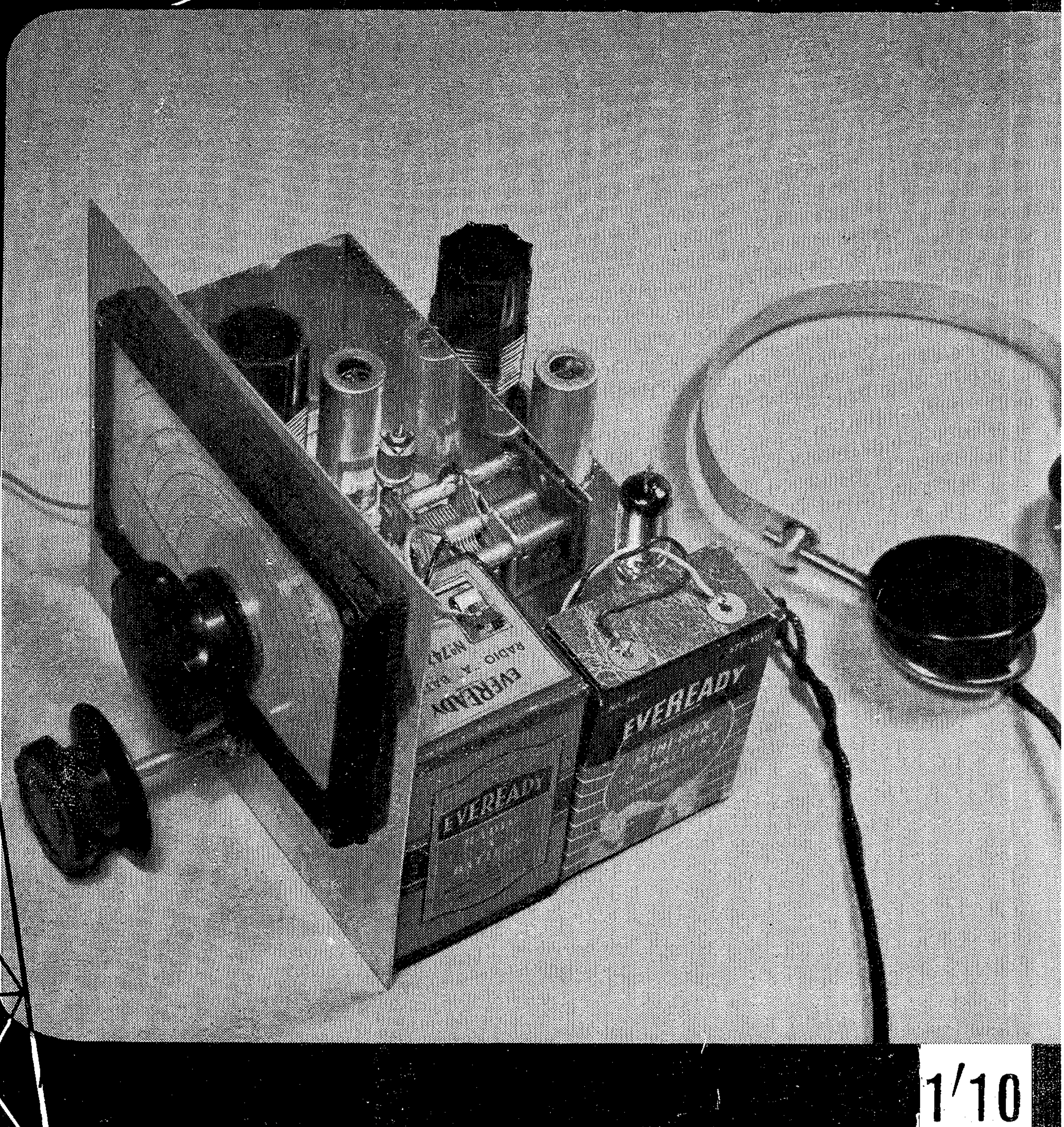
RADIO *and* ELECTRONICS



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THE SHORT-WAVE MINIATURE THREE

This little set is a living example of the fact that the regenerative T.R.F. still has its usefulness in spite of the universal popularity of the superhet for more ambitious purposes. With its modern miniature battery valves, and its miniature batteries, it represents a considerable advance on what could be done with the same basic circuit in the past, when regenerative sets were used much more than they are today.

INTRODUCTION

It has for some time been the habit of many radio enthusiasts to decry the once-popular regenerative set. Nothing less than the latest commercial communications receiver for them, they say, completely forgetting that there are many occasions when this sort of set, however superlative its performance may be, is quite useless. For example, the newcomer to radio as a hobby, whether as a constructor, or a budding "ham," often realizes that to outlay a hundred pounds or more on a commercial receiver will not teach him anything about the practical side of radio design and construction. Nor, if he is new to the game, will it do him much good to tackle the construction of a complex superhet whose principles of operation he barely understands, as yet. For him, the logical set to start off with is the regenerative. The outlay for parts and valves is not excessive, the possible faults in building and components are much smaller in number, and he has a perfectly good chance of "making it go" if it does not at first work properly. Again, once he has built such a set, it will be extremely useful to him, because in spite of the limitations of a simple receiver, it will very rarely show up to such great disadvantage that he longs for a large and lusty superhet instead. Indeed, many of us who have been in the game for a long time, and who have become quite blasé about everything except the "hottest" multi-valve receivers, have quite forgotten how well a set of this nature can perform. For low noise level and high sensitivity, together with quite adequate selectivity for all ordinary purposes, and combined with low first cost, the set that used to be described as "one of R.F., detector, and one of audio" takes quite a lot of beating, even today. And where a small, easily portable receiver is needed, as when camping, there is no kind of set which will give comparable performance for the same size and weight.

