A Combination A.C. and D.C. Amateur-Band Receiver

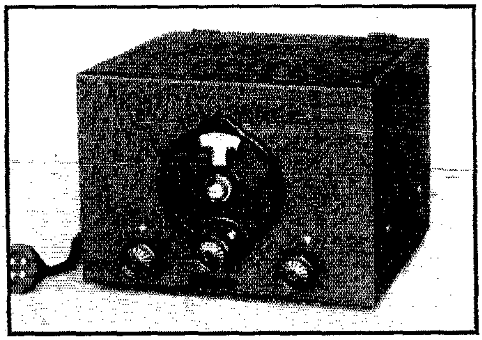
By James Millen, W1AXL*

THE advent of the 1931 crop of new tubes served to open up wider horizons in high-frequency receiver design than the tube and b.c. set manufacturers' advertisements would lead one to believe. The characteristics of several of the new types of tubes are such as to satisfy very nicely some of the requirements peculiar to amateur-band frequencies that were not so well taken care of by the tubes available in the past. Specifically, in the realm of a.c. type detectors, the new Type '35 variable-mu provides a real solution of the regeneration control problem when using grid-leak detection; while the heater type '36 and '37 tubes wipe out the microphonic and other troubles that beset the d.c. receiver previously restricted to using the notoriously noisy '22's and '01-As. Still better, the coming of these d.c. heater type tubes, with their UY bases, has made possible the design of a single receiver that can be used optionally as an a.c. or d.c. set without making a major change in its internal connections. Where the appropriate heater type tubes are employed alternatively for either a.c. or battery operation, the same self-biasing resistors, by-pass condenser arrangement and other such circuit details, that generally vary so widely in the two types of receivers, become identical.

Although little over a year ago a.c. operation of an amateur-band receiver was generally considered rather impractical by the amateur fraternity, the readily recognized superiority of a.c. tubes over the battery type resulted in such an accelerated development of the a.c. receiver that it was not long before the problems of a.c. operation were rather well mastered and the use of a.c. operated receivers became pretty well recognized as standard practice.[1]

In recent months, however, an increasing number of experienced operators has been switching to the use of combination a.c. and battery operated receivers. It is well known that unless an unusually high quality power pack is employed for the completely a.c. operated high-frequency receiver, it is generally found that the combination of a.c. filament heating and battery plate supply results in a steadier reception when receiving weak c.w. signals with an oscillating detector. Possibly this may be due to the isolation of the two sources of power supply, or perhaps merely to the elimination of fluctuations in the plate supply voltage caused by minor variations in the line voltage. Regardless of the exact reason, it must be admitted that battery plate supply is an improvement under some receiving conditions.

The life of the "B" batteries will be long, with the usual few milliamperes drain demanded by a three-tube set, and the first cost of the filament transformer and 135-volt block of batteries will be considerably lower than that of a high grade "r.a.c." supply designed for satisfactory high-frequency receiver work. There is also another advantage to the use of "B"-battery plate supply; and that is the complete elimination of that slight trace of regeneration-control "detuning effect" generally encountered to at least some degree in all completely a.c. operated ham receivers. Probably it is the superior "regulation" characteristic of "B" batteries that overcomes the trouble but, in any event, the combination a.c. filament supply "B"-battery plate supply type of operation seems to be as free from such trouble as when the receiver is entirely battery operated.



SINGLE-CONTROL TUNING OF TWO TUNED CIRCUITS

Band spreading, calibrated volume control, complete shielding and adaptability to either a.c. or battery operation are the salient features of this receiver. The "set and forget" antenna trimmer control is at the left and the regeneration control at the right, with the operating edge of the calibrated volume control disc immediately below the main tuning dial.

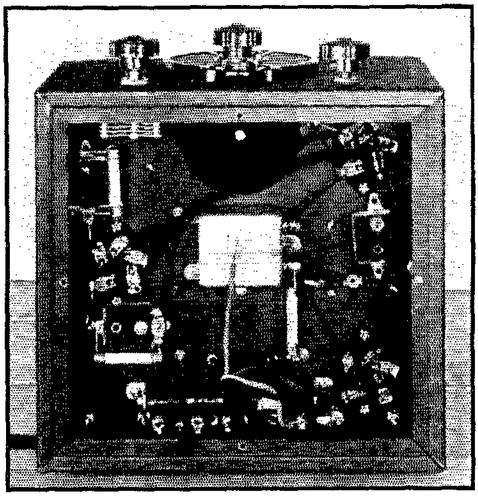
For complete battery operation the new 6-volt d.c. heater type tubes are far superior to any others previously available for such work. Gone are all the noises, microphonics, and other such troubles of former battery tubes. Also, the heater being designed for 6-volt operation restores to use the storage battery or "A" eliminator generally to be found in every amateur station.

