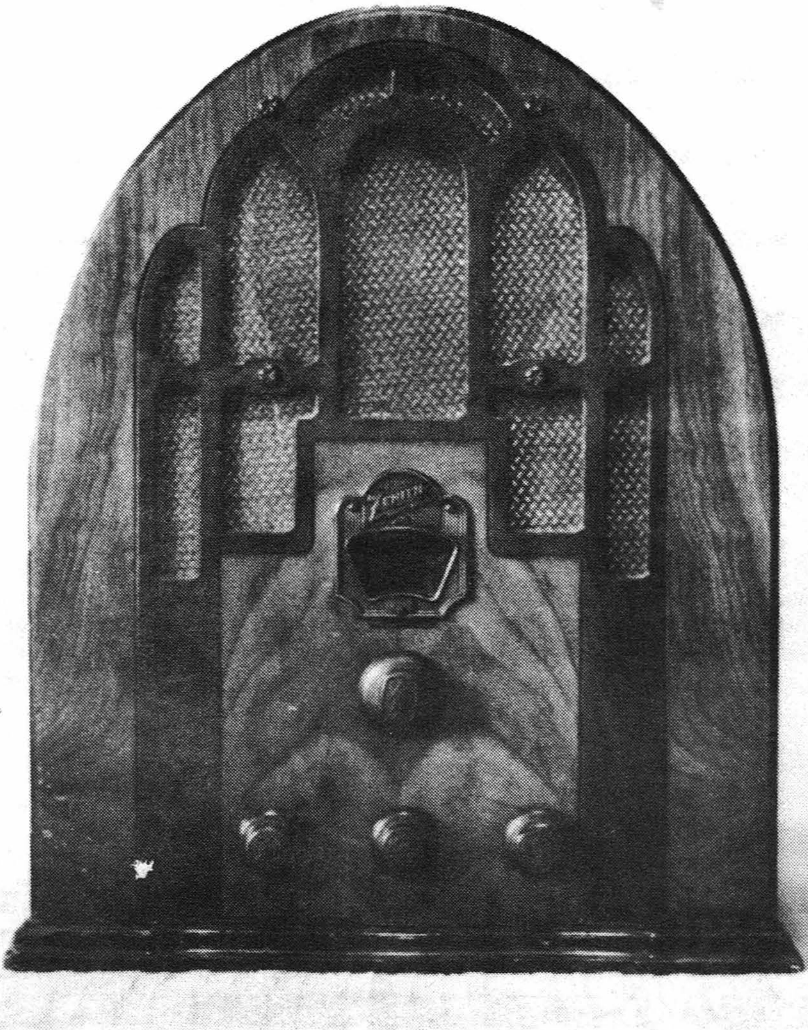
CHRS **official**

JOURNAL

JAN - MAR 1985



CALIFORNIA HISTORICAL RADIO SOCIETY

PRESIDENT: NORMAN BERGE
SECRETARY: BOB CROCKETT
TREASURER: JOHN ECKLAND
EDITOR: HERB BRAMS
PHOTOGRAPHY: GEORGE DURFEY

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THE SOCIETY

The California Historical Radio Society is a non-profit corporation chartered in 1974 to promote the preservation of early radio equipment and radio broadcasting. CHRS provides a medium for members to exchange information on the history of radio with emphasis on areas such as collecting, cataloging and restoration of equipment, literature, and programs. Regular swap meets are scheduled four times a year. For further information, write the California Historical Radio Society, P.O. Box 1147, Mountain View, CA 94042-1147.

THE JOURNAL

The official Journal of the California Historical Radio Society is published six times a year and is furnished free to all members. Articles for the Journal are solicited from all members. Appropriate subjects include information on early radio equipment, personalities, or broadcasts, restoration hints, photographs, ads, etc. Material for the Journal should be submitted to the Editor, Herb Brams, 2427 Durant #4, Berkeley, CA 94704.

MEMBERSHIP

Membership correspondence should be addressed to the Treasurer, John Eckland, 969 Addison Ave., Palo Alto, CA 94301.

CHRS SWAP MEETS

CHRS swap meets have tentatively been set for the following dates: June 1, Aug. 31, and Nov. 9 at Foothill College. Notices will be sent if these dates are changed. For further information call Norm Berge or John Eckland at (415) 323-0101.

JUNE SWAP MEET

For our Swap Meet in June, we are planning to have a contest after the usual buying, selling, and trading in the morning. We encourage all CHRS members to participate. Entries for the contest should be in the following categories: wireless gear, crystal sets, regenerative receivers, TRF receivers, AC table radios, novelty sets, pre-1950 amateur equipment, speakers and microphones, and miscellaneous. Due to space limitations, no consoles, please. Accompanying your entry should be a card listing manufacturer, model, date, description of unit, information on historical or technical significance of unit, rarity, etc. If you are interested in submitting an entry, please contact Norm Berge, President, 969 Addison Ave., Palo Alto, CA 94301 (415) 323-0101 as soon as possible. For future contests we will vary the categories so that all aspects of early radio may be considered. If you have any suggestions on what you would like to see entered in a contest, send them to Norm. For future meets we hope to have other activities such as guest speakers, slide shows or movies, and other entertainment.

POSITIONS OPEN

The terms of office for CHRS officers have expired and positions are now open for those interested in serving on the Board. These positions include President, Secretary, Treasurer, Editor, Public Relations, Photographer, Printer, etc. Call or write Norm Berge or John Eckland at 969 Addison Ave., Palo Alto, CA 94301 (415) 323-0101.

OPEN BOARD MEETINGS

We will be holding regular, open monthly board meetings to discuss CHRS business and hear new ideas. We invite anyone who would like to give his ideas, views, or suggestions to attend. We would like to have more input from our members. Write or call Norm Berge or John Eckland at 969 Addison Ave., Palo Alto, CA 94301 (415) 323-0101.

RADIO GET-TOGETHERS

Bill Wakefield of Sunnyvale, CA has come up with a good idea. Every month or so a radio enthusiast holds open house and invites people over for an informal get-together. Activities may include showing off the collection, showing slides, giving a talk on some subject, discussing important news or events, holding a mini-swap meet, or just plain yakking. The get-togethers are completely voluntary and the nature of them is entirely up to the person holding them. These meets are a good way to spend a few pleasant hours with fellow enthusiasts, make new friends and find out what their interests are, or just to see what's around. Each get-together is hosted by a different person and at a different location so that everyone can get a chance to go to one. Already Gary Halvorsen of San Jose, Paul Giganti of San Carlos, and Jim Cirner of San Jose have held a get-together. Gary discussed some important technological events in amateur radio. Paul presented a slide show of early wireless and electric equipment and showed some interesting sets, including a Crosley Pup and some early Swedish electric table radios. A lively discussion followed with people expressing what their own interests were. Jim showed off his collection and then held a mini-swap meet. Will Jensby will host the next get-together, with a slide presentation of a tour of the AWA museum. Bill Wakefield is the coordinator of these events and is the one to whom inquiries should be directed as to time, place, and nature of the meets. Write or call: Bill Wakefield, 1753 Kimberley Dr., Sunnyvale, CA 94087 (408) 746-0873. A notice of forthcoming meets will appear in the Journal. CHRS will make available a listing of members by zip code for those who would like to invite members in their area. Send a SASE with your zip code to H. Brams, 2427 Durant #4, Berkeley, CA 94704.

