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Volume 7
Number 7
FEBRUARY 1954

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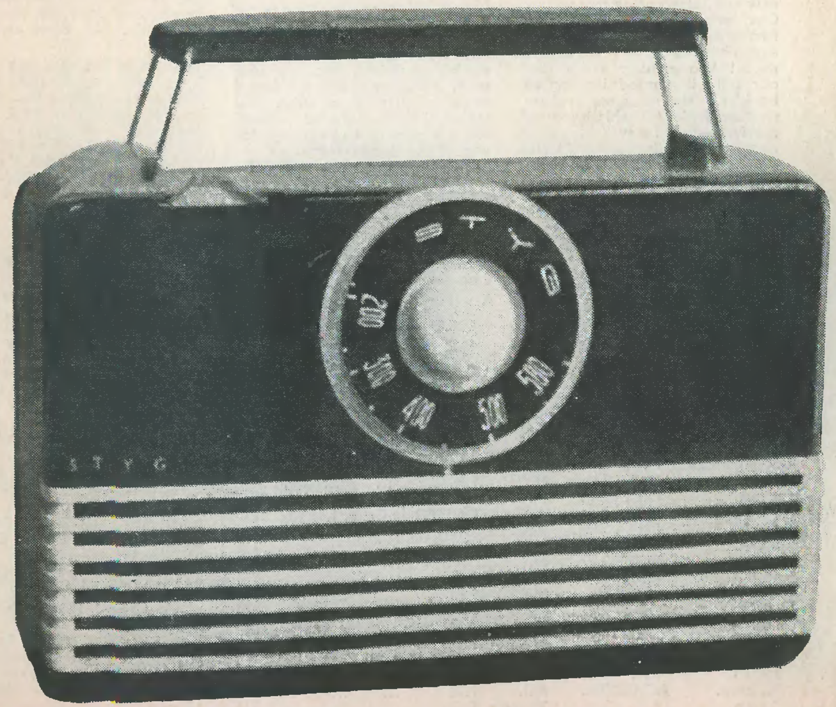

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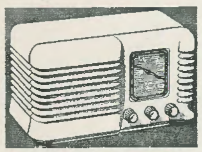

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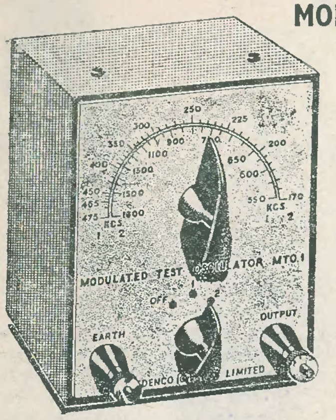

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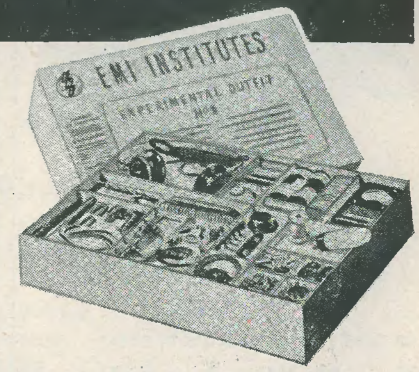

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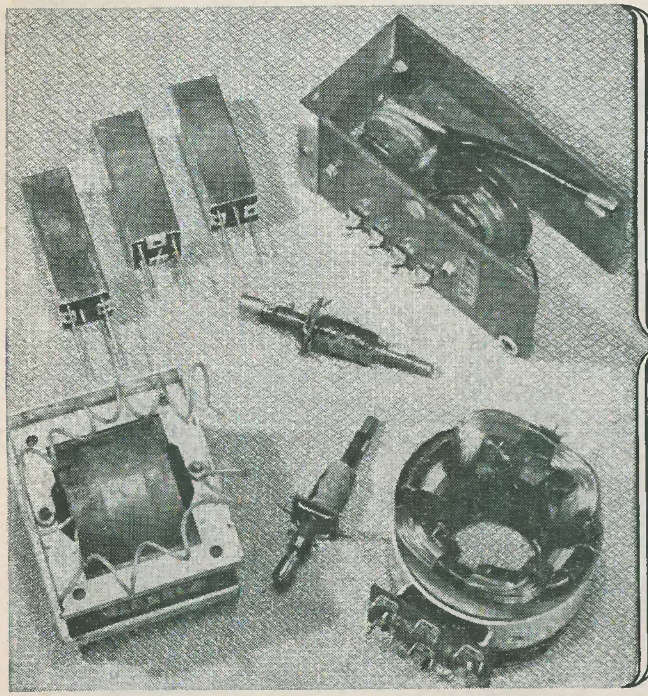

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The

Radio Constructor

INCORPORATING *The Radio Amateur*

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VOL. 7 NO. 7

ANNUAL SUBSCRIPTION 18/-

FEBRUARY 1954

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Editor
C. W. C. OVERLAND, G2ATV

Advertising Manager
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NOTICES

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.

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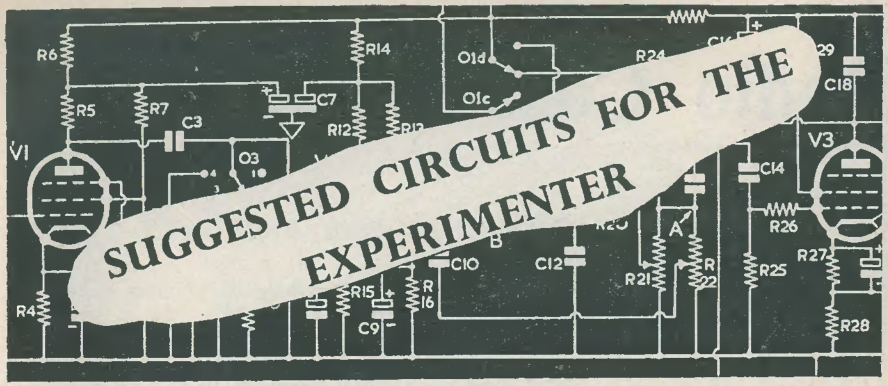


The circuits presented in this series have been designed by G. A. FRENCH specially for the enthusiast who needs only the circuit and essential relevant data.

No. 39: Obtaining AF Gain without Hum

OBTAINING high levels of AF amplification without introducing hum has been a problem which has always given trouble to designers of AF amplifiers. Hum pick-up raises difficulties not only in normal audio amplifiers but also, and perhaps to a higher degree, in more specialised high-fidelity equipment designed for operation over a wide frequency spectrum. In both cases, the eradication of hum necessitates a considerable amount of care in design, particular attention being paid to the layout of chassis earthing points, to the decoupling of supply circuits, and to the dress of connecting leads.

The part of an amplifier most susceptible to extraneous pick-up is obviously the first stage; and it is at this point that the most effective precautions have to be taken to prevent hum. Whilst it is possible to almost completely remove ripple from HT and similar supply lines, and to prevent inductive and electrostatic pick-up by means of suitable screening and one-point chassis connections, the question of unwanted couplings from the heater supply still remains. Indeed, when taken to its ultimate point, the only obstacle in the way of completely hum-free operation lies in the necessity of supplying 50-cycle AC to the heater of the first valve.

Supply at RF

This month's circuit shows an entirely new and, to the best of the writer's knowledge, hitherto unpublished method of feeding the heater of the first valve of an AF amplifier. Owing to recent development work by a manufacturer, this form of supply is now available to the home-constructor. It is capable of removing hum completely for all audio applications.

The circuit of the arrangement used is shown in Fig. 1. In this diagram, V1 is an RF oscillator, the tuned circuit for which is supplied by the winding L1 of the step-down RF transformer and the capacitor C2. The secondary winding, L2, on the transformer is connected to the heater of a second valve, V2. The RF voltage developed across L2 and applied to the heater is identical to the 6.3 volts given by conventional AC circuits. V2 may be the first valve of an amplifier, whereupon it becomes completely free from hum pick-up for the obvious reason that its heater is supplied at a radio frequency.

Practical Considerations

It will be seen that the circuit is extremely simple to build up into practical form and that, apart from the self-demonstrable lack of hum, it has several other considerable advantages.

To begin with, owing to the low impedance at which the RF voltage is taken from the transformer, it is possible to add capacitance to as high a value as 1,000pF across the heater leads without materially affecting the voltage applied to the valve. This allows the heater supply to be carried by any desired type of wiring, including twin screened wire or conventional twisted pair.

Secondly, as the frequency at which the RF transformer oscillates may be made very much higher than the highest audio frequency to be handled by the amplifier, any RF pick-up by the first valve from its heater pins may be neutralised by a simple decoupling circuit, if this is needed at all. As the most probable source of pick-up is liable to be given by the self-capacitance existing between grid and heater pins of the valve itself, this may be ignored in most instances, as sufficient attenuation to RF should exist in the remainder of the amplifier. Alternatively, a simple by-pass circuit consisting of a small RF choke and capacitor may be connected in the anode circuit. It will be remembered that the cathode of the first valve will be automatically decoupled to chassis by means of its bias capacitor.

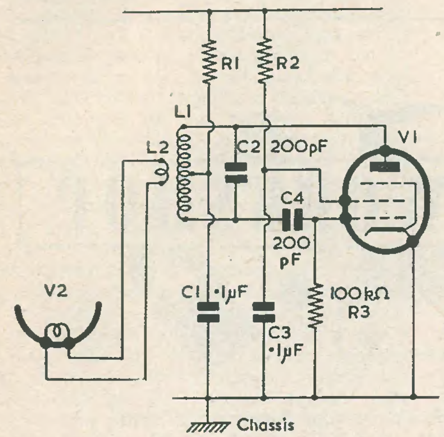


FIG.1.

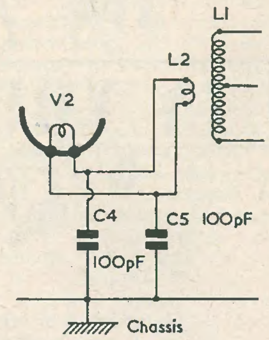


FIG.2.

OBTAINING AF GAIN WITHOUT HUM

RC470

The possibility of RF pick-up in the first stage may be even further reduced by connecting two balancing capacitors across the heater supply, as shown in Fig. 2. If one of these were made a trimmer, the RF could be "balanced out" completely; but it is doubtful if such an arrangement would be needed in most practical applications.

A third advantage is given by the fact that a range of negative bias voltages is immediately made available by tapping into the grid leak, R3, of the oscillator V1. This point has already been dealt with in Suggested Circuits No. 32, published in the August 1953, issue.

Further Points

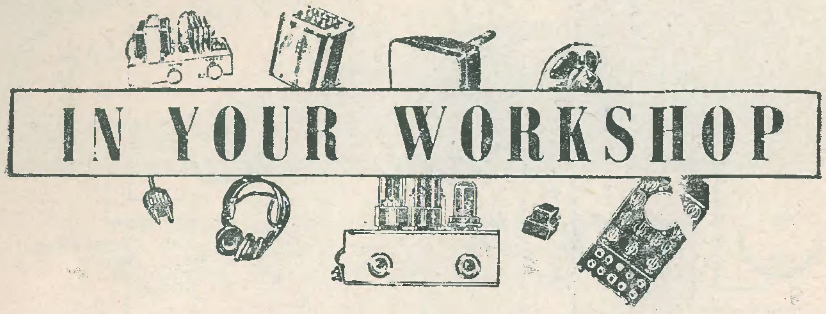
The only disadvantage of the circuit lies in the fact that an extra valve is needed to drive the RF transformer. In normal amplifier design this is by no means a great problem, as the advantages conferred by a hum-free heater supply heavily outweigh the small extra cost involved. As a case in point, it may even be possible, by means of a reflex-type circuit, to have an output valve perform the secondary function of RF oscillator without detracting from its AF performance! Another suggested scheme would consist of having a single valve perform the dual roles of bias and heater generator in a tape recorder.

The design of a coil capable of acting as an RF transformer in this way is not easy, and great care is needed to prevent losses. It is possible, however, to heat a 6.3V 0.3A valve by means of a driver valve taking only 15mA from a 200V HT line. The efficiency of the RF transformer in such a case is quite high.

On the other hand, the choice of the driver valve, itself, presents hardly any difficulty at all. It is best, in an application of this type, to use a valve capable of handling two or three watts and to keep it slightly underrun. A 6V6, for instance, would be an excellent choice, and would have the advantage of requiring a heater current of 0.45A only.

Acknowledgments

As mentioned above, this method of valve heating is now available to the home-constructor. The writer is indebted to Allen Components Ltd., the manufacturers of the RF heater transformer, for permission to publish advance information on their product; and also for allowing him to make suggestions which may enhance its usefulness to the amateur. (The Allen RF transformer best suited to the home-constructor is marketed under the type number RF 507.)



In which J. R. D. discusses Problems and Points of Interest connected with the workshop side of our Hobby based on Letters from Readers and his own experience.

I HAVE RECENTLY BEEN READING a booklet published in the Philips Technical Library which describes two methods of remotely controlling model ships by radio. Although the subject of the booklet may not appeal to a large section of the technical reading public, and although the particular equipments shown are rather beyond the pocket of the average constructor — one of the receivers has 40 valves! — there is much in the booklet which is, so far as this particular application is concerned, new and interesting. The booklet is entitled "Remote Control by Radio," and is written by A. H. Bruinsma. The translation into English is reasonably competent, although the same cannot always be said of the printing.

The writer starts off by describing a system of remote control using amplitude modulation. He makes the point that, in a control system using AF tones, the individual tones must lie sufficiently far apart in frequency to be capable of separation at the receiving end, and that they must be chosen such that any harmonics generated by individual tones are not liable to cause interference with other tones. Also, that sum and difference frequencies created by two or more tones transmitted at the same time should, similarly, not cause interference. The writer states that this limits the feasible number of tones with simple equipment to four or five. He then points out very lucidly that, whilst it is possible to modulate a carrier 100 per cent by a single tone, it is impossible for two tones used together to achieve more than 50 per cent modulation each. Three tones can only achieve 33-1/3 per cent modulation, and so on.

It appears to follow from this, so far as one may learn from the booklet, that the use of tones alone for remote control is consequently unreliable. I fail to see this, especially as I have had some experience of remote control arrangements using such a system. Whilst A. H. Bruinsma's limit of four or five tones is borne out in practice, it must be remembered that the various "commands" which can be passed by the permutations of four tones amounts to fourteen; and, of five tones, twenty-eight.

There is, furthermore, no reason why the permissible modulation depth problem cannot be met by using, say, five tones, each of which modulates to a depth of 15 per cent only. Combinations of tones would then cause no trouble from this point of view at all.

"Sorting out" the tones at the receiving end involves, in a practical design, the use of at least two tuned circuits per tone. Three tuned circuits per tone should give almost perfect results, even during periods when the transmitted carrier varied beyond the capabilities of the receiver AVC system.

A. H. Bruinsma continues the first part of his booklet with a description of a simple control system using two tones. An interesting method of continuously varying rudder steering is given by varying the "space-mark" relationship of a multivibrator.

In the second part of the booklet, a more complicated arrangement is employed using pulse modulation. Although a considerable number of valves are used in both transmitter and receiver, this method of modulation is one which, with modifications, may be of considerable interest to the amateur. A. H. Bruinsma gives full circuit diagrams, with values, of a system capable of handling eight pulse channels on one carrier. Although only one of the channels in his own particular application carries audio frequency in the form of speech and music, there is no reason why the other seven could not do so as well. As is to be expected, the total bandwidth is wide, it being about 2 Mc/s. This bandwidth could easily be reduced, nevertheless, by reducing the number of pulse channels, or by increasing the individual pulse times. Pulse repetition frequency, however, must be at least twice the highest audio frequency carried. His receiver is also of considerable interest, as he has obtained mains valve performance from battery-type valves.

(The Philips valves mentioned in the booklet are, of course, available, under the same type-numbers, in Mullard).

Note: Our own publication, entitled *Radio Control for Model Ships, Boats and Aircraft,* is now available at 8s. 6d. with art board cover, and 11s. 6d. bound in cloth with gold lettering.

Plastic-Covered Wiring

It is becoming more and more apparent that, whether we like it or not, we are on the verge of entering a new Plastic Age. Whilst plastics are every day creating new fields for themselves, they are also beginning to take over many of the uses which were previously reserved for metals only. The particular instances of plastic aircraft mainplanes and plastic car bodies are two immediate cases in point.

We, in the electronic world, are always fortunate, insofar that new advances of this type find their way into radio equipment more quickly than in almost any other industry. The plastic known as PVC is a typical example. This particular plastic has become extremely well-known amongst radio engineers as it is now a universally-employed covering for insulated wires; and appears to be rapidly overtaking all the previous materials which have hitherto held this field.

PVC insulation, when used in electronic chassis, however, has its disadvantages; foremost among which is its readiness to melt on the application of heat. The earlier types of insulated wire did not suffer from this trouble. Many readers will remember the old varnished sleeving and the rubber-covered "push-back" wire which were so popular before the war. Both of these are now rather difficult to obtain. I recently bought some plastic sleeving in London and found that it melted away from the wire it covered at almost every joint I made. This was not due to inefficient soldering on my part, either; in each instance the iron was applied for only a second or two. The sleeving that remained soon found its way into the junk box!

PVC wire is not, of course, as bad as that, and it does not normally take anyone very long to get "used to it." When carrying out work on a chassis wired with PVC wire it is first of all necessary to ensure that any heat-radiating part of the soldering-iron, including its element housing, does not approach any of the wiring. Soldering, itself, must be done quickly and reliably. If a first attempt results in a poor joint it is a good plan to let the work cool off for a few moments before applying the iron once more. The secret of rapid soldering is, of course, clean surfaces, preferably already tinned, and the correct amount of flux. Occasionally, one meets valveholder tags and similar components which, due presumably to a long shelf-life, have oxydised and do not tin well. If PVC wire is being used, it is sometimes worth while tinning such tags before soldering is attempted.

The question of flux is of considerable importance. Now that the flux tin has disappeared almost completely from the workshop and its place taken by cored solder, care has to be exercised in the choice of solder used. As readers are aware, there are several very well-known manufacturers of cored solder, the products of which can be relied on implicitly. Other types of cored solder may, or may not, function as well. Additionally, from my own experience, I find that a thin gauge solder gives most markedly quicker results than does a quick gauge.

For the experimenter, PVC wire may not always be a good choice. When an experimental item of gear is being built, it often happens that different values of resistor have to be tried out, wiring changes have to be made, and so on. This causes a lot of unsoldering and resoldering and, unless a great deal of care is taken, the insulation of PVC-type wire will definitely suffer. Whilst a PVC-wired chassis always looks extremely presentable when it is completed, nothing is worse than when, on closer inspection, it is found that the insulation at many of the joints has become "cooked up."

Amongst the Worms

I sometimes think that the happiest job any radioman could hold would be that of constructing the control panels and equipment used as "props" in our present spate of science-fiction films. Just imagine the pleasure there must be in constructing some of those impressive and fearsome-looking machines; armed always with the knowledge that they would never be called upon to work! And yet, how far short of the ideal some of the film-makers go!

Recently, for my sins, I was forced to sit through a supporting film in which a party of people managed to delve under the Earth's crust so far that they should, to my calculations, have come out the other side. This intrepid party, unaffected by atmospheric pressure at 30,000 feet below the surface, travelled in a most ingenious burrowing machine whose engine could be started by the simple process of pressing button A on a war-surplus VHF control box. Their equipment included a very handsome Hallicrafter receiver which was not used. However, it must have had some purpose, because its dial lights always came on whenever the engine started.

There was also a control unit for an SCR269 Radio Compass. Although this was unwired, I still waited with bated breath for it to be used for compass bearings. However, the director of the film must, very wisely, have realised that such bearings would be a little difficult to obtain below the surface; for this instrument was also not brought into use.

Now, I am not seeking to condemn science-fiction, nor to condemn science-fiction films, of which many are very good entertainment indeed. But I do dislike this secondary sort of film where the audience is pre-judged as having a level of intelligence which is slightly sub-moronic. The proportion of the cinema-going population which is versed in radio is nowadays quite high, and ridiculous shortcomings in presentation such as those I have just described will only add more people to the crowds who do not nowadays visit the cinema.

Tool Review

There are a fair number of tools on the market these days which are applicable mainly to the instrument, electrical and electronic trades. These are what are best described as "specialist" tools and consist of such things as wire-strippers, contact-cleaners, and so on. Many of these tools are relatively expensive; quite a few lying in the region between £2 and £5. Some of these tools are not easy to obtain in the smaller towns. Others, especially those which employ new and unfamiliar designs, are sometimes not heard of by the average technician until they have been on the market for several years.

Whenever a group of tradesmen gather to talk "shop," one very often finds that the subject of these specialised tools crops up; and it is surprising to find how many of the lesser-known types of tool are mentioned or described only with knowledge gained by hearsay. If a tool is capable of saving a tradesman time, it also saves him money. The decision of whether the initial cost of a specialised tool will prove a worthy investment rests, therefore, with the tradesman. Unfortunately, however, due to lack of immediate knowledge which I have just mentioned, the tradesman very often finds it difficult to make a choice.