In the case of the 3-tube receiver described

* The National Co., Malden, Mass.

[1] Kruse, "Revising Amateur Tuner Design," *QST*, January, 1931.

herewith, the total current consumption at six volts is under one ampere. Unfortunately, however, at this writing a variable-mu screen grid battery tube has not as yet made its appearance, but no doubt when the advantages of the Type



THE UNDERSIDE OF THE A.C. MODEL WITH ITS BASE-PLATE REMOVED

'35 become more generally realized, a companion battery tube will also make its appearance.

Of course there is always a demand for a d.c. receiver from those who must operate in localities where there is no a.c. available, and now with the new heater-type battery tubes it is possible to design a battery receiver of similar characteristics to the a.c. models. Thus the amateur in the rural districts, as well as those on exploration parties, expeditions, etc., may have essentially the same type of set as their brother operators located in the a.c. districts.

GENERAL DESIGN OF THE RECEIVER

The peculiarities of amateur reception, both c.w. and 'phone, seem to be such as to make headsets preferable to loud speakers. For this reason there is little point in equipping the typical ham receiver with a power output stage; a single stage of a.f. amplification is ample. Such is particularly true when the detector is of the screen-grid type and preceded by an r.f. stage that actually has some gain.

As has been discussed in detail in the article previously referred to, the screen-grid type of tube, combined with certain design essentials, has made possible an r.f. stage that actually has real gain all the way up to 50 megacycles, and perhaps higher. The new '35 variable-mu tube, with its lower plate impedance, makes possible the further increase in gain from the r.f. stage of the a.c. set,[2] and the similarly low plate impedance of the Type '36 screen-grid tube gives a corresponding advantage for the d.c. receiver.

While the combination of a single high-frequency stage and a regenerative screen-grid detector is not so selective as a double-detection or superheterodyne arrangement, it is equally as sensitive as any such receiver and has a very definitely better "signal to noise" ratio. This one feature alone should justify the one r.f. stage and screen-grid detector combination, in preference to a number of more elaborate circuits with their marked shortcomings in this respect.

Aside from the value of the gain obtained from the single audio stage, it serves as a very essential coupling medium between the output of the detector and the headphones, so as to insure smooth regeneration, freedom from fringe howl and backlash, as well as the elimination of undesired feedback from the 'phone cord to the input circuit of the receiver. Then again, the audio stage makes possible the calibrated attenuation control of which more will be said later.

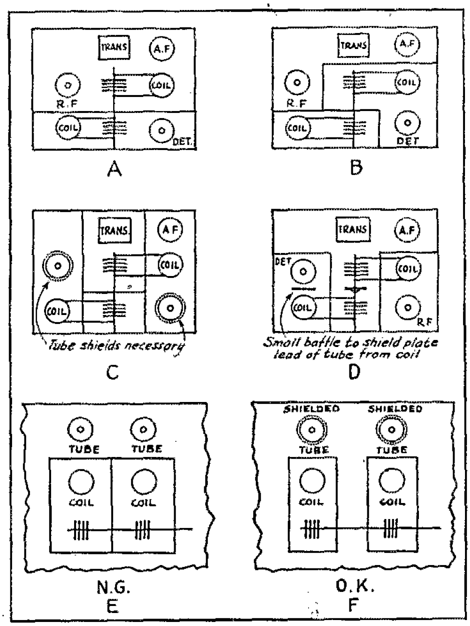


FIG. 1 — SHIELDING ARRANGEMENTS, GOOD AND BAD

That shown at D is used in the receiver described.