JOURNAL NEWS

Improvements in the CHRS Journal are being planned with the addition of the talents of three new members of the club, Gary Halvorson, Bob Malin, and Doug Martin. There will be an improvement in the appearance of the Journal with better paper, better printing, more photographs and artwork, new cover design, etc. There will also be additional features such as club news, spotlighting collectors, editorial comments, etc. We are thinking of having both a Newsletter and a Journal. The Journal would contain the feature articles and would come out four times a year. The Newsletter would contain ads, club news, reports of activities, notes of forthcoming events, etc. and would come out between the Journals. Or, should we combine the two and have only a Journal, coming out six times a year, as is done presently? Do you have any other suggestions for the Journal? Write: H. Brams, 2427 Durant #4, Berkeley, CA 94704.

THE SUPERHETERODYNE RECEIVER

The history of superheterodyne receivers begins with the heterodyne system of receiving radio signals, developed by Fessenden in 1905. In Fessenden's system a receiver was tuned to pick up a particular signal, e.g. at 1000 kc. Another signal was injected into the set, its frequency being set close to that of the desired signal (e.g. 98 kc). The two signals combined in the set by heterodyning to produce a difference frequency (100 kc - 98 kc = 2 kc) that was audible in the earphones or loudspeaker. By this means the radio signal could be heard directly. At this time the injected signal was produced by a low-powered, high frequency arc generator or alternator since vacuum tubes had not yet been developed.

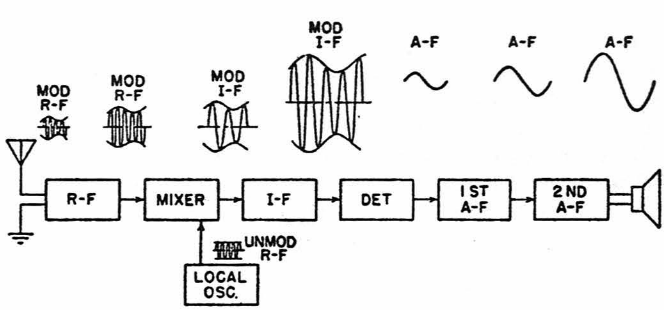
Although Fessenden's technique of heterodyne detection was effective, it was not widely used because the requirement for an external signal generator made it cumbersome and expensive. Also, the arc generators and alternators were noisy and difficulty to tune. In 1912-13 Lee de Forest and E.H. Armstrong discovered that the newly-developed triode vacuum tube, connected in a regenerative circuit, could act as an oscillator, producing the necessary high-frequency radio signal. The arc generators and alternators could now be replaced by vacuum-tube oscillators, which were smaller, simpler,more efficient and more easily tuned.

During World War I Edwin H. Armstrong served in France as Chief of the Signal Corps Radio Laboratory. One of the problems he faced was the difficulty in receiving signals of very high frequency. There were many problems in tuning, separating, and amplifying these signals and in preventing feedback and oscillation. Armstrong sought to develop a more efficient type of receiver that would be simple, compact, and lightweight so that it could easily be used by ground troups and in airplanes. Armstrong realized that if the signals were converted to a lower frequency, they could be tuned and amplified more efficiently. The necessary frequency conversion could be accomplished by heterodyning, as in Fessenden's technique. Rather than converting the signals to an audible frequency, however, as in Fessenden's system, the signals could be converted to a supersonic <u>radio</u> frequency where they could be tuned and amplified efficiently. This intermediate radio frequency could then be detected by the usual means. Receivers with this system of supersonic heterodyning could be called "superheterodynes." Armstrong then went one step further. He realized that by varying the frequency of the local oscillator, each signal tuned in could be converted to a <u>single</u>, fixed frequency. This offered a significant advantage: amplification and selection of a single fixed frequency would be much simpler and more efficient than systems in which signals were tuned and amplified each at their own particular frequency.

Armstrong built the first superheterodyne receiver in 1917. In the next few years superheterodyne receivers were manufactured mainly for the military and for commercial purposes. Most of these sets were built by Western Electric. In 1920 Armstrong received a patent for the superheterodyne circuit. Later that year he sold the patents to Westinghouse and these became the property of RCA in 1921. In the early 1920's Armstrong had granted licenses to seventeen manufacturers to make superheterodyne receivers--for amateur use only. In 1922-23 a number of these companies began to manufacture and sell these sets on a substantial scale. These included Tri-City Electric Co. of Davenport, Iowa, Cutting and Washington Corp., and Radio Craft Co. Many sets were sold as kits. In 1923 RCA, fearing competition, brought suit against the manufacturers for infringement on the patents it now owned and stopped production. The superheterodyne was not developed for the public until 1924. In that year RCA manufactured the first superheterodyne for home use, the model AR 812 or Radiola VIII.

The superheterodyne radio was not widely adopted in the 1920's. The sets required a large number of tubes, making them expensive. Tuning the set was relatively complicated and there were problems in reception. More importantly, RCA refused to license its patents to other radio manufacturers and maintained a near-monopoly on production of this type of set. Only in 1930, in the face of an anti-trust suit and continued pressure from other manufacturers, did RCA agree to license its superheterodyne patents. By then developments in tubes and other technology had improved its performance making the superhet practical and economical. The superiority of the superheterodyne over previous types (regenerative, TRF, reflex, and neutrodyne sets) was quickly recognized and it soon replaced all other types. By the early 1930's the superheterodyne had been almost universally adopted, and it maintains that position to this day.

ANALYSIS OF OPERATION



Radio-frequency signals are picked up by the antenna.
Tuned circuits in the antenna stage select the desired signal and reject unwanted signals.
Another radio-frequency signal is generated within the set by a tunable oscillator.
The oscillator tuning is made to change simultaneously with the tuning of the signal-selecting circuit in such a way that, when each station is tuned in, the oscillator frequency is higher than the signal frequency by a fixed amount. This relationship is obtained by mechanically coupling the variable condenser for the oscillator tuning circuit to that of the signal-selecting circuit ("ganged" condensers).

The RF signal and oscillator signal are fed into a tube called a converter, mixer, or first detector. (A single tube may carry out the functions of both converter and oscillator.)
In the converter tube the RF and oscillator signals combine by heterodyning to produce new frequencies, the sum and difference of the two.
Because of the fixed difference between the oscillator frequency and the signal frequency, the frequencies of the heterodyne signals remain the same for any signal tuned in.
The heterodyne signals contain the same modulation as the original RF signal.

One of the heterodyne signals, usually the lower (difference) frequency, is selected by circuits tuned to this frequency and is amplified by one or more stages. This signal is called the intermediate frequency, or IF, and the stages that amplify this signal are called the IF amplifier stages.
Tuned circuits in the IF stages are fixed-tuned since the IF frequency remains the same for all signals tuned in.
Most of the amplification and selectivity of the receiver occurs in the IF stages (selectivity: ability to separate the desired signal from nearby unwanted signals).

The amplified IF signal is detected in the usual way and the audio modulation is recovered.
The audio is amplified and fed to a loudspeaker or earphones to produce sound.