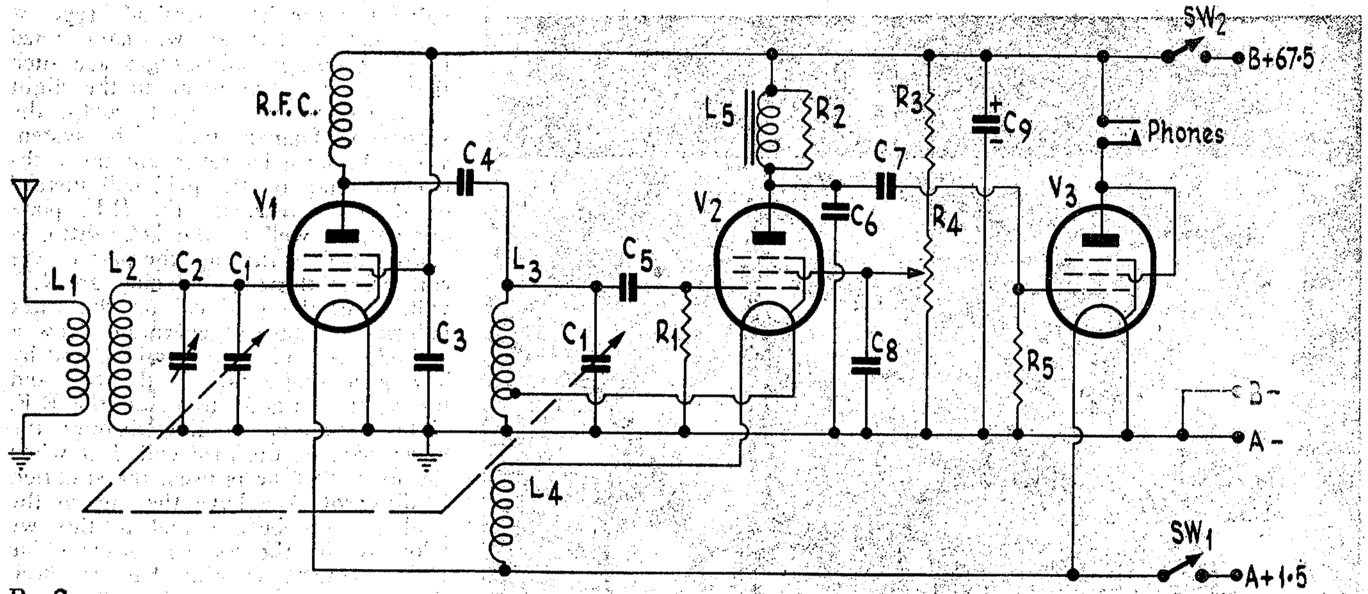
It is with these ideas in view, then, that we present this little set. It is intended for short-wave only, and covers from 3.5 to over 30 mc/sec., with three sets of plug-in coils. It uses three 1T4's, which with their diminutive size and small current drain, make an ideal line-up. Their characteristics are a great improvement compared with those of the older battery valves—30, 32, and 34—so that with modern components used throughout, it is possible to make from them a receiver which will give a much better performance, on many counts, than would the same theoretical circuit several years ago. If there are any who wish to build it as a stand-by receiver for the ham shack, for emergency use (and we think there should be many) they will be amazed at its sensitivity and at the way it can bring in the distant and weak signals. For the DX-er, who wants to carry on his hobby while away from his main receiver, or the amateur transmitter "gone mobile," we think it will fill the bill exactly, and at very small cost too.

CIRCUIT FEATURES

Perhaps the first thing to note about the circuit is that it uses the same valve type in all three positions in the set. For emergency or portable use, this is a distinct advantage, as it should be necessary to carry only one spare valve instead of possibly three. In addition, there is no loss of efficiency in so doing, since the modern sharp-cut-off pentode, as exemplified by the 1T4, is designed as a radio frequency amplifier, can act as a very reliable and sensitive detector, and can also be strapped as a triode, making an excellent audio amplifier.

