NEW RADIO QUESTIONS AND ANSWERS

ANSWERS TO QUESTIONS MOST FREQUENTLY ASKED BY BOTH NOVICES AND EXPERTS

BY ROBERT EICHBERG

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RADCRAFT PUBLICATIONS, INC.
99-QA HUDSON ST.
NEW YORK, N. Y.
New Radio Questions and Answers

Answers to Questions Most Frequently Asked by Both Novices and Experts

By

Robert Eichberg

Radcraft Publications, Inc.
Publishers

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Introduction

Ever since the first radio enthusiast put the crystal detector in series with a pair of phones and listened to old KDKA sending out its test programs, questions have arisen relative to circuits, components and theories.

In eighteen years of radio experience the writer has answered many hundreds of thousands of questions from radio listeners. From these, those of most general interest have been selected, tabulated and classified under general headings for easy reference.

Radio developments bring such rapid changes that it is virtually impossible for anyone not actively engaged in the radio industry to keep abreast without reference to some work of this nature. Therefore, questions relating to automatic tuning, automatic volume control, phono-radio, auto-radio and various other phases of the art have been selected for inclusion in this volume.
Set Ailments and Their Symptoms

In order to save space, numerous questions as to "Can defective A.F. transformers be the cause of insufficient volume?" or "Do you think my loud speaker is going bad? My set sounds tinny," etc., the following table, adapted from material which has appeared in Radio-Craft and Radio Today. It lists the elements of the receiver, and the symptoms which defects in them may cause.

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NEW RADIO QUESTIONS AND ANSWERS

CHAPTER 1

Definitions

A.C. AND D.C. (Q) What is the difference between Alternating Current (A.C.) and Direct Current (D.C.)? (A) Alternating current reverses its direction of flow at regularly recurring intervals. In standard house lighting current, the cycle is: Zero, maximum positive, Zero, maximum negative, Zero, and takes place completely 60 times per second. In brief, both terminals of the line go through this cycle, one being maximum positive when the other is maximum negative.

Direct current flows in one direction only, like the current from a battery. A.C., for radio purposes, is more flexible; its voltage may be raised or lowered through the use of a transformer, and it is easily rectified (changed to direct current) when D.C. is needed. D.C.

![Fig. 1](image)

may have its voltage reduced by being passed through a resistor; its voltage raised by charging it into a pulsating D.C. (which acts like A.C.) by mechanical means, such as a vibrator, or by certain tubes. It may then be handled like A.C., but must be rectified again to be used as D.C. at the new voltage.

AUDIO-FREQUENCY AMPLIFIER (Q) What is an audio frequency amplifier? (A) Frequency is the number of vibrations (or electrical impulses) per second. If the air is caused to vibrate at any frequency from about 30 to 14,000 times per second, the vibrations are audible—they can be heard by the human ear. An Audio-Frequency Amplifier is a device constructed to strengthen electrical impulses of the frequencies lying between these limits.

AUTOODYNE CIRCUITS (Q) I have been told that my set is an autodyne receiver, but I bought it for a superheterodyne. Was I misled? (A) No. An autodyne is a superhet which uses the same tube as oscillator and first detector.

AUTOMATIC VOLUME CONTROL (Q) What is an automatic volume control? Does it replace the usual manual volume control? (A) The automatic volume control is a highly ingenious circuit which keeps the output of an intermediate frequency amplifier approximately constant, though the signal input to the amplifier may vary widely. It does not replace the manual volume control.

Quiet automatic volume control (Q.A.V.C.) is a means of reducing the set’s sensitivity at will; so that background noise between stations will not be heard while the set is being tuned, though the signal input of a station’s carrier wave will cause the set to function.

BAFFLES (Q) What are baffles, and what are the “magic voice,” the “labyrinth” and similar set features? (A) When a loud speaker is reproducing the program of a station, its diaphragm vibrates, causing the air which rests against the back of the diaphragm to vibrate, as well as that which rests against the front of the diaphragm. There is some tendency of these vibrations to “cancel out,” especially in the lower registers, but by placing the speaker in the center of a partition, the path which air vibrations must travel to get from the front of the speaker around to the back is greatly lengthened, and bass reproduction is improved. The longer the path, within certain limits, the better the reproduction, and the “labyrinth” forms a long, non-resonating path. The “magic voice” is another baffle system, tuned to resonate at frequencies which usually come through the amplifier weakly; thus it builds them up.

Of course, if the back of the loud speaker were sealed in, there would be no path from front to back, but this cannot be done. One reason is that the air cushion formed in the rear chamber would muffle the speaker tones.

BY-PASS CONDENSER (Q) How can you tell a by-pass condenser from other condensers by looking at it? (A) By-pass does not describe the condenser itself, but its use. It is simply a condenser used to provide a low impedance path for an alternating (or pulsating direct) current around some unit which has a higher A.C. impedance. For example, it is used to by-pass radio-frequency currents through a circuit, so that they will not have to travel through a power pack. You cannot tell by looking at a condenser; you can tell by analyzing its purpose in a circuit.

CARRIER WAVE (Q) What is the difference between a broadcasting station’s wave and its carrier wave? (A) In a broadcasting station, an alternating current is generated by oscillating vacuum tubes and fed into the antenna, after being amplified. The wave then radiated by the antenna is the station’s carrier wave.

When sound is picked up by a microphone and amplified, then used to shape or “modulate” a carrier wave, the result is a modulated carrier, which is probably what you have in mind. But, in all practical intent, a station’s wave and its carrier wave may be said to be identical.

![Fig. 2](image)
NEW RADIO QUESTIONS & ANSWERS

BAND-PASS FILTER

(Q) My set is said to have a band-pass filter. What is that? (A) A filter, electrically, is a circuit which prevents the passage of certain frequencies. A band-pass filter prevents the passage of all frequencies not in a certain continuous group, or "band."

CATHODE AND FILAMENT

(Q) Is the cathode of a tube the same as its filament? (A) In some cases it is, in others it is not. The cathode of a tube is the element which emits electrons. In some models of tubes, particularly those designed for battery operation, the element which is heated by the passage of current (the filament) also emits electrons. In this case, the filament is also the cathode. In other tubes, designed for A.C. operation (especially in the earlier stages of the set), the alternations of the current would cause an irregular emission of electrons and hum in the set. For this reason, the filament (called a "heating filament") is kept separate from the cathode, which is made of a substance that heats and cools relatively slowly; so that the fluctuations of the heat in the filament have no effect on the electronic emission.

AMPLIFIERS

(Q) I have heard of Class A, Class B, Class AB and Class C amplifiers. Please tell me what each of these is. (A) The difference is in the degree of grid bias and its effect upon plate current. Class A: balance of grid bias with alternating grid voltage is such that the tube's plate current flows at all times. Class AB: balance is such that tube's plate current flows more than half, but less than all, of the electrical cycle. Class B: balance is such that plate current is zero when no alternating grid voltage is applied; thus plate current flows for approximately half of each electrical cycle. Grid is biased to about cut-off point. Class C: balance is such that plate current is zero when no alternating grid voltage is applied; thus plate current flows for measurably less than half of each electrical cycle.

LOUD SPEAKERS

(Q) A set I just bought is supposed to have a dynamic loud speaker, but I just got a manual for one magnetor tube and find that there is no field winding. Does this make it a regular magnetic speaker? (A) Not necessarily, for some dynamic speakers are now made with powerful permanent magnets to supply the field, instead of using electromagnets. The mark of the dynamic speaker is the voice coil, affixed to the diaphragm. A dynamic speaker is a "moving-coil" speaker. A magnetic speaker has fixed (i.e., stationary) coils which act upon an armature that transmits motion to the speaker diaphragm.

ELECTRONS

(Q) I hear of cathodes emitting electrons. What are electrons? (A) They are generally considered the smallest possible particles of matter, and are sometimes defined as minute charges of negative electricity. This definition is supported by their tendency to be attracted by a positively charged electrode, such as the plate in a vacuum tube.

FIDELITY

(Q) Some radio sets are called "high fidelity" sets. What is high fidelity? (A) In this application, fidelity means the degree to which a radio receiver accurately reproduces, at its loud speaker, the audio-frequency component of the wave which reaches its antenna. Some broadcasting stations radiate waves modulated by audible frequencies which range from 30 to 14,000 cycles, the average limits of human hearing. While almost any set will reproduce the frequencies from 100 to 4,000 cycles (and many up to 7,500) most will not. Those which do so, give more faithful reproduction—are, in short, high fidelity sets.

FILTERS

(Q) What are filters, as used in radio sets? (A) Filters have several purposes in radio receivers. One kind of filter, used in the power pack, permits the passage of direct current from the rectifier, but will not pass the fluctuations which result from rectification. Another common type is the band-pass filter, which permits the passage of certain frequencies, but cuts off, in whole or in part, frequencies lying above or below the desired band. Others include the "line noise filters" used to keep R.F. disturbances in the house current lines from getting into the set, while permitting the passage of the power; and needle scratch filters used in phonograph installations, to cut off the high frequencies generated by the friction between the needle and the record's surface. Filters may consist of chokes or condensers, or combinations of the two; in a few applications, resistors may also be used.

FADING EFFECTS

(Q) Sometimes when I am listening to distant stations, the signals get weaker for a while and sometimes do not appear, then come back again without my returning the set. What is wrong with my radio? It does not happen on my friend's set. (A) Probably nothing. Fading is an effect which often occurs when distant stations are received. It is due to atmospheric conditions between the transmitter and the receiver. There is nothing you can do about it. Your friend's set probably has an automatic volume control, which your set lacks. While AVC does not entirely overcome fading, it does tend to minimise the effects, by keeping volume relatively constant.

RECTIFIERS

(Q) What types of rectifiers are in general radio use, and what are their purposes? (A) Vacuum tube and metallic. The former are used to change A.C. to D.C. in radio receivers; the latter, principally in metering form, to convert D.C. meters to A.C. use.

HETERODYNE RECEPTION

(Q) Please define heterodyne reception. (A) The type of reception in which a locally-generated oscillation (usually of different frequency from the received wave) is combined with a received wave. This is also called as "beat" reception. A superheterodyne is so called because the combined wave is supersonic (above audible frequency).

INTERFERENCE

(Q) What are the causes of interference? (A) Interference is of many types. Some of the causes are: (1) Atmospheric electricity—the
true "static"; (2) Electric disturbances caused by motors, switch, arcing, etc.—called "man-made static"; (3) Signals of undesired stations; (4) Heterodyning between the waves of a received station and an undesired station; (5) Line noise, entering the set through the power pack; etc.

Kilocycles
(Q) I see stations rated according to kilocycles. Does this mean their power?
(A) No. A station's wave is A.C., and kilocycles refers to the frequency, or number of times this current alternates from Zero to maximum positive to Zero to maximum negative to Zero each second. Each complete alternation described is one cycle; 1000 cycles per second is one kilocycle. Frequency (of cycles per second) has nothing to do with power; power is rated in watts or kilowatts (a kilowatt is 1000 watts).

MEANING OF MEG.
(Q) I know what ohms and cycles are, but what are megohms and megacycles? Are they larger or smaller than ohms and cycles?
(A) Larger. The prefix "meg" or "mega" means 1,000,000. Thus 1 megohm is 1,000,000 ohms, etc. Other prefixes and their common abbreviations will be found at the beginning of this chapter.

MERCURY VAPOR RECTIFIERS
(Q) What is the difference between a mercury vapor rectifier and other rectifiers?
(A) The mercury vapor rectifier, as the name implies, contains a little mercury which becomes vaporised when the tube is in operation. This decreases the internal resistance of the tube, so that there is less voltage drop in it.

MICROPHONES
(Q) What is a microphone, and how does it work?
(A) A microphone is simply a device for converting sound waves to pulsating D.C. or A.C., of corresponding frequency and proportional amplitude. There are five principle types in general use; dynamic, crystal, ribbon, condenser and carbon. The latter is merely a variable resistance, varied by movement of a diaphragm, actuated by sound waves, and controlling contact between the carbon grains in a small container. The dynamic is a diaphragm moving a coil in a magnetic field, and thus generating currents; the crystal is a diaphragm applying torque (twist) to a piezo-electric crystal, and thus generating currents; the ribbon is a metal strip cutting a magnetic field, and thus generating currents. The condenser makes use of the diaphragm as one of its plates, and thus varies the grid charge of a pre-amplifier.

MODULATION
(Q) When they say that a radio wave is modulated, what do they mean?
(A) They mean that the wave is "shaped" in accordance with an audio signal. This is done by decreasing the amplitude, phase or frequency of some of the waves in the carrier.

PULSAT D. C.
(Q) Is there any difference between A.C. and pulsating D. C.?
(A) Yes. A definition of A.C. is given at the beginning of this chapter. Pulsating D.C. is current which flows in but one direction; it may be interrupted, coming to a full stop at intervals, or may simply be flowing with greater and lesser force. It is as though an equal or lesser A.C. were flowing in the same circuit as the D.C.

PUSH-PULL
(Q) What does push-pull mean?
(A) It is generally used to refer to a stage of audio amplification, in which two tubes operate 180 degrees out of phase, the grid of one being maximum negative when that of the other is maximum positive. It may also refer to a microphone in which the two elements are similarly out of phase, as the double-button carbon microphone.

SELECTIVITY
(Q) What is the selectivity of a radio set?
(A) It is the ability of the set's circuits to tune to a desired carrier wave, while rejecting all others.

SENSITIVITY
(Q) And what is a set's sensitivity?
(A) The set's ability to respond to the signal to which it is tuned. A sensitive set will pick up and reproduce signals which a less sensitive set will miss.

SIDE BANDS
(Q) I know what a carrier wave is, but what are the side bands? And what is single-side-band transmission?
(A) The side bands are the frequencies on either side of the carrier wave's frequency and result from modulation. If a set is too selective, part of these side bands may be cut off, with resulting loss of fidelity. In single side band transmission, one of the side bands (and sometimes the carrier) is suppressed.

SUPERHETERODYNES
(Q) How is a superheterodyne different from other radio sets?
(A) In most other circuits, the signal is amplified at radio frequencies, detected, and amplified at audio frequencies. In superheterodynes, it may be amplified at radio frequencies, but must be "mixed" with a locally generated fre-
frequency, the resulting intermediate frequency being amplified in I.F. (intermediate frequency) stages, then detected and amplified at audio frequencies. (See Heterodyne). The mixer tube is also known as a modulator, frequency changer or first detector; the detector tube then being second detector.

WAVELENGTH

(Q) What is a wavelength, and how can these invisible things be measured in meters?

(A) Elsewhere in this chapter, there is a description of radio waves. The distances between the peaks of two cycles may be measured in meters or fractions thereof. If the distance between two such peaks is, say, 20 meters, the wave may be called a 20-meter wave.

Ridiculous as it may sound, a wave-length may be measured with an ordinary ruler. The output of a transmitter may be fed into two parallel wires. An electric light bulb connected across these two wires will, if the connections are shifted along the wires, glow brightly at the positive and negative peaks of the wave, and fade gradually as it passes them, going out entirely when it reaches the Zero points. If a measurement is made from one Zero point to the next, it will show one half a wavelength.

LINEAR POWER DETECTION

(Q) What is meant by “linear power detection”?

(A) The older methods of detector connection resulted in distortion on high power, due to the fact that the signal input exceeded the grid-bias potential. By raising the grid bias to a value not exceeded by the signal, operation on the “straight (linear) portion” of the tube’s “characteristic” curves results.

OSCILLATOR COUPLER

(Q) What is an “oscillator coupler”?

(A) This term is applied to the oscillator coil of a superheterodyne receiver and usually comprises a grid winding, a plate (feed-back or tickler) winding, and a coupling or pick-up winding of but a few turns. The grid and plate inductance are coupled to produce circuit oscillation, and the pick-up coil transfers a small portion of this high-frequency current to the frequency-changer.

ZERO BEAT TUNING

(Q) What is “zero beat” tuning

(A) With an oscillator or oscillating detector circuit, it means tuning exactly to the center of a station’s carrier wave. Adjustment of the tuning dial a hair’s breadth left or right will start a howl heard in the reproducer first as a growl and then, as the dial motion is continued, as a note rising in intensity and pitch to a powerful shriek, in most cases, going finally beyond the limits of hearing. Figure 5A illustrates this in exaggerated form.

COMPUTING THE DECIBEL

(Q) What is the “decibel” and how is the term used in connection with radio equipment?

(A) Since the decibel indicates a geometric relation between two figures, it may be used to indicate a rate of change either in sound energy or in electrical units.

The ear responds not in linear but in logarithmic proportion to changes in sound intensity. For example, although the energy ratio of a band playing soft or loud is 1,000,000/1, the ear appreciates it only as about 60/1; the figure 60 also is the “db” value.

The decibel, so often used in the work of audio amplification, transmission and reproduction, is simply the ratio between the strengths of any two signals, or the ratio of change in the energy of a signal when it is amplified or attenuated.

Ten decibels “up” on a signals means that the power has been increased tenfold; ten decibels down, that it has been divided by ten. The steps are unequal, but the peculiarities of this method of rating are based on physiological and engineering reasons. The decibel, as a mathematician would instantly see from the table given here, is a logarithmic unit (the number of decibels is represented by ten times the “common” logarithm of the ratio of change.)

Since the sound energy of the reproducer should be, approximately, in proportion to the electrical output power, and since electric power is measured by “voltage times current,” the power varies as the square of the voltage (or current). Therefore, the ratio of energy change corresponding to ten decibels is as much as the ratio of voltage (or current) change, corresponding to twenty decibels.

Fig. 6
Any signal strength may be taken as the base (or zero) in computing relative intensities. However, for voice-transmission measurements, six milli-watts (1.73 volts across a 500-ohm line) is a standard used by engineers. The ratio of change in power, and in voltage (or current) corresponding to any number of decibels, may be quickly found from the following table. Multiply the signal strength (or voltage) which is taken as the base, by the factor given in the proper column, opposite the appropriate number of decibels.
CHAPTER II

Vacuum Tubes

INACTIVE TUBES

(Q) My set stopped playing and I called a service man in. He tested my tubes and said I needed two new ones. He installed them and my set played all right. But what I cannot understand is why my old tubes were no good; they lit. Will you explain this?

(A) The filament or cathode of a tube is coated or impregnated with a substance which emits electrons when heated by the passage of filament or heater current. These electrons, being negative, are attracted by the positively charged plate. Their flow—the plate current—is controlled by the signal reaching the grid (among other factors). When the substance is used up to some degree, the flow of electrons is greatly decreased, so the electronic stream which the grid controls is greatly cut down, and the signal has little effect. The tube must then be discarded.