I have decided, therefore, to start a series of specialist tool reviews in this column. These reviews will deal only with tools applicable to the radio trade and will occupy a small amount of space every three or four months. Such common tools as nippers, wiring pliers, etc., unless they be of strikingly new design, will not. of course, be included.

In the reviews I will quote the manufacturer's address, the price, and the results claimed. Whenever possible, I shall check samples to see whether they meet the specification. It will be impossible for me to do more than check the immediate possibilities of any particular tool. If a manufacturer states, for instance, that a tool is capable of 10,000 operations, I shall quote the figure but will not be able to verify it.

On the other hand, if any tool does not appear to me to be suitable for the work it is claimed to do I shall not include it in the review.

I would be very grateful for the help of readers in this matter, especially welcoming any suggestions for tools to be included. I feel certain that, given sufficient co-operation, this series will prove of great value, not only to the amateur but, equally, to the professional engineer as well.

CAN ANYONE HELP?

..with the loan or sale of the circuit of the MCR1 or the valve line-up and power pack circuit.—J. Cubitt, "Yresco," Dunston, Lincs.

..with the instructions and/or circuit of the American "Espey" 104 Combination Tester.—J. Levick 9 Myddleton Square, Finsbury, London, E.C.1.

..with details of coils for ranges 1, 2 and 3 for the MCR1, and I would like to know how range 1 manages to cover 188-3,000 metres on one coil.—E. M. A. Barrell, 47 Madeira Road, Holland-on-Sea, Essex.

Versatile Audio Preamplifier

By **M. C. PAUL**

MOST AUDIO TYPES OF preamplifiers are designed for amplifying a weak input signal voltage to a level sufficient to drive the first stage of a main audio amplifier. Tone correction is conveniently embodied in this stage, which must necessarily provide a fairly high gain when inputs of an order of 0.05 volts are used, such as many types of microphones give.

Normally an impedance matching input transformer is used, and an appreciably higher input grid voltage obtained. However, such a unit, if used for experimental purposes (such as a photo-cell amplifier) should possess really high gain and a really good frequency response curve with an absolute minimum of valve noise. An orthodox type circuit is depicted in Fig. 1, and has a number of outstanding weaknesses.

The RF Pentode

The conventional circuit employing an RF pentode of the 6J7 type does give reasonably high gain of some 150 units, and is invariably worked under near-maximum gain conditions. Tone correction greatly depreciates the available gain in any amplifier stage, as does negative feedback where used. This latter addition is the only real answer to the pentode valve's inherent quality of generating third harmonics, which greatly colours audible reproduction and deforms the response curve. Even when feedback is employed, care is essential in preventing

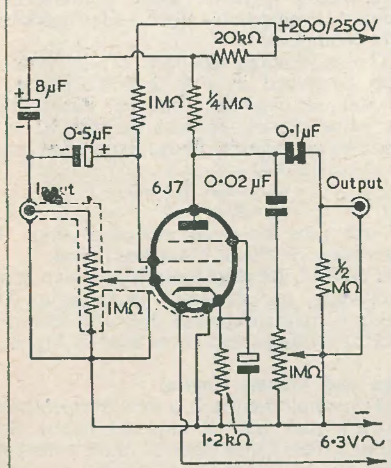
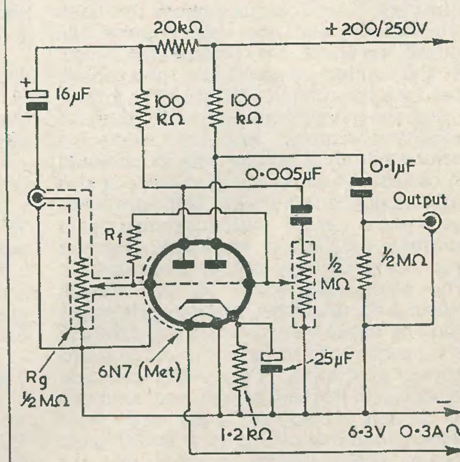


FIG.1.



Tone control has been omitted (see text)

FIG.2.

RC 465

supersonic or spurious frequencies creating positive feedback. This type of instability is very real where pentode valves are so used. With a carefully designed preamplifier of this type employing, say, 10% NFB and some 15% of bass lift, the nominal gain of 150 will drop to approximately 100, which of course is adequate for many orthodox requirements.

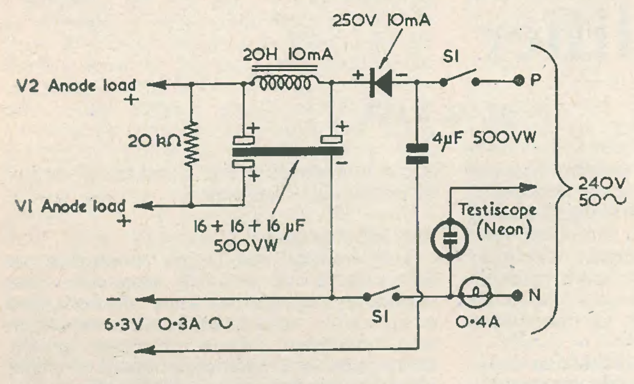


FIG.3.

High Gain Phenomena

Good screening will, of course, diminish possibility of instability by providing capacitative paths to earth for the unwanted frequencies. This does not remove the cause of the trouble and does not improve the response curve of the preamplifier stage, and the author prefers the preventitive rather than the curative method. The greater the gain the more pronounced this form of instability becomes, and in employing screening unduly a further loss in potential gain occurs. Thermal agitation noise is also greatly amplified in a simple high gain valve stage, which under near-maximum gain conditions, i.e. highest sensitivity, becomes prone to serious hum pick-up also.

The obvious approach to the over-all problem is the use of two medium gain stages employing triode valves, which are nowhere near so prone to third harmonic and spurious frequency generation. For greater gain and stability can in this way be obtained, although such a unit would be larger and more expensive than that of Fig. 1. It is with these foregoing considerations in mind that the author advocates the use of a double triode valve of the 6N7, 6SN7, 6SL7, type. These may be obtained as small metal cased valves, which with screened grid leads should provide all the screening necessary.

Double-Triode Preamplifier

Fig. 2 depicts a circuit employing a metallised 6N7 which gives a number of marked advantages over the conventional preamplifier. Each stage has a gain of over 26, thus eliminating some of those problems just discussed. The over-all gain is well over 700 without negative feedback and is more than sufficient for any requirement. Not many more components than in Fig. 1 are employed, and its physical dimensions can remain the same.

A very high degree of NFB is permissible, as spurious frequencies are virtually absent, and a great improvement of the over-all response curve may be effected at the expense of surplus gain. The NFB incorporated consists of a single resistor between the two signal grids, which should be wired directly across the valve holder. Its value will depend upon that percentage of feedback (β) required. The usual 5 to 15% feedback may here be increased to 25% or more, if desired, but 20% gives a beautifully flat response curve, and is adequate. Since NFB greatly improves signal to noise ratio, the unit is remarkably quiet under maximum gain conditions.

The percentage feedback of the type of loop employed in Fig. 2 is expressed as $\beta = 100 \times Rg/Rg+Rf$, but in determining the value of the feedback resistor Rf it is easier to arrange the above expression as:—

$$\frac{100-\beta}{\beta}\ Rg = Rf$$

Rf can now be easily evaluated once the percentage feedback β has been fixed.

If desired, Rf may be split into two series resistances, one of which is variable, thus giving a manual control over the factor β. Such an arrangement is outlined in Fig. 4.

Tone and Volume Control

With ample feedback, a tone compensatory network may not be required unless Bass Lift or Treble Lift is desired. Such a network must not be incorporated in grid or anode circuits that are within the NFB loop. The input grid circuit of the first stage or the output circuit of the second stage are good positions. If a variable tone control is used, it should occupy the latter position, otherwise any roughness of its action will be unduly amplified in the preamplifier. For the same reason the manual volume control has been placed in the second stage, although it could well replace the final output load resistor. However, some connected apparatus may require a different value for this grid-to-earth 0.5MΩ resistance, and it is easier to change this than to re-position the volume control.

Under strong input signal conditions the first stage will easily overload the second unless precautions are taken. In a general purpose unit of this type, it is best prevented by incorporating a volume control of the preset pattern in the input grid circuit. For any particular operation this can be set and then ignored.

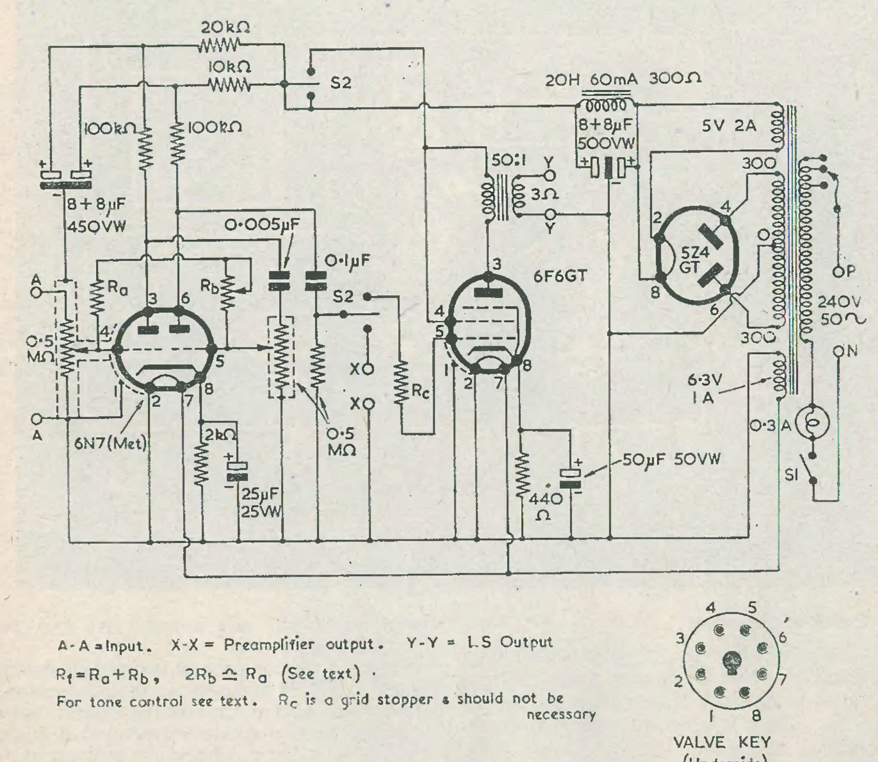


FIG. 4.

Power Supplies

The anode load resistors should be decoupled as shown in Fig. 2, and a large decoupling capacitor used. If this is too small the overall response curve will be deformed and instability incurred; 8 to 16μF is adequate, permitting comprehensive Bass response to be handled. This decoupling electrolytic can be a 3-capacitor can type, as shown, thus economising in space. Fig. 3 depicts an inexpensive power pack for the preamplifier, and requires little comment. A 4μF 500VW paper dielectric condenser is in series with the heater, this avoiding losses in this direction. The total mains input power is in the region of 2.8 watts. The two pole on/off switch can be associated with the volume control in the usual manner.

Since this "AC/DC" type pack is prone to the danger of crossed polarity, the author thought it expedient to incorporate a small "testiscope" as shown in Fig. 3. This will function before the preamplifier is energised by S1, and by touching its cap indication of wrong polarity is given by its glow. The mains plug can then be reversed before switching on. A suitable "testiscope" is the 5/- Philips neon now obtainable.

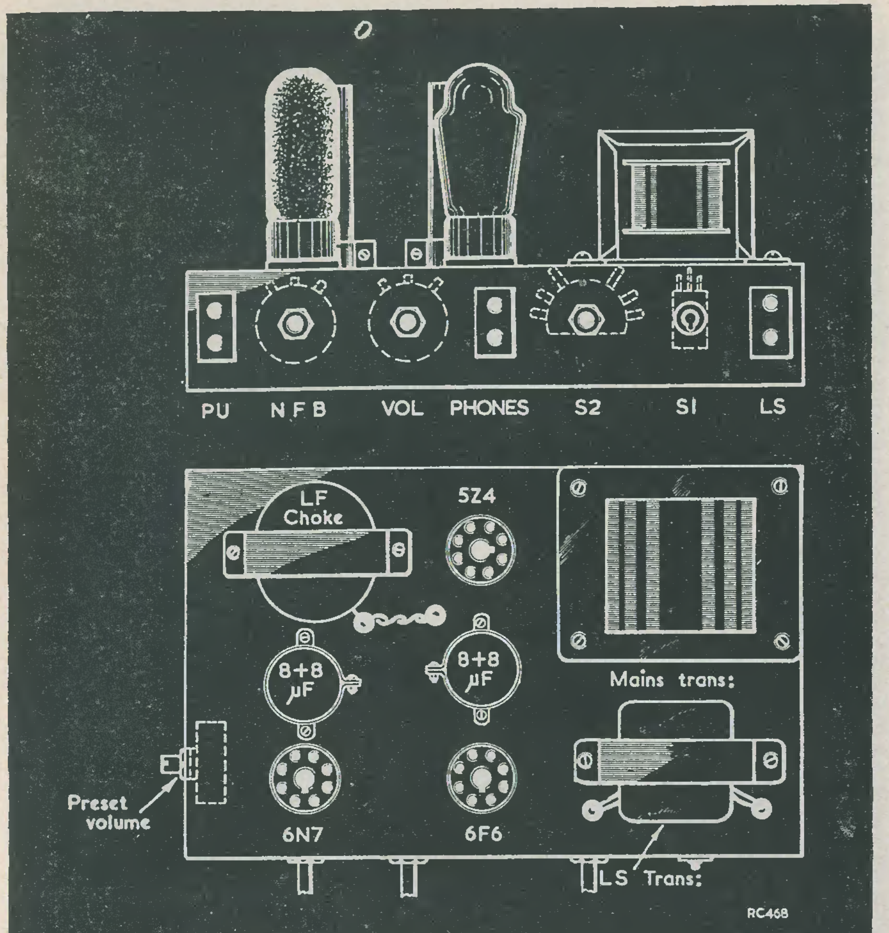


FIG.5. PLAN AND ELEVATION SHOWING CHASSIS LAYOUT

A useful arrangement

In its existing form, the preamplifier may be used to drive an output valve without recourse to an extra stage of voltage amplification. There is sufficient output available to fully drive an output triode of the PX4, PX25 type, thus a good quality output may be obtained without additional feedback. If 9 per cent distortion can be tolerated at an output of 4.5 watts, a 6F6GT may be used, and the surplus gain largely eliminated by means of the preset volume control. Such an adjustment will prevent overloading of the 6F6 grid circuit at maximum setting of the manual control. By this method of adjustment, practically any power valve may be driven from the unit.

In Fig. 4, S_2 comprises a two-pole two-way switch which is arranged so that the output valve may be cut out of the circuit, thus enabling the preamplifier to be used as such. Feedback has been deliberately omitted from the power stage for this reason. Should it be required to construct this unit (Fig. 4) for a specific purpose, S_2 may be omitted, also the preamplifier feedback loop, and a more comprehensive feedback system incorporated. Thus the need for a separate 4-volt heater winding, as demanded by the use of a power triode, is obviated, and really good quality obtained.

Layout

In Fig. 5 the component layout of the original general purpose amplifier is shown, and this requires little comment. The author would, however, stress that whilst layout is not critical, grid leads and feedback loop wiring should be as short as possible, and the metal cases of controls earthed to chassis. The chassis can, of course, be mounted in a small wooden case and an "internal" speaker installed. The chassis used was approximately 9″ × 6″ × 2½″ and was of aluminium.

Cover Feature

A SMALL TRANSPORTABLE

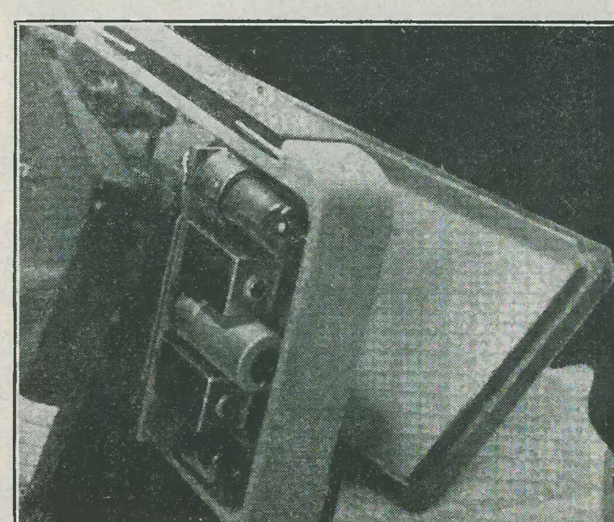
By M. ALLENDEN

I HAVE FROM TIME TO TIME occasion to travel, and invariably on arrival at my new abode I find that I am without radio entertainment of any sort. Such isolation prompted me to construct this set, which I felt would answer my needs.

The specifications to which it is built are therefore set by its rather ubiquitous use. A battery set was decided against at the outset, on the count that, for semi-permanent use, it would be expensive; so a mains set was decided upon. AC/DC it had to be, and by using a piece of line cord that could be plugged into the set, odd voltages like 115V could be catered for by altering the cord, or having two cords — one for 220 volts and another for a lower voltage. The narrow shape was employed so that the set could be packed easily in a bag or suitcase without being awkward, whilst the size of 8″ × 5″ × 2″ approx. ensures that it doesn't monopolise one's luggage.

The construction of such a receiver is obviously rather 'bitty,' and cabinet and set are built together, the components being bolted to the cabinet walls. By this form of construction, however, the very valuable advantage that NO METAL parts can be

"Exploded" view showing the manner in which the three main parts fit together



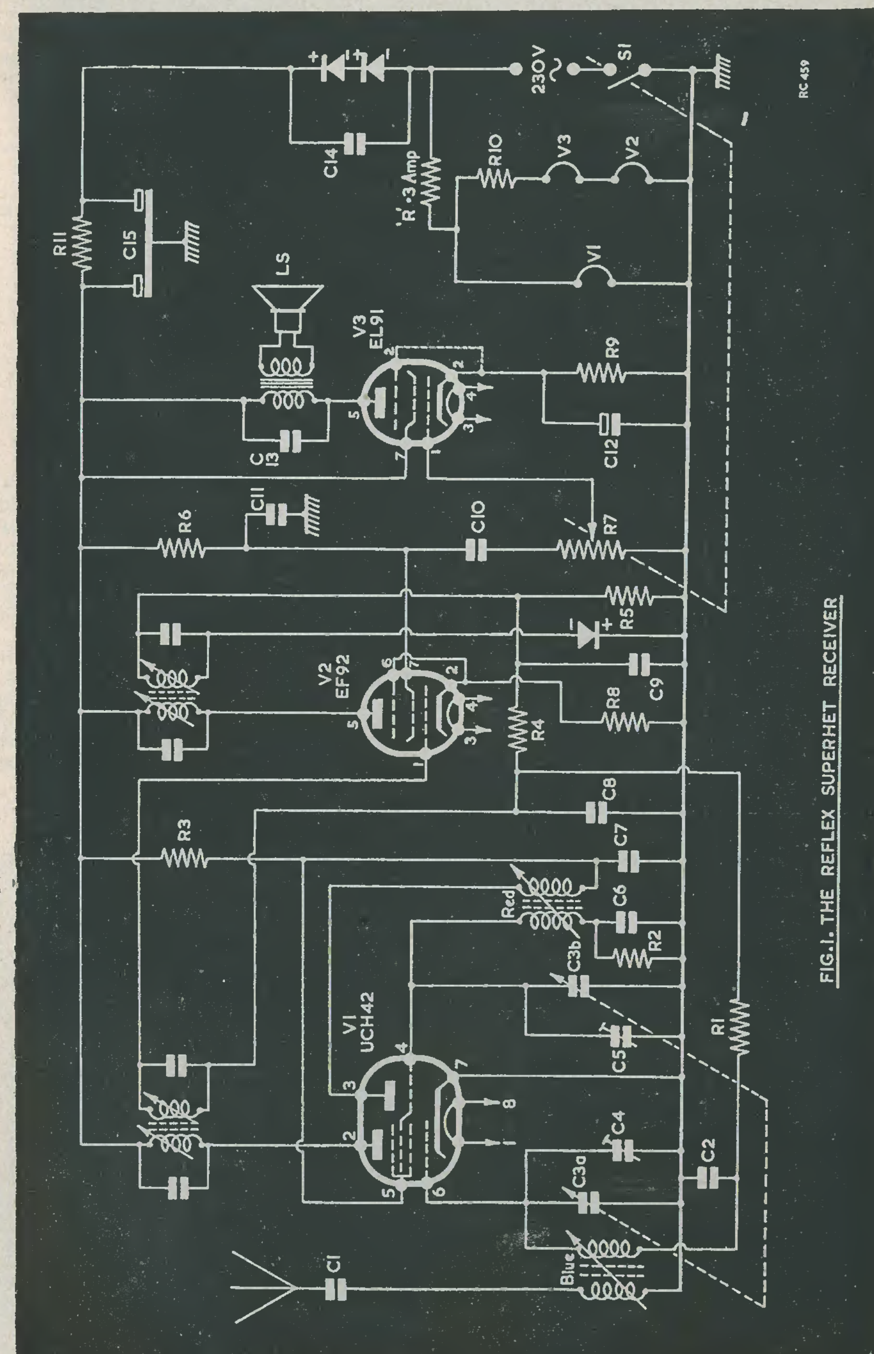


FIG. 1. THE REFLEX SUPERHET RECEIVER

touched is realised; with an AC/DC "hot-chassis" set, this advantage will be fully appreciated. The chassis holding the tuning portion can be constructed separately, and then bolted in the cabinet frame; this simplifies wiring, and to allow for alignment the chassis can be tilted. The cabinet itself has its external design based on the American type of portable, and a glance at the photographs will show the general form which the construction takes, viz, a central frame holding the chassis, rectifier, smoothing condensers, resistors and volume control. The front supports the tuning condenser and loudspeaker, whilst the back of the set holds the aerial socket and miniature Jones socket for the power. The whole cabinet is constructed from plywood of various thicknesses, and by giving the finished product several coats of brushing cellulose, a plastic-like finish can be obtained as seen in the photographs.

