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BRINGING ELECTRIC SETS UP TO DATE

and

Modernizing Radio Receivers

by Clifford E. Denton

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Contents

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Preface

WITH the rapid strides of receiver development in the last year one finds many interesting ideas that can be incorporated in older model sets. This revised edition of "Bringing Electrical Sets Up To Date" presents many interesting solutions of the problems encountered in modernizing radio receivers. One of the most pertinent topics covers "High Fidelity Reception" and this section should be of great interest and value to the skilled radio man.

As a rule economic considerations are limiting factors in the improvement of existing radio receivers and audio systems. It is well to consider carefully, if finances are restricted, as to the worth of any given type of alteration as against the expense involved. Forethought is far less costly than hind-thought, therefore it will pay to study carefully the results desired and the means of accomplishment.

There are many receivers so antiquated that little can be done to awaken them from their present comatose state. Receivers in such condition should be dropped from consideration because the cost of improvements will be greater than that of a new set.

Since it is impossible to place between the covers of a book, no matter how large, all the ramifications which may be employed in bringing a receiver up to date, the contents of this book will treat with the interesting problems of receiver improvements in a broad sense, with practical interpolations which will have all the physical and electrical specifications required for the solution of definite problems.

The man who makes a hobby or profession of building and improving radio receivers should find many points of interest in the following chapters, as the material contents are based on practical work which has been done under the supervision of the author.

The author wishes to thank those interested persons who expressed themselves so kindly regarding the first printing of this book, and sincerely hopes that the subjects covered in this edition will prove as interesting and useful as the first edition.

The Author.

CHAPTER 1

General Improvement

Selectivity

One of the most common requests received from the man interested in receiver improvement is for information on increasing receiver selectivity.

This is a difficult question to answer because of the many limiting factors which exist due to mechanical placement of the parts in the receiver and the general lack of electrical shielding. Many times the writer has been called in on a case of broad tuning to find that the set, which was shielded thoroughly, had enough coupling through the common impedance circuits of the power supply unit to destroy the selectivity; of which more will be said later.

Wave Traps

Wave-traps are useful at times aiding in the elimination of unwanted signals and sometimes offer a simple solution for overcoming an otherwise difficult job. Nevertheless wave-traps will not always work unless the correct type is used. It is best to build several types and then determine the type which works best under the local conditions.

The average trap is simple in theory and in construction and does not cost much to build. The condenser is adjusted so that the circuit absorbs the energy from the undesired station but permits energy from the other station or stations to be passed.

The "trap" illustrated in the circuit in Fig. 1 will permit elimination of the unwanted station but will also cause a considerable decrease in signal strength from other stations operating on adjacent channels. In the construction of a trap such as described in the preceding paragraphs, the coil may consist of 47 turns of No. 22 wire wound on a 3 in. diameter form if the tuning condenser has a capacity of .0005-mf. If the condenser is of the .00035-mf. variety, then the coil should have 60 turns of the same wire. There are many possible circuit variations that can be used although they are not included here. Most text books refer to these units in detail.

Pre-Selectors and Band-Pass Units

The desire for greater selectivity often leads to the reduction of the higher audio frequency response which is so necessary for quality reproduction. Older types of receivers which are capable of excellent reproduction will sound very drummy if the tuned circuits which make up the R.F. end are sharpened up too much. In cases of this kind it is necessary to change the audio system as well.

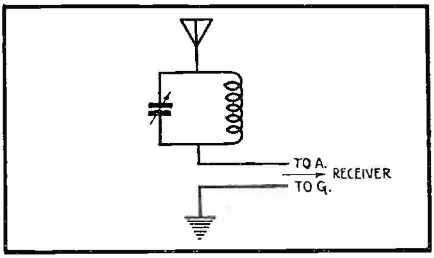


Fig. 1
A simple form of wavetrap

Band-pass units made up of several coils and condensers can have the peaks staggered so that the over-all selectivity will be increased without materially changing the quality of reproduction. Fig. 2 shows the ideal square-top resonance curve and the sharply tuned resonance curve which will not permit high quality reproduction. The double humped curve is an indication of the improvement that can be expected with the band-pass type of pre-selection.

There are many types and modifications of pre-selector circuits which can be made up to be used ahead of the older types of sets. Remember, whenever additional tuned circuits are used ahead of an existing receiver there will be a loss in volume, and the receiver must be sensitive enough to make up for this loss if the change is to be beneficial. What good is it to add selectivity if at the same time the volume level is reduced to such a point that the reception will be unsatisfactory?

Examples of band selectors are

sketched in Fig. 3. Tuning condensers are .00035-mf. each and can be ganged together. There are many coils available already wound and mounted in shield cans which can be used satisfactorily. Buy two standard antenna coils for use with .00035-mf. condensers; remove the primary of one of the coils, if the coils are matched, there will be little trouble in aligning the two tuned circuits. If the coils are home-made they should be mounted in individual shield cans as all the energy which is to be transferred from the first coil to the second appears across the coupling condenser, except in the case of mutual inductive coupled circuits. The capacity of condenser in the capacity coupled type of circuit can be varied to suit the conditions and the values recommended in the figure may not be the exact one for your particular requirements.

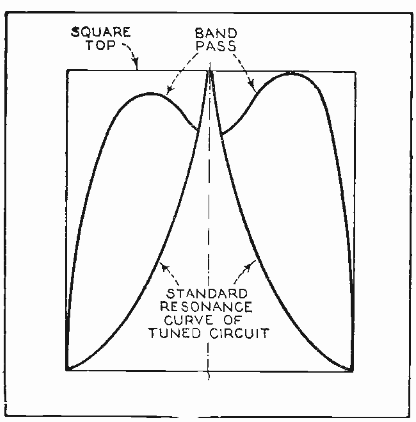


Fig. 2
Typical resonance curves

It is difficult to increase the selectivity of an existing receiver if there is insufficient gain to overcome the losses due to the introduction of the added tuned stages and all changes must be made with the understanding that the addition of tuned circuits must generally be accompanied with an increase in amplification in some other portion of the receiver.

Some have attempted to increase the selectivity of a receiver by removing turns from the primaries of the R.F. transformers. This generally leads to the over-all reduction of the sensitivity of the receiver and is to be avoided unless the receiver has ample gain.

A simple way to tell if the set is capable of improvement is to remove the antenna and ground wires from the receiver. If the set does not pick up signals with the antenna and ground off, there is a good chance that a wave-trap or pre-selector circuits will help in obtaining the proper degree of selectivity. If the set picks up signals without the antenna or ground then the set should be entirely shielded first.

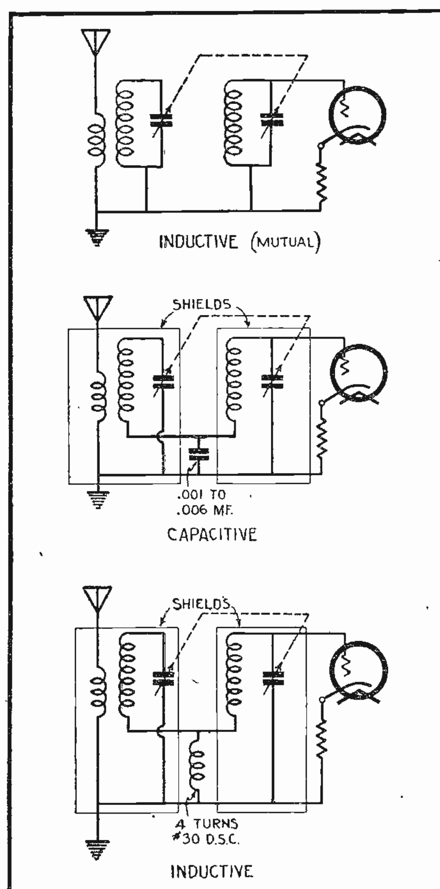


Fig. 3
Three practical band-pass circuits

If the removal of one of the R.F. tubes from the receiver while the set is in operation does not kill the signal, there is coupling between the coils (magnetic), or the tuning condenser units (electrostatic), or through the common impedance in the power supply unit or batteries. In some cases of common coupling through the power supply unit it is best to incorporate de-coupling resistors and condensers as shown in the circuit of Fig. 4. It will be noticed that the condensers offer low impedance paths for the R.F. currents while the resistors limit the flow of current (R.F.) through the power supply. Care must be taken that the value of the resistors be such that the current through them will not drop the available plate voltage to such a low value as to reduce the amplifying efficiency of the tubes.

and the sensitivity as well, if the tuned input circuits are used instead.

The values of the coil and condenser in Fig. 5 are the same as any conventional tuned circuit capable of covering the broadcast band.

Single Control

Single control operation of multiple-stage radio frequency amplifiers is quite a problem at its best.

Let us examine the various stumbling blocks in the path of good single-dial control as listed below.

A—Variations in antenna-ground capacity.

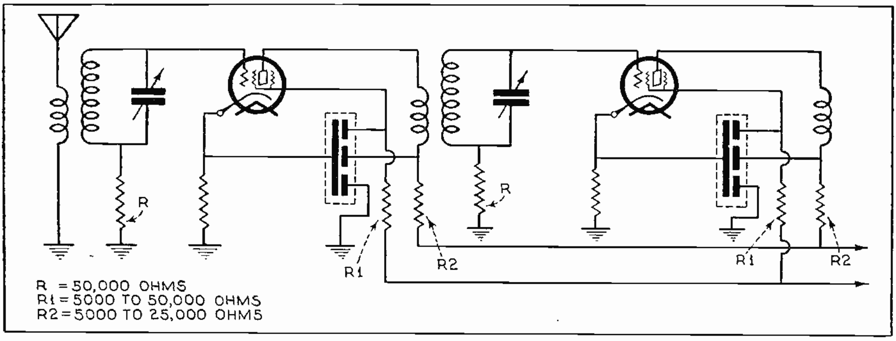


Fig. 4
Proper methods of using isolating resistors and condensers

Many receivers have untuned input circuits and sets of this type can be improved by the addition of a tuned input circuit. For example, the input circuit of Fig. 5 shows the simple untuned input circuit of one of the earlier types of tuned R.F. receivers. The value of the resistor ranges from 2,000 ohms to about 15,000 ohms. The selectivity of a receiver of this type can be increased,

B—Non-uniformity of tuning condenser capacity in the several sections.

C—Tuning coil inductance variation.

D—Non-uniform circuit capacities due to the wiring, tubes, etc.

In A, one finds that with every change in antenna the tuning of the input R.F. transformer will vary. This condition can be easily traced to the antenna capacity.

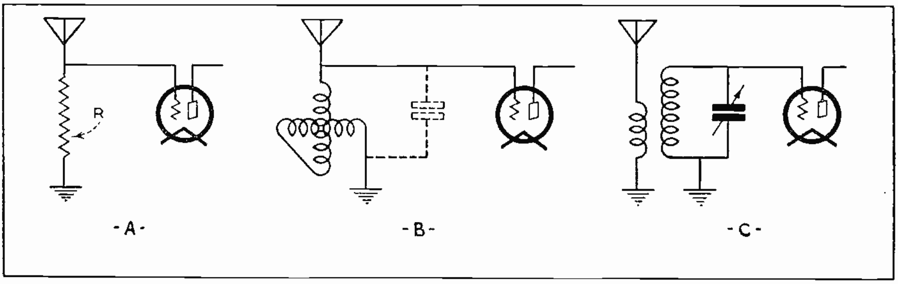


Fig. 5
Three common methods of antenna input connection

In design work this capacity is considered as a whole. The capacity of the average antenna is about .0002-mf. and varies in effect as the grid circuit is tuned. This capacity should be taken into consideration whenever one is confronted with a problem of this kind.

Tuning condensers can be obtained at reasonable prices, today, accurate within one-half of one per cent. This is perhaps the only problem in the case of tuning condensers. The remaining point to consider is the mechanical limitations imposed by the chassis. Do not try to place one of the small multi-gang condensers on a large chassis. Use a tuning unit that looks as though it were made for the chassis. There are hundreds of styles and types and it is possible to find a unit that will fit almost any set.

Today, coils are sold in sets to match standard tuning condensers and are wound with great precision. If the coils and condensers are changed to permit ganging then the R.F. stages could be converted for screen-grid tubes instead of the older three-element tubes with which the receiver may be equipped. Additional filtering and bypassing may prove necessary if such a change is made.

In older sets the tubes were placed indiscriminately with regard to the placement of the tuning condensers and coils. Changes should be avoided in receivers of this type as the resultant circuit capacities will vary to such a degree that the constructor will have difficulty in tracking the tuning condensers. The best way to determine if the layout of the receiver is adaptable for single-dial control is to check over the grid and plate lines. Are they all the same length? Are the distances from the soldering terminal of the tuning condenser gang-unit, to the coil and tube socket the same? Are they short? If the above questions can be answered in the affirmative then the set can be made over to single-dial operation.

Most readers will be interested in circuits which can be used in antenna input stages. Fig. 6A to 6H, show several modifications of antenna input circuits.

In A, the addition of the small condenser C, which is placed in series with the capacity of the antenna, materially reduces the effect of the shunting capacity as shown in the dotted lines.

Circuits, as shown in B, are common with high gain tuned R.F. inputs. The choke is resonated by the condenser shunted across it to a frequency below the broadcast band. The choke is placed at right angles to the secondary winding near the grid return end of the coil. A small winding in series with the choke and condenser affords magnetic and capacitative coupling to the secondary. The capacity effect is important and becomes the main source of energy transfer at the higher frequencies.

A small variometer is connected in series with the secondary in C with a control on the front panel. This variable inductance is adjusted as the tuning control is varied so that the effect of the antenna capacity is minimized and a condition of absolute resonance is maintained.

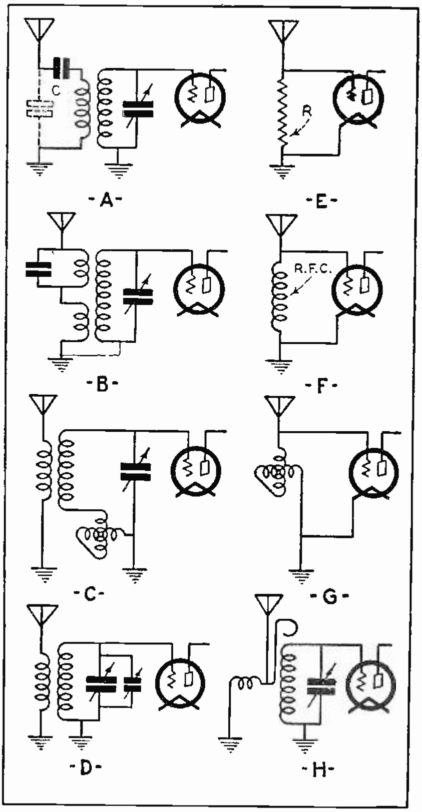


Fig. 6
Antenna input circuits

The use of a trimming condenser is shown in D and serves the same purpose as the variometer described in C.

Untuned antenna systems with a choke or resistor connected as shown in E and F, offer an economical solution, but the results are not as satisfactory as a tuned circuit.

For example, G with its variometer for antenna tuning is much better even though it necessitates the use of additional control.

The primary in 6H is a choke resonating with its own distributed capacity and the capacity of the antenna to some point below the broadcast band. This reduces the effect of the antenna capacity and gives greater amplification at the lower radio frequencies. The energy transferred at the higher frequencies, so far as the choke is concerned, is very small and the loop of heavy wire above couples capacitatively to the secondary. This increases the efficiency at the higher frequencies.

Detector Circuits

Many times the tube which is selected requires considerable circuit alteration.

If the tube selection is wisely made the improvement in most cases justifies the cost.

There are several rules which are handy to follow in changing over radio receivers, and the task of determining the proper constants for plate resistors, chokes, bias resistors, and by-pass condenser is often a troublesome one.

The values of the resistors depend upon the currents flowing through them and the effective voltages required. It is assumed that the voltage actually applied to the plate is the effective plate voltage.

For example, in Fig. 7 a biased detector is shown. This circuit is typical of that seen in most modern sets.

The bias is supplied by the voltage drop in resistor R1, and as a general rule the voltage between the cathode and ground should be equal to one-tenth the effective plate voltage. If the plate voltage is 45 volts then the drop in R should be 4.5 volts. Care should be taken so that the voltage drop in resistor R2 caused by the tube plate current does not fall to such a low value that it kills the operation of the tube. If this condition exists the detector circuit will not be sensitive. A proper choice of R1 and R2 will always result in greater sensitivity and quality.

Resistor R1 should be by-passed for the most efficient action and the size of the condenser will depend on the value of the resistor used. If the resistor R1 is less than 10,000 ohms use a 1. mf. condenser for bypassing. A condenser of .5-mf. can be used with resistor values of 15,000 to 25,000 ohms, and for higher values of resistance the use of a .1-mf. condenser is permissible but the larger values of capacity are always desirable.

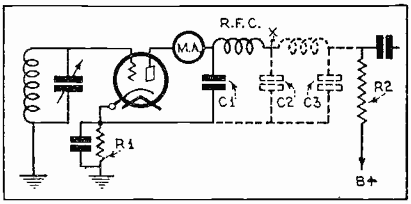


Fig. 7
Detector plate R.F. filter circuit

Many sets develop a high degree of instability after changes are made in the various circuits. Especially when gain in the R.F. section of the receiver has been raised. If the set develops these symptoms touch the detector plate circuit at the point marked "X" in Fig. 7. A squeal, when this test is made, indicates that the choke (R.F.C.) does not offer sufficient impedance to the R.F. component present in the plate circuit and this current is being fed back to the preceding stages by common impedance paths through batteries or power supply units.

The remedy lies in the use of larger values of condenser at C1. In a single section filter it is often impossible to preserve quality if the value of the condenser is increased. Condenser values greater than .001-mf. generally cause high audio frequency attenuation. In all cases the condenser should be as small as possible and still permit satisfactory filtering action.

The best way to handle a situation of this kind is to add another choke in series with the original one and juggle the values of C1, C2 and C3 for maximum R.F. blocking with minimum attenuation of the high audio frequencies.

Double chokes require smaller values of capacity to produce a given result; thus the average size for broadcast receivers will be .00025-mf. or less. Superheterodyne second detectors require larger chokes and generally larger values of capacity due to the lower frequencies present in the output.

Perhaps more space should be devoted to the determination of resistor R1, Fig. 7. Select the value of R1 which will reduce the plate current to about .2-ma. for screen-grid detectors and about .4-ma. for triode detectors.

The best way to determine this is to place a 0-5 ma. meter in the plate circuit and change the biasing resistor until the proper current flows.

All tests for plate current should be made with "no signal."

A handy rule to remember is that with bias detectors the plate current increases with an increase in signal. The opposite effect is noted in the circuit shown in Fig. 8 where the increase in signal causes a decrease in plate current.

In circuits using grid leak and condenser detection, care must be exercised in limiting the input to the detector. Overload at this point is the cause of about 40 per cent. of the distortion in a receiver.

If the R.F. end of a receiver has been improved so as to be more sensitive, it may be necessary to decrease the values of R and C (Fig. 8) so that distortion will be maintained at a minimum. Capacity values of .00015-mf. at C and 50,000 to 1 meg. at R should be tried to determine the values which will give the best results. Although the ear is not a satisfactory criterion of distortion the resistors and condensers should be chosen for output at high volume levels. If the music or speech tends to "mush" up at high volume, and the insertion of milliammeters in the plate circuits of the audio and power stages fail to show signs of distortion, decrease the values of the condenser and the resistor.

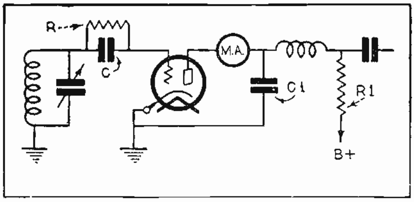


Fig. 8
Detector Plate M.A. connection

There are times when the output of the detector sounds thin and stringy. This is sometimes caused by lack of power reserve in the "B" supply. Connect a 2 or 4 mf. condenser as shown in Fig. 9; this tends to round out the response to a more satisfactory degree. The condenser connected at this point acts as a reservoir for the current demands of the plate circuit. This condenser is useful with both types of detectors.

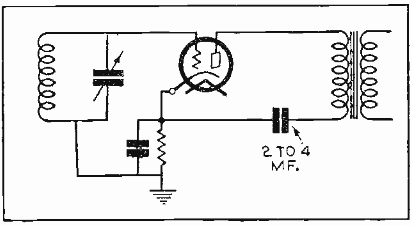


Fig. 9
Position of reservoir condenser

The following tables give values of bias voltage for rectification for various tubes used as detectors at different plate and screen potentials.

Type	Bias	Plate V.	Screen V.
'99	9.0 v.	90.0 v.	
'12A	13.5 v.	135.0 v.	
'22	7.0 v.	135.0 v.	67.5 v.
'24, 57	4.5 v.	180.0 v.	45.0 v.
'27	25.0 v.	250.0 v.	
'27	20.0 v.	180.0 v.	
'30	7.5 v.	235.0 v.	
'32	4.0 v.	135.0 v.	
'01A	13.5 v.	135.0 v.	45.0 v.
'01A	4.5 v.	45.0 v.	
'01A	9.0 v.	90.0 v.	
'37	13.5 v.	135.0 v.	75.0 v.
'36, 77	1.5 v.	135.0 v.	

This tabulation should be useful in deciding the proper values of resistance required for the bias detector.

Electrifying Battery Receivers

There are many battery operated receivers in use today which are good enough to electrify. The physical condition of the set should be the criterion by which the worth of a conversion should be estimated.

Note if the tuning condensers are well made; the coils shielded; without loose windings or warping of the coil forms; good A.F. transformers giving satisfactory audio response; and mechanical construction of the chassis such as to permit the necessary additional parts. If the analysis of these points in a set finds satisfactory answers to all of them, it is worth the time and money to make the change-over.

The most important rule to remember in conjunction with operations of this kind is to substitute tubes of the same class. This always simplifies the work and tends to insure success.

The most satisfactory change-overs on battery receivers have been made with the following tube substitutions:

The use of the 2.5 volt tubes for D.C. operation is not justified now that the 6.3 volt tubes are so highly developed. A current drain of 1.75 amperes demands the use of a series filament resistor which is wasteful. The new 6.3 volt tubes in the series connection consume .3 amperes. This drain is within reason.

Do not try to change over sets for A.C. or D.C. operation and change from triodes to pentodes or screen-grid tubes. The coils were not designed for such operation. If the R.F. circuit of the set had '99 type tubes don't try and replace them with '24's or '36's. In order that such a change be made the receiver might as well be completely rebuilt.

If the above plan is carried out there will be a minimum of socket change and other mechanical labor.

Build the power supply separately so as not to disturb the set chassis. This will result in less hum and greater stability.

Place all bypass condensers, bias resistors, etc., on the receiver chassis. That is where they belong—not in the power supply unit.

Always try to change over to tubes with the same inter-electrode capacity (as close as possible) and the same plate impedance. By changing over circuits with this in mind it is possible to maintain the stability in the R.F. amplifier and the quality in the A.F. amplifier which was present in the original set and tubes.

It should be apparent to the reader that the idea of "tube-of-some-classification use" limits the amount of work necessary for any change-over.

The major changes under the above condition lie in the addition of the power supply units and the filament wiring. It is best to start out with the thought of keeping the power supply unit separate from the rest of the set. Mounting it on a small chassis or even on a wooden baseboard simplifies matters and reduces the actual work on the receiver itself.

Changes necessary for the conversion of battery sets over to D.C. receivers are quite simple and the progressive steps necessary for such a job will be described in detail. For example, a set consisting of three R.F. stages, detector and two A.F. stages, the output stage being connected in push-pull, will be used.

The circuit of Fig. 10 is typical of thousands of battery receivers that are still popular in the rural or farming sections of this country. The two R.F. stages are neutralized by condensers C. Under these conditions one can see that any change in the interelectrode capacity of the tube elements will upset the stability of the circuit and cause the set to oscillate. This tends to complicate tuning and lower the efficiency; so tubes with approximately the same interelectrode capacities should be used.

We can use tubes such as the '27, '26, '56 or the '37. The '37 is the ideal tube for this purpose, as the filament consumption is low (0.3 amperes), and is of the cathode type.

Fig. 11 shows the original filament circuit and the revised circuit for the same set wired for 110-volt operation, with cathode-type tubes. In the output stage, '38-type pentodes have been used to replace the '71A's.

So many say that the '01A tubes could be used in series just as well. That is true, but the cost of the filter circuit necessary for humless operation is high compared to the cost of the tubes, and the fact is that no filter is required for the filament circuit of these new type tubes.

For those interested in knowing how the value of resistor R in Fig. 12 is obtained, the following will be helpful.