INTERNAL RESISTANCE

(Q) In a table of tube characteristics, is the plate resistance an A.C. or a D.C. value?

(A) The values are the A.C. resistances of the tubes. For three-element tubes this may be considered approximately the same for D.C. measurements. Four-element (screen-grid) tubes do not come within this class; their plate circuits' resistances (in ohms) are A.C. values, and are above the D.C. value.

TUBE CONNECTIONS

(Q) Please tell me how to know which are the plate, grid, screen-grid, suppressor-grid, filament, heater and cathode prongs on the more common tubes, by looking at them.

(A) It cannot be done with any degree of success, for tube types now vary so widely. You must refer to a chart, such as that given in Fig. 10. This chart also shows recommended plate, filament and grid voltages, the various tubes' uses, and their electrical characteristics.

"BLUE" TUBES

(Q) In the old days, when a tube showed a blue light around the plate, we were told it was no good and must be thrown away. Now when I buy certain tubes, I see a blue haze around the plate and the dealer tells me this is all right. What's the truth about this?

(A) The blue glow is caused by the ionisation of gases in the tube. In certain types of tubes, there is supposed to be a high vacuum, no gas being present; when such tubes show the effect, they are defective. Other types of tubes, however, have minute quantities of certain gases purposely sealed within their envelopes; it is perfectly normal for these tubes to show the effect.

BLOCKING TUBE

(Q) Does a "blocking" tube amplify?

(A) Ordinarily, yes; but the input and output coupling circuits may be so poorly matched as to amplify and pass only a small portion of the signal current; and the effect of a reduction in volume may in fact be obtained.

By using the new pentode-type tubes and correct resistors it is possible to obtain very effective amplification from one of these connected as a blocking tube.
CHAPTER III

The Antenna System

GOOD GROUNDS

(Q) What is the best way to ground my radio set?

(A) The best ground is a cold-water pipe. If none is convenient, the next-best ground is the RX cable in your house wiring system. The third-best is the steam pipe; it is far more convenient to use than the RX and is safer to install. If you live in a private house, and can get to the water meter, it is well to put a heavy wire lead (or "jumper") from the pipe that enters the meter to the pipe that leaves the meter, when using a water pipe ground. In using a steam pipe, it is best to put a jumper from it to a good ground, such as the water pipe. In making all ground connections to piping, use an approved ground clamp, and sandpaper the pipe bright before applying it. Should you live in the country where no piping is available, a good ground can be made by driving a piece of pipe (iron will do, but brass or bronze is better, being less affected by corrosion) at least 6 feet into moist soil. Burying a large metal plate, of the same metal, at a similar depth in moist soil in equally good. Solder connections to the outdoor pipe or plate, and use at least a No. 8 wire for the ground lead. The ground wire to an indoor ground is preferably No. 8, but wires as small as No. 14 are perfectly satisfactory. It does not matter whether the ground lead is insulated or not.

TYPES OF ANTENNAS

(Q) Will you please tell me the difference between doublet and other good antennas? What types of antennas do you recommend? Please describe each.

(A) The writer favors the "zeb," the single wire, the doublet and the spider-web, in the order named. The "zeb," shown in Fig. 11A, is much like the straight (or inverted L) antenna, save that a pair of twisted wires is used as the lead-in to decrease the pick-up of local interference. The lower end of the twisted pair is connected to a coil placed in inductive relationship to the grid coil of the first stage in the set; one side of the upper end is connected to the antenna wire, the other side, between two insulators. The straight antenna is equally good in areas where there is little or no locally generated interference. If interference exists, the zeb is better, or the lead-in may be a shielded line, as shown. In this case, impedance-matching transformers must be used at both ends of the lead, as shown in Fig. 11B if good results are to be obtained. The doublet is similar to the zeb, in that it uses a twisted pair lead-in. It consists of two separate antennas, each usually half as long as the wave most desired, and arranged end to end. The twisted pair is connected to the inner ends, as shown in Fig. 11C. Best results are obtained if impedance-matching transformers are used at both ends of the lead-in. The spider-web, Fig. 11D, is best described as a number of different length doublets, connected to the same lead-in. It is efficient, but somewhat more costly than the other systems.

NOISY ANTENNA

(Q) My set is very noisy when connected to my antenna. When the antenna is disconnected, the signals come in much more weakly, but without noise. Is there something the matter with my aerial?

(A) Most likely there is a bad joint somewhere in the system, or defective insulation. The bad joints are most likely to occur between (1) ground and ground clamp; (2) ground clamp and ground wire; (3) ground wire and ground post on set; (4) Antenna post on set and lead-in to window; (5) lead-in and window lead-in strip; (6) lead-in strip and external lead-in; (7) lead-in and antenna. All these joints (except the first, when made with an approved ground clamp) must be cleaned and soldered for best results. If antenna coupling transformers are used, joints to them should likewise be soldered. Leaky insulation may occur where a lead-in comes in contact with anything besides an insulator; see that this does not occur. It may also happen at a defective window lead-in strip, or at a dirty or cracked strain insulator on the antenna proper. The most usual cause of noise, however, is a twisted (instead of soldered) joint somewhere in the circuit.
NEW RADIO QUESTIONS & ANSWERS

PROTECTIVE CONDENSERS

(Q) What size condenser do you recommend for insulating aerial and ground against causing D.C. line fuses to blow?

(A) About 0.1-mf. will be quite large enough. The "operating voltage" rating should be at least 250 volts and preferably higher.

![Fig. 12](ANTENNA BINDING POST) (GND BINDING POST)

LIGHTNING ARRESTERS

(Q) Are lightning arresters really necessary? I understand that they are not used as much as formerly.

(A) It is quite true that a lower percentage of antenna installations use arresters for, if lightning ever really strikes an antenna, the whole system is likely to fuse. But the writer strongly recommends the use of these devices for two reasons. First, Underwriters' regulations call for them. Second, a thunderstorm may induce a sufficient charge in the antenna to burn out the R.F. primary coil, without lightning actually striking the antenna; in this case, the arrester by-passes the charge harmlessly to ground.

ENERGY PICK-UP

(Q) What proportion of the energy radiated from a station actually reaches my antenna?

(A) This depends upon a number of factors, including your distance from the station, the placement of your antenna, and the directive effect of the station's signal, if any. A good analogy is: Consider a big stone dropped into the middle of the ocean. It causes ripples to spread out in all directions, growing weaker as their distance from the source of disturbance increases. Stick a pin into the surface of the water, and the ripples caused by the stone will affect it with about as much power as the signals of a station fifty miles away affect your antenna.

LENGTH OF ANTENNA

(Q) I want to put up a plain, inverted L antenna. Which is best, a long one or a short one?

(A) In general, a long antenna makes the set more sensitive; a short one makes it more selective. You will have to strike a happy medium, getting the best possible sensitivity without sacrificing selectivity to the extent that the signals of two stations interfere with each other. In general, if you are distant from powerful local stations, use a long antenna; if such stations are nearby, use a short one. If you have an instruction sheet with your set, follow it.

MINIMIZING INTERFERENCE

(Q) A power line runs near my house. How can I cut down interference from it?

(A) Use a twisted pair or shielded lead-in, as described earlier in this chapter. Also, locate your antenna at right angles to the power line, with the lead-in at the end furthest from the line, if this can be done conveniently.

TREE ANTENNA

(Q) Is there a "correct" way of "hanging" an antenna between a house and a tree? It seems those installed without due regard for the swaying of the tree do not stay up very long.

(A) Apropos of this subject here is some interesting information furnished by the Jacey Tree Expert Co., as follows:

Where radio antennas are attached to trees, the manner in which the attachment is made may determine whether the tree or part of it will be killed. Too often the antenna is fastened by means of a wire that encircles a branch or perhaps the main trunk. In those cases where the encircling wire is used, no immediate harm will result aside from a certain amount of chafing which may or may not damage the living bark tissue. But, as the trunk or branch grows in diameter, the wire begins to press against the bark. In a relatively short time it becomes deeply imbedded and strangulation results, for the sap that flows in the inner bark is cut off by the wire barrier. The death of the branch or trunk quickly follows.

"To avoid the possibility of injury, the safe method is to use either a lag hook or a pulley with a screw end. These should be attached in the manner shown in the illustration." (Reproduced here as Fig. 13), "using first a bit to make the holes in which threaded attachments are to be turned. The hole bored by the bit should, of course, be a little smaller than the diameter of the lag or screw, in order that the threads will hold firmly.

"The system suggested will not interfere with the life functions or normal growth of trees. It will prevent much of the needless injury that has often been done to fine shade trees in the past."

Certainly this is valuable data for the Service Man who wants his installation to be as good as possible. We might add that it is well to keep the aerial itself about ten feet from the leaves of the trees; this may necessitate the use of an insulator at this distance from the tree end of the antenna. Of the two methods illustrated above, the weight seems preferable, as most springs, through the action of strong winds, gradually lose their elasticity and become inefficient.

"COMPENSATING" THE ANTENNA COIL

(Q) Is it possible to balance the antenna circuit of a receiver by taking turns from the antenna coil only?

(A) It is best to balance all the inductances first.

It is preferable to balance a coil by removing or adding turns until resonance at a particular frequency is obtained when a given value of tuning capacity is used in shunt. A Small "trimmer" condenser may then be placed in shunt with the tuning condenser and coil when assembled as a unit, and the minimum capacity of the circuit matched to the minimum of the other circuits. If the placement and design of the parts have been correct, the circuits should tune correctly throughout the tuning range. If they do not, the origin of the fault should be determined.
CHAPTER IV
Radio Frequency Circuits

HAND-CAPACITY EFFECT
(Q) I cannot seem to eliminate "hand capacity" effect in a receiver I have. I can tune stations in and out by moving my hands in relation to the tuning dials (metal). Have grounded everything in sight, including condenser rotors and the dials. What is the cause?
(A) Probably high ground lead resistance.
1. Ground lead may be too long;
2. Ground wire may have a high resistance or be open;
3. Earth to which grounding conductors lead may be dry;
4. Defective ground clamp;
5. Open at the set "ground" binding post.
6. If house piping is used, this may have several high-resistance joints. (In many gas or electric piping systems, remember that "insulating couplings" are used; employ "jumpers.")

DUSTING OF CONDENSERS
(Q) Isn't it carrying things to extremes, to dust between the plates of variable condensers?
(A) Not at all. During dry weather the dust may not cause much trouble but as soon as the air becomes damp, the dust absorbs moisture and becomes very conductive. These hundreds of conductive paths from rotor to stator form a resistance network of very low value. The observable results are broad tuning, cracking sounds and loss of sensitivity. Modern radio sets are well shielded instruments and are seldom affected by dust.

BLOCKING-TUBE USAGE
(Q) What is the reason for using a "blocking" tube?
(A) The inductance and capacity values of the aerial, and the primary of the input transformer form a circuit having frequency-discrimination characteristics, resulting in uneven operation over the tuning band. "Dead spots," these are called. (This effect is particularly pronounced on the waves below 200 meters.) The use of a blocking tube greatly reduces this effect; and it accomplishes two other results.
First, it makes "ganging" of the tuned stages a more convenient and satisfactory proposition. Second, it greatly reduces the radiation of interfering signals when circuit oscillation results due to a "spill-over" of a regenerative circuit.

ALIGNING T.R.F.
(Q) What is the best way to align the T.R.F. stages of a set? I have no oscillator equipment.
(A) Pick the range (i.e., upper or lower end of the dial) that is most used. Take a station about the midpoint in that range—preferably a rather weak station—and tune it in. Adjust the trimmer condensers on the first, second and third stages, going back to each one several times if necessary, until the station is received with maximum clarity and volume. About 850 kc. is a good frequency if the upper end of the dial is most wanted; about 1200 if the lower end. Then tune in several stations, making "compromise" adjustments if any cannot be heard. Reset the dial scale to conform to the new trimmer settings, if necessary.

STANDARD R.F. CHOKE
(Q) What size and kind of wire and number of turns should be used in winding an 85-milli-henry choke coil of small dimensions for use in a radio-frequency circuit?
(A) An R.F. choke of this rating may be made by winding three 'pies' of number 34 S.C.C. wire on a form 3/8-in. in diameter; each section should be 3/16-in. wide. (A wooden rod with three grooves turned in it will be a convenient method of obtaining this form.) In one end section, wind 550 turns; next, 700; and last, 800. The end of the 800-turn section should be connected to the plate (or high-potential) side of the circuit for best results as this construction results in a "polarized" unit having greater choking action in one direction.

T.R.F. REGENERATION
(Q) Would the sensitivity of a tuned-radio-frequency receiver be increased by adding regeneration to the R. F. stage, as per marked diagram?
(A) This circuit, which we reproduce as Fig. 14, is quite practical, if the operator does not object to the difficulty of tuning. This arrangement is only for those who have infinite patience, and due appreciation of what happens in a neighbor's radio set when circuits such as this are adjusted.
As to the sensitivity; it is no greater than would be that of the standard circuit if the number of turns in L4 were increased to the point of oscillation, and some oscillation control incorporated in the set. As the rotary L3 and L6 unbalance the tuning of circuits L2 and L5, a critical condition obtains; varying L3 or L6 disturbs the stability of the system again, and causes everything to go out of adjustment.

COIL ALIGNMENT

(Q) Is it harmful practice to compensate, for capacity between turns in an R.F. coil that has been space-wound, by forcing together a few turns at one end in order to increase or decrease the turn-to-turn capacity? Will this practice result in a change in the over-all capacity and prove detrimental to the operation of a radio receiver?

(A) It is presumed that operation of a gang condenser is the objective; otherwise, such accurate balancing of coil characteristics would not be necessary. The first point to be considered is that each tuned circuit should have its inductance and capacity distributed in the same proportions. For best results, the self (turn-to-turn) capacity of the coil should be evenly distributed along the length of the winding; however, if it is "lumped" at one end or the other of one coil, it should be similarly lumped in the other coils. If the turns are forced out of their original positions the wire is usually loosened slightly, and then the entire coil becomes loose in a fairly short time, since temperature variations cause expansion and contraction of the tube on which the wire is wound. See Fig. 15.

MULTI-STAGE T.R.F.

(Q) Is it possible to build a receiver with six or seven stages of tuned R.F.?

(A) Receivers having this number of stages have been built. They are impractical for ordinary commercial production because it is too difficult to maintain circuit resonance and selectivity throughout the tuning band, with one-dial control, except as a laboratory job.

D.C. COILS—A.C. TUBES

(Q) Can D.C. screen-grid coils be used with A.C. tubes? Can coils designed for type '26, '27 and '24 tubes be used with equivalent battery tubes?

(A) Coils designed for A.C. operation may be used in battery sets, but coils designed for battery operation may cause circuit oscillation when used in conjunction with A.C. tubes, because of the higher amplification and the higher inter-element capacity of the latter.
CHAPTER V
Audio Frequency Circuits

PUSH-PULL OR PARALLEL
(Q) I am planning to build an amplifier, and want maximum output. What do you suggest, push-pull or parallel? The latter will cost me less. As it uses two tubes, it should give the same output as push-pull, but I have heard this is not the case. What are the facts?
(A) Push-pull, by all means, for it will afford, in many cases, about 40% more undistorted output than the same two tubes in parallel. Unless cost is a factor, consider push-pull parallel, which uses a pair of tubes in parallel in each side of the push-pull stage. You might also consider the use of "beam" power tubes, if the circuit you have in mind is suited to them, as to available voltages, etc.

TRANSFORMER DEFECTS
(Q) In a set having low volume, I found that placing my fingers across the first A.F. primary brought the volume up to normal. Continuity tests, etc., failed to indicate any defect in the transformer. Condensers and resistors across the primary failed to be of any use. Could you explain such a case?
(A) You're lucky you didn't get a shock!
It is probable that the correct voltages were not being supplied to the tubes. Whenever a signal of even moderate amplitude reached the grid of the first A.F. tube it overloaded the grid which, operating at the wrong point on the characteristic (for lack of sufficient "B" or "C" potential) choked up. Reducing the input by shunting the primary with a resistance kept the input to the tube within the working limits of the first stage of A.F.

Also, a defective transformer might cause such a condition by leakage between primary and secondary, whereby the signal energy transferred is in inverse proportion to the amount of energy in the input circuit. A similar effect is sometimes caused by a defective socket. It is assumed that the tube has been tested, or replaced, to see that it is not the source of trouble.
Connect an R.F. choke coil in the detector plate and bypass it to ground with a fixed condenser; this unit may have a capacity of about .0005-mf. or .001-mf. The purpose is to prevent R.F. energy getting into the A.F. circuits.
Another cause of trouble may be an open circuit, in the primary, that is partially closed through a high resistance. Testing for continuity with a high-resistance voltmeter would give an indication that might seem to indicate a perfect winding; while under the load of the tube the current passed through the circuit would be too little. Of course, a simple "cut-and-try" method of proving the case is to substitute another transformer for the questionable one. If this remedies the trouble, the defective unit may be sent to the makers for test and report by their laboratories.

TONIC CONTROL
(Q) What is a tone control, and how does it work?
(A) It is a method of by-passing or blocking certain audio frequencies to prevent their reaching the reproducer. A common means of attenuating or weakening the highs is to connect a fixed condenser and variable resistor (values may be .01 mf. and 500,000 ohms) across the primary of the first audio transformer. The lows may be blocked by means of a fixed condenser in series with a speaker lead. A switching system, used with a number of fixed condensers of various values, permits the degree of bass attenuation to be controlled. See Fig. 17.

SCRATCH FILTER
(Q) In a radio phonograph, what is a scratch filter, to remove needle noise?
(A) It is merely a fixed tone control or filter, set to cut off the highs. A .02-mf. condenser in series with a 25,000-ohm resistor, connected across the pick-up will do it. It will also eliminate the high notes; however, it is suggested that a variable resistor of 250,000 ohms be used in placed of the fixed one.
A.F. AMPLIFIERS

(Q) Please print several diagrams of amplifiers that can be used as separate units, apart from the radio set; and adaptable to operation on dry cells.

(A) We are showing two circuits, in Figs. 16 and 18, which may be what you desire.

The use of two tubes in parallel is illustrated at 16B, while A shows the manner in which the output tubes would be connected in push-pull, for still greater output. In 18A, transformers T1 and T2 are of the standard type. If high ratio parts are used, high volume will result at the expense of quality; using relatively low-ratio units will result in relatively better quality. The voltages are as indicated. This is the arrangement for a single stage of audio amplification. It may be desirable to shunt the input, or primary winding, of the first A.F. transformer with a fixed condenser of .001-mf. capacity, as indicated by dotted lines; the output of the tube may connect to a pair of headphones or to the primary of a matching transformer, T2.

