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COLLECTING OLD RADIOS AND CRYSTAL SETS

by
MAX ALTH

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Acknowledgement

The author herewith thanks Stanley Jacob for his technical assistance and encouragement in the preparation of this manuscript.

Dedication

Dedicated to

Char
Sime
Misch
Aaron
Arabella and
Mendel

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Introduction

Among other things, this is the age of television. Our children are born to it; some of them learn their first words watching and listening. Almost all of us spend some time each day in front of the screen. But not too far back we lived in the age of radio. In those days children and infants played in front of the radio receiver and most of us spent some part of the day listening.

This book is concerned with the beginning of that time: when it was a thrill and an accomplishment to listen in on Pittsburg with the aid of a receiver in distant Baltimore and when people bragged of how many tubes their sets had. Particularly, this book is concerned with the equipment used; the home constructed and assembled crystal sets and radios and the early, awkward but beautiful, factory constructed equipment.

That time is not completely gone. Some of the sounds are preserved on records. A little of the old equipment remains and much of the old gear still works or can be made to work.

For many people the artifacts remaining from the first days of radio are redolent with memories. For myself especially this is so because my early love was radio.

I first encountered radio in the form of a crystal set, which appeared to me to be made mostly from an empty oatmeal container. The crystal set rested atop an icebox in the home of a friend of my mother's. The set had been constructed by the friend's grown son, Stanley. I wasn't allowed to touch it and I could not have unless I pulled a chair over. All I could do was stand on tiptoe and try to see more of it. My mother and her friend always promised me that I could hear it work when Stanley came home. But Stanley was never at home when we visited and I never heard it work.

My relatives in Paterson, New Jersey had a battery operated, metal-box Atwater Kent. They kept it on their enclosed porch on a rattan table. The receiver had a loud speaker that looked like an umbrella on edge. We visited them in the summers and the batteries were always dead when we arrived. I never got to hear that either.

I heard my first radio voice in 1924 or 1925 in the home of our landlord who lived directly below us when we lived in Yonkers, New York. One of his four sons was in the radio business, or perhaps was working in a radio "parlor." They had one or more radio receivers in their apartment. One day I was permitted to listen to something with the aid of earphones. They placed earphones in a large kettle and by keeping very quiet and listening very hard, it was possible to hear the sound a short distance away.

Twice the boys tricked me into accepting a shock from a small diathermic machine. Once I touched the long glass bottle with the blue light inside. The second time two of the sons shook hands with me simultaneously. I completed the electric circuit and we all received a shock. They knew it was coming, I didn't. They thought it was fun, I thought it was a rotten trick for "adults" to play on a kid.

Meanwhile I kept asking for a little radio. I would go to the radio parlor where the son worked and look in the window. At that time radios had sloping panels of black rubber and lots of large dials in front. There was one small box with only a single dial in front. I imagined it couldn't cost very much and kept asking the son for it. He kept promising, but we eventually moved away and I never got anything.

The landlord's son kept a large open cardboard box in the basement behind the shop his parents ran, which was beneath our apartment. The box was filled with beautiful radio parts; smooth coils wound from wire covered with green silk, glass tubes with silver inside, and big black dials with large white numbers. The son later worked in or owned (I never knew) a radio shop on Courtland Street in lower Manhattan in New York City—Mecca of radio buffs the world over. But, Courtland Street is gone now, displaced by progress in the form of the twin towers, each one hundred stories high and each covering one acre. Most of the dozen or more half-century old radio shops that lined Courtland Street are gone. They carried electrical and radio parts from as far back as World War I; you could even purchase an **unused** Edison cylinder record in one shop. One or two shops moved north to Cannal Street, but didn't bring their stock of old radio parts with them. At the present there is no one that stocks only old radio parts and tubes anymore, at least not to this writer's knowledge.

chapter one

THE FIRST BROADCAST

If you question a grammer school student as to who invented radio, the student will most likely answer, Marconi. If the student is particularly bright he or she may include the inventor's first name, Guglielmo and his native land, Italy.

If you ply a high school student or a college student with the same question, you will more than likely receive the name, Heinrich Rudolph Hertz as your answer.

Although both of these men did contribute enormously to the broad field of science now called radio, neither man can be said to have invented radio. No one man invented radio, not even a series of men; but a series of groups of men, each working on or near the multitude of problems contributed to our present knowledge of the subject.

If; however, any man is to singled out as the "father" of wireless communication, that man to this writer's way of thinking, is neither Marconi nor Hertz, but the far lesser known American, Joseph Henry.

The story, tremendously simplified, runs this way. In 1831 in England, Michael Faraday determined by experiment how it was possible to produce electricity by using magnetism. Heretofore, scientists were able to produce magnetism by running an electrical current through an insulated wire wound in a coil. A compass, positioned in the center of the coil, formed a crude galvanometer and its needle would respond to the passage of electricity and the magnetic field that passage produced. That the phenomenon should be reversible was obvious, but how?

Faraday solved it by wrapping two separate coils of insulated wire around one ring. One coil he connected to a galvanometer. The other he connected to a battery through a switch. When he opened and closed the switch and current flowed through coil one, a current was induced in coil two and activated the galvanometer. The process of making and breaking the circuit to a coil produces by virtue of the collapsing field) an alternating current which is always surrounded by an alternating magnetic field. He found that magnetism could be used to generate electricity, but only when the field moved; i.e., alternated.

Somewhat concurrently, Joseph Henry duplicated the same experiments on the other side of the ocean. But Henry delayed somewhat in publishing his findings. As a result, the International Electrotechnical Commission credited Faraday with the discovery of mutual induction and to immortalize his name, designated the unit of electrostatic charge in a capacitor, the Farad. Henry was equally honored by the name of the unit of inductance, the Henry.

It may be of interest to note, before continuing with the history of radio, that Joseph Henry set up a telegraph line between the College of New Jersey (Princeton) and his home, adding a relay to the line and eliminating one wire by using the earth as a return conductor. He also devised and built a small electric motor in 1832, the first of all electric motors.

Whereas Faraday more or less left his experiments in magnetic induction behind and went on to learn more about the voltaic cell (electric battery), Henry intensified his study of induced currents. Returning from a trip to Europe in 1837, Henry began experimenting with Leyden jar discharges. A Leyden jar is an early form of capacitor (condenser). He concluded that the discharge of current from one plate of the capacitor to another was not a uni-directional flow of electrical current but an alternating flow. The current flowed first in one direction and then another, rapidly diminishing in strength as it did so.

Possibly by studying the principles of mutual induction, or possibly by sheer intuition or dogged experiment, he discovered that the magnetic effect of the alternating current could be transmitted over a distance without the use of an iron core intermediate. Henry began these experiments sometime in 1840, but delayed his announcement of his conclusions until June 17, 1842, when he submitted a paper to the American Philosophical Society. In part his paper read:

"The electric discharge is not correctly represented by the single transfer from one side of the Leyden jar capacitor to the other. The phenomena requires us to admit the existance of a principal discharge in one direction and then several reflex actions, backward and forward, each more feeble than the preceeding, until equilibrium is obtained."

At this point, Joseph Henry had produced and recognized the presence of high frequency alternating current which is the basis of radio transmission.

Reporting on further experiments, he stated, "A single spark thrown at the end of a circuit wire in an upper room, produced an induction sufficiently powerful to magnetize needles in a parallel circuit of wire placed in the cellar beneath, at a perpendicular distance of 30 feet with two floors and ceilings intervening.

By October of 1842, Henry succeeded in sending his signal between parallel wires 220 feet apart. He reported the results of his experiments to the American Philosophical Society in Philadelphia on October 21. This was **wireless**. Crude and limited, but wireless or radio nonetheless.

We shall skip over the work of Reiss, Helmholtz, Wollaston and William Thomson (Lord Kelvin) that stemmed directly from Joseph Henry's revelations, and go on to Heinrich Daniel Ruhmkorf. If you have read Jules Verne's "Journey to the Center of the Earth," you will recall the travelers carried "Ruhmkorf" coils which furnished a continuous source of light.

Ruhmkorf's coils were by no means capable of generating continuous electrical power. They were, and still are, electrical transformers that differed from Faraday's induction coil in that one coil had many more turns than the other. The resultant effect was to "transform" whatever voltage was supplied the smaller coil into a proportionally higher voltage in the larger coil. Ruhmkorf constructed a coil in 1867 that had a secondary winding more than 62 miles long. It produced a 16 inch long spark. (Approximately 32,000 volts.)

Not germane to our story, but interesting, is the construction by one A. Appes of a "spark" coil that had a 280 mile long secondary that produced a 42 inch spark. These spark coils powered the early transmitters and the struggle to increase the length of the spark, which was not merely one of keeping miles of wire straight but of confining high voltage as well, was an effort to increase the power of the transmitted signal and thus the distance of the transmission.

The spark coil is not the only means of producing an electric spark. Another source is the very atmosphere above our heads. It is always charged and may be considered a giant capacitor that discharges itself in the form of lightning every now and then. Mahlon Loomis, a dentist practicing at Earlville, New York, gave the matter much thought and came up with an invention that was granted Patent Letters, July 30, 1872, titled, "Improvement in Telegraphing." Its number is 129,971. (At present, nearly four million patents have been granted.)

His invention consisted of a large kite covered with fine wires and flown from a thin wire. When the lower end of the wire was brought close to the ground or a pool of water, sparks jumped the gap. This was his transmitter. His receiver was an identical arrangement a distance away.

Congress listened to a proposal for a "Loomis Aerial Telegraph Bill" that terminated in a request for fifty thousand dollars to develop the invention on May 21, 1872. Unfortunately for Loomis and the rest of the country, the bill was defeated. For although the device as Loomis presented it wasn't highly practical, there is no doubt that it did work. In 1886 he transmitted signals a distance of 14 miles using a kite transmitter above Mount Cohocton in Virginia and a similar receiver on Mount Beorse Deer. Still later, he demonstrated the usefulness of his device on shipboard by sending signals between ships 2 miles apart on Chesapeake Bay.

All through this period and up until 1864, men of science viewed the wireless transmission of electric signals as a vague "action at a distance." In the year just mentioned, James Clerk Maxwell presented a treatise on electricity and magnetism to the Royal Society in England. In his treatise he proposed the existence of an "ether" derived from mathematical reasoning and substantiated his arguments with his now famous equations. (The unit of magnetic flux, the Maxwell, is named after him.)

Maxwell pictured the universe as filled with an almost weightless substance which responded to magnetic fields and that moved the way water responds to waves produced by a falling stone.

We now go through a period in which many men experimented with radio using variations of the system or method originated by Henry. William Henry Preece, for example, placed two wires in parallel positions on either side of a river in England. Each long wire was connected to the earth at both ends. One had a key (switch and a battery in its middle), the other had a galvanometer in a similar position. Operating the key caused the galvanometer to move in unison. Later Preece improved this system by adding a buzzer in the transmitting line, which acted to generate a higher frequency current than was possible by the simple make-and-break key. The galvanometer was replaced with a telephone receiver and proved far more sensitive.

Sensitivity, of course, was the limitation, as much as a lack of knowledge of all the other factors necessary to effective radio broadcasting. Transmitting power, the spark, could be increased by brute force, but reception fell off rapidly with distance because of the comparatively large amount of energy necessary to activate a galvanometer, telephone receiver and, of course, jump a spark gap. It wasn't until a more sensitive "detector" was invented that the distance radio could span was increased without increasing transmitting power several times over. The first major improvement in detection was a device called a coherer—the work of the French physicist, Eduard Branly.

During his studies of electrical conductivity while a professor at the Institute Catholique in Paris, Branly observed that various powders varied in conductivity when exposed to a magnetic field. To further his work he placed a pinch of iron filings between two metal plugs and placed the whole in series with a galvanometer and a battery. When the filings were loose they hardly conducted electricity. When exposed to a magnetic field the metal particles cohered and conducted electricity quite well.

Branly refined his device until it became two silver plugs in a glass tube, separated by a "hair's breadth" and a "gnat's eyeful" of nickel dust. To loosen the metal dust after each "coherence," the glass tube was repeatedly struck by a tiny hammer operated by a mechanism similar to that of an electric doorbell.

Branly demonstrated his detector before the French Academy of Science in 1891, and we can assume that the world at large became aware of his invention after that time. This invention and other work led to his winning the Nobel Prize for Physics in 1921.

It is interesting to note that Branly wasn't the only one to recognize the effect of a magnetic field on particles of matter. In 1850 George Guitard noticed how particles behaved when electrified. And in 1866, S.A. Varley used carbon dust for a lightning protector of telegraph lines. An Italian professor, Calzecchi Onesti reported on the change of electrical resistance occuring between copper filings when exposed to a high voltage discharge. But his 1884 announcement went unnoticed and unrecognized for what it was. Such is the way of science and invention.

Let us jump forward in time to 1888 when Heinrich Rudolph Hertz published the results of his experiments in a paper entitled, "Electromagnetic Waves in Air and Their Reflection." Although he used a Ruhmkorff coil to produce his spark and two short rods with metal plates at their ends as his "exciter," many believe he did not draw upon the work of his predecessors but started from scratch. In any event, so far as we know his was the first "tuned" receiving circuit. His resonator, or detector, consisted of a single loop of wire, terminating in a micrometer gap, which could be adjusted. Hertz discovered the "tuned" circuit and reported that best results were secured when his "search" coil was in electrical resonance with his exciter.

More than one Hertz demonstrated the device to his class at the University of Kiel. With the lecture hall darkened, he could span the room and produce visible sparks at his receiver.

Hertz went on to measure the velocity of radio waves, to compute wavelengths and frequency; to prove that radio waves could be reflected by metal surfaces and refracted by giant prisms of wax and pitch, exactly as light. He found radio a fascinating mystery and left it a science. However, Hertz was not given "official" credit for the tuned circuit. Instead, Sir Oliver Lodge is recognized as its discoverer.

In 1894 a rich, young Italian boy vacationing in the Alps read an account of Hertzian waves in an electric journal. He was twenty-two-years-old and his name was Guglielmo Marconi. He cut his vacation short and rushed home to test some ideas that had struck him. We don't know his thinking, but it must have run along these lines: If tuning enabled Hertz to send enough energy across a room to produce a visible spark, using a coherer in place of a spark gap would multiply the distance a thousand times over because a coherer required less than one thousandth of the energy necessary to produce a visible spark.

Marconi never claimed to be a scientist. He always stated his ability lay in combining certain facts discovered and developed by others.

Marconi's first transmitter consisted of an elevated antenna with the spark gap located at its lower end, the end itself was solidly connected to the earth. His receiving antenna carefully duplicated the transmitting antenna with the coherer positioned where the spark gap was. His first efforts succeeded in transmitting a signal three-fourths of a mile across his father's estate.

In the course of his subsequent work he improved the coherer, eventually evacuating the glass tube to produce a stable, dependable device. He introduced coils with which he varied the electrical characteristics of his transmitting and receiving antennas, thereby tuning them. This made it possible for a great number of stations to use the "air" at one time without interference.

Marconi applied for his original and basic patent in 1896. Four years later he was granted a patent on a four circuit tuning system, which demonstrated his use and understanding of series tuning systems wherein the second tuned circuit refined that which was selected by the first, and so on. In March, 1898 Marconi flashed a message across the English Channel. In 1899, at the invitation of the **New York Herald,** Marconi came to America and transmitted reports on the America Cup races from a ship out of sight of land to a shore-based receiver.

Marconi made to prove the value of wireless telegraphy, but we will go on to his most dramatic feat. His equipment spanned 2,000 miles of broad, curving ocean, a barrier which many famous scientists said could not be done: Electromagnetic waves would not travel around a curve. But on December 12, 1910 his antenna, held aloft by a kite, responded to the signal letter, **S**, broadcast from Poldhuin Cornwall, Wales.

The coherer, as invented by Branly and refined by Marconi, was essentially a go-no-go device. In the presence of a magnetic field its particles cohered and lost most of their electrical resistance so that a batter-derived electric current could be directed through the device and activate a telegraphic sounder. Then the coherence would be mechanically interrupted while the system awaited a following pulse of magnetic energy. While this is satisfactory for telegraphy, it is next to useless for the reception of sound-modulated electromagnetic waves. To "detect" such waves, radio waves, if you will, a device that responded to the intensity or amplitude of the signal was required.

Strangely enough, Thomas Edison discovered in 1883 a device by accident that would work admirably as a detector of varying intensity electromagnetic waves. He properly identified its action, but did not realize its possible application. Called the Edison Effect, it remained for John Ambrose Fleming, appointed as an electrical adviser to the Marconi Wireless Telegraph Company to conceive of its use.

Fleming was attempting to find a detector superior to the coherer when he thought of some experiments he had made with Edison Effect lamps about one year earlier. It occurred to him that the special lamps made by Edison, and also by Sir Joseph Swan in England, could be used. As we know, it worked. He named it an oscillation valve and applied for a patent in Great Britain in 1904.

More people than ever began experimenting with wireless: scientists, inventors and amateurs. Cross-Atlantic transmissions had not yet come but were not far away in time and neither was radio—wireless voice transmission.

The first transmission of a voice signal appears to have gone unrecorded, or at least recorded so unobtrusively that all that could be found was a reference to Reginal Aubrey Fessenden as having developed radio telephony along with the high frequency alternator, the electrolytic detector, and the hetrodyne receiver. (More on the latter will be presented a bit farther on in this book.)

This writer believes no fuss in print was made over the first voice transmission because it was probably accomplished by amateurs. All the equipment was on hand; the microphone, the source of a continuous alternating high frequency current, and a choice of detectors capable of demodulating a voice signal. In addition to the Fleming valve, there were chemical detectors, magnetic detectors and crystal detectors, of which the crystal of lead galena is the best known and is still used. Many people, who lived by chance next to powerful transmitters, learned that almost anything served as a detector if the signal was strong enough: rusty nail on a metal plate, a razor blade against a spoon, and even a set of false teeth while in use by their owners.

Looking backwards from our present level of knowledge, the electrical "set up" was simple enough. Remove the key from the primary of the spark transformer and establish a continuous spark. Use a coil to couple radio frequency energy generated by the spark to a coil, one end of which is connected to an antenna, the other end of which is connected through a microphone to the earth. Inefficient, true, but it will work well enough.

In any event, Fessenden, active as a member of the National Electric Signaling Company, founded on the basis of his patents in 1902, directed his activities to the company's new station at Brant Rock, Massachussets. The station first gained fame by establishing communications with Machrihanish in Scotland. On Christmas Eve of 1906, Fessenden broadcast speech and phonograph music from his Brant Rock station. The broadcast was received by ships up and down the coast, inland some distance in New York State and Maryland and as far away as New Orleans.*

*Fessenden later said the first wireless transmission of speech was accomplished in December 1900 as part of an experiment.

In the same year, Lee De Forest, carried the Fleming valve one step further. He positioned a zig-zag wire of platinum between the filament and the plate. Without truly realizing what he had accomplished, he advanced the art of electronic communication a greater distance with this single step, in this writer's opinion, than anyone since Faraday. But as fate would have it, De Forest really didn't understand what he had devised, and what is and was equally costly to an inventor, he did not know how to use his device properly.

The Fleming oscillation valve is a diode and as such it rectifies. Alternating current can flow through it in one direction only. Thus, it converts alternating current—current that flows back and forth—into direct current—current that flows in one direction. As useful as the Fleming valve may be, it does not **add** to the current, it rectifies and detects. A receiver using a Fleming valve is dependent entirely on the electrical energy picked up by its antenna.

The De Forest "triode," three element valve, is capable of amplification. The "trigger" wire can be used to control the flow of current from the filament to the plate. Thus, where milliwatts were necessary, because the human ear requires roughly 0.02 watts of audio power to hear, with a Fleming valve or any of the equivalent detectors, only microwatts or millionths of a watt are necessary with the De Forest "Audion," as he named it. The microwatt signal is used to control and produce an equal but more powerful signal in the earphones or, in much later years, the loudspeaker. Unfortunately, Lee De Forest didn't know how to "hook it up" properly. He connected his Audion much the same as the Fleming valve and results were only slightly better.

Following, the story becomes garbled because too many "actors" enter upon the stage. Thousands of amateurs searched for the "hook up," the correct or best way of connecting tubes, coils, resistors, batteries, earphones, antennas, grounds, capacitors, transformers and more that would produce maximum results in reception and amplification. The search spread to thousands of homes.

Edwin Howard Armstrong, from Yonkers, New York, joined the search. He published his first report on his feed-back or regenerative circuit in **Electrical World**, December, 1914. Up until this time, De Forest and others were mystified by the strange behavior of the Audion under certain circumstances. They felt it a basic flaw and, we assume, did not look much further in this direction.

Armstrong recognized the strange behavior as oscillation, meaning the tube that was properly supplied with direct current acted to change this current to alternating current—the stuff from which radio transmissions are made. In his first paper, and subsequent papers and talks, Armstrong showed how the amplified signal taken from the plate of the Audion could be used to strengthen the incoming signal, which then would be amplified and returned again to the incoming signal (grid of the tube) and so until the point of oscillation was almost reached.

Suddenly the barriers to consistent long range radio communications were down. No longer was it necessary for the transmitter to actually power the earphones producing the sound. Now all the receiver required was a "smell" of the signal and the receiver furnished the power.

At the same time radio—voice and music—became practical. To broadcast sound it is necessary to have a continuous signal, which with the spark transmitter meant a constant arc that consumed energy at a voracious rate and generated a broad band of radio frequencies that interfered with reception. With the audion, the triode, it suddenly became possible to generate a single frequency at high efficiency without the heat and danger of the open electric arc.

The triode could (and was) used as an amplifier to strengthen voice signals so that they could be sent across the country. The triode also made the hetrodyne receiver practical. Fessenden invented it, but Armstrong is credited with inventing the super-hetrodyne receiver, which is still used today for AM radio reception. To get a little ahead of our story, Edwin Armstrong also invented and developed FM radio transmission and reception.

For Armstrong and Lee De Forest, the invention of the feedback circuit and the superhetrodyne was not an unmixed blessing. It is reported that the two men took a dislike to each other on sight, and this mutual dislike didn't do anything to alleviate their many years of legal battles in the courts over their respective patent claims. To read Armstrong's side of it, this writer recommends, **Man of High Fidelity** by Lawrence Lessing. (I haven't encountered anything that does equally well by Lee De Forest.)

Speaking of patents, Marconi said they were no more than titles to lawsuits and proof of this lies in the fact there are several more times the number of financially successful lawyers than inventors.

The country's attitude and especially the attitude of congress towards inventors is ambivalent. Inventors receive high praise in the press and insults in the marketplace. For many years inventors have striven to change the patent laws from first to invent (and make a practical model) to first to file. The present law gives all the advantage to the large company. It is little problem for a large corporation to actually construct their device, at which moment they have legal claim to the invention. It is much more difficult for the lone inventor to do the same, in most cases. When it comes to court and the company fields their group of lawyers, their argument—if the inventor can get a lawyer to represent him for what he can pay—is that while the inventor did file, he never did actually construct, and while an inventor did file in August, the corporation actually had the machine going in July. The fact they did not file right away is of secondary importance as the law now stands.

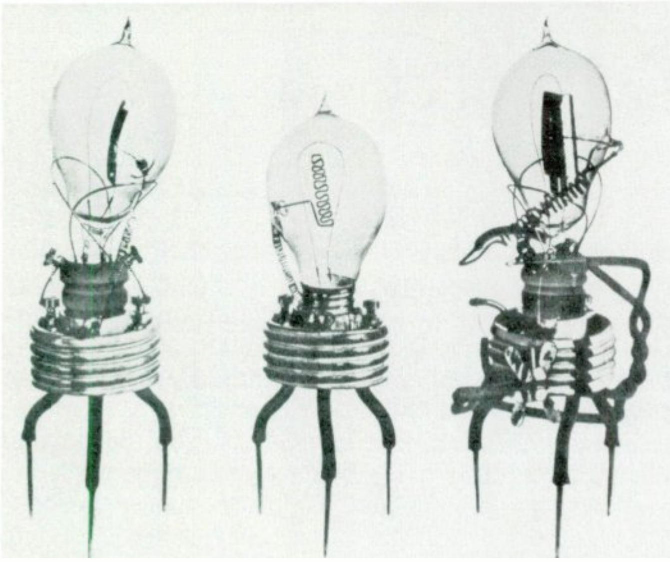
As unfair as all this is and sounds (in Europe it is first to file), half of all our major inventions are the work of lone inventors hacking away in their basement laboratories.

Continuing with our story, as we have seen, Fessenden was the first, or at least the first to gain recognition for his radio broadcast of 1906. No doubt there were others.

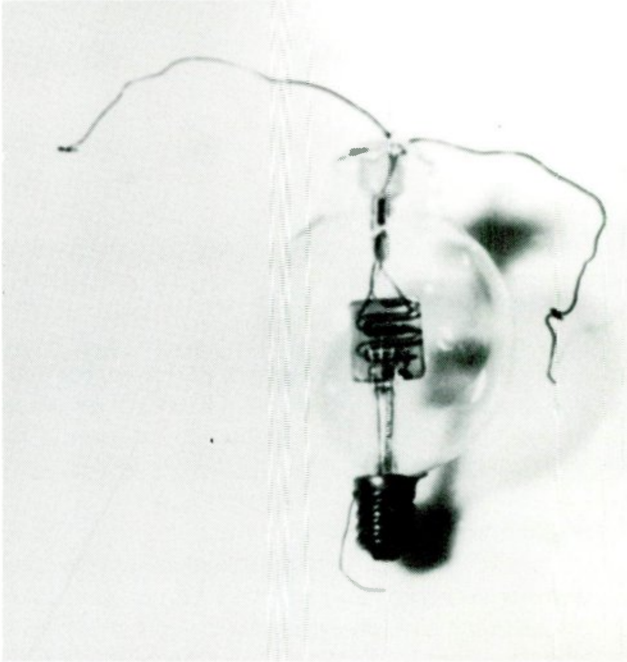
By the end of World War I, many experimenters were working in radio-telephone broadcasting and reception. But so far as we know, only one caught the eye of historians—Frank Conrad. Sometime in 1916 he constructed a wireless receiver in his home to receive the regularly broadcast time signals from the Naval Observatory broadcast station, NAA, in Arlington, Virginia. His only interest was in setting his watch accurately. When we hear of him again, it is after the war and he is operating an amateur station in Wilkinsburg, Pennsylvania. The station is in his garage and he has begun broadcasting phonograph music in addition to conversing with other amateurs. At this point a Pittsburg department store began advertising wireless receivers that would pick up Conrad's broadcast. Sales were phenomenal.

David Sarboff's prediction was coming true. In 1916, while assistant wireless traffic manager for the Marconi Wireless Telegraph Company in the United States, Sarnoff had proposed a "Radio Music Box" plan to the company's general manager. Sarnoff estimated that gross sales of entertainment receivers would amount to seventy-five million dollars in three years if the company would promote and sell broadcasting. (In the years 1922—1924, RCA gross receiver sales totaled $83.5 million.)

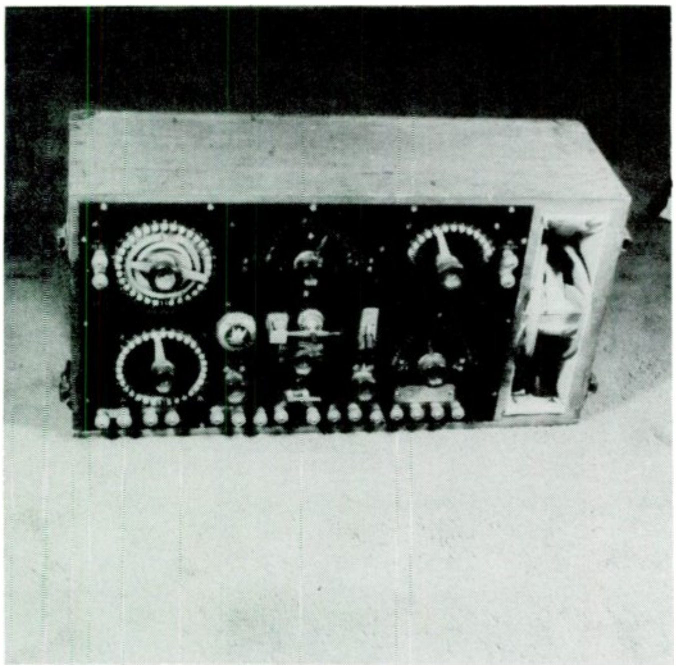
Westinghouse was the first of the corporate giants to see "gold under their noses." The company secured a commercial license with the assigned call letters KDKA on October 27, 1920. On November 2, 1920 the station broadcast the results of the Harding-Cox election. Suddenly we were in the age of radio.



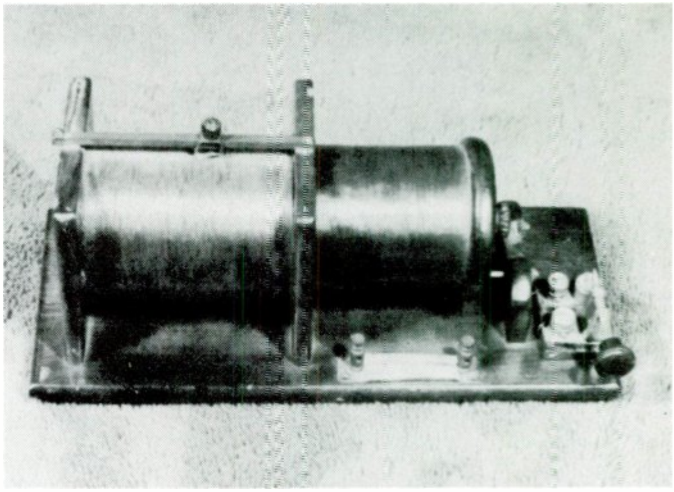
Early Fleming valves. **Courtesy Stromberg-Carlson.**



Early Audion. **Jacob collection.**



Military crystal receiver made by Westinghouse. Covers long wave and broadcast band. Jacob collection.



Homemade crystal receiver circa 1918. Slide is used to vary tuning. Coupling is varied by sliding smaller coil in and out of larger coil. Jacob collection.

chapter two

EVOLUTION OF THE EARLY RECEIVER

The era called radio began on a high note November 2, 1920 at a station in Pittsburgh called KDKA, when it broadcast election news. The broadcast and the license to broadcast at an assigned frequency of 618.3 hz (cycles per second) was the result of the encouragement of Frank Conrad, who had been broadcasting music and talk out of his garage intermittently and by Harry P. Davis, a vice-president of Westinghouse, for whom Conrad also worked as an engineer.

Davis had heard the Conrad broadcasts and knew of the widespread interest they had aroused. He also knew that his company and others had idle wireless-telegraph making equipment on hand, left over from their World War I efforts. He reasoned regular broadcasting would create a demand for receivers and more or less simultaneously planned to manufacture radio receivers for the public under the name of the "Music Box." (Westinghouse as well as General Electric produced receivers for RCA up until 1930.)

The first broadcast on KDKA was accomplished with a 100 watt transmitter and was listened to by some 5-to-10,000 receivers. The following day the first of a series of regular, single-hour broadcasts was begun, but was soon increased in response to listener interest. By March of the same year, there were approximately fifty thousand receivers tuned in. By May the figure had grown to an estimated 750,000 sets. In 1920 only one station was licensed to broadcast. by 1924, fourteen hundred stations had received Federal permission to broadcast. Not all of them remained long in business. Some of them started with as little as 10 watts in the output stage of their transmitters, which wasn't as bad as it may sound because commercial broadcasting at the time was limited to two frequencies: 833.3 for music and the like and 833.3 for weather reports. If all the stations had remained on the air and all of them had the 500 watts, the most powerful at that time, no one would have been able to hear anyone.