For maximum performance in all locations a superhet circuit is employed, and by reflexing the IF stage more can be achieved with less valves.

Circuit Details

No claims to originality for this circuit are made, the reflex idea being widely used, but by its use a large saving in components can be made. The circuit itself is a reflex superhet, the IF stage being used both as a normal IF amplifier and first AF; this saves one valve without impairing very much the performance of the IF stage.

For those not familiar with this type of circuit, a glance at the circuit diagram will

Component List

Resistors

R1	1.5MΩ ¼W
R2	47kΩ ¼W
R3	6.8kΩ 1W
R4	20kΩ ¼W
R5	500kΩ ¼W
R6	100kΩ ¼W
R7	500kΩ miniature pot'meter with SP switch
R8	220Ω ¼W
R9	330Ω ¼W
R10	6Ω approx., wire-wound—see text
R11	1,000Ω 2W

Condensers

C1	0.001µF tubular 1,000 VDC
C2	0.1µF miniature tubular 150 VDC
C3A & B	2-gang 300 or 350pF per section miniature type
C4 & C5	3.30pF trimmers on 2-gang miniature type
C6	350pF ±2% padder
C7	0.1µF min. tub. 350 VDC
C8	300pF mica
C9	500pF mica
C10	0.02µF min. tubular 350 VDC
C11	500pF mica
C12	25µF, 25 VDC miniature electrolytic
C13	0.002µF min. tub. 350 VDC
C14	0.01 tub. 1,000 VDC
C15	16+16µF, 350 VDC min. electrolytic

Speaker Rola 3" PM

Output Transformer Radiospares midget for personal portables

Rectifiers Two S.T.C. RMI's 150V 60mA ea.

Crystal diode G.E.C. germanium with wire ends

Line Cord 3-way, length to suit mains e.g. 0.3Amp system 753Ω (230V mains) 0.2Amp system 1,020Ω (230V mains)

Coils Denco (Clacton) Ltd. noval based dual purpose, slug tuned
Range 2 — Blue (Ae)
Range 2 — Red (Osc)

IF Transformers Radiospares miniature matched pair

Valves UCH42; EF92; EL91

Valve Bases 2 B7G McMurdo; 1 B8A McMurdo

Plugs, etc. 4-pin miniature Jones plug, or other type
1 Ae socket

The Cover Illustration

The Cover Illustration shows the really fine professional appearance of the finished receiver which is the subject of this article.

show that the AF is developed in the first instance across the diode load R5, and then filtered for the RF component via C9, R4 and C8. The resultant AF (filtered) is now fed to the grid of V2 via the secondary of the first IF transformer. Amplification takes place normally in the valve, but the AF is taken out at the screen of V2, the resistor R6 forming the load. Thus it will be seen that the pentode, for IF, becomes in effect a triode for AF. It will be noted that V1 is run without cathode bias; instead, bias is fed from the AVC line, which, having no delay, is quite satisfactory for supplying minimum bias. Nevertheless, it was found that a little standing bias was necessary, hence the inclusion of R10. The power unit is of conventional design, resistance capacity smoothing is employed, and advantage is taken of the S.T.C. Centercel miniature rectifiers. The types used are the RM1's and, as they have a maximum voltage rating of 135 volts, two are used in series. The valve line-up of a UCH42, EF92 and EL91 was used mainly because the author had those types at hand; to save space and simplify the heater arrangement a crystal diode is utilised.

The heaters on the original model were wired in series/parallel in order that 0.3Amp line cord could be used, but by shunting the UCH42 heater with a 140Ω resistor it can be wired in series with the other two valves, and 0.2Amp line cord used. The latter is, to the author's mind, the better arrangement — for in the event of a failure, only one valve is likely to suffer. The length of line cord, of course, depends on the ohms-per-foot of the type used, and if the 0.3A or 0.2A system is decided upon. The resistance of the line cord is calculated from the usual application of Ohms Law, viz:

(0.3Amp) Resistance of cord $= \frac{(\text{mains voltage} - 14) \times 1{,}000}{300}$

(0.2Amp) Resistance of cord $= \frac{(\text{mains voltage} - 26) \times 1{,}000}{200}$

It will be seen that a resistance of 200-1,000Ω is the usual value; the original employed eleven feet.

As it is possible to have a "live" chassis in this type of set, the aerial must be isolated from it, and this is done with a 0.001μF 1,000 volt condenser; *this must on no account be omitted.*

The coils used are the new Denco (Clacton) Ltd. miniature type, which tune with a 300pF condenser; by the employment of slug-tuned coils, the oscillator padding can be done by adjusting the core of the oscillator coil. The padding condenser is a fixed high stability type, which it will be seen is used as the oscillator self-bias condenser, R2 forming the grid leak. By using a series-fed oscillator circuit, plenty of output can be obtained on the lower mains voltages. In the original, on high mains voltages some whistles were apparent, but the inclusion of a grid stopper of about 100-200Ω in the grid of the oscillator should remove trouble from that source.

The IF transformers used are not critical, especially the last one, as this is considerably damped by the circuit arrangement. The type used on the original was a pair of "Radio Spares," but most miniature types would fit the chassis. As mentioned earlier, a G.E.C. crystal diode is used as combined detector-AVC rectifier. This type has the advantage that it can be wired straight into the circuit; care must be taken, however, and the use of a thermal shunt whilst soldering is advised. The red end of the diode goes to chassis, the black to the IF transformer. The output stage is very conventional and nothing need be said except that the output transformer was a "Radio Spares," the type for personal portables; in spite of its design for low currents, it will take the 10-15mA asked of it and shows no signs of heating. To eliminate modulation hum which crept in on local stations, C14 was included and removed all traces of it.

Construction

The reader may not want to follow the original in every detail, and a simplified cabinet could be constructed and/or a different design; however, the author felt that a little time spent on the cabinet to give it that professional finish was well spent, and probably the best salute to your finished cabinet is when people ask on inspection, "Is it plastic?"

Reference to the diagram will show the details of construction. They are fairly self-explanatory, but a few notes will not be out of place. The main frame is first constructed from plywood (part A), being glued and pinned together. A square is best used in setting to ensure a true rectangle. When dry, small wedge reinforcement pieces are glued in at each corner. Next construct parts **B** and C; these are best made together, and when gluing mount them on the main frame to ensure the same shape as part A is obtained. When the glue is set, handle carefully, for until the sides are glued on they are rather delicate. Now parts **D** and **E** are cut from $\frac{1}{16}$" plywood. Make sure that it is good plywood; the waterproof type is excellent and its extra cost is amply rewarded by the results. The parts D and E, which are the front and back, are now glued and pinned to the frames B and C, a good weight being placed on them whilst the glue sets. When the glue is hard, the flanges of $\frac{1}{32}$" ply are stuck to the inner sides of the back and front. We have now a case with a back and front which fit snugly into it. The piece cut from piece **E** is kept on one side, as it will be used later for the speaker baffle and grille backing. Two pieces of ply are now shaped as at **F** and **G**, and stuck on the main frame. This having been done, the whole "box" can be shaped with a file and sandpaper to give a rounded, pleasing shape. An idea can be obtained from the photographs as to what extent this is carried out. The speaker grille can now be added; this is constructed from strips of $\frac{1}{32}$" ply which are steamed round the corners, and then glued in place.

The main components can now be fitted into the cabinet, holes being drilled in the sides to fix them by countersunk 6-BA bolts—don't worry about holes, for you can always fill them up with plastic wood. The main chassis is cut from aluminium and is fixed to the cabinet by two angle brackets. It can then be wired up. A small bracket is made for the potentiometer, and bolted to the cabinet. A word about the volume control here — the actual volume "knob" is cut from $\frac{1}{8}$" perspex to the shape shown on the photograph; the projection on the disc is for a little extra leverage for the on-off switch. The disc just slips on the potentiometer shaft, which is filed to the shape shown in Fig. 2. Before construction progresses too far, it is best to paint the front and back "lids" of the case. First make sure that the wood is clean and all cracks are filled in, pins punched in, and resulting holes filled. The author used Naylors Brushing Belco. This is a slower drying cellulose and can be purchased from any good cycle stores; it is excellent for the purpose. Give the "lids" two or three coats, leave to dry overnight

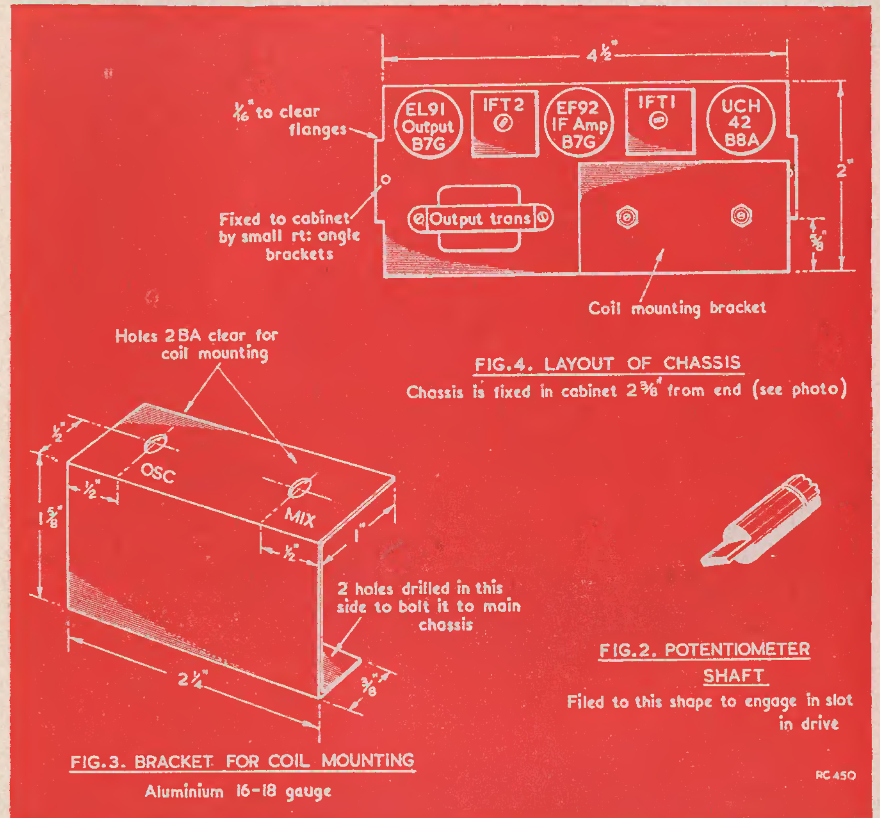


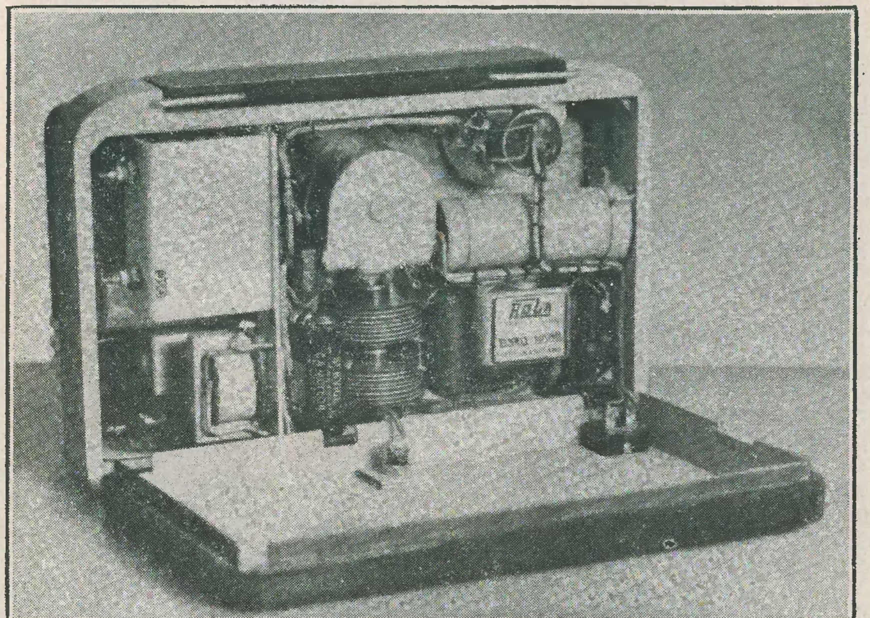
FIG. 4. LAYOUT OF CHASSIS
Chassis is fixed in cabinet 2⅜" from end (see photo)

FIG. 3. BRACKET FOR COIL MOUNTING
Aluminium 16-18 gauge

FIG. 2. POTENTIOMETER SHAFT
Filed to this shape to engage in slot in drive

and then sandpaper down with fine paper (known as "wet and dry," and used with water) until you have a smooth surface. A couple more coats can now be applied, working rapidly with a soft brush. Don't go back on your first strokes, as the cellulose

The dial-cum-tuning drive was cut from perspex, and is fitted to the tuning condenser spindle in the same manner as the volume finger drive, except that it is anchored by a piece of plastic which has a 6-BA screw embedded in it. The shaft of the variable



The back of the receiver removed to show the main components at the rear of the centre portion

tends to "pull." More sandpapering when it's hard — don't rush this stage; then another couple of coats. The last coat when definitely hard (leave at least one day to ensure this) can be polished. To polish use metal polish and a soft rag, rub gently but with even firmness over the whole painted area, and finally polish with a clean, soft rag; the result will amaze you as, depending on the number of coats used, a beautiful plastic-like finish will result. The main frame A is cellulosed last of all, when all the holes have been drilled and filled in with plastic wood. The handle is made from two pieces of perspex laminated, cemented with any of the various cements available on the market. The metal clips are made from anodised aluminium knitting needles of any of the lower gauges, which may be obtained from most stores for only a few pence.

condenser is drilled and tapped 6-BA, so that the finger drive/dial can be held in place without exposing any metal.

The piece cut out of the front panel E can now be utilised; two holes are cut out, one a piece to allow clearance for the speaker, and another to give air access to the valves (see sketch). The whole is covered with a piece of cloth and cemented behind the speaker grille.

The front and back can be fixed to the main frame by means of spring clips which press tightly down on the flanges — if spring clips such as the type for holding screwdrivers are purchased, they can be cut in half, softened at one end and drilled. The original set only needed two clips to hold the sides on very firmly.

A lot of the wiring will have to be done when the set is practically finished, such as

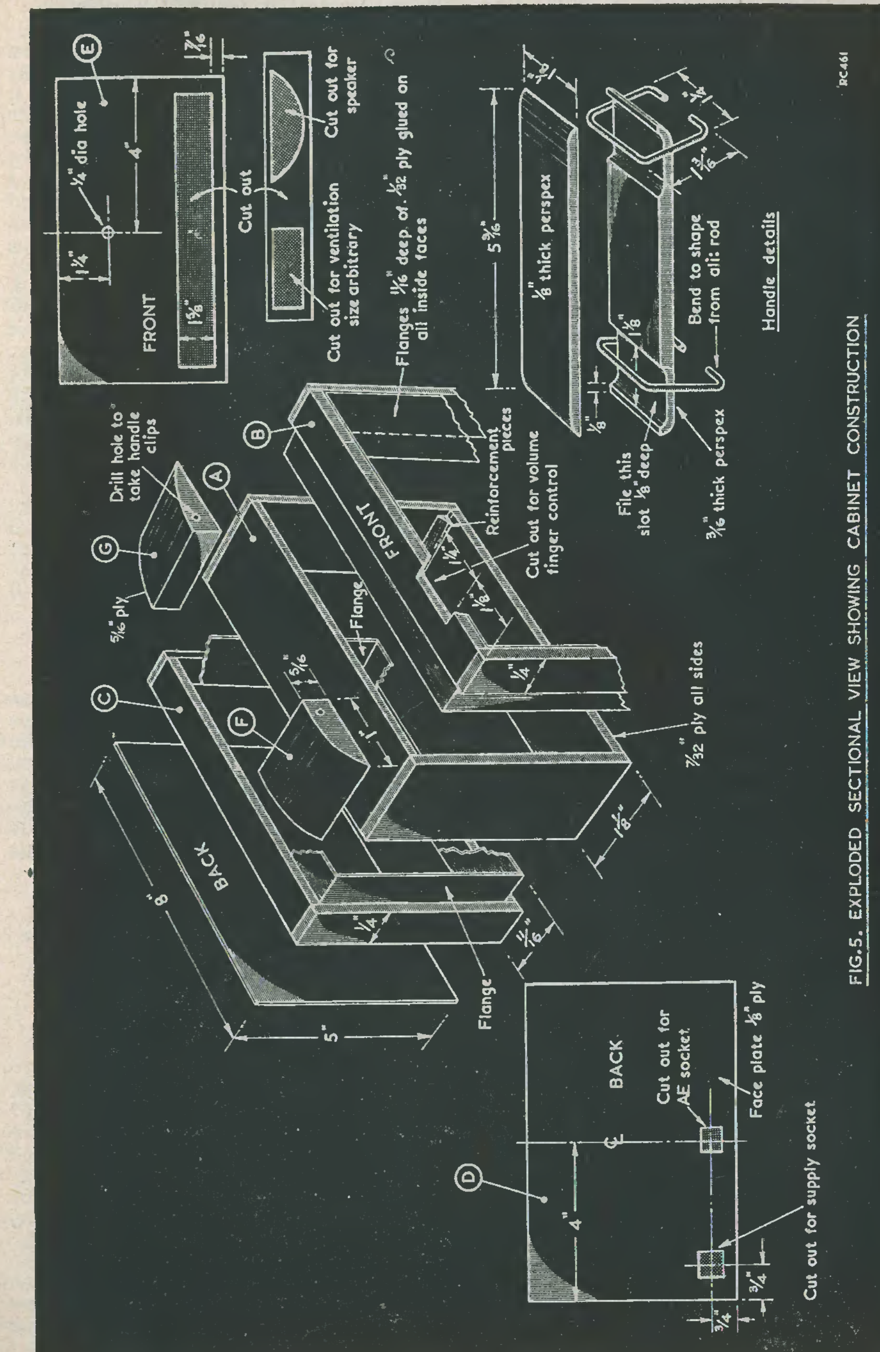


FIG.5. EXPLODED SECTIONAL VIEW SHOWING CABINET CONSTRUCTION

the connections to the plug, aerial socket and variable condenser; these leads should, however, be just long enough to allow the sides to come away a small distance from the main frame.

Alignment

This is best done with a signal generator, but it is quite easy to align on signals — the author using the latter method.

With a sig. gen., first short out the osc. grid, and inject 465kc/s into the mixer grid, peaking up the IF transformers for max. output. Then take the short from the osc., inject via the aerial socket 1,500kc/s, setting the condenser to about one-fifth mesh, and adjust the osc. trimmer until the signal is heard — adjust the mixer trimmer for maximum output. Next set the generator to about 600kc/s and set the variable condenser to about four-fifths mesh; adjust the slug on the osc. coil, at the same time rocking the tuning condenser until the signal is heard, and endeavour to get it at four-fifths mesh. Now adjust the slug of the mixer coil for max. output. Return to 1,500kc/s again, reset condenser to original position, and adjust the trimmer on the mixer section only. Return to 600kc/s and adjust mixer coil slug only for max. response. Now plug in an aerial and retrim for max. sigs. at high frequency end and low frequency end.

To align without a sig. gen., don't touch the original setting of the IF cores — or if they have been tampered with, set them at about the centre of their tuning travel. Set the oscillator coil slug to about half- to three-quarters of an inch out, and by swinging the condenser something should be heard; if not, vary one of the IF cores and try again. As soon as a signal is heard, peak up the IF's for max. output. Now try and identify a station — the 3rd programme on about 192 metres is good if it is strong enough — and set it to its approx. position on the dial; if you can get the 3rd programme it will be received with the condenser vanes practically full out. By varying the oscillator trimmer it should be possible to put the signal roughly where you want it; when it is there, set the trimmer of the mixer portion of the two gang to give max. output. Now go to the low frequency end of the condenser swing and identify a station (Brussels, Eiran or 3rd programme are examples) and vary the slug on the oscillator coil to put them roughly where they should be. Denco (Clacton) Ltd. coils give a range of 515kc/s to 1,545kc/s, which is 580-195 metres, so that should give you plenty to go on. Having set the osc. range, adjust the mixer trimmer and the mixer slug at the high and low frequency ends of the condenser respectively, until max. response is obtained at both ends and no further adjustment is required. Now retrim the IF's on a weak signal.