SHIELDING

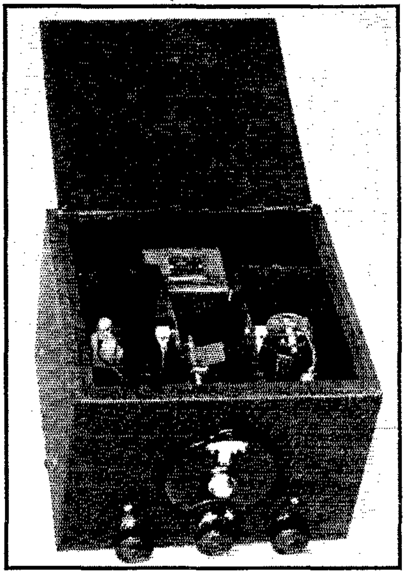
While it would seem that the single stage of r.f. and regenerative detector type of circuit is about as simple an arrangement to build as can be imagined, such has been found far from true where just more than mediocre performance is

[2] Grammer, "The Variable-Mu Tetrode," *QST*, May, 1931.

demanded. Take, for instance, the shielding; if it is not serving its purpose, the r.f. tube will oscillate whenever the detector regeneration control is advanced. This condition exists to a surprising extent in both homemade and commercial receivers in use to-day. Such receivers are tolerated, it would seem, simply because the owners have never operated a properly functioning receiver employing the same circuit *properly shielded*. There just isn't any comparison.

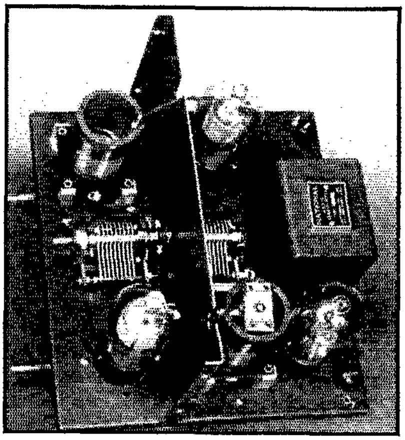
The mere fact that the r.f. stage is apparently stable when the detector is approaching an oscillating condition is not necessarily an indication of perfect shielding, as "interlocking" still may be present to a most obnoxious degree. There is, moreover, far more to shielding than the mere boxing off of the different parts of the circuit. Take, for example, the receiver being described. If you were starting to design such a job, wouldn't you try an arrangement as shown in Fig. 1A? At least, that is what we did, and the results were most disappointing. At first thought, this seemed an ideal arrangement because the coils, tubes and condensers of the two circuits were completely shielded from each other. It was found that with a "watertight" joint between the shield and the base there was no oscillation trouble with the r.f. amplifier, although there was an annoying amount of tuning interlocking. As soon as the chassis was put in a metal cabinet, however, and the cover closed, the r.f. stage oscillated violently!

Next tried was the arrangement shown at *B* in Fig. 1, but here the results were not even so satisfactory as the previous arrangement. Furthermore, the lack of symmetry of the shielding made it very difficult to gang the r.f. and detector tuning condensers.



WITH THE COVER OPENED

The plan of the internal arrangement is the same as that shown at D in Fig. 1. With the band-spreading coils in place, the normal control-grid clips fasten to the dummy insulating plugs mounted on the compartment walls. The partitions are welded to the sides of the cabinet but are insulated from the base by an air gap.



A GOOD EXAMPLE OF HOW NOT TO SHIELD

A study of shielding in the development of the receiver described brought out some surprising points. The example illustrated looks good but isn't, as explained in the text. This arrangement is the same one shown at A in Fig. 1.

The next attempt was as shown at *C* in Fig. 1. This arrangement worked fairly well in comparison with its predecessors, but here, too, there was still excessive interaction. Perhaps the compartments were so large that the shielding effect was nowhere near complete since the effect of isolation of the coil compartments decreases very rapidly as the compartment size increases. Another disadvantage of this arrangement was the requirement of tube shields. There was, however, no detrimental effect when the chassis was placed in a metal cabinet.

After the experience gained with models *A*, *B* and *C*, we were able to arrive at the arrangement as illustrated at *D*. Here the compartments were small enough to properly shield and yet large enough so as not to increase the coil losses appreciably. Furthermore, there was no common partition between the coil compartments as had existed in models *A* and *B*; and which, no doubt, was responsible for the "cover" effect. The small baffle between the r.f. tube base and the coil was found essential in order to shield the plate lead and prevent oscillation.

In the final model it was found advantageous to make the vertical parts of the shielding integral with the metal cabinet rather than to weld them directly to the chassis. It was found also of further advantage to insulate the vertical parts of the shielding compartments from the chassis itself with a ⅛" air gap and to weld them very thoroughly to the sides of the metal cabinet. The chassis, in turn, is grounded to the cabinet by several mounting screws on each side. Such an arrangement completed the shielding job by reducing interlocking to a negligible degree.