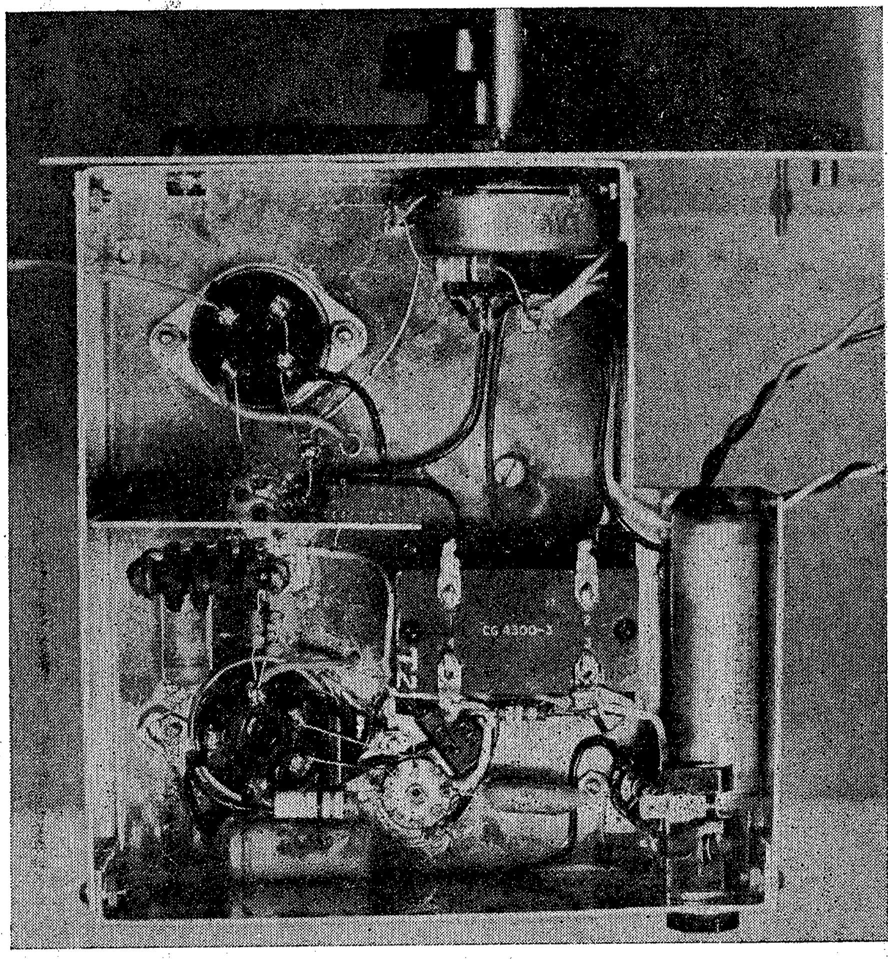
The R.F. amplifier circuit is one which has never been very popular in any kind of set, but which in this application, has much to recommend it. We refer to the method of coupling from the plate of the R.F. amplifier to the grid of the detector valve. In the early days of regenerative sets, this scheme was frowned upon because mica condensers were not all they might have been, so that leakage was able to damage the detector, and at the best to cause unwanted crackling noises in the output. Also, the older valves had rather higher inter-electrode capacities than their modern counterparts, so that the direct connection of the output capacity of the R.F. valve across the detector's grid circuit had the double effect of limiting the tuning range, and, which was probably more important, of making it difficult to obtain good tracking between the R.F. and detector tuned circuits. In fact, it was almost unheard of to gang the tuning of such a set without using a panel-controlled trimmer in the aerial circuit. In this set, however, it has been found entirely practical to dispense with an aerial trimmer, and yet to have accurate tracking between the two circuits. This is done by using a pre-set trimmer, C_2 on the circuit diagram. This is set at the right value to make the stray capacities across the aerial circuit equal to those across the detector circuit, as a result of which the coils can be adjusted to have identical inductances, thereby keeping the circuits in tune with each other at all points on the dial, and on all coil ranges.

The method of regeneration used is a variation of one which has always been very popular for regenerative detectors employing an indirectly heated cathode, but which requires a slight modification to make it usable with a filament type tube. We refer to the use of a grid coil tapped a few turns from the "cold" end, with the cathode of the valve connected to the tap. With this arrangement, the usual method of obtaining regeneration control is to provide a panel control of the tube's screen-grid voltage, and this feature has been retained. This method of obtaining and controlling regeneration is perhaps the best that has yet been devised. It gives a very smooth control, with no suggestion of "plops" when the circuit goes in and out of oscillation, and causes practically no de-tuning of the signal, even when the detector is very near the threshold of oscillation. These two attributes are perhaps the most important ones for a regenerative detector to possess, because they make it easy to adjust the set for maximum sensitivity, and particularly easy to tune, even on weak signals. Another important advantage of the scheme is that, unlike others, it does not require widely different settings of the regeneration control at different positions of the tuning



R_1, 2 meg.
R_2, 250k. (See text).
R_3, 25k.
R_4, 50k. pot. with D.P.D.T. switch.
R_5, 10 meg.
L_1, L_2, L_3, L_4, see text.
L_5, audio transformer primary (see text).
R.F.C., 2.5 mH. R.F. choke.
V_1, V_2, V_3, 1T4.
A battery, 1.5v. type 742.

B battery, 67.5v. type 467.
C_1, midget 2-gang, 100 $\mu\mu$f. max. capacity per section.
C_2 3–30 $\mu\mu$f. trimmer.
C_3, 0.05 μf.
C_4, 50 $\mu\mu$f.
C_5, C_6, 100 $\mu\mu$f.
C_7, 0.01 μf.
C_8, 0.1 μf.
C_9, 8 μf. electrolytic.

