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PRACTICAL RADIO CIRCUITS

**A Comprehensive Guide
to All Types of Radio Circuits
for the Service Man,
Constructor and Experimenter**

by David Bellare



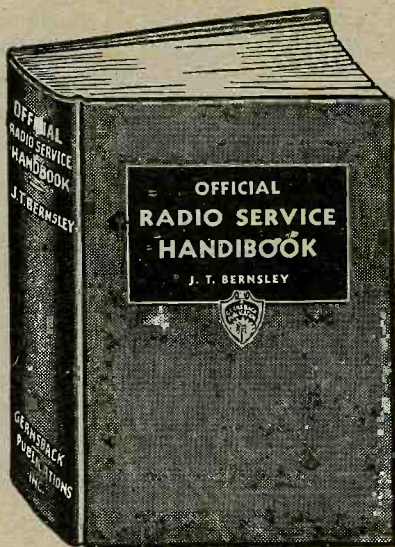
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RADCRAFT PUBLICATIONS, INC.
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Here's the Greatest Book for Service Men!

OFFICIAL RADIO SERVICE HANDBOOK

By J. T. Bernsley



HERE'S the book on radio servicing that contains everything Service Men must know. The book, **OFFICIAL RADIO SERVICE HANDBOOK**, is edited by J. T. Bernsley, foremost radio service authority. This 1936 service guide is the only book of its kind—its editorial material is so well prepared that the technical information can be understood by even beginners in radio servicing. Every page contains new material, new illustrations—no reprinted literature.

The **OFFICIAL RADIO SERVICE HANDBOOK** covers thoroughly over 500 radio topics. It tells you how to analyze the latest commercial receiver circuits; how to really make money servicing midget sets; and, how aligning supers can be made easy. It stresses the many uses of different types of test equipment; it gives you short cuts in trouble-shooting and repairing; and, contains over 250 pages of operating notes on 1,000 manufactured receivers. So up-to-date is the **OFFICIAL RADIO SERVICE HANDBOOK** that it explains thoroughly the features and innovations in the most modern of receivers.

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OVER 250 PAGES OF OPERATING NOTES

Whether it is a fading job, lack of sensitivity, noise within the receiver, aligning a chassis, poor A.V.C. action, or any other trouble that is usually the "bugaboo" of most Service Men, you will find the symptoms and remedy clearly described in **OFFICIAL RADIO SERVICE HANDBOOK**. The exact procedure for repairing, as well as the characteristic trouble in almost all models of manufactured sets, will be found in the section on **OPERATING NOTES**—over 250 pages of this data, the most important information to any radio man in the servicing field. The material in this section has been arranged, as well as classified, so there is no difficulty in immediately locating the necessary information.

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PART 7—OPERATING NOTES AND PRACTICAL DATA LISTINGS

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PRACTICAL RADIO CIRCUITS

A COMPREHENSIVE GUIDE TO
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CONSTRUCTOR AND EXPERIMENTER



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INTRODUCTION

In preparation of this text due consideration has been given to the various kindred phases of Electronics.

Servicemen will find of particular use some of the explanations preceding the Chapter on Broadcast Receivers. A thorough knowledge of some of the Basic Principles should help the Serviceman analyze troubles in receivers and effect a speedy remedy. Automatic Systems are also covered together with a brief explanation of their functions.

The average Serviceman is not versatile enough to build efficient Public Address Systems, since his problems are of a different nature. But the experienced Sound Technician can.

The ever increasing popularity of automobile radios has compelled the engineers to include some of the better features of the home receivers in them.

The early promise of commercial Television is at hand, and presents a wonderful opportunity for both the experimenter and the experienced technician to prepare themselves for this marvelous new industry.

Chapter I

RADIO SYMBOLS

Schematic circuits are the shorthand of experimenters and technicians. By their use and careful scrutiny, he can determine the best manner of connecting the various components in order to obtain the desired effects needed.

In the early days of radio design, symbols were not uniform and were very confusing to many constructors and sometimes caused considerable damage to many electrical units because of the inability of those constructors to understand them.

However, a measure of uniformity is now established among all recognized laboratories, with the release of circuit diagrams for the trade.

The type tubes shown in schematic drawings can invariably be identified by the operating potentials feeding them, because many types of tubes have similar socket connections, and are usually confused unless careful examination is made before hand.

It is the opinion of most experts that the metal tube socket has simplified and standardized designs so that trouble shooting in receivers is much more easily determined since all connections are uniform.

For AC-DC use, many new types of 25 volt tubes are illustrated, since it is entirely possible to construct receivers with a range and amplification undreamed of a few years ago. Incidentally they do not require a power transformer to supply the operating voltages which were usually essential prior to their development.

Many new tubes have been developed for a specific purpose, in order to accommodate the needs that engineers have required.

Advanced technicians have known that in order to use receivers in automobiles, first consideration must be to draw a minimum of current from the battery. Therefore, they are the first to accept and use the newest tubes which draw the least amount of battery current. Because of the development of modern tubes, many automobile receivers can favorably compare with the finest of home receivers, that usually cost a great deal more.

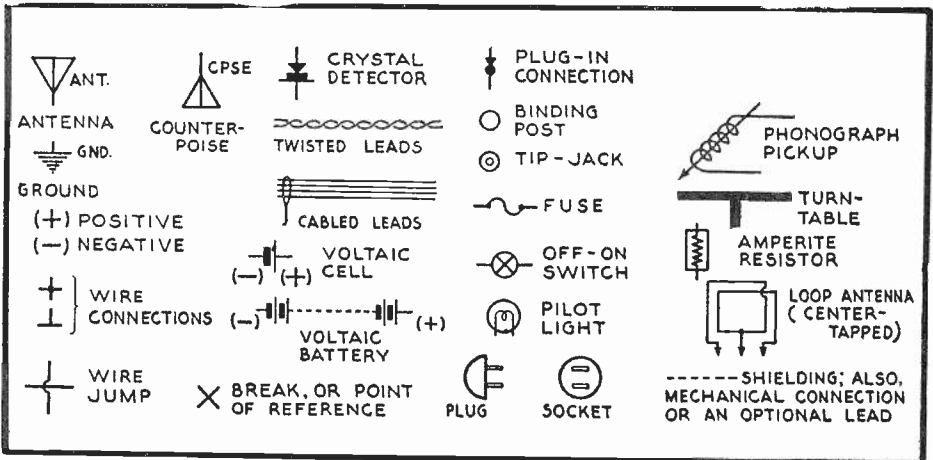
A great many expensive home sets now use Class B powered tubes. They have definitely proven to be far superior to the older Class A type tubes.

All the above types of tubes are listed in this chapter.

High gain coils that are being made of smaller dimensions are generally now used, and find favor among short wave fans since it permits the construction of receivers in a smaller space than heretofore possible.

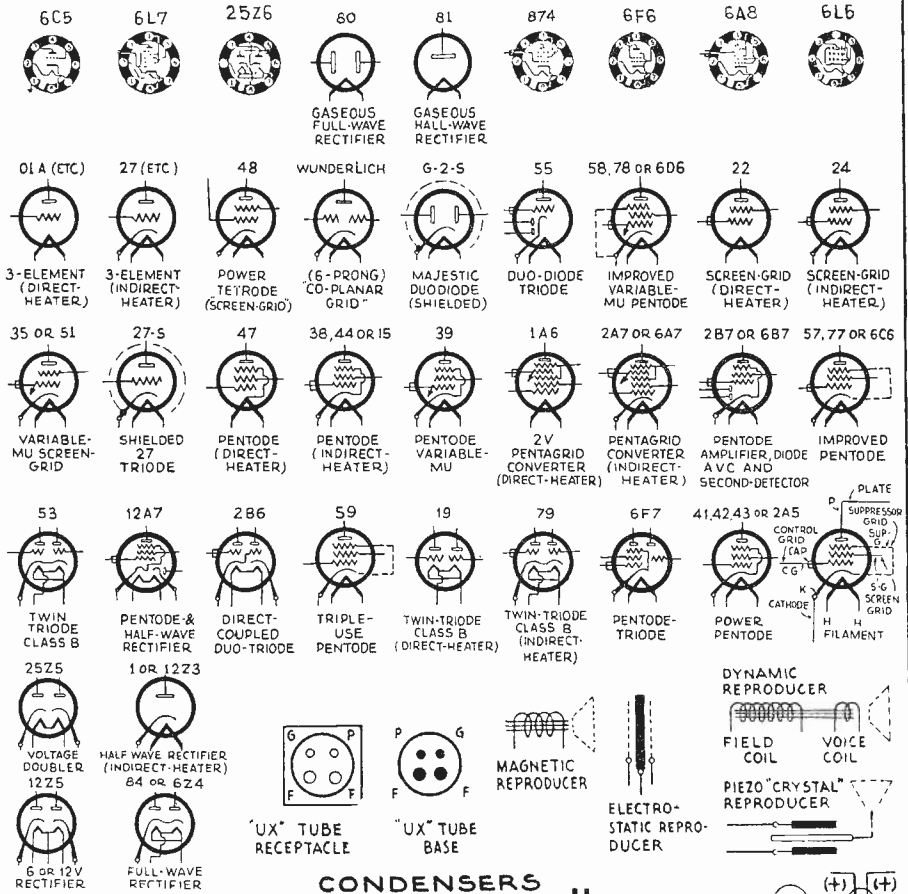
Sound technicians can now build Public Address systems with a power output that capably fills any size auditorium. This is made possible with the development of the new Beam Powered power amplifier tube. The Magic Eye (6E5 or 6G5) tube can be added to any receiver to indicate exact resonance in tuning.

Another use for the 6E5 is its application in a sound system which can be arranged to control maximum point that the amplifier should be raised before feed-back is reached.



Radio symbols of components used in receivers.

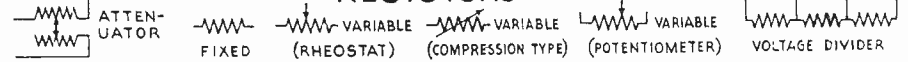
VACUUM TUBES



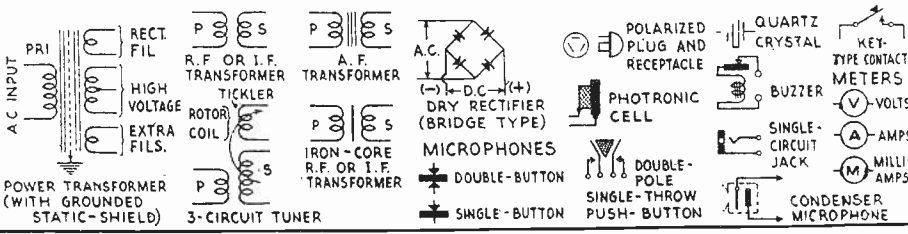
CONDENSERS



RESISTORS



INDUCTANCES



Chapter II

BROADCAST RECEIVERS

I have selected one hundred of the most practical circuits that are illustrated in this text, for the sole purpose of acquainting both experimenters and advanced technicians with their functions and application.

In order to fully understand the new and highly complicated circuits, a brief review of some of the early designs in radio receivers is given here in simple language.

No circuit text is complete without the simple crystal set which, incidentally is still universally used with satisfactory results.

Illustrated you will find the popular regenerative circuits in various arrangements. You will observe that the super-heterodyne receivers are based on this fundamental principle. A brief explanation of the feed-back circuit now follows.

Regeneration, or feed-back, may be produced by feeding more energy from the plate or output circuit on the grid or input circuit than is needed to equal the power loss in the tube. Feedback may be produced by electro-static or electro-magnetic coupling between the input and output circuits.

Following the above, we find the tuned radio frequency circuits, in the days of three element tubes, which used grid suppressors to squelch unstable oscillations between stages. The neutrodyne circuit used neutralizing condensers to control oscillation before the development of the screen grid tubes.

The screen grid tube contributed much to the progress of receiver design. These tubes made possible the tremendous R.F. amplification which engineers were long seeking.

I have illustrated a circuit using the tuned grid-tuned plate with the 24A R.F. screen grid tubes, successfully used by a prominent manufacturer.

Also included is a schematic diagram of a band-pass or pre-selector circuit with untuned R.F. stages. With this particular type of circuit for maximum efficiency, it is essential to erect an extremely long aerial.

Most engineers are in accord that the super-heterodyne circuit is the supreme development in radio receivers. By far it is the most sensitive designed to date, and makes possible the inclusion of various features, such as automatic

volume control, noise suppression, volume expansion, and lately automatic frequency control.

Some fundamental notes on the principle of the oscillator will greatly assist in understanding its function.

By producing sufficient feedback to more than equal the tube losses, the tube will oscillate.

A radio tube to act as an oscillator can be employed to generate a continuous alternating voltage.

In a super-heterodyne receiver, a local oscillator mixes with an incoming signal. As the result of this mixing an intermediate frequency is produced. This action may be classified as a frequency converter device.

One method uses a mixer tube in which the radio signal and local frequency are coupled to the same grid. The local oscillator may be either a separate tube or may be generated within the mixer tube. This system depends on coupling the oscillator and mixer circuits by inductive or capacitive means.

The other system of coupling the oscillator to the mixer is through the electron stream. This arrangement offers many advantages by eliminating undesired inter-coupling effects between the input signal, local generator, and mixer circuit, and in the reduction of radiation by the oscillator. This latter method permits more dependable oscillation constancy on the high frequencies.

I have illustrated several commercial schematic diagrams that are of particular interest, and also that contain some novel features.

A brief analysis on the principle of automatic volume control action is given.

(Automatic volume control is a system of automatically regulating the grid bias of the R.F. or I.F. stages in proportion to the strength of the incoming signal.) This AVC system begins to function as soon as any signal is received. Sometimes we wish to delay the control action until a signal exceeding a minimum amplitude is received. This is done by applying a negative voltage to the diode plate. Therefore, in order for diode current to flow, the positive signal must overcome this negative potential.

Automatic noise suppression is accomplished by utilizing the current flow in the detector tube to generate a control voltage to a separate tube, generally known as a squelch tube, to mute the audio tubes until a desired carrier is correctly tuned in.

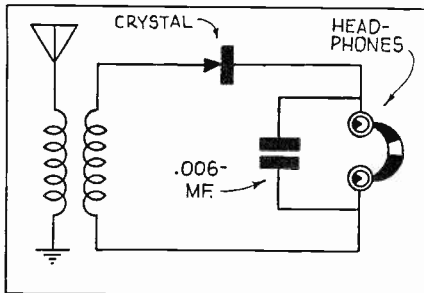
Resonance indicators are generally used in various selective or sharp-tuning receivers, to permit correct tuning without cutting side bands, which tend to cause distortion. Several commercial receivers use a plate milliamperemeter, or shadow graph. Still others use either a neon bulb or lately, the magic eye (6E5.)

One system uses a pilot light dimmer reactor, which causes the pilot to dim upon resonance. Another novel system is known as colorama tuning, which changes from the red pilot light to the green bulb upon exact resonance.

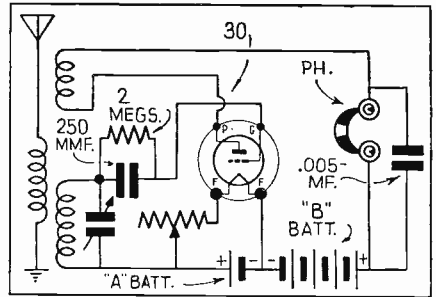
Automatic frequency control is accomplished by the addition of a tube or tubes and associated circuit, which corrects errors in the setting of the tuning condensers, in a superheterodyne, by bringing the oscillator setting to such a frequency that the incoming signal will be mixed (or first detector) to give exact I.F. to which the set's amplifier is peaked. The advantage is not so much to find a station by hasty mechanical tuning, but to eliminate audio distortion and other consequences of inaccurate frequency selection.

Recently radio receivers were presented with push-button tuning. This arrangement is accomplished by adding adjustable condensers that cover the tuning range of the receiver. By a series of switches the regular tuning condensers are disconnected and the small trimmers are shunted across the antenna oscillator and R.F. tuning coils. In some commercial receivers the touch tuning switch disconnects the antenna coil from the tuning condenser, and instead attaches it to the control grid of the mixer tube. With this sort of arrangement only two sets of touch tuning trimmers are needed. Other commercial receivers make use of an electrically driven motor that rotates the Tuning condensers to the designated range desired for Touch Tuning.

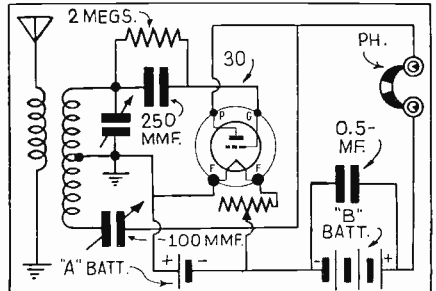
Many of the above mentioned early type circuits were arranged in a chronological order, beginning from the crystal set, regenerative circuits, tuned radio frequency circuits, the well known neutrodyne and a great many superheterodyne designs.



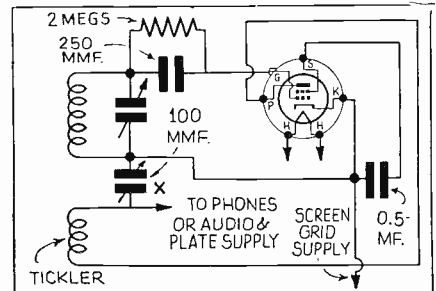
Students will find this simple crystal of great interest inasmuch as it uses a conventional tuner consisting of a solenoid and variable condenser to cover the broadcast band. A fixed crystal .006 MF mica condenser, and a pair of phones complete the balance of parts needed.



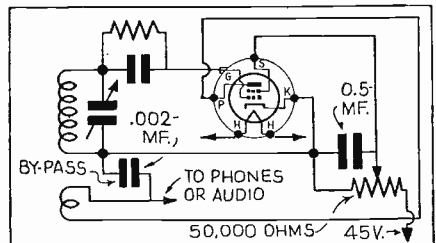
A regenerative circuit using a three circuit tuner battery-operated. The ability to receive long distance stations is well known, if properly constructed.



Regeneration by capacitive coupling. Feedback is controlled by the 100 MMF capacitor.



Another form of regeneration control with the screen grid tube is by varying the regeneration by-pass condenser.



A screen grid tube can be used successfully in a regenerative circuit by varying the mutual conductance of the tube.

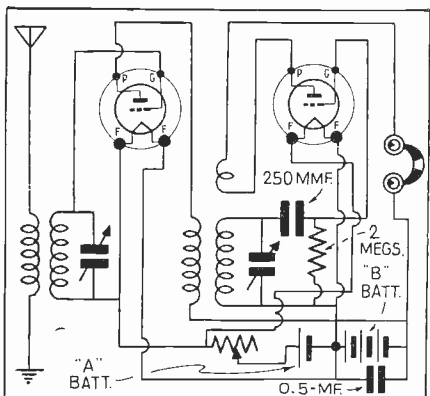


Fig. 6—Illustrates a non-radiating regenerative circuit with a stage of R.F. ahead of the detector. This is done for a two-fold purpose, one to raise the sensitivity of the receiver and the other to prevent radiation through the aerial.

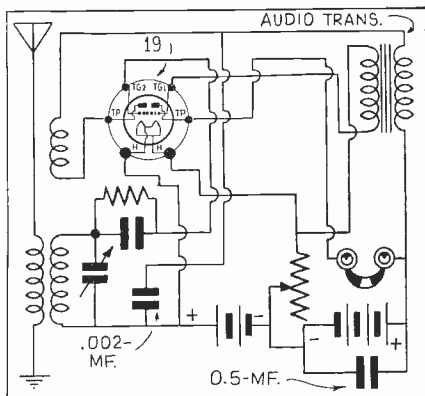


Fig. 7—Shows a composite tube in a regenerative circuit. One section of this dual tube is used as the det. and the other as the audio stage. Many experimenters have constructed receivers similar to this arrangement for portable use.

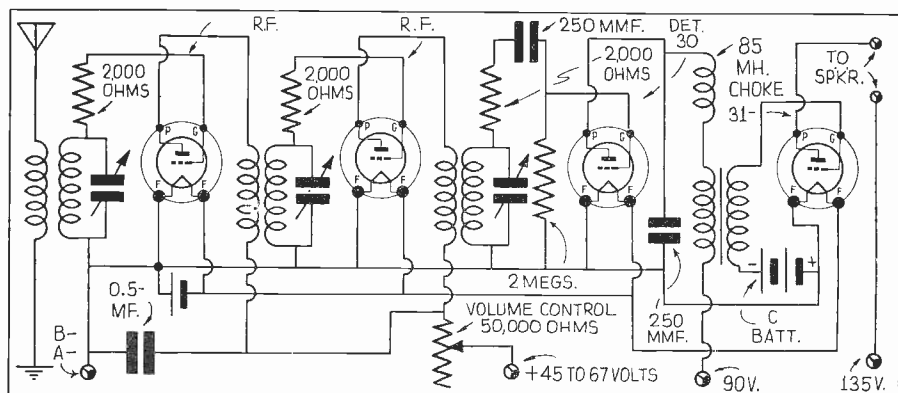


Fig. 8—A tuned radio frequency circuit to limit oscillation between stages. .00025 MF. condensers may be shunted across each grid suppressor for greater response on the high frequencies. This method is successfully used in a great many receivers using the three element tubes.

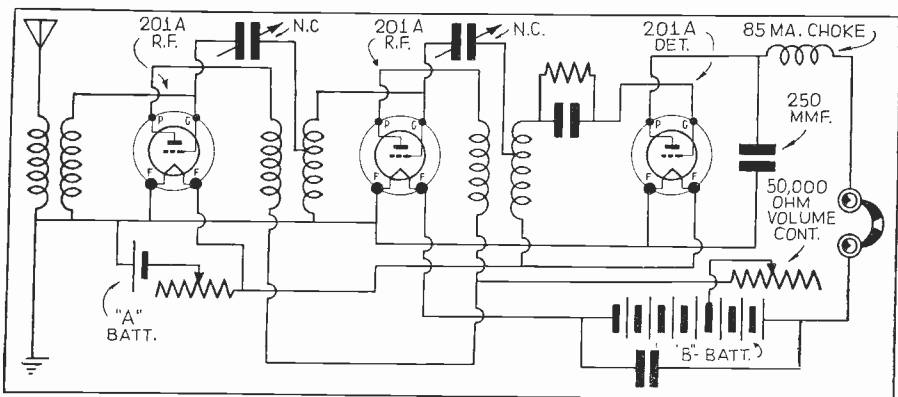


Fig. 9—The well known neodyne circuit which used neutralizing condensers to balance out oscillation between the stages. It is also necessary to mount each coil in a position where the electro magnetic flux would not interlock with any of the other coils. It is customary to arrange them at a 57.8° angle.

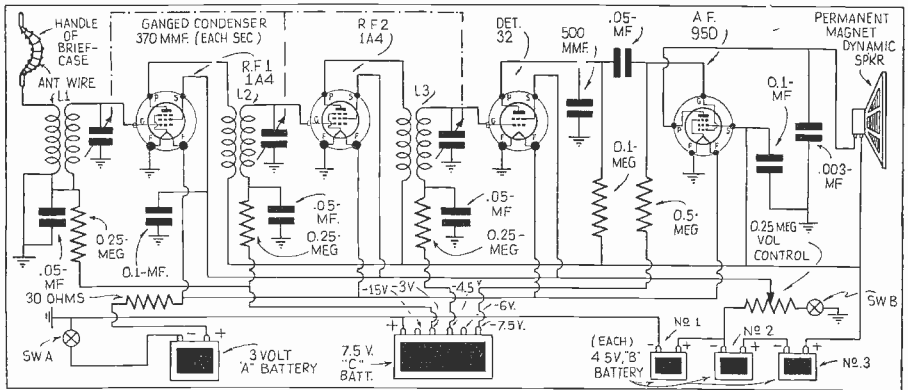


Fig. 10—Shows a recent briefcase portable receiver, battery operated, and a permanent magnet dynamic speaker fed by a 950 Power Pentode Tube. You will observe that high gain R.F. coils are used, which permit resistance coupling from the detector to the output tube.

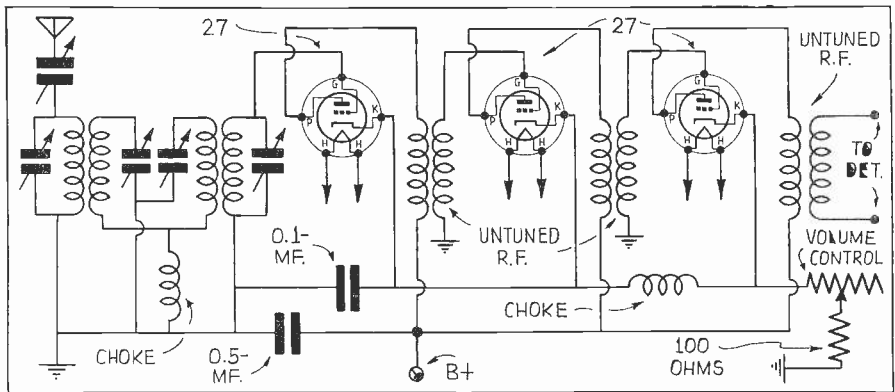


Fig. 11—Illustrates a pre-selector or as commonly referred to, band-pass tuning for selectivity. The band-pass stage is followed by 3 stages of untuned R.F. coils. If good material is used in the band-pass section, image response should be eliminated.

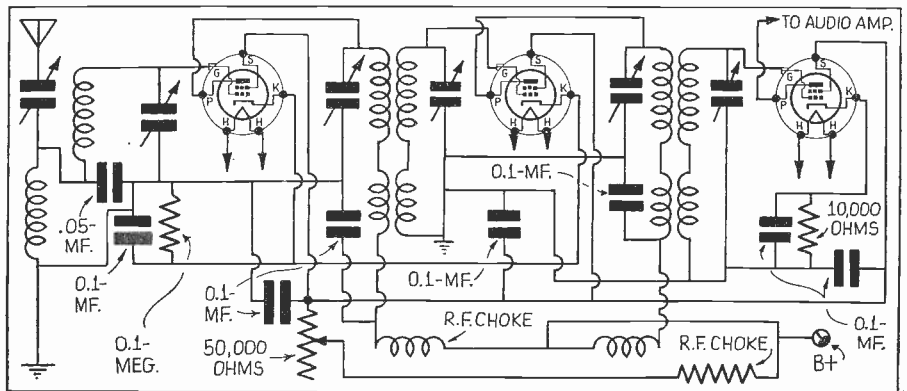


Fig. 12—Shows a tuned radio frequency circuit which tunes both the grid and plate circuits. Screen grid tubes are used in this circuit, and in order to take advantage of the tremendous amplification gained by them, high impedance choke coils are connected in series with the primary winding.

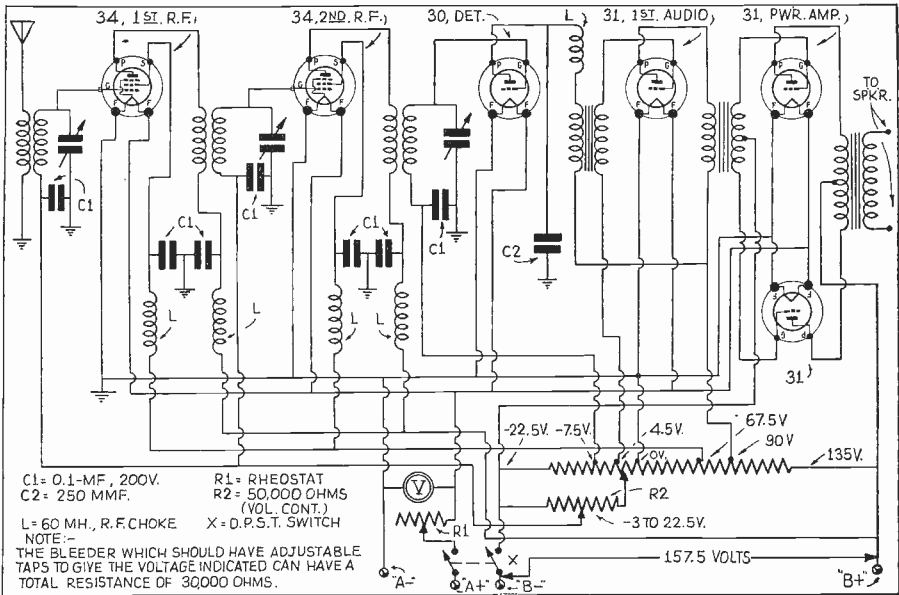


Fig. 13—Illustrates battery operated tuned radio frequency receiver with two volt tubes. It contains a voltage-divider network for proper regulation and a bleeder with adjustable taps. The total resistance of this divider should be approximately 30,000 ohms.