A further indication of the trouble to be experienced in attempting to use a common partition between the coils in a short-wave receiver is illustrated at E and F in Fig. 1. This problem was recently encountered in the design of another receiver employing the same circuit. The separate compartments completely eliminated the r.f. oscillation and interlocking difficulties.

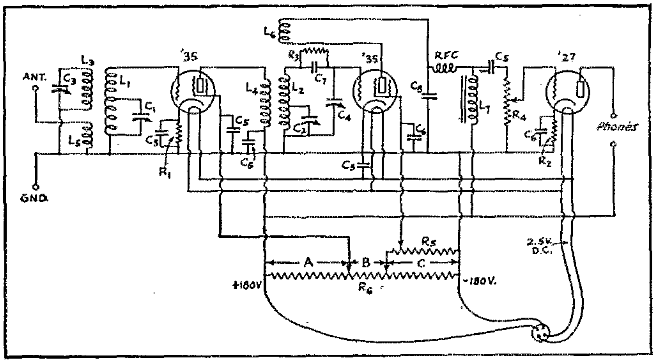


FIG. 2 — THE ALL-A.C. VERSION OF THE RECEIVER

L_1, L_2, L_3, L_4, L_5 and L_6. See table of r.f. transformer specifications.
L_7 — 750-henry plate coupling reactor. A good audio transformer with primary and secondary connected in series might be used.
C_1 and C_2 — 90-μμfd. ganged tuning condensers with insulating shaft coupling.
C_3 — Midget type trimmer condenser.
C_4 — 8-μμfd. detector transformer trimmer condenser (incorporated in coil form), Hammarlund No. 35.
C_5 — .01-μfd. non-inductive mica fixed condensers.
C_6 — .5-μfd. non-inductive paper fixed condensers.
C_7 — 100-μμfd. mica grid condenser, small type. Incorporated in detector r.f. transformer.
C_8 — 250-μμfd. mica by-pass condenser.
R_1 — 500-ohm cathode resistor, 2-watt type.
R_2 — 2000-ohm cathode resistor, 2-watt type.
R_3 — 5-megohm grid leak, one in each detector transformer.
R_4 — 500,000-ohm calibrated tapered type potentiometer. See text.
R_5 — 50,000-ohm regeneration control potentiometer.
R_6 — B-voltage divider, total resistance 12,000 ohms divided as follows: A, 6900 ohms; B, 2000 ohms; C, 3100 ohms.

STEEL *VS.* ALUMINUM

Perhaps a word regarding our experiences with steel and aluminum as shielding material also might be of interest at this point. It is only too well known that on the extremely low frequencies, say for instance 60 cycles, iron is definitely better as a magnetic shielding material than aluminum. As the frequency increases, however, this difference rapidly diminishes until at broadcast frequencies it has practically completely disappeared; and from then on up, from a purely shielding point of view, there appears little, if any, actual difference.

But there are several other aspects to be considered additional to the pure shielding effect. One of these is the introduction of losses when shielding is placed close to a coil. It is for this reason that in the design of the receiver care has been taken to keep the steel shielding partitions everywhere separated from the r.f. transformers by distances at least equal to the coil diameter. At this, or greater distances, there seems to be no noticeable difference in the resistance of the r.f. transformers whether the shielding be aluminum or steel. In the design of receivers where it is necessary to place the shield closer than the diameter of the coil at any point, then there is a marked advantage in using aluminum or some other non-ferrous material.

In high frequency work our present concern, the real advantage of the use of steel over aluminum, lies in its shielding of the receiver as a whole from the low frequency (60-cycle) magnetic field which generally so completely envelops the ham operating table and which, in many cases, results in a strong a.c. hum in connection with aluminum shielded battery type receivers. Then, of course, there is the matter of the so-called "water-tight" shield joints, which are so hard to obtain with aluminum and so easy to obtain commercially by welding with steel or by soldering with copper.

GANGING

At the present state of the radio art there is no excuse for a 2-condenser type receiver that is not truly single-dial control in the fullest sense of the term. In the present receiver, such control is obtained by the mounting of the two tuning condensers in tandem by means of a flexible insulating coupling unit.

The trimmer condenser, C_3, shown in the diagram and photograph is not an auxiliary tuning control to be juggled along with the main tuning dial. It is for the sole purpose of supplying the varying amounts of capacity "padding" required with the different transformers. This capacity well might be incorporated in the transformer itself if it were not for the unknown capacity-loading effect of the antenna system. Therefore, it is merely necessary to set the trimmer whenever a pair of r.f. transformers is plugged in and then not touch it until the transformers are replaced or a different antenna is connected. Many operators determine the proper adjustment of this trimmer condenser by adjusting for maximum background noise but a more accurate way is to adjust the trimmer for the point of minimum setting of the regeneration control that will produce oscillation in the detector circuit.