The dial was calibrated directly from received stations, ink marks being put at marker points, and then the points painted on afterwards — a sig. gen. is invaluable here, but the author did it by identification of stations.

Conclusion

Although most of the construction has been described in some detail, quite a few points have not been mentioned, but careful inspection of the photographs and diagrams should make them clear. The set is capable of a good performance and the audio section is such that local signals can be quite deafening, and good results are forthcoming on a fairly short, throw-out aerial.

A Christmas Card with a Difference!

The most interesting "Christmas Card" which came our way this past festive season was from Hugo Gernsback, the American technical publisher.

It was in the form of a small thirty page magazine — of normal Christmas card proportions, entitled *Forecast* 1954. It is the latest of a long series which Mr. Gernsback has prepared each year; each edition featuring scientific prognostications for the future. In this latest edition, Mr. Gernsback outlines the first flight to the moon in an unnamed spaceship, equipped to televise its journey back to the earth. "A and H Bombs for Defence" forms another subject for discussion — very suitable for those who enjoy letting off Christmas crackers at every opportunity during the festive season! A miniature radio receiver in the form of a pocket watch is forecast for production in 1954, and in the medico-electronic world Mr. Gernsback's prophecies should eventually make an incorrect diagnosis quite impossible, whether the defect be a physical or an emotional malady of the heart.

FRINGE AREA TELEVISION

By **J. GLAZER**

Part 2 — THE SOUND UNIT

No trouble, whatsoever, should be experienced in obtaining enough gain from a television sound receiver, as the bandwidth is so narrow that the coils can be "peaked" for maximum gain. In areas of very poor reception, however, RF stages using only one tuned coil are not enough; and the use of more than three or four RF valves is not only inconvenient in that they use more HT and heater current and take up extra space, but they also accentuate valve noise, which issues from the loudspeaker as a mixture of hiss and frying sounds. Superhet sound is, of course, really the best method of overcoming this trouble, but again there is the extra worry of the oscillator, its coils and the IF's, to say nothing of the cost. (If the average constructor is anything like the writer, he usually shies away from anything to do with superhet television, unless it is in the form of ex-Govt. surplus junk). Fortunately a TRF sound unit, employing the same tuned-grid, tuned-anode arrangement as in the vision unit, can come to the rescue, and even in bad reception areas three RF valves should produce ample gain.

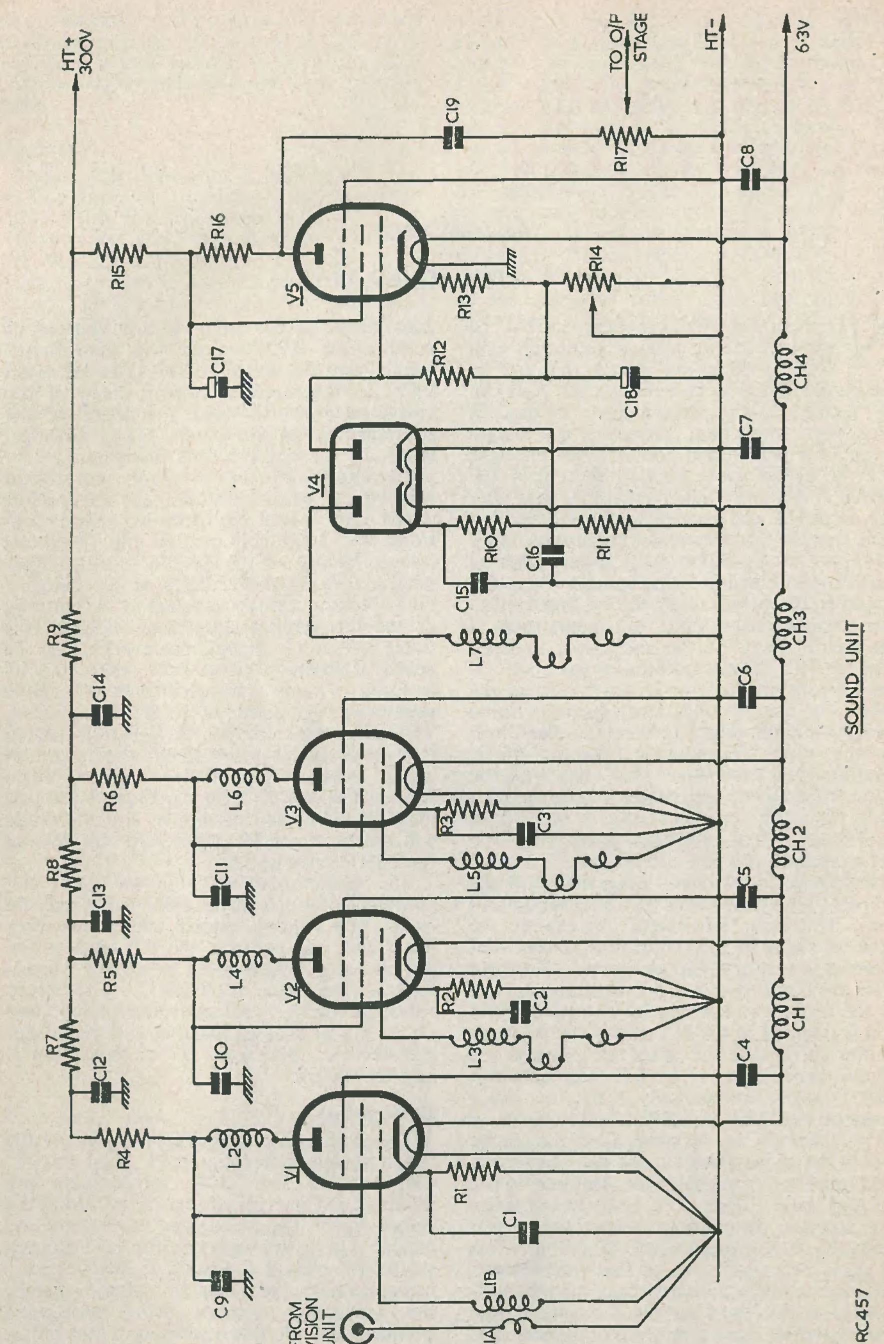
Reference to the circuit diagram shows the first EF91 RF valve with the usual tuned-grid coil. The three RF stages are exactly the same as those in the vision unit, except that there is, of course, no damping. The grid coils are coupled to the previous anode coils in the same way (the earthy end of the grid coil is coupled to the HT end of the previous anode coil), and the stage components are of the same values. The RF filter network, which comes immediately after the diode detector, (half of an EB91), and consists of C15, R10 and C16, bypasses all of the carrier hiss in the audio signal to chassis. The writer, for simplicity of construction, omitted to use an AVC line. Using AVC helps to cut down car ignition interference, and the writer strongly recommends employing it in areas of good reception, but of bad interference. (When the TV signal is strong, a high AVC voltage is fed back to the RF stages, and reduces their gain; so making them less sensitive and, therefore, less likely to pick up any stray interference). If the constructor does decide to use an AVC line, the use of variable-mu EF92 valves will give better results than the stated EF91. (The use of an EF92 in the contrast control stage of the vision receiver will make the action of the contrast control less harsh. This, however, is left to the constructor's discretion).

The sound unit, however, incorporates an efficient car ignition interference suppressor, which cuts down the irritating noise considerably. Its function is to clip the interference peaks off the audio signal. The diagram shows the cathode of the detector diode feeding a positive signal to the cathode of the interference suppressor diode. This diode will not conduct, however, unless its anode is made positive with respect to its cathode. This is accomplished by a variable resistor in the cathode of the first audio valve. This suppressor control, R14, is adjusted so that the diode just starts to clip the maximum sound peaks. The higher ignition interference peaks will drive the diode's cathode more positive than its anode, and the diode will cease to conduct, therefore suppressing the interference peaks.

The first audio valve is an EF37 AF pentode, although any similar valve may be used. The volume control comes just after this stage, and controls the AF level to the output valve, which is fed by a $0.1\mu F$ capacitor from the anode of the EF37. The output valve, an EL33, is for convenience mounted on the power chassis, together with its output transformer. The total HT consumption is approx. 65mA.

Construction

The sound chassis is the same size as the vision chassis, (15″ long by $2\frac{3}{4}$″ wide and $1\frac{1}{2}$″ deep). The four B7G valveholders are mounted at intervals of two inches along the centre line. The mica disc capacitors are mounted in their $\frac{3}{8}$″ holes on top, and up each side of the chassis. The octal valveholder is mounted near the other end of the chassis, the suppressor control being positioned between the double diode and this valve. Four screens are mounted across each RF valveholder, as in the vision chassis. All the



COMPONENT LIST

R1, 2, 3	220Ω
R4, 7	4.7kΩ
R5	5.6kΩ
R6	6.8kΩ
R8	3.3kΩ
R9, 17	2.2kΩ
R10, 15	47kΩ
R11	330kΩ
R12	1MΩ
R14	10kΩ variable (suppressor)
R16	150kΩ
R17	0.5MΩ variable (volume), with on/off switch
All resistors ¼-watt except where stated	
C1, 2, 3, 9, 10, 11	0.001μF ceramic or mica
C4, 5, 6, 7, 12, 13, 14	500pF mica discs
C15, 16	50pF ceramic
C17	8μF electrolytic, 350V wkg.
C18	50μF electrolytic, 50V wkg.
C19	0.1μF 500V wkg.
CH1, 2, 3, 4	10 turns of 21-gauge plastic copper wire ¼" dia. made self-supporting
V1, 2, 3	EF91 or Z77
V4	EB91 or D77
V5	EF37 or 6SJ7
Grid Coils (A.P.)	Anode Coils (A.P.)
L1a 2½ turns	L2 12½ turns
L1b 8 turns	L4 12½ turns
L3 8 turns*	L6 12½ turns
L5 8 turns*	
L7 12 turns*	
* +1½ turns around previous anode coil (see Part 1)	

coils are wound in the same way, except that there are slightly more turns.

Alignment

Very little trouble should be experienced in aligning the sound unit, the coils just being "peaked" for maximum gain. If a coil in either the vision or sound unit requires another turn, i.e. the dust-iron core is right inside the former for maximum gain, it is advisable to rewind that coil completely. When altering the coils, only do one at a time; the number of times the writer has mumbled unprintable words under his breath because he has rewound two or three coils at once and has completely lost the signal, is unbelievable. When initially aligning the sound receiver, disconnect it from all the other units, except the power, and plug in the aerial direct. When the alignment is completed, connect all the units together, and re-align both sound and vision units. It may be found that aligning one unit may affect the other, therefore the best balance between them must be discovered. If it is found that the vision tunes well, at the expense of the sound, or vice-versa, do not overlook the dipole aerial as a possible source of the trouble. If the dipole is not cut to the correct length, it may receive the sound signal well, but not the vision; or the vision signal, but not the sound. After all, the dipole is the first tuned stage of the television receiver.

[*to be continued*

From the UNESCO publication *Television—a World Survey*

. . . . we learn that TV is now operating or about to be introduced in 52 countries. In 21 of these, public broadcasters are on the air whilst another 7 are carryiing out technical broadcasts of an experimental nature. In the remaining 24, either the governments or private organisations have reached the planning stage.

Some rather surprising facts are brought to light in this publication. In the Soviet Union for instance, amateur television is widespread, where enthusiasts have built not only receivers, but an entire television centre at Kharkov. In France, communal sets have been purchased by entire villages, and placed in the school house. In Thailand, TV sets are on sale before the TV transmitter has been completed! In Mexico, it is reported that colour TV has been developed by a Mexican firm and is used for medical education at the University. It is not stated whether this is a 'closed' circuit. In Brazil, plans have been made to cover the entire country with 290 stations in 186 localities.

This publication is available in this country at 9/6 and contains a wealth of material ranging from the history of television in each country, organisation, technical facilities available, types of programmes and so on, to details of colour television systems available and the training of personnel for new stations.

VALVE VOLTMETER FOR AERIAL TUNING

By JOHN PICKARD

AT THIS TIME OF THE YEAR many amateurs are thinking about and preparing for the annual R.S.G.B. National Field Day, which usually takes place in June. One of the essentials of success in any contest, particularly so under the "portable" rules of NFD, is that the operator should be able to set his VFO to a particular frequency and retune the other stages with the minimum of delay. Valuable points are often lost through operators, who are not intimately acquainted with the transmitter in use, failing to tune it "on the nose," with the result that a poor signal is radiated and someone else gets the contact and the points!

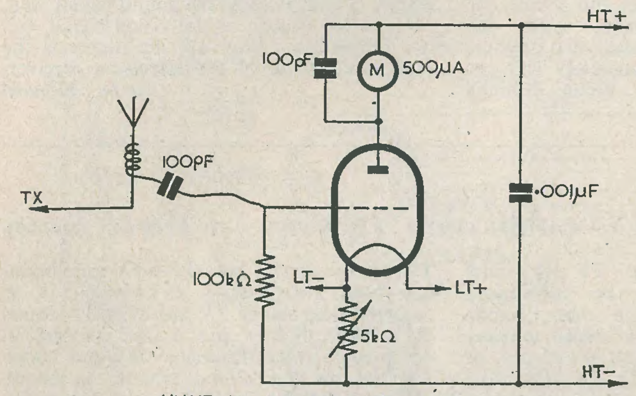
The preference of many groups is to use end-fed aerials, so considerably easing multi-band operation. The difficulty which immediately arises is that in most cases the aerial is voltage fed, and hot wire ammeters frequently fail to give a satisfactory reading when employed in such circumstances, bearing in mind the modest DC input power of 5 watts or less. Even if the aerial is current-fed some operators will find that, due to the low current, time is required in order to ensure that the transmitter is properly tuned and matched to the aerial.

Having met trouble of this nature for years, the author devised a "Valve Volt-Meter" which has been used with great success in the last three NFD's. A small 1.4 volt torch cell and a 9 volt grid bias battery have powered it for fully the 24 hours of the contest (and, in fact, were on each occasion subsequently used in the shack for many weeks). It may therefore be left switched on for the entire duration of the contest.

The unit is placed as near as possible to the aerial post of the transmitter, suitable precautions being taken to prevent any leakage of RF to ground. An insulated wire is taken from the input of the valve voltmeter and wrapped for approximately 3 to 5 turns round the aerial wire, to form a capacity coupling to the grid of the indicating valve.

The batteries should be built in with the indicator, so making it completely self-contained for easy transport and erection. It will be seen that the only controls are:

1. An on/off switch which may be used to reduce drain on the batteries, although, as already stated, this is entirely unnecessary for the duration of the contest, due to the low cost of the batteries.
2. The variable resistance which is used to adjust the bias on the valve.



VALVE—1A5 STRAPPED AS TRIODE

RC458

The valve volt-meter requires no further description, as the accompanying diagram will be easily understood. In operation it should be switched on and the cathode bias resistor adjusted so that the micro-ammeter reads approximately 50-100μA — this setting is not critical. The transmitter should then be switched on and adjusted for proper radiating conditions. With the key depressed, the insulated input wire to the valve voltmeter should be twisted round the aerial lead until the micro-ammeter reads nearly full scale deflection — say, 450μA for 500μA FSD.

The unit is now ready for use. As a test, change the frequency of the transmitter and it will be seen how quickly and easily the PA anode and aerial condensers can be adjusted for maximum deflection on the valve voltmeter. A careful check will show that the results are as good as the more usual "dip and draw" method, which will take much longer to adjust.

A further interesting check is to adjust the transmitter by the normal dip and draw method or by using an RF ammeter, and then to see how much more accurately the transmitter may be tuned by using the valve voltmeter.

BOOK REVIEWS

Three new books recently added to the Philips Technical Library have been received, each of which is up to the standard expected of the books in this collection. They are available from the distributors for the United Kingdom, Cleaver Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8.

The first to be dealt with here is entitled DATA AND CIRCUITS OF TELEVISION RECEIVING VALVES, by *J. Jager*. It contains 216 pages and 226 photographs, diagrams and charts. The price is 21s. This book is numbered III.c in the Electronic Valve series. A companion volume, No. III.a, was reviewed in the January 1953 issue of this journal. The present volume follows the same pattern as its companion, describing 11 thermionic valves and 3 picture tubes in great detail. The data presented is very comprehensive, particularly with regard to graphs of operating characteristics.

Each of the valves dealt with is found in the modern television receiver, and it is obvious from the many circuit diagrams and other essential data in the book that no pains have been spared to provide the design engineer with all he needs.

A section of the book is given over to circuit descriptions which finally evolve into a complete design for a modern receiver. Some emphasis is placed on intercarrier sound reception, possibly due to this system being more popular on the Continent than here.

LOW FREQUENCY AMPLIFICATION, by *Dr. N. A. J. Voorhoeve*, is Volume (b) in the Miscellaneous series of the Library, and is a monumental work on the subject, containing 495 pages, and 479 illustrations and diagrams. The price is 50s.. Unlike the books in the Electronic Valve series, which delve deeply into theoretical considerations, this book takes a grasp of the practical aspect of the sound engineer's calling. Consequently the mathematics encountered are very easily understood, and indeed have been made deliberately so in order to give space to subjects of a practical nature.

The wide range of matters dealt with include general principles, amplifier valves, pre-amplification, feedback, matching, power units, acoustics, input sources, reproducers and measurements, to mention a few. A useful chapter describes various components such as resistors, capacitors, potentiometers, transformers, etc., and gives a good insight into the desirable features embodied in modern components as a result of research.

In the chapter on amplifiers and amplification systems, the widely different circumstances in which sound re-inforcement plays a part in modern life is revealed, e.g., railway station and train announcers, swimming baths, exhibitions, studios, the cinema, and so on. Radio relay and rediffusion systems are also included.

This is a book that covers an enormous subject in such a way that the reader can learn much while being entertained by Dr. Voorhoeve's authoritative but readily understandable exposition.

INDUSTRIAL ELECTRONICS, by *Dr. R. Kretzmann*, is volume (i) in the Miscellaneous series. It, also, is a highly interesting book, particularly for those who have been searching for one that deals with this widening field. It contains 236 pages, and 226 photographs and diagrams. The price is 25s.

The applications of rectifiers, thyratrons, senditrons, ignitrons, excitrons, cathode-ray tubes, etc., and their basic circuits, provide early indication that the book deals with a considerable number of electronic devices that can perform certain functions in industrial plants that hitherto had to be done by some mechanical means. The main headings of such devices include electronic relays, counting circuits, timers, special rectifier circuits, welding, high-frequency heating, etc. These, and other themes, are subdivided into discussions on special examples designed to perform particular functions. For example, applications of the electronic relay can include automatic door control, smoke detection, the examination of food cans, etc.

Essentially this book is divorced from electronics which are devoted to telecommunications; it aims at being a guide to the wider application of electronic circuits, particularly to plant and production engineers who may view with some understandable reserve the devices of this new age which are not so familiar to them as are the methods and processes that have been their faithful servants for so many years.

Many of the electronic circuits are described in detail, and in several cases component values are given. Tables of the principle data for several of the Philips range of industrial valves are provided at the end of the book.

TV SETS ON TRIAL, by *Ronald Finnigan*. 48 pages. Price 1s. Published by Television News Ltd., 147 Victoria Street, Westminster, London, S.W.1.

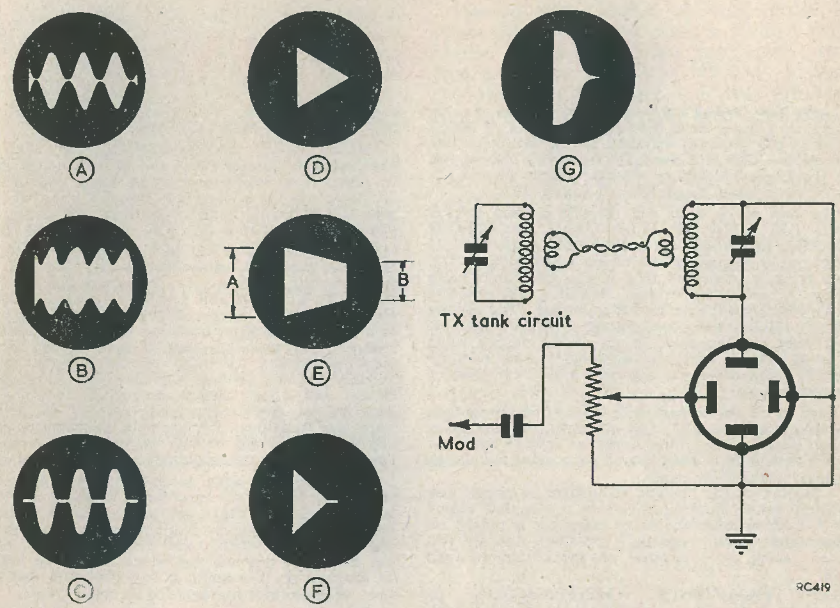
A booklet obtainable from booksellers and newsagents, compiled by the Technical Editor of TV News. It contains a selection of reviews published over the past 18 months in TV News. Well presented in clear type and sharp photographs on art paper, this little booklet can be a useful guide to a prospective purchaser who *knows nothing about wireless*. An innovation is the appendage to each technical review which provides a *Viewer's View* of each set described.