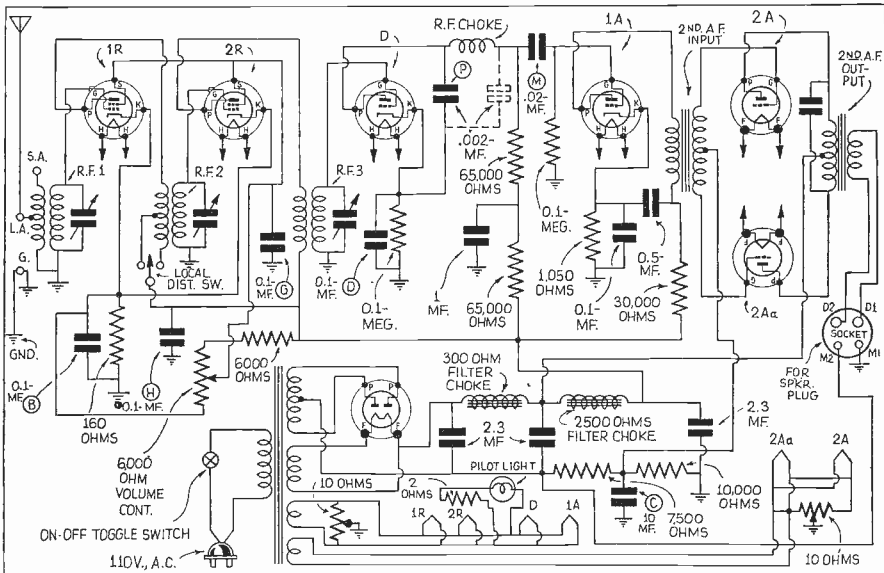


Fig. 14—Illustrates an AC operated tuned radio frequency receiver. A dynamic speaker, which is fed from a pair of 45 tubes arranged in push-pull, is used. Of particular interest is the local-distance switch which is connected to the second radio frequency primary coil. The volume is controlled by varying the screen grid voltage of the radio frequency tubes. A full wave rectifier tube supplies all the voltages necessary. The antenna coil primary is tapped to accommodate either a long or short aerial. This method helps to increase the sensitivity of the receiver when properly matched.

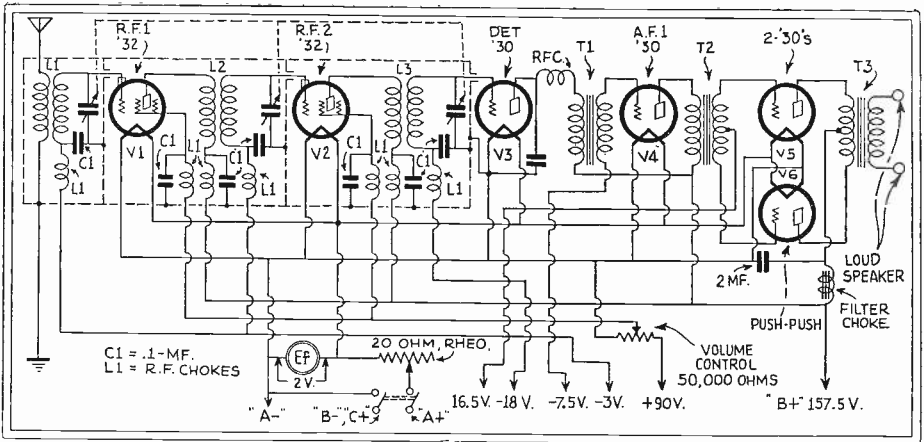


Fig. 15—A Push-push battery model receiver. Two "30's" are the output tubes, and develop one watt of power. This type of receiver is commonly used in communities where power lines are not available. Screen grid tubes are used in the R.F. stages for maximum amplification.

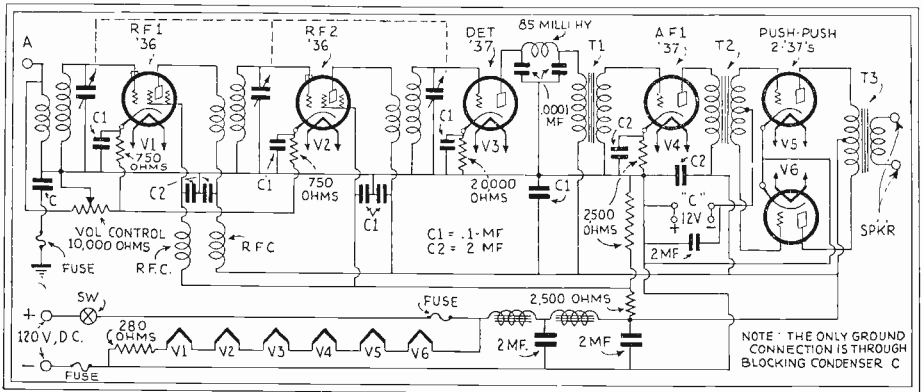


Fig. 16—A Push-Push 110 volt D.C. receiver. Two "37's" are the output tubes and arranged for Class B amplification. The only ground connection is through the blocking condenser C.

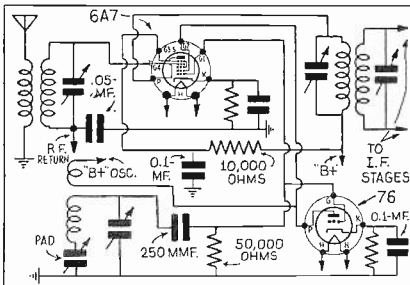


Fig. 17—Illustrates a pentagrid converter for mixing the oscillator and input signals using a separate oscillator tube. It is coupled electronically in the 6A7 tube. This arrangement is more reliable on the higher frequencies.

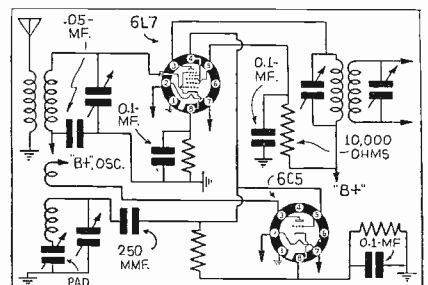


Fig. 18—Shows a similar system to Fig. 17, but using a 6L7 metal pentagrid converter tube. The fourth grid of this tube connects with the output on the oscillator, and mixing is accomplished electronically.

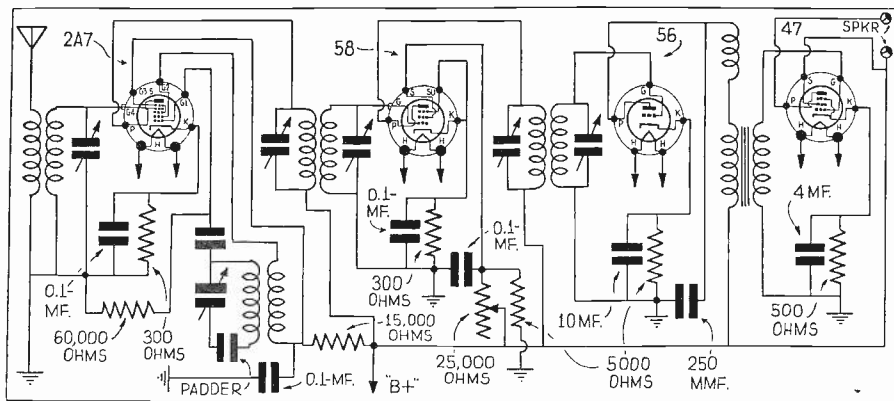


Fig. 19—A four tube superheterodyne receiver using a 2A7 oscillator and converter tube with one IF stage and followed by a 56 detector tube. A 47 power pentode is used in the output.

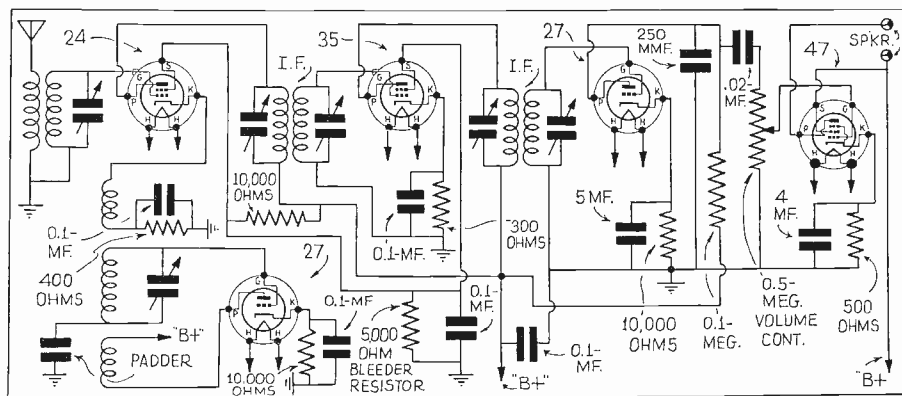


Fig. 20—A superheterodyne using a separate oscillator tube coupled through a pickup coil which is connected in series with the cathode of the first detector tube. A 47 power pentode is used in the output.

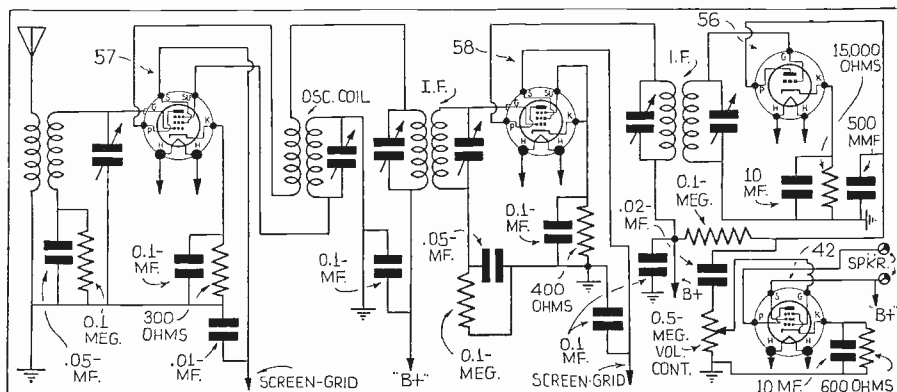


Fig. 21—The oscillator and first detector are both combined in the first 57 tube. This arrangement is most commonly used by a great many commercial manufacturers for midget receivers. Notice that the oscillator secondary is connected in series with the suppressor grid.

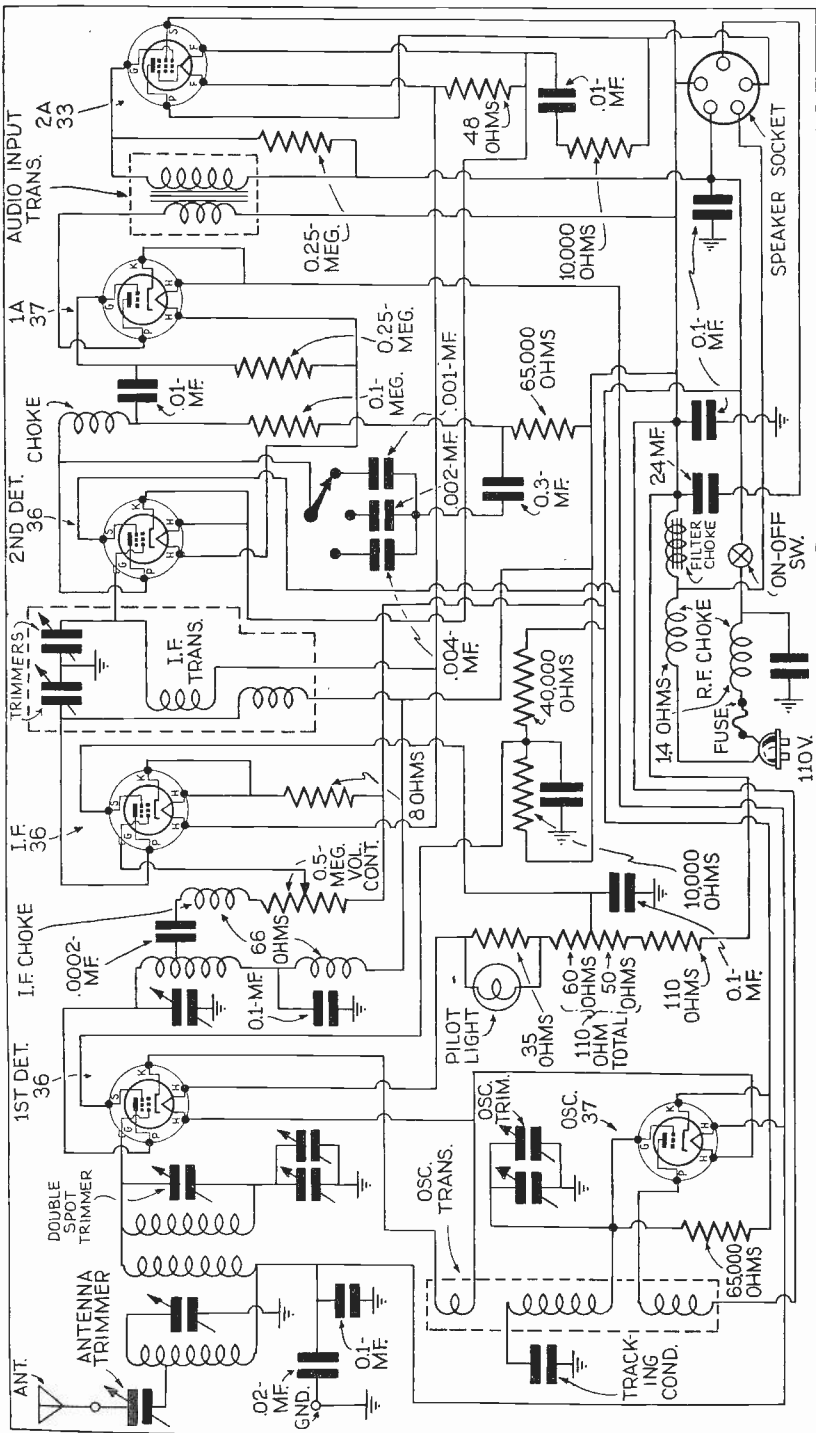


Fig. 22—An Atwater Kent Model 228-D, 110 volt DC receiver. RF chokes are used in series with each leg of the supply line. The IF frequencies are peaked at 130 KC. De-coupling resistance is used in the second detector plate return lead. This, in most cases, helps to reduce line interference, especially in areas where factories using DC motors are found which tend to feed back into the line.

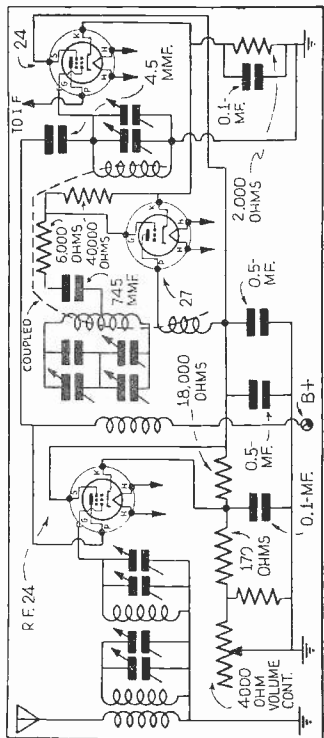


Fig. 23—Illustrating a pre-selector unit to suppress image response. This type of circuit was used in an RCA Model receiver. You will notice that the oscillator coils and the secondary coil of the first detector tube are coupled by reason of their being wound on one form. Volume is controlled in this circuit by varying the bias on the RF tube.

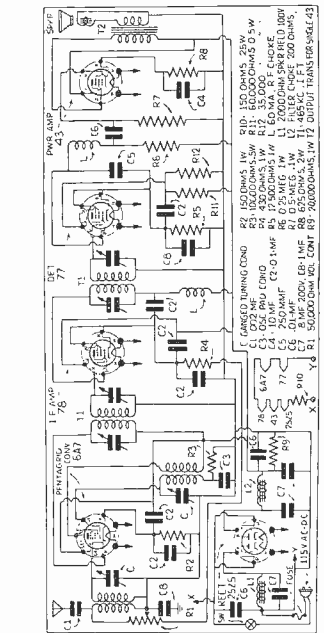


Fig. 25—Shows an AC-DC Superheterodyne receiver using a 25Z5 rectifier tube, which permits AC-DC operation. A pentagrid converter 6A7 tube is used as the oscillator and first detector tube. This is followed by a 7B IF amplifier tube, a 77 second detector, and a power amplifier type 43 is used in the output.

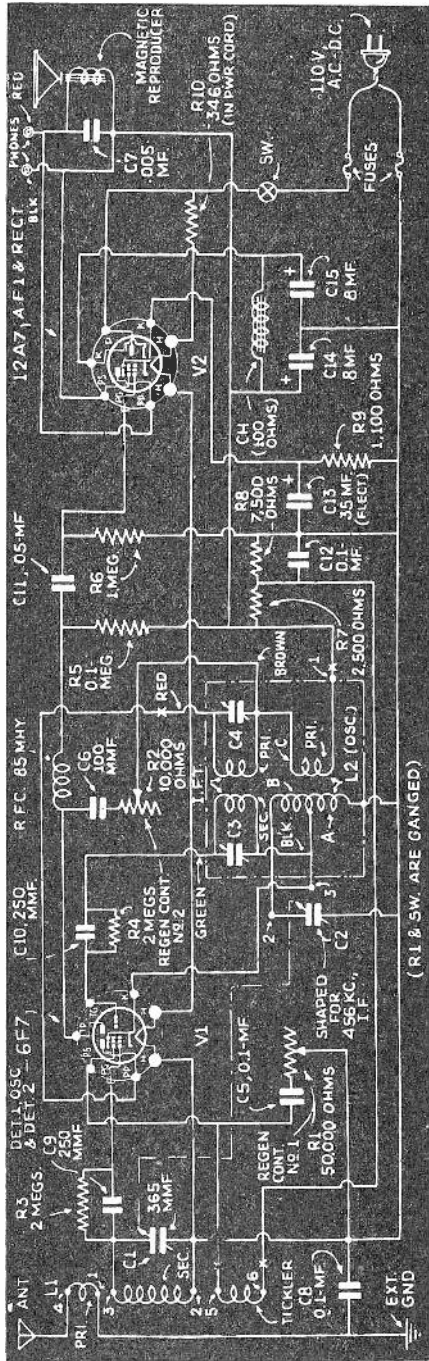


Fig. 24—An AC-DC beginners Super "2". Here is an interesting double regenerative superheterodyne circuit that embodies the fundamental operations of most radio sets; that is, two tubes do the work of five. A 12A7 composite tube is used as a rectifier and power pentode tube.

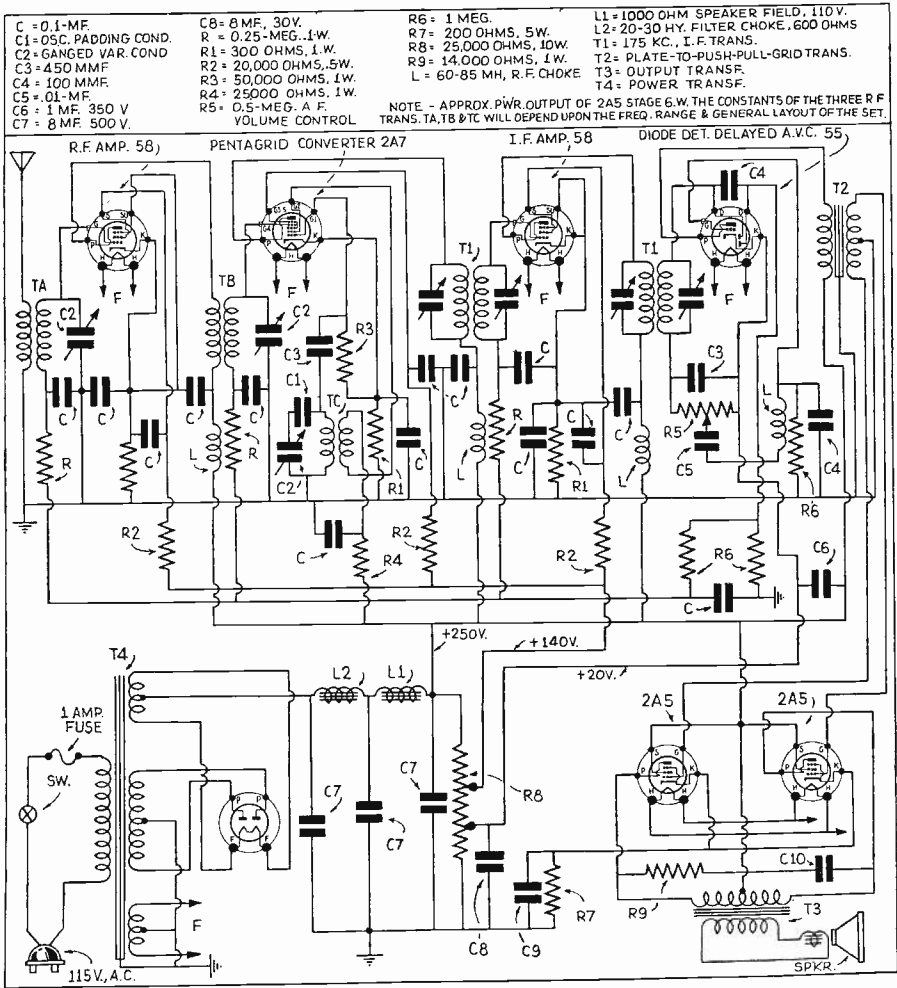


Fig. 27—A seven tube AC operated Superheterodyne receiver which uses a type 55 tube as a diode detector and delayed automatic volume control. A stage of RF is used before the Pentagrid Converter 2A7 tube in order to build up sufficient signal voltage that is necessary to overcome the high diode bias before an audio signal is received. This arrangement is most satisfactory in cutting out background noise between stations.

Metal tubes can be interchanged with the tubes shown in this diagram. In place of the 58's, 6K7's, in place of the 2A7 Pentagrid Converter, use a 6A8. For the 55 Diode Detector delayed A.V.C. tube, substitute a 6Q7. Also, for the 2A5's power output tubes, a pair of 6F6's will produce the desired output. A 5Z4 can be used instead of the 80 Full Wave Rectifier. However, metal tube sockets must replace the other type shown here. The operating voltages remain the same and it is up to the constructor to select either the glass tubes or the newer metal ones, since the characteristics are similar. The R.F. stage is also used to prevent any possible image response in a locality where a powerful local signal is radiated.

A pair of 2A5 tubes are arranged in push pull. A 5Z3 full wave rectifier is used in order to supply sufficient plate current for these power pentodes that usually operate around 350 volts. Decoupling resistors and de-coupling RF. chokes are used in the grid plate return circuits. Speaker field may be used as a choke in the power supply if it has a value of 1000 ohms.

Volume is controlled by R5 which is a 500,000 ohm potentiometer, connected from a secondary diode return and is coupled by means of a .01 mf audio coupling condenser.

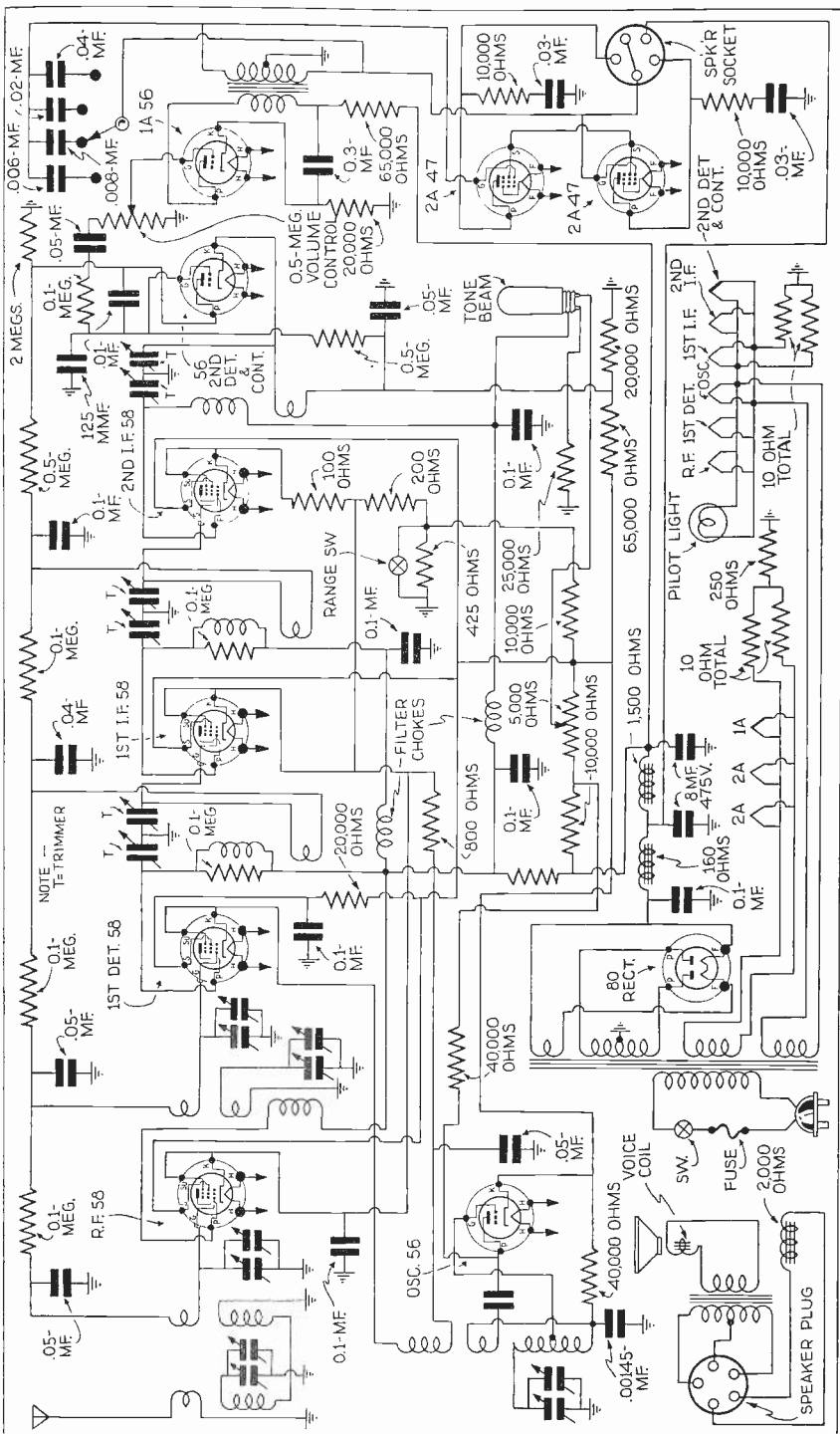
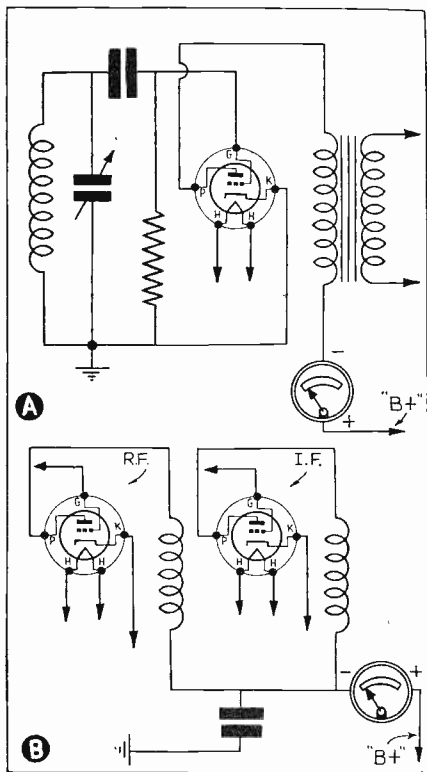


Fig. 29—An Atwater Kent Model 260 Receiver AC operated. This superheterodyne receiver is of special interest to experimenters in that it uses tone-beam neon bulb indicator. This type of resonance indicator is easily applied to any receiver if care is taken in selecting proper value resistors.