A two-tube circuit is illustrated at 18B. A power tube in the last stage is recommended and illustrated; it is of the dry-cell type. Resistors are ballasts designed for the particular tubes in the filament circuits of which they are shown. In lieu of 3.3-volt tubes, the 2-volt or 6.3-volt type may be used, the "A" supply being changed accordingly.

TUNED A.F. AMPLIFICATION

(Q) Is it possible to tune the secondary of an audio transformer to receive only one audio frequency from the primary?

(A) This is common practice in selective, or multiplex, commercial code transmissions; and amateurs have used "peaked" transformers, which respond to only a few frequencies, for a long time for amateur code transmission. (This renders it possible to select one station from several others on the same wavelength). It is a laboratory feat to select a particular frequency to the almost total exclusion of all others (thus obtaining a "flat-top" characteristic). These degrees of selectivity are illustrated in Fig. 19.

VOLUME CONTROL

(Q) Please mention a few ways in which volume of a set may be controlled.

(A) Potentiometer-type variable resistors are the most usual form of volume controls. For the purpose of clarity of explanation, consider that one end of the resistance strip is lettered "A," the other end "B" and the slider "C." Common circuits, then, are:—A to Antenna end of antenna coil, B to (ground end of antenna coil, C to antenna lead-in. Or reverse A and B, and connect C to ground (this is not as satisfactory as the foregoing). Or A to one side of first A.F.T. secondary, B to other side of secondary and grid return, C to grid of first audio tube. Or (and this is by no means as satisfactory) A to grid and transformer secondary, B to other side of secondary, C to grid return. Or A to one side of output transformer secondary, B to other side of secondary and one side of speaker, C to other side of speaker. The third method given is generally preferred. It is also possible to use the control between the first and second A.F. stages. Another method makes use of a variable resistor of the rheostat type, connected in a grid or plate lead. This, however, unless carefully engineered, is likely to cause poor reception by upsetting the characteristic of the tube with which it is employed. Definite values for resistors of either type cannot be given, as they depend upon the tubes used and other circuit details. Normally they will lie between 25,000 and 250,000 ohms.

A.F. TRANSFORMER REACTIVATION

(Q) I have an audio transformer which has a Permalloy core, I understand. The quality did not sound good so I changed it for another of the same type and immediately the beautiful tones I had originally were duplicated. Is it possible for transformers to change with age?

(A) Yes, it is possible and occurs more often than is realized. Age, tube plate current and mechanical shocks can cause it. Particularly, transformers having a special nickel-iron core material are the only ones subject to this condition, so far as we know. It is our guess, that, perhaps unknown to you, the primary of the transformer was shunted across the direct current plate supply.

If, due to a fault in the tube, or to an accidental contact of some tool, the plate contact of the audio tube should be momentarily connected to the "A" circuit, this would result.

To re-activate your transformer, connect only the primary winding to the 110 volt A.C. lighting circuit for one minute, with the secondary entirely disconnected. This will rearrange the molecular structure of the special iron which, incidentally, is not Permalloy.
CHAPTER VI
Reproducers

PERMANENT-MAGNET DYNAMICS

(I) I have always understood that the dynamic loud speaker has a field coil, supplied with current from an external source. Now I understand that there are some dynamic speakers which do not have field coils. Are not these just the inductor-dynamics under another name?

(2) By no means! The regular and permanent magnet dynamics are moving coil speakers; the inductor dynamics are moving armature speakers.

Developments in metallurgy have produced metals which will take and hold a high degree of magnetism. Magnets made of these metals are used in the fields of permanent magnet dynamics. But, as in the field-coil dynamics, the audio currents are fed into a voice coil which is attached to the diaphragm of the speaker. As the magnetic flux set up in the voice coil by the passage of the A.F. currents causes the voice coil to be attracted into or expelled from the field, the diaphragm is caused to vibrate.

The inductor-dynamic is purely a magnetic speaker. It does not have a field coil; and the "voice coils" correspond to the usual two (or four) magnet windings of the ordinary magnetic reproducer. However, in the latter instrument electromagnets are in permanently fixed relation to the armature, and operate to vary the strength of the field of permanent magnets. In the inductor-dynamic construction, the voice-coils, or electromagnets, are mounted on the moving armature. In addition, the armature does not approach and recede from the permanent magnets; instead, it sways past them. Thus, the armature is not limited in its swing (as when reproducing a low note) by the pole-tips of the permanent magnets. This mechanical action is clearly shown in Fig. 21 (A, magnetic; B, inductor; C, dynamic.)

For the sake of simplicity the permanent magnet system of this type reproducer has not been shown. Although experiments have been conducted, to use an electromagnet, mechanical difficulties have prevented this design.

DYNAMIC REPRODUCER DISTORTION

(1) What is the cause of low-note distortion in dynamic reproducers when the high notes can be heard without distortion?

(2) If the leather backing is loose, the reproducer will rattle on the lower audio range. If the voice coil goes off-center, the rattling will be noted on the over-tones. Most reproducers are equipped with a central "spider" which is fastened to the voice coil and to the core of the field magnet. If this spider cracks—a not unusual occurrence—high-note distortion will usually result. This distortion will be most evident when certain single high notes are being sounded, such as the "scale" solo; when the tone will "go sour.

Lack of good low-note reproduction is sometimes traced to hardening of the leather ring which supports the outer edge of the cone. This ring, in a dynamic reproducer of poor workmanship, is cut from a cheap grade of leather, and often loses its flexibility. A person with a well-trained ear can detect the distortion this causes; for extremely low notes will lack fullness, or "depth," and the harmonics of the low fundamentals will be unduly emphasized.

Distortion caused by the voice coil's touching the walls of the channel, in which it should ride freely, is almost always a very pronounced and loud "rattle"; although an even louder rattle will result if the screw in the center of the spider should loosen.

Another source of distortion, and one usually blamed unjustly on the reproducer, is loose parts within acousti-dynamic range of the loud speaker. In other words, little, unsuspected things like picture frames, screws in the radio cabinet, brick-a-brac, furniture, or even two pieces of furniture which barely touch each other, a loose grille in the radio cabinet, and loose window panels, may sometimes start to vibrate audibly when their resonant frequency is sounded by the reproducer. The higher the pitch of this resonant frequency, the more difficult it is to localize its origin. In fact, it sometimes has taken hours to find the source of an annoying buzz which the trained Service Man would know, by past experience and listening close to the reproducer, did not originate in the loud speaker. It will be understood why this form of distortion is almost always confined to a single note or two in the audio scale.

Still another form of distortion is the annoying buzz that appears over the greater portion of the high-frequency end of the band. This fault, usually, is due to foreign particles in the air gap between moving coil and fixed pole-piece. If the Service Man has a "lucky break," he may succeed in blowing them out; then again, he may need to "operate." (The latter procedure should not be attempted on a customer's reproducer until the technician has thoroughly familiarized himself with dynamic-reproducer assembly and adjusting study and practice on his own experimental equipment.)

A damaged cone will sound very much like the "dusty air-gap," just described. Only experience enables the Service Man to recognize its characteristic sound.

If the primary of the output transformer is not accurately wound to the plate output of the power tube, or if the secondary does not ac-
curately match the voice-coil winding, very pronounced distortion may result. This may take the form in insufficient bass reproduction, or "fuzzy" high-register notes.

**BINAURAL RECEPTION**

(Q) How can two loud speakers at opposite ends of a room be wired and operated to produce a "binaural" ("both ears") effect? I have had the pleasure of listening to two reproducers, at a friend's house, connected this way. There did seem to be any directional effect and, consequently, a realism resulted which seems quite unobtainable with any other arrangement.

(A) The circuits of Fig. 22 may be followed to create the illusion of binaural reception. In A, a 100,000-ohm potentiometer is shown; other sizes may be used for experiment. If lower resistance is used, there will be a proportionate drop in the output volume. The setting of the potentiometer arm will depend upon the reproducers and the location of the listener; the listener should, preferably, be about half-way between the two reproducers. These units may have similar, or dissimilar characteristics, as desired. One peaked for the highs, the other for the lows, gives a good effect.

The resistors indicated in B as R1 and R2 may have a value of about 100,000 ohms each. As shown, these need not be of the potentiometer type. This circuit has the advantage that one may obtain a variation in quality and volume, in addition to the binaural effect desired. Unit T is the usual output transformer.

In circuit A, it is necessary to use the radio set controls for volume, after the two speaker outputs have been balanced against each other. The indicated variation of the output connections employs an output impedance L; and C, the usual fixed condenser.

**CENTERING VOICE-COIL**

(Q) When a loud speaker rattles because of the voice-coil's striking the pole-piece of the field winding, what is the easiest way to center it?

(A) Loosen the screw or screws holding the spider which supports the voice coil. Get three shims of the proper thickness (heavy paper or very light cardboard will do) to fit snugly but not tightly between the central pole and the voice coil. Cut these a couple of inches long and about 3/16-inch wide. Space them equally around the pole, to center the voice coil. Tighten the spider screw or screws, and remove the shims one at a time.

**THREE-DIMENSIONAL SOUND**

(Q) What is three-dimensional sound, and how do I make my set give it?

(A) First, you cannot get three-dimensional sound without the proper transmission—and it isn't on the air. You can, however, get "binaural reception," which is somewhat more like threedimensional sound than straight reception. The means of securing it is given in the answer to the next question.

As to three-dimensional sound—it is a system whereby the sound appears to travel from one side of the room to the other, as a person would move about. That is a simplified explanation. The basis of the system is given in Fig. 23. Each of two microphones is connected to a separate amplifier which feeds a separate speaker. As the actor stands at Microphone A, his voice comes through Speaker A, but as he walks across the studio from Mike A to Mike B, the former picks up his voice with decreasing, and the latter with increasing, volume, the effect being manifested through the respective speakers. When he has reached Microphone B, his voice comes through Speaker B. Increasing the number of microphone-speaker channels improves the effect.

![Fig. 22](image-url)

![Fig. 23](image-url)
CHAPTER VII

Power Supplies

25 or 60 CYCLES?

(Q) Can an electric set be used on 25- or 60-cycle supply, optionally? If not why not?

(A) A radio set designed to be used with 60-cycle supply cannot, except by special design, be used with 25-cycle current supply.

The 25-cycle supply changes polarity very slowly, as compared to 60-cycle supply and the lower impedance at this frequency permits a much greater current flow in power transformer windings, which causes them to heat to a high degree. In fact, the primary of a transformer designed for 60-cycle operation would probably burn out.

It is easier to filter properly 60-cycle current than 25-cycle current. For the latter, it is necessary to double or triple the capacity values of the units in the filter condenser bank, and generally to increase the inductance of the choke coils.

A power transformer designed for 25-cycle supply must be substituted for the 60-cycle transformer. If a current-regulating line ballast is used, this must be changed for one having the correct value.

Ordinarily, a 25-cycle set will work very well, and usually with less hum than a 60-cycle receiver, when connected to a 60-cycle current supply of the same voltage rating.

CHOKES IN POWER PACKS

(Q) Why do some power packs have choke coils in them and others not? Why don't they all use chokes if chokes are needed, and why do any of them use chokes if chokes are unnecessary?

(A) It is a matter of circuit design. Some sets use chokes, others use the field coil of the dynamic speaker as a choke, and still others merely employ greater capacity condensers. All these systems work satisfactorily.

INCREASING "B" VOLTAGE

(Q) What is necessary to change a "B" eliminator to deliver 250 volts instead of 180?

(A) You be determined to put power into it completely. A scheme sometimes employed is to increase voltage to change the rectifier for one of higher output rating. However, this puts an added strain on the transformer, granting that the condenser pack has been changed for one having a higher break-down rating; and a burned-out transformer may result. Use a higher voltage transformer and condensers, and whatever resistors are required for the voltage taps you need. You can still use the same filter chokes, however. A modern rectifier tube, adequate to whatever output you need, should also be used.

CHANGE FROM BATTERIES?

(Q) I have a battery operated radio receiver. Would you advise me to build a power pack to work with it? If so, please give diagram.

(A) You do not state the age or type of your set, so it is hard to answer you. If it is old, by all means buy or build a completely new set. It will be well worth the little more it will cost you. If it is a modern battery-operated set, it will probably be best for you to retain the present "A" battery and powerise for the "B" and "C". Should you be determined to put power into an old battery-operated set, we suggest that you replace the tubes with more modern A.C. tubes, and use a power pack similar to that shown in Fig. 24.

HUM FROM POWER-PACK

(Q) There is an annoying hum in my radio set. How can I test to see whether it is caused by the power pack or one of the stages in the receiver?

(A) Solder two leads to an 0.5-mf, condenser of the non-electrolytic type. Touch these two leads across the primary of the transformer feeding the output stage of your set, while the set is turned on. If the hum ceases, it is probably not caused by the pack, but may originate in the loud speaker. Connect the condenser across the primary of the speaker transformer. If the hum continues, it comes from the speaker (perhaps indirectly from the power pack, but more likely due to poor speaker design). If it stops, it comes from the pack.

CONDENSER BURN-OUTS

(Q) What causes condensers to blow in power packs?

(A) There are a number of reasons: (a) Turning the set on with one or more tubes out of the sockets; the diminished current drain may cause an excessively high voltage to build up in the power pack. (b) Defective or deteriorated apparatus; sometimes wet electrolytic condensers dry out after long service. (c) A sudden surge of line voltage. (d) A burned-out bleeder resistance. The effect is similar to that in (a). (e) Incorrect design. The use of condensers incapable of withstanding the voltage normally ob-
tained from the pack (for instance the use of a condenser rated for a peak voltage of 400, where one with a working voltage of 400 should have been used). There are also other causes, but these are the most common.

CONNECTING TWO "B" UNITS

(Q) Can two "B" eliminators, each delivering 180 volts, be hooked up to deliver 360 volts?
(A) Yes, the highest positive lead of the first unit being joined to the negative lead of the second. But be careful not to connect the grounds in such a way that a short circuit may result. For example, use a 1 mfd. fixed condenser in series with each ground. See Fig. 25.

Before connecting the increased output to a receiver, the latter should be examined to determine whether the by-pass condensers within the set, from "B plus max" to "B minus" are capable of operating at the increased potential.

RECEIVER OPERATION COST

(Q) What is the cost of current per month for operating a 75-watt radio set?
(A) Find the total wattage required to operate the set for an average month, and find the relation this figure bears to 1,000 watts—the usual basis on which the current cost is rated.

For example: the receiver is operated on an average of four hours every day, requiring a total current approximately 9,000 watt-hours (1 watt used for 1 hour equals 1 watt-hour) per month. This is nine times 1,000 watt-hours. In some localities the charge is "ten cents per kilowatt-hour (1,000 watt-hours)") and this would make the cost of operation 90 cents per month.

GASEOUS-RECTIFIER "B" UNIT

(Q) I have a "B" eliminator of the type shown in Fig. 21. Please advise the range of the two variable resistors.
(A) Two "universal range" resistors are used in this "B" eliminator, in the positions shown in the schematic diagram (Fig. 26). The rectifier is a "BH" or gaseous-type tube. The power-line resistor may be set to take care of differences in line-voltage. Resistor R1 measures 200 ohms.

"C" FROM "B" UNIT

(Q) Please advise me as to whether a "B" eliminator can be wired to supply the "C" bias for a '71A power tube and also a 4⅞-volt bias. An eliminator in question supplies 60 milliamperes at 180 volts.
(A) A 2000-ohm resistor, connected between the center-tap of the power transformer secondary and the negative terminal of the power unit, will supply the required bias for a '71A tube. The center-tap is now "C" minus and the regular "B" minus post is now also the "C" plus connection. If the resistor is equipped with a sliding contact, the bias may be varied and, if two contacts are provided, the 4⅞ volts negative required as the bias potential for '01A-type tubes may also be obtained.

When securing a bias voltage in this manner, the "C" voltage is obtained at the expense of the "B" voltage; and causes a corresponding reduction in the total "B" available.

See Fig. 27 for the general idea.

OLD

NEW
CHAPTER VIII
Superheterodyne Receivers

ALIGNING I.F. STAGES
(Q) How should I go about aligning the I.F. of a superheterodyne receiver?
(A) For factory-made sets, almost every manufacturer recommends a different method as particularly suited to his set. Procure a manufacturer's service sheet for your set (or look up your set in a Service Manual) and follow instructions. (Fig. 29 is a specimen service sheet.)

If no data are issued on your set, connect an output meter in place of the loud speaker, and connect the output of the R.F. oscillator to the primary of the first I.F. transformer, with the first detector out of its socket. Try a 456-kc. and a 1-kc. signal. Adjust the I.F. for whichever frequency gives the greatest reading on the output meter. Then disconnect the R.F. oscillator, and put the set into operating condition. Connect the output of the R.F. oscillator to the antenna and grid-condenser of the set, and set it to produce a frequency about 1000 kc. Set the receiver's dial for this frequency, and adjust the trimmer on the tuning condenser for maximum reading on the output meter. Have the output control of the oscillator adjusted for the faintest signal which will give a usable reading on the output meter at all times. Then disconnect the oscillator and meter, and the set is ready to use. If you cannot get an R.F. oscillator, don't try to align the set.

MATCHING I.F. TRANSFORMERS
(Q) How can a set of home-made intermediates be matched?
(A) It is presupposed that the design is approximately correct for the desired frequency. The problem, then, is not to match the coils exactly to a given frequency, but to match one set of coils to the other. The best method involves the use of a calibrated, A.F.-Modulated, R.F. oscillator. Its output is transferred to a detector tube, the intermediate-frequency transformer being introduced between the two units. Maximum deflection on a milliammeter indicates resonance, which is obtained by varying the number of turns on the secondary. Varying the adjustment of the long-wave oscillator until the meter indicates a current will show whether there are too many or too few secondary turns.

A more simple method is to connect antenna and ground to the primary winding, and a detector tube to the secondary; one side of the coil connecting to the grid-condenser and latter, and the other side to "A plus." A pair of headphones, shunted by a .001-mf. fixed condenser, are connected in the circuit of the detector tube. A .0005-mf. variable condenser is connected across the secondary coil and varied until a spark signal is heard; if no spark signal is obtained within this long-wavelength range, a .0005-mf. variable condenser may be connected from detector plate to antenna, and varied until there is circuit oscillation (to obtain this condition it may be necessary to reduce the capacity of the fixed condenser in shunt with the headphones).