Let us consider the tubes as a group of resistors, in Fig. 12. Studying the tube chart shows that the tubes selected require a voltage of 6.3 with a current of 0.3 amperes; and as all the tubes are connected in series the same current flows through all the filaments, and

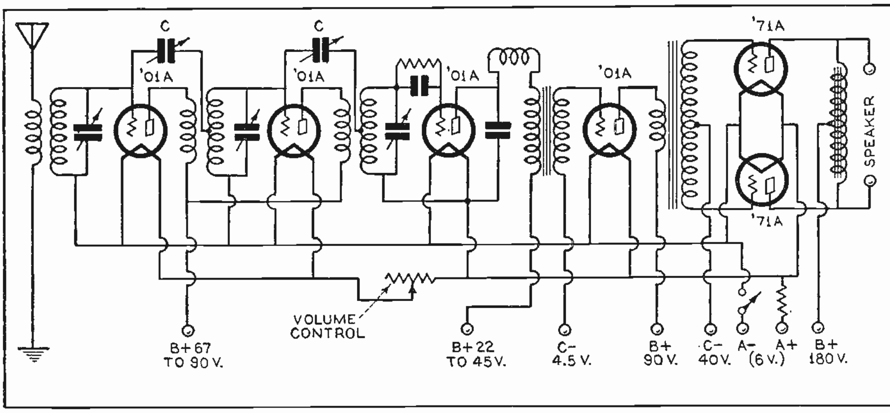


Fig. 10
Typical battery type receiver

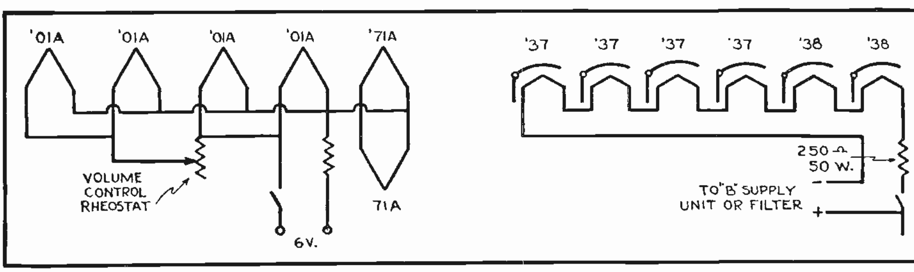


Fig. 11
Break-down analysis of filament circuits

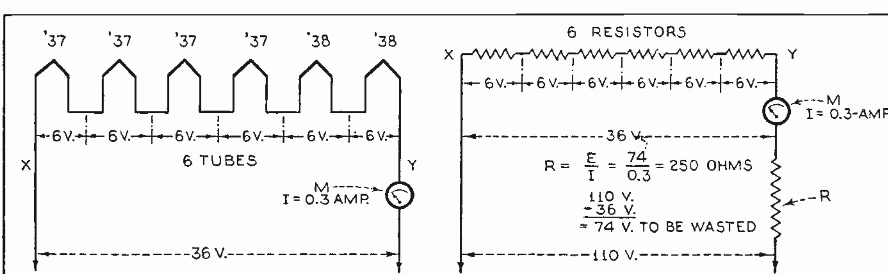


Fig. 12
Proper method of calculating value of filament current limiting resistance

the voltage across the filaments will be the same. Now there are six of these filaments in series and, as the voltage drop across each tube is six volts, the total voltage required across all of them must be thirty-six volts (six times six equals thirty-six).

In any circuit where current flows there will be a limit to the current due to the amount of the applied voltage and the value of the total circuit resistance. In other words, if the voltage is raised and the resistance kept constant there must be an increase in the flow of current. Under this condition the tubes would burn out, so, we must add a current-limiting resistor that will dissipate that extra current which would burn out the tubes.

The current .3 ampere required through the series circuit will cause a voltage drop of thirty-six volts and as we have 110 volts at the source it becomes necessary to consume the difference between these voltages which is seventy-four volts.

When the voltage to be dissipated is known it is a simple matter to determine the value of the resistor R. The answer to the problem is worked out in Fig. 12 and while the absolute answer is 246 ohms, commercial practice and standard values of resistors suggest the use of the 250 ohm size. Odd values of resistance are difficult to obtain.

As no filter is required in the filament circuits of these tubes and the proper value of resistance has been determined, this part of the circuit can be dropped from consideration for the moment.

The voltage available for the plate supply of all the tubes is limited to the line voltage less the drop in the filter choke or chokes. This voltage should be kept at a high value by using low resistance chokes (D.C. resistance) and as the frequency of the ripple from the generators is quite high, filter-condenser capacities can be quite small with remarkable results. Fig. 13 shows electrical details for the plate supply filtering unit.

It is well to include a power fuse in the input circuit to take care of any unexpected shorts which may develop.

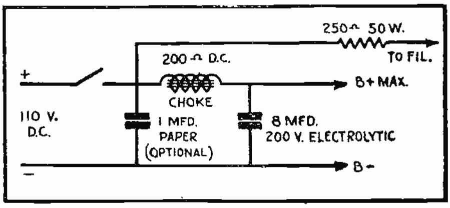


Fig. 13
Simple form of D.C. power supply filter

Also, it is not necessary to ground the receiver as it will be grounded through to the power lines.

The circuit of the original receiver in Fig. 10 revised for D.C. operation is shown in Fig. 14. Correct values for all resistors and condensers are marked in the diagram.

The following items are of importance and must be stressed. One .1-mf. condenser should be placed in series with the antenna R.F. coil primary. This prevents shorts if the antenna happens to "ground."

The volume control is changed from the simple rheostat control of the filament to that of the bias voltage control so widely used today. The condensers C must be adjusted so that the set will not oscillate at the lower wavelengths. Last but not least, the output transformer or choke must be one designed for use with the '38 type output pentodes. There are several manufacturers making 110 volt D.C. speakers with output transformers to fit the require-

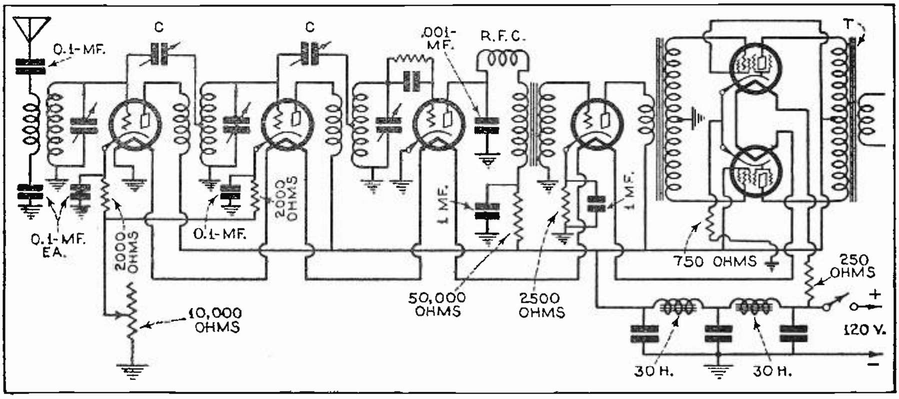


Fig. 14
Circuit of Fig. 10 revised for D.C. operation

ments of the circuit.

The results of a change-over of this kind are remarkable and well worth while. The secret of it all lies in the fact that the balance of the original circuit has not been radically changed and a minimum of added parts and labor enters into the job.

Remember, stick to tubes of the same type and it is hard to go wrong!

Alternating Current Conversions

The same principles as stated in the section devoted to D.C. conversions apply to changes for A.C. receivers.

Always stick to tubes of the same type except in the case of power tubes; in which case higher power rated tubes may be used if there is sufficient signal energy inherent in the R.F. and A.F. sections of the set to swing the output tube grids.

Taking the same circuit of Fig. 10 and planning the conversion for proper operation we find that the '27 type tube will be the best for the R.F. stages, detector, and first A.F. amplifier, with a choice of output tubes.

There are two suggestions for the power tubes, '45's or '47's. Push-pull would be best using either type.

As the greatest gain will be obtained by the use of the pentode type output tubes the circuit in Fig. 15 shows the completed conversion.

If the R.F. coils are changed over to the screen-grid type then screen-grid tubes can be used.

Build the power supply unit separately as recommended for the D.C. conversion. This results in less hum and a minimum of labor on the original chassis.

The output transformer should be selected to match the tubes used in the output stage and the speaker, for maximum power and output. The standard dynamic speaker can be purchased with any type of output transformer so this does not present a problem.

Instead of the two chokes a speaker-field can be used if the voltage supplied by the power transformer is high enough to permit the proper voltages on the tubes. The circuit shown in Fig. 16 may be used with the receiver shown in Fig. 15, with speaker field used as a choke. Condenser C should be insulated from the chassis so that the speaker-field will not be shorted. This method of using the speaker-field as part of the filter system is ideal for converted receivers. The additional parts necessary for the A.C. conversion, other than the speaker, will be the power transformer, filter condenser, and rectifier tube with its socket. The choice of the proper transformer depends on several considerations; the maximum voltage re-

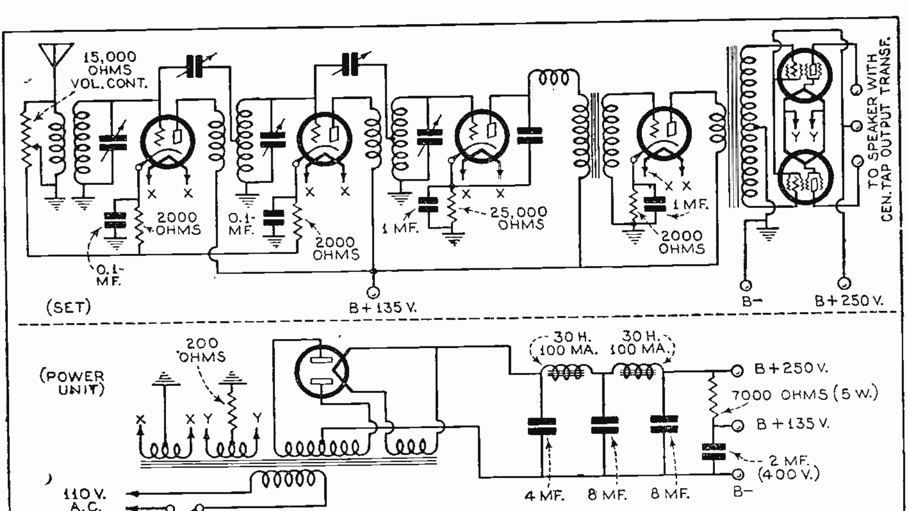


Fig. 15
The A.C. version of Fig. 10

quired, the current at that voltage, and the current consumed by the filaments or heaters.

Use filter condensers with a suitable voltage rating so that they will not be punctured by any ordinary surge. Electrolytics fill the bill as they are small in size even when their capacity is rated at 8-mf. Cost in general will be less than a paper condenser of smaller electrical capacity.

It will be noted that the four-prong sockets on the original set have to be changed over to the five-prong type.

Adapting Old Battery Models to the New Two Volt Tubes

There are many good receivers in use today using the standard five volt tubes on a storage battery. Some times the storage battery goes bad, but when the Service Man is called in, the owner of the set may not want to purchase a new receiver but would be willing to pay for a simple conversion.

As a rule the method of procedure follows closely along the lines set forth before.

Select tubes of the same general type and replace the filament controls with suitable values of resistance. The circuits of a job done by one Service Man is illustrated in Fig. 17 and Fig. 18.

This shows the Atwater Kent models "33" and "49," rewired for 2-volt tubes. Since with 90 volts "B" on the R.F. tube-plates a negative bias of 4½ volts is required, the secondaries of the first three R.F. transformers are disconnected from the filament, grounded through a .1-mf. condenser, and brought out to the "C" connection. There are only six wires in the cable, so the detector "B plus" is cut loose and connected to the R.F. and first audio plate-lead through a 10,000-ohm resistor and by-passed by a .5-mf. condenser. Then, the wire in the cable that originally went to the detector (yellow wire) is connected to the R.F. grid lead and the first A.F. transformer grid return lead.

The best volume control was determined by the use of the "antenna adjusting condenser," as this has a knob on the front panel for manual adjustment. Of course, the filaments are cut loose from the two rheostats and connected direct. If an "air cell" type of "A" supply is to be used, a 7-ohm resistance is wired in at point X.

To the Service Man it is at once apparent that the changes called for are not such as to demand a lot of new parts or a lot of labor. It is jobs like this that make receiver modernizations an interesting proposition.

Many write in for information as to the proper size of rheostat to use with a certain tube or tubes. So, let's clear that question up.

In Fig. 17A there are three tube filaments connected in parallel. Resistor R is connected in series to limit the

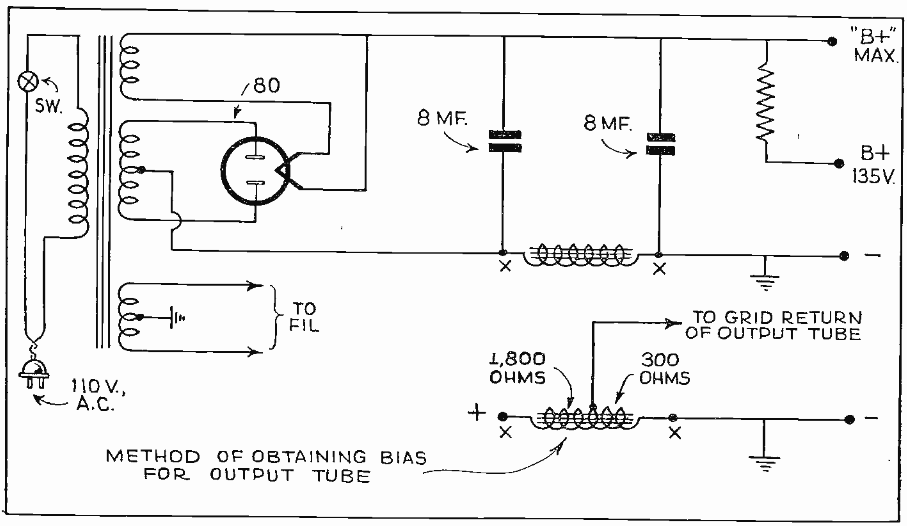


Fig. 16
Speaker field as filter choke.

flow of current through the filaments. This resistor may be a fixed resistor or rheostat as the cause may require. If a rheostat is used then the value of the minimum resistance essential to drop the applied voltage must be found.

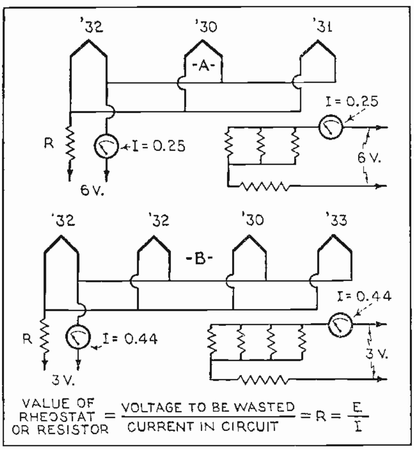


Fig. 17
Filament break-down analysis of Fig. 16

Refer to the tube charts and it will be noted that the filament current of the '32 and '30 is .06 amperes, while the current of the '31 is .13 amperes. Two tubes with .06 and one with .13 gives a total filament consumption of .25 amperes. This is the value of the total current which will flow when the proper voltage is applied. This voltage is two volts, but the source of supply is a six-volt storage battery. Therefore it becomes necessary to reduce the six volts of the battery to two volts for the tubes. The difference between six and two volts is the voltage to be dissipated in the resistor, which is four volts. Ohm's law tells us that the voltage across a resistor is proportional to the current flowing through the resistor. Thus, by dividing the current flowing through the circuit into the voltage which is to be dissipated we find the value of the current limiting resistor will be sixteen ohms. Fig. 17B gives a problem along the same lines with a different source of voltage such as two No. 6 cells in series. The resistor in this case is 2.2 ohms.

The rating in watts of resistor and rheostats to be used should also be considered. In other words, always select a resistor or rheostat that will easily carry .the current. To determine the power to be dissipated in any circuit simply multiply the value of the current flowing through the circuit by itself, and then multiply the resulting product by the resistor in ohms. This will give the watts dissipated in the circuit and a resistor should be selected with a rating of about three times the value figured.

The following information may be useful in conversions where coil and tuning condenser combinations permit the use of screen-grid tubes.

A typical circuit of a three stage R.F. amplifier is shown in Fig. 18.

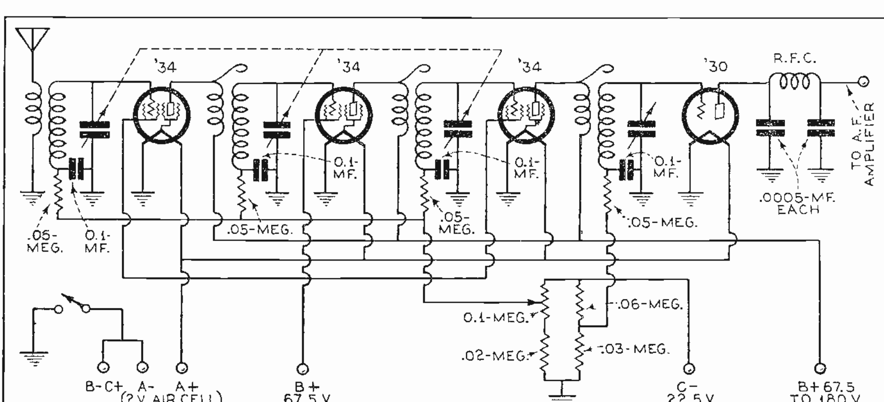


Fig. 18
Two volt battery model of A.K. "33"

A.C. to D.C. and D.C. to A.C. Conversions

Here are two problems that can be discussed at the same time. The conversion of A.C. receivers for operation on D.C. should be profitable for Service Men living in large cities where both A.C. and D.C. are available.

When people move from one neighborhood to another, it is often necessary to change the radio set because of different power supply. If the set is a good one it is worth while changing over, and usually the cost of material and labor reach fair figures and the job should pay a good profit.

The reader should, in general, follow the instructions outlined before.

A good example of a D.C. to A.C. conversion will be found in Figure No. 19. It is a standard commercial receiver built for D.C. operation by the Lang Radio Company. It has two stages of screen-grid radio frequency amplification, a screen-grid detector resistance-coupled to the '30 type first audio stage, which is in turn transformer-coupled to the push-pull power stage.

All constants for the various parts are given in the circuit diagram and the receiver as a whole is representative of the average D.C. electric set sold today.

In Fig. 20 the same set is shown, only in complete A.C. form. Note that tubes

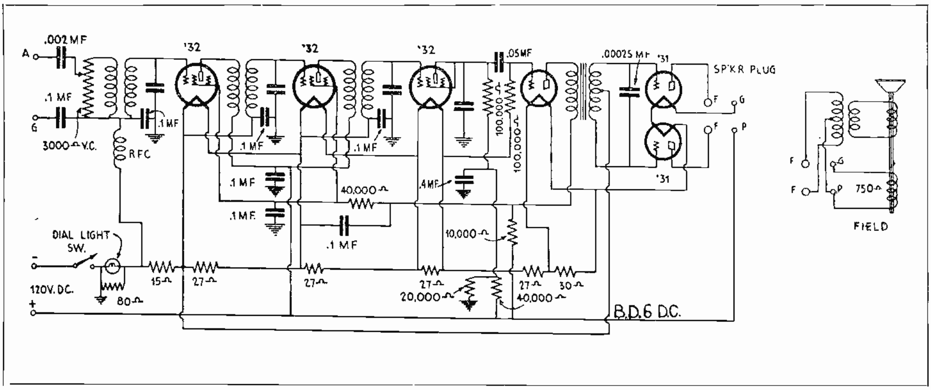


Fig. 19
D.C. Receiver using low-current, two volt tubes

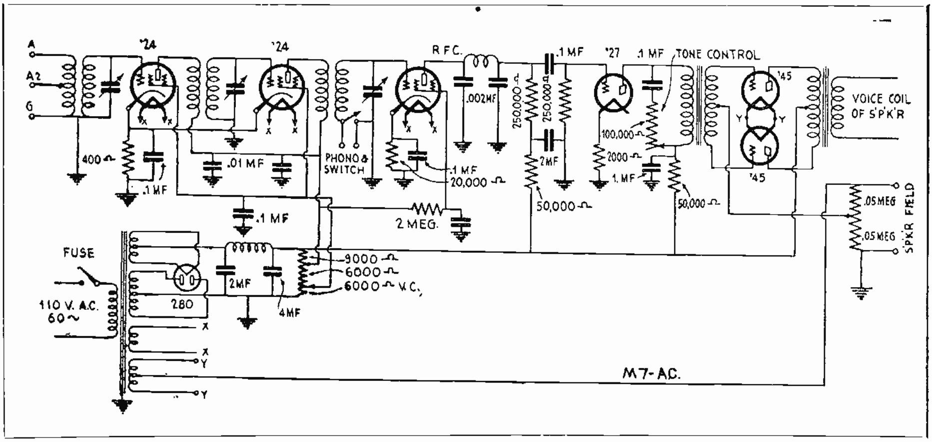


Fig. 20
The A.C. model of the above receiver with power supply

of the same general classification have been used; type '24 for the '32's, '27 for the '30's, and '45 for the '31's.

The additional material needed for this conversion consists of the following items:

Power supply transformer.

Filter choke.

'80 socket.

Two filter condensers. (Use electrolytics.)

Incidental resistors and bypass condensers.

Five prong sockets.

Iron or other metal chassis for the new power supply.

New volume control.

Study these circuits as they show better than written words just how to make a conversion. Note the removal of the series condensers in the antenna and ground leads in the A.C. model. The volume control is placed in the screen-grid circuit and removed from the antenna primary.

When the filament circuits are changed over to the parallel connection that is the time to change the sockets from the four prong to the five prong type. The change-over does not affect the '45 tube sockets. Use the original sockets.

Mount the power supply unit on a small metal chassis and place it in the receiver cabinet. Use heavy wire for the filament leads especially those leads marked X.

The man that expects to make money with such conversions must use his head. It is impossible to cover all of the variations in circuit design in the space allotted to this section, therefore read up on the ideas expressed in other sections and chapters of this book.

1. The main points to remember in conversions of this type are as follows:

2. Use tubes of the same general classification.

3. Build a separate power supply unit when making D.C. to A.C. conversions.

4. Study the tube charts when deciding on the values of resistance to be used in any of the circuits.

5. Use good material and workmanship.

6. Plan the job completely before you start.

The steps to be taken in converting an A.C. receiver over to D.C. operation are as follows:

1. Use the automotive type tubes (6.3 volt filament).

2. Wire the filaments in series.

3. Place .5-mf., 200-volt bypass condensers in the antenna and ground leads.

4. Change bias resistors to conform with specifications given in tube chart.

5. Use the filter chokes and filter condensers of the original power unit for the D.C. plate filter.

6. Do not remove the power transformer or any of the other units which, though used for A.C. operation, may not be necessary for D.C. This leaves the set in its original condition so far as appearances are concerned.

7. The only addition to the outside of the set should be the series filament resistor, and this should be placed in a position where the resulting heat will not raise the temperature of the chassis nor heat the wooden case to such a degree as to effect the finish, or warp the wood.

The method of determining the value of the filament series resistor and its watts rating is covered earlier in the chapter.

Do not change R.F. circuits over for screen-grid operation if the set was designed for triode operation, unless there is adequate shielding and a complete new set of coils are substituted in place for the low gain coils which were in the set.

Plan the job carefully and then check before doing a single thing to the set. Know what you are doing before you start and then do a careful job.

Do the job right and there will be no loss in time and money for additional service work.

Modernizing Superheterodynes

Everyone knows that the superheterodyne type of receiver has reached the peak of popularity in the last few years. Thousands of sets using this circuit have been built and many of them can be improved.

While multi-band reception is common enough in today's superhet models, one finds that this angle was ignored or not used due to the lack of public interest in short wave reception. This angle is so important that a special chapter of the book deals with the circuit problems in such receivers.

This chapter deals with the possible improvements that can be made in earlier models operating over the broadcast band only.

There are a few outstanding features that deal with the major improvements in recent superhet design. These features can be used in early model sets with excellent results in many cases.

Suggestions for changes are listed below:

A—Use of the new composite types of tubes (2A7—Oscillator and first detector, 2B7—Diode detector and audio amplifier).

B—Automatic volume control.

C—Build pre-selector units.

D—Selection of better I.F. transformers and intermediate frequencies.

While most of the necessary information necessary for the use of all composite types of tubes can be obtained from the tube charts, more complete information is furnished by RCA-Cunningham on the 2A7. This tube is quite similar in characteristics to other tubes except for the value of cut-off for minimum mutual conductance. The charts and coil data are also furnished by RCA-Cunningham.

As a frequency converter in superheterodyne circuits, the 2A7 can supply the local oscillator frequency, and at the same time mix it with the radio-input frequency to provide the desired intermediate frequency.