The two tuning condensers are of the same maximum capacity, namely, 90 μμfd., and are of the straight-frequency-line type with 270° rotation. This latter feature gives a 50% greater spread of the tuning range for a given set of transformers; or, conversely, for a given degree of criticalness of tuning it reduces by 50% the number of coils required to cover the entire frequency range from 33 mc. to 1500 kc. While it might seem that a more compact and better mechanical arrangement would be the employment of a special single unit 2-gang condenser, such has proven not to be the case. It was found that even though the frames of the two separate condensers were grounded to the main chassis, the breaking of the common shaft by means of the insulated flexible coupling unit, in the manner illustrated, was a very important factor contributing to the complete elimination of the natural tendency of the r.f. stage to interlock and oscillate when the detector was thrown into oscillation by the regeneration control. In a specially constructed single unit, 2-gang condenser, using the same general type of design as employed in the individual condensers but having a common shaft, it was found that while shielding partitions would eliminate the greater part of this interlocking tendency, there was always a trace left that could not be completely cured.

The special mechanical features of the condensers, such as the insulated main bearings (to eliminate the shorted turn effect of the frame), the constant impedance pigtail and the special insulation material have already been described in detail in *QST* in the article to which there has been previous reference.

R.F. TRANSFORMERS AND BAND-SPREADING

Following the policy of careful attention to all details of a simplified circuit, in order to secure maximum performance a special molding material was selected for the transformer forms. The use of this low-loss material permits the winding of the coil turns into grooves turned into the solid walls of the forms, thus resulting in a rigid transformer that will stand up under quite rough handling. This special molding material, known as "R-39," differs from the ordinary in that it contains absolutely no wood flour or other moisture absorbing filler, the presence of which has been discovered by the R.F.L. people to be the cause of the losses and variations in dielectric qualities of molded bakelite when placed in high frequency fields.[3] As a result of the practical elimination of dielectric losses in the transformer field, not only is the sensitivity materially increased, particularly in the r.f. stage where no appreciable amount of regeneration exists, but also the selectivity is improved due to the very substantial reduction of the r.f. resistance of the tuned circuits. In the case of the transformers that were developed for the 33- to 20-mc. range, it was found that the detector refused to oscillate when these coils were wound on forms molded of ordinary bakelite, whereas no difficulty whatsoever was encountered when the special "R-39" low-loss material was used in the same molds for making the forms for this range.

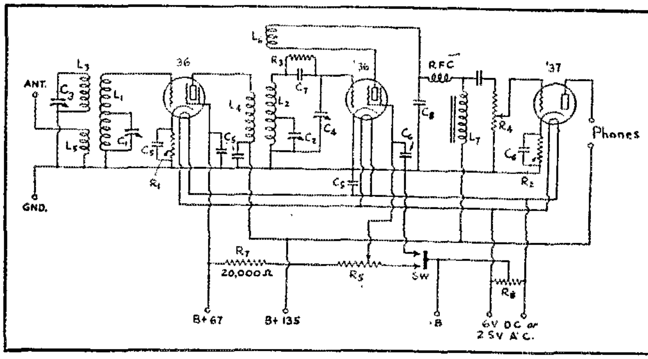


FIG. 3 — CIRCUIT OF THE COMBINATION A.C.-D.C. MODEL

Specifications are identical with those of Fig. 2, with the following exceptions:
R_7 — 20,000-ohm 2-watt type resistor.
R_8 — 50- or 100-ohm filament center-tap resistor, necessary only with a.c. filament supply.
SW — Regeneration control and cathode circuit switch.

While this new receiver is so designed that any of the standard six-prong transformers developed originally for another receiver [1] may be used with it in order to cover the range from 33 mc. to 350 kc., since it has been designed primarily for amateur work it has a special set of band-spread transformers as standard equipment. The three pairs of band-spread transformers are for the 14-, 7- and 3.5-mc. amateur bands. In general appearance, as will be seen from the accompanying photographs, the new band-spread coils differ from the conventional coils only in that a lead comes out of the top for clipping directly to the cap of the screen grid tube, in place of the lead built into the receiver. In order that the clips in the receiver may not dangle about and short circuit on the metal chassis or cabinet, dummy

R.F. TRANSFORMER SPECIFICATIONS

Winding	*14,000-kc. Band*	*7000-kc. Band*	*3500-kc. Band*	*Size Wire*
L_1 and L_2	10 t.	21 t.	35 t.	No. 22 Enam.
Tap, turns from bottom	2¼	5¾	16¾	
L_3 and L_4	8 t.	16 t.	22 t.	No. 34 d.s.c.
L_5 and L_6	3 t.	4 t.	4 t.	No. 34 d.s.c.