When a whistle is heard, as the best frequency between a CW signal and the circuit under test becomes audible, the reading of the variable condenser in shunt to the secondary is noted, and the second intermediate-frequency transformer is substituted for the first. The shunt condenser is again varied until the same signal is recognized. Then, turns are removed from (or added to) the secondary coil until the variable condenser's reading is exactly the same as it was when the same signal was heard with the first transformer in circuit.

This is a very accurate method, the only requirements are care and common sense in applying it. In this arrangement, a code station is commanded to supply the A.F.-modulated R.F. longwave signal of a modulated signal; or the R.F. signal may be the code transmissions of the C.W. station (the A.F. modulation being obtained by the heterodyne method as mentioned above).

To facilitate rapid comparison, a circuit, shown at Fig. 28, has been developed. Although 1, 2 and the antenna may all be connected together, a refinement, an antenna switch, is indicated in the dotted enclosure.

![Fig. 28](image-url)

ANTENNA COUPLED
(Q) Please furnish construction details for an antenna coupler to be used with a superheterodyne. The I.F. coils are peaked at 456 kc.

(A) An essential value, the capacity of the tuning condenser, is lacking. However, no difficulty should be found in making an antenna coupler. There is nothing to it but a primary and secondary winding. The exact number of secondary turns is to be determined by experiment; try 110 turns of No. 28 D.C.C. wire on a tube 1 1/8 in. in diameter. Over this coil, at the filament end, bunch 30 turns of the same (or smaller) wire; taking taps at the 10th and 20th turns. This antenna coupler should be shielded, with a minimum of 1 inch between coil and can.

Connect the antenna coupler in an ordinary detector circuit, with antenna and ground connected to the primary, to determine whether turns should be added to, or removed from, the secondary to cover the broadcast band properly. The peak of the I.F. transformers had no bearing on the design of the antenna coupler.

22
SPARTON SELECTRONNE RECEIVERS MODELS 1068 AND 1068X

10-tube superheterodyne; three bands; push-button (Selectronne) tuning; automatic frequency control; automatic volume control; discriminator circuit; "Vis-a-glow" tuning indicator.

(See Data Sheet 218 for schematic diagram and operating voltages)

The 6 buttons of the Selectronne are arranged in 3 groups according to frequency limits (440 to 800 kc., 700 to 1,300 kc., and 1,000 to 1,500 kc.). The 6 lights corresponding to the desired station must be arranged in the steel plate so that each station frequency will be included in the proper frequency group. To align, push in the Selectronne button and a corresponds to the desired station and adjust for maximum response as indicated by the Vis-a-glow tube. The aligning sequence is: (1) oscillator trimmer (center hole), (2) first I.F. trimmer (center hole), and (3) antenna trimmer (top hole). (The Vis-a-glow tube and socket may be removed from its clamp and the tube turned toward the back of the cabinet for observation.) Adjust Selectronne trimmers for equal shaded area with hand switch knobs either in or out. During above operations the Elgin discriminator is removed from chassis. In the event that all 3 Selectronne buttons became depressed through improper manipulation they may be released by applying a slight pressure at the fingers under the locking band which runs across the framework in front of the trimmer box. Care should be taken to prevent housing the Selectronne adjusting screws to the point where they may become damaged.

The above-mentioned locking bar is seen in the photographs of the locations of the Selectronne trimmers. This locking bar, on the back of the box that carries the Selectronne trimmers, is in direct line with the arm on the Selectronne (view 1) a quarter of the locking bar extends past the rear right side of the trimmer panel.

Sparton model 1068 Selectronne repair; a new 1918 model using latest push-button tuning. The photo at extreme right of this page is a rear view of the locations of the trimmers for this tuning buttons (view 1 f). Above front view of this receiver.

Viso-Clo tube in socket

**ALIGNMENT**

<table>
<thead>
<tr>
<th>OPER-</th>
<th>ALIGNMENT OF</th>
<th>GENERATOR CONNECTED TO</th>
<th>DUMMY ANTENNA</th>
<th>GENERATOR FREQUENCY</th>
<th>BAND SWITCH</th>
<th>TUNING</th>
<th>TRIMMER</th>
<th>REMARKS</th>
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<tbody>
<tr>
<td>3</td>
<td>Broadcast</td>
<td>Ant.</td>
<td>200 m/m.</td>
<td>1500</td>
<td>BC</td>
<td>1500</td>
<td>C49 B</td>
<td>Adjust to minimum</td>
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<tr>
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<td>Ant.</td>
<td></td>
<td>200 m/m.</td>
<td>800</td>
<td>BC</td>
<td>600</td>
<td>C11 Pad</td>
<td></td>
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<tr>
<td>5</td>
<td>(Repeat operation 5)</td>
<td>(Check calibration and sensitivity 1500 KC, 900 KC and 8000 KC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>6</td>
<td>1st Short Wave</td>
<td>Ant.</td>
<td>200 m/m. series</td>
<td>6 MC</td>
<td>Lat S.W.</td>
<td>6 MC.</td>
<td>C3</td>
<td>Dec.</td>
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<tr>
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<td>Ant.</td>
<td></td>
<td>200 m/m.</td>
<td>1.99 MC.</td>
<td>1st S.W.</td>
<td>1.99 MC.</td>
<td>C12 Pad</td>
<td>Dec.</td>
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<tr>
<td>8</td>
<td>(Repeat operation 7)</td>
<td>(Check calibration and sensitivity at 6 MC. and 1.99 MC.)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>9</td>
<td>2nd Short Wave</td>
<td>Ant.</td>
<td>1000 m/m.</td>
<td>10 MC</td>
<td>2nd S.W.</td>
<td>10 MC.</td>
<td>C10</td>
<td>Dec.</td>
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<td>1000 m/m.</td>
<td>10 MC</td>
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<td>10 MC.</td>
<td>C10</td>
<td>Dec.</td>
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<td>11</td>
<td>Ant.</td>
<td></td>
<td>6 MC</td>
<td>10 MC.</td>
<td>6 MC.</td>
<td>C11 Pad</td>
<td>Rock dial slightly while adjusting</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>(Repeat operation 11)</td>
<td>(Check calibration and sensitivity at 15 MC. and 6 MC.)</td>
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<td>13</td>
<td>(Repeat operation 1 to 14 inclusive)</td>
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* Check APC by connecting generator to converter grid cap and tuning generator and receiver to 1500 KC. Note output meter reading with APC switch "on." Switch APC "off" and if output changes appreciably, touch up discriminator trimmer until there is no change in sensitivity.

Fig. 29
NEW RADIO QUESTIONS & ANSWERS

I.F. TUNING CAPACITY

(Q) What is the recommended capacity for a variable condenser to be used as a shunt capacity to balance the secondaries of home-made intermediate-frequency transformers?

(A) A small unit (100-mmf. rating) is usually suitable. However, a larger capacity may be required if the transformers were not carefully constructed to close limits. This is usually evident by pronounced lack of resonance in one I.F. stage.

I.F. TRANSFORMER DESIGN

(Q) Numerous issues of Radio-Craft have contained descriptions of service oscillators, designed for use in aligning superheterodynes in which the intermediate frequency is in the neighborhood of 175 or 180 kc. However, I never have seen a description of an I.F. transformer operating in this range.

While this may not be a service request, at least, it should be of interest to a large number of set builders; and even, perhaps, to a few Service Men who sometime might be stuck with a badly burned I.F. transformer and have no immediate repair unit on hand for replacement. Please publish construction details for an I.F. transformer of the shielded type, similar to average I.F. transformers. This should be a good item for use in modernizing old superhets.

(A) In Fig. 30 is illustrated a suitable design for an I.F. transformer which, by adjustment of variable condensers C, will operate over the frequency band of 100 to 200 kc. The copper plate is required only when exceptional selectivity is required—such as when a limited number of stages are to be used. Selectivity and volume are controlled also by the spacing of coils L. Brass supports may be used, bent as shown. The formers, or spools, may be lathe-turned bakelite or wood, or a job built up of insulating washers and rods. Scramble-wind the coils.

HETERODYNE CIRCUITS

(Q) What is the difference between a heterodyne receiver, a homodyne receiver, a superheterodyne receiver and an autodyne receiver?

(A) Heterodyne and superheterodyne receivers are defined in the first chapter of this book. A homodyne receiver makes use of a locally generated frequency which is of the same frequency as the carrier wave being received. It employs the familiar "zero beat" method of reception. An autodyne is simply a superheterodyne in which a single tube acts as both oscillator and first detector.
CHAPTER IX
Television & Facsimile

TELEVISION & FACSIMILE
(Q) What is the difference between television and facsimile? Aren’t they both used to transmit pictures?
(A) They may be likened to a telescope and a photograph, respectively. Television enables you to see moving images transmitted from a distance, but gives you no permanent record of them. Facsimile gives you printed reproductions on a piece of paper, but these are more like a newspaper; they are motionless.
The systems used for television transmission and reception vary greatly from those used for facsimile work.

OBsolete EQUIPMENT
(Q) I have an old Jenkins television receiver, complete with motor, scanner and neon tube. How can I adapt it to work on the 441-line transmissions that are being used today? Can I hook it up to an ultra-shortwave receiver?
(A) You cannot use it. The systems are too radically different.

CATHODE RAY TUBE
(Q) What makes the electronic beam in a cathode ray tube scan the screen from left to right and up and down? In other words, how is the beam controlled?

(A) You are, no doubt, familiar with the way in which a positively charged plate attracts the electrons emitted by the cathode in a standard vacuum tube, as used in radio reception.
Now visualise a cathode ray tube, as shown in Fig. 31.
Below you see a simplified sketch of the tube as viewed from the side. The cathode emits the electrons, which are attracted by the highly-charged target. To reach it, they must pass through the space between the plates, which are arranged as the end-on diagram indicates. A voltage (lower than that of the target) is applied to the plates. When Plate 1 is positive in respect to Plate 2, the beam will be deflected toward Plate 1; but, since the voltage applied to these plates is A.C., their polarity reverses, and the beam is caused to deflect on each half-cycle toward Plate 2, instead. The same is true of voltages applied to Plates 3 and 4. This combination of plates affords both horizontal and vertical scanning, at a frequency which may be controlled by local oscillating tubes, or by the frequency of the video component (similar to an audio component, but generally of far higher frequency) of the signal being received, or by a combination of both. The electronic beam travels at such velocity that it passes the target and strikes the fluorescent screen, which glows where the beam strikes it.
**CAN'T BUILD EQUIPMENT**

(Q) How can I build a facsimile reproducer to connect to my present set, so that I can pick up the transmissions of the broadcasting stations that are putting out facsimile programs?

(A) Facsimile equipment is not of a nature adapted to construction in the home workshop. You will have to wait until you can buy the reproducer.

**FACSIMILE OPERATION**

(Q) How does a facsimile reproducer operate?

(A) There are several systems. In all, assume that there is an electro-mechanical means of causing a stylus, or similar device, to pass across a sheet of paper in synchronism with a scanner at the transmitter, and of causing it to progress one line in relation to the paper at the end of each complete traversal. Various means of securing this action are used in the different systems.

The other function is to cause the stylus to make marks on the paper, in accordance with the signal transmitted. Several methods of achieving this end are in use. One employs a stylus which is similar in action to the drive-rod of a magnetic loud speaker; the vibrating rod, driven by signal impulses, strikes against a piece of carbon paper, causing marks to be imprinted on a plain piece of paper. In other systems, the paper is impregnated with chemicals that are discolored (or eradicated) by the passage of electric current; the stylus forms one pole of a circuit and a plate behind the paper is the other; the current is controlled by the incoming signal. Tiny ink-sprays, with electrically controlled deflectors, and other systems, have also been used.

**LARGE-PICTURE TELEVISION**

(Q) Why is it impossible to have a sheet several feet square and covered with fluorescent material, and to hang this some distance in front of the television receiver, and have a clear glass end in the cathode-ray tube, so that the electrons could be projected right to the big screen? If it is not impossible, why is it not being done?

(A) Air is a complex gas, and electrons cannot pass through it freely. A cathode-ray tube must be highly evacuated, to enable the electronic stream to travel from the cathode to the screen, both of which are sealed within the same envelope.

Projected images are possible, and have been demonstrated; but in this case, the image, small but extremely brilliant, appears on the usual screen in the end of the tube, and is projected by optical means, much in the way that the old-time stereopticon projected the picture from a postcard onto the wall.
CHAPTER X

Short Waves

COIL-WINDING DATA
(Q) Please give me the necessary information for winding T.R.F. and regenerative detector coils for a short-wave receiver?
(A) Coil specifications depend upon the capacity of the tuning condensers used. You do not state what capacity condensers you plan to use. However, the most commonly employed is .00014 mF. Therefore, the data in Fig. 34 are calculated for condensers of that capacity.

Fig. 34

LACK OF OSCILLATION
(Q) I have a short-wave receiver, the circuit of which will not oscillate at any point, on five coils ranging from 20 to 200 meters. How can this be remedied?
(A) You do not enclose your circuit, so we can give you only a general answer. Granting the circuit is correct, check off the following points:
1. Defective tube.
2. Shorted antenna coupling condenser (antenna coupling too close).
3. Defective detector plate circuit choke.
4. Incorrect grid or plate potentials.
5. Reversed tickler leads.
6. Defective R.F. condenser (secondary or primary).
7. Leaky tuning condenser insulation.
8. Corroded connections.
9. Open or shorted tickler coil.
10. Defective tickler control.

BAND SPREAD
(Q) I find it very hard to tune my short-wave receiver, although I am using a vernier dial. How can I make it tune more broadly, so that it will be easier to bring in stations?
(A) It is very unwise to make your set tune more broadly, but here are two methods: couple primaries of R.F. coil windings more closely to secondaries; add 1,000-ohm resistors in grid leads of R.F. coils. Far better than that would be to add vernier condensers (3-plate midgets) in parallel with each section of the tuning condensers.

SHIELDING
(Q) What is the recommended distance between tuning inductances and shields, for short-wave operation?
(A) This depends considerably upon the operating wavelength. For very short waves, it has been suggested that special wire screening be used to overcome certain losses which result when even the best of solid shields are used at very short wavelengths.
In general, copper shielding may be placed not closer than one to one and one-half inches from the sides of coils, and not closer than two to three inches from the ends. However, such figures are a matter of discussion, as many factors enter into the situation. For example, certain coil shapes produce magnetic and electrostatic "fields" with different arrangements of the lines of "flux"; and each type of coil, therefore, is best used with shields of a certain pattern.

ANTENNA DESIGN
(Q) What are the correct length and height of an antenna for best short-wave operation? We are located about thirteen miles west of the down-town district of Chicago.
(A) The correct design of the antenna for short-wave transmission or reception is determined by local conditions, as well as the wavelength, or wavelengths, at which the equipment is to operate, and the circuit design of the instruments.

GRID LEAK VALUE
(Q) Is the grid-leak value on short-waves the same as for broadcast waves?
(A) Usually, higher for the short wavelengths; one or two megohms for 200 meters and up, and two to eight, below.

ADAPTERS AND CONVERTERS
(Q) What is the difference between a short-wave converter and a short-wave adapter, if any? I notice the adapters are usually cheaper than the converters.
(A) The adapter couples directly between the A.F. amplifier of a receiver and the antenna. It is simply a detector (with, occasionally, one or two stages of R.F.) that will tune to the higher frequencies.
A converter normally consists of a first detector (with, sometimes, one or two stages of R.F.) and an oscillator, which tune to the higher frequencies and produce a beat frequency that is fed into the antenna circuit of a set, so that amplification is obtained in the set's R.F. or other pre-audio stages. The converter and set thus form a superheterodyne, in which the set's R.F. stages act as I.F.
CONSTRUCTION OF ADAPTER

(Q) Please show, as a matter of interest, the schematic circuit of a short-wave adapter to be used with A.C. sets.

(A) A circuit arrangement of a short-wave adapter using the type '27 tube is depicted, in Fig. 35, in answer to this query.

It must be mentioned, this is a throw-back to the old single-circuit regenerative set of some time ago; and the comparison of results obtained on this arrangement with those of the radio set at the broadcast wavelengths, will not be a good recommendation for the adapter. At the short wavelengths, however, code and phone should be heard. Squeals and whistles and distorted reception generally will result when trying to tune in the harmonics of broadcast stations. This is quite natural, as the harmonics cannot be expected to reproduce as clearly as the fundamental frequencies.

Inductances L1 and L2 are the standard windings, which constitute one of the units of a short-wave kit. The 5-prong plug is a standard tube base. Resistor R is a grid leak with a value of about 3 megohms or more. Condensers C4 and C5 are of .00025-mf. capacity. Condensers C2 and C3 are the usual tuning and regeneration units, the capacities of which may be .00014-mf. each, if used in conjunction with coils shown in this section. The antenna coupling condenser, C1, is very necessary and has a value of about .0001-mf. The grid condenser, C6, is .00015-mf.

CONSTRUCTION OF CONVERTER

(Q) Please print a diagram of a short-wave converter to work with an A.C. set. The simpler the circuit, the better. I would like to get the power for the converter out of the set, so as to save buying parts for a power pack. The filament voltage in the set is 2.5.

(A) See Fig. 36. The band-spread condensers are optional.
R.F. CHOKE DESIRABILITY

(Q) How is it possible to tell whether a choke coil is needed in a short-wave receiver?

(A) The purpose of a choke coil is to prevent the passage of alternating current. Its location in a receiver depends upon the design of the receiver. Some sets call for the use of choke coils in dozens of places, while other sets entirely dispense with their use.

The usual place for at least one choke coil, in a short-wave receiver, is in the plate circuit of the detector. In one position, it makes regeneration a possibility; without it, no regeneration or circuit oscillation is possible. This is probably the use you have in mind.

Another action of the choke coil, also in the plate circuit of the detector, is to prevent R.F. currents getting into the A.F. amplifier. In this position, it will be found in a majority of the better commercial broadcast receivers.

These same receivers, as well as the short-wave receivers, use choke coils in the leads which supply plate potential to R.F. stages, as well as bias potentials for the screen-grid of screen-grid tubes. When used to prevent R.F. currents passing into the current supply units, these choke coils are almost always bypassed with fixed condensers, as is seen upon inspection of most any schematic circuit; the R.F. is "led" from the "high potential end" of the R.F. choke to a point at low potential. This is ordinarily the ground or the "B" circuit.