For the oscillator circuit, the coils may be constructed according to conventional design, since the tube is not particularly critical. The supply voltage applied to the anode-grid (No. 2) should not exceed the maximum value of 250 volts. In fact, from a performance standpoint, a lower value is to be preferred, because it will be adequate to provide for optimum "conversion" gain. The size of the resistor in the grid circuit of the oscillator is not critical but requires design and adjustment depending upon the values of the anode-grid voltage and of the screen voltage. Adjustment of the circuit should be such that the cathode current is approximately 11 milliamperes. Under no condition of adjustment should the cathode current exceed a recommended maximum value of 14 milliamperes. The following tabulation gives suitable values for different voltages on the electrodes:

Plate Voltage	100	250	250 Volts
Screen Voltage (Grids No. 3 and No. 5)	50	75	100 Volts
Anode-Grid (No. 2) Voltage	100	100	*250 Volts
Grid (No. 1) Resistor	10,000-25,000	25,000-50,000	50,000-100,000 Ohms

*Applied through resistor of 20,000 ohms.

The bias voltage applied to grid No. 4 can be varied from —3 volts to cutoff to control the translation gain of the tube. With lower screen voltages, the cut-off point is less remote. The extended cut-off feature of this tube in combination with the similar characteristic of super-control tubes can be utilized advantageously to adjust receiver sensitivity.

Since the capacity between grid No. 4 and plate is in a parallel path with the capacity and inductance of the plate load, it is important to use a load capacity of sufficient size to limit the magnitude of the r-f voltage built up across the load. If this is not done, r-f voltage feed-back will occur between plate and grid No. 4 to produce degenerative effects. For this reason, the size of the load condenser in the plate circuit should be not less than 50 mmf.

Converter circuits employing the 2A7 may easily be designed to have a conversion gain of approximately 60.

For second detector circuits the 2B7 can be used for performing the simultaneous functions of automatic volume control, detection and audio amplification.

For detection, the diodes can be used in a half wave or full wave circuit. The use of the half wave circuit will provide approximately twice the rectified voltage as compared with the full wave arrangement.

For automatic-volume-control, a rectified voltage which is dependent on the

R.F. or I.F. carrier is usually employed. This voltage is utilized to regulate the gain of the R.F. or I.F. amplifier stages so as to maintain essentially constant-carrier input to the audio detector. Refer to chapter of automatic volume control methods.

ployed in conventional circuit arrangements. It is designed so that its cut-off is somewhat extended to permit of moderate gain control by grid-bias variation, without introducing cross-modulation effects. The cut-off point and the ability to handle the larger signals may

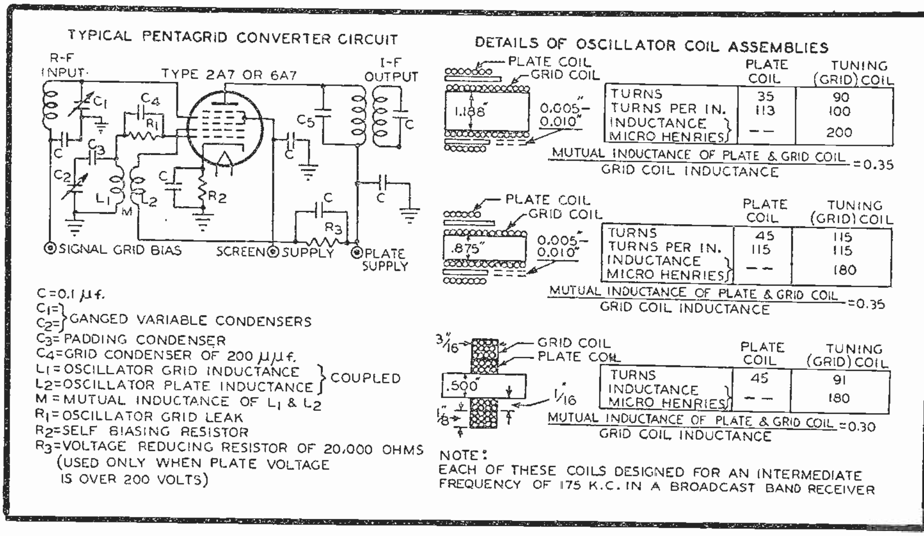


Fig. 21
Pentagrid Converter Circuits. (Courtesy R.C.A.)

The complex structure of the 2B7 permits obtaining automatic volume control voltage in a number of ways. In one case, the required voltage is obtained from the detector circuit by utilizing the voltage drop caused by the rectified current flowing through a resistor in the detector circuit. In another case, the required voltage is obtained by utilizing one diode for the sole purpose of automatic volume control. This latter method is of particular interest since it confines the sensitivity and time-delay function to the a.v.c. circuit. Time-delay action is determined by the use of a resistance and condenser combination having the desired time constant. The a.v.c. action may be postponed by applying a negative voltage to the a.v.c. diode plate. Another a.v.c. arrangement capable of various adaptions is to use the pentode as a D.C. amplifier to supply the regulating voltage.

For R.F. and I.F. amplification, the pentode unit of the 2B7 may be employed in conventional circuit arrangements. ...

be altered by choice of screen voltage to suit the requirements of the circuit.

For many types of circuits a convenient and practical method of obtaining the desired benefit of the extended cut-off is to supply the screen voltage from a high-voltage tap through a series resistor. This arrangement provides, automatically, an increase in the voltage applied to the screen as the grid-bias is made more negative, with the result that the maximum signal-handling ability is obtained. When this method is used, the voltage applied to the screen should be limited to 125 volts for —3 volts grid-bias, and to 200 volts for more negative values of grid-bias.

For A.F. amplification, the pentode unit of the 2B7 may be used in a resistance-coupled circuit arrangement to provide high gain. Typical operating conditions for such service are: plate-supply voltage, 250 volts, applied through a load resistor of 0.2 megohm; screen voltage, 50 volts; grid-bias, —4.5 volts; and plate current 0.65 milliampere.

Grid-bias should be obtained from a fixed-voltage tap on the D.C. power supply. The value of resistor in the grid-circuit should not exceed a maximum value of 1.0 megohm.

An example of the possibilities when using composite types of tubes will be found in the block diagram of Fig. 23. Here a standard two gang tuning condenser was used to tune the detector coil and a separate oscillator tube. In this set a 27 tube had been used as the oscillator and a 24 type tube as the first detector.

By combining the function of detection and oscillation in the same tube, a socket was left open. This socket was used to add a tuned stage of radio frequency before the first detector. This really improved the performance of the set tremendously.

The set had to have another three gang tuning condenser and a new radio frequency transformer. The extra R.F. transformer was placed in a convenient place under the chassis, and one of the new midget types of tuning condensers was used in place of the original two gang unit. The parts fitted very well, and the whole job completed in three hours. The block diagram of Fig. 24 indicates the changes. Fig. 21 shows the circuit of the oscillator—detector combination. The circuit of the additional R.F. stage was of the conventional type usually employed in such receivers.

An excellent use of the new 53 type tube in audio frequency circuits was incorporated in another super. Here the audio amplification was not sufficient to swing the output tubes. The double grids and plates of the 53 type

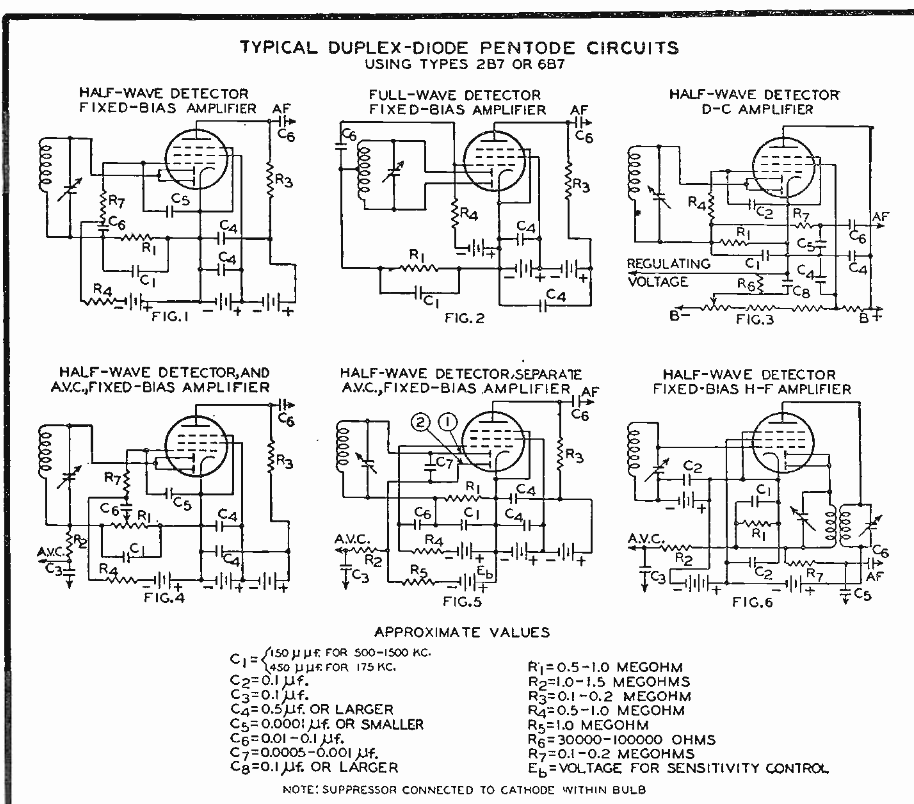


Fig. 22

Duplex-Diode circuits. (Courtesy R.C.A.-Cunningham) tube were used in the circuit of Fig. 25 and due to the high gain worked out very well. A new socket and a few resistors were the main expense.

The addition of A.V.C. is of major importance and is taken up in great detail in Chapter 4.

The circuit changes of Figs. 23 and 24 indicate the possible improvements that can be obtained from pre-selection, and the addition of more tuned circuits before the first detector will help to reduce image interference and other undesirable effects. These pre-selector units can be built up on a separate chassis with a dial for tuning purposes. Units of this kind will reduce the sensitivity in most cases, but this must be expected.

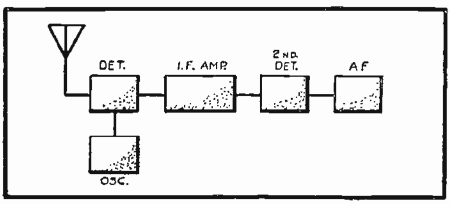


Fig. 23
Block diagram simple super circuit

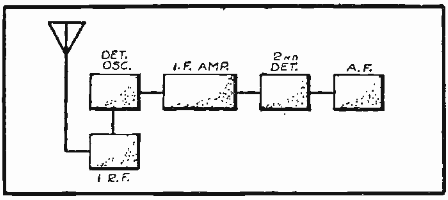


Fig. 24
Block diagram using pentagrid converter

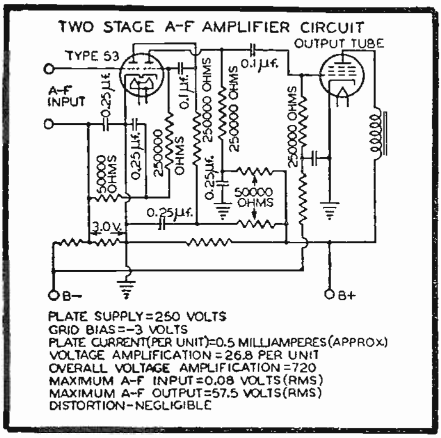


Fig. 25
Circuit of high-gain voltage amplifier

New and more efficient intermediate frequency transformers are available and can be used to give greater gain and selectivity. Use intermediate frequency transformers tuning to the same intermediate frequency for which the set was designed unless you can change the oscillator coil. This is very necessary as changes in the intermediate frequency will throw off the tracking of the oscillator tuning condenser.

The use of 465 k.c. for the intermediate frequency is quite common today and, because of this, along the coast code interference appears in such receivers. These code signals seem to come in all over the tuning dial and are very exasperating. There are several stations transmitting code signals around 465 k.c. and these signals are picked up by the set and amplified by the intermediates. The way to clear the difficulty is to use a trap in antenna circuit as shown in Fig. 26. The coil can be one of the windings from an old 465 k.c. I.F.T. and the condenser one of the compression type. Tune this coil and condenser combination to the frequency of the intermediate amplifier and leave it alone. This will prevent this code interference.

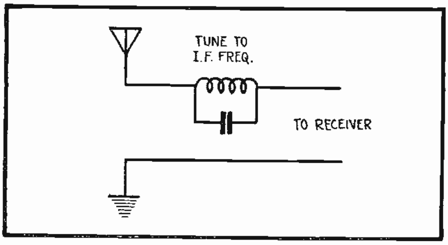


Fig. 26
465 KC wave trap for code elimination

CHAPTER 2

Selecting Tubes

Special purpose tubes are available everywhere today and the proper selection of tubes can be made to really improve an existing receiver. It might be advisable to reread Chapter 1, and with proper thought given to the various considerations stated proceed to the selection of tubes.

A close study of the comprehensive Tube Chart in this chapter will give the set builder many ideas in tube combination which will permit real improvements in receiver operation.

An interesting wrinkle in tube possibilities, especially for audio work will be found in connection with the popular 57 and 77 type tubes. In this case the screen grid and suppressor grid are connected directly to the plate and the tube functions as a triode. The plate voltage applied can be from 180 to 250 volts. The amplification or gain will be 20 when resistance coupled to the next stage with a plate coupling resistance of 100,000 ohms. The plate impedance of the tube under this condition will be about 12,000 ohms and of course can be used transformer coupled with greater resultant amplification. It is a real improvement to use one of these tubes in the first stage of radio sets built with two stages of audio amplification. The resultant high gain of the 57 type tube connected as a triode gives excellent frequency response plus the generally needed increased amplification. Try this sometime and note the results. It's well worth while. If the transformer used in the set is a real old timer with high turns ratio and low primary inductance then use a parallel-feed circuit with a 100,000 ohm plate loading resistor and at least .1 mf. capacity as the coupling condenser. The larger this coupling condenser the better the low frequency response, as this condenser resonates with the primary of the audio transformer. If improvements in quality have to be made, then this is one way to get quality and more amplification at a very low cost.

Many set builders have hesitated to use diode detection because they did not want to incorporate A.V.C. circuits. Tubes such as the 2A6, 2B7, 55, 75, 6B7, 85 can be used as diode detectors with their triode or pentode portions connected to give increased audio gain. The addition of the separate tube elements in the same glass envelope is really necessary due to the lack of amplification in diode circuits. Diode circuits serve one function only, rectification. Changes of this kind can always be undertaken in circuits with high radio frequency gain, i. e., superheterodyne receivers. Ordinary second detector circuits have a tendency to overload easily and the substitution of the diode detector will help improve the quality of output in many cases. Remember that the loading effect of the diode is greater than that of the ordinary triode type of tube, and for this reason there will be a decrease in the selectivity when this circuit is installed.

The improved cathode construction used in most of the new tubes results in less hum. This simplifies the filtering system of the receiver, and for this reason it is well to use cathode types whenever changes are made so that the present filtering system of the receiver will be adequate.

The 2A6, 2B7, 6B7 and 75 type tubes should be used with resistance coupled circuits, or tuned radio frequency circuits, because of their high plate impedance. The 55 and the 85 type tubes can be used with transformer coupling or resistance coupling connections due to their low plate impedance.

The audio frequency response of one receiver was improved tremendously by the use of the 2A6 tube transformer coupled to the output stage. A rising audio characteristic was obtained in this manner which compensated for the "sideband cutting" of this very selective receiver. Prior to this change, the high frequency audio signals were badly attenuated by the receiver; the audio transformer when used with the 2A6 had poor low frequency response. The resultant output due to the use of this combination was very pleasing to the ear and satisfied the owner of the set.

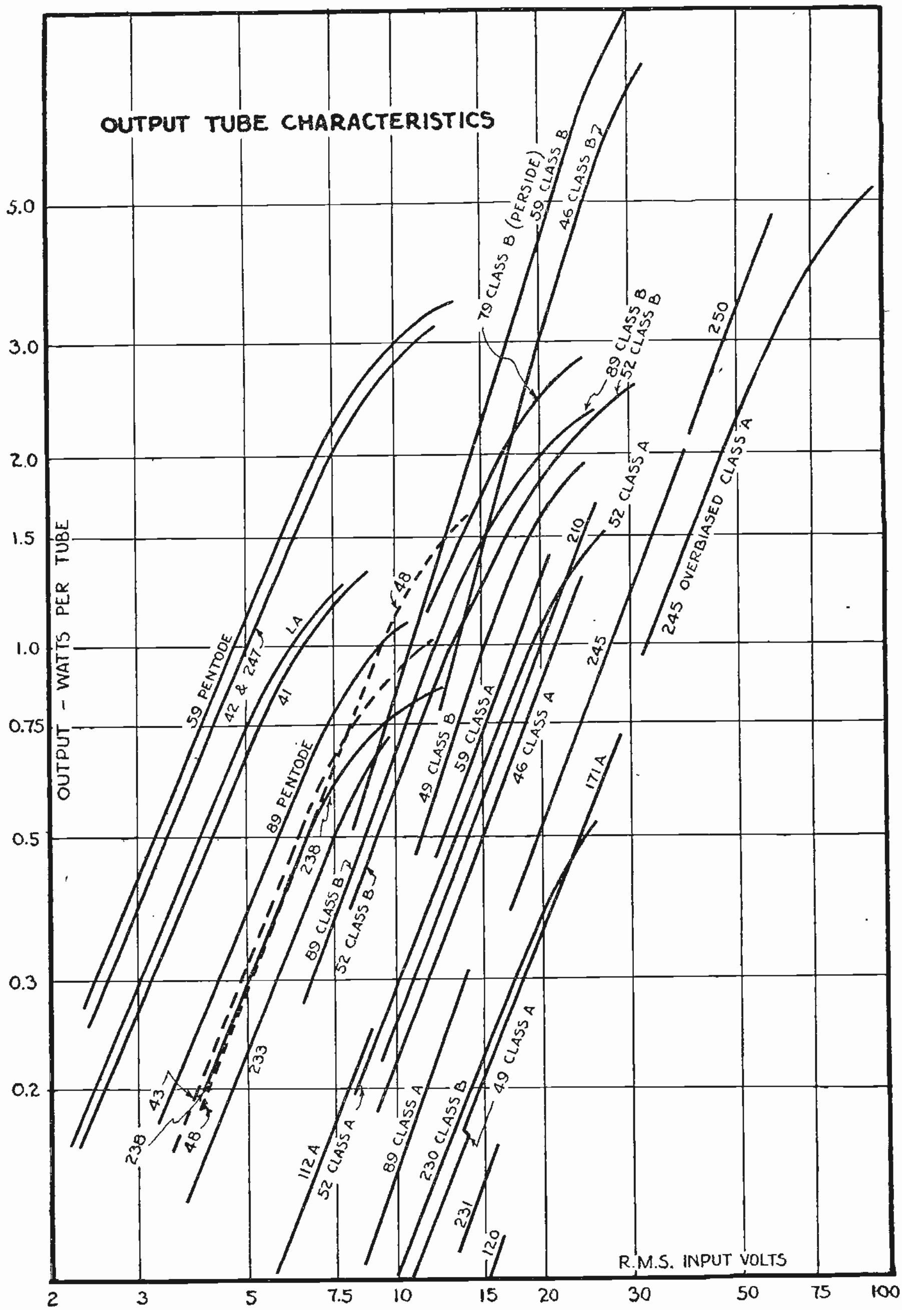
Output Tube Chart

The accompanying chart has been prepared as a convenient means of comparing the various types of output tubes with respect to the relation between watts output and input voltage applied to the grid. The curves shown represent these characteristics under approximately the rated operating conditions with optimum values of load resistance and in most cases, with the maximum rated plate voltages. The corresponding values of plate and grid voltages are listed in the accompanying table. In the case of the triodes and pentodes in Class A operation, the maximum values of power output shown correspond to the point at which grid current just begins to flow, or, in other words, at which the peak value of the input voltage is equal to the grid bias voltage. The type 52 tube under zero bias Class A conditions and the type 245 under over-biased Class A conditions are exceptions. In these cases, as well as in the cases of Class B operation the grid normally swings positive and the maximum output is determined primarily by consideration of permissible distortion. It should be understood that the values shown on these curves are approximate only, as the relations may be materially changed by variations in operating conditions, such as the value of the load resistor, the characteristics of the input transformer, power available for driving, etc.

In the cases of Class B and overbiased Class A operation where tubes are always used in pairs, in push pull, the curves represent the input voltage and output for each tube of the pair. Thus the output for a pair of 52 tubes under Class B conditions would be approximately 5.0 watts or double the value shown for a single tube and the corresponding input voltage from grid to grid would be 60 volts. In the case of the 79 tube which is a complete full-wave Class B tube, the curves represent the output and input for one side, the total output and input being double the values shown.

Logarithmic coordinates have been used so that the characteristics are represented by straight lines for tubes having the ideal square law relation between input volts and watts output. Variations from this straight line relation and the square law slope, such as occur at high output levels with pentodes and with triodes under Class B conditions, ordinarily indicate the presence of third or other odd harmonics. The higher slope in the case of some triodes operated under Class B conditions is due to increased mutual conductance and reduced plate resistance at high signal levels.

The position of the characteristic curve indicates the relative power sensitivity of the tube; the higher or farther to the left the curve is, the higher the power sensitivity. The numerical value of power sensitivity in milliwatts per input volt squared is equal to ten times the intercept on the 10 volt axis; for instance, the output from a type 89 tube used as a Class A triode is 0.15 watts with an input of 10 volts RMS, corresponding to a power sensitivity of 1.5 milliwatts per volt squared. For convenience the approximate values of power sensitivity for medium signal amplitudes are listed in the accompanying table. The power sensitivity will of course vary with the factors affecting total power output and in many cases also with the signal amplitude.



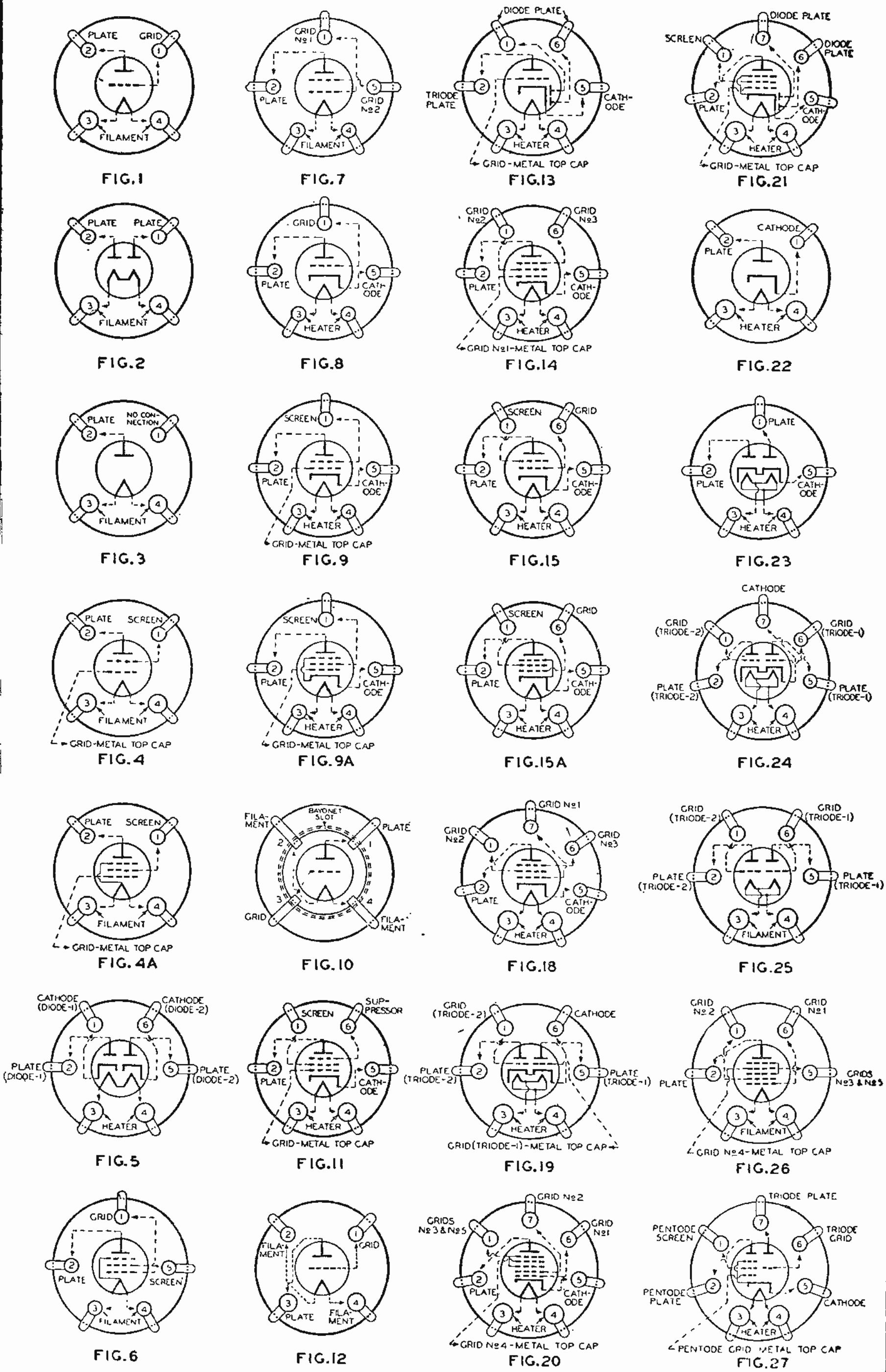
OUTPUT TUBE CHART

Power output vs. R.M.S. input volts of all modern power tubes. (Courtesy Raytheon Corp.)