Summary: In the superheterodyne receiver incoming signals are converted by heterodyning to a fixed lower frequency that is selected, amplified, and detected by the receiver. In this way a high degree of amplification and selectivity is obtained, amplification and selectivity are constant for all signals tuned in, and the stability of operation is improved.

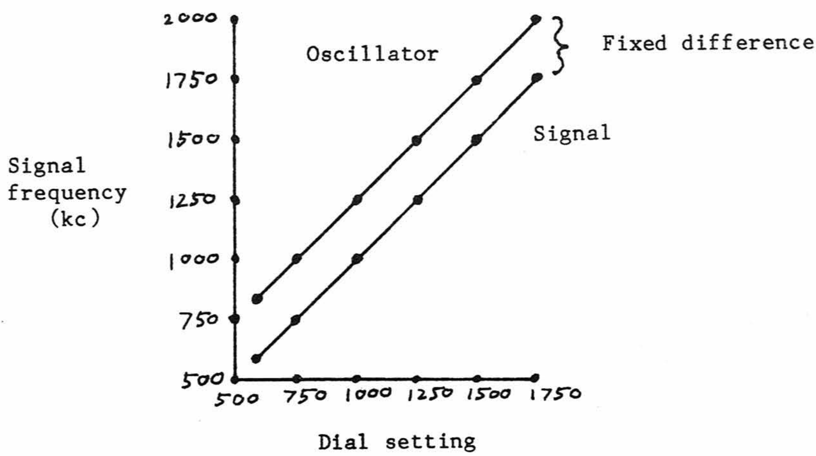
DISCUSSION

Tuning

In superheterodyne sets signals are tuned in by varying the oscillator frequency so that, one by one, the signals are converted by heterodyning to the fixed, lower IF frequency that is selected and amplified by the receiver. Reception of a signal occurs when the oscillator frequency differs from the signal frequency so as to produce a signal at the IF frequency of the set. The IF signal is produced when the oscillator frequency differs from the signal frequency by the IF frequency. Tuning is accomplished by varying the oscillator frequency so that the IF is produced from incoming signals of various frequencies in the tuning range.

Relation of the oscillator frequency to the signal frequency.

To produce the IF signal, the oscillator frequency must differ from the signal frequency by the IF frequency of the set. The frequency of the oscillator may be either above or below that of the incoming signal. Example: Suppose the frequency of the desired signal is 1000 kc and the IF is 460 kc. The oscillator frequency may then be either 1460 kc (1460-1000 = 460 kc) or 540 kc (1000-540 = 460 kc). Either one may be used but in practice the frequency of the oscillator is usually maintained higher than that of the signal as the tuning range of the oscillator is less than that if the oscillator frequency were lower than the signal frequency. This simplifies design of the oscillator tuning circuit and reduces the possibility of interference. In short-wave receivers where very high frequencies are involved, the oscillator frequency may be maintained lower than the signal frequency to obtain better stability.



Relationship of oscillator frequency to signal frequency.

Oscillator tuning circuit.

In superheterodyne receivers signals are tuned in by varying the oscillator frequency so that when the oscillator frequency differs from the signal by the IF frequency the IF signal that is selected and amplified by the set is produced. It is not difficult to have the oscillator cover the necessary frequency range. However, a signal-tuning circuit is usually placed ahead of the converter to eliminate unwanted signals that may cause interference (this will be discussed in more detail later). The tuning of the signal-selecting circuit must vary to allow the desired signal to reach the converter and so the condenser controlling the tuning of this circuit is mounted on the same shaft as the condenser controlling the tuning of the oscillator so that both are varied together during tuning. The selecting of signals by the signal-tuning circuit and the fact that the oscillator condenser is ganged to the signal-tuning condenser places a special requirement on the characteristics of the oscillator: the oscillator tuning must keep in step with ("track") the tuning of the signal-selecting circuit ahead of the converter, always remaining higher by an amount equal to the IF frequency of the receiver. When the tuning knob is set to receive a station the signal-selecting circuit allows the signal to reach the converter. At this point the oscillator frequency must differ from the signal frequency by exactly the IF frequency so that the IF signal may be produced. These conditions must be maintained for all signals tuned in within the tuning range of the receiver. Fulfillling these requirements presents some difficulty and a variety of techniques are used to attain them.

The variable condenser controlling the oscillator frequency is usually mounted on the same shaft as the signal-tuning condenser ("ganged" condensers) so that as the tuning knob is turned to select stations of higher or lower frequency, the frequency of the oscillator is simultaneously changed in a similar fashion. The plates of the oscillator tuning condenser are specially shaped to maintain the frequency of the oscillator approximately a fixed amount above the signal frequency. In addition to the main oscillator tuning condenser, small variable capacitors are provided to adjust the oscillator frequency at the high end of its tuning range (trimmer capacitor) and at the low end of its tuning range (padder capacitor). Slots are cut into the oscillator condenser plates so that by bending a section of the plate in or out (thereby increasing or decreasing its capacitance) minor corrections can be made in oscillator tuning at various points throughout the tuning range. The oscillator coil itself may be made adjustable by means of a movable ferrite core.

By these techniques the frequency of the oscillator is able to cover the necessary frequency range and to track the signal-tuning circuit fairly closely throughout the entire tuning range. Perfect tracking is usually obtainable at three points in the tuning range: at the mid-point and at a point near the low and high ends of the tuning range. Some mistracking occurs in other parts of the tuning range but the effects (decreased sensitivity and increased reception of unwanted signals) are usually not serious since the signal-tuning circuits are fairly broad in response. Improved tracking may be obtained by providing adjustments on the signal-tuning circuits similar to those on the oscillator tuning circuit. The method of adjusting the various tuned circuits to obtain proper tracking ("alignment") will be discussed later.

In early superheterodyne receivers the signal-tuning and oscillator circuits were separate and individually controlled. This eliminated the problem of mistracking but made tuning the set a cumbersome and time-consuming procedure and caused other problems in reception. By the mid-1920's tuning circuits in most sets were mechanically coupled in some fashion. With improvements in circuit technology and design, mistracking became much less of a problem.

The arrangement of station frequencies along the dial is determined by the position of the tuning knob that allows the oscillator to generate the frequency that, when mixed with the incoming signal, produces the IF signal of the set. The plates of the oscillator and signal-tuning condensers are usually specially shaped so that incoming signals are spaced evenly across the tuning range.

The Intermediate Frequency (IF)

The intermediate frequency of superheterodyne receivers may have almost any value. For the AM broadcast band (540-1600 kc) various frequencies from about 30 kc to 460 kc have been used. The IF frequency that is used is a compromise of many factors. Early superheterodyne receivers used low IF's, around 30-175 kc. A low IF had several advantages. With a low IF the oscillator frequency is close to the signal frequency and so the oscillator tuning circuit is similar to the signal tuning circuit. This makes the oscillator tuning circuit easier to design and adjust to track the incoming RF signal. With a low IF feedback within the tubes in the IF stages is reduced so that high amplification can be obtained without oscillation or instability. This was important in early sets because the tubes used at this time had appreciable internal feedback. With a low IF, greater selectivity can also be obtained. With a low IF tuned circuits in the IF stages have a high capacitance. Changes in tube input capacitance that occur when a tube is replaced cause little change in total circuit capacitance and so cause little change in the alignment or selectivity of the tuned circuits. With a low IF harmonics of the oscillator or IF signal or those generated in the detector stage are less likely to fall within the tuning range and cause interference.

