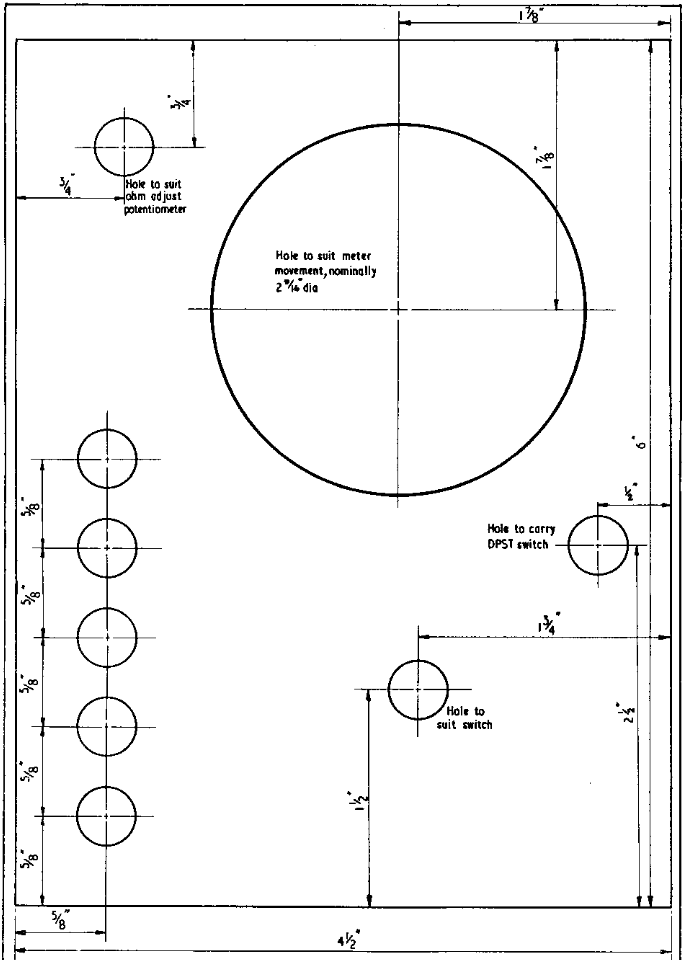


Fig. 3
Layout of panel

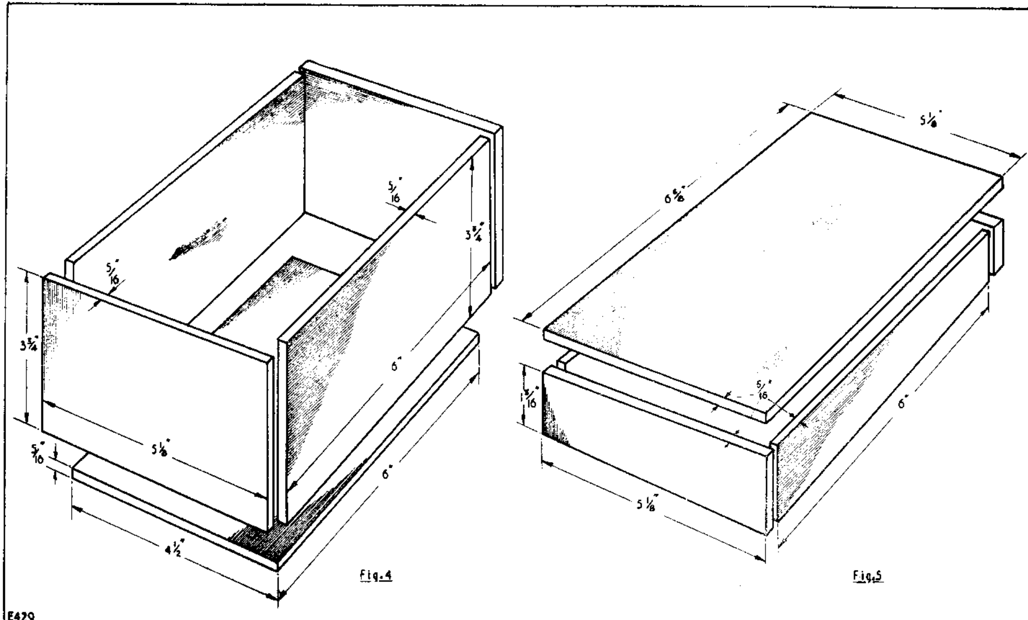


Fig. 4. The simpler method of constructing the box. The base fits flush inside the sides, and all joints are glued and pinned. Fig. 5. The box lid. All parts are of 5/16in wood, joints glued and pinned.

plywood. If it is necessary to smooth the surface of the wood with a plane, remember to plane both sides as unequal absorption of moisture on the planed side will cause later warping of the wood. In my own case, the joints were grooved together to present a pleasant appearance with adequate strength, and readers used to woodwork will require no suggestions on the method of jointing. Perhaps, however, it would not be inappropriate to describe a simple method which may be used by those who do not possess woodworking facilities. Since the box is small, plain butt joints may be used provided that

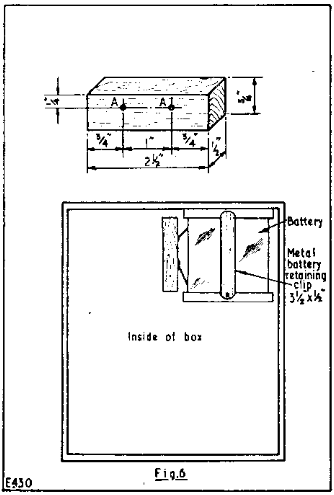


Fig. 6. Three pieces of wood should be prepared as shown, one of which should then carry two ½-in × 6 RH brass screws at A, to make contact with the battery terminals. Trap solder tags under the screw heads and, after driving in the screws, unite the tags and heads with solder, allowing the latter to cover the screw heads and so minimise possible corrosion later.

the edges are cut straight and square (hacksaw and file will do with hard wood) and a first-class gap-filling waterproof resin glue, such as Cascamite One Shot, is used. To make the box in this way the pieces should be prepared and assembled as shown in Fig. 4, all joints to be liberally coated with resin glue and pinned with ⅜″ panel pins punched just beneath the surface (a nail will serve as a pin punch). The lid is made in a similar fashion, to the dimensions shown in Fig. 5.

All excess glue should be removed from the joints before hardening, as it is difficult to produce a uniform finish with varnish or polish unless this is done. When dry the whole of the exterior may be sanded and coated with a good, hard, clear varnish, such as Valspar. If this is sanded lightly when dry, and then re-varnished, a pleasant effect can be produced. The battery retainers are made as shown in Fig. 6, and should be glued and pinned to the inside of the box as shown. A case clip (ninepence per pair at the hardware stores) fitted to each side enables the lid to be completely detached during use. The small brackets into which the screws securing the panel are tapped are best made and fitted after the panel has been completely wired, as there is not a lot of room to spare.

Wiring up

The "fuse" visible in the cover illustration requires some explanation. Originally it was desired to bring the total meter circuit resistance to 100 ohms by an overload trip of 25 ohms resistance. However, no successful trip could be made and the hole provided for it in the panel had to be filled by something! The fuse holder happened to fit—so in it went. It does not, of course, carry a fuse, but the 25 ohms was retained as a series resistor for use in all but the 1mA d.c. range, and is housed in the fuse holder.

The meter possessed two 4-BA tapped holes in the back, and these were used with a metal strap to clip the meter to the panel. A two-wafer ten-way switch was mounted, together with the five plug sockets, a d.p.s.t. toggle switch and a ten-way resistor tag board as shown in the other photograph. The rectifier was attached to the end of the resistor tag board remote from the panel by a 6-BA screw. The shunt board was made from a piece of ⅛in Paxolin 3in × 1in with eight 1/16in diameter holes drilled along one edge, and fixed to the panel by a small bracket. Short lengths of tinned copper wire inserted through the holes and twisted together formed excellent terminals for the shunts as shown in Fig. 7.

No small 10Ω potentiometer could be found for the "ohms adjust" control, so this was made from a small preset type 250kΩ non-logarithmic type. It was dismantled and the annular track of graphite on Paxolin filed on the inner and outer periphery to provide clearance for the 20 s.w.g. Eureka wire (about 8in of it) used to wind the resistance. The wire was connected to the existing end terminals and the whole thing dipped in shellac. When dry, a dead smooth file was used to cut through the silk covering and provide flats on the turns in the path of the sliding contact. As it was a preset type I had to solder a ¼in diameter brass extension (made from a brass bolt) to the spindle to carry the knob.

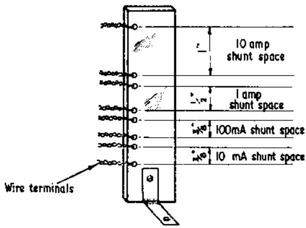


Fig.7
Shunt board of 3x1x⅛ paxolin

E431

The 25Ω series resistor was made in the following way. No Manganin wire was available, so Eureka (otherwise known as Constantan or Advance) had to be used. Since the temperature coefficient of resistivity of this material is approximately 0.00025, corresponding to a 0.01% change of resistance for 1°F, it was decided that it would do well enough. Wire tables indicated that a little over 6in of the 22 s.w.g. available would be 25Ω, so 8in was cut off and wound round a matchstick previously dipped in shellac. The circuit of Fig. 8 was made up. The potentiometer was then adjusted to give full scale deflection on the meter and the resistance was then introduced at X. Its length was then adjusted until the deflection of the meter was 0.75mA. (With the circuit shown, the error introduced by not allowing for the insertion of the 25Ω resistance is of the order of 0.2% and was ignored.)