The dollar value of radio receiver sales is estimated at much less than 2 million for 1920. By 1929, the figure was up to six hundred million.

Some two years were to pass before the hucksters recognized the effectiveness of radio as a sales medium. Frank Conrad had mentioned something for sale in a Pittsburgh department store during one of his informal broadcasts from his backyard garage before the first "licensed" broadcast. And the day following, the store had been inundated with customers for the item, even though no "sales pitch" as we know it had been given. Yet, two years were to pass before WEAF in New York City was to broadcast a sponsored program. The sponser was a real estate corporation interested in selling their building lots, but because of the public's attitude—airwaves were a public trust and were not to be polluted by crass commercialism—the corporation did little more than mention its name. That; however, was enough. Advertisers henceforth fought each other for air time.

That era is now gone; pushed offstage and out of our homes sometimes after World War II by television. Except for the occasional re-broadcast of old radio programs, today's radio is not the radio of yesteryear. Today's radio is an adjunct to television. There are neither stars nor entertainment in the old sense on radio today; just music and news. During the years we are concerned with, radio was an entire and complete world in itself. To someone born to television it may be difficult to appreciate a world limited to sound. It may appear as if a blind man is telling a sighted individual that eyes are a handicap. Sight isn't a handicap and yet there was something about radio that is missing in television. The difference, of course, is imagination. Television "tells" you much more than radio ever could; most often, too much. Very little is left to the imagination; you are shown everything. There is no mystery. There is, however, still another difference between radio and television: radio was first.

To fully appreciate the impact of radio in the era we are discussing we have to examine life as it was lived then. World War I had recently ended (1918). America was experiencing a boom that would hold more or less until Black Friday, 1929 when the stock market collapsed. But until that day, everything was more or less rosy. In 1920 the motorcar was just beginning to make its appearance. Our network of the finest, longest, most expensive roads in the world was begun. The horse was still around in large numbers.

There were newspapers in great numbers and movie theaters, many with vaudeville, but most without. Yonkers a city of about one hundred souls at the time, had better than twenty-five movie houses and one "ligit" theater. Everyone went to the movies or seemed to. I do not remember the cost for tickets to the "first-run" movie houses, but seats were to be had at the "Nickelets" (a nickle lets you in) for five cents. On a Saturday or Sunday night, if you didn't time your arrival and missed the start of the performance, you would have to stand through a three hour show. People stood behind the rear rail three and four deep, waiting their turn to sit down and the larger theaters held better than three thousand people. Before talkies, the vaudeville theaters had twenty piece bands and a man who played a huge pipe organ after the movie and before the acts came on.

Each home, however, was isolated. The telephone company had experimented with "telephone broadcasts" for years but they weren't successful, perhaps it was because of the limited audience possible: only those with their ears next to the receiver could hear anything. But at one time it was possible for a phone subscriber to be connected to any of a number of musical and similar events at his request. I never heard any of these programs. We didn't have a phone in our home until well after this experiment was long over. In fact, like many others of the period, we had a radio well before we had a telephone.

Radio put the individual home in contact with the world. Radio changed the home far more than television. Many decry the lost art of conversation, placing the blame on the idiot box that replaces thought and speech much of the time. However, television is not and was never the autocrat that radio was. You can talk to some extent with a TV program in progress. You couldn't talk at all with the radio on: it was all sound. In the days of radio, silence was the order of the evening, and since it was a novelty—people came to our house just to hear a program, which happened in the early days of TV too—radio was respected far more than television was in its infancy.

I would like to state that the quality of the programs on radio were better on the average than that of television today. I can make the statement but it wouldn't be true. Radio insulted the intelligence of its listeners as much as television does today. Imagine a detective who used a thousand disguises to catch his man—all portrayed by voice change alone. (Mr. Keen, Tracer of Lost Persons.)

But the radio programs that were good were more effective than the equally good television programs of today. Imagine, or remember if you can, listening to a mystery story with the lights out. One's imagination supplied more than the eyes could ever see. The "Witch's Tale," for example, still rings clear in my mind. In one story the disembodied heads of two victims of the French Revolution speak to each other. Do that on TV!

And, many of the performers were especially fine. Bing Crosby with his theme, "When The Moon Comes Over The Mountains," was a constant accompaniment to our dinner for years. Then there was Amos and Andy, the longest running program on the air. If you wonder why, I'll give you just one of the many lines that have remained with me for half a century. (Amos to a newly-married friend, "Welcome to the ranks of the living dead.")

Edgar Bergen and Charlie McCarthy made us all laugh, though they were both invisible—an invisible ventriloquist and an invisible dummy: Hard to believe it was possible.

Perhaps not seeing the performers of radio made them more real to the listeners. Many of today's TV's actors suffer visually. Radio seduced, charmed, and fascinated in a way that can never be duplicated by television.

Going back to the early days of radio, much of the charm and pleasure of listening arose from having constructed one's own receiver. Up until the first commercial broadcast, no receivers were manufactured specifically for entertainment listening. Complete receivers were made for the military, weather stations, commercial wireless and radio-phone companies, scientists, and experimenters. Comparatively few complete receivers were sold to the latter group; they were too expensive. Most "Ham" (amateur) equipment was assembled from manufactured parts and some homemade parts.

Up until the first commercial broadcasts in 1920, there were more or less only three groups of radio enthusiasts: commercial and military organizations interested solely in the transmission and receptions of messages on a serious basis; scientists such as Marconi and Fessenden, working to improve the state of the art; and Hams (amateurs) actively engaged in both communication and experimentation for the fun of it.

Ham transmission at the time was almost entirely confined to code powered by "spark" outfits constructed in part or in whole by the Hams themselves. They took pride in their "fists"—the ability to send quickly and cleanly—many an amateur could be readily recognized by his style of keying. And although the public at large considers them scientists after the fact; as a group they aided immeasurably to the growing science of radio by evolving and testing many new circuits.

Following the first broadcasts a new group of enthusiasts appeared. They differed in two ways from the others. Firstly, their interest was primarily in listening. They did not care to construct and operate transmitters; they weren't able or willing to learn the Morse code, a prerequisite to securing an amateur license. Members of this new group wanted no more than the thrill of listening to a distant station. Later, they wanted no more than to be entertained.

Secondly, the new group differed in another important way from the first. Their numbers grew at a prodigious rate. So rapidly did this group grow that in less than a decade, listeners were no longer the tail of the beast; they were the entire dog and a good portion of its tail. Where previously, the military, commercial, scientific and amateur radio enthusiasts purchased and utilized almost the entire output of the radio manufacturers of that period, by 1930 the listening market was a billion dollar industry. The original three groups became "small potatoes" proportionally.

The growth in numbers and the changes in the design and construction of the receivers during the two decades following the early broadcasts are of great interest to collectors of old radios and associate memorabilia because this is a period of great flux and change. During this time radio has been invented but had as yet not been formalized. Whereas in years immediately previous, great inventors and scientists had wrought immense improvements but they weren't readily visible. Much of the great work was done in theory and on paper. What equipment was produced at that time is now very rare and confined to museums. So many receivers were constructed in radios growing years and so many different manufacturers and innovators were at work, that despite the attrition of time, these sets are still available and reflect the turmoil of those years.

No one is on record, excepting David Sarnoff, as having forecast the tremendous growth in the number of receivers following the early broadcasts. As a result there was a tremendous wave of do-it-yourself radio builders. These people wanted radios and took to building their own because they couldn't wait and to save money.

Also it was fun to assemble a receiver. The parts were large and limited, the connections simple and out in the open, and few tools were needed. The difference in complication between an early TRF (tuned radio frequency) receiver and a modern color TV set is easily 100 to 1. The part count is probably higher. Whereas you needed no test equipment to adjust a TRF or a reflex receiver, you need complicated, expensive and difficult-to-understand-and-use test equipment to adjust a color receiver.

Up until 1920, radio receivers, receiver parts, components, and the like were sold mainly through commercial channels and magazines directed towards the experimentor. After this armorphous point in time, radios and radio parts were sold literally by everyone: hardware shops, auto parts stores, radio parlors, even five and ten cent stores. All of them exhibited and sold radio components, tools, tubes, wire and batteries. Whereas our present day "electronic" shops feature complete receivers, transmitters and such in their windows, the early radio shops most often displayed boxed radio tubes. Why so much space was given to tubes I do not know. Perhaps the early tubes were short lived or perhaps the early experimenters were prone to blowing them; but tube advertisements in the news papers and magazines and even over the radio were fairly common.

One of the early goals of radio listeners was to DX—receive distant stations—and since reception was and is always better at night and during the winter, more than one cold and bad case of chilblains could be attributed to this activity. In those days and even today, many stations are eager to secure transmission reports from distant areas. In response to a letter or card informing the station that its signal had been received a goodly distance away, the station would send an attractively printed acknowledgement. Avid DX'ers had walls plastered with acknowledgements from all over the world.

Another goal of the early days was to devise a crystal receiver hookup that would drive a loudspeaker. I do not know whether or not this was ever accomplished in the twenties, since transmitters were low powered and the early speakers were inefficient, but in about 1934, a friend of mine did accomplish just this. The trick was to harness every possible bit of energy available; construct an antenna parallel to the transmitting antenna, tune the antenna to that one particular frequency, use a good ground and a highly efficient speaker. Another requirement was to set up the receiver within a reasonable distance of the transmitter. (Get close enough to a powerful transmitter and you can light an electric bulb with energy drawn from an antenna.)

The crystal almost always used by experimenters and listeners in those days was a hunk of lead galena, which is lead sulfide, bluish grey in color and cleaving normally in a perfect cube. It is the principle ore of lead. Although many detectors had been devised since Hertz used a minutely spaced gap for detection, the crystal, as it was called, was most popular. The coherer had to tapped after each signal. Marconi's improved coherer, the magnetic detecter required a continuously moving iron wire, the Fessenden electrolytic detector could not be used for CW (continuous wave) detection and so could not be used for radio reception. The Carborundum and the silicon detectors were not as sensitive. One so/called/scientist even used a frog's leg as a means of detecting a weak signal. No doubt he secured the idea from Galvani.

Crystals of lead galena were simple, inexpensive and to some extent fun to work with. You had to adjust the cat's whisker (a fine wire) so that it would barely touch a particular point on the face of the crystal and leave it there. If you sought to find a more efficient point you could spend ten minutes searching. If the receiver was accidentally shaken, the whisker's point might jump and you would have to start searching all over again. If lightning struck not too far away, the energy induced in the antenna could render that particular point on the crystal inoperative. You would have to find another sensitive spot. And, if for any reason you decided your crystal was defective, you could cleave a fresh facet on the crystal and expose a more sensitive surface.

Fleming's valve made little headway with the experimenters. Lee De Forest's Audion sold for about $5.00 when it was first manufactured, so we can assume the valve sold for $2.00 or $3.00. It wasn't more efficient than the crystal, and it required a constant current on its filament. However, it wasn't fickle so for many years it was first choice on shipboard and other commercial installations.

Crystal receivers were not supplanted by "tubes" for many years despite De Forest's Audion. De Forest's associates thought so very little of his invention that when he resigned from the company, he was allowed to retain his patent application on his Audion.

The story as it continues is a bit murky but it goes something like this. Lee De Forest formed the Wireless Telegraph Company of America in 1901 with one thousand dollars borrowed from a friend. Later the same year, De Forest joined forces with Abraham Schwartz and the company changed its name to De Forest Wireless and Telegraph Company. Schwartz, who later changed his name to White, sold stock and the company's capitalization increased to one million dollars. Early the following year a new company, still using the De Forest name was incorporated in Maine. Capitalization was upped to three million, Schwartz was president and De Forest was vice-president and scientific director. In November of 1902 more stock certificates were printed and capitalization was increased to five million dollars.

Business was excellent. Less than four years later the company was far and away the largest wireless telegraphy company in America. It had 27 land-stations with spark transmitters ranging from 1 to 2 kw in power (kw-kilowatts or a thousand watts). At sea the ships utilized the two-slide tuning coils connected to a loop antenna and either the De Forest responder or an electrolytic detector.

At the time the Audion was capable of a gain of no more than three. (Some transistors and tubes have a gain of better than one thousand under certain conditions.) A gain of three means that an incoming signal could be increased or amplified three times. By following one tube with another, De Forest was able to multiply signal strength once again. Thus by cascading three tubes he was able to amplify a signal 3x3x3 or 27 times. He demonstrated his device to the telephone company in October, 1912 and sold the patent rights to its use as a telephone repeater (amplifier) the following spring for fifty thousand dollars. To friends De Forest confided that he had hoped to receive half a million dollars.

When it had first been offered to the public in 1906 or so, the Audion was slow to be accepted. It cost about $5.00 and required a constant supply of current for its filament. What was worse it didn't work much better than Fleming's valve nor the lowly lead-galena crystal. The main reason for its poor performance was the scientific world's ignorance of the device. Even De Forest believed some residual gas was necessary to its operation. We, of course, now know that the harder the vacuum—the less residual gas present—the better the tube works. In any event De Forest more or less ignored his invention until 1912 or so when he developed the cascade audio amplifier.

In 1913, Edwin Armstrong delivered a paper before the Institute of Radio Engineers in which he described his regenerative circuit. About five months later, shore stations used a three-coil tuner for greater selectivity and similar detectors.

Then came a reversal in the courts for the booming company. De Forest's responder was judged an infringement of Fessenden's electrolytic detector, which had been patented in 1900. Because of this, the De Forest company had to change all of its equipment, or pay Fessenden a royalty. Fortunately, a member of the company, H. H. Dunwoody had patented a silicon detector which was used in place of the Fessenden detector.

According to some, this incident led to De Forest quitting the company. According to others, White and other directors of the company reorganized the American De Forest Wireless Telegraph Company into the United Wireless Company of America by not completely legal means. De Forest did not approve and refused to be part of the deal. He left the company, being paid the paltry sum of one thousand dollars for his patents, but the "brilliant" manipulators let him keep his Audion patent application.

Unfortunately, De Forest also did not realize the importance and ultimate value of the triode he had invented. In fact, he more or less ignored his device or at least conducted no experiments until 1912. At this time he found that he could cascade a number of tubes and thus multiply the amplification secured from each. De Forest applied for a patent on the same circuit. There was no "dirty work" here: The circuit was discovered simultaneously. De Forest proved that he and his associate, Van Etten, had observed regeneration (signal feedback) months prior. This, of course, led to the most famous patent litigation of our times; twenty or so years in the courts and lawyers enriched by several millions of dollars. But, that is not germane to the store of the development of early receivers.

What is relevant, is that crystal receivers for commercial and military use continued to be manufactured and used well after the invention of the regenerative circuit, and that when tubes were first introduced they were generally utilized as a stage or two of audio amplification following the detector, which was a crystal. A stage is the technical term used to define a single tube, or transistor, which produces a specific signal treatment. A stage of audio means a tube connected so as to amplify a signal that is at audio frequency. An RF stage would be a tube connected to amplify a signal at radio frequency. An untuned RF stage will amplify all radio frequency signals more or less (not actually) equally. A tuned RF stage will only amplify that frequency to which it is tuned.

To list a few of the better known crystal receivers to illustrate the comparatively slow change over from crystals to tubes; Wireless Specialty Apparatus Company made a crystal detector with loose coupling for the U.S. Navy in 1907. The same company made a long wave receiver with a crystal detector in 1918 which sold for $425. National Electric Supply

Company produced a somewhat similar crystal receiver, model CN239 during the same period and sold it for the same price.

These, of course, were commercial and military pieces of equipment. Crystal receivers for amateur and entertainment reception were simpler and far less expensive. King of the Air, made by Aerex in 1922 sold for about $25. The Meepon and the Betta-Tone were made and sold in 1923 and 1924 respectively; with their prices probably lower.

Although crystal receivers were made for home entertainment use as late as 1925, the peak of crystal receiver purchasing and use was probably about 1922. Crystal receivers continued to be manufactured in as late as 1960. The Philmore was probably the last of the crystal set makers. But following 1922, they disappeared rapidly from the living room.

The first tube was the Fleming valve which was patented in 1904, closely followed by the Audion in 1906. Neither tube, nor the few imitators and minor variations used to break the patents, were given the reception they were due. The lack of enthusiams for the diode was understandable. Its only advantage over the much cheaper crystal was its dependability. But it required a constant supply of filament current and didn't last very long. The triode should not have suffered the same fate, but it more or less did.

Looking in the past one would imagine the triode would have pushed all opposition aside, but it didn't. The Fleming valve was in use as late as 1914 in an American Marconi receiver. Audions were used as audio amplifiers following crystal detectors. Two examples are the long wave receiver made by the Wireless Specialty Apparatus Company in 1920 utilizing a crystal detector followed by one stage of audio.

Some companies did use Audions fairly early. Pacific Wireless produced an "Audion Receiver" in 1910. De Forest himself produced a Fifteen Panel Unit receiver in 1919. It utilized three of his tubes and sold for $160. That same year his company manufactured his P-300. It sold for $85.00 and used two tubes.

When we go past 1922 or so, the scene changes. Crystal detectors were no longer harnessed to audio amplifiers and the Fleming valve was completely forgotten. Thousands of manufacturers sprung up to satisfy the tremendous demand. In their competition for a greater share of the market or any share of it, they searched for better circuits, improved selectivity and sensitivity and greater output. Some went the TRF route, some turned to regenerative circuits and some manufactured both types of receivers.

Their choice of circuits is curious. No doubt some of the selection was done in an effort to avoid patent difficulties, although there is no doubt there were many companies that simply copied existing circuits and let the patent holders worry about collecting royalties. Others possibly made their choice on the basis of public acceptance. It couldn't have been ignorance because there was a tremendous quantity of published material. Radio News, for example, claimed a publication of more than 240,000 copies in their 1923 issue and it contained a large number of useful circuits. One, for example, showed a self-contained loop receiver. The loop functioned as both the antenna and the tuning coil for the one tube regenerative receiver.

The reason for considering the choice of circuits used by manufacturers in the early 1920's is that the regenerative circuit was by far the most efficient circuit of its time. Not only did regeneration amplify the signal several times more than the basic gain offered by the tube, but it also increased selectivity. And yet, companies did manufacture one tube straight detector sets, two and three tube sets with one stage of RF, a detector followed by one stage of audio amplification.

The first Atwater Kent, offered as bread-board components to be assembled by the purchaser was a two tube job with a straight detector followed by a single audio stage. His famous and scarce Model 5 simply had more audio power. But his 10 A and possibly 10 B did feature regeneration. The Federal 57 receiver had a straight detector followed by two audio tubes in 1922. The Magnavox TRF 50 was a five tube receiver without regeneration. The Pacific Claratone of 1925 was a five tube TRF receiver that sold for $75. Stewart Warner offered a five tube TRF in 1925 for $75.

On the other hand, some of the manufacturers produced mainly regenerative receivers in their early years. Notably there was RCA, Grebe and Paragon, which incidentally used the Armstrong regenerative circuit in the RA-6 model produced in 1916 which sold for $35.00 then. Purportedly, this was the first time the regenerative circuit was used in a commercially constructed entertainment receiver.

The reluctance of many manufacturers to build regenerative sets or to limit their production to these receivers stems from a duality of reasons. Although the regenerative circuit is highly efficient it is unstable at its most efficient point, which is just below oscillation. Thus a slight change in temperature, a movement of anyone or anything close to the receiver can cause it to literally howl: the louder the signal produced prior to oscillation, the louder the howl. And, when the set oscillated it generated radio frequency signals which would interfere with nearby receivers. Some old-timers claim an oscillating receiver next door would help them receive the same station although this is doubtful. In any event, regeneratives could cause neighbors trouble. This could be reduced by introducing an RF stage ahead of the detector, but that upped costs.

The second drawback to the Armstrong or De Forest circuit was that it required adjustment. The user had to know a little about what he or she was doing and operate the controls properly.

TRFs did not oscillate. However, they did not have the selectivity per stage nor the gain. To overcome this deficiency multi-RF stages were added, each with its own tuning control (dial). On strong stations each dial could be set to about the same marking; on weak stations you had to go back and forth to peak each tuner. This deficiency was overcome in about 1925 when the first ganged capacitors began to appear. The multiple tuning dials were replaced by a single control.

Still, the TRF did not duplicate the regenerative set. There was a limit to the number of capacitors that could be ganged and a limit to the number of RF stages that could precede the detector. The limit was established by feed-back. Build two or three RF stages ahead of the detector and the set would oscillate and howl just like any regenerative, but without the means to stop it.

The problem was solved by Professor L. A. Hazeltine, of Stevens Institute of Technology, who invented the neutrodyne circuit. Essentially a small amount of "negative" feedback was used to offset the positive feedback that caused oscillation. Fada was the first to bring out a set based on the circuit. He was soon joined by other "independents" who had formed a group to buck RCA's apparently permanent hold on the patents controlling the regenerative circuit and was charging what they believed to be exorbitant royalty fees. The independents formed an associate and despite the six thousand dollars admission charge, they soon had fourteen members. For about two years business was that brisk for this group. But by 1924 RCA had the bugs out of Armstrong's superhetrodyne circuit and was manufacturing a line of superhetrodyne receivers. It was all over except for the licensing. The superhet has never been surpassed for broadcast reception of AM (amplitude modulated) signals.

From 1924 on it was just a matter of time before all the entertainment receiver manufacturers dumped their existing stock of radios and tooling and turned to the superhet. Now the discussion goes to development of an AC power supply for the receivers.

Tubes require power in the form of direct current. The very earliest receivers used wet batteries. These were followed by dry cells and storage batteries. Although the then new "battery" tubes required only ¼ ampere at 5 volts or less, one needed a lot of batteries for the hours of listening common to families that had receivers. The rechargeable storage battery was an improvement, but not much. Unless it was held in a porcelain-coated tray, the acid would creep out and over the battery case and onto the floor. Acid fumes, which are normal to battery operation would also drift about to rot anything of cotton they touched. Each week the battery had to be taken to a battery store for a recharge or the battery man would call, just like the butcher or ice man.

The first solution was a series of battery chargers of which the GE unit using the Tungar rectifier was most popular. B batteries were sometimes replaced by multi-cell storage batteries, but they were very expensive and a nuisance to care for. Still, many were sold. B batteries lasted no more than about three months and cost about $10.00 for two units producing 90 volts. When the C batteries were introduced, B battery life was roughly doubled.

The second solution was a combination A and B battery eliminator which "eliminated" all the bother with batteries. Unfortunately the combination eliminator, at least the early models, cost as much if not more than the receiver itself. Some types went for as much as $125.00 and some of the earliest designs needed attention. They either incorporated an acid storage battery with an automatic trickle charger or they used a liquid rectifier that required a little distilled water from time to time.

The first "electric" radios weren't offered to the public until well into 1927. Atwater Kent's first AC receiver had an external power supply and seven tubes, but it costed $77. The company put out its first completely self-contained AC receiver in 1928. This is the famous model 40, of which so many were sold they are still fairly plentiful today. The price was the same as its predecessor. Grigsby-Grunow put out its line of Majestic Neutrodyne receivers starting in 1928 with the power supply in a metal box on a lower shelf. The following year they moved the power supply onto the metal radio chassis. RCA's AC Radiola of 1928 was its first and sold for $130. (Incidentally, the Majestic model 80 single chassis AC receiver sold for $150.) By 1929 no one manufactured home entertainment receivers that couldn't be plugged into the wall.

The AC receiver was made financially feasible by two inventions, the electrolytic capacitory and the "AC" tube. Paper capacitors large enough in capacity and with sufficient insulation to withstand the high plate voltages used were available before the electrolytic capacitor and were used in the aforementioned Grigsby-Grunow and other receivers of that time. However, they were large and expensive. Not only did the electrolytic capacitor cost much less it was tremendously smaller and led to still another development in the radio industry as we shall soon see.

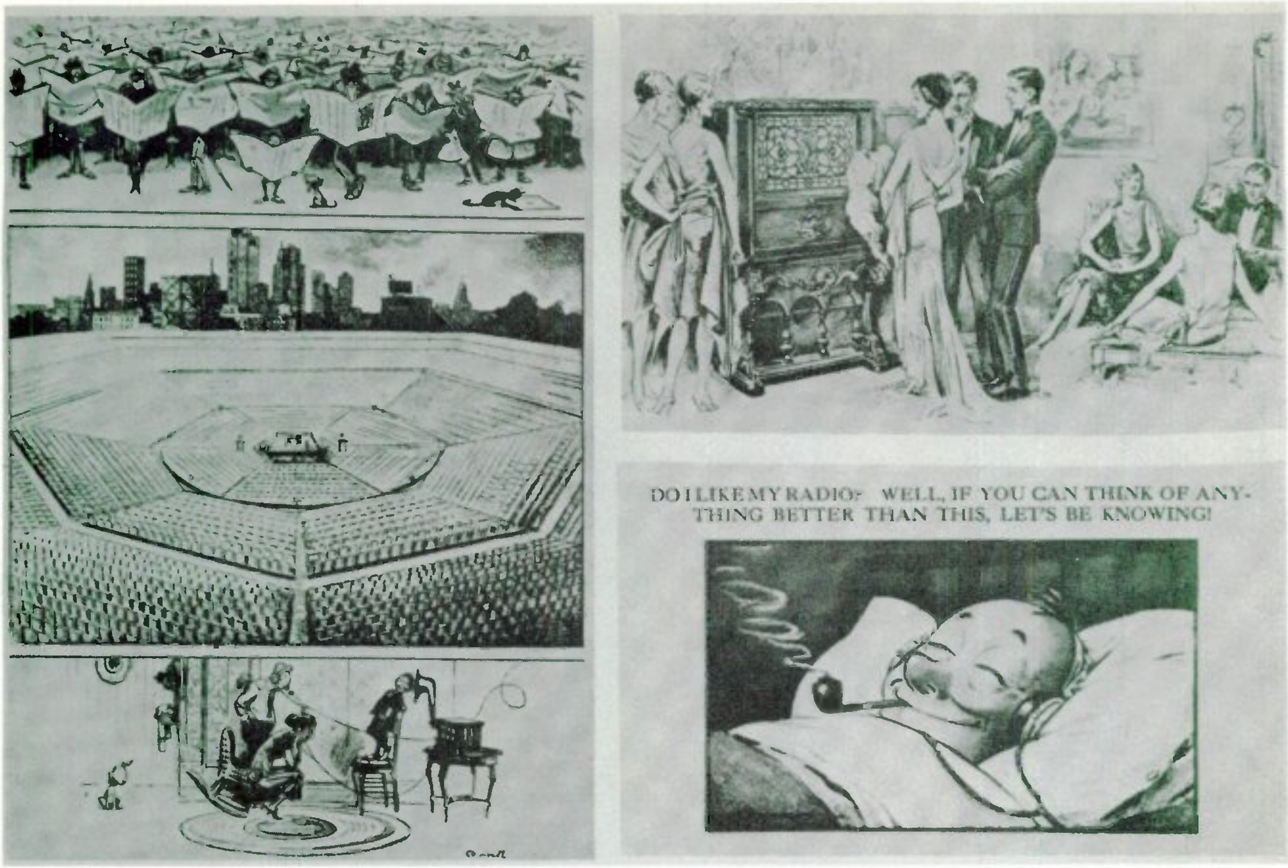
The AC tube solved another problem in that it eliminated the need for a direct current filament supply. Filter costs and size are directly related to current and only indirectly related to voltage. Thus if 20 Mmf. and a 1-Henry choke are sufficient for a plate supplying 50 milliamperes of current at 150 volts; you need 25 times more capacitance to filter the 1.25 amperes required by five tubes because there is 25 times more current flowing. While a choke of the same inductance will suffice, wire size must be 25 times larger which makes for a comparable increase in choke core size. Thus a direct-current, filament supply would be physically many times larger as well as more costly than a plate supply for the same receiver.

The first attempt to eliminate this problem resulted in the type 1926 tube which was an ordinary triode with a very heavy filament: so heavy it didn't fluctuate thermally with each cycle. To eliminate the hum induced by the AC filament circuit, connections to the filament were made through a center-taped resistor. The hum controls on old receivers are usually adjustable, center-tap resistors in the filament circuit.

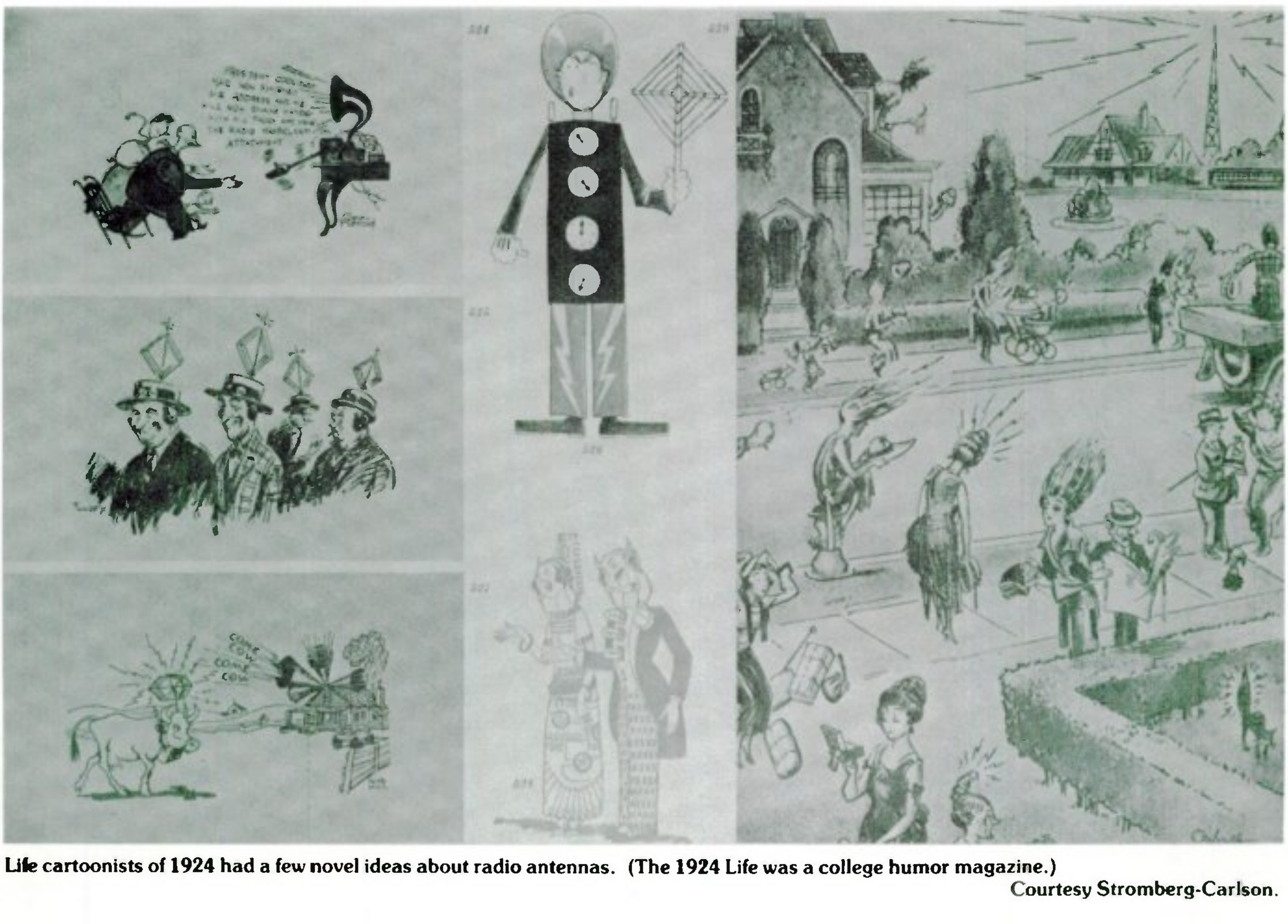
The 1926 was shortly replaced by the 1927 model (and later the 1929 which is more efficient, direct-replacement tube). The newer tube differed in that it had a cathode, an insulated metal sleeve indirectly heated by the filament. This insulated the filament thermally and electrically from the AC voltage. AC receivers were now practical.