Fifteen sets, of various kinds and prices, by some of the leading makers are given praise and criticism. The *Viewer* who gives his *Views* seems to have an allergy for rubber-stops-for-cabinet-doors. To the present critic, the booklet seems worth a shilling; the sprinkling of facetious replies to typical requests for information afforded him some amusement on a drab afternoon.

NORMAN CASTLE

OSCILLOSCOPE TRACES

By A. B.



No. 7. MODULATED CARRIERS

TWO EQUALLY EFFECTIVE METHODS of checking depth of modulation from a transmitter or signal generator can be used with an oscilloscope.

The simplest way is to couple the oscilloscope to the RF tank circuit, and set the timebase to run at, say, one third of the modulating frequency. Traces representing the RF "envelope" can then be observed quite easily. Three examples of the sort of picture you might get are given in Figs. A, B and C above, which represent 100%, 50% and overmodulation respectively.

Alternatively, traces giving the same information can be obtained by making the connections shown in the circuit, and Figs. D, E and F illustrate this.

The trace at G shows non-linear operation, as well as overmodulation.

To calculate the depth of modulation, the following expression is used:

$$\text{Depth of modulation} = \frac{A - B}{A + B} \times 100\%$$

The transmitter must, of course, be fed with constant frequency modulation in both cases.

An Efficient MODULATED OSCILLATOR

by T. W. DRESSER

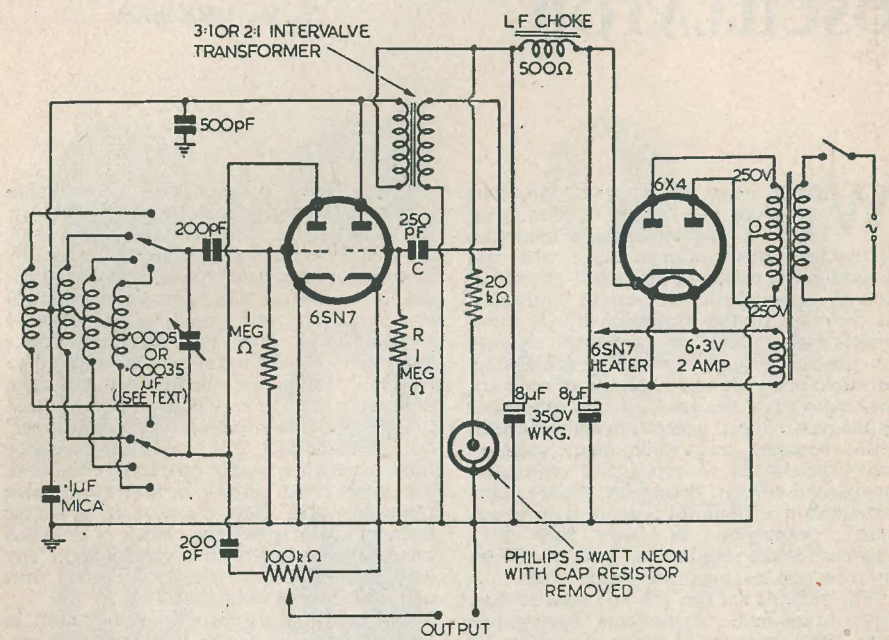
WHILE MANY THOUSANDS OF AMATEURS get along in a fashion without them, there is no question that a minimum of two instruments, a multi-range meter and a modulated oscillator or signal generator, are as essential to the serious enthusiast as they are to the professional. Of these, multi-range meters are comparatively easy to construct provided one has a good milli- or micro-ammeter and a handful of resistors, and many good designs have been published in the past. Signal generators are in another class, however, and while many attempts have been made to produce a reasonably priced and efficient design for amateur construction, it is doubtful if more than a very small proportion of them have even approached the standard of quality of even the cheapest commercially-made types.

The reasons for this are not hard to find. Few home-built instruments incorporate even the minimum of items necessary for stable oscillation, let alone refinements such as negative temperature co-efficient fixed condensers; and in addition the majority of them attempt to perform the entire operation, RF oscillation and modulation, with one valve, usually a 6K8 or something similar. It can be done, but it is rather singular that the manufacturers, who are as keen as any amateur to keep down the price for obvious reasons, rarely use less than two and often use three!

Taking the elements of a signal generator separately, there is really nothing much to them. On the one hand we have a simple form of RF oscillator, which, after all, is just a valve with reaction applied, whatever form it may take on paper; and an audio oscillator which is just as simple and usually operates on a fixed frequency around 400 c/s, to modulate the RF oscillator and provide an audible signal. There is nothing particularly complicated about that arrangement, and it should be an easy matter for amateurs to achieve the same degree of reliability and efficiency, *pro rata*, that the manufacturers do.

Where, then, does amateur construction fall down? Principally in frequency stability, it is to be feared. Frequency drift, and shift, is the bogey of all receiver designers, especially in communication instruments, and a great deal of trouble is taken to reduce and control it. Similarly, with good class all-wave receivers, how often do instruction books state that the receiver should be allowed to warm up for a few minutes before tuning in a station? The explanation given is that it is to allow the receiver to "settle down" but, in actual fact, it is to give the oscillator time to reach a stable operating condition. The point about all this is, how much more frequency drift must there be in a simple form of signal generator, which is switched on and used forthwith and which, in any case, has little or no compensation for drift and no means of reducing it?

The principal cause of frequency shift in any oscillator is change in supply voltages, particularly in that of the anode. The matter is more complicated where mixer valves are concerned, as in superhets, but we are not dealing with that now. The cure for the condition is, obviously, a regulated power supply. Frequency *drift* is another matter altogether, and shows itself as a decrease in oscillator frequency as the temperature of the unit increases. The effect is usually greater at the higher frequencies. The cause is rather complex but much of it is due to the use of poor dielectric materials such as ebonite, bakelite and other synthetic resins, and varnished cambric in the oscillatory circuit. Drift can be considerably reduced by using porcelain or polystyrene coil formers and insulation on the tuning condenser, and a porcelain valveholder. The remaining smaller drift can then be further reduced, indeed almost cancelled out, by using negative temperature co-efficient condensers so adjusted in relation to the other circuit components that balance is secured. Positive temperature co-efficient, by the way, is defined as an increase in capacity with an increase in temperature, and negative temperature co-efficient as a decrease in capacity with an increase in temperature. It will readily be seen how useful condensers of the latter type can be in oscillator circuits.



RC 409

FIG. 1

From this information it should be possible to design a signal generator which will remain tolerably stable in frequency (i.e. the dial indication really means what it states) and yet be inexpensive and easy to construct. The remainder of this article will be devoted to the description of such a signal generator, evolved from the theoretical considerations stated in the previous paragraphs.

The circuit of the instrument is given in Fig. 1. One half of a 6SN7 is used as RF oscillator, and the other half as modulator. The coverage is dependent upon the capacity of the tuning used, and the coil details are given in a table for both a 500pF and a 350pF condenser. Whichever is used, all the frequencies likely to be needed are there. Polystyrene formers (Denco [Clacton] Ltd.) should be used, and the windings fixed down with coil fixing dope from the same firm. The switch is ceramic insulated, as are the tuning condenser and the valveholder.

The RF circuit is quite a conventional arrangement, but the modulator may call for a little explanation, perhaps. The circuit used is such that the primary of a small intervalve transformer (1:1, 2:1 or 3:1, it is immaterial) is used as a Heising modulation choke and also as a feedback winding for the audio oscillator. The tone may be changed by altering the values of the resistor R and condenser C in the grid circuit.

Except for the regulator, which is of the gaseous type, the power supply, too, is conventional. The action of the regulator is as follows: On the application of the HT, the regulator commences to conduct, and with a high load resistance (a circuit taking little current) almost the whole of the current drain goes through the regulator. With a low load resistance (a circuit taking a heavy current) the current through the regulator is decreased proportionally. The voltage at the load, therefore, remains substantially constant. This also applies to a fluctuating DC input voltage. The resistor in series with the regulator is necessary to prevent the maximum current rating of the valve from being exceeded.

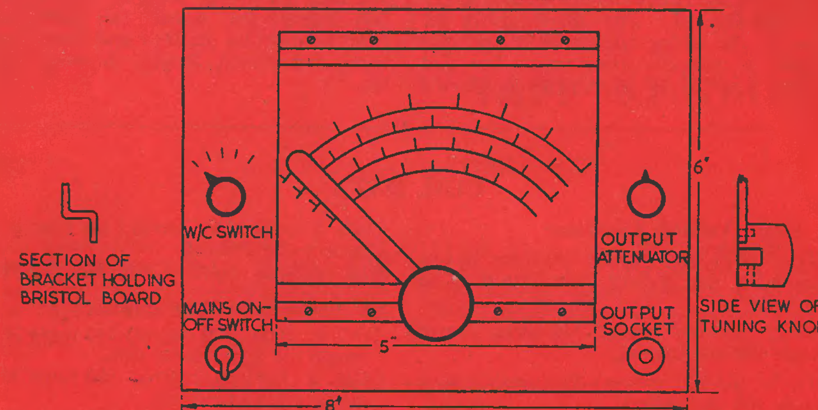


FIG. 2A

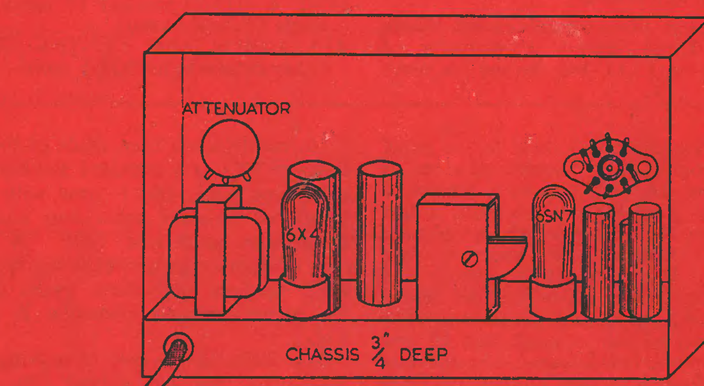


FIG. 2B

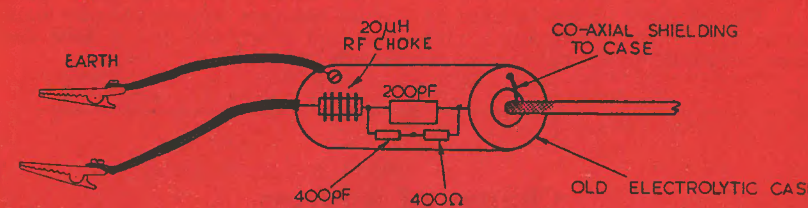


FIG. 3

RC 410

The step attenuator in the output circuit will be found very useful in adjusting the input to a receiver, and as it is made up from standard resistors there should be no difficulty in assembling it. For fine control of frequency the tuning condenser is operated through an epicyclic drive unit. The dial is simply a 3½″ by 2½″ piece of Bristol board

BBC stations are extremely accurate in frequency and can be used to cover from 1500 metres down to 20 metres, the points at which they occur being marked in on the dial. Additional signals can be obtained from continental stations and from trawler band radiophone, Rugby shipping service, etc.

COIL DATA

For 500pF Variable Condenser

COIL 1. (600-1900 metres) 330 turns 36 swg single silk and enamel wire pilewound to cover 1½″.

COIL 2. (190-630 metres) 140 turns 36 swg single silk and enamel.

COIL 3. (65-220 metres) 39 turns 28 swg single silk and enamel.

COIL 4. (15-75 metres) 10 turns 28 swg single silk and enamel.

All windings close-wound except where indicated. Three formers, 1″ diameter, of Denco (Clacton) Ltd. Polystyrene are used.

Coils 3 and 4 are wound on one former. Formers are 2″ long.

ALL COILS ARE CENTRE TAPPED.

For 350pF Variable Condenser

COIL 1. (600-2000 metres) 440 turns 36 swg single silk and enamel wire.

COIL 2. (180-610 metres) 180 turns 36 swg single silk and enamel.

COIL 3. (70-210 metres) 51 turns 28 swg single silk and enamel.

COIL 4. (15-75 metres) 15 turns 28 swg single silk and enamel.

ALL COILS ARE CENTRE TAPPED.

Other details as for 500pF coils.

or similar drawing board, held to the panel by short lengths of ¼″ aluminium sheet as shown in Fig. 2A. The pointer is a piece of Perspex, 3½″ long by ½″ wide, with a line drawn down the centre length by a razor blade, and fastened the knob by two 4-BA bolts. Fig. 2 shows the above- and below-chassis layouts of the finished instrument, and also the chassis dimensions. The material used in the original was 16 swg sheet aluminium, but if there is any difficulty in getting aluminium, steel chassis and cases of similar dimensions are obtainable from Denco (Clacton) Ltd. and Webb's Radio, at reasonable cost.

Regarding calibration—in the absence of a commercial signal generator with which to check it, a pretty good job can be done by beating the signal from the generator against a known broadcast signal on a receiver.

No mention has been made of the output socket. This is a standard Belling-Lee co-axial type 6045, and is used with a short length of co-axial cable and a standard Belling-Lee plug type 642F. A suitable type of dummy aerial which can be used on long, medium and short waves down to ten metres without alteration is given in Fig. 3.

It is believed the cost of making up this instrument will not exceed four pounds, and may be a good deal less with judicious buying and the help of the junk box. That of the original worked out to sixty three shillings and twopence. But whatever it is, it is a small price to pay for a generator which has some claim to accuracy and stability and which will give a good deal of satisfaction in use.

Change of Address

Osmor Radio Products Ltd., announce that their offices, stores and despatch departments have been moved to larger premises at 418 Brighton Road, S. Croydon, Surrey (on the main Croydon-Purley Road). Telephone numbers are still CROydon 5148/9. Their Bridge View Works, in Borough Hill, are now retained only as a manufacturing department, and all communications should in future be addressed to Brighton Road.

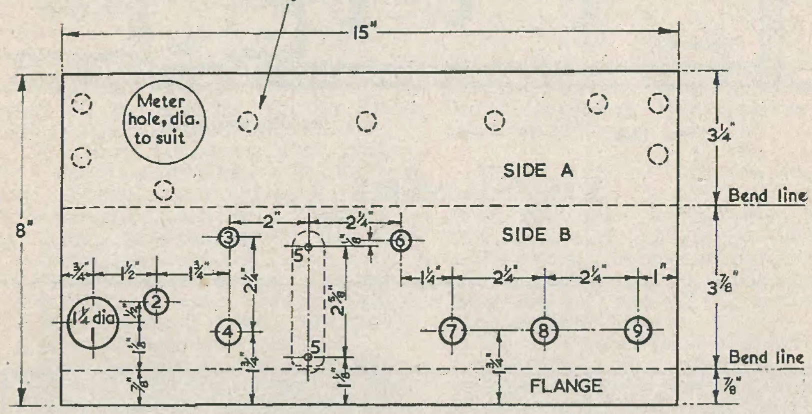
The ORPHEUS TAPE RECORDER

PART 3 *Described by* **A. S. TORRANCE**

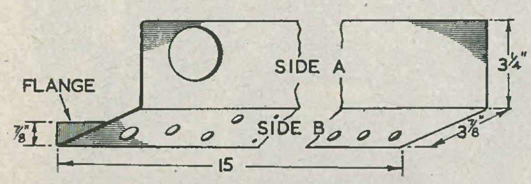
Chassis Construction and Drilling

The two drawings given in this issue show the layout of the tape deck with the location of the chassis as shown by the controls,

First study the diagram relating to the chassis. It will be seen that this is bent up, from a single sheet, into an open ended chassis which, however, is quite strong and



Chassis before bending



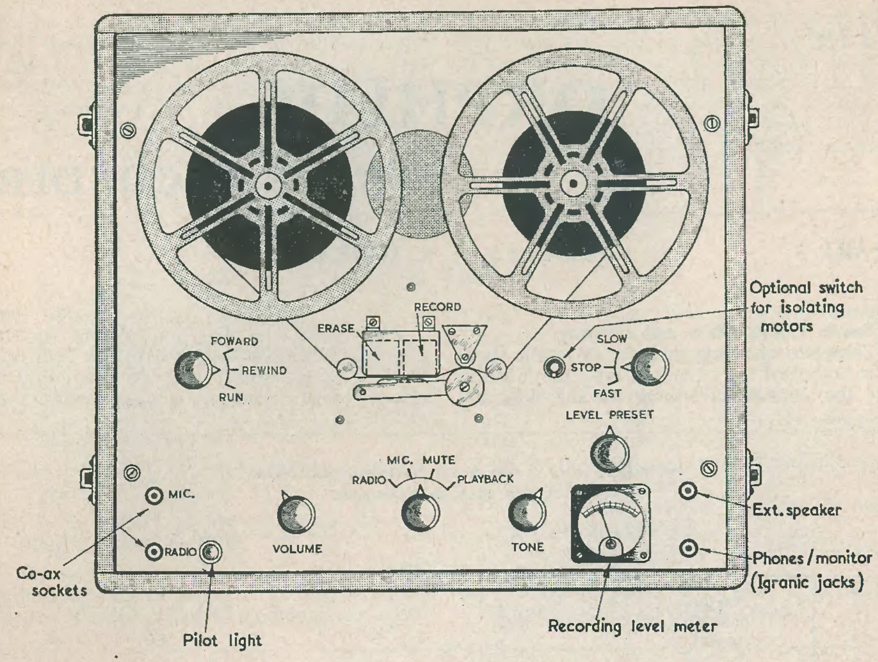
Form of chassis after bending

Hole functions	dia:
1. Power octal socket	1¼"
2. Meter det: & amp: V4	⅝"
3. Erase head co-ax. socket	½"
4. Oscillator. V5	⅝"
5. Output transformer	6 BA
6. Record head co-ax. socket	½"
7. Output. V3	⅝"
8. 1st & 2nd amplifiers V2	⅝"
9. V1	⅝"

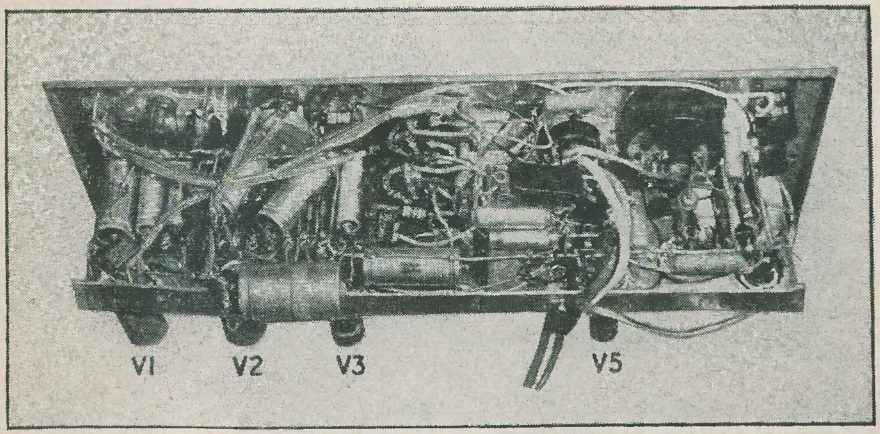
DETAILS OF AMPLIFIER CHASSIS

and measurements which will enable the chassis to be constructed and drilled ready for the assembly of components.

rigid because of its cross-sectional "channel" formation. If a fairly heavy gauge aluminium is used, it will be found possible to do the



PLAN VIEW OF TAPE DECK



"Under chassis" view of the prototype amplifier section

drilling after the bending has been completed.

To assist the constructor by rendering the drawing more readable, the larger holes have been numbered, and their dimensions are given in a table below the diagram. The holes shown dotted on side A are located by holding the chassis up to the deck, after the latter has been drilled, and then temporarily locking the two in position by means of the input and output sockets whilst the hole positions are marked on the chassis by means of a scriber, or similar sharp pointed instrument. Alternatively — and this will ensure a better register — the holes may be drilled whilst the deck and chassis are locked together, the deck acting as a jig.

After the edges of the holes have been cleaned up, assembly may be commenced, starting with those components which are attached to the deck — in other words, the controls. The recording level meter, of course, should not be mounted until wiring has otherwise been completed, in order to avoid any damage to this sensitive, and expensive, item.

The valveholders should be so located that the control grid sockets are towards the flange of the chassis. By so doing, the control grids and succeeding anodes will be brought close to each other, thus enabling the coupling condensers to be wired with the shortest possible leads.

The photograph, studied in conjunction with the chassis diagram, will enable the position of the larger components to be determined. This will be amplified by an actual layout drawing which will appear in next month's issue.

Before concluding this instalment, one point may be mentioned with regard to the sketch of the deck. This shows the same symbols for the input and output sockets; in actual fact the outputs are taken from Igranic jacks, whereas the inputs are via co-axial sockets, which make possible complete screening of these sensitive leads.

[To be Continued

We have received from the G.P.O. the following announcement relating to the testing of applicants for Amateur Transmitting Licences in Morse Code operating.

"As from the 1st January, 1954, prospective Amateur Licence holders will no longer be given their morse test at any Head Post Office. *The tests will be conducted on request at:—*

(a) **G.P.O. Headquarters**, St. Martins-le-Grand, London, E.C.1.

(b) **Post Office Coast Stations**, i.e. Burnham, Cullercoats, Humber, Land's End, Niton, North Foreland, Oban, Port Patrick, Seaforth, Stonehaven and Wick.