R.f. and detector stage transformers are identical except that a grid leak, grid condenser and trimmer condenser are incorporated in each detector transformer. The grid leaks are each 5 megohms, the grid condensers each 100 μμfd. and the trimmer condensers each approximately 8 μμfd. The plate winding (L_3 or L_4) is wound between the turns of the grid winding (L_1 or L_2), starting at the bottom of the coil. Additional details are given in the text.

[3] Kruse, "A Multi-Range Receiver," *QST*, October, 1930.

insulating terminals are furnished for fastening them out of the way.

Inside each detector coil form there is a small grid leak and grid condenser, as well as an ad-

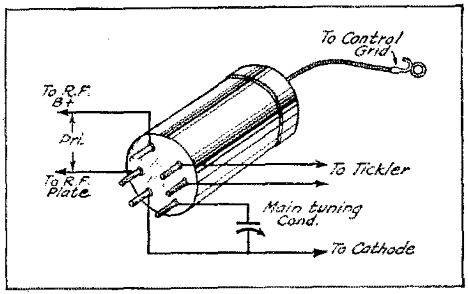
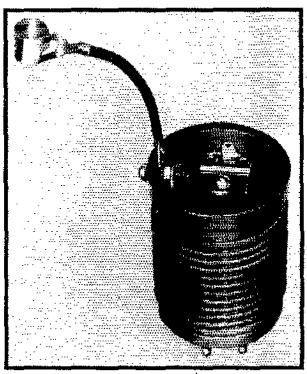


FIG. 4 — A SPECIAL SIX-PRONG BASE AND A FLEXIBLE LEAD ARE NECESSARY FOR THE SEVEN CONNECTIONS TO EACH R.F. TRANSFORMER

justable low-capacity trimmer condenser. The schematic diagrams of Figs. 2 and 3 show how the band-spreading is accomplished. Here it will be seen that C_2, the regular variable tuning condenser, now shunts only a portion of the total inductance while the grid leak R_3 and the condenser C_2 connect directly to the top of the coil. Finally, the trimmer condenser C_4 shunts this whole arrangement and is in parallel with the tube capacity, connecting directly from the grid to the filament. Fig. 4 shows a sketch of the coil, indicating how the prongs of the coil are connected and the disposition of the screen grid lead which comes out of the top of the coil. The particular l/c ratio in this arrangement results in a circuit of a high order of sensitivity; sufficiently more so than with the conventional arrangement as to be readily detectable by listening tests.

Full constructional details are given in the table of transformer specifications. In all three sets of transformers the grid winding has its turns spaced so that the length of winding is equal to the diameter. The primary or plate winding is then wound between the turns of the grid winding, starting from the "ground" end and working up approximately two-thirds of the way toward the grid end. The location of the tap for the tuning condenser must be accurate to the fraction of a turn indicated in order to spread the particular band over approximately 75 dial divisions. The tickler or antenna coil is wound in the slot at the bottom of the coil form and the center of this slot is located approximately ¼-inch below the end of the grid winding.



THE 7000-KC. BAND-SPREADING DETECTOR TRANSFORMER

A special six-prong form is used with the turns of the plate coil for the r.f. tube wound between the turns of the detector grid coil. The adjustment screw of the trimmer condenser is readily accessible from the top. The tickler winding is in a slot at the lower end of the form and the grid condenser and leak are inside, beneath the trimmer condenser.

The value of approximately 8 $\mu\mu$fd. for the trimmer condensers given in the table is the capacity at which the condensers are set when in normal use. The particular condensers used for this purpose are the standard Hammarlund Type No. 35.

VARIABLE-MU REGENERATIVE DETECTOR

From a purely circuit point of view, one of the several outstanding features of the all-a.c. version of the receiver lies in the use of the Type '35 variable-mu tube as a regenerative detector. Perhaps the reasons that intrigued us into the investigation of the possibilities of the '35 as a high-frequency regenerative detector was the statement made on the data sheets supplied with the tubes, to the effect that their use as detectors was not recommended, plus George Grammer's story on this tube in the May issue of *QST*, in which he intimated that while perhaps the tube manufacturers were right with reference to the use of the '35 as a plate detector, it certainly ought to make a good grid detector. Numerous investigations and experiments during the past few months have borne out this theory.