The AC tube and the electrolytic capacitor led directly to the introduction of the "midget" receiver some time in 1929 and 1930. At first a power transformer was used to furnish the high plate voltage and the low filament voltage required. The Atwater Kent 84 of 1931 and the Philco 90 of the same year are two examples of this design. This was the period of the "Cathedrals." During the years immediately following, tube efficiency was increased by adding additional grid elements. The number of tubes in the smaller receivers were reduced and the sets themselves were made smaller. About 1935 the series filament tube was introduced. The filaments of the four or five tubes in the receiver were connected in series with each other and a line resistor. Next the line resistor was made a part of the line cord. These line cords grow warm when the set is operating. Finally, tube filament voltages were increased to where there was no longer any need for a series filament resistor. The "true" midget of the period was on hand and superhetrodynes no larger than a cigar box were available for $10. They were more sensitive, more selective, had more volume and better tone than all the "battery" radios that preceded them and many of the early "electric" sets.

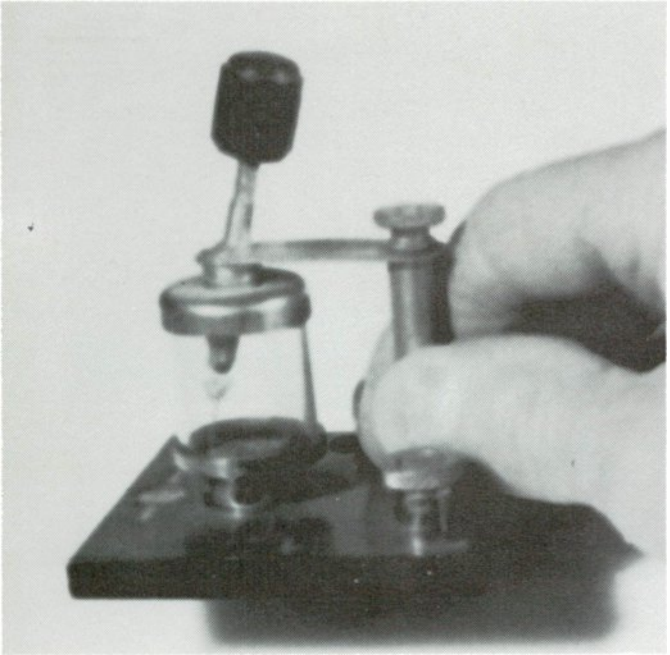
Not until FM, transistors and television were developed were there any further major changes in the entertainment receiver industry.



Early cartoonists had a field day when radio was young. A few 1922 drawings. **Courtesy Stromberg-Carlson.**



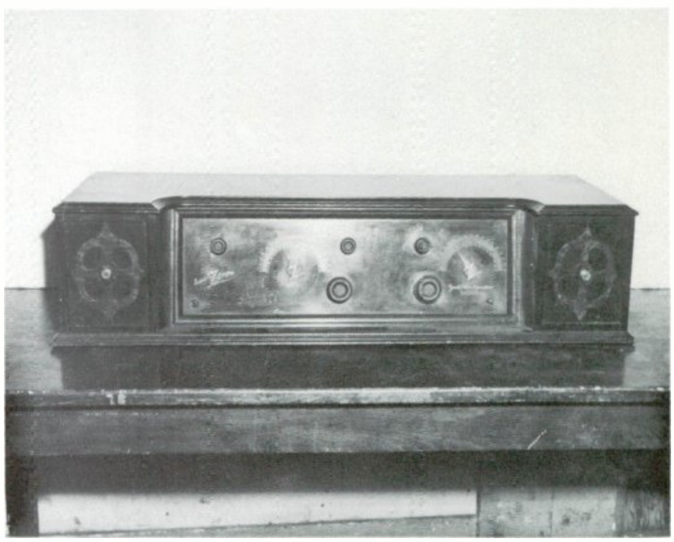
Life cartoonists of 1924 had a few novel ideas about radio antennas. (The 1924 Life was a college humor magazine.)
Courtesy Stromberg-Carlson.



Crystal holder and cat's whisker made by Frank A. D'Andrea, circa 1920. Sold as an individual component. Jacob collection.

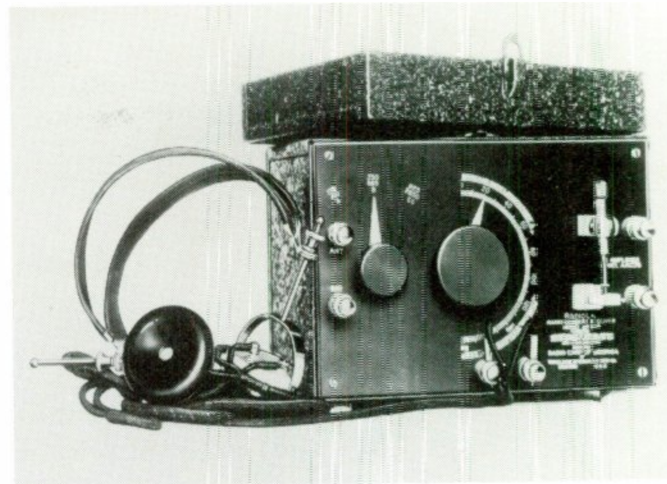
First mass-produced receiver. Made for RCA by Westinghouse, it is called Aeriola Jr. and uses a lead galena crystal and a single tunable circuit. Courtest Westinghouse.

RCA advertisement of 1923 offering the company's Radiola RS, complete with its two tubes, batteries, and headphones for $85.00. RCA receivers were available from $25.00 to $250.00 during this period, according to the free booklet that could be had for the writing. Courtesy RCA.



The 1926 Zenith Super, advertised as the first commercially produced receiver to operate an AC current. Whether or not it was actually the very first is a matter of history, but there is no doubt it was among the very first. Courtesy Zenith.

A Zenith ad from about 1926. Note the price range of the DeLuxe receivers; five hundred dollars to two thousand dollars, and their slogan, "It Costs more — but it Does more. Courtesy Zenith.



The Radiola, Model AR 1375. A crystal receiver. It covered 170 to 2650 meters with the aid of a three-position switch. Sold by RCA, it was made by the Wireless Specialty Company of Boston in 1922. Jacob collection.

By 1925 the receivers have grown larger and more complicated. This is the Radiola Super VIII, with two tuned stages and a built-in horn. Courtesy RCA.

chapter three

COMPONENTS

Components prior to 1900 and shortly after are very scarce indeed. Not only were there very few scientists and experimenters engaged in developing the art of wireless, as it was then called, the components they used were more or less of two particular types, neither of which were and are likely to fall into the hands of the collectors.

When and where the experimenters used established pieces of equipment such as galvonometers, switches and the like, the equipment was very often constructed by highly skilled and expensive laboratory specialists. The components and equipment they constructed were beautiful. They used polished and varnished hardwoods, marble, brass, and in later years, black hard rubber panels. These components were retained and used by the laboratories and universities in which the early experimenters worked. Little was ever relegated to the attic for later discovery by lucky collectors.

In contrast to the exquisitely wrought "laboratory" equipment used by the better heeled and famous scientists, much of the equipment was constructed by the not so famous scientists and amateur experimenters themselves. The reasons were simply that the parts required had never been constructed before. There were no models from which the craftsmen could work, and experimenters then are no different than experimenters today: they were too eager to try their ideas. It was results they wanted and not appearance. Even the great Faraday had to insulate his own wire, using strips of cotton cloth held in place with varnish.

Even the crudest components constructed by or for our electrical godfathers have been preserved in various museums. The work of lesser lights, unfortunately has been more or less completely discarded. So, if by some strange chance you encounter a beautiful laboratory component or a hand-made mess that looks like a poorly designed mouse trap, you are lucky indeed.

Closer to this century we find various commercial organizations were engaged in constructing complete receiving and transmitting sets. Although the number of amateur experimentors interested in wireless had grown considerably in numbers, they weren't a sufficiently large or affluent group to warrent specific component manufacturer. Guglielmo Marconi formed his Wireless Telegraph and Signal Company in England in 1899 for the express purpose of building wireless stations on ships and lighthouses along the English Coast. During the same year an American company was formed called the American Marconi Wireless Company. Capitalized at ten million dollars, the first thing this company did (after selling a few shares) was to install their equipment on the Nantucket light ship (a floating lighthouse) and at Siasconset on the sea-side of Nantucket Island.

Other United States companies were formed in rapid order over the next few years. Most of them, it now seems, were more intent on selling stock then "developing the art." It is interesting to note that by 1902 many, if not all the American companies were bankrupt. The remains of these companies were re-organized with a capital stock of 7.5 million dollars into a new, single company called Consolidated Wireless Telegraph Company. But this company fared little better than the rest and was absorbed the American De Forest Wireless Telegraph Company.

All of which is to say, the amateur experimenter was much "too small a potato" to even consider when control of national and international wireless communication appeared to be within reach. This if anything at all was manufactured specifically for the experimenter by Marconi or De Forest at the turn of the century, it was very little and no published record remains.

It is not until 1900 or 1901, that companies did manufacture, and/or distribute and sell amateur wireless components.

The first such company of any size was probably Electro Importing of New York City. It was started by Hugo Gernsback, who is credited with inventing the book condenser (capacitor) and fathering modern science fiction. One title sticks in my mind. It was a serial called Ralph 3573+ (or some such number) and his space craft was propelled and supported by an ingenious arrangement of gryroscopes. Gersback also edited and published Radio News for many years. (Eventually the magazine was sold to Ziff-Davis, had its name changed to Radio and Television News, then Electronic World before petering out of existence because of poor editorial management.)

Gernsback started his radio component business early in the century, directing these activities mainly toward the amateur and experimenter. More or less at the same time, the Duck brothers, J. J. and William began offering radio parts by means of a catalog distributed from Toledo, Ohio. Shortly afterwards, approximately in 1903, the Electric Supply Company of Manhattan, New York issued a competing radio parts catalog. One item, their Skindervikin button was a "hot" item for many years. It was a carbon microphone button. As their advertisements read, the button was to be placed against any wall to give the user immediate audio entrance into that room. I remember that particular "spy" button ad appearing in magazines as late as the 1930s.

Still another early starter in the radio component business by mail was F. D. Pitts of Boston, and Firso, the name used by John First of New York City to promote his line of equipment. Merker-Flock of Pittsburgh entered the field in 1914, offering a more complete line of components and equipment, including transmitters. In 1916 Pacific Labs of San Francisco offered Auditron and Moorehead tubes through the mail. Still another was the National Radio Supply of Washington, D.C.

De Forest got into the mail order act after World War I, offering unit parts for the assembly of a few of his receivers.

These companies listed are just a few of the many that entered the component business after 1900. Electro Importing was probably the largest in terms of volume; certainly it is now one of the best known. (Today, two companies, Lafayette and Radio Shack dominate the mail order parts and equipment field.)

During post World War I period the growth in the number of companies offering parts and complete receiving and transmitting sets was phenomenal. One reason for the growth is obvious; there was a sudden, unbelievable demand. Another was the high margin of profit to be made with some of the items, but not all.

To appreciate the high prices asked for some of the early wireless components one must bear in mind the wage scale of the period. At the turn of the century, 90 per cent of our population lived on farms. There was no minimum wage law, no child labor laws, no income tax, no unemployment insurance and no social security. Apartments rented from $5.00 a month and skilled mechanics such as carpenters, masons, etc., earned about $5—6.00 a week. As we come closer to our time, component prices rose a little, then fell while income rose, numerically at least. The biggest profits were supposedly to be made by those who were first, but judging from the number of companies that entered the field and left just as quickly, not many benefited from their opportunities.

Following are some of the components offered to the inventors and experimenters of those by-gone days, along with the listed prices and approximate dates, when known.

The Marconi Company either manufactured or had made for them a beautiful, meshed-plate, variable capacitor. It had a capacity of .003 Mmf., was completely enclosed in glass and was mounted on a polished hardwood base along with two binding posts. In 1906 it sold for $6.

In 1908, Electro Importing offered a variable Leyden jar capacitor for $2.50. It means of variance is not obvious from existing photographs, but it was probably done with brass tubes that could be slid up and down inside the jars. The same company offered a switched mica capacitor in a moulded bakelite container for $1.25. Compression type capacitors consisting of alternate layers of aluminum foil and mica with a maximum capacity of .001 Mfd. went for $6.50 in 1910.

The Branley coherer, mounted on varnished oak along with binding posts was offered for sale in 1902. And J. J. Duck offered a Ferron detector mounted on a blue marble base for $4.00 in 1913. This appears to be some type of crystal detector which could be minutely adjusted. Electro listed a precision cohorer in their 1910 catalog and a Radison electrolytic detector in 1914. The following year you could purchase a "Baby" detector, which was simply a galena crystal detector, for 25 cents. The same year, a De Forest D101 crystal detector sold for $2.60.

In 1909 a De Forest Audion mounted on an oak battery box repleat with a controlling rheostat sold for $18. Whereas De Forest used an Edison-type screw base for his tubes, Moorehead used a bayonet base (similar to present-day auto lamps) in an attempt to circumvent the De Forest patents.

Tuning, first recognized and appreciated by Sir Oliver Lodge and patented in 1898 called syntony, had been in general use since 1900. Early amateurs and experimenters use a variety of "tuners" for the purpose; mainly it appears they wound their own coils on oatmeal boxes and arranged a slider or tapped the coil every dozen turns or so.

By 1910 or so the crude slider had been improved with a ball bearing beneath the slider's point. The bearing and its support was sold as a separate item by Electro. At approximately the same time, multi-point switches became less expensive so amateurs stopped making their own and began using manufactured switches in conjunction with their home-wound coils. To improve the efficiency of their coils, both the experimenters and the manufacturers turned to Litz wire, which consisted of a number of fine, insulated strands of copper wire, joined only at the ends of the coil.

To reduce the capacity of the coil itself, various schemes were introduced including the honeycomb coils, which were very difficult to wind by hand. Thus various manufacturers began making and selling tuning coils, vari-couplers, which were two coils whose electrical coupling could be varied either by sliding one coil in and out of another (loose coupling) or rotating one coil within another, and sometimes by altering the angle of one flat coil in relation to another.

The earliest manufactured coils and coupling arrangements consisted of coils with sliders, tapped coils, loose couplers and combinations thereof. The

1912 Clapp Eastham tuner used a slide. The Murdock model 334 tuning transformer of 1913 used two coils, one varied by a sliding contact, the other vari-coupled by sliding on rods within the first. It sold for $25. Their model 337 which was put out only a year later sold for only $15. In 1915, Duck offered an Arlington receiving transformer, very similar to the two transformers just described for only $9. The same year Duck sold a Navy-type receiving transformer consisting of one coil sliding within another but with each coil varied by means of a multitap switch. This sold for $19.95. The Wireless Shop sold A. J. Edgecomb Navy-type tuners for $24.00 in 1917. This too was similar to the Duck transformers but had what appears to be a much larger tuning range as there were more taps on the coil and a secondary tuning arrangement.

The honeycomb coils went for much more. De Forest sold a three-coil and mounting tuner for $16.50. Crown had a two-coil job for $10. The Atwater Kent coupled circuit tuner was made of bakelite and sold replete with a tuning dial for only $14. The Simplex, made by Adams Morgan, was merely a vari-coupler positioned within a tapped coil mounted on a small board. This sold in 1920 for $7.

Of all the coils offered during this period the Atwater Kent coils are by far the most attractive and complete in the matter of hardware. Of course, they were designed for broadcast band operation and not longwave as were the Navy-type coils.

Early registors were of wire wound on a ceramic form when more than a short length of resistance wire was needed. Rheostats, which were wire-wound resistors over which a moving contact point could be moved, were used when it was necessary to vary a resistor, as for example in series with a tube filament. Just when the now ubiquitous carbon resistor was devised appears to have been forgotten. Probably the first was the grid leak. This resistor had a value in the megohms (millions of ohms) and could not be constructed of wire because of the length of wire that would be needed and because, even if the wire were folded back on itself, it would still present an inductance to some extent. Grid leaks were made of fine carbon rods supported by two brass plugs within a little glass tube. If you had no grid leak you could sometimes get by with a pencil lead of the correct length. A few types could be varied: some by pulling one brass plug out of the glass a distance, others by turning a knob that compressed or released the pressure on discs of carbon.

Grid leak resistors, of course, were used in conjunction with the early triods. Used in conjunction with a small, fixed capacitor, the high-value resistor produced a low, negative bias voltage on the grid of the tube. This enabled the tube to handle signals without distorting them.

It wasn't until tubes were self-biased by means of resitors in the cathode circuit was there a need for comparitively low-value resistors in the 100 ohm range. And it wasn't until much later when tubes had sufficient gain to "throw some away" that audio coupling transformers could be eliminated and replaced with resistance coupling. Resistance coupling requires resistors in the one hundred to one hundred thousand ohm range. Both cathode resistors and coupling resistors are too high in value to be made from wire. Besides, wire resistors in this range would be unnecessarily large.

The first carbons then can be assigned to approximately the late 1920s. They were made of a moulded carbon rod, the composition of which, as well as its size, determined its resistance value. Connections to the rod was made by soldered-in-place wire wrapped around the rods ends. In time, and especially if heated by overloading, the carbon tended to change resistance and disintegrate. Later, the carbon resistors were tremendously improved by moulding them inside a plastic cover.

The first capacitors were Leyden jars, which were simply glass jars or bottles with a layer of metal foil inside and out. Leyden jar capacitance could be varied by varying the number of jars you used or by using a brass rod on the inside and moving the rod in and out. The jars were eventually replaced by capacitors made of alternate layers of glass and metal foil. These could be varied by switching the number used and by varying the spacing between the plates. This was the "Book" capacitor invented by Hugo Gernsback. In time, mica was substituted for the glass and permanently sealed within a bakelite housing. Capacitance could be varied by switching. A mica, book capacitor appeared about 1919. This could be varied over a modest range by the appliance and removal of pressure. The plates were made of thin strips of spring brass and were bent to normally stay apart. With no pressure the spacing between the plates was at maximum and the capacitance was at a minimum—but there was always considerable capacitance. When pressure was applied, the plates were brought together and there was maximum capacitance.

Since the highest frequency a coil can reach is limited by the number of turns in the coil, its own capacitance and the minimum capacitance of the capacitor connected across it, the residual capacitance in a mica book condensor limited its usefulness for tuning. This writer believes that this led to the invention of the meshed-plate capacitor which could be varied over a range of at least ten to one.

None of the capacitor types mentioned so far could furnish the capacitance necessary for the coupling, by-passing and filtering necessitated by multi-stage amplification, at least not in physical volumes that were practical. This need led to the invention and development of the paper capacitor. At first multiple layers of paper and foil were used. Later, strips of paper and foil were laid atop one another and rolled up. The relatively large-value capacitor in a modest size had arrived.

To protect the paper capacitor from physical damage, and especially to keep the wires from breaking away from the foil, paper capacitors were (and still are) enclosed in metal and plastic containers. Those that are metal encased are called bathtub capacitors or condensors.

The problem with the old capacitors is that they weren't constructed or assembled under perfectly sterile conditions. As a result they often short out when subjected to their rated or even lower voltages. So while recently manufactured paper capacitors will last indefinitely, those prior to about 1935 may not. Some collectors install a new capacitor in the old "tub" to retain authenticity. If you unsolder the seal and then freeze the capacitor it can be more easily pulled out.

Earphones were used for telephone reception and so were on hand when they were required for radio. However, as radio signals were often much weaker than telephone signals, (the big search in those days was for distance which meant weak signals,) phones or headphones or headsets were designed especially for radio reception. They differed from telephone receivers in that the diaphragm was thinner and more turns of finer wire was used to wind the coils. Whereas the impedance of a telephone receiver might have been 100 or so ohms, radio phones were at a minimum 1000 ohms and some were even 3,000 ohms in impedance. (Impedance is resistance to alternating current. The direct current resistance, as measured by an ohmmeter, would be about 200 and 600 ohms respectively.) The higher the impedance, the more efficient the phones because they more nearly matched the electrical nature of the incoming signal.

Many companies manufactured headphones. Most likely Western Electric was the first, merely because of its early dominant position in the industry. Other early headphone makers were Murdock, Holtzer-Cabot, Mesco, Brandes, Brownies and Baldwin, just to mention a few. Kellogg, Frost, Automatic Electric, Kennedy, Federal, Red Head and Stromberg-Carlson were among the best known in the 1920s.

Murdock sold a 2,000 ohm headset for $4.50 as early as 1913. Later, they also offered a similar appearing headset with 3,000 ohms of impedance for $5.50. Both types carried the same number, 55. Eisemann sold a single head phone for $3.50 about 1912. By 1925 the price or ordinary headphones was down to $2.95, the price Tower's asked for theirs.

Baldwin probably made the best phones of all. Often called Baldies, they used fiber diaphragms in their Type C, selling for $16.50 in 1910; aluminum diaphragms in their Type G selling for $20.00 and mica diaphragms also called Type C and selling for the same $16.50. The Type Gs probably were made in around 1912. At any rate, by 1922 they were still manufacturing their mica diaphragm phones in three versions: C, E, and F for $16.50 to $21.00 respectively and a C and E for $8.50 and $10.00 for use as driver units for loud speakers. What is most interesting about these earphones is that they were advertised as being equal to two stages of audio amplification and they were not earphones any longer. Actually they were magnetic speakers. In place of a flat, thin disc of mild steel (the diaphragm) placed close to the coil, there was a thin strip of steel inside the coil. One end pivoted, the other end connected to the center of the diaphragm. This, of course, is a version of the basic magnetic speaker.

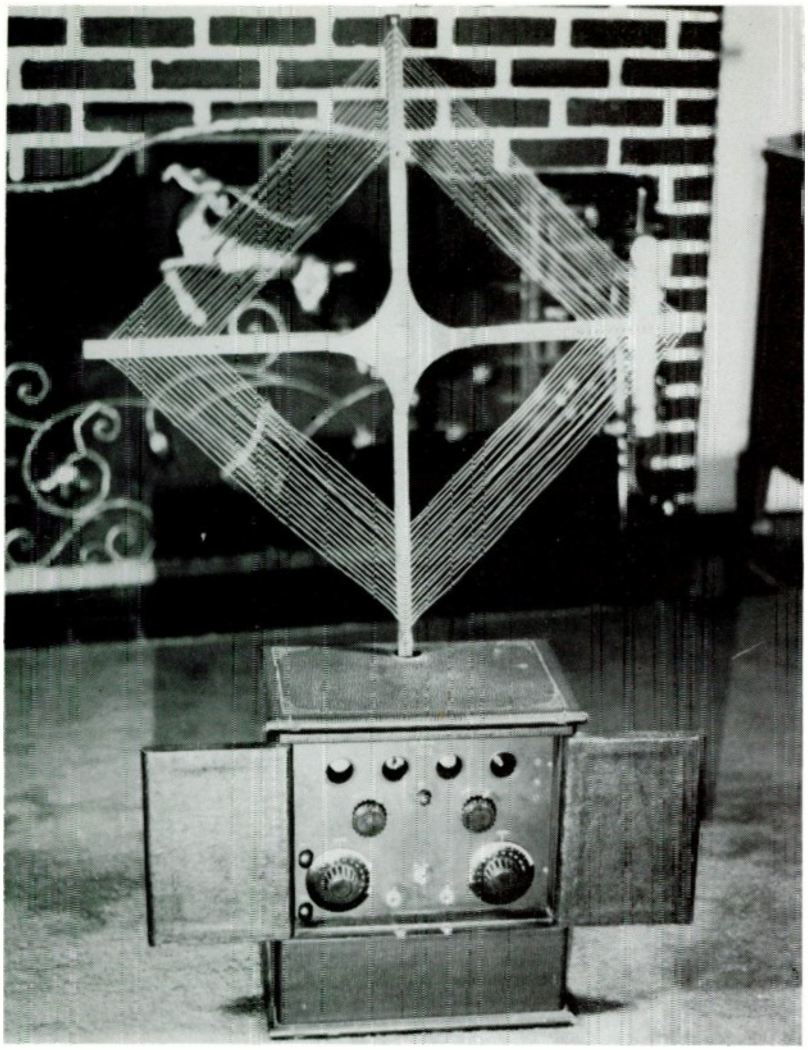
The first loud speakers were merely earphones attached to the end of a horn. Later the phones were designed for the purpose and by using heavier wire were able to handle the output of one or two stages of audio amplification. They were satisfactory so far as tonal quality was concerned because broadcasts of those times were confined to an audio frequency band of no more than 200 to 2,500 cycles. (Most of us can hear from 20 to 18,000).

Cone speakers which were driven by mechanisms very similar to those used by Baldwin were marketed about 1922 or 1923. They were made by Stromberg-Carlson, Thorola, Crosley, Atwater Kent, Acme (which offered a double cone), and many others. Typically, the larger the cone the higher the price since the tone was slightly deeper. Western Electric offered an 18 inch, a 24 inch and a 36 inch cone speaker. They were priced respectively at $35.00, $50.00 and $60. The largest hung on the wall.

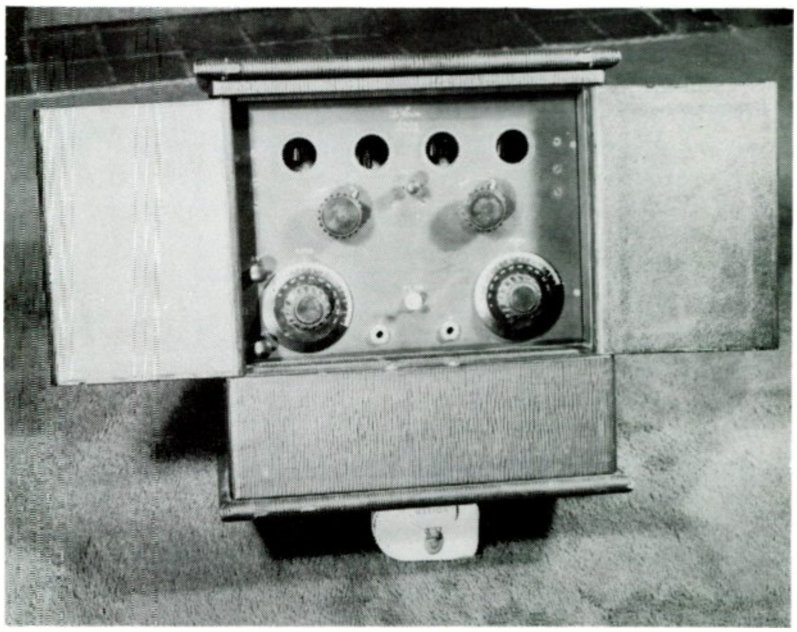
Magnavox offered an improved horn as early as 1920, selling it as a part of its public address system for $150. In 1921 you could buy their improved horn speaker, model TS-2 for $95. By 1924 the speaker had been redesigned once or twice again, was called the R-3 and sold for only $35.

Magnavox had increased the size of the magnet used with the basic horn or headphone design. This improved efficiency considerably but didn't do too much for tone. Cone speakers had a better tone albeit their volume was limited by the moving bar striking a pole.

In 1926 RCA brought out the first dynamic speaker; a voice coil positioned within an intense magnetic field and attached to a paper composition cone. The dynamic speaker has been improved but slightly to this day, no matter what the high fidelity fans may claim. What essentially has been done is that the space between the voice coil and the pole has been increased and the pole face has been made longer. This permits the voice coil more latitude in movement at a tremendous cost in efficiency. Overall tonal response is still poor. You need several speakers to cover the range, and whereas an amplifier can remain true within 0.1 or so per cent, speakers have a hard time holding their overall distortion under fifteen or more per cent.



Lee De Forest four tube, D-10, reflex portable. The spider web antenna visible above the receiver can be folded for carrying. It was this receiver or a similar model of the period, about 1923, that was advertised as being capable of receiving stations 1,500 miles away on earphones. This set also uses a crystal detector in a manner the author is as yet unable to comprehend. Jacob collection.



Close up of the Lee De Forest four tube, D-10, reflex portable.

chapter four

MANUFACTURERS

The early companies were formed primarily for the purpose of constructing and installing wireless equipment in ships and shore stations. Following companies broadened their aims to include competition with the existing telegraph companies who owned or controlled all the land lines and the marine cables. Early telegraph rates were about 25 cents a word; wireless stock salesmen told their prospective customers wireless stations could afford to transmit a message for one tenth that price.

Few, if any, of the early companies considered the experimenters and amateurs of that period as worthy customers, so little equipment was ever actually manufactured with them specifically in mind.

The first company to do so was probably the Wireless Telegraph and Signal Company organized in England in 1899 by Marconi. The second was probably the American Marconi Wireless Telegraph Company, incorporated in New Jersey the same year. A few of the better known receivers this company produced at its Roselle Park, New Jersey plant include the 101, the 103, and the 106, manufactured in 1912, 1913 and 1915 respectively.

When Marconi succeeded in spanning the Atlantic with his now historic letter "S" in December 1901, a number of promoters formed companies for the express purpose of exploiting the "new" discovery. Few of these hastily organized efforts lasted much past 1917. One that did was the American Wireless Telephone and Telegraph Company formed by a Dr. Gehring, utilizing inventions patented by Charles Dolbear and Harry Shoemaker. Another was Lee De Forest's company.

To the best of this writer's knowledge, the Marconi Company never made receivers specifically for either the amateur or the home listener and neither did Gehring's company. De Forest did, of course. First, so far as we know, by selling his Audion alone for use by experimenters, and later adding crystal detectors coils and coil supports to his line of products. The company's early efforts were primarily military and commercial. Early receivers include the Fifteen-Panel Unit set of 1919, the P-300 two tube Audion-Ultraudion of 1919, the T-200 multi-wave tuner of 1920, the Interpanel set of 1921, the regenerative D6 of 1923 with three tubes. In the same year he put out a portable reflex (regenerative) four tube set called the D10, a crystal set, the MR6, D5 Radiophone, D7 Reflex and others. The following year, 1924, De Forest put out only three models: D12, D14, and F5. In 1925 his company produced some twelve more or less improved models, but De Forest was gone, his interest had turned to talking pictures. The company is credited with no further production through 1929, but in 1930 they produced their CS5, a short wave receiver.

The prices charged by the De Forest company for its equipment were typical of their times. Here are a few examples: The Fifteen Panel Unit set of 1919 went for $100. The two tube Audion-Ultraudion went for $88.50 in the same year. The T-200, Multiwave Tuner released in 1920 sold for $87.50. the 1924 F5, which was a five tube T.R.F. receiver sold for only $75. His portable of 1923, the D10, a four tube reflex with a folding spider-web antenna sold for $150. So far as we can judge, both the De Forest portable and the Zenith portable were manufactured about the same time. Zenith, however, claims its 1924 portable was the true first.

The De Forest "Everyman Crystal Set" of 1923 sold for $31.50 and came, this writer believes, with a set of plug in honeycomb coils which gave it a wide tuning range.

The Radio Corporation of America, now legally called RCA, was formed sometime after April, 1919, more or less at the behest of the Department of Navy, then under the direction of Franklin D. Roosevelt, Acting Secretary of the Navy. When the war ended only the Marconi Wireless Telegraph Company of America was capable of handling commercial transatlantic communications, and though this company was a part of the British Marconi Company and owned mainly by British interest, it was thought best that transatlantic transmissions be in the hands of an American company.