The wiring of the d.c. potential ranges was quite straightforward and was conducted with 21 s.w.g. tinned copper wire.

The current ranges presented something of a problem, since no method was available for the measurement of the small resistances required for the shunts. Another factor to be allowed for was that on the 1 and 10 amp ranges the resistances of the leads from the shunts to the meter would have a significant effect. As the meter was intended only for simple purposes it was decided to employ a crude and direct approach. Four shunts were made according to the wire tables (and available bits of wire!) to the lengths shown below:

11.1 ohms	22in of 18 s.w.g. Eureka wire
1.0 ohms	2 in of 18 s.w.g. Eureka wire
0.1 ohms	14in of 32 s.w.g. copper wire
0.01 ohms	14in of 20 s.w.g. copper wire

When each of the shunts had been wound on the shunt board between the wire terminals, the following very crude methods were used for adjustment of the shunts. The 10mA range was selected and a new grid bias battery (nominally 9 volts) was connected in series with the meter, the 25Ω resistor, and each of the several 1,000Ω resistors which I had. All gave almost exactly full scale deflection on the meter, the similarity thus implied in the ohmic value of the resistors adding confidence which helped to allay my conscience! The shunt was adjusted to give an indicated reading of 0.89mA, which had to serve as the calibration of the 10mA range!

In order to obtain a check value on the 100mA range, a second 25Ω resistor made in a similar way to the first was used in series with a new 1.5 volt cell, the meter and the original 25Ω resistor. The appropriate shunt was adjusted to give a meter deflection of 0.58, corresponding to 58mA. The 1 amp and 10 amp ranges were adjusted by using the lighting system of my car (though anyone else's car would have done just as well!). My particular veteran has a 12-volt system and the "sidelights" consist of five 6-watt lamps. All but one were removed, and with the meter in series with a positive lead from the battery each lamp was used in turn on its own. With the meter on the 1 amp range, three out of the five bulbs gave an identical deflection. Each of these was, therefore, considered to take 0.5 amp and with one of them in circuit (and the appropriate air of confidence assumed) the 1 amp shunt was adjusted for half-scale deflection. The 10 amp range was similarly adjusted using all five sidelights as 2.5 amps, and with two 18 watt stop lights in addition, the current was assumed to be 5.5 amps.

It was considered that the use of the headlamps to provide a check at a larger current would only introduce an extra error due to voltage drop in the battery. The above methods may be abandoned with advantage if any other meters are available for direct calibration.

The alternating voltage ranges were checked against every available transformer secondary, in each case delivering approximately its correct current. Check values were thus obtained from 2V to 500V.

The only remaining ranges were those for resistance. The basic circuit required was a 4.5 volt battery feeding a potential divider circuit at 50mA, the circuit itself to be tapped at approximately 0.1, 1.0 and 4.0 volts. Three resistors were, therefore, made to approximate to 2Ω, 18Ω and 60Ω (respectively 4in of 18 s.w.g., 4½in of 22 s.w.g. and 14in of 22 s.w.g. Eureka wire). They were connected in series with the "ohms adjust" potentiometer—set to its maximum resistance—and a new 4.5 volt flat battery, as shown on the right-hand side of Fig. 7; and the resistances trimmed until the potential as measured by the partly completed meter was 0.1 across A–B, 1.0 across A–C and 4.0 across A–D. Final calibration was checked against a variety of resistors with reasonably encouraging results. In this case, also, the recent opportunity to check the calibration against an Avometer has greatly increased the value of these ranges, and incidentally has shown that the original calibration was surprisingly good.

Finally, the small brackets to locate the panel flush with the top of the box were made, and suitable clearance holes drilled in the panel to coincide with tapped holes in the brackets secured to the inside of the box. The various components passing through the panel were then temporarily disconnected and removed, and the paper bearing the necessary lettering was inserted, covered by the Perspex over-panel.

The meter thus completed has proved invaluable for a large number of domestic and automobile purposes during the last four years, in addition to its employment for general purpose work on radio "bits and pieces." Although now supplemented by additional equipment, it still remains very useful and well worth the month of spare time occupied in its construction. As mentioned before, if precision resistors (now readily and cheaply available) are used in conjunction with one or two odd meters for calibration purposes, the time of construction

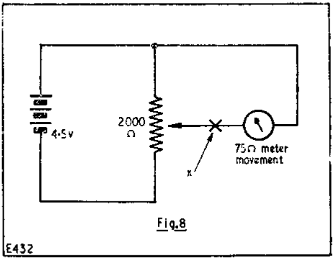


Fig. 8. With no resistance inserted at X and full scale deflection of 1mA on the meter, the potentiometer will be divided in the ratio 60/1940. Take care that when the meter is first connected to the circuit it is not overloaded by too high a setting of the control.

would be shortened and the accuracy increased. The extremely crude methods described have been given only for the benefit of those people who do not possess other odds and ends of equipment.

Two "Different" Superhets—*continued from page 639*

condenser acts as an impedance for aerial coupling, with the result that volume would be very poor with 0.1μF. These difficulties do not arise with the form of coupling shown in the diagrams.

Alignment

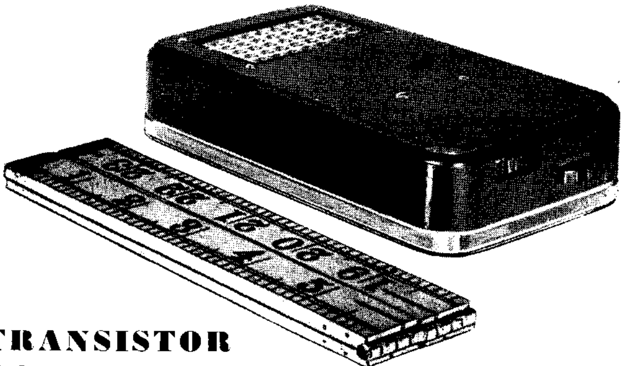
Proper results, or, indeed, any reception at all, may be impossible if alignment is wrong. But this need not prove difficult, even with no test oscillator.

Assuming no superhet has previously been constructed, the local station should first be searched for. Once found the i.f. transformer cores or trimmers are peaked for maximum volume. A very great increase in sensitivity will result, and other stations should be heard. Rough alignment of aerial and oscillator can then follow. To do this, tune in a station of high wavelength on one band and adjust the coil cores for maximum volume. Then tune in a station of low wavelength on the same band, and adjust the trimmers for maximum volume. The whole procedure is then repeated, with the a.v.c. line shorted to chassis, or a meter included in the anode circuit of the i.f. stage. Weak stations should not be chosen. The i.f.t.'s are peaked, coil cores adjusted at a high wavelength, and trimmers at a low wavelength. Alignment is then correct. Other bands are treated the same, the i.f. transformers not being touched however. An ebonite or other insulated blade must be used, as the presence of a metal blade in the coils, or near trimmers, will make exact adjustment impossible. No core or trimmer should be at the limit of its travel.

Warning

Both circuits, as shown, employ the "live chassis" technique, and due precautions should be taken when handling and when assembling in a cabinet. Articles elaborating on this theme have recently appeared in this magazine.

The "MINI-MAX"



TRANSISTOR POCKET RADIO

for Local Station Reception

PART 2

by I. F. GREGORY

Transistor Mounting

TRANSISTORS ARE VERY LIGHT IN WEIGHT, but they should not be allowed over-free movement, as this may possibly cause damage. It is, therefore, suggested that an Ebonite, Perspex or Paxolin strip $\frac{1}{2}$in by $\frac{1}{4}$in approximately be drilled with holes just larger than the cross-section of the transistors. (Since this article was written, suitable holders have become available, and these could be used instead.—ED.) The length of these strips can be judged from the illustration Fig. 4 given in the last issue. The body of the transistor rests in these strips, and the leads are terminated by using the 12-BA screw arrangement shown in Fig. 6.

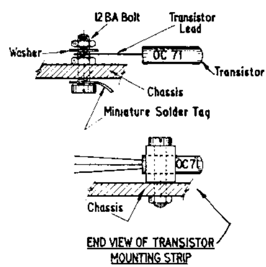


FIG. 6

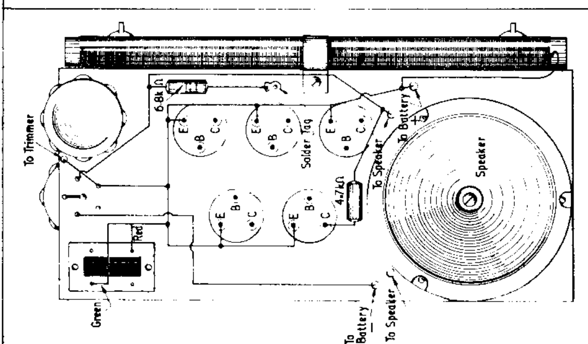
TRANSISTOR CONNECTIONS

G 429

The Speaker

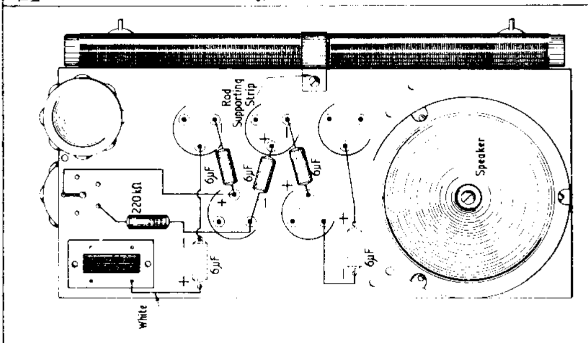
The "speaker" inserts may be sold in their cases. If so they may easily be removed by unscrewing the case and cutting the lead-out wires as far away from the insert as possible.