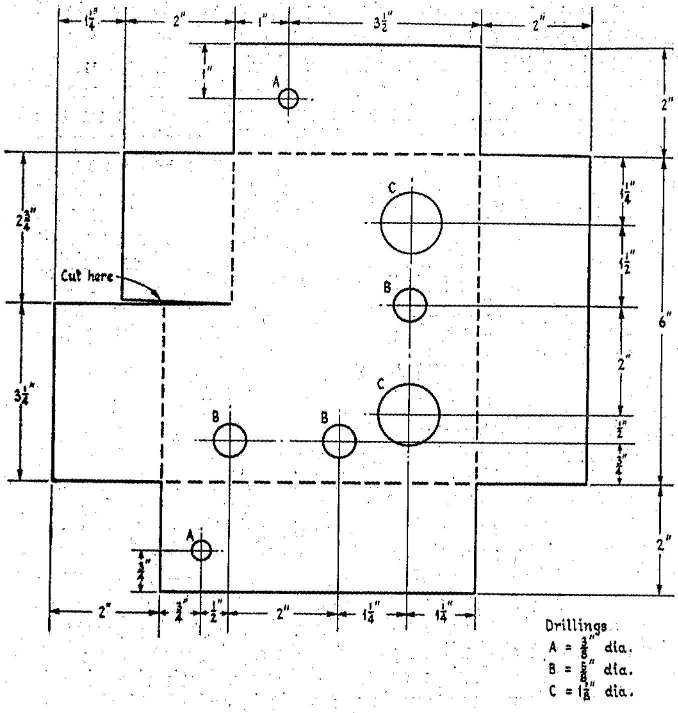


condenser; and as a by-product, the sensitivity does not vary much from one end of the wave range to the other. Those who have built many sets of this kind will remember how annoying it is to have to try and adjust a detector that plops in and out of oscillation instead of taking up smoothly and almost imperceptibly, and how, with a set that does this, one always knows that with a smooth control, the usable sensitivity would be greatly increased. Also, there is nothing more annoying than a set in which small changes in the setting of the regeneration control necessitate constant adjustment of the tuning condenser. In bad cases, a slight movement of the reaction control is often sufficient to cause the signal to disappear altogether, so that one has to start searching again in order to find it. Actually, although the regenerative set is often despised, or discounted as "elementary," there is a real art in getting the best out of a circuit when it has to be designed and built from scratch, and there are many whose objections to it really arise from the fact that they themselves have never been able to build a satisfactory one through insufficient attention to the several apparently small points, that nevertheless make quite a difference to the final performance. However, there is seldom any difficulty in duplicating the results from a well-designed regenerative set, as long as the necessary precautions, as recommended by the designer are adhered to, and those who decide to build this one need make no apologies to the scoffers, if any!

The cathode-tap-cum-screen-control method of regeneration is certainly less trouble to apply when the detector valve has the heater-cathode type of construction, but as we have tried to point out, its advantages are such that it really pays to go to the slight extra trouble necessary to adapt the scheme to filament tubes. The system works because by returning the cathode to a tap on the grid coil instead of directly to earth, the R.F. plate current, as well as the D.C. ditto, is caused to flow through the part of the coil below the tap, inducing an R.F. voltage in the grid coil in the right polarity to cause regeneration. Now a cathode has only one terminal, and by having a single tap on the coil and taking the cathode to it, *all the* R.F. plate current has to flow through the lower part of the grid coil. But when the filament tube is used, the situation is different. We have the tap on the grid coil, as before, and to this we take one of the filament leads. The D.C. filament current has to flow through part of the grid coil, therefore, but this does not matter, because the resistance of the short piece of wire that makes up the coil is so small as to have no effect on the filament current. Now suppose we take the other end of the filament straight to the A battery. The latter, as well as providing direct current at 1.5 volts, acts towards alternating currents, and therefore towards R.F., as a very efficient bypass condenser. Thus, if we were foolish enough to expect such a scheme to work, we would be disappointed, because the A battery would act as a very effective short circuit for R.F., making the part of the coil below the tap completely ineffective, both as part of the tuning coil, and as a means of coupling part of the plate current into the grid circuit. One way out of the difficulty would be to insert an R.F. choke in the lead between the A battery and the free end of the filament. This would prevent the battery from short-circuiting the R.F. present on the filament, and would enable the scheme to work. The only difficulty would be that the choke used would have to have a very low D.C. resistance, so as not to drop the voltage actually applied to the filament. The usual short-wave R.F. choke of about 2.5 millihenries has a resistance of around 30 ohms, so that these could not be used. If a suitable low-resistance R.F. choke were specially made, it would be very bulky, and would almost certainly give trouble in other ways, so that the R.F. choke scheme is not really practicable. What we do instead is as follows. Suppose, for example, that the negative filament terminal is connected to a tap on the grid coil five turns up from the bottom of the coil. We now wind five turns over the top of the bottom five of the grid coil, take the upper end of this extra winding to the positive filament pin of the valve, and the other end to the postiive terminal of the battery. How does this scheme work?

Well, we now have two parallel paths by which R.F. components of plate current can flow to earth from the filament of the valve. One through the negative filament pin and the lower five turns of the grid coil, and the other through the positive filament pin and the extra five-turn winding we have added. These two paths enable half the R.F. plate current to pass through each, and this will actually happen, because whatever the impedances of the paths may be at any particular radio frequency, they will always be equal, because each path consists of the same number of turns of wire, wound in the same way exactly, and coupled to the grid coil in the same way. Anyway, all the R.F. plate current must pass through one or other of the filament legs, and both legs are coupled to the grid coil, and will thus produce regeneration. This brief description of the working of the arrangement may not be strictly accurate, but from the functional point of view it is close enough to the truth to enable one of see why it works, as compared with the use of only one filament leg, which does not.