From past experience in designing high-frequency receivers employing the Type '24 screen-grid tube as a regenerative grid detector, it had been found that of the various methods of regeneration control the most satisfactory was the variation of screen voltage by means of a potentiometer. But how would the action of the '35 tube as a grid detector differ from the '24 when its screen voltage was shifted? For some unknown reason the tube manufacturers in their data sheets and their "engineering and specification reports," as supplied to the radio set manufacturers, seem to be surprisingly consistent in at least one respect; namely, the complete omission of any curves that might throw some light on the subject. It was soon found that this relation is of an inverse exponential nature. Thus when the screen voltage of the '35 is increased from a low value, the tube rapidly approaches an oscillating condition. The nearer the tube approaches the spill-over point, however, the less effect the increasing of screen voltage has upon its tendency to oscillate. Consequently we have a regeneration control that permits of readily obtaining and maintaining a higher degree of regeneration with the attendant smooth sliding into oscillation so much sought after in ham receivers of the past and obtained only to a fair degree by the careful selection of tubes and the juggling of grid leak and condenser values.

This same characteristic of the '35 that permits of this higher order of regeneration also results in a more stable condition with regard to the holding of the regeneration adjustment when once set. There seems to be entirely lacking that tendency of regenerative detector tubes of ordinary kinds to suddenly "pop" into oscillation on the slightest provocation.

THE AUDIO SYSTEM

The detector output is impedance coupled to the single audio stage by means of a plate choke coil of extremely high inductance value. It was found that the use of an inductance of much higher order than possible with practicable transformer coupling resulted in much higher coupling efficiency and complete elimination of any tendency towards howling, roughness or "backlash" in the regeneration control. These difficulties were encountered to a very objectionable degree when straight resistance coupling was employed.

The grid leak of the impedance coupling arrangement is the attenuation control potentiometer. Such a control was found essential due to the high sensitivity of the receiver and consequent "too loud for comfort" signals when using a head set. Such an audio coupling system results in an extremely flat characteristic over a wide frequency band, making the receiver ideally suited for phone reception.

Originally, serious consideration was given to the inclusion in the circuit of a tuned filter arrangement to follow this coupling device, so as to give a highly peaked audio characteristic for c.w. reception; but as a result of observing some investigations being conducted by Ross Hull, Jim Lamb, and George Grammer at A.R.R.L. headquarters, undoubtedly to be discussed in *QST* in the near future, the peaked audio idea was abandoned, at least for the present.

CALIBRATED ATTENUATION CONTROL

With a potentiometer in the grid circuit as the volume control, it has already been shown how it may perform the double duty of volume control and audibility meter.[4] Fig. 11 shows how the taper of the resistor is determined so that the angle of rotation is directly proportional to the "R" rating of signal intensity. In this case, the total resistance used is 500,000 ohms.

When the contact arm is at the high end, there is zero attenuation and the level of a signal just audible at such an adjustment would be "R1." Likewise, when the control arm is at the other extreme, only a signal of enormous intensity will "get through" and thus the rating of "R9." Physically, the attenuation control is mounted under the chassis; so, like all the other audio components, it is completely shielded from the r.f. circuits and consequently not likely to cause any back coupling which would result in fringe howl. Furthermore, the control wheel is so mounted that it may be operated simultaneously with the main tuning dial, leaving the other hand free for the regeneration control. After operating the receiver a short time, one finds that he unconsciously shifts the attenuation control up and down as he moves from station to station so as to maintain the same signal intensity to the ear, thus making available at a glance a sufficiently accurate audibility reading at all times.