A hole must now be cut in the chassis just large enough to allow the magnet and coil assembly to be passed through from the underside. Two 8-BA screws will then hold it in position. Four threaded holes will be found on the rear side of the diaphragm mounting frame, and two holes must be drilled in the chassis to correspond with two of these. The 8-BA screws are then inserted from the top of the chassis and screwed into the speaker.



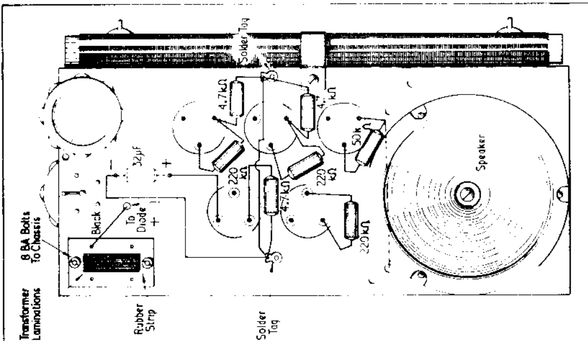
FIRST WIRING STAGE (underside of Chassis)

FIG. 7



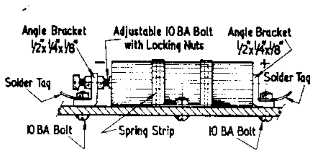
SECOND WIRING STAGE (underside of Chassis)

FIG. 8



THIRD WIRING STAGE (underside of Chassis)

FIG. 9



BATTERY MOUNTING

FIG. 10

G 431

Extension Insert

In Fig. 4 readers will notice a small block on the edge of the chassis, close to the speaker. This is a miniature two-pin socket, which enables a deaf-aid type insert to be employed if so desired. A switch to cut out the internal speaker can be fitted, but this has not been shown in any of the diagrams. The deaf-aid insert should have an impedance of 1,000Ω at 1,000 c/s, or thereabouts, to give optimum results. A suitable type is manufactured by Ardente and Fortiphone, and is obtainable from advertisers in this magazine.

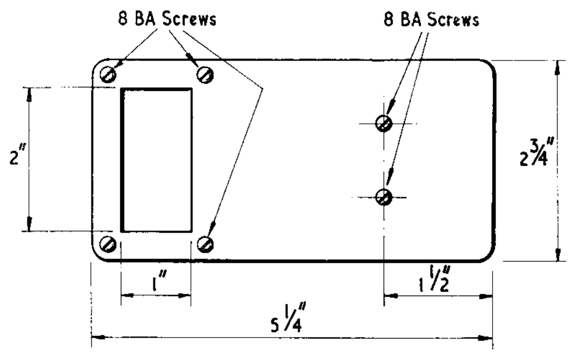
It may also be noticed that the speaker shown in the photographs differs slightly in appearance to that specified in the component list. The one illustrated and used in the prototype is now in short supply, but that specified has been tried out and gave an equally good performance.

Wiring

Wiring has been divided into three stages, so that the "fiddling" process of wiring may be made a little easier to do and so that the point-to-point wiring diagrams Figs. 7, 8 and 9 may be clearer to follow. The connecting wire employed should be as thin as practicable, around 34 s.w.g., and it should be covered with thin sleeving. It is strongly recommended that the transistors should not be inserted until the final stage of construction.

The Battery

Three Mallory mercury type hearing-aid cells are used in this receiver. These cells are not cheap; but they have the advantage of long life and small physical dimensions, so making them ideal for a receiver of this type. As with all transistor equipment, it is once again stressed that if the battery is connected with reversed polarity, the transistors may be ruined. This point is of particular importance in the case of the Mallory cell, as the positive connection is the reverse of that encountered



PAXOLIN SHEET FOR FACIA

FIG. 11

G 432

in an ordinary cell, and is, in fact, the outer casing, whilst the negative connection is the small, slightly raised button on one end.

The method of mounting is shown in Fig. 10. The three cells are placed end to end, thus making 4.5V, inside a container of insulating material. A piece of thin celluloid formed into a tube by folding around the cells, and with the joint fastened by means of Cellotape, will do quite nicely. A length of thick brass strip may be used instead of the iron angle shown in Fig. 10, if preferred.

Completing the Plastic Box

Finally comes the last stage of preparing the cabinet. Two slots will be required in one end, in order to allow the volume and tuning control knobs to protrude. These slots should be carefully drilled and filed to shape, fitting the chassis into the case at intervals to ascertain that the slots are in the correct position and are being made with sufficient, but not too much, clearance.

Fig. 11 shows the second piece of Paxolin cut to form a facia for the box. The length of this should be slightly less than the length of the box, all the edges being chamfered to give a neat finish. The holes seen in the diagram are for fixing the facia to the bottom of the plastic case. However, before doing this a few holes must be drilled in the base of the box (opposite the speaker) and these holes covered with thin speaker fabric; a piece about ¼in larger all round than the aperture in the Paxolin sheet should be used.

The suggestion is put forward that the transparent parts of the box be painted, partly as a precaution against light entering a transistor through a scratch in its light-resistant covering, and partly to improve the final appearance.

If any damage to transistor paint work is noticed it should, of course, be repainted (this is not necessary with metal cased transistors).

One final point—remember that this receiver is, in effect, a crystal receiver followed by an audio amplifier. The performance will, therefore, depend upon the quality of the r.f. section—hence it is necessary to ensure that the crystal diode is a good component—and equally as important, on there being adequate field strength in the location where the receiver is in use. This latter point is beyond the control of the user, and in low field strength areas it may be necessary to use an aerial. The reader is referred, in this connection, to the Field Report on the "Eavesdropper" printed in last month's issue, where information on connecting an external aerial was given. The r.f. stages of both the "Mini-Max" and the "Eavesdropper" are practically identical, and the aerial information applies equally well to both receivers.

THE "ISOTRON" Self-powered Amplifier *—continued from p. 610*

material and the pole-pieces via high values of resistance.

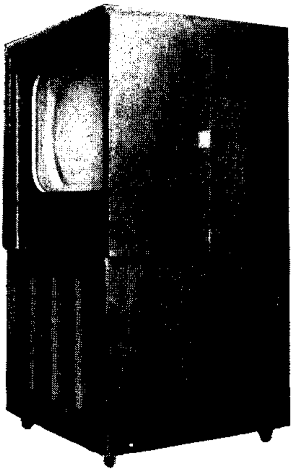
The positive alpha particles travelling towards the base of the envelope arrive at what is called the "high potential plate," thereby causing a positive charge to appear on this electrode. This charge, which is positive with respect to the propagator, is used to power the remaining part of the device. As a result, a continual current flows from the high potential plate, this preventing the formation of a large remanent charge. If current is not allowed to flow from the high potential plate, it takes up an excessive positive charge, thereby repelling further alpha particles. When this condition occurs, the Isotron is described as being "blocked."

The beta particles which are deflected up the cylinder of the Isotron pass through two focusing systems. The first of these consists of an extension of the magnetic polepiece assembly, and provides partial focusing only. Final focusing is given by an electrode similar to that employed in a conventional cathode ray tube.

After focusing, the beta particles pass through the control grid, this consisting of a very small aperture across which is stretched a mesh, the strands of which have a thickness of 0.003in only. Great care has to be taken at this point to prevent secondary emission, and the strands of the grid mesh are in consequence plated with a very thin surface of gold. After passing through the grid, the beta particles strike the first multiplying anode. On striking this anode, secondary emission takes place; the secondary electrons travelling to a further anode in exactly the same manner as occurs in the conventional electron multiplier considered earlier in this article. An impedance is connected in series with the final anode, whereupon an output voltage consisting of an amplified version of the voltage impressed on the grid may be obtained therefrom.

It will be noted that the device operates at a relatively high potential; this having a value of approximately 2kV. The "stabilising condenser" shown in Fig. 2 has a capacity of 4μF at a working voltage of 3kV and maintains a low return impedance from the load to the propagator. Condensers suitable for this application will be available from the manufacturers of the Isotron.

continued on page 635



A CONSOLE TELEVISION CABINET

for the

Home Constructor

by **H. G. BAILEY**

CABINET-MAKING IS QUITE RIGHTLY CONSIDERED a craftsman's job, and even the mass-produced article today is often a thing of beauty, etc. But many home t.v. constructors can use woodworking tools with some skill, and for them it is possible to make a very presentable cabinet with the help of modern materials and only simple tools; though much of the work is facilitated, and made more interesting, by the elimination of most of the hard labour if they possess one of the small electric drills having as accessories a small circular saw and sanding discs.

The photograph shows a console cabinet housing a televisor based on the Premier Wide Angle kit using a 16in metal cone tube, but it would also serve for any similar outfit up to a 17in tube. The construction is based on the use of plain unveneered ½in Weyroc board, plus ⅞in deal flooring, which is also readily available; but the real secret lies in the use of Aga veneer. This is a very thin real wood veneer attached to a tough paper backing, and it will be seen that it is simple to use. It is obtainable in a variety of woods; in the present case a mahogany finish was used, but if desired contrasting woods can be used with very little extra difficulty. The method of applying the veneer will be described later.