In Non-AVC receivers resonance does not cause a noticeable change in the plate current of any of the tubes except the detector. Therefore, the tuning meter should be connected in series with either the plate or cathode circuit of the detector. The plate circuit is preferable as the resistance of the meter need not be considered.

Fig. 30—Many radio programs are spoiled by improper tuning. Few listeners are gifted with an ear for tonal qualities, and can seldom tune a receiver to the exact resonance point. Therefore, two types of resonance indicators are shown, and either system can be added to any set. The type of receiver determines which resonance indicating system is most desirable. Those sets with an AVC system already included will find the proper method to connect this tuning meter in series with either the plate or cathode circuits. A minimum reading on this tuning meter will indicate exact resonance because the plate currents of the RF and IF tubes decrease with resonance.

Any inexpensive meter that will adequately fill the requirements may be used since it is not critical, or exact readings are not necessary. The leads to connect the tuning meter can be long ones if no other way is possible without affecting the readings.

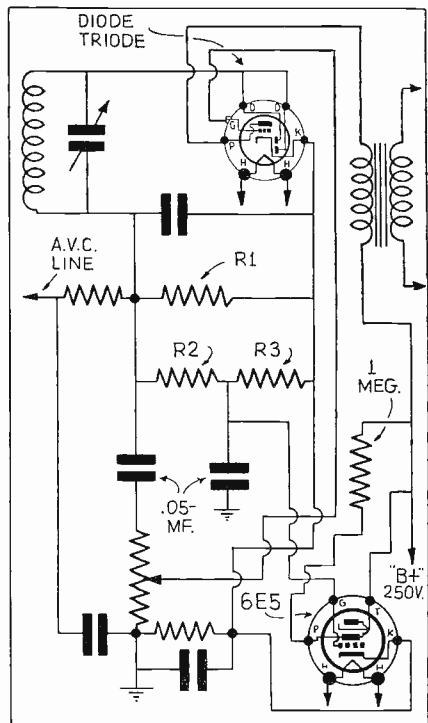


Fig. 31—Shows a magic eye 6E5 tube connected to an ordinary diode circuit. The plate and target of the 6E5 should be connected together by means of a 1 megohm carbon resistor. The target terminal should then be connected to a potential approximately of 250 volts. The cathode of the 6E5 should then connect to the cathode of the diode tube. You will observe resistor marked R1 which is the load resistor for the ordinary diode type of circuit, and it is shunted by resistors R2 and R3. These two resistors should be chosen with two purposes in mind. One: to have a high enough value so that the parallel effect across R1 will not be noticeable. It will require a total of from 3 to 6 megohms. Two: R2 should be chosen so that when the receiver is tuned to a strong local signal, the fluorescent pattern on the magic eye will not go cross-eyed or blur. Because of differences in design, individual receivers will require R3 to have any value between 250 thousand ohms and 1 megohm. It is wise to start with 250 thousand ohms and gradually increase the value of R3 until the desired effect is achieved. All leads to the tube should be kept as short as possible.

The 6E5 magic eye can be replaced with the newer type known as 6G5. The characteristics are the same with the exception that on a strong signal the eye will not overlap as the 6E5 does at times in most commercial receivers equipped with the magic eye.

The 6G5 is a hi-mu type requiring a greater bias than the 6E5 with the same current drain.

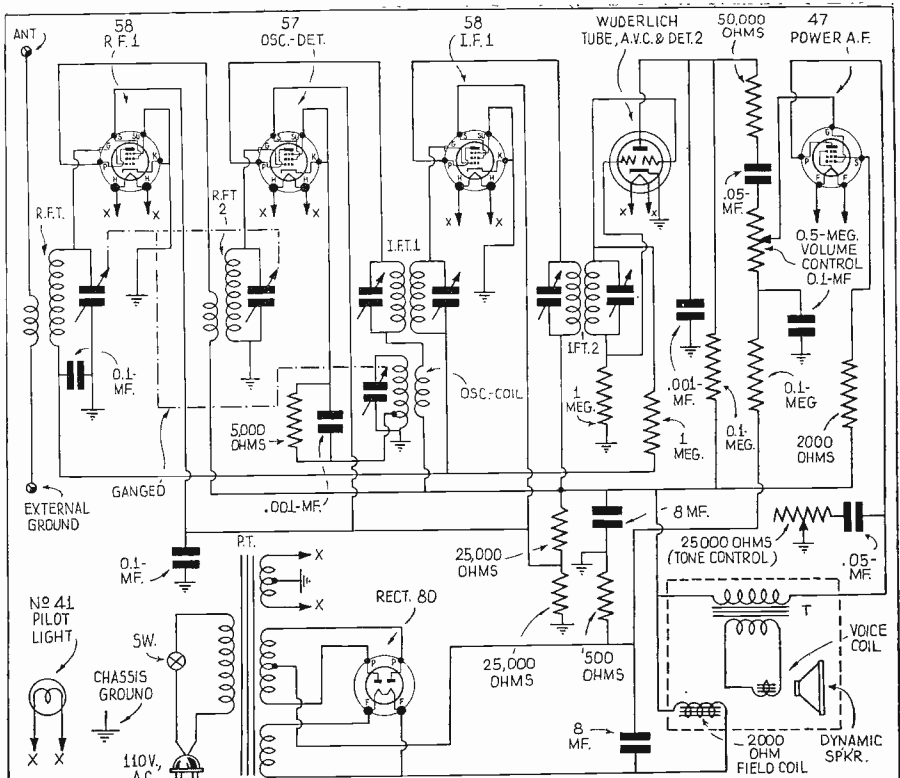


Fig. 32—An Ultra-Modern, Wunderlich-Tube, A.C. Superheterodyne. Tube V2 combines oscillator and first-detector; V4, A.V.C. and second-detector. This set is the Reverse Model 2 chassis; the I.F. is 175 kc. Tube V4 is a "coplanar-grid" type Wunderlich "A" or "B."

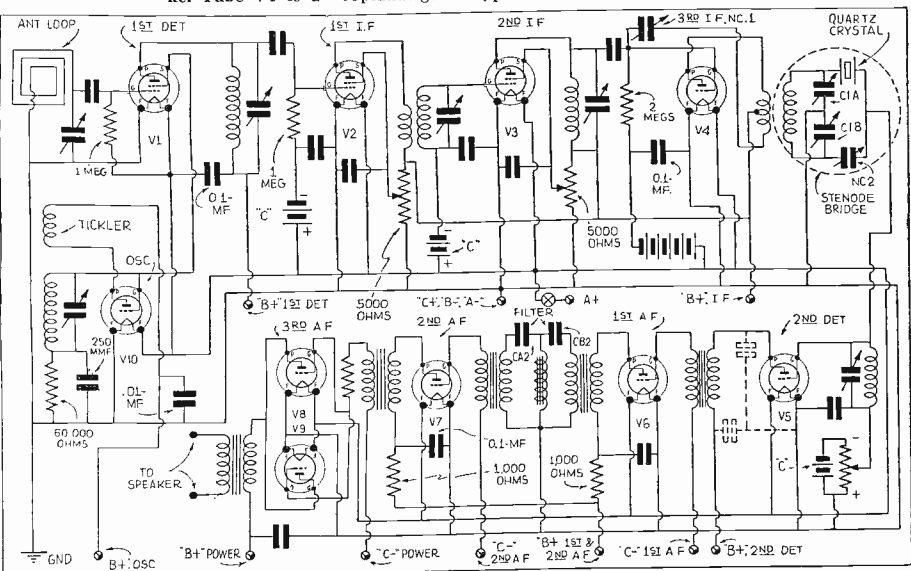


Fig. 33—A Stenode Receiver, Super-selectivity is obtained by means of the "Stenode bridge"; A. F. correction is then applied.

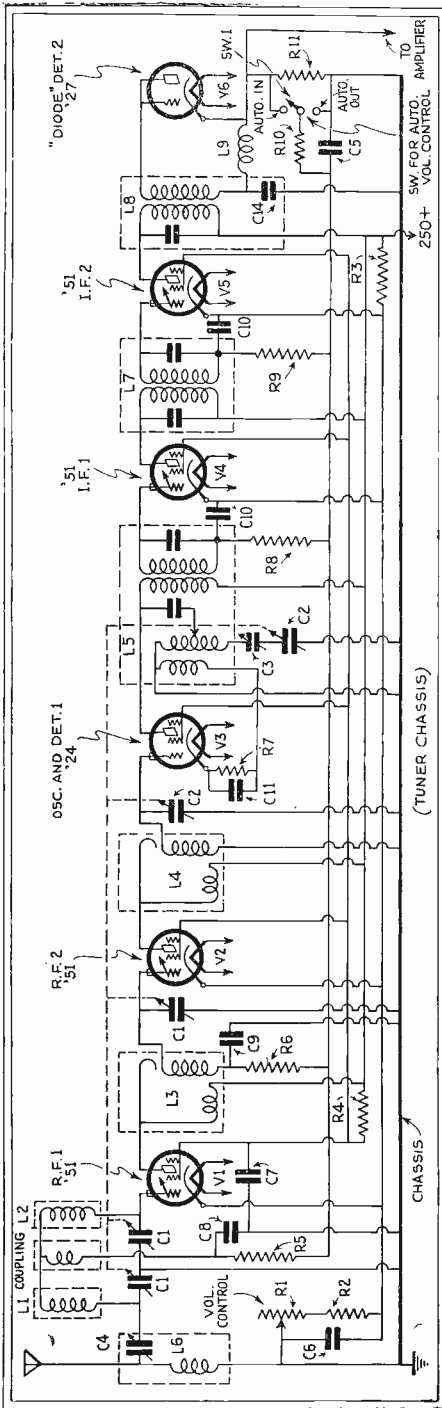


Fig. 34—A Modern Superheterodyne Tuner-Chassis—The Super-Da-lite-R. Readily adaptable to any power unit; Includes A.V.C. and band-selection. To reduce cross-talk to minimum, type '51 variable-mu tubes are used in R.F. and I.F. Second-detector V6 is a diode.

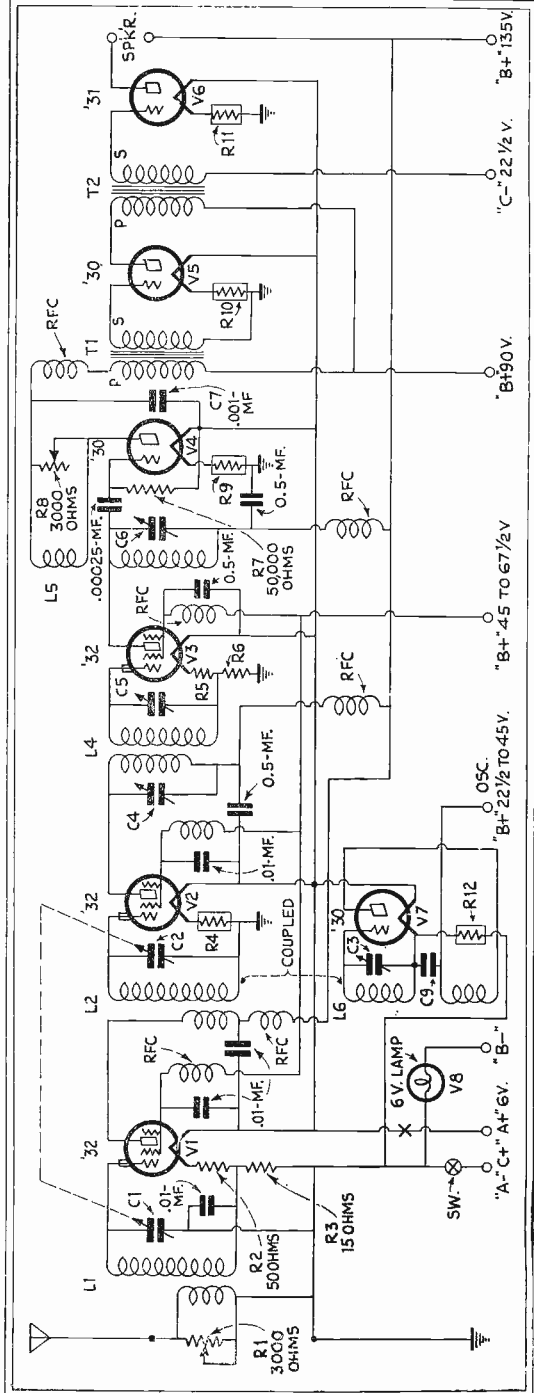


Fig. 35—A Superheterodyne Using 2-Volt Tubes. High sensitivity and "CW" reception are obtained by regenerating V4.

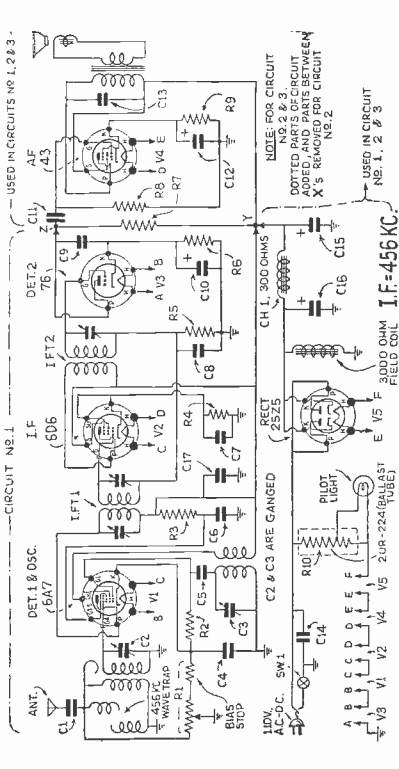


Fig. 36A—Illustrates a typical 5 tube AC-DC Super-heterodyne receiver designed to operate efficiently where space is at a premium. One of the worthwhile features in this particular receiver is the employment of a composite 6A7 Demodulator and Oscillator tube which functions efficiently over the entire domestic broadcast band. You will notice one IF. stage is used, the reason being that a high gain coil with tremendous amplification is obtained and is transferred to the second detector. A conventional triode is used as the second detector which in turn feeds a 43 power pentode output tube. The volume is regulated by varying the bias on the mixer 6A7. This volume control has a bias stop arranged at a minimum of 500 ohms so that at all times the mixer tube is sufficiently biased. For the rectifier a 25Z5 is included and is shunted across the output of the rectifier. Care should be exercised in the construction of this circuit to choose the best material possible. In the selection of a dynamic speaker be sure and use no less than 3000 ohms, otherwise the voltages may be upset and loss in power will be the result.

You will observe that all the filaments are wired in series. A line cord of 130 ohms may be used instead of the ballast resistor R10. A pilot light shunt resistor of 25 to 40 ohms, with a carrying current rating of 20 watts should be used.

A high gain antenna coil should be used to effect maximum transfer of energy from antenna to the mixer tube.

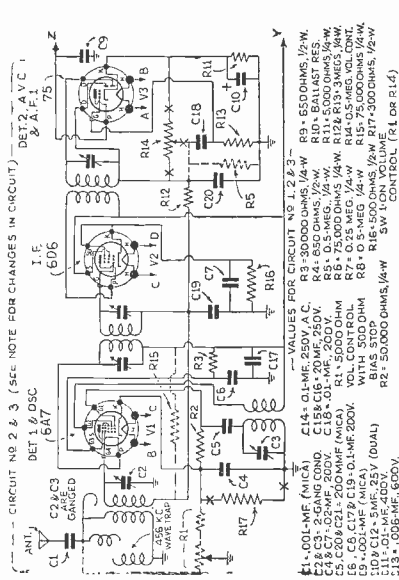


Fig. 36B—Shows the same circuit with the exception that instead of a 76 second detector a 75 Diode-Triode is used. This diode-triode serves a two-fold purpose, one, the diode section is the second detector and the triode section as the first audio frequency, thereby adding to the amplification. As is commonly understood diodes do not amplify but simply function as a rectifier. Another very important reason why the 75 tube was chosen was that Automatic Volume Control could also be included in this tube. The advantages of automatic volume control are covered in this text. You will notice that the volume is differently controlled than in Fig. 36A. Instead of regulating the bias of the mixer tube, it varies the audio signal obtained from the diode return. A 500,000 ohm control is used, and is coupled through a .01 mf. condenser to the grid of the 75. Point Z then is connected to 250,000 ohm plate resistor.

A .465 KC wave trap is used in the antenna circuit to minimize any interference caused by powerful large commercial code stations which operate at the IF frequency of the set. Metal tubes of similar characteristics may be interchanged.

VALUES FOR CIRCUIT NO. 1, 2 & 3—
 R9 - 650 OHMS, 1/2-W.
 R3 - 3000 OHMS, 1/4-W.
 R4 - 100 OHMS, 1/4-W.
 R5 - 0.5 MHS, 1/2-W.
 R6 - 111,500 OHMS, 1/4-W.
 R7 - 75,000 OHMS, 1/4-W.
 R8 - 25,000 OHMS, 1/4-W.
 R12 & R13 - 3 MHS, 1/4-W.
 R14 - 75,000 OHMS, 1/4-W.
 R15 - 75,000 OHMS, 1/4-W.
 R16 - 500 OHMS, 1/4-W.
 R17 - 300 OHMS, 1/2-W.
 R18 - 50,000 OHMS, 1/4-W.
 R19 - 100 OHMS, 1/4-W.
 R20 - 300 OHMS, 1/2-W.
 R21 - 300 OHMS, 1/2-W.
 R22 - 50,000 OHMS, 1/4-W.
 R23 - 500 OHMS, 1/4-W.
 R24 - 300 OHMS, 1/2-W.
 R25 - 300 OHMS, 1/2-W.
 R26 - 300 OHMS, 1/2-W.
 R27 - 300 OHMS, 1/2-W.
 R28 - 300 OHMS, 1/2-W.
 R29 - 300 OHMS, 1/2-W.
 R30 - 300 OHMS, 1/2-W.
 R31 - 300 OHMS, 1/2-W.
 R32 - 300 OHMS, 1/2-W.
 R33 - 300 OHMS, 1/2-W.
 R34 - 300 OHMS, 1/2-W.
 R35 - 300 OHMS, 1/2-W.
 R36 - 300 OHMS, 1/2-W.
 R37 - 300 OHMS, 1/2-W.
 R38 - 300 OHMS, 1/2-W.
 R39 - 300 OHMS, 1/2-W.
 R40 - 300 OHMS, 1/2-W.
 R41 - 300 OHMS, 1/2-W.
 R42 - 300 OHMS, 1/2-W.
 R43 - 300 OHMS, 1/2-W.
 R44 - 300 OHMS, 1/2-W.
 R45 - 300 OHMS, 1/2-W.
 R46 - 300 OHMS, 1/2-W.
 R47 - 300 OHMS, 1/2-W.
 R48 - 300 OHMS, 1/2-W.
 R49 - 300 OHMS, 1/2-W.
 R50 - 300 OHMS, 1/2-W.
 R51 - 300 OHMS, 1/2-W.
 R52 - 300 OHMS, 1/2-W.
 R53 - 300 OHMS, 1/2-W.
 R54 - 300 OHMS, 1/2-W.
 R55 - 300 OHMS, 1/2-W.
 R56 - 300 OHMS, 1/2-W.
 R57 - 300 OHMS, 1/2-W.
 R58 - 300 OHMS, 1/2-W.
 R59 - 300 OHMS, 1/2-W.
 R60 - 300 OHMS, 1/2-W.
 R61 - 300 OHMS, 1/2-W.
 R62 - 300 OHMS, 1/2-W.
 R63 - 300 OHMS, 1/2-W.
 R64 - 300 OHMS, 1/2-W.
 R65 - 300 OHMS, 1/2-W.
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 R67 - 300 OHMS, 1/2-W.
 R68 - 300 OHMS, 1/2-W.
 R69 - 300 OHMS, 1/2-W.
 R70 - 300 OHMS, 1/2-W.
 R71 - 300 OHMS, 1/2-W.
 R72 - 300 OHMS, 1/2-W.
 R73 - 300 OHMS, 1/2-W.
 R74 - 300 OHMS, 1/2-W.
 R75 - 300 OHMS, 1/2-W.
 R76 - 300 OHMS, 1/2-W.
 R77 - 300 OHMS, 1/2-W.
 R78 - 300 OHMS, 1/2-W.
 R79 - 300 OHMS, 1/2-W.
 R80 - 300 OHMS, 1/2-W.
 R81 - 300 OHMS, 1/2-W.
 R82 - 300 OHMS, 1/2-W.
 R83 - 300 OHMS, 1/2-W.
 R84 - 300 OHMS, 1/2-W.
 R85 - 300 OHMS, 1/2-W.
 R86 - 300 OHMS, 1/2-W.
 R87 - 300 OHMS, 1/2-W.
 R88 - 300 OHMS, 1/2-W.
 R89 - 300 OHMS, 1/2-W.
 R90 - 300 OHMS, 1/2-W.
 R91 - 300 OHMS, 1/2-W.
 R92 - 300 OHMS, 1/2-W.
 R93 - 300 OHMS, 1/2-W.
 R94 - 300 OHMS, 1/2-W.
 R95 - 300 OHMS, 1/2-W.
 R96 - 300 OHMS, 1/2-W.
 R97 - 300 OHMS, 1/2-W.
 R98 - 300 OHMS, 1/2-W.
 R99 - 300 OHMS, 1/2-W.
 R100 - 300 OHMS, 1/2-W.

Chapter III

ALL WAVE RECEIVERS

It is astonishing to note what changes have been taking place in all-wave receiver designs.

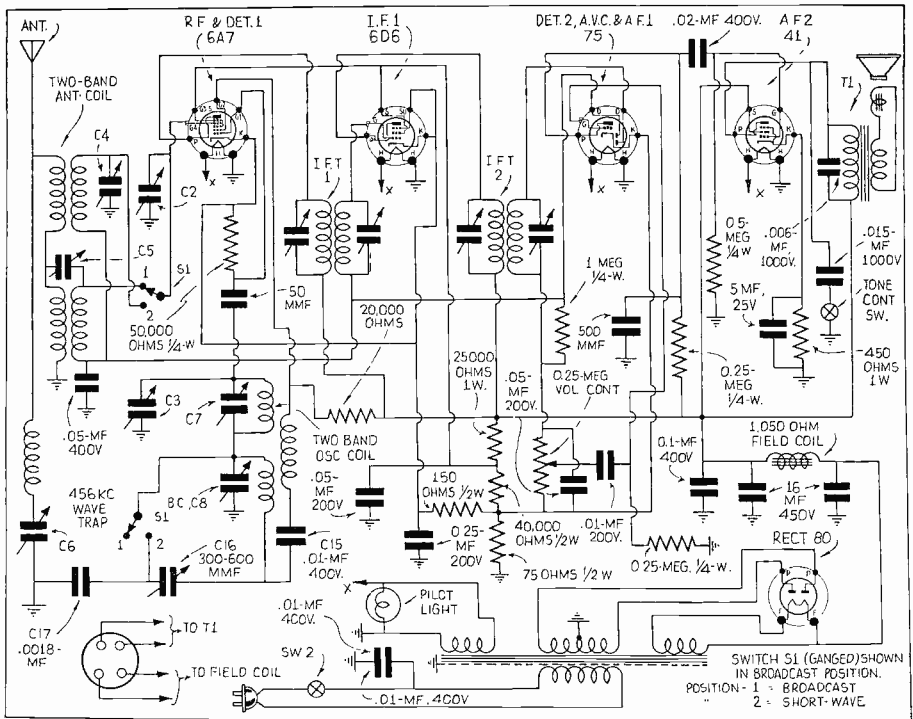
It is entirely possible to construct all-wave receivers today to cover all the domestic broadcast bands as well as foreign and high frequency bands, without mechanically changing coils.

With the development of high gain tubes and associated circuits, short wave reception can now actually be tuned in almost as loud as

some of our local stations. This can be accomplished by the constructors if extreme care and efficient components that make up this receiver are used.

Several commercial schematic diagrams are illustrated, some with novel features; as for instance, resonance indicators that permit proper tuning without background noise.

Refer to the previous chapter on resonance indicators.



EMERSON MODEL L117

Fig. 37—A five tube superheterodyne receiver with AVC and covers the band from 540-1750 KC, and from 2200 to 7500KC. This receiver includes a changeover switch to cover the above bands. A 6A7 first detector and oscillator tube, a 6D6 IF stage and a 75 second detector AVC and first AF and a 4L1 power output tube. A tone control switch is included and is shunted across the output transformer.

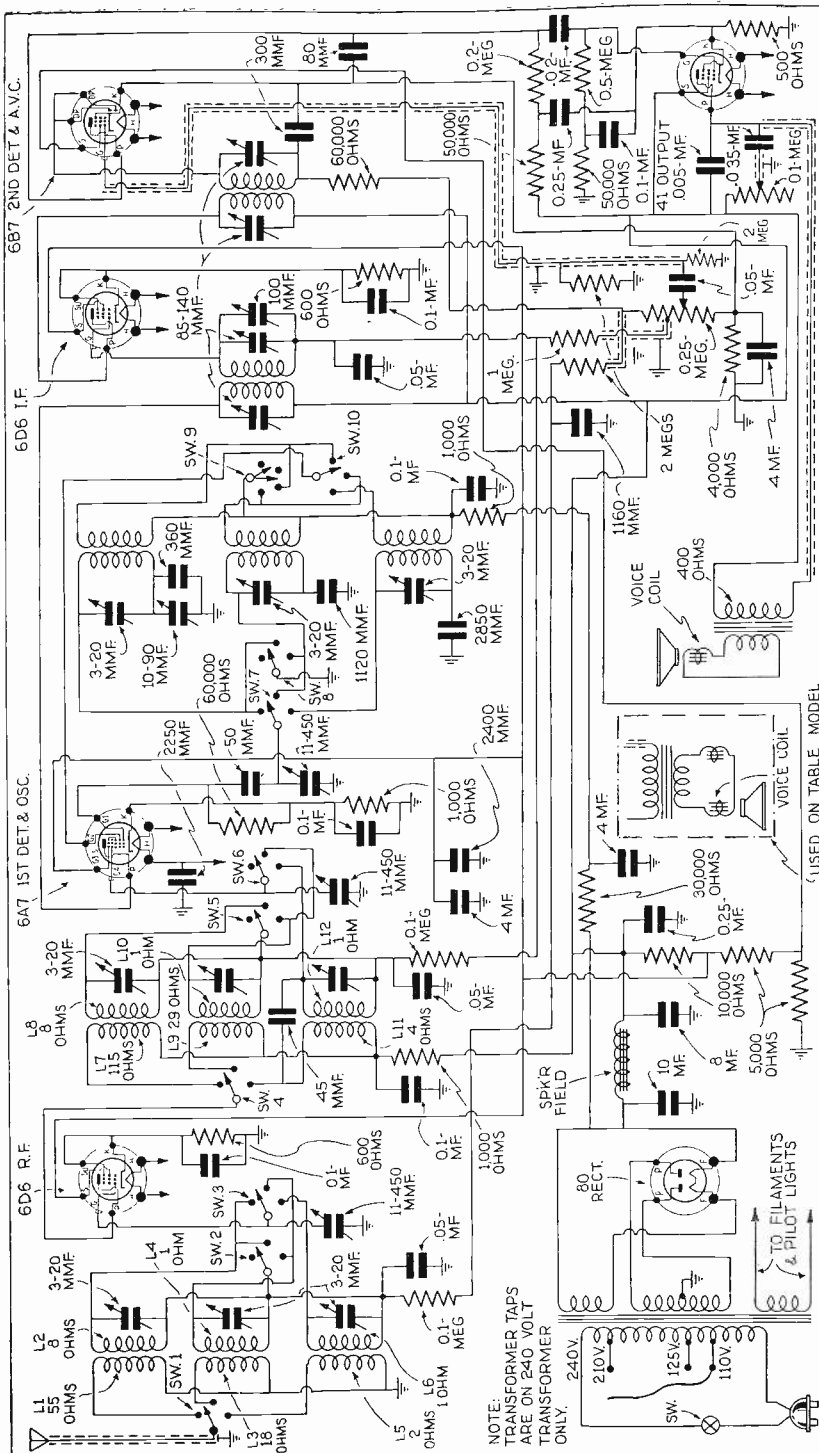


Fig. 38—RCA Victor Model 128. This circuit contains some very interesting features. This is a three-band 6 tube superheterodyne receiver with a stage of RF ahead of the first detector and oscillator, a 6D6 IF stage, a second detector, and AVC 6B7, and a 41 output tube. The 6B7 tube differs from most diode detectors inasmuch as it contains a screen grid element.