A disadvantage of a low IF is that the oscillator frequency is close to the signal frequency and so may interact with it, resulting in instability, difficulty in tuning ("pulling"), or unwanted oscillation. Because of the similarity in tuned circuits the oscillator signal may pass through the antenna circuit and be radiated by the antenna, causing interference in nearby sets. Most importantly, however, with a low IF certain types of unwanted signals ("images") become difficult to eliminate and these interfere with reception. This will be discussed in detail below.

During the 1920's improvements in tubes, tuning circuits, and other developments made it possible to use higher IF frequencies. In the mid-1920's more effective means were found to make the oscillator frequency track the signal frequency. A major step forward was the "ganging" of tuning condensers, i.e., mounting condensers on the same shaft so that they turned together and thereby kept in tune with each other. In 1929-30 screen-grid tubes were developed. With their low input capacitance and shielded elements, these tubes could perform well at high frequencies, giving high amplification and selectivity without instability or oscillation. In 1929-30 the diode detector was widely adopted. This type of detector reduced the production of harmonics in the detector stage that often caused interference. In 1931 tubes with a "remote cut-off" characteristic were developed. These could handle large signals without being overloaded, thereby reducing the production of unwanted signals. Also about this time, AVC circuits were widely adopted, further reducing the problem of overloading. With these developments higher IF's could be used, and these offered several advantages. With a high IF the oscillator frequency is farther from the signal frequency and so interaction of the two is decreased. More importantly, however, a high IF reduces the problem of image reception. This will be discussed in detail below.

In order to prevent interference IF frequencies are selected so that they are not at, or close to, signal frequencies used by other radio services. The IF that is used presently for most AM broadcast radios is 455 kc. This has been more or less standard since the mid-1930's. This frequency represents a compromise between the degree of selectivity and stability that may be obtained and freedom from images.

Images

Images are signals received at a tuning position different from their normal one. These unwanted signals are produced by various combinations of oscillator and signal frequencies that give the IF signal of the receiver. There are several combinations of oscillator and signal frequencies that can produce a signal at the IF frequency.

Oscillator images - "Double-spot reception"

With double-spot reception the same station can be received at two different settings of the tuning dial. Double-spot reception occurs because there are two settings of the oscillator frequency that, when mixed with the desired signal frequency, will produce the IF of the receiver. One occurs when the oscillator frequency is less than the signal frequency by an amount equal to the IF, and the other occurs when the oscillator frequency is greater than the signal frequency (by the same amount). Example: The frequency of the desired signal is 1000 kc and the IF is 460 kc. The station may be received if the oscillator frequency is 540 kc (1000-540 = 460 kc IF) or 1460 kc (1460-1000 = 460 kc IF). The two points of reception will always be separated by twice the IF frequency.

Double-spot reception is eliminated by providing signal-tuning circuits ahead of the converter and by coupling the tuning condenser for these circuits to that for the oscillator tuning circuit so that at the normal oscillator setting the signal-tuning circuit allows the signal to reach the converter, permitting its reception; at the other possible oscillator setting the signal-tuning circuit prevents the signal from reaching the converter and so prevents its reception. The coupling of the condensers is obtained by the use of "ganged" (mechnically-coupled) tuning condensers. A high IF frequency may also be used to reduce double-spot reception. With a high IF the alternate setting of the oscillator frequency that allows reception of the signal is farther from the normal setting. The increased separation allows the incoming signal to be eliminated more effectively by the tuned circuits ahead of the converter. It may be possible to use an IF high enough so that the alternate oscillator frequency is outside the tuning range of the oscillator circuit and so cannot be produced. Modern superheterodyne receivers usually use both a high IF frequency and tuned circuits ahead of the converter to eliminate oscillator images.

Double-spot reception is more likely to occur in sets in which the IF frequency is low or if high-frequency shortwave signals are to be received. Under these conditions, the alternate setting of the oscillator that allows reception of the signal is relatively close to the normal setting, making it more difficult for the tuned circuit ahead of the converter to eliminate the signal. Additional tuned circuits may have to be used to obtain the necessary selectivity to reject the signal. In these cases, a double-tuned antenna circuit or a tuned RF stage is often used.

Examples

Effect of lower IF. Suppose signal frequency is 1000 kc.

If IF = 455 kc, alternate oscillator setting is (2 x 455) = 960 kc = (960 ÷ 1000) x 100% = 96% from normal setting. If IF = 50 kc, the alternate oscillator setting is only (2 x 50) = 100 kc = (100 ÷ 1000) x 100% = 10% from normal setting.

Effect of higher signal frequency. For 1000 kc signal and 455 kc IF, the alternate oscillator setting is 96% from normal setting (see above). For 10,000 kc signal, the alternate oscillator setting is only (960 ÷ 10,000) x 100% = 9.6% from normal setting.

If double-spot reception occurs, the following relationship is observed: if the oscillator is designed to track above the signal frequency, the image will appear when the tuning dial is set lower (oscillator frequency is then below the signal frequency). If the oscillator is designed to track below the signal frequency, the image will appear when the tuning dial is set higher (oscillator frequency is then above the signal frequency. In both cases the difference in dial settings is equal to twice the IF frequency of the set.

Double-spot reception was a common problem in early superheterodyne receivers. Many of these used a separate control knob for oscillator tuning and so it was possible to obtain the IF signal at two separate settings of the oscillator tuning knob. Even in sets with ganged condensers the IF frequency was usually so low that the alternate setting of the oscillator frequency that allows reception of the signal was close to the normal setting, making it difficult for the tuned circuits ahead of the converter to eliminate the signal.

Signal images

With signal images two different stations may be received at a given setting of the tuning dial. This occurs because for any one oscillator frequency there are two signal frequencies that, when mixed with the oscillator signal, will produce the IF of the receiver. One occurs when the signal frequency is less than the oscillator frequency (by an amount equal to the IF) and the other occurs when the signal frequency is greater than the oscillator frequency (by the same amount). Example: The oscillator frequency is 1000 kc and the IF is 460 kc. A station may be received if its frequency is 1460 kc (1460-1000 = 460 kc) or 540 kc (1000 - 540 = 460 kc). The two points of reception will always be separated by twice the IF frequency. The undesired signal that produces the IF frequency is called the image signal; it may cause interference with the desired signal if it is not eliminated.

Image signals are eliminated by using signal-tuning circuits ahead of the converter stage to eliminate the unwanted image signal and allow only the desired signal to be received.

The condenser for the signal-tuning circuit is coupled to that for the oscillator so that for any setting of the oscillator, only the desired signal is received and the image signal is rejected. A high IF frequency may also be used to eliminate image signals. With a high IF the image signal is farther in frequency from the desired signal and so is more easily eliminated by the tuned circuits ahead of the converter. Modern super-heterodyne receivers usually use both these techniques to reduce signal images.