(c) **Radio Surveyor's Offices**, i.e. Belfast, Cardiff, Falmouth, Glasgow, Hull, Leith, Liverpool, London, E.C.3, Newcastle-on-Tyne and Southampton.

In order to meet the need of applicants who cannot conveniently reach the above places, tests will also be held, provided there are sufficient candidates, twice a year (January and September) at the following Head Post Offices:—Birmingham, Cambridge, Derby, Leeds and Manchester.

* * *

Constructors of portable equipment, miniature and radio control receivers, etc., will be interested in a new range of small transformers in encapsulated block form available from John Bell and Croydon, 117 High Street, OXFORD.

The following features of these transformers are particularly worthy of merit:—

Fixing screws are moulded into the block and are an integral part of the unit. Rigid terminal pins are supplied in place of loose lead-out wires. Chassis mounting is simplified and when impregnated they are proof against damp and suitable for tropical conditions. Full details can be had upon application.

* * *

Mullard Ltd., announce two new valves which have been specially designed for use in domestic radio and television receivers at frequencies up to 220 Mc/s. These valves will enable sets to be designed for reception of transmissions in the V.H.F. broadcast band (Band 2) and the "competitive TV" band (Band 3).

The new valves are a double triode, type PCC84, and a triode pentode, type PCF80, both on a normal base. The PCC84 is designed for use as a "cascode" low noise R.F. amplifier, and the PCF80 is intended for use as a frequency changer following an R.F. stage employing the PCC84. Both valves have 0.3A heaters and are suitable for use in AC/DC sets where the heaters are connected in series. They operate effectively on an HT voltage as low as 180V.

* * *

The Radio Amateur Emergency Network (R.A.E.N.) recently organised by the RSGB, received good publicity in the national press and radio.

Progress is proceeding well, some 28 local organisers having been appointed to date. It is open to any radio amateur whether he be a member of the RSGB or not, and enrolment forms can be obtained from the Organising Secretary, R.A.E.N. c/o RSGB, New Ruskin House, Little Russell Street, LONDON, W.C.1.

Radio Miscellany

Centre Tap talks about The Radio Amateur · The Amateur Spirit · Commercial TV

A "CEASING SEPARATE PUBLICATION" announcement is a rather sad occasion for a magazine's readers, particularly when they have grown to hold it in an almost affectionate regard. To many, the passing of *The Radio Amateur* is felt as something of a personal loss, almost as the passing of an old friend. To those of its readers who, I hope, will join us regularly from this month, I would extend a specially friendly welcome, and hope they will find a continuance of its fraternal spirit in *The Radio Constructor*. As a former regular contributor to *The Radio Amateur*, back in its *Short Wave News* days, it is fitting for me, more than most, to welcome them to our much wider circle of readers.

The final decision to discontinue *The Radio Amateur* as a separate journal was not brought about because it failed to hold its place among radio periodicals. Indeed it had a healthy and enthusiastic readership, but its expansion was limited by virtue of its specialisation. It was holding its own despite the recession of interest in the communications side of our hobby. The inflated post-War interest in amateur radio is falling back to more normal proportions. Thus to expand its circulation would have entailed a widening of its scope. In other words, it would have had to become a second *Radio Constructor*.

There were, of course, other considerations which made this an expedient time, not the least being that its Editor, Dr. Arthur C. Gee, had been nominated as a candidate for the R.S.G.B. Council. Perhaps it is a little late for me now to announce that he was elected — highly placed in the Poll. As a member of the Council, his experience and enthusiasm will find expression in a new form, and not be lost to the movement.

The Amateur Spirit

Arthur Gee's name will be familiar to readers both for his activity on the air under the call-sign G2UK, as well as for his experimental work on model control and his contributions to radio journalism. He is quite an old-timer in radio writing, and pre-War our articles appeared side-by-side in the same magazine. Despite this, it was not until 1946 that we had our first personal contact, when we very soon became good friends and grew to know each other quite well.

At the end of the War the *Short Wave News*, as it was then, was first off the mark. Under Arthur's editorship I sort of rallied round, writing my first two contributions while still in uniform. Nor had he yet returned to Civvy Street, and it was not until the third issue was in preparation that we first met in person. He was still in uniform, as a Major in the R.A.M.C. — I was in my demob. suit looking like a Bookie's tout got up for the Ascot Meeting! Alas, a few of those whose names were familiar as contributors on amateur affairs, in pre-War periodicals, had figured in the Bulletin as "Silent Key."

Dr. Gee's friendly spirit which has animated the pages of *The Radio Amateur* is, unlike the pretended bonhomie of a few figures in the amateur movement, natural and spontaneous, and his election to the Council will be a great asset — and a reassurance to B.R.S. members and potential newcomers who sometimes doubt whether the R.S.G.B. really has a place for the beginner. They have been allowed to feel neglected. While it is not easy for the Society at higher levels to extensively cater for their interests, insufficient effort has been made to check the spread of that idea. In fact, one or two of the "superior" type have aggravated the situation by their condescending treatment of even the more youthful of the G3-plus-three's.

I am sure G2UK's concern with B.R.S. interests will be vigorously maintained, and I hope to see the Council policy more markedly framed to meet their particular requirements. The amateur world has every reason to be proud of its fine tradition, but unfortunately in recent years standards have been allowed to decline, and the leadership by example has, at times, not been all that it might.

Much of the dissension of recent years has grown from the sudden influx of amateurs who, whatever their technical knowledge, had acquired little of the real amateur give-and-take spirit and the traditional good fellowship of "ham" radio. A "build-up-the-spirit-of-the-hobby-as-they-start" policy should be pursued in the interest of the coming generation of amateurs. It is no more than the repayment of the debt we owe to those pioneers who made the hobby what it is.

A Memorable Beginning

Frankly, I don't think any youngster can start off too soon. All old-timers were youngsters once. I remember in the early days, together with a school-chum, writing off in support of an organisation who were struggling to get wider recognition for "wireless" experimenters and also BC facilities. To my surprise I got a reply almost by return — they addressed me as "Esq." and I felt no end flattered. It was an invitation to a Meeting at a London hotel. The Commissionaire practically refused to let us in, but we defiantly flourished our invitations — and dodged by smartly.

We were simply overawed when we discovered that several very well-known scientific figures were present — in fact everybody there looked, to us, like Important Scientists, or, at the least, University Professors. I have often wondered what they thought when they saw a couple of schoolboys in knickerbockers take their seats. Luckily nobody said "Who let those little squirts in?" If they had, we should have curled up with shame. Instead we sat there marvelling and scarcely daring to breathe. Naturally we had not realised that such important people were behind it, but to our great relief one or two of them even spoke to us and gave us a few words of encouragement after the Meeting finished. We felt awfully proud, especially when they let us sign some sort of petition they were presenting to the PMG or some other big-wig. I've often wondered what the PMG, or whoever it was, would have thought if we had put "aged 13" after our signatures.

I recall we left the Meeting feeling like a couple of millionaires. Naturally we'd have loved to have been able to cock a snoot at the Commissionaire, but of course our newly-acquired sense of dignity ruled that out. I am sure that if we had had the money we would have left by taxi. As it was, we walked part of the way home to save the fare. With the money saved we stopped at a coffee-stall for a cup of tea, which we furtively drank hoping that nobody from the Meeting would see us.

As I say, you can't start too young — but there was no organisation for us to get into in those days, let alone provision for junior associates. Incidentally, my schoolboy companion is now a high-ranking Naval Technical Officer, although I haven't seen him for years. Inwardly I have always blamed him for leading me into that affair, but I guess his sense of Naval discipline still relaxes when some young cadet's zeal gets the better of his discretion.

TV And All That

In recent weeks I have been greatly surprised to find how many people there still are who hold back from buying a TV receiver, for fear the market will be suddenly flooded with sets costing between £25 and £30. It is hard to discover quite why they should be suspicious about the modern set, as invariably they are extremely vague about quite what it is they expect to happen. They seem to have a curious idea that mass production will bring prices down with a rush. Such a notion is absurd. When you discount Purchase Tax, current prices are amazingly low. With the present system, a receiver must have upwards of 15 valves, an expensive CRT and several well-designed circuits which must have a high order of stability. Further price reductions could only be made at the expense of quality, and the use of cheap components might easily put the purchaser to greater expense in servicing costs than the cost of the receiver, within the first twelve months.

Others seem to nurture a fear that some cunning "Cartel" is holding back for an opportune moment to bring out a cheap set of revolutionary design. That, again, is simply nonsense. True, there may be a revolutionary design. I should be the last to suggest that a monster-sized CRT for direct viewing is the final word in design. But if anything really new comes along, it will take years in the developing.

The only other alternative is projection TV, and that will certainly be no cheaper than direct viewing. True, it does save on the large-size CRT, but you still want a super-brilliant small one, plus an EHT supply of up to 20,000 volts and a separate screen.

As we decided in this column long since, TV inevitably involves a heavy outlay, and the hire companies who charge a weekly rental of 15*s* upwards are not making their fortunes out of it. Now that knock-out price components and valves are disappearing from the market, the home constructor does not show any very great saving unless he's clever at improvisation. In fact, it is actually dearer to build a set from specified parts. Even so, the home constructor gets lots of extra fun out of it and he wins hands down on the score of running costs. His really big advantage comes when he decides on something bigger, or of later design (such as when we want tuneable sets for a second programme) when most of his components, etc., can be carried over into the revised edition. The ordinary viewer will, of course, be able to get a converter, but that means extra bits and pieces *and* another power supply.

Confession

Talking of alternative programmes reminds me that a certain MP, who seems to spend most of his time campaigning against it, is striking a new line. His previous arguments have failed to sway public opinion, so he now discovers that it is going to be an Awful Thing for the children. Fancy letting the poor little blighters have the choice of programmes when there is a dreadful risk they might not choose the BBC.

I have yet to see anyone give a satisfactory answer to the points we have raised in this column.

ONE Is it good to have only one employer of broadcast talent?

TWO It puts too much power in the hands of too few people.

THREE Any monopoly grows big and clumsy and, when Government controlled, gets stiff with bureaucracy.

FOUR New technical developments are dominated by the old.

FIVE Bureaucrats prefer to do nothing rather than risk doing anything which either does not suit their organisation, or might not please the people that matter.

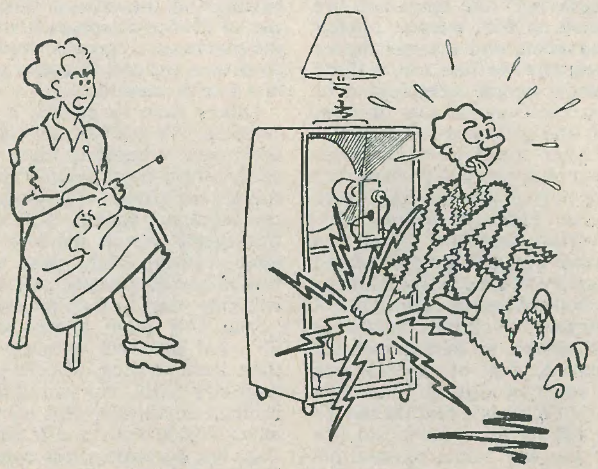
SIX Who can doubt that BBC programmes will improve when they have got to fight to retain their audiences?

SEVEN If advertising is so degrading, should the BBC be allowed to collect millions selling space in their publications?

EIGHT Would anyone seriously propose we should have our theatres controlled by one body, only one film company, or a single newspaper?

Now for a fearful admission. I don't want more TV, or even colour! From an amateur transmitting point of view I think the short-wave and VHF spectrums are already far too crowded, and that we are in grave danger of becoming a nation of watchers rather than a nation of do-ers.

RUFUS — THE RADIO CONSTRUCTOR



"Rufus—Stop tinkering, you're spoiling the picture!"

Query Corner

A Radio Constructor Service for Readers

Receiver Whistles

I am finding that reception on the medium waveband is becoming increasingly marred by whistles, the effect being much more apparent during the early hours of darkness. The set is a standard five valve superhet and, thinking that the interference was caused by maladjustment of the tuned circuit, I have had the alignment checked without any appreciable improvement. Is it possible to modify the receiver to effect some improvement?

D. Barnes, Brighton

Whistles may be regarded as the audible counterpart of the patterns which sometime mar television reception. They can unfortunately be due to a variety of causes, and it is perhaps useful to consider these in turn. They may be divided as follows:

1. Constant whistle which does not vary as the tuning is adjusted.
2. Whistles which vary only in intensity as the tuning is varied.
3. Whistles which vary in both intensity and pitch with the tuning.

Category 1

A whistle which is independent of the tuning control is almost certainly due to instability in the audio side of the receiver. It will occur even when the aerial terminal is shorted to earth. The remedy lies in checking all anode and screen grid decoupling components and adding further decoupling if necessary. If the receiver is battery powered and the HT battery partially run down, the inclusion of a 2μF capacitor across the HT may effect a cure.

Microphony also falls within this heading, and may be due to a faulty valve or vibrating tuning condenser vanes. The source may be easily located by gently tapping suspected components. Anti-microphony valveholders and a resilient mounting for the tuning condenser are possible remedies for this trouble. If a resilient type of valveholder is used, the leads to the connecting tags must be reasonably flexible to prevent vibration being conveyed to the valve via the leads.

Category 2

Whistles which only vary in intensity with the tuning are not normally due to the receiver, but are the beats formed between the carriers of adjacent signals. Broadcast stations are usually spaced 9 kc/s apart on the medium wave band, and stations on adjacent channels are normally located some considerable distance apart. However, particularly after dark when conditions for long

Query Corner

RULES

(1) A nominal fee of 2/6 will be made for each query.

(2) Queries on any subject relating to technical radio or electrical matters will be accepted, though it will not be possible to provide complete circuit diagrams, for the more complex receivers, transmitters and the like.

(3) Complete circuits of equipment may be submitted to us before construction is commenced. This will ensure that component values are correct and that the circuit is theoretically sound.

(4) All queries will receive critical scrutiny and replies will be as comprehensive as possible

(5) Correspondence to be addressed to "Query Corner," Radio Constructor 57 Maida Vale, Paddington, London, W.9.

(6) A selection of those queries with a more general interest will be reproduced in these pages each month.

distance reception are most favourable, this form of whistle may occur. Congestion on the medium wave band has been getting progressively worse since the war; there are, for example, many districts in which reception of the London Home Service is marred after dark by a most pronounced whistle. To find a solution to this problem the BBC have been carrying out extensive tests during the past five years, using VHF frequency modulated transmissions. This mode of transmission provides high quality interference-free signals, but requires a special set for reception.

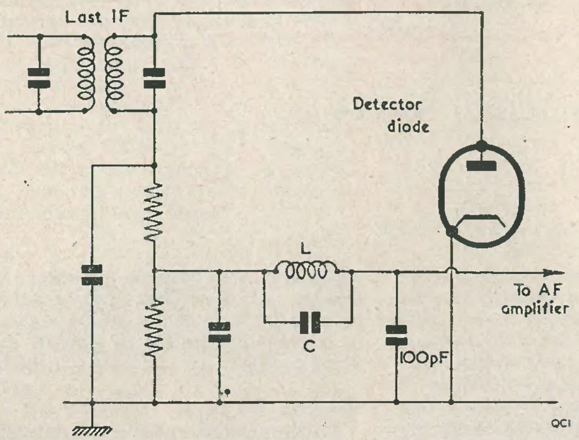


Fig. 1. Showing the position of the 9 kc/s whistle filter in a detector stage

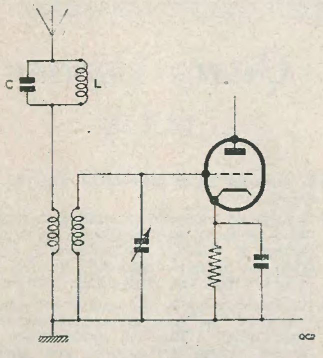


Fig. 2. The adjacent-channel rejector connected in the aerial circuit

However, there are two simple methods of bringing about some improvement on standard receivers. The first is to provide a tuned filter to remove the whistle from the audio side of the set. The second solution lies in rejecting the unwanted signal which is causing the beat note. The circuit diagram in Fig. 1 indicates a typical diode detector circuit to which a whistle rejector has been added. The extra components are L and C, and these are sharply tuned to the unwanted frequency. To reject a 9 kc/s note, L should have a value of 0.8H and C a value of 500 pF. The coil must be well screened to prevent the pick up of hum from stray fields within the receiver.

The unwanted signal rejector or wave trap is shown in Fig. 2. This rejector is sharply tuned and located as close as possible to the aerial terminal of the receiver. It is tuned to the signal which is causing the beat note on the wanted carrier and, as already explained, it will be resonant some 9 kc/s away from the required signal. If there are two stations which are masked by whistles it is possible to employ two such rejectors in the aerial circuit. Rejectors of this type are made by the Osmor Company, and when ordering it is necessary to state the frequency to which they are to be tuned.

If the whistle appears on all stations regardless of the position on the dial, the trouble may be due to interference from a signal which is adjacent to the intermediate frequency of the receiver. In this case the solution lies in the use of an aerial circuit rejector as shown in Fig. 2, but the trap must be tuned to the intermediate frequency.

A whistle having a rough note and occurring only at the high frequency end of the tuning range indicates that the local oscillator in a superhet receiver is squegging. To prevent this, a 47 ohm carbon resistor should be connected directly in the lead to the grid of the oscillator section of the frequency changer.

Category 3

Whistles which vary in both pitch and intensity may be due to instability in the RF stages of the receiver. The causes of this trouble have been discussed on many occasions, and the remedy lies in checking the decoupling components and the earthing of metal screens. In superhet receivers the trouble may be rather more difficult to cure, because there are many combinations of signal, oscillator and IF harmonics which can cause whistles. With the exception of IF harmonic feedback, the possibility of this trouble is reduced as the preselection, or RF sensitivity and gain is increased. The first step, therefore, is to ensure that the RF stages are accurately aligned and that the RF valve is operating correctly. Most forms of interference of this type are also less likely to occur as the intermediate frequency is increased, and for this reason an IF of around 465 kc/s is superior to one of 110 kc/s. Harmonics of the IF can be recognised because they are usually tuned in as whistles on frequencies of two or three times that of the intermediate frequency. These harmonics are usually generated at the detector stage or in the last IF amplifier, particularly if the latter has a tendency to overload on strong signals. The remedy lies in reducing the unwanted coupling between RF and IF stages. Such coupling may be via HT or AVC lines or simply by stray capacitance. Very careful screening of the leads and components associated with the detector stage is most important. If the trouble still persists, however, an IF harmonic rejector circuit may be added in the output lead from the detector. The circuit is as shown in Fig. 1, but in this case the L-C combination is tuned to the IF harmonic which is causing the whistle. Once again the components in the rejector circuit must be carefully screened, but this time the screening is necessary to prevent radiation of the unwanted harmonic.

It is hoped that these notes will assist readers in tracking down and eliminating at least most of those annoying whistles which beset some medium wave listeners.

— CLUB NEWS —

An Amateur Tape Recording Society has been formed by Mr. P. H. Hollis, 143 Lymington Avenue, Leigh-on-Sea, ESSEX.

The idea is to encourage the use of tape recording as a means of communication other than by usual methods. Each member converses on to tape and the reels are sent through the post to other members. (Cost is usually about 8*d* for a 1,200*ft* reel). Those interested should communicate with Mr. Hollis and ask for the Society's rules, etc.

CHESTER AND DISTRICT AMATEUR RADIO SOCIETY

CLUB REPORT for FEBRUARY 1954

The New Year began well with a large attendance at our first meeting of the year on the 5th January, 1954, when a Auction Sale was held, with G2YS calling the Odds.

On the 12th January, a very interesting lecture was given on an All Band TX, Portable, by B. O'Brion, (G2AMV) Regional Representative.

Not yet held, due to going to Press. The C. and D.A.R.S. sixth Annual General Meeting, being held at the Tarron Hut, Y.M.C.A., Chester at 7.45 p.m. on Tuesday, 19th January, 1954.

The monthly News Letter is available to all interested on application to the Club Secretary.

Reports of the Club Station on the "AIR" of a Tuesday evening on Top Band or 80*m* will be welcome at H.Q. For now on C.W. only.

Visitors and new members are welcome any Tuesday evening at Club H.Q.—E. Yates, G3ITY, Press Sec., for C. and D.A.R.S.

CLIFTON AMATEUR RADIO SOCIETY

Although no meeting was held on Christmas Day a net was organised on Top Band by G3DIC and most of the licenced members of the Society had their equipment tuned to 1925 kc/s at 10.30 Christmas morning. Some of our SWL members visited stations operating in the net whilst others had their own receivers running to listen-in on the proceedings.

On December 18th D. Reed gave an interesting talk describing his record player and home-built amplifier. His talk was illustrated with excerpts from both LP and standard 78 r.p.m. recordings. January 1st again attracted a large gathering for a Junk Sale when, as usual on these occasions, much equipment changed hands.

Meetings are held every Friday at the Society's H.Q., 225 New Cross Road, S.E.14, and a warm welcome awaits new members both young and old. We are, of course, always pleased to receive visitors and anyone finding themselves in S.E. London on a Friday evening are invited to give us a call.