Negotiations between the General Electric Company, which owned patents on the Alexanderson high frequency alternator, at the time the most practical means of generating high frequency current, and the American Marconi Company, which had the stations and equipment but not the alternators, had been under way for a number of years prior to America's entrance into the war. The war, of course, halted negotiations. The navy took over operation of the transatlantic equipment during the war and afterwards encouraged completion of the negotiations that terminated with the formation of RCA on October and November of the same year; the physical assets and operation of the Marconi Company was transferred.

Shortly afterwards the construction of new, high-power stations using the Alexanderson alternator was begun in California, Hawaii, and Massachusetts. Since General Electric owned a substantial interest in RCA, cross-licenses were granted on various radio patents the two companys owned.

The value of long distance communication over wavelengths under 200 meters was not recognized at this time, and these bands were left to the amateurs. High power, long wave transmission was satisfactorily accomplished with the alternator. However, the alternator was much too heavy and cumbersome for medium and low power transmission. This area was best handled by tubes. Unfortunately, patents on vacuum tubes were held by both General Electric and Western Electric and neither would budge. Each claimed the other infringed on their patent rights. Fortunately, the Navy stepped in once again and brought them to an agreement in 1920, otherwise the development of the vacuum tube would have been delayed for many yers.

Meanwhile, Westinghouse engineers had been experimenting with voice receivers and the company established a subsidiary called the International Radio and Telegraph Company for the express purpose of developing and constructing receivers for "listener" use. Westinghouse purchased rights to Pupin and Armstrong patents including the now-famous Armstrong regenerative circuit.

Westinghouse fostered the first radio station in the country and the world, KDKA, licensed by the Department of Commerce, October 27, 1920. RCA began with a one day broadcast on July 2, 1929, reporting on the Dempsey-Carpentier fight. Shortly following, RCA began more or less regular broadcasts over WDY in Roselle Park, New Jersey. They then ran into trouble because of WJZ, operated by Westinghouse. Not only were the stations physically close, their frequencies were the same. The outcome was that RCA and Westinghouse joined forces in operating WJZ.

Typical of the period was the entrance into the radio set manufacturing business in 1921 by the Wireless Specialty Apparatus Company of Massachusetts. They made equipment for the Tropical Radio Company, which was owned by the United Fruit Company. Specialty Apparatus wasn't large, even for those days, but they had some important patents. To reduce the possibility of conflict, General Electric purchased an interest in the company.

Prior to the early broadcasts, RCA had been responsible for the manufacturer and sale of some equipment to amateurs. Following the broadcasts, RCA began selling home broadcast receivers manufactured by General Electric and Westinghouse, with Wireless Specialty supplying a few parts and equipment. This was RCA's entrance into the home broadcast receiver field.

Less than a year later, RCA published a catalog titled, **Radio Enters The Home.** In it they advertised a more or less complete line of home receivers. The least expensive was a single-circuit crystal set in a metal box. Complete with headphones, instructions, antenna wire, insulators, and ground, it sold for $25. More complex crystal receivers were offered for $32.50 and $47.40. The least expensive, one tube set cost $65.00 stripped. With earphones, antenna-ground equipment, and batteries it went for $79.50. Called the "Aeriola Senior," it was a feedback circuit using a WD-11. There was another set that utilized three tubes and was assembled in two boxes. One box contained the tuner only, the second box contained the three tubes. One functioned as a detector, the other two were audio amplifiers. The two units and associate equipment went for $250. The same arrangement but in one bigger box of wood bore a price of $261.75.

A four tube receiver, called the "Aeriola Grand," used a regenerative detector followed by three amplifiers, plus four ballast tubes which sole function was to eliminate the filament rheostat. Complete, this receiver sold for $401.00 and had a self-contained horn speaker. It was the most expensive and complicated receiver listed in the company's first radio catalog.

The rheostat was an important part of the early battery radios. Tube filaments were designed to be operated at a voltage **below** that of the supplying battery. The 01A, for example, was designed for 5 volts. Since a fully charged battery provided slightly more than 6 volts, the rheostat was necessary to cut the voltage down. Then as the battery lost its charge and its voltage dropped, the rheostat could be adjusted to apply the full—at that time—battery voltage to the tube filament. The only trouble with this arrangement was that it was possible to apply 6 volts to a 5 volt filament, and many a midnight listener probably did so. The higher filament voltage increased tube sensitivity and output; but it also shortened its life considerably.

At this early date the number of tubes in a receiver wasn't featured in radio receiver sales literature, but distance was. De Forest advertised his D-7A reflex set as having received a station clear across the continent—7,000 miles away—on an indoor loop and headphones. In 1923 his company's logo showed a child next to a receiver with the statement, "His Daddy's Choice." RCA, by contrast, in an ad of approximately the same time, claimed no more than 1,500 miles for its Radiola C or Radiola RC. Lyradion manufacturing Company of Mishawaka, Indiana, was even more modest and claimed no more than 1,000 mile reception, but they featured a horn speaker, and their "Lyradions" ranged from $250.00 to $1,100—as per a 1922 advertisement.

Later, competing radio manufacturers were to feature the number of tubes per receiver in their ads.

The claims became so grandiose that one company, Midwest, which sold kits to be assembled by the purchaser, advertised a 46 tube receiver. Most of the tubes were dummies; their filaments were powered and the tubes lit up, but that is all they did.

RCA's first catalog also featured a horn-type loudspeaker. It was priced at $30. The first loud speakers were merely single earphones that had been increased in size to make them capable of handling more electrical power. A horn of one type or another—most common was the bent or curved horn—was affixed in the position so one normally held one's ear to the device.

Since many homes at the time contained a Victrola or a Graphanola, the RCA company of the time also offered a loudspeaker **sans** horn. To use it, the device was attached to the phonograph horn. There were two models listed, each at $18.00, one for the Victrola and the other the Graphanola.

I don't know whether or not the reader appreciates the high prices asked for the radio equipment of the time. To put the figures in perspective; hot dog, mustard, and kraut only cost a nickel at the time. In 1923 the Essex Six sedan was advertised for $975. The Willys-Overland Touring Sedan sold for $595. A year later you could take a round trip to Europe and back in a cabin on a Cunard ocean liner for only $170.

RCA brought out a superhetrodyne in 1924, and in the year following, the company brought a receiver with accessories that enabled it to operate from an AC (house) current line. The first of the company's truly AC receivers was the Radiola 17, which had tubes designed for AC operation, probably type '26. It had six tubes and a rectifier and came equipped with a magnetic speaker, single-dial tuning, volume control, and an on-off switch. In a true sense it was the first modern receiver. At about the same time RCA licensed other companies to use some of its patents, but with held permission on its superhetrodyne circuits for two more years.

In 1929 RCA bought out the almost defunct Victor Talking Machine company and its famous Victor listening dog trademark. That same year RCA began manufacturing its own tubes, purchasing the Edison Lamp Works which belonged to General Electric at Harrison, New Jersey, and the Westinghouse works at Indianapolis to enable it to do so. This is how RCA got into the record and phonograph business (RCA had supplied parts to Victor to make a combination record player and radio with a single speaker in 1925) and that is how RCA got into the tube business—RCA Radiotron Co.

By 1934 De Forest, who seems to have been brilliant in everything other than business, "threw in the towel" and RCA purchased patents enabling the company to manufacture transmitting tubes and associate components.

E. T. Cunningham who had been a competitive tube manufacturer had given up his company three years earlier and joined RCA.

Final RCA consolidation more or less took place in 1935 when RCA Victor joined RCA Radiotron to become RCA Manufacturing Company.

Atwater Kent began some time late in 1920 with a line of quality radio components for home assembly. In 1921 the company produced five models, none the following year, but jumped forward in the years following to produce a total of 53 different models. The company manufactured bread-board receivers until 1924, when it presented its model 12 for $105. This appears to have been a seven tube receiver with two stages of tuned RF amplification and a tuned detector. Following models were installed within attractive, polished wooden boxes. The company's first AC receiver had an external power supply produced in 1927, called model 36 and sold for $77.00 with seven tubes. In 1928 they produced a self-contained AC receiver with a metal cabinet. Called model 40, it sold for the same $77. Their model 44 of 1928 had seven tubes and sold for $106. By 1929 their more attractive model 55, again with seven tubes, sold for only $88.

A. Atwater Kent was president of the company and guided it with a firm and clever hand. His advertisements were quietly distinguished and he appreciated radio as a sales medium. In 1925 and possibly other years, Atwater Kent Radio Artists could be heard every Sunday evening at 9:15 Eastern Standard time over eleven of the major Eastern and Middle West radio stations. By 1930 Atwater Kent was more or less sharing second place with Grigsby-Grunow and Crosley behind the all-powerful RCA. The 1930's were the depression years and by 1932 Atwater Kent simply closed shop stating, it is reported, that he did not wish to compete by producing inferior equipment.

Grigsby-Grunow manufactured the Majestic receiver, many of which—if not all, were neutrodynes. They began in 1928 with their model 61, were close to being the leader of the industry in 1929 and went out of business by 1934. All of their receivers appear to have been console models selling for over $100. One of their first sets, model 62, had a separate AC power pack, eight tubes and a dynamic speaker and sold for $138. Their later models mounted the power supply on the same metal chassis as the balance of the receiver. All the Majestic receivers had large dynamic speakers with heavy field coils and their tone was as good as many of the receivers sold today.

Powell Crosly, Jr. took a different stance than did many of his competitors since he was interested in volume and specialized in the manufacture and sale of low priced receivers. His Crosley Pup, for example, a one tube regenerative receiver, sold for only ten dollars in 1925. The previous year he had produced a one tube cabinet set. (The Pup was built partially outside a tin box), model 50 that sold for $14.50. His model 51 of the same year was a portable that sold for only $28. His advertisements listed a number of receivers for sale in contrast to Atwater Kent's "mood" approach. And the Crosley ad usually carried this line: A Crosley, better-costs-less radio. At the same time, Crosley didn't let the bigger "fish" get away. He also ran ads pushing his more expensive receivers which weren't particular bargains. For example, his model X-L sold for $140.00 in 1924. It had four tubes and a built-in speaker. However it was a table model: a stand cost an additional $25.00 and the "cost of necessary accessories $40.00 up."

Like Atwater Kent and Grigsby-Grunow, Crosley had a similar run of good fortunate and business that peaked with the advent of the depression years. Crosley purchased Amrad Radio in 1929, but kept losing ground after 1930. Even after its radio manufacturing division was reorganized in 1937, it still didn't do nearly as well as it had earlier.

From this point in time, Crosley appears not to have joined the group of independents that bucked RCA by encouraging Professor Halzeltine to develop his neutrodyne circuit. At least none of the Crosley receivers carry the word neutrodyne in their titles. Perhaps he waited too long since the number of companies allowed to manufacture this type of circuit was limited to fourteen.

Most of the Crosley receivers appear to have been under five tubes, with three and four tube jobs most popular. Such circuits would rely on feedback to develop the output of a six or seven-tube neutrodyne.

Beginning in 1922 and ending sometime after 1930 the Crosley company appears to have produced better than 129 models, or at least receivers bearing individual titles and designations. Crosley favored receiver names such as Ace, Chum, Playmate, Buddy, Pup, Bandbox, Showbox, Gemchest, and Showchest. Their pricing appears to have reached a peak in 1924 or so when they sold their Trirdyn Neuport for $100.00 and the X-L for $140. In 1936 their Model 5-38 sold for $38. The company's first plug-in AC was contained in a rectangular metal box somewhat similar in appearance to the Atwater Kent of the same period. Called the 608 Gembox, it had six tubes and sold for $65.

Records show that Amarad Corporation, marketing name of the American Radio and Research Corporation, began with a short wave receiver in 1922 and continued manufacturing radios until 1930. Crosley gained control of Amarad early in 1929 but probably closed Amarad for the same reason he shut his own manufacturing facilities down; the advent of the mind-numbing depression. Powell Crosley, Jr. later went onto acquire WLW in Cincinnati which at one time was the most powerful broadcast station in the world, having an output of 100 kw.

The Amarad Corporation was no slouch itself at producing a variety of models, or at least model names and numbers. Between 1925 and 1929 they produced 38 models. Their taste in receiver names was more romantic than Crosley's, bearing such titles as DC&C Hastings, 70 Sonata, 81 Aria, 3500-1 Cabinette, and the Inductrole, Neutrodyne.

Zenith began on a kitchen table at the end of 1918 when Karl E. Hassel and R. H. G. Mathews, two young radio "hams," began "manufacturing" components for other radio hams and later receivers. The company name was derived from the call letters of their amateur station, 9ZN. The corporation itself was formed in 1923, more or less under the direction of Eugene F. McDonald, Jr., who joined the two in 1921, and Hugh Robertson who joined as treasurer that year. First the corporation was the sales organization for the Chicago Radio Laboratory, which did the actual construction and later Zenith consolidated with Chicago Radio to form one organization.

According to an advertisement appearing in the April, 1921 issue of **Radio News**, the first "Zenith" was called a C.R.L. Regenerette and was offered for only $15.00 by the Chicago Radio Laboratory. It appears not to have been a "true" receiver in that it required the addition of a loose coupler. This ad supports the statement made by some radio historians that Chicago Radio was founded by the radio hams and made much of the equipment assembled by Zenith, which was formed by supersalesman, McDonald, Jr.

In any event the next Zenith was called the Z-nith Long Distance Receiver and was sold in 1922. It appears to have had three tubes with a tuned RF, and a tuned detector with a calibrated regeneration control. In 1923 the name Zenith appears on a receiver for the first time. It is the Zenith 3R Long Distance Receiver, with four tubes and a list price of $175. This was closely followed by the 4R receiver.

In 1924 the company produced seven models, including a portable receiver completely contained in a small suitcase—even the horn was inside. It had six GE tubes, a single tuned stage, probably regenerative, very small B batteries and three large dry cells of the type used for powering bell circuits. (A cells). The company produced its first AC receiver in 1926 and offered automatic pushbutton tuning in 1927. In 1935 they introduced the first of the "airplane" dials. Their Stratosphere multi-band receiver of that year sold for $750.

From 1929 to 1941, Zenith went from a sales volume of ten million dollars to twenty-five million dollars. The company's skill lay in marketing rather than technical advances. Their receivers were on the whole easy to operate, large and somewhat gaudy. From just two models called Chinese and English in 1925, they went on to five models in 1926 with such names as Colonial DeLux, Chinese DeLux, Spanish DeLux. In 1927 they gave their sets numbers: 11, 12, etc., and letters 15Ep, etc., for a total of fourteen models. The following years they remained with number designations manufacturing twenty-one models in 1928, nine in 1929 and twelve in 1930.

At first their prices were not low. The DeLux receivers of 1926 ranged from $240.00 to two thousand dollars, with other sets starting at $100. Later they shifted their marketing gears as the depression hit and in the thirties were making small sets somewhat similar to their competitors. During this period they were among the first to introduce plastic cabinets and probably were first in the number of different-in-appearance receivers they put up for sale.

Stromberg-Carlson was always in the mind of the public as the Rolls Royce of radios. The radios were always mechanically beautiful with all the wires neatly tied in place and had physical evidence of excellent workmanship. Electrically they were approximately the equivalent of other receivers utilizing the neutrodyne circuit.

The Stromberg-Carlson Company was formed in 1894 as a partnership between two Swedish engineers, Alfred Stromberg and Androv Carlson, who had met while working for the Chicago Bell Telephone Company. They each invested five hundred dollars and went into the difficult business of bucking the telephone establishment by making telephone equipment.

Stromberg-Carlson entered the radio business through the manufacturer of small components; jacks, cords, plugs and headsets in 1922. Because of the strong patent control RCA had over the industry, Stromberg-Carlson waited until 1923, when it joined the Independent Radio Manufacturers and secured a license, to manufacture receivers using the Hazeltime neutrodyne circuit.

The five tube model 1A made in 1924 was the company's first. It had three tuned circuits, each with its own dial. In the table model form it sold for $180. The same receiver was also offered in a console, but its list price has been lost. In 1926 they increased production to five models; increased their number of models each year and peaked with twenty models in 1930. So far as we know, they were all neutrodynes until about 1927, after which they turned to superhets.

Motorola was born as the Galvin Manufacturing Corporation in September, 1928 in a small section of a fifth floor rented from an understanding landlord at Harrison Street in Chicago. The company had five employees and a working capital of about five hundred dollars. Another five hundred dollars had been invested on the rights and the equipment for making the Steward dry battery eliminator.

At first the company scratched along making and selling eliminators to Sears, Roebuck and similar outlets. But Paul V. Galvin knew eliminators were not long for this world; the AC receiver had made its public appearance in 1926, so he began assembling receivers from purchased parts under various company labels. His men started with a nine tube chassis on which they affixed any of some twenty different private names. The profit margin was low, competition was fierce; there were hundreds of similar shoe-string operation in other Chicago lofts at the time.

With the advent of the Depression, the private-label radio manufacturing business just about disappeared and the eliminator business was in even worse shape. During this period Galvin was in New York trying to work out a compromise on the cancellation of material he had previously ordered but now no longer needed, when he chanced to observe the custom installation of a radio in a car. The process involved removing the car's dashboard, building a supporting shelf for the receiver, drilling holes in the dashboard so that when the receiver was on its shelf the control shafts poked through. The antenna went under the running board or up in the cloth roof. The car's battery powered the filaments and large B batteries powered the plates. The charge for the installation alone was $240. The need for a practical auto radio was obvious but satisfying the need was another thing. By dint of much hardwork, Galvin's crew produced a receiver that was controlled by a pair of jointed metal rods terminating in knobs near the car's steering wheel shaft. Galvin and his wife drove their car with the radio to the Radio Manufacturer's Association Convention in Atlantic City in June of 1930. In something under three months a practical auto radio had been conceived, designed, and constructed. Galvin had no space at the show, but managed to demonstrate his radio to dealers outside the convention hall. Acceptance wasn't overwhelming, but he was able to secure a few orders: auto radio had arrived. By 1941 the annual demand for auto radios reached the 2.5 million mark, with Motorola supplying the greatest share at six hundred thousand units. At the same time, the company also manufactured and sold four hundred thousand home receivers. In 1940 Galvin had been fifth in the total number of radios sold. RCA was first with 1.7 million, Philco was second with 1.67 million, Zenith was third with 1 million, Emerson was credited with a million receivers but theirs were mostly midgets and Galvin followed with .95 million receivers.

When the Philadelphia Storage Battery Company, which was founded in 1892 as the Helios Electric Company, began manufacturing battery eliminators for radios in 1924, they had a large and experienced organization of battery dealers throughout the country to assist them in their effort. The company remained more or less satisfied with this share of the radio market until 1928 when the AC receiver was a proven and accepted device. Since RCA had accepted no new and additional licensees after the start of 1927, the battery company entered the field by the only practical means open to them. They purchased the William J. Murdock Company for one hundred thousand dollars. As Murdock had an RCA license, the batter company was in the radio business.

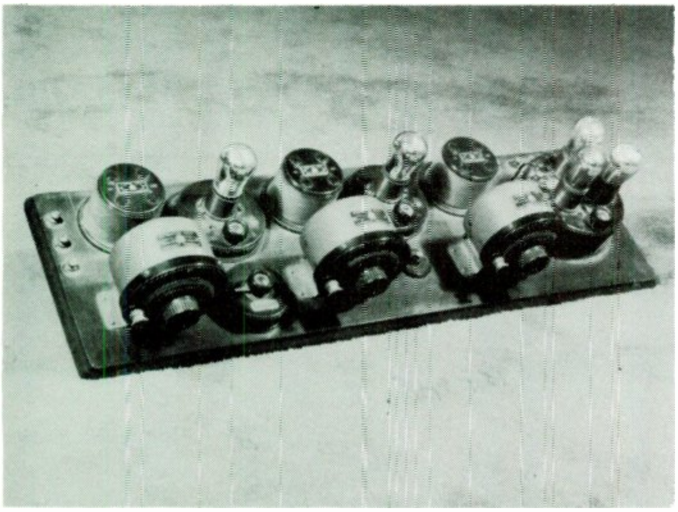
Philco's first receiver, judging by model numbers, was their 512, which was followed closely by the 513 and 514 as a not particularly distinguished appearing table model, with one turning control, seven tubes and a circular speaker that sat atop the radio. It listed for $127. In their first year the company put out fourteen models, or at least models bearing fourteen different numerical designations. Ten models were put out in 1929 and twenty-three models in 1930. Despite RCA's head start and patent advantage, Philco, by designing for the public's taste, aggressive marketing, and clever advertising, pulled up equal sales volume by 1941.

Philco was first to design for the farm market, building battery-operated sets for the many farms generating their own DC power. The company was also first to develop the portable radio market, made practical by the development of small, low filament-current tubes.

Another famous name of the early days of radio is Emerson. The company was founded by the Abrams brothers sometime in 1923 and until approximately 1932 the position of Max and Benjamin Abrams in the industry was less than significant. At this mid-point in the depression, the brothers felt there was a need for a small, very low-priced set. Perhaps they were witnessing too many of the high-priced receiver manufacturers going under, or perhaps they were aware of the continued good business the movies were doing and believed everyone was desperate for entertainment but just couldn't afford it. The brothers selected a radio cabinet styled like a clock for their first effort; just 10 inches wide, 6½ inches high and only 4 inches deep. There were no standard components available to fit their case, but they found companies to manufacture the parts. Like Philco, Zenith and others, Emerson also merely assembled and marketed components manufactured by others. Their first "small" midget receiver sold for only $25.00 complete. It was so popular that it took more than one year for the company to catch up with its orders. The Emerson midget and competing small receivers resulted in reducing the average price of receivers by $98.00 in less than four years. In 1929 the average radio sold for $133—by 1933 the average price had dropped to $35.

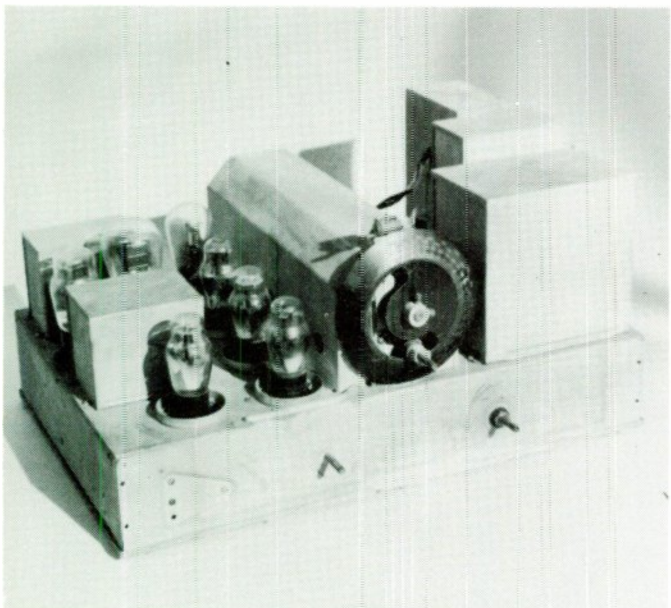
By 1941 the sale of midgets sets represented 80 per cent of the total number of receivers sold. Prices continued to be reduced with Emerson leading the way. Their all-time low was $6.95 for a set in 1939. Now almost everyone could afford to have a radio, and many homes owned several radios. Listeners increased in number from an estimated 12 million in 1932 to more than 55 million by 1941. Emerson had a sales volume of more than 14 million dollars in 1941, mostly from midget receivers.

These are by no means the only nor even the most interesting radio manufacturing companies of the early days. They are merely a number selected from literally hundreds of companies so engaged. They were selected because they are probably the best known. Just a few of the other names that may be familiar to the reader include National Carbon Company, Brunswick, Freshman, Freed-Eisemann, Federal, A. H. Grebe, Colin B. Kennedy, Paragon, Niehoff Company, Boston Scale & Machine, Clapp-Eastham, Jones, Industrial Radio Service, Kellogg, J. L. Reinartz, C. D. Tuska, Fada, National Monodyne and many, many more.

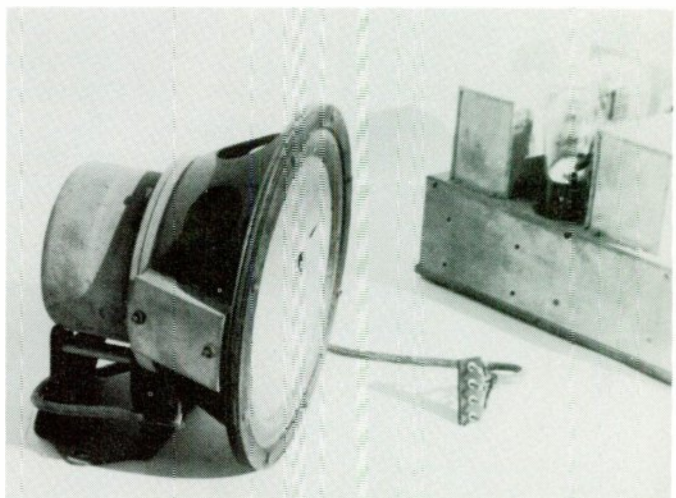


Atwater Kent Model 10-B, circa 1923. A battery-powered, TRF, five-tube breadboard receiver. It uses four 201A tubes in the audio amplifier and 1-200A as a detector. There are three tuning controls.
Jacob Collection

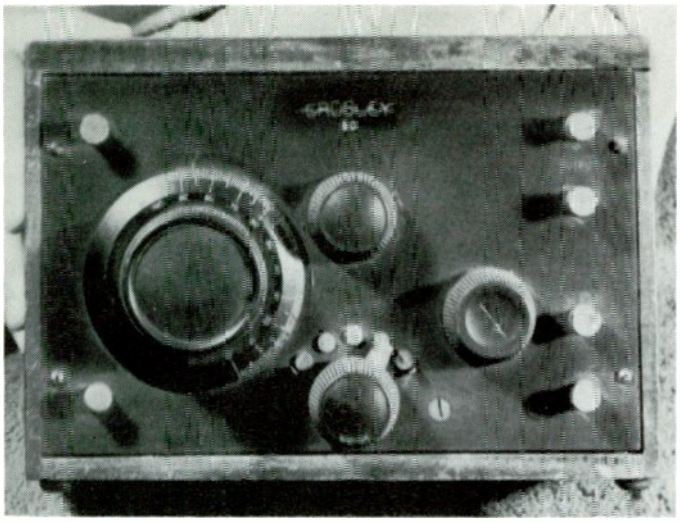
Close-up of the same receiver showing the audio section.
Jacob collection.



The "all electric" 90-B chassis of the Majestic (Grigsby-Grunow) receiver. It utilizes a neutrodyne circuit, four tuned stages with a four section, ganged capacitor, one single tube audio driving a pair of 1945 output tubes in push-pull. Metal boxes at the right are the power transformer, choke, and paper capacitors forming the power supply.
Author's collection.



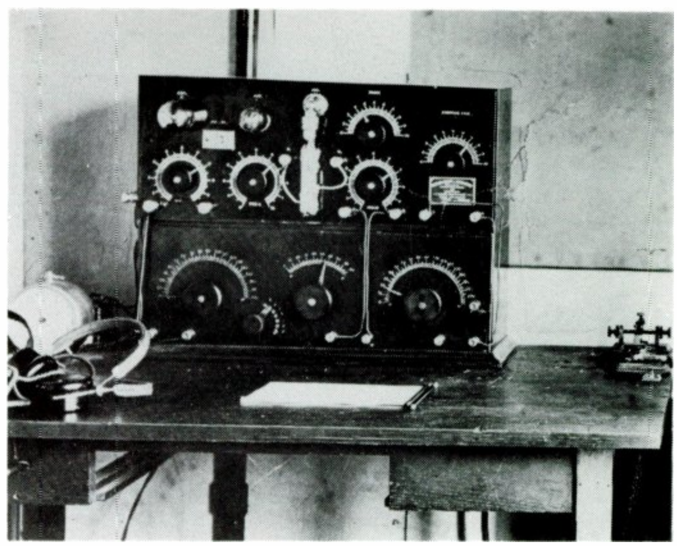
Eight inch dynamic speaker driven by the Majestic 90-B receiver. Speaker weights about ten pounds, chassis about thirty pounds. Tone quality is excellent, station selectivity is poor. Set was made in early 1930's.
Author's collection.



Crosley Model 50, one tube regenerative receiver. It uses a WD11 tube. A somewhat similar receiver called the model 5 was also made in the same year, 1923. Jacob collection.

1926 Crosley Ad that appeared in the November Radio News. Note that neither the regenerative nor the neutrodyne nor the superhet circuit is mentioned. Author's collection.

Admiral D. B. MacMillan field testing Zenith's first portable receiver in 1924. Courtesy Zenith.

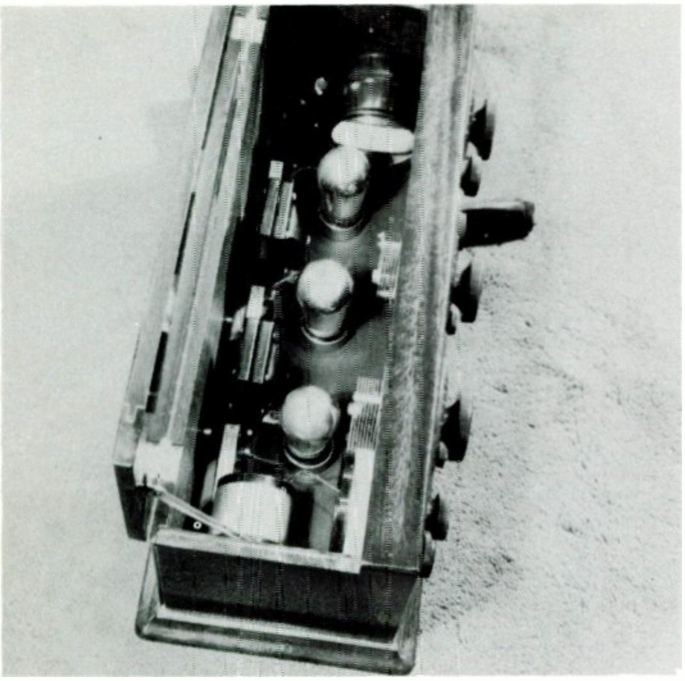


The original 1919 Z-Nith receiver, installed at station 9ZN, the amateur station owned by the two men who started Zenith radio. Courtesy Zenith.

Zenith longwave equipment used by the Chicago Tribune in 1919 to be first with the news on the Versailles Peace Conference. Courtesy Zenith.

Inside the first Zenith portable receiver; six tubes and a single tuned stage. Everything else appears to be audio amplification.
Courtesy Zenith

Paragon RB2A, three tube regenerative receiver of 1923. It sold for $135.00 at the time. It was made by the Adam Morgan Company of New Jersey. Typically, it had a detector followed by two stages of audio amplification. Jacob collection.



Inside the Paragon RB2A. Note the two audio transformers at the rear of the cabinet. Jacob collection.

The Zenith giant Stratospher receiver with actress, Irene Hervey featuring the big black dial. It sold for about $750.00 in 1935. Courtesy Zenith.

chapter five

OPERATING OLD RECEIVERS

Modern receivers are simple to operate and difficult to damage, at least from the front end or their battery side. AC receivers are simply plugged in. They are designed for 60 Hertz current but can take 50 Hertz if they have to. Twenty-five Hertz alternating current is no longer commercially generated so far as this writer knows and neither is DC (direct current).

It is equally difficult, but not impossible, to damage a battery-powered receiver from its rear. The battery connections are clearly marked. In some receivers it is physically impossible to install the batteries incorrectly. In others, you can install them incorrectly only if you try real hard.

Modern receiver antenna requirements are in the main, negligible. All the portables and most of the non-portable receivers AM and FM have built-in antennas. An external antenna is rarely needed and when it is, it is no more than a short length of wire for an AM set and a pre-connected T-shaped set of wires for an FM receiver.