Image reception is more likely to occur in sets in which the IF frequency is low or if high-frequency shortwave signals are to be received. Under these conditions, the image frequency is relatively close to that of the desired signal, making it more difficult for the tuned circuit ahead of the converter to eliminate it. Additional tuned circuits may have to be used to obtain the necessary selectivity to reject the image signal. In these cases, a double-tuned antenna stage or a tuned RF stage is often used.

If signal images occur, the following relationship is observed: if the oscillator is designed to track above the desired signal frequency, the image signal will be higher than the desired signal by twice the IF. If the oscillator is designed to track below the desired signal frequency, the image will be lower than the desired signal by twice the IF.

Image reception was a common problem in early superhetero-dyne receivers because of the low IF frequencies that were used. Sets with a separate oscillator tuning control, not coupled to a signal-tuning circuit, were even more susceptible to images. The problem became increasingly serious as more and more stations crowded the broadcast bands. Image reception was alleviated by the use of ganged condensers, higher IF frequen-cies, and improvements in coil design that increased the selectivity of tuned circuits.

Signal-tuning circuits

As has been discussed, signal-tuning circuits are used ahead of the converter stage. The function of these circuits is to eliminate unwanted signals that might cause interference from reaching the converter. The circuits also prevent the local oscillator signal from reaching the antenna and being radiated. The signal-tuning circuits are fairly broad in response. This is not a disadvantage since the function of these circuits is mainly to eliminate image signals, which are spaced relatively far apart in frequency. Because these circuits are fairly broad in response they have little effect on tuning. The circuits also have little effect on the selectivity of the set (separation of signals). Selectivity is determined mainly by tuned circuits in the IF stages. The tuning of the signal-selecting circuits must vary simultaneously with that of the oscillator and so the condensers controlling the tuning of these circuits are ganged to the condenser controlling the oscillator frequency.

The number of signal-selecting circuits used to reject unwanted signals depends on the selectivity needed to reject these signals. Sets that cover only the broadcast band usually need only one signal-tuning circuit to obtain satisfactory rejection of unwanted signals. If the IF is low the image signals are more difficult to eliminate and so two signal-tuning circuits are used. Sets that cover shortwave bands in addition to the broadcast band are also more susceptible to image reception and so usually also have two signal-tuning circuits. More than two circuits are usually not used because of the difficulty in obtaining close tracking among the various circuits: slight variations occur among the different circuits and as they are varied across the tuning range they cannot keep exactly in step with one another. The mistracking that results reduces the sensitivity and selectivity that may be obtained. Moreover, the sensitivity and selectivity vary across the tuning range, which is undesirable.

It is seen that the tuning knob simultaneously controls several functions: it varies the oscillator frequency to carry out tuning and it varies the signal-selecting circuits to allow them to select desired signals and eliminate unwanted signals. The tuning condenser will therefore have several sections: one that controls the oscillator frequency and one or more that control the tuning of the signal-selecting circuits. The number of sections on the tuning condenser depends on the number of signal-tuning circuits required to eliminate unwanted signals. Sets that receive only the broadcast band usually need only one signal-tuning circuit for adequate rejection of unwanted signals and so have a two-section tuning condenser (oscillator and one signal-tuning circuit). If the IF frequency is low two signal-tuning circuits are usually necessary for adequate rejection of unwanted signals and so the tuning condenser has three sections (oscillator and two signal-tuning circuits). Sets that receive shortwave bands in addition to the broadcast band are also more susceptible to image reception and so usually also have two signal-tuning circuits. In these sets the tuning condenser also has three sections (oscillator and two signal-tuning circuits). In exceptional cases three signal-tuning circuits are used and the tuning condenser has four sections. To reduce costs many inexpensive sets that receive shortwave bands in addition to the broadcast band use only one signal-tuning circuit and so have only a two-section tuning condenser. These sets perform satisfactorily on the broadcast band but have a relatively high degree of image interference on the shortwave bands.

In early superheterodyne receivers the effects of mistracking between the oscillator and signal-tuning circuits (decreased sensitivity and increased reception of unwanted signals) were relatively serious problems. The loss of sensitivity meant that more tubes had to be used and this was expensive. Because low IF frequencies were used image signals were close to the desired signal and thus were difficult to eliminate if there was any degree of mistracking. In many early superheterodyne receivers the oscillator circuits and signal-selecting circuits were separate and individually controlled. This eliminated the problem of mistracking but made tuning the set a cumbersome and time-consuming procedure. Double-spot reception also became a problem. By the mid-1920's tuning circuits in most sets were mechnically coupled in some fashion. Some mistracking was inevitable but with improvements in circuit technology and design and with the use of higher IF frequencies mistracking became much less of a problem.

Image ratio.

The degree to which signals at the image frequency are eliminated is called the image ratio. The image ratio is the ratio of receiver output from the desired signal to that from the image. A large value indicates a high degree of reduction of the interfering signal. The image ratio depends on the signal frequency, on the IF frequency of the set, and on the number of tuned circuits preceding the converter stage. With higher signal frequencies the image ratio decreases since the image differs from the desired frequency by a smaller percentage and so is more difficult to eliminate by tuned circuits ahead of the converter. With higher IF frequencies the image ratio is increased since the image signal is farther in frequency from the desired signal and so is more easily eliminated by the tuned circuits. Increasing the number of tuned circuits ahead of the converter provides greater selectivity, increasing the image ratio.

With an IF of 455 kc (which is now standard) and one tuned circuit ahead of the converter, image rejection is adequate for signal frequencies up to about 7 mc (7000 kc). At 14 mc the image ratio is poor but is adequate when there is a tuned RF amplifier between the antenna and converter (two tuned circuits ahead of the converter). At 28 mc and higher the image ratio is very poor even with an RF stage. Additional tuned stages do not significantly increase the image ratio because the difficulty in obtaining close tracking among the various circuits limits the selectivity that may be obtained. Thus, most radios designed for reception of both the broadcast band and shortwave bands seldom go above 28 mc.

Spurious responses

Because signals of many different frequencies are involved in the operation of superheterodyne receivers (RF, oscillator, and IF signals), superheterodyne receivers are susceptible to a variety of spurious (unwanted) responses. These arise when any two signals combine to produce the intermediate frequency or a signal close to that frequency. The result may be reception of unwanted signals, interference with a desired signal, or simply annoying whistles, squeals, howls, or dead spots.

The signals causing interferences may be external signals entering the set through the antenna or wiring in the set or signals generated within the set. The latter includes harmonics of the oscillator signal, harmonics of signals generated in the converter tube, signals produced by heterodyning in the converter tube (cross-modulation), harmonics of the IF signal generated by rectification in the detector stage, and harmonics of any signal generated when a tube is overloaded by a strong signal. Interaction of any of these signals may produce a spurious response.

Unwanted external signals may be reduced by using tuned circuits in the antenna or RF stages and by better shielding. Unwanted signals generated within the set may be eliminated by better shielding, adequate bypassing of signal-carrying circuits, or redesign of the circuit involved. Diode detectors produce fewer harmonics than other types of detectors. Overloading of tubes is prevented by use of remote cut-off tubes and AVC. Wave-traps (circuits tuned to the IF frequency) may be used to eliminate IF signals from entering the antenna. Spurious responses were a problem in early superheterodyne receivers but with advances in technology modern receivers are relatively free of them.