The Carcase

Fig. 1 gives a perspective view of the main carcase, without the front panel or the back, whilst for clarity the top is shown detached. Each of the two sides is one piece of ½in Weyroc. Local timber yards vary in their methods, but it should be possible to obtain the two pieces sawn accurately to size, 21in by 37½in, at the same time asking for another piece 19in by 20in for the front panel; if you have any doubt about their accuracy, ask for ½in oversize each way, leaving the surplus to be cleaned off at home. You may be required to buy the whole boards from which they are cut; these may be two of 4ft by 4ft, or one of 8ft by 4ft, but the yard can generally be persuaded to keep the larger spare piece. The remainder will be found surprisingly useful later at home.

Having the two side pieces to size, the 1¼in strip is first sawn out of the upper front edge of each, see Figs. 1 and 2; then cramp the two pieces together, taking care that the smoothest sides are put face to face, and clean up and square off the saw cuts and all edges with the sander, first using a touch with a plane if necessary, Whilst still cramped, mark off the positions of the cross pieces marked A and B, and the rails E, in Fig. 1. A and B are 4in

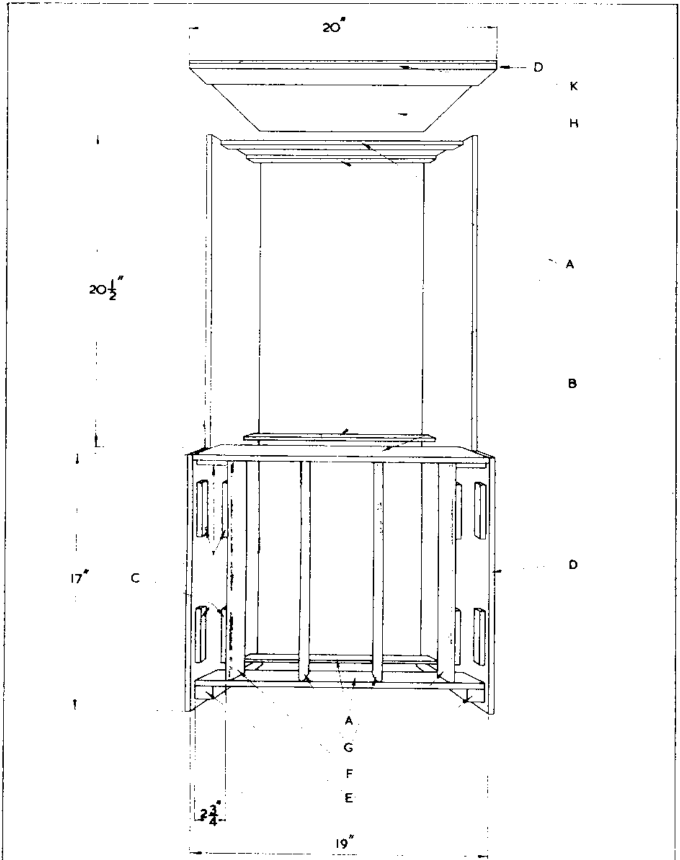


FIG. I.

The main carcase, with top detached for clarity.

M412

wide ¾in flooring, whilst E is 2in by 1½in deal. Note that all crosspieces at the rear are set in ½in from the back, to allow of the hardboard back being recessed in; B at the middle front is fitted flush at the angle where the width of the side reduces, whilst A at bottom front and the rails E are set in by ¼in. Now drill through both boards for the fixing screws with a 5/32in drill. Next uncramp and countersink all holes *on the unmarked faces*, going deeper than the screws need so that there will be room later for filling.

The cross pieces A and B are now cut off and cleaned up exactly to the same length, and the rails E likewise. These being ready, cramp the rails E each in turn to its main side piece, and fix with 2in 8's c.s. woodscrews; uncramp and prop one side piece against bench or table, and cramp in place the two bottom cross pieces A and fix with similar screws. Bring the second main side piece up into place and cramp to the free ends of the cross pieces, and fix as before with 2in 8's c.s. screws.

The work will now be self-supporting if treated carefully, and the remaining pieces A and B are fixed; it will be as well to drill pilot holes 1/16in diam. in the ends of these, and added rigidity will result if the joints are painted with resin glue. Check the carcase for squareness; it is unlikely that it will be "out," but if it is, temporarily nail diagonal struts to top and bottom cross pieces, pulling square as you do so, and leave until the glue has set. For the cabinet top, H in Fig. 1, cut a piece of ¼in plywood, pin and glue in place, and trim flush with the sides; but note that the front overhangs by 1¼in. To this overhang, pin and glue a strip of 1¼in by ¾in deal. Now the vertical angles marked D in Fig. 1 are rounded off on each side of the carcase; the rails E are drilled fore and aft on the underside to take sockets for 2in wheel castors (not illustrated). Cut strips G in Fig. 1 of 1¼in by ¾in deal, round off their front edges, and fix each with two 1½in 6's c.s. wood screws top and bottom, and glue; cut two similar strips for those marked F, but in this case round off only the inside corner, and screw and glue in place.

Pin and glue in place the ½in square glue blocks marked C, noting that they are set back ¼in from the front. Fit a strip of ¼in plywood and pin and glue, to cover the front edge of the bottom front cross piece A and the ends of E, so as to fill in the whole space below the speaker aperture. Then strips of similar material are fitted on to the glue blocks C so as to fill in at each side of the aperture; these and the bottom piece should present faces flush with A, F, and the main sides.

Finally, all surfaces over the whole of the outside of the carcase are to be made as smooth, even and true as possible; this work should not be skimped, for the better the surface now, the better the final result will be. The method is, to fill all screw countersinks with Brummer stopping, leaving it very slightly rounded up—not because it shrinks, it does not, but to be sure that the final surface is flat—then to rub a stiff creamy paste of the stopping into all crevices, joints, and other inequalities; and when the stopping is really hard, sand all over every bit of surface. Whilst the sanding disc is safe on flat places, beware of making edges untrue or bevelled; a sanding block may be best here, or there is a new little Opex smoothing block which is very good; it has a non-clogging cutting surface of fine-toothed metal strips.

The Doors

Doors may not always be required, but they serve to keep dust out during non-viewing hours. As shown here, the doors are made to open flat back against the sides of the cabinet, and they are put together as in Fig. 3. The main panel is again of Weyroc, and a strip of ¾in by ½in deal is attached along one edge with ⅜in by 4's c.s. wood screws; the other edge of the strip is rounded off; in each end at the centre of the curve is driven a short length of brass tube, taken from a Yaxley switch spacer, in which the hinge pin will work. A hole is, of course, drilled for it. The height of the door panel is ⅛in less than the opening which it is to fill, to allow for the hinges to be fitted, and the measurement should be taken from the carcase. The door width is best cut a bit full to allow for final fitting. Hinges are made as shown in Fig. 4. Taking one door at a time, hinge pins are placed in the tubes top and bottom and the door put in place; the fit should be such that slight pressure is required, the brass strips gently jamming between door and carcase; square the door in position, and carefully open so that one screw hole can be pricked through and a ⅜in by 6 c.s. screw put in. Then open further and put in the second screw. When both doors are in, try the closing fit and trim as necessary. In the prototype, for domestic reasons the doors are made to lock, but generally a small ball catch will be enough at top and bottom of each. Remove the doors now for filling and sanding smooth.

Front Panel and Back Cover

Shown in Fig. 5 as made to suit the televisor already mentioned, the front panel may, of course, be cut out to suit individual needs. It, too, is of ½in Weyroc, and the viewing aperture is easily cut out with a pad-saw, and the edge smoothed with chisel and glass paper. There is a further cut-out at the bottom for access to front pre-set controls. This is covered by a small ¼in plywood panel

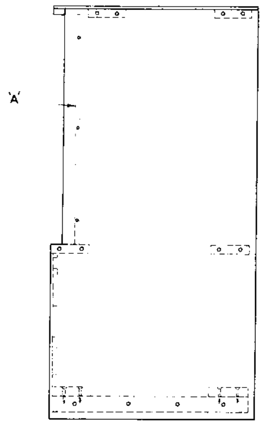


FIG. 2.
Side elevation of carcase
showing positions of cross pieces etc.
'A' is front panel, see text.

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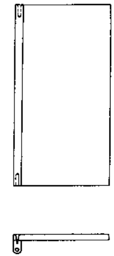


FIG. 3.
One of the doors.

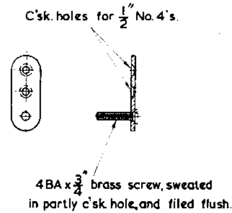


FIG. 4.
Door Hinge. 4 required.

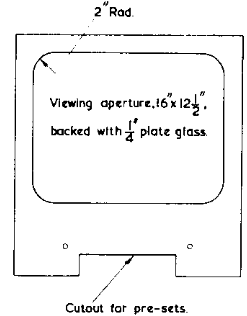


FIG. 5

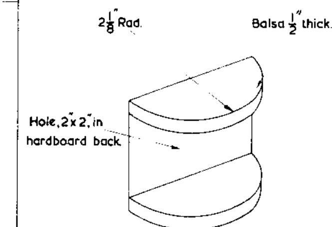


FIG. 6.
Cover for C.R.T. socket. Card sheet to be pinned and glued around balsa.

with bevelled edges, which overlaps the opening by 3/16in at top and sides. The bottom rests on cross piece B, Fig. 1; attached to the back of the ply is a piece of thick wood cut to a loose fit in the opening, with felt or baize stuck round the edges to make it a push fit. A small knob is attached to the front.