Front panel operation is equally simple. The small portables have but three controls; an on-off switch combined with a volume contol and a station selector or tuning control. More complicated portables will have an AM-FM switch or possibly a band switch. The larger non-portable receivers may have more switches; a mode switch, for example, marked AM, FM, Tape, Phono, plus other switches. Their uses are clearly marked. Not only is the printing legible, we are conversant with the abbreviations. This is not so with old receivers harking back half a century or so. Whatever was common knowledge among radio fans has been forgotten by now: The markings are not always legible, the instruction booklets are gone and the battery wires have often lost their tags or if color coded, the colors have faded.

Radio five decades back was in a greater state of flux than it is today. There is more research at the present and scientists are pressing forward on many more fronts than ever before, but we, the users, are hardly aware of this. The results are behind the front panel. For example, many color TV receivers now have automatic color control, which is a complicated circuit that keeps track of the color portion of the TV signal and corrects receiver variations due to temperature and vibration automatically. All the user sees is a button he pushes. The growth of transistors is another example. Since their introduction, several thousand different types have been marketed, yet we the users are hardly aware of the proliferation.

Perhaps it is all due to our sophistication. There are as many changes in radio and television today as there were in the old days, but today we take them for granted and pay no attention. Perhaps the absence of awareness is the result of the better equipment: We don't have to work at radio and TV reception to secure results; in the old days we did. Then it required lots of time, skill, and effort to secure any reception at all.

Crystal sets certainly required the most effort because they were and still are powered by the energy emitted by the station's broadcast antenna. Therefore, to receive anything any distance from the radio station it is necessary to erect a substantial antenna and install a good ground. If you are close to a broadcasting station, or if you merely wish to see whether or not the crystal receiver you acquired works at all, you can use a window screen for an antenna and a nearby radiator for a ground.

A proper antenna, of the type used in the days of the crystal set, consists of a 50 to 100 foot long wire, supported between two insulators and hung as high as practical. For best reception the side of the antenna wire should face the broadcast station. Any wire can be used for an antenna but the best consists of half a dozen strands of copper wire, preferably enameled. The antenna wire is not cut but is led down to the receiver, where each of the individual strands are scraped brightly clean. If you have to go through a wall, an insulating tube may be used. If you have to come in beneath a metal window such as a storm window, be certain to insulate the wire at that point so that the metal cannot make contact.

A good ground is equally important because the ground is essentially the other half of the antenna system. In other words the single wire antenna described is only half the antenna; the complete circuit begins at the ground, runs through the receiver and up to the end of the antenna. Together wire, ground and the coil within the receiver should ideally tune to the frequency of the desired station or stations.

To make a good ground, drive a pipe at least 5 feet into moist earth as close to your window as convenient. If there is a choice between driving the pipe into dry earth nearby and moist earth a distance away, opt for the moist earth. Use a clamp and run a length of number 18 or heavier wire from the pipe to your receiver ground connection. The wire may be bare or covered, but the wire ends must be scraped bright for a good connection. As an alternative you can use a radiator or a water pipe, both of which ultimately contact the earth through either the cold water pipe leading to the city water main or your well.

To protect your home against lightning you need an arrester. This is a fixed-gap device that is connected between the antenna lead and the ground wire. The idea here is that the lightning will jump the gap rather than enter your home and travel through your receiver on its way to the earth. If the need for an arrester appears to be far fetched, remember that lightning always strikes the highest and best conductor. Antennas generally meet these requirements, so it is advisable to install a lightning arrester.

Whether or not your crystal receiver will be easy to operate the first time depends upon its design and calibration, if any. Start by testing your earphones. Use a single dry cell, any kind. Touch one earphone lead to the bottom of the cell; the other lead to the top of the cell. You should hear a loud, clear thump. If there is no sound at all, your phones are defective, and we will treat that condition in a moment. If the sound is definite but weak; try a different cell. It may be weak. If a fresh cell doesn't improve the volume, unscrew the phone cap and see if the space below the disc is free of debris.

If there is no click, disconnect the earphone wires where they connect to each phone; then using two pieces of wire, make the test again. You may find the original flexible lead made of tinsel wire is broken inside. You may find one earphone is defective, in which case you can simply use the other alone. Should you find one or more earphones defective—no responding click to a shot of juice—open the phone and look for a broken wire. It isn't likely, but there is always the possibility.

Repair or replace the earphones—the higher impedance phones are best— and connect them to the crystal set as indicated. Connect the antenna and the ground leads as indicated. Should there be no indication, all you can do is keep trying all the connections; you can do no harm, at least not to the receiver, though you may go a bit "batty" trying the innumerable combinations. The alternative is to trace the circuit, which is simple enough if you know radio, but can be utterly confusing if you don't. However, the antenna and ground connections usually go to a coil near the tuning (main coil), or to the main coil directly. The phone connection usually has one wire going directly to the crystal detector.

You will know you have made the correct connection, or partially correct, when you hear something in the earphones. Unfortunately, when you do not know the correct antenna-ground-phone connections, which are rarely marked on a homemade crystal set, you have at least four variables to contend with: the just mentioned connections, tuning, and the crystal detector.

To get yourself out of this maze, start with the crystal detector. If the cat's whisker rests lightly on the crystal, let it be. If not, bend the wire as necessary to make the whisker touch lightly and let it be for the moment. There is no point in experimenting with the crystal until you know that your connections are correct and that you are tuned to a station.

Next, go to the contols—whatever they may be. If there is a dial calibrated in KC (kilocycles) or meters (wavelength), turn that dial to the frequency or wavelength of a nearby broadcast station. If the dial reads 1 to 100, it is most likely the tuning control. Turn the dial slowly from one end of its swing to the other. Stop if you hear any sound.

If there is a single knob and it is connected to a variable capacitor (set of meshed metal plates), turn it from side to side while searching for a sound. If the single knob turns a coil, which is part of a variometer, do the same. If there is a slide that makes contact with bare wires on a coil, slide it to and fro. If there is a multi-step switch with wires leading to a coil; swing that. If there are two dials, or two switches, etc., continue to do the same, always searching for a sound—any sound. Even static will be helpful.

Assuming all is like a silent tomb, you will have to move the phone and antenna-ground connections around—assuming you are working with unmarked binding posts—and keep on searching for a sound. If you have gone through the entire drill with no results, move the cat's whisker to another point and try again.

Ultimately, if your ear phones are operative, and they must have an internal impedance of 1,000 ohms or more, you will find the correct combination, meaning you will connect all the wires to their correct positions and you will hear something since crystal sets and their crystals are virtually indestructable.

A word about earphones before going on. Standard phones, made for radio use will work on crystal sets. The higher their impedance, the more efficiently they work. However, World War II American Air Force phones cannot be used as they are. They have low impedance. To use them you need a matching transformer. Use a single-tube output transformer. Connect the phones to the voice coil side and the input side to the receiver.

When you hear a sound other than your breathing, and eventually you will, you have the basis from which to accurately determine the nature of your receiver's controls and locate a highly sensitive spot on the crystal. Start by varying the position of the tuning control, or the control you believe varies receiver tuning. The tuning control can be identified by the means just described and by its ability to "peak" on the signal. That is to say, varying the tuning should produce an increase, a peak, and then a decrease in signal.

Now adjust the antenna coupling control for maximum signal. This control may or may not peak.

Its effect on tuning should be to broaden the peak on the tuning control. If the presumed coupling control does not broaden and reduce the peak on the tuning control, the presumed coupling control may be a second tuning control. In any event, at this stage of your experimentation, settle for a clearly audible signal with any position of these controls.

Next, go back to your antenna-ground-phone connections and carefully vary them to find the loudest response. There may be a better arrangement and there may not be. Also, you may find changing the connections causes several stations to come in at the same time. No harm done, just go back to the best arrangement.

Following, go to the crystal and experiment until you find a good spot. Bear in mind that a crystal may have a dozen sensitive spots, so don't waste your time seeking them all out. Should the volume go very high, use the coupling control or de-tune the receiver. Doing so will assist you in finding, possibly, the most sensitive spot. Your ear is most sensitive to change at very low volume.

Having read this far you may believe that all crystals receivers, connections and controls marked and unmarked, are very difficult to operate. But, they are not. The above drill is only necessary when you are far away from a broadcast station or have a very poor antenna and ground. In most localities, with even a fair antenna and ground, a signal will come in with almost any connection and the controls in almost any position. Once you have a signal, you just work towards maximum volume and control identification.

So much for operating "straight" crystal receivers. Next in line of complexity are the crystal-tube receivers. We must break these down into types or groups because each requires somewhat different handling. However, before doing so, the great danger common to operating all battery-powered tube receivers of all types (circuit arrangements) must be explained. It is this: All triodes and more complex battery-powered tubes (which leaves the Fleming valve tube out) require two different voltages—a low voltage for the filament, a high voltage for the plate. Some circuits require a third voltage, called bias or grid voltage. Filament voltages range from 1.4 to 5.0 volts; plate voltages range from 45 to 90 volts and bias voltages range from 1.5 to 7.5 volts.

As is obvious, should you connect the "B" battery, which is the plate battery, to the "A", which is the filament battery, by mistake, you will place a minimum of 45 volts across a filament which is designed to take no more than 5 volts maximum. Within the micro-second of having made this error your tube will be burned out; null, void and useless. The bias battery called the "C" battery will do the same, not as quickly, but faster than your hand and eye can react. The great danger with working with battery-powered tubes is burning them out by accident, and the associate warning is that you can in no way disconnect a B battery fast enough to prevent burn-out, so don't try.

The proper procedure is as follows: Determine the tube(s) type. You will find this sometimes on the tube socket or on a metal plate nailed to the inside of the cabinet, or sometimes on a printed sheet bearing basic specifications and tube location glued to the inside bottom of the cabinet. Most often you will find the tube's designation stenciled on the side of the tube itself or inscribed on its base.

Tubes made after the original Audion, which had a screw base, are held in their sockets by either a pin or spring prongs. Pin sockets form a metal shell around the base of the tube. With these, you press the tube down a fraction of an inch and then turn the tube counter clockwise. The tube then comes up and can be lifted out. Tubes in prong sockets are released by gently rocking them from side to side while pulling upwards. To return the tubes to their sockets, repeat the procedure, taking note of the pin and its slot, and the fat and skinny tube prongs. Both these arrangements assure the tube entering the socket just one way.

Tube out, look for its marking. If you cannot find it, try breathing close and hard on the tube's glass bulb. The condensing moisture will sometimes clarify weak printing. Following, refer to the tube chart in the Appendix for the correct filament (and plate) voltage. Note that most receivers of this period used but one filament voltage for all the tubes. However, if the binding posts or wires indicate more than one A-battery connection, START WITH THE LOWEST VOLTAGE.

The reason for the next step is that the receivers we are dealing with are more than half a century old and may have seen many owners. The original rubber-covered battery wires may have been replaced more than once. The tags or other markings may have been interchanged and so on, and as you already know or will soon learn, tubes are very hard to come by. In time old tubes will be more valuable than the receivers in which they reside. (Perhaps, like old auto tires, some company will manufacture them again.)

Darken the room. Open the receiver cover so as to expose the tubes. If there are any rheostats, filament controls, power controls, volume controls, or other controls other than obviously tuning controls, turn them all counterclockwise (to low). Now, if you are positive you have properly identified the tubes and they are listed in the tube manual in the appendix—which doesn't list all tube types—connect the proper A voltage to the receiver's A connections, taking care to match the polarity as indicated. (More about polarity a bit later on.)

Tubes having 1.4 volts are powered by a single, dry-cell A battery which produces 1.5 volts. Tubes requiring 5 volts are powered by four A cells or a three cell storage battery. Both arrangements provide 6 volts, which is what we need.

Should you not know or not be certain of the tube filament requirement and have to work blind, START WITH THE SINGLE DRY CELL. In doing so, you take no chance on damaging the tube(s) With the A cell or batter connected as believed correct, look at the tubes. If they show no light at all, go to the front of the receiver and slowly turn the rheostat or filament knob to the right. On some receivers, there will be an on-off switch. Turn this to "on."

With the correct A voltage and the tube filament control, a variable resistor, in mid-position or so, the filament should glow a dull red or orange. If there is no glow at all, carefully turn the control up to full. At this point, if there is no light within the tube(s), the tube(s) is burned out, something is wrong with your connections, something is wrong with the rheostat and/or you haven't sufficient filament voltage. Assuming the latter condition, add another dry cell in series with the first and try again. Or, go to 6 volts, rheostat in minimum position and try carefully again.

Should the tube's filament go beyond orange with the control at mid-point, you are applying too much A voltage. Reduce it by using a lower A voltage at the feed connections. Do not depend on the rheostat to hold the voltage safely down. For one thing, you may burn the rheostat out doing this. For another, a careless turn of the control can burn out your tubes.

Note that maximum tube efficiency and performance occurs with maximum filament temperature (up to burn-out), but that maximum tube life is consonant with **minimum** filament temperature. So, when you are operating any receiver that enables you to control filament temperature, always turn the control back down as far as you can consistent with satisfactory operation. In this way you will extend the tube's life many thousand hours.

Having explained the safe way to find the correct filament voltage and hook up the A battery, there is only one point to discuss before going on to the B battery. In most receivers, it makes little difference whether you connect the A cell's plus to the A plus on the receiver, or mix them up: A minus to receiver A plus. However, it does on some and you should always make these connections correctly.

The B battery supplies the plate voltage and if its terminals are incorrectly connected to the receiver, there will be absolutely no reception. At the same time, there will be no harm done. When and where the B connections are clearly identified, you have no problem. When they aren't you can make a test connection. When the connection is correct you will hear a sound in the speaker or phones; when incorrect, there will be no sound or very little sound.

B battery voltages range from a maximum of 45 to 90 for the tubes constructed in the early battery-radio era. As with tube filament voltage, higher B voltages produce greater output and increased efficiency, at the same time reducing tube life. However, the penalty for over-voltage is not nearly so severe. Running a tube rated at 45 plate volts maximum on 90 will not burn it out, but will shorten its life materially. Continued high plate voltage causes a tube to lose its ability to perform; electron emission from the filament falls rapidly off and you get to a point where the tube will not function unless its filament is heated beyond normal temperature. (This what a TV picture tube booster does—ups its filament temperature.) Very often you can secure satisfactory operation using only 45 volts in the plate circuit of a set designed for 90 and sometimes you can get by with only 22.5 volts on an earphone, tube set.

Now, let's get back to the crystal-tube receiver and how they may be operated. Most crystal-tube receivers are in actuality a crystal receiver followed by an audio amplifier. Not all, however. The Lee De Forest D10, for example, has the crystal connected in a strange feedback circuit, the purpose of which has long been forgotten. When you encounter one of these "strange" circuits (the period was rife with them), there is nothing this writer can give you by way of advice. Just experiment cautiously until you figure out how the thing can be operated.

Operation of the straight crystal-tube receiver is simple. The crystal front end is the RF detector stage. That is to say it is tuned to the frequency of the incoming signal, as previously discussed. The tube or tubes then amplifies the signal. In some of these receivers it is possible to plug your earphones in directly behind the detector, which makes it easy to determine whether or not lack of operation is due to the front end or the amplifier. It is also easier to tune closely to the signal when it isn't being amplified by the tube stage. A stage is a tube and its associate parts that provides a specific function. In the case of a crystal-tube receiver, the audio stage amplifies the audio signal. As previously suggested, always operate the tube portion of these receivers at lowest satisfactory filament voltage for maximum tube life.

Multi-stage crystal-tube receivers are operated exactly as just described. The use of more than one tube may make loud speaker operation possible. You may also find that each stage or pair of stages has a filament control: Keep this turned back as much as possible.

Multi-stage audio amplifiers often utilize a C battery for grid-bias voltage. Without going into tube operation theory in detail, the grid bias is always negative and reduces the normal flow of current (electrons) from the hot filament to the positive voltage plate—in this way causing the tube to operate in the straight-line portion of its characteristics. In other words, with the grid biased negatively, an incoming signal will not ask the tube to release more current than it can, which would cause distortion.

C battery polarity is critical. If the polarity is reversed for only a short time the tubes can be damaged. Obviously, you will take care to connect the Fahnestock clip on the C battery marked - (minus) to the binding post or wire on the receiver similarly marked. And the + (plus) to the same connection on the receiver.

Start with the lowest voltage after you have adjusted everything else and are listening to a signal (station).

Correct polarity will always lower the volume of the signal and usually will clarify it. When the signal is very weak, the C battery's function may have no apparent effect.

In addition to improving the fidelity of the signal, the C battery acts to reduce plate current, extending the life of both the batteries and the tubes. If the lowest voltage has no audible effect, try the next voltage up. If your C battery increases the volume, your connections are reversed. Stop and correct immediately.

The TRF receiver is next on our list although you may encounter as many reflex receivers from this period as TRF's. The reason is that it is easier to understand and operate the TRF than the reflex; though both are simple enough once you understand the principles involved.

TRF stands for tuned radio frequency amplification. In the crystal-tube receiver, the crystal detected the signal. In doing so, it converted the alternating, high frequency signal fetched in by the antenna to a pulsating, direct current signal which was converted to audio frequency by virtue of the time lag of the components. (Earphones cannot vibrate at radio frequency, but they try. The result is that the phones vibrate at the average volume or power of the radio frequency signal, and since the average is the impressed audio or voice signal, you hear the voice signal. This is not an exact explanation, but it is close enough for our understanding.

In the crystal set, the coils and capacitors associated with the crystal tune the desired station in. In a TRF, a tube replaces the crystal detector, but in addition there is another stage—tube and coils and capacitor—ahead of the detector that is also tuned to the same station. And just as the audio stage amplified the signal presented by the crystal, the RF stage amplified the signal, but at radio frequency, and then presents the amplified signal to the detector. The result is not only signal amplification, but increased selectivity because the signal is filtered through two tuning stages, the RF amplifier and the detector. The disadvantage is that you get less amplification for the same effort and you also increase operational difficulties because of the necessity of tuning two stages instead one. That is why in the early days when there weren't many broadcasting stations and distance was the thing, manufacturers used a number of audio stages following a crystal detector instead of RF stages and fewer audio stages.

Some TRF receivers have two tuning stages, some have three. You can recognize a tunable stage by the presence of its tuning control on the front panel. On TRF receivers you have to keep all the tuning controls aligned to the same frequency. Therefore, to sweep across the broadcast band in search of a station you have to rotate all the tuning controls simultaneously. And then, when you have tuned in a station, you have to go back to each dial and "peak" it on that station. The old sets had closely coupled stages which interacted with each other somewhat.

What has been discussed in regard to batteries and filament voltages is all there is to operating a TRF receiver.

One of the first, if not the very first, manufacturers to rid the listener of the nuisance of keeping three or more dials aligned as he searched the airwaves for stations was the Thermiodyne Radio Corporation of Plattsburgh, New York. Their receiver had six tubes and a single tuning control calibrated in wavelengths. The newspapers of that day listed broadcast stations by call letters and wavelengths. Today, the use of kilohertz (kilocycles) is more common. Incidentally, to convert frequency in kilohertz to wavelength divide three hundred million by the frequency in cycles per second. A kilohertz is one thousand cycles per second.

An early 1924 Thermiodyne advertisement showed a child operating their receiver, with the implication and statement that even a child could operate it. The receiver was that simple.

Reflex receivers, often called regenerative receivers, were patented by Armstrong sometime in 1918. A portion of the signal as passed through the detector tube, which is usually but not always the first tube in the line-up, is fed back to the input to that tube. In the early days it was most often done with a "tickler" coil, sometimes called a wing circuit.

The tuning coil was connected to the filament and grid. A wire from the plate led to a coil placed close to the tuning coil. The other end of the tickler coil was connected to the earphones, in the simpler circuits, and then to the positive post on the B battery.

Any signal that energized the tuning coil affected the tube's grid. The tube would then amplify the signal and a portion of the amplified signal would be fed back to the grid via the tickler coil. Thus, a weak signal would be amplified many times over and in addition, station selectivity would be increased.

However, there was a practical limit to feedback. If the limit was exceeded, you would soon know it: The receiver would go into oscillation and howl. Various arrangements were devised to control feedback, not one any better than any other. These controls on a reflex receiver are usually marked regeneration.

To operate a single tube regenerative receiver, or a regenerative receiver that includes any number of **audio** amplifiers, the regeneration control is turned to its minimum position, usually fully counterclockwise. The tuning dial is turned to the station of interest and the regeneration is increased almost to the point of oscillation. This done, the tuning dial is peaked and the filament voltage is reduced. You can now operate at this point, or if you wish, increase regeneration.

The operational point just below regeneration is very interesting. If you tune the station right on the "nose," you can let the set oscillate without interferring with reception. However, at this point, just moving your hand in relation to the receiver may cause it to howl.

You will also find that varying the coupling to the antenna, assuming the set has a means of doing so, will also affect regeneration. Increasing coupling decreases feedback and vice versa.

Regenerative receivers with a stage of RF amplification are operated the same way; however, you have to tune the RF amplifier to the same station for maximum results. In addition to providing gain and increased selectivity, an RF stage protects the neighbors. When a receiver oscillates at radio frequency it broadcasts at that same frequency. In other words it becomes a little transmitter and the shifting of the frequency as you move the dial or the control knobs will produce a similar howl in the receivers of your neighbors if they are tuned to the same station, or a harmonic (an even multiple of your frequency).

Just what enabled Armstrong to devise his superhetrodyne is unknown, but the step from TRF and regenerative receiver to the superhetrodyne was sheer genius. A "superhet" at a minimum consists of a first detector, which is tuned to the incoming signal; a local oscillator which is tuned a specific number of cycles away from the incoming signal. Usually the local oscillator is set to a higher frequency. The incoming signal is "mixed" with the local oscillations to produce a "hetrodyne" or third signal. This third signal is the difference between the first two signals and is called the intermediate frequency or the IF signal. The IF is fed to a second detector which converts the signal to audio, whereupon it may be heard or further amplified.

Hetrodyning or beating the broadcast signal with a local signal results in amplifying the third signal by about a factor of three. In addition, selectivity is increased so that hetrodyning is worth one or two RF stages so far as selectivity is concerned. Since the IF frequency is always the same, it is easy to construct a receiver with any reasonable number of IF amplifiers. Thus, in place of three or four variable capacitors being ganged to tune an equal number of RF stages, the same job can be done with two capactiors that are connected together. One tunes the detector, the second tunes the oscillator.

On a fairly modern receiver there is only one tuning control. An older superhet may have several tuning controls. There may be a tuned RF stage followed by a tuned detector, an independently tuned oscillator and a tuning control for the second detector.

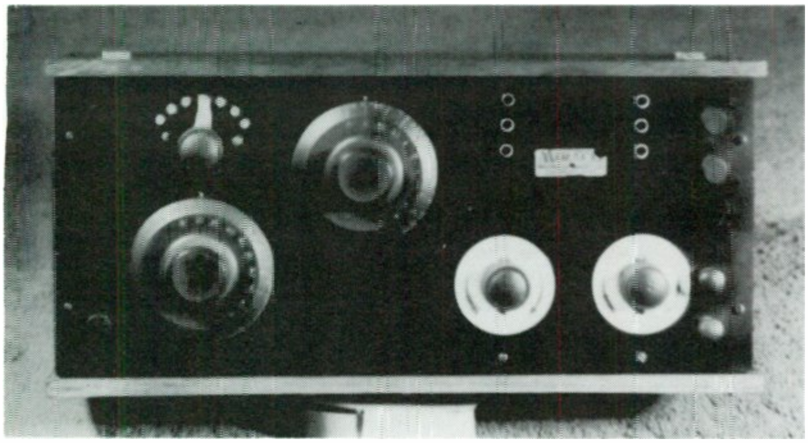
You can recognize an RF tuning control by its action: turning the control merely varies signal strength but to a much greater degree and it may possibly enable you to tune in another station. Varying the oscillator control; however, swings you all over the band, from station to station. The second detector tuning control has little effect on station selectivity and a little more on signal strength.

Work your oscillator and first detector simultaneously to select your stations. Work your remaining controls for maximum volume and interference rejection.

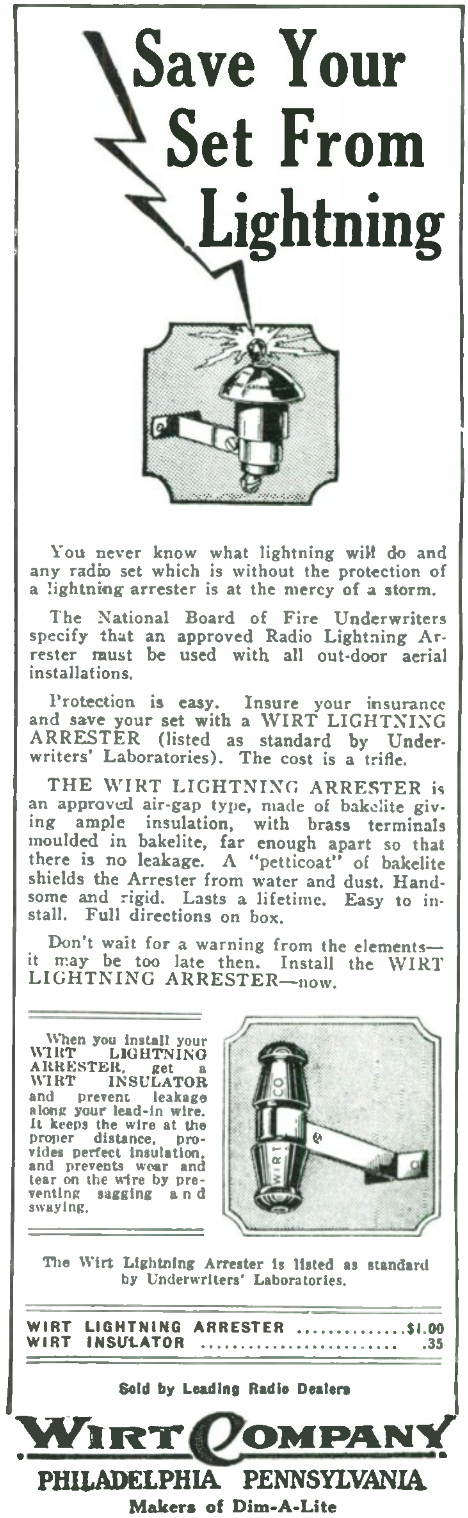
The so-called electrics are much easier to operate, but a few tips to the wise won't be wasted. There are a number of "DC" electrics around. These receivers were designed to be used in lower Manhattan, New York where the old Edison generators purred. These receivers will not work on standard AC current and they will not work on DC either, unless their plug is in the correct way—the polarity must be correct. You can recognize them by the absence of a rectifier tube and the fact that they will hum horribly when plugged into an AC outlet. Do not use a ground on these receivers.

The "midget" AC receivers are simply plugged into an AC or DC line. Some have a built-in loop antenna. These sets will work best when the rear is pointed towards the desired station. Sometimes you can reduce local static by reversing the plug in the receptacle. Do not use a ground on these sets and do not connect the antenna—if there is one—to a radiator or any other ground.

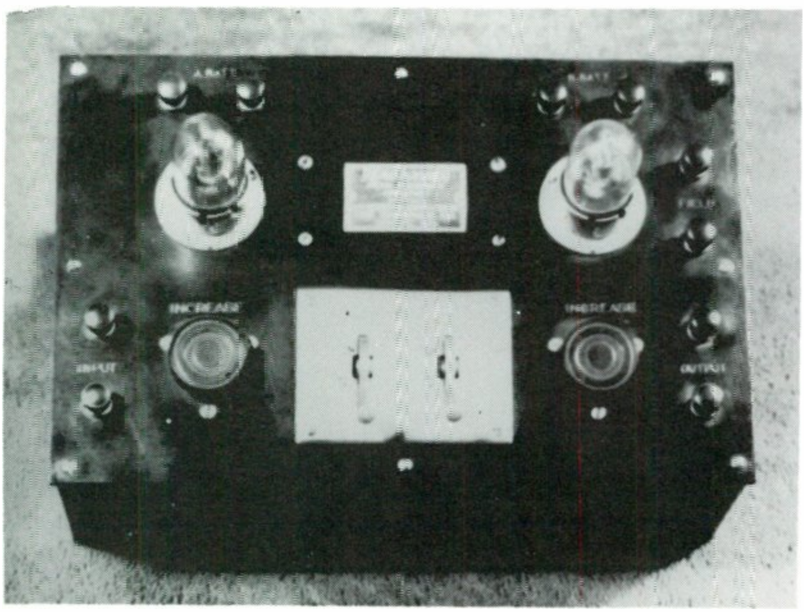
Some of the older midgets have line cords that grow warm during use. These line cords include resistors. The warmth is normal operation.



Miraco, 1923 Midwest receiver. Sold mainly through the mails for $29.50. It had two battery-powered tubes in a modified regenerative circuit. Jacob collection.



Typical lightning arrester of the mid-twenties. The device itself cost only one dollar. An accompanying insulator, only an additional thirty five cents. Author's collection



Magnavox, two-tube, battery-powered audio amplifier, circa 1920 (?). Jacob collection.

chapter six

REPAIRING OLD RADIOS

Repairing radios, old or new, consists mainly of finding the trouble. The effort required for the actual repair is usually negligible. The only sensible way to work with electricity is with a meter that will respond to electricity.

At this writing we have all sorts of advanced and complicated test gear available: scopes, oscillators, tube testers and more. They are very useful if you are in the business. However; for our purpose, a multimeter will do very nicely. Without unduly belaboring the point, get a multimeter or VOM (volt-ohmmeter) with a 4 inch or so scale. There are larger meters, which are convenient but unnecessary, and smaller meters which are much cheaper but difficult to read. Modern meters go to 20,000 and even 50,000 ohms per volt, which simply means the meter is that much more sensitive and can be more accurate when measuring high resistance circuits. However, for our purpose a 1,000 ohm per volt meter is fine. It is far sturdier than the 20,000 or 50,000 ohm job and less likely to be damaged by over-voltage. A suitable multimeter can be had for about $20.00 from any of the mail-order radio houses—addresses are listed in the appendix.

A multimeter will measure voltage, current, and resistance. It will enable you to make a great number of tests. Without a meter you are working blind.

In addition you will need a small soldering iron, rosincore, wire solder, and the usual small tools. The 40 or 50 watt, pencil-type iron selling for around $5.00 will probably be large enough for most of the work you will encounter. Again, you can purchase an iron and a wide range of tools fairly reasonably from one of the mail-order houses.

Now to get on with our work: This book isn't intended to be a primer in electricity or radio theory, and since this book has to cover many different receivers and different receiver problems, our approach will be a little unorthodox, to understate our position. However, if you follow the suggestions carefully you will be able to solve a large number of repair problems. Not all for no one has ever solved every defective radio problem he has encountered. (Not even this writer. There are two that he still remembers: A four tube Philco midget that wouldn't oscillate continuously at the low frequency end of the dial and a Zenith midget, that had a combination first-detector tuning coil and antenna-pickup coil, that wouldn't oscillate at all.)

Bear in mind that your problem is basically one of searching among the satisfactory components and connections until you find the unsatisfactory component or connection. Because of this you must never do two or more things at once, or you will lose track of where you are. And be comforted in your searching that many radio repairmen and TV men also earn their living following the same seek-and-search pattern you will follow.

To simplify my instructions, I have broken the task down into seven groups of problems or seven possible receiver conditions, ignoring combination conditions.

1. No operation
2. Weak operation
3. Noisy operation
4. Lack of clarity (distortion)
5. Lack of sensitivity
6. Lack of selectivity
7. Intermittent operation

Now we will posit various types of receivers in each of the seven possible conditions, and suggest how you may go about finding the cause and or causes and rectify them. To avoid repetition as much as practical, some of the tests early on described will not be described a second time, but merely referred to. So if you skip a few pages and miss a test, just go back until you find it explained.