Amplification and selectivity

In superheterodyne receivers incoming signals are converted to a fixed, low frequency, the intermediate frequency (IF). The functions of amplifying and selecting the desired signal are carried out at this frequency. At the fixed, low frequency of the IF a high degree of amplification and selectivity may be obtained. Most of the amplification and selection of signals occurs in the IF stages.

Amplification

In superheterodyne sets most of the amplification of the set occurs at the low, fixed frequency of the IF. At this low frequency feedback, instability, and oscillation are less likely to occur. As a result, higher amplification and greater stability may be obtained. Since the frequency of the IF signal is fixed, the IF amplifier stages can be designed to give a high degree of amplification. In modern sets, most of the radio-frequency amplification of signals can be carried out by a single IF amplifier tube. Because the IF is fixed, amplification does not vary with tuning and is constant across the entire tuning range.

Selectivity

Selectivity is the separation of the desired signal from unwanted signals close to it in frequency. In superheterodyne receivers selection of signals occurs at a low IF frequency rather than at the signal frequency. At this frequency higher selectivity can be obtained. Since the IF frequency is fixed, tuned circuits in the IF stage can be adjusted precisely to the IF frequency to give a high degree of selectivity. In modern sets adequate selectivity is obtained from just two double-tuned circuits in the IF stage. Because the IF is fixed, selectivity does not vary with tuning and is uniform across the tuning range. The signal-tuning circuit ahead of the converter is relatively broad in response and so contributes little to the overall selectivity of the receiver. Most of the selectivity of the receiver occurs in the IF stages.

Reason for improved selectivity at a lower IF frequency.

Example: Consider a desired signal at 1000 kc and an undesired signal at 1010 kc. The difference in frequency is 10 kc. The undesired signal is only (10/1000) x 100% = 1% from the wanted frequency and so would be difficult to eliminate by a tuned circuit. In a superheterodyne receiver with a lower intermediate frequency, e.g. 175 kc, the desired signal would appear as 175 kc and the undesired signal at 185 kc. The difference in frequency is still 10 kc. However, the frequency of the undesired signal is now (10/175) x 100% = 6% from the desired frequency and so is easier to eliminate by tuned circuits in the IF stages.

Alignment of superheterodyne receivers.

Alignment means adjustment of a tuned circuit to give maximum response to the frequency for which it is designed. Alignment of superheterodyne receivers is fairly complex as several different frequencies are involved. IF circuits must be aligned to the IF frequency of the set. The oscillator circuit must be adjusted so that its frequency is always greater than signal frequencies by the IF. Signal-selecting circuits must be aligned to be in tune with signal frequencies in the tuning range.

In alignment, signals of various frequencies are injected into the set and the appropriate tuned circuits are adjusted to give maximum response at those frequencies. Maximum response is usually determined by injecting modulated signals and adjusting the circuits to give the loudest volume. This is most easily and precisely indicated on an AC voltmeter connected to the audio output stage of the receiver.

The IF stages are aligned first. A signal of the intermediate frequency is injected into the set and tuned circuits in the IF stages are aligned to give maximum response at that frequency.

Next, the oscillator is aligned. It must produce the intermediate frequency of the set when combined with the signal frequencies of stations tuned in across the dial. The tuning dial is set to a point near the high end of the tuning range. An RF signal corresponding to the frequency indicated on the dial is injected into the set. The oscillator frequency is then adjusted to give maximum response at that frequency. At this point the correct IF frequency is being produced. The tuning dial is then set to a point near the low end of the tuning range and the procedure is repeated with a signal of low frequency. The oscillator is then usually checked again at the high end since adjustments at the low end of the tuning range may affect the accuracy of alignment at the high end. When the oscillator is aligned correctly, it produces the correct IF frequency for all signals tuned in throughout the entire tuning range of the set. With shortwave sets care must be taken to align the oscillator to the correct frequency and not to an image.

Finally, the RF and antenna circuits are aligned. These circuits must be in tune with desired stations when the set is tuned to receive these signals. The dial is set to a frequency at the high end of the tuning range. An RF signal corresponding to the frequency indicated on the dial is injected into the set and the RF and antenna circuits are aligned to give maximum response at that frequency. The procedure is repeated at the low end of the tuning range, and then the high end is checked again. As with the oscillator, care must be taken not to align the RF and antenna circuits to an image frequency. The oscillator and antenna circuits are usually aligned together in one step to simplify the alignment procedure and ensure greater accuracy.

The above procedure is a generalized one; exact alignment instructions are usually provided with other circuit data for the set. In many inexpensive sets no adjustments are provided for the oscillator and antenna circuits at the low end of the tuning range; the tuning circuits are designed to be more or less in correct alignment at these frequencies.

Antennas for superheterodyne receivers

The sensitivity and stability of superheterodyne receivers is so great that a small, self-contained antenna is often sufficient for reception. This eliminates the need for bulky external antennas. With a self-contained antenna the receiver can be matched to the antenna for greatest efficiency,rather than having to allow for the use of various individual external antenna systems. Loop antennas are often used for the built-in antenna. Besides being compact, these antennas offer the advantage of being directional. They can be turned to reduce unwanted signals or to reduce static. Modern broadcast radios use a loop antenna wound on a ferrite core, making them even more compact and efficient. The ability of superheterodyne receivers to operate satisfactorily with a self-contained antenna allowed the possibility of portable sets that could be taken and used anywhere. Such sets began to be manufactured as early as the mid-1920's.

Shortwave converters

Shortwave converters were devices that could be connected to an ordinary radio that was capable of receiving only the broadcast band to enable it to receive shortwave stations as well. These devices used the superheterodyne principle to convert high frequency shortwave signals beyond the range of the receiver to signals that could be received. The converters consisted of the "front end" of a superheterodyne receiver, i.e., an appropriate tuning circuit, oscillator, and converter tube. The converter picked up the shortwave signals and by heterodyning converted them to an unused frequency in the broadcast band. This signal was fed into the radio set and the set was tuned to receive this frequency. The converter was then tuned to receive the various shortwave stations. It is seen that with the converter in use the radio set acted as an IF amplifier. For covering different bands some converters used sets of plug-in coils; others used switch-selected tapped coils. Some converters were self-powered; others obtained their power from the radio. The radio could be any type of set, TRF, neutrodyne, reflex, or regenerative. Any type of set would work as long as it could receive the frequency put out by the converter.

Reception of code signals

Code signals used by radio amateurs or "hams" for communication are unmodulated signals and so produce no sound in the ordinary type of home radio. To receive these signals the principle of heterodyning is used. The code signal, usually in the form of an IF signal in a superheterodyne receiver, is mixed with a signal generated by a special oscillator in the set called a Beat Frequency Oscillator (BFO). The frequency of the BFO is adjusted to be a few kilocycles different from that of the IF signal so that when the two signals are combined in a tube, heterodyning occurs and an audible tone is produced. The code signal is then heard in the form of interrupted tones corresponding to the dots and dashes of the signal. It can be seen that this technique is essentially a form of Fessenden's method of heterodyne reception and can be used in any type of receiver.