Tube Type	Amplifier Type	Class	Plate Volts	Grid Bias Volts	Power Sensitivity in Milliwatts / (RMS input V.)^2
112A	Triode	A	180	13.5	3.2
120	Triode	A	135	22.5	.43
171A	Triode	A	180	40.5	.90
210	Triode	A	425	39	2.55
230	Triode	B	157	22.5	1.0
231	Triode	A	135	22.5	.66
233	Pentode	A	135	13.5	9.0
238	Pentode	A	165	17	12.0
41	Pentode	A	167	12.5	29.0
42	Pentode	A	250	16.5	43.0
43	Pentode	A	95	15	12.0
245	Triode	A	275	56	1.3
245	Triode	A[1]	300	75	.90
46	Triode	A	250	33	2.25
46	Triode	B	400	0	6.0
247	Pentode	A	250	16.5	43.
48	Pentode	A	95	20	11.5
49	Triode	A	135	20	.86
49	Triode	B	180	0	4.0
250	Triode	A	450	80	1.30
52	Triode	B	180	0	6.2
52	Triode	A	110	0	3.0
59	Triode	A	250	28	3.2
59	Pentode	A	250	18	46.
59	Triode	B	400	0	8.0
79	Triode	B	180	0	8.2
89	Triode	A	160	20	1.5
89	Pentode	A	163	17	15.2
89	Triode	B	180	0	6.7
LA	Pentode	A	165	11	31.

Acknowledgement is made to the RCA Cunningham Company for the use of charts 26 to 33; to A. M. Flechtheim Co. for the excellent power output chart and tables; also, to Hygrade Sylvania for the condensed tube characteristics on page 36.

Tube Symbols and Bottom Views of Socket Connections



OPERATING CONDITIONS FOR RESISTANCE—COUPLED A-F AMPLIFIER SERVICE

Tube																	
2A6 and 75	PLATE SUPPLY∞ (Volts)	100				135				180				250			
	SCREEN SUPPLY (Volts)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	GRID BIAS (Volts)	-1.05	-1.05	-1.10	-1.05	-1.05	-1.10	-1.05	-1.10	-1.25	-1.20	-1.30	-1.30	-1.30	-1.30	-1.35	-1.35
	CATHODE RESISTOR (Ohms)	10500	15400	11550	15000	6200	9150	5850	10000	4900	7100	5450	9000	3170	5200	3380	5600
	PLATE RESISTOR (Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR* (Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT (Milliamp.)	0.10	0.07	0.09	0.07	0.17	0.12	0.18	0.11	0.25	0.17	0.24	0.14	0.41	0.25	0.40	0.24
	VOLT. OUTPUT** (Peak Volts)	11-16	10-14	15-19	14-19	17-23	17-21	20-30	18-27	26-33	24-30	32-40	30-38	33-38	28-35	36-46	35-44
	VOLTAGE AMPLIFICATION	30	29	36	37	42	38	50	48	48	46	56	55	51	48	59	58
2B7 and 6B7	PLATE SUPPLY∞ (Volts)	100				135				180				250			
	SCREEN SUPPLY (Volts)	20	20	20	20	20	20	20	20	25	25	25	25	50	50	50	50
	GRID BIAS (Volts)	-2.00	-2.50	-2.15	-2.60	-1.80	-2.25	-1.95	-2.40	-2.10	-2.60	-2.10	-2.60	-4.5	-5.0	-4.5	-5.0
	CATHODE RESISTOR (Ohms)	5550	12200	9350	19250	3800	8300	4850	10900	3700	7600	3500	7300	5500	11400	5500	11400
	PLATE RESISTOR (Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR* (Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT (Milliamp.)	0.27	0.15	0.23	0.13	0.35	0.20	0.30	0.16	0.43	0.26	0.45	0.26	0.65	0.35	0.65	0.35
	VOLT. OUTPUT** (Peak Volts)	28-30	25-27	36-38	32-33	38-40	32-35	48-50	42-44	50-53	45-48	65-68	64-66	55-65	55-60	65-70	66-75
	VOLTAGE AMPLIFICATION	35	36	47	46	36	38	53	56	50	53	63	70	54	55	65	75
55 and 85	PLATE SUPPLY∞ (Volts)	100				135				180				250			
	SCREEN SUPPLY (Volts)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	GRID BIAS (Volts)	-4.75	-3.75	-5.00	-5.50	-6.80	-4.75	-7.00	-7.00	-7.50	-7.00	-7.00	-7.50	-11	-10	-14	-12
	CATHODE RESISTOR (Ohms)	16800	25800	21200	46000	21200	24300	22000	42500	16300	28000	14900	31200	17600	28500	25200	38600
	PLATE RESISTOR (Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR* (Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT (Milliamp.)	0.28	0.14	0.23	0.12	0.32	0.19	0.31	0.16	0.46	0.25	0.47	0.24	0.625	0.35	0.55	0.32
	VOLT. OUTPUT** (Peak Volts)	24-26	17-22	27-29	26-27	34-36	27-30	38-42	36-40	38-40	36-38	40-44	40-45	55-60	45-55	65-75	65-70
	VOLTAGE AMPLIFICATION	6.1	6.0	6.6	6.2	6.1	6.1	6.5	6.3	6.4	6.4	6.7	6.5	6.4	6.3	6.7	6.6
77	PLATE SUPPLY∞ (Volts)	100				135				180				250			
	SCREEN SUPPLY (Volts)	20	20	20	20	25	25	25	25	30	30	30	30	52	54	50	52
	GRID BIAS (Volts)	-1.10	-1.25	-1.05	-1.25	-1.20	-1.35	-1.25	-1.40	-1.25	-1.50	-1.30	-1.55	-2	-2.2	-2.1	-2.3
	CATHODE RESISTOR (Ohms)	3760	6450	3400	7250	3100	5600	3750	6300	2180	4550	2600	4850	3100	5700	3500	6200
	PLATE RESISTOR (Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR* (Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT (Milliamp.)	0.22	0.14	0.23	0.13	0.29	0.18	0.25	0.17	0.43	0.25	0.38	0.24	0.52	0.31	0.48	0.285
	VOLT. OUTPUT** (Peak Volts)	15-23	17-22	16-29	18-28	21-32	27-31	29-37	34-38	31-43	36-41	36-52	45-52	50-60	50-55	60-70	60-70
	VOLTAGE AMPLIFICATION	40	39	54	53	54	52	61	62	76	65	92	93	80	75	100	110

∞ Voltage at plate will be PLATE SUPPLY voltage minus voltage drop in plate resistor caused by plate current.

* For the following amplifier tube. The tabulated values illustrate design practice. For any particular set of conditions, however, the grid resistor for the following amplifier tube should conform to the recommendations given on the DATA page of the type involved.

** Developed across plate resistor of inter-stage coupling circuit including grid resistor of following tube. Value to left is maximum undistorted output voltage obtainable: value to right is maximum output voltage obtainable with some distortion.

Note: In the above data, the use of a coupling condenser between the plate resistor and the grid resistor of the following tube is assumed. A 0.1 microfarad condenser is usually adequate to insure good low-frequency response.

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL	CATHODE TYPE ■	RATING			
				LENGTH X DIAMETER		FILAMENT OR HEATER		PLATE	SCREEN
						VOLTS	AMPERES	MAX. VOLTS	MAX. VOLTS
RCA- 36	R-F AMPLIFIER TETRODE	SMALL 5-PIN	FIG. 9	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	90
RCA- 37	DETECTOR★ AMPLIFIER TRIODE	SMALL 5-PIN	FIG. 8	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	—
RCA- 38	POWER AMPLIFIER PENTODE	SMALL 5-PIN	FIG. 9A	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	250
RCA-39-44	SUPER-CONTROL R-F AMPLIFIER PENTODE	SMALL 5-PIN	FIG. 9A	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	90
UX -240	VOLTAGE AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	D-C FILAMENT	5.0	0.25	180	—
RCA- 41	POWER AMPLIFIER PENTODE	SMALL 6-PIN	FIG. 15A	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.4	250	250
RCA- 42	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	HEATER	6.3	0.7	250	250
RCA- 43	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	HEATER	25.0	0.3	135	135
RCA- 45	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	FILAMENT	2.5	1.5	275	—
RCA- 46	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	FIG. 7	$5\frac{5}{8}''$ x 2 [illegible]/16"	FILAMENT	2.5	1.75	250 400	— —
RCA- 47	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	$5\frac{5}{8}''$ x $2\frac{3}{16}''$	FILAMENT	2.5	1.75	250	250
RCA- 48	POWER AMPLIFIER TETRODE	MEDIUM 6-PIN	FIG. 15	$5\frac{3}{8}''$ x $2\frac{1}{16}''$	D-C HEATER	30.0	0.4	125	100
★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.									
RCA- 49	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	FIG. 7	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	D-C FILAMENT	2.0	0.120	135 180	— —
UX -250	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	$6\frac{1}{4}''$ x $2\frac{11}{16}''$	FILAMENT	7.5	1.25	450	—
RCA- 53	TWIN-TRIODE AMPLIFIER	MEDIUM 7-PIN	FIG. 24	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	HEATER	2.5	2.0	300	—
RCA- 55	DUPLEX-DIODE TRIODE	SMALL 6-PIN	FIG. 13	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	2.5	1.0	250	—
RCA- 56	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	FIG. 8	$4\frac{1}{4}''$ x $1\frac{9}{16}''$	HEATER	2.5	1.0	250	—
RCA- 57	TRIPLE-GRID AMPLIFIER DETECTOR	SMALL 6-PIN	FIG. 11	$4\frac{15}{16}''$ x $1\frac{9}{16}''$	HEATER	2.5	1.0	250	100
RCA- 58	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	$4\frac{15}{16}''$ x $1\frac{9}{16}''$	HEATER	2.5	1.0	250	100
RCA- 59	TRIPLE-GRID POWER AMPLIFIER	MEDIUM 7-PIN♯	FIG. 18	$5\frac{3}{8}''$ x $2\frac{1}{16}''$	HEATER	2.5	2.0	250 250 400	— 250 —
RCA- 71-A	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	$4\frac{11}{16}''$ x $1\frac{13}{16}''$	FILAMENT	5.0	0.25	180	—
RCA- 75	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	FIG. 13	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	—
RCA- 77	TRIPLE-GRID AMPLIFIER DETECTOR	SMALL 6-PIN	FIG. 11	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	100
RCA- 78	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	$4\frac{17}{32}''$ x $1\frac{9}{16}''$	HEATER	6.3	0.3	250	125

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.
■ Either A. C. or D. C. may be used on filament or heater, except as specifically noted. For use of D. C. on A-C filament types, decrease stated grid volts by ½ (approx.) of filament voltage.
♯ Requires different socket from small 7-pin.

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID VOLTS ■	SCREEN VOLTS	SCREEN MILLIAMP.	PLATE MILLIAMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
SCREEN GRID R-F AMPLIFIER	100 180 250	− 1.5 − 3.0 − 3.0	55 90 90	— — 1.7*	1.8 3.1 3.2	550000 500000 550000	850 1050 1080	470 525 595	—	—	C - 36
BIAS DETECTOR	100● 250●	− 5.0 − 8.0	55 90	—	Plate current to be adjusted to 0.1 milliampere with no signal.						C - 36
CLASS A AMPLIFIER	90 180 250	− 6.0 −13.5 −18.0	—	—	2.5 4.3 7.5	11500 10200 8400	800 900 1100	9.2 9.2 9.2	—	—	C - 37
BIAS DETECTOR	90 250	−10.0 −28.0	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						C - 37
CLASS A AMPLIFIER	100 180 250	− 9.0 −18.0 −25.0	100 180 250	1.2 2.4 3.8	7.0 14.0 22.0	140000 110000 100000	875 1050 1200	120 120 120	15000 11600 10000	0.27 1.00 2.50	C - 38
SCREEN GRID R-F AMPLIFIER	90 180 250	{− 3.0 min.}	90 90 90	1.6 1.4 1.4	5.6 5.8 5.8	375000 750000 1000000	960 1000 1050	360 750 1050	—	—	C -39-44
CLASS A AMPLIFIER	135✖ 180✖	− 1.5 − 3.0	—	—	0.2 0.2	150000 150000	200 200	30 30	—	—	CX-340
CLASS A AMPLIFIER	100 180 250	− 7.0 −13.5 −18.0	100 180 250	1.6 3.0 5.5	9.0 18.5 32.0	103500 81000 68000	1450 1850 2200	150 150 150	12000 9000 7600	0.33 1.50 3.40	C - 41
CLASS A AMPLIFIER	250	−16.5	250	6.5	34.0	100000	2200	220	7000	3.00	C - 42
CLASS A AMPLIFIER	100 135	−15.0 −20.0	100 135	4.0 7.0	20.0 34.0	45000 35000	2000 2300	90 80	4500 4000	0.90 2.00	C - 43
CLASS A AMPLIFIER	180 250 275	−31.5 −50.0 −56.0	180 250 275	—	31.0 34.0 36.0	1650 1610 1700	2125 2175 2050	3.5 3.5 3.5	2700 3900 4600	0.82 1.60 2.00	C - 45
CLASS A AMPLIFIER □	250	−33.0	—	—	22.0	2380	2350	5.6	6400	1.25	C - 46
CLASS B AMPLIFIER ◆	300 400	0 0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				5200 5800	16.0 20.0	C - 46
CLASS A AMPLIFIER	250	−16.5	250	6.0	31.0	60000	2500	150	7000	2.7	C - 47
CLASS A AMPLIFIER	95 125	−20.0 −22.5	95 100	9.0 9.0	47.0 50.0	10000 10000	2800 2800	28 28	2000 2000	1.6 2.5	C - 48
● Applied through plate coupling resistor of 250000 ohms or 500-henry choke shunted by 0.25 megohm resistor. ✖ Applied through plate coupling resistor of 250000 ohms. ◆ Two grids tied together. *Maximum.											
CLASS A AMPLIFIER □	135	−20.0	—	—	5.7	4000	1125	4.5	11000	0.17	C - 49
CLASS B AMPLIFIER ◆	180	0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				12000	3.5	C - 49
CLASS A AMPLIFIER	300 400 450	−54.0 −70.0 −84.0	—	—	35.0 55.0 55.0	2000 1800 1800	1900 2100 2100	3.8 3.8 3.8	4600 3670 4350	1.6 3.4 4.6	CX-350
CLASS B AMPLIFIER	250 300	0 0	—	—	Power output value is for one tube at stated load, plate-to-plate.				8000 10000	8.0 10.0	C - 53
TRIODE UNIT AS CLASS A AMPLIFIER	135 180 250	−10.5 −13.5 −20.0	—	—	3.7 6.0 8.0	11000 8500 7500	750 975 1100	8.3 8.3 8.3	25000 20000 20000	0.075 0.160 0.350	C - 55
CLASS A AMPLIFIER	250	−13.5	—	—	5.0	9500	1450	13.8	—	—	C - 56
BIAS DETECTOR	250	−20.0	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						C - 56
SCREEN GRID R-F AMPLIFIER	250	− 3.0	100	0.5	2.0	exceeds 1.5 meg.	1225	exceeds 1500	—	—	C - 57
BIAS DETECTOR	250	− 3.9	100	Cathode current 0.97 ma.		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms**				C - 57
SCREEN GRID R-F AMPLIFIER	250	{− 3.0 min.}	100	2.0	8.2	800000	1600	1280	—	—	C - 58
MIXER IN SUPERHETERODYNE	250	−10.0	100	—	—	Oscillator peak volts = 7.0.					C - 58
AS TRIODE ¶ CLASS A AMPLIFIER	250	−28.0	—	—	26.0	2400	2600	6.0	5000	1.25	C - 59
AS PENTODE ■■ CLASS A AMPLIFIER	250	−18.0	250	9.0	35.0	40000	2500	100	6000	3.00	C - 59
AS TRIODE ⊛ CLASS B AMPLIFIER	300 400	0 0	—	—	Power output values are for 2 tubes at indicated plate-to-plate oad.				4600 6000	15.0 20.0	C - 59
CLASS A AMPLIFIER	90 180	−19.0 −43.0	—	—	10.0 20.0	2170 1750	1400 1700	3.0 3.0	3000 4800	0.125 0.790	C - 71-A
TRIODE UNIT AS CLASS A AMPLIFIER	250✖	−1.35	—	—	0.4	—	—	Gain per stage = 50-60			C - 75
SCREEN GRID R-F AMPLIFIER	100 250	− 1.5 − 3.0	60 100	0.4 0.6	1.7 2.3	650000 1500000	1100 1250	715 1500	—	—	C - 77
BIAS DETECTOR	250	− 1.95	50	Cathode current 0.65 ma.		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms**.				C - 77
SCREEN GRID R-F AMPLIFIER	90 180 250 250	{− 3.0 min.}	90 75 100 125	1.5 1.0 2.0 3.0	5.4 4.0 7.0 10.5	315000 1000000 800000 600000	1275 1100 1450 1650	400 1100 1160 990	—	—	C - 78

■■ Grid #1 is control grid. Grid #2 is screen. Grid #3 tied to cathode. ◆ Two grids tied together.
¶ Grid #1 is control grid. Grids #2 and #3 tied to plate. ✖ Applied through plate coupling resistor of 250000 ohms.
⊛ Grids #1 and #2 connected together. Grid #3 tied to plate. **For grid of following tube.

TYPE	NAME	BASE	SOCKET CONNEC-TIONS	DIMENSIONS MAXIMUM OVERALL — LENGTH X DIAMETER	CATHODE TYPE ■	RATING — FILAMENT OR HEATER — VOLTS	RATING — FILAMENT OR HEATER — AMPERES	RATING — PLATE — MAX. VOLTS	RATING — SCREEN — MAX. VOLTS
RCA-1A6	PENTAGRID CONVERTER ◘	SMALL 6-PIN	FIG. 26	4 17/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5
RCA-2A3	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	5 3/8" x 2 1/16"	FILAMENT	2.5	2.5	250	—
RCA-2A5	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16" x 1 13/16"	HEATER	2.5	1.75	250	250
RCA-2A6	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	FIG. 13	4 17/32" x 1 9/16"	HEATER	2.5	0.8	250	—
RCA-2A7	PENTAGRID CONVERTER ◘	SMALL 7-PIN	FIG. 20	4 17/32" x 1 9/16"	HEATER	2.5	0.8	250	100
RCA-2B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	FIG. 21	4 17/32" x 1 9/16"	HEATER	2.5	0.8	250	125
RCA-6A4 *also LA*	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 8	4 11/16" x 1 13/16"	FILAMENT	6.3	0.3	180	180
RCA-6A7	PENTAGRID CONVERTER ◘	SMALL 7-PIN	FIG. 20	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	100
RCA-6B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	FIG. 21	4 17/32" x 1 9/16"	HEATER	6.3	0.3	250	125
RCA-6F7	TRIODE-PENTODE	SMALL 7-PIN	FIG. 27	4 17/32" x 1 9/16"	HEATER	6.3	0.3	100 250	— 100
UX-200-A	DETECTOR TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	45	—
RCA-01-A	DETECTOR★ AMPLIFIER	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	135	—
RCA-10	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	5 5/8" x 2 3/16"	FILAMENT	7.5	1.25	425	—

◘ Grids #3 and #5 are screen. Grid #4 is signal-input control-grid.
★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.

TYPE	NAME	BASE	SOCKET CONNEC-TIONS	DIMENSIONS MAXIMUM OVERALL — LENGTH X DIAMETER	CATHODE TYPE ■	RATING — FILAMENT OR HEATER — VOLTS	RATING — FILAMENT OR HEATER — AMPERES	RATING — PLATE — MAX. VOLTS	RATING — SCREEN — MAX. VOLTS
WD-11 WX-12	DETECTOR★ AMPLIFIER TRIODE	WD 4-PIN MEDIUM 4-PIN	FIG. 12 FIG. 1	4 1/8" x 1 3/16" 4 11/16" x 1 7/16"	D-C FILAMENT	1.1	0.25	135	—
UX-112-A	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	180	—
RCA-19	TWIN AMPLIFIER	SMALL 6-PIN	FIG. 25	4 1/4" x 1 9/16"	D-C FILAMENT	2.0	0.26	135	—
UX-120	POWER AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/8" x 1 3/16"	D-C FILAMENT	3.3	0.132	135	—
RCA-22	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	FIG. 4	5 1/32" x 1 13/16"	D-C FILAMENT	3.3	0.132	135	67.5
RCA-24-A	R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	FIG. 9	5 1/32" x 1 13/16"	HEATER	2.5	1.75	275	90
RCA-26	AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	FILAMENT	1.5	1.05	180	—
RCA-27	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 5-PIN	FIG. 8	4 11/16" x 1 13/16"	HEATER	2.5	1.75	275	—
RCA-30	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/4" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	—
RCA-31	POWER AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/4" x 1 9/16"	D-C FILAMENT	2.0	0.13	180	—
RCA-32	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	FIG. 4	5 1/32" x 1 13/16"	D-C FILAMENT	2.0	0.06	180	67.5
RCA-33	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	4 11/16" x 1 13/16"	D-C FILAMENT	2.0	0.26	135	135
RCA-34	SUPER-CONTROL R-F AMPLIFIER PENTODE	MEDIUM 4-PIN	FIG. 4A	5 1/32" x 1 13/16"	D-C FILAMENT	2.0	0.06	180	67.5
RCA-35	SUPER-CONTROL R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	FIG. 9	5 1/32" x 1 13/16"	HEATER	2.5	1.75	275	90

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.
■ **Either A. C. or D. C. may be used on filament or heater, except as specifically noted. For use of D. C. on A-C filament types, decrease stated grid volts by ½ (approx.) of filament voltage.**

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID VOLTS■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICRO-MHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
CONVERTER	180	−3.0 min.	67.5	2.4	1.3	500000	Anode-Grid (#2) 135 Max. Volts, 2.3 Ma. Oscillator Grid (#1) Resistor, 50000 Ohms. Conversion Conductance, 300 Micromhos.				C-1A6
CLASS A AMPLIFIER	250	−45	——	——	60.0	300	5250	4.2	2500	3.5	C-2A3
PUSH-PULL AMPLIFIER	300 300	−62 −62	Self-bias Fixed-bias		40.0 40.0	Power Output is for 2 tubes at stated load, plate-to-plate			5000 3000	10.0 15.0	
CLASS A AMPLIFIER	250	−16.5	250	6.5	34.0	100000	2200	220	7000	3.0	C-2A5
TRIODE UNIT AS CLASS A AMPLIFIER	250✖	− 1.35	——	——	0.4	——	——	Gain per stage = 50-60			C-2A6
CONVERTER	250	− 3.0	100	2.2	3.5	360000	Anode Grid (#2) 200 Max. Volts, 4.0 Ma. Oscillator Grid (#1) Resistor, 50000 Ohms. Conversion Conductance, 520 Micromhos.				C-2A7
PENTODE UNIT AS R-F AMPLIFIER	100 250	− 3.0 − 3.0	100 125	1.7 2.3	5.8 9.0	300000 650000	950 1125	285 730	——	——	C-2B7
PENTODE UNIT AS A-F AMPLIFIER	250✠	− 4.5	50	——	0.65	——	——	——	——	——	
CLASS A AMPLIFIER	100 180	− 6.5 −12.0	100 180	1.6 3.9	9.0 22.0	83250 45500	1200 2200	100 100	11000 8000	0.31 1.40	C-6A4 *also LA*
CONVERTER	250	− 3.0	100	2.2	3.5	360000	Anode Grid (#2) 200 Max. Volts, 4.0 Ma. Oscillator Grid (#1) Resistor, 50000 Ohms. Conversion Conductance, 520 Micromhos.				C-6A7
PENTODE UNIT AS R-F AMPLIFIER	100 250	− 3.0 − 3.0	100 125	1.7 2.3	5.8 9.0	300000 650000	950 1125	285 730	——	——	C-6B7
PENTODE UNIT AS A-F AMPLIFIER	250✠	− 4.5	50	——	0.65	——	——	——	——	——	
TRIODE UNIT AS AMPLIFIER	100	− 3.0	——	——	3.5	17800	450	8	——	——	C-6F7
PENTODE UNIT AS AMPLIFIER	250	− 3.0	100	1.5	6.5	850000	1100	900	——	——	
PENTODE UNIT AS MIXER	250	−10.0	100	0.6	2.8	Oscillator peak volts = 7.0. Conversion conductance = 300 micromhos.					
GRID LEAK DETECTOR	45	Grid Return to (−) Filament			1.5	30000	666	20	——	——	CX-300-A
CLASS A AMPLIFIER	90 135	− 4.5 − 9.0	——	——	2.5 3.0	11000 10000	725 800	8.0 8.0	——	——	C - 01-A
CLASS A AMPLIFIER	350 425	−31.0 −39.0	——	——	16.0 18.0	5150 5000	1550 1600	8.0 8.0	11000 10200	0.9 1.6	C - 10

✠ Applied through plate coupling resistor of 200000 ohms.
✖ Applied through plate coupling resistor of 250000 ohms.