The plate circuit of the detector is choke-capacity coupled to the grid of the audio amplifier. This is very much better than the somewhat cheaper one of using resistance-capacity coupling, which is not very desirable as a means of coupling a regenerative detector to a succeeding audio amplifier stage. The reason is that a resistor considerably drops the voltage applied to the detector plate, thereby reducing the sensitivity of the detector. It is necessary to have a very high impedance in the plate circuit, and as far as the detector sensitivity is concerned, the higher the better. But it is undesirable to have a D.C. resistance of more than a few thousands of ohms, so that the A.F. choke is obviously the best sort of load impedance to use. Its impedance may be several hundred thousand ohms, but its D.C. resistance may be only a few thousand ohms. Thus, the plate voltage is kept high, and the gain is increased, both because of the high plate voltage and the high impedance of the choke. In commercial receivers and amplifiers, audio frequency chokes are very rarely used these days, but it is a simple matter to buy a small and cheap audio transformer and use one of its windings as a choke, the other being left unconnected. The correct transformer to use is any small inter-stage transformer with a step-up ratio of 3:1 or higher. An output transformer *could* be used as long as care was taken not to use the secondary winding, but it would not be likely to give as much gain as a small inter-stage transformer. The best method of using the transformer is to tape up the secondary leads so that they cannot come into contact with each other or with anything else, and then pretend that the secondary winding does not exist. The primary is then wired into the circuit. The purpose of the resistor R_2 should now be explained. Old hands will know all about "fringe howl," but for those who are perhaps building their first regenerative set, it will be a treat in store! Fringe howl is a very annoying and troublesome defect that often occurs in regenerative receivers. If one knows the cure (which is very simple) all is well, but should one not, it can render the set almost useless. It functions this way. When the reaction control is advanced in order to bring the set just to the point of oscillation (at which point the sensitivity is greatest) a loud howl is heard in the output, just *before* the proper R.F. oscillation of the detector commences. As a result of this howl, it is quite impossible to set the controls so that the detector is *just not* oscillating. It is either quite a long way from oscillation, in which case the sensitivity is too low for all but the strongest signals to be heard, or else it is actually oscillating, when 'phone stations cannot be listened to, even though their presence can be detected. Or, of course, it is producing this ear-splitting howl, too strong for anything else but an air-raid siren to be heard! This is what fringe howl does. Actually, it is an oscillation at some audio frequency, and its mechanism is rather too advanced for description in an article such as this. The main point is to know how to cure it



Note that all folds should be made downwards.

should it occur. This is effected simply by shunting a resistor of high value across the detector's audio choke. The value needed to stop it will vary from set to set, so that builders may have to experiment with values to find just what is necessary. The idea is to use as high a value as possible, consistent with removing the howl. A very low value would certainly stop the howl, but it would also greatly reduce the sensitivity of the detector. In the original model the best value was 250k., but since no two transformers are the same, readers can expect to find quite large variations in the value required. Another point to remember is that fringe howl starts more easily when the batteries are nearing the end of their life, and is harder to cure the greater the internal resistance of the B battery. Thus, when the value of R_2 is chosen with new batteries in use, it may be found that when the B battery is nearly finished, the howl reappears. All that will have to be done, should this occur, is to put in a new R_2, of low enough value to stop the howl, even with the flat batteries. Then, it will not be necessary to change the value of R_2 again.

CONSTRUCTION

Many radio enthusiasts in the past have not paid sufficient attention to the mechanical construction of their gear, and no doubt there are many who will do the same thing in the future also. Because we are primarily interested in circuits, we have a perhaps natural tendency to say, "Is this a good circuit?" rather than "Is it a good *set?*" The two things have quite different meanings. Because any set is only as good as its construction, whatever the theoretical advantages of the circuit may be. The circuit is less than half the story, because it tells us only the electrical part of the design, and does not indicate in the slightest degree how the set can be built, or what is a suitable way of building it. How many people have admired a certain set, and its performance, gone away impressed with the "circuit," and had no success in building one for themselves because they used a different mechanical lay-out, or a different method of wiring it up? What these people should have admired is the *set,* of which the circuit is only a shorthand way of saying *what* electrical connections should be made, not *how* they should be made. Of course, there is actually a great deal of latitude with some electronic devices. They can be laid out and wired up in a multitude of different ways, each of which will produce as successful results as the other. But other things, of which radio receivers are a good example, must be built in accordance with certain mechanical principles if they are to work properly. This does not mean that there is only one lay-out that will give a successful set from a given circuit—far from it. But we would like to impress on builders, and especially on newcomers to set building, that it is much more likely to be a successful receiver if it is built according to the recommended lay-out, because this one is one that has been tried out in practice, and found to work well. Even with a particular lay-out, there is some degree of latitude in the way in which the actual wiring can be performed, but it is our practice in this magazine to mention, as far as possible, all points about the wiring that need to be carefully followed. The photographs cannot give the exact position of all the small parts under the chassis, because some are unavoidably obscured, but we ourselves think, and there will be many that agree with us, that to give every detail, down to the exact position of the last ½-watt resistor, does not help anyone to become proficient at set-building. To get the greatest enjoyment out of building electronic equipment, one must learn enough to design one's own gear, both the circuit and the physical construction, and it is only by leaving a little to the initiative of the constructor that he is able to profit by experience. We hope, therefore, that our readers will agree that it is a good thing that we do not print detailed wiring diagrams showing the position of every component on the chassis. The complete tyro will in any case do better to get an experienced radio man to show him the small points about actual construction that he is unsure about, thereby learning a practical craft in the most practical way.

We have embarked on this rather long dissertation on construction in order to impress new readers with the fact that the way in which a set is built is every bit as important as the circuit it is built from. Ask anyone who now makes a neat, workmanlike job of his wiring whether or not it really pays! And then witness the disappointment of one who has made a very rough, untidy job of wiring, and finishes up with a set that does not work—and probably will not unless it is rewired!