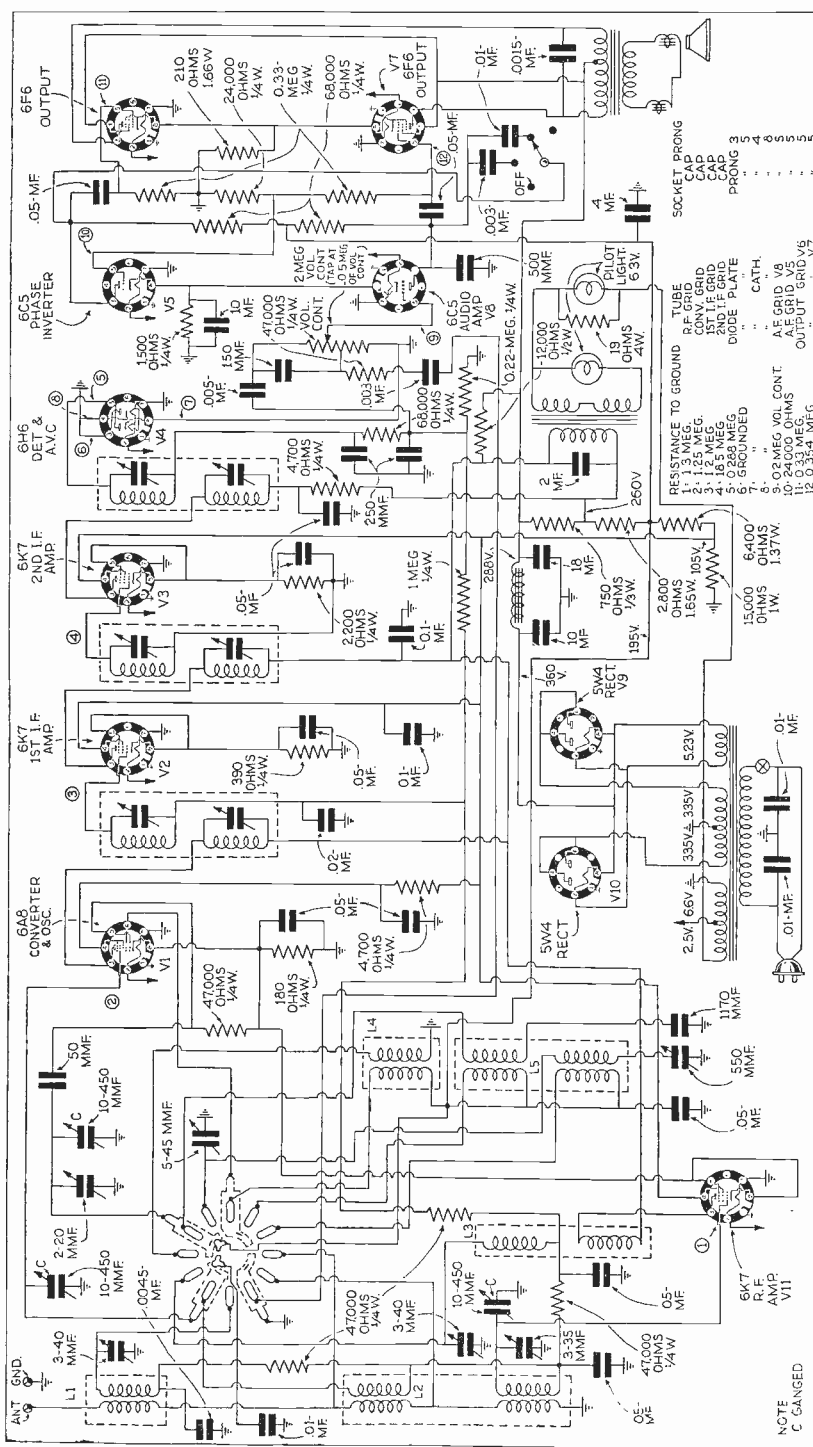


Fig. 39—A G.E. 105 receiver with many unusual features. This set uses a colorama tuning for exact indication of resonance. A phase inverter 6C5 tube and a pair of 6F6 metal output tubes. The colorama reactor can easily be attached to any receiver providing care is taken and proper equipment is used. For this circuit a 6H6 diode detector and AVC tube is included.

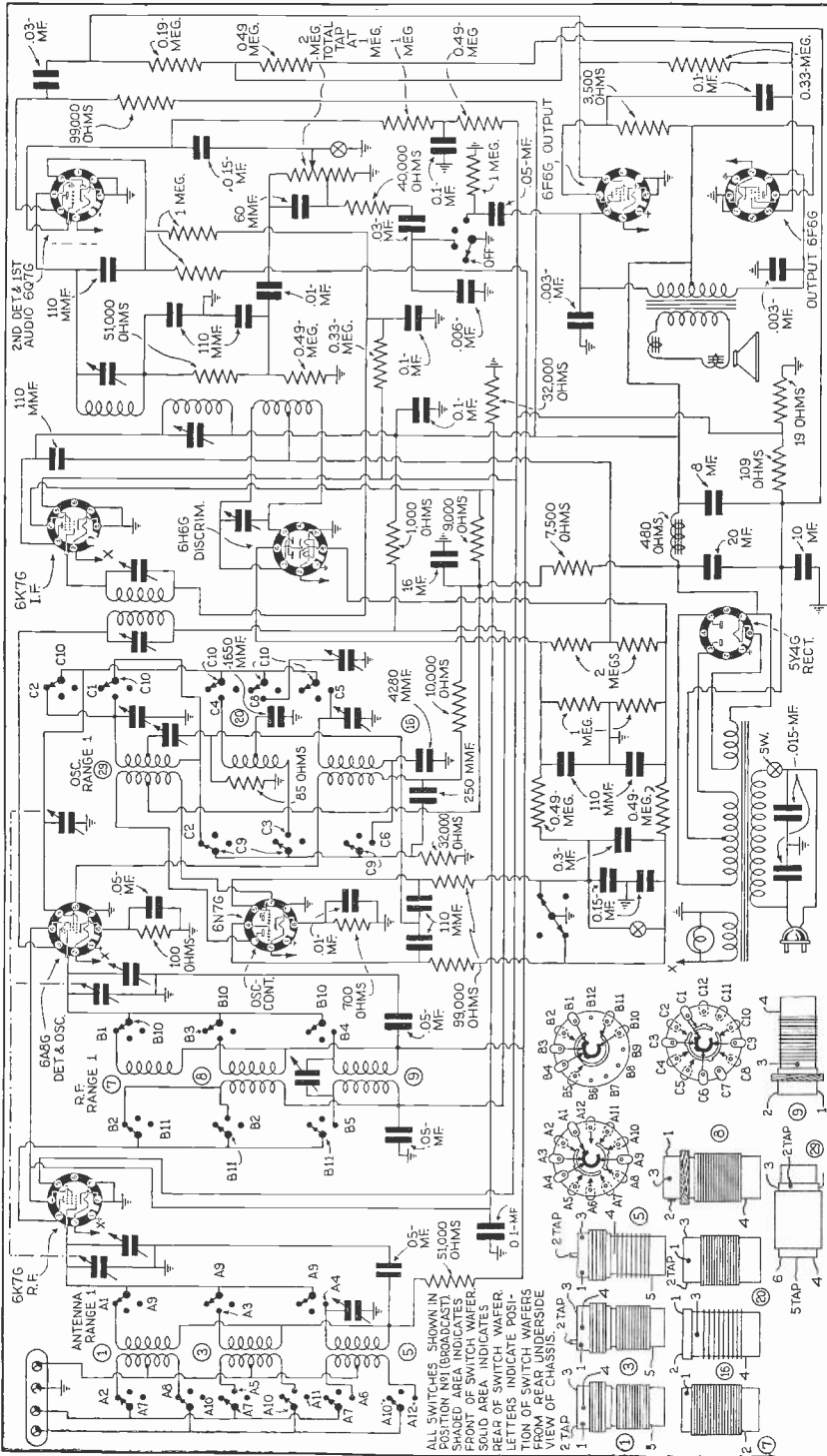


Fig. 40—A Philco 37-9 Receiver with the newest development known as automatic frequency control. A 6H6G discriminator tube is used together with a 6N7G oscillator tube for correction of mistuning.

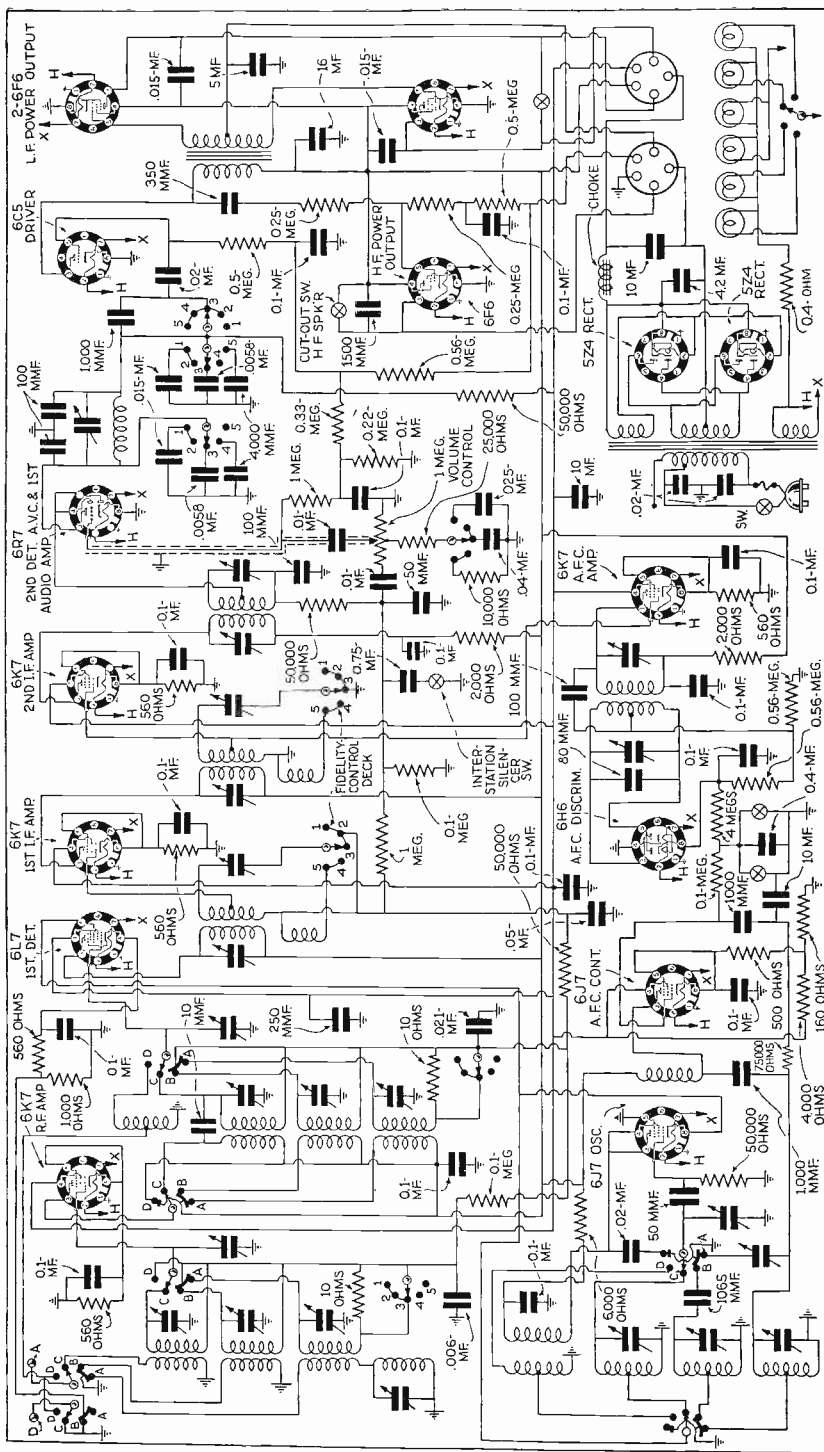


Fig. 41—Illustrates a Grunow Model 1291 superheterodyne receiver with automatic frequency control for correction of mistuning. This AFC system can be added to any receiver.

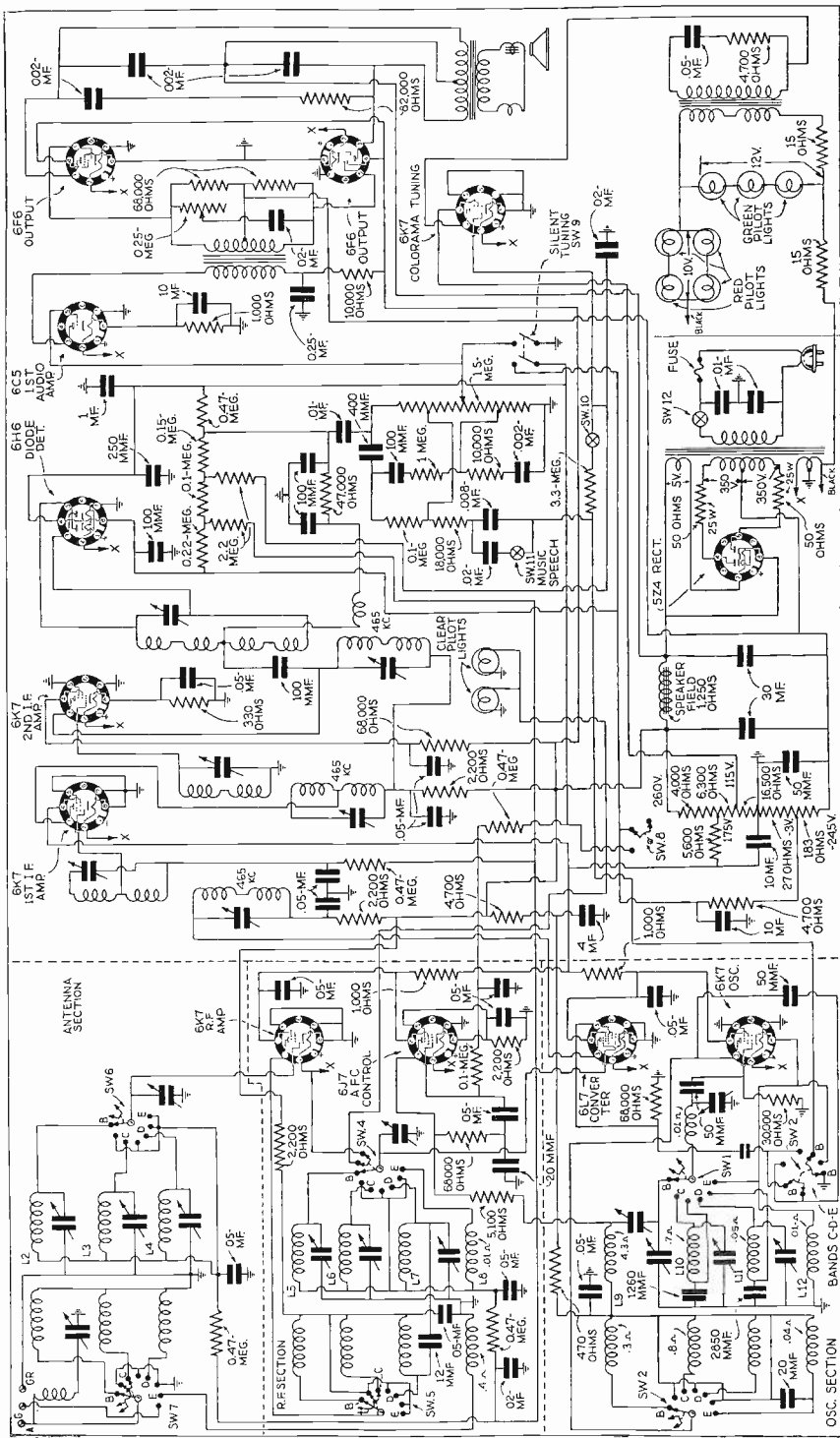


Fig. 42—A G.E. E126 Superheterodyne receiver with colorama and AFC tuning that differs from the model 105 in that it uses three green bulbs and four red bulbs. The green bulbs are connected in series with the reactor, and the red bulbs are arranged in series parallel.

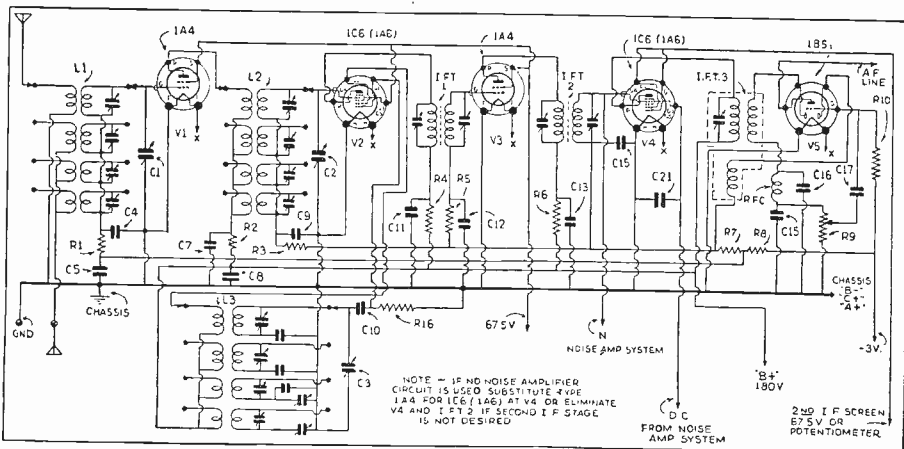


Fig. 43A—Illustrates a Battery operated Super-Heterodyne receiver designed for the farm areas where no power lines are available. You will notice that this is a four band receiver that completely covers Domestic and Foreign stations.

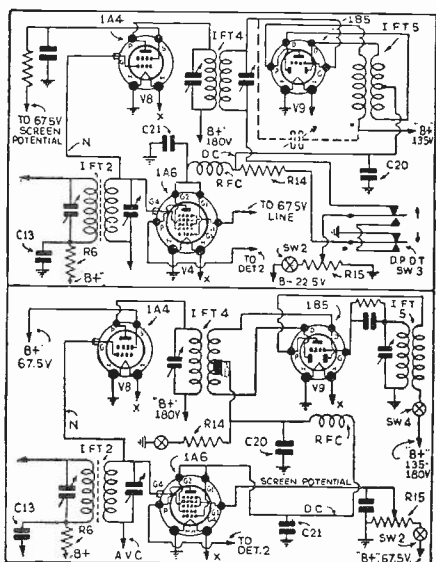


Fig. 43B—Noise suppressor circuits. See text.

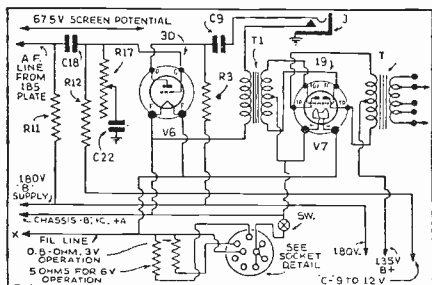


Fig. 43C—Audio channel of the battery super-heterodyne tuner shown in Fig. 43A.

In designing the new RADIO-CRAFT battery superheterodyne for the farmer, the listener in localities where A.C. is not available, and for the fan who enjoys truly quiet operation and complete freedom from power-line interference, several objectives, among others aimed at, were first set forth as definitely prerequisite—that we might engineer the practical "last word" in battery receivers. The complete set is shown in the heading illustration, above. (This is Fig. 43A.)

These were: (1) all-wave operation to practical limits and using a standard coil assembly; (2) adequate sensitivity and a good overall R.F.-I.F. gain; (3) effective A.V.C. action; (4) sufficient power output to permit full speaker reproduction approaching as nearly as possible the theoretical perfect fidelity; (5) some means for suppression of lightning surges and static and other noises more obnoxious in remote communities than in localities close to broadcasting stations because of the higher relative gain and sensitivity required for speaker reception; (6) economy of operation—with leeway in favor of the first 6 objectives if necessary.

Two volt tubes were used throughout the set to avoid battery drain. Among the many interesting features of the set is the newly developed noise limiter, which effectively blocks any instantaneous bursts of static above the signal level. This noise silencer incorporates three tubes and three intermediate frequency transformers for its operation. You will observe that one of the intermediate frequency transformers has a split secondary winding.

Two noise suppressor circuits are shown in Fig. 43B. A brief explanation of how the noise silencing unit operates is herewith given. As an instantaneous burst of noise is received, it is amplified by the 1A4 and 1B5 in the noise silencing circuit. By reason of this amplification, resistor R14 develops a signal voltage which effects the amplification factor of the 1A6 control tube. The output of the 1A6 tube is in turn fed back to the second detector which will block any signal from reaching the audio circuit if a large passage of static should be received.

Chapter IV

SHORT WAVE SET CONVERTERS AND ADAPTERS

There are many experimenters who wish to add short wave converters to their present broadcast without making any changes in the set itself. This chapter is devoted to various types of easily constructed short wave converters that do not require expensive equipment.

Converters may be defined as units which change the short wave signals from their incoming wave length to the longer wave length, for which their broadcast receiver is designed. They may be either self-powered or they may derive their operating potential from the broadcast receiver.

Short wave adapters usually connect to the detector stage of the broadcast receiver. In order to attach an adapter to a broadcast receiver, it is necessary to disconnect that part of the circuit which feeds the detector stage.

Short wave converters are by far the better of the two because of the added amplification that is derived from the radio frequency end of the broadcast receiver.

The regenerative short wave set has been superseded by the super-heterodyne receivers because the superheterodyne set has been proven to be less critical in tuning than the regenerative set.

Fig. 44 illustrates a five tube superheterodyne receiver arranged for plug-in coils. Many experimenters who have constructed this receiver report that it rivals most expensive commercial receivers. By using plug-in coils intricate wiring is dispensed with and simplicity is attained. Another point to bring out with this type set is that it is compact and therefore less costly to build.

The new metal tubes have greatly increased the sensitivity of short wave receivers by enabling all necessary components to be placed nearer the sockets, thereby shortening the leads to them with a minimum loss, which was a hindrance to the old type of bulky tubes.

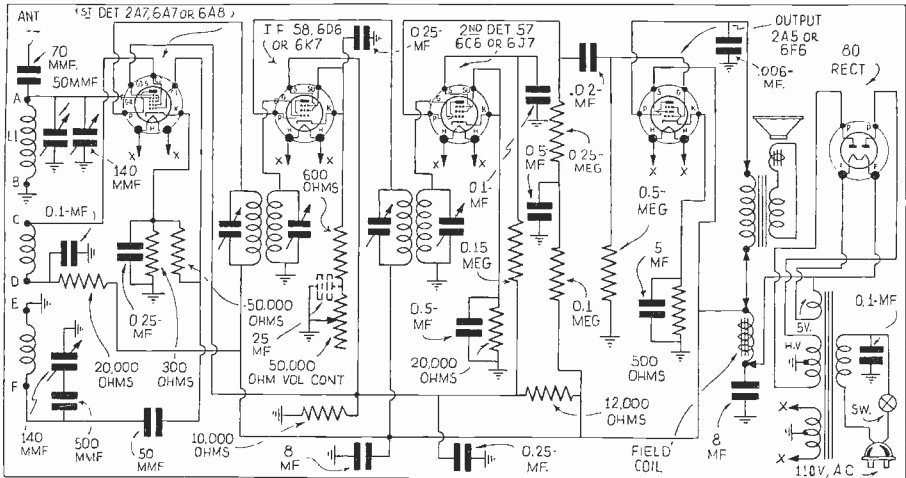


Fig. 44—A Short-Wave receiver that satisfactorily covers any band with plug in coils. This is a super-heterodyne with one stage of I.F. The cathode of this I.F. tube is biased with a 600 ohm resistor, which is connected to a 50,000 ohm potentiometer for volume regulation. By using plug in coils, costly change over switches are dispensed with, and also the wiring of the receiver is greatly simplified. You will observe that three (3) different types of tubes can be used with equal results in the first detector, I.F. or second detector stages. The only requirements when metal tubes are used are metal tube sockets with the various potentials remaining the same. Foreign Short-Wave programs have been tuned in, with more volume than was necessary, to fill a large room with this receiver.

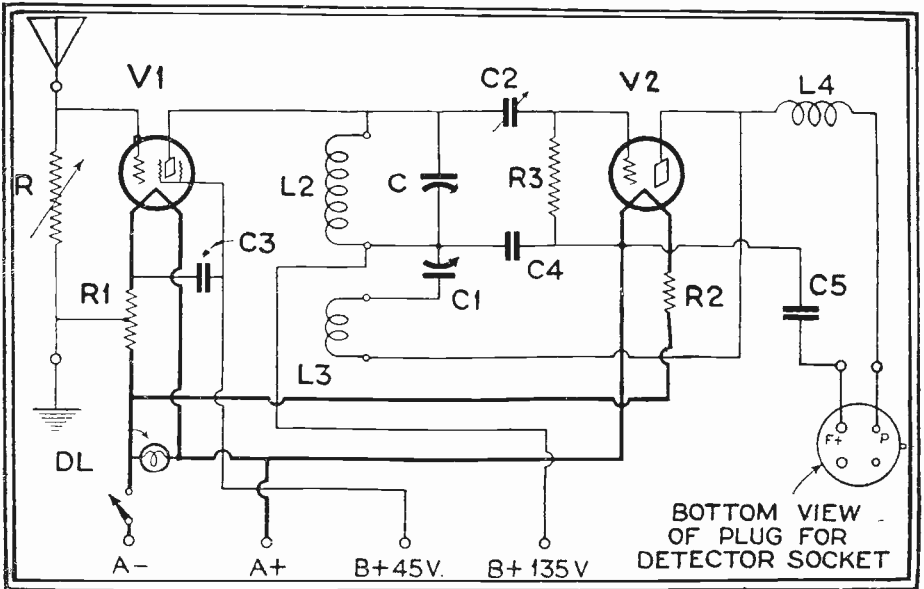


Fig. 45—The Hammarlund Short-Wave Adapter-Receiver. An easily constructed unit. This Short Wave adapter does not require many parts and for a nominal sum can be built and added to most any broadcast receiver. Battery operation is shown inasmuch as it was originally designed for farm use, where no electric power is available.

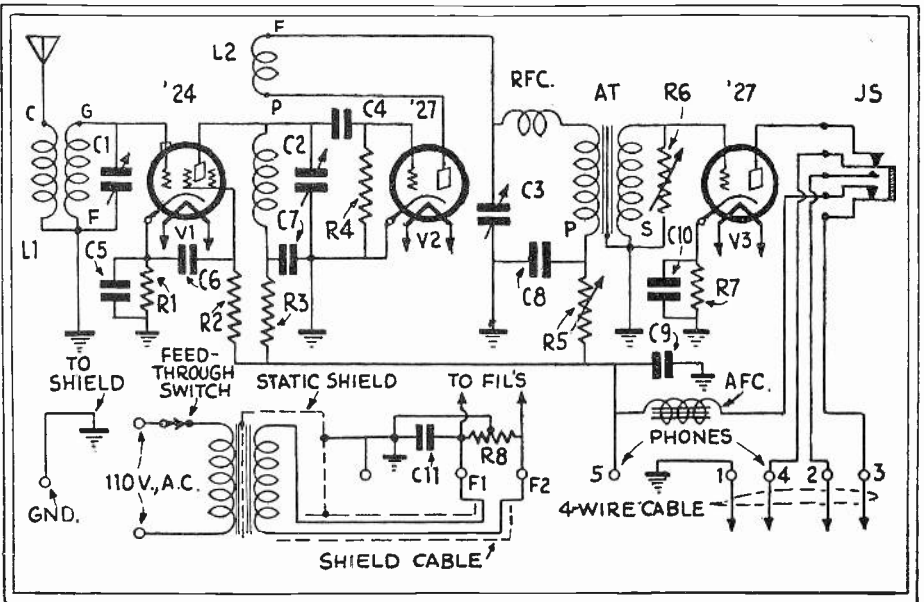


Fig. 46—A Short-Wave Adapter-Receiver. An R.F., detector, and A.F. combination.