QRP RESEARCH SOCIETY

One of the latest Society Services — "The Student Adoption Scheme" — shows great promise. This scheme caters for the novice to the hobby of amateur radio, and arranges for him or her to be instructed in radio theory, and to be given that "helping hand" over the pitfalls that can discourage so many an enthusiastic beginner. This Service is entirely free of charge, each novice being personally supervised by an experienced member of the Society through the medium of correspondence.

A Top Band QRP Net has recently commenced, and is proving an attraction to licenced members. All stations with the common interest of QRP are welcomed on the Net, which is held on the frequency of 1,900 kc/s, at 1430 G.M.T., every Sunday. SWL reports would be very acceptable.

All those interested in the low power aspect of wireless communication, be it receiving, transmitting, or even radio control of models, are invited to send for full details of membership, together with a specimen copy of the Journal. Only a postcard or QSL card is necessary, addressed to the Hon. Sec., J. Whitehead, "The Retreat," 92 Rydens Avenue, Walton-on-Thames, Surrey.

9: A SENSE OF VALUES

By A. BLACKBURN

The Easy Way to the Right Component

LAST MONTH WE LOOKED into some of the factors involved in the design of an audio amplifier. The specific details, however, were ignored—for example, all the grid bias voltages were derived from some mysterious source marked 'G.B.' In practice, of course, particularly in mains driven equipment, the required bias is derived from a resistor in the cathode circuit of the valve. You are also frequently faced with the problem of estimating the correct wattage rating for resistors.

Fortunately, it is not a difficult matter to avoid those dense clouds of smoke resulting from an overloaded resistor, burning happily away somewhere in the heart of a newly constructed instrument.

It is hoped that this article may help to avoid some of the minor disappointments and difficulties which face everyone when the published design is cast aside, and an experimental design of one's own attempted.

Series and Parallel

We will start at the beginning and talk about resistors, capacitors and inductors in series and parallel, in that order.

Figure 1a shows two resistors in series, the total resistance being R_1 plus R_2. The voltage developed across them can be calculated in two ways. If the current I flowing through them is measured, the voltage across R_1 is, from ohm's law, IR_1, and across R_2 is IR_2. If, however, the voltage V_1 is known, but the current is not, V_2 can be calculated from the expression:

$$V_2 = \frac{R_2}{R_1 + R_2} \times V_1$$

This is only true when no load is placed across R_2. The voltage across R_1 is, therefore,

$$V_1 - V_2.$$

All you have to do to find the total resistance of a number of resistors in series is merely to add the values together.

Figure 1b shows two resistors in parallel. In this case, I'm afraid, finding the total resistance (R_T) is a little more complicated. It is evaluated by using the expression:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

For a number of resistors this becomes

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \ldots \text{etc.}$$

Another expression may be used where there are two resistors only,

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

In the following example, let $R_1 = 200\Omega$ and $R_2 = 400\Omega$

$$\text{then } R_T = \frac{200 \times 400}{200 + 400} = 133\Omega$$

If a 100Ω resistor is now paralleled with these two, the result will be:

$$\frac{1}{R_T} = \frac{1}{200} + \frac{1}{400} + \frac{1}{100}$$

$$= \frac{2+1+4}{400}$$

$$= \frac{7}{400}$$

and therefore

$$R_T = \frac{400}{7} = 57.1\Omega$$

You will notice that the total resistance is always *less* than the smallest resistance in the circuit.

When the resistors are in parallel, the voltage developed across each resistor is the same, as may be seen from Fig. 1b. On entering the circuit the current I splits up and flows through the resistors, the value of current in each depending upon the value of resistance.

$$I_1 = \frac{R2}{R_1 + R_2} \times I, \text{ and } I_2 = I - I_1$$

A problem that often arises is to find the value of a resistor which, when wired in parallel with an existing known value, will produce a particular required value. For example, the bias resistor of a valve is 200Ω, but when the valve is replaced by a different type the required value is 180Ω. What parallel resistor is required? A slight reshuffle of the above expression produces

$$\frac{1}{R_1} = \frac{1}{R_T} - \frac{1}{R_2}$$

$$\text{or } R_1 = \frac{R_T \times R_2}{R_2 - R_T}$$

R_T is 180Ω, R_2 is 200Ω, and therefore,

$$R_1 = \frac{180 \times 200}{200 - 180}$$

$$= \frac{36000}{20} = 1800\Omega$$

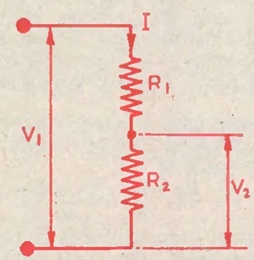


FIG. 1a
SERIES RESISTORS

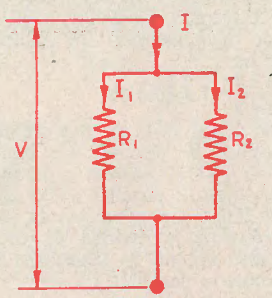


FIG. 1b
PARALLEL RESISTORS

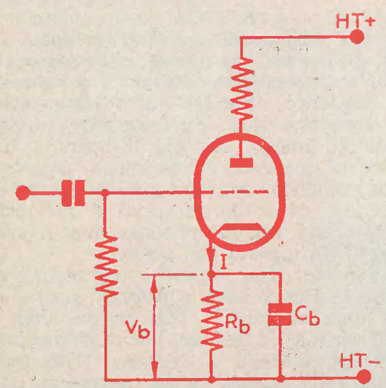


FIG. 2
AUTO BIAS DECOUPLING

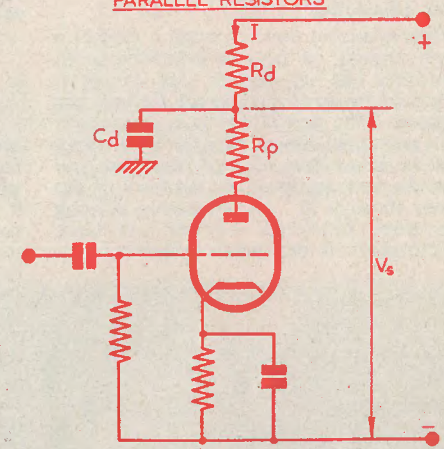


FIG. 3
ANODE DECOUPLING

RC469

The original value of 200Ω must have 1800Ω wired in parallel with it to produce the required 180Ω. In practice, 2000Ω would be chosen as this is a readily obtainable value, the error in the final result being very small.

Capacity and Inductance

Suppose we now substitute two capacitors, C_1 and C_2, for the resistors R_1 and R_2 in Fig. 1a. We can calculate the resultant capacity C_T from the expression:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{or } = \frac{C_1 \times C_2}{C_1 + C_2}$$

The similarity between this expression and the one for resistors in parallel is readily apparent.

Substituting C_1 and C_2 for the resistors R_1 and R_2 in Fig. 1b gives us the total capacity C_T:

$$C_T = C_1 + C_2.$$

Again the expression is of the same form as that for resistors in series.

These results summarised in words sound more complicated than the sums — which proves that maths. are only a simpler and shorter way of expressing facts. We can state these principles as:— The values of resistors in series and capacitors in parallel are added, but the values of resistors in parallel and capacitors in series are reciprocated and added. Reciprocated merely means turned upside down, i.e. the reciprocal of C is $\frac{1}{C}$.

Inductance follows the same law as resistance, providing there is no coupling between them. Two coils in series, one of 2 Henrys and 5 Henrys, have, therefore, a total inductance of 7 Henrys. In parallel the total would be

$$\frac{2 \times 7}{2+7} = 1.5 \text{ Henrys.}$$

One important fact to notice is that similar values of resistance in parallel are easily worked out. Two 1,000 Ω resistors in parallel result in 500 Ω, three in parallel 333 Ω and four in parallel 250 Ω. In other words, the value of the resistors is divided by their number. This also applies to capacitors in series and inductors in parallel.

Power Dissipation

When a current flows through a resistor a certain amount of heat is generated in it. From this fact we deduce that power is being used to drive the current through the resistance. The unit of power is the watt.

The power (P) dissipated is $P = E \times I$. Very often we know the value of resistance and either the voltage developed across it or the current through it. An expression relating these three properties — power, resistance and current — is derived as follows:

$P = E \times I$, but from Ohm's Law, $I = \frac{E}{R}$

Therefore $P = E \times \frac{E}{R} = \frac{E^2}{R}$:

or, alternatively,

$E = IR$, and

$P = I \times IR$

therefore, $P = I^2R$.

We now have three ways of calculating the wattage rating for a resistor. If, for example, a 10kΩ resistor has 10mA flowing through it, the wattage is expressed as

$$P = I^2R = \frac{10}{1000} \times \frac{10}{1000} \times 10{,}000$$
$$= 1 \text{ watt.}$$

The thousands underneath are introduced to take care of the *milli*amperes. (Always remember if you are working in Ohms, the other quantities must be Watts, Volts and Amps.)

Another typical case may be an auto-bias resistor of 200 Ω with 10 volts developed across it. In this instance we use

$$P = \frac{E^2}{R} = \frac{10 \times 10}{200} = \tfrac{1}{2} \text{ watt.}$$

The Bias Resistor

Fig. 2 shows a self-biased audio stage. It is often necessary, when designing an amplifier, to calculate the value of the bias resistor R_b. This is to ensure the correct bias voltage. As a rule, manufacturers state the bias voltage and the relevant current through the valve for this bias. Sometimes they also give the value of R_b, but if this is not included it only needs a simple equation to assess its value.

A valve with a cathode current of 40mA and a required bias of 8 volts gives a bias resistor value of

$$R_b = \frac{V_b}{I} = \frac{8 \times 1000}{40} = 200\,\Omega$$

(A point to remember is that when dealing with pentodes, the *total* cathode current must be used in this expression, i.e. the anode current plus the screen current).

The wattage is

$$P = \frac{E^2}{R} = \frac{64}{200} = 0.3 \text{ watts approx.}$$

A half watt resistor is called for here.

In most cases the resistor is by-passed in order to prevent loss of gain. The value of this capacitor, although not critical, varies with the bias resistor. For correct functioning it should remain charged throughout the period of one cycle of the lowest frequency to be amplified. For instance, the period of one cycle of a 100 c/s signal is obviously 1/100 second, and the condenser must remain charged throughout this period.

A resistor and capacitor connected as shown in Fig. 2 have a property known as the 'time constant.' This means that a capacitor takes a definite time to charge and discharge through a resistor. The time constant (T) is given by the expression:

$T \text{ seconds} = R \times C$

$\therefore \quad C = \frac{T}{R}$ Where R is in Ohms and C is in Farads.

Assuming as before that R_b has a value of 200 Ω and the lowest frequency is 100 c/s, the capacity becomes:

$$C = \frac{0.01 \text{ (secs)}}{200 \text{(Ohms)}} = 0.00005 \text{ Farads}$$
$$= 50\ \mu\text{F.}$$

Special low voltage condensers of such values are easily obtainable.

A probable stumbling block in this calculation is converting the answer from Farads to microfarads. Simply remember that the microfarad is one millionth of a farad, i.e. $1\mu F = 0.000001$ F, or, if you are familiar with the operation of indices, $1\mu F = 10^{-6}$F.

Anode Decoupling

Anode decoupling, as shown in Fig. 3, is frequently used to aovid coupling between circuits. In addition to serving this purpose, the decoupling filter R_dC_d is used to reduce hum injected into the anode circuit from the HT+ line. There must be a voltage drop across R_d, and as it is decoupled by C_d, it plays no part in the signal amplification by the valve. If, therefore, the valve requires an HT voltage of 250V (V_s in the diagram), the total HT must be greater by an amount equal to the volts lost due to R_d.

A good general rule is to make R_d one-fifth of R_p; values of 10kΩ to 30kΩ are therefore representative for R_d.

The valve draws a current of, say, 10mA and R_d is 10kΩ. The voltage developed across it is

$$E = I \times R = 10 \times 10 = 100 \text{ volts,}$$

working in milliamps and kΩ.

If the valve requires a supply voltage V_s of 200 volts, the total HT voltage must be 200+100=300 volts.

The value of C_d is normally chosen to be between 2 and 8μF with a resistor of one-fifth the value of R_p.

Perhaps a more scientific approach may be to decide upon a factor by which the ripple from the HT supply must be reduced. The smoothing effect of a filter such as $R_d C_d$ is expressed by:

$$C_d \times R_d = \frac{N}{2f},$$

where N is the factor by which the hum is to be reduced, and f the frequency of the hum. HT ripple is 100 c/s for full-wave rectifiers and 50 c/s for half-wave.

The fact that C_d and R_d are on the right-hand side of the expression means that we can choose either C_d or R_d to meet the circumstances. The formula to reduce by 10 a hum of 100c/s is:

$$C_d \times R_d = \frac{10}{2 \times 3.14 \times 100}$$
$$= 1.6 \times 10^{-2} \text{ approx.}$$
$$\text{or} \quad .016.$$

We now have the choice of either R_d or C_d, whichever is the more suitable. A possible case is that with a total HT of perhaps only 250 volts, we want to retain the supply voltage V_s at 200 volts. We cannot afford a loss of more than 50V across R_d, so R_d must be

$$R_d = \frac{50 \text{ volts}}{10 \text{ mA}}$$
$$= 5k\Omega$$

Now $C_d \times R_d = 1.6 \times 10^{-2}$, and therefore

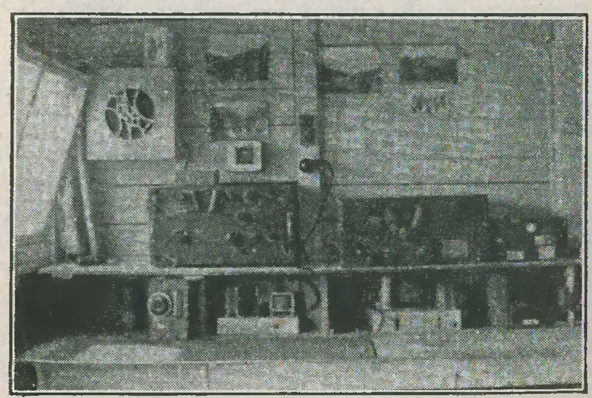
$$C_d = \frac{1.6 \times 10^{-2}}{5 \times 10^3}$$
$$= 3.0\mu F \text{ approx.}$$

If, on the other hand, a 16μF capacitor is available, then R_d may be calculated for this capacitor.

$$R_d = \frac{1.6 \times 10^{-2}}{16 \times 10^{-6}}$$
$$= 1\ k\Omega.$$

Screen Decoupling

The screen of a pentode is normally decoupled by a capacitor connected between its feed resistor and earth. This is mainly to prevent loss of gain through the screen operating as an auxiliary anode and robbing the true anode of some of the current through the valve.



The neat and very efficient looking den of reader C. Wetton of Cannock, Staffs. He is a member of the Cannock Chase Amateur Radio Society, and his equipment includes a BC312 a BC348 and a converter for 21 Mc/s home built out of an RF24 Unit.

The value of the resistor is fixed by the manufacturer's recommended voltage and current.

If we have a current of 1 mA, a voltage of 200 volts, and an HT voltage of 250 volts, it follows that the voltage to be dropped is 50. To find the value of resistor we want, we use:

$$R=\frac{E}{I}$$
$$=\frac{50 \text{ volts}}{1 \text{ mA}}$$
$$=50 \text{ k}\Omega.$$

The decoupling capacitor can now be calculated, in the same way as in the case of the cathode, by using the expression:

$$T=CR$$

Assuming 100 c/s is the lowest audio frequency, the decoupling capacitor is evaluated by

$$T=\frac{1 \text{ sec}}{100}=0.01 \text{ secs.}$$
$$=\frac{0.01 \text{ secs.}}{50 \text{ k}\Omega}$$
$$=0.2\mu F.$$

RF Stages

The principles for decoupling anodes, screens and cathodes of RF valves are the same as for the audio frequencies we have already explained. However, there is little point in calculating the values of decoupling capacitors because the lowest frequency to be amplified is normally higher than 100 kc/s. It is good practice to calculate the values for a stage dealing with a frequency of this order. You will find that the capacitor values are very small, usually below 0.1μF and so, in practice, a capacitor of 0.1μF is used. It is a good idea to place a 500 pF capacitor in parallel with the 0.1μF. The reason for this is that capacitors of relatively high values, say above 0.01μF, are very often inductive, by virtue of their construction. Sometimes they are 'lossy', and their effectiveness is reduced at high frequencies. The addition of a high quality capacitor of small value helps to overcome this effect.

Gain

There are often times when it is very useful to be able to get an approximate idea of the gain of a stage without having to trouble about drawing the load line. All you need to know is the μ, gm and Ra of the valve concerned. As you are nearly always given two of these three quantities, in the manufacturer's data, the third may easily be worked out, if required, by

$$\mu=gm\times Ra.$$

Supposing gm and Ra are 5.5 mA/volt and 10kΩ respectively, then

$$\mu=5.5\times 10$$
$$=55$$

working, of course, in mA and kΩ.

With triode stages, unfortunately, the anode load must also be known before we can calculate its gain. The gain is then given as

$$\text{Gain } A=\frac{\mu\times R_L}{Ra+R_L}$$

At this point I must emphasise that the gain of a triode can never exceed μ. Now if the required gain is known and we want to find out the value of the load resistor R_L, we use

$$R_L=\frac{A\times Ra}{\mu-A}$$

If A were to be equal in value to μ, the denominator of this equation i.e. $\mu-A$, would become zero and R_L would therefore become infinite, which as you know is impossible. Always make sure that you do not try to calculate R_L for a gain of 100 if μ is only 50. It just can't be done!

Let's see what result we get when we give values to gm, Ra and μ, and use this expression to find R_L. With a gain of 30, a μ of 50 and an Ra of 10kΩ,

$$R_L=\frac{30\times 10{,}000}{50-30}$$
$$=15k\Omega.$$

For a gain of 45 with the same valve, R_L would be

$$\frac{45\times 10{,}000}{50-45}$$
$$=90k\Omega.$$

Despite the more complicated appearance of the pentode, the expression for the gain of a pentode stage is simpler than for a triode. It is

$$A=gm\times R_L.$$

Since the μ of the pentode is very high, we need not worry about limiting our gain as before. So for R_L we get

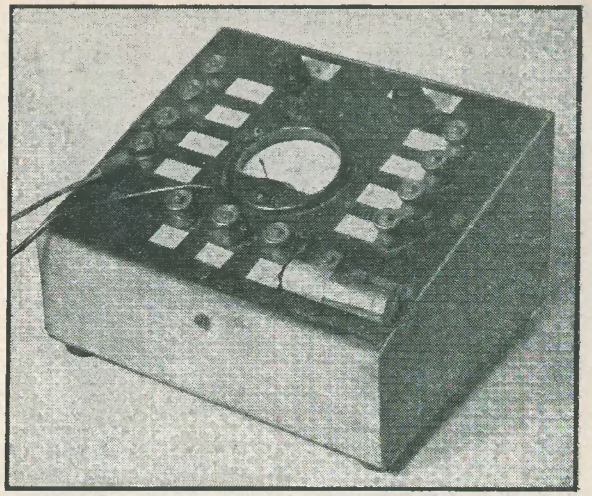
$$R_L=\frac{A}{gm}$$

For a gain of 100 and a gm of 5 mA/volt

$$R_L=\frac{100}{5}$$
$$=20k\Omega.$$

The load line method is a more complete guide to the capabilities of a stage than the systems outlined above, which are not intended to give any more than a good estimate of what to expect.

DESIGNING A MULTI-RANGE METER



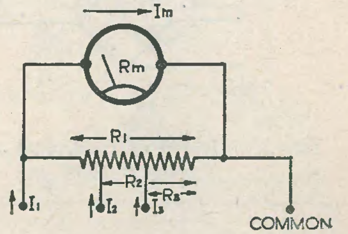
By

R. K. VINYCOMBE
B.Sc.

MOST MULTI-RANGE METERS consist of a basic current-measuring movement with circuits which enable it to read on a variety of different ranges. Some of the more expensive commercial instruments incorporate elaborate switching arrangements, overload protection and so on, which make them easy and quick to use. Many of us, however, cannot afford such luxury and this article describes how a meter covering nearly all the usual requirements can be constructed without any complicated wiring or switching.

Principles

The basic movement should be a moving-coil meter having as small a current range as possible. 1mA is adequate but 500μA is better. The higher the sensitivity of the meter—that is, the smaller its full-scale deflection—the less interference it is likely to cause in the circuits where it will be used. To enable this meter to read higher currents, it is necessary to by-pass some of the current through a shunt. The most convenient form of shunt consists of a tapped resistor R1 connected in parallel with the meter as shown in Fig. 1. One end of the shunt is the common negative terminal while the tappings form the connections for the various current ranges. Provided that the internal resistance and the full-scale deflection of the meter are known, it is possible to calculate the value of the shunt and the position of the tappings. It is best to make the full-scale deflection on each range a convenient multiple (say 10) of the next lowest range. With a 500μA meter, therefore, the shunted ranges will read 5mA, 50mA and 0.5A; whereas with a 1mA meter the higher ranges may be 10mA, 100mA and 1A.