The general appearance of the set can be seen from this month's cover photograph, which gives a partial view of the front panel and the top of the chassis. Unfortunately, this photo suffers rather from reflections occurring in the polished aluminium of the shield partition that separates the R.F. stage from the detector and audio tubes. However, if this photograph is taken in conjunction with the diagram of the chassis it will be quite easy to follow the the lay-out. The two large (1⅛ in. diameter) holes on the chassis are for the valve sockets which hold the plug-in coils. The one near the front edge of the chassis is for the R.F. coil, and immediately behind it is the R.F. amplifier valve, V_1. Then comes the shield partition, and directly behind the R.F. valve, but on the other side of the shield is the detector coil. The valve next to this coil is, of course,

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the detector, while the remaining $\frac{5}{8}$ in. hole is for the audio valve's socket. On the chassis front is a $\frac{3}{8}$ in. hole which takes the reaction control potentiometer, R_4. This hole is so placed that it comes in the centre of the front panel, but, owing to the cut-out which allows the A battery to be set in flush with the outside of the B battery, when the latter is placed against the side of the chassis, the hole is *not* in the centre of the front of the chassis. The main dial is centred on the hole for the potentiometer shaft, but is directly above it, so that if on the chassis drawing a line is drawn parallel to the sides, and passing through the potentiometer's mounting hole, this line will show the position occupied on the top of the chassis by the shaft of the tuning condenser. The latter is a midget two-gang type, and in the photograph looks as if it is all on the panel side of the shield partition. But what appears to be the second half of the gang is really a reflection of the front half. Actually, the shield partition is cut out so as to fit round the centre plate of the gang condenser, and the back section is hidden behind the shield in consequence of this. If the under-chassis photo is consulted, it will be noted that mounted right across the socket of the R.F. valve is a small partition. Its purpose is to shield the portion of the aerial and grid circuit that is under the chassis from the similar portion of the detector grid circuit (and R.F. plate circuit therefore).

In this view can be seen the four-pin Amphenol-type valve socket used for the aerial coil, the five pin socket for the detector coil, and the miniature ceramic R.F. amplifier valve's socket, with the shield across it. Also visible is the reaction potentiometer, the transformer used for L_5, the detector's ceramic socket, the phone jack, and a number of the small parts. The large condenser under the phone jack, and tucked into the corner of the chassis, is the electrolytic, C_9. Also to be seen are the leads out to the batteries, and the cut-out on the right-hand side of the chassis in which the A battery is fitted. The socket for the audio tube can be glimpsed at the left-hand side of the phone jack, with C_7 running between the plate pin of V_2 to the grid pin of V_3. Between the five-pin coil socket and the underneath shield partition can be seen the four-pin 2.5 mH. R.F. choke in the plate circuit of the R.F. tube. One end is connected directly to the plate pin of the tube's socket, while the other end is securely anchored to an insulated solder lug mounted on the chassis near the valve socket.

PERFORMING THE WIRING

In a set of this nature, the best results are obtained if the wiring is done by the shortest and most direct routes, except in cases where the length of a lead is of no consequence. In building any gear that uses valves, it is essential to know which leads must be kept as short as possible, and which can be made of any desired length. This knowledge alone can make all the difference between the gear working well or not at all, and is very worth-while knowledge to acquire. Partly it comes from experience, and partly from common sense, and as one's radio knowledge grows, so does one's innate "wiring sense," for want of a better term. For the newcomers (and be it whispered for some of the not-so-newcomers) here are the main rules to be watched.

(1) Leads carrying R.F. currents or voltages should be as short as possible.

(2) R.F. leads in the grid and plate circuit of the same valve should be as far as possible from each other as is consistent with (1) and should preferably be on opposite sides of a shield partition.

(3) Coils in the grid and plate circuits of the same valve should be shielded from each other, either by enclosing them in shield cans, or by the use of partitions or compartments built into the chassis.

(4) Bypass condensers should be connected as close as possible to the points which they are supposed to bypass, *e.g.*, C_6 in the present circuit, whose job it is to make the R.F. voltage at the plate of V_2 as small as possible without affecting the audio output voltage of the valve.

(5) If possible, it is desirable, but not always essential to make one point on the chassis (*e.g.*, a single solder lug) an earth-point to which are

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Measuring Insulation Resistance

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.1 μf. condenser will have ten times the insulation resistance of a 1 μf. condenser of the same type. Consequently in order to compare the merits of condensers of different sizes, the insulation resistance is multiplied with the capacity. The insulation resistance is then expressed in megohm-microfarads; this quantity being the same for condensers of different sizes. A good condenser would have an insulation resistance of say 450 megohm-microfarads. This means that its resistance would be 450 megohms for a capacity of 1 μf., or 4500 megohms for a capacity of .1 μf.

Finally, the fact that a condenser has an insulation resistance which is low, is no definite indication that it cannot be used. It all depends in what circuit it is to be placed.

Amateur TV Project

(Continued from Page 28.)

procured our own multiplier photo-cells, and have built up a small two-stage pre-amplifier for a 931A, and it is with this that confirmation was made of the unsuitability of the green-screen P1 tubes. However, even with a short-persistence tube, it seems likely that a rather special video amplifier will be needed, with a response rising sharply at the high-frequency end of the video spectrum, so that as yet we will not describe this pre-amplifier unit, since it is likely to be considerably altered before being fit for actual picture-making.

Next month, therefore, it is proposed to describe a simpler deflection unit that will be more suitable for the VCR112 than the one already described. The latter was really designed with the VCR97 in view, and not the VCR112. The latter is not nearly so sensitive as the VCR97, and so requires much greater deflecting voltages to get the same amount of deflection. The new time-base unit will therefore have to include more amplification at least for the line time-base. Since this will necessitate more valves, it will probably be desirable to simplify the saw-tooth generator, if possible, so as not to bring the whole set-up up to an inordinate number of valves.

(To be continued.)

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taken all earths belonging to a single stage. This becomes progressively more important, the higher the operating frequency, and at very high frequencies should be made a major matter of policy.