Behind the viewing aperture is ¼in plate glass fixed with mirror clips. The front panel is fixed into the carcase so as to be set back enough to clear the control knobs when the doors are closed. This is indicated in Fig. 2, from which it will also be seen that the top stops ½in short of the cabinet top; this gap is not seen and gives excellent ventilation. The back cover of hardboard should also be drilled with brace and bit to give a dozen or so holes for further ventilation.

The c.r.t. is likely to protrude beyond the back, and Fig. 6 shows a simply made cover to protect the case. A square hole is cut out of the hardboard, and along opposite sides of the hole are fitted semicircular cheeks of ½in balsa; these are easily cut with a sharp knife or a razor blade, and glued in place, and a strip of stout card is pinned and glued around them. The cover may be painted flat black.

Veneering

Go over the whole cabinet again to make sure it is as smooth as possible. The whole of it is first to be covered with ordinary lining wallpaper; this serves a double purpose, for it will give some practice in cutting and fitting and also gives the final surface to which the Aga veneer is applied. Use a cellulose paste, and take care that no dust or dirt is mixed with it, and that a smooth paste is obtained. A single width of the paper will cover each side; cut a length ½in oversize, lay flat on a table (on newspaper!) and paste liberally; apply carefully to the cabinet and smooth it out with a soft cloth. Allow to dry throughly, and then trim exactly to match with a razor blade. Next similarly apply a piece to the cabinet top. Then another piece to the front panel, cutting the viewing aperture and the pre-set control space out when dry. Now, two pieces to cover the spaces at the sides of the speaker opening from top to bottom; then the horizontal surface at the bottom of the front panel. Then fill in the extreme bottom front below the speaker and the narrow strip immediately above; then the front panel and the spaces before it; finally smooth suitable strips around the vertical bars in the speaker opening. Lastly, the doors are dealt with, The vertical side edges by the front panel in the prototype were finished in dull cream paint, as were the inner edge of the viewing aperture and the door edges; it should be applied at this stage of the proceedings because any slight straying of colour will be covered by the veneer.

Leave the whole job overnight to dry and harden. Next day, careful inspection may show very slight and small protuberances here and there possibly due to dust in the paste brush. They can be removed by *very light* hand sanding with dead smooth glasspaper.

The Aga veneer is obtainable in at least two widths, and both "off the roll", and the 27½in wide is suitable; the surface is already semi-polished. It is best cut with straight-edge and razor blade, and is fitted just in the same way as the lining paper, taking care to keep paste off the outer surface. It will pay to work slowly, and to be very sure of sizes so that meeting edges leave no gap or overlap. Scrap pieces are used to cover the pre-set control panel.

Again leave overnight; next day the result should be surprisingly attractive, and the final finish may be considered. For those who feel capable, one of the amateur french polishes is ideal, used exactly as instructed for the make used. Otherwise, a waxed finish may be preferred and a high quality neutral coloured floor or furniture polish is suitable. The first application should be liberal and left a day to dry off; after this a light coat is well rubbed in. Later, weekly polishing will, in due course, give a fine finish. The last job is to fix whatever material is preferred to fill the speaker aperture, and to fix the doors. The pride of achievement, not to mention the cash saved, will be a continual reward.

TRADE REVIEW

We have received for review samples of new items now being manufactured and distributed by R.C.S. Products (Radio) Ltd. of 11 Oliver Road, London, E.17.

A miniature solid dielectric tuning condenser measuring only 1⅜in square with an overall depth from back of panel of ⅝in should prove very useful in the construction of miniature transistor receivers. The sample submitted was checked on a bridge and found to have a minimum capacity of 20pF and a maximum of 400pF. Solidly constructed, it is also fitted with an insulated anchoring tag which adds to its usefulness. It is very reasonably priced at 4s. 6d. retail (post. 3d.).

The second item was a miniature transistor interstage transformer, with a ratio of 5 : 1. This also appears to be of sound construction. The overall size, including solder terminals, is a ¾in cube. The retail price is 7s. 6d. (post 6d.)

RIGHT—*From the Start*

PART 14

RESISTANCE

by **A. P. BLACKBURN**

THE MEASUREMENT OF VOLTAGE AND current (a.c. and d.c.) was briefly discussed in the last article. Four basic quantities were mentioned: the two already dealt with, resistance, and frequency.

Resistance measurement is carried out in a number of ways, depending upon the circumstances and, to some extent, the value to be measured. The range of resistance commonly met in radio work is from 0.1 ohm to 10M Ω. Higher values than this generally come into the category of "insulation resistance." Insulation is, of course, a very high resistance, perhaps some hundreds or thousands of megohms. A poor insulator has a relatively low resistance, therefore, and a good one a high resistance.

The necessity for measuring resistance often arises. Colour coded resistors sometimes are wrongly coded, or their value has changed through being overrun; in fact, any number of accidents can occur to such a component. Sometimes, also, it is required to actually wind a resistor for an experiment, and some means of measurement is very useful.

Direct Methods

Probably the simplest method for measuring a resistance is by a simple application of Ohms' law. Fig. 1 shows the circuit. R_x is the unknown resistance, and it is connected to a battery via an ammeter. The voltmeter V_m reads the voltage across the resistor. As we know the current and the voltage,

$$R_x = \frac{V_m}{I} \quad \ldots\ldots\ldots\ldots (1)$$

Despite its simplicity, this method is seldom used. Firstly, it means doing a sum every time a resistance is measured. For example, if the ammeter resistance were 1 Ω and the voltage measured were 2 volts, and the current 0.5 amp, from (1)

$$R_x = \frac{2}{0.5} = 4\Omega$$

The objection to doing this sum can be fairly easily overcome. The voltmeter is left out of circuit and the ammeter left in. If we know the resistance of the ammeter and the battery voltage, the ammeter may be directly calibrated in ohms. The circuit now becomes that of Fig. 2. R_x becomes

$$R_x = \frac{V - IR_m}{I} \quad \ldots\ldots\ldots (2)$$

As the scale of the ammeter is now calibrated in ohms, it is not necessary to use (2) except when first carrying out the calibration. The snag with this system is that if the battery runs down a little, the calibration will no longer be accurate.

The next step is as shown in Fig. 3. The addition of R_s enables us to overcome the battery problem. If the test prods are connected together, before taking the measurement, and R_s adjusted for full-scale reading, we are assured of always having the same voltage across the test prods each time we use the instrument. Now, disconnecting the test prods from one another and connecting them to the unknown resistance will produce a reading on the meter which, once again, may be directly marked off in ohms.

This system is used in some commercially obtainable multi-range meters incorporating resistance measuring facilities. Its accuracy is limited by the non-linearity of the scale. A typical graph showing meter deflection against resistance for a typical meter is depicted in Fig. 4.

Comparison Methods

There are many variants on the basic principle of direct measurement mentioned above. Many have been dealt with in detail in this and other journals.

A more accurate but less simple system is measurement by comparison. Here the unknown resistance is compared with one of known value. The circuit normally employed for doing this is called the "bridge." Bridge methods in all branches of electricity are very important, but they are indispensible in making measurements.

A simple resistance bridge is shown in Fig. 5. The meter is preferably a centre-zero instrument, as will be seen later. The bridge is said to be in balance when no current is flowing in the meter. This will obviously occur when the voltages at points B and C are the same. Now this condition is achieved when

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \ldots\ldots\ldots\ldots (3)$$

i.e., the *ratios* of the resistors on either side of the bridge are equal. If three of these

may have been higher than at point C before R_3 was adjusted. When balance is achieved, these voltage will be the same, but if R_3 is further rotated the voltage at point B will become lower than C; the current will have reversed direction therefore. This is why a centre-zero meter is required, so that it can register current in the other direction.

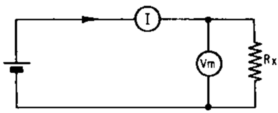


Fig.1

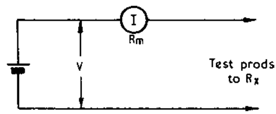


Fig.2

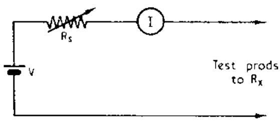


Fig.3

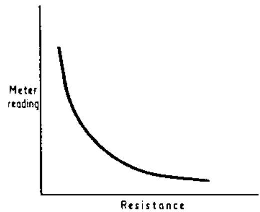


Fig.4

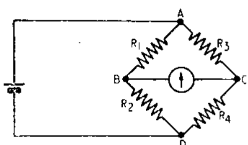


Fig.5

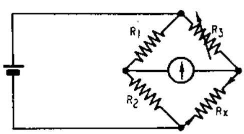


Fig.6

E440

resistors are known, the fourth may easily be found from (3). Let us assume that we know R_1, R_2 and R_3, then,

$$R_4 = \frac{R_3 R_2}{R_1}$$

The next step is to make the bridge direct reading. One way of doing this is to make R_3, say, variable and to calibrate it. Fig. 5 then becomes like Fig. 6.

When R_x is connected, there will be a deflection on the meter if the bridge is not in balance. Variation of R_3 should change this deflection until zero is reached, then the value of R_x may be read off the scale under the control knob of R_3. The voltage at point B

The important thing about bridges is that the accuracy is dependent only upon the standard resistors R_1, R_2 and R_3. The calibration of the meter does not matter at all, but the more sensitive it is the greater the accuracy of the balance obtained.