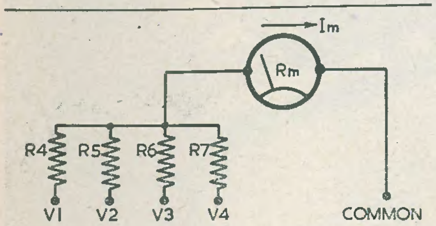
RC354

Fig. 1. The arrangement of a milliammeter and a universal shunt to extend its range

If the full-scale readings for each range are I_1, I_2 and I_3, the full-scale reading of the basic meter is I_m and its internal resistance R_m, then:

$$R_1 = \frac{R_m I_m}{(I_1 - I_m)}$$

The two tapping points R_2 and R_3 may, in practice, be determined by experiment as described later, but for those who wish to



RC355

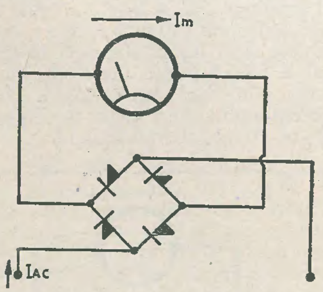
Fig. 2. The milliam meter and multipliers arranged to give a number of voltage ranges

calculate them an adequate approximation may be made by taking:

$$R_2 = \frac{(R_m + R_1)\, I_m}{(I_2 - I_m)}$$

Similarly:

$$R_3 = \frac{(R_m + R_1)\, I_m}{(I_3 - I_m)}$$



RC356

Fig. 3. Method of connection for the meter rectifier

For the voltage ranges, by the application of Ohm's law, the meter is made to measure the current through a known resistance. A separate resistor is provided for each range and each resistor can be connected in series with the meter, as is shown in Fig. 2. A common negative terminal can be used and a different positive connection provided for each voltage range, designated V_1, V_2, V_3 and V_4 in the figure. For a 500µA meter, suitable voltage ranges are 0.5V, 5V, 50V and 500V. With a 1mA meter, ranges of twice these values make dial readings convenient. The "multiplying" resistors, R_4, R_5, R_6, R_7 are all calculated in the following manner: where V is the full-scale voltage range required and R is the appropriate value of multiplying resistor for that range:

$$R = \frac{(V)}{(I_m)} - R_m$$

where I_m and R_m are the full-scale current and internal resistance respectively of the basic meter.

The "ohms-per-volt" of a voltmeter is an indication of its quality. A high value means that the meter causes less disturbance in the circuit to which it is connected. However, since Ohm's Law states that current is equal to "volts-per-ohm", the "ohms-per-volt" of our instrument is simply the inverse of the full-scale current of the meter. A 500µA meter gives 2,000 ohms-per-volt and a 1mA meter gives 1,000 ohms-per-volt.

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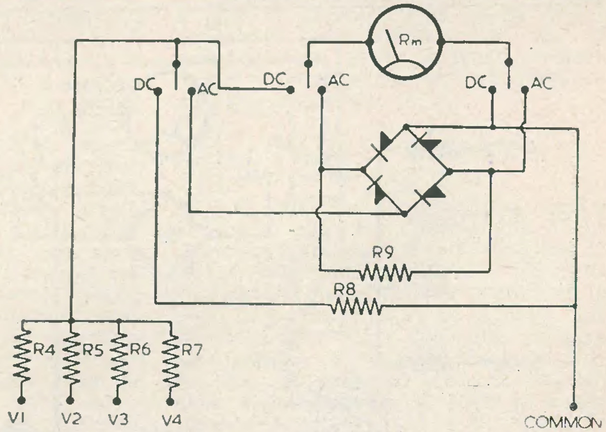
There are two ways out of this difficulty. The simplest is to use the same multiplying resistors for the AC voltage range as are used on the DC range and to remember that it will always be the *average* value of AC which is read on the meter. To obtain RMS values, the readings will have to be multiplied by the form factor—in most

Fig. 4. The use of compensating shunts R_8 and R_9 on the AC and DC voltage ranges



RC357

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A more elaborate solution, which some constructors might like to incorporate, is to adjust the sensitivity of the basic meter to compensate for the factor of 1.11 which is introduced when reading RMS AC volts. Such compensation will only bring the scale readings correct when the applied voltage has sine waveform. It is achieved by shunting the basic meter with two different resistors. When used for the measurement of DC volts, it has a full-scale deflection current of 1.11 times the current required when connected to the rectifier. A circuit for achieving this is shown in Fig. 4. It will be seen that a 3-pole switch is required, although this may be part of a selector switch already incorporated in the instrument. When switched to DC the shunt resistor R_8 is connected across the meter. It is usually convenient to make this resistor equal in value to the internal resistance of the meter, R_m, in which case the full-scale current for the meter will be doubled, i.e. a basic 500µA meter will take 1mA to give full-scale deflection. It is important to remember that the *modified* full-scale current must be used in the calculations to obtain the values of the multiplying resistors R_4 to R_7 as described above. Also, the value of internal resistance, used in these calculations, is the resultant of the meter resistance, R_m, and the shunt resistor, R_8, in parallel. If these resistors are made equal, then the *effective* internal resistance is $\frac{1}{2}R_m$. Now when switched to AC, the meter must read 1.11 times higher. This results in AC volts being indicated accurately when applied to the same inputs, namely V_1, V_2, V_3 and V_4, as were used for the DC ranges. The shunt R_9 must therefore be of such a value that:

$$R_9 = \frac{1.11\ R_8}{0.89} = 1.25\ R_8$$

In practice this ratio may be found by experiment.

Another feature which can be readily added to this kind of meter is a continuity

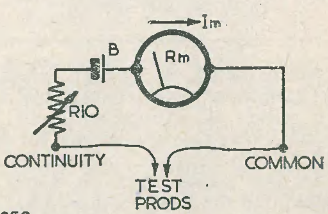

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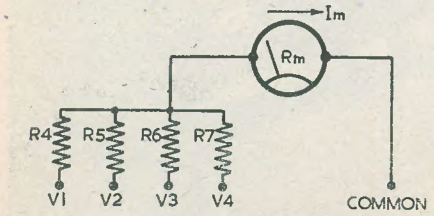
Fig. 5. The meter used as a continuity tester. "B" is a dry cell

tester. It consists of a single dry cell and a variable resistor connected to the positive terminal of the meter, as shown in Fig. 5. Two leads and test prods enable wiring to be traced readily. The prods are first held together and the variable resistor R_{10} adjusted so that the meter reads full-scale.

basic meter is I_m and its internal resistance R_m, then:

$$R_1 = \frac{R_m I_m}{(I_1 - I_m)}$$

The two tapping points R_2 and R_3 may, in practice, be determined by experiment as described later, but for those who wish to



RC355

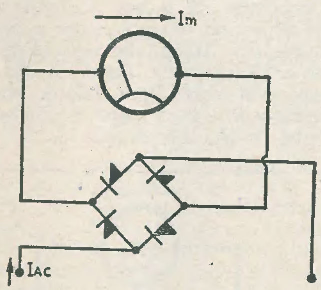
Fig. 2. The milliam meter and multipliers arranged to give a number of voltage ranges

calculate them an adequate approximation may be made by taking:

$$R_2 = \frac{(R_m + R_1)\, I_m}{(I_2 - I_m)}$$

Similarly:

$$R_3 = \frac{(R_m + R_1)\, I_m}{(I_3 - I_m)}$$



RC356

Fig. 3. Method of connection for the meter rectifier

For the voltage ranges, by the application of Ohm's law, the meter is made to measure the current through a known resistance. A separate resistor is provided for each range and each resistor can be connected in series with the meter, as is shown in Fig. 2. A common negative terminal can be used and a different positive connection provided for each voltage range, designated V_1, V_2, V_3 and V_4 in the figure. For a 500μA meter, suitable voltage ranges are 0.5V, 5V, 50V and 500V. With a 1mA meter, ranges of twice these values make dial readings convenient. The "multiplying" resistors, R_4, R_5, R_6, R_7 are all calculated in the following manner: where V is the full-scale voltage range required and R is the appropriate value of multiplying resistor for that range:

$$R = \frac{(V)}{(I_m)} - R_m$$

where I_m and R_m are the full-scale current and internal resistance respectively of the basic meter.

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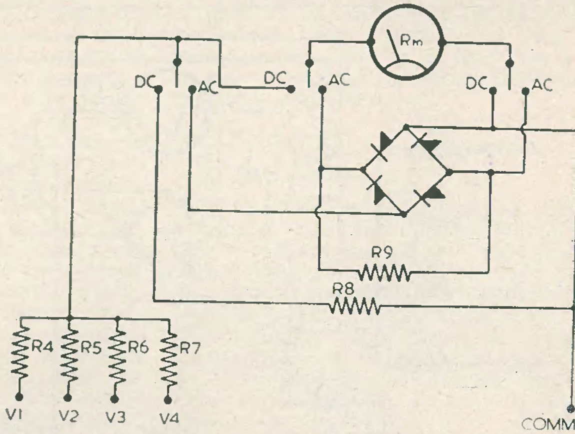

RC357

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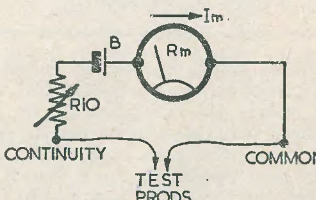

RC358

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tester. It consists of a single dry cell and a variable resistor connected to the positive terminal of the meter, as shown in Fig. 5. Two leads and test prods enable wiring to be traced readily. The prods are first held together and the variable resistor R_{10} adjusted so that the meter reads full scale.

During circuit tracing, a similar indication means that a direct connection has been established while a reading over only part of the scale shows that a finite resistance exists between the test points. Since larger resistances result in smaller deflections, a little experience soon enables the approximate values of resistance to be judged. The meter may thus also be used for detecting short circuits in such components as capacitors and transformers. It is not recommended that the meter be scaled in "ohms", because without more elaborate circuitry the indications depend upon the state of the dry battery, and this is obviously uncertain. It is far better to construct a separate simple measuring bridge for checking the actual values of components, since this can be made to measure capacitors and inductors as well as resistors.

A Simple Practical Instrument

A circuit diagram of an instrument designed on the lines described above is shown in Fig. 6, and the appearance of the completed unit can be seen from the accompanying photographs. A 2-inch dial ex-government 500µA meter was used as the basic movement and this is mounted in the centre of a paxolin panel. The multiplying resistors, shunt and rectifier are wired into the circuit at the back of the panel. One "common" terminal is provided and there is a separate terminal for each of the current and voltage ranges. For those who prefer to use the same pair of input terminals for all ranges, a multi-way switch could obviously be arranged to connect the input terminals to the appropriate part of the circuit. A word of warning is necessary here, however, since the contacts of this switch must be capable of carrying up to 0.5A (on the highest current range) and withstanding potentials in excess of 700 volts peak (on the highest AC voltage range). The ordinary wave-change type of wafer switch is not usually satisfactory in these respects. A terminal is also provided for

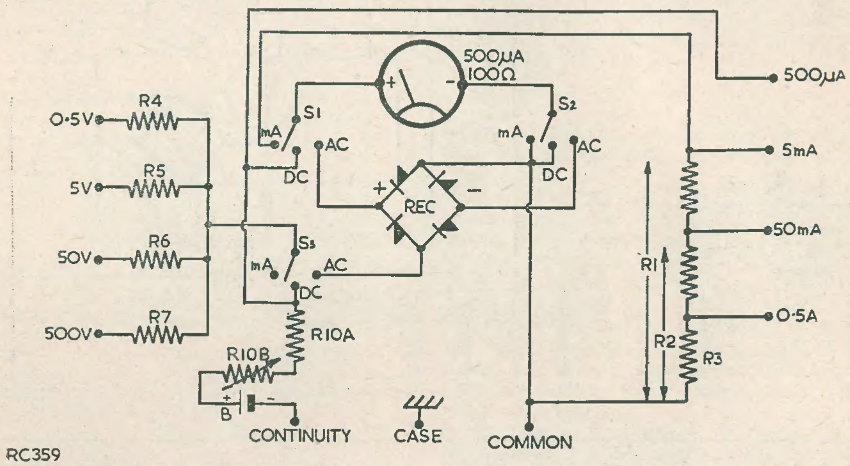


Fig. 6. A practical circuit

Meter
500µA
100Ω internal resistance.

Switch
3-pole, 3-way ganged (S1, S2, S3).

Rectifier
500µA bridge-type meter rectifier (Rec.).

Battery
1½ volt, pen-cell (B).

Resistors
900Ω (R4), 10kΩ (R5), 100kΩ (R6), 1MΩ (R7) — 1% accuracy
2.5kΩ miniature variable (R10B).
2kΩ ¼watt (R10A).
Current shunt (R1, R2, R3)—see text.

continuity testing, making a total of 13 ranges. One of the two knobs on the front panel is for the selection of "AC volts," "DC volts" and "milliamps," while the other is the zero adjustment for continuity testing. A terminal is also provided for earthing the metal box which contains the instrument. A clip, made from a small piece of sheet brass, is bolted to the front panel and holds a pen-torch cell in position. The body of the cell connects with the clip while another brass contact strip bears against the central positive pole of the cell.

It will be seen from the circuit that, in the interest of simplicity, no compensating shunts are used on the voltage ranges. Since the same terminals are used for both "AC volts" and "DC volts," the meter reads *average* voltage on the AC ranges, and this must be remembered when making measurements, as explained earlier. Also, in order to make use of the maximum current sensitivity of the meter, the lowest current range (500µA) is operative when the instrument is switched to "DC volts." The remaining current ranges, however, depend upon the universal shunt (R1, R2 and R3) and this is brought into circuit in the "milliamps" position of the selector switch. The continuity-testing circuit is available when the selector is set to "DC volts."

Construction

When a suitable meter has been obtained, it is first necessary to determine the value of the internal resistance. This may be marked on the meter dial, but, if not, the following method of determination gives a result of sufficient accuracy.

Set up the meter in series with a dry battery and fixed resistor so that a deflection near the full-scale is obtained. A 9-volt battery and a resistor of 20kΩ is about right for a 500µA meter. Note the meter reading. Now connect a resistor of *known* value across the meter and without further disturbing the circuit, again read the meter. The known resistor (which, if not clearly marked, should have been checked on a friend's or serviceman's ohm-meter) should have a value of around 100 ohms. If the two readings of the meter are I_1 and I_2 respectively and the known resistor had a value of R, then the meter internal resistance, R_m, is given by:

$$R_m = \frac{R(I_1 - I_2)}{I_2}$$

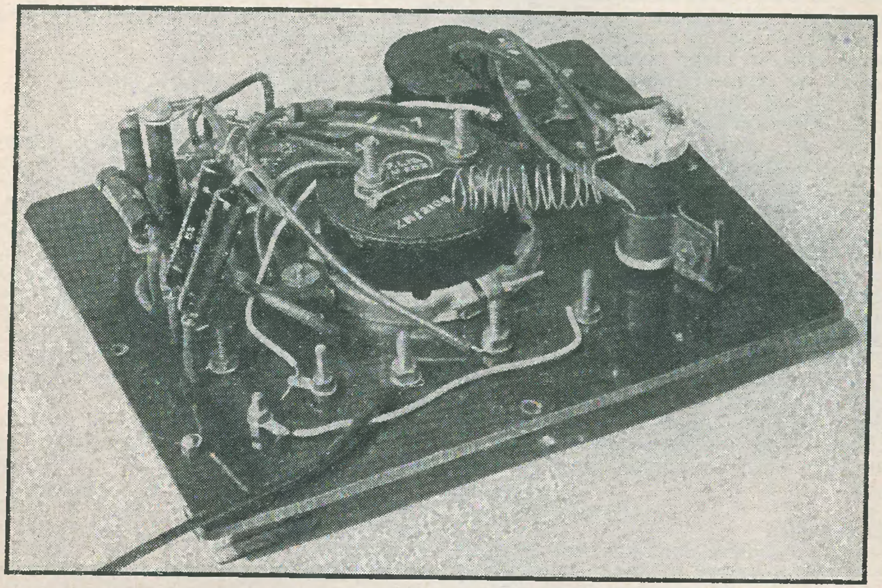
Having determined the value of the internal resistance, R_m, it is now possible to calculate the value of the shunt for the current ranges (R_1) and the tapping points required (at R_2 and R_3) as described earlier. In the instrument illustrated, section R_3 of the shunt was made from stiff nickel-chrome wire (from a new 1 kilowatt electric firebar) and suspended in the wiring. The remaining sections of the shunt were wound with a convenient gauge (actually 28 swg) of resistance wire on to a small porcelain former. Calculation showed that the required resistance values were:—

$R_1 = 11.1$ ohms.
$R_2 = 1.12$ 0hms.
$R_3 = 0.111$ ohms.

When assembling the instrument, lengths of wire to make the three sections of the shunt should be cut off with something to spare. The shunts may then be accurately adjusted by connecting the instrument in series with another of known accuracy, and shortening the shunts until the readings agree. When carrying out this procedure, R_3 should be adjusted first and then left alone while the end of R_2 is cut to length. Finally, the positive end of R_1 should be adjusted to bring the lower current range correct.

If a calibrated meter cannot be obtained for comparison, a satisfactory method is to set up a circuit in which the multi-range meter can be connected in series with a battery and an adjustable resistor so that a steady current passes. The battery should be of at least 9 or 10 volts. The meter is operated on its lowest current range, where the shunt is not in circuit. The resistor is then adjusted so as to obtain nearly full-scale deflection. The meter is then connected to the next highest range and the shunt adjusted until the meter reads one-tenth of its previous value. The adjustable resistor is next altered so as to increase the current until full-scale deflection is again reached. The meter is then changed to the next highest range and the relevant section of the shunt altered until a reading of one-tenth the previous indication is obtained. This procedure is repeated until all the sections of the shunt have been cut to length. With a little patience, the factor of 10 between each current range can be readily achieved.

The values of the resistors for the four voltage ranges are given in the list of components. These resistors should preferably be of the type with a guaranteed accuracy of 1%, although 5% may be good enough for many purposes. The multiplier for the 0.5 volts range may have to be made up from two or more resistors in series or in parallel, if the exact value is not readily available. The zero-adjusting resistor, R_{10}, is split in two parts. The fixed portion, R_{10A}, ensures that a current sufficient to damage the meter cannot pass if the variable resistor R_{10B} is inadvertently turned "all out" when the test prods are shorted. Sufficient adjustment is still available on the 5-volt AC range. For the same reason, the 0.5V AC range can be little more than a *voltage detector*. AC voltages indicated on this range will always be much higher



Rear view of the practical instrument, the circuit of which is given in Fig. 6

variable resistor R_{10B} to enable full-scale deflection to be reached until the battery potential has fallen to 1 volt.

Operation

The operation of the instrument requires no special comment. Test leads are simply connected to the common terminal and the terminal appropriate to the range desired. Correct polarity should be observed on DC and the selector switch set to the required position. When in any doubt as to the right range, always use the highest one to start with. If the deflection is less than one-tenth of full-scale, the connectors may then be changed to the next lowest range.

Owing to the characteristics of the rectifier, indications of AC volts below about 1 volt are inaccurate. This should be remembered when working near the lower end of the than the readings shown on the meter. This range can, however, be used for the detection of small AC voltages where their actual values need not be known. These limitations do not, of course, apply to the DC voltage range.

For those who wish to fit compensating shunts for the AC and DC voltage ranges, as described earlier, reference should be made again to Fig. 4. R_8 should be connected between the "common" terminal and the "DC" tag on switch pole S_3 (which may be seen in Fig. 6). R_9 can be connected directly across the DC output corners of the bridge rectifier (marked + and − in Fig. 6). As mentioned before, the use of such resistors modifies the effective internal resistance, R_m, of the meter and thus alters the lowest available current range. The values of all the resistors also have to be re-calculated.

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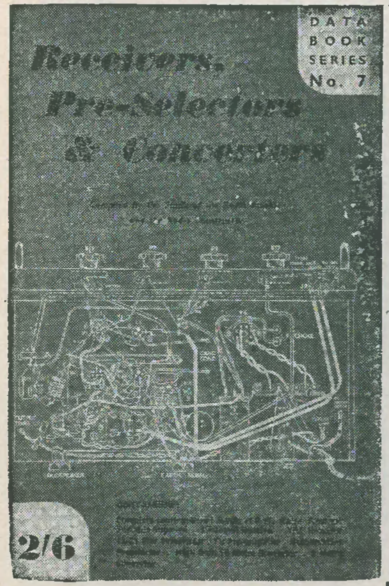

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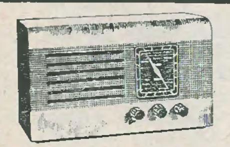

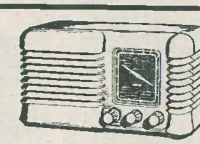

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NOTE: We would respectfully suggest to those interested in building these receivers that OUR circuit diagrams be compared with those of other firms. Intending constructors can then judge for THEMSELVES which Instruction Booklet is the most comprehensive.

Instruction Booklet and priced Parts List for either of the above available separately at 1/– each. This money will be refunded if circuit diagram is returned as NEW within 7 days.

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PRIVATE

FOR DISPOSAL Truvox Tape Deck. Best offer around £15. J. Davidson, 50 Lorne Gardens, London, E.11. Tel.: WAN 9912.

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