The above points cover the main requirements for wiring any set, and are sound constructional principles, to be adhered to as far as possible. Sometimes they are mutually opposed, because it is clearly impossible to satisfy both (1) and (2) simultaneously, in that a miniature socket is a small affair, in which the grid and plate pins are actually close together, so that for at least some distance the grid and plate leads cannot be far apart. But here (3) comes to the rescue, for if opposite sides of the socket are shielded from each other then it clearly does not matter if the leads referred to are close together. The whole question is one which must be regarded with ordinary common sense, both when the lay-out of the chassis is being decided, and also in actually performing the wiring. If the chassis is badly laid out, it may be impossible to obey the rules of wiring set out above, and the art of laying out a chassis is simply that of arranging things so that the wiring *can* be done in accordance with the rules, while retaining, say good accessibility and appearance, to mention only two things.

In the next and final instalment of this article, the construction of the coils will be described in detail, and for the beginner, hints will be given on the operation of regenerative sets, that will apply not only to this one, but to any of the type.

(To be Continued.)

New Products

(Continued from Page 18.)

skill in both fundamentals and details. The foregoing make this an ideal unit for sound film applications.

T-25 SUPER SILENT TURNTABLE

A professional type turntable for amateur use, available with or without pick-up. The T-25 will rotate at constant speed. As a result, the "wow," "flutter" and "rumble" so often found in ordinary turntables have been completely eliminated. The wide margin of reserve power of the motor, and the inertia of the cast turntable overcome the common tendency to slow down on the heavier passages and more violent transients. The motor, mounted on floating buffers, is synchronous and gives constant correct speed, at either 78 or 33⅓ r.p.m.

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NEW DECCA STYLI

W. G. Leatham Ltd., announce that the new Decca styli suitable for long-playing records, and all models of Decca heads are now available.

THE SHORT-WAVE MINIATURE THREE

PART II: MAKING THE COILS AND OPERATING THE SET

In the first instalment of this article, which appeared in the March 1951 issue of *Radio and Electronics,* the circuit and construction of the set was described, and photographs of the prototype were featured so that builders would be able to duplicate the original layout as closely as possible. In this, the final instalment, details of the coils are given, and this is followed by some tips on operating the set so as to get the best results out of it.

MAKING THE COILS

The set covers the whole of the normal short-wave range of 3 to 30 mc/sec. To do this, three sets of two coils per set are needed, making six coils in all. They are not difficult to make, being wound on commercially available coil formers with enamelled wire that is in all cases thick enough to be quite easy to handle. The numbers of turns on all winds are given in the table below:

	L_1	L_2	L_3	L_4	Tap on L_3
RANGE A					
No. of Turns	5	26	26	3½	3½
RANGE B					
No. of Turns	4½	13	13	2½	2½
RANGE C					
No. of Turns	2½	5½	5½	2½	2½

NOTE.—L_2 and L_3 for Range A are wound with 30-gauge enamelled wire. For Ranges B and C, these windings are of 20-gauge. For all ranges, windings L_1 and L_4 are of 30-gauge wire.

All coils are wound on ribbed formers, 1¼ in. in diameter. These formers are provided with bases carrying the pins with which the whole is plugged into the valve-socket holders, and which carry the electrical connections from the coils. The bases are held to the base of the former by a single screw, threaded into the bakelite, and so can be removed entirely while the windings are being put on. To hold the windings on the former, small holes are bored in it with a sharp instrument, such as scriber point, or a bradawl, with the business end filed down to a width of about one thirty-second of an inch. To commence a winding, one hole is bored in the former, close up to one of the ribs, and a short length of the wire threaded through, on to the inside of the former. It is then taken down to the bottom of the former, where there is a flange, with several small holes already provided. The wire is taken round the flange, to the outside of the former, and then passed down through the nearest hole, where it is left projecting. The wire can then be pulled taut without fear of its coming adrift. The required number of turns is now wound on, which brings the winding near the bottom of the former, and wire is held while a further hole is bored in the former. The wire is cut from the reel, leaving several inches to spare, and threaded through the newly-made hole, just as at the start of the winding. It is then brought out at the bottom of the former, as before, and anchored in a further hole in the flange. All the coils are space-wound. That is, L_2 and L_3 are wound with the turns spaced from each other by a distance equal to the diameter of the wire. This is easily accomplished in the following way. After the wire has been anchored for the start of the winding, a second piece of the same wire is temporarily anchored by passing it through the same hole as the main wire, but this time, taking it out through the top of the former, and simply bending it over. We now have two wires coming out of the starting hole, and these are wound on, side by side, so that the whole makes a solid winding, with the turns tightly pressed up to each other. On coming to the end of the winding, the additional wire is released, and springs away from the former, leaving the main wire wound on, very accurately spaced. Since bakelite formers are slippery, care is needed to ensure that after the spacing wire has been released, the turns of the main winding do not slip, or the spacing will be lost, and it will be necessary to start again.

ADDING THE SMALL WINDINGS

Of course, the main windings are L_2 and L_3, which are the tuning coils, and these should be put on first. Then the small windings can be added. In the case of L_1, the following procedure will do the trick. A small hole is bored in the former, five turns up from the bottom of the main winding. It will not be possible to do this without disturbing the spacing of the lower turns of the coil a little, but as long as its ends are secure, this does not matter. L_1 is then started from the bottom end, by reeving it through one of the holes provided in the flange. The turns are then wound on, in between the turns of L_2, until the ending hole, which has just been made, is reached. It is then passed through this hole, and taken down and anchored, as before. Since both windings are of the same wire, the turns will bed together closely, and will automatically correct the spacing that was displaced while boring the finishing hole.