Extending the Range

With the simple bridge shown, only a limited range of resistance is measurable with any accuracy. For example, if R_1 and R_2 were equal, the range of R_x that can be measured would be the same as the range of R_3. If R_3 were a simple variable resistance of range 1Ω to $10k\Omega$, the range of R_x that could be measured would be 1Ω to $10k\Omega$ also.

If we now changed R_1 and R_2 so that the ratio of R_2 to R_1 were two to one, the range of R_x would now be 2Ω to $20k\Omega$ if the same R_3 resistor were used.

Resistor R_2 may be variable also, then, to change the range over which R_3 will operate. A complete bridge is shown in Fig. 7. The range of measurement is 1Ω to $1M\Omega$. The accuracy depends upon the accuracy and stability of the standard resistors used.

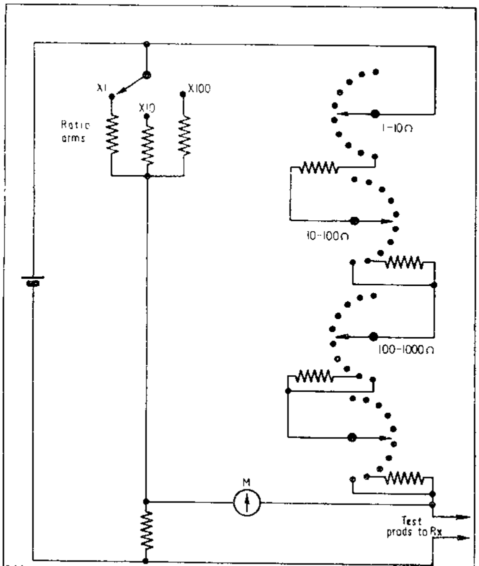


Fig. 7

A.C. Bridges

There is a vast range of a.c. bridges, but we will concern ourselves here with only the simpler types.

Just as a purely resistive d.c. bridge (Fig. 7) measures, so a bridge may be constructed to measure inductance, mutual inductance, capacitance and even frequency.

All we have to do is reconsider the basic bridge of Fig. 5 as having reactive arms instead of resistive. Fig. 8, for example, shows a simple capacity bridge. Now this bridge measures the *reactance* of the capacity, so the frequency must be known, because

capacitive reactance $X_c = \frac{1}{2\pi fC}$ where

f is frequency
C is capacity

Note that the battery of Fig. 5 has been replaced by an a.c. source; a transformer operating at 50c/s from the mains, for example.

As before, $\frac{R_1}{R_2} = \frac{X_s}{X_x}$

but $X_s = \frac{1}{2\pi fC_s}$ and $X_x = \frac{1}{2\pi fC_x}$

$\therefore \frac{R_1}{R_2} = \frac{C_2}{C_1}$

Once again, the standard C_s may be made variable and calibrated direct in capacity. It is fairly common to use headphones in place of a meter in this type of bridge. Firstly, because an ordinary moving coil meter will not respond to a.c. and, secondly, because headphones are very sensitive. When using headphones it is necessary to listen for a "null," that is, a point of no noise. This is the indication of bridge balance.

The resistors R_1 and R_2 may be used for range multiplication just as with the resistance bridges. Sometimes, a variable resistor is included in the standard capacity "arm" of the bridge, in order to balance out any losses in the unknown capacitor. A sharper balance may be obtained by this means.

Inductance may also be measured by a similar method. One arm of the bridge is made a standard inductance in place of C_s in Fig. 8, say. The bridge is then used just as for capacity measurement. The inclusion of a variable resistor in the standard arm to balance the resistance of the inductance under measurement is very important in this case, as inductances are normally more lossy than capacitors.

Substitution

A method of resistance measurement not often used because of its limited accuracy, but of use where limited equipment is available, is that of substitution. It is rather similar to the direct method, but the indicating instrument is uncalibrated.

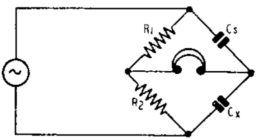


Fig. 8

E442

A battery is connected in series with a meter and the unknown resistor. A low value of variable resistor is connected in parallel with the meter. The shunt resistor is adjusted for an arbitrary reading on the meter. The unknown resistor is now replaced by known values until one is found which produces the same deflection as before. Obviously, this is only an indication, unless a very large number of known resistors is available.

Frequency

The measurement of frequency can only be briefly mentioned here. There are a great number of methods, just as there are for almost anything in this art. Calibrated tuned circuits controlling oscillators, or even just absorbing power from the oscillator under test form the basis for the majority of systems.

An ordinary radio receiver which is fairly accurately calibrated in frequency is quite useful. All that is necessary is to tune in to the unknown signal, whether it be an experimental oscillator or radio signal, and read off the frequency on the dial of the receiver.

Many of the techniques for obtaining a wide range of accurately controlled frequencies are outside the scope of this article, and will have to be left, therefore, until another time.

Can Anyone Help?

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

E. Adams, 69 Staunton Street, Landport, Portsmouth, Hants, wonders if any reader can help with data on the ex-A.M. Oscillator Test Set type 210, ref. no. 10S/16002.

* * *

F. N. Howard (ex-G3DEX), 49 Elm Road, Evesham, Worcs, would like to hear from any reader who can give information on the circuit of a transistor QRP rig for the 160m band for CW and fone.

* * *

N. F. Whale, 51 Lawson Road, Colwyn Bay, N. Wales, wishes to borrow, hire, or buy the construction book for the Premier electrostatic t.v. receiver using a VCR97 tube.

* * *

D. A. Hobbs, 49 Wycombe Road, Hall Green, Birmingham 28, wishes to obtain the October and November 1953 issues of this magazine. Can anyone help?

* * *

F. C. Pratt, Beaumaris, Chowdean, Durham Road South, Gateshead 9, wishes to borrow or buy the service sheets for the H.M.V. Radiomobile receiver, model 100A.

D. Evans, 113 Lulworth Road, Birmingham 28, asks if anyone can lend or sell to him a copy of the second article on the "Mains Operated Bridge" from the June 1952 issue of this magazine.

* * *

H. G. Weston, 16 Pitfold Road, Lee, London, S.E.12, would like to contact anyone who has successfully "married" the Collaro tape deck with the Mullard "A" type amplifier, using the Collaro deck switches for Record/Playback switching.

* * *

M. W. Humphrey, The Old Palace, Brenchley, Kent, has a rectifier approx. 2¼in long, including terminals, and 5/16in diameter, marked H1 and APW.4061, believed to be ex-Naval. Can anyone give any information on this?

* * *

Thomas Fay, EI16K, Site 137, Marian Park Estate, Artane, Dublin, Ireland, wishes to hire or purchase the circuit or manual for the Signal Generator model 110, made by the Clough-Brengle Co. of Chicago. All letters answered.

DESIGN CHARTS FOR CONSTRUCTORS

No. 13 SIMPLE R-C TONE CONTROL AND FILTER CHART

by **HUGH GUY**

SIMPLE TONE CONTROL MAY BE EFFECTED BY the two circuits shown in this month's design chart, circuit A producing treble cut and the other bass cut. Ideally, the response of an audio frequency amplifier is "flat" at all useful frequencies, but due to unavoidable restrictions imposed on the design, this uniformity of response is limited to a very narrow band of frequencies in the simple amplifier, the response to extremes of frequency being much less than to this band, resulting in a humped frequency characteristic. The effect of such a characteristic is well-known, and is the cause of the rather thin and unreal output obtained from amplifiers devoid of any form of frequency correction or tone control circuit.

The same circuit arrangements as those depicted are sometimes known as filters, the response of curve A being due to what is termed a low pass filter and that of B to a high pass filter. The derivation of the names is obvious when the response curves are examined.

It will be noted that the charts are calibrated in decibels, and, as pointed out in a previous issue, the decibel system of measure deals in ratios. In each case this ratio is the amplitude of the signal appearing at the output, e_o, as a fraction of the input signal amplitude e_i. This ratio is generally termed the attenuation, and for the circuit A is given by

$$\frac{e_o}{e_i} = \frac{1}{\sqrt{1 + (\omega CR)^2}}$$

where $\omega = 2\pi f$
and f = frequency of the input signal.

For circuit B, the attenuation is

$$\frac{e_o}{e_i} = \frac{1}{\sqrt{1 + (1/\omega CR)^2}}$$

Uses of the Circuits

Circuit A is used principally for attenuating unwanted high frequency signals, and several instances of such a requirement can be quoted. The first that comes to mind is its application to ripple reduction in simple h.t. smoothing filters. In such an application any frequency higher than zero frequency (i.e., d.c.) is undesirable. Since at the output of a rectifier there is a very large frequency component at the supply frequency or twice this frequency, depending on whether half-wave or full-wave rectification is used, a high degree of attenuation is required at these frequencies.

Once this required attenuation has been specified, the components necessary to achieve it are speedily determined with the aid of the chart, and a design example will be cited later in the text covering such a use.

This same circuit is also widely used to suppress the inter-station whistle experienced on the Medium waveband of the average radio set.