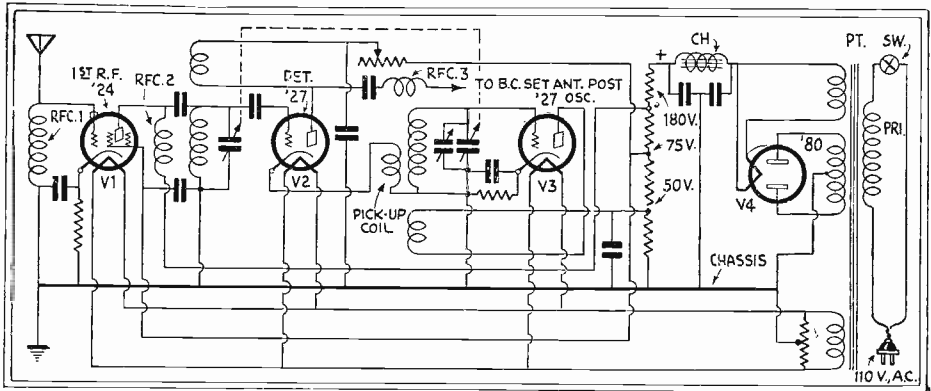


Fig. 47—The Walker "Model 4" Short-Wave Converter. A self-powered instrument. There are a great many owners of receivers who are well pleased with its performance and do not wish to discard the set, yet on the other hand desire an attachment that will enable Short wave reception to be added to their present set. This circuit can be used with favorable results.

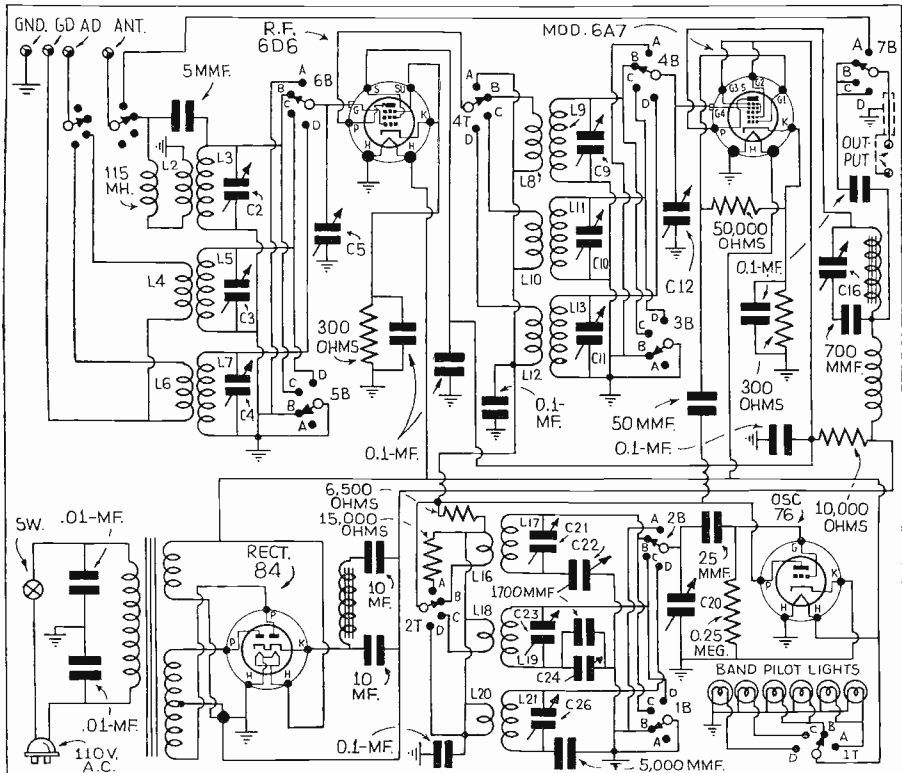


Fig. 48—The No. 69 All-Wave Selector contains the frequency changer circuits of a superheterodyne system which connected to the input (Ant. and Gnd. connections) of a good standard broadcast receiver gives an extension of the tuning range from 1500 kilocycles to 25 megacycles. Thus all frequencies between 550 kilocycles and 25 megacycles can be readily tuned. The No. 6D6 tube is used as the R.F. Amplifier. The No. 6A7 tube is used as the Modulator. The No. 76 tube is used as the Oscillator. The No. 84 tube is the self-contained power supply.

Chapter V

AUTOMOBILE RECEIVERS

The popularity of mobile radio sets is unquestioned. This is entirely due to the advancement made in their design and sensitivity, pickup ability, and remarkable tone quality.

I have illustrated several commercial automobile receivers, one a recent development with many desirable features, including automatic frequency control.

Automatic volume control is more essential in mobile receivers than in home sets because of driving conditions, which alter signal strength with directional changes.

Included is a receiver that has a special noise reducing automatic volume control circuit.

All of these mobile receivers use the super-heterodyne circuit with a stage of R.F. amplification ahead of the detector oscillator. This is the prime reason for their extreme sensitivity which is necessary with the new all steel turret tops in the latest automobiles. Spark plug suppressors are no longer necessary with these modern automobile receivers.

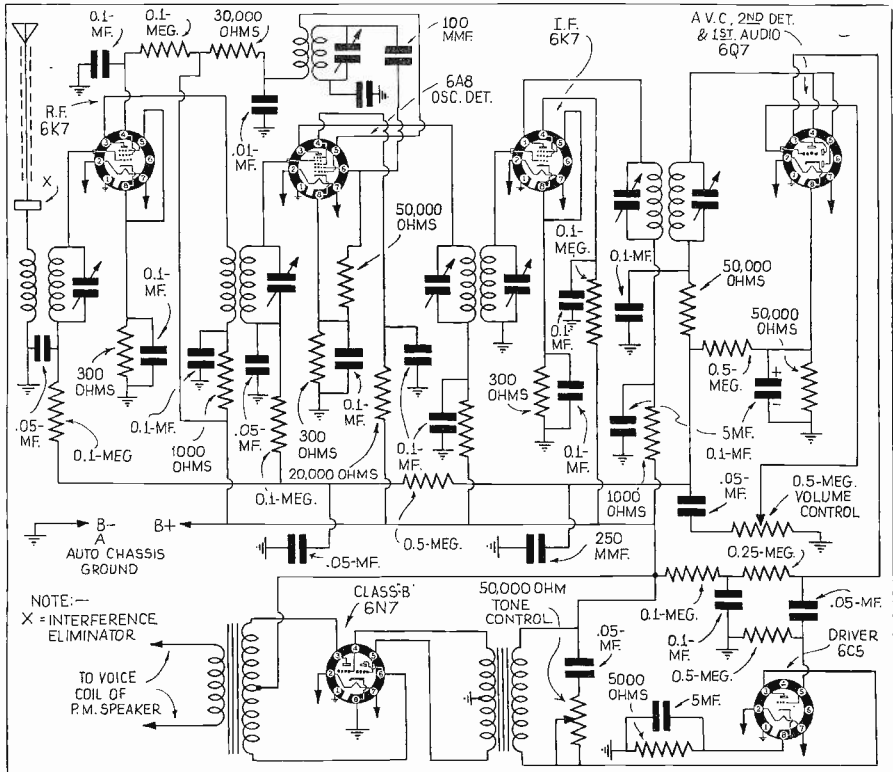


Fig. 49—Illustrates a battery operated Super-Heterodyne Auto receiver with numerous desirable features, such as automatic volume control, a driver stage which feeds a class B push pull 6N7 twin output power amplifier tube.

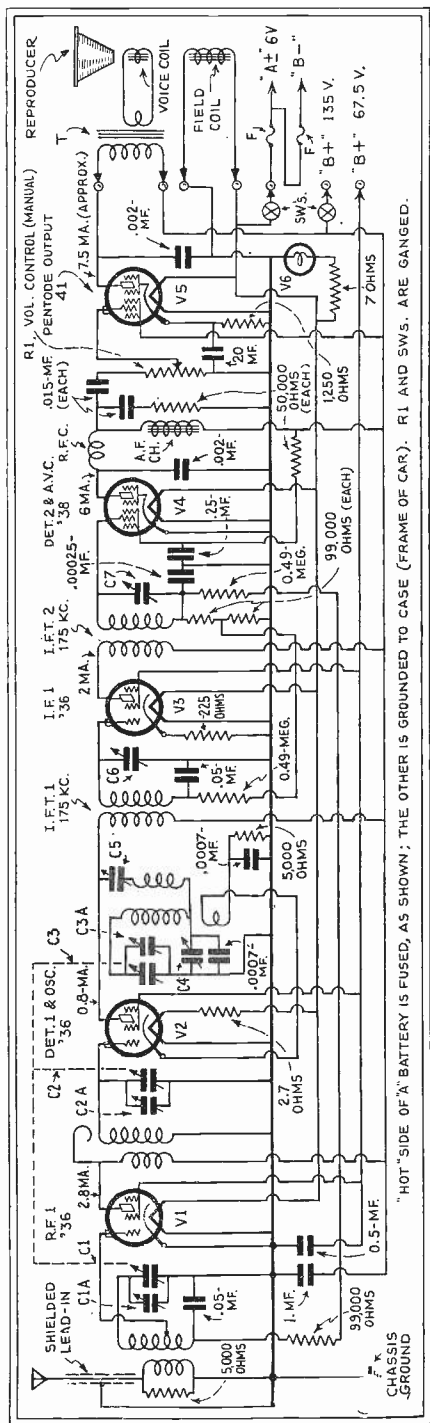


Fig. 51—The Philco "Transitone 7" A.V.C. Superheterodyne. Units C, C2, C3, 325 mmf.; C4, 250 mmf.; C5 to C7, C1A to C3A, 50 mmf.

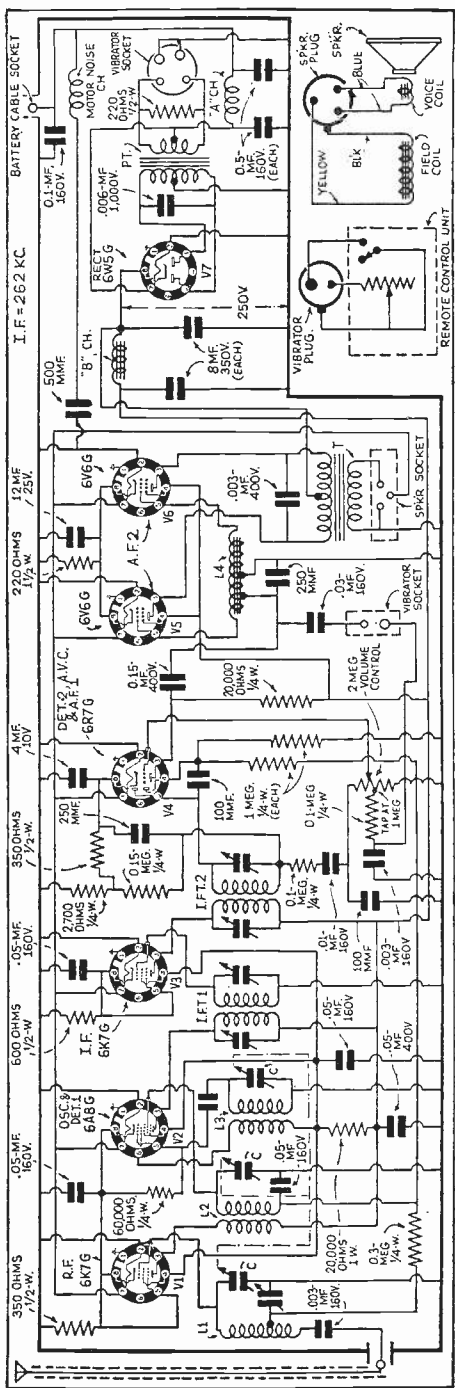


Fig. 50—Crosley Roamto model A-177. Here is a diagram that shows how the new "G" or octal-base glass tubes are used in a modern, high-gain circuit. Also included is a special noise-reducing A.V.C. circuit. The circuit accommodates dual loudspeakers; it also provides for a special General Motors heater loud-speaker.

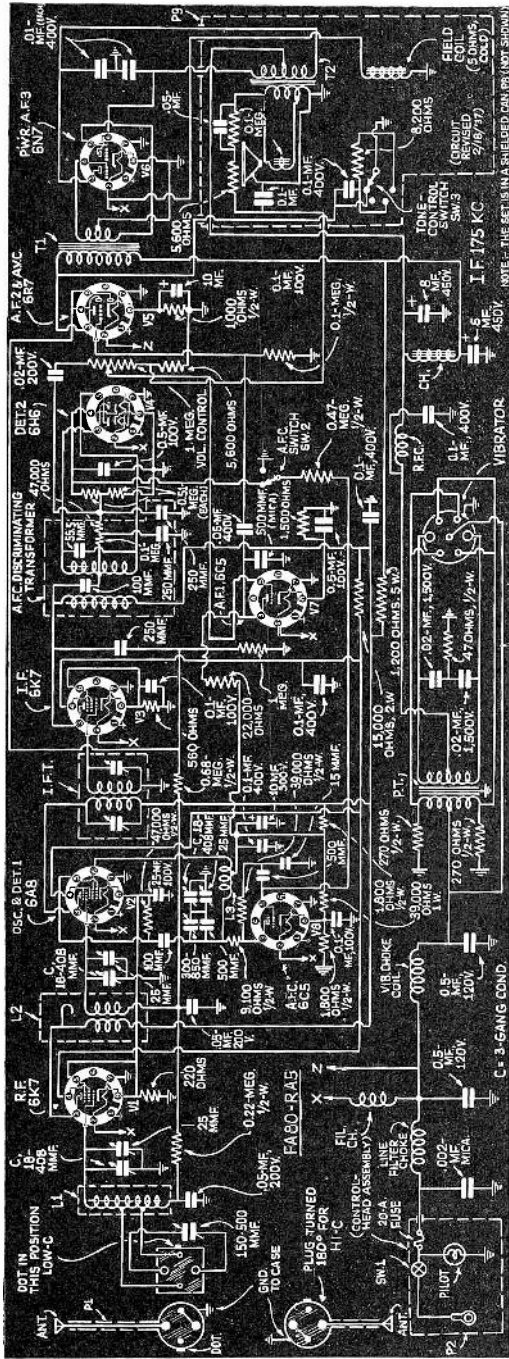


Fig. 52

General Electric FA-80. Of exceptional interest in connection with this circuit is the use of the new series of C. E. metal tubes; and the inclusion of Automatic Frequency Control. The circuit shown here is taken from the Revised Preliminary Service Notes. The A.F.C. circuit affords a desirable "safety factor"—the driver has only to tune to the approximate setting of a given station and the circuit then automatically does the vernier tuning. This receiver compares in performance with any high priced home set. A 6K7 R.F. tube preceding the mixer adds to the sensitivity and also builds up sufficient signal level for A.V.C. and A.F.C. operation. A 6A8 is used as the converter tube which mixes the incoming signal and local oscillator. The result of the mixing of the two signals leaves a 175 K.C. designated frequency to which the I.F. peaked transformers are tuned. A 6K7 tube is used in the I. F. stage for maximum amplification. A 6H6 twin diode as the second detector feeds a 6C5 first audio tube. Particularly interesting is the manner in which A.V.C. regulation in a combination 6R7 is done. This tube functions both as the A.V.C. and second Audio frequency amplifier. A 6N7 twin triode amplifier in push pull Class B arrangement supplies sufficient power output. A 6C5 triode is the A.F.C. tube that is used for correction of improper tuning. A tone control is included that capably cuts out background noises that may interfere with good radio reception in noisy areas.

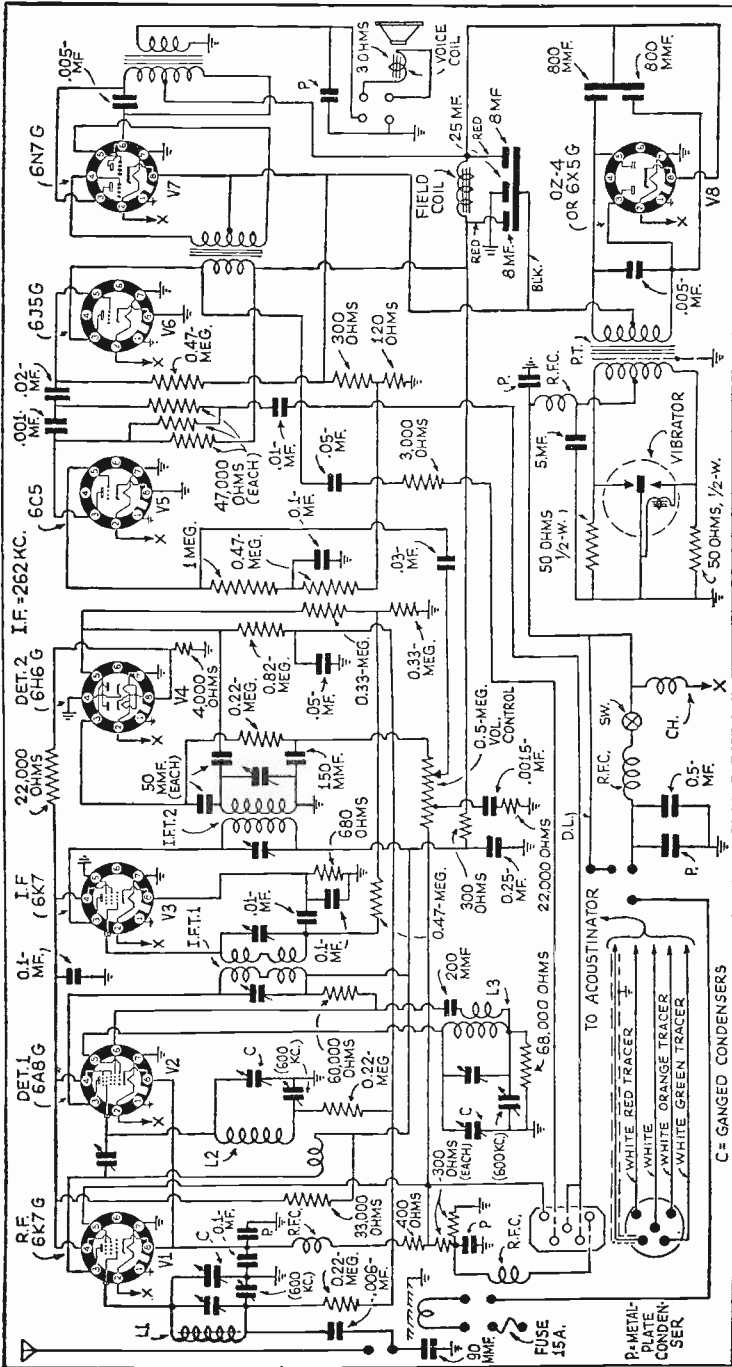


Fig. 53.—Galvin Motorola. An outstanding feature of this circuit is the low current drain from the car's storage battery. Other points of interest are the antenna-matching control and the connection of the "acoustinator". The output is 13 W., with only 7 Amp. "A" drain. Exceptionally low "B" drain, for a set of this high power-output rating, is accomplished by using a class B output circuit. The "Golden Voice" model is diagrammed.

Chapter VI

PUBLIC ADDRESS

This chapter is devoted entirely to public address systems, and deals with the latest designs in high gain tubes and their associated circuits.

For portable use I have illustrated an economical battery operated, class B, low power amplifier capable of delivering from five to eight watts of power to the speaker. A carbon microphone is used, since its level is quite high. Provision is made for either a high impedance magnetic or crystal pickup.

A metal tube six watt AC amplifier to accommodate either carbon velocity or crystal mike, a high impedance pickup arrangement is included for recordings. This particular system will find favor in small club-rooms or meeting rooms.

Illustrated is a ten watt amplifier using a pair of 2A3 tubes in push-pull arrangement with many desirable features. Three input circuits are provided, one mike, one line, and one phono. Of special interest to public address experimenters is the new mixer and fader system designed by leading engineers of a large commercial transformer company.

The new beam power amplifier tubes have permitted designs of amplifiers capable of pro-

ducing 60 watts of undistorted output which are appropriate for outdoor installations, and large ballrooms. I will now illustrate a 60 watt beam power amplifier in class AB.

This amplifier uses 4 6L6 tubes in parallel push-pull. You will notice that this amplifier uses a 6E5 magic eye tube which if properly controlled will indicate the maximum point before feedback occurs.

Included among these amplifiers, you will find one of particular interest which is one called the anti-howl audio amplifier. Of the features of special interest is the volume expander which uses a 6E5 magic eye as expansion and output indicator.

For the various needs of sound men, I have illustrated numerous types of amplifiers, ranging from 5 watts to 100 watts.

A wise practice among Sound Technicians is to use a low powered sound system, but adding more than one speaker distributed in advantageous locations. By doing so an equalized sound distribution is obtained, and objectional complaints by those seated directly in front of the speaker's platform is done away with. The placement of the added speakers is important in order to prevent undesired feedback.

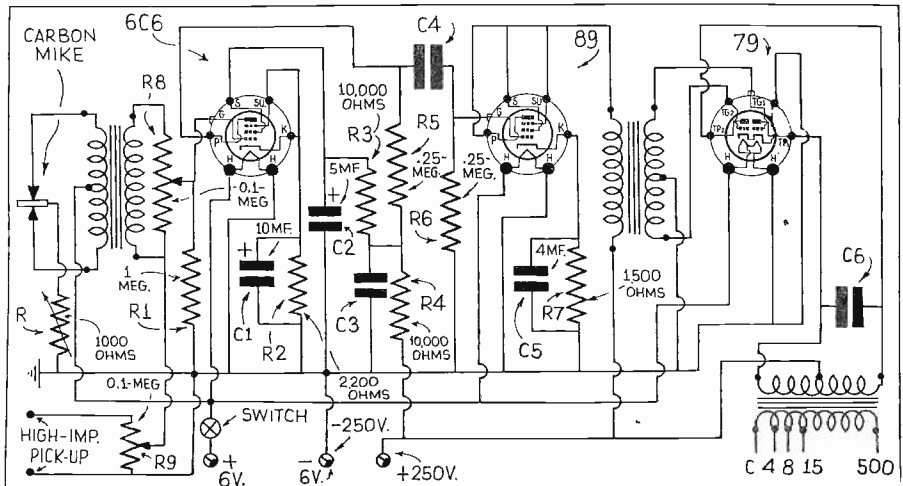


Fig. 54—A public address system for a carbon microphone and a high impedance pickup for portable use. It is battery operated, Class B output, capable of delivering from five to eight watts of power.

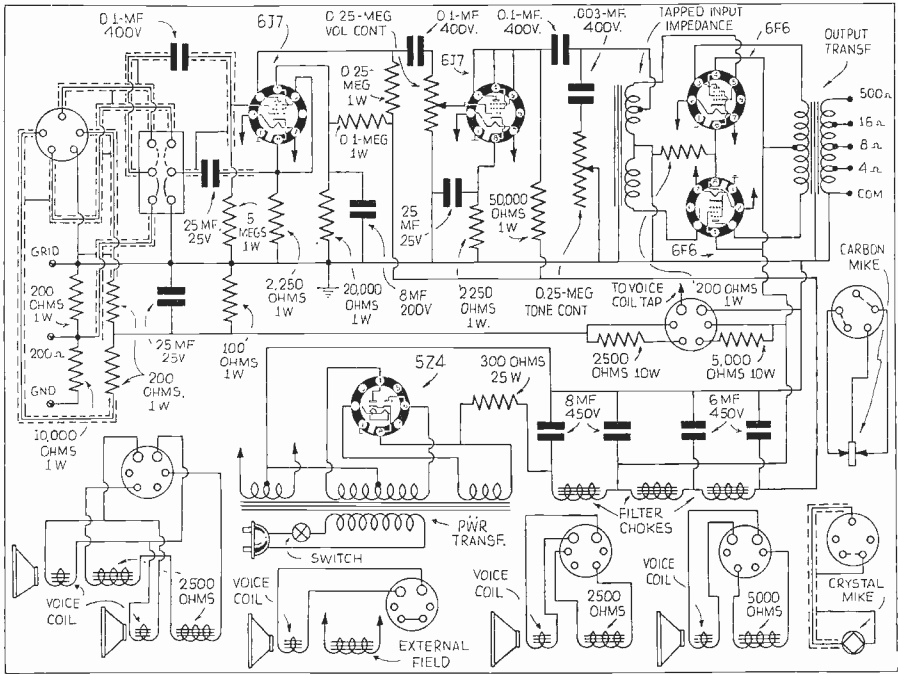


Fig. 55—A public address metal tube six watt AC operated amplifier, for velocity or crystal mike. A high impedance pickup input circuit is also arranged.

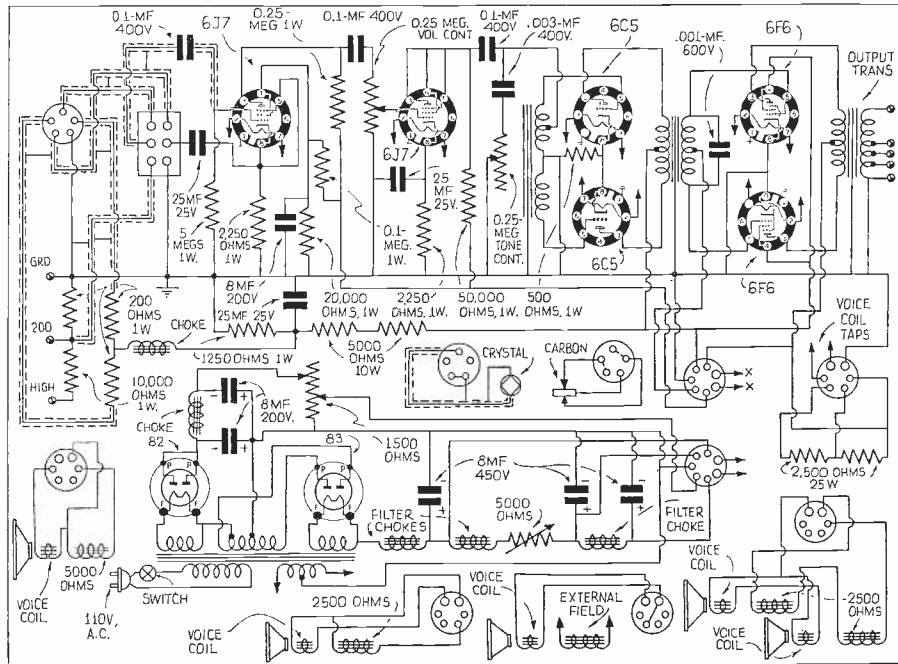


Fig. 56—An eighteen watt public address system using a pair of 6F6's in push-pull. Arrangement is made for either a crystal or carbon microphone.

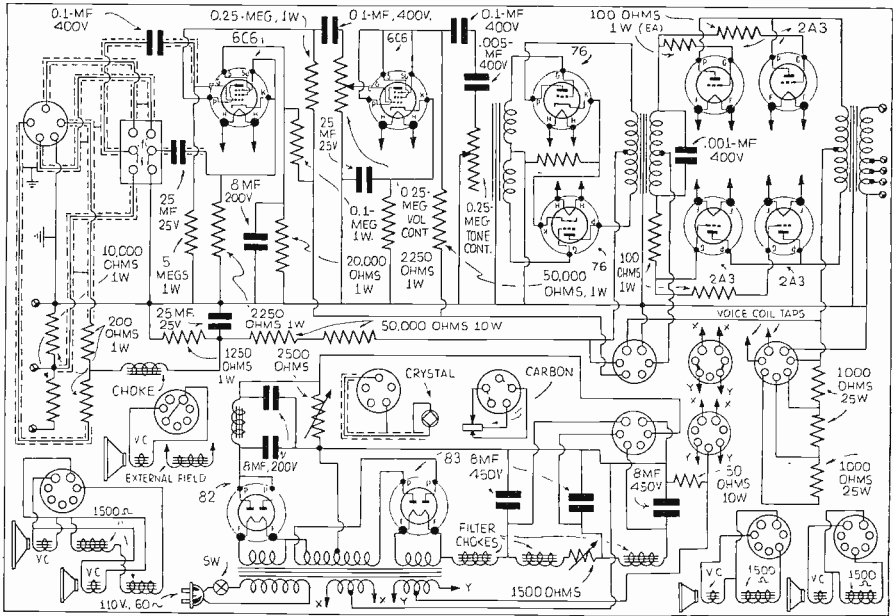


Fig. 57—A thirty watt public address system with four 2A3 tubes in parallel push-pull arrangement, driven by a pair of 76 tubes in push-pull. Crystal or carbon microphones are arranged for. This type of amplifier is currently used and will capably fill a large hall or meeting place without requiring maximum power output of the amplifier. The usual practice is to install more than one speaker with regard to the capacity expected.