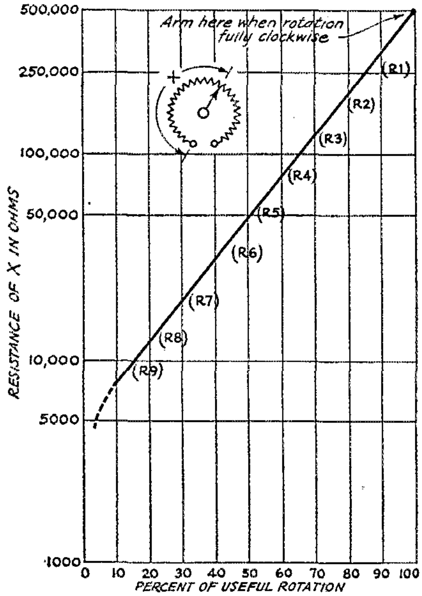


FIG. 5 — CALIBRATION CURVE OF THE COMBINED VOLUME CONTROL AND AUDIBILITY INDICATOR

To determine the audibility of signal, the control is rotated to the setting where the signal is just audible, the marking on the disc at this setting indicating the audibility in terms of the "R" system. The calibration is, of course, an approximation.

POWER SOURCES

For complete a.c. operation of the receiver, the type of power pack that has been previously described is recommended.[1] This power unit employs a Type '80 tube as a rectifier, an r.f. filter and a 2-section hum filter. The power transformer, in addition, is equipped with an electrostatic shield between the secondaries and the 110-volt winding, thus not only preventing any r.f. disturbances originating in the power supply from getting into the receiver, but also preventing

[4] McLaughlin and Lamb, "What Is This Thing Called Decibel?" *QST*, August, 1931.

r.f. disturbances originating in the rectifier tube from causing trouble. The elimination of this latter source of r.f. disturbance makes the operation of the receiver entirely free from the so-called "tunable" hum. As shown by the illustration and circuit diagram, the voltage divider resistor for the "B"-supply is located inside the receiver chassis, so as to eliminate any r.f. or common coupling in the power supply leads. By having the power supply a separate unit, any a.c. hum due to coupling between the power transformer and the detector plate coupling impedance is completely eliminated, thus reducing hum in the output of the receiver to an extremely low level.

A unique feature of the battery model is its design to use either battery or a.c. type tubes. When used purely as a battery operated receiver, then the new 6-volt 5-prong heater Type '36 and '37 tubes are recommended so as to permit operation from the standard 6-volt storage battery or "A" eliminator. As will be seen from the circuit diagram, a separate "B-minus" lead is brought out in the battery model. Thus the standard a.c. tubes, also being of the 5-prong UY-base variety, may be plugged in at any time in place of the heater-type battery tubes and the receiver adapted to a.c. operation.

As mentioned previously, an arrangement finding particular favor with many experienced amateur operators at this time is the use of a.c. on only the heaters of the a.c. tubes, so as to take advantage of economical operating costs and the superior characteristics of the '35 as a regenerative detector, "B" batteries being used for plate supply in preference to the so-called "B-eliminator." The operating advantage of such a combination shows up mainly on weak c.w. signals where a higher order of detector stability is obtained, due probably to the elimination of plate supply variations caused by line voltage fluctuations. It would also seem that there is a slight increase in freedom from detuning effects of the regeneration control when using batteries in place of "r.a.c." power supply. The extent of this improvement, of course, depends upon the type of power pack involved and is much more noticeable when using the conventional type "B-eliminator" than when using a special type of power unit designed strictly for high frequency receiver operation.

When using the battery model of the receiver with the combination a.c.-d.c. power supply, a common center-tap resistor should be connected across the heaters *inside the base of the chassis.* It has been found that erratic operation will result on some frequencies if this center tap resistor is placed across the heater terminals of one of the sockets, particularly the detector. If the receiver is to be used alternatively with a.c. and d.c. type tubes, provision should be made for removing this resistor from the circuit when operating with a filament battery so as not to impose a parasitic load on the batteries.

For complete battery operation, the 6-volt heater tubes were selected not only because of the convenient 5-prong base making them interchangeable with the a.c. tubes and because of the general availability of 6-volt storage batteries, but also because of their freedom from the microphonic howls that are causing so much grief where the 2-volt type d.c. tubes are being used. At this writing, a variable-mu tube with a low-current d.c. heater is not available so that it is necessary to use the Type '36 as the screen-grid detector, for the present at least. As soon as the value of the variable-mu tube as a regenerative high-frequency detector is more generally appreciated, however, battery operated models will no doubt become available.

Since the receiver measures but 9¾" x 7", it should prove well suited to portable aircraft, and other services where space is an important factor. Replacement of the Type '37 audio output tube by one of the Type '38 pentodes of the same series (in the battery model) provides a genuinely compact outfit for speaker operation. In fact, such a change in the audio system results in a rather good short wave b.c. receiver.

Strays

The current consumption of the a.c. relay described on page 32 of the May issue is not one ampere, as stated, but one-tenth ampere.