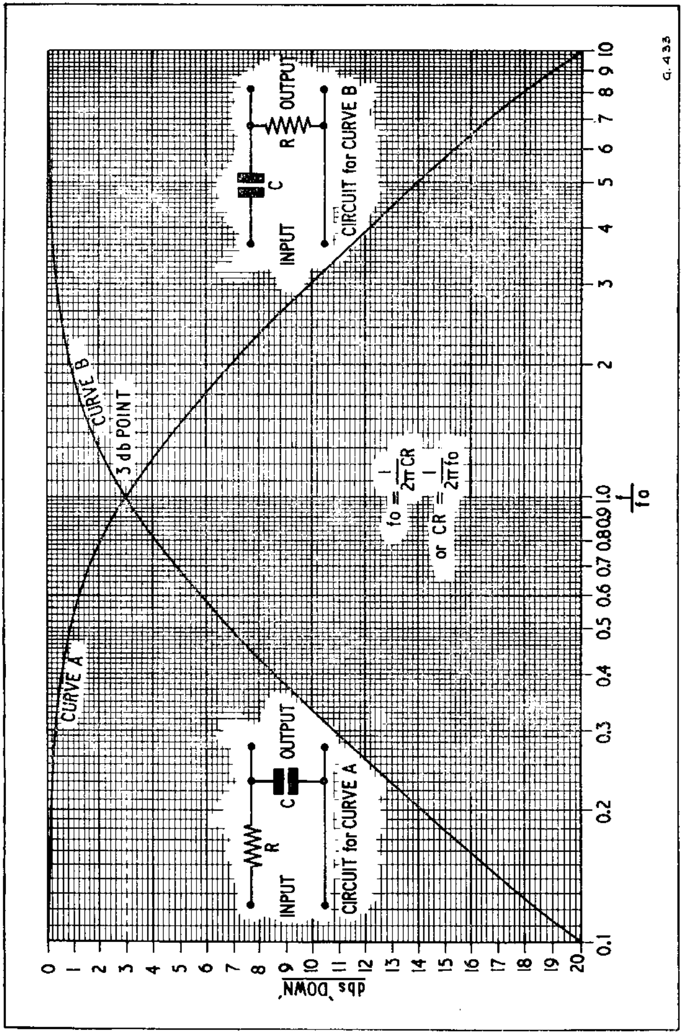
Circuit B is merely a straightforward R-C inter-coupling circuit. Occasionally such circuits are used to attenuate unwanted hum pick-up in the circuit in which they are connected. Examples of this use are found in baby alarms, office inter-communication sets, and amplifiers designed specifically for speech frequencies. Here again a design example is given to enable the reader to follow the workings of the chart more clearly.

The 3dbV Point

In either of the two circuits shown, when the frequency is at such a value as to make the product ωCR equal to 1, then the output will be 3dbV down on the input level. Below this frequency the ratio of output to input has been changing only gradually, while above this frequency the output changes at a nearly constant rate. This transitional frequency f_o, when ωCR is 1, gives rise to the widely used reference response, the 3dbV point. The performance of amplifiers is often specified in terms of this limit, at which in these simple circuits, $f_o = \frac{1}{2\pi CR}$ or,

rearranging, $CR = \frac{1}{2\pi f_o}$.

Using the curves, we can determine the performance of either of the filters in terms


CURVE A
CURVE B
3 db POINT
INPUT
R
C
OUTPUT
CIRCUIT for CURVE A
INPUT
C
R
OUTPUT
CIRCUIT for CURVE B
fo = 1/2πCR
or CR = 1/2πfo
f/fo
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 2 3 4 5 6 7 8 9 10
dbs 'DOWN'
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
G.433

of its 3dbV point by reading off the required attenuation in decibels against the ratio f/f_o. A simple preliminary example will easily demonstrate this process, which is applicable to both types of filter.

Preliminary Example

Suppose it was required to attenuate the high frequencies at the anode of a pentode amplifier, the value of whose anode load is 120kΩ, so that the response at 15 kc/s would be 10dbV down on the l.f. response. Then using the appropriate curve (curve A), we see that an attenuation of 10dbV corresponds to the ratio f/f_o of 3. This means that 15 kc/s is 3 times as great as the frequency f_o at the 3dbV point which hence makes f_o equal to 5 kc/s. Now the product of capacity and resistance CR required for this 3dbV point is obtained from $CR = \frac{1}{2\pi f_o}$ and by this means CR must be 31,800 if C is in pF and R is in kΩ.

The value of R is that of the pentode anode load, that is 120kΩ, and therefore, for a product 31,800, capacitor C will be 270pF, and will shunt the anode load to give the desired attenuation.

In a later issue a chart will be given to assist in solving values of C and R from a known value of f_o, determined from the chart in the above manner.

Now let us consider some more specific examples.

Example 1

The circuit A is to be used as a mains filter to attenuate the 50 c/s ripple appearing at the output of a half-wave rectifier. The series resistor must not drop more than 80 volts when the power supply delivers its maximum current of 80mA. What value of capacitor is required to attenuate the ripple by 20dbV?

At 20dbV attenuation f/f_o is 10
f is 50 c/s, thus f_o is 5 c/s.
From $CR = \frac{1}{2\pi f_o}$, C.R. must be 31.8, where C is in μF, and R is in kΩ.

Now the loading requirement of not more than 80 volts drop for 80mA load current makes the value of R 1kΩ as a maximum. In this case the value of C will be 32μF for approximately 20dbV attenuation.

Example 2

How much attenuation is provided by circuit A at 12 kc/s if the response is 6dbV down at 2.5 kc/s?

At 6dbV, f/f_o is 1.73.
f is 2.5 kc/s and thus f_o is 1.45 kc/s.
At 12 kc/s f/f_o will be 8.3, and from the chart the attenuation will be 18.4dbV.

Example 3

Circuit B is to be used as an interstage R-C coupling to minimise 50 c/s hum pick-up which is to be attenuated by 15dbV. What is the l.f. 3dbV point of the stage?

At 15dbV, f/f_o is 0.18.
If f is 50 c/s, f_o, the l.f. 3dbV point, is 278 c/s.
A 470kΩ resistance and 1,200pF condenser would prove suitable component values.

This frequency would be regarded as the lower useful limit to the frequency response of the amplifier.

These examples should cover sufficient ground to enable the reader to attempt successfully a wide variety of design problems of this nature. Used in conjunction with the voltage-decibel conversion chart in the February issue of this journal, practical problems dealing in voltage ratios can be tackled. For instance, in Example 1 the ripple would normally be quoted as a peak-to-peak voltage, and this could be converted to decibels by expressing the ripple as a fraction of the output voltage that the power unit in question delivers.

This month's chart has an attenuation range restricted to 20dbV, since it is rarely economical to use a simple filter of this nature for attenuations greater than this, due to its relatively slow rate of attenuation of approximately 6 decibels per octave.

The "ISOTRON" SELF-POWERED AMPLIFIER—*cont'd. from p. 623*

Technical Queries

The above has been intended to give a simplified version of the operation of this new amplifying device. The writer understands that, although production has not yet commenced, the company which has carried out the development work is now prepared to deal with technical queries concerning applications.

All queries should be sent to:

The Mongolian Electronic Manufacturing Co. Ltd.,
135 North-West Street,
Lower Puderley,
BIRMINGHAM 65.

All envelopes to the company should be marked in the top left-hand corner with the words: APRIL FOOL.

TWO "DIFFERENT" SUPERHETS

by **F. G. RAYER**

For some years the usual superhet circuit has been of a very conventional form, but some departures from this are feasible. Of the two circuits given here, one may be regarded as using the very minimum number of components, without undue sacrifice of efficiency. In this, 10 to 12 resistors and condensers, found in conventional circuits, have been eliminated, thereby simplifying wiring and reducing expense. Despite this, no deterioration in results, compared with the usual type of circuit, can be noticed.

The second circuit uses only those valve types found in t.r.f. or "straight" receivers, and should be particularly useful for the constructor who has built a number of t.r.f. sets, but wishes to try a superhet without purchasing further valves. As both circuits are the result of practical experiment, they may be built with confidence. They may also be adapted to battery valves, or other types to hand.

"Minimum Component" Superhet

The circuit for this is shown in Fig. 1, and may best be compared, stage by stage, with a conventional circuit, so that the elimination of unessential components may be followed.

The frequency changer and i.f. stages employ common screen-grid and cathode circuits, thereby eliminating two resistors and two bypass condensers. So that suitable voltages will be obtained, the resistor values are somewhat lower than those best for valves used alone. In these stages individual decoupling of the a.v.c. circuit was also eliminated, and no undesirable coupling effects or instability resulted from these changes.

The two diodes of the double-diode-triode stage are strapped for detection and a.v.c., thereby eliminating separate load resistors. A filter circuit was not required, and thereby a further resistor and condenser were avoided. The bias resistor and condenser normally used with the 6Q7 were also eliminated, bias being developed across the 7MΩ grid leak. No audible difference could be found between this method and the usual bias circuit, but it is essential to use a high value of grid leak (5 to 10MΩ) so that grid potential will arise.

I.F. transformers are of the usual type, and any aerial and 465 kc/s oscillator coils can be used, P being the padder of the value specified by the coil makers. Dual range coils may be employed, or a coil-pack. The usual 2-gang 500pF condenser, with trimmers, is employed. If individual unit coils are switched in for various bands, separate trimmers for each set of coils are best.

When setting up initially, the 0.3 amp dropper is adjusted for correct heater voltage and the rectifier tap so placed that the output valve anode and screen-grid voltages do not exceed 160V and 135V respectively. If they do, the clip is moved towards the heater's end of the dropper. Excess voltage will only cause distortion, deterioration of the valve, and heating.

It is feasible to use a resistor of 3kΩ to 5kΩ, 5 watts, for smoothing, instead of the choke, but some hum will then arise. The choke is thus best. If a 0.3 amp rectifier such as the 25Z4 is to hand, it may be used instead of the metal rectifier with advantage.