When it is desired to use the choke as a "load impedance" or coupling unit between stages, the fixed condenser connecting to the high potential end of the choke "leads" the R.F. to the stage which follows, instead of to ground.

Erratic regeneration will result if a choke coil is not used in certain circuits. Without choke coils, a tuned R.F. receiver may operate with only one-half the volume it should. Radio frequency choke coils often prevent R.F. circuits from going into uncontrollable oscillation. In screen-grid circuits they are almost a necessity.

If a choke coil is poorly made, "holes" in tuning result; there will be points at which the short-wave receiver circuit goes out of regeneration or oscillation; or, it may go into oscillation with an uncontrollable "thump."

AMATEUR LICENSES

(Q) How can I go about getting a license for an amateur short-wave transmitter?

(A) The required forms may be obtained from the office of the Supervisor of Radio in the Inspection District where you live. The correct local address may be found in the telephone books of the cities shown in parentheses below. Look under U. S. Government, Federal Communications Commission. Be sure to write the supervisor of the correct district, as given herewith:

First District: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut. (Supervisor of Radio, Boston, Mass.)

Second District: New York (New York City, Long Island, and the counties on the Hudson River to and including Schenectady, Albany, and Rensselaer) and New Jersey (counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson and Ocean). (Supervisor of Radio, New York, N. Y.)

Third District: New Jersey (all counties not included in Second District), Pennsylvania (counties of Philadelphia, Delaware, all counties south of the Blue Mountains, and Franklin County), Delaware, Maryland, Virginia, and the District of Columbia. (Supervisor of Radio, Baltimore, Md.)

Fourth District: Alabama, Tennessee, North Carolina, South Carolina, Georgia, Florida and the territory of Porto Rico. (Supervisor of Radio, Atlanta, Ga.)

Fifth District: Mississippi, Louisiana, Texas, Arkansas, Oklahoma, and New Mexico. (Supervisor of Radio, New Orleans, La.)

Sixth District: California, Nevada, Utah, Arizona and the Territory of Hawaii. (Supervisor of Radio, San Francisco, Calif.)


Eighth District: New York State (all counties not included in the Second District), Pennsylvania (all counties not included in the Third District), West Virginia, Ohio and Lower Peninsula of Michigan. (Supervisor of Radio, Detroit, Mich.)

Ninth District: Indiana, Illinois, Wisconsin, Michigan (Upper Peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, North Dakota and South Dakota. (Supervisor of Radio, Chicago, Ill.)


Further procedure is explained on the forms, which are obtainable gratis.
CHAPTER XI
Automotive Radio

NOISE REDUCTION
(Q) How may interference be minimised on an auto radio installation?
(A) First, make sure that the set and tubes are in perfect condition, and that all connections to it from power supply and antenna system are well made. Check the vibrator, if one is used, to see that it is not causing interference. If necessary, employ suppressors on the spark plugs and distributor; these may be obtained in kits. There are also means of securing good electrical contact between wheels and axles, to reduce the effects of static generated by the friction of the tires on the pavement. The set, of course, should be shielded, and the shield well grounded.

LAWS ON AUTO-RADIO
(Q) Do I need any special license to install a radio in my car? Are there any laws governing the use of auto radio?
(A) If you refer to a transmitter, you need a license, just as for any other amateur radio transmitting apparatus. If you refer to a receiver, there is no Federal regulation at this writing, but some states have laws prohibiting the use of short-wave equipment. The reason is that police cars receive their alarms by means of short wave, and their usefulness would be impaired if the cars they were pursuing were similarly equipped. Communicate in writing with your state police, to learn whether you can legally install a short-wave set, before putting one into your car, for in some areas the penalties provide for fines up to $1,000, or imprisonment not to exceed 6 months, or both. As there are 48 states in the Union, each with different laws, no general answer can be given.

AUTO RADIO ANTENNAS
(Q) Please tell me about the various types of antennas which may be used in auto-radio installations, mentioning the best features of each. Which do you recommend?
(A) Practically any standard type of auto-radio antenna will give satisfactory results, if carefully installed. Some of the available types are: (1) Plate under one or both running boards; easy to install. (2) Tubular under one or both running boards; easy to install. (3) V-shaped wire under chassis; claim greater freedom from interference. (4) "Fish-pole" on bumper or running board; claim greater sensitivity. (5) Tubular on top of car; claim greater sensitivity. (6) Screening inside top of car; claim good sensitivity and complete concealment. Some makes and models of cars now come equipped with a built-in antenna of some type, generally No. 6. See Fig. 37.

B-POWER SUPPLIES
(Q) What do you think of using storage "B" batteries for auto-radio receiver, and charging them from the auto generator?
(A) There are other methods which are more satisfactory. Among the latter are the vibrator, and the small motor-generator. The vibrator is now used in most installations.
B-POWER VIBRATOR

(Q) Please explain how a vibrator is used to secure B-power for an auto-radio receiver.

(A) As you know, the B voltage needed by radio receivers is far higher than the voltage supplied by the usual automobile starting and lighting battery. You also know that such a battery supplies smooth direct current, and that it is impossible to step up such direct current by means of a transformer. See Fig. 38.

In order to increase the voltage, the battery current is interrupted by a vibrator, and fed into the primary of a transformer. This pulsating direct current acts much like alternating current, and so induces a current in the transformer secondary. As a step-up transformer is used, the secondary voltage is adequately high for the purpose. It is rectified in the usual way, and supplied to the plates of the tubes in the receiver.

REDUCING INTERFERENCE

(Q) Can you suggest any way of reducing interference, in addition to the use of spark-plug circuit series resistors? The use of these does not entirely eliminate interference from the motor.

(A) Apparently bypass condensers have not been applied to the several radiating circuits of the ignition wiring in the car. Two bypass condensers, one on each terminal, at the ammeter may reduce certain forms of car interference. The receiver should not be located near the car’s ignition coil, due to its strong field. Interchanging its primary connections may reduce interference. Whether the antenna lead-in shield should be grounded to reduce interference should be determined by test.
CHAPTER XII

Sound Equipment

APPLICATIONS

(Q) What are possible markets for a modern "public-address" type of audio amplifier, aside from the generally known ones: (a) at parks; (b) at political gatherings; (c) in theatres; (d) in dance halls?

(A) Airplanes, amusement parks, apartment houses, auditoriums, athletic fields, bathing beaches, banquet halls, baseball parks, brokerage offices, cabarets, charitable institutions, churches, clubs, conventions, dancing schools, encampments, factories, fairs, filling stations, flying fields, football games, hockey matches, home entertainments, hospitals, hotels, ice skating rinks, merry-go-rounds, motor cars, open-air assemblies, orphan asylums, paging systems, polo games, racetrack receptions, race tracks, restaurants, roller skating rinks, sanitariums, schools, stores, summer resorts, swimming pools, veterans' homes and carnivals.

The sound requirements of such possible customers vary within wide limits, from one reproducer or pair of headaphones to forty or fifty reproducers and perhaps fifteen hundred or two thousand pairs of headphones.

From a study of the above list, it becomes evident that the chances for placing a public-address system are very numerous, for the capable technician with a little sales ability.

SCRATCH FILTERS

(Q) Please furnish construction data for a "scratch filter" to be used in conjunction with a phonograph pickup.

(A) For all practical purposes, it is only necessary to shunt the pickup leads with a fixed condenser of suitable capacity to be determined by test (usually, about .05 mf.). Choice coils are quite unnecessary.

It is recommended, however, that you double this value and connect in series with the condenser a variable resistor of 25,000 ohms. This will result more nearly in a "tone" control; at the same time, "scratch" of any type may be suitably controlled, or eliminated (as found desirable), no matter whether it is due to the use of a needle of incorrect shape, worn records, poor recording, poor matching between the pickup and amplifier, or to peaks in the amplifier, the reproducer, or the pickup.

The precise value of condenser capacity cannot be given, as it will depend upon the above conditions; also, whether the pickup is of low- or high-impedance type.

MIXING PANEL

(Q) I want to install a P.A. system for playing continuous phonograph music for high school dances. Please show a way in which a connection can be made to fade from one phonograph to the other. Also, how a microphone circuit can be added, for making announcements.

(A) The simplest means is to connect a potentialometer, R1, as shown in Fig. 39. The total resistance of this unit may be from 25,000 to 100,000 ohms. The double-pole double-throw switch may be used to cut the microphone in and out of the circuit, the changeover to be made while pickup B is in use. The variable resistor, R2, is optional; it simplifies the task of monitoring. Its resistance may be from 75,000 to 250,000 ohms. The precise values of R1 and R2 will depend upon the pickups and the amplifier input.

REDUCING BASS RESPONSE

(Q) My set is "boomy" when reproducing speech; the speakers sound as though they are talking into a barrel. What can be done to overcome this?

(A) Perhaps an incorrectly designed or matched loud speaker may be causing the distortion. It may also be due to cabinet resonance,
in which case it can be decreased by draping the inside of the cabinet with heavy cloth.

If, however, it is caused by amplifier design that over-accentuates the bass, it can be decreased by inserting a fixed condenser in series with the speaker. (Note that this can be done only if the speaker is shunt-fed or transformer-fed, so that the condenser will not block the plate current flow.) The smaller the capacity of the condenser, the more the bass response will be decreased. Experiment with an 0.1 mf. condenser, letting your ear determine whether greater or lesser capacity is needed. See Fig. 40.
BAFFLE SIZES

(Q) Is there available any ready reference, which will indicate the size of baffle recommended for various cut-off frequencies?

(A) This information is given in the chart herewith (Fig. 41), which was developed by Mr. A. A. Ghirardi of the Pilot Radio and Tube Company.

![Fig. 41](image-url)
CHAPTER XIII
Home Recording

HOME RECORDING
RECORDING RADIO PROGRAMS
(Q) What is the way to hook up the least possible amount of apparatus in order to make records of radio broadcasts?
(A) Simply connect a magnetic pick-up to the output of your radio set, by means of a suitable impedance-matching transformer. Use a turntable with a motor powerful enough to drive the disc when the pick-up has a weight of about ½ pound resting on it. Put a home-recording record on the turntable; put a home-recording needle in the pick-up, attach the weight, and proceed to record, with a good, loud signal. If you use an output meter (a low range A.C. voltmeter or ammeter) you can monitor your recording, after a little practice. A single-pole double-throw switch will enable you to shift from radio to recording. The playback is accomplished through the phonograph connections of the set, a home-recording needle again being used, but the recording weight being removed.

CHOOING A MICROPHONE
(Q) What sort of microphone is best for home recording?
(A) A crystal microphone or a dynamic microphone, or a velocity microphone will give the most faithful reproduction. However, these require greater amplification than single- or double-button carbon microphones. In other words, if you do not object to having one or more additional stages of pre-amplification, use one of the first three mentioned; if you want to save stages, though at some sacrifice of quality, use a carbon mike.

HOME RECORDING RECORDS
(Q) What is the best type of record—aluminum, celluloid or composition—to use for home recording?
(A) This is largely a matter of taste, and depends to some extent upon the cutting equipment used. The writer's personal preference is for composition, when pre-grooved records are used, and for standard "wax" when blanks are used.
(Q) Do you favor pre-grooved or blank records for home recording?
(A) Better recordings can be had by using blanks, but these necessitate the use of some mechanical means of feeding the cutter. For simplicity's sake, the pre-grooved records may be used—and they are capable of providing acceptable reproduction, too.

LACK OF VOLUME
(Q) I am using a special celluloid for recording and find it difficult to get the grooves deep enough to give sufficient volume. I have seen "electrical transcription" records, that seem to be made on this same material. How is it possible to overcome this lack of volume?
(A) Your lack of volume is not due to the shallow groove. A shallow groove might make it difficult for the reproducing needle to track, but the lack of volume is due to the modulations (the indentations in the sides of the groove) being too small. This can be caused by several things: perhaps the amplifier's gain is not high enough or there is incorrect impedance matching between cutting head and amplifier; or the material might be too resistant for good recording; or the cutting head may be defective or of poor design; or the cutting needle may be dull or incorrectly set. The transcription records are "processed"—that is, a metal stamper is used to impress the sound track. In that case the hardness of the material is reduced considerably, by heating, so that it will take an impression. Try using records of a different material.

TONE QUALITY
(Q) I am using my radio receiver for recording, and the results are poor. When I reproduce commercial records, the volume is good; but with home-made records the volume is very low. My pickup (when recording) is connected to the plates of the output tubes. Can you tell where my trouble may be?
(A) Evidently your trouble lies in a poor impedance match between the cutter and the amplifier output. A transformer, to match the cutter and the set's output, should solve the problem.
STROBOSCOPE

(Q) How does a stroboscope work to help one to check the speed of a phonograph turntable? How can it be made?

(Q) The stroboscope is a mechanical device which depends for its effectiveness upon the "inertia" of the optic nerve, or more familiarly, the "persistence of vision." By courtesy of the Marconi Radio Co. of Canada, we are able to reproduce in Fig. 43, a stroboscope designed for 60 cycles per second.

When a disc of this type is rotated at the correct speed by a phonograph turntable, the lines appear to stand still when the disc is illuminated by an electric bulb which is lighted by an A.C. supply of the stated frequency.

MATCHING-TRANSFORMERS

(Q) What are the average impedance values, of the primary and secondary windings of transformers designed to match a carbon-button microphone to a vacuum-tube grid circuit?

(A) The average values are: Primary, 200 ohms (each side, if a double-button microphone is used); secondary, 400,000 ohms. These values are for the usual 1,000-cycle standard.

FREQUENCY RANGE

(Q) Will you tell me if a frequency range of 35 to 6000 cycles will record the highest and lowest frequencies?

(A) A frequency range of 35-6000 cycles is very suitable for average good recording.

RECORDING-POWER FIGURES

(Q) How much gain does it take to make a good recording? What impedances of pickups are suitable for recordings?

(A) For recording on aluminum, the level at the cutting head should be about plus 20 decibels. If a carbon microphone is used, the pickup volume level is down about minus 36 db. It is obvious, therefore, that an amplifier having a gain of at least 56 db is necessary. If celluloid is to be used, the required recording level is near plus 36 db. Consequently, an amplifier having a gain of at least 72 db is necessary. A good three-stage transformer-coupled job will serve the purpose very nicely.

The impedance of the cutting head does not make any difference, so long as it is properly matched to the output of the amplifier. The use of a high-impedance cutter of the order of 4000 ohms is common practice.

Fig. 43
MICROPHONES

(Q) Are there any convenient corrective measures that may be applied to packed carbon-button microphones? The one in question is noisy and, though sensitive, it is difficult to keep at the best operating point.

(A) If buttons become packed because of moisture, or long standing in one position, it will often be possible to loosen the carbon granules by holding the “mike” with the diaphragm in a horizontal position, in one hand, and striking this hand gently against the other hand. Also, try tapping the edge of the microphone gently against one hand. Note that damage may result if this procedure is followed with the current on. Make certain that the microphone is disconnected from the battery circuit while undergoing this manipulation. Do not strike the diaphragm. See Fig. 43 A.

If the “mike” is located in an excessively moist place it may be advisable to place it under an electric light bulb, in front of an electric heater (at some distance), or in the rays of strong sunlight, to drive out the moisture that has caused the packing of the carbon. Most microphones are, after assembly, tested and balanced with meters; and they should not be opened or tampered with. The diaphragm should never be touched.

![Diagram of Hold Mike with Diaphragm in Horizontal Position and Strike One Hand Against the Other](Fig. 43 A)
CHAPTER XIV

Test Apparatus

CAPACITY METER

(Q) Please show the circuit arrangement of a simple capacity bridge to use headphones and measure capacities less than one microfarad.

(A) The circuit arrangement of an excellent bridge of this type, developed by Beverly Dudley, is shown in its elementary form in Fig. 44A, and in detail Fig. 44 B. Its capacity range as shown in approximately 10 mmf. to 0.05-mf. Its operating graph in position 1 of the selector switch is shown in C of the same figure. However, this is only approximate, and the completed test instrument must be sent to a laboratory for calibration.

A device of this nature is almost indispensable to the radio Service Man. A test unit of this type eliminates guesswork as to whether condensers of 10 mmf. to 0.05-mf. are open—or have their rated capacity.

METER INTERNAL RESISTANCE

(Q) What is, approximately, the internal resistance of a 0 to 1-ma. meter?

(A) The internal resistance of a milliammeter of this rating may be from 20 to more than 100 ohms, depending upon make and model. The value may vary five percent, plus or minus. Each instrument is a hand-made unit and this causes slight variations which do not noticeably effect the scale readings. The exact constants of all meters are individually recorded and may be obtained by writing to the makers, if special laboratory work should necessitate the data.

METER ACCURACY

(Q) Using a 0 to 1-ma. milliammeter with resistors of the correct value in series for operation as a voltmeter, will the accuracy of the meter be as good or better than one of the high-grade standard voltmeters?

(A) If the meter is of good make and in perfect condition, the results will equal those afforded by a standard voltmeter, provided the resistors are of the correct value and do not change their characteristics in use.
CIRCUITS OF SET

(Q) Please show the various circuits of a radio set and tell how a Service Man may determine what unit is causing bad reception.

(A) The four figures reproduced herewith show the more common connections to triode, tetrode, pentode and other tubes. The accompanying chart indicates how to analyze the various indications of faulty operation. Detailed instructions for using these figures follow, through the courtesy of RCA Mfg. Co., Inc.

Illustrated in this treatise are three fundamental schematic diagrams of the complete filament, plate, grid, and screen-grid circuits for (Fig. 45) filament emitting type tubes; (Fig. 46), cathode-heater type tubes; and (Fig. 47), for output pentodes, filament emitting type; and (Fig. 48) for multi-grid tubes. The various circuits are numbered as Example:

1—grid return from grid of tubes to negative C in grid circuit;
2—plate circuit from positive B on voltage divided to plate of tube; and so forth.

Fig. 49 is a chart listing the effects noted (as compared to the normal readings) when the various circuits or parts are open or shorted. By the use of this chart, knowing what normal conditions are, and how the abnormal conditions compare with them, it is possible for a service man to narrow his tracing of the suspected tube circuit, down to the testing of one or two of the parts of that circuit.

It will be noted that circuit No. 14 (Fig. 47) applies only to the pentode tubes. It represents the connection within the tube itself from the center of the filament to the suppressor grid, located between the space charge grid and the plate. Since there is no external connection to this element on the base of the tube, the only way in which an open connection between these two elements can be determined is by the effects which this condition would have upon the normal analyzer current and voltage readings. These are listed under circuit No. 14 on the chart, Fig. 49.