CRYSTAL SETS

No operation. If the phones are absolutely dead and the only thing you can hear in them is the sound of your pulse, start by eliminating them from the possible causes of malfunction. Test the phones by either using a single dry cell or your meter. To use the dry cell, connect (hold) one metal tip of the phones to the bottom of the cell. Then touch the other tip to the top of cell. Doing this should cause a solid clunk in the phones. If there is no clunk, the phones are open, meaning the wires leading to them, or the coils inside are open.

Assuming there is no sound, set the knob on your multimeter to ohms, range switch to 0 to 5,000 ohms or so. Then place one meter test lead on each metal phone wire tip. The needle should read about 200 ohms if the phones are ok; but since we had no click, the needle will remain above 5,000 (infinity).

Next, you place the test leads on the two metal screws that hold the phone wire to the phone. If you get a reading of about 100 ohms here, you know the phone is probably OK. Check the other phone. If that is also OK, you know the break is in the wires leading to the phones. If one phone is good, the other bad (open-meter reads infinity), disconnect one phone and just use the other. To do so you must "jump" the open phone. Use a small piece of bare wire to connect the two metals screws on the phone.

There is another possibility that we must consider and eliminate. Crystal receivers require high impedance phones to operate. Generally their impedance is on the order of 2,000 ohm or so, which on DC works out to about 200 or so ohm. However, World War II Air Force earphones have a normal internal DC resistance of just a few ohms and modern phones designed for transistor amplifier operation have equally low resistance. These phones will click when driven by a dry cell, but they will be almost silent on a crystal receiver. You can tell you have a low impedance pair of phones by measuring their resistance.

To use these phones on a crystal set or old tube job, you need a small output transformer. Connect the phones to the output (thick wire-low resistance) side of the transformer, and the other side to where the phones normally go.

Having cleared the phones, and finding the crystal set is still as dead as a door nail, take it carefully apart and look for a loose or otherwise open connection. This suggestion is made at this point in the search directions because in this day and age with the air filled with electrical static as well as powerful broadcast stations, it is unlikely that the crystal set will be completely dead no matter how poor the antenna may be.

With all the wires definitely in place and the antenna and ground properly connected, check the crystal to make certain the cat's whisker is actually touching the crystal. If it is, try the point of the wire at a different spot and slowly swing the tuning dial over the band. If there is a second control, which may be a second tuning control or an antenna coupling control, keep trying the second control in different positions as you swing the tuning dial over the band.

If you still cannot get a peep out of the receiver no matter how many places you try the crystal and how you swing the controls, check the antenna and ground connection. Very possibly the antenna wire is broken just outside the window. Or the antenna wire is grounded to a metal screen as it passes out of the building.

Still no sound: Try another crystal. It is very unlikely the crystal is completely "dead," but it does happen. If you wish, take a sharp knife and split the top layer from the in-place crystal to expose a new surface. Then try this surface for a sensitive spot.

Weak operation. Try all the controls to make certain you are tuning the station in properly. Quite possibly you are using the antenna coupling control incorrectly, or you are not using the taps on the tuning control correctly. This will usually be the case when you find that selectivity is very poor: The station comes in over a broad portion of the tuning dial and cannot be peaked. Try different taps on the tuning coil. Try connecting the antenna to a different binding post. Try connecting the phones to a different binding post.

Check your antenna and ground. If you can peak the station, chances are you are using the equipment properly but the antenna is too short for the wavelength, or not parallel to the transmitting antenna, or you are too far from the station, your phones are inefficient or your crystal isn't sensitive. Also, try another spot on the crystal.

And, of course, when you are far away from the station, there is nothing you can do to secure a stronger signal after you have erected the largest practical antenna that can be tuned to that station.

Noisy operation. The first step is to determine the source of the noise: Is it within the receiver or external, meaning electrical static of one kind or another. This is easily done. Try shaking the receiver. Try moving each wire going to the receiver. Open the receiver and try each wire gently. If moving a wire makes your noise, solder the wire in place and you are done with it.

If the noise is external—radio static and the like—there is nothing you can do about it. If you reduce the coupling between your receiver and the antenna you will also reduce the volume of the incoming signal. You might try running antenna in another direction. This can reduce electrical noise, but definitely will not eliminate it.

Lack of clarity. This is never a problem with a crystal set because the receiver never distorts the incoming signal; it can't.

Lack of sensitivity. Your receiver's inability to pick up a comparatively distant station can be due to a poor antenna; wrong length, too low, wrong direction, and a poor ground. It can also be due to local noise, which lowers your ear's sensitivity to sound. It can be due to insufficient coupling between the antenna and the tuning coil; experiment with the connections. And in the case of sets using a slide tuner, lack of sensitivity can be caused by the slide making contact with two or more coil turns. When this occurs you have one or more shorted turns which absorb energy. Broaden the tuning response and also reduce signal strength. The test and correction consists of moving the slide to and fro to make certain it contacts no more than one turn at a time. Should your volume jump upwards as you do so, this is your problem. On some of the homemade slide tuners the design is such that the slide point is too broad and two or more turns are always shorted. In such cases try altering the slide point.

Thinking along the same lines, try temporarily disconnecting whatever binding post jumpers may be present. In some designs the binding posts permit you to add coil turns to the tuner to reacher longer wavelengths. Misplaced jumpers can sometimes short these coils out, again causing loss of signal.

One of the advantages of working with crystal receivers is that nothing you do—short of physical damage—can harm the receiver, so don't worry about experimenting with these sets.

Lack of selectivity. This is normal with crystal receivers. In order to keep costs down, crystal receivers were rarely made with more than one tuned circuit and sometimes a second, partially tuned circuit for the antenna. Only the very early commercial and military crystal receivers had several tuned circuits, and they sacrificed a little signal strength to achieve selectivity.

To increase the selectivity of a crystal receiver place a small (value) fixed capacity in series with the antenna or better still a variable capacitor. The fixed value capacitor should be about .0001 mfd. It is not at all critical.

Intermittent operation. Shake the receiver and then pull on each of its wires and connections until you find the one that is loose. If nothing in the receiver is loose, examine the antenna and ground since loose or poor connections there can cause variations in receptions. Sometimes a poor connection will respond to lightning. Following one flash, reception will improve, only to fall again with the next flash.

CRYSTAL-TUBE RECEIVERS

The following applies to crystal-tube receivers that are tube amplifiers following a crystal detector. As stated previously, all types of crystal-tube circuits were developed and used in the early years. Whatever their value above standard arrangements may have been, the circuits have been forgotten. Your only recourse to repairing or even operating these receivers is to search old literature or secure the assistance of someone well versed in radio theory.

No operation. Carefully check all the connections to make certain they are sound and correct. Use your multimeter to measure filament voltage and plate voltage. Double check filament voltage by darkening the room and looking at the tube; it should glow pale orange. Use your meter to make certain the plate voltage polarity is correct. If you are uncertain as to whether or not the plate polarity is correct—perhaps the markings are blurred—carefully try the polarity in the reverse position.

Assuming that you haven't uncovered the difficulty and that the phones or speaker are "dead," disconnect one plate lead, leaving all the other connections in the "go" or operate position. Replace the plate lead (wire). Doing so should make a loud sound in your speaker or phones. If it does, this indicates that the phones or speaker is operative, that the plate voltage polarity is correct and that the tube—last tube in the series if there is more than one—is at least partially operative.

Now go to the front end of the receiver and remove and replace the antenna connection. Doing so will usually make a noise in the phones (or speaker). If there is a noise, it is indicative that some signal is being transmitted from the front of the receiver to its output (phones). If there is no sound, look for absent or bad connections between the crystal portion and the amplifier portion of the receiver.

Next, remove your phones and disconnect the batteries. Find, if possible, the points where you can connect your phones to the output of the crystal set portion of the unit. Some sets have jack connections at this point. In others there are visible binding posts. If neither condition exists, touch one end of your phone wire tips to the base of the crystal, and the other to the ground connection. Use alligator clip jumpers or bare wire for the purpose. Now operate the crystal set. If it is working at all, you should hear something. If it is completely silent, refer to the suggestions for treating "dead" crystal sets. If there is some sound—any sound, even noise and static—this sound should be coming out of your amplifier. Thus, by this test you have divided your troubles in half. Either the fault lies with the front end or the rear end.

This strategy is, of course, the basic approach to all radio repairing (trouble shooting). You keep making tests, exonerating one component after another, until none but the guilty remain.

Assuming your trouble lies in the amplifier; check the tubes to see if they are all lit. One defective tube can completely stop all sound from passing through. A lit battery tube will almost always work to some degree (which is not true of most other tubes); so if the tubes are lit, they would pass something and you would hear it.

Next, disconnect the batteries and remove the cover or covers and look for loose or disconnected wires. Pull gently on each to make certain it is connected. In the period we are considering, most connections were made with "Bus Bar" which is a thick, square shaped wire, generally left bare. Insulation was unnecessary because the wires are far and few between with lots of space around them.

The next step is to test individual components. Resistors and coils always pass some current so they always show a resistance when measured with the ohmmeter portion of the multimeter. Capacitors, by contrast, always show infinite resistance when tested the same way when they are **good**. If a capacitor of this period shows any less than several megohms—which may be your fingers across the test prods—it is defective. However, a good capacitor will always show a momentary resistance, which is produced by the flow of current into it. This is normal. A second test will not show this flow of current because the capacitor is already filled. To secure this, you must first discharge the capacitor by placing a wire or screw driver across its terminals.

Capacitance is indicated in Farads, but since that is a gigantic unit, the capacitors we meet are rated in mfd's—microfards—and even less. Thus a capacitor in a tuned circuit may read .0005. This size capacitor will show no current flow and since it is made of alternate sheets of mica and tin foil, it is just about indestructable. Larger capacitors may be capacitances rated .05 or .1 mfd. These will show surge current on the first test and since they are made of paper in place of mica, do occasionally give way.

Resistors are of two types: carbon and wire. The carbon types are little rods about the thickness of a pencil. Their value in ohms is indicated by their color markings. (A table in the appendix will give you these figures.) Any resistor within 20 per cent of its rating is satisfactory.

Wire wounds are larger. Sometimes you can see the wire, sometimes not; but they are usually ½ inch in diameter and often covered with vitrified glass. Rheostats are variable wire-wound resistors. The sliding arm makes contact with the wire. Moving the arm varies the amount of wire in the circuit and thus its resistance. Look for broken wire, poor contact between the wire and the end bolts or rivets, poor contact between the arm and the wire.

Grid leaks are resistors with values up in the millions—megohms. They look like short pencils pointed at both ends and are often held in place by brass clips fastened to the ends of a mica capacitor.

Audio transformers consists of two (or more) coils of fine wire wound on an iron core. Normally, the individual coils have no electrical contact with each other or the iron core. On battery sets each coil will have a DC resistance of 300 to 1,000 ohms. The value is a matter of design and is no reflection of its condition. With the exception of intermittent coils, they are either go or no go. If the ohmmeter indicates a very high resistance; it is no go. The unit is defective; the coil is "open." If you have no replacement transformer look for a poor connection between the coil wire and the binding or soldering post. Try disconnecting that coil completely and giving it a "shot" of high voltage—say 45 volts from your plate battery. Make the contact as short as possible, the theory here being that the high voltage will "weld" the broken wire ends, and sometimes it does.

It is often difficult to differentiate between a capacitor and a transformer, especially on the early "electric" sets, since both components were often placed in almost identical metal-boxes. The best way to differentiate is to check with the circuit. Otherwise, look for the metal core of the transformer and bear in mind that a transformer has to have at least four connections, a capacitor can have as few as two. Transformers usually have a rectangular outline; paper capacitors are also rectangular, but electrolytic capacitors are usually tubular.

Electrically, paper capacitors always show a complete open circuit, when good, and they are almost always good. Therefore, if you see four connections and none show a resistance of under one hundred thousand, you have a capacitor. Also, you will get that momentary surge of current which is visible on the ohmmeter as a low resistance that changed to high; which you won't on a coil.

Incidentally, when first connecting an old receiver start with a very low plate voltage to avoid "shorting" the capacitor and do not connect and disconnect the plate batteries with the set filaments on. This may set up a "reactance" voltage that can short the old, paper capacitors. Connect the battery then turn the filaments on.

Making electrical tests. When measuring voltage, make two checks. With no load—the batteries disconnected and with the batteries connected and the set in operation, whether it can operate or not. Very often a battery will have enough power to make the voltmeter read satisfactorily but will drop below normal operating voltage when it is called upon to actually supply a current.

When measuring resistance, make certain your batteries are disconnected. To be doubly sure do not depend on the receiver switch, but actually disconnect one wire from each battery. Should you accidentally place your test leads across a voltage with the unit in ohm-reading mode, you may damage the meter beyond recognition.

When attempting to measure high resistance, anything over 10,000 ohm, be certain you do not hold your fingers across the test lead tips; if you do, your meter will give you a false reading. When testing for low resistance, always turn the control switch to low, otherwise you get an inaccurate reading.

And, when making any component test, be certain to disconnect all but one (one does no harm) wire. Otherwise you will be taking a false reading. For example, capacitors are often connected across coils. Thus, if you measure the capacitor in place, it will appear to be shorted and defective. And, although it would appear as though you could check the coil—since the open capacitor would only have a momentary affect on the reading—without disconnecting one lead, there is a chance there is a resistor across the coil somewhere or even another coil. So unless you can read schematics and have or know the circuit on hand, disconnect the leads to the component in question if you want to be certain you are securing a correct reading.

Testing tubes. The best way to test a tube is by replacement with a known-to-be-good tube. However, if you do not have a replacement or understandably do not wish to risk a replacement, you can make crude but useful tests on the old battery tubes with your ohmmeter. Turn the tube bottom side up. The two "fat" prongs are always the filament connections. The resistance between these two should be on the order of 20 ohms. Lower means nothing, but an open (very high) indicates an open filament. To be certain, try another pair of prongs, possibly that tube is different. Having found the filament open, which makes the tube worthless, or having found the filament satisfactory, check for resistance between the filament and the two remaining pins. There should be a complete open circuit here (infinite resistance). If there is any resistance, there is unwanted contact between grid, plate, and the filaments; the tube is defective. Do not use.

Returning to our original theme and repeating the suggestions for finding cause of said same; non-operation can be due to the crystal end of the receiver, defective tubes, lack of proper voltage, incorrectly applied voltage and defective parts, including the phones or speaker.

Weak operation. Start your search for the cause by testing the crystal portion of the receiver to make certain that is passing a reasonably strong signal. You can do this easily if you have a plug-in connection to the crystal's output. If you don't disconnect all of the batteries. Connect one tip of your earphones to one A battery lead, remove the first tube following the crystal portion of the receiver, and then connect the second tip of the phones to the grid connection on the tube socket. Just try each in turn until you hear a sound. With the batteries completely disconnected you can do no harm unless you break something. If you cannot get decent crystal set volume at this point, something may be wrong with the crystal portion of the receiver. (See suggestions for repairing crystal receivers.)

Assuming you have fair to loud earphone volume at the grid of the first audio tube (that is what it is called), but little or low volume from the output of the audio amplifier portion of the receiver, check battery voltages, lower the C voltage—if there is a C battery—check your tubes. One may be dead. If not, check the tubes by replacement. Still no results; disconnect the batteries and check for open audio transformers and defective parts. Without a knowledge of amplifier operation, its the long route—part by part—but the only route.

Noisy operation. Listen and try to determine whether the noise is static or local electrical interference. If it is either or both, there is nothing to be done except reduce the antenna to reduce static, or move the antenna to reduce electrical interference. (There are ways of surmounting electrical interference, but there isn't room in this book to discuss them.)

If the noise is in the receiver, you can double check by disconnecting the antenna and ground, check to see whether the noise is responsive to mechanical vibrations. Tap the receiver a few times. If you get a howl, you have a microphonic tube. Tap each lightly until you find it. Then either replace it or try wrapping some lead wire around it to reduce its response. If the noise is due to a tube, keep tapping until you find the cause. Very likely it is a loose connection.

If the noise does not respond to mechanical vibration, the source is electrical. It can still be a tube, but most likely it is caused by a crumbling resistor, which may be visible, or a defective audio transformer. In the latter case, try to pinpoint the transformer by pulling tubes out (assuming there are more than one), one at a time, the tube nearest the crystal first. Obviously, if you pull out all the tubes but the last, the trouble lies in a transformer (or other parts) connected with the last tube, assuming the noise remains.

Lack of clarity. When the sound emitted by the phones or speaker is clear, all receiver components are in "go" condition as astronauts are wont to say. When the sound is unclear, something is wrong. That "something," i.e., the cause of the trouble can often be identified by the nature of the undesirable sound coming out of the phones or speaker.

Distorted sound, meaning a signal that is steady, unaccompanied by extraneous or unwanted sounds, but which is considerably unlike the original, is always caused by the tube portion of the crystal-tube receiver. Crystals are always true blue; they never distort a signal.

Distortion may be caused by a weak C battery, a reversed-connected C battery, an overly-high B battery (90 volts in place of 45 volts) a defective tube, and over-driving.

Over-driving means that you are attempting to get greater volume out of the amplifier than it was designed for. You can recognize this condition by turning the volume control or filament rheostat down and reducing the level of the sound. If the sound clears up and distortion disappears, you are over-driving. Sometimes you can increase the level of satisfactory sound by upping the C voltage a bit and by replacing a weak B battery. To test a tube for distortion, you must replace it with a good one. (Gassy triodes can cause distortion.)

Other and possibly additional causes of distortion are open audio transformer grid windings, poor connections in the grid circuit, open or greatly changed-in-value resistors, use of the wrong tube(s), defective capacitors.

Clarity may be lost by rapid, intermittent operation which "chops-up" the signal. This may be caused by the crystal portion of the receiver and to determine same, follow the suggestions given for noisy and intermittent crystal receiver operation. When the signal is being chopped up in the amplifier portion, look for defective tubes (tap them lightly), poor connections, and loose controls.

When signal clarity is ruined by unwanted sounds, remove the antenna and ground to determine if the sounds are coming in that way. If not, listen to the sounds. If there is a sort of burning, rushing noise, it can be due to a defective transformer, defective resistor, defective tube. If the sound is much like cats in the night, try tapping each tube: they may be microphonic. Then try connecting a 1.0 mfd., 200 volt, paper capacitor across the B battery, and a similar or smaller capacity capacitor across the C battery.

Howling is caused by loose tube elements, audio feedback. Rushing sounds are usually caused by defective connections, which may be inside a transformer or a resistor.

Lack of sensitivity. Assuming that some stations come in with sufficient strength, lack of sensitivity to other stations must be due to the detector portion of this type of receiver. (See Crystal Sets, lack of sensitivity.)

Lack of selectivity. Since we are dependent on the crystal end of the receiver for selectivity, see Crystal Sets, lack of sensitivity.

Intermittent operation. Regular, periodic intermittency is always caused by a defective tube; regularity is always a sign of thermal activity. Irregular intermittency can be caused by anything. If the change in sound is great and very sharp, the trouble is up at the front end. If the change in sound is not as great and the "edges" of the sounds are not as sharp the trouble is most likely near the "end" of the receiver. If there is a solid thump accompanying the change, it is most likely due to something in the speaker circuit.

First, clear the front end of the receiver by following the suggestions given for weak operation. If the problem is in the crystal receiver portion, follow suggestions given in Crystal Sets, intermittent operation.

Should you be able to receive a good, continuous signal from the crystal portion of the receiver, your trouble lies in the amplifier portion of the receiver. Look for loose wires and bad connections. Try replacing the tubes even if they do not respond to tapping.

If the period between on and off, or low and high volume reception is more than a couple of minutes and you have replaced **all** the tubes, you are going to have to replace each part of the receiver, component by component, until you find the trouble. Under such conditions, nothing responding to touch or vibration, but continuous on-off operation, I would guess an audio transformer was at fault. (In a more modern receiver, with the stages resistance coupled, and a little distortion accompanying the changes, I would vote for the coupling capacitors.)

TRF RECEIVERS [BATTERY OPERATED]

No operation. Start by measuring filament and plate voltages with the receiver in the on position. Check each tube by looking for a lighted filament. If the tube does not light, shut the receiver off, remove the tube and check its filament with your meter. Replace if necessary.

Tubes and battery voltages satisfactory, check B battery polarity. Check speaker by disconnecting and connecting one B battery wire with the receiver in the on position. If speaker "thumps" it is working. If it makes no sound, check speaker itself. Use a single dry cell across speaker leads; speaker must make a sound when so tested.

If speaker checks OK, re-connect. Turn set on. Remove last tube (tube feeding speakers nearest it). If there is no thump in speaker (or phones), tube is defective, though lit; output circuit is open. Turn off set, disconnect all batteries, and test all components associated with last stage as previously discussed after trying good tube in socket.

If last tube's removal and/or replacement makes a sound, work your way up to the front end (antenna end) tube by tube. Try known-to-be-good tubes in all stages wherein removal of tube doesn't make a sound in speaker. Should you find a silent stage, test all its components.

Weak operation. Since the simplest TRF receiver consists of at least a tuned radio frequency amplification stage followed by a detector stage, our first problem at the very least is finding which of the two stages is at fault. More complicated TRF receivers may have three RF stages, followed by a detector and one or more audio amplification stages. The initial problem; however, remains the same: Find the stages or stages that are not operating properly.

Eliminate problems common to all stages first: Check the battery voltages with the set turned on. Eliminate the easy-to-find problems next: Check antenna and ground. Check all external connections: Speaker connected to correct terminals?, etc. Make certain you have the correct (electrically) speaker. You may have a dynamic speaker with an impedance of 8 ohms connected to a circuit designed for 2,000 ohms or vice versa, in which case there will be a great loss of volume and possibly some distortion. Check the tubes next. Are they all lit? If so, check them further by replacing each of them.

If you still haven't found the trouble, try to determine which stage is at fault. Start with the output tube—tube nearest speaker—and pull each one out and replace it in turn, working towards the front of the receiver, with the receiver turned on. Normally, the sound in the speaker will grow louder and sharper as you work your way towards the front end. If one tube makes little noise, that stage is suspect—though not necessarily defective. Remove or disconnect all the batteries and test each component in that stage.

Lack of sensitivity. The differentiation between lack of sensitivity and weak operation is that an insensitive receiver will receive strong signals with normal volume, but will fail to receive weak signals or receive them poorly. A receiver that operates weakly does not produce sufficient volume tuned to any station.

Lack of sensitivity in a TRF may be due to poor tuning. Possibly you are turning all the dials to the same number, but failing to "peak" each tuning control to that station. It may also be due to an open capacitor in the antenna circuit, a poor antenna and or ground, and possibly an overly-high-value grid leak. This is the little removable resistor connected in the detector grid circuit. Replace, if necessary, with a 1 megohm resistor.

Lack of sensitivity may also be due to one or more weak tubes, low plate voltage or low filament voltage.

Lack of sensitivity may also be due to a defective RF stage. You can sometimes spot this stage by the broad response of its tuning dial—assuming that it is individually tuned—by the small sound its tube makes when pulled from the circuit, and by touching the tuning capacitor plate with your finger.

Again, we are making an assumption. In this case, that the tuning capacitor is open to your touch. If it is, touch it. If there is a noticable increase in signal, chances are that the state or the preceding stage or the antenna and its circuit are defective.

When you have a multistage TRF that has ganged capacitors, lack of sensitivity is often due to individual RF stage drift. Each capacitor and associate coils have gone its own way. Since de-tuned RF stages are much more common than component breakdown in old receivers, it is wise to try the following before you start unsoldering parts and testing.

Tune your receiver to a weak station in the high frequency end of the broadcast band. Disconnect the antenna. If the signal disappears, replace the old antenna with a short piece of wire. Turn the volume control all the way up. Do not, however, in the case of filament controls, exceed normal filament voltage. Vary your temporary antenna until you have a length that enables you to barely hear the station. Now, using a plastic screw driver or a plastic hex wrench (sold by radio supply houses) adjust the small adjustable capacitors to be found on the side of most variable capacitors. When you have peaked one, turn the gang control until you find the new peak position, which may be the same as the old one. Now go to the second little capacitor. Do the same and continue until you have done this with all—always peaking the gang each time you make an adjustment.

When and where each capacitor does not have an accompanying capacitor, but does have slotted plates, you have to bend each plate a little.

Lack of selectivity. Try everything just suggested for lack of sensitivity. If the results are still unsatisfactory, try inserting a variable capacitor in the antenna line. Then vary this capacitor to vary the antenna's response frequency. Some of the old sets sacrificed selectivity for gain. There weren't so many stations, nor such powerful stations in the old days and customers valued receivers more for their loudness than their selectivity.

Noisy operation. As discussed previously, our first step is to convict or exonerate the antenna and ground, and we do that by disconnecting both of them. Following, we search for tubes that respond to tapping and vibration, loose connections and the like. If these efforts do not turn up the cause or causes, try to pinpoint the stage by pulling out and replacing the tubes one by one. The trouble may be a defective audio transformer as discussed previously.

Multi-stage TRF receivers are also subject to the howls. The receiver goes into oscillation because some of the RF energy from the detector is being fed back to the RF amplifier. This is the kind of problem that cannot be overlooked, the speaker will literally howl and respond to your very presence; move your hand to or from the receiver and the sound will vary.

Howling may be caused by loose tube shields, which are metal covers placed over the tubes or loose stage shields, which are metal boxes placed over the parts associated with an RF or detector stage. It can also be caused by too high plate and or filament voltage or the use of the wrong tube or tubes. (The tube's gain is higher than that for which the receiver was designed.) The antenna and or ground lead may be too close to the receiver—running across it.

If nothing else helps, try placing a 1 mfd. or higher value, 200 volt paper capacitor across the B battery. Try it across the A battery. Try it from the A battery lead to one of the B battery leads. Try a longer, better antenna; try de-tuning the first RF stage.

Intermittent operation. Follow the suggestions given previously for intermittent operation, Crystal-Tube Receivers.

TRF RECEIVERS [POWER PACK OPERATION]

All that was suggested for TRF receivers, battery operation contained here with the addition of the following.

No operation. This may be caused by failure of the A portion of the power pack and or the failure of the B portion. Use your voltmeter to check for the presence of voltage. Shut off the power, pull out the plug and look for broken wires, shorted wires (the old cables used rubber covered wires which crack very badly with time) and defective components. When there is a rectifier tube, check the capacitors for shorts **before** you try a new tube. If there is a metal oxide rectifier—plates of metal stacked one next to the other—disconnect and check its resistance. Each section should have a low resistance with the ohmmeter leads across the section one way, and a high resistance when the test leads are reversed and connected the other way. The difference should be on the ratio of at least 20 to 1. To check out the set itself, disconnect the battery pack and use batteries.

Testing electrolytic capacitors. A paper or mica capacitor consists of two sheets of metal separated by paper or mica insulation. Mica capacitors are small because you can't bend mica much. Paper capacitors can be any size up to as big as a house because you can roll paper and foil up. Glass capacitors use glass as insulation. Air capacitors, which are usually adjustable (variable) use air as an insulation. Electrolytic capacitors use aluminum oxide as an insulator.

To make an electrolytic capacitor, a sheet of pure aluminum is emersed in a special, alkaline solution. The aluminum forms one plate of the capacitor; the solution, which is conductive, forms the other plate. The insulation separating the two plates consists of a layer of aluminum oxide that forms immediately after the aluminum is immersed. This layer is only a few atoms thick; therefore, the separation between the electrolytic capacitor's plates is very small, and since the closer the plates are to one another, the greater the unit's storage capacity. Electrolytics hold a big electrical charge in very little space.

Electrolytics differ from paper and mica capacitors in a number of very important ways, which you must know and understand in order to service line-powered receivers.

Electrolytics are polarized. The lead or wire marked + must always be connected to the positive voltage. If the leads are reversed, the electrolytic film breaks down and the capacitor shorts out. In other words, an electrolytic will not work with its leads reversed. An electrolytic, however, is self healing. Whereas a paper capacitor that shorts out remains shorted and must be discarded, an electrolytic can withstand temporary overloads. On the other hand, whereas a paper capacitor can be used at any voltage below its rating down to zero, an electrolytic cannot. For example, should you connect an electrolytic rated at 450 working volts across a 150 volt circuit, the capacitor, in a matter of months, will break down. The oxide film will disintegrate and the capacitor will either lose its capacitance or short out.

To test an electrolytic use your meter after you have disconnected the capacitor and "shorted out" its terminals to make certain no charge remains. Then expect the capacitor to show about 10,000 ohms per volt of rating, with the test leads in one position. This works out to 0.1 milliampere per applied volt. Therefore a 150 volt electrolytic will show about 150,000 ohms resistance in one direction. Reversing the test leads will probably reduce the resistance reading to 1,500 ohms or so.

And, whereas a paper, glass, air, or mica capacitor lasts almost forever, electrolytics have a limited life span, ten or 20 years at the most. The passage of current, small though it might be at the onset, increases with time. And as the current flows through the electrolyte it produces gas, which escapes through a provided little hole or a porus container. In time, the electrotype dries up and the capacitance—the ability to hold a charge of electricity—drops off to zero.

Should the oxide film break down from over-voltage, the quantity of current flowing through the capacitor increases, which increases the rate of gas production and shortens the remaining life of the capacitor. Should the vent be sealed, or should the current increase greatly, pressure builds up in the electrolytic capacitor and it will explode. Therefore, do not leave leaky (low resistance both ways) capacitors in the circuit. Replace without bothering to test if the can feels warm.

Weak operation. Again, everything suggested previously relates with the power pack TRF as well as the battery set. The difference is that instead of measuring battery voltages, you measure power pack output voltages. When the voltages are low, make the tests suggested for No operation, bearing in mind that a leaky electrolytic capacitor will hold voltages down.

Lack of clarity. In addition to all the other possible causes of malfunction mentioned previously, battery-pack-powered TRF sets can suffer from internal oscillation, hum, and distortion caused by the pack. Hum is most often due to defective capacitors. Test by placing a high capacitance, new capacitor across the old. No need to disconnect the old for the test. On rare occasions it can be caused by a dry disc rectifier. Internal oscillation, at either radio frequency or audio frequency, can be caused by too high plate voltage or defective capacitors. Check the plate voltage with your meter. Then examine the large—sometimes 6 inches long—wire-wound resistor. This is used as a voltage divider and when it is open, the voltages supplied to the receiver go up.

Should all the supplied voltages be within requirements, try a 3 to 5 mfd. paper capacitor across the plate voltage leads. Be certain its rating is sufficiently high. Very often feedback through the plate voltage leads can be stopped this way. Feedback is what produces oscillation.

Distortion can be caused by too high plate voltage. Follow the suggestions given previously for too high voltage. Distortion can also be caused by feedback that doesn't cause oscillation; so try the capacitor trick.

TRF [LINE POWERED]

All that was previously suggested for finding and curing troubles in TRFs that are battery powered and pack-powered prevail for TRFs that are on the same chassis with their power supplies which are plugged into a wall outlet, with one additional problem. The problem is tunable hum. The receiver picks up a hum at a number of places on the dial. These work out to be even multiples of the line frequency (60 Hz), as for example at 1200 Kc, 900 Kc, and so on. Usually tunable hum is most noticeable close to a broadcasting station frequency.

What is happening, of course, is that the receiver is picking up a harmonic of the line frequency. You can't get rid of the line frequency because that is what is powering the receiver, but you can reduce its entrance into the receiver by inserting a RF choke in the plate voltage supply line and by connecting a high voltage, paper capacitor across the high voltage side of the power transformer. Newer receivers do not have this problem as the power transformers have Faraday shields.