On the other coil, L_4 is put on in a similar manner, but not until the tap has been added to L_3. The best way to do this is to wind L_3 completely for a start, and then bore a hole at the appropriate spot on the former. Just opposite the hole, the wire of L_3 is carefully scraped to remove the enamel, and the bare surface is tinned with solder as quickly as possible, so that the wire will not stretch with the heat and become slack. Then a short piece of wire is anchored to one of the flange holes, and taken up inside the former, and out through the hole drilled for it. A piece of the wire is bared and tinned, and soldered to the tinned spot on the main coil, and the tapping is completed. L_4 is then put on exactly as for L_1, except that in this case, the finishing hole is made about ⅛ in. from the hole for the tapping wire, and it is necessary to see that inside the former, the wires from the tap and from L_4 do not touch. If they did, the filament of V_2 would be short-circuited, and so would the A battery when connected up.

The coil for Range A will be the most difficult to make, because all windings are of the same relatively thin wire, but with the others, there will be plenty of room between the wires of the tuning coil to bore the necessary holes, and to wind the thin wire.

CONNECTIONS TO THE COIL SOCKETS

Readers will probably have noticed that we have not shown any schedule for connecting the various coil windings to the pins of the coil formers, and so to the coil sockets on the set itself. This has been done on purpose, because there is no particular virtue in using any pins for a particular winding, and builders may please themselves what pins are used for what. The best plan, to avoid possible confusion, is to mark on the circuit diagram the socket pins that it is intended to use. The best sockets to use are of the Amphenol type, and these always have the pin connectors numbered. These numbers should be inserted in the circuit diagram in accordance with the way the underneath of the set has been wired. Then, when it comes to making the coils, the windings can be terminated on the right pins to make the circuit correct when the coils are plugged in. If the top (grid end) of L_2 is connected to pin No. 4 on the socket when the coil is plugged in, then pin No. 4 must be connected to the grid of V_1 and to the stator of the gang condenser when the set is wired—or vice versa. Needless to say, all corresponding coils must be made with the same pin numbers connected to corresponding ends of the windings.

PUTTING THE SET INTO OPERATION

If the wiring has been done without any mistakes, and if the coils have been made properly, according to specifications, then the set should go at first switching on. However, it is a very good plan to do some checking before connecting any of the batteries to the set. Go over the circuit carefully, and see that none of the connections have been accidentally misplaced, or omitted altogether. When satisfied that the wiring is correct, give the coils a close examination and make sure that the windings terminate on the right pins on the former. For example, if the aerial end of the aerial coil has been taken to pin No. 1 on the coil, make sure that No. 1 connection on the socket actually goes to the aerial, and so on, for all the connections. Choose one set of coils for this check, and until the set works with this set, ignore the others altogether. The best set to use for initial testing is Range A, for it will be easier to get it going on this range.

If you are satisfied that all wiring, and coil connections are correct, it is time to connect the A battery. Turn it on, and then examine the valves very carefully—preferably in the dark. If the filaments are alight, it will just be possible to see it glowing a faint red in the dark, or in subdued light. In this way we can check that all three filaments are running. If one does not light, then re-check the filament wiring, and if this is O.K., the valve would be suspected. To test it, connect one tag of the headphones to the A battery, one filament pin of the valve to the other A battery terminal, and complete the circuit by touching the remaining phone tip to the other filament pin. Needless to say, if there is continuity, a loud click will be heard in the phones. If not, the filament is open, and the valve useless. Of course, for the test, the valve is removed from its socket, and the battery disconnected from the set.

When the filaments are all alight, the negative end of the B battery can be connected, the phones plugged in, and finally, the postive terminal of the battery connected. This also should give quite a loud click in the phones, as V_3 starts to pass plate current. The next thing to do is to test for oscillation. The aerial is left disconnected, and with the condenser gang set at about mid-scale, the reaction control, R_4, is slowly advanced, and a sharp watch is kept for the appearance in the phones of a rushing noise, which should appear as the reaction control is rotated. *Slow* operation of the control is essential, because it is easy to go past the right point, after which the noise disappears again. If this noise is found, as it should be, then all is well, and we can proceed to see whether it is obtained, as it should be, at all possible settings of the tuning dial. The position of the reaction control will be slightly different, according to where the tuning dial is set, but if all is well, there will be little change in its setting as the tuning dial is moved from one end to the other. If it is found that at the low-frequency end of the tuning dial, no setting of R_4 enables the rushing sound to be heard, it means that L_4, and a few turns of L_3 below the tap, should be squeezed up a little towards the rest of L_3. Only a very slight adjustment in this way can produce a large effect, and such adjustment may be all that is needed to make the reaction control work properly even if no oscillation can be found at any point on the dial for a start.

With the rushing sound, which indicates that the detector is oscillating gently, it will now be possible to connect the aerial to the set. Then by turning the main dial, signals should be heard as whistles, which are tuned over in turn as the dial is rotated. Pick a loud one, ignoring the very weak ones that may be heard, and set the dial as close as possible to the spot where the whistle descends to a low growl. Then, *very carefully,* back off the reaction control until the whistle disappears. If the signal is speech or music, then this will now be heard. If the signal was morse code, then the dots and dashes would already have been heard as interruptions to the whistle. A station transmitting speech or music will be heard as a steady whistle, with perhaps just a suggestion of the music present. This is really all there is to tuning the set. The important thing to know is that the set is most sensitive when it is *just not oscillating,* and for hearing weak signals it will have to be tuned in very carefully. The best results will be had if, after backing off the reaction control to remove the whistle, the tuning is rocked very carefuly to see if the signal cannot be made just a little louder. However, with this set, re-tuning in this way will only need to be very slight, if any, since the reaction control has very little effect on the tuning of the signal.