Circuits No. 1 and 2 apply equally well to triodes of the filament and cathode-heater types by omitting circuit No. 13 and condenser No. 7 which apply to screen-grid types only.

Example:

If it is found that the readings at one tube socket show Eg (grid voltage) equals above normal, Ip (plate current) equals 0, Ekl (cathode voltage on cathode-heater type tubes) equals above normal, then, referring to the chart we see that when this condition exists it indicates a short in No. 6—the plate by-pass condenser—when its return is connected to positive side of grid bias resistor No. 4; or it indicates an open in the cathode circuit through conductor No. 3 or grid bias resistor No. 4.

The meanings of the symbols in the reference chart are as follows:

Fig. 45
Fig. 46
Fig. 47
Fig. 48
Handy Chart for Quick Receiver Circuit Analysis

Circuit No. | Combination | Egl | Eg2 | Ig2 | Ip | Ep | Ek1 | Eg3
---|---|---|---|---|---|---|---|---
2 | *Op | O | Nor | Hi. | 0 | 0 | 0 | 0
3 | +Op | Hi. | 0 | 0 | 0 | 0 | 0 | 0
4 | Op | Hi. | 0 | 0 | 0 | 0 | 0 | Hi.
5 | S | 0 | Nor | Hi. | Hi. | Lo. | 0.
5 | L | Forlo | Nor | Forhi | Forlo | Forlo | Forlo | Forlo
5 | P | 0 | Nor | Nor | Nor | Nor | Nor | Nor
6 | $S | Hi. | Lo. | Lo. | 0 | 0 | Hi.
6 | L | Forhi | Forlo | Forlo | Forlo | Forlo | Forlo | Forlo | Forhi
6 | Op | Nor | Nor | Nor | Nor | Nor | Nor | Nor
7 | $S | Hi. | 0 | 0 | 0 | 0 | Lo. | Hi.
7 | L | Forhi | Forlo | Forlo | Forlo | Forlo | Forlo | Forlo | Forhi
7 | Op | Nor | Nor | Nor | Nor | Nor | Nor | Nor
9 | Op | 0 | 0 | 0 | 0 | 0 | 0 | 0
10 | S | 0 | 0 | 0 | 0 | 0 | 0 | 0
11 | Op | Nor | Nor | Nor | Nor | Nor | Nor | Nor | HUM
12 | Op | Nor | 0 | Nor | Nor | 0 | HUM | Nor | 0
13 | Op | 0 | 0 | 0 | 0 | Hi. | 0 | 0
14 | Op | Nor | Nor | Hi. | Lo. | Nor | Hi. | Nor | Hi.

Exceptions
* Egl = "O" When Individual Bias Resistor.
* Egl = "Lo." When Common Bias Resistor.
+ Egl & Ek1 = "Hi." When Individual Bias Resistor.
+ Egl & Ek1 = "Lo." When Common Bias Resistor.
+ Egl & Ek1 = "O." When Condensers Return is to Negative End No. 4 or Negative Resistor.

Aligning Cage
(Q) What is meant by the term "aligning cage," and how is the device made?
(A) An aligning cage ("Faraday cage") is used by some radio manufacturers, to prevent the disturbing effect of radiations from powerful local stations, and the static radiations of electric machinery, from affecting the tests and adjustments which are made upon receivers in the final stages of production.

The cage is built of light copper screening, such as would be used in a screen-door. It can be constructed large enough to accommodate the entire cabinet together with the necessary meters and oscillator. See Fig. 49.

Although the cage must be built to fit the available space, it should be large enough to permit swinging the chassis, to couple it to the oscillator. The screening should preferably be of copper, 12 meshes to the inch. The sides are carefully bonded together to give maximum screening effect, and the entire screen is grounded. In all cases the open side of the cage should be placed away from the interfering station.

Fig. 49 A

Analyzer Theory
(Q) How does an analyzer enable the Service Man to tell what is wrong with a set?
(A) An analyzer is simply a means of connecting a voltmeter in parallel with (or an ammeter in series with) various circuits of a receiver. The Service Man knows what the meter readings should be on any given circuit, and also knows what the components of the circuit under test are. If the reading on the meters varies from the known normal, he is thus able to reason out which unit is causing the trouble. In most cases, he must use a manufacturer's service notes, or other data sheets, to know the precise circuit under test, and the readings which should be afforded.
VOLT-MILLIAMMETER

(Q) I have an 0-1 mil. meter. How can I make a volt-milliammeter out of it?

(A) See the accompanying Fig. 50. Find the resistance of your meter by asking the manufacturer. The series resistors may be calculated by the formula

\[ R = \frac{R_m \times I_m}{I_s - I_m} \]

where \( R \) is the resistance in ohms to be added; \( R_m \) is the resistance of the meter; \( I_s \) is the amperage of the scale being added (full scale deflection); \( I_m \) is the current in amperes that affords full scale deflection of the meter movement, without the added shunt.

![Fig. 50](image)

A.C. vs. D.C. METERS

(Q) How does an A.C. meter work? Why does it indicate, steadily, on A.C.; when the needle of an ordinary D.C. meter on this supply will flutter?

(A) The D.C. meter when measuring D.C. may be represented as shown at the top in Fig. 51 where a moving coil, (indicated by the arrow), carrying the current to be measured, produces a field which reacts against the stationary field of the permanent magnet. This reaction is physical and the coil, being freely suspended, moves in proportion to the amount of current through it. However, alternating current, flowing through this winding, at the rate of, say 60 cycles, changes polarity so rapidly and attracts and repels so quickly, that the coil cannot follow it. If there were some means of changing the field of the permanent magnet, at the same rate as the change in the moving coil, there would be continuous repulsion and the needle would indicate truly.

This action may be obtained by discarding the permanent magnet and substituting two coils (N, S, shown below it). These are connected in series with the moving coil, so that alternating current through these coils changes polarity at the same rate as the current through the single moving coil. This produces continuous repulsion, and indication on the A.C. meter scale.

In radio service work, small metallic rectifiers are often used to adapt D.C. meters to A.C. work.

CHARACTERISTIC GRAPHS

(Q) Please show a schematic circuit for taking the "characteristic curve" of an A.F. transformer, or for determining its comparative value.

(A) The circuit requested is given herewith. As shown, it is of value only for obtaining an approximation of the "gain" or voltage setup of a particular transformer, at 1000 cycles (1 kc.), as compared to another transformer used as a standard. The gain of a complete stage, including such a transformer, at other frequencies may not be in proportion to this volume.

To obtain a true picture, it is necessary to make a graph of the values obtained at other frequencies; this is possible by using an oscillator adjustable to these frequencies.

The constants of T3 will be determined by the design of the oscillator and the characteristics of the tube selected as VI (the voltages indicated are for an '01A). The milliammeter should read nearly zero, until the oscillator is started.

![Fig. 51](image)

![Fig. 52](image)
CHAPTER XV

General Inquiries

STATISTICS

(Q) How many radio sets are there in the United States? In New York City?

(A) Late U. S. census figures indicate that there are approximately 24,500,000 radio sets in operation in the United States; and that nearly five-sixths the population of the country, or a hundred million people, can be classed as "listening public." It is estimated that in New York, Pennsylvania and Illinois are to be found almost one-third of all the radio sets in the country; and one-fourth New York City is estimated to have about 2,000,000 receivers in use.

SET MODERNIZING

(Q) What is the usual procedure in modernizing radio receivers?

(A) This may be necessary to modernize any given receiver depend upon the characteristics of the individual set. In general, the wiring and component parts are changed to permit operation with the latest tubes; this may necessitate redesign of the power pack. In some cases the R.F. coils are replaced; a more modern volume control usually becomes necessary; a tone control usually improves the audio quality. Single-dial tuning may replace multi-dial operation; a power detector circuit improves the tone quality, as does the use of a pentode or other high-power output tube. Perhaps the major alteration is the use of A.C. tubes in place of battery-operated types.

HARMONIC PRODUCTION

(Q) I have a coil of 85 turns of No. 26 S.C.C. wire, which is tapped at the 40th turn. I use this in an A.C. oscillator, for balancing purposes, in a unit which covers the broadcast band from 550 to 1500 kc. I now find I am able to use this contraption on the 20-, 40-, and 80-meter amateur bands without the change of coils; thus giving me a range from at least 17300 kc. 17.34 meters, to 560 kc. 535.4 meters.

Would you kindly explain this phenomenon; and could its calibration be relied upon if such is obtained?

(A) It is due to harmonic frequency production. In an oscillatory circuit including an ordinary vacuum tube, there is produced not only the fundamental frequency of that circuit (due to the values of its inductance and capacity) but also numerous other frequencies which are multiples of the fundamental. These "harmonic" frequencies are rated in their numerical sequence: the first multiple being the "second harmonic" or double the fundamental frequency; the second multiple is the third harmonic, or three times the fundamental; and so on.

The practicality of calibration is evident at least for the 200- to 1500-kc. band specified. Pursuant to this method is used in amateur radio transmitting work to calibrate accurately short-wave wavemeters; the signals of crystal-controlled oscillators are used for the fundamental, to which may be tuned (by zero-beat) a vacuum-tube oscillator, whose harmonics may be logged on graph paper for further reference.

If the oscillator is stable, the calibration of the harmonics will be reliable.

Constancy and accuracy of calibration are largely a matter of obtaining constant current supply and uniform tube characteristics. In general, quite close work may be done.

BATTERY CARBONS

(Q) I would like to use an ordinary battery carbon as a resistance. What is the average value of one which is six inches long?

(A) These vary from about 50 to 60 ohms.

"NEWTON'S DISC"

(Q) I am conducting some experiments in television and would like to duplicate the physics experiment known as "Newton's Disc." By mounting on a rotatable shaft and twirling the card, all the colors of the rainbow painted on it merge into almost a clean white. Can you assist me?

(A) A sketch of the card to which you refer is given herewith, in Fig. 53. We suggest you use the following water colors or oils to get approximately the right effect, which may be close enough for your work.

For red, use vermilion with a little permanent violet; orange, orange cadmium; yellow, chrome yellow; green, blue green viridian plus a small amount of cobalt blue; blue, prussian blue and cerulean blue; violet, permanent violet and a little blue; indigo, permanent indigo. Due to optic nerve lag, the colors will, when rotated, resolve and afford the sensation of white.

Fig. 53

LONG-WAVE RECEIVER

(Q) As I would like to make up an experimental circuit to receive long-wave stations for code practice, please print details of this arrangement.

(A) The schematic circuit of an easily-built set, a 2-tube "autodyne," is shown in Fig. 41. Although the condenser C1 of .005-mf. capacity may be used, it is recommended that
this part have a capacity of about .001-mf.; which value may be obtained by spacing two .0005-mf. units. The larger capacity will make it easier to tune in a greater number of stations with a lesser number of coils, though the "band-
spread" effect will be halved. Any type of 3-
element tube may be used at V1 and V2.

Honeycomb coils may be purchased, or home-
made coils scramble-wound, with No. 30 enameled S.C.C. wire, on a form an inch wide and about two inches in diameter, to the following num-
ber of turns: 25, 80-1350 meters; 35, 100-1750;
50, 220-750 meters; 75, 330-1030; 100, 450-1460;
150, 660-2200; 200, 1300-4000; 250, 1550-4800;
300, 2050-6000; 500, 1000-8500; 600, 4000-
12,000; 750, 5000-15,000; 1,000, 6,200-19,000;
1,250, 7,000-21,000; 1,500, 8,200-25,000, meters.
The two smallest coils are listed merely for
completeness; the ranges are roughly those cov-
ered with a .001-mf. condenser. Some form of
mounting must be arranged so that the coils may
be conveniently interchanged. The coils should be
rigidly supported, so that the turns cannot move,
even slightly, when the coils are inter-
changed.

It may be desirable to insert a resistor of
about 1,000 ohms in the detector plate lead at X.
Once adjusted for a given coil, tube and plate
potential, resistor R1 need not be reset. The
adjustment of R3 is critical. Unit R2 controls
volume and sensitivity.

Blocking tube V1 prevents radiation of
interfering frequencies.

**SIGNAL BOOSTER**

(Q) Please show the circuit for an A.C. screen-grid booster unit to be added to the aver-
age receiver, for use on broadcast wavelengths.

(A) The circuit requested is Fig. 54: con-
nect its "output" to the "Ant." post of the first
R.F. tube in the set. The tuning condenser C2
will not "track" closely with the radio set dial
unless it is of the same capacity and design of
plates; and unless coil L2 has the same effective
inductance as the tuned windings in the as-
associated receiver.

![Fig. 54](image-url)

The experimental constants may be as fol-
lovs: L1, 10 turns of No. 26 D.C.C. wire on a
tube 2 inches in diameter; L2, 80 to 85 turns of
the same wire on a tube of the same diameter;
L13 standard R.F. choke, C1 and C3, 1 mf.
fixed condensers; C2, .0005-mf., variable; C4,
.00025-mf., fixed; R, 1200 ohms. Resistor R
is for biasing the tube.

Over-all shielding, grounded, is shown in dotted
lines. The coils should not approach the can
more closely than two inches at any point. It
is a good idea to connect a 1 mf. condenser as
shown in dotted lines.

**COLOR CODE**

(Q) Please explain the system used in color-
coding fixed resistors.

(A) Herewith is the color code:

<table>
<thead>
<tr>
<th>Color</th>
<th>Code</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>000000</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>000000</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>000000</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>000000</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>000000</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>000000</td>
</tr>
<tr>
<td>Purple</td>
<td>7</td>
<td>000000</td>
</tr>
<tr>
<td>Gray</td>
<td>8</td>
<td>000000</td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td>000000</td>
</tr>
</tbody>
</table>

The color of the Body of the resistor sig-
nifies the first figure; that of the End, the sec-
ond figure; and that of the Dot, the number of
zeros which follow the two figures.

Examples are: Resistor with brown Body,
black End and black Dot, 10 ohms. Resistor
with yellow Body, green End and orange Dot.
45,000 ohms. Resistor with blue Body, no color
on end (blue end on blue body obviously can-
not be seen) and red Dot, 6600 ohms. Resistor
with red Body, brown End and yellow Dot (red
Dot on red Body cannot be seen), 2100 ohms.

To remember the order of reading—Body,
End and Dot—think of the initials; they spell
BED.

**REMOTE SWITCH**

(Q) I want to connect up my radio with a
switch so that it can be turned on or off from
another room. That is, if I turn it on at the set
and then go to another room, I want to be
able to turn it off from this other room, and
if it is off at the set, I want to be able to turn
it on from the other room. Or, if it has been
turned on in the other room, I want to be
able to turn it off at the set, and vice versa.
Switches in series will let me turn it off from
both points, but not on if one is open; and
switches in parallel will let me turn it on from
both points, but not off if both are open. Is there
any way in which it can be done?

(A) You will need two single-pole double-
throw toggle switches, one at the set, the other
at the remote point. Use three-conductor light
cord to connect them as shown. Either switch
will then turn the set on or off, regardless of the
position of the other.
CHAPTER XVI
Causes of Set Failure

SOURCES OF TROUBLE
(Q) Please list various symptoms of trouble in radio receivers, and state what their causes may be.
(A) The chart herewith, which appeared in Radio-Craft, the magazine for Service Men and experimenters, shows the relation between various units of the radio receiver and symptoms of trouble which may be caused by defects in them.

WEATHER CONDITIONS
(Q) My set does not play as well in damp weather as in nice weather, and on rainy days it is terrible. Not only is reception noisy, but volume is decreased, and sometimes it whistles. What is the cause of this?
(A) There are a number of possible causes. Dirty or cracked antenna insulators, or an absorptive lead-in strip, or defective insulation of a lead-in wire touching a building can cause weakened and noisy reception on damp days. Coils wound on hygroscopic (moisture-absorbing) material, or insulated with a material that is affected by dampness, may cause the same trouble and, by varying their characteristics, may cause the whistles. Other set components, such as sockets and resistors, may have the same effect, if made of hygroscopic material; though this is most unusual.

BAD WEATHER IMPROVES SET
(Q) My set does not usually play very well, but during and right after a rainstorm, it is wonderful. How can I make it play that way all the time?
(A) The most likely reason for this is a poor ground. If your ground connection is in dry soil, it is not good; but when the rain has soaked the earth, the ground becomes excellent. Change the ground. Also possible, but less likely, is that the coils of the set change their characteristics due to dampness, and that the R.F. or I.F. stages are incorrectly aligned when the coils are dry but, through chance, align more nearly right when the weather causes the change. If this is the case, replace the coils. See Fig. 56.

LINE CORD BURNED-OUT
(Q) The line cord of my AC/DC set has always gotten very hot when the set was playing. The other night, it started to smoke, and the set stopped working. What went wrong?
(A) It is normal for line cords to get quite hot, for they contain resistors to reduce the filament current to the proper degree. In your case, the cord was probably damaged or defective, and so burned out. There is also the chance that a short in the set (most likely in the filament circuit) caused the cord to be overloaded and thus destroyed it. For that reason, check the set before replacing the cord.

BURNED ANTENNA COIL
(Q) I was using my new 2-volt battery set from one room to the other, I accidentally connected the "A" battery to the Antenna and Ground leads. Of course the set did not work. I soon found the trouble and corrected it up right, but still it will not work. I did not burn out the tubes, because they still light, and I had the "A" connections right all the time. Please advise me.
(A) You probably burned out the primary of the first R.F. transformer (antenna coil). Replace it with a new one if it appears to be burned, or if it tests open with a flashlight bulb and dry cell, as in Fig. 57.

FUSES BLOW OUT
(Q) My set is plugged into the light line through a so-called "line noise filter." The fuse in my house circuit blew out the other night. I replaced it and it blew again. This is the circuit that my set is on. It was a 10-amp. fuse, and the fuses in my set are 1-amp. fuses. If there is trouble in my set, why did not the 1-amp. fuses blow before the 10-amp. fuse?
(A) The trouble is probably in the line noise filter, not in the set. Most likely one of the condensers is shorted. Remove the filter and try again. You can test the condensers by connecting them in series with an electric light bulb across the line; if the bulb lights, discard the condenser. There is also the possibility of a short in the set's line-cord or plug; this also may be tested in series with an electric light bulb across the line. If the bulb lights with the set's switch OFF, the cord or plug should be replaced.
CHAPTER XVII
Service Problems

GROUNDED CIRCUIT

(Q) What is most likely to be the trouble in an A.C. set, when the 110-volt current passes through the ground wire of the set? Set cannot be used with ground lead. Would a condenser in the ground lead help, and what capacity should it be?