DC TRFS

A number of TRFs were constructed for operation on direct current power lines. As the line voltage is polarized, the receiver's plug must be properly connected for the receiver to work. If all appears well, but there is absolutely no sound, try reversing the plug in the wall. If you do not have DC current coming out of your wall, you will have to purchase a 110 to 110 volt invertor to convert your AC to DC. Do not plug a DC receiver directly into an AC line since you will damage it. (AC-DC receivers are different.)

SINGLE-TUBE REGENERATIVE RECEIVERS

A regenerative receiver has at least two controls, one for tuning and one for varying the feedback. In normal operation the receiver is operated at slightly below the oscillation point. However, a properly operating receiver always has sufficient feedback in reserve so that it can be made to oscillate.

Ordinary problems. All the undesirable conditions discussed previously for crystal receivers and TRFs can appear in a regenerative or reflex receiver and the suggestions for curing these troubles remain the same. Regenerative receivers; however, have a few problems entirely their own. Here are some of them along with suggested cures.

Receiver won't oscillate. When the regenerative control is fully advanced and the receiver will not oscillate, you cannot know whether or not you are close to the optimum point of regeneration. In other words, if you cannot see the edge you do not know whether or not you are close to it.

Failure to oscillate can be caused by an overly large or long antenna; try disconnecting the antenna. If that does it, insert a small .00002 mfd capacitor in series with the antenna. Low plate and filament voltages. Weak or wrong tube. Too low value grid leak. Remove and try. Magled coils. Shorted turn on the coil. In the case of a homemade receiver, tuning and tickler coil may be too well shielded. Wrong earphones; their internal resistance is too high, lowering plate voltage on tube. Bad connection in tuning circuit; even an open connection. Open capacitor. Some circuits have a small capacitor across the phones to make it easier for RF current to circulate.

Oscillates all the time. Grid leak open or missing. Voltages too high. Wrong tube. Insufficient antenna, insufficient coupling to antenna. Mangled coils. Wires in receiver have been moved causing increased internal feedback. If regeneration control is a variable resistor (volume control), its value may have decreased so far it no longer functions properly. Also, try a 1 or 2 mfd. high-voltage, paper capacitor across plate supply near the receiver. Try same or a second, similar capacitor between filament leads and plate lead. Do the same for slow oscillation: "motor-boating."

Drifts in and out of oscillation. You may be trying to work too close to the point of oscillation and minor changes, even body position, can cause the set to oscillate or not oscillate.

Or you are troubled with intermittancy, in which case, follow suggestions given previously for intermittent operation of TRFs and Crystal Receivers.

REGENERATIVE RECEIVERS [MULTI-TUBE]

Again, a multitube receiver will be prey to all the faults and problems found in previously discussed receivers with a few additional problems.

Will not oscillate. Follow all the suggestions given for nonoscillating single tube receivers. In addition, if you are not successful, try changing the RF tubes as well as the detector.

Oscillates all the time. Try everything suggested previously. In addition, make certain the shields on the RF stages are tight and making good electrical connections. Also try moving the speaker horn, if there is one, away from the receiver and try moving the antenna and ground leads so that they run directly away from the receiver.

SUPERHETRODYNE RECEIVERS

The first thing you have to do when you are faced by a recalcitrant superhet is obey this injunction: Keep your hands off the screws. Do not attempt to tune any of the IF transformers or adjust any of the trimmers on the oscillator or the tuning capacitors.

Again, all the suggestions given previously for TRF receivers and crystal sets may be followed with superhets. Problems peculiar to superhets are listed following.

Uneven reception. Receiver is much more sensitive at one end of the band than the other; may not receive at all over one end of the band.

Lack of equal sensitivity over the entire band may be due to faulty alignment. Lack of reception over a portion of the band may be due to an oscillator that quits over a portion of the band or faulty alignment.

Check all voltages. Then replace each tube in the RF section starting with the first detector, which may be a combination detector-oscillator.

Check alignment by noting position of station reception on dial. If station is received close to its assigned dial position (frequency marking on dial), chances are the alignment is not too far off. If the alignment is way off, which is almost always caused by someone tampering with the alignment screws, have a radio serviceman with an oscillator (signal generator) receiver for you. Or, give it a try yourself; you can't do it anymore harm.

Turn the receiver on. Give it some time to warm up. Turn the set to a weak signal somewhere near the high frequency end of the band. Remove or shorten the antenna so that you can barely hear the signal with the volume control full up. If the set has a built-in antenna turn the set to reduce pickup to a minimum.

Find the oscillator trimmer. Inspect the tuning capacitors. The capacitor that is physically smaller than the rest is the oscillator capacitor. If both or all the variable capacitors are identical in size, place your finger on the stator of each in turn. The capacitor that causes the station to disappear and other stations to come in is the oscillator capacitor. Locate the trimmer (small, semi-variable) capacitor at its side. Vary the trimmer slowly in a direction that will reduce the strength of the signal. Now turn the tuning control to increase the strength of the signal. If turning the control acts to bring the station in at its assigned frequency on the dial, you are doing fine. If you have to turn the dial farther off frequency, turn the trimmer in the other direction.

To explain: Assume you are tuning to a station that is broadcasting at 1200 KHz, but your dial is set to 1,000 KHz. Adjust the trimmer until you can receive the station with the dial at 1200 or very close to it. (If necessary, increase the volume.)

Some of the receivers will have a second oscillator trimmer in series with the oscillator tuning capacitor.

This is a very thick, semi-variable mica and metal capacitor, generally not integral with the variable capacitor. If there is a serious adjustment, turn the dial to the low frequency end of the dial. Pick up a weak station of known frequency and adjust the series capacitor until you can get that station on or near the correct marking on the dial. Then return to the high frequency end of the deal and repeat the adjustment on the small trimmer.

Now, with the volume all the way up and the set tuned to a very weak station, so weak you can hear the background noise, adjust the IF transformers. Generally, they are inside tall, square cans with a pair of holes (sometimes more) in their tops, through which you can see screw heads. Usually, but not always, these screws are turned to increase the volume of sound. As you do this, always adjust the receivers position or reduce its antenna so that the station remains weak. If you don't and are working on a 1935 or later superhet, the built-in automatic volume control will hold the sound output level and you will not notice any change as you adjust the IFs.

All IF (intermediate frequency) circuits are not the same. Most transformers are adjusted for maximum. Some, however, are too sharp and have to be adjusted to flatten their response; in other words, each side of the transformer is slightly detuned in a different direction (one higher, one lower). If very sharp IFs are peaked, they tend to clip the sound and you will be able to hear this on music.

And some interference traps look like IF transformers, but are not peaked for maximum signal. Instead they are peaked for a specific minimum signal. Without a circuit diagram there is no certain way of identifying such traps. If memory serves me correctly they are most often to be found in the old Philcos. In any event, they weren't used very often and you can do no permanent harm by adjusting them improperly.

In some instances you will find the receiver howls as you peak one or more of the IF stages. You can leave that stage slightly detuned. You can follow the suggestions given for howling receivers a while back, or you can have the set aligned against a service oscillator. Some sets will oscillate when improperly aligned. Many will oscillate correctly aligned and must be de-tuned a bit. Most often a set that howls when its IFs are correctly aligned has capacitor trouble. One of the bypasses (capacitors) are open; the filter capacitors have lost their capacity.

Sometimes you will encounter a superhet that will not pull in any stations anywhere near correctly on its dial, and attempting to adjust the oscillator doesn't help much. Such sets have badly mistuned IF amplifiers. You can experiment with IF adjustments, taking care not to turn the screws so much they will no longer hold a setting. Eventually, you may adjust the IF to nearly the correct frequency. Or, you can have a radio serviceman do it right off the bat with a calibrated signal generator—presuming you or he knows the correct IF frequency.

Shifting stations. This trait is limited to superhets, but fortunately doesn't occur very often. You are turned to a station at the high frequency end of the band. Suddenly, the station is switched off and you are tuned to a nearby station. This is caused by a change in oscillator frequency. The first suspect is the tube. The second is a loose connection. Thirdly, look for heat causing the components to change. Sometimes operating the receiver in a cooler or better ventilated spot in the room cures it.

AC/DC RECEIVERS

AC/DC receivers date from the early 1930's or so. They differ from other receivers designed to be operated from a wall outlet in that they will work on both AC and DC current at 110—115 volts. And, they hve no power transformer. Instead all the filaments are in series and are heated by being connected directly to the power line or in series with a line resistor. The absence of the power transformer greatly reduced the size, weight and cost of these sets. At one time, Emerson produced one that retailed for about $7.50. Most of their models sold for about $10. They were about 12 inches long, 5 inches high and 4 inches deep. Some of the cabinets in which they were enclosed were of wood—these cost a little more. Other cabinets were of cardboard covered with some sort of glazed paper embossed in leather or similar grain.

The early models had attached, external antennas which you rolled up on a bobbin when you wanted to carry the set about: It weighed less than 4 pounds.

Almost all were superhets, with a single tube acting as first detector and an oscillator and a second tube acting as IF amplifier. A third tube acted as a second detector and first audio and a single, audio amplifier stage feeding a 4 inch dynamic speaker. The fifth and last tube was the rectifier, which remained in the circuit whether AC or DC was applied to its plate. At first the speakers had field coils which doubled as a choke in the power supply filter circuit. Later PM speakers were used and the choke coil was replaced by a resistor. Loss of ripple-smoothing power was offset by use of higher capacitance but still small size, electrolytic capacitors.

The circuit described was more or less that used by all the AC/DC midgets of that period and following; there may even be a few sets like them still being manufactured. They did not have the tonal quality of the large TRFs of the period, but they cost ten dollars, whereas the consoles might cost over one hundred dollars. And, they did have far more sensitivity and selectivity. As a result, they dealt the "big" sets and the men who earned their living servicing and selling them a blow that was painful up until the advent of television.

No operation. The first and major cause of a dead "midget" is one or more of its tubes. If one tube filament is open, no tube lights. When replacing tubes make certain you have the correct one. Not only are their filament pins different, but differently numbered tubes, designed for the same function, have different filament voltages and current ratings. Thus, while all the other tubes light, one may be under powered and fail to do its thing. Or conversely, it may burn out.

Weak operation. Check the tubes by replacement. Subjected to overloaded filaments their life is short; and since they have cathodes, they can and do lose most of their emitting power without having an open filament.

Check the filter capacitors. When they lose capacitance, or they leak, plate voltage falls off rapidly.

Check the filter resistor. This is the one that has been "heat treated" by constant overload. A replacement resistor is usually about 200 ohms, 2 watt rating.

Noise. These receivers are very sensitive to all kinds of electrical noises. In addition, the tube types used are often themselves the cause of noise. Always suspect the detector-amplifier tube. Try a replacement there first.

EARPHONES

Earphones are generally go-no-go devices. They either work or they don't. When they don't, the trouble is very often in the phone cord because it is made of tinsel wire and easily damaged. Use your meter to check the wire. If the wire is "open," you will have to find a replacement. I have never been able to repair it, nor have ever heard of how to repair it.

If one of the phones tests open with the ohmmeter, open it up—the cap unscrews—and look for a broken lead. If you can't see it, try unwinding one of the coils and testing to see if you found an end. If you cannot find an end, either short that phone out and just use the other, or remove all the wire from the bobbins and rewind with the finest wire you can get. This will make it a low-impedance phone and you can use it by connecting it to the voice coil side of an output transformer and using the other side in place of the phones. Not too efficient, but it works.

HORN SPEAKERS

Horn speakers are merely oversized earphones mounted behind some kind of horn; the longer, the better it sounds. Check as previously discussed and repair the same way if necessary.

Horn speakers rattle when they are overloaded, and all the time if the thin metal disc, the diaphragm has been bent or if the spacer between the diaphragm and its support has been removed. There must be a space between the diaphragm and the poles.

Low horn volume can be caused by too much space between the poles and the metal disc and a weak magnet.

MAGNETIC SPEAKERS

These consist of a short metal bar mounted on a flexible arm and supported between two coils and within a strong magnetic field. One end of the bar is attached to some sort of sounding system; the paper cone was most popular.

If the coil is open, there will be no response at all. If the little bar is off center and touching the poles of the magnet, the speaker will squeak or rattle. If the flexible arm is loose, the speaker will rattle. If the permanent magents are weak; efficiency will be lost and the volume will be lower than normal.

Should the paper cone be bent, try a little moisture and a warm pressing iron. If the cone is ripped, do not join the ripped edges with a continuous bead of cement. Instead, use Duco or similar cement and join the edges with a number of beads of cement an inch or so apart. This permits the cone to flex with the sound. Make a solid joint and the cone will rattle.

DYNAMIC SPEAKERS

A dynamic speaker consists of a coil of wire mounted on a short paper cylinder, fastened to a paper or treated cloth cone. The coil of wire is positioned within an intense magnetic field. As current flows through the coil it moves and sets up corresponding motions in the cone which produces the sound.

The field on old speakers is produced by current flowing through a coil of wire (field coil). On new speakers, the field is produced by a permanent magnet. All dynamic speakers are interchangeable so far as voice coil connections are concerned. However, if the difference in impedance between the new and the old is great, there will be a loss of volume and a slight amount of distortion, but otherwise no harm will be done.

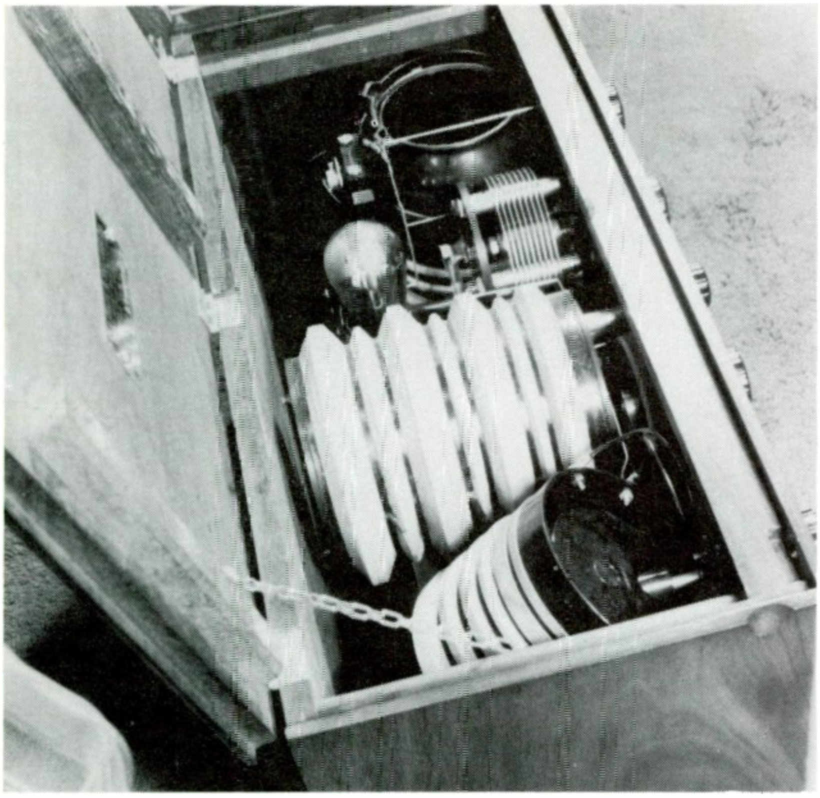
PM speakers can be used as replacements for field coil speakers; just leave the old coil in place if it is part of the power supply circuit. Field-coil speakers cannot be used in place of PM speakers unless provisions are made for supplying the field current.

In normal operation, the voice coil moves up and down in its well or slot without touching the pole pieces. With time and physical damage, the voice coil may contact the poles. When this happens you hear a hissing or rasping sound. To correct, the voice coil must be recentered.

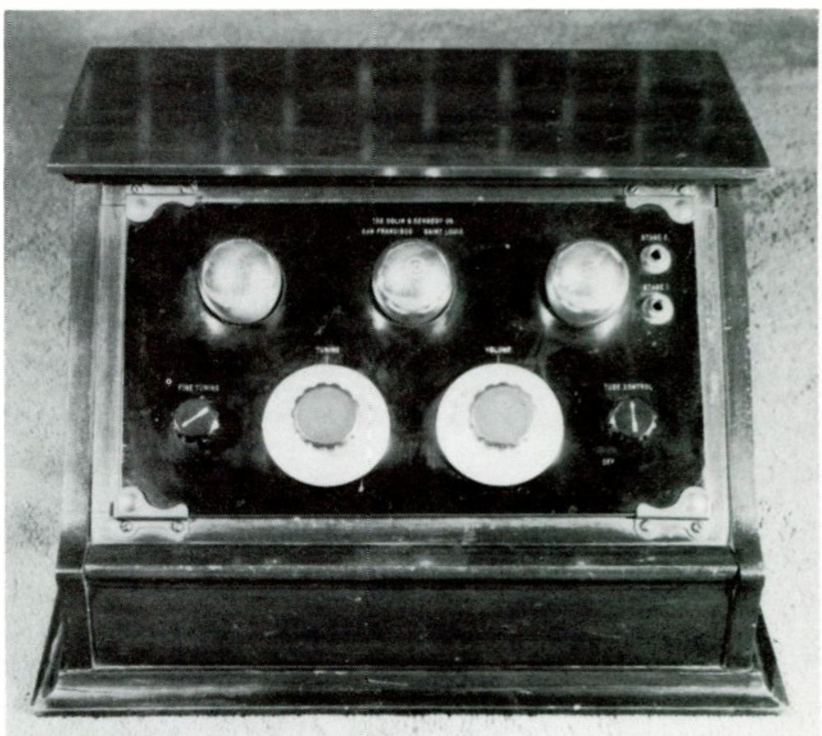
Remove the felt or paper cap from over the voice coil. Loosen the central bolt that holds the spider that supports the voice coil. Use slips of stiff paper or plastic and stuff them between the voice coil and the central pole to center the coil. Tighten the center bolt. If there is no center bolt, or if the just mentioned correction cannot center the cone, you have to loosen its edges. Use a razor knife or loosen the screws. Then readjust and center the cone. Re-cement the cone edges or tighten the bolts. Should the cone become oval shape, or should the coil open, the entire cone has to be replaced.

If the cone is ripped, follow the suggestions given previously for cones. Don't make a solid, unflexible repair in any cone.

Midget dynamic speakers. When a very small speaker rattles or hisses, you can follow the previous suggestions and loosen the entire cone: Or you can sometimes bend the speaker frame a little, or pour a few drops of very heavy motor oil into the space between the voice coil and the central pole. This doesn't cure anything, but it lubricates the parts and the rattles generally disappear. Turn the speaker on its back when you do this.



Inside the Colin B. Kennedy model 110. A single tube regenerative receiver made in 1922, it had a range that included frequencies below the broadcast band as well as the broadcast band. This receiver is highly prized by collectors for its complexity and fine workmanship. Jacob collection.



The Colin B. Kennedy Model 5 of 1923. It has a regnerative detector stage followed by two audio stages, with two output plugs so that you could use one or two stages of audio as you wished. Jacob collection.

chapter seven

A FEW TIPS ON COLLECTING

I can clearly recall a winter's day sometime in 1930, walking home for lunch from junior high school and seeing a long row of ash cans on the sidewalk. On this particular day, several of the cans held discarded battery radios. I remember clearly because none of the receivers were of a size that I could carry, and I had no tool with me with which to dismantle any of them. I was keenly disappointed, as I was a avid experimenter even then. But I did manage to get a pair of Baldwin earphones. They were beautiful, having instead of the usual earphone arrangement of magnet, coil, and metal plate, a mica diaphragm driven by a moving bar within a coil and magnet—just like a magnetic speaker.

During those years it wasn't unusual to see leather-covered furniture, Tiffany-type stained glass lampshades, and cut glass bowls discarded with the furnace ashes and other trash. (One generation's memorabilia is the previous generation's discards.)

It is estimated that in 1922, sixty thousand American families owned radio receivers of one kind or another. By 1930, almost fourteen million homes were equipped with radio receivers.

Where are all those receivers today? Most of them went into the junk pile, supersceded by simpler, better performing, non-battery equipment. Comparatively few were saved, and those by accident, rather than design. In 1937 I purchased a Model A, 1930 Ford for twenty-five dollars and sold it for ten dollars a year later. Had I stored it in the condition it was then, it would be worth close to eight thousand dollars today. But few of us examine the gadgets and machines we have on hand today with the thought of preserving them for future appreciation. So fourteen million pre-1930 receivers were casually discarded. I would estimate that less than ten thousand pre-1930 receivers of all types are extant today.

How can you secure receivers and associate equipment and memorabilia worth collecting? There are any number of sources. Here are some. You may possibly find more:

City dumps
Antique dealers
Junk shops, etc.
Garage and estate sales
Newspaper ads
Other collectors

While it may not appear possible to find old-time receivers left for trash pick up these days; it still does occur now and then. You can keep your eyes open as you drive down the street. You can visit the city dump. You will be amazed by the number of useful objects you can find there. And, you can possibly make a deal with some one working in or near the dump. Many people working for the municipality, and others actually earning a good living scouring the trash for metals, are willing to save items if they are certain of decent payment. All you need do is describe what you want and make the reward substantial. Remember, while these people may look like ragpickers; they aren't by any measure. So don't offer a couple of dollars; make it at least $25.

Antique dealers may appear to be an expensive source of radio memorabilia, and while this is too often true, it is not always the case. And sometimes it is wiser to pay more, than forego a choice item that may never surface again.

There are, however, methods and techniques of dealing with antique dealers and their ilk that can reduce the price of the item in question. First things first, after just one aside: If the following approach is one you have already used, the writer begs your indulgence.

Never ask the dealer if he has any old radios for sale. Ask for nothing more than permission to browse. If you are pressed for your sphere of interest, state something vague and undefinable. "Looking for some sort of gift for a friend."

Do not give the radios, if there are any, any more attention than any of the other items on display. Don't smile at any time. If the dealer has posted no prices, ask him or her and look keenly disappointed. At no time express pleasure at seeing anything, particularly an old radio you would like to purchase.

Circle your quarry; sidle up to it. How much for this? How much for that? Make it appear as if you are trying to decide on the basis of price which item you will purchase.

Having supposedly made a choice, go slowly to the radio and point out its defects, if any. Where are the knobs? Can these scratches be easily removed? And finally, the big one: "Does it work?" If it is a battery receiver, chances are good that he will not have the batteries on hand. Your stand, and it should be conveyed with a gesture and not words; what good is a radio if it doesn't work.

When you get down to actual price, be very careful not to insult and anger the dealer. If you do, he or she may not sell the radio to you at any price. There is nothing wrong in suggesting a lower price, but it must be done with tact.

If you take a stand and state, in one set of words or another, you will pay so much and no more, you run the risk of giving up the item or eating your words. Remember, if you walk out, you will possibly pay more than the original figure. He isn't bound to sell for the same price when you return.

One final point on price, and this is where your expertise, your advantage over the dealer, may come into play; if the receiver is a good buy, don't haggle. Pay the sum without a word and leave quietly. Dealers are very sharp. They have to be; it's a tough game. If they sense your interest, some of them will change the figure right under your nose "Oh, this is the wrong tag; someone erased a zero."

Your advantage over the average antique dealer is that radios are usually outside his experience. He may not know what they are worth and doesn't know the difference between receivers. At the present writing a cathedral-type, line-powered receiver in operating condition is enjoying a vogue with "campy" non-collectors who are furnishing their homes in a more interesting manner at comparatively low cost. For example, a Zenith table model circa 1935—36 fetches around $125. This is a fairly common receiver. Zenith sold thousands, perhaps millions of them, and the price at this writing is fairly steep compared to what older, less numerous receivers are going for.

Thus you can often secure battery receivers, which may be operable, for a low price merely because no batteries are on hand and the dealer is anxious to make a sale. Often they will go for less than "electrics" in working condition.

You may also pick up tubes and components for very little at an antique dealer because he is not a radio mechanic and cannot correlate the parts to others, and assemble or repair a receiver.

Incidentally, never let an opportunity to purchase old radio tubes or parts go buy. They are the coins of exchange between radio collectors; and tubes especially are invaluable.

One more point about antique dealers before going on: If you are fortunate enough not to have to count your dollars, it pays to **work with** antique dealers. Detail what you want and approximately how much you will pay for it. The dealer will then aid you in your search. It is an expensive way of collecting, but it works.

Another point; you will do better price wise in small towns and rural areas than you will in the large cities. But, the big city dealers have much more extensive collections.

Junk shops, thrift shops, and house-wrecking companies that save and sell what they find inside the buildings they wreck are another source of old radios. Unfortunately, you will have to scout a large number of these establishments before you come up with anything worth collecting. Thus you will be exchanging time, effort, gasoline and lunch money for what you will save on the purchase price of your collectibles.

Generally you will encounter weird prices in many of the junk and thrift shops. Some prices will be give-away bargains, others will be ridiculously high. The people operating these places usually know little or nothing about antique radios. They guess at the prices. If the figure asked is unrealistically high, send a friend back in a few days—there may be a surprising change.

Still another source of old radios is garage and estate sales. Garage sales, also called tag sales, are becoming more and more common in this country. If you haven't attended one (or held one yourself), let me explain. They are simply means used by one household to rid itself of unused, unwanted bric-a-brac and accumulations at the expense of other households. The turnout for these sales are surprisingly good. Some people go to sales regularly as a form of weekend entertainment. Prices are whatever the owner thinks he can get and are usually open to discussion. The usual knockdown is about one third. If you have the strength and patience, you can often find something you need at an almost-for-free price.

Estate sales are more formal sales, usually advertised in local newspapers. It is here that you are most likely to encounter old radios and associate memorabilia. However, it is also here that you are going to encounter serious opposition in the form of dealers who know their stuff and radio collectors with money. At some estate sales they will accept personal checks. At others, they will take nothing but cash or certified checks. Generally, it is inspect one day and bid at auction the following day. Best check on details before you attend.

Newspapers can also lead you to old radio receivers. Some of the larger papers carry classified ads under the heading, "Antiques." But, most often you will find what you are seeking through the "ad" papers. You will recognize them by their titles: Trading Post, Buy-Lines, Customart, Bargain Shopper, etc. They run ads for very little or nothing, charging a percentage of the sale price if and when items are sold. Some collectors run radio-wanted advertisements in these papers for comparatively small sums. Sooner or later the wanted ads will bring you to the attention of other collectors or people with radios to sell.

Collectors, of course, are another source of old radios as well as hobby gossip and companionship. Generally, collectors do not sell but swap their duplicate equipment for things they do not have. See the Appendix for additional information on collectors.

The prices you may have to pay for old radio equipment depends on many variables, and although the section of this book on Current Prices does list the approximate going rate for various radios and associate items, there are no hard and fast rules nor guides.

Primarily, scarcity is the major determinant. However, it isn't necessarily the major factor in every case. Another that affects price after scarcity is original appearance (not to be confused with present physical condition). Some of the old receivers are more interesting visually than others. Some have more dials and switches. Some have meters. Or, they look more like old radios should than possibly scarcer and older receivers look.

A good illustration of this point is the selling price of homemade equipment versus factory made equipment of the same period. Very little homemade stuff is visually attractive. Amateurs simply did not have the machine tools necessary to emboss a hard rubber panel, and they didn't have the time nor patience to construct a beautiful cabinet out of fine wood. Homemade equipment may have been better and more advanced technically than contemporary factory equipment, but the homemade stuff **doesn't look it.** In the main, there is little amateur-constructed equipment that you would want to display. Yet amateur receivers are scarcer than smiling crocodiles.

I believe the reason for the emphasis on appearance is due to the background of most collectors of old radios. Like myself, they grew up in the days of the black-rubber-paneled laboratory equipment and Amazing Stories with illustrations by Paul. The equipment sought has the 1900 look of mystery. Whereas the Sony 1 inch TV receiver is infinitely more complex and wonderous, no one is collecting 1 inch TV sets; at least not yet.

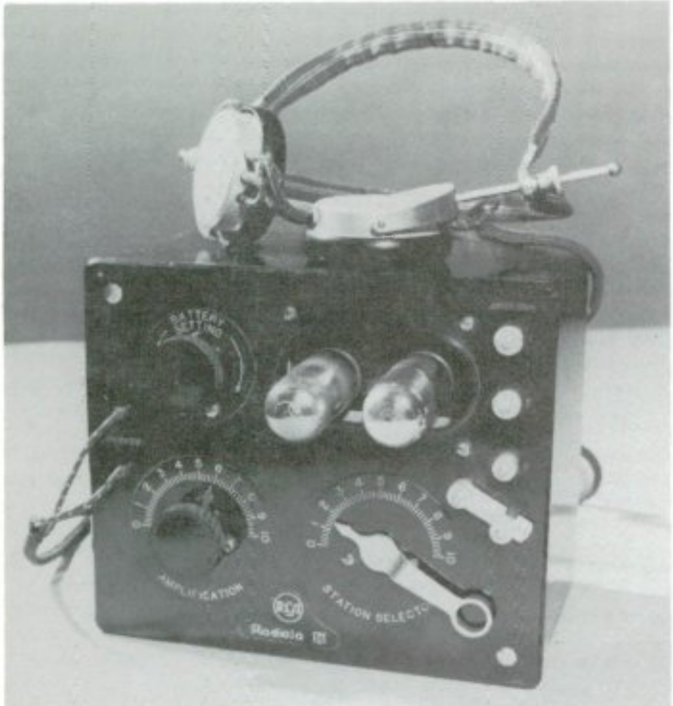
Others factors affecting the dollar value of old radios include their present physical condition and whether or not they work. To have any value at all, beyond personal, a receiver must be of museum quality.

A receiver may have a few touched up scratches as the result of ordinary wear. But, if there is a dial or knob missing, if the front panel is cracked or the cabinet is coming apart, the receiver is worth no more than its parts as replacement units for other receivers. And it is best to be cautious about purchasing a mashed piece of equipment. You may be unable to find replacement parts, especially front panels and cabinets.

Operating condition is another important consideration. True enough, few collectors keep their battery sets powered, but the serious collector will never exhibit a receiver that does not work. A great part of the pleasure of owning old equipment is that it does work, even if you do not turn it on every time you look at it.

Operating condition cannot be taken lightly, especially in the matter of tubes. Some tubes were fairly common in the old days and are still available today. Other tubes, especially the early tubes, were never common and cannot be found apart from their original receivers at any price. And although it isn't at all technically difficult to replace one tube with another, nor even to replace sockets in the old sets—they have so much inner space, changes alter a receiver. A changed receiver is no longer an original, it is a bastard, and as such cannot be considered a museum piece.

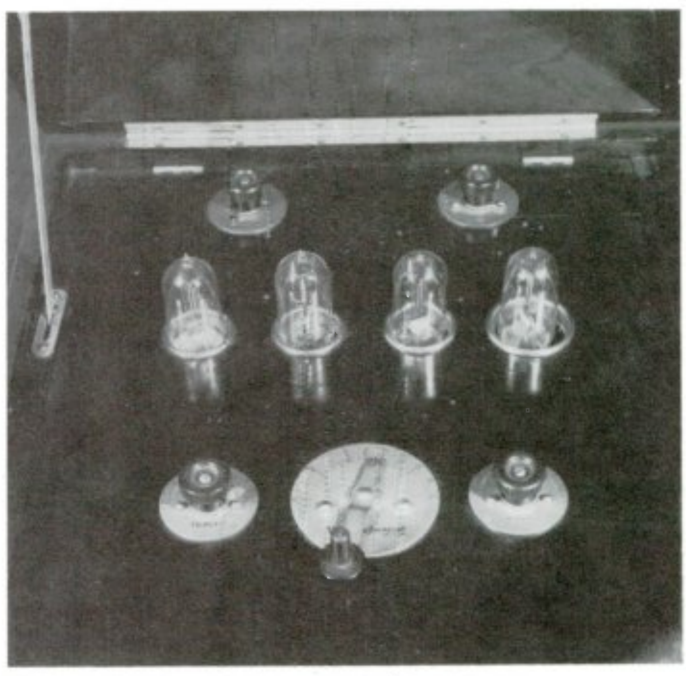
Some of the parts, capacitors, resistors, etc., can be replaced with identical parts of the same era without altering the essential originality of the receiver. But, very often major components of the receiver were manufactured specifically for the receiver, and electrically identical components simply will not fit physically, nor will they look as if they belonged. Just where you draw the line is a matter of personal preference and individual situations. There is no reason why a receiver should remain inoperative just because you don't want to install a "new" resistor or capacitor. (The "original" part can be installed whenever you secure it.) The belabored point is that an altered receiver is never as valuable as an unaltered, original receiver. And this is a vital consideration when discussing receiver price.