USE	PLATE SUPPLY VOLTS	GRID VOLTS■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICRO-MHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
CLASS A AMPLIFIER	90 135	− 4.5 −10.5	——	——	2.5 3.0	15500 15000	425 440	6.6 6.6	——	——	C - 11 CX- 12
CLASS A AMPLIFIER	90 180	− 4.5 −13.5	——	——	5.0 7.7	5400 4700	1575 1800	8.5 8.5	——	——	CX-112-A
CLASS B AMPLIFIER	135 135	0 − 3.0	——	——	Power output value is for one tube at stated load, plate-to-plate.				10000 10000	2.1 1.9	C - 19
CLASS A AMPLIFIER	90 135	−16.5 −22.5	——	——	3.0 6.5	8000 6300	415 525	3.3 3.3	9600 6500	0.045 0.110	CX-220
SCREEN GRID R-F AMPLIFIER	135 135	− 1.5 − 1.5	45 67.5	0.6* 1.3*	1.7 3.7	725000 325000	375 500	270 160	——	——	C - 22
SCREEN GRID R-F AMPLIFIER	180 250	− 3.0 − 3.0	90 90	1.7* 1.7*	4.0 4.0	400000 600000	1000 1050	400 630	——	——	C - 24-A
BIAS DETECTOR	275●	− 5.0 approx.	20 to 45	——	Plate current to be adjusted to 0.1 milliampere with no signal.						
CLASS A AMPLIFIER	90 180	− 7.0 −14.5	——	——	2.9 6.2	8900 7300	935 1150	8.3 8.3	——	——	C - 26
CLASS A AMPLIFIER	135 250	− 9.0 −21.0	——	——	4.5 5.2	9000 9250	1000 975	9.0 9.0	——	——	C - 27
BIAS DETECTOR	250	−30.0	——	——	Plate current to be adjusted to 0.2 milliampere with no signal.						
CLASS A AMPLIFIER	90 135 180	− 4.5 − 9.0 −13.5	——	——	2.5 3.0 3.1	11000 10300 10300	850 900 900	9.3 9.3 9.3	——	——	C - 30
CLASS A AMPLIFIER	135 180	−22.5 −30.0	——	——	8.0 12.3	4100 3600	925 1050	3.8 3.8	7000 5700	0.185 0.375	C - 31
SCREEN GRID R-F AMPLIFIER	135 180	− 3.0 − 3.0	67.5 67.5	0.4* 0.4*	1.7 1.7	950000 1200000	640 650	610 780	——	——	C - 32
BIAS DETECTOR	180♥	− 6.0 approx.	67.5	——	Plate current to be adjusted to 0.2 milliampere with no signal.						
CLASS A AMPLIFIER	135	−13.5	135	3.0	14.5	50000	1450	70	7000	0.7	C - 33
SCREEN GRID R-F AMPLIFIER	135 180	− 3.0 min.	67.5 67.5	1.0 1.0	2.8 2.8	600000 1000000	600 620	360 620	——	——	C - 34
SCREEN GRID R-F AMPLIFIER	180 250	− 3.0 min.	90 90	2.5* 2.5*	6.3 6.5	300000 400000	1020 1050	305 420	——	——	C - 35

● Applied through plate coupling resistor of 250000 ohms or 500-henry choke shunted by 0.25 megohm resistor.
♥ Applied through plate coupling resistor of 100000 ohms.

*Maximum.

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL LENGTH x DIAMETER	CATHODE TYPE ■	RATING: FILAMENT OR HEATER VOLTS	RATING: FILAMENT OR HEATER AMPERES	RATING: PLATE MAX. VOLTS	RATING: SCREEN MAX. VOLTS
RCA- 79	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	FIG. 19	$4\frac{17}{32}$" x $1\frac{9}{16}$"	HEATER	6.3	0.6	250	—
RCA- 85	DUPLEX-DIODE TRIODE	SMALL 6-PIN	FIG. 13	$4\frac{17}{32}$" x $1\frac{9}{16}$"	HEATER	6.3	0.3	250	—
RCA- 89	TRIPLE-GRID POWER AMPLIFIER	SMALL 6-PIN	FIG. 14	$4\frac{17}{32}$" x $1\frac{9}{16}$"	HEATER	6.3	0.4	250	250
UV -199 UX -199	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-NUB SMALL 4-PIN	FIG. 10 FIG. 1	$3\frac{1}{2}$" x $1\frac{1}{16}$" $4\frac{1}{8}$" x $1\frac{3}{16}$"	D-C FILAMENT	3.3	0.063	90	—
RCA-864	AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4" x $1\frac{3}{16}$"	D-C FILAMENT	1.1	0.25	135	—

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.
■Either A. C. or D. C. may be used on filament or heater, except as specifically noted. For use of D. C. on A-C filament types, decrease stated grid volts by ½ (approx.) of filament voltage.

RECTIFIERS

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS	CATHODE TYPE	VOLTS	AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS
RCA-5Z3	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 2	$5\frac{3}{8}$" x $2\frac{1}{16}$"	FILAMENT	5.0	3,0	—	—
RCA-12Z3	HALF-WAVE RECTIFIER	SMALL 4-PIN	FIG. 22	$4\frac{1}{4}$" x $1\frac{9}{16}$"	HEATER	12.6	0.3	—	—
RCA-25Z5	RECTIFIER-DOUBLER	SMALL 6-PIN	FIG. 5	$4\frac{1}{4}$" x $1\frac{9}{16}$"	HEATER	25.0	0.3	—	—
RCA-1-V°	HALF-WAVE RECTIFIER	SMALL 4-PIN	FIG. 22	$4\frac{1}{4}$" x $1\frac{9}{16}$"	HEATER	6.3	0.3	—	—
RCA- 80	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 2	$4\frac{11}{16}$" x $1\frac{13}{16}$"	FILAMENT	5.0	2.0	—	—
UX -281	HALF-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 3	$6\frac{1}{4}$" x $2\frac{7}{16}$"	FILAMENT	7.5	1.25	—	—
RCA- 82	FULL-WAVE ▶ RECTIFIER	MEDIUM 4-PIN	FIG. 2	$4\frac{11}{16}$" x $1\frac{13}{16}$"	FILAMENT	2.5	3.0	—	—
RCA- 83	FULL-WAVE ▶ RECTIFIER	MEDIUM 4-PIN	FIG. 2	$5\frac{3}{8}$" x $2\frac{1}{16}$"	FILAMENT	5.0	3.0	—	—
RCA- 84 *also 6Z4*	FULL-WAVE RECTIFIER	SMALL 5-PIN	FIG. 22	$4\frac{1}{4}$" x $1\frac{9}{16}$"	HEATER	6.3	0.5	—	—
RCA-866	HALF-WAVE ▶ RECTIFIER	MEDIUM 4-PIN	FIG. 3 See Note ⊟	$6\frac{5}{8}$" x $2\frac{7}{16}$"	FILAMENT	2.5	5.0	—	—

▶ Mercury Vapor Type. ° Interchangeable with type 1.
⊟ Plate connection made to top cap of tube.

AMPLIFIER CLASSIFICATION

There are three major classes of amplifier service. Definitions describing these have been standardized by the Institute of Radio Engineers:

Class A Amplifier

A Class A amplifier is an amplifier which operates in such a manner that the plate output wave form is essentially the same as that of the exciting grid voltage.

This is accomplished by operating with a negative grid bias such that some plate current flows at all times, and by applying such an alternating voltage to the grid that the dynamic operating characteristics are essentially linear. The grid must usually not go positive on excitation peaks and the plate current must not fall low enough at its minimum to cause distortion due to curvature of the characteristic. The amount of second harmonic present in the output wave which was not present in the input wave is generally taken as a measure of distortion, the usual limit being five percent.

The characteristics of a Class A amplifier are low efficiency and output with a large ratio of power amplification.

Class B Amplifier

A Class B amplifier is an amplifier which operates in such a manner that the power output is proportional to the square of the grid excitation voltage.

This is accomplished by operating with a negative grid bias such that the plate current is reduced to a relatively low value with no grid excitation volt-

USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID VOLTS ■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICRO-MHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
CLASS B AMPLIFIER	180 250	0 0	—	—	Power output value is for one tube at stated load, plate-to-plate.				7000 14000	5.5 8.0	C - 79
TRIODE UNIT AS CLASS A AMPLIFIER	135 180 250	−10.5 −13.5 −20.0	—	—	3.7 6.0 8.0	11000 8500 7500	750 975 1100	8.3 8.3 8.3	25000 20000 20000	0.075 0.160 0.350	C - 85
AS TRIODE ¶ CLASS A AMPLIFIER	160 180 250	−20.0 −22.5 −31.0	—	—	17.0 20.0 32.0	3300 3000 2600	1425 1550 1800	4.7 4.7 4.7	7000 6500 5500	0.300 0.400 0.900	C - 89
AS PENTODE ■■ CLASS A AMPLIFIER	100 180 250	−10.0 −18.0 −25.0	100 180 250	1.6 3.0 5.5	9.5 20.0 32.0	104000 80000 70000	1200 1550 1800	125 125 125	10700 8000 6750	0.33 1.50 3.40	
AS TRIODE ψ CLASS B AMPLIFIER	180	0	—	—	Power output values are for 2 tubes operating at indicated plate-to-plate load.				13600 9400	2.50 3.50	
CLASS A AMPLIFIER	90	- 4.5	—	—	2.5	15500	425	6.6	—	—	C -299 CX-299
CLASS A AMPLIFIER	90 135	- 4.5 - 9.0	—	—	2.9 3.5	13500 12700	610 645	8.2 8.2	—	—	C -864

■■ Grid #1 is control grid. Grid #2 is screen. Grid #3 tied to cathode
¶ Grid #1 is control grid. Grids #2 and #3 tied to plate.
ψ Grids #1 and #2 connected together. Grid #3 tied to plate.

RECTIFIERS

Maximum A-C Voltage per Plate .... 500 Volts, RMS Maximum D-C Output Current .... 250 Milliamperes	C -5Z3
Maximum A-C Voltage per Plate .... 250 Volts, RMS Maximum D-C Output Current .... 60 Milliamperes	C-12Z3
Maximum A-C Voltage per Plate .... 125 Volts, RMS Maximum D-C Output Current .... 100 Milliamperes	C-25Z5
Maximum A-C Voltage per Plate .... 350 Volts, RMS Maximum D-C Output Current .... 50 Milliamperes	C-1v°
A-C Voltage per Plate (Volts RMS) . 350 400 550 D-C Output Current (Maximum MA.) 125 110 135 The 550 volt rating applies to filter circuits having an input choke of at least 20 henries.	C - 80
Maximum A-C Plate Voltage .... 700 Volts, RMS Maximum D-C Output Current .... 85 Milliamperes	CX-381
Maximum A-C Voltage per Plate......500 Volts, RMS Maximum D-C Output Current ......125 Milliamperes Maximum Peak Inverse Voltage . 1400 Volts Maximum Peak Plate Current . 400 Milliamperes	C - 82
Maximum A-C Voltage per Plate . 500 Volts, RMS Maximum D-C Output Current ..... 250 Milliamperes Maximum Peak Inverse Voltage .....1400 Volts Maximum Peak Plate Current . .. 800 Milliamperes	C - 83
Maximum A-C Voltage per Plate .... 225 Volts, RMS Maximum D-C Output Current .... 50 Milliamperes	C - 84 *also 6Z4*
Maximum Peak Inverse Voltage........ 7500 Volts Maximum Peak Plate Current .... 0.6 Ampere	C -866 (CX-366)

age, and by applying excitation such that pulses of plate current are produced on the positive half cycle of the grid voltage variations. The grid may usually go positive on excitation peaks, the harmonics being removed from the output by suitable means.

The characteristics of a Class B amplier are medium efficiency and output with a relatively low ratio of power amplification.

Class A-Prime Amplifier

When the type of amplifier service is intermediate to the classes listed above, it is convenient to designate the service by other terms. The most important of these is the Class A-Prime (also called Class AB) service.

A Class A-Prime amplifier is one which is overbiased, operating as a Class A system for small signals, and as a Class B amplifier when the signals are large. The result is that plate current flows during appreciably more than half a cycle, yet less than 360 degrees of the cycle.

Several recent household radios have incorporated this type of amplifier service in the output stage, utilizing Type 42 tubes as triodes.

(Courtesy, Hygrade Sylvania Corp.)

BY-PASS CONDENSER, GRID-BIAS RESISTOR CHART

Type Tube	Purpose	Plate Volts	Screen Volts	Grid Volts	Grid Resistor In OHMS	By-pass Cap. in Microfarads
2A3	A	250	-	-45	750	20.
2A5	A	250	250	-16.5	400	25.
2A6	A	250	-	-2	2500	2.
2A7	C	250	100	-3	500	.1
2B7	A(rf)	100	100	-3	400	.1
2B7	A(rf)	250	100	-3	250	.1
2B7	A(af)	250	50	-4.5	7000	1.
6A4	A	100	100	-6.5	600	25.
6A4	A	180	180	-12	500	25.
6A7	C	250	100	-3	500	.1
6B7	A(rf)	100	100	-3	4000	.1
6B7	A(rf)	250	125	-3	2500	.1
6B7	A(af)	250	50	-4.5	7000	1.
6F7	A	100	-	-3	500	2.
6F7	A	250	100	-3	400	.1
6F7	Mixer	250	100	-10	2500	.1
24A	A(rf)	180	90	-3	500	.1
24A	A(rf)	250	90	-3	500	.1
24A	A(af)	500	75	-4.5	3000	1.
24A	Det	275	30	-5	50000	1.
26	A	90	-	-7	2500	1.
26	A	180	-	-14.5	2250	1.
27	A	135	-	-9	2000	1.
27	A	250	-	-21	4000	1.
27	Det	250	-	-30	50000	1.
35	A(rf)	180	90	-3	350	.1
35	A(rf)	250	90	-3	350	.1
36	A(rf)	100	55	-1.5	800	.1
36	A(rf)	180	90	-3	1000	.1
36	A(rf)	250	90	-3	600	.1
36	Det	100	55	-5	50000	.5
36	Det	250	90	-8	80000	.5
37	A	90	-	-6	2500	1.
37	A	180	-	-13.5	3000	1.
37	A	250	-	-18	2500	1.
37	Det	90	-	-10	50000	.5
37	Det	250	-	-28	140000	.5
38	A	100	100	-9	1000	10.
38	A	180	180	-18	1000	10.
38	A	250	250	-25	1000	10.
39	A(rf)	90	90	-3	400	.1
39	A(rf)	180	90	-3	400	.1
39	A(rf)	250	90	-3	400	.1
41	A	100	100	-15	600	25.
41	A	180	180	-13.5	600	25.
41	A	250	250	-18	500	25.
42	A	250	250	-16.5	400	25.
43	A	100	100	-15	600	25.
43	A	135	135	-20	500	25.
45	A	250	250	-50	1500	10.
46	A	250	-	-33	1500	10.
47	A	250	250	-16.5	400	25.
48	A	125	100	-22.5	400	10.
49	A	135	-	-20	350	10.
50	A	450	-	-84	1500	10.
55	A	180	-	-13.5	2250	10.
55	A	250	-	-20	2500	10.
56	A	250	-	-13.5	2500	1.
56	Det	250	-	-20	100000	.1
57	A(rf)	250	100	-3	1000	.1

BY-PASS CONDENSER, GRID-BIAS RESISTOR CHART (Continued)

Type Tube	Purpose	Plate Volts	Screen Volts	Grid Volts	Grid Resistor In OHMS	By-pass Cap. In Microfarads
57	Det	250	100	-4	4,000	.5
58	A(rf)	250	100	-3	300	.1
59	Triode	250	-	-28	1,000	20.
59	Pent	250	250	-18	400	25.
71A	A	180	-	-43	2,000	20.
75	A	250	-	-1.5	3,500	10.
77	A(rf)	100	60	-1.5	700	.1
77	A(rf)	250	100	-3	1,000	.1
77	Det	250	50	-2	3,000	1.
78	A(rf)	90	90	-3	400	.1
78	A(rf)	180	75	-3	600	.1
78	A(rf)	250	100	-3	350	.1
85	A	135	-	-10.5	3,000	10.
85	A	180	-	-13.5	2,250	10.
85	A	250	-	-20	2,500	10.
89	Triode	160	-	-20	1,000	10.
89	Triode	180	-	-22.5	1,000	10.
89	Triode	250	-	-31	1,000	20.
89	Pent	100	100	-10	900	25.
89	Pent	180	180	-18	800	25.
89	Pent	250	250	-25	700	20.

ABBREVIATIONS:

A -means class A amplifier.
Det -means Detector.
af -means audio frequency.
rf -means radio frequency.
Pent -means Pentode.
Mixer-means first detector of a superhet.

-Resistor values are given in sizes stocked everywhere and are satisfactory for most conditions.
-Condenser values are chosen with the question of frequency of signals involved and circuit conditions.

This tabulation of grid-bias resistors and by-pass condensers used with different tubes at different voltages and in different parts of the radio set circuits should be useful to servicemen and experimenters alike.

Biasing Volume Control Considerations

The method employed in older type receivers to control the volume was that of varying the screen voltage applied to the tubes. Later, with the advent of "super-control" tubes, the system of C-bias variation was universally adopted. The bias voltage was obtained either from a potentiometer across the negative portion of the bleeder, or by inserting a variable resistance in the common cathode lead of several tubes when manual control of sensitivity was desired.

Most modern receivers employ automatic volume control. The function of the a-v-c circuit is to properly regulate the bias applied to the control grids of the r-f and i-f tubes so that constant signal will be delivered to the input of the second detector. This is accomplished by utilizing the rectified voltage developed across the load resistor in the diode circuit for the control voltage impressed on the grids of the amplifier tubes. The diode current flowing through the resistor will place the cathode end at positive potential and the opposite end at negative potential. The negative voltage for biasing the grids is obtained from the negative end of this resistor. The value of the resistor should be such that for a given signal the drop in voltage across it will be sufficient to bias the tubes being controlled to a sensitivity consistent with the volume desired. An increase in the r-f signal input will raise the voltage drop, thereby applying more bias to the control tubes. This will decrease the receiver sensitivity and maintain the receiver output at normal volume. On the other hand, a decrease in r-f signal input reduces the voltage drop and thus lowers the bias on the control tubes. This increases the receiver sensitivity and automatically maintains the volume constant. *(Courtesy, Hygrade Sylvania Corp.)*

2.5-Volt Types

Type	*Use*	*Fil. Amps.*	*Plate Volts*	*Grid Volts*	*Screen Volts*	*Cathode Current Ma.*	*Bias Resistor Ohms*
27	Amp.	1.75	90	6.0	....	2.7	2,200
			135	9.0	....	4.5	2,000
			180	13.5	....	5.0	2,700
			250	21.0	....	5.2	4,000
	Det.		250	30.0	....	0.2	150,000
56	Amp.	1.00	250	13.5	....	5.0	2,700
	Det.		250	20.0	....	0.2	100,000
45	Amp.	1.50	180	31.5	....	31.0	1,050
			250	50.0	....	34.0	1,450
			275	56.0	....	36.0	1,550
2A3	Amp.	2.50	250	45.0	....	60.0	750
Push-pull for Two Tubes			300	62.0	....	80.0	750
24A	RF	1.75	180	3.0	90	5.7	525
			250	3.0	90	5.7	525
	Det.		250	5.0	20 to 45	0.1	50,000
57	RF	1.00	250	3.0	100	2.5	1,200
	Det.		250	4.0	100	0.1	60,000
35-51	RF	1.75	180	3.0	90	8.8	340
			250	3.0	90	8.0	375
58	RF	1.00	250	3.0	100	10.2	290
47	Pwr. Amp.	1.50	250	16.5	250	37.0	450
2A5	Pwr. Amp.	1.75	250	16.5	250	40.5	400
55	Triode Sect.	1.00	250	20.0	...	8.0	2,500
2A6	Triode Sect.	0.80 (thru .1 megohm)	250	1.3	...	0.26	5,000

6.3-Volt Types

Type	*Use*	*Fil. Amps.*	*Plate Volts*	*Grid Volts*	*Screen Volts*	*Cathode Current Ma.*	*Bias Resistor Ohms*
37	Amp.	0.30	90	6.0	....	2.5	2,400
			135	9.0	....	4.1	2,200
			180	13.5	....	4.3	3,100
			250	18.0	....	7.5	2,400
	Det.		250	28.0	....	0.2	140,000
76	Amp.	0.30	250	13.5	....	4.2	3,200
	Det.		250	20.0	....	0.2	100,000
36	RF	0.30	100	1.5	67.5	3.5	430
			135	1.5	67.5	4.5	330
			180	3.0	90.0	4.8	625
			250	3.0	90.0	4.9	615
77	RF	0.30	100	1.5	60.0	2.1	715
			250	3.0	100.0	3.0	1,000
	Det.		250	4.0	100.0	0.1	40,000
6C6	RF	0.30	250	3.0	100.0	2.5	1,200
	Det.		250	4.0	100.0	0.1	60,000
39-44	RF	0.30	90	3.0	90.0	7.2	415
			135	3.0	90.0	7.2	415
			180	3.0	90.0	7.2	415
			250	3.0	90.0	7.2	415
78	RF	0.30	90	3.0	90.0	6.9	435
			180	3.0	75.0	5.0	600
			250	3.0	100.0	9.0	335
			250	3.0	125.0	13.5	220
6D6	RF	0.30	250	3.0	100.0	10.2	290
38	Pwr Amp.	0.30	100	9.0	100.0	8.9	1,000
			135	13.5	135.0	11.4	1,200
			180	18.0	180.0	16.4	1,100
			250	25.0	250.0	25.8	975
41	Pwr. Amp.	0.40	100	7.0	100.0	10.6	670
			135	10.0	135.0	14.7	680
			180	13.5	180.0	21.5	625
			250	18.0	250.0	37.5	480
85	Triode Sect.	0.30	135	10.5	....	3.7	2,800
			180	13.5	....	6.0	2,250
			250	20.0	....	8.0	2,500
75	Triode Sect.	0.30 (thru .1 megohm)	250	1.3	....	0.26	5,000

Courtesy, Hygrade Sylvania Corp.

CHAPTER 3

Volume Controls

Circumstances alter recommendations when it comes to volume controls, and this chapter is devoted to these units in a manner calculated to give the greatest amount of information in the smallest possible space.

Volume controls should always be used in the radio frequency portion of the set. Always control the volume before the signal reaches the detector. In superheterodyne receivers the volume controls should be placed before the second detector.

Wire wound controls will usually be found more satisfactory than graphite or carbon element controls for volume control use, except where high values of resistance are required. The wire wound controls are better for use in circuits where the control is required to carry current, as in the case of grid bias or screen grid controls.

Graphite or carbon controls are excellent for use in circuits where low current values flow and resistance values must be high.

In the case of grid bias and screen grid volume control circuits, only one of the amplifier tubes are indicated in the diagram. In general practice at least two tubes are connected in the volume control circuit. The single tube is indicated for simplicity.

Filament Voltage Control

A circuit showing this method of control is shown in Fig. 27. The value of resistance and the current carrying capacity required in the rheostat depends upon the type and the number of tubes in the circuit. It is wise to select a control with a slightly higher resistance than necessary so that sufficient control can be obtained.

Untuned Antenna Volume Control Circuits

In Fig. 28 and 29, the resistance element of the volume control potentiometer is used as the coupling unit between the antenna and grid circuits. The signal variation being obtained by adjusting the moving arm of the potentiometer. Of the two circuits indicated, the one in Fig. 28 is the best as it absolutely kills the signal at the low volume setting by bringing the grid of the tube to the ground with respect to the incoming signal. The circuit used in 30 can be used in untuned antenna circuits where a choke or resistor is used as a coupling between the antenna and the grid.

Radio Frequency Plate Circuit Volume Controls

The circuits shown in Fig. 31 and 32 show volume controls that vary the plate voltage applied to the plates of the radio frequency tubes. These circuits work out well for battery type sets.

The circuit in Fig. 31 uses a high resistance potentiometer which is connected across the "B" supply. Variation of the moving arm controls the voltage applied to the plates of the tubes. In Fig. 32 the voltage is varied by means of the high resistance rheostat connected in series with the "B" supply. A compression type of control is best suited for this circuit, and will give greater life than that which can be obtained from the carbon or graphite type of control.