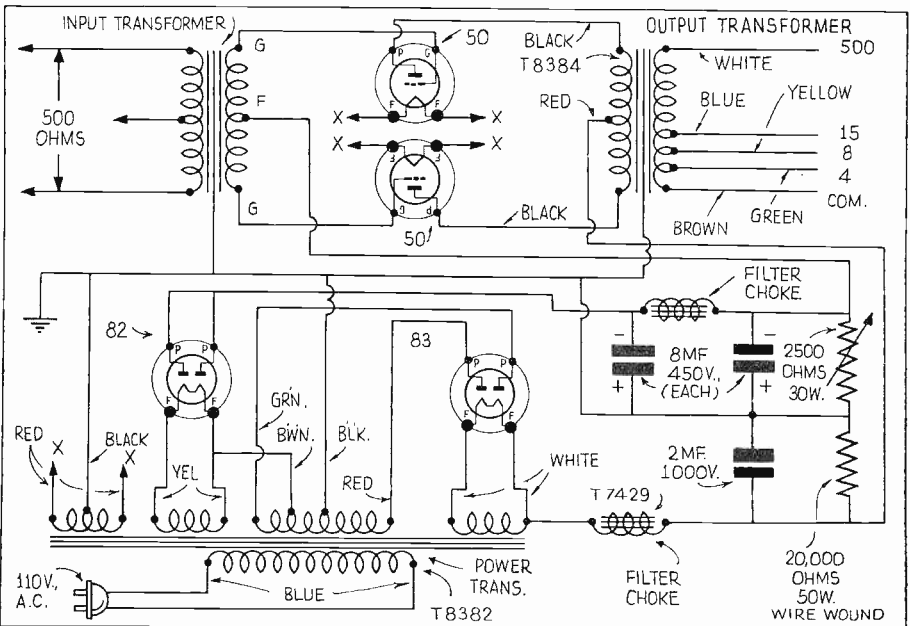


Fig. 58—A forty watt Public address system in Class AB using a pair of 50 tubes in push-pull. This may be added to a lower type amplifier. For outdoor work it is most satisfactory.

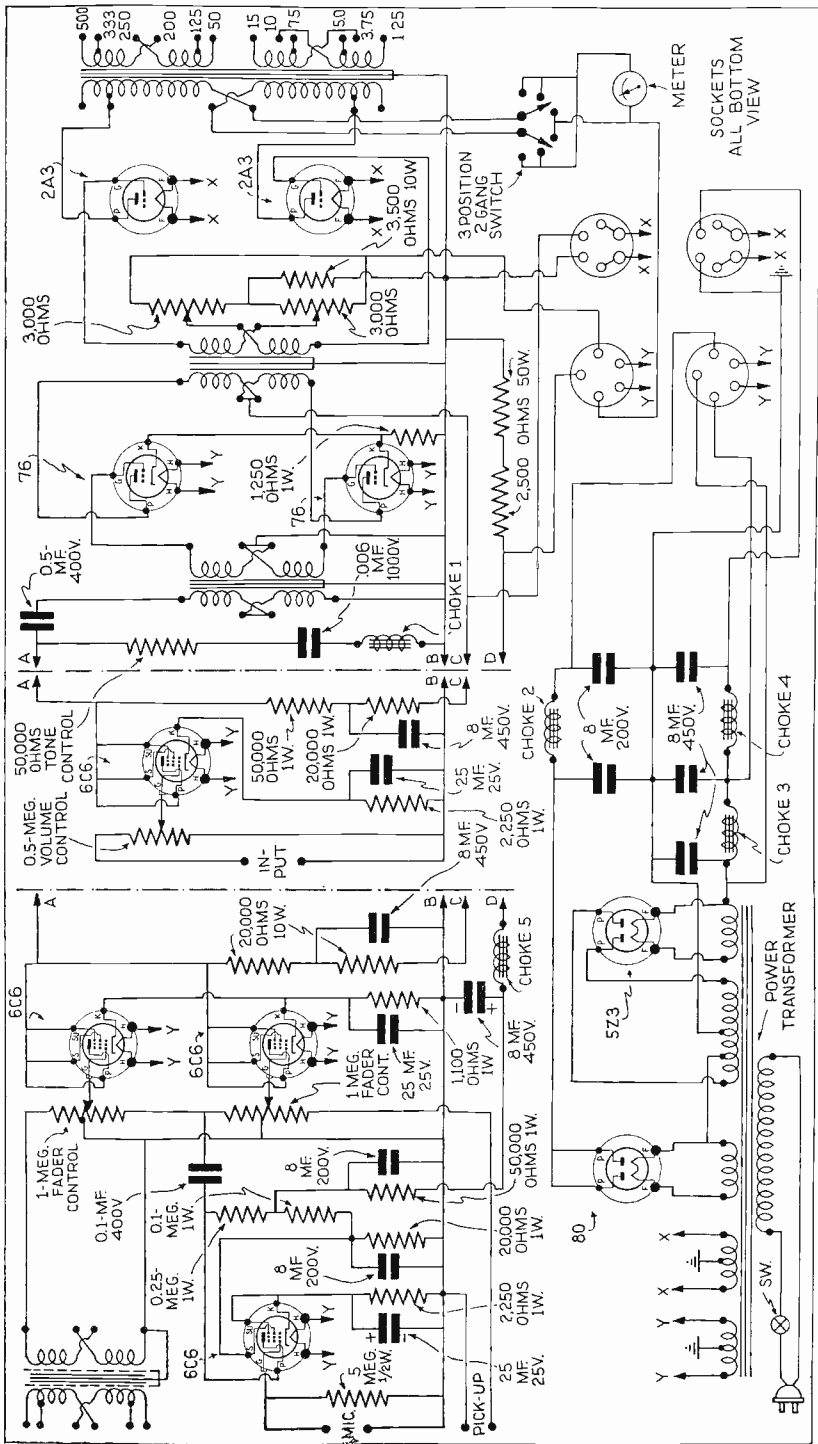


Fig. 59—A ten watt amplifier using a pair of 2A3 tubes in push-pull arrangement. Of special interest to public address experimenters is the new mixer and fader system designed by the Thordarson engineers. This amplifier can capably fill a large auditorium with sound, providing additional external speakers are placed in advantageous locations.

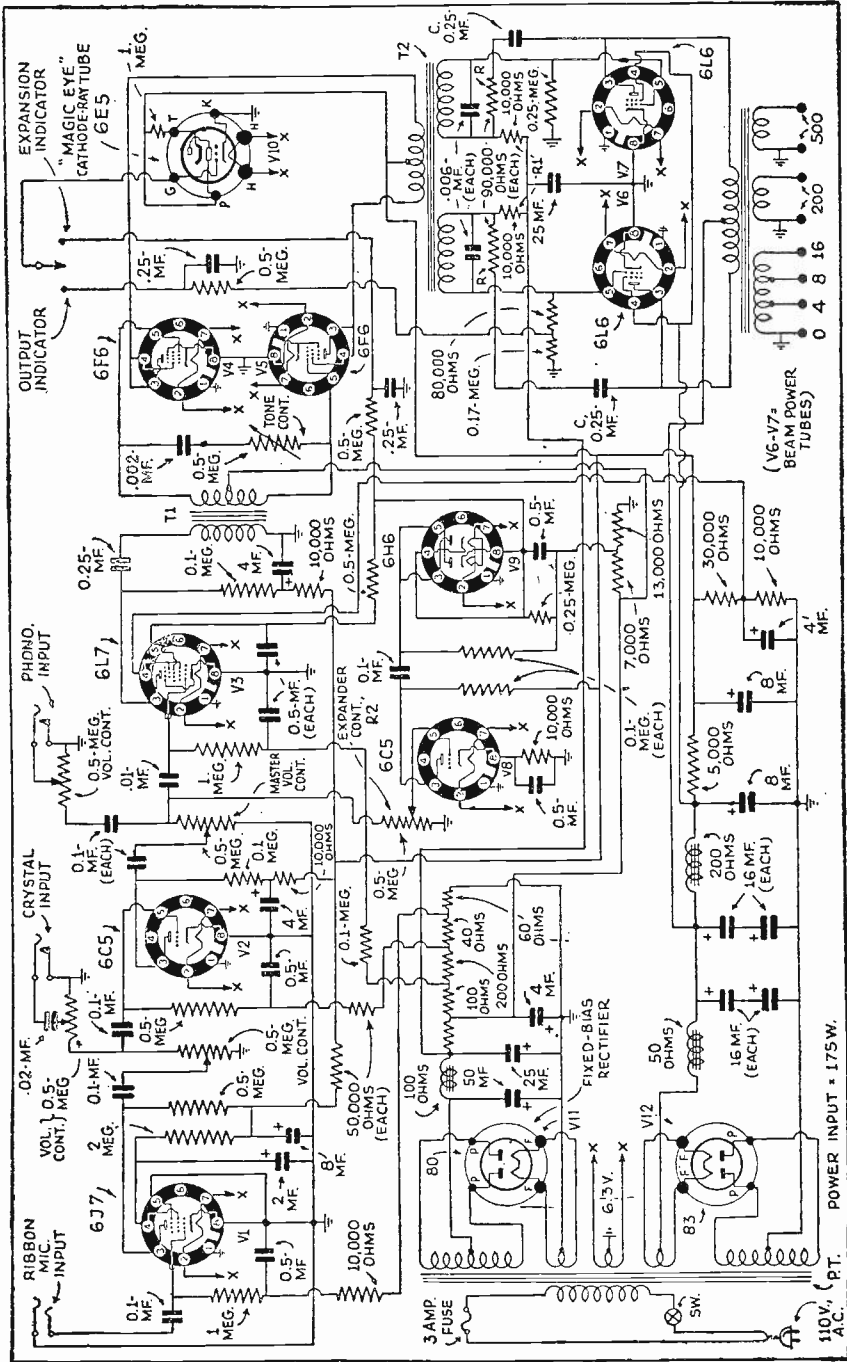


Fig. 60—A Circuit of a thirty-four watt amplifier that includes a volume expander and a 6E5 expander indicator. The expander, if controlled properly, will enable the operator to eliminate possible feedback.

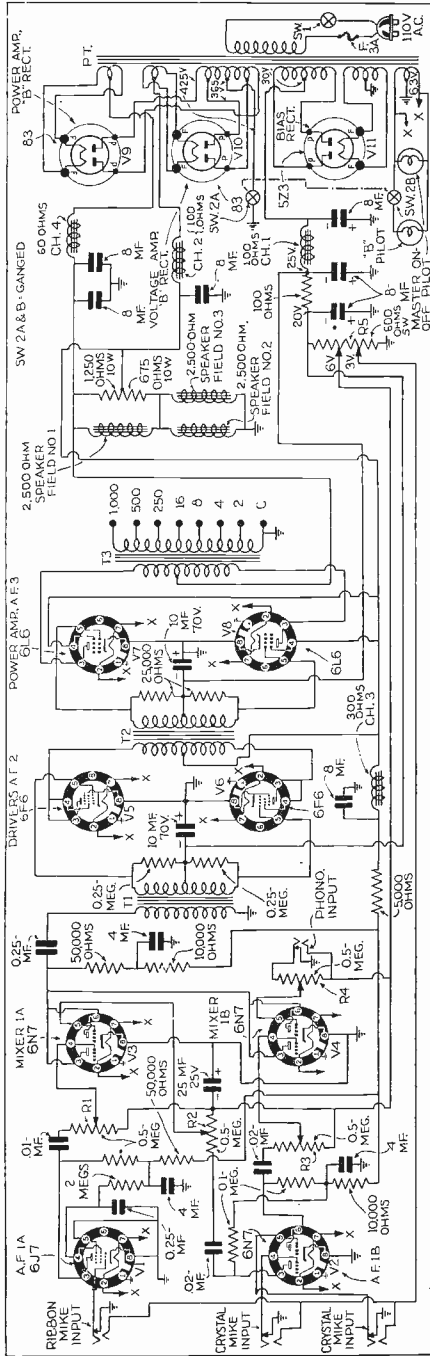


Fig. 61—A sixty watt public address amplifier arranged for two crystal and one ribbon microphones, and using three 6N7 tubes as mixer tubes. A pair of 6F6 drivers in push-pull feed into a pair of 6L6 power beam tubes, also in push-pull arrangement. The 6L6 tubes are operated under practically ideal conditions. Sound men who construct public address systems for large auditoriums will find this circuit with its tremendous amplification amply able to fill any sized hall with sound. For stage work where more than one microphone is needed, this setup is perfect. The 6N7 mixer tubes in this arrangement act quickly and smoothly and have no drawbacks compared with the older type of tubes. Sound men who have built this 60 watt amplifier state that it is not necessary to advance the output since the amplification is so tremendous, and practically no feedback trouble is encountered.

Three speakers distributed in correct locations will fill an armory with sound. The 2500 ohm speaker fields, as illustrated in this diagram, are part of the power supply unit. For rectification, a pair of 83's supply sufficient voltage for the amplifier. An 80 full wave rectifier supplies the bias potentials with the well designed filter circuit that eliminates possibility of distortion.

Care in the selection of parts is of prime importance in order to insure quiet and efficient performance. A pair of 6F6's as drivers deliver enough grid excitation for the pair of 6L6's in Class B amplification. In the filter circuit be sure and use a choke (swinging of 60 ohms to insure good power regulation. Also use resistors of at least 10 watts for correct heat dissipation. A tapped output transformer is shown to match any speaker on the market. The most important fact to remember is to purchase a matched pair of input and output push-pull transformers.

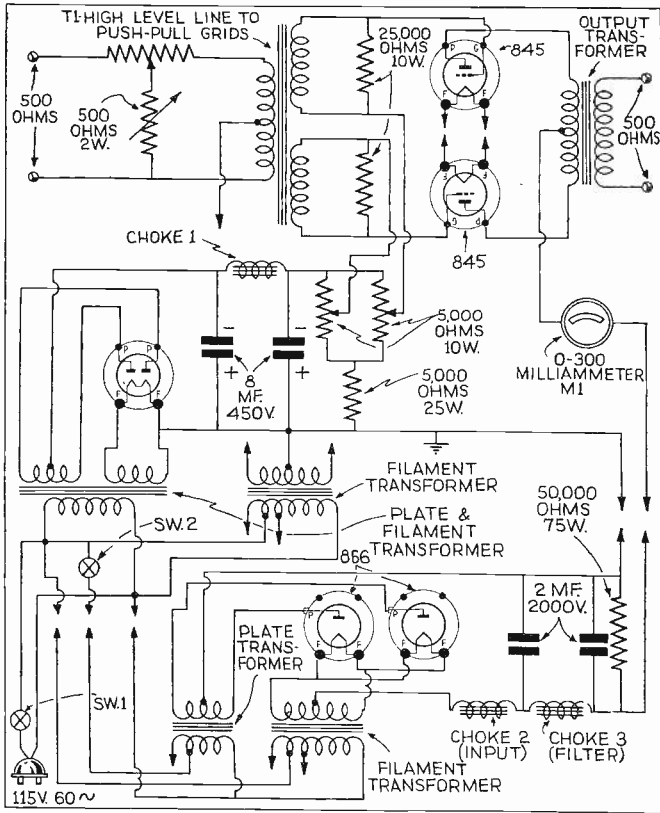


Fig. 63—A hundred watt public address system using a pair of 845 tubes in push-pull. The power needed to supply the 845's extreme high plate voltage and current consumption necessitates the use of two 866 half-wave rectifiers, and an 80 full-wave rectifier for the bias. This is an ideal amplifier for any large open-air requirement.

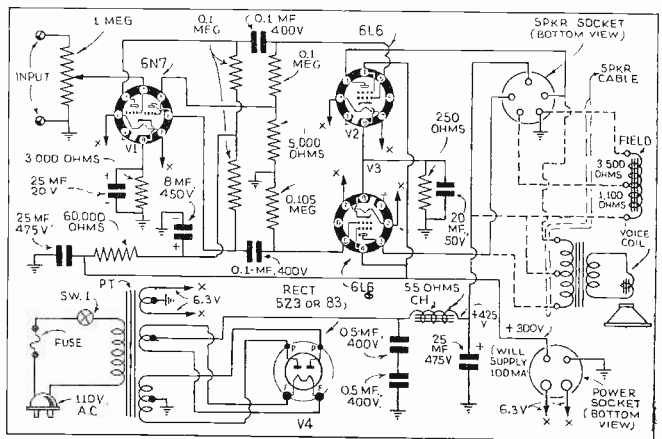


Fig. 62—An amplifier that is ideally suited for a good receiver tuner is shown here. A 6N7 driver which feeds a pair of 6L6's in resistance-coupled push-pull arrangement and is powered by a 5Z3 or an 83 full-wave rectifier.

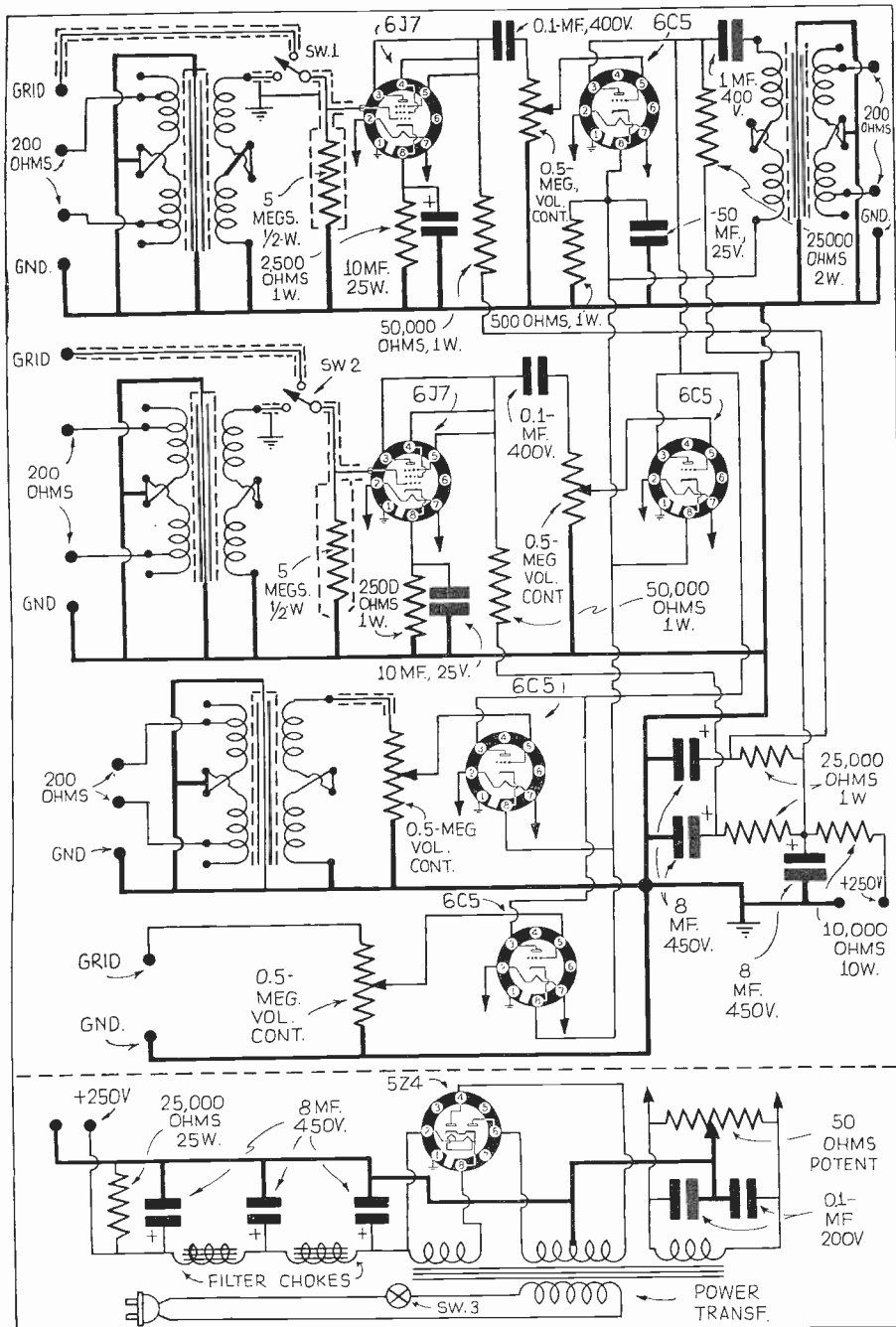


Fig. 6-1. A pre-amplifier and electronic mixer that is very versatile in its uses. Velocity, carbon or crystal microphone inputs are arranged for, and may be mixed at the will of the operator. This unit feeds into a 200 ohm line for transference over a short distance without any appreciable loss to the amplifier. Note that parallel feed coupling is used in the final stage to increase over-all response. High quality resistors and condensers must be used in order to keep the noise level to a minimum. Shielding as indicated in the drawing must be conformed to, to insure noise-free operation and absence of hum.

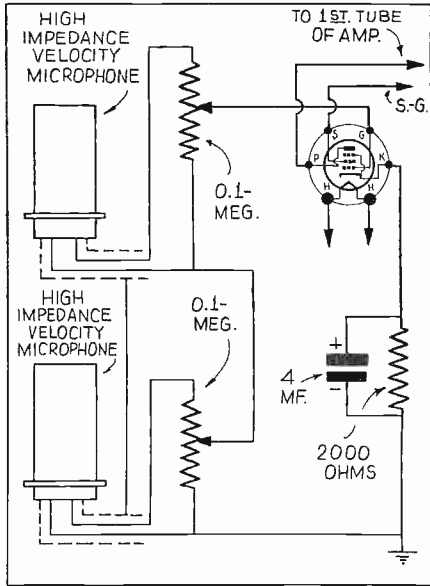


Fig. 65—Input circuit for two microphones with provision for mixing. Many well constructed Public address systems are troubled with unnecessary feed-back. If more care is taken at the microphone end most of this trouble can be eliminated. Of the utmost importance is to use a well shielded mike cable that will not pick up an induced hum, or cause feed-back.

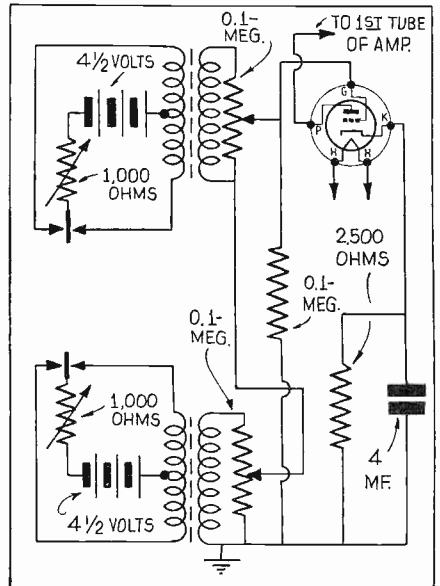


Fig. 66—A mixer circuit for two carbon microphones feeding a triode. Individual damping is shown with a 1,000 ohm control which regulates each mike. The matching transformers should be selected with care if microphone gain is to be realized. Carbon microphones require approximately 4 1/2 volts for excitation. Many sound technicians who still have in stock carbon mikes do not have to discard them for the newer types, but can use them with favorable results by adding this input circuit ahead of the amplifier.

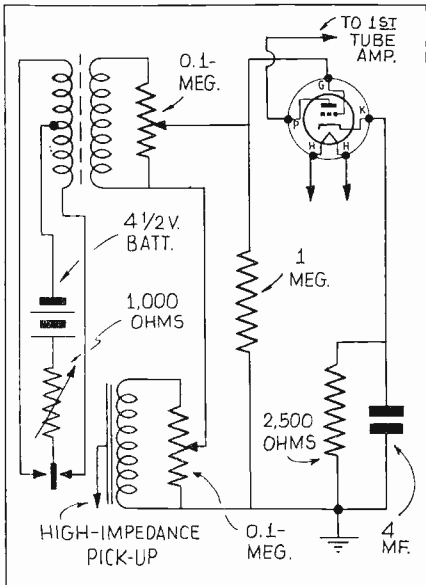


Fig. 67A—Another form of mixer circuit with an arrangement for a high impedance pick-up.

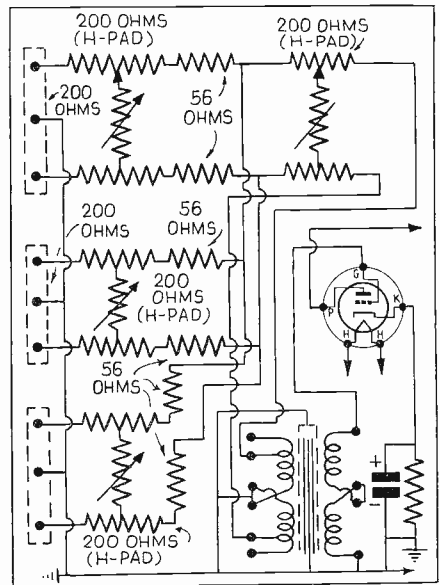


Fig. 67B—Mixer and input circuits with provision made for three microphones.

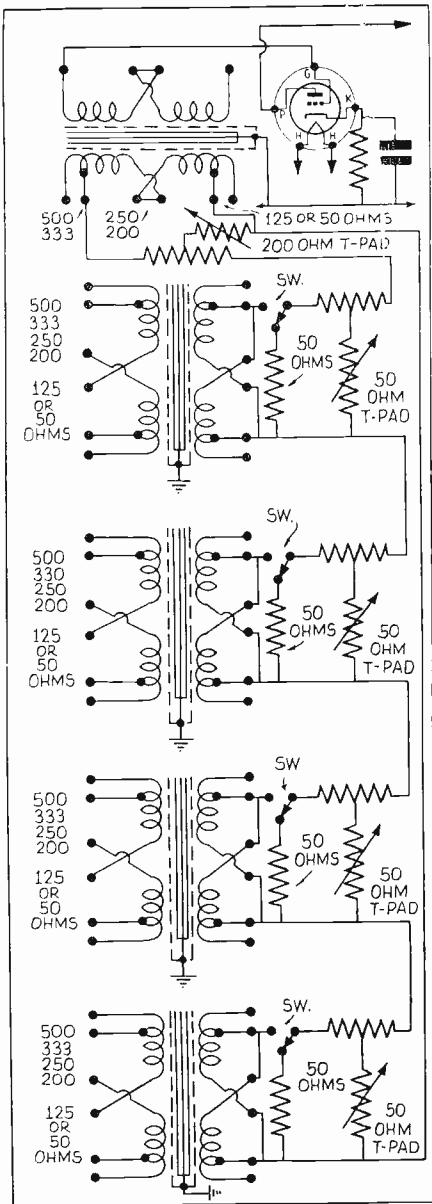


Fig. 68—A four circuit series mixer. This type of circuit has less loss than a parallel mixer, balanced "H" pads are not required, since a line to mixer transformer is used in each circuit. The series type low impedance mixer is the most popular. Sound technicians will find that this arrangement can be put to many uses; one, for instance, is stage work, where many people congregate and it is inadvisable to use only one microphone. Another use, where more than one microphone is needed, is in picking up and mixing the various instruments in order to avoid blasting or piercing notes which are bothersome to the audience.