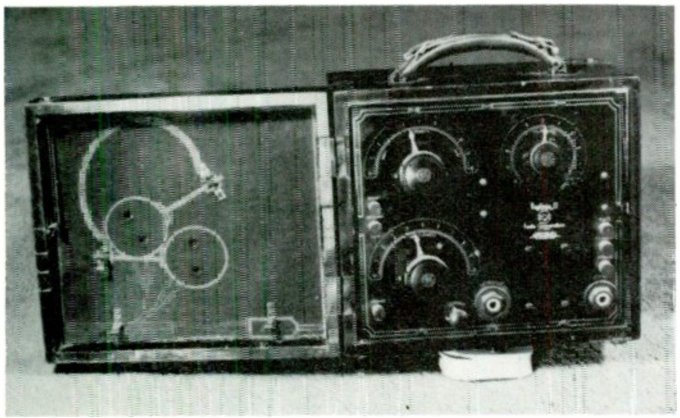
RCA Radiola III. Made in 1923, this two tube regenerative receiver has a bakelite panel that carries all the controls. The "Battery Setting" varies filament voltage. "Amplification" controls regeneration. Courtesy RCA.

Radiola Senior Amplifier, a two tube amplifier made for RCA by Westinghouse, was designed to be used in conjunction with company's one tube receivers. Circa 1923 Courtesy RCA.

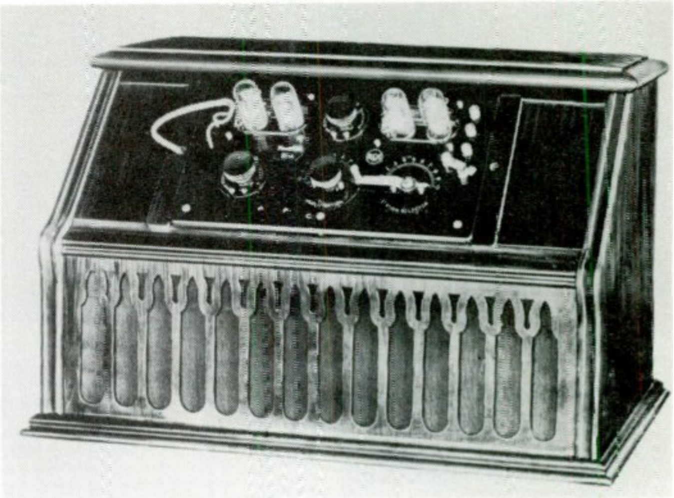
RCA Grand Radiola of 1922. Battery and horn were internal. Used four tubes in a regenerative circuit, with a single tuned stage. It sold for $350.00 in its day. Jacob collection.



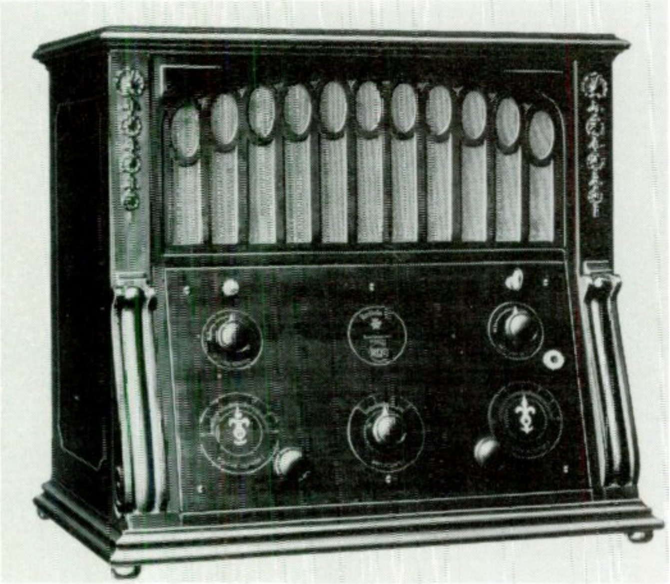
Close up of the Grand Radiola, made by Westinghouse. Jacob collection.



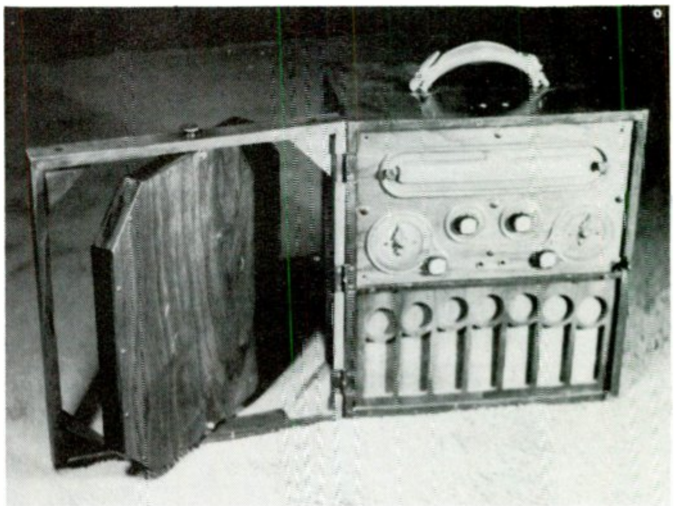
Portable Radiola II. It used two type 199 tubes in a regenerative circuit and sold for $97.50 in 1923. Two plug jacks permitted listener to choose between listening to one tube or two. Jacob collection.



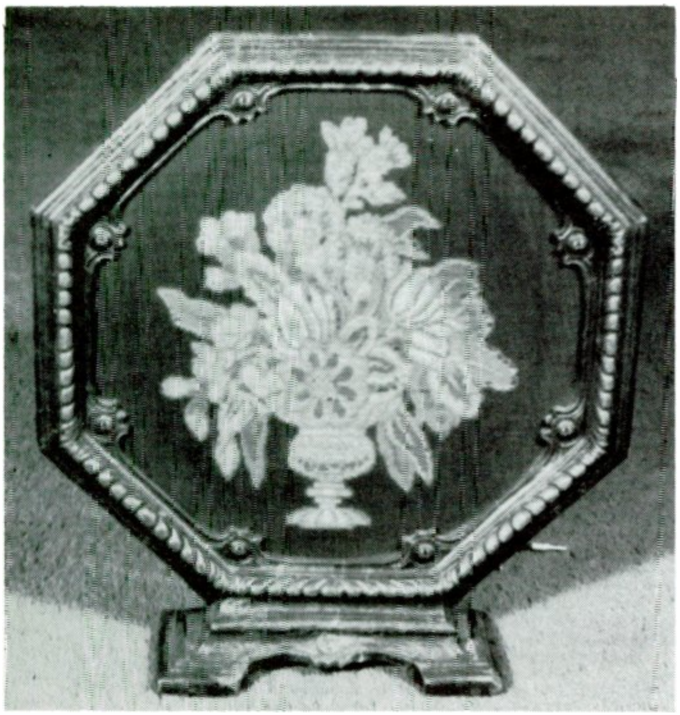
Four tube Radiola IIIA, DeLux. Still the same lever, station selector, and single tuned circuit. Probably utilized three stages of audio amplification. Horn is behind grill. Made in 1924. Courtesy RCA.



Another 1924 RCA, the Radiola X has a built in horn and two tuned stages. It was still regenerative. Courtesy RCA.

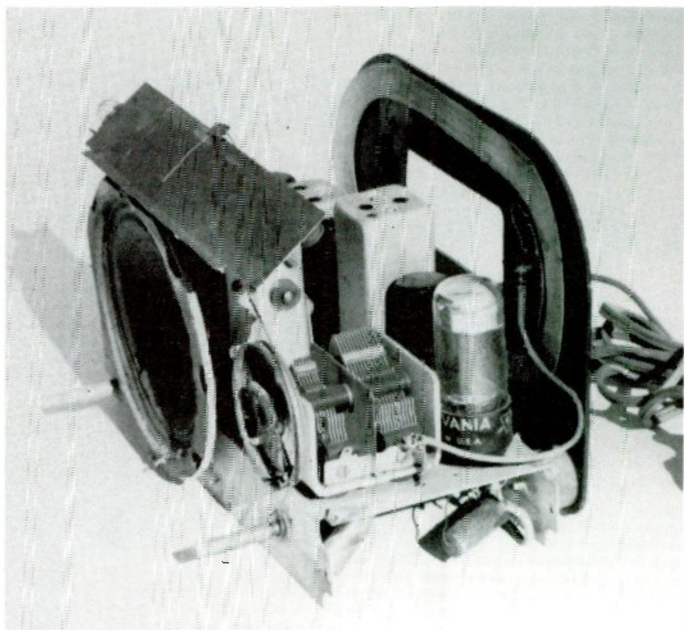


Possibly the most famous of the 1925 receivers, at least among collectors. This is the RCA model 26 portable superhet. It had six tubes, with all stages wax sealed against moisture. Jacobs collection.



RCA magnetic speaker, front and side view. It is their model 103 and has an internal transformer and a capacitor to alter and improve its tone. Protective cloth is a normal part of the speaker, which is about 14 inches high. Jacob collection.

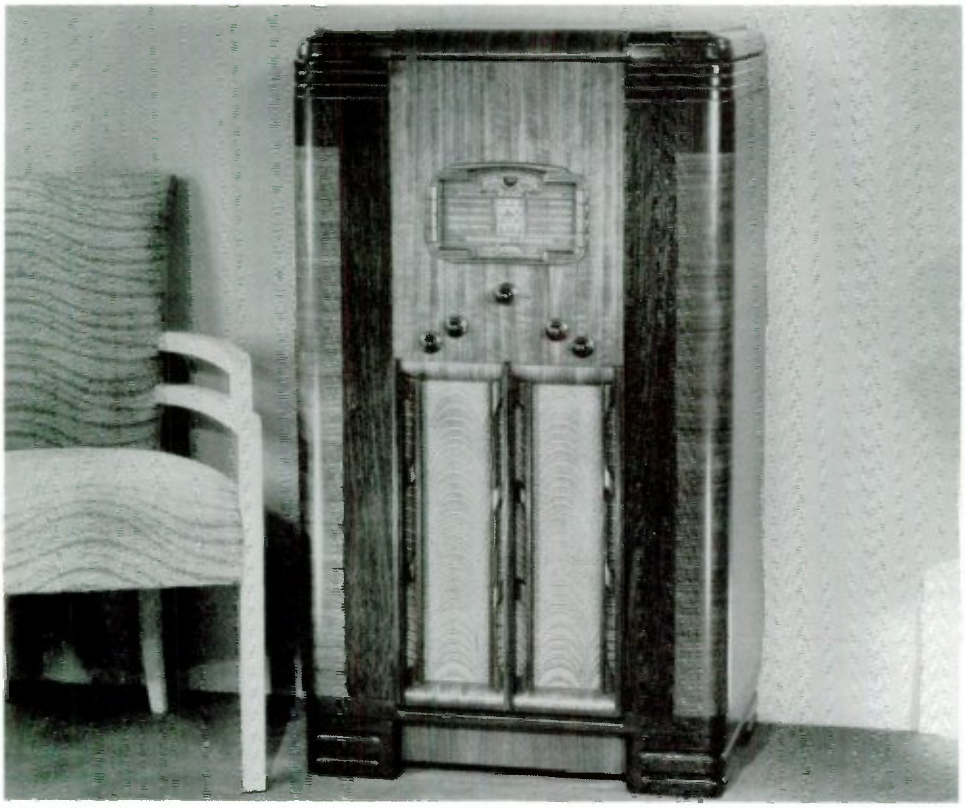
Exterior of RCA Model 12X2, a five tube, series filament, superhetrodyne midget, circa 1938. Author's collection.



Interior of RCA Model 12X2. Author's collection.

Stromberg-Carlson Model 654, a 1930 superhet with a record player beneath its lift-up top. This model dates from around 1927.
Courtesy Stromberg-Carlson

Stromberg-Carlson Treasure Chest model, circa 1928. Single-control tuning, but use of four additional controls is unknown.
Courtesy Stromberg-Carlson.

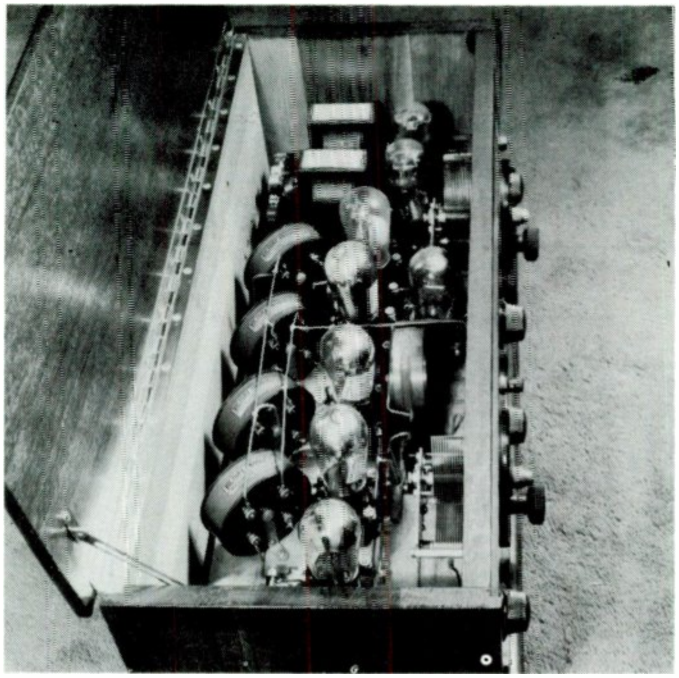


1935 Stromberg-Carlson. This is a four-band receiver with an electric eye for tuning assistance.
Courtesy Stromberg-Carlson.

An ornamental magnetic speaker manufactured by Tower sometimes in 1925. Jacob collection.

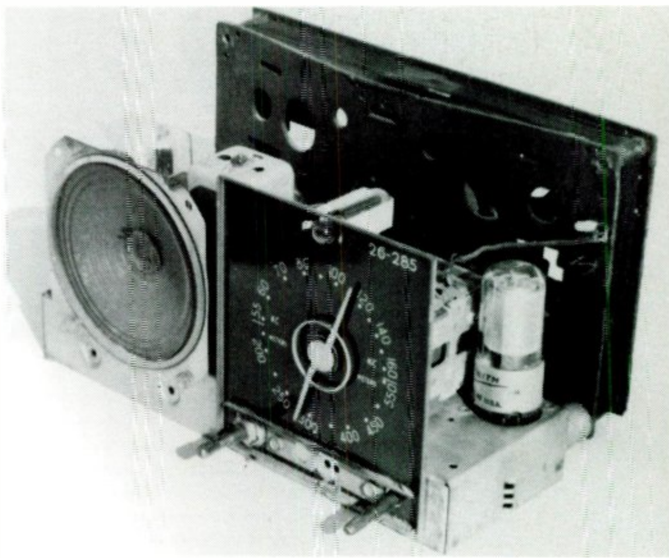
Western Electric amplifier, battery powered, circa 1922. Jacob collection.

Victoreen Super receiver, using an advanced superhet circuit and sold in kit form, 1928 to 1929. It had eight tubes and a tunable second detector. Jacob collection.



Inside the Victoreen receiver. Jacob collection.

Zenith 5D-611, a five-tube, series-filament superhet. Manufactured about 1941. Author's collection.



Inside the Zenith 5D-611.

Tel. Yonkers 7582

YONKERS RADIO SERVICE

- MAX ALTH -

Installation
Repair & Renting
of Sound Systems

106 Morris St.
Yonkers, N. Y.

Author's business card from when both he and radio were young.

chapter eight

ESTIMATED DOLLAR VALUES OF VARIOUS RECEIVERS

MANUFACTURER			
A.C. Dayton Co.	1923	Crystal set	$ 85.
	1924	Super Six	$125.
	1925	XL5	$140.
	1929	XL71, Navigator	$210.
Acme Apparatus	1924	Acmephone	$ 95.
Adams-Morgan	1921	Paragon Regen. RD5 (receiver)	$150.
		A-2 (amplifier)	$130.
		R10-short wave pre-tuner	$210.
		DA-2 Det & Amp.	$250.
Ajax	1924	Crystal set	$ 70.
Airphone	1920	Crystal set	$ 65.
All American Mohawk	1926	Duet	$105.
		R HiBoy	$130.
American Bosch Magneto Co.	1924	Amborola	$170.
	1925	16 Amborola	$150.
	1926	35 Royal	$125.
American Specialty	1924	Electrola	$225.
	1926	30 Republic	$170.
Amrad	1922	Short wave	$450.
	1925	35	$300.
	1927	DC7 Windsor	$220.
Andrews Radio	1924	A	$180.
Anylite Elec.	1925	King Cole	$250.
	1926	4 and 5	$180.
Apex Elec. Mfg.	1925	Super 5	$250.
	1927	Lyric	$100.
Atwater Kent	1921	5	$950.
	1923	10 (kit)	$400.
	1925	7960 Compact	$350.
	1926	30	$200.
	1927	36	$150.
	1928	40	$125.
	1929	55	$150.
Audiola Radio Mfg. Co.	1921	Audiola	$230.
	1924	Audiodyne, Super Midget	$450.
	1925	Sealed Five	$300.
		Big Six	$350.

Automatic Radio Mfg. Co.	1925	Bluebird	$200.
	1926	Arc	$200.
	1929	B Tom Thumb	$150.
Blue Seal	1925	Cincodyne	$300.
	1926	Blue Seal	$200.
Bosworth Electric Mfg. Co.	1925	B-1 Air Set	$275.
Branston Inc.	1924	R310 DeLux	$250.
		R304 Superhet	$250.
Bronx Radio Equipment	1923	Breco	$150.
Clapp-Eastham	1914	Crystal set	$200.
	1922	Radak HR	$250.
Crosley	1922	VI	$250.
	1922	X	$225.
	1925	Pup	$250.
	1924	51 (det)	$200.
	1924	51A (amp)	$150.
	1926	5-38	$200.
	1928	608 Gembox	$125.
De Forest	1919	15-panel unit	$800.
		P-300	$650.
	1920	T-200 Tuner	$500.
	1921	Interpanel set	$400.
	1923	D6	$300.
	1923	D10	$350.
	1923	Everyman crystal set	$150.
	1924	F-5	$275.
Federal	1921	Jr. crystal set	$120.
	1922	58 DX	$350.
	1922	57	$300.
	1923	61	$350.
Freed-Eiseman	1924	FE-15	$200.
	1923	NR-5	$250.
Freshman	1924	Masterpiece	$200.
	1925	Masterpiece	$150.
Gilfillan	1924	GN-2	$200.
	1925	Model 10	$200.
	1925	6-tube portable	$220.
Grebe	1919	CR-6	$400.
	1921	CR5	$250.
	1925	Synchrophase	$350.
	1928	A-C Six	$150.
Colin B. Kennedy	1921	220	$450.
	1923	Model V	$300.
	1924	Model 22	$300.
	1925	XV	$320.
Magnavox	1925	TRF-5	$220.
RCA	1923	Radiola Senior	$150.
	1922	Aeriola Jr. Crystal set	$100.
	1923	Radiola Special	$150.
	1923	Radiola III & AR-805 (amp)	$250.
	1925	Radiola X	$300.
	1925	Radiola 26	$350.

Fada	1924	175A	$200.
	1927	480B	$300.
	1929	18	$100.
	1930	81	$120.
Grigs-Grunow	1928	61, 62, 71	$ 85.
	1929	91	$ 75.
Hartman Electric Mfg. Co.	1925	10A Adam Period	$325.
	1926	Compact Jr.	$125.
Howard Mfg.	1924	Table	$220.
	1925	D4	$175.
Indiana Mfg. Company	1925	Hyperdyne 700	$400.
Jones	1921	H	$220.
	1925	Symphony	$200.
	1927	Harmonic	$150.
Kellog	1922	One Tube	$100.
	1925	Wavemaster	$325.
	1926	504	$270.
	1930	533	$185.
Kemper	1925	K52	$365.
	1926	K52	$350.
	1929	K57 Kompak	$260.
King	1926	Neutrodyne	$185.
Kodel	1922	S-1 (crystal set)	$150.
	1924	P-11	$175.
		P-12	$200.
		C-11	$220.
	1925	Logodyne 53	$275.
Lytton	1925	101 A Wav-O-dyne	$325.
Magnaformer	1926	Super	$250.
Mazda	1924	Grand	$180.
	1925	Junior	$175.
Metro Elec. Co.	1925	Metrodyne	$300.
	1926	Super 5	$220.
	1928	Super 8	$200.
Michigan	1922	Senior	$350.
	1923	Midget	$300.
	1925	MRC-14 DeLuxe	$260.
Midwest	1922	Miraco	$ 75.
	1924	K	$150.
	1929	AC8	$100.
Mission Bell	1930	Mantle	$200.
Mohawk	1925	A5	$320.
	1928	Cortez	$150.
Murdock	1923	5-tube Neutrodyne	$285.
	1925	100	$220.
	1927	350	$160.
National Carbon	1927	1	$180.
	1928	2	$150.
	1929	54	$120.
Operadio	1925	Empire C	$320.
Ozarka	1929	91 Viking	$150.
Philco	1928	551	$120.
	1929	525	$100.

	1930	20A	$100.
	1930	Baby Gra	$100.
	1930	41	$100.
Pilot Radio	1926	Universal	$250.
	1927	Super Wasp	$240.
Powerola	1925	C-3	$210.
	1926	Highboy 110	$140.
Q.T. Radio	1925	Little Giant	$180.
Radio Guild	1922	Harkness Super-Regen	$300.
	1923	RG 510	$320.
Randolph	1926	Borgia II	$285.
	1927	Randolph 7	$210.
Reichman	1925	50 Thorola Islodyne	$340.
	1926	58 Thorola	$300.
Silver-Marshall	1928	620 Silver Cockaday	$180.
	1930	30A Princess	$120.
Simplex	1926	6-A	$265.
	1927	B-Electric	$185.
Sleeper	1923	Monotrol	$260.
	1926	Scout 57	$185.
Sonora	1924	241 Ware	$250.
	1926	D800	$180.
	1928	A50	$145.
Spielman	1923	Seco	$125.
	1926	Air Pilot	$140.
Splitdorf	1928	Abbey Jr.	$265.
	1928	Devon	$200.
Steward-Warner	1928	801A	$175.
	1930	1 Avon	$150.
Stromberg-Carlson	1924	1A	$285.
	1926	330	$250.
	1927	801 B	$225.
	1928	Treasure Chest	$250.
	1930	652	$200.
Sun	1925	50 Sun Reflex	$265.
Tuska	1922	225	$350.
	1922	224	$280.
	1925	305 Superdyne	$220.
United Engine	1927	United Lan Sing 90	$195.
	1930	50-301	$150.
U.S. Radio and Television	1929	22	$150.
Vibroplex	1925	4 Martinola	$250.
Western Air Patrol	1926	100	$140.
	1927	AC100	$120.
	1928	80	$100.
Wilcox	1925	10H Hexair Coil	$300.
	1926	J Cathedral	$150.
Wireless Shop	1923	Perflex detector	$150.
Work Rite	1924	Neutro-Grand	$240.
	1925	Chum	$250.
	1926	Winner Five	$225.
	1929	33	$150.
Wright	1924	ARF	$250.

	1925	Acme Special	$240.
	1927	7A	$180.
Wurlitzer	1926	MF%	$180.
	1929	9A	$150.
	1930	840	$125.
Zenith	1923	Jr.	$250.
	1923	4R	$300.
	1924	Super Portable	$450.
	1925	Chinese	$350.
	1927	11	$150.
	1929	40A	$125.
	1930	40A	$100.

Appendix

ANTIQUE RADIO COLLECTOR ASSOCIATIONS

The Antique Wireless Association, Inc.
Write to Lincoln C. Cundall, W2QY
69 Boulevard Parkway
Rochester, N.Y. 14612

The Antique Radio Club of America
Write to John Drake
129 Oenoka Rd.
New Cannan, Conn.

ANTIQUE RADIO MUSEUMS

Electronic Communications Museum
East Bloomfield, N.Y.

Open May 4, through December. On Sunday from 2 to 5 and on Wednesday 7 to 9. No admission charge. Groups may phone (315) 657-7489 or (716) 224-9519 for opening the exhibit at other times.

The Motorola Museum
1303 E Algonquin Road
Schaumburg, Ill. 60196

This museum will be open to the public by appointment only. Call Miss Sherree Niepomink or Charles Sengstock at (312) 576-5305 for admission during the normal working day. There is no admission fee.

MAIL-ORDER RADIO PARTS AND EQUIPMENT HOUSES

Lafayette
111 Jericho Turnpike
Syosset, L.I. N.Y. 11791

Radio Shack
2617 West 7 Street
Fort Worth, Texas 76107

Publishers of antique radio books and data
Vintage Radio
P.O. Box 2045
Palos Verdes Peninsula
Calif. 90274

TUBE DATA AND SIMILAR TUBE TYPES

Tube Type	Similar To	Filament Voltage	Maximum Plate Voltage	Filament Current [Amperes]
Audio IV	—	1.2	45.	
AX	01A	5.	135.	0.250
B	V199	3.3	90.	0.063
H	01A	5.	45.	0.250
00	01A	5.	45.	0.250
00A	40	5.	45.	0.250
01	01A	5	90.	0.250
01A	—	5	135.	0.250
DV2	01A	5	135.	0.250
DV5	01A	5	135.	0.250
WD11		1.1	90.	0.25
WD12		1.1	90.	0.25
V99	B	3.3	90.	0.063
X99		3.3	90.	0.063
UV199	V99	3.3	90.	0.063
UX199	X99	3.3	90.	0.063
200	—	5.0	135.	1.0
201	—	5.0	135.	1.0
200A	0A	5.0	135.	0.25
201A	01A	5.0	135.	0.25
C299	V99	3.3	90.	0.063
CX299	X99	3.3	90.	0.063
300	00A	5.	45.	0.25
300A	00A	5.	45.	0.25
301	00A	5.	45.	0.25
301A	00A	5.	45.	0.25

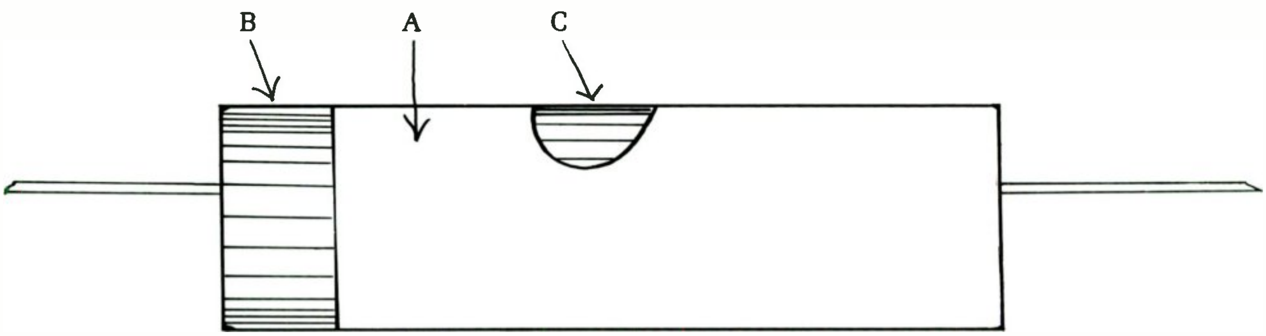
The resistor color code devised by RMA (Radio Manufacturers Association) and used on all resistors. Note that each of the ten colors always indicates the same numerical figure.

Color	Figure
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

(A) Body color
The first figure of the resistance value

(B) End color
The second figure

(C) Dot color
Number of zeros following the second figure.



If a carbon resistor has a body color (A) of green,
An end color (B) of yellow,
And a dot color (C) of red.
Its resistance is
Green = 5
Yellow = 4
Red = 00
5400 ohms
If its body color (A) is orange,
Its end color (B) is grey,
Its dot is green
Its resistance is 3,800,000 ohms.

ESTIMATING THE AGE OF A RECEIVER

You can estimate the age of a radio by the serial numbers on the patent notices often found on the back of old receivers. Bear in mind that the set may not be as old as the date of patent issue, because each patent has a life of fourteen years, but the receiver certainly cannot be any older.

If the patent number is the following or smaller number	The patent was issued on or before January
660,100	1900
720,010	1902
770,005	1904
831,000	1906
889,990	1908
950,012	1910
1, 19,900	1912
1,080,120	1914
1,151,760	1916
1,240,096	1918
1,319,896	1920
1,410,206	1922
1,490,988	1924
1,580,765	1926
1,659,998	1928
1,761,000	1930
1,849,076	1932
1,941,667	1934
2,010,654	1936
2,100,008	1938
2,179,765	1940
2,270,221	1942
2,340,106	1944
2,389,987	1946
2,430,701	1948
2,49,788	1950

ANTIQUE RADIO CLUBS

Antique Radio Club of America
1 Steeplechase Rd.
Devon, PA 19333

Antique Wireless Association
Main Street
Holcomb, NY 14469

Buckeye Antique Radio and Phonograph Club
1937 Stoney Hill Dr.
Hudson, OH 44236

California Historical Radio Society
c/o San Jose Historical Museum
635 Phelan Avenue
San Jose, CA 95112

Canadian Vintage Wireless Association
102 Parkhurst Blvd.
Toronto, Ontario, M4G 2E6
Canada

DeForest Pioneers
254 Vincent Ave.
Lynbrook, NY 11563

Indiana Historical Radio Society
245 N. Oakland Ave.
Indianpolis, IN 46201

Mid-America Antique Radio Club
2301 Independence Ave.
Kansas City, MO 64214

Northwest Vintage Radio Society
Box 13544
Portland, OR 97213

Old-Old Timers Club
Box B
San Gabriel, CA 91778

Quarter-Century Wireless Association
2012 Rockingham St.
McLean, VA 22102

Radio Club of America
Box 2112
Grand Central Station
New York, NY 10017

Rocky Mountain Antique Wireless Association
1638 Quebec Street
Denver, CO 80220

Society of Wireless Pioneers
PO Box 530
Santa Rosa, CA 95402

Southwest Vintage Radio and Phonograph Society
Box 19406
Dallas, TX 75219

PERIODICALS DEALING WITH ANTIQUE RADIOS

Antique Radio Topics
Box 42
Rossville, IN 46065

Antique Phonograph Monthly
3400 Snyder Avenue
Brooklyn, NY 11203

Oldtime Announcers Club
Box 1174 Littlerock, AR 72115

The Classic Radio Newsletter
Box 28572
Dallas, TX 75228

Collectors News
Box 156
Grundy Center, IA 50638

The Horn Speaker
9820 Silver Meadow Dr.
Dallas, TX 75217

Radio Age
1220 Meigs St.
Augusta, GA 30904

Worldradio News
2120 28th St. Sacramento, CA 95818

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