(A) This unusual phenomenon is probably due to a "ground" between the windings of the power transformer. If this transformer is carefully tested, it probably will be found that the insulation between windings has broken down. A fixed condenser of 0.25-mf. capacity may be connected in the ground lead; but it is best to have the transformer replaced or repaired. Otherwise, the insulation may break down still more, and eventually are—setting fire to inflammables in the cabinet.

CRACKLING SOUNDS

(Q) The power pack cable on a radio set produces a loud crackling sound when the cable is moved in a certain position, near the input to the set. I have tested this cable for open or short circuit, but find it OK in every respect; in fact, it is merely touching the cable with the finger causes the noise.

(A) This crackling sound is caused by loose connections (perhaps corroded contacts), partial breaks, or partial shorts.

The reason the cable tested perfect is that the tests were not carried sufficiently far, or else the trouble is not in the cable.

It is possible that the fault is due to poor connection at binding posts; perhaps a wire underneath a post is making intermittent contact.

A broken strand of the cable conductor will occasionally cause this effect, when the strand sticks through the insulation and intermittently touches another lead.

PHONO MOTOR INTERFERENCE

(Q) I replaced the spring in my phonograph with a 110-volt A.C. synchronous electric motor. It was my intention to operate this motor and an electric phonograph pickup in conjunction with my radio set, which is provided with connections for a pickup. However, the motor causes a loud hum in the reproducer when the motor is put in operation although there is no interference when the motor is not turning.

If the pickup head is moved about six inches from the motor, the hum stops. It can also be stopped by turning the pickup to an odd angle. The leads from the pickup are not inductively coupled to the motor, since shielding them does not reduce the hum. How can this trouble be remedied?

(A) If grounding the frame of the motor does not eliminate the interference, it may be necessary to shield the entire motor in the manner shown in Fig. 59. The shield is to be made from soft iron sheeting, of any convenient thickness.

Before making this shield, it may be advisable to try grounding the frame of the phonograph pickup and shielding the A.C. leads to the motor and to the switch controlling the motor.

SHOCKS

(Q) I have a D.C. "mains" set well insulated by antenna and ground series condensers. Why is it that I get a shock when the shield cans and radiator are touched at the same time?

(A) Evidently the shielding of your set is grounded to the set wiring, which is connected to the lighting lines, and contact with it and the ground (radiator) completes the lighting line's circuit to ground, through your body. It is also possible that the condenser used to isolate from the D.C. is broken down, or that the shock is merely due to the condenser's discharging through your body. See Fig. 58.
UNGROUNDED SETS

(Q) What is the explanation for an increase in signal volume when the ground wire is disconnected from a sensitive T.R.F. set. Aerial and ground have been inspected, and both seem to be in a perfect condition; all tubes test up to par.

(A) When the ground wire is removed from a radio set, the chassis no longer serves as a radio-frequency shield since it is ungrounded. Regeneration now takes place in the circuit, thus causing increased sensitivity. Indeed, the circuit may become so highly regenerative as to slip easily into oscillation. Another result of this instability is to decrease the noise-to-signal ratio, bringing in background noises not otherwise heard. Also, the hum level is often raised to an objectionable degree.

Under normal conditions, the various interfering noises picked up by the light-lines and chassis may pass directly to ground through a filter bank consisting of two center-tapped 0.1-mf. capacities, connected inside the amplifier unit. However, when the ground connection is removed, the effectiveness of the ground wire to carry off these static discharges is eliminated. Also, the signal gain obtained by removing the ground is not as noise-free when obtained in this manner, as when the volume control is advanced to obtain the same sensitivity, for it is seldom that a sufficient degree of sensitivity is not obtainable by adjustment of this control—if the receiver is otherwise properly balanced.

Signal pickup via the light-line, no longer bypassed to ground, now may back up through the set. If it is "in phase" with the antenna pickup, volume is increased; otherwise, decreased volume will be experienced.

"SCREEN-GRID" COILS

(Q) Please print details for the construction of R.F. transformers of a design suitable for use as antenna and interstage units in modernizing old 'OIA- and '27-(tube) type receivers to the use of screen-grids or variable-mu's. The coils should be small as possible.

(A) This is rather a large order. In the first place, the proximity of the shield to the R.F. coil will greatly affect the tuning range of the receivers, as will the characteristics of the particular tubes used. Perhaps the greatest factor

with which to contend is the minimum capacity and the capacity range of the tuning condenser.

A common design is illustrated in Fig. 60. The object here has been to obtain good operation, though using coil forms and shield cans of very small dimensions. The values are those of a commercial product.

The primary of the antenna coil fits tightly inside of the form, on the outside of which is wound the secondary. The primary of the screen-grid coils is to be spaced 1/16-in. from the inside of the celluloid winding form. All secondaries have the same number of turns, and each is tuned by a .00035-mf. variable condenser.

![Fig. 60](image-url)
CHAPTER XVIII
Choosing and Installing a Receiver

"THE BEST SET"

(Q) I am going to get a radio. What is the best set to get?
(A) The best set is the one whose tone you find most pleasing, whose controls you find easiest to manipulate, and whose features you prefer. If there was any one "best" set, no others would be sold. Radios, like automobiles, are largely a matter of personal taste.

HOW MUCH TO SPEND?

(Q) I want to get a real good radio set. How much should I have to spend?
(A) What you want is value for your money. Any set of standard make will give you this. How much you will have to spend is determined solely by your pocketbook and your taste. You can buy a set for about $10; it will be worth $10. You can buy a set for $500; it will be worth $500. Both will enable you to hear broadcasts.

If you plan to listen to the broadcast band only, and are not eager to have tonal quality similar to that heard in the studio, you will have to spend far less. If you want to hear amateur, police, airplane, foreign and domestic short wave stations. Likewise, if you wish to get the full bass of a symphony orchestra, as well as all the high notes of such instruments as violins and flutes, with the harmonics that make the instruments recognizable, you will have to spend more money. If you wish to have a phonograph with automatic record changer in your set, it will cost you more than if you do not want this.

Midget sets cost less than consoles, but the increased baffle area of a big set improves bass response.

You can get good value, no matter how much or how little you spend. The degree of perfection it takes to satisfy you will determine how much you will have to spend for a set which impresses you as "good."

FUISING A SET

(Q) I have bought an inexpensive set which does not have any fuses in it. For safety's sake, I should like to fuse the line. What is the easiest way to do this without taking the set apart?
(A) There is a type of fused plug new on the market which can be used to replace the plug now on the line cord of your set. These plugs come with 5-amp. or 10-amp. fuses in them. Remove these fuses and replace them with 1-amp. or 2-amp. auto fuses. These plugs fuse both sides of the line. If you prefer not to use a plug of this type, simply use a double fuse block, with a plug connected to one end, and an outlet to the other.

INSTALLING A SET

(Q) When buying a new set, what is the best way to install it? I mean, have you any suggestions as to antenna, placement in the room, etc.?
(A) The best thing to do is to follow the manufacturer's instructions exactly. Generally speaking, a 50-foot antenna is sufficient. Some different types are given in the chapter on antennas, which also contains information on grounds. Place the set so that there is a direct line from its speaker to the parts of the room where people sit. If in either way, do not hide it behind chairs or other furniture; doing so muffles the high notes. See Fig. 61.
CHAPTER XIX
How a Set Works

SUPER-HETERODYNE ACTION
(Q) Please explain what happens in a super-heterodyne; that is, how does its action differ from that of a simple T.R.F. or regenerative set?
(A) In a superhet, the incoming signal is amplified at radio frequency in the R.F. stage or stages which are usually present. It is then heterodyned, in a mixer tube or first detector, with a locally-generated frequency from the oscillator. There results a beat frequency (or intermediate frequency) which is amplified in the I.F. stage or stages, then rectified in the second detector. The resulting audio frequencies are amplified in the A.F. stages and fed into the reproducer. This is shown in simplified block diagram form as Fig. 62.

POWER PACK FUNCTIONS
(Q) What goes on in the power pack of a standard A.C. radio receiver?
(A) The line current is passed through the primary of a power transformer, which has two or more secondaries. One secondary steps the voltage up for the plate supply; another steps it down for the filament supply; another may supply the filament of the rectifier. The plate current is rectified (changed into D.C.) in the rectifier tube, and is filtered by means of chokes and condensers, or condensers alone, to remove the ripple from it. It is then fed to a voltage divider, from the taps of which the various voltages needed for the set are taken. In some sets, the voltage divider is omitted, individual resistors in various circuits performing the function. Fig. 63 shows this action.

---

![Block Diagrams](Fig. 62, Fig. 63)
Fig. 64

ACTION AT TRANSMITTER
(Q) What happens to a sound wave from the time it leaves the singer's lips until it reaches the receiver?
(A) It first strikes the diaphragm of a microphone, causing this diaphragm to vibrate. The vibrating diaphragm drives a mechanism which sets up electrical impulses, which are amplified and impressed upon a locally-generated frequency (the carrier wave). This is again amplified and fed into an antenna system, from which it is radiated into space. Part of this wave strikes the antenna system of the receiver and is carried down the lead-in to the first stage of the receiver. For typical receiver action, see the answer to the preceding question. Fig. 64 shows a transmitter layout.

PRINCIPLE OF A.V.C
(Q) Please tell me upon what principle an automatic volume control works.
(A) The I.F. stages of a superhet are so connected that their grids are biased by the same resistor which is used in the cathode-plate circuit of a diode second detector. On a strong signal, there is greater potential drop in the resistor, thus altering the bias on the I.F. grids. See Fig. 65 for diagram.
NEW RADIO QUESTIONS & ANSWERS

Fig. 66

CONNECTION OF A.F.C.

(Q) Can automatic frequency control be applied to any set? If so, please show a diagram.

(A) It can be, but it amounts to rebuilding the set, and should be done only by one who is thoroughly familiar with radio. The desired diagram is Fig. 66.

METHODS OF PUSH-BUTTON TUNING

(Q) Is it possible to have push-button tuning on a set without using a motor-driven tuning condenser? If so, how? And what is the basis of the condenser motor drive?

(A) It is possible. One such system makes use of a bank of trimmer condensers, each set of which can be adjusted to tune the R.F., desired station. Pressing button "1" puts one desired station. Pressing button "A" puts one set of these condensers into the circuit; button "2" puts in a second set, cutting out the first set; etc. Another system makes use of separate tunable inductances, similarly cut into and out of the circuit. The motor method simply makes use of a motor connected to the condenser by means of a clutch system. The motor is in circuit with a number of adjustable relays, which are closed by means of any of a number of push-buttons, and opened when the condenser shaft turns a disc or discs to a position which opens the relays. Fig. 67 shows various systems.

Fig. 67
**CHAPTER XX**

Handy Reference Data

**TABLE OF "L-C CONSTANTS"**

This table, reproduced on this page, shows the relationship which exists between wavelength, frequency, inductance, and capacitance; the latter two factors are combined under the heading CI—which is generally referred to as the "L-C constant," or the "oscillation constant." The calculations follow the Bureau of Standards figure, for the velocity of light, as 299,800,000 meters per second (instead of the older one—300,000,000 meters).

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Note: The values given are for frequencies ranging from 100 to 3,000,000 cycles per second. The values for other frequencies may be obtained by interpolation.

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50
Simply by measuring the length of a coil, you are enabled to calculate the number of turns by using this table.
NOMOGRAPH OF TUBE CHARACTERISTICS

This figure reproduced above represents the following tubes: 1, WD-11; 12; 2, '12A; 3, '20; 4, '71A; 5, '99; 6, '00A; 7, '01A; 8, '10; 9, '24; 10, '26; 11, '27; 12, '30; 13, '31; 14, '32; 15, '33; 16, '35; 17, '36; 18, '37; 19, '38; 20, '40; 21, '45; 22, '47; 23, '50; 24, 852; 25, 865; 26, 211; 27, 841; 28, 845; 29, L.A.; 30, Wunderlich; 31, 44; 32, 56; 33, 57; 34, 58; 75, 46 (Class A). To read, draw a line from the apex which permits the desired characteristic to be indicated when the particular index dot is bisected. Other data on tubes and other equipment may be similarly plotted.
CHART OF RADIO SYMBOLS

GROUND

SPEAKERS
MAGNETIC
DYNAMIC

SPEAKERS
MAGNETIC

PICKUPS
CRYSTAL

SWITCHES
S.P.S.T.
MULTI-
THROW
D.P.S.T.
D.P.D.T.
GANG

COILS OR CHOKES
AIR CORE IRON CORE

TRANSFORMER
IRON CORE
AIR CORE

PUSH-
PULL

OUTPUT INPUT

CONNECTIONS
CONNECTED
NOT CONNECTED

BATTERY

JACKS
OPEN CIRCUIT
CLOSED CIRCUIT

CRYSTAL
PHONES

CONDENSERS
FIXED VARIABLE BLOCK

RESISTANCES
FIXED TAPPED (C.T.) VARIABLE VARIABLE POTEN.

BATTERY

JACKS
OPEN CIRCUIT
CLOSED CIRCUIT

CRYSTAL
PHONES

CONDENSERS
FIXED VARIABLE BLOCK

RESISTANCES
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OHM'S LAW--RELATIONS BETWEEN VOLTAGE, RESISTANCE, CURRENT & POWER

DIRECT CURRENT
Where I is CURRENT INTENSITY in AMPERES, R is RESISTANCE in OHMS, E is ELECTROMOTIVE FORCE in VOLTS and P is POWER in WATTS.

then:
\[ I = \frac{E}{R} \]
\[ E = I \times R \]
\[ R = \frac{E}{I} \]
\[ W = E \times I = I^2 \times R = \frac{E^2}{R} \]

ALTERNATING CURRENT
Where Z is IMPEDANCE in OHMS, E is EFFECTIVE Electromotive Force in VOLTS, and I is CURRENT INTENSITY in AMPERES, then:

\[ I = \frac{E}{Z} \]
\[ E = Z \times I \]
\[ Z = \frac{E}{I} \]

Where L is the INDUCTANCE in HENRIES and C the CAPACITY in FARADS, f is the FREQUENCY in CYCLES (per second) the in ohms,

The INDUCTIVE REACTANCE is: \(- - \) \( X_L = 6.283 \times fL \)

The CAPACITIVE REACTANCE is: \(- - \) \( X_C = \frac{1}{6.283 \times fC} \)

The RESONANT FREQUENCY is: \( \frac{1}{6.283 \sqrt{LC}} \)

The IMPEDANCE Z is:

In a CAPACITIVE Circuit:
\[ Z = \sqrt{R^2 + \left(\frac{1}{6.283 \times fC}\right)^2} \]

In an INDUCTIVE Circuit:
\[ Z = \sqrt{R^2 + \left(\frac{1}{6.283 \times fL}\right)^2} \]

In a Circuit having RESISTANCE, CAPACITY and INDUCTANCE:
\[ Z = \sqrt{R^2 + \left(\frac{1}{6.283 \times fL \times fC}\right)^2} \]

The RESONANT FREQUENCY of a PARALLEL circuit is:
\[ f_r = 0.159 \sqrt{\frac{1}{LC}} = \frac{R^2}{L^2} \]
VACUUM-TUBE FORMULAS

AMPLIFICATION CONSTANT ("mu")
\[ \mu = \frac{\text{Change in Plate Voltage (Ep)}}{\text{Change in Grid Voltage (Eg)}} \]

PLATE IMPEDANCE (in ohms)
\[ \text{Ip} = \frac{\text{Change in Plate Voltage (Ep)}}{\text{Change in Plate Current (Ip)}} \]

MUTUAL CONDUCTANCE
\[ \text{gm} = \frac{\text{Change in Plate Current (Ip)}}{\text{Change in Grid Voltage (Eg)}} \]

When the Plate Current is measured in Amperes; the MUTUAL CONDUCTANCE \( \text{gm} \) in MICROHMS is \[ \frac{\mu}{\text{rp}} \times 1,000,000 \]

When \( Eg \) is the Input Voltage, \( rp \) is the Plate Impedance and \( Rp \) is the External Plate Impedance or Load Impedance, the Voltage Amplification is
\[ \frac{\mu \times \text{Eg}^2 \times \text{Rp}}{\text{rp} + \text{Rp}} \]

POWER OUTPUT

When \( Eg \) expresses the RMS (root-mean-square) Effective Value of the A. C. Input, the Power Output is
\[ \frac{\mu^2 \times \text{Eg}^2 \times \text{Rp}}{(\text{rp} + \text{Rp})^2} \]

The MAXIMUM Power Output is:
\[ \frac{\mu^2 \times \text{Eg}^2}{4\text{rp}} \]
The MAXIMUM UNDISTORTED Power Output is:
\[ \frac{2\mu^2 \times \text{Eg}^2}{9\text{rp}} \]

When \( Eg \) is the Maximum (Peak) A. C. Input Value

The Maximum Undistorted Power Output is:
\[ \frac{\mu^2 \times \text{Eg}^2}{9\text{rp}} \]

TRANSFORMER RATIOS

The Voltage across the Secondary = The No. of Secondary Turns
The Voltage across the Primary = The No. of Primary Turns
A. C. VOLTAGE and POWER

The **MAXIMUM** Voltage \( E_m \) is \( 1.414 \times \) the **EFFECTIVE** Voltage \( E_e \).

The **EFFECTIVE** Voltage \( E_e \) is \( 0.707 \times \) the **MAXIMUM** Voltage \( E_m \).

The **AVERAGE** Voltage \( E_a \) is \( 0.636 \times \) the **MAXIMUM** Voltage \( E_m \).

The **POWER** in an A. C. Circuit \( W = I \times E \times \frac{R}{Z} \)

Where the **ANGLE of LAG** or lead, \( \phi \) and the **Power Factor** \( \frac{R}{Z} \)

**COSINE** \( \phi \), **SINE** \( \phi \) and **TANGENT** \( \phi = \frac{X}{R} \)

**COMBINATIONS of RESISTANCES or CAPACITIES**

The **EFFECTIVE SUM** of a **COMBINATION of RESISTANCES** (R) or of a **COMBINATION of CAPACITIES** (C) is as follows:

**In SERIES**

| RESISTANCES: | \( R = R_1 + R_2 + R_3 \) |
| CAPACITIES:  | \( C = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \) |

**In PARALLEL**

| RESISTANCES: | \( R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \) |
| CAPACITIES:  | \( C = C_1 + C_2 + C_3 \) |

**OSCILLATORY CIRCUIT VALUES**

Where \( \lambda \) (lambda) is the WAVELENGTH in METERS, \( L \) is the INDUCTANCE in MICROHENRIES and \( C \) is the CAPACITY in MICROFARADS.