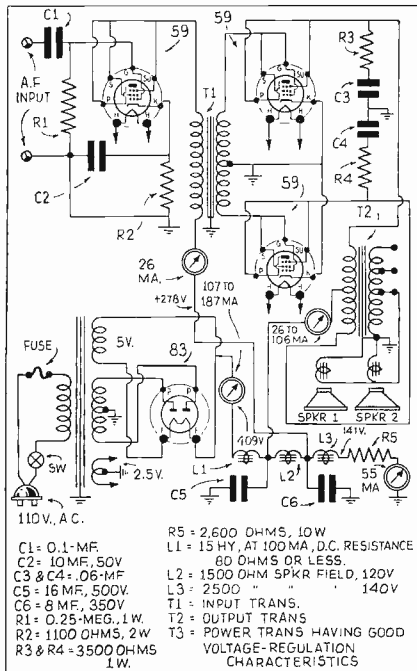


Fig. 69—A typical Class B audio frequency amplifier with an output of twenty watts.

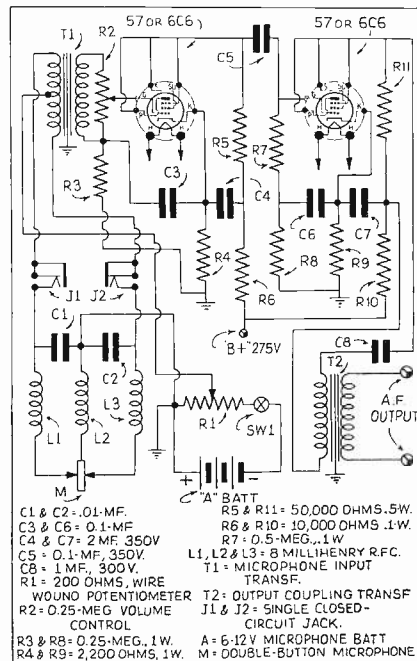


Fig. 70—A double button microphone pre-amplifier, with eight Millihenry RF shokes in series with each leg of the microphone.

Chapter VII

POWER PACKS

Current supply devices are controlled in their design by the current requirements of the design with which they are used, and by the type of available power supply line.

With the development of high power output tubes particularly with class B or class AB audio circuits proper regulation is most essential for efficient operation.

The selection of the various components which is to comprise the power pack is most important to the constructors if they expect long life, and efficient current distribution.

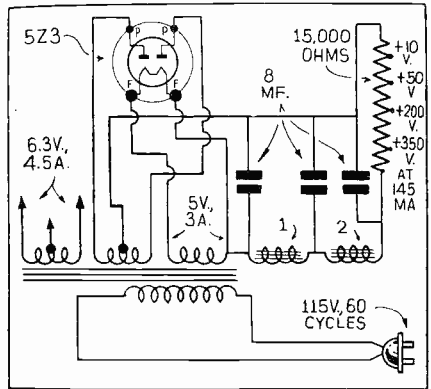
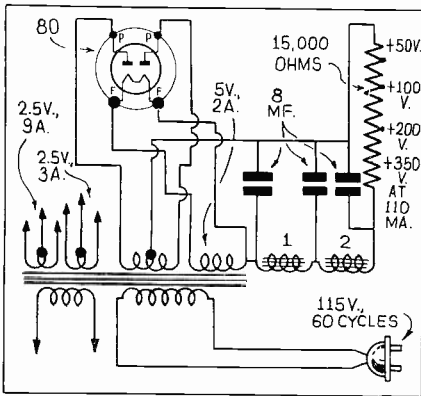
The performance of many well constructed and efficient receivers has been spoiled by a poorly constructed power supply. Therefore, I wish to point out to set builders never to fail to obtain the best possible equipment available with the rating that allows a safety factor of at least 100 per cent of their working voltage.

In the construction of power packs for high voltage use extreme care must be exercised in selecting the various components, making definitely sure that the insulation is heavy enough and will not arc to chassis.

Many commercial types of power packs after being in use for a time develop a terrific hum which always spoils good reception. This condition is accompanied by a lack of volume, and distortion which is quite unpleasant to the listener. The usual reason can be traced to filter condensers that have depreciated in capacity with a result that all potentials have been reduced, thus affecting the power gain of the tubes.

For some time a great many experimenters have used electrolytic capacitors, but are now going back to paper or oil type filter condensers, for their experiences indicate the advisability of paying more for good, long life capacitors.

Power transformers and filter chokes unless well selected for their rating operation are another source of trouble. It has been the experience of many experts to find poorly constructed components get too hot and sometimes go up in smoke, thus ruining many dollars' worth of good equipment as a result.



Figs. 71-72—Much has been written about the importance of good power supplies for transmitters but little has been said regarding receiver power supplies. Many well designed and constructed receivers are erratic in operation and are a constant source of trouble all because of a poor power unit.

The power transformer must be capable of furnishing full voltages to all the tubes without excessive heating. If the power supply is part of the receiver, and the complete unit is enclosed in a cabinet, there is little ventilation and a poorly designed transformer will heat very badly. This will cause changes in condenser capacities which will affect the tuning and alignment. Other parts may not be damaged immediately but the high temperatures will shorten their life.

Conventional circuits are shown in the two diagrams. Choice of power transformers will depend upon the current requirements of the receiver. Chokes should be selected which will carry the maximum current furnished by the transformer. An inductance of from 12 to 20 henrys at the rated current is satisfactory. Thordarson power transformers and filter chokes shown here.

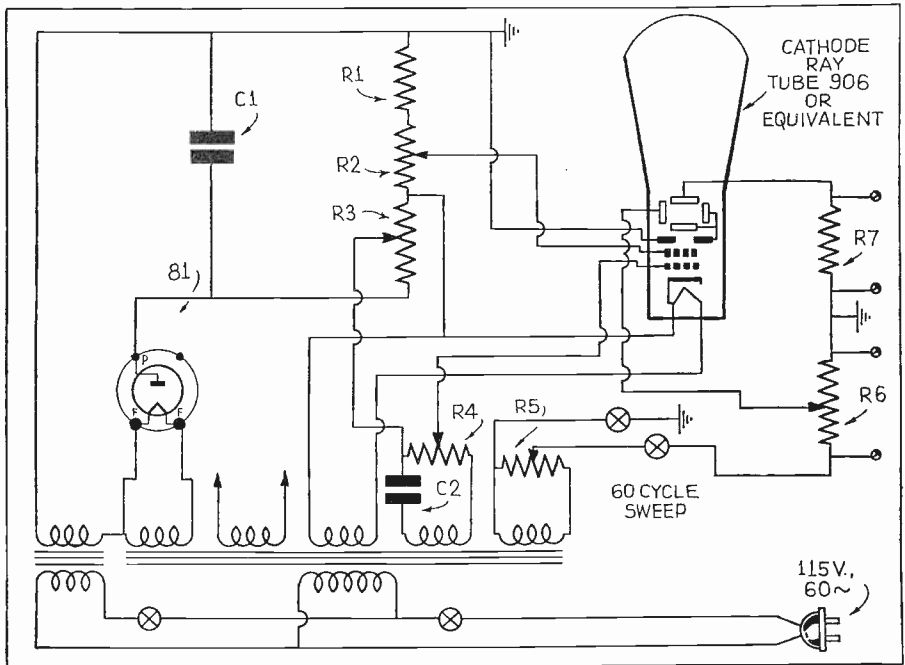


Fig. 73—The power supply for a 906 Cathode ray tube or its equivalent. It is customary to apply a potential in the neighborhood of 1000 volts to the deflecting plates.

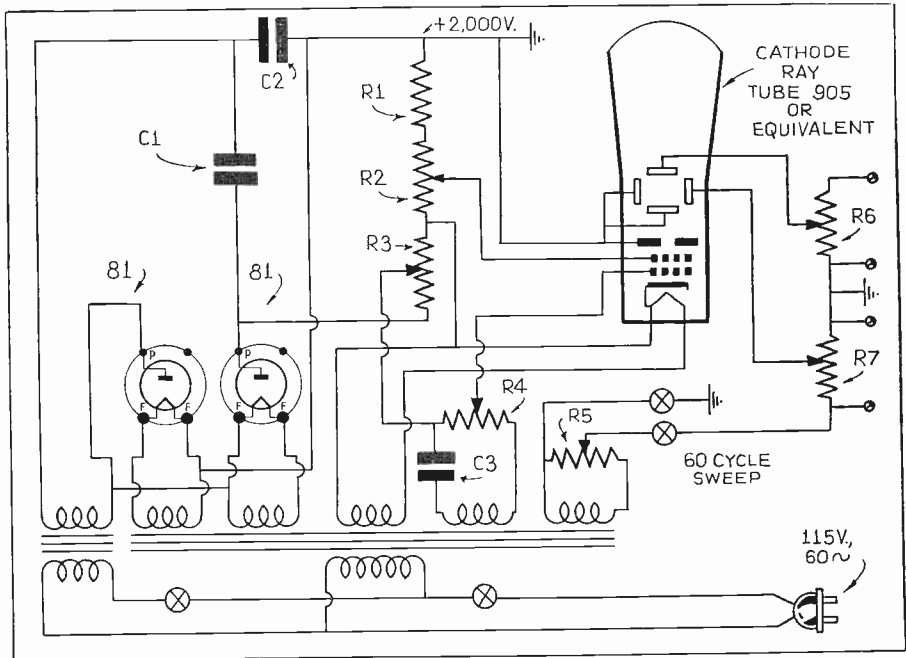


Fig. 74—Power supply for a 905 Cathode Ray tube or its equivalent is shown. The required voltage is 2000 volts.

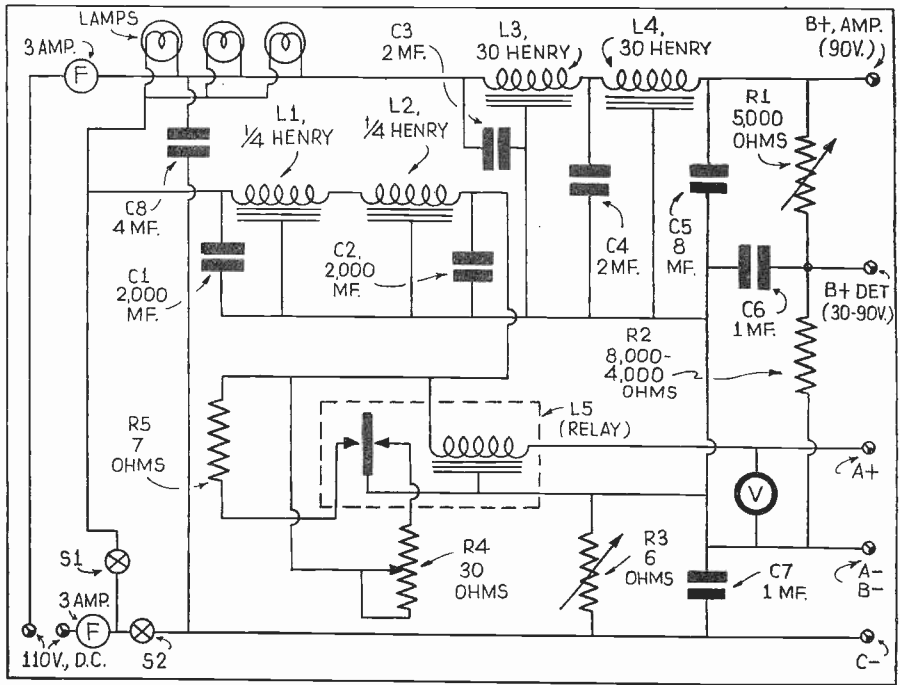


Fig. 75—An A-B-C Power Pack for D.C. Lines. Line voltage limits the output potential. With this power supply, frequent examination of the relay L5 is required. File the points if they become corroded or pitted, in order to insure stable operation; for, if this is neglected, varying output voltages will interfere with the radio reception.

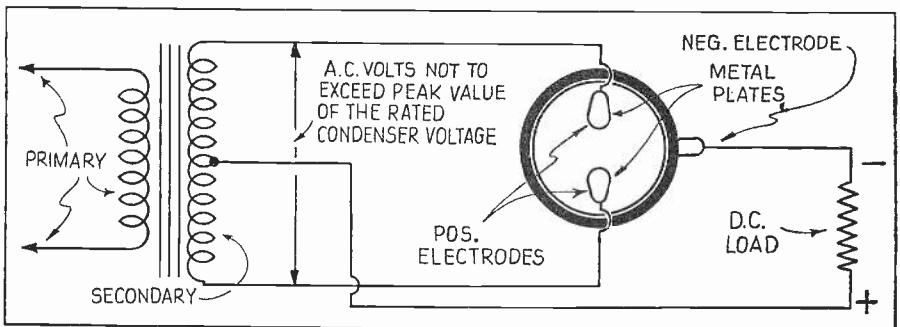


Fig. 76—An Electrolytic-Condenser Rectifier. A novel circuit of new design. The output of a unit of this type is limited by the characteristics of the electrolytic condenser. The voltage divider is indicated as "D.C. load." This arrangement is still in the experimental development stage. It is a well known fact that an electrolytic condenser will discharge when a maximum voltage is applied to its plates. Looking at the simple circuit illustrated one can readily see that the positive portion of the A.C. cycle will cause an electronic flow, or a discharge from positive to negative. When the A.C. cycle reverses and the plates reverse the plates become negatively charged. Due to the fact that both condenser plates are being alternately charged and discharged, there will be a current resulting in a pulsating D.C. voltage that can be filtered.

Chapter VIII

SIMPLE TRANSMITTERS

Amateurs deserve considerable commendation for some of their contributions in the art of transmitting improvements.

Since crystal oscillators have been found to be more stable in operation of transmitters, and do not cause frequency drifting it is generally used by most amateurs.

Several circuits of both crystal and tube oscillators are illustrated in this chapter.

Also illustrated in this chapter is a frequency meter monitor that is absolutely necessary to maintain the designated assigned frequency of any transmitter. Many amateurs who have strayed from their wavelength and have received "Pink Cards" as a warning fully realize the need of this monitor. This instrument can be exactly calibrated and generally, if care

is taken, will not change in its setting unless it is carelessly upset.

A circuit of a simple transmitter in Fig. 77 is indeed very interesting to recently licensed Amateurs, in as much as it is simple to construct and has quite a distance record.

Many advanced amateurs go to considerable expense in constructing a high-powered transmitter, yet cannot work any great distances. The usual reason for this is due to a poorly erected antenna. Care must be exercised in the installation with due regard for the exact length needed. Feeders of either the voltage or current fed types must at all times be attached in the exact position on the antenna. Avoid sharp bends or twisted feeders (except doubler types) if undesired standing waves are to be eliminated.

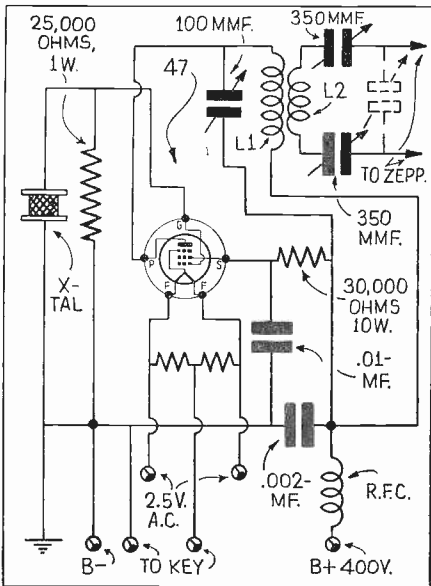


Fig. 77—Illustrates a simple crystal controlled one tube transmitter capable of reaching great distances on CW. A 47 pentode tube meets the requirements necessary providing the correct potentials are applied. The antenna coil L2 is coupled to the oscillator coil L1 by means of 6 or 8 turns of wire.

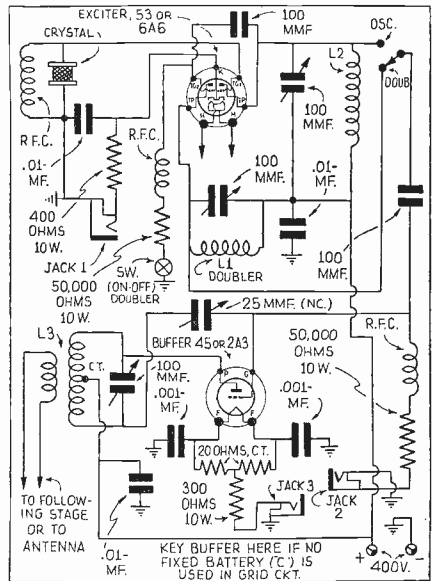


Fig. 78—Illustrates a two tube transmitter, a 6A6 exciter and a 2A3 buffer stage for CW. work. Approximately 400 volts is required on the plates of these tubes for maximum output efficiency. The oscillator is crystal controlled to assure permanent calibration of the designated wavelength to which the transmitter is tuned to.

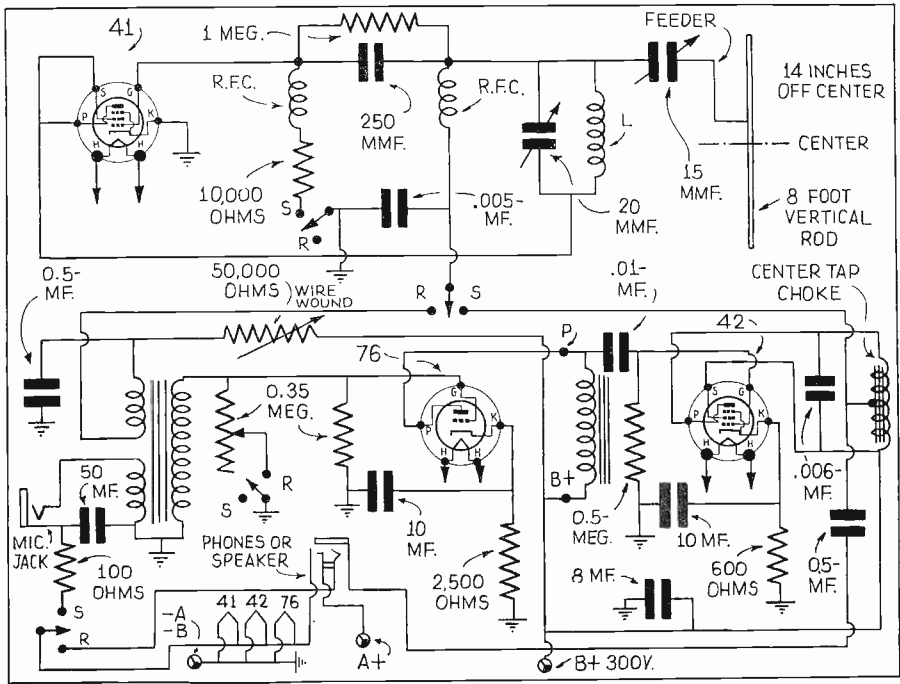


Fig. 79—A transceiver circuit that covers both 56 and 112 mc. For mobile use it is advisable to use components with as little weight as possible. The 42 tube is used as the modulator and the 76 as the speech amplifier. Care should be exercised in its construction particularly in the circuit of the 41 tube which uses super-regeneration. A number of amateurs have reported contacts over great distances with schedules arranged from time to time. For mobile use, an efficient plate supply either of the vibrator or Genemotor type that is well filtered, meets the necessary requirements.

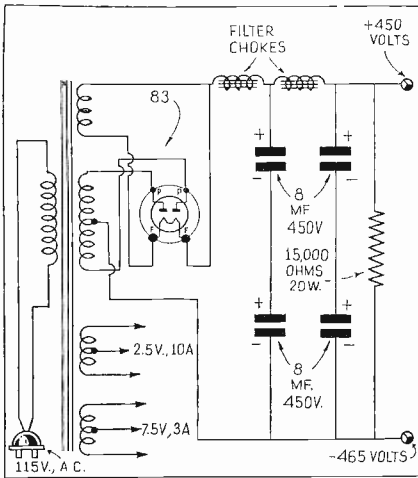


Fig. 30A—Illustrates a full wave rectifier using an 83 tube. For transmitters, power regulation is of the utmost importance if a clear note is expected, and freedom from modulation hum which can ruin any well constructed rig.

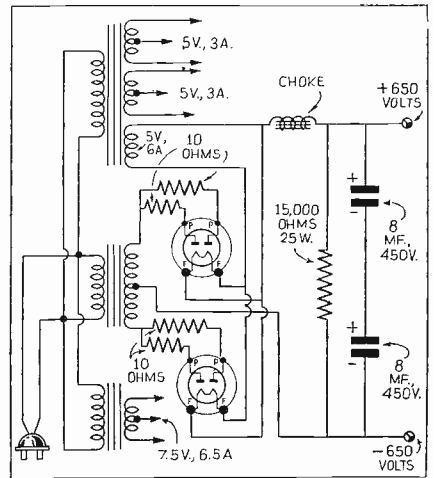


Fig. 30B—Illustrates an efficient power supply where more voltage and current consumption is required. Two type 83 full wave rectifier tubes function each in half wave fashion, in order to deliver sufficient power.

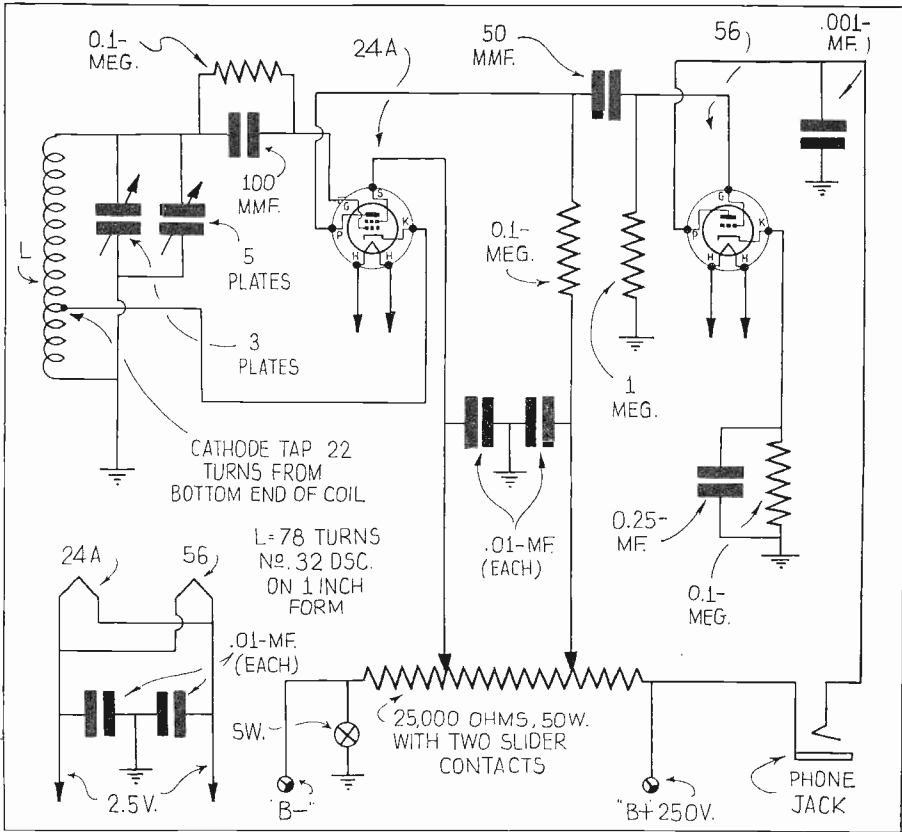


Fig. 31—Illustrates a circuit of a frequency meter monitor designed to maintain the assigned wavelength of a transmitter. A screen grid type 24A tube is the Zero beat oscillator and is followed by a 56 audio tube for greater amplification. This monitor is electronically coupled to insure stable operation and practically no drift will be experienced in a long period of time. It is recommended for the B power supply to use either B batteries or a well regulated B battery eliminator. Most of these parts can be found in most HAMS' shacks. It is quite simple to construct, but must be well shielded. Parts required to build this frequency meter monitor: A 78 turns No. 32DSC on a one inch form. A tap at 22 turns from the bottom end of the coil must be made for the cathode. Two tuning condensers are essential, a 5 and 3 plate. Three 100,000 ohm resistors, one watt. One meg. resistor, and one 25,000 ohm 50 watt with two slider contacts. Also, four .01 mf. bypass condensers. One .25mf. a .001 mf., a 50 mmf., and a 100 mmf., one phone jack, two sockets, and a small can to house the unit.

Chapter IX

TEST EQUIPMENT

Advanced technicians know the value of modern test equipment. The introduction of the cathode ray oscilloscope now permits wave form analysis and a complete understanding of components that comprise radio receivers and associated equipment. Audio and radio frequency distortion can be traced in their respective circuits and swiftly corrected without removing unnecessary parts, which was formerly common practice in the radio field.

Sound technicians will find the oscilloscope of great aid in measuring the percentage of distortion and hum level in audio amplifiers.

Among some of its recent uses are the adoption of wave form patterns of which photographs are made and used in designing clothes. Many prominent clock manufacturers use the oscilloscope for timing watches.

The oscilloscope is used by amateurs in checking percentage modulation of transmitters. An all wave oscillator is of inestimable aid in proper alignment of intricate and complicated circuits, which could not be done without an efficient generator.

Receivers that have been in operation for some time require re-alignment when distortion is present or a noticeable lack of sensitivity decreases the volume that the receiver previously had. This condition is usually due to moisture that changes the capacity of the trimmers. The tension of capacitors (trimmers) will also change due to natural mechanical structure, and will cause depreciation of sensitivity.

Obviously, as stated above, periodic adjustments by a competent radio service man is essential.

On the newer all-wave receivers, this condition is true, and the re-adjustment of these trimmers is very critical on the high frequencies, and sometimes these trimmers are disturbed by vibrations of the receiver itself.

The all-wave oscillator illustrated in this chapter completely covers the range of any commercial receiver, and is easily constructed at a nominal sum that rivals the highest priced generators.

A magic eye output indicator together with above equipment usually completes the set-up without an oscilloscope or when one is not available. The cost of construction of this output indicator is nominal.

The Vacuum tube voltmeter can be used in determining R.F. gain per stage without sacrificing any losses, or negligible losses due to inefficient equipment.

A.V.C. voltages can be measured with a vacuum tube voltmeter to determine whether that portion of a receiver is operating properly. This instrument can measure very minute quantities of electricity as it does not draw any appreciable amount of current.

It is no longer possible to correct trouble without the use of up-to-date equipment. The days of the screw driver mechanic is gone because modern day circuits are very intricate, and can no longer be repaired without essential test units that are required. With the development of circuits such as Automatic Volume Control, NOISE SUPPRESSION—and various other involved arrangements, some of the operating voltages are so small that unless the proper test units are used it is almost impossible to realign the new type receivers without messing up the delicate trimmers and padders.

The oscilloscope permits wave form analysis of all components in any part of circuit without distorting or disturbing the receiver under observation. This unit does not draw any appreciable current from the set under test, and that is why it is used by our leading service engineers.

The construction of an oscilloscope is the first step (in the opinion of many experts) for the Serviceman and experimenter if he expects to construct or service Television receivers in the near future. There is much to be learned by playing around with a Cathode Ray Tube, particularly the handling of high potentials required for its operation. Using a 906 type three (3") cathode ray tube the operating voltage is approximately 1000 volts. Be sure and use heavy insulated wire to carry this voltage, to prevent the possibility of arcing to chassis. Larger cathode ray tubes require even higher voltages ranging from 2000 volts up. To insure success in the construction of an oscilloscope be certain that the power transformer is placed behind the cathode ray tube. However if this advice is disregarded the spot on the tube will be distorted and broad instead of even and small. The saw tooth oscillator required for the time base is another important factor for successful results. Use the best material obtainable.