The aerial condenser, of about 500pF, should not be omitted, as it keeps mains voltages out of the aerial. The "earthed" main should preferably be taken to the chassis side of the switch. Here, a double-pole type is best, as with all a.c./d.c. sets. Very good results can be expected from the circuit.

"Straight Valve" Superhet

The circuit is shown in Fig. 2, and employs 6.3V valves, with heaters in parallel, operated from a heater transformer. There is no reason why such valves should not be used in Fig. 1, a 6V6 being employed for output. Similarly, series operation, with a 25Z4 rectifier and 25A6 or 43 output valve, may be used in Fig. 2, these changes not affecting the main part of the circuit.

One half of a 6SL7 is used as the local oscillator, permitting a 6K7 to be brought into service as mixer, with screen-grid injection. Coils, i.f.t.'s, etc., will be of normal type for the bands desired. As no diode is available for a.v.c., manual control of gain in the first stage is used. This

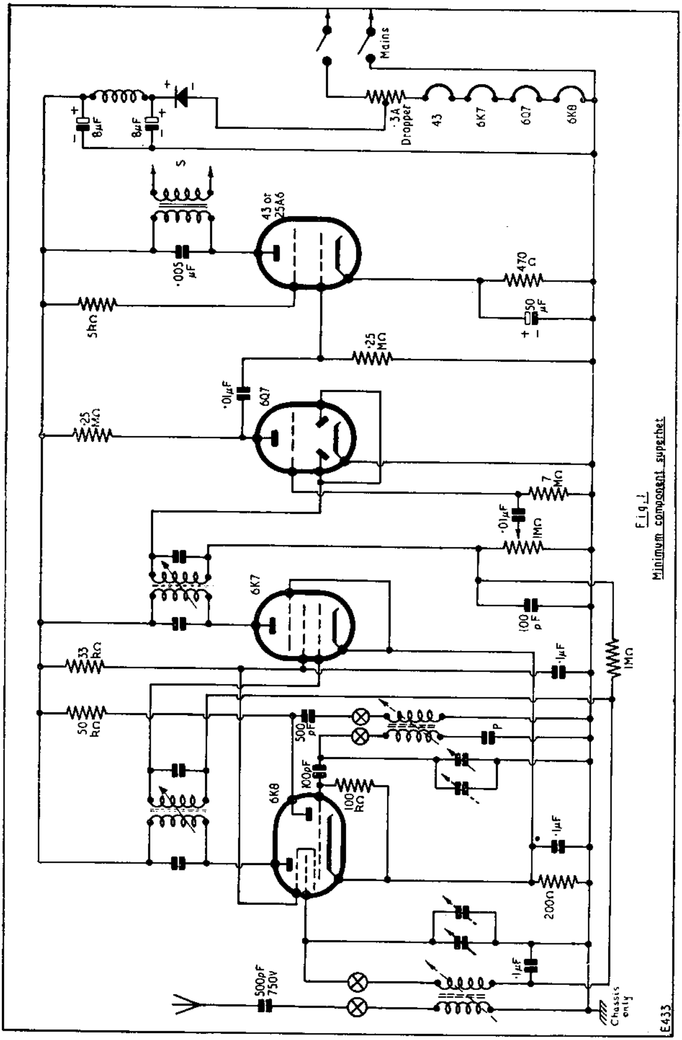


Fig. 1
Minimum component superhet

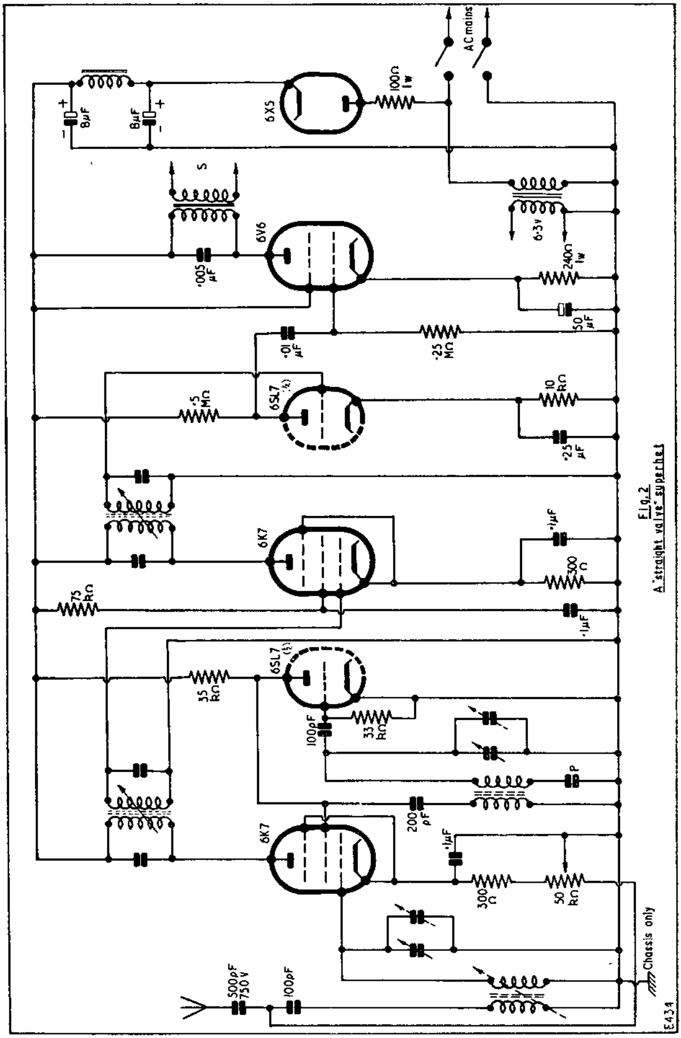


Fig. 2
A "straight valve" superhet

simultaneously increases bias and reduces aerial input, thus giving complete control of even local stations. I.F. and output stages are of usual type. For detection, the second half of the 6SL7 is employed as an anode-bend detector, the bias resistor being chosen to suit this application. This is a sensitive type of detector, and one able to handle quite a powerful signal.

If to hand, separate valves may be used instead of the twin triode. Types such as the 6J5, 6C5 or 6J7 or 6K7 are suitable, the latter types having anode and screen grid wired together, for triode use. If a 6SN7 is to hand it may be employed if the heaters are parallel operated. It cannot replace the 6SL7 with a.c./d.c. operation, however, as its heater is rated at 6.3V, 0.6 amp, compared with the 6.3V, 0.3 amp of the 6SL7.

If a valve is to be purchased for the first position, it is quite in order to use a 6K8, wired as in Fig. 1, or a 6L7, wired as in Fig. 3. The 6L7 still requires the separate triode oscillator, but is specially designed for this purpose, and gives some increase in sensitivity, compared with the 6K7 used as mixer.

Experimenters wishing to use valves to hand may combine the two circuits. For example, a single triode could be used as detector in Fig. 1, a.v.c. being abandoned. To avoid overloading, the manual volume control should then be placed in the first stage. Or a crystal diode may be used in this position, thereby eliminating the valve entirely, especially if only the more powerful stations are wanted. If the set will be used on a.c. mains, parallel operation of heaters is best if a 6.3V output valve is to hand, as a dropper tends to grow very hot. No difficulty need arise with either transformer or dropper operation, if the essential difference is kept in mind. For transformer operation, all the valves should have the same heater *voltage* rating, but the current rating need not be the same. For example, the 6V6 has a 0.45 amp heater, compared with the 0.3 amp heaters of 6K7, 6K8 and 6Q7. With dropper operation and heaters in series, all heaters must have the same *current* rating, the voltage rating being immaterial. The 25A6 or 43 will have a 25V heater.

If a dial lamp is wanted, a 6.3V, 0.3 amp bulb, wired in parallel with the heaters, is satisfactory when a heater transformer is fitted. With the mains-dropper circuit, a 6.3V, 0.5 amp bulb may be wired between output valve and dropper. Or a 6.3V, 0.3 amp bulb can be used, with a parallel resistor of about 30 ohms. (This is required to prevent early filament failure from the surge when switching on.)

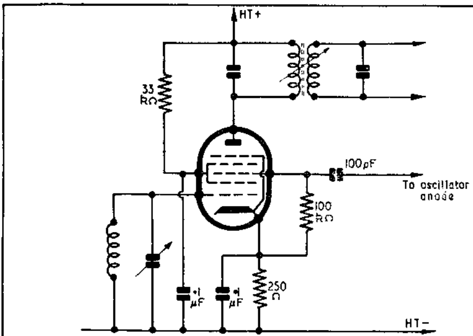


Fig. 3
Circuit for 6L7 mixer

Other Bands

Either circuit is satisfactory for all-wave operation, and pairs of coils for any band may be selected by using a 4-pole switch. The poles would switch aerial, signal grid, oscillator grid, and oscillator anode circuits, at the points marked "X" in Fig. 1. Each switch position would bring in a different aerial and oscillator coil for the bands desired. It must not be overlooked that each oscillator coil will require its own padder of the capacity stated by the maker. Small coils with adjustable dust cores, obtainable from many manufacturers, are particularly convenient.

It is also feasible to use a 3-waveband coil pack, but the connections given by the maker must then be followed. Where such packs employ bottom-end coupling, it is absolutely essential that the maker's circuit be followed. Usually a value as large as 0.1μF will not be found in the a.v.c. circuit, as in Fig. 1, with bottom-end coupling. Here, 0.05μF to 0.0025μF will be more usual, and the value given by the maker must be used, because the

(*continued on page 619*)