Use of oscillator second harmonic frequency

In early superheterodyne receivers a low IF frequency was common. As a result, the oscillator frequency in these sets was close to that of incoming RF signals. This resulted in many problems. The oscillator frequency was relatively high, and it was often difficult to obtain stable oscillation. The signal-tuning circuits "pulled" the oscillator frequency, making accurate tuning difficult to obtain. Because of the similarity in oscillator and signal frequencies, the oscillator signal could pass through tuned circuits and be radiated by the antenna, causing interference in nearby sets. To eliminate these problems, some receivers used a lower oscillator frequency such that its second harmonic, when mixed with the incoming signal, gave the proper frequency to generate the IF. (A second harmonic is the component of a signal with twice its frequency.) Example: The signal frequency is 1000 kc and the IF is 50 kc. The necessary oscillator frequency is (1000 + 50)= 1050 kc. With second harmonic operation, the oscillator operates at half the required frequency (½ x 1050) = 525 kc so that the second harmonic (2 x 525) = 1050 kc provides the frequency necessary to convert the incoming signal to the IF frequency.

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From Spark to Satellite, by S. Leinwoll, 1979.
Circumventing the Superhet, IEEE Spectrum, Feb. 1983.

BOOKS FOR BEGINNING COLLECTORS

The beginning collector seeking to increase his knowledge of the history of radio will find two books to be especially useful. A Flick of the Switch by Morgan E. McMahon, 311 pp. ($9.95) contains many pictures of radio, TV, and amateur equipment from 1930 to 1950. It provides an excellent overall view of radio styles during this period. Vintage Radio, 1887-1929, by Morgan E. McMahon, 264 pp. ($9.95) covers an earlier period of wireless equipment and battery sets. Another book, Antique Radios, Restoration and Price Guide, by David and Betty Johnson, 100 pp. ($10.95) has many photos and also chapters on how radios work, restoration, dates of manufacture, sources of information, etc. These books may be obtained from Antique Electronic Supply, 1725 W. University, Tempe, AZ 85281.

WHAT KIND OF COLLECTOR ARE YOU?

Aesthete - Considers old radios "beautiful." Collects them for their physical appearance. Radios must be in mint condition. Usually likes brightly-colored celluloid or glass radios or unusual-looking novelty sets. Becomes nervous is anyone wants to touch them.

Historian - Collects sets for their rarity or historical value. The older the better. Likes wireless equipment or early battery sets. Thinks AC sets are "trash."

Technician - Interested in the type of circuit used in the set or the performance of the set. Doesn't care about the physical condition of the set as long as it plays. Inclined to tinker with the set, hoping to improve it. Usually has quaint old Hi-Fi system with home-made speakers.

Snob - Collects only prestige sets such as E.H. Scott or McMurdo-Silver sets. Usually has very few sets, but these, of course, are the best.

Dealer - Interested in radios for their monetary value. Mainly likes to buy and sell. Doesn't really make that much money, but it makes him happy, so what the heck!

Accumulator - Goes for sheer numbers of sets. Boasts about how many he has. Often knows little about his sets and doesn't take very good care of them. Probably has a big pile of them rotting away in the garage. Very difficult to buy a set from this type.

Closet Collector - This is the little guy who occasionally picks up a few sets for his own amusement. Not a "gung-ho" type of collector. You seldom hear about these guys but there's a lot of them around. They usually don't have anything particularly interesting, but that rare gem that you've been looking for all these years is probably sitting right there in his collection.

BALLAST TUBES AND RESISTANCE LINE CORDS

From about 1933 to 1943 many table radios and some floor models were designed to operate directly from line voltage. These were called AC-DC or "transformerless" sets. The voltage for heating the tube filaments was supplied directly from the line. Since line voltage is 117v AC and the tube filaments required only about 6 or 12v (25, 35, or 50v for many rectifier and output tubes) a resistor had to be provided to drop the line voltage to the proper value to operate the filaments. The problem was simplified somewhat by connecting the filaments in series so that each filament acted as a resistor, dropping the voltage somewhat for the remaining filaments. In most cases, however, the line voltage was greater than the sum of the voltages required to heat the tube filaments and so an additional resistor was required to drop the remaining voltage.

Example: A typical five-tube set of the mid-1930's used three 6.3v tubes and two 25v tubes connected in series. The total voltage drop was (3 x 6.3) + (2 x 25) = 69v. Line voltage is 117v. Therefore, (117 - 69) = 48v must be dropped.

The resistor dropping the voltage often had to dissipate considerable power and so would become extremely hot. In many cases the resistor was built into the line cord in the form of a resistance wire running the entire length of the cord (resistance line cords). Since the heat generated was distributed along the entire length of the cord, the cord became only moderately warm and so posed little danger. In other cases the resistor was built into a tube called a ballast tube. These were glass or metal tubes that looked like ordinary radio tubes and plugged into a socket on the chassis. They were often identified by a code, such as the following:

RMA BALLAST CODE

Example: type B-K-55-B-G

The first letter (B) indicates a ballast tube but may not appear. The second letter (K) indicates the type of pilot light used in the set:

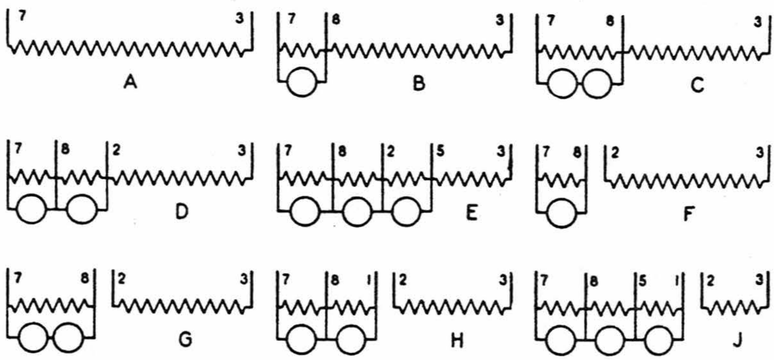
K - a 6-8v 0.15A bulb is used.
L - a 6-8v 0.25A bulb is used.

In practice, any type of bulb can be used without harm to the set.

The number (55) designates the voltage drop in the resistor, including that for the pilot light.
The letter following the voltage drop (B) indicates the circuit

and base wiring (see below).
The last letter (G) indicates a glass tube and may be disregarded. An "X" after the lamp-designating letter indicates a four-prong base e.g. LX55B.

In the wiring diagram below the numbers stand for the prong connections of an octal socket.

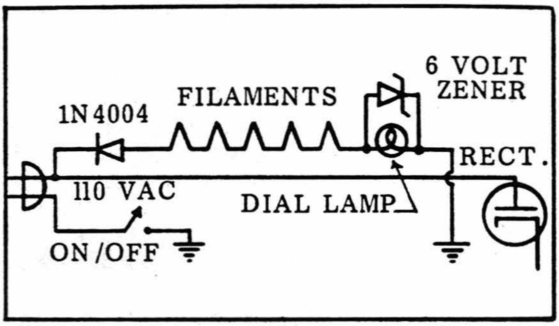


With glass four-prong base ballast tubes, a much-used system was to have a number indicating the overall resistance. <u>Example</u>: type 185R4. The unit has an overall resistance of 185 ohms. To convert this to the RMA code multiply the resistance by 0.3 to obtain the voltage drop: 185 x 0.3 = 55v. The tube is equivalent to type KX55B.