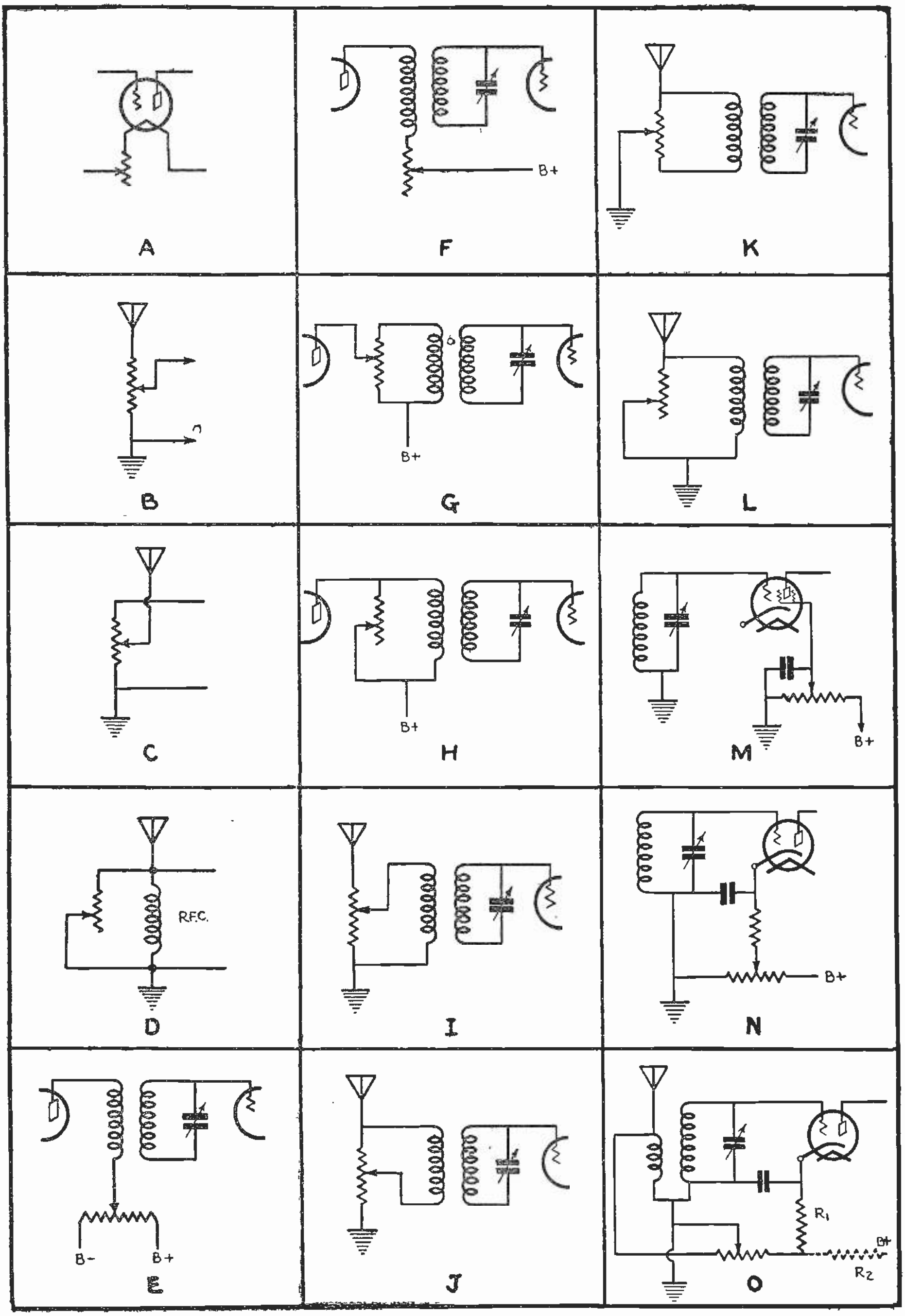
The plate circuit volume control of Fig. 33 and 34 was a favorite with older model sets and is not used to any great extent today, except in experimental circuits.

Tuned Antenna Volume Controls

The circuit shown in Fig. 35 is the most desirable method for tuned antenna volume control. At the minimum setting the primary of the T.R.F. coil is shorted and the resistance of the potentiometer is in series with the antenna and the primary coil.

The arrangement on Fig. 36 is not quite as effective as Fig. 35. Fig. 37 is still poorer, but there may be some applications where these circuits will provide sufficient control to be satisfactory.

Shunting rheostat connection method is shown in Fig. 38, and is one of the simplest methods of control and is very easy to install. It is generally used as a supplementary control.



Methods of Controlling Volume

Letters represent following Figure Nos.: A—27, B—28, C—29, D—30, E—31, F—32, G—33, H—34, I—35, J—36, K—37, L—38, M—39, N and O—40. Text describes each.

Screen Grid Voltage Variation Volume Control

Volume control by variation of the screen grid voltage works well with tubes of the 22 and 24 type, and the circuit is shown in Fig. 39. The resistance element of the control can be part of the voltage divider. In this case the control should be wire wound, since the bleeder current of the receiver will flow through this resistance. Under these conditions the resistance element will have a value from 10,000 to 15,000 ohms.

If it is not convenient to have the resistance control element in the bleeder circuit, it is possible to use a higher resistance unit of 50,000 ohms in shunt with some portion of the voltage divider. Also, it is more desirable to use wire wound resistors in these circuits because of their higher current carrying capabilities. The carbon or graphite types can be employed as shunts to the voltage divider, when their resistance is high enough to limit the current flow to a very low value. The current required by the screens being low good carbon types of resistance units can be used successfully for this purpose.

Grid Bias Variation Volume Controls

When variable-mu type of tubes are used in radio frequency circuits, bias control of volume will always be found. The control is used with a limiting resistor in the cathode return of each tube connected in the control circuit. As most of the variable-mu types have extended cut-off characteristic it is well to make the volume control part of the voltage divider system. In this case the control should be wire wound. When used as part of the voltage dividor system the control will have lower resistance due to the increased current flowing through it for a given required bias voltage. Do not control more than two tubes in this manner unless the fixed bias resistor is heavily by-passed to ground by a condenser.

Grid Bias and Antenna Combination Volume Controls

In circuits where greater control is necessary it is desirable to combine two volume controls as shown in Fig. 40. Here a single resistance unit serves as an antenna and a bias volume control. This is one of the most popular circuits and is used in many receivers today.

Resistor R1 maintains a minimum bias on the individual tube. The general value of this resistor is 300 ohms. In some cases it is necessary to increase the voltage available for bias regulation. A portion of the bleeder current is then permitted to flow through the volume control and this current is limited by resistor R2. The value of R2 will depend on the voltage required for proper control for the receiver circuit in question.

VOLUME CONTROL RESISTANCE CHART

CIRCUIT	OHMS	TAPER	ELEMENT
Fig. 28	2,000	L.H.T.	Wire, Carbon
	1,000		or Graphite
" 29	ditto		
" 30	2,000	L.H.T.	Wire
	10,000	L.H.T.	Wire
	10,000	L.H.T.	Carbon or
	100,000	L.H.T.	Graphite
	500,000		Compres'n
" 31	50,000	N.T.	Wire
	50,000	L.H.T.	Carbon or Graphite
" 32	500,000		Compres'n
	500,000	R.H.T.	Carbon or Graphite
" 33	10,000	L.H.T.	Wire
	10,000	L.H.T.	Carbon or Graphite
" 34	100,000	L.H.T.	Carbon or Graphite
" 35	10,000	L.H.T.	Wire
	10,000	L.H.T.	Carbon or Graphite
" 36	ditto		
" 37	ditto		
" 38	10,000	L.H.T.	Wire
	10,000	L.H.T.	Carbon or Graphite
	100,000	L.H.T.	Carbon or Graphite
	500,000		Compres'n
" 39	ditto		
" 40	7,500	R.H.T.	Wire
	10,000	R.H.T.	Wire
	20,000	R.H.T.	Wire
	10,000	R.H.T.	Wire
	15,000	R.H.T.	Wire

Volume control units are listed above in the order of their desirability, the first unit in each class being preferred..

CHAPTER 4

Automatic Volume Control Circuits

One of the most desirable features that can be incorporated in a radio receiver is automatic volume control. Many listeners, especially ladies do not like the sudden intense volume that blasts from the speaker when a local is tuned in. Especially when the volume control has been set for reception from one of the low power transmitters and the tuning dial is swung through the signal of 50,000 watt transmitter.

Smooth performance of a radio receiver demands automatic volume control and most receivers are so equipped today. However, there are many sets that haven't this feature, and this chapter gives data on the problems encountered when making changes for A.V.C. and how they can be overcome.

Automatic control of the volume in a radio set is generally obtained from a rectified voltage which depends on a carrier signal from the radio or intermediate frequency amplifier. This radio frequency (rectified) voltage is used to vary the gain of the radio frequency or intermediate frequency amplifier so that a practically constant carrier is fed to the detector circuit. This detector circuit will be the conventional detector circuit in a tuned radio frequency amplifier and the second detector in a super.

The regulating signal or voltage can be used in different ways to vary the amplification of the radio or intermediate frequency amplifier. This voltage may be applied to the suppressor grid, screen grid plate or control grid of a tube such as a 58 for example. The most common method is to use this regulating voltage as a grid bias control on the grids of the radio frequency or intermediate frequency amplifier tubes.

In Fig. 41 it will be noted that the current is flowing in the direction of the arrow. That is from the plate to the cathode, through the resistance R and then back to the tuned circuit. Thus the cathode end of resistor R is at a positive potential and the end nearest the tuned circuit at a negative potential. As this resistance R is generally large in value (500,000 ohms) fairly high values of A.V.C. voltage can be developed with the low diode currents available from the incoming signal.

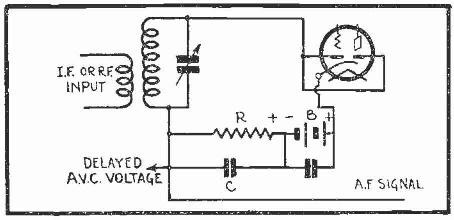


Fig. 41
Elementary delayed A.V.C. circuit

If the current through the diode is such that it will develop a voltage that will bias the controlled tubes for satisfactory reception volume in Fig. 41 what will happen as the current through the diodes varies? The current in the diode circuit will vary with the increase or decrease in radio frequency signal input. Thus a decrease in the radio frequency input will cause a decrease in the voltage drop across resistor R. This will lower the effective bias on the tubes being controlled, and the sensitivity will increase so that a normal volume of signal will be obtained. A stronger radio frequency signal will cause higher currents to appear in the diode circuits and a greater voltage drop will be obtained. This increased voltage will decrease the sensitivity of the controlled tubes so that the effective sensitivity of the receiver will be essentially the same as it was in the first instance.

The circuit of Fig. 42 shows the method of full wave diode detection and automatic volume control voltage generation. A very important point to remember when comparing half-wave and full-wave circuits of this type is that the half-wave method will provide approximately twice the voltage for A.V.C. action. The best feature of full-wave circuits is the elimination of radio frequency currents from the audio feed

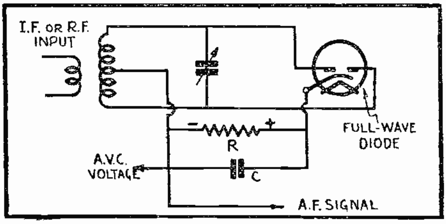


Fig. 42

Method of full-wave diode detection

line. This results in greater stability and minimizes the necessity for radio frequency filtering condensers and chokes always found in detector plate circuits. As the diode circuits are never absolutely in balance it is wise to include some filtering in both cases.

Delayed A.V.C.

The A.V.C. circuits of Fig. 41 and 42 start to operate as soon as a signal is received. In some cases it is desirable to delay this controlling action until the radio frequency signal reaches a certain value. This can be done with the circuit of Fig. 43. If a voltage from the power supply unit of the receiver or a bias battery is connected as shown in this illustration, then the radio frequency signal must swing to some value greater than the voltage from the power supply, or battery, before current will flow in the diode circuit. If the "delay" voltage is five volts then the positive peak swing of the radio frequency signal must be greater than five volts before the current will flow through resistor R. From this it will be noted that a certain value of radio frequency signal must be applied before the automatic volume control action will be obtained.

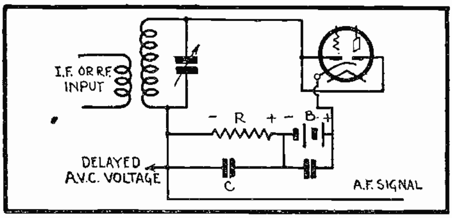


Fig. 43

Half-wave delayed A.V.C. circuit

A circuit that will be found in many receivers, with modifications of course is found in Fig. 44. Here the automatic volume control circuits are drawn in with very heavy lines. Note the filtering resistors and by-pass condensers used to prevent coupling between the various circuits. In this receiver the bias on the radio frequency amplifier tube, the pentagrid converter tube and the intermediate frequency amplifier tube is controlled by the A.V.C. action.

Radio frequency filtering is accomplished by means of the radio frequency choke in the grid circuit of the triode portion of the 55 type tube. This choke should be of the proper type for use at the intermediate frequency to which the intermediate frequency amplifier is tuned. The standard 85 mh radio frequency choke is generally satisfactory for use in this circuit.

For those interested in the constants of the condensers and resistors used in this receiver the following parts list is included.

R—250,000 ohm resistor
R1—300 ohm resistor
R2—20,000 ohm resistor
R3—10,000 to 50,000 ohm resistor
R4—25,000 ohm resistor
R5—.5 meg. (A.F. Volume Control)
R6—1. meg. resistor
R7—200 ohm, 5 watt resistor
R8—25,000 ohm, 10 watt resistor
R9—14,000 ohm resistor
L—R.F. Choke
R.F.C.—85 mh. choke
L1—Speaker field, 1,000 ohms
L2—20, 30 henry filter choke, 500 ohms D.C.
C—.1 mf. tubular condenser
C1—Padding condenser (depends on coils used)
C2—Tuning condensers
C3—.00025 mf. mica condenser
C4—.006 mf. tubular condenser
C5—.01 mf. tubular condenser
C6—.0005 mf. mica condenser
C7—1. mf. paper condenser
C8—8. mf., 500 volt electrolytic condenser
C9—8. mf., 500 volt electrolytic condenser
C10—.25 mf. paper condenser
C11—.02 mf. tubular condenser
T1—Intermediate frequency transformer
T2—Plate to push-pull grids A.F. Transformer

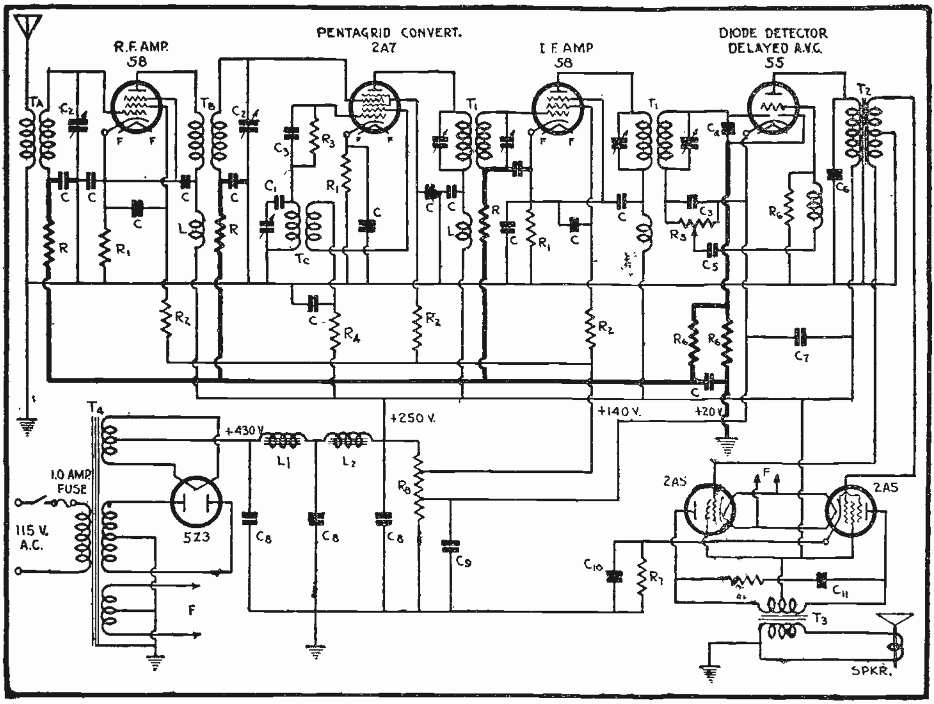


Fig. 44
Note heavy lines of A.V.C. circuit connections

T3 — Output transformer (generally mounted on speaker), 14,000 ohms plate-to-plate for 2A5 type tubes.

T4—Power transformer, 400 volts R.M. S. per side, under lead.

One of the most important problems encountered in placing A.V.C. circuits in existing receivers is the selection of the tubes to be controlled. Thought must be given to every receiver and each receiver will have to be considered as a special case. However, this is not a problem that cannot be solved by the experimenter. Every radio man can compare sets and circuit diagrams of sets equipped with A.V.C. in service manuals. Select a receiver with the same type of circuit and the same number of tubes if possible. Note the difference in the power sensitivity of the output tubes. If the set that you intend converting for A.V.C. has 45 type tubes and the diagram that you are studying has 2A5 tubes check for ample voltage amplification when the detector tube is changed over for A.V.C. and determine if ample audio voltage gain will be obtained to swing the 45 type tubes. These tubes have lower power sensitivity than the 2A5's and require more voltage amplification. This may necessitate an additional audio frequency amplifier stage. In some cases it will be best to change over the output tube circuits and use the output tubes with the higher power sensitivity. While this adds to the cost it may be found that another audio stage is impossible due to space and power supply limitations.

A very interesting chart showing the power sensitivity of the various types of output tubes on the market is printed by permission of the Raytheon Production Corp., and appears in the chapter on tubes. When adding A.V.C. study this chart and it will assist in laying out the necessary changes in the particular receiver.

While the unexpected inclusion at this point of the output tube considerations may seem odd it has a very important bearing on the selection of tubes to be controlled. It is always necessary to obtain ample audio volume and as the

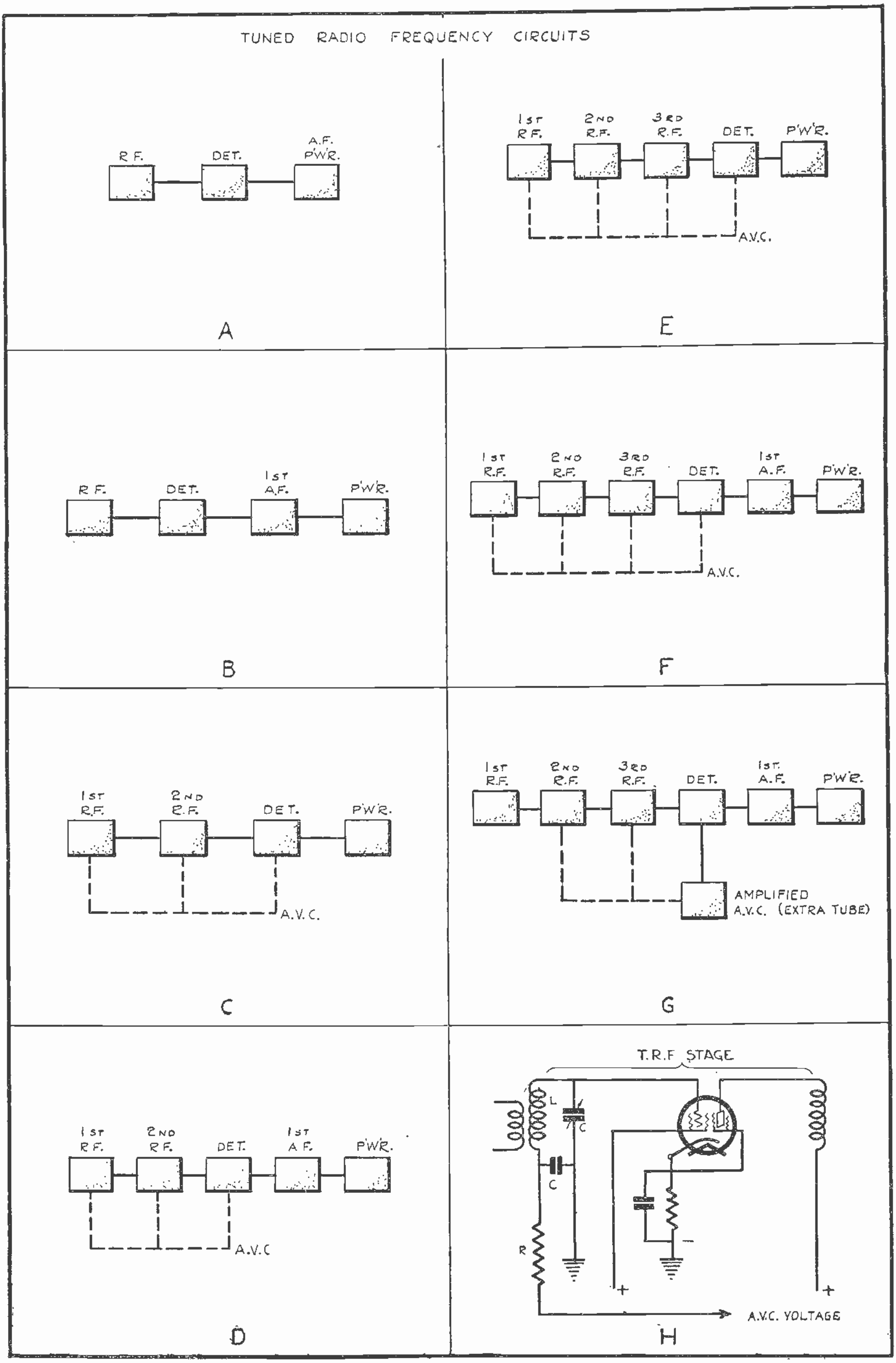


Fig. 45
Possible A.V.C. circuits for tuned R.F. receivers

tube used in the detector or second detector circuit will determine both the A.V.C. voltage and the audio output available some information must be available to tie these factors together.

Having decided as to the type of tube to be used in the detector or second detector circuit and the audio amplifier it is then necessary to examine the radio frequency portion of the receiver. The main requirement of the radio frequency end of the set will be its gain. If the receiver is of the low radio frequency gain type then it will be difficult to obtain sufficient radio amplification to swing the diode current to such a point or value where it will be useful for A.V.C. action.

Examine the block diagrams of Fig. 45 carefully as most of the common types of tuned radio frequency receivers are indicated. Notice that the indicated circuit of Fig. 45 A and B are not suited for A.V.C. action at all. The reason is simple, insufficient radio frequency amplification.

The circuit of Fig. 45C can be A.V.C.'d but the results will not be satisfactory unless the A.V.C. voltage is AMPLIFIED. Amplified A.V.C. will not fit in with the average receiver due to the complications in circuit wiring. Therefore it is best to leave this circuit alone.

Fig. 45D with the additional audio frequency stage will be less satisfactory than "C," due to the increased audio amplification.

If the circuit of Fig. 45E is of the real high gain type good A.V.C. action will be possible. Here the output of a high gain detector feeds the power tube. In most cases the power tube will be of the pentode type and have a high power sensitivity.

In Fig. 45F, the additional audio stage (unless the output power tube has low sensitivity) will necessitate greater A.V.C. action than the circuit of Fig. 45E.

The use of a separate A.V.C. tube is an excellent idea and finds its way into many short wave receiver designs. However, it is not widely used in broadcast-receivers as it adds an extra tube.

The method of A.V.C. voltage coupling to the grid circuit of the radio frequency tube should be done as indicated in Fig. 45H. Note that condenser C completes the resonant circuit of L and C and serves as a by-pass condenser to the radio frequency signal blocked by the resistor R. The value of C and R will depend on the frequencies tuned by L and C. The ratio of R to C should be in the order of 50 to 1. If the reactance of the condenser C at 1,000 kc. for example, is 1,000 ohms then R should have an ohmic value 50 times 1,000 or 50,000 ohms. As the current through this portion of the receiver is small, this resistor can be of the carbon .5 watt size.

Do not think that extended cut-off types of tubes can be used in A.V.C. circuits, and tubes like 57, 36, and the 24 may not. In many cases it is necessary to use tubes with the lower voltage cut-off. The reason is simple. Tubes with lower cut-off necessitate lower voltages from the A.V.C. voltage source. A tube that will have practically zero mutual conductance with 10 volts applied to the grid will afford quicker cut-off for a given receiver sensitivity than that will be obtained from a tube requiring 45 volts. In many cases, especially where the receiver sensitivity is low, it is best to use ordinary screen grid tubes so that the maximum effect can be obtained with the available A.V.C. voltage. In Fig. 45D greater A.V.C. action will be obtained when 24 type tubes are used. In this circuit 51 type tubes were tried and after a few minutes test the variable-mu tubes were removed and the 24 type tubes used instead.

If the audio amplification is high use greater A.V.C. voltages for satisfactory results. If the sensitivity of the R.F. portion of the receiver is low and you must use A.V.C. then use tubes with low cut-off. Tubes of the low cut-off type are the 77, 57, 24, etc.