The **RESONANT FREQUENCY** in CYCLES is: \( F_r = \frac{159.160}{\sqrt{L \times C}} \)

\( (\lambda = 1885 \sqrt{L \times C}) \)

The **DECREMENT** of a Circuit is [(Delta)] \( \delta = \frac{R}{2f_r L} = 3.1416 \times \frac{R}{xL} \)

Where the **POWER FACTOR** is: \( \frac{R}{xL} \)
Q. How may I succeed in opening and running a radio servicing business?

(NOTE:—This question comes from so many persons, and deals with such an important problem—that of earning a livelihood—that considerable space must be given to its answer. The following data is from "Official Radio Service Handbook" by J. T. Bernsley, Gernsback Publications, N. Y. C.)

The sincere serviceman assiduously reads through all radio technical and technical releases, keenly watching for new equipment, new servicing data and new developments, as well as constantly reviewing data on radio and electrical principles. The laggard in the servicing profession, who has only a mercenary interest in his work and who has no inclination to keep informed on developments in his profession may have been successful in fooling his customers and himself in the past. In all probability such servicemen are now confronted by numerous difficulties whenever modern receiver must be serviced, and exist only through the beneficence of their more skillful brethren to whom they "farm out" the more difficult repair jobs.

There is only one salvation for this type of serviceman and, incidentally, for beginners who may not lack for sincerity but require considerable additional practical experience and knowledge. This lies in a reawakening and concentrated effort to master the principles underlying modern receiver design and servicing. Failure to do this will most certainly result in their elimination from the servicing profession, since the struggle to repair the ever increasingly complicated receiver will prove too arduous and in most cases unsuccessful.

Lest the efficient serviceman be content to rest on his laurels, he too must be warned not to shirk the necessity for continuous improvement in his radio knowledge. The fact that the design of the future receiver promises to become more complicated than ever should serve as a warning that any let-down in his studies will result in a handicap which will be most difficult to overcome.

What To Study. The many complex and diversified circuit arrangements of radio design require that the serviceman have first of all, a thorough grounding in electrical and radio fundamentals. Principles of magnetism, electricity, fundamental laws of electricity, vacuum tube theory, etc., subjects which every self-sufficient serviceman should have at his finger tips. The beginner in servicing will find the small RadioCraft Library bulletins on a number of radio subjects decidedly informative as well as comparatively inexpensive. Elementary text books dealing with the principles of electricity and radio are published by the following: McGraw Hill Book Co., N. Y. C.; John Wiley and Sons, Inc., N. Y. C., and D. Van Nostrand Co., N. Y. C. Pamphlets or listings of these books may be obtained from any of these companies. As an aid to servicemen and radio students, RadioCraft magazine includes a book review department which describes in outline the contents of all valuable and newly released radio text books.

Many radio manufacturers continually release technical bulletins, pamphlets, service notes and diagrams, booklets and special instruction folders. While some of them are very essential to interested parties, those that are charged for are relatively so inexpensive and contain such valuable information that the serviceman should overlook them. For example, the tube manual published by the RCA-Radiotron Co. Inc., may be purchased for a maximum of 25c and contains complete characteristic and application data of all radio tubes as well as a wealth of fundamental data on tube operation. This information is of the greatest help to servicemen, especially when servicing receivers for which service diagrams may not be available. The tube manual released by the Sylvania Tube Corp. may be purchased for only 10c, and while not as elaborate as the RCA tube book, nevertheless contains much useful data on special receivers and types. The Volume Control Guide available from Electrad, Inc. (N. Y. C.) is also indispensable for service work, since it contains volume control data such as resistance value, type of control, list price, etc. (which guides the serviceman in estimating the price of the repair) for practically all manufactured receivers. A very interesting and informative bulletin concerning condensers of all types and their application in industrial and radio fields, as well as receiver design fundamentals, may be obtained monthly for a very nominal sum. This bulletin, known as "The Research Worker," is available from the Aerovox Condenser Corp. Up-to-date information, design and practical servicing of auto receivers is given in 'correspondence course' form from the Radiart Corp., Cleveland, Ohio. The course consists of a series of bulletins, for which there is no nominal charge, and which contain a wealth of valuable information concerning vibrators, elimination of motor interference, automobile antennas, practical servicing hints, etc. An interesting and extremely valuable, to independent servicemen 'free monthly release is available from the RCA Vic- tor Corp., Inc., Camden, N. J.' its title is "Good News". Besides containing a good deal of helpful servicing information, numerous suggestions are made for improving the servicing business, and frequently descriptions and suggestions are given of new sales help and dealer display equipment. Many of these suggestions are excellent, and the displays (available for a small sum from this company) are of real help in stimulating tube sales and servicing business. Many other radio manufacturers release informative bulletins of a similar nature to those mentioned. An announcement of their publication and how to obtain them will be found every month in Radio Craft, as they are released.

Personality—Its Importance to the Serviceman. The greatest requirement, next to skill and knowledge, is that of proper personality. This is one of the best aids in securing a good position, impressing and satisfying a customer and as a result having a successful business. By "proper personality" the author refers to the demeanor or conduct of the serviceman—that is, of being a diplomatic conversationalist as well as having that appearance of sincerity and efficiency. Some

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servicemen, for example, are loquacious on a service call, engaging the customer in general conversation (hence the 'independent' and
dealer-serviceman. Frankly, the author admits that he has some decided views on this subject which may not be shared by some of his fellow authors and
hence may cause some discussion. However, the reasoning is logical and the result of close study. In the first place the 'independent' serviceman is only independent in name. He may be quite capable of securing a permanent position and working with no qualms or apology or exaggerated guarantees. Such men are respected and sought after by all who deal with them.

Sales Hints—Improving Business. This subject will naturally interest both the 'independent' and dealer-serviceman. Frankly, the author admits that he has some decided views on this subject which may not be shared by some of his fellow authors and hence may cause some discussion. However, the reasoning is logical and the result of close study. In the first place the 'independent' serviceman is only independent in name. He may be quite capable of securing a permanent position and working with no qualms or apology or exaggerated guarantees. Such men are respected and sought after by all who deal with them.

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The really efficient serviceman with proper personal

sales ability is the one who quietly goes about his business of servicing the receiver, speaks only when spoken to or else when he has a suggestion to make or is attempting to obtain the case history of the set. He never attempts to 'kid' or entertain the customer, and while not reticent is
neither verbose. He is especially considerate of the receiver and the surrounding furnishings, and does not spread his tools or servicing equipment all over. When his appraisal of the servicing work necessary is concluded, he specifies his estimate of the repair job to the customer with a satisfactory estimate. If the work is done—without qualms or apology or exaggerated guarantees. Such men are respected and sought after by all who deal with them.

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more dignified appellation of "engineer." And few are the sincere servicemen who do not aspire "engineer." And few are the sincere servicemen who do not aspire and thoroughly versed service technician that greater advantage of being able to service all receivers in an effi-
ciently, but as a rule, such men are more success-
ful in obtaining advanced radio positions with
leading radio manufacturers. These positions per-
tain to the field, advertise sound equipment in-
stallation and service, lecturing engineer to other
servicemen, police radio installation and service,
aviation radio, marine radio, radio sales, etc. It is
evident that the mediocre or hapazard
hit-or-miss type of serviceman can never hope
for these positions unless, of course, he
ought to apply himself diligently to increasing his
radio knowledge and skill.

Uplifting The Profession
Since this book is intended chiefly for service-
men or those contemplating entering the servicing
field, a frank and open discussion of the evils
which exist in this profession is entirely in order.
It will be agreed by all who have been in it for
some time that conditions are far from being satis-
factory, and there is a decrease of liveli-
hood from radio service work at the present
time. The constant necessity for new test instruments
to facilitate repairs, the rate of incor-
porated tremendous changes in design from
year to year, the necessity for laborious and in-
tensive outside study, and the necessity of
being well versed, and the constant expense for periodicals
and books which furnish the information are all
facts which serve as a millstone around the
serviceman's neck.
The aforementioned expenses and effort would be
gladly tolerated as a necessary evil, if it weren't
for the fact that servicemen in general are so
poorly paid. This is true regardless of the classi-

cation of servicemen, whether independent,
dealer-serviceman, or factory-
corporated. As a rule, the average salary of men who are employed in this
profession in big cities seems to be approximately
$30.00 per week. What the independent or dealer-
servicemen earns may vary from a mere pittance
to as high as $70.00 per week, but the latter
figure is not only unusual but is attained only
in the case of aggressive and expensive adver-
sising, as well as long hours and hard work. In
addition, the prestige of the serviceman is rather
low, even where he is a skilled man. This means
other comments about the radio industry and, as a rule, discounted
by the average customer.

Cause of Evils in Servicing. What are the
reasons for such conditions in this profession? How
may they be overcome? What other profession,
excepting the medical, requires that its men have
such a thorough and diversified knowledge and
skill, and such a variety of expensive instruments
and tools to enable them to perform their work?
The answers to these questions can only be
obtained through close analysis and study of all
the factors which are associated with the pro-

First of all, how does a man enter the servicing
profession? How and where does he serve
his apprenticeship and when does he become a
full-fledged serviceman? Most would-be servic-
men start as constructors or experimenters, and
acquire their knowledge through practical experi-
cence in building sets and experimenting with cir-
cuits and by constant study of circuit design
and radio and electrical theory. Others are graduates
of radio schools and obtain their initial
ac-
quire, through this means, quite a bit of radio
knowledge. Naturally, these men are anxious to
perform servicing work at employed technique. The
fact that their practical training is still in-
sufficient for thorough and efficient work. Each
represents a possibility of making some
extra money, therefore why not do such work?
There are no restrictions, no obstacle placed in
their path, especially since replacement parts are
available to anyone at wholesale prices from prac-
tically any radio mail order house. What does it
matter that the repair job may not turn out com-
pletely satisfactory? An aura of ineffi-
cency may be placed on the profession as a
whole? Of course there is always the possibility of the repair being some simple and easy thing
to effect, but then this author has seen samples of simple radio jobs that were
performed by auto mechanics or radio salesmen that should never be allowed to enter a receiver chassis
than the tuning controls.
The unfortunate thing about this situation is that
there are a few radio radio servicemen.
They glut the market by competing in repair quotations, vying with regular servic-
men for positions, and indulging in all sorts of unethical and nefarious practices. It is
injury to both the business and the good name of
the profession. To eliminate them entirely is
impossible, but these organizations is Improvise give to educate the serviceman, are nothing but masqueraded
publicity talks.

A sincere and bona fide service organization can accomplish much towards "clean-up" in the
profession. By mass pressure radio mail order
houses can be asked to sell parts and equip-
ment at wholesale to legitimate service-
men only. What manufacturer or mail order house can afford to defy an organization of thousands of men?
And, of course, not desiring to be ostracised from
"servicemen" can then be ostracised from the
profession by refusing them membership in the
organization. Without a membership card they
will not be able (if the organization is success-
ful) to obtain replacement parts at wholesale
prices, and hence cannot offer competition to legiti-
mate servicemen. Apprentice servicemen (those not
thoroughly experienced) should be given a mem-

bership card which will allow them to be
employed as apprentices at a reduced wage scale.
Until they attain the efficiency and knowledge of
the skilled technician they should not be entitled
to purchase material at wholesale prices. This
would tend to discourage their activity as inde-
pendent servicemen and will keep them confined
to servicing sets under the supervision of their
more skilled brethren.

The Proper Organization to Join. Obviously,
for any such organization to be entirely success-
ful it must be directed by sincere and honest
men who are really interested in the welfare of the profession. Such an organization
as national in scope, although consisting of a number of
"chapters" or "locals", since the larger the or-
geation and the greater the number of mem-
bers, the more efficient are their endeavors to
accomplish reforms.
What should prove of great interest, and serve as
a model to servicemen in all parts of the coun-

NEW RADIO QUESTIONS & ANSWERS

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try, is the recent success of the Radio Technicians' League of New York City in becoming affiliated with the American Federation of Labor. By obtaining a charter under the International Brotherhood of Electrical Workers with separate autonomy and other privileges, it has made tremendous strides in membership and the elimination of many local professional problems. There can be no question as to the improvement in the morale of its members. While they once waged a losing and almost futile fight for reforms, they now have the support and backing of all affiliated A. F. of L. unions. It is considered that now they have the right to organize all metropolitan servicemen under a charter which recognizes them as a union of craftsmen to be governed by themselves.

Their platform consists of combating the policy of mail order houses to sell at wholesale to any Tom, Dick or Harry. They are making every effort to attain increased wages and lower working hours. Technical lectures and instruction talks are held twice a month. Each applicant for membership is given an examination and then graded as either a technician or apprentice. Examinations for grading are held each year, so that to maintain their status all technicians are forced to study and keep abreast with developments. The apprentice becomes a technician if he can pass the technician's examination. There are, of course, many local groups which are members of unions or organizations such as free medical service, insurance, technical aid and advice, etc.

While the author does not meant to imply that success in organization can only be accomplished by affiliation with the American Federation of Labor, there are numerous features or advantages which will help tremendously in reaching the desired goal of the profession. The formation of individual or joint unions with their petty differences has been tried time and again, and the lack of cooperation and disinterest in the common problems has always resulted in complete failure to accomplish anything for the profession.

On the other hand, an organization of national scope, with all its chapters or locals strongly tied together, and bound to cooperate and work for the common good of all servicemen, must obtain some measure of success since the strength of such a union cannot fail to impress and affect the public, the employer and all other related parties.

How to Organize. It is a comparatively simple matter for a group of servicemen to get together and form an association. However, to do any real good for the profession as a whole, the author strongly advises against the formation of individual and disjointed groups which may pull against each other and thus cause more harm than any common good. It is for this reason that the author is a strong proponent of unionism, since each local or chapter is tied to a parent organization, the officials of which are elected by representatives from each local, and who must strive to do their best for the profession as a whole. There are a number of other features the mention of which should be unnecessary since practically everyone is familiar with the prestige of union labor organizations.

The success of teamsters, laundry-wagon drivers, chauffeurs, electrical workers, machinists, etc., etc., in acquiring decent working hours and substantial increases due to union organization, serve as splendid examples of this point. In contrast with the radio servicemen, these men require no intensive training or study, no elaborate and expensive equipment and yet make considerably more (with less effort and hours) than the majority of skilled technicians. It is the author's belief that if union organization can do this for the aforementioned trades, then it certainly should be able to accomplish as much for the servicemen of this nation. And, if affiliation with the A. F. of L. will give the serviceman the "break" he is looking for in getting decent working hours and wages, then by all means servicemen should affiliate with the A. F. of L.

On one thing we can all agree, present conditions are far from satisfactory to the majority of men in this profession. Something must and shall be done about it, and that something has its solution in organization of all men who are doing service work. Let us not have disjointed and individual clubs or associations working against each other. We must cease fighting the football for privately owned and sponsored organizations that are operated for selfish reasons and not for the good of the profession. This applies especially to associations that exact "dues" from its members and give them nothing in return but manufacturer's lectures designed to stimulate the merchant's interest in his products. Usually that type of association never even pays for the costs of the lecturers, and accomplishes this by working in agreement with the manufacturer who pays for all expenses in return for the publicity and credit that the association gets.

Let us have an organization for the serviceman, a national union of servicemen and the interests of all servicemen. Avoid joining or affiliating with any club or association just for the sake of affiliation. Let us take up and maintain that seldom, if ever, facilitate your work or aid you in your economic problems. Such an affiliation only serves to give that organization undeserving prestige, and helps to minimize the efforts and accomplishments of sincere servicemen associations.

Investigate first whether the organization you contemplate joining is doing any real good for the profession. Determine whether the "club" has any interest in some particular radio manufacturer, and whether it runs sponsored lectures paid for by the manufacturer. Ascertain what its plans are in regards to the servicemen of the country, and look up its record for accomplishments in its period of existence. These points are all very important, if members of this profession are to be assured of the organization's sincerity to overcome the many evils that are responsible for the unwarranted and unsatisfactory conditions that exist in servicing today.

Best of all, if there is no sincere and active organized group of servicemen in your locality now, form such an organization as soon as possible. Hold technical or social and economic discussions and keep organized until an opportunity presents itself when you can affiliate with a larger and more active but thoroughly sincere organization that is national in scope. If present organizations are not sufficiently satisfactory to affiliate with, then such a national organization must appear soon. All it requires is the will and the spirit of the servicemen to create its existence.

This author will be pleased to hear from servicemen for comments, suggestions or desiring further advice concerning organization. It is conceded that the suggestions outlined may not be in accord with the beliefs or plans of all concerned in the servicing fraternity.
CHAPTER XXII

Conclusion

These, then, are the questions which seem to bother many radio fans and experimenters. But, of course, there are innumerable other queries which may rise to plague the radio enthusiast.

The most valuable knowledge which can be imparted to him is that which enables him to find the answers to his questions through independent investigation.

The procedure is simple: it consists merely in knowing whom to ask.

For problems involving the installation, operation or repair of factory-built apparatus, the best source of information is the service department of the manufacturer. In seeking information, give all the available data about the receiver in question, being sure to include the make and model number (usually to be found on a plate attached to the cabinet or chassis).

For problems involving the use of parts, the correct source is the manufacturer of the part. He is anxious that it perform to your satisfaction, and his service department will help you in every possible way.

Information relative to amateur requirements, broadcasting regulations, etc., may be obtained from the Federal Communications Commission, in Washington, D. C., or from the U. S. Supervisor of Radio in your district.

Data on schedules of short-wave or broadcast stations is best secured from the stations themselves. Information as to general station listings can be had from any of the call books sold on newsstands.

Technical information can be had by referring to standard text books and technical magazines. This includes circuits for sets which the inquirer wishes to construct.

All other queries (and there are not many which do not fall into the foregoing categories) can be had from the questions and answers departments of various technical radio magazines.

**BY-PASS CONDENSER, GRID-BIAS RESISTOR CHART**

<table>
<thead>
<tr>
<th>Tube</th>
<th>Purpose</th>
<th>Plate Volts</th>
<th>Screen Volts</th>
<th>Grid Volts</th>
<th>Grid Resistor in OHMS</th>
<th>By-pass Cap. in Mfd.s</th>
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**Abbreviations:**
- A—means class A amplifier.
- Det—means Detector
- rf—means radio frequency
- af—means audio frequency
- Pent—means Pentode
- Mixer—means first detector of a superhet

Resistor values are given in sizes stocked everywhere and are satisfactory for most conditions.
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