The section of resistor across which the pilot lights are connected serve to provide an electrical path in case the lamps burn out. Also, it helps to absorb the surge in current that occurs after the set is turned on while the tubes are warming up.

In the early 1940's tubes were designed with filaments that operated on higher voltages so that a set of these connected in series could operate off the line voltage with no dropping resistor being required.

Burned-out ballast tubes should not be replaced by resistors mounted in a set because a great deal of heat is generated. Sometimes the ballast tube can be opened and resistors mounted inside. This is hazardous, however, since resistors with a large power rating are required (15-20 watts), much heat is generated, space inside the tube is limited, and there is danger that connecting wires will short to each other or present a shock hazard. In many cases the ballast tube or resistance line cord can be replaced with a silicon diode, with a Zener diode across the dial lamps to prevent them from burning out.



The power dissipated in a ballast tube or resistance line cord can be found by multiplying the voltage drop across them by the current drawn by the tube filaments.

Example: The five-tube set considered previously required a voltage drop of 48v. The current drawn by the tube filaments is 0.3A. The power dissipated is (48 x 0.3) = 14.4 watts.

References:

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CHRS Newsletter, Nov-Dec 1983

RADIO ENTERS THE HOME

"I have in mind a plan of development which would make radio a household utility in the same sense as a piano or a phonograph. The idea is to bring music into the home by wireless. The receiver can be designed in the form of a "radio music box" and arranged for several different wavelengths, which should be changeable with the throwing of a single switch or pressing of a single button...Receiving lectures at home can be made perfectly audible; also events of national importance can be simultaneously announced and received. This proposition would be especially interesting to farmers...They could enjoy concerts, lectures, music, recitals, etc., which may be going on in the nearest city."

- David Sarnoff, 1916, in a memo to his superior while working for American Marconi.

ADVERTISEMENTS

For Sale: Zenith English deluxe cabinet only, with doors, drawers, and more, best offer. 1927 Zenith model 11E, seven-tube early AC set, works good, $125. 1928 Qualiphone rare cathdral with blue arcturus tubes, exc. cond., $110. 1929 Keller-Fuller Radiette, early cathedral, with tubes, $75. 1933 Jackson-Bell model 62 cabinet only, best offer. 1935 Stromberg-Carlson model 420-L, with shortwave bands, tuning eye, $95. 1936 Philco model 60 cathedral, parts radio, cabinet in exc. shape, $50. 1936 General Electric tombstone model E-81, eight tubes, recapped, three bands, exc. cond. $95. 1938 General Electric console, model A-82, ten tubes, four bands, deco cabinet, $125. 1939 Philco model 39-116 floor model, thirteen tubes, "Mystery Control" remote-controlled set, rare factory black lacquer cabinet with chrome escutcheon, exc. cond., $195. 1939 Mills "Empress" juke box parts, speaker, plastic, knobs, more. Best offer. 1940 Zenith model 6D614 table model radio, exc. cond, $50. 1940 Blaupunkt table model radio, $40. 1940's Meissner portable phono-radio-recorder, AC, unusual mint condition, with extra cutting stylus needles, dual microphones, and four blank records, $95. 1946 Philco model 46-420 stylish brown plastic radio, exc. cond., $40. 1946 Stromberg-Carlson model 1121 console, AM-FM-SW, 15" speaker, big sound, $95. 1946 Magnavox console, Drexel cabinet, four speaker, three chassis, 20 tubes, exc. cond. $95. 1947 RCA model 8-TR-29 10" television with AM-FM, table model with 35 tubes, works, $125. 30" morning-glory horn for Edison or Victrola phonograph, $50. 1950's Fisher power amp model SA-100, tuner model 400, and multiplex unit model 100, $50 each or all three for $100. 1950's H.H. Scott model 311-C tuner with pre-amp, $40, and H.H. Scott stereo power amp model 222-C, laboratory type, $75. Like new three year old Akai 4000-DS reel-to-reel tape recorder, one-micron gap head, three heads, two speeds, sound-on-sound, and more, $150. Wanted: Chassis for Atwater Kent model 325-E console, five tubes, airplane dial, four knobs. Bob Malin, 1825 Via El Capitan, San Jose, CA 95124 (408) 267-1396.

Wanted: RCA model 103 speaker with needlepoint tapestry front, standard two pin speaker connection. State price and condition in your letter. R.G. Weamer, 390 E. Foster Rd., Santa Maria, CA 93455.

For Sale: Quality hard-cover reprint of T.S. Curtis' "High Frequency Apparatus," 269 pages plus 42-page appendix of 1920 book catalog. $15.95 postpaid. Satisfaction guaranteed. Harry Goldman, RD3 Box 181, Glens Falls NY 12801.

For Sale: 1939 Zenith console model 9-S-367. Very good cond., works perfectly. Best offer. Wanted: Zenith radio literature. Bob Urban, 55 Hawthorne Ave. Los Altos, CA 94022 (415) 948-2815.

Wanted: Pre-1936 radios, tubes, horn speakers, repair manuals, victrolas, and radio literature. David T. Walters, 13805 Florida Ave., Cresaptown, Maryland 21502.

More Ads →

For Sale: Philco 16B cathedral radio, good cond., works well, $150. Power transformers for power supplies to operate battery sets: 125v 50 ma and 6.3v 2A secondaries. $5.00 plus shipping. Herb Brams, 2427 Durant #4, Berkeley, CA 94704 (415) 841-5396.

For Sale: Tubes - send list of what you need with SASE. Radios for sale: Silvertone tombstone model 1906, $50; large Sparton tombstone model 628; $75; Philco Jr. cathedral model 80, $95; Mantola 7-tube large tombstone, $95; Howard table model, $30; Mickey Mouse record player, new type, $30; Stromberg-Carlson table model, $40. Customer pays shipping. David T. Walters, 13805 Florida Ave., Cresattown, MD 21502.

For Sale: Battery eliminators, 1.4-6v adjustable and regulated up to 1.25 A. Three plate voltages and C bias voltage too. With or without case. Send SASE for information. Instruction sheet for your Aeriola Sr. $3.75. Tuning dials for Philco models 33B, 84B, 93B or 37-84, $7.50. White filler for engraved panels and knobs, $3.25. Prices are postpaid. Peter Yanczer, 835 Bricken Pl., St. Louis, MO 63122.

For Sale: Stock of new old-stock tubes, unused and in original boxes, about 150 in all. Mostly fairly modern octal and miniature tubes, but includes 4-#71A, 8-#81, 18-#50, 17-#112A tubes. Would like to sell as a lot. Make offer. Ray Miller, Box 306 Avalon, CA 90704.

Wanted: Radio News magazines, especially of the early 1920's and late 1930's. Have some copies for sale or trade. Jim Cirner, 149 Tyler Ave., San Jose, CA 95117 (408) 296-0860.

For Sale: Atwater Kent console radio, 1929, model 70. Good cond., works. $125. Rich Links, 643 43rd. Ave., S.F., CA 94121 (415) 751-9491

For Sale: Large 10-tube 1927 early electric Zenith console radio in Colonial cabinet, exc. cond. with original literature, $300 or offer. Bob Miller, 1922 San Antonio Rd., Berkeley, CA 94707 (415) 524-7610.

English

Colonial