The problems encountered in superheterodyne receivers are comparable to the problems covered in the last few paragraphs. Here at least one of the tubes may be used as a composite detector and oscillator, although early supers had a separate oscillator tube. However, the circuits of Fig. 46 are representative of the receivers on the market today, and can be used as examples.

Do not try to A.V.C. the circuit of Fig. 46A. There is nothing to control due to the lack of sensitivity.

In Fig. 46B a separate oscillator tube

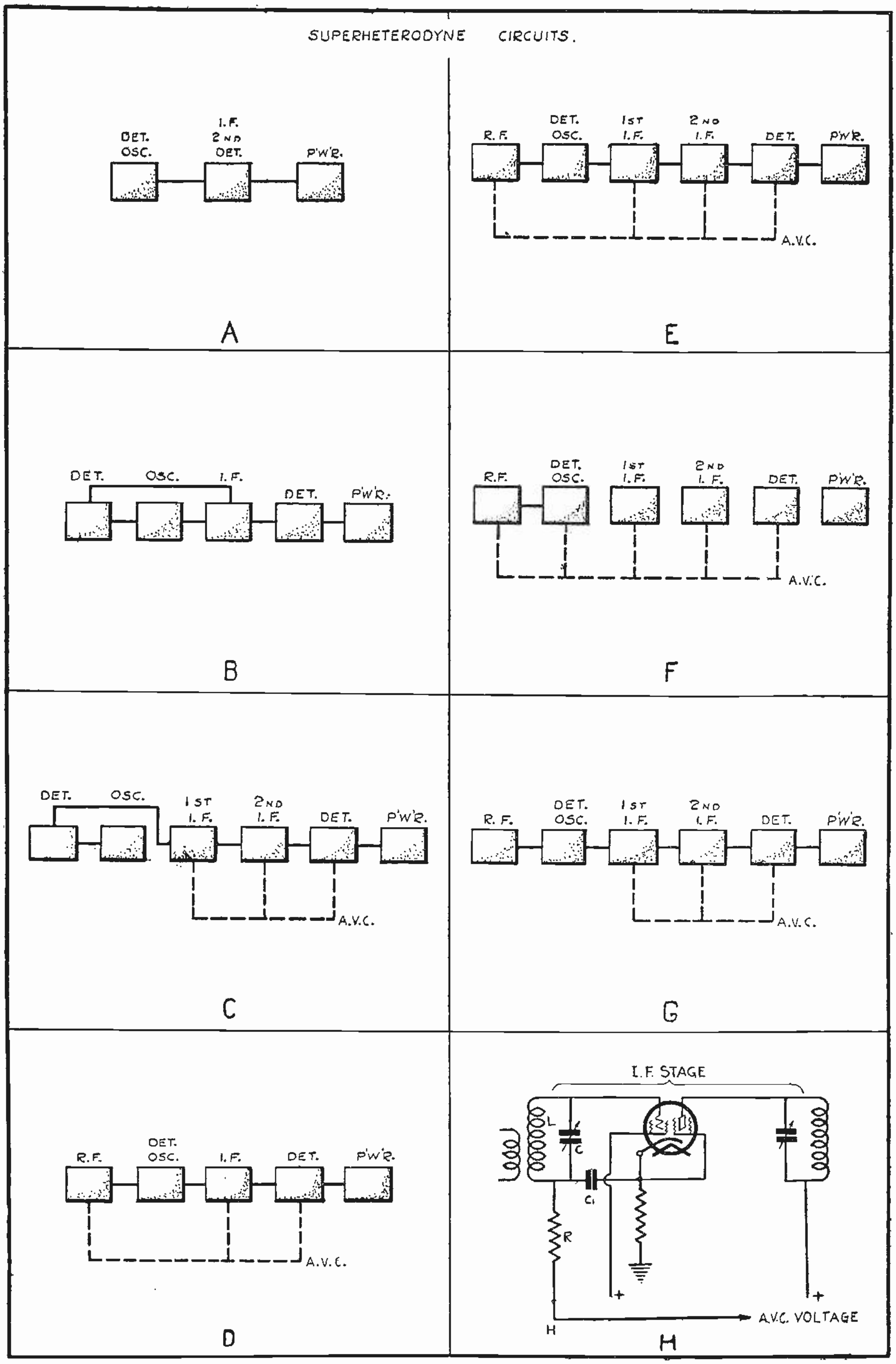


Fig. 46
Possible A.V.C. circuits for superhet receivers

is used and in the average receiver it is not advisable to include A.V.C. unless the set has very high gain, and is used in the vicinity of high-power broadcast transmitters.

A.V.C. action can be obtained with the circuit of Fig. 46C if the intermediate frequency amplifier is capable of high gain. It would be wise to use tubes with low values of cut-off, such as the 24 type.

A very common type of circuit is shown in Fig. 46D and the A.V.C. voltage should be applied to the radio and intermediate amplifier stages. This circuit works out when the received signals are great in value, and will be rather useless on weak stations.

The use of the two I.F. stages of Fig. 46E, and the additional control of the gain before the detector, will give good A.V.C. action in this receiver. This circuit has been followed in many of the commercially made receivers.

Additional A.V.C. control is obtained in the circuit of Fig. 46F by connecting the pentode grid of the first detector to the A.V.C. voltage feed line. While this circuit is practical the author prefers to leave the oscillator and detector circuits alone. The latter permits smoother operation of the receiver as a whole and enables the set operator to know just what voltages are applied to the detector tubes at all times. This point may be open to criticism but personal experience has shown that it is best to set oscillators and detectors to their best operating conditions, and so arrange their circuits that they will be operating at the maximum efficiency at all times.

In an endeavor to provide the maximum sensitivity with the minimum of back-ground noise the circuit of Fig. 46G is a great favorite. Here the radio frequency stage and the oscillator-detector stage are operated for the condition of maximum gain with the minimum back-ground noise and the A.V.C. voltage is applied to the two intermediate frequency amplifier stages.

The method of applying the A.V.C. voltage to the intermediate frequency stage is shown on Fig. 46H. This circuit is familiar to every one and the value of C1 and R will depend on the amplification of the intermediate frequency. Keep the ratio of Xc to R at least 50 to 1 as covered in the section devoted to A.V.C. in tuned radio frequency receivers.

Tuning Meters

The use of indicating devices on sets equipped with automatic volume control is a desirable convenience. One of the most satisfactory indicating devices is a milliammeter so built that the maximum current flowing through the meter movement will cause the indicating pointer to swing over to the left. Then, when the incoming signal is applied to the volume control tube, causing an increase in the bias voltage on the grids of the amplifying tubes, the needle will swing to the right. The greater the pointer swing to the right the closer will be the approach to station resonance.

The meter is placed in the plate circuits of the R.F. or I.F. tubes and the meter to be used will depend on the amount of current flowing in the plate circuits. This current will be the sum of the plate currents of the tubes connected to the meter.

Meters of this type can be purchased in several ranges and can be mounted with an escutcheon plate on the front panel. Fig. 47 shows the visual tuning meter made by Readrite Meter Works, Bluffton, Ohio. These meters can be had in several ranges. The following current ranges can be obtained; 0-5, 0-10,

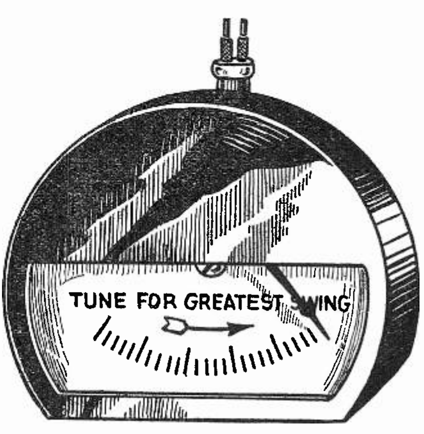


Fig. 47
Inexpensive type of tuning meter

0-15 ma (full scale of deflection). The current scale selected should be the one whose indicator will move to the extreme left and which is determined by the plate current of the tubes into which the meter is inserted.

In order that the proper range can be selected the circuit of Fig. 48 has been included. This circuit shows the plate circuits only and represents the R.F. or I.F. circuits which are controlled by the A.V.C. tube.

The plate current indicated in three plate circuits will be equal to the total value of plate currents of various tubes see the tube chart in Chapter 2. Select the meter range nearest to the value of plate current present when the tubes are supplied with the bias which gives normal plate current.

Increased input signal raises the bias, thus reducing the plate current, and the indicating needle moves to the right due to the increased current.

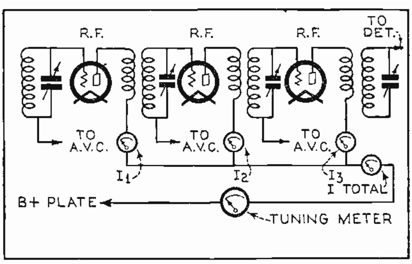


Fig. 48
Tuning meter circuit connections

Resonance Indicators

One of the methods available for visual tuning incorporates a neon gas filled tube. This tube has two elements; a long cathode over 3 inches long and a short cathode one-half inch long. These elements are inclosed in a glass tube three and one-half inches long and one half inch in diameter. Gas lamps connected across the loudspeaker terminals are instantaneous in responding to changes in signal strength which is indicated by the variation of the intensity of illumination. In the "Tune-A-Lite," the variations of sound intensity varies the height of a column of red neon light. This tube mounts in an automobile headlight socket. Of course the indicator should be mounted on the front panel of the receiver, above the tuning scale. As the voltage across any gas tube is increased from zero, a particular value of voltage will be reached when the tube just begins to glow. This voltage is called the "striking" voltage. If the potential across the tube is further increased, the intensity of the glow increases, but in this tube it is spread out so that the length of the glow increases.

The chart of Fig. 49 shows how the rise of the glow discharge varies as the current through the tube is increased.

To determine the ignition voltage, and the potential at which the tube will go out (called the extinction voltage) the circuit of Fig. 50 is used. The resistor of R is increased from zero until the tube just glows. The value indicated by V is the ignition voltage. If the value of the resistance R is decreased from high value until the tube just goes out, the value V will be the extinction voltage.

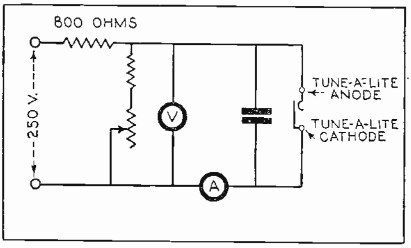


Fig. 50
Elementary Tune-A-Lite connections

These tubes are especially adapted to receivers using A.V.C. When the signal is applied to the grid of an amplifier tube, the plate current, of course, in-

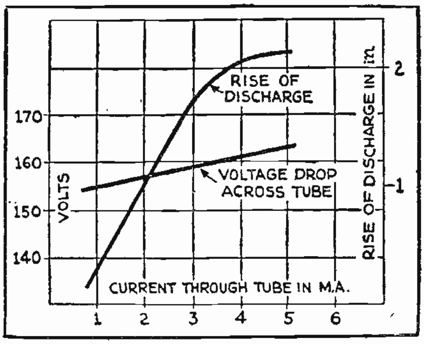


Fig. 49
Glow discharge vs. current chart

creases and decreases with the signal, with the average plate current remaining the same. The signal voltage passes to the A.V.C. tube which by its method of operation, increases the grid bias of the amplifier, thus lowering the average plate current. The actual plate voltage, therefore, rises, due to the decreased voltage drop in the plate circuit of the tube. The "Tune-a-light" tube takes advantage of this condition and uses it for its operating principle.

From the above, it is obvious that the tube should be connected in the circuit where a voltage will increase and decrease with the signal. For example, if the tubes which are controlled by the A.V.C. have all their "B" plus leads connected together at a common point before entering the power supply unit as shown in Fig. 51; then when the light is connected between the common point and the bleeder resistor in the power unit, it will work in the following manner.

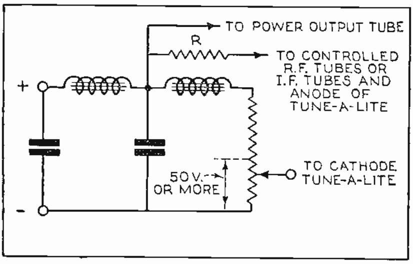


Fig. 51
Tune-A-Lite circuit connections

The A.V.C. tube will cause a decrease in the voltage drop across the resistor R, Fig. 51, as the signal is tuned in. The voltage between the terminals of the light will then increase, depending on the strength of the signal, which in turn depends on the condition of resonance. The height of discharge will be a maximum when the receiver is tuned to exact resonance.

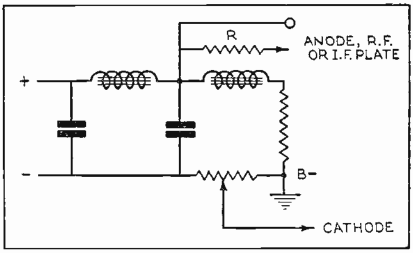


Fig. 52
Method of adjusting no-signal voltage

The circuit of Fig. 52 shows the cathode of the light connected to a variable arm on the voltage divider. This adjustment sets the "no-signal" voltage applied to the tube, and is adjusted so that it is just equal to the ignition voltage.

CHAPTER 5

Short Wave and Police Band Reception

Nothing has caught the interest of radio fans so rapidly as short wave and police band reception. Short wave receivers are the sets of the hour and there are many interested in changing over sets so that these interesting bands can be included. However, there are several considerations before adding short wave tuning bands to a standard broadcast receiver.

A study of the most popular receivers on the market for this year finds that present receivers are divided into several groups, and offer different classes or types of reception. A study of the small chart following indicates these groups.

1—Broadcast and Police Bands (550 to 1000 meters) Two tuning ranges.

2—Broadcast and International Broadcast Bands (200-550, 17-55 meters) Two Tuning ranges.

3—Broadcast and Short Wave Bands (200-550, 80-200, 40-80, 20-40 meters) Four Tuning ranges.

4—Broadcast, Short Wave and Long Wave (Same as No. 3 except an added range (750-1700 meters) Five tuning ranges.

The last is used for export and is seldom found in the U. S., however it was listed as a point of reference.

Of all the types No. 1 and No. 2 are the easiest to include in receivers, as they require a minimum of equipment and can be worked into most sets.

It is not practical from the viewpoint of simplicity to try and add several bands. A study of the limitations of the tuning coils, condensers, etc., will show that for the best efficiency at low cost, more than two wave bands or tuning ranges will complicate matters.

One of the easy ways to change over a standard broadcast receiver so that police and 160 meter amateurs can be received, is to remove turns from the tuning coils so that the tuning range is shifted. This method is workable with sets of the later type. Most of the older type receivers do not tune down to 200 meters, whereas most of the more modern sets of the superhet. type will, and these sets can be modified. The only necessary change is to remove turns from the coils. This will throw the tuning scale off if the scale is calibrated in kc. If this is not objectionable then proceed as follows.

If the set is a super remove five turns from the secondaries of the radio frequency or band-pass coils and the detector coils. Remove three and one half turns from the oscillator grid coil. Remove turns from the tuning coils at the end furthest from the primary. This end of the coil is called the grid end or "hot"end. Rebalance the tuning condensers and check the tracking of the oscillator. The set is ready for testing. In some cases, stations around 550 meters will be received due to the reduced inductance of the coils. This may be objectionable.

There are many sets on the market similar to the one shown in Fig. 53. In sets of this type it is best to obtain a set of coils suitable for broadcast and police band reception. In this circuit a double pole switch can be used to connect the upper secondary coils in parallel to the lower secondary coils. This shunting of the standard broadcast coil with a smaller coil reduces the effective inductance of the two tuned circuits. When the double pole switch is opened the smaller upper coils are floating and broadcast reception can be obtained. These coils can be purchased in sets of two and three at low prices and it does not pay to try and wind them by hand, unless you have the proper equipment for coil matching.

Some more coil and tube information has been made available by RCA-Cunningham which will serve the short wave super fan. This material gives data on coils, wire sizes, tubing sizes, etc. Fig. 54 covers the coil data for the various bands.

The pentagrid converter tubes 2A7, 6A7, and 1A6, frequently used as combination mixer (first detector and oscillator) in broadcast receivers, have application in short-wave or multi-range receivers.

This application note is devoted to a discussion of the conditions under which the pentagrid converter may be used in multi-range receivers, of the proper circuit conditions for best operation, and of the specifications and constants for the inductances and capacitances suitable for various frequency bands.

All of the advantages which these tubes have for applications at broadcast frequencies are retained at the higher frequencies. The fundamental circuits for the higher frequencies are found to be almost identical with those used for the broadcast band. Also, operating voltages are the same as those recommended for broadcast frequencies.

In such a receiver, it is generally desirable to use the same tuning condenser for each frequency band, a convenient capacity range being approximately 40 to 350 mmf.

In a multi-range receiver typical frequency bands are:

550 to 1,500 kilocycles—4 to 10 megacycles.

1.5 to 4 megacycles—10 to 25 megacycles.

The low frequency band of 150 to 400 kilocycles is sometimes included.

An intermediate frequency of approximately 450 kilocycles is suitable for use with all of these bands. The 2A7 and 6A7 will operate satisfactorily in all the bands to provide gain comparable with that obtained at broadcast frequencies. The 1A6 may be used in all except the 10 to 25 megacycle band. Although the 1A6 can be made to oscillate at frequencies higher than 25 mc., it is difficult to cover the 10 to 25 mc. band. To cover this and higher frequency bands, the 1A6 can be used in combination with a triode.

The table below gives for the frequency ranges considered the approximate values of inductances for r.f. and oscillator coils and of series condensers. The constants assumed are:

Frequency Band Megacycles	.15 to .40	.55 to 1.5	1.5 to 4.0	4 to 10	10 to 25	
R.F. coil inductance (L)........	3248	241.6	32.5	4.43	.709	microhenries
Oscillator grid coil inductance (L)	699	131.2	25.0	3.60	.648	microhenries
Tracking Condenser (C)........	120	385	1000	*	*	mmf.
Additional minimum capacity required in oscillator circuit....	22	9.5	4.3	11.3	4.2	mmf.
Ratio of oscillator grid coil inductance to r.f. inductance.......	.21	.54	.77	.81	.92	mmf.

*Not required for the 4 to 10 and 10 to 25 megacycle bands.

R.F. tuning condenser, 40 to 350 mmf.
Intermediate frequency, 450 kc.

The minimum capacity assumed will be somewhat higher for the high-frequency ranges, due to the close coupling between circuits necessary at high frequencies.

The design of the high-frequency oscillator coils requires care. The principle requirements are:

1. Low resistance in the grid coil.
2. High mutual inductance between grid and plate coils.
3. Low capacitance between grid and plate coils.
4. Low self-inductance in plate coil.

Since these requirements are to some extent contradictory, compromises are indicated. Other considerations such as restrictions on overall dimensions and wire size should be taken into account.

Grid and plate coils are made short in comparison with their diameters to facilitate proper coupling. The plate coil is wound at the end of the grid coil rather than inside of it in order to keep their inter-capacitance at a low value. The inductance of the plate coil is about twice that of the grid coil for the 10 to 25 mc. coil. Increasing plate turns beyond the number given will increase the amplitude of oscillation at the low-fre-

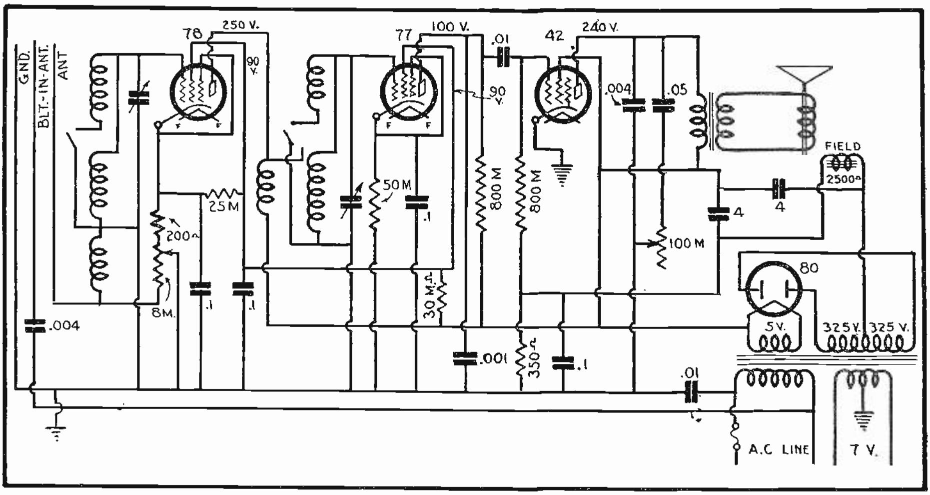


Fig. 53
Circuit of broadcast and police band receiver

quency end of the range, but will also limit the high-frequency end to a value considerably less than 25 mc.

All except the 10 to 25 mc. coil may be used with the 1A6, although it may be desirable to increase the plate turns on the "4 to 10 mc." coil for use with this tube. All coils will operate with the 6A7 and 2A7 in the circuit of Fig. 55.

It is possible to use the 1A6 in the 10 to 25 megacycle band and the 2A7 and 6A7 at still higher frequencies by connecting a triode in parallel with the oscillator portion of the pentagrid converter, as shown in Fig. 56. This combination may be used in any variation of this circuit without change in connections or voltages. The function of an extra tube is to increase the voltage available for excitation of the oscillator circuit. This is necessary at high frequencies because of the very unfavorable L/C ratios and consequent low impedances obtained with tuned circuits operating at these frequencies. Combinations suitable for use in this circuit are:

Pentagrid Converter	Triode
2A7	56
6A7	37
1A6	30

When these converter-triode combinations are used, it is not necessary to disconnect the triode for low-frequency operation. However, with this combination, it will probably be found desirable to reduce the number of turns in the low-frequency oscillator plate coils in order to keep the voltage developed across the grid coils at the value best suited for operation, of the converter.

Short Wave Converters

Perhaps the best solution to this problem of providing short wave reception with a standard broadcast receiver will be found in the use of a short wave converter. There is no reason why a short wave converter cannot be used with a standard broadcast set with excellent results. Many persons have reported to the writer that they have not had the results expected. In every case there has been some mistake made by the converter constructor, especially in connecting the converter to the broadcast receiver. This problem of coupling is one of the most important considerations.

Converter users claim that the system lacks sensitivity. Since the broadcast receiver contributes most of the amplification, it must be in good condition. The R.F. and I.F. stages must be properly lined up. Especially at the frequency to be used as the intermediate frequency.

After the broadcast receiver has been checked then look to the converter. The oscillator and first detector tuning con-

COIL DATA

FREQUENCY BAND MEGACYCLES		0.15 TO 0.40	0.55 TO 1.5		1.5 TO 4.0	4.0 TO 10	10 TO 25
ASSEMBLY NO.		1	1	2	2	3	3
R.-F. COIL L_1	TURNS	442	121	147	36.8	10.4	4.2
	WIRE	#36 S.S.C.	#30 S.S.C.	#32 ENAM.	#30 ENAM.	#30 ENAM.	#20 ENAM.
OSC. GRID COIL L_2	TURNS	194	83	91	33.4	9.1	4.0 *
	WIRE	#36 S.S.C.	#30 S.S.C.	#32 ENAM.	#30 ENAM.	#30 ENAM.	#20 ENAM.
OSC. PLATE COIL L_3	TURNS	90	45	30	12	12	6
	WIRE	#36 S.S.C.	#30 S.S.C.	#32 ENAM.	#30 ENAM.	#36 ENAM.	#36 ENAM.