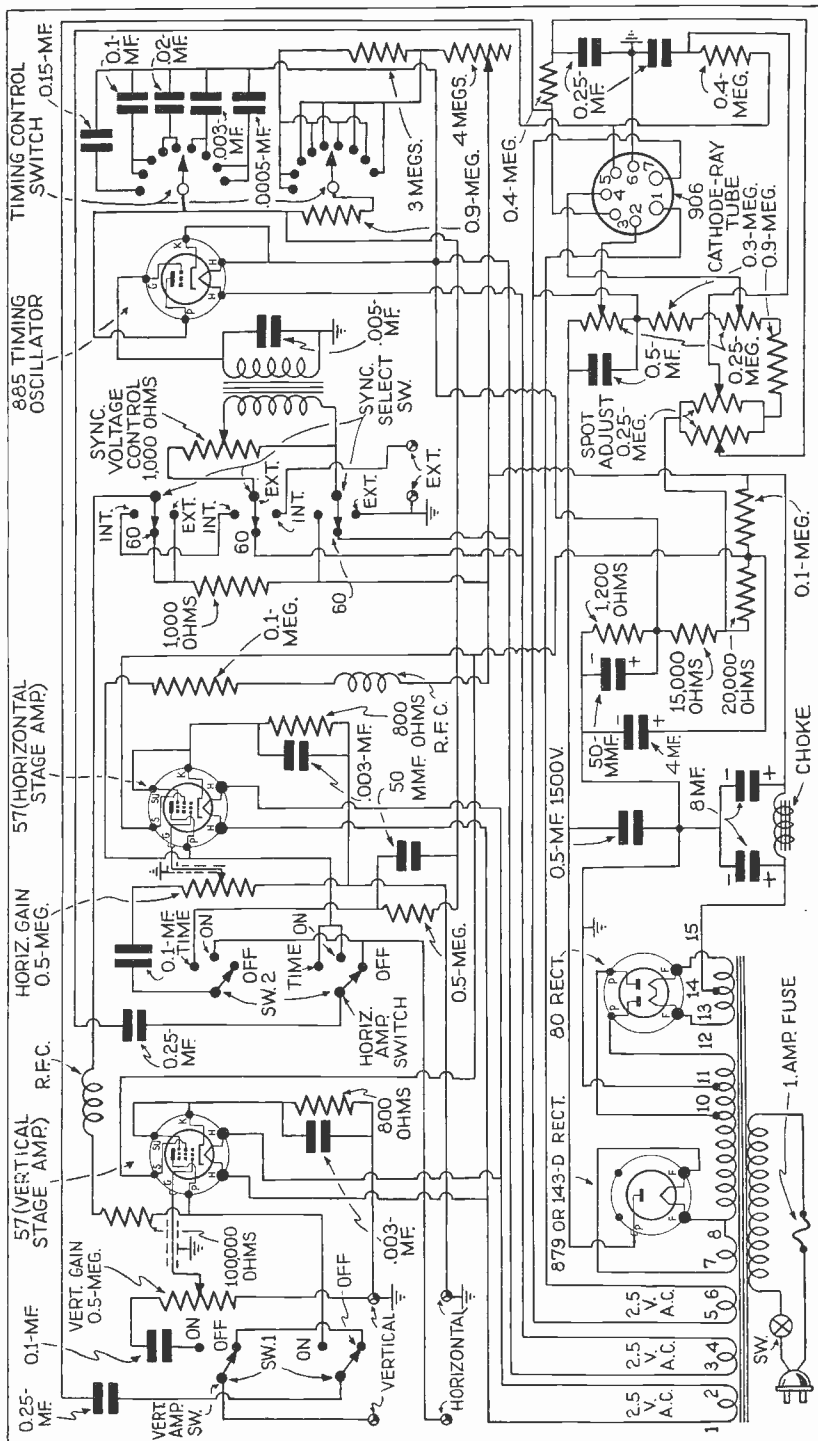


Fig. 82—Shows a well designed oscilloscope with vertical and horizontal amplifiers. A type 906 cathode ray tube operating on 1000 volts potential. A timing oscillator capable of generating frequencies of between 15 and 20,000 cycles per second using a type 885 tube.

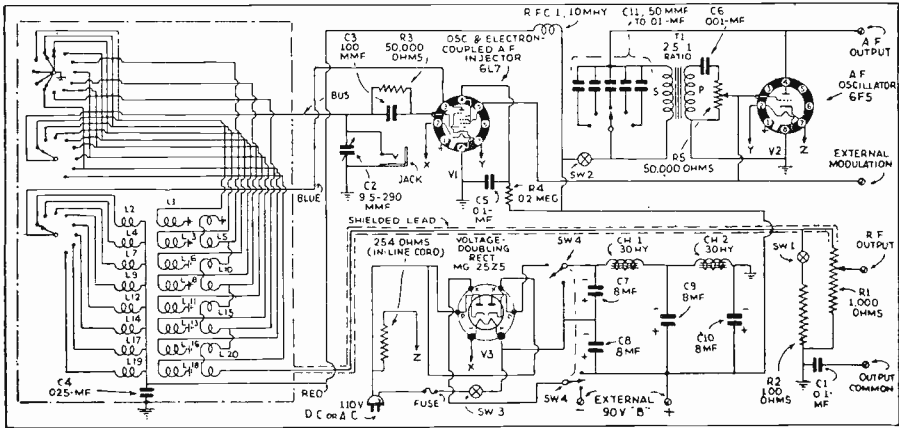


Fig. 84—Illustrates one of the designed all wave oscillator circuits. An efficient generator is considered the most essential piece of test equipment that is needed by all experimenters and technicians. The present day all wave super-heterodyne receivers require periodical realignment, and unless a good oscillator is used this job can not be accomplished. The generator shown here is A.C.-D.C. operated with 25Z5 rectifier. For A.C. operation the 25Z5 is used as a voltage doubler. The most important thing to remember in building this unit is to purchase the best coils possible that satisfactorily cover the various bands. A 6L7 is used as the oscillator tube and is electronically coupled for stability and has an oscillating constancy over the entire band. A 6F5 A. F. oscillator for modulation makes a satisfactory combination. This generator can be modulated or unmodulated at the will of the operator. It is advisable to house the coils in a metal container shielded from the rest of the components. An external modulator connection for a wobulator is provided for use with an oscilloscope. This is necessary in aligning I.F. transformers for visual observation. For D.X. fans, an unmodulated signal will greatly assist in bringing in distant stations which otherwise may be missed. The output of the oscillator is being attached to the second detector of the receiver, and set 1000 cycles above or below the I.F. peak.

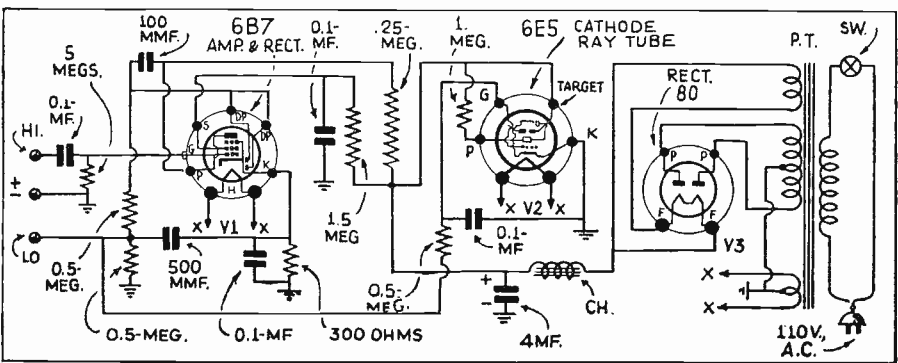


Fig. 85—Illustrates an extremely efficient magic eye 6E5 that can be used with an efficient oscillator in aligning receivers. This combination is satisfactory if an oscilloscope is not available. This indicator is self powered and uses a 6B7 tube as an amplifier and rectifier.

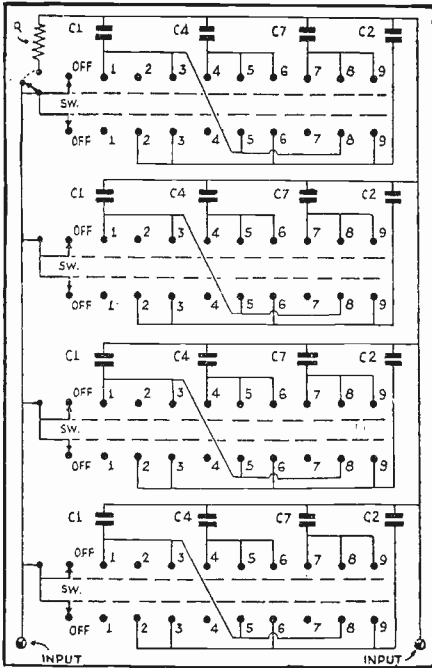


Fig. 36—Illustrates a simple decade condenser box. The technician will find a time saver in localizing condenser troubles. Many servicemen can make excellent use of this unit. Condensers that open up and motor-boating in midget receivers can be quickly traced by using this instrument. Many of the commercial receivers frequently have defective condensers and the capacities (not indicated on them) have for some time been a thorn in the side of the radio servicemen. It was necessary in order to correct the trouble to constantly refer to commercial data which wasted a great deal of time, and not always on hand. Therefore by constructing this unit, the Service Man will obviously save many precious minutes that may sometimes mean many dollars in his coffer.

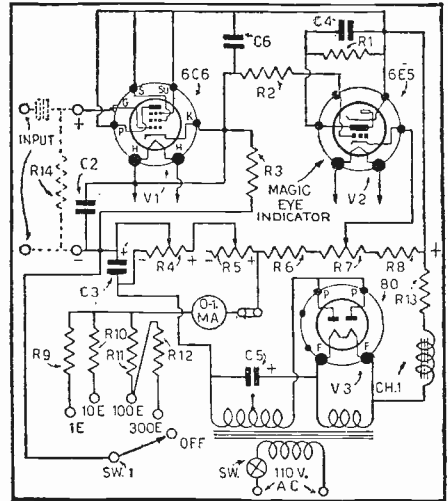


Fig. 38—Illustrates a magic eye 6E5 Vacuum Tube Voltmeter. This instrument can be used in R. F. tests without drawing any current that otherwise would disturb the circuit. A vacuum tube voltmeter can be put to a great many uses by ambitious experimenters such as measuring the gain per stage. A.V.C. measurements can accurately be made with this instrument. Checking TRUE A.V.C. variations with ordinary instruments, such as analyzers or voltmeters, does not indicate the correct voltages indicated on the scale; this is due to the current drawn by the meter for its movement. This vacuum-tube voltmeter is A.C. operated and uses an 80 full-wave rectifier, a 6C6 and a 6E5 magic eye tube. The resistors shown in this drawing must be absolutely the best obtainable in order to insure accurate readings. The 0-1 milliampere meter will measure voltages ranging from 0- to 1 volt, 10, 100 and 300 volts.

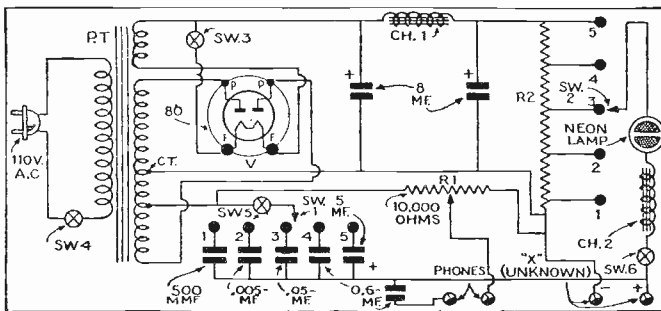


Fig. 37—Is a capacity analyzer. This instrument has many uses in checking the capacities of condensers where a positively accurate value is necessary and no guess work will do. This condenser analyzer is A.C. powered using an 80 full-wave rectifier. Most of the necessary parts are usually found in experimenters' or Service Men's homes. The only other parts needed are a neon bulb and selector switch.

Chapter X

TELEVISION RECEIVERS

Television receiver efficiency must be many times greater than the broadcast receiver, since it must cover a frequency band ten to twenty times as wide. Care must be exercised by the constructor and a knowledge of short wave receivers is absolutely necessary.

Commercial television transmission is now being conducted on the extreme high frequency bands with a limited range. Therefore, it is most important for the success of a television set that proper design and the best of equipment obtainable be used.

A brief review of some of the early television systems is herewith given. There are many experimenters who still use the whirling disc for scanning images. The success of this system is dependent upon the exact synchronization between the transmitter and the receiving system. The mechanical system is much cheaper to construct than the newer Cathode Ray (or, electrical system of scanning). The most essential equipment necessary for mechanical scanning is a perfect disc, coupled to an electric motor; and directly in line with the aperture holes is a sensitive neon tube for viewing.

The leading laboratories have superseded the mechanical scanning with the electrical means of scanning. (Cathode Ray Tube). This latter system is more costly, but the results obtained are worth the added expense. With the electrical scanning system, larger pictures can be received, and it has been found to be more reliable since it must, at all times, be in exact synchronization with the transmitter.

Illustrated, is a television receiver using the new metal tubes, with two separate channel amplifiers. One vision channel with I.F. peaked transformers at 3,100 K. C.; and the sound channel amplifier with I.F. peaked transformers at 5,350 K.C.

This is particularly interesting to many advanced technicians who wish to construct a television receiver with a minimum of tubes, and at the same time obtain maximum efficiency. This television receiver has been tested by experts and pronounced one of the best yet developed. The cost of this set does not exceed \$100, and is within the reach of many experimenters desiring an efficient receiver.

A three-inch Cathode Ray tube is used with low operating voltages. This compares favorably with the larger type Cathode Ray tubes

with higher operating voltages, and at less cost.

Recently the Radio Corp. of America has acquired two mobile trucks for outdoor television scenes. Unit number (A) houses the Television pickup units, and unit number (B) the subsequent amplifiers and Short Wave Transmitter. The main Television station in the Empire State Building picks up this signal and retransmits a stronger signal strength to the public in the metropolitan area. Unit number (B) is Airconditioned because of the intense heat generated by the amplifiers.

Research is constantly simplifying methods for scanning images with a minimum amount of luminous light. Prior to these recent developments the intense heat emitted by the terrific light banks made it unbearable for the person to be scanned for more than a brief period. However now with the use of the newer types of Iconoscopes this is done away with.

There are still some problems that must be solved before commercial television is possible. For instance, the cost of presenting an actual scene is still prohibitive. Stage-craft technicians who have had experiences with motion pictures setups will undoubtedly lend their knowledge in simplifying the above, thus reducing the cost.

Linking broadcasting stations with Coaxial cable (into a national network) costs are terrific. But I am sure this will be met with more research.

A famous engineer has recently developed an Iconoscope that will enable three dimensional viewing. The third known as Depth for more realism. This marvelous contribution which nearly matches the human eye for viewing will go far in selling the idea to the public and sponsors.

It is the firm belief of most experts that in order to obtain perfection in television, a procedure that Radio went through in the early days should again be followed. It is well known that many worthwhile developments were contributed by amateurs, and the cost of efficient receivers reduced. Another important consideration is that the amateur is in a position to iron out many wrinkles in the field. Since the various locations differ in reception, complex problems will be met, and remedied by those out in the field.

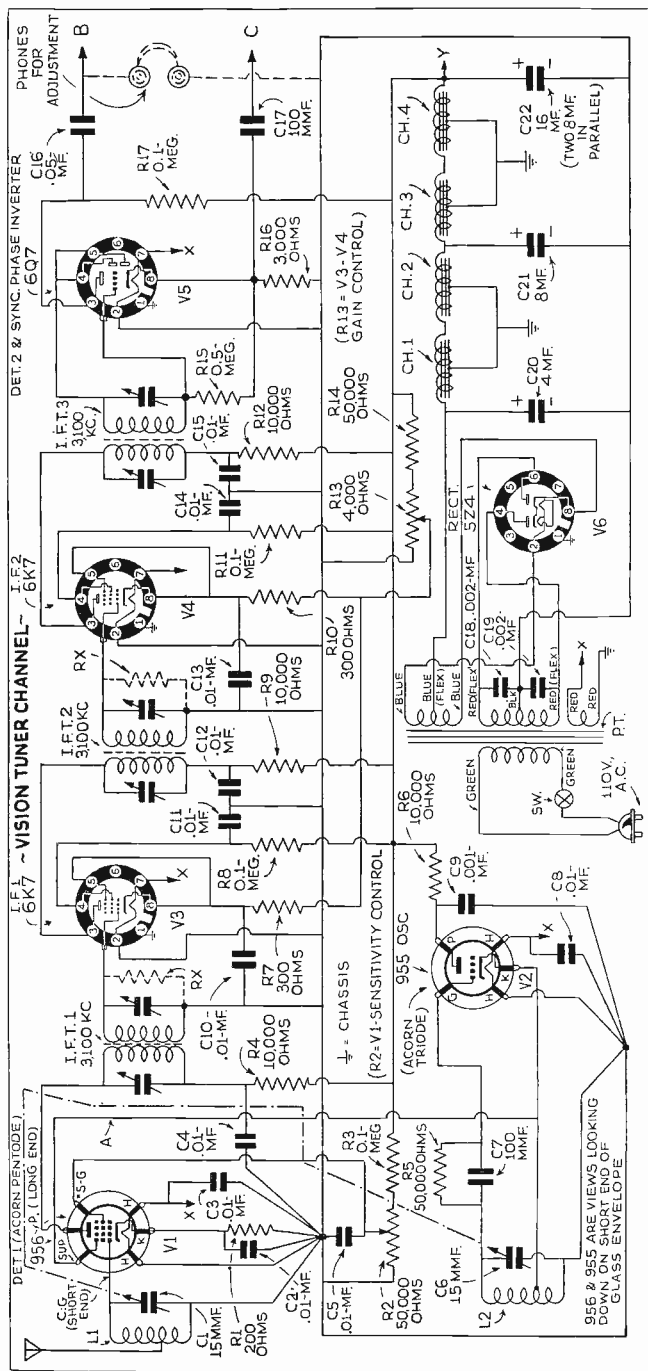


Fig. 39—Illustrates the Vision Tuner Channel. To insure the success of this tuner the best material available must be used. You will notice that a 956 variable mu acorn tube is the first detector, and a 955 acorn tube as the oscillator. Two stages of Iron Core I.F. Coils peaked at 3100 K.C. 6K7 metal tubes are used in these I.F. stages. This is followed by a 6Q7 second detector and syn. phase inverter. Care must be taken in the construction of the power pack in order to eliminate hum. Therefore four filter chokes and adequate filter condensers are needed together with a 5Z4 full wave rectifier. As indicated on the diagram Points A.B.C. are the connections for the sound channel amplifier.

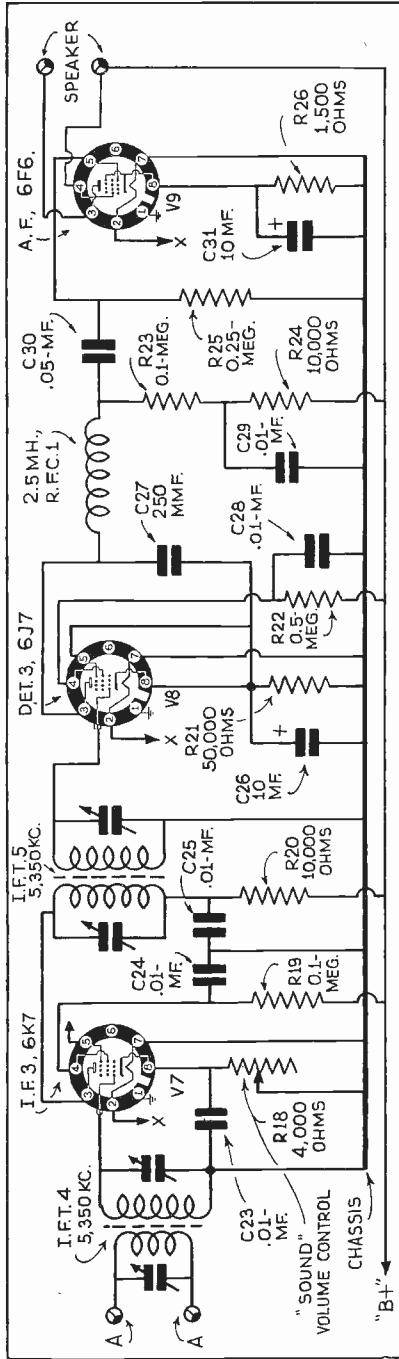


Fig. 90—Illustrates the sound channel amplifier with I.F. peaked transformers at 5350 K.C. Point A the input of this amplifier is connected to the first detector of Fig. 89. One stage I.F. stage was found to be sufficient for the sound channel amplifier, in order to avoid complications. A 6K7 is used as the I.F. tube and is followed by a 6J7 third detector, and in turn feeds a 6F6 power output tube for speaker operation. A 4000 ohm volume control is used to vary the bias of third I.F. 6K7 tube. Decoupling resistors are included to insure against possible interaction from the power supply, and sufficiently by-passed. All leads in constructing this unit must be made as short as possible. The television receiver shown in this chapter required a great deal of experimentation. Many types of systems were tried, and compared, yet the circuit illustrated here functioned best. Now with the addition of two Mobile Vans purchased by the R.C.A. for outdoor scenes more television programs will undoubtedly be transmitted. For good television reception on the Short Waves particular attention must be given to the construction of the receiving antenna. Another important fact to remember in order to avoid distortion that may be induced through the power lines is to add line filters that will adequately by-pass any undesired fluctuations, that may feed back into the receiver.

In the construction of this receiver be sure and use **HEAVY INSULATED WIRE** for the leads carrying **HIGH VOLTAGE** potentials. This is imperative if arcing is to be avoided.

Another important note; Keep the power transformer behind the Cathode Ray tube. For if this is not followed the spot on the fluorescent screen may be coarse and distorted.

The picture received will also have a tendency to vary in a way fashion seen when an object is viewed in water. The reason for this is obviously due to the field radiated by the power transformer. A well shielded transformer with the proper operating voltages is required.

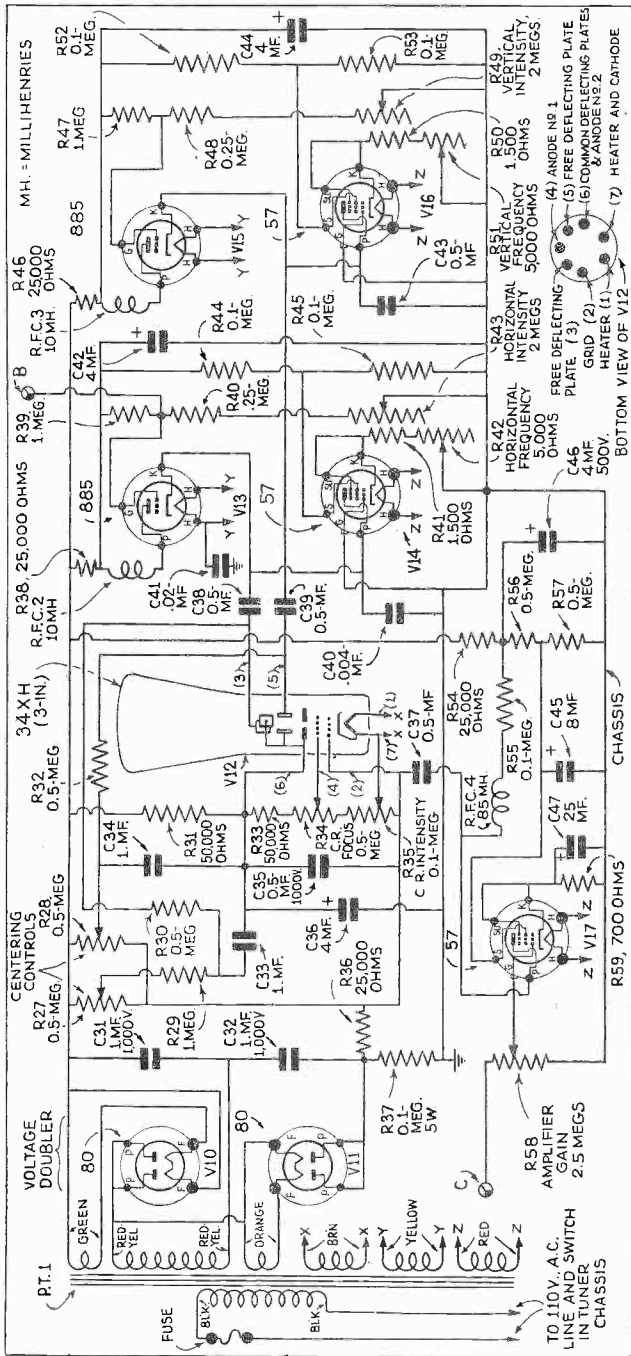


Fig. 91—Illustrates the most important unit of the television receiver to construct. Two amplifiers are used, one a 57 tube vertical amplifier. Two hydratron 885 gas sweep oscillators, a wide range A.F. amplifier 57 tube, two No. 80 rectifiers which supplies all necessary voltages for this unit, and lastly the cathode ray 3" tube. Precaution must be taken in wiring the high voltage leads. Use heavy insulated wire so that no arcing will take place and cause damage to some of the components. For more information regarding this receiver refer to Radio-Craft magazine issues from Jan. to April, 1937.

Chapter XI

MISCELLANEOUS APPARATUS

Experimenters will find numerous devices that undoubtedly will be of benefit to them in their desire for improvements in radio receivers.

For high fidelity reproductions of very selective receivers, it is essential to broaden the curve in order to allow a wide passage that accompanies high fidelity transmission.

On the high frequencies, listeners can much more easily tune in distant stations with a beat frequency oscillator that is easily constructed and costs but a few dollars and is worth the effort to build.

Illustrated is an AC-DC electronic relay. This device may be installed in many needed places, and can be made to perform many du-

ties, such as opening a garage door on the approach of a car in the driveway, or automatically doing any manual work possible by man. Its uses are many, and I'm sure experimenters will find this device of interest.

Another quite interesting device is the speech inverter. A skeleton circuit of the methods of connections will make possible garbled speech. A system somewhat like this is used for transatlantic telephone use. I am sure listeners on short waves have intercepted these garbled voices and at the time did not understand the reason for it. It is obvious that commercial companies must maintain secrecy for their clients.

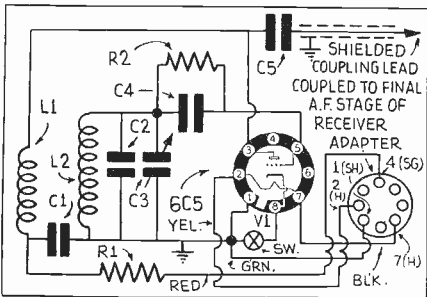


Fig. 91—Shows a circuit of a beat frequency oscillator that may be attached to any worthwhile receiver. Its purpose is to aid in bringing in distant stations.

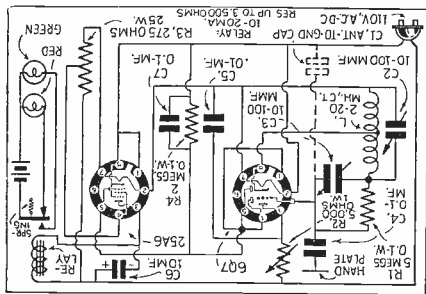


Fig. 92—Illustrates an AC-DC Electronic relay. This device may be installed in many needed places, and can be made to perform many duties.

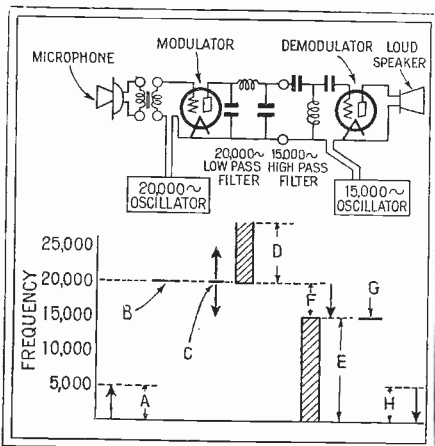


Fig. 93—The speech inverter. A skeleton circuit of the methods of connections which makes possible "garbled" speech.

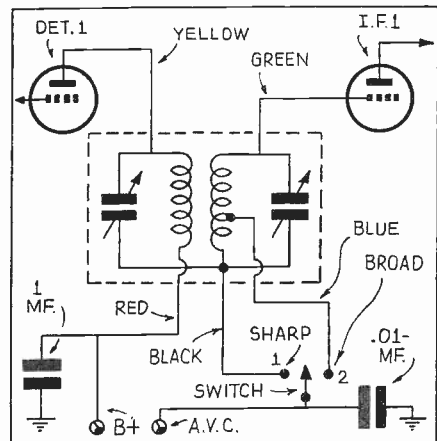


Fig. 94—Illustrates a basic circuit of band widener. For high fidelity reception it is necessary to broaden the frequencies passed.



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