* THIS COIL IS NOT SUITABLE FOR USE WITH THE 1A6 UNLESS A TYPE 30 TUBE IS USED IN PARALLEL

COIL ASSEMBLIES

NO. 1	NO. 2	NO. 3
MULTI-LAYER COILS	SINGLE LAYER COILS	SINGLE LAYER COILS

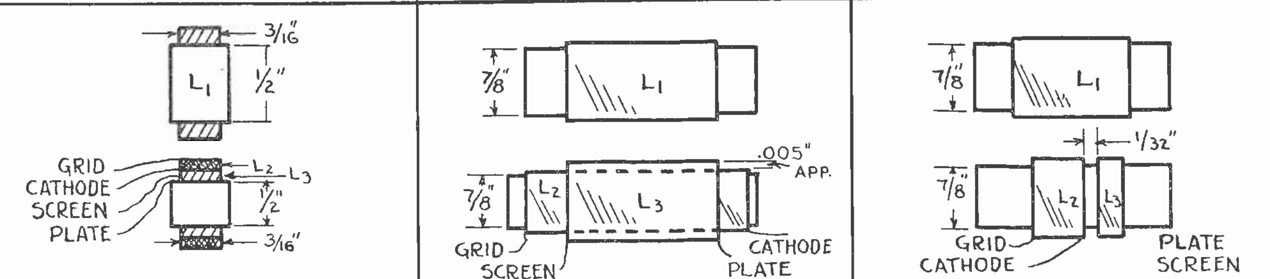


Fig. 54
Short wave coil data. (Courtesy R.C.A.-Cunningham)

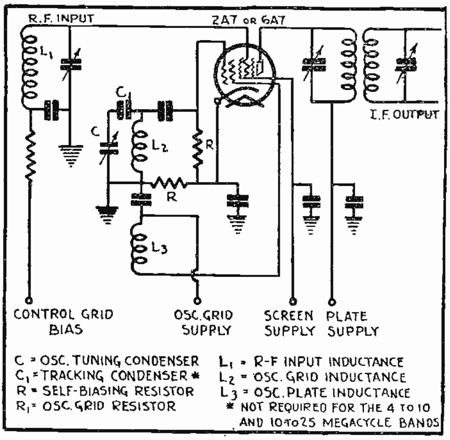


Fig. 55
Pentagrid converter constants

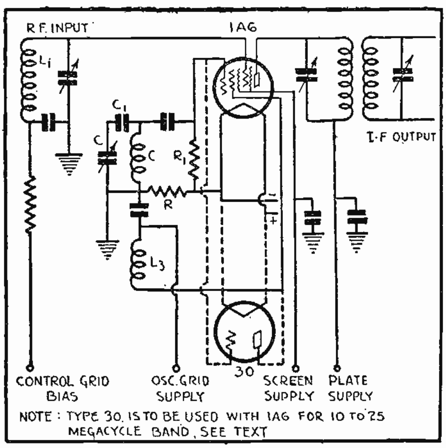


Fig .56
Using 30 type tube for H.F. oscillation

densers must be properly aligned. Most converters are made with a trimmer connected across the first detector tuning condenser. It should be possible, by turning this, to bring the signal sharply into resonance. Should this prove impossible, it means that the tuning coils are not properly lined up. Turns should be removed or added to the oscillator coil for that range until the two condensers track.

If the sensitivity is low after the converter and broadcast tuning has been lined up accurately it is probably due to R.F. losses in the coupling between the two (converter and the receiver).

The circuit of Fig. 57 is most generally used for coupling in short wave converters. Sometimes this method is inefficient because it can reflect back to the plate of the first detector the impedance to which it is coupled. This is usually the antenna winding as employed in a broadcast set, and this may be a low value of inductance, with the result that the output circuit of the converter is not sufficiently loaded and operates at very low gain. Many broadcast receivers have band-pass input stages. Do not couple converters to the grid of the first R.F. tube, couple to the antenna. Ground primary winding. This will improve selectivity.

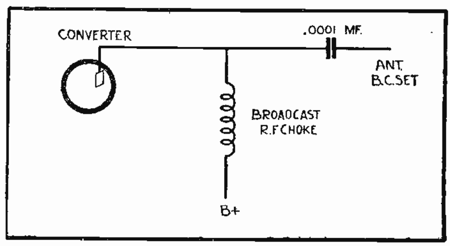


Fig. 57
Converter Coupling Circuit

A more complicated circuit is shown in Fig. 58 and is a real improvement in the sensitivity of a converter-broadcast combination. It employs a stepdown R.F. transformer with its primary tuned and its secondary arranged in an untuned link circuit with the antenna coil in the broadcast receiver. Link coupling in short wave transmitters has been used for years.

The twisted coupling line may be several feet long as the losses are low. The turns ratio of the output transformer prevents the low impedance of the link circuit from being reflected into the

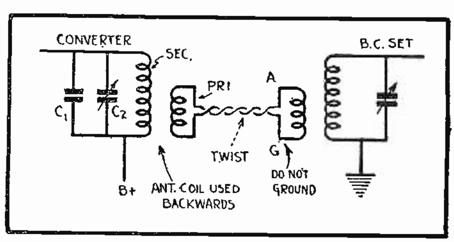


Fig. 58
Link coupling circuit

plate circuit of the converter detector.

This circuit was a standard broadcast antenna coupling coil such as is found in broadcast sets. It should not be of the high gain type. C should be about .00025 mf. (mica type), and C 2 a 100 mmf. compression type condenser. This will tune the unit to frequencies lower than 650. If the I.F. selected is greater than 650 reduce the size of C 1. Do not ground the primary of the antenna coil in the receiver.

Use twisted lamp cord as the coupling link. A better method of coupling by the link method permits grounding and is shown in Fig. 59. The windings are placed on a 1″ form and consist of 12 turns No. 29 or 30 D.S.C. wire with a center tap. The diagram indicates how the ground is specially connected, and which is an excellent method for reducing noises.

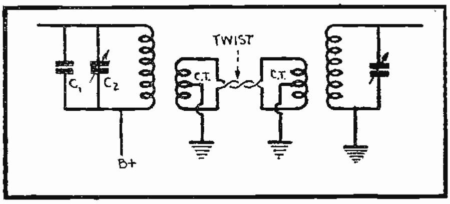


Fig. 59
Balanced-line link circuit

CHAPTER 6

High Fidelity Audio Systems

One of the most interesting developments of the present year is the trend towards high fidelity reception. While it has not reached a state of general public acceptance, one will find many persons interested in obtaining truly improved audio performance. This means that the receiver should be capable of handling audio frequency ranges from about 40 to 7,500 cycles. This is the greatest audio frequency range required today and will not be found in the average radio set. Most radio sets of the real selective variety have a tendency to cut off at about 1,000 cycles with a steady decrease in audio output until 5,000 cycles are reached, where the response is practically at complete cut off.

While there are a few 1934 receiver models manufactured that are capable of responding up to 5,000 cycles, the actual number of manufacturers turning out this high-grade type of receiver is rather limited. Therefore, there is a ready market for changes in radio receivers which will permit the amplification of these higher audio frequencies. It is necessary at this point to consider a very important factor. A radio set that will respond to frequencies up to 7,500 cycles will also respond to a greater noise area, which, of course, should be nullified so the reception could be enjoyed. If we have a receiver which is capable of responding to audio frequencies from 40 to 7,500 cycles, there will be a certain additional amount of noise coming in which up to the present, due to the attenuation of the higher audio frequencies, which has not been previously noticeable.

If the receiver has its audio frequency ranges extended down to 40 cycles and up to 7,500 cycles we can therefore see that noises within that additional frequency range will be amplified. It will be found that the amount of noise present in the output of the receiver is nearly equal throughout the audio band. Thus, as a high fidelity receiver will pass more noise, it will be absolutely necessary to use some means of noise elimination so that disagreeable effects can be eliminated.

If a high fidelity audio system is included in a radio receiver, the customer may not be satisfied, due to this increased noise, and blame it on the receiver itself (when it might be due to a noisy location) especially if he is not familiar with the problems of radio. Most of the noise encountered in the receiver is local and does not come in on the carrier from the transmitting station. Therefore, some type of noise reducing antenna system should be used in receivers of this kind.

A simple system using the antenna impedance matching transformer and impedance transmission line with a receiver matching transformer, located at the receiver as shown in Figure 60, is very satisfactory for use on broadcast bands, and for that purpose cannot be beat. Of course, it is necessary that the top part of the antenna be raised as high as possible away from any possibility of noise pickup for best results. The dimensions given in the illustration are very satisfactory for use with the modern radio set.

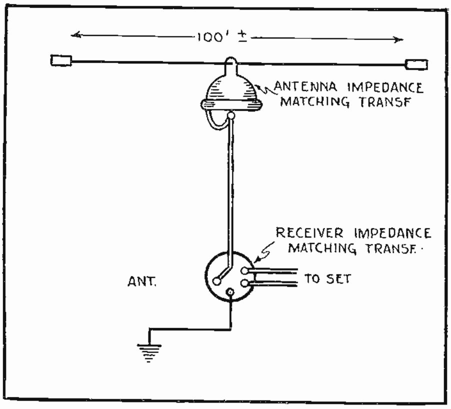


Fig. 60

Noiseless antenna connections

If a high fidelity audio system is being incorporated in one of the new all wave receivers, it would be wise to use a transposed double antenna as shown in figure 61. Doublet antennas of this type are directional, and in the United States, for best results, should be strung in north-west, south-east direction. Resonate the antenna by cutting off equal lengths from both halves until it will have a natural period of about 19 meters. This will be a very good antenna for the 25, 31 and 49 meter bands which are used for international broadcasts. This aerial while particularly good for the above wavebands, can be used for the amateur, police and aircraft bands, and while the antenna efficiency will fall off, from one band to the other, it will be made up by the increased efficiency of the receiver which will generally improve as the frequency goes down.

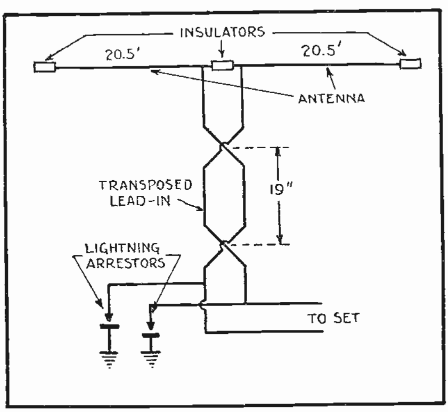


Fig. 61
S.W. transposed antenna

Numerous antenna kit manufacturers have done considerable work along these lines, and it would be well for the reader to pick up all the information he can on these antennas, as it will become more important as the frequency width of the audio channels in our present radio receivers are increased. In every case it will be necessary to broaden the tuned circuits so that no frequency discrimination occurs before the detector.

Tone Controls

It may seem strange to many readers for this sudden switching from the subject of high fidelity to tone controls.

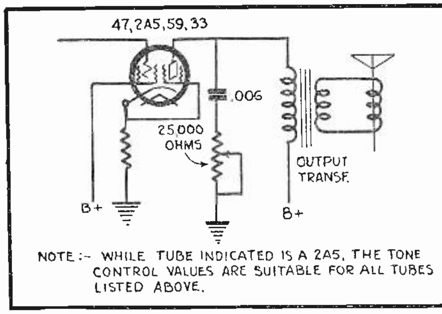


Fig. 62
Simple tone-control circuit

However, there are many set owners who still have a great desire for "Bass Note Reception." Many of the earlier models of radio sets did not have tone controls, and while most of the later model sets incorporated such devices, they did not prove satisfactory in giving the desired range, so that now there is always an opportunity for making changes in this portion of the receiver circuit. Tone controls are always located in the audio frequency portion of the receiver, generally between the detector and output power stage in the smaller sets, with the tendency on the part of some manufacturers to put the tone control in the plate circuit of the pentode output tube. In this position it serves two purposes—one to maintain the plate loading impedance constant; secondly, to cut off the higher audio frequencies which are not desired in the output. This also has a tendency to reduce the hash or noise present in a high gain receiver. Five interesting circuits are shown in figures 62, 63, 64, 65 and 66, with complete electrical specifications, showing some of the more popular methods in use today.

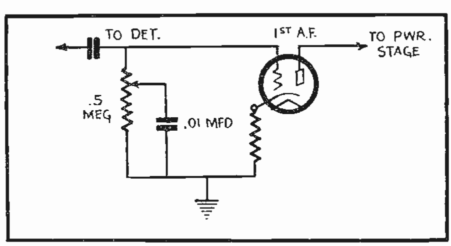


Fig. 63
Grid-circuit tone control

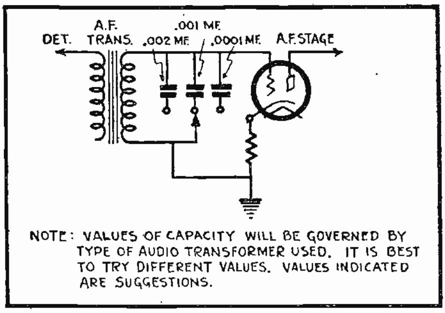


Fig. 64
Step type tone control

The type 51 tube has its control grid connected to the negative side of the diode load resistor, which, of course, is the source of the AVC voltage. The tube during operation acts as a variable capacity across the output circuit of the diode. The capacity increases with a decrease in signal. If the signal strength is high, then the total capacity across the diode output is the capacity of the grid-plate coupling condenser plus the grid plate capacity of the tube. This effective capacity has a value ordinarily used for shunting in the diode load circuit. This will not cause attenuation of the audio frequency output in this portion of the circuit.

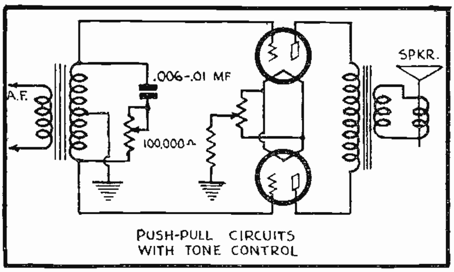


Fig. 65
P.P. circuit tone control

Modifications of these methods can be developed to fit the conditions of the particular receiver in question, and, of course, to suit the set owner.

The coming thing in tone controls will be the introduction of automatic tone control circuits. This is generally abbreviated as A.T.C.

The circuit in figure 67 shows how an A.T.C. circuit can be incorporated into one of the more modern receivers of the superheterodyne class.

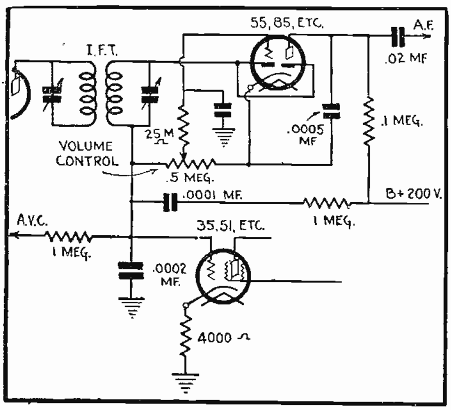


Fig. 67
Automatic tone-control circuit

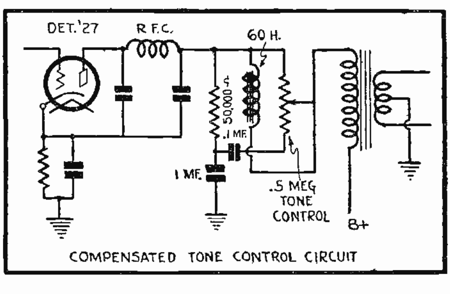


Fig. 66
Compensated tone control

If the signal is weak, the dynamic capacity of the condenser C will rise to a high value. The minimum signal gives a dynamic value (.0002 mf. cond.) of about 50 times the static value. The result is an increase in attenuation of the high audio frequencies with the actual audio cutoff extended down to 800 cycles (approx).

The operation is based on the fact that the input capacity of the tube varies with the mutual conductance and is controlled by the grid to plate capacity. The grid to plate capacity of the variable-mu tube plus a static capacity C permits larger values of input capacity to be obtained and in this particular circuit the capacity reaches .006 mfd.

This automatic tone control works right along with the automatic volume control and because of the high capacity developed across the diode load a very effective inter-carrier noise suppressor action is obtained. This circuit decreases the amount of noise present in proportion to the signal strength with the greatest removal at minimum signal. For this reason the "wash" on the end of a frequency channel is entirely removed.

Another method of A.T.C. control is found in Fig. 68. Here the value of resistance changes with changes in the grid bias voltage. A-B and C-D represent the audio feed circuit and the plate of the tube works into a very high impedance from the A.F. line to the plate by the condenser C. If the grid is connected to the most negative end of the diode circuit and the signal voltage is high then the grid bias will also be high. Under these conditions both Rp and the impedance L will have extremely high values and condenser C is an ineffective by-pass path. However, when the signal voltage is small the grid bias is also low. Then the value of the plate impedance drops and condenser C becomes effective as a by-pass. The effectiveness of C varies as the strength of the signal applied to the diode section of the detector tube. Circuit arrangements can be used introducing parallel resonant circuits by selection of C and L.

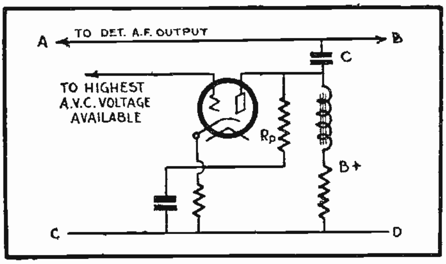


Fig. 68
Simple A.T.C. circuit

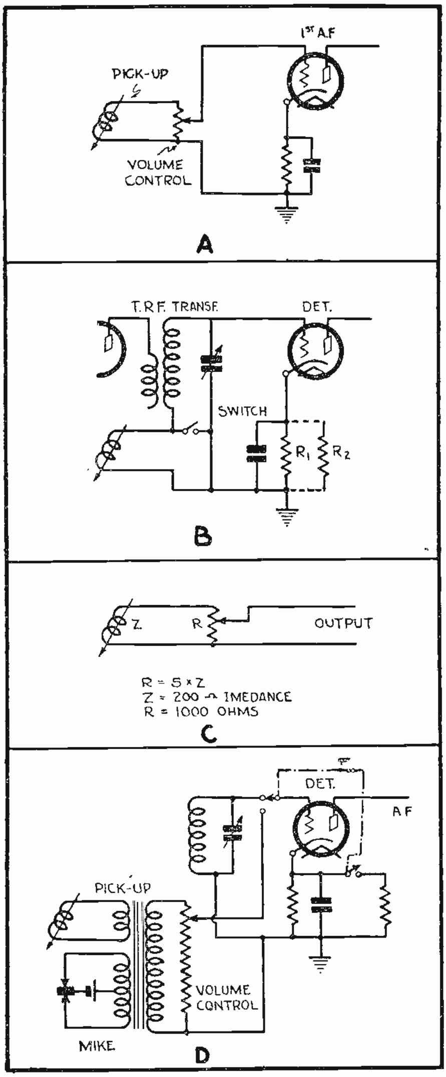


Fig. 69
Practical phono pick-up circuits

Phonograph Pick-Up Connections

Most radio receivers can be adapted for phonograph reproduction with very little difficulty. This is another source of income for the man specializing in modernizing radio receivers. The circuits given in Fig. 69 cover several of the most common circuits used. In A we find the common application of the pick-up and volume control connected to the input circuit of an amplifier tube. This circuit works very well with sets having two audio stages. The average pick-up does not have an audio output that approximates the gain in the radio frequency end of a set, thus it is necessary to have at least two stages to provide the proper signal volume.

In B we find the pick-up connected in series with the primary of the tuned R.F. transformer with a simple shorting switch which disconnects the phono-

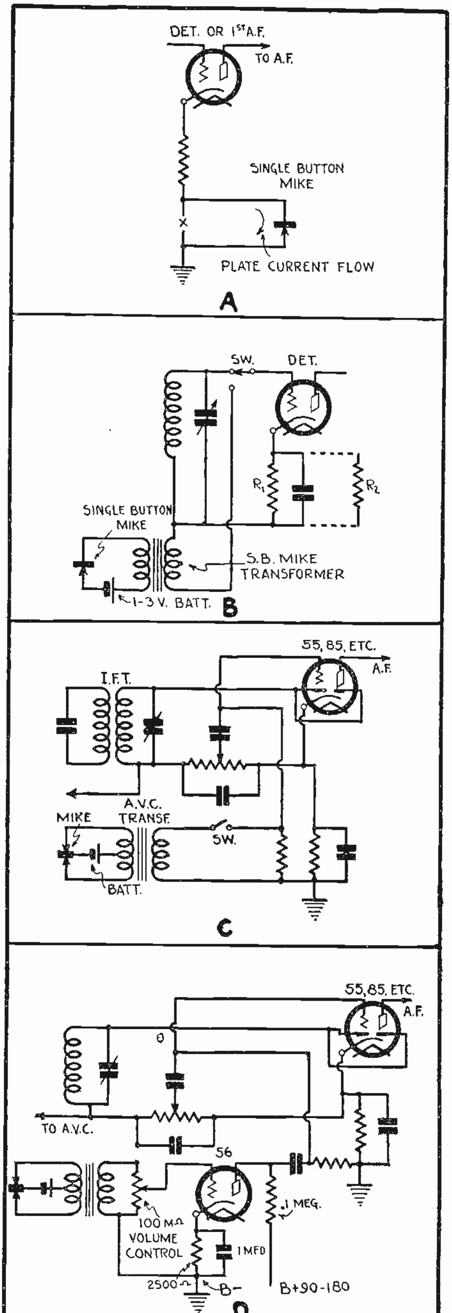


Fig. 70

Four methods of connecting microphones to radio receivers

graph pick-up from the tuned circuit when using the set as a radio receiver. It is necessary that R2 be chosen so that when parallel with R1 the tube will function as a amplifier, not as a detector. This resistor R2 should always be connected when using the pick-up and is absolutely necessary for quality reproduction.

In Fig. C we find a simple way to select the value of resistance used for volume controls with pick-ups. If the impedance of the pick-up is 200 ohms and you wish to use a volume control with it, select a control with a resistance having a value of 5 times the impedance of the pick-up. In this case the volume control will have a value of 1,000 ohms. The lower the value of this resistor the lower the gain from the pick-up. Therefore always select the volume control with the higher value. Thus, there will be no falling off in pick-up output.

In Fig. D we find a combination which can be used with a phonograph pick-up and a microphone with a volume control in the detector grid circuit. Notice the use of the additional resistor in the detector bias circuit. This changes the effective bias of the detector tube so that it will function as an amplifier. Circuits of this kind can only be used with radio sets having high audio gain due to the lower sensitivity of the mike. However, if the lower priced carbon mikes are used, satisfactory operation can be obtained if the turns ratio of the primary to secondary is at least 20 to 1.

Connecting Microphones

Several manufacturers have brought out a very simple microphone of the single button type. This microphone can be connected in the cathode circuit or plate and cathode of an audio stage tube, and operates on the plate current of the tube; connections are shown in Fig. 70.

While this microphone is quite sensitive and has a high output when connected as shown in Fig. A it is not noted for quality.

Fig. B shows the use of a single button microphone, generally of the "hand type" with its microphone transformer connected to the grid circuit of a radio tube. A double pole switch connects the bias adjusting resistor and connects the secondary of the microphone transformer to the grid of the tube. R2 is necessary, changing the operating condition of the tube so that it functions as an amplifier and not as a detector.

In all of these figures triode tubes have been indicated but tubes of the pentode or screen grid type can be used with this type of equipment in the same manner. The reason for working in ahead of the detector tube in circuits of this type is to obtain the maximum gain that the circuit affords. R2 should be of such a value as to reduce the effective resistance (cathode to ground) to about 3,000 ohms for tetrodes or pentodes, and about 2,000 ohms for triode type tubes.

In Fig. C a double button microphone is used with a microphone transformer, output switch with the secondary of the microphone transformer connected across the grid-ground circuit of the 55 type tube. Some tone control action will be obtained from the manual volume control, since the audio grid coupling condenser in series with the variable 500,000 ohm diode lead resistor also shunts the audio grid circuit. While this tone control is not entirely effective, not being designed for this purpose, some tone effect will be obtained in almost every case with this circuit.

In cases where additional amplification is necessary, prior to connecting the microphone and microphone transformer to the radio set, build a single stage amplifier as shown in Fig. D. You will note that the volume control is conected across the secondary of the microphone transformer. All constants for this circuit are stated and there should be no trouble in building such a unit. The filament and plate voltages can be taken from the radio set. If it is desired to have battery operation use a 30 type tube with two dry cells for the filament supply and about 22 volts B battery for the plate.

Carbon Vs. Condenser Mike

Most high quality two-button microphones produce on the average an output level lying between -30 and -50 db when operated under the usual pickup conditions. For the purposes of this article, the reference level is assumed to be 6 milliwatts (0.006 watts). The output level, however, depends on the condition of the buttons, on the button current and, of course, on the actual value of the sound pressure.

It is never possible to assume that a variable frequency sound source of constant pressure will deliver a constant sound pressure at the microphone diaphragm, for reflection, absorption and resonance due to surrounding acoustic conditions always introduce an unknown element. It should be remembered, however, that the human ear, if it were located at the pickup point, would likewise sense the effects of the acoustic conditions, so that these facts in no way imply improper functioning of the microphone itself.

The single-button microphone is intended for applications where high output is more important than a uniform frequency response. The response range is much more restricted and there is usually a diaphragm resonance peak rather low in the frequency scale. Hence the device is suitable in connection with headphones which in themselves are not capable of wide range reproduction, but would not be satisfactory on high quality systems for loudspeaker reproduction of music or voice.

All carbon microphones produce some "hiss" or carbon noise. In well designed microphones, the "hiss" has a very low level, but it is always present to a greater or lesser degree. Part of the noise is due to thermal agitation inside the carbon granules, but the greatest noise disturbances are caused by local heating where the granules are in contact. As current passes through the button, some heat is produced which tends to drive gas out of the more or less porous surface of the granules. This results in random variations in the resistance of the button, giving rise to a non-periodic noise. This noise lies principally in the upper portion of the frequency range.

The condenser microphone is almost entirely free from background noise, for there are no variable contacts such as those in the buttons of the carbon transmitters. The principal sources of noise in the condenser microphone are found in electrical leakage between back plate and diaphragm, dirt or foreign matter in the air gap, thermal agitation in resistors in the amplifier circuit and tube noises.

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